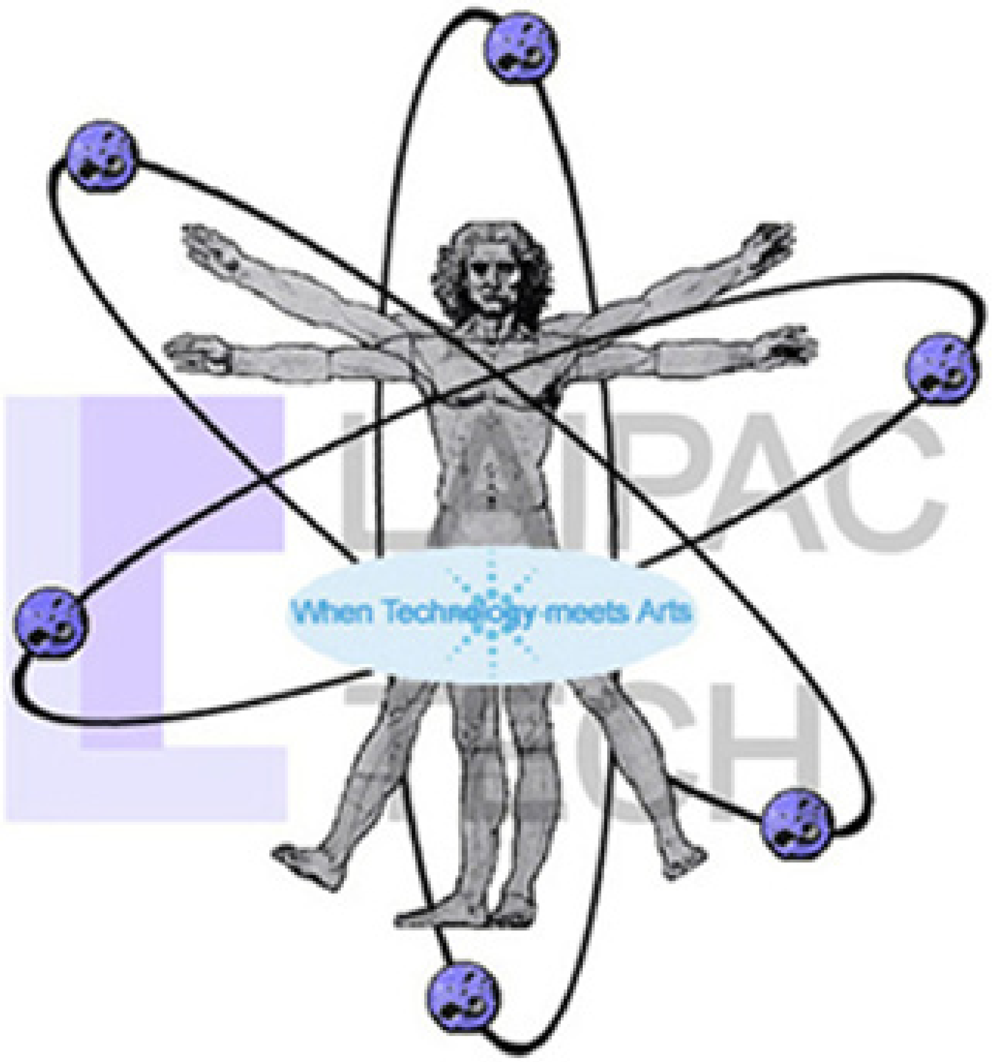
TF50 GPS & GLONASS



Embedded Solutions

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Contents

1. GENERAL DESCRIPTION

1.1. INTRODUCTION

TF50 is a OEM engine board designed for calculation of coordinates, velocity vector, heading and time using signals of the satellite navigation systems GLONASS (Russia) and GPS (USA). Receiver uses two asynchronous serial ports RS-232 to communicate with external equipment. The receiver can operate in autonomous and differential modes. TF50 generates one second time mark (1PPS signal) which is synchronous to the selected time scale.

Signal structures of GLONASS and GPS navigation systems are similar that allows to design combined receivers with lower extra components in comparison with one-system receivers (for example, GPS only). It is known, that GPS consists of 24 satellites, placed on six orbits in six planes. GPS uses CDMA (Code Division Multiple Access) for different space vehicles (SV). SV numbers comply with Gold codes numbers. The nominal carrier frequency value in L1 frequency range for all GPS SV is equal to 1575,42 MHz.

GLONASS provides 24 SV, placed on three orbits in three planes. GLONASS uses FDMA (Frequency Division Multiple Access) with uniform code sequence for all SV. The nominal values of carrier frequency at L1 frequency range are defined by following expression:

F_n = 1602,000 MHz + k × **a**F,

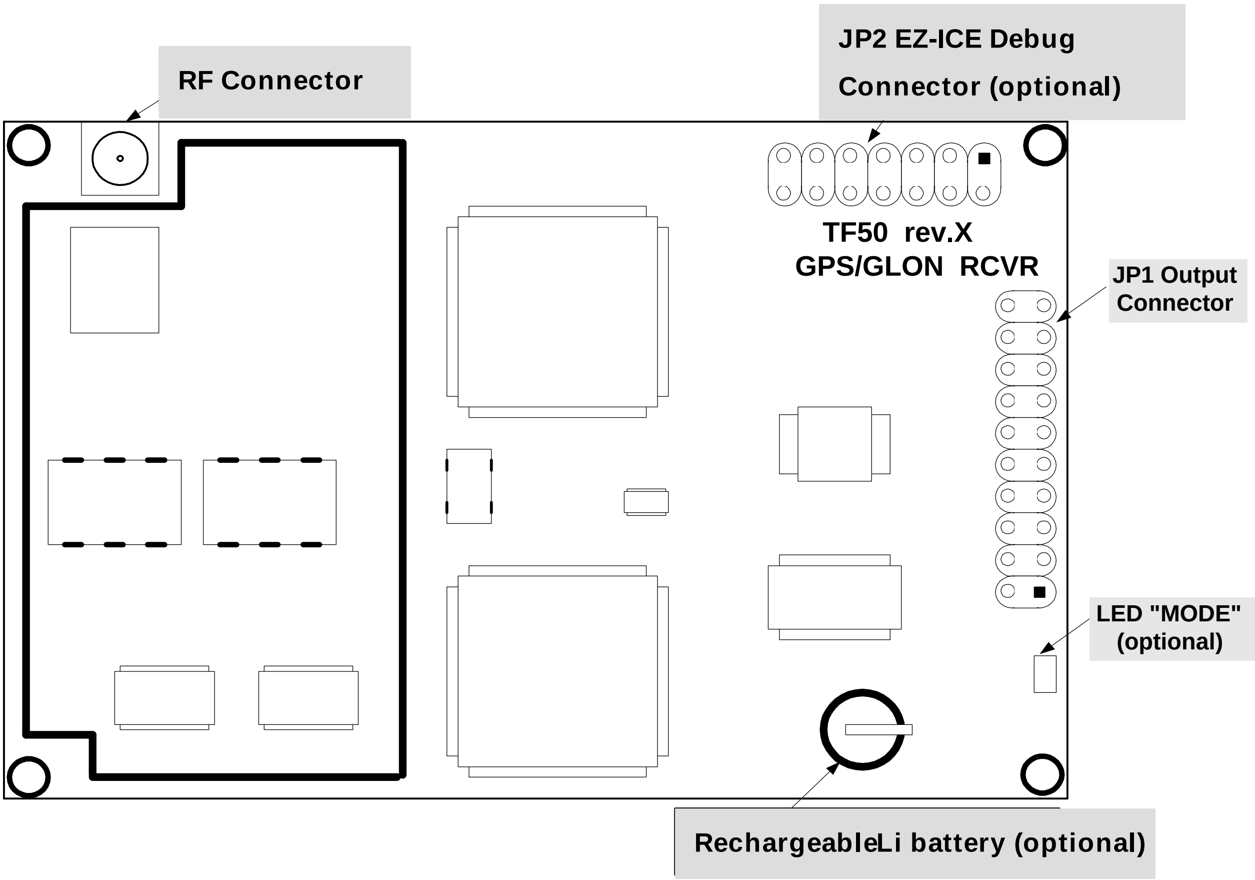
where k – frequency position number (frequency channel), k = -7…+12;

aF = 0,5625 MHz – frequency step between neighbor frequency positions.

At present time SV transmitting signals with numbers k = 0…12 only are available. 0 (zero) frequency channel signal is used for technical purposes only but not for navigation (refer to GLONASS ICD).

1.2. GENERAL VIEW

TF50 General view is shown in figure below.



The PCB of the receiver has dimensions 71 mm × 51 mm. MCX female connector is used for connection to an active antenna. Antenna power supply is provided via central wire of coaxial cable. Using antennas from third party vendors must be taken carefully because of TF50 antenna's power supplying circuit has 100 mA current limitations. Moreover for current design TF50 must use only active antenna so the connection to passive antennas is prohibited.

20-pin two rows 2.0x2.0 mm pin strip header (for example, 151220-2420TH from 3M) is used as a output connector.

