NR7000
*pico*POD

10, 50,100 MHz GNSS-Locked OCXO Reference with NMEA, PPS and Auto-Cal

Contents

1.0 Summary

The NR7000 is a GNSS-locked OCXO 10 MHz frequency reference with auto-calibration. It features a 10 MHz Sine output that is fault and transient protected.

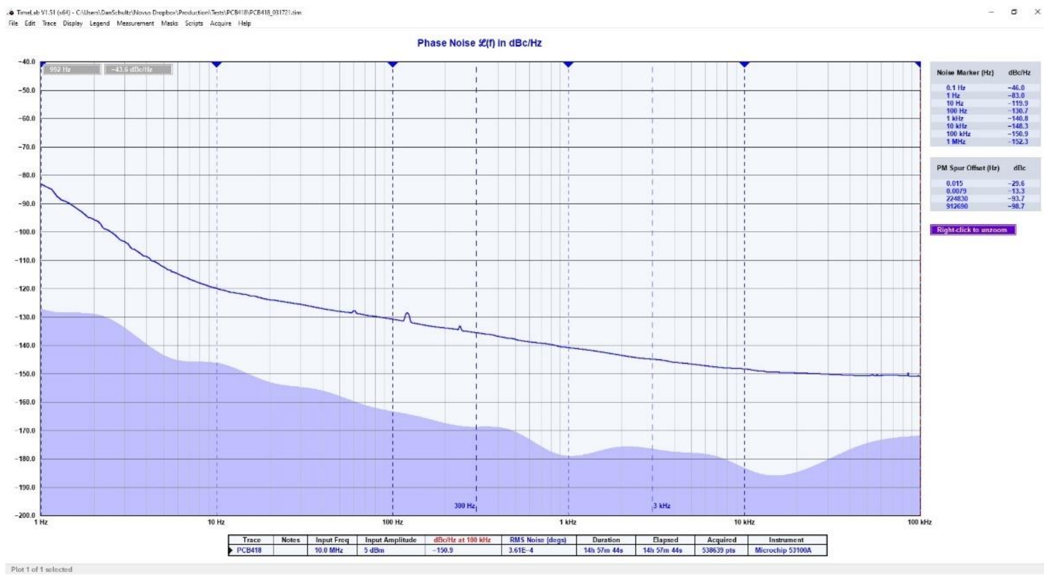
The unit is also available at 50 and 100 MHz

The unit also provides a PPS and NMEA 0183 at full RS232 levels. The RS232 ports can also be configured to operate at logic levels.

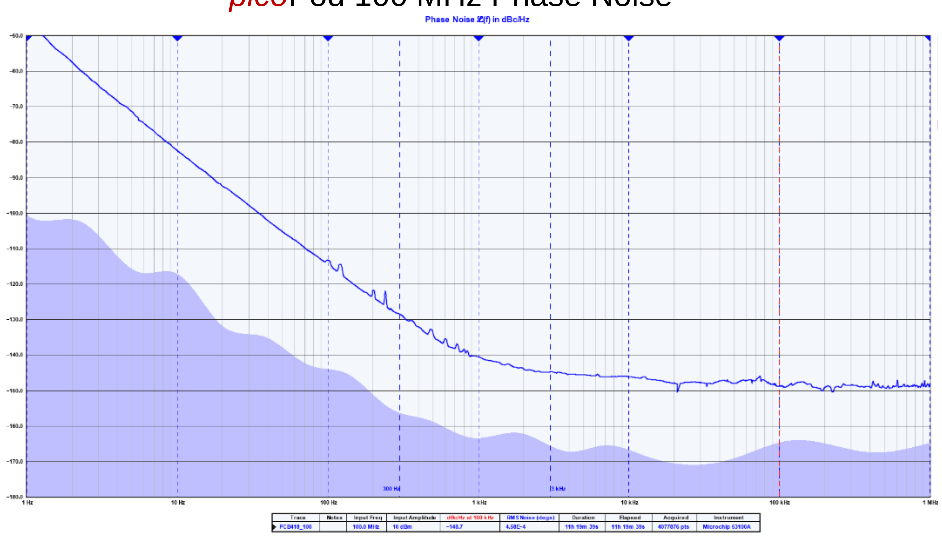
The master timing is from a 26 channel GNSS receiver that supports GPS, GLONASS, SBAS, QZSS. By being able to receive data from multiple satellite constellations, lower TIFF is achieved. With twice the number of satellites in view, as a GPS only configuration, achieving and maintaining lock in poor signal environments is enhanced.

