FURUNO

FURUNO
Timing Multi-GNSS Receiver

Model **GT-100**

PFEC Protocol Specifications

(Document No. SE22-600-007-07)

FURUNO ELECTRIC CO., LTD.

www.furuno.com

IMPORTANT NOTICE

The following satellite systems are operated and controlled by the authorities of each government.
- GPS, SBAS(WAAS): USA
- GLONASS: Russia
- Galileo, SBAS(EGNOS): Europe
- QZSS, SBAS(MSAS): Japan
- NavIC, SBAS(GAGAN): India
- BeiDou: China

Since this product receives satellite signals to operate, its performance may deteriorate significantly depending on the operational status and broadcast contents of each satellite. The items described in the various specifications of this product are not guaranteed, including the above cases. When using each satellite, it is necessary to fully understand the characteristics of the system and utilize its benefits at the user's responsibility.

This document is the specifications for the following products. If the target products are different or the associated software is different, please refer to the corresponding specifications separately.
・GT-100

The software of this product has been designed and verified with the utmost care, but if you find any problems during use, please contact us. We may check and provide a correction software. In addition, if we find a problem, we may contact you and provide a correction software.

When we provide a modified software, we may ask you to update the software. Therefore, we strongly recommend that the serial port of this product be accessible from outside your product so that you can easily update the software. We also strongly recommend that the serial port of this product be connected to a network, etc., so that software can be updated by remote download. If you need more information on how to update the software, please contact us.

The only protocol supported by these products is the one described in this manual or in the technical operation manual for these products provided by us. Please note that we cannot guarantee malfunctions caused by intentionally using protocols for other products not listed in them or protocols for debugging discovered by the user by chance.

For user evaluation and debugging, we may contact you with internal commands that are not described in this manual or the technical operation manual for this product provided by us. Please use the command only for evaluation and debugging, and refrain from applying it to mass-produced products.

FURUNO ELECTRIC CO., LTD. reserves the right to make changes to its products and specifications without notice.

Revision History

Version	Change contents	Date
0	Initial release	2022.4.12
1	Corrects “week number rollover” in chapter 2 Corrects table 6.12-2 Changes section 6.18 Corrects section 7.1 Corrects section 7.6 Corrects section 7.16 Changes and Corrects section 7.18 Corrects section 7.19 Adds and corrects chapter 8 Corrects chapter 9 Adds chapter 10	2022.7.13
2	Corrects section 4.2 Corrects section 7.1 Corrects table 8-1 and 8-2 in chapter 8	2022.7.25
3	Corrects section 4.2 Correct Table 6.11-1	2022.11.22
4	Update chapter 1 Correct the description in “Time only mode” and “Self-Survey mode” Add table 2-9 Correct section 4.1 Update Table 5.4-1 Correct section 6.11 Correct Table 6.12-2 Correct Table 6.12-3 Add section 6.14 Add section 6.15 Add section 6.16 Correct section 6.17 Correct section 7.1 Correct section 7.5 Correct section 7.6 and add Table 7.6-1 Correct section 7.8 Correct section 7.14 Correct section 7.15 Correct section 7.17 Add section 7.18 Correct section 7.20 Correct section 7.21 Add section 7.22 Correct chapter 8 Correct chapter 10	2023.06.16
5	Update chapter 1 Correct the example in section 7.14 Correct Table 8.2	2023.08.22
6	Update chapter 1 Add section 6.18 Correct section 6.20	2023.12.08
7	Add NOTE in section 6.15 Add section 6.23 Delete section 7.21 Correct Table 8.2	2023.12.22

Table of Contents

1 Outline

This document is the PFEC protocol specifications for GT-100.
The software version covered by this document is 4850569023.

2 Term

The following is a detailed description of the terms used in this document.
It contains a lot of important information about the behavior of this product, so we strongly recommend that you read it carefully.

Table 2-1. Terms related to communication

Terms	Description
Protocol	It is a communication procedure for sending and receiving data using the communication port.
Command	In this document, the data sent to the product is called a command.
Sentence	In this document, the data received from the product is called a sentence.
PFEC	It is one of the protocol formats. This is the format output by our (FEC: FURUNO ELECTRIC CO., LTD.) Products. This document provides details about this PFEC.
NMEA	It is an abbreviation for NATIONAL MARINE ELECTRONICS ASSOCIATION. In this document, the ASCII and communication protocols of the NMEA 0183 standard are referred to as NMEA. This product outputs serial data that complies with NMEA 0183 Ver. 4.11 established in November 2018.
ACK	It means acknowledgement. When a command is input into the product, if the command is accepted as being appropriate, the product returns ACK as a response sentence.
NACK	It means negative acknowledgement. When a command is input into the product, if the command is ignored as being inappropriate, the product returns NACK as a response sentence. If NACK is returned, please check whether the format of the transmitted command is appropriate, and checksum is appropriate.

Table 2-2. Terms related to satellites and satellite signals

Terms	Description
GPS	GPS (Global Positioning System) is a GNSS owned and operated by the United States of America
GLONASS	GLONASS (Global Navigation Satellite System) is a GNSS owned and operated by the Russian Federation.
Galileo	Galileo is a GNSS owned by the European Union and operated by the European GNSS Agency (GSA)
BeiDou	BeiDou Navigation Satellite System (BDS) is a GNSS owned and operated by the People's Republic of China.
NavIC	NavIC (Navigation Indian Constellation) is a GNSS owned and operated by India.
QZSS	QZSS (Quasi-Zenith Satellite System) is a GNSS owned and operated by Japan.
SBAS	A general term for satellite systems that broadcast GNSS augmentation information.
GNSS	Abbreviation for Global Navigation Satellite System. It is used as a general term for satellite constellation such as GPS, GLONASS, Galileo, BeiDou, NavIC, QZSS, and SBAS.
Satellite constellation	In the GNSS industry, constellation is sometimes used to refer to satellite systems in each country. For example, we may say, "This receiver supports two constellations, GPS and GLONASS."
ICD	It stands for Interface Control Document. It is a document that defines the contents and mechanism of broadcasting by a satellite as specifications by the relevant departments of the country that operates the satellite. There is an ICD for each satellite constellation. GNSS receivers are typically designed with reference to these documents. The ICDs referenced by this product are shown in the table below. The ICD does not claim a permanent specification definition and may be revised for the purpose of correcting errors or expanding functions. Part of the broadcast content may change accordingly. This product does not guarantee including the changes of those updated ICDs. Please note.

Satellite type	ICD version	Release date
GPS L1	IS-GPS-200K	04 Mar 2019
GPS L5	IS-GPS-705F	04 Mar 2019
GLONASS L1	5.1	2008
Galileo E1	OS SIS ICD V1.3	Dec 2016
Galileo E5a	OS SIS ICD V1.3	Dec 2016
BeiDou B1I	3.0	27 Feb 2019
BeiDou B1C	1.0	27 Dec 2017
BeiDou B2a	1.0	27 Dec 2017
NavIC L5	1.1	Aug 2017
QZSS L1	003	05 Nov 2018
QZSS L5	003	05 Nov 2018

<table>
<tr>
<td>Frequency band</td>
<td>In recent years, some GNSS broadcasts are also being broadcast in the frequency band called the L5 band centered on 1176.45 MHz, in addition to the conventional frequency band called the L1 band centered on 1575.42 MHz. The frequency bands for each satellite / signal name are as follows.
To receive the L5 band, an antenna corresponding to the L5 band is required. Also, the receiver must support L5 band reception. For satellite signals that can be received by this product, refer to the function specifications.
<table>
<tr><th>Signal name</th><th>Frequency band</th><th>Signal name</th><th>Frequency band</th></tr>
<tr><td>GPS L1</td><td>L1</td><td>GPS L5</td><td>L5</td></tr>
<tr><td>GLONASS L1</td><td>L1</td><td>Galileo E1</td><td>L1</td></tr>
<tr><td>Galileo E5a</td><td>L5</td><td>BeiDou B1I</td><td>L1</td></tr>
<tr><td>BeiDou B1C</td><td>L1</td><td>BeiDou B2a</td><td>L5</td></tr>
<tr><td>NavIC L5</td><td>L5</td><td>QZSS L1</td><td>L1</td></tr>
<tr><td>QZSS L5</td><td>L5</td><td>SBAS L1</td><td>L1</td></tr>
</table>
</td>
</tr>
<tr>
<td>Satellite number</td>
<td>The number assigned to each satellite. It is used in GSA sentences and GSV sentences. To distinguish satellite constellations from duplicate satellite numbers, you can use the GNSS system ID for GSA sentences and the talker ID for GSV sentences.</td>
</tr>
</table>

Table 2-3. Terms related to satellite broadcasting contents

Terms	Description
Ephemeris	An ephemeris is one of the information that each GNSS satellite broadcasts. It shows the time and the detailed orbital information of the broadcasting satellite. This information is necessary for positioning, and it is repeatedly broadcasted in short cycles. GPS satellites broadcast their ephemeris for the L1C/A signal in 30-second cycles and usually valid for the next 4 hours. Starting with valid ephemeris backup in the receiver is called HOT START.
Almanac	An almanac is one of the information that GNSS satellites broadcast. An almanac contains various correction information, UTC parameters, and rough orbital information for all the satellites of a constellation. In the case of GPS satellites, the almanac is broadcast in 750 second cycles. Therefore, it may take up to 750 seconds from GPS time synchronization to UTC synchronization after initial positioning. Starting with the almanac backup in the receiver is called WARM START. If neither the ephemeris nor the almanac is backed up in the receiver, this is called COLD START.
Differential data	SBAS in each country sends correction information that is useful when finding the current position and time using GPS or the like. This correction information is called differential information, and using it to correct the position, time, etc. is called differential correction.

Table 2-4. Terms related to signal reception

Terms	Description
Jamming signal	Jamming signals are electrical noises generated in or around the GNSS signal bands by other equipment or radios. Jamming signals are often intentionally broadcasted by malicious actors with the intend to affect the performance of near-by GNSS receivers. Jamming signals will interfere with the reception of genuine GNSS satellite signals, which may result in poor or failed positioning.
Anti-jamming	Anti-jamming is the function that helps a GNSS receiver to sustain normal operation by detecting and removing interference waves so that GNSS satellite signals can be received as usual. However, since it is extremely difficult to detect and remove all interference waves, it is important to properly understand what the anti-jamming can do and cannot do.
Spoofing signal	Spoofing signals are signals generated by malicious actors that mimic the broadcast contents of the GNSS satellite using something like a simulator. Receiving this signal can affect your position and time. This product has a function to detect spoofing signals and eliminate them.

Table 2-5. Terms related to time

Terms	Description
Leap second	A leap second refers to the occasional insertion of a one second to the Coordinated Universal Time (UTC) in order to maintain its synchronization with the earth rotation. In general, a decision on a leap second insertion, which can be the addition or the subtraction of one second, is made at least one to two months prior its implementation. A leap second insertion is usually scheduled at the end of a quarter, but preferably on January 1st or July 1st. Leap second insertions have taken place since 1972. Yet considering that the GPS and the QZSS satellites are operating with a starting date of January 6, 1980, our GNSS receivers are designed to output the cumulative value of leap seconds starting from January 6, 1980. As of February 2022, the cumulative value of leap seconds since January 6, 1980, is +18 seconds. Unless the concept of leap second insertion is abandoned in the future, other leap second insertion events may happen from time to time.
UTC time	UTC stands for Coordinated Universal Time and is the primary time standard in the world. It includes leap seconds and is the reference of the time we use on daily basis, that is without considering any time zone and daylight-saving adjustments. The UTC time is determined based on a network of atomic clocks located in many different countries all around the world. The time difference between all these reference atomic clocks is on the nanosecond scale. For example, in the case of the United States, the UTC time is set by the United States Naval Observatory and is called the UTC(USNO). Similarly, in the case of Russia, it is called UTC(SU).
GPS/QZSS time	GPS Time is the time system of GPS and is also the time system adopted by QZSS. It is broadcasted by the GPS and the QZSS satellites. It is a continuous time system that started on January 6, 1980, at midnight UTC. It does not consider any leap second. The GPS Time is broadcasted following the concept of the Time of Week (TOW) expressed in seconds and the week number. The GPS week ranges from 0 to 1023 (in case of GPS/QZSS L5 signal, the range is from 0 to 8191), effectively rolling over approximatively every 19.8 (or 158.4) years. After receiving both TOW and week number GNSS receivers can compute the current GPS time, modulo the GPS week epoch. The GPS satellites broadcast UTC parameters, allowing GNSS receivers to also compute the current UTC (USNO) time, including the leap seconds. In the last many years, the GPS Time is kept aligned to the UTC (USNO) time (modulo the leap seconds) within a few nanoseconds. There is no guarantee that this amount of error will be maintained in the future.

GLONASS time	GLONASS Time is the time system of GLONASS and is broadcasted by the GLONASS satellites. It is a continuous time system that started on January 1, 1996. It is synchronized with UTC (SU) minus 3 hours and includes leap seconds. GLONASS Time is broadcasted in a format allowing GNSS receivers to uniquely compute the current date and time util year 2100, without having to account for any week number rollover, unlike with the GPS Time. Since the GLONASS Time includes leap seconds, the correct alignment to UTC (SU) including the leap seconds is obtained by GNSS receivers as soon as the GLONASS time is decoded without having to wait for the reception of the UTC parameters. The GLONASS satellites also broadcast the time difference between the GLONASS Time and the GPS Time, simplifying the time alignment between two systems for the GNSS receivers.
Galileo time	Galileo Time is the time system of Galileo and is broadcasted by the Galileo satellites. It is a continuous time system that does not consider any leap seconds and that started on August 22, 1999, at 00: 00: 00, 13s ahead of UTC time. Galileo Time, GPS Time and QZSS Time are consistent with one another. Galileo Time is broadcasted in a format allowing GNSS receivers to uniquely compute the current date and time without having to account for any rollover until February 19, 2078. Like for the GLONASS Time, this is a significant advantage compared to the GPS and QZSS Time. The Galileo satellites broadcast UTC parameters, allowing GNSS receivers to compute the current UTC (EU) time. They also broadcast the time difference between the Galileo Time and the GPS Time, simplifying the time alignment between two systems for the GNSS receivers.
BeiDou time	It is a time system broadcast by BeiDou. It is a time that does not consider leap seconds after the starting point on January 1, 2006. There is a difference of 14 seconds from the GPS time. BeiDou broadcasts the time based on the concept of weekly seconds (0 to 607799) and week number (13 BITS for both L1 and L5 bands). The receiver generates the current time by converting that information. Since the size of the week number is 13 BITS, by receiving BeiDou, it is possible to display the correct time until 2100 without being aware of the problem of week number rollover.
NavIC time	It is a time system broadcast by NavIC. The starting point on the ICD is August 22, 1999, but since the GPS time and each parameter are substantially the same, it is broadcast as a continuous time that does not consider the leap second after the starting point on January 6, 1980. Will be done. Like the GPS L1 band, NavIC broadcasts the time based on the concept of weekly seconds and week number (10BIT), and the receiver converts the information to generate the current time.

UTC parameter	UTC parameters are information broadcasted by each GNSS satellite to allow converting a GNSS time system into UTC time. UTC parameters mainly include the leap second difference between a GNSS time and UTC time and the leap second insertion timing (except for GLONASS satellites as the GLONASS time already includes the leap seconds), as well as the nanosecond scale correction information. The UTC parameters are included in a group of navigation messages, commonly referred to as an almanac, broadcasted at a regular time interval.
Week number rollover	Several GNSS express their time system using the concept of time of week and week number. The data size to transmit the week number differs for different systems and signals. For example, the GPS L1C/A, QZSS L1C/A and NavIC L5 signals use a 10bit data size to transmit the week number, providing a week number from 0 to 1023. The week number that follows week 1023 is again week 0. This event is called week number rollover. After a week number rollover occurs, GNSS receivers without special measures may output a date 1024 weeks out of date. This receiver has been designed to deal with a GPS week number rollover and will continue to display the correct date after such an event. However, the range of date that can be properly converted is still up to 1024 weeks. Depending on the product, this date, until which the correct date can be computed independently, is different. In this product, the limit date is **from 00:00:00 1st May 2022 to 23:59:59 21st December 2041**. Once this limited period has past, upon a restart without backup, the receiver may display multiple of 1024 weeks out of date. In this case it is possible to set the correct date by sending a command to the receiver or by enabling the use of GLONASS, Galileo, BeiDou satellites or L5 band signal. In the case of a continuous operation, our receiver correctly maintains the current date and time upon week number rollovers.
Default leap second	The default leap second is a value that is applied to tentatively allow GNSS receivers to output the correct UTC time before the leap second information is obtained from the received UTC parameters. It is also possible to set the correct leap seconds upon start by sending a command to the GNSS receiver. GNSS receivers making use of the backup function are also able to apply the correct leap second upon start. This setting is only used to display the correct UTC time before obtaining the correct leap seconds from the GNSS signals, so even if the default leap second is incorrect, it will not affect the reception of the satellite signals nor the positioning.
LZT	LZT stands for Local Zone Time. It provides the time offset value between UTC time and the local time.

Table 2-6. Terms related to PPS and clock

Terms	Description
PPS	PPS stands for Pulse Per Second. The GNSS receiver output providing a one pulse per second signal is called 1PPS. 1PPS is equivalent to 1 Hz clock. GNSS receivers for timing applications provide highly accurate time information to the outside world by accurately synchronizing the edge of this 1PPS with UTC time or GNSS Time.
Cable delay	Cable delay refers to the time it takes for a signal to travel through a cable. It depends on the cable type and length. In our products, the cable delay can be compensated by sending a command. The cable connected between the GNSS antenna and the GNSS receiver (and if applicable, the cable connected between the 1PPS output of GNSS receiver and the equipment) should be considered.
Quantization error (time pulse jitter)	In a general GNSS receiver, when the positioning calculation is performed internally, the calculation result of the time can be obtained with extremely high resolution, but when it is output as PPS from the terminal, it depends on the clock installed in the product. It is known that the resolution is limited because of this. The PPS error caused by this resolution limitation is referred to as the quantization error or time pulse jitter in this document. This product is devised to make this quantization error extremely small.
UTC synchronization	UTC synchronization is the state in which the time, the PPS and the frequency are all synchronized with UTC time. For this synchronization to be complete, GNSS receivers must receive the GNSS satellite signals, including the UTC parameters and calculate the time.
GPS synchronization	GPS synchronization is the state in which the time, the PPS and the frequency are all synchronized with GPS time. GNSS receivers will transition into GPS synchronization when either expressly set in this state or when the UTC parameters are not received.
RTC synchronization	RTC stands for Real Time Clock. In some of our timing products, the expression "RTC time synchronization" is used to explicitly indicate that the PPS and the frequency are in an uncontrolled state, either before the satellite signals is received and the time is fixed, or when the reception of the satellite signals is temporarily interrupted.
PLL control mode	This value is used to determine how well the PPS output from this product is synchronized with the reference time. It consists of WARM UP, PULL IN, COARSE LOCK, FINE LOCK, HOLDOVER, and OUT OF HOLDOVER. Please refer to Table 6.12.1 for details.
Frequency	This product has a dedicated frequency generation block for timing applications, and can output low-noise, high-precision frequencies synchronized with UTC or GNSS time. The nominal frequency is 10MHz, 2.048MHz, 32.768MHz, and so on. The frequency and the edge of 1PPS which is output from OCLK0 are always synchronized, making it easy to handle.

