NAVMAN

Jupiter series Timing application software Application note

(TU60-D120 and TU36-D400 series)

Related documents

Jupiter T

- Product brief LA010039
- Data sheet LA010050

Jupiter Pico T

- Data sheet LA010093

Jupiter series

- Designer's guide MN002000

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Features

- time accuracy within 40 ns, 1 sigma of GPS time, with SA (Selective Availability) off

- position accuracy (stationary operation only) within 5 m 3D (Spherical Error Probable) with SA off and a PDOP (Position Dilution of Precision) ≤ 6.0

- TRAIM software warns when timing is not verifiable by the software

- serial interface with programmable baud rates

- adaptive threshold-based signal detection for improved reception of weak signals

- self-initialising

- accepts external position information

- user selectable visible satellite mask angle

- user selectable satellites

- TTFF (Time-To-First-Fix) values:
  < 22 s hot start
  < 48 s warm start
  < 120 s cold start

- re-acquisition time is typically <1 s following <10 s blockage

- Time from first fix until 1PPS is valid: typically <20 s for GPS time, UTC (Universal Time Coordinated) time valid within 20 s of receiving Ionospheric/UTC information from satellite navigation message (average 6.5 min)

1.0 Introduction

The Timing Application software is used to configure GPS (Global Positioning System) receivers that use the Zodiac chipset as precision timing references. The GPS system operates effectively because of precise time kept in the satellites and in ground-based control stations. GPS receivers can use the Timing Application software at any geographic location.

The software implements operating modes that greatly simplify the generation of precise time references. By installing the receiver and a suitable antenna, and applying power, an accurate position can be established and precise time can be generated without operator commands or actions. The software can be customised to include compensation for long cable runs and the use of pre-surveyed coordinates.

Integral TRAIM (Timing Receiver Autonomous Integrity Monitoring) provides alarms that indicate when the timing quality cannot be verified. The receiver can be configured to turn off the timing pulse whenever TRAIM reports an alarm.

Figure 1-1 shows a typical application of the Timing Application software.

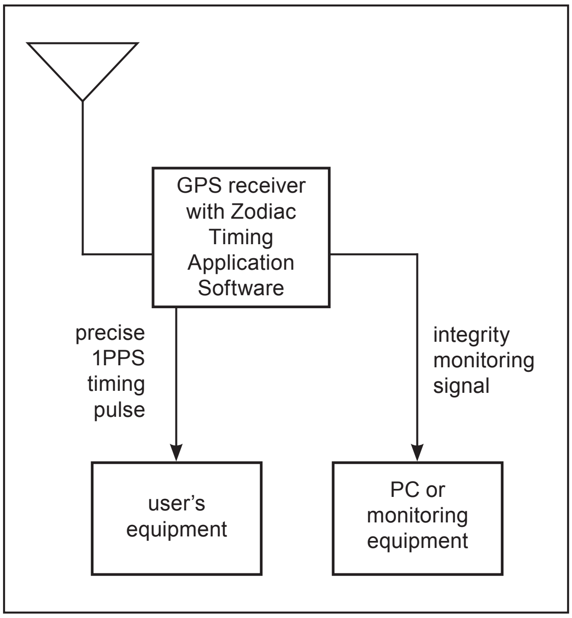

Figure 1-1 Timing software application block diagram

Applications

- network timing
- cellular telephone base stations
- precision time tagging

2.0 Technical description

The Zodiac GPS Timing Application software is based on Navman's standard GPS software with specific enhancements that improve timing performance. Software commands are used to configure a GPS receiver as a standard receiver or to put it into special timing modes.

In special timing modes, the receiver can determine its own position very precisely. It can hold its set position and use all received errors to correct its time. The software contains special integrity-monitoring algorithms that keep track of time error estimates and can notify the operator when time measurements appear to contain errors.

2.1 Zodiac GPS chipset

The Zodiac GPS Timing Application software is used with the Zodiac GPS chipset, including the Scorpio (CX11577) baseband processor, and either the Gemini/Pisces Monopac™ (R6732) or the CX76502 RF MCM (Multi-Chip Module) as the RF (Radio Frequency) element. The CX11239 hardware accelerator is not supported in the timing software.

2.2 Peripherals

The standard Timing Application software supports the following hardware features:

- Dallas Semiconductor DS1302 RTC (Real Time Clock)
- Atmel AT24C32 serial EEPROM
- 2 MB (or larger) ROM program memory
- minimum 32 k x 16 bit SRAM

3.0 Software description

The Timing Application software is developed from Zodiac software. It contains all of the standard features, and the following additional features:

- ability to self survey to determine a precision position
- ability to operate in Position-Hold mode, where the navigation solution is used only to update the timing rather than to change the position of the receiver
- ability to monitor and report on its own timing integrity using TRAIM
- ability to align the 1PPS time mark to either GPS or UTC time
- ability to adjust the 1PPS time mark signal by the number of ns configured by the operator
- support for new timing application messages for the new features

3.1 Operating modes

The Timing Application software features the position-hold and the self-survey operating modes, in addition to the standard Zodiac operating modes.

3.1.1 Position-hold mode

In position-hold mode, the receiver creates satellite observations. The navigation solution computed from those observations adjusts the receiver timing rather than creating a new position fix. Position-hold mode can be initiated from an operator command, automatically after successful completion of a self survey, or at start-up when the operator sets the appropriate configuration (see Message 1255).

