November, 2001

GPS RECEIVER

GT-77

SPECIFICATION/PROTOCOL MANUAL

By FURUNO ELECTRIC CO., LTD.
System Products Division

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1. OUTLINE

1.1 MODEL NAME

GT-77N _ _

The suffix (_ _) represents followings:

GT-77①②

① : Software version in numeric : _, 1, 2, …… (_ means blank)

② : Hardware revision in alphabet : _, A, B, ….. (_ means blank)

1.2 PROTOCOL

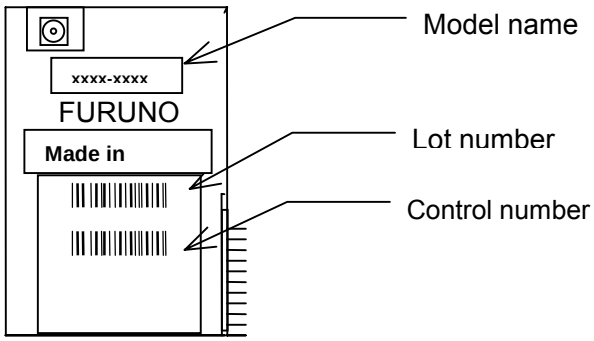
Based on NMEA-0183

1.3 PROGRAM NUMBER

48502070XX

Program version

1.4 LABEL

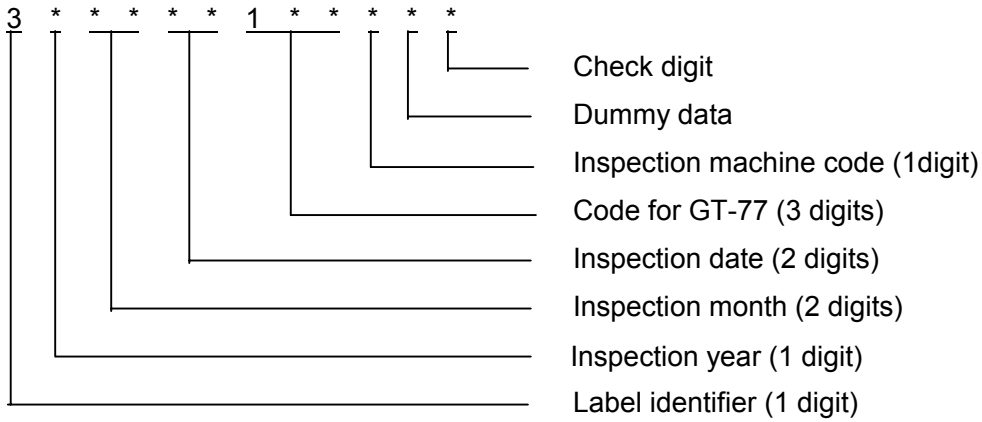


1.4.1 LOT NUMBER

Bar code and numeric indicate lot number.

Bar code : Interleaved 2 of 5

Numbering system is as follows :



1.4.2 CONTROL NUMBER

Used for internal control.

2. SPECIFICATION

2.1 PRODUCT SPECIFICATION

ITEM	SPECIFICATION
Receiving Frequency	1575.42 MHz
Tracking Code	C/A code
Numbers of Channel/Method	8 Ch/Parallel
Max. Number of Satellites Tracked	8 satellites
Dynamics Acceleration	>49m/s² (sustained tracking)
Positioning	All-in-view SPS positioning (DGPS RTCM-SC104)
Communication Channel	Channel each for input & output
UTC-Synchronized Pulse Output	1 pulse per second

2.2 POSITIONING PERFORMANCE

ITEM		SPECIFICATION	
Position Accuracy	Horizontal	<100 meters (95%)	
	Vertical	<156 meters (95%)	
1PPS accuracy		<340 nanoseconds (95%) with reference to UTC	
Time to First 1pps(*1)		Hot start(*2)	<13 seconds (average)
		Warm start(*3)	<41 seconds (average)
		Cold start(*4)	<510 seconds (average)
Re-acquisition time(*1)		10 sec. interruption	<2 seconds (average)
		60 sec. interruption	<5 seconds (average)
		10 min. interruption	<10 seconds (average)
		60 min. interruption	<40 seconds (average)
		24 hours interruption	<120 seconds (average)

(*1) Under Furuno's standard test conditions.

(*2) Backed-up value for position, time, almanac, ephemeris is valid.

(*3) Backed-up value for position, time, almanac is valid.

(*4) No backed-up value is valid.

2.3 ELECTRICAL SPECIFICATION

2.3.1 ANTENNA CONNECTOR

2.3.1.1 PIN ASSIGNMENT

Receptacle : S-FL2-R-SMT (by Hirose)

Matching connector : S-FL2-LP (by Hirose)

PIN LOCATION	SIGNAL	FUNCTION
Center Contact	SIG	Input of Receiving Signal
Outer Contact	GND	Antenna Ground

2.3.1.2 ABSOLUTE MAXIM RATINGS

ITEM	MAXIMUM	UNIT
Antenna Preamp. Power Voltage	-0.3 to VANT(*)	V
Antenna Preamp. Power Current	270	mA

VANT(*): Antenna preamp. power input. (at -30°C to +80°C)

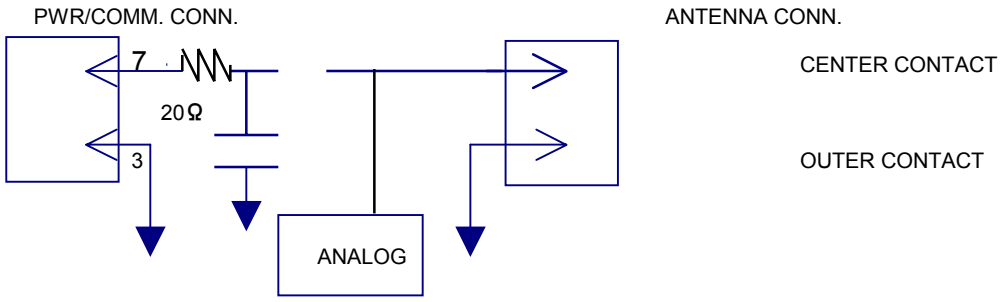
2.3.1.3 RATINGS

	ITEM	MINIMUM	TYPICAL	MAXIMUM	UNIT	REMARKS
SIG INPUT	Impedance		50		ohms	
	Frequency(fo)		1.57542		GHz	
	Receiving Sensitivity	-133			dBm	Input level to proper Antenna at fixed position
ANTENNA PRE. AMP POWER	Voltage	4.5			V	@VANT(*)=5.0V I=20mA
	Voltage	4.0			V	@VANT(*)=5.0V I=40mA

VANT(*): Antenna preamp. power input. (at -3°C to +80°C)

2.3.1.4 ANTENNA PREAMP. POWER SUPPLY

External power applied to Pin #6(VANT) of the Communication/Power Supply Connector is fed to the antenna/preamplifier through the internal protection resistor (20 ohms ±10%) and SIG pin of the antenna connector. Note that the signal is superimposed (biased) on this DC voltage.



2.3.1.5 ANTENNA SPECIFICATION

ITEM	REQUIREMENTS
Impedance	50 ohms
NF	<3 dB
Gain	10 to 35 dB (including cable loss)

2.3.2 POWER/COMMUNICATION CONNECTOR

2.3.2.1 PIN ASSIGNMENT

* Receptacle type 53254-0910 (By Molex Japan Co., LTD.)
* Matching connector type 51065-0900 (By Molex Japan Co., LTD.)

PIN NO.	SIGNAL	FUNCTION
1	RD1	Data input 1
2	TD1	Data output 1
3	GND	Ground
4	VCC	Power supply
5	VBAK	Back-up power supply (*)
6	1 PPS	1 pulse/sec output
7	VANT	Antenna pre. amp. power supply
8	RD2	Data input 2 (not used)
9	TD2	Data output 2 (not used)

(*) No internal backup power supply is available.

2.3.2.2 ABSOLUTE MAXIMAM RATING

ITEM	MAXIMUM RATING	UNIT
RD input voltage	-0.3 to +6.5	V
TD1, TD2 output voltage	-0.3 to +6.5	V
TD1, TD2 output current (*)	±20	mA
1 pps output voltage	-0.3 to VCC+0.5	V
1 pps output current (*)	±20	mA
VCC input voltage	-0.3 to +6.5	V
VBAK input voltage	-0.3 to +6.5	V
VANT input voltage *	-0.3 to +6.5	V

(at -30°C to +8°C)

(*) The current into the GT-77 should be (+).

2.3.2.3 RATING

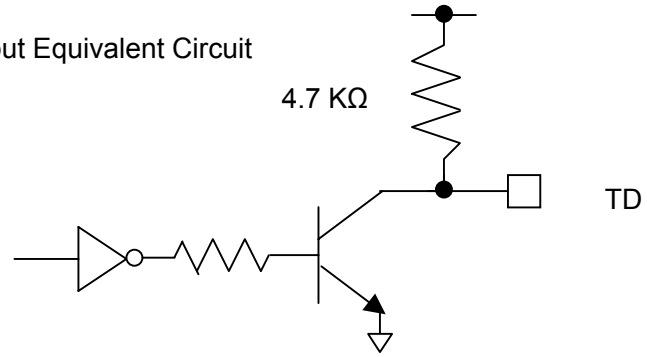
(At surrounding temperature of -30◦C to +80°C)

ITEM			MIN.	TYPICAL	MAX.	UNIT	REMARKS
TD1, TD2	H	VOLTAGE	VCC-1.0		VCC	V	@-0.15mA[*1]
(OUTPUT)[*2]	L	VOLTAGE	0		0.4	V	@4.0mA
RD1, RD2[*3]	H	VOLTAGE	2.6		VCC	V	
		CURRENT[*1]			±0.1	mA	@VCC
(INPUT)	L	VOLTAGE	0		0.8	V	
		CURRENT[*1]			-1.2	mA	@0.8V
1 PPS[*2]	H	VOLTAGE	3.8			V	@-4.0mA[*1]
	L	VOLTAGE			0.5	V	@4.0mA
(OUTPUT)	DUTY			50		%	
VCC	VOLTAGE		4.5	5	5.5	V	
	CURRENT[*1]			100		mA	@5.0V, 25°C
VBAK	VOLTAGE		2.5		5.5	V	
	CURRENT[*1]			3.0	10	μA	@VBAK=3.0V VCC=0V 25℃,
VANT	VOLTAGE		4.5	5	5.5	V	

[*1] The current into the GN-77N should be (+).

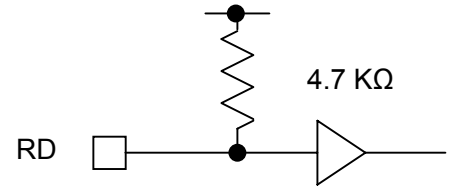
[*2] Open Collector Output, VCC through 4.7KΩ(±5%)Register.

TD Output Equivalent Circuit



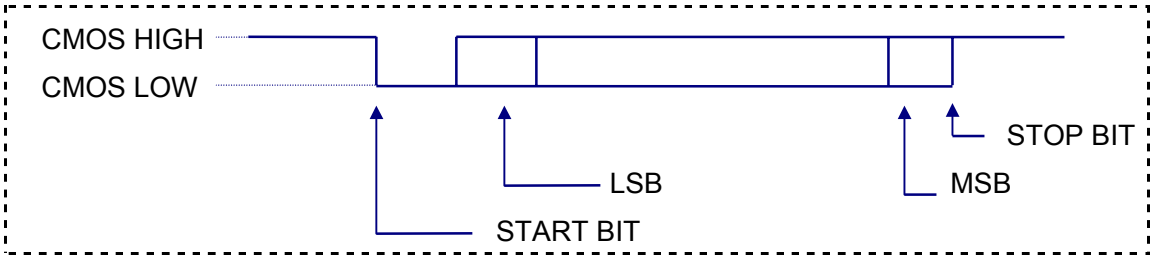
[*3] Pulled up to VCC through 4.7KΩ(±5%)Register.

