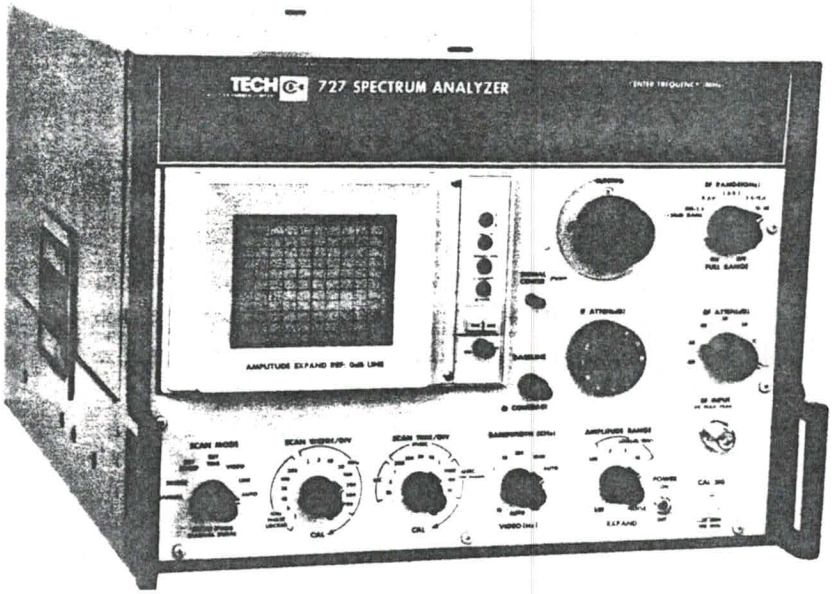
OPERATING MANUAL

727

SPECTRUM ANALYZER



REVISION B

ALTECH
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CONTROL
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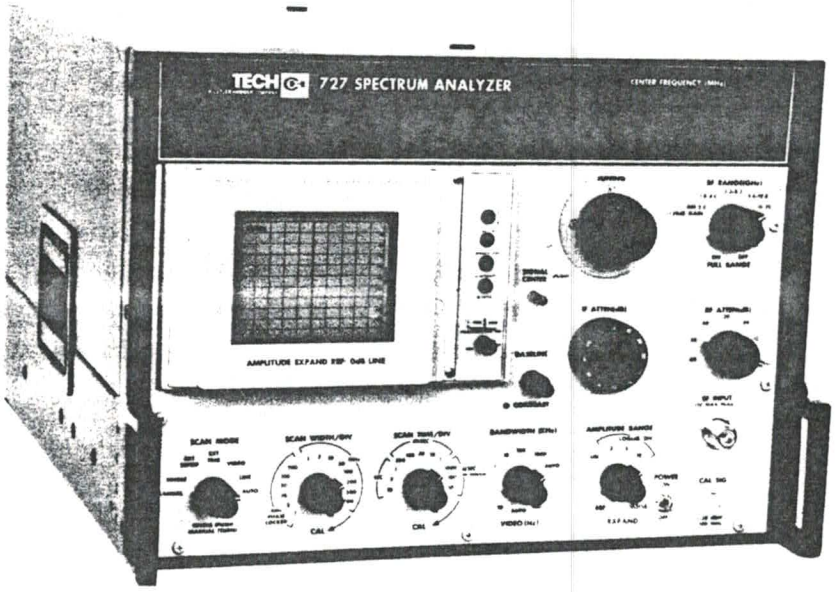
OPERATING MANUAL

727

SPECTRUM ANALYZER



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WARRANTY

Except for tubes, fuses, and batteries which carry no warranty, Cutler-Hammer, in connection with equipment sold, agrees to correct any defect in workmanship or material which may develop during the period of one year from the date of shipment under proper or normal use and not in excess of the original manufacturer's life expectancy ratings, by its option to repair or replace, FOB point of shipment, the defective part or parts, and such correction shall constitute a fulfillment of all Cutler-Hammer liabilities in respect to said apparatus.

February 1978

FOREWORD

The AILTECH 727 Spectrum Analyzer handbook information is divided into two applicable manuals. These are:

OPERATING MANUAL

Contains general information relating to the operational characteristics of the instrument.

SERVICE MANUAL

Contains all information required to service and maintain the instrument. Includes schematic diagrams, trouble-shooting procedures, calibration and adjustment procedures, and replaceable parts list.

ADDITIONAL SERVICE

Additional service information can be made available by calling AILTECH at 516-595-6478.

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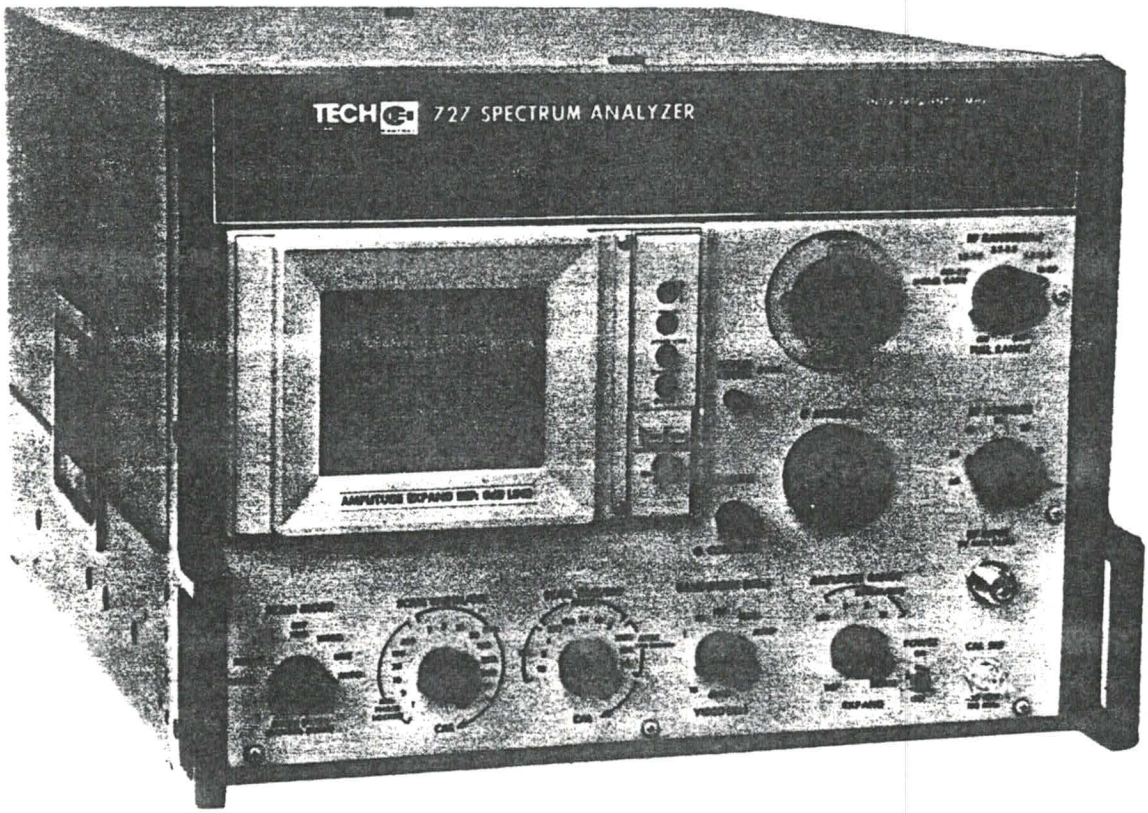


AILTECH 727 Series Spectrum Analyzers

SECTION I

GENERAL INFORMATION

1-1. SCOPE

This manual contains operating instructions for the AILTECH 727 Spectrum Analyzer. The technical and physical characteristics of the instrument, installation instructions, general data pertaining to the operation of the instrument, and some applications data are also presented. The applications section is in the form of typical display patterns, thus providing the user with some insight into the versatility of the instrument.

1-2. GENERAL DESCRIPTION

The AILTECH 727 Spectrum Analyzer is a sensitive superheterodyne receiver capable of scanning selected portions of the 0.001 MHz to 20 GHz frequency range. The output, displayed on a CRT with a 10 × 10 division viewing area, is a plot of the amplitude versus frequency distribution of an applied signal or group of signals. Signals can, therefore, be analyzed in the frequency domain. An alternate mode of operation provides a display of signal amplitude versus time.

The calibrated segment of the frequency spectrum scanned and displayed on the CRT (X-axis) may be as wide as 10 GHz or as narrow as 10 kHz. The center frequency of the display is continuously indicated by means of an accurate digital readout. The broad scanning capabilities may be used for applications such as EMI studies and spectrum surveillance. The narrow scan widths, coupled with an automatic frequency stabilization capability, permit more detailed study of signal characteristics.

The amplitude of the CRT display (Y-axis) is calibrated either linearly or logarithmically. In the logarithmic mode the sensitivity may be 2, 5, or 10 dB per division. Accordingly, signals differing by as much as 100 dB may be simultaneously displayed. In addition, the relative amplitudes of signals differing by as little as 1 dB may, with the aid of an integral attenuator, be easily measured.

SECTION II

SPECIFICATIONS

2-1. FREQUENCY SPECIFICATIONS

TABLE 2-1. FREQUENCY SPECIFICATIONS

(on 10-Division Horizontal Axis)

Tuning Range

0.001 to 20 GHz
With external mixer: 20 to 40 GHz

Scan Width

Per division: 14 calibrated scan widths from 1 kHz to 700 MHz per division.

Full Scan: 5 calibrated RF ranges may be viewed fully. Inverted marker positioned by TUNING control identifies the frequency that becomes the center frequency for SCAN WIDTH and TIME DOMAIN (zero scan) modes. The identified frequency is automatically indicated on digital readout.

Time Domain: Analyzer becomes fixed-tuned (zero scan width) receiver. Amplitude variations are displayed versus time on CRT. Three calibrated scan times including fast 10 μsec per division, and 4 IF bandwidths including a wide 1 MHz, are selectable for time domain analysis.

Filter Bandwidths

IF: Calibrated bandwidths of 1, 10, 100, and 1000 kHz may be manually selected. In AUTO position, proper IF bandwidth is automatically selected as SCAN WIDTH and SCAN TIME are varied.

IF Selectivity: 100-dB to 3-dB bandwidth ratio of all IF filters is less than 10 to 1; 60-dB to 3-dB ratio is less than 5 to 1.

Video: Calibrated bandwidths of 10 and 500 Hz may be manually selected. In AUTO position, proper video bandwidth of 5 kHz, 25 kHz, 150 kHz and 1000 kHz are automatically selected as SCAN WIDTH and SCAN TIME are varied.

