NAVMAN

Jupiter Pico T
GPS receiver module

Data sheet

Related products
• Development kit TU10-D007-362

Related documents
• Product brief LA010041
• Timing application note LA010105
• Development kit: Quick start guide
  LA010088
• Development kit: Guide LA010089
• Designer's guide MN002000
• Labmon application note LA010103

Contents

Figures

Tables

Features

- T-RAIM, position-hold, and self-survey functions (required for precision timing applications)

- very small size of 24.5 x 31.5 x 8.6 mm

- 250 mW (approx) power consumption with 3.3 V input

- very low current battery backup input for Real Time Clock (RTC) and SRAM

- power management control

- reliable single-chip RF containing
    —VCO

    —LNA

- 12 parallel satellite tracking channels for fast acquisition and re-acquisition

- fast Time-To-First-Fix (TTFF) performance
    —120 seconds TTFF cold start (typical)

    —24 seconds TTFF hot start (typical)

    —less than 60 seconds warm start with battery back-up

    —Less than 2 second re-acquisition after blockages for up to 10 seconds

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

- automatic altitude hold mode from three-dimensional (3D) to two-dimensional (2D) navigation

- automatic cold start acquisition process (when no initialisation data is entered by the user)

- operational flexibility and configurability via user commands over the host serial port

- position and velocity initialisation data through the host serial port

- user selectable satellites

- visible satellite mask angle.

- serial data output that includes Navman binary protocol, Motorola emulation, and selected National Marine Electronics Association (NMEA-0183) v2.1 messages.

1.0 Introduction

This specification defines the operation of the Global Positioning Satellite (GPS) receiver printed circuit board (PCB) assembly from Navman NZ Ltd, OEM division. Topics not covered in this specification should not be assumed to be similar for Pico T as for other Navman products.

Navman's Jupiter Pico T GPS timing module is a single board, 12 parallel-channel receiver that is intended as a component for an Original Equipment Manufacturer (OEM) product. The receiver continuously tracks all visible satellites, providing accurate satellite positioning data.

The highly integrated digital receiver uses the Zodiac chipset composed of two custom SiRF devices: the CX74051 RF Front-End and the CX11577 Scorpio Base-band Processor (BP). These two custom chips, together with memory devices and a minimum of external components, form a complete low-power, high-performance, high reliability GPS timing receiver solution for OEMs

The Jupiter Pico T decodes and processes signals from all visible GPS satellites. These satellites, in various orbits around the Earth, broadcast Radio Frequency (RF) ranging codes, timing information, and navigation data messages.

The received GPS L1 C/A signals from the antenna are down converted to base band and digitally processed to obtain a full navigation solution of position, velocity and time. These solutions can be sent over a serial data link to a host platform.

The Pico T is optimised for stationary timing applications where synchronisation to UTC or GPS timing is needed with One Pulse Per Second (1PPS) accuracy better than 25 ns. Included in the receiver is a precise 1PPS timing output T-RAIM, self-survey, position-hold and other specific features for optimal timing performance.

Note: Pico T can provide position and velocity navigation information. However, as it is optimised for stationary timing applications, its performance under motion dynamics will not be as optimal as other receivers in the Jupiter family.

The Jupiter Pico T receiver (see figures 1-1 and 1-2) is packaged on a miniature printed circuit board with a metallic RF enclosure on one side.

The 12-channel architecture provides rapid TTFF under all start-up conditions. While the best TTFF performance is achieved when time of day and current position estimates are provided to the
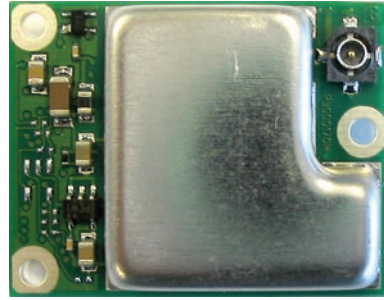
Figure 1-1 Jupiter Pico T GPS receiver (top view)
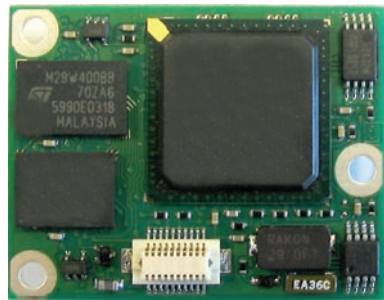
Figure 1-2 Jupiter Pico T GPS receiver (bottom view)

receiver, the flexible signal acquisition system uses all available information to provide a rapid TTFF.

Acquisition is guaranteed under all initialisation conditions as long as paths to the satellites are not obscured. The receiver supports 2D positioning when fewer than four satellites are available or when required by operating conditions. Altitude information required for 2D operation is assumed by the receiver or may be provided by the OEM application.

Communication with the receiver is established through one of two asynchronous serial I/O ports that support full duplex data communication. The receiver's serial port provides navigation data and accepts commands from the OEM application in proprietary Navman binary message format. NMEA formatted message protocol is also available with software selection.

Part No.	Description
TU36-D400-001	+3.3 V, Pico T, RF1 Timing

Table 1-1 Jupiter Pico T module description

Receiver architecture

The functional architecture of the Jupiter Pico T receiver is shown in Figure 1-3.

The receiver design is based on the SiRF Zodiac chipset: the RF1A and the Scorpio Base-band Processor (BP). The RF1A contains all the RF down-conversion and amplification circuitry, and presents the In-Phase (I) and Quadrature-Phase (Q) Intermediate Frequency (IF) sampled data to the BP. The BP contains an integral microprocessor and the required GPS-specific signal processing hardware. Memory and other external supporting components complete the receiver navigation system.

Product applications

The Jupiter Pico T receiver is intended for specific OEM GPS timing design applications such as:

- wireless telco net systems
- E911 caller location systems
- frequency standards
- cable and broadcast TV
- WANs

The interface between the applications processor and the receiver is through the serial data and timing interface.
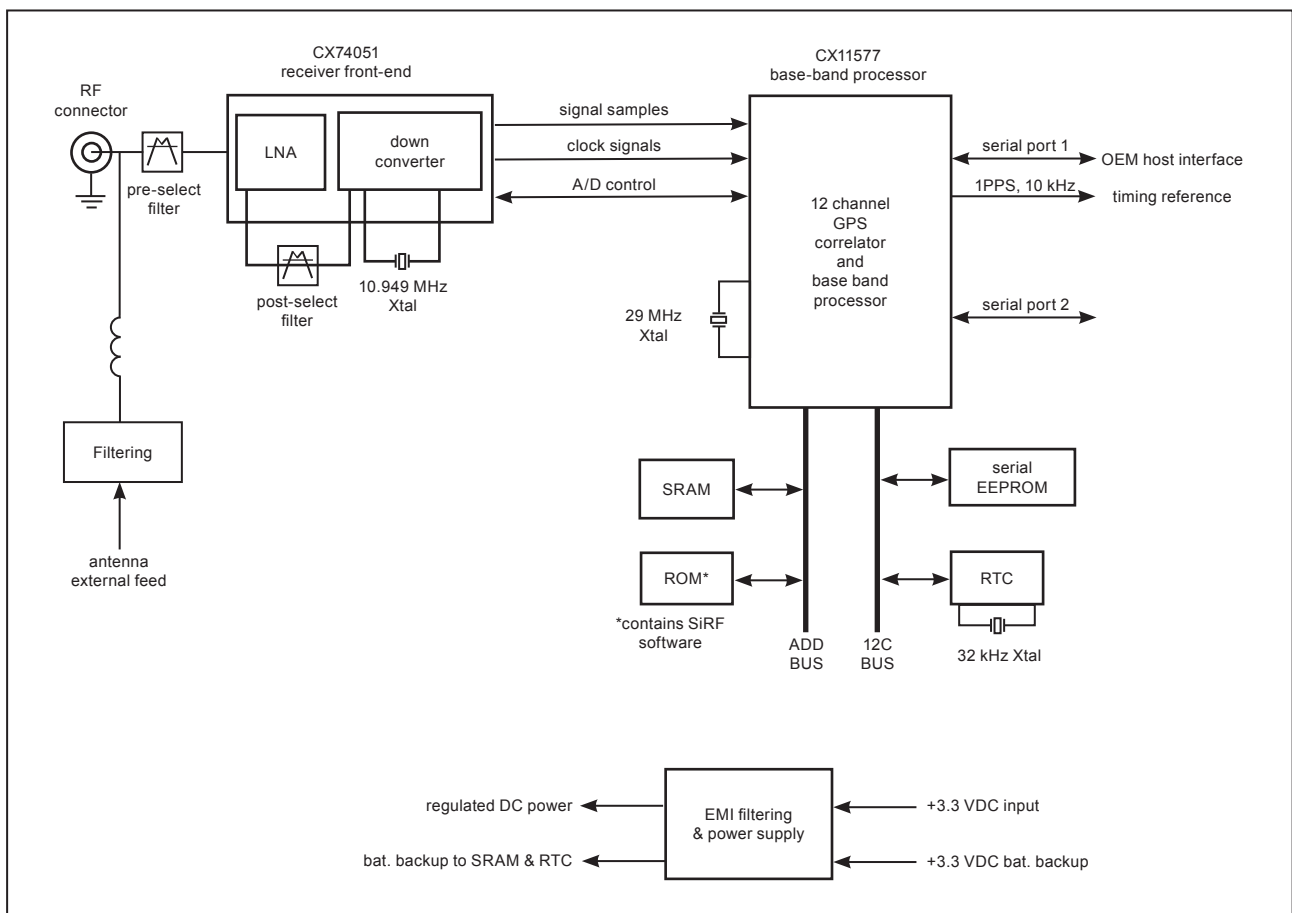
Figure 1-3. Jupiter Pico T block diagram

