Time·Master

NT9400/NR9400/9400

Contents

1.0 Overview

The NT9400 is a portable time source for GNSS and GNSS denied environments with the following capabilities:

- 10 MHz output locked to GNSS or atomic holdover.
- NMEA simulator that continues to provide NMEA data even after GNSS loss.
- PPS output that is GNSS derived with atomic holdover.
- Battery powered to provide > 6 hours field use.
- Optional NTP time server with atomic holdover
- Optional IRIG-B output, modulated or unmodulated
- Built-in drift estimation and measurement.
- Rugged water-resistant case.
- Pairs of events may be captured as close as 1µS with A/B inputs

When locked to the GNSS, the NT9400 operates as a standard GNSS locked frequency reference and PPS source with an accuracy 20 nS. While locked to the GNSS, the Rubidium internal reference is continually being disciplined in frequency and its internal PPS is aligned to UTC PPS within <200 nS. If GNSS is lost, the unit uses the disciplined Rubidium as the master time reference. The PPS remains aligned to UTC PPS with a drift rate of <40µS/day (procedure allows for better drift performance).

The deviation from PPS after an extended period of time of GNSS loss is presented in the drift counter display during a GNSS and Rb Lock state. This same display is used for differential measurements of an external PPS signal in a GNSS denied environment. If configured for differential measurements, an external PPS signal can be applied and the unit will measure the time difference between the leading edge of the internal-atomically stabilized PPS and the external PPS. Two event inputs can measure difference between two rising edge pulses.

NMEA and NTP data continues to be streamed using the Rubidium based PPS to increment internal counters. Position is reported as the last best known position.

Time and position stamping are available through the event function. A programmable rising/falling edge causes the current time and position to be recorded. This data is stored in non-volatile memory and can be read via the local display. If the Ethernet option is available, the unit can be configured to transmit an email with the event data. The event data can also be downloaded as a file to be manipulated off-line. Events are captured and stored to a resolution of 100 nS.

Up to 512 events can be stored in the memory. Events can be as close in occurrence as 1 µS. Events are captured and stored to a resolution of 1µS.

The external PPS monitor allows for the measurement and monitoring of an external PPS source. The external PPS is measured against the internal PPS that is GNSS derived with atomic holdover. The difference in time between the internal and external is displayed on the UTC drift display. Also, an alert can be set so that if the drift exceeds a certain bounds, an alert will be generated that will be displayed locally or an email can be programmed to be sent.

Multiple units may be synchronized thru the (optional) Aux connector by applying a PPS signal from a Master source to multiple units. This allows multiple high speed events to be captured time synchronized without having the expense of multiple atomic references.

Battery life is a function of configuration and use. The NT9400, in its base configuration, can achieve well over six hours of battery life. As you add features such as NTP, the battery life can fall to approximately six hours. The battery recharges in approximately six hours. Charge status and battery remaining capacity indicated on the front panel. The battery is accessible and easily replaced through a removable panel.

Power is provided by either a power adapter (PA0008) or nominal 12Vdc. The PA0008 operates from 90 to 260 Vac and has a splash proof housing. There is a storage compartment for the adapter in the unit when not in use. The battery is being charged when power is present in the DC input port.

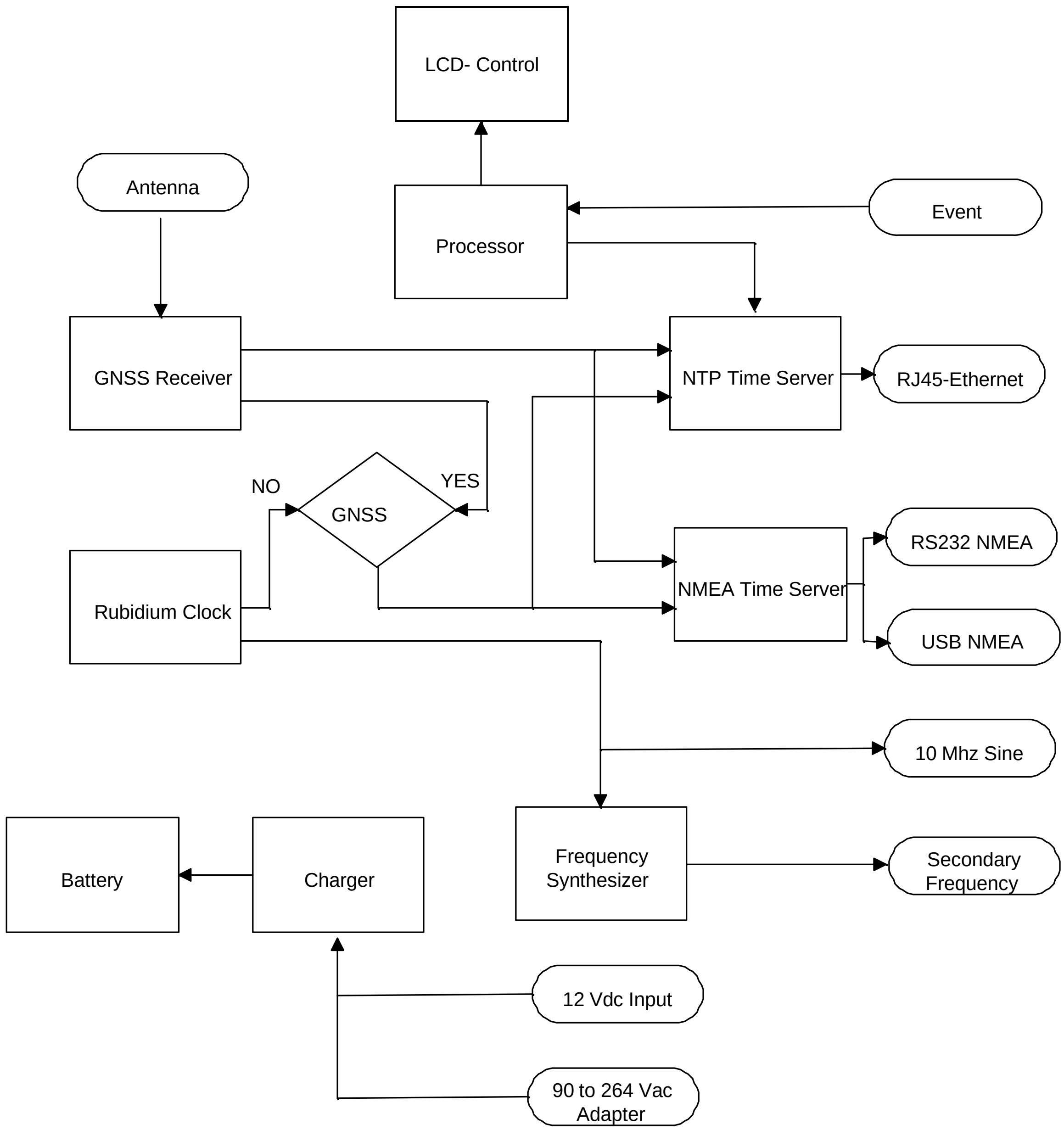
The NT9400 case is a high impact injection molded case. The lid seals with gaskets to provide weather resistance and the timing platform is shock protected from the case with isolators.