TABLE 2-1. FREQUENCY SPECIFICATIONS (cont)

(on 10-Division Horizontal Axis)

Frequency Accuracy

Digital Readout (5 digits):

±0.2% from 2 to 20 GHz
±8 MHz from 1 to 2 GHz
±6 MHz from 0.001 to 1 GHz

Digital Readout Resolution: ±1 MHz

Scan Width Accuracy: Frequency difference between two points on the display is within ±5% of the indicated separation.

Filter 3-dB Bandwidth Accuracy: 1 kHz: typically 1.3 kHz±20%
10 kHz: ±10%
100 kHz: ±10%
1 MHz: typically 1.5 MHz±20%

Spectral Purity and Stability

Phase-Lock (Stabilization) Range:

First LO is automatically phase-locked to internal crystal reference for scan width of 300 kHz per division, or less, all bands.

Residual FM:

< 200 Hz p-p when phase-locked, 1. MHz to 20 GHz
< 10 kHz p-p nonphase-locked for fundamental mixing

Residual Responses: Referred to signal level at RF INPUT: < -90 dBm

Frequency Drift:

Typically ±3 kHz/10 minutes; stabilized after 2 hours warmup.

Noise Sidebands (for fundamental mixing with 1-kHz IF bandwidth and 500-Hz video bandwidth)

Level Below CW Signal (dB)	Separation From Signal (kHz)
> 70	30
> 80	90
> 90	300
> 95	1.0 MHz

Resolution: Refer to Figure 2-1 for detailed specifications. For example, two signals differing in amplitude by 60 dB, and differing in frequency by 10 kHz, may be easily resolved on the Analyzer.

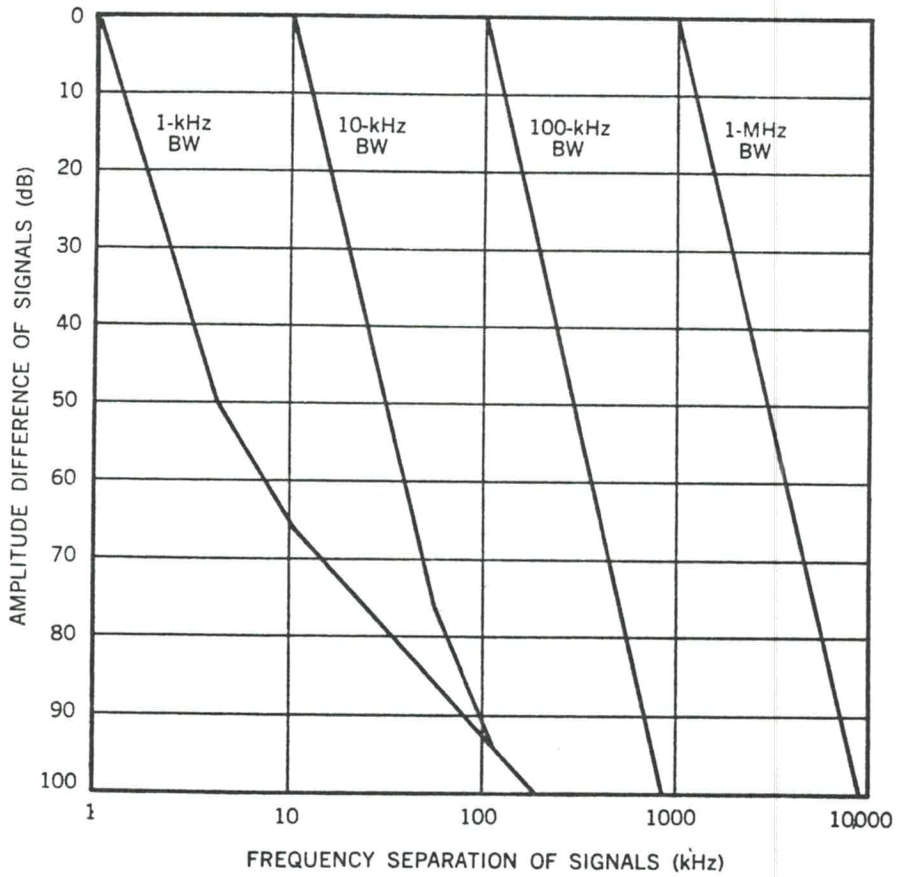


Figure 2-1. Typical Spectrum Analyzer Resolution as a Function of IF Bandwidth

2-2. AMPLITUDE SPECIFICATIONS

TABLE 2-2. AMPLITUDE SPECIFICATIONS

(on 10-Division Vertical Axis)

Full-Screen Display Range

Logarithmic Range: 100, 50, and 20 dB
Linear Range: 0 to 10 divisions

Dynamic Range

80-dB Spurious-Free Range: All in-band and out-of-band spurious responses are typically 80 dB down for an RF inputs below 1 milliwatt (0 dBm) from 1.8 to 20 GHz, and below -30 dBm from 0.001 to 1.8 GHz. Examples of spurious responses are those due to second-harmonic distortion, third-order intermodulation products image, multiple, and harmonic responses.

Spurious Response Due to Second Harmonic Distortion:

Frequency	Power Input	Distortion
1 MHz to 2 GHz	-50 dBm	-70 dB
1.8 GHz to 12.4 GHz	0 dBm	-120 dB
12 to 20 GHz	0 dBm	-120 dB

Spurious Response Due to Third Order Intermodulation Distortion:

1 MHz to 2 GHz (Typical for signals 200 kHz apart)	-50 dBm	-90 dB
1.8 to 12.4 GHz (Signals 200 kHz apart)	-30 dBm	-100 dB
1.8 to 12.4 GHz (Signals 100 MHz apart)	0 dBm	-120 dB
10 to 20 GHz (Signals 100 MHz apart)	0 dBm	-120 dB

Image Response

1 MHz to 2 GHz		Non Existent
2 to 4 GHz (454 MHz lower In frequency)	0 dBm	-70 dB
4 to 12.4 GHz (454 MHz lower In frequency)	0 dBm	-60 dB
12 to 20 GHz (454 MHz lower In frequency)	0 dBm	-50 dB

Local Oscillator Reradiation (0 dB Input Attenuator)

Frequency	Power Input	Distortion
1 MHz to 2 GHz (Typically	-70 dBm	
1.8 to 20 GHz (Typically)	-75 dBm	

TABLE 2-2. AMPLITUDE SPECIFICATIONS (cont)

(on 10-Division Vertical Axis)

Sensitivity (internal mixer): Based on average noise level, specified for a 1-kHz IF bandwidth and a 500-Hz video bandwidth:

RF Range (GHz)	Average Noise Level (max)
0.001 - 2.0	-125 dBm
1.8 - 4.0	-110 dBm
3.3 - 8.3	-105 dBm
5.4 - 12.4	-100 dBm
10 - 20	- 90 dBm

Maximum Input Power (with RF ATTEN switch set to 20 dB or greater): 2 watts (+33 dBm) average.

Maximum Input Power (with RF ATTEN switch set to 0 dB): 100 milliwatts (+20 dBm) average.

Attenuation Range

RF Attenuator: 0 to 60 dB in 10-dB steps.

IF Attenuator: 0 to 110 dB in 1-dB steps. One section provides 0 to 100 dB in 10-dB steps; the other, 0 to 10 dB in 1-dB steps.

Amplitude Accuracy

Frequency Response (including preselector) (with RF ATTEN switch set to 10 dB):

RF Range (GHz)	Freq. Response (dB)
0.001 - 2.0	±1.5
1.8 - 4.0	±2.0
4.0 - 8.3	±2.5
8.3 - 12.4	±3.0
10 - 20	±4.0

Relative Gain Variation Between RF Ranges: ±1.0 dB max.

IF Gain Variation with Different Bandwidth Settings: ±1.0 dB max.

Amplitude Display

Log: ±0.25 dB/dB but not more than ±2 dB over the full 100-dB display.

Linear: ±3% of full 10-division deflection.

RF Attenuator: ±1 dB max from 0.001 to 20 GHz

IF Attenuator: ±0.25 dB for 10-dB section; ±1.0 dB for 100-dB section.

Input SWR: 1.6 max for RF ATTEN settings > 10 dB. 50 ohms nominal impedance.

2-3. OTHER SPECIFICATIONS

TABLE 2-3. OTHER SPECIFICATIONS

Scan Time: 11 calibrated scan rates from 10 μsec to 10 seconds per division

Scan Time Accuracy: 10 μsec to 100 msec per division: ±10%; 100 msec per division to 10 seconds per division: ±20%

Power Requirements: 115 or 230 volts ±10%, 50 to 60 Hz, less than 220 watts

Dimensions: 12-1/2 inches high (including height of feet) X 16-3/4 inches wide X 20 inches deep (317 X 425 X 508 mm)

Weight: 83 pounds net (37.5 kg)

Temperature Range:

Operating: 32°F to 131°F
Storage: -40°F to 167°F

Humidity:

95% RH @ 104°F

DISPLAY SPECIFICATIONS

72710 NORMAL PERSISTANCE

CATHODE RAY TUBE:

Type: Aluminized P31 Phosphor
Graticule: 10 X 10 divisions INTERNAL, Parallax Free

72711 VARIABLE PERSISTANCE

CATHODE RAY TUBE:

Type: Aluminized P31 Phosphor
Graticule: 10 X 10 divisions INTERNAL, Parallax Free
Storage Time: Typically 1 hour in save mode; in excess of 5 minutes in store mode (depending on setting of operate level control)
Erase Time: Typically 256 msec.

72712 NORMAL PERSISTANCE/STORAGE

CATHODE RAY TUBE:

Type: Aluminized P31 Phosphor
Graticule: 10 X 10 divisions INTERNAL, Parallex Free.
Storage Time: 1 hour min at normal intensity
10 hours (typical) using brightness control
Erase Time: Typically 250 msec.

SECTION III

PREPARATION FOR USE

3-1. INTRODUCTION

This section contains information relative to the installation and power requirements of the equipment.

3-2. REAR PANEL

The AILTECH 727 Spectrum Analyzer is ready for use as soon as it is removed from its packing container. However, the rear panel should be checked to ensure that the rear panel connection is intact, and, the LINE VOLTAGE SELECT switch is in the proper position before applying power to the instrument.

The LINE VOLTAGE SELECT switch is located at the upper left-hand corner of the rear panel. Before applying power, make certain this switch is in the correct position: either 115 volts or 230 volts, and the correct fuses are in place. (NOTE: Unless specifically marked otherwise, the AILTECH 707 is set for 115 volts operation when shipped from the factory.)

If it becomes necessary to change the position of the LINE VOLTAGE SELECT switch, proceed as follows:

a. Make certain the ac line cord is unplugged.

b. Remove the two screws holding the locking plate.

c. Slide the switch to the opposite position.

d. Secure the locking plate.

e. Install the correct fuse for the voltage selected:

115 volt operation — install 3 amp slo-blow
230 volt operation — install 1.5 amp slo-blow

A coaxial patch cable (supplied) should be connected between the 21.4 OUTPUT and 21.4 INPUT jacks.