When an operator command entry into position-hold mode occurs, the current system position can be used as the reference position or the operator can specify another reference position. If the receiver is set to enter position-hold mode at start-up, and if there is no valid position stored in the system either from a self survey, operator entry, or prior navigation, the receiver does not enter position-hold mode, but instead enters self-survey mode and begins a 24-hour survey.

When the system passes into, or is commanded into position-hold mode, the timing solution becomes valid once the first valid-measurement, valid-ephemeris satellite is in track. When Position-hold mode starts successfully, the receiver can continue to indicate a valid timing solution with a minimum of one satellite in track. The receiver only leaves position-hold mode in response to an operator command or due to a restart.

3.1.2 Self-survey mode

In self-survey mode, the receiver navigates as a fixed receiver and computes an averaged position from the accumulated solutions to refine the final position. It also counts the number of fixes used to compute the position to indicate the estimated quality of the solution.

Self-survey mode may be started automatically at power-up or restart, or by operator command. Timing receiver software defaults to starting in self-survey mode upon power-on or reset, but this can be changed by operator commands (see Message 1255).

When the operator commands the receiver to either enter or remain in self-survey mode, the duration of the survey can be specified, or it can be allowed to remain in this mode continuously.

When self-survey mode is entered automatically at reset, or because the system was unable to start in position-hold mode, it remains in this mode for 24 hours by default.

Self-survey mode may be ended at any time by operator command. When the receiver is given a fixed time for the survey, upon completion of the appropriate number of valid measurements, the receiver exits self-survey mode, stores the computed position in EEPROM as a valid position, and transitions to position-hold mode.

The time specified for a self survey implies a fixed number of valid measurements rather than an explicit time. A 24-hour survey means that the receiver accumulates data from 86 400 valid measurements. If the receiver experiences loss of signal or periods with insufficient satellites to compute valid positions, measurements made during those times are not added to the total, and cause the survey to require more time than specified.

3.2 Mode transitions

The possible transitions between the self-survey mode, position-hold mode and standard navigation mode are illustrated in Figures 3-2, 3-3, 3-4 and 3-5.