The signal source is a GNSS disciplined low noise OCXO, actively controlled by a mixed-signal control loop. Typical phase noise performance follows.

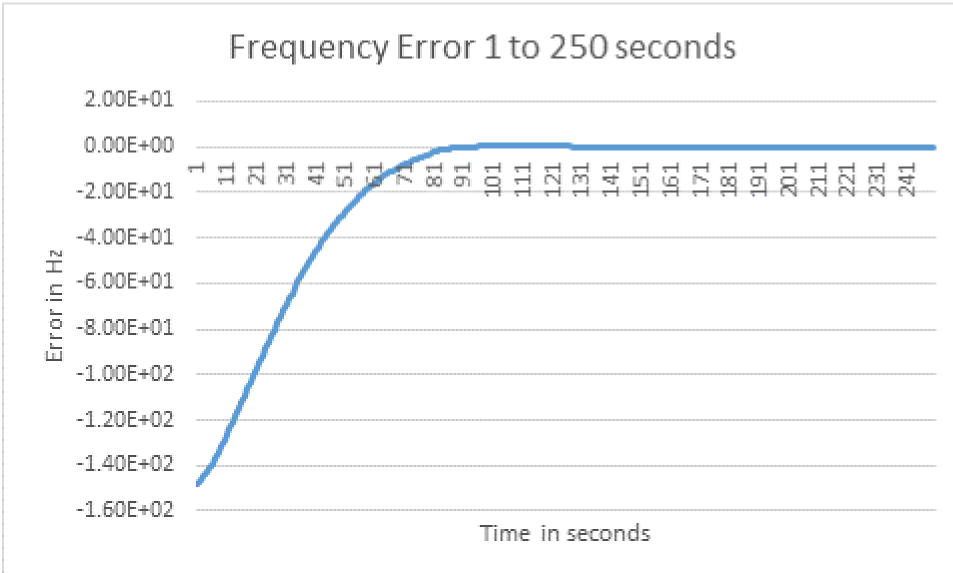
*pico*Pod 10 MHz Phase Noise



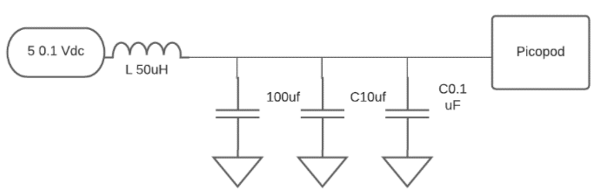
*pico*Pod 100 MHz Phase Noise



OCXO Warm-up Characteristics



Power required is 5.0Vdc to 5.5Vdc. This must be a low noise source. Local filtering is recommended. There is internal filtering but noise on the input power, while attenuated, can compromise phase noise. The input filtering should be near the device using design methods that are consistent with RF methodologies. The circuit below is recommended and uses three capacitor technologies- aluminum electrolytic, tantalum and ceramic.



The NR7000 continually monitors temperature and aging so that, when the unit goes into holdover or loses GNSS lock, the output frequency reverts to the last known locked frequency value. The calibration feature continually monitors the correction coefficients developed through GNSS timing information. These are sampled multiple times per day and stored in non-volatile memory and, in the event of a GNSS loss, the saved coefficients are applied to the OCXO. This effectively eliminates long-term crystal drift. Auto-Cal normally keeps the reference ±10 ppb.

There are two RS232 ports - one for NMEA 0183 and the other for unit status reporting. The NMEA port information and baud rate can be selected via commands detailed in the Appendix. The RS232 port provides the status of each channel and self-test results. The RS232 signals are made available through one DB-9 or a stacked DB-9 pair.

All inputs and outputs are electrostatic discharge protected. Any output can be shorted indefinitely with no permanent damage to the unit.

2.0 Inputs / 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 for each of the 10 MHz outputs on a LED on the PCB or via the RS232 link.

2.1 GNSS Antenna

SMA female antenna connection. Provides internal 3.3VDC power at 45mA max. The Novus NA103 pole mount antenna 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 Specifications:

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)

2.2 SAMTEC Connector (10-pin MiniMate)

The NR7000 has a single locking 10 pin SAMTEC MiniMate 0.1" connector (part number IPL1-105-01-L-D-RA-K).

