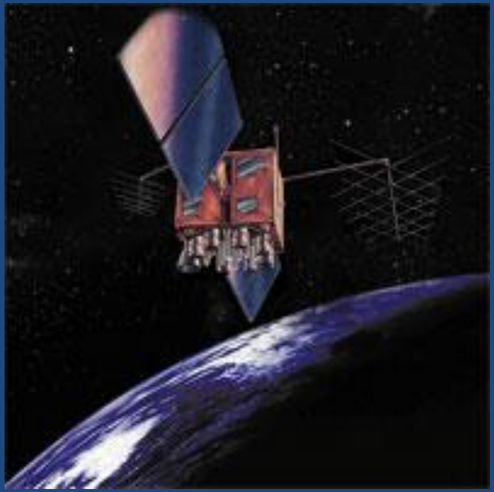
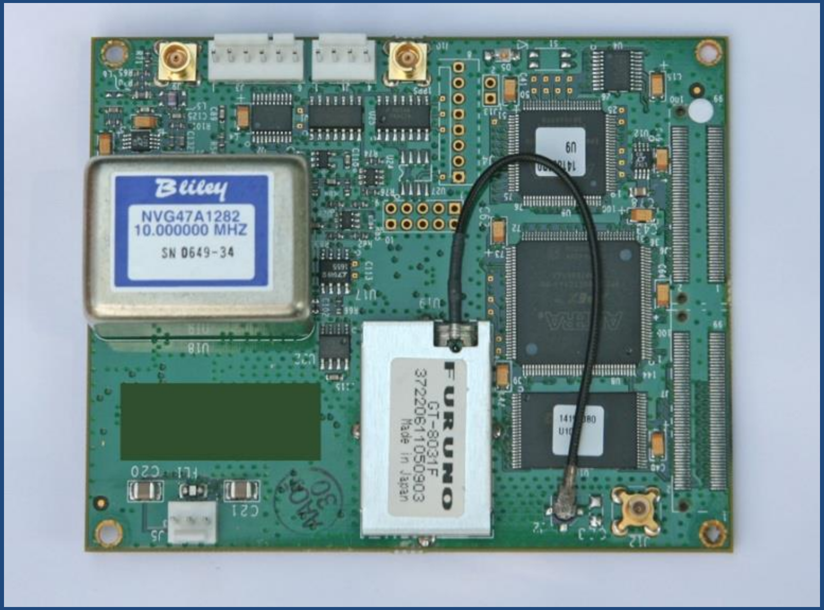
A Packrat GPS Receiver Project
By Gary, WA2OMY and Bruce, WA3YUE



Some of you may know what this is,

This is the same thing,



Well, almost ....

Note:

- This project was developed to use surplus GPS receiver boards to provide a precision 10 MHz reference for the ham community using equipment that accepts a 10 MHZ reference or clock. We hope to have accomplished this at a reasonable cost to the community.
- There may be other applications and uses for these boards, and we would like to hear about them, however we have no plans to support source code release, or changes at this time.

Surplus GPS receiver Boards from location monitoring equipment

The good:

- Uses standard GPS antenna (5V bias)
- Has all the standard functions like the Trimble
- Has disciplined 10 MHz oven output, +8 dBm, (nice!)
- Standard Ascii 9600 Baud interface
- 13 to 15 V supply
- Well designed, built for long term commercial use
- Two versions of this board have been available on the surplus market. Connection and pinout for both are in these instructions.

The not so good,

Or we can say minor differences ☺

- GPS board uses boot loader, needs to be commanded to operate. (Start application code)

- Self survey required to read position

  - That’s about it!

Note:- Software Rev

The software revision is not the same in all the receiver boards appearing on the surplus market. The Arduino software in this project will work with software rev- 10.1 and higher. Earlier revisions for example 8 and 9 have slightly different survey and status reporting formats. Some functions in the display will not work. The later design board with part number starting with 111603 will have later revision software.

This note applies to using the Arduino controller only, using the RS232 interface with a terminal program the software release is not important to receive GPS and provide a 10 MHz disciplined 10 MHz output.

- The GPS Board will power up in boot mode and output a message similar to the following until a command is sent to run application code. ($PROCEED) (Also will return to boot after a power cycle.)
- No GPS function will work until this command is sent.

This message shows the software revision installed, the S/N of the board and other information.
In this example the software is version 10.1.2 and the S/N begins with 061622. There is only a LF in boot output, no carriage return, so the message scrolls across the terminal screen. Once commanded into application code a standard CR, LF is sent, so messages are in the left in a standard column.

```
 $GETVER 10.1.2 BOOT 10 9e05 7437 061
62200C1000A2005411C55
                  $GETVER 10.1.2 BOOT 10 9e05 7437 06162200C1000A2005411C55
                                                           $G
ETVER 10.1.2 BOOT 10 9e05 7437 06162200C1000A2005411C55
                                              $GETVER 10.1.2 BOOT 10 9e
05 7437 06162200C1000A2005411C55
                            $GETVER 10.1.2 BOOT 10 9e05 7437 06162200C1000A2
005411C55
        $GETVER 10.1.2 BOOT 10 9e05 7437 06162200C1000A2005411C55
                                                       $GETVER 10.1.2
 BOOT 10 9e05 7437 06162200C1000A2005411C55
                                      $GETVER 10.1.2 BOOT 10 9e05 7437 0616
2200C1000A2005411C55
                 $GETVER 10.1.2 BOOT 10 9e05 7437 06162200C1000A2005411C55
                                                          $GE
TVER 10.1.2 BOOT 10 9e05 7437 06162200C1000A2005411C55
                                              $GETVER 10.1.2 BOOT 10 9e0
5 7437 06162200C1000A2005411C55
                           $GETVER 10.1.2 BOOT 10 9e05 7437 06162200C1000A20
05411C55
       $GETVER 10.1.2 BOOT 10 9e05 7437 06162200C1000A2005411C55
                                                      $GETVER 10.1.2
BOOT 10=
```

The GPS Board outputs messages once / second. Here are some definitions of common messages. Status, Sat and Clock.

$STATUS

Format: $STATUS <10M><1PPS><Ant><Hold><Nsat><State><debug>
Direction: Output
Parameters: 10M – 0=good, 1=bad
1PPS – 0=good (tracking within 25ns of engine), 1=bad
Ant – 0=no antenna fault, 1=antenna fault
Hold – number of seconds in holdover (0=not in holdover)
Nsat – number of GPS satellites being tracked.
State – State of the State Machine
0 = Time locked
1 = Acquisition
2 = Initialization
3 = Holdover,
4 = Forced Holdover
5 = Soft Holdover, 6 = No GPS,
7 = OCXO Training
8 through 17 are wait states

$SAT

Format: $SAT <Channel><Prn><El><Az><Sig>
Direction: Output
Parameters: Channel – receiver channel (0..7)
Prn – satellite PRN code.
El – satellite elevation (degrees).
Az – satellite azimuth (degrees).
Sig – signal strength (dBHz, 0 to
report satellite no longer tracked).
Usage: Reports satellite information.

