# TRIMBLE GPS / 10MHz REFERENCE MONITOR DISPLAY
## V2.1 January 2019



## A display and command module for the Trimble Thunderbolt GPS with 10MHz reference oscillator.

### by Hubbatech

**Revision Notes:**

1.2 - 2014 - Release version.

1.3 - Oct 2014 - Added display blanking after 10 minutes when not in scroll mode.

1.4 - Jan 2015 - Stopped leap second pending from beeping and flashing as an error.

2.0 - Aug 2015 - New PCB, minor software changes.

2.1 - Jan 2019 - Rewrite for Trimble incorrect output of date and time due to week number rollover.

**DESCRIPTION:**
The Trimble GPS Monitor Display provides an interface between the user and the Trimble Thunderbolt GPS Disciplined Oscillator or GPSDO.  These GPS units are available second hand at a reasonable price and when in service were usually mounted away from the operator and information from it was used for timing and reference. Therefore no hardware interface came standard with the unit.  It is capable of receiving up to 8 satellites at once to obtain accurate data.

These units provide excellent service as 10MHz reference oscillators for test equipment calibration or for use as an accurate reference for microwave communications requiring a very high degree of frequency stability.  The Trimble Thunderbolt GPS will only communicate via RS232 using Trimble's own TSIP protocol.  Several monitoring programs are available for the PC but for standalone functionality a monitor display is advantageous, especially if the unit is to be used in the field.

For Amateur Radio use, this monitor display should have all that would be required.

Similar displays have been made available. This design is a variation or combination of some common features from them all plus a few more.

The monitor has a 4 line x 20 character OLED display which gives clear text in all light conditions rather than an LCD which requires backlighting in certain locations. In the description below where applicable, the "normal" display is highlighted.

**Page 1 shows:**
*Date and time:*  in either GPS time or UTC time (a difference of about 18 seconds as of 2019).
A "G" or "U" at the end of line one shows which time is being displayed. (FROM SOFTWARE VERSION 2.1 THIS IS NO LONGER DISPLAYED AS TIME IS DISPLAYED IN UTC ONLY)
*GPS Decoding Status :*   One of the following will be displayed...
Doing Fixes,   No GPS time,  PDOP too high,   No Sats,     Only 1 Sat,    Only 2 Sats,   Only 3 Sats,   Sat unusable,   TRAIM rej  .
*Disciplining Activity:*   One of the following will be displayed…
Phase Locking,   Osc Warm Up,   Freq Locking,   Placing PPS,   Ini Loop Filt,   Comp OCXO,   Inactive, Recovery mode.
*10MHz Oscillator error:*  shown in parts per billion (ppb)
This value will vary constantly but will range between a small positive or negative value such as 0.001ppb or 0.01ppb indicating the accuracy of the reference oscillator.

**Page 2 shows:**
*Date and time:*   in either GPS time or UTC time.
A "G" or "U" at the end of line one shows which time is being displayed. (FROM SOFTWARE VERSION 2.1 THIS IS NO LONGER DISPLAYED AS TIME IS DISPLAYED IN UTC ONLY)
*Receiver Mode:*    One of the following will be displayed...
Automatic,  Single Sat,   Horiz 2D,   Full Pos3D,   DGPS Ref,   Clock Hold,   Overdet.
*Disciplining Mode:*    One of the following will be displayed…
Normal , Power-up,   Aut Holdvr,   Man Holdvr,   Recovery,   Disabled  .
*Survey Progress:*   displays % progress of the GPS when a survey has been started by pressing the Survey button on the front panel.

**Page 3 shows:**
*Date and time:*   in either GPS time or UTC time. (FROM SOFTWARE VERSION 2.1 THIS IS NO LONGER DISPLAYED AS TIME IS DISPLAYED IN UTC ONLY)
A "G" or "U" at the end of line one shows which is being displayed.
*Latitude:*   Displayed in decimal degrees. (updated only after a survey has been performed)
*Longitude:*   Displayed in decimal degrees. (updated only after a survey has been performed)
*Altitude:*   Displayed in meters (updated only after a survey has been performed)

**Page 4 shows:**
*Major Alarms:*    displays one of the following but scrolls through if more than one fault, at 4 second intervals…
ROM chksm,   RAM check,   Pwr Suppl,   FPGA chck,   Osc. volt
Or shows "Nil" if there are no alarms.
*Minor Alarms:*     displays one of the following but scrolls through at 4 second intervals if there is more than one fault …
E nr rail,  Ant o/c,   Ant s/c ,   No Sats,    Not Disc,   Surveying,  No pos st,   Leap Sec,    Test
Or shows "Nil" if there are no alarms.
*DAC Voltage:*     displays the voltage applied to the VCO to keep it on track. This should be a small value much less than 5v but will increase as the oven controlled oscillator gets older.
*Power Supply Voltage:*    displays the voltage of the supply connected to the Trimble Monitor board. Probably around 12v or 13.8v.  If the supply voltage falls below about 9.5v, the beeper will sound and the page number will flash as per a Trimble GPS alarm. The PSU reading will also flash when on page 4. The supply voltage is averaged over several readings and may take a short time to stabilize after selecting page 4.

