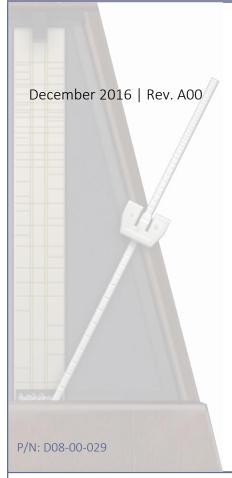


SYNC SERIES

GNSS Disciplined Oscillator Configuration Guide

Setting the GNSS Receiver and Chip-Scale Atomic Clock for Field Tests (For TX300S and RXT-1200 Test Platforms)



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The data for this article was acquired using VeEX's TX300S and/or RXT-1200 Test Platform with GPS and Atomic Clock options, and the RXT-3000 Multi-Service Test Module. TE graphs were captured with VeEX Wander Analysis PC Software.

For more technical resources, visit the VeEX Inc. website at www.veexinc.com.

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GNSS Disciplined Oscillator Configuration Guide

GNSS Receiver Installation & Configuration

This guide focuses on VeEX's built-in precision timing GNSS (GPS+GLONASS) receiver module (P/N: Z88-00-009P), introduced in March 2016. It provides a guide on how to install the module (new add-on or upgrading from an existing Z88-00-008P GPS receiver) and provides guidance on how to configure new parameters added to the GNSS and Atomic Clock user interface.

This new GNSS receiver module is timing oriented and provides better accuracy and stability. It can also use both GPS and GLONASS satellites for faster and more accurate location survey (compatible antenna required). This module works in conjunction with the built-in chip-scale Atomic Clock option (Z66-00-040G, factory installed) to provide short-term stability and long-term frequency (10MHz) and timing (1PPS) accuracy.

System Requirements:

TX300S or RXT-1200 test platform with the factory-installed Atomic Clock oscillator

TX300S Platform: 02.00.32 or newerRXT-1200 Platform: 02.00.0070 or newer

GNSS Module P/N: Z88-00-009P

Atomic Clock Firmware: 1.09 (a firmware update package is available for earlier versions)

An active GPS or GPS+GLONASS antenna installed for best signal reception and with a wide-open sky view. Antenna position and orientation (facing up) must remain stationary to achieve maximum location (survey) accuracy.

Installing or Replacing the GNSS Receiver Module

If the test set already came with the GNSS Receiver module installed, please skip this section. Whether you are adding a new High Precision GNSS Receiver module to an existing TX300S or RXT-1200 test platform, or replacing an old GPS Receiver module, you must follow the instructions in this section. Be sure to perform any required software updates to the platform and modules before you start.

Removing Existing GPS Module

- 1) Turn the test set OFF.
- 2) If replacing an existing GPS Receiver module, use a pencil or a sticker to mark the GPS plastic cap on the front (facing the screen) in order to identify its proper orientation (DO NOT reverse it).





TX300S

RXT-1200

- 3) Use a magnetized screwdriver to remove the two screws and plastic cover. Note that the plastic cover may adhere to the panel, so use gentle pressure to release it without causing any damage to the card.
- 4) Extract the old GPS Receiver module.

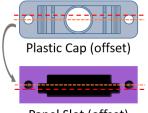
Installing the New GNSS Receiver Module

1) If this is a new installation, please remove the screws and metal plate covering the GPS slot.

2) IMPORTANT! Carefully insert the new GNSS Receiver module in the slot, following the orientation of the metal shielded component, as shown in the pictures below. Inserting the module incorrectly may cause permanent damage to the card. Use the connectors and label orientation in the pictures below as a reference.







TX300S

Panel Slot (offset)
Cap Alignment

- 3) Replace the plastic cap, minding the original orientation. Make sure the notches inside the cap align with the module's printed circuit board (PCB). The cap must lay flush with the connector panel (no rocking or gap).
- 4) Secure the plastic cap with the screws.
- 5) Turn the test set ON.
- 6) If this is a new installation, make sure to activate the GPS software option
 - a. Connect the test set to the Internet using LAN or Wi-Fi, go to >Utilities >VeExpress and tap on the Check button to retrieve the newly assigned GPS license and activate the option in the test set.
 - b. If a permanent license key was provided, go to >Utilities >Settings >About >Software Options, find the GPS option, tap on the button and enter the activation code you received via email.

