USER GUIDE

for the

MAGELLAN OEM GPS MODULES

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PART I — DEVELOPERS' KIT

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PREFACE

For ease of use, this guide is divided into four parts. Part I describes the items that are supplied with the Developers' Kits and provides an overview of the OEM firmware.

Part II is the Firmware Guide. It includes a detailed description of the firmware and startup procedures for both OEM GPS Modules. Other chapters in this section describe firmware requirements, message formats, and various input and output messages.

Part III is the Hardware Guide, which contains the hardware requirements of the OEM GPS Modules and system specifications. It also describes the Magellan antennas and mounting accessories.

Part IV is a brief description of the Global Positioning System for those who are new to GPS. It also contains several sources for updated information on satellite health and for additional information on GPS.

PART I

DEVELOPERS' KITS (DK)

CHAPTER 1

PRODUCT DESCRIPTION

INTRODUCTION

This chapter describes the Magellan OEM GPS Modules and provides documentation on the accessories contained in the Developers' Kit (DK) for each module. It also describes how to power-up the boards for the first time and how to use the OEM_CDU software program.

Two hardware versions of the OEM GPS Modules are available. Both are described in this document. The OEM board with power supply is P/N 00-85000-xxx, where "xxx" indicates the firmware configuration purchased. This board is referred to throughout this document as OEM/PS. The Developers' Kit for the OEM/PS is P/N 00-88500-000.

The OEM board without power supply is P/N 00-85001-xxx, where "xxx" indicates the firmware configuration purchased. This board is referred to throughout this document as OEM/5V. The Developers' Kit for the OEM/5V is P/N 00-88501-000.

In addition, the Developers' Kit for the OEM/5V contains a separate power supply board (P/N 23-80010-000) to allow testing and evaluation of the OEM/5V. The power supply board accepts both the OEM Power Cable and the OEM Data Cable, and has a 5-volt regulator and RS-232 drivers. It is referred to throughout this document as PS/5V.

This chapter should be read thoroughly before the modules are removed from the anti-static envelope, and before any power is applied to them.

CAUTION

Both the receiver and digital portions of the board contain sensitive CMOS components. They should be used only in a low-static environment, and all physical handling of the modules should be kept to a minimum.

The Developers' Kit for the OEM/PS (P/N 00-88500-000) consists of the following items:

QTY	P/N	DESCRIPTION
1	23-00013-000	Power Cable, 12" (30.48 cm) length
1	23-00014-000	RF Interface Cable, SMB to TNC
1	23-00015-000	Data Cable, 5' (1.5 meter) length
1	43-00005-000	115 VAC to 12 VDC Wall Adaptor
1	23-80007-000	OEM_CDU.EXE disk, 3.5"
1	22-80007-000	OEM User Guide

The Developers' Kit for the OEM/5V (P/N 00-88501-000) consists of the following items:

QTY	P/N	DESCRIPTION
1	23-00013-000	Power Cable, 12" (30.48 cm) length
1	23-00014-000	RF Interface Cable, SMB to TNC
1	23-00015-000	Data Cable, 5' (1.5 meter) length
1	43-00005-000	115 VAC to 12 VDC Wall Adaptor
1	23-80010-000	OEM Development Power Supply, stepdown 12 VDC to 5 VDC, PCA
1	23-80007-000	OEM_CDU.EXE disk, 3.5"
1	22-80007-000	OEM User Guide

Assorted spacers and mounting hardware

KIT DESCRIPTION

This section describes the parts included in the Developers' Kits in detail.

Power Cable

The power cable has a 7-pin Molex plug on one end and a switch block with a female miniature phono jack on the other. When used with the OEM/PS, the plug connects to J1 on the CPU board. (See Figure 3.) When used with the OEM/5V, the Molex plug connects to J1 on the PS/5V. (See Figure 4.) The phono jack connects to the 115 VAC/12 VDC wall adaptor; a power switch provides on/off capability. (See Figure 1.) The switch is in the OFF position when it is pointed away from the cable exit of the switch block.

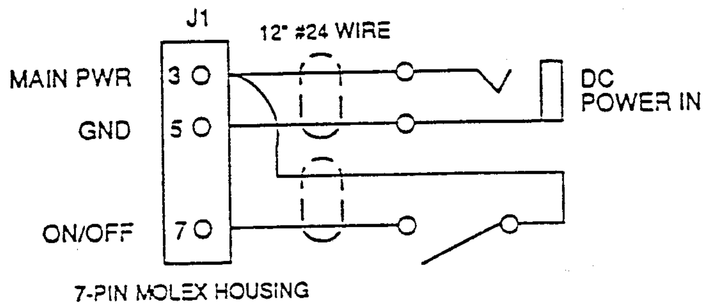


Figure 1. Developers' Kit Power Cable

Data Cable

When used with the OEM/PS module, the data cable connects to J2 on the CPU board; when used with the OEM/5V module, it connects to J2 on the PS/5V. The Molex end of the data cable is a 7-pin female that mates with a 10-pin male on the OEM/PS and a 7-pin male on the PS/5V. Care must be taken to ensure that the cable is installed as shown in Figures 3 and 4.

Both Developers' Kits are pre-configured for RS-232, and the data cable is wired to a DB-25 connector for the port 1 serial port of an IBM-PC or compatible. The supplied demo software (OEM_CDU.EXE) is designed to run under MS-DOS and operates through port 1 only. If you want to convert the DB-25 to DB-9, use an adaptor cable (such as Radio Shack P/N 26-269 or equivalent).

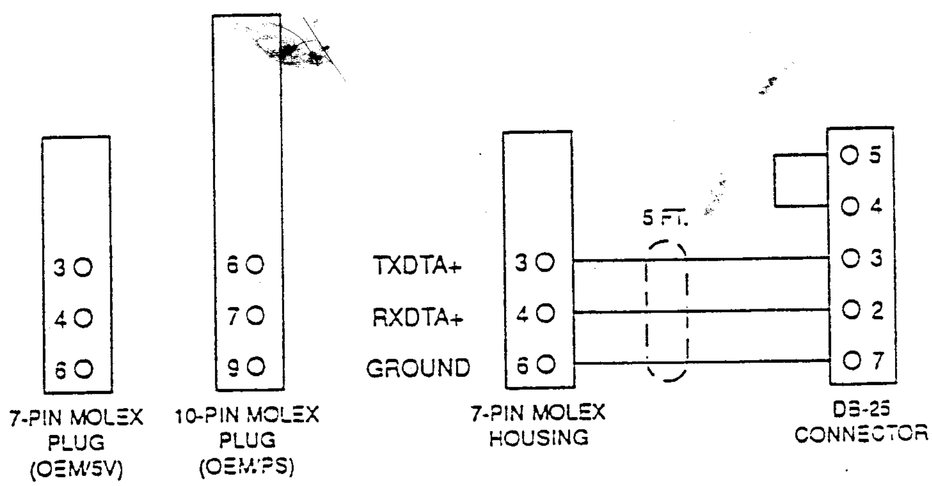


Figure 2. Developers' Kit Data Cable

TNC-to-SMB Adaptor Cable

The TNC-to-SMB cable is a converter cable that allows you to connect he SMB connector on the OEM units' RF boards to he TNC connector on the remote antenna's coaxial cable. (Both the A50 and A18 are supplied with an RG-58 coaxial cable terminated in TNC connectors.) It should be stressed that the force applied to the SMB connector on the RF board should be kept to a minimum. Although care has been taken to ensure a rugged connection, it has not been designed to withstand the constant movement that will be applied to the board in an open test environment.

> **NOTE**
>
> The TNC-to-SMB cable is part of the Developers' Kits for testing purposes. The cable is **not** part of the RF/CPU board, and is **not** supplied when the board is purchased separately. The TNC-to-SMB cable is available as a separate item.

> **WARNING**
>
> Do not install or remove the antenna connector when power is applied to the board. When powered, components in the area under the RF connector receive +5 VDC.

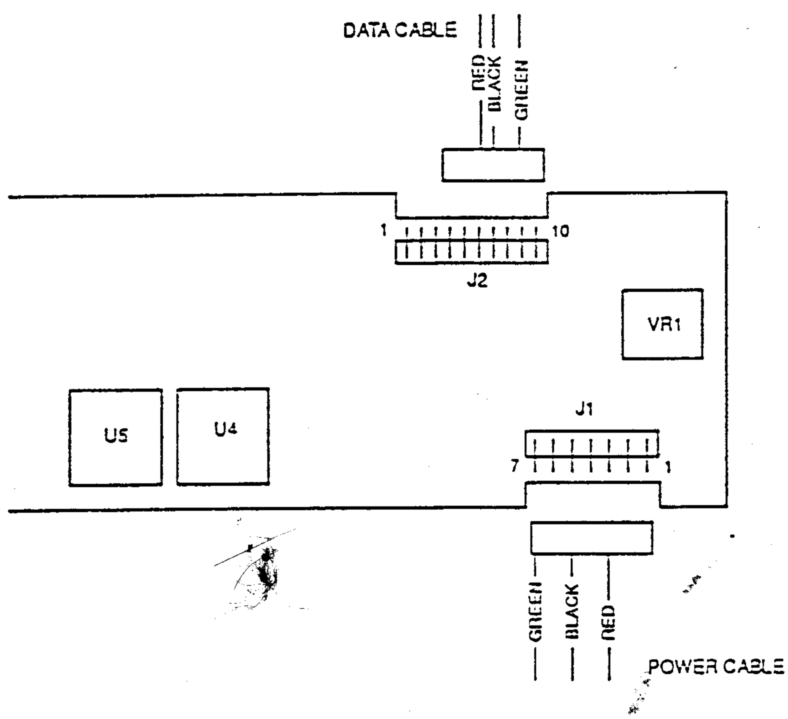


Figure 3. Connecting the Cables to the OEM/PS Board

115 VAC/12 VDC Wall Power Supply

The AC-to-DC wall adaptor is provided as a convenient method of supplying the board with the proper DC voltage. It plugs into a standard wall socket, and has a miniature male phono plug for connection to the board's power cable. (The adaptor conforms to U.S. Standards; users outside of the U.S. may require an adaptor for the wall plug or a transformer to step down to 115 VAC.)

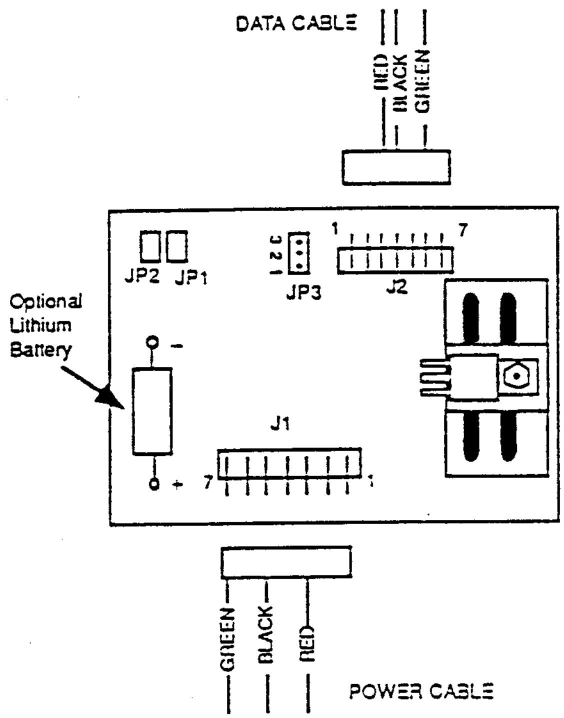


Figure 4. Connecting the Cables to the PS/5V Board

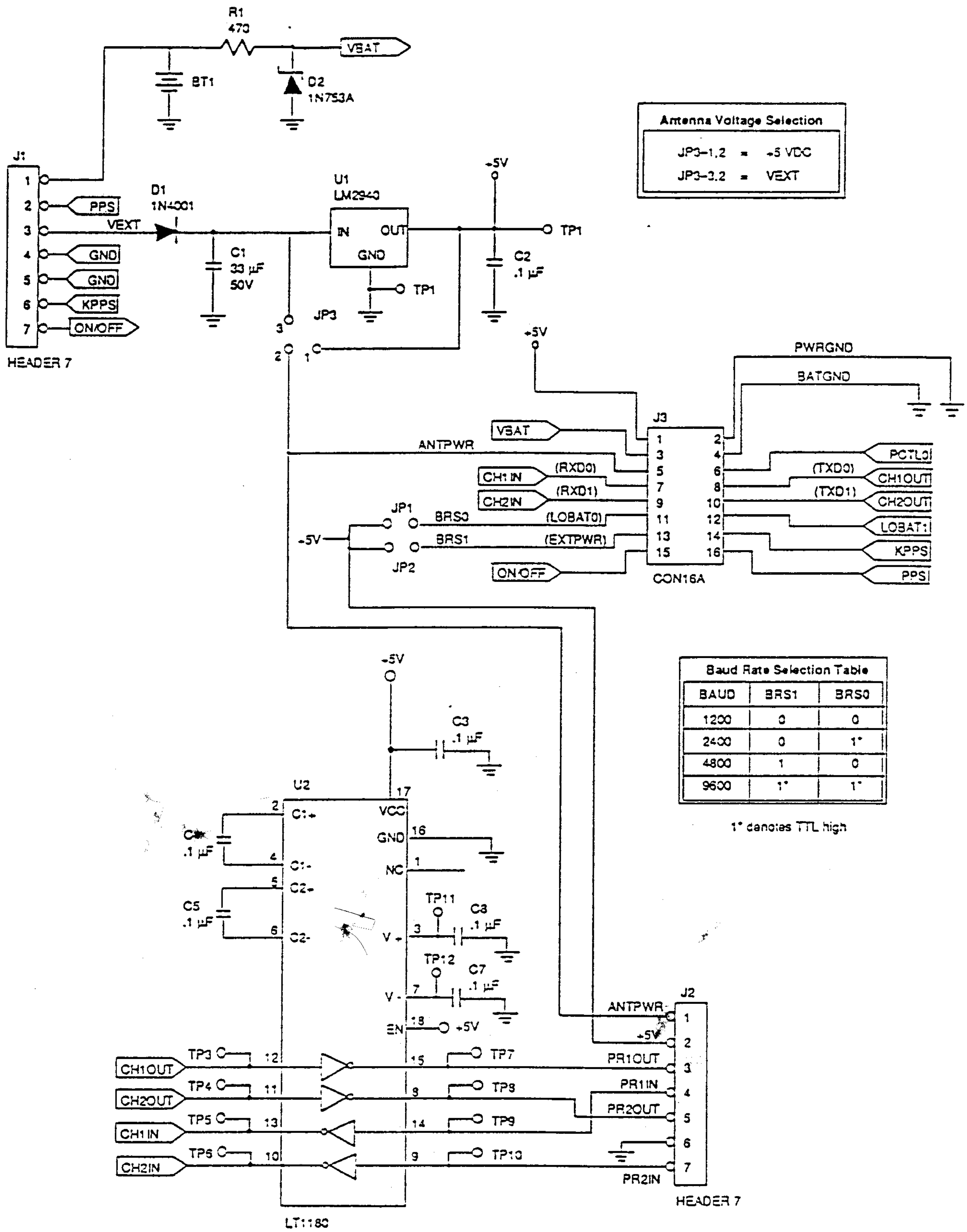
- *Power Supply Module for the OEM/5V (PS/5V)*
The OEM/5V module has no power supply interface and no input/output drivers. The power supply board (P/N 23-80010-000) is designed to provide power and drivers to the OEM board for testing; it is not designed for production.

The PS/5V can be mounted on the OEM/5V board with the spacers and hardware provided. The PS/5V converts +12 VDC to +5 VDC and provides RS-232 drivers for Port 1 and Port 2. (Only Port 1 on the data cable is connected.)

The PS/5V has reverse polarity protection, and holes for mounting a 3.6 V lithium battery for memory backup. Jumpers are provided for baud rate selection (JP1 & JP2) and antenna voltage selection (JP3-1, 2, 3).

CDU Software
The CDU (Control Display Unit) Software is an executable program that runs on an IBM-PC or compatible. Originally developed for in-house use, it provides communications with the board, allowing initialization, configuration, and testing. It is designed to exercise all of the functions of the OEM board in both the ASCII and binary protocol, converting the binary to ASCII-hexadecimal for display and logging purposes. The CDU software operates only on COM1. Although some of the program parameters can be changed while it is running, the default configuration (9600 baud) can not be altered.

NAV Software
The NAV.EXE software is also supplied on the demo disk. This software is provided free of charge and is not supported by Magellan Systems; all documentation for the NAV software is on the disk and is not included in this user guide.



Antenna Voltage Selection

JP3-1,2	=	+5 VDC
JP3-3,2	=	VEXT

Baud Rate Selection Table

BAUD	BRS1	BRS0
1200	0	0
2400	0	1*
4800	1	0
9600	1*	1*

1* denotes TTL high

Figure 5. Functional Block Diagram of the PS/5V Board

OEM SOFTWARE INSTRUCTIONS

This section describes the operation of the OEM_CDU (Control Display Unit) program. It runs under DOS on an IBM or compatible personal computer, and uses the applicable sentences from the OEM firmware protocol (see Firmware User Guide) to control the OEM GPS receiver and to display the messages returned from the receiver. It is capable of using all messages in the firmware protocol, both ASCII and binary.

OEM_CDU.EXE Menu

Effective use of this program will be difficult without some study and/or reference to the OEM Firmware Guide. Although some of the choices are self-explanatory, an understanding of the general philosophy of the data exchange protocol is necessary. Several operational tips are addressed here.

Keep in mind that because the firmware is capable of communicating in both ASCII or binary protocol (refer to Part II), most data sentences have both binary and ASCII versions. Where the reference 'GPGGA/B0' is used, it is understood that the first reference 'GPGGA' refers to the ASCII sentence and the 'B0' is the corresponding binary sentence.

```
===================== OEM CDU =====================
 1. Exit Program                    12. Clear/Rename Waypoint
 2. Initialize Receiver             13. Specify 2D or Auto 2D/3D
 3. Send Diff Corrections           14. Send Altitude
 4. Control Output Message          15. Select/Clear Route
 5. Send Magnetic Deviation         16. Recompute Satellite Selection
 6. Change Output Units             17. Master Reset(Clr RAM&Restart)
 7. Send Almanac to Receiver        18. Clear Remembered Position
 8. Send Ephemeris to Receiver      19. Toggle Binary/ASCII Mode
 9. Enable/Disable Satellites       20. Toggle Logging Data to File
10. Choose Satellite Set            21. Change Baud Rate/RTCM Selection
11. Enter Waypoint Definition       22. Time Transfer Setup/Time-Only Mode

            ENTER CHOICE:
     Last Error:
=====================9600=====================
```

Figure 6. The OEM Menu Screen

1. EXIT PROGRAM

2. INITIALIZE RECEIVER: Uses the position and altitude sentence GPGGA/B0, the day/date sentence GPZDA/A0, and the mode PMGLD/D0 sentence to initialize the receiver. The OEM_CDU takes its input in degrees.fractions of a degree, with a negative value for South or West. If the OEM_CDU.EXE is sending ASCII, this is translated into degrees/minutes.hundreds of a minute N,S,E, or W, placed into the GPGGA sentence, and sent to the board. ASCII/binary output of the OEM_CDU.EXE is toggled with menu selection 19.

3. SEND DIFFERENTIAL CORRECTIONS: Converts user-entered differential correction data to binary and sends it to the module in message J0. This message will be ignored by the OEM unless the current IODE and (UTC) time of correction for this satellite is obtained.

4. CONTROL OF OUTPUT MESSAGES: This function uses the PMGLI sentence to control the flow of data out of the module's serial port. With it you can turn sentences on or off, specify ASCII or binary, and repetition interval. For a further description and usage of the PMGLI sentence refer to INPUT MESSAGES in the OEM Firmware Guide.

After choice 4 is entered, the prompt will show:

```
Enter 3 character message type:
```

The three characters go into field 2 & 3 of the SPMGLI data sentence, (i.e., 'A00' for time and date, 'T01' for almanac data).

5. MAGNETIC DEVIATION: Uses the GPHVM/R4 data sentence to set the user-determined magnetic deviation. East is a positive value and west is negative. This value is applied only if 'user' is chosen in selection 6 (field 6 of the PMGLS/S1 data string).

6. CHANGE OUTPUT UNITS: Uses the PMGLS/S1 data sentence to set the terrain, datum, distance and speed units, altitude units, and magnetic variation mode. (Refer to page 4-26 for a description of terrain settings and a list of available datums.)

7. SEND ALMANAC TO RECEIVER: If you have previously collected and saved an almanac as described at the end of this section, you can use this to send the almanac to the receiver as part of a WARM START. The almanac is a binary-only sentence (T1). Although the almanac is pure binary the OEM_CDU.EXE converts it to binary-coded ASCII for data display (as it does all binary sentences), and that is the way it is stored on disk. When this program sends the almanac to the receiver, almanac data is converted back to pure binary. If you look at the file that is created, it will be much larger than 930 bytes.

8. SEND EPHEMERIS TO RECEIVER: If you have previously collected and saved ephemeris data as described at the end of this section, you can use this to send ephemeris to the receiver as part of a HOT START if the ephemeris is no more than 2 hours old.

9. ENABLE/DISABLE SATELLITES: Uses the PMGLU,04/U4 sentence to set user-selected satellite health. If the satellite is marked unhealthy in the almanac, this function allows you to force the receiver to regard it as healthy; if healthy, to regard it as unhealthy; or return the satellite status to normal.

10. CHOOSE SATELLITE CONSTELLATION: Uses the PMGLP/P0 message to send user-selected satellites to the unit. These three or four satellites will be continuously tracked or searched for unless they are changed with another selection 10 or cancelled with selection 16.

11. ENTER WAYPOINT DEFINITION: Uses the GPWPL/R5 sentence, which allows the entry of up to 100 latitude/longitude waypoints for storage and navigation. After a waypoint is entered, it will not be used until a route (selection15) is set. Waypoint ID can be any alphanumeric combination, but it must occupy four places. Spaces are allowed. Both ASCII and binary usage of waypoint identifiers have the same definition.

12. CLEAR OR RENAME WAYPOINT: Uses the PMGLR/R10 message to clear or rename waypoints. Also allows the current position (last fix) to be stored as a waypoint.

13. SPECIFY 2D OR AUTO OPERATING MODE: Uses PMGLD/D0 sentence to select 2D (3-satellite fix with user-provided altitude) or AUTO (3D if four satellites are above mask angle, 2D if not). AUTO will automatically go into 3D when there are at least four satellites above the current mask angle with a PDOP of 6 or less. When PDOP is greater than 8, the receiver switches to 2D.

14. SEND ALTITUDE: Uses the PMGLB/B02 message to send altitude to the receiver.

15. SELECT/CLEAR ROUTE: Uses the PMGLR,08/R8 sentence to clear an existing route or to designate a route by route number, origin, and destination waypoint. Only one point-to-point route can be set at a time; routes cannot have multiple legs. The route number is ignored.

16. RECOMPUTE SATELLITE SELECTION: This selection uses the PMGLM/M0 sentence to force the software to recompute the satellite selection. Satellite selection is done by optimum geometry from the available satellites in the sky. If the optimum selection is being used, this will have no apparent effect. If not, the unit will go into acquisition (status 5) and reacquire the new set of satellites for the selected mode (2D/AUTO).

17. MASTER RESET: This uses the PMGLN/N0 sentence to clear the RAM to all zeros (0) and to reset the CPU. When used all internal data will be erased, including the almanac, all stored waypoints, and the setup configuration.

18. CLEAR REMEMBERED POSITION: This selection uses the PMGLN,01/N1 message to force the unit into an abbreviated COLD START by ignoring the initial position. The almanac and time are retained.

19. TOGGLE BINARY/ASCII MODE: Changes the mode of operation of the OEM_CDU.EXE program. Default operation is ASCII output. Toggling this changes CDU output to binary. The selection affects the output of the OEM_CDU program only; it does not affect the output of the OEM receiver.

20. TOGGLE LOGGING DATA TO A FILE: All data being displayed on the lower portion of the OEM_CDU.EXE display can be logged to a DOS file. You will be prompted for a DOS file name. When entered, press <CR> to accept. To close the file do selection 20 and <CR>.

