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FURUNO

FURUNO GNSS Receiver

Model GV-8720

***GV-8720 is the exclusive product for the BOSCH SMI130 sensor users.**

Protocol Specifications

(Document No. SE16-600-005-04)

FURUNO ELECTRIC CO., LTD.

www.furuno.com

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Revision History

Version	Changed contents	Date
0	Initial release	2016.07.04
1	Corrected the range at Section 10.6 (GST). Updated the notes at Section 4.1. Added PERDSYS,DR command, and updated Table 5.6 and Table 7.4 Added N:Data invalid status at Field 2 in 10.8 RMC Corrected UTC upper limit when backup data is invalid in 10.8 RMC Corrected description of Field 8 in 10.8 RMC Corrected description of Field 1 in 10.9 VTG Corrected UTC upper limit when backup data is invalid in 10.10 ZDA Added description about varidation of output time when setting DRPERSEC in 12.2 DRPERSEC Added notes 1) in 10.1 GBS Added notes 3) in 10.2 GGA Added notes 2) in 10.3 GLL Added notes 3) in 10.4 GNS Added notes 2) in 10.6 GST Added notes 4) in 10.8 RMC Added notes 3) in 14.1.2 PERDCRD,I Added description in 12.1.7 ETPOS Updated 12.2.1 DR	2017.03.27
2	10.8 RMC Field 8 Fixed range 10.9 VTG Field 1 Fixed range 11.1.6 Added Table 11.1 11.1.7 Added Table 11.2 11.2.3 Added Note 12.2.2 Added Note 14.1.1 PERDCRD,C Field 17 Fixed range 14.1.3 PERDCRD,R Field 10 Fixed range	2017.10.25
3	12.1.1 Changed the range of roll and pitch 12.1.2 Changed the range of roll and pitch 12.2.3 Removed the model field 14.1.3 Added descriptions 14.2.1 Added note 3) 14.2.2 Added note 3) 14.3.1 Changed the range of model field	2017.11.16
4	Updated the cover page.	2018.03.29

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.”

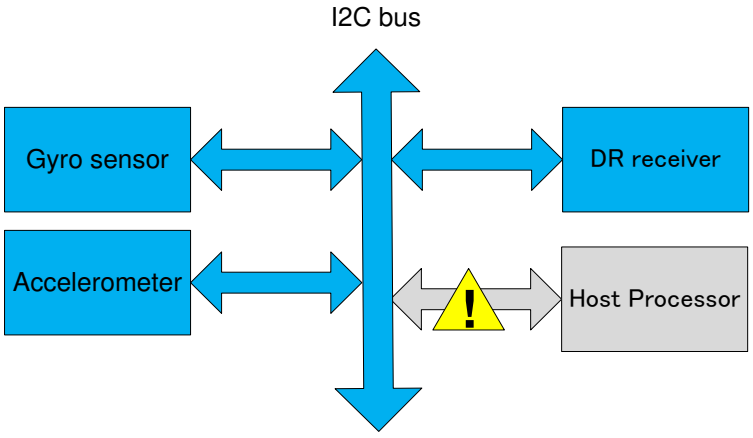
1.1 Interface

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.

NOT SUPPORTED MULTI-MASTER WITH DR RECEIVER AND HOST PROCESSOR



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 12.2.2 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[3)]	GL	X[4)]

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, or no position fix.
   - GP: Only GPS which is included SBAS and QZSS is available
   - GL: Only GLONASS is available
2) GPGSV is output in the following cases:
   - The receiver has GPS satellite information (including SBAS and QZSS) and GPS satellite system is set to 1, 2 or 3 by PERDAPI,GNSS command
   - No position fix.
3) GLGSV is output in the following cases:
   - GLONASS is used in positioning.
   - No position fix.
4) 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 field is null.

<Checksum field>
- 8 bits exclusive OR data between "$" and "*" (excluding "$" and "*").
- Convert the exclusive 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 field is null
- The fields inside [ ] are optional fields.