GNSS Receiver Settings and Operation

This section explains the GNSS Receiver configuration and basic settings required to quickly verify proper module installation and operation. Refer to the tables at the end of this document for application-oriented settings.

- 1) Install the portable antenna facing up, on a stable surface or mounting, with a wide unobstructed view to the sky or use a professionally-installed in-building roof-top antenna feed.
- 2) Connect the active GPS or antenna to the GNSS Receiver module's SMA connector. If a BNC-to-SMA or TNC-to-SMA adapters is required, use flexible adapter cables (not rigid adapters) to prevent any mechanical stress.
- 3) Go to >Utilities >Settings >More >High Precision Clock >GNSS.
- 4) Turn the GNSS Receiver = ON.
- 5) Set the Satellite System = GPS.
- 6) Set In-survey time (s) = 600, which is the time window used by the GNSS Receiver to assess stable location, using the specified accuracy (below). Having an accurate tri-dimensional location is required to calculate accurate time.
- 7) Set In-survey accuracy (m) = 5, which is a target of <5m for the Mean V accuracy reading. Smaller values tighten the location accuracy requirements, but the site survey process may take longer. It is possible to get better than 1.5m location
- GPS **GPS Status** Settings Settings | Satellites Time Zone,Offset UTC-08:00 Pacific T♥ 03 600 In survey time (s) 05 20 27 26 👺 VeExpress 07 43 28 30 n survey accuracy (mm) 5000 32 30 08 38 🤱 R-Server 46 05 \\ FTP Server -Time(UTC) 2016/03/25 Time 💽 M.Upgrade Date 21:11:05 2.753m Tools _atitude 37°28'15" N ongitude 121°55'56" W Files Reset GPS Sync ToD Altitude 12.8 M
- accuracy when using professionally-installed roof-top antennas.
- 8) Enter any antenna cable delay that needs to be compensated for (velocity of propagation is cable dependent, their values are around 5ns/m or 1.2ns/ft). Enter 20ns if using the 5m portable antenna.
- 9) Select the Time Zone Offset (it is used to calculate the local time of day).
- 10) Wait for GPS Status on top to show Lock and the licon at the bottom of the screen turns green. It indicates that it is successfully tracking enough GPS and GLONASS satellites.

- 11) Wait for about 15 to 30 minutes for the Mean V value to be below 5.00m and until the In Survey status also shows Locked. This indicates that the GPS position has reached the required accuracy (site survey finished) and that it has switched into Timing Mode.
- 12) At this point, the GPS Module should be providing accurate Time and Timing (1PPS).
- 13) Tap on the Sync ToD button to synchronize the test set's (system) real-time clock.

Although the GNSS Receiver is also capable of tracking GLONASS satellites, the table shown on the right side of the screen only lists GPS satellites, as the main reference. A **1602 MHz (L10F band) capable antenna is required** to track GLONASS satellites.

Atomic Clock Settings and Operation

This section explains the different disciplining parameters for the optional chip-scale Atomic Clock and provides the settings required to quickly verify its proper operation. For application-oriented configurations, please refer to the suggested configurations table at the end of this document.

Free Running Stage (Frequency only)

By default, the built-in Atomic Clock oscillator starts in free-running mode, providing a calibrated Atomic 10MHz frequency reference. (Its exact frequency could vary over time due to ageing, temperature, storage and other factors.) It also produces an arbitrary (non-traceable) 1PPS timing signal that is not aligned to the standard UTC second. Disciplining must be used in order to make the necessary frequency and timing corrections.

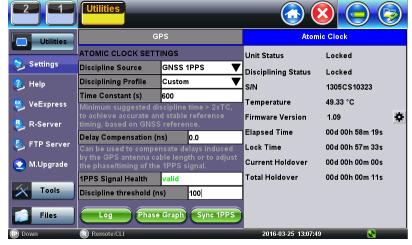
Oscillator Disciplining Process (Frequency & Phase)

The disciplining process acts as a continuous "soft calibration" that corrects any frequency deviation in the oscillator and aligns the timing pulse (1PPS) to the standard UTC second. The chip-scale atomic oscillator can be disciplined by:

- a. The built-in precision GNSS Receiver (GNSS 1PPS).
- b. An external traceable 1PPS signal from a primary reference time clock (PRTC) or time standard (Cs or Rb).