1.3. ANTENNA REQUIREMENTS

Third party vendor active GPS/GLONASS antenna for TF50 should meet following requirements:

1. 3dB Bandwidth 1570…1610 MHz
2. Impedance 50Ω
3. Polarization RHCP
4. Gain* 20…30 dB
5. Noise Figure 2.0 dB max

6. VSWR 1.5 dB
7. Current 100 mA Max
8. Supply Voltage** 5V

Notes:

* Actually TF50 requires 15~25 dB of additional gain for its proper operation. Additional gain less than 15 dB may cause the total receiver noise figure and sensitivity degradation. Additional gain more than 25 dB may cause easy non-linear suppression of GLONASS or GPS signals by out-of-band interfering signals.

Additional gain is defined as antenna LNA minus cable losses. Cable losses depend on cable type and its length. Generally, the greater outer diameter of cable, the less loss it will be.

** For TF50 “External ”Option.
If the receiver is expected to use as a GPS only receiver, it is possible to use GPS only antennas.

1.4. SPECIFICATION

1. General	
1.1 Frequency	
L1	+
L2	-
1.2 Supported signals	
GPS (C/A)	+
GLONASS (C/A)	+
WAAS	-
EGNOS	-
GALILEO	-
CHINA SATs	-
1.3 Channels	
16	+
1.4 Tracking capability	
Carrier-aided tracking	+
2. Performance	
2.1 Autonomous mode, PDOP <4	
2.1.1 Plane	
CEP	
GPS	9 m
GLONASS	8 m
GPS+ GLONASS	7 m
2Drms	

GPS	24 m
GLONASS	20 m
GPS+ GLONASS	14 m
2.1.2 Height	
CEP	
GPS	14 m
GLONASS	13 m
GPS+ GLONASS	8 m
rms	
GPS	40 m
GLONASS	38 m
GPS+ GLONASS	25 m
2.1.3 Velocity	
rms	
GPS+ GLONASS	0.05 m/s
2.1.4 Time	
rms	
GPS+ GLONASS	0.1 µs
2.2 Differential mode	
2.2.1 Coordinates	
CEP	3 m
2.2.2 Velocity	
2Drms	0.1 m/s
2.3 Acquisition time (TTFF) (mean)	
Hot start	5 s (stored almanac,ephemeris,time,position)
Warm start	30 s(stored almanac,time,position)
Cold start	120 s(no almanac,ephemeris,time,position)
Reacquisition	1 s
2.4 Dynamics	
Speed (max.)	950 m/s
Altitude (max.)	18 km
Acceleration	6g
Jerk	1 g/s
2.5 Update rate	
Hz (max.)	5 Hz
3. Interfaces	
3.1 Communication	
Baud rate	900 ~ 115200
EIA RS-232	+ (see “OPTION 5” in Section 4)
3.2 1 PPS	
Duration (u sec)	10
Level	TTL
Time scale	
GPS time	-
GLONASS time	-
UTC (USNO)	+
UTC (SU)	+
Pulse	

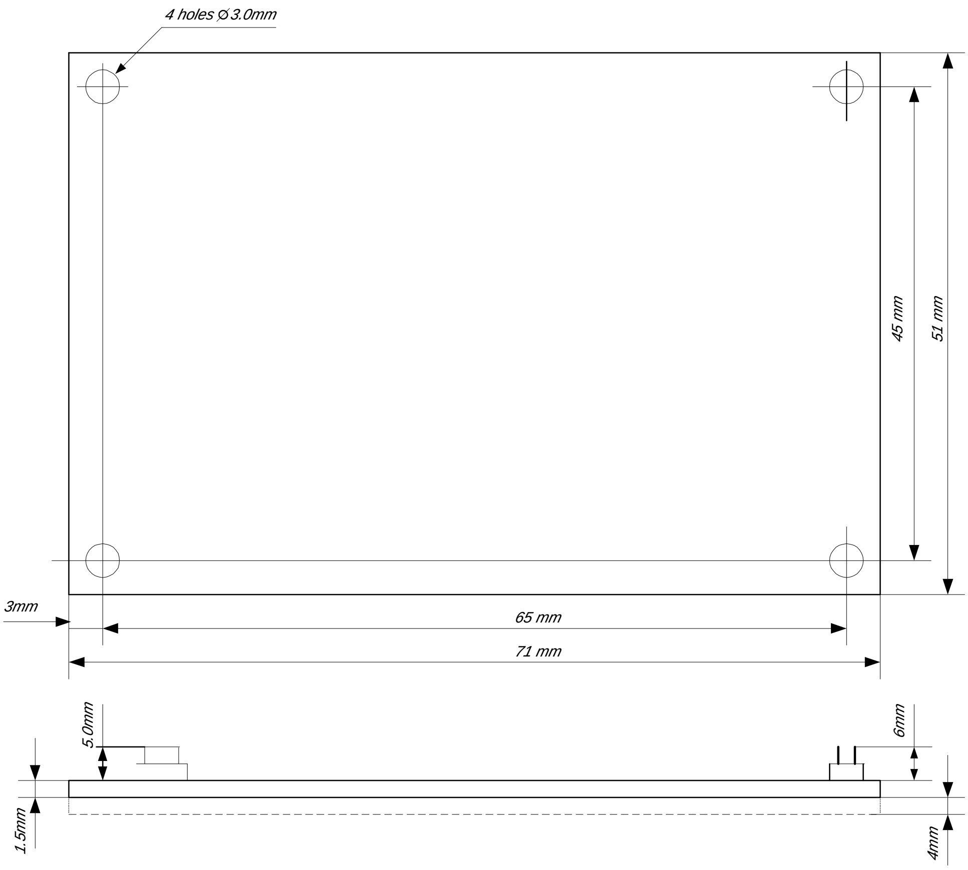
Positive/Negative	P
Programmable	-
3.3 Output data	
Datum	
WGS84 and PZ90	+
Time difference	+
Velocity	+
Heading	+
Channel status	+
Ephemeris data	+
Almanac data	+
Raw measurement data	+
3.4 Data formats	
Output	
NMEA 0183	
Version	2.30
Baud rate (default)	4800
Binary	
Version	4.0x
Baud rate (default)	9600
Differential	
RTCM SC-104	
Version	2.2
Baud rate (default)	9600
Types	TBD
3.5 Prime Power	
Input voltage	3.3 V +- 5%
Supplied current	200 mA typ.
Backup voltage	1.5 ~ 3.3 V
Backup current	50µA @ 3.0V
LED configuration	see “OPTION 3” in Section 4
On board rechargeable Li battery	see “OPTION 1 “ in Section 4
4. Physical	
4.1 Dimensions	
W x L x H (mm)	71 x 51 x 12
Weight (g)	< 50 g
4.2 Antenna connector	
Type	MCX(optional:SMA),straight or right angle
4.3 Output connector	
20-Pin I/O, 2.0 mm	Straight header (optional: other directions)
Debug 14-Pin I/O	- (see “OPTION 2” in Section 4)
5. Antenna	
5.1 Antenna type	
Active antenna	+ (passive antenna not recommended)
5.2 Requirement	see Section 1.3
5.3 Input Power	
External voltage	5.0 V (see “OPTION 4” in Section 4)
6. Environmental	

6.1 Operating temp.	
Degree	-40 to +85 °C
6.2 Storage temp.	
Degree	-40 to +85 °C
6.3 Vibration	
Hz	20 to 1000 Hz, 2 to 12 g

2. MECHANICAL CHARACTERISTICS

2.1. OUTLINE DRAWING

The outlines of the receiver are given in figure below.

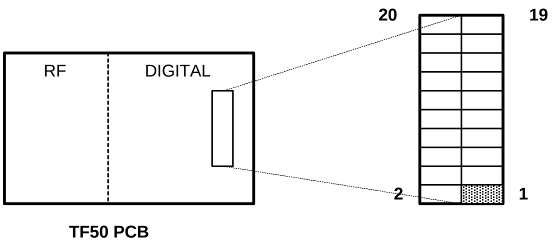


TF50 has the following dimensions: 71 mm (length), 51 mm (width).

The height of top side components is 5 mm. The height of bottom side components is 4 mm. There are 4 mounting holes 3.0 mm in diameter.

2.2. OUTPUT CONNECTOR

General top view of output connector (JP1) is shown in figure below.



The table below contains list of input/output signals.

Pin	Type	Name	Description
1	I	ANT_PWR	External Antenna Power
2		NC	Not Connected
3	I	BAT	Back Up Battery
4	I	VDD	3.3V Power Input
5	I	M_RES	Manual Reset Input
6	I	PRG_FL	Programming Control
7	I	NC	Not Connected
8		NC	Not Connected
9		NC	Not Connected
10		GND	Ground
11	O	TX1	Transmit Data, Serial Port 1
12	I	RX1	Receive Data, Serial Port 1
13		GND	Ground
14	O	TX2	Transmit Data, Serial Port 2
15	I	RX2	Receiver Data, Serial Port 2
16		GND	Ground
17	I	ETM	External Time Mark
18		GND	Ground
19	O	1PPS	1PPS Time Mark Output
20		NC	Not Connected

ANT_PWR

external antenna power supply voltage

BAT

external back-up battery voltage, 1.5~3.3V

VDD

main power supply voltage, +3.3V.

M_RES

manual reset signal, active low with internal pull-up in MAX793. M_RES has pull-up current 250µA max. Pulse width for this input should be at least 100ns.