RD Imput Equivalent Circuit



2.3.2.4 COMMUNICATION SPECIFICATION

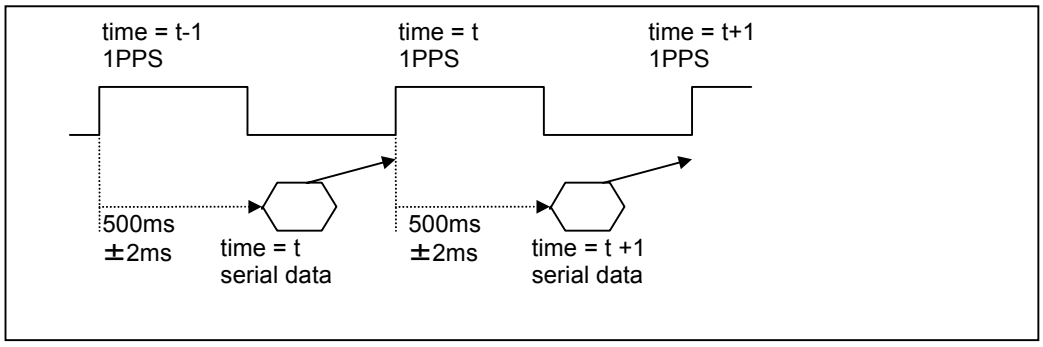
2.3.2.4.1 TD, RD SIGNAL LOGIC



2.3.2.4.2 1 PPS TIMING

1 PPS is output synchronized with UTC during when positioning is obtained.

Rising edge of 1 pps is synchronized with UTC one second.



For the details, refer to **4.1 SPECIFICATION FOR 1PPS CLOCK SIGNAL**.

2.4 MECHANICAL SPECIFICATION

ITEM	SPECIFICATION	REMARKS
SIZE	58.2mm × 39.6mm × 12.3mm	(Connector excluded)
WEIGHT	40 g	

2.5 ENVIRONMENTAL CONDITIONS

ITEM		UNIT	REMARKS
OPERATING TEMPERATURE	-30 to +80	°C	
BACK-UP TEMPERATURE	-30 to +80	°C	
STORAGE TEMPERATURE	-40 to +85	°C	
HUMIDITY	90 95	%RH	@ +60°C No condensation @ +45°C No condensation
VIBRATION	43.1	m/s²	@ 10 to 200 Hz

3. SOFTWARE SPECIFICATION

3.1 PROGRAM NUMBER

Program number : 48502070XX

3.2 COMMUNICATION SPECIFICATION

System: Full Duplex Asynchronous
Speed: 4800 bps
Start Bit: 1 bit
Data Length: 8 bits (MSB=0)
Stop Bit: 1 bit
Parity Bit: None

Start Bit	B0	B1	B2	B3	B4	B5	B6	B7	Stop Bit

Flow Control: None
Signal Lines used: TD1 and RD1 only (TD2 and RD2 not used)
Data Output Interval: 0 to 2 seconds

Character Codes used

NMEA-0183 Sentences: ASCII (HEX 0D,0A,20 to 7E)

Differential GPS Data: Binary (“6-of-8” format)
(B7=0, B6=1, Only B5 to B0 are used.)

Electrical specification Similar to RS-232C

Protocol:
NMEA-0183 Sentences: NMEA-0183 Ver 2.0
(Approved/proprietary sentences)
(Input/Output)
Differential GPS Data RTCM SC-104 Ver 2.0
(Input only)

NOTE: NMEA-0183 sentence and differential GPS data inputs may coexist because the GT-77 can distinguish them automatically.

3.3 ABOUT NMEA-0183 PROTOCOL

3.3.1 APPROVED SENTENCES

Approved sentences are those of which formats are defined and fixed within the NMEA 0183 Standard. Any portion within an approved sentence format is NOT user-definable. An approved sentence generally takes the following form:

$<address field>,<data field>.....[*<checksum field>]<CR><LF>

Where:

Field	Description
$	Start-of-Sentence marker
<address field>	5-byte fixed length. First 2 bytes represent a talker ID, and the rest 3 bytes do a sentence formatter. All sentences transmitted by GT-77 bear talker ID “GP” meaning a GPS receiver. For the sentences received from external equipment, the GT-77 accepts any talker ID. Talker ID “XX” found on the succeeding pages is a wildcard meaning “any valid talker ID”.
,<data field>....	Variable or fixed-length fields preceded by delimiter “,”(comma). Comma(s) are required even when valid field data are not available i.e. null fields. Ex. “,,,,,” In a numeric field with fixed field length, fill unused leading digits with zeroes.
*<checksum field>	Generally not required, with the exception of “RMC” sentence. 8 bits data between “$” and “*”(excluding “$” and “*”) are XORed, and the resultant value is converted to 2 bytes of hexadecimal letters. Note that two hexadecimal letters must be preceded by “*”, and delimiter “,” is not required before *<checksum>. Only RMC sentences are transmitted with checksum. All other output sentences do not include *<checksum>. For input sentences, *<checksum> is ignored.
<CR><LF>	End-of-Sentence marker

Maximum length from “$” to <CR><LF> is limited to 82 bytes including “$” and <CR><LF>.

Examples of Approved Sentences:
$GPGLL,3444.000,N,13521.00,E,E<CR><LF>
$XXGLL,3444.000,N,13521.00,E,E<CR><LF>

“XX” may be any valid talker ID, such as “LC”(Loran C).

3.3.2 PROPRIETARY SENTENCES

The NMEA-0183 standard allows nav-aid makers to send proprietary sentences if the minimum rules defined by the NMEA are obeyed. Proprietary sentences must take the following form, but it is free to makers what kind of fields are included and in what order they are transmitted out.

$P<maker ID>,<data field>.....<CR><LF>

Where:

Field	Description
$	Start-of-Sentence marker
P	Proprietary sentence identifier
<maker ID>	3-byte fixed length. GT-77's maker ID is "FEC" meaning Furuno Electric Company.
,<data field>....	Variable or fixed-length fields preceded by delimiter ","(comma). (Layout is maker-definable.)
<CR><LF>	End-of-Sentence marker

3.4 LIST OF NMEA-0183 SSENTENCES

The following NMEA-0183 sentences are supported by GT-77.

	INPUT SENTENCE		OUTPUT SENTENCE		
HIGH	$XXGGA	Set initial position	$GPGGA	Position, time etc.	OO
	$XXZDA	Set time, etc.	$GPZDA	Time etc.	OO
	$XXGLL	Set initial position	$GPGLL	Position, time, etc.	O
			$GPGSA	Status, DOP	O
			$GPGSV	Satellite details	OO
			$GPVTG	Speed, Course.	OO
	$XXRMC	Set initial position, time	$GPRMC	Position, time, speed, course	O
			$PFEC,GPalt	No. of satellites expected in coming 24 hours	O
			$PFEC,GPanc	Date of existing almanac	O
			$PFEC,GPacc	SV accuracy	O
			$PFEC,GPast	GPS fix (position, local time)	O
			$PFEC,GPtst	Selftest result	O
	$PFEC,GPsrq	Send GPS receiver parameters	$PFEC,GPssd	Answer to $PFEC,GPsrq	A
	$PFEC,GPirq	Send data output interval	$PFEC,GPisd	Answer to $PFEC,GPirq	A
	$PFEC,GPdrq	Send DGPS parameters	$PFEC,GPdsd	Answer to $PFEC,GPdrq	A
			$PFEC,GPdie	DGPS status	O
			$PFEC,GPtlp	UTC prediction	O
			$PFEC,GPtps	Time & 1PPS output flag	OO
			$PFEC,GPgpt	GPS time output	O
	$PFEC,GPrrs	Set TRAIM/1PPS	$PFEC,GPrrm	TRAIM status	O
	$PFEC,GPrrq	Send TRAIM/1PPS parameters	$PFEC,GPrsd	Answer to $PFEC,GPrrq	A
	$PFEC,GPclr	Restart			
	$PFEC,GPset	Set rx parameters			
	$PFEC,GPint	Set sentence output interval			
LOW	$PFEC,GPdif	Set DGPS parameters			

PRIORITY

NOTE 1: Higher priority data is output first, from top to bottom. (Highest priority:GGA for example).

O Sentence output interval is adjustable but if the back up is lost, the sentence will not be output.

OO Sentence output interval is adjustable and if the back up is lost, it goes back to the default value, which is one second interval.

A Sentence is output as an answer.

XX Any talker ID

3.5 LIST OF PARAMETERS & BACKED-UP DATA

	Data	Backed-up	Default	Range
GPS Data	Estimated position Lat. Long.	Yes	N34deg.44.0000 min. E235deg.21.0000 min.	S90deg. to N90deg. W180deg. to E180deg.
	Time	Yes	1997 Jan.1 0h.0m.12s	1997 Jan. 1 through 2040 Dec. 31
	Altitude	Yes	0 m	-999.9m to 17999.9m
	Almanac data	Yes	---	---
	Almanac date	Yes	1980 Jan. 6 0h.0m.0s	---
	Ephemeris	Yes	---	---
Parameters	Local Zone Time	Yes	+0h	-13h0m to +13h0m
	PDOP value	Yes	6	0 to 10
	Elevation Angle Mask	Yes	5 deg.	5 to 90 deg.
	Geodetic ID	Yes	1 (WGS84)	1 to 171
	Mask by Elevation Angle for Receivable Satellites Prediction	Yes	5 deg.	5 to 90 deg.
	Mask by Signal Strength	No	1dBHz (No mask)	1 to 99 dBHz
	1PPS Correction	Yes	0 μsec	-999.999 μsec to +999.999 μsec
	Delete Satellites	No	00000000	00000000 to FFFFFFFF
	Smoothing Index	No	2	1 to 3
	Dynamic Index	No	2	1 to 3
	Observation Point Mode	Yes	1 (Estimated Position Observation Mode)	1 : Estimated 2 : Fixed
	Almanac Validity	No	1 (With validity)	1 : With validity 2 : No validity
	Data Output Interval	Yes	GGA,ZDA,GSV,VTG	0-60 seconds (Only for those sentences that are adjustable. See 3.4 List of NMEA sentences.)
	DGPS parameter	Yes	1 (LSB first)	1 (LSB first) 2 (MSB first)
	TRAIM Function Switch	No	1 (ON)	0 : OFF 1 : ON
	1PPS Control Mode **Note 1**	No	2 (Ordinary output)	0 : No output 1 : Always output 2 : Ordinary output 3 : Output only when no alarm

Note 1 : Since 1PPS is always output in GT-77, the set above will be invalid. (Above set is described for GPS receiver only.)

3.6 NMEA-0183 INPUT SENTENCES

3.6.1 TIME AND POSITION

$XXGLL(in)

Set initial position

This sentence sets the initial latitude/longitude. The position data will be updated when position fixing begins.

