NR300

Portable Battery Powered Rubidium Reference

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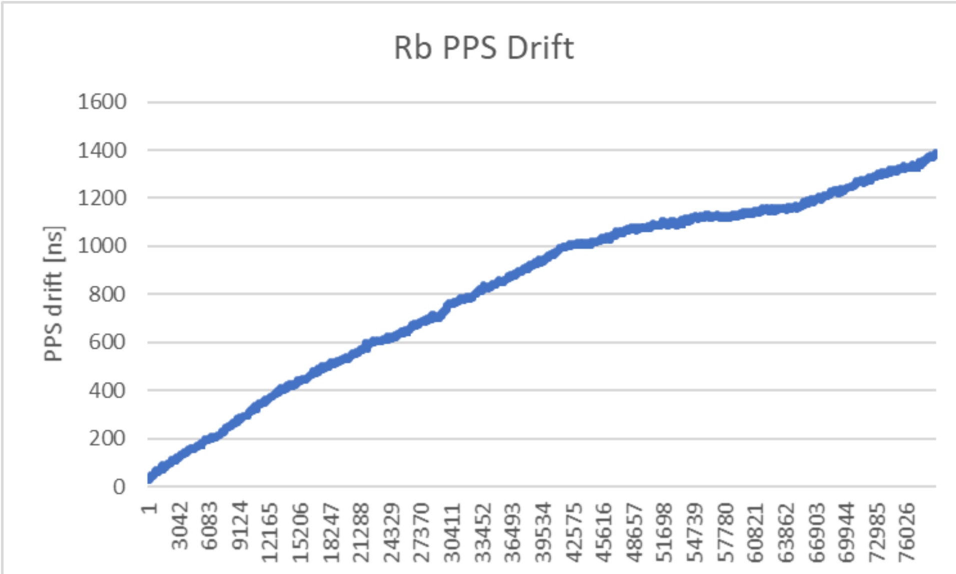
Overview

The NR300 is a sophisticated timing instrument that has a GNSS disciplined Rubidium source to provide 10 MHz frequency source with holdover of less <0.5 ppb for over six hours. The unit contains a 26-channel GNSS receiver and antenna to acquire navigation time to discipline the Rubidium. The unit is factory configurable to have three 10MHz sine outputs, IRIG-B, and PPS. Unit may also be used to capture timing events to within 1 usec.

The NR300 is a portable time source for GNSS and GNSS denied environments with the following capabilities:

- 10 MHz output locked to GNSS or atomic holdover.
- NMEA simulator that continues to provide NMEA data even after GNSS loss.
- PPS output that is GNSS derived with atomic holdover.
- Battery powered to provide > 5 hours field use.
- Optional IRIG-B output, modulated and unmodulated.
- Optional auxiliary output.
- Optional event input, with 1us timestamping.
- Built-in drift estimation and measurement.
- Rugged shock protected case.

When locked to the GNSS, the NR300 operates as a standard GNSS locked frequency reference and PPS source with an accuracy 20 nS. While locked to the GNSS, the Rubidium internal reference is continually being disciplined in frequency and its internal PPS is aligned to UTC PPS within <200 ns. If GNSS is lost, the unit uses the disciplined Rubidium as the master time reference. The PPS remains aligned to UTC PPS with a drift rate of <40µS/day (procedure allows for better drift performance).



Typical drift measurement of Rb PPS [s]

Time and position stamping are optionally available through the event function. A programmable rising/falling edge causes the current time and position to be recorded. This data is stored in non-volatile memory and can be read via the local display. The event data can also be downloaded as a file to be manipulated off-line. Events are captured and stored to a resolution of 100 ns.

Battery life is a function of configuration and use. The NR300, in its base configuration, can achieve well over five hours of battery life. The battery recharges in approximately six to eight hours. Charge status and battery remaining capacity indicated on the front panel. The battery is accessible and easily replaced through a removable panel.

Power is provided by either a power adapter (PA0003) or nominal 5Vdc. The PA0003 operates from 90 to 264 Vac and has a splash proof housing. When not in use, the power adapter can be stored in the carrying case storage compartment. The battery is being charged when power is present in the 5Vdc input port.

The NR300 case is an extruded aluminum case with impact protection. The timing platform is shock protected from the case with isolators.

Critical elements in the design are located on a shock/vibration isolated subassembly.

An active GNSS antenna is provided which is mounted to the top the unit (Antenna 2). It has a 17 dB LNA to provide gain in low signal environments. The antenna can be used for GNSS/Rb synchronization in open-air environments.

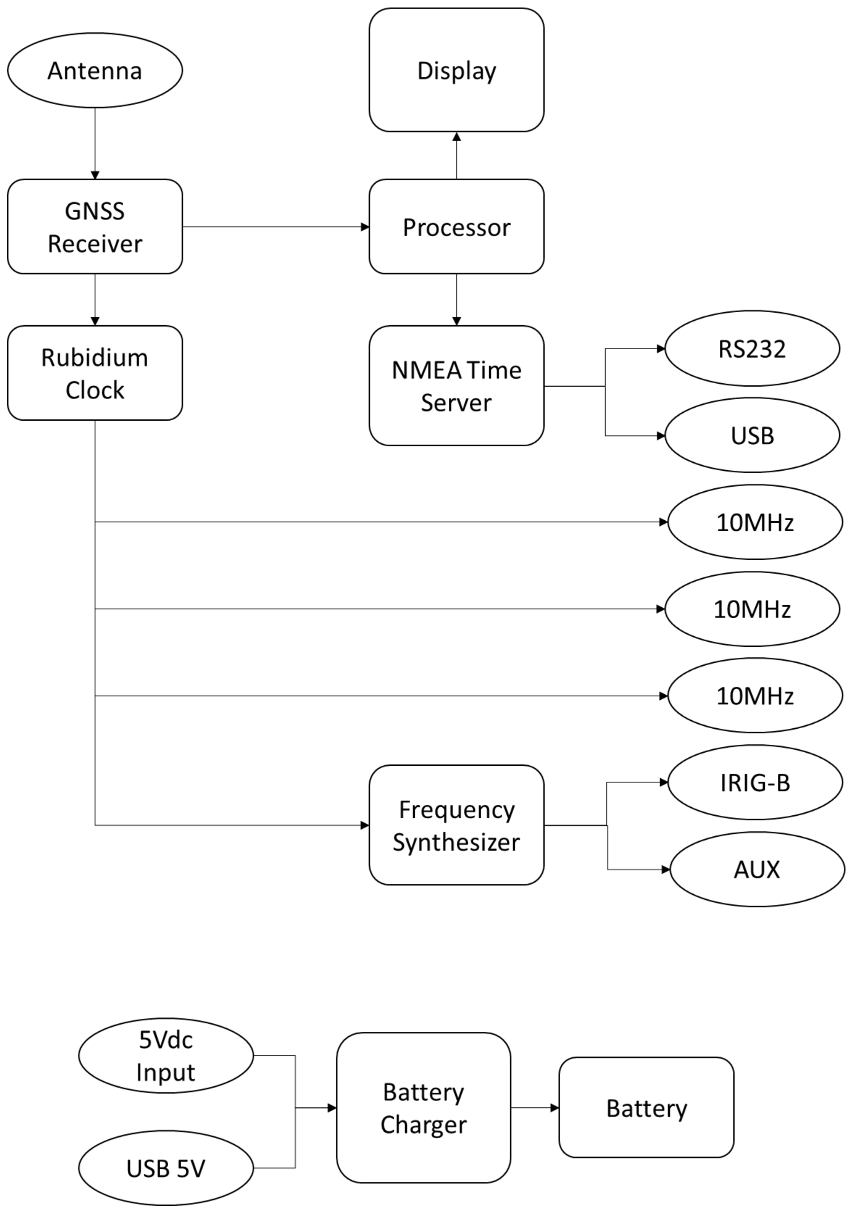
The antenna input to the GNSS can be easily switched to the external SMA antenna input (Antenna 1) and a different active antenna can be used. Antenna status is presented on the front panel screen “GNSS Status”.