Clock Disciplining - Using the built-in GNSS 1PPS

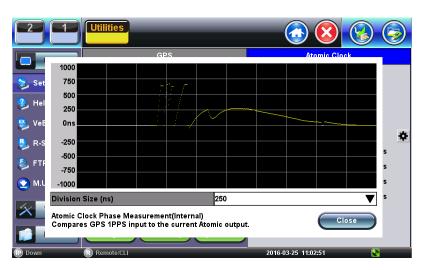
- 1) With the GNSS module already locked, go to >Utilities >Settings >More >High Precision Clock >Atomic Clock.
- 2) Set Discipline Source = GNSS 1PPS, to use the traceable (UTC aligned) 1PPS timing signal from the GNSS receiver.
- 3) Verify that 1PPS Signal Health = Valid, to confirm that the one-pulse-per-second signal is being detected.
- 4) Set Discipline Profile = Custom.
- 5) Set Time Constant (s) = 60 (this small window is only used to expedite the initial phase alignment process).
- 6) Set Discipline Threshold (ns) = 100 (a more stringent 50ns could also be tried if applicable. Use the Phase Graph to determine the stability range).

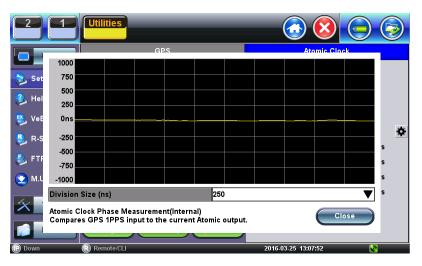


- 7) Verify that Disciplining Status = Acquiring. This indicates that the disciplining process is in progress.
- 8) Tap on the Phase Graph to monitor the relative phase error, until it becomes a horizontal line close to Ons. The time required for this may vary (it should take less than 15 minutes)

- 9) Close the Phase Graph and set the Time Constant (s) = 900. You can also experiment with larger time constants (e.g. 1800s, 3600s, 5400s). The larger the constant the more stringent the disciplining process becomes and the longer it takes to achieve disciplining lock. To declare lock, the Atomic Clock verifies that the relative phase stays within defined the Disciplining Threshold for about 2x Time Constant (to confirm its stability). You can use the Phase Graph to monitor the actual phase variations on your current GNSS environment for the past 600s.
- 10) Open the Phase Graph again to monitor the time error. Once it stabilizes again around Ons, wait for about 60 minutes. The line should stay flat and very close to Ons. If not stable, please check the GPS satellites and antenna installation.
- 11) Close the Phase Graph and verify that the Disciplining Status gets into Locked mode.

At this point the test set's internal "Atomic 10MHz" frequency and "Atomic 1PPS" timing reference signals can be considered accurate and stable.





The Phase Graph (above) can be used to monitor the short-term stability of the raw GPS clock, which can be used to determine the Discipline Threshold for a particular site or scenario. Zoom in to the 50ns grid and estimate how disperse the 1PPS samples are (in ns), then use a larger value as a threshold. A vertical variation of <30ns is OK.

Clock Disciplining - Using External 1PPS from a PRTC (Cs or Rb)

The TX300S can also be disciplined, quicker and more accurately, using a 1PPS reference signal from a traceable time standard (PRTC), which can be connected to the test set's ToD port (RS232).

An RJ11-to-BNC cable is required (RJ11 pin 2 to the BNC's center pin and RJ11 pin 4 to BNC shield/GND). Keep in mind that the same RJ11 form factor comes in 4 and 6-pin versions and this document refers to the 6-pin version.

- 1) Go to >Utilities >Settings >More >High Precision Clock >Atomic Clock.
- 2) Set Discipline Source = Ext. 1PPS (RJ11).
- 3) Verify that 1PPS Signal Health = Valid.
- 4) Set Discipline Profile = Custom.
- 5) Set Time Constant (s) = 600.
- 6) Set Discipline Threshold (ns) = 20.
- 7) Verify that Disciplining Status = Acquiring.
- 8) Tap on the Phase Graph to monitor the relative phase error, until it becomes a horizontal line at about Ons.
- 9) Close the Phase Graph and wait until the Disciplining Status = Locked.



At this point the test set's internal "Atomic 10MHz" frequency and "Atomic 1PPS" timing reference signals can be considered highly accurate and stable.

