FURUNO

FURUNO GNSS Receiver

Model GT-87

eSIP Protocol Specifications

(Document No. SE17-600-002-01)

FURUNO ELECTRIC CO., LTD.

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

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Revision History

Version	Changed contents	Date
0	Changed document number from G13-000-11-005-11.	2017.01.17
1	3 “Serial Data Output Timing” Added descriptions.	2017.04.21
	6.1.3 “PPS” Added Notes.	
	6.1.7 “SURVEY” Corrected the range of “latitude” and “longitude”.	
	10 “FAQ” Added.	

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1 Purpose

This document describes the *eRide* Serial communications Interface Protocol (eSIP) for GT-87.

2 Communication Specifications

Signal Lines used:	TXD, RXD
Flow Control:	None
System:	Full Duplex Asynchronous
Speed:	Configurable, Default 38400 bps [*1]
Start Bit:	1 bit
Data Length:	8 bits
Stop Bit:	1 bit
Parity Bit:	None
Data Output Interval:	1 second
Character Codes used:	NMEA-0183 Ver.4.10 data based ASCII code [*2]
Protocol:	Input data NMEA Standard sentence NMEA Proprietary sentence Output data NMEA Standard sentence NMEA Proprietary sentence

Notes:

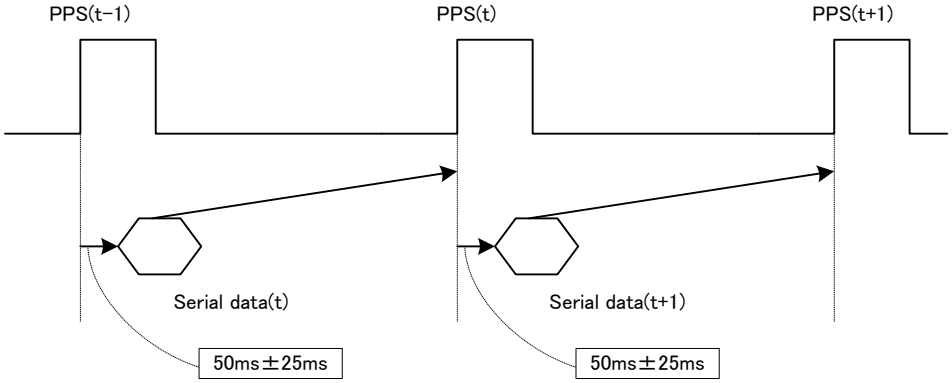
[*1] Communication speed can be changed into 4800, 9600, 19200, 38400, 57600 or 115200 bps. Please refer to section "UART1 – Serial Communication Port" for how to configure the communication speed. In case of using low baud rate, please adjust size of output sentence by NMEAOUT command and CROUT command to output all sentence within one second.

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

3 Serial Data Output Timing

The output timing of serial data is synchronous with PPS output timing. Serial data is begun to output in the 25ms to 75ms range after PPS is output. The time of serial data indicates the next PPS output timing. The positioning information other than the time is generated based on the positioning results of the previous second. This synchronous is started after acquisition of time information by satellite positioning.

▲1



4 NMEA Sentence Format

4.1 Standard Sentence

Format:

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

5 bytes

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

4.2 Proprietary Sentence

Format:

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

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

5 Standard NMEA Output Sentences

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

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

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

5.1 GGA – Global Positioning System Fix Data

Format:

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

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

Field	Data type	Range	Description
1	hhmmss.sss	000000.000 to 235959.999	Coordinated Universal Time (UTC) hh: [hour], mm: [minute], ss.sss: [second]
2	ddmm.mmmm	0000.0000 to 9000.0000	Latitude dd: [degree], mm.mmmm: [minute]
3	a	N,S	"N" (North) or "S" (South)
4	dddmm.mmmm	00000.0000 to 18000.0000	Longitude ddd: [degree], mm.mmmm: [minute]
5	a	E,W	"E" (East) or "W" (West)
6	x	0 to 2	GNSS Quality Indication 0: Fix not available or invalid 1: Valid fix 2: DGPS positioning
7	xx	00 to 12	Number of satellites in use [*1]
8	x.x	Null, 0.0 to 50.0	Horizontal dilution of precision (HDOP) A null field is output while positioning is interrupted.
9	x.x	-	Altitude above/below mean sea-level (Geoid)
10	M	M	Units of altitude, meters
11	x.x	-	Geoidal height
12	M	M	Units of Geoidal height, meters
13	xxx	n/a	Age of differential GPS data
14	xxx	n/a	Differential reference station ID

Example:

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

Notes:

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

5.2 GLL – Geographic Position - Latitude/Longitude

Format:

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

Field	Data type	Range	Description
1	ddmm.mmmm	0000.0000 to 9000.0000	Latitude dd: [degree], mm.mmmm: [minute]
2	a	N,S	"N" (North) or "S" (South)
3	dddmm.mmmm	00000.0000 to 18000.0000	Longitude ddd: [degree], mm.mmmm: [minute]
4	a	E,W	"E" (East) or "W" (West)
5	hhmmss.sss	000000.000 to 235959.999	Coordinated Universal Time (UTC) hh: [hour], mm: [minute], ss.sss: [second]
6	a	A,V	Status A: Data valid V: Data invalid
7	a	A,D,N	Mode Indication A: Autonomous D: Differential N: Data invalid

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

5.3 GNS – GNSS Fix Data

Format:

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

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

Field	Data type	Range	Description
1	hhmmss.sss	000000.000 to 235959.999	Coordinated Universal Time (UTC) hh: [hour], mm: [minute], ss.sss: [second]
2	ddmm.mmmm	0000.0000 to 9000.0000	Latitude dd: [degree], mm.mmmm: [minute]
3	a	N,S	"N" (North) or "S" (South)
4	dddmm.mmmm	00000.0000 to 18000.0000	Longitude ddd: [degree], mm.mmmm: [minute]
5	a	E,W	"E" (East) or "W" (West)
6	c-c	A,D,N	Mode Indicator for each satellite system (GPS, GLONASS, Galileo) A: Autonomous D: Differential N: Data invalid
7	xx	00 to 32	Number of satellites in use
8	x.x	Null, 0.0 to 50.0	Horizontal dilution of precision (HDOP) A null field is output while positioning is interrupted.
9	x.x	-	Altitude above/below mean sea-level (Geoid) [meter]
10	x.x	-	Geoidal height [meter]
11	x	n/a	Age of differential GPS data
12	x	n/a	Differential reference station ID
13	x	S,C,U,V	Navigation status indicator S: Safe C: Caution U: Unsafe V: Not valid

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

5.4 GSA – GNSS DOP and Active Satellites

Format:

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

Field	Data type	Range	Description
1	a	M,A	Operational mode M: 2D/3D fixed mode A: 2D/3D Auto-switching mode
2	a	1,2,3	Mode 1: No fix 2: 2D fix 3: 3D fix
3-14	xx	01 to 99	Satellite numbers used in positioning A null field is output unless a satellite is available.
15	x.x	Null, 0.0 to 50.0	PDOP A null field is output unless 3D-positioning is performed.
16	x.x	Null, 0.0 to 50.0	HDOP A null field is output while positioning is interrupted.
17	x.x	Null, 0.0 to 50.0	VDOP A null field is output unless 3D-positioning is performed.
18	h	n/a	GNSS System ID

Example:
$GNGSA,A,3,09,15,26,05,24,21,08,02,29,28,18,10,0.8,0.5,0.5,1*33
$GNGSA,A,3,79,69,68,84,85,80,70,83,,,,,0.8,0.5,0.5,2*30
2D/3D Auto-switching mode, 3D fix
Satellite used: 09, 15, 26, 05, 24, 21, 08, 02, 29, 28, 18, 10, 79, 69, 68, 84, 85, 80, 70, 83
PDOP: 0.8 HDOP: 0.5 VDOP: 0.5

Notes:
- To add extra fields to the GPGSA NMEA string to show more than 12 satellites used in the fix, please input “$PERDAPI,EXTENDGSA,num*hh<CR><LF>”. “num” is Number of fields for satellites used in the fix. Acceptable values are: 12-16. Default num is 12. By creating more fields for satellites used in the fix, the PDOP/HDOP/VDOP values shift by num12 fields.
- Satellite number means the below.
  Satellite number from 01 to 32 indicates GPS (01 to 32)
  Satellite number from 33 to 51 indicates SBAS (120 to 138)
  Satellite number from 65 to 92 indicates GLONASS (slot 01 to slot 28)
  Satellite number from 93 to 99 indicates QZSS (193 to 199)

5.5 GSV – GNSS Satellites in View

Format:

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

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

Field	Data type	Range	Description
1	x	1 to 4	Total number of messages
2	x	1 to 4	Message number
3	xx	00 to 16	Number of satellites in line-of-sight
4	xx	01 to 99	1st satellite ID number
5	xx	00 to 90	1st satellite elevation angle [degree]
6	xxx	000 to 359	1st satellite azimuth angle [degree]
7	xx	00 to 99	1st satellite SNR (Signal/Noise Ratio) [dB]
8-11	-	-	2nd satellite details
12-15	-	-	3rd satellite details
16-19	-	-	4th satellite details
20	h	1	Signal ID

Example:

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

- Not fixed
- Sentence Number
- Total number of Message

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

Notes:

- In this sentence, a maximum of four satellite details is indicated per each output. Five or more satellite details are output in the 2nd or 3rd messages. When there is an item which is not fixed in the satellite details, a null field is output. When there are only one to four satellite details, <checksum><CR><LF> is issued immediately after Sat. SV#, Sat. elevation angle, Sat. azimuth angle and SNR.
- Satellite number means the below.
  Satellite number from 01 to 32 indicates GPS (01 to 32)
  Satellite number from 33 to 51 indicates SBAS (120 to 138)
  Satellite number from 65 to 92 indicates GLONASS (slot 01 to slot 28)
  Satellite number from 93 to 99 indicates QZSS (193 to 199)

5.6 RMC – Recommended Minimum Navigation Information

Format:

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

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

Field	Data type	Range	Description
1	hhmmss.sss	000000.000 to 235959.999	UTC time hh: [hour], mm: [minute], ss.sss: [second]
2	a	A,V	Status A: Data valid V: Data invalid
3	ddmm.mmmm	0000.0000 to 9000.0000	Latitude dd: [degree], mm.mmmm: [minute]
4	a	N,S	"N" (North) or "S" (South)
5	dddmm.mmmm	00000.0000 to 18000.0000	Longitude ddd: [degree], mm.mmmm: [minute]
6	a	E,W	"E" (East) or "W" (West)
7	x.xx	-	Speed [knot]
8	x.xx	0.00 to 359.99	True course [degree]
9	ddmmyy	dd: 01 to 31 mm: 01 to 12 yy: 00 to 99	Date dd: [day], mm: [month], yy: [year] (last two digits)
10	x.x	-	Magnetic declination A null field is output unless magnetic declination information is available.
11	a	-	Correction direction of magnetic declination A null field is output unless magnetic declination information is available.
12	a	A,D,N	Mode Indicator A: Autonomous D: Differential N: Data invalid
13	a	S,C,U,V	Navigational Status Indicator S: Safe C: Caution U: Unsafe V: Not valid

