Introduction

This document describes using a surplus Trimble Thunderbolt GPS Disciplined Oscillator as a precision 10MHz reference source for a multi-transverter PLL Local Oscillator system, or for use as a master shack reference, which can be used as a reference for a frequency counter, spectrum analyzer, and even your transceivers.

Whilst there are many possibilities with enclosures and layout, this article brings to your attention the use of an inexpensive DC-DC converter board to generate 5 and -12V rails, and an easy to construct 10MHz Splitter/Amp kit that provides four isolated and filtered outputs.

Features

- GPS-locked 10MHz outputs @ +12dBm
- Outputs isolated and filtered
- Requires single +13V supply rail
- DC-DC converters for +5V and -12V

Power Supply

The Thunderbolt requires +12V, -12V and +5V.

To allow for portable operation from a nominal 13.8V supply, this project incorporates DC-DC converters based on the LM2575 regulator IC.

The cheapest and easiest way to obtain +5 and -12V rails is to buy a pre-built dual DC-DC converter board from Futurlec. These are only $9.90... less than the cost of the individual parts, and on a nice compact PCB.

These Futurlec power supply boards come in a dual +5/-5V version or as a dual +12/-12V board. We then swap out the undesired 5-pin LM2575 regulator chip. ie; purchase a +12/-12V board and replace the +12v regulator chip with a +5V version -or- purchase the +5/-5V board and replace the -5V regulator with a -12V version. Either way, we want to end up with +5 and -12V supplies on the same board.
PSU Board Modifications

Exercise care when removing the 5-pin regulator IC, as plated through holes tend to hold a bit of solder that needs sucking out. Alternatively, if you don’t have any use for the regulator you are about to remove, simply cut the legs just above the PCB, and it will be much easier to pull out one leg at a time with needle nose pliers as you heat the pin up from the solder side.

To avoid a 0.6V differential on the output rails, the input diode bridge on the board should be removed, and by-pass links fitted. See picture at right.

In this case, the negative input is the left terminal, and the +ve input is the right terminal.

The output ground and input ground should then be tied together with a short piece of wire, soldered on the underside of the board.

No heatsinks are required on the regulator chips, as they run barely lukewarm in operation.

The 13.8V current drawn is initially 1.0A, but falls to less ~500mA once the OCXO is at normal operating temperature.

4-Way Splitter/Amplifier/Filter

Having multiple 10MHz outputs is handy for feeding independent transverter LO systems.

The 4-way split is achieved with a Down East Microwave Inc "10MHz Amplified and Filtered 4-Way Divider" kit, 10-4K, and uses ERA-2 MMICs. All on-board components are SMD.

This kit accepts a 10MHz input, which is divided, amplified and then filtered to reduce harmonics, producing four clean outputs.

The DEMI kit comes in two versions, a board-only kit, and a complete kit. This project uses the board-only kit.

If you want to integrate an Amp/Splitter into your own project, choosing your own case and connectors, rather than using the DEMI supplied case and connectors, you are better off getting the cheaper board only kit.

Don’t forget to add the +ve supply rail wire links (red wires above).
**Mechanical**

In this particular installation, the Futurlec DC-DC converter board and DEMI Amp/Splitter are both housed within an aluminium diecast box, which is "piggyback" fastened to the Thunderbolt case with two M3 bolts.

These two bolts, along with M3 nuts (as standoffs), then become mounting points for the PSU board.

The feather weight amp/splitter is held in place with nuts and washers on the two outer SMA output connectors, and requires no further support. Nuts & washers from the two inner connectors are utilized so we have the right number of nuts and washers for both sides of the case.

The SMA sockets, from **RF Supplier**, are *End launch PCB mount wide flange .062" long version*.

A coaxial DC socket for 13.8V power and an SMA socket for 10MHZ input are also mounted on the diecast box, above the line of SMA output connectors.

The 10MHz input SMA is actually a bulkhead jack for 0.086 hardline, and RG316 Teflon cable fits perfectly.

**Serial Interface**

Although the **Thunderbolt** is essentially plug and play, having ready access to its serial port on the front of your enclosure is handy for interrogation, system configuration, and checking the status of your GPSDO system.

Use a short DB9-DB9 cable, to extend the **Thunderbolt**’s serial output to your transverter enclosure’s front panel.
### Thunderbolt Power Connector

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+12V</td>
<td>Prime voltage for the OCXO</td>
</tr>
<tr>
<td>2</td>
<td>Ground</td>
<td>Power ground</td>
</tr>
<tr>
<td>3</td>
<td>+5V</td>
<td>Load share voltage, Logic &amp; IO</td>
</tr>
<tr>
<td>4</td>
<td>+5V</td>
<td>Load share voltage, Logic &amp; IO</td>
</tr>
<tr>
<td>5</td>
<td>Ground</td>
<td>Power ground</td>
</tr>
<tr>
<td>6</td>
<td>-12V</td>
<td>Prime voltage for the OCXO</td>
</tr>
</tbody>
</table>

Power to the *Thunderbolt* is fed via a hole drilled into the side of the diecast case.

*Flyingbest* supplies a power connector with a short wiring harness with the Thunderbolt unit.

The power connector has 0.1" pitch pins.

It has been noted that actual wire colours may vary from unit to unit, so be alert when wiring up.