To switch between antenna inputs, use the SELECT button on the GNSS STATUS screen or the USER SETTINGS screen. When the “ANT” field is highlighted, use the AUXILIARY button to change inputs.

The following output options are available:

- NMEA - RS232, RS485, 115200 Baud, or USB VCOM Port
- 10 MHz sine wave - BNC
- PPS - BNC 3.3 Volt CMOS
- Auxiliary Output - BNC (other frequencies) (Event-In)
- IRIG-B (modulated 1kHz or DCLS)
- Event Inputs (1): BNC

Key Functional Elements



GNSS Receiver

The receiver and companion elements generate the GNSS sine wave, PPS and NMEA serial link. The serial link conforms to NMEA 0183 protocol. The GNSS receiver leverages 12,288 correlators in the baseband processor for low signal acquisition and tracking. The unit comes with a GNSS antenna with a built- in 28 dB LNA. The local antenna may be detached, and an external antenna used.

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 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 2D 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 2D mode if it goes down to seeing only 3 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 2D 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.

Rubidium Clock

The Rubidium reference employs a coherent trapping (CPT) technique to interrogate an atomic frequency. A laser illuminates atoms in a resonant cell with polarized radiation. The laser excitation significantly reduced Rb power consumption compared to a conventional Rb source plasma cell. A microwave synthesizer provides the energy for the two sub-bands. Light passing through the resonant cell is modulated at resonance and the intensity of the light transmissibility is used to control the microwave frequency. Locked to the atomic frequency, the microwave frequency is the basis for the 10 MHz generated. The stability of the source is less than 1 ppb/year which is almost two orders of magnitude better than a typical OCXO. It is successfully used in applications where long-term stability is a necessity, but GNSS may not be accessible.

During GNSS lock, the Rb atomic clock output frequency of 10 MHz is synchronized to the GNSS PPS. The 10 MHz clock drives a counter to generate a PPS signal. That counter is initially synchronized to the GNSS PPS to within 200 ns. During the discipline period, the Rubidium generated PPS will then follow the GNSS PPS until “Discipline Good” status is achieved. During this discipline period, the Rubidium status will show “Discipline Wait” while the Rubidium source adjusts its frequency output.

Once the full synchronization and discipline has taken place, the PPS accuracy is dictated by the atomic clock.

Power

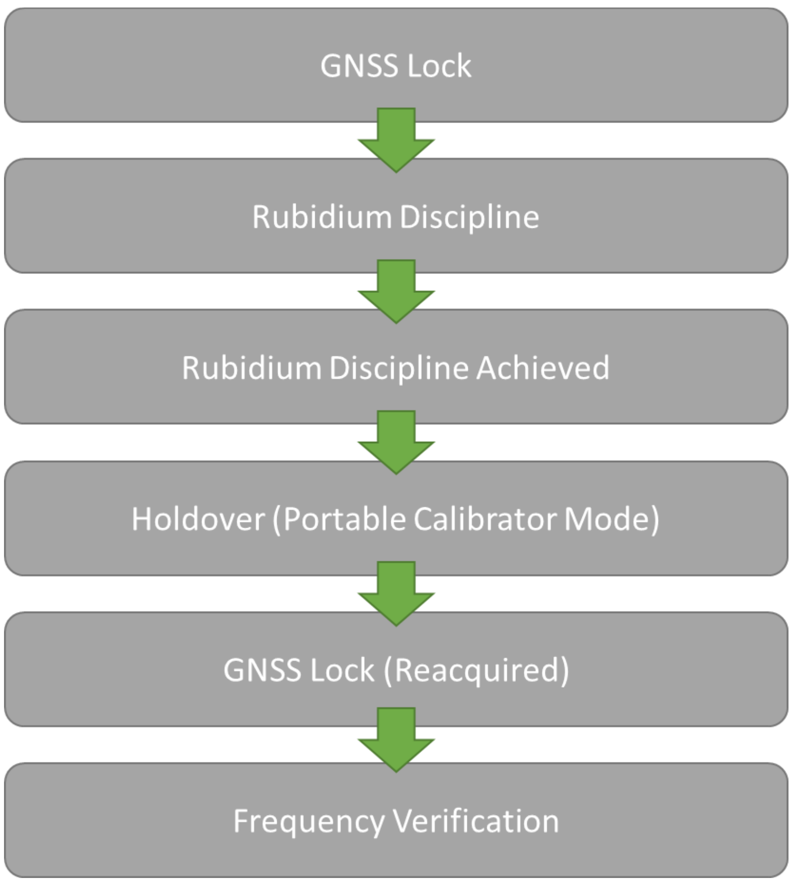
The primary battery pack is a two cell Lithium ion that can be easily replaced through an access panel.

The internal charger operates either from an external 5Vdc source (4.8 to 5.25Vdc) or a splash-proof charger that operates from 90 to 264Vac.

The charger is housed within the unit. The NR300 is fully functional during charging with the PA0003 adapter. A full charge takes approximately six to eight hours.

Operation

The NR300 is built to provide hours of accurate Rubidium holdover after a period of GNSS discipline. During this holdover period, the GNSS receiver can be powered off to reduce power consumption and extend battery life. This is done with HOLDOVER mode. During Holdover, the Rb module maintains frequency accuracy of ±0.5ppb/day, providing an ideal source for calibrating systems where a GPS signal is unavailable. After the NR300 has been used as a calibrator, the unit can be returned to an area where GNSS signal is available, and the GNSS can be restarted without disciplining the Rubidium. When the GNSS signal is reacquired, the Rb frequency can be measured, to verify the integrity of the Rb source.