ICLK	Abbreviation for Input terminal of Clock Signal, it is a terminal for inputting a clock prepared outside this product. If 1PPS is input, it remains as it is, and if a frequency of 2Hz or higher is input, it is divided by Clock Divider to become 1PPS, and the reference time EXT PPS is generated. User can set a division ratio by the command. In this document, when 1PPS is input to ICLK, that 1PPS may be called EPPS (External PPS). Also, when inputting a frequency of 2Hz or higher to ICLK, that frequency is sometimes called ECLK (External Clock).
OCLK	Abbreviation for Output terminal of Clock Signal, which is a terminal for outputting clock signal from this product. This product has three output terminals, which are named OCLK0, OCLK1, and OCLK2.

Table 2-7. Terms related to positioning processing

Terms	Description
Positioning calculation	It means that the GNSS receiver calculates various information such as the position, speed, time and direction of the receiver based on the information from the satellite. The accuracy of the position and time calculated by the positioning calculation depends greatly on the installation environment of the GNSS receiver (strictly speaking, the antenna connected to the receiver). How many GNSS satellites with high signal levels can be received (whether they are used in open areas) and whether they are scattered in all directions (biased toward the satellites that can be received due to obstruction).), etc. have a big influence.
Fix (First Fix)	The state in which the positioning calculation is performed by properly receiving the satellite is called fix. If the number of positioning satellites in the GNS sentence is 1 or more, it can be considered as fix. In addition, the first positioning calculation performed after the power is turned on or restarted is sometimes called the first fix.
No Fix	The state in which positioning calculation is not performed is called no fix. If the number of positioning satellites in the GNS sentence is 0, it is considered as no fix.
Pseudo range	Pseudo range is one of the information used by GNSS receivers for PVT calculation. It is the result of calculating the distance between a satellite and a GNSS receiver.
Doppler frequency	The Doppler frequency is one of the information that GNSS receivers use for PVT calculation. PVT means position, velocity and time of the receiver. As the satellites and/or the receiver move, the frequencies of the signals received by the receiver are observed to be different from the frequency transmitted by the satellites (Doppler effect). This change is called the Doppler frequency.
T-RAIM	Abbreviation for Time Receiver Autonomous Integrity Monitoring It is a mechanism to identify and eliminate satellites that may adversely affect the positioning calculation. It is based on the principle of combination and majority voting when the number of GNSS satellites is larger than the minimum number of satellites required for the positioning calculation. This function works automatically in this product.
LOS satellite	LOS stands for Line of Sight. It refers to the direct reception of a GNSS satellite signal at the GNSS receiver's antenna, without any blocking obstacles or reflections. It is synonymous with an unobstructed view between a GNSS satellite and the GNSS receiver's antenna. Such GNSS satellites are specifically called LOS satellites. The more LOS satellites are received, the more stable the observed signal levels are, and the more accurate the PVT calculation is.

NLOS satellite & Multipath	NLOS stands for Non-Line of Sight. A NLOS satellite is the opposite of a LOS satellite and indicates the presence of an obstruction between a GNSS satellite and the GNSS receiver's antenna. Strictly speaking, a GNSS satellite whose signal is not received at the GNSS receiver's antenna, is determined to be non-visible and is also included in NLOS satellites. However, in our case, we simply call such satellites as non-visible satellites and not as NLOS satellites. A NLOS satellite is defined as a GNSS satellite whose signal cannot be received directly at the GNSS receiver's antenna, but only a faint signal of it that is reflected by surrounding buildings or attenuated by an obstacle is received. A signal that is received from a reflection and/ or by travelling through an obstacle is referred to as multipath. Using multipath GNSS satellite signals for the PVT calculation tends to result in poor position accuracy and time accuracy due to errors in the calculation of their pseudo ranges and Doppler frequencies. Determining which GNSS satellites are NLOS satellites, masking them appropriately, and using only LOS satellites for the PVT calculation improves the position accuracy and time the accuracy.
DOP	DOP stands for Dilution of Precision. It means the precision degradation rate. The smaller the precision degradation rate, the higher the precision. This value depends on the number of the received GNSS satellites and their positional relationship. If the satellites are evenly distributed in the sky, the DOP value will be smaller, and the positioning accuracy will be higher. On the other hand, if there are buildings, trees, or other obstructions in the surrounding area, and the direction of the satellites that can be received is uneven, the DOP value becomes larger, and the accuracy of the calculated position becomes worse. The DOP value was a very useful indicator for monitoring the accuracy when only GPS satellites that could be received. In recent years, however, the number of available GNSS satellites has increased so much that it has become difficult to obtain a large DOP value. Meanwhile, in harsh environments such as indoor environments, multipath satellite signals are sometimes included in the DOP calculation, giving small DOP value that does not necessarily equate to high accuracy. So, the DOP value should not be given too much importance. There are other types of DOPs, such as PDOP (Position Dilution of Precision), HDOP (Horizontal Dilution of Precision), and VDOP (Vertical Dilution of Precision), but the basic concept is the same for all of them.
DSS (Dynamic Satellite Selection)	DSS is a unique multipath countermeasure by Furuno that automatically detects satellites that may cause accuracy deterioration and excludes them from positioning calculations. It greatly reduces the effect of multipath and contributes to improved accuracy. This function is ON by default.

Table 2-8. Terms related to position mode

Terms	Description
Position mode	General GNSS receivers must receive four or more GNSS satellite signals for the PVT calculation, thus, to calculate information such as latitude, longitude, altitude, speed, azimuth, and time. Yet, if a GNSS timing receiver operates at a known static position and the latitude, longitude and altitude of this position are provided to the GNSS receiver, it can calculate accurate time and output PPS and VCLK frequency precisely synchronized with UTC time or a GNSS time, while receiving only one GNSS satellite signal. For this reason, our GNSS receivers dedicated to time sensitive applications can operate in four different modes: NAV mode, which assumes the GNSS receiver does not operate at a static position and calculates the latitude, longitude, altitude, speed, azimuth, and time; Time Only mode, which assumes the GNSS receiver operates at a static position and precisely knows its position, and calculates only the time; Self-Survey mode which assumes the GNSS receiver operates at a static position and precisely estimate this position while calculating the time.
Hold Position	Hold position is the term used in GNSS timing receiver applications to refers to the coordinates of the static position where the GNSS antenna is installed. It is expressed in terms of latitude, longitude, and altitude. When the antenna installation location is unknown, the hold position can be calculated and set automatically by the GNSS receiver using the Self-Survey mode.
Surveyed position & Position surveyed process	Surveyed position refers to the process of calculating the fixed position in Self-Survey mode (see following terms), while the position accuracy has not yet fully converged. In addition, the process of calculating the surveyed position is called position surveyed process
NAV mode	NAV mode stands for Navigation Mode. In this mode the GNSS receiver calculates the latitude, longitude, altitude, speed, azimuth, and time every second. The time precision of this mode is inferior to Time Only mode, but it must be used for non-static applications, in in-vehicle applications. In this mode, at least four or more satellites, except SBAS satellites, must be received.
Time Only mode	Time Only mode stands for Time Only mode. In this mode the GNSS receiver must operate in static position, must already know its precise position, and only calculates the time every second. It is possible to set the receiver in Time Only mode, by sending a command to the receiver with its precise position coordinates. In Time Only mode, a GNSS receiver outputs a more accurate and stable PPS and VCLK frequency. In this mode a GNSS receiver can continue to calculate the time even when it receives only one GNSS satellite signal. **For calculating timing with a single satellite, the signal level (C/N0) of that satellite must be 40 dB or higher.**

Self-Survey mode	Self-Survey mode stands for Self-Survey mode. Self-Survey mode is the mode for position estimation processing, which calculates the latitude, longitude, altitude of the static antenna installation location and time every second. The Self-Survey mode is suitable for applications where the use of Time Only mode is desired but the exact static position of the GNSS receiver is unknown and must be first determined. Once the GNSS receiver has calculated its static position for a long enough period (24 hours by default) and/ or with certain accuracy (configurable), it automatically transitions into Time Only mode. In addition, even if there are less than 4 units in Self-Survey mode, if there is 1 or more units, the same processing as in Time Only mode is performed using the position information calculated so far, and accurate 1PPS is possible to output. **For calculating timing with a single satellite, the signal level (C/N0) of that satellite must be 40 dB or higher.**

Table 2-9. Terms related to Holdover

Terms	Description
HOLDOVER	This function maintains the accuracy and precision of 1PPS as much as possible even when GNSS signals cannot be received, and positioning is not performed. About this function, please refer to the HOLDOVER command.
Learning time	The FINELOCK duration time required in advance to perform holdover is referred to in this document as learning time.

3 Communication Specifications

Signal Lines used	: TXD、RXD
Flow control	: None
System	: Full Duplex Asynchronous
Speed	: 115200 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. 4.11 based ASCII code [*2]
Content	: It consists of the flowing data.

- Input data
  NMEA Proprietary sentence

- Output data
  NMEA standard sentence
  NMEA Proprietary sentence

[*1] Baud rate
It can be changed by a command.
Please refer to BAUDRATE command in section 7.17 for details.

[*2] NMEA format
It complies with: NMEA 0183 STANDARD FOR INTERFACING MARINE ELECTRONIC DEVICES Version 4.11 (NATIONAL MARINE ELECTRONICS ASSOCIATION, November 2018)

4 Sentence Output Timing

4.1 Output Timing of 1PPS and Sentence

After the time is confirmed by GNSS positioning, the output timing of the sentence of this product is synchronized with the correct second of the reference time to be synchronized and 1PPS which output from the each OCLK ports. By default, the sentence output starts within 200ms after the rising edge of 1PPS, which is synchronized to UTC time.
However, please note that if a cable offset larger than 1 msec is set by OCLK0, OCLK1, OCLK2 command, etc., the timing between the PPS and sentences output from that OCLK port may not satisfy this relationship, so please be careful when entering a large cable offset.
By default, the time given to the sentence indicates the time when the next 1PPS is output.
This time can be changed with a command, and the time display of the sentence output at time T+1 can be changed to T. See Chapter 7.6, NOTE in the ALIGN command, for details.
Positioning information and status are generated based on the positioning result 1 second ago.

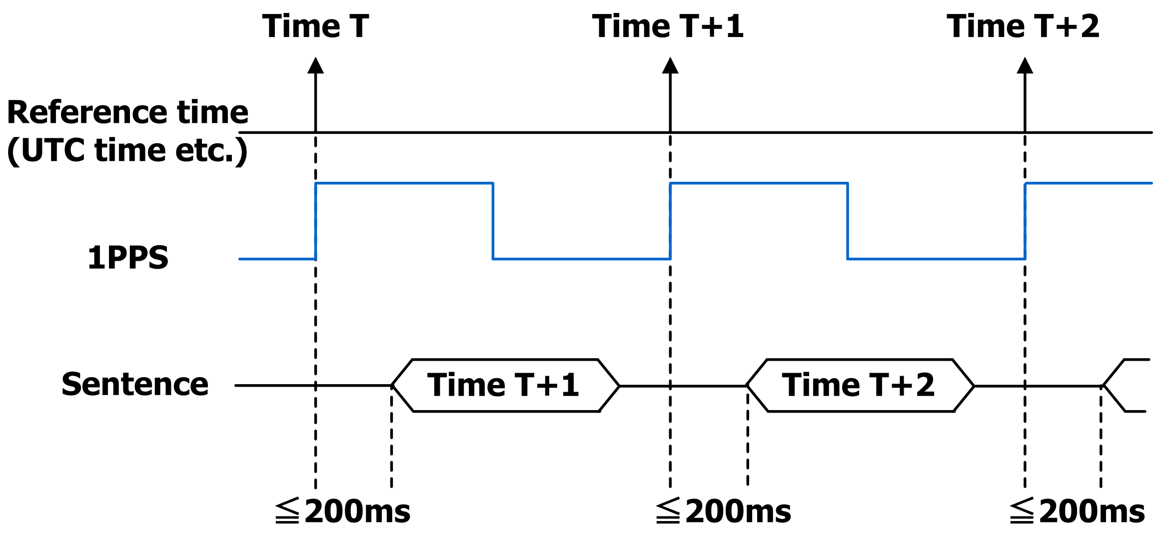


Figure 4.1-1. Relationship between 1PPS, sentence, and output time

4.2 Notes on sentence output

When using commands that switch the output content of sentences, please keep the amount of sentences output per second to 90% of the number of bytes that can be output at the current baud rate, in order to maintain the relationship between 1 PPS and sentences output. For example, if the baud rate is set to 9600 bps, the formula is as follows:

9600[bps] / 10[bits] * 0.90 = 864[bytes]

The data size for all sentences that can be output per one second is 864 bytes. If this is exceeded, sentences after 865 bytes per one second may not be output.
If there is a risk of exceeding the number of sentences that can be output, take measures such as increasing the baud rate or reducing the content of the sentences to be output.

5 NMEA Sentence Format

The details of the NMEA format are described below.

5.1 Standard Sentence

The details of the standard NMEA format are described below.

Format:

$	Address Field	,	Data Field	…	*Checksum	<CR>	<LF>
	5 bytes						

Field	Description
$	Start-of Sentence marker
Address field	It is 5-byte fixed length. The first 2 bytes represent the talker ID. The next 3 bytes represent the type of data. See Chapter 5.3 for more information on Talker IDs.
Data filed	It is mainly variable length, and each field is always separated by a delimiter ",". If there is no corresponding data in the field, it is represented by a null field. For fields represented by a fixed length, if the value is less than or equal to the specified number of digits, 0 is inserted till the specified number of digits.
Checksum	All data from the data after "$" to the data before "*" is XORed for all 8 bits, and the result is converted into a 2-byte ASCII character. All output sentences are output with a checksum. To get the proper sentence, we recommend that you make sure the checksum is correct before accepting the sentence.
<CR><LF>	End-of-Sentence marker <CR> is 0x0D. <LF> is 0x0A.

5.2 Proprietary Sentence

The following details the Proprietary NMEA format.

Format:

$	P	Maker Code	,	Data Field	…	*Checksum	<CR>	<LF>
		3 bytes						

Field	Description
$	Start-of Sentence marker
P	Proprietary sentence identifier
Maker code	This is a manufacturer-specific code represented by a fixed length of 3 bytes. In this product, it is "FEC" which means FURUNO ELECTRIC CO., LTD.
Data filed	It is mainly variable length, and each field is always separated by a delimiter','. If there is no corresponding data in the field, it is represented by a null field. The data length is determined by the type of sentence. See the chapter below for more details. If there is a part surrounded by "[]" in the explanation of the command in the following chapter, it means that the command can be input by omitting the field. When you enter a command, each field has its own range. If any of the fields is out of the input range, the command will be rejected and will return NACK, including the fields that were entered correctly.
Checksum	All data from the data after "$" to the data before "*" is XORed for all 8 bits, and the result is converted into a 2-byte ASCII character. All output sentences are output with a checksum. To get the proper sentence, we recommend that you make sure the checksum is correct before accepting the sentence. Also, the input sentence must have a checksum. The checksum is checked when the sentence is entered, and if the checksum is incorrect, the sentence is considered invalid and returns NACK.
<CR><LF>	End-of-Sentence marker

5.3 Talker ID

The talker ID displayed in the standard NMEA format changes depending on the type of satellite being received and the settings in the talker ID field of the GNSS command. Below are the types and meanings of talker IDs in RMC, GNS, GSA, GGA, GLL, VTG, ZDA, and GST sentences, and the conditions under which they are displayed.

Table 5.3-1. Relationship of talker ID (other than GSV)

Output type	Meaning of Talker ID	Output conditions
GP	GPS	Setting to GPS dependent reception
GL	GLONASS	Setting to GLONASS dependent reception
GA	Galileo	Setting to Galileo dependent reception
GB	BeiDou	Setting to BeiDou dependent reception
GQ	QZSS	Setting to QZSS dependent reception
GI	NavIC	Setting to NavIC dependent reception
GN	GNSS	Setting other than the above

Taking the GNS sentence as an example, for example, GPGNS is displayed when GPS dependent reception is set, and GNGNS is displayed when multiple satellite systems are set to receive. The output conditions depend on the setting status of the satellite system to be used (the setting status of the GNSS command described later), and it does not matter whether the satellite signal is received.

Next, the type and meaning of the talker ID in the GSV sentence and the output conditions are described.

Table 5.3-2. Relationship of talker ID (GSV)

Output type	Meaning of Talker ID	Description
GP	GPS	Reports GPS satellites related information
GL	GLONASS	Reports GLONASS satellites related information
GA	Galileo	Reports Galileo satellites related information
GB	BeiDou	Reports BeiDou satellites related information
GQ	QZSS	Reports QZSS satellites related information
GI	NavIC	Reports NavIC satellites related information

The GSV sentence is designed so that multiple lines can be displayed for each satellite system. For example, if it is set to receive only GPS L1C/A, only GPGSV will be displayed. GPGSV and GLGSV are displayed when both GPS L1C/A and GLONASS L1OF are set to be received. Therefore, the GSV sentence can identify which satellite system information is shown by the type of talker ID. The output conditions depend on the setting status of the satellite system to be used (the setting status of the GNSS command is described later), and it does not matter whether the satellite signals are received.

The GGA sentence is fixed to GP regardless of the satellite system settings.

The GSA sentence always uses the GN talker ID when the reception of more than one constellation is enabled. When this product is set to receive only one constellation, the specific talker ID of this constellation is used for the GSA sentence (this is in depend on the reception of one or more signals for the enabled constellation).

5.4 Sentence output priority and default output sentence

The priority of the sentence output of this product and the sentences output per second by default are as follows. The sentence output availability and cycle can be set with the NMEAOUT command.

Table 5.4-1. Sentence output priority and default output sentence

Output Priority	Sentence	Default Output
HIGH	RMC	○
	GNS	○
	GGA	-
	GLL	-
	VTG	-
	GSA	○
	ZDA	○
	GSV	○
	GST	-
	GNtps,A	○
	GNtps,B	○
	GNtps,C	○
	GNtps, other than above	-
LOW	QUERY related	-

6 Details of output sentences from this product

This chapter describes details of sentences output by this product. There are unsupported fields in the output sentences. This document shows these fields as “NULL”. These fields are null fields.

6.1 RMC – Recommended Minimum Navigation Information

The following details the RMC sentence in standard NMEA format.

Format:

$XXRMC	,	TIME	,	STATUS	,	LATITUDE	,	LATITUDAL DIRECTION	,	LONGITUDE	,
		1		2		3		4		5	

LONGITUDINAL DIRECTION	,	SPEED	,	COURSE	,	DATE	,	MAGNETIC VARIATION	,
6		7		8		9		10	

MAGNETIC DIRECTION	,	MODE INDICATOR	,	NAVIGATION STATUS	*hh	<CR>	<LF>
11		12		13			

	Data	Range	Default	Description
1	TIME	000000.000 to 235960.000	000000.000	It shows the current time. It is output at RTC, GNSS or UTC time according to positioning status, synchronization setting, UTC parameter acquisition status and so on. 60 seconds is displayed only when the leap is inserted.
2	STATUS	A, V	V	A: Data valid V: Data invalid
3	LATITUDE	0000.0000 to 9000.0000	0000.0000	It shows Latitude. The first two digits are degrees, and the following are minutes.
4	LATITUDAL DIRECTION	N, S	N	N: North latitude S: South latitude
5	LONGITUDE	00000.0000 to 18000.0000	00000.0000	It shows Longitude The first three digits are degrees, and the following are minutes.
6	LONGITUDINAL DIRECTION	E, W	E	E: East Longitude W: West Longitude

	Data	Range	Default	Description
7	SPEED	-	0.00	It shows speed in knots.
8	COURSE	0.00 to 359.99	0.00	True course The unit is degrees. It is a variable length.
9	DATE	010100 to 311299	020100	It shows the current date. The last two digits are displayed in the order of day, month, and year.
10	MAGNETIC BARIATION	NULL	NULL	Always NULL.
11	MAGNETIC DIRECTION	NULL	NULL	Always NULL.
12	MODE INDICATOR	A, D, N	N	A: Position fix without differential D: Differential position fix N: No position fix
13	NAVIGATION STATUS	V	V	It always displays "V" which is disabled.

