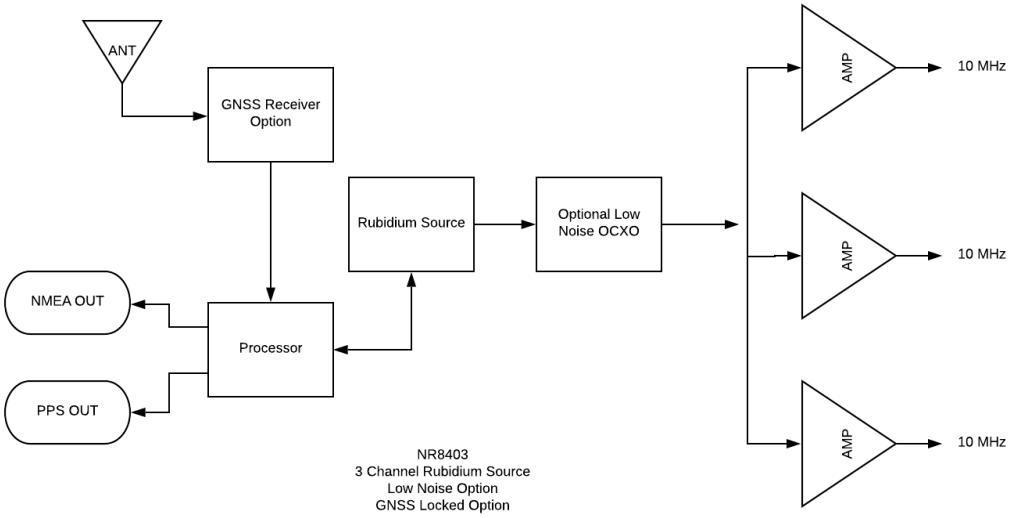
User Manual **Model NR8403**

Triple Channel Rubidium Reference with GNSS Locking and Low Noise Options

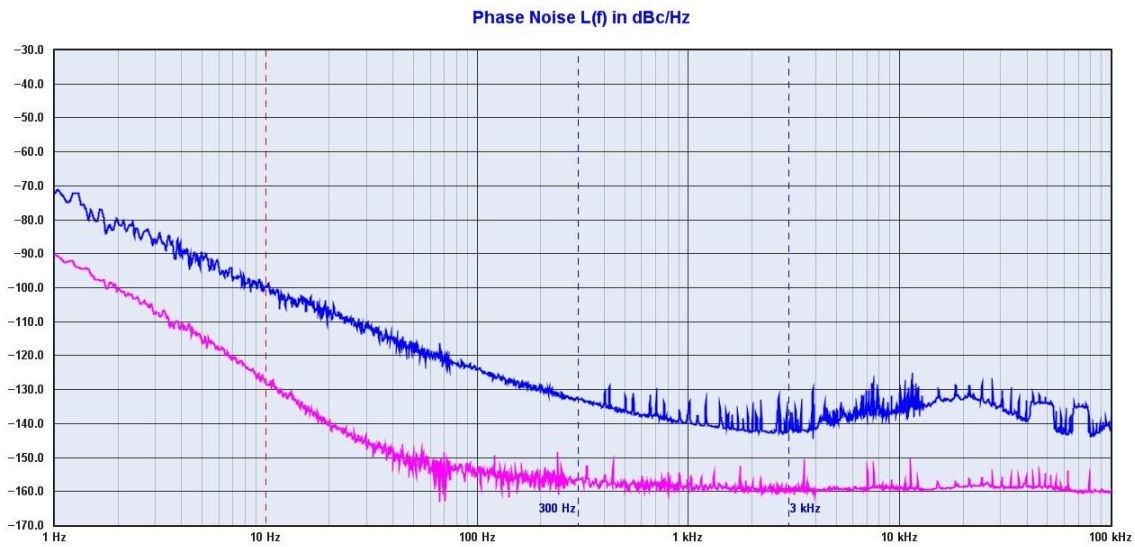
Contents

Summary

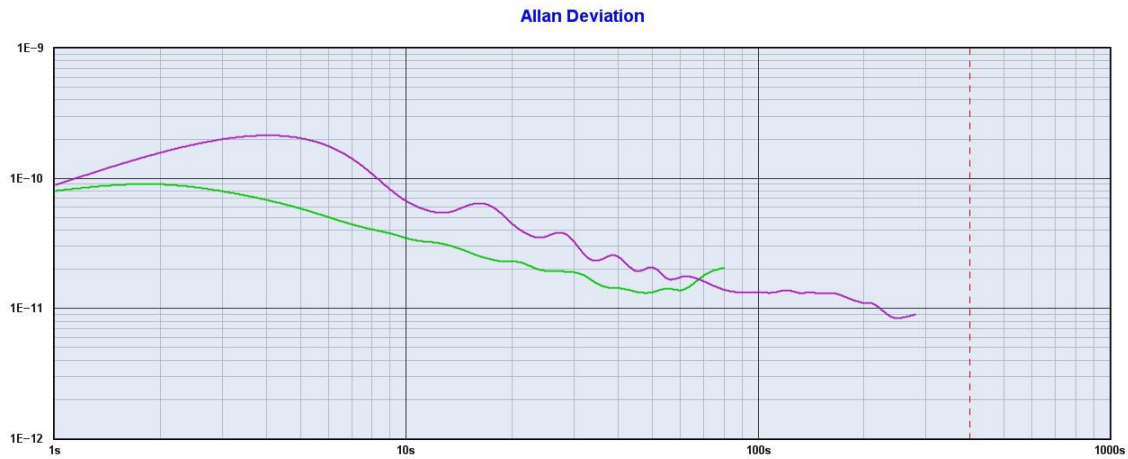
The NR8403 is a three channel Rubidium source which options that include GNSS locking and Ultra Low noise. A low power Rubidium source and low power OCXO are used in the design to allow a compact design with little cooling air required. There is a fan that is modulated by the processor to handle worst case temperature conditions.



The Rubidium source is a CPT device (Coherent Population Trapping). The main advantage of the CPT atomic clocks compared to the traditional atomic clocks is the absence of a microwave cavity, allowing substantial reductions in size, power, and cost while maintaining the stability. While a Rubidium source provides outstanding stability-phase noise performance may not be enough for many applications. The NR8403-O option adds a low noise OCXO that is locked to the Rubidium source. The phase noise plot below demonstrates the improvement in phase noise with the O- Option:



Trace	Notes	Input Freq	Input Amplitude	dBc/Hz at 10 Hz	RMS Noise (degs)	RMS Jitter	Duration	Acquired
NR8403-R		10.000 MHz	7.3 dBm	-99.6	4.81E-4	1.3E-13 s	3m 0s	180 pts
NR8403-RO		10.000 MHz	8.1 dBm	-128.0	4.98E-5	1.4E-14 s	10m 0s	600 pts



The base unit is standard Rubidium reference with no GNSS locking or phase noise enhancement. The Rubidium source affords a stability of < 3E-10/month. The unit consumes < 10 watts of power from a DC source that can be from -60 to +60 Vdc in three ranges.

