Jupiter T - GPS Timing Receiver

TU60-D120 Series

Conexant's Jupiter-T is a single-board, 12 parallel-channel Global Positioning System (GPS) receiver designed especially for precision timing applications. The Jupiter-T is intended as a component for an Original Equipment Manufacturer (OEM) product. The receiver (shown in Figures 1 and 2) continuously tracks all satellites in view, providing accurate satellite positioning and timing data. It is designed for high performance and maximum flexibility in a wide range of OEM configurations including time measurement equipment, cellular telephone base stations, and E911 emergency applications.

The highly integrated digital receiver uses the Zodiac chipset composed of two custom Conexant devices: the Gemini/Pisces MonoPac™ and the Scorpio Baseband Processor. These two custom chips, together with memory devices and a minimum of external components, form a complete low-power, high-performance GPS receiver solution for OEMs.

The Jupiter-T receiver 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 receiver uses all available signals to produce a highly accurate and robust navigation solution that provides superior timing performance for a wide variety of end product applications.

The Jupiter-T is packaged on a miniature printed circuit board. The typical operating power requirement is +5.0 V at 195 mA.

The all-in-view tracking of the Jupiter-T receiver provides robust performance in applications that require a fixed position or that operate in areas of high signal blockage such as dense urban centers. The receiver continuously tracks all visible GPS satellites and uses all the measurements to produce an over-determined, smoothed navigation solution. This solution is relatively immune to the position jumps induced by blockage that can occur in receivers with fewer channels.

Figure 3 shows the typical 1PPS performance of the Jupiter-T GPS receiver. The 10 kHz output is also available from the receiver and is phase coherent with the 1PPS signal. This output is made available for functions such as phase locking of crystal oscillators, frequency synthesizers, and similar applications.

Features

- Twelve parallel satellite tracking channels for fast acquisition and reacquisition
- Timing Receiver Autonomous Integrity Monitoring (TRAIM) functions.
- TRAIM user selectable alarm parameters
- Both 1PPS and 10 kHz timing outputs
- EEPROM for storage of critical parameters
- +5.0 V operation includes active GPS antenna voltage supply and antenna current-monitoring capability
- Enhanced algorithms provide superior timing application performance
- Adaptive threshold-based signal detection for improved reception of weak signals
- Asynchronous serial interface with multiple baud rates available
- Position-Hold mode to permit going from Three-Dimensional (3-D) to Two-Dimensional (2-D), even to a single satellite for best timing accuracy
- Automatic cold start acquisition process (when no initialization data is entered by the user)
- Maximum operational flexibility and configurability with user commands over the host serial port
- Ability to accept externally supplied initialization data over the host serial port
- User-selectable satellites for common view applications
- User-selectable visible satellite mask angle or highest in the sky for best timing performance
- Mechanical form factor compatible with other popular timing receivers
- OEM product development is fully supported through applications engineering
- Antenna voltage output with short circuit protection

Applications

- Wireless telecommunication network synchronization
- E911 caller location systems
- Frequency standards
- Cable and broadcast television
- Wide area networks

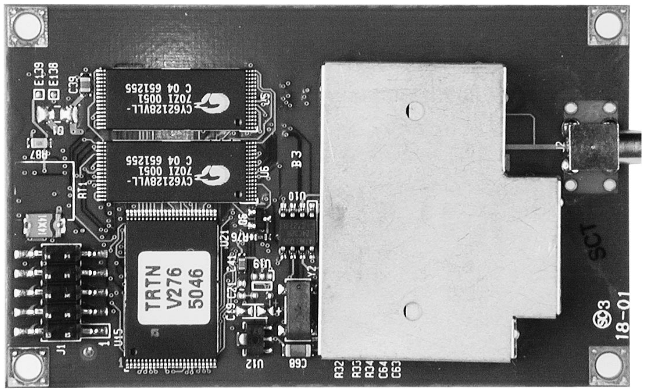

Figure 1. The Conexant Jupiter-T (Top View)