Example:
$GNRMC,020113.229,A,3442.8158,N,13520.1219,E,0.31,0.00,240920,,,A,V*06
Time 02:01:13.229, Data valid, 34 deg 42.8158 min (North latitude) , 135 deg 20.1219 min (East longitude) , Speed: 0.31 knots , True course: 0.00, Date: 24th September ,2020 , Position fix without differential

NOTE:

- In SS (Self Survey) mode, the surveyed position currently being calculated is displayed in latitude, longitude, and height. In TO (Time Only) mode, the fixed position is displayed for latitude, longitude, and height.

6.2 GNS – GNSS Fix Data

The following details the GNS sentence in standard NMEA format.

Format:

$XXGNS	,	TIME	,	LATITUDE	,	LATITUDAL DIRECTION	,	LONGITUDE	,
		1		2		3		4	

LONGITUDINAL DIRECTION	,	MODE INDICATOR	,	TOTAL NUMBER OF SATs	,	HDOP	,
5		6		7		8	

ALTITUDE ABOVE SEA LEVEL	,	GEOIDAL SEPARATION	,	AGE OF DIFFERENTIAL DATA	,
9		10		11	

DIFFERENTIAL STATION ID	,	NAVIGATION STATUS	*hh	<CR>	<LF>
12		13			

	Data	Range	Default	Description
1	TIME	000000.000 to 235960.000	000000.000	It shows the current time. It is output at RTC, GNSS or UTC time according to positioning status, synchronization setting, UTC parameter acquisition status and so on. 60 seconds is displayed only when the leap is inserted.
2	LATITUDE	0000.0000 to 9000.0000	0000.0000	It shows Latitude. The first two digits are degrees, and the following are minutes.
3	LATITUDAL DIRECTION	N, S	N	N: North latitude S: South latitude
4	LONGITUDE	00000.0000 to 18000.0000	00000.0000	It shows Longitude The first three digits are degrees, and the following are minutes.
5	LONGITUDINAL DIRECTION	000000.000 to 235960.000	E	E: East Longitude W: West Longitude

	Data	Range	Default	Description
6	MODE INDICATOR	NNNNNN to DDDDDD (A,D,N)	NNNNNN	From left to right, it refers to GPS, GLONASS, Galileo, BeiDou, QZSS and NavIC. A or D: Positioning one or more target satellites (D: Differential position fix) N: No target satellite has been positioned
7	TOTAL NUMBER OF SATs	0 to 62	00	The number of satellites used for positioning. It contains all satellite signals. However, the counting in this field is performed for satellites. For example, even if GPS No. 1 satellite is received by both L1C/A signal and L5 signal, the number of positioning satellites is counted as one.
8	HDOP	0.0 to 50.0 or NULL	NULL	Horizontal dilution of precision (HDOP) It is a variable length. A null field is output while positioning is interrupted.
9	ALTITUDE ABOVE SEA LEVEL	-1000.00 to 18299.99	-18.0	The unit is meters. It is a variable length.
10	GEOIDAL SEPARATION	-1000.00 to 18299.99	18.0	Geoid height The unit is meters. It is a variable length.
11	AGE OF DIFFERENTIAL DATA	NULL	NULL	Always NULL.
12	DIFFERENTIAL STATION ID	NULL	NULL	Always NULL.
13	NAVIGATION STATUS	V	V	Always invalid.

Example:
$GNGNS,020112.219,3442.8156,N,13520.1224,E,ANNNNN,07,1.0,40.5,33.6,,,V*2D
Time: 02:01:12.219
34 deg 42.8156 min (North Latitude), 135 deg 20.1224 min (East Longitude)
GPS: Position fix without differential, GLONASS: No position fix, Galileo: No position fix, BeiDou: No position fix, QZSS: No position fix, NavIC: No position fix,
Total number of satellites: 7 , HDOP: 1.0
Altitude above sea level: 40.5 meters , Geoid height: 33.6 meters

NOTE:
- In SS (Self Survey) mode, the surveyed position currently being calculated is displayed in latitude, longitude, and height. In TO (Time Only) mode, the fixed position is displayed for latitude, longitude, and height.

6.3 GGA – Global Positioning System Fix Data

The following details the GGA sentence in standard NMEA format.

Format:

$GPGGA	,	TIME	,	LATITUDE	,	LATITUDAL DIRECTION	,	LONGITUDE	,
		1		2		3		4	

LONGITUDINAL DIRECTION	,	QUALITY INDICATOR	,	NUMBER OF SATs IN USE	,
5		6		7	

HDOP	,	ALTITUDE ABOVE SEA LEVEL	,	M	,	GEOIDAL SEPARATION	,	M	,
8		9		10		11		12	

AGE OF DIFFERENTIAL DATA	,	DIFFERENTIAL STATION ID	*hh	<CR>	<LF>
13		14			

	Data	Range	Default	Description
1	TIME	000000.000 to 235960.000	000000.000	It shows the current time. It is output at RTC, GNSS or UTC time according to positioning status, synchronization setting, UTC parameter acquisition status and so on. 60 seconds is displayed only when the leap is inserted.
2	LATITUDE	0000.0000 to 9000.0000	0000.0000	It shows Latitude. The first two digits are degrees, and the following are minutes.
3	LATITUDAL DIRECTION	N, S	N	N: North latitude S: South latitude
4	LONGITUDE	00000.0000 to 18000.0000	00000.0000	It shows Longitude The first three digits are degrees, and the following are minutes.
5	LONGITUDINAL DIRECTION	E, W	E	E: East Longitude W: West Longitude

	Data	Range	Default	Description
6	QUALITY INDICATOR	0 to 2	0	It shows the positioning status. 1: Position fix without differential 2: Differential position fix 0: No position fix
7	NUMBER OF SATs IN USE	00 to 12	00	This is the number of satellites used for positioning when limited to GPS satellites. It counts both L1 C/A and L5 signals. However, the counting in this field is performed for satellites. For example, even if both the L1 C/A signal and L5 signal of GPS satellite No.1 are received, it is counted as 1 in the number of received positioning satellites.
8	HDOP	0.0 to 50.0 or NULL	NULL	Horizontal dilution of precision (HDOP) It is a variable length A null field is output while positioning is interrupted.
9	ALTITUDE ABOVE SEA LEVEL	-1000.00 to 18299.00	-18.0	The unit is meters. It is a variable length.
10	M	M	M	Units of altitude, meters
11	GEOIDAL SEPARATION	-1000.00 to 18299.00	18.0	Geoid height The unit is meters. It is a variable length.
12	M	M	M	Units of Geoidal height, meters
13	AGE OF DIFFERENTIAL DATA	NULL	NULL	Always NULL.
14	DIFFERENTIAL STATION ID	NULL	NULL	Always NULL.

Example:
$GPGGA,020112.219,3442.8156,N,13520.1224,E,1,07,1.0,40.5,M,33.6,M,,*6C
Time: 02:01:12.219
34 deg 42.8156 min (North Latitude), 135 deg 20.1224 min (East Longitude)
GPS positioning status: Position fix without differential
Number of GPS positioning satellites: 7 , HDOP: 1.0
Altitude above sea level: 40.5 meters , Geoid height: 33.6 meters

NOTE:
- In SS (Self Survey) mode, the surveyed position currently being calculated is displayed in latitude, longitude, and height. In TO (Time Only) mode, the fixed position is displayed for latitude, longitude, and height.

6.4 GLL – Geographic Position - Latitude/Longitude

The following details the GLL sentence in standard NMEA format.

Format:

$XXGLL	,	LATITUDE	,	LATITUDAL DIRECTION	,	LONGITUDE	,	LONGITUDINAL DIRECTION	,
		1		2		3		4	

TIME	,	STATUS	,	MODE INDICATOR	*hh	<CR>	<LF>
5		6		7			

	Data	Range	Default	Description
1	LATITUDE	0000.0000 to 9000.0000	0000.0000	It shows Latitude. The first two digits are degrees, and the following are minutes.
2	LATITUDAL DIRECTION	N, S	N	N: North latitude S: South latitude
3	LONGITUDE	00000.0000 to 18000.0000	00000.0000	It shows Longitude The first three digits are degrees, and the following are minutes.
4	LONGITUDINAL DIRECTION	E, W	E	E: East Longitude W: West Longitude
5	TIME	000000.000 to 235960.000	000000.000	It shows the current time. It is output at RTC, GNSS or UTC time according to positioning status, synchronization setting, UTC parameter acquisition status and so on. 60 seconds is displayed only when the leap is inserted.
6	STATUS	A, V	V	A: Data valid V: Data invalid
7	MODE INDICATOR	A, D, N	N	A: Position fix without differential D: Differential position fix N: No position fix

Example:
$GNGLL,3442.8158,N,13520.1219,E,020113.229,A,A*44
34 deg 42.8158 min (North Latitude), 135 deg 20.1219 min (East Longitude)
Time: 02: 01: 13.229
Status: Data valid, Positioning mode: Position fix without differential

NOTE:

- In SS (Self Survey) mode, the surveyed position currently being calculated is displayed in latitude and longitude. In TO (Time Only) mode, the fixed position is displayed for latitude and longitude.

6.5 VTG – Course Over Ground and Ground Speed

The following details the VTG sentence in standard NMEA format.

Format:

$XXVTG	,	COURSE	,	T	,	MAGNETIC DIRECTION	,	M	,
		1		2		3		4	

SPEED KNOT	,	N	,	SPEED KM/H	,	K	,	MODE INDICATOR	*hh	<CR>	<LF>
5		6		7		8		9			

	Data	Range	Default	Description
1	COURSE	0.00 to 359.99	0.00	True Course. The unit is degree. It is a variable length.
2	T	T	T	Unit of true course, "T" (True)
3	MAGNETIC DIRECTION	NULL	NULL	Always Null
4	M	M	M	“M” fixed
5	SPEED KNOT	-	0.00	Speed [knot]
6	N	N	N	"N" (knots)
7	SPEED KM/H	-	0.00	Speed [Km/h]
8	K	K	K	"K" (Kilo meters/ Hour)
9	MODE INDICATOR	A, D, N	N	A: Position fix without differential D: Differential position fix N: No position fix

Example:
$GNVTG,0.00,T,,M,0.28,N,0.52,K,A*2E
True course: 0.00 degree
Speed: 0.28 kts 0.52 km/hour
Position mode indicator: Position fix without differential

6.6 GSA – GNSS DOP and Active Satellites

The following details the GSA sentences in standard NMEA format.

Format:

$XXGSA	,	OPERATION MODE	,	FIX MODE	,	ID NUNBERs OF SATs USED IN SOLUTION 1	,
		1		2		3	

ID2	,	ID3	,	...	,	PDOP	,	HDOP	,	VDOP	,	GNSS SYSTEM ID	*hh	<CR>	<LF>
4		5		6-14		15		16		17		18			

	Data	Range	Default	Description
1	OPERATION MODE	A	A	It means to switch 2D / 3D positioning automatically. This field is “A” fixed.
2	FIX MODE	1 to 3	1	It shows the positioning mode. 1 : No fix 2 : 2D fix 3 : 3D fix
3	ID1	01 to 99	NULL	The satellite numbers of the satellites used for positioning calculation are displayed in order. If it is less than 12 satellites, it will be filled with NULL thereafter.
4	ID2	01 to 99	NULL	
5	ID3	01 to 99	NULL	
6-13	...	01 to 99	NULL	
14	ID12	01 to 99	NULL	
15	PDOP	0.0 to 50.0 or NULL	NULL	Position Dilution of Precision (PDOP) It is a variable length. A null field is output unless 3D-positioning is performed.
16	HDOP	0.0 to 50.0 or NULL	NULL	Horizontal dilution of precision (HDOP) It is a variable length. A null field is output while positioning is interrupted.
17	VDOP	0.0 to 50.0 or NULL	NULL	vertical dilution of precision (VDOP) It is a variable length. A null field is output unless 3D-positioning is performed.
18	GNSS SYSTEM ID	1 to F	-	It shows for which satellite system this GSA sentence is displaying information. Please refer to NOTE below for details.

Example:
$GNGSA,A,3,02,04,05,06,07,09,12,17,19,,,,1.3,0.8,1.1,1*3D
3D fix, PDOP: 1.3, HDOP: 0.8, VDOP: 1.1
Satellite used [GPS]: 02, 04, 05, 06, 07, 09, 12, 17, 19

$GNGSA,A,3,07,13,26,33,,,,,,,,,1.3,0.8,1.1,3*38
3D fix, PDOP: 1.3, HDOP: 0.8, VDOP: 1.1
Satellite used [Galileo]: 07, 13, 26, 33

NOTE:

- The table below shows the contents indicated by GNSS SYSTEM ID and the values that ID1 to ID12 can take for each GNSS SYSTEM ID.

Table 6.6-1. Detail of GNSS SYSTEM ID

GNSS SYSTEM ID	Applicable satellite system	Range of possible ID values	Note
1	GPS	1 to 64	1 to 32 indicates the GPS satellite number. 33 to 64 indicates the satellite number of SBAS. In the case of SBAS, satellite 120 corresponds to ID = 33.
2	GLONASS	1 to 99	1 to 13 indicates before the GLONASS satellite number is confirmed. 65 to 99 indicates the satellite number of GLONASS.
3	Galileo	1 to 36	1 to 36 indicates the satellite number of Galileo.
4	BeiDou	1 to 63	1 to 63 indicates the satellite number of BeiDou.
5	QZSS	1 to 10	1 to 10 indicates the satellite number of QZSS. Satellite 193 corresponds to ID = 1.
6	NavIC	1 to 14	1 to 14 indicates the satellite number of NavIC.
7 to F	Reserved	-	Reserved value

- ID1 to ID12 are arranged in ascending order of satellite number.
- GSA sentences can identify satellite constellations, but not satellite signals. For example, if the GSA sentence with GNSS SYSTEM ID = 1 says 01, you can tell that you are using GPS 1 satellite; it can be a GPS L1C/A signal, a GPS L5 signal, or both. It is not possible to distinguish which signals are received or not received.
- The GSA sentence is defined as one line per satellite constellation, so it can only display up to 12 satellites. Therefore, please note that if the receiver is using 13 or more satellites of a constellation, only the first 12 satellites of the constellation, ranked in an increasing order, will be displayed.

6.7 ZDA – Time & Date

The following details the ZDA sentence in standard NMEA format.

Format:

$XXZDA	,	TIME	,	DAY	,	MONTH	,	YEAR	,
		1		2		3		4	

LOCAL ZONE HOURs	,	LOCAL ZONE MINUTEs	*hh	<CR>	<LF>
5		6			

	Data	Range	Default	Description
1	TIME	000000.000 to 235960.000	000000.000	It shows the current time. It is output at RTC, GNSS or UTC time according to positioning status, synchronization setting, UTC parameter acquisition status and so on. 60 seconds is displayed only when the leap is inserted.
2	DAY	01 to 31	02	It shows the current day. When LZT (Local zone time) is set, it will be displayed after adding LZT.
3	MONTH	01 to 12	01	It shows the current month. When LZT is set, it will be displayed after adding LZT.
4	YEAR	00 to 99	00	It shows the last two digits of current year. It is output in the range of 2000 to 2099. When LZT is set, it will be displayed after adding LZT.
5	LOCAL ZONE HOURs	-14 to +14	+00	It shows the LZT value set by the TIMEZONE command. The unit is hour.
6	LOCAL ZONE MINUTEs	00 to 59	00	It shows the LZT value set by the TIMEZONE command. The unit is minutes.

Example:
$GNZDA,014811.000,13,09,2021,+09,00*6D
Time: 1: 48: 11 (included local zone offset)
Date: 2021/9/13 (included local zone offset)
Local zone time setting: +9: 00

6.8 GSV – GNSS Satellites in View

The following details the GSV sentences in standard NMEA format.

Format:

$XXGSV	,	TOTAL NUNVER OF SENTENCEs	,	SENTENCE NUMBER	,
		1		2	

TOTAL NUMBER OF SATs IN VIEW	,	SATs ID NUMBER	,	ELEVATION	,	AZIMUTH	,	SNR	,
3		4		5		6		7	

...	,	SIGNAL ID	*hh	<CR>	<LF>
8-19		20			

	Data	Range	Default	Description
1	TOTAL NUNVER OF SENTENCEs	1 to 9	1	It shows the total number of GSV rows in the GSV sentence for this talker ID.
2	SENTENCE NUMBER	1 to 9	1	It shows the current line in the GSV sentence of this talker ID.
3	TOTAL NUMBER OF SATs IN VIEW	1 to 32	0	It shows the number of satellites in the field of view of the satellite constellation associated with the talker ID of this GSV sentence.
4	SATs ID NUMBER	01 to 99 or NULL	NULL	It shows the satellite number in the field of view. If not acquired, it will be NULL.
5	ELEVATION	00 to 90 or NULL		It shows the elevation angle of the above satellite. If not acquired, it will be NULL.
6	AZIMUTH	000 to 359 or NULL		It shows the azimuth angle of the above satellite. If not acquired, it will be NULL.
7	SNR	00 to 69 or NULL		It shows the signal strength (C/N0 [dB-Hz]) of the above satellite. If not acquired, it will be NULL.
8-19	...			After that, the set of satellite number, elevation angle, azimuth angle, and signal strength will be displayed for up to 4 satellites.
20	SIGNAL ID	1 to F		For details on SIGNAL ID, refer to NOTE below.

Example:
$GPGSV,3,2,9,07,10,114,37,09,48,062,46,12,14,275,40,17,34,167,45,1*5B
The GPS L1C/A satellite information are described as follows. There is a total of 3 GPGSV lines, and 9 satellite information are described over 3 lines. This line is the second line of GPGSV.
Satellite No. 07, Elevation 10 degrees, Azimuth 114 degrees, C/N0 37 dB-Hz
Satellite No. 09, Elevation 48 degrees, Azimuth 062 degrees, C/N0 46 dB-Hz
Satellite No. 12, Elevation 14 degrees, Azimuth 275 degrees, C/N0 40 dB-Hz
Satellite No. 17, Elevation 34 degrees, Azimuth 167 degrees, C/N0 45 dB-Hz

$GAGSV,2,2,7,20,,,40,26,67,092,46,33,52,325,46,,,,,7*4F
The satellite information of Galileo E1 is described as follows. There are two lines of GAGSV in total, and the information of seven satellites is described over two lines. This line is the second line of GAGSV.
Satellite No. 20, Elevation Unacquired, Azimuth Unacquired, C/N0 40 dB-Hz
Satellite No. 26, Elevation 67 deg, Azimuth 092 deg, C/N0 46 dB-Hz
Satellite No. 33, Elevation 52 deg, Azimuth 325 deg, C/N0 46 dB-Hz

NOTE:
- GSV satellite information is output in ascending order of satellite number.
- The meaning of each SIGNAL ID for each talker ID of GSV is as shown in the table below.