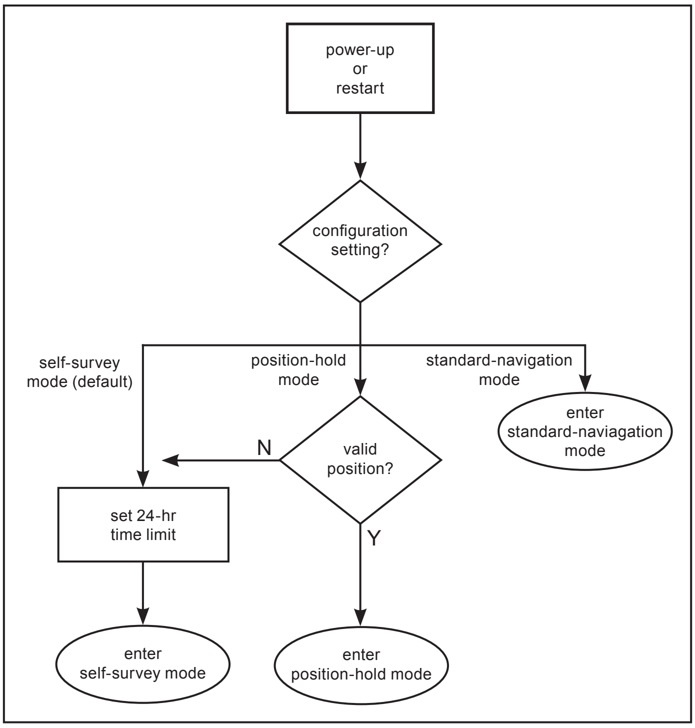

Figure 3-1 Mode transitions at power-up or reset

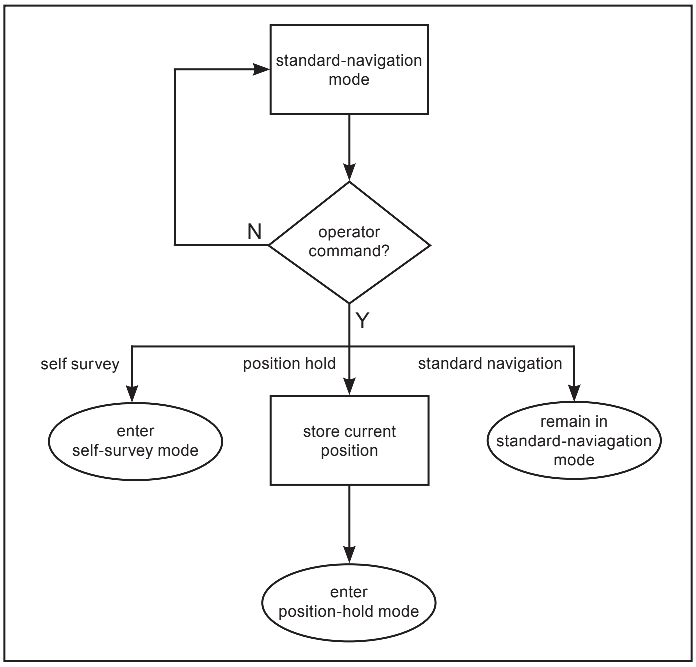

Figure 3-2 Mode transitions from standard navigation mode

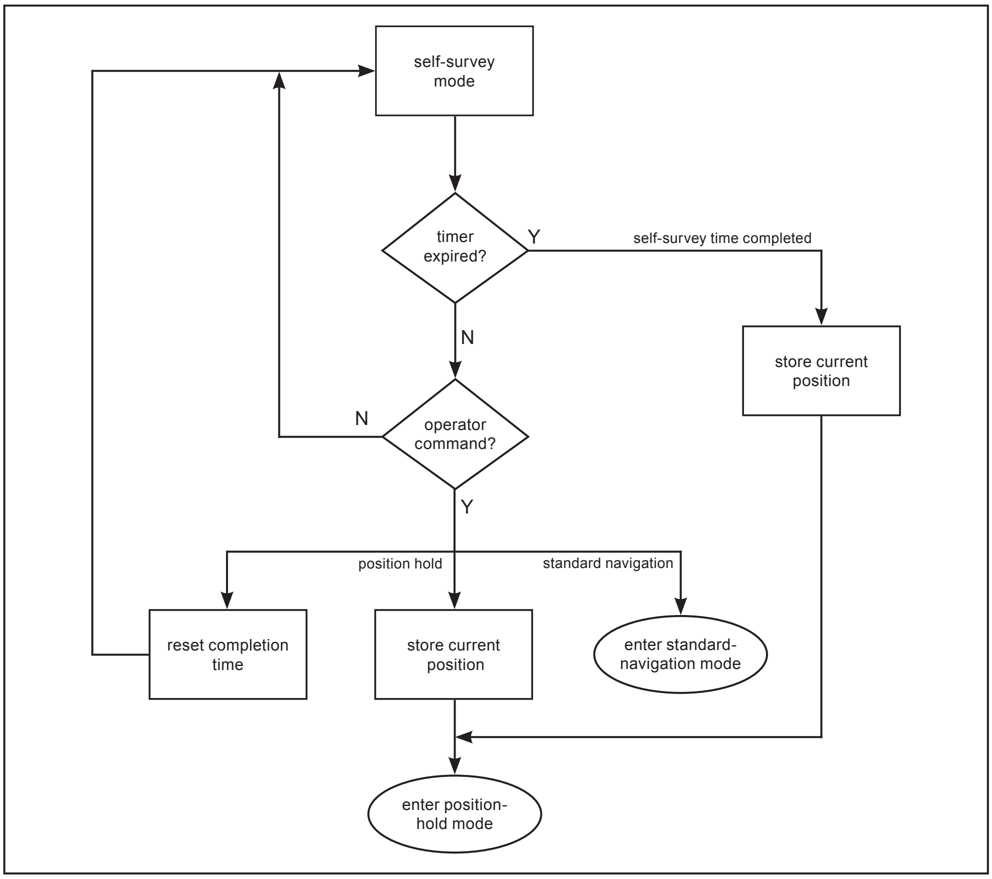

Figure 3-3 Mode transitions from self-survey mode

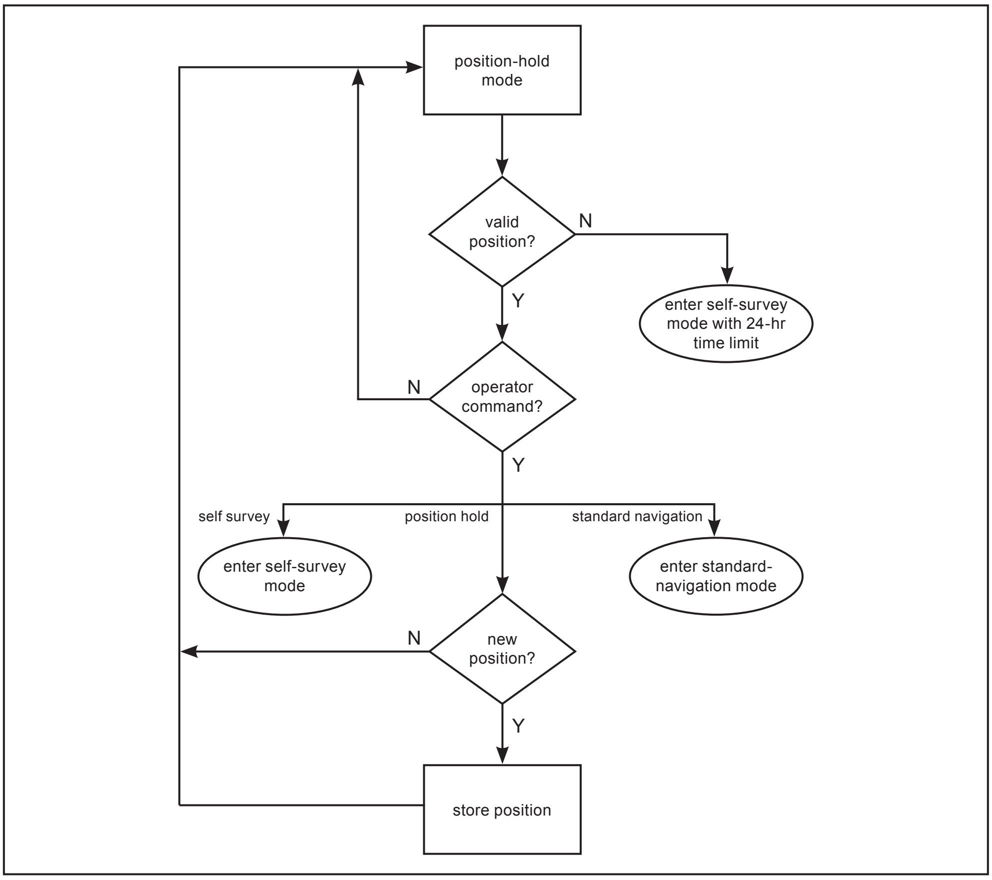

Figure 3-4 Mode transitions from position-hold mode

4.0 Message interface

Binary and NMEA-formatted serial data messages are used to control the Zodiac GPS software. Tables A1-1 and A1-2 list the binary and NMEA messages that the standard Zodiac software supports. Three binary messages have been added to the standard Zodiac message set to control the Timing Application software. Refer to the Jupiter receiver designer's guide for a complete description of the message protocol and a definition of existing messages.