Example

$XXGLL	,3444.123,N	,03521.5,E	, ,	CR LF
Field#	1	3	56	

#.	Description	Range	[Bytes]
1.	Latitude		
	"34":degree	00-90	[2]
	"44": minute (integer)	00-59	[2]
	"123": minute (fraction)	0-9999	[variable] See NOTE.
	"N": North/South	N or S	[1]
3.	Longitude		
	"035": degree	000-180	[3]
	"21": Minute (integer)	00-59	[2]
	"5": Minute (fraction)	0-9999	[variable] See NOTE
	"E": East/West	E or W	[1]
	NOTE: Digits below 1/10000 are ignored.		
5,6.	Null Fields	Any entry is ignored.	

Interpreting Example

34 deg 44.123 min N
35 deg 21.5 min E

$XXGGA (in)

Set initial position

This sentence sets the initial latitude/longitude. The position data will be updated when position fixing begins.

Example

$XXGGA	,	,3444.123,N	,03521.5,E	, , , , , , , , ,	CR LF
Field#	12		4	6-14	

#.	Description	Range	[Bytes]
2.	Latitude		
	“34”:degree	00-90	[2]
	“44”: minute (integer)	00-59	[2]
	“123”: minute (fraction)	0-9999	[variable] See NOTE.
	“N”: North/South	N or S	[1]
4.	Longitude		
	“035”: degree	000-180	[3]
	“21”: Minute (integer)	00-59	[2]
	“5”: Minute (fraction)	0-9999	[variable] See NOTE.
	“E”: East/West	E or W	[1]
	NOTE: Digits below 1/10000 are ignored.		
6-14.	Null Fields	Any entry is ignored.	

Interpreting Example

34 deg 44.123 min N
35 deg 21.5 min E

$XXZDA (in)

Set date/time

Example

$XXZDA	,123456	,01	,02	,1997	,-09	,00	CR LF
Field#	1	2	3	4	5	6	

#.	Description	Range	[Bytes]
1.	UTC: Time		
	"12": hh	00-23	[2]
	"34": mm	00-59	[2]
	"56": ss	00-59	[2]
2.	UTC: Date		
	"01": DD	01-31	[2]
3.	UTC: Month		
	"02": MM	01-12	[2]
4.	UTC: Year		
	"1997": YYYY	1997-2040	[4]
5.	Local Zone Time (Hour)		
	"-09": hh	-13 ... +00 ... +13 (-/+: East/west of date line)	[3]
6.	Local Zone Time (Minute)		
	"00": mm	00 to 59	[2]

NOTE: Local zone time setting is used for calculating local time when outputting GPS fix ($PFEC,GPast): (Local Time)=(UTC)-(Local Zone Time)

Interpreting Example

February 1, 1995
12:34:56
Local Zone Time: -09:00

$XXRMC (in)

Set initial position/UTC

Example

$XXRMC	,123456	,	,3444.123,N	,13521.456,E	,,	,020194	,,	CR LF
Field#	1	2	3	5	7 8	9	10 11	

#.	Description	Range	[Bytes]
1.	UTC: Time		
	"12": hh	00-23	[2]
	"34": mm	00-59	[2]
	"56": ss	00-59	[2]
2.	Null Field	Any entry is ignored.	
3.	Latitude		
	"34":degree	00-90	[2]
	"44": minute (integer)	00-59	[2]
	"123": minute (fraction)	0-9999	[variable] See NOTE.
	"N": North/South	N or S	[1]
5.	Longitude		
	"135": degree	000-180	[3]
	"21": Minute (integer)	00-59	[2]
	"456": Minute (fraction)	0-9999	[variable] See NOTE.
	"E": East/West	E or W	[1]
	NOTE: Digits below 1/10000 are ignored.		
7-8.	Null Fields	Any entry is ignored.	
9.	UTC: Date		
	"02": DD	01-31	[2]
	"01": MM	01-12	[2]
	"94": YY	94-40 (1994-2040)	[2]
10-11.	Null Fields	Any entry is ignored.	

Interpreting Example

January 2, 1994
12:34:56
34 deg. 44.123 min. N
135 deg. 21.456 min. E

3.6.2 RE-START SENTENCES

$PFEC,GPclr (in)

Restart

Example

$PFEC,GPclr	,1	CR LF
Field#	2	

This sentence clears the data in the GPS receiver and restarts the receiver. The restart works in the same way as the power is first on. The function mode goes to “PRIMARY” and the unit is ready to accept SCPI command.

#.	Description	Range	[Bytes]
2.	Mode	1-3 “1”: Clear mode 1 “2”: Clear mode 2 “3”: Clear mode 3	[1]

Receiver Data	Clear mode		
	1	2	3
Latitude/Longitude	Returned to default	Same as clear mode 1	Same as clear mode 2
Time	Returned to default		
Almanac Data	Deleted		
Ephemeris Data	Deleted		
Receiver Parameters (Note 1)	All parameters returned to default	Backed-up value used.	

Note 1: Receiver parameters are those set by “$PFEC,GPset” sentence. Refer to the “2-4. List of Parameters & Backed-up data” to see whether the value set by the sentence is backed up or not.

Interpreting Example

Clear mode 1

$PFEC,GPset (in)

Setup receiver parameters

Example

$PFEC,GPset	,D05	,U00200000	.....	CR LF
Field# 1	2	3	4.....	

#.	Description	Range	[Bytes] (Unit) {Default}

2.
3.
4.....
Up to eight parameters in any order preceded by delimiter ","(comma).
See parameter syntax below:

NOTE: Do not send same parameter twice within the same sentence.

"Dnn": PDOP Threshold D00-D10 [3] (n/a) {D06}
In 3D positioning mode, 2D positioning is forced when PDOP is higher than this threshold. If D00 is set, 3D positioning is not performed. In 2D positioning, the altitude is not updated and the same altitude is continuously output as set at the first 2D positioning.

"Enn": Elevation Angle Mask for Receivable Satellite Prediction
E05-E90 [3] (deg.) {E05}
This parameter affects $PFEC,GPalt output sentence. Satellites below this angle are excluded from prediction.

"Gnn": Geodetic ID G001-G171 [4] (n/a) {G001)

"Hnnnnnn.n": Altitude for 2D positioning H-00999.9 to H017999.9 [9] (meter) {H000000.0}
NOTE: When 3D positioning is performed, this data is updated.

"Mnn": Mask by Elevation Angle M05-M90 [3] (degree) {M05}
Satellites below this angle are ignored when positioning.

"Snn": Mask by Signal Strength S01-S99 [3] (dBHz) {S01}
Satellites weaker than this level are ignored when positioning. The minimum level is practically limited by the lowest tracking signal level (38dBHz).

"Tnnnnn": 1PPS Correction T-9999 to T+9999 [6] (x0.1 us) {T+0000}
0.1us corresponds 30 meter antenna length. Note that negative setting advances 1PPS pulses.

"tnnnnnn": 1PPS Correction t-999999 to t+999999 [8](x0.001 us){T+000000}

"Uhhhhhhhh": Delete satellites U00000000 - UFFFFFFFF [9] (n/a) {n/a}
hhhhhhhh means eight hexadecimal letters, representing a bit map of 32 bits. Each bit within the bit map represents one satellite; 0000001 and 8000000, for example, indicate satellite SV#1 and SV#32, respectively.

Example: "PFEC,GPset,U0000000F"<CR><LF> declares unhealthy satellites SV#1 to SV#4.

Satellites declared by this sentence are ignored when positioning. It should be noted that satellites with their bits cleared are declared as “healthy”. In the above example, satellites SV#5 to SV#32 are implicitly declared as “healthy”.

In the following example, the first sentence declares satellite SV#5 as “unhealthy”, and it is restored later by the second sentence.

Example:“PFEC,GPset,U00000010”<CR><LF>
“PFEC,GPset,U00000000”<CR><LF>

“Zn”: Observation Point Mode	1-2 1 : Estimated Position Observation Point Mode 2 : Fixed Position Observation Point Mode	[2] (n/a) (Z2)
“An”: Almanac validity	1-2 1 : Valid 2 : Not valid	[2] (n/a) (A2)
“Wn”: Smoothing Index	W1-W3	[2] (n/a) (W2)
“Xn”: Dynamic Index	X1-X3	[2] (n/a) {X2)

$PFEC,GPsrq (in)

Get receiver parameters

Issue this sentence when you need receiver parameters set by $PFEC,GPset.
The answer will be output as $PFEC,GPssd sentence.

$PFEC,	GPsrq	CR LF

$PFEC,GPint (in)

Request output/Set log output intervals

Example

$PFEC,GPint	,GGA01	,GLL00	.....	CR LF
Field#	2	3	4.....	

#. Description **Range** **[Bytes](Unit){Default}**

2.
3.
4.....

Up to 11 (eleven) parameters in any order preceded by delimiter ","(comma). See parameter syntax below:

"Param": Log Output Sentence
<Log Output Sentence Length in bytes>

"GGAnn":$GPGGA<79 max>	GGA00-GGA60	[5](sec){GGA01}
"ZDAnn":$GPZDA<33>	ZDA00-ZDA60	[5](sec){ZDA01}
"GLLnn":$GPGLL<41>	GLL00-GLL60	[5](sec){GLL00}
"GSAnn":$GPGSA<66 max>	GSA00-GSA60	[5](sec){GSA00}
"GSVnn":$GPGSV<201 max>	GSV00-GSV60	[5](sec){GSV01}
"VTGnn":$GPVTG<41 max>	VTG00-VTG60	[5](sec){VTG01}
"RMCnn":$GPRMC<72 max>	RMC00-RMC60	[5](sec){RMC00}
"altnn":$PFEC,GPalt<49>	alt00-alt60	[5](sec){alt00}
"ancnn":$PFEC,GPanc<59>	anc00-anc60	[5](sec){anc00}
"accnn":$PFEC,GPacc<46>	acc00-acc60	[5](sec){acc00}
"astnn":$PFEC,GPast<82>	ast00-ast60	[5](sec){ast00}
"tstnn":$PFEC,GPtst<29>	tst00-tst60	[5](sec){tst00}
"dienn":$PFEC,GPdie<24>	die00-die60	[5](sec){die00}

NOTE: If zero interval (nn=00) is specified, that sentence is output once when $PFEC,GPint is executed, then output is disabled.

GT-77 can output 480 bytes or so per second. Do not set the log sentence output intervals too short, or this capacity will be exceeded. When estimating the output volume, refer to byte count of each sentence enclosed within < > in the above list.

Example
$PFEC,GPint,tst00<CR><LF> ..... Output self-test result once.
$PFEC,GPint,RMC05<CR><LF> ....Output $GPRMC sentence every five seconds.

$PFEC,GPirq (in)

Get log sentence output intervals

Issue this sentence when you need the log sentence output intervals set by $PFEC,GPint. The answer will be output as $PFEC,GPisd sentence.

$PFEC,	GPirq	CR LF

$PFEC,GPdif (in)

Set DGPS parameter

Example

$PFEC,GPdif	,D0	CR LF
Field#	2	

#.	Description	Range	[Bytes]
2.	Bit Stream Direction of RTCM SC-104 DGPS data.	D0-D1 “D0”: MSB first “D1”: LSB first	[2]

Interpreting Example

DGPS data will be transmitted from MSB.

$PFEC,GPdrq (in)

Get DGPS parameter

Issue this sentence when you need the DGPS parameter set by $PFEC,GPdif.
The answer will be output as $PFEC,GPdsd sentence.

$PFEC,	GPdrq	CR LF

$PFEC,GPrrs (in)

Set TRAIM/1PPS output

Example

$PFEC,GPrrs	,1	,100	,1	CR LF
Field#	2	3	4	

#.	Description	Range	[Bytes](UNIT){Default}
2	TRAIM switch	0-1 0: TRAIM OFF 1: TRAIM ON	[1](N/A){0}

NOTE: TRAIM functions when Fixed Observation Point Mode is selected.

