

18 More
Scanner Enhancements!

Scanner Modification Handbook

Volume 2

*Step-by-Step
Upgrading Instructions!*



by Bill Cheek

Scanner Modification Handbook

Volume 2

By Bill Cheek

CRB Research Books, Inc.

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Dedicated to: The Hackers of the world.

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Introduction

Introduction To Volume 2

The first volume of my **Scanner Modification Handbook** was a fishing expedition into uncharted waters for both its publisher and me. I had never written a book like that before, and the publisher had no firm idea of how it would be received. It was a gamble for the both of us. This second volume, however, is no blind step. I made a commitment to the publisher to write this volume within less than a month of the release of the first volume, based upon your immediate warm reception and overwhelming response. In fact, the initial printing of the first volume was practically sold out and was being reprinted within only eight weeks of publication.

Your enthusiasm and clamor for more, more, more... served to etch my commitment into stone, and here it is, by popular demand. A commitment alone, however, would not have brought us to this point. There had to be more, and there was. When Volume 1 was issued, my mail box was stuffed daily with your gracious replies, positive critiques, pertinent suggestions, and detailed comments. Among that overwhelming response were a number of contributions of technical material, ideas, suggestions, and variations including diagrams and notes for additional scanner modifications. By the third month, I had three file folders filled with ideas and information for this volume. In jiffy time, ample material for Volume 2 had been collected and laid out into organized piles around my shop. All I then had to do was research, develop and debug the many designs; bring it all together and write; a task that proved to be far more formidable and challenging than my efforts on Volume 1. That's because Volume 1 was completely mine in concept and content, from start to finish, and all points between

This volume is **yours**. A substantial portion of the material herein was inspired and developed, in whole or in part, by others. My job was less to create and to develop than it was to review, debug, test, evaluate, interpret, translate, and write. It was a job that suited me well, though I was forced to learn and to assimilate more data and information than in any other comparable period of my life. That was fine with me, for seeing how others approach the task of modifying and enhancing the performance of a piece of communications equipment is quite fascinating to me.

Many people purchase a scanner and take it home to place it on a shelf, where it becomes a useful tool to tune them in on the pulse of their community. The extent of their interest in the scanner might never go beyond that, and it's OK if that happens.

Some of us, however, aren't satisfied to leave it there. Not when a dollar's worth of parts and an hour's worth of tinkering can result in something a little more suitable, more functional, and/or better performing. We tinkerers are **hackers**, we dare to modify, to change, probe and improve upon the efforts of those before us. And why not? There is at least one reason why not.

It's that those who manufacture the products generally don't want their wares modified. Maybe they fear liability should someone get hurt, or even killed. Maybe they feel that should their design be changed, they can't be responsible for the product's continued performance to its technical specifications. Maybe they think that, while you are attempting to modify their products, you will make some serious mistake and then not be able to enjoy their products in the way they had planned. Scanner manufacturers neither recommend nor endorse modifications of their equipment. Modifications always void any manufacturer's warranty on the scanner. Manufacturers want their customers to be happy, but many seem to demand the right to define happiness.

On the other hand, both you and I are a breed of cat that demands the right to define our own happiness. Right? That being the case, let's get right down to the business at hand. I want to mention that when I was writing Volume 1, I had some doubts as to how well the majority of average scanner users were going to do the modifications I was describing. My publisher also had some doubts. So, I went back and rewrote most of them, adding detail after detail, until we felt that our doubts were dispelled. At that point, I thought maybe what I had was ~~too~~ too detailed and boring, but deadlines were looming and I decided that too much information was better than too little.

Shortly after Volume 1 was released, I received a letter from a scanner enthusiast in Texas that was very meaningful in regard to my doubts. He related that although he had only a 6th grade education, he was able to follow my instructions in order to successfully complete all of the modifications to his scanner. Of course, there was a big response from others, too, but this gentleman's letter meant a lot to me. It was proof that my objectives had been achieved. While I also received many complimentary letters about the book's instructions from communications technicians and engineers, my main intent was to create a book that would be of use to non-technical persons.

To technicians and engineers who may find some of my information a shade too detailed and elementary for their purposes, I beg indulgence. In this volume, the author again strives to set forth information that will be of use to auto mechanics, secretaries, farmers, taxi drivers, police officers, shop keepers, reporters, members of the armed forces, and all of the many other average folks who use scanners.

To all who dare to leap into the dark, dank, bottomless void of your scanner of with nothing with more to go on than a wisp of confidence on my say so to hack, snip, and chop, while painstakingly following detail after detail: I salute you!

You, who patiently and persistently follow every detail to the success of a modification; **you**, who ride an an emotional yo-yo through the agonies of a hitch to the thrill of final victory; and **you** who fall into the depths of despair over a tiny oversight you made, before eventually realizing what it was; all of you will at some point in your modification adventures, reap the ultimate reward. That will be when you turn on your modified scanner and enjoy the enhanced performance with which you have graced the unit. This will be your badge, and you will henceforth and forever more, be proudly known and recognized among your peers as: **Hacker**.

Bill Cheek
San Diego, California

Scanner Modification Handbook

Volume 2

Chapter 1: Hints & Tidbits

HINT-1

Introduction To Modifying Your Scanner

It would be most helpful, although not absolutely necessary, to have read Volume 1 of this series. It contains a lot of introductory, preparatory, and incidental material that will be mentioned briefly here, as needed, but will not be delved into with nearly as much detail. While Volume 2 is highly detailed on newly presented material, it doesn't repeat any more than absolutely necessary. Volume 2 assumes several things, briefly highlighted as follows:

1: You **must** have a copy of the service manual(s) for your scanner(s). I cannot emphasize this strongly enough. The service manual is usually different than the "owner's manual" supplied with a scanner. If a picture is worth a thousand words, a service manual counts for about a thousand pictures. Your having one permits me to most effectively utilize the space in this book for better detail and more modifications. You can't expect to successfully perform any of the modifications in either Volume 1 or 2 without the aid of a service manual. It's as basic as that.

You can order a service manual for your scanner from the Parts Department of the company that manufactured your scanner. All the major manufacturers can supply highly detailed service manuals with schematic diagrams, parts lists, troubleshooting procedures, and other helpful information. The relevant information, updated and amended from Volume 1, is in Table 1-1.

2: You must have learned basic soldering techniques. The importance of good soldering cannot be understated. You don't have to be an expert, but you should be practiced in the essentials. Soldering techniques are explained in many books on electronics, as well as in Volume 1 of this series.

3: You must know some circuitry basics-- like telling a resistor from a capacitor, and be able to follow along with elementary electronics terminology and symbols; nothing highly sophisticated, but definitely the meat 'n 'taters basics.

4: You must be willing and able to follow instructions and exercise discipline to adhere to the fine detail. Otherwise, you must be willing to accept whatever ghastly consequences that might befall your scanner as a result of deviating from the recommendations.

Hints & Techniques To Avoid Trouble

Despite my offer to assist anyone who had difficulties with the modifications in Volume 1, there were relatively few requests for help. I believe that in every case, I was able to guide the derailed hacker back on track to success. To my knowledge, no one ended up with a basket case scanner, or even one that was

TABLE 1-1
SERVICE MANUALS & TECHNICAL SUPPORT FOR SCANNERS

(Realistic Scanners)

Tandy National Parts Center
900 E. Northside Dr.
Fort Worth, TX 76102

(Uniden & Bearcat Scanners)

Uniden Corporation
9900 West Point Drive
Indianapolis, IN 46250

(ADR Scanners)

Ace Communications
10707 E. 106th Street
Indianapolis, IN 46256

(Cobra Scanners)

Dynascan Corporation
6460 W. Cortland
Chicago, IL 60635

(Regency Products)

Regency Electronics, Inc.
7707 Records St
Indianapolis, IN 46226

(Regency Products)

Regency Two-Way Products Grp
1227 S. Patrick Dr
Satellite Beach, FL 32937

(Icom Radios)

Icom America, Inc.
2112 - 116th NE
Bellview, WA 98004

(Icom Radios)

Icom Canada, Inc
3071 - #5 Road
Richmond, BC, Canada V6X 2T4

(Kenwood Radios)

Kenwood USA Corporation
2201 E. Dominguez St
Long Beach, CA 90801-5745

(Yaesu Radios)

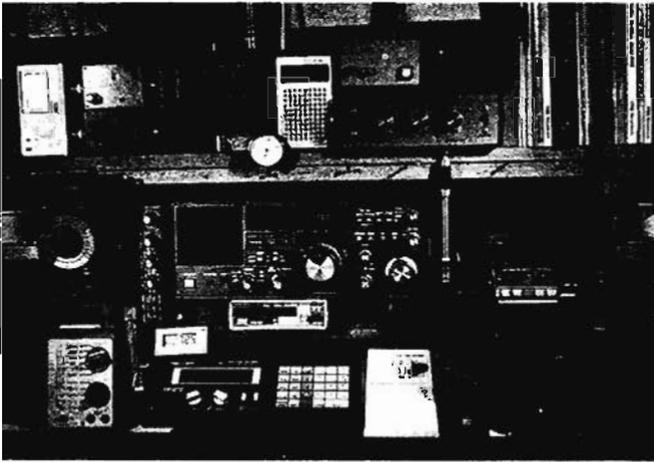
Yaesu-Musen USA
17210 Edwards Road
Cerritos, CA 90701

worse off for their time and trouble! Because so few problems were called to my attention, I didn't attempt to evaluate why there was any problem at all. In several instances, I actually troubleshot and fixed up the work performed by others, so I was able to spot where things went astray. A few common threads kept appearing, and I would like to share them with you in order to make any future problems fewer and even farther between.

Deviation From Recommended Procedures

My techniques and recommendations are not always the very best possible, but they are specifically geared to guiding you to success in the most expedient and cost effective manner, consistent with a minimum of knowledge and electronics savvy. If you don't know the ins and outs of everything you're doing at any given time, let me be the pilot, and consider yourself the co-pilot in training. After a measure of success or two, and if you know of or find a better way of doing something, have a go at it, by all means. But, don't inject "better ways" right in the middle of a project without fully assessing the impact of your actions.

I have taken pains to develop preliminary test procedures wherever possible so that the modifications can be fully tested before they are installed in the scanner. This will ensure all is right before the scanner is torn down. Then, if a question or problem arises, it will be easier to diagnose and remedy. Stick to the directions if you are not absolutely certain of a better way.



A cozy corner of the author's monitoring post. Most of the equipment has been enhanced by modifications.

Poor Soldering Techniques

It's hard to tell whether to attribute this to a lack of skill or just being in a hurry. Probably the latter more than the former. I'm not going to get as deeply into soldering techniques here as I did in Volume 1, but here are some basics that may avoid future problems:

When joining two or more wires or components into a common connection, first pre-tin with solder each individual wire or component lead. That means, first give each wire or lead a good coating of solder. Then, wrap, twist, or touch them together before soldering the whole union into a single connection. When each wire or lead is first tinned with solder, the connection is easier to make and it has a much better chance of being perfect. When soldering a wire or component to a circuit board spot, tin both the lead and the spot with solder first, then touch the lead to the circuit spot and solder the union. Two presoldered items solder together into a final connection very readily with minimal effort.

Poor Drilling Procedures

I don't know if it's common practice, but it happened to one unfortunate fellow. It also happened to me many years ago in my apprenticeship days. He drilled a $\frac{1}{4}$ " hole in the rear chassis of some equipment (in his case, a PRO-2006 scanner), and the drill bit suddenly broke through and ran amok around the scanner's circuit board. Before he was able to regain sufficient presence of mind to extract the drill, it ate and chewed up things on the board. It wasn't as big a disaster as it might have been. The final tally was only three damaged components. To say the least, it was a traumatic experience.

There's an easy prevention for this: wrap several layers of tape tightly around the end of the drill bit, about $\frac{1}{4}$ " from the tip. If and when the bit suddenly pokes through, the extra diameter of the tape will act as a brake and prevent further penetration. Black electrical tape is dandy for this, although not for much of anything else.

Improper Application of Electrical Tape

I was amazed at the number of situations where black electrical tape was used for insulation of wire splices and other electrical connections. The stuff is just wonderful so long as you sit there and look at it. But it's waiting for you to turn your back for a moment. At that point, it will come undone just as surely as a

snake has no hips. Electrical tape is intended to be tightly stretched before application. A stretch puts a friction tension on the pressure sensitive material and improves adhesion. Electrical tape applied without this tension, as is done when insulating a spliced wire, begins to unwrap itself as soon as the temperature changes; usually after you've buttoned everything up and put the scanner back into use.

So, **do not use electrical tape** as an insulating media for anything associated with your scanner. If you must use any tape at all, use one or layers of clear cellophane tape; otherwise, the best bet is to take a little more time and do your insulating with heat-shrinkable tubing. It's available from electronic supply houses everywhere, including Radio Shack (the Radio Shack catalog number is 278-1627). A small butane cigarette lighter is ideal for shrinking the tubing-- be careful not to burn up any components, any fingers, or other things you might need. But please don't use electrical tape. For one thing, it's gooey and sticky, and it always comes undone when you least want it to. And, don't use duct (silver) tape, friction tape, medical adhesive tape, bandages, or similar.

Use of Poor Quality Hookup Wire

This is one of the greatest sources of problems going. Almost universally, everyone seems to use Radio Shack's hookup wire, which is readily available but pretty sorry stuff for hookup purposes in communications equipment. I stay clear of Radio Shack's common electronic hookup wire.

Ironically, Radio Shack also has the best hookup wire of all, though the people behind the counters in the stores don't seem to realize it. In fact, if you bother to share this secret with them, they'll look at you as if you as if you're crazy. So don't bother. Just wander in like you know what you're doing and ask for two or three feet of their 25-conductor Multiconductor Shielded Computer Cable (#278-776). The stuff comes on a big roll and is sold by the foot. If they ask what you want with it, just say you don't and that your brother asked you to pick up some. That way, you won't have to do a lot of explaining and then stand through a lecture on how what you really want is their common hookup wire; which is just what you **don't** want.

When you get home, carefully slit the gray outer insulation; peel off the shield, and inside will be 25 of the finest little different color-coded hookup wires you ever saw in your life. Not quite (but almost) as flexible as hair, these wires strip easily with a pinch of the thumbnail, and they take solder very well without the insulation dribbling off like candle wax. Now that I've told you about how good this stuff is, I can lay it to rest without taking up a lot of space here explaining all of the reasons I don't like Radio Shack's conventional hookup wire. If you and I are playing from the same sheet of music here, we can move on.

This multiconductor cable makes for the best interconnect hookup wire you're likely to find, like for connecting a special circuit board to the main board, wiring from board to controls, etc. It's not too good for point-to-point wiring directly on circuit boards, though, like between pins of transistors and IC's. Radio Shack offers three different colors of 30-ga. wire that (when stripped) makes for excellent on-board, pin-to-pin wiring. It's listed as #278-501, 278-502, and 278-503. These two grades of wire are about all you'll need for the scanner mods in this book, though it won't hurt to also have handy a roll of 18-ga. solid hookup wire (Radio Shack #278-1291, or equivalent), expressly for mounting your modification circuit boards to the chassis.

One of my favorite mounting techniques where a standoff stud won't do is to

solder a stiff wire to the sidewall metal chassis and then solder a ground trace on the small board to this stiff wire. It's "quick and dirty," functional, and unlikely to cause problems. Radio Shack's 18-ga. solid wire is OK for this.

Inadequate Planning for the Modifications

Think ahead, especially if you are an apprentice hacker and can't second-guess some of the things you'll be facing several steps down the line. You'll be able to do this later, as you gain experience and confidence. Poor planning can run you headlong into delays and problems that might have easily been avoided with a little advance thought. In some instances, I've seen where a novice hacker thought at first that he'd do "just a few modifications." That's OK for starters, especially since you can't do them all at once, anyway. The thing is that after you've done a few, you've gotten smarter and more confident than when you started out. What seemed too complex at first, has lost its mystique and intimidating aura. Before you know it, you're planning for the next mod...and the next. Here's a case in point.

You like the speedup mod (MOD-2) in Volume 1 for the PRO-2004. So you install D-514, and you're happy for a day or two. But then you get to reading and thinking, and see that MOD-3 might be even more effective. So, you perform that mod, and it scans even faster. Now, you're in ecstasy for about a week. Then you notice how the DELAY function has shortened up, and that gnaws at you. Of course, you've already seen the EXTENDED DELAY mod in this book, and at first, dismissed it. But, you look some more...and, well, it uses only two chips in a pretty simple arrangement, and, well you only need to cut one wire in the scanner...OK, maybe you can do it, after all. Sure enough you can, and do! See the progress involved here? You started off stumbling and faltering, but now you're sailing right along. This is the growth process. Before long, you're ready to do MOD-16, adding 6,000 channels to the scanner's memory!

Whoa, wait a minute! Somewhere along the line, adding a mod here and one there in a haphazard, random basis there's the most bizarre rat's nest of wiring to contend with that you've ever seen in your life. That's a fine howdy-do, and it could have been prevented before it began. Plan and perform each mod as though it were the first of fifty more that will follow. Maybe you won't be able to anticipate right now doing all the mods, but at least pretend that you're going to, and make believe that what you're about to do now has to fit into the smallest possible nook or cranny in order to succeed. Make it take up as little room as possible. Route all wiring in neat bundles around the perimeter of the main circuit board instead of across it via the most direct route.

With only a few exceptions, most of our wiring carries pure DC or logic level DC and therefore length isn't critical. Plan your wire bundles to avoid major areas of the main scanner board, and certainly so that access to subassemblies and adjustments isn't hampered or severely restricted. You'll be glad later!

I'm just trying to keep you from painting yourself into a corner, something you could easily do if you think you are only going to a couple of mods and then proceed to act that way! Think ahead; plan!

What if You Run Into Trouble? I'll Help!

You have to have the service manual for your scanner before performing any mods, otherwise you won't even be able to help yourself if you hit an unforeseen snag. Most authors issue a caveat that if you have questions or problems, you're on your own. As is my custom, I'm going out on a limb and continuing my offer to lend a helping hand if you have trouble with any mods in this book. The offer is

qualified as follows:

1. You must have the service manual for your equipment.
2. If I don't happen to have a copy of your scanner's service manual in my files, you'll have to loan me yours or else send a good photocopy so that I can understand and try to resolve your problem.
3. You must clearly and fully explain the nature and symptoms of your technical problem in a letter. If you don't use a typewriter, please write clearly and legibly so that I can easily make out what you are trying to tell me.
4. You must enclose with your letter a business-sized, self-addressed, stamped (US stamps only) envelope, plus one loose, unstuck, extra postage stamp. Correspondents outside the USA should send the self-addressed envelope plus three International Reply Coupons (IRC's).
5. My offer to assist is related only to the mods described in this book and in Volume 1, and is limited to written suggestions, discussions, and my personal opinions of potential, probable, and possible remedies-- and only if all of the qualifications are met.
6. Under no circumstances will the author attend to these matters via telephone; letter inquiries and replies only. All inquiries to the author for help must be addressed only to: Bill Cheek, c/o Operation Assist, Commtronics Engineering, P.O. Box 262478, San Diego, CA 92196-0969. Note that my ZIP Code has changed from the one shown in Volume 1. Technical inquiries for the author sent to any other address may not receive a response.
7. Under no circumstances, now or in the future, does the author and/or publisher of this book assume or accept any responsibility or obligation for any malfunction of, loss of use of, damage to, legal sanctions related to the use of, or any other problems related to your equipment or its use, whether or not related to any information contained herein. Your equipment is under your control and any decisions you make regarding its use or modification are wholly your own responsibility.

Simply stated, I'll offer written professional opinions and suggestions if you run into trouble with any of these modifications, but you have to meet the stipulations. I now have on hand service manuals for the following scanners: PRO-31, PRO-32, PRO-34, PRO-2002, PRO-2003, PRO-2004, PRO-2005, PRO-2006, PRO-2022, BC-200XLT, and BC-760/950XLT.

HINT-2

How To Use a VCR to Record the Action From Your Scanner

Preliminary Discussion

Every so often the blatantly obvious exists totally unobserved right under our noses until someone sharp of eye says, "Looky here!" My reaction to the following hint was something like, "Huh?"-- followed by scratching my head. And the more I thought about the idea the better (and more obvious) it appeared.

Ms. Judy Norton, of Billerica, MA came up with a tip for something that's

been right under all of our respective noses for a very long time. Why didn't anybody think of this sooner? I dunno, but Judy Norton put the idea very clearly in her letter:

"Dear Mr. Cheek-- May I offer a suggestion for recording shortwave, scanner or BCB action? Simply connect your receiver's Phone/Record hack to the AUX audio input on your VCR for up to 6 to 8 hours of continuous recording. You can even use the VCR's timer function as needed. A stereo VCR is a plus, especially if your receiver and VCR are a part of your hi-fi audio system. The sound is astonishingly improved!

"The VCR timer function works best with a receiver that has a separate timer. I use a SONY 2020, but any timer will do so long as frequencies are preset manually. Up to eight hours' continuous recording may be done, and video cassettes are easy to use, reuse, and store as required.

"VCR setups may vary regarding the AUX audio input. Please advise your readers to be careful to note if their VCR has a panel switch to allow for Tuner/Aux inputs. If not, then connecting the scanner/SW/BCB radio to the VCR will probably disable the regular recording feature unless the AUX/Input cable(s) are disconnected after each monitoring session.

"A stereo hi-fi VCR may solve this: hook up the receiver to be recorded from to the 'simulcast input.' Then you can record both the desired radio comms and the audio/video of tuner/CATV broadcasts as well. At least, my VCR permits dual audio tracks in this manner.

"Now I get maximum utilization of my radio equipment and VCR, especially since I can't seem to stay awake or otherwise always be available in my shack for some of the best monitoring. Sincerely-- Judy Norton."

So, there it is! There's as much or more modern, high-tech in a VCR as in the present crop of scanners. How could we not be interested in the quantity and quality recording features offered by a VCR? I've spent so much time frantically messing around with various audio cassette recorders and related mods, trying to get them to jump through hoops for me, and yet I had never tried using the VCR.

Maybe it's because I'm not enough of a video buff that I hadn't thought of trying to figure out how a VCR might fit into a monitoring post. There are two VCR's in my home, but they've been under the supervision of my wife. Looks like one of these units could soon be reassigned for comms use.

Now then, Judy Norton's idea has sparked all sorts of spinoff concepts... the first of which is how to apply a VCR to MOD-6 (in Volume 1), the Automatic Tape Recorder Switch. Should we somehow interface it to the VCR's PAUSE feature? I'll have to see if our own VCR's have "Remote" control jacks, but the Pause function should serve if nothing else. Thank you, Judy. Your great idea is probably the best thing to happen to VCR's since John Wayne movies that run at 3 a.m. There hasn't been a thing around my house that hasn't been modified in some way or another... except the VCR's...until now.

How to Break The Weld-Bonds on Certain PRO-34 Handheld Scanners

Preliminary Discussion

On page 145 of Volume 1 in this series, I noted that some PRO-34's might have a certain metal shield spot-welded to the main frame of the scanner. When I wrote that, it was a rumor. In fact, to this day, I still have not seen such an assembly technique. I've seen many PRO-34's of all vintages, and they've all had the shield between the RF Board and the Logic/CPU Board held in place by three tiny screws. This offers no problem in gaining access to the Logic/CPU board beneath for various mods. If that shield happens to be spot-welded to the frame, look out, because a wholly different disassembly technique will be required.

We now have concrete evidence that at least some PRO-34's are showing up with that shield spot-welded in place. Thanks to Tom Scott, of Knoxville, TN we also have a good idea of exactly what to do about the shield. Tom tells us in his own words, how to "crack the safe":

"Today I received the Scanner Modification Handbook (Volume 1), and headed for my workbench carrying the book and my PRO-34. Within minutes I had tools arranged and was all set to go.

"The little beastie disassembled just as you said it would, up to a point. But it seems your information on the spot-welded shield is correct! That made the mod I wanted to do a lot more difficult, but those with electronic repair experience and a moderate amount of chutzpah should be able to see their way through. I would strongly suggest that folks without both qualifications desist from trying this.

"After removing the exposed upper circuit board and the volume/squelch controls, one must pry apart the spot-welded shield from the metal "frame." The shield is welded in three places: two welds on the volume control side; one on the opposite side. The welds can be located by looking for the dark spots on the frame. These welds can be pried apart if one is very careful. The way to do it is to first, unplug the red and black twisted wire pair that go to the bottom Logic/CPU Board, and untape them from the shield.

"Next, carefully pry apart the welds. This is accompanied by beginning with a very small screwdriver, using it to create a small (about 1/16") gap between the shield and the frame at the welds. Insert a 1/4" blade screwdriver into the gap you have created and carefully twist it from side to side. You will have to distort the plastic case a bit before the weld pops loose, but the weld will pop before the case is stressed too much. You will also find that the metal frame becomes bent as you break the welds, but don't worry-- it can be straightened out after the shield and the frame are removed.

"The next hassle you're faced with is the small circuit board for the two voltage input jacks (PWR and Charge). I call this the Power Board. This board is soldered to the shield from underneath, via a small slot in the shield, and you can't get at it to desolder that miserable connection. This is where the chutzpah comes in-- you must very carefully break the shield from the circuit board. This is not as gruesome as it sounds, and the connection is simply a ground that is easily replaced.

"When you break the ground to the power circuit board, you must next pry the shield away from the radio, starting at the top of the unit. The bottom side of the shield is attached to the main circuit board by a screw that is accessible after

you pull the shield out 90° from the radio and main circuit board. We're really not supposed to gain access to this area! After removing the screw, the shield is removed and the diode for the cellular restoration mod can be clipped and other work performed as required.

"The metal frame must be removed from the radio, because (A) the power circuit board is attached to it by screws inaccessible from the top; (B) you must straighten it out, as it became distorted when you pried apart the spot welds, and (C) you must solder a ground wire to the power board to replace the connection you just broke.

"Remove the four screws that hold the frame to the main circuit board, and be careful of the red and black pair that run from the power board to the battery connections. Turn the frame over to access the foil side of the power board, and solder a short (3" to 4") length of small gauge wire to the ground wire to the ground of the power circuit board, to replace the connection you broke when removing the shield. Using a pair of pliers (and vice grips?), straighten any warps or bends created by prying the shield from the frame.

"Note the four 'tabs' on the shield (which probably gave you ulcers while trying to remove the shield). These tabs will now be used to hold the shield in place when reassembled, as there are holes in the shield that match up with the tabs. Reassemble the radio by attaching the shield with the small screw to the main circuit board. Bend it back into place and align the holes in the shield with the tabs on the frame. Solder the (new) ground wire from the power board to the shield. At this point, reassembly mostly follows published procedures, although the radio might require reprogramming later.

"After reassembly, my PRO-34 could receive all frequencies between 806 to 960 MHz with no problems. Sincerely, Tom Scott."

HINT-4

Understanding & Diagnosing +5v Problems in The PRO-2004/2005/2006

Preliminary Discussion

If you're a confirmed hacker with more bravado and courage than discretion and fortitude (like me), then sooner or later you're going to do something so rash that it's downright dumb (like I did) and blow up something in your trusty scanner. That can give you a bad attitude for a couple of days. When you turn on your scanner after monkeying around, and you see a blank display, or even worse, a display that reads out something like "9H7.E33B" for the frequency, then you know how a yo-yo feels upon hitting a sidewalk. Face it, you just screwed up and you know that you're going to have to pay for the error of your ways.

These things happen to us all. But there's probably a way out, and usually without paying an exorbitant price. First, you need to calm down. Have a cold one, or a steaming hot one, or put on that CD of Kenny G-- then think.

This discussion centers on the CPU and Logic areas of the PRO-2004, PRO-2005, and PRO-2006 because that's where one of the greatest chances of a disaster will be. It's beyond the scope of this book to lay out a troubleshooting guide for the entire scanner, but in all my experience, the most befuddling and potentially catastrophic failures will occur after you've had a turn at working on the Logic/CPU Board. Problems in other areas of these fine scanners are easier to

localize, diagnose, and repair. Once you get to the Logic area, you find that things aren't always very logical.

Just relax and don't get too upset when a problem arises. If you're a hacker, you know that things don't always go 100% right, and Murphy's Law is always waiting to prove its existence. But it need not prove it in too grand a style. The PRO-200(x) chassis is exceptionally rugged and forgiving of error. The chips on the Logic/CPU Board appear to be of sound internal design. When something goes awry, it's unlikely to be one of these chips. In all my experience with this chassis, my rig, and others, I've never get seen a regular chip failure! You can bet I've made some bad moves, too-- probably more than you ever will. In fact, since August of '86, when the PRO-2004 was introduced, I've experienced only one component failure of any kind, and that includes all of the units I've taken in for service, in addition to my own equipment! A single, solitary component failure in my own rig (no less), and it was caused by my own error. It is that component and some related areas that will be discussed here. So, let me dispel some of the mystery. For one thing, most problems will be bad soldering; miswires; or solder blobs. Remove or correct the problem and operation will usually return to normal.

IC-9: The Most Critical Component In The PRO-2004/5/6

IC-9 (so designated in all units) is a very special little voltage regulator that provides memory retention power (+5 VDC) to the CPU and the static RAM memory chip. Don't confuse this little guy with the larger, general purpose +5V regulator (IC-8), which is a standard, garden variety 7805 regulator. IC-8 also provides +5V to the Logic/CPU Board, but that's different and not nearly as critical. IC-8 is very rugged and capable of considerable abuse (believe me). However, little IC-9 is quite another story. It is perhaps the weakest link in the entire scanner, especially to the hacker. By the way, neither IC-8 nor IC-9 are located on the Logic/CPU Board. They're out on the main board and your service manual will pinpoint exactly where, so I need not take up valuable space here with that description.

IC-9 is a small CMOS, low-power +5V regulator that looks like a small, black transistor (TO-92) package. The service manual notes its part number is S-81250HG, whatever that means. Don't try to cross reference it to a more common part; I tried without success. IC-9 resembles a more common 78L05 regulator in appearance and function, but there's a big difference in a small way.

All voltage regulators consume something of the power they regulate and put out. For example, IC-8, the larger 1-amp rated 7805 draws about 6-ma when nothing is connected to the output. No problem? No. In most situations, it's no problem at all. Now the common 78L05 miniature version draws 2.5-ma even when nothing is connected to the output. No problem? Right, same as above. But there's a teenie weenie little problem when either of these two regulators are used in the Memory Retention circuit!

If you want, check your battery specifications, Radio Shack's premium alkaline 9V cell (#23-553), which is about the best around, is rated to crank out 18-ma for about 24-hours. Getting the picture yet? The Memory Retention Battery in the PRO-2004/5/6 will expire just from the regulator's current consumption within three to seven days. THAT short of a time is not at all good, especially when that time will be reduced further, since obviously the CPU and the static RAM memory chip have to nibble on some current to keep things alive and kicking when the scanner is unplugged from power, or during a power outage.

Somewhere, somehow, Radio Shack came up with the IC-9, a CMOS version of the 78L05, that draws so little current that my milliammeter registers zero! What

that really means is that it draws something down in the low microamp range, which we can live with. A 9V battery will produce a few microamps for a long time. Since IC-9 is CMOS, it is very fragile and unforgiving of abuse and excessive current drain. THAT is how I popped the one in my PRO-2004. A momentary short circuit on the CPU +5v line, and IC-9 was gonzo in a whoosh of smoke. Not even time for any good-byes. Boy, I was out of luck, was I ever. Couldn't cross-reference the stupid part number, and couldn't find anything like it in local stocks. What to do? Well, I finally reasoned that IC-9 must be a 78LO5 masquerading under under an alias, so I installed one and everything worked perfectly... sort of.

Keep in mind that I work on my scanner a lot; a lot. This involves it being disconnected from any external power for lengthy periods. After a couple of weeks of normal use alternated with R&D, I noticed that the Memory Retention Battery was getting anemic at a faster rate than normal. It didn't take long for me to realize that the 78LO5 regulator I had installed to be IC-9 was not exactly the same thing as the mysterious part #S-81250HC that I had detonated. OK, so no big deal. I just made sure to keep the PRO-2004 plugged into power whenever possible. And then I ordered some spare IC-9's from Tandy's National Parts Center. When they came in, I tested them for current drain and that's when I discovered that these little guys were something pretty special and not at all like the 78LO5's that I assumed them to be.

Before I go on to explain some things, you could think about the wisdom of ordering a spare IC-9 or two from Tandy. At a little over \$4 each, it's a small enough insurance premium for the future eventuality that you might make a slip of the soldering iron or somehow short out CPU +5V like I did and-- **BLAMMO!**

Theory of Operation of The +5V Regulated Supply

You might think you'll be smarter than I was and unplug your scanner from power before you go soldering up things in the CPU area. Guess again, Bunky. Plugged in or not, IC-9 constantly supplies power to the CPU and RAM memory. It has to! Otherwise, the unit would get amnesia in a power failure. So long as a good 9V Memory Retention Battery is installed, IC-9 and its associated circuitry are ALIVE and functioning under all circumstances, whether the scanner is plugged in or not, and whether it is turned ON or OFF. If there are a few hundred channels (or thousand) programmed into your scanner, you are not about to disconnect that battery "just to be safe." No, you'll take your chances-- just like I did.

CPU +5V Input Power Distribution

If you'll follow along on your schematic diagram with me, I'll explain the intricacies of this essential, critical little circuit.

PRO-2004 Only: IC-9 is fed with source power through R-237, a current limiter that doesn't fully do the job. That source power comes from one of two places, depending upon whether the scanner is plugged into AC/DC power or not. As long as external power is available to the PRO-2004, and regardless of whether the scanner is ON or OFF, the DC power supplies are alive and working. Most of that power is fed through the ON/OFF switch as 12 volts, but a tap just ahead of the switch that supplies continuous power to Q-33 to provide regulated +9.2 volts to R-237 and subsequently to IC-9. Of course, IC-9 provides a solid, steady regulated +5V output.

Now then, D-53 is in series with the Memory Retention Battery and connects to R-237 at the same point as the +9.2V regulated output of Q-33 described above. D-

53 senses whether or not Q-33 is operating. Q-33 will always operate whenever the scanner is plugged into external power. So if Q-33 is operating, D-53 will not conduct any current from the Memory Retention Battery. At all times, when the scanner is plugged into external DC or AC power, the Memory Retention Battery will be dormant and in standby. IC-9 gets its power from Q-33 and produces the necessary regulated memory retention CPU +5V.

If there is a power failure or if the scanner is disconnected from external power, then D-53 instantly conducts current from the Memory Retention Battery to IC-9 via R-237. So, as long as the battery terminal voltage is around 6.5V or higher, IC-9 will provide reliable memory retention power to the CPU and the RAM memory. D-53 drops about 0.6 volts and IC-9's input voltage has to be about 0.5 to 1 volt higher than the desired output, so when the Memory Retention Battery's output drops down to 6.5 volts, then only 5.9 volts is left for input to IC-9, minus a little more than that will be dropped by R-237, so IC-9 will cease to operate reliably when the battery gets down to less than 6.5V. Words to the wise: Check your Memory Retention Battery periodically, and replace it when the terminal voltage drops to 7 or 8 volts.

Incidentally, the Memory Retention Battery is sampled continuously through R-224 and R-223, a total resistance of about 4.4 megohms. This means that 2 microamps will continuously drain from the battery ($I=E/R$ or $I=9/4,400,000$). This is to provide a sample of the battery voltage into Pin 13 of IC-6 where it is continuously compared with a sample of the power supply's voltage. That's why the battery will slowly degrade over several months even if the unit remains connected to power during that period.

When the battery voltage sinks to a certain level, that section of IC-6 will send a signal to the CPU to turn on the BATTERY WARNING INDICATOR. In my PRO-2004, the warning flag and beep don't activate until the battery voltage has dropped to 4.5V. At that level, you don't have much time left before the memory will be wiped out. Take action as soon as possible.

Simple PRO-2004 Mod: If you'd like more advance warning of a failing battery, replace R-224 with a 5-megohm resistor. Easier still, just snip one leg of R-224 and install another 2.2-meg (Radio Shack #271-061) in series between the cuts. This will make the CPU sound the alarm when the battery voltage drops to around 7.5 volts.

PRO-2005 & PRO-2006: The CPU circuits are the same in the PRO-2004/5/6, however the circuit symbol numbers in the older PRO-2004 became changed when they brought out the PRO-2005/6, so the discussion for the PRO-2004 and its simple mod remains valid, so long as you realize that you'll need to refer to some different circuit symbol numbers in the PRO-2005/6.

IC-9 and Q-33 remain unchanged, but these numbers are different for the PRO-2005/6:

PRO-2004		PRO-2005/6
D-53	=	D-59
IC-6 Pin 13	=	IC-5 Pin 9
R-223	=	R-232
R-224	=	R-235
R-237	=	R-247

CPU +5V Output Power Distribution

Follow along on your schematic diagram and I'll explain the maze of the CPU +5V output distribution circuit.

PRO-2004 Only: Remember, IC-9's mission is to provide memory retention power and a slight trickle of power to the CPU,, so its distribution network is very simple and uncomplicated. The regulated +5V output of of IC-9 is fed directly to Pin 2 of CN-504, which happens to be a good place to measure the CPU +5V any any time you need to check this. CN-504 is a connector that is fed from a 15-wire bundle that comes up from the main scanner board. CN-504 is located on the main scanner board. Pin 2 of CN-504 passes the CPU +5V directly to L-501 and one capacitor of CA-504. These two components are for noise filtering of the CPU +5V line.

After CA-504, the CPU +5V line goes directly to a branch just before Pin 1 of IC-503, the CPU. One leg of the branch feeds Pin 1 of the CPU; another branch feeds Pin 24 of IC-504, the memory chip. A third branch feeds D-501, R-501, and R-503. Another branch comes off Pin 1 of the CPU through R-514 to provide the CE (chip enable) voltage for the memory and CPU chips. All branches must have full time regulated +5V in order for the scanner to operate properly and to retain memory when the scanner is disconnected from external power.

You can, however, lose or interrupt +5V to the CPU chip (IC-503) under certain conditions and retain programmed channel memory. The static RAM chip, IC-504, must always have +5V on Pin 24 or else, but the branch of the CPU +5V line that goes to the CPU chip, IC-503, can be interrupted with only minor side effects when the +5V is later restored. IC-504 must never lose +5V if it is desirable to retain programmed channel memory.

PRO-2005 & PRO-2006: The circuitry is essentially the same as the PRO-2004, although some of the circuit components in the PRO-2005/6 have different symbols. These renamed components are as follows:

PRO-2004		PRO-2005/6
CA-504	=	C-511 & C-512
CN-504 Pin 2	=	CN-3 Pin 10
CN-504 Pin 5	=	CN-3 Pin 2
D-501	=	D-501 (same)
IC-503	=	IC-501
IC-503 Pin 1	=	IC=501 Pin 67
IC-504 Pin 24	=	IC=505 Pin 24
L-501	=	L-503
R-514	=	R=525
R-517	=	R-501
R-518	=	R-503

Troubleshooting The PRO-2004/5/6 CPU +5V Supply

If ever your scanner experiences permanent CPU lockup as evidenced by a completely blank display, or "garbage" in the display that can't be controlled, there's an excellent chance that something in the CPU has been disrupted or failed. Follow the below suggestions:

PRO-2004: Measure the voltage at the RED wire on Pin 2 of CN-504. Best to use a needle or pin as the (+) probe of your voltmeter. Insert it down into the contact of Pin 2 of CN-504. The meter should read +5V, $\pm 0.2V$. If correct, go to Step "B." If not correct, go to Step A.

Step A: Measure the voltage at the OUPUT lead of IC-9. The meter should read +5V, $\pm 0.2V$. If OK, the problem is a broken or cut circuit trace between that point and Pin 2 of CN-504. If not OK, the proceed as follows:

Measure the voltage at the INPUT lead of IC-9. The meter should read +9.2V, $\pm 1.2V$. If OK, then IC-9 is defective and should be replaced. If not correct, then proceed as follows:

Check diodes D-51 & D-53, then Memory Retention Battery, then Q-33, D-52, and R-234. If all is well, check voltage on the Collector of Q-33 and you should get a reading of +14V, $\pm 2V$. If not OK, check D-55 and T-801.

Step B: Assuming that +5V, $\pm 0.2V$, is available at Pin 2 of CN-504, then open the top lid of the Logic/CPU Board and measure again at both legs of L-501. Again, the reading should be +5V, $\pm 0.2V$. If OK on one leg of L-501, but not the other, then L-501 has burned open and should be replaced. If voltage on both sides of L-501 is OK, then check the voltage on Pins 1 and 26 of IC-503, and on Pin 24 of IC-504. Again, the reading should be +5V, $\pm 0.2V$. If not OK, then follow the affected circuit trace and look for damaged or burned spots.

PRO-2005/2006: Check voltage at the RED wire on Pin 10 of CN-3. Best to use a needle or pin as the (+) probe of your voltmeter. Put it down into the contact of Pin 10 of CN-3. The meter should show +5V, $\pm 0.2V$. If correct, move on to Step B. If not OK, then go to Step A.

Step A: Measure the voltage at the OUTPUT lead of IC-9; the reading should be +5V, $\pm 0.2V$. If OK here, the problem is a broken or cut circuit trace between that point and Pin 10 of CN-3. If not OK, then move on as follows;

Measure the voltage at the INPUT lead of IC-9 and you should see a reading of +9.2V, $\pm 1.2V$. If OK, then IC-9 went west and must be replaced. If not correct, then proceed as follows:

Check diodes D-56 and D-59. Check Memory Retention Battery. Check Q-33, D-57, C-236, and R-248. If these are OK, check the voltage on the Collector of Q-33, which should be +12.5, $\pm 1V$. If not OK, check D-60 and T-801.

Step B: Assuming that +5V, $\pm 0.2V$, is available at Pin 10 of CN-3, then there's not much else you can do because of the mechanical design of the Logic/CPU Board which makes it rather difficult to troubleshoot. You can use the service manual as a guide and attempt to follow the CPU +5V line around the board, but the presence of that large chrome shield makes it tough. If CPU +5V is OK at Pin 10 of CN-3, most likely either the Logic/CPU Board is OK or else has a fault that would elude you, anyway.

But, Try These Before Sinking Into Despair

Sometimes the CPU will "lock up" for no good reason. Well, there is a good reason somewhere, but you might never track it down. No matter. Use the RESTART button in the little hole on the rear panel. Sometimes, just pressing and releasing this button while the scanner is ON will release the CPU. Memory will be retained if you do it this way. The next step, if that doesn't work, might erase the memory, but there's a good chance it won't. Turn the scanner OFF; press and hold the RESTART button on the rear panel; then turn the scanner back on, then release the RESTART.

If that fails, then the following steps will definitely wipe out the memory, but then again you may have no choice. With the scanner ON, press and hold the CLEAR key on the keyboard and then press and hold the RESTART button on the rear panel. Hold both down for about 2 seconds and then release. If **that** doesn't unlock the CPU, then there's one more thing to try.

Disconnect the scanner from all external power. Remove the Memory Retention Battery. Then go to the kitchen and have a frosty cold or hot steamer for about fifteen minutes or so. Maybe even don't return till the next morning. Then, reconnect the power to the scanner; reinstall the battery; press and hold the RESTART button on the rear panel, and turn the scanner ON. Then release the RESTART button. If this doesn't get the CPU unlocked and if you have determined that CPU +5V exists at all points where it's supposed to, then professional troubleshooting will probably be required.

A Likely Problem Source: IC-9, the CPU +5V supply is the weakest link in the entire scanner, as mentioned previously. Since several mods will take you in and around areas where this critical power line runs, there is always a slight chance that sooner or later, you'll momentarily short it to ground. That's all it will take, too. Case in point: when I first developed Volume 1's MOD-2 for my PRO-2004, I replaced CX-501, the 7.37 MHz Clock Resonator, with a 10 MHz quartz crystal. I used a crystal in a metal holder, mounting it in a horizontal position above where CX-501 had been removed.

Little was I aware that just below the crystal, the cathode end of D-501 protruded into the general vicinity. Later, the grounded metal shell of the crystal figured out how to commit hari-kari by touching the cathode of D-501. Just so happens that CPU +5V is tied at that point. The momentary surge caused by the short circuit was more than enough to say Sayonara to IC-9. It wasn't any party replacing it, either, although I have subsequently worked up a better technique for replacing IC-9.

How to Replace IC-9 If Necessary

PRO-2004 Only: Owners of this scanner have a bit of a problem since it's not easy to access the solder side of the main RF Board to desolder the three legs of IC-9. You can remove the whole RF Board, but with several mods installed, this may be easier said than done. Even with no mods installed, it's a hairy task to pull the main RF Board. Fortunately, there's a simpler, though non-professional way to proceed.

First, remove the Memory Retention Battery and disconnect the scanner from all power. Don't worry, if IC-9 is blown, there won't be anything in memory anyway.

Next, locate IC-9 on the top side, left-rear of the main RF Board, just behind and to the left of CN-4. Using vice grips and/or large diagonal cutting pliers, simply crush the body of IC-9, taking care to preserve the integrity of its three leads. Crush the body of IC-9 and separate the three legs that should remain soldered to the circuit board below.

Pre-tin with solder the three leads of the old IC-9. Make the contact time with the soldering iron short and sweet or else the heat will travel down those leads and melt the solder joints. Then you'll really have problems! Pre-tin with the three leads of the new replacement IC-9. Tack-solder, one at a time, the new IC-9's leads to the existing three leads. That's it, you're done.

PRO-2005 & PRO-2006: Owners of these scanners have it made in the shade. First, remove the Memory Retention Battery and disconnect the scanner from all power. Don't worry about losing the memory, if IC-9 is blown, the memory is already gone.

Next, locate IC-9 on the top side, left-middle-rear of the main RF Board, just in front of CN-6. Flip the scanner over and find the three points where it solders

to the main RF board. Use standard desoldering tools and techniques, and remove IC-9. Replace it with a new one, pin for pin. It's done.

IC-8: Another Candidate For CPU Trouble

PRO-2004/5/6 (All Units): In the foregoing discussion, I mentioned IC-8 several times; a standard 1-amp. +5V regulator in a TO-220 package. It's mounted to the metal frame of the scanner on the left side of the main RF Board as you look down from the top. IC-8 is just forward of another similar-appearing device, Q-32, which is a transistor. IC-8 provides regulated +5V to many different areas of the scanner using the Logic/CPU Board. I suppose it could blow if its output were short circuited or otherwise abused through such an error. It's easy to troubleshoot and replace, if necessary. Here's how:

The INput and OUTput pins of IC-8 are clearly marked on the circuit board. Turn the scanner ON and measure the voltage on the OUTput lead of IC-8. It should be +5VDC, $\pm 0.2V$. If it isn't, turn the scanner OFF, remove it from its power source, and desolder the OUTput leg and raise it slightly so it doesn't touch the circuit board below it.

Step A: Plug scanner back into power source. Turn it back ON and remeasure the voltage at the OUTput lead of IC-8. If the voltage is now +5VDC, $\pm 0.2V$, see Step B which follows. If the measurement is still not right, then remove and replace the IC-8. You can use a Radio Shack #276-1770.

Step B: If the measurement with the OUTput lead of IC-8 lifted from the board reads OK, then there's a problem down the line in one or more of the circuits to which IC-8 feeds power. Professional troubleshooting will probably be required.

Summary and Wrap Up: If you're a total klutz, you may have problems, but it's unlikely that you'll blow anything on the Logic/CPU Board of your PRO-2004/5/6. If you're a pro or skilled hacker, there's a chance you'll blow IC-8 or IC-9 someday. If you are a casual hobbyist with enough knowledge and skill to be dangerous, you just might escape the Cosmic Hacker's wrath altogether! Huh?

Sure. A fellow who doesn't know what he is doing and knows he doesn't is apt to be super-cautious, painstakingly careful and methodical about everything he does to his prized scanner. THAT approach should assure a long life to IC-9 and other things as well. But professionals tend to get a bit complacent, at times working in favor of time and expediency. When something blows up, a pro can get ticked off at the loss of time and momentum-- but it's no big deal because there's another replacement part sitting on the shelf.

But you? You've got all the time in the world. And you're smart enough to do things like unplugging your scanner from the power lines while digging around and working inside its case, and insulating the metal body of your speedup crystal. Right?

Above All Else!: Don't immediately suspect you've blown something to Kingdom Come the first time your scanner doesn't work properly after you've worked on it. If worse comes to worse, and you can't find the problem, just backtrack-- remove the modification from the scanner and test it again. Most of the time, your problem will be an error in assembly or installation of the modification. Even if you are all thumbs, it's not likely that any chips or transistors will zap out as a result of your misdirected handiwork. Keep calm. Retrace all your steps, making certain you followed all instructions and precautions. You'll find the problem, for sure!

Some Thoughts on Scanner Preamplifiers

A scanner preamplifier is a device that hooks up between the scanner and its antenna in order to boost the strength of incoming weak signals, thus giving the scannist a chance to monitor stations that might otherwise not be heard. If it does what it's supposed to do, it can be a vital ingredient of a monitoring effort. The trick is working it out so that you have a scanner preamplifier that does enough, but not too much. It's worse when they do too much, causing scanner noise, intermod, overload, desense, and other unpleasant things.

It's not easy to produce a true low-noise, wideband preamplifier, and market it to scanner users at a popular price.

GRE America, Inc. makes a unit known as the Super Amplifier which is designed to be used with handheld scanners. Presently, this unit appears to have become popular with scannists, offering adjustable gain up to +20 dB and a bandwidth of 100 MHz to 1000 MHz (1 GHz). It sports a bypass switch for straight through operation when signal boosting isn't required, which is a nice feature. The adjustable gain feature permits setting the amplification to the point required for monitoring specific stations. The unit requires a 9 volt battery to operate, or your 9 VDC power supply.

Radio Shack offers several wideband preamplifiers, mostly designed for TV applications. These are not preferred for low noise scanner requirements, and I'd stay clear of them for scanner use. Some scannists report varying degrees of success with Radio Shack's "bullet" preamps (#15-1115 and 15-1117). All I can say here is that there are a number of reasons why a low performance preamp can work under certain conditions and make a non-technical scannist think he has discovered the greatest thing since DoubleStuf Oreo cookies. Neither of the two Radio Shack preamps mentioned will perform across the entire bandwidth of your scanner, however. So keep that in mind.

Those of you who use a PRO-2004/5/6 are lucky in that these scanners have a relatively strong immunity to caving in under the assault a preamp that might normally add a lot of noise, interference, and garbage to the proceedings. Neither scanner nor preamplifier design are quite yet where I'd call them state of the art, and there's certainly room for improvement all around, even in the basics. If you live in a weak signal area, like in the boonies, a preamp could well bring up signals to a useful level. But, if you're smack dab in the middle of a big city, you may not require anything more than a decent antenna to hear what you're seeking.

A Hot Preamplifier Tip: By the way, there are a couple of incidental uses for a wideband preamp that you may not have considered. The use of frequency counters in the scanning hobby is becoming more prevalent these days. It's kind of handy to pack a portable frequency counter around to get a reading on nearby transmitters at sporting events, security installations, and other areas you can figure out using a little imagination.

Generally speaking, you have to be pretty close to the transmitter to get a stable readout, particularly if the transmitter is a low power handheld. You can, however, increase your effective range of frequency snooping when you hook a wideband preamplifier to the input of your frequency counter, and then put the frequency counter's antenna on the preamplifier.

The same principle can be applied to "bug detectors," too. If you have any of the RF sniffers or bug detectors on the market, a wideband preamp will increase its effective detection range. A little practice and skill may be required to get the best results from the combination.

HINT-6

Using a Computer Bulletin Board (BBS) as a Scanning Resource

Preliminary Discussion

Perhaps the greatest single supporting factor behind the popularity of radio is **information**. Yet, few (if any) hobbyists have ever been fully satisfied that they had enough information about their hobby. Regardless of your specialty, there's always a new product, a new frequency addition/change, a new technique, a new modification, hint, trick, or kink to learn, master and apply to your particular facet of the hobby.

I've always stressed the importance of collecting information in order to best pursue the monitoring hobby. The written word and direct contact with others are the most pertinent sources of information, and now there are newly emerging sources to amplify these. You can join clubs, and you can meet other scannists. You can (and should) keep abreast of things via hobby magazines, the better newsletters, and frequency guides. Nothing can ever replace these resources for you to draw upon in support of your interest in communications. Still, you can supplement them with a different, although related, media known as Computer Bulletin Board Services (BBS).

What Is a BBS?

Perhaps a bit intimidating at first, until you get to know your way around, a BBS is no more than a computer (with an operator called a SysOp) that serves as a central collection point for information on one or more topics. A BBS is similar to a library in that it stores information in a manner organized for easy access. There is no theoretical limit to the number of users, and becoming a user is about as easy (or easier) than getting a library card. The primary requirements to use a BBS are a computer, a modem, communications software, and a telephone line.

What You Need to Link Up

Your regular home or office 'phone line can serve this purpose. Your computer needn't be anything sophisticated, 'most any will serve the purpose from the Commodore 64 to the Apple II series, the Tandy Color Computer, and, of course, the higher ended computers including IBM's and compatibles, MacIntosh's, etc. Even the modem isn't critical, and good ones can be had for \$100 or less.

A modem is the device that interfaces the computer with the 'phone line, or in some instances, a radio link. Most any computer and modem will do, but the software must be more specific. It has to be a program that's specifically designed for data communications. That means it's unlikely that your word processing, data base, or spreadsheet software will be suitable. Still, some can, so check first. Assuming that you have a computer, but no modem or comms software, you'll have to make a small investment, maybe \$200 all told. Frankly, package deals are available for less than that if you're willing to shop around.

Hobby Radio & the BBS

The first BBS started up some years ago, and was dedicated to computers, programming, and telephone system hacking ("phreaking"). Since then, they've come a long way to the extent that computing itself is no longer the prime subject it once was. Now, there are thousands of special interest BBS's, and hobby radio (including scanning) is well entrenched. Virtually every commercial computer-accessed information service has a special interest section dedicated to hobby radio. Scattered around North America are thousands of privately run non-commercial BBS's that also cater to the interest of radio hobbyists.

Plug into one of these services and you'll be instantly associated with hundreds or even thousands of other hobbyists who share your interests. The pool of knowledge among this gathering is enough to provide answers to most questions you might ever.

Commercial information services (such as GENie, CompuServe, and America on Line) charge a flat monthly fee plus an hourly charge. If you aren't careful with your time, the hourly charge can click up to a tidy little sum. That's why many hobbyists opt for local hobbyist-run BBS's, which may be accessed without monthly fees or time charges. The trick is to find a local BBS whose operator is also a radio buff. Keep in mind that BBS system operators tend to hang around together, so they are familiar with each other's special interests and activities. Just contact any BBS in your area and ask if you can be provided with a list of BBS's that cater to scanner users and/or SWL's. You'll find one or more in no time at all.

After a while, however, you could find that a strictly local BBS can become rather stifling because it put you in contact with only from as few as three to maybe as many as twenty or so other hobbyists. Eventually, you may begin to itch for a wider scope of hobbyists to contact. At a cost, you could head for the commercial national information services. There's yet another option.

FidoNet: A Worldwide Computer Network

There is an international net of local, private BBS's, thousands of them, organized and linked together to provide a huge service at the local level. Essentially, it springs to life in the wee morning hours when long distance telephone rates are lowest. That's when FidoNet affiliated local BBS's automatically call their assigned "hub" BBS's to exchange information from that day's activities. Then the "hubs" call the regional "nodes" for an identical exchange. The process is repeated a couple of times during the night. The result is that each morning, every affiliated local BBS contains data and information from all other affiliated BBS's throughout the entire network.

FidoNet consists of hundreds of special interest topics, from computers to ham radio, to military service members, to SWL'ing and scanners. Not every local BBS can possibly carry all of the special interest topics, so you may have to search around for the one that carries the shortwave and scanner "echo." When you find it, you've found a gold mine, because you've become linked up with an international meeting place for shortwave and scanner buffs.

Here's an example of how the FidoNet Shortwave Echo works. Say, on Tuesday, you log onto your local FidoNet BBS, Shortwave Echo, and address a message to me, Bill Cheek. During the night, the message will be posted on all other FidoNet BBS's that carry the Shortwave Echo. On Wednesday morning, I'll log onto my local FidoNet BBS and your message will be waiting for me, automatically! I'll compose a reply and send it back the same way. You'll get it on Thursday.

Not only will **you** see your own message and my reply, so will hundreds or thousands of others. So, if you ask a question about a certain mod for a particular scanner, many others will benefit from the question and reply. Now, expound upon this by several orders of magnitude where there are maybe fifty specialists and experts on various aspects of hobby radio and hundreds of questions and answers. Get the idea? And it's all free or very low cost because chances are there's a FidoNet Shortwave/Scanner BBS in or near your local calling area.

There are quite a few well known hobby people affiliated with the FidoNet Shortwave and Scanner Echo, such as "Havana Moon," Larry Van Horn, Tom Sundstrom, and several others who use pseudonyms to protect their privacy. The wealth of information to be tapped into is staggering-- loggings, station skeds, opinions of new equipment, equipment mods, and more. You'll see.

I am available on the FidoNet Shortwave Echo to answer questions and do my share in advancing hobby radio. On behalf of FidoNet and its participants, I extend to you an invitation to join in. I am a member of two local computer BBS's in the San Diego area, on either of which I can receive private E-mail. While I don't accept verbal telephone calls because of the disruption to my work routine, I will answer E-mail, and usually within 24-hours of receipt. If you wish to contact me, via computer E-mail, on either of these two BBS's, you only need dial as follows:

The CIA BBS: (619) 273-6339, or

The Tierrasanta HamNet BBS: (619) 560-7659.

Both of these BBS's are radio related, so you may enjoy looking through their files and message boards while you're about leaving a message or two for me. Of course, you can also post a public message for me on any FidoNet Shortwave and Scanner BBS, and I'll get a reply to you as quickly as possible.

Chapter 2: Information

INF-1

Official Frequency Allocation Table

If you've tried referring to the back page section of Police Call to look up a frequency allocation, it probably didn't take you long to realize the complete and total inadequacy of that data. I also got sick and tired of seeking and not finding, and when I did find, then flipping around to see what the "codes" meant. Phooey!

I relegated my copy of Police Call to propping up the short leg of a bench out in the shed, then obtained a copy of a federal publication showing the allocations, and transcribed from 25 MHz to 2200 MHz into a computer data base. It was hard work, since I'm not a "copy typist," but the job got done and the difficult part is over. It took only seconds to call that file back from the computer's memory banks and print it out for you here. I thought you might appreciate a quick reference table to get a feel for who belongs to those weird frequencies you've been monitoring lately,

The federal regulations that yielded this data (Chapter 47, Section 2.106 of 1979) are generally accurate, although some changes have been made in the years since CFR 47 was issued. I've made corrections for those changes of which I was aware, but it's possible that I've missed a couple.

Use of this information (shown in Table 2-1-1) will usually provide the information you're seeking, although for lack of space, I had to omit some detail to fit in the more important stuff. This is most apparent in the column for "Service; Class of Station & Nature of Service." Only so much could be wedged into the spaces available. The "From / To" columns are self-explanatory and there are only three "codes" with which you have to deal in the "?" column:

- N= Non-government; everything except government;
- G= Government only;
- B= Shared government and non-government.

In most instances next to the "G" code, the description will be blank. That's because the government feels it's necessary to consider its frequency allocations and usage to be secret. Most government bands and frequencies are shared by a variety of agencies and military branches, anyway, and relatively few are reserved for use by fewer than a whole slew of federal users. One of my own high-priority scanning interests is federal agency communications, and if you also pursue this

fascinating aspect of monitoring your government in action, you'll want the current edition of **The "Top Secret" Registry of U.S. Government Radio Frequencies (25 to 470 MHz)**, by Tom Kneitel, published by CRB Research Books, Inc. This is the standard and ultimate reference source for federal frequency information, used by scannists, the news media, law enforcement agencies, the communications industry, and even many federal agencies.

The non-government (N) classification includes pretty much everything else, which is one of the ways CFR 47 lists things, so you can use that column to make a quick distinction between the two. A few frequency bands (B) are shared by government and non-government users. These are largely scientific or aerospace frequencies and are usually used for data telemetry, radio control, or radio navigation signals rather than voice.

Table 2-1-1 is neither 100% complete nor 100% accurate, but I've found it more useful and suited to general monitoring needs than anything else available in such a compact and easy-to-access format. I hope you find this Table as practical as I do. Maybe, if you have suggestions or additional data, you can pass the information along and Table 2-1-1 can be improved.

TABLE 2-1-1
FREQUENCY ALLOCATION TABLE, 25 MHz to 2.2 GHz

FROM	TO	?	SERVICE;	CLASS OF STATION;	NATURE OF SERVICE
25.010	25.070	N	Land Mobile; Base/Land Mobile; Industrial		
25.070	25.760	N	Maritime Mobile; Ship calling, A1 Morse telegraphy)		
25.760	25.090	N	Maritime Mobile; Ship; Ship (Morse & data -100 baud)		
25.090	25.110	N	Maritime Mobile; Ship; (working, A1 Morsetelegraphy)		
25.110	25.330	N	Land Mobile; Base/Land Mobile; Industrial		
25.330	25.600	G			
25.600	26.100	B	Broadcasting; International Broadcasting;		
26.100	26.480	N	Land Mobile; Base/Land Mobile; Remote pickup broadcast		
26.480	26.950	G			
26.620	26.620	G	EMERGENCY; Bases/Mobiles; Civil Air Patrol		
26.950	26.960	N	Fixed; International Fixed, Public		
26.960	27.230	N	Personal; Fixed/mobile; Citizens Band		
27.065	27.065	N	EMERGENCY; Personal; Fixed/mobile; Citizens Band		
27.120	27.120	N	Fixed; Industrial, Scientific, Medical		
27.230	27.410	N	Personal; Fixed/Mobile; Citizens band		
27.410	27.540	N	Land Mobile; Base/Mobile; Industrial		
27.540	28.000	G			
28.000	29.700	N	Amateur, 10-meter band		
29.700	29.800	N	Land Mobile; Base/mobile; Industrial		
29.800	29.890	N	Fixed, Aeronautical; International fixed public		
29.890	29.910	G			
29.910	30.000	N	Fixed; Aeronautical; International Fixed Public		
30.000	30.560	G			
30.560	32.000	N	Land Mobile; Industrial; Transportation, Public Safety		
32.000	33.000	G			
33.000	33.010	N	Land Mobile; Base/Mobile; Land Transportation		
33.010	33.110	N	Land Mobile; Base/Mobile; Public Safety		
33.110	33.410	N	Land Mobile; Base/Mobile; Industrial		
33.410	34.000	N	Land Mobile; Base/Mobile; Public Safety		
34.000	35.000	G			
35.000	35.190	N	Land Mobile; Base/Mobile; Industrial		

35.190	35.690	N	Land Mobile; Bases; Domestic; Industrial; Public Safety
35.690	36.000	N	Land Mobile; Base/Mobile; Industrial
36.000	37.000	G	
37.000	37.010	N	Land Mobile; Base/Mobile; Industrial
37.010	37.430	N	Land Mobile; Base/Mobile; Public Safety
37.430	37.890	N	Land Mobile; Base/Mobile; Industrial
37.890	38.000	N	Land Mobile; Base/Mobile; Public Safety
38.000	39.000	G	
39.000	40.000	N	Land Mobile; Base/Mobile; Public Safety
40.000	42.000	G	
40.680	40.680	N	Industrial; Scientific; Medical
42.000	42.950	N	Land Mobile; Base/Mobile; Public Safety
42.950	43.190	N	Land Mobile; Base/Mobile; Industrial
43.190	43.690	N	Land Mobile; Domestic Public; Industrial; Public Safety
43.690	44.610	N	Land Mobile; Base/Mobile; Land Transportation
44.610	46.600	N	Land Mobile; Base/Mobile; Public Safety
46.600	47.000	G	
47.000	47.430	N	Land Mobile; Base/Mobile; Public Safety
47.430	47.690	N	Land Mobile; Base/Mobile; Public Safety; Industrial
47.690	49.600	N	Land Mobile; Base/Mobile; Industrial
49.600	50.000	G	
50.000	54.000	N	Amateur; 6 meter band
54.000	72.000	N	Broadcasting; Lo VHF Television; Ch 2, 3 & 4
72.000	73.000	N	Fixed Operational Fixed Operational Fixed
73.000	74.600	B	Radio Astronomy Radio Astronomy Radio Astronomy
74.600	75.400	B	Aeronautical Radionavigation; Marker Beacons
75.400	76.000	N	Fixed Operational
76.000	88.000	N	Broadcasting; Lo VHF Television; Ch 5 & 6
88.000	108.000	N	Broadcasting; FM Radio
108.000	117.975	B	Aeronautical Radionavigation; VOR & Localizers
117.975	121.400	B	Aeronautical Mobile; Aircraft
121.500	121.500	B	EMERGENCY;
121.600	121.925	B	Aeronautical; Emerg postn radio beacons, locators
121.950	121.950	B	Aeronautical; Aircraft utility/land; ELT test
121.950	123.075	N	Aeronautical Mobile; Private aircraft
123.100	123.100	N	Aeronautical; Aero SAR; ships, survival craft
123.125	123.275	N	Aeronautical; Aircraft Flight Tests
123.300	123.575	N	Aeronautical; Aviation instructional; Flight Tests
123.600	128.800	B	Aeronautical; Aircraft; Aeronautical mobile
128.825	132.000	N	Aeronautical; Aircraft; Aeronautical mobile
132.025	135.975	B	Aeronautical; Aircraft; Aeronautical mobile
136.000	137.000	B	Space Research; Space communications
137.000	138.000	B	Meteorological; Satellite Space & Research Space
138.000	144.000	G	
144.000	148.000	N	Amateur; 2-meter band
148.000	149.900	G	
148.150	148.150	G	Civil Air Patrol
149.900	150.050	B	Radio Navigation, Satellite,
150.050	150.800	G	
150.800	150.980	N	Land Mobile; Bases/mobiles; Land Transportation
150.980	151.4825	N	Land Mobile; Bases/mobiles; Public Safety
151.4825	151.4975	N	Land Mobile; Bases/mobiles; Industrial, Public Safety
151.4975	152.000	N	Land Mobile; Bases/mobiles; Industrial
152.000	152.255	N	Land Mobile; Bases/mobiles; Domestic-Public
152.255	152.465	N	Land Mobile; Bases/mobiles; Land Transportation
152.465	152.495	N	Land Mobile; Bases/mobiles; Industrial

152.495	152.855	N	Land Mobile; Bases/mobiles; Domestic-Public
152.855	153.7325	N	Land Mobile; Bases/mobiles; Industrial
153.7325	154.4825	N	Land Mobile; Bases/mobiles; Industrial; PublicSafety
154.4825	154.6375	N	Land Mobile; Bases/mobiles; Industrial
154.6375	156.250	N	Land Mobile; Bases/mobiles; Public Safety
156.250	157.0375	N	Maritime Mobile; Ships, boats; Maritime Mobile
157.0375	157.1875	G	US Coast Guard Liason
157.200	157.425	N	Maritime Mobile; Ships, boats; Maritime Mobile
157.450	157.725	N	Land Mobile; Bases/mobiles; Land Transportation
157.725	157.755	N	Land Mobile; Bases/mobiles; Industrial
157.755	158.115	N	Land Mobile; Bases/mobiles; Domestic-Public
158.115	158.475	N	Land Mobile; Bases/mobiles; Industrial
158.475	158.715	N	Land Mobile; Bases/mobiles; Domestic-Public
158.715	159.480	N	Land Mobile; Bases/mobiles; Public Safety
159.480	161.575	N	Land Mobile; Bases/mobiles; Land Transportation
161.575	161.625	N	Maritime Mobile Coast; Maritime Mobile
161.625	161.775	N	Land Mobile; Bases/mobiles; Remote pickup broadcast
161.775	162.000	N	Maritime Mobile Coast; Maritime Coast
162.0125	173.200	G	
173.200	173.400	N	Land Mobile; Bases/mobiles; PublicSafety, Industrial
173.400	174.000	G	
174.000	216.000	N	Broadcasting; Hi VHF Television Channels 7 - 13
216.000	220.000	B	Land Mobile Telemetry; Bases/Mobiles;Industrial
220.000	222.000	N	New Land Mobile Band; Amplitude Companded Sideband
222.000	225.000	N	Amateur; 1.3 meter band
225.000	243.000	G	Military aviation
243.000	243.000	B	EMERGENCY; Aeronautical Mobile; aircraft & ships
243.000	328.600	G	Military Aviation
328.600	335.400	B	Aeronautical Navigation; Radionav Land; Glide path
335.400	399.900	G	Military Aviation
399.900	400.050	B	Radionavigation-Satellite; Space
400.050	400.150	G	Standard Frequency, Satellite & Space
400.150	403.000	B	Meteorological Aids; Space Operations; Radiosonde
403.000	406.000	B	Meteorological Aids; Radiosonde
406.000	406.100	B	Satellite; earth-to-space; Emergency Postn Beacons
406.100	410.000	B	Radio Astronomy
410.000	420.000	G	
420.000	450.000	N	Amateur; 70 cm band
450.000	451.000	N	Land Mobile; Bases/mobiles; Remote pickup broadcast
451.000	454.000	N	LandMobile;PublicSafety;Industrial;LandTransprtation
454.000	455.000	N	Land Mobile; Bases/mobiles; Domestic-Public
455.000	456.000	N	Land Mobile; Bases/mobiles; Remote pickup broadcast
456.000	459.000	N	LandMobile;PublicSafety;Industrial;LandTransprtation
459.000	460.000	N	Land Mobile; Bases/mobiles; Domestic-Public
460.000	462.5375	N	LandMobile;PublicSafety;Industrial;LandTransprtation
462.5375	462.7375	N	Land Mobile; Bases/mobiles; Personal; GMRS
462.7375	465.0125	N	LandMobile;PublicSafety;Industrial;LandTransprtation
467.5375	467.7375	N	Land Mobile; (Repeater Input); Personal; GMRS
467.7375	470.000	N	Land Mobile;(Rprr In);PublicSafety;Indstrl;Transport
470.000	512.000	N	Land Mobile; Broadcasting; UHF TV Ch 14-20; Others
512.000	806.000	N	Broadcasting; UHF Television Broadcast Ch 21 - 69
806.0125	810.9875	N	Land Mobile; mobiles; conventional systems,25 KHz sp
811.0125	815.9875	N	Land Mobile; mobiles; trunked/conventional;25 KHz sp
816.0125	820.9875	N	Land Mobile; mobiles; trunked systems,25 KHz spacing
821.0125	823.9875	N	Land Mobile; mobiles; Public Safety; new; 12.5 KHz
824.010	834.990	N	Land Mobile; Cellular System Mobiles; non-wireline A
835.020	844.980	N	Land Mobile; Cellular System Mobiles; wireline co. B
845.010	846.480	N	Land Mobile; Cellular System Mobiles; non-wireline A

846.510	849.000	N	Land Mobile; Cellular System Mobiles; wireline co. B
849.000	851.000	N	Airphone, mobiles, temp; SSB, 6 KHz spacing
851.0125	855.9875	N	Land Mobile; bases; conventional systems; 25 KHz sp
856.0125	860.9875	N	Land Mobile; bases; trunked/conventional; 25 KHz sp
861.0125	865.9875	N	Land Mobile; bases; trunked systems; 25 KHz spacing
866.0125	868.9875	N	Land Mobile; bases; Public Safety; new
869.010	879.990	N	Land Mobile; Cellular System Bases; non-wireline A
880.020	889.980	N	Land Mobile; Cellular System Bases; wireline co. B
890.010	891.480	N	Land Mobile; Cellular System Bases; non-wireline A
891.510	894.000	N	Land Mobile; Cellular System Bases; wireline co. B
894.000	896.000	N	Airphone, bases, temp; SSB, 6 KHz spacing
896.0125	900.9875	N	Land Mobile; private; mobiles; new; 12.5 KHz spacing
901.0125	901.9875	N	Land Mobile; general purpose; mobiles; new; 12.5 KHz
902.000	928.000	G	
915.000	915.000	G	Gov't; Industrial, Scientific & Medical equipment
(928.000	947.000)	N	Land Mobile; new; Studio-Transmitter Links (STL)
935.0125	939.9875	N	Land Mobile; private; bases; new; 12.5 KHz spacing
940.0125	940.9875	N	Land Mobile; general purpose; mobiles; new; 12.5 KHz
947.000	952.000	N	Fixed; Studio Tx Links; Aeronautical Fixed
952.000	960.000	N	Fixed; Fixed Public; Operational Fixed
960.000	1215.000	B	Aeronautical Radio Navigation
1215.000	1300.000	N	Amateur; 23 cm band
1300.000	1350.000	B	Aeronautical; Radio Navigation
1350.000	1400.000	G	
1400.000	1427.000	B	Radio Astronomy
1427.000	1429.000	B	Space Ops; Land Mobile; Industri; Transport; Public Safety
1435.000	1535.000	B	Mobile Aeronautical Telemetry; Aviation
1535.000	1542.500	B	Maritime, Mobile, Satellite; Coast, ship, space
1542.500	1543.500	B	Aeronautical; Maritime; Mobile Satellite
1543.500	1558.500	B	Aeronautical, Mobile, Satellite
1558.500	1636.500	B	Aeronautical radionavigation
1636.500	1644.000	B	Maritime, mobile, satellite
1644.000	1645.000	B	Aeronautical, Maritime, mobile, satellite
1645.000	1660.000	B	Aeronautical, mobile, satellite
1660.000	1670.000	B	Meteorological aids; Radio astronomy
1670.000	1690.000	B	Fixed; Meteorological aids; satellite, mobile exc Aero
1690.000	1700.000	B	Meteorological aids; satellite
1700.000	1710.000	B	Fixed; mobile, space research
1710.000	1790.000	G	
1790.000	2200.000	N	Fixed; mobile; TV STL, remote pickup, intercity relay

INF-2

Historical Scanner Listing

The Table in this section is a listing of all known VHF-UHF scanners as of this writing. I wanted to share it with you for several reasons. One is for pure nostalgia and for the sake of historical reference. The scanning hobby is growing at an unprecedented rate and has come of age by reaching a market equal to (or greater than) that of SWL'ing. So far I as know, until now, nobody has attempted to compile a comprehensive listing of all scanners that have ever been marketed in the USA. If not for historical reference, then such a listing is needed to settle arguments and barroom bets.

The list may also promote collecting data on the various scanners. It is unlikely that any central data source exists yet, but a listing of known scanners is

a starting point for someone who might wish to pursue such a worthwhile endeavor. Sooner or later someone (you?) will begin a clearinghouse or library dedicated to the preservation of information on the history of scanners, which date back to 1968. Information can include specs, photos, schematics, service manuals, and owners' manuals. Vintage scanners could possibly become collectable someday, and our list can be of use in seeing what's around.

Also, my hope is that the information in Table 2-2-1 will jog your memory and call up any scanners that either I forgot or else never knew about. There are certain to be some, even though I've dug up and listed more than 200 of them. If you know one or more scanners to add, then please let me know. For each scanner to be added to the list, I need at least the manufacturer's name and the model name/number. Also, it would be helpful to have a year of manufacture.

Don't get me wrong, I'm not planning on being "the" clearinghouse and library I suggested above, so I'm not interested in receiving a ton of data that I can't process or use. It's just a simple goal to provide the hobby with an accurate, comprehensive, and chronological listing of scanners for those who can use the data for various applications. Don't forget, scanners may be desktop, mobile, and handheld to make it on our list. They may be programmable or designed for use with plug-in crystals. But they have to be scanners, not the tunable-only VHF receivers that existed prior to the invention of the scanner in 1968.

If you can provide data for scanners not shown in Table 2-2-1, please send it to: Scanner Data, Commtronics Engineering, P.O. Box 262478, San Diego, CA 92196. I'll be updating my list as information comes in, and if you'd like an up-to-date list, send a self-addressed, stamped envelope (SASE) with one uncanceled US stamp, plus an extra loose stamp, to the address above.

TABLE 2-2-1
VHF/UHF SCANNER RADIOS KNOWN TO DATE: August 31, 1998; 2:36 pm

* AOR AR-1000	AOR AR-160	AOR AR-2001
* AOR AR-2002	AOR AR-22A	AOR AR-22B
AOR AR-22C	AOR AR-22D	AOR AR-22E
* AOR AR-2515	* AOR AR-3000	AOR AR-33
AOR AR-800	AOR AR-880	* AOR AR-900
* AOR AR-950	* Bearcat 1 Info Radio	Bearcat 20/20
Bearcat BC-100	Bearcat BC-100XL	* Bearcat BC-100XLT
Bearcat BC-101	Bearcat BC-12	Bearcat BC-140
Bearcat BC-140XL	Bearcat BC-142	Bearcat BC-142XL
* Bearcat BC-145XL	Bearcat BC-15	Bearcat BC-150
Bearcat BC-155	Bearcat BC-160	Bearcat BC-170
* Bearcat BC-172XL	* Bearcat BC-175XL	Bearcat BC-175XLT
Bearcat BC-180	Bearcat BC-20/20	Bearcat BC-200
* Bearcat BC-200XLT	Bearcat BC-201	* Bearcat BC-205XLT
Bearcat BC-210	Bearcat BC-210XL	* Bearcat BC-210XLT
Bearcat BC-210XW	Bearcat BC-211	Bearcat BC-220
Bearcat BC-220RC	Bearcat BC-250	Bearcat BC-260
Bearcat BC-3	Bearcat BC-300	Bearcat BC-310A
Bearcat BC-350	Bearcat BC-4	Bearcat BC-400XLT
Bearcat BC-5	Bearcat BC-5 HLU	Bearcat BC-50XL
* Bearcat BC-55XLT	* Bearcat BC-560XLT	Bearcat BC-580XLT
* Bearcat BC-590XLT	Bearcat BC-600XLT	Bearcat BC-70XL
* Bearcat BC-70XLT	* Bearcat BC-760XLT	* Bearcat BC-800XLT
* Bearcat BC-950XLT	Bearcat BC-One	Bearcat CompuScan 21
Bearcat Five/Six	Bearcat Four/Six	Bearcat III

Bearcat IV	Bearcat ThinScan	Bearcat Two/Four
Black Jaguar BJ-200	Cobra SR-10	Cobra SR-11
Cobra SR-12	Cobra SR-15	Cobra SR-900
Cobra SR-9000	Cobra SR-901	Cobra SR-925
Craig 1254	Craig 4351	Craig 4530
Fanon M8-HLU	Fanon Slimline 6-HLU	Fox BMP 10/60
G.E. 7-2990	Heathkit GR-110	HyGain ProScan 16
* Icom R-1	Icom R-100	* Icom R-7000
* Icom R-9000	JIL SX-100	JIL SX-200
JIL SX-400	Johnson Duo-Scan	Johnson Mini-Scan
Jupiteru MVT-5000	* Kenwood RZ-1	RCA 16S300
RCA SCAN-AIRE	RCD MRP-1H	RCD MRP-1L
RCD MRP-1U	Realistic COMP-100	Realistic PRO-10
Realistic PRO-11	Realistic PRO-12	Realistic PRO-13
Realistic PRO-14	Realistic PRO-16	Realistic PRO-16A
Realistic PRO-2001	Realistic PRO-2002	Realistic PRO-2003
Realistic PRO-2004	Realistic PRO-2005	* Realistic PRO-2006
Realistic PRO-2009	Realistic PRO-2010	Realistic PRO-2011
Realistic PRO-2020	Realistic PRO-2021	* Realistic PRO-2022
* Realistic PRO-2023	* Realistic PRO-2024	* Realistic PRO-2025
Realistic PRO-20A	Realistic PRO-21	Realistic PRO-21A
Realistic PRO-22	Realistic PRO-23	Realistic PRO-24
Realistic PRO-25	Realistic PRO-26	* Realistic PRO-27
Realistic PRO-30	Realistic PRO-31	Realistic PRO-31A
Realistic PRO-32	Realistic PRO-32A	Realistic PRO-33
* Realistic PRO-34	* Realistic PRO-36	* Realistic PRO-38
Realistic PRO-4	Realistic PRO-40	Realistic PRO-47
Realistic PRO-48	Realistic PRO-4A	Realistic PRO-5
Realistic PRO-52	Realistic PRO-53	Realistic PRO-54
Realistic PRO-55	Realistic PRO-56	* Realistic PRO-57
Realistic PRO-6	Realistic PRO-7	Realistic PRO-77
Realistic PRO-77A	Realistic PRO-7B	* Regency 156XL
Regency ACT R-1-High	Regency ACT R-1-Low	Regency ACT R-1-UHF
Regency ACT R-10HLU	Regency ACT R-20	Regency ACT R-92AP
Regency ACT T-16K	Regency ACT T-720A	Regency C403
Regency D310	Regency HX-1500	Regency HX-2000
Regency HX-2200	Regency HX-650/H-604	* Regency INF-10
Regency INF-3	Regency INF-5	* Regency INF-50
* Regency INF-7	Regency K-100	Regency K-500
Regency M-100	Regency M-400	Regency MX-3000
Regency MX-4000	Regency MX-4200	Regency MX-5000
Regency MX-5500	Regency MX-7000	Regency R1040
Regency R1050	Regency R106	Regency R1060
* Regency R1070	Regency R1075	* Regency R1077
Regency R1080	Regency R1090	* Regency R1099
* Regency R1600	Regency R2060	* Regency R2066
* Regency R3020	* Regency R4010	* Regency R4020
* Regency R4030	Regency R806	Regency TK-16
Regency TMR-1	Regency TMR-12	Regency TMR-8H
Regency TMR-8HL	Regency TMR-8L	Regency TMR-8U
Regency TS-1 Turboscan	Regency TS-2 Turboscan	Regency WHAMO-10
Regency Z10	Regency Z30	Regency Z45
Regency Z60	SBE Optiscan 125M	Shinwa SR-001
Sonar FR-104	Sonar FR-105	Sonar FR-2512
Tennelec MCP-1	Tennelec MS-2	* Uniden MR-8100
* Yaesu FRG-9600		

* = Current market models

Buying Used Scanners - The Best Deals Around

Preliminary Discussion

The used radio market is hot-- no, often volatile! Prices of used equipment can range from practically free to exorbitant. Condition ranges from basket cases to like new. As in most used-product markets, there are few standards or specific grading categories, and the buyer should always beware. The prices are the most variable and tentative factor. The seller wants top dollar while they buyer wants to relieve him of the burden for as close to free as possible. Somewhere in the middle, a deal can be struck. Where that point lies depends upon how badly the seller wants to get rid of it, and how much the buyer feels he needs to own the set.