A magnetic mount GNSS antenna is provided which is stored in the unit. It has a 28 dB LNA to provide gain in low signal environments. The antenna can be easily removed and a different antenna/source can be used. Antenna status is presented on the front panel (open/fault).

The following output options available:

NMEA - RS232, USB 38400 Baud
NTP Time Code - RJ45
10 MHz sine wave - BNC
PPS - BNC 3.3 Volt CMOS
Auxiliary Output - BNC (other frequencies) (Event-In)
IRIG-B (modulated 1kHz or DCLS)
Event Inputs (2): A/B Dual Event Input

2.0 Key Functional Elements



2.1 GNSS Receiver

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

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

The receiver's antenna must have a clear view of the sky to acquire satellite lock. Remember, it is the location of the antenna that will be given as the position fix. If the antenna is mounted on a vehicle, survey pole, or backpack, allowance for this must be made when using the solution.

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

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

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

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

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

2.3 Rubidium Clock

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

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

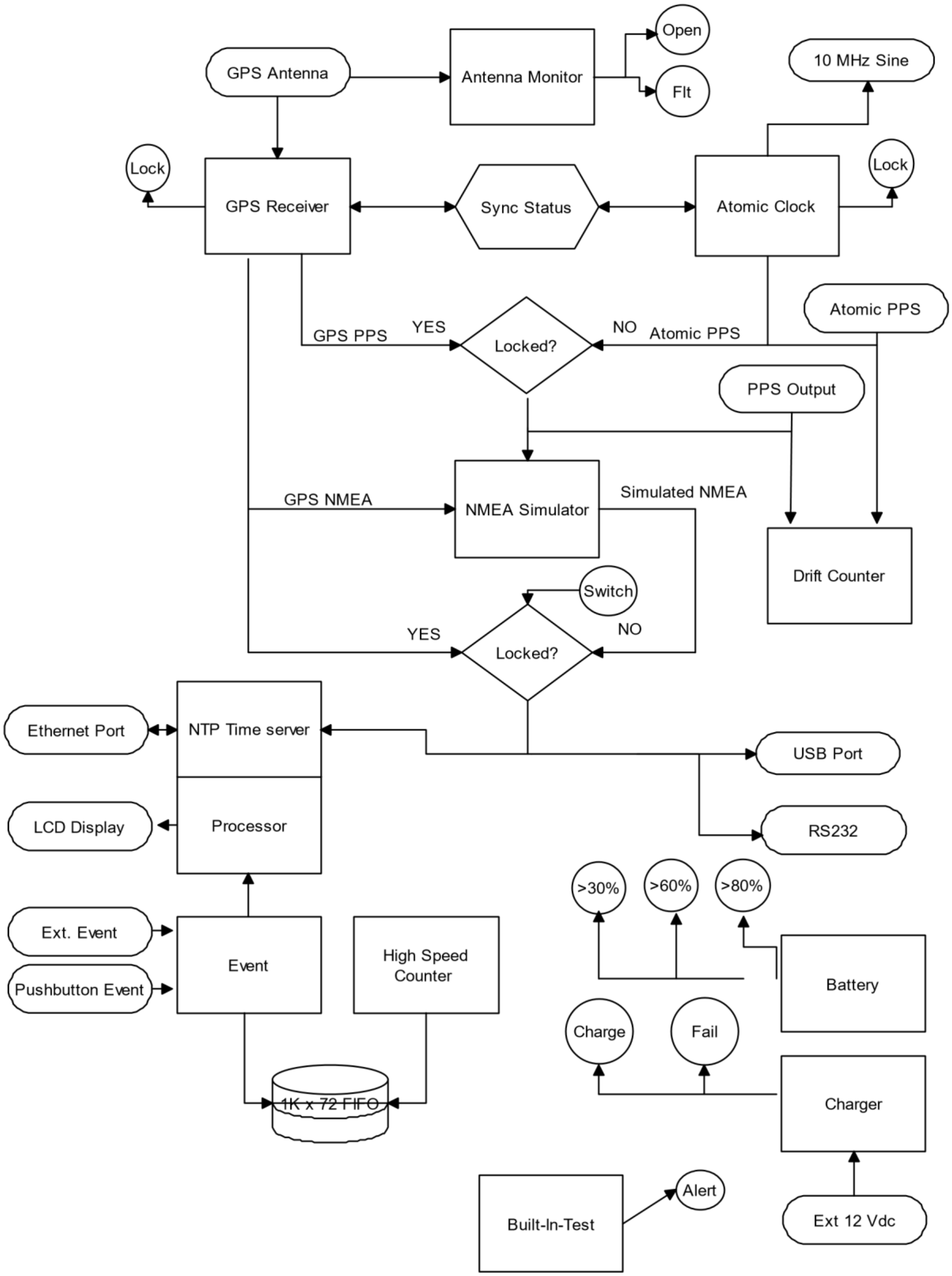
Once the full synchronization and discipline has taken place, the PPS accuracy is dictated by the atomic clock. Below is an estimate of the drift performance of the PPS when the NT9400 is no longer connected to GNSS.

2.4 Power

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

The internal charger operates either from an external 12Vdc source (11 to 15Vdc) or a splash-proof charger that operates from 90 to 264Vac.

The charger is housed within the unit. The NT9400 is fully functional during charging. A full charge takes approximately six hours.

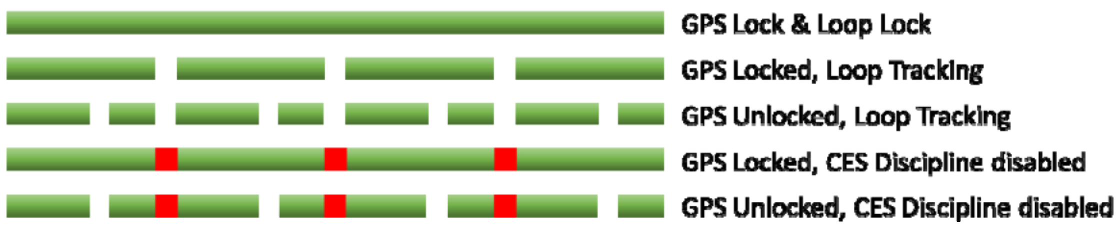

GPS Antenna
Antenna Monitor
Open
Flt
10 MHz Sine
Lock
GPS Receiver
Sync Status
Atomic Clock
Lock
Atomic PPS
GPS PPS
YES
Locked?
NO
Atomic PPS
PPS Output
GPS NMEA
NMEA Simulator
Simulated NMEA
Drift Counter
Switch
YES
Locked?
NO
Ethernet Port
NTP Time server
USB Port
LCD Display
Processor
RS232
>30%
>60%
>80%
Ext. Event
Event
High Speed Counter
Battery
Pushbutton Event
Charge
Fail
1K x 72 FIFO
Charger
Built-In-Test
Alert
Ext 12 Vdc

3.0 Functional Controls and Indicators

3.1 Acquire/Lock

The “GNSS LOCK” indicator LED provides a quick reference for the status of the GNSS lock, as well as the Rubidium Oscillator status.