The following messages have been added to the existing message protocol:

- Message 1255 — timing receiver configuration input
- Message 1055 — timing receiver configuration output
- Message 1056 — timing receiver status output

The existing Message 1108 (UTC time mark pulse output) has been modified for use in the Timing Application software.

Message 1255 — timing receiver configuration input
This message specifies all timing receiver settings. These include the current mode, start-up mode, timing pulse performance, and TRAIM settings. The contents of the Message 1255 are described in Table A1-3.

Message 1055 — timing receiver configuration output
This message describes the current settings of the timing functions. The data format and contents are almost identical to Message 1255. The contents of Message 1055 are described in Table A1-4.

This message is automatically output by the receiver whenever the receiver's mode changes. The contents of this message can be viewed at any time by sending a query message to the receiver.

Message 1056 — timing receiver status output
This message reports on the current status of the timing functions, including any TRAIM alarm conditions, TRAIM status, progress of the self-survey or position-hold modes, and the reason the receiver is not in a specific mode previously specified. The contents of Message 1056 are described in Table A1-5.

This message is output automatically by the receiver any time a TRAIM alarm condition occurs, or in response to a query message sent to the receiver.

Message 1108 — UTC time mark pulse output
Bit 19.2 of the existing 1108 message has been modified to indicate when the receiver has UTC correction data from the satellites' navigation message that is less than two hours old. In this case, bit 19.2 is set. Bit 19.3 has been modified to reflect the TRAIM alarm status; this bit is set whenever TRAIM reports an alarm. The contents of Message 1108 are described in Table A1-6.

5.0 Timing signal definition

The Zodiac chipset outputs both a 1PPS signal and a 10 kHz signal. When the 1PPS signal is properly aligned to GPS or UTC, as specified by Message 1255, the receiver indicates in Message 1108 (UTC Time Mark Pulse Output) and Message 1056 that the time mark is valid, and whether it is aligned with GPS or UTC time.

In the timing receiver, when UTC is the designated alignment, the time mark is not marked valid unless the receiver has an Ionospheric/UTC corrections data block, less than two weeks old, from the satellite navigation message (subframe 4, page 18 as described in the ARINC document, Navstar GPS Space Segment/Navigation User Interfaces, document number ICD-GPS-200, available from the ARINC website at http://www.arinc.com/gps/gpshome.html).

When the receiver determines that it has an Ionospheric/UTC corrections data block less than two week old, it sets bit 19.1 in Message 1108. When the data block is less than two hours old, the receiver sets bit 19.2 in Message 1108, and bit 16.3 in Message 1056.

The US Government constantly compares UTC and GPS time, and reports the relationship between the times in the Ionospheric/UTC corrections data block. The two times differ by a number of seconds (called leap seconds) and by a fraction of a second (GPS-UTC alignment) that is usually very small. Leap seconds only change one or two times a year at most. A two-week warning is sufficient to be able to track leap-second changes. The GPS-UTC alignment constantly changes, but is usually no more than 20 ns. However the US Government guarantees it to 90 ns (1 sigma). So, with an Ionospheric/UTC corrections data block no more than two hours old, the timing receiver is able to align the time mark pulse to UTC to the limits of the receiver's capability and to the accuracy limits of the GPS system.

5.1 1PPS time mark

The 1PPS time mark starts on the rising edge of one of the 10 kHz pulses, and has a duration of approximately 25.6 ms. The rising edges of both signals are aligned with either GPS or UTC according to the specifications of Message 1255 (see Table A1-3). The 1255 message is used to specify that the 1PPS signal is disabled when TRAIM is enabled and reporting an alarm.

The 1PPS time mark is only output by the receiver when the receiver declares the time mark valid, as indicated by bit 19.0 in Message 1108 and bit 16.2 in Message 1056.

5.2 10 kHz signal

The 10 kHz signal is a square wave with approximately a 50% duty cycle. It is phased so that one rising edge is aligned with either GPS or UTC time within the specified performance tolerance for the 1PPS signal.

5.3 System time delay compensation

The 1PPS and 10 kHz signals can be adjusted to compensate for system time delays using Message 1255. When a value other than 0 is entered in the 1255 message, the receiver adjusts the 1PPS time mark pulse by the specified number of nanoseconds.

The timing pulse is advanced to adjust for delays caused by antenna or equipment interconnect cables, or delayed to adjust for differences between timing systems. Positive compensation values advance the signals.

6.0 Performance characteristics

Position:

- 5 m SEP 3D with SA off
- 100 m 2dRMS (95%) horizontal with SA on

Altitude:

- 10 m RMS (95%) with SA off
- 156 m RMS with SA on

Velocity:

- 0.02 m/s with SA off

Timing Pulse (1PPS) Absolute Error:

- <130 ns (one sigma) with SA
- <40 ns (one sigma) in position-hold mode
- <100 ns (three sigma) in position-hold mode

7.0 TRAIM

TRAIM is a feature that verifies the integrity of the timing solution. When there are at least three satellites present, TRAIM compares the timing among the satellites. If any one satellite’s timing is significantly different from the others, TRAIM detects this and removes the satellite from the timing solution. This is referred to as ‘detect and isolate’. If there are only two satellites present, TRAIM can still determine that there is significant disagreement between the time signals, but it cannot tell which satellite is correct. This is referred to as a ‘detect only’ condition. If there is only one satellite available, TRAIM is ‘unavailable’ to monitor integrity.

