

NOVATECH INSTRUMENTS

Model 1450B Disciplined Rubidium Frequency Standard

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1.0 DESCRIPTION

1.1 The Model 1450B is a rubidium frequency standard which can be disciplined to an external 1pps (one pulse per second) reference signal. This 1pps is commonly derived from primary, or other standards, such as GPS (global positioning satellite). When disciplined to 1pps, the 1450B provides primary standard accuracy and stability.

1.2 The 1450B provides one fixed frequency sine wave output of 10MHz and up to 8 additional auxiliary outputs that can be fixed sine or TTL or synthesized sine or TTL. The 1450B is particularly useful in applications which require non-standard or customer specified frequencies. The auxiliary outputs are locked to the internal rubidium oscillator.

1.3 The most recent version of this manual can be found on Novatech Instruments, Inc. web site.

2.0 SPECIFICATIONS

2.1 FREQUENCY STABILITY (Df/f, Typical)

Short Term: $t=1s$ $<3 \times 10^{-11}$
 $t=10s$ $<1 \times 10^{-11}$
 $t=100s$ $<3 \times 10^{-12}$
Aging: Monthly $<\pm 5 \times 10^{-11}$ after 1 month
Yearly $<\pm 5 \times 10^{-10}$ after 3 months

Holdover (24Hours, $\pm 2^{\circ}C$): $<\pm 1 \times 10^{-11}$ ($<\pm 1\mu s$ after $>10x$ 1pps tracking time constant)

Temperature: $+5$ to $+45^{\circ}C$ $<\pm 1 \times 10^{-10}$

Line Voltage: $\pm 10\%$ $<\pm 5 \times 10^{-12}$

2.2 FREQUENCY ACCURACY

At shipment: $< \pm 5 \times 10^{-11}$ at $20^{\circ}C$.

Retrace: $< \pm 5 \times 10^{-11}$ from last frequency after 1hour ON and 24hours OFF (constant environment).

2.3 FIXED SINEWAVE OUTPUTS

10MHz, $1V_{RMS} \pm 0.25V_{RMS}$ into 50Ω .

2.4 SYNTHESIZED SINEWAVE OUTPUT

Frequency programmable from 100Hz to 50MHz in 0.1Hz steps.

Amplitude: $1V_{RMS} \pm 0.25V_{RMS}$ at 10MHz into 50Ω ($\pm 3dB$ from 100Hz to 50MHz, referenced to 10MHz).

Phase Noise: Typical, $<-140dBc$, 10kHz offset, 1MHz output.

Harmonics: Typical $<-45dBc$, spurious: $<-55dBc$.

2.5 SPECTRAL PURITY (10MHz fixed output, typical)

Harmonic $<-25dBc$.

Spurious/Non-Harmonic/Sub-Harmonic: $<-45dBc$.

2.6 PHASE NOISE (Typical, 10MHz output, 50Ω)

Frequency Offset dBc

1Hz	-70
10Hz	-90
100Hz	-120
1kHz	-140
10kHz	-140

2.7 1pps IN and OUT

1pps IN: DC-coupled, accepts TTL or CMOS. 1pps OUT: TTL, 133 μs negative pulse width. Typical output jitter: 20ns peak-peak (1 minute measurement time).

2.8 ENVIRONMENTAL

Temperature: $+0^{\circ}C$ to $+50^{\circ}C$ operating.

Humidity: 80% to $31^{\circ}C$, decreasing linearly to 50% at $40^{\circ}C$.

2.9 SIZE

3.47" H, 16.73" W, 12.0" D, standard 19" rack.

2.10 CONNECTORS

BNCs on rear panel for fixed 10MHz sine output 1pps input, 1pps output and eight auxiliary outputs.

2.11 LINE POWER

120/240VAC $\pm 10\%$, 50/60Hz. 30VA (50VA max during warm up <20 minutes). (internal line voltage switch)

2.12 FRONT PANEL INDICATORS

POWER OK: AC power is applied and on.

RUBIDIUM LOCK: Green: Oscillator is locked.

Red: Warm-up.

1 PPS LOCK: Locked to and tracking a 1pps input.

2.13 ACCESSORY

GPS1: Matching GPS smart antenna system.

3.0 INSTALLATION

WARNING:

The 1450B line power input receptacle is provided with a 3-wire cord. Do not defeat the grounded conductor.