Table 6.8-1. Detail of SIGNAL ID

GSV Talker ID	Applicable satellite system	SIGNAL ID	Meaning of SIGNAL ID
GP	GPS	1	GPS L1C/A
		7	GPS L5
GL	GLONASS	1	GLONASS L1OF
GA	Galileo	7	Galileo E1
		1	Galileo E5a
GB	BeiDou	1	BeiDou B1I
		3	BeiDou B1C
		5	BeiDou B2a
GQ	QZSS	1	QZSS L1C/A
		4	reserved
		7	QZSS L5
GI	NavIC	1	NavIC L5

For example, if the SIGNAL ID of a GAGSV sentence is 7, it means that the GSV line contains information about Galileo E1.

6.9 GST – GNSS Pseudo range Error Statistics

The following details the GST sentence in standard NMEA format.

Format:

$XXGST	,	TIME	,	SDEV1	,	SDEV2	,	SDEV3	,	ORIENTATION OF SEMI-MAJOR AXIS	,
		1		2		3		4		5	

SDEV4	,	SDEV5	,	SDEV6	*hh	<CR>	<LF>
6		7		8			

	Data	Range	Default	Description
1	TIME	000000.000 to 235960.000	000000.000	It shows the current time. It is output at RTC, GNSS or UTC time according to positioning status, synchronization setting, UTC parameter acquisition status and so on. 60 seconds is displayed only when the leap is inserted.
2	SDEV1	0.0 to 999.9 or NULL	0.0	Accuracy Index (RMS) [meter] The variance of pseudo range residual
3	SDEV2	0.0 to 999.9 or NULL	0.0	Standard deviation of semi-major axis of error ellipse [meter]
4	SDEV3	0.0 to 999.9 or NULL	0.0	Standard deviation of semi-minor axis of error ellipse [meter]
5	ORIENTATION OF SEMI-MAJOR AXIS	0.0 to 179.9 or NULL	0.0	Orientation of semi-major axis of error ellipse [degree] (Degrees from true north)。
6	SDEV4	0.0 to 999.9 or NULL	0.0	Standard deviation of latitude error [meter]
7	SDEV5	0.0 to 999.9 or NULL	0.0	Standard deviation of longitude error [meter]
8	SDEV6	0.0 to 999.9 or NULL	0.0	Standard deviation of altitude error [meter]

Example:
$GNGST,043737.517,0.0,0.0,0.0,0.0,0.0,0.0,0.0*7E
Time: 04:37:37.517

6.10 GNtps,A – sentence of timing product A : Time information

The following details the TPS,A sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	A	,	DATE AND TIME	,	TIME STATUS	,	LEAPSEC UPDATE DATE	,
		1		2		3		4		5	

CURRENT LEAPSEC	,	FUTURE LEAPSEC	,	PPS STATUS	,	DRIFT	*hh	<CR>	<LF>
6		7		8		9			

	Data	Range	Default	Description
1	GNtps			Sentence name
2	A	A	A	It means line A of TPS. A is fixed.
3	DATE AND TIME	20000102000000 to 20991231235959	20000102000000	The current date and time are displayed in the order of the year, month, day, hour, minute, and second from the left. Only the year is displayed in 4 digits, and the others are displayed in 2 digits. It reports RTC, GNSS or UTC time according to the positioning status, synchronization setting, UTC parameter acquisition status and so on. 60 seconds is displayed only when a leap second is inserted.
4	TIME STATUS	0 to 2	0	0: Before the time is confirmed from satellite information 1: The time is fixed, but the leap second is unfixed or ignored 2: Time is fixed, and leap second is fixed. It shows the status of the time output in each sentence.
5	LEAPSEC UPDATE DATE	20000102000000 to 20991231235959 or 00000000000000	00000000000000	It is the execution time of the leap second insertion. It is displayed in the order of the year, month, day, hour, minute and second from the left. Only the year is displayed in 4 digits, and the others are displayed in 2 digits. If the UTC parameter has not been received, or if it has been received but there is no plan to insert a leap second, it will be filled with 0s.

	Data	Range	Default	Description
6	CURRENT LEAPSEC	-99 to +99	+18	Current leap second Please note that the values displayed in this field are the cumulative values of the leap seconds since January 6, 1980. See also the Glossary in Chapter 2 for more information.
7	FUTURE LEAPSEC	-99 to +99	+00	Future leap second Differences from the above field will only occur if a leap second insertion is scheduled.
8	PPS STATUS	0 to 12	0	PPS synchronization status 0: RTC synchronization 1: GPS time 2: UTC(USNO) time 3: GLONASS time 4: UTC(SU) time 5: Galileo time 6: UTC(EU) time 7: BeiDou time 8: UTC(NTSC) time 9: QZSS time, 10: UTC(NICT) time 11: NavIC time 12: UTC(NPLI) time
9	DRIFT	10 bytes	+0.000E+00	Receiver's clock drifts. The unit is sec/sec.

Example:
$PFEC,GNtps,A,20200924070027,2,00000000000000,+18,+18,2,+1.223E-08*22
Current date and time: 2020/9/24 07: 00: 27
Time status: 2 (UTC time), Leap second update scheduled time: None
Current leap second: +18 sec, Future leap second: +18 sec
PPS status: UTC (USNO) synchronization, Drift: +12.23nsec/sec

NOTE

■ **About TIME STATUS**

TIME STATUS shows the synchronization status of the time in each sentence displaying the time, including GNS, ZDA etc. It can be used as a basis for determining whether the time information is obtained from the satellite or whether it contains an appropriate leap second.

Ⅰ. When "0: Before time confirmation derived from satellite information" is displayed in this field

→ The displayed time is incorrect because the time is not obtained from the satellites.
→ Even if the time is set by the command, a “0” will be reported in this field as the time is not obtained from the satellites.

Ⅱ. When "1: Leap second unconfirmed or leap second ignored" is displayed in this field

(1) When "Leap second ignore" is selected in the ALIGN command
→ The current time is properly displayed as the GPS time. Leap seconds are not used.
(2) When "Leap second use" is selected in the ALIGN command
→ Since the leap second information has not yet been received from the satellites, the time is displayed in relation with the default leap second.
→ If the default leap second deviates from the actual leap second, the time may be off by that deviation amount.

Ⅲ. When "2: Time is confirmed and leap second is confirmed" is displayed in this field

The correct current time can be displayed as the UTC time including the leap seconds.

- **About LEAPSEC UPDATE DATE**

LEAPSEC UPDATE DATE faithfully displays the broadcast content received from the GNSS satellites. Therefore, the time of the leap second insertion may remain displayed for a while until the broadcast content on the satellite side is updated.

- **About CURRENT LEAPSEC**

In this field, the default leap second is displayed until the "current leap second information" is obtained from the GNSS satellite. Also, after acquiring the current leap second information from the GNSS satellite, the latest leap second at that moment is displayed.

- **About FUTURE LEAPSEC**

In this field, 00 is displayed until "future leap second information" is obtained from the GNSS satellites. In addition, after acquiring the future leap second information from the GNSS satellites, the broadcast content from the satellites will be displayed faithfully. Therefore, 00 may be displayed if there is no plan to insert leap seconds. On the other hand, if a leap second insertion is scheduled to occur, a numerical value is set for this field, but that value may be maintained for a while even after the leap second insertion is performed. However, please be assured that the current time displayed by the receiver will be displayed in a form that properly considers leap seconds. The broadcast content is updated approximately every few days, and as soon as it is received, this field will be updated in an appropriate manner.

- **About PPS STATUS**

The PPS status shows the synchronization status of the output 1PPS. RTC synchronization when in the self-propelled state, GNSS synchronization when the time is acquired from the GNSS satellites, and then transition to the corresponding UTC time synchronization as soon as the necessary UTC parameters are acquired according to the setting of the ALIGN command. While TIME STATUS shows the synchronization state in terms of seconds, PPS STATUS shows the synchronization state of the PPS pulse in terms of nanoseconds, which is the difference in STATUS.

6.11 GNtps,B – sentence of timing product B : Receiver various statuses

The following details the TPS,B sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	B	,	POSITION MODE	,	POSITION ERROR	,	SURVEY COUNT	,
		1		2		3		4		5	

RECEIVER STATUS1	,	RECEIVER STATUS2	,	RECEIVER STATUS3	*hh	<CR>	<LF>
6		7		8			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	B	B	B	B is fixed.
3	POSITION MODE	0 to 2	1	It shows current position mode. 0: NAV mode 1: Self-Survey mode 2: Time Only mode
4	POSITION ERROR	0000 to 9999	0	The deviation between the fixed position (or surveyed position) and the calculated position calculated by the positioning calculation in this second is displayed in meters.
5	SURVEY COUNT	000000 to 999999	000000	Displays the number of calculations for the surveyed position. During 3D positioning, this value is incremented by 1. When 999999 is reached, it will be clipped at that value.
6	RECEIVER STATUS1	0x00000000 to 0xFFFFFFFF	-	It displays various statuses of the receiver. Please show NOTE about detail.
7	RECEIVER STATUS2	0x00000000 to 0xFFFFFFFF	0x00000000	It displays various statuses of the receiver. This field is reserved for now.
8	RECEIVER STATUS3	0x00000000 to 0xFFFFFFFF	-	It displays various statuses of the receiver. This field is for internal use only.

Example:
$PFEC,GNtps,B,1,0003,004142,0x00000001,0x00000000,0x00000017*52
Position mode: Self-Survey mode
Position error: The error between the surveyed position currently held and the position of this positioning calculation is 3 meters.
Survey count: 4142

NOTE:

■ **About POSITION ERROR**

When the position mode is SS or Time Only mode, the fixed position (or surveyed position) held is compared with the current position obtained by the positioning calculation for that second, and the deviation is displayed in meters. This value can be used as an index of the certainty of the fixed position information that has been set. It returns 0 in NAV mode or if there is no fixed position.

■ **About RECEIVER STATUS**

This field allows you to check the operating status of the GNSS receiver. It is possible to comprehensively judge the quality of the reception environment. If you contact us due to a problem with the reception environment, we may ask you to send log data in that reception environment. In that case, we recommend that you also acquire this sentence in a log. Details of this field are as shown on the next page.

Table 6.11-1. Detail of RECEIVER STATUS 1

BIT (LSB=0)	Item	Description
00	UTC parameter	It determines if the UTC parameters required to perform the UTC time synchronization specified by the ALIGN command have been acquired. 0: It has not received UTC parameters yet. 1: It has received UTC parameters.
01	RTC check	This flag indicates the operating state of the RTC 0: RTC failure detected 1: RTC is operating normally
02	Backup check	It is the backup flag. It checks only when the power is turned on. It will be 1 if the backup was performed using the BACKUP command of chapter 7.20 when the power was turned on last time. If there is no backup, it will be 0.
03	Reserved	Reserved BIT
04 – 05	TRAIM solution	It shows the result of TRAIM implementation. 0: No anomaly detection by TRAIM 1: TRAIM alarm is occurring. 2: Since the number of satellites in use is not enough, TRAIM is not being implemented.
06 – 07	TRAIM status	It determines whether TRAIM is ready. 0: There are enough satellites in use. 1: There are several satellites for alarm determination. 2: There are not enough satellites in use.

BIT (LSB=0)	Item	Description
08 – 11	Antenna current detection	If the antenna detection circuit is properly connected, it displays the status of antenna current. 0: Normal 1: Antenna open 2: Antenna short 3: Reserved
12 – 15	Spoofing signal detection	It notifies when a spoofing signal is detected. 0: No spoofing signal has been detected. 1 or more: Spoofing signals are being detected. It displays the number of detected spoofing satellite signals. 15 satellites and above are indicated by 15. If GPS L1C/A No. 1 satellite signal and GPS L5 No. 1 satellite signals are judged to be spoofing signals at the same time, it is counted as if there were two spoofing signals.
16 – 19	Jamming signal detection	It notifies when a jamming signal is detected. 0: Jamming signal is NOT detected. 1: Jamming signal is detected.
20 – 23	Number of satellites excluded by DSS	It displays the number of NLOS satellites excluded by the Dynamic Satellite Selection™ algorithm, which is Furuno's multipath countermeasure. If the number of excluded satellites is 15 or more, 15 is displayed.
24 – 27	Number of satellites excluded by TRAIM	It displays the number of satellites excluded by TRAIM.
28 – 31	SW version	It shows the last one digit of software version.

■ **About Spoofing signal detection**

After initial positioning with the appropriate GNSS satellites, if there is an apparent anomaly (except for unhealthy satellites) in the content of the navigation messages received from any of the GNSS satellites, this field may be used to notify the user while the message is being received. This bit can be used to help determine the cause of a significant decrease in the number of satellites used for positioning, for example.
When health information is not yet collected, depending on the failure status of an unhealthy satellite, the satellite may be determined to be a spoofed satellite. Please understand this beforehand.
If the actual satellite and the simulator are connected at the same time or alternately, one of the satellites may be treated as a spoofed signal. When using the simulator for verification, etc., be sure to destroy the ephemeris and almanac with the FACTORY RESTART command, etc., before connecting to the actual satellite.

■ **About Jamming signal detection**

If noise or jamming is detected from the antenna end of the receiver, this bit will notify you. This bit can be used to help find the cause when the number of satellites used for positioning has decreased significantly.
This notification is given when the jamming intensity is about -50 dB or more in J/S ratio and C/N0 is reduced on all satellites, but the judgment result may be greatly affected by the characteristics of the connected antenna. Therefore, please do not treat this bit as an

alarm, but use it only as an aid to find the cause when the number of satellites used for positioning decreases significantly.

6.12 GNtps,C – sentence of timing product C : OCLK port information

The following details the TPS,C sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	C	,	PLL MODE	,	PHASE DELAY	,	DELTA PHASE DELAY	,
		1		2		3		4		5	

SYNC STATUS	,	OCLK0 STATUS	,	OCLK1 STATUS	,	OCLK2 STATUS	*hh	<CR>	<LF>
6		7		8		9			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	C	C	C	C is fixed.
3	PLL MODE	0 to 5	0	It outputs the PLL control mode. See NOTE for details.
4	PHASE DELAY	12bytes	+0.00000E+00	Outputs the phase difference. The unit is seconds. The sign of the phase difference means that the PPS under control is delayed with respect to the reference time to be synchronized when it is positive.
5	DELTA PHASE DELAY	12bytes	+0.00000E+00	The amount of fluctuation in the phase difference. It shows the change in phase difference from the previous second. The unit is seconds / second.
6	SYNC STATUS	0x0000 to 0xFFFF	0x0000	The status related to the synchronization status. Please refer to NOTE for details.
7	OCLK0 STATUS	0x000 to 0xFFF	0x000	The status of the OCLK0 pin. Please refer to NOTE for details.
8	OCLK1 STATUS	0x000 to 0xFFF	0x000	The status of the OCLK1 pin. Please refer to NOTE for details.
9	OCLK2 STATUS	0x000 to 0xFFF	0x000	The status of the OCLK2 pin. Please refer to NOTE for details.

Example:
$PFEC,GNtps,C,1,+1.23454E-07,+1.00235E-09,0x0000,0x000,0x000,0x000*0E

PLL Control mode: 1 (Pull-In mode)

Phase delay: 123.454 nsec , Delta phase delay: 1.00235 nsec/sec

NOTE:

■ **About PLL control mode**

The state transition diagram of the PLL control mode is as follows.

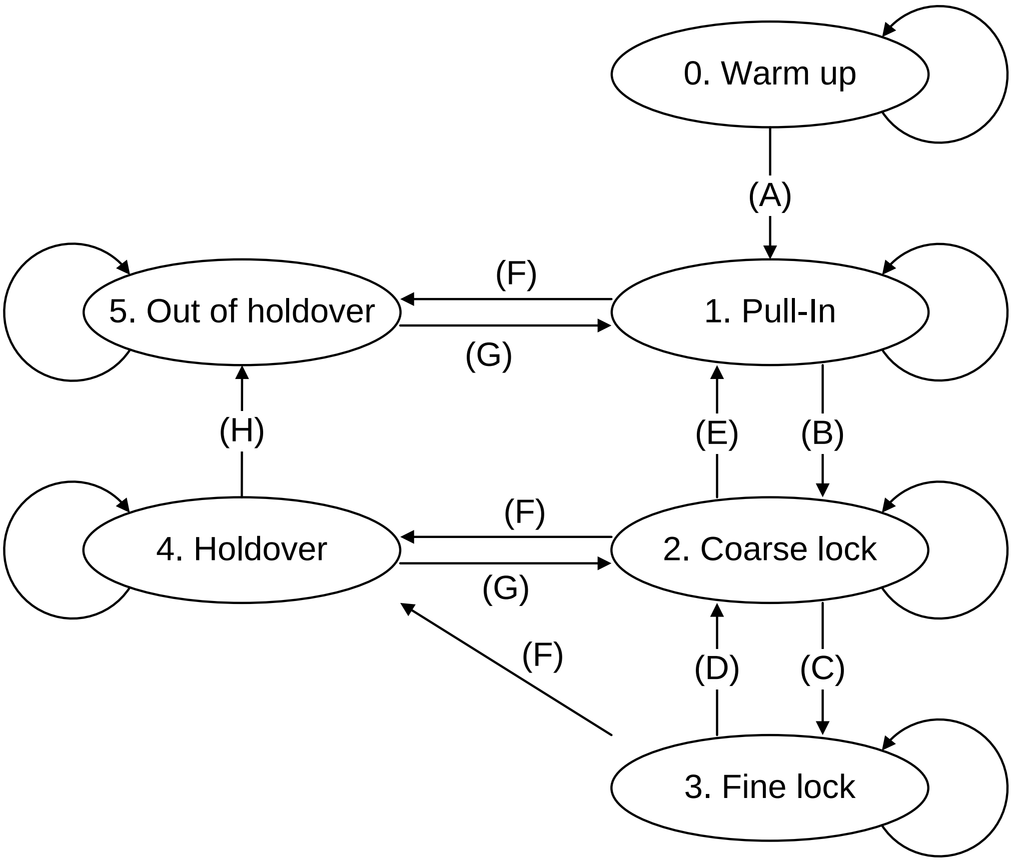


Figure 6.12-1. PLL Control mode State Diagram

Table 6.12-1 About PLL control mode

	Control mode name	Description
0	WARM UP	Immediately after startup, it is waiting for the information required for control. It means that the time performance is not guaranteed.
1	PULL IN	It is in the process of synchronizing with the synchronization target. It means that the time performance is not guaranteed.
2	COARSE LOCK	Although it is synchronizing with the synchronization target, the accuracy is still poor.
3	FINE LOCK	It is in a state where it is very well synchronized with the synchronization target. The best PPS accuracy has been achieved.
4	HOLDOVER	There is no synchronization target, and it is free run. By default, this product transitions to OUT OF HOLDOVER after 1 second. If a clock is input to the ICLK pin, the clock can be used to perform holdover. Alternatively, you can use the free-run HOLDOVER without using the ICLK pin. You can use the HOLDOVER command to set the HOLDOVER time.
5	OUT OF HOLDOVER	There is no synchronization target, and it is self-propelled. It means that the time performance is not guaranteed.

