FURUNO

FURUNO GNSS Receiver

Model GV-8720

Protocol Specifications

(Document No. SE16-600-005-00)

FURUNO ELECTRIC CO., LTD.

www.furuno.com

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Revision History

Version	Changed contents	Date
0	Initial release	2016.07.04

Table of Contents

1 Outline

This document describes the protocol specifications for FURUNO Dead Reckoning GNSS receiver GV-8720 (DR receiver).

The DR receiver provides more accurate positioning information by using the GNSS positioning information and the positioning assistance information which is input from external sources. This function also enables to continue positioning in GNSS signal interruption with positioning assistance Information. The positioning assistance information is Vehicle Speed Pulse (VSP), Forward/Reverse signal (RVS), gyro sensor data, accelerometer data and thermometer data.

- VSP is the pulse which is output depending on the speed of the vehicle.
- RVS is the traveling direction of the vehicle.
- Gyro sensor[1)] is the sensor which detects the angular velocity of the object.
- Accelerometer[1)] is the sensor which detects the acceleration of the object.
- Thermometer is the sensor which detects current temperature or amount of the temperature change.

Notes:

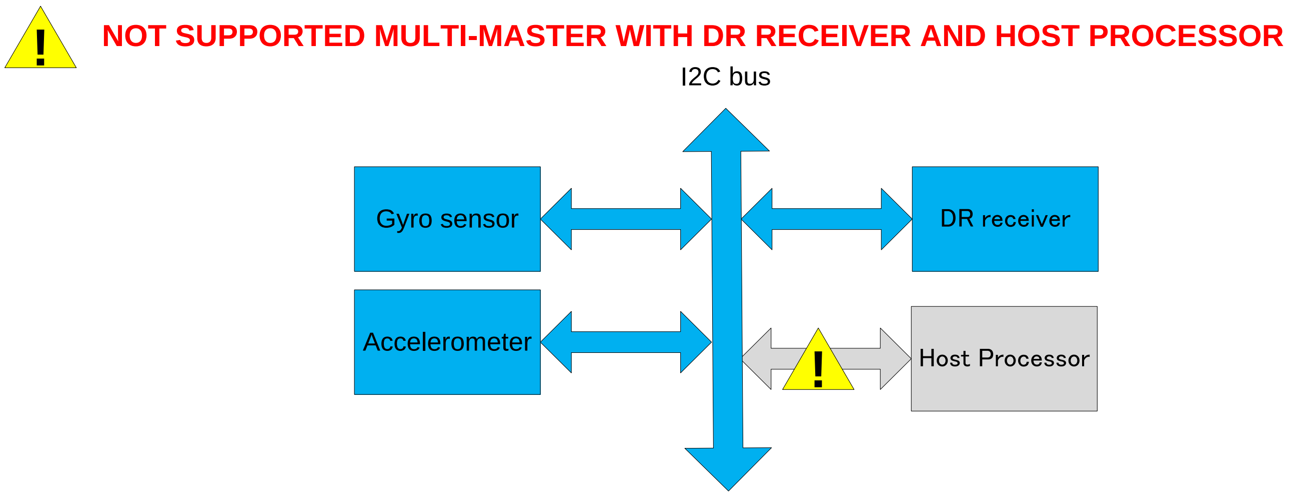
1) In this document, gyro sensor and accelerometer are collectively described as “IMU sensor.”

1.1 Interface

The DR receiver has the following two serial interfaces (I/F).

I/F1: UART port for communicating between the DR receiver and the host processor with NMEA sentence.

I/F2: Inter-Integrated Circuit (I2C) port for communicating between the DR receiver and the IMU sensor with Version 4.0.



2 Valid Software Version

ENP653A and newer

3 Communication Specifications

Table 3.1 shows the communication specifications of UART.

Table 3.1 Communication Specifications

	NMEA protocol (eSIP)	
Communication port	UART(TXD, RXD)	
System	Full Duplex Asynchronous (Flow Control None)	
Speed [1]	**Baud rate [bps]**	**Deviation error [%]**
	4,800	+0.00
	9,600	+0.11
	19,200	-0.11
	38,400	+0.32
	57,600	-0.54
	115,200 **(Default)**	-0.54
	230,400	+2.08
Byte size [1]	8 bit	
Stop bit [1]	1 bit	
Parity bit [1]	None	
Data output rate	**1000 ms (1 Hz) (Default)**[2] 500 ms (2 Hz) 200 ms (5 Hz) 100 ms (10 Hz)	
Character codes used	NMEA-0183 Ver. 4.10 data based ASCII code[3]	
Protocol Data type	- Input data NMEA Proprietary Sentence - Output data NMEA Standard sentence NMEA Proprietary sentence	

Notes:
1) These setting can be changed. Please refer to Section 11.2.4 for details.
2) These setting can be changed. Please refer to Section 12.2.1 for details.
3) ”NMEA 0183 STANDARD FOR INTERFACING MARINE ELECTRONIC DEVICES Version 4.10” (NATIONAL MARINE ELECTRONICS ASSOCIATION, June, 2012)

4 NMEA Sentence Format

NMEA format has two kinds of sentence which is standard and proprietary sentence. All letters in this sentence which is included checksum are capital letters. Data in backup RAM area by calling BBRAM command from host processor includes small letters.

4.1 Standard Sentence

Here are definitions of standard sentence.

$	<Address field>	,	<Data field>	・・・	*<Checksum field>	<CR>	<LF>
	5 bytes						

"$"
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. The talker IDs are GN of GNSS, GP for GPS and GL for GLONASS and are changed by GNSS command and valid satellite systems for positioning. Table 4.1 shows the talker ID of standard NMEA sentences.

Table 4.1 Talker ID of Standard NMEA Sentences

Standard NMEA Sentence		Talker ID Configuration with PERDAPI,GNSS		
		AUTO	**GN**	**LEGACYGP**
RMC	Recommended Minimum Navigation Information	GN/GP/GL[1)]	GN	GP
GNS	GNSS Fix Data	GN/GP/GL	GN	GP
GGA	Global Positioning System Fix Data	GN/GP/GL	GN	GP
GLL	Geographic Position - Latitude/Longitude	GN/GP/GL	GN	GP
VTG	Course Over Ground and Ground Speed	GN/GP/GL	GN	GP
GST	GNSS Pseudo Range Error Statistics	GN/GP/GL	GN	GP
GBS	GNSS Satellite Fault Detection	GP	GP	GP
GSA	GPS DOP and Active Satellites	GN/GP/GL	GN/GP/GL	GP
ZDA	Time & Date	GN/GP/GL	GN	GP
GSV	Satellites in View (GPS, SBAS, QZSS)	GP[2)]	GP	GP
	Satellites in View (GLONASS)	GL[2)]	GL	X[3)]

Notes:
1) GN/GP/GL is changed by the following configuration valid satellite system.
   - GN: Multi satellite system (GPS, SBAS, QZSS and GLONASS) is available.
   - GP: Only GPS which is included SBAS and QZSS is available
   - GL: Only GLONASS is available
2) The sentences of satellite systems used in position fix are output. GPGSV (GPS, SBAS, QZSS) is output when the receiver uses any of GPS, SBAS or QZSS in position fix.
3) The satellite system is valid for positioning but the sentence is not output.

<Data field>
- Basically, this field length is variable
- Field partition is delimiter "," (comma).
- The valid data character is based on all ASCII characters from 0x20-0x7D except "!" (0x21), "$" (0x24), "*" (0x2A), "¥" (0x5C), and "^" (0x5E).
- When there is no applicable data, this filed is null.

<Checksum field>
- 8 bits excusive OR data between "$" and "*" (excluding "$" and "*").
- Convert the excusive OR data to 2 bytes of hexadecimal character.

<CR><LF>
End of sentence marker with the following character
- <CR>: 0x0D
- <LF>: 0x0A

4.2 Proprietary Sentence

Here are definitions of proprietary sentence.

$	P	<Maker code>	<Sentence type>	,	<Data field>	・・・	*<Checksum>	<CR>	<LF>
		3 bytes	3 bytes						

"$"
Start of sentence marker

"P"
Proprietary Sentence ID

<Maker code>
It indicates the maker and it is "ERD".

<Sentence Type>
It indicates the type of sentence with the following class.
- API
- CFG
- SYS

Table 4.2 shows the relation between the command categories and the default events.

Table 4.2 Relation between Command Categories and Default Events

	Command category		
Default event	$PERDAPI	$PERDCFG	$PERDSYS
Power ON/OFF	●	●	●
Hardware reset	●	●	●
PERDAPI,STOP/STOPNOFPR	●	-	-
PERDCFG,FACTORYRESET	●	-	-

●: Return to the default setting

<Data field>
- Basically, this field length is variable
- Field partition is delimiter "," (comma).
- The valid data character is based on all ASCII characters from 0x20-0x7D except "!" (0x21), "$" (0x24), "*" (0x2A), "¥" (0x5C), and "^" (0x5E).
- When there is no applicable data, this filed is null
- The fields inside [ ] are optional fields.

<Checksum field>
- 8 bits excusive OR data between "$" and "*" (excluding "$" and "*").
- Convert the excusive OR data to 2 bytes of hexadecimal character.

<CR><LF>
End-of-Sentence marker. It is able to skip this item in transmission.
- <CR>: 0x0D
- <LF>: 0x0A

5 State Specifications

Figure 5.1 shows a state diagram of the DR receiver. Whenever user operates the following process, user should set the DR receiver to Fix session off (S3):

- Load program in Flash ROM
- Registry ESIPLIST in Flash ROM
- Read/Write access to backup data in backup RAM

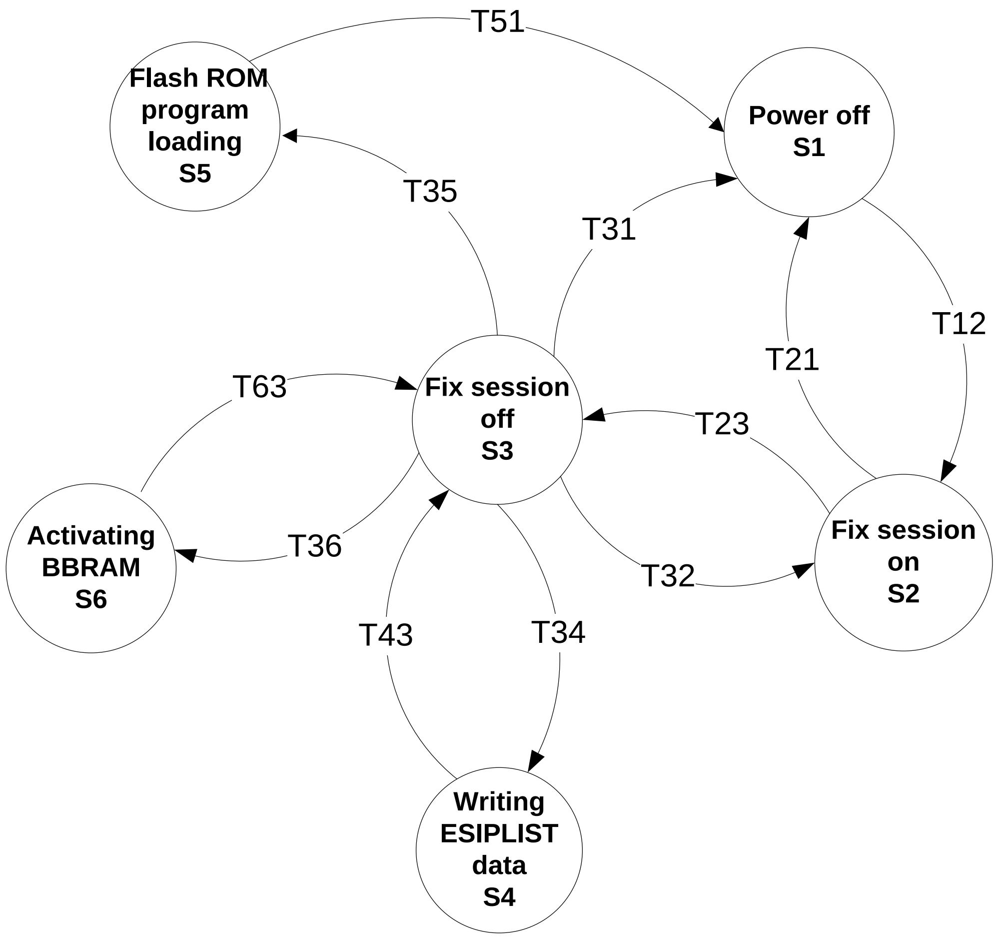


Figure 5.1 State Diagram of DR receiver

Table 5.1 shows explanations of specifications about each sate.

Table 5.1 Receiver's State

State	Description
Power off	Invalid all function
Fix session on	Activating normal position fix process
Fix session off	Normal position fix process halt Not available UART port
Activating BBDATA	Bidirectional access session between the host processor and the DR receiver about backup data in RAM area data
Flash ROM program loading	Programming session about program data in Flash ROM between the host processor and the DR receiver
Writing ESIPLIST data	Bidirectional access session between the host processor and the DR receiver about ESIPLIST data in Flash ROM

Table 5.2 shows events of each state transaction.

Table 5.2 Event of Each State Transaction

State transaction	Event	Notes
T12	Power on	-
T21	Power off	
T31		
T51		
T23	Input the following command -PERDAPI,STOP,DRPARK -PERDAPI,STOPNOFPR,DRPARK	
T32	Input the following command -PERDAPI,START	Host processor can check that fix session state is available by reception of PERDACK and PERDSYS, FIXSESSION,ON.
T34	Input the following command -PERDCFG,ESIPLIST,NEW -PERDCFG,ESIPLIST,APPEND	
T43	Input the following command -PERDCFG,ESIPLIST,CLOSE	
T36	Input the following command -PERDSYS,BBRAM	
T35		Refer to "Flash ROM Programming Procedures with WinUppg" (Doc # SE13-900-009) about Flash ROM program rewriting.
T63	Complete session sequence between host processor and DR receiver	

Table 5.3 shows the relation between the standard NMEA sentences and Fix session.

Table 5.3 Standard NMEA Sentence Output Condition

Output sentence	Description	Fix session on	Fix session off
RMC	Recommended minimum navigation information	●	-
GNS	GNSS fix data	●	-
GGA	Global positioning system fix data	●	-
GLL	Geographic position - latitude/longitude	●	-
VTG	Course over ground and ground speed	●	-
GST	GNSS pseudo range error statistics	●	-
GBS	GNSS satellite fault detection	●	-
GSA	GPS DOP and active satellites	●	-
ZDA	Time and date	●	-
GSV	Satellites in view	●	-

●: Output is available. It is possible to control output function (ON/OFF) and output period by PERDCFG,NMEAOUT command.
-: Output is not available.

Table 5.4 shows the relation between input condition of proprietary NMEA and Fix session.

Table 5.4 Proprietary NMEA Input Condition

Input command	Description	Fix session on	Fix session off
PERDAPI,			
ANTIJAM	Anti Jamming	I	I
CROUT	CR original sentence output	I	I
DATUM	Geodetic Datum	I	I
EXTENDGSA	GSA sentence re-definition	I	I
EXTENDNMEARSL	NMEA sentence resolution	I	I
FIXMASK	Satellite Mask	I	I
GNSS	GNSS satellite system configuration	I	I
PIN	Static pinning	I	I
PPS	PPS (Pulse per second)	I	I
SBASBLS	SBAS priority search select	I	I
START	Start request	NACK	I
STOP/STOPNOFPR_DRPARK	Stop request	I	NACK
TIME	Time aiding	I	I
PERDCFG,			
ESIPLIST	Save/query ESIP commands to FLASH	q	I / q
FACTORYRESET	Clear backup data into Backup RAM and Flash ROM.	NACK	I
NMEAOUT	Configure the standard NMEA outputs	I	I
UART1	Serial communication port (UART) configuration	I 1)	I
PERDSYS,			
ANTSEL	Antenna selection control	I / q	I / q
BBRAM	Backup data output query	q 2)	q
	Backup data input	NACK	I
GPIO	GPIO output query	q	q
RECPLAY	Diagnostic mode ON/ OFF	I 1)	I
VERSION	Software version query	q	q

I: Input is available.
q: Query is available.
NACK: Not related to internal process.

Notes:
1) Input this command at fix session off state.
2) Request to output the backup data at fix session off state to avoid mix transmission with the backup data and the other data.

Table 5.5 shows relation between output condition of proprietary NMEA and Fix session.

Table 5.5 Proprietary NMEA Output Condition

Output sentence	Description	Fix session on	Fix session off
PERDACK			
ACK	Command acknowledgement	A	A
PERDCFG			
ADDON	Startup status	S	-
ESIPLIST	eSIP command query into ESIPLIST	Q	Q
PERDCRx			
CRF,GxACC	Satellite accuracy information	O	-
CRF,GxANC	Satellite health information	O	-
CRV	Velocity information	O	-
PERMSG			
MSG	Event message	E	E
PERDRPx			
RPx	Diagnostics mode ON/OFF	O	-
PERDSYS			
ANTSEL	Antenna input status	S/ Q	Q
BBRAM	Backup data	Q 1)	Q
FIXSESSION	GNSS session	R/ S/ E	Q
GPIO	GPIO status	Q	Q
VERSION	Software version	S/ Q	Q

A: Output as ACK or NACK for input command.
E: Output when certain events occur.
O: Output is available.
Q: Output when the query command is input.
R: Output at the following conditions:
- The state transfers from fix session off state to fix session state by PERDAPI,START command.
- The state transfers from fix session state to fix session off state by PERDAPI,STOP or PERDAPI,STOPNOFPR command.

S: Output at power on.
-: Output is not available.

Notes:

1) Output the backup data at fix session off state to avoid mix transmission with the backup data and the other data.

Table 5.6 shows the relation between input condition of proprietary NMEA for DR and Fix session.

Table 5.6 Proprietary NMEA for DR Input Condition

Input command	Description	Fix session on	Fix session off
PERDAPI			
GYROALIGN	Misalignment angle of gyro sensor data	N/A	I
ACCELALIGN	Misalignment angle of accelerometer data	N/A	I
AUTOORIENT	Auto orientation extend angle setting	N/A	I
DROUT	CRx sentence output	I	I
ODOREVERSE	Reverse signal setting	N/A	I
ETCONFIG	Position feedback configuration	I	I
ETPOS	Input position feedback information	I	I
PERDSYS			
DRPERSEC	Update rate of DR positioning setting	N/A	I
DRSELFTEST	Self-Test for IMU sensor	N/A	I

I: Input is available.
N/A: Not available to input this command during fix session.

6 Backup Data

The receiver backs up the last updated position, last updated time, the ephemeris, the almanac, the CSM, the LTCSM and the DR parameters. These backup data are used for shortening the position fix time at the next start-up.

(1) Last updated position
This data shows the last position data calculated by the receiver. It shows the position data in GGA, GLL, GNS or RMC sentence. This data is backed up every position fix.

(*) GGA, GLL, GNS and RMC sentences are output by PERDCFG,NMEAOUT command, or GLL, GNS and RMC sentences are output by default.

(2) Last updated time
This data shows the last UTC calculated by the receiver and the RTC counter value. It shows the UTC data in GGA, GLL, GNS or RMC sentence. This data is backed up after fixing the time at first.

(*) GGA, GLL, GNS and RMC sentences are output by PERDCFG,NMEAOUT command, or GLL, GNS and RMC sentences are output by default.

When the receiver's state is power off state and a backup power is supplied to the receiver, the time at power on can be calculated from the delta between the last updated time and RTC counter value.

This document defines the time calculated the delta between the last updated time and the RTC counter value as RTC time. RTC time is valid when the receiver can calculate it and RTC time is invalid when the receiver cannot calculate it because backup power is not supplied.

(3) Ephemeris
These data show the ephemeris data broadcasted from GNSS satellites. These are backed up, when the receiver gets these and updates these.

(4) Almanac
These data show the almanac data broadcasted from GNSS satellites. These are backed up, when the receiver gets these and updates these.

(5) CSM
These data shows the all GPS satellites ephemeris model downloaded from an assist server. (These are FURUNO original format.) These are backed up into a backup RAM at downloading the data.

