GARMIN

GPS 25 XL

GPS SENSOR BOARD

TECHNICAL SPECIFICATION

190-00076-01 Rev. D

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SECTION 1

INTRODUCTION

1.1 OVERVIEW

The GARMIN GPS 25 is a GPS sensor board designed for a broad spectrum of OEM (Original Equipment Manufacturer) system applications. The GPS 25 will simultaneously track up to twelve satellites providing fast time-to-first-fix, one second navigation updates and low power consumption. Its far reaching capability meets the sensitivity requirements of land navigation as well as the dynamics requirements of high performance aircraft.

The GPS 25 design utilizes the latest surface mount technology as well as high level circuit integration to achieve superior performance while minimizing space and power requirements. All critical components of the system including the RF/IF receiver hardware and the digital baseband are designed and manufactured by GARMIN to ensure the quality and capability of the GPS 25 sensor board. This hardware capability combined with software intelligence makes the board set easy to integrate and use.

Although the GPS 25 is designed to withstand rugged operating conditions, it must be mounted in an enclosure as part of a larger system designed by an OEM or system integrator. A minimum system must provide the sensor board with conditioned input power and L1 GPS RF signal. The system may communicate with the board set via a choice of two RS-232 compatible bi-directional communication channels. A highly accurate one-pulse-per-second (PPS) output can be utilized in applications requiring precise timing measurements. An on-board memory backup battery allows the sensor board to retain critical data such as satellite orbital parameters, last position, date and time. Non-volatile memory is also used to retain board configuration settings even if backup battery power fails. End user interfaces such as keyboards and displays are added by the application designer.

1.2 FEATURES

The GPS 25 sensor board provides a host of features that make it easy to integrate and use.

1) Full navigation accuracy provided by Standard Positioning Service (SPS)

2) Compact design ideal for applications with minimal space

3) High performance receiver tracks up to 12 satellites while providing fast first fix and low power consumption

4) Differential capability utilizes real-time RTCM corrections producing less than 5 meter position accuracy

5) On-board clock and memory are sustained by a memory backup battery or optional external standby power

6) User initialization is not required

7) Two communication channels and user selectable baud rates allow maximum interface capability and flexibility

8) Highly accurate one-pulse-per-second output for precise timing measurements

1.3 TECHNICAL SPECIFICATIONS

Specifications are subject to change without notice.

1.3.1 Physical Characteristics

1) Single board integrated with shielding

2) Weight: 1.1 ounce

3) Size: 1.83" (w) x 2.75" (l) x 0.45" (h)

1.3.2 Environmental Characteristics

1) Operating temperature: -30°C to +85°C (board temperature)

2) Storage temperature: -40°C to +90°C

1.3.3 Electrical Characteristics

1) Input voltage: +5VDC +/- 5% regulated, 50 mVp-p ripple.

2) Input current: 220 mA typical, 180 mA while in reset, 350 mA max

3) Backup power: 3V Lithium coin cell battery, up to 10 year life

4) Receiver sensitivity: -165dBW minimum

1.3.4 Performance

1) Tracks up to 12 satellites (up to 11 with PPS active)

2) Update rate: 1 second

3) Acquisition time
    - 15 seconds warm (all data known)
    - 45 seconds cold (initial position, time and almanac known, ephemeris unknown)
    - 1.5 minutes AutoLocate™ (almanac known, initial position and time unknown)
    - 5 minutes search the sky (no data known)

4) Position accuracy:

    Differential GPS (DGPS): Less than 5 meters RMS
    Non-differential GPS: 15 meters RMS (100 meters with Selective Availability on)

5) Velocity accuracy: 0.2 m/s RMS steady state (subject to Selective Availability)

6) Dynamics: 999 knots velocity, 6g dynamics

7) One-pulse-per-second accuracy: ±1 microsecond (subject to Selective Availability)

1.3.5 Interfaces

1) Dual channel RS-232 compatible with user selectable baud rate (1200, 2400, 4800, 9600)

2) NMEA 0183 Version 2.0 ASCII output (GPALM, GPGGA, GPGSA, GPGSV, GPRMC, GPVTG, PGRME, PGRMT, PGRMV, PGRMF, LCGLL, LCVTG)

Inputs

- Initial position, date and time (not required)

- Earth datum and differential mode configuration command,PPS Enable, almanac

Outputs

- Position, velocity and time

- Receiver and satellite status

- Differential Reference Station ID and RTCM Data age

- Geometry and error estimates

3) Real-time Differential Correction input (RTCM format)