2.0 SPECIFICATIONS

2.1 Environmental

2.1.1 Operating

Environmental conditions for Pico T during operation are shown in table 2-1. The Pico T will continue to operate under the following sinusoidal vibrations:

- 10 mm pp displacement limited from 5 Hz to 17.3 Hz

- 6 G from 17.3 Hz to 100 Hz

- 1.5 G from 100 Hz to 200 Hz

Note: the 1PPS accuracy specifications are met only under conditions of minimal incidental vibration, and not under an environment subject to continuous vibration.

2.1.2 Storage

Environmental conditions for Pico T during storage are found in table 2-2.

2.1.3 EMI/EMC

The Jupiter PICO T meets the requirements of FCC Part 15 Sub-part J Class B for radiated emissions when supplied with a shielded power and signal cable and connected to a passive resonant helical antenna on a 3 m length of RG-316 coaxial cable.

Temperature	−40 °C to +85 °C, rate of change <10°C per minute
Humidity	up to 95% (non-condensing) or a wet bulb temperature of +35 °C, whichever is less
Altitude	−300 m to 15000 ms
Vibration	full performance (see figure 2-1)
Shock (non-operating)	18 G peak, 5 ms duration
Maximum vehicle dynamics	will track at up to 500 m/sec (acquisition and navigation), but 1PPS accuracy specifications are met only when unit is stationary for more than 24 hours

Table 2-1 Environmental conditions (operating)

Temperature	−40 °C to +85 °C
Humidity	up to 95% (non-condensing) or a wet bulb temperature of +35 °C, whichever is less
Shock (in shipping container)	10 drops from 75 cm onto concrete floor

Table 2-2 Environmental conditions (storage)
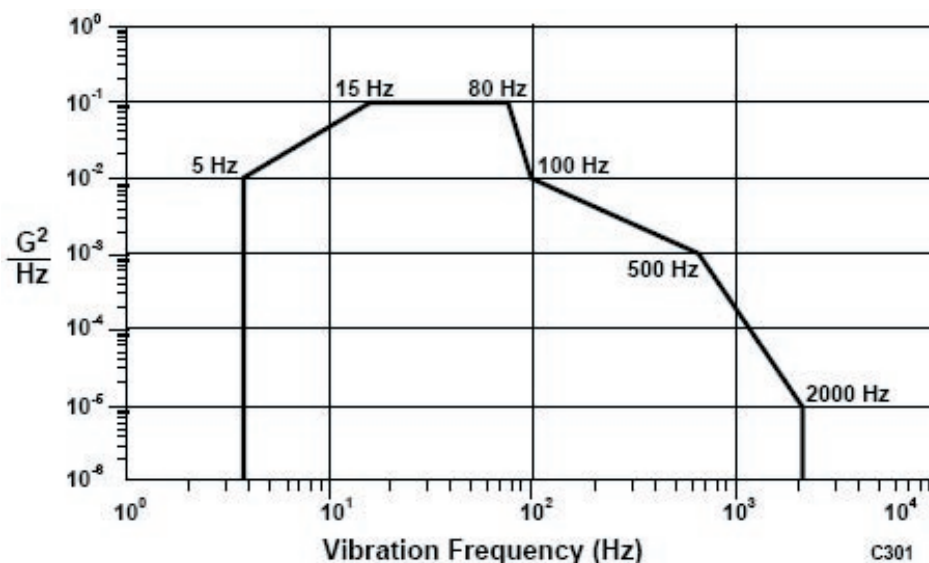
Figure 2-1 Random vibration specification

3.0 Mechanical

The mechanical dimensions of the Pico T receiver module are shown in figure 3-4

3.1 Antenna connector

The RF connector on the Pico T board is an H.FL Hirose type (see figure 3-1). The mating connector to the Pico board is a Hirose H.FL-LP female contact. The mating connector usually requires a special tool that produces tension perpendicular to the board surface.

Hirose type H.FL-LP antenna connector mounted on the corner of the Pico T board.
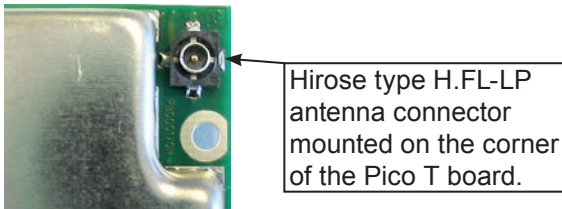
Figure 3-1 Antenna Connector Information

3.2 Input/Output (I/O) connector

The I/O connector is a 20 pin header in a 2 x 10 array (see figure 3-2). The Hirose part reference is DF12-20DS-81). The mating connector is also available from Hirose, part number DF12(3.5)-20DP-0.5 V.

Pin #1

```
2  4  6  8  10 12 14 16 18 20
┌─────────────────────────────┐
│            J1               │
└─────────────────────────────┘
1  3  5  7  9  11 13 15 17 19
```
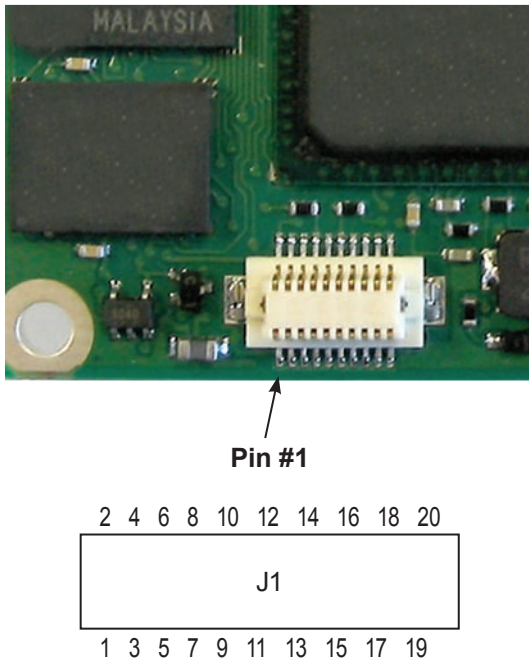
Figure 3-2 The 20-pin I/O connector

3.3 Marking/serialisation

The module label (see figure 3-3) is placed on the RF shield on the top side of the board.

serial no. (128 bar code)
text serial no.
part number
Navman website
country of origin
software version

B03104735
TU36-D120-001
www.navman.com
Made in New Zealand
s/w Ver. xx.xx

Figure 3-3 Pico T serial label

Bar code: code 128 for serial number.
Material: paper.
Serial number: the Navman serial number shows the year and month of manufacture as follows:

• first character is sequential Month, from A to L (e.g. A = Jan, B = Feb)

• next 2 characters is year e.g. 04 = 2004, 05=2005

• next 6 characters = sequential s/n.

Note: month codes repeat annually, so the serial number code for year and month must be read together in order to determine the manufacturing date of the product.

4.0 ELECTRICAL

4.1 Power supply

4.1.1 Primary power

The receiver is designed to operate from a single supply voltage meeting the requirements in the tables below:

Voltage	3.15 to 3.63 VDC
Current (typ)	85 mA
Current (max)	100 mA
Ripple	must not exceed 50 mV peak to peak
Reflected ripple	must not exceed 5 mVpp from DC to 3 GHz

Table 4-1 Operating power for Jupiter Pico T

4.1.2 Backup power (SRAM/RTC)

During 'powered down' conditions, the SRAM contents may be maintained and the RTC may be kept operating by supplying power to the backup power pin. See table 4-2 for details of backup power.