3 Alarm Limit 25-999 [3](10nanosec){100}

Set the limit value by 10 nanosecond to go off the alarm in TRAIM. When there is a satellite which has larger error than the value set.

Limit value to detect abnormal satellite	Number of satellites tracked
T≧750	3
T≧500	4
T≧375	5
T≧300	6
T≧250	7
T≧210	8

4. 1PPS Control Mode 0-3 [1]{2}

Value	Mode	Contents
0	No output	1PPS output is completely stopped.
1	Always output	1PPS is always output.
2	Ordinary output	1PPS is output in an ordinary way.
3	Higher reliability	1PPS is output only when number of satellites tracked are sufficient to judge the alarm but still no alarm goes off.

NOTE: Since 1PPS is always output in GT-77, the set above will be invalid. (Above set is described for GPS receiver only.)

Interpreting Example

TRAIM ON,
Alarm limit is 1000 nanosecond
1PPS is always output.

$PFEC,GPrrq (in)

Send TRAIM/1PPS parameters

Example

$PFEC,GPrrq	CR LF
Field# 1	

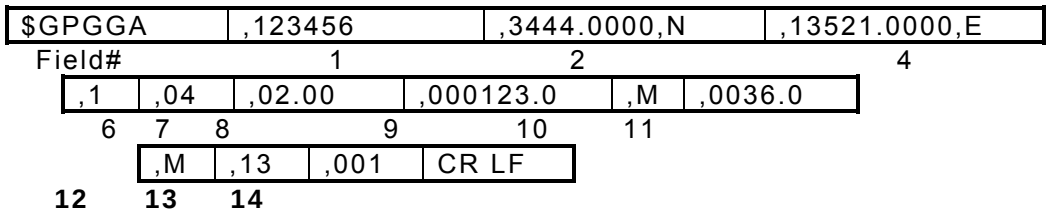
Data set by **GPrrs** is output.
NOTE: As $PFEC,GPrsd is used to get an answer to $PFEC,GPrrq.

3.7 NMEA-0183 OUTPUT SENTENCES

$GPGGA (out)

Position, altitude, UTC, etc.

Example



#.	Description	Range	[Bytes]
1.	UTC		
	"12": hh	00-23	[2]
	"34": mm	00-59	[2]
	"56": ss	00-59	[2]
2.	Latitude		
	"34": degree	0-90	[2]
	"44": minute (integer)	0-59	[2]
	"0000": minute (fraction)	0000-9999	[4]
	"N": North/South	N or S	[1]
4.	Longitude		
	"135": degree	000-180	[3]
	"21": Minute (integer)	00-59	[2]
	"0000": Minute (fraction)	0000-9999	[4]
	"E": East/West	E or W	[1]
6.	Status	0-2	[1]
		"0": Positioning not started yet.	
		"1": Stand-alone GPS positioning	
		"2": Differential GPS positioning	
7.	No. of satellites usedfor positioning	00-08	[2]
8.	DOP (2D: HDOP 3D: PDOP)	n/a	[5]
	NOTE: "00.00" is output while positioning is interrupted.		
9.	Altitude	-00999 9 to 017999.9	[8]
10.	Unit for altitude	M	[1]
11.	Geoide Altitude	-999.9 to 9999.9	[6]
12.	Unit for geoide altitude	M	[1]
13.	DGPS Data Time	00-99	[variable]
	This value indicates the time elapsed since the last RTCM-SC104 TYPE 1 or 9 data updating.		
	Unless DGPS mode is selected, a null field is output.		
14.	DGPS Station ID	0000-1023	[4]
	Unless DGPS mode is selected, a null field is output.		

Interpreting Example

UTC 12:34:56
34 deg 44.0000 min N
135 deg 21.0000 min E
Status: Stand-alone GPS
No. of satellites: 4 satellites
DOP: 2.00
Altitude: 123.0 meters high
Geoide Altitude: 36.0 meters high
DGPS Data Time: 13
DGPS Station ID: 1

$GPZDA (out)

Date/Time

Example

$GPZDA	,123456	,01	,02	,1995	,+09	,00	CR LF
Field#	1	2	3	4	5	6	

#.	Description	Range	[Bytes]
1.	UTC: Time		
	"12": hh	00-23	[2]
	"34": mm	00-59	[2]
	"56": ss	00-59	[2]
2.	UTC: Day of Month		
	"01": DD	01-31	[2]
3.	UTC: Month		
	"02": MM	01-12	[2]
4.	UTC: Year		
	"1995": YYYY	1994-2040	[4]
5.	Local Zone Time (Hour)		
	"+09": hh	-13 ... +00 ... +13 (-/+: East/west of date line)	[3]
6.	Local Zone Time (Minute)		
	"00": mm	00 to 59	[2]

NOTE: Local zone time setting is used for calculating local time when outputting $PFEC,GPast: (Local Time)=(UTC) - (Local Zone Time)

Interpreting Example

February 1, 1995
12:34:56
Local Zone Time: +09:00

$GPGLL (out)

Position, UTC, etc.

Example

$GPGLL	,3444.1234,N	,03521.0000,E	,123456	,A	CR LF
Field#	1	3	5	6	

#.	Description	Range	[Bytes]
1.	Latitude		
	“34”:degree	00-90	[2]
	“44”: minute (integer)	00-59	[2]
	“1234”: minute (fraction)	0000-9999	[4]
	“N”: North/South	N or S	[1]
3.	Longitude		
	“035”: degree	000-180	[3]
	“21”: Minute (integer)	00-59	[2]
	“0000”: Minute (fraction)	0000-9999	[4]
	“E”: East/West	E or W	[1]
5.	UTC		
	“12”: hh	00-23	[2]
	“34”: mm	00-59	[2]
	“56”: ss	00-59	[2]
6.	Status	A or V	[1]
		“A”: Positioning (Stand-alone or DGPS)	
		“V”: Positioning interrupted	

Interpreting Example

34 deg 44.1234 min N
35 deg 21.0000 min E
UTC: 12:34:56
Status: Positioning

$GPGSA (out)

Positioning status

Example

$GPGSA	,A	,3	,01	,02	,03	.....	,02.00	,03.00	,04.00	CR LF
Field#	1	2	3	4	5	6.....	15	16	17	

#.	Description	Range	[Bytes]
1.	Operational Mode	M or A “M”: 2D-only Mode “A”: 2D/3D Auto-switching Mode	[1]
2.	Positioning Status	1-3 “1”: Positioning interrupted “2”: 2D-positioning “3”: 3D-positioning	[1]
3-14.	Satellite Numbers used for positioning NOTE: A null field is output unless a satellite is available.	01-32	[2]
15.	PDOP NOTE: “00.00” is output unless 3D-positioning is performed.	n/a	[5]
16.	HDOP NOTE: “00.00” is output while positioning is interrupted.	n/a	[5]
17.	VDOP NOTE: “00.00” is output unless 3D-positioning is performed.	n/a	[5]

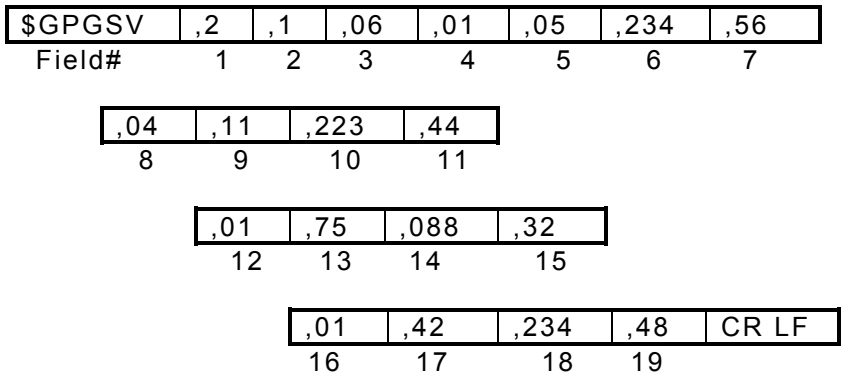
Interpreting Example

2D/3D Auto-switching Mode
3D-Positioning
Satellites used: 01,02,03....
PDOP: 2.00
HDOP: 3.00
VDOP: 4.00

$GPGSV (out)

Satellite details

Example



#.	Description	Range	[Bytes](unit)
1.	Total No. of Messages	1-3	[1](n/a)
2.	No. of Message	1-3	[1](n/a)
3.	No. of satellites in line-of-site (with elevation angle higher than 5 degrees only)	00-12	[2](n/a)
4.	1st Sat. SV#	01-32	[2]
5.	1st Sat. Elevation Angle	05-90	[2](degree)
6.	1st Sat. Bearing Angle	000-359	[3](degree)
7.	1st Sat. SNR(Signal/Noise Ratio)(C/No)	00-99	[2](dBHz)

8-11. 2nd Sat. Details
12-15. 3rd Sat. Details
16-19. 4th Sat. Details

$GPVTG (out)

Course and speed

Example

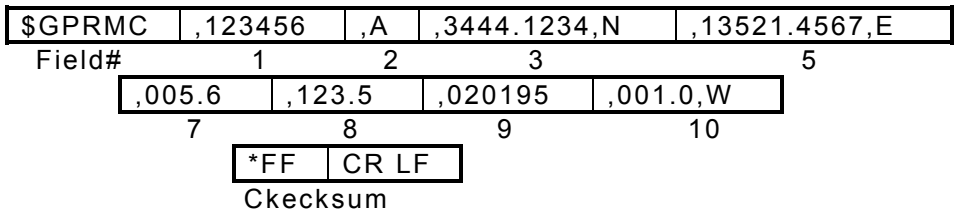
$GPVTG	,012.3,T	,001.1,M	,001.2,N	,0002.2,K	CR LF
Field#	1	3	5	7	

#.	Description	Range	[Bytes](unit)
1.	True Course		
	“012.3”	000.0-359.9	[variable](degree)
	“T”(meaning TRUE)	T	[1](n/a)
	NOTE: A null field is output unless true course information is available.		
3.	Magnetic Course		
	“001.1”	000.0-359.9	[variable](degree)
	“M”(meaning MAGNETIC)	M	[1](n/a)
	NOTE: A null field is output unless magnetic course information is available.		
5.	Speed (kts)		
	“001.2”	000.0-999.9	[variable](kts)
	“N”(meaning kNot)	N	[1](n/a)
	NOTE: A null field is output unless speed information is available.		
7.	Speed (km/h)		
	“0002.2”	0000.0-9999.9	[variable](km/h)
	“K”(meaning Km/h)	K	[1](n/a)
	NOTE: A null field is output unless speed information is available.		

$GPRMC (out)

UTC, position, course, speed, etc.

Example



#.	Description	Range	[Bytes]
1.	UTC: Time		
	"12": hh	00-23	[2]
	"34": mm	00-59	[2]
	"56": ss	00-59	[2]
2.	Status	A or V	[1]
		"A": Positioning (Stand-alone or DGPS)	
		"V": Positioning interrupted	
3.	Latitude		
	"34":degree	00-90	[2]
	"44": minute (integer)	00-59	[2]
	"1234": minute (fraction)	0000-9999	[4]
	"N": North/South	N or S	[1]
5.	Longitud		
	"135": degree	000-180	[3]
	"21": Minute (integer)	00-59	[2]
	"4567": Minute (fraction)	0000-9999	[4]
	"E": East/West	E or W	[1]
7.	Speed (kts)		
	"005.6"	000.0-999.9	[variable]
	NOTE: A null field is output unless speed information is available.		
8.	True Course (degree)		
	"123.5"	000.0-359.9	[variable]
	NOTE: A null field is output unless true course information is available.		
9.	UTC: Date		
	"02": DD	01-31	[2]
	"01": MM	01-12	[2]
	"95": YY	94-40	[2]
		(1994-2040)	
10.	Magnetic Deviation (degree)		
	"001.0"	000.0-180.0	[5]
	"W"	W or E	[1]
		"W": West (MAG=TRUE-DEV)	
		"E": East (MAG=TRUE+DEV)	

*Ckecksum

8 bits data between "$" and "*"(excluding "$" and "*") are XORed, and the result is converted to 2 bytes of hexadecimal letters. Only RMC sentences are transmitted with checksum. All other output sentences do not include checksum fields.