4) One-pulse-per-second timing output

1.4 APPLICATION

GPS 25 BLOCK DIAGRAM

3

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              ▽


        ┌──────────────┐
        │ Pre-Amplifier │
        │ (Optional)    │
        └──────────────┘
               │
               ▼
┌─────────────────────────────────────┐          ┌──────────┐
│              GARMIN                   │          │  Power   │
│            GPS Sensor                 │   +5V    │  Supply  │
│                                       │ ◄─────── │          │
│                                       │          └──────────┘
│  Receiver      Transmitter   Pulse P er Second │
│  1    2        1    2                  │
└─────────────────────────────────────┘
```
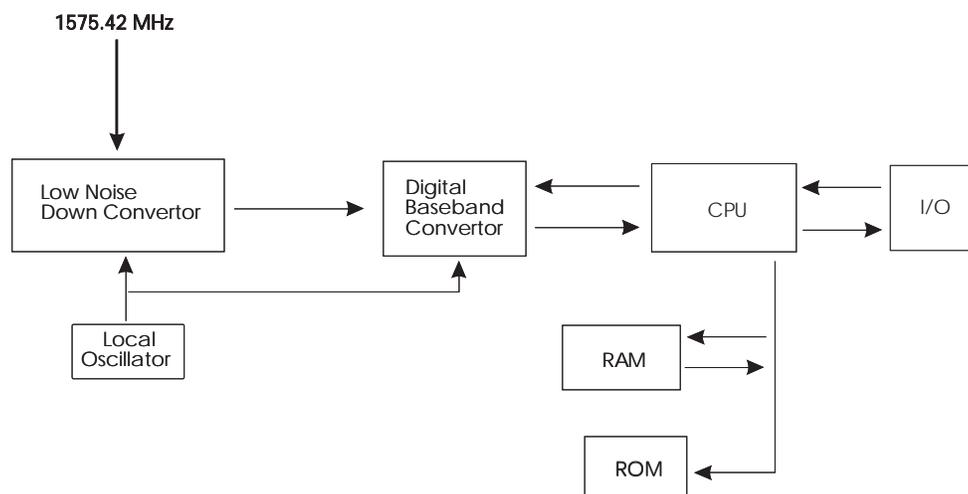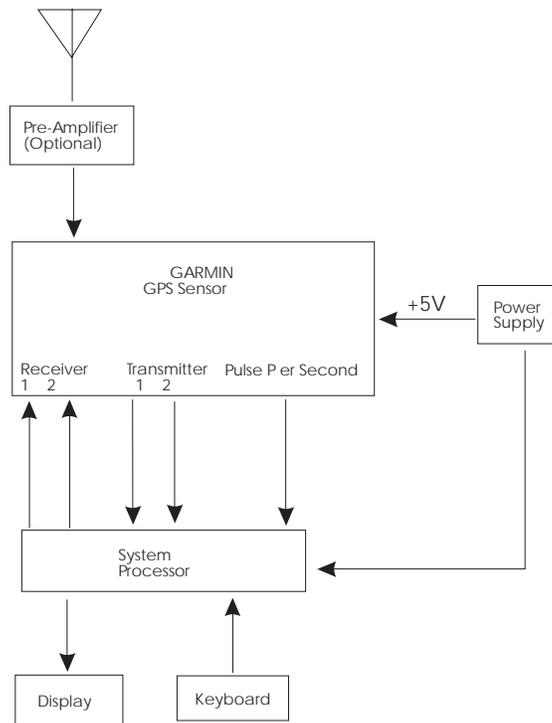
TYPICAL APPLICATION ARCHITECTURE

1.4.1 Application Considerations

1) The GPS 25 sensor board contains a sensitive receiver and uses high speed digital signals. Electromagnetic shielding may be required to prevent undesirable interference with or by other nearby circuits.

2) The GPS 25 sensor board uses approximately one watt and requires minimal cooling. Forced air cooling is not recommended since it may cause rapid temperature changes which may temporarily affect the frequency stability of the internal oscillator.

3) Interruptions in the RF signal can increase acquisition time. Antenna location with clear line-of-sight to all directions in the sky will yield the best performance.

4) The GPGSV sentence contains signal strength information for the visible satellites. Typical values will be between 33 db and 50 db. A majority of values near the lower limit may indicate a marginal RF signal.

SECTION 2

OPERATIONAL CHARACTERISTICS

This section describes the basic operational characteristics of the GPS 25 sensor board. Additional information regarding input and output specifications are contained in Section 4.

2.1 SELF TEST

After input power has been applied to the GPS 25 sensor board and periodically thereafter, the unit will perform critical self test functions and report the results over the output channel(s). The following tests will be performed:

1) RAM check

2) ROM test

3) Receiver test

4) Real-time clock test

5) Oscillator check

In addition to the results of the above tests, the board set will report software version information.

2.2 INITIALIZATION

After the initial self test is complete, the GPS 25 will begin the process of satellite acquisition and tracking. The acquisition process is fully automatic and, under normal circumstances, will take approximately 45 seconds to achieve a position fix (15 seconds if ephemeris data is known). After a position fix has been calculated, valid position, velocity and time information will be transmitted over the output channel(s).

Like all GPS receivers, the GPS 25 utilizes initial data such as last stored position, date and time as well as satellite orbital data to achieve maximum acquisition performance. If significant inaccuracy exists in the initial data, or if the orbital data is obsolete, it may take 1.5 minutes to achieve a navigation solution. The GPS 25 AutoLocate™ feature is capable of automatically determining a navigation solution without intervention from the host system. However, acquisition performance can be improved if the host system initializes the board set following the occurrence of one or more of the following events:

1) Transportation over distances further than 1500 kilometers

2) Failure of the on-board memory battery without system standby power

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3) Stored date/time off by more than 30 minutes

See Section 4 for more information on initializing the GPS 25.

2.3 NAVIGATION

After the acquisition process is complete, the GPS 25 will begin sending valid navigation information over its output channels. These data include:

1) Latitude/longitude/altitude

2) Velocity

3) Date/time

4) Error estimates

5) Satellite and receiver status

The GPS 25 sensor board will select the optimal navigation mode (2D or 3D) based on available satellites and geometry considerations. When navigating in the 2D mode the board set utilizes the last computed altitude or the last altitude supplied by the host system, whichever is newer. The host system must ensure that the altitude used for 2D navigation is accurate since the resulting position error may be as large as the altitude error. See Section 4 for information altitude initialization.

The GPS 25 will default to automatic differential mode -- "looking" for real-time RTCM differential corrections, attempting to apply them to the satellite data, in order to produce a differential (DGPS) solution. The host system, at its option, may also command the board set to choose differential only mode. When navigating in the differential only mode, the board set will output a position only when a differential solution is available.

2.4 SATELLITE DATA COLLECTION

The GPS 25 sensor board will automatically update satellite orbital data as it operates. The intelligence of the board set combined with its hardware capability allows these data to be collected and stored without intervention from the host system. A few key points should be considered regarding this process:

1) If the sensor board is not operated for a period of six (6) months or more, the unit will "search the sky" in order to collect satellite orbital information. This process is fully automatic and, under normal circumstances, will take 3-4 minutes to achieve a navigation solution. However, the host system should allow the board set to remain on for at least 5 minutes after the first satellite is acquired (see Section 4 for more information on status indications).

2) If the memory backup battery fails or is not installed while the host system power is

off and not connected to standby power, the sensor board will search the sky as described above. The system designer should be aware of the availability of standby power input to the board set to prevent this situation.

3) If the initial data is significantly inaccurate, the board set will perform an operation known as AutoLocate™. This procedure is fully automatic and, under normal circumstances, will require 1.5 minutes to calculate a navigation solution. AutoLocate™, unlike search the sky, does not require that the sensor board continue to operate after a fix has been obtained.

SECTION 3

HARDWARE INTERFACE

3.1 MECHANICAL DIMENSIONS

The GPS 25 sensor board mounts via four #4 or M-3 size screws (see drawing).

Top View

Side View
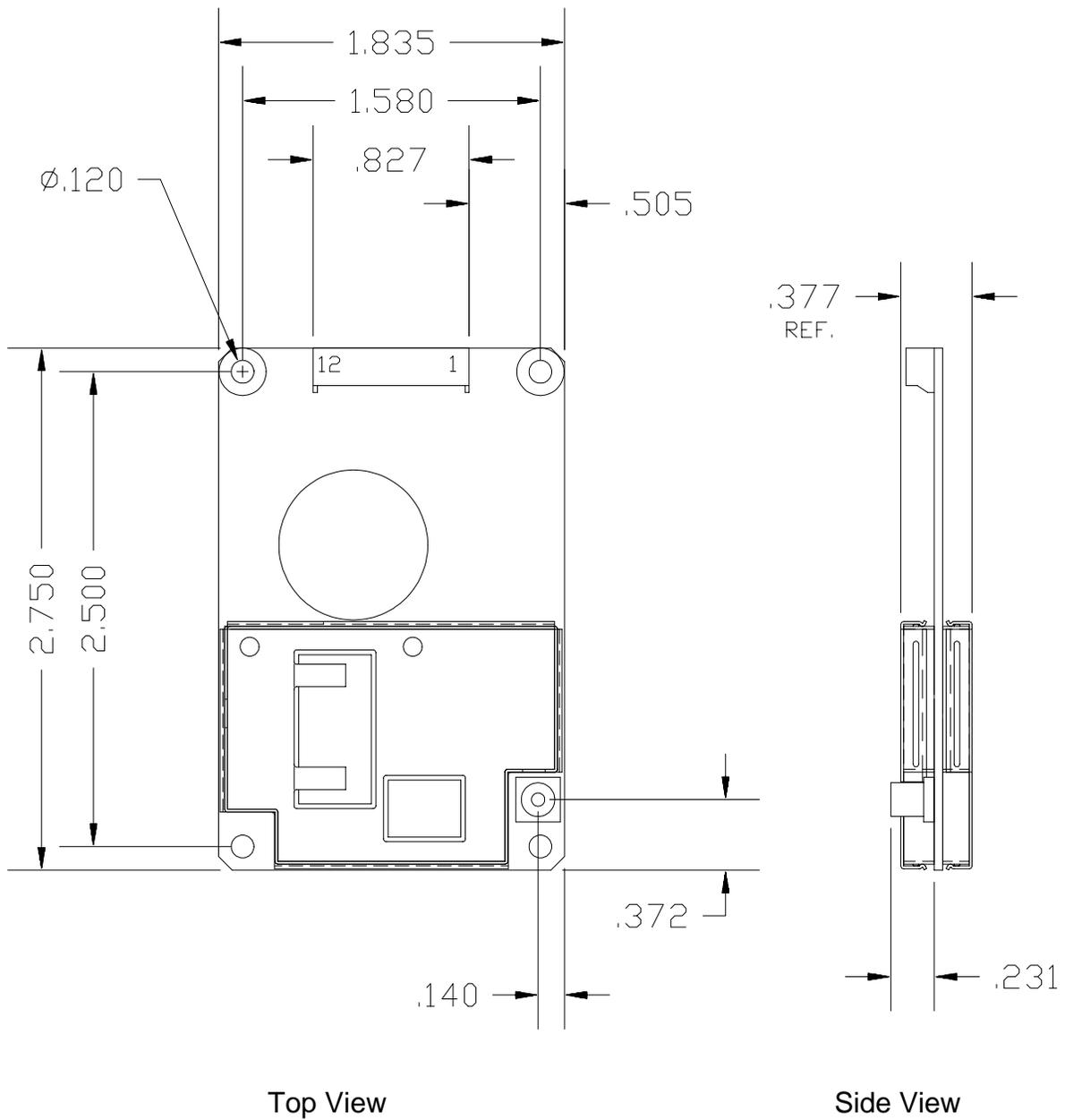
3.2 CONNECTOR SPECIFICATIONS

The GPS 25 sensor board features a single row, right angle, 12-pin male connector. The mating connector is available from JST Corporation (see appendix B).

3.3 CONNECTOR PIN-OUT

TXD2	1	Serial Data Output 2
RXD2	2	Serial Data Input 2
PPS	3	Pulse-per-second Output
TXD1	4	Serial Data Output 1
RXD1	5	Serial Data Input 1
RESET	6	External Reset Input
VAUX	7	Standby Power Input
GND	8	Ground
NC	9	Reserved
VCC	10	5 V DC 5% 220mA Input
NC	11	Reserved
NMEA	12	NMEA Output

PIN-OUT DIAGRAM

The following is a functional description of each pin of the interface connector.

Pin 1:   TXD2 - Second Serial Asynchronous Output. Electrically identical to TXD1.

Pin 2:   RXD2 - Second Serial Asynchronous Input. Electrically identical to RXD1. This input may be used to receive serial differential GPS data formatted per *"RTCM Recommended Standards For Differential Navstar GPS Service, Version 2.0"* (see Section 4 for more details).

Pin 3:   PPS - One-Pulse-Per-Second Output. Typical voltage rise and fall times are 300 nSec. Impedence is 250 ohms. Open circuit output voltage is 0V and 5V. Format is a 1 uS high pulse at a 1Hz rate. Rising edge is synchronized to the start of each GPS second. This output will provide a nominal 700 mV p-p

signal into a 50 Ohm load. The pulse time measured at the 50% voltage point will be about 50 nSec earlier with a 50 Ohm load than with no load.

Pin 4: TXD1 - First Serial Asynchronous Output. RS-232 compatible electrical specification. This output normally provides serial data which is formatted per *"NMEA 0183, Version 2.0"*. Switchable to 1200, 2400, 4800 and 9600 BAUD. This output functions in parallel with pin 12.

Pin 5: RXD1 - First Serial Asynchronous Input. RS-232 compatible with maximum input voltage range -25 < V < 25. This input may be directly connected to standard 5Vdc CMOS logic. The minimum low signal voltage requirement os 0.8V, and the maximum high signal voltage requirement is 2.4V. Maximum load impedance is 3K ohms. This input may be used to receive serial initialization/configuration data, as specified in Section 4.1.

Pin 6: RESET - External Reset Input. Inactive if not connected or less than 0.5V. Active if greater than 2.5V. Typical switch point is 0.9V @ 4 μA. Input impedence is 100K Ohms. A connection to this pin is optional.

Pin 7: VAUX - Optional External Backup Power Connection. Not required if on-board battery is installed. On-board battery capacity is 180 mA hour. Typical current requirement is 50 μA. If used, a 4VDC to 33VDC power source is required.

Pin 8: GND - Power and Signal Ground

Pin 9: NC - Do NOT connect this pin on the GPS 25.

Pin 10: VCC - Regulated +5V ±5%, 350 mA (maximum). When reset, current is typically 180 mA. Typical operating current is 220 mA. A well regulated, filtered and transient protected 5V power source is required. Transients, over voltages or reverse voltages will damage the GPS 25 circuitry. Inexpensive 3 terminal linear regulators may be used to make suitable supplies, but any supply should be tested before connecting it to the sensor board.

Pin 11: NC - Do NOT connect this pin on GPS 25.