To further enhance long-term stability a GNSS locking options is available. A 26 Channel GNSS receiver is added that continually disciplines the Rubidium source to the GNSS. The configuration is also available with the low noise OCXO- offering the best of three core technologies.

The three 10 MHz outputs (0.5 Vrms into 50 Ohms), NMEA and PPS are fault and transient protected.

The RS232 interface provides access to the NMEA-0183 data from the GNSS receiver at a baud rate of 38.4K. The baud rate can be changed through the RS232 port using commands described in the Output Format Section (8.0). In addition to NMEA data, the serial data also provides equipment status-

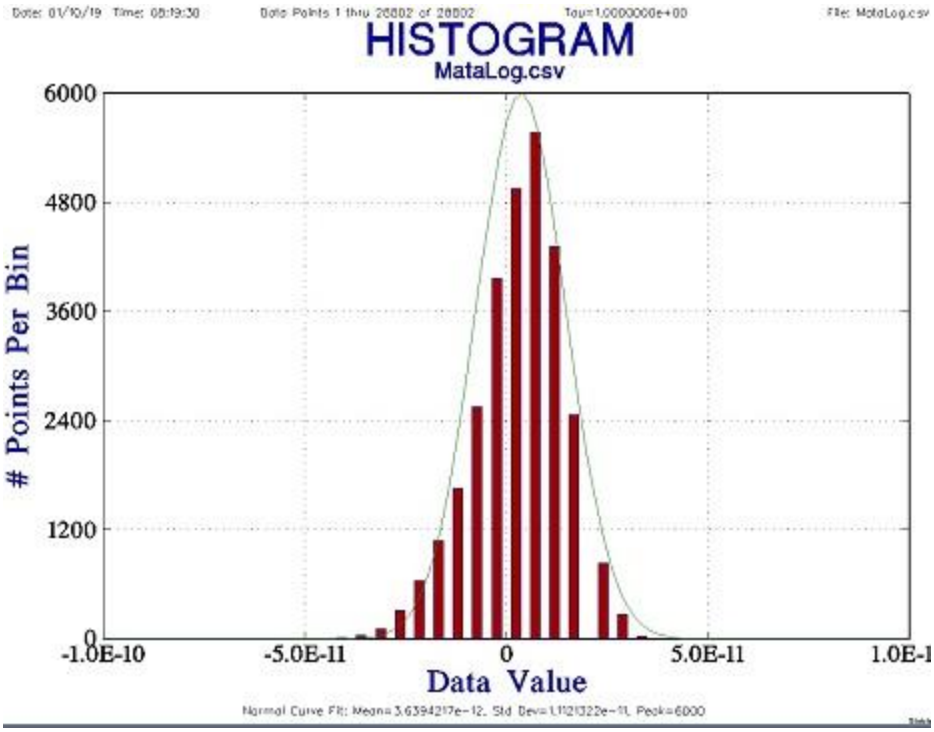
The PPS pulse is capable of driving into a 50 ohm load at 5 volt logic levels.

The discipling loop for the 10 MHz OCXO features an algorithm that affords very low close in phase noise. The bandwidth is such that many of the low frequency artifacts of the transmission path are successfully attenuated.

The PPS pulse is selectable as being directly from the GNSS receiver or synthesized from the Rubidium source or low noise OCXO. The synthesized PPS has significantly improved jitter versus the PPS directly from the GNSS receiver. In addition to selecting the source of the PPS the user can program in cable delay compensation in 1 ns increments and program the PPS pulse width.

The 4-line display in conjunction with the two push buttons provide local status and display. For embedded applications, the unit is available without the display or pushbuttons.

Synthesized PPS pulse jitter



2.1 Power

The equipment will need a power source of approximately 15 watts- Steady state power is < 10 Watts
Power can be from an AC power adapter or a DC source. The DC power required is specified at the time of ordering to be within 1 of three ranges:

12VDC (10 to 15VDC)
24VDC (20 to 30VDC)
48VDC (40 to 60VDC)

The unit has reverse polarity protection and will operate within any given range positive or negative.

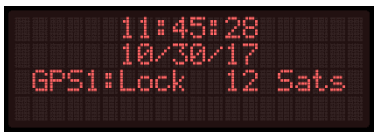
Power consumption is highest at turn-on as the crystal is warming up or if it is a very cold environment. Under normal conditions, warm is less than five minutes.

Power max < 10 Watts
Steady state power < 6 Watts

GNSS Receiver (option)

GNSS Status

On power up, the unit will display the Time and Date as well as the current status of the GNSS receiver.



GNSS: The GNSS status indication allows the user to observe the Lock status of the receivers, and the number of GNSS satellites in view. Before GNSS lock is acquired, the status will be "Tracking" and the number of satellites will be shown. When GNSS lock is acquired, the status will change to "Lock."

Time and Date: The time zone will be UTC by default, but the hour can be offset to the local time in the UTC Offset menu. Changes to UTC offset and Hour mode will be reflected on this screen, but will not change the NMEA output data.

UTC Mode

The user can select how the time is displayed on the screen by choosing between three formats: UTC, 24 hour mode, or 12 hour mode. Toggle through the modes by pressing the SELECT button.

If 24 hour mode or 12 hour mode is chosen, the GMT offset will be applied to the displayed time. If GMT mode is selected, no offset will be applied to the displayed time.

GMT Offset

The user can select how the time is displayed on the screen by choosing between three formats: UTC, 24 hour mode, or 12 hour mode. Toggle through the modes by pressing the SELECT button.

If 24 hour mode or 12 hour mode is chosen, the GMT offset will be applied to the displayed time. If GMT mode is selected, no offset will be applied to the displayed time.

The 26 channel GNSS receiver and companion elements generate the GNSS PPS and NMEA serial link. The serial link conforms to NMEA 0183 protocol.

GPS, GLONASS, QZSS, SBAS, Active Anti-Jamming and Advanced Multipath Mitigation Functions.

Supports concurrent GPS, GLONASS, SBAS and QZSS. Galileo Ready.

Sensitivity

GPS

Tracking: -161 dBm
Hot Start: -161 dBm
Warm Start: -147 dBm
Cold Start: -147 dBm
Reacquisition: -161 dBm

GLONASS

Tracking: -157 dBm
Hot Start: -157 dBm

Warm Start: -143 dBm
Cold Start: -143 dBm
Reacquisition: -157 dBm

TTFF (Time to First Fix)
Hot Start: <5 sec (@-130 dBm)
Warm Start: 35 sec (@-130 dBm)
Cold Start: 40 sec (@-130 dBm)

- Active Anti-Jamming
- Advanced Multipath Mitigation

The receiver needs at least four satellite vehicles (SVs) visible to obtain an accurate 3-D position fix. When travelling in a valley, or built-up area, or under heavy tree cover, you will have trouble acquiring and maintaining a coherent satellite lock. Complete satellite lock may be lost, or only enough satellites (3) tracked to be able to compute a 2-D position fix, or a poor 3D fix due to insufficient satellite geometry (i.e. poor DOP). It may not be possible to update a position fix inside a building or beneath a bridge. The receiver can operate in 2-D mode if it goes down to seeing only three satellites by assuming its height remains constant. But this assumption can lead to very large errors, especially when a change in height does occur. A 2-D position fix is not considered a good or accurate fix; it is simply “better than nothing”.