(6) LTCSM
These data shows the extend satellites ephemeris model which the receiver can use for one week. (These are FURUNO original format.) These are backed up into Flash ROM area at downloading the data.

(7) DR parameters
These data shows the DR parameters for positioning assist at last updated UTC which is output in GGA, GLL, GNS and RMC sentences. See the section 0 about the positioning assist data.

Notes:
Because the data from (1) to (5) and (7) of above are saved into the backup RAM, these are continued to save whiling a backup power is supplied to the receiver. The receiver can also save these into Flash ROM when PERDAPI,STOP command is sent.
Data (6) of above are saved into the Flash ROM area for LTCSM.

7 Transmission and Reception Sequence

This chapter shows the transmission and reception sequences between the DR receiver and the host processor. The DR receiver outputs the response sentence ($PERDACK...) or the requested data when the commands written in Chapter 11 and 12 are input.

In case the DR receiver does not return a response though the correct command is input, an error may occur on transmitting line. Please input the command again.

7.1 Startup Sequence

The DR receiver outputs the version message ($PERDSYS,VERSION...), the configuration data[1)] and the fix session start message ($PERDSYS,FIXSESSION,ON) and do start process soon after power on. Until finishing the initial process, the DR receiver is not able to receive an input command. It takes max 600 milliseconds as maximum inhibition reception time for host processor to be able to input the command.

Figure 7.1 shows the session sequence from power on to command input available.

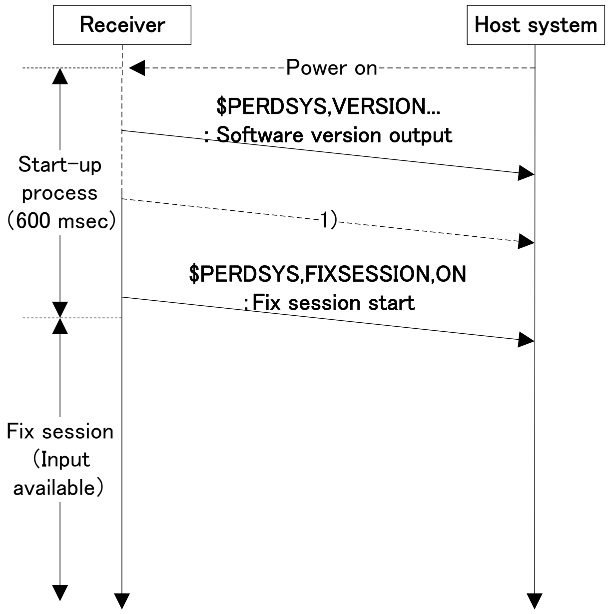


Figure 7.1 Session Sequence from Power on to Command Input Available

Notes:

1) The configuration data are output. The DR receiver outputs the following sentences. (In case that LNA setting is High gain mode.)
   $PERDSYS,ANTSEL,FORCE1H,1HIGH*6C
   $PERDCFG,ADDON,GV8687,DEADRECK*26
   $PERDSYS,VBKERR,OK*44
   $PERDSYS,FIXSESSION,INIT*49

7.2 Sequence from Fix Session OFF to Fix Session ON

Figure 7.2 shows the session sequence from fix session off state to fix session on state.

The DR receiver's state will change to fix session state after PERDACK,PERDAPI sentence and PERDSYS,FIXSESSION,ON sentence are output, when PERDAPI,START command is input at fix session off state.

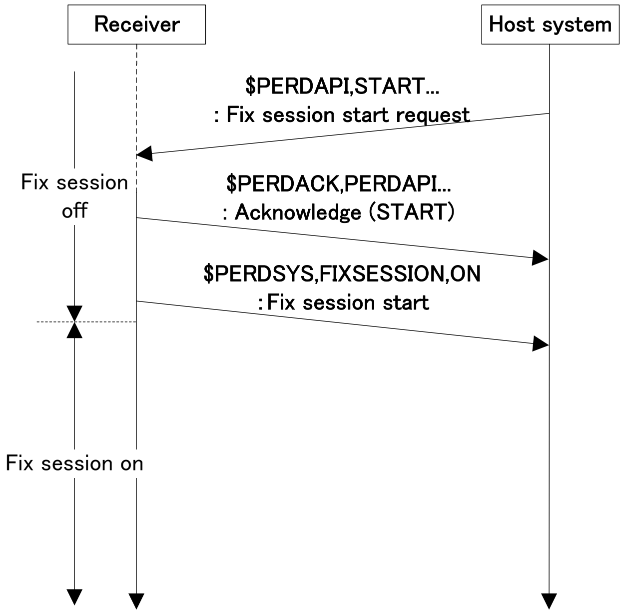


Figure 7.2 Session Sequence from Fix Session OFF to Fix Session ON

7.3 Periodical Output Sentence (Default Setting)

Figure 7.3 shows the periodical output sequence when the following NMEA sentences are output synchronized with positioning interval which is 1Hz.

(Output NMEA sentences)
RMC, GNS, GST, GSA, ZDA and GSV (Talker ID other than GSV are GN, and Talker ID for GSV is GP.)

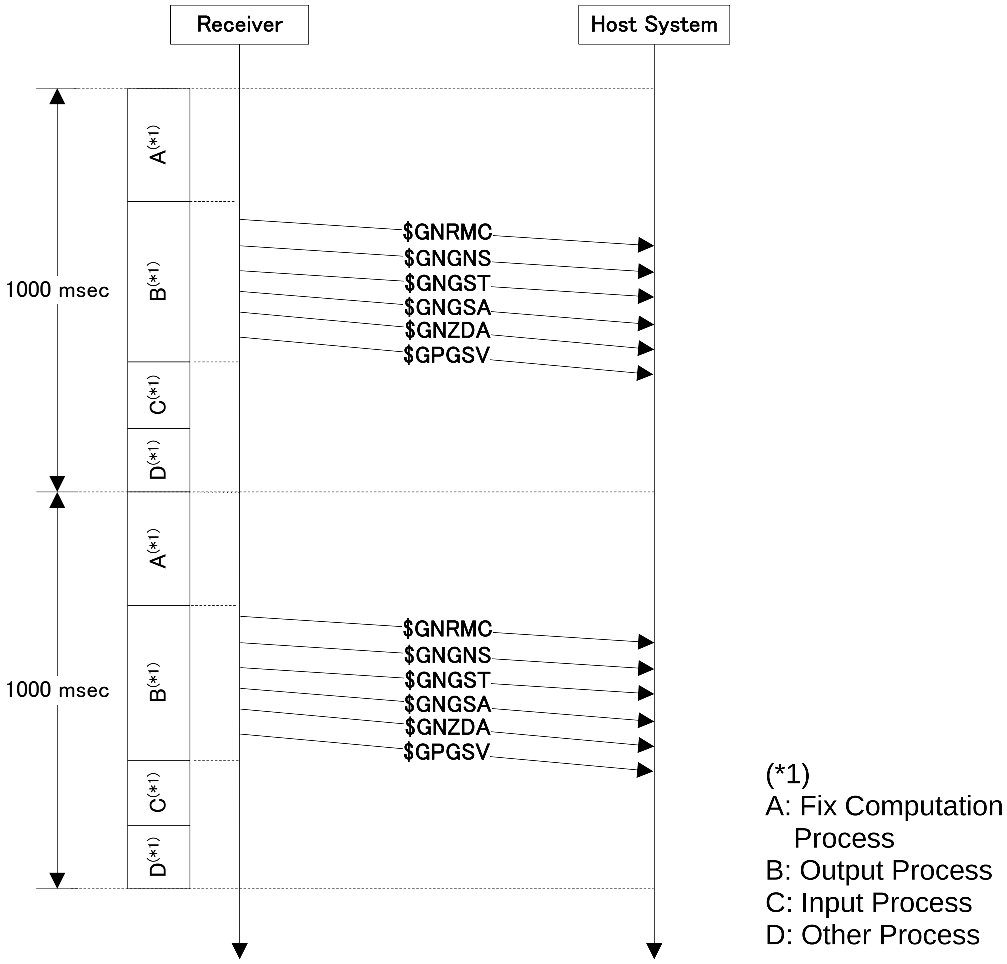


Figure 7.3 Session Sequence of Periodical NMEA Output Sentence

7.4 Receiver Configuration Setting Sequence

Figure 7.4 shows the session sequence for the DR receiver which is update rate 1Hz and output positioning data synchronized with positioning cycle of RMC, GNS and GSV sentences when the DR receiver setting is changed by sending the following commands.

- PERDAPI,FIXMASK command
- PERDAPI,PIN command

The following figure shows the difference in response time which is a response of each input of command by input timing and the time which is reflected to positioning results against input command setting by input timing.

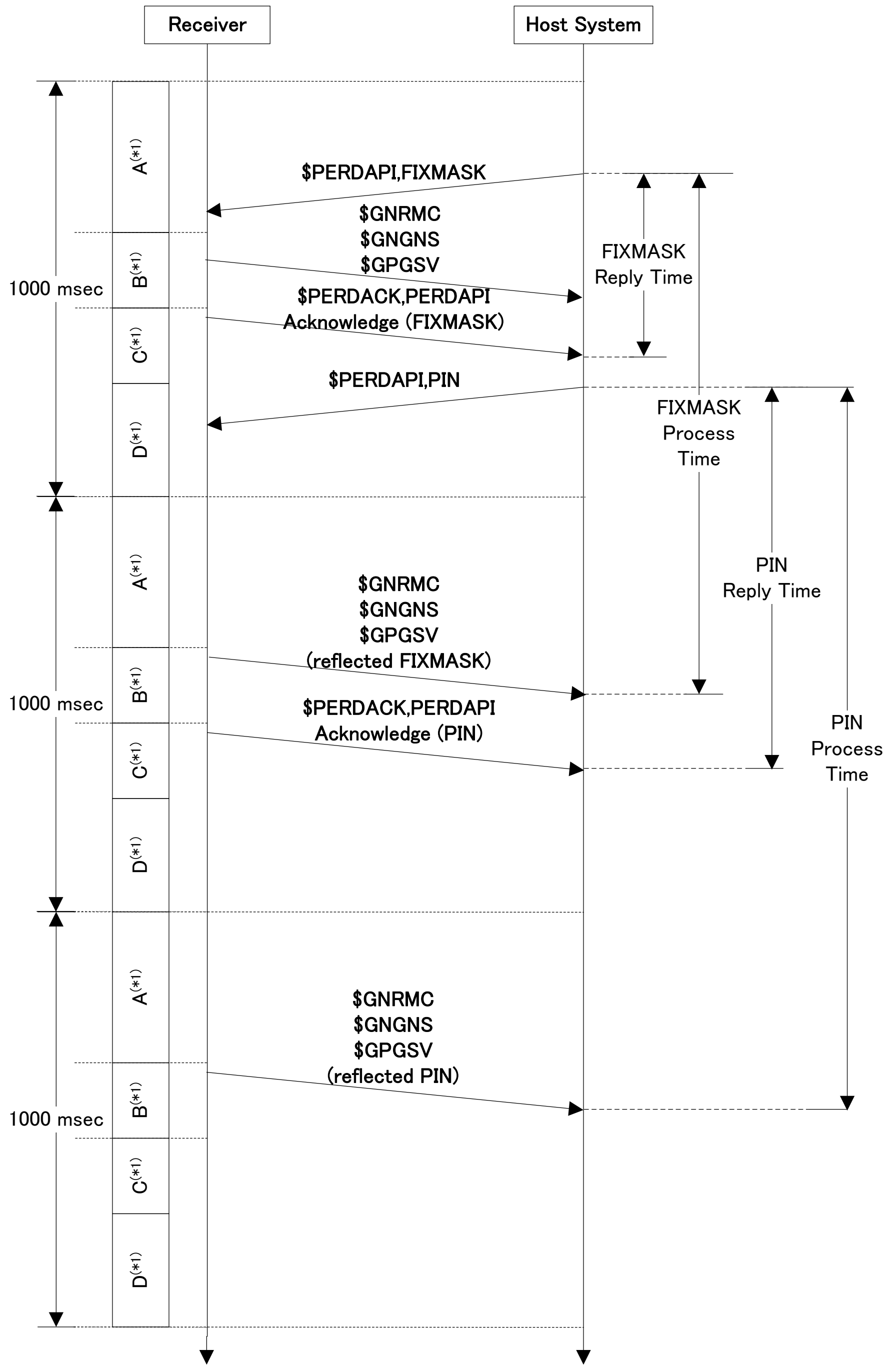
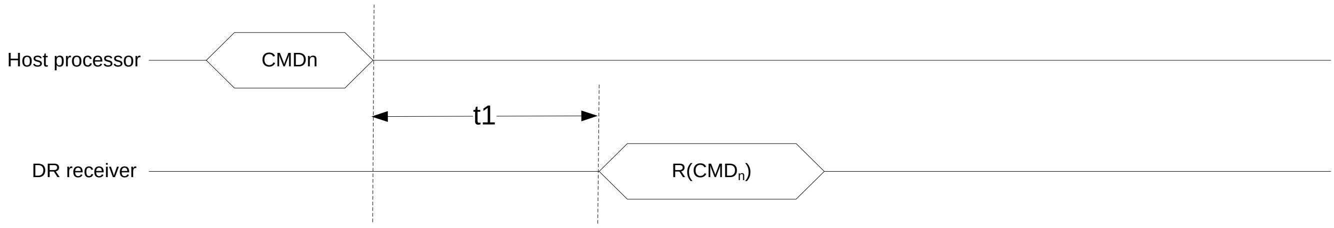


Figure 7.4 Session Sequence Example in Case of Changing Receiver Setting (1 Hz)

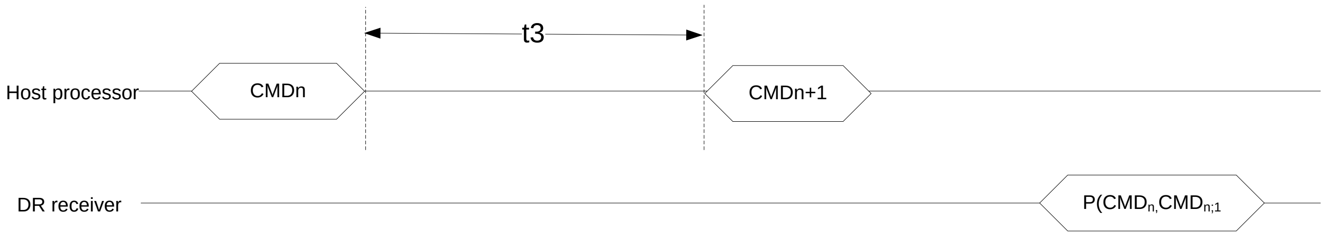
Figure 7.5 shows the timing charts of the relation between the command and the behavior of DR receiver based on the command and Table 7.1 shows the timing specifications.

A) Response time from the DR receiver after sending the command data from the host processor.
B) Valid time for reflecting the command data to position fix data.
C) Continues assertion grant time of the next command data.



A) Response time

B) Command valid time



C) Continues Assertion Grant Time

Figure 7.5 Timing Chart

Table 7.1 Timing Specifications

Symbol	Description	Condition	Min	Max	Unit
t1	Response time of position fix data which is reflected command parameter	State: Fix session on Update rate: 1/2/5/10 Hz	-	1000	ms
t2	Valid position fix data which is reflected command parameter		-	2000	ms
t3	Continues assertion grant time of command		1000	-	ms

Maximum number of command input one time is 20 at Fix session off state. It is able to input the next command at the timing of finishing output of receiver response against the command group which are input first.

7.5 Receiver Data Output Request

The following is the sequence when host processor requests DR receiver data output request. Figure 7.6 shows the sequence from input of PERDSYS,GPIO command and PERDSYS,VERSION command to the DR receiver 1Hz positioning to output requested data.

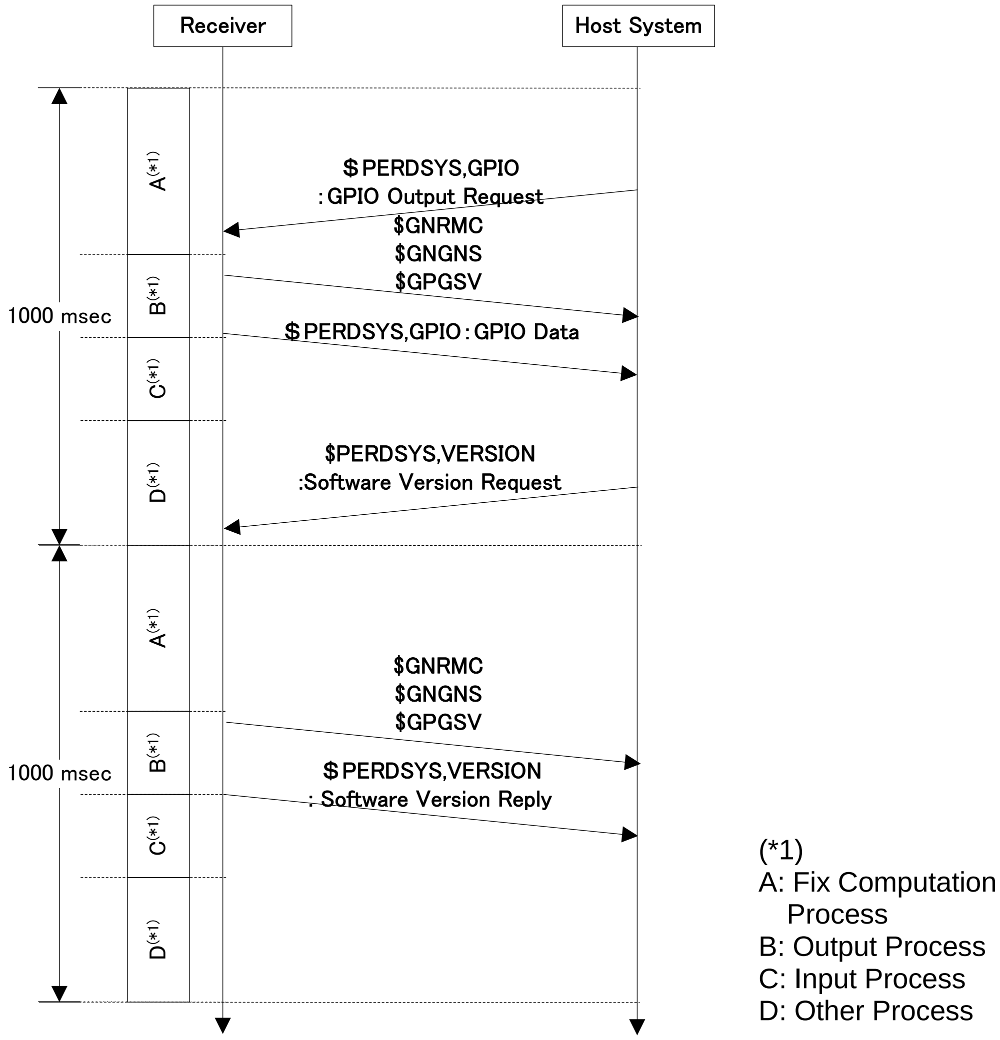


Figure 7.6 Session Sequence Example in Case of Requesting Receiver Output Data (1 Hz)

Figure 7.7 shows the response time from the DR receiver after sending an output request command from the host processor and Table 7.2 shows the timing specifications.

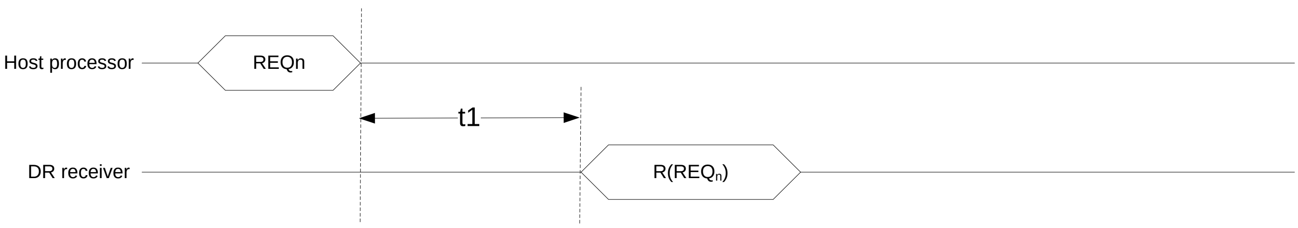


Figure 7.7 Response Time

Table 7.2 Timing Specifications

Symbol	Description	Condition	Min	Max	Unit
t1	Response time of position fix data which is request command parameter	State: Fix session on Update rate:1/2/5/10 Hz	-	1000	ms

7.6 Backup Data Input/Output

Here is the explanation of sequence to output and to input the DR receiver backup data in MULTIB64 format and ESIP64 format.