Pin 12: NMEA - NMEA 0183, Version 1.5 electrical specification compatible serial output. This output os also CMOS compatible with a no load voltage swing of 0.2Vdc to 4.8Vdc. This output normally provides ASCII sentences formatted per "NMEA 0183, Version 2.0". User selectable baud rates of 1200, 2400, 4800, and 9600 are available. The data output om this pin is identical to the data output on pin 4.

Typical Embedded Application Interconnect

For embedded applications where the sensor board will be connected directly to the host system microprocessor through standard CMOS logic, the following connections are suggested.

GPS Sensor Board		Host Processor
TXD2	1	Phase Data Output (0Vdc to 5Vdc)
RXD2	2	
PPS	3	
TXD1	4	
RXD1	5	Serial Data Input (0Vdc to 5Vdc)
RESET	6	
VAUX	7	
GND	8	Signal Ground
NC	9	
VCC	10	+5Vdc Regulated, 5%
NC	11	
NMEA	12	Serial Data Output (0Vdc to 5Vdc)
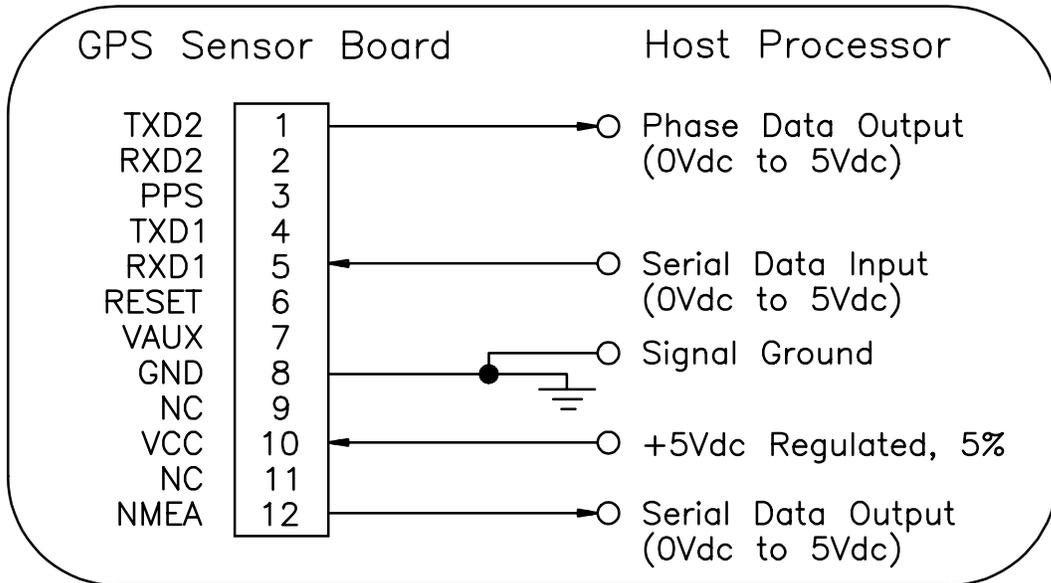
Typical Personal Computer Application Interconnect

The following connections are suggestions for applications where the sensor board will be connected to a personal computer via a standard RS-232 interface.

GPS Sensor Board		RS-232 Interface
TXD2	1	
RXD2	2	
PPS	3	Serial Data Output (−5Vdc to 5Vdc)
TXD1	4	
RXD1	5	Serial Data Input (−15Vdc to 15Vdc)
RESET	6	
VAUX	7	Signal Ground
GND	8	
NC	9	
VCC	10	+5Vdc Regulated, 5%
NC	11	
NMEA	12	
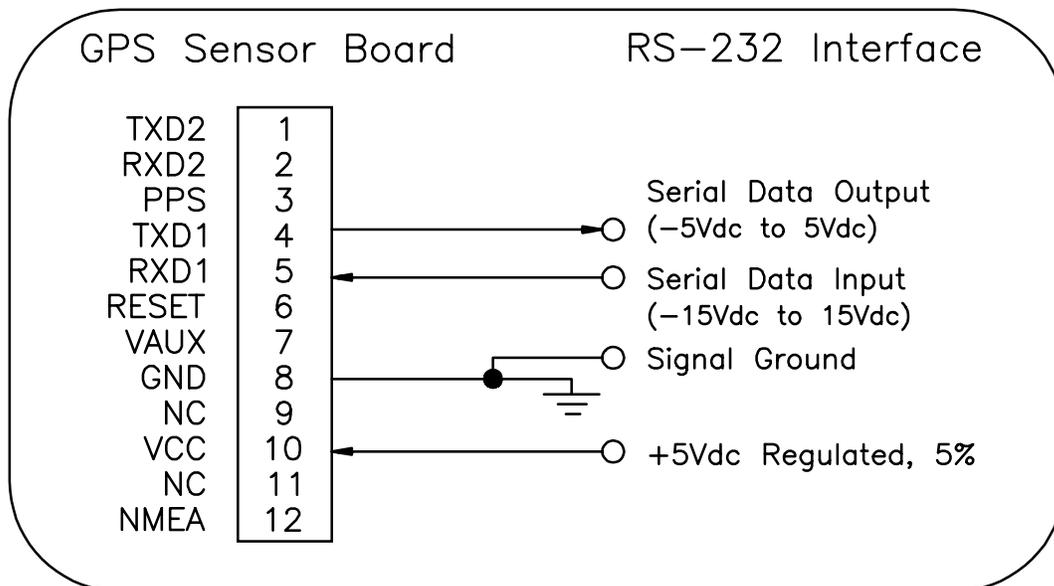
3.4 ANTENNA CONNECTION

The GPS 25 sensor board makes its antenna connection via a 50 ohm MCX style connector attached directly to the sensor board (+5V @ 15 mA power is supplied on the center conductor for the antenna).

RF CONNECTOR   REMOTE ANTENNA
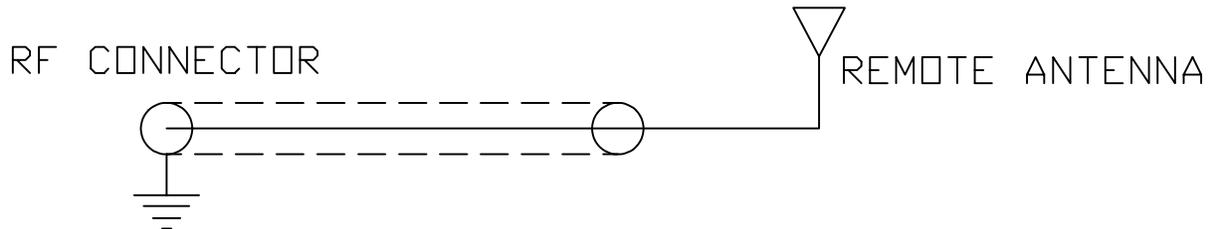
Coaxial cable supplies +5V @ 15 mA to antenna/preamp. 1.57542 GHz signal returns to the sensor board.

The standard GPS 25 antenna has eight feet of RG-174A/U type cable with a MCX connector installed for attachment to the sensor board. An extension cable with up to 5 dB attenuation at 1.5 GHz also may be used (either 50 Ohm or 75 Ohm impedance cable may be used). An additional 1 dB of extension cable loss is allowed for each six feet of standard cable that is used.

The following table may be used to estimate the typical attenuation of various cable types at 1.5 GHz. For example, a 15 foot length of RG-188 may have 4.5 dB attenuation. The attenuation of different styles of the same cable type may vary. Refer to the specifications of the actual cable that will be used.

Type	Typical Attenuation dB/100' @ 1 GHz
RG-211A/228A	4.5
RG-217/224/293/14	5.8
RG-8/215/216	9
RG-6	11
RG-59	11.5
RG-58	20
RG-188	30
RG-174	31
RG-178	45

SECTION 4

SOFTWARE INTERFACE

The GPS 25 interface protocol design is based on the National Marine Electronics Association's NMEA 0183 ASCII interface specification, which is fully defined in *"NMEA 0183, Version 2.0"* (copies may be obtained from NMEA, P.O. Box 50040, Mobile, AL, 36605, U.S.A.) and the Radio Technical Commission for Maritime Services' *"RTCM Recommended Standards For Differential Navstar GPS Service, Version 2.0, RTCM Special Committee No. 104"* (copies may be obtained from RTCM, P.O. Box 19087, Washington, D.C., 20036, U.S.A.). The GPS 25 interface protocol, in addition to transmitting navigation information as defined by NMEA 0183, transmits additional information using the convention of GARMIN proprietary sentences.

The following sections describe the data format of each sentence transmitted and received by the GPS 25 sensor board. The baud rate selection, one-pulse-per-second output interfaces and RTCM differential GPS input are also described.

4.1 NMEA RECEIVED SENTENCES

The subsequent paragraphs define the sentences which can be received on RXD1 by the GPS 25.

4.1.1 Almanac Information (ALM)

$GPALM,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15> *hh<CR><LF>

The $GPALM sentence can be used to initialize the sensor board's stored almanac information if battery back-up has failed.

<1> Total number of ALM sentences to be transmitted by the sensor board during almanac download. This field can be null or any number when sending almanac to the sensor board.
<2> Number of current ALM sentence. This field can be null or any number when sending almanac to the sensor board.
<3> Satellite PRN number, 01 to 32.
<4> GPS week number.
<5> SV health, bits 17-24 of each almanac page.
<6> Eccentricity
<7> Almanac reference time.
<8> Inclination angle.
<9> Rate of right ascension.
<10> Root of semi major axis.

<11> Omega, argument of perigee.
<12> Longitude of ascension node.
<13> Mean anomaly
<14> afo clock parameter
<15> af1 clock parameter

4.1.2 Sensor Initialization Information ($PGRMI GARMIN proprietary format)

The $PGRMI sentence provides information used to initialize the sensor board set position and time used for satellite acquisition. Receipt of this sentence by the board set causes the software to restart the satellite acquisition process. If there are no errors in the sentence, it will be echoed upon receipt. If an error is detected, the echoed PGRMI sentence will contain the current default values. Current PGRMI defaults can also be obtained by sending $PGRMIE, to the board.

$PGRMI,<1>,<2>,<3>,<4>,<5>,<6>,<7>*hh<CR><LF>

<1>   Latitude, ddmm.mmm format (leading zeros must be transmitted)
<2>   Latitude hemisphere, N or S
<3>   Longitude, dddmm.mmm format (leading zeros must be transmitted)
<4>   Longitude hemisphere, E or W
<5>   Current UTC date, ddmmyy format
<6>   Current UTC time, hhmmss format
<7>   Receiver Command, A = Auto Locate, R = Unit Reset

4.1.3 Sensor Configuration Information ($PGRMC GARMIN proprietary format)

The $PGRMC sentence provides information used to configure the sensor board operation. Configuration parameters are stored in non-volatile memory and retained between power cycles. The GPS 25 will echo this sentence upon its receipt if no errors are detected. If an error is detected, the echoed PGRMC sentence will contain the current default values. Current default values can also be obtained by sending $PGRMCE, to the board.

$PGRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>*hh<CR><LF>

<1>   Fix mode, A=automatic, 2 = 20 exclusively (host system must supply altitude), 3 = 3D exclusively
<2>   Altitude above/below mean sea level, -1500.0 to 18000.0 meters
<3>   Earth datum index. If the user datum index (96) is specified, fields <4> through <8> must contain valid values. Otherwise, fields <4> through <8> must be null. Refer to Appendix A for a list of earth datums and the corresponding earth datum index.
<4>   User earth datum semi-major axis, 6360000.0 to 6380000.0 meters (.001 meters resolution)
<5>   User earth datum inverse flattening factor, 285.0 to 310.0 (10^{-9} resolution)
<6>   User earth datum delta x earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)

<7>   User earth datum delta y earth centered coordinate, -5000.0 to 5000.0 meters (1
       meter resolution)
<8>   User earth datum delta z earth centered coordinate, -5000.0 to 5000.0 meters (1
       meter resolution)
<9>   Differential mode, A = automatic (output DGPS data when available, non-DGPS
       otherwise),   D = differential exclusively (output only differential fixes)
<10>   NMEA Baud rate, 1 = 1200, 2 = 2400, 3 = 4800, 4 = 9600
<11>   Velocity filter, 0 = No filter, 1 = Automatic filter, 2-255 = Filter time constant (10 = 10
       sec filter)
<12>   PPS mode, 1 = No PPS, 2 = 1 Hz

All configuration changes take effect after receipt of a valid value except baud rate and PPS.
Baud rate and PPS changes take effect on the next power cycle or an external reset event.

Null fields in the configuration sentence indicate no change the particular configuration
parameter.

4.1.4 Output Sentence Enable/Disable ($PGRMO GARMIN proprietary format)

The $PGRMO sentence provides the ability to enable and disable specific output sentences.

The following sentences are enabled at the factory: GPGSA, GPGSV, GPRMC, PGRME,
PGRMT and PGRMV

$PGRMO,<1>,<2>*hh<CR><LF>

<1>   Target sentence description (e.g., PGRMT, GPGSV, etc.)
<2>   Target sentence mode, where:
             0 = disable specified sentence
             1 = enable specified sentence
             2 = disable all output sentences
             3 = enable all output sentences (except GPALM)

The following notes apply to the PGRMO input sentence:

1) If the target sentence mode is '2' (disable all) or '3' (enable all), the target sentence
   description is not checked for validity. In this case, an empty field is allowed (e.g.,
   $PGRMO,,3), or the mode field may contain from 1 to 5 characters.

2) If the target sentence mode is '0' (disable) or '1' (enable), the target sentence
    description field must be an identifier for one of the sentences being output by the GPS
    25.

3) If either the target sentence mode field or the target sentence description field is not
   valid, the PGRMO sentence will have no effect.

4) $PGRMO,GPALM,1 will cause the sensor board to transmit all stored almanac
   information. All other NMEA sentence transmission will be temporarily suspended.

4.2 NMEA TRANSMITTED SENTENCES

The subsequent paragraphs define the sentences which can be transmitted on TXD1 by the GPS 25 sensor board.

4.2.1 Sentence Transmission Rate

Sentences are transmitted with respect to the user selected baud rate.

Regardless of the selected baud rate, the information transmitted by the GPS 25 is referenced to the one-pulse-per-second output pulse immediately preceding the GPRMC sentence.

The GPS 25 will transmit each sentence (except where noted in particular transmitted sentence descriptions) at a periodic rate based on the user selected baud rate and user selected output sentences. The sensor board will transmit the selected sentences contiguously. The contiguous transmission starts at a GPS second boundary. The length of the transmission can be determined by the following equation and tables:

$$\text{length of transmission} = \frac{\text{total characters to be transmitted}}{\text{characters transmitted per sec}}$$