SECTION IV

OPERATION

4-1. INTRODUCTION

This section contains identification of the front panel and rear panel controls, indicators, and connectors, preliminary control settings, and operating adjustments and characteristics.

4-2. CONTROLS AND INDICATORS

Figure 4-1 shows the operating controls, indicators and connectors on the front panel and identifies the basic function of each. Figure 4-2 provides similar information for the rear panel.

4-3. MAXIMUM INPUT LEVEL - CAUTION

Before connecting a signal to the RF INPUT, observe the following precautions.

The band 1 (.001 to 2 GHz) mixer can tolerate a continuous power input of 100 milliwatts (+20 dBm) with the RF ATTEN switch set at 0 dB. Frequently, spectrum analyzer users will test low-level 0 to 2 GHz transistorized equipment by making direct connection to intermediate or final stages with alligator clips on a length of coaxial cable. If the voltage present at the point being monitored is greater than 1 volt ac or dc, the mixer specification is being exceeded and failure could result.

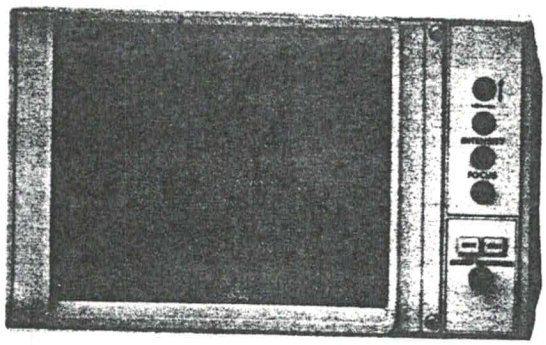
Some spectrum analyzer users are aware of the presence of dc potentials in the circuits under test and will isolate the center conductor of the coaxial cable with an appropriate coupling capacitor. However, this capacitor does not protect the mixer from the transient which will occur when this probe is first connected to a circuit. Failure could also occur if the capacitor has an initial charge greater than 1 volt.

The solution is to test intermediate stages with a capacitor dc isolated probe. This can be accomplished if certain precautions are observed:

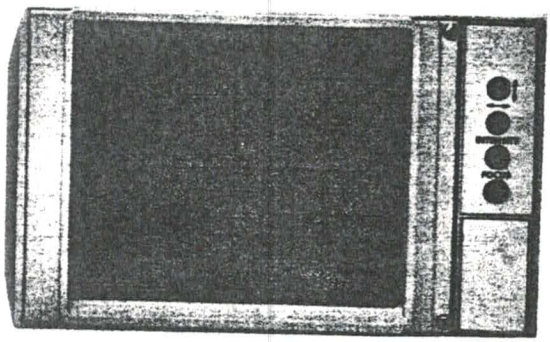
1. Connection or disconnection to a circuit should not occur unless the RF ATTEN switch is set at 40 dB or higher

2. If greater sensitivity is required, the RF ATTEN switch can be set to less than 40 dB after a good connection is made to the circuit under test. Care should be exercised that circuit transients do not occur during less than 40 dB RF ATTEN switch settings. Damaging transients can occur when: the power supply is turned on or off. The power supply is shut down due to current limiting, or if the probe is accidentally shorted to ground or V_{DC}.

3. The RF ATTEN switch should be returned to 40 dB before the probe is moved or removed from the circuit under test.



MODEL 72712
DISPLAY



MODEL 72710
DISPLAY

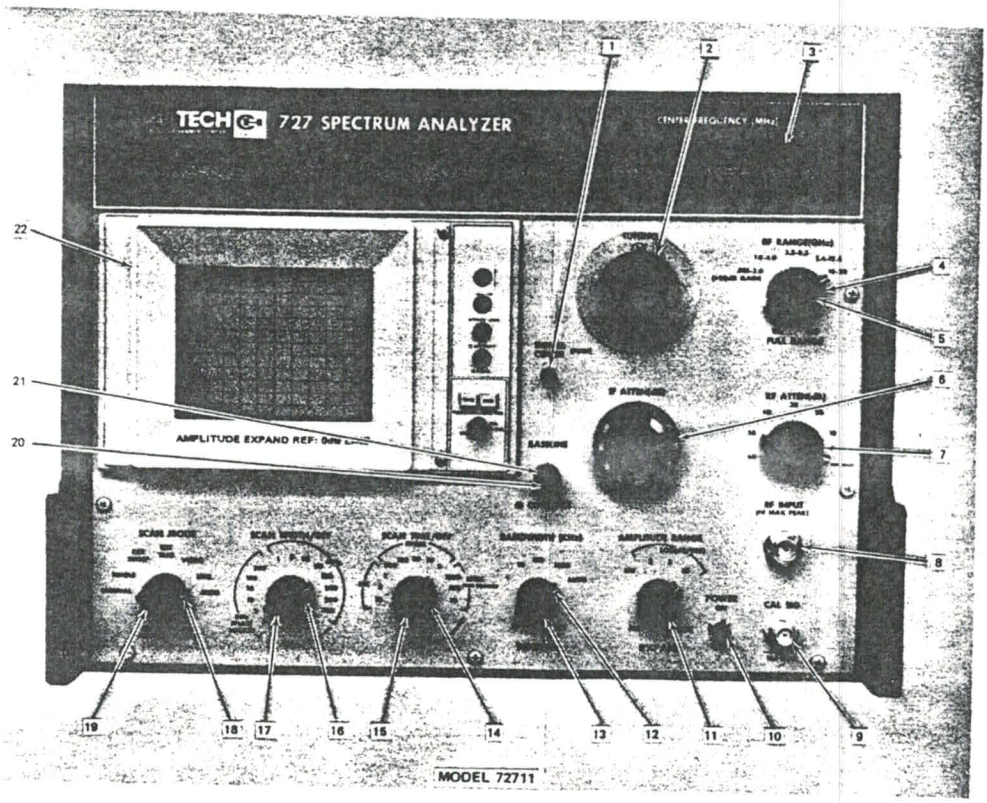


Figure 4-1. Front Panel Controls and Indicators
(Sheet 1 of 2)

Reference No.	Nomenclature and Function

1 SIGNAL CENTER control

Push-to-turn continuous control adjusts the center frequency in MHz increments when operating at kHz scan widths. Acts as a fine frequency vernier and amplitude peaker by allowing user direct access to main LO and preselector. This eliminates any amplitude degradation caused by poor tracking of the preselector with the main LO.

2 TUNING control

Sets the center frequency of the interval being scanned. Outer knob is for coarse tuning; inner-knob is mechanically reduced for fine tuning. Sets marker frequency in FULL RANGE scan mode.

3 CENTER FREQUENCY (MHz) readout

Indicates center frequency of the interval being scanned or marker frequency in FULL RANGE scan mode.

4 RF RANGE (GHz) switch

Switch selects frequency limits of the spectrum being scanned as follows:

0.001	-	2.0 GHz
1.8	-	4.0 GHz
3.3	-	8.3 GHz
5.4	-	12.4 GHz
10.0	-	20.0 GHz

5 FULL RANGE switch

Two-position switch concentric with the RF RANGE (GHz) switch. In the ON position the analyzer scans the entire spectrum indicated by the RF RANGE (GHz) switch setting. In the OFF position, spectrum width reverts to the SCAN WIDTH/DIV switch setting.

6 IF ATTEN (dB) switch

Step attenuator adjusts display amplitude. Outer ring provides 100-dB attenuation in 10 -dB steps; inner knob provides 10-dB attenuation in 1-dB steps.

7 RF ATTEN (dB) switch

Attenuates RF input signal. Provides 60-dB attenuation in 10-dB steps.

8 RF INPUT jack

Precision type N female connector: input for signals in the range from 0.001 to 20.0 GHz.

9 CALIBRATE SIGNAL

Supplies a -30 dBm ±.5 dB signal @ 100 MHz.

10 POWER switch

On-off switch for primary power.

11 AMPLITUDE RANGE switch

Four-position switch selects logarithmic amplitude display (LOG) with sensitivities of 2, 5, or 10 dB/DIV of vertical deflection or linear amplitude display (LIN).

12 BANDWIDTH (kHz) switch

Five-position switch manually selects IF bandwidths of 1, 10, 100, and 1000 kHz, or, in the AUTO position, the analyzer automatically selects the best available IF bandwidth for the combination of SCAN TIME/DIV and SCAN WIDTH/DIV in use.

13 BANDWIDTH (kHz) VIDEO switch

Three-position switch, concentric with the BANDWIDTH (kHz) switch for manual selection of the bandwidths of 10 and 500 Hz, or, in the AUTO position, the analyzer automatically selects 5 kHz, 25 kHz, 150 kHz, 1000 kHz, or whichever is the best available bandwidth for the IF bandwidth in use.

14 SCAN TIME/DIV switch

Eleven-position switch selects eight calibrated scan times from 10 seconds to 300 msec per division or, three calibrated sweep times of 10, 100 and 1000 μsec per division for zero scan width (time domain) displays.

15 SCAN TIME vernier

Concentric control for interpolation. Scan or sweep times are calibrated when the vernier is fully clockwise.

16 SCAN WIDTH/DIV switch

Fourteen-position switch selects calibrated scan widths from 1 kHz to 700 MHz per division in a 1, 3, 10 sequence and 200, 500, and 700 MHz per division.

17 SCAN WIDTH vernier

Concentric control continuously adjusts scan width from zero to the setting of the SCAN WIDTH/DIV switch. Scan widths are calibrated when the vernier is fully clockwise.