Since the capacity of backup data exceeds transmission capacity in one sentence, the backup data is divided when the backup data is output or input.

Figure 7.8 shows the outline of process of backup data input/output.

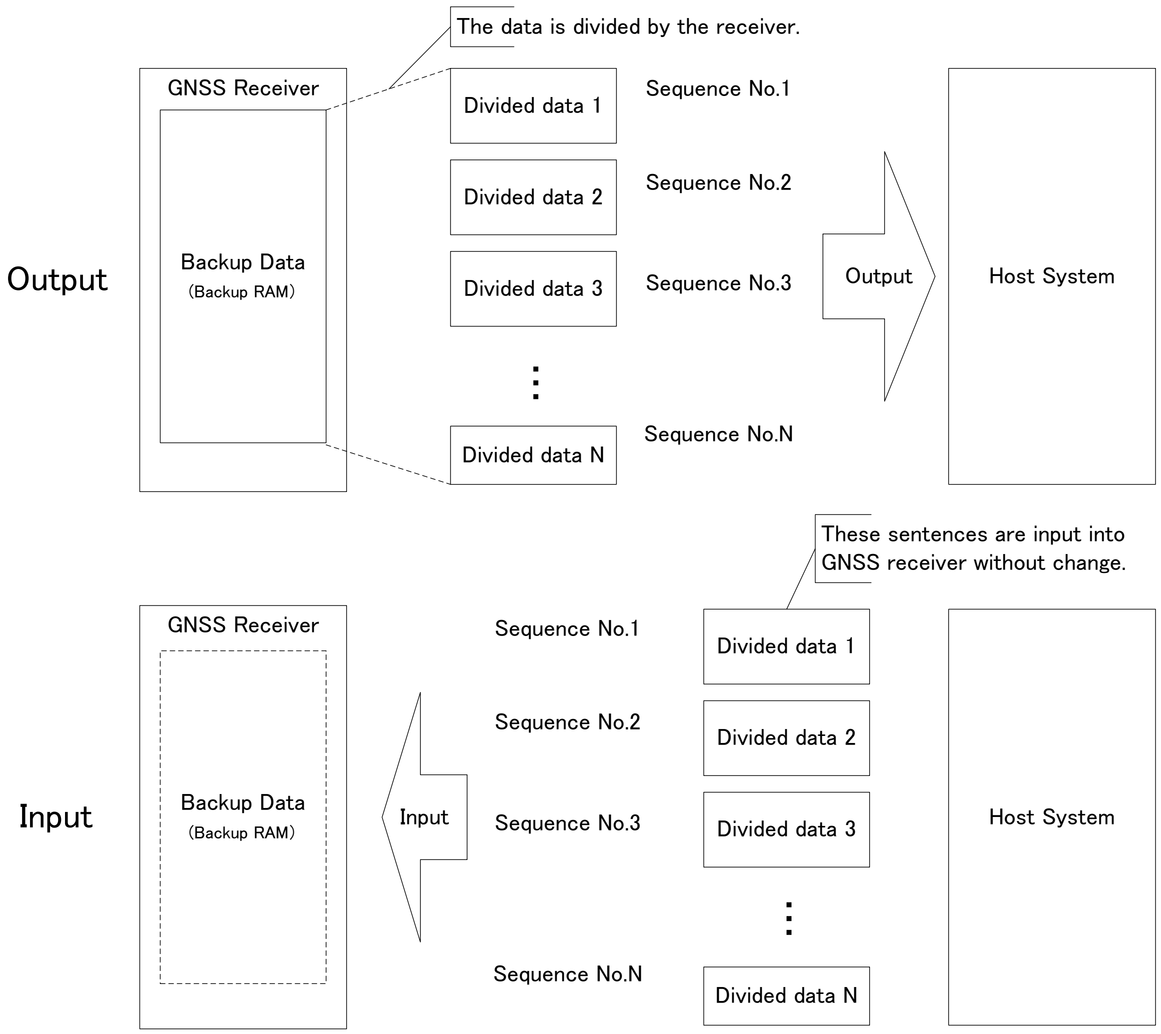


Figure 7.8 Outline of Backup Data Input/Output

7.6.1 Backup Data Output Request Sequence

To request a backup data output, input PERDAPI,STOP or PERDAPI,STOPNOFPR command to move receiver state to "Fix session off". Input PERDSYS,BBRAM,QUERY command and output PERDSYS,BBRAM sentence in a row after the DR receiver state is "Fix session off". When a command is input during the backup data is output, the DR receiver will process the command after completion of backup data output.

Figure 7.9 shows the backup data output sequence.

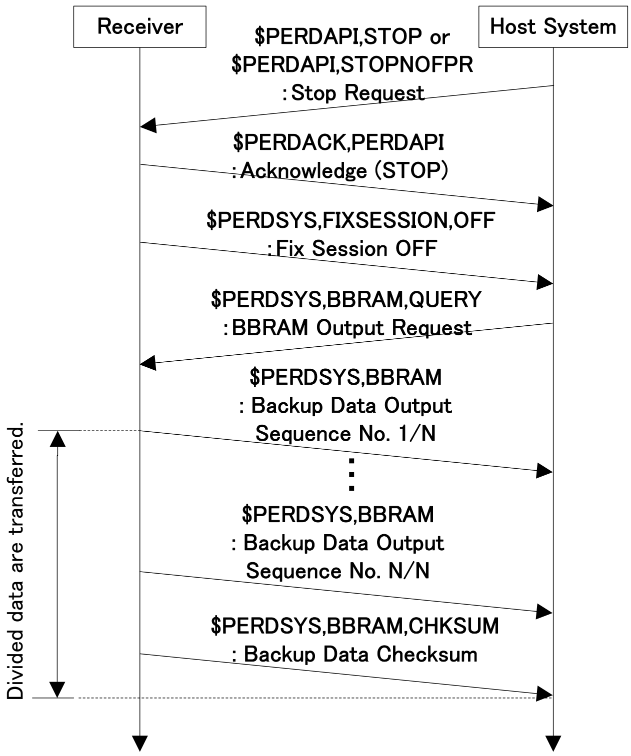


Figure 7.9 Backup Data Output Session Sequence

7.6.2 Backup Data Input Sequence

To request a backup data input, input PERDAPI,STOP or PERDAPI,STOPNOFPR command and input the data requested backup data output in numerical sequence after the DR receiver status is “Fix session off”.

Figure 7.10 shows the backup data input sequence.

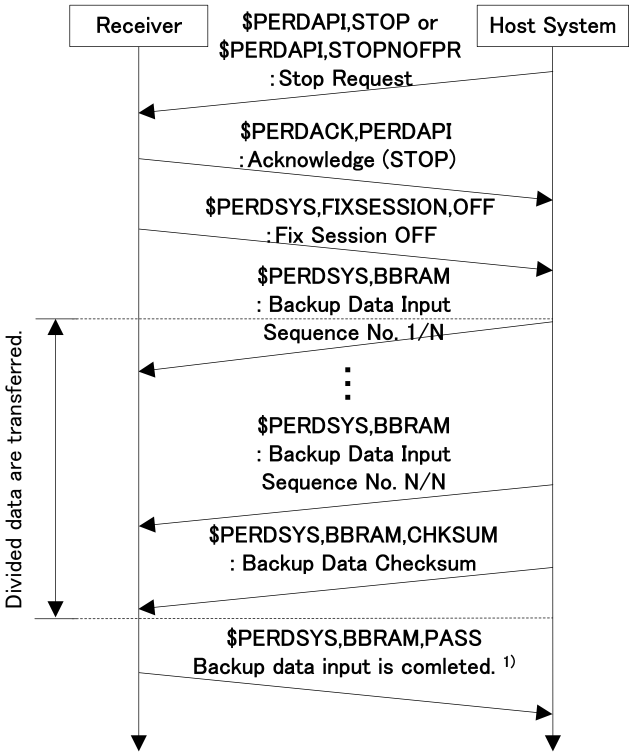


Figure 7.10 Backup Data Input Session Sequence

Here is the operation notice regarding back up process from the host processor:

1. Backup data is available in receiver before input of backup data
Once the DR receiver receives the backup data with sequence number 1, the existing backup data in the backup RAM is invalid.

2. Backup data invalid
The DR receiver will not reflect the input of backup data in the following cases:
a) Any commands except backup data are input during input of backup data.
b) A sequence number does not start from 1 or a sequence number is a lack of continuity.
c) There is a check sum error in input data.
d) There is a check sum error in backup data.

3. Recovery method when backup data cannot be input
When the backup data cannot be input, input PERDCFG,FACTORYRESET[2)] command and delete all backup data stored in the DR receiver, and then input again backup data.

Notes:
1) "$PERDSYS,BBRAM,PASS*15" is output when the backup data can be input to the DR receiver. "$PERDSYS,BBRAM,FAIL,MISSING,..." is output when the backup data cannot be input to the DR receiver.
2) All backup data including ESIPLIST will be deleted when sending PERDCFG,FACTORYRESET command. When ESIPLIST is used, please set ESIPLIST again.

7.7 Serial Communication Format Configuration

Figure 7.11 shows the sequence when the DR receiver changes the serial communication format. It needs to change a serial communication configuration after the DR receiver state was "Fix session off". The DR receiver reflects the serial communication configuration after sending ACK sentence.

The DR receiver outputs PERDACK,PERDCFG sentence and reflect the configuration when PERDCFG,UART1 command is input at "Fix session off".

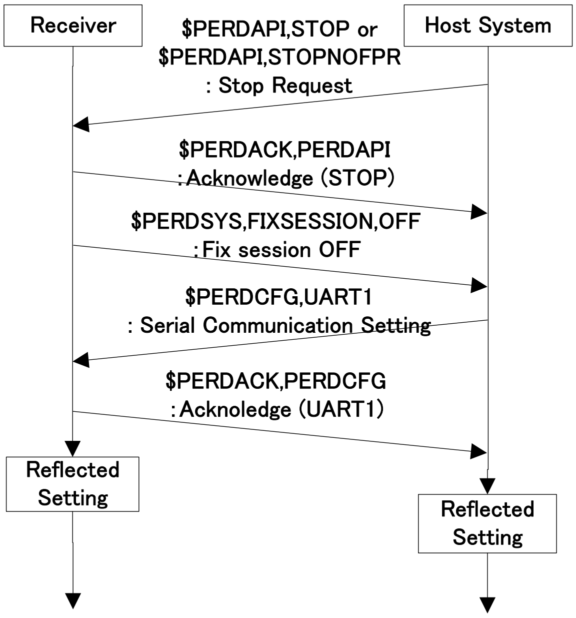


Figure 7.11 Session Sequence of Serial Communication Format Configuration

7.8 Time Setting

This section shows the time setting sequence when the DR receiver's time is unknown.

PERDAPI,TIME command is used to set the time. It is necessary to the following conditions to set the time.
- RTC time is invalid.
- The DR receiver does not get any time from GNSS satellites.

Figure 7.12 shows a time setting sequence when the DR receiver conditions meet the above.

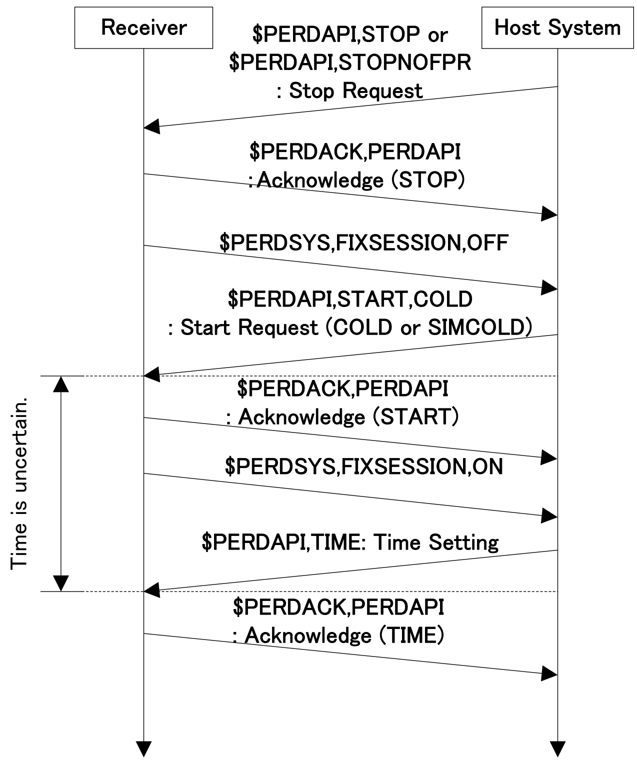


Figure 7.12 Time Setting Session Sequence (Request at Start up)

In Figure 7.12, the time can be set by sending PERDAPI,TIME command during the time is unknown after sending PERDAPI,START command.

Here is the operation notice regarding time setting process from the host processor:

1. In case input of time setting command is delayed
When the DR receiver time is fixed, the input time with PERDAPI,TIME command is not reflected because the DR receiver does not satisfy the condition that the DR receiver does not get any time from the satellites.

2. In case the wrong time (YYMMDD) is set
When the difference between the actual date (YYMMDD) and the input date (YYMMDD) with PERDAPI,TIME command is less than +/-512 weeks, the DR receiver outputs a correct date (YYMMDD) once time data is obtained from the satellites.

When the difference between the actual date (YYMMDD) and the input date (YYMMDD) with PERDAPI,TIME command is more than +/-512 weeks, the DR receiver will set a wrong rollover number of GPS week number starting from January 6^{th}, 1980.

The DR receiver will calculate the date based on rollover number of GPS week number regardless of satellite used. When an error date which is more than +/-512 weeks is set, output date will have error in increments of 1024 weeks. The wrong rollover number of GPS week number which set wrongly will not be corrected even if time data is obtained from the satellites. The rollover number of GPS week number will be corrected by resetting the date which is less than +/-512 weeks.

Figure 7.13 shows an example of setting of wrong rollover number of GPS week number.

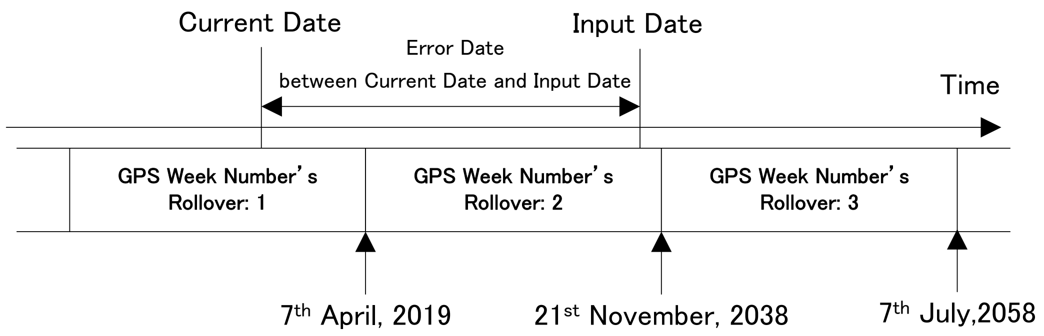


Figure 7.13 Relation between Current Date and Input Date

The DR receiver sets "2" as rollover number of GPS week number if the difference between the actual date (YYMMDD) and the input date (YYMMDD) is more than +/-512 weeks (Correct value is "1").

Once time data is obtained from the satellites, the DR receiver will output the date based on wrong rollover number of GPS week number:2 starting from 7th April, 2019, GPS week number and GPS week time calculated by a time obtained from the satellites. (In this example, actual date plus 1024 weeks)

3. In case wrong time (HHMMSS) is set

Even if a wrong time (HHMMSS) is input, the DR receiver will output a correct time (HHMMSS) once time data is obtained from the satellites.

7.9 ESIPLIST Registry

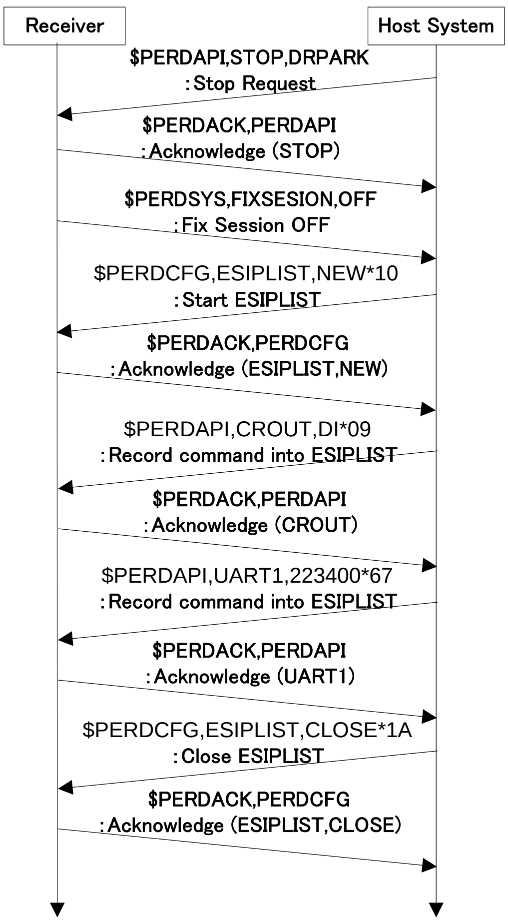
If it is necessary to automatically set up with command parameters, without having the host sending commands to the GNSS receiver, using the ESIPLIST function is ideal. This function programs the commands into the Flash ROM and sends the commands programmed at start-up automatically.

7.9.1 New ESIPLIST Create

Figure 7.14 shows ESIPLIST creating session sequence based on the below operation number from 1 to 5.

Here is new ESIPLIST creating as an example. Register the setting below in ESIPLIST newly.

- Output CRD, CRI sentences
- Set baud rate at 230400 bps



Operation

1. $PERDAPI,STOP,DRPARK*5D or
$PERDAPI,STOPNOFPR,DRPARK*18
Send STOP command

2. $PERDCFG,ESIPLIST,NEW*10
Start creating new ESIPLIST

3. $PERDAPI,CROUT,DI*09
Register “CRD, CRI sentences output”

4.$PERDCFG,UART1,230400*67
Register “Configure Serial Communications port 1”

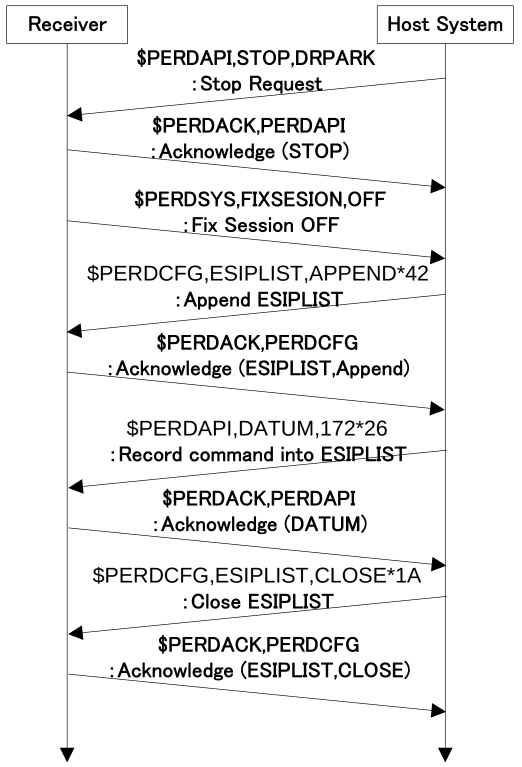
5.$PERDCFG,ESIPLIST,CLOSE*1A
Close creating ESIPLIST

Figure 7.14 ESIPLIST Creating Session Sequence

7.9.2 ESIPLIST Append

Figure 7.15 shows session sequence of ESIPLIST appending with Tokyo datum as example based on the below operation number from 1 to 4.