+5Vdc	RES	PPS IN	TX	RES
GND	GND	PPS OUT	RX	RES

10 pin MiniMate pinout

The reserved pins should not be connected.

There is an optional auxiliary output configuration. This option provides a programmable LVCMOS output that is an n-divisor of the internal bus frequency.

+5Vdc	RES	PPS IN	TX	AUX OUT
GND	GND	PPS OUT	RX	GND

Optional Auxiliary LVCMOS output

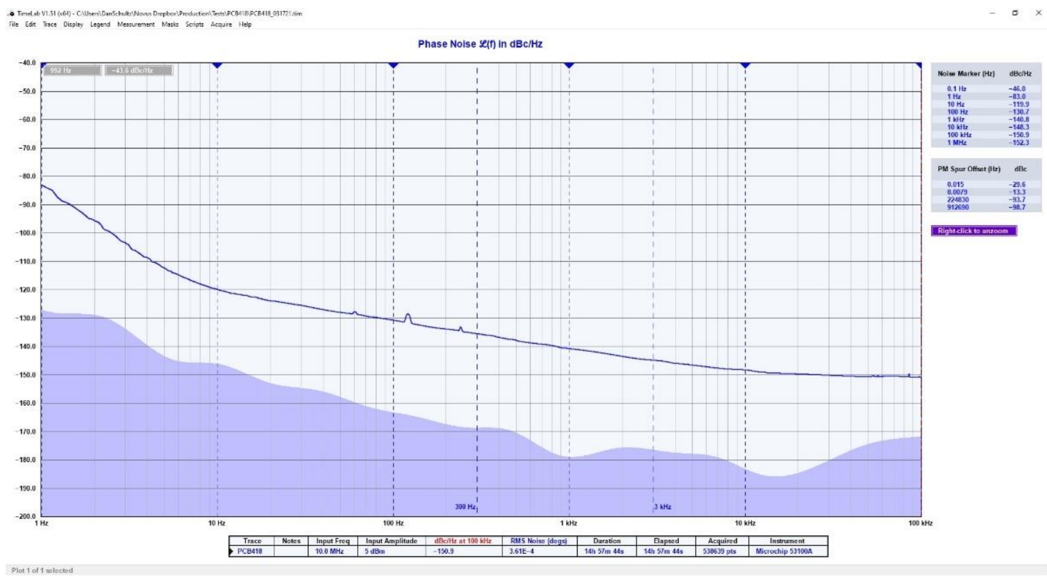
2.3 PPS (Pin)

The PPS is a one pulse per second, LVCMOS, 3.3V signal into 1KOhm. The pulse width is nominally 100 ms but can be programmed at the factory or in the field with the serial port (see Appendix A). The PPS may be advanced/delayed via serial port commands in 1 ns to compensate for antenna cabling delays.

2.4 10 MHz sine (SMA)

1 Vrms into 50 Ohms. The unit can be alternately configured to output a square wave.

3.0 Typical Phase Noise



10MHz Sine- Primary Output

Offset Frequency (Hz)	Typical (dBc / Hz)
10	-102
100	-110
1K	-140
10K	-145

There are optional phase noise performance levels available - contact factory.

4.0 Built-in Test

There are a number of power supplies in the design to meet special needs and noise reduction. Each supply is monitored and a power failure will be reported through the $GPNVS status strings.

Channel faults are also monitored and reported via serial TX/RX.

The lock status is a combination of GNSS receiver lock and the Kalman filter locking. A failure of the Kalman filter to lock is considered a failure mode.

5.0 Power

The platform is designed to operate from +5Vdc to 5.5Vdc.

The unit is also fused with a 5 Amp slow blow. Caution should be exercised when connecting power to the NR7000. The unit is reverse voltage protected with a TVS diode. Applying a negative voltage will result in a surge current that can blow the fuse.

Power is less than 1.5 watts. Power is highest at turn on as the OCXO is warmed rapidly. Crystal power will start over 4 Watts and drop to approximately 1.5 Watts after three minutes at 25°C.

6.0 GNSS Function

The receiver needs to be able to see at least four satellite vehicles (SVs) to obtain an accurate 3-D position fix. When travelling in a valley or built-up area, or under heavy tree cover, you will experience difficulty 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 3-D fix due to insufficient satellite geometry (i.e. poor DOP). Inside a building or beneath a bridge, it may not be possible to update a position fix. 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.

To measure the range from the satellite to the receiver, two criteria are required: signal transmission time and signal reception time. All GNSS 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.