The receiver’s antenna must have a clear view of the sky to acquire satellite lock. Remember, it is the location of the antenna that will be given as the position fix. If the antenna is mounted on a vehicle, survey pole, or backpack, allowance for this must be made when using the solution. The GNSS receiver provides power for the LNA in the antenna. The unit was designed to provide 3.5 Vdc < 40 mA of current.

To measure the range from the satellite to the receiver, two criteria are required: signal transmission time and signal reception time. All GPS satellites have several atomic clocks that keep precise time and are used to time-tag the message (i.e. code the transmission time onto the signal) and to control the transmission sequence of the coded signal. The receiver has an internal clock to precisely identify the arrival time of the signal. Transit speed of the signal is a known constant (the speed of light), therefore: time x speed of light = distance.

Once the receiver calculates the range to a satellite, it knows that it lies somewhere on an imaginary sphere whose radius is equal to this range. If a second satellite is then found, a second sphere can again be calculated from this range information. The receiver will now know that it lies somewhere on the circle of points produced where these two spheres intersect.

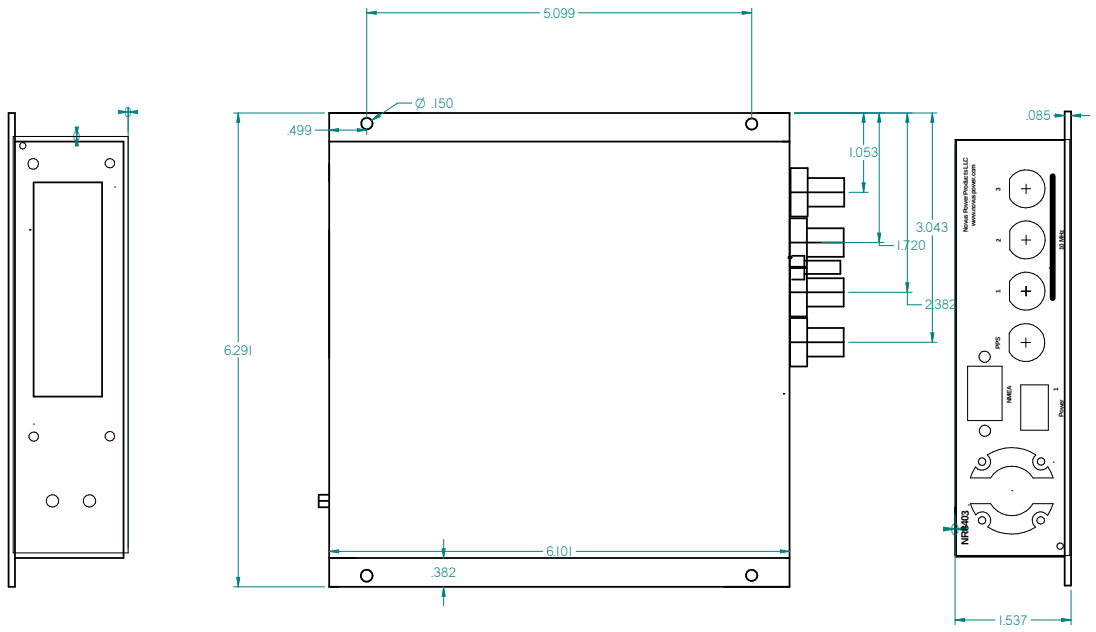
When a third satellite is detected, and a range determined, a third sphere intersects the area formed by the other two. This intersection occurs at just two points. A fourth satellite is then used to synchronize the receiver clock to the satellite clocks.

In practice, just four satellite measurements are sufficient for the receiver to determine a position, as one of the two points will be totally unreasonable (possibly many kilometers out into space). This assumes the satellite and receiver timing to be identical. In reality, when the receiver compares the incoming signal with its own internal copy of the code and clock, the two will no longer be synchronized. Timing error in the satellite clocks, the receiver, and other anomalies mean that the measurement of the signal transit time is in error. This, effectively, is a constant for all satellites since each measurement is made simultaneously on parallel tracking channels. Because of this, the resulting ranges calculated are known as “pseudo-ranges”.

To overcome these errors, the receiver then matches or “skews” its own code to become synchronous with the satellite signal. This is repeated for all satellites in turn, thus measuring the relative transit times of individual signals. By accurately

knowing all satellite positions and measuring the signal transit times, the user's position can be accurately determined.

Mechanical



The 4 line display and two buttons provide status and control functionality. The display also features a "saver" function that dims the display if no button presses are made in 30 minutes. An activation of either buttons restores the display brightness.

For embedded systems, the unit is available without the display or pushbuttons.

Antenna

Antenna 1 - SMA
SMA female antenna connections. Provides internal 3.5VDC power at <30mA max. The Novus NA103 pole mount antennas or the Novus NA106 magnetic mount antenna are recommended for optimal performance.

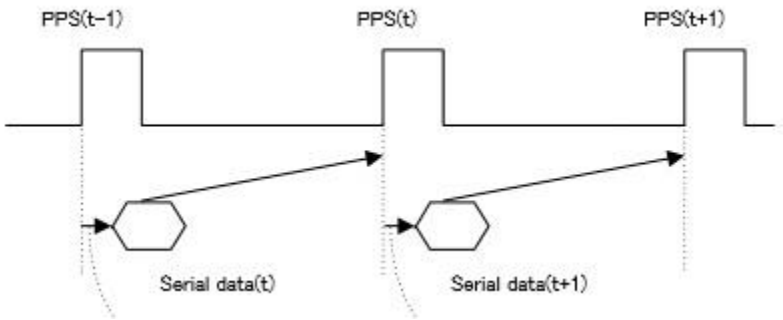
The receiver and companion elements generate the PPS and NMEA serial link. The serial link conforms to NMEA 0183 protocol. The 26 channel high-sensitivity, high-accuracy Multi-GNSS receiver supports TRAIM, GPS, GLONASS, QZSS, SBAS, Active Anti-Jamming and Advanced Multipath Mitigation Functions.

Typical Antenna Specs:

Frequency Band	1574 – 1607 MHz
Antenna Gain	2 dBic @ 90°
Amplifier Gain	@ 3.0Vdc: 26dB (typ)
Polarization	RHCP
Out-of-band Rejection	>60dBc @ f0 ± 50MHz
Impedance	50Ω
VSWR	2.0 Max
DC Input	2.8V - 6V
Noise Figure	<2.0dB
Power Consumption	25mA (typ)

PPS (Pulse Per Second)

The PPS (one Pulse Per Second) relationship with the NMEA data is shown below:



The serial data timing is for the next rising edge of the PPS pulse.

There are a number of attributes for the PPS that can be controlled via the RS232 port with the radio:

GNSS PPS Availability

There is a TCXO that is used to maintain the PPS in the event of GNSS loss. The radio can be programmed to either have the PPS stop when GNSS lock occurs or continue with the stability of the internal TCXO. The TCXO has a stability as shown below.