There are five conditions which are indicated:



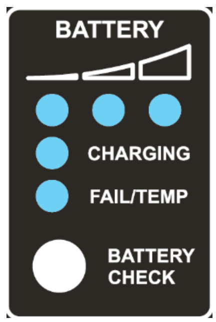
When the GNSS is locked and is producing a disciplining PPS to the Rubidium oscillator, the “GNSS LOCK” indicator will be illuminated solid Green. This indicates that the frequency of the Rubidium is within the threshold loop variance. The solid green also indicates the Rubidium physics package is functional, self-test has passed and the frequency is stable. Once the Rb and GNSS functions have locked, the process of disciplining the atomic clock to GNSS begins. This process has a time constant on the order of 1000 seconds. Therefore, the accuracy of the disciplining process is very much dependent upon the time spent in the disciplining mode. The loop variance threshold can be user defined. Refer to the Programmer’s Guide.

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

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

A single RED flash in an illuminated green “GNSS LOCK” indicator warns the user that, even though GNSS lock has been achieved, the Rubidium discipline is disabled. The GNSS PPS pulse is active and available, but it is not disciplining the Rubidium. This is the case if the user has the RBDiscipline setting disabled in the Menu Screen or via the serial port. See the Menu Settings and the Programmer’s Guide for how to enable/disable the Rubidium Discipline setting.

3.2 Battery



The battery is a 2-cell Lithium ion. It is designed to provide approximately six hours of service. To achieve maximum service, start with a charged battery (about six hours of charge time).

3.2.1 Fuel Gauge

There are three LEDs that give an approximate status of how much charge is in the battery. The LEDs are set to approx. 30%, 60% and 80%. The gauge is accurate to ~±10%. The Fuel Gauge is activated by depressing the BATTERY CHECK button. Battery Voltage can also be monitored via the serial port, $GPNVS,9 string, ninth field. This provides a voltage measurement that is +/- 20mV.

3.2.2 Charging

Indicates the battery is charging. Charging occurs when the unit is connected to the external power source. The external power source can be the provided power adapter or a 12Vdc (11Vdc to 15Vdc, 3A nominal source). The unit will operate while being charged.

3.2.3 Fail/Temp

This indicator is active if the battery is beyond its operating temperature range, cannot be charged, or the charger has entered sleep mode. The battery can be charged in the temperature range of 0 to 40 C.

The battery can be easily replaced. It is attached to the bulkhead with Velcro and there is a simple three terminal connector. There is sufficient room in the battery compartment for a spare.

3.3 Antenna

The unit comes with a magnetic mount antenna with an attached three-meter cable. The cable is stored in the antenna compartment and can be extended as required. The antenna has a built in LNA with 28 dB of gain to improve the receiver performance. The receiver provides 3.3Vdc to the antenna to power the LNA and a maximum current of 45 ma. The provided antenna can be disconnected, and another used provided it can operate within the DC power capability of the antenna power supply (3.3Vdc, 30mA). The two indicators turn red if the antenna is detected as being shorted or open. There is a right angle SMA adapter provided. The adapter provides a more direct antenna connection and, more importantly, extends the life of the SMA bulkhead connector by being used for the more frequent connections and disconnects and can be easily and inexpensively replaced.

3.4 NTP time server option

When first turned on, the time server will try to establish an IP address for the unit. Procedure and software required are described in Section 14. The default IP address is shown on the IP Address Menu. The IP Address and other network settings can be configured with a terminal connection, eg PuTTY.

3.5 NT9400 Display and Menu Navigation

3.5.1 NEXT and SELECT buttons, LCD Menus

The LCD is used to provide information regarding the status of the NT9400, network configuration, and Event history. The NEXT and SELECT buttons are used for navigation of the LCD based menus and displays. Pressing the NEXT button will advance the display to the next screen or menu. The select button is used to navigate further options in each menu.

3.5.2 Standard Screen

During normal conditions, the display shows time and GNSS lock status. Time is UTC by default but can be changed to local time via the NEXT and SELECT buttons by simply following the prompts in the “UTC Offset” Menu. The display will also indicate the number of satellites in view, and the number of satellites acquired, and whether the unit is in a lock condition. The display remains operational at all times.

The time is presented as UTC. The time format can be changed to 12 hour or 24 hour format from the “UTC Mode” menu screen, and the time zone can be changed from the “UTC Offset” menu when the unit is GPS locked.

Note that the changes to UTC Offset will be reflected in both NMEA output, IRIG output and display. The time is read and updated from the ZDA NMEA string, which also contains the offset value. If the user needs to verify offset in the output data, refer to the ZDA string.

Example:

*$GPZDA,081231.000,22,03,2018,-06,00*7C*

The ZDA string indicates a time of 08:12:31, on March 22, 2018.
The offset, "-06:00", indicates that the time displayed is actually UTC–06:00.

The Event output also logs the events to reflect the offset time. The "local" time zone is used to mark the event, and the UTC offset is included in the event output.

Example:

*$E,001,P,08:15:54.16820285-06:00,39055972N094261191W,032218*1C*

"001": The event number is 001 out of 512 events.
"P": The event was triggered by the push button EVENT TEST.
"08:15:54.16820285": The event time in 24 hour format hh:mm:ss.dddddddd.
"-06:00": The offset from UTC.
"39055972N": Latitude in dd.mm.mmmm (decimals removed) + direction.
"094261191W": Longitude in ddd.mm.mmmm (decimals removed) + direction.
"032218": Date in mmddyy.

3.5.3 Orange Screen

This screen shows the Date/Time information in a specific user defined format:

The top row shows the Date in DDMMYYYY format. This is followed by a “T” indicator, followed by the time in hhmmss format.

If the time format is 12hr, the bottom row will start with AM or PM. If the time format is 24hr, the space will be blank.

The TZ “Time Zone” is shows UTC offset: ±hh:mm.

The SV “Satellites in View” is followed by the number of satellites that the GNSS receiver is currently reporting.

3.5.4 Position Screen

This screen displays the current Latitude and Longitude of the unit, as last observed by the GNSS receiver.

3.5.5 Event Enable

The Event inputs A and B can be enabled/disabled by the user. This is designed to prevent spurious event triggers during setup, or for selective enabling.

When Event Inputs are enabled, events can be triggered by either input and will be saved in flash (up to 512) with 1us resolution. Event inputs can be set to rising edge or falling edge via the serial RS232 command “$EDGE.”

“$EDGE=1” Rising Edge event detection. 100kΩ pulldown.
“$EDGE=0” Falling Edge event detection. 100kΩ pullup.

Event logs will be reported with an “A”, “B” input designation, or a “P” designation for the source of the input. A “P” indicates a pushbutton test event has been triggered. A pushbutton EVENT TEST will still cause an event trigger, even if the Event inputs are disabled.

Event output can be viewed via the serial port, or by navigating to the Events Page on the ethernet connection. To retrieve a 10 event series from the serial output, enter the command “$EVENT<nnn>”, where <nnn> is the starting event to retrieve. For example, “EVENT025” would output events 25 to 35, if they exist.

The EVENT lists the offset time, as well as the UTC offset. That means the “local” time zone is used to mark the event, and the UTC offset is included in the event output.