$CLOCK

Format: $CLOCK <Gps><Leap><TFOM>
Direction: Output
Parameters: Gps – seconds since Jan 5, 1980 (at next PPS).
Leap – number of leap seconds
TFOM – time figure of merit, 1=best, 7=worst [1..7].
Usage: Output automatically once a second to report timing information

The GPS Board can be commanded, for example to start a self survey or output Lat, Long

Command $GETPOS

Response: $GETPOS <Lat><Lon><Amsl>

Parameters: Lat – latitude (degrees north * 1 million) [-90000000..90000000]

Lon – longitude (degrees east * 1million) [-180000000..180000000]

Amsl – antenna meters above sea level [-32768..32767]

Usage: Returns GPS position currently in use.

Command $SURVEY <duration>

Response: $SURVEY message

Parameters: duration number of hours to perform self-survey, 1 to 48.

If no value is entered, then the default of 8 hours is used.

Usage: Places the TPGPS into Self Survey mode and enables the output of the $SURVEY message.

Note: Do not experiment with commands in boot mode, some commands will erase the embedded code.

The GPS board can be commanded and output messages monitored on a PC running a standard serial ACSII terminal program.

- For example Putty or ProComm.

Connections to a standard 9 pin D connector are on the schematics in this document.

To make a standalone GPS receiver for the shack or workbench a Arduino controller with software has been developed so no PC or terminal has to be connected.

This project can be built around one of two options,

1)- Arduino to control the GPS receiver and output status to a 2 line display.

2)- No display and the receiver runs like a Trimble with Arduino to control. Data is sent to the USB monitor port on the Arduino, see note below to monitor.

Note on RS232 interface

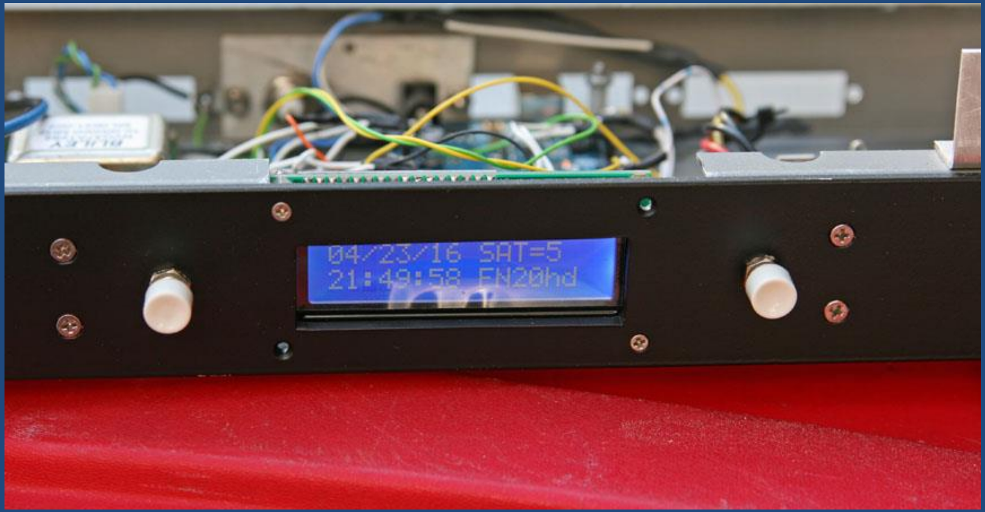
Note: - Putty, ProComm, Arduino IDE serial monitor, or other terminal emulation program can be used to monitor GPS receiver status with a PC from the GPS board RS232 port or the Arduino USB port in option 2 from the last slide. The board can also be commanded. Standard ASCII, 9600 baud. Connection and pin details on the schematic.

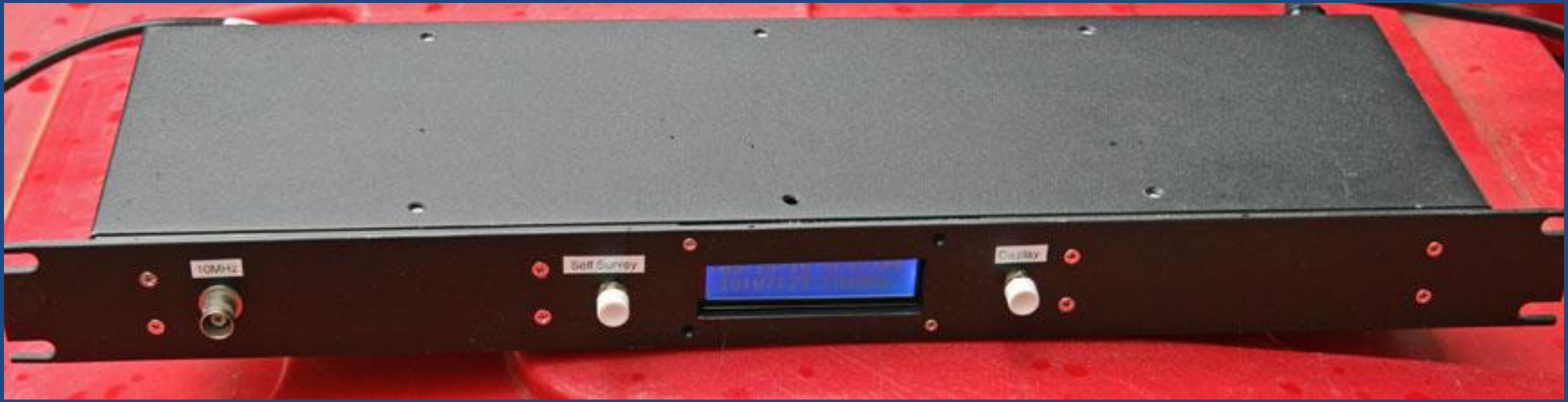
If the RS232 interface is used to communicate with the GPS board, pins 4 and 5 need to be connected as shown in the schematic for this interface. (jumper) The RS232 interface can be used to **monitor** (output only) the GPS board for troubleshooting and testing under Arduino control, but pins 4 and 5 need to be open or not connected.

Either make sure the jumper for pins 4 and 5 is removed or remove the RS232 interface connector when running the Arduino controller. Pins shown on the schematic and the board picture in these directions.

Here is a project built around these surplus boards that can be used in place of a Trimble on the bench or in the shack.

This one built in a surplus 1U rack chassis.