Example:

$GNRMC,012344.000,A,3442.8266,N,13520.1233,E,0.00,0.00,191132,,,D,V*0B

UTC: 01:23:44.000 Differential 34 deg 42.8266 min N 135 deg 20.1233 min E Speed: 0.0 kts
True Course: 0.0 degrees UTC Date: 19th November, 2032

5.7 VTG – Course Over Ground and Ground Speed

Format:

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

Field	Data type	Range	Description
1	x.x	0.00 to 359.99	True course [degree]
2	T	T	"T" (True)
3	x.x	-	Magnetic direction A null field is output unless magnetic direction information is available.
4	M	M	"M" (Magnetic direction)
5	x.xx	-	Speed [knot]
6	N	N	"N" (knots)
7	x.xx	-	Speed [km/h]
8	K	K	"K" (Kilo meters/ Hour)
9	a	A,D,N	Mode Indicator A: Autonomous D: Differential N: Data invalid

Example:
$GNVTG,0.00,T,,M,0.00,N,0.00,K,D*26
True Course: 0.00 degree Speed: 0.00 kts, 0.00 km/h Mode: Differential

5.8 ZDA – Time & Date

Format:

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

Field	Data type	Range	Description
1	hhmmss.sss	000000.000 to 235959.999	UTC time hh: [hour], mm: [minute], ss.sss: [second]
2	xx	01 to 31	UTC Day
3	xx	01 to 12	UTC Month
4	xxxx	1999 to 2099	UTC Year
5	xxx	(+/-) 00 to 23	Local zone hours
6	xx	00 to 59	Local zone minutes

Example:
$GPZDA,014811.000,13,09,2013,+00,00*7B
UTC: 01:48:11.000 13th September, 2013

6 Proprietary NMEA Input Sentences

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

6.1 API – *eRide* GNSS Core Library Interface

6.1.1 GNSS – Satellite System Configuration

Format:

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

Field	Data type	Range	Default	Description
1	GNSS	-	-	Command Name
2	talkerID	AUTO LEGACYGP GN	AUTO	AUTO: GLGSV is omitted in case of no glonass. GPGSV is omitted in case of no GPS, SBAS and QZSS. LEGACYGP: GL and GN sentence is omitted. GN: GLGSV is output even if no glonass. GPGSV is output even if no GPS, SBAS and QZSS.
3	gps	0,2	2	GPS Mode
4	glonass	0,2	2	GLONASS Mode
5	galileo	0	0	Galileo Mode (unimplemented)
6	qzss	0,2	2	QZSS Mode
7	sbas	0,1,2	1	SBAS Mode

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

Notes:

- This command controls which Global Navigation Satellite Systems are used by the receiver. The mode can be set to 0 or 2 for each satellite system. User can also set SBAS mode to 1.
  Mode 0 means to disable the system.
  Mode 1 means to enable tracking only (do not use in position fix etc).
  Mode 2 means to enable tracking and use in position fix calculation.
- In GT-87, default setting of SBAS mode is 1, because to use calculation data of SBAS tends to reduce the accuracy of 1PPS. Therefore although GT-87 becomes to differential fix, SBAS is not appeared in GSA sentence in default setting. Improvement of 1PPS precision can be expected by acquiring the differential information of SBAS at GPS positioning. ▲1
- The response which is inserted current value to each field is obtained by receiving an effective command for setting or inputting a command which is omitted the fields after Command Name, that is, $PERDAPI,GNSS,QUERY*18.
- “SBAS only configuration” and “No tracking configuration” are not accepted.
  $PERDAPI,GNSS,AUTO,0,0,0,0,2*43
  $PERDAPI,GNSS,AUTO,0,0,0,0,1*40
  $PERDAPI,GNSS,AUTO,0,0,0,0,0*41
- Cold restart (time also be cleared) is run when satellite system configuration is changed from/to GLONASS only fix configuration. In the others configuration, hot restart is run.

6.1.2 FIXMASK – Setting of Positioning and Satellite Mask

Format:

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

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

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

Example:
$PERDAPI,FIXMASK,USER,10,0,37,0,0x92,0x01,0x00,0x00,0x20000*50
Elevation mask: 10 degrees Signal level mask: 37 dB-Hz
GPS mask: GPS (BIT2 = SVID 2), GPS (BIT5 = SVID 5) and GPS (BIT8 = SVID 8)
GLONASS mask: GLONASS (BIT1 = SVID 65) SBAS mask: SBAS (BIT18 = SVID 50)

Notes:
- It is applied not only to First Fix or the time of a positioning return but to all the positioning.
- It is omissible after the 7th field.
- The response which is inserted current value to each field is obtained by receiving an effective command for setting or inputting a command which is omitted the fields after Command Name, that is, $PERDAPI,FIXMASK,QUERY*52.

6.1.3 PPS – Setting of PPS (Pulse per Second)

Format:

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

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

Field	Data type	Range	Default	Description
1	PPS	-	-	Command Name
2	type	LEGACY GCLK	LEGACY	PPS type
3	mode	0 to 4	4	PPS mode 0: Always stop 1: Always output 2: Output only during positioning more than one satellite 3: Output only when TRAIM is OK 4: Output only when estimated accuracy is less than estimated accuracy threshold which is 8th field on this command.
4	period	0 to 1	0	PPS output interval 0: 1PPS (A pulse is output per second) 1: PP2S (A pulse is output per two seconds)
5	pulse width	1 to 500	200	PPS pulse width [ms]
6	cable delay	-100000 to 100000	0	PPS cable delay [ns] Plus brings delay PPS. Minus brings forward PPS.
7	polarity	0 to 1	0	PPS polarity (LEGACY PPS is rising edge only) 0: rising edge 1: falling edge
8	PPS accuracy threshold	5 to 9999	1000	PPS estimated accuracy threshold This threshold is used for mode 4.