21. CHANGE BAUD RATE/SELECTION: The Magellan OEM GPS module has four baud rates, which are jumper-selectable through JP2 and JP3 on the OEM/PS (see Table 7 on page 6-5) and through JP1 and JP2 on the PS/5V (see Figure 5, page 1-5) and through BRS0 and BRS1 (see Figure 10 on page 6-8 and Table 9 on page 6-11). The available baud rates are 1200, 2400, 4800, and 9600; default is 9600. The baud rate can also be set through the firmware. This menu selection uses the PMGLO,00/O0 sentence to change the baud rate for port 1, and then changes the OEM_CDU.EXE baud rate to agree. If the PMGLI,01/O1 sentence is selected to change the baud rate for port 2, the OEM_CDU.EXE remains unchanged. If you maintain main or back-up power to the unit, any baud rate change is remembered when the power-up command is given. If all power is removed, the unit will come up in its default rate, as indicated by the jumpers. Port 2 follows port 1 switch settings on cold power-up.

    If RTCM is selected with the PMGLO,02/O2 senetence, you will be prompted to turn port 2 on or off for RTCM input.

22. TIME TRANSFER SETUP/TIME-ONLY MODE: The time transfer setup uses the PMFLK,01/K1 data message to configure the timing receiver (P/N 00-8500X-003). The time only mode uses the PMGLK,02/K2 data message to turn the time only mode on and off. Using these messages on other firmware versions has no effect.

To Log Ephemeris or an Almanac

If the module is currently outputing data to the OEM_CDU.EXE program, turn off all data output. This will have to be done one sentence at a time with selection 4. Turn on a log file with selection 20. Next, do selection 4 and respond with 'T01' (for almanac) or 'T02' (for ephemeris). Then enter '1' for 1 time, and '2' for binary. You will see the data dump to the screen and disk. (Ephemeris data is output for a specific satellite; specify which satellite.) When the dump is complete, close the disk log with selection 20.

TYPICAL COLD START SCENARIO

1. It is best to connect all cables to the board before the power is applied and before the data cable is connected to the computer. This will allow you to rectify any problems before possible damage occurs. A good way to prevent damage on the OEM/PS board, especially damage related to the antenna output voltage, is to double-check the JP1-JP14 jumpers.

WARNING
There is NO protection for reverse polarity on the OEM/5V.

2. Connect power to the switch block. The proper sequence is to plug the miniature phono plug into the switch block and then plug the wall supply into 115 VAC. (The power switch may be on or off.)

3. Connect the data cable to COM1 of your PC. If a converter cable is used to convert the DB-25 connector to a DB-9, you must use a straight-through cable, not a null modem cable. (Radio Shack P/N 26-269 is acceptable.)

4. If the OEM_CDU.EXE program is not running, start it. There is no handshaking, so it can be started at any time. The OEM_CDU.EXE always comes up on the default 9600 baud. If you have selected a different baud rate, you will have to change the OEM_CDU baud rate before the board will recognize any commands.

NOTE
The antenna must be placed with as clear a view of the sky as possible for proper satellite signal reception. The receiver will operate without the antenna being connected, but will not locate any satellites.

Menu Selection

First, test the receiver to see if it is powered-up. Press menu selection 4. Answer with H00 <CR> 2 <CR> 1 <CR>. This requests the status sentence, PMGLH. (All sentences are referred to by their binary header. The header for the status sentence is $SH0. The 'H' is ASCII, and is used as-is . The subindex is binary, in this case '0', and is converted to hexadecimal ASCII to become '00'). The '2' indicates continuous output at a 1-second interval, and the '1' is for ASCII. You should see the sentence begin scrolling down the bottom of the screen at a 1-second rate.

If everything checks out so far, continue with initialization. If not, remove power and rectify the problem. If you can not identify the problem, call us at (909) 394-5000, and ask for customer service. We will not be critical of any oversights on your part; we would rather hear from you than have you spend your time unnecessarily.

Initialize Receiver

If you do not initialize the receiver yourself the unit will search the sky, locate satellites, collect an almanac, and produce a position fix. No data will be output until you request it.

Choose menu selection 2 to initialize the receiver. You will be prompted for:

1. Mode — 2D mode should be chosen first to allow the quickest path to position-fixing. You can change it after you get things up and running.

2. GMT time — You can enter your own GMT time or, if your computer has correct local time, you can use it.

   If you use computer time the program will prompt you for a GMT offset from your current time zone. If this is the first time you have powered up the receiver and have never collected an almanac, the accuracy of this time is not critical. When the board starts to collect an almanac, the first thing it will do is get accurate GMT time.

If you have loaded a previously collected almanac to the board, this time is critical. After accepting an almanac, initial position and GMT time, the board will use these to decide which satellites are visible.

If you choose to use computer time and enter a GMT offset, that offset is maintained in the OEM_CDU.EXE program until exited. If you initialize the board again and select computer time, you will not be prompted for another offset. If you make a mistake in entering the offset you must exit the program and start again.

3. Lat/Lon — Enter latitude/longitude (degrees.fractions of a degree, i.e., 34.08 and -117.59) within 300 miles (482.7 km) of your present position. Southern latitudes and Western longitudes are negative values in the binary sentences and when entered through the OEM_CDU.EXE program.

4. Altitude — Enter altitude in meters for your present position. This value is not critical for just getting a fix, but becomes quite critical when solving for best accuracy. This value is used only when in the dedicated 2D mode or in AUTO/2D when the unit has not been in 3D since power-up.

To check the accuracy of the data you have just entered, ask the receiver to give it back to you. Press "4 B00 2 1" and then "4 A00 2 1". The GPGGA message will contain L/L and altitude. The GPZDA message contains the UTC day, date, and time. Verify that the information is correct. Remember that the L/L you entered in degrees.fractions is now displayed in degreesminutes.fractions N S E W. If the information is not accurate, locate the error and re-enter it. Then cycle the ON/OFF switch off and back on.

The receiver will proceed through the abbreviated COLD START process, which is described in the Firmware Section (Part II). The status (field 11 of PMGLH) should proceed from 2 to 3 to 5 to 4 to 6. The time from 5 to 6 should be less than 1 minute, depending on satellite visibility from your antenna placement.

FOR A QUICKER STARTUP

The first time you start up the receiver, it must go through search the sky and almanac collect, taking anywhere from 5 to 20 minutes before fixes are produced. You can avoid the delay in future startups by doing one of two things:

1. Maintain standby power on the module. This will keep the almanac, time, and initial position alive in memory. The module will give fixes within 45 – 75 seconds of power-on.

2. Save the almanac as described above and send it to the receiver (OEM_CDU menu selection 7) right before you do the Initialize Receiver command (section 2). Again, you should get your first fix in 45 – 75 seconds.

HAVING PROBLEMS?

If your receiver doesn't seem to be working, here is a quick checklist of things to look into before you call us for assistance:

1. Check your cables. Are the connectors right-side-up and connected to the right pins?

2. Are your jumpers configured for the right communications parameters (baud rate, RS-232/RS-422/TTL/NMEA)? Are they in the right configuration to power your antenna with the appropriate voltage?

3. The antenna must have line-of-sight view of most of the sky.

4. Check your GPGGA message to see if your latitude and longitude (including the N/S and E/W indicators) are correct. Remember the OEM_CDU program requires a negative sign for longitude in the Western Hemisphere and a negative sign for latitude in the Southern Hemisphere.

5. Check UTC time and date in the GPZDA message. An incorrect time could be caused by inaccurate computer time or an erroneous offset. (For your reference, the UTC offset for Pacific Standard Time to UTC time is +8 hours, or +7 hours for Pacific Daylight Savings Time.)

6. If items 1 – 5 are in order and the receiver still isn't working, do a Master Reset (or remove all power for at least one minute). Then turn on the H00, B00, A00, and G00 messages and observe what the receiver does. It should be in status 6 (POS) long before one hour has elapsed.

7. If the receiver powers up but cannot find satellites, make sure the antenna has a clear view of the sky. When using the OEM/PS, check JP-11 (5V) or JP-12 (VEXT) to be sure the active antenna (if used) has been installed correctly. When using the OEM/5V with the Developers' Kit power supply, check JP3-1 & 2 (5V) or JP3-2 & 3 (VEXT) to be sure the proper voltage has been selected. If using the OEM/5V without the Developers' Kit power supply, you are responsible for the voltage on J3-5.

8. If you continue to have problems, turn on the following messages at the indicated rates and log the data:

H00	1 second
F02	1 second
A00	1 second
B00	1 second
E00	1 second
B02	1 second
G00	5 seconds
R04	30 seconds
F01	30 seconds
D00	30 seconds
S01	30 seconds

This data will help you and us determine the nature of your problem.

CHAPTER 2
FIRMWARE OVERVIEW

BASIC THEORY OF OPERATION

A GPS receiver uses two sets of semi-permanent data (almanac and ephemeris) as a basis for its calculations and to find its way around in the GPS constellation. Both sets of data are broadcast synchronously by each GPS satellite, and are collected by a GPS receiver as needed. Almanac data provides trajectory and health information on the satellites. It is collected in 12.5 minutes. Ephemeris data provides more precise information on satellite location, and is collected in 30 seconds.

Magellan's GPS receiver module uses four channels to continuously track the four optimum satellites for three-dimensional position calculations. These channels also continuously collect the almanac and update the ephemeris for the satellites they are tracking.

The fifth channel continually tracks and collects ephemeris data from all satellites above the mask angle that are not currently being used in the position solution. A backup satellite is assigned to each tracking channel and is quickly switched in if the primary satellite sets below the horizon or becomes blocked.

FIRMWARE VERSIONS

There are two firmware versions for each of the two Magellan OEM GPS receivers, providing the integrator a total of four products to choose from. All of the data messages are presented in Chapter 3, OEM MESSAGE DEFINITIONS. An explanation of the timing firmware is presented later in this chapter. Specific messages for the timing firmware is called out in the first section of Chapter 3.

Standard Navigation Firmware (SNF)

P/N 00-85000-000 and 00-85001-000

The SNF is used for general navigation and positioning information. The firmware protocol in the SNF is the basis for all versions of the OEM firmware. Data port 1 provides communication for all data transfer. Port 2 can be dedicated to input RTCM SC-104.

Single Satellite Timing Firmware (SSTF)

P/N 00-85000-003 and 00-85001-003

The primary focus of the SSTF is to provide accurate 1PPS and 1KPPS synchronized to UTC or GPS second rollover. In the SSTF, data port 1 provides communication for all data transfer. Data port 2 can be dedicated to the output of the one-second timing message (PMGLK,03/K3). Although this will prevent data port 2 from being used for RTCM input, differential corrections can still be input through port 1 with the Magellan-specific J0 message.

Raw Data Firmware (RDF)

P/N 00-85000-002 and 00-85001-002

The RDF is used for high-accuracy differential positioning applications. With RDF, the board outputs raw data for all satellites being tracked through the binary V01 message. Raw data consists of pseudorange, phase count, time of reception, and C/N_0. RDF also supports the standard navigation functions, including the input of RTCM-104 on port 2.

OPERATIONAL STATES

NOTE: Statuses 1 through 7 are reflected in field 11 of the PMGLH message, field 4 of the PMGLF,01 message, and field 6 of the PMGLF,02 message.

Status 1 – Idle (IDL)

This state is entered when the unit has a valid almanac but there are not enough satellites in the sky to calculate a position fix. Typically, 17 satellites are needed for 24-hour 2D coverage with a 5° mask angle.

Status 2 – Search The Sky (STS)

Indicates that the unit is searching the sky for a satellite in order to collect an almanac, obtain current time, or calculate initial position. STS is part of the COLD START procedure and can be entered in one of five ways:

1. On power-up, if the unit does not have almanac, and/or time, and/or position it will go to status 2 until a satellite is found.
2. The Master Reset command (PMGLN/N0) is used. Master Reset clears all memory, resets all defaults and places the unit in COLD START, starting with STS.
3. If the message PMGLN,01 is issued to the board it will force the unit into STS. It will retain the almanac and time/date, but will ignore the initial position.
4. If the receiver produces a position fix that locates it further than 300 miles (482.7 km) from where it thinks it should be, it will enter STS.
5. In COLD START, if three satellites have not been found by the time an almanac has been collected, the unit re-enters STS.

Status 3 – Almanac Collect (ALM)

Indicates that the module is collecting an almanac from a satellite or satellites. The almanac contains a rough schedule of satellite locations and information on satellite health. It is used by the receiver to determine which satellites to look for given the time, date, and approximate position.

The only time this status will be seen is during COLD START. Collecting an almanac requires 12.5 minutes of continuous satellite view. If, during parallel almanac collect (see COLD START), the unit loses sight of all satellites, it will go back to status 2 until it locates another satellite. Unless you are on the ocean with a clear view of the horizon, it is very difficult to collect an almanac while moving.

During ALM, the fix time in message GPGGA/B0 has no meaning unless field 8 of PMGLH/H00 is 0 (continuous fixes are being produced).

Status 4 – Ephemeris Collect (EPH)

Ephemeris is the timing information used to compute exact satellite position. It takes 30 seconds per satellite to collect ephemeris on power-up. Ephemeris must be collected for each satellite used in the navigation solution before a position fix can be computed. A large portion of ephemeris collection is often accomplished while the module is still in status 5 (ACQ).

This status is entered after enough satellites are found (three for 2D, four for 3D) in status 5 (ACQ) to calculate a navigation solution. Ephemeris collect is done in parallel on all five channels.

Ephemeris data is usable for about 2 hours but is generally replaced every hour. Once the receiver is in continuous mode, the ephemeris on the satellites being used in position calculations is continuously refreshed and updated by the four tracking channels. The fifth receiver channel keeps the ephemeris updated for the backup satellites.

Status 5 – Acquisition (ACQ)
Acquisition is entered several ways. In a warm start, the receiver already has a position fix, time and almanac; the receiver enters Status 5 immediately. After reaching Status 6, acquisition is re-entered immediately when fewer than three satellites are visible for more than 5 minutes.

During normal warm start the unit looks for three satellites (2D) or four satellites (3D), according to visibility information computed from the almanac. Once it has located a satellite, the receiver immediately begins collecting the ephemeris for that satellite. Once the required satellites have been located and ephemeris collection is proceeding normally, the unit will switch to status 4 (EPH).

Status 6 – Continuous Position-Fixing (POS)
During normal operation the unit goes into continuous position-fixing mode following ephemeris collect. Position and velocity information will be updated at approximately a 1-Hz rate.

The module will drop out of status 6 and into status 5 when fewer than three satellites are visible for more than 5 minutes.

There are four flags associated with status 6:

1. NAV SOLUTION FLAG — field 7 of PMGLH/H0. This is the least responsive flag. It monitors the one-second updating of the position solution, with a 0 in this field indicating that fixes are being generated continuously. If the update stops for more than 15 consecutive seconds, this flag will toggle from 0 to 1 to indicate that the update has been interrupted. On the next successful update it will toggle back to 0. This flag is valid in any status.

2. GPS AVAILABILITY FLAG — field 6 of GPGGA/B0. This flag also monitors the fix updates. It toggles from 1 (GPS available, taking fixes) to 0 (GPS not available, fixes interrupted) when the last fix update is more than 10 seconds old. This flag is also valid in any status.

3. DEAD RECKONING FLAG – see field 4 of the PMGLH/H0 for the flag states. When cleared, the unit is updating the navigation solution with pseudorange measurements. When set the receiver is updating the navigation solution with dead reckoning information.

4. RTCM APPLIED – see field 4 of the PMGLH/H0 data message for flag states. When cleared, the receiver is producing navigation solutions without differential corrections. When set the receiver is applying differential corrections to all satellites. If corrections are not available for all of the satellites in the navigation solution the flag will be cleared although the receiver will apply the corrections that are available.

Developers should consider the dynamics of their application when deciding which flag (10-second timeout or 15-second timeout) to use.

Status 7 – Navigation Mode (NAV)
The navigation mode is entered when both of the following conditions apply:

1. The receiver is continuously calculating position fixes.

2. Waypoints have been designated with GPWPL/R5 and a route has been set with PMGLR,08/R8.

Navigation calculations are not done if a route is not set. All of the functions of status 6 are performed in addition to the navigation calculations.

Messages GPAPA/R1, GPBOD/R2, GPBWC/R3, GPZTG/R6, and GPZTA/R7 are produced only in NAV and never in POS. If turned on in POS, these messages are produced when NAV is entered and stopped when NAV is exited.

GENERAL STARTUP PROCESS

A GPS receiver needs three pieces of information in order to calculate which satellites to look for in the sky:

1. Almanac. The almanac contains the information necessary to compute the positions of all satellites, given items 2 and 3 below.

2. Time and Date. Since the GPS constellation is in motion, time and date are needed to know which satellites are visible.

3. Position. The receiver must know where it is within 300 miles (482.7 km) in order to determine which satellites are visible. If the unit computes a position fix that is 300 miles (482.7 km) or more from where it thinks it is, the unit will enter Abbreviated COLD START.

Using these three pieces of data, the receiver knows which satellites are above the horizon and which of those satellites are in the best configuration to provide an accurate fix. Once this data is obtained, the following GENERAL STARTUP procedure is followed:

1. Calculate best satellites for navigation. Selection of satellites will depend on the mode (2D or 3D) and the selected terrain setting. This takes only a few seconds.

2. ACQ (status 5) – search for and acquire the selected satellites, begin collecting ephemeris.

3. EPH (status 4) – finish collecting ephemeris for the selected satellites and compute the navigation solution.

4. POS (status 6) – continuous output of position information.

This GENERAL STARTUP process takes approximately 45 to 75 seconds in total, assuming good satellite visibility. Although the receiver does not need to be stationary during this process, the intermittent satellite blockages that can occur when under way may cause the time to first fix to be longer.

Most data sentences turned on at power-up will immediately begin output at the requested rate, and except for status, most values will be meaningless until status 6 (POS) is attained. Ground Course and Velocity (E00) will not be output until the module is taking fixes. Almanac (T01), Ephemeris (T02), Satellite Schedule (U01), and Satellite Data (U03) are not output until they have been collected or computed for the first time. If turned on continuously, almanac and ephemeris will be output only when updated.

COLD START

Cold Start processing occurs when one or more of the three required pieces of information (almanac, time/date and/or approximate initial position) are not available. The lack of this information slows down the time to first fix, as additional processing must be done to obtain the missing data before a fix can be generated.

True COLD START

A True COLD START is entered upon power-up when all power has been removed and memory has been lost or corrupted, or a firmware reset has been issued using the PMGLN/N0 message. No almanac, position, or time/date are available to the receiver. The following processing occurs:

1. STS (Search The Sky). The unit starts by searching for a different satellite on each of the five channels. It takes five minutes to complete the search for one satellite. Generally, the receiver will locate a satellite

in the first five or ten it searches for (which takes about 1 to 7 minutes); a worst-case scenario entails searching through 20 satellites, which requires 20 minutes. The difficulty of the search is determined by how many satellites are in the sky at the time of the search.

2. ALM (Almanac Collect). Upon finding a satellite on one channel, the receiver enters Almanac Collect (status 3). At the same time, the other four channels continue to search for satellites, and fall into parallel almanac collect as satellites are found.

   Since the almanac is received from the satellites in sync, 12.5 minutes is the minimum time from first satellite acquisition to completion of almanac collect. Parallel almanac collection ensures that the blockage or setting of any one satellite does not halt almanac collection since collection can continue on the other channels.

3. Calculation of Initial Position. Since ephemerides are a subset of the almanac, the receiver collects ephemerides as it collects the almanac. If the receiver is tracking and has ephemerides for at least three satellites it will calculate and output position fixes, even if the almanac collect is not complete. The initial fixes are used to provide initial position, but they may have a very poor DOP (dilution of position — a measure of the quality of the fix) because the receiver does not yet know the best satellites to look for since the almanac is incomplete. The receiver therefore remains in status 3 (ALM) throughout this stage until the optimum satellites are identified and acquired and the best possible fix is calculated. If, however, ALM (Almanac Collect) is completed before three satellites are found, the module will re-enter STS until three satellites are found to calculate an initial position.

4. GENERAL STARTUP processing. Once almanac collect is complete and an initial position is calculated, the receiver has the three pieces of information it needs and will proceed through the steps of GENERAL STARTUP. Since ephemeris has already been collected on the satellites, the receiver can usually go through the entire process in 20 to 30 seconds.

The True COLD START process typically takes 15 to 20 minutes.

Abbreviated COLD START
If almanac, time/date, and/or initial position are provided to the receiver, Abbreviated COLD START processing can be performed:

1. Almanac Only. The receiver will enter STS to locate a satellite from which it will get time and date. Once it gets the time and date, the receiver will search for satellites on all five channels until three satellites are found. A preliminary fix is then taken to get initial position. Using the initial position, almanac, and time/date, the receiver will then perform the GENERAL STARTUP procedure.

2. Position Only. Same as True COLD START, but if the unit has not found three satellites when almanac collect is completed, it will use the supplied position and proceed to GENERAL STARTUP (instead of re-entering STS).

3. Time Only. Operates the same as True COLD START, above.

4. Almanac and Time. Operates the same as almanac only.

5. Almanac and Position. The unit will enter STS, with each of the five channels searching for different satellites until one is found and time is acquired from it. Once a satellite is found, ACQ status is entered, and time can be established almost immediately. As soon as time/date is determined, the receiver will proceed through GENERAL STARTUP.

6. Position and Time. Same as position only.

WARM START

To go into WARM START, the receiver must have almanac, time and date, and initial or last position prior to startup. This can be done in two ways.

1. Maintain power to the board at all times. This enables the board to retain RAM, which means that upon startup, the receiver will immediately look for the appropriate satellites. Power can be maintained by leaving main power connected or by providing a battery for RAM backup.
2. Maintain the required data externally, bring the board up cold, and download the data through the serial port. The receiver will behave as though memory has been maintained. The accuracy of externally maintained memory must be ensured, and the host must also maintain time.

As long as ephemeris is less than two hours old when the receiver is turned on or data is downloaded, the receiver does not need to collect ephemeris again and will enter HOT START, described below. Otherwise, the receiver will proceed through GENERAL STARTUP.

HOT START

A HOT START is accomplished when the receiver is supplied with almanac, time/date, initial position, and current ephemeris (less than two hours old) for the satellite set that will be used for the first position fix. This occurs when the unit is turned off, standby power is maintained, and the unit is powered up again within one or two hours. The availability of current ephemeris cuts the time to first fix by 30 seconds, because step 3 of the GENERAL STARTUP process can be skipped.

Typically, if a receiver has been off for about 30 minutes, a better satelite set than the one last used may have become available. If the set includes satellites for which the unit does not have ephemeris, the receiver will use the original satellite set until it collects ephemeris for the new satellite(s).

MOVING THE RECEIVER WHILE POWERED OFF

If the receiver is moved more than 300 miles (482.7 km) while turned off and while backup power is maintained, it will look for the wrong satellites when turned back on. This is because the receiver will use its last fix as the approximate initial position and will calculate (incorrect) satellite visibility using that position.

The receiver may locate three satellites after it has been moved 300 miles (482.7 km) or more from its last position, and calculate a position fix. The fix will be labelled suspect because it is so far from the last position. The receiver will use the current almanac and the time and date (collected from the satellites acquired for the suspect fix), and the satellites that it is tracking to determine its correct location. This will take from one to two minutes.

If the receiver is unable to locate the satellites that it believes should be visible, the receiver will search for those satellites endlessly. The only way to force the receiver to search for different satellites is to re-initialize position or to use the PMGLN/N1 message to force the receiver into Search the Sky.

DEAD RECKONING OPERATION

The receiver provides dead reckoning operation during brief periods of satellite blockage.

REAL-TIME DIFFERENTIAL CORRECTIONS

The Magellan OEM GPS receiver allows for real-time differential corrections in two formats. One is the proprietary Magellan format using the J0 (binary only) message, the second is the RTCM-104 Version 2.0.