The GNSS lock status can be monitored on the RS232/serial connector.

If the GNSS indicator remains unlocked for an extended period of time, it could be an indication of an antenna, cabling or unit malfunction. Confirm the antenna is still connected and has not become obstructed from a clear view of the sky. To check the unit, an alternate antenna can be tried in order to isolate the malfunction. For further support, please contact the factory at 866-313-9401.

There is free software that can be downloaded from www.synreference.com that will allow baud rate changes, cable compensation and other features (see screen shots).

7.0 Programming Guide (STATUS Port)

The NR7000-OG can accept user commands which will provide particular fault detection performance which may be customized by the user, and saved in non-volatile flash memory.

If the user makes several changes which are intended to be kept between power off cycles, the command "$SAVEFLASH<CR><LF>" will update flash to reflect all current settings.

Table 1 shows a complete list of input commands and descriptions. As a general rule, a command can be input without "=" or 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 "$?<CR><LF>"
NOTE: All commands should be followed by <cr><lf>.

A checksum can be added to all input commands, and the requirement for a checksum can be turned on. 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: $BAUDNV=38400*08

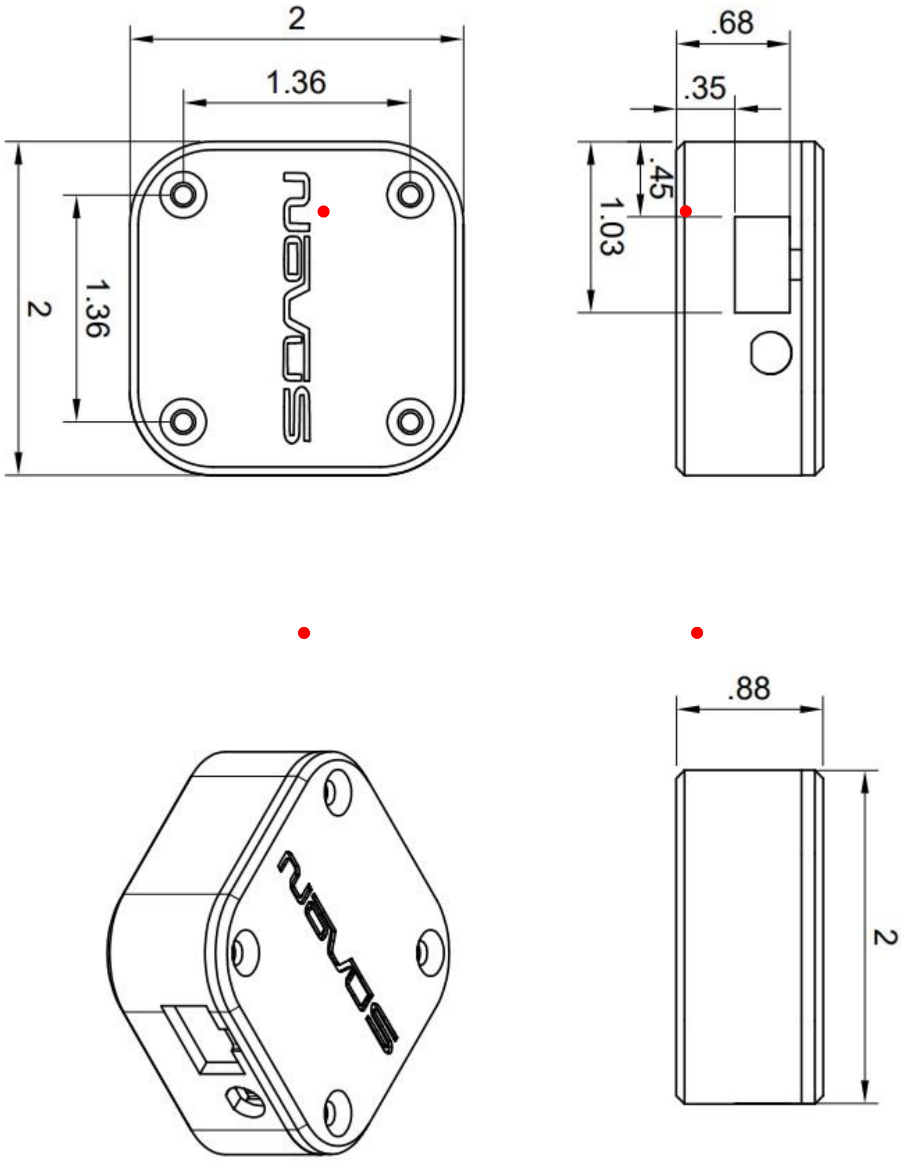
7.1 Status Commands

Setting	Command	Response	Description
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.
	$STAT14	<$GPNVS,14….>	Outputs current $GPNVS,14 string on demand.
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=<current CSUM>	Query or set mandatory checksum on all incoming STATUS port communication. For $PERD commands, checksum is always required. 1 = Enabled, 0 = Disabled. Default = 0.
	$CSUM=1		
$GPNVS	$NVS<n>	$NVS7=1	Enables/Disables output of $GPNVS strings. For $NVS<n>=<m>, where <n> is the $GPNVS string ID, and <m> is the output frequency in seconds.
		$NVS9=1	Example: $NVS9=0 disables output of $GPNVS,9.
		$NVS10=1	
		$NVS11=1	
AUXILIARY FREQUENCY OUTPUT	$AUXFR=<INTEGER>	$AUXFR=<INTEGER>	Sets the auxiliary frequency output. For 100MHz units, even integer devisors of 50,000,000 are recommended. Remainders of the calculation 50,000,000/AUXFR are truncated. Enter $AUXFR=0 to disable output. If disabled, allow 10 seconds for an enabled output to restart. For 10MHz units, use even integer divisors of 70,000,000.