Table 6.12-2 PLL Control mode State Diagram
(When GNSS is selected as the synchronization target)

(A)	The GNSS position was fixed, and the time information was confirmed.
(B)	The PLL was roughly controlled and synchronized with the synchronization target to a certain extent.
(C)	The PLL was sufficiently controlled and synchronized with the synchronization target with accuracy. In other words, the Phase delay, etc. is below a predetermined threshold value.
(D)	The antenna was placed in an adverse environment, and the accuracy deteriorated because of particularly severe multipath. In other words, Phase delay, etc. exceeded the predetermined threshold value for a certain period.
(E)	The accuracy of the synchronization target was not stable, and the threshold value for re-control was exceeded.
(F)	It can no longer receive GNSS.
(G)	Positioning by GNSS has been resumed.
(H)	The HOLDOVER enable time has expired. (The default is 1 second.)

Table 6.12-3 PLL Control mode State Diagram
(When EPPS is selected as the synchronization target)

(A)	EPPS from the ICLK is Confirmed.
(B)	The PLL was roughly controlled and synchronized with the synchronization target to a certain extent.
(C)	The PLL was sufficiently controlled and synchronized with the synchronization target with accuracy.
(D)	EPPS accuracy from ICLK pin degraded for a certain time .
(E)	The accuracy of the synchronization target was not stable, and the threshold value for re-control was exceeded.
(F)	EPPS from the ICLK pin can no longer be confirmed.
(G)	EPPS from the ICLK pin has been restarted.

(H)	The HOLDOVER enable time has expired. (The default is 1 second.)

- **About SYNC STATUS**
  The details of the SYNC STATUS are as follows.

Table 6.12-3 The detail of SYNC STATUS

BIT (LSB=0)	Item	Description
00 – 03	PLL control synchronization target	These bits show the current synchronization target in PLL control. 0: Synchronized with GNSS. During non-positioning, then free run. 1: Reserved. 2: Reserved. 3: Synchronized with GNSS. During non-positioning, then Holdover using the clock of the ICLK. 4: Reserved. 5: Reserved. 6: Always synchronized with 1PPS (EPPS) of the ICLK.
04-11	Reserved	This bit is reserved.
12	Assumed input of ICLK	This bit Indicates the input from ICLK that the receiver expects. 0: It is assumed that 1PPS is input to the terminal. 1: It is assumed that a clock of 2 Hz or higher is input to the terminal.
13	Reserved	This bit is reserved.
14 – 15	Input status of ICLK	This bit indicates the status of the clock input from ICLK. 0: Nothing is input to the terminal. 1: The signal is input normally and accurately. 2: The signal is input, but the accuracy is low. (Measured based on GNSS time) 3: The signal is input, but the accuracy has not been verified. (Because the GNSS time has not been acquired)

■ About OCLK0 STATUS

The details of the OCLK0 STATUS are as follows.

Table 6.12-4 The detail of OCLK0 STATUS

BIT (LSB=0)	Item	Description
00	Output status of OCLK0	This bit Indicates whether the clock is output from OCLK0. 0: Clock is stopped, 1: Clock is being output
01	Sync edge setting of OCLK0	This bit indicates the synchronization edge setting of the clock output from OCLK0. 0: Positive edge / 1: Negative edge
02 - 03	Output mode of OCLK0	These bits Indicate the clock output mode setting for OCLK0. 0: Always stop, 1: Always output, 2: Output at FINE LOCK 3: Output when FINE LOCK and TRAIM is OK
04 - 11	Clock type of OCLK0	These bits Indicate the setting of the clock type output from OCLK0. 0: 1PPS, 1: FGEN CLOCK, 2: DIV CLOCK

■ About OCLK1 STATUS

The details of the OCLK1 STATUS are as follows.

Table 6.12-5 The detail of OCLK1 STATUS

BIT (LSB=0)	Item	Description
00	Output status of OCLK1	This bit Indicates whether the clock is output from OCLK1. 0: Clock is stopped, 1: Clock is being output
01	Sync edge setting of OCLK1	This bit indicates the synchronization edge setting of the clock output from OCLK1. 0: Positive edge / 1: Negative edge
02 - 03	Output mode of OCLK1	These bits Indicate the clock output mode setting for OCLK1. 0: Always stop, 1: Always output, 2: Output at FINE LOCK 3: Output when FINE LOCK and TRAIM is OK
04 - 11	Clock type of OCLK1	These bits Indicate the setting of the clock type output from OCLK1. 0: 1PPS, 1: FGEN CLOCK, 2: DIV CLOCK

■ About OCLK2 STATUS

The details of the OCLK2 STATUS are as follows.

Table 6.12-6 The detail of OCLK2 STATUS

BIT (LSB=0)	Item	Description
00	Output status of OCLK2	This bit Indicates whether the clock is output from OCLK2. 0: Clock is stopped, 1: Clock is being output
01	Sync edge setting of OCLK2	This bit indicates the synchronization edge setting of the clock output from OCLK2. 0: Positive edge / 1: Negative edge
02 - 03	Output mode of OCLK2	These bits Indicate the clock output mode setting for OCLK2. 0: Always stop, 1: Always output, 2: Output at FINE LOCK 3: Output when FINE LOCK and TRAIM is OK
04 - 11	Clock type of OCLK2	These bits Indicate the setting of the clock type output from OCLK2. 0: 1PPS, 1: FGEN CLOCK, 2: DIV CLOCK

6.13 GNtps,G – GPS time information

The following details the TPS,G sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	G	,	GPS TOW	,	GPS WEEK	*hh	<CR>	<LF>
		1		2		3		4			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	G	G	G	G is fixed.
3	GPS TOW	000000 to 604799	000000	Displays time of week based on the GPS time starting from the timing of January 6, 1980.
4	GPS WEEK	1043 to 6144	1043	Displays week number based on the GPS time starting from the timing of January 6, 1980.

Example:
$PFEC,GNtps,G,266397,2202*24
Time of Week (GPS time) : 266397
Week number (GPS time) : 2202

NOTE:

- The time of this sentence always displays as GPS time regardless of the setting of the ALIGN command. However, in situations where only UTC time can be obtained, such as in case that only the GLONASS time can be obtained when the leap second is not got, the value adjusted the obtained UTC time with the default leap second is displayed.

6.14 GNtps,H – Holdover information

The following details the TPS,H sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	H	,	LEARNING CNT	,	HOLDOVER REMAIN CNT
		1		2		3		4

,	HO TYPE	,	FORCE HOLDOVER FLAG	*hh	<CR>	<LF>
	5		6			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	H	H	H	H is fixed.
3	LEARNING CNT	0 to 2592000	0	Accumulated learning time. Unit is seconds.
4	HOLDOVER REMAIN CNT	0 to 2592000	0	Remaining time enable to set holdover. Unit is seconds.
5	HO TYPE	0 to 2	0	Holdover is ready to be executed. 0: Holdover is not possible. 1: Short-term holdover possible 2: Long-term holdover possible
6	FORCE HOLDOVER FLAG	0 to 1	0	When the forced holdover flag is ON, 1 is displayed.

Example:
$PFEC,GNtps,H,10000,200,1,0*24
Learning time: 10000 seconds Remaining holdover available time: 200 seconds
Holdover possible state: Short-term holdover possible
Forced holdover flag: OFF state

NOTE:

- This setting can be config with the HOLDOVER command.

6.15 GNtps,I – sentence of timing product I : Spectrum data

Below are details of the TPS,I sentences in the dedicated NMEA format.
Outputs Spectrum data used for Noise Testing in FURUNO GNSS TIMING MONITOR.
The user does not need to be aware of this sentence, except in special cases, because this sentence is automatically output requested and analysed only when connected to the above MONITOR.

(1) Start sentence
Sentence indicating the start of Spectrum data output.

Format:

$PFEC	,	GPtps	,	I	,	START	,	header	,	number of z 1	,	number of z 2	*hh	<CR>	<LF>

	Data	Range	Default	Description
1	GNtps	-	-	Sentence Name
2	I	-	-	I is fixed.
3	START	-	-	Indicates the start of Spectrum data output, fixed at START.
4	header	Max 40 chars	-	Header information of Spectrum data.
5	number of z 1	0 to 512	0	Outputs the value encoded.
6	number of z 2	0 to 512	0	

(2) Spectrum data sentence
Output sentences for Spectrum data.
The encoded values are divided into multiple lines in this sentence and output.
(Maximum 37 lines)

Format:

$PFEC	,	GNtps	,	I	,	spectrum data	*hh	<CR>	<LF>

	Data	Range	Default	Description
1	GNtps	-	-	Sentence Name
2	I	-	-	I is fixed.
3	spectrum data	Max 70 chars	-	Spectrum data.

(3) End sentence

Sentence indicating the end of Spectrum data output.

Format:

$PFEC	,	GNtps	,	I	,	END	*hh	<CR>	<LF>

	Data	Range	Default	Description
1	GNtps	-	-	Sentence Name
2	I	-	-	I is fixed.
3	END	-	-	Indicates the end of Spectrum data output.