<Checksum field>
- 8 bits exclusive OR data between "$" and "*" (excluding "$" and "*").
- Convert the exclusive 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 the user operates the following process, the 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

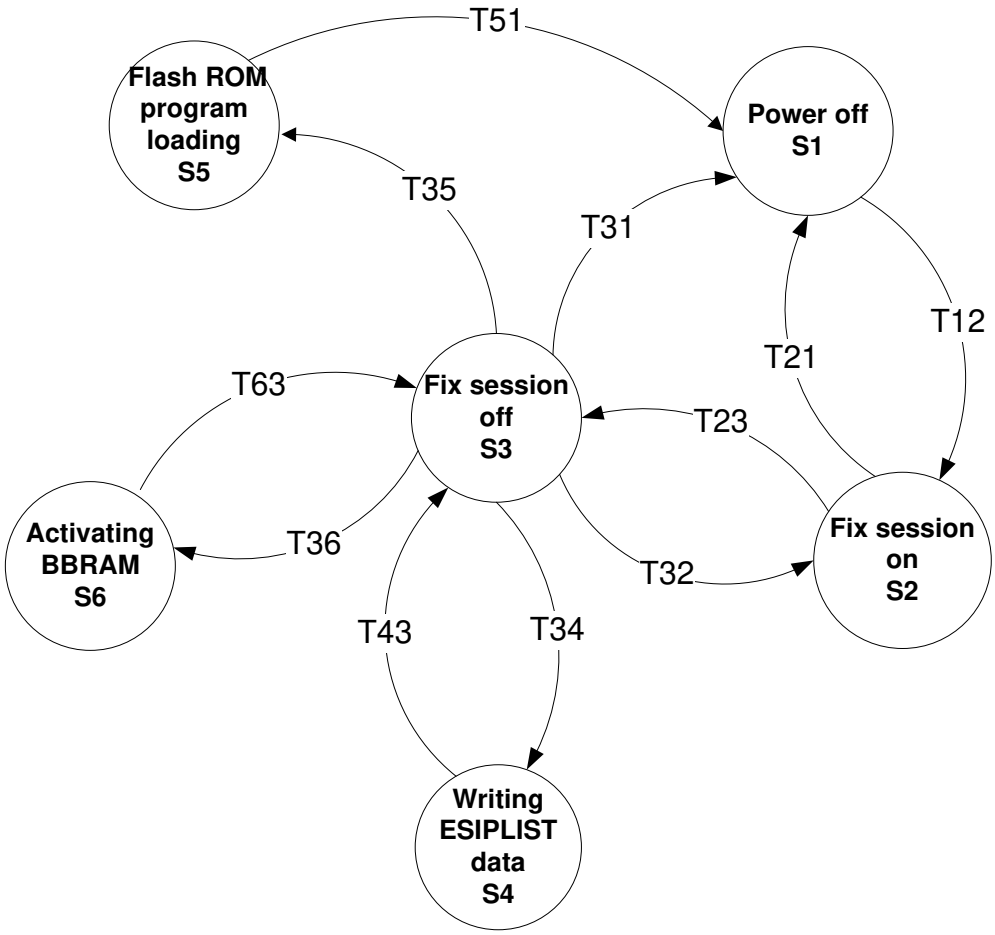


Figure 5.1 State Diagram of DR receiver

Table 5.1 shows explanations of specifications about each state.

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	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	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 in 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 the 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			
DR	DR communication port setting	N/A	I
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, the last updated time, the ephemeris, the almanac and the DR parameters. These backup data are used for shortening the position fix time at the next start-up.

Because the backup data 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.

(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) 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 Chapter 1 about the positioning assist data.

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 input commands. 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.

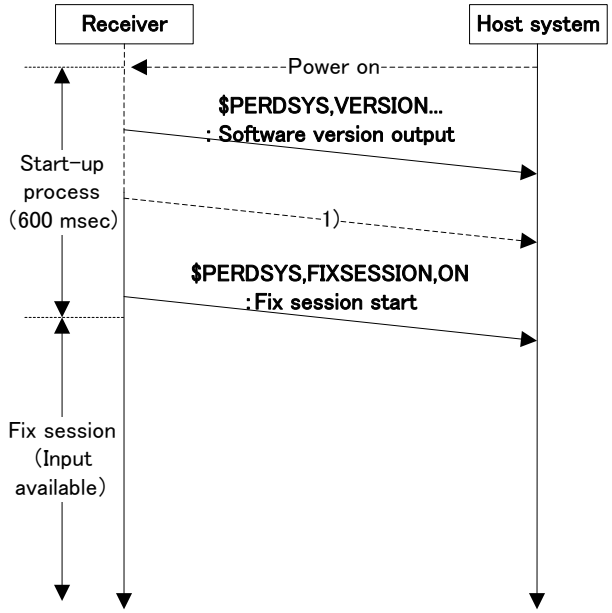


Figure 7.1 Session Sequence from Power on to Command Input Available

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.