Here is new ESIPLIST appending as an example. Add the setting below to the ESIPLIST created at Section 7.9.1.
- Set “Tokyo Datum”



Operation

1. $PERDAPI,STOP,DRPARK*5D or
$PERDAPI,STOPNOFPR,DRPARK*18
Send STOP command

2. $PERDCFG,ESIPLIST,APPEND*42
Start adding command to ESIPLIST

3.$PERDAPI,DATUM,172*26
Register “Set Tokyo Datum”

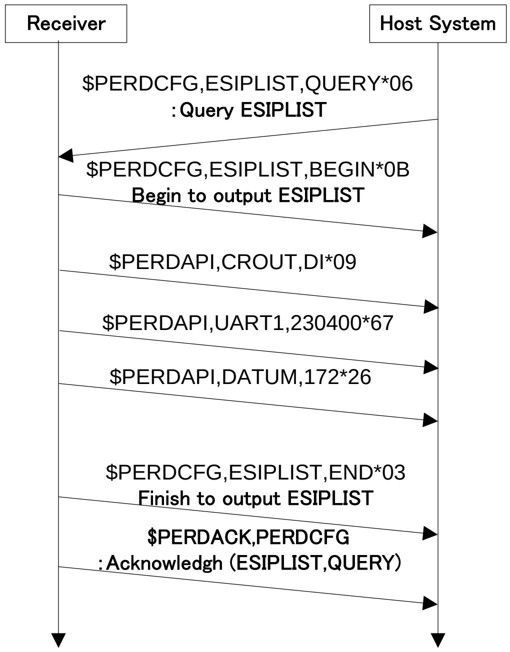
4. $PERDCFG,ESIPLIST,CLOSE*1A
Close creating ESIPLIST

Figure 7.15 ESIPLIST Appending Session Sequence

7.9.3 ESIPLIST Query

The Data type of ESIPLIST can be confirmed by sending "$PERDCFG,ESIPLIST,QUERY*06". The example below shows the procedures to confirm the Data type of ESIPLIST set at Section 7.9.1 and 7.9.2 when the DR receiver stops positioning.

Figure 7.16 shows ESIPLIST query session sequence based on the below operation number from 1 to 3.



Operation

1. $PERDCFG,ESIPLIST,QUERY*06
   Request output of Data type of ESIPLIST

2. Following data are output when the Query ESIPLIST is received.

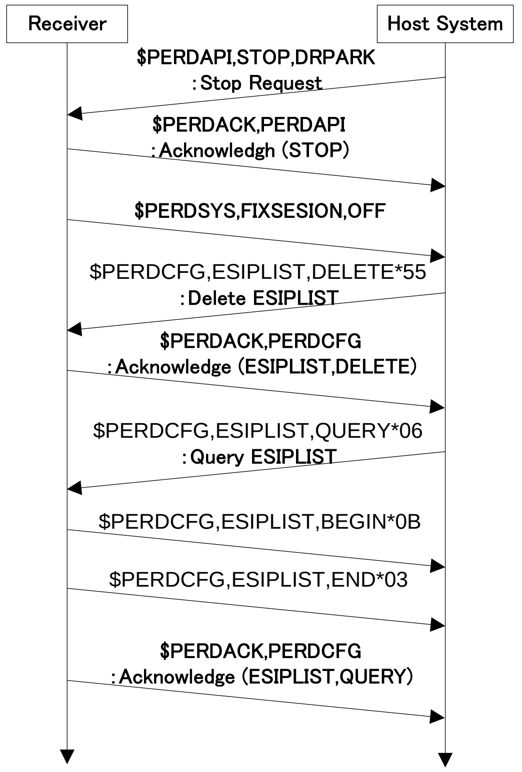
$PERDCFG,ESIPLIST,BEGIN*0B : Start outputting the contents
$PERDAPI,CROUT,DI*09
$PERDCFG,UART1,230400*67
$PERDAPI,DATUM,172*26
(the three lines above) : Registered commands
$PERDCFG,ESIPLIST,END*03 : Stop outputting the contents

3. Acknowledgement (ACK) of Query ESIPLIST is output after outputting the Data type of ESIPLIST.

Figure 7.16 ESIPLIST Query Session Sequence

7.9.4 ESIPLIST Delete

Figure 7.17 shows ESIPLIST delete session sequence based on the below operation number from 1 to 4.



Operation

1. $PERDAPI,STOP,DRPARK*5D or
$PERDAPI,STOPNOFPR,DRPARK*18
Send STOP command

2.$PERDCFG,ESIPLIST,DELETE*55
Delete ESIPLIST

3. $PERDCFG,ESIPLIST,QUERY*06.
Check ESIPLIST data delete

4.$PERDCFG,ESIPLIST,BEGIN*0B
$PERDCFG,ESIPLIST,END*03
Receive empty information of ESIPLIST

Figure 7.17 ESIPLIST Delete Session Sequence

7.9.5 ESIPLIST Configurable Command

Table 7.3 shows configuration of ESIPLIST for NMEA command.

Table 7.3 NMEA Command

Command Name		Description	Registry configuration[1)]
API	ANTIJAM	Anti Jamming	●
	CROUT	CR original sentence output	●
	DATUM	Geodetic Datum	●
	EXTENDGSA	GSA sentence re-definition	●
	EXTENDNMEARSL	Standard NMEA sentence resolution	●
	FIXMASK	Satellite Mask	●
	GNSS	GNSS satellite system configuration	●
	PIN	Static pinning strength set	●
	PPS	PPS (Pulse per second)	●
	SBASBLS	SBAS priority search select	●
	START	Start request	N/A
	STOP/STOPNOFPR	Stop request	N/A
	TIME	Time aiding	N/A
CFG	ESIPLIST	Save/query ESIP commands to FLASH	N/A
	FACTORYRESET	Clear backup data into Backup RAM and Flash ROM.	N/A
	NMEAOUT	Configure the standard NMEA outputs	●
	UART1	Serial communication port configuration of UART	●
SYS	ANTSEL	Antenna selection control	●
	BBRAM	Backup data output query	N/A
	GPIO	GPIO output query	N/A
	RECPLAY	Diagnostic mode ON/ OFF	N/A
	VERSION	Software version query	N/A

Table 7.4 shows ESIPLIST configurable command which is related to DR function.

Table 7.4 DR Function Command

Command Name		Description	Registry configuration[1)]
API	GYROALIGN	Set misalignment angle of gyro sensor	O
	ACCELALIGN	Set misalignment angle of accelerometer	O
	AUTOORIENT	Auto orientation extend angle setting	O
	DROUT	CRx sentence output	O
	ODOREVERSE	Reverse signal setting	O
	ETCONFIG	Position feedback configuration	O
	ETPOS	Input position feedback information	N/A
SYS	DRPERSEC	Update rate of DR positioning setting	O
	DRSELFTEST	Self -Test for IMU	N/A

Here is operation notice regarding ESIPLIST registry process from host processor.
- Do not register the same command multiply with different setting.
- In case duplicated commands are registered, the last command will be reflected.

For example, in case register commands $PERDCFG,NMEAOUT,GGA,1*54 (output GGA sentence in 1 positioning cycle) followed by $PERDCFG,NMEAOUT,GGA,2*57 (output GGA sentence in 2 positioning cycles) in the ESIPLIST, the latter command $PERDCFG,NMEAOUT,GGA,2*57 is to be set.

7.9.6 ESIPLIST Executing Condition with EXECUTE command in ESIPLIST

This section describes operation notice regarding execution of ESIPLIST command by EXCUTE command which is PERDCFG,ESIPLIST,EXECUTE from host processor. Table 7.5 shows valid condition about each command class which is API, CFG and SYS class. API is the exclusive relation to CFG and SYS with START and EXECUTE command.

Table 7.5 ESIPLIST Executing Condition

Execute event of ESIPLIST	API	CFG	SYS
Transfer to Fix session on state from power on	●	●	●
Transfer to Fix session on state by PERDAPI,START	●	N/A	N/A
Send PERDCFG,ESIPLIST,EXECUTE	N/A	●	●

In order to cover execution ESIPLIST at combination of API,CFG and SYS, Figure 7.18 shows executing operation for all combination of class.

Figure 7.18 Executing Operation at Combination of API, CFG and SYS

7.10 Fix Session OFF Sequence

Figure 7.19 shows the sequence transit from fix session state to fix session off state.

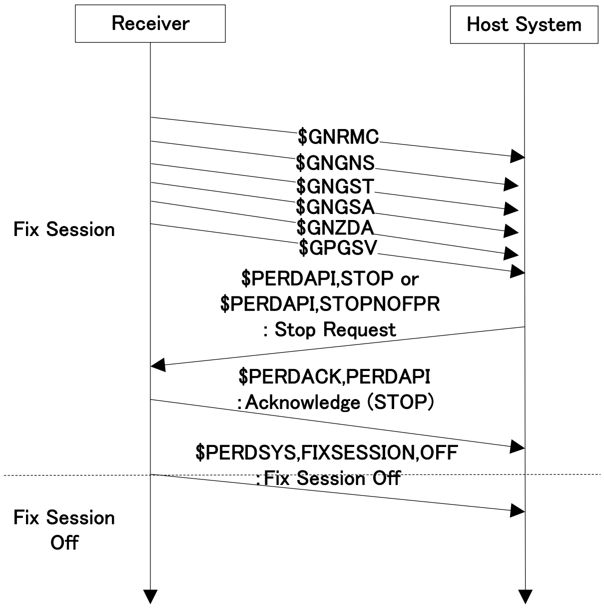


Figure 7.19 Sequence Transit from Fix Session State to Fix Session OFF State

7.11 Power OFF Sequence

Even if the DR receiver is turned off during positioning, the DR receiver will be operated properly at restart and user can turn off the DR receiver at any timing. However, in case the DR receiver is turned off during writing the backup data in BRAM area, the backup data can be invalid and not be used. There is no way to know when the backup data is saved in BRAM area from the Host System. Therefore, by sending PERDAPI,STOP or PERDAPI,STOPNOFPR command to stop positioning before turning off the DR receiver at any timing, the possibility to destroy the backup data can be eliminated. The backup data will be written in Flash ROM other than BRAM when PERDAPI,STOP command is sent. After sending PERDAPI,STOP or PERDAPI,STOPNOFPR command, turn off the DR receiver after receiving PERDSYS,FIXSESSION,OFF sentence. Figure 7.20 shows the Power OFF sequence.

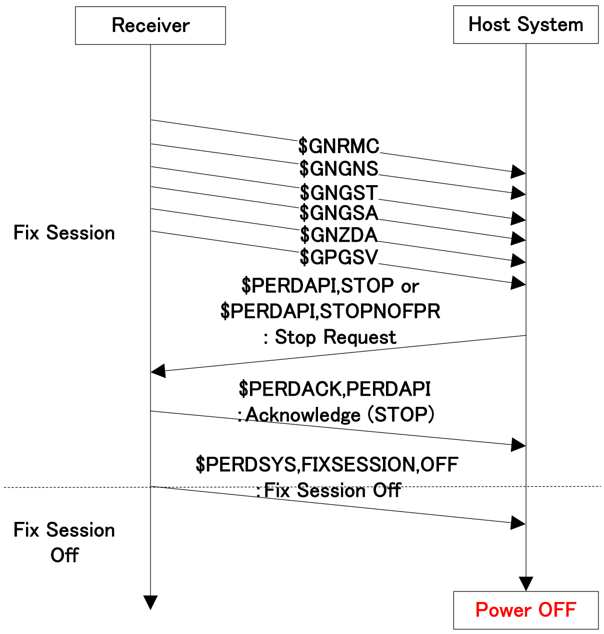


Figure 7.20 Power OFF Sequence

7.12 Flash ROM Rewriting

See "Flash ROM Programming Procedures with WinUppg" (Doc # SE13-900-009) about Flash ROM program rewriting.

8 Receiving NMEA Sentence

8.1 Receiving Data

Save all data received through UART1 of DR receiver in receive buffer of Host System.

8.2 Cutout from String

Start analyzing from the beginning buffer storing the received data with Section 8.1. Search for “$” at first to cutout from Data type.

If “$” is found, search for “*” next. XOR in every 8 bit by using all the data between “$” and “*” and compare with checksum in 1 byte (convert ASCII 2 character into 1 byte data in binary) followed by “*”.
- If matches with checksum, determine as sentence satisfied and move to splitting the data.
- If mismatched with checksum, determine as sentence not satisfied and discard the data.

Discard <CR>,<LF> followed by checksum.

If checksum is correct, read out 5 characters followed by “$”. The first 2 bytes represent Taker ID (GP, GL, GN).

Identify the sentence by the 3 characters followed by Talker ID. If the sentence not supposed to be output (not set to be output), abnormal situation is suspected e.g. the command setting sentence output is not reflected properly or the DR receiver is restarted.

8.3 Cutout from Data type in Fixed Interval

The DR receiver outputs positioning results with sentence set to be output once per positioning. For example, if the DR receiver is set to output RMC, GNS, GSV sentences once per positioning, these sentences are output once in a second in case of 1Hz positioning (GSV outputs multiple sentences depending on the number of satellites tracked or used satellite system). The order of sentences to be output is predetermined (see Section 11.2.3). With this example, RMC comes out first followed by GNS, then GSV to be output at the last. Therefore, it can be regarded to have received a whole sentence for 1 positioning when RMC through GSV sentences are received.

With 1Hz positioning, the interval to output sentence in each positioning is just about 1 second which may vary slightly depending on the time for position calculation. If the interval (the time between first RMC output and next RMC output) becomes more than 2 seconds, abnormal situation is suspected e.g. the baud rate is set improperly or the output from receiver has stopped.

8.4 Cutout from Every Data type

The data fields in the string are split by “,”.

Since the number of “,” is fixed depending on the sentence, abnormal sentence can be detected by checking the number of “,”. If abnormal sentence is detected, discard the sentence data.

8.5 Talker ID

The Talker ID “GP” represents GPS, “GL” represents GLONASS, “GN” represents multi-GNSS (use multiple satellite systems). Except GSA and GSV sentence, only 1 sentence is read out in 1 output. The Talker ID can be discarded except GSA/GSV sentence especially in case separate the process in application by difference of positioning results between GPS, GLONASS or multi-GNSS.

With GSA/GSV sentence, the GNSS system of Talker ID and that of data field in the sentence must be the same. With GSA sentence, the GNSS system can be identified by satellite number and GNSS system ID in the 18th field. With GSV sentence, the GNSS system can be identified by the satellite No.

If the GNSS systems are different in the same sentence, the data may be abnormal data, a fault receiving data. In this case, discard the data.

8.6 Satellite No.

As described in Section 8.5, abnormal sentence can be detected by checking satellite number corresponding to each Talker ID because the GSA/GSV sentence output satellite number.
GPS:01 to 32 : Same as PRN No.
SBAS:33 to 51 : Subtract 87 from PRN No.
QZSS:93 to 97 : Subtract 100 from PRN No.
GLONASS:65 to 96 : Same as PRN No.

8.7 Time Source

The DR receiver has the following three kinds of time information:

- Current time
- GPS time
- Position fix time

The difference between current time in ZDA sentence and position fix time in other sentences can be roughly estimated. The DR receiver outputs the position after 800 milliseconds from GPS time. For example, when the GPS time is xxxx01.000, the time in RMC sentence is output as xxxx01.800. ZDA sentence outputs current time which is xxxx01.500 (observables used for positioning are total for 1 second in the range of +/-500 milliseconds centered at GPS time) + time for position calculation. If the time for position calculation at 1Hz positioning is 150 milliseconds, the time of ZDA sentence is xxxx01.650.

Therefore, the delta between position fix time of RMC and current time of ZDA is 150 milliseconds. During 1Hz positioning, time for position calculation is not more than 1 second, the maximum current time of ZDA sentence with this example is xxxx02.500. Therefore, the maximum gap from RMC sentence is 700 milliseconds.

Abnormal situation can be detected by monitoring this time gap. If the maximum time gap becomes more than 700 milliseconds with the setting of example above, it is suspected that the sentences of different position fix are received as that of the same position fix. Or, abnormal situation is suspected e.g. abnormal sentence reception, missing sentence output from the DR receiver or improper setting of baud rate.

8.8 Position Fix Status

To confirm if position is fixed with the DR receiver, check the position fix state and position fix mode output from several sentences. The sentences outputting position fix state are as below;

GGA, GLL, GNS, GSA, RMC

(*) Please refer to descriptions of each sentence in this manual for status of position fix state and position fix mode.

In each sentence, if the position fix status is not fix or invalid, the positioning data of that position fix cannot be used. With 1 position fix, if the position fix status in each sentence is different, it is suspected that the sentences of different position fix are received as that of the same position fix. Or, abnormal situation is suspected e.g. abnormal sentence reception, missing sentence output from the receiver or improper setting of baud rate.

8.9 The Case Position Fix State Becomes Valid While No Position Fix

The DR receiver can perform position calculation under environment where the GNSS satellite is not available for positioning by using positioning supporting information from IMU sensors and position fix status becomes valid. During this period, the position fix mode becomes DR and position fix state becomes data valid.

8.10 Direction

Direction in RMC and VTG sentence is output in “true direction”. The magnetic direction in VTG sentence is NULL.

The direction while parking is unreliable and cannot be used. Treat the data as invalid.

9 Exception Process

The DR receiver has irregular behavior as exception operation due to internal or external issue.

9.1 Exception Operation

1. Occurerance of restart
The receiver perform restart by itself when the software processing takes more time than expected to run out of time and the watchdog timer is activated.

2. Running the Mask ROM program
The software installed in Mask ROM may be operated without running program in Flash ROM when the access anomaly to Flash ROM occurs. If the software of Mask ROM is run, following messages will be output.

$PERDSYS,VERSION,OPUS6_ROM_ES2_64P,ENP610F1229005R,BOOT*05
$PERDSYS,FIXSESSION,ON*52

The reasons not to be able to access to Flash ROM properly are suspected as below:
- Malfunction of Flash ROM devise
- Abnormal data bus/ address bus
- Abnormal contact of Flash ROM terminal
- Interruption of power supply to Flash ROM (Malfunction of BB IC)

3. Irregular communication between host processor and receiver at UART interface
The following irregular communication may occur regarding the output sentence from the DR receiver:
- Missing sentence (sentence is not output which is requested to output)
- Checksum error caused by missing data
- Unstable output period
- No output NMEA sentence

Those phenomena are caused by following reasons:
- Abnormal output interval occurs since request of sentence output is more than the data size that can be output for the setting of baud rate and fail to output sentence in each position fix.
- Missing data or sentence occurs due to malfunction of communication pathway.
- Infinite loop occurs inside of the receiver.

4. Exception occurerance message output
When an unexpected exception processing occurs with running software inside the receiver, the receiver outputs PERDMSG sentences as below to alert an exception occurrence and perform restart by itself.

$PERDMSG,90,val1,val2,val3,val4*hh<CR><LF>
$PERDMSG,91,val1,val2,val3,val4*hh<CR><LF>
$PERDMSG,92,val1,val2,val3,val4*hh<CR><LF>

Table 9.1 shows the Key of PERDMSG sentence and the type of exception processing.

Table 9.1 Exception Processing

Key	Type	Description
90	UndefInstrException	Running command is not recognized by processor nor any coprocessor
91	PrefetchAbort	Processor trying to run the command not fetched due to bad address
92	DataAbort	Attempting to load or store the data by data transfer command with bad address

val1, val2, val3 and val4 are eight character hexadecimal values.
Example:
$PERDMSG,92,3805A454,A000003F,10003870,38018C8B*05

5. No position fix at normal condition
No position fix for more than 15 minutes even if more than five satellites with C/No at 10 dB-Hz or higher are tracked continuously.

The reason not to be able to fix the position is suspected as below:
- Ephemeris data cannot be obtained or updated if there is wide gap between satellite position calculated with almanac data and satellite position calculated with ephemeris data because almanac data in backup has anomaly.

6. Irregular communication between IMU sensor and receiver at I2C interface

The following sentences come up in case of detecting an irregular communication of I2C. The irregular communication is, for example, that the clock line (SCL) and the data line (SDA) are driven to Low level, or a violaton of I2C communication protocol.