18 SCAN MODE switch

Seven-position switch selects trigger mode for internal scan or an external sweep signal as follows:

AUTO:	Recurrent scan, internally generated
LINE:	Scan triggered by the ac line
VIDEO:	Scan triggered by the detected RF input signal

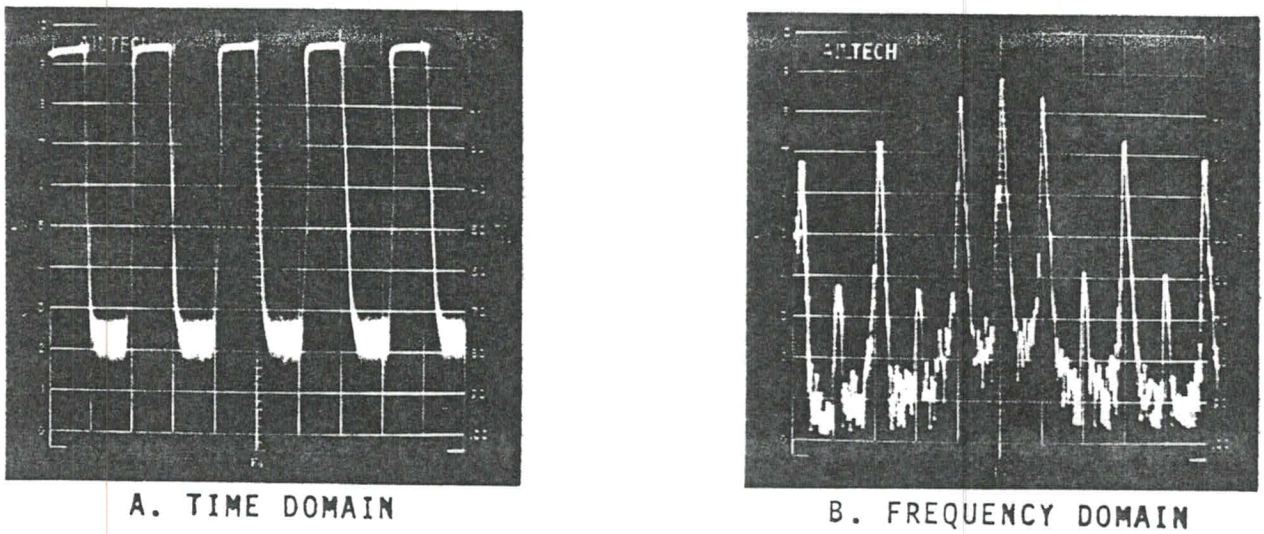


Figure 5-3. Square Wave Carrier Analysis

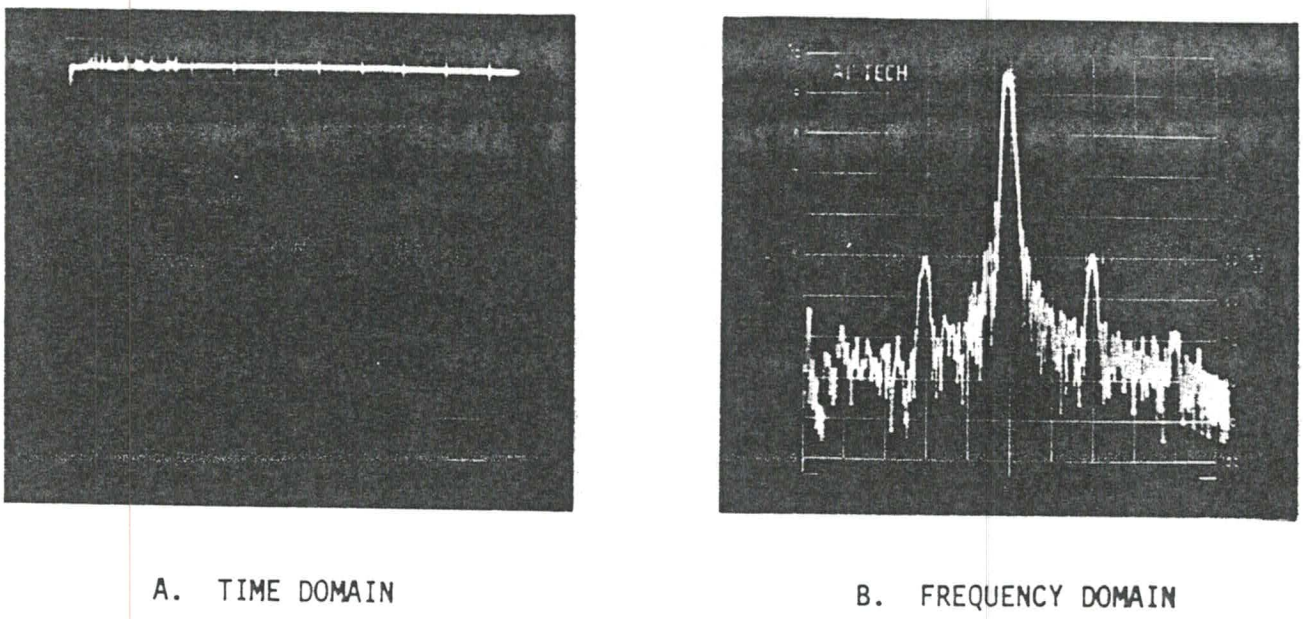


Figure 5-4. Amplitude-Modulated 5.1-GHz Signal

SECTION VI

THEORY OF OPERATION

6-1. BASIC OPERATING PRINCIPLES

The AILTECH 727 Spectrum Analyzer consists of a superheterodyne receiver and ac calibrated CRT display. The receiver may be manually tuned to a fixed frequency or swept tuned through a selected frequency interval. Figure 6-1 is the simplified block diagram of the instrument.

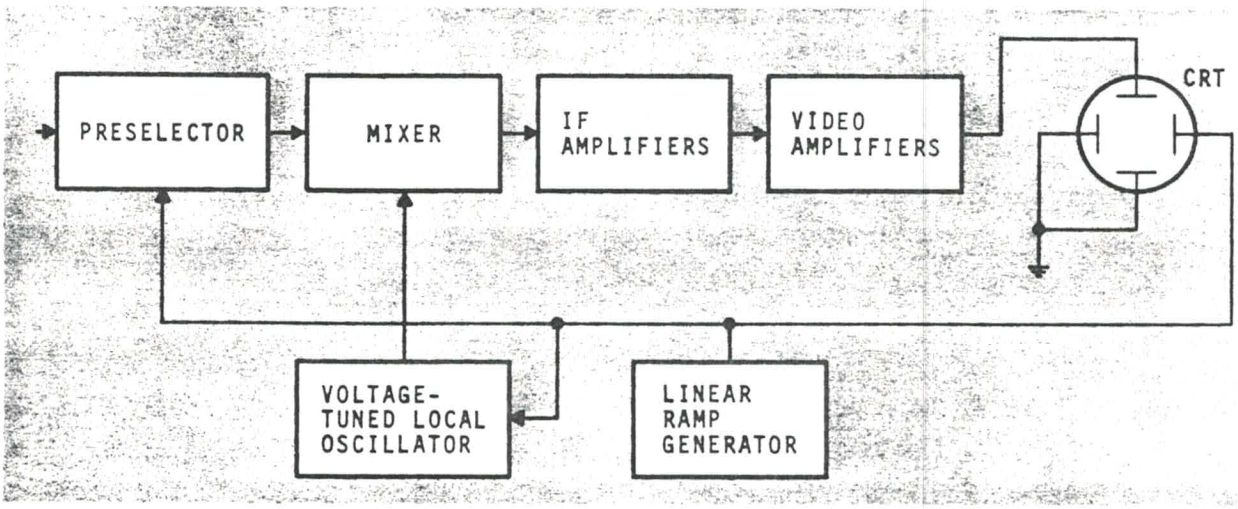


Figure 6-1. AILTECH 727 Spectrum Analyzer Simplified Block Diagram

The linear ramp generator provides the horizontal deflection signal for the CRT and the tuning voltages for the preselector and voltage-tuned local oscillator. Shaping circuits in the preselector and voltage-tuned local oscillator ensure that frequency tuning is linear with respect to horizontal deflection of the CRT. These same shaping circuits also ensure that the preselector frequency is maintained at a fixed interval from the voltage-tuned local oscillator frequency, that interval being the first intermediate frequency.

When a signal is passed through the preselector, it is mixed with the output of the voltage-tuned local oscillator to provide an output at the intermediate frequency. The signal is amplified, detected, and applied to the vertical deflection plates of the CRT. Since the horizontal deflection is proportional to frequency, the display is a plot of amplitude versus frequency of the applied signal.

6-2. THEORY OF OPERATION

Figure 6-2 is the block diagram of the AILTECH 727 Spectrum Analyzer.

The signal is first applied to the RF attenuator. The RF attenuator provides 60 dB of attenuation in 10-dB steps. It is used to reduce the signal level so that spurious signal

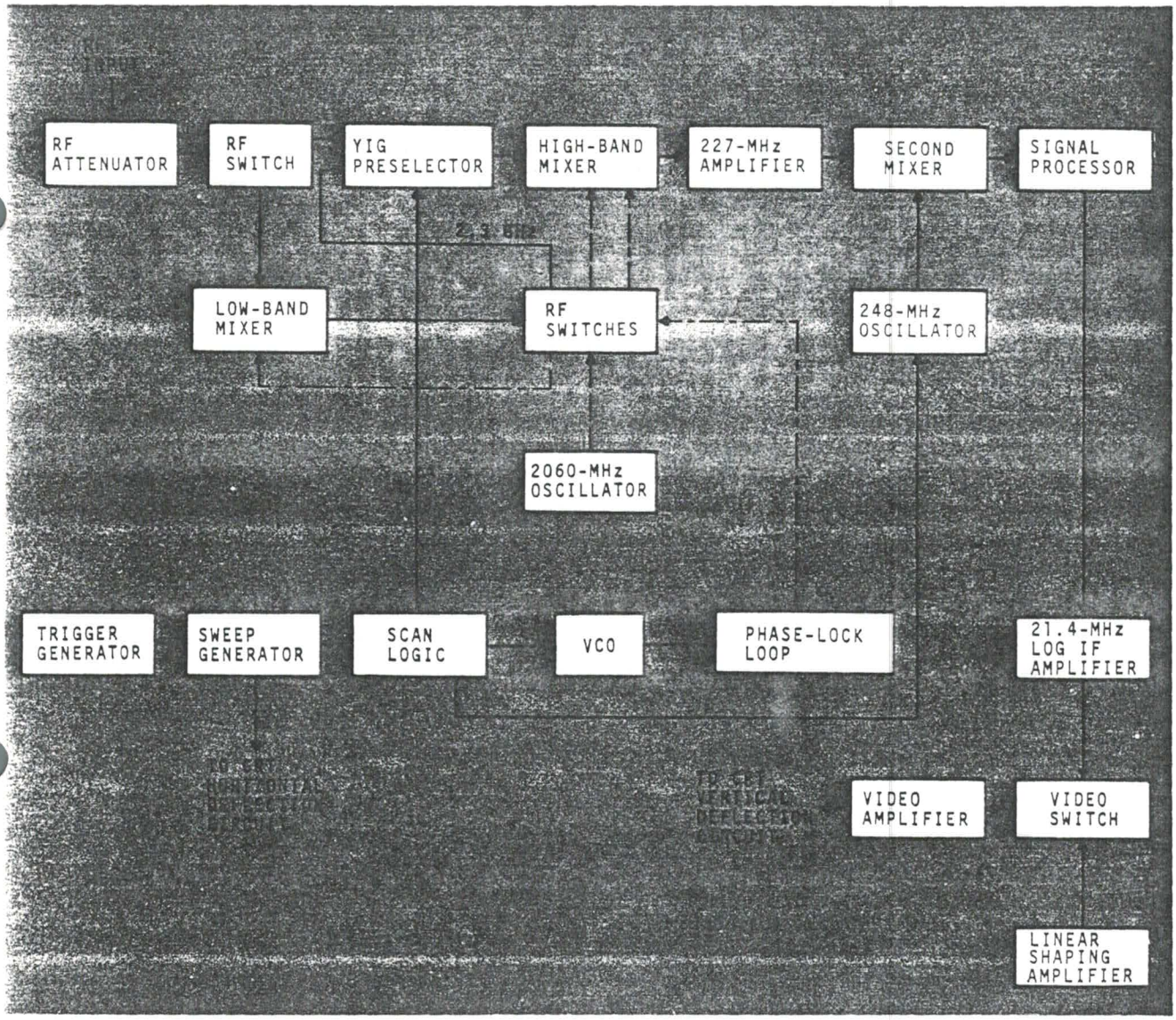


Figure 6-2. AILTECH 727 Spectrum Analyzer Functional Block Diagram

generation within the AILTECH 727 is minimized. In general, the signal at the output of the RF attenuator should not exceed -10 dBm. For maximum sensitivity, it is left in the 0-dB position.