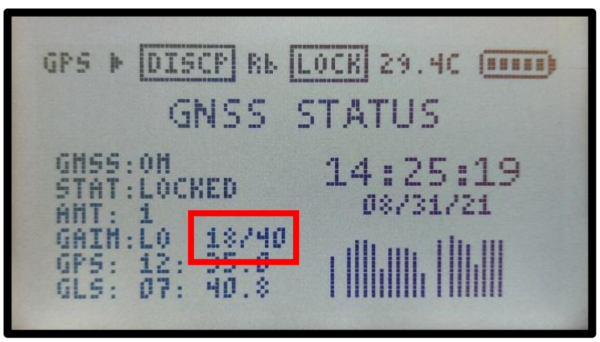
GNSS Lock

On power-up, the first menu “GNSS Status” provides information about the lock status of the GNSS receiver.

The right side of the display provides UTC time and date indication, as well as a bar graph showing relative signal-to-noise (SNR) values for each satellite in the GPS and GLONASS satellite constellations.

The left side of the display includes a tag for both GPS and GLONASS satellite count, as well as the average SNR of both groups.

Both of these indicator groups provide a quick reference for measuring the quality of the GNSS lock status. When GNSS lock is achieved, the LOCK LED indicator is solid green, and Rubidium discipline begins.



PPS Est. Accuracy vs Accuracy Threshold “18/40” [ns]

If the unit indicates “LOCKED”, but the PPS accuracy is not within range, the “STAT” indicator will flash “ACCY” to indicate the accuracy indicator is beyond the threshold. The PPS estimated accuracy is listed next to the GAIN indicator when the unit has GNSS lock. The first number is the GNSS estimate of PPS accuracy. The second number is threshold, over which the PPS will not be used for discipline or measurement. If the estimate is greater than the threshold, the GNSS antenna does not have adequate access to a view of the open sky.

Rubidium Discipline

During Rubidium discipline, the Rubidium module updates internal loop coefficients to provide optimal frequency tuning.

When the sample period extends long enough, the Rubidium reports discipline good.

Rubidium Discipline Achieved

The NR300 illuminates the READY LED indicator. The Rubidium module is now able to be used as a calibration source in holdover mode.

Holdover (Portable Calibrator)

At this point, the user can press the HOLDOVER button. After confirming with a long press of the button, the HOLDOVER LED indicator illuminates, and the unit suspends power to the GNSS receiver, reducing power consumption. The LOCK indicator shuts off, and the READY and HOLDOVER indicators are lit.

The unit can be taken away from the area where GNSS signal is available and used as a Rubidium source.

GNSS Lock (Reacquire)

When the NR300 has completed its calibration duties, the unit can be returned to an area where GNSS signal is available and reacquire GNSS lock. To do this, press and hold the HOLDOVER button. The screen prompts for confirmation, then indicates that GNSS power up has been started.
It is important at this point to ensure the unit has adequate GNSS signal to achieve lock. To verify, return to the GNSS Status menu.

Frequency Verification

Once the GNSS has reacquired lock, the user can navigate to the FREQUENCY screen by pressing the NEXT button. This screen reports the frequency of the source as measured against the GNSS PPS.

Functional Controls and Indicators

LED Indicators

Power

The “Power” LED indicator is illuminated green if the unit is active. If the unit is not active, the battery status indicators are still operational.

Lock

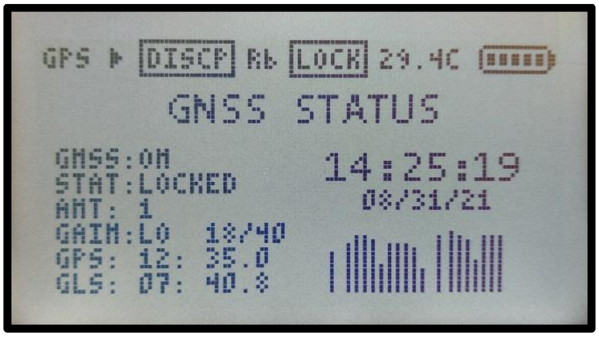
The “LOCK” indicator is a bi-color LED which provides a quick reference for the status of the GNSS lock. There are three LOCK conditions which are indicated as follows by varying green blinking:

When the GNSS is locked and is producing a disciplining PPS to the Rubidium oscillator, the “GNSS LOCK” indicator will be illuminated solid green. This indicates that the frequency of the Rubidium is within the threshold loop variance.

A single blink in a green GNSS “LOCK” illumination indicates that the GNSS is locked and is producing a disciplining pulse to the Rubidium, but the loop variance is outside the specified parameters, or the Rubidium is not locked. On startup, one blink indicates the GNSS receiver has acquired a sufficient number of satellites to generate the PPS pulse. Once acquired, timing can be maintained with a single satellite.

A double blink in a green “GNSS LOCK” illumination indicates that the GNSS receiver is not locked, does not have enough satellites for lock, or is tracking towards lock. The receiver is not producing a PPS to discipline the Rubidium, so there is insufficient information to determine health of the frequency loop.

The user should ensure that the unit has access to an open view of the sky, or the attached antenna has access to open sky.



The GNSS STATUS screen has immediate indication of satellite count, relative signal strength, and general GNSS lock status.

The Status Banner has indication of presence of PPS. "►" indicates a pulse is provided to the Rubidium from the GNSS.

Ready

The "Ready" indicator is illuminated if the GNSS has successfully completed discipline of the Rubidium oscillator. This happens when, after a period of time, the disciplined Rubidium reports "Discipline Good". The "Ready" indicator illuminates, and the status banner shows "DGOOD". The NR300 is now ready to enter HOLDOVER.

Holdover

Holdover is mode the unit needs to be in if the instrument is to be used in a GNSS denied environment. The unit will hold frequency accuracy for < 0.5 ppb. Actual holdover performance will be measured when the unit is returned to a GNSS environment. At this point, the unit will measure the actual drift of the NR300 against the now restored GNSS. If the actual drift exceeds the required performance, the unit may have been exposed to excessive shock and vibration or excessive temperature range. Restabilize the Rb by allowing the GNSS to relock the Rb. The Holdover LED provides a quick indicator that shows if the Rubidium source has successfully disciplined and is in holdover mode. The NR300 provides holdover mode to save power when GNSS lock is not available. To enter holdover mode, the unit will have successfully achieved GNSS lock, completed Rb discipline, and the READY indicator illuminated. If the battery is below 15% capacity - a warning will be shown that you are going into holdover with a low battery.

Battery

The battery is a 3-cell Lithium ion. It is designed to provide approximately five hours of service. To achieve maximum service, start with a charged battery (about six to eight hours of charge time). Be certain you have charged the battery sufficiently to perform the required holdover time.

Power Good

The “Power Good” indicator illuminates when the adapter input is in an acceptable range for the charger to provide charge to the battery and run the system power. If the “Power Good” LED indicator is not illuminated, the power input is either not present or not in the correct range for the battery charger to operate correctly. The input power is 5Vdc.