7.1 Sensitivity

When TRAIM is able to detect and isolate, it can verify the timing pulse integrity within the following limits:

- >150 ns (one sigma) when in position-hold mode with three or more satellites used
- >100 ns (one sigma) when in position-hold mode with four to six satellites used
- >50 ns (one sigma) when in position-hold mode with seven or more satellites used

When TRAIM is able to detect, it prevents >1.0 µs timing errors at all times when the position is valid (and accurate to within 20 metres) and two or more satellites are used.

7.2 Operation

TRAIM constantly monitors the time mark with respect to the satellite signals present and determines if any alarm conditions exist. For an alarm condition to exist, TRAIM must be enabled, the particular alarm condition must be enabled, and the TRAIM software must detect the specified condition.

TRAIM is configured by Message 1255. By default, TRAIM is enabled, and generates alarms if the status is either ‘unavailable’ (less than two satellites valid) or if the computed time pulse is estimated to be greater than the Timing Error Threshold, which is 1 µs by default. Using the 1255 message, the active alarm conditions can be altered; the Timing Error Threshold can be set to any value from 50 ns to 1 ms, in 50 ns steps; and TRAIM can be disabled.

Possible alarm conditions are: unavailable, detect only, and Timing Error Estimate > Timing Error Threshold. When TRAIM detects an alarm condition that is enabled, it reports the alarm by setting GPIO 8 low and sends Message 1056. The GPIO line will remain low as long as the alarm condition exists.

The timing pulse may also be stopped at any time a TRAIM alarm is reported. By default, the timing pulse is always present, but Message 1255 (bit 18.0) can change that setting so that the pulse stops during alarm conditions.

7.3 Self-survey

The Self-survey mode computes a 3D antenna position within 5 metres (95%) after surveying for 24 hours.

8.0 Glossary and acronyms

2Drms: Two Dimensional root mean square.

3D: Three Dimensional.

almanac: a set of orbital parameters that allow calculation of approximate GPS satellite positions and velocities. The almanac is used by a GPS receiver to determine satellite visibility and as an aid during acquisition of GPS satellite signals. The almanac is a subset of satellite ephemeris data and is updated weekly by GPS control.

DGPS: Differential Global Positioning System. A technique to improve GPS accuracy that uses pseudo-range errors recorded at a known location to improve the measurements made by other GPS receivers within the same general geographic area.

EEPROM: Electrically Erasable Programmable Read Only Memory.

ephemeris: a set of satellite orbital parameters that is used by a GPS receiver to calculate precise GPS satellite positions and velocities. The ephemeris is used to determine the navigation solution and is updated frequently to maintain the accuracy of GPS receivers.

GPS: Global Positioning System. A space-based radio positioning system that provides accurate position, velocity, and time data.

NMEA: National Marine Electronics Association.

OEM: Original Equipment Manufacturer.

PDOP: Position Dilution Of Precision. A measure of how much the error in the position estimate produced from satellite range measurements is amplified by a poor arrangement of the satellites with respect to the receiver antenna.

PPS: Pulse Per Second.

re-acquisition: the time taken for a position to be obtained after all satellites have been made invisible to the receiver

RF: Radio Frequency.

ROM: Read Only Memory.

RTC: Real Time Clock.

RTCM: Radio Technical Commission for Maritime services.

SA: Selective Availability. The method used by the DoD to control access to the full accuracy achievable with the C/A code.

SEP: Spherical Error Probable. The radius of a sphere, centred at the user's true location, that contains 50% of the individual three-dimensional position measurements made using a particular navigation system.

SRAM: Static Random Access Memory.

TRAIM: Timing Receiver Autonomous Integrity Monitoring.

TTFF: Time-To-First-Fix. The actual time required by a GPS receiver to achieve a position solution. This specification will vary with the operating state of the receiver, the length of time since the last position fix, the location of the last fix, and the specific receiver design.

UTC: Universal Time Coordinated. This time system uses the second defined true angular rotation of the Earth measured as if the Earth rotated about its conventional terrestrial pole. However, UTC is adjusted only in increments of one second. The time zone of UTC is that of Greenwich Mean Time (GMT).

Appendix A

Output Message Name	Message ID
geodetic position status output	1000
channel summary	1002
visible satellites	1003
channel corrections	1006
channel measurement	1007
best user measurement	1008
reduced ECEF position status output	1009
receiver ID	1011
user-settings output	1012
raw almanac output	1040
raw ephemeris output	1041
raw ionospheric and UTC corrections output	1042
RAM status	1050
timing receiver configuration output	1055
timing receiver status output	1056
built-in test results	1100
global output control parameters	1101
measurement time mark	1102
UTC time mark pulse output	1108
frequency standard parameters in use	1110
serial port communication parameters in use	1130
EEPROM update	1135
EEPROM status	1136
frequency standard table output data	1160
flash boot status (flash builds only)	1180
error/status	1190

Table A1-1 Zodiac Binary data messages (1 of 2)