VERTICAL AXIS MAXIMUMS

SECTION AA

Top	4.7
PCB	1.2
Bottom	1.8

SECTION BB

Top	4.7
PCB	1.2
Bottom	2.7

SECTION CC

Top	1.3
PCB	1.2
Bottom	1.0
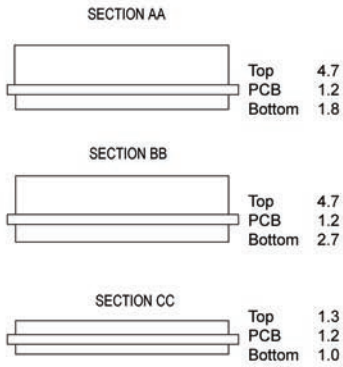
All Dimensions in mm

Mounting option

M2 machine screw, with nut or fastening on underside of main board

MAIN BOARD

Spacer to suit Connector option used

ASSEMBLED PCB HEIGHTS

Main PCB

See Note

Note: dependant on connnector option, assembled heights available 3.5, 4.0, 5.0 mm

All dimensions in mm

TOP SIDE

4.69 NOM.   6.22   11.43

3.18 NOM.

RF Connector

31.5 ±0.2   26.16   27.18

Hole size Ø 2.2
3 Off

BOTTOM SIDE

24.5 ±0.2
10.92 NOM.
7.49

2.16 NOM.
15.24

DATA CONNECTOR

2.16 NOM.

1.27
2.15 NOM.
20.19

P4   P3
P2   P1

Figure 3-4 Jupiter Pico GPS receiver board (dimensions mm)
(vertical sections do not include protrusions due to I/O connector dimensions)

Vbatt voltage	2.5 V (min) to 3.6 V (max)
Current	1 µA (typ) at 25°C, max 5 µA

Table 4-2 Keep-alive power

4.1.3 Antenna pre-amp voltage

Voltage applied to this pin is presented to the centre conductor of the RF connector. The receiver does not use this voltage. This voltage is limited to a maximum of 12 VDC (either polarity) with a maximum current of 100 mA. The maximum pre-amp current must be externally limited to 120 mA. There is NO built-in over-current protection on this line. The Pico T firmware supports external digital inputs for open/short antenna signals that are used to generate specific messages to the host

Note: Navman can provide an application note to allow users to utilise the open/short antenna detection functionality (see also 4.3.1.1).

4.2 RF interface

RF interface is via a Hirose H.FL RF connector.

4.2.1 RF input

1575.42 MHz at a level between –115 dBm and –133 dBm into a 50 Ω impedance. This input may have a DC voltage impressed upon it to supply power to an active antenna as noted above.

4.2.2 Burnout protection

The receiver shall accept without damage a signal of –10 dBW from 0 to 2 GHz carrier frequency.

4.2.3 Jamming performance

Table 4-3 presents the jamming performance of the Pico T receiver based upon a 3 dB degradation in C/No performance.

Frequency MHz	Jamming signal power dBm
1400	-24
1530	-28
1555	-36
1575.42	-96
1625.42	-23
1425.42	-21
1725.42	-21

Table 4-3 Jamming performance

4.3 I/O connector

All communications between the host and the receiver are through the I/O connector. This connector consists of 20 pins which provide the contacts for power, ground, serial I/O (2 channels), timing, and control. Table 4-4 describes the I/O pin assignments. See previous sections for power and ground requirements.

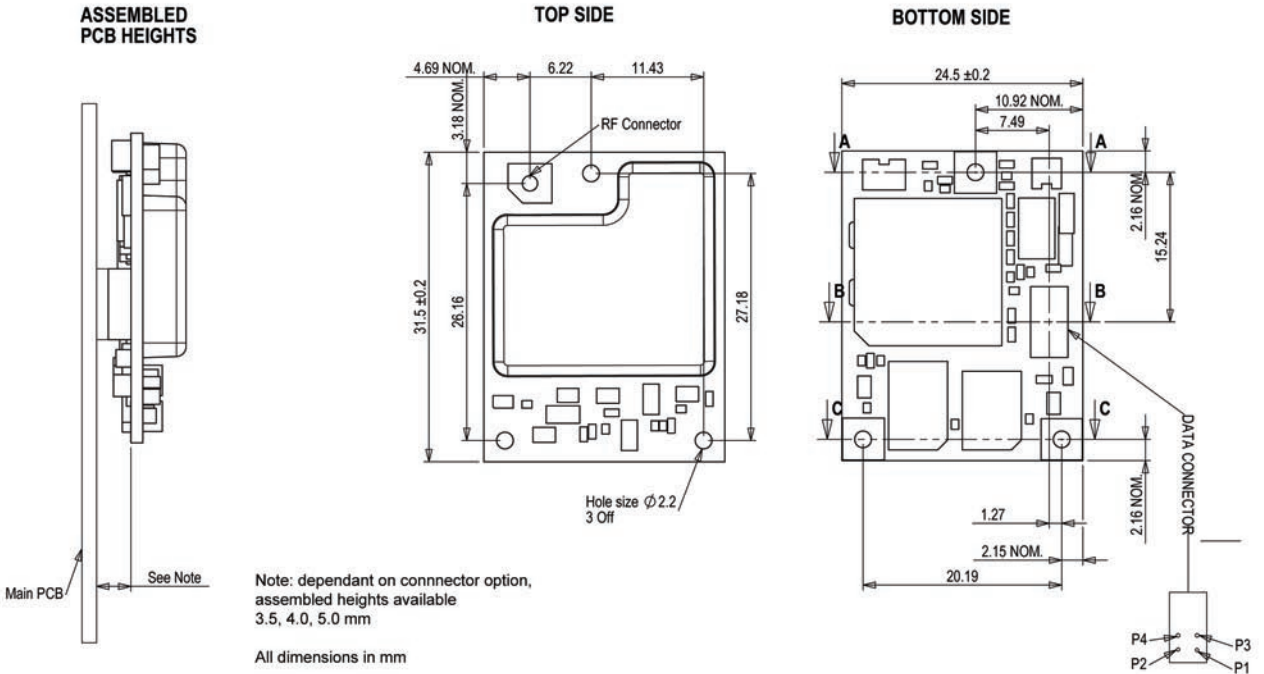| Pin #	Name	Description
1	PREAMP	pre-amp power input
2	No Connect	unused
3	VBATT	back-up power input
4	PWRIN	primary power input
5	M_RST	master reset input (active low)
6	N/C	reserved (no connect)
7	SHORT	antenna short input
8	GPIO3	ROM default select
9	OPEN	antenna open input
10	GND	ground
11	SDO1	serial data output port #1
12	SDI1	serial data input port #1
13	GND	ground
14	N/C	reserved (no connect)
15	N/C	serial data input port #2
16	GND	ground
17	GND	ground
18	GND	ground
19	TMARK	1 PPS time mark output
20	10KHZ	10 kHz clock output

Table 4-4 Receiver I/O pin assignments

4.3.1 Voltage levels (CMOS)

Table 4-5 describes the interface voltage levels.

4.3.1.1 Pin J1-1: pre-amp voltage

Active antenna power input. The Pico T accepts a pre-amp supply voltage not exceeding +/–12 V and current not exceeding 120 mA (see also 4.1.3).

CAUTION: *exercise care when using passive antennas, as some have a DC ground on the coax centre conductor. Whatever voltage is supplied, pre-amplifier operation will short circuit to ground and may cause over-current damage to the Pico T. Users must verify characteristics of the passive antenna and take necessary precautions—either do not supply any voltage to this pin or provide DC isolation within the passive antenna.*

Connection	Parameter	Value	Notes
GPIO2,3,4 SDI0 SDI1	VIH (min)	0.7 x PWRIN	1
	VIH (max)	PWRIN	1
	VIL (min)	-0.3 V	1
	VIL (max)	0.6 V	1
	VOH (min) at IOH = −4 mA	0.8 X PWRIN (V)	1
	VOH (max)	PWRIN (V)	1
	VOL (min)	0 V	1
	VOL (max) at IOH = 4 mA	0.2 X PWRIN (V)	1
M_RST input	VIH (min)	2.4 V	2
	VIH (max)	PWRIN + 0.3 V	2
	VIL (min)	-0.3 V	2
	VIL (max)	0.4 V	2

Note 1: GPIO3 short, open, and SDI0, SDI1 have 100 k pull-up resistors to PWRIN. These inputs can be driven high without damage when the unit is powered down either by removing the power from the PWRIN connection or by holding down the M_RST low.

Note 2: M_RST cannot be driven by a voltage higher than PWRIN and cannot be driven high at all when power is removed from the PWRIN pin M_RST has a pull-up resistor to PWRIN with a minimum value of 10 k.

Table 4-5 Interface voltage levels

4.3.1.2 Pin J1-2: unused

This is pin is NOT connected .