Interpreting Example

UTC Time 12:34:56
Positioning
34 deg. 44.1234 min. N
135 deg. 21.4567 min. E
Speed: 5.6 kts
True Course: 123.5 degrees
UTC Date Jan 2, 1995
Magnetic Deviation: 1.0 degree, West

$PFEC,GPalt (out)

No. of satellites coming within 24 hours

Example

		Column 1	24
$PFEC,GPalt	,1	,08300100	,78ABAABBA987777788889999	CR LF
Field#		2 3	4	

#.	Description	Range	[Bytes]
2.	Status	0 or 1 "0": Calculating (Prediction data invalid) "1": Calculation completed	[1]
3.	Local Date/Time		
	"08": MM	01-12	[2]
	"30": DD	01-31	[2]
	"01": hh	00-23	[2]
	"00": mm	00-59	[2]
	NOTE: Data as of this date/time is calculated and output.		
4.	Number of satellites which come in line of site within 24 hours This field is 24-byte long, and each byte represents one hour. The number of satellites is output in hexadecimal notation. (A=10, B=11, ... F=15) It should be noted that tomorrow's data come first, then today's data follows. See below.		

Interpreting Example

Column	DATE	TIME	No. of visible satellites
1	Aug. 31	00:00	7
2	Aug. 30	01:00	8
3	Aug. 30	02:00	10
4	Aug. 30	03:00	11
5	Aug. 30	04:00	10
6	Aug. 30	05:00	10
7	Aug. 30	06:00	11
8	Aug. 30	07:00	11
9	Aug. 30	08:00	10
10	Aug. 30	09:00	9
11	Aug. 30	10:00	8
12	Aug. 30	11:00	7
13	Aug. 30	12:00	7
14	Aug. 30	13:00	7
14	Aug. 30	14:00	7
16	Aug. 30	15:00	7
17	Aug. 30	16:00	8
18	Aug. 30	17:00	8
19	Aug. 30	18:00	8
20	Aug. 30	19:00	8
21	Aug. 30	20:00	9
22	Aug. 30	21:00	9
23	Aug. 30	22:00	9
24	Aug. 30	23:00	9

$PFEC,GPanc (out)

Almanac date and satellite's health condition

Example

	Column 1		32
$PFEC,GPanc	,940102030405	,22222200222222222222000000222221	CR LF
Field#	2	3	

#.	Description	Range	[Bytes]
2.	Almanac Date/Time (Local Date/Time) "940102030405": YYMMDDhhmmss		[12]
3.	Heath conditions for 32 satellites Each column represents each satellite.	0-2 "0": Almanac not collected yet, or that satellite is not launched yet. "1": unhealthy (Not used for positioning). "2": healthy (Usable for positioning)	[32]

Interpreting Example

Almanac: Jan. 2, 1994
03:04:05

SV#1 healthy
SV#2 healthy
SV#3 healthy
SV#4 healthy
SV#5 healthy
SV#6 healthy
SV#7 unhealthy
SV#8 unhealthy
SV#9 healthy
.....

$PFEC,GPacc (out)

SV(satellite) Accuracy

Example

Column 1		32
$PFEC,GPacc	,222222XXXXXXXXX77777XXXXXXXXXXBF	CR LF
Field#	2	

#.	Description	Range	[Bytes]
2	SV accuracies for 32 satellites Each column represents each satellite.	0-F: SV Accuracy in hexadecimal notation X: SV Accuracy not available	[32]

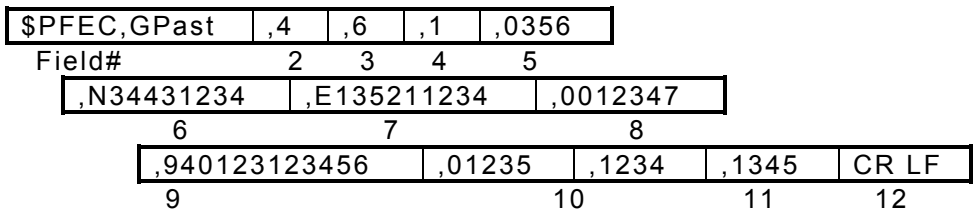
Interpreting Example

SV#1 2
SV#2 2
SV#3 2
SV#4 2
SV#5 2
SV#6 2
SV#7 data not available
SV#8 data not available
SV#9 data not available
.....

$PFEC,GPast (out)

Position, altitude, speed, course, local time, etc.

Example



#.	Description	Range	[Bytes]
2.	Status		
	"4"	0,3-6	[1]
		"0": Positioning not performed yet	
		"3": Stand-alone GPS, 2D	
		"4": Stand-alone GPS, 3D	
		"5": DGPS 2D	
		"6": DGPS 3D	
3.	No. of satellites used for positioning		
	"6"	0-8	[1]
4.	Seed/course calculation status		
	"1"	0-1	[1]
		"0": Data invalid (Can't calculate)	
		"1": Data valid	
5.	DOP x100 (2D: HDOP 3D: PDOP)		
	"0356"	0000-9999	[4]
	NOTE: For actual DOP, divide the above value by 100.		
	"0000" is output while positioning is interrupted.		
6.	Latitude		
	"N": North/South	N or S	[1]
	"34": degree	00-90	[2]
	"43": minute (integer)	00-59	[2]
	"1234": minute (fraction)	0000-9999	[4]
7.	Longitude		
	"E": East/West	E or W	[1]
	"135": degree	000-179	[3]
	"21": Minute (integer)	00-59	[2]
	"1234": Minute (fraction)	0000-9999	[4]
8.	Altitude (x10m)		
	"0012347"	-009999 to 0179999	[7]
	NOTE: For actual altitude, divide the above value by 10.		
9.	Local Date/Time		
	"940123123456": YYMMDDhhmmss	n/a	[12]
	NOTE: (Local date/time)=(UTC)-(Local Zone Time)		
	Unless local zone time information is available, UTC is output.		
10.	Speed (x10 km/h)		
	"01235"	00000-18519	[5]
	NOTE: For actual speed, divide the above value by 10.		
	If speed/course calculation status (field#4) is "0"(invalid), previous output value is held.		

11. True Course (x10 degrees)
    "1234" 0000-3599 [4]
    NOTE: For actual course, divide the above value by 10.
    If speed/course calculation status (field#4) is "0"(invalid), output value is held.
12. Magnetic Course (x10 degrees)
    "1345" 0000-3599 [4]
    NOTE: For actual course, divide the above value by 10.
    If speed/course calculation status (field#4) is "0"(invalid), output value is held.

$PFEC,GPtst (out)

Self-test results

Example

$PFEC,GPtst	,0	,4850211001	,0	,8	CR LF
Field#	2	3	4	5	

#.	Description	Range	[Bytes](unit)
2.	Status	0-1 "0": Testing now "1": Completed	[1]
3.	Program and Version Numbers		
	"4850211": Program No.	n/a	[7]
	"001": Version No.	n/a	[3]
4.	Self-test Results		
	Result of Test I	0-1 "0": Normal "1": GPS data backup error	[1]
5.	Self-test Results		
	Result of Test II	1-B	[1]

Code	Rx Param Backup	RAM	ROM
"1"	ok	ok	error
"2"	ok	error	ok
"3"	ok	error	error
"8"	error	ok	ok
"9"	error	ok	error
"A"	error	error	ok
"B"	error	error	error

$PFEC,GPssd (Answer to $PFEC,GPsrq)

Receiver parameters set by $PFEC,GPset

Receiver parameters set by $PFEC,GPset are output in two sentences. Each parameter is preceded by delimiter “,” (comma).

Example

$PFEC,GPssd	,G001	.....	CR LF
Field#	2	3.....	

$PFEC,GPs sd	,D08	.....	CR LF
Field#	2	3.....	

$PFEC,GPisd (Answer to$PFEC,GPirq)

Log output intervals set by $PFEC,GPint

Log output intervals set by $PFEC,GPint are output in two sentences. Each parameter is preceded by delimiter “,” (comma).

Example

$PFEC,GPisd	,GGA01	.....	CR LF
Field#	2	3.....	

$PFEC,GPisd	,tst00	.....	CR LF
Field#	2	3.....	

$PFEC,GPdsd (Answer to $PFEC,GPdrq)

DGPS parameters set by $PFEC,GPdif

DGPS parameters set by $PFEC,GPdif are output.

Example

$PFEC,GPdsd	,D0	CR LF
Field#	2	

$PFEC,GPdie (out)

Receiver status

Example

$PFEC,GPdie	,1	,08	,0	,0	,0	CR LF
Field#	2	3	4	5	6	

#.	Description	Range	[Bytes]
2.	DGPS status	0-1 "0": DGPS data not received yet "1": Receiving DGPS data	[1]
	NOTE: This flag will be set a few seconds after DGPS data entry.		
3.	No. of DGPS Satellites "08"	n/a	[2]
4.	DGPS Station's Health Condition "0"	0-1 "0": healthy "1": unhealthy	[1]
	NOTE: If DGPS station is unhealthy, stand-alone GPS function rather than DGPS is performed.		
5.	DGPS Data Status "0"	0-1 "0": Normal "1": Abnormal	[1]
	NOTE: If DGPS data is invalid, stand-alone GPS function rather than DGPS is performed.		
6.	DGPS Error Code "0" See xxxx Manual for further details.	0-F	[1]

Common Errors

If DGPS status (field# 2) can not set to "1"(Receiving DGPS data), or if DGPS fix is not obtainable, suspect:

* Invalid format of incoming DGPS data
* Insufficient number of satellites in DGPS data
* DGPS station is faulty
* DGPS data is too old to correct positioning

$PFEC,GPtps (out)

Time and pulse output

Example

$PFEC,GPtps	,940630123000	,3	,1	,1
Field# 1	2	3	4	5

,940701000000	,+1	,10	,940626120000
6	7	8	9

,0755	,390610	CR LF
10	11	

#.	Description	Range	[Bytes](Unit)
2.	Present Date/Time "940630123000": YYMMDDhhmmss NOTE: Range for year is 1994 to 2040. "94" to "99" for 1994 to 1999. "00" to "40" for 2000 to 2040. RTC, GPS time or UTC is output as a present date/time. See the succeeding field.	See NOTE.	[12]
3.	Time Standard ID	1-3 "1": RTC "2": GPS Time "3": UTC	[1]
	NOTE: The date/time based on the RTC is output after the GT-77 is turned on until it starts tracking a satellite. GPS Time is output after the GT-77 starts tracking a satellite until it collects a UTC parameter (including UTC offset) in the autonomous start condition. UTC is output after the GT-77 collects a UTC parameter while tracking a satellite. 1PPS is also output under this condition.		
4.	1PPS Availability Status Flag	0-1 "1": "1PPS will be output following this sentence". "0": 1PPS is not output.	[1]
5.	Mode	1-2 "1": Estimated Observation Point Mode "2": Fixed Observation Point Mode	[1]
6.	UTC Leap Second Adjustment Date/Time This field predicts when a leap second adjustment will take place. The example indicates that a leap second adjustment will be executed directly before 94/07/01 00:00:00 (YY/MM/DD hh:mm:ss). Unless a UTC parameter has been collected, this field will be filled with zeroes. See the following example. $PFEC,GPtps,940630123000,2,0,1,000000000000,00,00,000000000000,0755,390600<CR><LF>		[12](YYMMDDhhmmss)
7.	Leap Second This field indicates the magnitude of a pending or previous leap second adjustment to UTC. UTC is occasionally adjusted in one-second increments to limit its cumulative deviation from the Earth's rotational time (UT1). "+1" is reported if a leap second was/will be added to UTC. Inserting a second retards UTC: June 30 23:59:58 23:59:59 23:59:60 ← 60th second is inserted July 1 00:00:00	"-1", "00" or "+1" [2]	(second)

"-1" is reported if a leap second was/will be subtracted from UTC. Deleting a second advances UTC:

June 30 23:59:58
July 1 00:00:00 ← 59th second is deleted

"00" is reported when the magnitude of a pending or previous adjustment is unknown.