Input Message Name	Message ID
geodetic position and velocity initialisation	1200
user-defined datum definition	1210
map datum select	1211
satellite elevation mask control	1212
satellite candidate select	1213
differential GPS control	1214
cold start control	1216
solution validity input	1217
user-entered altitude input	1219
application platform control	1220
nav configuration	1221
raw almanac input	1240
raw ephemeris input	1241
raw ionospheric and UTC corrections input	1242
timing receiver configuration input	1255
perform built-in test command	1300
restart command	1303
factory test	1304
frequency standard input parameters	1310
serial port communication parameters	1330
message protocol control	1331
factory calibration input	1350
raw DGPS RTCM SC-104 data	1351
frequency standard table input data	1360
flash reprogram (flash builds only)	1380

Table A1-1 Zodiac Binary data messages (2 of 2)

Output Message Name	Message ID
Navman proprietary built-in test results	BIT
Navman proprietary error/status	ERR
GPS fix data	GGA
GPS DOP and active satellites	GSA
GPS satellites in view	GSV
Navman proprietary receiver ID	RID
recommended minimum specific GPS data	RMC
course over ground and ground speed	VTG
Navman proprietary zodiac channel status	ZCH

Table A1-2 Zodiac NMEA data messages (1 of 2)

Input Message Name	Message ID
Navman proprietary built-in test command	IBIT
Navman proprietary log control message	ILOG
Navman proprietary receiver initialisation	INIT
Navman proprietary protocol	IPRO
standard query message	Q

Table A1-2 Zodiac NMEA data messages (2 of 2)

Message ID: 1255 (only available in timing receiver software)					
Rate: As required; maximum rate 1 Hz					
Message Length: 24 words					
Word No.	**Name**	**Type**	**Units**	**Range**	**Resolution**
1-4	message header				
5	header checksum				
6	sequence number	I		0 to 32767	
7	timing receiver mode	UI		0 = no mode change 1 = standard navigation 2 = self-survey for 24 h 3 = self-survey for time specified (see word 11) 4 = self-survey for unlimited time 5 = position-hold with current position 6 = position-hold with specified position (see words 12-17)	
8	timing receiver start-up mode configuration word (note 1)	UI		0 = self-survey 1 = position-hold 2 = standard navigation	
9-10	timing pulse time-delay compensation (note 2)	UDI	ns	0 to ± 1000000	
11	self-survey mode time duration (note 3)	UI	h	0 to 65535	
12-13	position hold latitude (note 4)	DI	rads	0 to ± π/2	10^{-8}
14-15	position hold longitude (note 4)	DI	rads	0 to ± π	10^{-8}
16-17	position hold altitude (note 4)	DI	m	–2000 to 50000	10^{-2}
Timing Pulse Output Configuration Word (18.0 – 18.15)					
18.0	timing pulse suppressed on TRAIM alarm (default: do not suppress) (note 5)	Bit		1 = suppressed	
18.1	timing pulse alignment (default: aligned to UTC time)	Bit		0 = aligned to UTC time 1 = aligned to GPS time	
18.2-18.15	reserved (must be set to zero)				
TRAIM Alarm Configuration Word (19.0 – 19.15) (Note 6)					
19.0	TRAIM alarm when status is ‘unavailable’ (no navigation solution or only 1 satellite valid) (default: enabled)	Bit		1 = enabled	
19.1	TRAIM alarm when timing error estimate > timing error threshold (default: enabled)	Bit		1 = enabled	
19.2	TRAIM alarm when status is ‘detect only’ (2 satellites valid) (default: disabled)	Bit		1 = enabled	
19.3-19.15	reserved (must be set to zero)				
20	TRAIM disable (default: enabled)	UI		1 = disabled	
21	TRAIM timing error threshold (default: 1 µs)	UI	ns	1 to 20000	50 ns

Word No.	Name	Type	Units	Range	Resolution
22-23	reserved				
24	data checksum	I			

Note 1: Specifies the receiver's mode of operation after a reset or power cycling. When position-hold mode is used at startup, the receiver examines the position in SRAM and then the position in EEPROM. The first position found valid is used as the reference position. If neither is valid, the receiver enters self-survey mode and conducts a 24-hour survey, then switches to position-hold mode. Default is self-survey mode for 24 hours, then switches to position-hold mode.
Note 2: Timing pulse time-delay compensation permits adjustment for delays in the timing pulse caused by cables and connections. By default, compensation is zero. Positive adjustments advance the pulse to compensate for system delays. Negative adjustments may be used to adjust for unequal delays between separate timing systems. The available range permits adjustments up to ±1 ms.
Note 3: This word is ignored unless word 7 is set to 3. If this word is set to 0 the receiver switches to self-survey mode with unlimited time (the same as if word 7 was set to 4).
Note 4: These words are ignored unless word 7 is set to 6.
Note 5: Timing pulse suppressed means that when a TRAIM alarm occurs, the receiver stops sending the timing pulse, and does not restart the pulse until the alarm condition stops.
Note 6: These bits determine which conditions activate a TRAIM alarm. The alarm is only set if a particular condition exists, the associated alarm is enabled, and TRAIM is enabled (see word 20).