4.3.1.3 Pin J1-3: backup power in

Input power pin used for SRAM and RTC keep alive. (see table 4-2)

4.3.1.4 Pin J1-4: primary power in (PWRIN)

Input power pin.

4.3.1.5 Pin J1-5: master reset In (M_RST)

This input causes a reset of all hardware including SRAM. This signal is capable of being driven directly by an external microprocessor or by external logic without the need for any external pull-up or pull-down resistors, and may be left floating if not used. The receiver is reset by pulling the M_RST control signal low to ground. The M_RST signal must be pulled to a CMOS logic 'high' level or left floating coincident with, or after, the application of prime DC power for the receiver to enter its 'operate' mode. The M_RST must be held at ground level for a minimum of one microsecond to assure proper generation of a hardware reset to the receiver.

This signal can also be used to provide control of the receiver's operating mode without removing prime input power from the receiver. When M_RST is pulled to ground, the receiver will enter a low power state for as long as the M_RST signal is asserted low. In this state the SRAMs are transitioned into their low power data retention state, and the RTC device is maintained. When the receiver is placed into this low power state through the use of the M_RST control signal, the receiver will continue to draw current from the primary input power (PWRIN), but at a much reduced level.

When the M_RST signal is subsequently asserted high, or left to float, a system reset is generated, and the receiver will return to its normal operating mode.

4.3.1.6 Pin J1-6: no connect

Not used.

4.3.1.7 Pin J1-7: antenna short circuit (SHORT)

This pin is used to inform the GPS receiver that there is a short circuit condition on the antenna power feed. When this signal is pulled 'low' the receiver changes its antenna error status to 'short circuit'. This status then can be checked by the Motorola command @@Fa.

4.3.1.8 Pin J1-8: ROM default select (GPIO3)

This signal determines whether the message format, host port communication settings, receiver default message set, and initialisation data parameters are obtained from default values stored in ROM or from user-configurable settings stored in SRAM/EEPROM. If this signal is pulled 'low', the ROM-based factory default values are used. If this signal is left floating, or pulled 'high', the system operating parameters are accessed in the following priority:

1. If SRAM checksums are valid, the communication parameters and initialisation data parameters will be read from SRAM.

2. If SRAM checksums are invalid and EEPROM checksums are valid, the communication parameters and initialisation data parameters will be read from EEPROM.

3. If SRAM checksums are invalid and EEPROM checksums are invalid, the factory default values in ROM will be used.

Note: when the ROM defaults select (GPIO3) signal is pulled 'low', each power cycle or reset of the receiver will result in a much longer TTFF. This is because the receiver will use default initialisation parameters stored in ROM rather than the current initialisation parameters that may be available in SRAM or EEPROM.

4.3.1.9 Pin J1-9: antenna open circuit (OPEN)

This pin is used to inform the GPS receiver that there is a open circuit condition on the antenna power feed. When this signal is pulled 'low', the receiver changes its antenna error status to 'open circuit'. This status then can be checked by the Motorola command @@Fa.

4.3.1.10 Pin J1-10: ground

4.3.1.11 Pin J1-11: Serial Data Output (SDO1)

4.3.1.12 Pin J1-12: Serial Data Input (SDI1).

The SDO1 and SDI1 pins together comprise a full-duplex asynchronous CMOS-level serial link, typically connected to a host system. Both binary and NMEA initialisation and configuration data messages are transmitted and received across this port.

For extended range, the user must provide any Line Driver/Line Receiver (LD/LR) circuitry. Port idle is nominally a CMOS logical high (+3.3 VDC).

4.3.1.13 Pin J1-13: ground

4.3.1.14 Pin J1-14: reserved

This signal is reserved and NO electrical connections should be made.

4.3.1.15 Pin J1-15: Auxiliary Port Serial Data Input (SDI2)

The auxiliary port consists of a second half-duplex asynchronous serial data interface. For extended range, the user must provide any LD/LR circuitry. Port Idle is nominally a CMOS logical high (+3.3 VDC).

4.3.1.16 Pin J1-16: ground

4.3.1.17 Pin J1-17: ground

4.3.1.18 Pin J1-18: ground

4.3.1.19 Pin J1-19: UTC time mark pulse (TMARK)

The time mark output provides a 1PPS signal. When the receiver provides a valid navigation solution, the rising edge of each TMARK pulse is synchronised with the UTC one second epochs to within ±25 nanoseconds. (1 sigma).

The receiver software produces a Navman binary format and Motorola-equivalent format data message containing the UTC time associated with each time mark pulse. When the receiver's serial data communication port is set to 9600 bps, the UTC time mark pulse output message precedes the TMARK pulse by 400 to 500 ms (typically).

4.3.1.20 Pin J1-20: 10 kHz UTC synchronised clock

This is a 10 kHz clock waveform, synchronised to the UTC TMARK pulse. The output is 10 kHz TTL levels, square wave.

5.0 GPS PERFORMANCE

5.1 General information

The receiver can operate from either an active or passive GPS antenna to receive GPS carrier signals centred at 1575.42 MHz.

Note: observe all voltage precautions when using a passive antenna. (see section 4.3.1.1)

Timing precision requires accurate determination of position. As the receiver determines its position by ranging signals from four or more GPS satellites orbiting the Earth, its antenna must have good visibility of the sky so that pathways to available satellites are not obscured. This is generally not a problem when the antenna is outdoors in the open. Therefore, to provide greatest timing accuracy, an outdoor antenna is recommended. If it is necessary to use an indoor antenna, it should be positioned in such a way as to have the least obstructed view of the sky. The user must perform tests to determine if timing accuracy is adequate with degraded views.

To establish an initial navigation fix, the receiver attempts to use three satellites and a stored altitude (which may be zero). This initial fix may be inaccurate as stored altitude may be inaccurate. An accurate position fix requires a minimum of four satellites in track with Geometric Dilution of Precision (GDOP) <10).

5.2 Satellite Acquisition

5.2.1 Acquisition

The GPS receiver supports four types of satellite signal acquisition depending on the availability of critical data. The Pico T requires a valid 3D position fix for 24 hours duration in order to set the accuracy of the 1PPS pulse. After initial acquisition, the Pico T can maintain a 1PPS with lock to only one GPS satellite. However, during any signal interruption, the timing of the 1PPS pulse will drift. User systems must be able to account for this and adjust their processing accordingly.

5.2.2 Re-acquistion

This is the usual mode of operation of the GPS receiver subject to short signal interruptions from satellite obscuration or jamming. In order to prevent downstream circuitry from following the receiver-generated 1PPS when it is no longer locked to a GPS satellite, the user must either cause the 1PPS pulse to be squelched using T-RAIM command options or must read the status messages and respond appropriately. Re-acquisition search algorithms degrade to a cold start search after the cold start re-acquisition interval is reached.

5.2.3 Hot start

A hot start results from a software reset after a period of continuous navigation, or a return from a short idle period (i.e. a few minutes) that was preceded by a period of continuous navigation. In this state, all of the critical data (position, velocity, time, and satellite ephemeris) is valid to the specified accuracy and available in SRAM. Hot start mode requires backup power for SRAM and RTC in the event of primary power loss.

5.2.4 Warm start

A warm start typically results from user-supplied position and time initialisation data, or continuous RTC operation with an accurate last known position available from EEPROM. In this state, position and time data are present and valid but ephemeris data validity has expired.

5.3.5 Cold start

A cold start acquisition state results when position or time data is unknown, either of which results in an invalid satellite visibility list. Almanac information, available either from EEPROM or from original firmware definition, is used to estimate satellite visibility.

5.3 Navigation Modes

The Pico T GPS receiver is designed to derive accurate timing information when in a fixed position. The Pico T supports Two-Dimensional (2D) and Three-Dimensional (3D) navigation modes.

5.3.1 2D navigation

When three GPS satellite signals are available, the receiver will enter 2D navigation using a fixed value of altitude determined by the host, the last valid stored altitude, or an initial altitude of zero. In 2D navigation, the navigational accuracy is primarily determined by the relationship of the fixed value of altitude to the true altitude of the antenna. If the fixed value is correct, the specified horizontal accuracies apply. Otherwise, the horizontal accuracies will degrade as a function of the error in the fixed altitude.

Note: timing signals are not valid until an initial 3D fix is obtained or forced by the user.

5.3.2 3D navigation

The receiver defaults to 3D navigation whenever at least four GPS satellites are being tracked. In 3D navigation, the receiver computes latitude, longitude, altitude, and time information from satellite measurements

5.2.3 Automatic self survey

This is the default position-averaging algorithm that automatically determines user position and enters 'position hold' mode after averaging 10 000 2D or 3D position fixes. Resulting position accuracy in 2D is 20 m (95%) and in 3D is 10 m (95%). On start-up, if a 'set position' command is specified by the host, this command then terminates position averaging and the user-entered position is used for all subsequent timing computations.

