User Manual **Model NR2316-OG**

16 Channel GPS Locked OCXO Frequency Reference

Contents

1.0 Summary

The NR2316 is a 16 Channel precision GNSS/GPS locked 10MHz frequency reference. The amplifier is a low phase noise design to preserve the integrity of the reference signal. All outputs are transient and fault protected.

The unit features auto-calibration, which ensures the most recent OCXO compensation coefficients are stored in non-volatile memory. The compensation values eliminate drift due to aging and/or temperature, and are stored and applied to the OCXO during loss of GPS lock conditions. These coefficients are updated after eight hours of continuous GPS locked state. This effectively eliminates long-term OCXO changes.

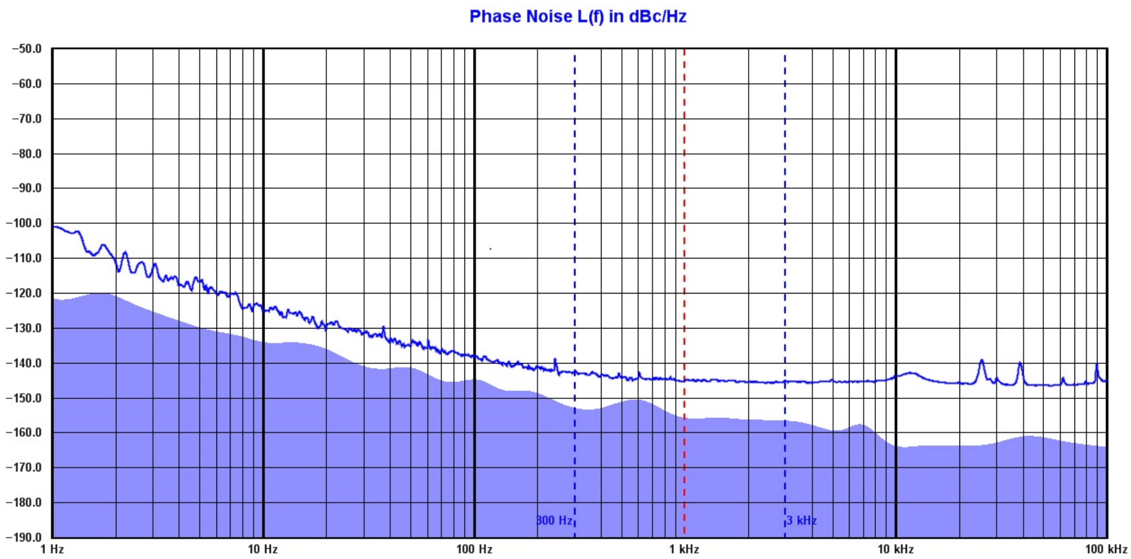
Excellent aging characteristics are achieved through the use of intrinsically low jitter overtone SC cut crystals in a temperature controlled oven. There are ten outputs on the rear panel (BNC) connectors. Low phase noise is achieved by the inherent crystal characteristics and appropriate design techniques for noise mitigation.

Units can be customized to any number of channels, can be changed to PPS output, or can be mixed to be 8 sine + 8 PPS outputs, etc.

Typical Phase Noise performance:

Offset Frequency, Typical	
Offset (Hz)	Standard (dBc/Hz)
10	-110
100	-135
1k	-145

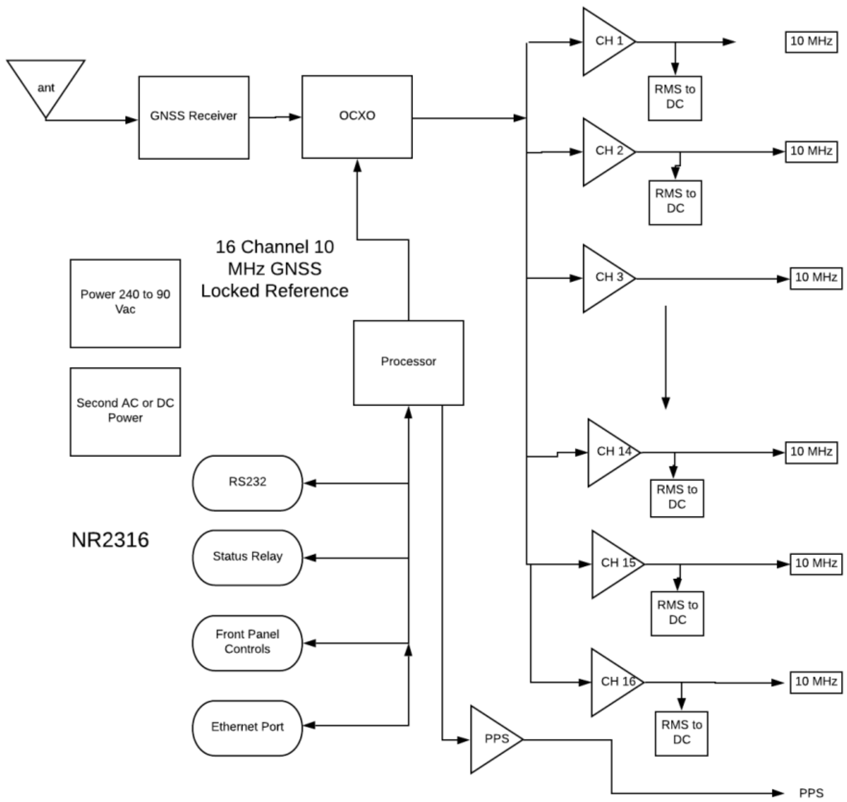
The NR2316-OG delivers a low phase noise curve, which can be seen in the sample production test below.



Trace	Notes	Input Freq	Sample Interval	dBc/Hz at 1 kHz	RMS Jitter	Acquired
NR2310-) 48130396 (Unsaved)		10.000 MHz	0.010 s	−144.8	6.6E−14 s	18000 pts

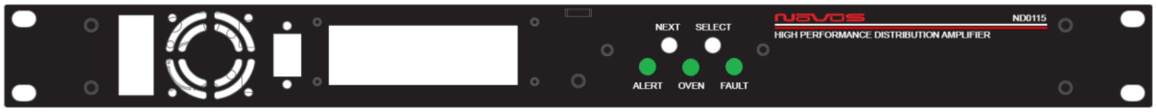
NR2316-OG Phase Noise Measurement

The unit features extensive reporting via the rear panel RS232 port. Equipment status, output voltage on each channel. By being able to monitor the output voltage, the user can detect cabling issues that cause an impedance change and replace cabling before it completely fails. Reporting is also easily accessible via the front panel display.



Nominal power is global AC power, but a DC power option can be ordered that acts as the back-up power supply. Nominally 24 vdc, this port is used for power when AC power fails. Switching between power sources is automatic and there is no transient power outage at the equipment level. The primary power supply is followed by low noise linear converters assemblies.

2.0 Controls and Indicators – Front Panel



This section describes the functionality of the front panel controls and indicators. Two buttons above the status LEDs provide navigation through the menus.

In general, the NEXT button advances through the menus to the next screen, while the SELECT button chooses between the available values on a menu.

Menus that allow selectable adjustments are the Input Threshold, Alert Threshold, and the Attenuation setting. To adjust these values from the front panel, hold down both buttons for two seconds, until the value begins to flash. To leave the menu with the new value, hold down both buttons until the value is solid.

2.1 GNSS Status

On power up, the NR2316-OG will display the Time and Date as well as the current status of both GNSS receivers.

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.

2.2 GNSS Detailed Status

The GNSS Status Menu gives the user a quick reference for the quality of the GNSS satellite signal and length of time that each receiver has been locked.

To toggle between each receiver, press the SELECT button. The screen will display which receiver status is being viewed.

The user can then see number of GPS satellites in view, number of GLONASS satellites in view, and the UTC time and date that lock occurred on the selected receiver.

2.3 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 ±55% 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. Channel Statuses can be cycled into view or can remain on a single channel. This feature can be accessed via the NEXT button, by advancing to the Channel Status screen. To cycle through channels in sequence, press the SELECT button.

2.4 Status LEDs

There are three status LEDs which provide a quick indication of valid unit operation.

Alert LED: The Alert LED will illuminate flashing red to indicate A GNSS failure or a power supply failure. The Alert LED will ***not*** flash RED if any valid input signal is present.

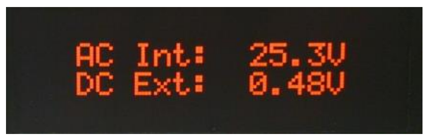
Oven LED (OCXO option only): The Oven LED will illuminate red to indicate an Oven Failure.

Oven LED (Onboard GPS): The Oven LED will illuminate steady green if all onboard GPS/GNSS units are locked. The LED will flash green if at least one unit is unlocked.

Fault LED: The Fault LED will illuminate flashing red to indicate a Channel Fault, when any single channel is outside the user defined threshold.

2.5 Power Supply Status

The Power Supply Status screen provides DC voltage values of the two available power supply sources. The 90-250V AC input is internally connected to an internal 12V/24V AC-DC convertor which powers the internal supplies with 12V/24V. This is diode connected with the external 12/V24V DC input, which can be used in addition to, or in place of, the AC input. The external DC input can be ordered to accommodate a variety of DC input levels. Contact Novus for options.



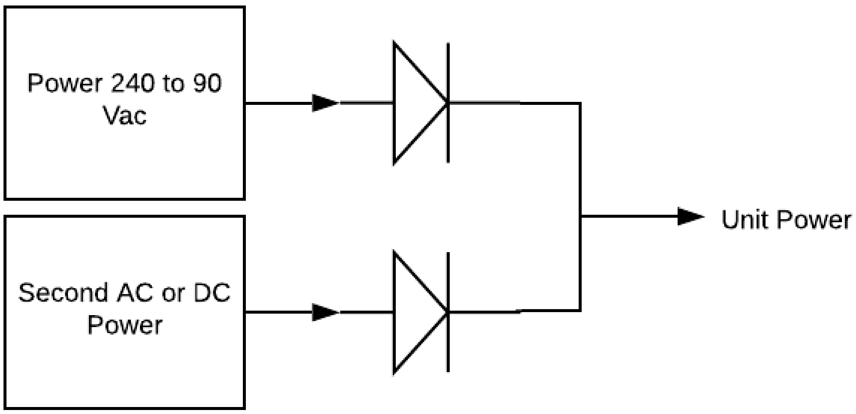
The values of both DC supplies are measured internally to validate connections. The measured values of the AC/DC convertor and the DC input are reported in the third and fourth fields of the second $GPNVS status string.

For details on the status strings, see Programmer's Guide.

In addition to direct value measurements, each redundant system has a Power Supply Status byte which is reported in the third $GPNVS status string, in the seventh and eighth fields respectively.

Any measurement of the power supply which results in an alert condition will be reported in the power supply status byte.

0x80 = External AC not connected.
0x40 = External DC not connected (if option is included).



Redundant power supplies operate on either the AC input or DC input, and function independently.

If a communications failure is reported, the backup system will automatically switch to the redundant system.

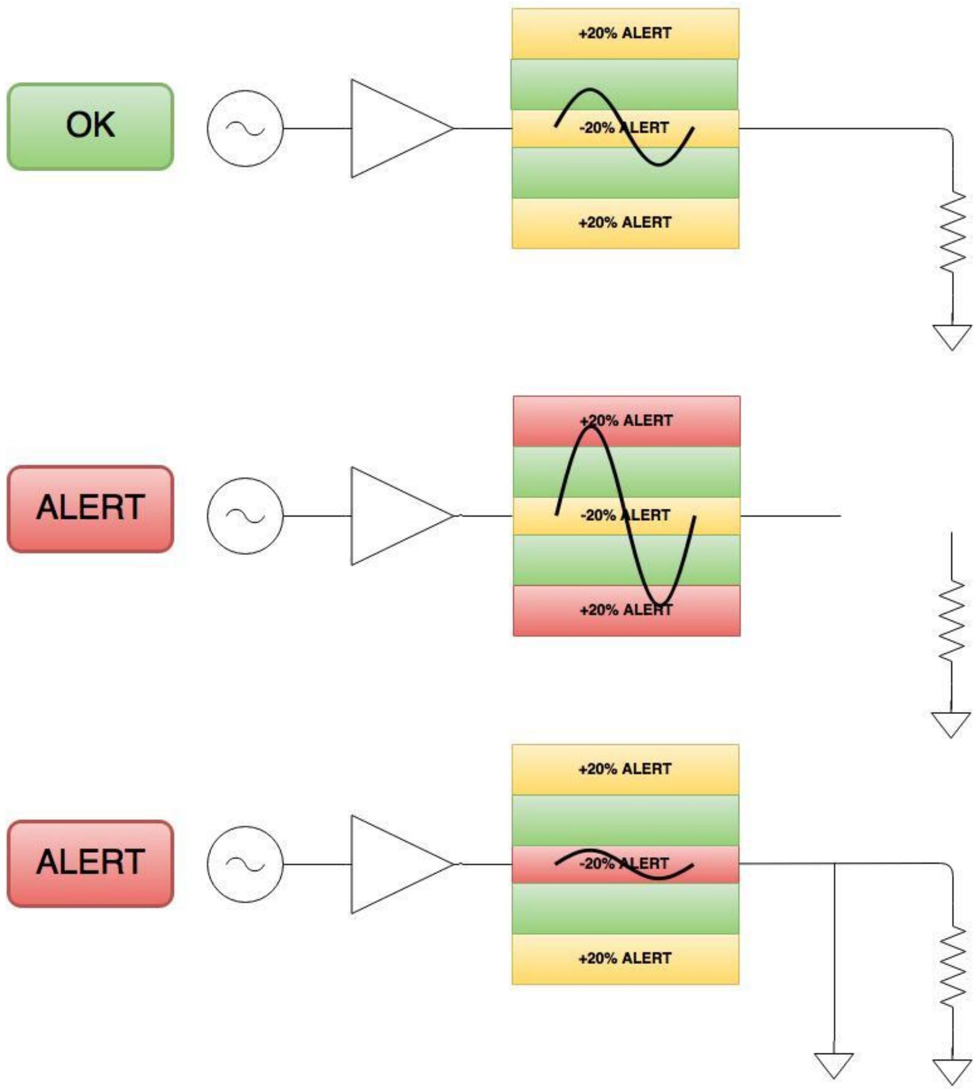
2.6 Alert Threshold

The Alert Threshold screen allows the user to adjust the tolerance from the Reference Voltage which, if exceeded in either direction, the output channels will report a fault status. The default threshold value is set at ±55% percent from the current state of the amplifier, and is user programmable in 5% increments, from ±10% to ±60%.

Each channel has a Reference Voltage which can be set, all at once, by latching the channels' current value in the Latch Channel Average Screen. Each channel's 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 channels 1 through 16.
2. Set Alert Threshold to desired range.
3. Save current channel voltages 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. The output of channel 2 is connected to a 50ohm terminated input, and reports 0.90Vrms 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*

The Channel 2 Alert will report when:
- *The Channel 2 output is higher than 1.08Vrms*
- *The Channel 2 output is lower than 0.72Vrms*

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.

2.7 Latch Channel Values

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

A channel Alert is triggered when a 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.

2.8 PPS Status

The PPS from the active GPS is monitored to verify output is active. The PPS output can be disabled or enabled, as well as set to AUTO, which disables the PPS during a user defined Warm Up period and after a user defined Hold Over period has been exceeded.

The $PWH (PPS Warmup/Holdover) setting can be changed via the serial port to one of the three available settings:

$PWH=0	Off: PPS is disabled regardless of Warmup/Holdover status.
$PWH=1	Auto: Disabled during Warmup, Disabled after Holdover is exceeded. (Enabled after warmup, during valid holdover)
$PWH=2	On: PPS is enabled regardless of Warmup/Holdover status.

Each GPS/GNSS may be addressed separately, and the settings can be viewed on the PPS Enable/Disable screen.

The GPS settings will be displayed for each GPS receiver, whether AUTO PPS, ENABLD PPS, or DISABLD PPS. If the option of a second GPS was not ordered, N/A will be indicated.

The PPS measurement will indicate ACTIVE PPS if the output measures a PPS present. If the PPS is not present due to the Warmup Period not having been completed, while in AUTO PPS mode, the screen will indicate WARMUP WAIT.

If the GPS has remained unlocked for a period which exceeds the user defined Holdover Period, the PPS status will indicate HLDOVR ERR.

Status of the Warmup and Holdover counters can also be monitored from the $GPNVS string 11, which includes Warmup Complete and Holdover Valid fields, as well as frequency valid fields.

If a dual GPS/GNSS option is installed, the currently selected GPS PPS will be noted with an arrow. This arrow indicates the actual source of the PPS. In addition, the Active GPS will be noted with an arrow as well. The arrow will indicate switching to backup in the case of failure of the primary, or loss of lock, as set in GPS Select setting.