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

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

- The condition of PPS synchronization is the follow.

[1] GPS alignment

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

[2] UTC (USNO) alignment (default)

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

[3] UTC (SU) alignment

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

- About PPS estimated accuracy, please refer to the page of CRX (TPS2) sentence.
- TRAIM is applied to GPS and GLONASS. ▲1

6.1.4 RESTART – Restart Command

Format:

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

Field	Data type	Range	Default	Description
1	RESTART	-	-	Command Name
2	restart mode	HOT WARM COLD FACTORY	-	Restart mode

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

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

6.1.5 TIME – Setting of Time Information

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

Format:

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

Field	Data type	Range	Default	Description
1	TIME	-	-	Command Name
2	time of date	00 to 23 00 to 59 00 to 59	0	UTC (Hour) UTC (Minute) UTC (Second)
3	day	1 to 31	22	UTC (Date)
4	month	1 to 12	8	UTC (Month)
5	year	2013 to 2099	1999	UTC (Year)

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

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

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

[In case that GT-87 does not have GLONASS]
GT-87 can keep outputting a correct date after 2032/08/15 during power distribution. GT-87 will output 2012/12/30 after 2032/08/15 unless the user sets a correct date by TIME command after the user turns off GT-87 and also turns off the backup current for BBRAM.

[In case that GT-87 has GLONASS]
GT-87 can adjust the millennium automatically in the timing of first fix of GLONASS and outputs a correct date until 2099/12/31 without the user setting even if the user turns off GT-87 and the backup current.

6.1.6 TIMEZONE – Local Zone Time

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

Format:

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

Field	Data type	Range	Default	Description
1	TIMEZONE	-	-	Command Name
2	sign	0 to 1	0	GMT sign 0: positive 1: negative
3	hour	0 to 23	0	GMT (Hour)
4	minute	0 to 59	0	GMT (Minute)

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

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

6.1.7 SURVEY – Position Mode

Format:

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

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

Field	Data type	Range	Default	Description
1	SURVEY	-	-	Command Name
2	position mode	0 to 3	2	0: Normal NAV (navigation) mode 1: Position Survey SS (self survey) mode 2: Position Survey CSS (continual self survey) mode 3: Position-hold TO (time only) mode
3	sigma threshold	0 to 255	0	Sigma threshold [m] which changes automatically to position-fixed. (When the threshold value is 0, it is not used.)
4	time threshold	0 to 10080	480 (8 hours)	Time threshold [minute] which changes automatically to position-fixed. (When the threshold value is 0, it is not used.)
5	latitude	-90.0000 to 90.0000 ▲1	0	Latitude for hold position in TO mode. [degree] A positive number means the north latitude and a negative number means the south latitude. This field can be set only when position mode is 3.
6	longitude	-180.0000 to 180.0000 ▲1	0	Longitude for hold position in TO mode. [degree] A positive number means the east longitude and a negative number means the west longitude. This field can be set only when position mode is 3.
7	altitude	-1000 to 18000	0	Altitude for hold position in TO mode. [m] This field can be set only when position mode is 3.

Example:
$PERDAPI,SURVEY,1,10,1440*74
Mode: SS mode Sigma threshold: 10 Time threshold: 1440

$PERDAPI,SURVEY,3,0,0,37.7870,-122.4510,31.5*48 ▲1
Mode: TO mode Sigma threshold: 0 Time threshold: 0
Fixed position: 37.7870 degrees north 122.4510 degrees west Altitude: 31.5 m

Notes:
- It is omissible after the 3rd field.
- When the position mode is “1”, a position is re-calculated after the power supply OFF/ON. Please use it, when the antenna position may change before the power supply OFF.
- When the position mode is “2”, after the power supply OFF/ON, the estimated position that calculated before the power supply OFF is kept, and the position is updated. By using it when the antenna position does not change after the power supply OFF, the time for changing to the Position-hold mode can be shortened.
- In order to change automatically to the Position-hold mode, it is necessary to set to the Survey mode.
- If both sigma threshold and time threshold are configured, the position mode changes to the Position-hold mode when either is fulfilled. When the threshold value is 0, it is not used.

- The displayed position may differ a little from the configured position due to conversion error.
- Hot start is occurred when the survey mode is shift to the NAV mode.