If alarm(s) exist a double beep will be heard and the page number will flash.  This beep will be heard every few minutes until the alarm has ceased or page 4 (alarm page) is selected in "NON" auto scroll mode. (from V1.4 the beep and flash will not occur for the "leap second pending" alarm. However the page 4 display will still show as a minor alarm until the leap second event occurs. If set to in "NON" auto scroll, the display will remain blanked but beeping will occur as above)

For explanations of the meanings of each displayed item, reference should be made to the Trimble manual.
By default, the pages will "auto" scroll with each page being displayed for about 10 seconds. See the programming section for disabling of this feature.

**OPERATION:**
The currently displayed page number is shown in the bottom right corner of each page.  When alarms are detected, the page number flashes at a one second rate and the beeper will sound every few minutes in case the flashing page number is not noticed.  Selecting page 4 will stop the beeping in "NON" auto scroll mode but the flashing page number will continue until all alarms have ceased. (see note regarding V1.4)
**Button – Page Scroll.**     To change pages, press the centre button. The displayed page will scroll to page 2, 3 and 4, then back to page 1 again.
**Button – GPS/UTC.**       Press this button to toggle between UTC time and GPS time which at the time of writing is 16 seconds. (FROM SOFTWARE VERSION 2.1 THIS BUTTON HAS NO FUNCTION AS TIME IS DISPLAYED IN UTC ONLY)
**Button – Survey Start.**   Press this button to trigger a Survey.  The number of survey points is set at 200 to give a reasonably quick position and altitude fix.
**Button – Full Pos. 3D.**    Press this button to change the GPS mode from Overdetermined Clock mode which gives most accurate time and oscillator data to Full Position 3D mode which will give the Latitude, Longitude and altitude of the current location. If not in 3D mode, position information shown on page 3 will be what was stored in memory when the last survey or 3D mode selection was made.
**Button – Overdet. Mode.**        Press this button to return to the Overdetermined Clock mode to give the most accurate time, 10MHz oscillator and 1PPS data. When a Survey is completed, the GPS returns to the Overdetemined mode automatically.

**Other Features:**
The display / monitor unit also monitors the temperature of the Trimble GPS and can optionally switch a logic "high" (5v) for control of a fan and /or external alarm. The setting for ON is 40°C and for OFF is 35°C.  The Trimble specifications call for an operating temperature between 0 and 60°C and this could be exceeded inside a cabinet on a hot day. If the temperature inside the GPS reaches 55°C, the display will flash a message indicating that the temperature is too high.  The highest temperature reached will be displayed on the bottom line. This message will remain on the display until the Page Scroll button is pressed. If the temperature has fallen below 55°C when the button is pressed, the Monitor will resume its normal display on Page 1 and the highest temperature reading will be reset.  If the temperature has not fallen below 55°C when the button is pressed, the display will retain the "too high" message but the current temperature inside the GPS will now be displayed on the bottom line and the beeping alarm will stop. Holding the button will display Page 1 to show if data is still being monitored.
From V1.3, The LCD screen will be blanked after 10 minutes if the "Auto Scroll" feature is not enabled. (see Programming section)
To enable the display after it has blanked, press any button briefly.

**PROGRAMMING:**
Several features can be disabled from the default settings if desired.
"**Auto Scrolling of pages** 1 to 4". This can be disabled so that the page selected will remain displayed.
If this feature is OFF, automatic blanking after 10 minutes will occur except if an alarm is present.
"**Beeping when alarms are present**" (except extremely critical alerts such as over temperature which will always beep)
"**Beeping when button is pressed**".

Default settings for all the above is ON.

To enter programming mode, select page 1 on the display. Press and hold the page scroll button for at least 5 seconds. The unit will beep 4 times and the display will show "SETTINGS" with the three options listed.  The top line also shows the current temperature inside the GPS module.
To change the settings ...........
Press the GPS/UTC button to toggle the auto page scroll feature.
Press the Full Pos 3D button to toggle the alarm beeping feature.
Press the Overdet. Button to toggle the button beeping feature.
The corresponding setting for each will change from Yes to No or vice versa.
To leave the program mode, press the page scroll button briefly. This will save your changes to memory.


The following pictures show an example of what each page would look like.



Page 1

Page 2

```
30-May-14 09:56:48 U
RX Mode :   Overdet.
Disc Mode: Normal
    Survey Prog:100%   2
```

Page 3

```
30-May-14 09:54:08 U
   Lat:  -38.2932 °
   Long:  +145.6723°
   Alt:   151.624m   3
```

Page 4

```
Major Alm:       Nil
Minor Alm:       Nil
   DAC: +0.3503 v
     PSU:  13.9 v       4
```