5.2.4 Time Receiver Autonomous Integrity Monitor (T-RAIM):

T-RAIM is an algorithm that uses redundant satellite measurements when available to check the integrity of the time solution. If an error is detected, the satellite causing the error is isolated and removed from the solution if possible. This depends on the user defined threshold, the number of satellites tracked and the constellation geometry. When the receiver is not in position-hold mode, T-RAIM will only be able to detect an error. If T-RAIM is not available, RAIM should be used with TDOP to detect, isolate and remove satellites with erroneous time.

5.2.5 Datum

Supports the default WGS-84 datum.

5.4 Position accuracy (while in GPS NAV modes)

Horizontal CEP: 2.8 m full accuracy C/A code
Horizontal (2 dRMS): 4.9 m full accuracy C/A code
Vertical VEP: 3.2 m full accuracy C/A code
3D SEP: 5.0 m full accuracy C/A code

5.5 Time to First Fix (TTFF)

TTFF values can be affected by changing the values of maximum Expected Horizontal Position Error (EHPE) validity, maximum Expected Vertical Position Error (EVPE) validity, criterion for the minimum number of satellites used for a solution, and use of 'held altitude'. Default conditions are 100 m EHPE, 150 m EVPE, number of satellites is zero and held altitude is enabled.

50% Probability
Hot start: 24 s (valid almanac, position, time and ephemeris)
Warm start: 60 s (valid almanac, position and time; invalid ephemeris)
Cold start: 180 s (valid almanac; invalid position, time and ephemeris)

Typical (mean values, continuous 24-hour observation period, latitude of 40 degrees)
Hot start: 24 s (valid almanac, position, time and ephemeris)
Warm start: 54 s (valid almanac, position and time; invalid ephemeris)
Cold start: 120 s (valid almanac; invalid position, time and ephemeris)
Note: the values given apply to GPS acquisition only.

5.6 Temperature Compensation

The Pico T has a predictive and heuristic temperature compensation algorithm allowing it to re-acquire satellite signals quickly after a power interruption when the thermal environment is changing (for example: in an outdoor cellular base station). The most accurate temperature compensation is learned during normal operation when the receiver undergoes temperature changes while tracking GPS satellites. Without the learned compensation, a generic preset temperature compensation method is used. Power-up at temperatures outside the range of 20°C to 30°C may exhibit an initial TTFF slightly longer than the TTFF exhibited after the frequency compensation has been learned.

5.7 Power management mode.

While the Pico T supports power management, this mode of operation is not recommended for timing applications since it significantly degrades the accuracy of the one PPS pulse.

5.8 Re-acquisition

Re-acquisition is typically 2 s (after 10 s of signal interruption).

5.9 Data latency

Position information is supplied once per second with the navigation solution valid at the leading edge of previous time mark pulse.

5.10 1PPS timing accuracy

The time mark pulse is supplied once per second and has a 25 ns standard deviation around the mean. The 1PPS pulse can be advanced or retarded by software command in order to compensate for delays inherent the system and to synchronise with other references.

6.0 Software interface

The host serial I/O port of the receiver's serial data interface supports full duplex communication between the receiver and the host application. The Pico T is supplied in two versions—one version supports Navman Binary and NMEA-0183 v2.1 protocols, the other version supports Navman binary, NMEA and Motorola equivalent protocols. The NMEA protocol provides only position information and does not support the information required in timing applications.

6.1 Navman binary data messages

Table 6-1 and 6-2 describe all of the output and input binary messages for the receiver, along with their corresponding message IDs. For a complete description of each binary message, refer to Navman document MN02000.

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
ECEF position output	1009
receiver ID (**)	1011
user-settings output	1012
raw almanac	1040
raw ephemeris	1041
raw UTC/iono corrections	1042
RAM status	1050
timing receiver configuration	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
power management mode	1117
serial port communication parameters in use	1130
EEPROM update	1135
EEPROM status	1136
frequency standard table output data	1160
flash boot status	1180
error/status	1190
(*) enabled by default at power-up (**) once at power-up/reset	

Table 6-1 Binary output messages

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
cold start control	1216
solution validity criteria	1217
antenna type select	1218
user-entered altitude input	1219
application platform control	1220
nav configuration	1221
raw almanac	1240
raw ephemeris	1241
raw ionospherics and UTC corrections	1242
timing receiver configuration input	1255
perform built-in test command	1300
restart command	1303
factory test command	1304
frequency standard input parameters	1310
power management control	1317
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 message	1390

Table 6-1 Binary input messages

6.2 Motorola Binary Data Messages

Table 6-3 describes the output and input Motorola Binary messages for the receiver, along with their corresponding Commands. See appendix A for a complete description of each binary message.

Note: while in Motorola-emulation mode, only eight satellites are reported. The Pico T firmware selects the eight satellites that have the highest elevation for use in all messages and commands while in this mode.

Binary command	Description
@@Ad	used to manually enter latitude
@@Ae	used to manually enter longitude
@@Af	used to manually enter altitude
@@Ag	used to set antenna mask angle
@@As	command to manually enter 'position hold' position
@@At	command to go to 'position hold' mode
@@Aw	command to select UTC or GPS time formats
@@Ay	used for setting 1PPS time offset
@@Az	used to offset the 1PPS signal for antenna cable delays or other system advance/delay parameters
@@Bb	commands report on visible satellites and status
@@Bj	used to get pending leap second information
@@Bo	provides UTC offset status
@@Cf	commands the receiver to default parameters
@@Cj	command to respond with manufacturer name, model, serial number information and software revision
@@Ea	status, position and other general data (this data can be set as regular, second boundary, timed output message)
@@En	sets alarm limits for T-RAIM and controls output (turns on/off) of 1PPS and 10 kHz timing signals
@@Fa	command to run self test on the receiver's hardware
@@Wb	commands the receiver to go to Navman binary protocol

Table 6-3 Motorola binary input and output messages

6.3 NMEA data messages

Table 6-4 and 6-5 describe all of the output and input NMEA messages for the receiver, along with their corresponding message IDs. For a complete description of each NMEA message, refer to Navman document MN02000.

Note: NMEA message protocol contains no information for timing applications. Also, due to processing priorities within the receiver, the date and time reported in NMEA messages may be advanced or retarded from UTC by up to one second.

Message ID	Output message name
BIT	Rockwell proprietary Built-In Test (BIT) results
ERR	Rockwell proprietary error/status
GGA	GPS fix data (*)
GSA	GPS DOP and active satellites (*)
GSV	GPS satellites in view (*)
VTG	track made good and ground speed
RMC	recommended minimum specific GPS data (*)
RID	Rockwell proprietary receiver ID (**)
ZCH	Rockwell proprietary Zodiac channel status (*)
(*) enabled by default at power-up (**) once at power-up/reset	

Table 6-4 NMEA output messages

Message ID	Input message name
BIT	Navman proprietary built-in test (BIT) Command
LOG	Navman proprietary log control Message
INIT	Navman proprietary receiver Initialisation
PRO	Navman proprietary protocol message
$LCGPQ	Navman standard query message

Table 6-5 NMEA input messages

7.0 Appendix A

7.1 MOTOROLA I/O command list

Table A-1 describes the sub-set of Motorola commands included in the Jupiter-PICO T GPS receiver

Binary command	Description
@@Ad	used to manually enter latitude
@@Ae	used to manually enter longitude
@@Af	used to manually enter altitude
@@Ag	used to set antenna mask angle
@@As	command to manually enter "position hold" position
@@At	command to go to "position hold" mode
@@Aw	command to select UTC or GPS time formats
@@Ay	used for setting 1PPS time offset
@@Az	used to offset the 1PPS signal for antenna cable delays or other system advance/delay parameters
@@Bb	commands report on visible satellites and status
@@Bj	used to get pending leap second information
@@Bo	provides UTC offset status
@@Cf	commands the receiver to default parameters
@@Cj	command to respond with manufacturer name, model, serial number information and software revision
@@Ea	status, position and other general data (Note that this data can be set as regular, second boundary, timed output message)
@@En	sets alarm limits for T-RAIM and controls output (turns on/off) of 1PPS and 10 kHz timing signals
@@Fa	command to run self test on the receiver's hardware
@@Wb	commands the receiver to go to Navman binary protocol

Table 7-1 Motorola commands included in the Pico T reciever

7.2 @@Ad - latitude

Latitude is measured in degrees north (+) or degrees south (–) of the earth's equator. The default datum for latitude is WGS 84. This input command sets the initial latitude coordinate only if the GPS receiver is not yet computing a position fix. If the GPS receiver is already computing a fix, the latitude is not changed.