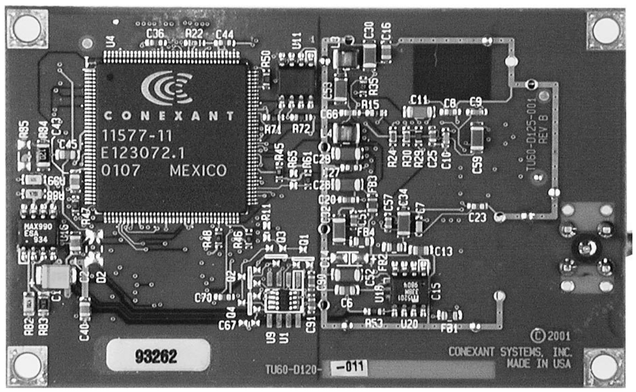

Figure 2. The Conexant Jupiter-T (Bottom View)

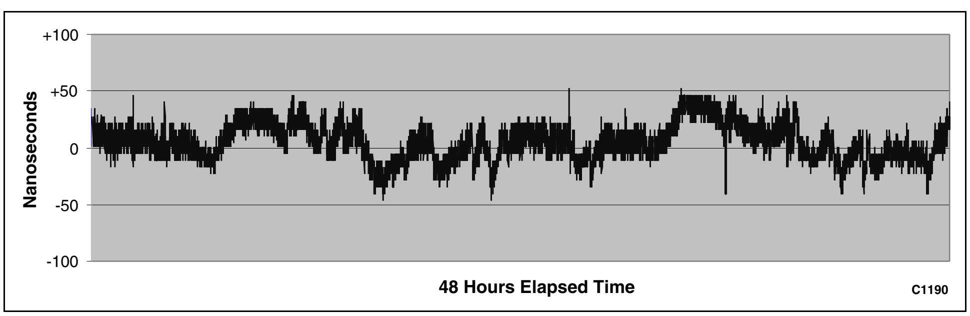

Figure 3. Typical 1PPS Output Performance

The 12-channel architecture provides rapid Time-To-First-Fix (TTFF) under all startup conditions. While the best TTFF performance is achieved when time of day and current position estimates are provided to the receiver, the flexible signal acquisition system takes advantage of all available information to provide a rapid TTFF. Acquisition is guaranteed under all initialization conditions as long as visible satellites are not obscured.

The receiver supports single satellite or 2-D operation (when less than four satellites are available) or when required by operating conditions. Altitude information required for 2-D operation is determined by the receiver or may be provided by the OEM application. For timing, only a single satellite is required and the user may enter position/altitude data where obstructions limit satellite view.

Communication with the receiver is established through an asynchronous serial I/O port that supports full duplex data communication. The receiver's serial port outputs timing and navigation data and accepts commands from the OEM application in proprietary Conexant binary message format. **Optional features include message format(s) of other popular timing receiver manufacturers. Contact your Conexant representative for additional details.**