Example:

*$E,001,P,08:15:54.16820285-06:00,39055972N094261191W,032218*1C*

“001”: The event number is 001 out of 512 events.
“P”: The event was triggered by the push button EVENT TEST.
“08:15:54.16820285”: The event time in 24 hour format hh:mm:ss.dddddddd.
“-06:00”: The offset from UTC.
“39055972N”: Latitude in dd.mm.mmmm (decimals removed) + direction.
“094261191W”: Longitude in ddd.mm.mmmm (decimals removed) + direction.
“032218”: Date in mmddyy.

3.5.6 Event Listing

The Event listing provides quick indication of the event number, event source, and event time. To view additional events in descending order, press the SELECT button. After each button press, the Event number will decrease by one, and the preceding Event information is displayed.

The Event output can be viewed via the serial port, or by navigating to the Events Page on the ethernet connection.

To retrieve a 10 event series from the serial output, enter the command "$EVENT<nnn>", where <nnn> is the starting event to retrieve. For example, "EVENT025" would output events 25 to 35, if they exist.

3.5.7 Clearing the Event List

To clear all events from Flash memory, navigate to the Event counter screen, and hold the SELECT button for five seconds until the message "Events Cleared" is displayed.

NOTE: Clearing Events from the Event list erases them from memory permanently. To keep a record of the Event list, connect the unit to Ethernet, and access the "Events" page. Events can also be retrieved via the serial port, with the $EVENT<nnn> command. See the Programmer's guide.

3.5.8 UTC Mode Menu

The UTC Mode Menu allows the user to display time and store events in 24 hour, and12 hour (am/pm) formats. This menu can be reached by pressing the NEXT button. Press SELECT to toggle between 24 hour and 12 hour mode.

Changes to the UTC Mode setting are automatically saved to flash.

Note that the NMEA standard does not allow NMEA output to reflect a 12 hour format. For this reason, the NMEA output and events will always reflect the 24 hour format hhmmss.

3.5.9 Compare Screen (Option)

This mode will compare an external PPS signal (from input A or B) to the internal Rubidium based PPS, and will report the difference in fractional seconds(s). This mode requires GNSS lock and RB lock to generate a valid PPS reference.

Note: The PPS between the GNSS and internal RB can be compared via the serial output ($GPNVS,10, in the sixth field) or the PPS Difference screen.

The user will be prompted to input an external PPS into either Event input if a source is not present at the input. As long as an external signal is present, the LCD will display the absolute time difference between the external (Event Input) signal and internal Rubidium based PPS signal.

3.5.10 Cable Delay / PPS Offset (Option)

An optional feature can allow the user to change the PPS timing. The PPS can be adjusted forward or backward relative to its original position in nanosecond increments. The PPS offset is then stored in the NT9400's non-volatile memory, and is loaded into the receiver on power up.

To adjust the PPS, press NEXT to reach the Cable Delay PPS menu page. Then press SELECT to enter the adjustment menu. The most recent stored offset delay value will show in the menu. This value is read from the receiver status output, and reflects the direct access to receiver settings. This value is also available from the serial output ($GPNVS,13 in the fourth field).

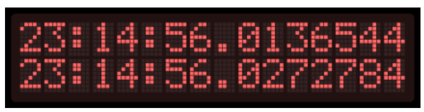
Press SELECT to advance the PPS forward (reduce delay). Press NEXT to move the PPS back (increase delay).

When the desired delay has been reached, press EVENT to store the value. The current value will now be updated in the GNSS receiver, and saved to non-volatile memory. The delay value will be reapplied if the unit is powered off and restarted.

3.5.11 Difference Screen (Option with Dual A/B Event Inputs)

The Difference mode will compare times between two events from the A/B inputs. The events compared are the last rising/falling edge signals from each of the two Event inputs.

When SELECT is pressed, the display will show the last event times. Event input A will appear on the top line, followed by the last event time from Event Input B on the bottom line.



NOTE: While in Difference mode, the user can continue to accumulate events at either input, and the displayed event times will be updated for either event A or event B.

To display the difference between the last of the two events listed, press Select, and the absolute time difference between the A-B events will be displayed. These events will also be saved to flash memory, like any other event, with the corresponding Event input appended.

3.5.12 UTC Offset

The UTC Offset menu allows the user to save the local time offset to non-volatile memory, and adjusts all time output accordingly. The offset setting is written to the $GPZDA string, and affects all output and display, both NMEA and IRIG.

Since the offset time is a modification of the ZDA string, the unit must have an antenna connected, and the GPS must be locked to set the UTC Offset. If the unit is not GPS locked, the UTC offset screen will not appear, and the $PERDAPI,TIMEZONE serial command will be rejected.

UTC Offset can be moved forward/backward ±23 hours. When the UTC offset menu is displayed, simply press the SELECT button, and then use the NEXT (+) or SELECT(-) button to adjust the UTC offset. When the correct offset is displayed, press the EVENT TEST button. The GNSS receiver will be updated, and the Offset value will be saved to flash.

3.5.13 Select USB Communication

The USB-B connector allows access to a serial COM port which can be addressed according to the needs of the user. The default connection at the USB port is a monitor-only listening connection to the internal processor. This is the MCU RX setting, which provides NMEA and Status data. This setting does not allow write access to the MCU/processor which is connected to the serial RS232 port.

To enable serial communication with the receiver (TX), press SELECT once to display MCU TX/RX setting. This allows two-way communication with the MCU/Processor/GNSS receiver through the USB port, and disables the user input to the serial RS232 port.

The “Select USB Com” setting is volatile, and will revert to “MCU RX” on startup.

3.5.14 IP Address

The IP address of unit is a Static IP Address of 192.168.7.200. The IP Address can be changed but the IP Address displayed on the NT9400 will only list this default IP address. Please contact Novus Technical Support for assistance in changing the IP Address if needed.

3.5.15 Frequency Error/Time Error

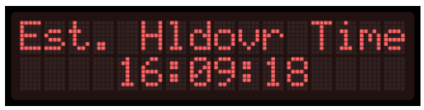
The Frequency Error screen totals the maximum frequency deviation over a 15 minute period. This can be used to verify loop stability, and to predict maximum time offset that will occur when the unit is in holdover. This error estimate is an averaged measurement based on the available GNSS PPS, which includes jitter, therefore, the best estimate can be observed by using the PPS Difference Screen, while disabling the RB Discipline.

Press SELECT to view the Frequency as measured against the GNSS PPS over the last sampling period. The sampling period extends to as long as 15 minutes to achieve the best resolution possible.

Time Error is a calculated error range based on the maximum drift measured over a 15 min period. The error reading predicts the maximum drift of the Rb in us/hr, however, the estimate is a worst case measurement based on the available GNSS PPS, which includes jitter, therefore, the best estimate can be observed by using the PPS Difference Screen, while disabling the Rb Discipline.

When the 9400 has an antenna connected and is GNSS locked, this screen reports the estimated drift that the user can expect. When the antenna is removed, or GNSS is no longer locked, this screen will report the amount of estimated drift [us] that has occurred since GNSS lock.