Following the RF attenuator is one section of the RF RANGE switch. If the low band (0.001 to 2.0 GHz) is selected, the signal is mixed with the output of the swept VCO and upconverted to 2.29 GHz. The YIG preselector is fixed-tuned to this frequency. The signal is then applied to the high-band mixer and mixed with a crystal-controlled 2060-MHz signal to derive the 227 MHz first intermediate frequency. If any other RF range is selected, the signal is applied directly to the YIG preselector and mixed with the output of the swept VCO in the high-band mixer.

The preselector is a YIG filter capable of being electronically tuned from 1.8 to 20 GHz. Shaping and sweep logic circuits in the scan logic ensure that the center frequency of the voltage-tuned local oscillator is always 227 MHz greater than the YIG preselector frequency. The purpose of the YIG preselector is to prevent the generation of on-screen image signals without having to resort to microwave intermdeiate frequencies.

The VCO is capable of being electronically tuned from 1.7 to 4.3 GHz. When the SCAN WIDTH switch is in a MHz position, the VCO is swept over the selected scan width. When the SCAN WIDTH switch is in a kHz position, the VCO is automatically stabilized and operates at a fixed frequency. Scanning is then done by the 248-MHz oscillator.

After down-conversion, the signal is amplified and applied to the second mixer. This mixer is driven by the 248-MHz oscillator and provides an output at 21.4 MHz. When the SCAN WIDTH switch is in an MHz position, the second LO operates at a fixed frequency. When a kHz scan is selected, this oscillator is swept over the selected interval.

The 21.4-MHz singal is then applied to a signal processor made up of an IF attenuator, an IF bandwidth selector, and an automatic gain compensation network. The attenuator is used to adjust the amplitude of the display. It consists of two sections, one providing 100 dB in 10-dB steps, the other providing 10 dB in 1-dB steps. Four IF bandwidths are provided. These are determined by four sets of filters selectable from the front panel.

The AILTECH 727 Spectrum Analyzer utilizes harmonic mixing to obtain operation at the three higher RF ranges (3.3 to 20 GHz). The conversion efficiency of the first mixer is poorer in these harmonic mixing modes than for fundamental mixing. The automatic gain compensation network senses the RF range to which the AILTECH 727 is tuned and inserts or removes attenuation to maintain the overall gain relatively constant with frequency.

Signal amplitudes are usually measured in logarithmic units (dB). Because of this, final IF amplification is provided by a wide-range 21.4-MHz log amplifier. This amplifier employs the successive limiting technique and converts linear IF to logarithmic video. The conversion is such that the amplifier's response is within ±2 dB over a full 100-dB dynamic range.

If the AMPLITUDE RANGE switch on the front panel is set to one of the LOG positions, the output of the 21.4-MHz log IF amplifier is applied directly to the video amplifier. However, some measurements are more convenient with a linear display. Placing the AMPLITUDE RANGE switch in the LIN (linear)position routes the signal through a shaping amplifier that restores the linear amplitude response.

Additional filtering is provided in the video amplifier. The signal is then further amplified and applied to the vertical deflection plates of the CRT.

OPTION MANUAL

SPECTRUM ANALYZER

AIL TECH
A DIVISION OF CUTLER-HAMMER
CONTROL
2070 FIFTH AVENUE • RONKONKOMA, NEW YORK 11779

EXT TRIG: Scan triggered by an external +2 volt minimum signal

SINGLE: Single scan initiated by concentric SINGLE pushbutton switch.

EXT SWEEP: Requires external 0 to +6 volts signal for 10 division left-to-right horizontal deflection

MANUAL: Allows manual scanning by use of the concentric MANUAL vernier.

19 SINGLE/MANUAL switch

Pushbutton concentric with SCAN MODE switch. SINGLE pushbutton indicates single scan. MANUAL vernier allows manual scanning.

20 CONTRAST control

Adjusts intensity of the clipped portion of the display.

21 BASELINE control

Adjusts baseline clipping level.

22 Display Unit Controls

Refer to applicable display manual for a description of the display unit controls which is located in the rear of the Service Manual.

DISPLAY

VERTICAL POSITION control (↕)

Screwdriver control for vertical position adjustment.

HORIZONTAL POSITION control (←→)

Screwdriver control for horizontal adjustment.

OPERATE LEVEL

Controls the sensitivity to the writing beam and brightness of the stored display.

INTENSITY

Controls the display brightness in the non-storage mode.

FOCUS

Provides adjustment to give a well defined display.

ERASE

Momentary pushbutton that initiates the erasure of all stored information.

STORE*

A Push Switch that initiates the storage operation.

PERSISTENCE/SAVE**

This switch controls the persistence level. Turning this switch counterclockwise increases the persistence which gives a longer retention to the display. Therefore turning the control clockwise will decrease the time a stored signal is retained. To retain the stored trace pull the switch out and turn it as required to retain the display at a convenient intensity level.

*72711, 12
**72711 only

Figure 4-1. Front Panel Controls and Indicators (Sheet 2 of 2)

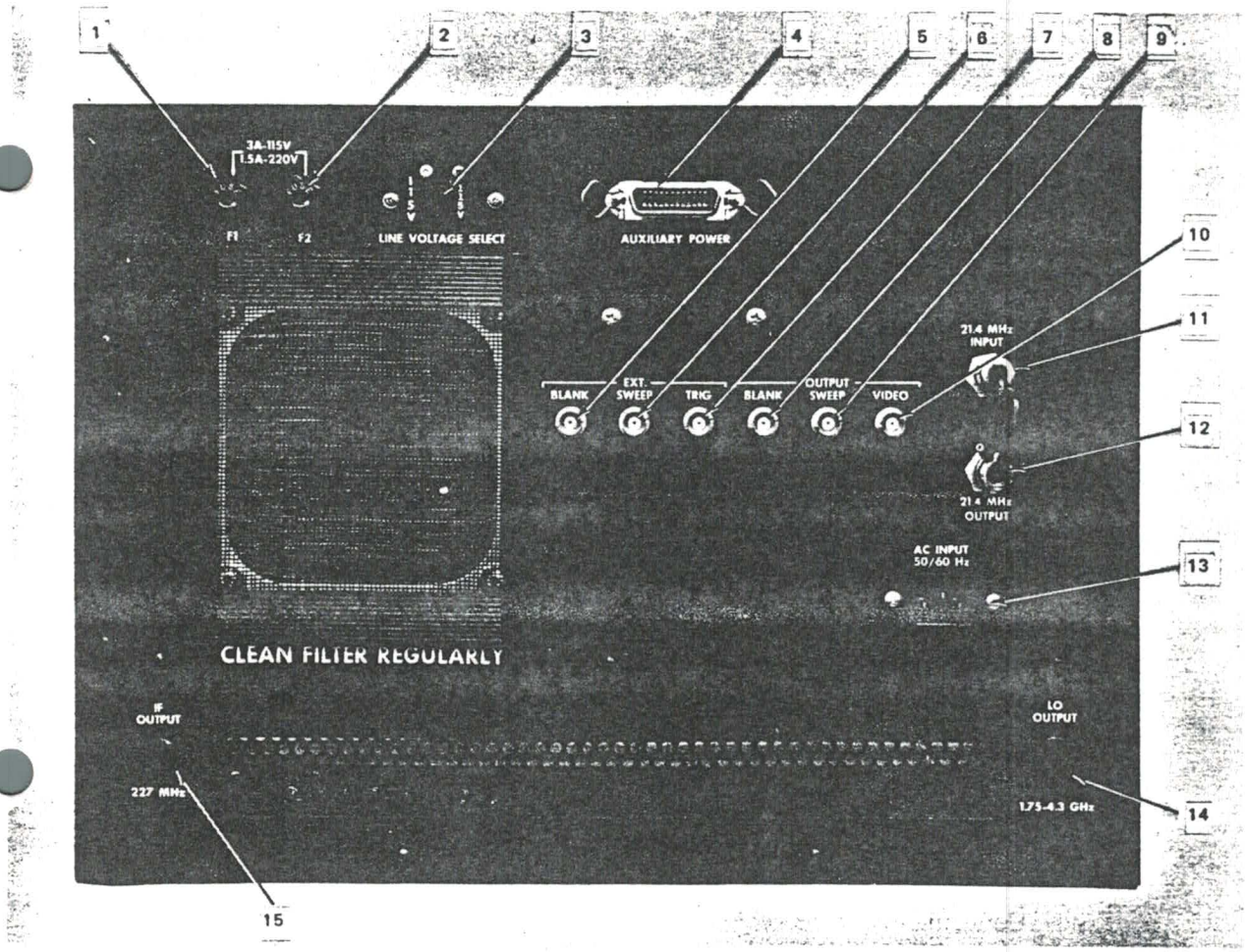
Reference No.	Nomenclature and Function
1	FUSE (F1) Main power fuse (3 ampere/115 volt, 1-1/2 ampere/230 volt)
2	FUSE (F2) Main power fuse (3 ampere/115 volt, 1-1/2 ampere/230 volt)
3	LINE VOLTAGE SELECT Two-position switch for 115 or 230 volt use (S10)
4	AUXILIARY POWER Used in conjunction with tracking generator 707-26, 707-27, additional display monitor, and other options.
5	EXT BLANK External blanking input to blank during retrace (+5 volts required)
6	EXT SWEEP External sweep input (0 to 6 volt ramp positive-going for left-to-right sweep required)
7	EXT TRIG External trigger input to initiate sweep, +1 volt required; triggers on positive going transition
8	BLANK OUTPUT Output voltage during retrace (greater than +2 volts)
9	SWEEP OUTPUT Output voltage proportional to horizontal sweep (0 to 6 volt ramp, positive-going for left-to-right sweep)
10	VIDEO OUTPUT Output voltage proportional to vertical deflection 1 volt (typical) = top of screen 0 volt = bottom of screen
11	21.4 MHz INPUT 21.4-MHz input to log amplifier
12	21.4 MHz OUTPUT 21.4-MHz linear output, 0 dBm (typical) = top of screen with -11 dBm input.
13	AC INPUT 50/60 Hz AC line cord input jack

14 LO OUTPUT (003 OPTION)

See appendix of service manual for detailed description

15 IF OUTPUT (002 OPTION)

See appendix of service manual for detailed description



NOTE: Items 11 and 12 must be connected by jumper for proper performance.