PRG_FL

programming flag, active low, connected with 20kOhm pull-up resistor. For TF50 it's possible to upload firmware to the FLASH via serial port. It's considered that for OK uploading no power, host personal computer or communication failures should occur during this procedure. If some failures took place and uploading procedure was completed with errors, it's necessary to make PRG_FL low and repeat the uploading procedure.

TX1, TX2

transmit data via serial port#1 and #2.

RX1, RX2

receive data via serial port#1 and #2.

ETM

external time mark. TF50 can measure the time of external time mark

1PPS

output one second time mark, pulse width is about 10 µs. Its polarity (positive or negative) can be programmed by control command via serial port. Default is positive.

3. INTERFACES

3.1. ELECTRICAL SPECIFICATION

The receiver has two serial asynchronous ports (Port#1 and Port#2) for communication with external equipment. Each port has two options: the first meets the EIA RS-232 standard electrical specification and the second has TTL logic levels.

The receiver supports following software selectable serial port parameters – 900…115200 bit/s baud rate; 5-, 6-, 7- or 8-bit data length; 1 or 2 stop bits; even, odd or no parity.

The default serial port configurations parameters are as follows:

- data length:8 bits

- two stop bits
- parity bit: not used.
- Baud rate: 9600, binary protocol

3.2. DATA FORMATS

The receiver supports the following data protocols:

- proprietary binary
- ASCII NMEA complying with NMEA 0183 v.2.30
- RTCM SC-104 V.2.2 for differential corrections data

4. TF50 OPTIONS

TF50 can have following options:

OPTION 1. In “On Board Battery” Option 8mAh rechargeable battery is mounted and used as a back-up power source when main power is off. There is a charger circuit for rechargeable battery consisting of diode and current limiting resistance. In “External Battery” Option no rechargeable battery is used and external battery should be connected to pin#3 of output connector as a back-up power source. Since TF50 operates under - 40 ~ +85ºC temperature, it’s necessary to keep in mind about the rechargeable battery more NARROW operating temperature range. Besides it the battery capacity can 1.5 times DECREASE under –20ºC temperature. The average discharge time (from 3.0 to 1.5V) for the mounted rechargeable battery is about 400 hours (more than 16 days). Default: “On Board Battery” Option. Important notice for the case of external backup battery use. Backup current strongly depends on value of backup voltage i.e. the greater backup voltage the greater current. For 3.0V supply voltage current will be about 50 microamperes. RTC and SRAM are operable up to 1.5V backup voltage. The backup current for this voltage is about several microamperes. Validity of data stored in SRAM is guaranteed by verifying data check sum.

OPTION 2. In “Debug” Option JP2 connector is mounted onto PCB. External ADSP EZ-ICE Elite-Kit development tool could be connected with JP2 to debug firmware design. Default: “Debug-No” Option.

OPTION 3. The aim for “LED” Option is to indicate different TF50 current modes of operation such as searching, tracking, or navigation. Default: “LED” Option.

OPTION 4. In “Internal 3.3V” Option, antenna is supplied directly with 3.3V power voltage from TF50 main power input (pin#4 in TF50 output connector). Otherwise (“External” Option) active antenna will be supplied with external voltage that must be connected to ANT_PWR pin #1 of output connector. At any case in order not to damage antenna power supply circuit in TF50, permitted antenna current mustn’t exceed 100mA. Default: “External “ Option

OPTION 5. Interface signals TX1, TX2, RX1, RX2 can have TTL levels for “RS-232 TTL” Option or +-6V levels for “EIA RS-232” Option. Default: “EIA RS-232” Option.

5. BINARY PROTOCOL SPECIFICATION

5.1 GENERAL

This Protocol defines the requirements for establishing a communication interface between the TF50 OEM board and external equipment via communication Port #1. TF50 can receive input messages from the external equipment, and can send output messages to the external equipment.

The input messages are control commands by which the external equipment can set or query various operating parameters. The output messages are used to indicate the acceptance or rejection of commands, to respond to query commands with requested operating parameters, and to output position data and raw measurements periodically.

The general message structure

Preamble	Message Identifier (MID)	Payload	Checksum	Postamble (for input messages only)

Preamble

The Preamble is sent in the following order: "F" is first byte, "T" is last byte.

Message Identifier

The possible values of the Message identifier are defined in Sections 5.2 and 5.3 of this Protocol.

Payload

The byte-length of the Payload is unambiguously defined by Message Identifier as specified in Sections 5.2 and 5.3 of this Protocol. The number of bytes is odd for all messages. The payload data may content any 8-bit value. Where multi-byte values are in the payload data, the big-endian order is used.

Note: Parameters indicated as "signed" are two's complement, with the sign bit (+ or -) occupying the MSB.

Checksum

The checksum is transmitted high order byte first followed by the low byte. The checksum is sum of all the 16-bit values formed by MID and payload bytes in big-endian order and then only low-order 16 bits are retained as the checksum.

Postamble

The Postamble 0xFF FF FF FF FF FF FF FF FF FF is sent with input messages to TF50 receiver. Output messages from the receiver have no Postamble.

5.2 INPUT MESSAGES

Table 1 lists the TF50 binary input messages.

Table 1 TF50 binary input messages

MID (Hex)	ASCII	Name
0x31	1	Set main serial port
0x56	V	Poll firmware version
0x32	2	Initialize data
0x54	T	Set GMT
0x46	F	Set clock frequency offset
0x58	X	Set approximate user position
0x33	3	Set GPS Almanac
0x34	4	Set GLONASS Almanac
0x35	5	Mode control
0x43	C	Poll clock status
0x41	A	Poll GPS Almanac
0x4C	L	Poll GLONASS Almanac
0x49	I	Poll GPS Ephemeris
0x45	E	Poll GLONASS Ephemeris
0x50	P	Poll Navigation parameters
0x53	S	Store Almanacs
0x55	U	Store last user position and frequency offset
0x44	D	DGPS control
0x5A	Z	Exclude SV
0x42	B	Debug data output ON/OFF
0x4D	M	Switch to NMEA Protocol

5.2.1 Set main serial port

Example:

FAST1 - Preamble & MID (ASCII)

0x00 01 97 0F 0F - Payload (ASCII)

0x41 A6 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x31		ASCII 1
Reserved	1		0x00		
Baud rate	2		0x01 97	coded	See Table 2
Data format	2		0x0F 0F	bitmap	See Table 3

Payload length: 5 bytes

Table 2 Baud rate codes

Baud rate	900	1200	1800	2400	3600	4800	7200	9600
Code	0x02 17	0x01 97	0x02 16	0x01 96	0x02 15	0x01 95	0x02 14	0x01 94

Baud rate	14400	19200	28800	38400	57600	76800	115200	153600
Code	0x02 13	0x01 93	0x02 12	0x01 92	0x02 11	0x01 91	0x02 10	0x01 90

Table 3 Bit allocation in the "Data format" word

MSB **LSB**

Transmitter								**Receiver**							
Reserved		P			S	L		Reserved		P			S	L	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

L is length field: number of data bits = L + 5

S is stop bit field: number of stop bits = S + 1

P is parity field:

P = 000 or 100 or 010 or 110: none

P = 001: even

P = 011: odd

P = 101: always zero

P = 111: always one

5.2.2 Poll Firmware Version

Example:

FASTV - Preamble & MID (ASCII)

0x00 00 00- Payload (ASCII)

0x56 00 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x56		ASCII V
Reserved	3		0x00		

Payload length: 3 bytes

5.2.3 Initialize data

Sets approximate user position, current time and receiver clock frequency offset.

Example:

FAST2 - Preamble & MID (ASCII)

0x00 10 FB 0D 09 1F 4D 3A 5D 82 62 00 00 27 10 - Payload (hex)

0x53 20 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x32		ASCII 2
Reset Config.	1		0x00	Bitmap	See Table 4
ECEF X	2, signed	$*2^{16}$	0x10 FB	cm	Approximate user position: X=2849 km, Y= 2187 km, Z= 5252 km
ECEF Y	2, signed	$*2^{16}$	0x0D 09	cm	
ECEF Z	2, signed	$*2^{16}$	0x1F 4D	cm	
GMT	4		0x3A 5D 82 62	seconds	Number of seconds elapsed since the beginning of January 1, 1970
Freq. Offset	2, signed		0x00 00	Hertz	Estimate frequency offset of the receiver clock relative to GPS carrier, range= ± 32767 Hz
Freq. Range	2		0x27 10	Hertz	Uncertainty of the clock frequency (10000 Hz)

Payload length: 15 bytes

Table 4 Bit allocation in the "Reset Config" byte

Config	Description
0x00	Enable warm/hot start
0x01	Clear ephemeris - set cold start
0x02	Clear ephemeris&almanac - set initial acquisition start
0x03…0xff	TBD

5.2.4 Set GMT

Sets Greenwich Mean Time for current moment .