2.9 GPS Select

The GPS Select screen is present on the NR2316 option with dual GPS/GNSS receivers. This screen allows the user to specify which GPS Source is the primary output source for the PPS and 10MHz outputs.

There are four settings, and these are the same as the serial command $GPS:

Setting	Description	Serial Command
GPS 1	GPS 1 is used as output regardless of lock status or error	$GPS=0
GPS 2	GPS 2 is used as output regardless of lock status or error	$GPS=1
AUTO (1)	GPS 1 is default, if locked and no errors, else GPS 2 is used	$GPS=2
AUTO (2)	GPS 2 is default, if locked and no errors, else GPS 1 is used	$GPS=3

To cycle through the selections, use the SELECT button. To save, go to the Save Configuration Screen, or use the serial $SAVEFLASH command. The default setting is Auto (1).

The GPS Select setting also determines the output of the GPS/GNSS specific strings to the serial RS232 and the SNMP GPS specific settings. The strings that follow the specified GPS are the RMC, GNS, GSA, GSV, ZDA, and NVS (strings 7 through 11).

2.10 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.

2.11 Fault Status

The Fault Status screen allows a quick overview of any Channel faults from the front panel. The total fault count is listed, as well as a visual flashing indication of any channels that are beyond the threshold values.

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 (24V, +8V, -8V, 5V) 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.

2.12 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.

2.13 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.

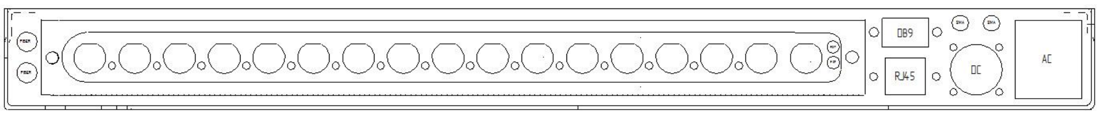
Adjusting the GMT offset will affect the displayed date. As the hour moves across the International Dateline, the displayed date will reflect the date in the selected time zone, and not necessarily the GMT date.

2.14 Power Switch

The front or rear panel Power Switch controls AC Power input to the unit. If the optional DC input is provided with 24V, or a valid DC supply, the unit will operate. In other words, the front panel switch will not remove power if the optional DC input is powered.

The AC and DC input option provides a redundant and automatic backup source in the case of failure of either input.

3.0 Rear Panel



3.1 Channel Outputs - BNC

There are 16 outputs across the left hand side of the rear panel. They are labeled 1 through 16. Nominally the outputs are 50 Ohm impedance.

3.2 Antenna Input A/B - SMA

SMA female – Internal 3.5V Supply, 25 mA max.

The unit can be connected to one or two antenna. If a redundant system is ordered, the second receiver can have its own antenna or the unit can be configured with a splitter to allow one antenna to drive both receivers.

3.3 DC Input

The DC input connector is a 3 pin Amphenol circular connector, P/N DL3102A10SL-3P. The mating connector is available as P/N DL3106A10SL-3S. The default DC input voltage is 24Vdc. Custom voltage ranges can be provided from -60Vdc to +60Vdc.

Pin A goes to the most negative voltage of the DC source. For a 24V source input this would be the ground or return output from the DC source.

Pin B goes to the most positive DC voltage of the DC source. For a 24V source input this would be the positive output from the DC source.

Pin C goes to the Earth ground of the DC source.

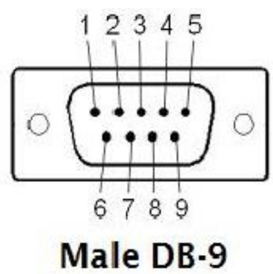
3.4 AC Input

The AC input accepts 90-250Vac, 50-60Hz. IEC 320-C14 Compliant.

3.5 RS232 DB9 Front (NMEA/Status)

An RS232 port is provided for local setup, and status monitoring. The embedded processor provides status strings, as well as command responses. Configuration and status commands are detailed in the NR2316 Programmer's Manual Section 5.0.

RS232 Serial Port: Front Panel Pin Connections



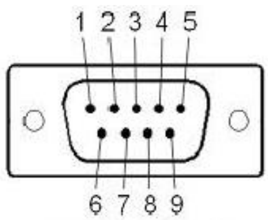
Pin	Function	I/O
1	NC	
2	Command Port TX	O
3	Command Port RX	I
4	NC	
5	GND	GND
6	NC	
7	NC	
8	NC	
9	NC	

The default settings for the rear panel RS232 port are 38400 baud, 8 bits, 1 stop bit, no parity.

3.6 RS232 DB9 Rear (Linux Console Debug)

The unit has an RS232 debug port for UART 0 of the embedded linux server. This RS232 level port defaults as the console stdin/stdout, and can be accessed by your favorite terminal program such as PuTTY, using a Serial Com port. The default baud rate is 115200, 8 bit, no parity, 1 stop bit. (Note: Remember to check the pinout.)

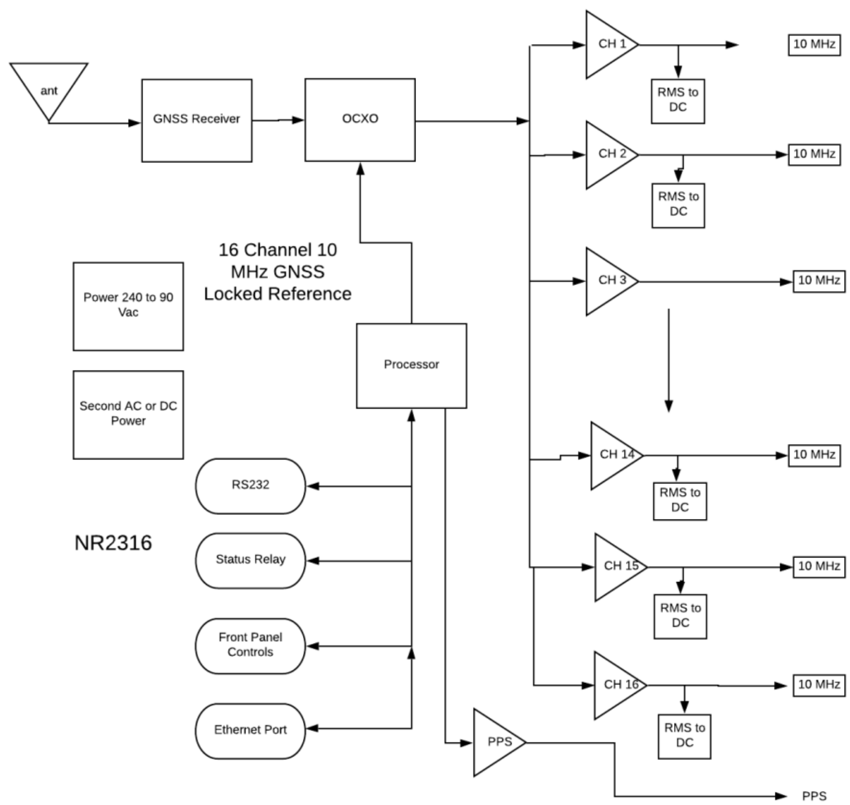
RS232 Serial Port: Rear Panel Pin Connections



Male DB-9

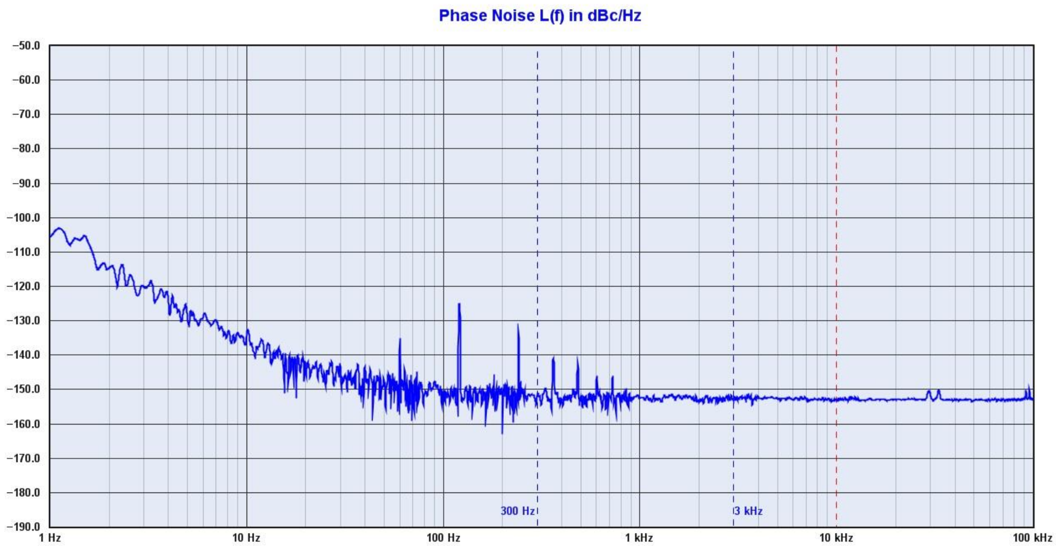
Pin	Function	I/O
1	NC	
2	Command Port RX	I
3	Command Port TX	O
4	NC	
5	GND	GND
6	NC	
7	NC	
8	NC	
9	NC	

4.0 Functional Description



4.1 Phase Noise

Low phase noise contribution is achieved through careful PCB design, component selection and minimization of power supply noise. Below is a typical phase noise performance for a 10 MHz reference application:



Trace	Input Freq	Input Amplitude	dBc/Hz at 10 kHz	RMS Noise (degs)	RMS Jitter	SSB C/N dB	Duration
NR2310-PN (Unsaved)	10.000 MHz	5.0 dBm	−153.2	1.04E−4	2.9E−14 s	−117.8	2m 0s

4.2 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 fault status and the protection on each output facilitates installation to help prevent damage.

The nominal application is for a 10 MHz sine wave output in the range of 1 Vrms.

Skewing between channels < 5 ns.

4.3 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. In addition, all current channel statuses, or Vrms values, can be monitored, as well as power supply health.

4.4 Power Supplies

The unit is designed to accept power in the range of 90 to 264VAC, 50 to 60 Hz. This allows global application. The design is such that no action need be taken to operate from global power types. This feature avoids installation damage that occurs in designs that require an input power switch mode be used.

There is an EMI filter between the internal power supply and the available power being used. This filter minimizes the electrical noise from entering the circuitry and negatively impacting noise performance. Also, in most applications, the equipment that surrounds this unit is sensitive and the filter also reduces noise that could impact the performance of other equipment.

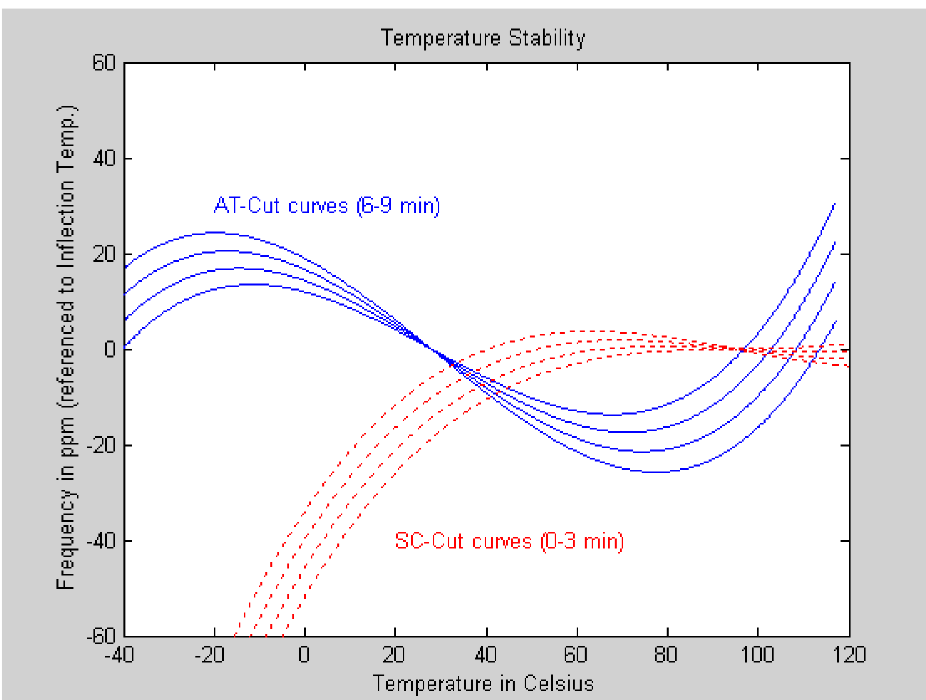
If the optional DC power option is installed the unit can be powered from nominal 24 VDC or optional -60 to +60Vdc. The output of the DC to DC converter is effectively diode OR’d with the AC supply and the DC power supply becomes the prime when the AC power fails.

5.0 Crystal

Novus crystal based frequency reference products are based upon either TCXO or OCXO technology. Temperature compensated crystal oscillators will normally use a AT cut crystal and electronically compensate the device with temperature. An OCXO device uses a SC (stress compensated) crystal and the part is held at a fix temperature to minimize temperature drift.

The TCXO implementation results in a temperature stable reference in the single digit parts per million. An OCXO device affords a reference that is almost 2 orders of magnitude more stable than the TCXO.

Comparison of an AT versus a SC cut crystal

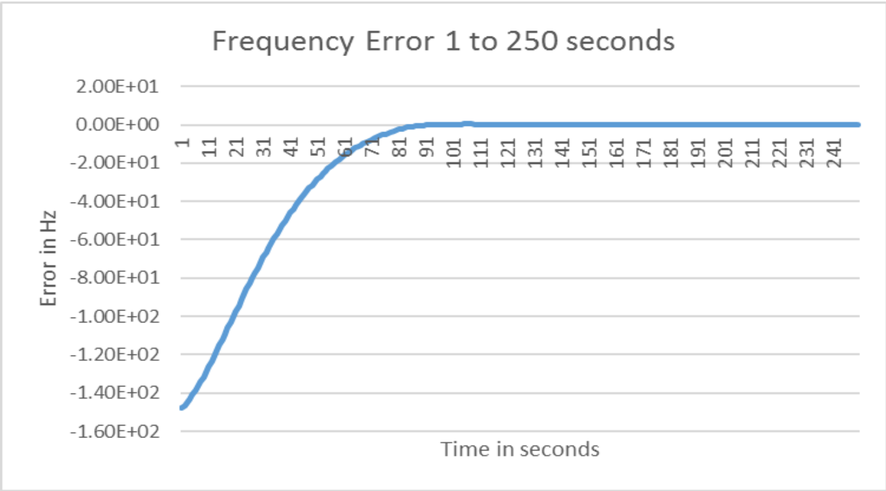


Over a broad temperature range, an AT performs very well and much easier to compensate electronically. It is also a simpler crystal to manufacture than a SC cut device. For applications where a stability of a few ppm is acceptable, a TCXO can be a cost effective alternative.

The SC cut results in a much higher Q device and achieves much lower phase noise than the AT cut. The device is also more sensitive to pressure and temperature variation is mounted in temperature controlled hermetic chamber.

OCXO oven temperature is in the range of 90 C. The devices heat-up and become stable within ~ 5 minutes.

OCXO Frequency Error from Cold Start

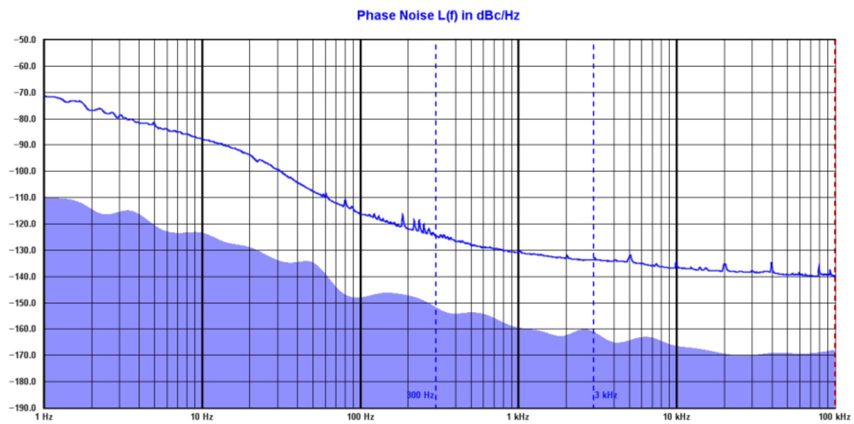


Typical OCXO

Another alternative for a frequency reference is an atomic reference. These devices use a change in atomic state of an isotope of Cesium or Rubidium for stability. Instead of a stability of ±50 ppb/year for a typical OCXO- stability of ±1 ppb/year is very common.

Atomic sources are very complex and while a very stable source, phase noise performance may not be acceptable for many applications.