Figure 4-2. Rear Panel

When the 727 Spectrum Analyzer is set to any other band (1.8-2.0 GHz) or higher, this precaution is unnecessary since the YIG preselector is in the input circuit, and this component can tolerate a 1-ampere input current transient. However, the operator should ensure that the RF RANGE switch is not inadvertently set to band 1 (.001 to 2 GHz) when this capability is being used.

4-4. POSITION ADJUSTMENTS

The horizontal and vertical position adjustments are screwdriver controls. In general, these adjustments need be made only once. The recommended procedure for setting these controls is as follows:

a. Preset the controls as shown below.

RF RANGE	1.8 - 4.0 GHz
FULL RANGE	OFF
IF ATTEN	100 dB
BANDWIDTH (kHz)	1 kHz
BANDWIDTH VIDEO	AUTO
AMPLITUDE RANGE	10 dB
SCAN TIME	3 msec
SCAN MODE	AUTO
BASELINE	Fully counterclockwise
CONTRAST	Fully counterclockwise

b. Make the following adjustments:

(1) Apply power to the unit by turning on the POWER switch. Allow the trace to stabilize - usually about 30 seconds

(2) Adjust the INTENSITY control for a clean, sharp trace at a convenient brightness level

(3) Adjust the horizontal control until the start of the baseline is aligned with the first scale mark on the left of the graticule

(4) Adjust the vertical control until the trace is aligned with the second lowest scale mark on the graticule. This corresponds to –102 dB graticule line.

4-5. PRELIMINARY SETTINGS

Table 4-1 lists the suggested preliminary control settings. These settings will usually ensure that an applied signal will appear on screen.

TABLE 4-1. PRELIMINARY CONTROL SETTINGS

Figure 4-1 Reference Number	Nomenclature	Setting
4	RF RANGE	Appropriate position for the signal to be analyzed.
4	FULL RANGE	On
2	TUNING	Adjust until MHz indicator (1) reads approximate frequency of signal to be analyzed.
7	RF ATTEN	According to signal level so that signal does not exceed -10 dBm after attenuation
6	IF ATTEN	10 dB
11	BANDWIDTH (kHz)	AUTO
12	BANDWIDTH VIDEO	AUTO
10	AMPLITUDE RANGE	10 dB
13	SCAN TIME	3 msec
15	SCAN WIDTH	10 MHz
17	SCAN MODE	AUTO

4-6. NARROWBAND SPECTRUM ANALYSIS

The AILTECH 727 Spectrum Analyzer provides calibrated scan widths as small as 1 kHz per division, thus permitting finely detailed analysis of signal spectra. In order to fully utilize these narrow scan widths, the internal lock oscillator of the analyzer is frequency stabilized. The stabilization system (phase-lock loop) activates automatically when the SCAN WIDTH switch is switched from a MHz to a kHz position.

To operate the AILTECH 727 Spectrum Analyzer at kHz scan widths, proceed as follows:

a. Set the controls per Table 4-1.

b. Adjust the TUNING control until the marker is under the signal of interest, and turn the FULL RANGE switch to OFF.

c. Reduce the SCAN WIDTH switch one step at a time to the 1 MHz position. Adjust the TUNING control as necessary to keep the signal centered.

d. Reduce the SCAN WIDTH switch to 300 kHz.

e. If the signal jumps off screen, depress the SIGNAL CENTER control and adjust until the signal is within 2 divisions of center. It should be noted that there are 1-MHz steps between adjacent phase locks in fundamental mixing only (band 1 & 2).

f. Readjust the TUNING control to center the signal.

g. Reduce the SCAN WIDTH switch as desired, centering the signal with the TUNING control if necessary.

4-7. BROADBAND SPECTRUM ANALYSIS

The AILTECH 727 Spectrum Analyzer provides two means by which large segments of the microwave frequency spectrum may be examined. These are: (1) full range scan and (2) the calibrated MHz scan widths.

The full range scan provides a display of the entire frequency spectrum indicated by the setting of the RF RANGE switch. The preliminary control settings of Table 4-1 will set the analyzer for this mode of operation. When the signal of interest is connected to the RF INPUT jack it should be visible on the CRT if it is within the RF range selected.

A triangular marker notch will also appear on the baseline of the display. The position of the notch is set by the TUNING control, and the marker frequency is displayed by the digital MHz indicator.

If it is desired to examine a particular segment of the full RF range in greater detail, proceed as follows:

a. Adjust the marker position until it is directly under the signal of interest - indicated by a dip in signal amplitude.

b. Set the SCAN WIDTH switch for the desired spectrum width - MHz scan widths only (see paragraph 4-7 for kHz spectrum widths).

c. Turn the FULL RANGE switch to OFF.

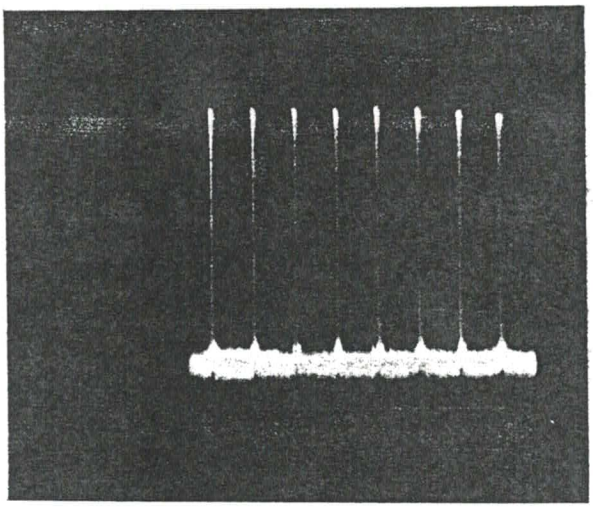
d. The signal of interest will now appear near the center of the CRT. Adjust the TUNING control for exact centering.

The AILTECH 727 Spectrum Analyzer provides calibrated scan widths up to 700 MHz per division and a calibrated spectrum display of 7 GHz. To use these broad scan widths, set the instrument controls per Table 4-1, and proceed as follows:

a. Set the SCAN WIDTH switch for the desired spectrum width.

b. Turn the FULL RANGE switch to OFF.

There are combinations of the RF RANGE, TUNING, and SCAN WIDTH settings which could result in portions of the display representing frequencies beyond the limits of the RF RANGE switch setting. If this condition should occur, the out-of-range areas are automatically blanked, and the display will be less than a full 10 divisions. Figure 4-3 illustrates this condition.



F_0 = 2.0 GHz
RF RANGE SWITCH AT 1.8 - 4.0 GHz
SCAN WIDTH SWITCH AT 100 MHz

Figure 4-3. Automatic Out-of-Range Blanking

4-8. AMPLITUDE VERSUS TIME DISPLAYS

The AILTECH 727 Spectrum Analyzer has a zero scan width mode of operation. This feature permits the operator to observe detected signals in the time domain as with a conventional oscilloscope. The zero scan width mode is useful for measurements not easily obtained from an amplitude-frequency display, such as the repetition rate of a pulse-modulated RF signal.

The three most clockwise positions of the SCAN TIME switch are used for time domain displays, providing calibrated sweep speeds of 10, 100, and 1000 μsec per division. When the SCAN TIME switch is placed in one of these three positions, the analyzer stops scanning and becomes a manually tunable, single-frequency receiver. The FULL RANGE switch must be OFF.

To obtain a time domain display:

a. Set up the instrument as for a MHz scan width display (see paragraph 4-6). Center the signal with the TUNING control.

b. Select the sweep trigger source by means of the SCAN MODE switch: VIDEO for internal trigger; or EXT TRIG for external trigger.

c. Set the SCAN TIME switch to 10, 100, or 1000 μsec as desired.

d. Set the AMPLITUDE RANGE switch for the desired logarithmic sensitivity or linear display.

e. Adjust the TUNING controls for maximum signal amplitude.

f. FM demodulation can be accomplished by adjusting the TUNING control until the signal is on the slopes of an appropriate filter. Audio will be present at the VIDEO output on the rear panel. More narrow filters should be selected for narrowband FM.

g. Zero scan width operation can also be obtained by turning the SCAN WIDTH vernier fully counterclockwise. Signals can then be displayed in the time domain at any setting of the SCAN TIME switch.

4-9. FREQUENCY MEASUREMENTS

The frequency of a signal displayed on the AILTECH 727 Spectrum Analyzer can be determined, without ambiguity, by means of the digital MHz readout. The signal is centered by means of the TUNING control. The SCAN WIDTH switch is set at 1 MHz for best resolution. The indication of the MHz readout is accurate, typically, to better than ±0.2% (See Table 2-1).

Since the frequency scan is very linear, the accuracy of a frequency measurement can be further improved by comparing the unknown signal to a known reference frequency. The reference and the unknown are simultaneously applied to the AILTECH 727 Spectrum Analyzer. The frequency difference between the two can then be read directly from the CRT. The AILTECH 707-90 Comb Generator is accurate to within 0.005 percent from 100 MHz to 20 GHz and therefore makes a very suitable frequency reference.

4-10. AMPLITUDE MEASUREMENTS

The relative amplitudes of signals displayed on the AILTECH 727 Spectrum Analyzer CRT can be determined directly from the graticule markings. To measure the voltage ratio of two signals, proceed as follows:

a. Set the AMPLITUDE RANGE switch to LIN.

b. Adjust the IF ATTEN switch until the larger of the signals is at the upper graticule mark.

c. Note the ratio (× 10) of the smaller signal on the linear scale at the left of the graticule.

To measure the dB difference between two signals, proceed as follows:

a. Set the AMPLITUDE RANGE control to a LOG position.

NOTE

The LOG range selected is dictated by the dB difference between the signals. For example, if the signals are less than 20 dB apart, use the 2 dB per division range; if the signals are less than 50 dB apart, use the 5 dB per division range; if the signals are more than 50 dB apart, use the 10 dB per division range.

b. Adjust the IF ATTEN switch until both signals are on the screen.

c. Determine the dB difference in signal level from the LOG scale at the right of the graticule.

Amplitude measurement accuracy can be improved by means of substitution measurements using the IF ATTEN switch as follows:

a. Note the level of the smaller signal on the graticule and the setting of the IF ATTEN switch.

b. Increase the IF ATTEN switch setting until the larger signal is at the graticule mark noted in step a.

c. Subtract the original reading of the IF ATTEN switch from that obtained in step b.