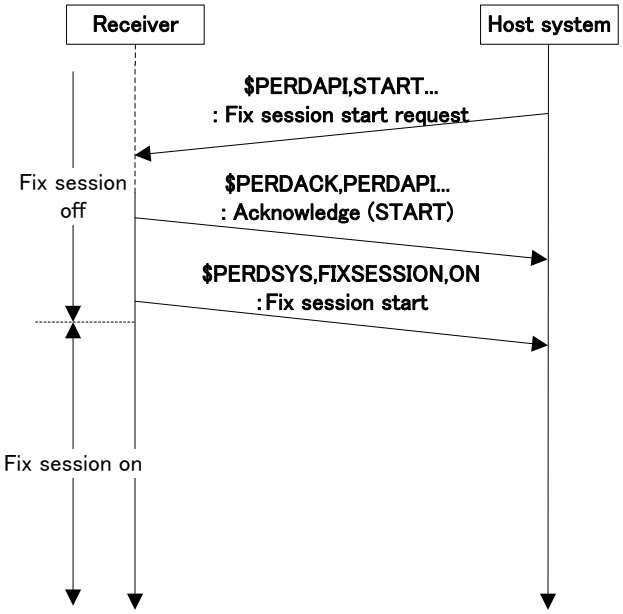


Figure 7.2 Session Sequence from Fix Session OFF to Fix Session ON

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.)