Typical phase noise performance for a Rubidium source



Trace	Notes	Input Freq	Sample Interval	dBc/Hz at 100 kHz	RMS Noise (degs)
rub		10.000 MHz	0.010 s	−139.7	1.18E−3

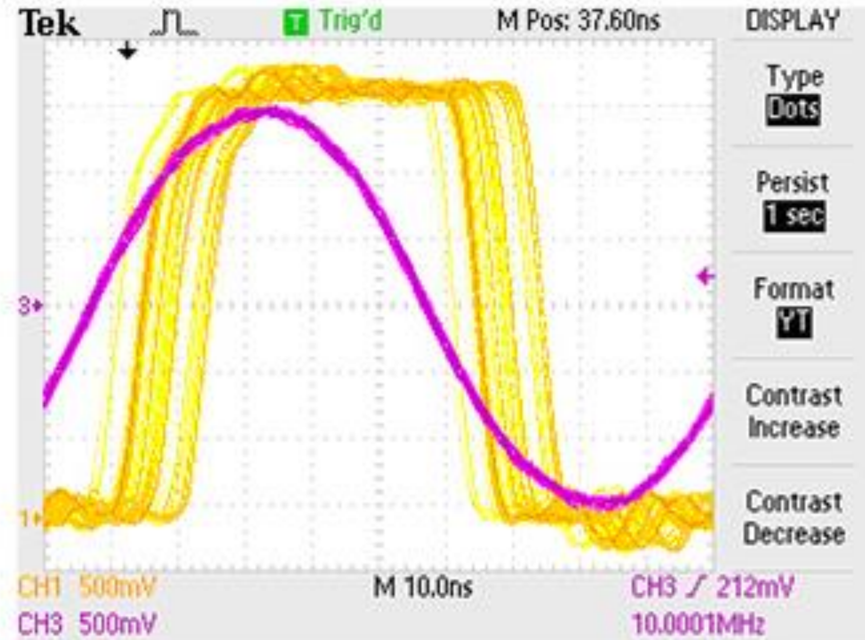
For applications requiring the stability of an atomic source but also requiring low phase noise a low phase noise OCXO is disciplined to an atomic source. The phase noise for the NR2310-RO has phase noise improved by well over 20 dB by this technique.

Typical Phase Noise Performance-Rubidium with OCXO

When the stability of an atomic or crystal source is not sufficient a GNSS disciplined source is an option. A GNSS receiver is installed and timing information from the GNSS is used to discipline the timing device. Timing accuracy to a few ppb is readily achievable.

The GNSS is used to provide timing for a DDS (direct digital waveform synthesizer). While the DDS has outstanding long-term accuracy, the short-term stability very poor due to the nature of the timing source. A GNSS timing source has considerable short-term instability due to the numerous radio effects-multi-path, signal weakness etc. In order to develop a stable reference, the GNSS timing waveform is used to discipline a low noise source with a Kalman filter. A good example of the improved jitter performance of a Kalman filter is shown below:

Kalman Filter Performance:



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6.0 Calibration

NR2316-OG:

The frequency is phase/frequency 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.

7.0 Programming Guide (RS232 Port: Front and Rear)

The NR2316 can accept user commands through the RS232 port which will provide specific fault detection performance, and which may be customized by the user. The settings can be saved in non-volatile flash memory.

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. 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

7.1 RS232 Commands

Setting	Command	Response	Description
RS232 REAR PANEL BAUD RATE	$BAUDNV	$BAUDNV=<current Baud Rate>	Query Baud Rate on rear panel RS232. (Default = 38400). Front Panel is 38400 baud.
	$BAUDNV=38400		Assign Baud rate to Rear Panel RS232 port. Default is 38400. Available baudrates are 19200, 38400, 57600, 115200. Note: Front panel baud rate is set to 38400.
CHANNEL FAULT THRESHOLD FACTOR	$FLTTHR	$FLTTHR=<current Channel Fault threshold factor (from 0.05 to 0.65)>	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 <0.nn>
	$FLTTHR=0.65		
INPUT LOW THRESHOLD VALUE (V)	$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
AMPLIFIER TEST ENABLE (REDUNDANT AMPLIFIER OPTION)	$AMP	$AMP=<current AMP setting>	Enables an amplifier gain test when fault is triggered. If AMP=1, when a fault occurs on a specific channel, the controller will switch to the backup amplifier assembly, and check the open circuit gain of the affected board. If the open circuit gain test fails, the board can remain switched out if the $BSW command is enabled. In addition, the channel will be tagged in the Amplifier bin in either the Primary or Secondary status word. If the channel passes the open circuit gain test, the fault will be tagged in the Channel Fault bin instead, indicating that the fault is external to the unit. Any binned fault is cleared when the general fault is cleared on the active board.
	$AMP=1		
BOARD SWITCH ENABLED (REDUNDANT AMPLIFIER OPTION)	$BSW	$BSW=<current setting>	Enables switching of Primary Amplifier Assembly to Backup Amplifier Assembly if an amplifier test fails. During an amplifier open circuit gain test, the affected amplifier assembly is switched out and tested while the backup assembly is active. If the test fails, and $BSW=1, the Backup assembly will remain active.
	$BSW=1		

Setting	Command	Response	Description
SET INDIVIDUAL CHANNEL REFERENCE VOLTAGE	$SET<nn>=n.nn $SET01=1.00 $SET02=1.00 $SET03=1.00 . . . $SET15=1.00	$SET<nn>=nn.nn	Set or query the Reference Voltage for a perticular channel with respect to the active input. Use in 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.
NVS OUTPUT	$NVS<n> (1 ≤ n ≤ 13)	$NVS1=< current ~~RMC~~ NVS1 STRING output frequency >	Query NVS String output Frequency. (Default = 1)
	$NVS1=1		Change NVS String output Frequency in seconds. (0-60)

Setting	Command	Response	Description
CAL FACTORS	$CAL<n>=nn.nn $CAL1=11.10 $ACTFRP=0	$CAL<n>=nn.nn	Query or set Cal Factors for specific ADC conversions. See list of Cal Factors numbered for appropriate measurement parameters. These settings should only be changed by an authorized technician.
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		$?	Command not recognized.
STATUS STRING QUERY ($GPNVS,<n>)	$STAT1 TO $STAT13	$GPNVS,1… $GPNVS,13…	Output a single specific status string (1-13). Use $NVS<n> command to turn on/off regular GPNVS string output. Use $STAT<n> command to query the individual strings.
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.

The following commands are passed to the internal GPS reference.

Setting	Command	Response	Description
DAC VOLTAGE	$DAC	$DAC=N.NNNNN	This command will force the DAC Control Voltage to a specific value. This value is modified perpetually by the GPS loop, and saved to flash memory. Do not modify this value except to test or calibrate unit.
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
PPS STABILIZATION MODE	$STBLM	$STBLM=1	Enable PPS Stabilization Mode. When Frequency variance decreases to within the margin of PSVAR, and PPS is aligned, the PPS will be manipulated by frequency assist to remain in GPS alignment, but with low jitter. Returns a 0 value if not ready. Also enables/disables “$STBWU”. 1 = Enable PPS stabilization if ready. 0 = Disable
ENABLE PPS STABILIZATION ON WARMUP	$STBWU	$STBWU=1	Enable PPS Stabilization mode when warmup and GNSS lock is complete. This value is saved to flash and allows the unit to recover PPS Stabilization mode after power cycle when ready. 1 = Enable PPS stabilization when ready 0 = Disable
FORCE PPS DISCIPLINE (PPS STABILIZATION OFF)	$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. 1 = Enable discipline of synthesized PPS 2 = Disable discipline
PPS PULL ACTION TIMER	$PACT	$PACT=2	Sets frequency of PPS Pull application to frequency loop in seconds. Lower value is more aggressive. (0-9 seconds)

FREQUENCY VARIANCE THRESHOLD FOR ACTIVATION OF PPS STABILIZATION MODE	$PSVAR	$PSVAR=20	In PPS stabilization mode, this threshold determines the number of bits of frequency correction below which the PPS is determined to be steerable. If the variance in frequency is below this threshold, and PPS stabilization is enabled, the PPS will be manipulated by frequency to maintain low jitter. If the PPS Stabilization is off, this value is the threshold by which frequency "lock" is determined. (<=100) [cycles]

PPS DRIFT THRESHOLD	$PSDIF	$PSDIF=100	In PPS stabilization mode, this threshold determines the number of nanoseconds from the true PPS, below which the Synth PPS will be steered by frequency, avoiding a hard synchronization. This value is measured from a 4 cycle (20ns) delay from the GPS PPS to the Synth PPS, ensuring center exactly at point of discipline. To move the PPS pulse, either advance or delay, use the receiver command "$PERDAPI,PPS,…" from Appendix A. Note: While frequency variance is greater than PSVAR, PPS will still be forced to synchronization. (<=250) [ns]
PPS DRIFT CALIBRATION FACTOR	$PSCAL	$PSCAL=0.5	In PPS stabilization mode, this Cal Factor determines how much the proportional PPS difference is applied to the frequency adjustment. Higher is more aggressive. 0.1 to 10.0

FREQUENCY LOOP LENGTH	$MLLEN	$MLLEN=15	Sets the integration loop period for the frequency measurement and correction cycle. A longer period allows more accurate frequency measurement, but reduces correction speed. (1-100 seconds)
FREQUENCY LOOP LINEAR CAL FACTOR	$MLCAL	$MLCAL=1.5	Sets the overall linear calibration coefficient which weights the frequency correction as it is applied. Higher values are more aggressive. (0.0 to 10.0)

FREQUENCY LOOP EXPONENTIAL CAL FACTOR	$MLPOW=2	$MLPOW=2	Sets the overall exponential calibration coefficient which weights the frequency correction as it is applied. Higher values are more aggressive. (0 to 6)

7.2 Status Byte Key

	Hex Value (OR'd)	Channel ID	Channel Status Word
Channel Status Byte	0x1<<0	Channel 1 Fault	General Channel Fault
	0x1<<1	Channel 2 Fault	
	0x1<<2	Channel 3 Fault	
	0x1<<3	Channel 4 Fault	
	0x1<<4	Channel 5 Fault	
	0x1<<5	Channel 6 Fault	
	0x1<<6	Channel 7 Fault	
	0x1<<7	Channel 8 Fault	
	0x1<<8	Channel 9 Fault	
	0x1<<9	Channel 10 Fault	
	0x1<<10	Channel 11 Fault	
	0x1<<11	Channel 12 Fault	
	0x1<<12	Channel 13 Fault	
	0x1<<13	Channel 14 Fault	
	0x1<<14	Channel 15 Fault	

	Hex Value (OR'd)	Channel ID	Channel Fault Bin
Channel Fault Bin	0x1<<0	Channel 1 Fault	External Fault: The ND0100 has completed an internal amplifier gain test and both primary and backup assemblies are functional. The fault is external to the ND0100
	0x1<<1	Channel 2 Fault	
	0x1<<2	Channel 3 Fault	
	0x1<<3	Channel 4 Fault	
	0x1<<4	Channel 5 Fault	
	0x1<<5	Channel 6 Fault	
	0x1<<6	Channel 7 Fault	

	0x1<<7	Channel 8 Fault	(cabling, short, etc) Amp Gain Test for Alert is enabled with $AMP=1
	0x1<<8	Channel 9 Fault	
	0x1<<9	Channel 10 Fault	
	0x1<<10	Channel 11 Fault	

	Hex Value (OR'd)	Channel ID	Primary PCB Amp Status
Primary PCB Amp Status	0x1<<0	Channel 1 Fault	Internal Fault Primary Assembly: The channel has failed an internal gain test on the primary PCB assembly, and the channel is not functional on the primary board. Amp Gain Test for Alert is enabled with $AMP=1 command via RS232
	0x1<<1	Channel 2 Fault	
	0x1<<2	Channel 3 Fault	
	0x1<<3	Channel 4 Fault	
	0x1<<4	Channel 5 Fault	
	0x1<<5	Channel 6 Fault	
	0x1<<6	Channel 7 Fault	
	0x1<<7	Channel 8 Fault	
	0x1<<8	Channel 9 Fault	
	0x1<<9	Channel 10 Fault	
	0x1<<10	Channel 11 Fault	
	0x1<<11	Channel 12 Fault	
	0x1<<12	Channel 13 Fault	
	0x1<<13	Channel 14 Fault	

	0x1<<11	Channel 12 Fault	
	0x1<<12	Channel 13 Fault	
	0x1<<13	Channel 14 Fault	
	0x1<<14	Channel 15 Fault	

	0x1<<14	Channel 15 Fault	

Primary and Secondary Power Supply Status	Hex Value (OR'd)	Status Message
	0x1<<0	Source Input A out of range
	0x1<<1	Source input B out of range
	0x1<<2	Digital PS out of range
	0x1<<3	Analog (+) PS out of range

	Hex Value (OR'd)	Channel ID	Backup PCB Amp Status
Backup PCB Amp Status	0x1<<0	Channel 1 Fault	Internal Fault Backup Assembly: The channel has failed an internal gain test on the backup PCB assembly, and the channel is not functional on the secondary board. Amp Gain Test for Alert is enabled with $AMP=1 command via RS232
	0x1<<1	Channel 2 Fault	
	0x1<<2	Channel 3 Fault	
	0x1<<3	Channel 4 Fault	
	0x1<<4	Channel 5 Fault	
	0x1<<5	Channel 6 Fault	
	0x1<<6	Channel 7 Fault	
	0x1<<7	Channel 8 Fault	
	0x1<<8	Channel 9 Fault	
	0x1<<9	Channel 10 Fault	
	0x1<<10	Channel 11 Fault	
	0x1<<11	Channel 12 Fault	
	0x1<<12	Channel 13 Fault	
	0x1<<13	Channel 14 Fault	
	0x1<<14	Channel 15 Fault	

	0x1<<4	Analog (-) PS out of range
	0x1<<5	Communication Failure
	0x1<<6	DC Power not present (option)
	0x1<<7	AC Power not present

Active Board	Hex Value (OR'd)	Status Message

Status	0x1<<0	Flash Read Boot Error (Deprecated)
	0x1<<1	Potentiometer Read/Set Fail (Optional)
	0x1<<2	Reserved
	0x1<<3	Reserved
	0x1<<4	PCB Assembly Input A/B Select Fail (Deprecated)
	0x1<<5	Reserved
	0x1<<6	Reserved
	0x1<<7	Reserved

8.0 Technical Specification

8.1 Performance

10 MHz Sine	1.0 ±0.1 Vrms, 16 channel, 50 Ohm - BNC	
Locked Accuracy	<3E-11 @ 200 seconds	
Temp Stability	±10 ppb unlocked	
Daily Aging	±5 ppb unlocked	
Yearly Aging	±50 ppb (unlocked) typically < ±10 ppb after 30 days auto-calibration	
Remote interface & control		
Protocol	RS232 NMEA-0183	
Connector	DB-9	
Location	Rear panel	
Protocol	Bit plus stop	
Standard Baud Rates	Selectable 4800, 9600, 19200, 38400, 57600 or 115200 bps	
Phase noise		

1 Hz	-95 dBc/Hz	
10 Hz	-120 dBc/Hz	
100 Hz	-145 dBc/Hz	
1 kHz	-150 dBc Hz	
SNMP (option)		
Remote monitoring & control	Internet	
Parameters monitored Locally – present on remote interface for monitoring	Output amplitude, all power supplies, GNSS lock status, number of satellites, Built-In test status,	
Transaction/decodable commands	English format	
Single monitoring command	Updated every second	
Connector	RJ-45	
Rubidium Atomic		
Accuracy at shipment	+/-5.0E-11	
Warm-up time	<15 minutes	
Time of lock	<5 min -130 dBm	
Time to achieve accuracy	<±1E-9<20 minutes	
Aging - monthly	<±5E-11	
Aging - yearly	<±1.0E-9	
Stability: Allan Deviation		
1s	<3E-10	
10s	<1E-10	
100s	<3E-11	
SSB Phase noise for 10Mhz		
	Standard	
10Hz	<-125dBc	
100Hz	<145dBc	
1000Hz	<-155dBc	
10000Hz	<-155dBc	
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	<10 ns (faster edge available)	
Jitter	GNSS-PPS < 10ns	
Connector	SMA	
Load Impedance	50 Ohm	
Location	rear	
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 Required		
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	
Power Input	90 to 250 VAC, 50/60hz, IEC 320-C14 or 24 VDC (contact factory for options)	
Phase Noise	-105 dBc/Hz@ 1 Hz, -135 dBc/Hz@ 10 Hz, -150dBc/Hz@ 100Hz	
RS232 Serial Status Port	Status-channel voltages	
Ethernet Port	RJ45-option	
SNMP		

Environmental and Mechanical

Operating Temperature	0 to 50C non-condensing	
Storage Temperature	-40 to 70C	
Height	1RU (~1.73)	
Width	19.0 inch	
Depth	13.0 inch	
AC input	90 to 250 VAC, 50/60Hz, less than 10 watts (DC power options)	
Weight	≈5.5lbs	

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.