3.1 Power Connection. Verify that the rear panel indicates your line power (120VAC or 240VAC 50Hz/60Hz). Connect the provided 3-wire line cord to your power source. The power switch is built-in to the input module on the rear panel. Line voltage is selected by an internal switch and set at the factory.

3.2 1450B Installation. The 1450B requires no user setup beyond the application of line power and connection to your application. Connect your 50Ω coaxial cables to the appropriate front panel BNC. See below for 1pps connections and use.

NOTE:

If you plan to use your 1450B as part of a calibration system or house standard, it is suggested that it be powered from an uninterruptable power supply (UPS) (along with your 1pps source, if used).

4.0 OPERATION

4.1 Power on. After power is applied, the 1450B **POWER OK** LED will illuminate green. This indicates that the applied line power is within tolerance and the unit is functioning.

4.2 Rubidium Warm-up. After power is applied, the 1450B will take up to 20 minutes to reach Rubidium Lock. During Rubidium warm-up time, the front panel LED labelled **RUBIDIUM LOCK** will illuminate red. When the lock has been achieved ($\Delta f/f < \pm 1 \times 10^{-8}$), this LED will illuminate green. This function is independent of 1pps tracking.

NOTE:

*During the Rubidium locking process, the front panel **RUBIDIUM LOCK** LED may switch between red and green. A steady green indicates LOCK.*

4.3 Proper operation in stand-alone mode, without a 1pps connection, is indicated by a green **POWER OK** LED and a green **RUBIDIUM LOCK** LED. The 1pps LED will remain off.

NOTE:

The 1450B will meet the specified accuracy within a few hours after power-up. For applications requiring verification of long-term stability, the periods shown in the specifications will have to be met.

4.4 See the section “1pps Operation,” below, for details on 1pps connections and operation.

5.0 1pps OPERATION

5.1 1pps In and Out. The 1450B is equipped with rear panel BNC receptacles which accept a 1pps input and provide a 1pps output. Use of 1pps allows synchronization of multiple 1450B, as well as providing a means of auto-calibration.

5.2 The 1450B will accept a long-term stable 1pps signal, typically derived from a GPS (global positioning system) receiver or from another frequency standard. It will auto-adapt to the supplied 1pps and adjust the internal Rubidium Oscillator to match the long term average frequency derived from the 1pps. The auto-adaptive algorithm selects the best tuning time constant based upon the stability of your supplied 1pps.

5.3 For low-jitter 1pps inputs (<20ns), the approximate tuning time constant will be 1,000 seconds. A typical timing receiver system, such as the GPS1 (with approximately 100ns peak-peak 1pps jitter), requires a time constant of approximately 10,000 seconds (about 3 hours) for optimum tracking.

5.4 For noisier 1pps inputs, the time constant may increase to 100,000 seconds. If the input is too noisy, the **1 PPS LOCK** light will not illuminate.

5.5 Proper operation when tracking a 1pps signal is indicated by all three front panel LEDs illuminated green.

NOTE:

Due to these long time constants necessary to track a 1pps input, temperature variations can cause fluctuations in the relative phase of the 10MHz output and the 1pps output.

NOTE:

The Df/f tracking range of the internal Rubidium oscillator is approximately $\pm 1 \times 10^{-8}$. If your 1pps source is in error, but within these limits, the 1450B will adjust to your source. This allows multiple units to be synchronized even in the absence of an absolute reference.

NOTE:

The auto-adaptive frequency adjustment has a resolution of $\pm 5.12 \times 10^{-13}$.

CAUTION:

Do not connect the 1pps input and 1pps output on an instrument together. This will force the instrument to track a moving value and reach its adjustment limit.

5.6 The 1450B is configured for automatic self-calibration. When continuously connected to a stable 1pps source, it will auto-save the disciplined frequency value into non-volatile calibration memory every 24 hours. The last-saved value will be used at next power on or when 1pps is lost. The 1pps output of a calibrated and tracking 1450B has lower jitter than a typical GPS receiver making it suitable for use as a master oscillator for further 1pps systems.

6.0 PERFORMANCE TEST & CALIBRATION

6.1 The performance test detailed below verifies that the 1450B accuracy is equal to the accuracy achieved immediately after calibration. Prior to performing this test it is recommended that the 1450B be calibrated.