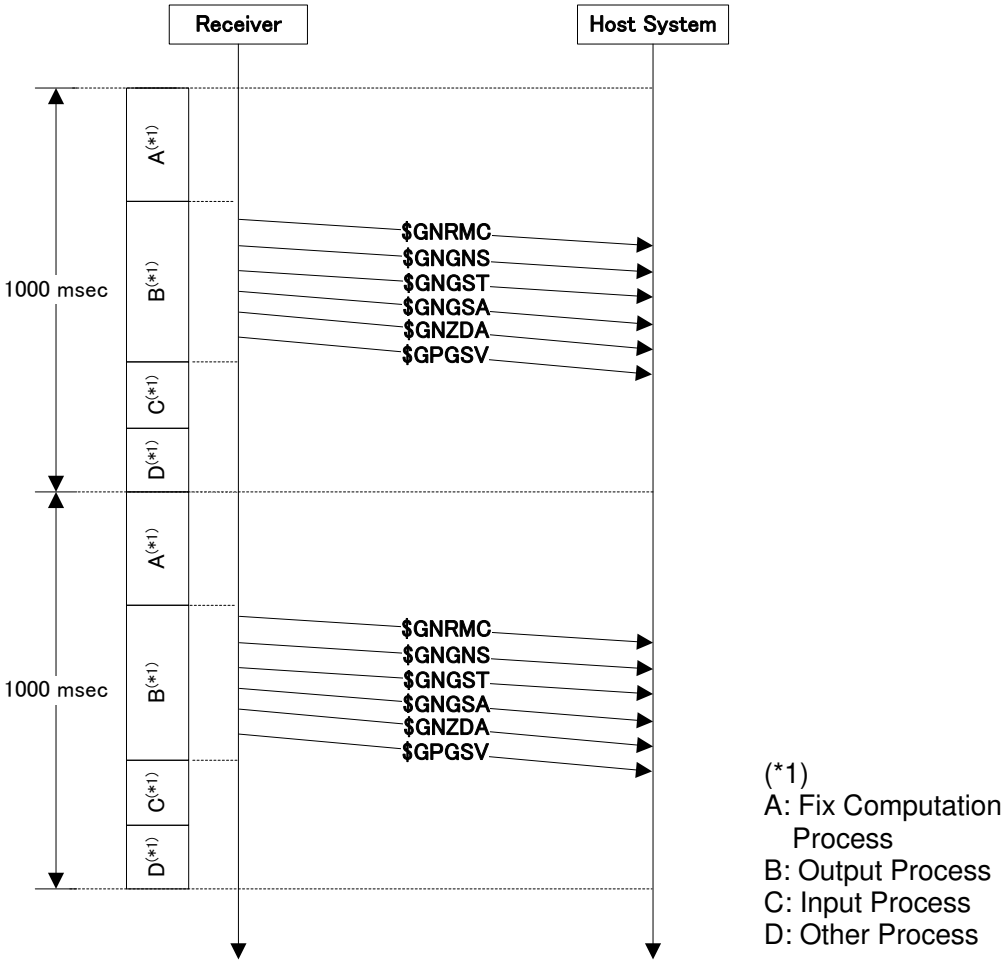


Figure 7.3 Session Sequence of Periodical NMEA Output Sentence

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.

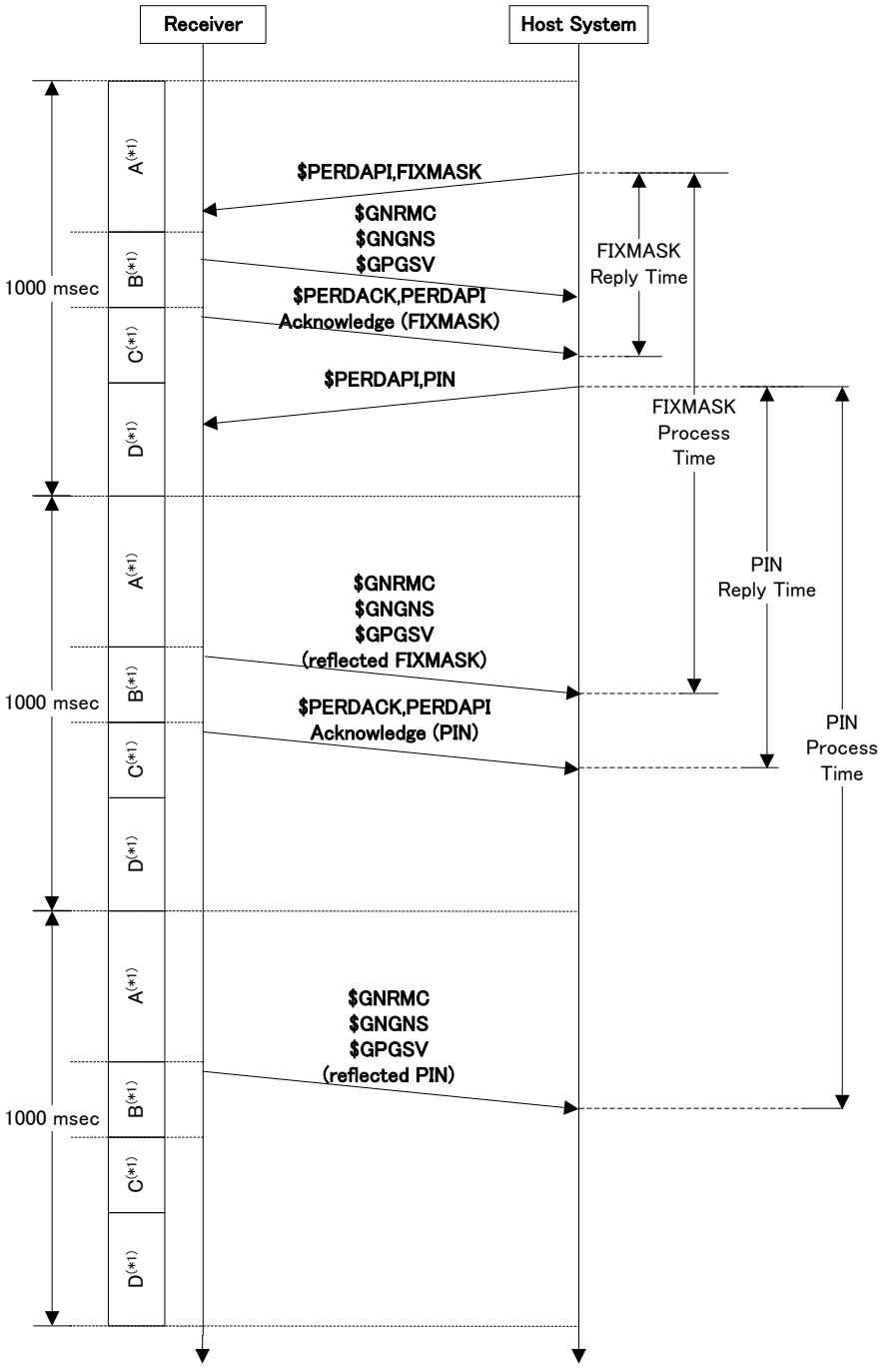
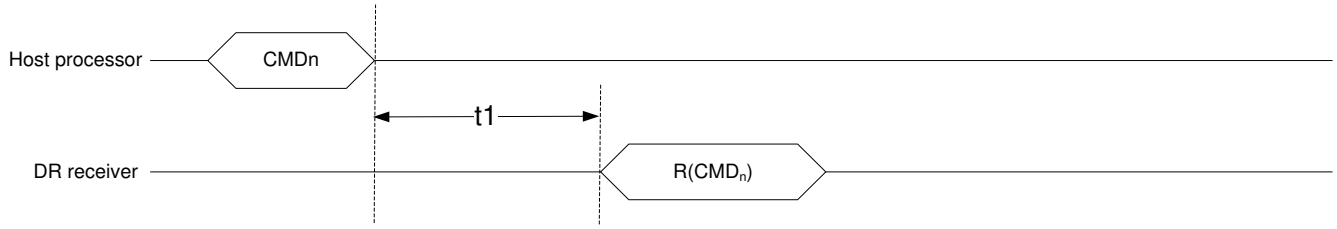