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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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10.0 Appendix: GNSS Command Reference

See attached.

Users Manual **Appendix A**

Appendix A

GPS/GNSS Receiver Communications Specification NMEA-0183

Table of Contents:

1 Communication Specification

Signal Lines used:	TXD, RXD
Flow Control:	None
System:	Full Duplex Asynchronous
Speed:	Configurable, Default 38400 bps (*1)
Start Bit:	1 bit
Data Length:	8 bits
Stop Bit:	1 bit
Parity Bit:	None
Data Output Interval:	1 second

Character Codes used: NMEA-0183 Ver.4.10 data based

ASCII code (*2) Protocol: Input data

NMEA Standard sentence NMEA Proprietary sentence

Output data

NMEA Standard sentence NMEA Proprietary sentence

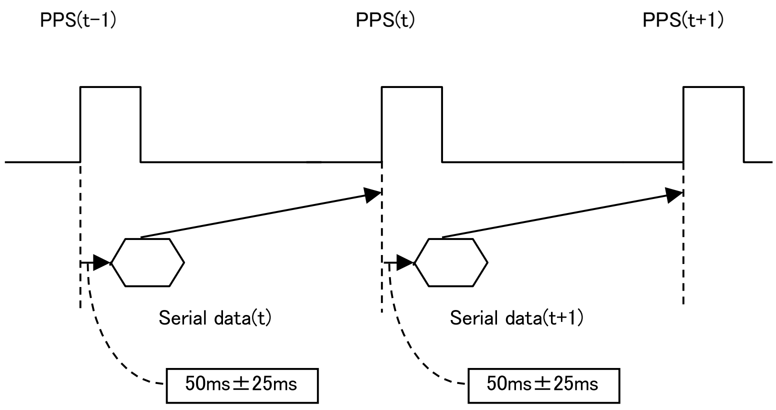
Note 1: Communication speed can be changed into 4800, 9600, 19200, 38400, 57600 or 115200 bps.

Please refer to section "UART1 – Serial Communication Port" for how to configure the communication speed. In case of using low baud rate, please adjust size of output sentence by NMEAOUT command and CROUT command to output all sentence within one second.

Note 2: "NMEA 0183 STANDARD FOR INTERFACING MARINE ELECTRONIC DEVICES Version 4.10" (NATIONAL MARINE ELECTRONICS ASSOCIATION, June, 2012)

2 Serial data output timing △4

The output timing of serial data is synchronous with PPS output timing. Serial data is begun to output in the 25ms to 75ms range after PPS is output.
The time of serial data indicates next PPS output timing.



3 NMEA Sentence Format

13.1 Standard Sentence

Format:

$	<address field>	,	<data field>	...	*<checksum field>	<CR>	<LF>

5 bytes

Field	Description
$	Start-of Sentence marker
<address field>	5-byte fixed length. First 2 bytes represent a talker ID, and the remaining 3 bytes do a sentence formatter. All output sentences must begin with a "$" followed by a TalkerID. The relevant Talker IDs are GP for GPS, GN for GNSS, GL for GLONASS and GA for Galileo. For the sentences received from external equipment, the GT-87 accepts any talker ID. Talker ID "XX" found on the succeeding pages is a wildcard meaning "any valid talker ID".
<data field>	Variable or fixed-length fields preceded by delimiter ","(comma). Comma(s) are required even when valid field data are not available i.e. null fields. Ex. ",,,,," In a numeric field with fixed field length, fill unused leading digits with zeroes.
*<checksum field>	8 bits data between "$" and "*" (excluding "$" and "*") are XORed, and the resultant value is converted to 2bytes of hexadecimal letters. Note that two hexadecimal letters must be preceded by"*", and delimiter "," is not required before *<checksum>. All output sentences have checksum. For input sentences, the resultant value is checked and if it is not correct, the sentence is treated invalid.
<CR><LF>	End-of-Sentence marker

4 Proprietary Sentence Format:

$	P	<maker ID>	<sentence type>	,	<data field>	...	*<checksum field>	<CR>	<LF>
		3 bytes	3 bytes						

Field	Description
$	Start-of-Sentence marker
P	Proprietary sentence identifier
<maker ID>	3-byte fixed length. GT-87's maker ID is "ERD" meaning eRide.
<sentence type>	Indicates the type of sentence.
<data field>	Variable or fixed-length fields preceded by delimiter ","(comma). (Layout is maker-definable.)
<checksum field>	8 bits data between "$" and "*"(excluding "$" and "*") are XORed, and the resultant value is converted to 2 bytes of hexadecimal letters. Note that two hexadecimal letters must be preceded by "*", and delimiter "," is not required before *<checksum>. All output sentences have checksum. For input sentences, the resultant value is checked and if it is not correct, the sentence is treated invalid.
<CR><LF>	End-of-Sentence marker

5 Standard NMEA Output Sentences

The receiver supports eight standard NMEA output sentences (GGA, GLL, GNS, GSA, GSV, RMC, VTG and ZDA) per NMEA standard 0183 Version 4.10 (June, 2012).
By default, the RMC, GNS, GSA, ZDA, GSV and TPS sentences will be output every second. The sentences can be independently enabled and disabled using the $PERDCFG,NMEAOUT and/or $PERDAPI,CROUT command described later in this document, as well as use differing transmission rates.

The NMEA sentence descriptions in this sentence are for reference only. The sentence formats are defined exclusively by the copyrighted document from NMEA.

e*Ride* does populate all the fields described in the NMEA specification. Uncalculated fields are indicated as "Not Supported".

GGA – Global Positioning System Fix Data Format:

$XXGGA	,	hhmmss.sss	,	ddmm.mmmm	,	a	,	dddmm.mmmm	,	a	,	x	,	xx	,
		1		2		3		4		5		6		7	

x.x	,	x.x	,	M	,	x.x	,	M	,	xxx	,	xxx	*hh	<CR>	<LF>
8		9		10		11		12		13		14			

#.	**Description**	**Range**
1.	UTC	
	"hh": hour	00 - 23
	"mm": minute	00 - 59
	"ss.sss": second	00.000 - 59.999
2-3.	Latitude	
	"dd": degree	00 - 90
	"mm.mmmm": minute	00.0000 - 59.9999
	"a": North/South	N or S
4-5.	Longitude	
	"ddd": degree	000 - 180
	"mm.mmmm": minute	00.0000 - 59.9999
	"a": East/West	E or W
6.	GPS Quality Indication	0 - 2 "0": Fix not available or invalid "1": Valid fix "2": DGPS positioning
7.	Number of satellites used for positioning	00 – 12 [*1]
8.	Horizontal dilution of precision (HDOP)	0.0-50.0
	Note: A null field is output while positioning is interrupted.	
9.	Altitude above/below mean sea-level (geoid)	
10.	Unit of Altitude, meter	M
11.	Geoidal height	
12.	Unit of Geoidal height	M
13.	Age of differential GPS data	n/a
14.	Differential reference station ID	n/a

Example:

$GPGGA,025411.516,3442.8146,N,13520.1090,E,1,11,0.8,24.0,M,36.7,M,,*66
UTC: 02:54:11.516 34 deg 42.8146 min N 135 deg 20.1090 min E
Status: Valid fix Number of satellites: 11 satellites HDOP: 0.8
Altitude: 24.0 meters high Geoidal height: 36.7 meters high

[*1] GPS, SBAS, QZSS only. Galileo and GLONASS are not counted. Upper limit is 12.

GLL – Geographic Position - Latitude/Longitude △6

Format:

$XXGLL	,	ddmm.mmmm	,	a	,	dddmm.mmmm	,	a	,	hhmmss.sss	,	a	,	a	*hh	<CR>	<LF>
		1		2		3		4		5		6		7			

#	Description	Range
1-2.	Latitude	
	"dd": degree	00 - 90
	"mm.mmmm": minute	00.0000 - 59.9999
	"a": North/South	N or S
3-4.	Longitude	
	"ddd": degree	000 - 180
	"mm.mmmm": minute	00.0000 - 59.9999
	"a": East/West	E or W
5.	UTC	
	"hh": hour	00 - 23
	"mm": minute	00 - 59
	"ss.sss": second	00.000 - 59.999
6.	Status △6	A or V "A": Data Valid "V": Data Invalid
7.	Position System Mode Indication	A, D or N "A": Autonomous "D": Differential "N": Data Invalid

Example:

$GPGLL,3442.8146,N,13520.1090,E,025411.516,A,A*5F
34 deg 42.8146 min N 135 deg 20.1090 min E
UTC: 02:54:11.516 Mode: Data Valid

GNS – GNSS Fix Data Format:

$XXGNS	,	hhmmss.sss	,	ddmm.mmmm	,	a	,	dddmm.mmmm	,	a	,	c--c	,	xx	,
		1		2		3		4		5		6		7	

x.x	,	x.x	,	x.x	,	x	,	x	,	x	*hh	<CR>	<LF>
8		9		10		11		12		13			

#.	**Description**	**Range**
1.	UTC	
	"hh": hour	00 - 23
	"mm": minute	00 - 59
	"ss.sss": second	00.000 - 59.999
2-3.	Latitude	
	"dd": degree	00 - 90
	"mm.mmmm": minute	00.0000 - 59.9999
	"a": North/South	N or S
4-5.	Longitude	
	"ddd": degree	000 - 180
	"mm.mmmm": minute	00.0000 - 59.9999
	"a": East/West	E or W
6.	Mode Indicator for each satellite system (GPS, GLONASS, Galileo)	
		"A": Autonomous
		"D": Differential
		"N": Data Invalid
7.	Number of satellites used for positioning	00 - 32
8.	Horizontal dilution of precision (HDOP)	0.0 - 50.0
	Note: A null field is output while positioning is interrupted.	
9.	Altitude above/below mean sea-level (geoid)	
10.	Geoidal height	
11.	Age of differential GPS data	n/a
12.	Differential reference station ID	n/a
13.	Navigation Status Indicator	S, C, U or V
		"S": Safe
		"C": Caution
		"U": Unsafe
		"V": Not Valid

Example:

$GNGNS,004457.000,3442.8266,N,13520.1235,E,DDN,22,0.5,40.6,36.7,,,V*60
UTC: 00:44:57.000 34 deg 42.8266 min N 135 deg 20.1235 min E
Status: Data Valid (GPS: differential, GLONASS: differential, Galileo: Invalid)
Number of satellites: 22 satellites HDOP: 0.5
Altitude: 40.6 meters high Geoidal height: 36.7 meters high
Navigation Status Indicator: Not Valid

GSA – GNSS DOP and Active Satellites △4

Format:

$XXGSA	,	a	,	a	,	xx	,	xx	,	xx	,	…	,	xx	,	x.x	,	x.x	,	x.x	,	h	*hh	<CR>	<LF>
		1		2		3		4		5		6-13		14		15		16		17		18			

#	**Description**	**Range**
1.	Operational mode	M or A "M": 2D/3D fixed mode "A": 2D/3D Auto-switching mode
2.	Mode	1 - 3 "1": No fix "2": 2D fix "3": 3D fix
3-14.	Satellite Numbers used for positioning Note: A null field is output unless a satellite is available.	01 - 99
15.	PDOP Note: A null field is output unless 3D-positioning is performed.	0.0 - 50.0
16.	HDOP Note: A null field is output while positioning is interrupted.	0.0 - 50.0
17.	VDOP Note: A null field is output unless 3D-positioning is performed.	0.0 - 50.0
18.	GNSS System ID	n/a

Example:

$GNGSA,A,3,09,15,26,05,24,21,08,02,29,28,18,10,0.8,0.5,0.5,1*33
$GNGSA,A,3,79,69,68,84,85,80,70,83,,,,,0.8,0.5,0.5,2*30

2D/3D Auto-switching mode, 3D fix
Satellite used: 09, 15, 26, 05, 24, 21, 08, 02, 29, 28, 10, 79, 69, 68, 84, 85, 80, 70, 83
PDOP: 0.8 HDOP: 0.5 VDOP: 1.5

Notes: △4

- To adds extra fields to the GPGSA NMEA string to show more than 12 satellites used in the fix, please input "$PERDAPI,EXTENDGSA,num*hh<CR><LF>". num is Number of fields for satellites used in the fix. Acceptable values are: 12-16. Default num is 12. By creating more fields for satellites used in the fix, the PDOP/HDOP/VDOP values shift by num12 fields.
- Satellite number means the follow.

Satellite number from 01 to 32 indicates GPS (01 to 32)
Satellite number from 33 to 51 indicates SBAS (120 to 138)
Satellite number from 65 to 92 indicates GLONASS (slot 01 to slot 28)
Satellite number from 93 to 99 indicates QZSS (193 to 199)

GSV – GNSS Satellites in View △4

Format:

$XXGSV	,	x	,	x	,	x	,	xx	,	xx	,	xxx	,	xx	,	xx	,	xx	,	xxx	,	xx	,
		1		2		3		4		5		6		7		8		9		10		11	

xx	,	xx	,	xxx	,	xx	,	xx	,	xx	,	xxx	,	xx		h	*hh	<CR>	<LF>
12		13		14		15		16		17		18		19		20			

#	Description	Range
1.	Total number of messages	1 - 4
2.	Number of messages	1 - 4
3.	Number of satellites in line-of-sight	00 - 14
4.	1st Sat. ID number	01 - 99
5.	1st Sat. elevation angle (degree)	00 - 90
6.	1st Sat. azimuth angle (degree)	000 - 359
7.	1st Sat. SNR (Signal/Noise Ratio) (dB)	00 - 99
8-11.	2nd Sat. Details	
12-15.	3rd Sat. Details	
16-19.	4th Sat. Details	
20.	Signal ID	

Example:

$GPGSV,4,1,14,15,67,319,52,09,63,068,53,26,45,039,50,05,44,104,49,1*6E
$GPGSV,4,2,14,24,42,196,47,21,34,302,46,18,12,305,43,28,11,067,41,1*68
$GPGSV,4,3,14,08,07,035,38,29,04,237,39,02,02,161,40,50,47,163,44,1*67
$GPGSV,4,4,14,42,48,171,44,93,65,191,48,,,,,,,,,1*60
$GLGSV,3,1,09,79,66,099,50,69,55,019,53,80,33,176,46,68,28,088,45,1*76
$GLGSV,3,2,09,70,25,315,46,78,24,031,42,85,18,293,44,84,16,246,41,1*7A
$GLGSV,3,3,09,86,02,338,,,,,,,,,,,,1*45

Not fixed
Message number
Total number of message

<checksum><CR><LF> is output right after the last satellite data output.

Notes: △4

- In this sentence, a maximum of four satellite details is indicated per each output. Five or more satellite details are output in the 2nd or 3rd messages. When there is an item which is not fixed in the satellite details, a null field is output. When there are only one to four satellite details, <checksum><CR><LF> is issued immediately after Sat. SV#, Sat. elevation angle, Sat. azimuth angle and SNR.
- Satellite number means the follow.