The UTC Leap Second Adjustment Date/Time (field #6) establishes the context of the Leap Second value. When the date of an adjustment is in the future, the Leap Second value is the magnitude of a pending adjustment; when this date is in the past, the value applies to the previous adjustent.

Leap second information can be invalidated by sending the "$PFEC, GPclr, 1" or "$PFEC, GPclr, 3" sentence, or by removing back-up power to the receiver.

Limitation of Leap Second Indication

Leap second adjustments offset UTC from GPS Time, the continuous time scale maintained by GPS that is referenced to an epoch of 0000 UTC, January 6, 1980. Satellites continuously broadcast current and pending cumulative offsets between these time scales.

The GT-77 calculates the magnitude of an adjustment by subtracting the current offset from the pending offset. The Leap Second field, however, is updated only when these values differ. For example, "+1" will be reported prior to and following the addition of a leap second. It will not revert to "00 ", and can only change to "-1" when a pending subtraction of a leap second is announced.

Accordingly, a GT-77 that received the announcement of a prior adjustment reports "+1" or "-1". A GT-77 placed in operation after this adjustment reports "00", since current and pending time scale offsets are identical.

Example:
$PFEC,GPtps,950630123000,2,0,1,940701000000,00,10,950626120000,0755,390610<CR><LF>

8. UTC-GPS Time Offset 00-99 [2](second)
This field accumulates leap seconds since the GPS system started operation on January 6, 1980. As of September 1995 this value was 10. This fact means that leap second insertion had been executed 10 times during the period from January 6, 1980 to September, 1995 because only positive ("+1") adjustments were made in that period. Take note that this field will be "00" unless a UTC parameter has been collected.
9. Date/Time stamp of UTC Parameter [12](YYMMDDhhmmss)
A UTC parameter (UTC correction value) is included in almanac, which the GT-77 requires to achieve ±1μsec accuracy. This field indicates when the UTC parameter was updated last time. This field will be "000000000000" unless a UTC parameter has been collected. See the following example:
$PFEC,GPtps,940630123000,2,0,1,000000000000,00,00,000000000000,0755,390600<CR><LF>
10. Count of GPS Weeks 0000-3182 [4](week)
This field counts up how many weeks have elapsed since the GPS system started operation at 1980/01/06 00:00:00 (YYYY/MM/DD hh:mm:ss).
11. Count of seconds within a GPS week 000000-604799 [6](second)
This field counts up how many seconds have elapsed in the current GPS week. The count is reset to "000000" every week.

How to enable “$PFEC,GPtps” output
Example: The following command line makes the GT-77 output “$PFEC,GPtps” sentence every second.
$PFEC,GPint,tps01<CR><LF>

$PFEC,GPgpt (out)

GPS time output

Example

$PFEC,GPgpt	,1	,0816	,100799	10	CR LF
Field# 1	2	3	4	5	

#.	Description	Range	[Bytes](Unit){Default}
2.	Validity Flag	0-1 "1": GPS Time is valid. "0": GPS Time not determined yet.	[1]
3.	Count of GPS Weeks This field counts up how many weeks have elapsed since the GPS system started operation at 1980/01/06 00:00:00 (YYYY/MM/DD hh:mm:ss).	0000-3182	[4](week)
4.	Count of seconds within a GPS week This field counts up how many seconds have elapsed in the current GPS week. The count is reset to "000000" every week.	000000-604799	[6](second)
5.	UTC offset This field indicates the offset second between GPS time and UTC.As of September 1995, the offset second is 10. However, if the UTC parameter has not been collected yet, "00" will be indicated.	00-99	[2](second)

How to enable "$PFEC,GPgpt" output

Example: The following command line makes the GT-77 output "$PFEC,GPgpt" sentence every second.

$PFEC,GPint,gpt01<CR><LF>

$PFEC,GPtlp (out)

Leap second adjustment prediction

Example

$PFEC,GPtlp	,3	,941230123450	,950101000000	CR LF
Field# 1	2	3	4	

#.	Description	Range	[Bytes](Unit){Default}
2.	Currently-used Time Standard	1-3 "1": RTC "2": GPS Time "3": UTC (1PPS available)	[1]

NOTE: For output of UTC, the following conditions must be met:
* Latest almanac is available within GT-77.
* At least on satellite is acquired by GT-77.

3. Date/time when the prediction was calculated [12](YYMMDDhhmmss)
   In case of the above example the prediction was calculated at 94/01/01 00:00:00(YY/MM/DD hh:mm:ss).
4. Date/time of leap second adjustment execution [12](YYMMDDhhmmss)
   In case of the above example leap second adjustment is scheduled at 95/01/01 00:00:00(YY/MM/DD hh:mm:ss).

How to enable "$PFEC,GPtlp" output

Example: The following command makes the GT-77 output "$PFEC,GPtlp" sentence once.

$PFEC,GPint,tlp00<CR><LF>

$PFEC,GPrrm (out)

TRAIM information output

Example

$PFEC,GPrrm	,0	,0	,17	,00	00
Field# 1		2	3	4	5	6

,01	,+000	,23	CR LF
7	8	9	

#.	Description	Range	[Bytes]
2.	1PPS output result status	0-2 "0" : Output normally "1" : Alarm on "2" : Not sufficient satellites to judge	[1]
3.	TRAIM status abnormal satellites abnormal satellites.	0-2 "0" : Possible both to detect alarm and to delete "1" : Possible only to detect alarm "2" : Not possible either to detect alarm or delete	[1]
4.	Deleted Satellites Number	00-32 "00" : No deleted satellites "01" to "32" : Deleted satellites number.	[2]
5.	Reserved		[2]
6.	Reserved		[2]
7.	Reserved		[2]
8.	Reserved		[4]
9.	Output of offset less than 43 nanosec	+0 to +42	[3]

$PFEC,GPrsd (out)

TRAIM/1PPS Control mode set by $PFEC,GPrrs

TRAIM/1PPS control mode set by $PFEC,GPrrs is output for verification.

Example

$PFEC,GPrsd	,1	,100	,3	CR LF
Field# 1	2	3	4	

2.-4 These fields indicates the output set by GPrrs sentence for verification purpose.

$PFEC,GPspe,ANCOUT (in)

Down-load almanac

Issue this sentence when you need the almanac data from GT-77.

$PFEC,GPspe,ANCOUT	CR LF

As an answer to the above sentence, GT-77 outputs internal almanac data (about 6.0K bytes of ASCII characters) in the following format.

Note that, after this sentence is received, the GT-77 stops positioning, receiving data, and outputting the other data than almanac data. After outputting the almanac data, the GT-77 will restart automatically (Restart clear mode 2).

Example:

#GP,TYP=GP77,	90A927FDE.....980FE3	CR LF

You may save the downloaded almanac for future uploading.

$PFEC,GPspe,ANCINP (in)

Up-load almanac

Issue this sentence when you want to send almanac data to GT-77. This function enables quicker Time-To-First-Fix.

$PFEC,GPspe,ANCINP	CR LF

Following the above sentence, send almanac data which you had saved by $PFEC,GPspe,ANCOUT before:

#GP,TYP=GP77,	90A927FDE.....980FE3	CR LF

If uploading is completed successfully, GT-77 outputs the following acknowledgment and restarts by itself (Restart clear mode 2).

$ANC, OK	CR LF

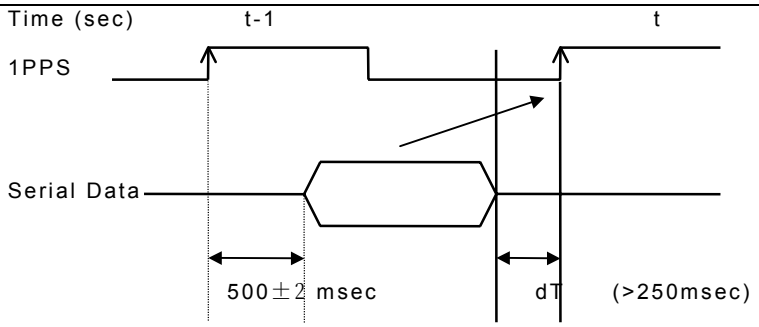
If uploading is failed, GT-77 requests you to send the entire almanac sentence again by outputting the following error message:

$ANC,NG	CR LF

"NG" means No Good.

4 1PPS, T-RAIM

4.1 SPECIFICATIONS FOR 1PPS CLOCK SIGNAL

Accuracy	± 1 μsec (with 2σ) referenced to UTC (The GT-77 should be placed at a fixed position. This accuracy can not be expected if the unit is moved during operation.)
Polarity	Rising edge of each pulse
Level	TTL HIGH: 2.4 V (with 0.8 mA flowing out of the 1PPS terminal) LOW:. 0.5 V (with 6.0 mA flowing into the 1PPS terminal)
Duty	50 % approx.
Conditions for 1PPS output	Almanac be available within the GT-77. There are additional conditions which differ between the estimated and fixed observation point modes, TRAIM function On/Off, 1PPS control mode. For further details see "**4.2 ESTIMATED AND FIXED OBSERVATION POINT MODES**" of this document.
Output timing of "tps"(Time and Pulse) serial data packet	 $PFEC,GPtps" sentence for pulse "t" (75 bytes fixed) NOTE A date/time stamp for a 1PPS pulse is included in the serial data packet which the GT-77 outputs directly before the rising edge of each 1PPS pulse. "dT(>250 msec)" is ensured when only a "$PFEC,GPtps" sentence is output as a date/time stamp data packet. If other sentences are output additionally, dT becomes shorter than 250 msec. If extremely many data packets are output, a date/time stamp data packet may be output after a 1PPS pulse. In order to avoid such a misleading situation, it is recommended to command the GT-77 to output "$PFEC,GPtps" only or to output minimum number of data packets.

Sample Command Lines to enable "$PFEC,GPtps" output

Example 1: Output only "$PFEC,GPtps" data packet every second
$PFEC,GPint,GGA00,ZDA00,GSV00,VTG00,tps01<CR><LF>

Example 2: Output both "$GPGGA" and "$PFEC,GPtps" data packets every second
$PFEC,GPint,GGA01,ZDA00,GSV00,VTG00,tps01<CR><LF>

Conditions for 1PPS Output

To output 1PPS the GT-77 requires almanac because almanac includes a UTC parameter(UTC correction factor) which is indispensable to achieve ±1 usec accuracy. This UTC parameter comprises of two values: one is "multiple of second" which adjusts GPS time to UTC, and the other a fraction in nano-sec resolution.