Differential Using RTCM SC-104 Version 2.0

The RTCM SC-104 Version 2.0 is a data exchange protocol, which is designed to convey a variety of navigational data including GPS differential and delta differential pseudorange corrections. RTCM SC-104 formatting is identical to the almanac format of the GPS receiver. Because of its intricate parity scheme, the RTCM SC-104 requires a dedicated data channel for transmission. The OEM port 2 data port in the -000 and -002 products is dedicated to RTCM SC-104 when activated. The PMGLO,02/O2 data message is used to turn port 2 on and off. The PMGLO,01/O1 data message is used to change the baud rate of port 2. When powered up with memory cleared, port 2 assumes the baud rate selected by JP2 and JP3 of of the configuration jumpers for port 1 (P/N 00-85000-xxx) or the BRS0 and BRS1 lines for port 1 (P/N 00-85001-xxx). If the baud rate of port 2 is changed through software selection, it is saved over power-down with memory backup. If port 2 is turned on for RTCM it is saved over power-down with memory backup. When turned back on, port 2 will be enabled for RTCM. The OEM receiver uses type 1, 2, and 9 RTCM data messages.

Differential Using the J0 Message

The J0 message is formatted exactly as the RTCM SC-104 Version 2.0 Type 1, 2 or 9 data message with the exception that the data is composed of 8 bit bytes for standard asynchronous data transmission. A J0 message is composed and sent to the receiver for each satellite. Because the data message has a defined start and stop character, the data can be mixed on a common data channel with other data. See the firmware protocol under the J0 data message for more information on formatting type 1, 2 and 9 messages.

SINGLE SATELLITE TIMING FIRMWARE

The single satellite timing firmware synchronizes the 1PPS and 1KPPS to the UTC or GPS second rollover. When the receiver is brought up cold the timing pulse is output, but is not syncronized. Using the PMGLK,01/K1 data message to turn off the timing turns off both the data message output from port 2 and the 1PPS and 1KPPS pulses. The PMGLK,03/K3 data message is available on port 1 or port 2. Because the data flow control provided by the PMGLI message addresses port 1 only, the PMGLK,01/K1 data message also controls port 2 timing message activity. When the timing output is activated the PMGLK,03/K3 data message is always output on port 2 at a 1-second rate. The timing messages PMGLK,01/K1 - PKMGL,02/K2 - PMGLK,03/K3 are also available through port 1 and are controlled by the same method as other port 1 messages, with the PMGLI flow control message. If the PMGLK,03/K3 data message is turned on at port 1, it is turned off if the timing is turned off and subsequently back on when timing is turned on. If no satellites are visible the timing will coast. The accuracy of the timing (coast or normal) can be monitored with the TFOM byte in the last field of the PMGLK,03/K3 data message. All timing modes and setups are remembered over power down with memory backup. Because port 2 is dedicated to the 1PPS data message, the RTCM-104 is not active in the Timing Firmware, but the proprietary J0 data message can still be used through port 1.

Standard Timing Mode

In order to provide accurate timing the receiver needs to know it's location within the GPS constellation. In the standard timing mode this information is provided by the navigation solution. On power-up the receiver must find its way to status 6 through one of the methods described in Chapter 2. When activated, the timing pulse is syncronized once the receiver enters status 6. If fewer than three satellites are available, the receiver drops into the Time-Only Mode, which provides synchronization using as few as one satellite with the last fix for position. Once three or more satellites are visible, the mode recovers. Because the timing solution is the first priority of the timing firmware the navigation solution update is less than that of the Standard Navigation Firmware, although not significantly so.

Time-Only Mode

In the time only mode the receiver expects a user-input position. As soon as a satellite is tracked the pulse is syncronized, then activated. No navigation solutions are generated. All GPS status flags are forced to valid. The only active status is the normal/coast byte in the PMGLK,03/K3 data message. The GPGGA/B0 message time of fix field is updated but the position is the user input position. If the receiver is brought up in the standard timing mode and then switched to the time-only mode, the position fix used for timing will be the last fix.

RAW DATA CHARACTERISTICS

The Raw Data module for the Magellan 5-channel OEM board is designed to provide pseudorange and carrier phase measurements for the user who needs more than the standard positioning information.

The data consists of records that contain a common reception time and the following information for each channel:

- Validity flags
- Satellite PRN
- Signal strength
- Integrated carrier phase
- Pseudorange

The OEM board will attempt to report raw data every second. The user, however, cannot count on this. Occasional throughput spikes (inside the OEM receiver), line noise garbling a message, or excessive message traffic (by requesting too much output) can all cause data to be lost.

Time of Reception

Time of reception is the common time at which all measurements (carrier phase, pseudorange, and signal strength) were made. This time is in corrected GPS time (not receiver time). Also, the receiver makes sure that the measurements of all five channels are synchronized with each other in time, are approximately synchronized with GPS time, and that measurements are made at integral GPS seconds. Pseudorange is a filtered measurement over one second (time of reception is at the middle of the one-second period). Integrated carrier is reported at the time of reception.

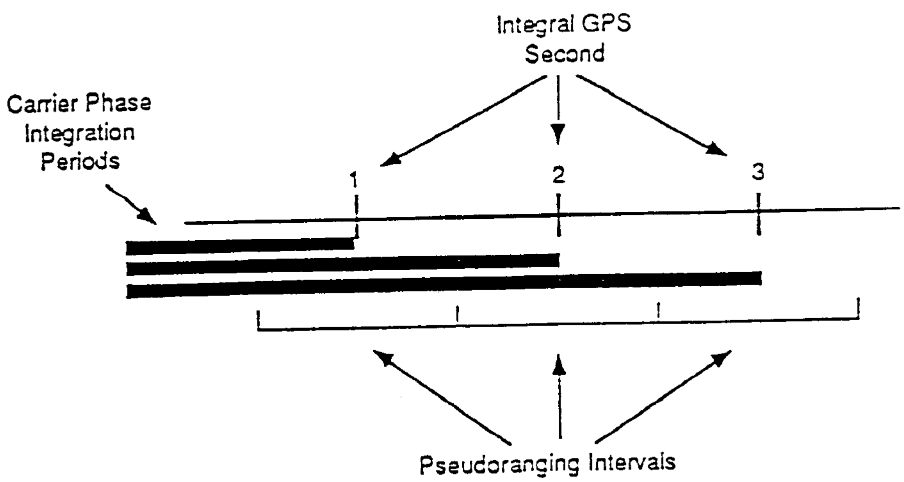


Figure 7. Measurement Timing Diagram

The timing of the measurements ensures that one can correctly propagate the pseudorange with difference in carrier phase (for purposes of smoothing). For example the following holds (excluding atmospheric effects and measurement noise) for any two sets of measurements at times t_2 and t_1 ($t_2 > t_1$) if there has been no loss of lock between t_1 and t_2:

$$PR(t_2) = PR(t_1) - (CP(t_2) - CP(t_1))^{*}0.1902936728$$

Where:

PR(t) is the pseudorange at time t (in meters, or one tenth the value in the raw data)
CP(t) is the integrated carrier phase at time t (in cycles, on one 256th the value in the raw data)

Time of reception is reported as two integers. The first is the integer part and the second is the fractional part in nanoseconds.

Validity Flags and Satellite PRN

This byte contains the PRN for the satellite currently being tracked on the channel with a PRN of 0 indicating an idle channel (no satellite). The pseudorange and carrier phase validity flags are set when the data is NOT valid. It is possible to have data with valid pseudorange and invalid carrier phase, but not the reverse (i.e., if the pseudorange is bad, so is the carrier phase). Note that data validity is determined on a channel basis. Some of the channels may contain good data while some may contain bad.

Signal Strength

This is the signal strength in dB-Hz as averaged over a period of 40 milliseconds at or slightly after the end of the measurement cycle.

Signal strength is reported as an integer value.

Integrated Carrier Phase

The integrated carrier phase measurement is an integer count of cycles from the last time the phase lock loop settled. This is measured directly from the carrier loop in the receiver and is not affected by the code phase measurement. The expected noise on this is 0.1 cycles (1 sigma RMS). Note that the phase lock loop may occasionally experience a "cycle slip", which will cause an unexpected loss (or gain) of 1 (or 0.5) cycle.

This is a signed value and can wrap from -2147483648 to +2147483647 or vice versa. This wrapping of data must be accounted for by the user. If the carrier data invalid bit is set for a channel that channels cycle counting will be reset. Unfortunately, one should not program assuming that one will get every data message. The period of carrier data invalidity may be missed. The user can detect this by looking for large decreases in the absolute value of the integrated carrier phase. If the channel should lose lock the integrated cycle count will reset to zero so that the next set of valid data that is received will have a decrease in the magnitude of the counts.

Integrated carrier phase is reported as an integer rounded to the nearest 1/256 cycle.

Pseudorange

The pseudorange measurement is a filtered value obtained over the interval from 0.5 seconds prior until 0.5 seconds after the time of reception. It is a direct measurement of the difference between transmission time (in satellite time) and reception time (in receiver time). Thus pseudorange is a direct measurement of the phase of the C/A code on the signal as referenced to a free running clock within the receiver:

$$PR = (TR - TT) * C$$

where:

TT is the transmission time as determined from data bits and C/A code phase

TR is the common reception time as determined from a free running receiver clock. This corresponds to the reception time reported with the raw data.

C is the speed of light

This is therefore a true pseudorange measurement, which incorporates satellite and receiver clock errors as well as any atmospheric and multipath delays.

Internally, the OEM receiver measures the code phase in such a way that the expected noise is approximately 8 meters (1 sigma RMS). This measurement is almost completely independent of the carrier phase measurement since it derives from the code tracking loop whose only carrier loop input is via a rate aiding (first order) input.

Pseudorange is reported as an integer rounded to the nearest 0.1 meter.

TIMED AUTOMATIC RESET (WATCHDOG TIMER)

On power-up with almanac and position, if the module has not been able to produce a fix in 60 minutes, it will automatically reset itself into a WARM START. After 60 minutes of operation, the module resets after 30 minutes of no fixes.

CHAPTER 3

OEM MESSAGE DEFINITIONS

PORT CONFIGURATIONS

The two dataports can be configured as follows:

Baud Rate options:	1200, 2400, 4800, 9600 baud
Data Bits:	8
Parity:	None
Stop Bits:	1

The baud rate on the OEM/PS is set by jumpers JP2 and JP3 on the PCB. The baud rate on the OEM/5V is set by voltage levels on J2-11, 13. (See Default PCB Configuration in Chapter 6.) Once in operation, firmware protocol will allow the baud rate to be changed. The change will be retained with memory backup, but if all power is removed the baud rate resets to the default as set by the jumpers/pins.

On power-up when memory has not been maintained by a backup battery, port 2 defaults to port 1 jumper settings.

MESSAGE FORMATS

Both binary and ASCII formats are provided for most of the sentences. The exceptions are listed below:

Binary only:	J00	–	Differential corrections (RTCM SC-104, version 2.0)
	T01	–	Almanac data
	T02	–	Ephemeris data
ASCII only:	PMGLI	–	Data flow control

Binary

The BINARY sentence starts with "$$" (two HEX 24) followed by a one-byte sentence identifier (from A to Z in ASCII) and a one-byte binary subindex (00 to FF HEX), followed by the binary data field. All of the binary data are in integers with defined precision. The sentence is terminated with a line feed (HEX 0A). The checksum of the sentence is one byte before the line feed, and is required in binary format. The checksum is calculated by XORing the 8 binary data bits of each byte in the sentence with each other, starting with the first byte after the "$$" and ending with the first byte before the checksum. For example:

```
$$R100000000CL
  xxxxxxxxxxx
```

("x" denotes data field to be XORed, "C" denotes checksum, "L" denotes line feed)

ASCII

The ASCII sentences conform to the NMEA (National Marine Electronics Association) 0183 software protocol. Two types of sentences are used. Where the 0183 protocol has a pre-defined sentence for specific data, this sentence is used. This includes GPGGA, GPZDA, GPVTG, GPBOD, GPBWC, GPHDM, GPHDT, GPAPA, and so forth. For information that does not have a predefined sentence, we used the method defined in the protocol for designing our own proprietary sentences so they will be compatible with the standard sentences. The headers for proprietary sentences use 'P' for proprietary, 'MGL' for Magellan as manufacturer's identification, and a primary index of 'A' through 'Z'. The first data field is a subindex, which has a range of from 00 to 99. The checksum is the 2-byte hexadecimal ASCII of the binary byte, and is calculated by XORing each successive byte in the sentence, between the '$' and the '*'.

All data output sentences have the checksum calculated. The board's firmware does not require a checksum on ASCII input, but without one the integrity of the data cannot be guaranteed. If you do not want to send the checksum, omit the '*' and the two following bytes.

Example with checksum:

```
$PMGLI,00,U03,1,A,02*CKRL
 xxxxxxxxxxxxxxxxxxxx
```

('x' denotes data field to be XORed, 'CK' denotes 2 bytes checksum, 'R' denotes carriage return - hex 0D, 'L' denotes line feed – hex 0A)

Example without checksum:

```
$PMGLI,00,U03,1,A,02RL
```

Timing-Specific Data Messages
The PMGLK,01/K1-PMGLK,02/K2-PMGLK,03/K3 messages are specific to the timing firmware (OEM P/N 00-8500X-003). These messages cannot be activated in other versions of the OEM GPS firmware, and if sent, will be ignored.

RTCM
The format of the RTCM data (word length, priority scheme, etc.) is the same as the format of the GPS almanac. Refer to Chapter 8 for information on where to obtain the current interface for RTCM SC-104 version 2.0.

CHAPTER 4

OEM FIRMWARE PROTOCOL

OUTPUT MESSAGES

Output messages are from the module to the host. Also, the ASCII reference included in each message title is the one used in the PMGLI (data flow control sentence) for that message.

Time and Date — A00

BINARY

```
$$A0xxxxxxxCL
    1234567
```

1: 1 byte, subindex
2: 1 byte, UTC hour
3: 1 byte, UTC minute
4: 1 byte, UTC second
5: 1 byte, day
6: 1 byte, month
7: 2 bytes, year

ASCII

```
$GPZDA,xxxxxx,xx,xx,xxxx,*CKRL
         1         2  3   4
```

1: 6 bytes, UTC hhmmss
2: 2 bytes, day
3: 2 bytes, month
4: 4 bytes, year

Position and Altitude — B00

BINARY

```
$$B0xxxxxxxxxxxxxxxxxCL
    12     3     4     5
```

1: 1 byte, subindex
2: 4 bytes, timetag in seconds, offset from the beginning of the GPS week (00:00 Sunday GMT)
3: 4 bytes, latitude in 10^{-7} degree (two's complement)
4: 4 bytes, longitude in 10^{-7} degree (two's complement)
5: 4 bytes, altitude in 0.01 meter/feet

ASCII

```
$GPGGA,xxxxxx,xxxx.xx,N,xxxxx.xx,W,x,x,xxx,xxx,M,xxxx,M*CKRL
       1      2       3 4        5 6 7 8   9   10 11  12
```

1: 6 bytes, UTC timetag of position fix (hhmmss)

2: 7 bytes, GPS latitude (DDMM.HH where D = degrees, M = minutes, H = hundredths of minutes)

3: 1 byte, latitude N or S

4: 8 bytes, GPS longitude (DDDMM.HH)

5: 1 byte, longitude E or W

6: 1 byte, GPS availability

    0 = GPS not available (last fix more than 10 seconds ago)

    1 = GPS available

7: 1 byte, number of satellites being used (1, 2, 3, or 4)

8: 3 bytes, HDOP (recalculated every 3 minutes or with every fix if PDOP > 8; see message G00 for a brief explanation of DOPs)

9-10: 3 bytes, antenna height, meters/feet

    (height above sea level)

11-12: 4 bytes, geoidal height, meters/feet

    (difference between antenna height and geoidal height in the WGS84 map datum)

Position Only — B01

BINARY

Same as $SB0

ASCII

```
$GPGLL,xxxx.xx,N,xxxxx.xx,W*CKRL
       1       2 3        4
```

1: 7 bytes, last fix latitude (DDMM.HH)

2: 1 byte, latitude N or S

3: 8 bytes, last fix longitude (DDDMM.HH)

4: 1 byte, longitude E or W

Extended Altitude — B02

BINARY

```
$$B2xxxxCL
    12
```

1: 1 byte, subindex

2: 4 bytes, altitude in 0.01 meters/feet

ASCII

```
$PMGLB,02,xxxxxx,M*CKRL
        1  2       3
```

1: 2 bytes, subindex

2-3: 6 bytes, altitude, meters/feet

Position and Altitude, UTM — B03

This message causes the receiver to display position and altitude data in the UTM format.

BINARY

```
$$B3xxxxxxxxxxxxxxxxxxxxxxxxxxCL
     123456 789    10   11 14   15
```

1: 1 byte, UTC hour
2: 1 byte, UTC minute
3: 1 byte, UTC second
4: 1 byte, day
5: 1 byte, month
6: 2 bytes, year
7: 1 byte, zone number
8: 1 byte, hemispheres; 1 = north, 0 = south
9: 4 bytes, easting
10: 4 bytes, northing
11: 1 byte, GPS Available Indicator; 0 = GPS not available, 1 = GPS available
12: 1 byte, number of satellites being used
13: 1 byte, PDOP
14: 4 bytes, altitude in 0.01 meter/feet
15: 2 bytes, geoidal height, 0.1 meter/feet

ASCII

```
$PMGLB,03,xxxxxx,xx,N,xxxxxx,xxxxxxx,x,x,xxx,xxxxxx,M,xxxx,M*CKRL
             1        2  3 4        5         6 7 8   9        1011   12
```

1: 6 bytes, UTC of position, (hhmmss)
2: 2 bytes, zone number
3: 1 byte, north or south hemisphere, N or S
4: 6 bytes, easting
5: 7 bytes, northing
6: 1 byte, GPS Available Indicator; 0 = GPS not available, 1 = GPS available
7: 1 byte, number of satellites being used
8: 3 bytes, PDOP
9–10: 7 bytes, Antenna Height, meters/feet
11–12: 5 bytes, Geoidal Height, meters/feet

ECEF Position — C00

ECEF = Earth Center Earth Fixed.

BINARY

```
$$C0xxxxxxxxxxxxxCL
    12    3    4
```

1: 1 byte, subindex

2: 4 bytes, ECEF X - coordinate, 0.01 meter

3: 4 bytes, ECEF Y - coordinate, 0.01 meter

4: 4 bytes, ECEF Z - coordinate, 0.01 meter

ASCII

```
$PMGLC,00,xxxxxxxxx.xx,xxxxxxxxx.xx,xxxxxxxxx.xx*CKRL
       1  2            3            4
```

1: 2 bytes, subindex

2: 12 bytes, ECEF X - coordinate, meter

3: 12 bytes, ECEF Y - coordinate, meter

4: 12 bytes, ECEF Z - coordinate, meter

Mode — D00

The default mode is AUTO, in which the receiver will navigate with four satellites in 3D if enough satellites are visible with an acceptable PDOP, otherwise it will revert to three satellites and 2D position calculations. In AUTO mode, the receiver will enter AUTO/3D when four satellites are visible with a PDOP < 6. The receiver will exit AUTO/3D and enter AUTO/2D if PDOP goes above 8. In AUTO/2D and forced 2D modes, the receiver will use the best three satellites to calculate two-dimensional position fixes, using the most recent of:

1. The altitude from the last 3D fix, or
2. The altitude entered in field 9 of the PMGLB,00/B0 sentence.
3. The altitude entered in the PMGLB,02/B2 sentence

If the module performed a COLD START, altitude will be "0" until the receiver is able to generate altitude with a 3D position fix.

NOTE: If altitude is changed with the PMGLB,00/B0 sentence while the module is in POS mode, the module will be forced into ACQ to evaluate the new L/L. You must use the PMGLB,02/B2 sentence if you want to perform altitude-aiding in 2D.

BINARY

```
$$D0xCL
    12
```

1: 1 byte, subindex

2: 1 byte, mode

2 = 2D mode

3 = AUTO/3D mode

ASCII

```
$PMGLD,00,x*CKRL
        1  2
```

1: 2 bytes, subindex

2: 1 byte, mode

2 = 2D mode

3 = AUTO/3D mode

Ground Course and Velocity—E00

This message will not be produced unless the receiver is producing fixes.

BINARY

```
$$E0xxxxCL
   12 3
```

1: 1 byte, subindex

2: 2 bytes, heading (true), 0.01 degree

3: 2 bytes, velocity, 0.01 KNOTS,KM/HR,MPH

ASCII

```
$GPVTG,xxx.xx,T,xxx.xx,M,xxx.x,N,xxx.x,K*CKRL
        1        2 3        4 5      6 7      8
```

1: 6 bytes, heading, degrees (true)

2: 1 byte, T = true

3: 6 bytes, heading, degrees (magnetic)

4: 1 byte, M = magnetic

5: 5 bytes, speed

6: 1 byte, N = knots or S = statute miles

7: 5 bytes, speed

8: 1 byte, K = km/hr

Satellites Used for Last Fix — F00

Provides the three or four satellites used to produce the last fix.

BINARY

```
$$F0xxxxCL
   12345
```

1: 1 byte, subindex

2-5: 1 byte each, satellite's PRN

ASCII

```
$PMGLF,00,xx,xx,xx,xx*CKRL
       1  2  3  4  5
```

1: 1 byte, subindex

2-5: 2 bytes each, satellite's PRN

Satellites in Active Use with Status—F01

NOTE: The PMGLF,01/F1 data sentence reflects the activity of the four tracking channels as closely as possible. This allows backward compatibility with single-channel systems developers. New developers should use the PMGLF,02/F2 sentence.

BINARY

```
$$F1xxxxxxxxxCL
   1232323234
```

4 sets of field 2 and 3 for 4 satellites:

1: 1 byte, subindex

2: 1 byte for the satellite's PRN

3: 1 byte for the status of the satellite in field 2

1 = now being looked for or collecting ephemeris

2 = has already been found or finished collecting

4: OEM receiver status (same as described in H00 and F02 messages)

ASCII

```
$PMGLF,01,xx,x,xx,x,xx,x,xx,x,x*CKRL
       1  2  3 2  3 2  3 2  3 4
```

4 sets of field 2 and 3 for 4 satellites:

1: 1 byte, subindex

2: 2 bytes for the satellite's PRN

3: 1 byte for the status of the satellite in field 2

1 = now being looked for or collecting ephemeris

2 = has already been found or finished collecting

4: OEM receiver status (same as described in H00 and F02 messages)

5-Channel Satellite Usage Information — F02

NOTE: All channels are logical channels. They may appear in any field of the data sentence.

BINARY

```
$$F2XXXXXXXXXXXXXXXXXXXXXCL
    12345234523452345234 56
```

5 sets (one for each channel) of fields 2, 3, 4, and 5:

1: 1 byte, subindex

2: 1 byte, PRN of the satellite being tracked on that channel.

3: 1 byte, constellation

  1 = satellite in navigation set

  0 = satellite not in navigation set

4: 1 byte, tracking status

  41 hex = ASCII "A" = acquisition/reacquisition

  53 hex = ASCII "S" = searching

  00 – 09 hex = SQ of the satellite being tracked

5: 1 byte, ephemeris

  1 = ephemeris has been collected for the satellite

  0 = ephemeris has not been collected for the satellite

6: OEM receiver status (same as described in H00 and F01 messages).

ASCII

```
$PMGLF,02,xx,x,x,x,xx,x,x,x,xx,x,x,x,xx,x,x,x,xx,x,x,x,x*CKRL
       1  2  3 4 5 2  3 4 5 2  3 4 5 2  3 4 5 2  3 4 5 6
```

5 sets (one for each channel) of fields 2, 3, 4, and 5:

1: 1 byte, subindex

2: 2 bytes, PRN of the satellite being tracked on that channel.

3: 1 byte, constellation

  1 = satellite in navigation constellation

  0 = satellite not in navigation constellation

4: 1 byte, tracking status

  A = acquisition/reacquisition

  S = searching

  0 – 9 = SQ of the satellite being tracked

5: 1 byte, ephemeris

  1 = ephemeris has been collected for the satellite

  0 = ephemeris has not been collected for the satellite

6: OEM receiver status (same as described in H00 and F01 messages).