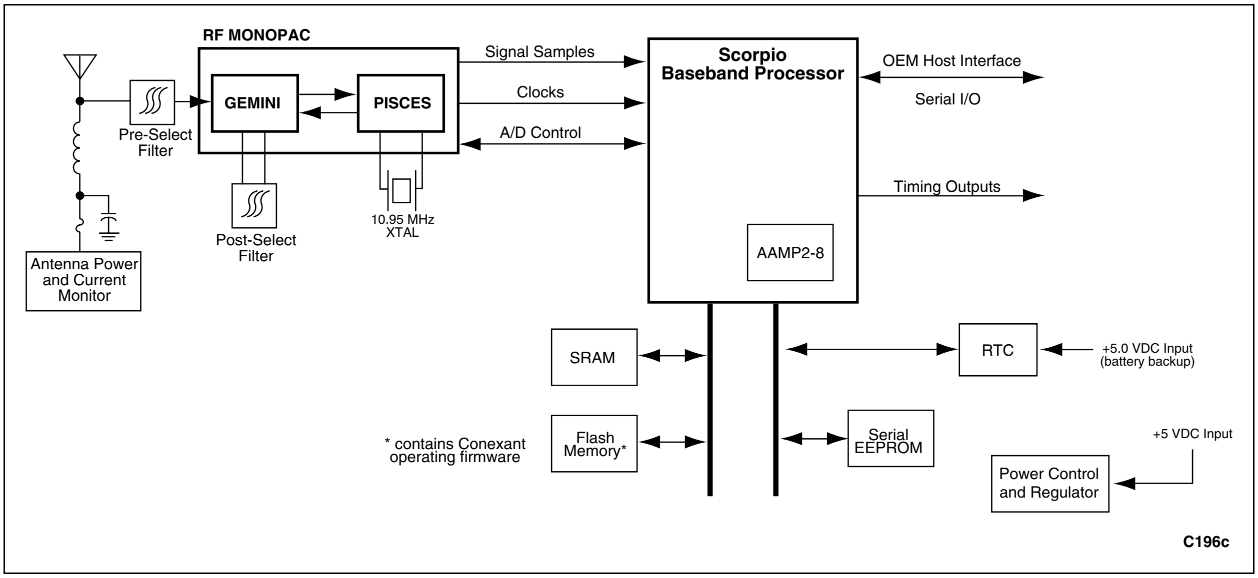

Figure 4. Jupiter-T Receiver Architecture

Receiver Architecture. The functional architecture of the Jupiter-T receiver is shown in Figure 4. The receiver design is based on the Conexant Zodiac chipset, the Gemini/Pisces MonoPac and the Scorpio Baseband Processor, which contains the required GPS functionality. The Gemini/Pisces MonoPac contains all the RF downconversion and amplification circuitry, and presents the In-Phase (I) and Quadrature-Phase (Q) Intermediate Frequency (IF) sampled data to the Scorpio device. The Scorpio contains an integral microprocessor and all the required GPS-specific signal processing hardware. Memory and other external supporting components configure the receiver into a complete timing system.

Technical Description

General Information. Since the receiver determines its position by ranging signals from three or more GPS satellites orbiting the Earth, its antenna must have reasonable visibility of the sky. This is generally not a problem. However, since GPS timing receivers are generally kept at a fixed location, care should be taken to install the antenna without obstruction (full view of the sky) and away from interference causing apparatus.

If satellite signals are blocked, it takes a longer time for the receiver to use those signals to determine its position. If fewer than three satellites are being tracked, or if the satellite geometry is degraded, signal blockage may result in a failure to provide adequate timing accuracy.

Satellite Acquisition. The Jupiter-T supports three types of satellite signal acquisition depending on the availability of critical data: hot, warm, and cold starts. Table 1 provides the corresponding TTFF times for each of these acquisition states.

- **Hot Start.** A hot start occurs when the receiver has been reset while navigating. Most recent position and time are valid in memory. Ephemerides of visible satellites are in SRAM, and are less than four hours old.
- **Warm Start**. A warm start typically results from user-supplied position and time initialization, or from a stored previous position and backed up Real-Time Clock (RTC). Table 2 shows the required accuracy of initialization data.
- **Cold Start**. A cold start acquisition state results when position and/or time data is unknown, either of which results in an unreliable satellite visibility list. Almanac information is used to identify previously healthy satellites.

Software Description

The Timing Application Software is developed from standard Zodiac software and contains all of the standard features with the following added features:

- A Self-Survey mode to determine precise position
- A Position-Hold mode in which 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 the receiver's own timing integrity using TRAIM
- An adjustable 1PPS time mark signal
- New timing-application serial messages

Operating Modes

Besides normal Zodiac operations, two new modes have been added to the Timing Application Software: Position-Hold mode and Self-Survey mode.

Table 1. Jupiter-T Signal Acquisition (T = 25° C With No Satellite Signal Blockage)

Satellite Acquisition State	Time To First Fix (minutes)		Initial Error Uncertainties (Note 1)		
	Typical	90% Probable	Position (km)	Velocity (m/s)	Time (min)
Hot Start (Note 2)	0.30	0.40	100	75	5
Warm Start (Note 3)	0.8	1.0	100	75	5
Cold Start (Note 4)	2.0	2.5	N/A (Note 5)	N/A (Note 5)	N/A (Note 5)

Note 1: Required accuracy of data used for Warm Start.