Table A1-3 Message 1255: timing receiver configuration input message

Message ID: 1055 (only available in timing receiver software)					
Rate: As required (default: upon timing mode change and in response to query)					
Message Length: 26 words					
Word No.	**Name**	**Type**	**Units**	**Range**	**Resolution**
1-4	message header				
5	header checksum				
6-7	set time	UDI	10 ms ticks	0 to 4 294 967 295	
8	sequence number	I		0 to 32 767	
9	timing receiver mode (note 1)	UI		1 = standard navigation 2 = self-survey for 24 hours 3 = self-survey for time specified (see word 11) 4 = self-survey for unlimited time 5 = position-hold with current position 6 = position-hold with specified position (see words 12-17)	
10	timing receiver start-up mode configuration word (note 2)	UI		0 = self-survey 1 = position-hold 2 = standard navigation	
11-12	timing pulse time-delay compensation	UDI	ns	0 to ± 1 000 000	
13	self-survey mode time duration (note 3)	UI	hrs	0 to 65 535	
14-15	timing receiver reference position latitude (note 4)	DI	rads	0 to ± π/2	10^{-8}
16-17	timing receiver reference position longitude (note 4)	DI	rads	0 to ± π	10^{-8}
18-19	timing receiver reference position altitude (note 4)	DI	m	–2000 to 50 000	10^{-2}
Timing Pulse Output Configuration Word (20.0-20.15)					
20.0	timing pulse suppressed on TRAIM alarm	Bit		1 = suppressed	
20.1	timing pulse alignment	Bit		0 = aligned to UTC 1 = aligned to GPS	
20.2-20.15	reserved (ignore)				
TRAIM Alarm Configuration Word (21.0-21.15) (Note 5)					
21.0	TRAIM alarm when status is ‘unavailable’ (no navigation solution or only 1 satellite valid)	Bit		1 = enabled	
21.1	TRAIM alarm when timing error estimate > timing error threshold	Bit		1 = enabled	
21.2	TRAIM alarm when status is ‘detect only’ (two satellites valid)	Bit		1 = enabled	
21.3-21.15	reserved (ignore)				
22	TRAIM disabled	UI		0 = enabled, 1 = disabled	
23	TRAIM timing error threshold	UI	ns	1 to 2000	50 ns

Word No.	Name	Type	Units	Range	Resolution
24-25	reserved (ignore)				
26	data checksum	I			

Note 1: Current operating mode of the receiver.
Note 2: Specifies the receiver's mode of operation after a reset or power cycling. When position-hold mode is used at startup, the receiver examines the position in SRAM and then the position in EEPROM. The first position found valid is used as the reference position. If neither is valid, the receiver enters self-survey mode and conducts a 24-hour survey, then switches to position-hold mode. Default is self-survey mode for 24 hours, then switch to position-hold mode.
Note 3: Only valid in self-survey mode with specified time (word 9=3). Specifies the number of hours to self survey before switching to position-hold mode.
Note 4: In position-hold mode, these words specify the position in use. In self-survey or standard-navigation mode, these words specify the most recently computed position.
Note 5: Bits indicate which conditions cause a TRAIM alarm to occur. An alarm occurs only if the appropriate bit is set, the alarm condition occurs, and if TRAIM is not disabled (see word 22).

Table A1-4 Message 1055: timing receiver configuration output message

Message ID: 1056 (only available in timing receiver software)					
Rate: Variable; maximum 1 Hz (default: on detection of TRAIM alarm or in response to query)					
Message Length: 26 words					
Word No.	**Name**	**Type**	**Units**	**Range**	**Resolution**
1-4	message header				
5	header checksum				
6-7	set time	UDI	10 ms ticks	0 to 4 294 967 295	
8	sequence number	I		0 to 32 767	
9	timing receiver mode status (note 1)	UI		0 = self survey 1 = position hold 2 = standard navigation	
Self-Survey Status Word (10.0-10.15) (Note 2)					
10.0	finished self survey	Bit		1 = finished	
10.1	self survey disabled	Bit		1 = disabled	
10.2	navigation solution has not yet converged in kalman filter	Bit		1 = not converged	
10.3	not enough satellites	Bit		1 = not enough	
10.4	expected time error too large	Bit		1 = too large	
10.5	expected horizontal position error too large	Bit		1 = too large	
10.6	altitude used – insufficient number of valid satellites	Bit		1 = altitude used	
10.7-10.15	reserved				
11-12	self-survey valid measurements count (note 3)	UDI		0 to 4 294 967 295	
13-14	self-survey duration (note 4)	UDI		0 to 4 294 967 295	
Position-Hold Status Word (15.0-15.15)					
15.0	position hold disabled	Bit		1 = disabled	
15.1	no valid reference position available (note 5)	Bit		1 = not available	
15.2-15.15	reserved				
Timing Pulse Status Word (16.0-16.15)					
16.0	timing pulse suppressed due to TRAIM alarm	Bit		1 = suppressed	
16.1	timing pulse alignment	Bit		0 = aligned to UTC 1 = aligned to GPS	
16.2	timing pulse validity	Bit		1 = valid	
16.3	timing pulse UTC precision (note 6)	Bit		1 = high precision	
16.3-16.15	reserved				
TRAIM Alarm Status Word (17.0-17.15) (Note 7)					
17.0	TRAIM status: unavailable (no navigation solution or only 1 valid satellite)	Bit		1 = alarm detected	
17.1	TRAIM timing error estimate > timing error threshold	Bit		1 = alarm detected	
17.2	TRAIM status: detect only (only 2 satellites valid)	Bit		1 = alarm detected	
17.3-17.15	reserved				

Word No.	Name	Type	Units	Range	Resolution
18	TRAIM disabled	UI		0 = enabled, 1 = disabled	
19	TRAIM status (note 8)	UI		0 = no error 1 = detect and isolate 2 = detect only 3 = unavailable	
20.0-21.15	TRAIM bad satellites (note 9)	Bit		1 = excluded satellite	
22-23	TRAIM timing error estimate	UDI	ns	0 to 429 496 729.5	10^{-1}
24-25	reserved				
26	data checksum	I			