The Estimated Holdover Time screen allows the user to see how long the 9400 is likely to be within the desired error threshold set by the Drift Absolute Threshold period (modifiable by setting the $DRAB serial command). By default, this threshold is set to 5us. The Estimated Holdover Time screen reports how long the unit is likely to be within this margin, based on the recent frequency measurements when GNSS locked, then reports the remaining time estimated to stay in range when the unit loses GNSS lock.



If alarm is enabled, the unit will provide an audible alert when this threshold is crossed. The alarm can be enabled by the serial command "$ALRM=1." The alarm can be silenced by pressing the NEXT or SELECT buttons.

3.5.16 PPS Difference

The PPS Difference display shows the difference in nanoseconds between the GNSS PPS and the Rubidium synthesized PPS. If the value is positive, the GNSS PPS leads the Rubidium PPS. If the value is negative, the GNSS PPS lags the Rubidium PPS.

By default, with Rb discipline enabled, the Rubidium will "synchronize" its synthetic PPS with the disciplining source if the difference is greater than ~700ns by a hard synchronization to within 100ns. Then the Rubidium will steer the frequency to align the PPS.

The PPS difference value can be read serially from the $GPNVS,10 string. When the GNSS receiver is locked and discipline is enabled, the value can be queried directly from the Rubidium via USB.

To test holdover function, disable the RB discipline, and monitor PPS difference.

3.5.17 Enable/Disable RBDiscipline

For the purposes of testing and verification, the user has the option to disable the GNSS discipline of the Rubidium oscillator. This setting, when disabled, prevents the GNSS PPS from reaching the Rubidium.

With RB Discipline disabled, the user can observe drift over time (after disciplining), or can verify difference from UTC after a period of reception loss. While the unit is warming up, there is a "*" on the lower, left hand side of the screen. When this astrick is present, the state of Rb Disciplining cannot be changed.

This setting is volatile. On power-up, the default setting will be "enabled." This is done to ensure that the user does not involuntarily use the PPS as a reference without having disciplined.

NOTE: The NT9400 requires access to the GNSS receiver input at the time of startup. Input commands to the receiver should be delayed until NMEA data appears at the RS232 output, following startup strings.

3.5.19 Rb Status

The NT9400 continuously monitors the health and status of the Rubidium oscillator. The menu screen provides both the Rb Lock status and the Rb Discipline status.

Upon power up, the Rubidium proceeds through three stages:

1) Heating and Initialization
2) Laser Lock
3) Lock

Full Lock will take up to fifteen minutes from cold start, and full Lock is necessary to have accurate frequency stability from the unit.

The Rubidium discipline status has three states:

1) Discipline Wait
2) Discipline Good
3) Holdover

When the GPS is locked, and Rb Discipline is enabled, the GPS is providing a reference PPS to the Rubidium source. The Discipline Wait message indicates that the Rb is still disciplining to GPS and is not yet optimum for holdover. When the Discipline Good message is displayed, the unit has achieved the necessary discipline time to meet its holdover specifications.

4.0 Frequency Reference Output

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

Typical Phase Noise Performance

Offset Frequency (Hz)	Typical (dBc / Hz)
10	-68
100	-110
1K	-125
10K	-140

5.0 IRIG-B Output

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

The following modes are available:

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

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

6.0 Data Outputs

6.1 USB Port

Located on the side of the unit, this port provides NMEA data, as well as access to the internal serial port. To determine the serial I/O behavior of the USB port, refer to the "Select USB Com" menu on the display.

6.2 RS232

Located on the rear panel. Provides NMEA and status data, default to 38400 baud, 1 stop bit, no parity.

DB9 Pin out:

1. NC
2. RS232 TX- out
3. RS232 RX- in
4. NC
5. Ground
6. NC
7. NC
8. NC
9. NC

RS232: Default 38400 Baud, No parity, 1 stop bit. Adjustable (19200, 38400, 57600, 115200)

NMEA: RMC, GNS, GSA, ZDA, GSV, NVS (See Novus String Definitions)

6.3 RJ45 Ethernet Port

Located on the side of the unit. For access to the internal ethernet module.

The default Static IP address is 192.168.7.200, with default mask 255.255.255.0.

To change settings, view status, or view events, use any browser to navigate to the web address.

7.0 BNC – Rear Panel

7.1 10 MHz sine wave:

0.5Vrms sinewave frequency locked to the GNSS or atomic. (50 Ohm termination).

7.2 PPS:

3.3Vdc CMOS logic output. Rubidium derived PPS.

When GNSS has achieved lock, and Rubidium discipline is enabled (default), the PPS is being disciplined to the GNSS PPS, and the difference is shown on the PPS difference screen.

When the GNSS lock is not present, or Rubidium discipline is disabled, the PPS is in holdover mode, and will drift relative to UTC.

7.3 AUX:

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

Event: If the option for a second event input is enabled, the AUX input activates an event time/position stamp. 3.3Vdc CMOS. Event is a rising edge.
Frequency – the NT9400 has the capability of generating a variety of frequencies as an option. This port is used to output special frequencies.

7.4 IRIG-B Sine

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

7.5 IRIG-B DCLS

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

8.0 Quick Start Guide

This guide is provided to allow the user a quick method for field use. The NT9400/NR9400 has been significantly redesigned to be easier to use, offer more features, and be field upgradable. The communications allow detailed information about the unit to be monitored via the RS232, but little intervention is needed for setup.

1. Turn on the Power Switch.

2. Connect the recommended GNSS antenna to the panel SMA labelled “antenna.” Place the antenna in such a manner as to have an unobstructed view of the sky. Note the antenna OPEN, FAULT indicators. If either are active, then the antenna or cabling to the antenna is incompatible or defective.

3. Allow full GPS Lock and warmup (<15mins). “GPS Lock” LED indicator will be solid green. Status can be viewed on the display.

4. Allow the GNSS locked unit to discipline the Rubidium oscillator (<60 min). “Holdover” LED indicator will be solid green. Status can be viewed on the “Rb Stat” screen of the display.

5. Check the battery. Depress the battery check button and note the activated LEDs. The LEDs are approximately 30%, 60% and >80%. A full charge takes approximately six to eight hours.

Battery life should be >6 hours (depending upon battery life, state of charge and use). The unit will be generating NMEA, IRIG, and NTP (option).

8.1 Differential Measurements (Compare Mode)

If configured at the factory for differential measurements, the NT9400 can be used to measure the integrity of a PPS signal at location where GNSS is inaccessible. For this measurement, the atomic clock is first disciplined to the GNSS. Once the atomic clock is disciplined, the unit can be moved to the location of the PPS signal to be tested. The PPS signal is connected to the NT9400 and the time between the leading edge of the atomic PPS and the leading edge of the external PPS is measured and displayed.

1. Await GNSS lock and RB Lock (<30 minutes).
2. Verify the unit is now synchronized to UTC by referring to the PPS Difference Screen. Note the PPS difference as well as the estimated Frequency Error, Frequency, and Time Error.
3. Connect the external PPS to either Event input channel (BNC).
4. The display will indicate the amount of time displacement between the unknown external PPS and the internal disciplined PPS.