There isn't any "blue book" for used scanners like there is for used cars. There aren't methods for evaluating and grading them, as with pre-owned homes and rare coins. Claims of used scanners having been "reconditioned" can mean anything from as much as a complete checking out and restoration of all components and functions, performed by a professional technician, to the seller having wiped off the scanner with a rag dipped in Fantastic. Basically, buyers are on their own, but there might be a few extra cartridges to toss into your warbag before setting out to hunt for that used scanner of your dreams. This isn't intended to be a "buyers' guide." Rather, it is an attempt to stop you from wasting your money on a piece of gear that you think is still going to be a scanner when, in fact, it has become a doorstop.

What to Buy/What Not to Buy

Simple, buy what you want, don't buy what you don't want. It helps to have decided what you want before shopping. Then you're an informed buyer. Yes, that's the hard way-- except there is no easy way. But there are some guidelines based upon my own opinions of intrinsic value.

To me, value consists of technology, vintage, features, frequency coverage, cleanliness, modifiability, and operation. If you have totally different values, I can't be of much use to you here, but I'll still try.

The technology of a scanner is my first and foremost value check. This eliminates from my shopping list virtually all scanners ever made, because the technology changes so rapidly from one year to the next that the older stuff (in my opinion) has become pretty worthless. So, my first rule of thumb is connected with the price: If you can get it for free (regardless of age/condition/brand/etc.) or, for less than \$10 if it works, then you've probably got a reasonable deal on your hands and technology isn't a factor. Any scanner that doesn't work at all may well not be able to be repaired because replacement parts might no longer be available. Any scanner that works and doesn't require more than pocket change to purchase is worth having. In the \$10 and under range, it probably doesn't matter.

Otherwise, if the price of a scanner inches up to the folding green stuff or, worse, to the category of plastic money, then you'd better beware, be fussy, and accept nothing less than exactly what you really want in a scanner in terms of make, model, and condition. For my money, I'd be very cautious about buying a combination of someone else's headache and yesterday's technology for any more than ten bucks, plus the cost of the gas or postage to get it to you. As you can probably tell by now, I'm not a big fan of yesterday's technology unless it's either free or certainly no more than a sawbuck. For that little, I say, "Go for it."

Let me pose a question that might clarify what I mean by current technology. Would anybody in their right mind pay good money for a several year old computer or VCR? Units even two or three years old look like dinosaurs compared to the current stuff on the market. If this didn't cause your "Aha!" alarm to sound, then maybe you'd better skip over the rest of this section because I don't wish to either hurt your feelings or get you angry.

If you are hell bent on paying good money for a used scanner, you might as well get one that is as current as possible and possesses some good features and capabilities. There are only a couple of models from which to select, so the confusion factor is minimal. Let's check the menu and separate the chef's specials from the leftovers.

I would point out that used scanners purchased from private parties are going to come much less dear than those obtained from dealers, although you may not care so long as the dealer will offer you a reasonable guarantee, and you know him to be trustworthy and reliable. When you buy from a private party, you buy in "as is" condition-- that means if it doesn't work when you get it home, then you've got no squawk. Ham flea markets and pawn shops are potential sources of used scanners, but only if they can be plugged in and demonstrated to work before the sale is made. Check out each channel and function to make certain it's operational. I would be disinclined to purchase a used scanner sight-unseen by mail from an unknown private party offering same via a classified ad in a magazine, club publication, or newsletter.

High Value Used Base Scanners

Easy, now. Scanner technology took a radical leap in August, 1986, when the Radio Shack division of Tandy Corporation introduced the Realistic PRO-2004. Light years ahead of everything else in its time and class, the amazing PRO-2004 evolved into the PRO-2005 in August, 1989, and, then into the PRO-2006 in May, of 1990. As of this writing, the PRO-2006 is the current model in this series.

These three radios, though there are some differences among unmodified, stock models, are essentially of the same electronic design and all possess virtually the same inherent or latent capabilities and features. My choice for the best deal on the used scanner market today would be a PRO-2004, if you're lucky enough to find one. Depending upon condition and other factors, used prices seem to run between \$150 and \$350. Even the top dollar isn't out of line with its intrinsic value. The easy \$1 addition of Modifications 2 and 15 (in Volume 1 of this series) retrofit the PRO-2004 up to the feature and performance stature of the PRO-2005, which I'd call the next best deal on the used scanner market today.

Because PRO-2005's are relatively new, they haven't appeared in substantial quantities on the used market. Expect prices between \$200 and \$325; and the top dollar isn't unreasonable if that's what it takes. The current PRO-2006 won't be showing up as used for a while, but you might see someone offering one on a "must sell" basis in order to make his next Corvette ZR-1, income tax, or alimony payment. Look for a range of \$250 to \$350, and I'd rate it as my third best deal on the used scanner market.

Any of these should provide you with everything you ever needed or wanted in a scanner, and then some. If they don't, then what you're seeking lies somewhere in the realm of sets like the ICOM IC-R7000, ICOM R9000, Kenwood R5000, Yaesu FRG-8800, FRG-9600, and other sets selling in the \$600 to \$5500 range (new).

So what else is there to choose from? Nothing really close, in my opinion. Like the "also ran" Uniden Bearcat BC-800XLT, for instance. New, it's about \$275, used around \$175 to \$200. You get fair coverage up to 912 MHz, but no 225 to 400 MHz military aero band! It's got a puny 40-channels and only two scan banks. That's only a fraction of the moxie of any one of the units in the PRO-2004/5/6 series, and at almost the same damage to your wallet. Not such a good deal, maybe.

Then there's the Uniden Bearcat BC-760XLT/BC-960XLT (also cloned as the Regency R1600). It's a better deal because it sells new for around \$275, and used for \$150 to \$200. Coverage is about the same as the BC-800XLT, except that the top end goes to 956 MHz and it has 100 channels in 5 scan banks. Still only 25% of a PRO-2004/5/6, so keep that in mind.

By the way, some of the Uniden Bearcat and Regency scanners, as noted above, and for whatever reasons, have several different model numbers but seem to be pretty much the same. The BC-100XLT is the same as the Regency R4020; the BC-200XLT is identical to the BC-205XLT and the Regency R4030. Interestingly, the BC-175XL is the same as the Cobra SR-925. You may find this information of interest and value when comparing sets and prices, or doing modifications.

What else is around? There's the J.I.L. SX-400 of a few years ago. I used to drool over it until I finally got a chance to test one. Looked good on paper, especially then, but a total dud nowadays-- intermod, images, overload, birdies. Spare me!

There are several AOR scanners currently being advertised, each having its own unique features. The high-end AR-2500, AR-2515 and AR-3000, from the spec sheets, look to incorporate just about all of the features, but who knows when any might ever appear on the used market. I have not had yet had an opportunity to use any of the current AOR scanners, so I don't know if they can be modified. So far as I can tell, neither have any other hackers explored the possibilities of modifications, either. From the published specifications, these scanners look very exotic. The AR-2515 covers from 5 MHz (in the HF band) to 1500 MHz with 2,016 memory channels, and has a \$695 price tag.

Super-receivers covering VHF/UHF, such as the ICOM R-7000 and the Yeasu FRG-9600 deserve a mention, but only that, since they're really in a league above and beyond what you and I would categorize as "scanners." They are excellent values if you can find them on the used market, but it's difficult to compare them feature-for-feature with regular scanners. They have features that scanners don't offer, and lack features available in the PRO-2004/5/6 series.

What else? Nada. Zero. Zip. Zilch. It makes little sense to shell out \$150 on a used scanner that does nothing really special and otherwise is long in the tooth and has a host of deficiencies inherent in almost all scanners-- limited frequency coverage; being prone to interference from overload, images; intermod; lack of mode options (selective AM/NFM/WFM; search steps 5, 12.5, 30 and 50 kHz); sound squelch, and less than 100 channel memories.

If you can find a used base scanner priced at \$100 or less, and which offers covers the VHF aero band plus all the standard 30 to 512 MHz public safety bands, 40 or more memory channels, 5 or more scan banks, and AC/DC power, then I might soften my position-- but only on the condition that you swore on the latest issues of both **Popular Communications** and **Monitoring Times** that you were not interested in 800 MHz coverage, and that your budget is fixed and can't be stretched out by even another penny. OK, so I'll back off anyway, because your

needs and desires are more important than what I think. My intent is to mix into your thinking process a sprinkling of views that might not have occurred to you.

If it sounds like I'm revved up on the PRO-2004/5/6 series... I am. No two ways about it. Those really look to be the best scanner deals around. They've got the specs, performance, and most features, and the least amount of undesirable things going for them. Also, Tandy has one of the very best consumer parts support systems in the industry and a service manual that is second to none. Parts and manuals are available within five to seven days at reasonable prices from any local Radio Shack store, or from the Tandy National Parts Center in Fort Worth, Texas. The service manuals are typically priced at \$8, while other companies charge \$20 for inferior service manuals relating to their own equipment.

Then there is the swelling tide of national interest and support that underlies the PRO-2004/5/6. Nothing else can compare. Engineers, technicians, authors, hackers, and hobbyists alike have generated a loosely knit information network devoted to exchanging ideas and information on this series. Nothing else in the rest of Radio Shack's, or anybody else's, scanner line has ever done this. This has produced a phenomenal amount of information relating to this series, enough to last for years to come.

Now let's consider modifiability. Never has there been such a modifiable consumer product, much less a scanner, than the PRO-2004/5/6. The series is hacker friendly and easily lends itself to modifications and retrofitting of dozens of high performance enhancements. A few bucks, a handful of parts, a couple of hours can result in exotic features found only in world class communications receivers costing well over \$1000.

There is another base scanner that has a special nostalgic place in my heart. It's the Realistic PRO-2002, a 50-channel top-of-the line scanner from 1982-83. I had one for several years, and if your budget doesn't allow more than pocket change, then it might serve your purposes. It can be modified a bit, and I recall that I either snipped or added a diode and thereby installed the 380 to 410 MHz federal band. Yes, the PRO-2002 suffered from intermod, image and spurious interference, but that was common in scanners of the early 1980's. The set had a very accurate digital clock with seconds readout, a rugged steel case, a mobile mounting bracket, and a DC power cable. And it was a good-looker, too. Sorry I sold mine a couple of years ago. Wish I had it back.

Another relic of yesteryear that has retained its reputation is the old Bearcat 250. It had a "Search/Store" feature that modern scanners still don't have, although you can add that feature to your PRO-2004/5/6 with MOD-23 of Volume 1. The Bearcat 250 also had a feature that would count and read-out the number of transmissions taking place on each of its memory channels. Disadvantages: The UHF band can search or accept programming only in 25 MHz steps, which doesn't allow owners to monitor 12.5 kHz spaced channels presently used in the UHF band. Also, some of the chips that are vital to the unit's operation are not available from Uniden, and nothing else will work in place of those chips. If a Bearcat 250 stops working, there's a very good chance it can never be repaired except with chips cannibalized from other used Bearcat 250 scanners.

And now let's briefly discuss some values in handheld scanners, on which I am less opinionated than base scanners.

High Value Used Handheld Scanners

Rarely is a handheld the only scanner a hobbyist will own. Handhelds are more

application-oriented than general purpose, so the specific needs for certain applications will have a lot of bearing on user choice. If you're a volunteer fireman and need to listen for your dispatcher, a \$10 swap meet special will probably serve your purposes as well as a Uniden BC-200XLT. A specific purpose is just that, and all of the bells and whistles are secondary to that purpose, provided that the scanner works to begin with and has a fundamentally sound design.

Therefore, if you need a handheld for a well-defined purpose and objective and not for general hobby monitoring, then most anything will suffice. In many instances, a simple two or four channel crystal controlled scanner may be the most economical and best suited approach to be taken. With this in mind, I will address the topic in a more general way for those who either can have only one scanner for all applications, or those who want the best possible deal to supplement their base station equipment.

Not that I've formed an opinion on the "best" hand held around, but there are three that I like a lot. Not in order of preference, they are the Uniden BC-200XLT/205XLT; the Radio Shack Realistic PRO-34; and AOR's AR-1000. I hasten to point out that I have not personally used an AOR AR-1000, but the specs look good, and I have heard some good things about them from those who own them. On the other hand, I did read one (and only one) negative user opinion from someone who was dissatisfied. The AR-1000 has 1,000 memory channels and continuous coverage from 8 MHz to 600 MHz, plus 805 to 1300 MHz. It features a 10 dB attenuator switch, manual tuning, AM/NFM/WFM, and selectable search increments. It's a new unit as this is being written, so don't look for them used for a while.

The Uniden Bearcat BC-200XLT (alias BC-205XLT and Regency R4030) is a charmer with spirit, style and performance features. Selling new for about \$275, it offers 200 channels and covers all of the popular bands between 29 MHz and 956 MHz, with the exception of the 88 to 108 MHz FM broadcast band, and the 225 to 400 MHz military aero band. The cellular bands are locked out, but can be restored. Some other mods are also possible, including scanning speedup. Memory appears limited to 200 channels. It's a popular radio and worth a couple of bucks. Used ones seem to go for \$100 to \$200.

Radio Shack's Realistic PRO-34 isn't the charmer that the BC-200XLT is, nor is it loaded for bear like the AR-1000, but it's right up there with the best. Catalog price is \$330, but has been offered on sale for \$230. Used prices range from \$100 to \$275, but the higher figure is way out of line considering the occasional sale price for new ones. The locked out cellular bands can be restored, but it lends itself to other mods, too. The PRO-34 comes with 200 channels, but with a little work (as described in Volume 1 of this handbook series), you can put 3,200 channels into one. Still other mods are also possible.

So far as I am concerned, two of the more important characteristics of a handheld scanner are a large memory (100 channels and up), and full digital display. Some handhelds display only the channel numbers and not the actual frequency itself, which is inconvenient as well as annoying. Memory is so cheap and abundant nowadays that there's no reason to settle for those 10 and 16 channel entry-level units any more. In 1983 they were acceptable, but today they reflect a technology way behind the times.

Collectable Scanners

Here's a subject I'm sometimes asked about, but don't profess to have much in the way of hard information. I take solace in the probable fact that no one else has

much more information than I do. All I can offer are some general tidbits of caution and fact:

1. Collectable markets, in general, are volatile, fickle, and tenuous. This is especially true in used radios, which is no place for speculators and wild, frenzied investing. Remember "tulipmania," in Holland (1634 to 1637), when individual tulip bulbs sold for inflated prices? Speculators went wild, investing fortunes in the bulbs the way modern simpletons sink fortunes into "junk bonds." Many people lost every Guilder they had. Yes, there are some valuable collector radios from yesteryear, but these are all well known, and they're mostly pre-1950. You don't find them at swap meets or in classified ads. You'd have to deal with a reputable dealer or serious collector. These people advertise in publications such as *Antique Radio Classified* (P.O. Box 802, Carlisle, MA 01741)-- a good publication that will send a sample copy upon request.

2. Value is based on rarity, demand, and condition. If there aren't enough to go around, then prices climb until there is enough to meet the needs of those who can afford the tariff. If there's a glut, then prices drop until there aren't enough. It's pretty simple. Don't complicate it with wishful thinking that your early Frammis scanner is worth megabucks, It ain't. Probably never will be.

3. As far as I know, scanners have not yet developed into a collectable market. The hobby is just now coming of age, and not more than a handful of old-timers are sufficiently waxing nostalgic to create any real demand for the older stuff. Since scanners were invented in 1968, by "antique" standards, they're still not really much more than pure junk. Any possible real collecting market for the pioneer scanners may not begin for another ten or fifteen years, if ever. Hardly seems like a worthwhile project to invest the time, money, and storage space in acquiring a bunch of old clunkers to gather dust on the off chance that they might possibly have some increased value more than ten years into the future. Sure, if you already own a few boat anchors, clean them up and put them away with their manuals in a sealed bag. But, good grief, don't go out any buy more of them!

4. CB radio began in 1959, years before the scanning hobby got off the ground. CB went through a boom period that had a billion dollar market that cranked out millions of radios. A collectable market does, in fact, exist there, but nobody is getting wealthy. The real values are very far between, like certain CB deluxe AM/SSB transceivers from Browning, Tram, and the Stoner SSB rig. Or the rare K-40 AM/SSB rig that never went on the market and exists only in the form of a couple of samples. Or, some of the very earliest limited-production CB rigs from companies such as Miratel, Vocaline, Herschel, Philmore, Globe, Gonset, International Crystal, Chickasha, Lincoln, Hallicrafters, and a couple of others. It's unlikely that scanning will ever reach the size or popularity that CB did.

5. OK, everyone wants to know which of the older scanners have a better chance than others of becoming desirable to future collectors. My crystal ball says to watch for the first programmable, frequency synthesized scanners of the kind that took a mechanical form of programming such as prepunched cards, metal "combs" from which certain "teeth" had to be removed, and perhaps those that used some form of toggle-switch programming. Some examples include: Tennelec MCP-1 and MS-2; Bearcat 101; Realistic COMP-100; SBE Optiscan; and Regency WHAM0-10. My true feelings are that these are great paperweights and should be used either as that or to scare off the crows from the corn. Someday, however, if in in pristine display/operating condition, one could possibly fetch you enough of a profit to take your grandchild over to Mickey D's for a "Happy Meal." But don't count on it.

Completing my predictions, crystal controlled scanners are a dime a dozen-- and you get a nickel change. Always have; always will be. Useful as feathers on a snake. Stay away from them as potential collectables. Also true from typical keyboard programmables, since these are as common as fleas on Fido. Maybe in twenty years, the PRO-2004 will be a collectable, but right now they're more valuable as working scanners than as investments packed away in cosmoline.

Summary & Conclusion: Check out the name of this book. The fact that you're reading this book validates my suggestion that most used scanners aren't going to interest you because they can't be modified to enhance their functions to any significant extent. As a hacker, you're a cut above the casual hobbyist. You know that it simply isn't feasible to go out and buy a used Yugo, then cut, chop, and "hack" it into a quarter-mile, fire-breathing, smoke-blowing, rubber-burning dragster-from-hell. And within the limits of reason and money, you can't turn a used 16-channel, bargain basement entry-level scanner into anything much more than it was when it left the factory. You can, however, transform an already excellent used Realistic PRO-2004/5/6 into something truly awe-inspiring.

It's all a matter of perspective. My perspective is that you took a big step out/up/away from the comfortable world of accepting what came from the factory as being an "end." You saw it as a means to a goal, by virtue of your free choice, you chose to explore the exciting world of hacking. I could have done you no better service than advise you against putting your money and time into any used scanners that were dead end driveways along the well-travelled boulevard to the commonplace and the mediocre.

So, forgive me if I seem to chide and poke fun at some of the wares on the scanner market. If I said that something wasn't for you, accept my word for it. Raking 16 and 20 channel scanners over the coals isn't aimed at you, it's targeted at the world you left behind when you found out that there was, indeed, a better world. My potshots are also aimed at those who are blissfully satisfied with the ordinary.

INF-4

Scanning's Newest Challenge: Trunked Radio Systems

Introduction to Trunking

The easiest way to explain "trunking" is to compare it with a visit to a modern day bank or post office. Can you remember the era when they had a separate line formed at each service window? Some lines moved rapidly, others slowly. Some were long, others were short. On occasion, one window would open up while lines were forming at other windows. There was always an uneven distribution of customers.

Now it's different. Busy post offices and banks have a single line of waiting patrons, with the one at the head of that line being directed to the next available window. The load of business is distributed evenly and fairly; maximum utilization is made of the available windows.

The analogy of the older line-at-each-window system compares to conventional multi-frequency communications systems, Use your scanner sometime to see that some frequencies in such a system are almost always in heavy use, while others a

relatively idle. This is an inefficient use of the radio spectrum. Trunking is the first automated attempt at conservation of this important natural resource.

Trunked systems each use between five and twenty channels. Users are lined up and assigned to an available channel, or (if all channels are in use) to the next available channel. One repeater is assigned to each channel, and all are coordinated to work together as a system. The system might be owned and used by a single agency or company, or it could be cooperatively shared by a number of unrelated users. A computer with special software coordinates everything, and works as a master controller for a trunked system.

When a member of the system first transmits, the computer directs it (via a dedicated data telemetry channel) to an unused repeater in the system. The computer directs all other radios in a particular group to go that same unused channel. This takes place almost in an instant. If all channels are in use, the computer forms a "waiting list" with the station at the head of the line assigned the next available channel.

Trunking has a number of advantages over conventional systems (although no joy to scannists). A trunked radio system of a given number of channels can support up to twice as many users as the same number of channels in a conventional system? Let's use a twenty channel system as an example to compare one system versus the other. Suppose that each of 20 channels in the conventional system was 75% busy. That level of usage would almost certainly have the dispatchers griping and moaning the blues. At any given time, some channels would be stacked up with those waiting to get through. Still, at the same time other channels would not be in use. How can this be?

Well, if a channel is 75% busy, that means that 25% of the time it isn't busy. Right? Mathematically, then, in a 20 channel system with each channel 75% busy, there will be five inactive channels. This is a waste of valuable RF spectrum. That same system, if trunked, would provide four more "free" channels to the entire group of users. The fifth channel would have to be reserved in a trunked system for the computer to transmit its data telemetry for controlling everything.

The instant that one user goes to a particular channel, the computer directs all other users in that group to the same channel. Simultaneously, all other unrelated users in that system are locked off that channel. This prevents eavesdropping by unrelated or unassigned users and also prevents interference since "outsiders" can't transmit there.

Presently, trunked systems exist only in the 800 to 900 MHz band, but some experimentation is being done in other bands. Operationally, it could work on any group of frequencies in the same band. By the way, telephone lines can be connected to a channel at each repeater site so that the users (if equipped with DTMF pushbutton handsets) can place landline telephone calls.

There are three major manufacturers of trunked radio systems, and while there are similarities between their approaches, there are also major differences. To be sure, radios are radios-- but it's the software and digital interfaces that distinguishes one system from the others. No system is compatible with the others. And while there are three different "brands" on the market, there are as many different and unique system configurations as there are users. That's because the software that runs each system must be custom designed to serve the particular needs of that user. As is often the case with systems of any sort that are dependent upon software, some of the larger, more complex radio systems in this country have run into unexpected serious snags. As a result, trunking hasn't become the universal immediate panacea it was once predicted to be.

There are communities that have spent millions of dollars on what turned out to be either inadequate or else completely useless. Stock "off the shelf" small systems for business users where the computers haven't been tasked with too many simultaneous chores appear to have fared well. But catastrophic software failures have been experienced in some of the busier public safety applications, where many contingencies must be met to serve entire metro areas. Interestingly, the trunking concept wasn't originally anticipated to include huge multitasking requirements. Some communities have been well pleased with their trunked systems; others aren't.

It will be quite a few years down the pike before scanners of existing technology are made obsolete by trunking. By then, it is said that scanner technology will have progressed to the point where scanners will have become available that can automatically keep up with the various switching schemes used in the trunking systems. In the mean time, let's briefly look at the three present approaches to trunking and how they work.

The Motorola Trunking System: Motorola's trunking is generally considered the best with strong advantages over the others. First, it has more features than any other system, some designed for public safety. General features include: unit numbers, fleets with subfleets, several types of calls, busy queueing, automatic transmit re-try, failsoft, automatic channel updating, telephone interconnect, and selective inhibit. The public safety features system features include: emergency call, regroup request, and dynamic regrouping. A special Motorola trunked system, called SmartNet, is used by public safety agencies.

There are some disadvantages. A continuous data channel takes up valuable spectrum and air time. Users receiving calls can interfere with one another. When a radio transmits, it sends a short data burst over the control channel requesting information such as: system ID, fleet ID, subfleet ID, and unit number. Then the control channel tells the unit to go to the repeater frequency the computer has selected. This data instruction is received by all units in the system that are tuned to the control channel.

All units, not only those with the same fleet and subfleet number, can then receive the selected working frequency. The repeater sounds a short audible connect tone. If the system is completely busy when someone wants to use it, their radio will not transmit. The control channel sends out a "wait" instruction and a "busy" indicator on the radio illuminates. When a repeater becomes available, the waiting unit automatically switches to the selected channel and transmits an audible "beep." The user can then transmit.

The control channel is changed every 12 hours. Up to four channels may be rotated. This is something like rotating car tires for equalizing wear and tear. The radios scan for the control channel, which transmits continuously. During transmission, the radio repeats a digital code along with the voice transmission. This digital code is subaudible, having an upper cutoff of 150 Hz. The same code is on the output of the repeater.

When the unit unkeys, it sends a digital "disconnect" code. The repeater stays on the air briefly waiting for others in the same subfleet. If it isn't accessed within that time frame, it unkeys and other users may be assigned to that repeater. So long as users don't let the repeater unkey, they will not relinquish that channel unless another subfleet activates a higher priority function. As soon as the radio unkeys or squelches, the radio reverts to the control channel.

Large, busy private sector systems during normal working hours are very difficult to monitor using conventional scanning techniques. Continuous

conversations can rarely be followed if users allow repeaters to unkey between transmissions. In a shared municipal system, on one frequency you could well hear part of a police conversation, followed by part of a fire transmission, followed by the city ambulance dispatcher, then the building inspection service-- all in sequence! Single user systems are obviously easier to monitor using conventional scanning techniques.

The Johnson LTR Trunking System: First, some disadvantages. Unit numbers are not supported. It's possible that the system can become full between transmissions, however this can be overcome by the user holding down the mike button while receiving a message. When the other person unkeys, the receiving unit will key up instantaneously. Several units can attempt access at the same time on the same repeater while the system is busy; this causes an unfair advantage to users with strong signals. Since there are no provisions for emergency break-in, this system, this could be disadvantageous to public safety applications.

LTR has a number of advantages, though. Air time is used most effectively. There's no continuous data channel. There's no wasteful repeater "hang" time when unkeying. Users can't interfere with each other's transmissions. Subaudible data is transmitted continuously when repeaters are keyed up. The upper cutoff of the data is about 150 Hz. There is no rotating data channel. Each repeater in the system is assigned a number from 1 to 20. Systems are usually established with from 5 to 20 channels, most often in increments of 5. Each radio is assigned one channel as a "home."

Groups of users are separated by 254 group ID numbers. Receivers remain muted on incorrect group numbers, regardless of home repeater. Whenever a transmitter keys up, the radio requests access. If the home repeater is available, it will transmit on that frequency. Otherwise, it will shift to a vacant frequency. If all channels are busy, a "busy" indicator will illuminate. When asking to transmit, the radio sends its area (1/0), home (1-20), channel transmitting on (1-20), and group ID (1-254). Immediately, the repeater sends: area, home, repeater number, go to, group, and free. If access was requested on a repeater other than the home repeater, the data currently going over the home repeater is mixed with the data coming from the repeater currently in use. This requires high speed data lines between repeaters.

Both the radio and the repeater cycle through the same data sent out on the initial request. If the user is not working through the home repeater, then it may be used by another group. Both data are mixed with the user's data via the interconnecting data lines between repeaters. When the mike button is released, the radio sends out a disconnect code through the repeater. The receiving radios and repeater immediately unscquelch, disconnect and go to the home repeater. "Scquelch tails" will never be heard because of this. It's a simple operation if all units stay on their home repeaters. But, if a user accesses a different repeater, then all other units need to know which repeater is involved, hence the need for data lines (usually telephone) lines between repeaters.

The user of the trunked radio doesn't need to know any of this, only not to talk unless the TX indicator is lit continuously. At the outer fringes of the signal coverage area, or inside a building (when the signal is weak), the TX/RX data may be erroneous. This could cause the radio to perform "rapid re-try" until it gains access. The TX indicator will flash, and after six times it will stop and the radio will keep beeping until the mike button is released. This indicates that the unit has determined that it is out of range of a repeater. All Johnson repeaters do short keyups-- a sort of data burst every 15 to 60 seconds to indicate to system radios that they are in range of the system.

When you're scanning a Johnson system that isn't in use, this is all you will hear. It may seem like adjacent channel interference because it's so short, but that's the way you'll know it's a Johnson system. Another typical Johnson thumbprint is the short open squelch sound at the beginning of each transmission, and NO final repeater delay ("hang") time. When monitoring, remember the user neither knows nor cares what frequency he is on, or whether or not it's his home repeater. For the user, it's all automatic. For the scannist, it's all difficult.

The General Electric Trunking System: The disadvantages of this system include the long time it takes to transmit. No special features are available.

General Electric trunked radio doesn't use digital data. Different user groups are assigned four-tone squelch codes. All repeaters use a tone squelch frequency of 3050 Hz at ± 1 kHz deviation. When a user transmits, the radio finds a vacant channel and transmits a four-tone code. Radios programmed to decode on this code will stop and open squelch on that channel.

When a unit unkeys, the repeater sends a short beep. The repeater will hang for a set time while awaiting a response. If the repeater is allowed to unkey during different transmissions within a conversation, an annoying wait for the four-tone (again) to encode will occur, and most likely on a different repeater. If the repeater isn't allowed to unkey, the four-tone won't be used.

Units not actively using the system will scan all channels for the proper tone code. Repeaters can be used conventionally, without interference from others, if the 3050 Hz tone squelch frequency is decoded and encoded.

Late Notes-- General Electric has now gone to four-tone encoding to allow increased system capacity, but still supports the older two-tone code. Only a limited number of two-tone assignments that were available restricted the number of different user groups on the system. I understand that the General Electric system now employs digital trunking.

Johnson has subsystems available as well as other OEM boards to retrofit to yield many of the features it had previously lacked. Also, I understand that General Electric's 900 MHz trunking uses a digital arrangement with a dedicated control channel. Codec, RCA, Fidelco, and Midland now have 800 to 900 MHz trunking with a channel management system.

Trunking Summary: So how does the scannist effectively deal with trunked systems? Mostly by trial and error, and it certainly helps to be aware of all of the frequencies used in that system. The best approach is to program your scanner with all of those frequencies allocated to the user you wish to monitor. Scan those frequencies to determine if there a data channel in use. If so, lock it out. Then scan the balance of the channels in the system.

When an interesting transmission takes place, listen until it switches over to another channel. Your scanner should immediately resume scanning. By trial and error, you'll find where the transmission has continued. This is pretty easy on five channel systems, but it gets progressively more difficult with 10, 15, and 20 channel systems. It helps to keep all frequencies of a given trunked system programmed into the same scan bank of your scanner, and even adjacent to one another in your scanner's memory. That way, you can de-select unrelated scan banks when not needed, and transmissions from unrelated systems can't pop up and interfere with your scanner's concentration upon the trunked system you're monitoring.

There are several rumors circulating through the technical grapevine that tell of scanners coming that will be electronically equipped to follow trunked transmissions. Skeptic that I am, I think I'll take a "wait and see" approach before I commence dancing in the street. It's going to be rather costly to equip scanners with circuits to analyze digital data on each transmission so it will "know" when the channel hops to another. Any scheme to do this will probably will be system specific, meaning that if it works on Motorola systems, it will ignore the others, etc., etc. So, if such scanners are coming, my guess is that the first ones would be low-enders sporting hefty price tags. Don't look for anything in the way of proven, top of the line, trunk-monitoring scanners any time soon. The first specialized trunking scanners probably won't be great performers; the trunking feature being their chief claim to fame.

There's no pat and easy way to keep up with trunked systems with existing scanners. You've got to get down and work at it, using manual methods and bank storage techniques. The more features, more memory, and more choices your scanner offers, the better you will be able to meet the challenge. Good luck!

INF-5

Do-It-Yourself Alignment of Your PRO-2004/5/6

Preliminary Discussion

I have spent some thirty years paying for the gas in the tank of my truck, and putting the food on my table, by modifying, peaking, repairing, and maintaining communications equipment belonging to radio hobbyists who owned and operated their own screwdrivers. Never mind that many were CB operators who are notoriously fond of screwdrivers, anyway. So, perhaps you think I should have my head examined for putting all of this good information into a book.

Understand my motive: While I like to put gas in my truck, and also sink my choppers into a thick porterhouse steak, I do not enjoy profiting from the fruit of my labor when it comes as a result of restoring the damage caused by someone's unskilled tinkering with the innards of their radio equipment. It's a fact of life, however, that if a piece of electronic equipment contains even a single IF, RF, oscillator, modulation, coil, or other tuning or adjustment screw, the general assumption is that miracles will obviously result if that screw is put to the use for which God intended. The more screws within sight, the more miracles to be performed. Unfortunately, lacking the knowledge and the proper equipment, the casual and well-meaning hobbyist, armed with nothing more than a 59¢ screwdriver, can wreak absolute havoc to a CB radio or scanner in jiffy time. Many's the time I have serviced an otherwise fine radio to do nothing more than undo the damage done to it by its owner and his magic screwdriver.

I've seen it all, so that's why I feel compelled to write a set of do-it-yourself alignment instructions for the PRO-2004/5/6 series of scanners. From the perspective of my experience, it is certain that sooner or later a goodly percentage of hobbyists will tweak something or other in the hopes that the "Scanner Genie" will guide their hands to an awesome increase in performance. Forget it. It won't happen, and there are many reasons why, even if it looks otherwise at the onset.

Here's a typical scenario: a hobbyist has his ear pressed to the speaker of a scanner, desperately trying to hear that juicy cordless telephone conversation from clear across town. What revelations are being made! If only he could hear a little

better. But didn't he read or hear something once about how PRO-2004's supposedly came from the factory misaligned? Yeah, that was it, misaligned.

So, he opens the case and looks around. Hmmmm--- 20 or so things look like they can be adjusted. Hoping for a sign from upon high, and donning his lucky New York Yankees cap, he quietly mutters, "Eenie, meenie, miney, mo; Which of these screws makes the signal grow?" Finally, Kismet guides his hand to that one single adjustment screw that will liberate all of the latent decibels that have for so long been trapped with no place to go. A careful, conservative, and slight tweak, first one way-- then the other-- results in nothing. Of course, he didn't notice anything since that particular tuning adjustment was for the UHF band, not the 46 MHz cordless telephone band. Oh well, no big deal-- he's smart, and he returned the screw adjustment to its original position... or almost exactly that position. Now the damage has evolved into being a "work in progress."

Half a dozen or so similar trial adjustments, and two accidentally broken tuning slugs later, he figures that the set was OK to begin with and he couldn't peak it for better reception. So he puts it all back together again, never realizing that one band was ever so slightly tweaked off center, and another in the opposite direction, etc., etc... and the scanner will never be the same again, and not to his or its advantage.

Basically, you can't reasonably expect to improve the performance of any electronic equipment without a methodology and the right equipment. Even then, there's still a good chance that you aren't going to improve anything enough so that you'll notice, or that it will have been worth the time and effort. Manufacturing quality control is very good these days. While an occasional error does occur, it will probably be spotted and corrected before leaving the factory. Sure, a couple might be missed, but the user isn't going to be able to correct the shortcoming(s) by tweaking something and listening to the speaker for obvious improvement. Doesn't work that way. Sorry.

If the factory spent \$50,000+ on a quality assurance work station, your 59¢ screwdriver and pair of ears probably isn't going to show it up. At the very least, a little knowledge plus a simple electronic eye and an ear can detect tiny, subtle changes far below the threshold of your personal auditory perception. It can be done, but first a bit more information.

Why Electrical Adjustments in The First Place?

Adjustments are sometimes required for the same reason that your car has ignition, timing, carburetor mixture, suspension, brake, linkage, and many other adjustments. Nothing can be mass produced with such perfect consistency that all units roll off the line and perform in exactly the same predictable or intended way. Tolerances and even minor variations of quality, quantity, size, depth, and other measurements in the myriad of component parts of a unit in some final products run off one way; others run off another way; and some run off in every which way. Adjustments are provided as a method of standardizing to a predictable and desired level of performance. Adjustments are provided to correct for the differences between the products of different component suppliers, and for humankind's imperfections and weaknesses. As such, they are necessary, and they fulfill their respective missions.

In order to adjust something, you need sensory feedback of the results of your adjustment. Without it, you'd have no point of reference and wouldn't know if you were making things better or worse. Imagine a blind person attempting to determine whether to move their arm left or right in order to catch a thrown ball.

Even if your personal senses are sharp enough to let you catch a ball, they're still not good enough to give you sensory feedback sufficient to adequately adjust a scanner. You need electronic eyes and ears to guide you. Then you need a method and some equipment. It's as basic as that.

Quality Control & Aging

Factory quality control departments do their jobs very well. Their delight in life is to catch the production staff (the profit center for the manufacturer) messing things up. If production quantity or quality drops, profits go into a tailspin. The Production Manager keeps count on quantity, but it takes trained specialists and sophisticated test equipment to accurately measure production quality. Every scanner coming off the production line is checked for quality on a separate line staffed by various personnel looking for specific defects. It is hooked to various instruments in order to be tweaked and peaked for specified readouts. When it is fully aligned, it gets a final test. If it passes, it gets put into its case, then sent on to the shipping section for boxing and shipment.

At least a few units are randomly singled out for "non-destructive" testing where they are subjected to extremes of temperature, vibration, and even simulated consumer abuse. So long as rejects remain below a certain percentage, production continues, unabated.

It is in this greater scenario where comedies of human error and factory test equipment failure can sometimes converge, resulting in a large production run of scanners that should have been rejected actually getting shipped out, perhaps improperly aligned. Sometimes it's a minor error that's never (officially) discovered. Instead, the scanner could be well received at first because of its attractive features. Over time, it might develop a vaguely rumored reputation among technicians, hackers, magazine writers/editors, and other hobby insiders as, for instance, being only "fair" in the sensitivity department. Rare then, but in a few cases, a minor touch-up of one or two internal adjustments will result in a boost in performance.

Another more common cause of misalignment is that of aging. Just like your car, or jeans, and your body, aging causes changes in electronic equipment. Unlike the changes aging produces in Gruyere cheese and Cognac, improving the situation, in most other things aging doesn't do a lot of good. In electronic equipment, certain internal components, such as crystals, coils, and capacitors can change in value with the passage of time. It's a slow change-- almost imperceptible in modern equipment-- but can be accelerated by extremes of heat, humidity, and other environmental factors. The bottom line is that the sharp edge of high performance becomes dulled after a period of time as certain critical components drift out of tolerance.

Internal adjustments are provided to compensate for that drift without major replacement of parts. So there those adjustments sit, begging, screaming, and pleading for someone-- perhaps **you**-- to please monkey around with them, even if ever so little, to restore to the set the vigor of its fading youth. Ah, if only someone could come along and do the same for you!

The loud bellow in your left ear tells you to go ahead, that just one can't hurt. A soft whisper in your right ear says, "You'll be sorry!" Too bad aging has caused you to be a little deaf in the right ear.

Don't Touch the Adjustments Unless Necessary!

Even if you halfway know what you're doing, it's best not to fix it if it ain't broke. I have checked out many scanners over the years, and quite frankly, most were right on the button and didn't need alignment unless they were tampered with by someone blindly trying to improve things. Most of those un-tampered sets that did require a bit of alignment touch-up did not show any dramatic improvement in performance. Only the ones that were butchered by their owners to almost the point of no return seemed to arise from their own ashes and displayed any great amount of relative improvement. All I did was restore the sets to what they were before the tampering.

Personally, I haven't seen any solid evidence that scanners routinely leave the factories in anything less than prime condition. So, if your MHz muncher is new or less than three years old, my best advice is to leave it alone. No matter what its age, unless there is strong evidence that something is amiss, leave it alone anyway. But how can you know? Even your best friends might not tell you. I will.

Mostly you won't know unless you have something with which it can be compared. A second scanner of similar quality and age is a good cross check. If one scanner outhears the other by a notable degree, hooked to the same antenna, then maybe the lesser one needs a realignment. **Maybe.** There is some variation to be expected from one scanner to the next, even among the same model. Radio Shack's permissible variation for sensitivity among all PRO-2005's is as high as 12 dB (a 4:1 ratio) between nominal value and the out-of-tolerance rejection limit. That's quite a healthy range and can make the difference between hearing well and having "no ears at all." A pity, then, that identical units, side by side, operating from the same antenna could exhibit that much variation and the lesser of the two still be considered A-OK! Naturally, this much (or more) variation can exist between two units of the same make and/or different model. So, you can always go by the comparison method. It's just an indicator; nothing more.

Regardless of what I or my peers recommend, the typical scannist will sooner or later feel compelled to have a go at the equipment with screwdriver in hand. So, my philosophy is that it should at least be done right. Even though such people may well never bother to read and follow my instructions, at least I know that I did my best to make it available. This clears my conscience and purifies my Karma. I will sleep well tonight, knowing that at least I tried.

Preparations for Aligning Your Scanner

For goodness' sake, get the service manual, if you don't already have one. The complete alignment procedures are given there, which I don't need to repeat here. My instructions are for the few adjustments most likely to drift out of tolerance or be set in error at the factory. My information is going to be in plain English, and I'm going to intentionally leave out some detail. There's no sense in my rewriting the danged service manuals when they already exist. Get one. I'll interpret it here for you and show you how to utilize simple test equipment and easy procedures to get equal or better results. Hey, don't try to fool me-- you'll still need the service manual if you want to know what you're doing and how to extract yourself from any problems you might encounter.

No excuses, now. Earlier in this book I explained how and where to get a service manual for your scanner.

Equipment required: Sorry, but you do need a few other things besides the service manual. But, once you've removed the scanner from its case, you can put

the screwdriver back up on the hook in the garage since you won't want to fiddle around with any adjustments in your scanner with a screwdriver. You'll want to use special alignment tools to keep from breaking the fragile powdered iron transformer slugs. Break one and you've got definite problems. The right tool will do the job without bringing about such a disaster.

You'll need an accurate, high performance voltmeter, preferably digital. The better analog, high impedance voltmeters, are OK, but these days a digital is hard to beat. You're using a \$400+ scanner and you don't have a good voltmeter? You'll have to either get one or move along to the next chapter.

It will be handy to have an S-meter, preferably the analog version given in MOD-25 just ahead in this book. It's inexpensive and very easy to build. Your digital voltmeter will work very well for this requirement, but the "diode detector" circuit has to be in place, so you may as well stick it in if you haven't already. You can use measurements of the receiver's AGC voltage in lieu of the S-meter if you have some particular aversion to installing the diode detector circuit. It's just that the S-meter is handier. Make it easy on yourself.

No, you don't need a frequency counter, nor a signal generator. Your frequency counter, if you have one, will probably not be accurate enough to use as a reference standard, and most VHF/UHF signal generators are too drifty and erratic for non-professionals. Refer to Table 2-5-1 for a list of recommended voltmeters and alignment tools.

TABLE 2-5-1
RECOMMENDED VOLTMETERS AND ALIGNMENT TOOLS

<u>RADIO SHACK CATALOG #</u>	<u>DESCRIPTION</u>	<u>COMMENT</u>
22-195	Benchtop/Portable Digital Multimeter	Ideal
22-164	Talking Multi-tester; autoranging	Great
22-194	Portable 30-range Digital Multimeter	Great
22-185	Portable 23-range Digital Multimeter	Great
22-193	Portable Auto-range Digital Multimeter	Great
22-165	Probe Style Auto-range Digital Multimeter	Fair
22-188	Compact Auto-range Digital Multimeter	Fair
22-171	Pocket Auto-range Digital Multimeter	Fair
22-220	FET-Input Analog Multimeter	OK
	Other voltmeters in the R/S 1990-91 catalogs are not suitable, period.	Poor
64-2220 and 64-2230	Alignment Tool Sets; Both are necessary or professional equivalents	Good "

Alignment Instructions: PRO-2004

Read This First:

A. Turn scanner ON and leave ON for at least 30 minutes before alignment is attempted. This is to warm up the unit to its normal operating temperature. Loosen the case but leave it on during the warm-up period. Prepare your voltmeter for specific measurement as specified below-- I assume you understand its use.

Note: Unless specifically stated otherwise, the (-) lead of the voltmeter will **always** be connected to ground, which is the scanner's metal chassis. The (+) lead of the voltmeter will be connected to various test points as described for each measurement.

B. Be critically aware of the results of everything you do! If any single adjustment results in a significant deviation from the expected measurement, you may be doing something wrong. **Always** note the original position of the adjustment **before** you tweak. It's helpful to **first mark the position of the adjustment**. Then, when you perform an adjustment, do so *s-l-o-w-l-y* and methodically instead of quickly and haphazardly. As you make adjustments, watch the voltmeter and/or the S-meter, and simultaneously **listen** to the signal. If you do something wrong, you'll be forewarned if you're paying attention to your "eyes and ears."

1. Alignment of VCO, PLL-1: Refer to service manual, Step 1, page 11 and the Location Guide on page 9, but **DO NOT EVER PERFORM THIS ADJUSTMENT**. If this has been erroneously adjusted in the past, then follow the procedure in the service manual, verbatim, with an accurate voltmeter.

2. Alignment of VCO, PLL-2: Refer to service manual, Step 2, page 11 and the Location Guide on page 9, but **DO NOT EVER PERFORM THIS ADJUSTMENT**. If this has been erroneously adjusted in the past, then follow the procedure in the service manual, verbatim, with an accurate voltmeter.

3. Alignment of NFM/AM 2nd I.F.: Refer to the service manual, Step 3, page 12, and then the Location Guide, page 9, but perform the following instead:

A. Select a NOAA weather broadcast station for your area (162.40, 162.475, or 162.55 MHz are the most common channels in the USA). If none are available, then select a transmitter of known quality; one regularly maintained and kept in optimum condition. An aero band (118 to 137 MHz) ATIS station in your area may suffice. Do **not** select military, business, or local government frequencies. The important thing here is a station of known frequency accuracy that also transmits most of the time. You will be using it as a signal generator, so it better be good! Also, it better **not** be exceptionally strong. For alignment purposes in this step, a slightly weaker signal is better than a strong one.

B. Connect your DC voltmeter to "TP-2." Voltage here will be very low, typically 0.2VDC, so set the voltmeter accordingly.

Note: As an alternative to, or in addition to, TP-2, you can attach a voltmeter to the analog S-meter function described above and in MOD-12 of the Review Chapter. You can also connect the voltmeter to the receiver's AGC function, IC-5, pin 10. The AGC voltage varies from 1.20 volts (no signal) to 0.820 volts (max signal), so the range is narrow and the function is inverse; that is, the AGC voltage decreases as the input signal increases.

C. Mark the present settings of T-1, T-9, T-10, T-11 and T-12, then (in order) adjust T-1, T-9, T-10, T-11, and T-12 for a maximum reading at TP-2 and/or the S-meter, and/or **minimum** reading of the AGC voltage at IC-5, pin 10.

Note: Modulation (the voice on the station you're monitoring) will probably cause fluctuations in the voltmeter's measurements. Adjustments should be made during pauses in the speech and otherwise account for those voice fluctuations as you perform this adjustment. An analog S-meter is ideal for these adjustments.

D. Connect a voltmeter to TP-2 and adjust T-12 for **minimum** voltage. Voltmeter **must** be attached to TP-2 for this step, even though you can observe an S-meter at the same time. (Adjust T-12 for a **maximum** S-meter reading.)

E. Repeat Steps C and D once or twice to ensure proper adjustment.

F. Mark all new settings with a different colored marking pen.

4. Alignment of the 455 kHz NFM Discriminator Coil: Refer to the service manual, Step 4, page 12, and the Location Guide, page 9, but perform the following instead:

A. Perform Step 3.A above, except that the chosen signal **must** be narrow band FM, typical of the NOAA weather broadcasts. Do not select an AM signal (such as aero band) for this adjustment. For this one procedure, the signal can be strong or weak, but it must be precisely on frequency.

B. Connect your DC voltmeter to "TP-4." Voltage here will be about 3 to 5 volts, so set your voltmeter accordingly. A very precise adjustment must be made here, so an accurate voltmeter is essential. The following adjustment is very "touchy" and may require several attempts to get it right.

C. Adjust T-13 for exactly 3.8 volts, $\pm 0.05V$. Yes, I realize the service manual says " $\pm 0.10V$." but surely you can do better than that! Besides, this adjustment is **very important** if you have done (or will do) the Center Tuning Indicator adjustment mod elsewhere in this book. See that section for a fuller description of the signal at this test point.

D. After you have set T-13 for exactly 3.80V at TP-4, take a break and observe the reading for a few minutes to be sure it does not drift off right away. The setting is very critical and may drift for a few seconds after the adjustment. Readjust as needed. Pre/post marking of this adjustment is not necessary since it may be adjusted quite a few times during the course of your "career."

5. Alignment of the 10.7 MHz WFM Discriminator Coil: Refer to the service manual, Step 5, page 12, and the Location Guide, page 9, but perform the following instead:

A. Select your favorite FM broadcast station between 88 and 108 MHz.

B. Connect your DC voltmeter to "TP-3." Voltage will be about 3 to 5 volts, so set your meter accordingly. A very precise adjustment must be made here, so an accurate meter is essential. The following adjustment is very "touchy" and may need several attempts to get it right.

C. Adjust T-6 for exactly 3.8 volts, $\pm 0.05V$. The service manual says " $\pm 0.10V$," but I want you to adjust it more precisely than that.

D. After you have set T-6 for exactly 3.80 volts at TP-3, take a break and observe the reading for a few minutes to see that it doesn't drift off right away. This is a critical setting and can take a few seconds to settle down. Readjust as or if required. No need to mark this adjustment since you may tweak it quite a few times in the course of owning the scanner.

6. Alignment of 455 kHz I.F. Coil: Refer to service manual, Step 6, page 13, and the Location Guide, page 9, but perform the following instead:

A. Select a NOAA weather station or an aero ATIS station. The scanner must be put into AM mode for this adjustment, even though you can still use an NFM signal. If you selected an NFM signal, just press the MODE key on the keyboard twice so that the "AM" indicator appears in the LCD display. It won't sound like much, but for our purposes here it's OK. A weaker signal is better for this step than a stronger one.

B. Connect your DC voltmeter to either the analog S-meter function (MOD-25) or to the receiver's AGC voltage function, IC-5, pin 10.

C. Mark the present setting of T-7 with a marking pen and then adjust T-7 for **maximum** indication on the S-meter function and/or for a **minimum** positive AGC signal.

Note: The modulation (voice) will probably cause fluctuations in the voltmeter's measurements. Make adjustments during pauses in the speech, or otherwise account for those voice fluctuations as you perform this adjustment.

Mark the new setting of T-7 with a different colored marking pen.

7. Alignment of 455 kHz AM Detector Coil: Refer to the service manual, Step 7, page 13, and the Location Guide, page 9, but instead perform the following:

A. Select a NOAA weather broadcast or aero ATIS station. The AM mode **must** be selected for this adjustment, though you can still use an NFM signal. A weaker signal is better than a stronger one for this step.

B. Connect your DC voltmeter to either your analog S-meter function or to the receiver's AGC voltage function, IC-5, pin 10.

C. Mark the current setting of T-8 with a marking pen and then adjust T-8 for a **maximum** indication on the S-meter function and/or for a **minimum** positive AGC signal.

Note: Modulation (voice) will probably cause fluctuations in the voltmeter's measurements. Make adjustments during pauses in speech, or otherwise account for those fluctuations as you perform this step.

Mark the new setting of T-8 with a different colored marking pen.

8. Alignment of 48.5 MHz & 10.7 MHz WFM I.F. Coils: Refer to the service manual, Step 8, page 14, and the Location Guide, page 9, BUT DO NOT PERFORM

THESE ADJUSTMENTS. Special equipment is required, but these adjustments are OK as they are. They have very little effect, anyway, so leave well enough alone.

9. Alignment of I.F. Trap Coils: Refer to the service manual, Step 9, page 14, and the Location Guide, page 9, BUT DO NOT PERFORM THESE ADJUSTMENTS. Special equipment is required. These adjustments are critical.

10. Alignment of 512 MHz I.F. Trap Coil: Refer to the service manual, Step 10, page 14, and the Location Guide, page 9, BUT DO NOT PERFORM THIS ADJUSTMENT. Special equipment is required and the adjustment is critical.

11. Alignment of 1st Band Pass Filter Coil: Refer to service manual, Step 11, page 15, and the Location Guide, page 9, BUT DO NOT PERFORM THIS ADJUSTMENT. Special equipment is required and this adjustment is **very** critical.

12. PRO-2004: Important Voltage Measurements

The accompanying voltage measurements are by no means intended to be complete, but are intended to be a guide to preliminary troubleshooting if ever something goes wrong with your PRO-2004. If you request my opinion in diagnosing a problem, it may be necessary for me to know some or all of these measurements. If you want to become familiar with the inner workings of your PRO-2004, these measurements are an excellent starting point for such knowledge. If you performed any of the mods in Volume 1, you may have already learned some of these voltages, anyway. Become comfortable with them. Refer to the service manual, pages 24, 25, and 70 through 73.

<u>No.</u>	<u>Location of Test Point</u>	<u>Should Measure</u>	<u>Conditions of Measurement</u>	<u>Comment & Discussion</u>
A	Top lead of R-235	+13v, +1v	Scanner ON	Main system DC from power supply
B	<i>NOTE: DC system current drain can be easily determined by measuring the voltage drop across R-235 (1-ohm) and dividing that reading by 1. Ohms Law, I = E/R, so current drain, in amperes, will be equal to the voltage drop across R-235. Typical value would be between .3 and .45 amps (300-450 ma). Place the (-) lead of the voltmeter on the Collector (middle lead) of Q-32 and the (+) lead of the voltmeter on the top leg of R-235 for a quick and easy measurement.</i>			
C	Out Lead of IC-8	+5v, +.2v	Scanner On	Main regulated +5v power supply
D	Pin #2 of CN-504	+5v, +.2v	Scanner On or Off	CPU regulated +5v power supply (operates CPU & retains memory)
E	Emitter of Q-32	+8.4v, +.3v	Scanner On	Regulated +8v power supply
F	Pin #10 of IC-5	+0.82v --->Max signal +1.20v --->No signal		Receiver Automatic Gain Control inversely proportional to signal

G	Pin #13 of IC-2	~+7v ----->Squelch CW 0v ----->Squelch CCW		Receiver SQUELCH Gate Trigger to (H) below
H	Pin #3 of IC-3	0v ----->Squelch CW +4.8v----->Squelch CCW		Squelch Logic Gate to CPU
I	Anode of D-53	+9v, ±.5v	Scanner On or Off	Memory Retention Battery Input Replace battery if below 8.5v
J	Cathode of D-51	+9v, ±.5v	Scanner On or Off	Same as (I); input to CPU +5v regulator
K	Cathode of D-52	+10.6v, ±.3v	Scanner On	Preregulates "scanner on" working voltage to input of IC-9
L	TP-5	RF No DC	NFM or AM	Last NFM/AM 455 KHz I.F. output. This is the most useful test point of all. It feeds your Diode Detector circuit (MOD-12b) for the S-Meter function

Alignment Instructions: PRO-2005/PRO-2006

The PRO-2005 and PRO-2006 are exactly alike inside/out except for two components on the Logic/CPU Board that differ: the CPU and the Clock Resonator. The alignment procedures and test measurements given here apply to both scanners. You should, however, have the proper service manual inasmuch (at this writing) the PRO-2006 is new and a few other differences may be found. Not likely, but why tempt Murphy and his infernal "law"? So far, I've been able to use either manual for either scanner, so I doubt there'll be any surprises, but you never know.

READ THIS FIRST:

A. Turn scanner ON and leave it ON for at least 30 minutes before attempting alignment. This allows the unit to warm up to its normal operating temperature. Loosen the case but leave it in place during the warm-up. Prepare your voltmeter for specific measurements outlined in the following steps. It is assumed you understand how to use your voltmeter.

Note: Unless specifically stated otherwise, the (-) lead of the voltmeter will **always** be connected to ground-- the metal chassis of the scanner. The (+) lead of the voltmeter will be connected to various test points as described for each step.

B. Be watchful of the results of all of your actions! If any single tweak or adjustment causes a significant change from the prescribed measurement, you may be doing something incorrectly. **Always** use a colored marking pen to note the original position of the adjustment **before** you tweak. When do adjust anything, do it s-l-o-w-l-y and methodically and not quickly and carelessly. As you make adjustments, watch the voltmeter and/or S-meter, also, at the same time, listen to the signal. If you do something wrong, being attentive to all of your "eyes and ears" will give you an early warning before you realign your scanner for picking up only ESP, dolphins, or whatever.

1. **Alignment of VCO, PLL-2:** Refer to the service manual, Step 1, page 11 and the Location Guide, but DO NOT EVER PERFORM THIS ADJUSTMENT. If it's been badly adjusted in the past, then follow the procedure in the service manual, verbatim and using an accurate voltmeter.

2. **Alignment of VCO, PLL-1:** Refer to the service manual, Step 2, page 11 and the Location Guide, but DO NOT EVER PERFORM THIS ADJUSTMENT. If ever before it had been misaligned, then use the procedure in the service manual, verbatim with an accurate voltmeter.

3. **Alignment of The 455 kHz NFM Discriminator Coil:** Refer to the service manual, Step 3, page 12, and the Location Guide, page 9, but perform the following instead:

A. Select a NOAA weather broadcast station for your area, such as on 162.40, 162.475, or 162.55 MHz. If none are available, then select an NFM station of known quality; one regularly maintained and kept in top condition. Certain well maintained NFM federal stations may be OK. Don't use military, local government, or business radio frequencies. Aero ATIS and other AM mode stations should **not** be used. The important thing here is an NFM mode station of known frequency accuracy that transmits most of the time. You will be using it as a signal generator, so it better be good.

B. Connect your DC voltmeter to "TP-2." Voltage here will be about 3 to 5 volts, so set your meter accordingly. A very precise adjustment must be made here, so an accurate voltmeter is essential. This adjustment is very "touchy" and may need several attempts to get it right.

C. Adjust T-8 for exactly 3.8 volts, $\pm 0.05V$. Forget that the service manual is willing to settle for " $\pm 0.10V$," you want better than that. Besides, this adjustment is very important if you have done (or will do) the Center Tuning Indicator mod elsewhere in this book. See that section for a fuller description of the meaning of the signal at this test point.

D. After you have set T-8 at exactly 3.8 volts at TP-2, observe the meter reading for a few minutes just to be sure it doesn't drift off right away. It's a critical setting and it could drift for a few seconds after the adjustment. Readjust if necessary. No need to mark this adjustment as you may be adjusting it from time to time during the course of your ownership of the scanner.

4. **Alignment of the 10.7 MHz WFM Discriminator Coil:** Refer to the service manual, Step 4, page 12, and the Location Guide, page 9, but perform the following instead:

A. Select your favorite FM broadcast station, 88 to 108 MHz band.

B. Connect your DC voltmeter to "TP-1." Voltage will be about 3 to 5 volts, so set your meter accordingly. A very precise adjustment must be made here, so you need an accurate voltmeter. This adjustment is very "touchy" and may require several attempts to get it right.

C. Adjust T-4 for exactly 3.8 volts, $\pm 0.05V$. Ignore the service manual's liberal " $\pm 0.10V$ " allowance, you need better than that.

D. After you have set T-4 for exactly 3.8 volts at TP-1, observe the reading for a few minutes to make certain it doesn't drift off. Readjust if needed. This is a critical setting. Don't bother to mark this adjustment, you'll probably want to tweak it once in a while as time goes on.

5. **Alignment of 48.5 MHz & 10.7 MHz WFM I.F. Coils:** Refer to the service manual, Step 5, page 12, and the Location Guide, page 9, but **DO NOT PERFORM THESE ADJUSTMENTS**. Special equipment is required, and they should be OK as they are. They will make very little difference anyway, so leave well enough alone.

6. **Alignment of 48.5 MHz NFM/AM 2nd I.F. Coils:** Refer to the service manual, Step 3, page 12, and the Location Guide, page 9, but do the following instead:

A. Perform Step 3.A above except that the chosen signal may either be NFM (such as an NOAA weather) or AM (such as aero band ATIS stations). For this one procedure, the signal should **not** be exceptionally strong-- a little weaker, the better, but it must be accurately on frequency.

B. Connect your DC voltmeter to IC-4, Pin 12, to measure the receiver's AGC control voltage, and/or you can attach a voltmeter to the analog S-meter function described above and in MOD-25 of this book. The AGC voltage varies from 1.20 volts (no signal) to 0.820 volts (max signal), so the range is narrow and the function is inverse; that is, AGC voltage decreases as signal increases. It's best to observe both the AGC voltage and an S-meter for this adjustment.

C. Mark the present settings of T-1 and T-7, then adjust T-1 and T-7 (in order) for a maximum reading on the S-meter and/or a **minimum** reading (dip) of the AGC voltage at IC-4, Pin 12.

Note: The modulation (voice) will probably cause fluctuations in the voltmeter's measurements. Adjustments should be made during pauses in the speech and otherwise account for those voice fluctuations as you perform the adjustment. An analog S-meter is ideal for this adjustment.

D. Repeat Step C once or twice to ensure proper adjustment.

E. Mark the new settings of T-1 and T-7 with a different colored pen.

7. **Alignment of 455 kHz I.F. Coil:** Refer to service manual, Step 7, page 13, and the Location Guide, page 9, but perform the following instead:

A. Select an NOAA weather broadcast station or an aero ATIS station. The scanner must be put into AM mode for this adjustment, even though you can still use an NFM signal. If you selected an NFM signal, just press the keyboard MODE switch twice so that the "AM" indicator appears in the LCD display. If you're tuned to an NFM station, it will sound awful this way, but that's OK for our purposes here. A weaker signal is better for this adjustment than a stronger one.

B. Connect your DC voltmeter to either your analog S-meter function or to the receiver's AGC voltage function, IC-4, Pin 12.

C. Mark the present setting of T-5 and then adjust T-5 for a maximum (peak) indication on the S-meter function and/or a **minimum** positive AGC signal.

Note: The modulation (voice) will probably cause fluctuations in the voltmeter readings. Adjustments should be made during pauses in the speech and otherwise account for those fluctuations as you perform the adjustment. An analog S-meter is OK for this adjustment.

Mark the new setting of T-5 with a different colored marking pen.

8. Alignment of 455 kHz AM Detector Coil: Refer to the service manual, Step 8, page 13, and the Location Guide, page 9, but perform the following instead:

A. Select an NOAA weather broadcast or an aero ATIS station. Regardless of the station chosen, the scanner must be put into AM mode for this adjustment. If you selected an NFM signal, just press the keyboard MODE button twice so that the AM indicator appears on the LCD display. The NFM station won't sound like much, but that's OK. A weaker signal is better than a stronger one for this step.

B. Connect your DC voltmeter to either your analog S-meter function or to the receiver's AGC voltage function, IC-4, Pin 12.

C. Mark the present setting of T-6 and then adjust T-6 for a maximum indication on the S-meter function and/or for a **minimum** positive AGC signal.

Note: The modulation (voice) will probably cause fluctuations in the voltmeter's measurements. Adjustments should be made during pauses in the speech and otherwise account for those voice fluctuations as you make the adjustment. An analog S-meter is ideal for this adjustment.

Mark the new setting of T-6 with a different colored marking pen.

9. Alignment of I.F. Trap Coil: Refer to the service manual, Step 9, page 14, and the Location Guide, page 9, but **DO NOT PERFORM THESE ADJUSTMENTS**. Special equipment is required and the adjustments are critical. Don't touch!

10. Alignment of 512 MHz I.F. Trap Coils: Refer to the service manual, Step 10, page 14, and the Location Guide, page 9, but **DO NOT PERFORM THIS ADJUSTMENT**. Special equipment is required and the adjustment is critical.

11. Alignment of 1st Band Pass Filter Coil: Refer to the service manual, Step 11, page 15, and the Location Guide, page 9, but **DO NOT PERFORM THIS ADJUSTMENT**. Special equipment is required and this adjustment is **very** critical.

12. PRO-2005 & PRO-2006: Important Voltage Measurements:

The voltage measurements on our table are by no means complete. They are intended to be a guide to preliminary troubleshooting if something should ever go awry with your PRO-2005/6. Should you request my opinion regarding the problem, I may need to know some or all of these measurements. If you want to become familiar with the inner workings of your PRO-2005/6, these measurements are an excellent starting point with which to work. If you performed the mods in Volume 1 and in this book, many will have become familiar, anyway. Get comfortable with them. Refer to the service manual, pages 25, 26, and 72 to 75.

<u>No.</u>	<u>Location of Test Point</u>	<u>Should Measure</u>	<u>Conditions of Measurement</u>	<u>Comment & Discussion</u>
A	Left lead of R-229	+12v, +1v	Scanner ON	Main system DC from power supply
B	<i>NOTE: DC system current drain can be easily determined by measuring the voltage drop across R-229 (2.2-ohms) and dividing that reading by 2.2. Ohms Law, $I = E/R$, so current drain, in amperes, will be equal to the</i>			

voltage drop across R-235 divided by 2.2. Typical value would be between .25 and .40 amps (250-400 ma). Place the (-) lead of the voltmeter on right leg of R229 and the (+) lead of the voltmeter on the left leg of R-235 for a quick and easy measurement.

C	Out Lead of IC-8	+5v, \pm .1v	Scanner On	Main regulated +5v power supply
D	Pin 10 of CN-3	+5v, \pm .2v	Scanner On or Off	CPU regulated +5v power supply (operates CPU & retains memory)
E	Emitter of Q-32	+8.3v, \pm .3v	Scanner On	Regulated +8v power supply
F	Pin 12 of IC-4	+0.82v --->Max signal +1.20v --->No signal		Receiver Automatic Gain Control inversely proportional to signal
G	Pin #13 of IC-2	\sim +7v ----->Squelch CW 0v ----->Squelch CCW		Receiver SQUELCH Gate Trigger to (H) below
H	Pin #3 of IC-3	0v ----->Squelch CW +4.8v ---->Squelch CCW		Squelch Logic Gate to CPU
I	Anode of D-59	+9v, \pm .5v	Scanner On or Off	Memory Retention Battery Input Replace battery if below 8.5v
J	Cathode of D-56	+9v, \pm .5v	Scanner On or Off	Same as (I); input to CPU +5v regulator
K	Cathode of D-57	+10.6v, \pm .3v	Scanner On	Preregulates "scanner on" working voltage to input of IC-9
L	Cathode of D-33	RF No DC	NFM or AM	Last NFM/AM 455 KHz I.F. output. This is the most useful test point of all. It feeds your Diode Detector circuit (MOD-12b) for the S-Meter function.

Chapter 3: Projects

PRJ-1

Two Easy DC Power Supplies For Your Electronic Projects

PRELIMINARY DISCUSSION

If you are even casually interested in electronics with any notion of doing the more exotic mods in either Volume 1 or 2 of this series, then you need a couple of DC power supplies in your work area-- that is, unless you're fond of taping flashlight batteries together to supply voltages for your projects. OK, you could effectively use battery holders in any number of combinations to come up with the right voltage.

But batteries can be expensive if you need 14V with a 1-amp capacity. Batteries run down, increasing the long term cost. As they run down, the voltage drops, so they don't maintain a constant voltage for very long. Even if you use NiCd's to minimize the long term expense, the voltage doesn't stay constant and recharging becomes a nuisance. There are several common voltages frequently required in electronics applications (like 5V, 8V, 12V, and 13.8V), and just try getting any of them, or maintaining them at that level, using flashlight or rechargeable batteries. There's a better, highly cost-effective way to provide a range of pure, constant, regulated DC voltages for most any application.

Build Your Own DC Power Supplies: At last count, my work bench had six DC power supplies. On a secondary bench there are three more. I also have a number of gel cell and NiCd battery packs to supplement those when needed, and at times all are in use and I wish I had more! For your purposes, two power supplies will get you started in style. If your needs aren't too heavy, one will do.

If one is about your limit, what I have in mind is an all-purpose, fully adjustable DC power supply that will produce up to one ampere over a selectable range of voltages from about 1.2V to 16V (maybe a little more). You can build it for less than you can buy a 12V/1-amp supply at Radio Shack. The one you build will have two valuable features not in the commercial model: it's fully adjustable and it has a **regulated output**.

If you're interested in digital electronics and/or want maximum flexibility for all occasions, the second power supply I think you'll need is a fixed, 5V regulated power supply capable of 300-ma in the economy version, or up to 1-amp in the deluxe model. These days, CMOS circuits commonly require 5 volts, and other circuits require anywhere from 6V to 14V. Quite often, a single project requires two different voltages. That's why I recommend the both power supplies. But let's talk first about the All Purpose Supply, since it can produce 5V or anything else between 1.2 and 16 VDC.

Power Supply Theory: Just a painless once-over-lightly about the theory so you'll know what's happening. The power mains in the walls of your home, office, or business produce 110 volts (actually, 110 to 120 volts depending upon your local power company), 60 Hz AC (alternating current). It's absolutely worthless for electronic circuits). It's wonderful for lights, typewriters, power tools, refrigerators, small appliances, and for accidentally electrocuting people who fail to give it the respect it demands and deserves. It's not good for much else, but it's convenient and it's all that you have to work with.

Thanks to "transformers" (heavy chunks of iron with four or five wires poking out), we can drop ("transform") 110VAC down to a voltage something not only a lot safer, but also more in line with the eventual voltage we'll need. There are many types of transformers, but our focus here is on the step-down variety that takes 110VAC as an input and typically puts out 6.3VAC, 12.6VAC, 18VAC, or as high as 25VAC, depending on the rating you select. Radio Shack offers a selection of transformers with outputs from 12.6VAC to 25.2VAC.

The transformer steps down the 110VAC into a more useful lower voltage, but it is still AC, which is worthless for your purposes. So, the next functional step of a DC power supply is to turn that AC into DC (direct current). This is readily accomplished by a Full Wave Bridge Rectifier, which is nothing more than four rectifiers (diodes) hooked together in a certain manner and then packaged as a single unit with four leads. The two low-voltage AC leads from the power supply connect to the two "AC" leads on the Bridge Rectifier. The other two leads of the Bridge Rectifier are the (+) and (-) DC outputs. The DC output from the (+) and (-) leads is not a pure DC; it actually pulsates at 120 Hz. That pulsating DC is still worthless for electronic circuits and must be "purified" and made stable just like a battery's voltage. This takes us to the third functional step, a filter capacitor that smooths out the rippling, pulsating DC into what passes as a fairly pure DC.

Some power supplies, such as Radio Shack's 12 volt DC #22-127, and 12 volt DC adapter, #273-1653, stop at this point. This is OK for some non-critical applications, but for radio and digital electronics, it's not quite enough. You can see what I mean by connecting a voltmeter to either of these two supplies and note that it measures as much as 15V at the output plug when no current is being drawn. Then, with any current drain at all, the voltage will drop slightly. The more current that is drawn, the more the supply's voltage will drop. Sensitive radio and digital circuits won't appreciate this since they demand voltages that remain stable, regardless of the current drain. So, this brings us to the next functional step of our power supply, the Regulator.

A regulator maintains a steady output voltage that is unaffected by current drain, so long as that drain is within specifications of the regulator device. Radio Shack's Regulated 12VDC Power Supply (#22-120) will actually put out a constant 13.8VDC throughout its rated current range of 0 to 2.5 amperes. Our 1-ampere rated power supply will put out whatever voltage you select from a dial, and maintain that voltage nice and steady throughout a range of 0 to 1 ampere.

There are two basic kinds of regulators: fixed and variable. Either can be known as a "three port" regulator," since they look like a power transistor and have three leads or terminals; one for unregulated DC-in; one for ground or an adjustment; and one for regulated DC-out. Rather simple, actually, especially when you consider that the innards of these things are an integrated circuit with a number of transistors and other parts. All you see are the three leads, however. The 5V Power Supply will use a "fixed regulator," while the Adjustable Power Supply will use (what else?) an adjustable regulator. There is really not much difference between the two, as you can see from the diagrams.

Basically that's it. Well, there are a couple of fancy frills and little trimmings we'll add, like an ON/OFF switch, and indicator LED, a fuse, and some extra filtering to remove noise and spikes, but I've given you the essential theory of the nature of the beast. Now, all that's left to do is get down to the business of building one or both at a price that won't send you reeling, and within a time frame that will be short enough to hold your interest.

Planning For Your Needs & Wants: You should pause for a little figuring before you rush off to the store to load up on goodies. What do you want your power supply to look like? Will you be satisfied with "bare bones" or do you prefer the luxuries of an ON/OFF switch and indicator light (neither is necessary)? Without an ON/OFF switch, you can simply plug the power supply into an AC outlet when you need DC power, then remove the plug when you're finished.

Do you want the flexibility of adding simple connectors or jacks to the box so that the DC power wires can be disconnected at times, or might you content with a fixed cable pair that goes through a hole in the box and is permanently fixed inside? Review the Parts List and the Schematic Diagrams to get a "big picture" of what you want, with or without frills. Then custom design the exact unit you will assemble.

Box? Of course! You don't want dangerous 110VAC out there in the open for the kids, your spouse, or your cat to come into contact with the stuff. You don't want to handle 110VAC, yourself! So it's absolutely essential that the electrics and electronics of your power supply be contained inside a suitable enclosure, preferably metal. Size of the box is the main consideration. The largest single component to be contained in the box is the transformer. To be on the safe side, you'll want the box to be about four times the volume of the transformer. If you're good (and experienced) at construction projects of this nature, you might be able to get away with a box only twice the volume of the transformer. Much depends upon your selection of fuse, ON/OFF switch, and indicator light, since these will require the majority of the remaining volume of the box.

A small circuit board (actually, you don't absolutely have to have one) will readily hold the Bridge Rectifier and filters. Generally, the regulator will be mounted to an interior surface of the metal box to take advantage of the "heat sink" properties of the metal. If you want current capability of anything approaching 1-ampere, the Regulator must be "heat sunk" in order to safely dissipate the heat that can build up within the device. Plan carefully for your box requirements, or take my word that Radio Shack's 270-253 will be adequate for most light or medium requirements.

A Medium Duty, Adjustable, Regulated DC Power Supply, 1.2 to 16 VDC: Refer to the Parts List (Table 3-3-1), and the Schematic/Wiring Diagram (Figure 3-3-1)) for the overall perspective of this project. Plan the layout in the enclosure and mark all places that need to have holes drilled.

Plan all drill spots and hole sizes before actually taking drill in hand. Then drill all required holes. Install the transformer first, followed in order by the fuse holder, ON/OFF switch, Voltage Adjust control, and output connectors or jacks. In other words, install all hardware, with the external fixtures/controls first. Don't attempt any of the electronic construction until the mechanical assembly has been completed. I also recommend installation of two or three tie-point terminals (Radio Shack 274-688, or equivalent), to which the electronic components can be soldered in lieu of a circuit board.

TABLE 3-1-1
PARTS LIST FOR THE ALL PURPOSE POWER SUPPLY

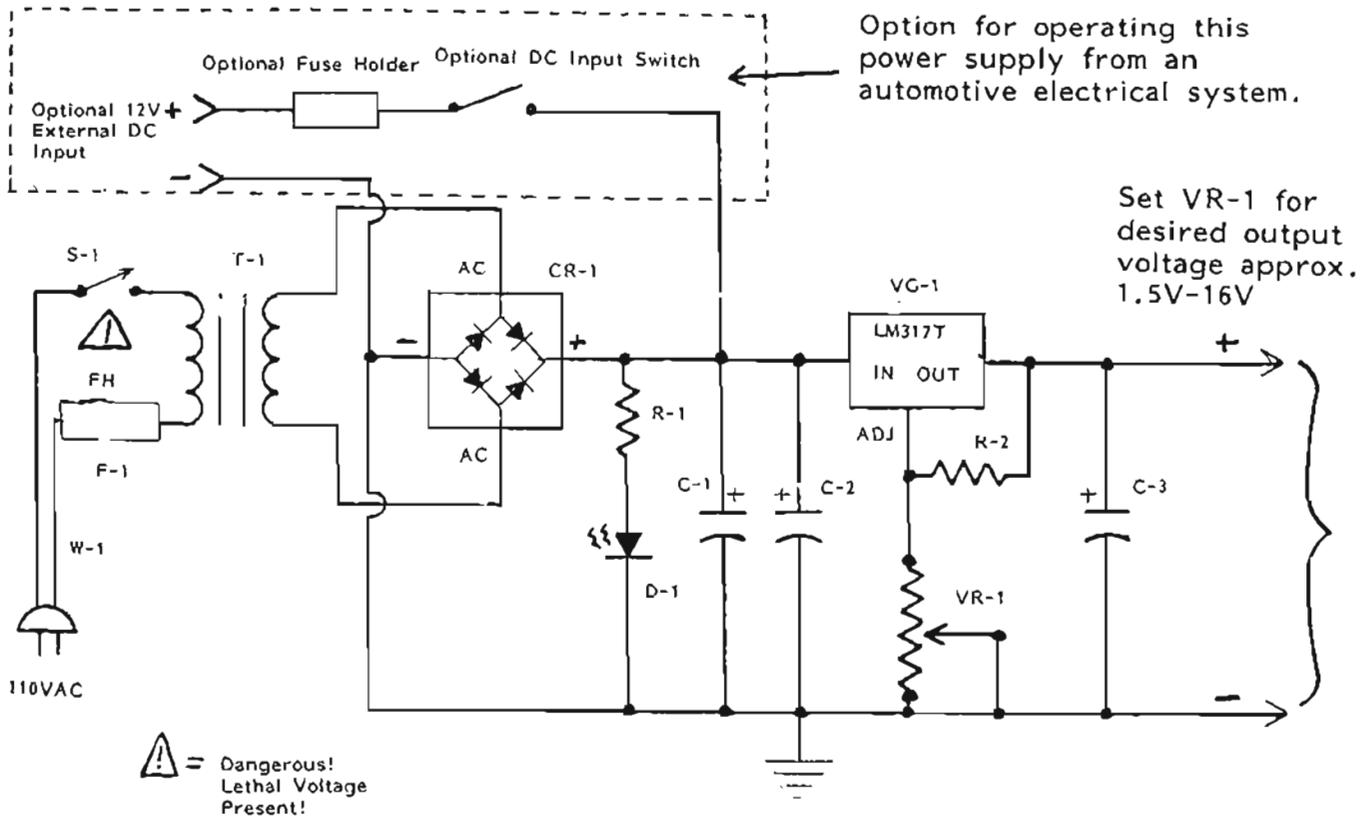
<u>Ckt</u>	<u>Symbol</u>	<u>Quan</u>	<u>Description</u>	<u>Radio Shack</u> <u>Catalog #</u>
C-1		1	Capacitor, 4700-uF/35WVDC	272-1022
C-2,3		2	Capacitor, 2.2-uF/35WVDC	272-1435
CR-1		1	Bridge Rectifier; 1.5 amp, 100 PIV	276-1152
D-1		1	LED w/holder	276-068
FH		1	Fuse holder	270-364
F-1		1	Fuse, 1 amp	270-1273
R-1		1	Resistor, 1.5-k, for LED above	271-025
R-2		1	Resistor, 220-ohm for Regulator	271-1313
S-1		1	Switch, SPST	275-1565
T-1		1	Power transformer; 18.0v CT/ 2 amps	273-1515
VG-1		1	LM-317T Adjustable Regulator	276-1778
VR-1		1	Potentiometer (Voltage Adjust); 5-k	271-1714
W-1		1	AC Power cord	278-1255
		1 pr	Nylon Binding Posts (Output terminals)	274-662
	Misc		Heat Sink Grease (for mounted Regulator)	276-1372
	Misc		Knob for Voltage Adjust	274-433
	Misc		Metal Project Box	270-253
	Misc		Hardware; machine nuts & bolts	64-3012
	Misc		Hardware; machine nuts & bolts	64-3019
	Misc		Vinyl Grommets	64-3025
	Misc		AC Wire nuts	64-3026
	Misc		Heat Shrinkable Tubing	278-1627
	Misc		Tie Point Terminals	274-688

Next, install the LM-317T Regulator. It goes flat against an interior metal surface of the box. Lightly sand the area where the Regulator will lie flat so as to expose bare metal. Apply and spread a dab of "heat sink grease" (Radio Shack 276-1372, or similar) on the back surface of the Regulator body and to the spot on the chassis where regulator will be mounted. Use mounting hardware such as Radio Shack 276-1373 (or equivalent), and be sure to use the mica insulator between the regulator and the chassis. Also be sure to use the special insulating washer to prevent the screw from shorting the regulator's metal back to the chassis. After the Regulator is installed and tightened to the metal surface, bend the three terminals outward a little so that they can be conveniently soldered to later.