$PERDMSG,40,DETECT,I2C,COM,ERROR*54
$PERDMSG,41,DETECT,I2C,COM,ERROR*55
$PERDMSG,42,DETECT,I2C,COM,ERROR*56

These sentences are output after power on or START command input.

9.2 Recovery Process

[Recovery process from exception operation 1 and 4]
The receiver has been already restarted for recovery, check if the sentence is output properly after restart. If the sentence is not output properly, conduct power-on reset and check again if the sentence is output properly after reset. If the status is not fixed, there is high possibility of failure of the receiver, stop supplying power to the receiver.

After the restart, the DR receiver operates with the setting registered in ESIPROM. When the receiver setting is changed with commands, it will return to the default setting by the restart. By registering the command in ESIPLIST, the receiver operates with the command setting of ESIPLIST even if the restart occurs. The ESIPLIST configurable command described in Section 7.9.5 should be registered in ESIPLIST.

[Recovery process from exception operation 2 and 3]
If the exception operation is detected, conduct power-on reset and check if the sentence is output properly after reset. If the status is not fixed after power-on reset, there is high possibility of failure of the receiver, stop supplying power to the receiver.

[Recovery process from exception operation 5]
If the exception operation is detected, stop positioning by sending PERDAPI,STOP or PERDAPI,STOPNOFPR command, then start positioning without backup by sending PERDAPI,START,SIMCOLD command. If the status is not fixed after restart positioning, stop positioning again by sending PERDAPI,STOP or PERDAPI,STOPNOFPR command, then clear the backup data by sending PERDCFG,FACTORYRESET command. After clearing backup data, conduct power-on reset and restart the receiver.

[Recovery process from exception operation 6]
If the exception operation is detected, check the voltage and waveform of I2C clock line (SCL) and data line (SDA).

10 Standard NMEA Output

The DR receiver supports ten standard NMEA output sentences (GBS, GGA, GLL, GNS, GSA, GST, GSV, RMC, VTG and ZDA) per NMEA standard 0183 Version 4.10 (June, 2012). By default, the RMC, GNS, GST, GSA, ZDA and GSV sentences will be output every second. The sentences can be independently enabled and disabled using the PERDCFG,NMEAOUT command, as well as use differing transmission rates.

10.1 GBS – GNSS Satellite Fault Detection

Format:

$--GBS	,	hhmmss.sss	,	x.x	,	x.x	,	x.x	,	xx	,	x.x	,	x.x	,	x.x	,	x	,	x	*hh	<CR>	<LF>
		1		2		3		4		5		6		7		8		9		10			

Field	Data type	Range	Description
1	hhmmss.sss	000000.000 to 235959.999	Coordinated Universal Time (UTC) of the associated GGA or GNS fix hh: [hour], mm: [minute], ss.sss:[second]
2	x.x	Null	The data from field 2 to field 8 is valid when RAIM function is ON. These data are always null field because the DR receiver does not support RAIM function.
3	x.x	Null	
4	x.x	Null	
5	xx	Null	
6	x.x	Null	
7	x.x	Null	
8	x.x	Null	
9	x	1	GNSS System ID 1: GPS (involve SBAS and QZSS)
10	x	1	Signal ID 1: L1 C/A (GPS), G1 C/A (GLONASS)

Example:
$GPGBS,081707.800,,,,,,,,1,1*5E

10.2 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	,	x.x	,	xxxx	*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	0,1,2,6	GNSS Quality Indication 0: Fix not available 1: GNSS fix 2: Differential fix[1)] 6: Estimated/Dead Reckoning Mode
7	xx	0 to 12	Number of satellites in use
8	x.x	NULL 0.0 to 50.0	Horizontal Dilution of precision (HDOP)
9	x.x	-	Antenna Altitude above/below mean-sea-level (Geoid)
10	M	M	Units of antenna altitude, meters
11	x.x	-	Geoidal separation, the difference between the WGS-84 earth ellipsoid and mean sea-level (Geoid), “-” means mean-sea-level below ellipsoid
12	M	M	Units of Geoidal separation, meters
13	x.x	Null	The data from field 13 and 14 is related to RTCM[2)]. These data are always null field because the DR receiver does not support RTCM function.
14	xxxx	Null	

Example:
$GPGGA,025411.516,3442.8146,N,13520.1090,E,1,11,0.8,24.0,M,36.7,M,,*66

Notes:
1) When three and more satellites are corrected by SBAS satellites, the receiver becomes to differential fix.
2) RTCM is an abbreviation for Radio Technical Commission for Maritime Service.

10.3 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,E,N	Mode Indication A: Autonomous D: Differential[1)] E: Estimated/ Dead Reckoning N: Data Invalid

Example:
$GPGLL,3442.8146,N,13520.1090,E,025411.516,A,A*5F

Notes:
1) When three and more satellites are corrected by SBAS satellites, the receiver becomes to differential fix.

10.4 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,E,N[1)]	Mode Indicator for each satellite system (GPS, GLONASS, Reserved) A: Autonomous D: Differential[2)] E: Estimated/ Dead Reckoning N: Data Invalid
7	xx	0 to 24	Number of satellites in use
8	x.x	NULL, 0.0 to 50.0	Horizontal Dilution of precision (HDOP)
9	x.x	-	Antenna Altitude above/below mean-sea-level (Geoid) [meter]
10	x.x	-	Geoidal separation, the difference between the WGS-84 earth ellipsoid and mean sea-level (Geoid), "-" means mean-sea-level below ellipsoid [meter]
11	x	Null	The data from field 11 and 12 is related to RTCM. These data are always null field because the DR receiver does not support RTCM function.
12	x	Null	
13	x	V	Field 13 is always output "V", because the DR receiver does not support RAIM function.

Example:
$GNGNS,092356.800,3442.8211,N,13520.1147,E,DDN,20,0.5,36.8,36.7,,,V*6A

Notes:
1) In case of multi-Hz update, it takes up to one second to become mode A, D or E from PERDSYS,FIXSESSION,ON output.
2) When three and more satellites are corrected by SBAS satellites, the receiver becomes to differential fix.

10.5 GSA – GNSS DOP and Active Satellites

Format:

PERDAPI,EXTENDGSA command is 12 satellites as the default[1)].

$--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	Selection mode M: Manual: forced 2D or 3D A: Automatic 3D/2D
2	a	1,2,3	Mode 1: No fix 2: 2D fix 3: 3D fix
3-14	xx	-	ID numbers of satellites used in solution
15	x.x	NULL, 0 to 50.0	PDOP
16	x.x	NULL, 0 to 50.0	HDOP
17	x.x	NULL, 0 to 50.0	VDOP
18	x	1,2	GNSS System ID 1: GPS (involve SBAS and QZSS) 2: GLONASS

Example:
When the DR receiver uses multi satellite systems (i.e. GPS and GLONASS), GSA sentence divide to multiline message such as the below sentence.

$GNGSA,A,3,24,29,15,21,20,14,12,25,18,42,41,93,,,,,1.0,0.5,0.8,1*34
$GNGSA,A,3,87,86,75,74,76,65,72,,,,,,,,,,1.0,0.5,0.8,2*39

Notes:
1) The above format is default setting when PERDAPI,EXTENDGSA command setting is 12 satellites. When this command setting is 16 satellites, the format is as follow.

$--GSA	,	a	,	a	,	xx	,	xx	,	xx	,	・・・	,	xx	,	x.x	,	x.x	,	x.x	,	h	*hh	<CR>	<LF>
		1		2		3		4		5		6-17		18		19		20		21		22			

Field 3-18: ID numbers of satellites used in solution
Field19: PDOP
Field20: HDOP
Field21: VDOP
Field22: GNSS System ID

10.6 GST – GNSS Pseudo Range Error Statistics

The accuracy index and the standard deviation in this sentence are calculated with GNSS positioning results, and not added correction by Dead Reckoning.

Format:

$--GST	,	hhmmss.sss	,	x.x	,	x.x	,	x.x	,	x.x	,	x.x	,	x.x	,	x.x	*hh	<CR>	<LF>
		1		2		3		4		5		6		7		8			

Field	Data type	Range	Description
1	hhmmss.sss	000000.000 to 235959.999	Coordinated Universal Time (UTC) of the associated GGA or GNS fix hh: [hour], mm: [minute], ss.sss: [second]
2	x.x	Null[1], 000.0 to 999.9	Accuracy Index (RMS) [meter] The variance of pseudoranges residual
3	x.x	Null[1], 000.0 to 999.9	Standard deviation of semi-major axis of error ellipse[meter]
4	x.x	Null[1], 000.0 to 999.9	Standard deviation of semi-minor axis of error ellipse [meter]
5	x.x	Null[1], 000.0 to 180.0	Orientation of semi-major axis of error ellipse[degree] (Degrees from true north)
6	x.x	Null[1], 000.0 to 999.9	Standard deviation of latitude error [meter]
7	x.x	Null[1], 000.0 to 999.9	Standard deviation of longitude error [meter]
8	x.x	Null[1], 000.0 to 999.9	Standard deviation of altitude error [meter]

Example:

$GNGST,111904.800,9.2,2.2,1.9,64.0,1.9,1.7,1.5*46
$GNGST,000011.340,,,,,,,*50

Notes:

1) These fields are null fields when it is impossible to calculate these standard deviations.

10.7 GSV – Satellites in View

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. Unknown items are output as null field.

$GPGSV sentences shows GPS, SBAS and QZSS satellites data, $GLGSV shows GLOANASS satellite data. When multi-satellite systems are used, GSV sentences are output in order of $GPGSV, $GLGSV. The satellite system in GPGSV is output in order of GPS, SBAS and QZSS.

The output order of Satellite data (other than SBAS and QZSS) is as follows.
- Until calculating satellite position: Ascending order of PRN No.
- After calculating satellite position: Descending order of satellite elevation

Format:

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

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

Field	Data type	Range	Description
1	x	1 to 4	Total number of messages
2	x	1 to 4	Sentence Number
3	x	00 to 16	Satellites in view
4	xx	01 to 99	1st satellite number[1)]
5	xx	00 to 89	1st satellite elevation [degree]
6	xxx	000 to 359	1st satellite azimuth in degrees to true
7	xx	00 to 69	1st satellite CN_0 [dB-Hz]
8-11		-[2)]	2nd satellite data (The satellite data like the field #4-#7)
12-15		-[2)]	3rd satellite data (The satellite data like the field #4-#7)
16-19		-[2)]	4th satellite data (The satellite data like the field #4-#7)
20	h	1	Signal ID 1: L1 C/A (GPS), G1 C/A (GLONASS)

Example:

$GPGSV,3,1,11,17,66,333,53,20,57,055,51,28,46,217,50,04,33,278,46,1*63
$GPGSV,3,2,11,32,28,045,45,01,26,062,45,23,24,117,47,11,14,083,41,1*66
$GPGSV,3,3,11,13,10,149,40,50,00,000,46,93,84,353,51,,,,,1*5F

→ Sentence Number
→ Total number of Message

Notes:

1) The numbers of each satellite system are as follows:
   GPS:01 to 32 : Same as PRN No.
   SBAS:33 to 51 : Subtract 87 from PRN No.
   QZSS:93 to 97 : Subtract 100 from PRN No.
   GLONASS:65 to 96 : Same as PRN No.
2) Same range as filed 4 to 7.

10.8 RMC – Recommended Minimum Navigation Information

Format:

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

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

Field	Data type	Range	Description
1	hhmmss.sss	000000.000 to 235959.999	UTC time[1)] 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.x	-	Speed over ground [knot]
8	x.x	0.00 to 359.99	Course over ground, degrees true
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	Null	-	Not supported field
11	Null	-	Not supported field
12	a	A,D,E,N[2)]	Mode Indicator A: Autonomous D: Differential E: Estimated/ Dead Reckoning N: Data Invalid
13	a	V	Navigational Status Indicator V: Invalid[3)]

Example:
$GNRMC,092406.800,A,3442.8211,N,13520.1148,E,0.01,353.80,230812,,,D,V*0A

Notes:

1) This receiver updatable UTC date is as follow table.

Backup Data	UTC upper limit
Backup data is invalid	August 20th, 2034 23:59:59
Backup data is available	December 31st, 2099 23:59:59 (System upper limit)

2) In case of multi-Hz update, it takes up to one second to become mode A, D or E from PERDSYS,FIXSESSION,ON output.
3) Field 13 is always output "V", because the DR receiver does not support RAIM function.

10.9 VTG – Course Over Ground & Ground Speed

Format:

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

Field	Data type	Range	Description
1	x.x	0.00 to 359.99	Course over ground, degrees True
2	T	T	"T" (True)
3	Null	-	Not supported field
4	M	M	"M" fixed
5	x.x	-	Speed over ground, [knot]
6	N	N	"N" (knots)
7	x.x	-	Speed over ground, [km/h]
8	K	K	"K" (Kilo meters/ Hour)
9	a	A,D,E,N1)	Mode Indicator A: Autonomous D: Differential2) E: Estimated/ Dead Reckoning N: Data Invalid

Example:
$GPVTG,156.27,T,,M,0.00,N,0.01,K,A*3B

Notes:
1) In case of multi-Hz update, it takes up to one second to become mode A, D or E from PERDSYS,FIXSESSION,ON output.
2) When three and more satellites are corrected by SBAS satellites, the receiver becomes to differential fix.

10.10 ZDA – Time & Date

Format:

$--ZDA	,	hhmmss.sss	,	xx	,	xx	,	xxxx	,	xx	,	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	to 2099	UTC Year
5	Null	-	Not supported field
6	Null	-	Not supported field

Example:
$GNZDA,092406.670,23,08,2012,,*48

Notes:
1) This receiver updatable UTC date is as follow table.

Backup Data	UTC upper limit
Backup data is invalid.	August 20th, 2034 23:59:59
Backup data is available.	December 31st, 2099 23:59:59 (System upper limit)

11 Proprietary NMEA Inputs

There are proprietary input commands. The valid commands only can be received. When an input command is received, ACK sentence is returned.

11.1 API – e*Ride* GNSS Core Library Interface

11.1.1 ANTIJAM – Anti Jamming

This command enables additional Anti Jamming hardware in the DR receiver.

Format:

$PERDAPI	,	ANTIJAM	,	mode	[,	notch]	*hh	<CR>	<LF>
		1		2		3			

Field	Data type	Range	Default	Description
1	ANTIJAM	-	-	Command Name
2	mode	GP,GL,USER	GP	Mode
3	notch	0 to 8[1)]	8	1.575GHz bandwidth allocation of notch filters

Example:
$PERDAPI,ANTIJAM,GP*18
$PERDAPI,ANTIJAM,USER,6*04[2)]

Notes:
1) Setting mode to GP means that the 8 notch filters are prioritized for GPS and setting mode to GL means that the notch filters are prioritized for GLONASS.
2) In the second example, where mode is USER, 6 notch filters are dedicated for GPS and 2 (8-6) are dedicated for GLONASS.

11.1.2 CROUT

This command controls the output of advanced proprietary ASCII Data type (PERDCRx). It can be sent at any time, and the debug output will immediately begin.

PERDCRx strings are not output by default. They are output after the standard NMEA sentences. The output order and the timing of them are as following table.

Output order	Sentence Type	Sub Type	Output Timing
First	PERDCRV	-	1Hz
	PERDCRD,	I	Every fix rate[1]
		R	
		C	
	PERDCRF	GxANC[2]	1Hz
		GxACC[2]	
	PERDCRI,	A	Every fix rate[1]
		G	
Last		O	

Notes:
1) These sentences are not output if corresponding data are not detected.
2) “x” shows the satellite type.

Format:

$PERDAPI	,	CROUT	,	codes	[,	off]	*hh	<CR>	<LF>
		1		2		3			

Field	Data type	Range	Default	Description
1	CROUT	-	-	Command Name
2	codes	F, V, D, I ALLOFF	ALLOFF	List of CRx letter codes to output. ALLOFF is a special key to disable all CRx Data type.
3	off	0	-	Disable individual code.

Example:
$PERDAPI,CROUT,DI*09
$PERDAPI,CROUT,ALLOFF*0A

11.1.3 DATUM – Geodetic Datum

This command configures the geodetic datum.

Format:

$PERDAPI	,	DATUM	,	nnn	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	DATUM	-	-	Command Name
2	nnn	001,172	001	Datum Number 001:WGS-84 172: Tokyo datum

Example:
$PERDAPI,DATUM,001*23
$PERDAPI,DATUM,172*26

11.1.4 EXTENDGSA – GSA Re-definition

This command adds extra fields to the GSA sentence to show more than 12 satellites used in the fix. Using this command will break NMEA compliance.

Format:

$PERDAPI	,	EXTENDGSA	,	num	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	EXTENDGSA	-	-	Command Name
2	num	12 to 16	12	Number of fields for satellites used in the fix

Example:
$PERDAPI,EXTENDGSA,14*0D

11.1.5 EXTENDNMEARSL – Extend NMEA Sentence Resolution

This command extends the NMEA sentence resolution[1).

Format:

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

Field	Data type	Range	Default	Description
1	EXTENDNMEARSL	-	-	Command name
2	mode	ON, OFF	OFF	Standard NMEA sentence resolution ON: Extend OFF: Not extend

Example:
$PERDAPI,EXTENDNMEARSL,ON*16

Notes:
1) The standard NMEA sentence resolution is extended as below.

NMEA sentence	Field	Item	Extended resolution
GGA	Field2	Latitude	1/10000 ⇒ 1/100000
	Field4	Longitude	1/10000 ⇒ 1/100000
	Field9	Sea level Altitude	1/10 ⇒ 1/100
	Field11	Geoid altitude	1/10 ⇒ 1/100
GLL	Field1	Latitude	1/10000 ⇒ 1/100000
	Field3	Longitude	1/10000 ⇒ 1/100000
GNS	Field2	Latitude	1/10000 ⇒ 1/100000
	Field4	Longitude	1/10000 ⇒ 1/100000
	Field9	Sea level altitude	1/10 ⇒ 1/100
	Field10	Geoid altitude	1/10 ⇒ 1/100
RMC	Field1	Latitude	1/10000 ⇒ 1/100000
	Field3	Longitude	1/10000 ⇒ 1/100000
	Field7	Velocity (Knot)	1/100 ⇒ 1/1000
	Field8	Course over ground	1/100 ⇒ 1/1000
VTG	Field1	Course over ground	1/100 ⇒ 1/1000
	Field5	Velocity (Knot)	1/100 ⇒ 1/1000
	Field7	Velocity (Km/h)	1/100 ⇒ 1/1000

11.1.6 FIXMASK – Mask Configuration

This command allows for the configuration of accuracy vs. sensitive fixes. The elevmask setting is applied after first fix. This command except for elevmask setting applies to all fix outputs, not just the first session or re-acquisition fix.

Format:

$PERDAPI	,	FIXMASK	,	mode	[,	elevmask	,	ephagemask	,	snrmask	,	tsmmask]	*hh	<CR>	<LF>
		1		2		3		4		5		6			

Field	Data type	Range	Default	Description
1	FIXMASK	-	-	Command Name
2	mode	SENSITIVITY[1], ACCURACY[2], USER	SENSITIVITY	Mode
3	elevmask	0 to 90	0	Elevation mask [degree]. Only SVs above this mask are used in the position fix calculation.
4	ephagemask	0 to 14400	14400	Ephemeris age mask [second]. Only SVs whose age is within threshold are used in the position fix calculation.
5	snrmask	0 to 49	0	CN_0 mask [dB-Hz]. Only SVs above this mask are used in the position fix calculation.
6	tsmmask	0,1	0	Value mask. 0: Tracking SVs which have available ephemeris are used in the position fix calculation. 1: Only SVs with TSM measurements are used in the position fix calculation.

Example:
$PERDAPI,FIXMASK,ACCURACY*05
$PERDAPI,FIXMASK,USER,10,7200,37,1*38

Notes:
1) SENSITIVITY sets the DR receiver to output more fixes in weaker signal environments.
2) ACCURACY requires the DR receiver to meet a higher integrity standard before declaring a fix valid. The above second example is ACCURACY mode parameters.

11.1.7 GNSS

This command controls which Global Navigation Satellite Systems are used by the DR receiver.