Program

```
       SETTINGS   32.0°
Auto Scroll   - Yes
Alarm Beeps   - Yes
Button Beeps - No
```
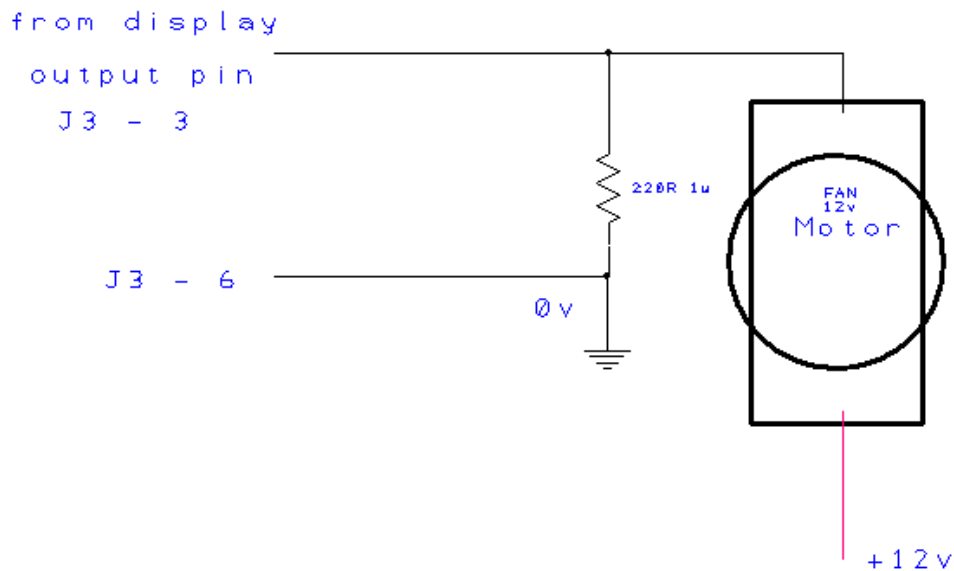
**Connecting to the GPS:**
The display will work using a supply between 7v and 14v DC. The Trimble Thunderbolt requires a 12v supply also, therefore the two would best be connected to the same supply. The input supply voltage to the display is monitored and is shown on page 4. If the voltage falls below the minimum required by the GPS, the display and beeper will alert that there is a problem.
Plug the DB9 plug into the serial port of the GPS and connect power to both display and GPS.

Depending on how long the GPS has been off will determine the time taken to sync with the satellites and give meaningful data on the display. Until then, errors will show on page 4. After that, the Survey, Overdetermined, Full Position 3d and GPS/UTC (if applicable) time buttons will work as described.

**Other connections:**
Fan Control: if this is required, a open collector output connection can be found at J3 - 3 pin. A circuit such as shown below is suitable for a 12v fan. Note that the output from this PCB is capable of sinking about 150mA only. For a fan requiring higher current, it is best to use a relay as well. Using this circuit, the fan runs continuously at roughly half speed and so is quiet until the GPS internal temperature rises above 40°C at which time the fan goes to full speed. The fan returns to half speed when the temperature drops to 35°C.

```
from display
output pin
   J3 - 3

                                          220R 1u        FAN
                                                         12v
                                                       Motor
   J3 - 6

           0 v


                                                         +12v
```

**Trimble Thunderbolt Pre Configuration:**
To enable the GPS to work as described, certain features must be set up. This can be achieved by connecting the Thunderbolt to a PC and using the TboltMon program to make the changes necessary. TboltMon is available from several locations plus there is a link to download it on our website. The quickest method to set the GPS to the correct settings is to connect and run TboltMon then select Control - Factory Reset from the pull down lists and confirm the selection. Assuming an appropriate antenna has been connected, the GPS will reset, then perform a self-survey. It may take a while (20 minutes) until the almanac has been downloaded and the survey completed. Completion will be indicated by a green instead of a yellow button beside the "Almanac" and "Survey" lines in the Minor Alarms list on the main screen of the program. When this has completed, the only yellow indicator should be beside the "Stored Position" line in the Minor Alarms list. Unless a position is stored in the GPS, an alarm will be indicated and the beeper will sound every few minutes on the display unit when it is connected. To store the current position, select Setup, then Position from the pull down lists, then enter the current co ordinates and altitude. These are shown on the left of the main screen which should be visible in the background. Click "Save Segment" and the indicator should change to green beside the "Stored Position" line. When all indicators are green, the monitor / display can be connected. Next select Setup, then Self Survey, then enter a value of 200 into the "Survey Length" area. (default is

2000) This will reduce the amount of time the GPS takes to obtain stable survey information when the "Start Survey" button is pressed. Click on "Set Survey" and close the page.
You may then select GPS or UTC time, or use the other push buttons to command the GPS.

**PCB Connections:**
J3 Connector has 6 pads. Their functions are as below;

1        +12v DC input at about 100mA
2        +5v DC output from the display PCB (a few mA only)
3        Fan control output (open collector) - small fan only or use a relay
4        RS232 I/P from GPS (RXD) - connect to the GPS - DB9(male) pin 2
5        RS232 O/P to GPS (TXD) - connect to the GPS - DB9(male) pin 3
6        Ground (0v of Supply) - also connect to the GPS - DB9(male) pin5

**Mounting the Display:**
The following page may assist when drilling mounting holes for the display, PCBs and for the push button switches. Print the page with no scaling to get the correct size to use as a template.
The four mounting points for the OLED display would normally be used and to support the controller PCB, the two holes near the push button switches are needed to give support when pressing the buttons.