Above: RG316 with BNC (m) to SMA (m) interconnects the *Thunderbolt* to the Splitter/Amp
## Bills of Material

<table>
<thead>
<tr>
<th>Item</th>
<th>QTY</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trimble Thunderbolt GPSDO</td>
<td></td>
<td>eBay: Flyingbest</td>
</tr>
<tr>
<td>Dual +12/-12DC-DC converter board</td>
<td></td>
<td>Futurlec, # MINIPOWERDUAL12V</td>
</tr>
<tr>
<td>LM2575 +5V regulator</td>
<td>1</td>
<td>Futurlec, RS</td>
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<tr>
<td>10MHz Amp &amp; Filter board kit</td>
<td>1</td>
<td>Down East Microwave, # 10-4K</td>
</tr>
<tr>
<td>Aluminium Diecast box</td>
<td>1</td>
<td>Jaycar, # HB5607</td>
</tr>
<tr>
<td>M3x15mm bolts, washers &amp; nuts</td>
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<td></td>
</tr>
<tr>
<td>SMA (f) long PCB jacks</td>
<td>4</td>
<td>RF Supplier</td>
</tr>
<tr>
<td>SMA (f) bulkhead jack for .086</td>
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<td>RF Supplier</td>
</tr>
<tr>
<td>RG316</td>
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<td>RF Supplier</td>
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<tr>
<td>BNC (m) for RG316/LMR100</td>
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<td>RF Supplier</td>
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<tr>
<td>SMA (m) for RG316/LMR100</td>
<td>1</td>
<td>RF Supplier</td>
</tr>
<tr>
<td>2.5mm DC bulkhead jack</td>
<td>1</td>
<td>Jaycar</td>
</tr>
<tr>
<td>GPS Timing Antenna, weatherproof, 5m, BNC</td>
<td>1</td>
<td>RF Supplier, # GA09-50-B01SP4</td>
</tr>
</tbody>
</table>

### Thunderbolt Monitor

Using the `TBoltmon.exe` program, we can use a PC (via a serial port) to interrogate the Thunderbolt, and manually setup and change the configuration. Annoyingly, you need to select the COM port each time you run TBoltmon.exe. Later model PCs and laptops generally do not have COM serial ports, but inexpensive USB to COM adapters are available from computer stores and eBay.

The following screenshot (supplied by eBayer supplier Flying Best) indicates typical operating conditions.

On the left we have time and position information, once we have acquired enough satellites for a fix. The critical and minor alarms (middle section) should normally be green. A yellow alarm indicates a problem.
On the right, the relative signal levels of the GPS satellites (referred to as “SV” for Space Vehicles) is shown, and in this example, six satellites are being received. The configuration setup allows us to ignore any satellites that are weaker than a specified “AMU” level, and this can help reduce errors in timing with marginal satellites being ignored.

For our purposes, the disciplining status of the 10MHz oscillator should be “normal” and “phase locking”.

Your Thunderbolt will probably be set to GPS time, and there is currently a 15 second offset between GPS and UTC time.

When your Thunderbolt is in a locked and stable condition (with 0.00ppb error), it is worth noting the DAC Voltage. Enter that voltage in the Initial DAC Voltage in the GPS Disciplining Parameter setup, and “Save Segment”. Given this known good starting point, it will help stabilize your GPSDO faster, the next time you power up.

Thunderbolt Configuration

The following screenshots were provided by eBay Thunderbolt supplier Flyingbest, and suggest a good starting point, should you wish to bring any settings back to "normal".

When making changes, press the appropriate Set button, and then Save Segment.
The **Thunderbolt** requires an external active antenna, and it's antenna socket has 5V appearing on it to power an active antenna.

Active antennas can be obtained from outlets that sell GPS equipment, eBay, and other online sources.

This particular active antenna is waterproof, has a 5m lead fitted with a BNC (m) connector. It was sourced from **RF Supplier**, a Chinese based supplier of RF connectors and other goodies. USD$28.

Mount is a standard 3/4" (20mm) plumbing thread, so a wide range of plastic, brass and galvanised steel plumbing fitting are available from Bunnings and other plumbing and hardware stores to fabricate your own custom mount.

A "pipe end" plumbing adapter is used to connect a 3/4" thread to a 1" hose. The 1" side is a clamp arrangement.

$4.32 from Bunnings.

For base-station use, this is perfect for attaching our GPS antenna to a standard barge board TV mount, which has a 1" tube.

It just clamps on top of the barge mount, and the antenna screws in! This make the antenna easily removable, if you want to take away for Field Day use.
Outputs

Above: Output of Thunderbolt @ +12dBm. Note 3rd harmonic

Above: Output of DEMI 10-4 ports @ +12.4dBm. 2nd harmonic @ -44dBm. 3rd harmonic reduced
Miscellaneous Notes

- RF Supplier: [http://www.rfsupplier.com](http://www.rfsupplier.com)
- Thunderbolt Antenna Connector is "F" (f). You will probably want an F(m) to BNC (f) adapter.
- When opening the case, two screws (one each side) are hidden underneath manufacturer’s date-stamp stickers
- Tboltmon.exe (585kb) and Thunderbolt Manual (pdf 1039kb) both downloadable (free) from; [http://www.trimble.com/support_trl.asp?pt=Thunderbolt%C3%82%C2%AE%20GPS%20Disciplined%20Clock&Nav=Collection-2357](http://www.trimble.com/support_trl.asp?pt=Thunderbolt%C3%82%C2%AE%20GPS%20Disciplined%20Clock&Nav=Collection-2357)