



GPS 20 SL

GPS SENSOR BOARD

TECHNICAL SPECIFICATION

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SECTION 1

INTRODUCTION

1.1 OVERVIEW

The GARMIN GPS 20 SL is a GPS sensor board designed for a broad spectrum of OEM (Original Equipment Manufacturer) system applications. Based on the proven technology found in all GARMIN GPS receivers, the GPS 20 SL will track up to eight satellites at a time while 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 20 SL 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 20 SL sensor board. This hardware capability combined with software intelligence makes the board set easy to integrate and use.

Although the GPS 20 SL 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. End user interfaces such as keyboards and displays are added by the application designer.

1.2 FEATURES

The GPS 20 SL 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 8 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) Navigation mode (2D or 3D) may be configured by the user
- 8) Two communication channels and user selectable baud rates allow maximum interface capability and flexibility
- 9) 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) Draws less than 180 mA @ 5 VDC
- 3) Backup power: 3V Lithium coin cell battery, up to 10 year life
- 4) Receiver sensitivity: -165dBW minimum

1.3.4 Performance

- 1) MultiTrac™ technology, tracks up to 8 satellites
- 2) Update rate: 1 second
- 3) Acquisition time
 - 15 seconds warm (all data known)
 - 2 minutes cold (initial position, time and almanac known, ephemeris unknown)
 - 7 minutes AutoLocate™ (almanac known, initial position and time unknown)
 - 15 minutes search the sky (no data known)

4) Position accuracy:

Differential GPS (DGPS): 3-10 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, 3g 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

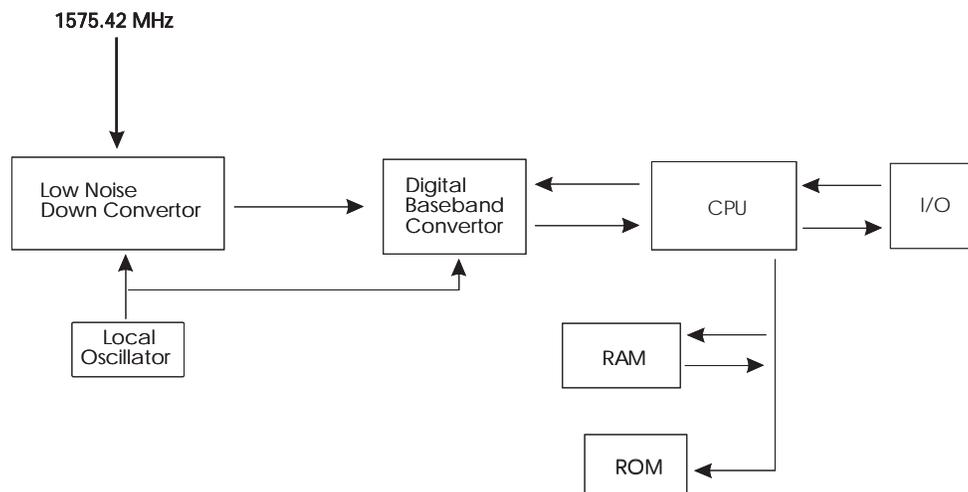
- Differential Reference Station ID and RTCM Data age

- Geometry and error estimates

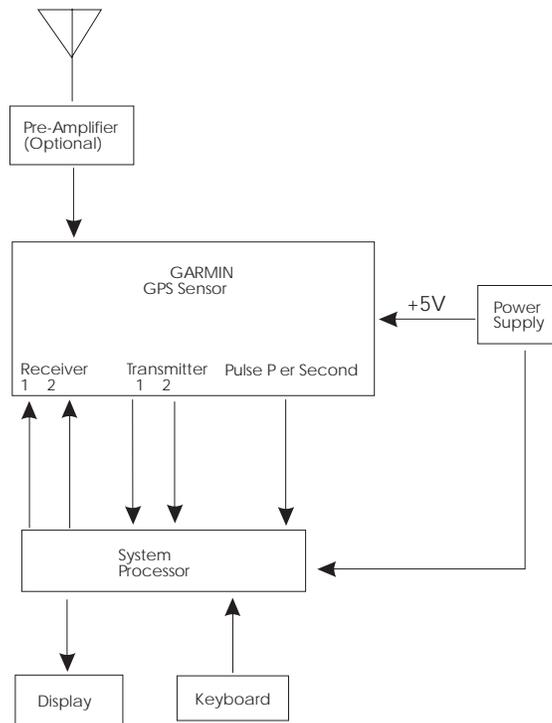
3) Real-time Differential Correction input (RTCM format)

4) One-pulse-per-second timing output

1.4 APPLICATION



GPS 20 SL BLOCK DIAGRAM



TYPICAL APPLICATION ARCHITECTURE

1.4.1 Application Considerations

- 1) The GPS 20 SL 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 20 SL 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 20 SL sensor board. Additional information regarding input and output specifications are contained in Section 4.