Unless almanac is available, the GT-77 must collect it by tracking then receiving a satellite signal for longer than 12.5 minutes.

The GT-77 outputs 1PPS so long as a UTC parameter received within 30 days is available.

If you require ± 1 usec accuracy, however, the UTC parameter received within 6 days is required. In other words the GT-77 should have been operated for longer than 12.5 minutes within the past 6 days to update the almanac. If the existing UTC parameter is older than 6 days, ± 1 usec accuracy can not be expected.

The date/time stamp of a UTC parameter is knowable from Time and Pulse data packet "$PFEC,GPtps". See the following example.

Example: Date/time stamp of a UTC parameter
$PFEC,GPtps,940630123000,3,1,1,940701000000,+1,10,940626120000,0755,390610<CR><LF>

The underlined portion indicates that the existing UTC parameter was received at 94/06/26 (yy/mm/dd) 12:00:00 (hh:mm:ss).

4.2 ESTIMATED AND FIXED OBSERVATION POINT MODES

The following two operational modes are available:

Estimated Observation Point Mode: (Default mode after power-on reset)	1PPS is obtainable without entry of own position information.
Fixed Observation Point Mode	Entry of own position information is required for 1PPS output

To selec the estimated or fixed observation point mode, send a “$PFEC,GPset” command. See the following examples.

$PFEC,GPset,Z1<CR><LF>	Select Estimated Observation Point Mode.
$PFEC,GPset,Z2<CR><LF>	Select Fixed Observation Point Mode.

To inquire which mode is selected currently, send command “$PFEC,GPsrq” command, and receive answer “$PFEC,GPssd”. See the following example.

$PFEC,GPsrq,<CR><LF>	Send this command sentence.
$PFEC,GPssd.....,Z2<CR><LF>	GT-77 will return “$PFEC,GPssd” sentence as an answer. “Z2” indicates Fixed Observation Point Mode. If Estimated Observation Point mode is in use, “Z1” rather than “Z2” will be answered.

4.2.1 ESTIMATED OBSERVATION POINT MODE (DEFAULT M0DE AFTER POWER-ON RESET)

This mode is used when GT-77's own position is unknown.

In this mode of operation the GT-77 outputs 1PPS while performing position-fixing. This mode is also usable to collect GT-77's own position which is used for fixed observation point mode operation. In this case collect own position data by operating the GT-77 for 12 to 24 hours continually, then use the average as the entry for the fixed observation point mode operation.

Conditions for 1PPS output in the estimated observation point mode are as follows:

1) 1PPS is output after a series of the following operations:

   Tracking four or more satellites
   Starting position fixing
   UTC calculation completes

   NOTE: UTC calculation is performed when the following conditions are met:

   A. A UTC parameter (included within almanac) is available.
   B. Ephemeris is collected from at least one satellite.
      (Required for precise time decision.)
      (Usually collected within 30 seconds.)

2) After own position has been fixed, the GT-77 outputs 1PPS by using the position data for time correction.

3) If position-fixing is interrupted, the GT-77 keep on outputting 1PPS so long as at least one satellite is receivable. It stops outputting 1PPS when it can not receive a satellite.

4.2.2 FIXED OBSERVATION POINT MODE

This mode is usable when GT-77's own position is known.

The GT-77 must be fixed at the known position. As soon as a satellite becomes receivable, the GT-77 starts outputting 1PPS based on the position information which you entered. For the details, refer to "4.1 Conditions for 1PPS output".

Bear in mind that the GT-77 does not perform position fixing in this mode of operation, but it merely outputs the position data which you entered.

* Fixed position entry
Enter latitude/longitude by sending "$GPGGA", "$GPGLL", or "$GPRMC" sentence, and altitude by sending "$PFEC,GPset" sentence. See the following examples.

$PFEC,GPset,Z2<CR><LF>	Select Fixed Observation Point Mode.
$GPGGA,3444.4700,N,13521.2000,E<CR><LF>	Declare latitude/longitude.
$PFEC,GPset,H000021.0<CR><LF>	Declare altitude.

You may enter both mode and altitude within a single "$PFEC,GPset" sentence if that is preferred. See the following example.

$PFEC,GPset,Z2,H000021.0<CR><LF>	Always place the "Z2" before altitude declaration.
$GPGGA,3444.4700,N,13521.2000,E<CR><LF>	Declare latitude/longitude.

4.3. TIME RAIM (RECEIVER AUTONOMOUS INTEGRITY MONITORING) (=T-RAIM)

T-RAIM is a function of receiver to detect abnormality of satellites by receiving signals from more satellites than necessary for position fixing (or 1pps output). Depending on the number of necessary satellites, the receiver can either detect the abnormality and issue the alarm or can isolate the abnormal satellites.

By issuing "$PFEC, GPrrm" command, TRAIM functions can be set on. Keep in mind that the T-RAIM function is only operative when the receiver is in fixed observation point mode.

<How to select 1PPS control mode>

You can select the 1PPS control mode by issuing "$PFEC,GPrrs" command.

There are four different modes.

0. No output mode : No output
1. Always output mode : Always output
2. Ordinary mode : Output with a single satellite tracked (except estimated observation point mode)
3. High reliability mode: Output when no T-RAIM alarm is being issued. (Need minimum of two satellites tracked).

Example:
$PFEC,GPrrs,1,100,3 <CR><LF>

This example shows T-RAIM On, High reliable 1pps output mode.

The details are explained in the sentence of $PFEC,GPrrs (in).

5. QUALITY CHECK TEST

5.1 DEFINITION

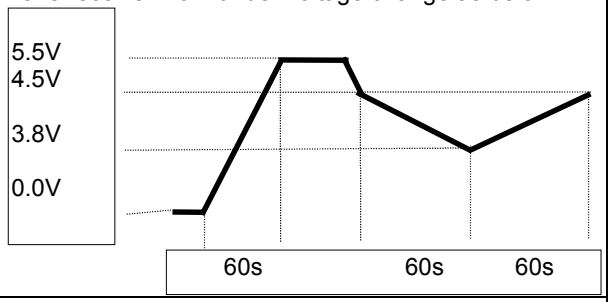
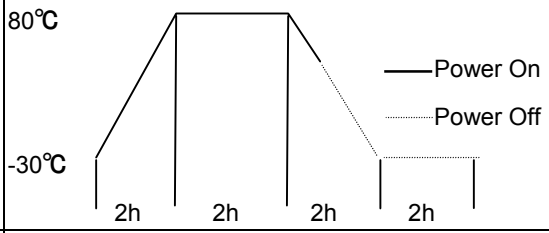
“Standard test conditions” are defined as follows:

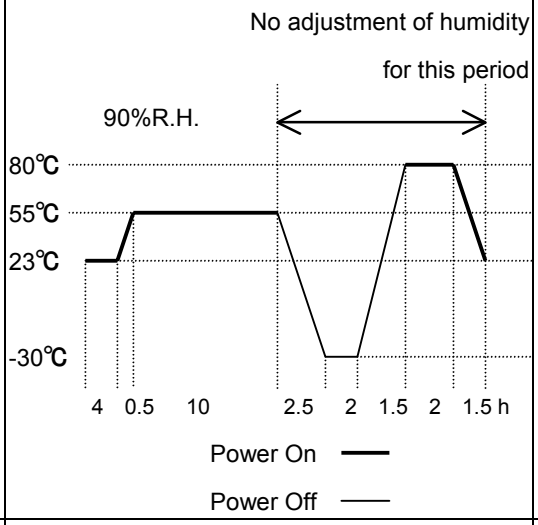
Temperature	20 ±15°C
Humidity	65±20%Rh
Input signal (SIG input)	-126dBm (by GPS simulator)
Power supply voltage (VCC)	5.0V
Power supply voltage (VBAK)	3.0V

“Fulfill the basic performance required” means following conditions:

Item	Specification
C/No value	>44dBHz when receiving input signal level of –126dBm at input terminal of preamplifier.
Power consumption	<100mA
Back up current	<10 μA
Self test result	No error in ROM, RAM checks. Data must be backed up.
Appearance	No soldering crack, no defective parts found.

5.2 STANDARD TEST

Test items	Conditions	Criteria
Temperature Voltage Performance Test	Make receiver work at each temperature of -30℃, -5℃ 25℃, 65℃, 80℃ at 4.5V, 5.0V, 5.5V.	Fulfill the specification at each temperature/voltage.
Ripple Test	Super-impose ripple voltage of 900Hz/10mV_{pp} and 9KHz/100mV_{pp} onto 4.5V, 5.5V power supply voltage.	C/No should not get inferior more than 1dB.
Over-voltage Test	Make receiver work at 6.5VDC, -0.3V for 60 minutes.	Fulfill the basic performance required.
Power Shut-down Test	Make receiver work at temperature of -30, 25, 80 ℃and shut down the power supply with an interval of 10μs, 100μs,1ms, 50ms.	CPU should work normally. When CPU is reset, the data backed up should be correct.
Power Supply Voltage Change Test	Make receiver work under voltage change as below. 	CPU should work normally. If CPU is reset, the data backed up must be correct.
High Frequency Surge Test	Put 1KV of 50ns, 200ns, 1μs of pulse wave and 1μs of triangle wave at 4.75V.	CPU should work normally.
Low Temperature Storage Test	Leave at -40℃ for 70 hours.	Fulfill the basic performance required.
Low Temperature Operation Test	Make receiver work at -30℃ at 4.5V for 70 hours.	Fulfill the basic performance required.
High Temperature Storage Test	Leave for 94 hours at 85℃	Fulfill the basic performance required.
High Temperature Operation Test	Make receiver work at 80℃ at 5.5V for 118 hours.	Fulfill the basic performance required.
Temperature Cycle Test	Repeat following cycle 30 times. 	Fulfill the basic performance required.
Heat Shock Test	Repeat cycle of -40℃ for 2 hours ⇔ 85℃ for 2 hours 20 times (transition time < 5 minutes).	Fulfill the basic performance required.

Test items	Conditions	Criteria
Temperature Humidity Cycle Test	Repeat following cycle 5 times. Repeat following cycle 10 times.  	Fulfill the basic performance required. Below 75%R.H. 95%R.H. 60%R.H. Below 75%R.H.
Humidity Test	Make receiver work for 94 hours under 55℃ 95% R.H.	Fulfill the basic performance required.
Vibration Test	Put vibration of 10 to 200Hz/10 min, 44.1m/s² for 4 hours in x axis, 2 hours in y/z axis.	Fulfill the basic performance required.
Shock Test	Put shock of 981m/s² onto each face 3 times.	Fulfill the basic performance required.
Drop Test	Drop receiver in package from 60cm height (two times of each 6 face, 3 side, 1 angle)	Fulfill the basic performance required.
Output Protection Test	Have short circuit + terminal of signal input/output and ground for 10 seconds.	Fulfill the basic performance required.
Connector Connection Test	Repeat connection/disconnection 50 times at 5.5V	Fulfill the basic performance required.
Soldering Test	Repeat cycle of -40℃ for 30 minutes ⇔ 85℃ for 30 minutes 500 times (transition time<5 minutes).	No soldering crack to be found and fulfill the basic performance required.

6. GEODETIC ID

There are many geodetic systems in the world. Enter a right geodetic system ID in accordance with your chart or map in use. If the geodetic ID you entered differs from the geodetic system employed in your chart or map, GPS fixes may be deviated from the actual position on the chart or map.