Battery Charge

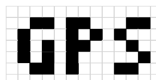
The “Battery Charge” indicator illuminates when the battery is being charged from the adapter input power. After a complete charge, the “Battery Charge” indicator will turn off.

Both the “Power Good” and “Battery Charge” indicators operate whether or not the unit is powered on.

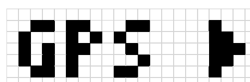
Status Banner/Notification Bar

GPS Lock Status and PPS

The status bar has a quick reference indicator for the GPS Lock and its PPS output. If the GPS is locked, the “GPS” indicator will remain on solid, without blinking. If the GPS is powered on, but is not locked, the “GPS” indicator will blink. If no GPS indicator is present, the GNSS receiver is inactive.

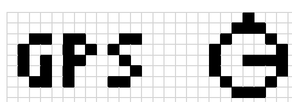


When the PPS is detected, the status bar will indicate that the PPS is currently being provided to the Rubidium for discipline by showing a flashing arrow that feeds the Rubidium Discipline State indicator.



If the flashing arrow is not present, no PPS is yet available to discipline the Rubidium. Consider moving the unit to get a better view of the sky.

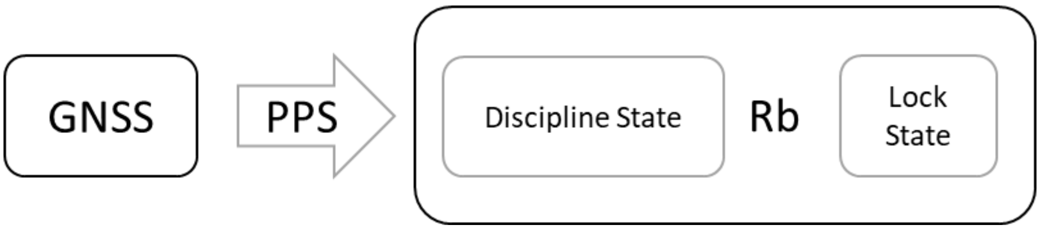
After the holdover period, and when the GNSS has been powered on again and GNSS lock has been achieved and the PPS is used to verify the Rubidium frequency (without discipline enabled), the GPS indicator will show a stopwatch icon to indicate that the PPS is timing the Rb.



In this mode, the PPS is compared to the Rubidium frequency and therefore is not provided to the Rubidium for discipline. The user can navigate to the FREQUENCY menu and verify the current frequency of the Rubidium source. If the actual drift exceeds the requirement, the ALARM screen may indicate excessive temperature and or excessive shock and vibration.

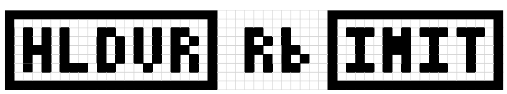
Rubidium Status – Lock State

The status bar provides a snapshot of the current Rubidium status, and its relationship to the GNSS PPS input.

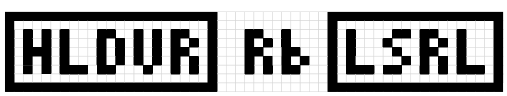


The status bar will report both Discipline State and Lock State as reported by the Rubidium module. The default status for the PPS input discipline is Holdover, until a valid PPS is detected. The Lock State will progress through stages.

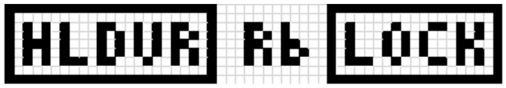
Upon power up, the Rubidium enters a heating and initialization period, during which the status bar reports "INIT" for the Rubidium Lock State. Until the Rubidium reaches Lock State, the border of the Lock State indicator will flash.



When the Rubidium has initialized, it will begin laser lock, and report "LSRL" on the status bar. The border around the Lock State will remain flashing.

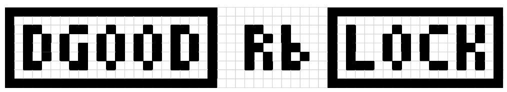


Within approximately fifteen minutes, the Rubidium module acquires lock, meaning the output frequency is now locked to the Rb package relative to its known tuning constants. The status bar Lock State is now "Lock" and the border no longer flashes.

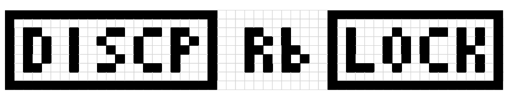


Rubidium Status – Discipline State

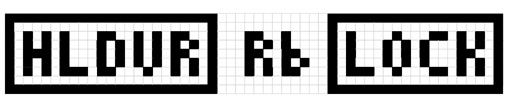
For reference, the Rb oscillator derives its frequency tuning algorithm constants from its reference to the GNSS PPS discipline. When the algorithm has sufficient averaging time from the available PPS, it indicates “DGOOD” for discipline good. At this point, the NR300 is ready to enter holdover mode.



Prior to discipline good, the Rubidium indicates “DISCP”, which indicates a valid PPS signal is present, and tuning is in process.

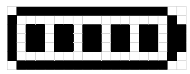


When no valid PPS is present, the Rubidium indicates that the unit is in holdover condition. The Rubidium considers holdover to be the default state any time a PPS reference is absent.



Fuel Gauge

The NR300 has an active fuel gauge, which reports state-of-charge, time remaining, etc. For quick reference, the status banner has a battery icon which reports the remaining battery status in 20% increments.



To see full status of the battery fuel gauge, including voltage, current, SOC, press the NEXT button until the menu reads BATTERY FUEL GAUGE.

NOTE: If battery is replaced, allow a complete charge/discharge/charge cycle to acquire accurate values.

Temperature

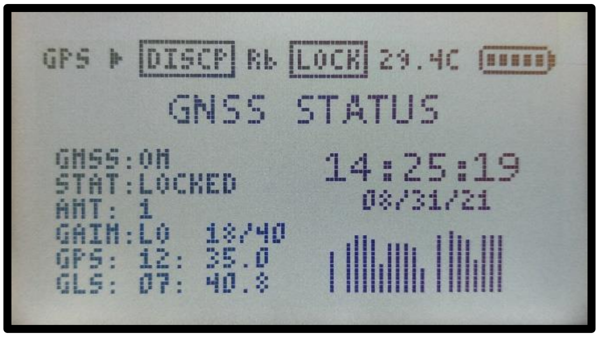
The NR300 has multiple internal temperature sensors. Included in the status bar is the indicator for general internal temperature. The units are C or F, selectable in the USER SETTINGS menu. During holdover, the temperature MIN/MAX values are updated to report total temperature variation and are shown on the ONBOARD SENSORS screen.

NR300 Display and Menu Navigation

NEXT and SELECT Buttons, LCD Menus

The LCD is used to provide detailed information regarding the status of the NR300. The NEXT and SELECT buttons are used for navigation of the LCD based menus and displays. Pressing the NEXT button will advance the display to the next screen or menu. The select button is used to navigate further options in each menu.