The best resolution is obtained using the highest sensitivity LOG range, or, for signals with nearly the same amplitude, the LIN position.

Absolute power measurements can be performed with the AILTECH 727 Spectrum Analyzer by first calibrating the display with a reference signal of known amplitude, such as the built in 100 MHz calibration signal.

4-11. BANDWIDTH EFFECTS

The resolution and sensitivity of a spectrum analyzer are functions of its IF bandwidth; the narrower the bandwidth, the better the resolution and sensitivity. However, narrow bandwidths require narrow scan widths, slow scan times, or both; otherwise, the IF filters may not have sufficient time to fully respond to the signal, resulting in an apparent loss in signal level. If the IF bandwidth is wider than the scan width, there will be a loss of resolution. For any particular combination of SCAN WIDTH and SCAN TIME switch settings, there is an optimum IF bandwidth providing the best resolution without loss of sensitivity.

The IF BANDWIDTH (kHz) switch provides four bandwidths and an AUTO position. When the switch is in the latter position, the analyzer automatically selects the bandwidth nearest to optimum of those available. This feature relieves the operator of the necessity of continually readjusting IF bandwidth as the SCAN WIDTH and SCAN TIME switches are operated. The bandwidths selected by the analyzer when in the AUTO bandwidth mode are shown in Figure 4-4 for reference.

As noted in paragraph 4-11, selection of an incorrect IF bandwidth can result in a distorted display. These effects are illustrated in Figures 4-5 and 4-6.

In Figure 4-5A, the proper IF bandwidth has been selected for the particular combination of SCAN WIDTH and SCAN TIME settings. In Figure 4-5B the IF bandwidth has been reduced to 1 kHz. Note the reduced amplitude, broadened display, and "ringing." In Figure 4-5C the SCAN TIME has been increased so that the combination of scan time and width is again compatible with the IF bandwidth selected.

In Figure 4-6A the total spectrum scanned is about the same as the IF bandwidth. The result is a severely distorted display. In Figure 4-6B the bandwidth has been reduced.

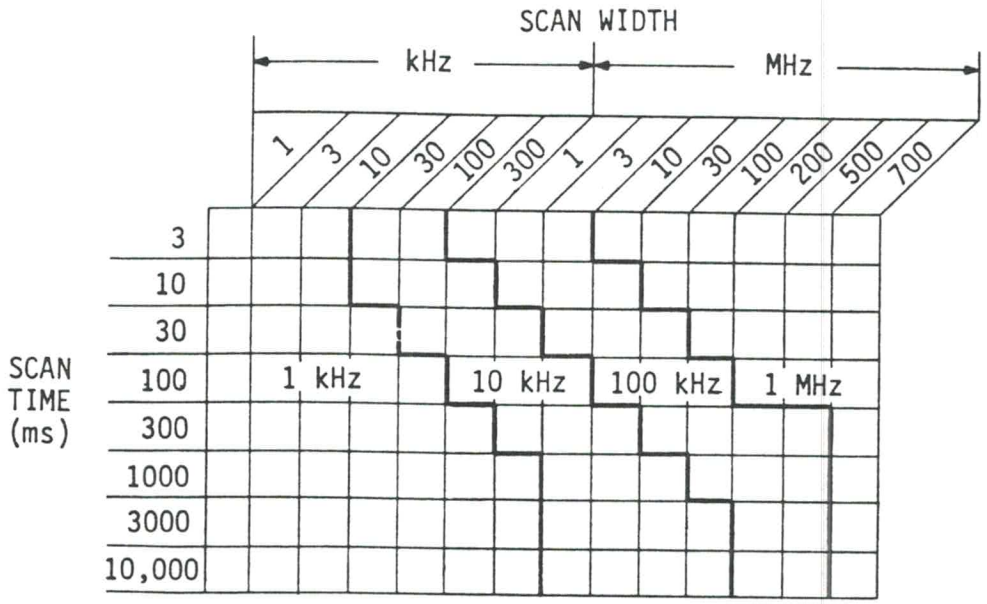
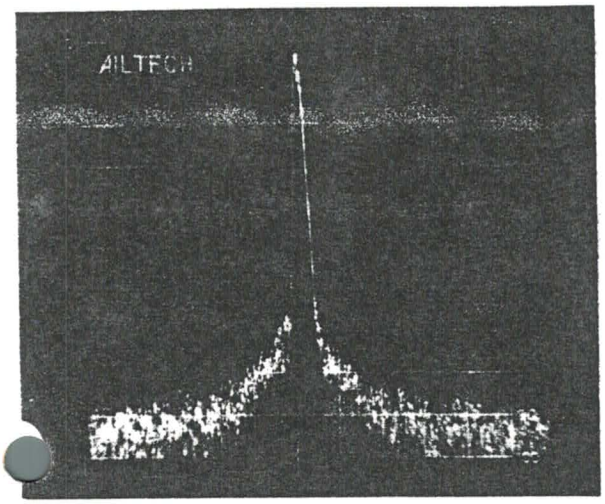
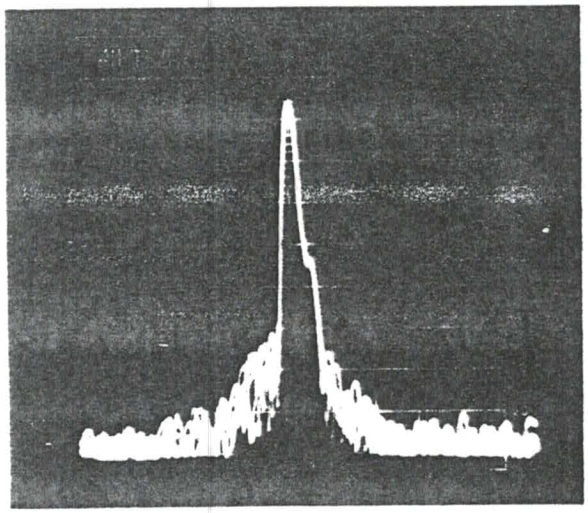


Figure 4-4. IF Bandwidth Selected by Spectrum Analyzer in AUTO Position

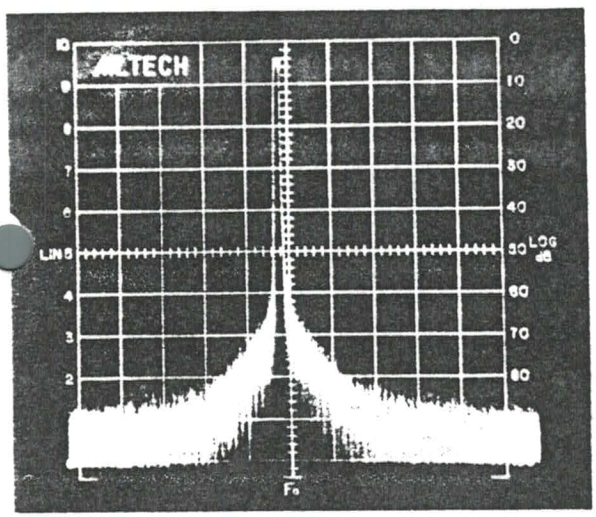
The function of the BANDWIDTH VIDEO switch is similar to that of the BANDWIDTH (kHz) switch. This switch also has an AUTO position, and provision is made for manual selection of two video bandwidths. When using wider IF bandwidths and observing signals near the noise level, switching to a smaller video bandwidth can provide an effective increase in sensitivity. The filter averages the noise peaks, and a signal all but obscured by noise becomes visible. Figure 4-7 illustrates the effect of the BANDWIDTH VIDEO switch.



A. IF BANDWIDTH = 10 kHz
SCAN WIDTH = 100 kHz
SCAN TIME = 3 msec
ACCEPTABLE FILTER RING
PROPER AMPLITUDE RESPONSE

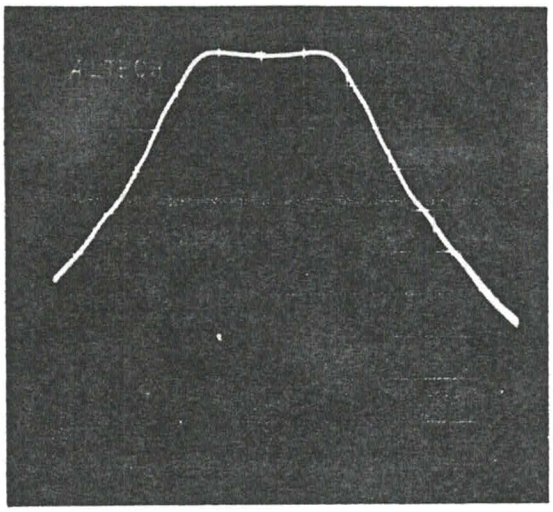


B. IF BANDWIDTH REDUCED TO 1 kHz
SCAN WIDTH = 100 kHz
SCAN TIME = 3 msec
UNACCEPTABLE FILTER
AMPLITUDE RESPONSE AND
RINGING