PDOP, GDOP, Error Estimate — G00

PDOP (Position Dilution of Precision) and GDOP (Geometric Dilution of Precision) are measures of the geometry of the satellites. So is HDOP (Horizontal Dilution of Precision) in GPGGA/B0. The more "spread out" the satellites are in the sky, the better the geometry of the satellites and the more accurate the resulting position fixes will be. Low DOP's indicate favorable satellite geometry and high DOP's indicate unfavorable geometry.

Generally, geometries with PDOP's below 5.0 provide good accuracy, PDOP's 5 – 10 signify moderate accuracy, and PDOP's above 10 indicate poor accuracy (use the position with caution).

PDOP is inversely proportional to the GQ value in field 7 of the PMGLH/H0 sentence. The table below illustrates the relationship between the geometric quality and PDOP.

Table 1. Comparison of Geometric Quality and PDOP

GQ Level	~PDOP	How to Evaluate
9	1-2.9	
8	3-3.9	Good accuracy
7	4-4.9	(Approx. 30 meters or better)*
6	5-5.9	
5	6-7.9	Fair accuracy
4	8-9.9	(Approx. 60 meters)*
3	10-14.9	
2	15-24.9	Poor accuracy
1	25-50	(Approx. 500 meters)*
0	50-75	

* without S/A

The error estimate is a measure of attainable accuracy and is a combination of the PDOP and the User Range Accuracy (URA) broadcast by the satellites. The URA, and therefore the error estimate, includes the influences of Selective Availability.

The error estimates do not reflect the effects of differential corrections.

This information is updated every three minutes, or with every fix if PDOP > 8.

BINARY

```
$$G0xxxxxxCL
    12 3 4
```

1: 1 byte, subindex

2: 2 bytes, PDOP, 0.01

3: 2 bytes, GDOP, 0.01

4: 2 bytes, error estimate, meters

ASCII

```
$PMGLG,00,xxx.xx,xxx.xx,xxx*CKRL
       1  2      3      4
```

1: 2 byte, subindex

2: 6 bytes, PDOP, 000.00

3: 6 bytes, GDOP, 000.00

4: 3 bytes, error estimate, meters

Receiver Status — H00

BINARY

```
$$H0xxxxxxxxxxCL
   12345678901
```

1: 1 byte, subindex

2: 1 byte, firmware version number, 0.1

3: 1 byte, customer number

4: 1 byte, composite flags.

 bit 0: DR flag
  0 = DR off
  1 = DR on

 bit 1: RTCM flag
  0 = RTCM off
  1 = RTCM on

5: 1 byte, oscillator (0=ok, 1= out of tune)

6: 1 byte, SQ (signal quality)

 A measure similar to C/N_0 (see Table 3 at message U03)

 Range of 0 to 9, where 0 = bad, 9 = good

 May lose lock if 3 or below

7: 1 byte, GQ (geometric quality)

 A measure similar to PDOP (see Table 1 at message G00)

 Range of 0 to 9, where 0 = bad, 9 = good

 If GQ is 3 or below fixes may be inaccurate — use such fixes with caution

8: 1 byte, navigation solution

 0 = continuously producing navigation solutions

 1 = continuous update has been interrupted

9: 1 byte, almanac data

 0 = ok

 1 = no almanac data

 2 = almanac is more than six months old

(The receiver will still use an old almanac, but the almanac will probably be somewhat inaccurate and it may cause inefficient receiver processing.)

10: 1 byte, memory

0 = memory ok to use

1 = lost memory data (initial position unavailable)

11: OEM unit status : 1=IDL, 2=STS, 3= ALM, 4= EPH, 5=ACQ, 6=POS, 7=NAV
(Refer to Chapter 2 for a description of status.)

ASCII

```
$PMGLH,00,xx.x,xx,x,x,x,x,x,x,x,x*CKRL
       1  2    3  4 5 6 7 8 9 0 1
```

1: 2 bytes, subindex

2: 4 bytes, firmware version number, 0

3: 2 bytes, customer number

4: 1 byte, composite flags.

bit 0: DR flag
0 = DR off
1 = DR on

bit 1: RTCM flag
0 = RTCM off
1 = RTCM on

NOTE: In the ASCII message, the high nibble is always 3.

30 (ASCII 0) = DR off/RTCM off

31 (ASCII 1) = DR on

32 (ASCII 2) = RTCM on

33 (ASCII 3) = DR on/RTCM on

5: 1 byte, oscillator (0=ok, 1= out of tune)

6: 1 byte, SQ (signal quality)

A measure similar to C/N_0 (see message U03)

Range of 0 to 9, where 0 = bad, 9 = good

May lose lock if 3 or below

7: 1 byte, GQ (geometric quality)

A measure similar to PDOP (see message G00)

Range of 0 to 9, where 0 = bad, 9 = good

If GQ is 3 or below fixes may be inaccurate – use such fixes with caution

8: 1 byte, navigation solution

0 = continuously producing navigation solutions

1 = continuous update has been interrupted

9: 1 byte, almanac data

0 = ok

1 = no almanac data

2 = almanac is more than six months old

(The receiver will still use an old almanac, but the almanac will probably be somewhat inaccurate and may cause inefficient receiver processing.)

10: 1 byte, memory

0 = memory ok to use

1 = lost memory data (initial position unavailable)

11: OEM unit status : 1=IDL, 2=STS, 3= ALM, 4= EPH, 5=ACQ, 6=POS, 7=NAV

(Refer to Chapter 2 for a description of status.)

Time Transfer Setup and Control — K01

Timing messages are only active in the appropriate timing firmware (P/N 00-85000-003 and 00-85001-003).

BINARY

```
$$K1xxxxxxxCL
   12345
```

1: 1 byte, subindex

2: 1 byte,

1 = enable 1 PPS, 1 KPPS pulse and time tag message on port 2

0 = disable 1 PPS, 1 KPPS pulse and time tag message on port 2

3: 1 byte,

1 = time tag message in ASCII format

0 = time tag message in BINARY format

4: 1 byte,

1 = output is referenced to UTC format

0 = output is referenced to GPS time

5: 4 bytes, user time bias offset in nanoseconds (signed integer)

ASCII

```
$PMGLK,01,x,x,x,±xxxxx*CKRL
          1 2 3 4 5
```

1: 1 byte, subindex

2: 1 byte,

1 = enable 1 PPS, 1 KPPS pulse and time tag message on port 2

0 = disable 1 PPS, 1 KPPS pulse and time tag message on port 2

3: 1 byte,

1 = time tag message in ASCII format

0 = time tag message in BINARY format

4: 1 byte,

1 = output is referenced to UTC format

0 = output is referenced to GPS time

5: 4 bytes, user time bias offset, ±00000 to 99999 nanoseconds

Time Transfer Mode — K02
Timing messages are only active in the appropriate timing firmware (P/N 00-85000-003 and 00-85001-003).

BINARY

```
$$K2xCL
  12
```

1: 1 byte, subindex

2: 1 byte,

1 = time-only mode on

0 = time-only mode off

ASCII

```
$PMGLK,02,**CLRL
       1  2
```

1: 1 byte, subindex

2: 1 byte,

1 = time-only mode on

0 = time-only mode off

Time Transfer Message — K03
Timing messages are only active in the appropriate timing firmware (P/N 00-85000-003 and 00-85001-003).

BINARY

```
$$K3xxxxxxxxxxxxxxxxxCL
   123456 78989898910
```

1: 1 byte, UTC/GPS hour

2: 1 byte, UTC/GPS minute

3: 1 byte, UTC/GPS second

4: 1 byte, day

5: 1 byte, month

6: 2 bytes, year

7: 1 byte, 1 = normal, 0 = coast

4 sets of:

8: 1 byte, PRN number

9: 1 byte, SQ of the satellite

10: 1 byte, TFOM

Table 2. Timing Figure of Merit (TFOM)

TFOM Value	Expected Time Error (ETE)
1	0 ns < ETE ≤ 1 ns
2	1 ns < ETE ≤ 10 ns
3	10 ns < ETE ≤ 100 ns
4	100 ns < ETE ≤ 1 µs
5	1 µs < ETE ≤ 10 µs
6	10 µs < ETE ≤ 100 µs
7	100 µs < ETE ≤ 1 ms
8	1 ms < ETE ≤ 10 ms
9	10 ms < ETE ≤ 100 ms
10–14	not used
15	no information available

ns = nanosecond   µs = microsecond   ms = millisecond

ASCII

```
$PMGLK,03,xxxxxx,xx,xx,xxxx,x,xx,x,xx,x,xx,x,xx,x,x*CKRL
          1       2  3   4    5 6  7 6  7 6  7 6  7 8
```

1: UTC/GPS hhmmss

2: UTC/GPS day

3: UTC/GPS month

4: UTC year

5: 1 = normal, 0 = coast

6: 1 byte, PRN number

7: 1 byte, SQ of satellite

8: 1 byte, TFOM

Autopilot — R01

This message will not be produced unless waypoints have been entered with GPWPL/R5 and a route has been set with PMGLR/R8.

BINARY

```
$$R1xxxxxxxxxxxxxCL
   1234 5678 9
```

1: 1 byte, subindex

2: 1 byte, navigation data status, 1 = valid, 0 = invalid

Valid if field 6 in GPGGA is valid and XTE < 9.99 Nm

3: 1 byte, navigation data status, 1 = valid, 0 = invalid

Valid if field 6 in GPGGA is valid and XTE < 9.99 Nm

4: 2 bytes, cross track error, 0.01 naut miles/km/stat miles

5: 1 byte, 0 = steer right , 1 = steer left.

Assumes that movement is toward the destination. Switches when the perpendicular to the courseline that intersects the destination waypoint is crossed.

6: 1 byte, arrival circle entered, 1 = yes, 0 = no

The arrival circle has a diameter of approximately 0.1 nautical mile.

7: 1 byte, perpendicular of waypoint crossed,

1 = yes, 0 = no

8: 2 bytes, bearing destination waypoint from origin waypoint, 0.1 degree, magnetic

9: 4 bytes, destination waypoint identifier (See Waypoints on page 4-30.)

ASCII

```
$GPAPA,A,A,x.xx,L,N,A,A,xxx.,M,cccc*CKRL
       1 2 3    4 5 6 7 8    9 10
```

1: 1 byte, navigation data status, A = valid, V = invalid

Valid if field 6 in GPGGA is valid and XTE < 9.99 Nm

2: 1 byte, navigation data status, A = valid, V = invalid

Valid if field 6 in GPGGA is valid and XTE < 9.99 Nm

3. 4 bytes, cross track error
4. 1 byte, L = steer left, R = steer right
5. 1 byte, units of XTE, N = nautical miles, K = km, S = statute miles
6. 1 byte, arrival circle crossed, A = yes, V = no

   The arrival circle has a diameter of approximately 0.1 nautical mile.
7. 1 byte, arrival perpendicular crossed, A = yes, V = no
8. 3 bytes, bearing to destination waypoint from origin waypoint
9. 1 byte, M = magnetic
10. 4 bytes, destination waypoint identifier (See Waypoints on page 4-30.)

Bearing — R02

This message will not be produced unless waypoints have been entered with GPWPL/R5 and a route has been set with PMGLR/R8.

BINARY

```
$$R2xxxxxxxxxxxxxxCL
   12 3 4 5    6
```

1: 1 byte, subindex

2: 2 bytes, bearing, true, 0.1 degree

3: 2 bytes, bearing, magnetic, 0.1 degree

4: 2 bytes, distance, 0.1 nautical miles/km/statute miles

5: 4 bytes, destination waypoint identifier (See Waypoints on page 4-30.)

6: 4 bytes, origin waypoint identifier

ASCII

```
$GPBOD,xxx.,T,xxx.,M,cccc,cccc*CKRL
        1    2 3    4 5    6
```

1: 4 bytes, bearing (true)

2: 1 byte, T = true

3: 4 bytes, bearing (magnetic)

4: 1 byte, M = magnetic

5: 4 bytes, destination waypoint identifier (See Waypoints on page 4-30.)

6: 4 bytes, origin waypoint identifier

Bearing and Distance — R03

This message will not be produced unless waypoints have been entered with GPWPL/R5 and a route has been set with PMGLR/R8.

BINARY

```
$$R3xxxxxxxxxxxxxxxxxxxxxxCL
   12345    6    7 8  9 10
```

1: 1 byte, subindex

2: 1 byte, UTC hour

3: 1 byte, UTC minute

4: 1 byte, UTC second

5: 4 bytes, latitude of waypoint, 10^{-7} degree

6: 4 bytes, longitude of waypoint, 10^{-7} degree

7: 2 bytes, bearing, true, 0.1 degree

8: 2 bytes, bearing, magnetic, 0.1 degree

9: 2 bytes, distance, 0.1 nautical miles/km/statute miles

10: 4 bytes, waypoint identifier (See Waypoints on page 4-30.)

ASCII

```
$GPBWC,xxxxxx,xxxx.xx,N,xxxxx.xx,W,xxx.x,T,xxx.x,M,xxx.x,N,cccc*CKRL
        1      2       3 4        5 6     7 8     9 10    1112
```

1: 6 bytes, UTC of bearing (hhmmss)

2: 7 bytes, latitude of waypoint (DDMM.HH)

3: 1 byte, N = north or S = south

4: 7 bytes, longitude of waypoint (DDDMM.HH)

5: 1 byte, E = east or W = west

6: 5 bytes, bearing (true)

7: 1 byte, T = true

8: 5 bytes, bearing (magnetic)

9: 1 byte, M = magnetic

10: 5 bytes, distance , nautical miles/km/statute miles

11: 1 byte, N = nautical miles, K = km, S = statute miles

12: 4 bytes, waypoint identifier (See Waypoints on page 4-30.)

Magnetic Variation — R04
When the ASCII version of this message is requested by PMGLI, GPHVD is returned if auto-derived magnetic deviation has been specified in Datum and Units Setup (PMGLS,01/S1 field six = 1). This is the default. If field six of PMGLS,01/S1 has been set to 0 (user-entered magnetic deviation), GPHVM will be returned.

BINARY

```
$$R4xxCL
    12
```

1: 1 byte, subindex

2: 2 bytes, variation, 0.1 degree (West is negative.)

ASCII

```
$GPHVD,xx.x,E*CKRL          (Derived)
$GPHVM,xx.x,E*CKRL          (Manually Set)
       1    2
```

1: 4 bytes, variation, 00.0 degrees

2: 1 byte, variation sense, E or W

Waypoints — R05
If PMGLR,05/R5 is requested with PMGLI, the unit will give all of the waypoints in memory, one at a time, at the selected data output interval. If the unit is asked to give the waypoints on a continuous basis, it will sequence through all of the waypoints in memory, one at a time, at the requested rate until turned off.

This message will not be produced unless waypoints have been entered with GPWPL/R5.

BINARY

```
$$R5xxxxxxxxxxxxxCL
    12    3   4
```

1: 1 byte, subindex

2: 4 bytes, latitude 10^{-7} degree

3: 4 bytes, longitude 10^{-7} degree

4: 4 bytes, waypoint identifier (See Waypoints on page 4-30.)

ASCII

```
$GPWPL,xxxx.xx,N,xxxxx.xx,W,cccc*CKRL
       1       2 3        4 5
```

1: 7 bytes, latitude (DDMM.HH)

2: 1 byte, N or S

3: 8 bytes, longitude (DDDMM.HH)

4: 1 byte, E or W

5: 4 bytes, waypoint identifier (See Waypoints on page 4-30.)

Time To Go — R06

This message will not be produced unless waypoints have been entered with GPWPL/R5 and a route has been set with PMGLR/R8.

BINARY

```
$$R6xxxxxxxxxxCL
    12345678
```

1: 1 byte, subindex

2: 1 byte, UTC hour

3: 1 byte, UTC minute

4: 1 byte, UTC second

5: 1 byte, time to go hours

6: 1 byte, time to go minutes

7: 1 byte, time to go seconds

8: 4 bytes, destination waypoint identifier (See Waypoints on page 4-30.)

ASCII

```
$GPZTG,xxxxxx,xxxxxx,cccc*CKRL
         1      2      3
```

1: 6 bytes, UTC (hhmmss)

2: 6 bytes, time to go to waypoint (hhmmss)

3: 4 bytes, waypoint identifier (See Waypoints on page 4-30.)

Estimated Time of Arrival — R07

This message will not be produced unless waypoints have been entered with GPWPL/R5 and a route has been set with PMGLR/R8.

BINARY

```
$$R7xxxxxxxxxxCL
    12345678
```

1: 1 byte, subindex

2: 1 byte, UTC hour

3: 1 byte, UTC minute

4: 1 byte, UTC second

5: 1 byte, estimate time of arrival, hour

6: 1 byte, estimate time of arrival, minute

7: 1 byte, estimate time of arrival, second

8: 4 bytes, destination waypoint identifier (See Waypoints on page 4-30.)

ASCII

```
$GPZTA,xxxxxx,xxxxxx,cccc*CKRL
       1      2      3
```

1: 6 bytes, UTC (hhmmss)

2: 6 bytes, estimated time of arrival (hhmmss)

3: 4 bytes, waypoint identifier (See Waypoints on page 4-30.)

Total Number of Waypoints — R09

This message is produced when requested.

BINARY

```
$$R9xCL
   12
```

1: 1 byte, subindex

2: 1 byte, total number of waypoints defined

ASCII

```
$PMGLR,09,xxx*CKRL
       1  2
```

1: 2 bytes, subindex

2: 3 bytes, total number of waypoints defined

Waypoints, UTM — R11

This message displays waypoints in the UTM format.

BINARY

```
$$RBxxxxxxxxxxxxxxCL
    123   4   5
```

1: 1 bytes, zone number

2: 1 byte, hemisphere; 1 = north, 0 = south

3: 4 bytes, easting

4: 4 bytes, northing

5: 4 bytes, waypoint ID

ASCII

```
$PMGLR,11,xx,N,xxxxxx,xxxxxxx,xxxx*CL
          1  2 3       4    5
```

1: 1 bytes, zone number

2: 1 byte, hemisphere; 1 = north, 0 = south

3: 6 bytes, easting

4: 7 bytes, northing

5: 4 bytes, waypoint ID

Datum and Units Setup — S01

See Datum and Units Setup under Input Messages for a detailed explanation of fields.

BINARY

```
$$S1xxxxxxCL
   123456
```

1: 1 bytes, subindex

2: 1 byte, terrain setting

  0 = clear

  1 = interrupted (default)

  2 = obstructed

3: 1 byte, map datum, 1 through 47 (default is datum 47)

4: 1 byte, distance and speed units

  0 = nautical miles, knots

  1 = kilometers, kilometers per hour (default)

  2 = statute miles, miles per hour

5: 1 byte, altitude units

  0 = feet

  1 = meter (default)

6: 1 byte, magnetic variation

  0 = user-entered

  1 = auto-derived (default)

ASCII

```
$PMGLS,01,x,xx,x,x,x*CKRL
       1  2 3  4 5 6
```

1: 2 bytes, subindex

2: 1 byte, terrain setting (See Table 4 on page 4-33.)

  0 = clear

  1 = interrupted (default)

  2 = obstructed

3: 2 bytes, map datum, 1 through 47 (default is datum 47) (See list of datums on page 4-32.)

4: 1 byte, distance and speed units

  0 = nautical miles, knots

  1 = kilometers, kilometers per hour (default)

  2 = statute miles, miles per hour

5: 1 byte, altitude units

  0 = feet

  1 = meter (default)

6: 1 byte, magnetic variation

  0 = user-entered

  1 = auto-derived (default)

Almanac Data — T01

The unit will retain almanac data on power-down as long as standby power is supplied. Over time, this data will become less and less accurate unless the receiver is periodically powered up to refresh the almanac. When the receiver is on and tracking satellites, it collects and updates the almanac as changes occur.

When requested continuously, this message will be produced immediately, and thereafter only when the almanac is updated. Since the 5-channel receiver updates the almanac whenever it changes, a continuous (1-second) request to output the almanac will sometimes produce an output as often as every 30 seconds.

NOTE : Almanac data is available in binary only.

BINARY

```
$$T1xxxx..........xxxxxCL
   12
```

1: 1 byte, subindex

2: 924 bytes almanac message. Formatted as follows:

bytes 1–24	almanac for SV 1
bytes 25–26	week number for SV 1's almanac
bytes 27–50	almanac for SV 2
bytes 51–52	week number for SV 2's almanac
:	
:	
:	
:	
bytes 781–804	almanac for SV 31
bytes 805–806	week number for SV 31's almanac
bytes 807–830	almanac for SV 32
bytes 831–832	week number for SV 32's almanac
bytes 833–853	healths from page 25 subframe 5
bytes 854–877	healths from page 25 subframe 4
bytes 878–900	special message from page 17 subframe 4
bytes 901–924	ionospheric and UTC parameters (page 18 subframe 4)

Each page of data consists of 24 bytes, representing words 3 through 10 of the transmitted data, with parity removed. The two exceptions are page 25 of subframe 5, which contains only words 3 through 9 of the data, and page 17 of subframe 4, which does not include the least significant byte of word 10. Bytes are transmitted in the same order as received from the satellite (most significant byte of word 3 is transmitted first for each page).

NOTE: The values of the spare and parity bits included in downloaded ephemeris and almanac may not be the same as those received from the satellite. Specifically, this means that the following bits in the almanac have semi-random values, which are sometimes unrelated to what the satellites are broadcasting.

The lsb of byte 24 of each almanac page
The 2 most significant bits (msb) of byte 894
The 6 lsb of byte 900
The 6 lsb of byte 923
All 8 bits of byte 924

As the spare bits are unused and the parity bits already served their purpose when the data was unpacked, they are not preserved when the unit is powered off.

Refer also to Table 5 at the end of this chapter.

Ephemeris Data — T02

When the continuous transmission of ephemeris is requested, it will be produced immediately and thereafter only when the ephemeris is updated, and only for the satellite specified in the PMGL1 request.

NOTE : Ephemeris data is available in binary only.

BINARY

```
$$T2xxxxxx..........xxxxxCL
   123
```

1: 1 byte, subindex

2: 1 byte, PRN number (PRN = satellite #)

3: 61 bytes ephemeris message, formatted as follows:

bytes 1–3	word 3 of subframe 1
byte 4	lsb of word 7 of subframe 1
bytes 5–7	word 8 of subframe 1
bytes 8–10	word 9 of subframe 1
bytes 11–13	word 10 of subframe 1
bytes 14–37	words 3 through 10 of subframe 2
bytes 38–61	words 3 through 10 of subframe 3

Each word contains the 24 data bits of the transmitted data (parity removed). The most significant byte of each word is transmitted first and the least significant byte is transmitted last.

NOTE: The values of the spare and parity bits included in downloaded ephemeris and almanac may not be the same as those received from the satellite. Specifically, this means that the following bits in the ephemeris have semi-random values, which are sometimes unrelated to what the satellites are broadcasting.

The 2 least significant bits (lsb) of byte 13
The 7 lsb of byte 37
The 2 lsb of byte 61

As the spare bits are unused and the parity bits already served their purpose when the data was unpacked, they are not preserved when the unit is powered off.

Refer also to Table 6 at the end of this chapter.

Satellite Schedule — U01

This message consists of a series of "satellite visible" counts for the current position (which is the last position fix) and GMT date. Each count represents the number of satellites that will be above the receiver's starting mask angle during the corresponding 15-minute period. The first period in the list corresponds to 00:00 to 00:15 of GPS/UTC time of the given day. Also included in the message is the position for which the data was computed (which is the last known position fix from the unit). The output of the schedule is affected by the terrain setting (clear, interrupted, obscured), which affects the mask angle above which the receiver looks for satellites. A change of terrain will not be reflected until the second generation of this data after the change was made.

This message cannot be produced without a valid almanac. The information in this message is updated approximately every ten minutes.

BINARY

```
$$U1xxxxxxxxxxxxxx........xxxxxCL
  12    3    456 7
```

1: 1 byte, subindex

2: 4 bytes, latitude in 10^{-7} deg.

3: 4 bytes, longitude in 10^{-7} deg.