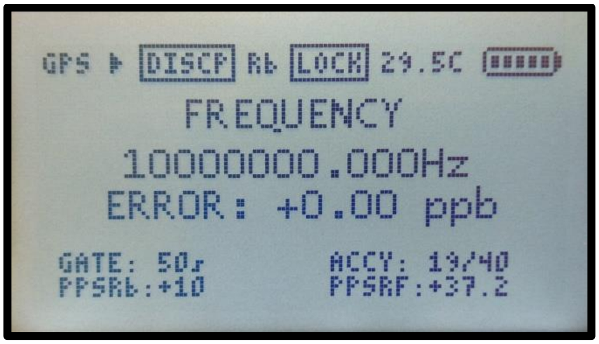
GNSS Status



Identifier	Values	Description
GNSS	ON/OFF	GNSS module is active (On), or inactive (Off) to reduce power consumption
STAT	LOCKED/UNLOCKED	GNSS has achieved lock, and provides reference PPS. If STAT is flashing "ACCY", the current PPS is not accurate enough to discipline the Rb or measure frequency.
ANT	1 / 2	Selects between antenna input 1 (chassis mounted) or antenna input 2 (external). To select, highlight this field by using the SELECT button, then press AUX to toggle value.
GAIN	HI / LO	Selects between high gain LNA or low gain. For active antenna, select low gain. For passive antenna, select high gain. To select, highlight this field by using the SELECT button, then press AUX to toggle value. When using the internal antenna the unit must be in the low gain setting.
ns	<nn/nn>	During GNSS lock, this is an estimate of the accuracy of the current GNSS provided PPS (in ns) versus the threshold required for PPS generation. This is the PPS used to discipline the Rb Pulse, excessive values (>threshold) indicate that the GNSS antenna should be moved to a better view of the sky.
GPS	Sat Count : Avg SNR	Displays number of satellites in view, and the average signal-to-noise ratio of the constellation.
GLS	Sat Count : Avg SNR	Displays number of satellites in view, and the average signal-to-noise ratio of the constellation.

TIME	UTC TIME	Displays UTC time reported by GNSS.
DATE	UTC DATE	Displays UTC date reported by GNSS.
SNR GRAPH		Graph shows SNR plot of individual GNS/GLS satellites normalized to 50.

Frequency



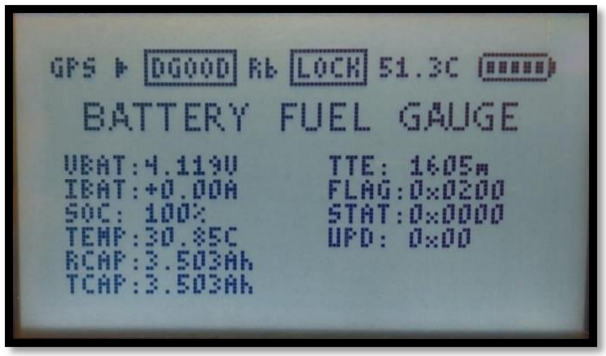
Identifier	Values	Description
FREQUENCY	Hz	Source frequency as measured relative to GNSS locked PPS. If the GNSS is not locked, the value will not appear, and the flashing Rb holdover indicator will appear.
ERROR	ppb	Calculation of frequency error in ppb relative to the GNSS PPS. If the GNSS is not locked, the value will not appear.
GATE	s	The sample period of the frequency counter, which expands up to 50 seconds as valid data is acquired.
PPSRB	ns	Difference between the GNSS PPS and Rb PPS as reported by the Rb module.
ACCY	ns/ns <estimate/threshold>	Estimate of current PPS accuracy provided by the GNSS receiver vs the current accuracy threshold needed to produce discipline and monitoring. High values (greater than the threshold) indicate the unit or the antenna should be moved to a better view of the sky.
PPSRF	ns	Difference between the GNSS PPS and Rb PPS

Rubidium Status

Identifier	Values	Description
STAT	Lock State	The Rubidium lock state as reported by the Rb module.
DISC	Disc State	The Rubidium discipline state as reported by the Rb module.
ALRT	Alert	Alert condition (if any) as reported by the Rb module.
MODE	Disc Mode (hex)	The current discipline mode as reported by the Rb module.
STATE	Holdover State	Holdover state machine counter value.
STATE	Holdover State	Holdover state machine counter description.

PHAS	Phase (ns)	The phase value reported by the Rb module.
STER	Steer	The steer value reported by the Rb module.

Battery Fuel Gauge

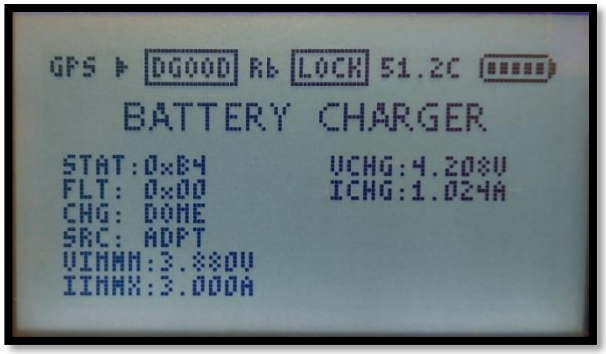


Identifier	Values	Description
VBAT	Vdc	Battery Voltage
IBAT	A	Current from battery (-) or charging battery (+)
SOC	%	Percentage of available battery capacity
TEMP	°C or F	Temperature as reported by Fuel Gauge
RCAP	Ah	Remaining battery capacity in Ah
TCAP	Ah	Total Battery capacity in Ah

TTE	minutes	Time to Empty in minutes
FLAG	hex	Reported values of Fuel Gauge Flag register
STAT	hex	Reported values of Fuel Gauge Status register
UPD	hex	Reported values of Fuel Gauge Update register

NOTE: If battery is replaced, allow a complete charge/discharge/charge cycle to acquire accurate values.