Example :

```
$PFEC,GNtps,I,START,!>b_i7nJ=5!'1NEA=:9no`+slzzz,0,0*5B
$PFEC,GNtps,I,!"&]5!"/c7!"&]6!"/c5!"8i7!"&]8!"&]7!"/c8!"8i8!"Ju=!"Ju=!"Ao:!"T&>!"Ju=*24
$PFEC,GNtps,I,!"Ju?!"Ju>!"T&@!"T&@!"]x@!"T&A!"f2D!"o8C!"f2C!"o8F!#xDH!##>F!#5JL!#xDL*32
~~~~~~~~~~~~~~~~ (omission (of middle part of a text)) ~~~~~~~~~~~~~~~~~~~
$PFEC,GNtps,I,!#5JL!#5JK!#>PJ!##>H!#xDH!##>H!"f2E!"o8E!"o8D!##>E!"f2D!"o8E!"f2C!"]xB*67
$PFEC,GNtps,I,!"T&@!"]xA!"f2D!"o8E!#5JG!##>H!#xDG!"o8D!"o8D!"T&@!"Ju=!"8i9!"8i7!"/c6*0C
$PFEC,GNtps,I,!"/c7!"&]7!"/c7!"&]6!"/c7!"/c7!"&]6!"&]5*09
$PFEC,GNtps,I,END*44
```

NOTE:

- Note that the jamming detection of GNtps,B is not activated during the output of this sentence.

6.16 GNtps,L : Log data information

The following details the TPS,L sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	L	,	DATA1	,	DATA2	,	DATA3	,	DATA4
		1		2		3		4		5		6

,	DATA5	,	DATA6	,	DATA7	*hh	<CR>	<LF>
	7		8		9			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	L	L	L	L is fixed.
3	DATA1	6 bytes	-	
4	DATA2	6 bytes	-	
5	DATA3	6 bytes	-	
6	DATA4	6 bytes	-	
7	DATA5	6 bytes	-	
8	DATA6	6 bytes	-	
9	DATA7	6 bytes	-	

Example:
$PFEC,GNtps,L,q07ZFG,q04eAY,B27DIY,B28DFY,B30ZHN,B36ZGN,b27ZCN*12

NOTE:
- Although it is not necessary to output this text for normal use, we may ask you to obtain this text as a means of gathering information to help us solve a problem.
- This text is encrypted and will be parsed by us if necessary.Because this sentence is encrypted, so we will analyze it in our side if necessary.
- The number of output lines and output fields varies depending on the number of received satellites, and up to 9 lines may be output per second. In addition, this sentence may not be output during non-positioning.

6.17 GNtps,J – Information about jamming

The following details the TPS,J sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	J	,	SENTENCE NUMBER	,	TOTAL NUMBER OF SENTENCES	,
		1		2		3		4	

JAMMING FREQUENCY	,	JAMMING SIGNAL PEAK	*hh	<CR>	<LF>
5		6			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	J	J	J	J is fixed.
3	SENTENCE NUMBER	NULL or 1 to 8	NULL	This field shows the current line of GNtps,J sentence.
4	TOTAL NUMBER OF SENTENCES	NULL or 1 to 8	NULL	This field shows the total number of rows in GNtps,J sentences.
5	JAMMING FREQUENCY	NULL or frequency	NULL	It indicates the frequency [MHz] of the jamming signal being detected.
6	JAMMING SIGNAL PEAK	NULL or -120.00 to 0.00	NULL	It indicates the signal strength [dB] of the jamming signal being detected with the frequency reported in the previous field.

Example:
$PFEC,GNtps,J,1,2,+1573.0000,-16.78*29
$PFEC,GNtps,J,2,2,+1567.4219,-17.65*2C
The following interference waves are detected.
Signal strength-16.78dB at frequency 1573.0000MHz
Signal strength-17.65dB at frequency 1567.4219MHz

6.18 GNtps,O – sentence of timing product O : Galileo OSNMA

The following details the TPS,O sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	O	,	SENTENCE NUMBER	,	SVID	,
		1		2		3		4	

UTC TIME	,	OSNMA BITS	,	WORD1to5	*hh	<CR>	<LF>
5		6		7			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	O	O	O	O is fixed.
3	SVID	01 to 36	-	Displays the satellite number of Galileo.
4	UTC TIME	000000.00 to 235959.99	000000.00	Displays the UTC time associated with this message. Displays hours, minutes, and seconds with two digits each, followed by a comma and two milliseconds.
5	OSNMA BITS	-	-	The OSNMA bit string encoded string is displayed.
6	WORD1to5	-	-	Encoded strings of data from Galileo navigation messages WORD1 to WORD5 are displayed.

Example:

$PFEC,GNtps,O,19,021525.08,Pw06E8Q=,BCwu4tLdaAAAZSUGqBO32wgsBVovtCdGwXKhTOVnDdUMLP/EoiJB/YcQ+hVB/RVrECxMAAf/pLuPkhezABnqARUSddAJQfh+ACY5YV6qqqo=*61

NOTE:

- Galileo satellites must be received in order to output the appropriate data in this sentence.
  The output of this Sentence may be subject to change due to ICD updates or specification changes.
  Please be aware of this beforehand.

6.19 GNtps,P – High precision position information

The following details the TPS,P sentence in proprietary NMEA format.
This sentence shows the current position with high accuracy.

Format:

$PFEC	,	GNtps	,	P	,	LATITUDE	,	LONGITUDE	,	ALTITUDE	*hh	<CR>	<LF>
		1		2		3		4		5			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	P	P	P	P is fixed.
3	LATITUDE	-90.0000000 to 90.0000000	0.0000000	It displays the current position (latitude) in degrees. North latitude is displayed as positive and south latitude is displayed as negative.
4	LONGITUDE	-180.0000000 to 180.0000000	0.0000000	It displays the current position (longitude) in degrees. The east longitude is displayed as positive, and the west longitude is displayed as negative.
5	ALTITUDE	-1000.00 to 18000.00	0.00	It displays the current position (altitude).

Example:
$PFEC,GNtps,P,+34.1234567,-51.6543210,35.12*3B
The current position (or the currently set fixed position) is 34.1234567 degrees north latitude, 51.6543210 degrees west longitude, and 35.12 meters above sea level.

NOTE:
- In NAV mode, the current position of the position record is displayed, in Self-Survey mode, the surveyed position calculated up to that point is displayed, and in Time Only mode, the fixed position is displayed.

6.20 GNtps,V – Version information

The following details the TPS,V sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	V	,	VERSION	,	PRODUCT ID	,	CHIP PKG	*hh	<CR>	<LF>
		1		2		3		4		5			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	V	V	V	V is fixed.
3	VERSION	-	-	It shows the software version number.
4	PRODUCT ID	-	-	It shows the product ID.
5	CHIP PKG	0x00 to 0xFF	-	It shows the HW version of GNSS chip.

Example:
$PFEC,GNtim,V,4850569002,0,0x03*6A
Software version: 4850569023
Product ID: 0
HW version of GNSS chip: 0x03

6.21 GNtps,Z – Information of ICLK

The following details the TPS,Z sentence in proprietary NMEA format.

Format:

$PFEC	,	GNtps	,	Z	,	ICLK PHASE DELAY	,	ICLK FILTERD PHASE DELAY	,
		1		2		3		4	

ICLK DELTA PHASE DELAY	,	ICLK FILTERD DELTA PHASE DELAY	*hh	<CR>	<LF>
5		6			

	Data	Range	Default	Description
1	GNtps			Sentence Name
2	Z	Z	Z	Z is fixed.
3	ICLK PHASE DELAY	12bytes	+0.00000E+00	his field displays the phase difference between the clock input to the ICLK and the GNSS time reference. The unit is seconds.
4	ICLK FILTERD PHASE DELAY	12bytes	+0.00000E+00	This field displays the value of the above field smoothed (low-pass filter) in the last 60 seconds.
5	ICLK DELTA PHASE DELAY	12bytes	+0.00000E+00	This field displays the amount of fluctuation in the phase difference between the clock input to the ICLK and the GNSS time reference. The unit is seconds.
6	ICLK FILTERD DELTA PHASE DELAY	12bytes	+0.00000E+00	This field displays the value of the above field smoothed (low-pass filter) in the last 60 seconds.

Example:
$PFEC,GNtps,Z,+2.14100E-08,+2.14121E-08,+1.46221E-10,+1.46256E-10*37
The phase difference of the ICLK clock from the GNSS time reference is about 21.41 nsec, and the phase difference fluctuation amount is about 0.146 ppb

NOTE:
This sentence outputs an appropriate value only when the clock is continuously input to the ICLK and the receiver continues positioning, and +0.00000E+00 is output otherwise. Whether an appropriate value is output can also be determined by checking whether the ICLK input status of the SYNC STATUS of the GNtps,C sentence is 1.

.

6.22 GNack – Acknowledge message

The following details the GNack sentence in proprietary NMEA format.
This sentence is output when the product receives a command.

Format:

$PFEC	,	GNack	,	SEQUENCE	,	SUB COMMAND	*hh	<CR>	<LF>
		1		2					

	Data	Range	Default	Description
1	GNack			Sentence Name
2	SEQUENCE	0 to 255 or -1	0	This field displays the number of successful commands received. One is added each time a command is successfully received. After 255, it returns to 0. It returns -1 if the command fails to be accepted for some reason, such as an incorrect command, an insufficient number of fields, or an incorrect checksum. If the sequence number is positive, it is an ACK, and if it is negative, it is a NACK.
3	SUB COMMAND		-	returns the third field of the command as entered.

Example:
$PFEC,GNack,12*73
The command has been accepted.

$PFEC,GNack,-1,GNSS*49
GNSS command was entered, but it was not accepted.

6.23 GNswi : Software Interrupt

This sentence is only output when an unexpected exception occurs and is not output in principle.

Format:

$PFEC	,	GNswi	,	TYPE	,	SENTENCE NUMBER	,	TOTAL NUNVER OF SENTENCEs
		1		2		3		4

,	MSG1	,	MSG2	’	MSG3	’	MSG4	*hh	<CR>	<LF>
	5		6		7		8			

	Data	Range	Default	Description
1	GNswi	-	-	Sentence Name
2	TYPE	88 to 93	-	Indicates the output trigger
3	SENTENCE NUMBER	01 to 14	-	The current output line of GNswi.
4	TOTAL NUNVER OF SENTENCEs	14	-	The total number of output GNswi sentences.
5	MSG1	-	-	Displays analysis information.
6	MSG2	-	-	
7	MSG3	-	-	
8	MSG4	-	-	

Example:
$PFEC,GNswi,91,01,14,00000000,00000000,0011A8D0,00000026554C*06
This is the output of an exception handling message.
This sentence may appear over multiple lines.

NOTE
- If this sentence is displayed, please contact us after obtaining a log of the situation when this sentence occurred and all multiple lines of this sentence.

7 Details of Input Command

These are input commands for the protocol of the receiver.

7.1 GNtim,GNSS: Satellite Constellation Configuration

This command is to configure the reception of the GNSS constellations.

Format:

$PFEC	,	GNtim	,	GNSS	,	SETTING VALUE	*hh	<CR>	<LF>
		1		2		3			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	GNSS	GNSS	GNSS	Command Name. GNSS is fixed.
3	SETTING VALUE	0x00000001 to 0xFFFFFFFF	0x00136313	Please select the satellite constellation to be received. Please refer to NOTE for details.

Example:
$PFEC,GNtim,GNSS,0x00000011*04
GPS L1C/A and GLONASS L1OF are to be received.

NOTE:
- After entering this command, please wait at least 1000 msec before entering the next command.
- **When this command is issued, COLD RESTART (including time reset) will be executed.**
- **The PPS ALIGN INDEX setting of ALIGN command determines from which satellite constellation the UTC parameters are obtained. Please refer to ALIGN command for more detail.**
- Although it is possible to set this command to receive only the L5 signal, it is strongly recommended to set this command to use both the L1 and L5 signals if user uses an antenna that can receive the L5 signal, because the combination with the L1 signal is expected to improve the environmental resistance and positioning performance.
- If GLONASS is set to be used together with other satellite constellations, GLONASS positioning will start after the time is fixed by the other satellite constellations due to time processing. For example, if this command is set to GPS + GLONASS, GLONASS will be used for positioning only after the time is fixed by GPS. If GLONASS is set to stand-alone positioning, GLONASS alone can be used for positioning.
- SBAS satellites are not included in the default settings. This reason is that the correction effect of SBAS is extremely limited, and if any of the 32 reception channels of this product are used for the reception of SBAS satellites, the number of received satellites from the other satellite constellations will be reduced. Therefore, we do not recommend the use of SBAS L1.
- It is not possible to set only SBAS satellite reception.
- When using SBAS satellites, please also refer to SBAS Commands below.

Refer to the below table for satellite settings.

Table 7.1-1. About the relationship of the corresponding BIT

Satellite setting BIT	Satellite constellation
0x0000 0001	GPS L1C/A
0x0000 0002	GPS L5
0x0000 0010	GLONASS L1OF
0x0000 0100	Galileo E1
0x0000 0200	Galileo E5a
0x0000 1000	BeiDou B1I
0x0000 2000	BeiDou B2a
0x0000 4000	BeiDou B1C
0x0001 0000	QZSS L1C/A
0x0002 0000	QZSS L5
0x0010 0000	NavIC L5
0x0100 0000	SBAS L1
BIT other than the above	Reserved (Please do not set)

■ The current setting value can be checked by issuing the following command.
$PFEC,GNtim,GNSS,QUERY*06

7.2 GNtim,ANGLE: Elevation Mask Setting

This command is to mask the satellites with a low elevation angle when a higher positioning accuracy is preferred.

Format:

$PFEC	,	GNtim	,	ANGLE	,	MASK VALUE	*hh	<CR>	<LF>
		1		2		3			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	ANGLE	ANGLE	ANGLE	Command Name. ANGLE is fixed.
3	MASK VALUE	0 to 90	5	Elevation Mask Please set the elevation angle mask [degree].

Example:
$PFEC,GNtim,ANGLE,15*00
Set the elevation angle mask at 15 degrees.

NOTE:
- The current setting value can be checked by issuing the following command.
$PFEC,GNtim,ANGLE,QUERY*4E

7.3 GNtim,CN0: Signal Level Mask Setting

This command is to mask the satellites with a low signal level when a higher positioning accuracy is preferred.

Format:

$PFEC	,	GNtim	,	CN0	,	SETTING VALUE	*hh	<CR>	<LF>
		1		2		3			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	CN0	CN0	CN0	Command Name. CN0 is fixed.
3	SETTING VALUE	00 to 99	0	Please Set the signal level mask [dB-Hz] Only satellites with a signal level above this value are used in positioning.

Example:
$PFEC,GNtim,CN0,20*7A
Satellites with a signal level above 20 are to be used in positioning.

NOTE:
- It is possible to set the mask value up to 99, however the strongest signal level that can be observed is around 55. Please note that a signal level mask over 55 may result in a setting that is always non-positioning.
- The current setting value can be checked by issuing the following command.

$PFEC,GNtim,CN0,QUERY*32

7.4 GNtim,SVID: Satellite ID Mask Setting

This command is to mask specific satellites.
Unless you have a specific reason, you do not need to set this command.

Format:

$PFEC	,	GNtim	,	SVID	,	CONSTELLATION	,	MASK SVID	,
		1		2		3		4	

ONOFF	*hh	<CR>	<LF>
5			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	SVID	SVID	SVID	Command Name. SVID is fixed.
3	CONSTELLATION	1 to 16	-	Please select the satellite constellation to apply a MASK. See NOTE for details.
4	MASK ID	Please refer to NOTE	-	Mask satellite ID Please select the satellite number to apply MASK. The setting range is different depending on the satellite system. See NOTE for details.
5	ONOFF	0 to 1	-	Set MASK ON/OFF for selected satellites. 0 means MASK OFF. 1 means MASK ON.

Example:
$PFEC,GNtim,SVID,1,20,1*4F
Set the MASK ON for GPS L1 No.20 satellite signal.

NOTE:

- The maximum number of masks allowed is 50.
- When masking an entire constellation is desired, please use the GNtim,GNSS command.

Table7.4-1. List of constellations and satellite IDs with corresponding BIT

CONSTELLATION Setting Value	Satellites Constellation	MASK ID Setting Range
1	GPS L1	1 to 32
2	GPS L5	1 to 32
3	GLONASS L1	65 to 99
4	Galileo E1	1 to 36
5	Galileo E5a	1 to 36
6	BeiDou B1I	1 to 63
7	BeiDou B1C	1 to 63
8	BeiDou B2a	1 to 63
9	QZSS L1	1 to 10
10	QZSS L5	1 to 10
11	Reserved	-
12	Reserved	-
13	NavIC L5	1 to 14
14	SBAS L1	33 to 64
15	Reserved	-
16	Reserved	-

- The current setting value can be checked by issuing the following command.

$PFEC,GNtim,SVID,QUERY*07

- For example, when mask of GPS L1C/A No.21, No.22 satellites, and GLONASS L1OF No.65 satellite is applied, QUERY command output is as below (up to 10 satellites per line): $PFEC,GNtim,SVID,1,22,23*7D

7.5 GNtim,SURVEY: Position Mode Setting

This command is to configure the position mode function.

Format:

$PFEC	,	GNtim	,	SURVEY	,	POSITION MODE	[,	THRESHOLD OF SIGMA	,
		1		2		3		4	

THRESHOLD OF TIME	[,	LATITUDE FOR TO MODE	,	LONGITUDE FOR TO MODE	,
5		6		7	

ALTITUDE FOR TO MODE]]	*hh	<CR>	<LF>
8			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	SURVEY	SURVEY	SURVEY	Command Name. SURVEY is fixed.
3	POSITION MODE	0 to 2	1	0: NAV mode 1: Self-Survey mode 2: Time Only mode
4	THRESHOLD OF SIGMA	0 to 999	0	Threshold that serves as a condition to complete position survey. Sigma threshold is set in [meter] and time threshold is in [times]. In Self-Survey mode, once the above two thresholds are both met, the system automatically switches to Time Only mode. If one of the thresholds is 0, it is disabled and only the other threshold is valid to make a transition. If both thresholds are set to 0, the system remains in Self-Survey mode and never switches to Time Only mode.
5	THRESHOLD OF TIME	0 to 999999	86400	
6	LATITUDE FOR TO MODE	-90.0000000 to 90.0000000	0	Latitude for hold position in Time Only mode. [degree] A positive number means a north latitude and a negative number means a south latitude. Only available in Time Only mode. (Up to seventh decimal places.)
7	LONGITUDE FOR TO MODE	-180.0000000 to 180.0000000	0	Longitude for hold position in Time Only mode. [degree] A positive number means an east longitude and a negative number means a west longitude. Only available in Time Only mode. (Up to seventh decimal places.)

	Data	Range	Default	Description
8	ALTITUDE FOR TO MODE	-1000.00 to 18000.00	0	Altitude for hold position in Time Only mode. [meter] Only available in Time Only mode. (Up to two decimal places.)

Example:
$PFEC,GNtim,SURVEY,1,0,3600*5F
Mode: Self-Survey mode : When the time of position survey reaches 3600 times, it automatically transits to Time Only mode.

$PFEC,GNtim,SURVEY,2,0,0,37.3787122,-122.451,31.32*7A
Mode: Time Only : Fixed position: 37.3787122 degree north and 122.4510000 degree west
Altitude: 31.32 meter

NOTE:
- The fourth and subsequent fields can be assigned only if POSITION MODE is specified as 1 or 2 in the command. The sixth and subsequent fields can be assigned only if POSITION MODE is specified as 2 in the command.
- In a shielded environment such as nearby window or in an urban area, the update of the estimated position may be withheld depending on the fluctuation of the calculated estimated position and the PDOP situation. In such cases, please note that the count-up of the number of times the calculated position estimation process is performed is not necessarily performed every second.
- If a command to switch to Time Only mode is sent without specifying the fixed position while operating in NAV mode or Self-Survey mode, the position calculated up to that point is regarded as the fixed position and transit to Time Only mode.
- Please notice that in case of initial positioning, if a command is sent from NAV mode or Self-Survey mode to switch to Time Only mode without specifying a fixed position, the command itself will not be accepted because there is no position information.
- If a fixed position is set by the 6th field or later, the fixed position and the position displayed in the sentences may differ slightly in the last digit, this is due to a conversion error in the coordinate system when displaying the sentences. Please note that there is no problem in performance. Due to the trigonometric calculation, when the position near the North or South Pole is set, there may be some error included in the reflected position.
- When setting a fixed position in the sixth field or later, please reduce the error from the true value as much as possible. The performance will deteriorate according to the error. If the error from the true value is more than 1 km, the positioning itself may not work because the satellite cannot be searched. If the value is set incorrectly, please use the RESTART command to perform a FACTORY RESTART.