Example:

FASTT - Preamble & MID (ASCII)

0x00 3A 5D 82 62 - Payload

0x10 BF FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x54		ASCII T
Reserved	1		0x00		
GMT	4		0x3A 5D 82 62	seconds	Number of seconds elapsed since the beginning of January 1, 1970

Payload length: 5 bytes

5.2.5 Set clock frequency offset

Example:

FASTF - Preamble & MID (ASCII)

0x00 00 00 27 10- Payload (ASCII)

0x6D 10 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x46		ASCII F
Reserved	1		0x00		
Freq. offset	2, signed		0x00 00	Hertz	Estimate frequency offset of the receiver clock relative to GPS carrier, range= ± 32767 Hz
Freq. range	2		0x27 10	Hertz	Uncertainty of the clock frequency (10000 Hz)

Payload length: 5 bytes

5.2.6 Set approximate user position

Example:

FASTX - Preamble & MID (ASCII)

0x00 10 FB 0D 09 1F 4D - payload (hex)

0x95 51 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x58		ASCII X
Reserved	1		0x00		
ECEF X	2, signed	$*2^{16}$	0x10 FB	cm	Approximate user position: X=2849 km, Y= 2187 km, Z= 5252 km
ECEF Y	2, signed	$*2^{16}$	0x0D 09	cm	
ECEF Z	2, signed	$*2^{16}$	0x1F 4D	cm	

Payload length: 7 bytes

5.2.7 Set GPS Almanac

Set GPS almanac data for usage in the current session. This command does not write the almanac data into the flash memory. The command "Store almanacs" is used to write the GPS and GLONASS almanacs of current session into the flash memory.

Example:

FAST3 - Preamble & MID (ASCII)

---…-- Payload

0x---- FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x33		ASCII 3
PRN	1				Satellite PRN number (1-32)
Wna	2				Almanac week number
Wn	2				Receive time week number
Tow	4			seconds	Second of GPS week (receive time)
config&health	2				See Table 5
E	2	$*2^{-21}$			Eccentricity
Toa	2			seconds	Almanac reference time
i0	2, signed	$*2^{-19}$		semicycles	Inclination angle
Omegadot	2, signed	$*2^{-38}$		semicycles/sec	Rate of right ascension
Roota	4	$*2^{-11}$		$meters^{1/2}$	Square root of semi-major axis
omega0	4, signed	$*2^{-23}$		semicycles	Longitude of ascending node
Omega	4, signed	$*2^{-23}$		semicycles	Argument of perigee
m0	4, signed	$*2^{-23}$		semicycles	Mean anomaly at reference time
af0	2, signed	$*2^{-20}$		seconds	Clock correction
af1	2, signed	$*2^{-38}$		sec/sec	Clock correction

Payload length: 39 bytes

Table 5 Bit allocation in the "config&health" word

MSB **LSB**

					SV config (see ICD GPS-200C)			Satellite data&signal health (see ICD GPS - 200C)							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

5.2.8 Set GLONASS Almanac

Set GLONASS almanac data for usage in the current session. This command does not write the almanac data into the flash memory. The command "Store almanacs" is used to write the GPS and GLONASS almanacs of current session into the flash memory.

Example:

FAST4 - Preamble & MID (ASCII)

---…-- Payload (hex)

0x---- FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x34		ASCII 4
SV ID	1				Satellite number (1-24)
Litera	1, signed				Satellite frequency number (-7…12)
Health	1				Satellite health: 0x30 = bad 0x31 = good
Reserved	8				TBD
Na	2			days	Reference day number
Ln	4, signed	$*2^{-20}$		semicycles	Longitude of first ascension node
Tln	4	$*2^{-5}$		seconds	Reference time of the first ascending node
Di	4, signed	$*2^{-20}$		semicycles	Correction to inclination

DT	4, signed	*2^{-9}		s/orbit_period	Correction to the mean value of Draconian period
Dtdot	1, signed	*2^{-14}		s/orbit_period^2	Rate of change of Draconian period
Reserved	5				TBD
E	2	*2^{-20}			Eccentricity
Omega	2, signed	*2^{-15}		semicycles	Argument of perigee
tn	2, signed	*2^{-18}		seconds	Satellite time correction

Payload length: 41 bytes

5.2.9 Mode control

Example:

FAST5 - Preamble & MID (ASCII)

---…-- Payload (ASCII)

0x---- FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x35		ASCII 5
Pos Mode	1			bitmap	Position fix mode control, see Table 6
Alt_For_Hold	2			meters	
Clock hold timeout	1			seconds	Time interval during which the clock bias extrapolation is allowable
Hold priorities	1				Priority against altitude and Tshift[(1)]: C(0x43) = clock priority A(0x41)= altitude priority
GLONASS Tshift	4, signed			cm	GLONASS system time shift (divided by speed of light) relative to GPS time
Tshift alg	1				Tshift fixing algorithm: N (0x4D)= never fixed ~ (0x7E)= flexible[(2)] F(0x46)= always fixed
NSV	1				Number of SV to compute Tshift
Tshift priority	1				Priority against altitude[(3)]: T(0x54)= Tshift higher priority A(0x41)= altitude higher priority
Elevation mask	1			degrees	Elevation mask for Navigation solution
SNR mask	1				SNR mask for Navigation solution
PDOP mask	1	*2^{-3}			PDOP mask for Navigation solution[(1)]
HDOP mask	1	*2^{-3}			HDOP mask for Navigation solution[(1)]
Update_rate	1	*0.2		seconds	Output position update rate
Reserved	6				TBD

Payload length: 23 bytes

Notes:

(1) If the number of SV in solution is 4 or less, this parameter sets priority of clock rate fixing against altitude fixing or GLONASS system time shift fixing, see also Note (3).

(2) Compute GLONASS system time shift if number of SV in solution is nSV or more, and hold it fixed if number of SV is nSV or less.

(3) If the number of SV in solution is 4 or less, this parameter sets priority of GLONASS system time shift fixing against altitude fixing.

Table 6 Bit allocation in the "Pos Mode" word

Mode	Description
0x00	Only 3D solution allowable
0x01	1 satellite solution allowable
0x02	2 satellite solution allowable
0x03	3 satellite solution (2D) allowable
0x04	4 satellite solution (3D) allowable
0x08	Reserved
0x10	Altitude hold mode allowable
0x20	Clock hold mode allowable
0x40	Recent computed altitude must be used for altitude hold mode, otherwise Alt_For_Hold
0x80	Reserved

5.2.10 Poll clock status

Example:

FASTC - Preamble & MID (ASCII)

0x00 00 00 - Payload (ASCII)

0x43 00 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x43		ASCII C
Reserved	3		0x00		

Payload length: 3 bytes

5.2.11 Poll GPS Almanac

Example:

FASTA - Preamble & MID (ASCII)

0xFF 00 00 - Payload

0x41 FF FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x41		ASCII A
PRN	1		0xFF		GPS satellite PRN number (1-32) 0xFF requests all available GPS almanac records
Reserved	2				

Payload length: 3 bytes

5.2.12 Poll GLONASS Almanac

Example:

FASTL - Preamble & MID (ASCII)

0x20 00 00 - payload

0x4C 20 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x4C		ASCII L
PRN	1		0x20		GLONASS satellite number (1-24) 0xFF requests all available GLONASS almanac records
Reserved	2		0x00 00		

Payload length: 3 bytes

5.2.13 Poll GPS Ephemeris

Example:

FASTI - Preamble & MID (ASCII)

0x20 00 00- Payload

0x49 20 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x49		ASCII I
PRN	1		0x20		GPS satellite PRN number (1-32) 0xFF requests all available GPS ephemeris records
Reserved	2		0x00 00		

Payload length: 3 bytes

5.2.14 Poll GLONASS Ephemeris

Example:

FASTE - Preamble & MID (ASCII)

0x18 00 00- Payload

0x45 18 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x45		ASCII I
PRN	1		0x18		GLONASS satellite number (1-24) 0xFF requests all available GLONASS ephemeris records
Reserved	2		0x00		

Payload length: 3 bytes

5.2.15 Poll Navigation parameters

Example:

FASTP - Preamble & MID (ASCII)

0x00 - Payload

0x50 00 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x50		ASCII P
Reserved	3		0x00		

Payload length: 3 bytes

5.2.16 Store Almanacs

Writes the GPS and GLONASS almanacs received in current session into the flash memory. Output position and raw measurement data may be suspended for several seconds during the process of writing into the flash memory.

Example:

FASTS - Preamble & MID (ASCII)

0x00 - Payload

0x53 00 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x53		ASCII S
Reserved	3		0x00		

Payload length: 3 bytes

5.2.17 Store last user position and frequency offset

Writes the latest user position and frequency offset of the receiver clock estimated in current session into the flash memory. Output position and raw measurement data may be suspended for several seconds during the process of writing into the flash memory.

Example:

FASTU - Preamble & MID (ASCII)

0x00 00 00 - Payload

0x55 00 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x55		ASCII U
Reserved	3		0x00		

Payload length: 3 bytes

5.2.18 DGPS control

TBD

5.2 19 Exclude SV from navigation solution

Example:

FASTZ - Preamble & MID (ASCII)

0x18 01 00 - Payload

0x5B 18 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x5A		ASCII Z
SVID	1		0x18		SV system number: GPS SV: 1…32 GLONASS SV: 33-56
ON/OFF	1		0x01		0x01 = OFF (exclude) 0x00 = ON (restore)
Reserved	1		0x00		

Payload length: 3 bytes

5.2.20 Debug data output ON/OFF

Example:

FASTB - Preamble & MID (ASCII)

0x30 00 00 - Payload

0x42 30 FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x42		ASCII B
ON/OFF	1		0x30		0x30 - OFF 0x31 - ON
Reserved	2		0x00 00		

Payload length: 3 bytes

5.2.21 Switch to NMEA Protocol

When a valid message is received, the parameters are stored in the non-volatile memory, and then the receiver restarts using the saved parameters.