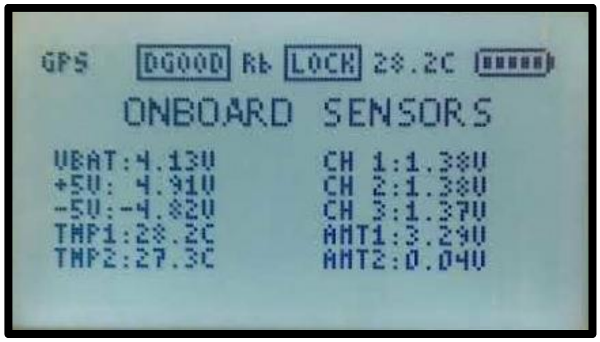
Battery Charger



Identifier	Values	Description
STAT	hex	Current Status register of battery charger circuit
FLT	hex	Current Fault register of battery charger circuit
CHG	Charge status	Status of charger PRE: Condition battery prior to fast charge FAST: Currently in Fast Charge Mode DONE: Charging complete NC: Not charging
SRC	Input Power	Input Power Source UNKN: Not known USB: USB input is current power source ADPT: Adapter Input is current power source
VINMNM	V	Minimum input voltage for charger operation
IINMX	A	Maximum input current allowed by charger

VCHG	V	Battery charge termination voltage
ICHG	A	Battery Fast Charge current

Onboard Sensors



Identifier	Values	Description
VBAT	V	Measured Battery voltage
+5V	V	Measured +5V analog supply
-5V	V	Measured -5V analog supply
TMP1	°C or F	Temperature sensor 1
TMP2	°C or F	Temperature sensor 2

CH1	Vrms	Output amplitude monitor channel 1
CH2	Vrms	Output amplitude monitor channel 2
CH3	Vrms	Output amplitude monitor channel 3
ANT1	V	Antenna 1 input active voltage measurement
ANT2	V	Antenna 2 input active voltage measurement

User Settings

To select a field, highlight the field by using the SELECT button, then press AUX to toggle value.

Identifier	Values	Description
BEEP	Off / On	Enable / disable audible beep on button press.
BKLT	s	Sets number of seconds backlight is illuminated when BACKLIGHT button is pressed (0 - 60 in 10s increments)
ANT	1 / 2	Selects between antenna input 1 (external) or antenna input 2 (chassis mounted).
GAIN	Hi / Lo	Selects between high gain LNA or low gain. For active antenna, select low gain. For passive antenna, select high gain. To select, highlight this field by using the SELECT button, then press AUX to toggle value.
SAVE FLASH		To save current settings to non-volatile memory, press the AUX button. Confirmation message will verify successful flash save.

Identifier **Values** **Description**

AUX	IRIG / AUX	Selects AUX output source. IRIG is IRIG-B unmodulated source. PWM is the auxiliary frequency output that is assigned by the user via serial port. Choose frequency output with $AUXFR command.
SER	RS232 / RS485	Selects DB9 serial connector I/O format. RS232 selects RS232 on pins 2,3. RS485 selects half duplex RS485 on pin 4 (RS485-A) and pin 7 (RS485-B).
TEMP	C / F	Selects temperature reporting format in Celsius or Fahrenheit.
OUT	SERIAL/USB	Select between serial (RS232/485) DB9 or USB VCOM data output.

Alerts

The ALERTS screen provides any Alarm indicators that the NR300 has detected.

To clear Alerts, press the AUXILIARY button.

Error	Description
HLDOVR EXPIRED	The valid holdover period has expired, and the unit should no longer be considered to be within specification. The unit should be disciplined to GNSS.
FREQUENCY DRIFT	The frequency reading is outside the 1ppb specification
EXCESSIVE TEMP	The unit has exceeded a temperature change of 20C while in holdover.
SHOCK COUNT	The unit has experienced moderate shock, as registered by the accelerometer. The number of hit counts is displayed.
BRD SENSOR FAIL	An internal sensor or component is providing an invalid response.
RUBIDIUM ALARM	The Rb module has reported an alarm state.
COMM ERROR	The unit has an internal communication failure.

Accelerometer

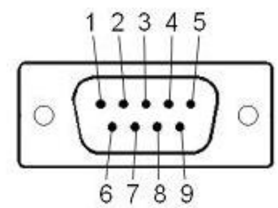
The ACCELEROMETER screen provides current readings of the NR300 orientation, and count of Shock and Freefall alerts.

Identifier	Values	Description
STAT(US)	0xFF	Accelerometer status register reading.
FRFL	<n>	Current count of freefall threshold alerts.
SHOX	<n>	Current count of Shock or hit threshold alerts.
SRC	0xFF	Contents of SRC register

X	+/-n.nn	Current acceleration reading in X coordinate (g)
Y	+/-n.nn	Current acceleration reading in Y coordinate (g)
Z	+/-n.nn	Current acceleration reading in Z coordinate (g)

When the NR300 is in an inverted position, an audible chirp is provided to alert the user that the unit needs to be flipped over while in use.

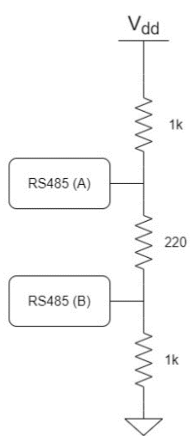
DB9 – RS232/RS485



Male DB-9

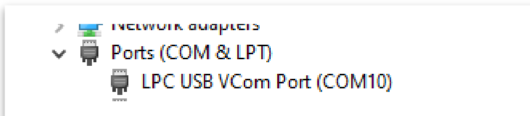
Pin	Function	I/O
1	Optional PPS	O
2	NMEA port / Command Port TX	O
3	NMEA Port / Command Port RX	I
4	RS485 (A)	I/O
5	GND	
6	NC	
7	RS485 (B)	I/O
8	NC	
9	NC	

The RS485 outputs are internally terminated in the following manner, with Vdd typically 5V.



USB Port (Mini B)

The USB port provides a Virtual COM port interface for command-and-control functions, status queries, and monitoring. The I/O functions and commands are the same as those entered on the RS232 serial port but are provided via USB.



When the USB port is connected to a PC, the device will enumerate as a Virtual Com Port. After enumeration, standard serial commands can be entered via a terminal program or script.

USB Power

A standard USB interface is not adequate to power the NR300, and therefore the NR300 will not draw in excess of 500mA when connected via the USB port. However, if the battery is depleted and the unit is not running, charging can take place via USB at 500mA charge.

To operate the unit while simultaneously charging the battery at the full 1A charge rate, plug in the provided 5V adapter.

Frequency Reference Output

Standard is a 10 MHz sine wave output that is locked to the atomic clock. It is a low noise 50 Ohm output (0.5 volts rms). There is an auxiliary port to support optional frequency outputs and other features.

Typical Phase Noise Performance

Offset Frequency (Hz)	Typical (dBc/Hz)	Low Noise Option Typical (dBc/Hz)
10	-68	-115
100	-110	-140
1K	-125	-155
10K	-140	-155

PPS

3.3Vdc CMOS logic output. Rubidium derived PPS.

IRIG-B Output

The unit features two ports for GPS locked IRIG-B output on BNC connections. One port is IRIG-B-0xx (DCLS), and one port is IRIG-B-1xx (Sine). The default setting of both IRIG-B ports is IEEE 1344 with straight binary seconds (SBS). The configuration of the IRIG-B output can be changed by using the $IMOD command over the RS-232 port. The IRIG format can be with or without year, SBS, or IEEE1344 bits enabled.

The following modes are available:

$IMOD	IRIG CODES		Year	SBS	IEEE 1344
	DCLS	Sine			
0	002	122			
1	006	126	✓		
2	003	123		✓	
3	007	127	✓	✓	
4	IEEE		✓		✓
5	IEEE w/SBS		✓	✓	✓

The IRIG-B output is affected by the UTC Offset setting and will report the offset in positions 64-68 of the 100-bit IRIG-B frame according to the IEEE 1344 format.