Baud	characters_transmitted_per_sec
1200	120
2400	240
4800	480
9600	960

Sentence	max_characters
GPGGA	72
GPGSA	65
GPGSV	210
GPRMC	70
GPVTG	34
PGRME	36
PGRMT	47
PGRMV	26
PGRMF	79
LCGLL	36
LCVTG	34

The factory set defaults will result in a once per second transmission at the NMEA specification transmission rate of 4800 baud.

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4.2.2 Transmitted Time

The GPS 25 sensor board outputs UTC (Coordinated Universal Time) date and time of day in the transmitted sentences. Prior to the initial position fix, the date and time of day are provided by the on-board clock. After the initial position fix, the date and time of day are calculated using GPS satellite information and are synchronized with the one-pulse-per-second output.

The GPS 25 uses information obtained from the GPS satellites to add or delete UTC leap seconds and correct the transmitted date and time of day. The transmitted date and time of day for leap second correction follow the guidelines in *"National Institute of Standards and Technology Special Publication 432 (Revised 1990)"* (for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, U.S.A.).

When a positive leap second is required, the second is inserted beginning at 23h 59m 60s of the last day of a month and ending at 0h 0m 0s of the first day of the following month. The minute containing the leap second is 61 seconds long. The GPS 25 would have transmitted this information for the leap second added December 31, 1989 as follows:

Date	Time
311289	235959
311289	235960
010190	000000

If a negative leap second should be required, one second will be deleted at the end of some UTC month. The minute containing the leap second will be only 59 seconds long. In this case, the GPS 25 will not transmit the time of day 23h 59m 59s for the day from which the leap second is removed.

4.2.3 Global Positioning System Almanac Data (ALM)

$GPALM,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>
*hh<CR><LF>

Almanac sentences are not normally transmitted. Almanac transmission can be initiated by sending the sensor board a $PGRMO,GPALM,1 command. Upson receipt of this command the sensor board will transmit available almanac information on GPALM sentences. During the transmission of almanac sentences other NMEA data output will be temporarily suspended.

<field information> can be found in section 4.1.1.

4.2.4 Global Positioning System Fix Data (GGA)

$GPGGA,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,M,<10>,M,<11>,<12>*hh<CR><LF>

<1>   UTC time of position fix, hhmmss format
<2>   Latitude, ddmm.mmmm format (leading zeros will be transmitted)
<3>   Latitude hemisphere, N or S
<4>   Longitude, dddmm.mmmm format (leading zeros will be transmitted)
<5>   Longitude hemisphere, E or W
<6>   GPS quality indication, 0 = fix not available, 1 = Non-differential GPS fix available, 2 = Differential GPS (DGPS) fix available
<7>   Number of satellites in use, 00 to 08 (leading zeros will be transmitted)
<8>   Horizontal dilution of precision, 1.0 to 99.9
<9>   Antenna height above/below mean sea level, -9999.9 to 99999.9 meters
<10>   Geoidal height, -999.9 to 9999.9 meters
<11>   Differential GPS (RTCM-SC104) data age, number of seconds since last valid RTCM transmission (null if non-DGPS)
<12>   Differential Reference Station ID, 0000 to 1023 (leading zeros will be transmitted, null if non-DGPS)

4.2.5 GPS DOP and Active Satellites (GSA)

$GPGSA,<1>,<2>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<4>,<5>,<6>
*hh<CR><LF>

<1>   Mode, M = manual, A = automatic
<2>   Fix type, 1 = not available, 2 = 2D, 3 = 3D
<3>   PRN number, 01 to 32, of satellite used in solution, up to 12 transmitted (leading zeros will be transmitted)
<4>   Position dilution of precision, 1.0 to 99.9
<5>   Horizontal dilution of precision, 1.0 to 99.9
<6>   Vertical dilution of precision, 1.0 to 99.9

4.2.6 GPS Satellites in View (GSV)

$GPGSV,<1>,<2>,<3>,<4>,<5>,<6>,<7>,...<4>,<5>,<6>,<7>*hh<CR><LF>

<1>   Total number of GSV sentences to be transmitted
<2>   Number of current GSV sentence
<3>   Total number of satellites in view, 00 to 12 (leading zeros will be transmitted)
<4>   Satellite PRN number, 01 to 32 (leading zeros will be transmitted)
<5>   Satellite elevation, 00 to 90 degrees (leading zeros will be transmitted)
<6>   Satellite azimuth, 000 to 359 degrees, true (leading zeros will be transmitted)
<7>   Signal to noise ratio (C/No) 00 to 99 dB, null when not tracking (leading zeros will be transmitted)

NOTE: Items <4>,<5>,<6> and <7> repeat for each satellite in view to a maximum of four
(4) satellites per sentence. Additional satellites in view information must be sent in
subsequent sentences. These fields will be null if unused.

4.2.7 Recommended Minimum Specific GPS/TRANSIT Data (RMC)

$GPRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>*hh<CR><LF>

<1>   UTC time of position fix, hhmmss format
<2>   Status, A = Valid position, V = NAV receiver warning
<3>   Latitude, ddmm.mmmm format (leading zeros will be transmitted)
<4>   Latitude hemisphere, N or S
<5>   Longitude, dddmm.mmmm format (leading zeros will be transmitted)
<6>   Longitude hemisphere, E or W
<7>   Speed over ground, 0.0 to 999.9 knots
<8>   Course over ground, 000.0 to 359.9 degrees, true (leading zeros will be transmitted)
<9>   UTC date of position fix, ddmmyy format
<10>   Magnetic variation, 000.0 to 180.0 degrees (leading zeros will be transmitted)
<11>   Magnetic variation direction, E or W (westerly variation adds to true course)

4.2.8 Track Made Good and Ground Speed with GPS Talker ID (VTG)

The GPVTG sentence reports track and velocity information with a checksum:

$GPVTG,<1>,T,<2>,M,<3>,N,<4>,K*hh<CR><LF>

<1>   True course over ground, 000 to 359 degrees (leading zeros will be transmitted)
<2>   Magnetic course over ground, 000 to 359 degrees (leading zeros will be transmitted)
<3>   Speed over ground, 00.0 to 99.9 knots (leading zeros will be transmitted)
<4>   Speed over ground, 00.0 to 99.9 kilometers per hour (leading zeros will be trans-
       mitted)

4.2.9 Geographic Position with LORAN Talker ID (LCGLL)

The LCGLL sentence reports position information.

$LCGLL,<1>,<2>,<3>,<4>,<5>,<CR><LF>

<1>   Latitude, ddmm.mm format (leading zeros will be transmitted)
<2>   Latitude hemisphere, N or S
<3>   Longitude, dddmm.mm format (leading zeros will be transmitted)
<4>   Longitude hemisphere, E or W
<5>   UTC time of position fix, hhmmss format

4.2.10 Track Made Good and Ground Speed with LORAN Talker ID (LCVTG)

The LCVTG sentence reports track and velocity information.

$LCVTG,<1>,T,<2>,M,<3>,N,<4>,K<CR><LF>

<1>   True course over ground, 000 to 359 degrees (leading zeros will be transmitted)
<2>   Magnetic course over ground, 000 to 359 degrees (leading zeros will be transmitted)
<3>   Speed over ground, 00.0 to 99.9 knots (leading zeros will be transmitted)
<4>   Speed over ground, 00.0 to 99.9 kilometers per hour (leading zeros will be transmitted)

4.2.11 Estimated Error Information ($PGRME GARMIN proprietary format)

The $PGRME sentence reports estimated position error information.

$PGRME,<1>,M,<2>,M,<3>,M*hh<CR><LF>

<1>   Estimated horizontal position error (HPE), 0.0 to 9999.9 meters
<2>   Estimated vertical position error (VPE), 0.0 to 9999.9 meters
<3>   Estimated position error (EPE), 0.0 to 9999.9 meters

4.2.12 GPS Fix Data Sentence ($PGRMF GARMIN proprietary format)

$PGRMF,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>
*hh<CR><LF>

<1>   GPS week number (0 - 1023)
<2>   GPS seconds (0 - 604799)
<3>   UTC date of position fix, ddmmyy format
<4>   UTC time of position fix, hhmmss format
<5>   GPS leap second count
<6>   Latitude, ddmm.mmmm format (leading zeros will be transmitted)
<7>   Latitude hemisphere, N or S
<8>   Longitude, dddmm.mmmm format (leading zeros will be transmitted)
<9>   Longitude hemisphere, E or W
<10>   Mode, M = manual, A = automatic
<11>   Fix type, 0 = no fix, 1 = 2D fix, 2 = 3D fix
<12>   Speed over ground, 0 to 999 kilometers/hour
<13>   Course over ground, 0 to 359 degrees, true
<14>   Position dilution of precision, 0 to 9 (rounded to nearest integer value)
<15>   Time dilution of precision, 0 to 9 (rounded to nearest integer value)

4.2.13 Sensor Status Information ($PGRMT GARMIN proprietary format)

The $PGRMT sentence gives information concerning the status of the sensor board. This sentence is transmitted once per minute regardless of the selected baud rate.

$PGRMT,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>*hh<CR><LF>

<1>   Product, model and software version (variable length field, e.g., "GPS 25 VER 1.10")
<2>   Rom checksum test, P = pass, F = fail
<3>   Receiver failure discrete, P = pass, F = fail
<4>   Stored data lost, R = retained, L = lost
<5>   Real time clock lost, R = retained, L = lost
<6>   Oscillator drift discrete, P = pass, F = excessive drift detected
<7>   Data collection discrete, C = collecting, null if not collecting
<8>   Board temperature in degrees C
<9>   Board configuration data, R = retained, L = lost

4.2.14 3D velocity Information ($PGRMV GARMIN proprietary format)

The $PGRMV sentence reports three-dimensional velocity information.

$PGRMV,<1>,<2>,<3>*hh<CR><LF>

<1>   True east velocity, -999.9 to 9999.9 meters/second
<2>   True north velocity, -999.9 to 9999.9 meters/second
<3>   Up velocity, -999.9 to 9999.9 meters/second

4.3 BAUD RATE SELECTION

Baud rate selection can be performed by sending the appropriate configuration sentence to the sensor board as described in the NMEA input sentences selection.

4.4 ONE-PULSE-PER-SECOND OUTPUT

The highly accurate one-pulse-per-second output is provided for applications requiring precise timing measurements. The signal is generated after the initial position fix has been calculated and continues until power down. The rising edge of the signal is synchronized to the start of each GPS second.