PPS PULSEWIDTH	$PULSW=<FLOAT>	$PULSW=<FLOAT>	Sets or returns the current PPS pulsewidth in ms.
			Range: 0.0001 to 500 [ms]
FREQUENCY TOLERANCE	$FQTOL	$FQTOL=0.01	Sets the frequency tolerance of the lock indication in Hz. (float)
RS232 BAUD RATE	$BAUDNV	$BAUDNV=<current Baud Rate>	Query Baud Rate on rear panel RS232. (Default = 115200)
	$BAUDNV=38400		Assign Baud rate to Rear Panel RS232 port. Default is 115200. Available baudrates are 9600, 19200, 38400, 57600, 115200.

7.2 Status Strings ($GPNVS)

See Appendix C $GPNVS String Definitions for detailed explanation of $GPNVS status strings

8.0 Mechanical



9.0 Performance

Technical Specifications

10 MHz sine	1.0 ±0.1 for 10 MHz. 0.5 ±Volts @ 100 MHz,50 Ohm - SMA	
Harmonics	Less than -30 dBc	
Locked stability (AD)	<~E-12 after 1000 seconds	
First year frequency stability	±100 ppb (long-term unlocked)	
Temperature stability	±100 ppb (unlocked)	
Yearly aging	±100ppb (unlocked)	
Phase Noise dBc/Hz		
10 MHz		
10 Hz	-120	
100 Hz	-130	
1 kHz	-140	
10 kHz	-150	
50 MHz		
10 Hz	-90	
100 Hz	-115	
1 kHz	-140	
10 kHz	-145	
100 MHz		
10 Hz	-80	
100 Hz	-110	
1 kHz	-140	
10 kHz	-145	
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	<5ns	
Connector	10 Pin 0.1" (Samtec IPL1-105-01-L-D-RA-K)	
Load Impedance	500 Ohm	
Location	Side Connector	
Remote interface & control		
Protocol	RS232 NMEA-0183: RMC,GSA,ZDA,GSV,NVS	
Connector	Side connector	
Location	side panel	
Protocol	Bit plus stop	
Standard Baud Rates	Selectable: 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	
Secondary Channel	Derived from 50 MHz master oscillator locked to 10 MHz. Sub 1 Hz to 25 MHz	
	Contact factory for valid synthesis values	
	Output impedance is 200 Ohm.	
Power	5 -0.1,+0.5 VDC Peak power < 3 watts, steady state < 2 watts	
Power connector	On ten pin connector	
Mounting	4 – M3.5x0.6 threaded mounting holes	
Chassis	Aluminum	

Environmental and Mechanical

Operating temperature	-20 to 50°C non-condensing (extended temperature range available)	
Storage temperature	-40 to 70°C	
Width	2”	
Depth	2” (exclusive of connectors)	
Height	0.9 (50,100 MHz 1.1) inches	
Weight	<3 oz	

10.0 LIMITED HARDWARE WARRANTY

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11.0 Appendix: GPS/GNSS Command Reference

See Attached.