Example:

FASTM - Preamble & MID (ASCII)

0x------- - Payload

0x-- -- FF FF FF FF FF FF FF FF FF FF - Message checksum and Postamble

Name	Bytes	Scale	Example	Units	Description
MID	1		0x4D		ASCII M
Reserved	1		0x00		
GGA Talker ID	1				NMEA Talker Identifier: P=GP, L=GL, N=GN, 0=OFF
GGA rate	1	*0.2		seconds	Output rate of GGA message
GGA Checksum	1				0x00 - disable checksum 0x01 - enable checksum
GLL Talker ID	1				NMEA Talker Identifier: P=GP, L=GL, N=GN, 0=OFF
GLL rate	1	*0.2		seconds	Output rate of GLL message
GLL Checksum	1				0x00 - disable checksum 0x01 - enable checksum
GSA Talker ID	1				NMEA Talker Identifier: P=GP, L=GL, N=GN, 0=OFF
GSA rate	1	*0.2		seconds	Output rate of GSA message
GSA Checksum	1				0x00 - disable checksum 0x01 - enable checksum
GSV Talker ID	1				NMEA Talker Identifier: P=GP, L=GL, N=GN, 0=OFF
GSV rate	1	*0.2		seconds	Output rate of GSV message
GSV Checksum	1				0x00 - disable checksum 0x01 - enable checksum
RMC Talker ID	1				NMEA Talker Identifier: P=GP, L=GL, N=GN, 0=OFF
RMC rate	1	*0.2		seconds	Output rate of RMC message
RMC Checksum	1				0x00 - disable checksum 0x01 - enable checksum
VTG Talker ID	1				NMEA Talker Identifier: P=GP, L=GL, N=GN, 0=OFF
VTG rate	1	*0.2		seconds	Output rate of VTG message
VTG Checksum	1				0x00 - disable checksum 0x01 - enable checksum

Payload length: 19 bytes

5.3 OUTPUT MESSAGES

Table 7 lists TF50 binary output messages.

Table 7 TF50 binary output messages

MID (Hex)	ASCII	Name
0x76	v	Firmware version
0x72	r	Raw measurement data
0x78	x	Measured position data
0x63	c	Clock status
0x61	a	GPS Almanac data
0x6C	l	GLONASS Almanac data
0x69	i	GPS Ephemeris data
0x65	e	GLONASS Ephemeris data
0x70	p	Navigation parameters
0x62	b	Debug data
0x2B	+	Command acknowledgement
0x3F	?	Command NAcknowledgement

5.3.1 Firmware version

Response to poll.

Example:

FASTv - Preamble & MID (ASCII)

1.02 - Payload (ASCII)

0xD7 60 - Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x76		ASCII v
Reserved	1		0x00		
F/W version	4		1.02		0x31 2E 30 32

Payload length: 5 bytes

5.3.2 Raw measurement data

Example:

FASTr - Preamble & MID (ASCII)

---…-- Payload (hex)

0x---- Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x72		ASCII r
PRN	1		0x21		Satellite PRN number (1…56). For GLONASS satellites this field content is 32 + SV slot number. The slot number information is derived from GLONASS Almanac. When TF50 has ephemeris data for a SV but no almanac, the PRN number is set to zero.
Warning	1				TBD
Carrier number	1		0x0F		GLONASS Carrier Number (-7…+12). For GPS satellites: 0xFF
Sat X	4, signed			cm	Satellite ECEF coordinate X
Sat Y	4, signed			cm	Satellite ECEF coordinate Y
Sat Z	4, signed			cm	Satellite ECEF coordinate Z
Channel number	1				unsigned char
SNR	1				Signal-to-noise ratio
SigR	1	*0.1		meters	unsigned char DLL residual
SigPhi	1	$*2^{-10}$		cycles	unsigned char PLL residual
Phase	6, signed	$*2^{-12}$		cycles	Full pseudo-doppler phase
Pseudorange	4	$*10^{-10}$		s	
Doppler	4, signed	$*10^{-4}$		Hz	Pseudo-doppler frequency
Status	2			bitmap	See Table 8

Payload length: 35 bytes

Table 8 Bit allocation in the "Status" word

MSB **LSB**

Reserved														E	u
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

u = 1 if data is used in navigation solution, u = 0 otherwise

E = 1 if ephemeris data is available, E = 0 otherwise

5.3.3 Measured position data

Example:

FASTx - Preamble & MID (ASCII)

---…-- Payload (hex)

0x---- Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x78		ASCII x
Reserved	1		0x00		
RcvTime	4			ms	Signal receive time in millisecond of week of GPS time
X-position	4, signed			cm	Antenna ECEF coordinate X
Y-position	4, signed			cm	Antenna ECEF coordinate Y
Z-position	4, signed			cm	Antenna ECEF coordinate Z
R-offset	4, signed			cm	Receiver clock offset in centimeters
X-dot	2, signed	*32		m/s	Antenna X velocity
Y-dot	2, signed	*32		m/s	Antenna Y velocity
Z-dot	2, signed	*32		m/s	Antenna Z velocity
R-dot	2, signed	*16		m/s	Receiver clock shift
DOP	1	*8			PDOP if position is obtained in 3D solution, and HDOP otherwise
GPS SVs in fix	1				
GLONASS SVs in fix	1				
Mode	1			Bitmap	See Table 9

Payload length: 33 bytes

Table 9 Bit allocation in the "Mode" word

Mode	Description
0x00	No navigation solution
0x01	1 satellite solution
0x02	2 satellite solution
0x03	3 satellite solution (2D)
0x04	≥4 satellite solution
0x08	Differential solution
0x10	Altitude hold mode
0x20	Clock hold mode
0x40	Recent computed altitude was used for altitude hold mode, otherwise Alt_For_Hold
0x80	Reserved

5.3.4 Clock status

Response to poll.

Example:

FASTc - Preamble & MID (ASCII)

---…-- Payload (hex)

0x---- Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x63		ASCII c
Reserved	1		0x00		
wn	2				GPS week number
RcvTime	4			ms	Signal receive time in millisecond of week of GPS time
R-offset	4, signed			cm	Receiver clock offset in centimeters
R-dot	2, signed	*16		m/s	Receiver clock shift
GLONASS Tshift	4, signed			cm	GLONASS system time shift relative to GPS time
Tshift alg	1				Tshift fixing algorithm: N (0x4D)= never fixed ~ (0x7E)= flexible(1) F(0x46)= always fixed
nSV	1				Number of SV to compute Tshift
Tshift priority	1				Priority against altitude(2): T(0x54)= Tshift higher priority A(0x41)= altitude higher priority
Reserved	1				
TDOP	1	*8			
GPS SVs in fix	1				
GLONASS SVs in fix	1				
Mode	1			Bitmap	See Table 10

Payload length: 25 bytes

Notes:

(1) Compute GLONASS system time shift if number of SV in solution is nSV or more, and hold it fixed if number of SV is nSV or less.

(2) If the number of SV in solution is 4 or less, this parameter sets priority of GLONASS system time shift fixing against altitude fixing.

Table 10 Bit allocation in the "Mode" word

Mode	Description
0x00	No navigation solution
0x01	1 satellite solution
0x02	2 satellite solution
0x03	3 satellite solution (2D)
0x04	≥4 satellite solution
0x08	Differential solution
0x10	Altitude hold mode
0x20	Clock hold mode
0x40	Recent computed was used for altitude hold mode, otherwise Alt_For_Hold
0x80	Reserved

5.3.5 GPS Almanac data

Response to poll.

Example:

FASTa - Preamble & MID (ASCII)

---…-- Payload (hex)

0x---- Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x61		ASCII a
PRN	1				Satellite PRN number (1-32) 0x00 means "No data for requested PRN"
Wna	2				Almanac week number
Wn	2				Receive time week number
Tow	4			seconds	Second of GPS week (receive time)
config&health	2				See Table 11
E	2	$*2^{-21}$			Eccentricity
Toa	2			seconds	Almanac reference time
i0	2, signed	$*2^{-19}$		semicycles	Inclination angle
Omegadot	2, signed	$*2^{-38}$		semicycles/sec	Rate of right ascension
Roota	4	$*2^{-11}$		$meters^{1/2}$	Square root of semi-major axis
omega0	4, signed	$*2^{-23}$		semicycles	Longitude of ascending node
Omega	4, signed	$*2^{-23}$		semicycles	Argument of perigee
m0	4, signed	$*2^{-23}$		semicycles	Mean anomaly at reference time
af0	2, signed	$*2^{-20}$		seconds	Clock correction
af1	2, signed	$*2^{-38}$		sec/sec	Clock correction

Payload length: 39 bytes

Table 11 Bit allocation in the "config&health" word

MSB **LSB**

					SV config (see ICD GPS-200C)			Satellite data&signal health (see ICD GPS - 200C)							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

5.3.6 GLONASS Almanac data

Response to poll.