Examine the Full Wave Bridge Rectifier. If it has a hole in the middle and a metal back area, it can be mounted similar to the regulator against the enclosure's metal surface. Mount it accordingly if desired. If no mounting hole, then wait until later for its installation.

Install the appropriate Voltage Adjust Control in the front panel of the chassis. The 5K linear potentiometer specified in the Parts List is adequate for most needs, but if you want something extra nice, precision, and with that professional touch, then get a 5K-ohm precision, ten-turn "helipot." Radio Shack doesn't have these, but an electronic surplus or electronics distributor might. A ten-turn helipot will allow very precise, repeatable setting of output voltages, typically to the second decimal place, such as 13.86VDC.

Figure 3-1-1
**ALL PURPOSE, ADJUSTABLE, REGULATED POWER SUPPLY
 SCHEMATIC & WIRING DIAGRAM**



Fit the AC power cable into the rear of the box using a rubber grommet (Radio Shack 64-3025, or equivalent) to prevent the edge of the hole from ever chafing through and eventually causing a dangerous 110VAC fireworks display and shock hazard. After the AC cord has been inserted through the grommet, tie a knot in the cord so that it can't pull back through the grommet. Make sure several inches of the cord is loose, ahead of the knot, so that the leads can be routed and connected to the ON/OFF switch and the fuse holder,

Solder one of the AC cord leads directly to one of the contacts on the ON/OFF switch. Solder the other AC cord lead to one of the two lugs on the fuse holder. Solder a hookup wire to the other lug on the fuse holder. Splice the other end of that hookup wire from the fuse holder to one of the primary leads of the transformer (usually a black wire). Insulate the splice with heat shrink tubing or a wire nut. **DO NOT USE ELECTRICAL TAPE.** Solder the remaining transformer primary lead to the remaining lug of the ON/OFF switch. This completes primary power distribution wiring. Check your work for errors and uninsulated, exposed connections. Insulate connections on the fuse holder and the ON/OFF switch with tightly wrapped electrical tape, followed by a wrap or two of cellophane tape.

You can perform a preliminary test at this stage. Install a 1-amp or lower fuse in the fuse holder. Attach an AC voltmeter to the secondary leads of the transformer. Select a voltage scale of greater than 25 volts to start with. Normally,

the secondary leads of a transformer are yellow, but there may be a third, different colored wire, which is the center tap. Clip the excess off that center tap wire (if present) and move it out of the way-- it isn't needed. The voltmeter should be connected to the two yellow or main secondary leads of the winding. Plug in the AC cord; turn the switch ON, and read the voltmeter. As long as it reads **approximately** (\pm a couple of volts) the specified rating of the transformer, things are OK. Turn switch OFF. **Unplug the AC cord!** Remove the voltmeter connections.

You can use Radio Shack's #278-688 Tie Point Terminals instead of a circuit board on which to install most of the electronic components and wire junctions, Use them creatively! Install the Full Wave Bridge now if not done previously. Solder the two transformer secondary leads to the two "AC" terminals on the Bridge Rectifier. Solder two 18-20-ga. hookup wires to the (-) DC output terminal of the Bridge Rectifier. Connect one of those wires to any metal ground connection on the chassis. Connect the other wire to the (-) output connector, jack, or lug wire that exits from the Power Supply.

Solder the 220-ohm resistor directly between the Regulator Output terminal and the Regulator Adjust terminal. Connect a hookup wire to the wiper arm (rotor) lead of the Voltage Adjust control, typically the middle lug. Connect another hookup wire from the ADJ terminal on the Regulator to the remaining end lug of the Voltage Adjust control. Later, if the rotation of the control causes the voltage to change in a direction opposite from desired, simply change (reverse) the two end lug connections on the control.

The rest of the job is quite self-explanatory if you review Figure 3-1-1, the Schematic/Wiring Diagram.

Operation & Use of The All Purpose Power Supply: A cinch. You'll have to use a voltmeter on the terminals of the power supply to set a desired voltage, after which it will remain constant until the knob is moved, either intentionally or by accident. Any voltage selected (from about 1.2V to 16V or so) will be maintained steadily through a range of demands up to a current of about 1-ampere. If a current demand is greater than about 750-ma., you may notice a slight drop of the output voltage as the current drain increases. This is normal, provided that the fluctuation does not exceed more than 0.25 volts or so.

Current demands greater than about $\frac{1}{4}$ -ampere (250-ma.) will cause the regulator to heat. If you mounted it solidly to the metal chassis, then that area of the chassis will heat up. Notably warm conditions are normal, but should the area actually become HOT to the touch, discontinue operation until it has cooled. You will want to make certain that the Power Supply is used where air can circulate freely around it for to permit adequate and safe heat dissipation.

The All Purpose Power Supply will power a wide range of electronic needs, including lower powered car stereos, portable cassette players, virtually all scanners, and most bench projects. The Power Supply is NOT intended or adequate for CB radios or quality stereos. It will not power anything that requires a current greater than 1-ampere.

You would do well to make up several sets of cables for plugging into the power supply for your various needs and projects. One of my favorite cable setups consists of Radio Shack's #278-704 test leads with the long probes removed and replaced with alligator clips (Radio Shack #270-346, or equivalent). You have to be careful of alligator clips because they can easily short out against things and cause fireworks. Still, they're very handy for quick hookups and tests.

able to get a regulated voltage from between 1.2V and maybe as much as 10.5V with the engine off, or up to 12V with the engine running. The reason for this is that the Regulator consumes about 2 volts when functioning. Well, with the car engine off, the system voltage is 12.6V at full charge. With the alternator cranking away, that goes up to about 14 volts. So you can power the All Purpose Power Supply from any DC source so long as you are willing to accept a maximum output of 2V less than the input. Of course, the Voltage Adjust will permit much lower voltages, too. To connect a DC source to the Power Supply, it needs no modification. Just add two DC **input** terminals, one being ground, and the other to connect internally to the (+) terminal of the Bridge Rectifier. You won't be able to shut it off using the ON/OFF switch, but that's no big deal.

One potential use of this unit in your car is to power your handheld scanner with pure, steady DC! Take the Realistic PRO-34 as an example. It needs six alkaline or NiCd batteries to operate-- that adds up to 9V. If you tried to power your PRO-34 directly with the car's 12V, the scanner might blow up. At the very least, its innards would be fried to a beautiful medium brown. So, connect your All Purpose Power Supply, or a DC-only version of it (which doesn't require any of the primary AC components, including the transformer and bridge rectifier). Fabricate an appropriate power cable for the supply; plug it into the PRO-34 and stop worrying about replacing those expensive alkaline batteries. Lots of things run on 9V that can benefit from this power supply, using the car's electrical system.

Only your imagination will be the limit on the number of uses for this power supply. When you realize how useful it is, you might want to build several!

A Low Cost, Medium Duty Fixed 5V Regulated Power Supply

Some of the mods and projects in this book should be tested before being installed in your scanner. Virtually all the digital projects require 5V for power. You could wire three flashlight batteries in series to get 4.5V, but it's a pain in the neck and it's not exactly the correct voltage.

Most of our digital projects are powered by the scanner's internal 5V regulator. Why not assemble your own convenient 5V supply for testing these things? And, who knows, maybe later it will come in handy again. Of course, you can always use the All Purpose Power Supply if preset to 5V, but then you can't simultaneously use it for anything else. And what if you have it set for 14V for another project and forget to lower the setting to 5V when you connect the CMOS circuit? **ZAP!** If you do any of the more involved mods herein and/or any digital circuit design, build this 5V supply.

Procedures are very similar to those given for the All Purpose Power Supply. The main differences are in a few components. If you're willing to accept "light duty" as dictated by the 300-ma. rating of the transformer I selected for this project, then the Regulator need not be mounted to the chassis (it won't get that hot); the transformer is a lot smaller, and therefore the box can be smaller. Certain complexities are also eliminated, such as the Voltage Adjust.

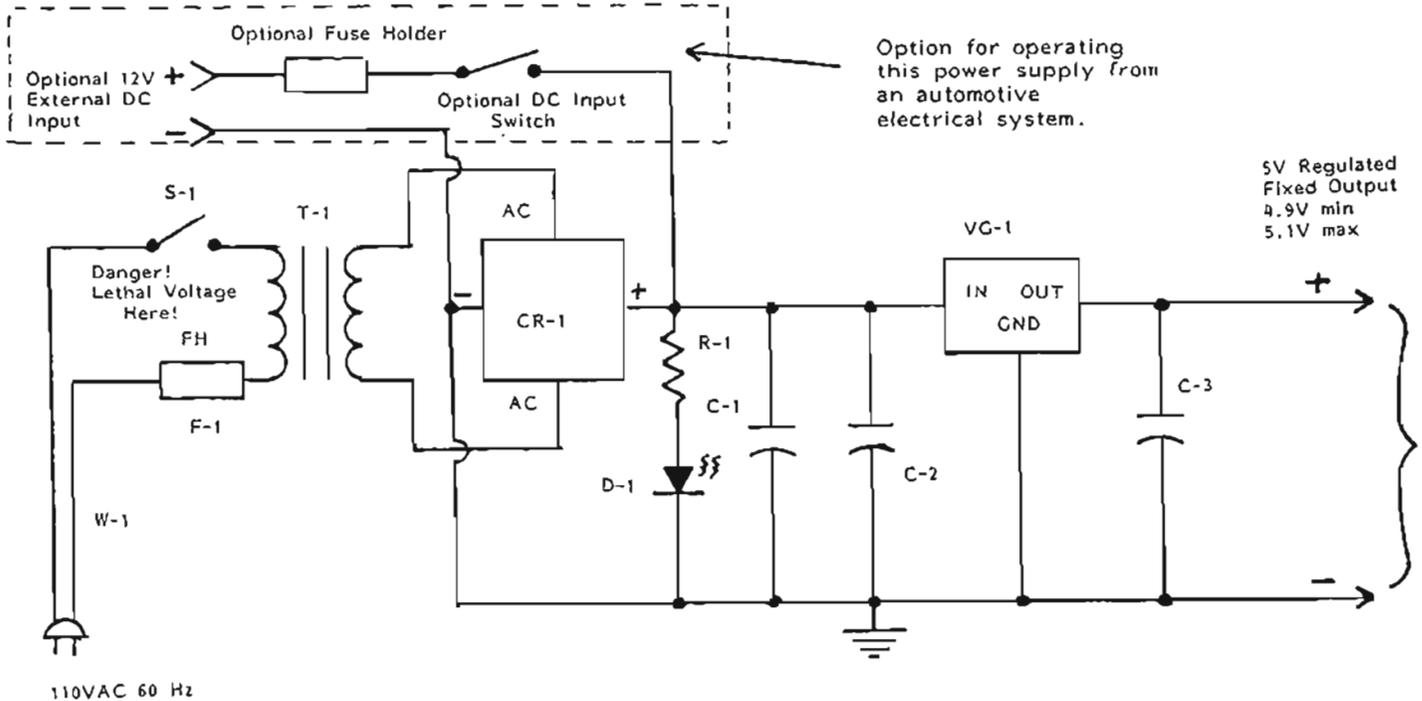
If you want your 5V Power Supply to be medium rated (1-ampere), then you'll need the larger transformer; the large box, and the Regulator will have to be mounted to the metal chassis. See the foregoing discussion for the All Purpose Power Supply; then check out Table 3-1-2, the 5V Power Supply's Parts List, also Figure 3-1-2, the Schematic/Wiring Diagram.

TABLE 3-1-2
PARTS LIST FOR THE FIXED 5 VOLT POWER SUPPLY

Ckt Symbol	Quan	Description	Radio Shack Catalog #
C-1	1	Capacitor, 4700-uF/35WVDC	272-1022
C-2,3	2	Capacitor, 2.2-uF/35WVDC	272-1435
CR-1	1	Bridge Rectifier; 1.5 amp, 100 PIV	276-1152
D-1	1	LED w/holder	276-068
FH	1	Fuse holder	270-364
F-1	1	Fuse, 1 amp	270-1273
R-1	1	Resistor, 1.5-k, for LED above	271-025
S-1	1	Switch, SPST	275-1565
T-1	1 *	Power transformer; 12.6v/300-ma	* 273-1385
VG-1	1	7805 Fixed Regulator	276-1770
W-1	1	AC Power cord	278-1255
	1 pr	Nylon Binding Posts (Output terminals)	274-662
Misc		Heat Sink Grease (for mounted Regulator)	276-1372
Misc		Metal Project Box	270-253 or ??
Misc		Hardware; machine nuts & bolts	64-3012
Misc		Hardware; machine nuts & bolts	64-3019
Misc		Vinyl Grommets	64-3025
Misc		AC Wire nuts	64-3026
Misc		Heat Shrinkable Tubing	278-1627
Misc		Tie Point Terminals	274-688

* If 1-amp rating is desired, use Transformer 12.6v CT/1.2 amp, 273-1352 and mount the 7805 Regulator to the metal chassis for heat sinking.

Figure 3-1-2
FIXED 5-VOLT REGULATED POWER SUPPLY
SCHEMATIC & WIRING DIAGRAM



Pay particular attention to the wiring of the Regulator terminals because you want to get it right on the first try. Radio Shack says their regulators are internally protected, so you're unlikely to blow it with wrong wiring, even a direct short circuit. Still, it's best not to test things that way if you can help it.

By the way, if you mount the 7805 regulator to the chassis for better heat dissipation, you need not use the mica insulator nor the insulating washer at the mounting screw. Adjustable regulators require the insulating materials but fixed regulators do not.

When you've completed the electrical and electronic wiring of the 5V Power Supply, test it with a voltmeter. There aren't any voltage adjustments, and what's coming out should measure between 4.85 and 5.15V. Within that range, the exact voltage isn't critical. Regulators vary a few hundredths of a volt from one to the next. If the output is out of tolerance, install another one and either trash the old one, or return it to wherever you obtained it and tell them it's defective.

Wrap Up: Power supplies are easy to build. They're fun to work with, and are the first step to master if you'd like to go further in the hobby, or perhaps eventually get into electronics as a profession. Everything you'll ever work with requires power, usually DC, and most often between 5 and 14 volts. This project could open doors into the future for you.

As those doors open, one of the things that will cross your mind is the notion of a heavy duty version of the two units described in this section. You may have already started thinking along those lines. Right? Well, light and medium duty power supplies are a simple technology well within your grasp. Heavy duty (2-amps and up) supplies can get very complicated-- although, with some preparation and study, hobbyists can build them up to about 10-amps or so.

There are three areas that serve to limit the current capacity of a regulated power supply. First is the transformer, which **MUST** be rated at least 10% to 25% above the desired current limit. That means, for instance, a 5-amp. supply **MUST** have a transformer rated at 6-7 amps or better.

Then, there's the current capacity of the Bridge Rectifier. This spec should be **double** the desired current limit. If it has to handle 5-amps., then the bridge rectifier should be rated at 10-amps. or better (and preferably better), with a 25-amp. rating not unreasonable.

Last, the Voltage Regulator rating must be considered. Most 3-port regulators are limited to 1.5-amps. or less, which heads you into another area of power supply design (pass transistors). Just get started with the two supplies given here, then you can progress into more esoteric designs. Those here are more than adequate for scanners and scanner mods.

Boosting The Audio Power Output of Your Handheld Scanner

PRELIMINARY DISCUSSION

Handheld scanners usually produce plenty of audio power, IF you have a headphone stuck in your ear. Otherwise, the puny audio power output and smallish speaker are sufficient mostly for use under exceptionally quiet conditions-- like maybe in your closet at 4 a.m. on Tuesday. Certainly, the audio output doesn't have enough punch for noisy environments, particularly in vehicles (where handhelds are frequently used).

This section presents a variety of methods to gain more audio punch from your handheld scanner, and for other audio devices, too. There will be a couple of specific quick/easy approaches for dedicated couch potatoes or those who just don't have the time and space to fool around with IC chips or separate external speakers. There's also a project approach to getting all the audio you'll ever need if you don't mind soldering an IC chip and some small parts together to make a simple circuit.

The project approach involves the construction of a power audio amplifier inside an external speaker using one of the commonly available audio power chips. The chip and a few components are mounted right inside the speaker enclosure, and the unit needs only external battery power or power from your vehicle. Of course, the homebrewed amplified speaker then plugs into the headphone jack of the handheld scanner. It'll knock your socks off if you turn it up too much-- all from a little speaker and a tiny chip!

The specific, quick/easy methods are just that, so pick up the parts. I've given Radio Shack part numbers because the components are so readily available. Put it together, hop into your car, plug it in, and you'll see a big difference in what you can hear from your handheld scanner. Let's look at the easy stuff first:

5 Minutes to Ear-Shattering Handheld Audio

Amplified Speakers: Radio Shack offers several types of ready-to-use amplified speakers which can work very well with handheld scanners. Install batteries, or operate from your car with an adaptor and you're in business. The Radio Shack salesperson can explain the ways to power up their units. All you need to know is that if you buy one of their amplified STEREO speaker sets, you'll need a little adaptor for the plug to fit into your scanner's MONAURAL headphone jack. Use either Radio Shack #274-877 or 274-368-- your choice. If you use a MONAURAL amplified speaker, no adaptor plug will be needed.

The hardest part of the job is selecting which amplified speaker(s) to get. Any will do the job, so you'll be evaluating based upon price, size, power consumption, and matters of convenience. You can select from:

Stereo Amplified Speakers: 40-166, 40-1267, 40-1303, 40-1259;
Monaural Amplified Speaker: 40-1262, 32-2031, 273-1454.

Another Easy Option For Mobile Handheld Audio: This one is pretty slick. I got the idea from an article by Paul M. Danzer (N1LL), in the July, '89, issue of **73 Amateur Radio Magazine**. The article was titled, "Good Mobile Audio - For

Pennies." I tried the idea presented and it worked just fine-- but I tinkered around a bit and discovered a quicker and easier commercial approach that works better, and which I'll show you here. If you'd rather do it from scratch, then see if you can pick up a copy of Paul Danzer's original article, it's quite clever and novel.

My own approach calls for you to go over to Radio Shack and get something they call a CD-to-Cassette Adapter, #12-1951, also one of their stereo-to-mono plug adapters, either #274-877 or 274-368. This gizmo looks like an ordinary cassette tape but it has a thin cord coming out of it and a mini stereo plug on the end of the cord. Normally, you'd insert the plug into the output of a portable CD player and then stick the thing that looks like a tape cassette into your car stereo player.

We scannists can find a better use for the device than that. Instead, you insert the plug into the headphone jack of your handheld scanner, then put the cassette part into the car's stereo system. The scanner then feeds its audio right into the car's stereo amplifier! Should be plenty loud enough for you to hear everything. And if your car happens to have one of those macho 1,000 watt stereo systems, you'll sure rattle 'em at the Burger King.

Make Your Own High-Powered Amplified Speaker: The visible part of this route to improved handheld scanner audio is Radio Shack's CB Extension Speaker #21-549. The speaker element has a very heavy magnet and is solidly constructed. I've used this model for years in many different projects and it's never let me down insofar as ruggedness and sound quality. There's plenty of room inside the case to build a small audio power amplifier using only a single, readily available IC chip.

These days, practically an entire audio power amplifier comes on a single chip. All you need do is add some external components, typically a few capacitors, a volume control (although your scanner already has one), and a fused power cable. Most handheld scanners produce about a half-watt of audio power. This little project, which takes roughly an hour, yields 5-watts of ear-splitting audio.

The heart of this project is a simple IC amplifier, and dozens of varieties are probably in stock at your nearest electronics distributor. The part numbers I've specified are ECG or NTE, but GE or RCA equivalents are fine and can be cross-referenced by the distributor. Because so many IC's are available, I'm going to provide only a single detailed schematic (Figure 3-2-1). Specific external designs vary a little from one chip to the other, and the dealer will have a data sheet for the one you purchase. They're all very similar and easy to put together.

Table 3-2-1
AUDIO POWER AMPLIFIER IC CHIPS

<u>Part #</u>	<u>Power</u>	<u>Part #</u>	<u>Power</u>
1388	5.8 watts	1127	4.5 watts
1370	5.8 watts	1116	5.0 watts
1362	5.5 watts	1114	4.5 watts
1169	5.5 watts	1111	4.0 watts
1155	5.8 watts	1115	7.0 watts
1160	5.2 watts	1098	4.0 watts
1153	4.2 watts	1037	5.5 watts

Table 3-2-2
PARTS LIST FOR AMPLIFIED SPEAKER FOR HANDHELD SCANNERS (and more)

<u>Ckt Sym</u>	<u>Description</u>	<u>Radio Shack Catalog #</u>
IC-1	ECG 1155 or NTE-1155 5.8 watt Audio Power Amplifier	n/a
R-1	Resistor, 82-ohms, 0.5-watt	271-011
R-2	Resistor, 1000 ohms, 0.5-watt	271-023
C-1	Capacitor, 1-uF/35vdc, tantalum	272-1434
C-2,5,6	Capacitor, 47-pF, disk	272-121
C-3,8	Capacitor, 47-uF, electrolytic	272-1027
C-4	Capacitor, 220-uF, electrolytic	272-1029
C-7	Capacitor, .047-uF	272-1068
C-9	Capacitor, 1000-uF/35WVDC	272-1019
C-10	Capacitor, 470-uF/35WVDC	272-1030
J-1	RCA Phono Jack; accessory input	274-346
S-1	Switch, DPDT, toggle	275-663
W-1	Power Cable, fused	21-550
LED-1	LED, Red, T-1	276-026
SPK-1	Extension Speaker, CB, 5-watt	21-549

Perhaps your main (or only) concern will be for which IC is most readily available. That's why I'm specifying several different chips. Find what's available, pick one, and ask to see the data sheet for that chip. Table 3-2-1 shows a list of audio power amp chips. Remember, the part numbers are ECG or NTE.

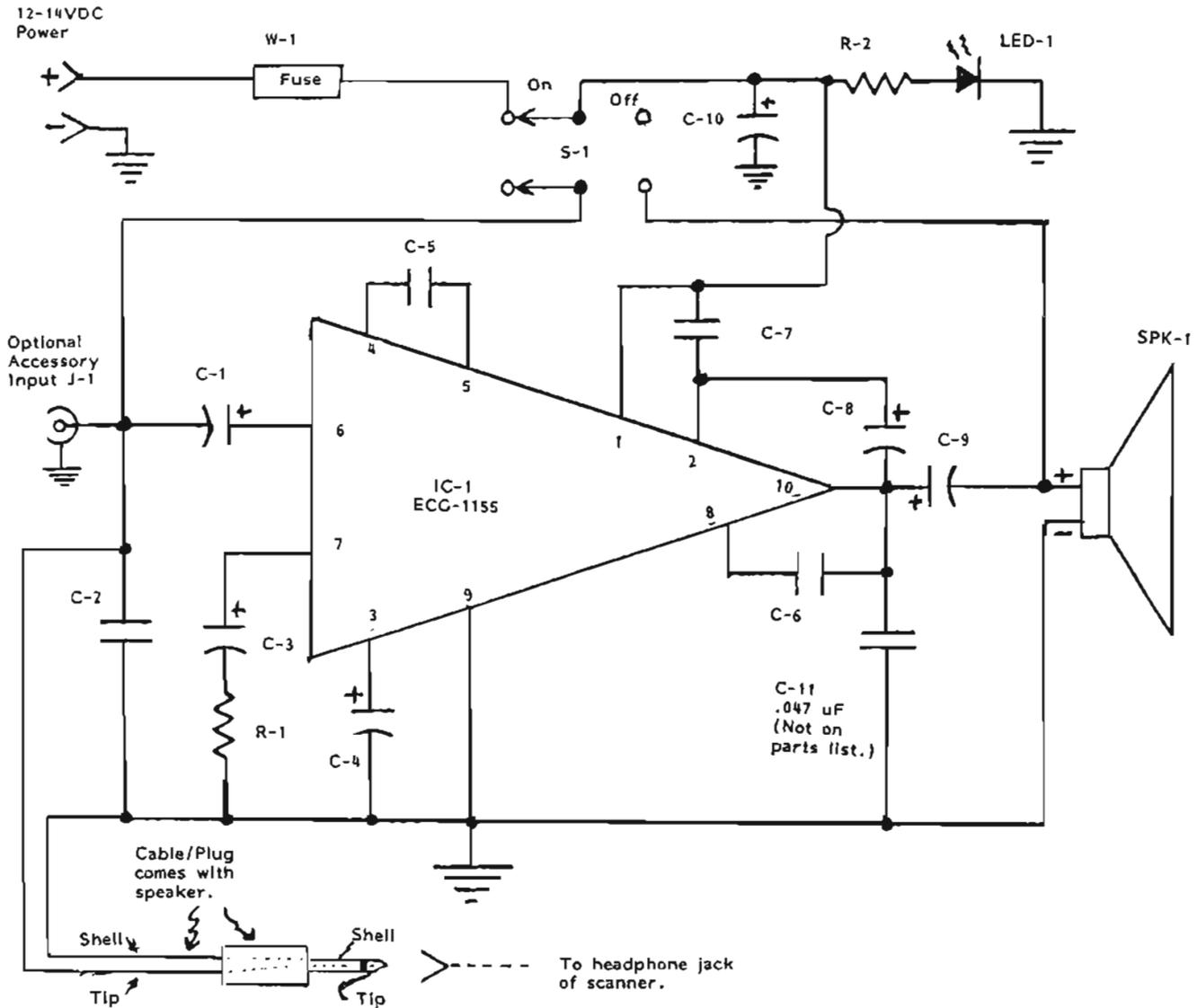
Table 3-2-1 shows only a few of the many audio power amplifier IC's available in the 4 to 7 watt range. The chip shown in Figure 3-2-1 is a type ECG/NTE 1155, just as an example. Other chips you might use could call for even fewer external components, some a couple more. But the 1155 was selected as a typical example of what you'll run into.

Probably the most complicated part of this project will be to physically mount the chip onto a heat sink. Most any piece of metal will do, the important thing is to mount the metal tab of the IC onto a section of metal that has as large a surface area as possible. Use some silicone heat transfer grease (Radio Shack #276-1372, or equivalent) between the IC's metal tab and the heat sink. Running at a couple of watts, the IC will generate heat that needs to somehow be dissipated. As long as you don't try to get full output from the chip (and I doubt that you will, if you value your ears), then the heat sink isn't too critical so long as you mount the IC to something metallic with a few square inches of surface area. That piece of metal may then be bolted inside the speaker enclosure somewhere. You probably don't need a circuit board, but can use one if you like to work that way. The external parts can be soldered directly to the IC's pins (in most cases).

Be sure to use a fused power cable. These audio chips can pull a modest bit of current and if something shorts out you could have a fire hazard. A 1-amp. fuse is adequate for 5-watt amplifiers; 2-amps. for up to 10-watts. A good, ready made, fused DC power cable is Radio Shack's #21-550. Just cut off the plug, you don't need it.

First, mount the IC to the heat sink. Make sure it fits inside the speaker enclosure, then solder the parts to the chip's pins. Reroute the (+) wire of the

Figure 3-2-1
AMPLIFIED SPEAKER DIAGRAM FOR HANDHELD SCANNERS (and more)



cable that goes to the (+) speaker terminal to the INPUT of the power amplifier circuit. Connect the output of the amplifier to the speaker (+) terminal. Install your ON/OFF switch and the DC power cable. Plug the speaker cable into the headphone jack of the scanner and you're all set!

You can embellish your amplified speaker a little by selecting a DPDT switch that not only switches the amplifier ON and OFF, but which will bypass the the amplifier when turned off so that it is just a regular extension speaker. An LED can be added to indicate when the amplified speaker is ON. You can install an "RCA" or other type of jack for an accessory input, as another customizing feature. Embellishments are limited only by your imagination. Adapt to suit your needs.

Build a Super-Snooper DTMF Decoder for Scanner/Telephone Experiments

PRELIMINARY DISCUSSION

It's late at night. You're monitoring the 49 MHz cordless band when your neighbor dials a number on his cordless phone. His clandestine lover across town answers and a sizzling conversation unfolds. It might all be amusing to you except that your two-timing neighbor happens to be married to your sister. She's suspected something for months, but could never get anything definite. You'd tell her who her competition is, if only you could correlate the dialing tones with specific numbers.

Or, maybe you're a federal agent doing an investigation, monitoring the cellular telephone calls of a suspected drug dealer. The person under surveillance makes his calls to other suspicious parties worthy of further investigation, and you have tapes of the calls, but no names. How do you quickly determine the numbers called?

DTMF tones are used extensively in ham radio, and situations might arise where it would be useful to know what numbers were dialed to access repeaters, autopatches, and remotely controlled equipment. How can you listen to the dialing tones and learn the numbers called?

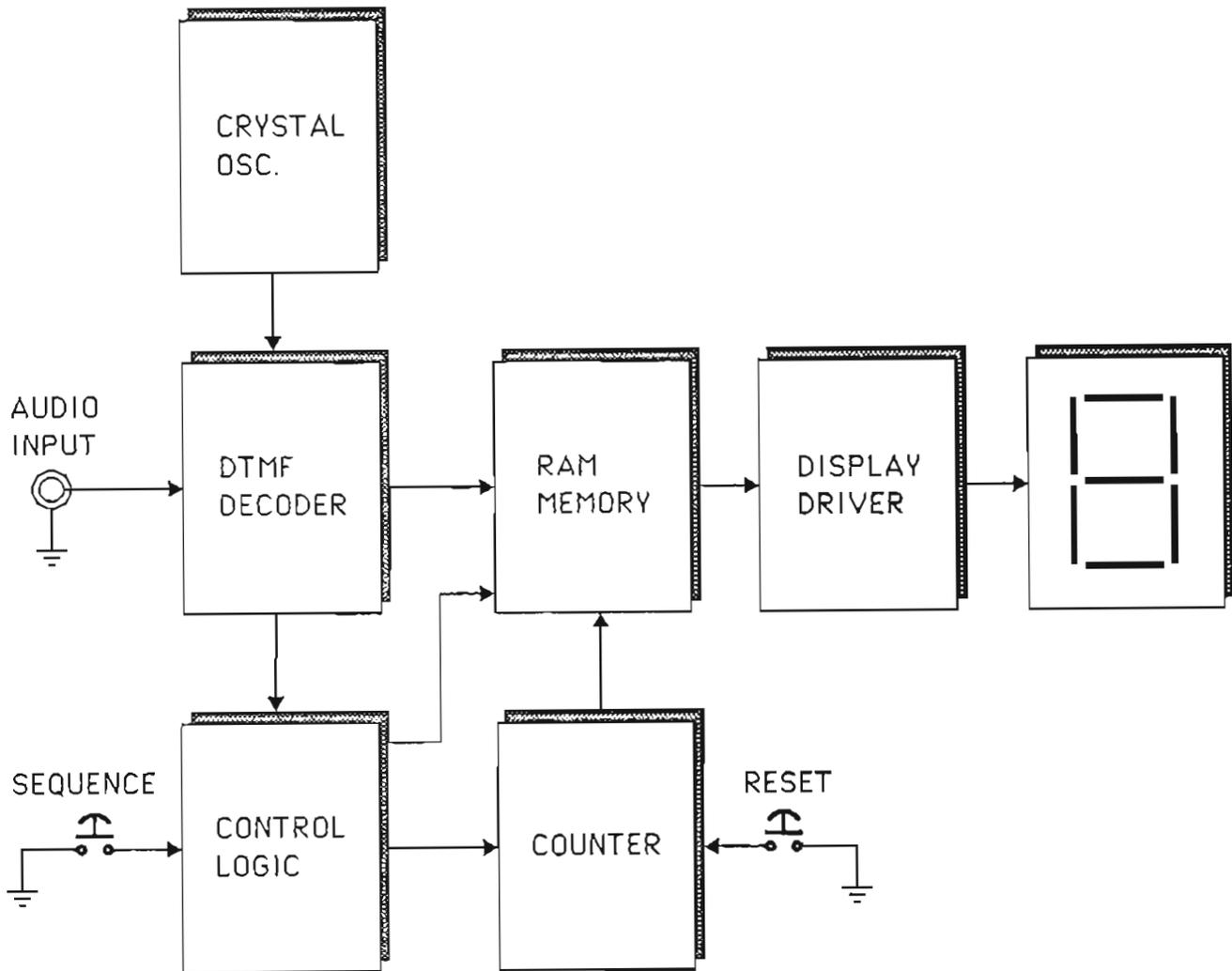
There are many applications for DTMF tones in the public radio spectrum. Just as there are many instances when it would be interesting, if not useful, to know the numbers those tones represent. One answer to the problem would be to purchase a commercial DTMF push-button dialing decoder or a similar device called a "pen register." These items could run you anywhere from a few hundred to a few thousand dollars, though. Another approach is to build an inexpensive "Snatch 'N Latch" DTMF Decoder from commercially available plans.

Functional Description: The Snatch 'N Latch circuit uses a proprietary DTMF decoder chip to decode the 12 standard telephone DTMF tones, and there's an option for the other 4 special DTMF tones not available on your phone. Up to 16 tones are stored in the circuit's static RAM memory. Once the tones are in memory, the user reads them out one-by-one on the circuit's single-digit LED display. The circuit can be hooked up to a telephone line, scanner, shortwave receiver, ham radio, or a tape recorder. Let's review the circuit.

Technical Description: This decoder uses six CMOS IC's; a 7-segment LED digit; and only a small handful of resistors and capacitors. A pending design change may reduce the chip count by one or two. The current total parts count is right at eighteen, give or take one or two.

The decoder chip stores its outputs in a 1K static RAM. Three of the remaining four chips are required to provide timing and proper gating for the data flow. The last chip is a driver for the single digit display LED. Four switches are needed; two are simple ON/OFF switches, one of which is a power ON/OFF control and the other one turns off the LED digit to conserve energy when not in use--it's powered by a 9V battery. Two push button switches are also required, one to advance the digits that were stored in memory and the other resets the memory to accept a new DTMF sequence. So, out of 18 parts, the six chips and four switches

Figure 3-3-1
"SNATCH 'N LATCH" DTMF DECODER
BLOCK DIAGRAM



don't leave much else to be hooked up. A functional block diagram for your inspection is given in Figure 3-3-1.

Operation: Using the decoder is easy, but a few operational details need attention. When the unit is first turned on, the RESET switch must be pressed to ensure that the tones (or rather the data sent from the decoder to memory) will be stored in the first memory location. Then you just wait for some DTMF tones to come rolling down the line in your general direction.

In fact, you can go about your business and just keep an eye out. When tones do come through, the device will capture them and store them in memory. When the tones have stopped, hit the RESET switch again. You will see a digit on the display, which is the DTMF number stored in the first memory location. Hit the SEQUENCE button and the numbers in successive memory locations will be displayed, one at a time, each time you hit the SEQUENCER. Once you've read out all the numbers and written them down somewhere, hit the RESET again and you're ready to start all over again. The numbers will be in memory as long as power is on and new numbers haven't been written over the old ones-- that's why you will want to write down the numbers. New numbers erase the old ones.

A few other helpful hints are in order to make use easier. First, be sure to install the switch to turn the LED display digit on and off. You only need the display while reading out numbers, so switching it off at other times prolongs battery life. Also, while reading out the numbers, you should remove the device from the scanner or whatever device it has been hooked up to. Should it happen to receive a tone while you're reading out the numbers in memory, that stray tone will be stored in whatever memory location you happen to generally be at and make things confusing. Of course, you could elaborate on the design with another switch in the INPUT line to the DTMF decoder to make temporary disconnection easier.

One aspect of this circuit makes it potentially less useful than commercial models-- it can only store 16 tones (digits). If more than 16 tones are read by the decoder, the counter resets the RAM to the first memory location and the excess tones are read into memory, erasing the previous ones. Local calls use 7 digits, and standard long distance calls use 10 digits (or 11, if the digit "1" is used first), so most calls shouldn't create any problem. But sometimes longer strings of digits are required to access certain long distance circuits and for other purposes, and if you anticipate reading in more than 16 tones at a single gulp, you can always record the tone sequence on tape and play them back into the decoder a few at a time.

When using the decoder with a tape recorder, hook it up to the earphone jack (or the LINE OUT jack, if it has one) and adjust the volume to the decoder will read the tones off the tape. The decoder isn't terribly fussy about input levels, but the peak input level must be less than the regulated supply voltage, which is +5V. When using the decoder with a scanner, it's best to hook it up to a TAPE OUT jack if one is available. Otherwise, use the earphone jack.

The decoder works fine when hooked directly to a phone line (parallel connected). A capacitor at the input of the decoder IC chip blocks the phone line's DC voltage. However, if you are going to hook up the decoder to a phone line for any extended period, additional circuitry (such as a diode shunt limiter) may be required on the input to protect the decoder from the ringer voltage. The 90V ring signal on the line might wreak havoc on the CMOS IC's.

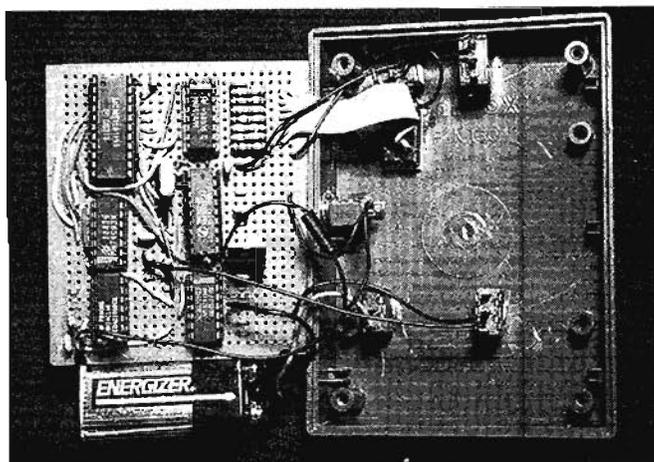
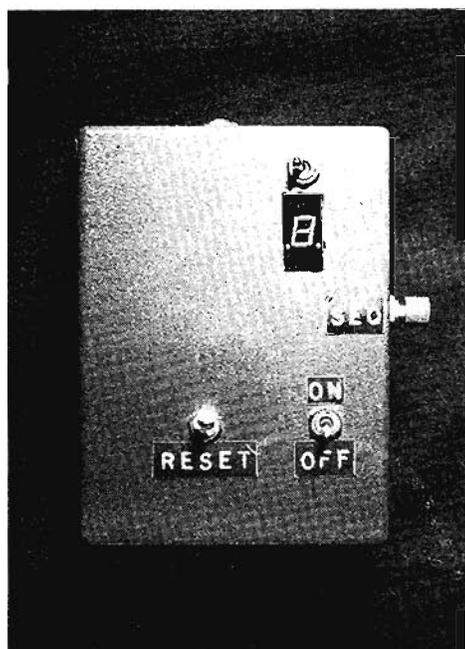
Applications: The decoder has many uses, not all legal. I'm not a lawyer, so I can't advise on specifically what is legal in your state and what is not, but rest assured that should you attempt to invade someone's privacy to the extent of using their bank account or credit card numbers, you will almost certainly be committing a prosecutable crime and could end up in the slammer for a while.

Basically, any time you want to know what a series of DTMF tones means in terms of digits, hook up the decoder and it will show you. When it is connected to a push-button telephone that generates DTMF tones for dialing, the dialed number will be memorized. It will also decode DTMF tones used to access bank-by-phone, credit card verifications, voice mail systems, etc. You'd be surprised at the amount of information passed by DTMF tones, once you keep an ear peeled for them. Of course, it's up to you to apply the information in ways that are legal and ethical.

With a scanner and a DTMF decoder, you can decode DTMF access tones used for repeaters and other communications systems features. If you are a communications technician, law enforcement officer, ham operator, or telephone service person, the legitimate uses of a DTMF decoder are many. If you're a scanner hobbyist, a DTMF decoder can be a valuable learning experience in the world of digital and CMOS electronics.

Getting Started: The ingenious DTMF decoder described here was devised by H.B. Technologies, P.O. Box 2771, Spring Valley, CA 91979. If you are interested in the the construction plans and the sole critical component (the DTMF Decoder chip), they are available at a very modest cost from this company. Should you write to them for information, please include a self-addressed, stamped envelope for their reply. All of the parts for construction (except for the DTMF Decoder chip) are readily available from electronics supply houses such as Radio Shack, DigiKey, Jameco Electronics, or any other one you like to deal with.

I have carefully reviewed the construction plans, checked out the components, and evaluated the prototype model of this unit. The plans are well written and the schematic is clear and easy to follow. It should be within the capability of the medium-level experienced hobbyist. Intimate knowledge of electronics isn't as important as a basic familiarity with projects, combined with the qualities of patience and persistence. In action, this decoder does a good job.



Left: Snatch 'n Latch DTMF decoder. Above: An inside look at the device. Most hobbyists can build and operate this unit effectively.

Chapter 4: Scanner Mods & Review of Volume 1

MODS 1 to 24: Review

A Review of The Modifications In Volume 1

PRELIMINARY DISCUSSION

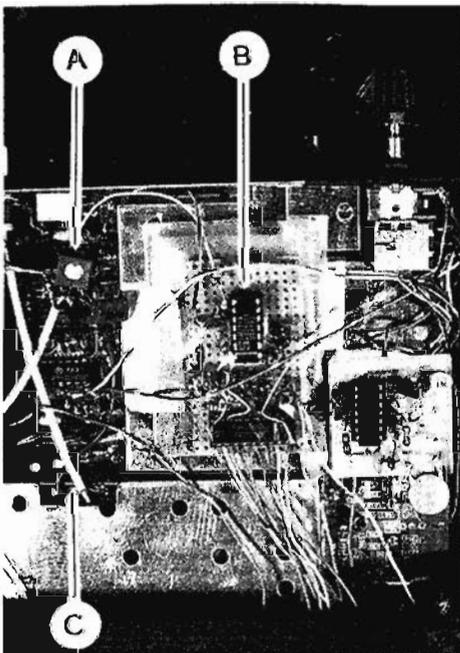
Volume 1 of the **Scanner Modification Handbook** offered 23 mods, and we won't repeat them in this volume, although we will get into any pertinent revisions, updates, and other relevant points about them. Should you not have a copy, of Volume 1, it is still available from the same publisher of this second volume-- you might wish to get a copy while it is still available.

This section will give you some thoughts, ideas, and new approaches to some of the Volume 1 mods, based upon my own further experimentation as well as input from many techs who contacted me regarding their own innovations. So, read it over, even if you're an old hand at this stuff-- you're likely to discover something new at every turn. As always, my information is presented with the assumption that you have a service manual side-by-side with our mods book.

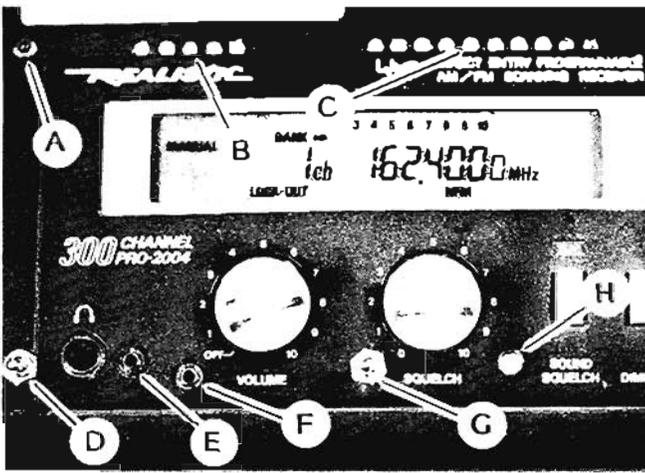
MOD-1 - Restoring Cellular Telephone Bands: PRO-2004/5/6:

A. PRO-2004/5. No changes.

B. PRO-2006. Perform same mod as described for PRO-2005.



*The general mods in a PRO-2004. A= MOD-5;
B= LED S-meter AGC Board; C= MOD-14
Software Interface.*



Placement of controls and indicators for several PRO-2004 mods: A= MOD-29 LED; B= MOD-27 Center Tuning Indicator; C= MOD-26 LED S-meter; D & E= MOD-33 ATRS; F= MOD-5 Tape Rec Out; G= MOD-29 On/Off; H= MOD-29 Ext Delay Adjust.

MOD-2 - Speeding Up Scan & Search Rates: PRO-2004/5/6, Method 1:

A. PRO-2004/5. No changes.

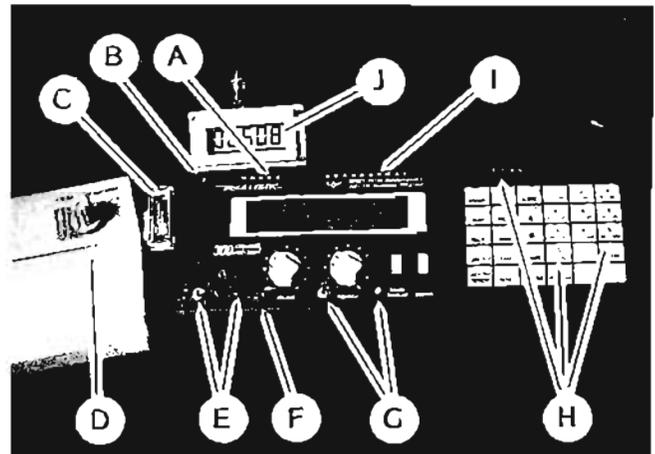
B. PRO-2006. This is different than PRO-2005 procedure. The CPU was redesigned to accommodate a 12 MHz Clock Oscillator, and apparently the D-501 inputs are dead-ended. You can, however, gain a free speed increase from 26 ch/sec to 30 ch/sec by clipping diode D-503 which is located immediately behind the numeral "3" key on the front panel. D-503 is in the open and readily accessible, despite the presence of a chrome metal shield that covers most of the Logic/CPU Board. This mod does not adversely affect any performance features.

Note: In the PRO-2006, adding D-501 to the unmarked spots for it (like we did in the PRO-2005), didn't appear to make any difference in the operation of the 2006. So, it's probably not worth bothering with unless you feel like being experimental and are willing to spend some time checking all of the many functions of the scanner to see if anything was affected.

MOD-3 - Speeding Up Scan & Search Rates: PRO-2004/5/6, Method 2:

Warning: MOD-3 is not compatible with MOD-23, the Search & Store Modules. Don't attempt MOD-3 if you plan on doing MOD-23. Also note that increasing SCAN

A= MOD-27; B= MOD-29; C= MOD-25;
 D= MOD-31; E= MOD-33; F= MOD-5;
 G= MOD-29; H= MODS 16 & 28;
 I= MOD-26; J= MOD-30.



and SEARCH speeds by MOD-3 will cause the scanner's DELAY function to be shortened by the exact same percentage as the speed increase. To get around this, see the EXTENDED DELAY (MOD-29) in this book.

A. PRO-2004. No changes.

B. PRO-2005. New detailed version. Replace the 7.37 MHz Clock Oscillator ceramic resonator (CX-501) with a quartz microprocessor crystal cut for between 9 and 10 MHz. Going above 10 MHz (which offers an additional 36% speedup) is not recommended. The exact procedure was not described in Volume 1, and given as follows:

1. Disconnect scanner from AC power. Remove top and bottom cases from chassis.

2. Disconnect all wires and cable bundles that go from the front panel assembly to the main circuit board. Disconnect the two ground straps that go from the Logic/CPU Board to the bottom side of the scanner chassis.

Note: There are six cable bundles and connectors to be disconnected from the top side of the scanner, and one cable bundle and connector on the bottom side of the scanner. Cable connectors and ground straps will disconnect from the main circuit board; NOT from the Logic/CPU Board.

Memory Retention Note: If you work quickly and proficiently, and reassemble everything within 15-minutes or so, it's probable that Memory won't be lost. You can ensure Memory retention, however, by leaving connector/cable assembly CN-3 connected to the main board during the entire process described here and after. There is a risk of blowing up IC-9 (CPU +5V) if you are not precision-careful when doing MOD-3's Step B-8 which follows. You can also leave CN-3 connected until just before performing MOD-3's Step B-8, but then reconnect it immediately after performing Step B-9.

3. Remove four (two on each side) countersunk machine screws from the sides of the front panel that secure it to the main chassis. Gently, pull the front panel assembly away from the scanner until it comes free.

4. Desolder from the chrome metal shield the bare ground wire that goes to the area by the volume control. Desolder at the chrome metal shield and push this wire out of the way.

5. Remove the six screws that secure the Logic/CPU Board to the front panel.

6. Face the inside of the front panel placed in an upright position, and locate the white 13-pin connector (CN-501) at the upper left corner of the PC board. This connector has no wires and at first doesn't look like a connector. Place a small flat blade screwdriver under that connector and gently pry upward. The entire Logic/CPU Board should then slip up and away from the plastic front panel and come loose in your hand.

7. Desolder the chrome metal shield at six places around the PC board and lift it up and off the board. This isn't complicated, and is fairly easy to do with a low wattage soldering iron. Apply upward pressure with your fingers while the shield is heated at each leg. As the solder melts, that leg of the shield will slip upward and pop free.

8. See MOD-3 Step B-2 and decide whether or not to disconnect CN-3 before performing the following: Locate CX-501 (the 7.37 MHz resonator), which is a three-legged bright blue device. Using a vacuum desoldering tool and desoldering wick, remove CX-501 and safely store away.

Safety Note: Should you chose to retain Memory by leaving CN-3 connected (MOD-3 Step B-2), be **extremely careful** to not short out either of the outer two legs of CX-501 to the center leg or any other point. If you do, IC-9 (CPU +5V) may blow up! You can momentarily disconnect CN-3 to perform MOD-3 Step 9, which follows, and be 95% assured that Memory will be retained. For 99.9% assurance, leave it connected and be extremely careful to avoid short circuits while desoldering and resoldering.

9. Disregard the middle hole of CX-501 and install a quartz microprocessor crystal up to 10 MHz in the two outer holes. First insulate the metal body of the crystal with tape, and install it so that it lays down flat on the circuit board.

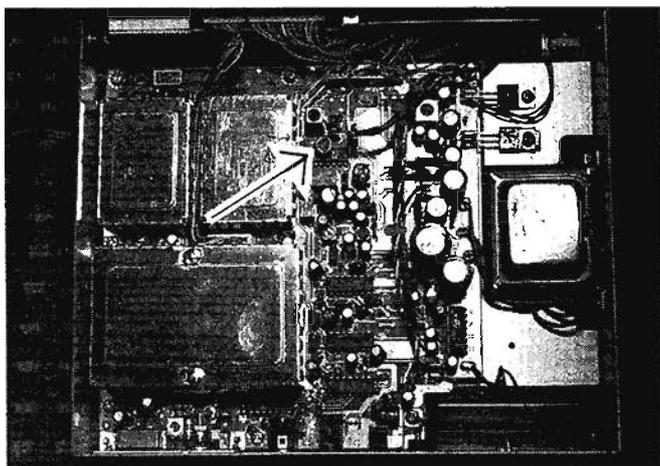
Memory Retention Note: Referring to MOD-3 Steps B-2 and B-8, above, reconnect CN-3 to preserve Memory as desired; otherwise do all reconnections after the Logic/CPU board has been fully reinstalled back into the front panel.

10. Reinstall and resolder the chrome metal shield removed in MOD-3 Step B-7. Install the Logic/CPU Board back into the front panel using reversed procedures from above. Be sure to resolder the bare ground wire removed in MOD-3 Step B-4, and make sure that it doesn't touch any of the lugs on the VOLUME CONTROL. If it does, you'll lose all speaker and headphone sound later. No damage will be done, but you'll panic when you hear the deafening silence. So make sure now that the ground wire doesn't touch anything except what it's supposed to touch.

11. Complete the reinstallation of the front panel to the main chassis, including reconnecting all cables and connectors. Energize the scanner and perform operational tests. Speed in ch/sec = the number of channels scanned (400) divided by the time (seconds) to scan that number of channels. A 10 MHz crystal will typically scan at about 27 ch/sec, if MOD-2 has also been done.

C. PRO-2006: New detailed version-- **Unproven/Untested**: Replace the 12 MHz Clock Oscillator ceramic resonator (CX-501) with a quartz microprocessor crystal cut for between 15 and 24 MHz. Use the instructions for disassembly, installation, and reassembly given for the PRO-2005 in MOD-3, Steps B-1 through B-11. The procedure is the same, though the results may differ.

Precautionary Note: I haven't tested this PRO-2006 speedup. It might not work-- period. Or if it works, there could be subtle changes (not necessarily for the better) with other functions. I simply can't predict the exact results, but logic and reason suggest that a moderate speed increase is obtainable by increasing the frequency of the Clock Oscillator. In most scanners we are able to at least double the frequency and thus double the speed with no adverse affects. If you feel experimental, you could try a 24 MHz quartz crystal. If it works, it would yield a scan rate of from 52 to 60 ch/sec, depending upon whether or not MOD-2(B) was performed. Lower frequency crystals would be presumed to offer lesser speed increases which, of course, might be more suitable than radically doubling the speed. The bottom line is that you're delving in unexplored areas and I can't tell you more as of this writing. In any case, the PRO-2006 Logic/CPU Board and its 12 MHz Clock Oscillator are otherwise just like those described for the PRO-2005 above, you you could use those procedures, and be careful. Let me know the results.



Arrow points to MOD-4 200K trim pot for improved squelch action.

MOD-4 - Improving Squelch Action in The PRO-2004/5/6:

A. PRO-2004 Revised Method. Unplug scanner from AC power. Clip one leg of R-148. Spread the cut ends apart so they don't touch. Solder the middle leg and one outer leg of a mini 200K trimmer potentiometer directly to Pins 12 and 14 (respectively) of IC-2. Adjust the trimmer for the desired SQUELCH action. About 120K ohms seems to be best.

B. PRO-2005 New Revised Detailed Method. Unplug scanner from AC power. Remove the top and bottom cases of the scanner; locate IC-2 from the top and perform the following steps:

1. Locate the solder-side of IC-2 from the bottom of the scanner. It's visible at an angle through an oval access hole on main frame of the scanner. Identify Pins 12 and 14 of IC-2. Note that these pins have short traces to the inner area of the pin configuration and terminate in a tiny black component (R-152).

2. Using an X-acto knife or small-tipped jeweler's screwdriver, sever the trace that runs from Pin 14 to resistor R-152. Make sure the trace is completely cut all the way through. This has the effect of removing R-152 from the circuit.

3. Now, work from the TOP side of the scanner and solder the middle leg and one outer leg of a 200K trimmer potentiometer to Pins 12 and 14, respectively, of IC-2. Adjust trimmer pot for desired SQUELCH action. About 120K ohms is best.

C. PRO-2006 New Data. Use the same procedure described for the PRO-2005.

MOD-5 - Better Tape Recorder Quality, PRO-2004/5/6:

A. PRO-2004. No change.

B. PRO-2005. Revised method. Solder a 0.1-uF capacitor to Pin 3 of IC-6,. Then follow the remainder of the instructions shown for the PRO-2004.

C. PRO-2006. New information. Solder a 0.1-uF capacitor to Pin 6 of IC-6. Then follow the remainder of the instructions shown for the PRO-2005.

MOD-6 - Automatic Tape Recorder Switch for PRO-2004/5/6 & Other Scanners:

Revised method. This circuit and the hookups given in Volume 1 remain pertinent and relatively problem free. If you have already performed MOD-6, and

are satisfied, then it may be best to leave it alone. If you haven't yet done MOD-6, you might wish to try the new Automatic Tape Recorder Switch (ATRS) circuit and hookups shown in this book's MOD-33. I think it's better because there are fewer parts and it's easier to fabricate. The chief drawback to MOD-6's circuit and (mostly the) instructions is that it was inadvertently connected to a +9VDC power supply that draws from the Memory Retention Battery Circuit when main AC or DC power is removed. This could cause premature drain of the Memory Battery if AC or DC power were lost and the ATRS power switch were left in the ON position. If you have done the original MOD-6 and encountered this problem, you might wish to revise the power hookup as detailed here. Reducing or eliminating the delay of the ATRS unkey time is also addressed in the following information.

A. PRO-2004 Revised Power Connection. Unplug scanner from AC power. Remove the power lead to the ATRS board from the cathode of D-51 and reconnect it to the emitter of Q-32 (the +8.4VDC supply). The ATRS should work as normal, but if any peculiarities arise, simply connect a jumper (short circuit) across R-5 on the ATRS board.

Revised delay constant: If you don't like the short delay before the ATRS unkeys, remove one or both capacitors, C-1a and/or C-1b from the ATRS board. Personally, I came to prefer an instant response instead of the delay.

B. PRO-2005 Revised Power Connection. Unplug scanner from AC power. Remove the power lead to the ATRS board from the cathode of D-56 or D-59 and reconnect it to the emitter of Q-32 (the +8.3VDC supply). The ATRS should work as normal, but if any peculiarities arise, simply connect a jumper (short circuit) across R-5 on the ATRS board.

Revised delay constant: If you don't like the short delay before the ATRS board unkeys, remove one or both capacitors, C-1a and/or C-1b, from the ATRS board.

C. PRO-2006 New information. Unplug scanner from AC power. Construct the circuit in accordance with Figure 4-6-1, Page 97, in Volume 1-- except eliminate C-1a and/or C-1b if you prefer no (or less) delay. Connect the power side of switch S-1 to the emitter of Q-32 (the +8.3VDC supply). If operation is erratic or unsteady, then connect a jumper (short circuit) across R-5 on the ATRS board.

All Note: See MOD-33 in this book for a new ATRS circuit and installation.

MOD-7 - Improved Low-Visibility Keyboard For PRO-2004: No change.

MOD-8 - Improved Headphone Audio For PRO-2004/5/6:

A. PRO-2004. Revised. Solder three 10-ohm resistors in parallel for an effective 3.3-ohm resistor. Radio Shack #271-1301, or equivalent. Solder one leg of the resistor combo to the ground lug (outer ring or shell) of the headphone jack (front panel). DO NOT CUT ANY WIRES. Solder the other end of the resistor combo to a nearby ground trace on the LCD Display Board.

B. PRO-2005. Revised. Solder three 10-ohm resistors in parallel for an effective 3.3-ohm resistor. Radio Shack #271-1301, or equivalent. Solder one leg of the resistor combo to the ground lug of the headphone jack on the front panel. This lug will be the center of three lugs on the tiny circuit board mounted to the back of the headphone jack. A black wire goes to that center lug. DON'T CUT ANY WIRES. Solder the other end of the resistor combo to a nearby ground wire located between the VOLUME and SQUELCH controls.

C. PRO-2006. New information. Use same procedure given for PRO-2005 to improve headphone audio quality and performance.

MOD-9 - Disabling The Beep in The PRO-2004/5/6:

A. PRO-2004. No change.

B. PRO-2005. Revised. Looking from the bottom of the scanner, locate the printed circuit traces on the bottom of the main board that go to either R-222 or C-219. Cut one or the other of the traces-- but not both. Should you later wish to restore the beep, just add a "solder bridge" across the trace cut.

C. PRO-2006. New information. Same procedure as for PRO-2005.

MOD-10 - Making All Base Scanners More Transportable: No change.

MOD-11 - Protecting Your AC Powered Scanner From Voltage Spikes/Surges: No change.

MOD-12 - Providing an Analog S-Meter for PRO-2004/5/6: Revised. This mod involves sampling the scanner's Automatic Gain Control (AGC) circuit to obtain a DC signal that is proportional to the received signal level. AGC is developed in the PRO-2004 by diode D-31, and in the PRO-2005/6 by D-33 at the anode. MOD-12 called for a 10K resistor to be installed at the point for coupling and isolation. The other end of the resistor was routed to an "RCA" type jack on the rear panel to enable external metering.

At the sampling point, the AGC voltage is slightly positive at +0.130 VDC with no signal coming in. The response, however, goes in a negative direction, and when faced with very strong signals, that voltage can go as negative as -0.31V. This pos-to-neg swing is not at all suited to analog voltmeters-- though digital types can read it just fine. Still, I found a better point to sample AGC after it has been processed a little more. Your sampling point (10K resistor) should be moved from the anode of D-31 (or D-33) to IC-5's Pin 10 (PRO-2004), or IC-4's Pin 12 (PRO-2005 and PRO-2006). No other modification is required. Just move the 10K sampling resistor from from the old point to the new point.

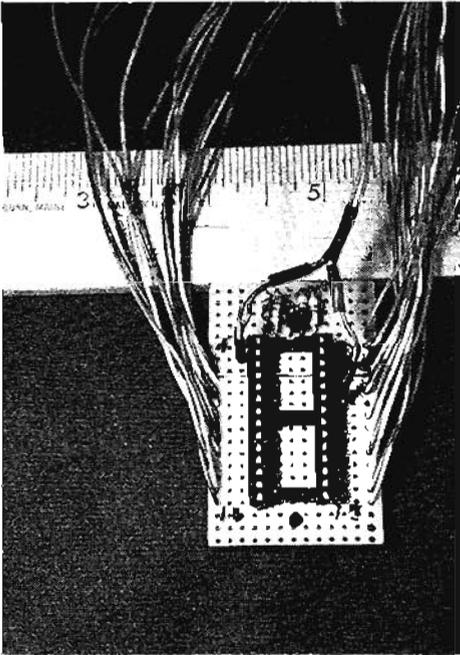
The AGC voltage at this new point is purely positive for all signal inputs, with about +1.20 volts at no signal in, and about +0.82 volts with a huge signal input. The range of "swing" remains about the same, but there is to transition from positive to negative polarity.

Let me point out that this book's MOD-25 features a superior and brand new analog S-meter. It involves only a few inexpensive parts that assemble in a few minutes. It offers a 0 to +1 VDC output, proportional to the strength of the incoming signal. It can be used with your present voltmeter or you can salvage an actual S-meter from a junked ham or CB radio, or communications receiver.

MOD-13 - Building an S-Meter Circuit (Approach #2): Given the extremely simple and effective analog S-meter featured in this book's MOD-25-- the MOD-13 shown in Volume 1 has lost most of its appeal, since it is far more complicated. If you want an S-meter, your best bet would be to go with MOD-25 and forget the earlier one (MOD-13), which we herewith relegate to the dinosaur's boneyard.

MOD-14 - Interfacing a Communications Receiver to The PRO-2004/5/6:

A. PRO-2004. No change.



Your 6,400/3,200 channel EMB for MODS 16, 19, or 37 should look like this. Component side: The four resistors are not needed if MOD-28 (the Keyboard Memory Block Controller) is used.

B. PRO-2005. No Change.

C. PRO-2006. New information. Same procedure as for PRO-2005.

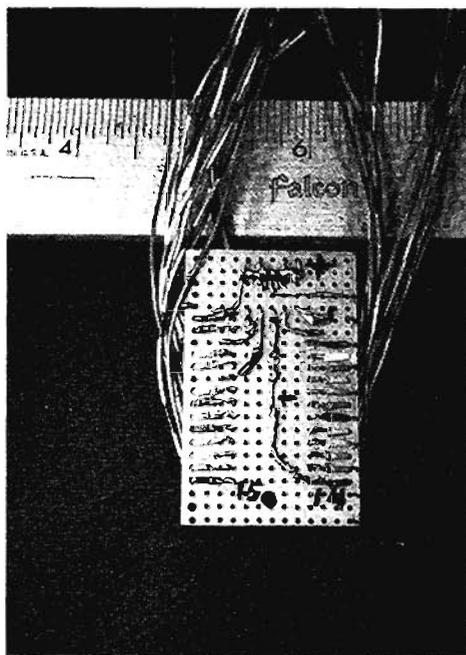
MOD-15 - Adding 100 Extra Channels To The PRO-2004: No change.

MOD-16 - 6,400 Programmable Channels For The PRO-2004/5/6: A few notable changes and revisions to discuss. First, I want to call your attention to something new, but only marginally related to this mod. There's now a better way of controlling the 16 blocks of 400-channels per block. Previously, we used a 4-segment DIP switch to yield 16 combinations of switching for the Memory Block control. That method is perfect for most applications, but there's now a way of controlling those 16 blocks solely from the keyboard without external switches and/or controls. See this book's MOD-28 Keyboard Memory Block Controller for details.

MOD-16's Extended Memory Board-- PRO-2004/5/6--

Change #1; Resistors: The four resistors (R-1 to R-4) on the Expanded Memory Board (EMB) were specified to be 1K ohms (in the first printing of the book) or 4.7K ohms (in the second printing). Resistors R-1 to R-4 perform their intended function well, but if any of the DIP switches are left ON during a power failure or when power is disconnected from the scanner, then the Memory Retention Battery has to dole out more current than necessary and its life will be considerably shortened. If all the DIP switches are OFF, no problem-- but it's a nuisance to have to remember little details like that. As it is, the Extended Memory Chip is CMOS, which means it draws (and requires) only a few microamps of current to operate and hold memory. Therefore, the four resistors (R-1 to R-4) should be upgraded to 47K (47,000 ohms). Put it on your priority list of things to do.

If you are reasonably careful, resistors R-1 to R-4 can be snipped from your EMB and new 47K resistors soldered to the snipped wire ends **WITHOUT LOSING**



*Solder side of the 6,400/3,200 channel
EMB for MODS 16, 19 or 37.*

MEMORY! Be sure to unplug scanner from the AC power before you start. Remove the DIP switch from its socket, then turn your attention to the four resistors. If necessary, you can just crush them with diagonal cutting pliers and then salvage the protruding wire ends by crushing the remaining bits of resistor with a regular pliers. Tin the resistor wire ends with solder and tack-solder the new 47K resistors in place of the removed resistors. There's very little jeopardy in making this change, so don't hesitate. Just stay clear of the Memory Chip pins with your soldering iron other than the four resistor connections.

Change #2; Capacitor: MOD-16's capacitor C-1 is a 0.1-uF type. If it is convenient to do so, change this capacitor to 2.2-uF, tantalum (Radio Shack #272-1435, or equivalent). This change is relatively insignificant, but it's worthwhile to incorporate if you haven't yet done MOD-16, or if you're a perfectionist and can be careful in changing the old one. Loss of memory isn't likely if you're careful and don't monkey with things you're not supposed to.

Change #3; Hookup Wire Specs: Of the questions that I received regarding the mods in Volume 1, I'd have to say that most were directly or indirectly related to the type of hookup wire used for MOD-16, and several other mods. Yes, there is a **right** and also a **wrong** type of hookup wire to use. The most commonly available hookup wire is not going to make you at all happy. The **only** suitable hookup wire recommended for obtaining satisfactory results for the mods in Volumes 1 or 2 is Radio Shack #278-776 Double Shielded Multiconductor Cable. It's explained elsewhere in this book. Don't use anything else-- don't leave home without it.

If you're a pro, you might opt for use of ribbon cable in MOD-16. OK-- you're on your own, and that's the way it should be. If you're a pro and know how to prep it and how to apply it, it's fine. It's not at all suitable for inexperienced hobbyists, and even for some pro's. Personally, I don't care to use it because I'm constantly digging around in my scanners, and ribbon cable doesn't like to be moved around much. That's the problem with most hookup wire-- it's OK so long as it's not subjected to the stresses of movement, temperature, and soldering. But everything in life has stress, especially things touched by hobbyists. So use the wire I recommend and you'll avoid this major potential problem area.

MOD-16 - Specific Instructions PRO-2004/5/6:

A. PRO-2004. No changes, except as discussed above.

B. PRO-2005/6. New Detailed Procedure. When I wrote Volume 1, the PRO-2005 was so new on the market that I didn't have the opportunity to spend any significant amount of time working with one. It was apparent from the schematic and the service manual that, electronically, the PRO-2005 was little more than a clone of the PRO-2004. Trouble was, however, that the physical construction, and mechanical layout of the PRO-2005 is radically different from the PRO-2004, so is the approach to installing 6,400 Memory Channels. Construction of the EMB remains the same (consistent with the changes above), and only the installation is different.

As mentioned, circuit-wise, the PRO-2004, PRO-2005, and PRO-2006 are essentially the same. The few minor differences are of no concern. The primary concerns are for the mechanical differences. To the eye, the insides appear to be completely different radios. The PRO-2004 is a lot "roomier," thus allowing more ease when installing various extras. The PRO-2005/6 has space to work, but not nearly as much, so it has to be more carefully utilized.

For the purposes of this discussion, the PRO-2006 is a carbon copy of the PRO-2005. Procedures shown are for both sets, and all terms are interchangeable. For both sets, see Figure 4-1-1, the Logic/CPU Board pictorial, for an illustration of the location of the EMB. Figure 4-1-2 shows a frontal view of the PRO-2005/6 with several modification controls installed. Figure 4-1-3 shows the rear panel of the PRO-2005/6 with several mods. Fig 4-1-4 shows a general wiring diagram of the EMB.

The first consideration is locating the $1\frac{1}{2} \times 2\frac{1}{4}$ EMB in the PRO-2005/6. The second consideration is wire length. The EMB could be installed in several different areas around the main circuit board, but the lengths of the wires from the EMB to the pads on the static RAM chip (IC-505) would be too long and might cause problems with the data flow to and from the new Extended Memory Chip. We want to keep the wires as short as possible and still maintain space for aesthetics, servicing, and overall reliability.

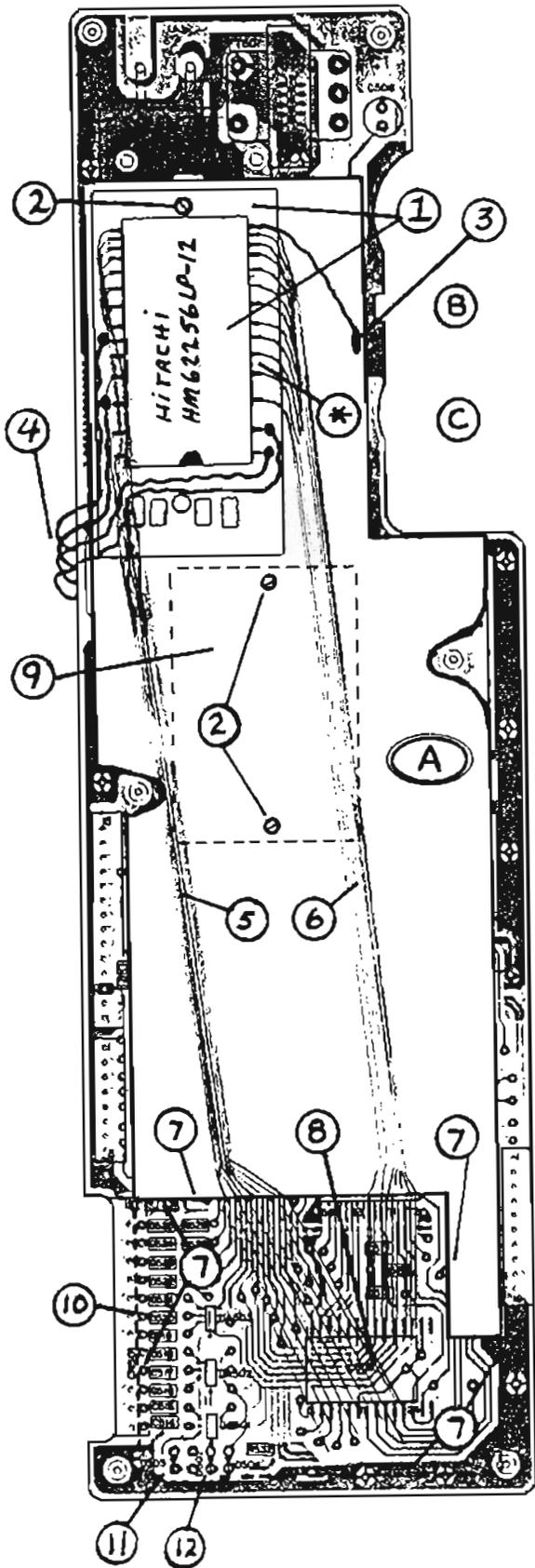
A third consideration is that the Logic and CPU Board is mounted flat against the inside front panel of the scanner. This is a radical departure from the mechanical design of the PRO-2004, so we have to keep in mind that sometime in the future there might be a need to service this board. If the EMB is installed on the main chassis, it could be difficult to remove the front panel for service. This, combined with added wire lengths and less available space than the PRO-2004, creates an undesirable situation, and possibly decreased scanner life.

There really is only one good choice for a mounting spot, on the Logic and CPU Board, where it rightfully belongs. It may (at first glance) seem impossible, but a prime spot is available. The extra work involved to clear it out is well worth the effort! Later, if ever necessary, the front panel can be removed for service or inspection without the EMB causing a problem.