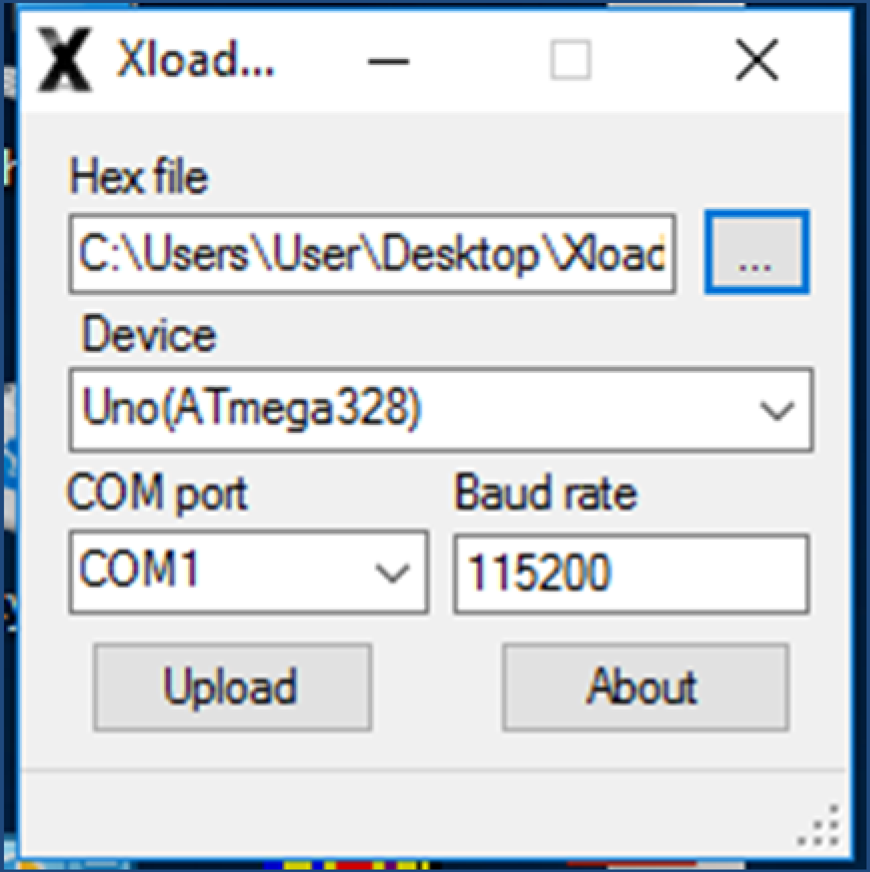


- Using a Arduino microcontroller, the GPS receiver boards can be commanded, GPS data read and displayed on a LCD display continuously.
- Arduino C code written by Bruce, WA3YUE.
- Front panel buttons send command to self survey, and toggle through display modes.

Arduino Software

- The code can be loaded to the Arduino from hex file using XL loader. A link is available to download the hex file.
- We will not be releasing source code at this time.

Xloader window



Hex file
C:\Users\User\Desktop\Xload

Device
Uno(ATmega328)

COM port
COM1

Baud rate
115200

Xloader can be downloaded free, google the internet.

What is required to build a GPS receiver?

- A surplus GPS board Member cost- $40.00
  - Note Ant cable, Male SMB to SMA Bulkhead supplied with board.
- Arduino microcontroller cost varies, $10 to $25.00
- GPS antenna, cost varies, $15 to $25.00, (Ebay)
- 2 Line LCD Display, Ebay item 221935534466, $6.50, discount for 3 or more displays
- A box, or chassis, and power supply, either fit in box or external.

About $75.00 total, depending on what’s on hand and using other resources.

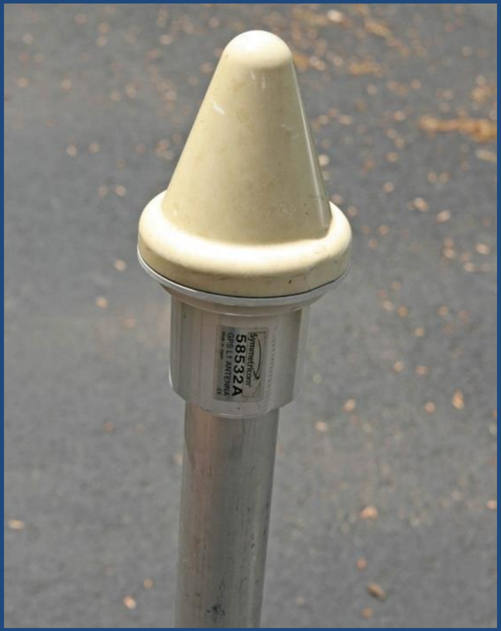
At times some kits may be available
Ask a Club member

- Included in the Kit
  - GPS board w/ antenna cable- SMB to female SMA bulkhead and 10 MHz MCX cable to pigtail.
  - Arduino
  - I2C Display
  - Group of 14 wires and header pins.
  - LM317, small board, resistors and capacitors to build regulator board for the Arduino
  - 2) pushbutton switches.
  - De-bounce parts, 1k, 10K, 1N4148, and 3.3 uF capacitor.
  - ¼” 4-40 standoff’s to mount GPS board.
  - E-mail contacts for Arduino code or technical questions.
    - Bruce WA3YUE wa3yue at ARRL.org
    - Gary   WA2OMY wa2omy at comcast.net

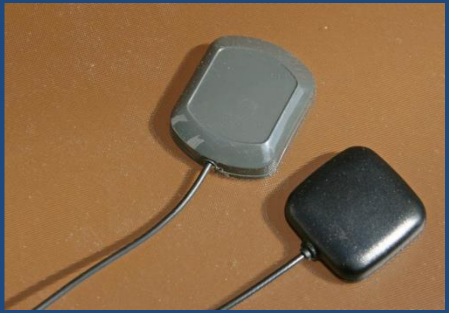
Not Included

- Box, use any box that will hold the boards and PS. Wall PS will work, or surplus box that may have a PS. A wood box is a option.
- 13.8 to 15V volt Power Supply
- 10 MHz output connector.
- Connector for RS232 interface. (6 pin header, optional).
- USB Type B cable to connect to Arduino
- GPS antenna
- Hardware, to mount boards and display.