Note 2: Hot Start occurs when the system has been tracking and undergoes a reset. Previous position, approximate time, and satellite ephemerides are all valid in memory.

Note 3: Warm Start occurs when the receiver is sent approximate position and time at startup. Satellite ephemerides, if in memory, are more than four hours old.

Note 4: Cold Start occurs when the receiver is lacking approximate position and/or time.

Note 5: Initial error uncertainties do not apply to Cold Start.

Table 2. Jupiter-T Navigational Accuracies

	Position (meters)				Velocity (m/s)
	Horizontal		3-D	Vertical	
	CEP	(2 dRMS)			3-D (2 sigma)
Full Accuracy C/A	25	50	93	78	0.1
Standard Positioning Service (SPS)	50	100 (95%)	200 (95%)	173 (95%)	Note 1

Note 1: Velocity accuracies for SPS are not specified for the GPS system.

Position-Hold Mode. In Position-Hold mode, the receiver creates satellite observations but the navigation solution computed from those observations only adjusts the receiver timing rather than creates a new position fix. Entry into this mode is from either an operator command, automatically after successful completion of a self-survey, or at startup when the operator sets the appropriate configuration (see Message 1255).

In the case of an operator-commanded entry into Position-Hold mode, the current system position can be used as the reference position or the operator can specify another reference position. If the receiver has the configuration set so that the receiver goes into Position-Hold mode at startup, 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.

Once the system transitions to, or is commanded into, Position-Hold mode, the timing solution becomes valid once the first valid-measurement, valid-ephemeris satellite is in track. Once Position-Hold mode successfully starts, the receiver can continue to indicate its timing solution is valid with a minimum of one satellite in track. Once the receiver is in Position-Hold mode, it only leaves Position-Hold mode in response to an operator command, or because of a restart.

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 either by operator command or automatically at power-up or restart. 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 upon reset, or because the system was unable to start in Position-Hold mode, it remains in this mode 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.

TRAIM Functionality

TRAIM detects and isolates faulty satellites that can cause timing errors with the following limits:

- >150 ns (one sigma) when in Position-Hold mode using three or more satellites.
- > 100 ns (one sigma) when in Position-Hold mode using four to six satellites.
- > 50 ns (one sigma) when in Position-Hold mode using seven or more satellites.

TRAIM also prevents >1.0 µs timing errors at all times when the position is valid (and accurate to within 20 meters) using two or more satellites.

Technical Specifications

Operational Characteristics

Signal Acquisition Performance. Refer to Table 1. The values shown are based on unobstructed satellite signals.

Accuracy. Accuracy is a function of the entire Navstar system and geometry of the satellites at the time of measurement. In general, timing accuracy is within 10 to 20 ns of GPS (UTC) time. In Position-Hold mode, The Jupiter-T is accurate to within ± 40 ns of UTC time.

Solution Update Rate. Once per second (maximum).

Reacquisition. Typically one second following a 10-second blockage.

Serial Data Output Protocol. Conexant binary serial I/O messages and NMEA 0183.

Power Requirements

The Jupiter-T receiver operates from a DC power source as specified in Table 3.

GPS antenna current detector circuit:

Current	Alarm
15 to 80 mA	Normal
<5 mA	Under current
>110 mA	Over current

Radio Frequency Signal Environment

RF Input. 1575.42 MHz (L1 band) at a level between –130 dBW and –163 dBW.

Burnout Protection. –10 dBW signal within a bandwidth of 10 MHz centered about the L1 carrier frequency.

Physical

Dimensions. 2.00” x 3.25” x 0.64” (50.8 mm x 82.6 mm x 16.3 mm)

Weight. 1.2 oz. (35 gm)

Environmental

Cooling (operating/storage). Convection

Temperature. –40°C to +85°C

Humidity. Relative humidity up to 95 percent non-condensing or a wet-bulb temperature of +35° C, whichever is less.