AUX

The AUX I/O is used as a port for a variety of functions:

Event - If the option for an event input is enabled, the AUX input activates an event time/position stamp. 3.3Vdc CMOS. Event is a rising/falling edge, as determined by edge direction command.

PWM Frequency Output - the NR300 has the capability of generating a variety of frequencies, programmable by $AUXFR command.

IRIG-B Unmodulated - Provides an unmodulated pulse output that conforms to the IEEE 1344 standard. The IRIG output is synchronized to the Rb PPS, such that GPS lock and holdover are consistent across the IRIG outputs. The synchronization of the IRIG-B DCLS to the Rb pulse is <1us.

Output of AUX BNC is selectable between IRIG-B or PWM output on the USER SETTINGS menu.

For event input, the function of the AUX must be configured at the factory.

IRIG-B Sine

The IRIG-B Sine output provides a 1kHz modulated sine output that conforms to the IEEE 1344 standard. The IRIG output is synchronized to the Rb PPS, such that GPS lock and holdover are consistent across the IRIG outputs.

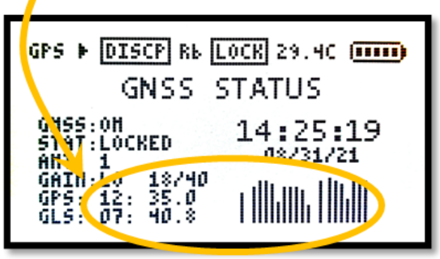
Quick Start Guide

1 Place NR300 in an area where GNSS signal is available, either by onboard antenna in open sky conditions, or by external antenna connected to the “ANT” input.

2 Press ON/OFF to turn on.

3 Allow unit to acquire GNSS lock. LOCK LED should be solid green.

4 Verify LOCK quality on GNSS STATUS screen. If lock quality is poor, move to an open sky location, or use external magmount antenna.



5 Rb Status shows “DISCP” Wait for Rb Status to reach “DGOOD”. READY LED will illuminate.

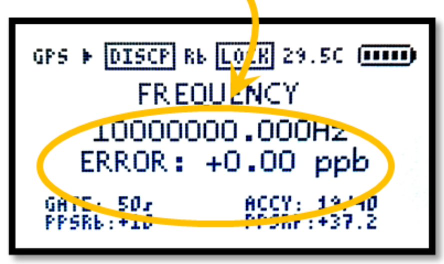
6 When READY LED is illuminated, press the HOLDOVER button, and confirm with long press. HOLDOVER LED should be illuminated.

7 You are now ready to use the NR300 for calibrating equipment in a GNSS denied environment.

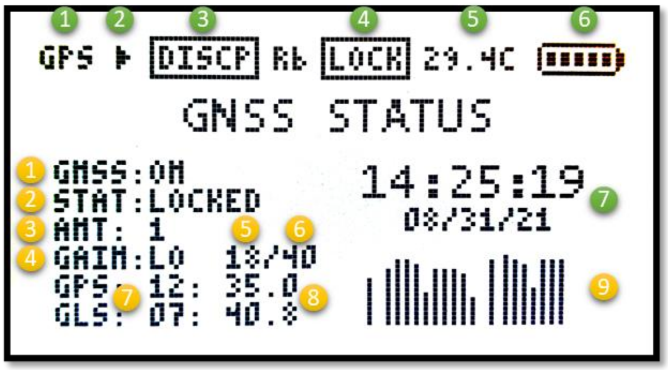
8 When you are finished using the NR300 as a reference, return to an area where GNSS signal is available.

9 Restart GNSS receiver. To do this, press HOLDOVER, then confirm, to restart GNSS. Wait for GNSS Lock.

10 Navigate to FREQUENCY screen to verify Rb frequency has not drifted beyond specifications. (Allow gate period to reach 50 seconds)

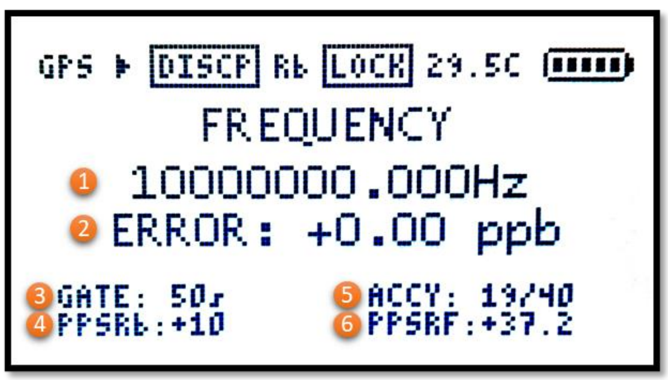


NR300 Quick Start Guide



1. GNSS Status (No Blink = Locked)
2. PPS present to discipline Rb ▶
3. Rb Discipline Status
4. Rb Internal Module Status
5. Internal Operating Temperature
6. Battery Status
7. UTC Time and Date

1. GNSS Power: ON/OFF
2. GNSS Stutus: Locked, Unlocked, ACCY
3. Active Antenna: 1) External 2) Chassis Mount
4. LNA Gain: LO/HI (LO for active antenna)
5. Estimated PPS Accuracy from GNSS [ns]
6. PPS Accuracy threshold for use in discipline
7. Number of Satellites in view (GPS, GLONASS)
8. Average SNR of satellites in view
9. Satellite Strength Graph



1. Output Frequency
2. Output Frequency Error (in ppb)
3. Gate Period (Samples in Frequency Measurement)
4. Rb PPS Difference from Rb Discipline input
5. GPS PPS estimated error / PPS allowed error [ns]
6. Measured PPS Difference from GPS [ns]

Programming Guide (RS232 Port)

The NR300 can accept user commands which will provide specific status and performance feedback, and which may be customized by the user. Many of the settings can be saved in non-volatile flash memory.

Commands that are handled by the GNSS receiver are passed through to the GNSS, and the responses returned. This allows the user to make all adjustments to the unit via a single serial port.