Examples of GPS Antennas

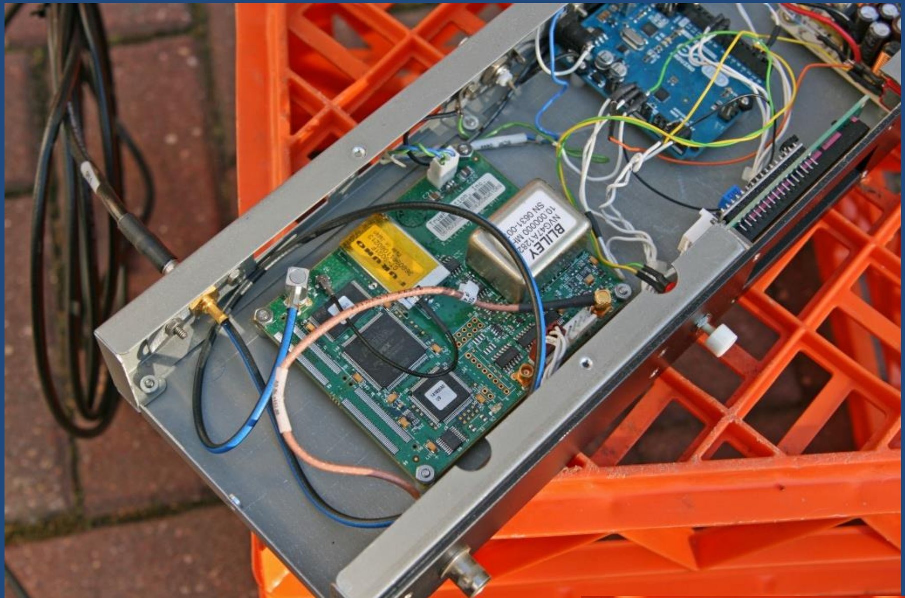


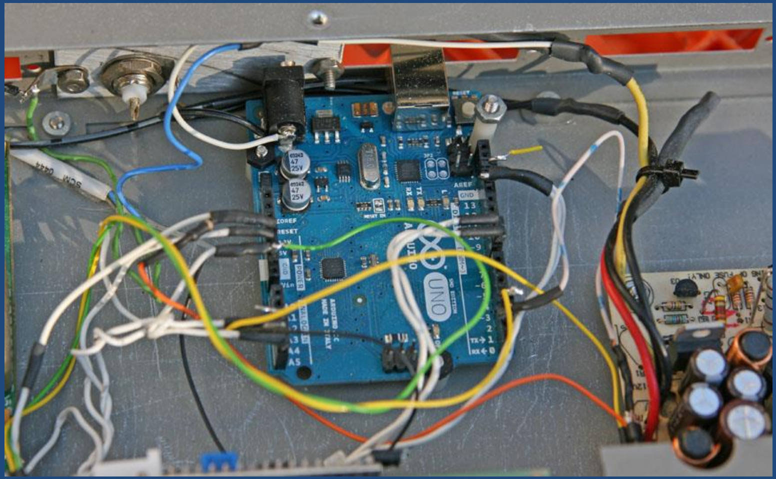
These work ok, find on EBay, and put out the word on Rat reflector

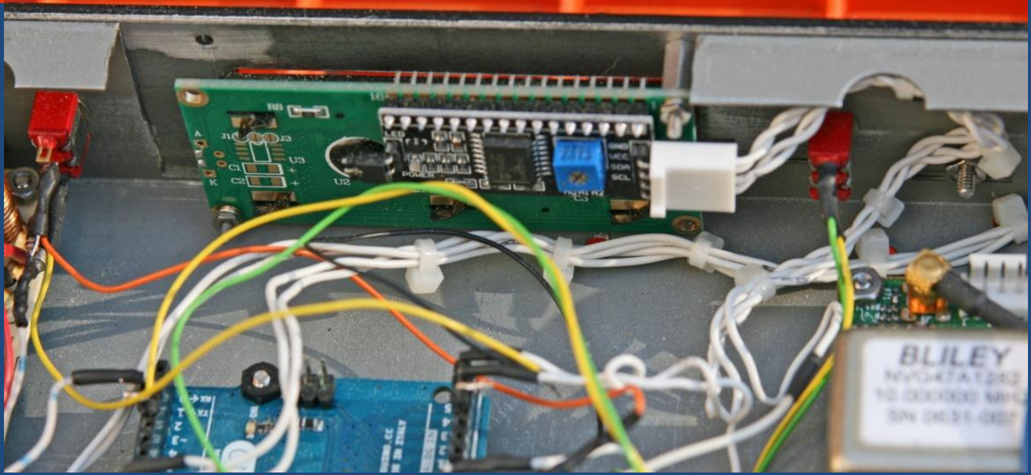


These do not appear to work, maybe current draw is low, maybe with modifications it is possible. GPS board and Trimble monitor 5V current.