Altitude (operating/storage). –1000 feet to 60,000 feet.

Vibration. Full Performance. See the composite SAE curve in Figure 5. Survival, 18G peak, 5 ms duration.

Transportation Shock. Shipping (in container): 10 drops from 75 cm onto a concrete floor.

Table 3. Jupiter-T Operational Power Requirements
(Measured at 25° C)

Version	Input Power	Power Requirement
TU60-D120	Voltage	+5.0 VDC ±5%
	Current (typical)	195 mA (not including antenna pre-amp)
	Current (maximum)	230 mA (not including antenna pre-amp)
	Ripple	150 mV

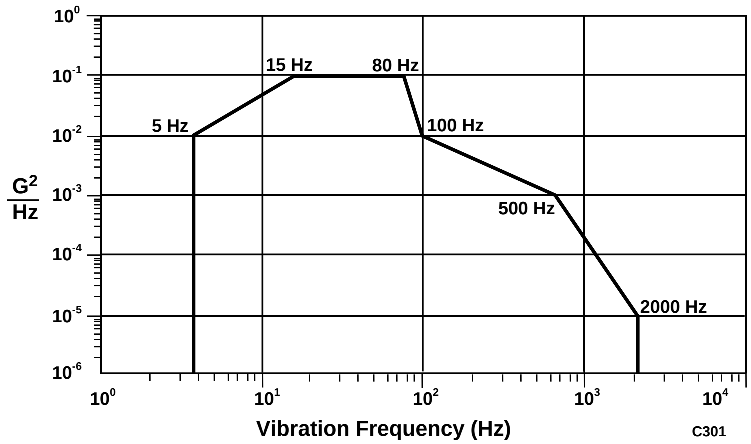

Figure 5. SAE Composite Curve (Random Noise)

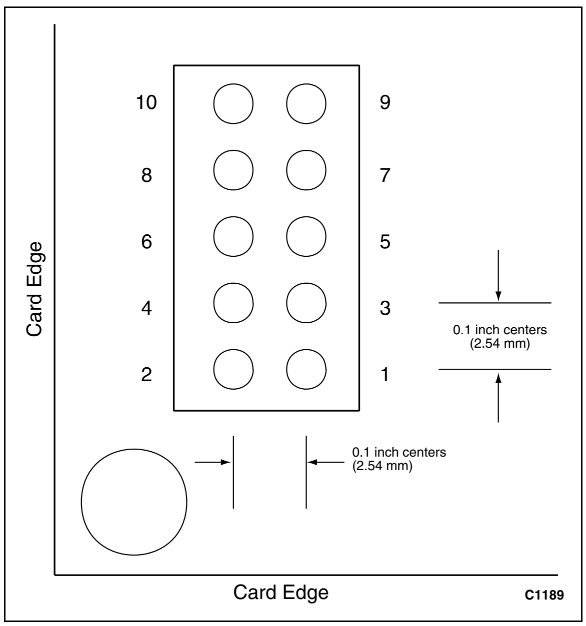

Figure 6. 10-Pin Interface Connector (J1)

OEM Interface Connector

The OEM communications interface is a standard, dual-in-line 10-pin male connector with 0.1-inch contact spacing. Figure 6 diagrams the pin 1 reference location.

Mechanical Layout

The mechanical drawing for the Jupiter-T board is shown in Figure 7.

ESD Sensitivity

The Jupiter-T contains Class 1 devices. The following Electrostatic Discharge (ESD) precautions are recommended any time handling of the receiver board is required:

- Protective outer garments.
- Handle device in ESD safeguarded work area.
- Transport device in ESD shielded containers.
- Monitor and test all ESD protection equipment.

Note: Treat the Jupiter-T as extremely sensitive to ESD when not installed in operating circuitry.

Hardware Interface

The electrical interface of the Jupiter-T GPS receiver is through a 10-pin miniature connector. The function of each pin is described in Table 4.