Satellite number from 01 to 32 indicates GPS (01 to 32)
Satellite number from 33 to 51 indicates SBAS (120 to 138)
Satellite number from 65 to 92 indicates GLONASS (slot 01 to slot 28)

Satellite number from 93 to 99 indicates QZSS (193 to 199)

RMC – Recommended Minimum Navigation Information △6

Format:

$XXRMC	,	hhmmss.sss	,	a	,	ddmm.mmmm	,	a	,	dddmm.mmmm	,	a	,	x.x	,
		1		2		3		4		5		6		7	

x.x	,	ddmmyy	,	x.x	,	a	,	a	,	a	*hh	<CR>	<LF>
8		9		10		11		12		13			

#	Description	Range
1.	UTC	
	"hh": hour	00 - 23
	"mm": minute	00 - 59
	"ss.sss": second	00.000 - 59.999
2.	Status △6	A or V "A": Data valid "V": Data not valid
3-4.	Latitude	
	"dd": degree	00 - 90
	"mm.mmmm": minute	00.0000 - 59.9999
	"a": North/South	N or S
5-6.	Longitude	
	"ddd": degree	000 - 180
	"mm.mmmm": minute	00.0000 - 59.9999
	"a": East/West	E or W
7.	Speed (kts)	
8.	True Course (degree)	
9.	Date "dd": date "mm": month "yy": last two digits of the year	
10.	Magnetic declination Note: A null field is output unless magnetic declination information is available.	
11.	Correction direction of magnetic declination Note: A null field is output unless magnetic declination information is available.	
12.	Positioning System Mode Indication	A, D or N "A": Autonomous "D": Differential "N": Data Invalid
13.	Navigation Status Indicator	S, C, U or V "S": Safe "C": Caution "U": Unsafe "V": Not Valid

Example:

$GNRMC,012344.000,A,3442.8266,N,13520.1233,E,0.00,0.00,191132,,,D,V*0B
UTC: 01:23:44.000   Differential   34 deg 42.8266 min N   135 deg 20.1233 min E
Speed: 0.0 kts   True Course: 0.0 degrees   UTC Date: Nov 19, 2032

VTG – Course Over Ground and Ground Speed Format:

$XXVTG	,	x.x	,	T	,	x.x	,	M	,	x.x	,	N	,	x.x	,	K	,	a	*hh	<CR>	<LF>
		1		2		3		4		5		6		7		8		9			

#	*Description*	*Range*
1-2.	True Course (degree)	
	"T" (meaning TRUE)	T
3-4.	Magnetic Direction	
	"M" (meaning Magnetic Direction)	M
	Note: A null field is output unless magnetic direction information is available.	
5-6.	Speed (kts)	
	"N" (meaning knot)	N
7-8.	Speed (km/h)	
	"K" (meaning km/h)	K
9.	Positioning System Mode Indication	A, D or N "A": Autonomous "D": Differential "N": Data Invalid

Example:

$GNVTG,0.00,T,,M,0.00,N,0.00,K,D*26

True Course: 0.00 degrees Speed: 0.00 kts, 0.00 km/h Mode: Differential

ZDA – Time & Date Format:

$XXZDA	,	hhmmss.sss	,	xx	,	xx	,	xxxx	,	xxx	,	xx	*hh	<CR>	<LF>
		1		2		3		4		5		6			

#	**Description**	
1.	UTC: Time	
	"hh": hour	00 - 23
	"mm": minute	00 - 59
	"ss.sss": second	00.000 - 59.999
2.	UTC: Day of Month	01 - 31
3.	UTC: Month	01 - 12
4.	UTC: Year	1999 - 2099 △3
5.	Local Zone Hours	(+/-) 00 - 23
6.	Local Zone Minutes	00 - 59

Example:

$GPZDA,014811.000,13,09,2013,+00,00*7B

UTC: 01:48:11.000 13th September, 2013

6 Proprietary NMEA Input Sentences

These sentences are input commands for the protocol of this receiver.

GNSS – Satellite System Configuration △4 △8

Format:

$PERDAPI	,	GNSS	,	talkerID	,	gps	,	glonass	,	galileo	,	qzss	,	sbas	*hh	<CR>	<LF>
		1		2		3		4		5		6		7			

Num	Contents	Range	Default	Remark
1	GNSS	-	-	Command Name
2	talkerID	AUTO, LEGACYGP or GN △8	AUTO	AUTO: GLGSV is omitted in case of no glonass. GPGSV is omitted in case of no GPS, SBAS and QZSS. LEGACYGP: GL and GN sentence is omitted. GN: GLGSV is output even if no glonass. GPGSV is output even if no GPS, SBAS and QZSS.
3	gps	0 or 2	2	GPS mode △3
4	glonass	0 or 2	2	Glonass mode △3
5	galileo	0	0	Galileo mode (unimplemented)
6	qzss	0 or 2	2	Qzss mode △3
7	sbas	0, 1 or 2	1	Sbas mode △2

Example:

$PERDAPI,GNSS,AUTO,2,2,0,2,2*41
Use: GPS, GLONASS, QZSS, SBAS
Mask: Galileo

Notes: △4

- This command controls which Global Navigation Satellite Systems are used by the receiver. The mode can be set to 0 or 2 for each satellite system. User can also set SBAS mode to 1. Mode 0 means to disable the system.

Mode 1 means to enable tracking only (do not use in position fix etc).

Mode 2 means to enable tracking and use the in position fix calculation.

- In GT-87, default setting of SBAS mode is 1, because to use calculation data of SBAS tends to reduce the accuracy of 1PPS. Therefore although GT-87 becomes to differential fix, SBAS is not appeared in GSA sentence in default setting.
- The response which is inserted current value to each field is obtained by receiving an effective command for setting or inputting a command which is omitted the fields after Command Name, that is, $PERDAPI,GNSS,QUERY*18.
- "Sbas only configuration" and "No tracking configuration" are not accepted.

$PERDAPI,GNSS,AUTO,0,0,0,0,2*43

$PERDAPI,GNSS,AUTO,0,0,0,0,1*40

$PERDAPI,GNSS,AUTO,0,0,0,0,0*41

- Cold restart (time also be cleared) is run when satellite system configuration is changed from/to glonass only fix configuration. In the others configuration, hot restart is run.

FIXMASK –Setting of Positioning and Satellite Mask △4

Format:

$PERDAPI	,	FIXMASK	,	mode	,	elevmask	,	Reserve1	,	snrmask	,	Reserve2	[,
		1		2		3		4		5		6	

Prohibit SVs (GPS)	,	Prohibit SVs (GLONASS)	,	Prohibit SVs (Galileo)	,	Prohibit SVs (QZSS)	,	Prohibit SVs (SBAS)]	*hh	<CR>	<LF>
7		8		9		10		11			

Num	Contents	Range	Default	Remark
1	FIXMASK	-	-	Command Name
2	mode	USER	-	Fixed Value
3	elevmask	0 to 90	0	Elevation mask (in degree) Only SVs whose age is within this threshold are used in the position fix calculation.
4	Reserve1	0	0	Reserve field
5	snrmask	0 to 99	0	Signal level mask (in dB-Hz) Only SVs above this mask are fixed.
6	Reserve2	0	0	Reserve field
7	Prohibit SVs (GPS)	32BIT (HEX)	0	GPS Satellite number mask Each bit represents one SVID. The GPS satellites indicated by this field are not used in the position fix calculation. Lowest order bit means SV=01. Highest order bit means SV=32. △4
8	Prohibit SVs (GLONASS)	28BIT (HEX)	0	GLONASS Satellite number mask Each bit represents one SVID. The GLONASS satellites indicated by this field are not used in the position fix calculation. Lowest order bit means SV=65. Highest order bit means SV=92. △4
9	Prohibit SVs (Galileo)	20BIT (HEX)	0	Galileo Satellite number mask Each bit represents one SVID. This field is unimplemented. △4
10	Prohibit SVs (QZSS)	7BIT (HEX)	0	QZSS Satellite number mask Each bit represents one SVID. The QZSS satellites indicated by this field are not used in the position fix calculation. Lowest order bit means SV=93. Highest order bit means SV=99. △4
11	Prohibit SVs (SBAS)	19BIT (HEX)	0	SBAS Satellite number mask Each bit represents one SVID. The SBAS satellites indicated by this field are not used in fix. Lowest order bit means SV=33. Highest order bit means SV=51. △4

Example:

$PERDAPI,FIXMASK,USER,10,0,37,0,0x92,0x01,0x00,0x00,0x20000*50

Elevation mask: 10 degrees
Signal level mask: 37 dBHz
GPS mask: GPS (BIT2 = SVID 2), GPS (BIT5 = SVID 5) and GPS (BIT9 = SVID 9)
GLONASS mask: GLONASS (BIT1 = SVID 65)
SBAS mask: SBAS (BIT18 = SVID 50)

Notes:

- It is applied not only to First Fix or the time of a positioning return but to all the positioning.
- It is omissible after the 7th field.
- The response which is inserted current value to each field is obtained by receiving an effective command for setting or inputting a command which is omitted the fields after Command Name, that is, $PERDAPI,MASK,QUERY*50.

PPS – Setting of PPS（Pulse per second）△4 Format:

$PERDAPI	,	PPS	,	type	,	mode	,	period	,	pulse width	,	cable delay	,
		1		2		3		4		5		6	

polarity	[,	PPS accuracy threshold]	*hh	<CR>	<LF>
7		8			

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

Example:

$PERDAPI,PPS,LEGACY,1,0,200,0,0,25*29
Type: LEGACY PPS   Mode: Always output
1PPS Pulse width: 200 ms   cable delay: 0 ns
Polarity: rising edge of PPS is synchronous with UTC time.
PPS estimated accuracy threshold is 25nsec.

Notes: △4

- LEGACY PPS setting is output legacy PPS which is not synchronized with frequency which is output from GCLK pin, but which is output immediately after first fix in case of cold start.
- GCLK PPS setting is output GCLK PPS which synchronized with frequency which is output from GCLK pin, but it takes some to become GCLK PPS steady after first fix (typically, 1~2 minutes after fist fix). User can confirmed whether GCLK PPS is steady by GCLK accurate field of TPS4 sentence.
- User can choose GPS, UTC (USNO) and UTC (SU) as alignment of PPS by TIMEALIGN command. The default is UTC (USNO). As for details, please refer to the page of TIMEALIGN command.
- The condition of PPS synchronization is the follow.

[1] GPS alignment

PPS mode	Before first fix	After first fix
0	OFF	OFF
1	Sync with RTC	Sync with GPS
2~4	OFF	Sync with GPS

[2] UTC (USNO) alignment (default)

PPS mode	Before first fix	After first fix	After taking UTC (USNO) parameter from GPS
0	OFF	OFF	OFF
1	Sync with RTC	Sync with GPS	Sync with UTC (USNO)
2~4	OFF	Sync with GPS	Sync with UTC (USNO)

[3] UTC (SU) alignment

PPS mode	Before first fix	After first fix	After taking UTC (SU) parameter from GLONASS
0	OFF	OFF	OFF
1	Sync with RTC	Sync with GPS	Sync with UTC (SU)
2~4	OFF	Sync with GPS	Sync with UTC (SU)

- About PPS estimated accuracy, please refer to the page of CRX (TPS2) sentence.

RESTART - Restart command △4 Format:

$PERDAPI	,	RESTART	,	restart mode	*hh	<CR>	<LF>
		1		2			

Num	Contents	Range	Default	Remark
1	RESTART	-	-	Command Name
2	restart mode	HOT WARM COLD FACTORY	-	Restart mode

Example:

$PERDAPI,RESTART,COLD*08
Mode: cold restart

Notes: △4
- As for the differences depending on the restart mode, please refer to the page of "Backup of the Receiver Parameters (for BBRAM)".
- The data which is stored by FLASHBACKUP command in Flash is not cleared even if FACTORY restart is occurred.
- Power off/on of GT-87 corresponds to hot restart when it is within 4 hours after last fix.
- Power off/on of GT-87 corresponds to warm restart when it is over 4 hours after last fix.

TIME –Setting of time information △4

Initial time is configured. The setting of time is effective only within the case that time is not decided by other factors. A setting of a millennium which is the times of GPS week rollover is received also after time decision.

Format:

$PERDAPI	,	TIME	,	time of date	,	day	,	month	,	year	*hh	<CR>	<LF>
		1		2		3		4		5			

Num	Contents	Range	Default	Remark
1	TIME	-	-	Command Name
2	Time of date	00 to 23 00 to 59 00 to 59	0	UTC (Hour) UTC(Minute) UTC(Second)
3	day	1 to 31	22	UTC (Date)
4	month	1 to 12	8	UTC (Month)
5	year	2013 to 2099	1999	UTC (Year) △3

Example:

$PERDAPI,TIME,021322,24,11,2020*64
Time: 02:13:22 on 24th November, 2020

Notes: △4
- This command is needed to input correct date within +/- 1 year.
- Under normal conditions, User needs not to set initial time because time is decided by satellite navigation data.
- As for GPS week rollover timing and GT-87 week rollover timing, please refer to the follow.

event	date	GPS week
GPS week rollover timing (1st) **default time of date of GT-87**	**1999/08/22**	**1024**
GPS week rollover timing (2nd)	2019/04/07	2048
rollover timing of GT-87	**2032/08/15**	**2745**
GPS week rollover timing (3rd)	2038/11/21	3072
…		
operable time limit of GT-87	**2099/12/31**	**6260**

[In case that GT-87 does not have glonass]

GT-87 can keep outputting correct date after 2032/08/15 during power distribution.
GT-87 will output 2012/12/30 after 2032/08/15 unless user sets correct date by TIME command after user turns off GT-87 and also turns off backup current for BBRAM.

[In case that GT-87 has glonass]

GT-87 can adjust millennium automatically in the timing of first fix of glonass and outputs correct date until 2099/12/31 without user setting even if user turns off GT-87 and backup current.

TIMEZONE – Local Zone Time △4

This sentence is reflected to ZDA sentence (not only local zone field but also UTC time field).

Format:

$PERDAPI	,	TIMEZONE	,	sign	,	hour	,	minute	*hh	<CR>	<LF>
		1		2		3		4			

Num	Contents	Range	Default	Remark
1	TIMEZONE	-	-	Command Name
2	sign	0 to 1	0	GMT sign "0" shows positive, "1" shows negative.
3	hour	0 to 23	0	GMT (Hour)
4	minute	0 to 59	0	GMT (Minute)

Example:

$PERDAPI,TIMEZONE,0,9,0*69
As GMT offset, display time is carried out +9:00.

Notes: △4
- In UTC (SU) alignment, GMT offset is changed to +3:00 automatically.

SURVEY – Position Mode △1 Format:

$PERDAPI	,	SURVEY	,	position mode	[,	sigma threshold	,	time threshold]
		1		2		3		4

[,	latitude	,	longitude	,	altitude]]	*hh	<CR>	<LF>
	5		6		7			

Num	Contents	Range	Default	Remark
1	SURVEY	-	-	Command Name
2	position mode	0 to 3	2	0: Normal NAV (navigation) mode 1: Position Survey SS (self survey) mode 2: Position Survey CSS (continual self survey) mode 3: Position-hold TO (time only) mode
3	sigma threshold	0 to 255	0 △3	Sigma threshold (m) which changes automatically to position-fixed. (When the threshold value is 0, it is not used.)
4	time threshold	0 to 10080	480 (8hours) △3	Time threshold (minute) which changes automatically to position-fixed. (When the threshold value is 0, it is not used.)
5	latitude △1	-90 to 90	0	Latitude for hold position in TO mode. (degree) A positive number means the north latitude and a negative number means the south latitude. This field can be set only when position mode is 3.
6	longitude △1	-180 to 180	0	Longitude for hold position in TO mode. (degree) A positive number means the east longitude and a negative number means the west longitude. This field can be set only when position mode is 3.
7	altitude △1	-1000 to 18000	0	Altitude for hold position in TO mode. (m) This field can be set only when position mode is 3.

Example:

$PERDAPI,SURVEY,1,10,1440*74

Mode: SS mode   Sigma Threshold: 10   Time Threshold: 1440

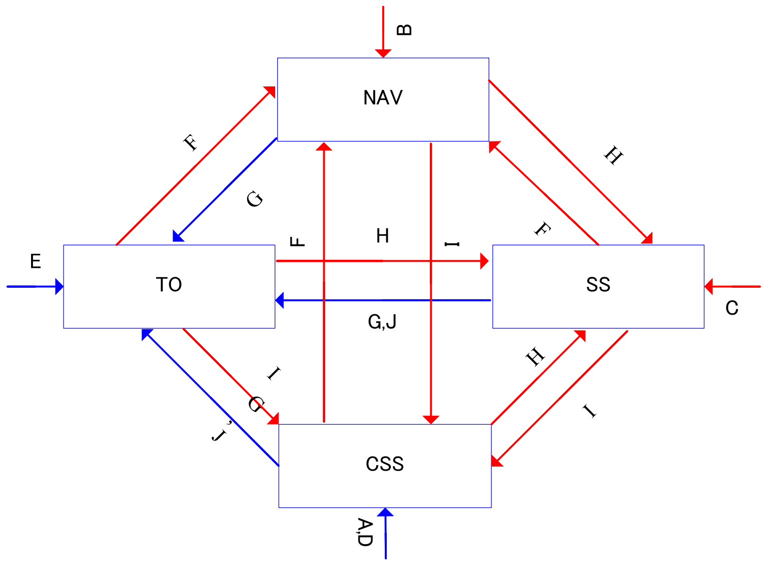
$PERDAPI,SURVEY,3,0,0,37.78700,-122.45100,31.5*53

Mode: TO mode   Sigma Threshold: 0   Time Threshold: 0

Fixed position: 37.78700 degrees north 122.45100 degrees west Altitude: 31.5 m

Notes:

- It is omissible after the 3rd field.
- When the position mode is "1", a position is re-calculated after power supply OFF/ON. Please use it, when the antenna position may change before power supply OFF.
- When the position mode is "2", after power supply OFF/ON, the estimated position that calculated before power supply OFF is kept, and the position is updated. By using it when the antenna position does not change after the power supply OFF, the time for changing to Position-hold mode can be shortened.
- In order to change automatically to Position-hold mode, it is necessary to set to Survey mode.
- If both sigma threshold and time threshold are configured, the position mode changes to Position-hold mode when either is fulfilled. When the threshold value is 0, it is not used.
- The displayed position may differ a little from the configured position due to conversion error.
- Hot start is occurred when survey mode is shift to NAV mode. △1