4: 1 byte, day

5: 1 byte, month

6: 2 bytes, year

7: 96 bytes, 24-hour satellite schedule with 15-minute windows

ASCII

```
$PMGLU,01,A,xxxx.xx,N,xxxxx.xx,W,xx,xx,xxxx*CKRL
       1  2 3       4 5        6 7  8  9
```

1: 2 bytes, subindex

2: 1 byte, sequence of this PMGLU,01 message (A)

3: 7 bytes, latitude of satellite schedule computation

4: 1 byte, hemisphere, N or S

5: 8 bytes, longitude of computation

6: 1 byte, longitude, E or W

7: 2 bytes, day of computation

8: 2 bytes, month of computation

9: 2 bytes, year of computation

```
$PMGLU,01,B,345323333334........44334456666777777*CKRL
       1  2 3
```

1: 2 bytes, subindex of satellite data module

2: 1 byte, sequence of this message (B)

3: 48 bytes, first 12 hours of satellite schedule with 15-minute windows. Each digit shows the number of available satellites for a successive 15-minute period. The first digit in the field represents 00:00 – 00:15 UTC.

```
$PMGLU,01,C,788877766554........5473334654333435 6*CKRL
       1  2 3
```

1: 2 bytes, subindex of satellite data module

2: 1 byte, sequence of this message (C)

3: 48 bytes, second 12 hours of satellite schedule with 15-minute windows. Each digit shows the number of available satellites for a successive 15-minute period. The first digit in the field represents 12:00 – 12:15 UTC.

Satellite Health — U02

This message consists of health data for each satellite (1 to 32). The health information is provided in three categories. The first category is health obtained from the broadcast almanac. The second is the health indication from the ephemeris that the unit collects when it actually tracks a satellite. No indication will be given on ephemeris health unless the ephemeris is less than two hours old. The last set of health information corresponds to that specified by the user through the "Include/Exclude Satellites" messages (PMGLU,04/U4).

BINARY

```
$$U2xxxxxxxxxxxxxxxxxxxxxxxxxCL
   12        3         4
```

1: 1 byte, subindex

2: 8 bytes, almanac health status

2 bits each for 32 satellites, 01 = healthy, 00 = unhealthy

3: 8 bytes, ephemeris health status, 2 bits each for 32 satellites,

01 = healthy, 00 = unhealthy, 11 = not available

4: 8 bytes, user health status, 2 bits each for 32 satellites,

01 = healthy, 11 = unhealthy, 00 = default

ASCII

```
$PMGLU,02,A,xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx*CKRL
        1  2 3
```

1: 2 bytes, subindex

2: 1 byte, sequence number of this message, A = almanac

3: 1 character each for the health status of 32 satellites

0 = unhealthy, 1 = healthy

```
$PMGLU,02,B,xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx*CKRL
        1  2 3
```

1: 2 bytes, subindex

2: 1 byte, sequence number of this message, B = ephemeris

3: 1 character each for the health status of 32 satellites

0 = unhealthy, 1 = healthy, - = not available

```
$PMGLU,02,C,xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx*CKRL
        1  2 3
```

1: 2 bytes, subindex

2: 1 byte, sequence number of this message, C = user

3: 1 character each for the health status of 32 satellites

1 = healthy, 0 = default, - = unhealthy

Satellite Data — U03

This message provides detailed information about a given satellite. The target satellite must be included in the PMGLI request for this message. If this message is set to continuous, the receiver will continually output the information about the one satellite indicated. If you wish to know about all satellites this message must be used for each satellite. If you wish to have a running list of this information, we suggest making a request for a satellite every 5 or 10 seconds or so, sequencing through the satellite list. The information can be kept in an external database for instant access. The satellite data is computed every three minutes.

C/N_0 is the correlator to noise ratio of the satellite signal being tracked. Values above 43 are very good, values from 40 to 42 are moderate, and values below 40 are weak (danger of losing lock).

The C/N_0 values have a direct relationship to the SQ values in field 6 of the PMGLH/H0) sentence. Refer to the table below.

Table 3. Comparison of SQ and C/N_0

SQ Level	C/N_0 (dB-Hz)*	How to Evaluate
9	≥45	
8	44	Strong
7	43	
6	42	
5	41	Not as strong
4	40	
3	39	
2	38	Weak
1	37	
0	<37	

*C/N_0 at antenna

BINARY

```
$$U3xxxxxxxCL
   123 4 5
```

1: 1 byte, subindex

2: 1 byte, PRN of satellite

3: 2 bytes, azimuth, 1 degree

4: 2 bytes, C/N_0, in db-Hz,

If the specified satellite is not tracked, the value will be 0.

5: 2 bytes, elevation angle, 1 degree

ASCII

```
$PMGLU,03,xx,xxx,xxx,xxx*CKRL
         1  2   3   4   5
```

1: 2 bytes, subindex

2: 2 bytes, PRN of satellite

3: 3 bytes, azimuth, degree

4: 3 bytes, C/N_0, in db-Hz,

If the specified satellite is not tracked, the value will be 0.

5: 3 bytes, elevation angle, degree

Raw Data — V01

Raw data output is available only with the raw data module.

NOTE: Raw data is available in binary only.

BINARY

```
$$V1xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxCL
    123   4   123   4   123   4   123   4 123   4   5
```

5 sets of data fields 1 – 4 are:

1: 1 byte, PRN and STATUS

bit 0 – 5: PRN number

bit 6 – 7: STATUS 0 = OK

1 = integrated phase count is bad

2 = pseudorange is bad

3 = both integrated phase count and pseudorange is bad

2: 1 byte, C/N_0, in db-Hz

3: 4 bytes, integrated phase count, in 1/256 cycles

4: 4 bytes, pseudorange, in 0.1 meter

5: 10 bytes, time of reception

bytes 1 – 4: seconds of week, in seconds

bytes 5 – 8: seconds of week, in nanoseconds

bytes 9 – 10: week number

INPUT MESSAGES

Input messages are from the host to the OEM module.

Time and Date

A0/GPZDA — Same as output.

Position and Altitude

B0/GPGGA — Same as output except the only valid fields are L/L and altitude.

Position and Altitude, UTM
B3/GPGLB,03 — Same as output.

Extended Altitude
B2/PMGLB,02 — Same as output.

This message will be ignored if the module is in AUTO mode computing 3D fixes.

NOTE: The receiver will not produce fixes with altitudes greater than 57,000 feet (17,500 meters). Special software is available for high altitude applications such as atmospheric research.

Mode
D0/PMGLD — Same as output

Differential Corrections
This message enables the user to specify what differential pseudorange and delta pseudorange corrections will be used by the OEM firmware for position computation. The contents of this message are based on, but are not in exact compliance with, the RTCM (version 2.0) Type 1 and Type 2 message formats; the difference is that the differential corrections message does not contain the complicated parity scheme of the RTCM message. In addition, this alternative formatting method allows corrections to be sent over a common data network channel, whereas RTCM requires a dedicated data channel for successful operation. Note that a different message must be sent for each satellite for which range corrections are desired.

Pseudoranges need not be received for all satellites being tracked in order for the information received to be applied. The OEM firmware will "time out" corrections 60 seconds after their time of reception by the OEM module. Delta (Type 2) corrections have the same format as pseudorange (Type 1) corrections. They are differentiated by the lowest bit in the 16-bit word of field 7 (time). The RTCM SC-104 data message uses only 13 bits to indicate time, with each bit having a 0.6 second resolution. The 13 bits are placed into the 13 most significant bits of field 7. The lower 3 bits are padded with zeros and their resolution changes to 0.075 seconds/bit. This allows us to use the LSB to indicate whether the data message is type 1 or type 2. Type 9 data messages are processed in the same manner as type 1 data messages.

BINARY

```
$$J0bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbDCL
                                          6       7
    12 3    4                   5
```

("b" denotes bit, not byte — "D" denotes delta/not delta bit)

1: 1 bit, scale factor, 0 or 1.

2: 2 bits, UDRE

3: 5 bits, satellite ID

4: 16 bits, pseudorange correction, 0.02 meters if scale factor = 0, 0.32 meters if scale factor = 1

5: 8 bits, range rate correction, 0.002 m/s if scale factor = 0, 0.032 m/s if scale factor = 1

6: 8 bits, issue of data

7: 16 bits, time of validity, 0-3599.4 seconds, LSB = 0.075 seconds.

Bit 0 is decoded as:

0 = pseudorange correction

1 = delta pseudorange correction

Message ON/OFF, Binary/ASCII Selection

NOTE : PMGLI is an ASCII-only message

ASCII

```
$PMGLI,00,xxx,x,x,xx*CKRL
       1  23  4 5 6
```

1: 2 bytes, subindex

2&3: Specific sentence ID as follows:

2: 1 byte, 'A–Z' primary index for messages

3: 2 bytes, '0–99' subindex for messages

or 2&3: 3 bytes, '100' indicates all messages

4: 1 byte

0 = Turns off output. If field 2 = 'A–Z' and field 3 = '00–99' then the individual sentence is turned off. If field 2&3 = '100' then all output is turned off and the previous configuration is retained. A field 4 command of 1 with a field 2&3 command of '100' must be issued before any output can be obtained or the configuration can be altered again.

1 = Provided a field 4 command of '0' with field 2&3 = '100' was not the last command issued, if field 2 = 'A–Z' and field 3 = '00–99' then this command will produce a one time output for the selected sentence. If this particular sentence was turned on as continuous, it will be subsequently shut off. If the last command issued was field 4 command '0' with a field 2&3 = '100' then this command with field 2&3 = '100' will turn on the configuration retained. If other values are in 2&3, the message will be ignored.

2 or greater = Turns on data for the specified sentence in field 2&3 with continuous output at a repetition rate as indicated below. If field 2&3 = '100' then all sentences currently selected for output will be changed to the binary/ASCII mode indicated in field 5.

2	=	1 second
3	=	2 seconds
4	=	5 seconds
5	=	10 seconds
6	=	30 seconds
7	=	60 seconds
8	=	2 minutes
9	=	5 minutes

5: A= ASCII format
B= binary format

6: PRN if satellite data or ephemeris data message is specified.

NOTE: There are no ASCII format messages for almanac and ephemeris. Also, if the continuous output selection is made for almanac or ephemeris, they will be output only when new data is collected instead of at the selected fixed interval rate.

Time Transfer Setup and Control

K1/PMGLK,01 — Same as output.

Time Transfer Mode

K2/PMGLK,02 — Same as output.

Force Satellite Reselection

BINARY

```
$$M0xCL
   12
```

1: 1 byte, subindex

2: 1 byte, 1 = force satellite selection

ASCII

```
$PMGLM,00,x*CKRL
       1  2
```

1: 2 bytes, subindex

2: 1 byte, 1 = force satellite selection

Master Reset

BINARY

```
$$N0xCL
   12
```

1: 1 byte, subindex

2: 1 byte, 1 = cause master reset with memory lost

ASCII

```
$PMGLN,00,x*CKRL
       1  2
```

1: 2 bytes, subindex

2: 1 byte, 1 = cause master reset with memory lost

Force Sky Search

This forces the receiver into an abbreviated COLD START with almanac & time/date.

BINARY

```
$$N1xCL
   12
```

1: 1 byte, subindex

2: 1 byte 1 = force sky search

ASCII

```
$PMGLN,01,x*CKRL
       1  2
```

1: 2 bytes, subindex

2: 1 byte 1 = force sky search

Change Baud Rate — Port 1
This message changes the baud rate for data port 1.

BINARY

```
$$00xCL
  12
```

1: 1 byte, subindex
2: 1 byte, 0 = 9600
1 = 4800
2 = 2400
3 = 1200

ASCII

```
$PMGLO,00,x*CKRL
       1  2
```

1: 2 bytes, subindex
2: 1 byte, 0 = 9600
1 = 4800
2 = 2400
3 = 1200

Change Baud Rate — Port 2
This message changes the baud rate for data port 2.

BINARY

```
$$01xCL
  12
```

1: 1 byte, subindex
2: 1 byte, 0 = 9600
1 = 4800
2 = 2400
3 = 1200

ASCII

```
$PMGLO,01,x*CKRL
       1  2
```

1: 2 bytes, subindex
2: 1 byte, 0 = 9600
1 = 4800
2 = 2400
3 = 1200

Set RTCM Input — Port 2
This message turns port 2 on to accept RTCM SC-104 differential corrections. It is not available on the timing firmware (P/N 00-8500X-003).

BINARY

```
$$02xCL
   12
```

1: 1 byte, subindex

2: 1 byte, 0 = Port 2 off
1 = Port 2 on

ASCII

```
$PMGLO,02,x*CKRL
       1  2
```

1: 2 bytes, subindex

2: 1 byte, 0 = Port 2 off
1 = Port 2 on

Force User-Selected Satellites

This message will force the receiver to use the user-selected satellites to compute the navigation solution. The selected satellites will be tracked or if not visible, searched for unless changed with another PMGLP/P0 message or cancelled with a MPGLM/M0 (Force Satellite Reselect) message, provided the following conditions exist:

1. the number of satellites matches the mode (3 = 2D, 4 = 3D)
2. the PDOP of the user-selected satellite set is <50
3. the selected satellites are above the mask angle of the current terrain setting

BINARY

```
$$P0xxxxCL
   12345
```

1: 1 byte, subindex

2: 1 byte, first satellite to use

3: 1 byte, second satellite to use

4: 1 byte, third satellite to use

5: 1 byte, fourth satellite to use (if in 3D)

ASCII

```
PMGLP,00,xx,xx,xx,xx*CKRL
      1  2  3  4  5
```

1: 2 bytes, subindex

2: 2 bytes, first satellite to use

3: 2 bytes, second satellite to use

4: 2 bytes, third satellite to use

5: 2 bytes, fourth satellite to use (if in 3D)

Waypoints

Each waypoint must have a unique identifier consisting of exactly four characters (alpha upper case, lower case, numeric, or space characters only). Both binary and ASCII navigation messages use this format for waypoint identifiers; this is required to enter and retreive waypoints across both formats.

Up to 100 waypoints can be stored by the OEM unit. If a waypoint is entered with an identifier that is already in use, the existing waypoint is replaced with the new one. If the waypoint memory is full when a new waypoint is entered, the oldest waypoint in the memory is replaced with the new one. Waypoints are retained during power down by continuous power or battery backup.

R5/PMGLR,05 — Same as output

Waypoints, UTM
R11/PMGLR,11 — Same as output

Clear/Rename a Waypoint
If "LFIX" is entered as the waypoint name in field 2, the receiver will take the last fix (current position) and save it as a waypoint with the name indicated in field 3.

BINARY

```
$$RAccccxxxxCL
   12   3
```

1: 1 byte, subindex (A = hex 0A = decimal 10)

2: 4 bytes, waypoint to be cleared or renamed

3: 4 bytes, clear waypoint if "0000", rename if other

ASCII

```
$PMGLR,10,cccc,xxxx*CKRL
       1  2    3
```

1: 2 byte, subindex of waypoint module

2: 4 bytes, waypoint to be cleared or renamed

3: 4 bytes, clear waypoint if "0000", rename if ASCII

Route
Once waypoints have been entered into the unit (with GPWPL/R5), a route can be set with the route message. This message also causes the unit to go from status 6 (POS) to status 7 (NAV); any navigation data sentences that have been turned on will be output subsequently.

A route is a planned course of travel from one waypoint to another. The "from" waypoint is entered in field 3. When LFIX is entered in field 3, the present position (last fix) is saved as temporary waypoint "strt." The "to" waypoint is entered in field 4.

An existing route can be cleared by entering the same values in fields 3 and 4. This will also put the unit back into status 6.

BINARY

```
$$R8xxxxxxxxxCL
   123   4
```

1: 1 byte, subindex

2: 1 byte, route number (ignored)

3: 4 bytes, from waypoint identifier (See Waypoints on page 4-30.)

4: 4 bytes, to waypoint identifier

ASCII

```
$PMGLR,08,xx,cccc,cccc*CKRL
          1  2   3    4
```

1: 2 bytes, subindex

2: 2 bytes, route number (ignored)

3: 4 bytes, from waypoint identifier (See **Waypoints** on page 4-30.)

4: 4 bytes, to waypoint identifier

Magnetic Variation

This message allows magnetic variation to be entered manually. The receiver will automatically compute the magnetic variation used in course and bearing, unless it is entered via this message (GPHVM/R4) and field 6 of Datum and Units Setup is set to 0 to indicate User-Entered Magnetic Variation.

This input message will be ignored unless the receiver has previously been set to User Magnetic Variation in field 6 of PMGLS,01/S1.

Same as output (HVM only)

Datum and Units Setup

S1/PMGLS,01 —Same as output

This message allows various parameters to be changed. The defaults settings are:

Terrain: 2 (obscured)
Map Datum: 47 (WGS84)
Distance/Speed Units: 1 (km/kph)
Altitude Units: 1 (meters)
Magnetic Variation: 1 (auto-derived)

This message allows the selection of 47 pre-programmed transformations of map data, which will be applied to the output Latitude and Longitude. The 47 map data are:

01-ADIND	11-GUNSG	21-LUZON	31-QORNO	41-VOIRO
02-ARC50	12-GUNSRS	22-MERCH	32-SIERR	42-SDIND
03-AUSTR	13-HERAT	23-MONTJ	33-CAMPO	43-SDLUZ
04-BUKIT	14-HJOR	24-NIGER	34-CHUAA	44-SDTOK
05-ASTRO	15-HUTZU	25-NAD27	35-CORRE	45-SDWGS
06-DJAKA	16-INDIA	26-ALASK	36-PROVI	46-WGS72
07-EUROP	17-IRELA	27-MAUI	37-YACAR	47-WGS84
08-GEO49	18-KERTA	28-OAHU	38-TANAN	
09-GHANA	19-LIBER	29-KAUAI	39-TIMBA	
10-GUAM	20-NAD83	30-OSGB	40-TOKYO	

Terrain setting is also selected in this message. Terrain setting influences the mask angle above which the receiver looks for satellites. It also affects the PDOP cutoff above which the receiver will look for a different constellation of satellites for better accuracy. Set the terrain setting to clear for navigating in environments where satellite visibility is good (like the ocean). The clear setting ensures that the best constellation of satellites will

Table 4. Terrain Setting and Mask Angle.

TERRAIN	MODE	MASK ANGLE		SWITCHING CONSTELLATION AT PDOP OF
		START	FALLS TO [1]	
CLEAR	2D	5	5	EVERY TIME
	AUTO/3D	5	5	EVERY TIME
INT	2D	15	10, 5	> 4
	AUTO/3D	15	10, 5 → 2D [2]	> 6
OBS	2D	20	10, 5	> 10
	AUTO/3D	20	10, 5 → 2D [2]	> 10
If VDOP > 7, the receiver will automatically drop into 2D mode, regardless of the terrain setting.				

1 In the AUTO mode the unit will provide a 3D solution whenever possible. When the unit is in 3D/AUTO, the receiver will switch to 2D operation when the 3D PDOP is >8. When the unit is in 2D/AUTO, the receiver will switch to 3D operation when 3D PDOP is <6.

2 When the module is in the AUTO mode and there are insufficient satellites above the mask angle for a 3D position fix, the mask angle is systematically lowered as shown in an effort to find enough satellites for a 3D satellites set. If satellites still cannot be found, the unit falls into 2D.

always be chosen for maximum accuracy. Use the interrupted or obstructed modes when satellite visibility is hindered (as in land mobile applications). The interrupted and obstructed settings place less emphasis on the best constellation and more on finding and holding onto satellites that are visible.

Almanac Data
T1 — Same as output

Ephemeris Data
T2 — Same as output

Set Satellite Health
This message allows you to do the following :

1. Mark any satellite in the almanac unhealthy, which prohibits the unit from using the marked satellite in the navigation solution.
2. Mark any satellite in the almanac healthy. This allows the receiver to try to use the satellite in the navigation solution, regardless of its health.
3. Return to normal health. If either 1 or 2 above is issued, this selection returns the satellite to normal health as indicated by the almanac/ephemeris.

NOTE: Under normal conditions, this message is not used. Also, the user cannot affect satellites that are not included in the current almanac.

BINARY

```
$$U4xxCL
   123
```

1: 1 byte, subindex

2: 1 byte, satellite's PRN

3: 1 byte, set satellite health

0 = unhealthy

1 = healthy

2 = return satellite to its natural health

ASCII

```
$PMGLU,04,xx,x*CKRL
         1  2  3
```

1: 2 bytes, subindex

2: 2 bytes, satellite's PRN

3: 1 byte, set satellite health

0 = unhealthy

1 = healthy

2 = return satellite to its natural health

Table 5. Almanac Description.

START BYTE	END BYTE	DESCRIPTION	ICD-GPS-200 EQUIVALENT SUBFRAME	PAGE	WORDS/BITS
1	24	Almanac for SV 1	5	1	Most significant 24 bits of each words 3-10
25	26	Week number for almanac of SV 1			
27	50	Almanac for SV 2	5	2	Most significant 24 bits of each words 3-10
51	52	Week number for almanac of SV 2			
53	76	Almanac for SV 3	5	3	Most significant 24 bits of each words 3-10
77	78	Week number for almanac of SV 3			
79	102	Almanac for SV 4	5	4	Most significant 24 bits of each words 3-10
103	104	Week number for almanac of SV 4			
105	128	Almanac for SV 5	5	5	Most significant 24 bits of each words 3-10
129	130	Week number for almanac of SV 5			
131	154	Almanac for SV 6	5	6	Most significant 24 bits of each words 3-10
155	156	Week number for almanac of SV 6			
157	180	Almanac for SV 7	5	7	Most significant 24 bits of each words 3-10
181	182	Week number for almanac of SV 7			
183	206	Almanac for SV 8	5	8	Most significant 24 bits of each words 3-10
207	208	Week number for almanac of SV 8			
209	232	Almanac for SV 9	5	9	Most significant 24 bits of each words 3-10
233	234	Week number for almanac of SV 9			
235	258	Almanac for SV 10	5	10	Most significant 24 bits of each words 3-10
259	260	Week number for almanac of SV 10			

Table 5. Almanac Description (cont).

START BYTE	END BYTE	DESCRIPTION	ICD-GPS-200 EQUIVALENT SUBFRAME	PAGE	WORDS/BITS
261	284	Almanac for SV 11	5	11	Most significant 24 bits of each words 3-10
285	286	Week number for almanac of SV 11			
287	310	Almanac for SV 12	5	12	Most significant 24 bits of each words 3-10
311	312	Week number for almanac of SV 12			
313	336	Almanac for SV 13	5	13	Most significant 24 bits of each words 3-10
337	338	Week number for almanac of SV 13			
339	362	Almanac for SV 14	5	14	Most significant 24 bits of each words 3-10
363	364	Week number for almanac of SV 14			
365	388	Almanac for SV 15	5	15	Most significant 24 bits of each words 3-10
389	390	Week number for almanac of SV 15			
391	414	Almanac for SV 16	5	16	Most significant 24 bits of each words 3-10
415	416	Week number for almanac of SV 16			
417	440	Almanac for SV 17	5	17	Most significant 24 bits of each words 3-10
441	442	Week number for almanac of SV 17			
443	466	Almanac for SV 18	5	18	Most significant 24 bits of each words 3-10
467	468	Week number for almanac of SV 18			
469	492	Almanac for SV 19	5	19	Most significant 24 bits of each words 3-10
493	494	Week number for almanac of SV 19			
495	518	Almanac for SV 20	5	20	Most significant 24 bits of each words 3-10
519	520	Week number for almanac of SV 20			
521	544	Almanac for SV 21	5	21	Most significant 24 bits of each words 3-10
545	546	Week number for almanac of SV 21			
547	570	Almanac for SV 22	5	22	Most significant 24 bits of each words 3-10
571	572	Week number for almanac of SV 22			
573	596	Almanac for SV 23	5	23	Most significant 24 bits of each words 3-10
597	598	Week number for almanac of SV 23			
599	622	Almanac for SV 24	5	24	Most significant 24 bits of each words 3-10
623	624	Week number for almanac of SV 24			
625	648	Almanac for SV 25	4	2	Most significant 24 bits of each words 3-10
649	650	Week number for almanac of SV 25			
651	674	Almanac for SV 26	4	3	Most significant 24 bits of each words 3-10
675	676	Week number for almanac of SV 26			
677	700	Almanac for SV 27	4	4	Most significant 24 bits of each words 3-10
701	702	Week number for almanac of SV 27			
703	726	Almanac for SV 28	4	5	Most significant 24 bits of each words 3-10
727	728	Week number for almanac of SV 28			
729	752	Almanac for SV 29	4	7	Most significant 24 bits of each words 3-10
753	754	Week number for almanac of SV 29			
755	778	Almanac for SV 30	4	8	Most significant 24 bits of each words 3-10
779	780	Week number for almanac of SV 30			

Table 5. Almanac Description (cont).