Here's how to get started on MOD-16 for the PRO-2005/6:

A. Have the appropriate service manual at hand.

Figure 4-1-1
PRO-2005/2006 MOD-16/28 EXTENDED MEMORY INSTALLATION GUIDE

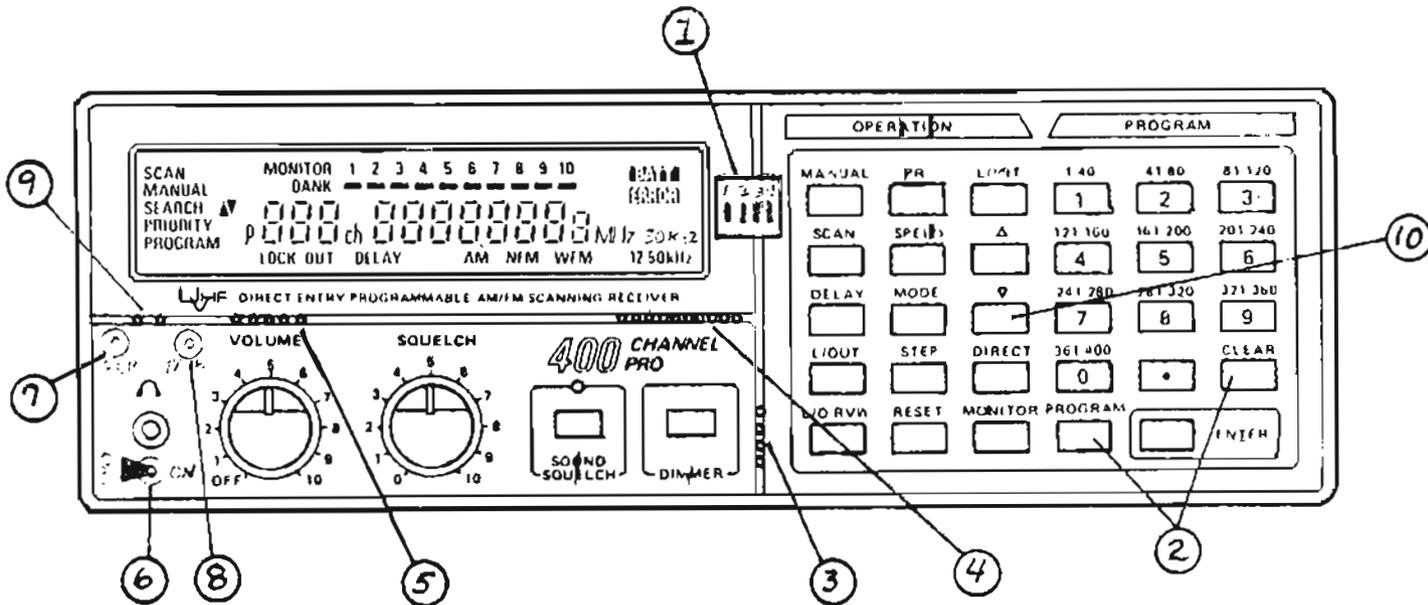


NOTES

- (A) Chrome metal shield on Logic/CPU Board
- (B) Volume Control area
- (C) Squelch Control area
- (*) This row of pins, 1-14, on the EMB will short against a screw on the MAIN RF board when the front panel is reinstalled to the chassis. Remove that screw first!
- (1) Extended Memory Board, MOD-16
- (2) Hold-down screw to standoff stud under board
- (3) Solder point for EMB Pin 14 ground wire
- (4) Memory Block control wires from EMB Pins 1,2,23 & 26 to 4-segment DIP Switch on front panel
- (5) Wire bundle from EMB, Pins 15-28 to area of IC-505
- (6) Wire bundle from EMB, Pins 3-13 to area of IC-505
- (7) Cut out the chrome metal shield to expose IC-505. Follow the pattern shown
- (8) PRO-2005/2006 stock memory chip, IC-505
- (9) Area to install the Keyboard Memory Block Controller board, MOD-28
- (10) CN-501, a pry-apart connector. Used for connection points in MOD-23
- (11) D-503; Clip in PRO-2006 for 30 ch/sec; leave it alone in PRO-2005
- (12) D-502, Clip in both PRO-2005/6 to restore cellular bands

Not To Scale

Figure 4-1-2
PRO-2005/2006 FRONT PANEL MODIFICATION INSTALLATION GUIDE



NOTES:

- ① Ideal location for the 4-segment DIP Switch for control of the 16 Extended Memory Blocks in MOD-16. See 2 and 3 below for alternate Block switching concept.
- ② See MOD-28 in this book for a new way of switching the 16 Extended Memory Blocks per MOD-16. By pressing CLEAR and PGM at the same time, the 400-chan Blocks can be auto-stepped at a rate of about two Blocks per second. See 3 below.
- ③ These four LEDs will light and remain lit to indicate which of the Extended Memory Blocks has been selected, relative to 2 above, and MOD-28 herein.
- ④ An ideal location for the LED S-Meter, MOD-26 in this book, consisting of six green LEDs, two yellow and two red. All are T-1 size and can fit perfectly here.
- ⑤ An ideal spot for the LED Center Tuning Meter, MOD-27 in this book.
- ⑥ On/Off Switch for MOD-6 or MOD-33, Automatic Tape Recorder Switch. See 7,8,9 below.
- ⑦ Remote Output Jack from MOD-6 or MOD-33.
- ⑧ Improved Tape Recorder Output Jack from MOD-5.
- ⑨ An ideal location for the LED "Carrier On Indicator" associated with MODs 32 & 33.
- ⑩ Pressing this key for 1-sec or 5-sec activates the functions of the SEARCH & STORE Modules, MOD-23

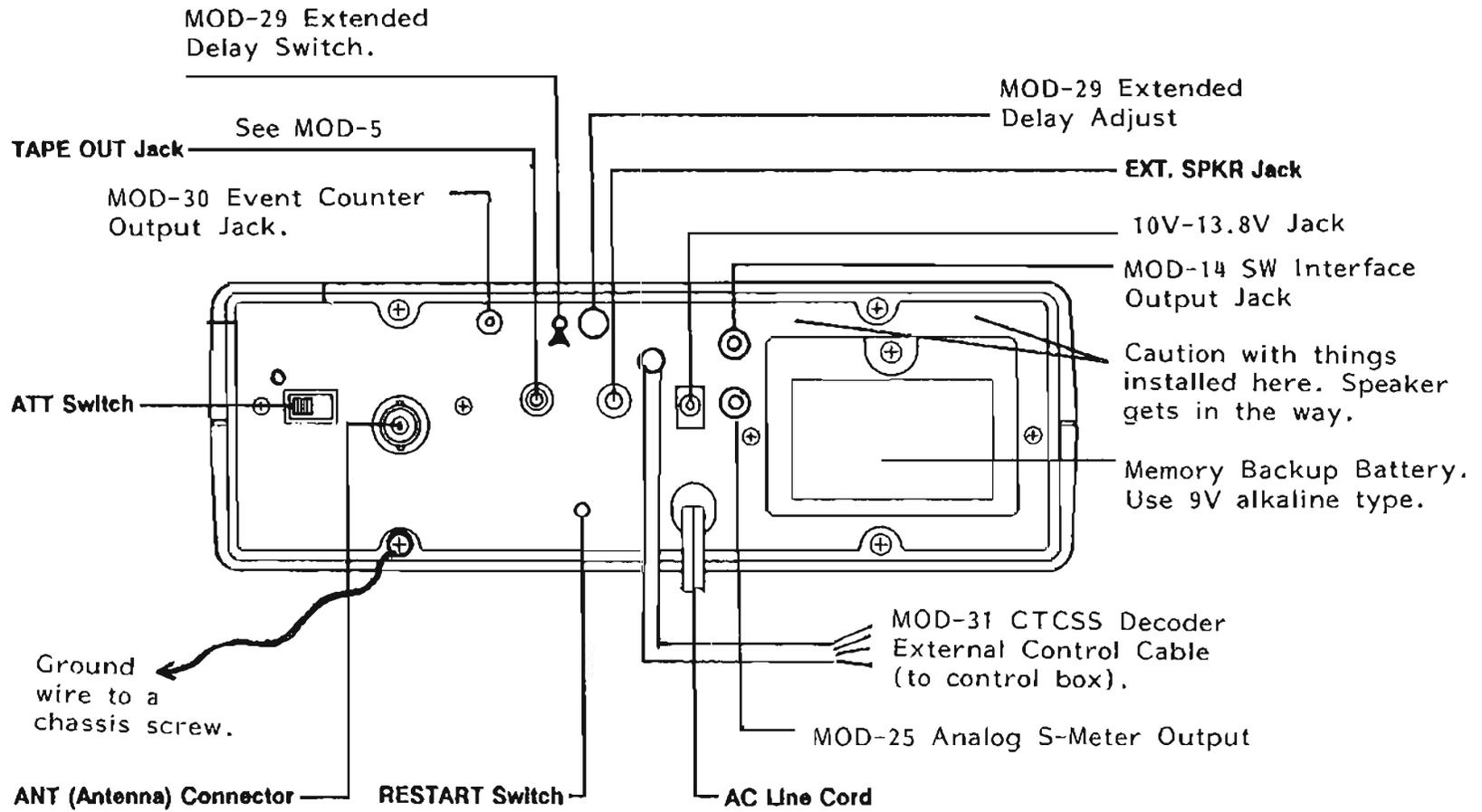
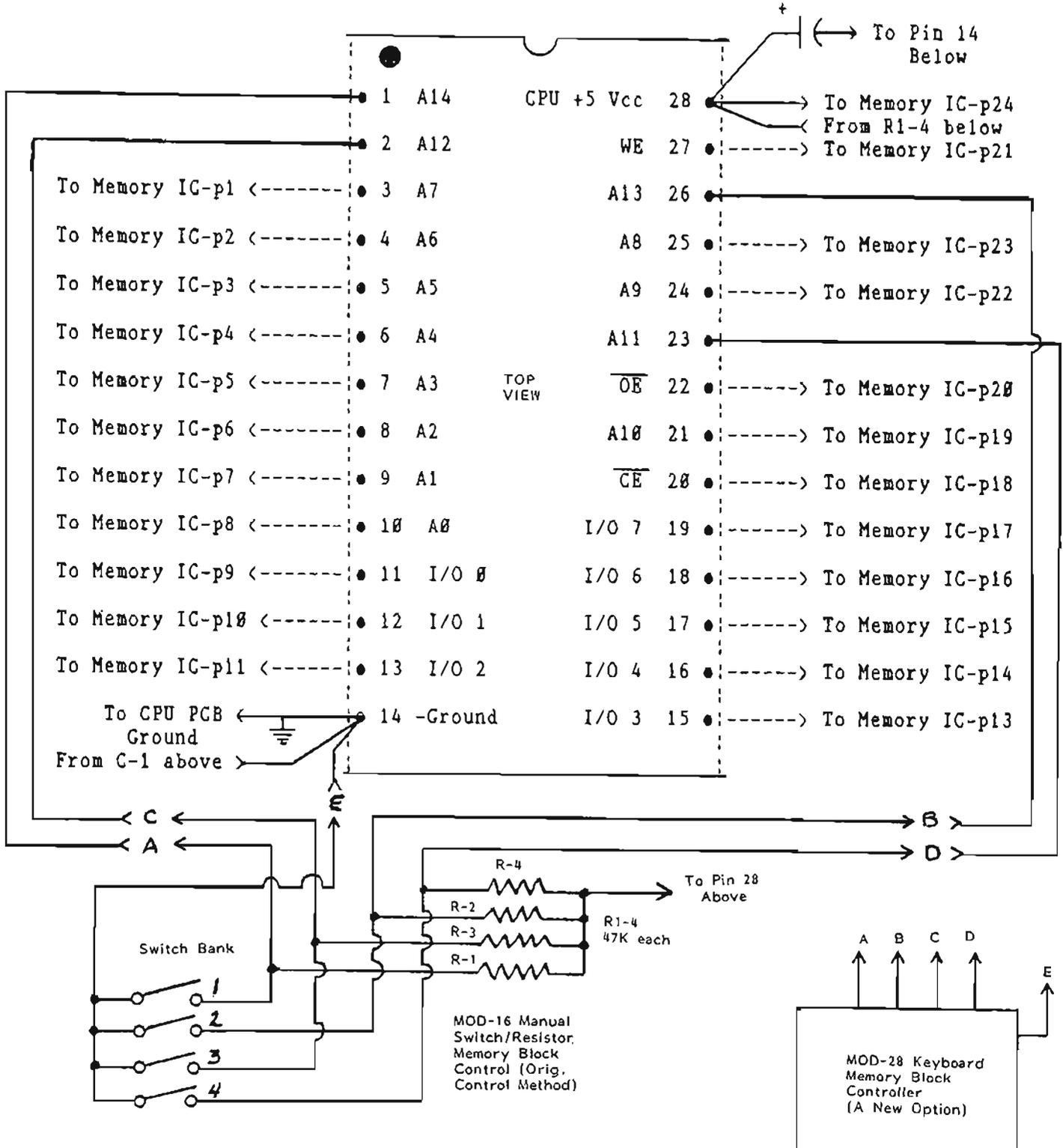


Figure 4-1-4

MODs 16, 19 & 28
 GENERAL WIRING DIAGRAM FOR
6,400 CHANNEL EXTENDED MEMORY MODIFICATIONS

HITACHI HM62256LP-15, -12
 32k x 8 SRAM

C-1 2.2-uF Tantalum



B. The EMB must have been constructed per the steps given in **The Scanner Modification Handbook**, Volume 1, pages 132 to 134. If you can't (or don't wish to) build it yourself, contact me-- I have some available at a reasonable price.

Be certain to incorporate Changes #1, 2, and 3 on the EMB as discussed in the beginning of the section on MOD-16. The four resistor network will **not** be required on the EMB if MOD-28, the Keyboard Memory Block Controller, in this book is selected for your switching method. See the information in Step 22, below.

C. Have basic hand tools, soldering iron, etc., as outlined on page 130 of Volume 1.

Assuming that everything is ready to go, the following are the steps to take for the PRO-2005/6:

1. Disconnect the scanner from the AC power line. Remove the internal Memory Retention Battery. Remove the top and bottom cases from the chassis.

2. Disconnect all wires and cable bundles that go from the front panel assembly to the main circuit board. There are six cable bundles and connectors to be disconnected from the top side of the scanner, and one cable bundle and connector on the bottom side of the scanner,

Disconnect the two ground straps that go from the Logic/CPU Board to the bottom side of the scanner chassis. Cable connectors and ground straps will disconnect from the main circuit board; NOT from the Logic/CPU board.

3. Remove four (two on each side) countersunk machine screws from the sides of the front panel that secures it to the main chassis. Gently, pull the front panel assembly away from the chassis until it comes free.

4. Desolder from the chrome metal shield the small ground wire that goes to the area by the VOLUME control. Desolder at the chrome metal shield and push this wire out of the way.

5. Remove the six screws that secure the Logic/CPU board inside the front panel.

6. Face the inside of the front panel placed in an upright position, and locate the white 13-pin connector (CN-501) at the upper left corner of the PC board. This connector has no wires and doesn't look like a connector. Place a small, flat-blade screwdriver under that connector and gently pry upward. The entire Logic/CPU Board should then slip up, away from the plastic front panel, and come loose in your hand.

7. Desolder the chrome metal shield at six places around the PC board and lift it up and off the board. This isn't complicated, and is fairly easy to do with a low-wattage soldering iron. Apply upward pressure with your fingers while the shield is heated at each leg. As long as the solder melts, that leg of the shield will slip upward and pop free. See Figure 4-1-1 for hints on a superior installation.

8. The factory-stock static RAM chip (IC-505) must now be removed. You'll need some desoldering wick (Radio Shack #64-2090). Lay some desoldering wick along a row of pins on one side of IC-505, and heat up the braid over each pin, one at a time. You'll see where the solder on the pins will get sucked up into the wick braid. Repeat this procedure for the row of pins on the other side of IC-505.

Some pro's prefer to destroy the chip by snipping all of its pins just above the solder pads; remove the chip (which comes out after all the pins are cut); and then desolder the cut pin ends from the solder pads. This procedure offers better assurance against damaging the solder pads than the above method. IC-505 gets destroyed in the process, and you'll have to buy one from Tandy National Parts (about \$6) if you ever need one again, whereas a permanently damaged Logic/CPU Board costs a lot more than that. Decide for yourself which is best for you.

9. Slip a medium sewing needle under the pins on one side of IC-505 and reheat each pin, one at a time. One by one, the pins along that row will pop free. Be very gentle with the upward pressure of the sewing needle to prevent the solder pads from ripping loose. Repeat this procedure for the pins on the other side of IC-505. Lift IC-505 out and store it in a safe place.

Take care not to damage the solder pads of IC-505. Don't force it loose. When it has been desoldered correctly, it will pop free from the solder pads with a gentle upwards pressure from the sewing needle.

10. Use the desoldering wick one more time on the now empty pin pads of IC-505 to clean things up.

11. Temporarily lay the chrome metal shield back in place over the Logic/CPU Board. Note how one end of the shield covers the area of IC-505, This end of the metal shield must be cut off to facilitate wiring of the EMB to the pin pads of IC-505. Don't cut off any more of the shield than necessary, but cut enough so that the area around IC-505 is fully exposed. A good rule of thumb is that the shield should still cover the nearby CPU chip (IC-501), but you can cut away all the shield up to that area. Again, temporarily place the metal shield over the board so you can inspect the "fit" of the cutaway area. I use a "nibbling tool" for clean cuts without warping the shield. See the illustrations in this section.

12. If all still appears well, reinstall the chrome metal shield over the Logic/CPU Board. Resolder all shield legs to their original solder spots on the board. Resolder the ground wire from the VOLUME CONTROL area to the back of the metal shield. Be sure this ground wire doesn't short against the VOLUME CONTROL pins.

13. Now, examine the other end of the metal shield, next to which is T-501, a small transformer. The EMB will be installed on the metal shield at this end.

14. Position the end of the EMB with the hole toward T-501. Pins 1 and 28 of the EMB should be farthest from T-501, and closest to the now-vacant IC-505. The Pin 15 corner of the EMB should be flush with the upper right corner of the metal shield.

15. The exact, most correct position of the EMB will be with its top edge flush with the top edge of the metal shield cover, and with its right-side (the end with the hole) positioned flush with that end of the metal shield. If everything is OK and you are facing the inside of the Logic/CPU Board with Diodes D-501-504 to your left, and Transformer T-501 to your right, then the EMB upper and right edges will be flush with the upper and right edges of the metal shield.

16. With the EMB properly positioned as described above, make a mark through the EMB's mounting hole onto the metal shield. A metal standoff will be soldered on this mark for a perfect installation.

17. Radio Shack's #276-195 standoff studs are perfect for this, but you'll have to cut one to a length of not more than 1/8". The standoff should be long enough to keep the solder side of the EMB from touching the metal shield cover, but no longer-- 1/8" is just right.

18. Tin the cut end of the standoff with solder. Take care that solder does not flow into the threaded hole of the standoff.

19. Tin with solder the area around the mark you made on the metal shield. Then solder the standoff to this spot on the metal shield.

20. Place the EMB over the standoff; insert and tighten a screw (you may have to use a shorter screw). The EMB should be level with the plane of the metal shield and should not compress enough to short anything against the metal shield. If the EMB is not parallel with the plane of the metal shield, melt the standoff solder junction and adjust the level while the solder is molten.

21. When the EMB is level or parallel with the plane of the metal shield, stuff a rubber grommet, sponge rubber, or other insulating material under the free-hanging end of the EMB (the end with Pins 1 and 28 of the new memory chip). This will prevent the free end of the EMB from ever compressing down onto the metal shield and shorting something out.

22. Now is the time to connect the wires from the EMB to the empty solder pads of the former location of IC-505. Follow the pinout wiring given in Volume 1 (Figure 4-16-1, page 131). Substitute "IC-505" anyplace "IC-504" is mentioned. That illustration was for the PRO-2004, but otherwise is identical to the PRO-2005/6. Also, see Figure 4-1-4 in this section.

Hints/Tips/Ideas: Examine the solder pads of IC-505. Pins 1, 2, and 9-11 must be soldered-to directly. No problem if you have 20/20 eyesight, a magnifying glass, good light, and a good soldering iron. Pins 3-8, which are nearby, have unused solder pads that are spaced better-- so use those!

Pin 12 of IC-505 is ground, so it doesn't need need any connections. Pin 14 of the EMB can solder directly to the metal shield near the EMB. Short ground wires are best.

Note that Pins 13-18 of IC-505 go off to nearby, better spaced, unused solder pads, so use these rather than soldering directly to IC-505's pin pads. Still, you'll have to solder directly to IC-505 at pin pads 19-23-- but this offers little problem. Pin 24 of IC-505 is +5V VDC, and has a better spaced extra solder spot nearby that you'll see.

When collecting the wires from the EMB to the IC-505 pads, work up in order, starting with IC-505's Pin 1, through to Pin 11. Then start on the opposite row of IC-505 and work down from Pin 24 to Pin 13. This way, you'll always have adequate space in which to solder.

After making each solder connection, examine that connection with a strong magnifying glass under good light. Immediately attend to any suspect or poor solder joints. Watch for and remove bridges (shorts) between adjacent pins.

When 24 wires of the EMB (all except 1, 2, 23, and 26) have been soldered to the proper places, tape the EMB's wire bundle flat against the metal shield at a point halfway between the EMB and IC-505. This will prevent the wires from moving around and weakening the solder joints at IC-505. DO NOT USE BLACK ELECTRICAL TAPE because it will only come undone at the most inopportune time. Use clear cellophane tape.

Inspect your work several times to ensure accuracy and good technique. Now, before going further, you must decide on the Memory Bank switching scheme you will use. The approach beginning at Step 23 is for a 4-segment DIP switch, socket-mounted on the front panel of the scanner between the LCD Display and the MANUAL key. Other switch schemes might be equal to (or better) than this one and may better suit your needs. You may also elect to use the Keyboard Memory Block Controller featured in this book's MOD-28.

23. Prepare to install the 4-segment DIP socket on the front panel. Examine the area between the LCD display window and the MANUAL and SCAN keys on the keyboard-- a perfect place for the DIP socket, and easier to install than you might think. See illustrations in this section.

24. First, fabricate a template about 1/2" W by 3/4" L out of ordinary perf board with standard DIP holes spaced 0.1" by 0.1". Temporarily insert an 8-pin DIP socket into this template and mark the eight holes that the socket pins come through.

25. Position this template over the face of the front panel, and adjust left and right, up and down so that the eight holes are symmetrical and centered between the LCD Display window and the MANUAL key on the keyboard. If you've done it right, the third pair of vertical template holes to the right will lay precisely over the vertical groove that separates the keyboard area from the left side of the scanner.

Hints/Suggestions: Specifically, DIP Switch segment #3 (see Volume 1, page 131) will fit directly over the vertical groove on the face plate of the scanner. See the illustrations in this section.

The DIP socket should be vertically centered precisely between the upper and lower edges of the LCD Display windows.

When the centering and positioning template is perfect, tape it to the front panel so that it cannot shift or move.

26. You can drill the eight holes for the DIP socket using the template (assuming you have the right tools), but I find equal or better results using a heated sewing needle to melt the eight holes! Use a larger sewing needle with a diameter approximately equal to the diameter of the holes in the perf board. You could also use a heated stiff wire of the same diameter. The idea is to make eight holes to accommodate the 8-pin DIP socket. After the eight holes are drilled or melted, use an **X-acto** knife or a sharp single-edge razor blade to trim and clean up the area around the holes.

Hints/Suggestions: I like the kind of DIP socket that has a screw mounting hole in its base (Radio Shack #276-1988, or equivalent). Once the DIP socket seats against the front panel, use the hole in the base of the DIP socket as a template and drill the same sized hole through the front panel of the scanner. Insert a tiny machine screw through the hole and a matching nut onto the screw from inside the front panel. Tighten securely. I suppose you could superglue the DIP socket to the front panel, but a machine nut and screw is better.

27. Referring to Volume 1, follow the wiring diagram (page 131)-- or see Figure 4-1-4 in this book-- and wire the DIP socket pins. First, clip, trim, and

bend the leads of the DIP socket so that they do not protrude above the plane of the keyboard PC board which is mounted inside the front panel next to where you are working. Wire the DIP socket pins as shown in Steps 27-A and 27-B:

27-A. Solder all four pins of one side of the DIP socket together and then solder a single wire about 8" long to the common joint of these four pins. Route and tape this wire along the inside of the front panel to the VOLUME control area. Trim to length and solder it to the exposed ground wire near the VOLUME control.

27-B. Color coded 4-conductor ribbon wire about 8" long (Radio Shack #278-757), one wire to each of the remaining four DIP socket pins along the other side. Leave the free end of this 4-wire bundle hanging loose, but position it so it protrudes up and over the top of the front panel.

28. Reinstall the Logic/CPU Board in the front panel, taking care to mate the CN-501 socket and pins perfectly before pushing the circuit board back into the front panel. Also ensure that the SOUND SQUELCH and its LED and the DIMMER knobs come back through the holes in the front panel. When everything is lined up, press the Logic/CPU Board into place in the front panel. Reinstall and tighten the six mounting screws.

29. Resolder the ground wire in the area of the VOLUME CONTROL back to its spot on the metal shield of the Logic/CPU Board, if not already done in Step 12 above.

30. Solder the 4-wire ribbon cable, one wire each to EMB's Pins 1, 2, 23, and 26, per Volume 1, Figure 4-16-1 on page 131. Install the new Memory Chip into the socket on the EMB if you haven't yet done this. Follow the guidelines in Volume 1, page 140, Step 56.

31. **Very Important!** Locate the front-left corner of the main circuit board near IC-8, C-218, C-227, and C-228. Locate and remove the chassis screw that secures the main PC board to the chassis in that corner. This screw may interfere with the bottom row of pins of the new memory chip on the EMB when the front panel is reinstalled, so remove and discard that screw before remounting the front panel.

32. Remount the front panel assembly to the main chassis, replacing and tightening the four countersunk machine screws. Watch the routing of the cable bundles/connectors and adjust as necessary around the EMB and its wiring bundle,

33. Reconnect the six cable bundles/connectors to the top area of the main circuit board. Reconnect the one cable bundle/connector to the bottom area of the scanner. Reconnect the two ground straps from the metal shield of the Logic/CPU Board to the bottom side of the main chassis.

34. That's it, you're about done. Now, get your Volume 1 and turn to page 141, Step 57, and continue with the instructions through Step 63 (disregard Step 64).

MOD-17 - 68-88 & 806-960 MHz for the PRO-2021: No change in info.

MOD-18 - Restoring Cellular Bands in The PRO-34: No change.

MOD-19 - 3,200 Channels For The PRO-34 Handheld: No change.

MOD-20 - Restoring Cellular Bands in The Uniden BC-950XLT: A second version. Apparently there are two versions of the BC-760/950XLT-- an "early" model and a "later" one. I don't know how to tell the difference, but in some cases MOD-20 doesn't do what it's supposed to do. I did some snooping around and came up with an alternative approach, which appears in this book as MOD-42. If you have a BC-760/950XLT, regardless of its age, my suggestion is to try MOD-42 first and then, only if it doesn't work for you, try MOD-20 in Volume 1.

MOD-21 - Restoring Cellular Bands in The Uniden BC-200/205XLT: A second version. There are apparently "early" and "later" versions of the BC-200/205XLT, although I can't determine which is which. In some cases, Volume 1's MOD-21 doesn't work. An alternative approach appears in this edition as MOD-40. If you have a BC-200/205XLT, any age, I suggest trying MOD-40 first and if it doesn't work, then try the MOD-21 version in Volume 1.

MOD-22 - Restoring Cellular Bands in The Uniden BC-760XLT: See comments regarding MOD-20, above.

MOD-23 - Automated Search & Store For The PRO-2004/5/6: Will work with the PRO-2006. Note, however, that in PRO-2004/5/6, MOD-23 does not work in harmony with MOD-3. It has been found that lower frequency (8-9 MHz) speedups can work, but 10 MHz does not. I have found that MOD-23 works fine with the stock PRO-2006, even though it runs at 12 MHz. The reason isn't apparent at this time, but speeding up the PRO-2006 will probably result in the same problems encountered with the PRO-2004/5. More research is needed.

MOD-24 - The Wish List: Since Volume 1 came out, my "wish list" of eleven special features and functions for scanners has made remarkable progress. When the list was compiled, there were doubts that any would materialize. Since then, a few have come true, a few are around the corner, and some are still distant. Here's the status:

1. RS-232 Computer Interface: The "RS-232" part is still a way off. RS-232 is a standard for data communications, and the standardization is the hard part. There are computers interfaced to scanners, but there's no standardization and each hookup and software is customized.

2. Hewlett-Packard HP-41/HP-1L Interface: Forget this one. HP has discontinued the HP-41 and HP-1L, so it's not feasible now.

3. Wideband, Low Noise Preamplifiers: Progress has been made.

4. 520 to 760 MHz Reception: No progress here. A converter would be an answer, but none seem to be available. Only thing to monitor here is UHF-TV. A major obstacle is that PRO-2004/5/6 have 1st I.F. in the 600 MHz band so reception, if it were possible, would be fraught with problems and interference.

5. SSB Reception for Scanners: Some progress here, but not enough yet. The most likely mod would consist of a 455 kHz beat frequency oscillator (BFO) connected just before the Detector or if the 455 kHz AM/NFM I.F. strip.

6. Electronic R.F. Gain Control: No progress here, but it's a minor priority.

7. Faster Scan & Search Speeds: Lots of progress here. The PRO-2006 is faster than the PRO-2005 was. If you absolutely need to try and update your PRO-

2005 to the PRO-2006, based upon the schematic and parts layout of both units, I think it's possible to exchange the CPU (IC-501) and the Clock Oscillator Resonator (CX-501) with replacement versions from the PRO-2006. In other words, the only differences I have yet seen between the PRO-2005 and PRO-2006 are those two components. So, if you were to order the PRO-2006's CPU and resonator and then put them into your PRO-2005... well, nobody ever said it would be an easy job because of the 72 surface mount pins of the CPU. Still, that might be a viable way of upgrading your PRO-2005 and retain compatability with all all other mods. Unfortunately, the older PRO-2004 uses a DIP configuration for its CPU and exchange with the PRO-2006 CPU isn't feasible. Possible, yes. But not feasible.

My educated guess here is that speed limitations are typically hung on the CPU that can only operate so fast before it completely freaks out. More research is needed to find out how fast the PRO-2006 can pushed, but it's probably somewhere around 50-60 channels. For intrepid hackers who want to experiment with finding out if the PRO-2005 can be upgraded to a PRO-2006, the parts to be ordered from Tandy National Parts are: PRO-2006 CPU circuit symbol IC-501 (manufacturer's part # GRE-0918); also PRO-2006 circuit symbol CX-501 (manufacturer's part # CST12.0MT).

If you have a spare 7.37 MHz resonator from your speeded up PRO-2004/5 kicking around, you can install it in the PRO-34 or the PRO-2022 for blinding fast turbo speeds. There's also evidence that the PRO-2004 and PRO-2005 can support speeds up to 15 MHz or so, despite my warnings to keep it at or below 10 MHz.

8. Center Tuning Meter. Fantastic success! See MOD-27 in this book.

9. New and Improved S-Meters: Again, success! See MOD's 25 and 26,

10. Indirect Illumination of PRO-2004 (and 2005/6) Keyboard: No progress, yet it's a low priority item.

11. CRT Spectrum Scope: Not much progress, but I have evolved it to a conceptual stage. However, the total cost of the mod (including the \$500+ cost of a useful oscilloscope) hangs around \$1,000-- which is more than twice the price of the scanner. It's definitely a possible mod, but beyond the realm of all but the most dedicated purist's winter project.

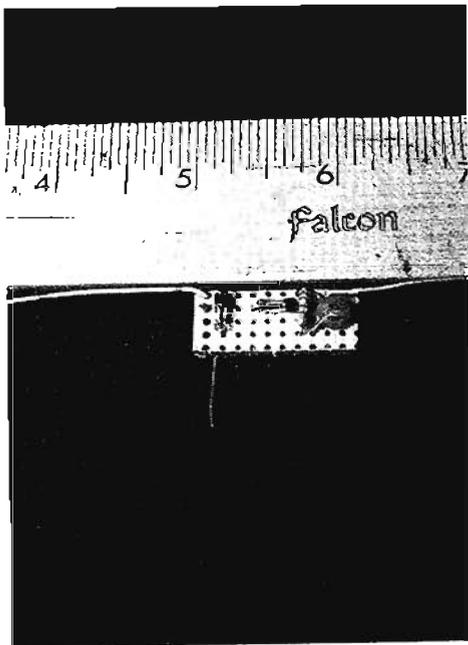
MOD-25

High Performance Analog S-Meter For The PRO-2004/5/6

PRELIMINARY DISCUSSION

Please also read the Preliminary Discussion and Operating/Utilization notes for MOD-26. This information applies here, too.

MOD-25 is far better than, and is intended to replace MOD-12 and 13 in Volume 1. The S-meter circuit shown here in MOD-25 provides an output of 0 to 1 VDC, proportional to the relative strength of the incoming signal, and is well suited for connection to any sort of external voltmeter, including an actual S-meter salvaged from an old CB, ham, or SWL radio. The S-meter circuit needs only a few minutes to construct and is easily installed in a scanner. The output of the Analog S-Meter Circuit goes to a jack mounted in a convenient location on the rear chassis. Any DC voltmeter that can measure from 0 to about 1 volt can be connected to this jack to show the relative strength of incoming signals.



MOD-25: Component side of the Diode Detector Board.

An actual S-meter salvaged from an old CB, ham, or SWL radio can be housed in a small metal or plastic case. One internal part (calibration trimmer pot) for the S-meter and an external connecting cable/plug are needed to attach to the jack on the rear of the scanner. This S-meter is far better than any other approach I've seen, with the possible exception of the fine LED S-meter shown in MOD-26 of this book which calls for this circuit as a detector.

If you have a "pocket tester" or digital voltmeter, you need only connect it to the S-meter jack on the scanner, (+) lead to the center lug of the jack and (-) lead to the scanner chassis (ground). A real S-meter needs the same direct connection, but should have a 1K to 5K calibration trimmer installed in series with the (+) lead of the S-meter. Later, you'll adjust this trimmer so that the S-meter shows a precise full-scale deflection for a very strong signal. All other signals will read proportionately less.

Theory of Operation: The circuit uses two common germanium diodes (D-1 and D-2) to rectify the AM/NFM 455 kHz last I.F. signal into a pulsating DC. C-1 first samples a portion of the scanner's 455 kHz I.F. signal for input to the diode rectifier. C-2 filters the diode rectifier's pulsating DC output and turns it into a smooth DC that is proportional to the level of the 455 kHz input signal. R-1 is a load for the DC output as a discharge path for C-2 when a high impedance voltmeter (1 Meg ohm and up) is used to measure the output. If a low impedance meter is used, such as a real S-meter, the resistor will have no effect. If a real S-Meter (M-1) is used, it should be calibrated with the series trimmer potentiometer (VR-1) to set the maximum deflection of the S-meter. VR-1 isn't needed for multi-range voltmeters and bench meters-- just for real S-meters and other panel-mount type of fixed range meters.

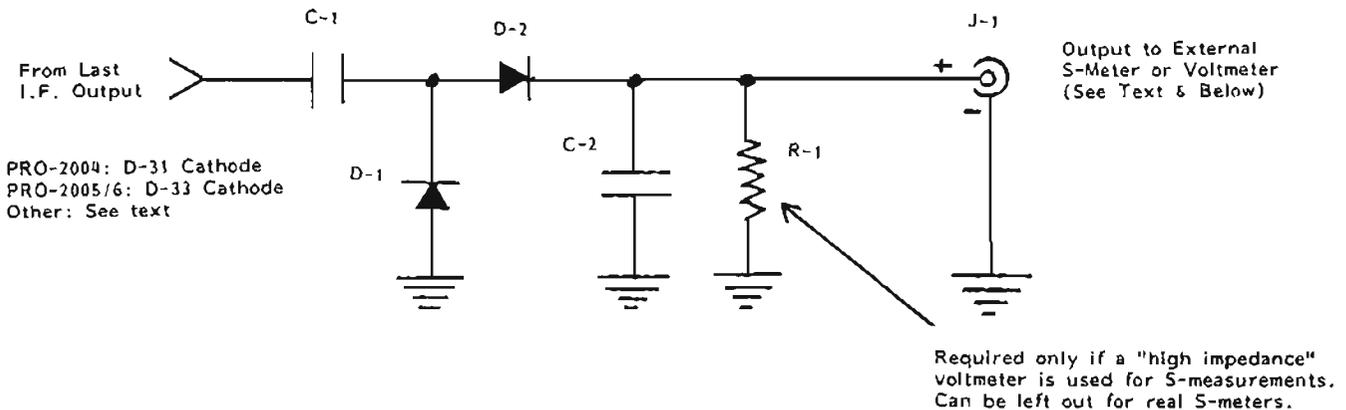
One of Many Uses For This S-Meter: Elsewhere in this book you'll read how to align PRO-2004/5/6 scanners. An S-meter is one of three essential aids you'll need to precisely align your equipment without guesswork. The service manual enumerates an impressive array of sophisticated test equipment which is great for a service center working on a time and profit basis. But, look at it this way, if you were to look at a car manufacturer's official procedures for changing tires, you wouldn't have many of their specified tools, either. Still, with only a lug wrench

Table 4-25-1
ANALOG S-METER CIRCUIT PARTS LIST

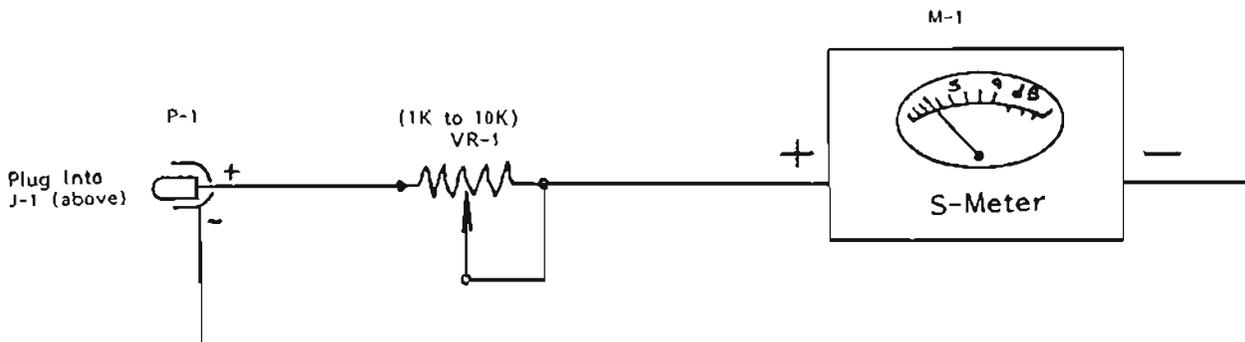
Ckt Symbol	Quan	Description	Radio Shack Catalog #
C-1,2	2	Capacitors, 0.01-uF/50 WVDC	272-1065
D-1,2	2	Germanium diodes; 1N34A	276-1123
R-1	1	Resistor, 33-k ohms, 1/4-watt	271-1341
J-1	1	RCA Phono Jack	274-346
P-1	1	RCA Phono Plug	274-339
VR-1	1	Variable trimmer potentiometer; 4.7-k ohms	271-281
M-1	1	External voltmeter or S-meter	See Notes

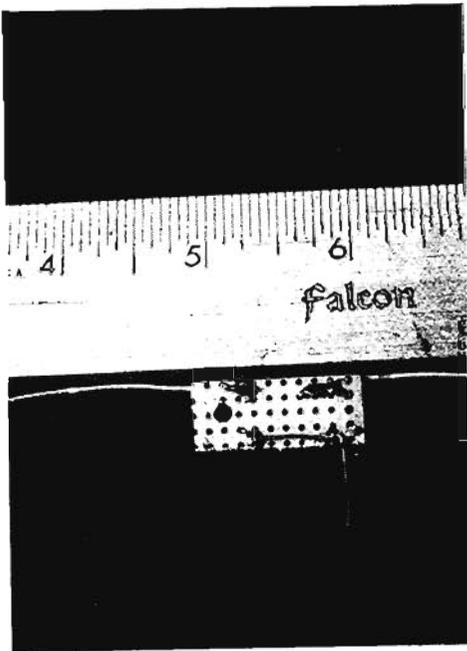
Figure 4-25-1
ANALOG S-METER CIRCUIT DIAGRAM

Germanium Diode Detector Board



External S-Meter





MOD-25: Solder side of the Diode Detector Board.

and a jack, the job can be accomplished. Trust me, your scanner can be properly and successfully aligned with an S-meter.

Refer to the Parts List and the Schematic/Wiring Diagram and the following instructions for your particular scanner:

Steps of Procedure: First, unplug scanner from AC power.

1. Select a Location For The S-Meter Output Jack (All Scanners). Select a suitable location on the rear metal chassis of the scanner for installation of a small jack. It may be any type, but an "RCA" type jack is easiest to install and wire up. Before you drill a hole in the metal chassis, wrap several layers of tape around the drill bit about $\frac{1}{4}$ " from the end so that when it breaks through, it won't go all the way in and cause destruction. The tape will stop a sudden breakthrough.

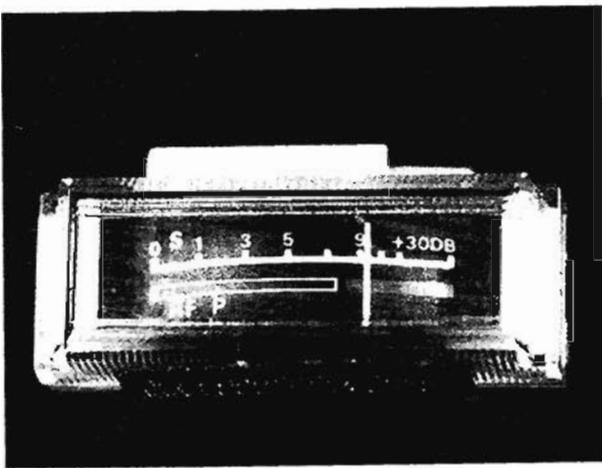
2. Building the RF-to-DC Germanium Diode Detector Board (All Scanners). Construct on a tiny piece of perf board the Germanium Diode Detector circuit shown in Figure 4-25-1. The circuit needs no power, and only three small leads will come off the board:

- A. Ground, to main circuit board ground;
- B. RF Input, from the scanner's last I.F. amplifier;
- C. DC Output, for the LED S-meter and/or an external analog M-meter.

3. Installation of The Diode Detector Board.

A. PRO-2004:

A-1. Solder the ground wire from the Detector board to a chassis ground or circuit board ground spot located near "TP-5." TP-5 is inside the covered metal box with the 13-hole lid just under the sloping face plate of the scanner. Remove the lid of that box to access TP-5. There might not be enough room in that box to install your small circuit, so install it just outside the box near TP-5. Cut a slot in the lid so that the .01-uF capacitor on your board can connect to TP-5 without shorting out on the metal lid or box.



MOD-25: A typical S-meter salvaged from a CB radio.

A-2. Solder the .01-uF capacitor from your Detector Board to TP-5, ensuring the ground from your board is already soldered to chassis or circuit board ground.

A-3. Solder a hookup wire to the DC output lead on your Detector Board. Route that wire to the rear of the scanner and solder it to the center lug of a new "RCA" type jack for an external S-meter.

A-4. Replace the lid on the metal box and go to Step 4, below.

B. PRO-2005/PRO-2006:

B-1. Locate Diode D-33, right out in the open, center area of the main circuit board. Install the ground lead of your Detector Board to a ground trace just to the left of D-33 as you look down from the top. You'll first have to scrape away some of that green lacquer on the ground trace.

B-2. Connect the .01-uF input capacitor from your Detector Board to the cathode leg of D-33. The cathode is the upper, exposed lead and is very easy to access.

B-3. Solder a hookup wire to the DC output lead on your Detector Board and either let it hang free or route it to the rear of the scanner and install an "RCA" type jack for an external S-meter if desired. Solder this DC output wire to the center lug of the "RCA" type jack and then go to Step 4, below.

C. Other Scanners and Radios:

Locate the last I.F. amplifier stage that feeds the NFM detector circuit of the radio. The .01-uF input capacitor on your Germanium Diode Detector Board should be soldered to a point closest to but just before the signal from the last I.F. stage goes into the NFM detector. Then solder the DC output lead to a wire that goes to a convenient jack on the scanner's chassis for connection to the external S-meter.

For some selected scanners, these points have been tentatively identified as:

PRO-2022: IC-1, Pin 5 or Pin 8 (or last resort, cathode of D-29)

PRO-2021: IC-2, Pin 5 or Pin 9 (or last resort, cathode of D-24)

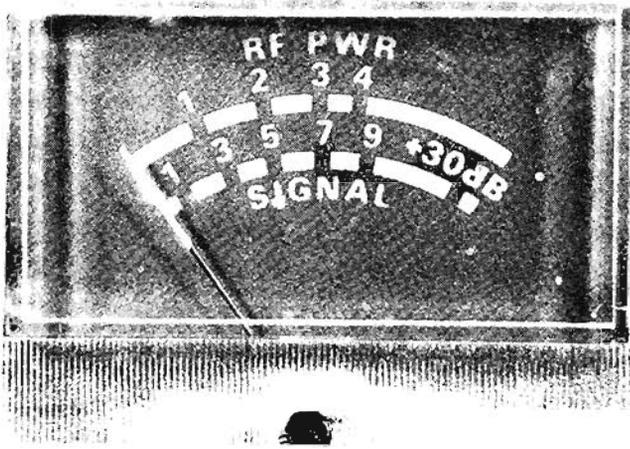
PRO-2020: IC-101, Pin 5 or Pin 8 (or last resort, cathode of D-120)

PRO-2003: IC-104, Pin 5 or Pin 8 (or last resort, cathode of D-122)

PRO-2002: IC-101, Pin 5 or Pin 8 (or last resort, cathode of D-119)

PRO-34: IC-101, Pin 5 or Pin 8 (or last resort, cathode of D-117)

PRO-32: IC-101, Pin 5 or Pin 8 (or last resort, cathode of D-122)



MOD: Another nice S-meter removed from an old CB radio.

BC-200/205XLT: IC-401, Pin 6 or Pin 9
BC-760/950XLT: IC-2, Pin 5 or Pin 8
HX-1000: U-201, Pin 5 or Pin 8

The point shown as a "last resort" is the AM-mode detector, and might not work with FM signals. Some scanners pass FM signals to the AM detector even though not used, to develop AGC voltage. In those cases, the S-meter would work there. I might add that I have spent considerable time without success attempting to adapt an S-meter to the PRO-34 and PRO-2022, and it might not be possible.

4. Selecting an appropriate S. Meter. The last step is to figure out what to do for a meter. While any voltmeter will do nicely, pocket testers, multimeters, and bench meters are bulky and unwieldy. Your best bet is to acquire a real S-meter. There are jillions of junked CB radios around, and your local CB shop or technician probably can be considered as a source. For little more than pocket change, you should be able to purchase one of these junkers. I'll tell you about another possible source in a few minutes.

If you select an actual S-meter or some kind of panel meter, install it in a small metal or plastic box. Local electronic supply houses carry a number of project boxes from which to choose. The calibration trim pot should be soldered to the (+) of the S-meter. Consider back lighting for the meter face. Radio Shack has the necessary low current light bulbs, and you'd need two of them. Hook a pair of 12V bulbs (#272-1141) in parallel, or better still, a pair of 6V bulbs (#272-1140) in series. To power them, it will take only one more wire from the scanner (since a ground wire is already in place between the meter and the scanner). Connect one of the lamp wires to the ground lead inside the box. The power lead for the hot side of the lamp wires to the ground lead inside the box. The power lead for the hot side of the lamp wires can come from the scanner's ON/OFF switch if you don't know where else to find a source of 12-14VDC in the scanner. Be sure to tap the low side of the switch so that when you turn the scanner off, the S-meter lights will go off, too. Check that point with a meter first to confirm the voltage. BE SAFE!

One of the best real S-meters suitable for this application came stock in the Yaesu FRG-7700 communications receiver. It's attractive and has precision calibration markings on the scale. I believe they can still be purchased directly from Yaesu as replacement parts-- it's worth a try. If you try to order this, specify a replacement S-meter for your FRG-7700 receiver, circuit symbol M-1, part #M0290021, description number AP-170. The company is: Yaesu-Musen USA, 17210 Edwards Road, Cerritos, CA 90701. Order by mail, or give them a call, ask for the Parts Department, and see if you can order it by phone using a credit card. But

don't let on why you really want the meter. Parts departments don't like to deplete their reserve parts to meet demands unrelated to their products.

The same approach can be used for any of the current/recent crop of CB, ham, or SWL radios, if one has a meter you like. Order a replacement from the manufacturer's parts department. Just give them the model number of the set.

You could also use a 0-1V fixed panel meter, a microammeter of any range, or a 0-1 ma. milliammeter. Still, the best choice is an actual S-meter. Second choice would be a microammeter, 0-5uA; 0-100uA, or 0-250uA. The required calibration trimmer (VR-1 on Parts List) may need to be smaller in value (1K) than specified, or in the case of microammeters, it may need to be 10K or more, depending upon the sensitivity of the microammeter.

MOD-26

A Digital S-Meter Readout for The PRO-2004/5/6 & Others

PRELIMINARY DISCUSSION

A relative signal strength meter (S-meter) is probably more useful than you might have thought. It can provide you with lots of quality information about your equipment and also what's going on beyond your receiving antenna. And, with the raw data it provides, you can derive a great deal of other information, related and unrelated-- all based upon the measurement of how much signal your receiver processes.

Related and unrelated information that might be derived or deduced includes: quality and efficiency of your antenna system (including coaxial feedline and connectors); performance differences between two or more of your antennas; sensitivity of your receiver; electrical alignment/adjustment status of your receiver; frequency errors in your receiver; distance to a transmitter; power radiated by a distant transmitter; quality and efficiency of the distant transmitting station; variations in a distant transmitter's performance; frequency errors in a distant transmitter; terrain, weather, and other influences on signals.

Perhaps you can add more to the list. At the end of this section, under the heading **Operating & Utilization**, we'll get into obtaining maximum usage from your S-meter.

I really don't know why manufacturers don't build S-meters into scanners. Virtually all CB radios, ham radios, and communications receivers have S-meters. Some cellular phones even display the relative strength of received signals. Obviously, manufacturers understand that these devices are of value, but for some reason, scanners have managed to get themselves excluded from this roster.

Several industry people have told me that cost was the obstacle. I don't buy that answer. The CB market has always been one of the most cost-conscious and competitive in the field of communications. Yet even some \$39.95 cheapo special CB rigs have S-meters. So, I can't believe that cost is the reason why they are left out of scanners. Mostly, I suspect, that scanner manufacturers haven't yet fully awakened to the wants and needs of scannists, and they have been able to successfully market their wares without including S-meters. In that case, we users are at least partially to blame since we haven't demanded that S-meters be included in our equipment. But then, maybe manufacturers don't know how to build S-meters in scanners. If that's the problem, let's show them how.

S-Meter Theory: It's simple. A very weak RF signal enters the antenna connector on the back of a scanner. From there, it gets amplified, first by the RF Amplifier, then several stages of intermediate frequency (I.F.) amplification. At the end of the signal's useful RF life, just before it gets converted into audio at the Detector, there's the last stage of I.F. amplification. At that point, the weak RF signal has been amplified to a level of anywhere from a hundredth (.01V) of a volt to maybe as much as one volt (depending on the receiver and on the original strength of that signal).

If you were to attach an RF voltmeter to the output of that last I.F. amplifier, you would see a reading that was directly proportional to the original strength of that signal as it first entered the receiver. A signal of about one millionth of a volt, also called one microvolt (1-uV), into the receiver would be amplified to maybe 5 hundredths of a volt (.05V) at the last I.F. A stronger signal of 100 microvolts might be amplified to a half volt (.5V) at the last I.F., and a powerhouse signal of 1,000-uV might be amplified to as much as 1V.

RF voltmeters are complex and expensive, not to mention unnecessary. A simple germanium rectifier circuit strategically placed at the output of the last I.F. amplifier can turn that RF voltage directly into a more useful DC voltage that is still directly proportional to the original strength of the RF signal. Very weak RF signals might result in a DC output from the rectifier of only a few hundredths of a volt. Strong signals might result in a maximum output of a volt. This is a really nice range for measurement, since 0 to 1V is handy and measurable by even the simplest and cheapest of meters. For the sake of simple definition, when I refer to an S-meter, I mean both the meter and the circuit required for the meter to produce measurements.

OK, the theory can get more complex, but I'm going to leave it at that. This is really all we need to know about the theory for our purposes here.

Types of S-Meters: Basically, there are two types of S-meters, analog and digital. The analog variety is characterized by a pointer or a needle that swings along a pivot so that it shows a reading on a printed calibration scale-- like the minute hand on a clock, or the needle in your car's gas gauge or speedometer. A digital S-meter can be of either the Liquid Crystal Digit (LCD) type or the Light Emitting Diode (LED) variety. Either of the digital types can be characterized by actual digits (though it's uncommon in S-meters), or simply a row of from five to ten separate dots or LED's. LED S-meters are the most common digital types, and the easiest to work with.

An analog S-meter is the best kind, overall, by a wide margin, because of the finer resolution of the information offered by its pointer. A fair sized analog S-meter has a physical scale between one and two inches wide, along which there are ten distinctive calibrations starting at S-0 through S-9, then there are usually several more calibrations for dB above S-9. Besides the number of calibration marks, there is a visible range between each mark, so the total number of resolvable measurement points on an analog scale is certainly thirty or more, and possibly as many as a hundred, depending on your eyesight.

A typical LED S-meter has from four to ten LED's when lit, and that's all of the resolution it is able to offer. So, there are up to ten points of resolution in an LED S-meter compared to as many as a hundred in the analog kind. That's why I prefer the analog type.

The major drawback to the analog S-meter is serious, that being its size. It's fine if a manufacturer designs the face plate of a radio to accommodate an analog S-

meter. But, what about scanners, where space is at a premium? Except in the most extraordinary cases, the average hobbyist simply can't retrofit a bulky analog S-meter into the face plate of a scanner-- although that would be its location of choice. So, it has to be an external or outboard attachment. I have nothing against this approach per se, mind you. But an external attachment ceases to be an integral part of the radio. As such, it becomes a limitation that affects a large segment of the hobby.

This LED S-meter consists of twelve basic parts. One is the simple detector circuit. One is a simple electronic driver circuit. The other ten are the tiny individual LED's. How nice-- because the circuit can go anywhere inside the scanner where there's a little cubby hole. Even in the cramped face plate of the PRO-2005/6, there is ample space for LED's-- lots more than ten. So space consideration is one reason why many scannists will be interested in this LED S-meter. Of course, an LED S-meter has its own unique advantages. Minimal space consumption is one, aesthetics is another. Given the somewhat drab scanner faceplates around, there's nothing to dress them up more than a row of brightly colored, moving, LED's. There's more on the plus side, too.

While there are actually ten segments to an LED S-meter, with a little understanding and practice, the operator can learn how to utilize another ten points for a total of twenty. That's because, there are times when an incoming signal isn't strong enough to light a certain LED in the row, but is still too strong for the next one down. This results in the higher are blinking rather than being continuously lit. So there can be twenty points of resolution on a ten-segment LED S-meter, and that's sufficient to soften the otherwise decided advantage of analog over digital. So much that it can sway all but the most absolute purist into having either both kinds of S-meter, if not the LED version, alone. Personally, I use both types. MOD-25 has a fine analog S-meter circuit. The very same circuit can be used, not only to run an external analog S-meter of your choice, but also to drive the simple electronic circuit for my built-in LED S-meter; the best of two worlds! So check out MOD-25 if you want to go the analog route, but read on for the LED S-meter.

Steps of Procedure: There are two approaches to building the LED S-meter. One is simple, needing a minimum of parts and offering an output for an external analog S-meter in addition to the built-in LED S-meter. That approach begins in Step 1, which follows.

For the purist, there is a slightly more complicated and less versatile approach using an op-amp to detect and process the scanner's AGC voltage to drive the LED S-meter. This method doesn't offer an analog S-meter output. The AGC-driven LED S-meter is probably the best way to go, but I'll spare you the complex explanation why. Suffice it to say that this approach is more a more critical connection and adjustment than the first method described. It will be detailed in Method 2, and it applies only to the PRO-2004/5/6.

Method 1 is suitable for most needs and should work with just about all scanners.

Method 1 - Germanium Diode Detector-Driven LED S-Meter:

1. Build the RF-to-DC Germanium Diode Detector Board (All Scanners)- Construct the Germanium Diode Detector circuit shown in MOD-25. Use a tiny piece of perf board to build it on. External power isn't required, and only three leads will come off this board:

A. Ground, to main circuit board;

- B. RF Input, from the scanner's last I.F. amplifier;
- C. DC Output, for LED S-meter and/or external analog S-meter.

2. Installation of The Diode Detector Board In Your Scanner-

A. PRO-2004:

A-1. Unplug scanner from AC power. Solder the ground wire from the Detector Board to a chassis or circuit ground spot that is located near "TP-5." TP-5 is located just inside the covered metal box with the thirteen hole lid just under the sloping face plate of the scanner. Remove the lid of that box to access TP-5. There might not be enough room inside that box to install your small circuit board, so install it just outside the box near TP-5. Cut a slot so that the .01-uF capacitor on your board can connect to TP-5 without shorting out on the metal lid or box.

A-2. Solder the .01-uF capacitor from your Detector Board to TP-5, ensuring that the ground lead from your board is already soldered to chassis or circuit board ground.

A-3. Solder a hookup wire to the DC output lead on your Detector Board and either hang free, or route it to the rear of the scanner and solder it to the center lug of a new "RCA" type jack for an external S-meter jack, if desired. If you're not interested in an external S-meter, just let it hang free.

A-4. Replace lid on metal box. Move to Step 3, below.

B. PRO-2005 & PRO-2006:

B-1. Unplug scanner from AC power. Locate diode D-33. It's in plain sight in the center area of the main circuit board. Install the ground lead of your detector board to a ground trace as you look down from the top.

B-2. Connect the .01-uF input capacitor from your Detector Board to the cathode leg of D-33. The cathode is the upper, exposed lead and is easy to access.

B-3. Solder a hookup wire to the DC output lead on your Detector Board and either let it hang free or route it to the rear of the scanner and install an "RCA" type jack for an external S-meter if wanted. Solder this output wire to the center of the "RCA" type jack. If you aren't interested in an external S-meter, then just let the wire hang free for now. Proceed to Step 3, below.

C. Other Scanners & Radios. You must locate the last I.F. amplifier stage that feeds the NFM detector circuit. Unplug the radio from AC power. The .01-uF capacitor on your Germanium Diode Detector Board should be soldered to the same point shown for other scanners and radios listed in this book's MOD-25 (q.v.).

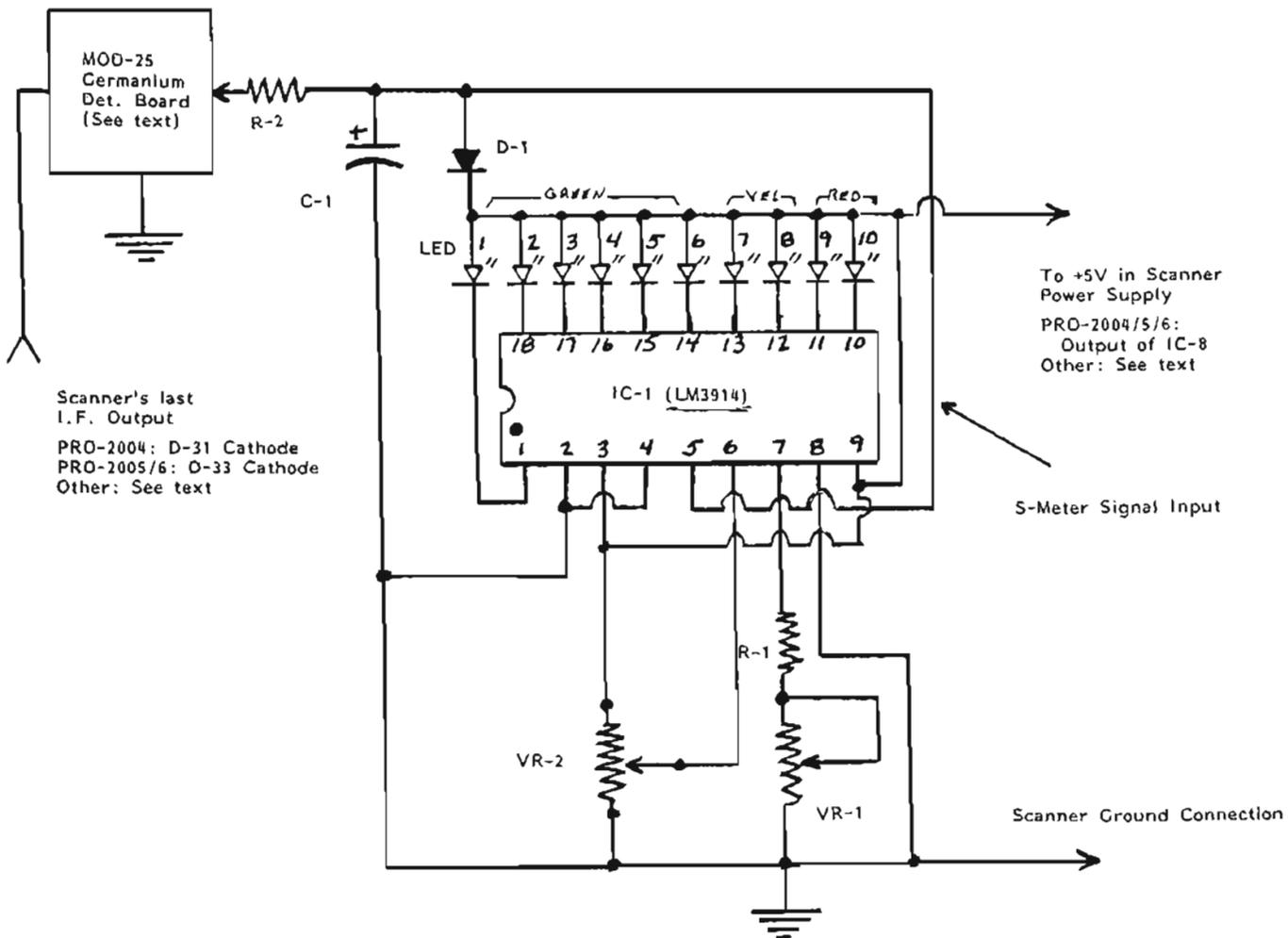
3. Other Considerations & Preparations For The LED S-Meter Project (All Scanners)-- The heart of this circuit is the LM-3914 Voltage Level Indicator IC with ten outputs. It's essentially a digital voltmeter on a chip! Only a few external parts are needed including ten LED's. I strongly suggest the smaller T-1 sized LED's because most scanners don't offer much working room. T-1 LED's can be too bright, so a brightness control is included.

Some might prefer to have an LED bar graph display that contains ten rectangular LED's embedded in a standard 20-pin DIP package (Radio Shack #276-081). If you can install it and make it look good, be my guest! I don't care for bar

Table 4-26-1
PARTS LIST FOR THE LED S-METER

Ckt Symbol	Description	Radio Shack Catalog #
IC-1	LM-3914 Bar-Dot Display Driver; IC	not at RadioShack
VR-1	Trimmer potentiometers; 10-k	271-282
VR-2	Trimmer potentiometer; 20-k; precision	271-340
C-1	Capacitor; 2.2-uF/35 WVDC, tantalum	272-1435
LED	LED, T-1, Red; 2 ea required	276-026
LED	LEDs, T-1; 2 variety-paks; 2-yellow, 6-green	276-1622
R-1	Resistor; 220 ohms	271-1313
R-2	Resistor; 10-k ohms	271-1335
D-1	Diode, switching, 1N914/1N4148	276-1122 or -1620
Misc	Hookup wire (VERY IMPORTANT)----->	278-776
MISC	Wire, 30-ga, ckt board wiring, point to point	278-501, 502, 503
Misc	Perf Board	276-1395 or -1394
Misc	IC socket, DIP, 18-pin	276-1992

Figure 4-26-1
DIGITAL LED S-METER SCHEMATIC & WIRING DIAGRAM
PRO-2004, PRO-2005, PRO-2006



graphs, myself, for three reasons: 1) They're too big, bulky, and hard to install; 2) monochrome gets boring after a while; and 3) the individual LED's are too closely spaced and hard to count from a distance. I prefer ten individual T-1 sized LED's; 6-green, 2-yellow, 2-red, spaced 0.2" apart. You might prefer 4-green, 3-yellow, and 3-red. Green denotes weak-medium signals; yellow for strong signals; red for band blasters! The different colors and wider spacing is eye catching and impressive to watch. The LM-3914 will drive either type of display you choose. The Steps of Procedure are, however, for the ten LED's.

You can pick up the LM-3914 chip at many electronics distributors (but not at Radio Shack). One source of T-1 LED's is the variety pack sold by Radio Shack. (Yellow and green T-1 LED's aren't sold separately by Radio Shack.) Two each of the yellow and green T-1 LED's come in the variety pack in addition to red, but the red T-1's in the variety pack aren't very good. So, you'll need a single pack of red T-1's and three of the variety packs to end up with 6-green T-1 LED's.

A. Select the location of your S-Meter. Determine where you want to install the LED's. Installation will be a snap the way I'll show you, but you have to pick a location. Consider this when deciding: An LED S-meter can be installed either on a horizontal (left/right) plane, or vertically (up/down).

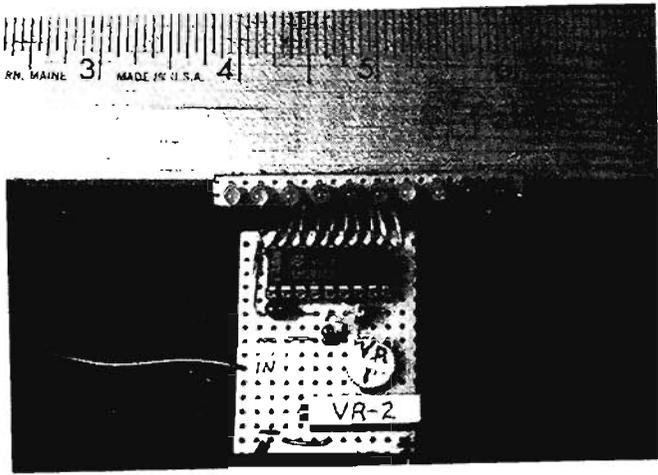
PRO-2004: If you bother to remove the LCD display Board from inside the front panel, there will be more choices of where the LED's can go than you'd imagine. Forget removing the board to simplify the choices, there's a much better area. Note the rectangular edging strip that surrounds the entire front panel. It's a little flat edge on the same plane as the sloping front panel that completely encircles the front panel. While looking at it from the outside won't give you the impression that it can accommodate T-1 LED's, it will easily do so. The best spot for the LED S-meter is just above the "UHF-VHF Direct Entry Programmable" logo along the top edge of the face plate. But don't make hasty decisions, plan ahead and consider that there are several other LED projects in this book.

PRO-2005/6: You have fewer choices than PRO-2004 owners. Still, there are some places, the best of which is on the little horizontal and vertical grooves on the front face of the scanner. These grooves divide different areas-- keyboard, display, and controls. Anywhere along these grooves is a great spot for T-1 LED's. But, remember that there are other LED projects in this book, so leave plenty of room for others later. A good spot for the LED S-meter is along the horizontal groove directly above the VOLUME and SQUELCH controls. Decide for yourself after you check out the other LED projects in this book.

Other Scanners & Radios: Sorry, you're on your own here. Each radio has its own best spots that should be discernible after some study by its owner-- it's impossible to generalize. Tear down your own radio and search around. The length of the T-1 LED string will be right at two inches, so keep that mind.

B. Preparation for Constructing the LED S-Meter Board (All Scanners): Once you've selected a mounting site, the electronic circuit board can be built and then tested BEFORE any holes are drilled in the scanner, or otherwise defaced. After the board is built and tested, and it checks out A-OK, then we'll start with the drilling. Building the little circuit board to hold an IC and some trimmer pots won't be difficult. Make the board as small as possible to that it take up the least amount of space possible inside your radio so that you'll have room for additional mods later. A small board (2"X2" or even less should do fine.

4. Constructing the LED S-Meter Electronic Board (All Scanners):



MOD-26A: Component side of the LED 5-meter Board. This one is driven by MOD-25, the diode detector.

4-A. Cut a piece of perf board about 2"X2" unless you took the time on paper to design it smaller. See Figure 4-26-1. Wiring isn't critical, but stick to established principles and practices. Preset VR-1 and VR-2 to the middle of their adjustment ranges. Review the below steps if you like, but finish the circuit board before proceeding.

4-B. DO NOT INSTALL THE LED'S ON THIS BOARD. Instead, solder hookup wires about 8 to 10" long to Pins 1, 10, 11, 12, 13, 14, 15, 16, 17, and 18 of the LM-3914 socket. These will go to the LED's later.

4-C. Solder a length of hookup wire to the common tie (ground) trace of the board and let hang free.

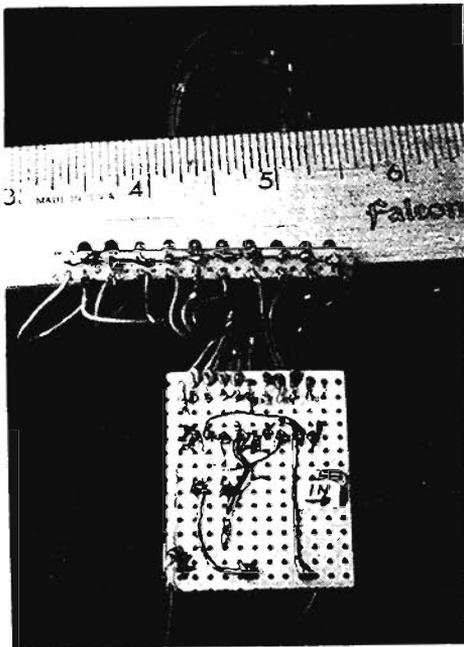
4-D. Solder two lengths of hookup wire to Pin 3 of the LM-3914 socket and let hang free.

4-E. Solder another length of hookup wire to Pin 5 of the LM-3914 and let hang free. When you're done, there should be fourteen (count 'em) hookup wires about 8-10" long hanging free from the board; one for each LED cathode, one for ground, one for DC power, one for LED common anode return, and one for signal input from the Detector Board.

5. 10-Segment LED Board Assembly. Assemble the ten LED's on a tiny piece of perf board as follows:

5-A. Cut a piece of perf board exactly 4-holes wide (0.3"W) by 21-holes long (2.0"L). Sand or file the edges to remove burrs and rough spots. Continue to file the two long edges of the board to remove the outer two rows of holes. The idea is to make this strip of board **very** narrow, at least two full holes wide, but not much wider than that.

5-B. Observing that each LED has one long lead and one shorter lead, insert them into the holes along thin board strip so that each LED is separated by one empty hole. The LED's centers will be exactly 0.2" apart if you did this correctly. Make sure that all long leads are side-by-side as are all the short leads (i.e., all oriented in the same direction). The usual placement is with the two red LED's at the extreme right; six green LED's on the left; the two yellows between the greens and reds. For discussion purposes here, the green LED's will be numbered 1 through 6; the yellow LED's 7 and 8; and the red LED's 9 and 10.



MOD-26A: Solder side of the LED S-meter Board.

5-C. Bend the anode lead of each LED 90° outward. Position a single, small, bare wire flush along the row of LED's on the wiring side between the board and the bent leads so that it touches each of the anode leads. Make sure all the LED's are seated all the way into the holes and then solder this bare wire to each of the anode leads to permanently fix the LED's in place so they can't move or fall out. This will be the common anode strip. The anode lead is the longer of the two leads.

5-D. Snip off all the excess lengths of anode leads. Snip off all except about $\frac{1}{4}$ " of the exposed cathode leads of the ten LED's, but do **not** solder anything to them at this time. Bend the snipped cathode leads 90° outward (opposite direction of the anode leads) and flush against the bottom of the board.

5-E. Manipulate the ten LED's so that they are perfectly parallel and in a straight line.

5-F. Position the LED Board assembly so that you are facing the LED's as they will appear when installed into the face plate of the scanner-- green on the left, red on the right, and numbered 1 through 10 respectively. Refer accordingly to the following soldering steps for wires from pins of the LM-3914 to the various LED's:

- 5-F-1. From Pin 1 to the cathode of LED #1.
- 5-F-2. From Pin 18 to the cathode of LED #2.
- 5-F-3. From Pin 17 to the cathode of LED #3.
- 5-F-4. From Pin 16 to the cathode of LED #4.
- 5-F-5. From Pin 15 to the cathode of LED #5.
- 5-F-6. From Pin 14 to the cathode of LED #6.
- 5-F-7. From Pin 13 to the cathode of LED #7.
- 5-F-8. From Pin 12 to the cathode of LED #8.
- 5-F-9. From Pin 11 to the cathode of LED #9.
- 5-F-10. From Pin 10 to the cathode of LED #10.

5-F-11. From one of the two hookup wires at Pin 3 (per Step 4-D) to the common anode strip prepared in Step 4-C.

The LED S-meter is now ready for testing. First, look over your work to ensure that there are no errors.

6. Testing The LED S-meter Board (PRO-2004/5/6): Place some temporary layers of tape on the bottom of the LED S-meter Board to prevent short circuits. Lay the board inside the top area of your scanner, off to one side for temporary connection of the wires. Let the LED Display Board hand hang free off to one side and tape the bottom of it temporarily to avoid accidental shorts.

6-A. Solder the loose ground wire of the LED S-meter Board to a handy ground spot on the scanner's main board.

6-B. Solder the power supply wire from the LED S-meter Board at the LM-3914, Pin 3 to the output of IC-8, the 7805 +5V regulator on the left front side of the main board. This provides +5VDC to the LED S-meter Board.

6-C. Solder the wire from the LM-3914, Pin 5 to the DC Output wire on the Germanium Diode Detector Board (Step B-3).

6-D. Turn on the scanner and program in a strong signal. Observe the LED indications. Adjust VR-2, first one way and then the other. The correct response should be a substantial variation in the number of LED's that light up, from none or a few, to as many as eight or ten, depending upon the adjustment of VR-2. If a proper response isn't observed, troubleshoot and correct the problem. Should trouble have arisen, use a voltmeter capable of measuring 0 to 1VDC to measure the output of the Germanium Diode Detector Board (since an output is necessary for the LED S-meter to work properly). If an output of 0.2V to 1V is there, but the S-meter isn't responding properly, then the problem is on the S-meter Board. If there is no output from the Diode Detector Board when a strong signal is tuned in, then the problem is on the Diode Detector Board.

6-E. Adjust VR-1, 10K trimpot, for desired LED brightness. **Caution:** Up to $\frac{1}{4}$ -amp (250-ma.) can be drawn if the LED's are set for high brilliance. This will increase the heat dissipation inside the scanner and may contribute to eventual failure of the power supply. Dimmer is better than brighter, both to reduce current consumption and for better night vision. With the LED's set for reduced but adequate brilliance, the current drain can be 50-ma. or even less. If you have a milliammeter, connect it in series between the scanner's +5V supply and the anode strip of the LED string (Step 6-B) and adjust VR-1 for less than 50-ma. If you don't have a milliammeter, then set VR-1 first for **maximum** brilliance of the LED's, then back off to **minimum** brilliance while observing the physical rotation range of VR-1. Then increase VR-1 to a point not more than half of its total rotation. This setting will result in a current drain of 50-ma. or less which won't cause problems. The brilliance of the LED's may be subdued under bright daylight, but will be just right for night use.

You can adjust VR-1 by trial and error, but the best way is to generate a strong signal. This can be done with a 49 MHz walkie talkie or even a cordless telephone handset. Program the proper 49 MHz channel into the scanner and hold the walkie talkie or cordless phone handset about two feet away from the scanner's antenna. Then, adjust VR-2 so that LED #10 goes off, then readjust VR-2 so that LED #10 just comes back on.

VR-2 is a "reference high" calibration adjustment and is for the purpose of setting LED #10 to come on only when a very strong signal is present. All other LED's will automatically be referenced accordingly at roughly 10% increments. Ideally, LED #10 will light up only on extremely strong signals, preferably like when transmitting mobile units pass in front of your home. VR-2 adjusts at that point. If VR-2 is over adjusted, then everything will light up the red LED's. If under adjusted, then nothing will light the LED's.

7. Installation of The LED Assembly (All Scanners): Once everything checks out OK, it's time to mutilate the face plate of your scanner. Regardless of which scanner you have, the procedure to be described will produce excellent results. Read throughly and understand everything before taking any action.

7-A. Fashion a template out of a tiny piece of perf board twenty-one holes long (2") by four holes wide (.3").

PRO-2004 Only: Sand or file one long edge so that the holes are just **barely** ground away, leaving a smooth, straight edge. Don't worry about the other three sides.

PRO-2005/6 Only: Your template isn't critical in size so long as it is at least twenty-one complete holes long.

7-B. PRO-2004: Starting with the row of holes along the smooth edge prepared in step 7-A, mark every **other** hole with a black marker pen so that you have ten holes marked. **IT IS IMPORTANT THAT YOUR BORE HOLES BE IN A ROW NEXT TO THE SMOOTH EDGE OF THE TEMPLATE.**

PRO-2005/6: Your template bore holes can be anywhere on the template so long as they are in a straight line with one another. Mark every **other** hole with a black marker pen so that you have ten holes marked.

PRO-2004/5/6: The marked holes will be your bore template holes. Lay the template up to the LED assembly, and you will see that the ten LED's line up with the ten marked holes. If not, correct it before you get into trouble.

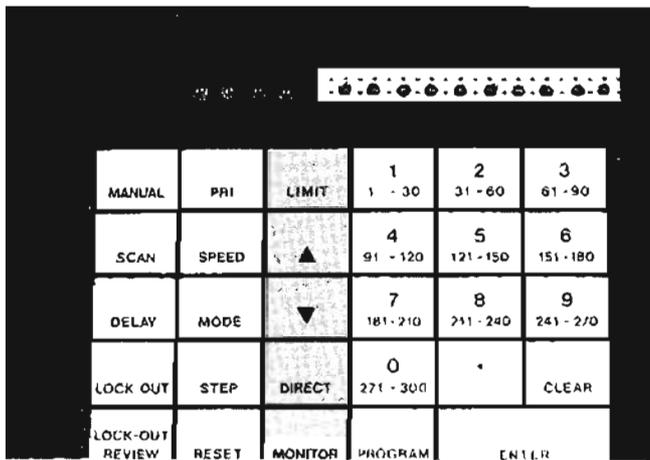
7-C. PRO-2004 Only: You may wish to loosen and remove the top two countersunk machine screws that hold the front panel to the main chassis. That way, the front panel will swing forward and down to provide you some extra room in which to work.

Lay the bore template against the narrow, slanted flat edge that encircles the face plate of the scanner. Position the template precisely above the "UHF-VHF Direct Entry Programmable" logo so that the ten bore holes line up starting just above the "U" of "UHF" and ending just above the "mm" of "Programmable." The smooth edge of the template prepared in Step 7-A should rest squarely on the intended rim while the back of the template should rest against the slanted flat "frame" that borders the face plate. It will just lay there without moving if you did it right. Press a piece of cellophane tape over the bore template to hold it against the face plate of the scanner. If you look at the marked bore holes now, it will be noted that they are **not** vertically centered with the flat indented rim that encircles the front panel. That's OK, it's supposed to be slightly off-center toward the bottom edge. Now, move on to Step 7-E.

7-D. PRO-2005 & PRO-2006 Only: Your job is a little tougher. The LCD Display/Logic Board must first be removed from where it's mounted inside the face plate. It might be a bit scary the first time you try, but after that it's a cinch. Here's how:

7-D-1. Disconnect scanner from AC power line. Remove the top and bottom cases from the chassis. Remove the VOLUME and SQUELCH knobs.

7-D-2. Disconnect all wires and cable bundles that go from the front panel



MOD-26: The bore template for the LED S-meter should look like this.

assembly to the main circuit board. There are six cable bundles and connectors to be disconnected from the top of the scanner, and one cable bundle and connector on the bottom side of the connector. If you want to save the scanner's programmed memory, do **not** disconnect the large 15-pin connector and cable bundle, CN-3. Leave it connected to the main board, but go ahead and remove all other connectors. All cable connectors and ground straps will disconnect from the main circuit board, **not** from the Logic/CPU Board.

Disconnect the two ground straps that go from the Logic/CPU Board to the bottom side of the scanner chassis.

7-D-3. Remove four (two on each side) countersunk machine screws from the sides of the front panel that secures it to the main chassis. Gently pull the front panel assembly away from the scanner until it comes free.

7-D-4. Desolder from the chrome metal shield the small ground wire that goes to the area near the VOLUME control. Desolder it at the chrome metal shield and push this wire out of the way.

7-D-5. Remove the six small screws that secure the Logic/CPU Board inside the front panel.

7-D-6. Face the inside of the front panel placed in an upright position, and locate the white 13-pin connector (CN-501) at the upper left corner of the PC board. This connector has no wires and may not look to you like a connector. Place a small flat-blade screwdriver under that connector and gently pry upward. The entire Logic/CPU Board will slip up and away from the plastic front panel and come loose in your hand. Lay the Logic/CPU Board aside near the scanner chassis.

7-D-7. Position the bore template so that the marked holes are directly over your preselected area along the horizontal groove that divides the Display area from the Control area. The bore holes must line up evenly with (and exactly over) the groove. Press a piece of cellophane tape over it to hold the template to the front panel. Now move to Step 7-E.

7-E. PRO-2004/5/6: Assuming that your bore template has been properly positioned and taped, obtain a fairly large sewing needle or piece of stiff wire that can fit through the holes of the perf board. Place the needle or wire firmly in a pliers, pointing forward, and heat it with a blow torch until it is red hot-- then quickly thrust it into the first marked bore hole and let it melt through the plastic front panel. Remove it, re-heat again until red hot, melt a second pilot hole. Do

this until you have the ten pilot holes melted through. Don't wiggle or move the hot needle around while it is melting through-- a small hole is sufficient. Take care not to touch the hot needle or wire with your fingers, also use caution when dealing with the blow torch-- keep flammable items, children, pets, etc., far away.

7-F. Assuming that you are using T-1 sized LED's, drill a 1/8" hole through each of the pilot holes. Exert light pressure and drill gently and slowly, maintaining a perpendicular angle to the hole. Drill out all ten holes and then blow away the dust and residue. That's it!

7-G. Slip the LED Assembly through the back side of the front panel so that the ten LED's protrude through the ten holes. Make sure that LED #1 is in the far **left** hole and LED #10 is in the far **right** hole. Then you can superglue the LED Assembly in place, but you'll find that if you just push hard as it slips into place, it should hold fairly tight on its own. If you're unsure, or if the holes aren't a close fit, you could paint the bases of the LED's with clear fingernail polish first, then insert the assembly back into the holes. The fingernail polish will act as a weak glue allowing things to be removed later, if needed, without much effort. You could also hold the assembly in place (once its fitted in) with cellophane tape.

7-H. PRO-2005 & PRO-2006 Only: Put two or three layers of cellophane tape along the back of the LED board you just installed to prevent the LED pins from shorting to the LCD Display Board when it is reinstalled.

Reinstall the Logic/CPU Board inside the front panel, making sure the eleven LED Assembly wires are routed up and over the topside of the Logic/CPU Board as it slips back into the front panel. Make sure the CN-501 seats properly down onto its pins. Push the Logic/CPU Board firmly down into place so that the screw holes line up with their counterpart mounting post holes. Insert/tighten the six screws. Resolder the ground wire near the VOLUME control back to its spot on the Logic board shield. Make sure the ground wire does not touch any of the lugs on the VOLUME control, which could easily happen if you aren't careful. You'll lose audio if this happens. Double check this before going further.

Reconnect all disconnected cables, wire bundles, and ground straps. Then reinstall the front panel assembly to the main chassis. Insert/tighten the four screws. Plug radio in and turn it on for a brief checkout to make certain nothing amiss so far. Correct any problems before proceeding further.

7-I. PRO-2004 Only: Swing front panel back into place and reinstall the two machine screws. Turn the scanner on and give it a brief checkout to make sure nothing amiss so far. Correct any problems before proceeding on.

8. Final Installation of the LED S-Meter Board, PRO-2004/5/6: Unplug scanner from AC power line. Find a place to permanently mount the LED S-meter Board inside the main area of the scanner. Remember that you will probably want to install other mods in there at some future date so don't do a haphazard job with this mod. There are many ways to install a small circuit board, and one you decide upon could be better than mine. Two methods I like are: #1- Use a threaded standoff stud; and #2- Solder a heavy solid copper wire (#18 or larger) to the LED S-meter board ground trace and then solder the other end of this heavy wire to the metal sidewall of the scanner chassis. Wherever the LED S-meter Board is installed, remember that you may want to make occasional adjustments. It helps if those adjustments are relatively accessible.