Flow chart about position mode

	Transition condition	Whether keep or not survey position and number of times of survey process
A	After first power on, or after factory restart (default)	Discard
B	After power on in case that last mode is "SURVEY,0".	Discard
C	After power on in case that last mode is "SURVEY,1".	Discard
D	After power on in case that last mode is "SURVEY,2".	Keep
E	After power on in case that last mode is "SURVEY,3".	Keep
F	"SURVEY,0" command	Discard
G	"SURVEY,3" after self survey position is fixed. "SURVEY,3" with user's hold position.	Keep
H	"SURVEY,1" command	Discard
I	"SURVEY,2" command	Discard

J	The condition of survey is satisfied. [*] Position mode is always started by time only mode if TO mode by this condition and power off.	Keep

FREQ – Setting of GCLK FREQUENCY △2△7 Format:

$PERDAPI	,	FR	,	mode	,	freq	[,	duty	,	offset]	*hh	<CR>	<LF>
		1		2		3		4		5			

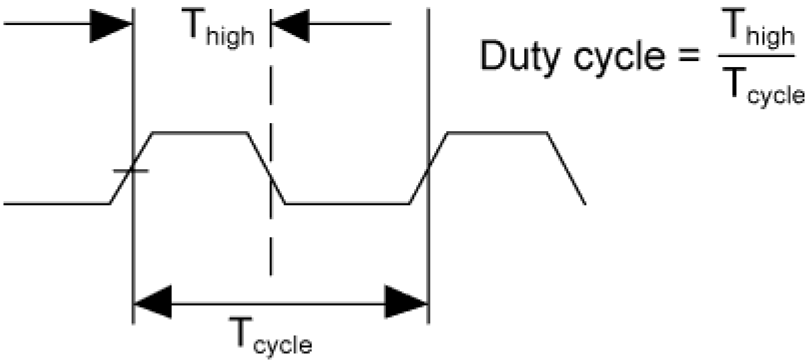
Num	Contents	Range	Default	Remark
1	FREQ	-	-	Command Name
2	mode	0 to 1	0	0 : stop 1 : output
3	freq	4000 to 40000000	10000000 (10MHz)	frequency[Hz]
4	duty △2	10 to 90 △7	50	duty cycle [%]
5	offset △2	0 to 99	0	phase delay in cycle [%] from GCLK-PPS edge

Example:

$PERDAPI,FREQ,1,10000000*47
Mode: output
Frequency: 10MHz

Notes:

- It is omissible after the 4th field.
- The response which is inserted current value to each field is obtained by receiving an effective command for setting or inputting a command which is omitted the fields after Command Name, that is, $PERDAPI,FREQ,QUERY*11.
- Duty cycle is derived from Thigh / Tcycle in the follow figure. △2
- User can stock current FREQ command setting on Flash by FLASHBACKUP command.



DEFLS – Setting of default leap second △4 △6 Format:

$PERDAPI	,	DEFLS	,	sec	[,	mode]	*hh	<CR>	<LF>
		1		2		3			

Num	Contents	Range	Default	Remark
1	DEFLS	-	-	Command Name
2	sec	0 to 32	16	Default leap second
3	mode	AUTO or FIXED	AUTO	AUTO: default leap second is updated automatically after taking leap second from satellites. FIXED: default leap second is kept as user setting.

Example:

$PERDAPI,DEFLS,16,AUTO*27

Default leap second: 16 second (this value is updated automatically).

Notes:

- It is omissible after the 3rd field.
- This value is used before leap second is confirmed by other factors which are to take UTC (USNO) parameter which is broadcasted from GPS or to take time difference between GPS and GLONASS.
- GT-87 can store current DEFLS command setting in Flash by FLASHBACKUP command.
- Cold restart (time also be cleared) is run when this command is run. △6

TIMEALIGN – setting of time alignment ⊿*4 Format:*

		1		2			
$PERDAPI	,	TIMEALIGN	,	mode	*hh	<CR>	<LF>

Num	Contents	Range	Default	Remark
1	TIMEALIGN	-	-	Command Name
2	mode	1 to 3	2	1 : GPS alignment 2 : UTC(USNO) alignment 3 : UTC(SU) alignment

Example:

$PERDAPI,TIMEALIGN,2*31
UTC (USNO) alignment

Notes:

- Please note that mode 0 is invalid value.
- User can store current TIMEALIGN command setting on Flash by FLASHBACKUP command.
- This command is used to set output time alignment and 1PPS alignment.

[1: GPS alignment]

･Leap second is not applied to output time even if GT-87 already has leap second.
･PPS is output in synchronization with GPS even if GT-87 already has UTC parameter.
･In Glonass only mode, correct default leap second is needed to output correct time.

[2: UTC (USNO) alignment]

･Leap second is applied to output time.
･PPS is output in synchronization with GPS before taking UTC (USNO) parameter from GPS.
･PPS is output in synchronization with UTC(USNO) after taking UTC (USNO) parameter from GPS.
･In Glonass only fix, because GT-87 can't take UTC (USNO) parameter from GLONASS, PPS is kept to output in synchronization with GPS.

[3: UTC (SU) alignment]

･Leap second is applied to output time. And, GMT offset is set as +3:00.
･PPS is output in synchronization with GPS before taking UTC (SU) parameter from GLONASS.
･PPS is output in synchronization with UTC(SU) after taking UTC (SU) parameter from GLONASS.
･In GPS only fix, because GT-87 can't take UTC (SU) parameter from GPS, PPS is kept to output in synchronization with GPS.

Restriction:

Output time

	GPS only fix setting	GLONASS only fix setting	GPS + GLONASS setting
GPS alignment	OK	**accurate default leap second is required [*1]**	OK
UTC(USNO) alignment	OK	OK	OK
UTC(SU) alignment	OK	OK	OK

PPS

	GPS only fix setting	GLONASS only fix setting	GPS + GLONASS setting
GPS alignment	OK	OK	OK
UTC(USNO) alignment	OK	**NG**	OK
UTC(SU) alignment	**NG**	OK	OK

[*1] In GPS alignment and GLONASS only fix setting, to output correct output time, user needs to set accurate default leap second by DEFLS command.

- In this graph, QZSS is treated as GPS.

FLASHBACKUP – Setting of backup in Flash 4 Format:

$PERDAPI	,	FLASHBACKUP	,	type	*hh	<CR>	<LF>
		1		2			

Num	Contents	Range	Default	Remark
1	FLASHBACKUP	-	-	Command Name
2	type	0x00 to 0x07 (HEX)	0x00	Target of backup Each bit represents one command setting 0x01 : FREQ command setting 0x02 : DEFLS command setting 0x04 : TIMEALIGN command setting 0x00 means that flash backup is initialised.

Example:

$PERDAPI,FLASHBACKUP,0x03*4E

Current setting of FREQ and DEFLS command is stored in flash.

Notes:

- This data stored in Flash is erased when software update.
- This data stored in Flash is not erased by factory cold restart.
- Hot start is occurred when this command is input.
- Please don't turn off GT-87 during this command is sent.

Restriction:

GT-87 has two ways to backup data.

[1] BBRAM

BBRAM is RAM which is available to store data as long as backup current is impressed. GT-87 can store ephemeris data, almanac data and configuration which user sets by commands etc in BBRAM, and the data is not erased even if GT-87 is turned off.

The backup timing of BBRAM is every second. The data is cleared when user inputs RESTART command and/or user turns off backup current.

[2] FLASH

GT-87 can store FREQ command setting, DEFLS command setting and/or TIMEALIGN command setting in flash when user inputs FLASHBACKUP command. The data is not erased even if GT-87 is turned off or RESTART command. The data is cleared when user inputs FLASHBACKUP command or software update.

If GT-87 has different backup data between BBRAM and Flash, BBRAM data have a priority over flash. In this case, when the data of BBRAM is invalid because that backup current is turned off, Flash data is applied.

CROUT – Setting of CR Output Format:

$PERDAPI	,	CROUT	,	type	,	rate	*hh	<CR>	<LF>
		1		2		3			

Num	Contents	Range	Default	Remark
1	CROUT	-	-	Command Name
2	type	N,M,W,X,Y,Z	W,X,Y,Z	Output CR sentence [*] Alphabets of outside range are reserved.
3	rate	W,X,Y,Z : 0 to 255 N,M : 0 to 1	1	W,X,Y,Z : 1-255:Update interval of the sentence (sec) 0: The sentence(s) is/are stopped. N,M : 1: Sentence(s) is/are output every event occurred. 0: The sentence(s) is/are stopped.

Example:

$PERDAPI,CROUT,W,1*4E
CRW (TPS1) sentence is output every second.

$PERDAPI,CROUT,XZ,3*19
CRX (TPS2) sentence and CRZ(TPS4) sentenced are output every 3 seconds.

$PERDAPI,CROUT,W,0*4F
CRW (TPS1) sentence is stopped.

$PERDAPI,CROUT,N,1*57
CRN sentence is output every event occurred.

Notes:

- “M” or/and “N” can be output only in case that baud rate is 115200bps. △1

7 CFG – Setting of Application Software

NMEAOUT – Standard NMEA Output △9

Format:

$PERDCFG	,	NMEAOUT	,	type	,	interval	*hh	<CR>	<LF>
		1		2		3			

Num	Contents	Range	Default	Remark
1	NMEAOUT	-	-	Command Name
2	type	[*1]	-	Standard NMEA sentence [*1] GGA, GLL, GNS, GSA, GSV, RMC, VTG, ZDA, ALL△9. (ALL means all sentences from GGA to ZDA.)
3	Interval	0 to 255	-	Update interval of the sentence (sec) When the value is "0", the sentence is output only once. After that, the sentence is stopped.

Example:

$PERDCFG,NMEAOUT,GGA,2*57
Interval: 2 seconds

$PERDCFG,NMEAOUT,GSV,0*56
GSV sentence is output only once. After that, GSV sentence is stopped.

UART1 – Serial Communication Port Format:

$PERDCFG	,	UART1	,	baud	*hh	<CR>	<LF>
		1		2			

Num	Contents	Range	Default	Remark
1	UART1	-	-	Command Name
2	baud	4800, 9600, 19200, 38400, 57600 or 115200	38400	Baud rate (bps)

Example:

$PERDCFG,UART1,115200*65
Baud rate: 115200 bps

Notes:

- When the setting of the serial communication port is changed by this command, ACK sentence is output by the baud rate which was being used.

- In case of using low baud rate, please adjust size of output sentence by NMEAOUT command and CROUT command to output all sentence within one second.

SYS – PVT System

1.2 VERSION – Software Version

Format:

$PERDSYS	,	VERSION	*hh	<CR>	<LF>
		1			

Num	Contents	Range	Default	Remark
1	VERSION	-	-	Command Name

Example:

$PERDSYS,VERSION*2C

GPIO – General Purpose Input/output Format:

$PERDSYS	,	GPIO	*hh	<CR>	<LF>
		1			

Num	Contents	Range	Default	Remark
1	GPIO	-	-	Command Name

Example:

$PERDSYS,GPIO*67

8 Proprietary NMEA Output Sentences

This sentence is a protocol only for our company. It starts from "$PERD" which shows that it is an original sentence.

ACK – Output the Command Reception Check Format:

$PERDACK	,	command 1	,	sequence 2	,	subcommand	*hh	<CR>	<LF>

Num	Contents	Range	Default	Remark
1	command	-	-	First field of received command
2	sequence	-1 to 255	0	The number of times successful for the reception. It is added 1 whenever it succeeds in command reception, and 0 to 255 is repeated. When command reception is failed, -1 is returned.
3	subcommand	-	-	Second token of input command

Example:

$PERDACK,PERDAPI,-1,PPS*72
PERDAPI,PPS command input is failed.

Notes:

- As for the command, check sum must be effective before ACK is sent.

9 CR – eRide GNSS Core Library Interface

CRW(TPS1) – Output Time Transfer Info per Second (Date and leap second) △4 △5 *Format:*

$PERDCRW	,	TPS1	,	Date & Time	,	time status	,	update date	,	present LS	,
		1		2		3		4		5	

future LS	,	pps status	*hh	<CR	<LF>
6		7			

Num	Contents	Range	Default	Remark
1	TPS1	-	-	Command Name
2	Date & Time	14-byte fixed length	19990822000000	Present date and time year, month, day, hour, minute, second
3	time status	0 to 2 (1byte)	0	Present time status of output sentence 0: RTC 1: GPS (GT-87 doesn't apply leap second or has only default leap second) 2: UTC (GT-87 has confirmed leap second and applies it.)
4	update date	14-byte fixed length	00000000000000	Leap second update schedule year, month, day, hour, minute, second This date indicates zero when no leap second update schedule.
5	present LS	-31 to +32 (3byte)	+16 △5	Present leap second received from satellites
6	future LS	-31 to +32 (3byte)	+00	Future leap second received from satellites
7	pps status △4	0 to 3 (1byte)	0	Present pps is synced with the follow. 0:RTC 1:GPS 2:UTC(USNO) 3:UTC(SU)

Example:

$PERDCRW,TPS1,20120303062722,2,20120701000000,+15,+16,2*09

Present date: 2012/03/03 06:27:22
Time status: present time of output sentence is sync with UTC.
Leap second update schedule: 2012/7/1 00:00:00
Current leap second: +15
Future leap second: +16

Pps status: present pps is sync with UTC (USNO)

Notes:

- This command is output every second.
- Present LS is current leap second. This is updated in the timing of leap second update schedule.
- $PERDAPI,CROUT,W,0*4F stops outputting this command.
- Update data indicate zero when no update schedule.

Restriction:

About time status

alignment	Before first fix	After first fix	After taking confirmed leap second
GPS	RTC	GPS	GPS
UTC(USNO)	RTC	GPS	UTC
UTC(SU)	RTC	GPS	UTC

About leap second which is used to adjust output time

alignment	Before first fix	After first fix	After taking confirmed leap second
GPS	0	0	0
UTC(USNO)	Default leap second	Default leap second	confirmed leap second
UTC(SU)	Default leap second	Default leap second	confirmed leap second

GT-87 takes confirmed leap second when GT-87 takes UTC (USNO) parameter which is broadcasted from GPS or takes time both GPS and GLONASS.

CRX(TPS2) – Output Time Transfer Info per Second (PPS) △4 Format:

$PERDCRX	,	TPS2	,	pps status	,	pps mode	,	pps period	,	pulse width	,	cable delay
		1		2		3		4		5		6

,	polarity	,	pps type	,	estimated accuracy	,	Sawtooth	,	pps acc threshold	*hh	<CR>	<LF>
	7		8		9		10		11			

Num	Contents	Range	Default	Remark
1	TPS2	-	-	Command Name
2	pps status	0 to 1 (1byte)	0	Output status of 1PPS 0: 1PPS OFF 1: 1PPS ON
3	pps mode	0 to 4 (1byte)	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
4	period	0 to 1 (1byte)	0	1PPS output interval 0: 1PPS (A pulse is output per second) 1: PP2S (A pulse is output per two seconds)
5	pulse width	001 to 500 (3byte)	200	1PPS pulse width (ms)
6	cable delay	-100000 to +100000 (7byte)	+000000	1PPS cable delay (ns)
7	polarity	0 to 1 (1byte)	0	0 : rising edge 1 : falling edge
8	pps type	0 to 1 (1byte)	0	0 : LEGACY PPS 1 : GCLK PPS
9	estimated accuracy	0000 to 9999 (4byte)	0	1PPS estimated accuracy. (ns)
10	Sawtooth	-1.760 to +1.760 (6byte)	+0.000	Sawtooth correction (ns)
11	pps acc threshold	0000 0005 to 9999 (4byte)	1000	PPS estimated accuracy threshold (ns) This threshold is used for pps mode 4. 0 means that this threshold is not used.

$PERDCRX,TPS2,1,2,0,200,+001000,0,0,0005,+0.000,1000*29

PPS status: PPS ON (1)
PPS mode: during on fix (2)
PPS period: 1PPS (0)
PPS pulse width: 200ms
PPS cable delay: +1000ns
Polarity: rising edge
Type: LEGACY PPS
Estimated accuracy: 5ns
Sawtooth: +0.000ns
PPS estimated accuracy threshold: 1us

Notes:

- This command is output every second.
- $PERDAPI,CROUT,X,0*40 stops outputting this command.
- Output Values of period, pulse width, polarity are switched by pps type (LEGACY or GCLK).
- PPS estimated accuracy means estimated difference between PPS of GT-87 and GPS, UTC (USNO) or UTC (SU) timing which user sets by TIMEALIGN command. This is not guarantee value, but user can use this value to get a rough idea.
- Sawtooth means correction value under the resolution of GT-87, that is, about 3.5 ns.
- Sawtooth value is applied to prior to the one second PPS.