Note 1: Word 9 displays the receiver's current mode. Words 10 and 15 give the status of self-survey and Position-Hold modes. If a bit is set in either word 10 or 15, the receiver indicates a different mode from the one commanded, and the set bits indicate the reason that mode is not currently active.
Note 2: Any time the receiver leaves self-survey mode, a bit is set in this word. If bit 10.0 is set, which indicates the self-survey is complete, the receiver switches to position-hold mode. If the receiver is unable to add valid measurements to the current self survey, the receiver switches to standard-navigation mode, and bits 10.1 to 10.6 indicate the reason the self survey has been suspended.
Note 3: When in self-survey mode, this indicates the number of valid measurements that have been taken since the mode started. When in position-hold mode, this indicates the number of valid measurements completed in the self survey that generated the reference position (0 means that the reference position was manually entered and 1 means it was the result of standard navigation rather than self survey).
Note 4: This number is only valid when in self-survey mode, or in standard-navigation mode because self-survey mode has been suspended. The number represents the number of valid measurements required to complete the current self survey. If the receiver is in self-survey mode with no time limit, this value is 0. For each hour of self survey time requested by the command that starts the self survey, this value is increased by 3600 (default: 86 400 for a 24-hour self survey). If the receiver is in self-survey mode, and another command to enter self-survey mode is received, the duration of the requested survey is added to the current number of valid measurements so that the survey continues for the number of hours indicated.
Note 5: If this bit is set, the receiver tried to enter position-hold mode but did not have a valid reference position either in SRAM, EEPROM, or in the command message. The receiver automatically enters self-survey mode and conducts a 24-hour survey, then enters position-hold mode.
Note 6: This bit is set when the receiver has a valid Ionospheric/UTC corrections data block from the satellites' navigation message (subframe 4, page 18) that is less than two hours old.
Note 7: Word 17 indicates the current TRAIM alarm status. For a bit to be set in this word, TRAIM must be enabled, the specific alarm must be enabled, and the alarm condition must have been detected in the receiver.
Note 8: Word 19 indicates the current TRAIM status without regard to the alarm settings.
Note 9: Words 20 and 21 indicate which satellites have been excluded from the timing solution by TRAIM. The value is a bit-mapped word with bit 0 of word 20 representing satellite 1, and bit 15 of word 21 representing satellite 32.

Table A1-5 Message 1056: timing receiver status output message

Message ID: 1108 (enabled in selected versions only)					
Rate: 1 Hz					
Message Length: 20 words					
Word No.	**Name**	**Type**	**Units**	**Range**	**Resolution**
1-4	message header				
5	header checksum				
6-7	set time	UDI	10 ms ticks	0 to 4 294 967 295	
8	sequence number	I		0 to 32 767	
UTC TIME					
9-13	reserved				
14-15	UTC seconds of week (note 1)	UDI	s	0 to 604 799	
16	GPS to UTC time offset (integer part) (note 2)	I	s	–32 768 to +32 767	
17-18	GPS to UTC time offset (fractional part) (note 2)	UDI	ns	0 to 999 999 999	
UTC TIME VALIDITY (19.0-19.15)					
19.0	time mark validity (note 3)	Bit		1 = valid	
19.1	GPS/UTC sync (note 4)	Bit		0 = GPS, 1 = UTC	
19.2	timing pulse UTC precision (note 5)	Bit		1 = UTC second	
19.3	TRAIM alarm (note 6)	Bit		1 = alarm detected	
19.4-19.15	reserved				
20	data checksum				

Note 1: When this message is output automatically (rather than in response to a query), the indicated time is the time at the next time mark pulse.

Note 2: GPS time and UTC time differ by an integer number of leap seconds (GPS time is ahead of UTC), and by a fractional part of a second representing the offset between the UTC and GPS start of each second. While the fractional offset is steered to be 1 μs or less by the GPS control segment, that offset can be positive or negative. Conversely, leap seconds are always positive. To compute leap seconds, add the reported integer and fractional parts to arrive at the total offset. Then, round the result. The difference between the computed leap seconds and the total offset represents the GPS-UTC offset:
Integer part: 12
Fractional part: 999 999 000 ($\times 10^{-9}$)
Total offset: 12.999 999
Leap seconds (rounded offset): 13 seconds
GPS-UTC in alignment: (total offset – leap seconds) = (12.999 999 – 13) = –0.000 001

Note 3: For timing receivers, this bit is set when the time mark is steered to align with GPS or UTC as specified by Message 1255. When UTC is specified, this bit is not set unless the Ionospheric/UTC corrections data block broadcast by the satellites' navigation message (subframe 4, page 18) is less than two weeks old. For non-timing receivers, this bit is set as soon as the time mark is steered to either GPS or UTC time. Bit 19.1 indicates to which time the time mark is steered.

Note 4: For timing receivers, this bit is set whenever the receiver has an Ionospheric/UTC corrections data block from the satellites' navigation message (subframe 4, page 18) that is less than two weeks old, and the time mark alignment is set to UTC (see Message 1255). For non-timing receivers, this bit is set when bit 19.0 is valid (indicating the receiver is aligned to UTC time).

Note 5: Timing receivers only. When this bit is set, the receiver has an Ionospheric/UTC corrections data block from the satellites' navigation message (subframe 4, page 18) that is no more than two hours old. If the time mark should be aligned to UTC time, this bit and bit 19.0 are set when the time mark is aligned to UTC time within the specified accuracy of the receiver and to the accuracy of the GPS navigation message. According to US Government specifications, the data broadcast by GPS satellites allows computation of UTC to about 100 ns (1 sigma).

Note 6: Available in timing receivers only.

Table A1-6 Message 1108: UTC time mark pulse output message