9. Reinstall the ground wire from the LED S-Meter Board, making the wire no longer than necessary. The ground connection can be made directly to the metal

chassis or to a ground trace anywhere throughout the scanner's PC boards, but keep the wire as short as possible.

Reinstall the +5V power wire and the Diode Detector DC signal input wire, shortening those wires as may be needed, and otherwise routing them into a neat, out of the way, bundle. Do the same with the eleven wires that go to the LED Assembly. Don't allow the wire runs to turn into a chaotic jumble. Make them neat and orderly. Length isn't important (except for the ground wire).

10. Fully test the scanner and all of its functions to verify that nothing was undone, and to otherwise ensure that no mistakes were made. Then test the LED S-meter again, making adjustments as necessary to calibrate it to precision specs. Refer to Steps 6-A through 6-E for the tests and necessary adjustments.

That should do it, except for perhaps an occasional adjustment to tweak things back into calibration. Mine needed tweaking a couple of times the first week but then stabilized. If you use an external analog S-meter also driven by the Germanium Diode Detector Board, you may have to recalibrate VR-2 each time the external meter S-meter is plugged in or unplugged. Accuracy can be restored by recalibrating VR-2 per Step 6-E whenever there is a metering change.

Operation & Utilization Notes: Understand that an S-meter is a visual representation that directly advises you of how much signal your receiver processes. The variables that determine how much signal gets into your receiver are interesting to know. They include--

A. Quality and Efficiency of Your Antenna: The antenna is the single greatest control the you have over how much signal gets into the receiver. The higher the and in the clear of nearby obstructions it is mounted; resonant for the bands you monitor, and the more gain it has, the more signal it can provide for your receiver to use. The S-meter will account for these things, and accordingly rate the signal strength.

B. Quality and Efficiency of Your Coaxial Cable Feedline and Connectors: Similar to "A" (above), your feedline and connectors are the next greatest control you have on how much signal gets through to your receiver. All feedlines and connectors are lossy, but some are worse than others. An S-meter will take into account the effects of losses in your cable and connectors, and respond accordingly.

C. Performance Differences Between Two or More of Your Antennas: Again, similar to "A" (above), but using a distant transmitter of known stability, you can use your S-meter to compare two different antennas as you switch between one and another. You may note that one antenna performs better on one band than other bands, while others may excel on different. Your S-meter tells you which antenna is best for which situation and band.

D. Sensitivity of Your Receiver. A given amount of signal ultimately gets into the receiver via the antenna/feedline system. The receiver's sensitivity determines how much of that signal can be effectively utilized by the set. The S-meter takes this into account.

E. Electrical Alignment/Adjustment Status of Your Receiver: Some of the signal that enters the receiver can be wasted by an improperly aligned and adjusted receiver. As shown in this book, you can use your S-meter in assisting to peak tune a receiver for maximum performance.

F. Frequency Errors of Your Equipment: Similar to "E" (above), but if certain portions of your receiver are off frequency, or if you aren't tuned to the correct frequency, then sensitivity will suffer. The S-meter shows the effects of being tuned to a frequency different than the one upon which the station is transmitting. One example is to program in your local NOAA weather broadcast, say 162.55 MHz, and then compare S-meter readings when you program in the frequency 5 kHz higher, 162.555 MHz, and alternate between the two channels.

G. Distance to a Transmitter: RF waves weaken at a predictable, mathematical rate as the distance to a transmitter increases. Therefore, the S-meter indication has a relationship to the distance from the transmitter.

H. Power Radiated by a Distant Transmitter: If a transmitter increases its power, the S-meter indication will rise. If the transmitter decreases in power, the reading on the S-meter will drop. Therefore, the S-meter indication is related to the power transmitted by the station being monitored.

I. Quality and Efficiency of a Distant Transmitting Station: Similar to "H" (above), but other factors are also combined in the S-meter indication, such as coaxial cable losses and the gain/efficiency of the transmitting station's antenna system. The S-meter reading is therefore related to the efficiency of the transmitting station.

J. Variations in a Distant Station's Performance: Similar to "H" and "I," except that if the station is using a directional beam antenna, or periodically changes its power, the S-meter will detect these changes.

K. Frequency Errors in a Distant Transmitter: Just as your receiver being off frequency can be detected by your S-meter, so too can frequency errors in the station being monitored be reflected in the S-meter indication.

L. Terrain, Weather, and Other Influences on Signals: Radio waves weaken as they travel. The rate at which they weaken above 30 MHz can be affected by sea water, hills, swamps, deserts, valleys, mountains, buildings, heavy vegetation, and even variations in the weather (plus other factors). The S-meter senses it all.

Hope this isn't confusing. Essentially, the S-meter only senses one thing, which is how much signal your receiver processes. The amount of signal that gets into your receiver is dependent upon A, B, C, H, I, J, K, and L. And, once in the receiver, the final result is dependent upon D, E, and F. So, a reading on an S-meter of a particular signal is a combination of virtually all of these factors. So, how can you ferret out any single bit of data?

That can neither be taught nor learned in one sitting, but here are some thoughts on the topic. You will learn to intuitively "guesstimate" certain things after a while because some of the variables drop out of the equation once your station is on line and settled-in. Factors A, B, D, E, and F become stabilized and won't change from day to day.

The closer a mobile gets to your station, the stronger the S-meter indication. The farther away it gets, the lower its reading. A signal that remains unchanged indicates a unit at a stationary location. Your ears may not easily discern such subtle changes, but an S-meter will. With a little experience, you'll be able to guess at the distance of mobile units, and if they're inbound or outbound.

Figure 4-26-2
Method 2
DIGITAL LED S-METER SCHEMATIC & WIRING DIAGRAM
PRO-2004, PRO-2005, PRO-2006

AGC-Driven LED S-Meter

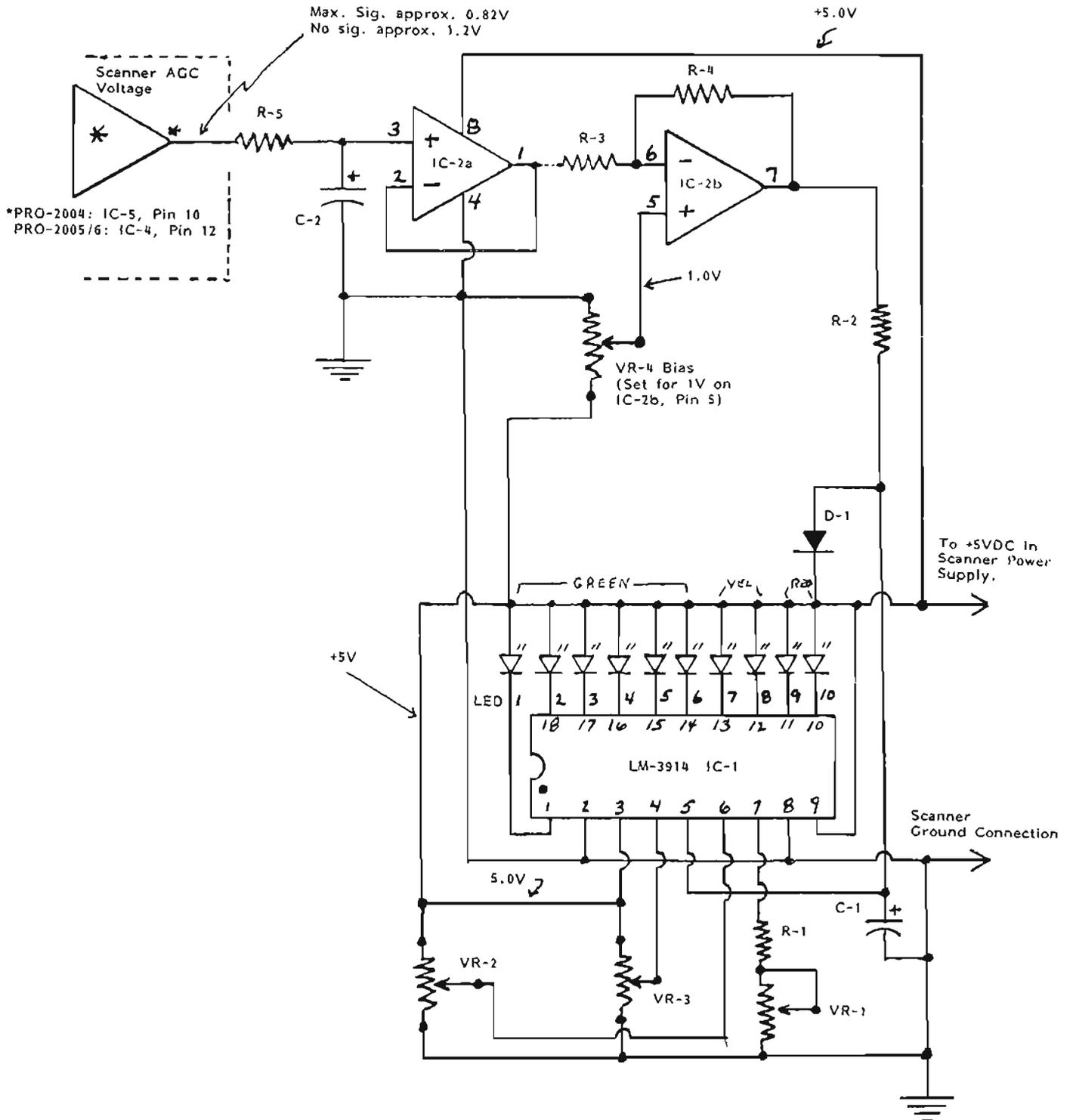


Table 4-26-2

PARTS LIST FOR THE LED S-METER - Method 2

<u>Ckt</u>	<u>Symbol</u> <u>Description</u>	<u>Radio Shack</u> <u>Catalog #</u>
IC-1	LM-3914 Bar-Dot Display Driver; IC	not at RadioShack
IC-2 *	LM-358 Dual Op Amp; 8-pin DIP; single supply *	not Radio Shack
VR-1,4	Trimmer potentiometers; 10-k	271-282
VR-2	Trimmer potentiometer; 20-k; precision	271-340
VR-3	Trimmer potentiometer; 10-k; precision	271-343
C-1	Capacitor; 2.2-uF/35 WVDC, tantalum	272-1435
C-2	Capacitor; 0.1-uF/35 WVDC, tantalum	272-1432
LED	LED, T-1, Red; 2 ea required	276-026
LED	LEDs, T-1, 2 variety-paks; 2-yellow, 6-green	276-1622
R-1	Resistor; 220 ohms	271-1313
R-2,3	Resistor; 10-k ohms	271-1335
R-5	Resistor; 33-k ohms	271-1341
R-4	Resistor; 22-k ohms	271-1339
D-1	Diode, switching, 1N914/1N4148	276-1122 or -1620
Misc	Hookup wire (VERY IMPORTANT)----->	278-776
MISC	Wire, 30-ga, ckt board wiring, point to point	278-501, 2, 3
Misc	Perf Board	276-1395 or -1394
Misc	IC socket, DIP, 18-pin	276-1992
Misc	IC socket, DIP, 8-pin	276-1995

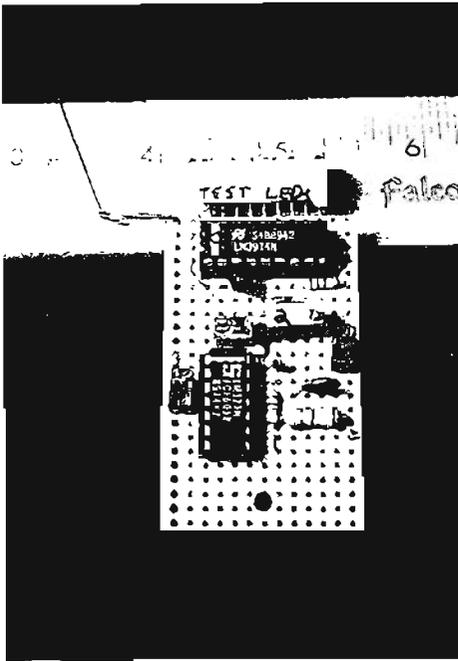
- * Radio Shack's LM-324 Quad Op Amp can be used, only two sections of which are needed. Pins 8,9,10,12,13 & 14 not used. Pin 4 = V_{CC} and Pin 8 = Ground, otherwise Pins 1,2,3 & 5,6,7 are same as in below schematic. The LM-324 is a 14-pin chip and therefore larger than the 8-pin LM-358 specified above. Requires a 14-pin DIP socket, 276-1999. DO NOT USE WHERE SIZE & SPACE ARE OF MAJOR IMPORTANCE, otherwise ok. DO NOT USE OP AMPS THAT REQUIRE A DUAL (+) POWER SUPPLY!

In due time, H, I, J, and K will be within your ability to assess to some extent. When you intercept the same signals over a period of time, you'll recognize their characteristic readings on your S-meter. When something happens to a familiar transmitter, your S-meter will let you know right away. You'll become familiar with the effects of weather and terrain.

Perhaps the most useful benefit from an S-meter at the start will be variable A, B, C, D, and E. If you have two scanner antennas in use, try them both. First one, then the other. Make notes of the S-meter indications on certain signals, like NOAA weather and FAA aero stations, which are well maintained. You'll be able to see which antenna works best at specific frequencies. Likewise, your S-meter will show you how much (or if) you've actually improved things by replacing that tired old coax with newer, low-loss type cable.

And, later we'll show you how handy an S-meter is during any attempts you might make to align the equipment.

I'm pretty certain that you'll really grow to love and depend upon your S-meter. It will enhance your ability to know more about your station and the transmissions it receives. In turn, it will add to your monitoring results and



MOD-26B: Component side of the AGC-driven LED S-meter board.

enjoyment. It will take your radio, which normally looks a bit lifeless, and give it a sparkling personality that enhances its value to you.

Method #2- AGC Driven LED S-Meter For Purists (PRO-2004/5/6 Only)

This is mostly for hackers and techie-types who demand nothing but the best and don't mind adding some complexity to their projects. There aren't any fancy frills here, mostly a diagram and some basic notes to keep you pointed in the right direction.

This version of the LED S-meter differs from Method #1 because it samples the receiver's AGC feedback loop and derives a proportional interpretation of the AGC response curve. The AGC varies from about +1.20VDC at zero signal input to +0.820VDC with a very strong signal input. Notice the inverse response combined with the narrow range here? We'll use an op-amp to invert and amplify that response to something a little more useful for the LM-3914.

Steps of Procedure: Method 2:

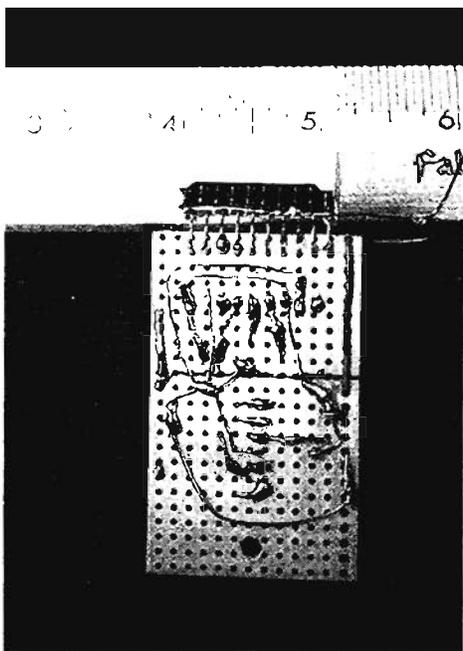
1. Build the LED S-meter circuit board according to Figure 4-26-2 and Table 4-26-2. Build and install the LED assembly in accordance with Method 1. Preset VR-1, 2, 3, and 4 to the middle of their ranges of adjustment.

2. Install the AGC sampling output circuit as follows:

- 2-A. PRO-2004 Only. Unplug scanner from AC power line. Clip off all but about $\frac{1}{4}$ " of both ends of the 33K resistor, and solder one end to IC-5, Pin 10.

- 2-B. PRO-2004 Only. Solder the (+) lead of the 0.1-uF capacitor to the free end of the 33K resistor, and the other lead (-) of the capacitor to a nearby circuit board ground point.

- 2-C. PRO-2005/6 Only. Unplug scanner from AC power line. Clip off all but about $\frac{1}{4}$ " of both ends of the 33K resistor and solder one end to IC-4, Pin 12.



*MOD-26B: Solder side of the
AGC-driven LED S-meter board.*

2-D. PRO-2005/6 Only. Solder the (+) lead of the 0.1-uF capacitor to the free end of the 33K resistor, and the other lead (-) of the capacitor to a nearby circuit board ground point.

2-E. All models. Solder a hookup wire to the junction of the 33K resistor and the 0.1-uF capacitor. The other end of this hookup will go to the other end of the op-amp, U-1a.

3. All models. Install the LED S-meter Board and the LED Assembly in your scanner. Refer to Method 1 for the general approach, and to Figure 4-26-2 for specific information.

4. All models. Plug scanner in to AC power line. Turn the scanner on and make basic checks for proper performance and any obvious errors. See test procedures in Method 1 for the basic checks. Correct any problems before proceeding.

5. All models. Attach a digital voltmeter to the wiper arm of VR-4 and ground. Adjust VR-4 for +1.0V ($\pm 0.1V$).

6. All models. Disconnect the antenna from the scanner, and make sure no signals are coming in. Adjust VR-3 so that LED #1 just comes on, and then readjust VR-3 so that LED #1 just goes off. This is the zero signal point.

7. All models. Reconnect the antenna and program the scanner for a 49 MHz cordless phone or walkie talkie held close to the scanner's antenna. Adjust VR-2 so that LED #10 just comes on. In lieu of the walkie talkie or cordless phone, VR-2 can be adjusted for similar results using a known extremely strong reference signal. The idea here is that you don't want LED #10 coming on except on the rarest of rare strong signals. Note that the adjustments in Steps 6 and 7 might interact and have to be redone several times to calibrate both ends of the LED S-meter.

8. All models. Adjust VR-1 for desired brightness of LED's. **Caution:** See the cautionary information in Step 6-E of Method 1. You don't want the LED's to be very bright!

**Center Tuning Indicator For The PRO-2004/5/6:
Two Versions-- Analog & Digital**

PRELIMINARY DISCUSSION

According to the FCC Rules and Regulations, transmitter frequency tolerances are supposed to be kept within .001% of the assigned frequency. This tolerance may vary somewhat from one band to another. For example, CB transmitters must be within .005% of the channel frequency. All frequency tolerance standards are rather tight, as you'll see from the following example for CB:

CB Channel 9= 27.065 MHz X .005/100 = ±1353.25 Hz allowable variance from center frequency! That's tight. Now check out the following example for a VHF public safety frequency:

Frequency 158.970 MHz X .001/100 = ±1589.7 Hz allowable variance from center frequency. That pretty tight, too. But, trouble arises...

In the first place, it's not difficult to maintain tight frequency tolerances with state of the art design and a good maintenance program. Problem is that there's a lot of lower-quality, no-brand name radio equipment on the market that doesn't necessarily meet FCC standards. While it's uncommon with public safety or federal agencies, it could be more common among business and other private users where the ability to purchase equipment cheaply may overshadow the will to adhere to tight FCC standards. So, the first snag is that VHF/UHF transmitters do not necessarily operate precisely on the frequencies to which they are assigned.

The second trouble area is the same as the first, although the cause is different and it's probably more common. You can't just plug in a communications system and expect it to operate properly for a prolonged period of time unless it receives periodic attention from a technician. Maintenance of communications systems is an essential ingredient to effective, reliable communications that meet FCC standards; but it's an expensive commodity. Public safety agencies, governmental entities, business and private users typically relegate maintenance to a lower level on the priority list. That's fine for saving a buck, but after the first year or two of operation, radio equipment can begin to degrade in performance. Quartz crystals, which determine operating frequency, slowly age and drift off frequency. Mobile radio equipment is exposed to humidity and temperature extremes. One of the first effects is a slow but sure drift off frequency.

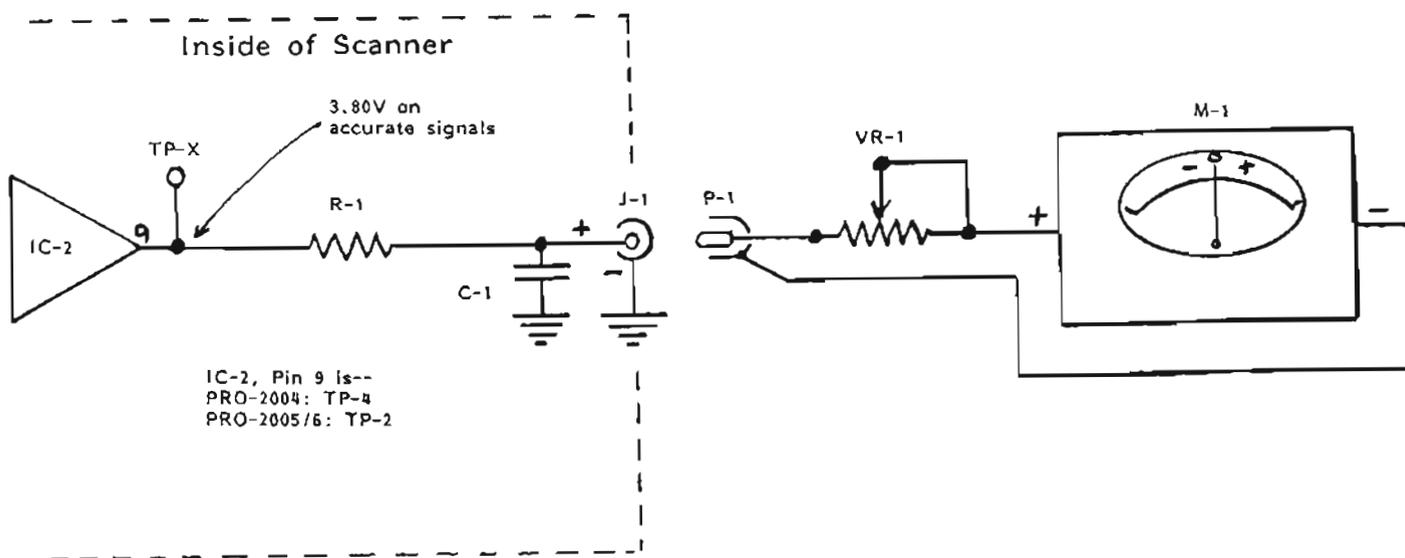
Most of the time, this drift occurs so slowly that it isn't noticed by the users until it gets drastically out of tolerance. Unfortunately, FM receivers (including scanners) have rather wide-banded I.F. sections and aren't highly selective. FM receivers will tolerate an off-frequency transmitter with minor or no adverse affect on communications for a time. Because of the expense, lack of or poor maintenance is quite common among the non-broadcast radio services. Therefore, it's not unusual for the scannist to encounter signals that have wandered off frequency by as much as 2 to 5 kHz. Compounding this problem is a lack of prompt detection and enforcement by the FCC. While the agency keeps a close eye on broadcasters, it casts only a casual and rare glance at personal and land mobile services, unless a specific interference complaint is filed with the agency.

Table 4-27-1
PARTS LIST FOR ANALOG EXTERNAL CENTER TUNING METER

Ckt Symbol	Description	Radio Shack Catalog #
M-1	* Microammeter, 50-uA to 200-uA, panel type	Electronic Parts Supply
VR-1	Trimmer potentiometer; 47-k	271-283 or 271-219
R-1	Resistor; 2.2k	271-1325
C-1	Capacitor; .01-uF/50 WVDC	272-1065 or 272-131
J-1	RCA Phono Jack	274-346
P-1	RCA Phono Plug	274-339 or 274-451
Misc	small wire, pair; 24 ga	278-1509 or equivalent

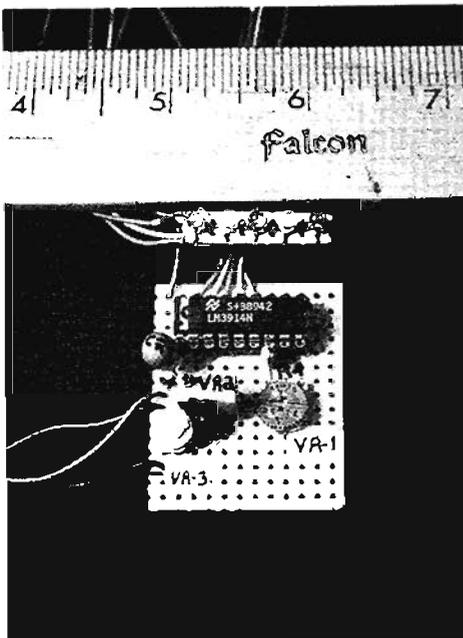
* Any voltmeter, 0-6 vDC, may be used.

Figure 4-27-1
 ANALOG EXTERNAL CENTER TUNING METER SCHEMATIC DIAGRAM
 PRO-2004/5/6



When a signal first begins to drift off frequency, usually there is no ill effect. The receiver isn't able to tell the difference, anyway, so the error goes undetected until it is gross and communications are affected. Then comes the needed, overdue maintenance. The scannist, however, may notice his favorite channel drifting off frequency much sooner than the users will. Scannists are picky and finicky with regard to clarity of the signals monitored and are apt to notice rough edges and other symptoms of a transmitter that has strayed. When the error gets bad enough, the scannist can simply reprogram that frequency into his scanner, compensating by ± 5 kHz and then go right on monitoring. Unfortunately, most scanners don't have a "fine tune" control to optimize the reception of each incoming signal.

You can, however, with the installation of a simple circuit, instantly see whether or not an incoming signal is smack on frequency or if it has wandered. You can see if it took the high road or the low road, and how far it's traveled.



MOD-27: Component side of the LED Center Tuning Meter Board.

This mod isn't one of those "must have" projects you need to keep up with the times, but it sure is useful and will reveal to you a lot about the communications systems in your area. The circuit requires a couple of chips if you want to go with a digital (LED) readout; otherwise, for an analog indicator, about all it needs is an external voltmeter of your choosing, be it a panel meter or a VOM. First, we will discuss the analog (external meter) version, since it is the simplest.

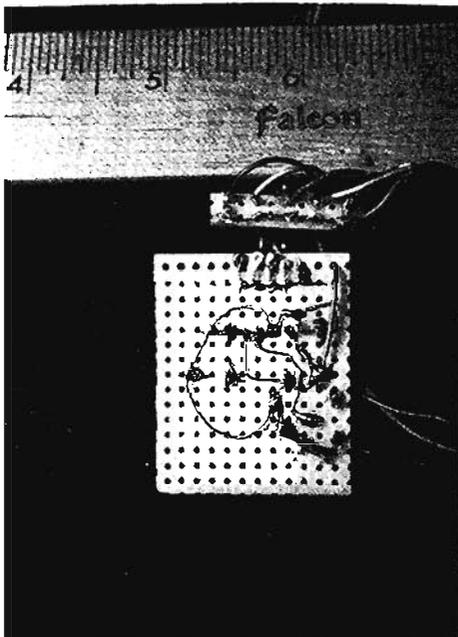
If you don't like the idea of "defacing" your scanner with LED's on the front panel, then this variation of the Center Tuning Meter is for you. It's also just for you if you don't want to have to do anything really out of the ordinary. Fact is, this function already exists inside the PRO-2004/5/6 and all you have to do is run a wire from that point to a jack on the rear chassis. Then, connect a voltmeter to that jack and you're done!

My suggestion is to install the microammeter in a plastic or metal box of your own preference, but I'll leave that up to you. But, let's get on with making everything happen. First, the analog version:

1. All models. Unplug from power line and remove the case (PRO-2004) of the scanner, or the top cover (PRO-2005/6). Drill a $\frac{1}{4}$ "-hole somewhere on the rear chassis of the scanner and install an "RCA" type phono jack. Slip on the ground lug and washer, then securely tighten the inner lock nut. When drilling, wrap several layers of tape around the end of the drill bit about $\frac{1}{4}$ " from the end to prevent the bit from suddenly boring through and doing damage to scanner components.

2-A. PRO-2004 only. Locate "TP-4," which is at IC-2, Pin 9. Clip all but about $\frac{1}{4}$ " off both ends of the 2.2K resistor, and solder one leg of the resistor to IC-2, Pin 9, or (preferred) directly to "TP-4."

2-B. PRO-2005/6 only. Locate "TP-2," which is at IC-2, Pin 9. Clip all but about $\frac{1}{4}$ " off both ends of the 2.2K resistor, and solder one leg of the resistor to IC-2, Pin 9, or (preferred) directly to "TP-2."



*MOD-27: Solder side of the LED
Center Tuning Meter Board.*

3. All models. Solder a length of hookup wire to the free end of the 2.2K resistor and route it to the "RCA" type jack on the rear of the chassis. Solder the free end of this wire to the center (hot) lug of the "RCA" type jack.

4. All models. Solder the .01-uF capacitor to the "RCA" jack terminals, one lead of the capacitor to the hot lug and the other to the ground lug.

5. All models. Install the "RCA" type plug on one end of a wire pair, one of the wires to the center lug of the plug and the other wire to the ground lug of the plug. Which wire doesn't matter at this point. Slip on the plastic or metal plug shell and screw firmly.

6. All models. Solder the middle lug of the trimmer pot to the positive (+) terminal of the microammeter.

7. All models. Solder the other end of the wire pair from the "RCA" plug to the microammeter as follows:

7-A. The hot wire (that comes from the center lug of the "RCA" phono plug) to either one of the outer lugs on the trimmer potentiometer.

7-B. Solder the other wire of the wire pair that comes from the ground lug on the "RCA" phono plug to the negative (-) terminal on the microammeter.

8. All models. You're about done, but first hook up the power and turn the scanner ON and program in a local NOAA 162 MHz band weather station, or some other station that you know to be precisely right on frequency. Don't use a business band or public safety agency station. Let the station remain playing on your scanner from now until you've completed Step 9. If you have an accurate digital voltmeter handy, we will first calibrate the scanner's internal circuitry. If you don't have one handy, then skip right from here to Step 9.

With an accurate signal tuned in, measure the voltage at TP-4 (PRO-2004) or

at TP-2 (PRO-2005/6). If the voltage measures +3.8V ($\pm 0.05V$), then leave well enough alone and skip from here to Step 9.

8-A. PRO-2004 only. If the voltage at TP-4 is less/greater than 3.80V by .05V or more, then adjust T-13 for a reading of 3.80V.

8-B. PRO-2005/6 only. If the voltage at TP-2 is less/greater than 3.80V by .05V or more, then adjust T-8 for a reading of 3.80V.

9. All models. Plug the External Center Tuning Meter into its mating "RCA" type jack, and observe the meter indication. Adjust the trimpot on the microammeter so that the meter registers exactly mid scale, halfway between the 0 on the left and full scale at the right. That is, the needle should be straight up and down. If the meter reads too high and can't be adjusted far enough downwards, then a larger value trimpot is required. Try a 100K pot (Radio Shack #271-284, #271-220, or equivalent). On the other hand, if the meter registers too low and doesn't smoothly come up to mid scale until the trimpot nears the end of its adjustment, the trimpot is too large. Try a 10K to 20K trimpot (Radio Shack #271-281, #271-340, or equivalent) if that's the case.

The idea here is to calibrate the external meter so that it reads exactly mid scale when a known accurate signal is coming in. Later, when other signals come in, if the needle pulls to the right, the station is actually operating on a frequency **higher** than what is programmed into the scanner's display. If it swings towards the left, then the received frequency is **lower** than the scanner's display readout. Starting with a known accurate signal, such as the NOAA, allows you to calibrate the meter so that it registers mid scale at a precise reference point.

That should do it, except for learning how to use and interpret the information. The following exercise will fill in the gaps for you.

Program your scanner with a NOAA or other signal of known accuracy. Then add and subtract 5 kHz from that frequency and program the sum and difference frequencies into two channels of the scanner. For example, if your local NOAA broadcast is on 162.400 MHz, then program in the following three frequencies: 162.395, 162.400, and 162.405 MHz. Use MANUAL mode to set the -5 kHz frequency. If everything is done correctly, the -5 kHz frequency will make the meter deflect to the right; the +5 kHz frequency will cause the meter to deflect to the left; and the proper frequency will show a mid scale reading. You should mark the meter panel at the -5 kHz, +5 kHz, and exact center points so you'll have a frame of reference to measure other stations.

The response of the meter should be fairly linear, which means that a deflection to a point halfway between the mid scale (0) reference and either of the 5 kHz marks would indicate the incoming signal is ± 2.5 kHz off.

Now, for those who like things neat, tidy, compact, good looking, eye-catching and 100% functional, check out the digital version of the Center Tuning Meter.

Adding a Digital (LED) Center Tuning Indicator (PRO-2004/5/6)

This one is slick, and not at all difficult. The "worst" part is fabricating a little circuit board to hold an IC and some trimmer pots. Make the board as small as possible so that it won't take up too much space inside the scanner in order to leave room for other mods. Keep the board small!

The heart of the Digital Center Tuning Meter is an inexpensive LM-3914 Dot-Bar Display Driver chip. You can't get it at Radio Shack, but it's available at many electronics parts supply houses. Besides the chip, you'll need five LED's and three colors. I selected 2-green, 2-yellow, 1-red. These LED's should be of the T-1 size, which is quite a bit smaller than LED's you may be used to. They're plenty bright, and their smaller size is suited to mounting on the front panels of the PRO-2004/5/6. The best source of yellow and green T-1 LED's is in the variety packs sold by Radio Shack. They sell red T-1's separately, two to a pack, but not yellow or green. On the other hand, you'll get a couple each of the yellow and green in the variety pack, but the red ones in the pack aren't very good. So you'll need to get both packs.

Basically, the circuit we're going to build is a Digital Voltmeter in simplest form. The LM-3914 chip does all the work for you, and the LED's provide the visual indication of -5, -2.5, 0, +2.5, +5 kHz deviation. For mine, the two 5 kHz LED's are green, the two 2.5 kHz LED's are yellow, and the zero reference is red. You can, of course, use any color scheme you prefer.

Steps of Procedure: PRO-2004/5/6

Preliminary: First, determine precisely where you want to install the LED's. The actual installation will be a snap once you've decided where they're going. As you decide, remember that Center Tuning LED Meters should be installed on a horizontal plane (left-to-right) rather than the vertical (up/down). Just seems to be more logical that way. Most of the time, the center LED will be on and the others will be off.

PRO-2004 Only: If you bother to remove the LCD Display Board from inside the front panel, there will be many possible installation locations. But don't bother because here's a better idea. See the rectangular frame strip surrounding the front panel? It's flat-edged and on the same plane as the sloping front panel. This strip can easily accommodate T-1 LED's, and the best spot for the Digital Center Tuning Meter is just above the **Realistic** logo, between the "e" and the "c." Decide if that area is OK with you, keeping in mind that there are several other LED projects in this book and you'll want to plan ahead for them, too.

PRO-2005/6 Only: The best installation place is on the little horizontal groove line on the front face of the scanner, above the DIMMER control switch. Decide for yourself, though, remembering that there are several other LED projects in this book.

PRO-2004/5/6: Let's build the electronic circuit board first, and test it before we make any holes in the faceplate of the scanner.

Digital LED Center Tuning Meter Board Assembly Instructions

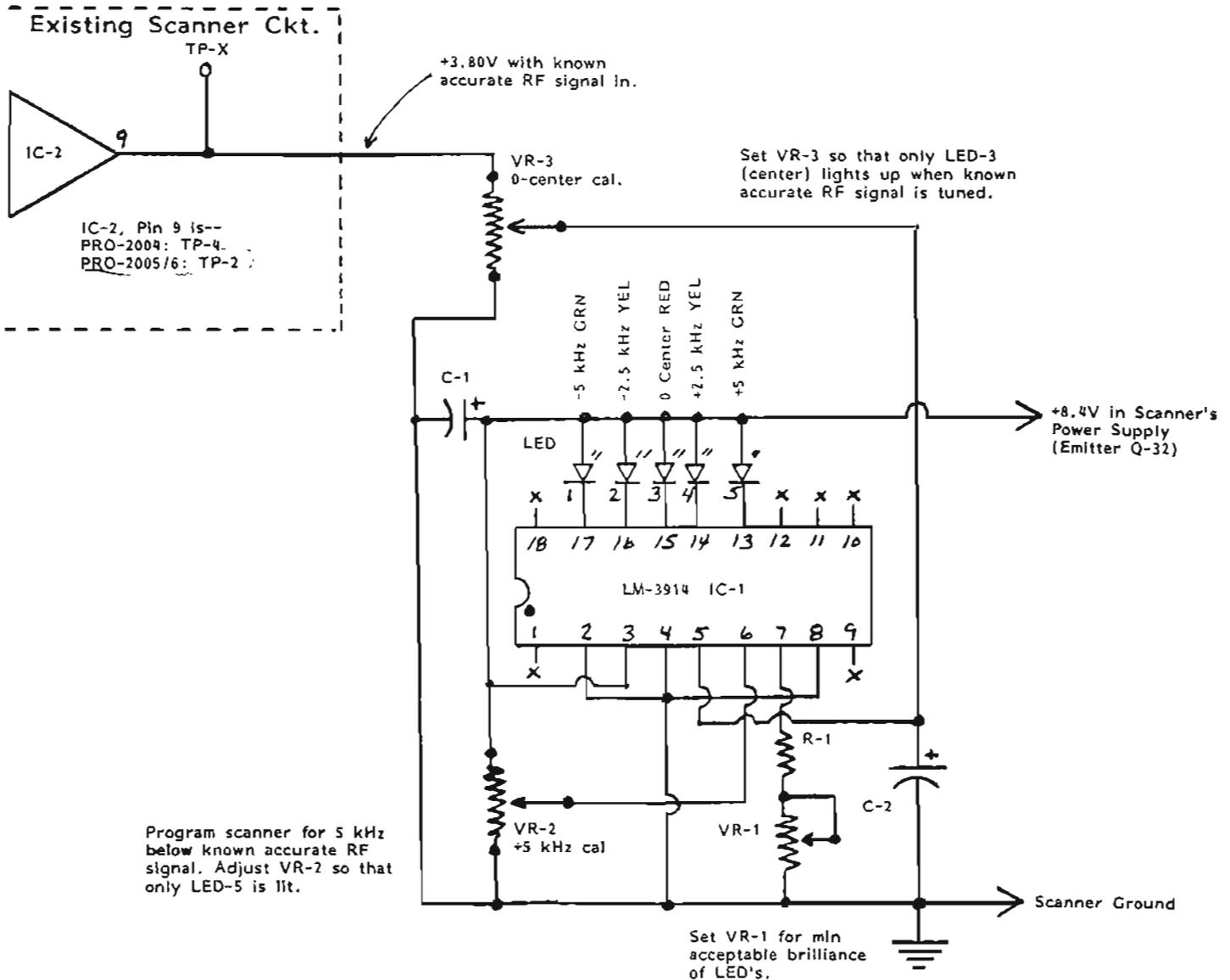
PRO-2004/5/6 - All (Except as noted):

1. Cut a piece of perf board about 2" X 2½." See the photos for component

Table 4-27-2
PARTS LIST FOR DIGITAL LED CENTER TUNING METER

Ckt Symbol	Description	Radio Shack Catalog #
IC-1	Bar-Dot Display Driver; IC	LM-3914 (not RadioShack)
VR-3	Trimmer potentiometer; 100-k	271-284
VR-1,2	Trimmer potentiometers; 10-k	271-282
C-1,2	Capacitors; 47-uF/35 WVDC	272-1027
LED	LED, T-1, Red	276-026
LED	LEDs, variety-pak	276-1622
Misc	Hookup wire	278-776
Misc	Perf Board; holes .1" x .1"	276-1395 or 276-1394
R-1	Resistor, 220 Ohms	271-1313

Figure 4-27-2
DIGITAL LED CENTER TUNING METER SCHEMATIC DIAGRAM; PRO-2004/5/6



layout in accordance with Figure 4-27-1. Wiring isn't critical, but stick to good principles and practices. Do **not** install the LED's on this board. Instead, solder hookup wires about 6-8" long to Pins 13, 14, 15, 16, and 17 of the LM-3914. These will go to the LED's later. Also, solder a length of hookup wire to the common tie (ground) trace of the board and let it hang free. Then solder another hookup wire to the unconnected end lug of the 100K trim pot and let hang free. Solder a length of hookup wire to Pin 3 of the LM-3914 and let it hang free. When you're done, there should be eight hookup wires about 6-8" long hanging free from the board: five for the LED's, one for ground, one for DC power, and one for signal input.

2. Assemble the five LED's on a tiny piece of perf board as follows:

2-A. Cut a piece of perf board exactly 4-holes wide (0.3"W) by 11-holes long (1.0"L). Sand or file the edges to remove burrs and rough spots. Continue to file the two long edges of the board to remove the outer two rows of holes. The idea is to make this strip very narrow, at least (but not much more than) two full holes wide.

2-B. Observing that each LED has one long lead and one shorter lead, insert them into the holes along the thin board strip so that each LED is separated by one empty hole. The LED's will be exactly 0.2" apart if you do it right. Make sure all the long leads are side-by-side as are all the short leads, i.e., they should all be oriented in the same direction. Unless you have chosen to do it differently, the red LED is in the center, flanked by two yellow LED's, then the two outer green LED's.

2-C. Position a single, small bare wire flush along the row of LED's on the wiring side of the board so that it touches each of the anode leads. The anode lead is the longer of the two leads. Make sure all the LED's are seated all the way into the holes, and then solder this bare wire to each of the anode leads to permanently fix the LED's in place so they can't move or fall out.

2-D. Solder a single 6-8" long hookup wire to this common anode line and let hang free.

2-E. Snip off all the excess lengths of the anode leads. Snip off all but about $\frac{1}{4}$ " of the exposed cathode leads of the five LED's, but don't yet solder anything to them. Bend the snipped cathode leads outward and flush against the bottom of the board.

2-F. Manipulate the five LED's so that they are perfectly parallel, and in a straight line.

3. Position the LED assembly so that you are facing the LED's as they will appear when installed into the faceplate of the scanner. I will refer to them as Left, Center Left, Center, Center Right, and Right in the following steps as wires are soldered between pins of the LM-3914 and the various LED's.

3-A. From Pin 17 to the cathode of the Left LED.

3-B. From Pin 16 to the cathode of the Center Left LED.

3-C. From Pin 15 to the cathode of the Center LED.

3-D. From Pin 14 to the cathode of the Center Right LED.

3-E. From Pin 13 to the cathode of the Right LED.

3-F. Solder the common anode hookup wire (Step 2-D) back to Pin 3.

The board can now be temporarily installed in the scanner for testing and adjustments.

4. Unplug scanner from AC power line. Place some temporary layers of tape on the bottom of the Digital Center Tuning Meter Board (DCTMB) to prevent short circuits. Lay the board inside the top area of your scanner, off to one side for temporary connection of the wires. Let the LED assembly hang free off to one side and temporarily tape the bottom of it to avoid accidental shorts.

5. Solder the loose ground wire of the DCTMB to a handy ground spot on the scanner's main board.

6. Solder the loose power supply wire from the DCTMB's LM-3914 Pin 3 to the emitter of Q-32, which is the power transistor on the left front side of the main board. This provides +8.4VDC to the DCTMB.

7. Solder the loose wire from the end-lug of the 100K trimpot on the DCTMB to:

PRO-2004-- "TP-4" (preferred), or Pin 9 of IC-2;

PRO-2005/6-- "TP-2" (preferred), or Pin 9 of IC-2.

8. Plug in the scanner and turn it on, observing LED indications. If any are on, adjust VR-1, the 10K trimpot, for desired brightness. **Caution:** Up to 125-ma. can be drawn if the LED's are set for high brilliance. This will increase heat dissipation inside the scanner and may contribute to eventual power supply failure. Dimmer is better than brighter, both for reduced current consumption and better night vision. With the LED's set for reduced but adequate brilliance, only 20-ma. or less will be needed. If you have a milliammeter, connect it in series between the scanner's +5V supply (Step 6) and adjust VR-1 for less than 20-ma. If you don't have a milliammeter, then set VR-1 first for **maximum** LED brilliance, then back off to **minimum** brilliance while observing the physical rotation of VR-1. Then increase VR-1 to a point not more than half of its rotation, which should be about 20-ma. or less. The LED's brilliance may seem dim in bright daylight, but will be just right under night lighting conditions.

9. The other two trimpots should now be adjusted. First, tune in a known accurate station such as a 162 MHz band NOAA weather broadcast facility. Have the station in operation on your scanner as you perform the following steps:

9-A. If you have an accurate digital voltmeter handy, we will first calibrate the scanner's internal circuitry. If you don't have a good voltmeter handy, then skip this part and go directly to Step 10.

With an accurate signal tuned in, measure the voltage at at TP-4 (PRO-2004), or at TP-2 (PRO-2005/6). If the voltage measures +3.8V ($\pm 0.05V$), then leave well enough alone and move on to Step 10.

PRO-2004 Only: If the voltage at TP-4 is less or greater than 3.80V by .05V or more, then adjust T-13 for a reading of 3.80V.

PRO-2005/6 Only: If the voltage at TP-2 is less or greater than 3.80V by .05V or more, then adjust T-8 for a reading of 3.80V.

9-B. Attach a voltmeter to the center lug of VR-3 (the 100K trimpot) and adjust to exactly .386V.

9-C. Attach a voltmeter to Pin 6 of the LM-3914 and adjust VR-2 (10K) trimpot for a reading of .640V.

10. Program a NOAA weather channel or other known accurate signal into a channel on your scanner. Then add and subtract 5 kHz from that frequency and program the sum and difference frequencies into two or more channels of the scanner. For example, if your local NOAA station is on 162.550 MHz, then program in the following three frequencies: 162.545, 162.550, and 162.555 MHz. Use the MANUAL mode to select the -5 kHz frequency. If everything has been done correctly, the Right LED will indicate that the actual frequency is 5 kHz higher than what is on the scanner's LCD display.

10-A. If not, then adjust VR-2 (10K) so that the Right (green) LED comes on and all others are extinguished.

10-B. Then, select the +5 kHz frequency and the Left (green) LED should light up to indicate that the actual frequency is 5 kHz lower than the reading on the scanner's LCD display. If not, select the center frequency and adjust VR-3 (100K) trimpot so that only the Center (red) LED is lit. Then repeat Step 10-A again.

There is some interaction between the settings of VR-2 and VR-3, so several adjustments back and forth may be necessary to cause the Center LED to be lit on center frequency and the outer LED's to light up on the +5 and -5 kHz frequencies. At this point, don't be concerned with the Center Left and Center Right LED's, they'll take care of themselves when Steps 10-A and 10-B have been properly completed. These will indicate errors of ± 2.5 kHz, which are not programmable as such in the scanner.

Installation of the LED Assembly

11. All models. Once everything checks out to your satisfaction, it's time to have fun poking holes in the faceplate of your scanner. Read thoroughly and understand what's involved before you take any action.

11-A. Fashion a template out of a tiny piece of perf board as follows: eleven holes long (1") X four holes wide (.3").

PRO-2004 Only: Sand or file one long edge so that one outer row of holes is just barely ground away, leaving a smooth, straight edge. Don't worry about the other three sides.

PRO-2005/6 Only: Your template isn't critical in any dimension provided it's at least eleven complete holes in length.

11-B. PRO-2004 Only: Starting with the row of holes along the smooth edge prepared in Step 11-A, mark every **other** hole with a black marker pen so that you end up with a total of five holes marked. IT IS IMPORTANT THAT YOUR BORE HOLES BE IN A ROW NEXT TO THE SMOOTH EDGE OF THE TEMPLATE,

PRO-2005/6 Only: Your template and bore holes can be anywhere so long as they are in a straight line with one another. Mark every **other** hole with a black marker pen so that you have a total of five holes marked.

All Models: The marked holes will be your bore template holes. Lay it up to the LED Assembly, and you'll see that the LED's will line up with the marked holes. If not, correct it before you get into trouble.

11-C. PRO-2004 Only. Unplug scanner from power line. You may wish to loosen and remove the top two countersunk machine screws that hold the front panel to the main chassis. That way, the front panel will swing forward and down to provide you some extra room.

Lay the bore template against the narrow, slanted, flat edge that encircles the faceplate of the scanner. Position the template precisely above the **Realistic** logo, so that the five bore holes line up between the "e" and the "c" of that logo. The smooth edge of the template prepared in Step 11-A should rest squarely on the indented rim while the back of the template should rest against the slanted frame encircling the faceplate. If you did it right, it should just lay there without moving. Press a piece of cellophane tape over the bore template to hold it against the faceplate of the scanner. If you look at the marked bore holes now, it will be noted that they are **not** centered with the flat indented rim that encircles the front panel. That's OK, it's supposed to be slightly off centered toward the bottom edge. Now move on to Step 11-E.

11-D. PRO-2005/6 Only: Your task will need more effort than the PRO-2004 owners. The LCD Display/Logic Board needs to be removed from its location behind the faceplate before you proceed. It's not all that hairy a task. Here's how:

11-D-1. Unplug scanner from power line. Remove the top and bottom cases from the chassis. Remove the VOLUME and SQUELCH knobs.

11-D-2. Disconnect all wires and cable bundles that go from the front panel assembly to the main circuit board. There are six cable bundles and connectors to be disconnected from the top side of the scanner, and one cable bundle and connector on the bottom side of the scanner. If you want to save the frequencies you have programmed into memory, do **not** disconnect the large 15-pin connector and cable bundle, CN-3. Leave it connected to the main board, but go ahead and remove all other cable connectors.

Disconnect the two ground straps that go directly from the Logic/CPU Board to the bottom side of the scanner chassis. All cable connectors and ground straps will disconnect from the main circuit board, **not** from the Logic/CPU Board.

11-D-3. Remove four (two on each side) countersunk machine screws from the sides of the front panel that secures it to the main chassis. Gently, pull the front panel assembly away from the scanner until it comes free.

11-D-4. Desolder from the chrome metal shield the small ground wire that goes to the area by the VOLUME control. Desolder it at the chrome metal shield and push this wire out of the way.

11-D-5. Remove the six small screws that secure the Logic/CPU Board inside the front panel.

11-D-6. Face the inside of the front panel placed in an upright position, and find the white 13-pin connector (CN-501) at the upper left corner of the PC board. This connector doesn't have any wires and doesn't look like a connector at first. Place a small flat blade screwdriver under that connector and gently pry upward. The entire Logic/CPU Board should then slip and away from the plastic front panel which will come loose in your hand. Gently lay the Logic/CPU Board aside near the scanner chassis.

11-D-7. Position the bore template so that the marked holes are directly over your preselected area along the horizontal groove on the faceplate. The bore holes

must line up evenly with and exactly over the groove. Press a piece of cellophane tape over it to hold the template to the front panel. Now move to Step 11-E.

11-E. All models. Assuming that your bore template has been properly positioned and taped, obtain a fairly large sewing needle or a piece of stiff wire that can barely fit through the holes of the perf board. Place the needle or wire in a pliers and, heat the needle or wire with a blow torch until it is red hot, and quickly thrust it into the first marked bore hole and let it melt through the front panel. Then remove it; heat it red hot again, and melt a second bore hole. Do this again until you have the five pilot holes melted out. Don't wiggle or move the needle around as it melts through. Just a small pilot hole is sufficient. Take care not to burn your fingers, and to keep the blowtorch out of the reach of children and far away from pets and flammable objects-- gasoline, clothing, curtains, wooden shelves, gunpowder, or whatever.

11-F. All models. Assuming you are using T-1 sized LED's, drill a 1/8" hole through each of the pilot holes. Use light pressure and drill gently and slowly, maintaining a perpendicular angle to the hole. Drill out all five holes and then blow away the dust and residue. That's all there is to this part of the job.

11-G. All models. Slip the LED Assembly into the back side of the front panel so that the five LED's protrude through the five holes. Make sure that the -5 kHz LED is in the **left** hole, and the +5 kHz LED is in the **right** hole. You can superglue the LED assembly in place, but if you just push it hard as it slips into place, it should hold fairly tight. If you're unsure, or if the fit isn't sufficiently snug, you could paint the bases of the LED's with some clear fingernail polish first, and then insert the assembly back into the holes. The fingernail polish will serve as a weak glue, allowing things to be removed without permanent damage later if needed. You could also use some cellophane tape to hold the assembly in place once it's fitted in. After the LED assembly is installed, place a piece of tape over the back side of the LED board to insulate the exposed solder joints.

11-H. PRO-2005/6 only. Reinstall the Logic/CPU Board back inside the front panel, making sure the five LED Assembly wires are routed up and over the top side of the Logic/CPU Board as it slips back into the front panel. Make sure that connector CN-501 seats properly down into its pins. Push the Logic/CPU Board firmly down into place and observe that the screw holes line up with their counterpart matching post holes. Insert and tighten the six screws. Resolder the ground wire near the VOLUME control back into its spot on the Logic Board shield. Make sure this ground wire doesn't touch any of the lugs on the VOLUME control, as can easily happen if you aren't careful. If it does happen, you'll lose audio volume later. So double check this before proceeding further.

Reconnect all the disconnected cables and wire bundles, and ground straps. Then reinstall the front panel assembly to the main chassis. Insert and tighten the four screws. Plug in the scanner, turn it on, and give it a brief checkout to make certain everything's OK so far. Correct any problems before going further.

11-I. PRO-2004 only. Swing the front panel back into place and reinstall the two machine screws. Plug scanner in and turn it on for a brief checkout to make sure nothing is amiss so far. Correct any problems before proceeding.

Final Installation: PRO-2004/5/6

12. Find a place to permanently mount the DCTMB inside the main area of the scanner. Don't do a haphazard job, leave room for other mods in the future. There are many ways to install a small circuit board like this one, you'll come up with

several. I have two favorites to suggest. You could use a threaded standoff stud. Or, alternately, solder a heavy solid copper wire (#18 or larger) to the DCTMB ground trace and then solder the other end of this heavy wire to the metal sidewall of the scanner chassis. Wherever you install the DCTMB, keep in mind that it will be convenient if you leave the adjustment controls easily accessible.

13. Reinstall the ground wire from the DCTMB, making the wire no longer than necessary. The DCTMB ground connection can be directly made to the metal chassis or to a ground trace anywhere throughout the scanner's PC boards. Just keep the ground wire as short as possible.

Reinstall the power wire and the signal input wire, shortening those wires as may be needed. Route them into a neat, out of the way bundle. Do the same with the five wires that go to the LED Assembly. Don't let your wire runs turn into a confusing jumble. Length isn't important except for the ground wire.

14. Fully test the scanner and all of its functions to make sure nothing was undone, and otherwise ensure that no errors were made. Then test the DCTMB again, making adjustments as necessary to calibrate it to precision specs. Refer to Steps 8 through 10-B for tests and adjustments. It might require a couple of readjustments the first week before it stabilizes, but should require only infrequent tweaking after that.

Operating Notes. This 5-LED Digital Center Tuning Meter is rather accurate and offers more resolution than you might imagine. For example, it's possible for any two adjacent LED's to be on simultaneously. If both the Left and Center Left LED's were on, that would mean the incoming signal is 3.75 kHz lower than what's on your LCD Display. The LED's are advising you, in that instance, that the error is greater than 2.5 kHz and less than 5 kHz.

If the Center and Center Left LED's were on at the same time, that would indicate that the incoming frequency is lower than the LCD Display frequency by 1.25 kHz. So, you can see that five LED's actually provide nine resolution points.

There is one more indication that will happen on occasion. If a transmitter is off frequency by more than 5 kHz, there is a chance that none of the LED's will light up. In that case, you won't know which way the frequency is off. You'll have to do a DIRECT SEARCH to find out for sure. This is a rare case, though, because when transmitters get so scuzzy that they've gone more than 5 kHz off frequency, maintenance is usually called in without further delay.

When a transmitter is 10 kHz or more off frequency, the LED's may flicker randomly and behave strangely. Don't worry about that, you won't encounter it often.

When the scanner is in the MANUAL mode and no signals are coming in, or when in the SCAN or SEARCH modes and no signals come in, the Center LED should be on, though occasionally certain bands may cause a flicker from the Center to one of the other adjacent LED's. This could be a normal indication.

Should you suspect that the DCTM has drifted out of calibration, just get into the MANUAL mode and select a quiet frequency where there are no signals and see if either the Center LED is on, or the +2.5 kHz LED is on; then go to a known accurate signal such as a NOAA 162 MHz weather broadcast and see if the Center LED lights exclusively. If so, then the board and scanner are within calibration tolerances. If not, then recalibration may be required in accordance with Steps 8 through 10-B.

**Keyboard Memory Block Controller For 6,400 Channel
PRO-2004, PRO-2005, & PRO-2006**

Credit, honors, and thanks are due to Mark Persson of Bay Shore, NY who designed this circuit based on little more than an idea and a rough outline with which I provided him to work. I like to call Mark, "Mr. Digital" because of his thorough understanding of digital electronics. Those 1's and 0's readily jump through hoops for him, and all I have to do provide express a concept. Next thing I know he's come up with exactly what's needed. So, thank you, "Mr. Digital," for your significant contributions to hobby radio-- and for awakening and strengthening my digital experience.

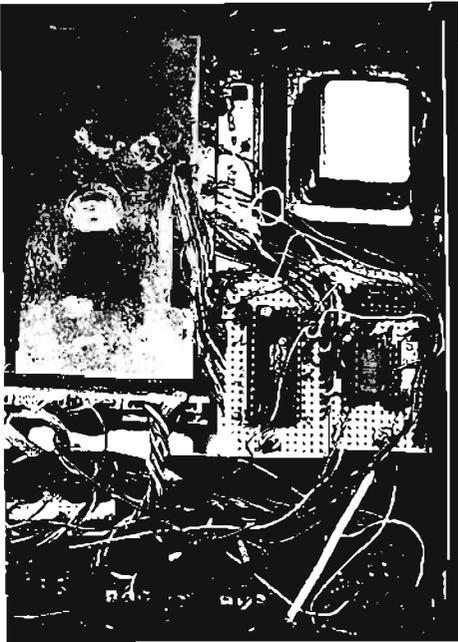
PRELIMINARY DISCUSSION

If you aren't familiar with the multi-thousand channel Channel Memory mods, check out the **Scanner Modification Handbook's** Volume 1, MOD-16 on page 124, and MOD-19 on page 148. The Keyboard Memory Block Controller (KMBC) circuit shown here (MOD-28) replaces all of the switching components and permits the sixteen Memory Blocks to be controlled strictly from the keyboard of the scanner. Operation is simple, since two keys are pressed simultaneously to initiate the Block selection sequence. When one or both keys are released, the Block selection sequence stops and the indicated Block is selected for action. Four small LED's are installed on the faceplate of the scanner to provide a visual indication of the selected Memory Block.

The KMBC can be easily retrofitted for previously installed Extended Memories, or incorporated into new installations. If retrofitted into an existing Extended Memory, the KMBC can be built onto a single board and installed in one session. Construction of an external switching assembly such as the 4-segment DIP switch scheme used in MOD-16 is completely eliminated. On the other hand, actual installation of the KMBC is much easier than any external switching scheme, so the complexity of the overall project isn't greatly changed.

The KMBC can be retrofitted into existing Extended Memories without loss of memory. It can also be fully tested prior to installation to ensure perfect operation before it is installed. The KMBC advances the Memory Blocks at a rate of two Blocks per second. This may be quite rapid, but will be adequate for you to release the keys as the desired Block is displayed on the LED Block Indicator. The KMBC features an automatic reset to Home Block (00) each time the scanner is turned on. If you don't mind installing one external control (a pushbutton switch), then you can also have a quick Home Block Reset feature. This isn't necessary since you get this whenever the scanner is turned on, but it's on the diagram (Figure 4-28-1) as an option. It requires only a few seconds to run the Memory Block sequence to any desired Block, including through a full cycle if necessary, so a Home Block Reset is strictly a luxury.

The KMBC utilizes high speed CMOS chips and a minimum of other parts for minuscule current drain. In fact, the total current demand from the Extended Memory plus the KMBC is much less than the Extended Memory alone where external switching methods are used. Current drain is only a few microamps plus about 1.5-ma. per each LED Block Indicator that is lit.



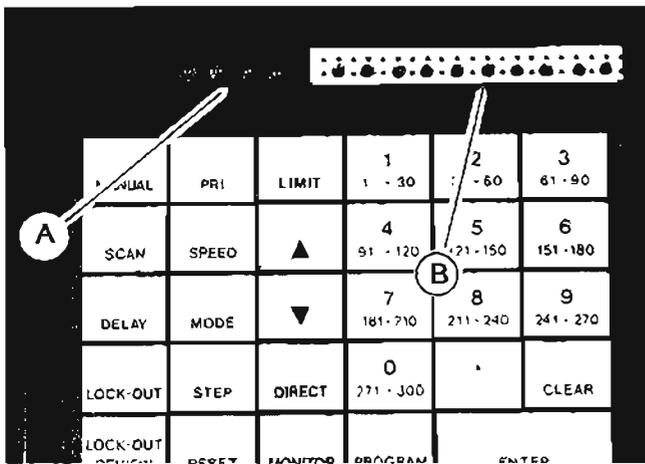
MOD-28: The KMB Controller mounts easily inside the PRO-2004 right next to the original 6,400-ch. (MOD-16) Board.

The KMBC converts the 6,400 channel Memory Expansion mod into something so convenient and easy to use that it's about the same as if it were factory designed and installed!

Functional Description of the KMBC. The KMBC, if being retrofitted into an existing Extended Memory, can be comfortably fitted onto a piece of perf board measuring about 2" X 2½." If for a new installation, then a board size of about 4" X 2½" (PRO-2004), or 2" X 5" (PRO-2005/6) will accommodate both the Extended Memory and the KMBC circuit. If you are contemplating a new installation for a PRO-2005/6, see the review information in this book for MOD-16 which will provide insight on optimum space utilization. The PRO-2004 has plenty of room.

The KMBC utilizes a quad NAND CMOS chip (74HC00) for the interface to the keyboard. A NAND circuit requires two simultaneous inputs in order to produce an inverted output. This is why two keys must be simultaneously pressed. Interestingly, the CLEAR key and its little-known subsidiary function is part of our secret to success here. Whenever the CLEAR key is pressed and held, it tells the CPU to ignore any other operations. The only time the CLEAR key has any visible function is when an ERROR message is displayed during any interval when you are entering digits, but before the MANUAL, PROGRAM, or ENTER keys are pressed. Obviously, the CLEAR function is to erase any errors you've made. Press and hold clear at any other time and it does absolutely nothing that you can perceive. Internally, it is telling the CPU to ignore any other keypresses. Isn't that dandy?

Therefore, we can use the CLEAR key in conjunction with just about any other key to send the two needed signals to the KMBC's decision-making circuit. Pressing CLEAR and any other key doesn't disrupt or change anything the scanner is doing at the moment. Pressing any one key, including CLEAR, doesn't register on the KMBC since the NAND circuit demands two simultaneous inputs. Therefore, the KMBC doesn't interact with the scanner, nor interfere with any ongoing operation. As an example, say you are in the SCAN mode and then press CLEAR plus the second key at the same time. The SCAN mode continues, unaffected, but the Memory Blocks begin to advance, one at a time, until one or both keys are released.



MOD-28: A= KMB Controller LED indicator. B= The Bore Template for all LED installations should look something like this. This one is on a PRO-2004, but all will be similar.

I have selected PROGRAM as the second key to be pressed simultaneously with CLEAR to activate the KMBC function. The PROGRAM and CLEAR keys are within comfortable reach of the index and middle fingers one hand. If you don't like the PROGRAM key, if absolutely necessary you can pick another key in its stead. There is no alternate choice allowed for the CLEAR key, however-- it's essential. As an advance note here, the CLEAR key must be pressed a fraction of a second **before** the second key to take advantage of the CLEAR's hidden function of disabling the keyboard. If you pressed PROGRAM an instant before the CLEAR button, the scanner would obey by going into the Program mode.

The NAND (74HC00), IC-1, logic circuit receives a dual input from the keyboard as described and produces an inverted output to switch a driver transistor (Q-1) off for the duration of the keypresses. When the transistor shuts off, a binary counter chip (IC-2, a CD-4060) goes into the "count" mode, performing an "up" count as a rate of about two counts per second. Timing is determined by the values of C-1 and R-3, either of which can be varied to change the count rate. If the values are increased, the count slows. Decrease the values, the count speeds up. There are ten counter outputs on the binary counter (CD-4060) chip, but only the first of four are used (since the Extended Memory chip has only four address ports that need external control. Four outputs, each with a logic state of 0 or 1 (low or high), yields sixteen combinations. This is exactly what we need to control the Extended Memory chip.

The CD-4060 Binary Counter's (IC-2) four outputs directly drive a 74HC04 CMOS Hex Inverter chip, IC-3, the purpose of which is twofold:

A. To produce the correct logic for address Block switching of the Extended Memory chip, in conformity with the logic used by any external switching schemes such as the 4-segment DIP switch. So, if you convert from external switching to the KMBC, you'll see no difference in the way the Memory Blocks are sequenced and numbered.

B. To drive the four Block Indicator LED's with the proper logic. When an LED is ON, we want that to signify that a certain Block has been selected. Also, the CD-4060 chip isn't designed to directly drive LED's, but the 74HC04 can do that job handily in addition to Block switching the Extended Memory chip.

When the output of a given section of the Hex Inverter is high (+5VDC), then 5V is sent to the cathode of its associated LED. Since there is a full time +5V on the anode of the LED, there can be no current flow, so the LED is off. When the

TABLE 4-28-1
400 CHANNEL BLOCK INDICATOR LED INTERPRETATION

----- 0 = OFF and 1 = ON -----

* --->	(8) D-4	(4) D-3	(2) D-2	(1) D-1		Indicated 400-ch Block
	0	0	0	0	=	00 Home Block
	0	0	0	1	=	01
	0	0	1	0	=	02
	0	0	1	1	=	03
	0	1	0	0	=	04
	0	1	0	1	=	05
	0	1	1	0	=	06
	0	1	1	1	=	07
	1	0	0	0	=	08
	1	0	0	1	=	09
	1	0	1	0	=	10
	1	0	1	1	=	11
	1	1	0	0	=	12
	1	1	0	1	=	13
	1	1	1	0	=	14
	1	1	1	1	=	15

NOTES: D-1 through D-4 should be physically positioned for visibility as shown above, i.e., with D-4 to the LEFT and D-1 to the RIGHT.

* a "1" in the D-4 column has a decimal value of 8; in D-3 column, a 4; in D-2 column, a 2 and in D-1 column, a 1. Zeros are always zero. Example for Row 13 above: 8 + 4 + 0 + 1 = 13. (Block 13 selected)

output of the Hex Inverter goes low (0VDC), then the anode of the LED becomes more positive than the cathode and current will flow, thereby lighting the LED. A high (+5V) into the Hex Inverter produces a low (0V) output. The whole circuit is nothing but logic; pure, simple logic consisting of 0's (low) and 1's (high).

The Power-On, Automatic Reset is accomplished by the combination of C-2 and R-4. When the unit is first turned on, C-2 begins to charge through R-4, thereby creating a voltage drop across R-4. C-2 becomes fully charged to +5V and the voltage across R-4 drops to 0V, all in milliseconds. But in that time, the charging voltage waveform across R-4 is a 5V peak pulse that is fed to Pin 12 of IC-2, the Reset Port. The optional pushbutton switch connected across C-2 accomplishes the same thing whenever it is momentarily pressed; i.e., the binary counter is reset to 0-count (0-0-0-0).

The four Block Indicator LED's can display a total count of 16, starting with 0-0-0-0 and ending with 1-1-1-1. All LED's off (0-0-0-0) indicates the "Home Block," while 1-1-1-1 indicates Block 15. Refer to Table 4-28-1 for all possible combinations of the Block Indicator LED's.

Binary arithmetic is very easy; much easier than decimal. But it can be confusing when you first get started. Here's a simple binary counting exercise for you. Make a fist. It signifies zero (0). Now, raise the little finger; that's 1. Close the little finger and raise the one next to it; that's 2. Now, keep it raised, but raise the little finger again; that's 3. Now, close both fingers and raise the the middle finger; that's 4. Now, keep repeating that pattern while checking Table 4-

Table 4-28-2
KEYBOARD MEMORY BLOCK CONTROLLER PARTS LIST

<u>Ckt Symbol</u>	<u>Quan</u>	<u>Description</u>	<u>Radio Shack #</u>
C-1,3	2 ea	Capacitor, 2.2-uF, tantalum	272-1435
C-2	1 ea	Capacitor, 0.1-uF, tantalum	272-1432
D-1,2,3,4	2 pkg	LED, T-1 size, (red preferred), 4 ea	276-026
IC-1	1 ea	74HC00 CMOS Quad NAND chip	nonRadio Shack
IC-2	1 ea	CD-4060 Binary Counter chip	nonRadio Shack
IC-3	1 ea	74HC04 CMOS Hex Inverter chip	nonRadio Shack
Q-1	1 ea	Transistor, NPN, switching; 2N2222A	276-2009
R-1,2,4	3 ea	Resistors, 5.1-k ohm, 1/4-watt	nonRadio Shack
R-3	1 ea	Resistor, 10-k ohm, 1/4-watt	271-1335
R-5,6,7,8	4 ea	Resistors, 1.5.-k ohm, 1/4-watt	nonRadio Shack
S-1	* 1 ea	Switch, SPST, push button, normally open	275-1571 *
Misc	2 ea	IC sockets, 14-pin, DIP	276-1999
Misc	1 ea	IC socket, 16-pin, DIP	276-1998
Misc	2 ft	Shielded Multiconductor cable, 25 wires for use as hookup wires	278-776
Misc	1 ea	Perf Board	276-1394
Misc	1 pkg	Standoff Studs	276-195
Misc	1 rl	30-ga wire, stripped, for point-to-point connection of components on circuit board	278-501,2,3

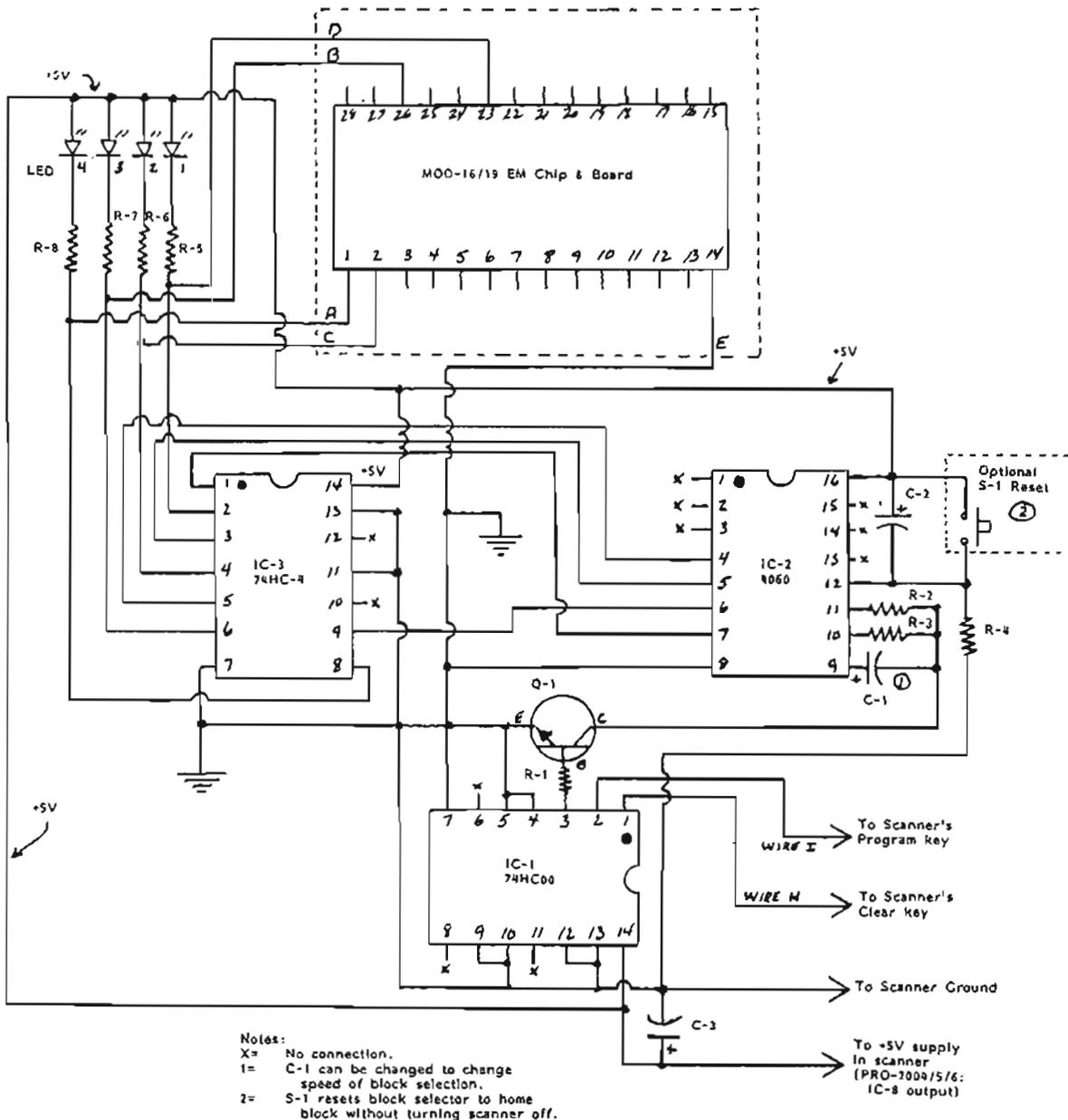
* Optional RESET SWITCH; smaller version than Radio Shack's preferred.
 See text above for discussion of this option.

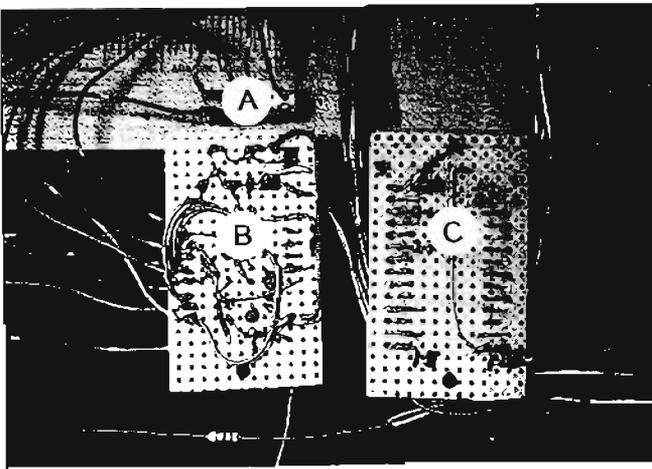
28-1 and you'll begin to comprehend the binary counting scheme. Now we can get to building a Keyboard Memory Block Controller for your 6,400 channel scanner.

PRELIMINARY PREPARATION

You'll need basic electronic hand tools; decent soldering equipment and a thorough understanding of the mechanics of the 6,400 Channel Extended Memory mod. This is **not** going to be something you are going to start and finish in only one sitting, so plan it through and be prepared to take your time. Thanks to the chips we're going to use, the work isn't highly sophisticated, but it does require attention to detail. The proper materials are essential to success. Do **not** use heavy hookup wire, only the type specified in the Parts List (Table 4-28-2). Do not substitute for any of the electronic parts unless you wish to experiment with different speeds of the Memory Block selection sequence. As mentioned previously, speed is determined by the values of C-1 and R-3. To start with, don't vary these values beyond $\pm 25\%$. It will be easier to vary the capacitor by 0.5-uF increments than changing the resistor value unless you use say a 20K trimmer pot. I have specified 1/4-watt resistors for the sake of easy access, but it's OK to use 1/8-watt values if you have a source of supply. Otherwise, stick to the specified parts if you don't want to waste a lot of time troubleshooting later. Now review the Parts List and the Schematic/Wiring Diagram and we can move right on.

FIGURE 4-28-1
KEYBOARD MEMORY BLOCK CONTROLLER
SCHEMATIC & WIRING DIAGRAM





MOD-28: Wiring of the KMBC can be a little tricky, but results will be good if you're patient and methodical. Don't confuse the IC pin numbering from one side of the board to the other! A= LED assembly; B= KMBC (MOD-28); C= MOD-16/19/39 Board. On the auto-reset function of MOD-28, at times when the power is turned on, the Home Block 00 should be selected. If other blocks are sometimes selected, change C-2 (page 140) to a 2.2-uf type capacitor (Radio Shack 272-1435) to cure the problem.

Steps of Procedure

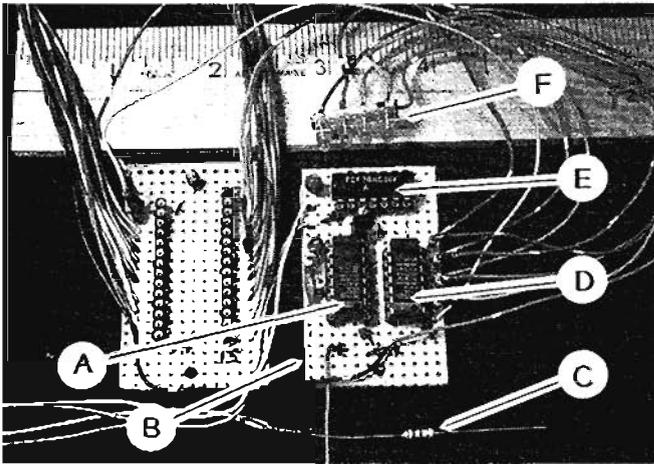
1. Installation Planning

1-A. New Installations (If retrofitting, see Step 1-B). Since you are starting from scratch, the Extended Memory Chip and the KMBC can all be on one board. You should now carefully evaluate your scanner for space in which to install the EMB/KMBC board(s):

1-A-1. PRO-2004 Only. Ample space is located on the bottom side in the scanner in the right, front corner where there's a fair-sized area of bare-metal chassis exposed. This is directly behind the LCD display on the main chassis. Measure this area and design your board accordingly. A board of about 4" W by 2½" L should fit this space nicely. That part of the metal chassis can be drilled to accommodate standoff spacer studs to hold your EM/KMBC Board. Plan this part and the associated drill holes on the circuit board very carefully. The standoffs should not be longer than about ½" (but a little shorter would be perfect).

1-A-2. PRO-2005/6 Only. You are urged to design your EM/KMBC Board to mount as shown for MOD-16 in the Review Chapter of this book. There's ample room on the chrome metal shield of the Logic/CPU Board that fits inside front panel of the PRO-2005/6. Instead of that shown in the Review Chapter, though, you'll need to extend the length of the board by about 100% to allow room for the KMBC and the EMB. Standoff studs are ideal for this purpose, but shouldn't be longer than about 1/8." A stud at each of the EMB/KMBC Board will be necessary because of its length. This circuit board will be approximately 2" W by 5" L. Mount the whole deal right there on that chrome metal shield of the Logic/CPU Board. Of course, part of the left end of the metal shield will be cut away to expose the stock memory chip for the necessary wiring. See the instructions for this phase the project in MOD-16 of this book's Review Chapter.

1-B. For Retrofitting to Existing Memories (Only). The KMBC must, obviously, be built on a separate board of its own unless you want to start over from scratch, in which case this section isn't for you. The KMBC, as a separate board, will measure about 2" W by 2½" L. If you were parsimonious in your use of space for the EMB, then you can probably install the KMBC right next to it. Strive to work it out that way, if possible, but the location of the KMBC isn't critical. The four wires that go to the EMB are DC levels 0 and +5V, so length isn't critical here. Just keep the installation neat and orderly.



MOD-28: If you've already done MOD-16, -19, or -37, the KMBC can be built on a separate board. Otherwise, all can be combined on a single board. A= IC-2; B= MOD-28 board; C= test resistor; D= IC-3; E= IC-1; F= LED assembly.