Corrected PPS [t-1] = output PPS [t-1] + Sawtooth value [t]

CRY(TPS3) – Output Time Transfer Info per Second (Survey & TRAIM) Format:

$PERDCRY	,	TPS3	,	pos mode	,	sigma	,	sigma threshold	,	time	,	time threshold	,
		1		2		3		4		5		6	

TRAIM solution	,	TRAIM status	,	Removed SVs	,	Receiver status	*hh	<CR>	<LF>
7		8		9		10			

Num	Contents	Range	Default	Remark
1	TPS3	-	-	Command Name
2	pos mode	0 to 3 (1byte)	2	Positioning mode 0: Normal 1: Survey mode (re-calculation for every power supply OFF/ON) 2: Survey mode(calculation continuously before and after power supply OFF/ON) 3: Position-hold mode
3	sigma	0000 to 1000 (4byte)	1000	Current variance value of survey position (m)
4	sigma threshold	000 to 255 (3byte)	000 △3	Sigma threshold (m) which changes automatically to position-fixed.
5	time	0 to 999999 (6byte)	000000	Current update times of survey position (sec). It is not updated at the time of positioning interruption.
6	time threshold	0 to 604800 (6byte)	028800 △3	Time threshold (sec) which changes automatically to position-fixed.
7	TRAIM solution	0 to 2 (1byte)	2	TRAIM solution 0: OK 1: ALARM 2: UNKNOWN, due to a. alarm threshold set too low b. insufficient satellites being tracked
8	TRAIM status	0 to 2 (1byte)	2	TRAIM status 0: detection and isolation possible 1: detection only possible 2: neither possible
9	removed SV	0 to 3 (2byte)	00	number of the removed satellite by TRAIM
10	Receiver status △3	10byte	0x00000000	Reserve field

$PERDCRY,TPS3,2,0003,001,002205,086400,0,0,00,0x00000000*68

Positioning mode: Survey mode (calculation continuously) (2)
Survey sigma: 3 [m]
Survey sigma threshold: 1 [m]
Survey time: 2205 [seconds]
Survey time threshold: 86400 [seconds]
TRAIM solution: OK (0)
TRAIM status: OK (0)
Removed SVs: 0
Receiver status: 0x00000000

Notes:

- This command is output every second.
- $PERDAPI,CROUT,Y,0*41 stops outputting this command.

CRZ (TPS4) – Output Time Transfer Info per Second (FREQUENCY) ⊿3 Format:

$PERDCRZ	,	TPS4	,	freq mode	,	Freq status	,	GCLK accuracy	,	e	,	de	,
		1		2		3		4		5		6	

lock cnt	,	lockoff cnt	,	reserve	,	IDtag	GCLK setting 1	,	GCLK setting 2	*hh	<CR>	<LF>
7		8		9		10	11		12			

Num	Contents	Range	Default	Remark
1	TPS4	-	-	Command Name
2	freq mode	1 to 6 (1byte)	1	1: warm up 2: lock 3: hold over 4: free run 5: coarse mode 6: fine mode
3	Freq status	0 or 1 (1byte)	0	0: Not output 1: Output
4	GCLK accuracy	0 or 1 (1byte)	0	0: Not accurate 1: GCLK PPS and GCLK frequency are accurate
5	e	-999999 to +999999 (7byte)	-	Phase delay between LEGACY and GCLK PPS (no dimensional)
6	de	-999999 to +999999 (7byte)	-	Amount of change of phase delay (no dimensional)
7	lock cnt	0 to 999999 (7byte)	-	Duration time of Lock (sec)
8	lockoff cnt	0 to 999999 (7byte)	-	Duration time of holdover/free run (sec)
9	reserve	0x00 to 0xFF (6byte)	-	Reserve field
10	IDtag	(6byte)	-	Product name and last two digits of product version In case of GT-8777 of "4850466003" ➔ 8777 + 03 = 877703 In case of GT-87 of "4850466005" ➔ 8700 + 05 = 870005
11	GCLK setting 1	(4byte)	-	Reserve field
12	GCLK setting 2	(4byte)	-	Reserve field

$PERDCRZ,TPS4,1,1,0,+000000,+000000,+000000,+000000,000000,000000,0x15,0000*57
Freq mode: warm up
Freq status: output
GCLK accuracy: accurate

Notes:

- This command is output every second.
- $PERDAPI,CROUT,Z,0*42 stops outputting this command.

CRM – Measurement Data of GPS

Format:

$PERDCRM	,	time	,	sennum	,	maxsen	,	system	,	svid	,	reserve
		1		2		3		4		5		6

snr	,	adr	,	doppfreq	,	pseudorange	*hh	<CR>	<LF>
7		8		9		10			

Num	Contents	Range	Default	Remark
1	time	0 to 604799	-	GPS time of week
2	sennum	1 to 32	-	Sentence number
3	maxsen	1 to 32	-	Maximum number of sentences
4	system	1	-	GNSS system ID (1=GPS)
5	svid	1 to 99	-	Satellite number
6	reserve	1 to 3	-	Reserve field
7	snr	0 to 55	-	Signal to Noise Ration [dB-Hz]
8	adr	32bit	-	Accumulated Doppler Range [Cycles, LSB=-6]
9	doppfreq	32bit	-	Doppler Frequency [meters/sec, LSB=-12]
10	pseudorange	32bit	-	Pseudrange [meters, LSB=-6]

Example:

$PERDCRM,467055,9,10,1,18,2,40,251470,-225117,1630912949*4C

Notes:

- This sentence will be output as a set once per second and will contain measurements for all GPS systems.
- To output this sentence, please input "$PERDAPI,CROUT,M,1*54" when baud rate is 115200bps.

CRN – Navigation Data

Format:

$PERDCRN	,	system	,	svid	,	subframe data	*hh	<CR>	<LF>
		1		2		3			

Num	Contents	Range	Default	Remark
1	system	1	-	GNSS system ID (1=GPS)
2	svid	1 to 99	-	Satellite number
3	subframe data	10 words (60 strings)	-	Subframe data no parirt included

Example:

$PERDCRN,1,7,8B0B349809AC00424A2471C5FF9F27BB10C82EB5884CC987FFA50C0BF2A8*0C

Notes:

- For each GPS satellite decoding data, this string is output once every 6 seconds.
- For GPS, the subframe field is a hexadecimal representation of all 10 words of a subframe.
- If a word was not decoded or contained a parity error, the six characters associated with that word will be reported as "------".
- To output this sentence, please input "$PERDAPI,CROUT,N,1*57" when baud rate is 115200bps.

SYS – Answer of PVT System

7.3.1 ERSION- Software Version

Format:

$PERDSYS	,	VERSION	,	device	,	version	,	reserve1	,	reserve2	*hh	<CR>	<LF>
		1		2		3		4		5			

Num	Contents	Range	Default	Remark
1	VERSION	-	-	Command Name
2	device	-	-	Device Name
3	version	-	-	Version number
4	reserve1	-	-	Reserve field
5	reserve2	-	-	Reserve field

Example:

$PERDSYS,VERSION,OPUS7_SFLASH_ES2_64P,ENP622A1226410F,QUERY,N/A*1A

Notes:

- Character string of the device and version is free format.

GPIO- General Purpose Input/output Format:

$PERDSYS	,	GPIO	,	state	*hh	<CR>	<LF>
		1		2			

Num	Contents	Range	Default	Remark
1	GPIO	-	-	Command Name
2	state	H or L	-	GPIO state (H:High , L:Low)

Example:

$PERDSYS,GPIO,HHHHLLLL*4B

Notes:

- This first character represents GPIO 0 and the last character represents GPIO 8.

FIXSESSION- Fix Session ▵1 Format:

$PERDSYS	,	FIXSESSION	,	reserve1	[,	reserve2	,	reserve3]	*hh	<CR>	<LF>
		1		2		3		4			

Num	Contents	Range	Default	Remark
1	FIXSESSION	-	-	Command Name
2	reserve1	-	-	reserve field
3	reserve2	-	-	reserve field
4	reserve3	-	-	reserve field

Example:

$PERDSYS,FIXSESSION,ON,19015,19.015*7C

Notes:

- This string is sent when certain events occur. This is for *eRide* use only.

ANTSEL- Antenna selecting ▵1 Format:

$PERDSYS	,	ANTSEL	,	reserve1	,	reserve2	*hh	<CR>	<LF>
		1		2		3			

Num	Contents	Range	Default	Remark
1	ANTSEL	-	-	Command Name
2	reserve1	-	-	reserve field
3	reserve2	-	-	reserve field

Example:

$PERDSYS,ANTSEL,FORCE1L,1LOW*32

Notes:

- This string is sent when certain events occur. This is for *eRide* use only.

BBRAM - Battery Backup Random Access Memory △1 Format:

$PERDSYS	,	BBRAM	,	reserve1	[,	reserve2]	*hh	<CR>	<LF>
		1		2		3			

Num	Contents	Range	Default	Remark
1	BBRAM	-	-	Command Name
2	reserve1	-	-	reserve field
3	reserve2	-	-	reserve field

Example:

$PERDSYS,BBRAM,PASS*15

Notes:

- This string is sent when certain events occur. This is for *eRide* use only.

MSG – Event Driven Message △1 Format:

$PERDMSG	,	key	[,	string]	*hh	<CR>	<LF>
		1		2			

Num	Contents	Range	Default	Remark
1	key	-	-	Alphanumeric event indicator
2	string	-	-	Description of event

Example:

$PERDMSG,1A*06

Notes:

- This string is sent when certain events occur. Some strings are for *eRide* use only and contain only an alphanumeric key. Others provide user feedback and contain description of the event.

10 Backup of the Receiver Parameters (for BBRAM) △4

The parameters which this receiver has backed up are shown below.

Chart. Backup of the receiver parameter

CONTENTS	PARAMETER	HOT	WARM	COLD	FACTORY	POWER OFF/ON
Present time	Date & Time	YES	YES	YES	NO	YES
	Millennium	YES	YES	YES	NO	YES
Receiver's present position	Latitude	YES	YES	YES	NO	YES
	Longitude	YES	YES	YES	NO	YES
	Altitude	YES	YES	YES	NO	YES
Receiver's hold position[*1]	Latitude	YES	YES	YES	NO	YES[*3]
	Longitude	YES	YES	YES	NO	YES[*3]
	Altitude	YES	YES	YES	NO	YES[*3]
Ephemeris	Ephemeris data	YES	NO	NO	NO	YES[*2]
Almanac	Almanac data	YES	YES	NO	NO	YES

Chart. Backup of the receiver parameter of command

COMMAND NAME	PARAMETER	HOT	WARM	COLD	FACTORY	POWER OFF/ON
GNSS	GNSS setting	YES	YES	YES	NO	YES
FIXMASK	FIXMASK setting	YES	YES	YES	NO	YES
PPS	PPS setting	YES	YES	YES	NO	YES
TIMEZONE	GMT setting	YES	YES	YES	NO	YES
SURVEY	position mode	YES	YES	YES	NO	YES
	Sigma threshold for survey	YES	YES	YES	NO	YES
	Time threshold for survey	YES	YES	YES	NO	YES
	Current sigma for survey	YES[*3]	YES[*3]	YES[*3]	NO	YES[*3]
	Current time for survey	YES[*3]	YES[*3]	YES[*3]	NO	YES[*3]
FREQ	FREQ setting	YES	YES	YES	NO	YES
CROUT	CROUT setting	YES	YES	YES	NO	YES
DEFLS	Default leap sec	YES	YES	YES	NO	YES

TIMEALIGN	Time alignment	YES	YES	YES	NO	YES
FLASHBACKUP	Backup in flash	YES	YES	YES	YES	YES

Chart. Backup of the configure parameter of command

COMMAND NAME	PARAMETER	HOT	WARM	COLD	FACTORY	POWER OFF/ON
UART1	Baud rate of UART1	YES	YES	YES	YES	NO
NMEAOUT	NMEA output interval	YES	YES	YES	YES	NO

[*1] The position calculated by position survey mode or input by $PERDAPI,SURVEY,3. [*2] There is a time limitation (4 hours).
[*3] CSS (continues survey) mode or TO (time only) mode only

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User Manual **$GPNVS**

Appendix C: $GPNVS Status String Definitions

Contents

1.0 The $GPNVS Serial Status String

Novus products provide, in many cases, serial data output from a standard GNSS receiver matching the NMEA 0183 protocol. This is usually a direct connection to the receiver.

In addition to NMEA, Novus Products which provide an additional RS232 serial port for status monitoring, will be set up to meet the following protocols. These are designed to be standardized across different products, and easy to port and use via serial-to-ethernet connections.

Many products will have some, but not all, of the following strings, if configured for the optional status RS232.

The following products comply with this document:

1. ND0115
2. NR2310-OG
3. NR2315
4. NR2110-O
5. NR2110-OG (Separate Status Port)
6. NR2110-OG (Combined NMEA/Status Port)
7. NR6720
8. NR2304

Note: The NR2110-OG with combined NMEA and Status Port complies with section 2.0 "Combined NMEA/Status RS232"

1.1 Status String ($GPNVS,1) Fault Bytes

$GPNVS	1	hhmmss	mmddyy	A	A	nn	nn	0x0000	0x00	0x00	n	n	*	XX
1	2	3	4	5	6	7	8	9	10	11	12	13		14

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	1
3.	Time (UTC)	hhmmss
4.	Date	mmddyy
5.	GPS 1 Lock (Valid)	"A" = Valid, "V" = Not Valid, "N" = N/A
6.	GPS 2 Lock (Valid)	"A" = Valid, "V" = Not Valid, "N" = N/A
7.	# of Sats in View (1)	Greater of GPS or GNSS count, "N" = N/A
8.	# of Sats in View (2)	Greater of GPS or GNSS count, "N" = N/A
9.	Channel Fault Byte	0x0000 to 0xFFFF (Hex OR'd value)
10.	Power Supply Fault Byte	0x00 to 0xFF (Hex OR'd value)
11.	Error Message Byte	0x00 to 0xFF (Hex OR'd value)
12.	Antenna 1	"0" = Ok, "1" = Error, "N" = N/A
13.	Antenna 2	"0" = Ok, "1" = Error, "N" = N/A
14.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,1,233518,092516,A,A,10,11,0x0000,0x00,0x00,0,0*23

1.2 Status String ($GPNVS,2) Channel Values 1-8

$GPNVS	2	hhmmss	ddmmyy	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	*	XX
1	2	3	4	5	6	7	8	9	10	11	12		13

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	2
3.	Time (UTC)	hhmmss
4.	Date	mmddyy
5.	Channel 1 Vrms	0.00 to 3.30 [V]
6.	Channel 2 Vrms	0.00 to 3.30 [V]
7.	Channel 3 Vrms	0.00 to 3.30 [V]
8.	Channel 4 Vrms	0.00 to 3.30 [V]
9.	Channel 5 Vrms	0.00 to 3.30 [V]
10.	Channel 6 Vrms	0.00 to 3.30 [V]
11.	Channel 7 Vrms	0.00 to 3.30 [V]
12.	Channel 8 Vrms	0.00 to 3.30 [V]
13.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,2,233518,092516,2.56,2.48,2.51,2.60,2.44,2.53, 2.51,2.60*6C

Note: For units with fewer than the number of channels listed, a null value will be present.

1.3 Status String ($GPNVS,3) Power Supply Values

$GPNVS	3	hhmmss	ddmmyy	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	n	nn	*	XX
1	2	3	4	5	6	7	8	9	10	11	12	13	14		15

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	3
3.	Time (UTC)	hhmmss
4.	Date	mmddyy
5.	Power Supply 1	-30.0 to 30.0 [V]
6.	Power Supply 2	-30.0 to 30.0 [V]
7.	Power Supply 3	-30.0 to 30.0 [V]
8.	Power Supply 4	-30.0 to 30.0 [V]
9.	Power Supply 5	-30.0 to 30.0 [V]
10.	Power Supply 6	-30.0 to 30.0 [V]
11.	Power Supply 7	-30.0 to 30.0 [V]
12.	Power Supply 8	-30.0 to 30.0 [V]
13.	Built in Test (BIT)	0 = Ok, 1 = Fail
14.	Temperature (C)	-40 to 99
15.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,3,233518,092516,-7.84,7.93,-11.8,12.1,0.00,0.00,0.00,1.92,0,
26*62

Note: Depending on configuration, Power Supply values will be defined differently, and some Power Supply values may not be present.

1.4 Status String ($GPNVS,4) Channel Values 9-16

$GPNVS	4	hhmmss	ddmmyy	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	*	XX
1	2	3	4	5	6	7	8	9	10	11	12		13

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	4
3.	Time (UTC)	hhmmss
4.	Date	mmddyy
5.	Channel 9 Vrms	0.00 to 3.30 [V]
6.	Channel 10 Vrms	0.00 to 3.30 [V]
7.	Channel 11 Vrms	0.00 to 3.30 [V]
8.	Channel 12 Vrms	0.00 to 3.30 [V]
9.	Channel 13 Vrms	0.00 to 3.30 [V]
10.	Channel 14 Vrms	0.00 to 3.30 [V]
11.	Channel 15 Vrms	0.00 to 3.30 [V]
12.	Channel 16 Vrms	0.00 to 3.30 [V]
13.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,4,233518,092516,2.56,2.48,2.51,2.60,2.44,2.53,2.51,2.60*6A

Note: For units with fewer than the number of channels listed, a null value will be present.