START BYTE	END BYTE	DESCRIPTION	ICD-GPS-200 EQUIVALENT SUBFRAME	PAGE	WORDS/BITS
781	804	Almanac for SV 31	4	9	Most significant 24 bits of each words 3-10
805	806	Week number for almanac of SV 31			
807	830	Almanac for SV 32	4	10	Most significant 24 bits of each words 3-10
831	832	Week number for almanac of SV 32			
833	853	Healths	5	25	Most significant 24 bits of each of words 3-9
854	877	Healths	4	25	Most significant 24 bits of each of words 3-10
878	900	Special message	4	17	Most significant 24 bits of each of words 3-9 and most significant 16 bits of word 10
900	924	Ionospheric and UTC parameters	4	18	Most significant 24 bits of each of words 3-10

The week numbers output by Magellan's OEM GPS receiver module are modified versions of the week number as transmitted by the satellites. Therefore, week numbers have no direct ICD-GPS-200 equivalent.

Table 6. Ephemeris Description.

START BYTE	END BYTE	DESCRIPTION	ICD-GPS-200 EQUIVALENT SUBFRAME	WORDS/BITS
1	3	Week number Codes on L2 channel User range accuracy (ephemeris error) Health of satellite Issue of data number for clock	1	3
4	4	Estimated group delay differential (L1 – L2 correction parameters)	1	lsb of word 7
5	7	Satellite clock correction parameters	1	8
8	10	Satellite clock correction parameters	1	9
11	13	Satellite clock correction parameters	1	10
14	37	Ephemeris parameters describing satellite orbit	2	3 – 10
38	61	Ephemeris parameters describing satellite orbit	3	3 – 10

CHAPTER 5
OEM FIRMWARE MESSAGES QUICK REFERENCE

This is a quick reference to locate the different data sentence by ASCII, by BINARY, or by data content. The BINARY reference used here is the same as you would use in the PMGLI sentence to reference the ASCII or BINARY data sentence in the protocol. (B00 as opposed to B0.) The I/O indicates whether the sentence is both input/output, just input, or just output. Page is the location in this document.

SORTED BY BINARY CODE

ASCII	BINARY	FUNCTION	I/O	PAGE
PMGLI00	—	Message On/Off, Binary/ASCII	I	4-27
GPZDA	A00	Time and Date	I/O	4-1
GPGGA	B00	Position, Altitude etc.	I/O	4-1
GPGLL	B01	Position (Last Fix)	O	4-2
PMGLB02	B02	Altitude (alt, 6 digits)	I/O	4-2
PMGLB03	B03	Position and Altitude, UTM	I/O	4-3
PMGLC00	C00	ECEF Position	O	4-4
PMGLD00	D00	Mode	I/O	4-4
GPVTG	E00	Ground Course and Velocity	O	4-5
PMGLF00	F00	Satellites Used	O	4-5
PMGLF01	F01	Satellites Used Including Status	O	4-6
PMGLF02	F02	5-Channel Satellite Usage	O	4-7
PMGLG00	G00	PDOP, GDOP, Error Estimate	O	4-8
PMGLH00	H00	Receiver Status	O	4-9
—	J00	Differential Corrections	I	4-26
PMGLK01	K01	Time Transfer Setup/Control	I/O	4-11
PMGLK02	K02	Time Transfer Mode	I/O	4-12
PMGLK03	K03	Time Transfer Message	O	4-12
PMGLM00	M00	Force Satellite Reselection	I	4-28
PMGLN00	N00	Master Reset	I	4-28
PMGLN01	N01	Force Sky Search	I	4-28
PMGLO00	O00	Change Baud Rate — Port 1	I	4-29
PMGLO01	O01	Change Baud Rate — Port 2	I	4-29
PMGLO02	O02	Set RTCM Input — Port 2	I	4-29
PMGLP	P00	Force User-Selected Satellites	I	4-30
GPAPA	R01	Autopilot	O	4-13
GPBOD	R02	Bearing (Dest and Orig Wypts)	O	4-14

SORTED BY BINARY CODE (con't)

ASCII	BINARY	FUNCTION	I/O	PAGE
GPBWC	R03	Bearing and Distance to Waypoint	O	4-15
GPHVD	R04	Magnetic Variation (derived)	O	4-16
GPHVM	R04	Magnetic Variation (manual)	I/O	4-16
GPWPL	R05	Waypoints	I/O	4-16
GPZTG	R06	Time To Go to Waypoint	O	4-17
GPZTA	R07	ETA to Waypoint	O	4-17
PMGLR08	R08	Route	I	4-31
PMGLR09	R09	Number of Waypoints	O	4-18
PMGLR10	R10	Clear/Rename Waypoint	I	4-31
PMGLR11	R11	Waypoints, UTM	I/O	4-18
PMGLS01	S01	Datum, Terrain, and Units Setup	I/O	4-19
—	T01	Almanac Data	I/O	4-20
—	T02	Ephemeris Data	I/O	4-21
PMGLU01	U01	Satellite Schedule	O	4-21
PMGLU02	U02	Satellite Health (Alm, Eph, User)	O	4-23
PMGLU03	U03	Satellite Status	O	4-24
PMGLU04	U04	Set Satellite Health	I	4-33
—	V01	Raw Data	O	4-25

SORTED BY ASCII CODE

ASCII	BINARY	FUNCTION	I/O	PAGE
—	J00	Differential Corrections	I	4-26
—	T01	Almanac Data	I/O	4-20
—	T02	Ephemeris Data	I/O	4-21
—	V01	Raw Data	O	4-25
GPAPA	R01	Autopilot	O	4-13
GPBOD	R02	Bearing (Dest and Orig Wypts)	O	4-14
GPBWC	R03	Bearing and Distance to Waypoint	O	4-15
GPGGA	B00	Position, Altitude etc.	I/O	4-1
GPGLL	B01	Position (Last Fix)	O	4-2
GPHVD	R04	Magnetic Variation (derived)	O	4-16
GPHVM	R04	Magnetic Variation (manual)	I/O	4-16
GPVTG	E00	Ground Course, Velocity	O	4-5
GPWPL	R05	Waypoints	I/O	4-16
GPZDA	A00	Time and Date	I/O	4-1
GPZTA	R07	ETA to Waypoint	O	4-17

SORTED BY ASCII CODE (con't)

ASCII	BINARY	FUNCTION	I/O	PAGE
GPZTG	R06	Time To Go to Waypoint	O	4-17
PMGLB01	B01	Position (Last Fix)	O	4-2
PMGLB02	B02	Altitude (alt, 6 digits)	I/O	4-2
PMGLB03	B03	Position and Altitude, UTM	I/O	4-3
PMGLC00	C00	ECEF Position	O	4-4
PMGLD00	D00	Mode	I/O	4-4
PMGLF00	F00	Satellites Used	O	4-5
PMGLF01	F01	Satellites Used Including Status	O	4-6
PMGLF02	F02	5-Channel Satellite Usage	O	4-7
PMGLG00	G00	PDOP, GDOP, Error Estimate	O	4-8
PMGLH00	H00	Receiver Status	O	4-9
PMGLI00	—	Message On/Off, Binary/ASCII	I	4-27
PMGLK01	K01	Time Transfer Setup/Control	I/O	4-11
PMGLK02	K02	Time Transfer Mode	I/O	4-12
PMGLK03	K03	Time Transfer Message	O	4-12
PMGLM00	M00	Force Satellite Reselection	I	4-28
PMGLN00	N00	Master Reset	I	4-28
PMGLN01	N01	Force Sky Search	I	4-28
PMGLO00	O00	Change Baud Rate — Port 1	I	4-29
PMGLO01	O01	Change Baud Rate — Port 2	I	4-29
PMGLO02	O02	Set RTCM Input — Port 2	I	4-29
PMGLP	P00	Force User-Selected Satellites	I	4-30
PMGLR08	R08	Route	I	4-31
PMGLR09	R09	Number of Waypoints	I	4-18
PMGLR10	R10	Clear/Rename Waypoint	I	4-31
PMGLR11	R11	Waypoints, UTM	I/O	4-18
PMGLS01	S01	Datum, Terrain, and Units Setup	I/O	4-19
PMGLU01	U01	Satellite Schedule	O	4-21
PMGLU02	U02	Satellite Health (Alm, Eph, User)	O	4-23
PMGLU03	U03	Satellite Status	O	4-24
PMGLU04	U04	Set Satellite Health	I	4-33

SORTED BY FUNCTION

ASCII	BINARY	FUNCTION	I/O	PAGE
PMGLO00	O00	Change Baud Rate — Port 1	I	4-29
PMGLO01	O01	Change Baud Rate — Port 2	I	4-29
PMGLS01	S01	Datum Select	I/O	4-19
GPBOD	R02	Destination Waypoint	O	4-14
—	J00	Differential Corrections	I	4-26
GPBWC	R03	Distance to Waypoint	O	4-15
PMGLS01	S01	Distance Units	I/O	4-19
PMGLC00	C00	ECEF Position	O	4-3
PMGLU03	U03	Elevation of Satellite	O	4-24
—	T02	Ephemeris Data	I/O	4-21
PMGLG00	G00	Error Estimate	O	4-8
GPZTA	R07	ETA to Waypoint	O	4-17
PMGLU04	U04	Exclude Satellites	I	4-33
PMGLF02	F02	5-Channel Satellite Usage	O	4-7
PMGLM00	M00	Force Satellite Reselection	I	4-28
PMGLN01	N01	Force Sky Search	I	4-28
PMGLP	P00	Force User-Selected Satellites	I	4-30
PMGLI00	—	Frequency of Message	I	4-27
PMGLG00	G00	GDOP	O	4-8
GPGGA	B00	Geoidal Height	I/O	4-1
GPGGA	B00	GPS Quality	I/O	4-1
PMGLH00	H00	GQ	O	4-9
GPVTG	E00	Ground Course	O	4-5
GPGGA	B00	HDOP	I/O	4-1
GPVTG	E00	Heading	O	4-5
PMGLU02	U02	Health (Alm, Eph, User)	O	4-23
PMGLU04	U04	Include Satellites	I	4-33
GPGLL	B01	Last Fix	O	4-2
GPBWC	R03	Lat of Waypoint	O	4-15
GPBWC	R03	Lon of Waypoint	O	4-15
PMGLS01	S01	Magnetic Variation (User vs Auto)	I/O	4-19
GPHVD	R04	Magnetic Variation (Derived)	O	4-16
GPHVM	R04	Magnetic Variation (Manual)	I/O	4-16
PMGLS01	S01	Map Datum	I/O	4-19

SORTED BY FUNCTION (cont)

ASCII	BINARY	FUNCTION	I/O	PAGE
PMGLH00	H00	Memory	O	4-9
PMGLI00	—	Message Frequency	I	4-27
PMGLI00	—	Message On/Off	I	4-27
PMGLD00	D00	Mode	I/O	4-4
PMGLH00	H00	Navigation Solution Quality	O	4-9
GPGGA	B00	Number of Satellites Used	I/O	4-1
PMGLR09	R09	Number of Waypoints	I	4-18
GPBOD	R02	Origin Waypoint	O	4-14
PMGLG00	G00	PDOP	O	4-8
GPGGA	B00	Altitude	I/O	4-1
GPGLL	B01	Position (Last Fix)	O	4-2
PMGLB02	B02	Position	I/O	4-2
PMGLB03	B03	Position and Altitude, UTM	I/O	4-3
—	V01	Raw Data	O	4-25
PMGLH00	H00	Receiver Status	O	4-9
PMGLR10	R10	Rename Waypoint	I	4-31
PMGLN00	N00	Reset, Clear Memory	I	4-28
PMGLR08	R08	Route	I	4-31
PMGLU02	U02	Satellite Health (Alm, Eph, User)	O	4-23
PMGLU03	U03	Satellite Location (Elev, Azimuth, C/N_o)	O	4-24
PMGLU01	U01	Satellite Schedule	O	4-21
PMGLF00	F00	Satellites Used	O	4-5
PMGLF01	F01	Satellites Used (With Sat Status)	O	4-6
PMGLM00	M00	Satellite Reselection, Forced	I	4-28
PMGLO02	O02	Set RTCM Input — Port 2	I	4-29
PMGLS01	S01	Speed Units	I/O	4-19
PMGLH00	H00	SQ	O	4-9
PMGLS01	S01	Terrain Setting	I/O	4-19
GPZDA	A00	Time	I/O	4-1
GPZTG	R06	Time To Go to Waypoint	O	4-17
PMGLK01	K01	Time Transfer Setup/Control	I/O	4-11
PMGLK02	K02	Time Transfer Mode	I/O	4-12
PMGLK03	K03	Time Transfer Message	O	4-12
—	V01	Transmit Raw Data	O	4-25
PMGLH00	H00	Unit Status	O	4-9
PMGLS01	S01	Units	I/O	4-19
GPVTG	E00	Velocity	O	4-5

SORTED BY FUNCTION (cont)

ASCII	BINARY	FUNCTION	I/O	PAGE
GPWPL	R05	Waypoints	I/O	4-16
PMGLR11	R11	Waypoints, UTM	I/O	4-18

PART III

HARDWARE GUIDE

CHAPTER 6

OEM HARDWARE CHARACTERISTICS

This chapter describes the hardware characteristics of the OEM/PS and the OEM/5V. To avoid confusion, the two boards are described separately.

MECHANICAL DETAILS, OEM/PS

The OEM/PS 5-channel module consists of a single circuit board that is a complete operational GPS receiver. The board is provided with mounting holes in each of the four corners and two mid-board mounting holes, for #4 mounting hardware. Refer to Figure 8 for the critical dimensions of the board and the physical locations of the interface connectors and the configuration jumper block.

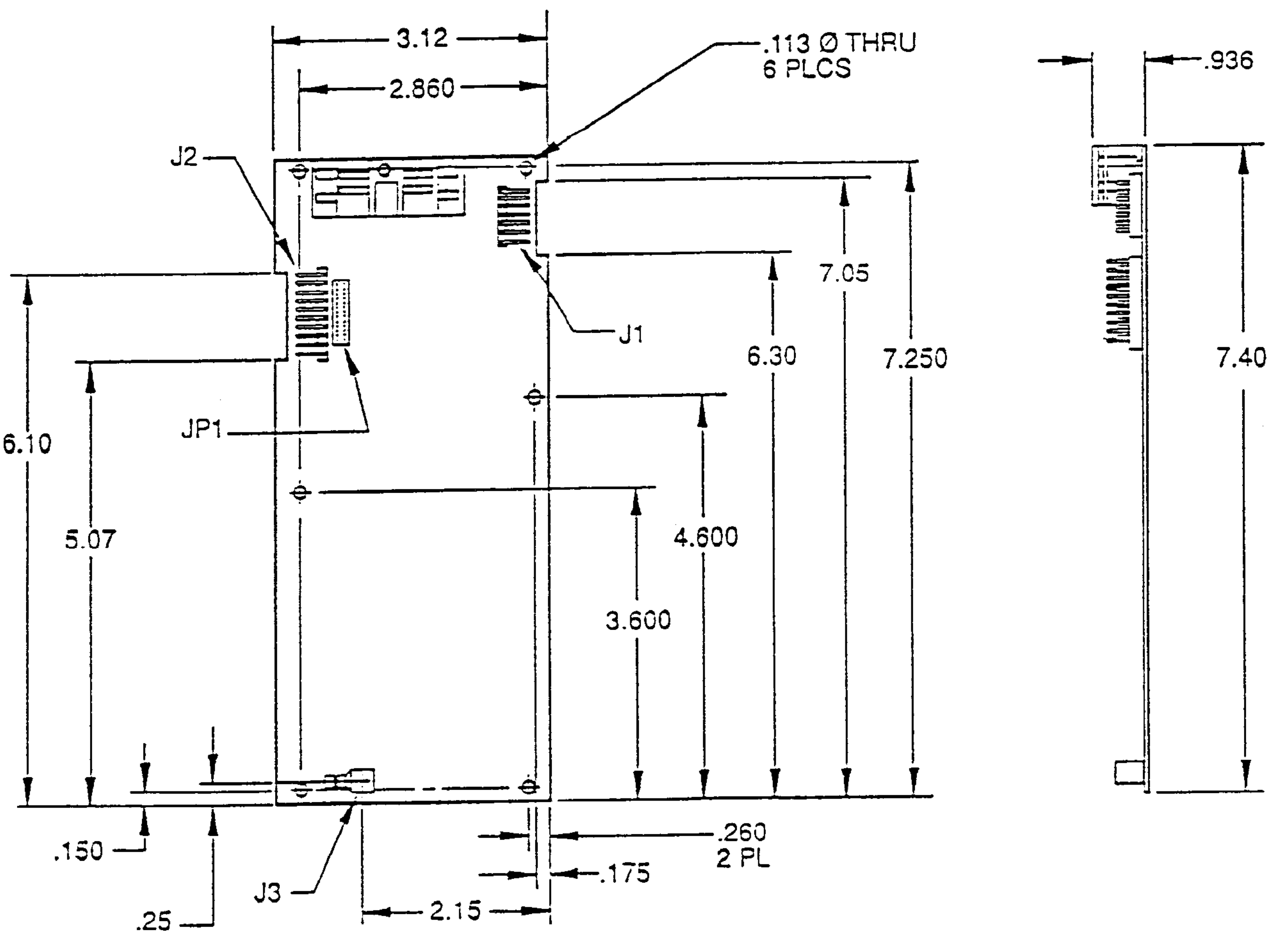


Figure 8. OEM/PS 5-Channel Installation Drawing

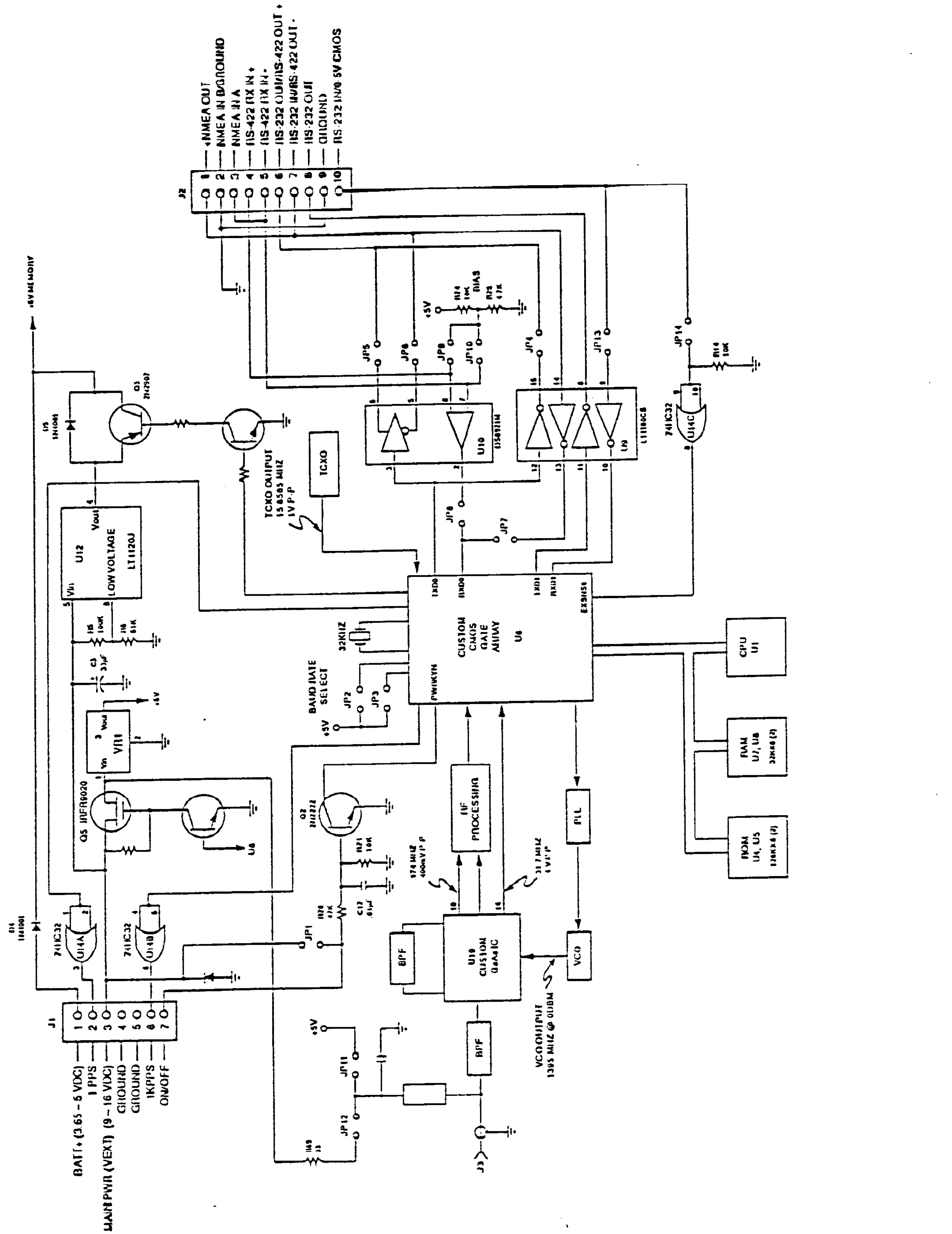


Figure 9. Functional Block Diagram of the OEM/PS 5-Channel Board

There are three connectors on the assembly that are of interest to the user. The RF input connector (J3) is an SMB connector designed to interface to an internal cable. The two other connectors are the power interface (J1) and the data interface (J2). The functions of these are defined in detail in Figure 9. JP1 through JP14 are located on a jumper block. Their functions are defined in Table 7 and Table 8.

ELECTRONIC DETAILS, OEM/PS

The OEM/PS 5-channel module is driven by a standard NEC V30H CPU (U1) running at 16 MHz. The RAM is two 32K x 8b (U7 & U8) and the ROM is two 128K x 8 (U4 & U5). GPS signal processing is accomplished by U8 and U19. U8 is a proprietary gate array, and U19 is a proprietary Gallium Arsenide IC. Both are designed by Magellan Systems. RS-232 communications is provided by a LT1180CS (U9), which is a dual bi-directional RS-232 driver. RS-422 communications is provided by a DS8921M (U10), which is a single bi-directional RS-422 driver. U12 (LT1120J) is a voltage regulator IC that serves two purposes. U12 provides a regulated +5 VDC for memory backup as long as +9 VDC to +16 VDC main power is supplied. It also overrides memory battery use when external voltage is present, and forces shutdown when it senses a low voltage condition (low voltage is < +8.5 VDC). The unit will warm-start when the voltage rises above +9 VDC. VR1 is the +5 VDC regulator for main board power. All board circuits (outside of power control) operate from +5 VDC.

There are no user-adjustable items on the board. The TCXO in the receiver is set by the manufacturer and should not be touched in the field. Any attempt to do so without the proper test equipment will cause the receiver to fail to acquire signals.

POWER INTERFACE, OEM/PS

Connector Information

Connector J1 is the power interface connector. This is a 7-pin, right-angle Molex on the circuit board. The recommended housing and pin for mating with this connector are:

Housing — Molex part number 22-01-2071

Pin — Molex part number 08-50-0114

The functions provided on J1 are as follows:

Pin 1: Battery — Memory backup, +3.6 VDC to +5 VDC

Pin 2: 1PPS — One Pulse Per Second (00-85000-003 only)

Pin 3: Main Power (VEXT), +9 VDC to +16 VDC

Pin 4: Ground

Pin 5: Ground

Pin 6: 1K PPS —1K Pulses Per Second (00-85000-003 only)

Pin 7: On/Off control, +3.5 VDC to +16 VDC

Input Power Requirements

> **WARNING**
>
> Memory standby voltage (Batt+) is specified to be between +3.6 VDC and +5 VDC. Application of voltage in excess of +5 VDC will destroy critical circuits.