Example:

FASTl - Preamble & MID (ASCII)

---…-- Payload (hex)

0x---- Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x6C		ASCII l
SV ID	1				Satellite number (1-24) 0x00 means "No data for requested PRN"
Litera	1, signed				Satellite frequency number (-7…12)
Health	1				Satellite health: 0x30 = bad 0x31 = good
Reserved	8				TBD
Na	2			days	Reference day number
Ln	4, signed	$*2^{-20}$		semicycles	Longitude of first ascension node
Tln	4	$*2^{-5}$		seconds	Reference time of the first ascending node
Di	4, signed	$*2^{-20}$		semicycles	Correction to inclination
DT	4, signed	$*2^{-9}$		s/orbit_period	Correction to the mean value of Draconian period
dTdot	1, signed	$*2^{-14}$		$s/orbit\_period^2$	Rate of change of Draconian period
Reserved	5				TBD
e	2	$*2^{-20}$			Eccentricity
omega	2, signed	$*2^{-15}$		semicycles	Argument of perigee
tn	2, signed	$*2^{-18}$		seconds	Satellite time correction

Payload length: 41 bytes

5.3.7 GPS Ephemeris data

Response to poll.

Example:

FASTi - Preamble & MID (ASCII)

---…-- Payload (hex)

0x---- Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x69		ASCII i
PRN	1				Satellite PRN number (1-32) 0x00 means "No data for requested PRN"
tow	4			seconds	Second of GPS week
Reserved	2				
wn	2				GPS week number
prec&health	2				see Table 12 for bit allocation
tgd	2, signed	$*2^{-31}$		seconds	Group delay
iodc	2				Clock data issue
toc	2	$*2^{4}$		seconds	Clock data reference time
af2	2, signed	$*2^{-55}$		sec/sec^2	Clock correction
af1	2, signed	$*2^{-43}$		sec/sec	Clock correction
af0	4, signed	$*2^{-31}$		seconds	Clock correction
iode	2				Ephemeris data issue
cuc	2, signed	$*2^{-29}$		radians	Harmonic correction term
cus	2, signed	$*2^{-29}$		radians	Harmonic correction term
crc	2, signed	$*2^{-5}$		meters	Harmonic correction term
crs	2, signed	$*2^{-5}$		meters	Harmonic correction term
cic	2, signed	$*2^{-29}$		radians	Harmonic correction term
cis	2, signed	$*2^{-29}$		radians	Harmonic correction term
deltan	2, signed	$*2^{-43}$		semicycles/sec	Mean anomaly correction
m0	4, signed	$*2^{-31}$		semicycles	Mean anomaly at reference time
e	4	$*2^{-33}$			Eccentricity
roota	4	$*2^{-19}$		$meters^{1/2}$	Square root of semi-major axis
toe	2	$*2^{4}$		seconds	Reference time for ephemeris
omega0	4, signed	$*2^{-31}$		semicycles	Longitude of ascending node
i0	4, signed	$*2^{-31}$		semicycles	Inclination angle
omega	4, signed	$*2^{-31}$		semicycles	Argument of perigee
omegadot	4, signed	$*2^{-43}$		semicycles/sec	Rate of right ascension
idot	2, signed	$*2^{-43}$		semicycles/sec	Rate of inclination
Valid	4			bitmap	Data valid flag: 0x80 00 00 00 - valid otherwise - invalid

Payload length: 77 bytes

Table 12 Bit allocation in the "prec&health" word

MSB **LSB**

Reserved						URA (see ICD GPS - 200C)				Satellite health (see ICD GPS - 200C)					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

5.3.8 GLONASS Ephemeris data

Response to poll.

Example:

FASTe - Preamble & MID (ASCII)

---…-- payload (hex)

0x---- Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x65		ASCII e
SV ID	1				Satellite number (1-24) 0x00 means "No data for requested PRN"
Litera	1, signed				Satellite frequency number (-7…12)
Health	1				Satellite health: 0x30 = bad 0x31 = good
Flags	2			bitmap	Combined n1, n2, n3 flags in accordance with GLONASS ICD. See Table 13
Tb	2	*15		min	Ephemeris data reference time within the day expressed in GLONASS time scale = UTC(SU)+ 3 hours
X	4, signed	$*2^{-11}$		kilometers	Satellite PZ-90 X coordinate
Y	4, signed	$*2^{-11}$		kilometers	Satellite PZ-90 Y coordinate
Z	4, signed	$*2^{-11}$		kilometers	Satellite PZ-90 Z coordinate
Xdot	4, signed	$*2^{-20}$		km/c	Satellite PZ-90 velocity X'
Ydot	4, signed	$*2^{-20}$		km/c	Satellite PZ-90 velocity Y'
Zdot	4, signed	$*2^{-20}$		km/c	Satellite PZ-90 velocity Z'
Xdotdot	2, signed	$*2^{-30}$		km/c^2	Satellite perturbation acceleration X"
Ydotdot	2, signed	$*2^{-30}$		km/c^2	Satellite perturbation acceleration Y"
Zdotdot	2, signed	$*2^{-30}$		km/c^2	Satellite perturbation acceleration Z"
Tk	4			seconds	Start time (modulo one day) of the 30-second frame in satellite time scale tk from which the ephemeris data is derived.
tn	4, signed	$*2^{-30}$		seconds	Bias between satellite time scale and GLONASS system time scale at tb time moment
Tc	4, signed	$*2^{-27}$		seconds	Bias between GLONASS system time scale and UTC + 3 hours time scale, τ_c. The same as in Almanac data.
Gn	2, signed	$*2^{-40}$		dimensionless	Frequency offset of the on-board frequency standard at tb time moment
Dn	2			days	Age of ephemeris (interval from the moment when ephemeris data was uploaded to tb time moment
Reserved	4				

Payload length: 57 bytes

Table 13 Bit allocation in the "flags" word

MSB															LSB
Reserved												n1		n2	n3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

5.3.9 Navigation parameters

Response to poll.

Example:

FASTp - Preamble & MID (ASCII)

---…-- Payload (ASCII)

0x---- Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x70		ASCII p
Pos Mode	1			bitmap	Position fix mode control, see Table 14
Alt_For_Hold	2			meters	
Clock hold timeout	1			seconds	Time interval during which the clock bias extrapolation is allowable
Hold priorities	1				Priority against altitude and Tshift(1): C(0x43) = clock priority A(0x41)= altitude priority
GLONASS Tshift	4, signed			cm	GLONASS system time shift (divided by speed of light) relative to GPS time
Tshift alg	1				Tshift fixing algorithm: N (0x4D)= never fixed ~ (0x7E)= flexible(2) F(0x46)= always fixed
nSV	1				Number of SV to compute Tshift
Tshift priority	1				Priority against altitude(3): T(0x54)= Tshift higher priority A(0x41)= altitude higher priority
Elevation mask	1			degrees	Elevation mask for Navigation solution
SNR mask	1				SNR mask for Navigation solution
PDOP mask	1	$*2^{-3}$			PDOP mask for Navigation solution(1)
HDOP mask	1	$*2^{-3}$			HDOP mask for Navigation solution(1)
Update_rate	1	*10		seconds	Output position update rate
Reserved	4				TBD

Payload length: 21 bytes

Notes:

(1) If the number of SV in solution is 4 or less, this parameter sets priority of clock rate fixing against altitude fixing or GLONASS system time shift fixing, see also Note (3).

(2) Compute GLONASS system time shift if number of SV in solution is nSV or more, and hold it fixed if number of SV is nSV or less.

(3) If the number of SV in solution is 4 or less, this parameter sets priority of GLONASS system time shift fixing against altitude fixing.

Table 14 Bit allocation in the "Pos Mode" word

Mode	Description
0x00	Only 3D solution allowable
0x01	1 satellite solution allowable
0x02	2 satellite solution allowable
0x03	3 satellite solution (2D) allowable
0x04	4 satellite solution (3D) allowable
0x08	Reserved
0x10	Altitude hold mode allowable
0x20	Clock hold mode allowable
0x40	Recent computed altitude must be used for altitude hold mode, otherwise Alt_For_Hold
0x80	Reserved

5.3.10 Command acknowledgement

Example:

FAST+ -Preamble & MID (ASCII)

V- Payload (ASCII)

0x2B 56 - Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x2B		ASCII +
Ack. ID	1		V (ASCII)		"Poll F/W version" command has been received OK

Payload length: 1 byte

5.3.11 CommandNAcknowledgement

Example:

FAST? Preamble & MID (ASCII)

0x56- Payload

0x3F 56 - Message checksum (hex)

Name	Bytes	Scale	Example	Units	Description
MID	1		0x3F		ASCII ?
Nack. ID	1		V (ASCII)		"Poll F/W version" command has been received with an error

Payload length: 1 byte

6. NMEA PROTOCOL SPECIFICATION

6.1 GENERAL

This Protocol defines the requirements for establishing a communication interface between TF50 navigation receiver and external equipment via communication Port #1 in the NMEA-0183 format. The NMEA-0183 format is defined by the National Marine Electronics Association (NMEA) Standard for Interfacing Marine Electronic Devices, Version 2.30, March 1, 1998. TF50 can receive input messages from the external equipment, and can send output messages to the external equipment.

6.2 OUTPUT MESSAGES

Table 1 contains list of TF50 NMEA output messages.