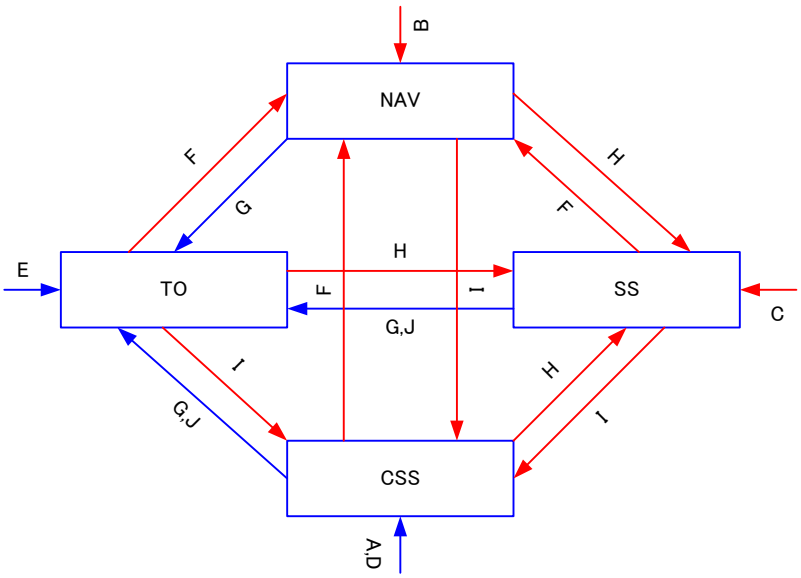


Figure 6.1 Flow Chart about Position Mode

	Transition condition	Whether keep or not survey position and number of times of survey process
A	After first power on, or after factory restart (default)	Discard
B	After power on in case that last mode is “SURVEY,0”.	Discard
C	After power on in case that last mode is “SURVEY,1”.	Discard
D	After power on in case that last mode is “SURVEY,2”.	Keep
E	After power on in case that last mode is “SURVEY,3”.	Keep
F	“SURVEY,0” command	Discard
G	“SURVEY,3” after self survey position is fixed. “SURVEY,3” with user’s hold position.	Keep
H	“SURVEY,1” command	Discard
I	“SURVEY,2” command	Discard
J	The condition of survey is satisfied. [*] Position mode is always started by time only mode if TO mode by this condition and power off.	Keep

6.1.8 FREQ – Setting of GCLK Frequency

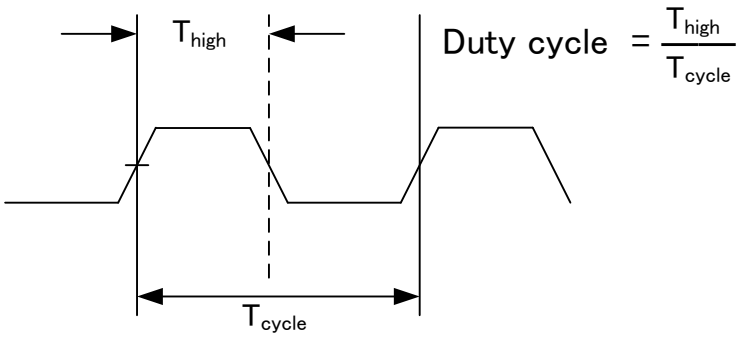
Format:

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

Field	Data type	Range	Default	Description
1	FREQ	-	-	Command Name
2	mode	0 to 1	0	0: Stop 1: Output
3	freq	4000 to 40000000	10000000 (10MHz)	Frequency [Hz]
4	duty	10 to 90	50	Duty cycle [%]
5	offset	0 to 99	0	Phase delay in cycle [%] from GCLK-PPS edge

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

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



6.1.9 DEFLS – Setting of Default Leap Second

Format:

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

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

Example:
$PERDAPI,DEFLS,16,AUTO*27
Default leap second: 16 second (this value is updated automatically).

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

6.1.10 TIMEALIGN – Setting of Time Alignment

Format:

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

Field	Data type	Range	Default	Description
1	TIMEALIGN	-	-	Command Name
2	mode	1 to 3	2	1: GPS alignment 2: UTC (USNO) alignment 3: UTC (SU) alignment

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

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

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

[2: UTC (USNO) alignment]
・ Leap second is applied to the output time.
・ PPS is output in synchronization with GPS before taking the UTC (USNO) parameter from GPS.
・ PPS is output in synchronization with UTC (USNO) after taking the UTC (USNO) parameter from GPS.
・ In GLONASS only fix, because GT-87 cannot take the UTC (USNO) parameter from GLONASS, PPS is kept to output in synchronization with GPS.

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

Restriction:
Output time

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

PPS

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

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

- In this graph, QZSS is treated as GPS.

6.1.11 FLASHBACKUP – Setting of Backup in Flash

Format:

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

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

Example:
$PERDAPI,FLASHBACKUP,0x03*4E
Current setting of FREQ and DEFLS command is stored in flash.

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

Restriction:
GT-87 has two ways to backup data.

[1] BBRAM
BBRAM is a RAM which is available to store data as long as the backup current is impressed. GT-87 can store the ephemeris data, the almanac data and the configuration which the user sets by commands etc in the BBRAM, and the data is not erased even if GT-87 is turned off.
The backup timing of BBRAM is every second. The data is cleared when the user inputs RESTART command and/or the user turns off the backup current.

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

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

6.1.12 CROUT – Setting of CR Output

Format:

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

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

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

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

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

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

Notes:
- "M" or/and "N" can be output only in case that baud rate is 115200 bps.

6.2 CFG – Setting of Application Software

6.2.1 NMEAOUT – Standard NMEA Output

Format:

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

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

Example:
$PERDCFG,NMEAOUT,GGA,2*57
GGA sentence is output every 2 seconds.

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

6.2.2 UART1 – Serial Communication Port

Format:

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

Field	Data type	Range	Default	Description
1	UART1	-	-	Command Name
2	baud	4800, 9600, 19200, 38400, 57600, 115200	38400	Baud rate [bps]

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

Notes:
- When the setting of the serial communication port is changed by this command, ACK sentence is output by the baud rate which was being used.
- In case of using low baud rate, please adjust the size of output sentence by NMEAOUT command and CROUT command to output all sentence within one second.

6.3 SYS – PVT System

6.3.1 VERSION – Software Version

Format:

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

Field	Data type	Range	Default	Description
1	VERSION	-	-	Command Name

Example:
$PERDSYS,VERSION*2C

6.3.2 GPIO – General Purpose Input/Output

Format:

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

Field	Data type	Range	Default	Description
1	GPIO	-	-	Command Name

Example:
$PERDSYS,GPIO*67

7 Proprietary NMEA Output Sentences

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

7.1 ACK – Output the Command Reception Check

Format:

$PERDACK	,	command	,	sequence	,	subcommand	*hh	<CR>	<LF>
		1		2		3			

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

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

Notes:
- As for the command, the checksum must be effective before ACK is sent.