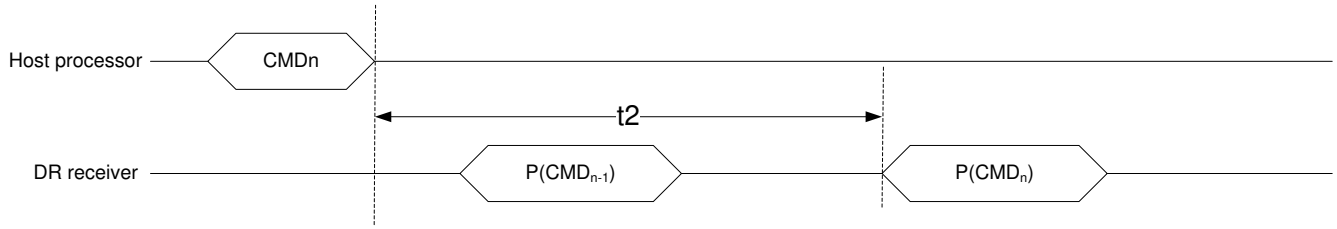
Figure 7.4 Session Sequence Example in Case of Changing Receiver Setting (1 Hz)

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.

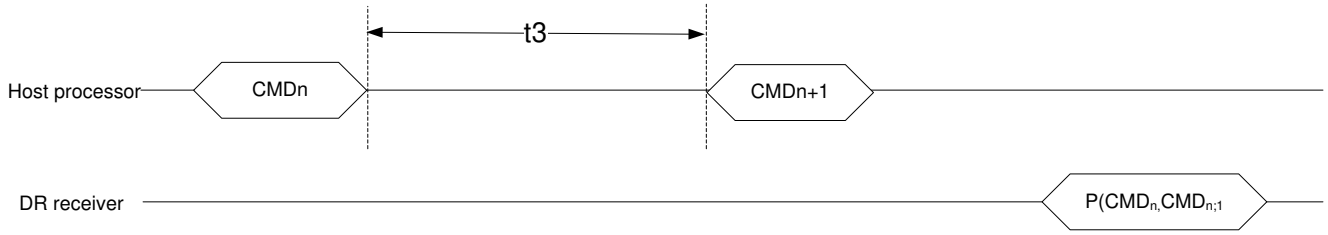
A) Response time from the DR receiver after sending the command data from the host processor.
B) Valid time for reflecting the command data to position fix data.
C) Continues assertion grant time of the next command data.