Range: –90° (South Pole) to 90° (North Pole)
Default value: 0° (Equator)
Units: milliarcseconds (mas) (1° = 3 600 000 mas)

7.2.1 'Ad' input command

Poll current latitude:
@@Adxxxx<C><CR><LF>
xxxx = 4 out of range bytes $999999999
<C> = checksum character
Message length: 11 bytes

Change current latitude:
@@Addddd<C><CR><LF>
dddd = latitude in mas, –324 000 000 to 324 000 000 (–90° to 90°)
<C> = checksum character
Message length: 11 bytes

7.2.2 'Ad' response message

To either command:
@@Addddd<C><CR><LF>
dddd = latitude in mas, –324 000 000 to 324,000,000 (–90° to 90°)
<C> = checksum character
Message length: 11 bytes

7.3 @@Ae - longitude

Longitude is measured in degrees east (+) or degrees west (–) of the Greenwich Meridian. The datum for longitude is WGS 84. This input command sets the initial longitude coordinate only if the GPS receiver is not yet computing a position fix. If the GPS receiver is already computing a fix, the longitude is not changed.

Range: –180° to 180°
Default value: 0° (Greenwich Meridian)
Units: milliarcseconds (mas) (1° = 3 600 000 mas)

7.3.1 'Ae' input command

Poll current longitude:
@@Aexxxx<C><CR><LF>
xxxx = 4 out of range bytes $999999999
<C> = checksum character
Message length: 11 bytes

Change current longitude:
@@Aedddd<C><CR><LF>
dddd = longitude in mas, –648 000 000 to 648 000 000 (–180° to 180°)
<C> = checksum character
Message length: 11 bytes

7.3.2 'Ae' response message

To either command:
@@Aedddd<C><CR><LF>
dddd = longitude in mas, –648 000 000 to

648 000 000 (–180° to 180°)
<C> = checksum character
Message length: 11 bytes

7.4 @@Af - altitude

Altitude is measured with respect to the GPS reference ellipsoid (WGS 84), and the units are in metres. The input command sets the initial altitude coordinate only if the GPS receiver is not yet computing a position fix. If the GPS receiver is already computing a fix, then the altitude is not changed.

Range: –1 000.00 to 18 000.00 m
Default value: 0.00 m (WGS-84 ellipsoid)
Resolution: 0.01 m

7.4.1 'Af' input command

Poll current altitude:
@@Afxxxxx<C><CR><LF>
xxxxx = 5 out of range bytes $9999999999
<C> = checksum character
Message length = 12 bytes

Change current altitude:
@@Afaaaat<C><CR><LF>
aaaa = altitude in cm (-100 000 to 1 800 000)
t = altitude type (0 = WGS-84 ellipsoid altitude)
<C> = checksum character
Message length = 12 bytes

7.4.2 'Af' response message

To either command:
@@Afaaaammmm<C><CR><LF>
aaaa = altitude in cm (-100 000 to 1 800 000)
mmmm = not used
<C> = checksum character
Message length = 15 bytes

7.5 @@Ag - satellite mask angle

The GPS receiver will attempt to track satellites for which the elevation angle is greater than the satellite mask angle. This parameter allows the user to control the elevation angle that is used for this decision.

Range: 0° to 89°
Default value: 0°

7.5.1 'Ag' input command

Poll current mask angle:
@@Agx<C><CR><LF>
x = $ff (one byte, hex ff)
<C> = checksum character
Message length: 8 bytes

Change current mask angle:
@@Agd<C><CR><LF>
d = degrees (0 to 89)
<C> = checksum character
Message length: 8 bytes

7.5.2 'Ag' response message

To either command:
@@Agd<C><CR><LF>
d = degrees (0 to 89)
<C> = checksum character
Message length: 8 bytes

7.6 @@As - position hold

The user can specify coordinates to increase the timing accuracy. This command is used to enter the position to be held. Note that this command will only be executed if the position-hold mode is disabled. The position held is specified in the same units and referenced to the same datum (WGS 84) as the initial position coordinates of latitude, longitude and altitude (to the same resolution). The altitude parameter is referenced to the GPS reference ellipsoid. Note that all three parameters must be specified. The valid ranges of each parameter are the same as those specified in the latitude, longitude, and altitude commands.

Default values:
Latitude = 0° (Equator)
Longitude = 0° (Greenwich Meridian)
Altitude = 0 m (WGS-84 ellipsoid)

7.6.1 'As' input command

Poll current position hold position:
@@Asxxxxxxxxxxxxx<C><CR><LF>
xxxxxxxxxxxxx = 13 out of range bytes $7fffffff7ffffff7ffffff
<C> = checksum character
Message length: 20 bytes

Change current position hold position:
@@Asllllooooaaaat<C><CR><LF>
llll = latitude in mas, –324 000 000 to 324 000 000 (–90° to 90°)
oooo = longitude in mas, –648 000 000 to 648 000 000 (–180° to 180°)
aaaa = altitude in cm (-100 000 to 1 800 000)
t = type altitude (0 = WGS-84 ellipsoid altitude)
<C> = checksum character
Message length: 20 bytes

7.6.2 'As' response message

To either command:
@@Asllllooooaaaat<C><CR><LF>
llll = latitude in mas, –324 000 000 to 324 000 000 (–90° to 90°)

oooo = longitude in mas, –648 000 000 to 648 000 000 (–180° to 180°)
aaaa = altitude in cm (-100 000 to 1 800 000)
t = type altitude (0 = WGS-84 ellipsoid altitude)
<C> = checksum character
Message length: 20 bytes

7.7 @@At - go to position hold mode

The position hold mode enables/disables the position hold function. The coordinates for the position hold must be specified before the position hold mode is enabled; the receiver will not use the current position fix coordinates.

7.7.1 'At' input command

Poll current position hold mode:
@@Atx<C><CR><LF>
x = one out of range byte $ff
<C> = checksum character
Message length: 8 bytes

Change current position hold mode:
@@Atm<C><CR><LF>
m = mode (0 = disabled, 1 = enabled, 2 = start automatic self survey)
<C> = checksum character
Message length: 8 bytes

7.7.2 'At' response message

To either command:
@@Atm<C><CR><LF>
m = mode (0 = disabled, 1 = enabled, 2 = automatic self survey in progress)
<C> = checksum character
Message length: 8 bytes

7.8 @@Aw - time mode

This command selects the type of time (either GPS or UTC) to be output in the status, position and general information message (@@Ea) and to be used as the synchronisation point for the 1PPS timing pulse.

Note: if the receiver does not yet have the UTC parameters portion of the almanac, then UTC time will be output as being equal to GPS time. The receiver will have UTC parameters after an almanac has been received from the GPS satellites.

Default value: UTC

7.8.1 'Aw' input command

Poll current time mode:
@@Awx<C><CR><LF>
x = one out of range byte $ff
<C> = checksum character

Message length: 8 bytes
Change current time mode:
@@Awm<C><CR><LF>
m = mode (0 = GPS, 1 = UTC)
<C> = checksum character
Message length: 8 bytes

7.8.2 'Aw' response message

To either command:
@@Awm<C><CR><LF>
m = mode (0 = GPS, 1 = UTC)
<C> = checksum character
Message length: 8 bytes

7.9 @@Ay - 1PPS time offset

The GPS receiver outputs a 1PPS with the rising edge aligned with the GPS/UTC one second tick mark. The 1PPS offset command allows the user to offset the 1PPS time mark in one nanosecond increments. This offset can place the 1PPS anywhere within the one second epoch.

Range: 0 to 999 999 999 ns
Default value: 0 ns
Resolution: 1 ns

7.9.1 'Ay' input command

Poll current 1PPS offset:
@@Ayxxxx<C><CR><LF>
xxxx = 4 out of range bytes $ffffffff
<C> = checksum character
Message length: 11 bytes

Change current 1PPS offset:
@@Aytttt<C><CR><LF>
tttt = time offset in ns (0 to 999 999 999)
<C> = checksum character
Message length 11 bytes

7.9.2 'Ay' response message

To either command:
@@Aytttt<C><CR><LF>
tttt = time offset in ns (0 to 999 999 999)
<C> = checksum
Message length 11 bytes

7.10 @@Az - offset the 1PPS for antenna cable delay or other system advance/delay parameters

The GPS receiver outputs a 1PPS signal with the rising edge aligned with the GPS/UTC one second tick mark. The 1PPS cable delay command allows the user to offset the 1PPS time mark in one nanosecond increments relative to the measurement epoch.

This parameter commands the GPS receiver to output the 1PPS output pulse earlier in time to compensate for antenna cable delay. Up to one millisecond of equivalent antenna cable delay can be removed. Zero cable delay is used for a zero-length antenna cable. This parameter also allows the user to adjust the relative time of the 1PPS to compensate for other system delays.