2.1 SELFTEST

After input power has been applied to the GPS 20 SL 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 20 SL will begin the process of satellite acquisition and tracking. The acquisition process is fully automatic and, under normal circumstances, will take approximately 2 minutes to achieve a 2D position fix and 2.5 minutes for 3D fixes (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 20 SL 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 5 to 15 minutes to achieve a navigation solution. The GPS 20 SL 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
- 3) Stored date/time off by more than 30 minutes

See Section 4 for more information on initializing the GPS 20 SL.

2.3 NAVIGATION

After the acquisition process is complete, the GPS 20 SL 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

Normally the GPS 20 SL sensor board will select the optimal navigation mode (2D or 3D) based on available satellites and geometry considerations. The host system, at its option, may command the board set to choose a specific mode of navigation, such as 2D. The following modes are available:

- 1) 2D exclusively with altitude supplied by the host system (altitude hold mode)
- 2) 3D exclusively with altitude computed by the board set
- 3) Automatic mode in which the board set determines the desired mode based on satellite availability and geometry considerations

When navigating in the 2D mode (either exclusive or automatic), 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 more information on altitude control.

Operation in the exclusive 3D mode may cause undesirable navigation outages due to satellite shading or limited satellite availability. However, because the GPS 20 SL sensor board tracks up to 8 satellites in view, this condition will be minimal, as the GPS satellite constellation status has reached initial operational capability.

The GPS 20 SL 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 20 SL 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:

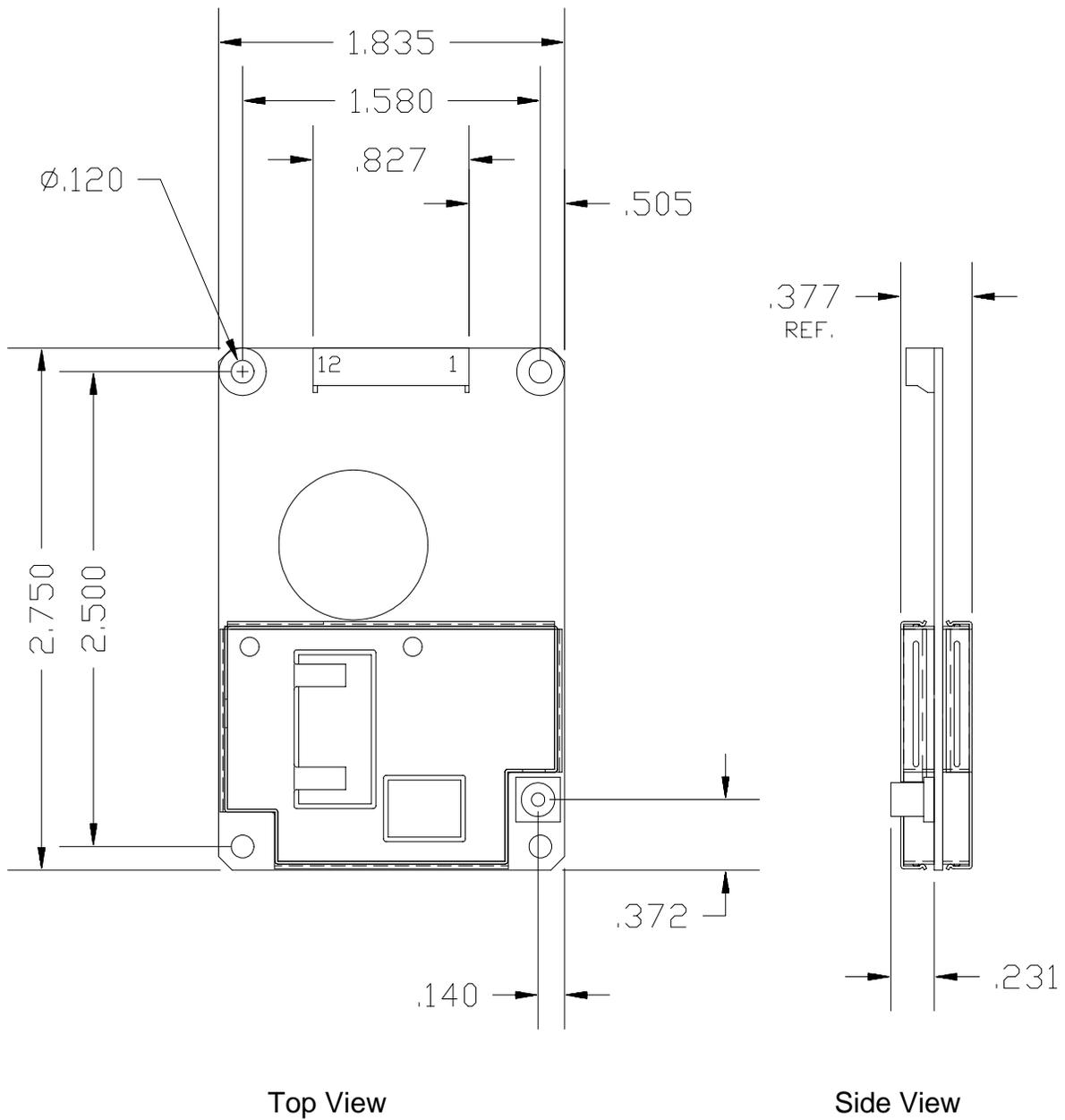
- 1) If the sensor board is not operated for a period of six (6) months or more, the unit will “search the sky” in order to collect satellite orbital information. This process is fully automatic and, under normal circumstances, will take 7-8 minutes to achieve a navigation solution. However, the host system should allow the board set to remain on for at least 12.5 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 4-10 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 20 SL sensor board mounts via four #4 or M-3 size screws (see drawing).



