

GPSDO Selection Guide

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This AN explains how to select and use a GPSDO with the USRP B-, N-, and X-series devices.

Ettus Research provides a number of GPS Disciplined Oscillator (GPSDO) options that improve both frequency accuracy of USRP Software Defined Radios and enable global synchronization and position location using GPS. GPSDO modules integrate inside the USRP box and work seamlessly with the USRP Hardware Driver (UHD?) to enable global timing alignment of devices, coherent operation for MIMO applications, phased array processing, and general synchronization with external devices, e.g. test equipment. Additionally, most USRP devices accept an external PPS signal for time alignment, and a 10 MHz reference for frequency alignment ? this allows for external time and frequency sources, like the [OctoClock-G](#) eight-channel clock distribution, to be used for more accurate synchronization. For more information about USRP synchronization features, please see "[Synchronization and MIMO Capability with USRP Devices](#)".

This application note will specifically address selection criteria for the various internal GPSDO options available for the USRP product line. The first rule of synchronization is that sharing a clock is always better than trying to synchronize over GPS. In lieu of a shared clock, GPSDOs will provide the next best level of synchronization that is more than sufficient for most applications. GPS is also much more flexible in that devices can be geographically separated and remain synchronized.

All GPSDOs share some common features. Each GPSDO includes a 10 MHz oscillator, which can be either a TCXO or OCXO. The 10 MHz oscillator can operate in a stand-alone fashion ? i.e., it can provide a clock even if the GPSDO is not locked to the satellite constellation. Depending on the GPSDO model, an unlocked oscillator will provide system frequency accuracies between 20 and 75 ppb. The GPSDO modules will also produce a 1 PPS signal, which can be used for timing synchronization. If a GPS antenna is connected, the GPSDO will lock to the GPS satellite constellation and the 10 MHz oscillator can be disciplined to the global GPS standard. In this case the 1 PPS signal will also be aligned to the global standard within 50 ns.

Ettus Research offers several GPSDO options. Board-mounted GPSDOs are compatible with the USRP X300/X310 and B200/B210, while the GPSDO Kit is compatible with USRP N200/N210 and E100/E110. To avoid damage, the user must also select the proper antenna for the GPSDO. Device compatibility and recommendations are summarized in the Table 1 below.

GPSDO Type	Recommended for use with:	Compatible Antenna	B200/B210	N200/N210	X300/X310	E100/E110
GPSDO Kit	USRP N200/N210	3V Active		X		X
	USRP E100/E110					
	USRP X300/X310				X	
Board-Mounted GPSDO (OCXO)	OctoClock*	5V Active	X		X	
	USRP B200/B210		X		X	

Table 1. * Please note, the [OctoClock-G](#) already includes an internal Board-Mounted GPSDO (OCXO).

However, customers that have ordered the [OctoClock](#) without the internal GPSDO, can upgrade their device.

The internal GPSDO options available for the USRP product line are ideal for synchronizing a single device to the GPS standard. In some cases, users may want to use a single GPSDO to synchronize multiple devices. In this case, Ettus Research recommends the [OctoClock-G](#). The [OctoClock-G](#) includes an internal Board-Mounted GPSDO (OCXO), and splits both the PPS and 10 MHz signals in a manner that assures minimum skew between the signals. This is important for coherent operation of multiple USRP devices.

It is possible to use the USRP B200/B210 with bus power, instead of an external power supply. This allows users to use a single USB cable to provide an interface for data streaming and power. While the Board-Mounted GPSDO (OCXO) and Board-Mounted GPSDO (TCXO) are both compatible with the USRP B200/B210, bus power cannot be used with the OCXO version. We recommend that customers use the TCXO version with the USRP B200/B210.

The architecture and theory-of-operation of both the Board-Mounted OCXO and Board-Mounted TCXO are identical. However, the TCXO consumes less power, provides less accuracy throughout its temperature range, and has different phase noise characteristics. Table 2 below summarizes the minor differences between these two modules. For detailed specifications, please see the respective product pages.

Specifications	OCXO	TCXO
Frequency Accuracy w/out GPS Lock	20 ppb	75 ppb

Phase Noise	Better Wideband Phase Noise	Better Close-In Phase Noise
Hold-Over Stability	20 us	Not Specified
Power Consumption	0.7 W	0.5 W
Price	Click here	Click here <i>Table 2</i>

- [Open Source Ionospheric Sounder with High-Accuracy Reference](#)
- [Product Page - Board-Mounted GPSDO \(OCXO\)](#)
- [Product Page ? Board-Mounted GPSDO \(TCXO\)](#)
- [Product Page ? GPSDO for USRP N200/N210 and USRP E100/E110](#)