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 the 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 the requested data.

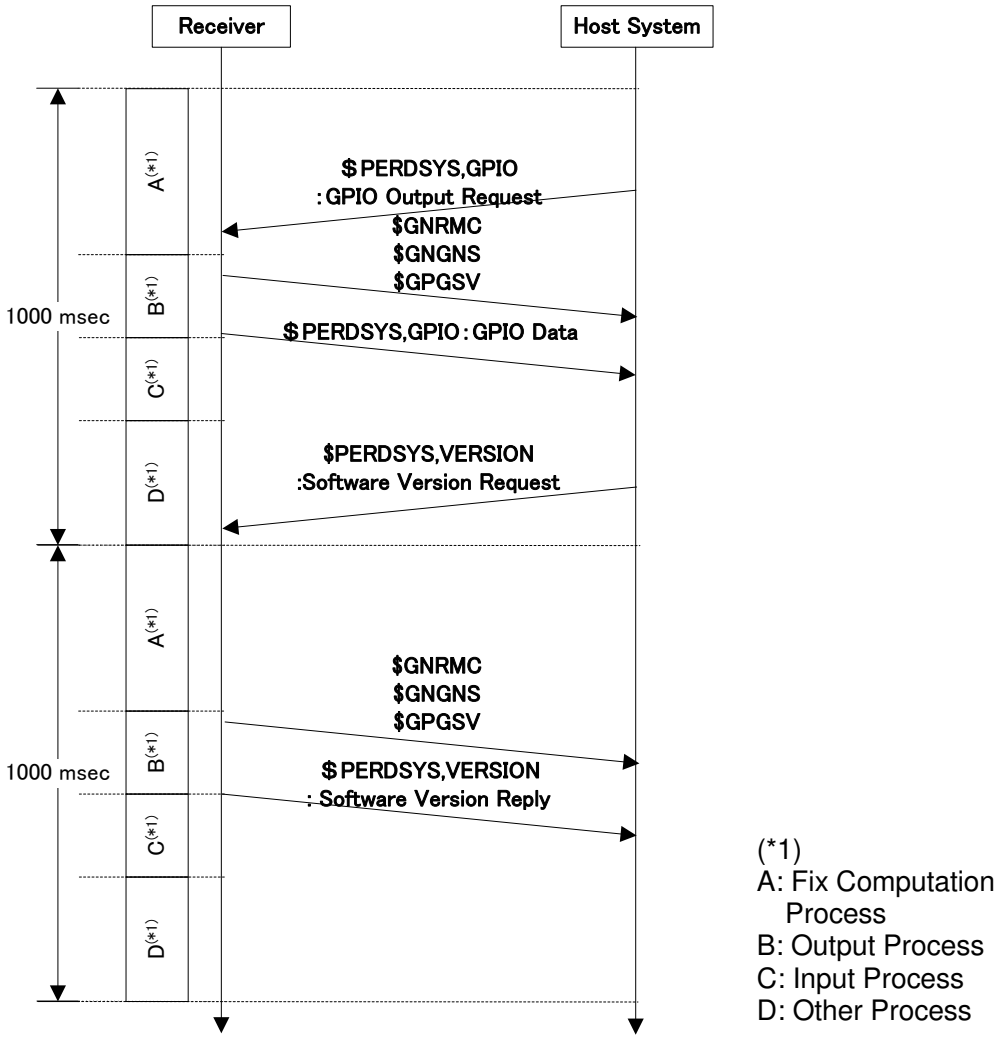


Figure 7.6 Session Sequence Example in Case of Requesting Receiver Output Data (1 Hz)

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.