1-B-1. PRO-2004 Only. If at all possible, locate the KMBC board next to the EMB Board in the area that was discussed in Step 1 for the PRO-2004. There should be sufficient room unless you've already put something else there. If so, you're on your own. Well, you're somewhat on your own in almost any event. Just find a spot that's handy but not in the way of other things, including things you will be doing in the future. That means, plan your installation and do it neatly.

1-B-2. PRO-2005/6 Only. Regardless of where you have your present EMB located, the best place for the KMBC is on that chrome metal shield that covers most of the area of the Logic/CPU Board that's inside the front panel. If your EMB is already there, so much the better. Just install your KMBC in the center area of the chrome metal shield using standoff spacer studs not more than 1/8" long. If you can't (or don't wish to), then you're on your own. Just plan carefully and don't waste any valuable space that will be needed for other mods down the line. Location of the KMBC isn't critical, since only DC levels are on the four wires that go to the EMB. Just try to keep it close to the EMB and keep the wire routing as simple as possible.

1-C. Selecting a Location for The Block Indicator Assembly. You've selected a location for the KMBC Board, now you must pick a spot for the Block LED Indicator Assembly. Ideally, the four LED's will be installed somewhere on your scanner so as to be readily visible when your two fingers are on the CLEAR and PROGRAM keys. The prime location choice is somewhere on the scanner's front panel. Some scannists opt to install LED's in the top cover of the scanner to avoid defacing the front panel, or simply to make the job easier. This isn't a good idea because the scanner's cover will be removed many times for various mods and other reasons, and anything you've mounted there will only get in your way and cause grief. Besides, visibility of the top area of your scanner isn't very good, anyway. The following discussion will help you select a good location.

1-C-1-A. PRO-2004 Only. Note the rectangular frame edge stripping that surrounds the front panel? It's a little flat edge on the same plane as the sloping front panel and completely runs around the rectangular front panel. The entire strip can easily accommodate T-1 LED's, and the best spot for the KMBC Block LED Indicator assembly is just above the PRIORITY and LIMIT keys on the flat rim that encircles the face plate of the scanner. Keep in mind, though, that there are several other LED projects in this book, so you'll want to plan for them all before you finalize your decision. This is the best location, and the one I suggest.

1-C-1-B. PRO-2005/6. The suggested mounting location is in one of the groove lines on the front face of the scanner, remembering that several other mods in this book call for LED's that will also be mounted in these grooves. I think the best spot for this particular mod is along the vertical groove directly to the left of the L/OUT and L/O RVW keys, or even just to the left of the MANUAL key-- you decide for yourself. The LED's aren't hard to install. You have to first remove the Logic/CPU Board from inside the front panel, which seems a lot more imposing than it actually is.

2. Construction of The KMBC or KMBC/EMB (All Models). Construct as appropriate to your plans, Note that there are two different sources of +5V in the scanner. One is **CPU +5V** and absolutely **nothing** should be connected to it except Pin 28 of the EMB. The scanner's regular source of +5V will be what operates the KMBC. As you near completion of the KMBC, make certain that all +5V points on the board are connected to one common point. It's **very important** that you use only the hookup wire specified in the Parts List to solder hookup hookup wires of appropriate length to the KMBC. At this time, make the wires longer than necessary, later they can be trimmed as needed. The hookup is as follows:

Wire Designation/Purpose

A	from common +5v	(to +5 volt power in scanner)
B	from common ground	(to PCB or chassis ground in scanner)
C	from R-8 to cathode of D-4	(do not connect to LED at this time)
D	from R-7 to cathode of D-3	(do not connect to LED at this time)
E	from R-6 to cathode of D-2	(do not connect to LED at this time)
F	from R-5 to cathode of D-1	(do not connect to LED at this time)
G	common wire from anodes of D1-4 back to +5 volt common on KMBC (do not connect to the LEDs at this time)	
H	from IC-1, Pin 1	(to CLEAR key function in scanner)
I	from IC-1, Pin 2	(to PROGRAM key function in scanner)
J	from IC-3, Pin 8	(to Pin 1 of EMB, Memory Block address)
K	from IC-3, Pin 6	(to Pin 26 of EMB, Memory Block address)
L	from IC-3, Pin 4	(to Pin 2 of EMB Memory Block address)
M	from IC-3, Pin 2	(to Pin 23 of EMB (Memory Block address)

These wires should originate on the KMBC, but (for the time being) not connected at the ends. In our instructions, these wires will be referred to by the letter designator shown in the left column. Wire G will be connected to to the same point as Wire A on the KMBC.

For New Installations (Only): If your EMB and KMBC share one common board, then there will be 23 more wires from the EM chip in addition to those just listed. These are explained in detail in **The Scanner Modification Handbook**, Volume 1, under MOD-16. After reviewing the EMB instructions, you might quickly note that there are 28 wires, but Pin 14 of the EMB is ground and may be shared as one wire with Wire B shown in the list here; also, Pins 1, 2, 23, and 26 of the EMB will be connected to Wires J, K, L, and M given here. That leaves 23 wires from the EMB in addition to those given here.

Don't install the newly assembled board just yet in your scanner, but it should be as complete as possible at this point.

3. Construction of The Block LED Indicator (All Models). Assemble the four LED's on a tiny piece of perf board as follows:

3-A. Cut a piece of perf board exactly 4-holes wide (0.3"W) X 9 complete holes long (0.8"L). Sand or file the edges to remove any burrs and rough spots. Continue to file the two long edges of the board to remove the outer two rows of holes. The idea is to make this strip of board **very** narrow, at least (but not much more than) two holes wide.

3-B. Observe that each LED has one long (anode) lead, and one shorter lead. Insert them into the holes along the thin board strip so that each LED is separated by one pair of empty holes. If you've done it correctly, the LED's will be exactly 0.2" apart. Make sure the long leads are all side-by-side, as are all the short leads, i.e., are all oriented in the same direction.

3-C. Position a single, small bare wire, about 1" long, flush along the row of LED's on the wiring side of the board so that it touches each of the long (anode) leads. Make sure all the LED's are seated all the way into the holes and then solder this bare wire to each of the anode leads to permanently fix the LED's in place so they can't move or fall out.

3-D. Snip off all the excess lengths of the anode leads. Snip off all but about $\frac{1}{4}$ " of the exposed cathode leads of the four LED's, but do **not** solder anything to them at this time. Bend the snipped cathode leads outwards and flush against the bottom of the board.

3-E. Manipulate the four LED's so that they are perfectly parallel, in a straight line, and perpendicular to the board.

3-F. Position the LED assembly so that you are facing the LED's as they will appear when when installed into the faceplate of the scanner. I'm going to refer to them as Left (D-4), Center Left (D-3), Center Right (D-2), and Right (D-1) in the following steps:

- 3-F-1. Solder Wire C from KMBC, R-8 to Left LED cathode, D-4.
- 3-F-2. Solder Wire D from KMBC, R-7 to Center Left LED cathode, D-3.
- 3-F-3. Solder Wire E from KMBC, R-6 to Center Right LED cathode, D-2.
- 3-F-4. Solder Wire F from KMBC, R-5 to Right LED cathode, D-1.
- 3-F-5. Solder Wire G from KMBC to the common anode strip (Step 3-C).

Allow the LED assembly to hang free when the above is completed. Position it so the LED's are visible for the tests that follow.

4. Testing The KMBC (All Models, New & Retrofit Installations). Don't proceed past this point until your KMBC or KMBC/EMB has been fully constructed, wired to the Block LED Indicator assembly, and triple checked for errors, solder blobs, and

proper connections. Do not connect Wires J, K, L, and M to the EMB at this time. Insulate the ends and let them hang free. Your KMBC should not be installed for this test procedure. This is an external test to ensure perfect operation before installation in the scanner.

4-A. Set up a 5V power supply for this test or fabricate one using three fresh flashlight batteries connected in series. Three 1.5V batteries (AAA, AA, C, or D cells) will put out 4.5V, but that may be close enough for testing. Whatever it takes, have a power supply that puts out between 4.5V and 5.5V, no more, no less.

4-B. Temporarily twist (short) together the two leads of Wires H and J. Temporarily solder a 5.1K-ohm resistor to that junction. Let the other end of the resistor hang free.

4-C. Connect the negative (-) lead of the 5V power supply to the ground Wire B of the KMBC.

4-D. Turn the KMBC on by connecting the positive (+) lead of the 5V power supply to the +5V Wire A of the KMBC. Observe everything carefully at this moment. Nothing visible should happen; the LED's should remain off. If you have a milliammeter, it would be a good idea to connect it in series between the (+) terminal of the power supply and the +5V Wire A of the KMBC in order to observe current flow as the unit is first powered up. If current is less than 6-ma., move on to the next step. If appreciably more than a few milliamps, stop and troubleshoot. If everything is OK, current drain should be very low.

4-E. Touch the free end of 5.1K resistor connected in Step 4-B to the positive (+) terminal of the 5V power supply. This simulates the simultaneous pressing of the CLEAR and PROGRAM keys. Observe the Block LED Indicator, which should begin a sequence of counting starting with D-1 and advancing in the order depicted in Table 4-28-1. As long as the resistor is connected to the +5V terminal, the count will advance until all LED's are lit (1-1-1-1), after which the count will start over (from 0-0-0-0).

4-F. Now remove the resistor from the +5V terminal and the count should freeze and hold steady with whatever is indicated. This simulates releasing the CLEAR and PROGRAM keys when a desired Memory Block has been selected.

4-G. Briefly touch the resistor to the +5V power supply terminal and the count should advance from where it left off. Remove the resistor, and the count should stop again and hold steady with a new indication.

4-H. Alternatively, touch and remove the resistor from the +5V power supply terminal to become accustomed to starting and stopping the count. Practice stopping on various predetermined Block LED Indications. Then remove the resistor from the +5V terminal.

4-I. Temporarily disconnect the +5V Wire A of the KMBC from the positive (+) terminal of the 5V power supply. All LED's should go off. Then reconnect the +5V Wire A of the KMBC to the positive (+) terminal. Again, nothing should happen because of the automatic power-up Reset feature. Now, repeat Step 4-H a few more times to get used to it.

4-J. If you have a voltmeter available, test the output logic on wires J, K, L, and M as follows: Connect the negative (-) lead of the voltmeter to the KMBC

ground Wire B. Connect the positive (+) lead of the voltmeter to the end of Wire J. Repeat Step 4-H, noting that every time D-4 turns off, a +5V (high) logic signal should appear on Wire J. Likewise, there should be a similar correlation for Wire K and D-3; Wire L and D-2, and Wire M and D-1. In all cases, when the LED is lit, the voltage at the wire end should be zero; when the LED is off, the voltage on the wire end should be +5V. If you used a 3-battery (4.5V) power supply, then "high" logic level readings will be +4.5V, not +5V. If you achieved the results described in Step 4-J, then the KMBC works properly. If not, you must troubleshoot, diagnose, and correct any problems before proceeding further.

4-K. Remove the resistor connected in Step 4-B. Separate Wires H and I that were temporarily shorted together in Step 4-B.

4-L. Disassemble your test apparatus and test wiring at this time.

4-M. Desolder Wires C, D, E, F, and G from the Block LED Indicator Assembly. Lay the LED assembly aside in a safe place.

5. Installing The KMBC or KMBC/EMB in Your Scanner.

5-A. Installation of The Block LED Indicator. Once everything checks out OK, it's time to put some holes in the faceplate of your scanner. The LED assembly should be installed first to get it done and out of the way. Regardless of which scanner you have, the procedure to be described here will ensure excellent results. Read thoroughly and understand everything before proceeding further.

5-A-1. All models. Fashion a template out of a tiny piece of perf board as follows: Nine holes long (0.8") X four holes wide (0.3").

PRO-2004 only: Sand or file **one** long edge so that the holes are just barely ground away, leaving a smooth, straight edge. Don't worry about the other sides.

PRO-2005/6 only: Your template isn't critical in any dimension, but must be at least nine complete holes long.

5-A-2. Mark your template for hole boring.

PRO-2004 only: Work with the row of holes next to the smooth edge prepared in Step 5-A-1, and mark every **other** hole with a black marker pen so that you have four holes marked. It is important that your bore holes be 0.2" apart in a single row next to the smooth edge of the template.

PRO-2005/6 only: Your template bore can be anywhere on the template so long as they are in a straight line with one another. Mark every **other** hole with a black marker so that you have four holes marked, 0.2" apart.

All Models: The marked holes will be your bore template holes. Lay the template up to the LED Assembly, and you'll see that the LED's will line up with the marked holes. If they don't, then correct the situation now.

5-A-3. Unplug the scanner from the power lines. Position the template on your scanner.

PRO-2004 only: You may wish to loosen and remove the top two countersunk machine screws that hold the front panel to the main chassis. That way, the front panel will swing forward and down to give you some extra working space. Lay the bore template against the narrow, flat edge that encircles the perimeter of the scanner's faceplate. Position the template precisely above the Priority key so that the four bore holes line up over all of the Priority key and part of the LIMIT key. The smooth edge of the template you prepared (Step 5-A-1) should rest squarely on the indented rim, while the back of the template should rest against the slanted flat "frame" that encircles the faceplate. It will just lay there if you did it right. Press

a piece of cellophane tape over the bore template to hold it against the scanner's faceplate. If you look at the marked bore holes now, you'll see that they are **not** centered vertically with the flat indented rim that encircles the front panel. That's OK, it's supposed to be slightly off-center towards the faceplate proper. Now, move to Step 5-A-4.

PRO-2005/6 only: The LCD Display/Logic Board has to first be removed from its mounting spot inside the faceplate. If you follow the instructions (a to g), it will be less scary than it might at first appear.

a). Make certain scanner is disconnected from AC or DC power. Remove top and bottom cases from the chassis. Remove the VOLUME and the SQUELCH knobs.

b). Disconnect all wires and cable bundles that go from the front panel assembly to the main circuit board. There are six cable bundles and connectors to be disconnected from the top side of the scanner, and one cable bundle and connector on the bottom side of the scanner. If you want to save the frequencies programmed into the memory, do **not** disconnect the large 15-pin connector and cable bundle, CN-3, but go ahead and remove all other cable connectors. Disconnect the two ground straps that go from the Logic/CPU Board to the bottom side of the scanner chassis. All cable connectors and ground straps will disconnect from the main circuit board, **not** from the Logic/CPU Board.

c). Remove four (two on each side) countersunk machine screws from the sides of the front panel that secure it to the main chassis. Gently pull the front panel assembly away from the scanner until it comes free.

d). Desolder from chrome metal shield the small ground wire that goes to the area by the VOLUME control. Desolder it at the chrome metal shield and push this wire out of the way.

e). Remove the six small screws that secure the Logic/CPU Board inside the front panel.

f). Face the inside of the front panel placed in an upright position, and locate the white 13-pin connector (CN-501) at the upper left corner of the PC board. CN-501 doesn't have any wires and doesn't look like a connector, but it is one. Place a small flat blade screwdriver under that connector and gently pry upward. The entire Logic/CPU Board should then slip up and away from the plastic front panel which should come loose in your hands. Gently lay the Logic/CPU Board aside near the scanner chassis.

g). Position the bore template so that the marked holes are directly over your preselected area along previously the discussed (Step 1-C) vertical groove on the faceplate of the scanner. The bore holes must line up evenly with, and exactly over, the groove. Press a piece of cellophane tape over it to hold the template to the front panel. Proceed to Step 5-A-4.

5-A-4. (All models:) Using your template, drill or melt the bore holes as follows:

a). Obtain a fairly large sewing needle or a stiff wire that can barely fit through the holes of the perf board. Grip the needle or wire in a pliers and heat the needle or wire with a blow torch until it is red hot. Then quickly thrust it into the first marked bore hole and let it melt through the plastic front panel. Then remove it; heat it red hot again, and melt a second bore hole. Do this until you have the four pilot holes melted out. Don't wiggle, jiggle, or move around the hot

needle as it melts through. Just a small pilot hole is sufficient. Take care not to burn your fingers, and exercise caution not to use the blow torch near flammable materials, or near children or pets.

b). Assuming that you are using T-1 sized LED's, drill a 1/8" hole through each of the pilot holes. Use light pressure and drill gently and slowly, using a perpendicular angle to the hole. Drill out all four holes and then blow away the dust and residue.

5-A-5. Install the LED Assembly into the holes (All Models). Slip the LED Assembly through the back side of the front panel so that the four LED's protrude through the four holes. In the PRO-2004, make sure that the D-4 LED is in the **left** hole, and that D-1 LED is in the **right** hole. Solder color coded hookup wires to each of the cathodes of D-1 to D-4 and another wire to the common anodes of D-1 to D-4. Let the wires hang free. Make a record of your color coded wires. In the PRO-2005/6, you probably selected vertical mounting. If you do this with D-4 at the top of the vertical row, and D-1 at the bottom, the "count" will go from low to high, which is appropriate.

You can use superglue to hold the LED Assembly in place, but if you just push hard it should pop right in and stay fairly tight on its own. If you're unsure, or if the LED's aren't a snug fit, you could paint the bases of the LED's with some clear fingernail polish, and then insert the assembly back into the holes. The fingernail polish will serve as a weak glue and allow you things to be removed later without damage. You could also use some cellophane tape to hold it in place, as well as to insulate the exposed solder joints at the rear of the LED assembly.

5-A-6. LED Assembly Installation Wrap-Up.

PRO-2004 only: Dress up the five wires from the LED Assembly so that they are conveniently routed into the main area of the scanner. Swing the front panel back into place and reinstall the two machine screws. Turn the scanner on and give it a brief checkout to make sure everything OK thus far. Correct any problems before going to Step 5-B.

PRO-2005/6 only: Reinstall the Logic/CPU Board inside the front panel, making sure the five LED assembly wires are routed up and over the top side of the Logic/CPU Board as it slips back into the front panel. Make sure the connector CN-501 seats properly down onto its pins. Push the Logic/CPU Board firmly down into place and observe that the screw holes line up with their counterpart mounting post holes. Insert/tighten the six screws. Resolder the ground wire near the VOLUME control back to its spot on the Logic Board shield. Make sure this ground wire doesn't touch any of the lugs on the volume control, which could easily happen. If it does, you'll lose audio volume later.

Dress up the five wires from the LED Assembly so that they are conveniently routed into the main area of the scanner. Reconnect all the disconnected cables, wire bundles, and ground straps. Then reinstall the front panel assembly to the main chassis. Insert/tighten the four screws. Turn on scanner and give it a brief checkout to make certain nothing is amiss. Correct any problems before moving to Step 5-B.

5-B. Installation of The Keyboard Memory Block Controller.

5-B-1. For Retrofitting to Existing Extended Memories (Only). This section applies only to those who have previously installed/operated the 6,400 Channel Extended Memory from plans in Volume 1 of the **Scanner Modification Handbook**. If

yours is a brand new installation from scratch, with both the EMB and KMBC on one board, then refer to Step 5-B-2 first (although it will refer you back here a couple of times).

All Models:

a). Mechanically install the KMBC in accordance with plans developed in Step 1 (Installation Planning).

b). Connect the KMBC ground wire B to any circuit ground or to any metal chassis point. Keep this wire as short as possible.

c). Connect KMBC +5V Wire A to the output of the main 5V regulator, IC-8. The output is the lead farthest from the front panel.

d). Splice the KMBC Wire C to the color coded wire installed on the cathode of D-4 in Step 5-A-5. Insulate splice with heat shrink tubing or cellophane tape.

Splice the KMBC Wire D to the color coded wire installed on the cathode of D-3 in Step 5-A-5. Insulate splice with heat shrink tubing or cellophane tape.

Splice the KMBC Wire E to the color coded wire installed on the cathode of D-2 in Step 5-A-5. Insulate splice with heat shrink tubing or cellophane tape.

Splice the KMBC Wire F to the color coded wire installed on the cathode of D-1 in Step 5-A-1. Insulate the splice with heat shrink tubing or cellophane tape.

Splice the KMBC Wire G to the color coded wire installed on the common anodes of D-1 to D-4 in Step 5-A-5. Insulate splice with heat shrink tubing or cellophane tape.

Dress up these wires in a neat bundle and route them out of the way so that they do not interfere with internal adjustments or future mods.

e). Connect Wires H and I to the CLEAR and PROGRAM keys as follows:

PRO-2004 only: Turn the scanner upside down and locate the cable bundle that comes from the keyboard. Follow that bundle to where it terminates at a connector on the Logic/CPU Board (PC-3). The circuit symbol of the proper connector is CN-502, a 13-pin connector. Find the wire that goes to Pin 12 of CN-502. Splice Wire H from the KMBC to the wire with heat shrink tubing or cellophane tape. Also splice Wire I from the KMBC to the wire that runs to Pin 10 of CN-502. Insulate the splice with heat shrink tubing or cellophane tape.

PRO-2005/6 only: Locate CN-501 on the upper left, rear side of the Logic/CPU Board (as seen when looking down at it from inside the front panel). CN-501 is the one that doesn't look like a connector. Identify the pin numbering of that connector, which starts with Pin 1 closest to the sidewall of the metal chassis, and ends up with Pin 13 closest to the interior of the board. Find Pins 2 and 10.

Examine the rear side of CN-501 and poke a piece of 18-ga. or 20-ga. solid wire into Pin hole 10 of CN-501. There will be some resistance at first, but then it should give way and enter the connector hole to a $\frac{1}{4}$ " depth. Clip off the excess of this wire so that about $\frac{1}{4}$ " protrudes out of the connector hole. Now, poke another piece of 18-ga. or 20-ga. solid wire into Pin hole 12 of CN-501. Make sure it seats at least $\frac{1}{4}$ " deep into the connector pin hole and clip off the excess so that about $\frac{1}{4}$ " sticks out of the connector pin hole.

Solder Wire H of the KMBC to the wire stub protruding from Pin 12 of CN-501 as performed above. Solder Wire I of the KMBC to the Wire stub protruding from Pin 10 of CN-501.

f). Don't worry about doing this next step. Make certain the scanner is still unplugged from its power source, and turn off the four external switches that were once used to control the memory blocks. Follow the directions: Examine your existing EMB and locate the four resistors that were used in conjunction with your memory address switching scheme. These resistors are no longer needed and should be removed from the EMB. Since you are likely to want to retain memory, the least amount of fooling around with the EMB, the better you'll be. Frankly, it's OK to just slip in there with a diagonal cutting pliers and snip out those resistors. Clip them at the ends if possible, or otherwise just cut each resistor in half and remove the pieces-- whatever it takes to get them out of there. Just avoid unnecessary touching of any other pins of the EMB. Try to preserve and make accessible the wire lead ends of the resistors that go directly to Pins 1, 2, 23, and 26 of the EM chip because they'll make solder termination points for the KMBC points for the KMBC wires in the next step.

g). Solder KMBC Wire J to EMB Pin 1; solder KMBC Wire K to EMB Pin 26; solder KMBC Wire L to EMB Pin 2; solder KMBC wire M to EMB Pin 23.

h). Now, remove the old memory addressing switches and wiring. They're no longer needed. If you used a permanently mounted 4-segment DIP switch or other switches that you'd prefer not to remove, leave them in. Maybe you'll use them for something else later. Just roll up the wiring and tape it out of the way. Now, move to Step 6.

5-B-2. For New Installations Only, EMB/KMBC on One Board (All Models). First, familiarize yourself with MOD-16, page 124 in Volume 1 of the **Scanner Modification Handbook**, also MOD-16 in the Review Chapter of this book. For the purposes of this section, the installation of the EMB is considered a separate project unrelated to the KMBC (though, in your case, it's all one project). You'll just have to jump around a little since the information is already in print and there's no point in duplicating it all.

So, at this point, mechanically install your EMB/KMBC board in accordance with previous material including commentary and notes in this chapter. Wire the EMB in accordance with Volume 1, page 131 (MOD-16, Figure 4-16-1), and as modified in MOD-16 in the Review Chapter of this book. At this time, don't connect anything to the EMB's Pins 1, 2, 23, and 26. Otherwise, the remaining 24 wires from the EMB part of your board should be connected before commencing as follows:

a). Solder KMBC Wire J to EMB Pin 1; solder KMBC Wire K to EMB Pin 26; solder KMBC Wire L to EMB Pin 2; solder KMBC Wire M to EMB Pin 23. These wires needn't be very long since they're all on the same board. Refer to them as "jumpers" and connect accordingly.

b). Complete the electrical hookup of the KMBC section of your board, referring to Step 5-B-1 parts b) though e). When completed, go to Step 6.

6. Checking Out and Operating The KMBC (All Models). By now, you should be thoroughly familiar with all aspects of the work performed. Take a few minutes to go back over everything. Look for missed steps, as evidenced by loose wires not hooked up. Next, use a strong light and a magnifying lens to help you examine all board connections for solder blobs and unwanted short circuits. Check for wires that may have come loose due to faulty soldering or breakage. Dress up your

wiring bundles and make them neat and orderly. Insulate all splices if not yet done. Be sure of your work, then proceed.

6-A. For KMBC Retrofits to Existing Memories (Only). New Installations refer to Step 6-B: Your checkout is simple. Your Extended Memory worked before you began this project, and you did nothing to cause it grief. Essentially, you're just going to verify the operation of the KMBC that now replaces the external switching arrangement you previously used. The KMBC worked when tested independently of the scanner (Step 4), so you should experience smooth sailing:

6-A-1. Turn scanner on. The Block LED Indicator should remain unlit, and the scanner should begin normal SCAN function in Home Memory Block 00.

6-A-2. Press and hold, first the CLEAR key immediately followed by the PROGRAM key. The Block LED Indicator should begin a count sequence starting with 0-0-0-1, 0-0-1-0, 0-0-1-1, 0-1-0-0, etc. Continue the sequence until the cycle is complete; stop on Home Block 00.

6-A-3. Pressing the CLEAR and PROGRAM keys, advance the Memory Blocks one at a time and check out the programming and contents of each memory block to

be sure they conform to what you were accustomed to in the past. This step is where any problems would first rear their little heads. You might discover that the blocks have come up out of order-- what was once Block 07 might now be Block 08, etc., although the Home Block may have been unaffected. Don't panic yet. Everything may be OK. Chances are that when you first installed the EMB long ago, you didn't wire the external switching precisely in accordance with Volume 1's Figure 4-16-1 (page 131). A miswired switch bank will not cause any functional problems; it merely throws your block numbering system down the dumper. If you have problems of this nature at this point, then you have a choice. Either (1) learn to love the new numbering system, or (2) change the wiring terminations of Wires J, K, L, and M to restore the numbering system you previously used.

If you decide on (2), you're on your own since I would have no way of knowing the way you had your former switches wired. You'll have to figure it out by comparing the old block numbering system to what you've got now. You'll see where two or more of Wires J, K, L, or M can be changed around to EMB Pins 1, 2, 23, or 26. Unless it's really causing you serious anguish, your best bet is to get used to the new numbering system.

If you wired your own external switching scheme in accordance with MOD-16 in Volume 1, then the present numbering system should match up with what you had previously.

6-A-4. Evaluate the speed of the Block Advance Sequence. When you press the CLEAR and PROGRAM keys, the sequence rate should be about about two blocks per second, or about eight seconds for a complete cycle from Home Block back to Home Block again. If you want to change this speed, see comments about this given earlier in our discussion of this mod. Before you change it, try it for a week or two the way it is-- you may decide it's OK, after all.

6-A-5. If ever, in the future, the Block Advance Sequence doesn't seem to work, try this before you get too upset. Hold down the CLEAR key continuously, and rapidly press and release the PROGRAM key. It might require up to eight keypresses of the PROGRAM key (with the CLEAR key held down) to force it to advance the block sequence by one. This is a most unusual "safety valve" procedure to cure a problem that probably will never befall you.

Also, you could try just turning off the scanner for a half hour or so to let it cool off. Then turn it on again and see if it advances normally. If this solution works, then you could have a heat related problem. In any event, feel free to contact me about the problem.

6-A-6. If you installed the optional Reset Switch, test it to make sure that the Block Indicator resets to Home Block 00.

6-B. Only For New Installations of EMB and KMBC (All Models). Your first concern will be to determine that the scanner itself operates. Turn it on and observe the display. Disregard the "junk" that may appear in the display, but ensure that the SCAN mode is in progress as is normal for the unit when first turned on. Then take up with Step 57 on page 141 of Volume 1 of the **Scanner Modification Handbook**. You'll have to use the KMBC to advance the block selections, so refer to Steps 6-A-1 through 6-A-6 for a checkout of the KMBC while at the same time following Steps 57 through 65 in Volume 1.

C. Summary and Wrap-Up-- If You Encounter Trouble (All Models). If you run into a snag, first isolate the section of the circuit where the trouble lies, i.e. EMB or KMBC. If in the EMB circuit, most likely it's a wiring error or a short caused by a solder blob between two adjacent pins or wires. Or, maybe a once-good connection came loose after being wiggled a few times. It's possible, though rare, that you may have done some unseen damage to the Logic/CPU board. If the problem is in the KMBC, chances are it's in the interconnect wiring to the scanner. Don't forget that when the KMBC was checked out (Step 4), it worked. The only problem that that could exist to cause confusion as to where the problem is, is if the memory blocks are out of the order you had expected (per Step 6-A-3). Otherwise, any problem must first be (and is easily) isolated to the particular circuit.

Rarely do the chips ever go faulty unless (of course) you hook them up radically wrong. Even then, CMOS chips are hardier than you'd imagine. I can't recall ever having blown one, and I've certainly come up with some golden opportunities for that to happen during some of the circuit experiments I've tried. The Memory chip is expensive, but the others run between 80¢ and \$1, so maybe you ought to get some spares for confidence-bolstering. Or, just take my word that you probably won't be the death of one.

Based on the reader feedback from Volume 1, I'd say that virtually every problem is the result of either not following directions explicitly or an inadvertent mistake. The problem with not following directions is that we all know to improve upon someone else's job and/or how to make the job easier/better. But that causes a special problem here because there is a certain amount of "between the lines" stuff that just doesn't turn up as the printed word. For one example, you'll note in the Parts List, I specified "Tantalum Capacitors." But, if you know anything about electronics, you'll figure that other varieties will work, too. That line of reasoning could get you into trouble, even though it is technically correct.

Considerable engineering has gone into these mods. Many times, I'll specify rugged, fail-safe components or certain unfamiliar techniques to spare the hobbyist from peculiar failures under bizarre circumstances that I happen to know about from long experience. Specifically, tantalum capacitors are very resistant to heat; they exhibit extremely low leakage and otherwise are more rugged than the aluminum electrolytic alternatives. Yet electrolytics will work, and perhaps they'll do so for a lifetime, But they're also known to fail under the weirdest circumstances, too. So, as designer, I have exercised certain prerogatives and ask that you humor my little

idiosyncratic component choices since they're all extensively thought out and tested, and presented what I believe are your best interests.

In any event, if you run into a problem, and you didn't follow my instructions to the letter, start your troubleshooting at the component or procedural point where you veered off from my steps and other recommendations. Because neither I nor my publisher wished to make this book the size of the Tokyo telephone directory, in most instances we have presented explicit information on just what to do, but there hasn't been any great amount of wordage devoted to what **not** to do. Should you deviate from the given directions, who knows what forbidden ground you might tread upon and which demons you might summon from the very bowels of Hell. Still, if you'll invoked one of those demons and can't figure out a proper exorcism, I'll help you out as much as I can for no more than the price of a self-addressed, stamped reply envelope plus one loose extra stamp. A good deal.

MOD-29

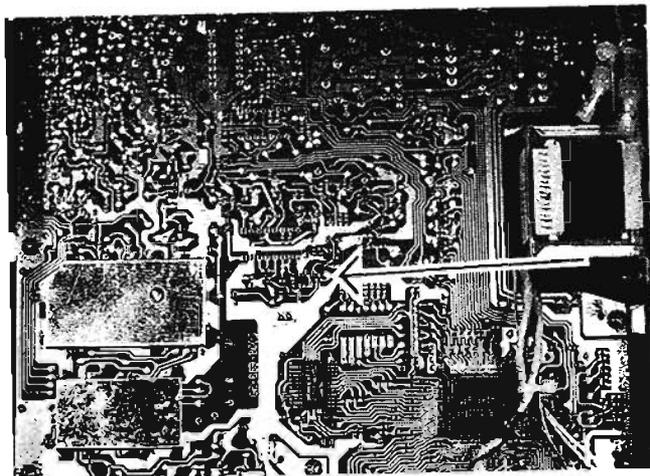
Extended Delay, Adjustable 0-12 Seconds For PRO-2004/5/6; PRO-2022 & Others

PRELIMINARY DISCUSSION

The DELAY function in most modern scanners is useful and necessary. Usually, it can be turned on or off from the keyboard on a per-channel basis, and we tend to take it for granted. You can't do much more with the DELAY, however, than turn it on and off. Well, some hackers have learned that one other thing can be done to the DELAY; shorten it! What?

Yup, just stick in a higher frequency Clock Oscillator Crystal in order to make the scanner SCAN and SEARCH faster and see what also happens. The scannists goes into Warp Factor 1--even when you put on the DELAY, that function is also sped up to a fraction of the time it had been before. There are times, when scanners feel their stock scanners don't come from the factory with a DELAY interval they prefer. The (average) two-seconds delay sometimes seems too long, and other times isn't long enough. The obvious conclusion is that it would be great if the DELAY function was more under the user's control, especially if it were adjustable in order to meet changing needs and situations.

Basic Theory of Normal DELAY and Our Extended DELAY: The typical scanner DELAY function works from the SQUELCH circuit, under the premise that when the SQUELCH (SQ) activates ("breaks"), an RF signal is present. When the SQ resets, presumably the signal is gone. Therefore, the Central Processor Unit (CPU) in most scanners has an input to sense the absence or presence of a SQ "gate." When the SQ is present, the CPU directs the scanner to do whatever you programmed it to do, such as SCAN. So the scanner scans along until it encounters an active channel. The SQ breaks and the CPU senses that the SQ logic is gone and sets some special wheels to rolling. One sequence in particular is that the CPU will check to see if the DELAY function has been set for that channel. If not, then as soon as SQ returns, the CPU will instantly resume the SCAN function. If the DELAY has been set, then the CPU starts an internal countdown timer based upon some interval of the Clock Oscillator, usually about two seconds, or so. When the countdown hits zero, and if the SQ is still set and wasn't retrIGGERED during that countdown interval, then the CPU directs the SCAN function to resume. So long as the SCAN function is occupied with the activities on a certain channel, the countdown timer resets and starts over every time the SQ breaks.



MOD-29: The arrow (center right) shows the inside of a PRO-2022. Remove R-156 and replace with a regular wire-lead resistor. Use this point for SQ/In-SQ-Out of the EMB.

From the above, it can be seen that the DELAY function will suffer if the Clock Oscillator is changed to a much faster speed. If speed increases, then the countdown interval is shortened. Even if you don't have high-speed scanning, it might be advantageous to be able to control the DELAY time. One thing's for sure, you can't do this by hacking your way into the CPU and tinkering around. But you can intercept that SQ gate before the CPU finds out what's going on, use it a little first, and then send it along to the CPU. All we do is cut that SQ gate path to the CPU and wire in a little circuit to artificially stretch the SQ gate. Our EXTENDED DELAY is little more than a "pulse stretcher." It senses when SQ disappears. When SQ returns, it merely delays its return to the CPU by an adjustable amount of time, 0 to maybe about 12 seconds. The EXT DELAY circuit uses CMOS chips and draws less than 2-ma. of current without the LED; only slightly more with the LED.

Two types of Squelch Logic: There are two versions of SQ logic, and it's important to know which one your scanner uses. The method to determine which type is used by your scanner is given later. Basically, though, it's like this: All SQ logic is based upon two voltage levels at the CPU SQ pin, low and high. In some scanners (such as the PRO-2004/5/6), a "low" (or 0 volts) means that the SQ is broken and that RF signals are coming in. A "high" (or about +5V) means that the SQ is set and no signals are coming in. In most other scanners (including the PRO-2022, which will serve herein as the opposite example) use a reversed logic in which a "low" means that the SQ is set, and a "high" means that the SQ is broken. There is a simple EXTENDED DELAY circuit given here for either type of SQ logic.

So far as I am able to determine, the PRO-2004/5/6 are the only scanners using the "SQ Low = Broke" and "SQ High = Set" logic. All other scanners with which I am familiar use opposite logic. The PRO-2004/5/6 use the common TK-10420 FM-IF-DEMULATOR chip like most other scanners, but between that chip (IC-2) and the CPU is a logic NAND chip (IC-3) which inverts the SQ logic before the SQ gate gets to the CPU. Figure 4-29-1 is the EXTENDED DELAY circuit design for the PRO-2004/5/6, and Figure 4-29-2 should meet the needs of the rest. The two circuits are pretty similar, with the latter requiring one extra 74HC00 Quad NAND chip and three more resistors. Nothing major.

External Functions of The Extended Delay: There are three external hardware aspects of the EXTENDED DELAY, though they aren't mandatory and you can leave some (or all) out if desired. But check 'em out before you decide.

Table 4-29-1
PARTS LIST FOR EXTENDED DELAY BOARD - PRO-2004/5/6

<u>Ckt Symbol</u>	<u>Quan</u>	<u>Description</u>	<u>Radio Shack #</u>
C-1	1 ea	Capacitor, 220-uF/16 WVDC	272-956
D-1	1 pkg	LED, T-1 size; choice of colors	276-1622
U-1	1	74HC00 HiSpeed CMOS Quad NAND gate	nonRadio Shack
U-2	1	74HC123 HiSpeed CMOS Dual Multivibrator	nonRadio Shack
R-1,2	2	Resistor, 100-k, 1/4-watt	271-1347
R-3	1	Resistor, 1.5-k, 1/2-watt	271-025
S-1	1	Switch, SPST, submini toggle	275-624
VR-1	* 1	Trimmer pot; 50-k;	*
Misc	1	Perf Board	276-1395
Misc	1 pkg	Standoff Studs	276-195
Misc	2 ft	Shielded Multiconductor Cable (for use as interconnect hookup wire)	278-776
Misc	1 rl	Wire, 30-ga, for wiring on ckt board (Strip & use for point to point wiring only; not as interconnect hookup wire)	278-501,2,3
Misc	1	IC Socket, DIP, 16-pin (for U-2)	276-1998, 1994
Misc	1	IC Socket, DIP, 14-pin (for U-1)	276-1999

* Radio Shack's trimpots cannot be glued inside the front panel, otherwise they are ok for this project: 271-219; 271-283; 271-1605; 271-1716

Figure 4-29-1
SCHEMATIC & WIRING DIAGRAM FOR THE EXTENDED DELAY BOARD - PRO-2004/5/6

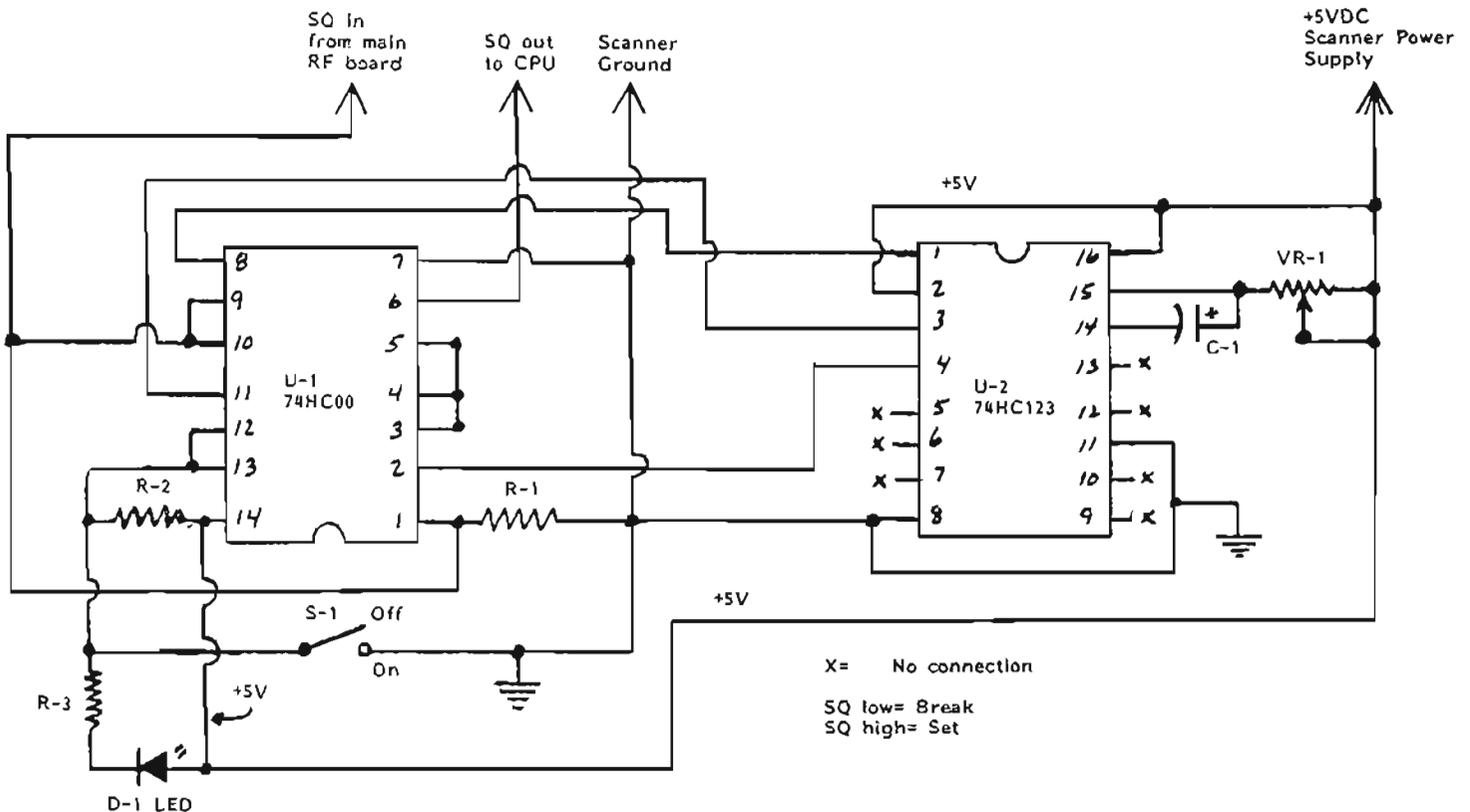
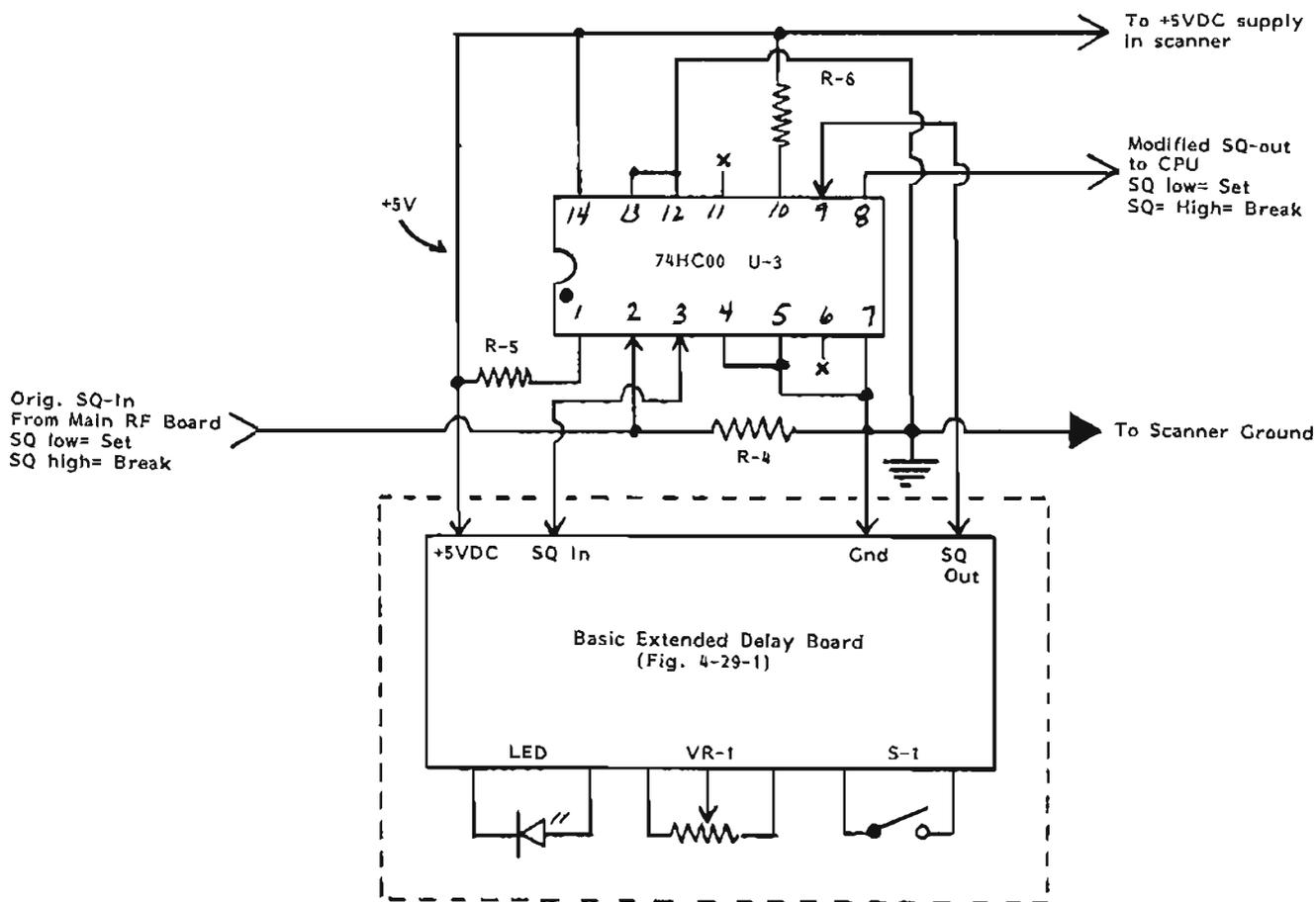


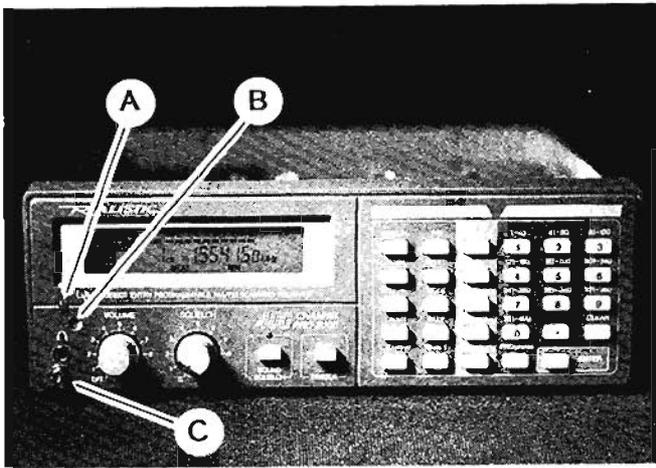
Table 4-29-2
EXTRA PARTS LIST FOR MODIFIED EXTENDED DELAY BOARD
FOR PRO-2022, PRO-34 AND PROBABLY MOST OTHER SCANNERS

<u>Ckt Symbol</u>	<u>Quan</u>	<u>Description</u>	<u>Radio Shack #</u>
U-3	1	74HC00 HiSpeed CMOS Quad NAND gate	nonRadio Shack
R-4,5,6	3	Resistor, 100-k, 1/4-watt	271-1347
Misc	1	IC Socket, DIP, 14-pin (for U-3)	276-1999

Figure 4-29-2
MODIFIED EXTENDED DELAY BOARD
REVERSE SQUELCH LOGIC ADAPTOR FOR THE PRO-2022, PRO-34
AND PROBABLY MOST OTHER SCANNERS



Circuit in dotted lines is that given in Fig. 4-29-1. Do not change it, just add new circuit as shown above dotted lines.



MOD-29: The controls for extended delay are easily mounted inside the front panel of the PRO-2005/6. A= LED; B= Recessed adjustment for extended delay; C= extended delay on/off.

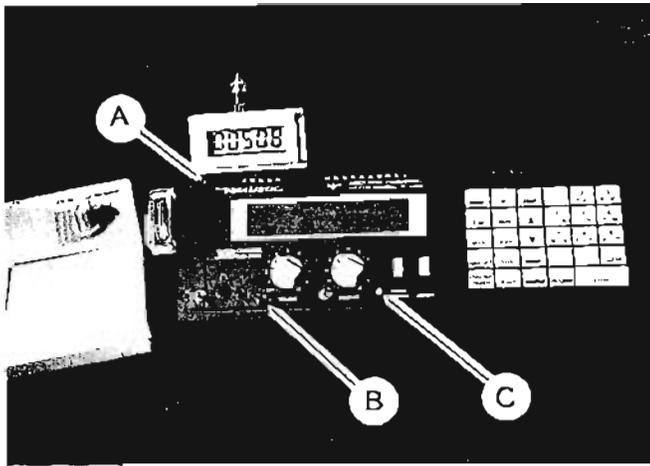
ON/OFF Switch: A simple SPST on/off switch, nice for manual selection between normal scanner DELAY and our EXTENDED DELAY. You can internally wire the EXTENDED DELAY for full time ON if you wish, otherwise a small switch mounted somewhere outside the scanner is required.

ON/OFF Indicator LED: This isn't required, of course, but I dig LED indicators and it's kind of nice to be able to tell from a distance if you've activated the EXTENDED DELAY. If the LED is lit, your EXTENDED DELAY is on duty. It's a simple arrangement, but you can leave it out if you don't want to bother or poke a hole in your scanner for the LED.

Extended Delay Adjustment: Our circuit has the capability for adjustable DELAY (0 to 12+ seconds). There are at least three ways to approach this. One is to install the EXTENDED DELAY adjustment so that you control it from outside the scanner. That's my preference, and I drilled an inconspicuous hole in the front panel, behind which I glued a tiny trimmer potentiometer. I can now use a quick screwdriver adjustment to set my EXTENDED DELAY for any delay I want. The second approach is to install a regular pot with an adjustment shaft that sticks out either from either the front or rear panels of the scanner. This also permits quick access for adjusting the delay interval. The third approach is to install a small trimmer pot right on the EXTENDED DELAY circuit board, presetting it for whatever delay time suits you-- and then forgetting about having external control.

Planning & Calculating: Therefore, you'll want to think about what controls and indicators (if any) you want to be external to the scanner for easy access. Personally, I like the ability to have this external control-- but maybe you don't think much of that idea for yourself. Now is the time to decide. What follows are some ideas on the elbow room in various scanners to help you make up your mind.

PRO-2004: There's loads of space inside front and rear panels of the PRO-2004. Your main consideration is to think and plan ahead for other mods that will also need to be externally controlled. So, you'll want to use up no more space than necessary, and work from the most inaccessible places first (to make it easier to add other things later on. For the Indicator LED of the EXTENDED DELAY circuit, I suggest the upper-left corner of the faceplate, left of the vertical groove that runs up/down the left side of the faceplate, and up the flat "picture frame" rim that encircles the entire front panel. It will easily accommodate a T-1 size LED. For the circuit's ON/OFF switch, I like a spot on the lower front panel about 1/3" to the left of the "Squelch" logo, and more or less centered between the 0 and the 1 of the SQUELCH calibration increments. For the EXTENDED DELAY adjust, I drilled



MOD-29: Plenty of room inside the PRO-2004's front panel for extended delay controls, plus other functions, too! A= extended delay LED; B= extended delay on/off; C= recessed adjustment for extended delay.

a 3/16" hole exactly halfway between the SQUELCH's "10" increment and the word "Sound" of the "Sound Squelch" logo, behind which I glued a 50K mini trimmer pot offering a screw-slot adjustment.

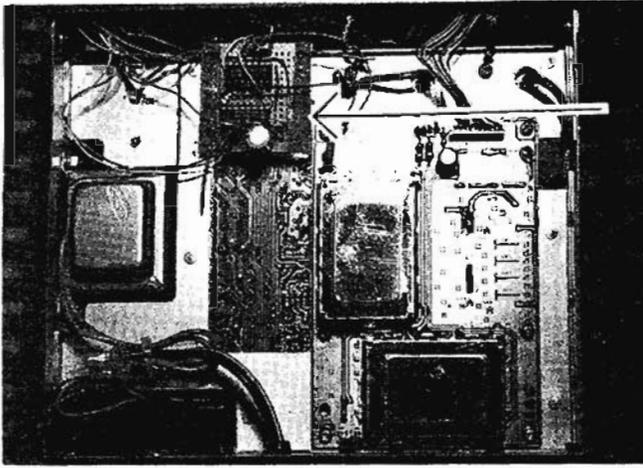
By the way, nothing needs to be removed from inside the front panel to access the points I've described. Just unplug the scanner from its power source, remove the two countersunk machine screws from the sides of the front panel to allow the panel to swing down for easy inspection and work. Don't remove the bottom two screws unless you just absolutely want to. Leaving them in permits the panel to remain attached to the chassis and makes it less likely anything can become damaged. Incidentally, the rear metal chassis panel also has plenty of installation space.

PRO-2005/6: These sets are less spacious than the PRO-2004. Yes, there's ample space on the front panel, but you must remove the Logic/CPU Board to make use of that space. If you don't know how to do that, see MOD-16 in the Review Chapter, or see MOD-27, where detailed instructions are provided.

A word to the wise for PRO-2005/6 hackers-- it's even more important for you to plan ahead for future mods on the front/rear panels since you have less space in which to work, and what there is must be gotten to with more difficulty than PRO-2004 owners. It's an easy trap to fall into to start off with a couple of easy mods, and take up too much room with your workmanship. Then, a month later when you've gotten some experience and enthusiasm, plus a taste for getting into some more complex mods, you look at your scanner and realize that you haven't left enough room for a flea to do a fandango. So, don't make any planning mistakes now that will cost you later.

Areas to consider include the vertical groove that divides the Keyboard and Display areas of the faceplate. Also the horizontal groove dividing the Display and Control areas. There's also the area just above/below the Headphone jack, plus the area between the VOLUME and SQUELCH controls. The thin areas just left of and also above the Display window might also offer some installation room. The Keyboard side of the front panel is a lost cause, so keep out of there. The rear metal chassis has a fair amount of space, but do some planning because what's there is squandered and used up all too easily.

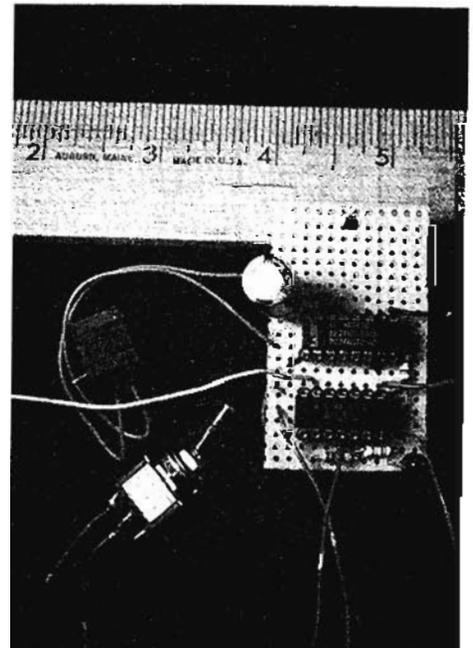
PRO-2022: I haven't worked on a PRO-2022 recently, so the area in back of the front panel isn't fresh in my memory. I can't offer concise suggestions here as with the PRO-2004/5/6, which I can describe in detail with both eyes shut and one



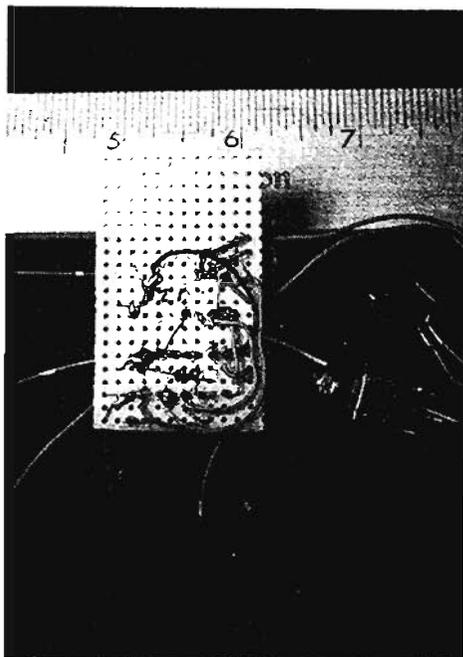
MOD-29: The EDB shown inside a PRO-2005/6. The arrow (top center) shows exact location.

hand tied behind my back. Still, if you read my thoughts on the PRO-2004/5/6, it should give you a "feel" for what to look for and what to do. Most likely, the Keyboard side won't offer any prospects. If you unplug the scanner from its power source and then (carefully, please) remove whatever board lurks behind the Display and Control area, you'll probably find lots of work area. You might even find room around the edges of that board without ever having to remove it (as with the PRO-2004). Mostly, you're on your own, but I've given you a couple of hints I hope will help. Also see further info I'll provide on PRO-2022 hookups.

Other Scanners: As with the PRO-2022, I can't give you more than generalities for lack of detailed memory on their physical layouts. I do recall that the old PRO-2002 has almost enough space to hide a cop on a big Harley behind its front panel, but I can't give you the finer details. Still, read what I had to say about the PRO-2004/5/6 and the PRO-2022 and you may find some kernels of information and guidance. Also see the hookup info for the PRO-2022.



MOD-29: Component side of the EDB.



MOD-29: Solder side of the EDB

Getting Started

PRO-2004/5/6: Review Table 4-29-1 and Figure 4-29-1 to become familiar with the project. In addition to the parts, you'll also need hand tools, soldering equipment, and the ever popular service manual for your scanner. And may the Cosmic Cudgel thrash you severely about the head and shoulders should you dare attempt this mod without benefit of your scanner's service manual.

Most Other Scanners (Including PRO-2022): Review Tables 4-29-1 and 4-29-2, and Figures 4-29-1 and 4-29-2 to become familiar with the project. In addition to the parts, you'll also require basic electronic hand tools, soldering gear, and your scanner's service manual. Don't dare let me catch you trying this mod without having your scanner's service manual.

Steps of Procedure (All Scanners): Use Radio Shack's Multiconductor Shielded Cable (#278-776) for **all** interconnect hookup wire requirements in this mod. Use bare 30-ga. single strand wire for point-to-point connections on the board itself.

1. Regardless of what type of scanner you have, start by fabricating the basic EXTENDED DELAY circuit board (Table 4-29-1 and Figure 4-29-1). If your scanner isn't a PRO-2004/5/6, leave room on the board for a second logic NAND chip and the extra resistors, which can be added after the following test procedure.

Leave out D-1 and R-3 if you aren't going to install the LED Indicator. Install VR-1 in the form of a mini trimpot directly to the basic EXTENDED DELAY Board if you do **not** want an external Delay Adjust. Omit R-2 and S-1 and run a jumper from U-1 Pins 12 and 13 to board ground if you want the EXTENDED DELAY to be ON all the time without any external control.

When you cut the perf board to size, give a thought as to how you will later mount the board inside the scanner. Why not seriously consider a standoff stud? If you like that idea, leave a bit of room at one end of the board for a screw hole to accommodate the stud. Another good method is to solder a stout, solid copper wire (#18 ga. or so) to the board's ground trace. Later this copper wire can be soldered

to the metal sidewall of the chassis somewhere inside the scanner. Select your mounting location inside the scanner with a little forethought and future planning for other mods in mind. This is good advice, please regard it as such.

2. When the basic EXTRA DELAY Board (EDB) is completed, solder four wires about 8-10" long, one each to the EDB as follows: Board ground; SQ Input; +5V power; SQ Output.

You will also need two wires for the LED Indicator (if used), and two wires for the ON/OFF Switch (if used). Two more wires will be needed to run the EXTENDED DELAY ADJUST trimmer pot if it is to be mounted somewhere for easy access.

3. You should first test the basic EDB Board before installing it in your scanner. Testing is easy if you have a source of +5VDC power and some sort of a voltmeter. You could make a convenient test power supply by connecting three flashlight batteries in series-- the 4.5V you get should be OK. The idea is to first test the EDB Board independently of the scanner. Here's how it's done:

3-A. Preliminary Test (All Scanners): Whether or not you're going to use the final design, now (temporarily) connect S-1, D-1, and VR-1 to the EDB as shown in 4-29-1, and as discussed in Step 2.

3-B. Connect the ground wire of the EDB to the negative (-) side of the test power supply. Connect the +5V power wire on the EDB to the positive (+) side of the test supply.

3-C. Close S-1 (ON), and ensure that the LED lights up. If not, find out why and then correct the problem before proceeding.

3-D. Normal Delay Function Test. Open S-1 (OFF); LED should go out. Temporarily connect one end of a resistor (approximately 4K to 10K ohms) to the (+) lead of the power supply. Connect the other end of that resistor to the SQ **Input** wire on the EDB. This will be the wire that goes to U-1's Pins 1, 9, and 10. Attach the (-) lead of the voltmeter to the EDB ground and the (+) lead of the meter to the SQ **Output** wire of the EDB (which connects to U-1's Pin 6). The meter should be showing you about a steady 4V to 5V. This simulates a Squelch Set condition as if no signals were present. These connections can be made quick and simple by using alligator clips (Radio Shack #278-1156 or 278-1157, or equivalent).

3-E. Keep S-1 open (OFF) and remove one leg of the resistor attached in Step 3-D while you observe the results on the meter. It should instantly drop to 0 volts, steady. This simulates a Squelch Break condition as if a transmitter were keyed.

3-F. Now, reattach the resistor and watch the reading on the meter. It should instantly go back to 4V-5V. This simulates the Squelch Set condition again, as if the transmitter had just unkeyed.

This completes the test of the **NORMAL** DELAY mode. In this mode, the scanner's delay will function as normal. The basic EDB merely passed the SQ signals without any extra delay. If everything was normal, move on to Step 3-G. If not normal, troubleshoot and remedy the problem before proceeding.

3-G. Extended Delay Function Test. Close S-1 (ON); LED should light. Preset VR-1 to about the middle of its adjustment range. Make sure the voltmeter is still attached to ground and to the SQ **Output** of the EDB. Make sure the resistor is still attached to the SQ **Input** and to the (+) side of the test power supply. The

meter condition should read approximately 4V to 5V, steady. This simulates a Squelch Set condition as if no signals present.

3-H. Keep S-1 closed (ON) and remove one leg of the resistor attached in Steps D and G. Observe the action of the meter, which should **instantly** read 0 volts, steady. This simulates a Squelch Break as if a transmitter were keyed.

3-I. Now, reattach the resistor and watch the meter reading, which should remain at approximately 0 volts for a few seconds (depending on the setting of VR-1). Keep watching the meter, and within about 4-10 seconds, the meter should suddenly jump to 4-5V and remain steady. This simulates the Squelch Set condition again, but as if the transmitter had just unkeyed. The EXTENDED DELAY should now be obvious because the meter remained at 0 volts for a few seconds and then suddenly jumped back to 4-5V. In actual use, the scanner's CPU will not restart the SCAN or SEARCH modes until the SQ signal goes back to a "high" (4-5V) condition.

3-J. Repeat Steps 3-G, 3- H, and 3-I several times, but with different VR-1 settings. Observe different time delays in Step I before the meter goes back to 4-5V. With VR-1 set to maximum rotation in one direction, the EXTENDED DELAY will be zero. At the other extreme end of VR-1's rotation, the EXTENDED DELAY will be 10 seconds or longer.

3-K. Before concluding this test, preset VR-1 so that the EXTENDED DELAY is about four seconds. This should be a good starting point for when the EDB is installed in the scanner. If everything working OK, proceed to Step 4. If not, troubleshoot and remedy the problem before proceeding.

4. Only after the basic EDB has passed all tests up to Step 3-K, unplug your scanner from the power lines and tear it down to a convenient working status. Install the LED Indicator (D-1), the switch (S-1), and DELAY Adjust (VR-1) in the scanner per your pre-planning. The LED Indicator can be cemented into place, but then it's more or less permanent. Maybe a better approach would be to use some clear fingernail polish to help it stay stuck, but still allow its later removal, if desired. If you have opted for no external indicators or controls, then prepare the EDB accordingly as discussed in Step 1.

5. Scrutinize the innards of your scanner for a convenient mounting location for the EDB, although you should have pretty much settled on a mounting location back in Step 1. Mount the EDB inside the scanner at a location of your choice. Wire length isn't important here, but a good, firm mount is important.

6. Connecting the EDB: Connect the two LED Indicator wires to the LED's, if used. The longer lead of an LED is usually the anode.

7. Connect the two switch wires from the EDB to the switch (S-1), if used.

8. Connect the two trimmer wires from the EDB to the trimpot (VR-1) if mounted remotely from the EDB.

9. Connect the ground wire of the EDB to any ground in the scanner, if not already done via the mounting method in Step 5.

10. Perform the following to your particular scanner:

10-A. PRO-2004/5/6: Connect the +5V wire of the EDB to the scanner's +5V power supply at the Output lead of IC-8, the large transistor-like device mounted

on the left-front side of the main scanner board as you look down into the top (facing the front of the scanner). IC-8 is well marked, so don't confuse it with Q-32 located right next to it. The Output lead of IC-8 is the lead farthest away from the front panel, and closest to Q-32. Now, solder the +5V wire from the EDB to the Output of IC-8.

10-B. PRO-2022: First, complete your EXTENDED BOARD by adding the second logic NAND chip (U-3) and the three extra resistors. Use Table 4-29-2 and Figure 4-29-2 to assist in the completion of your board. Then, connect the +5V wire of the EDB to the scanner's +5V power supply, which is the Output of IC-5. IC-5 is the large transistor-like device mounted on the left rear area of the scanner board as you look down from the top (facing the front of the scanner). The Output lead is the left one of three as IC-5 is viewed from the front of the scanner. There are what appear to be two convenient hookup spots. One is the anode of D-35, just to the left of D-35 (just to the left of IC-5); or there is a jumper strap just in front of the Output lead of IC-5 that runs toward the front panel for about an inch. Either point is the scanner's main +5V supply.

10-C. Other Scanners: If your scanner's SQ logic is SQ Low = Broken / SQ High = Set, then your basic EXTENDED DELAY board will be fine without the extra logic NAND chip and resistors. Your EDB should remain as shown in Figure 4-29-1. Connect the +5V wire of the basic EDB to the scanner's +5V power supply. You can proceed to Step 11.

If your scanner's SQ logic is SQ Low = Set / SQ High = Broken, then complete your EXTENDED DELAY board by adding the second logic NAND chip (U-3) and the extra resistors per Table 4-29-2 and Figure 4-29-2. Connect the +5V wire of the basic EDB to the scanner's +5V power supply. Proceed to Step 11.

Although you're somewhat on your own, your service manual should provide you with information on locating the +5V source in your particular scanner. Just make certain it's the **main** source, and not a light duty memory retention +5V supply.

11. Now it's time for the final two connections, SQ-In and SQ-Out:

11-A. PRO-2004:

11-A-1. Locate the CPU Board on the bottom side of the scanner. Identify connector CN-504 there, it's the one with fifteen wires. Now identify Pin 9 (white) (the pins are marked down on the board). Pin 3 is a ground wire and should be colored black. Knowing Pin 3, even though you have to trace it around until you find it going to ground, will make it easy to determine Pin 9.

11-A-2. Cut Pin 9's wire about midway between CN-504 and where it ties to the Main RF Board. Unravel both ends of that wire from the bundle of fourteen other wires until both ends hang loose and free. Strip about $\frac{1}{2}$ " of insulation from each exposed end and tin those ends with solder.

11-A-3. Route the two SQ-In and SQ-Out wires from the EDB to this area, and splice the wire that comes from CN-504 to the SQ-Out wire to the EDB. Insulate this splice with heat shrink tubing or cellophane tape. Never use black electrical tape for insulations.

11-A-4. Splice the cut wire at Pin 9 that comes from the Main RF Board to the SQ-In wire from the EDB. Again, insulate this splice as above. Proceed to Step 12.

11-B. PRO-2005/6:

11-B-1. Locate the Logic/CPU Board on the scanner's inside front panel and identify the bundle of fifteen wires that goes from there to connector CN-3 on the main scanner board. Now identify CN-3's Pin 5. Pins 1 and 15 are marked on the main circuit board. Pin 3 is a (black colored) ground wire. Pin 5's wire is red, but color codes have been known to change, and there's another red wire at Pin 14-- so be sure you actually identify Pin 5.

11-B-2. Cut the Pin 5 wire midway between CN-3 and where it ties to the Logic/CPU Board. Unravel both ends of that wire from the bundle of fourteen other wires until both ends hang loose and free. Strip about $\frac{1}{4}$ " of insulation from each exposed end and tin those ends with solder.

11-B-3. Route the two wires (SQ-In and SQ-Out) from the EDB to this area, and splice the wire that comes from CN-3 to the SQ-In wire to the EDB. Insulate the splice with heat shrink tubing or cellophane tape. Never use black electrical tape for insulating connections and splices.

11-B-4. Splice the cut wire #5 that goes to the Logic/CPU Board to the SQ-Out wire from the EDB. Insulate the splice as described above. Proceed to Step 12.

11-C. PRO-2022/PRO-34:

11-C-1. The PRO-2022/PRO-34 generates an SQ Low = Set / SQ High = Broken signal at IC-1's Pin 13. This signal is directly coupled to the CPU Pin 16 via R-156 and R-189. This means that a "high" logic signal (roughly +5V) tells the PRO-2022 that SQ has a break and a signal is coming in. A "low" logic signal from IC-1's Pin 13 tells the CPU that SQ is Set and no signals are coming in.

11-C-2. Connection of your modified EDB needs some forethought and planning, but this should get you rolling. Locate IC-1's Pin 13 and Resistor R-156. Lift the end of R-156 that ties to IC-1's Pin 13. The loose end of R-156 will go to the new SQ-Out on your modified EDB. The spot from which one end of R-156 was lifted will go to the new SQ-In on your modified EDB. R-156 appears to be a "tiny chip resistor." If so, just remove it and replace it with a normal 10K type with leads. Solder one end of the 10K resistor to the trace that goes toward the CPU's Pin 16. The free end of the 10K resistor goes to the new SQ-Out on your modified EDB, and the new SQ-In of your modified EDB goes back to the point where the trace runs to IC-1's Pin 13. When the two connections are made, go to Step 12.

11-D. Other Scanners: Locate the pin on the CPU that has the SQ gate input. Follow that trace away from the CPU pin a short way until you can find a point to cut that trace. The cut end leading to the CPU will be connected to the SQ-Out of the EDB; the other cut end goes to the EDB's SQ-In. When the two connections are made, go to Step 12.

12. Inspect your work for a clean, error-free installation. Route and bundle all interconnecting wires into a neat, out of the way configuration. Insulate all exposed splices and bare wires.

13. Final Testing & Initial Operation: Turn the scanner on and make basic operational performance tests, Ensure that everything works properly. Turn S-1 on and off (then leave it off) to make sure the LED Indicator works. Troubleshoot and remedy any problems that appear.

14. Test the scanner's normal DELAY ON/OFF mode (with S-1 off). Troubleshoot and remedy any problems that appear.

15. Turn S-1 on and test EXTENDED DELAY. Start a SCAN or SEARCH function and momentarily turn the SQUELCH control down until the SQUELCH "breaks." Then reset SQUELCH. SCAN or SEARCH should not resume until the preadjusted EXTENDED DELAY interval has transpired.

Comment & Wrap-Up: Incidentally, the EXTENDED DELAY function works in series with the scanner's normal DELAY function. So, if you have the EXTENDED DELAY set up to 4-seconds, and if the scanner's normal DELAY is 2-seconds, then the total DELAY will be 6-seconds. Of course, you can press the scanner's DELAY button to cancel that feature any time, and you can switch S-1 off to cancel the EXTENDED DELAY at any time.

Too lengthy an EXTENDED DELAY interval wears out its welcome in short order. One reasonable method of operation is to adjust the EXTENDED DELAY for about 2 seconds, and then leave the scanner's normal DELAY off for all channels except those special ones for which you might want a longer delay. You'll develop your own styles and preferred methods as you use this feature.

Special Notes & Considerations

PRO-2004/5/6: There's a little peculiarity associated with these scanners when the SOUND SQUELCH is used simultaneously with the EXTENDED DELAY. I won't bother to delve into it here, because you'll notice it and quickly become accustomed to it. It's not the result of any error on your part, and there are times you may even find it a bit useful. Of course, at other times you may find it annoying, but I haven't yet figured out anything that can be done about it. So, it's a matter of learning to live with it, or else not using the SOUND SQUELCH when the EXTENDED DELAY is functioning. At least for the time being, and maybe forever.

All Radio Shack Realistic Scanners Except PRO-2004/5/6: Locate a TK-10420 chip or its equivalent. Cut the trace anywhere convenient between Pin 13 and the CPU to insert the EXTENDED DELAY board. The SQ logic is probably similar to that described here for the PRO-2022.

Uniden BC-200/205XLT: Locate the output of the "IF Unit" and cut the appropriate circuit trace. Anywhere between the SQ-Out of the IF Unit and the junction of D-6 and R-24 is the line to cut for insertion of the EXTENDED DELAY board. This unit will require the Modified EDB and uses inverted SQ logic.

Uniden BC-760/950XLT: Locate D-15. Somewhere between the anode of D-15 and the input to the CPU (Pin 2) may be the line to cut for insertion of the EDB. The SQ logic is uncertain and will have to be determined. Your voltmeter placed at the anode of D-15 while the SQUELCH is rotated back and forth will tell for sure which version of the EDB is appropriate.

Regency HX-1000: Locate U-201's Pin 13. Cut the trace somewhere between U-201's Pin 13 and the CPU (U-401). A handy spot might be at a connector, P-203. The SQ logic is probably similar to that explained for the PRO-2022.

If you are aren't sure, I'll be pleased to try to offer suggestions to help you locate the Squelch Logic circuit trace to be cut for the EDB. But you must have the set's service manual, and (if I don't already have a copy of my own) you'll have to supply me with either a complete copy of that manual, or (at the very least) a complete schematic diagram. Send it to me, along with the required SASE and extra loose stamp (only) at the address provided in HINT-1. I'll try to get back to you as promptly as possible.

Adding an Event Counter to Your Scanner

PRELIMINARY DISCUSSION

Have you ever wondered if a certain frequency was busy enough to warrant being added to the program memory of your scanner? Or have you wondered how much activity took place within a given SEARCH band? A tape recorder would let you know, but sometimes it's too much effort to hook one up, much less spend an hour auditioning the tape later to take count. We often wonder about frequency activity and traffic density, but realize that it requires a lot of time and effort to come up with hard data. Rejoice: there's a easy hands-off way to monitor the relative activity of any channel you're scanning, or band you're searching.

Like, all you need do is push a button to reset this little gizmo to zero, then go about your business while it counts every transmission that takes place within the scanner's operating status. You could set the thing and then go fishing for a week. When you returned, you'd know how many thousand times there were transmissions on the frequency or band you're surveying-- well, providing that the number isn't higher than 99,999! Set it to do its thing while you're sleeping, working, watching TV, on vacation, or at the beach. All you need is a scanner that has a SQUELCH function, and that includes most scanners.

Down deep inside your scanner there's a circuit that turns the SQUELCH on or off by means of a digital logic circuit. When the SQUELCH (SQ) is properly set, the scanner operates in silence until a signal arrives to open ("break") the SQ. Every time this happens, the SQ breaks and then closes again, is an indicator (by inference) that a transmission took place. Find that circuit and use it for your own purposes, because those clever digital 0's and 1's that operate the SQ will also trigger an external counter module. It's an easy mod requiring only a few parts.

The Event Counter I added to my scanner is ideal for conducting studies and surveys related to channel usage and crowding. I used mine and among the things I learned was that in one 24-hour period, one of my local police frequencies accommodated 7,200 transmissions (an average of one transmission every twelve seconds)!

Adding a Transmission/Event Counter to The PRO-2004/5/6: The heart of our Event Counter is the Radio Shack Electronic Counting Module (#277-302). To make this mod complete, you need an SPST pushbutton switch to reset the counter; a bit of two-conductor wire; a mating plug and jack; one resistor and an "AA" battery to power the module. The current drain in the module is so low that the battery will last for months.

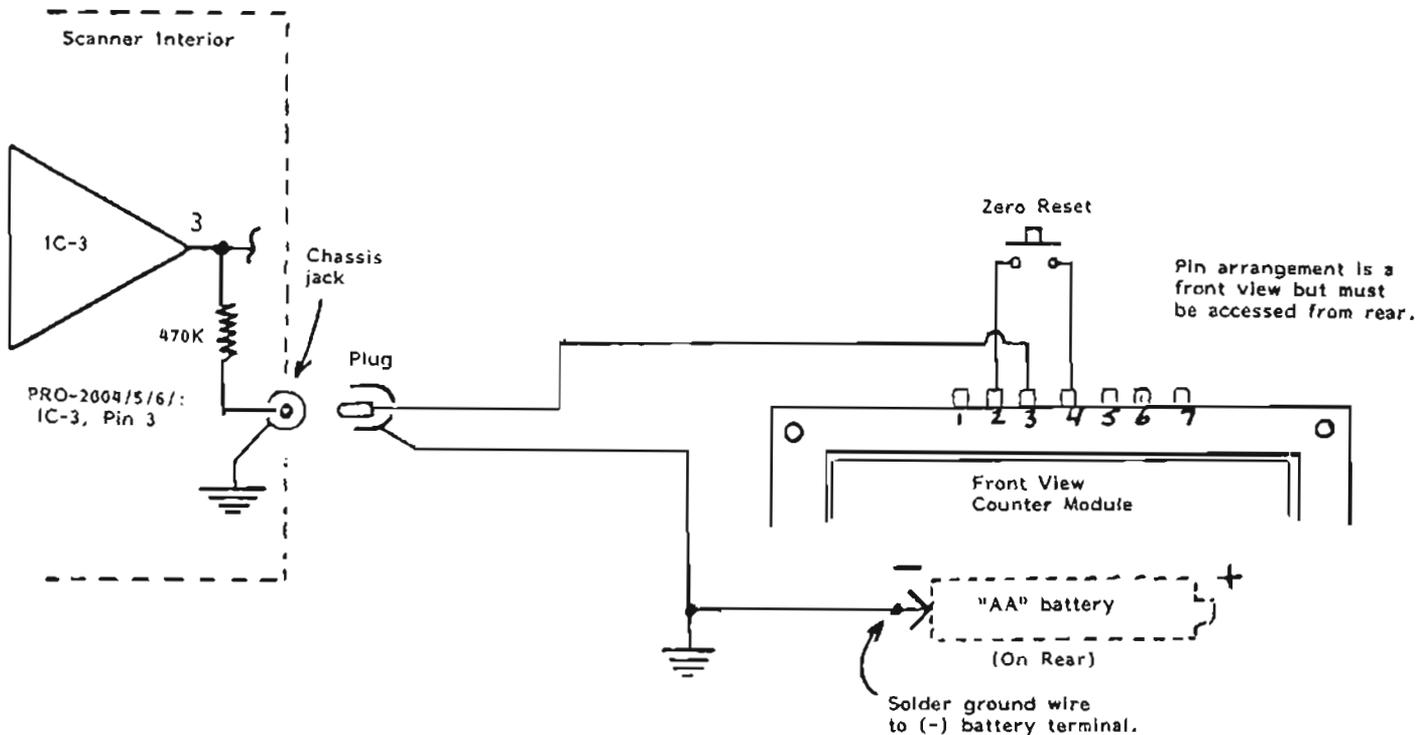
Installation Instructions: Partially disassemble the plastic housing of the Electronic Counting Module to gain access to the seven-pin terminal strip along the top edge of the counter's circuit board. Facing the FRONT of the counter, the pins are numbered from left-to-right, 1 through 7. A set of directions supplied with the module helps clarify this and other matters. In the following steps, Steps 1 through 3-B are for all scanners.