Electric characteristics	Condition	Description	Unit	Notes
frequency stability vs. Temperature	-30 to +85°C	Max. +/-0.5	ppm	Reference temperature: +25+/-2°C
	-40 to -30°C	Max. +/-2.0	ppm	
Frequency stability vs. Power supply	+1.8 V +10/-5%	Max. +/- 0.2	ppm	
Frequency stability vs. Load	(5.19 kΩ // 6.21 pF) +/-10 %	Max. +/- 0.2	ppm	
Frequency tolerance	+25+/-2 °C, # of reflow:4	Max. +/-2.0	ppm	Reference frequency: Standard
Frequency stability vs. Aging	One year	Max. +/-1.0	ppm	
	Five years	Max. +/-3.0	ppm	
	Ten years	Max. +/-5.0	ppm	
Waveform symmetry	DC Decupling	50 +/-10	%	Reference: Ground
Harmonic distortion		Max. -5	dBc	
Short term stability	τ=50 to 200ms	Max. 0.5	ppb	Reference: Allan variance

The PPS may also be selected from an internal synthesizer operated from the 10 MHz. This source is much more stable with pulse-to-pulse jitter below 1 ns while being within 100ns of the received PPS.

GNSS PPS Accuracy

15ns(1σ) (@-130 dBm)
50ns(1σ) (@-150 dBm)

The nominal accuracy of a PPS signal that is directly from the radio is on the order of 25 ns rms. The signal will also have ~5 ns of jitter. The jitter is due to the characteristics of the transmission channel - multi-path and other radio effects. The long-term accuracy of the PPS is excellent. There are numerous reference documents produced by NIST that define accuracy.

For those applications where the 5 ns of jitter is unacceptable, there is a more stable source. To solve the jitter problem, a stable oscillator is locked to the PPS and the output of the oscillator is then counted down to 1 Hz to have a jitter level that is dominated by the oscillator and associated electronics. PPS jitter can be improved from the 5 ns range to less than 1 ns

PPS Holdover

PPS holdover is concerned with the stability of the PPS when GNSS lock is lost. The circuitry discussed to improve jitter also improves holdover. If the oscillator is an OCXO - then a PPS drift of 5 to 10 ppb/day is achievable (< 1ms). A Rubidium source can be used to achieve drift rate well over an order of magnitude better than the OCXO < 20 usec/day.

Cable Delays

The unit can be programmed to compensate for PPS errors due to cable length. A compensation factor of +/-100000 ns can be used.

Pulse Width:

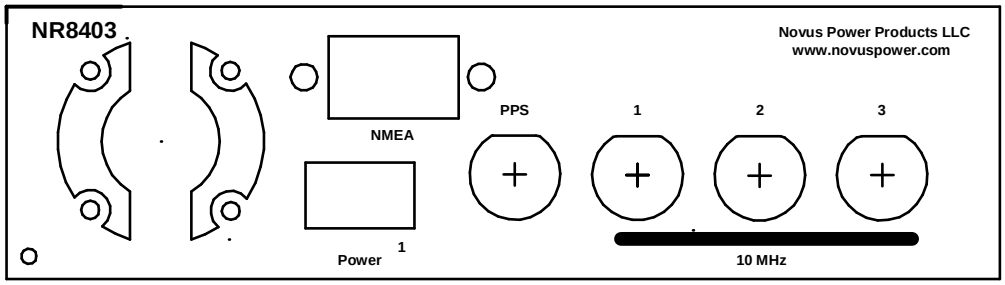
The pulse width can be programmed from 1 to 500ms.

Factory Default Settings:

PPS on when estimated accuracy is within 1 usec.
Pulse width is 200ms.

Num	Contents	Range	Default	Remark
1	PPS	-	-	Command Name
2	type	LEGACY GCLK	LEGACY	PPS type
3	mode	0 to 4	4	PPS mode 0: Always stop 1: Always output 2: Output only during positioning more than one satellite 3: Output only when TRAIM is OK 4: Output only when estimated accuracy is less than estimated accuracy threshold which is 8th field on this command.
4	period	0 to 1	0	PPS output interval 0: 1PPS (A pulse is output per second) 1: PP2S (A pulse is output per two seconds)
5	pulse width	1 to 500	200	PPS pulse width (ms)
6	cable delay	-100000 to 100000	0	PPS cable delay (ns) Plus brings delay PPS. Minus brings forward PPS.
7	polarity	0 to 1	0	PPS polarity (LEGACY PPS is rising edge only) 0 : rising edge 1 : falling edge
8	PPS accuracy threshold	5 to 9999	1000	PPS estimated accuracy threshold This threshold is used for mode 4. ▵4

Rear Panel



Channel Output – BNC (10MHz Option)

There are three 10MHz output on the rear panel, BNC 50Ω

Antenna Input - SMA

SMA female – Internal 3.5V Supply, 30 mA max to power an LNA located at he antenna. Located jut above the Channel 1 BNC.

DC Input

The power connector is a 4 pin terminal block connector:
(Phoenix Contact part #1844236 or ON-Shore Tech Part# OSTOQ041251)

and the unit ships with its mate pictured below:
(Phoenix Contact part #1840382 or ON-Shore OSTTJ0411530)
Wires can be installed and secured with a slotted screwdriver.

Pin assignments:

1. V-
2. V+
3 Relay Contact
4. Relay Contact

The unit is designed to operate from 12 VDC nominal power and is reverse polarity protected.

Pin 1 is designated on the panel and is the far right pin as directly viewed.

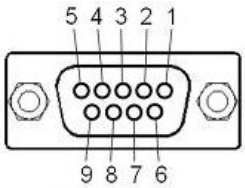
3.4 RS232 DB9 (Status and NMEA)

An RS232 port is provided for NMEA output from the GNSS receiver, and for the optional status of the 10MHz source .

Status(10MHz Option): The embedded processor provides status strings, as well as command responses. Configuration and status commands are detailed in the NTP0100 Programmer's Manual Section 5.0. (default 38400 baud)

NMEA: The GPS/GNSS receiver provides NMEA-0183 formatted serial data. (default 38400 baud)

RS232 Serial Port: Rear Panel Pin Connections



Female DB-9

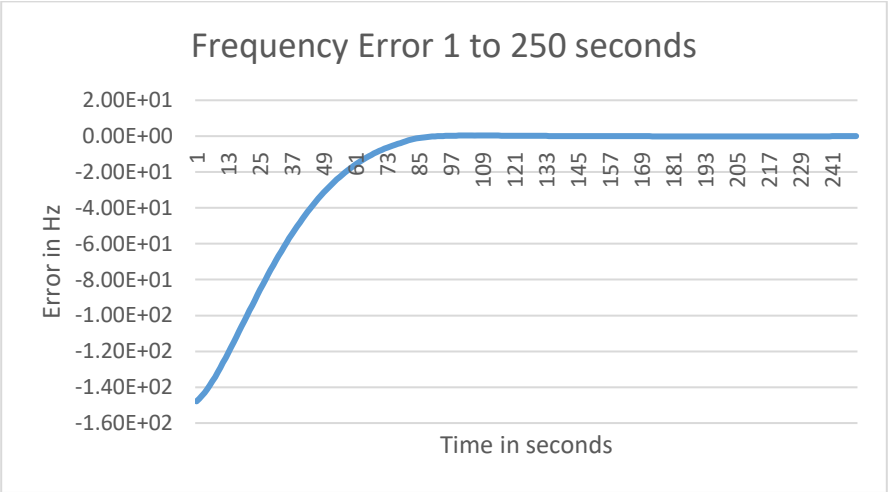
Pin	Function	I/O
1	Optional PPS	O
2	NMEA port / Command Port TX	O
3	NMEA Port / Command Port RX	I
4	NC	
5	GND	GND
6	NC	
7	NC	
8	NC	
9	NC	

NMEA Configuration: The default settings for the rear panel RS232 port are 38400 baud, 8 bits, 1 stop bit, no parity. The baud rate may be changed per instructions in section

Operations

At the application of power the Rubidium begins its lock process. The locking time is typically less than 5 minutes. If the low noise OCXO option is purchased then the OCXO must lock to the Rubidium. The OCXO has its own warm-up time illustrated below.