Regardless of the selected baud rate, the information transmitted by the GPS 25 sensor board is referenced to the pulse immediately preceding the NMEA 0183 RMC sentence.

The accuracy of the one-pulse-per-second output is maintained only while the GPS 25 can compute a valid position fix. To obtain the most accurate results, the one-pulse-per-second output should be calibrated against a local time reference to compensate for cable and internal receiver delays and the local time bias.

4.5 RTCM RECEIVED DATA

Position accuracy of less than 5 meters can be achieved with the GPS 25 by using Differential GPS (DGPS) real-time pseudo-range correction data in RTCM SC-104 format. These corrections can be received by the GPS 25 sensor board on RXD2. Correction data at speeds of 300, 600, 1200, 2400, 4800 or 9600 baud can be utilized, as the GPS 25 automatically detects the incoming baud rate. For details on the SC-104 format, refer to *RTCM Paper 134-89/SC 104-68* by the Radio Technical Commission for Maritime Services.

APPENDIX A

EARTH DATUMS

The following is a list of the GARMIN GPS 25 earth datum indexes and the corresponding earth datum name (including the area of application):

  0 ADINDAN - Ethiopia, Mali, Senegal, Sudan
  1 AFGOOYE - Somalia
  2 AIN EL ABD 1970 - Bahrain Island, Saudi Arabia
  3 ANNA 1 ASTRO 1965 - Cocos Island
  4 ARC 1950 - Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe
  5 ARC 1960 - Kenya, Tanzania
  6 ASCENSION ISLAND 1958 - Ascension Island
  7 ASTRO BEACON "E" - Iwo Jima Island
  8 AUSTRALIAN GEODETIC 1966 - Australia, Tasmania Island
  9 AUSTRALIAN GEODETIC 1984 - Australia, Tasmania Island
10 ASTRO DOS 71/4 - St. Helena Island
11 ASTRONOMIC STATION 1952 - Marcus Island
12 ASTRO B4 SOROL ATOLL - Tern Island
13 BELLEVUE (IGN) - Efate and Erromango Islands
14 BERMUDA 1957 - Bermuda Islands
15 BOGOTA OBSERVATORY - Colombia
16 CAMPO INCHAUSPE - Argentina
17 CANTON ASTRO 1966 - Phoenix Islands
18 CAPE CANAVERAL - Florida, Bahama Islands
19 CAPE - South Africa
20 CARTHAGE - Tunisia
21 CHATHAM 1971 - Chatham Island (New Zealand)
22 CHUA ASTRO - Paraguay
23 CORREGO ALEGRE - Brazil
24 DJAKARTA (BATAVIA) - Sumatra Island (Indonesia)
25 DOS 1968 - Gizo Island (New Georgia Islands)
26 EASTER ISLAND 1967 - Easter Island
27 EUROPEAN 1950 - Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland
28 EUROPEAN 1979 - Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland
29 FINLAND HAYFORD 1910 - Finland
30 GANDAJIKA BASE - Republic of Maldives
31 GEODETIC DATUM 1949 - New Zealand

32 ORDNANCE SURVEY OF GREAT BRITAIN 1936 - England, Isle of Man, Scotland, Shetland Islands, Wales
33 GUAM 1963 - Guam Island
34 GUX 1 ASTRO - Guadalcanal Island
35 HJORSEY 1955 - Iceland
36 HONG KONG 1963 - Hong Kong
37 INDIAN - Bangladesh, India, Nepal
38 INDIAN - Thailand, Vietnam
39 IRELAND 1965 - Ireland
40 ISTS O73 ASTRO 1969 - Diego Garcia
41 JOHNSTON ISLAND 1961 - Johnston Island
42 KANDAWALA - Sri Lanka
43 KERGUELEN ISLAND - Kerguelen Island
44 KERTAU 1948 - West Malaysia, Singapore
45 L.C. 5 ASTRO - Cayman Brac Island
46 LIBERIA 1964 - Liberia
47 LUZON - Mindanao Island
48 LUZON - Phillippines (excluding Mindanao Island)
49 MAHE 1971 - Mahe Island
50 MARCO ASTRO - Salvage Islands
51 MASSAWA - Eritrea (Ethiopia)
52 MERCHICH - Morocco
53 MIDWAY ASTRO 1961 - Midway Island
54 MINNA - Nigeria
55 NORTH AMERICAN 1927 - Alaska
56 NORTH AMERICAN 1927 - Bahamas (excluding San Salvador Island)
57 NORTH AMERICAN 1927 - Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua)
58 NORTH AMERICAN 1927 - Canal Zone
59 NORTH AMERICAN 1927 - Canada (including Newfoundland Island)
60 NORTH AMERICAN 1927 - Caribbean (Barbados, Caicos Islands, Cuba, Dominican Republic, Grand Cayman, Jamaica, Leeward Islands, Turks Islands)
61 NORTH AMERICAN 1927 - Mean Value (CONUS)
62 NORTH AMERICAN 1927 - Cuba
63 NORTH AMERICAN 1927 - Greenland (Hayes Peninsula)
64 NORTH AMERICAN 1927 - Mexico
65 NORTH AMERICAN 1927 - San Salvador Island
66 NORTH AMERICAN 1983 - Alaska, Canada, Central America, CONUS, Mexico
67 NAPARIMA, BWI - Trinidad and Tobago
68 NAHRWAN - Masirah Island (Oman)
69 NAHRWAN - Saudi Arabia
70 NAHRWAN - United Arab Emirates
71 OBSERVATORIO 1966 - Corvo and Flores Islands (Azores)
72 OLD EGYPTIAN - Egypt
73 OLD HAWAIIAN - Mean Value

74   OMAN - Oman
75   PICO DE LAS NIEVES - Canary Islands
76   PITCAIRN ASTRO 1967 - Pitcairn Island
77   PUERTO RICO - Puerto Rico, Virgin Islands
78   QATAR NATIONAL - Qatar
79   QORNOQ - South Greenland
80   REUNION - Mascarene Island
81   ROME 1940 - Sardinia Island
82   RT 90 - Sweden
83   PROVISIONAL SOUTH AMERICAN 1956 - Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela
84   SOUTH AMERICAN 1969 - Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Venezuela, Trinidad and Tobago
85   SOUTH ASIA - Singapore
86   PROVISIONAL SOUTH CHILEAN 1963 - South Chile
87   SANTO (DOS) - Espirito Santo Island
88   SAO BRAZ - Sao Miguel, Santa Maria Islands (Azores)
89   SAPPER HILL 1943 - East Falkland Island
90   SCHWARZECK - Namibia
91   SOUTHEAST BASE - Porto Santo and Madeira Islands
92   SOUTHWEST BASE - Faial, Graciosa, Pico, Sao Jorge, and Terceira Islands (Azores)
93   TIMBALAI 1948 - Brunei and East Malaysia (Sarawak and Sabah)
94   TOKYO - Japan, Korea, Okinawa
95   TRISTAN ASTRO 1968 - Tristan da Cunha
96   User defined earth datum
97   VITI LEVU 1916 - Viti Levu Island (Fiji Islands)
98   WAKE-ENIWETOK 1960 - Marshall Islands
99   WORLD GEODETIC SYSTEM 1972
100   WORLD GEODETIC SYSTEM 1984
101   ZANDERIJ - Surinam
102   CH-1903 - Switzerland
103   Hu - Tzu - Shan
104   Indonesia 74

APPENDIX B

GPS 25 CONNECTORS

The mating power/data connector is available from JST Corporation. The information is listed below.

Mating Connector Part Number:

    Housing: ZHR-12

    Crimp Contact: SZH-002T-P0.5   (for 26 to 28 AWG wire)

                               SZH-003T-P0.5   (for 28 to 32 AWG wire)

U.S.A.   **JAPAN**

U.S.A.	JAPAN
J.S.T. CORPORATION	J.S.T. TRADING CO., LTD.
1200 Business Center Drive	Hankyu Senrichuo Building
Suite #400	No. 4-1, 1-Chrome
Mount Prospect, IL 60056 U.S.A	Shin-senri higashi-machi
Phone: (708) 803-3300	Toyonaka, Osaka 565, Japan
Fax: (708) 803-4918	Phone: (06) 831-6555
	Fax: (06) 835-2107

A completely assembled connector with twelve inch pre-stripped wires is available from GARMIN Corporation as part number 325-00026-00. Contact GARMIN for pricing and availability.

An MCX terminated RF cable pig-tail assembly is also available from GARMIN Corporation as part number 320-00048-00.

APPENDIX C

GPS 25 EVALUATION KIT
010-10055-00

GPS 25 evaluation kits are available from Garmin International. These kits include a GPS 25 sensor board, a GPS antenna, a 5V power supply, an interface cable for PC serial port connection, and software to monitor GPS 25 output and configure the sensor board.

To install the evaluation and configuration software run the program, **setup**, by using the FILE - RUN command in Windows.

The NMEAVWR program in the GARMIN program group can accept NMEA data from either the com1 or com2 PC serial port at 1200, 2400, 4800, or 9600 baud. The default settings are com1 at 4800 baud. NMEAVWR receives NMEA sentences and displays sentence information in a formatted display on the screen. The top portion of the screen displays the 5 character identifier of sentences received, the age in seconds since the last transmission, and a count of the number of times the sentence has been received. The middle portion of the screen displays the most recently received data in the sentence with the selected NMEA identifier (highlighted in the top portion of the screen using the arrow keys). The lower portion contains a formatted presentation of the currently selected sentence. In addition to receiving data the program will also upload NMEA sentences to the sensor board. The ALT-U key sequence will upload the file NMEA.TXT in the current directory to the unit. Received data can also be logged to a file. NMEAVWR can be invoked from a DOS prompt with the following optional parameters:
c:\garmin> nmeavwr /b:4800 /com1 log_file.txt

The configuration program will configure the sensor boards based on user selected parameters. Some program features include the ability to download sensor board configuration, maintain different configurations in files, and perform sensor board configurations quickly with the use of one function key. Online program help is available.

APPENDIX D

PHASE OUTPUT DATA

Phase Output Data Binary Format

Two records are transmitted once per second by the GPS 25 XL. One record contains primarily post-process information such as position and velocity information. The second record contains receiver measurement information. The records are sent at a default baud rate of 9600 baud, 8 bits, no parity.

Records begin with a delimiter byte (10 hex). The second byte identifies the record type (28 hex for a position record, 29 hex for a position record). The third byte indicates the size of the data. The fourth byte is the first byte of data. The data is then followed by a chksum byte, a delimiter byte (10 hex), and an end-of-transmission character (03 hex).

Note - If RTCM-104 differential data is sent to the GPS 25 XL the board will reset the Phase Output Data baud rate to the same baud rate used for RTCM-104 data. If the differential inputs are used on the GPS 25 XL then the RTCM-104 data must be sent to the GPS 25 XL at 9600 baud(preferred) or 4800 baud. RTCM-104 baud rates at 1200 or 2400 baud are not supported by the GPS 25 XL since it would limit bus bandwidth past the point where a once per second phase output data rate could be maintained.

Position Record

- 0x10   (dle is first byte)
- 0x28   (position record identifier)
- 0x36   (size of data)
- cpo_pvt_type (see description below)
- one byte chksum   (the addition of bytes between the delimiters should equal 0)
- 0x10   (dle)
- 0x03   (etx is last byte)