1. Solder the two lugs of the pushbutton switch to module terminals 2 and 4, respectively. The switch lugs may either be soldered directly to the module terminals, or a length of paired wire can be used between the switch and the module-- your option. The Event Counter can be installed in a suitable metal or plastic box for a nicer appearance, or it may be used as is.

TABLE 4-30-1
EVENT COUNTER PARTS LIST

<u>Quan</u>	<u>Description</u>	<u>Radio Shack Catalog #</u>
1	Electronic Counting Module	277-302
1	Push Button SPST Switch, Normally Open:	275-1571 or equivalent
1	"AA" Alkaline Battery	23-552 or 23-582
1	Submini Phone Plug, 3/32"	274-289 or 274-290
1	Submini Phone Jack, 3/32"	274-247 or 274-292
4-ft	approx, small wire, pair; 24 ga	278-1509 or equivalent
1	470-k resistor, 1/4-watt	271-1354

Figure 4-30-1
EVENT COUNTER INTERCONNECTION SCHEMATIC DIAGRAM: PRO-2004/5/6



2. Install the 3/32" sub-mini phone plug on one end of a wire pair. One of the wires goes to the plug's center lug, the other to the ground lug (right now it makes no difference which wire goes to which lug). Slip on the plastic plug shell and screw firmly into place.

3. Solder the other end of the wire pair from the sub-mini phone plug to the module as follows:

3-A. The hot wire (that comes from the center lug of the phone plug) to the module's terminal #3.

3-B. Solder the other wire of the wire pair that comes from the ground lug on the phone plug to the negative (-) battery terminal of the module.

The following steps (#4 to 7) apply to the PRO-2004/5/6:

4. Unplug the scanner from the power line. Remove the case of the PRO-2004, or the top cover of the PRO-2005/6. Drill an appropriately sized hole somewhere on the rear chassis of the scanner and install the sub-mini phone jack. Tighten securely. When you're drilling, wrap several layers of tape around the end of the drill bit about $\frac{1}{4}$ " in from the end to prevent the bit from suddenly popping through and doing any damage inside the scanner.

5. Locate IC-3 (identical in PRO-2004/5/6), then identify Pin 1. Trim all but about $\frac{1}{4}$ " from each lead of the 470K resistor. Solder one end of the resistor directly to IC-3, Pin 1. Solder a length of hookup wire to the free end of the 470K resistor.

6. Solder the other end of the hookup wire to the hot lug of the 3/32" sub-mini phone jack installed in Step 4. A ground connection isn't necessary.

7. Insert the 3/32" sub-mini phone plug into the mating jack on the rear chassis of the PRO-2004/5/6 and operate the scanner as usual. Every time the SQ closes after a break, the Event Counter will increment by one, thereby giving an indication of how many transmissions occurred since the last RESET. Press the pushbutton switch on the Event Counter as needed to RESET the count to zero.

A schematic of the internal circuitry and connections in the PRO-2004/5/6 is provided in Figure 4-30-1, together with a schematic of the necessary external hookup.

Other Radio Shack Realistic Brand Scanners: Most Realistic scanners made since the early 1980's use a TK-10420 chip, which is a combination IC containing an Oscillator, Mixer, IF Amplifier, Noise Limiter, and a digital SQ output function. Pin 13 of this IC is suitable for connecting the 470K resistor. Otherwise, the installation will be nearly identical to that described for the PRO-2004/5/6.

Other Scanners: With the aid of a service manual for any particular set, you should be able to locate the chip or signal point that has a high/low signal to turn the SQ on or off. Which logic state doesn't really matter, just as long as zero volts (or nearly so) is one level, and somewhere between +4V and +7V is the other level. Every scanner has a CPU chip that has a pin for input of this SQ logic gate, so look for the SQuelch, or Scan Control pin on the CPU, and then follow it back to some point where you can tap for an output to the Event Counter.

Use a simple voltmeter to determine this signal as you rotate the SQ control back and forth. Once you locate the proper signal point, build the external portions of the counter module as described above. Then start with the 470K resistor as described. The precise value may have to be changed, depending upon factors that there's little reason to fully expound upon here, but as high as 1-meg ohm might have to be used-- or as low as 100K. Maybe your best bet would be to start with a 1-meg ohm potentiometer and adjust it for proper triggering of the module as you rotate the SQ control back and forth. Then measure the resistance at the point where the pot is adjusted and select a fixed resistor close to that value.

The trigger voltage should **not** be higher than the battery voltage, i.e. +1.5V-- and even a little less (0.5V to 1.0V) will do nicely. The purpose of the resistor is to drop the +4V to +7V trigger signal down to a useful level, as described.

Using the Event Counter: Little needs to be said since you'll immediately understand the entire scenario of counting transmissions as soon as you put this gadget to work for you. One thing worth mentioning is that the counter can't tell the difference between noise bursts and real transmissions. It will increment the count by one every time the SQ closes after a break. So, if you set your SQ right at its threshold point, then you'll probably pick up more false counts than you either need or want. To avoid this, just set the SQ a little beyond the critical cutoff point. Signals will still trigger the SQ normally, but noise bursts will be minimized.

MOD-31

CTCSS Decoders For The PRO-2004/5/6 & Other Scanners

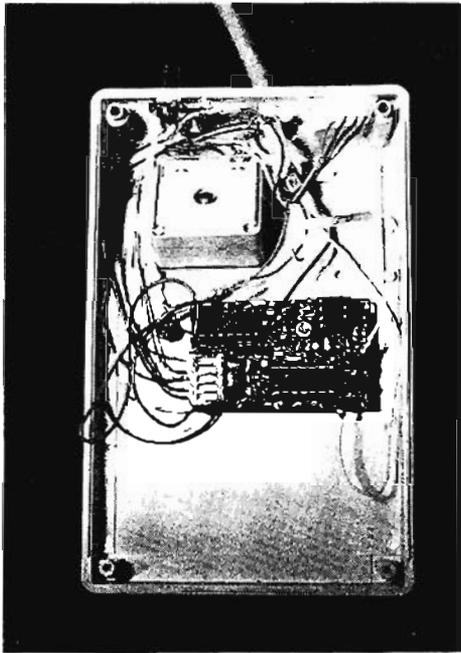
INTRODUCTION TO CTCSS

Continuous Tone Code Squelch System (CTCSS) is the generic term of a controversial but necessary feature in modern FM and repeater equipment. CTCSS may be better known to you as "PL" (Private Line), which is a Motorola Company trademark. So the buzz terms you may hear will include "CTCSS tones" and "PL tones." CTCSS has two purposes in communications systems, one of which is of direct interest to you, as a scanner user. We'll discuss this use.

The CTCSS concept is rather easy to understand. A transmitter equipped with a CTCSS Tone Encoder activates one of 32 standard subaudible tones when it begins transmitting, and continues to send out that tone for the duration, along with the normal speech. The receiver (and most scanners) doesn't reproduce this tone because all 32 CTCSS tones are below the bandpass of the audio section of the receiver. Other circuits within the receiver may readily detect and subsequently react to one of those tones, but the limited audio bandpass ignores them, therefore they aren't reproduced in the loudspeaker. Very convenient!

A designated receiver is (or system of receivers are) equipped with a CTCSS Tone Decoder at the detector, which is interfaced to the squelch and low level audio circuits. When the CTCSS function is turned on at the receiver, the squelch (SQ) will appear to be remain set (unbroken) until the proper tone comes in. At that time, the SQ appears to "break" (open) so normal speech can be received. If no CTCSS tone is present (or an incorrect one), the receiver remains muted and doesn't reproduce other signals. The CTCSS Tone Decoder blocks the receiver audio until the proper one is decoded. At first glance, this is a distinct liability to the general scannist and monitoring buff, because usually we want to hear everything that goes out there in Radioland.

The CTCSS concept is, for example, that a business with a fleet of mobile units doesn't want its drivers distracted or confused by the dispatching or conversation of other individuals and businesses locally using that same frequency. The CTCSS is a wonder of wonders in such an application. The CTCSS equipped communications system of the XZZ Widget Corp. can share a frequency with the ZXX Pizza Shop, and the widget people don't have to hear about pepperoni, while there's no danger at all that someone waiting for an emergency widget delivery will have a pizza van show up to drop off a large pie because the driver read the wrong dispatcher. Their respective receivers will hear only desired transmissions. When the signals with the proper tone aren't present, the receiver's audio remains muted and the loudspeaker remains silent.



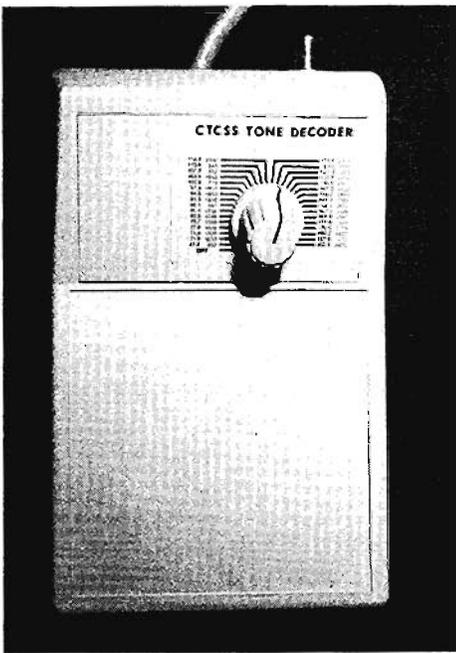
MOD-31: The TS-32P CTCSS tone decoder board and a 33-position special rotary switch can fit neatly into a small project box. Note the umbilical that exists in the box on the left. Just below that exit is a jack for a frequency counter. Extra wires (upper left) are for some future project.

CTCSS can also be used to make repeaters accessible only to authorized users, or to permit mobile units within one system to access any one of that system's several local-area repeaters operating on the same frequency. The input (receive) side of a repeater will not key the repeater (transmit) unless the proper tone accompanies the input signal. Ham radio and business repeater operators have long taken advantage of CTCSS tones to restrict access to their repeaters. Hams who want to access a private ("closed") repeater usually need to join the local repeater club and pay a fee or dues which conveys they right to use the repeater. Businesses typically lease radio systems from professional communications shops that also own and rent on repeater services. A leased system is configured for a unique tone the lessor has assigned only to that business on a particular frequency. So long as the business pays its monthly bills on time, it gets to use the repeater for wide range coverage, and still enjoy the benefits of CTCSS.

The 32 standard subaudible tones have been defined and established by the Electronics Industries Association (EIA). They are shown in Table 4-31-1.

TABLE 4-31-1
EIA STANDARD SUBAUDIBLE CTCSS TONES

<u>Tone No.</u>	<u>Tone Code</u>	<u>Tone Freq (Hz)</u>	<u>Tone No.</u>	<u>Tone Code</u>	<u>Tone Freq (Hz)</u>	<u>Tone No.</u>	<u>Tone Code</u>	<u>Tone Freq (Hz)</u>
1	XZ	67.0	12	1Z	100.0	23	4B	146.2
2	XA	71.9	13	1A	103.5	24	5Z	151.4
3	WA	74.4	14	1B	107.2	25	5A	156.7
4	XB	77.0	15	2Z	110.9	26	5B	162.2
5	SP	79.7	16	2A	114.8	27	6Z	167.9
6	YZ	82.5	17	2B	118.8	28	6A	173.8
7	YA	85.4	18	3Z	123.0	29	6B	179.9
8	YB	88.5	19	3A	127.3	30	7Z	186.2
9	ZZ	91.5	20	3B	131.8	31	7A	192.8
10	ZA	94.8	21	4Z	136.5	32	M1	203.5
11	ZB	97.4	22	4A	141.2			



MOD-31: The CTCSS tone decoder in a box external to the scanner.

The CTCSS tone spectrum extends from 67 Hz to 203.5 Hz. Actually there are a few more tones used for special purposes above 203.5 Hz, but they're rarely used and we haven't included them in this discussion. The audio bandpass of a typical receiver is 300 Hz through 3,000 Hz (3 kHz), so you can see why most of these tones will not be heard in your scanner. Some scanners, especially those with modified audio sections, might pass a few of the higher tones (#26 to #32), in which case some transmissions might be heard to contain a noticeable low-frequency hum. If you hear this in your scanner only on some transmissions and not others, chances are it's a CTCSS tone that's sneaking through.

Certain scannists will be interested in CTCSS at times when it's wanted to monitor only one signal source on an otherwise crowded frequency. If that frequency is allocated for public safety, business, or amateur use, then a CTCSS mod to the scanner will be useful. Here's an example:

A volunteer paramedic wishes to keep a low cost scanner tuned to the county dispatch frequency. Unfortunately, every ambulance corps for miles is also dispatched on that frequency. With more than a dozen ambulance corps throughout a county being dispatched there, the channel is buzzing day and night. The paramedic doesn't want to spend the big bucks for a commercial CTCSS receiver to block out the unrelated transmissions, neither does our paramedic wish to hear the constant chatter, nor turn off the set and miss hearing an urgent call. The way to go is to know only when there's a call for the local ambulance corps, to not know about unrelated calls, and to do it without spending major funds.

A relatively inexpensive, programmable CTCSS Decoder board can readily be installed in the scanner and preset with the CTCSS tone for only the local ambulance corps. Mission accomplished! What about when there's nothing on TV and the paramedic wants to spend the evening monitoring the general traffic on the dispatch channel? No problem! A switch is flipped and the CTCSS option goes into standby mode and all traffic comes through uninhibited.

The serious hobby scannist will also be interested in the CTCSS option for those times when it's desirable to sort through a crowded and busy frequency to

pick out the communications of only one system. There are many times this could happen. Moreover, it's feasible to obtain and install a CTCSS Tone Decoder in almost any scanner that offers a little internal space to accommodate a small circuit board and switch. A CTCSS Decoder can even be installed in an outboard box, interfaced to the scanner with a few simple connections.

Adding a CTCSS Tone Decoder Decoder to a Scanner: I suppose that it would theoretically be possible for a person to fabricate their own programmable CTCSS tone decoder, made from proven design and construction plans. Most likely, it's been done many times by intrepid and experienced projects enthusiasts. Some ham radio suppliers may even offer tone decoders on prefab boards or in packaged units, either of which would have to be interfaced with the scanner, anyway. In either case, it's a moderate cost combined with plenty of work to accomplish. Any plans and designs for scratch-building would also entail considerable effort and expense. These approaches all entail more hunting and working than you need.

There's yet another way, one that minimizes the drudgery and holds down the cost to a manageable level. You can buy a fully assembled, ready to install, programmable CTCSS Tone Decoder module. We found excellent units (Models TS-32P and DCS-23) from Communications Specialists, Inc., 426 West Taft Ave., Orange, CA 92665-4296. Their modules come with fine instructions, including specific installation information for several scanners such as the PRO-2004/5/6, and maybe others. Actually, just about any base station scanner can accommodate one of these decoders. Write to them for more information on the TS-32P and DCS-23.

I found the CSI Model TS-32P to be a small PC board (1¼" X 2") that's loaded with components and ready to use. There's a 5-segment DIP switch mounted on the board for programming any one of the 32 CTCSS tones. Naturally, this would be a bit inconvenient for the serious scannist who needs external control of all things potentially controllable. No problem. The on-board DIP switch can be left with all segments turned off, and another DIP switch just like it can be installed on the scanner's front panel and connected internally via a small cable bundle and wired in parallel with the DIP switch on the CTCSS board. There's an even better option, however! CSI also offers 16 and 33 position binary coded rotary switches that make tone selection as simple as turning a TV or CB channel control knob. The 16-position BCD switch (CSI #40-1017) is less expensive than the 33-position (CSI #BS-1), and when used in conjunction with a toggle switch will still yield all 32 tones! The 33-position BCD switch comes with a knob and calibration decal.

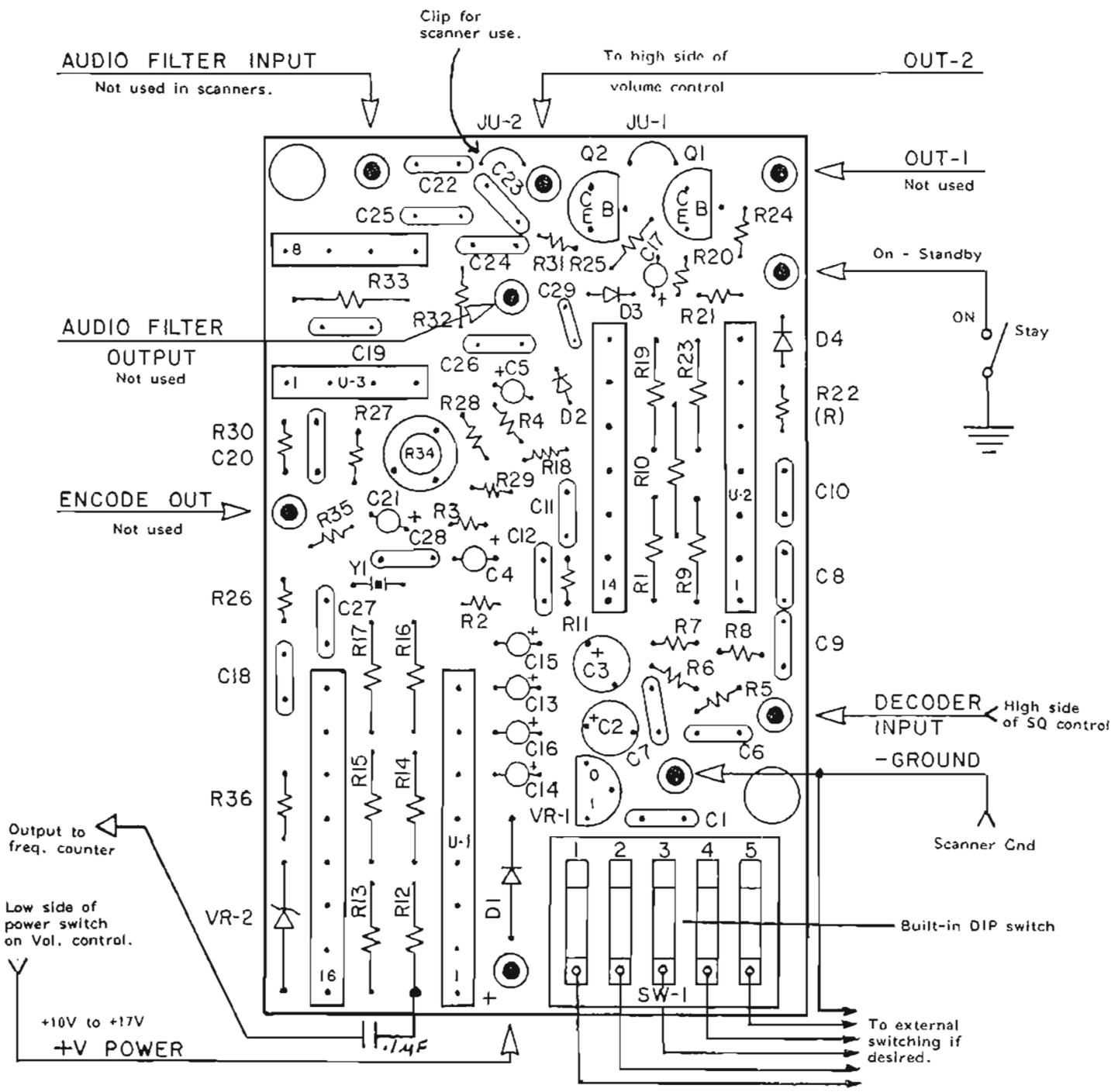
An enlarged mechanical drawing of the CSI Model TS-32P is shown in Figure 4-31-1, which also shows the simple wiring necessary to adapt it to work with most any base scanner. Installation is as simple as any mod in this book, with nary a single wire to snip inside the scanner, and only four wires to hook up plus an SPST switch to activate/deactivate the decoder. Six more wires will be necessary if external programming is desired. CSI's 33-position BCD rotary switch will require eight wires, **but** it also contains a separate internal SPST switch that eliminates the requirement for a separate SPST switch. The BCD rotary switch can probably be mounted in the front panel of some scanners (although not the PRO-2004/5/6, where space is at a premium). The best bet for the PRO-2004 is a complete external installation of the TS-32P and the 33-position switch into a project box. If this isn't desirable, a 5-segment DIP switch can be installed on or around the front panel of the PRO-2004.

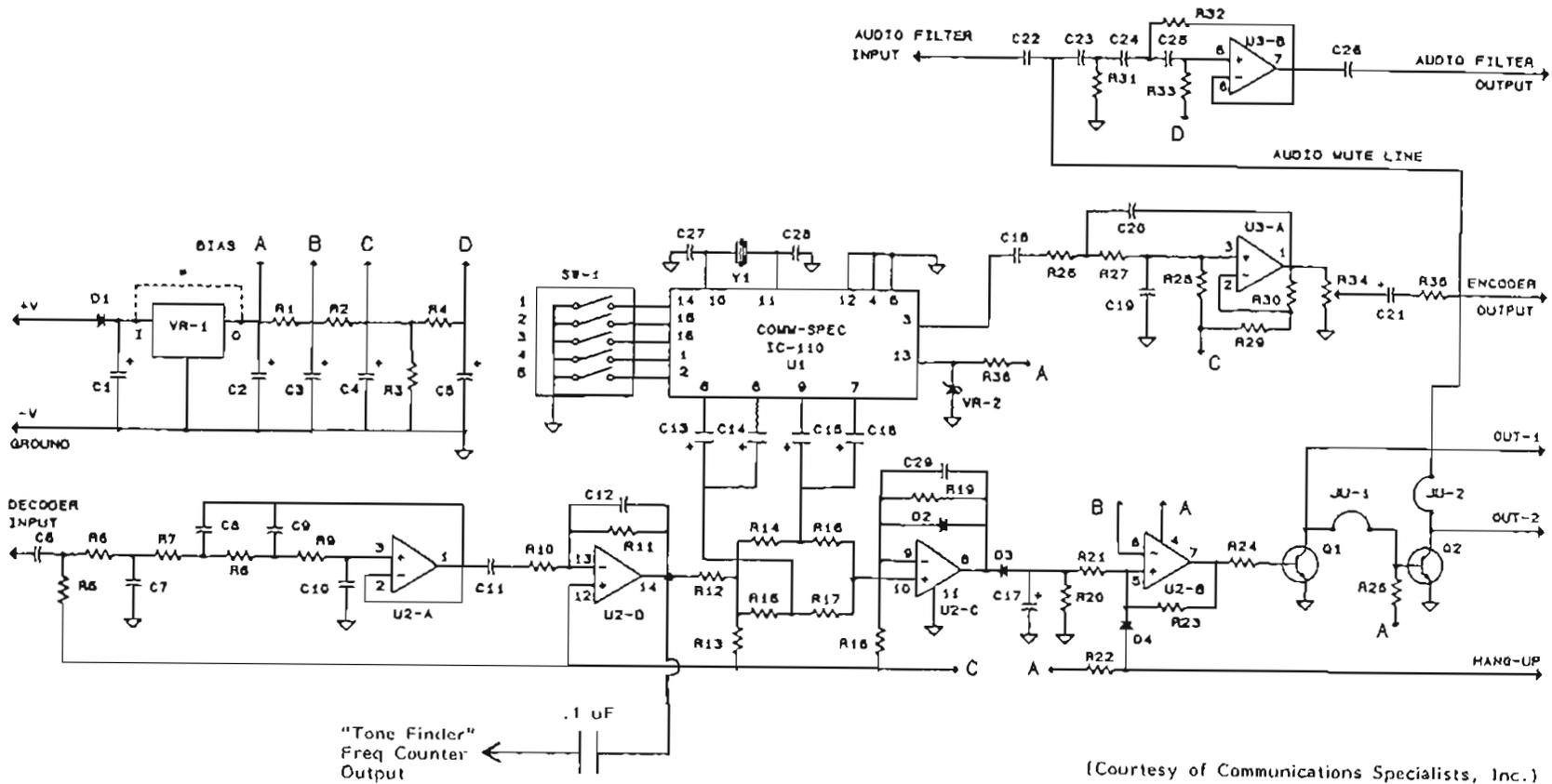
In the case of the PRO-2005/6, the 33-position BCD switch can be mounted on either **side** of the scanner, centered along the middle where the top and bottom covers meet. A small semicircular cutout in the plastic edge over each cover-half will permit permanent installation of the BCD switch and still allow the upper and

Figure 4-31-1
MECHANICAL DRAWING OF THE CSI TS-32P CTCSS TONE ENCODER/DECODER

(Courtesy of Communications Specialists, Inc.)

(Note: This shows PRO-2004/5/6 connections, but may be connected to most other scanners.)





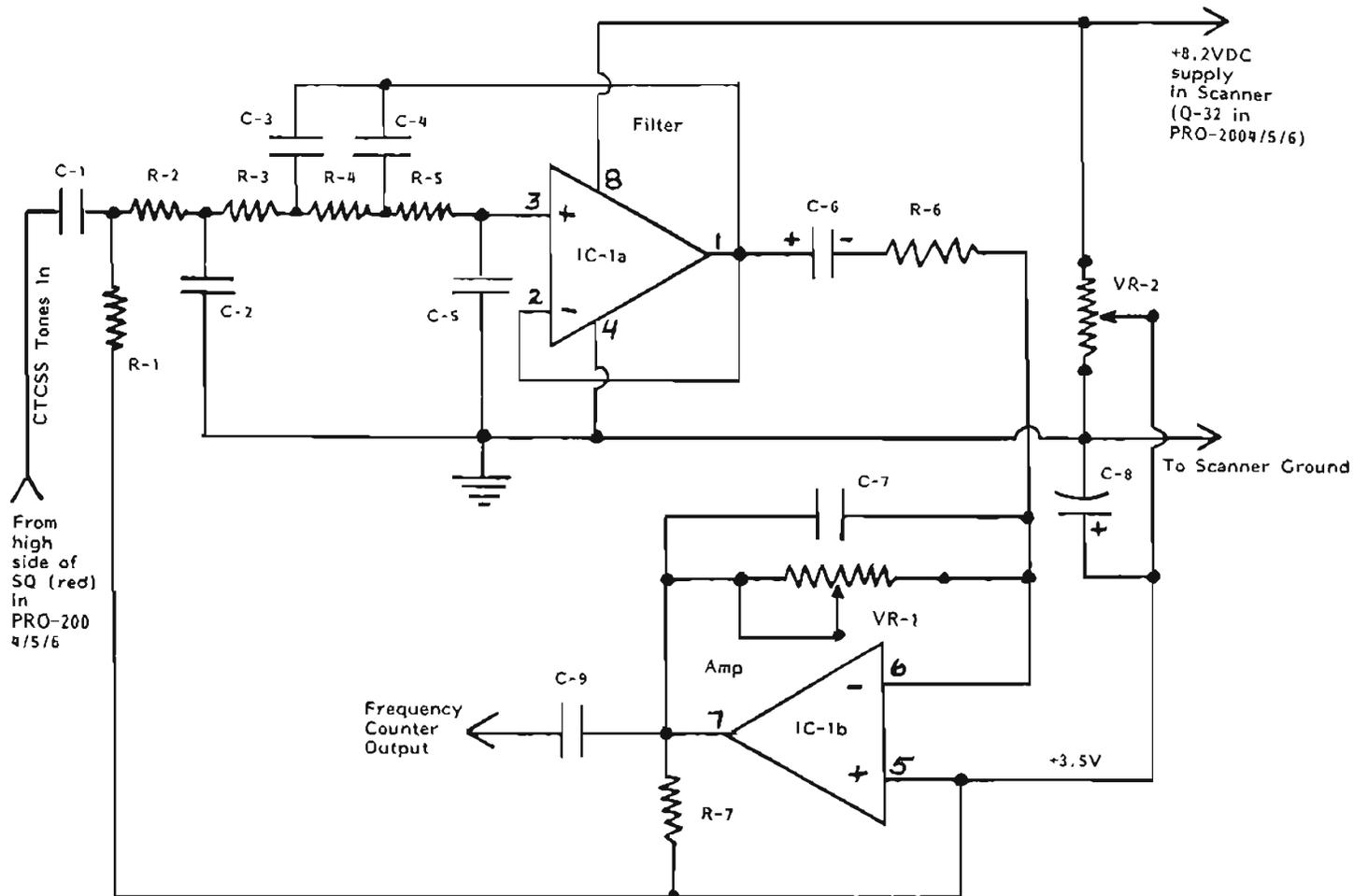
(Courtesy of Communications Specialists, Inc.)

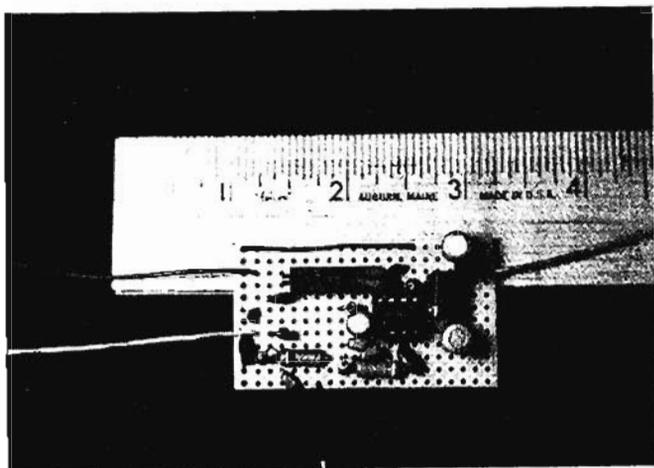
Figure 4-31-2
SCHEMATIC DIAGRAM OF THE CSI TS-32P CTCSS TONE ENCODER/DECODER

Table 4-31-2
PARTS LIST FOR CTCSS TONE BANDPASS FILTER/AMPLIFIER

Ckt Symbol	Description	Radio Shack Catalog #
IC-1	Dual Op Amp, LM-358; Single Supply; 8-pin DIP or Quad Op Amp, LM-324, Single Supply, 14-pin DIP	nonRadio Sh 276-1711
C-1, 9	Capacitor, .01-uF	272-1065
C-2,3,4	Capacitors, 3300-pF (.0033-uF); disk or monolythic	nonRadio Sh
C-5	Capacitor, 220-pF	272-124
C-6	Capacitor, 0.47-uF, Tantalum	272-1433
C-7	Capacitor, 470-pF	272-125
C-8	Capacitor, 10-uF	272-1025
R-1,2	Resistor, 1-meg	271-1356
R-3,5	Resistors, 470-k	271-1354
R-4	Resistor, 560-k	nonRadio Sh
R-6	Resistor, 10-k	271-1335
R-7	Resistor, 150-k	nonRadio Sh
VR-1	Trimmer potentiometer, 1-meg, (Gain Control)	271-229
VR-2	Trimmer potentiometer, 47-k, (Bias Control)	271-283

Figure 4-31-3
SCHEMATIC DIAGRAM FOR CTCSS TONE BANDPASS FILTER/AMPLIFIER





MOD-31: Component side of the CTCSS tone finder filter & amplifier board.

lower covers to be removed for service and maintenance. A 5-segment DIP switch can be installed on the face of the PRO-2005/6 between the LCD Display and the MANUAL key. See the Review Chapter's MOD-16 for specific instructions on a DIP switch option.

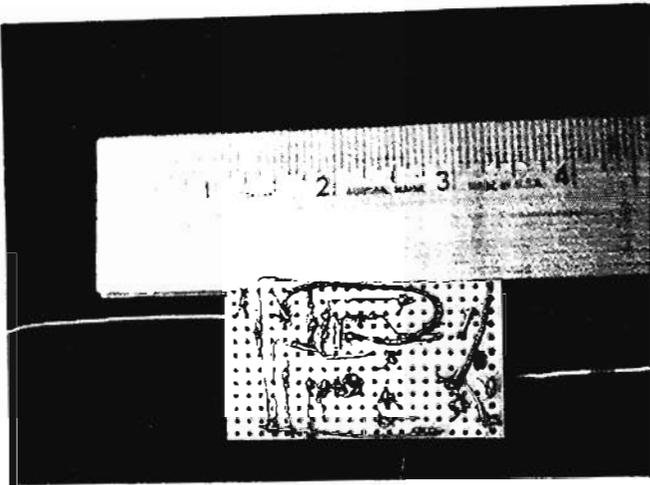
For those with a technical inclination, a schematic of CSI's TS-32P Tone Decoder is given in Figure 4-31-2 (courtesy Communications Specialists, Inc.). The critical IC shown in the schematic was designed by CSI and is proprietary to CSI. As such, it is unique and is available only from CSI and its authorized dealers. One look at the dense electronics of the TS-32P, coupled with its moderate price, is about all the convincing most hackers need to realize that purchase of the finished board is the most prudent approach to acquiring a CTCSS capability.

CSI also offers a Miniature Digital Coded Squelch Encoder-Decoder (their Model DCS-23). It contains a microprocessor that does all the work. The DCS-23 is compatible with digital coded SQ systems regardless of the various proprietary trade names under which these systems are marketed. The DCS-23 is even smaller than the TS-32P.

And, just for the record, Uniden Bearcat scanners BC590/600XLT and BC760/950XLT can be equipped with an optional Uniden CTCSS decoder board accessory that quickly plugs right in to the scanners' main board.

More About CTCSS: The actual decoding of CTCSS tones is only half the job for the serious scannist. The other half of the job is determining which one of the tones to program the Tone Decoder module so it can do its job. Unless you're a volunteer paramedic, volunteer firefighter, or otherwise affiliated with or employed by the agency or company using CTCSS in their radio system, how are you going to know which of the thirty two different tones is used by a given system? One thing's pretty certain, and it's that they're not going to tell you what it is. For one thing, chances are that if you ask someone there they won't even know what you're talking about. Probably the only one there who knows is the communications tech who services the equipment, or someone at the communications shop that leased out the equipment. But even if someone at the agency or company did know, you'd have another guess coming if you thought they'd tell an outsider.

OK, there are several ways to find out. A few scanner directories now include this type of data (where known) for some agencies covered. The least costly and simplest way is to refer to Table 4-31-1 and, by trial and error, rummage through the 32 tones when the target system is noted communicating, and when you hit the right tone, audio will come through. This is time consuming and not much fun.



MOD-31: Solder side of the CTCSS tone finder filter & amplifier board. A frequency counter connected to the output will display a CTCSS tone on a transmission.

The most convenient and effective way is good if you have a relatively unlimited budget. You can purchase an item known as a "CTCSS tone finder," and there are a number of models on the market. This is a piece of professional "service bench" equipment that includes a fairly sophisticated electronic low pass filter and audio amplifier fed into a special frequency counter to display the tone. In order to do its thing, it needs to be connected to the detector of a receiver in order to sample the signal and determine if any CTCSS tones are present. Prices range from \$250 to \$1,000, depending upon the bells and whistles. Another type of tone finder is the AIE TF-1. It consists of a Regency R1070 scanner fitted with a special digital display permanently interfaced to the scanner. The unit connects to an antenna but displays CTCSS tones and codes in the readout. Not real cheap, the TF-1 is available from: Automated Industrial Electronics, 141 Granite St., Batesburg, SC 29006.

Perhaps the most cost effective tone finder exists, in part, right in the CSI TS-32P Tone Decoder module! Look at Figure 4-31-2 and find IC-1, Pin 14. This is the output of an electronic low pass filter/amplifier combo where the voice band and noise above 300 Hz have been filtered out. About the only things that can pass through here are CTCSS tones (67 to 203 Hz). If you already own a frequency counter, you can connect it to Pin 14 of IC-A via a coupling capacitor and probably obtain a readout of any resident CTCSS tone. Some frequency counters may be better suited to this application than others, but my preliminary tests indicate that plenty of tone signal will be at Pin 14 to trigger most frequency counters.

I injected a range of frequencies between 67 and 205 Hz at an input level of 3 mV (0.003V) into a CSI TS-32P. The amplified, filtered output at IC-A, Pin 14 was better than 1V. I tested this method with two different frequency counters, one a lab instrument and the other an inexpensive hobby-grade unit. Both worked equally well. Neither counter could display the decimal fraction of a tone, but both measured within ± 2 Hz of the input tone. Since CTCSS tones are spaced by 4 Hz or more, it appears that you can reliably measure to within one or two consecutive tones at least, and a quick flip of the Program Switch will then put you right on to the correct tone. So this method is just waiting to be used by those scannists who already own frequency counters. I'm not suggesting that anybody run out and buy a frequency counter for this purpose, but for those who already own one, it could be one of the more cost effective methods of tone finding. CSI might be able to offer advice on this.

Installing the CSI TS-32P Tone Decoder in Your Scanner: The directions supplied with the TS-32P are clear and concise, and installation is so easy, that

there's no purpose served here with reproducing the detailed steps. But for those of you from Missouri who (like I) need to be shown, the following will suffice in addition to Figure 4-31-1:

1. One wire goes to chassis or circuit board ground.
2. One wire goes to a source anywhere between +10V and +17V DC.
3. One wire goes to the "high" lug of the Volume Control.
4. One wire goes to the "high" lug of the Squelch Control.
5. One wire goes from the TS-32P board to a separate SPST Switch.
6. One wire goes from the SPST Switch to ground.

There are other input/output points on the TS-32P module, but they aren't used for scanners. So that's the whole job, unless you want an external Program Control BCD rotary switch or a 5-segment DIP switch to select the 32 CTCSS tones. The DIP switch will require six easy-to-connect wires, but the BCD rotary will require eight wires (but eliminates Steps 5 and 6, above). It doesn't get much easier than this.

The TS-32P is fully assembled and ready to go, and it's supplied with a hardware kit, plus jumper and interconnect wires, mounting studs, screws, tape, and even a tool for setting the DIP switches. This, plus a schematic, instructions, and miscellaneous relevant information is also provided in the packet. They've made it as painless as possible.

An Easy Installation Alternative: If you deplore the idea of defacing your scanner, or if (like mine) your scanner is almost sinking under the weight of other mods you've done, here's another idea. The CTCSS board can be installed in a small project box and hooked up to a multi-pin connector installed on the rear of the scanner. Four wires in the umbilical cable will be required. One must be dedicated for +12V to +14V power. One for ground. One to the high side of the SQ control and one to the high side of the Volume Control. The internal wiring of the scanner will be super simple, needing only the three pickup points plus ground. The ON/OFF switch of the decoder can be installed in the project box as an extended DIP switch or either of the BCD rotary switches. If you elect this alternative, be sure to install the jack on the project box to provide an output for a frequency counter "tone finder."

For my external decoder, I built the whole deal into a Pac-Tac HPS electronic enclosure. Pac-Tac is a division of LaFrance Corp., Philadelphia, PA. I used sticky-backed **Velcro** strips to secure the TS-32P board inside the box. The eight lugs on the BCD rotary switch were wired to the TS-32P, and an umbilical cable was fashioned out of Radio Shack's 9-conductor, shielded cable #278-775. A permanent (but short) "pigtail" was wired through through a hole in the rear of the scanner using the same 9-conductor shielded cable, and an 8-pin DIN in-line jack (Radio Shack #274-027, or equivalent) was wired to the end of the "pigtail." A longer section of the 9-conductor cable was permanently wired in the box, at the end of which was installed an 8-pin DIN in-line plug (Radio Shack #274-026, or equivalent). This arrangement allows the decoder box to quickly be disconnected from the scanner at any time. The short pigtail that hangs out of the back of the scanner doesn't get in the way when not in use.

You're probably wondering why I used the 9-conductor cable when only four wires are actually needed between the scanner and CTCSS box. It was so something else could be fitted into the box at some future point and the wires will already be in place. I have plenty of room left for another project. The BCD rotary switch was mounted off-center to the right to allow for another control of some sort to be installed on the left someday.

The shield of the cable is ground and should be soldered to the metal chassis of the scanner, and to the metal shells of the DIN plug and connectors. The CTCSS decoder box is plastic, but the cable shield still serves as the ground return. Mine connects to the ground lug of the "RCA" type phono jack used for the frequency counter output. From there, a short ground wire goes to the CTCSS board ground connection. The rest is a cinch.

Testing & Using Your CTCSS Option: After you've installed a CTCSS decoder in your scanner, open a scanner frequency directory and select several business radio frequencies that are assigned to various users. With your CTCSS decoder **deactivated** (off), monitor a few of those channels for a while to determine which frequency is busiest, and then settle down on that one.

Activate your decoder (the scanner will go silent) and casually flip through the 32 tones, one at a time, pausing briefly on each one (see Table 4-31-1 for specific tone frequencies and codes). It may be of interest to have a second scanner nearby, programmed to the same frequency so you can tell when stations are transmitting. When you select an active tone, the transmission will come through your decoder-- loud and clear. You won't hear anything else other than that one company or system. Now, search through the rest of the CTCSS tones and the communications of others using that same frequency will pop in and out. It won't take you long to determine the tones used by each user sharing that frequency.

If you have a frequency counter, and are using the CSI TS-32P decoder, then solder a coupling capacitor to the outboard side of R-12-- a 0.1-uF disk capacitor will do nicely. On the free side of the coupling capacitor, connect the center conductor from a bit of coaxial cable. Any type will do, but the miniature variety (including shielded microphone cable) will be best. Run that cable to an "RCA" type or BNC jack on the rear chassis of the scanner (or box, if that's what you're using). Connect one end of the shield of the cable to a ground lug at the jack, and the other end of the shield to the same ground point where the ground wire of the TS-32P module is connected. Then connect your frequency counter to the new jack on the rear of the scanner.

The TS-32P decoder can be on or off with the use of your frequency counter, provided that its DC wire is not switched. Whenever a CTCSS tone is being used in a transmission, that tone will be displayed on the counter. When CTCSS tones aren't present, the counter will display zeros or it may have an erratic or unstable display. You'll get used to it soon, and when it does display a CTCSS tone (even if it's not dead accurate), the readout should be close enough so that trial and error checking of all 32 tones can be avoided. At worst, you may have to check two or three. If your counter isn't grossly out of calibration, it will display within 1 or 2 Hz of the correct tone and you won't have to search at all.

A quick thought on frequency counters is due. A laboratory grade counter has a specified accuracy of 1 part in 10^8 or better. A good bench counter is accurate to within 1 part in 10^6 . A hobbyist grade frequency counter may be accurate only to 1 part within 10^4 or 10^5 . There's one more error **all** digital instruments have, and that's due to the "rounding off" characteristic in the digital circuits that makes the least significant digit accurate only to ± 1 digit. Now, let's examine the

worst case for a hobbyist frequency counter, if its accuracy is 1 part in 10^4 (10,000), then inherent error could be as high as 100/10000, or 0.01 Hz. That error won't affect the 100 Hz reading. The greatest error will be ± 1 digit in the last decimal place, which means that if the displayed frequency is 100 Hz, then the actual could be as low as 99 Hz or as high as 101 Hz. So, even if you're using an El Cheapo Special frequency counter with poor accuracy specs, chances are excellent that it will still be good enough to display CTCSS tones.

A major stipulation here, of course, is that the counter **must** be capable of reading and displaying to at least 1 Hz. Some really cheap frequency counters can read only to the nearest 1,000 Hz, 100 Hz, or 10 Hz. The 1 kHz and 100 Hz limits will be useless for CTCSS tone finding, though a 10 Hz readout could be effectively used to reduce the trial and error of switch flipping. If you could read to within 15 to 20 Hz, that's better than randomly flipping through all 32 switch positions.

If You Are Not Sure You Want To Experiment With CTCSS: You can, at least, construct a simple little circuit (a bandpass filter) and connect a frequency counter to it to measure the CTCSS tones that might be used in your area. Yes, you'll need a frequency counter capable of measuring to 1 Hz, but they're a dime a dozen (well, almost, anyway). The bandpass filter circuit should cost only a few bucks at the most. Build it on a small piece of perf board; install it anywhere convenient in your scanner; and tap the output to an "RCA" type jack on the rear of your scanner.

Connect the frequency counter to the jack, and you're in business. It would be advisable to use mini-coaxial cable or small shielded microphone cable for the signal output to the "RCA" type jack and for the patch cable to the counter. See Figure 4-31-3 for the schematic, and Table 4-31-1 for the parts.

Construction & Adjustment Hints:

1. Adjust VR-2 (Bias Control) for +3.50V on IC-1's Pin 5.
2. Adjust VR-1 (Gain Control) for only enough gain so that all tones are easily displayed on the frequency counter. Too much gain is not good.
3. Reduce values of C-7 (270 to 350 pF) if all tones are not easily and readily displayed on the frequency counter. Do not exceed 470-pF.
4. Pin numbers will differ from those shown if Radio Shack's LM-324 Quad Op amp is used instead of the dual LM-358.

Other Tone Code Possibilities

Dual Tone CTCSS: Another tone scenario in common use for repeater access is a two-tone coded arrangement. This arrangement is far more secure than the one-tone system, but since it is used mostly for accessing repeaters it will be of less interest to the curious scannist. The one tone system offers up to 32 different access codes for a repeater. Assorted rogues can easily figure out which tone is necessary to access a one-tone ham, business, or other repeater. A dual CTCSS tone coded system, however, is quite another challenge in that there are 32^2 (that's 1,024) possibilities, and that's nothing to take lightly. Dual tones are usually sent in sequence, as a preamble when the transmitter is first keyed-- that is, one tone after the other, but then the tones go inactive for the duration of the message.

Dual-Tone Multi-Frequency (DTMF): Standard DTMF telephone dial tones are in common use in two-way radio communications. These tones, of course, are audible,

TABLE 4-31-3
STANDARD DUAL TONE MULTI-FREQUENCY CODES

Low Tone (Hz)	<-----High Tone (Hz)----->	1209	1336	1477	1633
697	:	1	2	3	"A"
770	:	4	5	6	"B"
852	:	7	8	9	"C"
941	:	*	0	#	"D"

both to the ear as well as the receiver audio section, and are referred to as "in band signalling." CTCSS tones are sometimes referred to as "out of band signalling." A DTMF tone actually consists of two separate tones derived from a combination of eight individual tones for up to sixteen combinations. The standard DTMF tone chart is shown in Table 4-31-3.

As an example, when you press "2" on your pushbutton telephone, two distinct tones are simultaneously generated, 687 Hz and 1336 Hz. Or, when you press the "#," both 941 Hz and 1477 Hz are generated. The far right (A-D) column in Table 4-31-3 isn't used in standard telephone dialing, but is a functional part of the overall DTMF scheme. Amateur and business radio situations may include a full sixteen button keypad, although your telephone has only the more familiar twelve (and only ten of those are used for placing calls).

Sophisticated repeater access schemes are now available where up to four tones are sent sequentially, for up to 10,000 different access code combinations. In some cases, these codes can be sent manually, with the operator punching a keypad just like a telephone. Or, the codes may be sent manually whenever the transmitter is keyed. There are other applications for DTMF tones in radio signalling and control, but they're beyond the scope of this book. Communications Specialists, Inc., discussed earlier in this chapter, offers a line of DTMF decoders and related information for many of these applications.

See elsewhere in this book for a project where you can build your own DTMF decoder and memory unit to capture and decode such data monitored on a scanner.

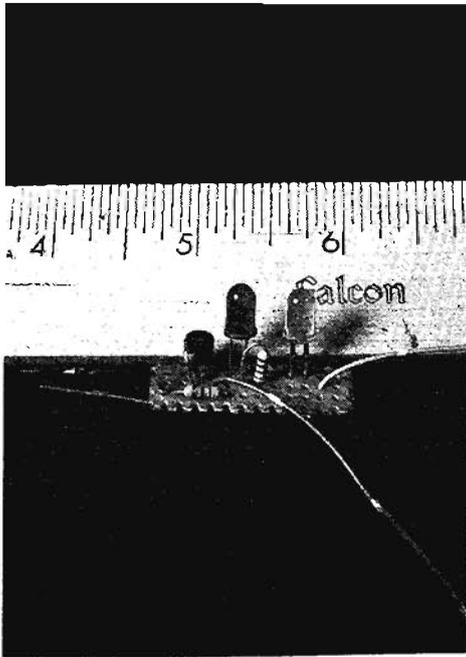
MOD-32

A Carrier-On Indicator For The PRO-2004/5/6 & Other Scanners

PRELIMINARY DISCUSSION

If you're like me, sometimes you enjoy fiddling around with easy projects that have no great, earth-shattering practical value. It's the icing on the cake, though, if the project is enjoyable, neat, appealing, and has even the flimsiest shred of justification to exist.

This project fits that description. It's uncomplicated, inexpensive, and it's sufficiently snazzy and "high tech" to dress up the otherwise dull faceplate of your scanner. If you want to know a little more about transistors and LED's (like, how they work and what absolutely neat things they can do), then this is for you. Besides, it's a great conversation piece to amuse and amaze all visitors to your radio shack.



MOD-32: Component side of the COI.

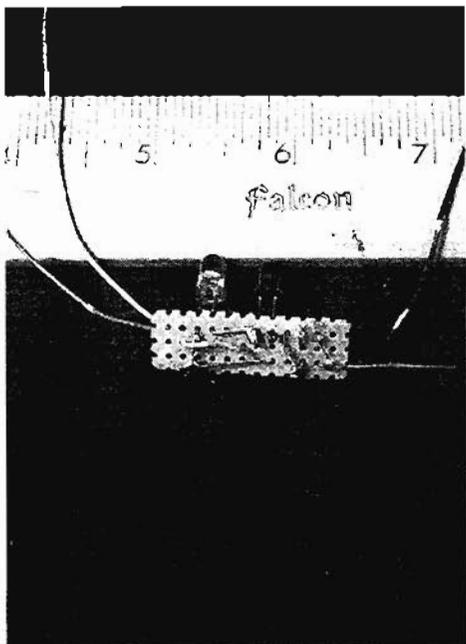
So, what exactly is a "Carrier On Indicator," (COI) anyway? As far as the visual effect is concerned, mine is two LED's, one green and one red that alternate on and off when a signal comes in. When a signal is being received, the red LED is lit. When no signals are coming in, the green LED comes on.

Internally, there's only a little more in addition to the two LED's: one NPN transistor, and four resistors. Connections are simple and few. A circuit board isn't necessary since the simple circuit can be mounted in any of two dozen vacant areas of the scanner. The only concern at all is picking a location to mount the two LED's. I'll leave it up to you, but ample hints are given elsewhere in this book in other mods (such as MOD-26, MOD-27, and MOD-28). Read the LED installation instructions in those sections and you'll know what do and how to go about it.

You can gain a COI for free if you choose to do MOD-33, so check out that mod before getting started with this one. MOD-33 isn't much more complicated than this one, but definitely has more to offer you.

Discussion of The Theory & Practical Application: The COI is a simple, basic transistor switch, nothing more. The control (ON/OFF) signal for the Base of the transistor is taken from the scanner's SQUELCH logic circuit, which goes "high" when the SQUELCH breaks (signal comes in), and to zero when the SQUELCH is set. When the Base of the transistor has 0 volts, the transistor can't conduct, therefore the red LED can't conduct and is OFF. The green LED, however, conducts independently of the transistor, and therefore is ON. When the SQUELCH breaks, a positive voltage is applied to the Base of the transistor, which makes it conduct through the red LED. Therefore, the red LED glows brightly. The voltage at the junction of the 1K resistor and the anode of the red LED drops significantly when the red LED conducts, therefore the green LED dims appreciably at the instant the red LED comes on. This has the effect of making the green LED seem to go off, although it actually doesn't. Another circuit could be devised to make the green LED go off completely when the red LED is on, but that complicates matters somewhat and defeats my purpose of keeping this mod simple and inexpensive. Moreover, the difference it would make wouldn't be that noticeable.

OK, why would you want to bother with a COI, other than having something technical but easy to do? Well, if you're like me, the scanner is on much of the



MOD-32: Solder side of the COI.

time while you're around. There are times when you, or another member of your household, maybe turns down the volume in order to answer a phone call. My wife does it to me all the time when I'm not looking. Sometimes I turn it down myself, then become preoccupied with other things and forget to turn the volume back up. The subsequent visible flicker of activity on the COI eventually attracts my attention and causes me to turn up the volume before I miss something hot.

Other times, I'm trying to concentrate on something while the scanner is devoting a lot of time to routine radio checks, check ins, and the like. I'll reach over and turn it down. However, if I notice the red/green lights operating at a significantly longer rate of change, I'll assume that maybe they've gotten into more interesting traffic-- so I can sneak a quick peek at what's happening by briefly turning up the volume.

One hobbyist I know runs no less than three scanners at once, apparently not an uncommon practice. With that arrangement, a COI will immediately indicate which of the various radios is producing traffic at any given moment.

And then there's the ultimate satisfaction that comes when an uninitiated visitor sees the red and green LED's blinking back and forth, and says, "Wow, what are those lights for?" At that point, you can swell up with pride and say you put them there yourself because-- well, you can invent any story you like, ranging from the lights detecting UFO's to their sensing holes in the ozone layer. So, grab that service manual and let's get started.

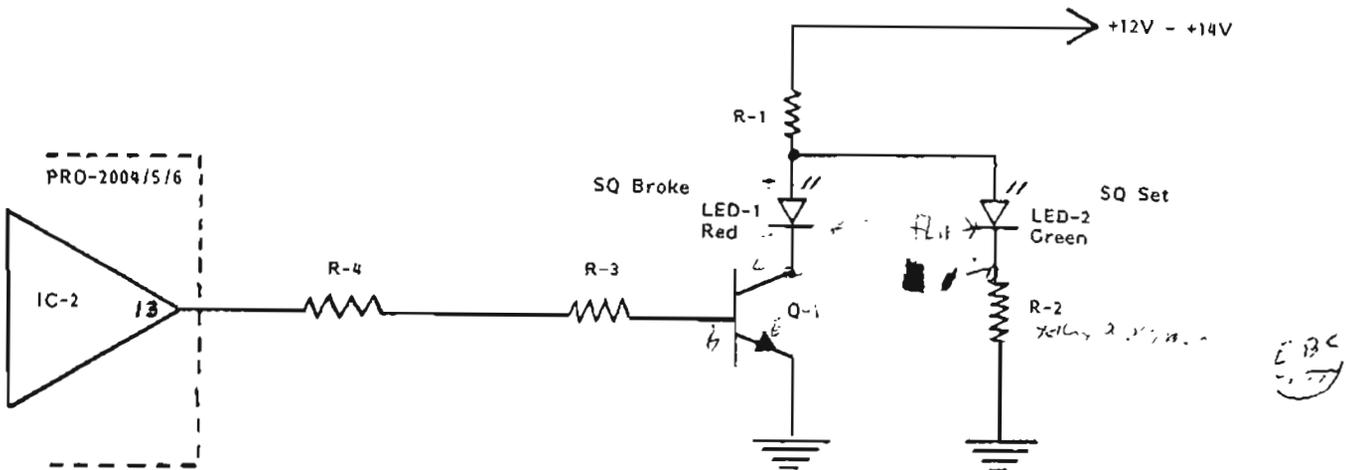
Steps of Procedure: Refer to Table 4-32-1 and Figure 4-32-1, then move along with the following steps, which apply to the PRO-2004/5/6 and most other scanners:

1. Decide where you want the two LED's mounted. For maximum effect, mount them fairly close together (about 0.2" apart) and on a prominent part of the scanner's faceplate. On my PRO-2004, I mounted them on the thin, flat rim that encircles the entire faceplate, and I placed them just to the left of the Headphone jack. In any case, don't physically install the LED's until after Step 14 when the circuit has been tested and determined to function properly.

TABLE 4-32-1
CARRIER ON INDICATOR PARTS LIST

Ckt Symbol	Quan	Description	Radio Shack Catalog #
LED-1	1 pk	LEDs, T-1 size, red, 1 ea	276-026
LED-2	1 pk	LEDs, T-1 size, green (assortment pak), 1 ea	276-1622
Q-1	1	Transistor, NPN, 2N2222A,	276-2009
R-1	1 pk	Resistor; 1-k ohm, 1/4-watt; 1 ea	271-1321
R-3	1 pk	Resistor; 3.3-k ohm, 1/4-watt; 1 ea	271-1328
R-2	1 pk	Resistor; 470 ohm, 1/4-watt; 1 ea	271-1317
R-4	1 pk	Resistor; 33-k ohm, 1/4-watt; 1 ea	271-1341
Misc	2-ft	Multiconductor Shielded Cable, 25 (use as hookup wire)	278-776

Figure 4-32-1
CARRIER ON INDICATOR SCHEMATIC & WIRING DIAGRAM

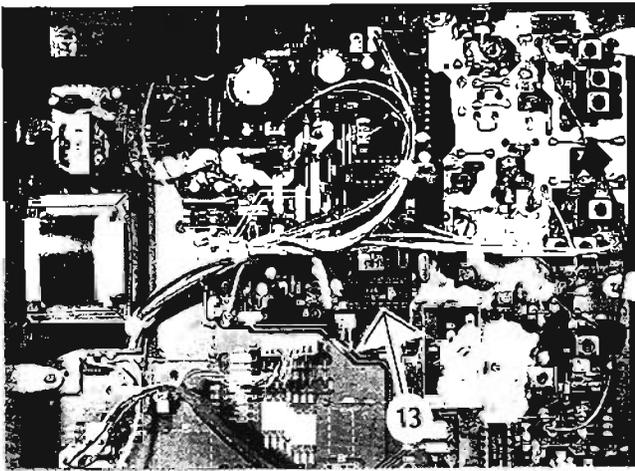


2. Unplug scanner from power lines. Find a vacant area on the main or any of the subsidiary circuit boards on which to mount the transistor. All it needs is a ground trace to which the Emitter of the LCD transistor should be soldered. In my PRO-2004, I used a ground trace on the LCD Display Board inside the faceplate and right next to where I installed the LED's. The transistor doesn't connect anywhere else on the scanner's boards, so you just need a handy ground spot at which to solder the Emitter (only). Solder the Emitter to circuit ground at a place you select.

3. Bend the Base lead of the transistor outward about 90° and clip off all but about 1/4 inch. Clip off all but about 1/4" of both leads of the 3.3K resistor. Solder one end of the 3.3K resistor to the Base lead of the transistor.

4. Solder a length of hookup wire to the free end of the 3.3K resistor connected in Step 3. Let it hang free for now.

5. Bend the Collector lead of the transistor outward about 90° and clip off all but about 1/4 inch. Solder a length of hookup wire to the Collector. For now, let it hang free.



MOD-32: In a PRO-2022, use Pin 13 (arrow) of IC-1 to trigger your. Also the output for MOD-30.

6. Solder one end of the 1K resistor to a source of +12V to +14V in your scanner. The best spots in the scanners indicated are:

PRO-2002: The positive (+) lead of C-246.

PRO-2003: Either lead of R-293.

PRO-2004: Either lead of R-235.

PRO-2005/6: Either lead of R-229.

PRO-2021: Either lead of R-143.

PRO-2022: Either lead of R-229.

Uniden BC-200/205XLT: Try the low side of the power switch.

Uniden BC-760/950XLT: Try the low side of the power switch.

Regency HX-1000: Try the low side of the power switch.

Others: You'll have to find it yourself. The +12 to +14V can usually be found on the switched side of the ON/OFF switch on most scanners. First make certain that the scanner is unplugged from the power lines and 110VAC isn't on the switch terminals.

7. Solder a length of hookup wire to the free end of the 1K resistor connected in Step 6. Let it hang free for now.

8. Solder the hookup wire from the Collector of the transistor (Step 5) to the cathode (-) of the red LED. The cathode is the shorter lead.

9. Solder the hookup wire from the 1K resistor (Step 7) to the anode (+) lead of the red LED. The anode is the longer lead. Let the LED hang free for now.

10. Solder one lead of the 470-ohm resistor to the cathode of the green LED. The cathode is the shorter lead.

11. Solder a length of hookup wire to the anode of the green LED. The anode is the longer lead. Solder the other end of the hookup wire to the same end of the 1K resistor that connected the anode of the red LED in Step 9.

12. Temporarily solder the free end of the 470-ohm resistor to a handy circuit board ground spot.

13. Trim all but about $\frac{1}{2}$ " of one end of the 33K resistor and that lead to the below indicated spot in your scanner:

PRO-2002: IC-1, Pin 13.*

PRO-2003: IC-104, Pin 13.*

PRO-2004/5/6: IC-2, Pin 13.

PRO-2021: IC-2, Pin 13.*

PRO-2022: IC-1, Pin 13.*
Uniden BC-200/205XLT: Anode of D-7.
Uniden BC-760/950XLT: Anode of D-15.
Regency HX-1000: U-201, Pin 13.
Other: You'll have to find it yourself.*

* The objective is to find a digital DC signal point where the signal goes from +4VDC to +8VDC whenever the SQUELCH breaks, then drops to approximately 0 volts when the SQUELCH is set. It's possible that you'll find the SQUELCH logic to be reversed from that just described, i.e. 4V to 8V when SQUELCH breaks and zero volts when set. No problem, just exchange the green and red LED's, pin for pin. The PRO-2002, -2003, -2021, and -2022 **might** fall into this reversed logic category. You'll have to check.

13. Refer to Step 4, and solder the free end of that hookup wire from the 3.3K resistor to the 3.3K resistor connected in Step 12. You're ready for a functional test. First, double check your work.

14. Test the COI by turning on the scanner and setting the MANUAL mode. Adjust the SQUELCH back and forth while watching the LED's. When SQUELCH is set, the red LED should be completely off, the green one on. When SQUELCH breaks, red should come on brightly, green should go very dim-- but not completely off.

15. When you're sure the COI functions properly, then remove the temporary ground connection of the 470-ohm resistor (Step 12). Install the LED's. Resolder the loose end of the 470-ohm resistor to a nearby ground spot. Use an extension of hookup wire if necessary. If you use T-1 LED's (and you should), then a 1/8" drill bit cuts the right diameter hole, but first see the other LED mods in this book for producing perfect holes with a template.

Your COI is now ready to serve you, and to amaze your visitors.

MOD-33

A New Automatic Tape Recorder Switch For The PRO-2004/5/6 & Other Scanners

PRELIMINARY DISCUSSION

One of the most useful scanning accessories could be an Automatic Tape Recorder Switch (ATRS). The purpose of an ATRS is to keep the tape recorder in the PAUSE mode at all times except when signals are being received by the scanner. When signals come in, the recorder activates. With an ATRS, it's possible to compress a day or more of scanner communications on your favorite frequency on to one side of a 90 or 120-minute cassette tape, or one side of a 90-minute microcassette. And you get continuous chatter with no dead air time.

All scanners have a SQUELCH (SQ) function that offers a logic signal to activate the recorder. This is because when the SQ "breaks," signals are usually present. When the SQ is set, signals are absent. Tapping into the electrical activity of the SQ circuit provides the wherewithal to trigger a transistor switch to operate an electromechanical relay. A pair of "normally open" contacts on the relay are interfaced to the tape recorder's REMOTE jack via a plug and patch cable from the ATRS circuit.

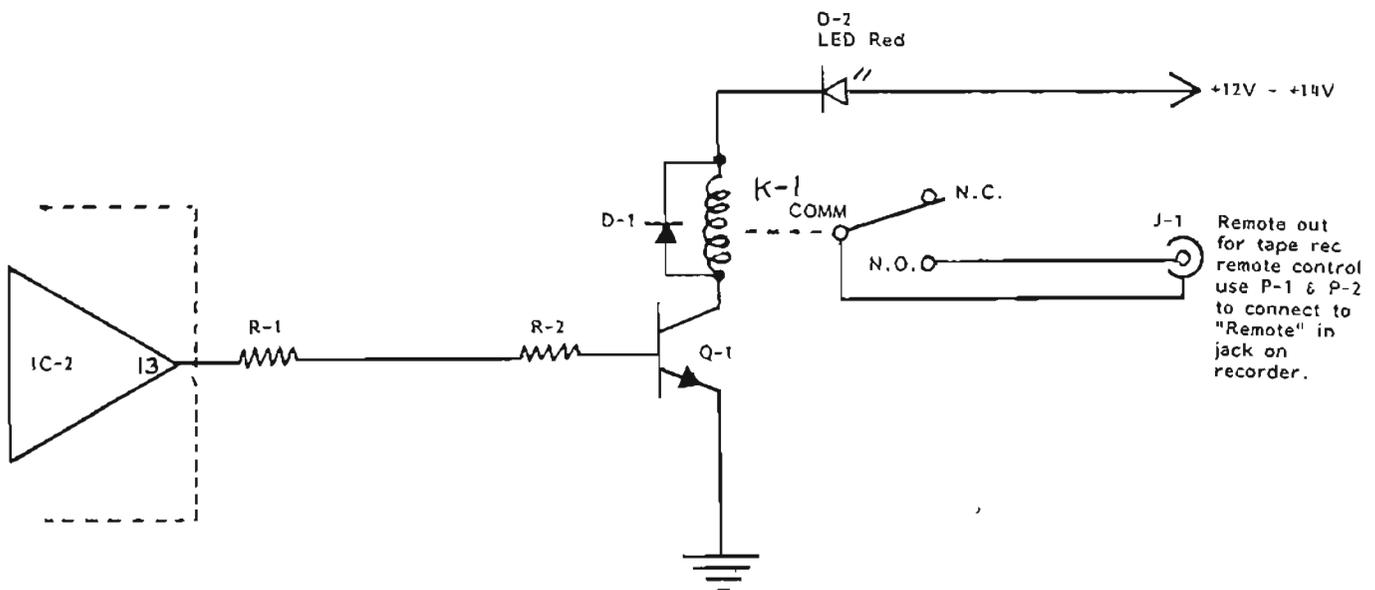
Table 4-33-1
PARTS LIST: NEW AUTOMATIC TAPE RECORDER SWITCH

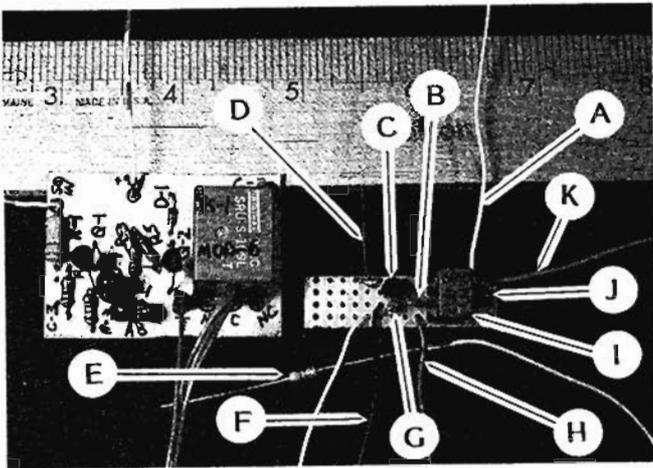
<u>Ckt Symbol</u>	<u>Description</u>	<u>Radio Shack Catalog #</u>
D-1	Diode, switching, 1N914/1N4148	276-1620
D-2	Diode, LED; Red (or your choice of color)	276-026
K-1	Relay, SPDT, 12-volt (low current is important!)	275-241
J-1	* Jack, 3/32", mini	274-292 *
P-1,2	Plug, 3/32", mini	274-289
Q-1	Transistor, NPN, switching; 2N3904, 2N2222A, etc	276-1617
R-1	Resistor; 47-k	271-1342
R-2	Resistor; 33-k	271-1341
S-1	Switch; SPST; micro/miniature	275-624
W-1	Cable (2-conductor, for P-1 & P-2)	278-752
Misc	Hookup wire; good quality	278-776
Misc	Perf Board	276-1395

* See the Note under Step 3 of these instruction first!

NOTE: Also see the Carrier On Indicator mod elsewhere in this book!

Figure 4-33-1
SCHEMATIC & WIRING DIAGRAM
NEW AUTOMATIC TAPE RECORDER SWITCH





MOD-33: The new ATRS is smaller than MOD-6, also simpler and better. A= relay normally open; B= D-1; C= Q-1; D= ground; E= R-1; F= ground; G= R-2; H= relay common; I= K-1; J= D-2 LED; K= +12V to 14V.

Volume 1 of this book featured an ATRS (MOD-6) of excellent quality that will perform in most radios having a SQ. After Volume 1 was published, I evolved an additional ATRS circuit that uses fewer components and is a bit more versatile with respect to its power requirements. This new ATRS can be built on a much smaller perf board to occupy far less space than the earlier ATRS.

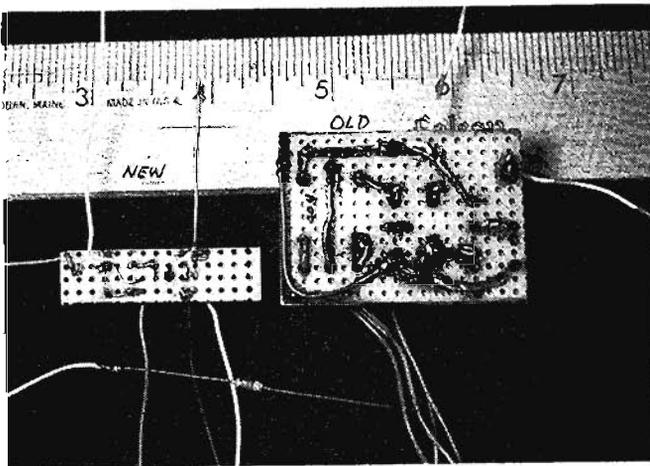
You'll need an LED. Color isn't important, unless you wish to install it in your front panel as a Carrier On Indicator (COI) to visually indicate when signals are coming in. But, whether or not you use it as a COI, you'll still need the LED, anyway. It's needed to drop some of the excess voltage to the relay and transistor and thereby keep current drain at a minimum. There's nothing very critical about resistors R-1 and R-2, however note that I selected their values and their physical placement to eliminate the possibilities of several pesky little problems I could foresee arising should other types be used. So, please don't deviate from the instructions on R-1 and R-2.

R-1 samples the scanner's SQ gate on Pin 13 of IC-2 (PRO-2004/5/6). When the SQ is set, the voltage is low at zero and Q-1 can't conduct, so the relay is de-energized. When the SQ breaks (signals coming in), then Pin 13 of IC-2 goes high to about 7.5V. R-1 and R-2 pass a tiny sample of that SQ signal to the Base of Q-1 which makes the transistor conduct through the coil of the relay. The relay then switches the "Normally Open" contacts to the closed position. This switch closure (based upon SQ breaks) is what triggers the tape recorder auto-start operating when its REMOTE control function is connected to the "Normally Open" relay contacts. We are using the scanner's SQ signal to electronically operate a switch that is connected to a tape recorder's REMOTE control jack. Really quite simple.

Assembly & Installation: This circuit is expressly for scanners that use a positive SQ logic, where some high logic voltage level (+4V to +8V) represents a SQ break, and where a low logic level (zero volts) represents a SQ set. If your scanner has negative SQ logic, or even a positive logic but reversed from that just described, then this circuit will not work for you without an "inverter" in the Base circuit of the transistor switch. If in doubt, consult your service manual and check around the SQ circuit with a voltmeter until you can determine the nature of the SQ logic.

All Scanners:

1. Build the ATRS Board in accordance with Table 4-33-1 and Figure 4-33-1. Install R-2 so that it connects directly to the Base of Q-1, but **do not** install R-1 on the ARTS Board. If you want the LED to be visible from the front panel of the



MOD-33: Solder side wiring of the new ATRS compared to the old MOD-6.

scanner as a COI, then install it accordingly and route two wires from the LED back to the ATRS Board (observe proper polarity). The longest lead of the LED is the anode. If you don't want the LED in your front panel, then install it directly on the ATRS Board. When the ATRS Board has been completed, "weave" a bare 18-20 ga. copper wire in and out of a couple of holes in the perf board and then solder it to the ground connection of the ATRS board. Make the free end of this out of stiff copper ground wire about 2" long. It will be used both as the ground connection to the scanner and as a "mounting post" for the ATRS board.

2. Solder four hookup wires about 8"-10" long to the ATRS board as follows:

2-A. Power wire: to the anode of the LED.

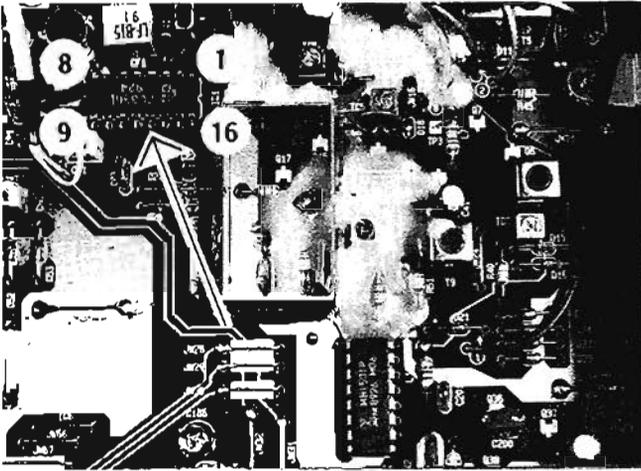
2-B. Squelch-In wire: to the free end of R-2.

2-C. Remote Output Common: to the "Common" terminal of the relay.

2-D. Remote Output Switch: to the "Normally Open" terminal on the relay.

3. Unplug scanner from power line. Install Switch S-1 in a location of choice on either the front or rear panels of your scanner.

4. Install the Remote Control output jack (J-1) in a location of choice on either the front or rear panels of your scanner. Note that the Remote Control function of most tape recorders won't work when the "shell" of the Remote Jack is grounded. Strange, but true. The shell of J-1 in the ATRS cannot be grounded to, or be in electrical contact with, the metal case of the scanner in any way. When it is installed in a plastic front panel, obviously there's no problem. If it's installed in the rear metal panel, then it must somehow be isolated from the metal chassis. There are special phone jacks made for this purpose. They're either plastic with an insulated ground lug, or else with an insulator bushing to keep the ground shell from touching the metal chassis. A prime source of this type of jack is a junked CB radio. You can salvage either the PA speaker jack or the EXT SPKR jack from a CB radio which, if you look closely, is obviously the isolated type. Radio Shack doesn't sell the isolated type phone jacks, so you've got to be creative or else just mount J-1 in the plastic front panel (where it will be more accessible, anyway). If you use a different phone jack from that specified in Table 4-33-1, then P-1 must also be changed to match the jack.



MOD-33: For the PRO-2022, use Pin 13 of IC-1 as the pick off point for input to the ATRS.

5. Install the ATRS Board in your scanner.

PRO-2004/5/6:

5-A. Select a location for the ATRS Board in your scanner. Keep in mind that space comes at a premium after several mods have been performed, so plan carefully. The ATRS board is so small and light that it can be installed by means of the stiff ground wire (at the end of Step 1). This ground wire can be soldered to the metal scanner chassis, or even to a ground circuit trace on one of the boards. Once it has been soldered, you'll see how the ATRS Board will be suspended, manipulated, and positioned firmly in place. The stiff wire should not be more than about $\frac{1}{2}$ " long after installation.

5-B. Solder the power wire from the ATRS Board (Step 2-A) to one lug of Switch S-1.

5-C. Solder a hookup wire to the other lug of Switch S-1.

5-D. Solder the free end of the wire in Step 5-C to a source of +12V to +14V. There are a few easy choices, pick one:

5-D-1. PRO-2004/5/6: to the low side of the ON/OFF switch at the Volume Control, or,

5-D-2. PRO-2004 only: to the exposed lead of R-235.

5-D-3. PRO-2005/6 only: to either exposed lead of R-229.

5-E. Solder the two Remote Output wires from the relay of the ATRS Board to the common "hot" lugs of J-1. Polarity is not important so it doesn't matter which wire goes where.

5-F. Trim both leads of R-1 to about $\frac{1}{4}$ " long; tin with solder and then solder one end of R-1 directly to the SQ logic Gate in the scanner (IC-2 Pin 13 in PRO-2004/5/6).

5-G. Solder the wire from the free end of R-2 to the free end of R-1.

5-H. This completes the installation of the ATRS Board in your PRO-2004/5/6. Now, test the unit as follows:

5-H-1. Turn the scanner on. Set the channel to either a blank or inactive frequency. Set the SQ so that sound is silenced. Turn ATRS switch ON. Nothing unusual should happen.

5-H-2. Turn SQ so that it "breaks" (sound is heard in loudspeaker), and observe D-2 (the LED), which should light up. Set the SQ again so that the sounds are silenced and the LED should go out. If you have excellent hearing, you might hear the relay "click."

5-H-3. Connect either an ohmmeter or a tape recorder (set to RECORD mode) to the Remote Output Jack (J-1). If an ohmmeter, the reading should be infinite ohms. If a tape recorder, it should be paused and not doing anything.

5-H-4. Rotate the SQ control back again to that it "breaks" and the LED lights up. If an ohmmeter is connected to J-1, the reading should be a near short circuit and otherwise 1-ohm or less. If a tape recorder is connected to J-1, then the machine should commence operating. To actually make recordings, not only must a patch cable be connected between the ATRS Remote Output (J-1) and the Remote Control input jack of the recorder, but also a patch cable must be connected from the scanner's TAPE REC out jack to the MIC or RECORD INPUT jack of the recorder.

5-H-5. Set the SQ again so that sounds are silenced; the LED should go out. The ohmmeter should again read infinite ohms or, if a tape recorder is connected, it should pause again.

This completes installation and testing of the ATRS Board in your PRO-2004/5/6.

All Other Scanners: Follow steps 5-A to 5-H-5, except you will install R-1 (Step 5-F) to an appropriate SQ logic point in your scanner. First, look for a TK-10420 chip which is common to most scanners nowadays. If you find one, Pin 13 is the right place. If your scanner doesn't have a TK-10420 chip, then look in the service manual for the SQ Logic circuits, starting at the CPU chip which always has to have a SQ Logic chip. Now, follow that CPU SQ line back to the area where it originates and, using your voltmeter, start testing various points while rotating the SQ control back and forth. Find a point where, when the SQ "breaks," the voltage is "high" at +4V or more, and where SQ "set" is nearly 0 volts. Solder R-1 to that point and follow the rest of the procedures in Step 5. The correct hookup point for R-1 in selected scanners is:

PRO-2002, PRO-2022: IC1, Pin 13.

PRO-2003: IC-104, Pin 13.

PRO-2004/5/6, PRO-2021: IC-2, Pin 13.

Uniden BC-200/205XLT: Output pin of IF Unit.

Uniden BC-760/950XLT: IC2, Pin 15.

Regency HX-1000: U-201, Pin 13.

Other: You'll have to find it on your own.

The 47K resistor (R-1) was expressly selected for SQ Logic levels of 0 and about +7V. If your SQ Logic "high" is less than 7V, then R-1 may have to be decreased a little. First, try a 33K, and if that doesn't work, then (in order) try 22K and 10K until one of these values for R-1 works. If 10K doesn't work, then there's another problem and troubleshooting and evaluation will be needed.

If the SQ Logic is wrong for this ATRS board (that is, if SQ Low = Break, and SQ High = Set) then this circuit isn't for you. In this circuit, it takes a

positive voltage to make Q-1 conduct, and Q-1 conducting when the SQ is set is what you **don't** want! Most scanners will have some point where the "logic" is of the correct polarity, so don't despair. Get your voltmeter and your service manual and go hunting.

Tips, Hints & Wrap-Up: I put all of the tape recording controls and jacks on the front panels of my scanners. In the PRO-2004/5/6, there's ample room. I like the convenience of quick access, so I even installed the Improved Tape Rec Output jack (MOD-5 in Volume 1) on the front panel, too. If you want to keep a tape recorder hooked up and dedicated full time to a single scanner, then having the jacks on the rear chassis will be cleaner and neater.

While access to the inside of the front panel of the PRO-2004 offers no problem, it's a bit awesome getting inside the front panel of the PRO-2005/6 for the first time. Once done, it isn't too bad. This book's MOD-16 Review and MOD-26 provide ample instructions.

Radio Shack's microcassette tape recorder (#14-1044) makes an excellent recorder for use with a scanner. Many other microcassette recorders aren't any good with scanners because they lack the necessary remote control jack. Several of Radio Shack's regular cassette recorders are fine for scanner recording.