The OEM/PS Module requires DC power to be supplied from the host system. The power requirements for the module alone are 9.0 to 16.0 VDC at 240 mA. When used with the Magellan antenna, the power requirements are 9.0 to 16.0 VDC at 270 mA. In this configuration, power is supplied to the antenna pre-amp circuits from the RF through the interconnecting coax cable. The jumper block allows selection of +5 VDC, switched external DC input (VEXT), or no voltage for the antenna coax supply. (See Figure 9.)

The source of power must be relatively clean (ripple <100 mV), even though the input voltage is regulated within the module prior to usage. Voltage spikes should not fall below +6 VDC or go above +18 VDC. If the unit is operated with the ON/OFF line tied to the power input, voltage should drop to less than +4 V in under 250 ms when power is removed, and should be under 1 V in less then 1 minute.

When turning the unit off from the on state, there should be at least 2 seconds until the next off/on power cycle.

When power is applied but the unit is in the OFF condition (as controlled by the ON/OFF line), it is in a standby condition in which memory and other critical circuits remain powered. In standby, the current drain from VEXT is less then 200 µA.

DC input power is connected to pins 3 and 5 of J1. Reverse polarity protection is provided by shunt diode D7 (see Figure 8), which is designed to blow an external fuse.

Unless a backup battery is used, standby power must remain on the module at all times to avoid loss of all RAM data.

Backup Battery

WARNING

Memory standby voltage (Batt+) is specified to be between +3.6 VDC and +5 VDC. Application of voltage in excess of +5 VDC will destroy critical circuits.

Provision has been made for the user to connect a backup battery to support memory in the event that external power is intentionally or accidentally removed from the module. This battery would be mounted external to the module itself.

The recommended battery voltage is between 3.6 VDC and 5 VDC. A 3.6 V lithium battery with 300 to 800 mAH capacity is adequate. Other types of batteries could also be used, depending on the specific requirements of the user. The battery must provide a source voltage of no less than 3.6 VDC and no greater than 5.0 VDC. The most efficient operation is provided by 3.6 VDC.

ON/OFF Control

The ON/OFF control line (J1 pin 7) is used by the host system to power the module up and down. This control line works as follows:

The control line is connected to Q2, which buffers the input and drives the PWRKYN line on U8. If pin 7 is left open (high impedance) or if it is connected to a voltage source less than 1.5 VDC (with respect to GND), then the unit will be off.

If the line is taken to a voltage source between +3.5 VDC and +16 VDC (with respect to GND), then the unit will be on. In order to keep the unit in the desired state, the ON/OFF line must be maintained in the condition described above. The input resistance of this line is 47K.

A jumper is provided (JP1) to connect the ON/OFF line to main power for consolidated on/off by application and removal of main power. To ensure proper start-up with JP1 on, the power input must ramp from 0 to 9 volts in less than 60 ms.

Interface Connector
The data interface connector, J2 is a 10-pin, right-angle Molex. The recommended housing and pins to mate with this connector are:

Housing — Molex part number 22-01-2101

Pins — Molex part number 08-50-0114

Three functions can be performed through these 10 pins :

1. Serial I/O through Port 1
   RS-232 or
   RS-422, NMEA 0183 compatible or TTL compatible
2. Serial I/O through Port 2, RS-232
3. One bit CMOS toggle input, TTL compatible (not implemented)

Figure 9 shows a simplified drawing of the I/O circuitry. Table 8 shows the necessary connections and jumpers for each I/O configuration.

Default PCB Configuration
Default jumpers are installed as follows:

JP2 JP3	9600 baud
JP4	Port 1 RS-232
JP7	Port 1 RS-232
JP9	RS-422 bias
JP10	RS-422 bias
JP11	Antenna active to 5 VDC
JP13	Port 2 RS-232

Pins 9, and 10 are used to store spare jumpers.

WARNING

Never install jumpers on both JP11 and JP12. Failure to observe this warning will result in damage to the module.

Table 7. Baud Rate Truth Table, OEM/PS

BAUD	JP3	JP2
1200	OFF	OFF
2400	OFF	ON
4800	ON	OFF
9600	ON	ON

Table 8. Jumper Functions, OEM/PS

Port	Connection	J2 Pin	Jumpers On	Jumpers Off
Port 1 — RS-232	OEM Receive OEM Transmit Ground	7 6 2 or 9	JP7 JP4	JP6 JP8 JP5
Port 1 — RS-422	OEM Transmit + OEM Transmit - OEM Receive + OEM Receive -	6 7 4 5	JP5 JP6 JP8	JP4 JP7 JP9 JP10
Port 1 — NMEA	NMEA A NMEA B NMEA Out + NMEA Out -	3 2 or 9 1 2 or 9	JP8 JP6 JP9	JP7 JP10 JP4 JP5
Port 1 — TTL Normal Polarity	OEM Transmit OEM Receive Ground	6 4 2 or 9	JP5 JP8 JP10	JP4 JP6 JP7 JP9
Port 1 — TTL Inverted Polarity	OEM Transmit OEM Receive Ground	7 5 2 or 9	JP6 JP8 JP9	JP4 JP5 JP7 JP10

JP1 – JP14 Description	
JP1	FORCES POWER OFF/ON TO ACTIVATE WITH VEXT OFF/ON
JP2	ALLOWS USER SELECTABLE BAUD RATES – 1200 – 2400 – 4800 – 9600
JP3	ALLOWS USER SELECTABLE BAUD RATES – 1200 – 2400 – 4800 – 9600
JP4	CONNECTS PORT 1 RS-232 OUTPUT TO J2 PIN 6
JP5	CONNECTS PORT 1 RS-422 NON-INVERTING OUTPUT TO J2 PIN 6
JP6	CONNECTS PORT 1 RS-422 INVERTING OUTPUT TO J2 PIN 7
JP7	CONNECTS PORT 1 RS-232 INPUT TO U8 RX DATA
JP8	CONNECTS PORT 1 RS-422 INPUT TO U8 RX DATA
JP9	ALLOWS BIAS OF PORT 1 RS-422 INPUT FOR NMEA OR INVERTED TTL
JP10	ALLOWS BIAS OF PORT 1 RS-422 INPUT FOR NON-INVERTED TTL
JP11	CONNECTS ANTENNA COAX CENTER TO +5 VOLTS
JP12	ALLOWS CONNECTION OF VEXT (9 VOLT – 16 VOLT) TO COAX CENTER
JP13	CONNECTS PORT 2 RS-232 INPUT TO J2 PIN 10
JP14	CONNECTS CMOS INPUT TO J2 PIN 10 (not implemented)

MECHANICAL DETAILS, OEM/5V

The OEM/5V 5-channel module consists of a single circuit board that is a complete operational GPS receiver without power supply or I/O drivers. The board is provided with mounting holes in each of the four corners for #4 mounting hardware. Refer to Figure 10 for the critical dimensions of the board and the physical locations of the interface connectors.

There are two connectors on the assembly that are of interest to the user. J1 is the RF input; it is an SMB connector that provides signal connection to the receiver and an optional voltage path to an active antenna. All other voltage and data activity moves through J2 at the 16-pin header connector.

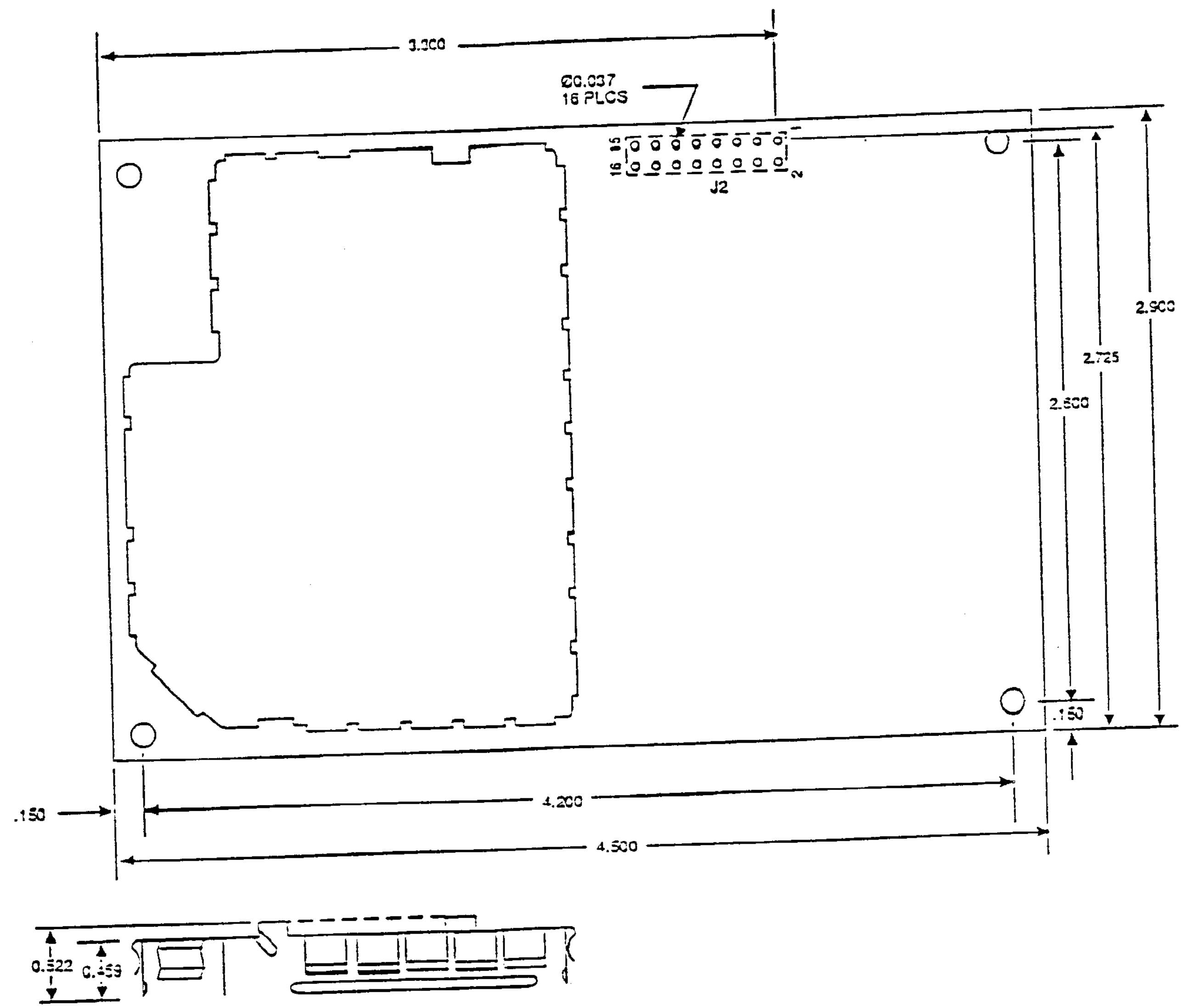


Figure 10. OEM/5V 5-Channel Installation Drawing

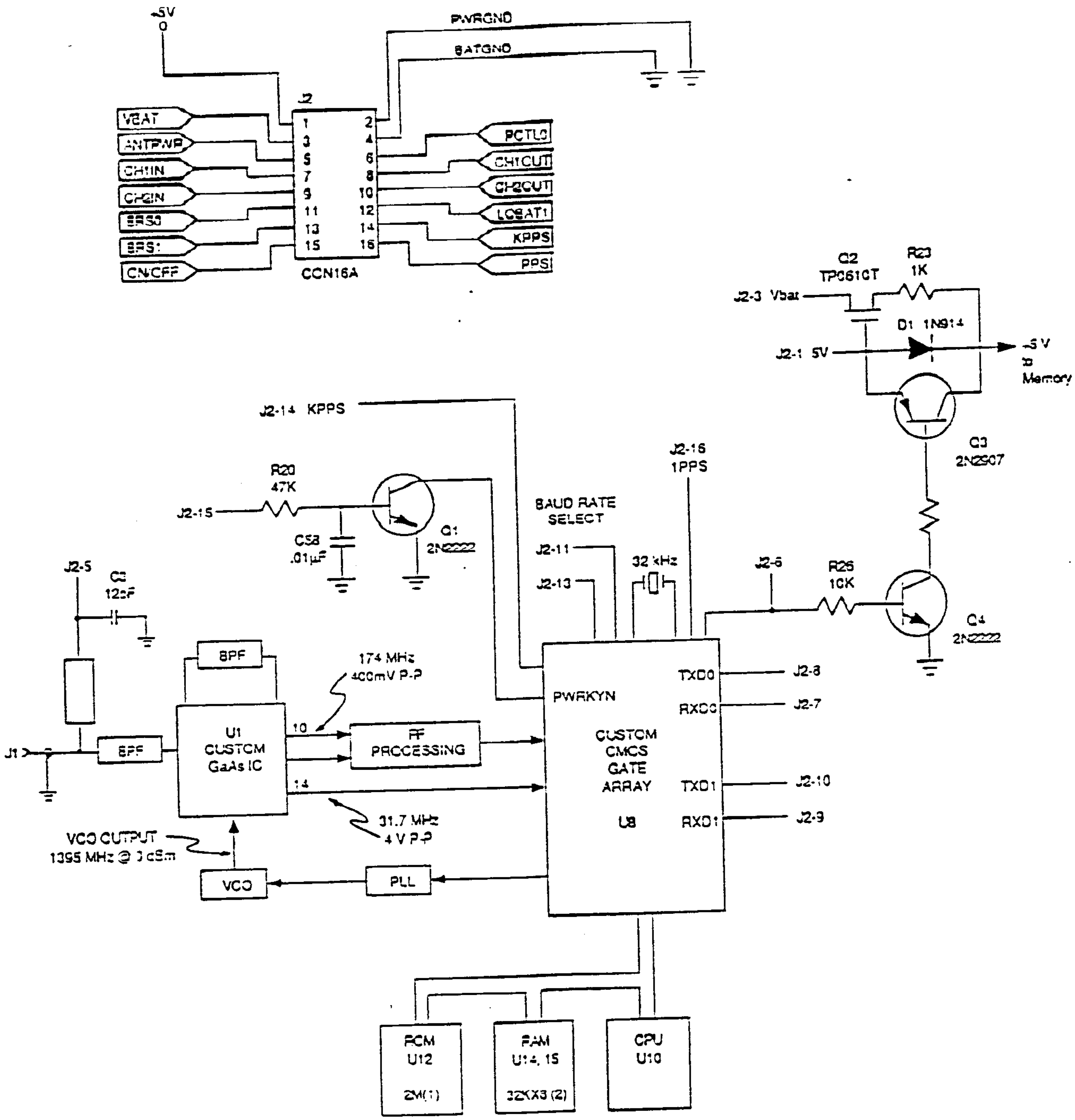


Figure 11. Functional Block Diagram of the OEM/5V 5-Channel Board

ELECTRONIC DETAILS, OEM/5V

The OEM/5V 5-channel module is driven by a standard NEC V30H CPU (U10) running at 16 MHz. The ROM is 128K x 16b (U12) and the RAM is two 32K x 8 (U14 & U15). GPS signal processing is accomplished by U1 and U8. U8 is a proprietary gate array, and U1 is a proprietary Gallium Arsenide IC. Both are designed by Magellan Systems. Serial communication is accomplished by an industry-standard UART with CMOS compatible TTL output and standard UART output polarity (inverted from RS-232 output). The UART is embedded within gate array U8. The module has input for +3.6 VDC to +5 VDC for memory backup. Current is drawn from the backup supply only when main +5V power is removed. There are no timing restrictions for application of an ON/OFF signal simultaneous with main +5V supply, but the ON/OFF line must be switched to the OFF state 250 ms prior to +5V power removal (with memory backup applied) to ensure that memory data is preserved.

There are no user-adjustable items on the board. The TCXO in the receiver is set by the manufacturer and should not be touched in the field. Any attempt to do so without the proper test equipment will cause the receiver to fail to acquire signals.

POWER INTERFACE, OEM/5V

Connector Information

Connector J2 is the power interface connector. This is a 16-pin, 2x8 male header on the circuit board. The recommended mating connector is:

Header — Samtec part number MTSW-108-07-T-D-210

Interface and Power Connector

Connector J2 provides all connections to the board.

The functions provided on J2 are as follows:

Pin 1:	Main Power +5V VDC (±5%)	5V
Pin 2:	Ground	PWRGND
Pin 3:	Memory Backup Battery, +3.6 VDC to +5.0 VDC	VBAT
Pin 4:	Ground	BATGND
Pin 5:	Antenna Power +5 VDC to +12 VDC	ANTPWR
Pin 6:	"Unit turned on" indicator, 0=off, 1=on	PCTL0
Pin 7:	Receive Data, Dataport #1	CH1IN
Pin 8:	Transmit Data, Dataport #1	CH1OUT
Pin 9:	Receive Data, Dataport #2	CH2IN
Pin 10:	Transmit Data, Dataport #2	CH2OUT
Pin 11:	Baud Rate Select Bit 0 (Refer to Table 9)	BRS0
Pin 12:	Critical Power Supply Warning not implemented	LOBAT1

Pin 13:	Baud Rate Select Bit 1 (Refer to Table 9)	BRS1
Pin 14:	1K Pulses per Second 00-85001-003 only	KPPS
Pin 15:	ON/OFF Control +3.6 VDC to +5.0 VDC	ON/OFF
Pin 16:	One Pulse per Second 00-85001-003 only	PPS

Input Power Requirements

The OEM/5V Module requires DC power to be supplied from the host system. The power requirements for the module are +5.0 ±0.2 VDC at 170 mA. Ripple is <100 mV. A path is provided to supply antenna voltage to the RF connector from an external source (ANTPWR).

When power is applied but the unit is in the OFF condition (as controlled by the ON/OFF line), the unit is in the standby condition and the current draw will be in the area of 77 mA from the main +5 V supply. With the unit in the OFF condition with +5V removed, the current draw through Batt+ will be 30 µA (with 3.6 V battery).

WARNING

There is no reverse polarity protection.

Unless a backup battery or a suitable alternative is used, standby power must remain on the module at all times to avoid loss of all RAM data.

Backup Battery

WARNING

Memory standby voltage (Batt+) is specified to be between +3.6 VDC and +5 VDC. Application of voltage in excess of +5 VDC will destroy critical circuits.

Provision has been made for the user to connect a backup battery to support memory in the event that external power is removed from the module. This battery would be mounted external to the module itself.

The recommended battery voltage is between 3.6 VDC and 5 VDC. A 3.6 V lithium battery with 300 to 800 mAH capacity is adequate. Other types of batteries could also be used, depending on the specific requirements of the user. The battery must provide a source voltage of no less than 3.6 VDC and no greater than 5.0 VDC. The most efficient operation is provided by 3.6 VDC.

ON/OFF Control

The ON/OFF control line (J2 pin 15) is used by the host system to power the module up and down. This control line works as follows:

The control line is connected to Q1, which buffers the input and drives the PWRKYN line on U8. If pin 15 is left open (high impedance) or if it is connected to a voltage source less than 1.5 VDC (with respect to GND), then the unit will be off.

If the line is taken to a voltage source between +3.6 VDC and +5 VDC (with respect to GND), then the unit will be on. In order to keep the unit in the desired state, the ON/OFF line must be maintained in the condition described above. The input resistance of this line is 47KΩ.

> **NOTE**
>
> The ON/OFF line must be taken to the off state at least 250 ms prior to the removal of the +5 VDC power to preserve memory.

Table 9. Baud Rate Truth Table, OEM/5V

BAUD	BRS1	BRS0
1200	0	0
2400	0	1*
4800	1	0
9600	1*	1*

BRS1 is pin 13 of J2; BRS0 is pin 11 of J2.

* 1 denotes TTL high

ANTENNA OPTIONS

The dimensions and electrical information of the antennas that are available from Magellan Systems Corporation can be found in Chapter 7. This section describes the requirements of the OEM board with respect to connected antennas.

OEM/PS with Active Antennas

The OEM/PS board has two supplies for active antennas. One is the on-board, 5-volt supply (JP11 on, JP12 off). If this supply is used, the current draw changes the upper temperature characteristics of the board. The other supply is 9 VDC to 16 VDC, switched from the main unregulated DC input (JP11 off, JP12 on).

The antenna output voltage default setting is +5 VDC to prevent the accidental application of VEXT 9 VDC to 16 VDC to a 5-volt antenna. If you are using a Magellan antenna (A50 or A18), we suggest that the Magellan antenna be run from the VEXT option to reduce heat.

OEM/5V with Active Antennas

The voltage for active antennas is applied to J2, pin 5. This is a pass-through voltage line, which must be +13.6 VDC or less.

Passive Antennas

The receivers may be connected directly to a GPS antenna without a pre-amplifier if the cable loss between the antenna and the RF input is less than 0.5 dB at 1575 MHz. This implies a very short cable run if a cable with a modest diameter is to be used. Also, jumpers JP11 and JP12 on the OEM/PS board or pin 5 of J2 on the OEM/5V board must be left open.

The RF termination is an SMB-type connector. It is anticipated that, in most cases, the OEM Module will be mounted inside the host system enclosure. The input to the RF should be via a short cable with a mating SMB on one end and a panel mount of some kind on the other to interface to the outside world.

Most of the antennas (with a 50-ohm impedance) that we have tested have worked satisfactorily, but Magellan cannot guarantee the proper operation of the Magellan OEM GPS Module with a non-Magellan antenna. It is the responsibility of the integrator to assure the compatibility of a non-Magellan antenna to the OEM module and its satisfactory operation.

ELECTRO-MAGNETIC COMPATIBILITY

The OEM Modules contain a very sensitive RF receiver, which means that certain precautions must be taken by the user to ensure that operation is not degraded when the module is integrated into the host equipment. The possiblity of interference to the host system from spurious signals generated by the OEM Module should also be remembered.

Since the electromagnetic environment will be different for each OEM application, it is not possible to define exact guidelines to assure electromagnetic compatibility.

It is expected that, in most cases, there will be no EMC problems. Critical RF circuitry is shielded. Digital circuitry is mostly CMOS with good threshold margins. The circuitry within the OEM Module is very low power, and therefore generates relatively low amounts of RFI. In a worst-case situation, the OEM Module could be enclosed in a metal shield to eliminate any EMC problems, although this extreme measure is not likely to be needed.

In the end, only actual test of the OEM Modules in the user's environment will demonstrate the presence or absence of EMC problems and validate their solutions.

EMI compliance is also the responsibility of the user. Users should note that the Magellan OEM GPS modules share technology with other Magellan products, which have successfully passed and exceeded FCC standards for Class 'B' computing devices. Refer to Figures 8 and 11 for the internal signal sources and levels that will be required for system compatibility and compliance issues.

THERMAL FACTORS

The OEM/PS Module consumes less than 1.4 W when operating; the OEM/5V module consumes less than 1 W because there is no power supply. Most excess power dissipation, and therefore, generated heat occurs in the voltage drop from VEXT (9 – 16 VDC) to +5 VDC in voltage regulator VR1. The modules have a heatsink on VR1 that is adequate for operations below the ambient temperature range in free air.

Thermal issues are the responsibility of the developer.

The user should perform a thermal analysis to ensure that VR1 does not exceed +125°C (and enter thermal shutdown) when:

1. Air circulation in the installation is poor.
2. Other electronics are installed in the enclosure with the GPS module.
3. The GPS module is in its own tightly sealed box for EMI reasons.

If the analysis indicates thermal stress, move VR1 to a chassis, rail guide, or external heat sink that is near its original position on the module. Please contact Magellan if you require production boards with VR1 unmounted.