Example of construction

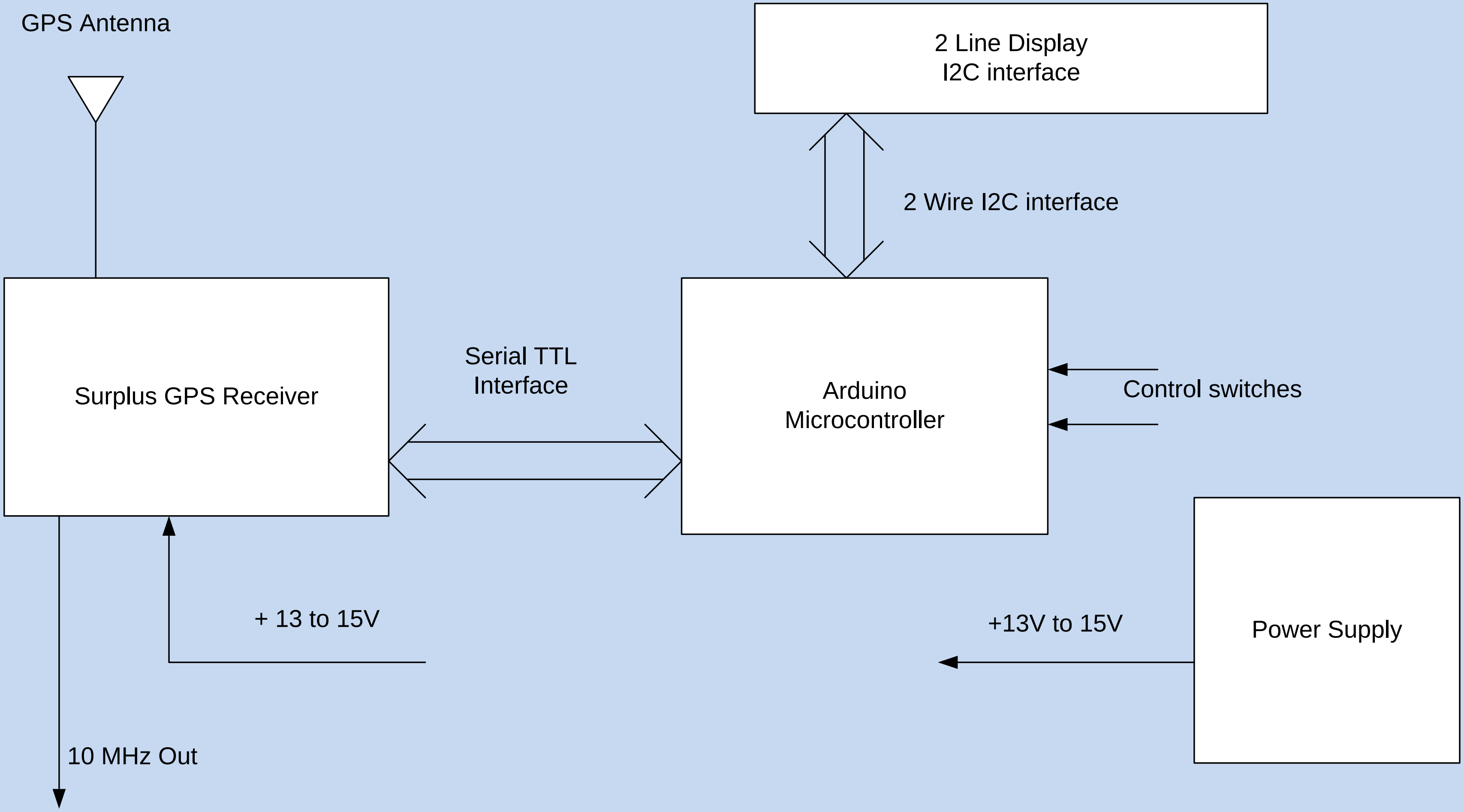




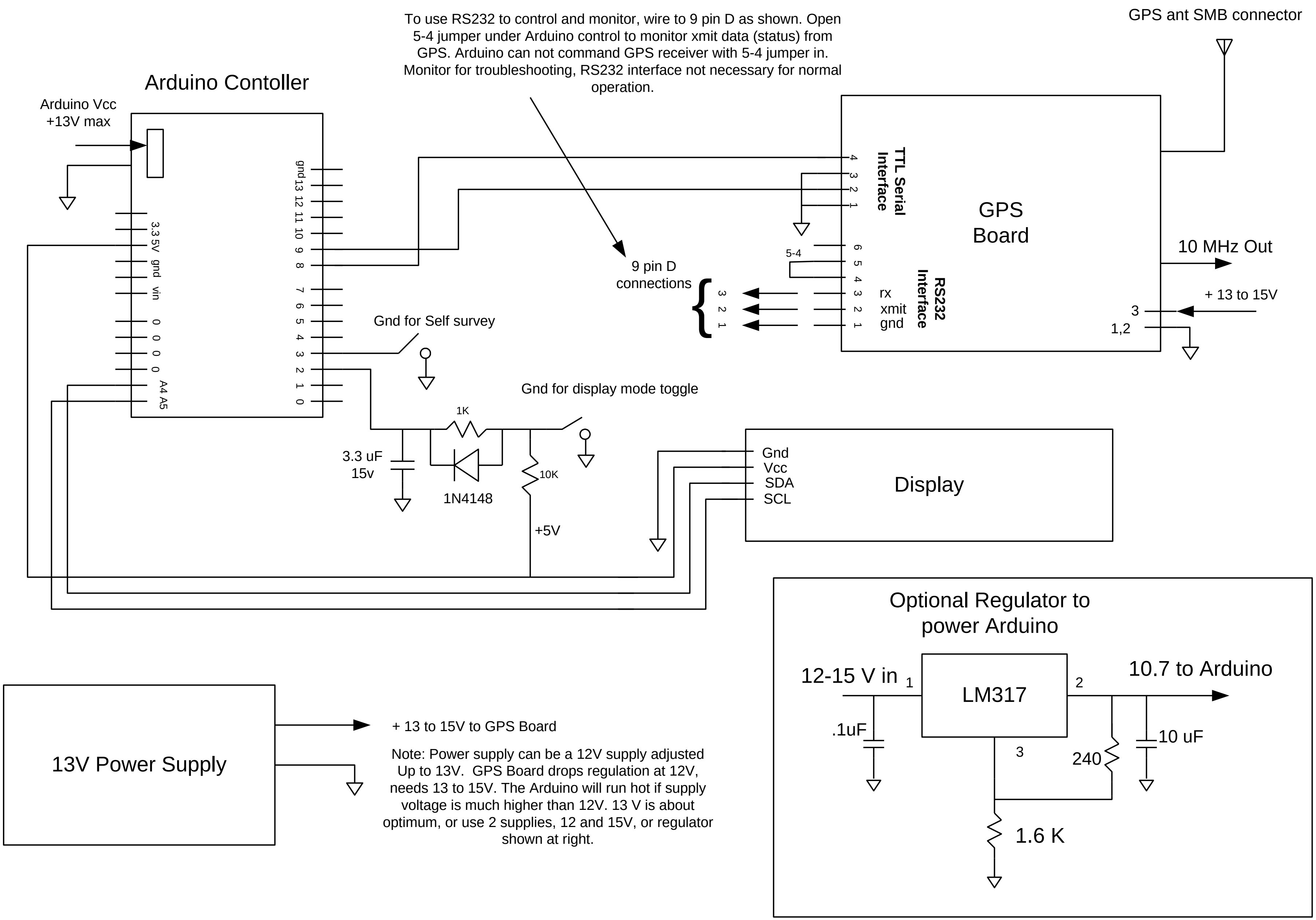


Block Diagram

GPS Receiver Block DIagram



Schematic Diagram Packrat GPS Receiver

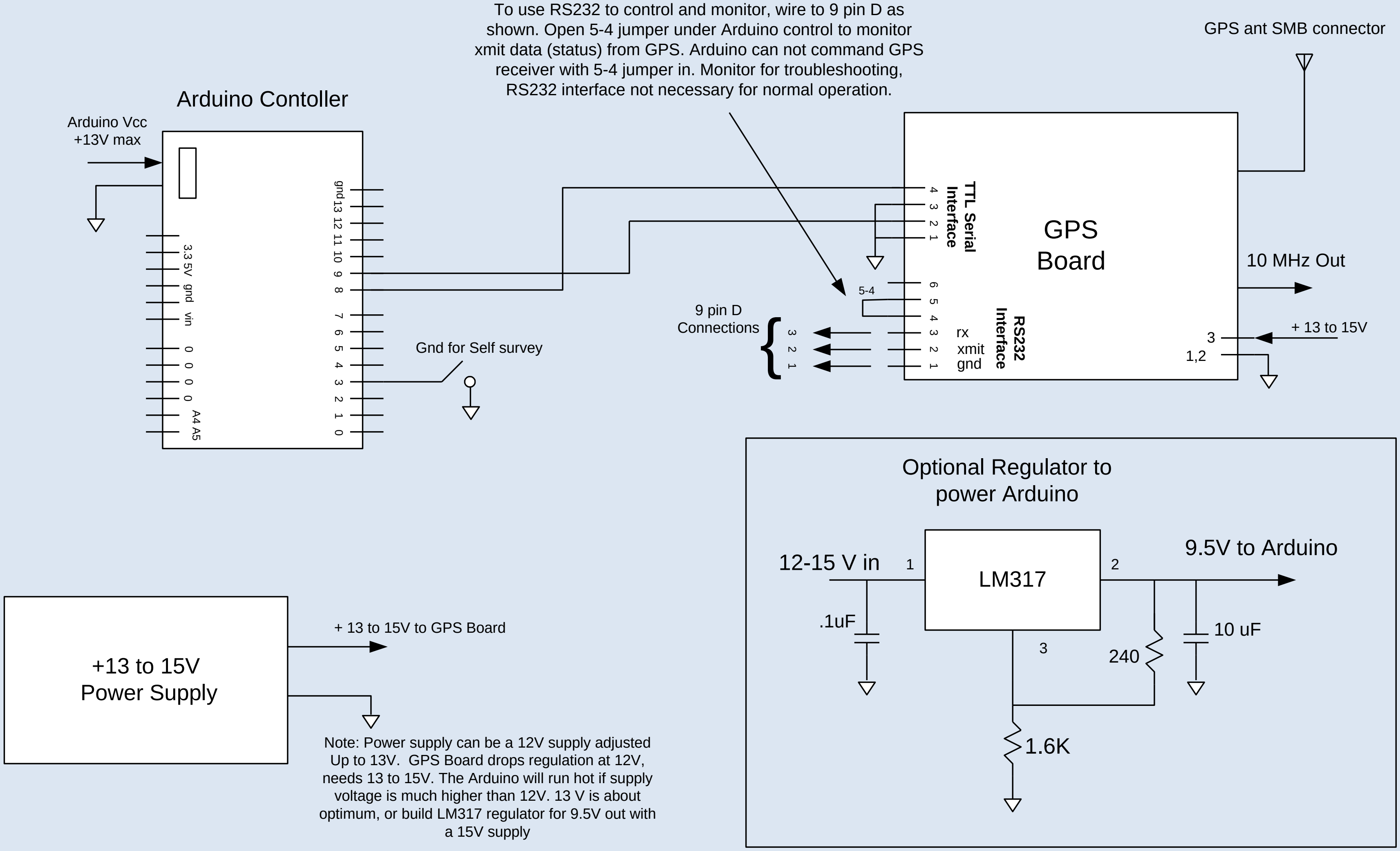


To use RS232 to control and monitor, wire to 9 pin D as shown. Open 5-4 jumper under Arduino control to monitor xmit data (status) from GPS. Arduino can not command GPS receiver with 5-4 jumper in. Monitor for troubleshooting, RS232 interface not necessary for normal operation.