MOD-34

Shielding Scanners & Other Electronics Equipment In Plastic Cases

PRELIMINARY DISCUSSION

Peers as though the day of metal-cased (shielded) consumer electronics equipment has gone the way of the 10¢ pay phone call, the the 5¢ morning newspaper, the 50¢ gallon of gasoline, and mailing a letter for 3¢. The PRO-2004 was the last of the Realistic line of base scanners to come with a metal case. Just about everything these days comes encased in plastic-- TV's, VCR's, stereos, CB's tape recorders, radar detectors, most worldband portable radios, video monitors, word processors, and even some ham radio gear. Sure, it's "high impact" plastic, light weight, and all that, but it's certainly done more for economic reasons than for anything else. Plastic can be formed, trimmed, and made to look attractive at a much lower cost than metal. Even a plain metal case is probably more expensive to produce than an intricate "high tech" plastic version. Too bad, because metal is difficult to replace for some of its special qualities. But maybe today's consumers are more interested in low cost and good aesthetics than the trade-off plastic cases bring. The price they pay is ineffective or no shielding. Obviously, most people don't care.

But the military cares. So does the government. So do spies. So do communications professionals, even hip SWL's and sharp Amateur radio operators. Serious scannists should also care. With few exceptions, all radio and electronics equipment should be shielded for two reasons:

- 1. Shielding prevents or reduces radiation** of undesirable RF fields from internal electronic circuitry. Radios typically use two or more oscillator circuits as an integral part of their design, and oscillators are micro transmitters. Transmitters radiate RF energy, and that's what they're supposed to do. Good design techniques will reduce RF emissions from oscillator circuits, but those techniques are neither fool-proof nor perfect. Some RF always escapes from the circuit where it is

supposed to be confined. Inadvertent and unnecessary radiation from electronic equipment should be minimized or eliminated. Effective shielding is one of the best ways to do this. Plastic, as a rule, is transparent to RF.

2. Shielding prevents or minimizes absorption of stray RF fields from external sources. Sensitive precision electronics circuits can pick up stray RF signals with the same degree of ease that they can be radiated, not only via the antenna, but also by proximity to nearby electronic equipment such as other receivers, TV's, computers, etc. A shielded case prevents or reduces the amount of interference from stray RF fields that can get to the electronics within the case. Again, plastic is invisible to RF energy-- passes right through without being inhibited!

Proper shielding is a great protective wall against RF interference. It blocks radiation from electronics circuits before it can escape to cause interference to other equipment, and it serves as a barrier to the entry of RF interference from other sources. It seems that manufacturers and consumers alike have lost interest in that cutting edge of performance quality that shielding offers. Only metal does the job. Plastic does piffle. And everything's cased in plastic now.

Have you ever tried to operate two scanners side-by-side at the same time? Sooner or later, you noticed that they interacted with one another, and not for the benefit of either set. One scanner is radiating birdies, the other scanner is receiving them. Proper shielding can eliminate or reduce that interference at either end (preferably at both ends) by helping to prevent excess radiation in the first place, and then by blocking out what little radiation there may be from being received through the case.

Yes, modern technology has brought about plastics that can shield against RF radiation. Apparently this highly specialized product is very expensive because it's rarely seen in consumer electronics outside the field of computers. My own computer has a conductive plastic case, though it doesn't seem to serve its intended purpose very well as it still permits lots of RF to escape-- much to the dismay of my scanners. Conductive plastics aren't quite ready to serve us yet.

In the meantime, you sit there trying to enjoy your radio hobby, but your shack is polluted with stray RF from as many as a dozen different sources. "Birdies" of unknown origin run amok throughout your domain. You are probably personally responsible for some of the problem. Just part of the general pollution of our environment-- the rivers, wells, the atmosphere. But there's really no reason you have to accept it as your fate. All is not hopeless.

Shielding of Plastic Equipment Cases: First, understand that there are sources of RF interference that will always be beyond your control. For instance, interference that enters via your antenna, although modern receivers go a mile and a half in their design to control this type of interference. But that's not what we're talking about here. The type of interference that passes through a plastic case and enters one of the receiver's mixer or I.F. strips is an example of something you can control by shielding the plastic case.

So what's to be done? You could take your plastic scanner case down to a machine shop and pay them to duplicate it in metal. An excellent approach, although with a staggering price tag. But there are some cost-effective shielding methods, providing you don't object to your scanner having a slightly new look.

Aluminum foil: If you were willing to go to a lot of time and trouble, you could apply a layer of aluminum or copper foil to the inside surfaces of the covers that encase your sensitive electronics equipment. The general approach to this would



MOD-34: This is the right stuff for scanners with plastic cases.

include spraying the inner surfaces with a coating of adhesive, and pressing the foil into place. Then you'd want to cut and trim the cutouts for loudspeaker, air vents, screw holes. I've done this. It works, but it's an enormous amount of work, messy, and quite tedious.

Conductive Spray Coatings: Among the hundreds of innovative and useful creations in recent years have been a family of products called "Conductive Coatings." Little known outside technology industries, they come in various types, one of which could find immediate use around your radio room. Possessing the texture and appearance of paint, a liquid conductive coating comes in a spray can expressly designed for application to plastic surfaces. When properly applied and dried, the coating bonds to the plastic and acts like a layer of metal.

Several thin layers of this spray applied to the inside surfaces of the plastic covers of your PRO-2005/6 (or other plastic cased equipment) could, in effect, achieve a shielding effect similar to that of metal. There are several types and price ranges of conductive spray coatings, but the least costly is a nickel-based coating that offers 78-dB attenuation at 1 MHz, and 44-dB at 1000 MHz. Other types of spray coatings are available containing copper and silver. Of course, these are even more effective, although also more expensive. Let's analyze the least expensive coating for the sake of the hobbyist's budget, and do some math using the lower figure since it's more relevant to scanners. The 44-dB figure equals a ratio of $10^{4.4}$ which is an attenuation factor of over 25,000 to 1. This means that a signal that passes through the coating will be diminished to .00004 of its original strength!

Reports have appeared in the hobby press to the effect that this technique has proven successful in protecting treated scanners from stray RF field generated by nearby equipment in the radio room. But it took some planning, and masking of those parts not to be painted (such as outside surfaces).

How to Proceed: There's a strategy involved. The most likely place to start applying the conductive spray coating is the equipment that receives the interference-- unless you happen to know exactly from where the interference

originates. You could spend weeks trying to track down interference sources. You could also shell out lots of money on the conductive coatings needed to spray up everything encased in plastic. While this stuff is very cost effective, the cost per can will make it impractical for spraying up everything in your house from the microwave oven to Grandpa's heart Pacemaker, and the family dog. But you already know what gets interference, so your scanner with its plastic case is a good starting point.

Source of Conductive Spray Coatings: The nickel based conductive spray coating carries part number MS-485. A can is approximately \$10. The part number for the copper based type is MS-490; the silver-based coating carries part number MS-495. Both cost more than the nickel type, but will be even more effective. These are offered by the Miller-Stephenson Co., 55 Backus Avenue, Danbury, CT 06810. Contact this company for details of availability and exact prices.

Other Reasons for Effective Shielding: Not to be too paranoid, but who knows when some day in the future a sinister "radio police" could come rolling down your street in a van loaded with sensitive electronic equipment-- looking for you and your scanner! Don't laugh! In states where there are bans on vehicles using radar detectors, police are using a device called the Technisonic VG-2 to detect the radar detectors. The VG-2 is placed in operation on the dashboard of a police car parked by the side of an Interstate. It operates by monitoring 11.5 GHz (11500 MHz), which is the frequency of the local oscillator of all superheterodyne radar detectors. When it picks up these signals it flashes audio and visual warnings. The signal level rises, peaks, and then drops off as the detector-equipped vehicle passes the VG-2. That's when a description of the vehicle is radioed ahead to a waiting chase car.

One of the more expensive radar detectors can be sniffed out this way from ½-mile down the road, but cheaper units generating more stray RF were able to be detected from as far away as 2 miles in VG-2 tests. So, you can see some of the distinct disadvantages of electronics equipment inadvertently generating low level RF, aside from causing interference. Who knows what they'll be sniffing out next?

So, what the heck. Spend a few bucks and a little time to shield your plastic cased scanners and other critical electronics-- maybe toss a few squirts of the stuff into your radar detector, while you're about it. And, maybe best of all, you'll be doing your share to reduce RF pollution. As a responsible user of the electromagnetic spectrum, you are one of the stewards of this vital natural resource. Anything you can do to minimize and eliminate unnecessary and useless signals from propagating around your neighborhood, your property, your home, your family, yourself, and your electronics is a step in the direction away from RF pollution.

MOD-35

Restoring The Cellular Telephone Bands In The Realistic PRO-2022

PRELIMINARY DISCUSSION

Although (according to the Electronic Communications Privacy Act of 1986) it's not legal to monitor cellular telephone calls, it's perfectly OK to make, sell, and possess scanners that include coverage of those frequencies along with their other coverage. Although manufacturers design scanners to pick up the 800 MHz band,

Each computer has a different approach. Can anyone offer an approach to this dream? It's worth noting that the AOR model AR2500 and AR3000 scanners are built with RS-232 connectors and may be used with an optional computer control package consisting of software and a cable. Use of this package offers spectrum display and database. In addition, the Uniden MR-8100 scanner is also equipped with an RS-232 port. There is an optional interface cable, plus optional software available on 3.5" and 5.25" diskettes. The software permits certain programming options for the scanner's 100 channels (including cellular), alphabetic labeling of each programmed channel, and other features including the ability to clone program other Uniden MR-8100 scanners.

2. A Low Noise, Wideband GAsFET Preamplifier remains on my wish list even though there are several on the market now that actually do a good job with scanners. There's always room for refinement, switched bypassing with lower insertion loss is essential, and improvement in the "1-dB intercept" spec is required. The commercially available preamps are welcome accessories for now, but there is a "next generation" preamp just waiting to be designed by someone.

3. Single Sideband Reception Capability remains high on any listing of things to be desired, and even more so now that Amplitude Companded Sideband (ACSB) has been approved for the new Land Mobile Band on 220 MHz. I haven't yet intensively pursued mods for scanner SSB reception, but the solution appears to be to be not overly complicated. Almost certainly a Beat Frequency Oscillator (BFO) added to the last I.F. section of the receiver will accomplish the task. The oscillator should be quite stable and preferably crystal controlled with a varactor diode tuning mechanism for a "fine tune" feature. The BFO should be switchable (ON/OFF) so it can be activated only when needed.

4. An Electronic RF Attenuator to replace the -10 dB mechanically switched ATTenuator on the rear of the PRO-2004/5/6 remains on the list, though I haven't had time to dwell on it. Ideally, the mechanical slide switch on the rear of the scanner will be wired out or replaced with an electronic attenuator controlled from the front panel.

5. Faster Scan and Search Speeds are always desirable. Areas where research is needed include: Upgrading a PRO-2005 to a PRO-2006 by replacement of the CPU and Clock Resonator is routinely being done, then can the older PRO-2004 also be retrofitted with a PRO-2006 CPU and resonator? The CPU functions among the three scanners are essentially identical, though the actual chips vary from one unit to the next.

Can the 64-pin DIP CPU chip in the PRO-2004 be replaced with the 72-pin Surface Mount CPU in the PRO-2006? In a service manual comparison of the functional diagrams of both chips, they appear to be the same. The PRO-2004's 64-pin CPU has 61 active pins. The PRO-2006 72-pin CPU has 62 active pins, but two of those are Ground. So, among all three, we're still looking at 61 active pins. Are they interchangeable?

If so, then the PRO-2004 can be upgraded to PRO-2006 specs. This is especially pertinent since the MOD-23's Search and Store Modules, don't work with sped up PRO-2004's and PRO-2005's, yet they work fine with the PRO-2006 at 30 ch/sec. Why? Almost certainly, it relates to the CPU. The PRO-2006's CPU was redesigned for faster speeds at 12 MHz.

And, just how fast can the PRO-2006 be pushed to scan before the Search and Store modules won't work, or when the PRO-2006, itself, quits? Research is needed, though 45-60 ch/sec appears to be the limit.

6. **A CRT Spectrum Scope/Analyzer** like that in the ICOM R9000 remains on Wish List, though such a project is apt to be so expensive that it would have very limited general appeal to PRO-2004/5/6 owners. Still, there's room for development here with an inexpensive oscilloscope at the heart of the scheme. The software for a spectrum display, using a computer, is already an optional accessory on two AOR base scanners, so maybe we're really not all that far from home plate with the PRO-2004/5/6, after all.

7. **A Lower Noise, Higher Gain Replacement Transistor** for the 2SC3356 silicon bi-polar transistor currently used as the RF amplifier in the PRO-2004/5/6 chassis. Nothing has turned up thus far, but you parts experts and hackers might uncover something great one of these days.

8. **Reception of 520 to 760 MHz** remains a desirable dream. One of these days, the FCC will gnaw off more off more of the UHF-TV spectrum and reallocate it to other services. Sure, it could go to frequency-hungry HDTV, but not necessarily. Some of it could go to Land Mobile. Even if they don't reallocate anything, one wonders what surreptitious and clandestine two-way activities are taking place right now in your own area on all of those "unused" UHF-TV channels. Are they used for surveillance, or by organized crime? Who knows? The PRO-2004/5/6 uses a 1st I.F. frequency of 607 to 611 MHz, so anything short of an external converter is probably out of the question.

9. **High Speed Electronic Antenna Switcher** controllable by the PRO-2004/5/6's CPU and the Switching Decoder. If you take a look at the schematic diagram for these scanners, you'll see that it's within the realm of possibility. Note the Band Pass Filter (BPF) in the front end of the PRO-2004/5/6! In the PRO-2004, the BPF controller network is IC-501 and Q-501 thru Q-507. In the PRO-2005/6, it consists of IC-502 and Q-501 thru Q-507.

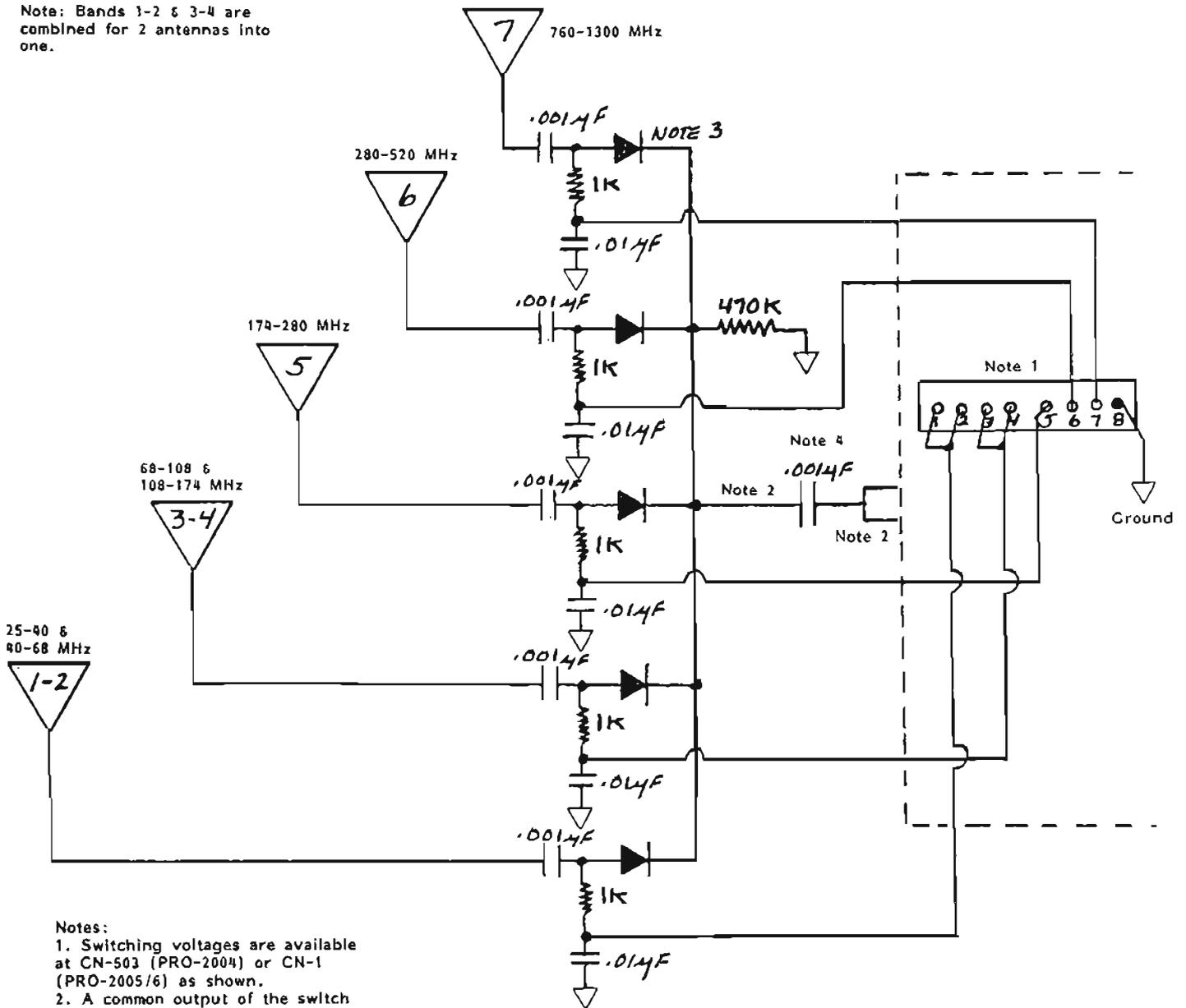
The controller chip is a 74LS145 BCD-to-decimal decoder that's driven by the CPU. The controller chip then drives the seven band-select switching transistors which, in turn, select and deselect among the seven BPF's in the receiver's front end. Wonderful! Why? Because the switching speed of the CPU/controller chip/switching transistors is so fast that the proper BPF is always activated in sufficient time to admit the desired signal for that band, even at a scan rate of 30 ch/sec (33-ms per channel)!

Let's look at the switching transistors (Q-501 to Q-507) and see what they control: Q-501 controls 25 to 40 MHz; Q-502 controls 40 to 68 MHz; Q-503 does 68 to 108 MHz; Q-504 handles 108 to 174 MHz; Q-505 controls 174 to 280 MHz; Q-506 does 280 to 520 MHz; and Q-507 handles 760 to 1300 MHz.

Simply stated, what happens is that as the receiver scans programmed channels, or as a SEARCH is done, the CPU outputs a BCD signal (coded for the band any given frequency is in) to Pins 13, 14, and 15 of the controller IC. As an example, suppose that a certain SCAN program contains 158.97 MHz. When the scanner samples that channel the CPU sends a BCD signal that corresponds to the 108 to 174 MHz band to the controller IC. The controller IC then produces a positive (high) output on its Pin 5 which turns ON transistor Q-504. For about 30 milliseconds, Q-504 then activates the appropriate BPF by forward biasing diodes D-20 and D-21. For that brief instant, all signals in the 108 to 174 MHz band are allowed to pass into the receiver's front end. Of course, a bit more than that needs to happen in order for 158.97 MHz to actually be received, but this is enough to go on for our switching needs.

Figure 5-1
 ELECTRONIC ANTENNA SELECTOR DRIVEN BY THE
 PRO-2004/5/6 RESIDENT ELECTRONIC BANDPASS FILTER SWITCH
 (A Possible Approach)

Note: Bands 1-2 & 3-4 are combined for 2 antennas into one.



- Notes:
1. Switching voltages are available at CN-503 (PRO-2004) or CN-1 (PRO-2005/6) as shown.
 2. A common output of the switch is fed to the antenna connector on rear of scanner.
 3. Switching diodes possibly can be 1N914/1N4148, but low cap microwave switching diodes might be better. Maybe PiN diodes or "hot carrier" schottky's.
 4. All capacitors should be "chip" caps or microwave qualified. Chip resistors should be used, too.

You see, if the CPU, controller IC, switching transistors, and BPF switching diodes are all fast enough to switch in time to admit the programmed frequencies, then that switching is also fast enough to control a set of antennas through a retrofitted switching network. Get the idea?

That is to say, I think it's possible to put up several antennas at your monitoring station, each optimized for a specific band, and interface them to an electronically switched selector. As the scanner goes about its job of briefly sampling each programmed frequency, the best antenna for that particular frequency will be instantly selected. You wouldn't necessarily need seven antennas, as few as two could work, or four would probably do just fine. Suppose one was optimized for 25 to 68 MHz; another for 68 to 280 MHz; a third 280 to 520; and finally one for 760 to 1300 MHz.

Figure 5-1 depicts a starting approach for those who might like to pick up the ball and run with this intriguing concept. I don't represent that the depicted rough circuit will work as shown-- it may not work, but it will convey the general concept and the simplicity of the idea. To actually get this working might require extensive revision.

The hope is that the PRO-2004/5/6's built-in Electronic BPF selector mechanism can be made to take on the added task of selecting antennas. The actual antenna switcher should be external to the scanner and best directly connected to the scanner's antenna terminal. The seven switching outputs from Q-501 thru Q-507 should be brought out the rear of the scanner and into the external antenna switcher. High speed switching diodes along with a few resistors, RF chokes and capacitors would complete the job. Wish to take a try at this? Be my guest! I think it can be done, and that it won't necessarily take an engineer to do the honors.

10. There are plenty of weird, far fetched or even whimsical things we could wish for, although I'm not sure that a practical approach is on the horizon. I'll list a few of my own favorites:

- A. CTCSS Tone storage or recognition on a per-channel basis.
- B. Automated "follower" for tracking trunked system activities.
- C. Low insertion loss Surge Protector for antenna terminal.
- D. Variable I.F. Shift and/or Pass Band Tuning.
- E. Front panel selectable I.F. bandwidths, 5 kHz to 100 kHz.
- F. Cloned CPU chips, programmed to do more and better things.

Those are some of my wishes. Why not add to that list? Or maybe you've already heard about a solution to something on this list, or something else new and exotic to use with the Realistic PRO-2004/5/6 or other modern scanners. If so, please share it with me. I welcome correspondence on all such matters. If you include a self-addressed, stamped envelope and one loose extra stamp, your letter will rise to somewhere near the top of the stack for a timely reply.

If You Run Into Trouble With The Modifications

If you hit a snag with any of the mods in this book or in Volume 1, I'll be glad to lend a helping hand with written suggestions for remedial measures. Please see HINT-1 in this book for details of how to get this assistance from me.

If You Can't Do The Work Yourself, Or Can't Find The Parts & Materials

This book is designed to make it as easy and inviting as possible for the average scanner user to do the modifications. Still, there may be a number of reasons a person can't or doesn't wish to do these mods in that manner. Or,

perhaps the spirit is willing, but there's a problem in rounding up all of the parts, tools, and other materials. Don't fret. All is not lost!

Can't do it yourself? My first suggestion is that you take this book to a competent friend, communications shop, or CB or scanner store and ask them to do the work for you. Not many professional two-way communications shops can do this type of work profitably. Shops that sell and repair scanners and/or CB radios will probably gladly do the work, and at a reasonable price. Perhaps you can find a friend that will do the job for a lot less, or for nothing more than just the cost of the parts alone.

If these approaches don't work out after several tries, my services are available on a mail order basis. I have been doing mail order servicing and mods on communications equipment since 1975, offering reliable service, quick turnaround time, and decent prices.

I recommend that before you actually ship any equipment to me, you first write and fully explain what equipment you have and what you want done. Provide as much information as possible. I'll get back to you with a written quotation or estimate, along with any available information relative to your needs. If and when you eventually ship equipment, it's best to use UPS ground or 2nd day air (depending upon urgency), and be certain to insure at par value.

Commtronics Engineering offers full repair, custom modification, design and engineering services for industry, and for hobbyists, in all areas of electronics and communications. We draw the line in that our work will not turn equipment into anything illegal, nor will we violate any laws or regulations. Please don't ask us to.

You can do the work, but need parts, materials, or kits: By and large, we can't obtain parts and materials any cheaper than you can if you shop around at your local stores or from mail order suppliers. In fact, we do incur considerable extra expense in the purchase, testing, stocking, handling, packaging, and reshipping-- and that must be passed along when people purchase parts from us. We aren't in the "parts" business, anyway, so it's highly suggested that you attempt to procure the necessities on your own. For your convenience, in most instances we have shown Radio Shack catalog numbers and other sources wherever possible. Unless we have specified otherwise, this doesn't mean that we require or endorse those those items or sources-- equivalents will usually work fine-- and you can shop wherever you please. But if you shop at any of the 7,000 Radio Shack locations, knowing their catalog numbers will save you some time, and you can also look up the items in their catalog to find out their specs and prices before starting a project.

But, if you just can't locate needed components, Commtronics Engineering can supply them at cost plus a margin for expenses and shipping. We have preassembled and tested circuit boards available for most of the mods shown in Volumes 1 and 2. Let us know what you need. Send a self-addressed, stamped return envelope with an extra loose stamp and we'll get back to you soonest. Please mark on your envelope: "Price Quote Request."

Updates? After a mods book is published, sometimes we come up with feedback from readers regarding new ways of doing things related to a particular mod. You can remain abreast of any developments that might evolve along these lines. Obviously, I can't personally correspond with all of the thousands of people who use these books, but periodically I prepare an informative brochure to list any news of interest relating to the mods. The brochure is changed as additional information arrives, typically two to four times each year. To receive a copy of this

newsgram, send me (at Commtronics Engineering) a self-addressed return envelope and one loose, extra stamp. Mark the outside of the envelope addressed to me: "Newsgram."

Be sure to keep abreast of late happenings in the national periodicals covering scanners. These include **Popular Communications** (76 North Broadway, Hicksville, NY 11801), **Monitoring Times** (P.O. Box 98, Brasstown, NC 28902), and **Popular Electronics** (500-B Bi-County Blvd., Farmingdale, NY 11735).

I suspect that these two **Scanner Modification Handbook** volumes have played a role in launching another revolution in the scanning hobby. Modifying electronic equipment in order to enhance its performance is nothing new, but who ever dreamed that the average scannist could take a soldering gun, clippers, and cutters to poke around at the innards of a computerized high tech scanner and significantly enhance its potentials? Until the Realistic PRO-2004 came out, even engineers didn't wander past their ankles into such deep waters. But the PRO-2004 was the gateway. Clip a diode and add entire bands. Add a diode for 33% more memory. Add another diode for 25% faster scanning speed. Wow!

Soon, more sophisticated mods followed, as engineers, technicians, and hackers decided that this scanner could do lots of other tricks. Moreover, virtually all of its tricks could be triggered by the average scannist! Then, as the Realistic PRO-2005/6 models appeared, even more ideas and mods were sparked. It didn't happen over night, but it did happen.

Somehow, I think that the wheels are turning now, and they're going to keep turning as new scanners arrive on the market. Who knows, maybe there will eventually be mods you can do on your TV set, stereo, VCR, and even the family sewing machine. Why stop at scanners? Hams modify their equipment all the time, so do CB'ers, and car owners, and lots of other folks. What's next?

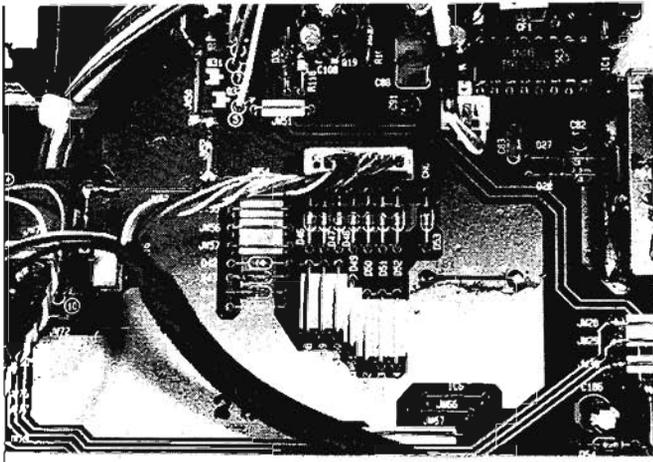
There is a universe of technology out there, and certainly I don't presume to have done more than contribute just a very little to adapting that technology to serving us better. Moreover, there have been others who have also produced excellent scanner mods and published them in the hobby press. So, although my own personal contribution is perhaps no more than a single grain of sand, remember it's not the singleness of that grain of sand that makes the difference. It can just sit there on the beach and never be anything more than an infinitesimal part of a dune. Or, with some effort and magic, it can become a pearl. It all depends on who does what with it.

At any rate, I hope that you will turn these grains of sand into pearls. What's more, I'm pleased that you have provided me with the opportunity to share them with you. And now, hackers arise! Grab your schematics and soldering guns! To work!

Note: No text, diagram, photo, modification, technique, method, procedure, or product in this book should be construed to imply any endorsement whatsoever of this book by any manufacturer or distributor of scanning receivers or related products. Neither does the mention or depiction herein of any commercial product or service indicate or imply any connection with, recommendation, or endorsement of those products and/or services or their manufacturing, importing, service, or sales/distribution facilities or agents by the author and/or publisher of this book.

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Bearcat and Regency are Registered Trademarks of Uniden Corporation of America.



MOD-35: Clip one leg of D-44 to restore locked out 800 MHz bands in the PRO-2022.

some manufacturers temporarily lock out the cellular bands before they put the units on sale. In many instances, it is very easy for the hobbyist to restore these locked out frequencies. The Realistic PRO-2022 is about the easiest scanner yet to restore the locked-out coverage. It should take about two minutes if you pay attention.

Steps of Procedure

1. Unplug scanner from power line. Turn scanner upside down and remove the top plastic case of the PRO-2022.

2. Locate the diode matrix containing several silicon switching diodes, D-42 to D-45. This diode matrix is located roughly in the center-front area of the main board. Specifically, look for D-44.

3. Clip an exposed lead of D-44 and push the cut ends slightly apart so they can't touch. Do **not** clip any other diodes or you will lose capabilities.

4. Reinstall the top plastic case. Plug in the power, turn the scanner on and program in any frequency between 870 and 890 MHz. If the scanner accepts and displays that input, you were successful. If not, then you cut the wrong diode.

If you should set up a SEARCH through the 869 to 894 MHz cellular bands, the scanner will automatically SEARCH in 30 kHz increments while in those bands. Stations operating in those bands are spaced at 30 kHz increments.

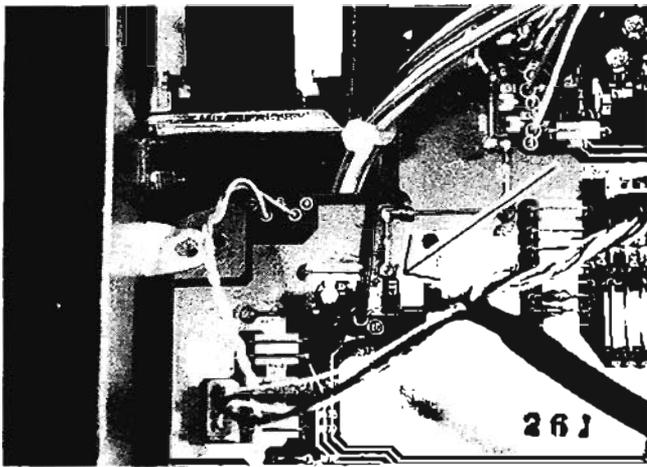
Note that the Realistic PRO-2022 is a virtual clone of the Realistic PRO-34 handheld scanner. The circuits and specs are practically identical, although the PRO-2022 has a few extra features such as a Tape Recorder Output jack, a lit display, and an AC power supply.

MOD-36

Revving Up The Speed Of The PRO-2022

PRELIMINARY DISCUSSION

The Realistic PRO-2022 uses a 2 MHz ceramic resonator to generate the Clock frequency for the CPU. Tests have shown that the resonator can be exchanged with another resonator or quartz crystal up to at least 7.37 MHz to achieve much better



MOD-36: For speeding up the PRO-2022, remove CX-1 and replace with a 4 to 8 MHz crystal or resonator.

than double the specified SEARCH and SCAN speeds of 20 or more channels per second. Stock resonators from the PRO-2004 and PRO-2005 (7.37 MHz) will work just fine here. Just be aware that increasing the clock frequency will shorten the DELAY function time from 2 seconds by the same percentage of the speed up. Otherwise, no problem.

Based upon a careful review of the schematics, it appears that MOD-28 in this book can work with the PRO-2022. When you speed up your PRO-2022 and discover that you've cut back on the DELAY, look up MOD-28 and give it a try.

The mod shown here (MOD-36) is proven and tested for the PRO-2022. If you follow the instructions, there's no reason why you should run into any trouble. I suspect that the specific type of quartz crystal is important, but I don't know which specifics work and which ones don't. The job isn't at all difficult, so if one crystal doesn't work, try another. I think your best bet will be for a standard "microprocessor" type crystal. CB crystals probably won't work, but I had joy with a 4.6 MHz crystal of unknown origin that was laying around my shop.

Radio Shack can special order most any type of crystal for you, but there is one they carry in stock that might work for this mod. Try their TV Colorburst Crystal, which runs at 3.58 MHz. For less than \$2, you can't really go too wrong. If it doesn't work, try something else. My 4.6 MHz crystal did just fine, so I'm pretty confident that you can go at least that fast if you don't mind the shortened DELAY function. Several recent reports from the hacker grapevine suggest that 7.37 MHz works, and produces a scan rate of 29 ch/sec!

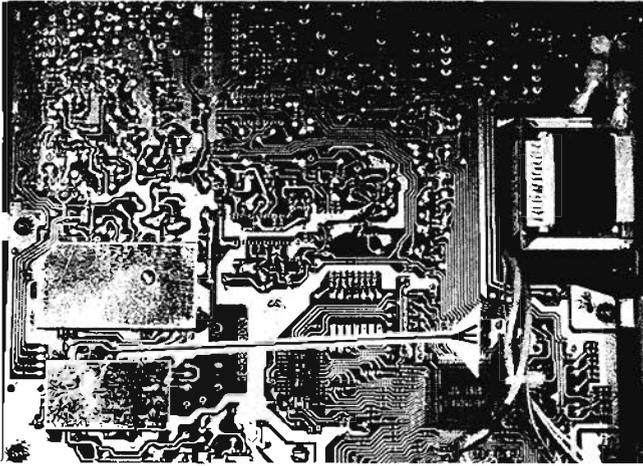
This mod is very easy to perform, thanks to all the space in which you have to work. So, if one crystal doesn't work, just pop it out and try another in a jiffy.

You'll need a soldering iron, desoldering tools, and basic hand tools. Before going further, it is important that you review the service manual pictorials and exploded views to become familiar with the project at hand.

Chances are that the scanner will retain its memory since you don't need to remove the memory retention battery. Still, as a backup, and "just in case," write down what you had programmed into the scanner.

Steps of Procedure

1. Unplug the scanner from the power line. Remove top and bottom covers of



MOD-36: Desolder CX-1 at the arrow. Disregard the center hole when installing the new crystal.

PRO-2022. Locate the CPU and Logic area of the main circuit board (use the service manual to help you with location of parts and various areas inside the set). The CPU and Logic area is on the **bottom** side of the main board and toward the rear chassis. It will be distinguished by the presence of a large chrome metal shield that covers the precise area you want to access.

2. Carefully desolder the chrome metal shield, one leg at a time. Exert a bit of upward pressure as you heat each leg and it will pop free when the solder melts. Remove and lay aside the chrome metal shield.

3. Locate and identify the 2 MHz resonator (CX-1). It's just forward of the CPU (IC-7), adjacent to Pins 1 through 5. CX-1 is a white rectangular component.

4. Desolder CX-1 from the opposite side of the main board. Use some desoldering wick to remove solder from CX-1's pins, and then lift and remove it from the board. Be careful to avoid shorting the soldering iron to the chassis or to other solder points in the nearby vicinity. Your soldering iron should contact only one CX-1 pin at a time.

5. Install a microprocessor crystal of your choice (4 MHz max recommended, though 7.37 MHz is known to work) at the spots where CX-1 was removed. If you haven't already done so, as long as you're inside the scanner, you might want to clip one leg of diode D-44 (located on the top side of the main board, just above the CPU, which is on the bottom side of the board). Cutting one leg of D-44 will restore operation on those 800 MHz frequencies that were locked out at the factory.

6. You can, at this time, plug the scanner into power, turn it on and make some basic performance tests to determine if the job was successful. If so, then turn it off, unplug from the power line, and reinstall the chrome metal shield. Reinstall the scanner's plastic covers, and you're back in business with a scanner that does its work with a lot more hustle than before.

7. If there's a problem, unplug the set from the power lines, then check and recheck all your work. If no errors, and no solder blobs or other problems are found, then it's a good chance that the crystal you selected is simply the wrong type. Desolder it and temporarily resolder CX-1 back into place. Run performance tests. If everything works, then obviously the job calls for a different crystal. This process of trial and error is neither time consuming nor beset with problems because of the spacious interior of the PRO-2022.

8. If the reduced DELAY is a bother to you, see MOD-29 and adapt it to your needs. Refer to the specific PRO-2022 procedures given in that section.

3,200 Channels For Your PRO-2022

PRELIMINARY DISCUSSION

The Realistic PRO-2022 has essentially the same electronics as the PRO-34 handheld. I have already added 3,000 memory channels to the PRO-34, so why not the PRO-2022? The PRO-2022 uses the same 2K X 8 Static Random Access Memory (SRAM) chip as the PRO-34 and the PRO-2004/5/6 and it's located out in a wide-open area having easy access. In fact, it's a pleasure to work inside the spacious PRO-2022 because it's so roomy in there. This mod is a relative snap.

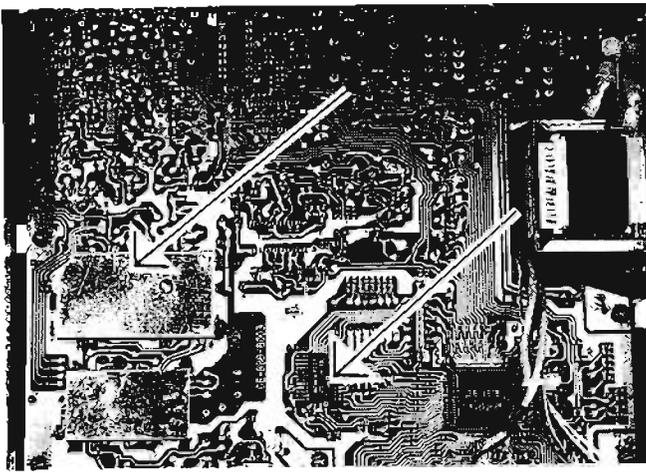
Getting Prepared. For this mod, you'll find that a copy of Volume 1 of the **Scanner Modification Handbook** will be an asset because it will allow you to become thoroughly initiated with the concept of memory expansion. You will require one previously assembled Extended Memory Board (EMB) as fabricated from detailed instructions in Volume 1 (MOD-16, page 131)-- or I have ready-made (and tested) ones available at only slightly more than the cost of buying and assembling the components yourself. If you decide to build your own, be sure to see the revisions here in Volume 2's Review Section for Volume 1's MOD-16. I would also suggest as being most helpful, reviewing Volume 1's MOD-19 (starting on page 148), which features 3,200 programmable memory channels for the PRO-34 handheld. That information and mod will be directly adaptable to the PRO-2022 since the scanners are so similar (although working in the more spacious PRO-2022 will make the job easier). Volume 1 is available from the dealer where you obtained Volume 2, or, if not, then contact the publisher directly: CRB Research Books, Inc., P.O. Box 56, Commack, NY 11725, and request information on ordering a copy.

You'll also need a copy of the service manual for the PRO-2022, obtainable from Tandy National Parts Center.

You will need to determine which memory address switching scheme you want to employ for this mod. There's the conventional 4-segment DIP Switch arrangement (or equivalent) described in Volume 1's MOD-16. There's also this volume's Keyboard Block Controller (MOD-28). Make that decision early in your planning for this mod. Should you opt to use external switches to control the sixteen blocks of 200 channels each, then you'll need to decide where to install those switches-- be it on the front panel somewhere on the rear panel.

In this mod, use only Radio Shack #278-776 Double Shielded Multiconductor Cable for hookup wires in this project. Buy a couple of feet of this cable and salvage the 25 individual wires for use as hookup wire. Use this for interconnection to the EMB as well as for all other hookup needs. This is good advice.

Application Theory of This Modification: Adding 3,000 channels to your PRO-2022 isn't going to be the nightmare you might suspect. It's just that there are a number of mechanical steps to getting there. Overall, you're just going to replace a surface-mount 24-pin, 2K X 8 SRAM chip with a larger DIP 28-pin, 32K X 8 SRAM chip. Twenty-four pins of the new chip will be connected to the 24-pins of the old chip (more or less), and practically pin-for-pin (though the numbers are offset). The four remaining pins of the new chip are simply memory block address pins and are connected to four separate switches for a total of sixteen switching combinations. Each different combination of the sixteen settings yields 200 programmable channels. Multiply 200 X 16 and you get 3,200 channels! It's almost like having sixteen 200-channel scanners side-by-side, except that you can run only one at a time. Now, to work!



MOD-37: Arrow at mid-left shows good location (on shield) for the EMB. Arrow at lower-center shows where to remove IC-6.

Steps of Procedure

1. When everything is ready, including the EMB, desired switching arrangements, all necessary documents, tools and materials, the first step is to unplug the scanner from the power line. Then, remove the top and bottom plastic covers of the PRO-2022. Locate the Logic and CPU area of the main circuit board. Use the service manual to help you with locating the various components and areas in the PRO-2022. The CPU and Logic area is on the **bottom** side of the main board and toward the front panel. It will be easily spotted by the large chrome metal shield that covers the precise area you want to use for access.

2. Carefully desolder the chrome metal shield, one leg at a time. Exert a hint of upward pressure as you heat each leg and it will pop free when the solder melts. Remove the chrome metal shield and set it aside for now.

3-A. Locate and identify the SRAM memory chip (IC-6), which is located in the area from which the metal shield was just removed. IC-6 is a 24-pin, surface-mount chip in the approximate center-front area of the bottom side of the main board. The memory chip must now be removed. You'll need some desoldering wick (Radio Shack #64-2090, or equivalent). Lay some wick along a row of pins on one side of IC-6, and heat the braid over each pin, one at a time. You'll see where the solder on the pins will get absorbed by the wick braid. Repeat this procedure for the row of pins on the other side of IC-6.

3-B. Some hackers prefer to just destroy this chip by snipping all of its pins just above the solder pads, then remove the carcass of the chip, which comes loose after all the pins are cut. Then the cut pin-ends are desoldered from the solder pads. This method offers better assurance against damaging the solder pads than the above described procedure. Yes, IC-6 gets sacrificed in the process, but if you ever need one again it's available from Tandy National Parts for only about \$6-- whereas a permanently damaged circuit board costs a lot more than that. Decide which method you prefer.

4. Slip a medium sewing needle underneath the pins on one side of IC-6 and reheat each pin, one at a time. One by one, the pins along that row will pop free. Be very gentle with the upward pressure of the sewing needle to prevent the solder pads from ripping loose. Repeat this procedure for the pins on the other side of IC-6. Lift IC-6 out and store it in a safe place.

Take care not to damage the solder pads of IC-6. Don't force IC-6 loose. When it has been desoldered correctly, it will pop free from the solder pads with a gentle upward pressure from the sewing needle. As you exert that gentle upward pressure with the sewing needle, it might help you to run the tip of the soldering iron along the row of pins at the same time.

5. Use the desoldering wick one more time on the now-empty pin pads of IC-6 to clean things up.

6. Now you must install the previously assembled EMB somewhere. You pick a spot of your liking where maintenance won't be hampered by the EMB and its wiring bundle. Another objective is to keep the wiring bundle as short as possible, like not more than 8" long, and preferably 6" or so. Of course, the wiring harness for the DIP or other switching arrangement can be as long as you need-- only DC is switched, so length isn't important. But the length of data wires is important.

For installing the EMB, you can use Radio Shack's #276-195 Standoff Studs, which are a perfect mounting accessory. You may want to cut one in half and then solder the cut end to a nearby sidewall of the metal chassis, or for that matter, you could screw it to a metal sidewall. I suppose you could even solder the cut end of a standoff to a PC board trace somewhere nearby where there's room. Use lock washers on any end of the standoff where a screw is used. You don't want that board coming loose at an inopportune time.

7. Connect the 24-wire bundle from the EMB to the now-vacant spot for IC-6. Study that area closely and look for nearby (but better spaced or unused) solder pads instead of the IC pin pads which are so closely spaced. Undoubtedly you'll have to use some of the pin pads, but there are better spaced solder points down the traces. Look for them and use them whenever possible.

Figure out a pattern in which to solder the EMB wires to the vacant IC-6 pads. Judging from the service manual, it appears that you might want to begin at IC-6's Pin 24 and work backwards to Pin 13. Then start the second row at Pin 1 and work in ascending order. Use the diagram in Volume 1 (MOD-16, page 131) as a connection guide-- merely substitute "IC-6" wherever it mentions "IC-504."

IC-6's Pin 12 is circuit board ground, so the wire from EMB Pin 14 can go to any ground spot near the EMB. It doesn't necessarily have to go to Pin 12. The shorter that wire, the better. The PRO-2022 doesn't use IC-6's Pins 14, 15, 16, and 17, therefore the wires from EMB Pins 16, 17, 18, and 19 can be clipped since they're not needed in the PRO-2022. That saves a few steps.

8. After the EMB wire bundle has been soldered to the IC-6 pads, the last step is to connect the switching arrangement to the EMB's Pins 1, 2, 23, and 26 (per the diagram in Volume 1, MOD-16, page 131). If you decided to do the Keyboard Memory Block Controller (MOD-28), then follow the explicit instructions in that section here in Volume 2. When the switching arrangement is connected, you're ready to plug the new memory chip into the EMB if not yet done. Then you're ready for a system test. Use the programming chart in Volume 1 (MOD-16, Table 4-16-4 on page 141) to enter a Block ID number into Channel 1 of each of the 16 Blocks. The actual number you'll program into each Channel 1 will differ from that shown in the Table because the PRO-2022 can't program 1000.000 MHz, etc. In this case, begin with 900.000 MHz, 901.000 MHz, etc., through 915.000 MHz.

9. Conclude this project by picking up with Step 56 in Volume 1's MOD-16

(Page 140). Also read the preliminary discussion for the PRO-34 on pages 148 and 149 of Volume 1. It is relevant because the PRO-34 and PRO-2022 are clones of one another.

Now your PRO-2022 is a 3,200 channel super-scanner! Now you've got plenty of room to program in test bands, and all of those oddball frequencies that have interested you but you never had the available empty channel space to explore. You'll find value in Volume 1, the section beginning on page 48, which will give you good insight on how to best utilize and manage a scanner with 3,200 channels.

MOD-38

Revving Up The Speed of The PRO-34

PRELIMINARY DISCUSSION

The Realistic PRO-34 handheld scanner uses a 2 MHz ceramic resonator to generate the Clock frequency for the CPU. Tests show that the resonator can be exchanged with a quartz crystal up to at least 4.6 MHz to obtain twice the specified SCAN and SEARCH speeds to around 16 ch/sec. A 7.37 MHz ceramic resonator salvaged from a PRO-2004 or PRO-2005 can be used for even faster speeds. But note that increasing the Clock frequency will shorten the DELAY function. In the PRO-2004/5/6 there was ample room to counteract this by installing a DELAY EXTENDER, but that's probably not feasible in the condensed PRO-34. The normal DELAY function can be expected to shorten from about 2 seconds to about 1 second if a 4 MHz crystal replaces the Clock frequency resonator (CX-1).

Precautionary Note: This mod has not been extensively tested for the PRO-34. If you attempt it, it's possible that you could sail into uncharted territory and encounter serious trouble. I tried it once without success. Another hacker tried it and was successful. Then another time, I was successful. The reason I am including the idea and procedures here is because the PRO-34 is electrically the same radio as the PRO-2022 base scanner, and that unit speeds up quite easily, and is modified routinely. The mechanical approach is what distinguishes the PRO-34 mod from the PRO-2022 mod. There are at least three ways to approach this mod and all are discussed here to make it as easy as possible for you.

Radio Shack can special order most any type of crystal for you, but they already carry one that might work for this mod. Try the TV Colorburst Crystal, which operates at 3.58 MHz. It's less than \$2, so you can hardly go too wrong. I used a 4.6 MHz crystal in my PRO-2022 to speed it up, so I'm fairly confident that you can run a PRO-34 up that fast so long as you can live with the shorter DELAY.

The hairiest part of this mod is the major mechanical and electrical disassembly necessary to get at the ceramic resonator (CX-1) which you're going to replace with a quartz crystal. If you're patient and careful, you'll taste victory. One of the reasons for my failure was my haste to complete the procedure because I wanted to retain the 2,000 frequencies I had stored-- yes, I did the 3,200 channel expansion mod). Therefore, I tried only one way at first and any of several things could have caused my downfall. When it didn't work the first time around, I restored everything back to normal and then went on to other endeavors. Later, I tried it again and had success. Your situation could be different. For one thing, you probably won't have 3,200 channels like I do, and if your scanner gets amnesia, reprogramming a mere 200 channels is a stroll in the park. So, you won't be in a hurry, as I was.

You'll need a soldering iron, desoldering tools, small wire cutters, a small adjustable wrench or various miniature open-end wrenches, small-tipped phillips screwdriver, and something with which to pry. Before actually doing anything, review the service manual pictorials and exploded views to familiarize yourself with the territory in which you'll be working.

Caution: Chances are that you PRO-34 will retain the memory if the work is completed within a half hour or so. Memory is sustained by a large internal capacitor for when the batteries are removed. As a backup, it's best to write down any important frequencies you had programmed just in case memory is lost.

Steps of Procedure: Disassembly

1. Remove the antenna, battery pack, and the VOLUME and SQUELCH knobs. You might need pliers to pull the knobs off.

2. Remove the four **small** phillips screws from the rear cover.

3. Starting at the battery-pack end of the radio, pry the back cover loose. Do not pry at the top-- it's snap-hinged there. Swing the back cover up in an arc from the bottom end while pushing toward the top of the radio. The "hinge" at the top will work loose and the rear cover can be worked off over the antenna connector and the VOLUME and SQUELCH shafts. Lay the rear cover aside.

4. Loosen and remove the four hex shaft/spacer screws from the upper exposed PC board.

5. Note the VOLUME control and the two bare wires going from it to the circuit board. Desolder those bare wires **at the circuit board** and push them up out of the way against the body of the volume control.

6. Locate the antenna connector where it solders to the circuit board in two places. Desolder the antenna connector ground lug from the circuit board and bend it back out of the way. Use a solder sucker to remove the solder blob at the center conductor of the antenna connector at the circuit board.

7. Looking at the rear of the radio (exposed circuit board) with the antenna pointed up, locate the small, bare ground wire on the right side of the radio, about halfway down from the top. Actually, it's at the lower-right corner of the exposed circuit board. This wire connects the metal can of a small transformer to a metal shield cover beneath. Desolder that wire from the metal shield cover.

8. Follow the mini green, yellow, and black wire bundle from the VOLUME control to the little BROWN connector on the exposed circuit board. Disconnect that brown connector. Follow the mini red, white, and black cable from the SQUELCH control to the little WHITE connector on the circuit board. Disconnect that white connector. Position both wire bundles back and up over the VOLUME and SQUELCH controls out of the way.

9. On a left-to-right line, about where the little BROWN connector is located (described in Step 8), carefully and gently pry up the exposed circuit board. It's held in place from beneath by a hidden connector. Use a small flat object to pry with, using the sides of the plastic case as a fulcrum and pry only near the top end of the board on either side where two brass hex shaft/spacer screws were removed. If you look on the board on the line of the BROWN connector, you'll see a line of "pins" which are the backside of the connector that has to be pried up. You'll feel a little "give" as the board works up, you'll be able to see the connector

hidden beneath the board. Continue working the exposed circuit board up, straight away from the body of the radio until it comes apart from the connector beneath. The entire upper board should now be free and placed aside in a safe place.

10. Hold the shield cover now fully exposed within the body of the radio. It must be removed. That shield is held in place by three small phillips screws, one at the lower edge of the shield next to the battery compartment, and the others, one on either side of the shield cover near the upper end of the shield cover. Remove those three tiny screws and lift the shield cover out of the way to expose the CPU and Logic Board underneath. The shield will not come completely free because of some wiring and the PWR and CHG jacks. Remove the small connector with the red/white wires from the inner circuit board that goes to the now-removed shield body. Now flip the shield cover over and let it lay there next to the radio. You'll now see the CPU/Logic Board laying inside the front plastic case. **Do not** remove it from the front case at this time. See HINT-3 in this book for what to do here if your PRO-34 has this metal shield held in place by spot welds instead of by screws.

Doing The Work

11. If you haven't yet performed the mod to unlock the cellular frequencies, you may wish to do it at this time. Observe to the left side of the Logic and CPU Board (the side opposite the PWR and CHG jacks), and locate diodes D-10 and D-11. These are on the extreme left edge of the Logic Board, and just to the left of IC-2. Clip the exposed leg of D-11 (only) and spread the cut ends slightly apart so they can't touch. Don't fool around with D-10 or you'll lose 900 MHz! With D-11 clipped, you will have restored the PRO-34's full frequency coverage.

12. Back to the speed-up mod. Examine the now-exposed Logic/CPU Board, and locate the ceramic resonator, CX-1. It's a rectangular, white component located on the opposite side of the Logic/CPU Board from the diode matrix containing D-10 and D-11. That (CX-1) is the thing that has to come out and be replaced by a quartz crystal. There are three approaches, 13-A, 13-B, and 13-C.

13-A. The Hairiest Approach. Locate the two remaining screws that hold the Logic/CPU Board to the front plastic case. They are located down at the battery compartment end of the board. Remove these two screws and gently lift the Logic/CPU Board out of the front case. Flip it over and note that chrome metal shield that covers the solder connections of CX-1. Desolder that shield, if you want (I didn't), and then desolder and remove CX-1. Solder in the quartz crystal of your choice, making sure that it lays flat on the Logic/CPU Board. Resolder that chrome metal shield back into place on the bottom side of the Logic/CPU Board. Reinstall the Logic/CPU Board in the plastic front case. Install and tighten the two screws. Move to Step 14.

13-B. A Possible Approach. This is the way I tried. Locate the CPU's (IC-1) Pins 5 and 6. These two pins connect the traces that run over to CX-1, so if you slit one of those traces between CX-1 and IC-1, that effectively disconnects CX-1 from the circuit. I decided to slit the trace that goes to IC-1's Pin 5. Use microsurgery techniques and solder a very fine wire to Pin 5 of IC-1 and another fine wire to Pin 6. Lay your quartz crystal down flat against the Logic/CPU Board in the nearly-vacant area between CX-1 and a nearby 16-pin chip (IC-8). Solder the fine wires from Pins 5 and 6 of IC-1 to the quartz crystal terminals. Place a piece of tape across the quartz crystal and nearby parts to keep it from moving around. Go to Step 14.

If Step 13-B doesn't work out for you, you can always go back and solder a bridge across the trace that you cut to isolate CX-1 from the circuit. That's what I had to do. My failure may have been due to faulty solder joints of the fine wires to Pins 5 and 6 of IC-1. Because I didn't want to risk too much heat on IC-1's pins, I may have been so overly-cautious that I created a cold joint.

13-C. Yet Another Approach? I'm a bit hesitant about this approach, but it has a lot of merit if you're willing to do some intentional damage. Prepare for this one by having a spare ceramic resonator (CX-1) on hand to replace if the crystal doesn't work. The resonator is available from Tandy National Parts-- specify that you have a PRO-34 (catalog #20-135) and you want to order "CX-1," which is part #EFO-FC2004A4.

When you have the spare CX-1 sitting on your workbench, then you can literally destroy the one that's in the circuit. Use something like a diagonal cutting pliers to cut CX-1 in half. Then crush each half, perhaps with a regular pliers until all that's left of CX-1 are its solder terminals. Is this fun, or what? Now, you can solder your quartz crystal to these exposed outer two solder terminals and proceed to Step 14. Note: The center point of the three is ground. Ignore it.

This approach has a lot to be said for it, although I didn't personally try it. You need not cut any traces, there's no direct soldering to the CPU, the Logic/CPU Board doesn't have to be removed from the case, and the chrome metal shield doesn't have to be removed. Each of those things not having to be fiddled with reduces the chances for Murphy's Law becoming a factor in the proceedings.

Reassembly

14. Hold the metal shield cover over the scanner and reconnect the cable with the red/white wires to the connector on the Logic/CPU Board. Carefully replace the metal shield cover so that it aligns with the three screw holes. Replace and tighten the three screws.

It would probably help a lot to magnetize the shaft of your phillips screwdriver for this operation. Just wipe or stroke a magnet along the shaft in one direction only about 6 to 10 times. The screwdriver will then hold the tiny screws on the point so you can more easily align them with the holes in the shield cover. Tighten the screws.

15. Gently reposition the top circuit board over the metal shield cover and then adjust the position of the board so that its male connector pins on the bottom side align perfectly with the matching female connector on the Logic/CPU Board. When the pins are aligned, work the upper circuit board until it seats. It may help to press with your thumbs directly over the connector pins.

16. Replace and tighten the four hex shaft/spacer screws.

17. Bend the two wires from the VOLUME control jack back down to their spots on the circuit board and resolder them to the board.

18. Resolder the antenna connector's ground lug back to its spot on the circuit board.

19. Resolder the center conductor of the antenna connector back to its spot on the circuit board. There's a gap between the antenna connector center pin and the solder spot on the board that might be very difficult to fill with solder without excessive heat and contact time. So, position a small bare wire about 3/16" long

across the gap and then solder. There was was such a wire present when you desoldered that spot, but it probably got lost and you might not have noticed it, anyway.

20. Resolder the interconnecting ground wire removed in Step 7.

21. Replace the rear cover, hinging it at the top first, before swinging the cover down into place. It will snap back into place with a little pressure applied along its length on both sides.

22. Replace the knobs, battery pack, and the battery compartment cover.

23. If you performed the frequency restoration mod in Step 11, test the unit by programming the limits 868.500 and 894.000 MHz into the SEARCH bank. The scanner should accept this programming and function on these frequencies. Then, use a watch to test the SCAN speed. Speed, in ch/sec, equals the number of channels divided by elapsed time.

Don't check the scanner's speed using blank channels because you'll get a false indication of high speed. It seems the CPU knows which channels are blank and samples them at a much faster rate than the channels that are programmed. The SCAN and SEARCH rates slow down to the proper speeds when the channels are filled with actual frequencies. So, program in at least twenty channels' worth and then run SCAN BANK #1 for five to 10 cycles while timing the interval with a stop watch. If you SCAN 20 channels 10 times, that's the same thing as scanning 200 channels once.

Feedback: If You were successful at this mod, please drop me a note and let me know which method you used, and the overall nature of the job. If you had any problems, let me know that, too. If you want a personal reply, please enclose a business sized SASE and one loose extra stamp. Write to me at: Bill Cheek, Commtronics Engineering, P.O. Box 262478, San Diego, CA 92196.

MOD-39

Double The Battery Power For The Uniden BC-200XLT & BC-100XLT

PRELIMINARY DISCUSSION

Damaged or abused battery packs can result in diminished operating time between recharges. If your BC-200XLT has a good battery pack but gives a very short time between recharge cycles before the "Low Battery" indicator comes on, there are a couple of quick fixes that you can do yourself. Of course, you could also contact Uniden and see if they'll correct the situation at no cost under the set's warranty, but that involves sending away your scanner. You don't mind if it's a major disaster, but this problem could be easily corrected without shipping the set away.

I assume you have the service manual to guide you through these procedures.

Method #1 - The best way:

1. Disassemble the scanner down to the lowest board. See disassembly procedures under other BC-200XLT modifications in this book.

2. Replace D-203 and R-208. It seems that D-203 is the main ogre in the problem of short battery life, and a new one should be obtained from Uniden's Parts Department. Ask for part #HZK3C LLO1TR. I don't know what this zener diode would cross reference to, but if you know (or can find out), the common replacement should be just as good.

R-208 may or may not be OK. While you're in that area, however, it's a good idea to replace it with a known value of 150,000 ohms.

3. Reassemble using procedures given under other BC-200XLT mods in this book. Fully charge the battery pack doing a before/after comparison test.

Method #2 - The next best way:

1. Disassemble the scanner down to its lowest board. See disassembly procedures given under other BC-200XLT mods in this book.

2. Locate R-208 and D-203. Remove these two components from the circuit board.

3. Reassemble using the procedures given under other BC-200XLT mods in this book. Fully charge the battery pack prior to doing a before/after comparison test.

Method #3 - Questionable:

1. Disassemble the scanner down to the lowest board. See disassembly procedures given under other BC-200XLT mods in this book.

2. Locate D-203. Solder a very short jumper wire across D-203, effectively shorting it out.

3. Reassemble using procedures given under other BC-200XLT mods in this book. Fully charge the battery pack, then do a before/after comparison test.

Methods #2 and #3 both disable the "Low Battery" indicator and allow the scanner to operate continuously for 6 to 8 hours without interruption until the delay blanks out. When this happens, the battery pack should be recharged as soon as possible to prevent loss of memory.

More Ideas: Even if you aren't having any problems with a short recharge time on your BC-200XLT (or BC-100XLT), you may note that the set's battery pack has been damaged, or is simply getting a bit long in the tooth. It might be time for a new battery pack. It happens, they don't last forever. Or, if you rely upon your scanner heavily, or during emergency situations, you should think about getting a second battery pack as a backup or spare. You can use it while the other one is recharging. These are available from Uniden and its dealers.

An alternative you could also consider is a rather potent replacement battery pack that is rugged and heavy duty. It is designed to double the operating time (between charges) for a BC-100XLT or BC-200XLT, yet it fits perfectly into the case of either scanner in the existing battery compartment. It's called the "MetroWest Pro Pack 1200." I've tested this battery pack on the bench and found that it produced over 100-ma. at voltages within specs for a period of 12 hours. In actual use, the "Low Battery" indicator in the BC-200XLT is set to turn on when the battery terminal voltage decays to between 6.5V and 7.2V, so you may not get a full 12 hours of operating time out of it (depending upon the tolerances of your particular unit), but it should still (at the very least) double the time over

whatever you had before. Another factor that will affect battery operating time is the ratio of unsquelched to squelched time, since the scanner draws more current when signals are being received than when squelched and quiet. I have heard unconfirmed reports of operating times of more than 17 hours using this battery pack. For more information on the "MetroWest Pro Pack 1200," contact: MetroWest, 822 North Spring, LaGrange Park, IL 60525.

MOD-40

Another Cellular Restoration Procedure For Uniden BC-200XLT & BC-205XLT

PRELIMINARY DISCUSSION

Note, before going further, that Uniden (as other scanner manufacturers) strongly urges customers not to modify its products. Modifications will void the manufacturer's warranty and product liability.

It seems that there are two production varieties of the BC-200/205XLT, an "early" version, and a "later" variant. I don't know how to tell the difference, based either upon external appearance or serial number. Still, in some cases the MOD-21 in Volume 1 doesn't work in restoring factory locked-out 800 MHz frequency bands.

I did some snooping around and came up with an alternative approach that is tested and proven to work. If you have a BC-200/205XLT, regardless of age, serial number, or early/late version, and are determined to attempt to restore the factory blocked 800 MHz frequency bands, then it is suggested that this alternative procedure be tried before any other method. If it doesn't work, then try the version given on MOD-21 (page 152) of the **Scanner Modification Handbook**. Also, this procedure is less ruinous than MOD-21.

Steps of Procedure

1. Disassemble BC-205/205XLT to access the microprocessor (CPU) area.
 - 1-A. Slide off the battery pack.
 - 1-B. Remove the two screws from the rear of the scanner and the two screws that hold the battery retaining the spring at the base. Then remove the spring.
 - 1-C. Carefully pry the bottom of the rear cover from the scanner and remove the cover,
 - 1-D. Locate the two small screws at the base of the circuit board and remove them. Gently pull the front panel from the main frame at the base and separate them.
2. Locate the leadless 10K resistor (brown/black/orange) just above the "den" portion of the **Uniden** logo on the CPU chip, a UC-1147.
3. Solder one end of a small ($\frac{1}{4}$ -w. or less) 10K resistor to the **left** side of the 10K resistor you located in Step 2 where R-215 connects to Pin 40 of the CPU.
4. Solder other end of 10K resistor to Pin 8 of nearby "K-1013" chip (IC-206, Pin 8). Chip is above and slightly to the right of the 10K resistor.

Beware the small screw in that vicinity and don't ground the 10K resistor against it!

5. Reassemble: Insert top of the front panel into the slot under the VOLUME/SQUELCH control panel. Carefully noting the alignment of the dual in-line connector at the bottom of the board with the mating socket, press the front panel firmly into place. Be sure that the holes at the bottom of the circuit board line up with the holes in the plastic standoffs below them. Insert the two screws and tighten.

6. Replace the rear cover by inserting the top of the cover into the slot under the VOLUME/SQUELCH control panel. Press cover into place. Insert and tighten the screws.

7. Reposition the battery retaining spring (slotted side toward notched hole). Insert the two remaining screws and gently tighten them.

8. Slide the battery pack into place. Switch scanner ON to ensure that the display comes on. If not, the battery may be discharged or the dual in-line connector was misaligned during reassembly (Step 7). Assuming the display comes ON, press MANUAL : 880.0 : E -- within two seconds, 880.000 should appear in the display.

If this doesn't happen for you, before you decide to try Volume 1's MOD-21, thoroughly check your work on the job just completed.

MOD-41

Speeding Up The Scan & Search Rates In The Uniden BC-200/205XLT

Speedups are very fashionable these days, and we have shown you how its done in several popular scanners. Replace the Clock Oscillator resonator with a quartz crystal at up to double the frequency, and you're in business at double the scanner's previous scanning speed. Impressive, with the slight glitch that the duration of the DELAY function is cut in half.

We haven't yet discussed speeding up the BC-200/205XLT. For the inspiration leading up to this mod, and for additional valuable information, I am indebted to Brent Combs, of Springfield, OR. Brent asked me if a speedup could be done to the BC-200XLT. He also supplied me with the service manual. I sent him some suggestions, which he employed along with considerable initiative of his own and then prepared a comprehensive report on the results. I'd like to point out that I found it very impressive that Brent is a junior in high school, and has (as yet) had no formal training in electronics. Here's what Brent and I found to be the best approach to this mod:

Specific Discussion: Imagine my surprise, after being accustomed to Clock Oscillators that run anywhere between 7 and 12 MHz, to find that the resonator in the BC-200XLT loafs along at a leisurely 400 kHz! A surprise and also, at first, a formidable obstacle. Probably 400 kHz was selected to minimize "birdies," since the Clock frequency and up to the tenth harmonic (octave) will show up as "birdies" in all scanners if within their tuning range. The tenth harmonic of 400 kHz is 4 MHz, and far below the tuning range of the BC-200XLT.

To obtain any appreciable speed increase, I knew that we had to double the Clock frequency to around 800 kHz. But how? Has anybody seen an 800 kHz quartz

crystal? Most crystals at that frequency are good for seeing into the future at carnivals, or for strapping to your ankle for a training weight. Fortunately, there's a company that manufactures small ceramic resonators of many types and kinds, and they just happen to have one right smack on 800 kHz. There are probably other sources, but this was the one I located and you can check directly with them regarding their wares. They are: Murata-Erie North America, Ltd., 1140 Franklin Rd. S.E., Marietta, GA 30067.

In lieu of a ceramic resonator, a quartz crystal cut for 800 MHz should still work well, providing it will physically fit. Try electronic surplus stores, and other electronic supply firms. Don't accept anything larger than about $\frac{1}{2}$ " long by maybe $\frac{1}{2}$ " wide by approximately $\frac{1}{3}$ " thick. Well, low frequency crystals can get bulky. Anyway, obtain some kind of small crystal or ceramic resonator in the 600 to 800 kHz range, depending upon how fast you want to go and how short a DELAY you can tolerate, then proceed as follows:

1. Disassemble the unit to access the microprocessor (CPU) area.

- 1-A. Slide off the battery pack.

- 1-B. Remove the two screws from the rear of the scanner and the two screws that hold the battery retaining spring at the base. Then remove the spring.

- 1-C. Carefully pry the bottom of the rear cover from the scanner and remove the cover.

- 1-D. Locate the two small screws at the base of the circuit board and remove them. Gently pull the front panel from the main frame at the base and separate them. If you separate them slowly, you'll notice a dual in-line connector hard-wired between the two layers. Remember that for later reassembly; the pins will have to be lined up perfectly before you slip the sections back together.

2. Search around the Logic/CPU Board (Uniden calls it the "MICOM PCB Assembly"), and locate Y-201, which is a little rectangular component. This is the stock 400 kHz resonator. Your replacement can be a bit larger, if necessary, but not grossly so.

3. Carefully desolder and remove Y-201. Put it in safekeeping because you may want it for something else someday.

4. Install (solder) your newly procured replacement Clock resonator, be it a crystal or another ceramic resonator, in place where Y-201 came out.

5. Reassemble: Insert top of the front panel into the slot under the volume/squelch control panel. Carefully noting the alignment of the dual in-line connector at the bottom of the board with the mating socket, press the front panel firmly into place. Be sure that the holes at the bottom of the circuit board line up with the holes in the plastic standoffs below them. Insert the two screws and tighten them.

6. Replace the rear cover by inserting the top of the cover into the slot under the VOLUME/SQUELCH control panel. Press cover into place. Insert and tighten the screws.

7. Reposition the battery retaining spring (slotted side toward notched hole). Insert the two remaining screws and gently tighten them.

8. Slide the battery pack into place. Switch scanner ON to ensure that the display comes ON. If not, the battery may be discharged or the dual in-line connector might have been misaligned during reassembly (Step 5). Another possibility would be that the new resonator either doesn't work, is unsuitable, or may have been incorrectly installed. Another possibility (if you installed something greater than 800 kHz) is that it's just too fast.

Assuming that the display comes ON, leave the antenna disconnected, and run a speed test. Speed in channels-per-second equals the number of channels scanned divided by time (in seconds). Using a Murata-Erie 800 kHz ceramic resonator, Brent Combs clocked the BC-200XLT's scanning speed at 43 ch/sec.

In addition to the shortened DELAY time, Brent Combs reports one additional side effect. The panel lamp will "time out," and that's also controlled by the Clock Oscillator. Doubling the Clock frequency, halves the LIGHT ON time.

MOD-42

Another Cellular Restoration Procedure For The Uniden BC-760XLT & BC-950XLT, & The Regency R-1600

PRELIMINARY DISCUSSION

There are apparently two production varieties of the BC-760/950 in circulation, an "early" version, and a "later" variant. I don't know how to differentiate the versions based on serial numbers, but the earlier units have a rear deck hole that accepts a so-called "Motorola" type antenna connector, while the later units have a BNC type antenna connector. In some cases, the MOD-20 (in Volume 1) fails to work-- probably on the later units. I have an alternate approach that is tested and proven.

If you have a Uniden Bearcat BC-760/950XLT, or a Uniden Regency R-1600 (they're all the same), regardless of age or version, and if you are determined to restore the 800 MHz bands blocked at the factory, then it is suggested that you try this approach first. If it doesn't work for you, then you can try MOD-20 in Volume 1 (page 152). This procedure is less destructive than MOD-20, anyway.

Should you decide to perform this or any other modification on your scanner, it voids the manufacturer's warranty and product liability. Uniden strongly urges against modification of its products.

Steps of Procedure

1. Disconnect scanner from AC power. Remove four screws and the covers. Turn unit over to expose the solder side of the main board.

2. Locate the exposed 24-pin surface mounted SANYO LC3517BM-15 or FUJITSU (F) MB-8416-20L chip near the front end of the scanner. This LC3517 or MB-8416 is for reference **only**. It will not be modified!

Note the two rows of 32 pins each of the much larger UC-1246 on either side of the Sanyo or Fujitsu chip. This is where the modification will be done. You'll have to flip the scanner over to actually see the UC-1246 chip, but all work is from the solder side.

3. Cut the two traces leading to Pin 26 of the UC-1246 chip. There is one trace on each side of Pin 26. Cut them both so that Pin 26 is totally isolated and not in contact with anything. The thicker trace that you will cut is circuit board ground and the very thin trace takes ground over to Pin 19.

4. Solder one end of a 10K resistor to Pin 26 of the UC-1246 chip. Solder the other end of the 10K resistor to Pin 32 of the UC-1246 chip. Watch out for shorts and solder blobs.

5. Solder-bridge one end of a $\frac{1}{2}$ " insulated wire across the two **vacant** solder pads next to Pins 19 and 20 of the UC-1246. This shorts Pins 19 and 20 together. Solder the OTHER end of the $\frac{1}{2}$ " wire back to the part of the circuit that was cut away from Pin 26-- not the thin trace, but the thicker one. Note: This spot is circuit board ground, so if you find a handier ground spot which to connect the $\frac{1}{2}$ " wire from Pins 19 and 20, that's just fine. But watch out for shorts, solder blobs, and errors. Recheck your work.

6. Plug into AC power. Turn unit ON. Press MANUAL : 880.0 : E : and if 880.000 appears in the display, great! If not check for errors. Then, press MANUAL : 868.500 : LIMIT : 894.000 : LIMIT : SEARCH. Observe that the unit performs a complete SEARCH from the lower limit to the upper limit. If not, check for errors in your work.

Should this approach not work, and no fault is found in your workmanship, then try MOD-20 on page 152 in Volume 1 of the **Scanner Modification Handbook**.

Conclusion

Those are the mods for Volume 2. Will there be a Volume 3? It depends on several factors, one of them being **you!** The great reception and popularity of Volume 1 brought about Volume 2. If there's a brisk demand for Volume 2, then that goes a long way towards being a factor in bringing about a Volume 3. But there's more.

Supply is another factor. All the demand in the world without an adequate supply doesn't get anything done. It's called, "You can't pump water out of a well that's gone dry." The question is whether we may have devised and collected just about all of the scanner mods available to the average hobbyist. What else is there? I mean, if you did all of the applicable mods in Volumes 1 and 2 to your PRO-2004/5/6, you're sitting on a scanner that can hold its own against just about any receiver available this side of the Pentagon.

Still, there are more new scanner models to roll off manufacturer's production lines, and who knows how they might be enhanced? I certainly don't want to be like the Registrar of the U.S. Patent Office who resigned his job in the mid-19th Century because he claimed that there wasn't anything left to invent!

My research and development of retrofit scanner mods will go on, regardless of whether or not I do a Volume 3 in this series. The things that we have accomplished, thus far, are largely simple and essentially non-technical. To go much further into PRO-2004/5/6 mods will require a level of effort and expense that is not likely to be within the means or expertise of the average hobbyist. I'm talking about really high tech stuff that is cooked up only by companies employing a staff of engineers-- not do-it-yourself scanner mods you can do on your basement workbench.

Don't get me wrong. There will always be one more new modification, or maybe a better version of an old one. The trick is whether there will be enough of these generated within a time frame suited to compiling a Volume 3. Maybe so, but only time will tell.

But, time works against us, too. Although I have spent several years investigating the enhancements to the great Realistic PRO-2004/5/6 chassis, sooner or later this chassis is going to go by the wayside when a new super-whizbang chassis will be introduced by Radio Shack, or Uniden, or AOR, or another company. Then, the learning process will start all over again. Unless you know more that can be done to the PRO-2004/5/6 than we have yet presented.

Many readers of the **Scanner Modification Handbook** are engineers or communications professionals. Maybe your favorite mod hasn't yet been published. If you, and maybe a dozen others like you, shared this information with me, there might well be enough for a dazzling Volume 3. But, for now, my own files on the PRO-2004/5/6 are pretty well emptied out.

Perhaps the first step towards inspiration is to examine the Wish List and see if you can make any contributions there. The next step is to add to the wish list. Just because I concluded that there isn't much more to be done to the PRO-2004/5/6, doesn't make it so. Prove me wrong. Dream up or invent something for this popular series of scanners that I can translate into a series of step-by-step instructions for the average hobbyist!

Don't be concerned with how complex you think the project might be, let me worry about that. It may not be as difficult as you'd imagine to translate the idea into something quite workable. Just share with me, if you will, the technology that you have adapted to your needs, or the technology you'd like to see available, and permit me take it back to my own lab and workbench.

Let's take a look at that Wish List.

The New Wish List - Something Old, Something New

1. **A Universal Computer Interface/Controller & Software** for the PRO-2004/5/6 remains at the top of my wish list. I've seen and worked with specialized versions for Commodore, Apple II, and the Tandy Color Computer. These have been wonderful, but... what's really needed here is a universal interface, preferably RS-232, but otherwise a specific circuit and software that can be easily adapted to all the popular computers. I'm an Apple IIe specialist, so my work cannot benefit owners of other types. In recent months, several computer systems engineers surfaced to discuss with me details of evolving an RS-232 interface. It was generally conceded that the project would most likely not be profitable as a commercial venture, and it's doubtful that anybody would take it on as a hobby project.

For those of you who want to dabble with a specific interface for your "Brand X" computer, the simplest and easiest approach is to tap a single pin in a serial or game port of your computer that can be addressed and controlled with BASIC programming. That pin and ground return are all that's necessary to wire into a serial/parallel adaptor interface mounted in your PRO-2004/5/6 scanner. The interface connects to the scanner's keyboard switch matrix. The computer and software merely emulate your pressing the keys on the keyboard. This approach has been proven to work, and the necessary adaptor/interface board requires only five or six chips plus a small handful of parts. Your computer can program your scanner with 400-channels at a whack in just minutes.

Scanner Modification Handbook, Volume 2

Volume 1 of the Scanner Modification Handbook proved that the average hobbyist could easily perform some relatively simple changes in the equipment and emerge from the experience with a greatly enhanced scanner. The step-by-step instructions and photos left no questions unanswered, and even totally "non-technical" persons found that they could restore bands that had been locked-out at the factory, or add anywhere from 100 to 6,000 more memory channels, and more, to popular scanners such as the Radio Shack Realistic PRO-2004, PRO-2005, and several others.

Now, in Volume 2, modification master Bill Cheek brings you eighteen more great enhancements for the Radio Shack Realistic PRO-2004, PRO-2005, and PRO-2006, and also several others, including PRO-2022, PRO-34, and Uniden Bearcat BC-100XLT, BC-200/205XLT, and BC-760/950XLT. Many modifications are adaptable to other scanners. In Volume 2, you'll get new approaches to adding signal-strength meters, varying the scan delay time, speeding up the search/scan rate, decoding CTCSS tones, adding channels, adding an event counter, adding shielding, reducing interference, restoring locked-out bands, adding a center-tuning meter, and more. There are also updates to the modifications that appeared in Volume 1, plus many other tips, hints, explanations, and tricks of the trade to make your scanner more useful and versatile.

Learn how to align your Realistic PRO-2004/5/6 scanner, how to use a VCR to record the action from your scanner, how to diagnose common scanner problems, how to use computer BBS' to improve your scanning. Find out about buying a used scanner, about collecting scanners, how to boost the audio output of your scanner, how to build a bench power supply, and lots more. It's all in Volume 2. You'll even learn about dealing with those new "trunked" 800 MHz systems that seem so difficult to monitor.

There are plenty of photos, and the text is written so that the average hobbyist can follow the clear step-by-step instructions. And you don't require exotic test equipment or tools to do these modifications. Every scanner owner will find Volume 2 to be a valuable and constantly useful reference in many ways. A few modifications suggest the user be familiar with information in Volume 1.

About The Author

Bill became a legendary CB technician known as "Doctor Rigormortis," however his talents have spanned the full spectrum of professional & hobby communications for more than 30 years. Bill started as a teenage SWL & experimenter, but just before the Viet Nam era he was trained as a U.S. Navy electronics technician specializing in electronics surveillance, countermeasures, radar & communications. He later developed & taught courses at the USN's Amphibious Warfare & Advanced Electronics Schools, also working with the U.S. Border Patrol & Arizona Highway Patrol in the deployment of the nation's first electronic border surveillance system. Cheek's civilian career developed into bench repair, design, & field maintenance of various types of systems, including CB, ham, land mobile, SWL, & scanners. He has also authored technical features appearing in Popular Communications, Monitoring Times, Fox-Tango Newsletter, S9 Magazine, & others. From 1983-99, Bill published the controversial Elenen Meter Times & Journal. Bill has held memberships in many groups, including the Radio Club of America, the Institute of Electrical & Electronics Engineers, Associated Public Safety Communications Officers, REACT, & other professional & hobby organizations.

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