ID	Geodetic System	
001	WGS-84	
002	WGS-72	
003	TOKYO	: Mean Value (Japan, Korea & Okinawa)
004	NORTH AMERICAN 1927	: Mean Value (CONUS)
005	EUROPEAN 1950	: Mean Value
006	AUSTRALIAN GEODETIC 1984	: Australia and Tasmania Island
007	ADIADAN	: Mean Value
008		: Ethiopia
009		: Mali
010		: Senegal
011		: Sudan
012	AGF	: Somalia
013	AIN EL ABD 1970	: Bahrain Island
014	ANNA 1 ASTRO 1955	: Cocos Island
015	ARC 1950	: Mean Value
016		: Botswana
017		: Lesotho
018		: Malawi
019		: Swaziland
020		: Zaire
021		: Zambia
022		: Zimbabwe
023	ARC	: Mean Value (Kenya & Tanzania)
024		: Kenya
025		: Tanzania
026	ASCENSION ISLAND 1958	: Ascension Island
027	ASTRO BECON “E”	: Iwo Jima Island
028	ASTRO B4 SOR. ATOLL	: Tern Island
029	ASTRO POS 714	: St. Helena Island
030	ASTRONOMIC STATION 1952	: Marcus Island

031 AUSTRALIAN GEODEDIC 1966	: Australia and Tasmania Island
032 BELLEVUE (IGN)	: Efate and Erromango Islands
033 BERMUDA 1957	: Bermuda Islands
034 BOGOTA OBSERVATORY	: Columbia
035 CAMPO INCHAUPE	: Argentina
036 CANTON ISLAND 1966	: Phoenix Islands
037 CAPE	: South Africa
038 CAPE CANAVERAL	: Mean Value (Florida & Bahama Islands)
039 CARTHAGE	: Tunisia
040 CHATHAM 1971	: Chatham Island (New Zealand)
041 CHUA ASTRO	: Paraguay
042 CORREGO ALEGRE	: Brazil
043 DJAKARTA (BARAVIA)	: Sumatra Island (Indonesia)
044 DOS 1968	: Gizo Island (New Georgia Islands)
045 EASTER ISLAND 1967	: Easter Island
046 EUROPEAN 1950 (Cont'd)	: Western Europe
047	: Cyprus
048	: Egypt
049	: England, Scotland, Channel & Shetland Islands
050	: England, Scotland, Channel & Shetland Islands
051	: Greece
052	: Iran
053	: Italy-Sardinia
054	: Italy-Sicily
055	: Norway and Finland
056	: Portugal and Spain
057 EUROPEAN 1979	: Mean Value
058 GANDAJIKA BASE	: Republic of Maldives
059 GEODEDIC DATUM 1949	: New Zealand
060 GUAM 1963	: Guam Island
061 GUX 1 ASTRO	: Guadalcanal Island
062 HJORSEY 1955	: Iceland
063 HONG KONG 1963	: Hong Kong
064 INDIAN	: Thailand and Vietnam
065	: Bangladesh, India and Nepal
066 IRELAND	: Ireland
067 ISTS 073 ASTRO 1969	: Diego Garcia
068 JHONSTON ISLAND 1961	: Johnston Island
069 KANDAWALA	: Sri Lanka
070 KERGUELEN ISLAND	: Kerguelen Island

071 KERTAU 1948	: West Malaysia and Singapore
072 LA REUNION	: Mascarene Island
073 L. C. 5 ASTRO	: Cayman Brac Island
074 LIBERIA 1964	: Liberia
075 LUZON	: Philippines (Excluding Mindanao Island)
076	: Mindanao Island
077 MAHE 1971	: Mahe Island
078 MARCO ASTRO	: Salvage Islands
079 MASSAWA	: Eritrea (Ethiopia)
080 MERCHICH	: Morocco
081 MIDWAY ASTRO 1961	: Midway Island
082 MINNA	: Nigeria
083 NAHRWAN	: Masirah Island (Oman)
084	: United Arab Emirates
085	: Saudi Arabia
086 NAMIBIA	: Namibia
087 MAPARIMA, BWI	: Trinidad and Tobago
088 NORTH AMERICAN 1927	: Western United States
089	: Eastern United States
090	: Alaska
091	: Bahamas (Excluding San Salvador Island)
092	: Bahamas-San Salvador Island
093 NORTH AMERICAN 1927 (Cont'd)	: Canada (Including Newfoundland Island)
094	: Alberta and British Columbia
095	: East Canada
096	: Manitoba and Ontario
097	: Northwest Territories and Saskatchewan
098	: Yukon
099 NORTH AMERICAN 1927 (Cont'd)	: Canal Zone
100	: Caribbean
101	: Central America
102	: Cuba
103	: Greenland
104	: Mexico
105 NORTH AMERICAN 1983	: Alaska
106	: Canada
107	: CONUS
108	: Mexico, Central America
109 OBSERVATORIO 1966	: Corvo and Flores Islands (Azores)
110 OLD EGYPTIAN 1930	: Egypt

111 OLD HAWAIIAN : Mean Value
112 : Hawaii
113 : Kauai
114 : Maui
115 : Oahu
116 OMAN : Oman
117 ORDNANCE SURVEY OF GREAT BRITAIN 1936 : Mean Value
118 : England
119 : England, Isles of Man and Wales
120 : Scotland and Shetland Islands
121 : Wales
122 PICO DE LAS NIVIES : Canary Islands
123 PITACAIRN ASTRO 1967 : Pitacairn Island
124 PROVISIONAL SOUTH CHILEAN 1963 : South Chile (near 53°S)
125 PROVISIONAL SOUTH AMERICAN 1956 :Mean Value
126 : Bolivia
127 : Chile-Northern Chile (near 19°S)
128 : Chile-Southern Chile (near 43°S)
129 : Colombia
130 : Ecuador
131 : Guyana
132 : Peru
133 : Venezuela
134 PUERTO RICO : Puerto Rico and Virgin Islands
135 QATAR NATIONAL : Qatar
136 QORNOQ : South Greenland
137 ROME 1940 : Sardinia Islands
138 SANTA BRAZ : Sao Maguel, Santa Maria Islands (Azoes)
139 SANTO (DOS) : Espirito Santo Island
140 SAPPER HILL 1943 : East Falkland Island
141 SOUTH AMERICAN 1969 : Mean Value
142 : Argentina
143 : Bolivia
144 : Brazil
145 : Chile
146 : Colombia
147 : Ecuador
148 : Guyana
149 : Paraguay
150 : Peru

151	: Trinidad and Tobago
152	: Venezuela
153 SOUTH ASIA	: Singapore
154 SOUTHEAST BASE	: Porto Santo and Madeira Islands
155 SOUTHWEST BASE	: Faial, Graciosa, Pico, Sao Jorge and TerceiraIslands
156 TIMBALAI 1948	: Brunei and East Malaysia (Sarawak and Sadah)
157 TOKYO	: Japan
158	: Korea
159	: Okinawa
160 TRISTAN ASTRO 1968	: Tristan da Cunha
161 VITI LEVU 1916	: Viti Levu Island (Fiji Islnds)
162 WAKE-ENISETOK 1960	: Marshall Islands
163 ZANDERIJ	: Suriname
164 BUKIT RIMPAH	: Bangka and Belitung Islands (Indonesia)
165 CAMP AREA ASTRO	: Camp Memurdo Area, Antarctica
166 G. SEGARA	: Kalimantan Islands (Indonesia)
167 HERAT NORTH	: Afghanistan
168 HU-TZU-SHAN	: Taiwan
169 TANANARIVE OBSERVATORY 1925	: Madagascar
170 YUCARE	: Uruguay
171 RT90	: Sweden

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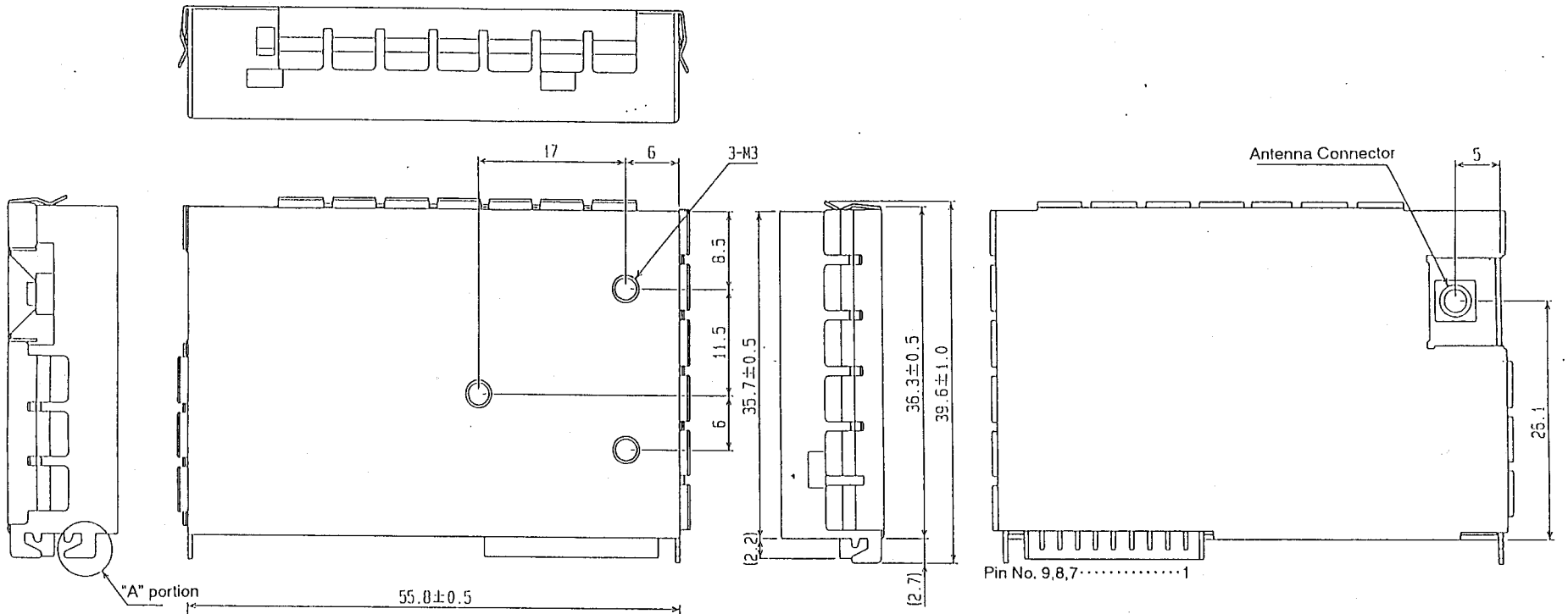

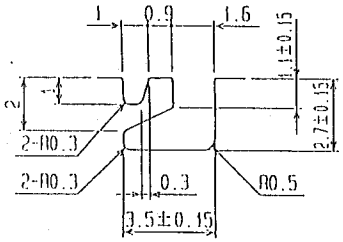

Enlarged "A" portion
Scale : 5/1

Specified Exterminal Tolerance : ±0.3mm
Thickness of Board : 1.6mm
Fixing by hooks : Recommend to use additional auxiliary fixing method.
(Do not rely on fixing hooks only.)
Fixing by screws : Recommend to use additional auxiliary fixing method.
(Do not rely on fixing screws only.)
Fixing Screws : The screw tip should not run through more than 3mm from the outer surface of the case.

品番 ITEM	品名 NAME	材質 MATERIAL	数量 Q'TY	図番 DWG.NO.	摘要 REMARKS
三角法 THIRD ANGLE PROJECTION		名称 TITLE	GT-77N 外寸図		
尺度 SCALE	2/1				
質量 MASS	約0.04 kg	図番 DWG.NO.			

FURUNO ELECTRIC CO., LTD.