9.0 Post Use

9.1 To record total drift after use (after using in a GNSS denied environment), *disable the RB Discipline*, and allow the unit to reacquire GNSS lock.

1. Before connecting GNSS Antenna, navigate to the "RB Discipline" Screen and press SELECT to disable. Verify Rb is "Disabled."
2. Bring the unit to a location with an unencumbered view of the sky.
3. Connect antenna.
4. Once GNSS is locked, record the drift time in nanoseconds from the "PPS Difference" screen. This will indicate the difference between the GNSS PPS and the undisciplined Rubidium source.

10.0 Event

The Event capability allows an external CMOS (3.3Vdc) signal to be connected to the device so that when an edge occurs, the time and position are captured. This information is displayed on the LCD, and can be retrieved serially via the RS232 port. If connected to the Ethernet, this information can be accessed via the Events page.

Events are recorded to a resolution of 100 ns relative to the internal Rubidium PPS. The total difference in event capture time from UTC is the total of PPS difference between GNSS and Rubidium. During holdover, events can be captured, and the Rubidium PPS can be compared when GNSS reacquires lock. This allows the user to determine maximum event offset during holdover.

The NR9400 can capture events at a frequency of 10kHz.

The unit accepts a rising or falling edge input (3V3 CMOS input). The input has a selectable pull-up/pull-down of approx. 100k ohms, so that a closing relay can function as an input in the falling edge mode.

The unit automatically disables events until GNSS has locked and default leap second is updated, then allows events, continuing in holdover if lock is lost. The user enable of Event trigger is set to “enabled” by default. Also, by default, the input is pulled down to 0V with a rising edge trigger.

To change Event rising/falling edge, use the serial $EDGE command.

The “$GPNVS,8” string identifies the following information:

10.1 Event String (RS232 and USB)

Example: $GPNVS,8,1,1,1,2,0,0,1,000005,0*53

Value	Description	Range
$GPNVS	String ID	$GPNVS
8	String #	8 (For event string only)
1	PPS is being actively disciplined	0 = False, 1 = True
1	Event input has been enabled by user	0 = False, 1 = True
1	Event input has been enabled by hardware	0 = False, 1 = True
2	GNSS lock has been achieved for synchronization, regardless of holdover.	0 = False, Nonzero = True
0	Number of events in RAM (Index)	0-512
0	Number of event errors (RAM)	Should be zero.
0	Number of events in Flash (Index)	0-512
0	Number of event errors (Flash)	Should be zero.
1	Status of Leap Second application	0: RTC only 1: GNSS (default leap second) 2: UTC (GNSS has confirmed leap second and applies it.)
000005	Estimated PPS error (ns)	(Programmable threshold to disallow events. Not yet implemented).
0	Even input edge direction	1 = Rising, 0 = Falling

Various Event commands are available via the status port. See Programming guide for details.

11.1 Programming Guide (RS232 Port)

The NT9400 can accept user commands which will provide specific status and performance feedback, and which may be customized by the user. Many of the settings can be saved in non-volatile flash memory.

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

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

Table 1 shows a complete list of input commands and descriptions that are handled by the internal processor. In general, a command may be input without "=" or an additional value, and the unit will respond with the current 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 for all input commands and the requirement for a checksum can be enabled or disabled (default setting is disabled). The checksum method is the twohexadecimal character representation of an XOR of all characters in the sentence between, but not including, the $ and the * character.

Example: $NVS1=1*76

11.1 $GPNVS String Definitions

The Status and control output of the NR6720 can be found in a separate document from the “Downloads” section of the website. The control terms are the same for this device.

$GPNVS_STRING_DEFINITIONS

The NR6720 may use the following status strings, in addition to the NMEA data.

$GPNVS,7…
$GPNVS,8…
$GPNVS,9…
$GPNVS,10…
$GPNVS,13…

11.1.1 Event Time Stamp Commands

Setting	Command	Response	Description
RETRIEVE EVENT LIST	$EVENT<nnn>	$E,nnn,…	Request event record, starting at nnn. Outputs the next 10 events after nnn with timestamp. (Range: 000 to 512)
EVENT INDEX	$EVIND	$EVIND=<nnn>	Returns the current event index. This number represents the total count of events acquired.
EVENT TRIGGER HOLDOFF PERIOD	$HLDFF=50	$HLDFF=50	Set/Query holdoff period for Event triggering in microseconds. If an event is triggered, the holdoff period will elapse before another event can be recorded. (Range: 1 to 2000000) [us] Default = 50
CLEAR EVENT HISTORY	$CLREV	$EVENTS_CLEARED	Clears all events from RAM, and starts event record at Event 1.
ENABLE EVENTS	$ENEV=1	$ENEV=1	Enable / Disable triggering of events and event functionality. The unit will determine if events are ready to be triggered based on GNSS lock, leap second, etc., but the user can use this as a global disable function. 0 = Disable 1 = Enable
TRIGGER MODE RISING/FALLING EDGE	$EDGE=1	$EV_EDGE_DIR=1	Set trigger to be rising edge (1) or falling edge (0). If falling edge is enabled, the input will be pulled to 3.3V through a 100k resistor. If rising edge is enabled, the event input will be pulled down with a 100k resistor. 0 = Falling edge (3.3V 100k pullup) 1 = Rising edge (0V 100k pulldown)

Setting	Command	Response	Description
STATUS OUTPUT	$STAT<n>	<$GPNVS,1….>	Query NVS<n> String. Useful for status output on demand when user does not require regular string output.
	$STAT1		Outputs current $GPNVS,1 string on demand.
	$STAT2	<$GPNVS,2….>	Outputs current $GPNVS,2 string on demand.
	$STAT3	<$GPNVS,3….>	Outputs current $GPNVS,3 string on demand.
SAVE ALL VALUES TO FLASH MEMORY	$SAVEFLASH	$SAVED TO FLASH. $FLASH SAVE FAILED.	This command will translate all current variables to flash string and write. Data is then read back for verification, and result reported.
RESET ALL TO DEFAULT	$RESETALL	$RESET FLASH VARIABLES.	Resets all user settings to default values and overwrites flash memory with defaults.
INVALID INPUT		$?	Command not recognized.
REQUIRE CHECKSUM	$CSUM $CSUM=1	$CSUM=<current CSUM>	Query or set mandatory checksum on all incoming STATUS port communication. For $PERD commands, checksum is always required. 1 = Enabled, 0 = Disabled. Default = 0.
ID	$IDN?	$IDN	Returns PCB and SW version information
IRIG OUTPUT	$IMOD	$IMOD=5	Sets the IRIG-B output format. 0 = No YR, No SBS 1 = YR, No SBS 2 = No YR, SBS 3 = YR, SBS 4 = YR, No SBS, IEEE-1344 5 = YR, SBS, IEEE-1344
SECOND OFFSET	$OFFSC	$OFFSC=1	Default value is '1'. The NMEA 0183 provides a description of the second that starts on the next PPS. The IRIG-B describes the current second. Advancing this value will affect both outputs.
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
WARM UP PERIOD	$WUP	$WUP=600	Set warm up period for OCXO tuning in seconds. Must be > 360.