3.2 CONNECTOR SPECIFICATIONS

The GPS 20 SL 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% 180mA 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. (not used)
- 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. Impedance is 250 ohms. Open circuit output voltage is 0V and 5V. Format is a 10% 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". Selectable 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 is 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 μ A. Input impedance 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 μ A. 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 20 SL.
- Pin 10: VCC - Regulated +5V \pm 5%, 200 mA (maximum). When reset, current is typically 70 mA. Typical operating current is 170 mA. A well regulated, filtered and transient protected 5V power source is required. Transients, over voltages or reverse voltages will damage the GPS 20 SL 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 20 SL.
- Pin 12: NMEA - NMEA 0183, Version 1.5 electrical specification compatible serial output. This output is 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 on this pin is identical to the data output on pin 4.

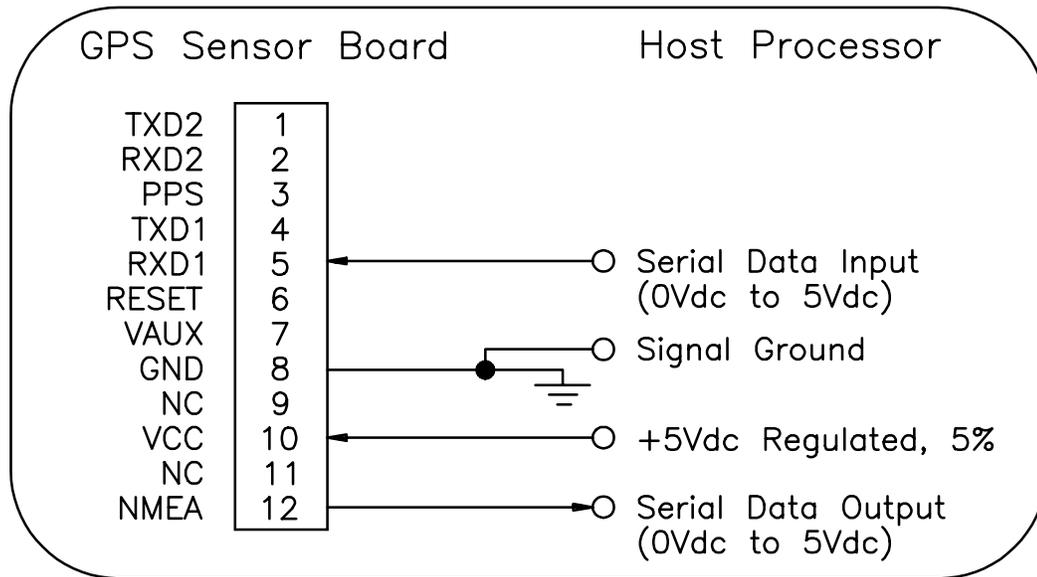
Typical Embedded Application Interconnect

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.