OCXO Frequency Error from Cold Start



Channel Status

The Channel Status can be determined by reading the actual RMS value on the output of each stage. This is compared to a threshold limit that is set by the user as a percentage variation from a saved value. The default variation value is set at ±25% percent from the current state of the amplifier, and is user programmable in 5% increments from ±10% to ±60%.

The range of acceptable Channel Amplitude can be narrowed around a connected balanced line, such that a Channel Status below the Alert Threshold indicates a shorted line, while a Channel Status above the Alert Threshold window indicates a potential disconnected cable.

The threshold value at which a channel alert is triggered can be programmed on the Alert Threshold screen, or programmed via the RS232 port. Once set, the unit

would continue to monitor each channel and a deviation beyond the set limits would be reported as a failure on the front panel and via RS232.

The Channel Status feature can quickly detect a cabling failure. Any change in the load impedance will change the output voltage with respect to the divider formed by the output impedance of the amplifier and the load impedance. Failing cables and connectors can be detected early.

The current threshold limits are displayed in addition to the actual measured value. These values reflect the percentage threshold defined in the Alert Threshold settings. If the output value is too low to give a valid reading. The display will read "LOW."

The status is displayed on the front panel and is accessible over the RS232 serial bus via DB9.

Built in Test

There are number of power supplies in the design to meet special needs and noise reduction. All power supply voltages are monitored, and can be accessed via RS232 or ethernet. In addition, all current channel statuses, or Vrms values, can be monitored, as well as power supply health.

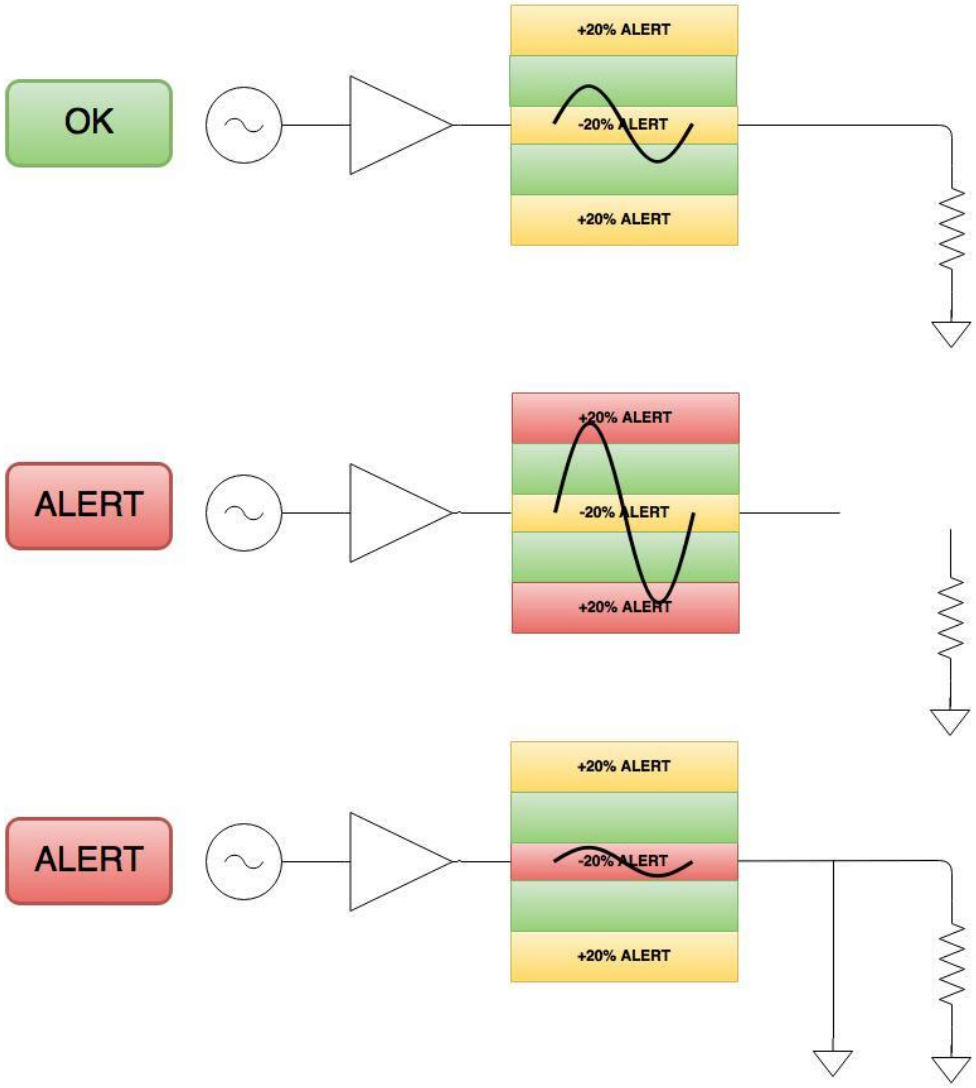
Alert Threshold

The Alert Threshold screen allows the user to adjust the tolerance from the Reference Voltage which, if exceeded in either direction, the output channel will report a fault status. The default threshold value is set at ±25% percent from the current state of the amplifier, and is user programmable in 5% increments, from ±10% to ±60%.

The output channel has a Reference Voltage which can be set by latching the channel's current value in the Latch Channel Average Screen. The output reference voltage can be set individually by writing the value serially with the $SET command. After saving the current configuration on a channel, any subsequent deviation on that channel which exceeds the Alert Threshold percentage will trigger an alert.

Steps to ensure correct Alert configuration:

1. Connect distribution cabling to the 10MHz output.
2. Set Alert Threshold to desired range.
3. Save current channel voltage with the Latch Channel Values Screen.
4. Save current settings on the Save Configuration screen.



The Alert Threshold can be optimized so that a channel short or an impedance change will cause an Alert.

Example:

The output of channel 1 is connected to a high impedance input and reports 1.25Vrms at the output.

Alert threshold is set to +/-20%.

The current state is saved in the Save Configuration screen.