1.5 Status String ($GPNVS,5) Sensors

$GPNVS	5	hhmmss	ddmmyy	nnn	nn	±nn	*	XX
1	2	3	4	5	6	7		8

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	5
3.	Time (UTC)	hhmmss
4.	Date	mmddyy
5.	Potentiometer	Hex Value 000 to FFF
6.	Fan PWM %	0 to 90
7.	Temperature	-40 to 99 [C]
8.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,5,233518,092516,45,00,25*70

1.6 Status String ($GPNVS,6) Status Bytes

There are two different Status Strings; one for everything except the NR2304 and one for the NR2304.

1.6.1 Status String ($GPNVS,6) Status Bytes; Standard

$GPNVS	6	0	A	0	0x0000	0x00	0x00	0x00	0	0x0000	0x0000	0x0000	*	XX
1	2	3	4	5	6	7	8	9	10	11	12	13		14

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	6
3.	Active PCB Assembly	0 or 1
4.	GNSS Lock	A = Locked, V = Unlocked
5.	Input Error	0 = Ok, 1 = A Error, 2 = B error
6.	Channel Status Word	0x0000 to 0xFFFF
7.	Primary PS Status	0x00 to 0xFF
8.	Secondary PS Status	0x00 to 0xFF
9.	Active PCB Status	0x00 to 0xFF
10.	Checksum Status	00 to 999
11.	Channel Fault Bin	0x0000 to 0xFFFF
12.	Primary PCB Amp Status	0x0000 to 0xFFFF
13.	Backup PCB Amp Status	0x0000 to 0xFFFF
14.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,6,0,A,0,0x0000,0x40,0x40,0x00,00,0x0000,0x0000,0x0000*63

See Status Byte Table for details.

1.6.2 Status String ($GPNVS,6) Status Bytes; Rubidium

$GPNVS	6	nnn	0x0000	nnn	0/1	*	XX
1	2	3	4	5	6		7

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	6
3.	Heat Sink Temperature	0-255
4.	Heater Current Voltage	0x0000-0x0136
5.	Measured Voltage in Heater	0-255
6.	Rb Locked	0 = Unlocked 1= Locked
7.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,9,136,0x002A,90,1*7E

1.7 Status String ($GPNVS,7) Status Bytes

$GPNVS	7	nnnnnn	nnnnnn	A	nn	0x00	0	0	0	nnnnnn	n.nn	n.nn	*	XX
1	2	3	4	5	6	7	8	9	10	11	12	13		14

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	7
3.	Time	hhmmss
4.	Date	mmddyy
5.	GPS Lock	“A” = Valid, “V” = Not Valid
6.	# of Sats in View (1)	Greater of GPS or GNSS count, “N” = N/A
7.	Error Byte	0x00 to 0xFF
8.	Freq Diff	±999 (last count, clock cycles)
9.	PPS Diff	±999 (last count, clock cycles)
10.	Freq Correction Slice	±999 (DAC bits, per second)
11.	DAC Value	Integer Representation, n x 1/(2^20)
12.	Power Supply	Vdc
13.	Power Supply	Vdc
14.	NMEA Checksum	*XX (xor’d value of bytes between $ and *)

Example:
$GPNVS,7,161505,081617,A,12,0x00,-1,-2,0,505610,+5.05,-4.66*58

1.8 Event String ($GPNVS,8) Event Status

$GPNVS	8	0	0	0	0	0	0	0	nnnnnn	0	*	XX
1	2	3	4	5	6	7	8	9	10	11		12

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	8
3.	Discipline Counter	0 = Off, 1 = Disciplined to Synthetic PPS
4.	User Enabled	0 = Off, 1 = On
5.	Event Enabled (System)	0 = Events Disabled, 1 = Events Enabled
6.	GPS Lock Achieved	0 = No Lock, 2 = Locked or previously locked
7.	Event Index	0-512, Current count of events in RAM
8.	Event Errors (RAM)	0
9.	Event Index	0-512, Current count of events in Flash
10.	Event Errors (Flash)	0
11.	Event Time Alignmet	2 = LS applied, 1 = GPS, 0 = RTC
12.	Estimated Accuracy	0-999999 [ns]
13.	Edge Detect Direction	0 = Falling Edge, 1 = Rising Edge
14.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,8,1,1,1,2,0,0,2,000005,0*60

1.9 Status String ($GPNVS,9) Frequency Measurement

The frequency measurement string has two versions, one standard version, and one for the NR6720.

1.9.1 Standard Frequency Measurement String

$GPNVS	9	hhmmss	ddmmyy	(n)nnnnnnn.nnn	nnn	(-)nn	*	XX
1	2	3	4	5	6	7		8

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	9
3.	Time (UTC)	hhmmss
4.	Date	mmddyy
5.	Measured Frequency	9999900.000 to 10000100.000
6.	Frequency Alert Range	0 – 240 (units of 0.0083 Hz)
7.	Temperature	-40 to 99 [C]
8.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,9,233518,092516,10000000.003,240,25*70

1.9.2 NR6720-HS Frequency Measurement String

$GPNVS	9	nnnnnnn.nnn	n.nnnnn	nnnnnnnn.nn	0	±n.nn	±n.nn	*	XX
1	2	3	4	5	6	7	8		9

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	9
3.	Frequency (Loop Period)	10000000.000
4.	DAC Voltage (Double)	2.00000
5.	Frequency (per second)	10000000.0
6.	Loop Period	0-99
7.	Antenna Current Mon	0.00 to 3.30V
8.	Sine Output RMS	0.00 to 3.30V
9.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,9,+10000000.003,+1.97493,+10000000.0,15,+1.03,+1.30*4A

1.10 PPS Alignment String ($GPNVS,10) PPS Status

$GPNVS	10	0	0	0	±n	±n	n	n	n.n	n	n	n	0	±n	n.n	n	*	XX
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		18

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	10
3.	PPS Stability Enabled	0 = Off, 1 = On
4.	PPS Disciplining to GPS	0 = Off, 1 = Actively Synchronized
5.	PPS Output Type	0 = Synthetic PPS, 1 = GPS PPS
6.	PPS Difference	±250 [ns]
7.	PPS Avg Difference	±250 [ns]
8.	PPS Avg Count	1-20
9.	PPS Synch Threshold	1-250
10.	PPS pull Cal Factor	0.1 to 10.0
11.	PPS active Time Cal Factor	0 to 9
12.	Frequency Variance	0-9999 (clock cycles per Loop period)
13.	Frequency Var Threshold	0-100 (clock cycles per Loop period)
14.	PPS Stabile Mode Post-Warm up	0 = Off, 1 = On
15.	PPS Slope Indicator	±250 (clock cycles per second)
16.	PPS Slope Cal Factor	0.1 to 10.0
17.	PPS Slope Distance	14 to 60 (seconds)
18.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,10,1,0,0,+0,+0,2,100,0.5,3,2,10,1,0,1.0*46

1.12 PPS Alignment String ($GPNVS,9) PPS Status

$GPNVS	9	nnn	0x0000	nnn	0/1	*	XX
1	2	3	4	5	6		7

#	Description	Range
8.	Identifier	$GPNVS
9.	String ID	9
10.	Heat Sink Temperature	0-255
11.	Heater Current Voltage	0x0000-0x0136
12.	Measured Voltage in Heater	0-255
13.	Rb Locked	0 = Unlocked 1= Locked
14.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,9,136,0x002A,90,1*7E

1.11 Response String ($GPNVS,R)

$GPNVS	R	n	<response>	*	XX
1	2	3	4		5

#	Description	Range
1.	Identifier	$GPNVS
2.	Response ID	R
3.	Command Success	1 = Success, 0 = Fail
4.	Response	<see example responses>
5.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,R,SET01=1.00*6F

1.12 Discipline Selection String ($GPNVS,13)

$GPNVS,	13,	n,	n,	n,	n,	n,	,	,	*	XX
1	2	3	4	5	6	7	8	9		10

#	Description	Range
1.	Identifier	$GPNVS
2.	String ID	13
3.	Priority Discipline Source	0 = GNSS, 1 = 10MHz input, 2 = Optical input
4.	Current Discipline Source	0 = GNSS, 1 = 10MHz, 2 = Optical, 3 = Holdover
5.	GNSS Lock	0 to 3, 0 = Unlocked, 3 = Fully Locked
6.	RF Present	0 = No RF source, 1 = RF Source found
7.	Opto Present	0 = No Optical source, 1 = Optical Source Found
8.	Loop Lock	1 = Lock, 0 = Loop acquiring lock
9.	Reserved	
10.	NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,13,0,0,3,0,0,1,*5C

2.0 Combined NMEA/Status RS232

NR2110-OG Combined NMEA?Status Port

2.1 Status String ($GPNVS,1) Fault Bytes

$GPNVS	1	hhmmss	mmddyy	A	nn	0x00	0x00	0x00	*	XX
1	2	3	4	5	6	7	8	9		10

# Description	Range
15. Identifier	$GPNVS
16. String ID	1
17. Time (UTC)	hhmmss
18. Date	mmddyy
19. GPS Lock (Valid)	"A" = Valid, "V" = Not Valid
20. # of Sats in View	Greater of GPS or GNSS count
21. Channel Fault Byte	0x00 to 0x3F (Hex OR'd value)
22. Power Supply Fault Byte	0x00 to 0x1F (Hex OR'd value)
23. Error Message Byte	0x00 to 0x0F (Hex OR'd value)
24. NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:

$GPNVS,1,233518,092516,A,10,0x00,0x00,0x00*62

Time: 23:35:18; Sep. 25, 2016, GPS locked; 10 Satellites in view; No channel faults; No power supply faults; No error messages.

2.2 Status String ($GPNVS,2) Channel Values

$GPNVS	1	hhmmss	mmddyy	n.nn	n.nn	n.nn	n.nn	n.nn	n.nn	*	XX
1	2	3	4	5	6	7	8	9	10		11

# Description	Range
14. Identifier	$GPNVS
15. String ID	2
16. Time (UTC)	hhmmss
17. Date	mmddyy
18. Channel 1 Vrms	0.00 to 6.60 [V]
19. Channel 2 Vrms	0.00 to 6.60 [V]
20. Channel 3 Vrms	0.00 to 6.60 [V]
21. Channel 4 Vrms	0.00 to 6.60 [V]
22. Channel 5 Vrms	0.00 to 6.60 [V]
23. Channel 6 Vrms	0.00 to 6.60 [V]
24. NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,2,233518,092516,0.99,1.01,1.06,0.97,1.52,1.54*4E

2.3 Status String ($GPNVS,3) Power Supply Values

$GPNVS	3	hhmmss	mmddyy	n.nn	n.nn	n.nn	n.nn	n.nn	*	XX
1	2	3	4	5	6	7	8	9		10

# Description	Range
15. Identifier	$GPNVS
16. String ID	2
17. Time (UTC)	hhmmss
18. Date	mmddyy
19. -5Vdc Power Supply(opt)	-30.0 to 30.0 [V]
20. +5Vdc Power Supply	-30.0 to 30.0 [V]
21. 10kΩ Thermistor(opt)	0.00 to 3.30 [V]
22. +5Vdc Power Supply(opt)	-30.0 to 30.0 [V]
23. OCXO Control Voltage	0.00 to 3.30 [V]
24. NMEA Checksum	*XX (xor'd value of bytes between $ and *)

Example:
$GPNVS,3,233518,092516,-4.84,4.93,1.45,4.90,2.12*42

3.0 Status Byte Key

	Hex Value (OR'd)	Channel ID	Channel Status Word
Channel Status Byte	0x1<<0	Channel 1 Fault	General Channel Fault
	0x1<<1	Channel 2 Fault	
	0x1<<2	Channel 3 Fault	
	0x1<<3	Channel 4 Fault	
	0x1<<4	Channel 5 Fault	
	0x1<<5	Channel 6 Fault	
	0x1<<6	Channel 7 Fault	
	0x1<<7	Channel 8 Fault	
	0x1<<8	Channel 9 Fault	
	0x1<<9	Channel 10 Fault	
	0x1<<10	Channel 11 Fault	
	0x1<<11	Channel 12 Fault	
	0x1<<12	Channel 13 Fault	
	0x1<<13	Channel 14 Fault	
	0x1<<14	Channel 15 Fault	

	Hex Value (OR'd)	Channel ID	Channel Fault Bin
Channel Fault Bin	0x1<<0	Channel 1 Fault	External Fault: The ND0100 has completed an internal amplifier gain test and both primary and backup assemblies are functional. The fault is external to the ND0100 (cabling, short, etc) Amp Gain Test for Alert is enabled with $AMP=1 command via RS232
	0x1<<1	Channel 2 Fault	
	0x1<<2	Channel 3 Fault	
	0x1<<3	Channel 4 Fault	
	0x1<<4	Channel 5 Fault	
	0x1<<5	Channel 6 Fault	
	0x1<<6	Channel 7 Fault	
	0x1<<7	Channel 8 Fault	
	0x1<<8	Channel 9 Fault	
	0x1<<9	Channel 10 Fault	
	0x1<<10	Channel 11 Fault	
	0x1<<11	Channel 12 Fault	
	0x1<<12	Channel 13 Fault	
	0x1<<13	Channel 14 Fault	
	0x1<<14	Channel 15 Fault	

	Hex Value (OR'd)	Channel ID	Primary PCB Amp Status
Primary PCB Amp Status	0x1<<0	Channel 1 Fault	Internal Fault Primary Assembly: The channel has failed an internal gain test on the primary PCB assembly, and the channel is not functional on the primary board. Amp Gain Test for Alert is enabled with $AMP=1 command via RS232
	0x1<<1	Channel 2 Fault	
	0x1<<2	Channel 3 Fault	
	0x1<<3	Channel 4 Fault	
	0x1<<4	Channel 5 Fault	
	0x1<<5	Channel 6 Fault	
	0x1<<6	Channel 7 Fault	
	0x1<<7	Channel 8 Fault	
	0x1<<8	Channel 9 Fault	
	0x1<<9	Channel 10 Fault	
	0x1<<10	Channel 11 Fault	
	0x1<<11	Channel 12 Fault	
	0x1<<12	Channel 13 Fault	
	0x1<<13	Channel 14 Fault	
	0x1<<14	Channel 15 Fault	

	Hex Value (OR'd)	Channel ID	Backup PCB Amp Status
Backup PCB Amp Status	0x1<<0	Channel 1 Fault	Internal Fault Backup Assembly: The channel has failed an internal gain test on the backup PCB assembly, and the channel is not functional on the secondary board. Amp Gain Test for Alert is enabled with $AMP=1 command via RS232
	0x1<<1	Channel 2 Fault	
	0x1<<2	Channel 3 Fault	
	0x1<<3	Channel 4 Fault	
	0x1<<4	Channel 5 Fault	
	0x1<<5	Channel 6 Fault	
	0x1<<6	Channel 7 Fault	
	0x1<<7	Channel 8 Fault	
	0x1<<8	Channel 9 Fault	
	0x1<<9	Channel 10 Fault	
	0x1<<10	Channel 11 Fault	
	0x1<<11	Channel 12 Fault	
	0x1<<12	Channel 13 Fault	
	0x1<<13	Channel 14 Fault	
	0x1<<14	Channel 15 Fault	

Active Board Status	Hex Value (OR'd)	Status Message
	0x1<<0	Flash Read Boot Error (Deprecated)
	0x1<<1	Potentiometer Read/Set Fail
	0x1<<2	Reserved
	0x1<<3	Reserved
	0x1<<4	PCB Assembly Input A/B Select Fail
	0x1<<5	Reserved
	0x1<<6	Reserved
	0x1<<7	Reserved

Primary and Secondary Power Supply Status	Hex Value (OR'd)	Status Message
	0x1<<0	PS 1 Fault
	0x1<<1	PS 2 Fault
	0x1<<2	PS 3 Fault
	0x1<<3	PS 4 Fault
	0x1<<4	PS 5 Fault
	0x1<<5	PS 6 Fault
	0x1<<6	PS 7 Fault
	0x1<<7	PS 8 Fault

Error Status	Hex Value (OR'd)	Status Message
	0x1<<0	FLASH_NOT_FOUND
	0x1<<1	FLASH_NOT_SAVED
	0x1<<2	LOOP_VOLT_ERROR
	0x1<<3	ANTENNA_VOLT_ERROR
	0x1<<4	GPS_FAILURE
	0x1<<5	POTENTIOMETER_ERROR
	0x1<<6	RAM_MEMORY_ERROR
	0x1<<7	Reserved