FORCE PPS DISCIPLINE	$DSC	$DSC=1	Enable PPS discipline to align the synthesized PPS to the GPS PPS within 50ns. The synthesized PPS will remain available even with loss of GPS lock. If PPS stabilization is enabled, the output will remain as the Rb 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]
$GPNVS	$NVS<n>	$NVS7=1 $NVS9=1 $NVS10=1 $NVS11=1	Enables/Disables output of $GPNVS strings. For $NVS<n>=<m>, where <n> is the $GPNVS string ID, and <m> is the output frequency in seconds. Example: $NVS9=0 disables output of $GPNVS,9.
$GPNVS	$PERDCFG,NMEAOUT		Same function as $NVS but uses format of GPS Appendix A. Must include checksum. Example: $PERDCFG,NMEAOUT,NVS,9,1*4B sets $GPNVS,9 to output at a 1 second frequency. For format usage, see Appendix A.
ENABLE/DISABLE DAYLIGHT SAVINGS (IRIG ONLY)	$DSTE=0	$DSTE=0	To enable DST bit in the IRIG-B IEEE1344 output, this bit should be set to 1. If this bit is 0, the DST pending and DST bits will always be 0. NOTE: The DST does not apply an adjustment to the output time. This is done by UTC offset setting. This bit enables the indicator in IRIG string to inform of DST.

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]
ABSOLUTE DRIFT THRESHOLD	$DRAB	$DRAB=4.0	Sets the drift threshold (in microseconds) at which the unit considers the frequency to be out of tolerance. This is compared to an estimated value that increases with holdover period. When the NT9400 is in holdover, this value is compared to the Time Drift Estimate, and is used as the threshold to indicate Holdover Red LED and audible alert.
ALARM ENABLE	$ALRM	$ALRM=1	Enables/Disables the audible alert. The alert confirms the drift estimate exceeds the absolute threshold (in microseconds) as set by $DRAB.
PPS AVG ARRAY LENGTH	$PSAVL	$PSAVL=20	Sets length of PPS input filtering array in seconds. Affects the delay of application of tuning parameters.
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
SLOPE CAL	$SLCAL	$SLCAL=1.0	Sets the CAL factor for PPS slope (float).
AUXILIARY FREQUENCY OUTPUT	$AUXFR=<INTEGER>	$AUXFR=<INTEGER>	Sets the auxiliary frequency output. Even integer devisors of 200,000,000 are recommended. Remainders of the calculation 200,000,000/AUXFR are truncated. Enter $AUXFR=0 to disable output. If disabled, allow 10 seconds for an enabled output to restart.

PPS PULSEWIDTH	$PULSW=<INTEGER>	$PULSW=<INTEGER>	Sets or returns the current PPS pulsewidth in ms. Range: 1 to 50 [ms]
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)
FREQUENCY TOLERANCE	$FQTOL	$FQTOL=0.100	Sets the frequency tolerance of the GNSS loop lock indication in Hz (float).
DRIFT ABSOLUTE THRESHOLD	$DRAB=5.0	$DRAB=5.0	The Drift Absolute Threshold, in microseconds, is used to calculate the estimated holdover period, based on the most recent frequency measurement. Ex: At 5us threshold, and frequency error of 6e-11, the estimated time which the unit will remain within specification is 23.14 hours.
REAL TIME CLOCK THRESHOLD	$RTCT=2.0	$RTCT=2.0	The threshold (in seconds) by which the onboard Real Time Clock can deviate from the Rb based time source before the holdover alarm sounds. The crystal based RTC is used to keep time while the power is off, and is synchronized to GNSS when lock is achieved. The RTC drift rate is on the order of 10-20 ppm. (Set to 0.0 to disable) (float)

12.0 Packaging

To protect the unit in field use, the electronics are housed in a rugged, water resistant case.

The Rubidium reference and other sensitive electronics are vibration isolated from the case to minimize the transference of shock and vibration.

While every effort has been made to design the product to be able to withstand field use - it should still be treated with care. Avoid excessive shock and vibration. Extremes in temperature can damage the LCD or battery.

13.0 Accessories

13.1 Antenna

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

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

13.2 Power

External power is provided by the included power adapter which can operate from 90 to 240Vac 50/60 Hz. Power can also be supplied from an external 12Vdc (2 Amps, 11 to 15Vdc). When connected to an external power source, the charger will activate if the battery requires charging. A full charge cycle is about six hours. The unit will operate while charging.

Power is provided by a commercially available Lithium ion 4.8 AH rechargeable battery which is modified for a special connector.

Depending on how the device is used, temperature, battery age, battery life will vary with the mode and user operating methods. User variability is a function of the functions used, time allowed for synchronization and whether the Ethernet port is active. Approximately 6 hours battery life is typical.

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

14.0 NTP Time Server (option)

NTP stands for Network Time Protocol and it is an Internet protocol used to synchronize the clocks of computers to some time reference. NTP is an Internet standard protocol originally developed by Professor David L. Mills at the University of Delaware.

The Network Time Protocol (NTP) is one of the most accurate and flexible means of sending time over the Internet. It can be used by almost any type of computer. The protocol is designed to compensate for some, but not all, network time delays between the server and the client. NTP is most successful across local area networks and can give accuracy as good as a few milliseconds. However, time transfer delays are at the mercy of server traffic and network bottlenecks and accuracy figures cannot be quoted as easily.

The NTP (verision 3.0) option uses time data from the GNSS. When GNSS is lost, the NTP time server continues to send out NTP using the Rubidium reference as the timing source.

14.1 Obtaining an IP Address

The NT9400 uses a customized Nano Pi for NTP. The IP address of unit is a Static IP Address of 192.168.7.200. The IP Address can be changed but the IP Address displayed on the NT9400 will only list this default IP address. Please contact Novus Technical Support for assistance in changing the IP Address if needed.

14.2 Setting up NTP

See Appendix E, NTP Configuration.

15.0 Technical Specifications

PPS Output	3.3Vdc CMOS (30 mA drive), Pulse width 1-50ms (adjustable), Rise-Fall < 10 ns
PPS Drift (unlocked State)	< 200 ns/hour for 4 hours (typical after full GNSS sync) < 50ms/year
PPS Locked	20 ns rms
Rubidium Atomic Frequency Standard:	
Accuracy at shipment	+/-5.0E-11
Warm-up time	<15 minutes
Time of lock	<5 min, -130 dBm
Time to achieve accuracy	<1E-9 <30 minutes
Aging - monthly	<3.0E-10
Aging - yearly	<1.5E-9
GNSS Disciplining	GNSS receiver Option
Time for valid output	<60 minutes
Frequency accuracy	<3E-11
Stability: Allan Deviation	
1s	<3E-10
10s	<1E-10
100s	<3E-11
SSB phase noise for 10Mhz	
	Standard
10Hz	< -95
100Hz	< -125
1000Hz	< -135
10000Hz	< -135