- If the receiver's antenna moves after the transition to Time Only mode, the performance will deteriorate according to the error. If the error from the true value exceeds 1 km, the positioning itself may not work because the satellite cannot be searched. In such case, please use the RESTART command to perform a FACTORY RESTART.

- **Advice on THRESHOLD OF SIGMA and THRESHOLD OF TIME**

Under the open sky environment, by using the default setting, it automatically transitions to Time Only mode after calculating the fixed position with high precision for 24 hours (86400sec). On the other hand, if you want to automatically transition to Time Only mode after computing a precise fixed position in an environment that is not an open sky such as an urban area, we recommend setting the Sigma threshold in the range of about 10 to 100 in addition to the Time threshold. As the Sigma threshold value to be set decreases, it may take time to automatically switch to Time Only mode. However, since it transits to Time Only mode after acquiring a more definite fixed position, the time (1PPS) performance obtained after that is good.

7.6 GNtim,ALIGN: Time and PPS Alignment Setting

This command is to configure the time and PPS alignment.

Format:

$PFEC	,	GNtim	,	ALIGN	,	TIME ALIGN INDEX	,	PPS ALIGN INDEX	,
		1		2		3		4	

NMEA SYNC TARGET	[,	DEFALT LEAP SECOND]	*hh	<CR>	<LF>
5		6			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	ALIGN	ALIGN	ALIGN	Command Name. ALIGN is fixed.
3	TIME ALIGN INDEX	0 to 1	1	Please set whether to add leap seconds after January 6, 1980, in NMEA output. 0: No leap second after January 6, 1980 (Output as GPS time) 1: with leap seconds after January 6, 1980 (Output as UTC time)
4	PPS ALIGN INDEX	1 to 12	2	Please select the synchronization target for PPS. 1: GPS time , 2: UTC(USNO) time 3: GLONASS time , 4: UTC(SU) time 5: Galileo time , 6: UTC(EU) time 7: BeiDou time , 8: UTC(NTSC) time 9: QZSS time , 10: UTC(NICT) time 11: NavIC time , 12: UTC(NPLI) time
5	NMEA SYNC TARGET	0 to 1	1	Select the sync target of 1PPS time in NMEA sentence.（Please refer to NOTE Figure 7.6-1） 0： the time of 1PPS when sentence output 1： the next 1PPS output timing
6	DEFAULT LEAP SECOND	-99 to 99	18	Set the default value of leap second. By setting the cumulative value of leap seconds from January 6, 1980, to the present, the NMEA output time can be closer to UTC time before obtaining the leap seconds information from the satellite navigation messages.

Example:
$PFEC,GNtim,ALIGN,0,1,1*38
Output GPS time in NMEA sentences without the leap second.
1PPS time displayed in each sentence is the time when sentence output.
1PPS is synchronized with GPS time.

NOTE:

- After entering this command, allow at least 1000 msec before entering the next command.
- The sixth field can be omitted.
- **When this command is issued, COLD RESTART (including time reset) is performed.**
- **The PPS ALIGN INDEX setting determines from which satellite constellation the UTC parameters are obtained. For example, when GPS time synchronization is set, UTC parameters are obtained from GPS satellites.**
  If the target to obtain UTC parameters from a satellite constellation that has not been set in the GNSS command, the UTC parameters cannot be obtained, which may interfere with leap second updates and other operations. Please set the PPS ALIGN INDEX from among the satellite constellations used in the GNSS command. Table 7.6-1 shows the correspondence with satellite constellations.

Table 7.6-1. Correspondence between sat constellations and PPS ALIGN INDEX

TIME ALIGN INDEX	satellite constellations
1: GPS time, 2: UTC(USNO) time	GPS
3: GLONASS time, 4: UTC(SU) time	GLONASS
5: Galileo time, 6: UTC(EU) time	Galileo
7: BeiDou time, 8: UTC(EU) time	BeiDou
9: QZSS time, 10: UTC(NICT) time	QZSS
11: NavIC time, 12: UTC(NPLI) time	NavIC

- When TIME ALIGN INDEX is set to 0, leap second insertion is not performed on the NMEA output time, even if the timing for leap second insertion occurs. (The 60-second display is lost, etc.).
- The current settings can be checked by issuing the following commands:
  $PFEC,GNtim,ALIGN,QUERY*42
- The relationship between NMEA SYNC TARGET and the time displayed in the message is shown in the figure below.

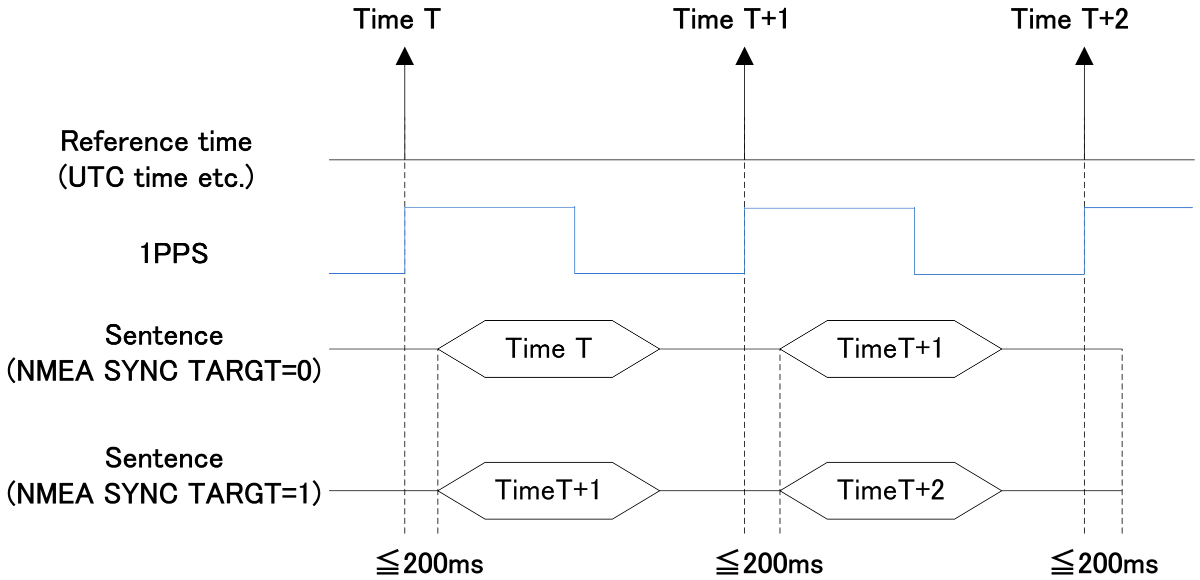


Figure7.6-1. Relation between Output Time and NMEA SYNC TARGET

7.7 GNtim,LZT: Local Zone Time Setting

This command is to configure the local zone time.

Format:

$PFEC	,	GNtim	,	LZT	,	SIGN	,	HOUR	,	MINUTE	*hh	<CR>	<LF>
		1		2		3		4		6			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	LZT	LZT	LZT	Command Name. LZT is fixed.
3	SIGN	0 to 1	0	LZT sign 0: Positive 1: Negative
4	HOUR	0 to 14	0	LZT Hour setting
5	MINUTE	0 to 59	0	LZT Minute setting

Example:
$PFEC,GNtim,LZT,0,9,0*3E
LTZ: +09: 00

NOTE:

- This setting is applied only to ZDA sentence.
- The current LZT setting value can be checked in ZDA sentence.

7.8 GNtim,TIME: Initial Time Setting

This command is to input the initial time and date.
Unless you have a specific reason, you do not need to set this command.

Format:

$PFEC	,	GNtim	,	TIME	,	HOUR	,	MINUTE	,	SECOND	,
		1		2		3		4		5	

DAY	,	MONTH	,	YEAR	*hh	<CR>	<LF>
6		7		8			

	Data	Range	Default	Description
1	GNtim	-	-	Command name GNtim fixed
2	TIME	TIME	TIME	Command name TIME fixed
3	HOUR	0 to 23	0	Initial Hour setting
4	MINUTE	0 to 59	0	Initial Minute setting
5	SECOND	0 to 59	0	Initial Second setting
6	DAY	1 to 31	2	Initial Day setting
7	MONTH	1 to 12	1	Initial Month setting
8	YEAR	2000 to 2099	2000	Initial Year setting

Example:
$PFEC,GNtim,TIME,23,55,0,4,1,2020*48
Initial time: 23: 55: 00(UTC) on January 4, 2020

NOTE:
- This command can be used before initial positioning only when all the following conditions are satisfied.

[1] After the timing of internal rollover
[2] Use only GPS L1, QZSS L1 and/or NavIC
[3] Start up with no time backup

- By setting the appropriate current date with this command, it is possible to output the correct date even after internal rollover. For details of internal rollover, please also refer to the technical document (SE18-100-034).
- The date and time set by this command should be within an error margin of less than ±510 weeks relative to the actual date and time (the current date and time at the time th command is entered).
- Please do not use this command after position fix since the time obtained from satellites is used.

7.9 GNtim,FREQGEN: settings for the frequency generation circuit

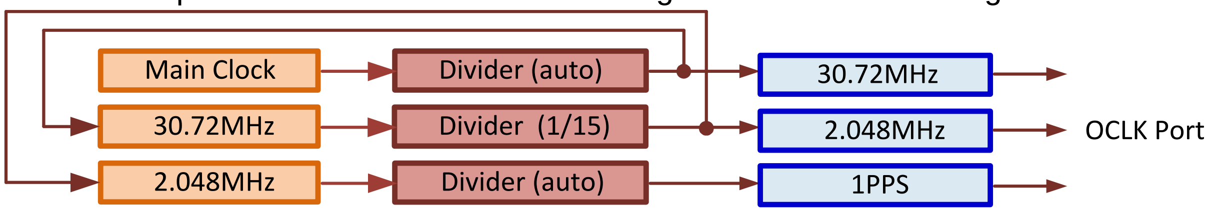
The details of the FREQGEN commands are shown below.
Format:

$PFEC	,	GNtim	,	FREQGEN	,	FGEN CLOCK	,	DIVIDER RATE	*hh	<CR>	<LF>
		1		2		3		4			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	FREQGEN	FREQGEN	FREQGEN	Command Name. FREQGEN is fixed.
3	FGEN CLOCK	1000000 to 40000000	20000000	Please set the clock value of FGEN CLOCK generated by the frequency generation circuit. It can be set within the range of 1MHz to 40MHz. FGEN CLOCK can be output from any OCLK pin by using the OCLK0 to OCLK2 commands.
4	DIVIDER RATE	Please refer to NOTE	2	This is the division ratio used in the frequency generation circuit. It is used to generate DIV CLOCK (clock obtained by dividing FGEN CLOCK by this division ratio). DIV CLOCK can be output from any OCLK pin by using the OCLK0 to OCLK2 commands.

Example:
$PFEC,GNtim,FREQGEN,30720000,15*3A
Set 30.72MHz to FGEN CLOCK and set the division ratio to 15.
(DIV CLOCK will be 2.048MHz because 30.72MHz will be 1/15)

The relationship between each clock in the settings is as follows in the figure.



NOTE:

- Please note that when this command is entered, the synchronization processing of 1PPS, FGEN CLOCK, and DIV CLOCK will be initialized and the PLL will be resynchronized. It is recommended that you enter this command between start up and initial positioning, and please do not set it during the production environment.
- DIVIDER RATE in the 5th field can be set only for values that satisfy all the following conditions.

[1] Must be in the range of 2 to 100.
[2] FGEN CLOCK is divisible by DIVIDER RATE. (It must be a divisor of FGEN CLOCK)
For example, if FGEN CLOCK is 10000000, DIVIDER RATE cannot be set to 3 or 9.

- You can check the current setting value by issuing the following command.

$PFEC,GNtim,FREQGEN,QUERY*57

7.10 GNtim,OCLK0: Settings for the OCLK0

The details of the OCLK0 commands are shown below.

Format:

$PFEC	,	GNtim	,	OCLK0	,	CLOCK TYPE	,	OUTPUT MODE	,
		1		2		3		4	

PULSE WIDTH	,	DELAY ADJUST	'	POLARITY	*hh	<CR>	<LF>
5		6		7			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	OCLK0	OCLK0	OCLK0	Command Name. OCLK0 is fixed.
3	CLOCK TYPE	0 to 2	0	Setting the type of clock output from the OCLK0. 0: 1PPS (rising edge synchronization) 1: FGEN CLOCK (rising edge synchronization) 2: DIV CLOCK (rising edge synchronization)
4	OUTPUT MODE	0 to 3	3	Setting the clock output mode. 0: Always stop 1: Always output 2: Output only during FINE LOCK 3: TRAIM OK and output only during FINE LOCK
5	PULSE WIDTH	1 to 999	500	When outputting 1PPS from OCLK0, please set the pulse width for that 1PPS. The unit is msec. It does not apply to 1PPS from other than OCLK0 and clocks other than 1PPS. If you do not want to output 1PPS from OCLK0, please set 500.
6	DELAY ADJUST	-500000000 to 500000000	0	When 1PPS is output from OCLK0, the delay for that 1PPS is corrected. The unit is nsec, and by setting the sign to positive, the delay of the cable is eliminated. It does not apply to 1PPS from other than OCLK0 and clocks other than 1PPS. If you do not want to output 1PPS from OCLK0, please set it to 0.
7	POLARITY	0 to 1	0	Setting whether to invert the sync edge. 0: Positive edge / 1: Negative edge

Example:
$PFEC,GNtim,OCLK0,0,1,200,30,1*7F
1PPS is always output from the OCLK0. The pulse width of 1PPS output from the OCLK0 is 200ms, setting the cable offset by 30ns. 1PPS output from the OCLK0 is falling edge synchronization.

NOTE:
- Please note that if you change the value of PPS_WIDTH or DELAY_ADJUST, the synchronization process of 1PPS, FGEN CLOCK, and DIV CLOCK will be initialized and the PLL will be resynchronized. It is recommended that you enter changes to this parameter between start up and initial positioning, and do not set it during the production environment.
- For details on FGEN CLOCK and DIV CLOCK, refer to the chapter on FREQGEN commands.
- You can check the current setting value by issuing the following command.

$PFEC,GNtim,OCLK0,QUERY*34

7.11 GNtim,OCLK1: Settings for the OCLK1

The details of the OCLK1 commands are shown below.

Format:

$PFEC	,	GNtim	,	OCLK1	,	CLOCK TYPE	,	OUTPUT MODE	,
		1		2		3		4	

PULSE WIDTH	,	DELAY ADJUST	'	POLARITY	*hh	<CR>	<LF>
5		6		7			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	OCLK1	OCLK1	OCLK1	Command Name. OCLK1 is fixed.
3	CLOCK TYPE	0 to 2	0	Setting the type of clock output from the OCLK1. 0: 1PPS (rising edge synchronization) 1: FGEN CLOCK (rising edge synchronization) 2: DIV CLOCK (rising edge synchronization)
4	OUTPUT MODE	0 to 3	3	Setting the clock output mode. 0: Always stop 1: Always output 2: Output only during FINE LOCK 3: TRAIM OK and output only during FINE LOCK
5	PULSE WIDTH	1 to 999	500	When outputting 1PPS from OCLK1, please set the pulse width for that 1PPS. The unit is msec. It does not apply to 1PPS from other than OCLK1 and clocks other than 1PPS. If you do not want to output 1PPS from OCLK1, please set 500.
6	DELAY ADJUST	-500000000 to 500000000	0	When 1PPS is output from OCLK1, the delay for that 1PPS is corrected. The unit is nsec, and by setting the sign to positive, the delay of the cable is eliminated. It does not apply to 1PPS from other than OCLK1 and clocks other than 1PPS. If you do not want to output 1PPS from OCLK1, please set it to 0.
7	POLARITY	0 to 1	0	Setting whether to invert the sync edge. 0: Positive edge / 1: Negative edge

Example:
$PFEC,GNtim,OCLK1,0,1,200,30,1*7E
1PPS is always output from the OCLK1. The pulse width of 1PPS output from the OCLK1 is 200ms, setting the cable offset by 30ns. 1PPS output from the OCLK1 is falling edge synchronization.

NOTE:
- Please note that if you change the value of PPS_WIDTH or DELAY_ADJUST, the synchronization process of 1PPS, FGEN CLOCK, and DIV CLOCK will be initialized and the PLL will be resynchronized. It is recommended that you enter changes to this parameter between start up and initial positioning, and do not set it during the production environment.
- For details on FGEN CLOCK and DIV CLOCK, refer to the chapter on FREQGEN commands.
- You can check the current setting value by issuing the following command.
  $PFEC,GNtim,OCLK1,QUERY*35

7.12 GNtim,OCLK2: Settings for the OCLK2

The details of the OCLK2 commands are shown below.

Format:

$PFEC	,	GNtim	,	OCLK2	,	CLOCK TYPE	,	OUTPUT MODE	,
		1		2		3		4	

PULSE WIDTH	,	DELAY ADJUST	'	POLARITY	*hh	<CR>	<LF>
5		6		7			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	OCLK2	OCLK2	OCLK2	Command Name. OCLK2 is fixed.
3	CLOCK TYPE	0 to 2	0	Setting the type of clock output from the OCLK2. 0: 1PPS (rising edge synchronization) 1: FGEN CLOCK (rising edge synchronization) 2: DIV CLOCK (rising edge synchronization)
4	OUTPUT MODE	0 to 3	3	Setting the clock output mode. 0: Always stop 1: Always output 2: Output only during FINE LOCK 3: TRAIM OK and output only during FINE LOCK
5	PULSE WIDTH	1 to 999	500	When outputting 1PPS from OCLK2, please set the pulse width for that 1PPS. The unit is msec. It does not apply to 1PPS from other than OCLK2 and clocks other than 1PPS. If you do not want to output 1PPS from OCLK2, please set 500.
6	DELAY ADJUST	-500000000 to 500000000	0	When 1PPS is output from OCLK2, the delay for that 1PPS is corrected. The unit is nsec, and by setting the sign to positive, the delay of the cable is eliminated. It does not apply to 1PPS from other than OCLK2 and clocks other than 1PPS. If you do not want to output 1PPS from OCLK2, please set it to 0.
7	POLARITY	0 to 1	0	Setting whether to invert the sync edge. 0: Positive edge / 1: Negative edge

Example:
$PFEC,GNtim,OCLK2,0,1,200,30,1*7D
1PPS is always output from the OCLK2. The pulse width of 1PPS output from the OCLK2 is 200ms, setting the cable offset by 30ns. 1PPS output from the OCLK2 is falling edge synchronization.

NOTE:

- Please note that if you change the value of PPS_WIDTH or DELAY_ADJUST, the synchronization process of 1PPS, FGEN CLOCK, and DIV CLOCK will be initialized and the PLL will be resynchronized. It is recommended that you enter changes to this parameter between start up and initial positioning, and do not set it during the production environment.
- For details on FGEN CLOCK and DIV CLOCK, refer to the chapter on FREQGEN commands.
- You can check the current setting value by issuing the following command.

$PFEC,GNtim,OCLK2,QUERY*36

7.13 GNtim,SYNC: Setting the synchronization target of PLL control

The details of the SYNC commands are shown below.
You can select the synchronization target of the PLL control from the GNSS or ICLK.

Format:

$PFEC	,	GNtim	,	SYNC	,	SYNC TARGET	,	RESERVED1	,	RESERVED2	,
		1		2		3		4		5	

ICLK CLOCK	*hh	<CR>	<LF>
6			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name.
2	SYNC	SYNC	SYNC	SYNC is fixed.
3	SYNC TARGET	0 to 6	0	select the synchronization target for clock control. For details, please refer to NOTE.
4	RESERVED1	1	1	This field is reserved.
5	RESERVED2	1	1	This field is reserved.
6	ICLK CLOCK	1 to 40000000	1	If a clock is input to the ICLK, please set the nominal frequency [Hz] of that clock. [*1]

[*1] If 1PPS is connected, please set 1 which means 1Hz. Please set 1 even if nothing is connected to the corresponding ICLK pin.

Example:
$PFEC,GNtim,SYNC,6,1,1,1*69
The PLL circuit is controlled to synchronize with the PPS input from the ICLK.

NOTE:

- Please note that when this command is entered, the synchronization processing of 1PPS, FGEN CLOCK, and DIV CLOCK will be initialized and the PLL will be resynchronized.
- It is recommended that you enter this command between start up and initial positioning, and do not set it during the production environment.
- With SYNC TARGET, you can select the clock control synchronization target during positioning and non-positioning as follows.

SYNC TARGET	During FIX	During No-FIX
0	Synchronized with GNSS	Free run
1	Reserved	Reserved
2	Reserved	Reserved
3	Synchronized with GNSS	Holdover 1PPS with the accuracy of the clock input from the ICLK [*1]
4	Reserved	
5	Reserved	
6	Synchronized with 1PPS input from the ICLK [*2]	

[*1] The clock must be continuously input to the ICLK, and the appropriate nominal frequen cy must be set for the ICLK's CLOCK in the 6th field.
[*2] 1PPS must be continuously input to the ICLK, and ICLK's CLOCK in the 6th field must be set to 1.

7.14 GNtim,HOLDOVER – Holdover setting

User can set PLL mode to free run forced and/or set a holdover time.

Format:

$PFEC	,	GNtim	,	HOLDOVER	,	Reserved 1	,	LEARNING TIME	,
		1		2		3		4	

Reserved 2	,	AVAILABLE TIME	,	FORCE HOLDOVER FLAG	*hh	<CR>	<LF>
5		6		7			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	HOLDOVER	HOLDOVER	HOLDOVER	Command Name. HOLDOVER is fixed.
3	Reserved 1	1	1	Please set as 1.
4	LEARNING TIME	1 to 2592000	1	Sets the study time required to perform holdover. The unit is seconds.
5	Reserved 2	1	1	Please set as 1.
6	AVAILABLE TIME	1 to 2592000	1	Sets the possible holdover time. The unit is seconds.
7	FORCE HOLDOVER FLAG	0 to 1	0	When this flag is set to 1, the PLL control is forcibly set to the free run state from that moment. If you are using GNSS synchronization and you want to synchronize again with the GNSS time, please set this setting back to 0 again. (This setting is not backed up by the BACKUP command.)

Example:
$PFEC,GNtim,HOLDOVER,1,600,1,3600,0*47

If the receiver could get more than 600 seconds of learning time, it can set HOLDOVER mode for max 3600 seconds when no satellite.

NOTE

- LEARNING TIME is recommended to be about 600 seconds.
- Because this product is a highly sensitive receiver, it may track satellites with extremely weak signal levels for a while even when, for example, antenna cables are disconnected, and may not immediately shift to holdover mode. If a period of tracking a satellite with such a weak signal level exists, the accuracy of 1PPS and frequency may

deteriorate during this period. To avoid this, users who expect holdover are strongly recommended to set the signal level mask to about 25 with the CN0 command. By setting the signal level mask, it is possible to smoothly transition to holdover after a reference disconnection.

7.15 GNtim,NMEAOUT: Serial Communication Port Setting

This command is to enable/ disable different types of sentences and their output intervals.

Format:

$PFEC	,	GNtim	,	NMEAOUT	,	SENTENCE TYPE	,	INTERVAL	*hh	<CR>	<LF>
		1		2		3		4			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	NMEAOUT			Command Name. NMEAOUT is fixed.
3	SENTENCE TYPE	RMC,GNS,GGA,GLL, VTG,GSA,ZDA,GSV, GST,ALL,TPSx (x=A to Z)	-	NMEA sentence type setting In case of TPSx sentence, please refer to details of NMEA format in Chapter 6 respectively (only those listed are available). However, TPSI is used by FURUNO GNSS TIMING MONITOR and cannot be entered by the user.