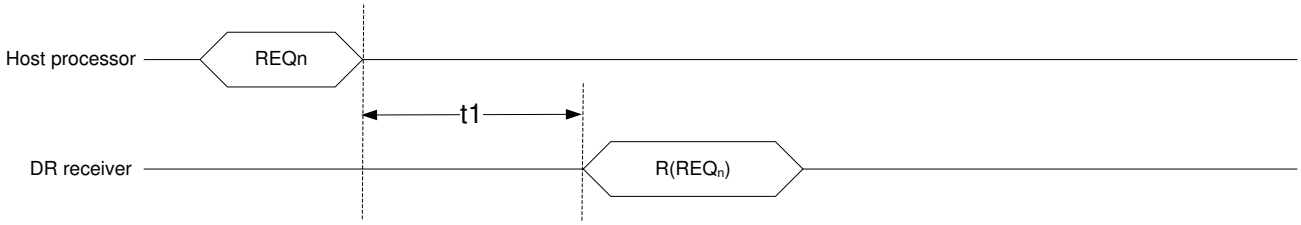


Figure 7.7 Response Time

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 the MULTIB64 format and the ESIP64 format.

Since the capacity of backup data exceeds a 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.

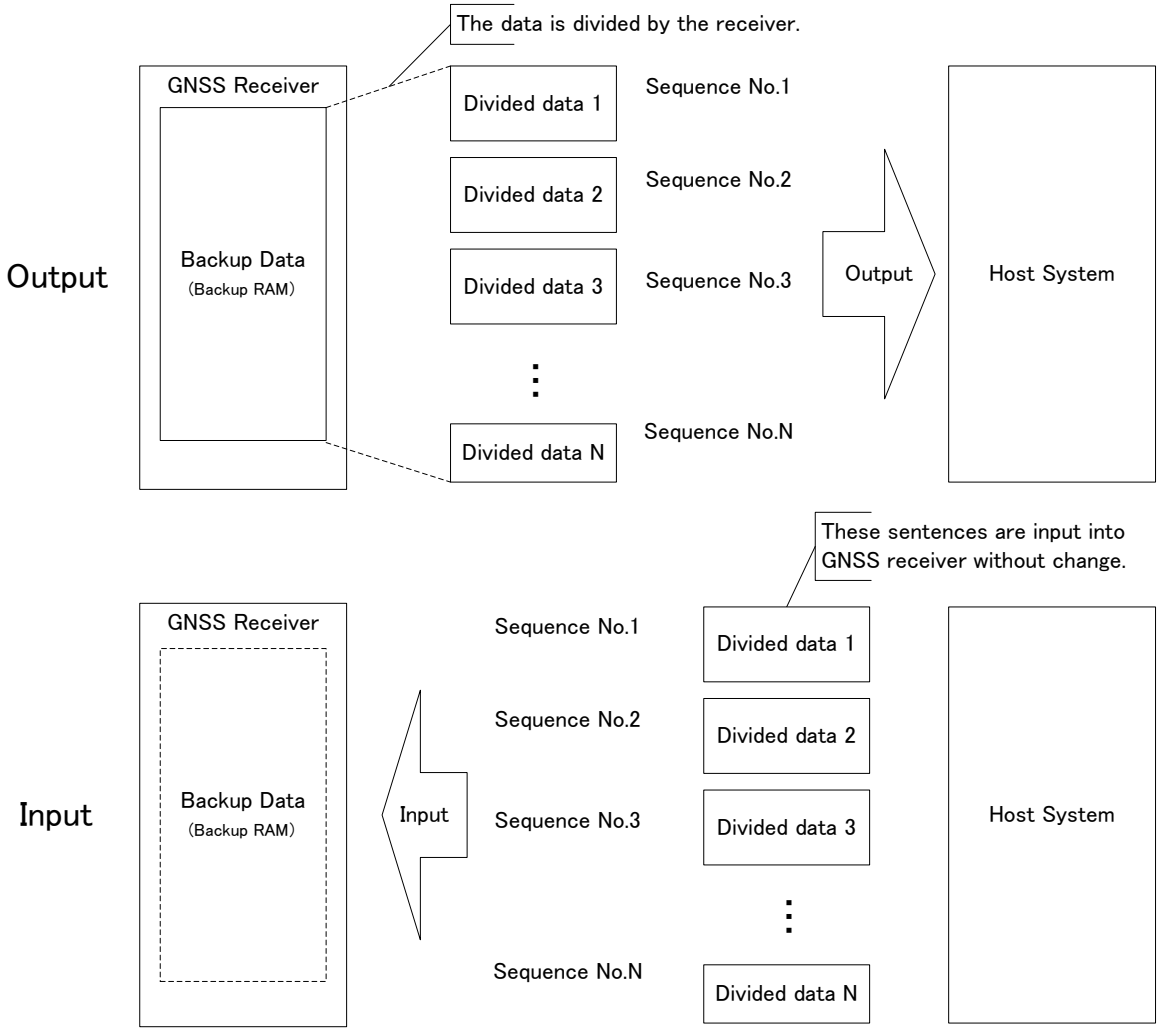


Figure 7.8 Outline of Backup Data Input/Output

7.6.1 Backup Data Output Request Sequence

To request a backup data output, input PERDAPI,STOP or PERDAPI,STOPNOFPR command to move the receiver state to the fix session off state. Input PERDSYS,BBRAM,QUERY command and output PERDSYS,BBRAM sentence in a row after the DR receiver state is in the fix session off state. 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.