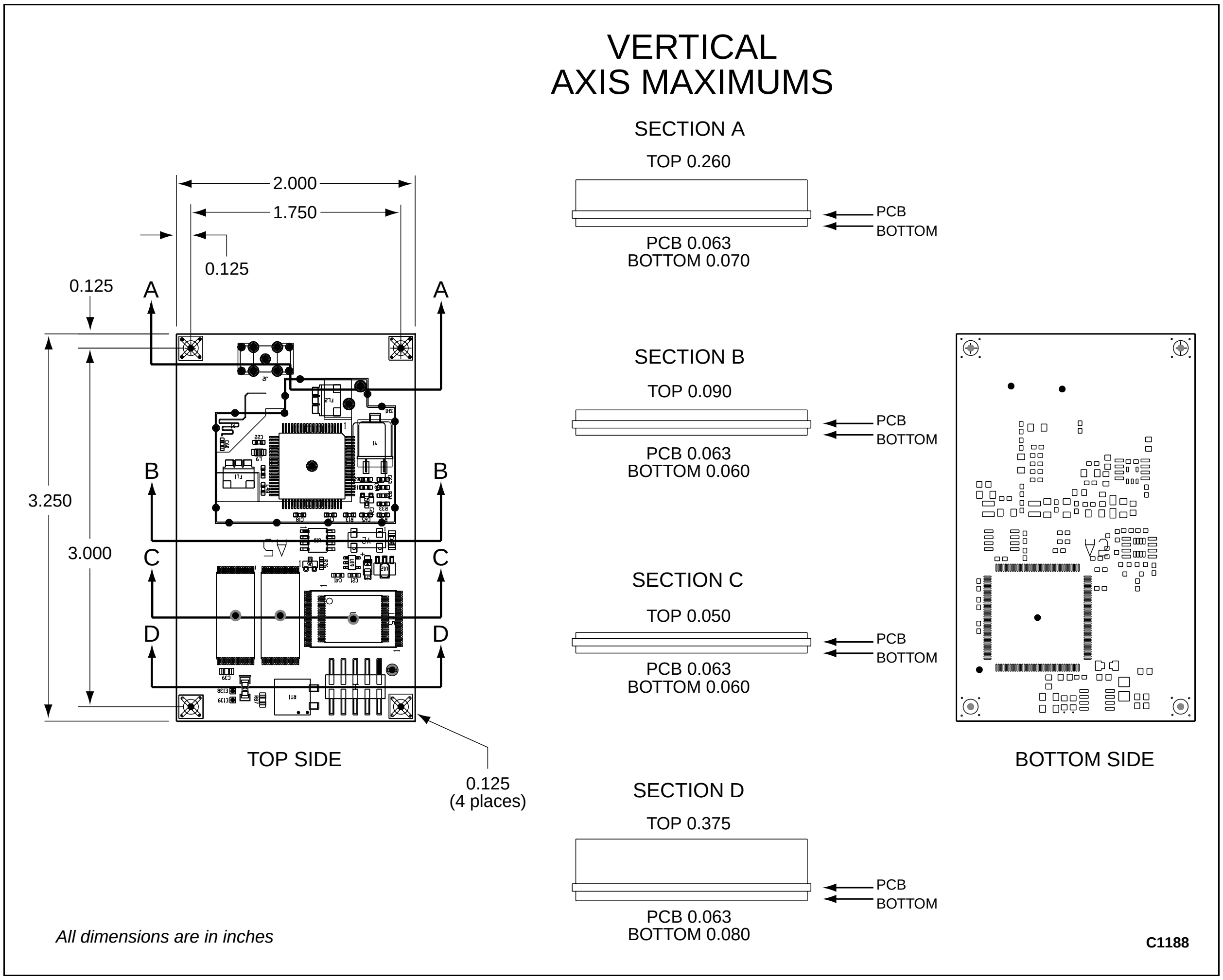

Figure 7. Mechanical Drawing of the Jupiter-T GPS Receiver Board

Table 4. Jupiter-T Receiver J1 Interface Pin Descriptions

Pin #	Name	Description	Pin #	Name	Description
J1-1	Batt	Battery backup (+5.0 VDC)	J1-6	1PPS	1 PPS clock output
J1-2	PWR	Main power + 5.0 VDC	J1-7	1PPS RTN	1 PPS return (ground)
J1-3	GND	Ground	J1-8	TXD	Transmit data output (CMOS levels)
J1-4	10 KHz	10 kHz clock output	J1-9	RXD	Receive data input (CMOS levels)
J1-5	NC	No connection	J1-10	RTN	Return (ground)