+ 13 to 15V to GPS Board

Note: Power supply can be a 12V supply adjusted Up to 13V. GPS Board drops regulation at 12V, needs 13 to 15V. The Arduino will run hot if supply voltage is much higher than 12V. 13 V is about optimum, or use 2 supplies, 12 and 15V, or regulator shown at right.

Schematic Diagram Packrat GPS Receiver
No Display option



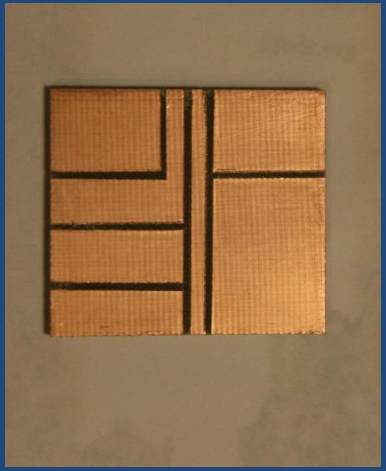
To use RS232 to control and monitor, wire to 9 pin D as shown. Open 5-4 jumper under Arduino control to monitor xmit data (status) from GPS. Arduino can not command GPS receiver with 5-4 jumper in. Monitor for troubleshooting, RS232 interface not necessary for normal operation.

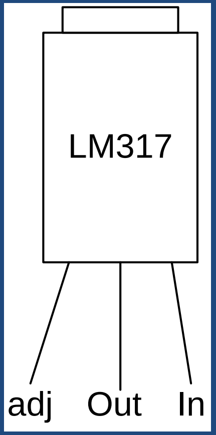
Note: Power supply can be a 12V supply adjusted Up to 13V. GPS Board drops regulation at 12V, needs 13 to 15V. The Arduino will run hot if supply voltage is much higher than 12V. 13 V is about optimum, or build LM317 regulator for 9.5V out with a 15V supply

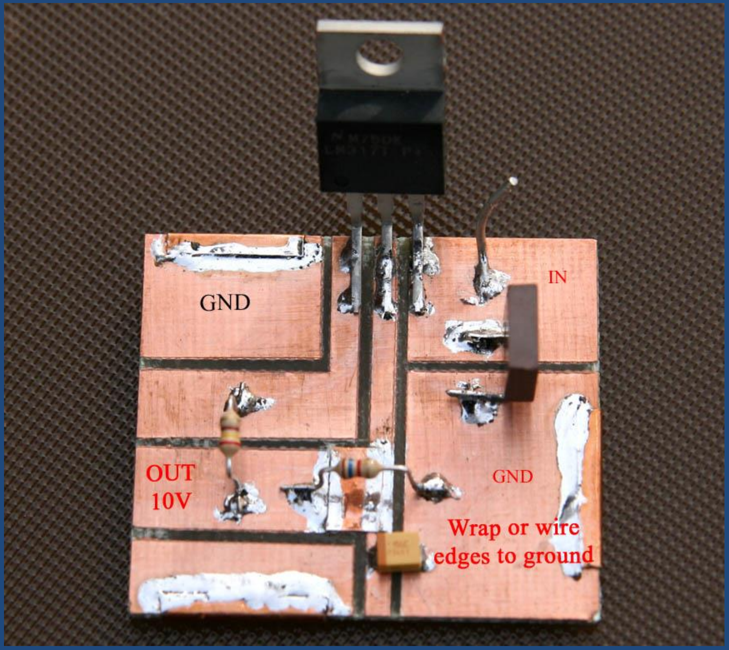
LM317 regulator

- Arduino voltage should be around 9 to 12V max, GPS board will run at 13.8 to 15V.

A regulator or diodes in series should be used to drop voltage to the Arduino. If you have the kit, parts are included to build the regulator shown below. The PC board will have to be x-acto etched or done “Manhattan” style. The regulator only requires 4 parts in addition to the LM317, see schematic. The resistors included provides about 10.7 V out.







Construction Notes

Do not attempt to remove and replace the SMB or MCX connectors on the GPS board, the board has many internal layers some with copper planes. Via holes will be damaged unless preheat and skilled de-soldering procedures are used.

Wires and header pins are included in the kit, use them to make header pin connections, or use header pins to solder longer or shorter wires as necessary.

De-bounce parts can be wired on switch pins and wires to Arduino header.

Install the 3.3uF capacitor with correct polarity.

Only the display mode switch needs de-bounce, self survey switch wire directly to Arduino as shown in the schematic.

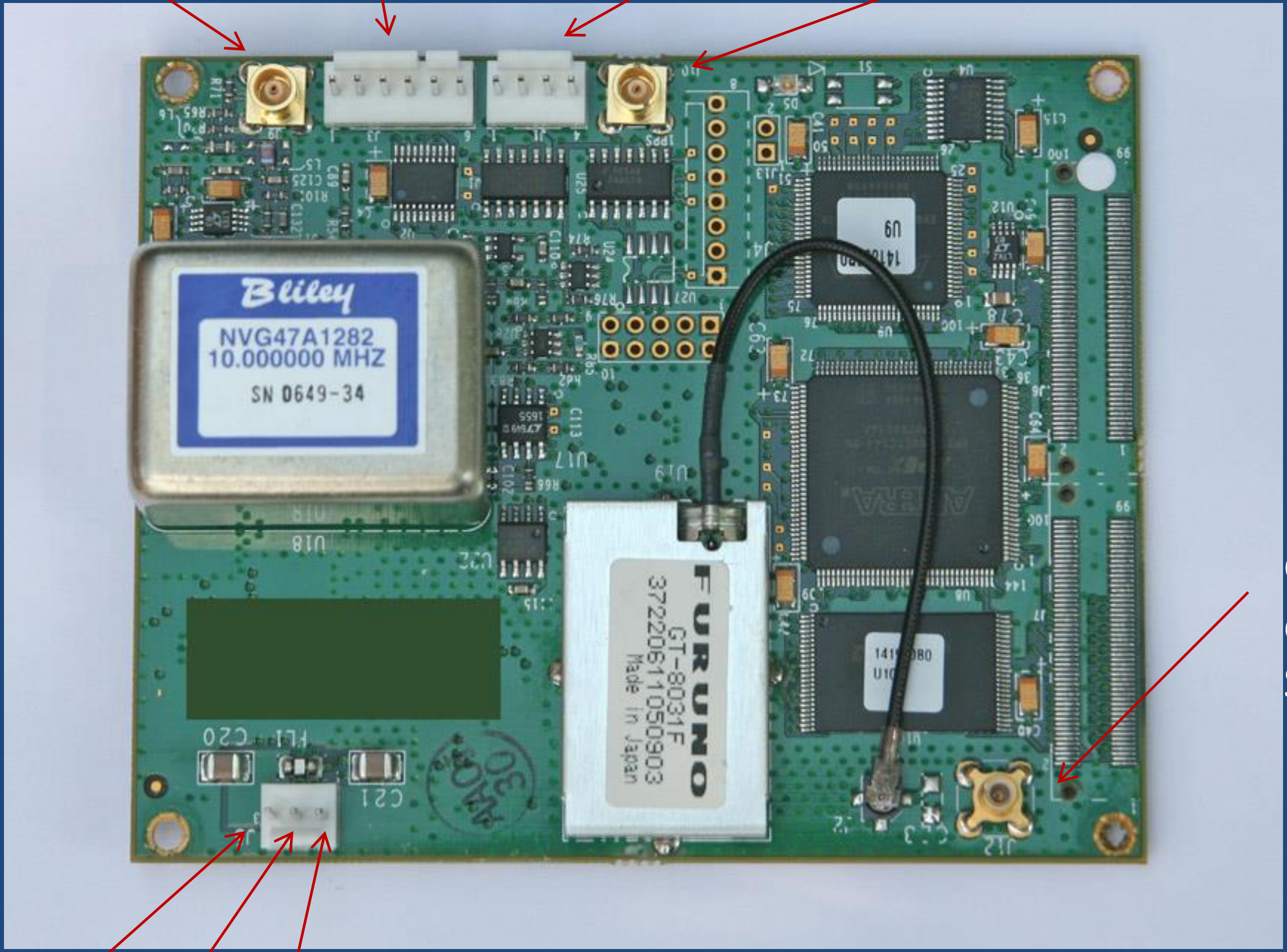
Verify voltages from power supplies and regulators before connecting boards!

