

A Brief Comparison of GPS Receivers for Measuring Frequency Standards

By Skip Withrow

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Review of the Technique

For many years I have been using GPS receivers that have external clock inputs to measure frequency sources. This article is a review and comment on the receivers I have used, in an attempt to provide information to other time-nuts that might be useful.

In the beginning I used Trimble Thunderbolt (actually Nortel NTBW50AA) GPSDOs with the oscillator removed and the DUT 10MHz used instead. Later I acquired a Novatel OEM6 L1/L2 receiver that has the ability to use an external 5MHz or 10MHz input. There are other receivers in the Novatel OEMx family that can also input an external clock (I also have an OEM4 that can use an external clock). And most recently I have acquired a Trimble NetRS L1/L2 receiver that has an external 10MHz clock input.

Using these GPS receivers the DUT clock offset from GPS can be logged and DUT frequencies adjusted or the data can be input to TimeLab or Stable32 to plot ADEV stability data.

Of course, with the use of an L1/L2 receiver you have to have a compatible antenna. I have also gotten around the 10MHz only (Trimble receivers) by using a Mini-Circuits RK-3 doubler for 5MHz oscillators (in-line with no external components).

L1/L2 receivers also allows you to submit RINEX files for post processing. My favorite is probably Natural Resources Canada (NRCAN) as it also provides a .CLK file in the output that can be used to generate ADEV graphs. It is pretty easy to measure down to low parts in $10E-15$ with post-processed data.

Trimble Thunderbolt (and cousins)

PROS

1. These receivers are very easy to come by. I actually prefer the Nortel units over the original Thunderbolts or the 911 versions, but they basically all work the same.

2. You can still use it as a GPSDO, even for your test oscillators, if you feed the EFC voltage to the oscillator. Normally for testing you would disable disciplining.

3. Lady Heather is a wonderful piece of software! You can get real-time graphical feedback and calculate frequency offsets on the fly as well as log data that can be extracted and submitted for ADEV analysis.

CONS

1. The Thunderbolt is L1 only. This is sufficient for a lot of situations. However, if you are trying to measure 1×10^{-14} (1ns/day) you will have to wait several days. (And make sure that your DUT is up to the challenge)

2. You have to remove the original oscillator. Some of the units (Nortel NTB50AA) already have pads on the circuit board to insert SMA connectors. I have bolted several of these units to rack panels and added connectors to make a nice test unit. You can even add a switch to switch between original oscillator or external DUT if desired.

Novatel OEM6

PROS

1. This receiver is an L1/L2 unit that can receive multiple GNSS constellations.

2. There are tons of operating mode options, including dual-band fixed position with WAAS corrections which gives a much lower noise solution than L1 only. I have tried NTRIP corrections as well, but they don't seem to be any better than WAAS (which is a lot easier to set up).

3. There is a huge variety of data that can be logged with this receiver. You need the Novatel CDU program to talk to the receiver. Data can be captured to a file on the computer, or displayed in an ASCII window (that can be copied and pasted to a file).

4. Receiver will accept 5MHz or 10MHz external clock inputs.

CONS

1. The receiver module needs a carrier board with interface electronics for power, serial ports, and Ethernet.

2. Fairly steep learning curve, the 600+ pages of manual can put you to sleep every night for months.

Trimble NetRS

PROS

1. Everything comes in a nice sturdy weather-proof box. Interface is easy, BNC-f for external clock, N-f for antenna, DA-26 for Ethernet and power, DE-9's if you want to use serial ports.

2. Ethernet! There is a Linux computer in the box that provides a user GUI via your favorite browser and you can ftp as well. No external software on a computer needed (except to translate data to RINEX files).
3. On board storage. You can configure logging sessions and have them run manually, automatically, or continuously.
4. Price. With relatively little work these units can be had on the usual auction site for reasonable prices.

CONS

1. Logging options are limited (but acceptable). You only have the choice of creating Trimble .T00 or Unavco .BNX (binary exchange) files. Within each file type there are several options for what data is included. With either file type it is a one step process to convert to RINEX for post-processing.
2. Unit will accept only 10MHz external frequency.