The Channel 1 alert will report when:
- *The Channel 1 output is higher than 1.50Vrms*
- *The Channel 1 output is lower than 1.00Vrms*

To adjust the Alert Threshold from the front panel, hold the NEXT and SELECT buttons down simultaneously for two seconds. The percentage value will begin flashing. To increase the value, press the SELECT button. To decrease the value, press the NEXT button.

When the desired value is reached, press the NEXT and SELECT button simultaneously to leave the settings mode.

The Alert Threshold settings can be modified via the RS232 serial port with the $FLTTHR command.

For details on the Alert Threshold, see Programmer's Guide.

Latch Channel Value

The Latch Channel Values Screen allows the user to save the current channel output value for use as the Reference Value for Alert settings.

A channel Alert is triggered when the channel output voltage exceeds or falls below a percentage of the Reference Value. This Reference value is 1.10Vrms as a default, but can be set by the user.

There are two ways to set the Reference Voltage. The RS232 serial port allows for setting an individual channel's reference voltage with the $SET command. The user can also use the Latch Channel Values to take a snapshot of all current outputs, and use these as the reference values.

Save Configuration

The Save Configuration screen allows the user to save the current settings for Alert Threshold, Input Threshold, Attenuation, Input Select, Reference Voltage and any other settings that have been modified via the RS232 port.

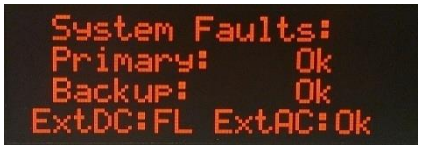
To save the current settings, press the SELECT button twice.

The Save Configuration action is equivalent to the $SAVEFL command on the serial port.

Fault Status

The Fault Status screen allows a quick overview of any Channel faults from the front panel.

Press SELECT to advance to the System Fault Screen.



The System Fault Screen indicates any failures in the primary system or the redundant backup system. All internal power supplies are monitored (12 V, +5V, -5V, 5Vlogic) on both the primary and backup systems. A failure on one of these supplies will be indicated with a “PS FAIL” fail warning for either system. A

communication failure would be indicated by a “Com FAIL” indicator. Either of these fault statuses will result in the change of the primary to the backup system. The individual statuses of the internal power supplies are also available via the RS232 serial port.

The presence of a valid DC input voltage is indicated on this screen, as well as a valid AC power input. If either of these supplies are not present, a “FL” indication will be shown next to the appropriate input.

UTC Mode

The user can select how the time is displayed on the screen by choosing between three formats: UTC, 24 hour mode, or 12 hour mode. Toggle through the modes by pressing the SELECT button.

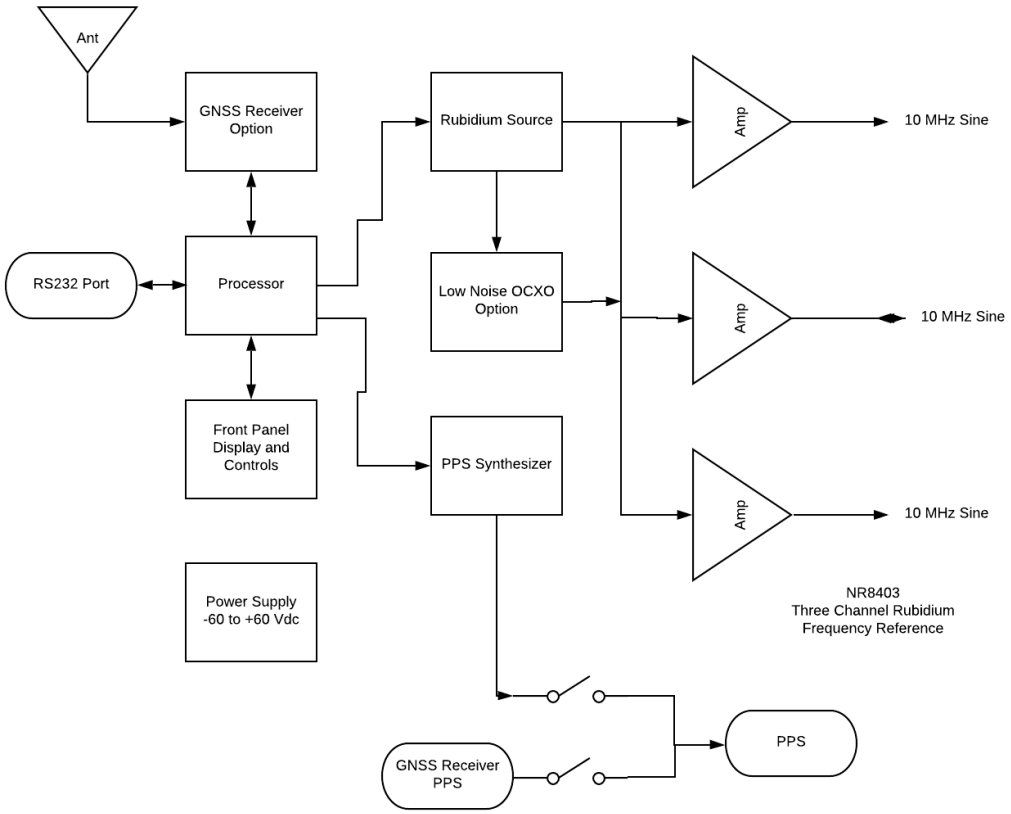
If 24 hour mode or 12 hour mode is chosen, the GMT offset will be applied to the displayed time. If GMT mode is selected, no offset will be applied to the displayed time.

GMT Offset

With 24 hour mode or 12 hour mode, the user can choose to align the displayed hour with their current time zone. Using the SELECT button, toggle to the desired offset. The offset will decrement through the 24 hour period, from UTC-11 to UTC +12, etc.

Adjusting the GMT offset will affect the displayed date. As the hour moves across the International Dateline, the displayed date will reflect the date in the selected time zone, and not necessarily the GMT date.

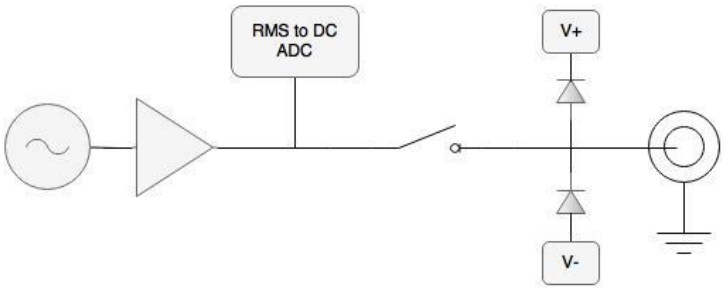
Functional Description



Outputs

Each output is fault and electrostatic discharge protected. Each output is independent and any output can be faulted for an indefinite period of time with no permanent damage. Each output is connected to a monitor circuit that detects a local fault on the output. The fault status is indicated on the front panel.

The three channel amplifier is designed for low noise and flexibility. Each channel has three possible output configurations.



Linear Amplifier

Built in Test

There are number of power supplies in the design to meet special needs and noise reduction. All power supply voltages are monitored, and can be accessed via RS232 or ethernet. In addition, all current channel statuses, or Vrms values, can be monitored, as well as power supply health.