```
typedef struct
   {
   float              alt;
   float              epe;
   float              eph;
   float              epv;
   int                fix;
   double             gps_tow;
   double             lat;
   double             lon;
   float              lon_vel;
   float              lat_vel;
   float              alt_vel;
   } cpo_pvt_type;
```

alt   ellipsoid altitude (mt)
epe   est pos error (mt)
eph   pos err, horizontal (mt)
epv   pos err, vertical (mt)
fix   0 = no fix; 1 = no fix; 2 = 2D; 3 = 3D; 4 = 2D differential; 5 = 3D differential;
          6 and greater - not defined
gps_tow   gps time of week (sec)
lat   Latitude (deg)
lon   Longitude (deg)
lon_vel   Longitude velocity (mt/sec)
lat_vel   Latitude velocity (mt/sec)
alt_vel   Altitude velocity (mt/sec)

Receiver Measurement Record

- 0x10   (dle is first byte)
- 0x29   (receiver record identifier)
- 0xFA   (size of data)
- cpo_rcv_type (see below)
- one byte chksum   (the addition of bytes between the delimiters should equal 0)
- 0x10   (dle)
- 0x03   (etx)

```
typedef struct
    {
    unsigned long        cycles;
    double               pr;
    unsigned int         phase;
    char                 slp_dtct;
    unsigned char        snr_dbhz;
    char                 svid;
    char                 valid;
    } cpo_rcv_sv_type;