7.2 CR – *eRide* GNSS Core Library Interface

7.2.1 CRW (TPS1) – Output Time Transfer Info per Second (Date and Leap Second)

Format:

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

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

Field	Data type	Range	Default	Description
1	TPS1	-	-	Command Name
2	Date & Time	14-byte fixed length	19990822000000	Present date and time year, month, day, hour, minute, second
3	time status	0 to 2 (1 byte)	0	Present time status of output sentence 0: RTC 1: GPS (GT-87 does not apply leap second or has only default leap second) 2: UTC (GT-87 has confirmed leap second and applies it.)
4	update date	14-byte fixed length	00000000000000	Leap second update schedule year, month, day, hour, minute, second This date indicates zero when no leap second update schedule.
5	present LS	-99 to +99 (3 byte)	+16	Present leap second received from satellites
6	future LS	-99 to +99 (3 byte)	+00	Future leap second received from satellites
7	pps status	0 to 3 (1 byte)	0	Present pps is synced with the follow. 0: RTC 1: GPS 2: UTC (USNO) 3: UTC (SU)

Example:
$PERDCRW,TPS1,20120303062722,2,20120701000000,+15,+16,2*09
Present date: 2012/03/03 06:27:22 Time status: present time of output sentence is sync with UTC.
Leap second update schedule: 2012/7/1 00:00:00 Current leap second: +15 Future leap second: +16
pps status: present pps is sync with UTC (USNO)

Notes:
- This command is output every second.
- $PERDAPI,CROUT,W,0*4F stops outputting this command.
- Update data indicate zero when no update schedule.

Restriction:

About time status

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

About leap second which is used to adjust output time

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

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

7.2.2 CRX (TPS2) – Output Time Transfer Info per Second (PPS)

Format:

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

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

Field	Data type	Range	Default	Description
1	TPS2	-	-	Command Name
2	pps status	0,1 (1 byte)	0	Output status of 1PPS 0: 1PPS OFF 1: 1PPS ON
3	pps mode	0 to 4 (1 byte)	4	PPS mode 0: Always stop 1: Always output 2: Output only during positioning more than one satellite 3: Output only when TRAIM is OK 4: Output only when estimated accuracy is less than estimated accuracy threshold
4	pps period	0,1 (1 byte)	0	1PPS output interval 0: 1PPS (A pulse is output per second) 1: PP2S (A pulse is output per two seconds)
5	pulse width	001 to 500 (3 byte)	200	1PPS pulse width [ms]
6	cable delay	-100000 to +100000 (7 byte)	+000000	1PPS cable delay [ns]
7	polarity	0,1 (1 byte)	0	0: rising edge 1: falling edge
8	pps type	0,1 (1 byte)	0	0: LEGACY PPS 1: GCLK PPS
9	estimated accuracy	0000 to 9999 (4 byte)	0000	1PPS estimated accuracy [ns]
10	Sawtooth	-1.760 to +1.760 (6 byte)	+0.000	Sawtooth correction [ns]
11	pps acc threshold	0000 0005 to 9999 (4 byte)	1000	PPS estimated accuracy threshold [ns] This threshold is used for pps mode 4. 0 means that this threshold is not used.

Example:
$PERDCRX,TPS2,1,2,0,200,+001000,0,0,0005,+0.000,1000*29
PPS status: PPS ON (1) PPS mode: during on fix (2) PPS period: 1PPS (0) PPS pulse width: 200ms
PPS cable delay: +1000ns Polarity: rising edge Type: LEGACY PPS Estimated accuracy: 5ns
Sawtooth: +0.000ns PPS estimated accuracy threshold: 1us

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

- Sawtooth means a correction value under the resolution of GT-87, that is, about 3.5 ns.
- Sawtooth value is applied to prior to the one second PPS.
  Corrected PPS [t-1] = output PPS [t-1] + Sawtooth value [t]

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

Format:

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

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

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

Example:
$PERDCRY,TPS3,2,0003,001,002205,086400,0,0,00,0x00000000*68
Positioning mode: Survey mode (calculation continuously) (2) Survey sigma: 3 [m]
Survey sigma threshold: 1 [m] Survey time: 2205 [seconds] Survey time threshold: 86400 [seconds]
TRAIM solution: OK (0) TRAIM status: OK (0) Removed SVs: 0 Receiver status: 0x00000000

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

7.2.4 CRZ (TPS4) – Output Time Transfer Info per Second (Frequency)

Format:

$PERDCRZ	,	TPS4	,	freq mode	,	Freq status	,	GCLK accuracy	,	e	,	de	,	lock cnt	,
		1		2		3		4		5		6		7	

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

Field	Data type	Range	Default	Description
1	TPS4	-	-	Command Name
2	freq mode	1 to 6 (1 byte)	1	1: Warm up 2: Lock 3: Hold over 4: Free run 5: Coarse mode 6: Fine mode
3	Freq status	0,1 (1 byte)	0	0: Not output 1: Output
4	GCLK accuracy	0,1 (1 byte)	0	0: Not accurate 1: GCLK PPS and GCLK frequency are accurate
5	e	-999999 to +999999 (7 byte)	-	Phase delay between LEGACY and GCLK PPS [no dimensional]
6	de	-999999 to +999999 (7 byte)	-	Amount of change of phase delay [no dimensional]
7	lock cnt	+000000 to +999999 (7 byte)	-	Duration time of Lock [sec]
8	lockoff cnt	+000000 to +999999 (7 byte)	-	Duration time of holdover/free run [sec]
9	reserve	(6 byte)	-	Reserve field
10	IDtag	(6 byte)	-	Product name and last two digits of product version In case of GT-8777 of ” 4850466003” ➔ 8777 + 03 = 877703 In case of GT-87 of ” 4850466005” ➔ 8700 + 05 = 870005
11	GCLK setting 1	(4 byte)	-	Reserve field
12	GCLK setting 2	(4 byte)	-	Reserve field