6.0 Calibration

The frequency is phase locked to the GPS signal, and no adjustment is required. The Auto Calibration feature tunes the OCXO, and stores the calibration coefficients in non-volatile memory.

Programming Guide (RS232 Port: Status Only)

The NR2110 can accept user commands which will provide specific fault detection performance which may be customized by the user. The settings can be saved in non-volatile flash memory.

This section is for the status commands, when the NMEA/Status port has been configured for status output, instead of NMEA output. In addition to the STATUS RS232

port, a unit configured with the serial to ethernet option can access these commands.

If the user makes changes which are intended to be kept between power off cycles, the command “$SAVEFLASH*51 <cr><llf>” will update flash to reflect all current settings.

Table 1 shows a complete list of input commands and descriptions. In general, a command may be input without “=” or an additional value, and the unit will respond with the current setting’s value. If the input is not understood, the microcontroller will return the value “$?*3F<cr><lf>”

NOTE: All commands should be prefixed with “$”, and followed by <cr><lf>. Checksum can be enabled which requires the command to be followed by an asterisk (*) and a two-digit hex value.

Example: $<*COMMAND*>*XX<cr><lf>.

The checksum can be required all input commands, and the requirement for a checksum can be enabled or disabled (default setting is disabled). The checksum method is the two-hexadecimal character representation of an XOR of all characters in the sentence between, but not including, the $ and the * character.

Example: $NVS1=1*76

All responses will be formatted in the following format:
$GPNVS,R,n,<response>*XX<cr><lf>.

Communication with the unit follows the outlined $GPNVS Status String format outlined in Appendix C.

RS232 Commands (Status Only, for GNSS, see Append. A)

Setting	Command	Response	Description

RS232 REAR PANEL BAUD RATE (STATUS OUTPUT ONLY)	$BAUDNV	$BAUDNV=<current Baud Rate>	Query Baud Rate on rear panel RS232. (Default = 115200). Front Panel is 115200 baud.
	$BAUDNV=38400		Assign Baud rate to Rear Panel RS232 port. Default is 115200. Available baudrates are 9600, 19200, 38400, 57600, 115200, 230400. Note: Front panel baud rate is set to 115200.
CHANNEL FAULT THRESHOLD FACTOR	$FLTTHR $FLTTHR	$FLTTHR=<current Channel Fault threshold factor (from 0.05 to 0.95)>	Query or set the ratio at which the Channel output monitors report a fault. For example, if the FLTTHR is set to "0.15", the Channel Fault Word will report an error if the measured value is greater or less than ±15% of its target value. Number format must be in the form <n.nn>
	$FLTTHR=0.15		
INPUT LOW THRESHOLD VALUE (NDxxxx ONLY)	$INPTHR	$INPTHR=<current InputThreshold (from 0.05V to 1.00V)>	Query or set the absolute voltage at which the Input monitor reports a llow input fault. For example, if the THR is set to "0.3", the Channel Fault Byte will report an error if the measured Vpp is lower than 0.3V.
	$INPTHR=0.20		

Setting	Command	Response	Description
SET INDIVIDUAL CHANNEL	$SET<nn>=n.nn	$SET<nn>=nn.nn	Set or query the Reference Voltage for a perticular channel with respect to the active input. Use in

REFERENCE VOLTAGE	$SET01=1.00 $SET02=1.00 $SET03=1.00 . . . $SET15=1.00		combination with the Channel Fault Threshold Factor to define Alert on an individual Channel. Reference Voltages are set with respect to the active input, allowing for variation in amplitude between Input A and Input B. *Example: Set Channel 4 to Alert if it is beyond +/-20% of 0.90Vrms when relayed to Input A:* $SET04=0.90<CR><LF> $FLTTHR=0.20<CR><LF> (To set all channel Reference values to their current average amplitude, use the Latch Average Channel Values command.)
LATCH AVERAGE CHANNEL VALUES	$LATCHAVG	$LATCHAVG=<currently Selected input>	Latches the current Channel Vrms measurement averages into memory as the average value to set the Channel Fault Threshold for each channel. Latches in all outputs with respect to the active input. Example: Response of "LATCHAVG=A" indicates input A is active, and the channel fault thresholds for Input A will now measure against the current output values. Use this command during setup, after cabling, to take a snapshot of the nominal system state.
NVS1 OUTPUT	$NVS1	$NVS1=<current RMC output frequency>	Query NVS1 String output Frequency. (Default = 1)
	$NVS1=1		Change NVS1 String output Frequency in seconds. (0-60)
NVS2 OUTPUT	$NVS2	$NVS2=<current RMC output frequency>	Query NVS2 String output Frequency. (Default = 1)
	$NVS2=1		Change NVS2 String output Frequency in seconds. (0-60)
NVS3 OUTPUT	$NVS3	$NVS3=<current RMC output frequency>	Query NVS3 String output Frequency. (Default = 1)
	$NVS3=1		Change NVS3 String output Frequency in seconds. (0-60)
NVS4 OUTPUT (OPTIONAL)	$NVS4	$NVS4=<current RMC output frequency>	Query NVS4 String output Frequency. (Default = 1)
	$NVS4=1		Change NVS4 String output Frequency in seconds. (0-60)

Setting	Command	Response	Description
CAL FACTORS	$CAL<n>=nn.nn	$CAL<n>=nn.nn	Query or set Cal Factors for specific ADC conversions. See list of Cal Factors numbered for

	$CAL1=11.10		appropriate measurement parameters. These settings should only be changed by an authorized technician.
SAVE ALL CAL FACTORS TO FLASH MEMORY	$SAVECAL	$SAVED CAL. $SAVE CAL FAILED.	This command will translate all Calibration Factors to flash string and write. Data is then read back for verification, and result reported. This will update Cal Factors in flash to the current Cal Settings.
ALLOWED FREQUENCY DEVIATION	$FRAL $FRAL=200	$FRAL=200	(For Dual Time Base only) This command changes the range of frequency allowed without an alarm. Allowed range is 0-240, units are 0.0083Hz.
GPS/GNSS COM SETTING	$GPSTX $GPSTX=0	$GPS_NO_TX $GPS_FRONT_NB $GPS_REAR	(GNSS Locked Only) This command enables communicaton to the internal GPS/GNSS receiver directly, if the port is a GPS listening port. (This is enabled for S/N higher than 1517xxxx). 0 = Transmit to GPS disabled. 1=Transmit to GPS enabled via Front Panel (optional) or ethernet port (optional). 2=Transmit to GPS enabled via Rear Panel.
STATUS OUTPUT	$STAT<n>	<$GPNVS,1….>	Query NVS<n> String. Useful for status output on demand when user does not require regular string output.
	$STAT1		Outputs current $GPNVS,1 string on demand.
	$STAT2	<$GPNVS,2….>	Outputs current $GPNVS,2 string on demand.
	$STAT3	<$GPNVS,3….>	Outputs current $GPNVS,3 string on demand.
ACTIVATE FRONT PANEL STATUS STRINGS	$ACTFRP=1 $ACTFRP=0	$ACTFRP=n	Set Front Panel RS232 to automatically output $GPNVS strings. 1 = Enable, 0 = Disable (Default)
SAVE ALL VALUES TO FLASH MEMORY	$SAVEFLASH	$SAVED TO FLASH. $FLASH SAVE FAILED.	This command will translate all current variables to flash string and write. Data is then read back for verification, and result reported.
RESET ALL TO DEFAULT	$RESETALL	$RESET FLASH VARIABLES.	Resets all user settings to default values and overwrites flash memory with defaults.
INVALID INPUT		$?	Command not recognized.
REQUIRE CHECKSUM	$CSUM $CSUM=1	$CSUM=<current CSUM>	Query or set mandatory checksum on all incoming STATUS port communication. 1 = Enabled, 0 = Disabled. Default = 0.