typedef struct
    {
    double               rcvr_tow;
    int                  rcvr_wn;
    cpo_rcv_sv_type      sv[12];
    } cpo_rcv_type;
```

rcvr_tow   Receiver time of week (sec)
rcvr_wn   Receiver week number
cycles   Number of accumulated cycles
pr   pseudo range (mt)
phase   to convert to (0 -359.999) multiply by 360.0 and divide by 2048.0
slp_dtct   0 = no cycle slip detected; non 0 = cycle slip detected
snr_dbhz   Signal strength
svid   Satellite number (0 - 31) Note - add 1 to offset to current svid numbers
valid   0 = information not valid; non 0 = information valid

dle and etx bytes:

Software written to receive the two records should filter dle and etx bytes as described below:

```
typedef enum
{
dat,
dle,
etx
} rx_state_type;

char            in_que[256];
int             in_que_ptr = 0;
rx_state_type   rx_state = dat;

void add_to_que( char data )
{

#define         dle_byte 0x10
#define         etx_byte 0x03

if (rx_state == dat)
   {
   if (data == dle_byte)
      {
      rx_state = dle;
      }
   else
      {
      in_que[ in_que_ptr++ ] = data;
      }
   }
else if (rx_state == dle)
   {
   if (data == etx_byte)
      {
      rx_state = etx;
      }
   else
      {
      rx_state = dat;
      in_que[ in_que_ptr++ ] = data;
      }
   }
```

```
else if (rx_state == etx)
   {
   if (data == dle_byte)
      {
      rx_state = dle;
      }
   }

if (in_que_ptr > 255)
   {
   in_que_ptr = 0;
   }
}
```

GARMIN PHASE MONITOR PROGRAM - GPS25PM.EXE

Command Line Arguments

default:
/com1   - selects which PC serial port to use for communication - com1, com2 (com1
              default).
/b:9600   - selects the baud rate - 1200, 2400, 4800, or 9600 (9600 default)

Description:

GPS25PM.EXE is designed to interface with a Garmin GPS 25 XL sensor board. The program will perform the following functions:
- display and log phase data output by GPS 25 XL,
- upload almanac, position, and time information.
- download almanac and ephemeris information.
GPS 25 XL is a DOS based program and will run on IBM 80286 or greater compatible PCs.

Displayed Information:

The GPS 25 XL display page is divided into 3 sections. The top-most section contains the following information updated at once a second:

A. Position
        1. WGS 84 Latitude, Longitude (degrees - minutes) - 0.0001 minute resolution.
        2. Ellipsoid Altitude (meters) - 1 meter resolution.

B. Velocity
        1. Each of 3 axis (meters per second) - 0.01 m/s resolution.
        2. Altitude (meters/minute) - 1 mt/m resolution.
        3. Ground Speed (kilometers/hour) - 0.1 km/h resolution

C. Estimated Position Error - Vertical, Horizontal, Total (meters) - 1 meter resolution

D. Track - (0 - 359 degrees) - 0.1 degree resolution

E. Time
1. GPS time (hours - minutes - seconds) - 1 sec. resolution (not leap second corrected)
2. Receiver Time of Week (GPS seconds) - 0.00000001 sec. resolution.

The middle section contains receiver measurement information for satellites which the GPS 25 XL is currently tracking. This information is updated once at second:

A Satellite Number (1 - 32)

B. Signal to Noise Ratio (dbHz) - 1 dbHz resolution.

C. Phase (0 - 359 degrees) - 0.1 degree resolution.

D. Pseudo Range (meters) - 1 meter resolution.

E. Accumulated Cycles (cycles) - 1 cycle resolution.

The bottom section contains program messages. Upload and download status messages will appear here as well as any program error messages.

Commands:

D - Download Almanac:

The GPS 25 XL will be sent a command to download almanac information. GPS 25 XL will created the file ALMANAC.DAT and locate it the current working directory. If an ALMANAC.DAT exists in the current directory it will be over-written.

U - Upload Almanac:

The ALMANAC.DAT file located in the current working directory will be read, converted to GPS 25 XL binary format, and sent to the GPS 25 XL. This command will over-write any almanac information already in the GPS 25 XL.

E - Download Ephemeris:

The GPS 25 XL will be sent a command to download ephemeris information. GPS 25 XL will created the file EPHEMERS.DAT and locate it in the current working directory. If an EPHEMERIS.DAT exists in the current directory it will be over-written.

P - Position and Time Upload:

The program will prompt the user for the local time offset from UTC time. This offset is then used to determine UTC time from the PC's real time clock. The UTC time is then uploaded to the GPS 25 XL. If an error occurs in the upload process a 'COMM ERROR' will be annunciated on the screen. After the UTC time has been uploaded the user is prompted for Latitude and Longitude for position uploading. An integer Latitude and integer Longitude should be entered on the same line separated by a space. If the board has not yet obtained a position fix it will restart its startup sequence based on the new position and time information.

R - Record Data

The program will prompt the user for a data file name. GPS 25 XL.DAT is the default. Once the file name is obtained all information displayed in the top two sections of the screen will be formatted and written to the data file. The format of this data file is described in the File Formats section. If the R option is selected again, the current file will be saved and closed and a new file will be opened. Data files will be over-written if same names are used.

File Formats

ALMANAC.DAT

Example almanac entry:

```
**** Week 794 almanac for PRN-01 ************
ID:                     01
Health:                 000
Eccentricity:           3.414630890E-003
Time of Applicability(s):  380928.0000
Orbital Inclination(rad):  9.549833536E-001
Rate of Right Ascen(r/s):  -7.771752131E-009
SQRT(A) (m^1/2):        5153.589843
Right Ascen at TOA(rad):  8.032501489E-002
Argument of Perigee(rad): -1.308424592E+000
Mean Anom(rad):         2.045822620E+000
Af0(s):                 9.536743164E-007
Af1(s/s):               8.367351256E-011
week:                   794
```

Almanac information for satellites with a bad health status will not be included in this file when downloaded from the GPS 25 XL and should not be included when uploading to the GPS 25 XL.

EPHEMERS.DAT

Example ephemeris entry:

```
**** Week 794.  Ephemeris for PRN-18 **********
Ref Time of Clk Parms(s):    233504.000000
Ref Time of Eph Parms(s):    233504.000000
Clk Cor, Group Dly(s):       -8.280389E-006
Clk Correction af1(s/s):     -3.410605E-013
Clk Correction af2(s/s/s):   0.000000E+000
User Range Accuracy(m):      33.299999
Eccentricity(-):             5.913425E-003
SQRT(A) (m**1/2):            5.153628E+003
Mean Motion Cor(r/s):        4.710911E-009
Mean Anomaly(r):             6.033204E-001
Argument of Perigee(r):      1.418009E+000
Right Ascension(r):          3.520111E-002
Inclination Angle(r):        9.434418E-001
Rate of Right Asc(r/s):      -8.210699E-009
Rate of Inc Angle(r/s):      4.503759E-010
Lat Cor, Sine(r):            1.212582E-005
Lat Cor, Cosine(r):          2.004206E-006
Inc Cor, Sine(r):            -1.490116E-008
Inc Cor, Cosine(r):          -9.872019E-008
Radius Cor, Sine(m):         38.375000
Radius Cor, Cosine(m):       132.937500
Issue of Data :              184
```

Ephemeris Record

- 0x10   (dle is first byte)
- 0x2A   (ephemeris record identifier)
- 0x94   (size of data)
- eph_type   (see description below)
- one byte chksum (the addition of bytes between the delimiters should equal 0)
- 0x10   (dle)
- 0x03   (etx)

```c
typedef struct      /* ephemeris record */
  {
  char   svid;      /* Satellite number (0 - 31)                    */
  int    wn;        /* week number (weeks)                          */
  float  toc;       /* reference time of clock parameters (s)       */
  float  toe;       /* reference time of ephemeris parameters (s)   */
  float  af0;       /* clock correction coefcnt - group delay (s)   */
  float  af1;       /* clock correction coefficient (s/s)           */
  float  af2;       /* clock correction coefficient (s/s/s)         */
  float  ura;       /* user range accuracy (m)                      */
  double e;         /* eccentricity (-)                             */
  double sqrta;     /* square root of semi-major axis (a) (m**1/2)  */
  double dn;        /* mean motion correction (r/s)                 */
  double m0;        /* mean anomaly at reference time (r)           */
  double w;         /* argument of perigee (r)                      */
  double omg0;      /* right ascension (r)                          */
  double i0;        /* inclination angle at reference time (r)      */
  float  odot;      /* rate of right ascension (r/s)                */
  float  idot;      /* rate of inclination angle (r/s)              */
  float  cus;       /* argument of latitude correction, sine (r)    */
  float  cuc;       /* argument of latitude correction, cosine (r)  */
  float  cis;       /* inclination correction, sine (r)             */
  float  cic;       /* inclination correction, cosine (r)           */
  float  crs;       /* radius correction, sine (m)                  */
  float  crc;       /* radius correction, cosine (m)                */
  byte   iod;       /* issue of data                                */
  } eph_type;
```

To initiate an ephemeris download for all tracked satellites send the following bytes in sequence:

0x10, 0x0D, 0x04, 0x02, 0x0C, 0x0, 0x0, 0xE1, 0x10, 0x03

GPS25PM.DAT

Example data file entry:

```
TIM time_of_week week_number
RCV svid snr (T)rack/(C)ycle_slip phase pseudo_range cycles
PVT time lat lon alt lat_vel lon_vel alt_vel epe eph epv
TIM  235537.99855650   794
RCV 18 50 T 120.2            19964528.44        2068193
RCV 29 50 T 133.2            20364313.25        1950557
RCV 28 45 T 176.5            21135153.13        2069992
RCV 19 47 T 145.2            21190271.83        2182643
RCV 31 45 T  75.8            21240354.20        2216421
RCV 22 42 T 195.1            22849183.41        1855826
RCV 27 36 T 155.2            24234175.55        2230462
RCV 14 39 T 202.3            25147694.34        1845263
PVT  235537.99999842         38.9499588         94.7463684 211.7 -0.19 -0.31  0.13  28  16  23
TIM  235538.99853500         794
RCV 18 50 T  38.8            19958107.10        2101947
RCV 29 50 T 132.4            20358247.54        1982431
RCV 28 45 T 189.5            21128713.01        2103829
RCV 19 47 T 284.6            21183470.16        2218374
RCV 31 45 T  19.0            21233441.89        2252746
RCV 22 42 T 263.0            22843381.08        1886300
RCV 27 36 T 311.7            24227194.88        2267146
RCV 14 39 T 308.3            25141899.86        1875708
PVT  235538.99999827         38.9499550         94.7463684 212.6 -0.19 -0.30  0.14  28  16  23
TIM  235539.99851349          794
RCV 18 50 T  76.6            19951681.26        2135704
RCV 29 50 T 284.4            20352180.11        2014308
RCV 28 45 T 320.8            21122272.68        2137669
RCV 19 47 T   8.3            21176671.33        2254110
RCV 31 45 T 170.2            21226528.82        2289074
RCV 22 42 T 315.9            22837584.50        1916778
RCV 27 36 T 132.4            24220207.85        2303835
RCV 14 39 T 127.4            25136106.23        1906158
PVT  235539.99999812         38.9499512         94.7463684 213.5 -0.19 -0.30  0.13  28  16  23
TIM  235540.99849199         794
RCV 18 50 T 174.9            19945258.21        2169465
RCV 29 50 T 177.7            20346113.87        2046190
RCV 28 45 T 159.6            21115834.07        2171514
RCV 19 47 T 324.7            21169868.61        2289849
RCV 31 45 T 111.8            21219615.05        2325407
RCV 22 42 T 261.7            22831782.87        1947261
RCV 27 36 T 259.1            24213226.41        2340528
RCV 14 39 T 318.7            25130310.86        1936612
PVT  235540.99999797         38.9499474         94.7463760 214.4 -0.19 -0.30  0.14  28  16  23
TIM  235541.99847244         794
RCV 18 50 T 325.5            19938831.69        2203229
RCV 29 50 T 152.1            20340045.44        2078075
RCV 28 45 T  52.4            21109392.21        2205362
RCV 19 47 T 125.3            21163068.15        2325593
RCV 31 45 T 159.4            21212700.30        2361743
RCV 22 43 T 117.1            22825981.54        1977748
RCV 27 36 T 352.1            24206248.88        2377225
RCV 14 39 T 141.3            25124515.72        1967071
PVT  235541.99999977         38.9499474         94.7463760 215.4 -0.19 -0.30  0.13  28  16  23
```

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