Example:
$PERDCRZ,TPS4,1,1,0,+000000,+000000,+000000,+000000,000000,000000,0x15,0000*57
Freq mode: Warm up Freq status: Output GCLK accuracy: Accurate

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

7.2.5 CRM – Measurement Data of GPS

Format:

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

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

Field	Data type	Range	Default	Description
1	time	0 to 6004799	-	GPS time of week
2	sennum	1 to 32	-	Sentence number
3	maxsen	1 to 32	-	Maximum number of sentences
4	system	1	-	GNSS system ID (1=GPS)
5	svid	1 to 99	-	Satellite number
6	reserve	1 to 3	-	Reserve field
7	snr	1 to 55	-	Signal to Noise Ratio [dB-Hz]
8	adr	(32 bit)	-	Accumulated Doppler Range [Cycles, LSB=-6]
9	doppfreq	(32 bit)	-	Doppler Frequency [meters/sec, LSB=-12]
10	pseudorange	(32 bit)	-	Pseudorange [meters, LSB=-6]

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

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

7.2.6 CRN – Navigation Data

Format:

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

Field	Data type	Range	Default	Description
1	system	1	-	GNSS system ID (1=GPS)
2	svid	1 to 99	-	Satellite number
3	subframe data	10 words (60 strings)	-	Subframe data no parity included

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

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

7.3 SYS – Answer of PVT System

7.3.1 VERSION – Software Version

Format:

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

Field	Data type	Range	Default	Description
1	VERSION	-	-	Command Name
2	device	-	-	Device name
3	version	-	-	Version number
4	reserve1	-	-	Reserve field
5	reserve2	-	-	Reserve field

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

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

7.3.2 GPIO – General Purpose Input/Output

Format:

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

Field	Data type	Range	Default	Description
1	GPIO	-	-	Command Name
2	state	H,L	-	GPIO state (H: High, L: Low)

Example:
$PERDSYS,GPIO,HHHHLLLLL*07

Notes:
- The first character represents GPIO 0 and the last character represents GPIO 8.

7.3.3 FIXSESSION – Fix Session

Format:

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

Field	Data type	Range	Default	Description
1	FIXSESSION	-	-	Command Name
2	reserve1	-	-	Reserve field
3	reserve2	-	-	Reserve field
4	reserve3	-	-	Reserve field

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

Notes:
- This string is sent when certain events occur. This is for FURUNO use only.

7.3.4 ANTSEL – Antenna Selecting

Format:

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

Field	Data type	Range	Default	Description
1	ANTSEL	-	-	Command Name
2	reserve1	-	-	Reserve field
3	reserve2	-	-	Reserve field

Example:
$PERDSYS,ANTSEL,FORCE1L,1LOW*32

Notes:
- This string is sent when certain events occur. This is for FURUNO use only.

7.3.5 BBRAM – Battery Backup Random Access Memory

Format:

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

Field	Data type	Range	Default	Description
1	BBRAM	-	-	Command Name
2	reserve1	-	-	Reserve field
3	reserve2	-	-	Reserve field

Example:
$PERDSYS,BBRAM,PASS*15

Notes:
- This string is sent when certain events occur. This is for FURUNO use only.

7.4 MSG – Event Driven Message

Format:

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

Field	Data type	Range	Default	Description
1	key	-	-	Alphanumeric event indicator
2	string	-	-	Description of event

Example:
$PERDMSG,1A*06

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

8 Backup of the Receiver Parameters (for BBRAM)

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

Table 8.1 Backup of the Receiver Parameter

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

Table 8.2 Backup of the Receiver Parameter of Command

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

Table 8.3 Backup of the Configure Parameter of Command

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

Notes:

[*1] The position calculated by the position survey mode or input by $PERDAPI,SURVEY,3.

[*2] There is a time limitation (4 hours).

[*3] CSS (continues survey) mode or TO (time only) mode only.

9 Instructions and Directions for Use

[1]
We pay through attention about the software of this product. But, if perchance you found a bug or a trouble, please feel free to contact us directly. We will check it, and if it is a bug, we may send you a new version with a bug fix. If perchance we found a bug or a trouble, we may send you a new version after we contact you.

When we send you new version software, we may ask you to update software. Therefore, we strongly recommend being able to access to serial port of this product from outside of your product to make software update easy.

In addition, we also strongly recommend connecting between serial port of this product and network to remote access and update software.

About detail of software update, please contact us and see the document.

Host Base FlashROM Programming User's Guide (Document No. SE13-900-010)

[2]
It is possible to not be able to keep tracking or time fix due to mismatch timing relation between collection of GLONASS navigation data and assertion of leap second [*1]. In case receiver has such a situation, it is necessary to do shut down of receiver for retime fix.

Notes:
[*1] There is no regulation about way of collecting navigation data of GLONASS correctly at assertion timing of leap time for GLONASS.

10 FAQ ▲1

[1PPS and Time]

Q. When will the forecast of leap second insertion be broadcasted?

A. The GPS satellite system does not specify the timing to start a leap seconds forecast. In the past results, the leap seconds forecast has been started one to two months ago.

Q. Is there a function that guarantees the precision and accuracy of 1PPS and frequency during GNSS interruption?

A. GT-87 does not have a holdover function, which guarantees the 1PPS and frequency performance during GNSS interruption. If you need the holdover function, we recommend the GF-87 series.