Suggested GPS-DO Settings

Handled test sets are often used for quick verification and troubleshooting tests, due the nomadic nature of field installation and verification crews. Nonetheless, all test sets may be required to run long-term stability and accuracy tests while attached to stationary GPS antenna or to a local PRTC. In general, when it comes to Wander and Time Error measurements, longer tests bring more information. The expected or allocated test time should include the initial preparation and disciplining time.

In synchronization applications, the GNSS and precision oscillator settings need to match the location, environment, resources, accuracy expectations and intended goals. Consider whether there is adequate access to GPS and GLONASS signals (full, partial or no view to the sky), or if there are other local reference signals that can be used, such as PRTC (Cs, Rb) or stand-alone GPS-DO (telecom-grade Precision Timing GPS-Clock with OCXO).

Field Testing

Use the suggested settings below as a starting point for short-term (one day or less) testing, then experiment and modify them to fit particular applications and environments, or make them more or less stringent. It is assumed that users would need to discipline the test set in the shortest (reasonable) amount of time possible, to achieve the required accuracy and then engage in the required synchronization verification tests.

Profile Type	Stationary - Roof Antenna	Portable - Wide Sky View	Portable - Partial Sky View
Application	Professional high-gain antenna installation on roof-top. Unobstructed sky view. Variable temperature environment.	Temporary antenna installation with unobstructed view to the sky. Assumes less than 20m of antenna cable.	Temporary antenna installation with partial view to the sky (buildings, walls, trees, etc.). Assumes less than 20m of antenna cable.
GNSS Parameters			
Synchronization Source	GPS + GLONASS	GPS + GLONASS	GPS + GLONASS
GNSS Mode	Timing, Survey-in	Timing, Survey-in	Timing, Survey-in
Dynamic Model	Stationary	Stationary	Stationary
Survey Observ. Time (s)	600	900	1200
Survey Accuracy Mask (m)	3	5	10
Time Source	UTC	UTC	UTC
UTC Standard	Based on USNO (GPS)	Based on USNO (GPS)	Based on USNO (GPS)
Estimated Time to First Fix	1 min	1 min	2 min
Estimated Site Survey time	15 min	20 min	40 min
Ant. Cable Delay Compensat	Check cable specs (ns/m)	≈ Length x 5ns/m (1.5ns/ft)	≈ Length x 5ns/m (1.5ns/ft)
Atomic Clock Parameters			
Time Constant (s)	600	900	1800
Discipline Threshold (ns)	50	50	100
Estimated Discipl. Time	<1 hour	<1.5 hours	2 hours

Stationary or Long Term Testing

Use the suggested settings below as a starting point for long-term (multi-day) always-on testing and then modify them to fit a particular application and environment, or make them more stringent. They should provide the best timing accuracy and stability. Longer disciplining and tests are better suited to measure clock stability and long-term accuracy, taking into account environmental changes (day vs. night, hot vs. cold, ionospheric changes, visible satellites, high vs. low traffic, etc.). If using the 1PPS reference from a traceable Cs or Rb PRTC standard, make sure it has been running for more than 7 days, so it has already reached its target accuracy and stability.

Profile Type	Long Term/Stationary	Ext. PRTC 1PPS	User Defined
Application	For long term high accuracy	External 1PPS (RJ11)	
	testing. (AC power and	reference from a traceable	
	professionally-installed in-	Cs or Rb time standard	
	building GPS antenna feed	(PRTC). Constant	
	always available). Constant	temperature environment.	
	temperature environment.		
GNSS Parameters			
Synchronization Source	GPS and/or GLONASS*	Local PRTC	
GNSS Mode	Timing, Survey-in	N/A	
Dynamic Model	Stationary	N/A	
Survey Observ. Time (s)	3600s	N/A	
Survey Accuracy Mask (m)	2	N/A	
Time Source	UTC	N/A	
UTC Standard	Based on USNO (GPS)	N/A	
Estimated Time to First Fix	1 min	N/A	
Estimated Site Survey time	<2 hours	N/A	
Ant. Cable Delay Compensat	Check cable specs (ns/m)	N/A	
Atomic Clock Parameters			
Time Constant (s)	900	600	
Discipline Threshold (ns)	50	20	
Estimated Discipl. Time	<2 hours	<30 min	

^{*} Only select GLONASS if the active antenna supports the L1OF band (1602 MHz). GLONASS alone is not recommended as the main timing source, it should be used only as GPS augmentation aid (GPS+GLONASS) or if no other option is available.