NOTE:

There are no periodic user adjustments required for operation of the 1450B. When necessary, calibration should be performed “closed-case” using an external 1pps source.

NOTE:

The unit under test or calibration must remain undisturbed during the calibration period. Changes in environmental conditions (temperature, electric field, magnetic field or physical orientation) affect the calibration. If possible, calibration should be performed at the application site.

6.2 **Calibration:** Calibration of the 1450B should be performed “closed-case” using an external 1pps source. Closed-case calibration is obtained by connecting the 1450B 1pps input to a known stable and accurate (better than 1×10^{-11}) 1pps source. Verify that the three front panel LEDs are all illuminated green. A stable 1pps source will allow this illumination within 15 minutes after connection. Leave the unit tracking the 1pps external signal in a stable environment for a minimum of 5 days. During this time the internal auto-adaptive algorithm will measure and qualify the 1pps source, adjusting the frequency to the long term average of the 1pps source. When continuously connected to a stable 1pps source, the 1450B will auto-save the disciplined frequency value into non-volatile calibration memory every 24 hours.

NOTE:

Calibration and verification of the frequency and frequency stability of the 1450B requires a laboratory environment of $23^{\circ}\text{C} \pm 3^{\circ}\text{C}$.

6.3 See Table 3 for a list of recommended test equipment to perform the following measurements.

Table 3: Recommended Test Equipment

Item	Minimum Specification	Recommended
Oscilloscope	300MHz, 50Ω termination	Tektronix TDS3032B
Frequency Counter	100MHz, 12-digits.	HP53132A
Counter Time Base	$< \pm 1 \times 10^{-11}$	Novatech Instruments, Inc. Model 2965AR with GPS1 smart antenna.

6.4 **Verify Frequency Accuracy.** To verify the frequency of the 1450B, set the frequency counter to display 12-digits of resolution. The frequency counter must use an external time base of accuracy better than $\pm 1 \times 10^{-11}$.

6.5 Verify that the frequency and amplitude of the fixed 10MHz sine wave output is within the tolerances as shown in Table 4. Allow the counter to average several readings. A counter time constant of 1000 seconds or longer is recommended. The error limits shown do not include time base or counter errors.

6.6 **Amplitude Verification.** Establish a measurement function of Volts RMS on the oscilloscope. Connect a 50Ω coaxial cable from the 1450B to the oscilloscope (set to 50Ω termination) Verify an amplitude of $1.0V_{rms} \pm 0.25V_{rms}$ on the fixed 10MHz sine wave output.

6.7 To verify the Auxiliary output signals see the option addendum for each specific 1450B configuration..

Table 4: Frequency Test Points

Frequency	Df	Voltage Tolerance
10MHz	$\pm 500\mu\text{Hz}$	$1.0V_{rms} \pm 0.25V_{rms}$

6.8 This concludes the verification test of the 1450B.

WARRANTY

NOVATECH INSTRUMENTS warrants that all instruments it manufactures are free from defects in material and workmanship and agrees to replace or repair any instrument found defective during a period of one year from date of shipment to original purchaser.

This warranty is limited to replacing or repairing defective instruments that have been returned by purchaser, at the purchaser's expense, to NOVATECH INSTRUMENTS and that have not been subjected to misuse, neglect, improper installation, repair alteration or accident. NOVATECH INSTRUMENTS shall have the sole right to final determination regarding the existence and cause of a defect.

This warranty is in lieu of any other warranty, either expressed or implied, including but not limited to any warranty of merchantability or fitness for a particular purpose. In no event shall seller be liable for collateral or consequential damages. Some states do not allow limitations or exclusion of consequential damages so this limitation may not apply to you.

All instruments manufactured by NOVATECH INSTRUMENTS should be inspected as soon as they are received by the purchaser. If an instrument is damaged in shipment the purchaser should immediately file a claim with the transportation company. Any instrument returned to NOVATECH INSTRUMENTS should be shipped in its original shipping container or other rigid container and supported with adequate shock absorbing material.

This warranty constitutes the full understanding between NOVATECH INSTRUMENTS and the purchaser and no agreement extending or modifying it will be binding on NOVATECH INSTRUMENTS unless made in writing and signed by an authorized official of NOVATECH INSTRUMENTS

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