Technical Specification

Output	10 MHz,0.5 Vrms ±0.2, into 50 Ohms	
Accuracy at Shipment	<±1E-9	
Monthly Aging	<±2E-11 after 3 months of operation	
Yearly Aging	<±1E-9 after 3 months operation (unlocked)	
Locked	<5 E-12	
Harmonic Distortion	< -30 dBc	
Power	DC options and AC power adapter available- < 15 W start, < 10 W steady state	
Alert	20Vdc/Vac, 0.2 Amp relay contacts- relay closed for normal condition, BNC	
Rubidium Atomic Frequency Standard:		
Accuracy at shipment	+/-5.0E-11	
Warm-up time	<15 minutes	
Time of lock	<5 min -130 dBm	
Time to achieve accuracy	<1E-9<15 minutes, (12 minutes)	
Aging - monthly	<5E-11	
Aging - yearly	<1.0E-9	
GPS Disciplining	GNSS receiver	
Time for valid output	<12 minutes	
Frequency Accuracy	<1E-11	
Stability: Allan Deviation		
1s	<3E-10	
10s	<1E-10	
100s	<3E-11	
SSB Phase noise for 10Mhz		
	Standard Low Noise Option	
10Hz	< -95 <-125dBc	
100Hz	<-125 <155dBc	
1000Hz	<-135 <-160dBc	
10000Hz	←135 <-160dBc	
Amplitude for 10Mhz frequency output	0.5 Vrms	
Harmonic	<40dBc	
Non-Harmonic	<-80dBc	
PPS		
Amplitude for 1PPS	3.3 Vdc CMOS (5 Vdc option)	
Pulse width for 1PPS	Programmable 1 to 500ms in 1 ms steps	

Rise time for 1PPS	<20 ns (faster edge available)	
Jitter	Two PPS modes- GNSS-PPS and stabilized PPS- GNSS-PPS < 6ns Stabilized PPS < 1 ns,	
Connector	BNC	
Load Impedance	50 Ohm	
Location	rear	
Remote interface & control		
Protocol	RS232	
Connector	DB-9	
Location	Rear panel	
Protocol	Bit plus stop	
Standard Baud Rates	Selectable 4800, 9600, 19200, 38400, 57600 or 115200 bps	
GNSS receiver	GPS L1 C/A, GLONASS L1OF, QZSS L1 C/A, SBAS L1 C/A (Ready): Galileo E1B/E1C, QZSS L1S	
Channels	26 channels (GPS, GLONASS, QZSS, SBAS)	
Sensitivity		
GPS	Tracking: -161 dBm	
	Hot Start: -161 dBm	
	Warm Start: -147 dBm	
	Cold Start: -147 dBm	
	Reacquisition: -161 dBm	
GLONASS		
	Tracking: -157 dBm	
	Hot Start: -157 dBm	
	Warm Start: -143 dBm	
	Cold Start: -143 dBm	
	Reacquisition: -157 dBm	
	With Novus recommended antenna	
Antenna with LNA		
Antenna power	3.5 Vdc, < 35 ma (on center conductor) (factory configurable to 5 Vdc)	
Frequency	1574-1607 MHz	
Nominal Gain	2 dBic	
Amplifier gain	26 dB	
Noise Figure	< 2.0 dB	
Out of Band rejection	Fo±50MHz=60 dBc, Fo±60 MHz	
DC current	<25 ma@3.5 Vdc	
Main Power		
DC input	-60 to +60 in three ranges	
Power	<15 W (steady state < 10 W)	
Warranty	1 year plus 3 year optional extended warranty from date of shipment	

Environmental and Mechanical

Operating Temperature	0 to 50°C non-condensing
Storage Temperature	-40 to 70°C
Height	1.58”
Width	6”
Depth	6” exclusive of connectors
Weight	1.5 lbs

9.0 LIMITED HARDWARE WARRANTY

Novus Power Products (hereinafter Novus) warrants its products to the original end user (“original purchaser”) and warranty is not transferrable. Novus guarantees that the NOVUS hardware products that you have purchased from NOVUS are free from defects in materials or workmanship under normal use during the LIMITED WARRANTY PERIOD. The LIMITED WARRANTY PERIOD starts on the date of shipment and for the period of 1 (one) year to be free from defects caused by faulty materials or poor workmanship, provided:

(a) NOVUS is notified in writing by Buyer of such defect prior to the expiration of the warranty period, and

(b) after receiving return authorization –RMA- from NOVUS, the defective item is returned with transportation prepaid to NOVUS, St. Charles, Missouri, with transportation charges prepaid by Buyer …see RMA policy in Terms and conditions, and

(c) NOVUSs’ examination of such unit shall disclose to its satisfaction that such defect(s) exist and have not been caused bisuse, neglect, improper installation, improper storage, unauthorized modifications, inadequate maintenance, operation outside the environmental specifications for the product, repair alteration, or accident. NOVUS assumes no risk or liability for results of the use of products purchased from it, including but without limiting the generality of the foregoing: (1) the use in combination with any electrical or electronic components, circuits, systems, assemblies or any other materials or substances; (2) unsuitability of any product for use in any circuit or assembly. Removal or tampering with tamper-proof label on merchandise will void warranty coverage unless with the written authorization from NOVUS

(d) an evaluation fee will be charged to Buyer to cover inspection and testing costs for any item returned by Buyer under this paragraph which is found to be within specifications and/or otherwise not the responsibility of NOVUS under the terms and conditions of this paragraph or any other part of this Agreement..

Your dated sales or delivery receipt is your proof of the purchase date. You may be required to provide proof of purchase as a condition of receiving warranty service. You are entitled to hardware warranty service according to the

terms and conditions of this document if a repair to your NOVUS product is required during the limited warranty period. Our obligation at NOVUS is limited to repair or replace products which prove to be defective.

Should Novus be unable to repair or replace the product within a reasonable amount of time, the customer's alternate remedy shall be a refund of the purchase price upon return of the product to Novus. The liability of NOVUS under this warranty is limited to replacing, repairing or issuing a credit, at its option, for any such item returned by Buyer under the terms of this warranty.

EXCLUSIONS: The above warranty shall not apply to defects resulting from improper or inadequate maintenance by the customer, customer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product or improper site preparation and maintenance (if applicable). For probes, cables, antennas and accessories, the warranty period is 90 (ninety) days.

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Appendix A: GNSS Command Reference

See attached appendix A.

Appendix C: $GPNVS Status Strings

See attached appendix C.