Forcing the Test Set's Oscillator into Holdover

In certain applications users may need to transport timing synchronization from one location to another (e.g. from outside or roof-top, where there is GNSS coverage, to indoors). Once the atomic oscillator has been disciplined (Disciplined Status = Locked), users can remove the GPS 1PPS feed, by turning the GPS OFF and disconnecting the antenna. The oscillator will then hold its last frequency correction and use it to maintain the last known 1PPS alignment to UTC. Here are just a few suggestions:

- A. For Frequency measurements (Wander TIE), the official procedure is to turn the GPS module OFF, so the oscillator's disciplining algorithm continues to make adjustments to the oscillator. This is recommended if changes in ambient temperature are expected.
- B. For Frequency-only applications, we may also recommend experimenting by turning the Disciplining OFF and then the GPS OFF, to initiate the "holdover". This way the Atomic Clock will free-run using the last frequency correction and potentially provide the most linear response, which should only be affected by ambient temperature changes and ageing.
- C. For Timing measurements (Phase TE) we recommend turning the GPS OFF, before disconnecting the antenna, to cleanly initiate the holdover.

Glossary and Acronyms

One Pulse-per-Second (usually aligned to the UTC second to distribute time around the world).

Almanac Data set containing information and status concerning all the global positioning satellites.

BNC Unbalanced coaxial connector used for data and clock signals.

Cs Cesium (Caesium). In synchronization, this generic term refers to the atomic oscillator element.

CSAC Chip-Scale Atomic Clock.

dBHz Or dB-Hz, is used to express carrier-to-noise-density ratio of the RF signal from each satellite.

Ephemeris Orbital information which allows the receiver to calculate the position of each satellite.

GLONASS Globalnaya Navigatsionnaya Sputnikovaya Sistema (Russian GNSS).

GNSS Global Navigation Satellite Systems (generic term).
GPS Global Positioning (satellite) System (USA's GNSS)

GPSDO GPS Disciplined Oscillator.

TNC Unbalanced coaxial connector (threaded) used in RF applications, such as GPS antennas.

OCXO Oven Controlled Crystal Oscillator.

ppb Parts Per Billion (1/1,000,000,000 or 1x10⁻⁹ or 1E-9).
ppm Parts Per Million (1/1,000,000 or 1x10⁻⁶ or 1E-6).
PRC Primary Reference Clock (frequency reference).

PRTC Primary Reference Time Clock (Phase, timing and/or time reference).

Rb Rubidium. In synchronization, this generic term refers to the atomic oscillator element.

Ranging Initial GNSS process of acquiring satellite data to calculate to satellites position and distance.

SAT Satellite number (same as SVN).

SMA Unbalanced coaxial connector (threaded) used for RF and clock signal applications.

Survey Site Survey is the process used by GNSS receivers to calculate their stationary position accurately.

SVN Space Vehicle Number (each GNSS satellite has a unique number).

TC Time Constant (time window used by disciplining control systems to assess and maintain sync).

TCXO Temperature-Compensated Crystal Oscillator.

ToD Time of Day. Label with the yyyy/mm/dd hh:mm:ss information related to the last 1PPS pulse.

UTC Coordinated Universal Time (it is the primary time standard by which the world regulates clocks).

XO Xtal (crystal) Oscillator (usually Quartz).

SNSS Disciplined Oscillator Configuration Guide		
Notes		

About VeEX Inc.

Founded in 2006 by test and measurement industry veterans and strategically headquartered in the heart of Silicon Valley, VeEX Inc. provides innovative Test and Measurement solutions for next generation networks, services and communication equipment.

With a blend of advanced technologies and vast technical expertise, VeEX's products diligently address all stages of network design, verification, deployment, maintenance, field service turn-up, troubleshooting and integrate legacy and modern service verification features across DSL, Fiber Optics, WDM, CATV/DOCSIS, Mobile backhaul and fronthaul/DAS (CPRI/OBSAI), next generation Core & Transport Network, Fibre Channel SAN, Carrier & Metro Ethernet technologies and Synchronization.

The VeEX team brings simplicity to verifying tomorrow's networks.

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