4	INTERVAL	-1 to 60	-	User can set the output cycle or stop, from 1 to 60, at which time the output will be sent out every cycle [second]. For example, a value of 5 will output the target sentence every 5 seconds, and a value of 1 will output it every second. If set to -1, the sentences will be stopped immediately and no further periodic output will occur; if set to 0, the sentences will be output once and no further periodic output will occur (a setting of 0 will change to the equivalent of -1 after the sentences have been output).

Example:
$PFEC,GNtim,NMEAOUT,GGA,2*53
GGA sentence is output every 2 sec.

$PFEC,GNtim,NMEAOUT,TPSA,0*06
TPS,A sentence is output only once, and then its outputting stops.

NOTE:
- If ALL is set in SENTENCE TYPE, the output cycle can be set for all the following standard NMEA format sentences. (RMC, GNS, GGA, GLL, VTG, GSA, ZDA, GSV, GST)

7.16 GNtim,EXTGSA: Extend GSA sentences

The details of the EXTGSA commands are shown below.

Format:

$PFEC	,	GNtim	,	EXTGSA	,	MULTIPLE LINES FLAG	,	TALKER ID FLAG
		1		2		3		4

,	L1 L5 SEPARATE FLAG	*hh	<CR>	<LF>
	5			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	EXTGSA	EXTGSA	EXTGSA	Command Name. EXTGSA is fixed.
3	MULTIPLE LINES FLAG	0 to 1	0	For each satellite constellation, set whether or not the GSA sentences are displayed in multiple lines. 0 : According to the NMEA 4.11 regulation, only one line of GSA sentences is displayed for each satellite constellation. Therefore, if the number of satellites used per satellite constellation exceeds 12, the information for the 13th satellite and beyond will not be displayed in the GSA sentences. 1 : If the number of satellites per satellite constellation exceeds 12, the 2nd line of GSA sentence is displayed. 13th and later satellites are displayed in the 2nd line of GSA sentence.

	Data	Range	Default	Description
4	TALKERID FLAG	0 to 1	0	This setting is for the display of the talker ID of the GSA Sentence. 0 : In accordance with the NMEA 4.11 regulations, the talker ID display for GSA sentences is as shown in Table 5.3-1. In other words, the talker ID is always "GN" when the GPS constellation is not set as the sole positioning configuration for a specific constellation. 1 : Even if it is not the sole positioning setting of a specific constellation, each line is displayed with the talker ID derived from the respective constellation, instead of GN.
5	L1 L5 SEPARATE FLAG	0 to 1	0	Enables/disables frequency band identification in GSA sentences. 0 : The GSA sentences are displayed on a single line, according to NMEA 4.11 regulations, with no distinction made between frequency bands. 1 : The GSA sentences for the L1 band and the L5 band are displayed so that the satellite used for positioning can be determined for each frequency band. The information corresponding to the SIGNAL ID of the GSV sentence is output in the 19th field of the GSA sentence.

Example:
$PFEC,GNtim,EXTGSA,0,1,1*69
It displays the talker ID of the GSA sentence ID by satellite constellation, and outputs the GSA sentences for the L1 and L5 bands separately.

- The following is a sample for each setting value. In this section, we assume that the constellation of receiving satellites that can be set with the GNSS command is GLONASS + BeiDou B1I + BeiDou B1C + BeiDou B2a.

In case of $PFEC,GNtim,EXTGSA,0,0,0

$GNGSA,A,3,**67,68,69,73,74,82,83,84**,,,,,0.9,0.5,0.7,2*33
$GNGSA,A,3,**01,02,03,04,07,08,10,13,14,27,28,32**,0.9,0.5,0.7,4*3C

Since the setting is to display only one line for each satellite constellation, regardless of the number of satellites used for positioning, there will be one line for GLONASS satellites and one line for BeiDou satellites, for a total of two lines with the GN talker ID.
Since the BeiDou line displays up to 12 satellites, it is not possible to determine if 13 or more satellites exist from this sentence alone.

In case of $PFEC,GNtim,EXTGSA,1,1,0

$GLGSA,A,3,**67,68,69,73,74,82,83,84**,,,,,1.0,0.5,0.9,2*37
$GBGSA,A,3,**01,02,03,04,07,08,10,13,14,27,28,33**,1.0,0.5,0.9,4*37
$GBGSA,A,3,**37,38,40,41,42,43,46,59,60**,,,,1.0,0.5,0.9,4*32

The line for the GLONASS satellite has a talker ID of GL, and one line for the GLONASS satellite is displayed. The line for the Beidou satellite has a talker ID of GB, and since BeiDou has more than 12 satellites in use, one line for the GLONASS satellite and two lines for the BeiDou satellite are displayed, for a total of three lines. However, it is not possible to determine whether the satellite number is BeiDou B1I, BeiDou B1C, or BeiDou B2a.

In case of $PFEC,GNtim,EXTGSA,1,1,1

$GLGSA,A,3,**67,68,69,73,74,82,83**,,,,,,1.0,0.5,0.9,2,**1***26
$GBGSA,A,3,**01,03,04,07,08,10,13,14,37,41,42,46**,1.0,0.5,0.9,4,**1***22
$GBGSA,A,3,**59,60**,,,,,,,,,,,1.0,0.5,0.9,4,**1***22
$GBGSA,A,3,**27,28,33,38,40,43**,,,,,,,1.0,0.5,0.9,4,**3***2D
$GBGSA,A,3,**27,28,33,37,38,40,41,42,43,46**,,,1.0,0.5,0.9,4,**5***2E

The line for the GLONASS satellite has a talker ID of GL, and one line for the GLONASS satellite is displayed. The line for the Beidou satellite has a talker ID of GB, and four lines for the BeiDou satellite are displayed. Here, the SIGNAL ID is assigned to the 19th field of the GSA, and this value shows two lines of GSA sentences for Beidou B1I (SIGNAL ID=1), one line for BeiDou B1C (SIGNAL ID=3), and one line for BeiDou B2a (SIGNAL ID=5). This enables us to accurately determine the relationship between the satellite number and the satellite signal. Even if there are more than 13 satellites in use, they will be displayed in the second line of GSA sentences, eliminating any omissions.

7.17 GNtim,BAUDRATE: Serial Communication Port Setting

This command is to configure baud rate of NMEA communication UART.

Format:

$PFEC	,	GNtim	,	BAUDRATE	,	SETTING	*hh	<CR>	<LF>
		1		2		3			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	BAUDRATE	BAUDRATE	BAUDRATE	Command Name. BAUDRATE is fixed.
3	SETTING	9600 19200 38400 57600 115200 230400 460800	115200	Baud rate setting [bps]

Example:
$PFEC,GNtim,BAUDRATE,9600*5A
Baud rate: 9600bps

NOTE:
- When changing the baud rate, please make sure it is high enough to output all enabled sentences properly. If the baud rate is set too low while processing many sentences, some may not be output properly.

7.18 GNtim,GPIO: Serial Communication Port Setting

For a particular GPIO, user can make it perform the desired output.

Format:

$PFEC	,	GNtim	,	GPIO	,	INDEX	,	SETTING	*hh	<CR>	<LF>
		1		2		3		4			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	GPIO	GPIO	GPIO	Command Name. GPIO is fixed.
3	INDEX	0 to 2	-	Enter the index of the target GPIO you wish to set. 0:GPIO 0 , 1:GPIO 1 , 2:GPIO 2
4	SETTING	0x0000 to 0xFFFF	0x0000	When the condition specified by SETTING occurs, the specified GPIO goes HIGH. The designation is in hexadecimal, and the corresponding contents are defined for each BIT. When multiple BITs are set to 1, the specified GPIO goes HIGH when one of the specified BITs satisfies the condition. See NOTE for details.

Example:
$PFEC,GNtim,GPIO,0,0x08*08
When PLL MODE is set to FINELOCK, GPIO 0 is set to HIGH.

NOTE:

- By default, GPIO 0, GPIO 1, and GPIO 2 are always 0V.
- Please refer to the following for the SETTING relationship.

Table 7.18.1 BIT contents of SETTING field

BIT	HEX	Description
0	0x0001	The specified GPIO is HIGH when WARM UP.
1	0x0002	The specified GPIO is HIGH when PULL IN.
2	0x0004	The specified GPIO is HIGH when COARSE LOCK.
3	0x0008	The specified GPIO is HIGH when FINE LOCK.
4	0x0010	The specified GPIO is HIGH when HOLDOVER.
5	0x0020	The specified GPIO is HIGH when OUT OF HOLDOVER.
6	0x0040	Reserved
7	0x0080	Reserved
8	0x0100	The specified GPIO is HIGH when the antenna is OPEN.
9	0x0200	The specified GPIO is HIGH when the antenna is SHORT.
10	0x0400	The specified GPIO is HIGH when a jamming signal is detected.
11	0x0800	The specified GPIO is HIGH when a spoofing signal is detected.
	Other than above	Reserved

7.19 GNtim,RESTART: Restart Command

This command is to restart the receiver according to different restart modes.

Format:

$PFEC	,	GNtim	,	RESTART	,	RESTART TYPE	*hh	<CR>	<LF>
		1		2		3			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	RESTART	RESTART	RESTART	Command Name. RESTART is fixed.
3	RESTART TYPE	0 to 4	-	0: HOT RESTART 1: WARM RESTART 2: COLD RESTART 3: Reserved 4: FACTORY RESTART This value makes a difference in the content of backups that are retained after a restart. For details on the information to be backed up, refer to Chapter 8, " About backup data ".

Example:
$PFEC,GNtim,RESTART,2*20
Mode: COLD RESTART

NOTE:
- Reserve 1000ms or more before sending another command.
- If the third field is omitted, HOT RESTART will be executed.

7.20 GNtim,BACKUP: Command Backup

This command is to configure the backup items in non-volatile memory.

Format:

$PFEC	,	GNtim	,	BACKUP	,	TYPE	*hh	<CR>	<LF>
		1		2		3			

	Data	Range	Default	Description
1	GNtim	-	-	Command Name. GNtim is fixed.
2	BACKUP	BACKUP	BACKUP	Command Name. BACKUP is fixed.
3	TYPE	0x00000000 to 0xFFFFFFFF	0x00000000	Selecting the item to be stored in the non-volatile memory. For the correspondence between BIT and command set in this field, refer to the NOTE table. Enter the setting in logical sum. In each BIT, 1 is memorized and 0 is cleared. All data will be cleared at 0x00000000.

Example:
$PFEC,GNtim,BACKUP,0x03*00
Back up GNSS command and ANGLE command setting.
Back up default setting if no GNSS/ANGLE command ever issued.

NOTE:

- After inputing this command, wait at least 1000ms before inputing the next command.
- **After this command is entered, a HOT RESTART command is applied.**
- **For the relationship between the RESTART command and the BACKUP command, refer to Chapter 8 "Backup".**
- The current setting values can be checked by issuing the following commands: $PFEC,GNtim,BACKUP,QUERY*01
- Please note that the RESTART command does not clear the settings stored by this command.
- When no setting has been made, the default value is stored in the backup area. However, the TIME and NMEAOUT commands are stored only when the settings are changed.
- If all sentences are set to OFF (-1) by the NMEAOUT command, even if the NMEAOUT command is backed up by this command, the output will return to the default output. (To prevent misinterpretation as a malfunction.)

The relationship between the BIT set in TYPE and the backup target is as follows.

Table 7.20-1. Backup target

Target BIT	Backup target
0x0000 0001	GNSS command setting
0x0000 0002	ANGLE command setting
0x0000 0004	CN0 command setting
0x0000 0008	SVID command setting
0x0000 0010	Reserved
0x0000 0020	SURVEY command setting
0x0000 0040	ALIGN command setting
0x0000 0080	LZT command setting
0x0000 0100	FREQGEN command setting
0x0000 0200	OCLK0 command setting
0x0000 0400	OCLK1 command setting
0x0000 0800	OCLK2 command setting
0x0000 1000	SYNC command setting
0x0000 2000	NMEAOUT command setting
0x0000 4000	EXTGSA command setting
0x0000 8000	BAUDRATE command setting
0x0001 0000	navigation messages (almanac, ephemeris, time, etc.).
0x0002 0000	Reserved
0x0004 0000	Reserved
0x0008 0000	HOLDOVER command setting
0x0010 0000	TIME command setting
0x0020 0000	SBAS command setting
0x0040 0000	Reserved
0x0080 0000	Reserved
Other than those above	Reserved

7.21 GNtim,SBAS: SBAS Satellite Selection

Below are the details of the GNtim and SBAS commands for the dedicated NMEA command.
This command selects the SBAS satellite to be used when SBAS reception is enabled. only one SBAS satellite can be selected from the following settings. The command acquires and tracks only the specified SBAS satellite and does not acquire any other SBAS satellites.
To enable SBAS reception, please refer to GNSS Commands separately.

Format:

$PFEC	,	GNtim	,	SBAS	,	SETTING	*hh	<CR>	<LF>
		1		2		3			

	Data	Range	Default	Description
1	GNtim	-	-	Command name. fixed GNtim
2	SBAS	SBAS	SBAS	Command name: SBAS fixed.
3	SETTING	0 to 5	3	Sets the SBAS satellite. 0：GAGAN (India) 1：WAAS (USA) 2：EGNOS (Europe) 3：MSAS (Japan) 4：Reserved 5：Reserved

Example
$PFEC,GNtim,SBAS,3*75
SBAS satellites to be captured and tracked are changed to MSAS.

8 About Backup data

This product is equipped with eMRAM as non-volatile memory for storing navigation messages and command settings. The eMRAM can be accessed (written or erased) with the BACKUP command described in Section 7.20. Please note that reading from eMRAM is only performed once, immediately after the product is started. In other words, reading from eMRAM is not performed immediately after the RESTART command described in Chapter 7.19 is issued.
On the other hand, during normal operation, navigation messages and command setting values are stored in SRAM, which is volatile memory. Some of the data stored in these SRAMs can be erased by the RESTART command.

Figure 8-1 below shows a concrete example of the relationship between eMRAM and SRAM. The figure shows an example of using the BACKUP and RESTART commands from a state in which nothing is stored in eMRAM.

[1st Start-up]

Since nothing is backed up in eMRAM at the first start-up, the eMRAM check immediately after power-on starts without reading any backup data. Next, suppose that during normal operation, the user inputs the GNSS command to change to the GPS only mode setting, and then requests the BACKUP command to store the GNSS command setting values. Then, the GNSS command settings for GPS only mode is recorded in eMRAM. Note that even if the next time the GNSS command is used to set GLONASS only mode, the GNSS command settings for GPS only mode will still be remained in eMRAM unless the BACKUP command is entered again.

[2nd start-up]

The next time the power is turned on, there is a backup in eMRAM, which is read immediately after start-up. In this case, the GNSS command settings for GPS only mode that were stored in the previous boot-up are read. The receiver then operates in GPS-only mode, and the user then enters another RESTART command to perform a FACTORY RESTART. At this point, the receiver settings are returned to defaults and the GPS only mode setting is cancelled. This is because the information stored in SRAM has been erased. Please note, however, that the RESTART command does not erase the information stored in eMRAM.

[3rd start-up]

Again, there is a backup in eMRAM, which is read out immediately after start-up. Here, the GNSS command settings for GPS only mode is read. After that, the product will remain in this state unless some command is input.

Although not shown in the figure below, the BACKUP command can be used to change or completely erase the information stored in eMRAM.

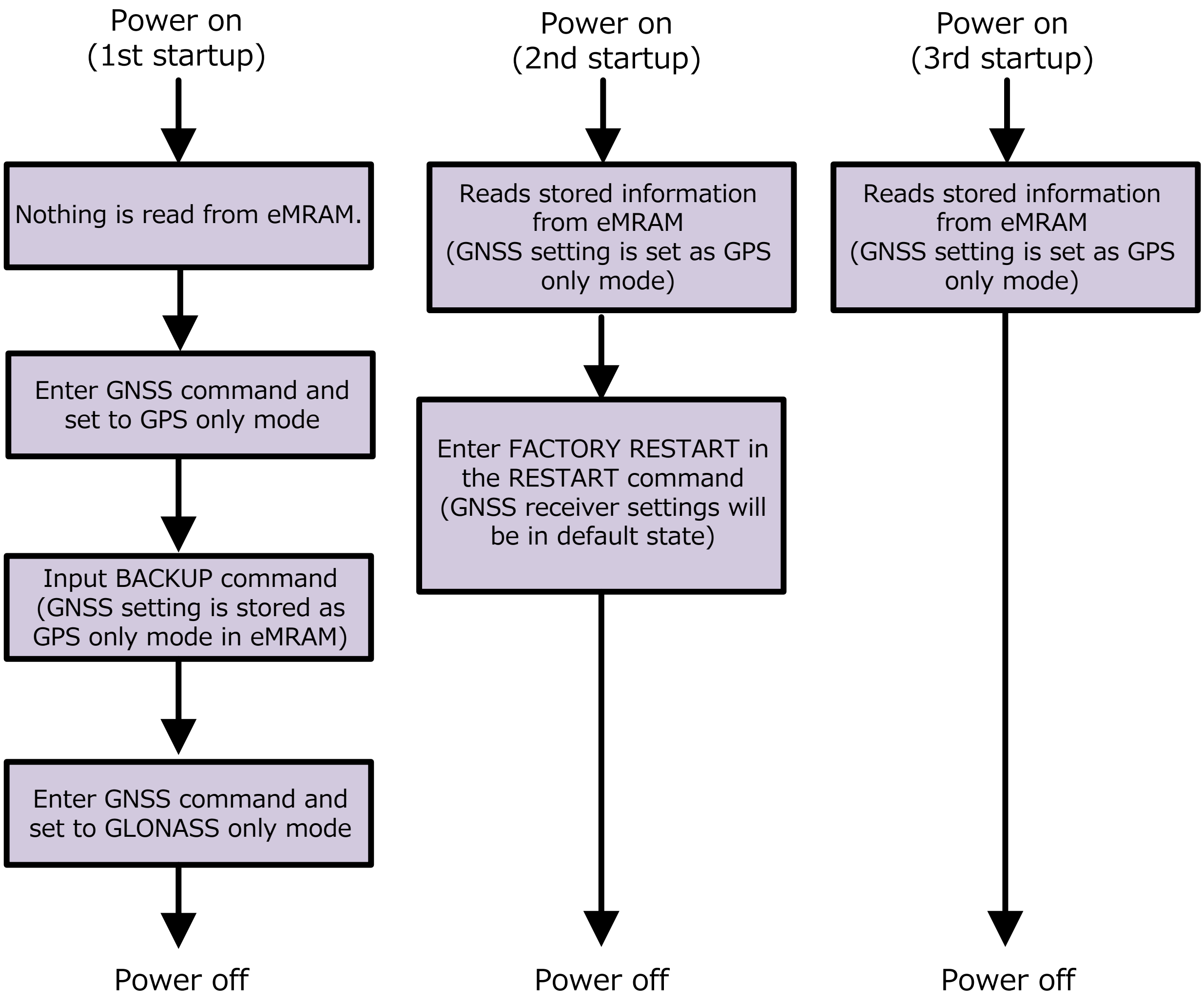


Figure 8-1: Example of using the BACKUP and RESTART commands

Please refer to the table below for the TYPE of the RESTART command and which parameters are erased by power OFF/ON. Items of data to be retained are indicated by "o" and items of data to be erased are indicated by "x". Please note that RESTART,3 command is reserved.

Table 8-1. Backup of Position, Time and Satellite Data

Parameter	RESTART				Power OFF/ON [*1]
	0	1	2	4	
Current position / Surveyed position /Hold position	YES	YES	YES	NO	YES
Current time	YES	YES	YES	NO	YES
Ephemeris	YES	NO	NO	NO	YES
Almanac	YES	YES	NO	NO	YES

[*1] Only if the information corresponding to eMRAM is backed up by the BACKUP command. If not, all information is cleared when the power is turned off and on. For the current time, in addition to backing up the current time with the BACKUP command, it is necessary to keep supplying power to the 32-kHz RTC by applying a valid voltage to the corresponding pin.

Table 8-2. Backup of Command Setting

Command name	Parameter	RESTART				Power OFF/ON [*1]
		0	1	2	4	
GNSS	Satellite constellation mask	YES	YES	YES	NO	YES
ANGLE	Elevation mask	YES	YES	YES	NO	YES
CN0	Signal level mask	YES	YES	YES	NO	YES
SVID	Satellite number mask	YES	YES	YES	NO	YES
ACCURACY	TRAIM setting value POS/TIME accuracy mask	YES	YES	YES	NO	YES
SURVEY	Position mode / Time Only mode threshold	YES	YES	YES	NO	YES
ALIGN	synchronization targets	YES	YES	YES	NO	YES
LZT	Local zone time	YES	YES	YES	NO	YES
FREQGEN	Frequency generation circuit settings	YES	YES	YES	NO	YES
OCLK0	OCLK0 pin setting	YES	YES	YES	NO	YES
OCLK1	OCLK1 pin setting	YES	YES	YES	NO	YES
OCLK2	OCLK2 pin setting	YES	YES	YES	NO	YES
SYNC	Setting the sync target of PLL control	YES	YES	YES	NO	YES
HOLDOVER	HO available time (Excluding FORCE HOLDOVER FLAG)	YES	YES	YES	NO	YES
NMEAOUT	Sentence output cycle	YES	YES	YES	NO	YES
EXTGSA	Setting the GSA display method	YES	YES	YES	NO	YES
BAUDRATE	UART baud rate	YES	YES	YES	NO	YES
GPIO	Setting of GPIO	YES	YES	YES	NO	NO

[*1] Only if the parameters corresponding to eMRAM are backed up by the BACKUP command. If not backed up, various data will be erased when the power is turned off/on.

9 Insertion of Leap Second

When a leap second is adjusted, this product updates the output time as follows.

[When a leap second (+1 second) is inserted]
When a leap second is inserted with a plus sign, 23:59:60 is inserted at the time of update.
The following is an example of GNtps,A sentence output.
If the leap second changes from 18 to 19 seconds on January 1, 2023

$PFEC,GNtps,A,20221231235958,2,20230101000000,+18,+19,2,-1.169E-08*6E
$PFEC,GNtps,A,20221231235959,2,20230101000000,+18,+19,2,-1.171E-08*66
$PFEC,GNtps,A,20221231235960,2,20230101000000,+19,+19,2,-1.170E-08*6C
$PFEC,GNtps,A,20230101000000,2,20230101000000,+19,+19,2,-1.174E-08*63
$PFEC,GNtps,A,20230101000001,2,20230101000000,+19,+19,2,-1.172E-08*64
$PFEC,GNtps,A,20230101000002,2,20230101000000,+19,+19,2,-1.168E-08*6C

[Leap second (-1 second) inserted]
When a leap second is inserted with a minus sign, 23:59:59 is excluded at the time of update. The following is an example of GNtps,A sentence output.
If the leap second changes from 18 to 17 seconds on January 1, 2023

$PFEC,GNtps,A,20221231235956,2,20221231235959,+18,+17,2,-1.233E-08*63
$PFEC,GNtps,A,20221231235957,2,20221231235959,+18,+17,2,-1.244E-08*62
$PFEC,GNtps,A,20221231235958,2,20221231235959,+18,+17,2,-1.243E-08*6A
$PFEC,GNtps,A,20230101000000,2,20221231235959,+17,+17,2,-1.233E-08*62
$PFEC,GNtps,A,20230101000001,2,20221231235959,+17,+17,2,-1.243E-08*64
$PFEC,GNtps,A,20230101000002,2,20221231235959,+17,+17,2,-1.241E-08*65

Please note that before and after the insertion of leap seconds, GLONASS may temporarily suspend positioning for several tens of seconds due to the need to reacquire navigation messages. Please be aware of this.

10 GLONASS positioning during leap second insertion

It is defined in the Interface Control document that the navigation messages broadcast from GLONASS are synchronized with the timing of leap seconds. Therefore, it is known that GLONASS broadcasts navigation messages intermittently when a leap second is inserted, and the receiver cannot continuously synchronize with the messages. Therefore, the GLONASS may not be able to use for positioning fix until getting ephemeris again since the leap second is inserted. Please understand this in advance.