Range: 0 to 0.000 999 999 s
Default value: 0.000 s
Resolution: 1 ns

7.10.1 'Az' input command

Poll 1PPS cable delay:
@@Azxxxx<C><CR><LF>
xxxx = 4 out of range bytes $ffffffff
<C> = checksum character
Message length: 11 bytes

Change current 1PPS cable delay:
@@Aztttt<C><CR><LF>
tttt = time offset in ns (0 to 999 999)
<C> = checksum character
Message length: 11 bytes

7.10.2 'Az' response message

To either command:
@@Aztttt<C><CR><LF>
tttt = time offset in ns (0 to 999 999)
<C> = checksum character
Message length: 11 bytes

7.11 @@Bb - visible satellite status

This command requests the results of the most content satellite alert computation. The response message gives the summary of the satellite visibility status showing the number of visible satellites, the Doppler frequency and the location of currently visible satellites (up to 12 satellites). The reference point for the most recent satellite alert is the current position coordinates.

Default mode: polled

7.11.1 'Bb' input command

Request visible satellite status message:
@@Bbm<C><CR><LF>
m = mode (0 = output message once, 1 = output message when visibility data changes)
<C> = checksum character
Message length: 8 bytes

7.11.2 'Bb' response message

To the above command:
@@Bbniddeaasiddeaasiddeaasiddeaasiddeaasid deaasiddeaasiddeaas

iddeaasiddeaasiddeaasiddeaas<C><CR><LF>
n = number of visible satellites (0 to 12)
For each visible satellite:
i = satellite ID
dd = Doppler in Hz (-5000 to 5000)
e = elevation in degrees (0 to 90)
aa = azimuth in degrees (0 to 359)
s = satellite health

    0 = healthy and not removed

    1 = healthy and removed

    2 = unhealthy and not removed

    3 = unhealthy and removed

<C> = checksum character
Message length: 92 bytes

7.12 @@Bj - leap second pending

This command causes the receiver to send a message to the user indicating the status of any pending leap second correction to UTC. If a leap second is pending, its direction is also indicated. This is a polled-only output message.

Leap seconds are occasionally inserted in UTC and can occur on midnight UTC June 30 or midnight UTC December 31. The GPS control segment notifies GPS users of pending leap second insertions to UTS several weeks before the event via a special message within the almanac. The receiver notes this data and inserts the time correction in the appropriate one second time bin.

When a leap second is inserted, the time of day will show a value of 60 in the seconds field. When a leap second is removed, the minute, hour and date will roll over after 58 seconds.

7.12.1 'Bj' input command

Poll current leap second status:
@@Bjm<C><CR><LF>
m = mode (0 = respond once)
<C> = checksum character
Message length: 8 bytes

7.12.2 'Bj' response message

To the above command:
@@Bjm<C><CR><LF>
m = status

    0 = no leap second pending

    1 = addition of one second pending

    2 = subtraction of one second pending

<C> = checksum character
Message length: 8 bytes

7.13 @@Bo - UTC offset status message

This message allows the user to request the UTC offset that is currently being used in the time solution. The value is reported as the integer number of seconds between UTC and GPS time. If the offset is zero, the receiver does not currently have the portion of the almanac that contains the UTC parameters.

This message can be set to output either once (polled), or any time the UTC offset has been updated or changed from the previous value.

Default mode: polled

7.13.1 'Bo' input command

Request UTC offset status message:
@@Bom<C><CR><LF>
m = mode

    0 = output UTC offset once

    1 = output UTC offset every time it is updated

<C> = checksum character
Message length: 8 bytes

7.13.2 'Bo' response message

To the above command:
@@Bou<C><CR><LF>
u = UTC offset in seconds (–128 to 127)
<C> = checksum character
Message length: 8 bytes

7.14 @@Cf - default parameters

This command sets all of the GPS receiver parameters to their default values. This results in all continuous messages being reset to polled only output, and clears the almanac and ephemeris data. The time and date stored in the internal real-time clock are not changed.

7.14.1 'Cf' input command

Set default parameters:
@@Cf<C><CR><LF>
<C> = checksum character
Message length: 7 bytes

7.14.2 'Cf' response message

To the above command:
@@Cf<C><CR><LF>
<C> = checksum character
Message length: 7 bytes

7.15 @@Cj - receiver ID message

This command displays receiver ID

7.15.1 'Cj' input command

Set default parameters:
@@Cj<C><CR><LF>
<C> = checksum character
Message length: 7 bytes

7.15.2 'Cj' response message

To the above command:
@@Cj<CR><LF>
COPYRIGHT<sp>1995-2000<sp>NAVMAN<sp><sp><sp>INC.<CR><LF>
SFTW<sp>P/N<sp>#<sp><15chars><CR><LF>
SOFTWARE<sp>VER<sp>#<sp><11chars><CR><LF>
SOFTWARE<sp>REV<sp>#<sp><11chars><CR><LF>
SOFTWARE<sp>DATE<sp><sp><11chars><CR><LFf>
MODEL<sp>#<sp><sp><sp><sp><15chars><CR><LFf>
HDWR<sp>P/N<sp>#<sp><15chars><CR><LF>
SERIAL<sp>#<sp><sp><sp><15chars><cr><lf>
MANUFACTUR<sp>DATE<sp><10chars><CR><LF>
OPTIONS<sp>LIST<sp><sp><sp><sp><10chars><C><CR><LF>
Where <sp> = space character, <nnchars> = number of characters in a text string value to be defined upon final software release.
<C>=checksum
Message length: 294 bytes

7.16 @@Ea - status, position and general data

This command sets the rate that the status, position and general data in the response message is output. The mode parameter (m) in the input message instructs the GPS receiver to output the message as either one time (polled), or at the indicated update rate (continuously). Once the GPS receiver is set to continuous output, the continuous message flow can be stopped by sending a one-time output request. The GPS receiver will output this message one more time, then terminate any further message outputs.

The state of the rate byte is stored in RAM. If the GPS receiver was continuously out-putting this message when turned off and back-up power is applied, then it will begin to output this message (at the selected output rate) again when the main power is re-applied. If back-up power is not applied during the power down, the GPS receiver will start-up in default (polled only) mode.

The contents of this message are described in the response message section. Refer to date, time, latitude, longitude and altitude for more details on these parameters.

The number of satellites visible is computed using the current date, time, position, almanac, and a mask angle of zero degrees representing the horizon. The receiver will attempt to track the eight highest satellites in the sky.

Default mode: polled

7.16.1 'Ea' input command

Requests status, position and general data message:
@@Eam<C><CR><LF>
m = mode:

    0 = output response message once only,

    1 to 255 = automatic output response message interval in seconds)

<C> = checksum character
Message length: 8 bytes

7.16.2 'Ea' response message

To the above command:
@@Eamdyyhmsffffaaaaaooooohhhhmmmmvvhh ddtntimsdimsdimsdimsdimsdimsdimsdimsds<C>< CR><LF>

Date
m = month (1 to 12)
d = day (1 to 31)
yy = year (1998 to 2018)

Time
h = hours (0 to 23)
m = minutes (0 to 59)
s = seconds (0 to 60)
ffff = fractional second

Position
aaaa = latitude in mas −324 000 000 to 324,000,000 (−90° to 90°)
oooo = longitude in mas −648 000 000 to 648 000 000 (−180° to 180°)
hhhh = ellipsoid height in cm (−100 000 to 1 800 000)
mmmm = not used

Velocity
vv = velocity in cm/s (0 to 51,400)
hh = heading 0 to 3,599 (0.0° to 359.9°) (true north, resolution 0.1°)

Geometry
dd = current DOP (0.1 res) 0 to 999 (0.0 to 99.9

DOP)
t = DOP type

    (msb)

    Bit 7: antenna undercurrent

    Bit 6: antenna over-current

    Bit 5: automatic survey mode

    Bits 4, 3, 2, 1: not used

    (lsb)

    Bit 0: set = HDOP (2D)

        clear = PDOP (3D)

Satellite visibility and tracking status
n = number of visible satellites (0 to 12)
t = number of satellites tracked (0 to 8)

For each of the eight receiver channels:
i = satellite ID 0 to 37
m = channel tracking mode

    0 = code search

    1 = code acquire

    2 = AGC set

    3 = preq acquire

    4 = bit sync detect

    5 = message sync detect

    6 = satellite time available

    7 = ephemeris acquire

    8 = available for position

s = carrier to noise density ratio (C/No) 0 to 255 dB Hz
d = channel status flag
each bit represents one of the following:

    (msb)

    Bit 7: using for position fix

    Bit 6: satellite momentum alert flag

    Bit 5: satellite anti-spoof flag set

    Bit 4: satellite reported unhealthy

    Bit 3: satellite reported inaccurate

    Bit 2: spare

    Bit 1: using for time solution

    (lsb)

    Bit 0: parity error

End of channel independent data
s = receiver status flag
each bit represents one of the following:

(msb)

Bit 7: position propagate mode

Bit 6: poor geometry (DOP > 12)

Bit 5: 3D fix

Bit 4: 2D fix

Bit 3: acquiring satellites / position hold

Bit 2: differential fix

Bit 1: insufficient satellites visible (<3)

(lsb)

Bit 0: bad almanac

<C> = checksum character
Message length: 76 bytes

7.17 @@En - set alarm limits for T-RAIM

The GPS receiver uses a robust Time-Receiver Autonomous Integrity Monitoring (T-RAIM) algorithm to exploit the redundancy of the GPS constellation in order to detect, isolate and remove faulty satellites. The set alarm limits for T-RAIM message allows the user to change the update rate, the configuration for the 1PPS output and the T-RAIM alarm limit.