Don’t forget to make sure all boards have a common ground.

- The following two slides show the connection information for the two versions of this board available on the surplus market. The functionally and output is the same for both boards.

- The later design has later revised software and was made to plug into a motherboard so the header pins are on the bottom of the board. With the pins on the bottom of the board, increased height will be necessary for a enclosure. It operates on +12V. Otherwise the 10 MHz and 1pps outputs have the same accuracy and output.

GPS board interface connections



10 MHz out MCX connector

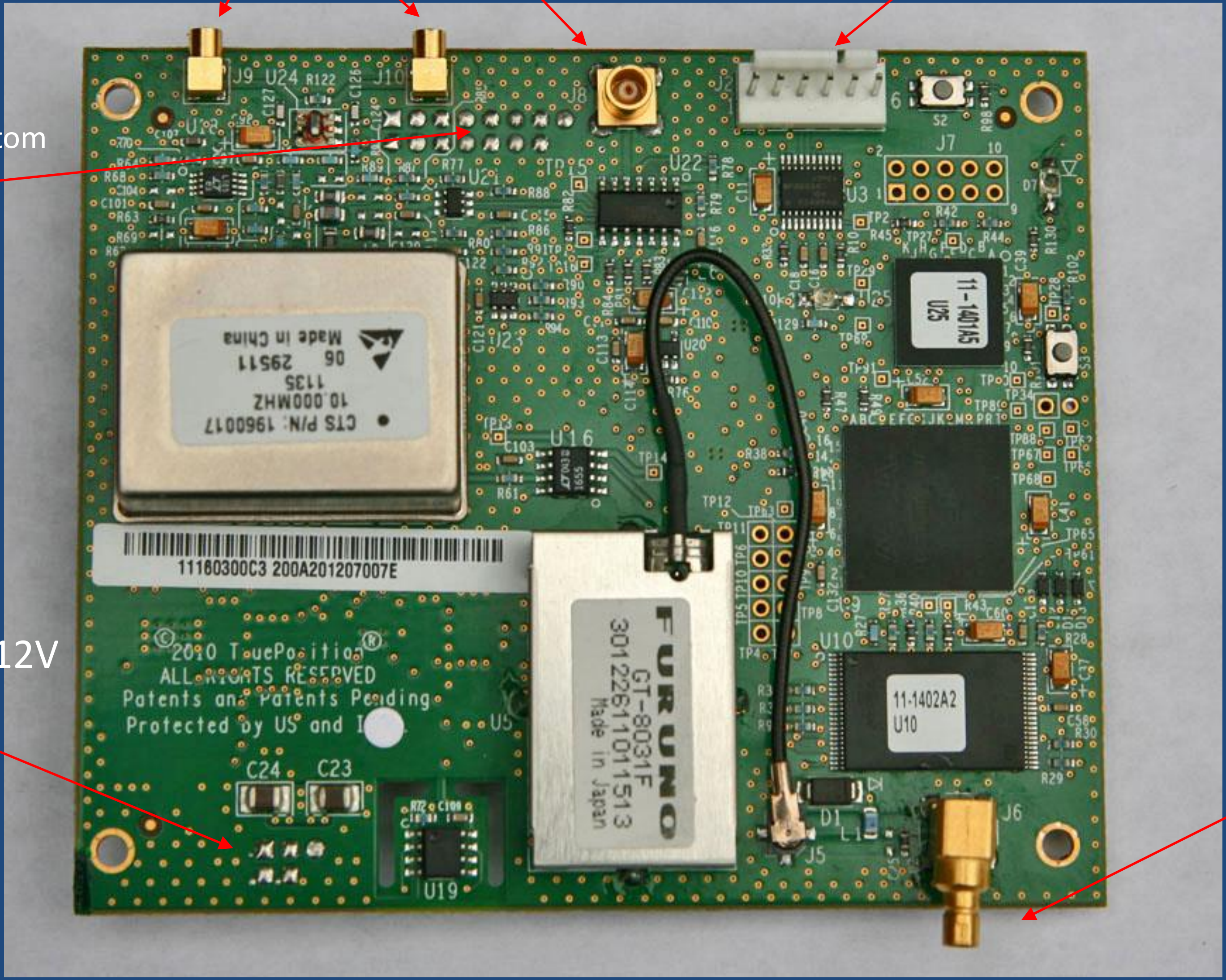
RS232 Serial interface
Gnd, TX, RX, Gnd, EN, RX-out