Format:

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

Field	Data type	Range	Default	Description
1	GNSS	-	-	Command Name
2	Talkerid1)	AUTO,GN, LEGACYGP	GN	NMEA talker id.
3	gps	-1,0,1,2,32)	2	GPS Mode
4	glonass	-1,0,1,2,32)	3	GLONASS Mode
5	reserved	0	0	Fixed value
6	qzss	-1,0,1,2,32)	3	QZSS Mode
7	sbas	-1,0,1,2,32)	3	SBAS Mode

Example:
$PERDAPI,GNSS,GN,2,3,0,3,3*46

Notes:
1) The talkerid of GN means to always use GN as the prefix for reporting these NMEA Data type: GNS/RMC/GGA/GLL/VTG/ZDA. AUTO means to use GN if multiple systems are used in the fix and the talkerid of the individual system (i.e. GP) if only a single system is used. LEGACYGP means to output using a GP prefix, even if there are multiple systems in the fix. Consequently, non-GPS GSA and GSV Data type will not be output.
2) The mode can be set to -1,0,1,2,3 for each satellite system. “-1” means to keep the current configuration, “0” means to disable the system, “1” means to enable tracking only (do not use in position fix), “2” means to enable tracking and use the in position fix calculation, and “3” means to use only after first fix (do not use in first fix calculation).

11.1.8 PIN – Static Pinning

This command controls the static pinning strength. This function is that the DR receiver keeps current position while the DR receiver determines that it stops.

Format:

$PERDAPI	,	PIN	,	strength	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	PIN	-	-	Command Name
2	strength	STRONG, OFF	STRONG	Pinning ON/OFF STRONG: Pinning ON OFF: Pinning OFF

Example:
$PERDAPI,PIN,STRONG*1F
$PERDAPI,PIN,OFF*43

11.1.9 PPS – PPS (Pulse per Second)

This command enables the PPS (Pulse per Second) function. When "type" field is OFF, the field 3 to field 6 are omissible.

Format:

$PERDAPI	,	PPS	,	type	,	mode	,	period	,	[pulsewidth	,	cabledelay]	*hh	<CR>	<LF>
		1		2		3		4		5		6			

Field	Data type	Range	Default	Description
1	PPS	-	-	Command Name
2	type	OFF,FINE	FINE	PPS Output Type OFF: PPS output OFF FINE: PPS output ON
3	mode	1,2	1	PPS Output Mode 1: Always ON 2: ON After Fix[1)]
4	period	1000, 2000	1000	Pulse Interval [millisecond]
5	pulsewidth	1 to 500	200	Width PPS pulse [millisecond]
6	cabledelay	-100000 to 100000	0	Cable delay [nanosecond]

Example:
$PERDAPI,PPS,OFF*47
$PERDAPI,PPS,FINE,2,1000,200,0*3D

Notes:
1) In On After Fix mode, PPS will not be output until after internal fix thresholds are met.

11.1.10 SBASBLS – SBAS Search Select

This command controls which SBAS satellite is searched as a priority satellite.

Format:

$PERDAPI	,	SBASBLS	,	provider_id	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	SBASBLS	-	-	Command Name
2	provider_id	0 to 3, 255, QUERY	2	Priority of Searched SBAS Satellite 0: WAAS, 1: EGNOS, 2: MSAS, 3: GAGAN 255: Blind search in ascending order of PRN QUERY: Request a searching provider_id

Examples:

$PERDAPI,SBASBLS,0*35	SBAS satellite search from WAAS
$PERDAPI,SBASBLS,1*34	SBAS satellite search from EGNOS
$PERDAPI,SBASBLS,2*37	SBAS satellite search from MSAS
$PERDAPI,SBASBLS,3*36	SBAS satellite search from GAGAN
$PERDAPI,SBASBLS,255*37	Blind search in ascending order of PRN
$PERDAPI,SBASBLS,QUERY*4F	Request a searching provider_id

11.1.11 START – Start the GNSS Core Library

This command starts a GNSS fix session. In case of sending START command, operation status of the DR receiver must be “Fixsession OFF”. Table 11.1 shows the relation between the START mode and back up data clear configuration.

Table 11.1 Backup Data Clear Configuration

Receiver Data	Clear mode			
	HOT	WARM	COLD	SIMCOLD
Latitude/Longitude/ Heading	Backed-up value used	Backed-up value used	Returned to default	Returned to default
Date Time	Backed-up value used	Backed-up value used	Returned to default	Returned to default
Almanac Data	Backed-up value used	Backed-up value used	Backed-up value used	Deleted
Ephemeris Data	Backed-up value used	Deleted	Deleted	Deleted
DR Parameter[1)]	Backed-up value used	Backed-up value used	Deleted	Deleted

Notes:
1) It is parameters for the position assistance information. See Chapter 1 for the position assistance information.

Format:

$PERDAPI	,	START	[,	mode]	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	START	-	-	Command Name
2	mode	HOT,WARM, COLD,SIMCOLD	HOT	Type of start to perform

Example:
$PERDAPI,START*37
$PERDAPI,START,HOT*48
$PERDAPI,START,WARM*12
$PERDAPI,START,COLD*1F
$PERDAPI,START,SIMCOLD*48

11.1.12 STOP/STOPNOFPR – Stop the GNSS Core

This command ends the current fix session. Figure 11.1 shows a stop sequence with STOP command.

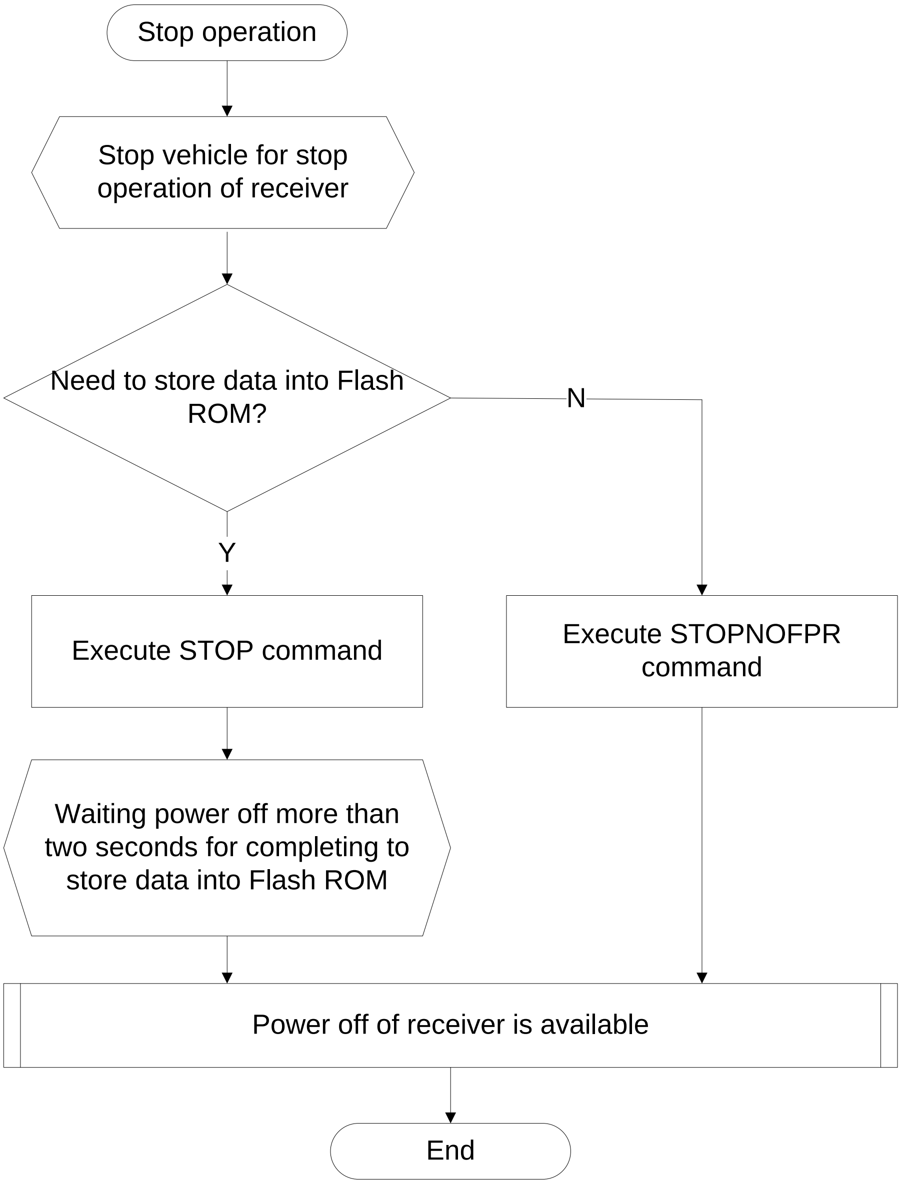


Figure 11.1 Stop Sequence of the DR Receiver

Format:

$PERDAPI	,	STOP STOPNOFPR	,	Drpark	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	STOP STOPNOFPR	-	-	Command name
2	Drpark	DRPARK	-	Backup data is stored in FLASH memory by STOP command.

Example:
$PERDAPI,STOP,DRPARK*5D

11.1.13 TIME – Time Aiding

This command provides a time aiding to the DR receiver. The acceptable date range is Jan 1, 2015 through Dec 31, 2099. The time provided in the command will not be adopted if the uncertainty is greater than the current internal uncertainty.

Format:

$PERDAPI	,	TIME	,	timeofday	,	day	,	month	,	year	,	uncertainty	*hh	<CR>	<LF>
		1		2		3		4		5		6			

Field	Data type	Range	Default	Description
1	TIME	-	-	Command Name
2	timeofday	000000 to 235959	-	UTC Time HHMMSS HH: hour, MM: minute, SS: second
3	day	1 to 31	-	UTC day
4	month	1 to 12	-	UTC month
5	year	2015 to 2099	-	UTC year
6	uncertainty	< 10	-	Time uncertainty in seconds.

Example:
$PERDAPI,TIME,021322,24,11,2015,10*4F

11.2 CFG – Application Software Configuration

11.2.1 ESIPLIST – Save ESIP Commands to FLASH

This command is just available at Fix session OFF state. The command in ESIPLIST is not executed during creating ESIPLIT.

Format:

$PERDCFG	,	ESIPLIST	,	action	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	ESIPLIST	-	-	Command Name
2	action	NEW, APPEND, CLOSE, DELETE, QUERY, EXECUTE	-	The type of data to allocate -NEW: Initiate to create newly ESIPLIST. -APPEND: Add command to the stored ESIPLIST as updated ESIPLIST. -CLOSE: Complete to register commands with ESIPLIST. -DELETE: Delete commands in ESIPLIST. -QUERY: Execute echo back of registered command in ESIPLIST. Start process of the echo back is based on replying with "BEGIN" as a header. End process is based on completing with END as footer after sending one sentence by sentence. -EXECUTE: Execute registered command in ESIPLIST immediately.

Example:
$PERDCFG,ESIPLIST,NEW*10
$PERDCFG,ESIPLIST,QUERY*06

11.2.2 FACTORYRESET – Clear Non-Volatile Memory

This command is used to erase all non-volatile memory in order to restore the DR receiver to its factory state. This command is just available at Fix session OFF state. It may take around 30 seconds to receive PERDACK sentence after sending this command.

Format:

$PERDCFG	,	FACTORYRESET	*hh	<CR>	<LF>
		1			

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

Example:
$PERDCFG,FACTORYRESET*6C

11.2.3 NMEAOUT – Configure the Standard NMEA Outputs

This command controls which standard NMEA sentences are transmitted by the DR receiver. This command can be sent at any time and will take effect immediately. Table 11.2 shows output sequence and default output of standard NMEA sentence.

Table 11.2 Output Order of Standard NMEA

Output Sequence	Data Type	Data type	Default output
Fast	RMC	Recommended Minimum Navigation Information	●
	GNS	GNSS Fix Data	●
	GGA	Global Positioning System Fix Data	N/A
	GLL	Geographic Position - Latitude/Longitude	N/A
	VTG	Course Over Ground and Ground Speed	N/A
	GST	GNSS Pseudo range Error Statistics	●
	GBS	GNSS Satellite Fault Detection	N/A
	GSA	GPS DOP and Active Satellites	●
	ZDA	Time & Date	●
Last	GSV	Satellite data	●

Format:

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

Field	Data type	Range	Default	Description
1	NMEAOUT	-	-	Command Name
2	type	GBS, GGA, GLL, GNS, GSA, GST, GSV, RMC, VTG, ZDA	See Table 11.2	Three-letter designation for sentence being configured.
3	interval	0 to 60	1	Number of fixes between reports. 0: disable the output

Example:
$PERDCFG,NMEAOUT,GGA,2*57
$PERDCFG,NMEAOUT,GSV,0*56

11.2.4 UART1 – Configure Serial Communications

This command configures the serial communications port. See Section 7.7 about changing the UART communication configuration.

Format:

$PERDCFG	,	UART1	,	baud	[,	databits	,	parity	,	stopbits	*hh	<CR>	<LF>
		1		2		3		4		5			

Field	Data type	Range	Default	Description
1	UART1	-	-	Command Name
2	baud	4800, 9600, 19200, 38400, 57600, 115200, 230400	115200	Baud rate
3	databits	8	8	Byte size
4	parity	NONE,EVEN,ODD	NONE	The parity format
5	stopbits	1,2	1	Number of Stop bit

Example:
$PERDCFG,UART1,115200*65
$PERDCFG,UART1,230400,8,ODD,2*0E

11.3 SYS – Control / Query the PVT System

11.3.1 ANTSEL – Antenna Selection Control

This command configures the antenna inputs.

Format:

$PERDSYS	,	ANTSEL	,	mode	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	ANTSEL	-	-	Command Name
2	mode	FORCE1H, FORCE1L, FLEXFS, QUERY	FLEXFS	Mode -FORCE1H: High gain mode of LNA1 -FORCE1L : Low gain mode of LNA1 -FLEXFS: LNA mode is configured by FLNA pin -QUERY: Receiver sends status of current antenna configuration with PERDSYS,ANTSEL sentence..

Example:
$PERDSYS,ANTSEL,FORCE1H*7F

11.3.2 BBRAM

This command enables the Data type of BBRAM to be passed to the Host Application. It is useful in scenarios where VBK is not powered and the customer would like to maintain HOT start capability. This command is only sent while the fix session is OFF.

The DR receiver software uses b64: Base-64 Encoding Library. This library copyright (include the discharge) is described at the end of the document.

11.3.2.1 BBRAM – Query Command

Format:

$PERDSYS	,	BBRAM	,	QUERY	[,	format]	*hh	<CR>	<LF>
		1		2		3			

Field	Data type	Range	Default	Description
1	BBRAM	-	-	Command Name
2	QUERY	-	-	Sub-Command Name
3	format	ESIPB64, MULTIB64[1)]	MULTIB64	Encoding format.

Example:
$PERDSYS,BBRAM,QUERY*4E
$PERDSYS,BBRAM,QUERY,ESIPB64*2D

Notes:
1) In ESIPB64 and MULTIB64, the raw data is Base-64 encoded into properly formatted NMEA sentences. MULTIB64 conforms to the NMEA specification for multiple Data type, where the data payload is preceded by the total number of sentences the current sentence number.

11.3.2.2 BBRAM – Push Strings

These input strings match the output strings that resulted from the above QUERY command. The Host Application inputs these at the subsequent power up. There is no corresponding PERDACK when inputting these Data type.

Format:

$PERDSYS	,	BBRAM	[,	supportdata,	] *hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	BBRAM	-	-	Command Name
2	supportdata	-	-	

Example:
$PERDSYS,BBRAM,189,001,MQFlMwe73jcDCAMIQnYOtEP+mt0AAA2DAAxR7AAACS8AAAApAAQ/*24
$PERDSYS,BBRAM,CHECKSUM,-962385454*3E[1)]

Notes:
1) A PERDSYS,BBRAM,[PASS|FAIL] string is output upon reception of the CHECKSUM substring.

11.3.3 GPIO – General Purpose Input/ Output for reverse signal

This command queries the state of the GPIO pins.

Format:

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

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

Example:
$PERDSYS,GPIO*67

11.3.4 RECPLAY

This command enables diagnostics mode. Figure 11.2 shows a process flow of RECPLAY execution.

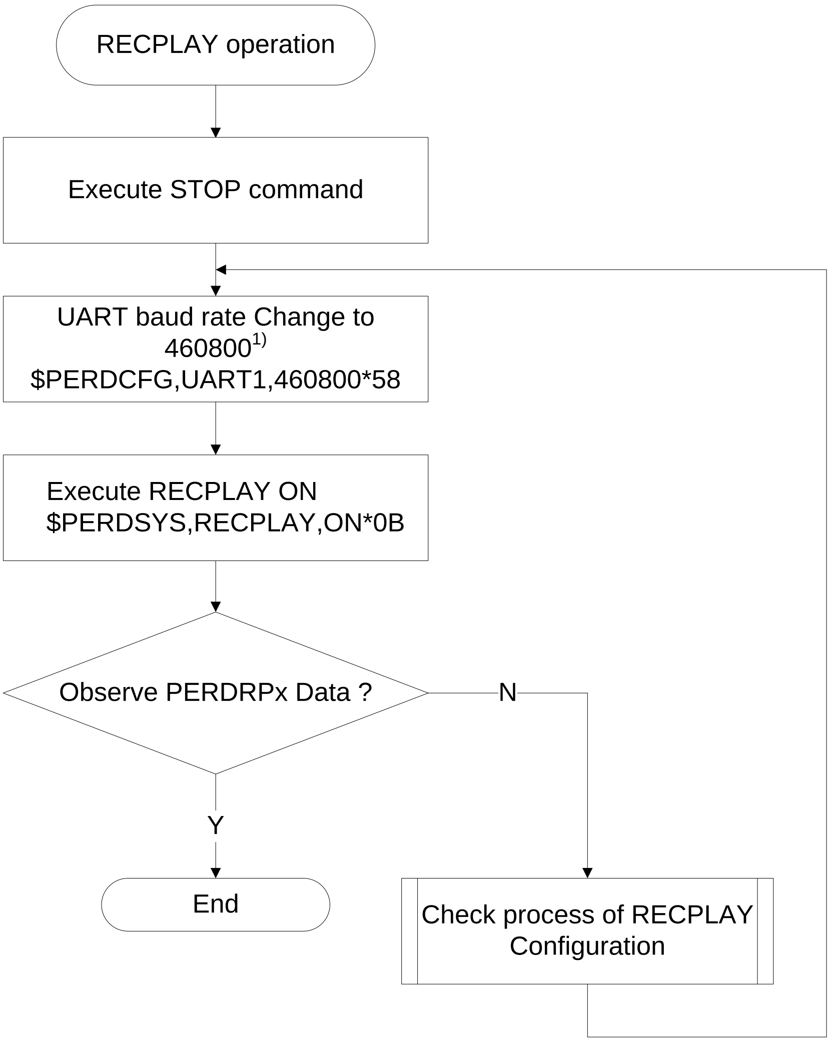


Figure 11.2 RECPLAY Execution

Format:

$PERDSYS	,	RECPLAY	,	mode	*hh	<CR>	<LF>

1 2

Field	Data type	Range	Default	Description
1	RECPLAY	-	-	Command Name
2	mode	OFF,ON	OFF	Output Mode

Example:
$PERDSYS,RECPLAY,ON*0B
$PERDSYS,RECPLAY,OFF*45

Notes:
1) In case user does not change to 460800 bps, user observes unexpected DR performance due to internal latency process issue.

11.3.5 VERSION – Ccontrol the GNSS Chip Set Power Mode

Query the DR receiver for software version Information. The response string is also PERDSYS,VERSION.

Format:

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

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

Example:
$PERDSYS,VERSION*2C

12 Dead Reckoning Input Sentences

12.1 API

12.1.1 GYROALIGN – Set Misalignment Angle of Gyro Sensor

This command configures the difference of the coordinate axis (Installation error) between the vehicle and the gyro sensor. It is recommended to execute GYROALIGN command with ESIPLIST. In case of not using ESIPLIST, execute the command after sending PERDAPI,STOP or PERDAPI,STOPNOFPR command and restart with PERDAPI,START,SIMCOLD command. This command cannot be used with AUTOORIENT command at the same time.