The rate parameter instructs the GPS receiver to either output this message one-time (polled), or output this message at the indicated update rate (continuously). If the message rate is the same as the 1PPS rate, then the message and 1PPS pulse are synchronised. Once the GPS receiver is set to continuous output, the continuous message flow can be stopped by sending a one-time message request. The GPS receiver will output the message one more time, then terminate any further message outputs.

The state of the rate byte is stored in RAM. If the GPS receiver was continuously outputting a message when turned off and backup power is applied, then it will begin to output this message continuously (at the selected output rate) again when main power is reapplied. If backup power was not applied during the power down, the GPS receiver will start up in default (polled only) mode. The other T-RAIM control parameters are also stored in RAM, so they will be reset to default values if backup power is not applied during the power down.

The pulse generation can be controlled with the 1PPS control mode byte. The pulse can be on all the time, off all the time, on only when the receiver is tracking at least one satellite, or only when the time solution is within the alarm threshold.

The number of satellites appearing in the table below are the minimum which must be tracked to ensure the detection, isolation, and removal of faulty satellites is greater than 99.999%, which corresponds to less than one missed detection every 10,000 failures. Given the infrequency of GPS satellite failures, this makes a missed detection virtually impossible. Given that lock is maintained on eight satellites, the T-RAIM alarm can be set as low as 300 ns without compromising performance.

Time alarm (ns)	satellites to detect	satellites to isolate
>1,000	2	3
1,000 to 700	3	3
700 to 500	4	4
500 to 300	4	8
300 to 250	8	8

Table 7-2 T-RAIM alarm settings

The T-RAIM setup and status message outputs the status of the T-RAIM solution when the algorithm is active. This message also outputs several values related to the T-RAIM solution.

The 1PPS is synchronised to either UTC or GPS time, as specified by the time mode.

The receiver can make an estimate of the overall accuracy of the time solution. The one sigma estimate is computed using the residuals of the least-squares time solution. This number is a measure of the spread of the observations, not an estimate of the absolute time accuracy.

Finally, the time solution of each individual satellite is output.

Default values:

T-RAIM algorithm = off

T-RAIM alarm limit = 1,000 ns

1PPS control mode = setting 1

7.17.1 'En' input command

Poll current T-RAIM setup and status:
@@Enxxxxxxxxxxxxxxxx<C><CR><LF>
x = 15 out of range bytes $ff ff ff ...

C = checksum
Message length: 22 bytes

Change current T-RAIM setup:
@@Enotaapxxxxxxxxxx<C><CR><LF>
o = output message rate

    0 = output response message once (polled)

    1 to 255 = output response message at indicated number of seconds (1 = once per second, 2 = once every 2 seconds)

t = T-RAIM algorithm on/off

    0 = off

    1 = on

aa = T-RAIM alarm limit in 100's of nanoseconds 3 to 65 535
p = 1PPS control mode

    0 = 1PPS output pulse off

    1 = 1PPS output pulse on all the time

    2 = pulse only active when tracking at least one satellite

    3 = pulse only active when T-RAIM algorithm confirms solution

time error is within the user defined alarm limit
xxxxxxxxxx = not used
<C> = checksum character
Message length: 22 bytes

7.17.2 'En' response message

To either command:
@@EanotaapxxxxxxxxxxpysreensfffffsfffffsfffffsfffffsfffffsfffffsfffffsfffffC<CR><LF>
o = output message rate 0 to 255
t = T-RAIM algorithm on/off

    0 = off

    1 = on

aa = T-RAIM alarm limit in 100's of nanoseconds 3 to 65 535
p = 1PPS control mode

    0 = 1PPS output pulse off

    1 = 1PPS output pulse on all the time

    2 = pulse only active when tracking at least one satellite

3 = pulse only active when T-RAIM algorithm confirms solution time error is within the user defined alarm limit
xxxxxxxxxx = not used
p = pulse status

    0 = off

    1 = on

y = 1PPS pulse sync

    0 = pulse referenced to UTC

    1 = pulse referenced to GPS

s = T-RAIM solution status

    0 = OK, solution within alarm limits

    1 = alarm, user specified limits exceeded

    2 = unknown due to:

    alarm threshold set too low

    T-RAIM turned off

    insufficient satellites being tracked

r = T-RAIM status

    0 = detection and isolation possible

    1 = detection only possible

    2 = neither possible

ee = time solution one sigma accuracy estimate in nanoseconds: 0 to 65 535
n = negative sawtooth time error of next 1PPS pulse in nanoseconds 0 (not applicable with Pico T)

For each of the eight receiver channels
s = satellite ID: 0 to 37
fffff = fractional GPS local time estimate of satellite in nanoseconds 0 to 999 999 999
<C> = checksum character
Message length: 69 bytes

7.18 @@Fa - self test

The GPS receiver has the ability to perform an extensive self test. Functions that are verified include:
Antenna connection
RTC communication and time
Temperature sensor
RAM
ROM
Correlator IC
SCI communication if RS-232 port is active

The output of the self test command is a 16-bit field where each bit of the field represents the go/no-go condition of the item tested.

When self test is initiated, the next output message may not be in the response. The self test may take up to ten seconds to execute. Once the self test is complete, the acquisition process starts all over as if the receiver were first powered on. The date, time, position, almanac and ephemeris information is all retained.

7.18.1 'Fa' input command

Initiate self test:
@@Fa<C><CR><LF>
C = checksum
Message length: 7 bytes

7.18.2 'Fa' response message

To the above command:
@@Faxx<C><CR><LF>
xx = self test results in two bytes as detailed below:

(msb)

Bit 15: antenna undercurrent

Bit 14: antenna over-current

Bit 13: RTC comm and time

Bit 12: temperature sensor

Bit 11: spare

Bit 10: RAM

Bit 9: ROM

Bit 8: 10 kHz presence

Bit 7: channel 8 correlation test

Bit 6: channel 7 correlation test

Bit 5: channel 6 correlation test

Bit 4: channel 5 correlation test

Bit 3: channel 4 correlation test

Bit 2: channel 3 correlation test

Bit 1: channel 2 correlation test

(lsb)

Bit 0: channel 1 correlation test

<C> = checksum character
Message length: 9 bytes
Note: each bit is zero for pass and one for failure. The antenna undercurrent and over-current should be interpreted together as follows:

Bit 15	Bit 14	Meaning
0	0	antenna properly connected
0	1	antenna shorted
1	0	open (antenna not connected)
1	1	antenna shorted

Table 7-3 Antenna connection status

7.19 @@Wb - go to Navman binary protocol

This commands the receiver to go to Navman binary protocol. Note that the receiver will always revert to Motorola-equivalent protocol upon power cycling or reset. When commanded to the Navman binary mode, all of the standard Navman messages are supported.
Below is a sample C code set of instructions of the @@Wb command to switch the receiver from Legacy to Navman protocol:

7.19.1 'Wb' input command
```
// send '@@Wb' message to the receiver
    send_byte(0x40);

    send_byte(0x40);

    send_byte(0x57);

    send_byte(0x62);

    send_byte(0x01);

    send_byte(0x34);

    send_byte(0x0D);

    send_byte(0x0A);

    }
```

These are the hex values that are required, in the sequence shown, to convert the receiver to Navman binary protocol. When the above command is sent to the receiver, the conversion takes place and responds with the following sequence on the serial interface:

7.19.2 'Wb' response message
@@Wb(Hex 01)(Hex34)(Hex0D)(Hex0A) and at that point in time, there is approximately 470 milliseconds delay. Then the receiver sends an Navman binary 1108 message to indicate that the conversion has occurred. For additional messages in Navman binary protocol, relating to timing, refer to the timing application note (Navman document LA010105).