Typical Personal Computer Application Interconnect

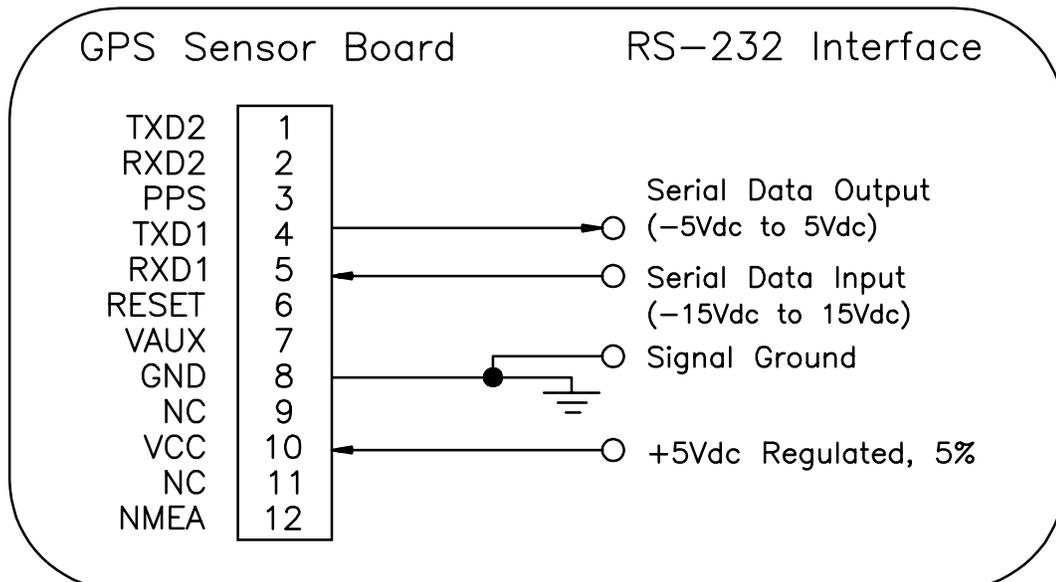
The following connections are suggestions for applications where the sensor board will be



connected to a personal computer via a standard RS-232 interface.

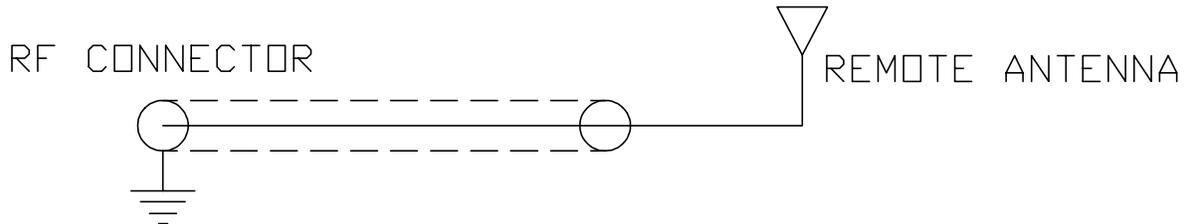
3.4 ANTENNA CONNETION

The GPS 20 SL 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).

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



The standard GPS 20 SL 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.

<u>Type</u>	<u>Typical Attenuation dB/100' @ 1 GHz</u>
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 20 SL 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 20 SL 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 20 SL 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 20 SL.

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, ddm.ddd 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 20 SL 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 = 2D 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 second filter)
- <12> PPS mode, 2 = 1 Hz (only option)

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: GPGGA, 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 20 SL.
- 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 20 SL 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 20 SL is referenced to the one-pulse-per-second output pulse immediately preceding the GPRMC sentence.

The GPS 20 SL 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	140
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.

4.2.2 Transmitted Time

The GPS 20 SL 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 20 SL 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 20 SL would have transmitted this information for the leap second added December 31, 1989 as follows:

<u>Date</u>	<u>Time</u>
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 20 SL 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. Upon 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, ddm.ddd format (leading zeros will be transmitted)
- <3> Latitude hemisphere, N or S
- <4> Longitude, dddmm.ddd 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>,,,<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 8 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, ddm.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 transmitted)

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, ddm.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, ddm.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 20 SL 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 20 SL 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 20 SL 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 3-10 meters can be achieved with the GPS 20 SL by using Differential GPS (DGPS) real-time pseudo-range correction data in RTCM SC-104 format. These corrections can be received by the GPS 20 SL sensor board on RXD2. Correction data at speeds of 300, 600, 1200, 2400, 4800 or 9600 baud can be utilized, as the GPS 20 SL 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 20 SL 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.

J.S.T. CORPORATION
1200 Business Center Drive
Suite #400
Mount Prospect, IL 60056 U.S.A
Phone: (708) 803-3300
Fax: (708) 803-4918

JAPAN

J.S.T. TRADING CO., LTD.
Hankyu Senrichuo Building
No. 4-1, 1-Chrome
Shin-senri higashi-machi
Toyonaka, Osaka 565, Japan
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 20 SL EVALUATION KIT

010-10059-00

GPS 20 SL evaluation kits are available from Garmin International. These kits include a GPS 20 SL sensor board, a GPS antenna, a 5V power supply, an interface cable for PC serial port connection, and software to monitor GPS20 SL 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.



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