TTL Serial interface
Gnd, rx, gnd, tx

1ppS output

GPS antenna connector SMB

+15, gnd, gnd



Two 10 MHz outputs.
2) MMCX connectors

1 ppS out

RS232 Serial interface
Pin1- Gnd, TX, RX, Gnd, EN, Furuno data out

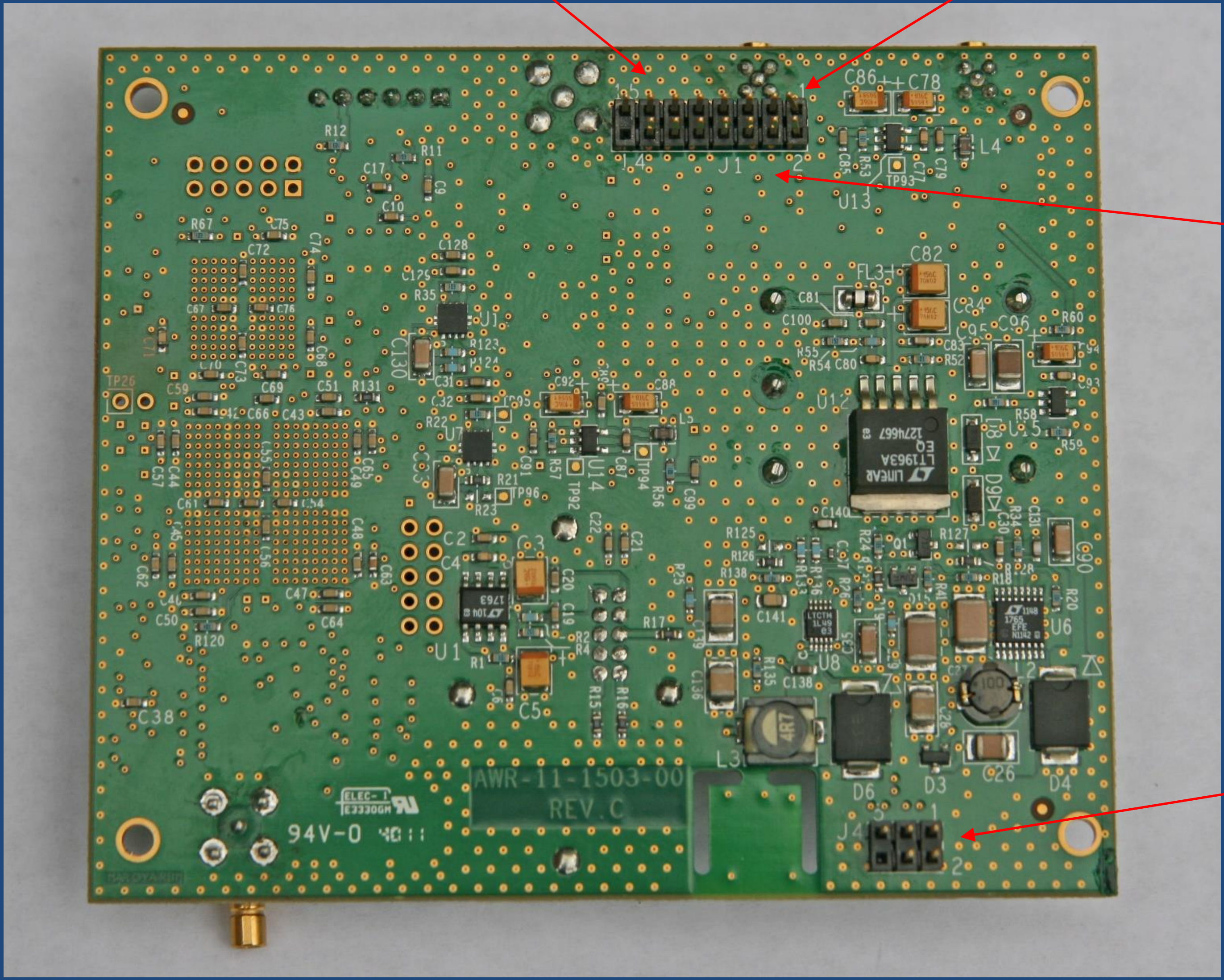
Serial TTL
interface
Pins on bottom

Power +12V

GPS antenna
connector
SMB

J1- TTL seral interface. 15 pin connector. Pin 16 removed.

Pins 1,2,5,6,9,10, 13,14 gnd.

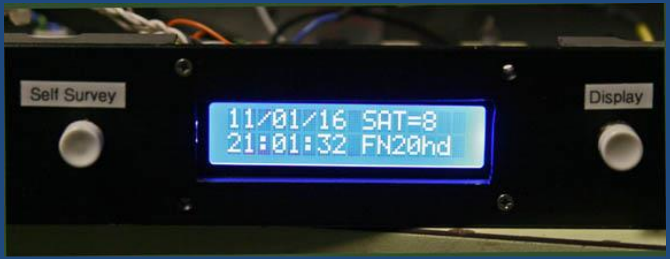


Pins 3,4 RX
Pins 5,6 TX
Pins 11,12 1ppS out

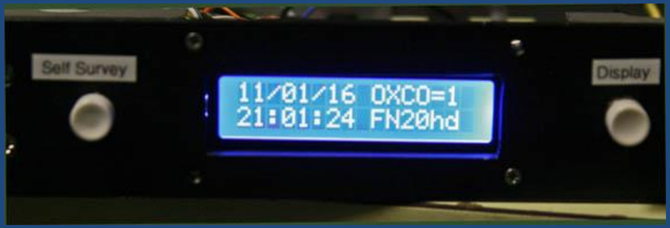
J4 Power
Pin 5 +12V

1,2,3,4 Gnd.

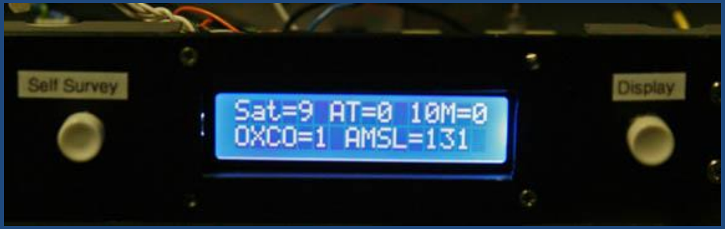
Display Definitions



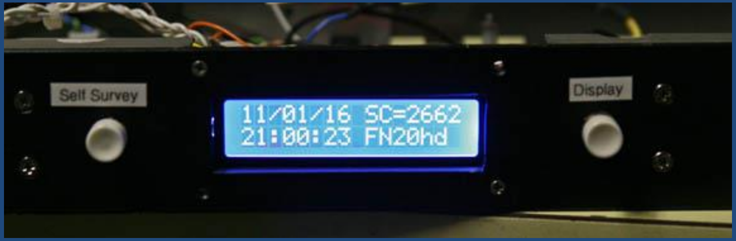
Date, number of satellites in use, time and gird square



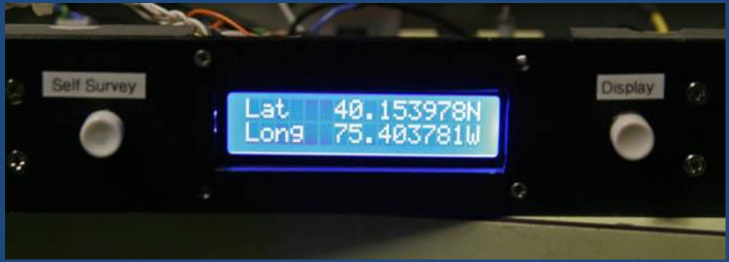
OCXO status, the definition is on page 5, under state machine. One of 8 possible states. 0 or 1 is normal operation when satellites are received. 0 time locked, 1 acquisition. 0 and 1 may toggle as satellites change.



Number of Satellites received.
Antenna status, 0 good, 1 bad.
10 MHz status, 0 good, 1 bad.
OCXO status, see previous definition.
Amount above sea level in meters.



SC, Survey count, when self survey is being performed. Once self survey is done, this will be 0



Lat – Long output

Summary

- Club benefits from sale of boards and kits!
- Three receivers have been built and design verified.
  - E-mail contacts for Arduino code or technical questions.
    - Bruce WA3YUE wa3yue at ARRL.org
    - Gary   WA2OMY wa2omy at comcast.net
    - George, KA3WXV ka3wxv at yahoo.com