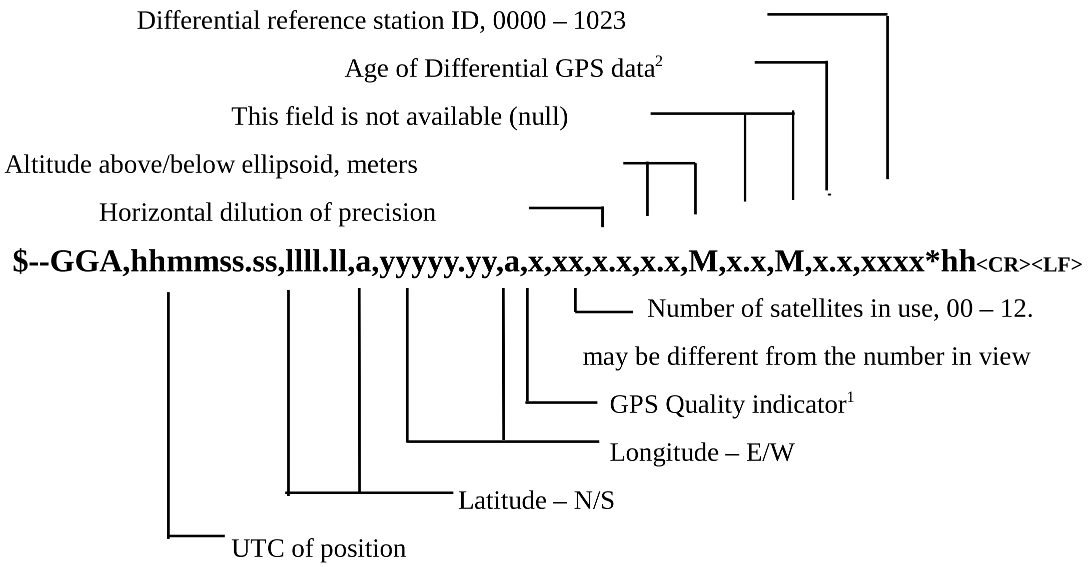
Table 15 TF50 NMEA output message

DATA	Talker Identifier	Sentence Formatter	Type
Position Fix Data	GP	GGA	A
Geographic Position – Latitude/Longitude	GP or GN	GLL	A
DOP and Active Satellites	GN	GSA	A
Satellites In View	GP and GN	GSV	A, Q
Recommended Minimum Specific GNSS Data	GP or GN	RMC	A
Track Made Good And Ground Speed	GP(default) or GN	VTG	A

Column "Type" of Table 1 defines type of output data. Character “A” means that output data are generated automatically if appropriate Character “Q” means that data are available on receiver output in response to correspondent query command.

6.2.1 GGA – Position Fix Data

Time, position and fix related data for a GPS receiver.



<u>Notes:</u>

1. GPS Quality Indicator: 0 = Fix not available or invalid
   1 = GPS SPS Mode, fix valid
   2 = Differential GPS, SPS Mode, fix valid
   3 = GPS PPS Mode, fix valid
   4 = Real Time Kinematic. System used in RTK mode with fixed integers
   5 = Float RTK. Satellite system used in RTK mode, floating integers
   6 = Estimated (dead reckoning) Mode
   7 = Manual Input Mode
   8 = Simulator Mode

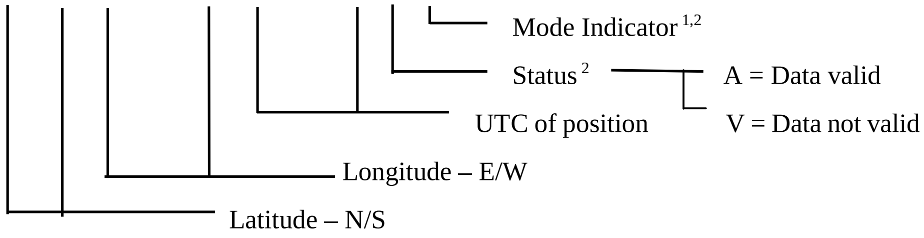
   The GPS Quality Indicator field shall not be a null field.

2. Time in seconds since last SC104 Type 1 or 9 update, null field when DGPS is not used.

6.2.2 GLL – Geographic Position – Lat/Lon

Latitude and Longitude of vessel position, time of position fix and status.

$--GLL,llll.ll,a,yyyyy.yy,a,hhmmss.ss,A,a*hh<CR><LF>



Notes:

1. Positioning system Mode Indicator: A = Autonomous mode
   D = Differential mode
   E = Estimated (dead reckoning) mode
   M = Manual input mode
   S = Simulator mode
   N = Data not valid
2. The positioning system Mode Indicator field supplements the positioning system Status field, the Status field shall be set to V = Invalid for all values of Indicator mode except for A = Autonomous and D = Differential. The positioning system Mode Indicator and Status field shall not be null field.

6.2.3 GSA – DOP and Active Satellites

GNSS receiver operating mode, satellites used in the navigation solution reported by the GGA or GNS sentence, and DOP values.

If only GPS or GLONASS is used for the reported position solution the DOP values pertain to the individual system. If GPS and GLONASS are combined to obtain the reported position solution, multiple GSA messages are produced, one with the GPS satellites, another with the GLONASS satellites. Each of these GSA messages shall have talker ID GN, to indicate that the satellites are used in a combined solution and each shall have the PDOP, HDOP and VDOP for the combined satellites used in position.

$--GSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,x.x,x.x,x.x*hh<CR><LF>

VDOP

HDOP

PDOP

ID numbers [1] of satellites used in solution (null for unused fields)

Mode: 1 = Fix not available, 2 = 2D, 3 = 3D

Mode: M = Manual, forced to operate in 2D or 3D mode

A = Automatic, allowed to automatically switch 2D/3D

Notes:

1. Satellite ID numbers. To avoid possible confusion caused by repetition of satellite ID numbers when using multiple satellite systems, the following convention has been adopted:

a) GPS satellites are identified by their PRN numbers, which range from 1 to 32.

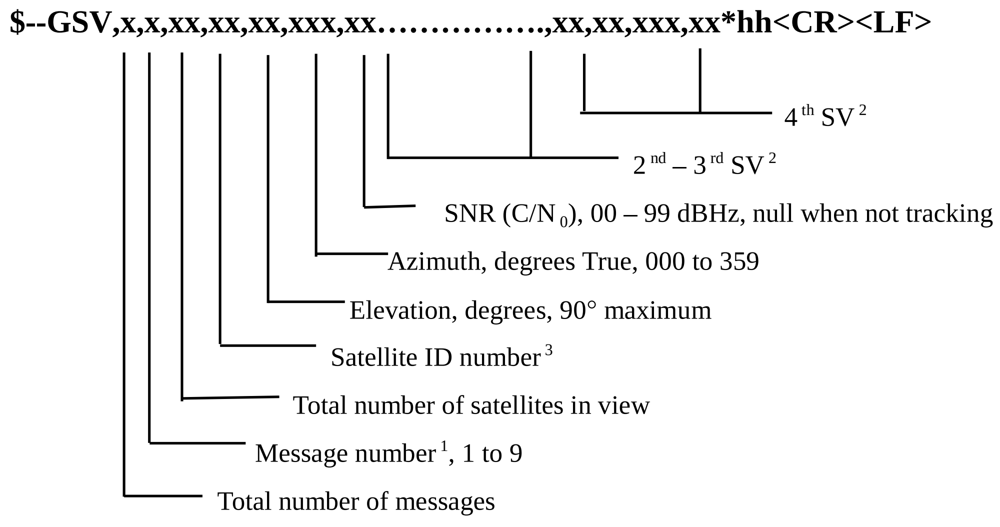
b) The WAAS system has reserved numbers 33 – 64 to identify its satellites.

c) The numbers 65 – 96 are used for GLONASS satellites. GLONASS satellites are identified by 64 + satellites slot number. The slot number are 1 through 24 for the full GLONASS constellation of 24 satellites, this dives a range of 65 through 88. The number 89 through 96 are available if slot number above 24 are allocated to on-orbit spares.

6.2.4 GSV – Satellites In View

Number of satellites (SV) in view, satellite ID numbers, elevation, azimuth, and SNR value. Four satellites maximum per transmission, additional satellite data sent in second or third message. Total number of message being transmitted and the number of message being transmitted are indicated in the first two fields.

If multiple GPS and GLONASS satellites are in view, use separate GSV sentences with talker ID GP to show the GPS satellites in view and talker GL to show the GLONASS satellites in view. The GN identifier shall not be used with this sentence.



Notes:

1. Satellite information may require the transmission of multiple messages. The first field specifies the total number of messages, minimum value 1. The second field identifies the order of these messages (messages number), minimum value 1.

2. A variable number of "Satellite ID – Elevation – Azimuth – SNR" sets are allowed up to a maximum of four sets per messages. Null fields are not required for unused sets when less than four sets are transmitted.

3. Satellite ID number. To avoid possible confusion caused by repetition of satellite ID numbers when using multiple satellite systems, the following convention has been adopted:

a) GPS satellites are identified by their PRN numbers, which range from 1 to 32.

b) The WAAS systems has reserved numbers 33 – 64 to identify its satellites.