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

Table 1 shows a complete list of input commands and descriptions that are handled by the internal processor. In general, a command may be input without “=” or an additional value, and the unit will respond with the current settings 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 for 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

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.
	$STAT3	<$GPNVS,3….>	Outputs current $GPNVS,3 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=1	$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.
ID	$IDN?	$IDN	Returns PCB and SW version information
PPS OUTPUT SELECTION	$PPS	$PPS=0	Select PPS output between the GPS PPS or the OCXO derived low-jitter synthesized PPS. Default is the OCXO PPS.
			1 = GPS PPS
			0 = OCXO PPS
WARM UP PERIOD	$WUP	$WUP=600	Set warm up period for OCXO tuning in seconds. Must be > 360.
FORCE PPS DISCIPLINE	$DSC	$DSC=1	Enable PPS discipline to align the synthesized PPS to the GPS PPS within 50ns. The synthesized PPS will remain available even with loss of GPS lock. If PPS stabilization is enabled, the output will remain as the OCXO derived PPS.
(PPS STABILIZATION OFF)			1 = Enable discipline of synthesized PPS
			2 = Disable discipline
$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	

$GPNVS	$PERDCFG,NMEAOUT		Same function as $NVS but uses format of GPS Appendix A. Must include checksum. Example: $PERDCFG,NMEAOUT,NVS,9,1*4B sets $GPNVS,9 to output at a 1 second frequency. For format usage, see Appendix A.
AUXILIARY FREQUENCY OUTPUT	$AUXFR=<INTEGER>	$AUXFR=<INTEGER>	Sets the auxiliary frequency output. Even integer devisors of 200,000,000 are recommended. Remainders of the calculation 200,000,000/AUXFR are truncated. Enter $AUXFR=0 to disable output. If disabled, allow 10 seconds for an enabled output to restart.
PPS PULSEWIDTH	$PULSW=<INTEGER>	$PULSW=<INTEGER>	Sets or returns the current PPS pulsewidth in ms. Range: 1 to 500 [ms]
RETRIEVE EVENT LIST	$EVENT<nnn>	$E,nnn,…	Request event record, starting at nnn. Outputs the next 10 events after nnn with timestamp. (Range: 0 to 512)
EVENT TRIGGER HOLDOFF PERIOD	$HLDFF=1000	$HLDFF=1000	Set/Query holdoff period for Event triggering in microseconds. If an event is triggered, the holdoff period will elapse before another event can be recorded. (Range: 1 to 2000000) [us]
CLEAR EVENT HISTORY	$CLREV	$EVENTS_CLEARED	Clears all events from RAM, and starts event record at Event 1.
ENABLE EVENTS	$ENEV=1	$ENEV=1	Enable / Disable triggering of events and event functionality. The unit will determine if events are ready to be triggered based on GPS lock, leap second, etc., but the user can use this as a global disable function. 0 = Disable 1 = Enable
TRIGGER MODE RISING/FALLING EDGE	$EDGE=1	$EV_EDGE_DIR=1	Set trigger to be rising edge (1) or falling edge (0). If falling edge is enabled, the input will be pulled to 3.3V through a 100k resistor. If rising edge is enabled, the event input will be pulled down with a 100k resistor. 0 = Falling edge (3.3V 100k pullup) 1 = Rising edge (0V 100k pulldown)
TEMPERATURE ALERT THRESHOLD	$TMPAL	$TMPAL=25.0	Set or query the temperature differential (in C) which will trigger a Temperature Alert during holdover.
FREQUENCY ALERT THRESHOLD	$FRQAL	$FRQAL=1.0	Set or query the frequency error (in ppb) which will trigger a Frequency Error alert. This is used after holdover, when the GNSS lock has been reacquired.

Accessories

Antenna

Included with the device is a GNSS antenna on a 3-meter cable. It includes a 28 dB LNA to assure GNSS acquisition even in weak signal environments. The antenna LNA is powered over the antenna cable with 3.3Vdc. The power level is limited to 45 mA.

The antenna can be easily removed and an alternate antenna used or the unit can be connected to an in-house GNSS signal source. If an alternate antenna is used and lock cannot be achieved, confirm that the antenna operates from 3.3Vdc or consider using a DC blocking connector.

Power

External power is provided by the included power adapter which can operate from 90 to 264Vac 50/60 Hz. (3 Amps, 5Vdc). When connected to an external power source, the charger will activate if the battery requires charging. A full charge cycle is about six hours. The unit will operate while charging.

Power is provided by a commercially available Lithium ion 7.2Ah rechargeable battery which is unmodified and can be replaced with an OTS battery. Battery vendor and part number: Ultralife UBBL07.

Depending on how the device is used, temperature, battery age, battery life will vary with the mode and user operating methods. User variability is a function of the functions used, time allowed for synchronization, etc. Approximately five hours battery life is typical.

The battery pack has a built-in "fuel-gauge" indicating the battery status.
The battery is stored inside the unit and easily accessed, disconnected and removed.

If the battery is disconnected for replacement, a full charge/discharge/charge cycle is needed before an accurate battery measurement is displayed.

Technical Specifications

Output	(3) 10 MHz,0.5 Vrms (optional 1Vrms) ±0.2, into 50 Ohms BNC (sine or square)
Rubidium	
Warm-up time	<15 minutes
Time of lock	<5 minutes -130 dBm
Time to achieve accuracy	<2E-9<15 minutes, (12 minutes)
GPS disciplining	GNSS receiver
Time for valid output	<12 minutes
Temperature stability	±0.4 ppb over the operating range
Aging	±1 ppb/year 0.05 ppb/day
Holdover accuracy	<0.2 ppb/4 hours unlocked after discipling
Frequency accuracy	<1E-10 (locked)
Stability: Allan Deviation	
1s	<3E-10
10s	<1E-10
100s	<3E-11
SSB phase noise for 10MHz	
	Standard Low Noise
10Hz	<-85dBc < -115
100Hz	<-110dBc < -140
1000Hz	<-130dBc < -155
10000Hz	<-140dBc < -155
Amplitude for 10MHz frequency output	0.5 Vrms (optional 1Vrms)
G sensitivity	<0.2 ppb/g
Temperature Stability	<0.5 ppb -10 to 60°C
PPS	
Amplitude for 1PPS	3.3 Vdc CMOS
Pulse width for 1PPS	Programmable 1 to 500ms in 1 ms steps
Rise time for 1PPS	< 5 ns (faster edge available)
Unlocked drift	< 20 usec/day
Connector	BNC
Load Impedance	50 Ohm
Location	rear
Remote interface & control	
Protocol	RS232/RS485 NMEA-0183
Connector	DB-9
Location	Rear panel
Protocol	Bit plus stop
Standard Baud Rates	Selectable 9600, 19200, 38400, 57600 or 115200 bps

IRIG-B-0,2	DCLF and 1 kHz Sine	
USB port	NMEA plus status and control	
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)	
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	Internal patch antenna or external antenna with LNA	
Antenna power	3.5 Vdc, < 35 mA (on center conductor)	
Frequency	1574-1607 MHz	
Nominal gain	2 dBic	
Amplifier gain	26 dB	
Noise figure	< 2.0 dB	
Out-of-Band rejection	F_o±50MHz = 60 dBc, F_o±60 MHz	
DC current	<25 mA@3.3 Vdc	
Battery Life	> 4 hours, battery charger included- Lithium ion, Time to charge	
Environmental		
Operating temperature	-10 to 50°C	
Height	3.2 inches	
Depth	8.25 inches exclusive of connectors	
Width	3.2 inches exclusive of connectors	
Weight	~1 lbs.	

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