Antenna	GNSS antenna with LNA and 3 ft.cable (3.3Vdc,<45 mA)
10 MHz Sine	0.5 ±0.1Vrms
NMEA	GNSS or Rubidium source driven (RS232 and USB monitoring) NMEA 0183: 38400, N, 1 (Default)
LCD (2 x 16)	Time, Position, Event, Status, Frequency, etc.
Indicators	Built-in test alert, GNSS lock, Rubidium lock, Sync, Holdover Status
Power	Lithium with "fuel gauge" (> 6 hours), External 12Vdc @ 2 amp
Event	Leading edge LVCMOS (512 non-volatile) Rising or Falling programmable
Outputs	
10 MHz Sine	0.5Vrms, 10 MHz stability < 1.5ppb/year unlocked, <5E-12 GNSS locked
PPS	Pulse Per Second 5V or 3.3Vdc CMOS, 30 ns rms GNSS Locked, <50ms/year
RBPPS	Derived PPS, 3.3Vdc CMOS - state dependent
IRIG-B (Sine)	3Vpp 1kHz modulated sine (500Ω min termination impedance), 10/3 Mark to Space ratio, +/-35us relative to PPS
IRIG-B (DCLS)	5V or 3.3V unmodulated pulse (200Ω minimum termination impedance), +/-1us relative to PPS
RS232	RS232 levels (+/-5V) NMEA-0183
NMEA Strings	RMC, GNS, GSA, GGA, ZDA, GSV, VTG, NVS (Status)
Inputs	
Event Input (BNC)	>47k input impedance, <100pF
	Accuracy: < 1us relative to PPS
Option	NTP protocol version 3
Drift display	Displays estimated drift from UTC in microseconds (100ns resolution)
	Displays estimated Holdover remaining until threshold is exceeded
Height	~5 inches
Width	~12 inches
Depth	~9 inches
Weight	≈3 lbs.

16.0 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, Independence,, 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 by misuse, neglect, improper installation, improper storage, unauthorized modifications, inadequate maintenance, operation outside the environmental specifications for the product, repair alteration, or accident. NOVUS assumes no risk or liability for results of the use of products purchased from it, including but without limiting the generality of the foregoing: (1) the use in combination with any electrical or electronic components, circuits, systems, assemblies or any other materials or substances; (2) unsuitability of any product for use in any circuit or assembly. Removal or tampering with tamper-proof label on merchandise will void warranty coverage unless with the written authorization from NOVUS.

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

Your dated sales or delivery receipt is your proof of the purchase date. You may be required to provide proof of purchase as a condition of receiving warranty service. You are entitled to hardware warranty service according to the terms and conditions of this document if a repair to your NOVUS product is required during the limited warranty period. Our obligation at NOVUS is limited to repair or replace products which prove to be defective.

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

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

PRODUCT SPECIFICATIONS: Published specifications whether contained herein or in any other materials or documents distributed to Buyer by Novus do not become final or binding on NOVUS until approved by NOVUS. NOVUS expressly reserves the right to change or modify specifications at any time without prior notice.

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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

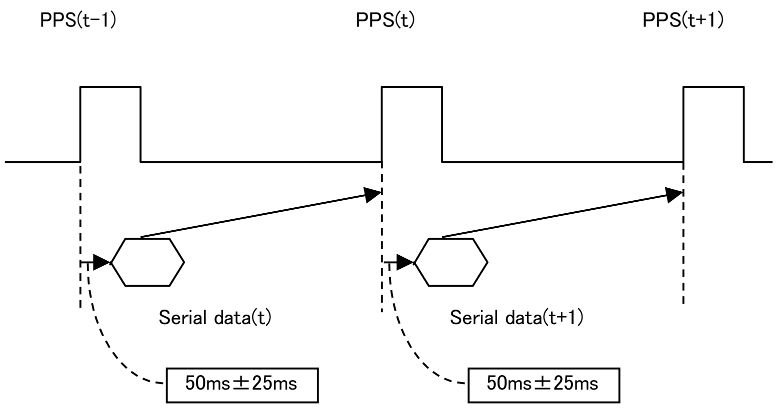
ASCII code (*2) Protocol: Input data
NMEA Standard sentence NMEA Proprietary sentence
Output data
NMEA Standard sentence NMEA Proprietary sentence

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) Note: A null field is output while positioning is interrupted.	0.0-50.0
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

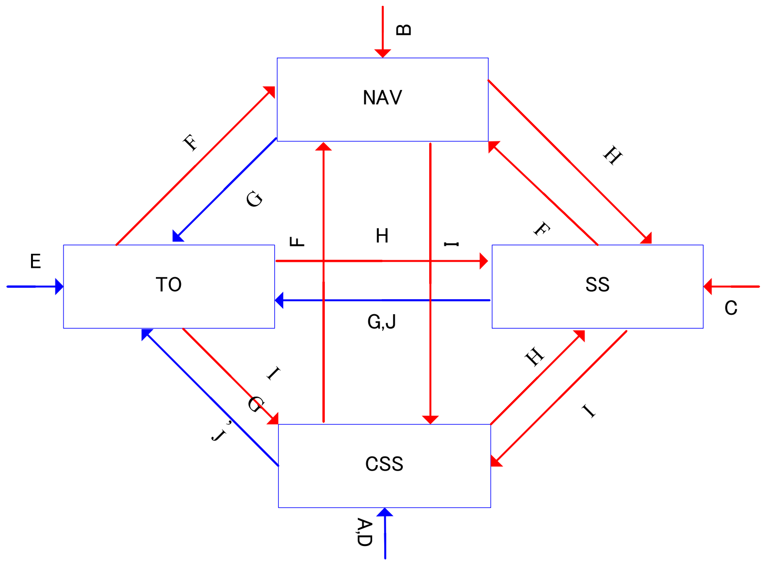
$PERDAPI,SURVEY,3,0,0,37.78700,-122.45100,31.5*53

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			

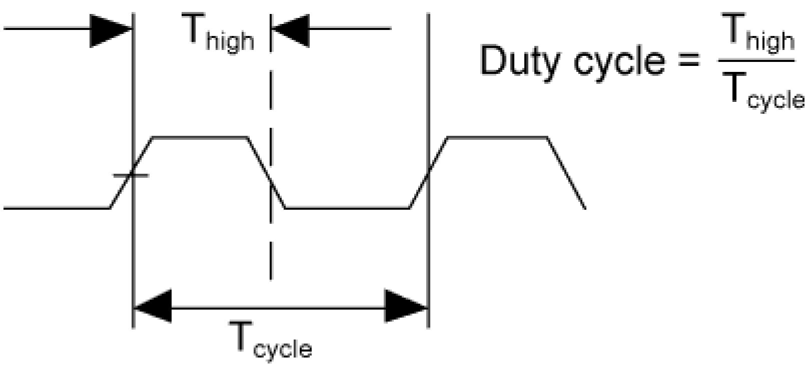
Num	Contents	Range	Default	Remark
1	FREQ	-	-	Command Name
2	mode	0 to 1	0	0 : stop 1 : output
3	freq	4000 to 40000000	10000000 (10MHz)	frequency[Hz]
4	duty △2	10 to 90 △7	50	duty cycle [%]
5	offset △2	0 to 99	0	phase delay in cycle [%] from GCLK-PPS edge

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	,	sequence	,	subcommand	*hh	<CR>	<LF>
		1		2					

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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