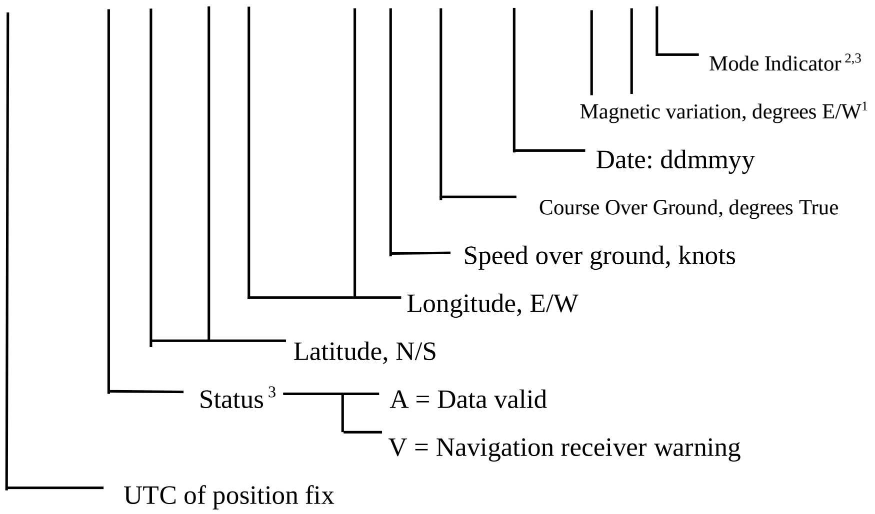
d) The numbers 65 – 96 are used for GLONASS satellites. GLONASS satellites are identified by 64 + satellites slot number. The slot number are 1 through 24 for the full GLONASS constellation of 24 satellites, this dives a range of 65 through 88. The number 89 through 96 are available if slot number above 24 are allocated to on-orbit spares.

Receiver updates satellites in view data one time per minute.

6.2.5 RMC – Recommended Minimum Specific GNSS Data

Time, date, position, course and speed data provided by a GNSS navigation receiver. All data fields must be provided, null fields used only when data is temporarily unavailable.

$--RMC,hhmmss.ss,A,llll.ll,a,yyyyy.yy,a,x.x,x.x,xxxxxx,x.x,a,a*hh<CR><LF>



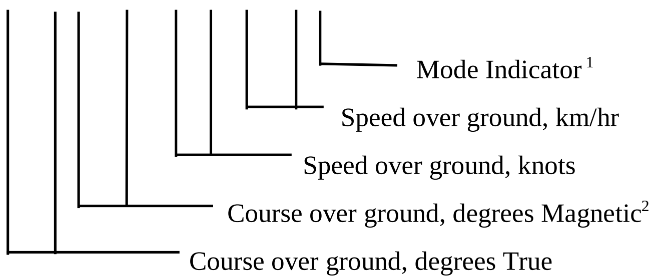
Notes:

1. TF50 does not support magnetic variation.
2. Positioning system Mode Indicator: A = Autonomous mode
   D = Differential mode
   E = Estimated (dead reckoning) mode
   M = Manual input mode
   S = Simulator mode
   N = Data not valid
3. The positioning system Mode Indicator field supplements the positioning system Status field, the Status field shall be set to V = Invalid for all values of Indicator mode except for A = Autonomous and D = Differential. The positioning system Mode Indicator and Status field shall not be null fields.

6.2.6 VTG – Track Made Good And Ground Speed

The actual course and speed relative to the ground.

$--VTG,x.x,T,x.x,M,x.x,N,x.x,K,a*hh<CR><LF>



Notes:

1. Positioning system Mode Indicator:

A = Autonomous mode
D = Differential mode
E = Estimated (dead reckoning) mode
M = Manual input mode
S = Simulator mode
N = Data not valid

2. TF50 does not support magnetic variation. The x.x field is always empty.

The positioning system Mode Indicator field shall not be a null field.

6.3 INPUT MESSAGES

NMEA input messages are provided to allow to control TF50 receiver while in NMEA protocol mode. TF50 receiver may be put into NMEA mode by sending the TF50 Binary Protocol message "Switch to NMEA Protocol". If the receiver is in TF50 Binary mode, all NMEA messages are ignored. Once the receiver is put into NMEA mode, the following transport-level message may be used to command the receiver:

Start Sequence	Payload	Checksum	End Sequence
$PFST,<MID>[1],	Data[2]	*CS[3]	<CR><LF>[4]

Notes:

1. Message Identifier (MID) consists of three alpha-numeric characters.
2. Message specific data: <data>,<data>,…,<data>
3. CS is one byte checksum as defined in the NMEA specification. Checksum field must be fill in correctly for each input messages.
4. Each message is terminated using Carriage Return (CR) and Line Feed (LF) symbols which is \r\n which is hex 0D0A

Table 16 lists TF50 NMEA input messages.

Table 16 TF50 NMEA input messages

Message	MID	Description
XYZ Initialization	XYZ	Approximate user position, time, etc.
LLA Initialization	LLA	Approximate user position, time, etc.
DGPS Control	DIF	Set Port B parameters for DGPS input/output
Rate Control	RAT	Set output message rate
Store Position	STP	Store last user position into non-volatile memory
Store Almanacs	STA	Store almanacs into non-volatile memory
Switch to Binary Protocol	BIN	Switch to TF50 Binary Protocol

6.3.1 XYZ Initialization

This command is used to initialize TF50 receiver by providing approximate user position in ECEF coordinates, clock offset and time. Correct initialization parameters enable the receiver to acquire signals quickly.

Example:

$PFST,XYZ,2845800,2196900,5251000,8000,76,223500,3*CS

Name	Example	Unit	Description
Start Sequence	$PFST,XYZ,		
ECEF X	2845800	Meters	X coordinate
ECEF Y	2196900	Meters	Y coordinate
ECEF Z	5251000	Meters	Z coordinate
Clock offset	8000	Hz	Clock Offset of the receiver
Week number	76		GPS Week Number
Time of week	223500	Seconds	GPS Time Of Week
Start Mode	3		See Table 17
Checksum			
<CR><LF>			End Sequence

Note: If a data field is empty, the corresponding parameter will not be changed.

Table 17 Start Mode

Hex	Description
0x01	Hot Start - all data valid
0x02	Warm Start - clear ephemeris
0x03	Cold Start

6.3.2 LLA Initialization

This command is used to initialize TF50 receiver by providing approximate user position in Latitude/Longitude/Altitude coordinates, clock offset and time. Correct initialization parameters enable the receiver to acquire signals quickly.

Example:

$PFST,LLA,55.7,37.6,200,8000,76,223500,3*CS

Name	Example	Unit	Description
Start Sequence	$PFST,LLA,		
Lat	55.7	Degrees	Latitude (range -90 to 90)
Lon	37.6	Degrees	Longitude (range -180 to 180)
Alt	200	Meters	Altitude
Clock offset	8000	Hz	Clock Offset of the receiver
Week number	76		GPS Week Number
Time of week	223500	Seconds	GPS Time Of Week
Start Mode	3		See Table 18
Checksum			
<CR><LF>			End Sequence

Note: If a data field is empty, the corresponding parameter will not be changed.

Table 18 Start Mode

Hex	Description
0x01	Hot Start - all data valid
0x02	Warm Start - clear ephemeris
0x03	Cold Start

6.3.3 DGPS Control

This command is used to control the serial port used to send or receive RTCM differential corrections. When a valid message is received, the parameters are stored in the non-volatile memory, and then the receiver restarts using the saved parameters.

Example:

$PFST,DIF,IN,9600,8,1,0*CS

Name	Example	Unit	Description
Start Sequence	$PFST,DIF,		
Input/Output	IN		OUT - if the receiver is used as differential correction station IN - if the receiver set to operate in differential mode
Baud	9600		Baud rate
DataBits	8		8 or 7
StopBits	1		1 or 0
Parity	0		0=None, 1=Odd, 2=Even
Checksum			
<CR><LF>			End Sequence

6.3.4 Rate Control

This command is used to control the output of standard NMEA messages.

Example:

$PFST,RAT,GN,VTG,DIS,1000,ECS*CS

Name	Example	Unit	Description
Start Sequence	$PFST,RAT,		
Talker	GN		Talker Identifier: GP, GL or GN
Message	VTG		Output message
Mode	DIS		ENA - enabled DIS - disabled QRY - query command (for GSV only)
Rate	1000	ms	Output rate. Will be rounded in the receiver to nearest multiple of 200 ms
Checksum enable	ECS		ECS - enable checksum DCS - disable checksum
Checksum			
<CR><LF>			End Sequence

6.3.5 Store Position

This command is used to store last computed user position and receiver clock offset into non-volatile memory.

Example:

$PFST,STP,POSITION*CS

Name	Example	Unit	Description
Start Sequence	$PFST,STP,		
Marker	POSITION		String constant
Checksum			
<CR><LF>			End Sequence

6.3.6 Store Almanacs

This command is used to store last received almanacs into non-volatile memory.

Example:

$PFST,STA,ALMANACS*CS

Name	Example	Unit	Description
Start Sequence	$PFST,STA,		
Marker	ALMANACS		String constant
Checksum			
<CR><LF>			End Sequence

6.3.7 Switch to Binary Protocol

This command is used to control the serial port used to send or receive RTCM differential corrections. When a valid message is received, the parameters are stored in the non-volatile memory, and then the receiver restarts using the saved parameters.

Example:

$PFST,BIN,115200,8,1,0*CS

Name	Example	Unit	Description
Start Sequence	$PFST,BIN,		
Baud	115200		Baud rate
DataBits	8		8 or 7
StopBits	1		1 or 0
Parity	0		0=None, 1=Odd, 2=Even
Checksum			
<CR><LF>			End Sequence