Q. What is a default leap second?

A. It is a parameter that is set tentatively to bring the sentence output time closer to the UTC time until the leap second information is acquired. The default leap second can be stored in the Flash ROM. By setting it properly in advance, you can obtain the time information corresponding to the UTC time from sentences before acquiring the UTC parameters. If the leap second information is acquired from the GPS satellites even once, the receiver uses it priority in the future. Therefore, even if this setting is incorrect, it is not affected to the time output and the positioning.

Q. Does GPS week number rollover on April 7, 2019 affect the output time of this product?

A. No. Since this product is designed with the GPS week number rollover taken into account, even when there is no command input or backup, after the satellite positioning the correct time can be output until August 15, 2032 as described in Section 6.1.5. See Section 6.1.5 for more details.

Q. Please tell me the definition of positive / negative of cable delay of PPS command.

A. A positive cable delay causes a delay in 1PPS output. A negative cable delay advances the 1PPS output.

Q. Is it possible to correct a 1PPS quantization error?

A. Yes. By adding the sawtooth of CRX(TPS2) sentence to 1PPS output 1 second before, it is possible to improve the resolution of 1PPS to 0.001 ns on customer's system. Even without using this, the 1PPS quantization error of this product is extremely small, less than ±2 ns, so high accuracy can be obtained.

Q. What is the difference between the time status and the pps status of TPS1 sentence?

A. The time status indicates the synchronization state of time in seconds. It is an index to check whether the output time of sentence is correct. In RTC alignment, the output time is not correct. In GPS alignment, the correct time is displayed except errors of leap seconds. In UTC alignment, the correct time including leap seconds is displayed.
The pps status is an index to check the synchronization state of 1PPS. In RTC alignment, the 1PPS edge is not synchronized with anything. In GPS alignment, the 1PPS edge is synchronized with the GPS time. In UTC alignment, the 1PPS edge is synchronized with the UTC correctly.
When a GNSS interruption occurs for more than 250 seconds, the pps status returns to the RTC alignment. After a re-positioning, it returns to the previous status.

Q. How is the PPS accuracy different between the GPS alignment and the UTC(USNO) alignment?

A. As of April 2017, the difference between GPS alignment and UTC(USNO) alignment is within several nanoseconds. However, there is no guarantee that this time difference will be kept for the future.

[Positioning and Position Information]

Q. The receiver cannot receive satellite signals. What kind of causes can you think of?

A. Please check whether this product and the antenna are properly connected. Especially when the signal level is low as a whole, there is a possibility that proper gain may not be maintained even if this product and the antenna are physically connected by cables. If the antenna environment is appropriate but the receiver cannot receive the satellite signals, please check whether it is in the TO (Position-hold) mode with the wrong hold position. In this case, the receiver can restart receiving by switching to CSS or SS mode with SURVEY command.

Q. What happens when setting a wrong hold position?

A. Depending on the error of the set position, the performance of 1PPS and frequency will degrade. Also, if a hold position is set several kilometers apart, positioning may not be possible. When setting a hold position, please set a value within ±5m from the true value. If you set it incorrectly, switch to Position Survey mode with SURVEY command. The same is true when moving the position of the antenna.

Q. What is the difference between the SS mode and the CSS mode in SURVEY command?

A. Both are the mode of estimating the position, but there is a difference when turning the power off / on in the state with backup. For example, if you set the threshold transitioning to the TO mode to 5 hours, it is assumed that 2 hours has passed. Then, when turning the power supply off / on, the SS mode recalculates the position from the beginning (5 hours is necessary again until transitioning to TO mode), in the CSS mode, the calculation is continued from there using past positioning information (3 hours remaining is enough for TO mode).

Q. How can I determine the threshold for automatic transition to the TO mode?

A. When the 1PPS precision is emphasized, we recommend disabling the sigma threshold to 0 and setting the time threshold to 480 minutes. This is because the 1PPS precision stabilizes if the position mode transitions to the TO mode after internally calculating sigma to a small value less than 1. On the other hand, when emphasizing the speed to transition to the TO mode, it is recommended to set the sigma threshold to 1~5 at the same time. As a result, at the timing when the receiver is judged that it has settled to a sufficiently good hold position, the position mode immediately transitions to the TO mode.

Q. What is TRAIM?

A. TRAIM is a function that the problematic satellite is detected by this product itself and eliminated from positioning calculation with the combination of satellites and the idea of majority vote when this product is receiving satellite signals required for 1PPS output +1 or more satellites. TRAIM normal means that the number of satellites used in position fix is more than necessary for TRAIM judgment and the problematic satellites can be eliminated properly. TRAIM alarm means that a problematic satellite can be detected, but because the number of satellites is insufficient, it cannot identify which satellite is the problematic satellite. Incidentally, the problematic satellite includes satellites themselves in abnormal condition, as well as satellites with significantly lower signal levels than other satellites.

Q. Can a GPS antenna receive GLONASS signals?

A. When using GLONASS with this product, please use a multi-GNSS antenna. When setting to use GLONASS with GPS antenna, GLONASS signals may be received in rare case. However, this product does not guarantee the operation in this state.

[Navigation message]

Q. What is UTC parameter?

A. It is a kind of navigation message broadcasted from GPS satellites or QZSS satellites. It contains information related to leap seconds and correction parameters used to synchronize 1PPS to UTC(USNO). Since the UTC parameters are periodically broadcasted from GPS satellites or QZSS satellites every 12.5 minutes, it may take time to receive them. Depending on the power-on timing of this product, the UTC parameters can sometimes be received immediately, but it may take up to 12.5 minutes.

Q. Is there a command to output the almanac acquisition time?

A. eSIP protocol does not have such command.

Q. Is there an expiration date for the almanac?

A. With this product, the almanac has no expiration date.