DC Input/Output Signals

This signal is the main power input to the Jupiter-T receiver. DC power requirements are shown in Tables 3 and 4.

Pin J1-6: 1PPS Output
This signal is a positive going pulse with the leading edge being the point of measurement for synchronization with the GPS satellite transmissions. The pulse width is approximately 26 ms.

Pin J1-4: 10 KHz Output
This is a 10 kHz square wave signal that is phase coherent with the leading edge of the 1PPS output.

Serial Communication Signals

Note: The serial communication signals described below must be applied according to the limits shown in Table 5.

The Host Port is the primary communications port for the receiver. Commands to the receiver are entered through RXD (pin J1-9) and data from the receiver is transmitted through TXD (pin J1-8). Both binary and NMEA messages are transmitted and received across the Host Port's serial I/O interface. This is a full-duplex, asynchronous serial data interface. Binary initialization, configuration, and data messages are transmitted and received across this port.

The logic needed to select between binary and NMEA messages is a function of the OEM software.

All of the output and input binary messages for the Jupiter-T receiver are listed in Table 6, along with their corresponding message IDs. All of the output and input NMEA messages are listed in Table 7, along with their corresponding message IDs.

The OEM application must provide any Line Driver/Line Receiver (LD/LR) circuitry to extend the range of the interface. Port Idle is nominally a logical high (+5 VDC).

Table 5. Jupiter-T Digital Signal Requirements

Symbol	Parameter	Limits	Units
PWRIN	Main power input to the GPS Jupiter-T	+5.0 ± 5%	volts
VIH (min)	Minimum high-level input voltage	0.7 x PWRIN	volts
VIH (max)	Maximum high-level input voltage	PWRIN	volts
VIL (min)	Minimum low-level input voltage	–0.3	volts
VIL (max)	Maximum low-level input voltage	0.3 x PWRIN	volts
VOH (min)	Minimum high-level output voltage	0.8 x PWRIN	volts
VOH (max)	Maximum high-level output voltage	PWRIN	volts
VOL (min)	Minimum low-level output voltage	0	volts
VOL (max)	Maximum low-level output voltage	0.2 x PWRIN	volts
tr, tf	Input rise and fall time	50	nanoseconds
C out	Maximum output load capacitance	25	picofarads

Table 6. Zodiac Binary Data Messages (1 of 2)

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
Input Message Name	**Message ID**
Geodetic Position and Velocity Initialization	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

Table 6. Zodiac Binary Data Messages (2 of 2)

Input Message Name (continued)	Message ID
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 7. Zodiac NMEA Data Messages

Output Message Name	Message ID
Conexant Proprietary Built-In Test Results	BIT
Conexant Proprietary Error/Status	ERR
GPS Fix Data	GGA
GPS DOP and Active Satellites	GSA
GPS Satellites in View	GSV
Conexant Proprietary Receiver ID	RID
Recommended Minimum Specific GPS Data	RMC
Course Over Ground and Ground Speed	VTG
Conexant Proprietary Zodiac Channel Status	ZCH
Time and Date	ZDA
Input Message Name	**Message ID**
Conexant Proprietary Built-In Test Command	IBIT
Conexant Proprietary Log Control Message	ILOG
Conexant Proprietary Receiver Initialization	INIT
Conexant Proprietary Protocol	IPRO
Standard Query Message	Q

Ordering Information

Model Name	Manufacturing Part Number	Product Revision
Jupiter-T	TU60-D120-xxx	

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