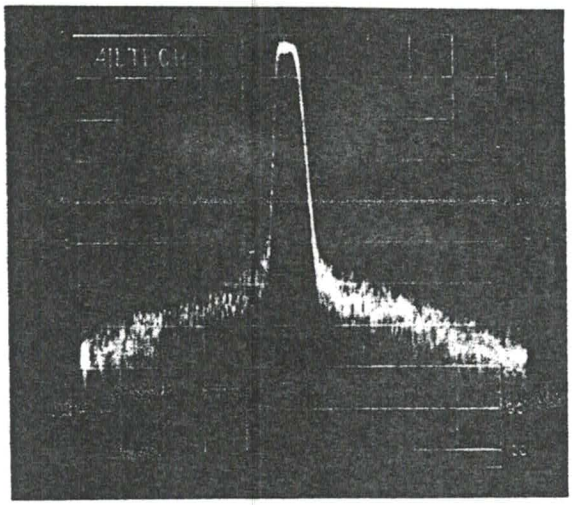


C. SCAN TIME INCREASED TO
100 msec
FULL FILTER RESOLUTION

Figure 4-5. Selection of IF Bandwidth and Scan Time

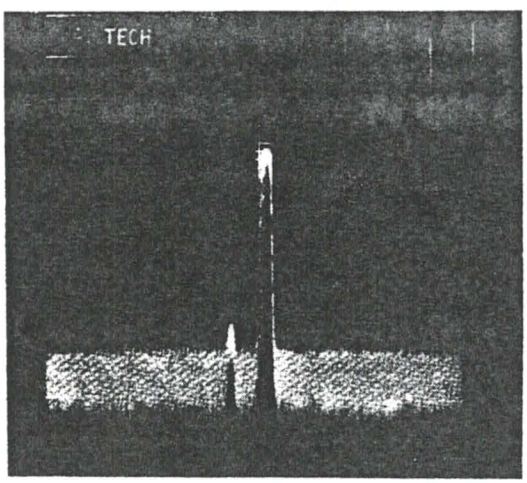


A. IF BANDWIDTH = 100 kHz
SCAN WIDTH = 30 kHz

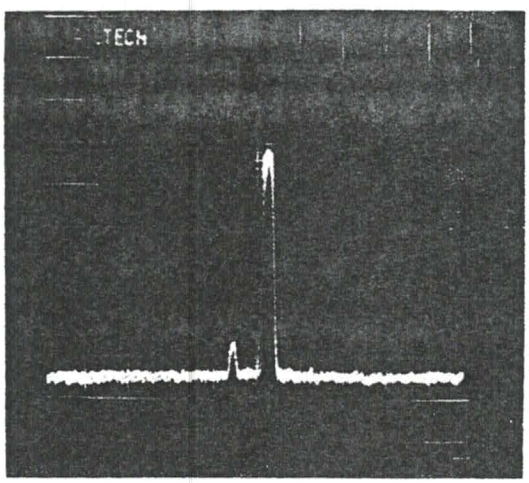


B. IF BANDWIDTH REDUCED TO 10 kHz
SCAN WIDTH = 30 kHz

Figure 4-6. Proper Selection of IF Bandwidth



A. IF BANDWIDTH = 100 kHz
VIDEO BANDWIDTH = AUTO



B. VIDEO BANDWIDTH REDUCED TO 500 Hz

Figure 4-7. Proper Selection of Video Bandwidth

SECTION V

APPLICATIONS OF AILTECH 727 SPECTRUM ANALYZER

5-1. GENERAL

Spectrum analysis is recognized as a valuable aid in the evaluation of circuits and systems. Because of its stability and wide range of scanning characteristics, the AILTECH 727 Spectrum Analyzer is capable of resolving most problems whose unknowns are amplitude and frequency. Typical applications include spectral purity, distortion, and stability of oscillators; distortion characteristics of amplifiers; frequency response of networks; modulation characteristics of signals; EMC/RFI measurements; and surveillance. To define every application is beyond the scope of this manual; however, the following examples will serve to illustrate some of the more important measurements that may be made with the instrument. Consult the factory for additional applications.

5-2. TYPICAL DISPLAYS

Signal sources often contain nonharmonically related RF outputs. Figure 5-1 displays the output of a BWO and a related spurious signal. The two signals differ by 60 dB in amplitude and are separated by only 35 kHz (the main signal is at 2 GHz and the scan width is 10 kHz per division). The 500 Hz VIDEO filter was selected to average the noise peaks and make the lower level signal appear more predominant.

By sweeping a band-pass filter with an external sweep oscillator, the filter response can be easily measured and recorded with the AILTECH 727 Spectrum Analyzer (Figure 5-2).

The signal applied to the filter input is at -20 dBm, which corresponds to the 0 dB reference line. The insertion loss of the filter is, therefore, seen to be 7 dB. The center frequency of the filter is 70 MHz (the scan width is 10 kHz per division with a 10 dB per division display). The 3-dB bandwidth is 20 kHz; the 3 to 60 dB ratio is 4 to 1. The stop band rejection is greater than 70 dB through most of the frequency observed.

To examine the filter band-pass characteristics with greater resolution, the analyzer may be used in the LIN mode of operation with a 3 kHz per division scan width (Figure 5-2B). The 3-dB points are clearly seen to be 10 kHz apart. The filter's insertion loss may be measured to be 7 dB by using the IF substitution method.

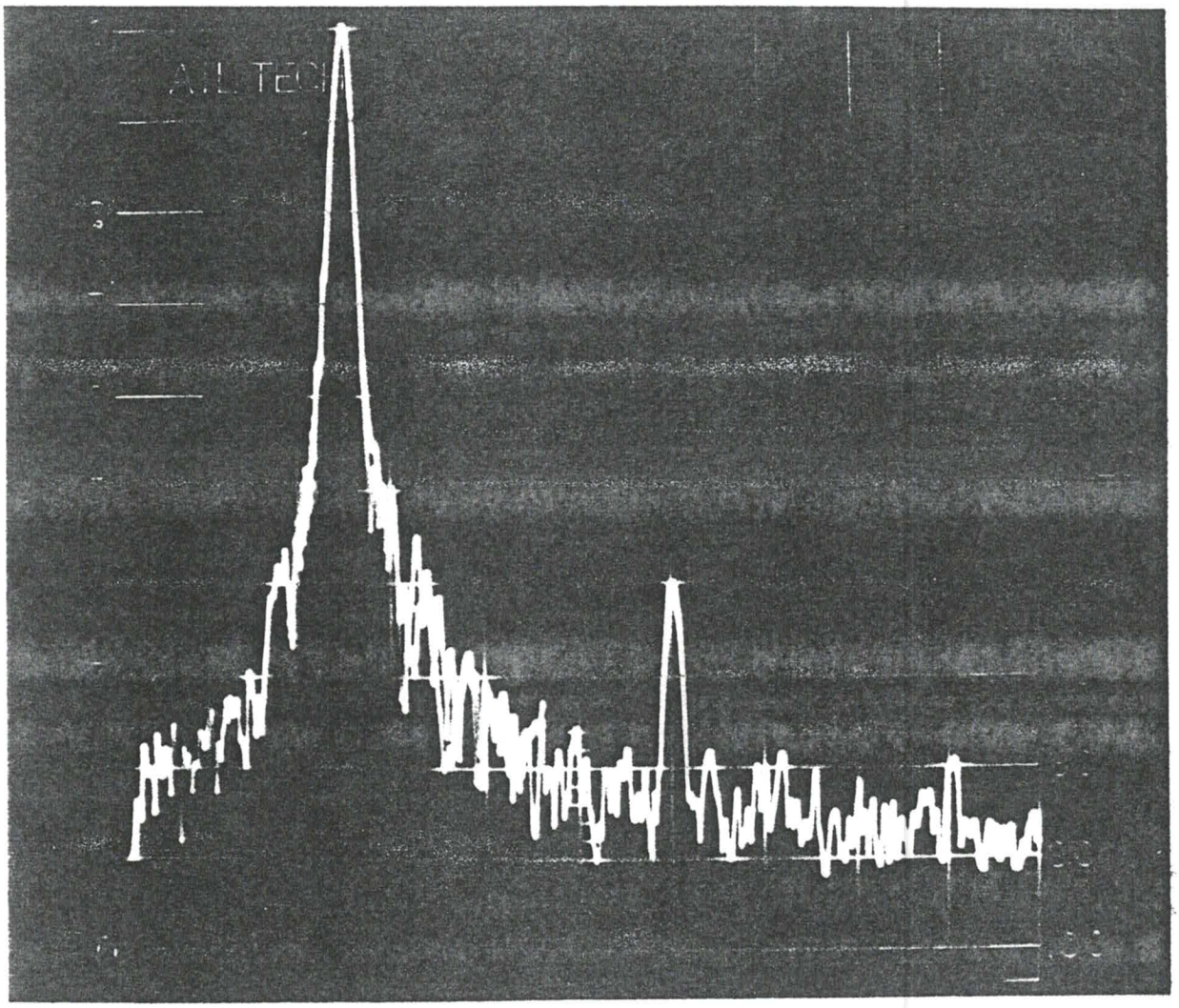
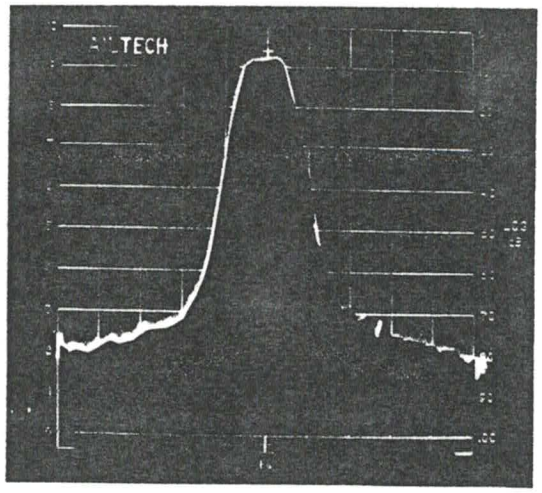
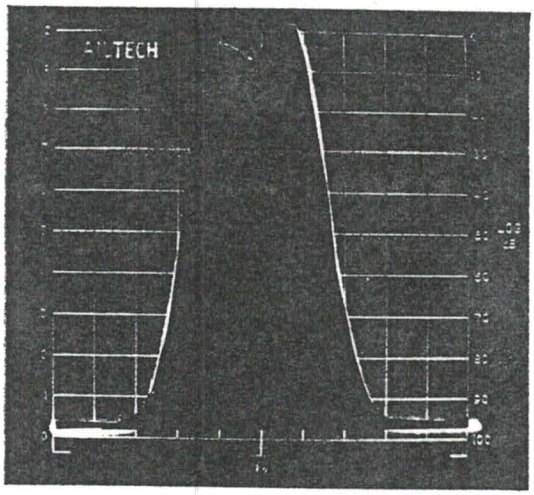


Figure 5-1. BWO Outputs and Spurious Signal Amplitudes



A. 10 kHz PER DIVISION SCAN WIDTH
10 LOG (dB/DIV) DISPLAY



B. 3 kHz PER DIVISION SCAN WIDTH
LIN DISPLAY

Figure 5-2. Filter Response

Figure 5-3A shows a time domain photograph of a square wave modulated carrier. The carrier is a 3.0-GHz CW signal and it is modulated at a 30 kHz rate. The on-off ratio is greater than 60 dB. (The analyzer is operating at 15 μsec per division and 10 dB per division.)

The same waveform is measured in the frequency domain in Figure 5-3B. Since the carrier and sidebands differ by 6 dB, the modulation index = 100 percent. The modulation rate is 30 kHz since the first harmonic appears as sidebands to the 3.0-GHz signal at ±30 kHz. The second harmonic distortion can also be measured on the waveform. These sidebands are at 3.0 GHz ±60 kHz and are 48 dB down. (The analyzer is operating at 30 kHz per division and 10 msec per division.)

A 5.1-GHz oscillator is sinusoidally amplitude-modulated at 20-kHz rate (Figure 5-4A). The low-level modulation cannot be resolved in the time domain (sweep time of 10 μsec per division and a 10 dB per division display).

However, considerable information may be obtained by operating the analyzer in the frequency domain (Figure 5-4B). (Scan width 10 kHz per division and scan time 1000 μsec per division.) Since the sidebands are 20 kHz and 56 dB down from 5.1 GHz, the modulation rate is 20 kHz and the modulation index is 0.3 percent. The second harmonic distortion on the waveform can be seen to be 40-kHz sidebands which are 64 dB down.