Format:

$PERDAPI	,	GYROALIGN	,	roll	,	pitch	,	yaw	*hh	<CR>	<LF>
		1		2		3		4			

Field	Data type	Range	Default	Description
1	GYROALIGN	-	-	Command name
2	roll	-180.0 to 180.0	0	[SMI130 or MPU-6500/ITG-3500] Real number of Roll mis-alignment [degree]
		±45.0 -165.0 to -180.0 165.0 to 180.0	0	[A3G4250D] Real number of Roll mis-alignment [degree]
3	pitch	-90.0 to 90.0	0	[SMI130 or MPU-6500/ITG-3500] Real number of Pitch mis-alignment [degree]
		-45.0 to 45.0	0	[A3G4250D] Real number of Pitch mis-alignment [degree]
4	yaw	0.0 to 359.9	0	Real number of Yaw mis-alignment [degree]

Example:
$PERDAPI,GYROALIGN,0,20,0*17
$PERDAPI,GYROALIGN,1.0,2.3,0.5*3E

12.1.2 ACCELALIGN – Set Misalignment Angle of Accelerometer

This command configures the difference of the coordinate axis (Installation error) between the vehicle and the accelerometer. It is recommended to execute ACCELALIGN command with ESIPLIST. In case of not using ESIPLIST, execute the command after sending PERDAPI,STOP or PERDAPI,STOPNOFPR command and restart with PERDAPI,START,SIMCOLD command. This command cannot be used with AUTOORIENT command at the same time.

Format:

$PERDAPI	,	ACCELALIGN	,	roll	,	pitch	,	yaw	*hh	<CR>	<LF>
		1		2		3		4			

Field	Data type	Range	Default	Description
1	ACCELALIGN	-	-	Command name
2	roll	-180.0 to 180.0	0	[SMI130 or MPU-6500] Real number of Roll mis-alignment [degree]
		±45.0 -165.0 to -180.0 165.0 to 180.0	0	[AIS328DQ] Real number of Roll mis-alignment [degree]
3	pitch	-90.0 to 90.0	0	[SMI130 or MPU-6500] Real number of Pitch mis-alignment [degree]
		-45.0 to 45.0	0	[AIS328DQ] Real number of Pitch mis-alignment [degree]
4	yaw	0.0 to 359.9	0	Real number of Yaw mis-alignment [degree]

Example:
$PERDAPI,ACCELALIGN,0,20,0*5C
$PERDAPI,ACCELALIGN,1.0,2.3,0.5*75

12.1.3 AUTOORIENT – Auto Orientation

This command extends the available range of the auto orientation function. In case of using AUTOORIENT, it is necessary to use three-axis accelerometer for automatically calculating installation angle of IMU sensor. As an operating condition of AUTOORIENT, it is not available of combination of GYROALIGN and ACCELALIGN command. It is recommended to execute AUTOORIENT command with ESIPLIST. In case of not using ESIPLIST, execute it after sending PERDAPI,STOP or PERDAPI,STOPNOFPR command and restart with PERDAPI,START,SIMCOLD command.

Format:

$PERDAPI	,	AUTOORIENT	,	enable	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	AUTOORIENT	-	-	Command Name
2	enable	0,1	0	Auto Orient Available Range 0: Default Range 1: Extended Range

Example:
$PERDAPI,AUTOORIENT,1*6E

12.1.4 DROUT

This command configures the output information for PERDCRD and PERDCRI sentence.It is necessary to output PERDCRD or PERDCRI sentence by CROUT command in advance.

Format:

$PERDAPI	,	DROUT	,	codes	,	sub codes	*hh	<CR>	<LF>
		1		2		3			

Field	Data type	Range	Default	Description
1	DROUT	-	-	Command Name
2	codes	D,I ALLOFF	ALLOFF	CRx letter codes to set D: CRD,x sentence[1)] I: CRI,x sentence[1)] ALLOFF: Disable CRD and CRI output
3	sub codes	I,R,C	I,R: Output[2)] C: Not output	[codes = D] I: IMU Adjusted Data R: IMU Sensor Result C: Calibration Data
		A,G,O	A,G,O: Output[3)]	[codes = I] A: Accelerometer Data G: Gyro Sensor Data O: Speed Pulse Data

Example:

$PERDAPI,DROUT,D,C*28	Output PERDCRD,C sentence only
$PERDAPI,DROUT,I,AGO*2F	Output all PERDCRI sentences
$PERDAPI,DROUT,ALLOFF*0D	Disable CRD and CRI sentences output

Notes:
1) These sentences are not output if corresponding data are not detected.
2) These sentences are output by default when CRD sentence is set to output by CROUT command.
3) These sentences are output by default when CRI sentence is set to output by CROUT command.

12.1.5 ODOREVERSE – Reverse Signal

This command configures logic of Forward and Reverse signal.

Format:

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

Field	Data type	Range	Default	Description
1	ODOREVERSE	-	-	Command Name
2	mode	0,1	0	Mode 0: High level signal: REVERSE Low level signal: FORWARD 1: High level signal: FORWARD Low level signal: REVERSE

Example:
$PERDAPI,ODOREVERSE,1*6E

12.1.6 ETCONFIG – Position Feedback Configuration

This command configures the position feedback threshold parameters. It may not need to input this command when using the position feedback because the default parameters have been set.

When the DR receiver determines that the feedback position is reliable, the reliability for feedback position will be increased. Then, when the reliability is more than a specified value, the feedback position is reflected to the position fix. When the reliability does not reach the value, the feedback position is not reflected.

When any of the following conditions continue, the DR receiver considers that the feedback data is not reliable:
- The DR receiver detects a smaller change in the heading than “gdeg” and the azimuth error between GNSS heading and feedback heading is bigger than “bdeg”.
- The distance between GNSS horizontal position and feedback horizontal position is bigger than “brel” and the deviation of DR receiver internal position is lower than “brel”.
- The distance between GNSS horizontal position and feedback horizontal position is bigger than “bdeg”.

When all of the following conditions continue, the DR receiver considers that the feedback data is reliable:
- The DR receiver measured the GNSS position.
- The distance between GNSS horizontal position and feedback horizontal position is lower than “rel”.
- The azimuth error between GNSS heading and feedback heading is lower than “gdeg”.

Format:

$PERDAPI	,	ETCONFIG	,	posoff	,	rel	,	brel	,	babs	,	gdeg	,	bdeg	,
		1		2		3		4		5		6		7	

turn	,	posup	*hh	<CR>	<LF>
8		9			

Field	Data Type	Range	Default	Description
1	ETCONFIG	-	-	Command Name
2	posoff	-1000 to 1000	-800	Time between the feedback position and the GNSS fix time [millisecond]
3	rel	0 to 255	25	Horizontal distance between GNSS and feedback position to consider feedback reliable. [meter]
4	brel	0 to 255	75	Horizontal distance between GNSS and feedback position to consider the feedback unreliable when the distance is bigger than this value. [meter]
5	babs	0 to 255	200	Horizontal distance between GNSS and feedback position to consider the feedback unreliable regardless of the GNSS confidence. [meter]
6	gdeg	0 to 359.9	5	Difference between GNSS heading and feedback heading to consider feedback reliable. [degree]
7	bdeg	0 to 359.9	15	Difference between GNSS heading and feedback heading to consider feedback unreliable. [degree]
8	turn	0 to 359.9	2	Threshold to consider a turn in progress. [degree] When the heading change of GNSS or feedback is bigger than this value, the DR receiver does not perform the determination of feedback position reliability.
9	posup	0 to 67108863	50	Distance to configure the timing to reflect the feedback position. [meter] When the distance from the last reflected feedback position exceeds this value, the position feedback will be reflected. However, the feedback data needs to pass the reliability determination.
10	Reserved	10	10	Fixed data

Field	Data Type	Range	Default	Description
11	Reserved	1	1	Fixed data
12	holdConf	0,1	0	Hold the reliability confidence at DR only fix 0: Decrease the reliability when the feedback data is unreliable. 1: Keep the reliability even if the feedback data is unreliable. Set to “1” when it is necessary to reflect the feedback data to the DR receiver continuously even in an environment where it is difficult to keep the feedback data accuracy.

Example:
$PERDAPI,ETCONFIG,-800,25,75,200,10,20,2,50,10,1,1*57

12.1.7 ETPOS - Input Position Feedback Information

This command should be input every second in order to use the position feedback. If the Map Matching is not performed, create ETPOS command with the positioning results of DR receiver.

Format:

$PERDAPI	,	ETPOS	,	time	,	lat	,	N/S	,	long	,	E/W	[,	head	,
		1		2		3		4		5		6		7	

alt	,	pitch	,	id	,	mode]	*hh	<CR>	<LF>
8		9		10		11			

Field	Data Type	Range	Default	Description
1	ETPOS	-	-	Command Name
2	time	-	-	UTC time that corresponds to the feedback position [second]
3	lat	0 to 90	-	Estimated true latitude (xxyy.zzzz: xx[degree], yy.zzzz[minute])
4	N/S	N,S	-	N: North, S: South
5	long	0 to 180	-	Estimated true longitude (xxyy.zzzz: xx[degree], yy.zzzz[minute])
6	E/W	E,W	-	E: East, W: West
7	head (optional)	0.0 to 359.9, -99	-	Estimated true heading [degree]
8	alt (optional)	-100 to 9999, -9999	-9999	Estimated true altitude [meter] -9999: Invalid
9	pitch (optional)	-90 to 90, -99	-99	Estimated true pitch [degree] -99: Invalid
10	id (optional)	0	0	Environment ID 0: Unknown
11	mode (optional)	0, 1	0	Confident Mode 0: Position Feedback function is used in case of DR only positioning. 1: Regardless of the reliability of the feedback data, Position Feedback function is used forcibly.

Example:
$PERDAPI,ETPOS,060400.800,3442.8442,N,13520.0228,E,90*0A
$PERDAPI,ETPOS,060400.800,3442.8442,N,13520.0228,E,90,37,-99,0,0*23
$PERDAPI,ETPOS,060400.800,3442.8442,N,13520.0228,E,90,-9999,4,0,0*13

12.2 SYS – System configuration

12.2.1 DRPERSEC – Set Update Rate of DR Positioning

This command enables to change the update rate of DR positioning. Use ESIPLIST to execute this command. Table 12.1 shows the relation between sentence type and valid update rate.

Table 12.1 Relation between Sentence Type and Valid Update Rate

Sentences	Valid Update Rate
RMC, GNS, GGA, GLL, VTG, GST, GBS, ZDA PERDCRD,I, PERDCRD,R, PERDCRD,C, PERDCRI,A, PERDCRI,G, PERDCRI,O	1,2,5,10
GSA, GSV, PERDCRF,GxACC, PERDCRF,GxANC, PERDCRV	1

Format:

$PERDSYS	,	DRPERSEC	,	Hz	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Default	Description
1	DRPERSEC	-	-	Command name
2	Hz	1,2,5,10	1	Update rate of DR positioning [Hz]

Example:
$PERDSYS,DRPERSEC,1*6F
$PERDSYS,DRPERSEC,2*6C
$PERDSYS,DRPERSEC,5*6B
$PERDSYS,DRPERSEC,10*5F

12.2.2 DRSELFTEST – Self-Test for IMU sensor

User can check normal operation of IMU senor with this command as self-test of IMU sensor. This command is available at Fix session OFF sate. In case the using accelerometer is AIS328DQ or LIS331DLH, input the model name in “model” field. This command does not support XV-8000CB and XV-8100CB since they are analog sensors.

Format:

$PERDSYS	,	DRSELFTEST	,	imutype	[,	model]	*hh	<CR>	<LF>
		1		2		3			

Field	Data type	Range	Default	Description
1	DRSELFTEST	-	-	Command name
2	imutype	ACCEL or GYRO	-	IMU Type GYRO: Gyro Sensor ACCEL: Accelerometer
3	model	AIS328DQ or LIS331DLH	-	Model Name

Example:
$PERDSYS,DRSELFTEST,GYRO*45
$PERDSYS,DRSELFTEST,ACCEL,AIS328DQ*55

13 Proprietary NMEA Output

The DR receiver will output proprietary data type to the host system. As with the inputs, standard NMEA format is used. Output data type will start with $PERD to indicate specific communication.

13.1 ACK – Command Acknowledgement

This string is sent in response to most correctly formed inputs to confirm successful receipt. It is up to the host to implement any error handling procedures. The commands must still pass checksum validate before any acknowledgement is sent. Input data type that pass checksum, but are incorrect formatted will return a sequence number of -1. “subcommand” will be "N/A" for Data type with inappropriate subcommand tokens.

Format:

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

Field	Contents	Range	Remark
1	command		Echoes the initial field of the command received by the client
2	sequence	-1, 0 to 255	Number of success regarding session sequence between the DR receiver and host processor. The number is incremented whenever session sequence between the DR receiver and host processor succeed. Initial number is 0 and rolling over at 255.In case of session sequence error, the DR receiver sends -1 as failure status.
3	subcommand		Second token of input command.

Example:
$PERDACK,PERDAPI,16,PIN*6D

13.2 CFG – Response to PERDCFG Input Commands

13.2.1 ADDON

This string lists the applicable user and feature set. It will also be output at power-up.

Format:

$PERDCFG	,	ADDON	,	name	,	feature	*hh	<CR>	<LF>
		1		2		3			

Field	Data type	Range	Description
1	ADDON	-	Command Name
2	name		
3	feature		

Example:
$PERDCFG,ADDON,N/A,BASIC*57
$PERDCFG,ADDON,GV8687,DEADRECK*26

13.2.2 ESIPLIST

This string is sent in response to the PERDCFG,ESIPLIST,QUERY command. It lists the commands in the ESIPLIST sector of FLASH. At least two Data type are output, the BEGIN and END labels. The data between the BEGIN and END labels are the exact ESIP commands input by the user.

Format:

$PERDCFG	,	ESIPLIST	,	label	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Description
1	ESIPLIST	-	Command Name
2	label	BEGIN, END	Indicates the start and end of the ESIPLIST data

Example:
$PERDCFG,ESIPLIST,BEGIN*0B
$PERDCFG,NMEAOUT,VTG,5*54
$PERDCFG,ESIPLIST,END*03

13.3 CRx – Core Library GNSS Data type

13.3.1 CRF – GNSS Accuracy and GPS Health

This sentence mimics proprietary FURUNO NMEA Data type. Two sub-types of this sentence are keyed with either GxACC or GxANC. Only the information of system specified by PERDAPI,GNSS command is output. Output Rate is 1Hz.

13.3.1.1 CRF,GxACC – GNSS Accuracy

The ‘GxACC’ key provides GNSS Satellite Accuracy information. $PERDCRF,GSACC sentence reports always “X” in latter half of field 2 (PRN139 to 158).

Format:

$PERDCRF	,	GxACC	,	accuracy	*hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Description
1	GxACC	-	Sub-Type Key "x" shows the following satellite type. P: GPS, L: GLONASS, Q: QZSS, S: SBAS
2	accuracy	0x0 to 0xF, X	GNSS accuracy data in ascending PRN No. sequence 0-F=accuracy in hexadecimal, X=not available GPS: 32 satellites, GLONASS: 24 satellites, QZSS: 5 satellites (PRN193 to 197), SBAS: 38 satellites (PRN120 to 138, 139 to 158)

Example:
$PERDCRF,GPACC,X1X10X0100XXXX0XXXXXXXX0X0XX1XXX*6A
$PERDCRF,GLACC,1XXXXX23343XXXXXXXXXX334*76
$PERDCRF,GQACC,0XXXX*33
$PERDCRF,GSACC,XXXXXXXXX7XXXXXXX7XXXXXXXXXXXXXXXXXXXX*59

13.3.1.2 CRF,GxANC – GNSS Health

The ‘GxANC’ key provides information of GNSS Almanac Date and GNSS Satellite Health. ”almdata” is time which last decoded health. ”almdata” is Null when the DR receiver has no health message.
$PERDCRF,GSANC sentence reports always “0” in latter half of field 2 (PRN139 to 158).

Format:

$PERDCRF	,	GxANC	,	almdata	,	health	*hh	<CR>	<LF>
		1		2		3			

Field	Data type	Range	Description
1	GxANC	-	Sub-Type Key "x" shows the following satellite type. P: GPS, L: GLONASS, Q: QZSS, S: SBAS
2	almdata	000101000000 to 991231235959	Date/Time of Almanac used to
3	health	0 to 2	Health for all GNSS satellites in ascending PRN No. sequence 0=Almanac not yet collected, 1=Unhealthy, 2=Healthy

Example:
$PERDCRF,GPANC,131220061259,02022022220000200000200202002000*29
$PERDCRF,GLANC,131220061300,222220222222222222222222*3A
$PERDCRF,GQANC,131202050103,20000*14
$PERDCRF,GSANC,131220061139,00000000000000000000000000000000000000*1F

13.3.2 CRV – Velocity information

This sentence provides the detailed velocity information with 1Hz update rate.

Format：

$PERDCRV	,	gpstime	,	qual	,	east	,	north	,	up	,	velsigma	,	possigma	,	*hh	<CR>	<LF>
1		2		3		4		5		6		7		8				

Field	Data Type	Range	Description
1	$PERDCRV	-	Command Name
2	gpstime	0.00 to 604799.90	GPS time
3	qual	0, 1, 2, 6	Position fix status 0: Fix not available 1: GNSS fix 2: Differential fix[1)] 6: Estimated /Dead Reckoning Mode
4	east	-	Velocity (Heading: West - East) [m/s]
5	north	-	Velocity (Heading: North - South) [m/s]
6	up	-	Velocity (Heading: Altitude) [m/s]
7	velsigma	0.1 to 44.0	Standard deviation of velocity [m/s]
8	possigma	1 to 13368000	Standard deviation of position [meter]

Example：
$PERDCRV,253206.00,2,-0.01,0.00,0.01,0.2,4*5F

Notes:
1) When three and more satellites are corrected by SBAS satellites, the receiver becomes to differential fix.

13.4 MSG – Event Driven Messages

This sentence comes up when the DR receiver has internal event as irregular process.

Format:

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

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

Example:
$PERDMSG,1A*06
$PERDMSG,5D,Cannot DELETE until CLOSED*53

13.5 RPx – Diagnostic Output Data

These set of Data type are diagnostic output data, used for debugging complex issues.

Format:

$PERDRP<x>	,	data	*hh	<CR>	<LF>
		1			

Field	Data type	Range	Description
1	data	-	Diagnostic Data

Example:
$PERDRPC,,AAAAAOI1FQBhDF0jeBqc//gGAIYK2QUAlwqSiw1/H9k9dABgCQCQCnE=,*4A
$PERDRPN,W28gTh3ST9/P3qPyac7XD0UmIQFYIjd+*36

13.6 SYS – PERDSYS Output Commands

The majority of these Data type are responses to PERDSYS input commands. Only FIXSESSION is output independent of a PERDSYS query.

13.6.1 ANTSEL – Antenna Selection Control Output

This sentence is reported at the following event:
- Initialization at power-on
- Reception of the QUERY command
- Change antenna configuration by ANTSEL command

Format:

$PERDSYS	,	ANTSEL	,	input	,	lnamode	*hh	<CR>	<LF>
		1		2		3			

Field	Data type	Range	Description
1	ANTSEL	-	Command Name
2	input	FORCE1H, FORCE1L FLEXFS	Mode specified in PERDSYS,ANTSEL input command.
3	lnamode	1AUTO 1HIGH 1LOW	LNA Mode 1AUTO :LNA1 is used, but gain selection is deferred to the Hardware. 1HIGH : LNA1 High gain mode 1LOW : LNA1 Low gain mode

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

13.6.2 BBRAM

This string is sent in response to the PERDSYS,BBRAM,QUERY command or upon proper initialization of BBRAM using ESIP commands. It represents Base64 encoded Battery-Backed RAM and comes as a series of Data type. The format specified in the input string drives the look of these output Data type. The DR receiver software uses b64: Base-64 Encoding Library. This library copyright (include the discharge) is described at the end of the document.

Format:

$PERDSYS	,	BBRAM	[,	supportdata,…	] *hh	<CR>	<LF>
		1		2			

Field	Data type	Range	Description
1	BBRAM	-	Command Name
2	supportdata	-	Additional data in various formats.