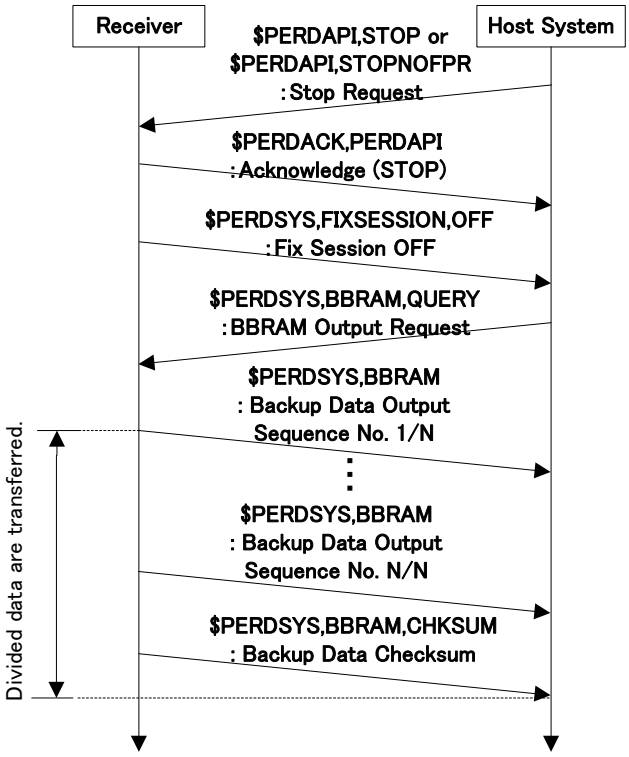


Figure 7.9 Backup Data Output Session Sequence

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 state is in fix session off state.

Figure 7.10 shows the backup data input sequence.

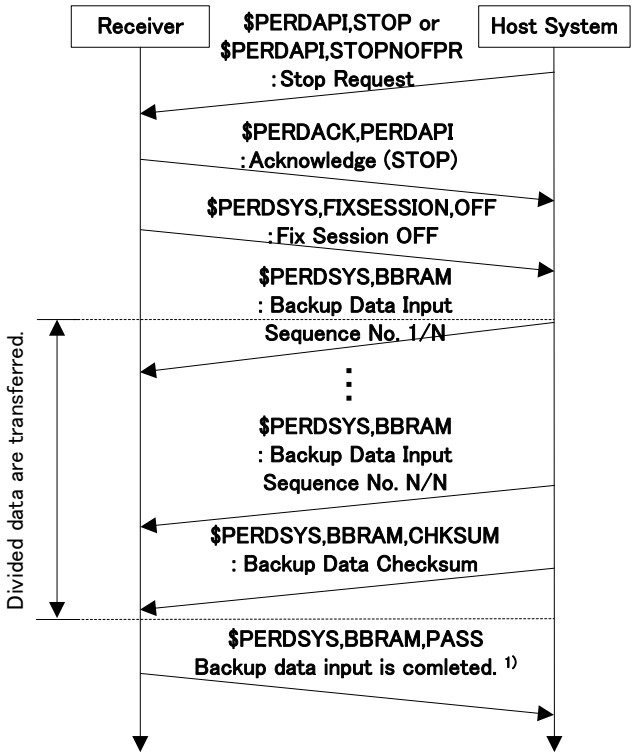


Figure 7.10 Backup Data Input Session Sequence

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

1. Backup data is available in the 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 will be 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 the 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.