Example:

[MULTIB64 Format][1)]
$PERDSYS,BBRAM,189,001,MQFlMwe73jcDCAMIQnYOtEP+mt0AAA2DAAxR7AAACS8AAAApAAQ/*24

[ESIPB64 Format][2)]
$PERDSYS,BBRAM,ESIPB64,161,*7D
$PERDSYS,BBRAM,MQFlMwe73jcDCAMIQnYOtEP+mt0AAA2DAAxR7AAACS8AAAApAAQ/7AMIHpQB*7C

[CHECKSUM][3)]
$PERDSYS,BBRAM,CHECKSUM,-1817865088*0C

[Pass message][4)]
$PERDSYS,BBRAM,PASS*15

[Fail message][4)]
$PERDSYS,BBRAM,FAIL,CHECKSUM,309253690,1*27

Notes:

1) There are three additional fields: total sentences, sentence number and the base64 encoded data.
2) The first output sentence indicates how many data sentences are coming. The next set of sentences contains the base64 encoded data (without the sentence number information).
3) The CHECKSUM line is output for all formats and marks the end of the data that needs to be pushed back into the DR receiver at the subsequent power on.
4) After the data is pushed back into the DR receiver, a PASS or FAIL message will be sent.

13.6.3 FIXSESSION – GNSS Fix Session State Information

These Data type are output at various points of a fix session to indicate some event occurred.

Format:

$PERDSYS	,	FIXSESSION	,	state	,	appttff	,	corettff	*hh	<CR>	<LF>
		1		2		3		4			

Field	Data type	Range	Description
1	FIXSESSION	-	Command Name
2	state	ON,OFF, STANDBY, COAST	GNSS State
3	appttff		Application TTFF in milliseconds
4	corettff		Core Library TTFF in seconds

Example:
$PERDSYS,FIXSESSION,OFF*1C
$PERDSYS,FIXSESSION,ON,1396,0.925*7F

13.6.4 GPIO – General Purpose Input/ Output

This string is the reply to PERDSYS,GPIO command. It indicates the current state of the pins.

Format:

GPIO 0 8

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

Field	Data type	Range	Description
1	GPIO	-	Command Name
2	status	H,L	State from GPIO0 to GPIO8 H: HIGH L: LOW

Example:
$PERDSYS,GPIO,HHHHLLLLL*07

13.6.5 VERSION – Software Version Information

This sentence shows the device name and the program version with free format specifications at the following event:
- Initialization at power-on
- Reception of PERDSYS,VERSION command
- Change UART communication configuration by PERDCFG,UART1 command

Format:

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

Field	Data type	Range	Description
1	VERSION	-	Command Name
2	device	-	Name of device
3	version	-	Version Number for the Client and HAL
4	reason	BOOT QUERY UART1	Output condition BOOT: Power on QUERY: VERSION command is available UART1: Change communication configuration of UART
5	custom	GV8687	Customer Name

Example:
$PERDSYS,VERSION,OPUS7_SFLASH_MP_64P,ENP633A1414503F,QUERY,GV8687*17

14 Dead Reckoning Output Sentences

This section describes eSIP output sentences for DR function. Please refer to Section 11.1.2 for output setting of the sentences. In case IMU sensor is invalid, there is no output.

14.1 CRD – DR Positioning Result Data

14.1.1 PERDCRD,C – General Status Information of IMU and Vehicle Signal

This sentence shows general status information of IMU and vehicle signal based on PERDCRD,I, PERDCRD,R, PERDCRI,A, PERDCRI,G and PERDCRI,O.

Format:

$PERDCRD	,	C	,	imuVerified	,	drUseMode	,	imuParamconf	,	validGyro	,	imuParamconf Gyro	,	learnmode Gyro	,
1		2		3		4		5		6		7		8	

validAccel	,	imuParamconf Accel	,	learnmode Accel	,	validThermo	,	odomtrConf	,	odomtrdir	,
9		10		11		12		13		14	

roll	,	pitch	,	heading	*hh,	<CR>	<LF>
15		16		17			

Field	Data type	Range	Description
1	$PERDCRD	-	Command name
2	C	-	Sub command name as reliability information of DR source
3	imuVerified	0 to 3	IMU result verified mode 0: invalid, 1: valid, 2: uncertain, 3: garage
4	drUseMode	0 to 2	DR Use Mode 0: GNSS only 1: DR only 2: DR/GNSS mixed
5	imuParamconf	0 to 3	IMU parameter confidence 1: Initial value 2: Estimating initial bias 3: Correcting by sensor error estimation filter
6	validGyro	0 to 7	Axis to valid gyro sensor. See Table 14.1
7	imuParamconf Gyro	0 to 3	Gyro sensor parameter confidence 1: Initial value 2: Estimating initial bias 3: Correcting by sensor error estimation filter
8	learnmode Gyro	0 to 15	Gyro learn mode. See Table 14.2
9	validAccel	0 to 8	Axis to valid accelerometer. See Table 14.3
10	imuParamconf Accel	0 to 3	Accelerometer parameter confidence 1: Initial value 2: Estimating initial bias 3: Correcting by sensor error estimation filter
11	learnmode Accel	0 to 3	Accelerometer learn mode 0: Not learned 1: Bias learned 2: Mis-alignment learned 3: Bias and mis-alignment learned
12	validThermo	0 to 2	Valid thermometer 0: None 1: External thermometer 2: Internal thermometer

Field	Data type	Range	Description
13	odomtrConf	0, 1, 3, 7, 9, 11, 15	Speed pulse confidence 0: Unknown 1: Initialized 3: Estimating pulse counts per revolution 7: Estimating pulse counts error per revolution 9: Initialized and verified back signal 11: Estimating pulse counts per revolution and verified back signal 15: Estimation pulse counts error per revolution and verified back signal
14	odomtrdir	0 to 3	Speed pulse direction 0: Ignore, 1: Unknown, 2: Forward, 3: Reverse
15	roll	-180.0 to 180.0	IMU Roll angle [degree]
16	pitch	-180.0 to 180.0	IMU Pitch angle [degree]
17	heading	0.0 to 359.9	IMU heading [degree]

Table 14.1 Relation between “validGyro” and Valid Axis of Gyro Sensor

validGyro	0	1	2	3	4	5	6	7
X axis	-	●	-	●	-	●	-	●
Y axis	-	-	●	●	-	-	●	●
Z axis	-	-	-	-	●	●	●	●

Table 14.2 Relation between “learnmode” and Status of Learning Process of Gyro Sensor

learnmode	0	1	2	3	5	6	7	9	11	13	15
Offset	-	●	-	●	●	-	●	●	●	●	●
Mis-alignment	-	-	●	●	-	●	●	-	●	-	●
Gain	-	-	-	-	●	●	●	-	-	●	●
Temperature compensation	-	-	-	-	-	-	-	●	●	●	●

Table 14.3 Relation between “validAccel” and Valid Axis of Accelerometer

validAccel	0	1	2	3	4	5	6	7	8
X axis	-	●	-	●	-	●	-	●	**1)**
Y axis	-	-	●	●	-	-	●	●	
Z axis	-	-	-	-	●	●	●	●	

Example:
$PERDCRD,C,1,2,3,7,3,7,7,3,3,1,15,2,-0.4,0.0,103.7*24

Notes:
1) validAccel is set to “8” when DR positioning is done only with speed pulse and gyro sensor.

14.1.2 PERDCRD,I – IMU Adjusted Data

Format:

$PERDCRD	,	I	,	imuParamconf	,	validAccel	,	xAccel	,	yAccel	,	zAxxec	,	validGyro	,	xGyro	,	yGyro	,	zGyro	,
1		2		3		4		5		6		7		8		9		10		11	

validThermo	,	temperature	,	odomtrConf	,	xOdomtrVel	,	xOdomtrDir	*hh	<CR>	<LF>
12		13		14		15		16			

Field	Data type	Range	Description
1	$PERDCRD	-	Command name
2	I	-	Sub command name for IMU adjusted data
3	imuParamconf	0 to 3	IMU parameter confidence 0:Invalid, 1: Initial value, 2: Estimating initial bias 3: Correcting by sensor error estimation filter
4	validAccel	0 to 8	Axis to valid accelerometer. See Table 14.4
5	xAccel	-[1)]	X axis accelerometer data [m/s^2]
6	yAccel	-[1)]	Y axis accelerometer data [m/s^2]
7	zAccel	-[1)]	Z axis accelerometer data [m/s^2]
8	validGyro	0 to 7	Axis to valid gyro sensor. See Table 14.5
9	xGyro	-[1)]	X axis gyro sensor data [dps]
10	yGyro	-[1)]	Y axis gyro sensor data [dps]
11	zGyro	-[1)]	Z axis gyro sensor data [dps]
12	validThermo	0 to 2	Valid thermometer 0: None, 1: External thermometer, 2: Internal thermometer
13	temperature	-[1)]	Temperature data [degreeC]
14	odomtrConf	0, 1, 3, 7, 9, 11, 15	Speed pulse confidence 0: Unknown, 1: Initialized, 3: Estimating pulse counts per revolution 7: Estimating pulse counts error per revolution 9: Initialized and verified back signal 11: Estimating pulse counts per revolution and verified back signal 15: Estimation pulse counts error per revolution and verified back signal
15	xOdomtrVel	-99.99 to 999.99	X axis speed pulse velocity [m/s]
16	xOdomtrDir	0 to 3	Speed pulse direction 0: Ignore, 1: Unknown, 2: Forward, 3: Reverse

Table 14.4 Relation between "validAccel" and Valid Axis of Accelerometer

validAccel	0	1	2	3	4	5	6	7	8
X axis	-	●	-	●	-	●	-	●	2)
Y axis	-	-	●	●	-	-	●	●	
Z axis	-	-	-	-	●	●	●	●	

Table 14.5 Relation between "validGyro" and Valid Axis of Gyro Sensor

validGyro	0	1	2	3	4	5	6	7
X axis	-	●	-	●	-	●	-	●
Y axis	-	-	●	●	-	-	●	●
Z axis	-	-	-	-	●	●	●	●

Example:
$PERDCRD,I,3,7,0.1,0.2,-9.8,7,-0.1,-0.1,0.1,1,23.0,7,0.00,2*1B

Notes:
1) These fields depend on the IMU sensor.
2) validAccel is set to "8" when DR positioning is done only with speed pulse and gyro sensor.

14.1.3 PERDCRD,R – IMU Sensor Result

Format:

$PERDCRD	,	R	,	imuVerified	,	drUseMode	,	velNorth	,	velEast	,	velDown	,	roll	,	pitch	,
1		2		3		4		5		6		7		8		9	

heading	,	countsStatus	,	sigmaPos	*hh	<CR>	<LF>
10		11		12			

Field	Data type	Range	Description
1	$PERDCRD	-	Command name
2	R	-	Sub command name for IMU sensor result
3	imuVerified	0 to 3	IMU result verified mode 0: invalid, 1: valid, 2: uncertain, 3: garage
4	drUseMode	0 to 2	DR Use Mode 0: GNSS only, 1: DR only, 2: DR/GNSS mixed
5	velNorth	-99.99 to 999.99	IMU North velocity [m/s]
6	velEast	-99.99 to 999.99	IMU East velocity [m/s]
7	velDown	-99.99 to 999.99	IMU Down velocity [m/s]
8	roll	-180.0 to 180.0	IMU Roll angle [degree]
9	pitch	-180.0 to 180.0	IMU Pitch angle [degree]
10	heading	0.0 to 359.9	IMU heading [degree]
11	countsStatus	0 to 3	DR vehicle speed counts status 0: invalid, 1: speed pulse, 2,3: Reserved
12	sigmaPos	0 to 999	Standard deviation of estimated position error [meter]

Example:
$PERDCRD,R,1,2,-2.28,-12.12,0.16,-1.3,-0.5,260.5,3,17*17

14.2 CRI – IMU Sensor Data and Sensor Parameters

14.2.1 PERDCRI,A – Accelerometer Data

Format:

$PERDCRI	,	A	,	imuParamconf	,	validAccel	,	xRawAccel	,	yRawAccel	,	zRawAxxec	,	xGain	,	yGain	,
1		2		3		4		5		6		7		8		9	

zGain	,	xOffset	,	yOffset	,	zOffset	,	rollAlign	,	pitchAlign	,	yawAlign	,	learnmode	*hh	<CR>	<LF>
10		11		12		13		14		15		16		17			

Field	Data type	Range	Description
1	$PERDCRI	-	Command name
2	A	-	Sub command name for accelerometer data
3	imuParamconf	0 to 3	Accelerometer parameter confidence 1: Initial value 2: Estimating initial bias 3: Correcting by sensor error estimation filter
4	validAccel	0 to 8	Axis to valid accelerometer. See Table 14.6
5	xRawAccel	-[1)]	X axis accelerometer raw data [digit]
6	yRawAccel	-[1)]	Y axis accelerometer raw data [digit]
7	zRawAccel	-[1)]	Z axis accelerometer raw data [digit]
8	xGain	-[1)]	X axis accelerometer gain (LSB-18) [m/s^2/digit]
9	yGain	-[1)]	Y axis accelerometer gain (LSB-18) [m/s^2/digit]
10	zGain	-[1)]	Z axis accelerometer gain (LSB-18) [m/s^2/digit]
11	xOffset	-[1)]	X axis accelerometer offset [digit]
12	yOffset	-[1)]	Y axis accelerometer offset [digit]
13	zOffset	-[1)]	Z axis accelerometer offset [digit]
14	rollAlign[2)]	-180 to 180	Roll accelerometer mis-alignment [degree]
15	pitchAlign[2)]	-180 to 180	Pitch accelerometer mis-alignment [degree]
16	yawAlign[2)]	0 to 359	Yaw accelerometer mis-alignment [degree]
17	learnmode	0 to 3	Accelerometer learn mode 0: Not learned 1: Bias learned 2: Mis-alignment learned 3: Bias and mis-alignment learned

Table 14.6 Relation between “validAccel” and Valid Axis of Accelerometer

validAccel	0	1	2	3	4	5	6	7	8
X axis	-	●	-	●	-	●	-	●	3)
Y axis	-	-	●	●	-	-	●	●	
Z axis	-	-	-	-	●	●	●	●	

Example:
$PERDCRI,A,3,7,-3,33,-965,643,643,643,-12,11,-967,0,-1,2,3*30

Notes:
1) These fields depend on the IMU sensor.
2) When the pitch angle is set to ±90 degree by PERDAPI,ACCELALIGN command, these values may be not stable since the expression method for the misalignment angle is not determined uniquely. Even in this case, there is no problem if the installation angle combined the x,y,z axes misalignment angle is stable.
3) validAccel is set to “8” when DR positioning is done only with speed pulse and gyro sensor.

14.2.2 PERDCRI,G – Gyro Sensor Data

Format:

$PERDCRI	,	G	,	imuParamconf	,	validGyro	,	xRawGyro	,	yRawGyro	,	zRawGyro	,	xGain	,	yGain	,
1		2		3		4		5		6		7		8		9	

zGain	,	xOffset	,	yOffset	,	zOffset	,	rollAlign	,	pitchAlign	,	yawAlign	,	learnmode	*hh	<CR>	<LF>
10		11		12		13		14		15		16		17			

Field	Data type	Range	Description
1	$PERDCRI	-	Command name
2	G	-	Sub command name for gyro sensor data
3	imuParamconf	0 to 3	Gyro sensor parameter confidence 1: Initial value 2: Estimating initial bias 3: Correcting by sensor error estimation filter
4	validGyro	0 to 7	Axis to valid gyro sensor. See Table 14.7
5	xRawGyro	-[1)]	X axis gyro raw data [digit]
6	yRawGyro	-[1)]	Y axis gyro raw data [digit]
7	zRawGyro	-[1)]	Z axis gyro raw data [digit]
8	xGain	-[1)]	X axis gyro gain (LSB-18) [dps/digit]
9	yGain	-[1)]	Y axis gyro gain (LSB-18) [dps/digit]
10	zGain	-[1)]	Z axis gyro gain (LSB-18) [dps/digit]
11	xOffset	-[1)]	X axis gyro offset [digit]
12	yOffset	-[1)]	Y axis gyro offset [digit]
13	zOffset	-[1)]	Z axis gyro offset [digit]
14	rollAlign[2)]	-180 to 180	Roll gyro mis-alignment [degree]
15	pitchAlign[2)]	-180 to 180	Pitch gyro mis-alignment [degree]
16	yawAlign[2)]	0 to 359	Yaw gyro mis-alignment [degree]
17	learnmode	0 to 15	Gyro learn mode. See Table 14.8

Table 14.7 Relation between “validGyro” and Valid Axis of Gyro Sensor

validGyro	0	1	2	3	4	5	6	7
X axis	-	●	-	●	-	●	-	●
Y axis	-	-	●	●	-	-	●	●
Z axis	-	-	-	-	●	●	●	●

Table 14.8 Relation between “learnmode” and Status of Learning Process of Gyro Sensor

learnmode	0	1	2	3	5	6	7	9	11	13	15
Offset	-	●	-	●	●	-	●	●	●	●	●
Mis-alignment	-	-	●	●	-	●	●	-	●	-	●
Gain	-	-	-	-	●	●	●	-	-	●	●
Temperature compensation	-	-	-	-	-	-	-	●	●	●	●

Example:
$PERDCRI,G,3,7,96,144,-16,655,655,653,102,135,-25,1,0,90,7*2D

Notes:
1) These fields depend on the IMU sensor.
2) When the pitch angle is set to ±90 degree by PERDAPI,GYROALIGN command, these values may be not stable since the expression method for the misalignment angle is not determined uniquely. Even in this case, there is no problem if the installation angle combined the x,y,z axes misalignment angle is stable.

14.2.3 PERDCRI,O – Speed Pulse Data

Format:

$PERDCRI	,	O	,	odomtrconf	,	odomtrcounts	,	odomtrdir	,	countsPerRev	,	meterPerRev	*hh	<CR>	<LF>
1		2		3		4		5		6		7			

Field	Data type	Range	Description
1	$PERDCRI	-	Command name
2	O	-	Sub command name for speed pulse data
3	odomtrConf	0, 1, 3, 7, 9, 11, 15	Speed pulse confidence 0: Unknown 1: Initialized 3: Estimating pulse counts per revolution 7: Estimating pulse counts error per revolution 9: Initialized and verified back signal 11: Estimating pulse counts per revolution and verified back signal 15: Estimation pulse counts error per revolution and verified back signal
4	odomtrcounts	0 to 2000	Speed pulse counts [counts/sec]
5	odomtrdir	0 to 3	Speed pulse direction 0: Ignore, 1: Unknown, 2: Forward, 3: Reverse
6	countsPerRev	-	Pulse counts per revolution [counts/revolution]
7	meterPerRev	1.569858	Meter per revolution [m/revolution]

Example:
$PERDCRI,O,7,0,2,4.09,1.569858*22

14.3 SYS – PERDSYS Output Commands

14.3.1 DRSELFTEST – IMU Self-Test Result

This string is sent in response to PERDSYS,DRSELFTEST command.

Format:

$PERDSYS	,	DRSELFTEST	,	imutype	,	model	[,	result]	,	*hh	<CR>	<LF>
		1		2		3		4				

Field	Data type	Range	Description
1	DRSELFTEST	-	Command Name
2	imutype	GYRO, ACCEL	IMU sensor type GYRO: Gyro sensor ACCEL: Accelerometer
3	model	(imutype = GYRO) SMI130, XV4001BC, ITG3500/MPU6500, A3G4250D (imutype = ACCEL) SMI130, MPU6500, AIS328DQ, LIS331DLH NOTEXIST, NONEEDEXTRAPARAM	IMU sensor parts name NOTEXIST: IMU sensor is not connected. NONEEDEXTRAPARAM: It is unnecessary to input model.
4	result	PASS, FAIL	Self test results PASS: The DR receiver had normal communication with IMU sensor via I2C Bus. FAIL: The DR receiver failed normal communication with IMU sensor via I2C Bus.

Copyright

■ The DR receiver Software uses b64: Base-64 Encoding Library. The following shows this library copyright (include the discharge).