SPECIFICATIONS

Operational Characteristics

Position Update Rate:	1 second continuous (approximate)
Time to First Fix	
Warm Start: (with almanac/date/time/initial position and ephemeris < 2 hours old)	30 seconds (approximate)
Cold Start: (with almanac/date/time/initial position)	75 seconds 2D/3D (approximate)
Autonomous Start: (no almanac/ephemeris/date/time/initial position)	5 – 12 minutes typical
Maximum Velocity:	950 mph (1529 kph)
Maximum Acceleration:	2 g

*Position Accuracy**

(HDOP < 2, CN_o > 47 db-Hz, 2D)

Horizontal Position:	25 meters RMS in 2D 30 meters RMS in 3D
Vertical Position:	50 meters RMS
Velocity	0.15 knots RMS

* with Selective Availability disabled

Physical Charactreristics

OEM/PS, Single Board	
Weight	4.8 ounces (0.136 kg)
Size:	3.21 x 7.40 x 0.94 inches (8.15 x 18.80 x 2.39 cm)
OEM/5V, Single Board	
Weight	2.90 ounces (0.082 kg)
Size:	2.9 x 4.5 x 0.5 inches (7.37 x 11.43 x 1.27 cm)

Environmental Characteristics

Operating Temperature:	
OEM/PS	-30°C to +85°C
OEM/5V	-30°C to +85°C
Save Storage Temperature:	-40°C to + 90°C
Relative Humidity:	
Operating:	Up to 95% non-condensing at 38°C
Survival:	Up to 95% non-condensing at 38°C
Altitude:	
Operating:	-1,000 to +58,000 feet (-0.30 km to +17.68 km) Domestic firmware for 2,000,000 meters is available
Survival:	-1,000 to +150,000 feet (-0.30 km to +36.58 km)

MTBF:	20,000 hours

Electrical Characteristics

Power:	
OEM/PS:	9 – 16 VDC 235 mA at 12 VDC typical, 250 mA max (no power to antenna) Keep-alive voltage 3.6 to 5.0 VDC; draws 75 µA typical at 3.6 V, 190 µA at 5.0 V
OEM/5V:	5 VDC ±0.2 VDC 170 mA Keep-Alive voltage 3.6 – 5.0 VDC; draws 30 µA at +3.6 VDC, 70 mA at +5 VDC
Interfaces:	OEM/PS: One industry-standard serial communications port configured as RS-232, RS-422, NMEA-compatible, or TTL-compatible. One industry-standard, serial communications port configured as RS-232 OEM/5V: Two industry-standard, serial communications port configured as CMOS/TTL
Baud Rates:	Jumper-selectable at 1200, 2400, 4800, or 9600
Receiver Type: (Five discrete channels)	4 channels dedicated to tracking satellites 1 channel dedicated to tracking all other satellites in the sky

Timing Characteristics (Timing modules only)

Pulse voltage levels:	On = TTL high, Off = TTL low
"On" Pulse Width:	100 nanoseconds (nominal)
Rise/Fall Time of Pulse:	<10 nanoseconds
Accuracy:	±100 nanoseconds (with SA disabled)
Stability:	50 nanoseconds (1 sigma)
Time Tag Locations:	Rising edge of pulse

RF Input Characteristics

Input Level Range:	-135 dBm to -110 dBm
Input VSWR:	1.8 to 1
LO Leakage:	-50 dBm

Input Filtering:	-3 dB with BW of 20 MHz centered at 1575.42 MHz Rolls off at 40 dB/decade
Input Spurious:	Co-channel 35 dB
Input Compression Point:	-50 dBm

Firmware Protocols

ASCII; NMEA compatible

Binary; Magellan specific

Firmware Functions

P/N 00-8500X-000

Primary:	Time & date Position & altitude Mode (2D/AUTO) Data output control Ground course & velocity Satellite ID (PRN) Real-time differential corrections (RTCM SC-104 ver. 2.0 and Magellan-specific) PDOP, GDOP, HDOP & error estimates Receiver status Software-selectable baud rate
Navigation:	Waypoints ETA Arrival alarm TTG Cross track error Distance to waypoint (GC) Bearing from point of origin Bearing from present position
Set up:	Magnetic variation (auto or user-defined) Datum selection Units or measure Terrain settings (3)
Satellite:	Auto- or user-selected satellites Import/export almanac Import/export ephemeris Coverage schedule Health (includes input to set health) Satellite azimuth, elevation and C/N_0

P/N 00-8500X-003

Timing:	Timing pulse ON/OFF UTC or GMT reference Time only mode Single satellite timing default all modes Hour, minute, second, day, month, year Status indicator Satellites in solution Signal Quality Timing Figure of Merit (TFOM) User bias input Dedicated timing message on Port 2
Other:	All functions of the standard navigation firmware operate in the background. (With the exception of RTCM SC-104, ver. 2.0.)

CHAPTER 7

ANTENNA OPTIONS

This chapter provides basic electrical specifications and dimensions for the antennas and accessories that are also available from Magellan Systems Corporation. More detailed information on these products is also available.

OEM ANTENNA AND PRE-AMPLIFIER SPECIFICATIONS

Part Numbers

00-81001-000	("A50" Antenna Kit with 50' coax)
00-81002-000	("A18" Antenna Kit with 18' coax)
23-10037-001	("A50" Active Quadrifilar Helix Antenna)
23-30014-000	("A18" Active Quadrifilar Helix Antenna)
23-80005-000	(Passive Quadrifilar Helix Antenna)

Electrical Performance (at 20°C)

Antenna Element (P/N 23-80005-000)

Center Frequency	1575.42 MHz
Polarization	R.H.C.P.
Absolute Gain	0 dBi min. (above 20°) -2 dBi min. (at 15°) -5 dBi min. (for 5° to 15°)
Axial Ratio	3 dB max. (at zenith)
VSWR	1.5 : 1 max.
Impedance	50 Ω
Bandwidth	2 MHz min. (VSWR ≤ 1.5 : 1)

Low Noise Amplifier (part of P/N 00-81001-000 and 23-10037-000)

Center Frequency	1575.42 MHz
Power Gain	37 ± 2 dB
Noise Figure (N.F.)	2.5 dB max.
VSWR	2 : 1 max.
Impedance	50 Ω
Passband Width	20 MHz min. (N.F. ≤ 1.5 dB)
Supply Voltage	5 – 15 VDC
Current Consumption	30 mA max.

Low Noise Amplifier (part of P/N 00-81002-000 and 23-10014-000)

Center Frequency	1575.42 MHz
Power Gain	27 ± 2 dB
Noise Figure (N.F.)	2.5 dB max.
VSWR	2 : 1 max.
Impedance	50 Ω
Passband Width	20 MHz min. (N.F. ≤ 1.5 dB)
Supply Voltage	5 – 15 VDC
Current Consumption	30 mA max.

Ratings

Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-40°C to +100°C

Contents of Antenna Kit (P/N 00-81001-000)

Active Quadrifilar Helix Antenna with 37 dB LNA
50 ft. Coaxial Cable
Pole-Mount Hardware
Surface-Mount Hardware
Threaded Antenna Mounting Base
Remote Antenna Mount Adaptor
Mounting Ring

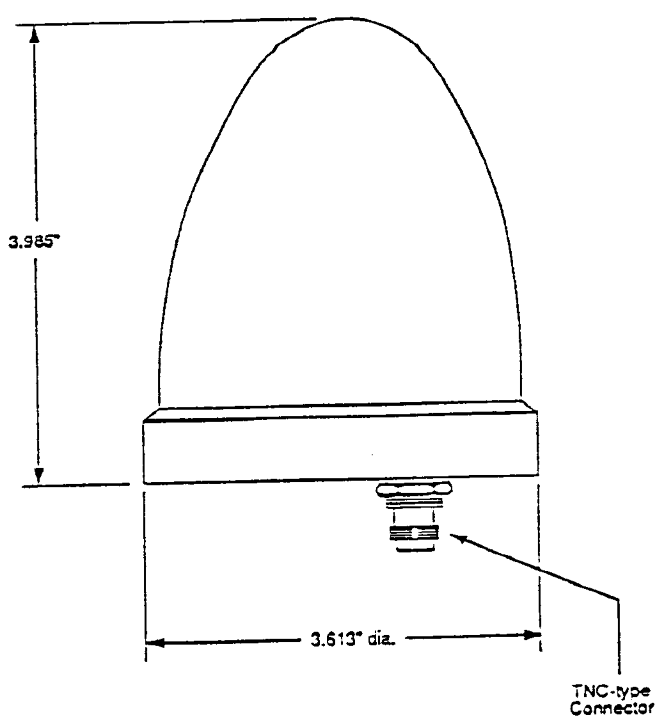


Figure 12. Active Quadrifilar Helix Antenna
(P/N 23-10037-001, 00-81001-000, 00-81002-000, 23-30014-000)

Contents of Antenna Kit (P/N 00-81002-000)

- Active Quadrifilar Helix Antenna with 27 dB LNA
- 18 ft. Coaxial Cable
- Pole-Mount Hardware
- Surface-Mount Hardware
- Threaded Antenna Mounting Base
- Remote Antenna Mount Adaptor
- Mounting Ring

Antenna Kit Options

- Magnet Mount (P/N 00-09004-000)
- SMB-to-TNC Cable (P/N 23-00014-000)

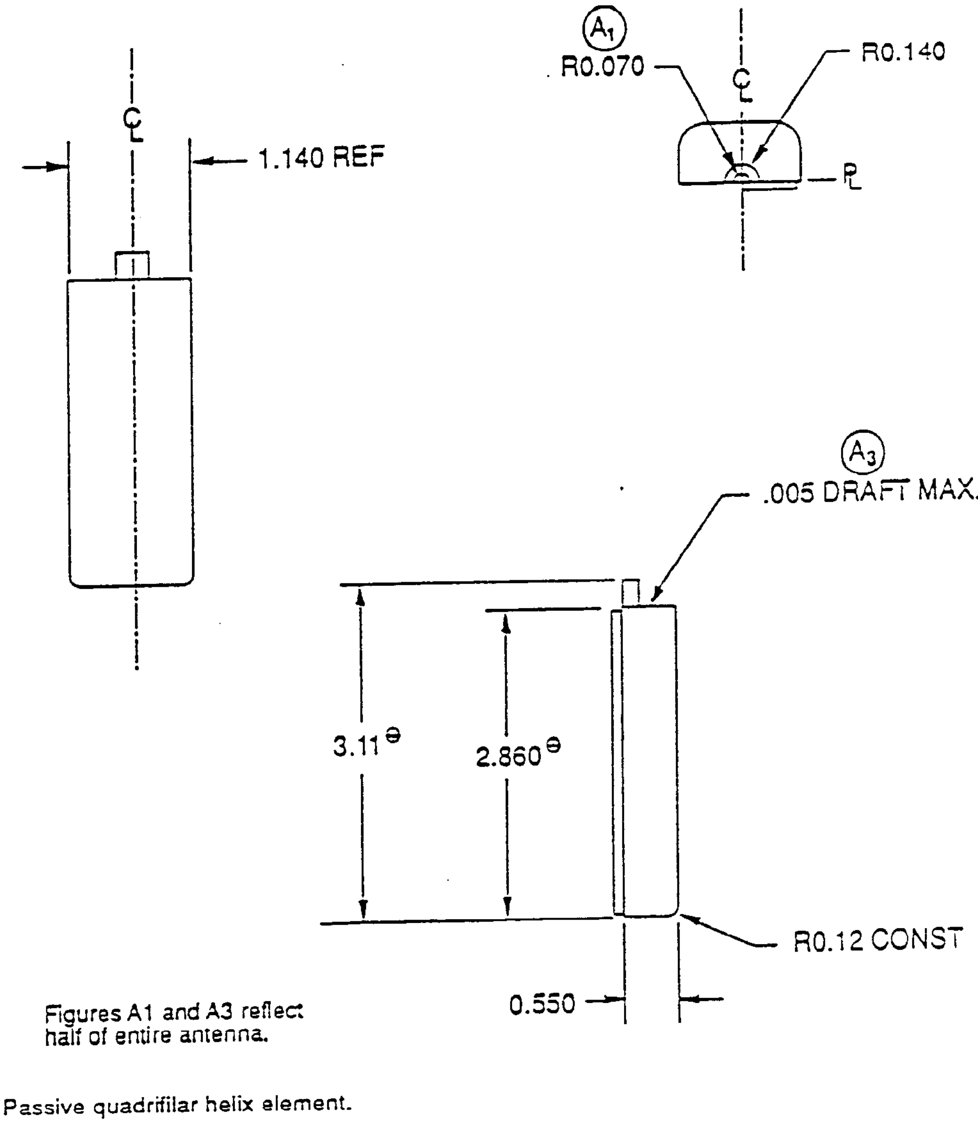


Figure 13. Passive Quadrifilar Helix Antenna
(P/N 23-80005-000)

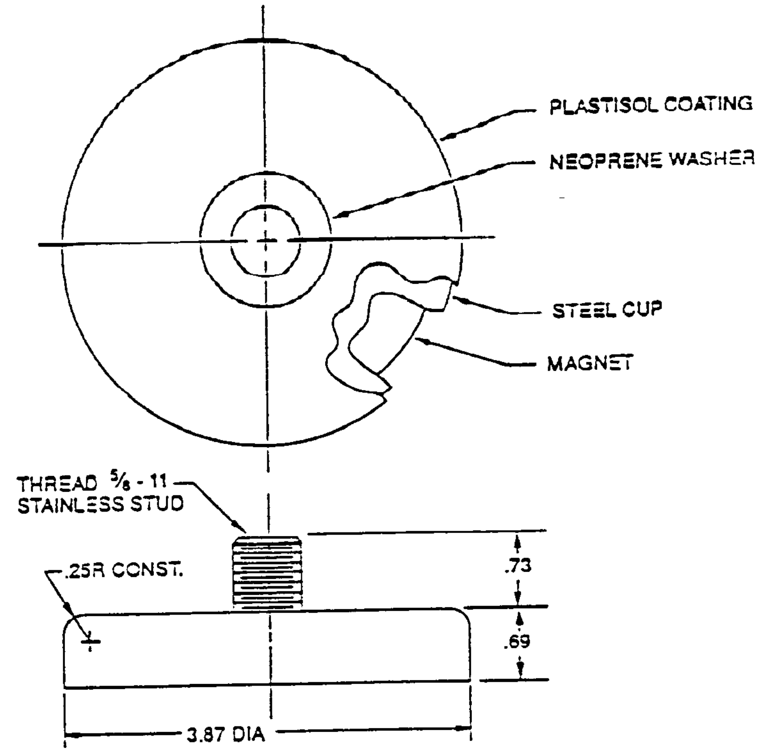


Figure 14. Magnetic Mount Assembly
(P/N 00-09004-0000)

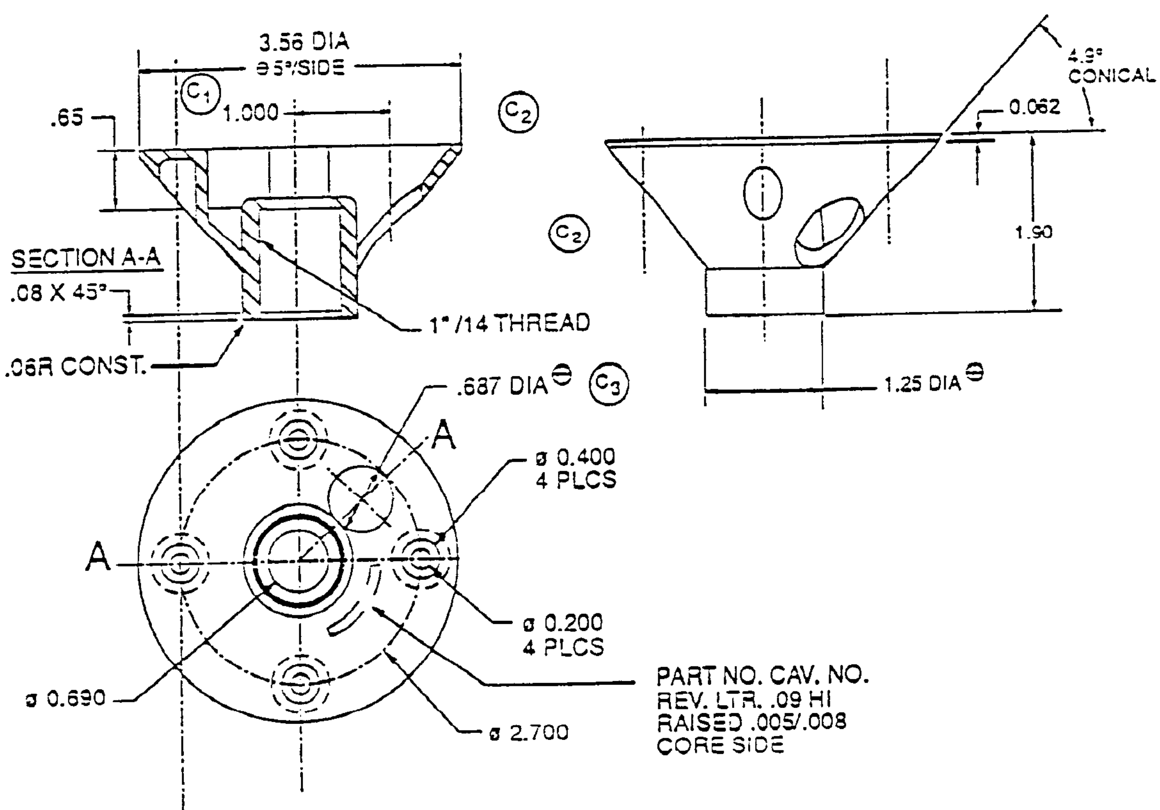


Figure 15. Threaded Antenna Mounting Base

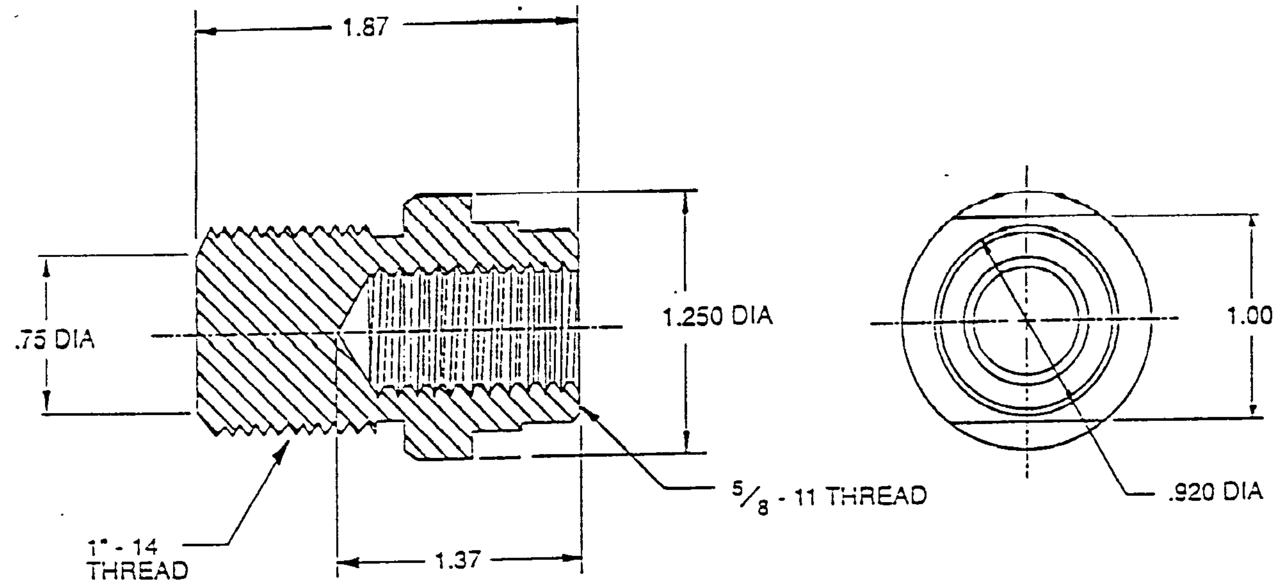


Figure 16. Remote Antenna Mount Adaptor

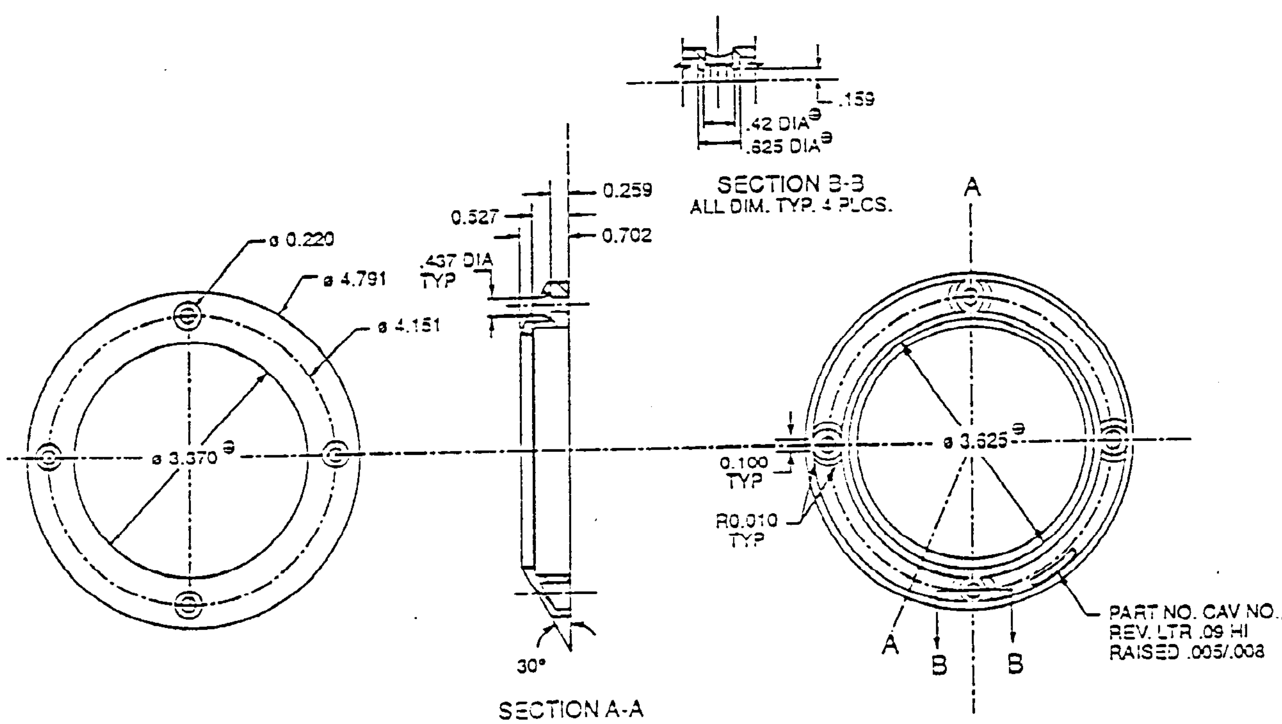


Figure 17. Mounting Ring (Remote Antenna)

PART IV

THE GLOBAL POSITIONING SYSTEM

CHAPTER 8
BRIEF GPS OVERVIEW

The Global Positioning System (GPS) is a constellation of satellites that orbit the earth twice a day, transmitting precise timing information. These transmissions can be collected by any GPS receiver at no charge and at any hour, and used to produce latitude, longitude, and altitude.

When complete in 1993, the GPS constellation will consist of 21 satellites and three active spares, orbiting the Earth in six fixed planes that are inclined 55° from the equator. Each satellite will be 10,500 miles above the Earth.

Since November, 1992, the 19 satellites now orbiting the Earth provide 24-hour coverage for two-dimensional positioning, and 22-hour coverage for three-dimensional positioning. Additional satellites are being launched approximately once every three months, and full three-dimensional coverage is expected before 1994.

The system was developed and deployed by the U.S. Department of Defense to provide continuous, worldwide positioning and navigation data to U.S. military forces around the globe. GPS also has broad civilian and commercial applications.

HOW GPS WORKS

Each GPS satellite continuously broadcasts two signals: a C/A-code signal for worldwide civilian use, and a P-code signal for U.S. military use only. The C/A code is a spread-spectrum signal broadcast at 1575.42 MHz. The signal is resistant to multi-path and night-time interference, and is unaffected by weather and electrical noise.

GPS receivers listen to signals from either three or four satellites at a time. Three satellites are required for two-dimension positioning (latitude/longitude), and four satellites are required for three-dimension positioning (latitude/longitude/altitude). The interval between the transmission and the reception of the satellite signal is used to calculate the unit's distance from each of the satellites being used. Those distances are used in algorithms to compute a position. Since the signals are acquired passively, the number of users is unlimited.

ACCURACY

A C/A-code GPS receiver can provide position information with an error of less than 25 meters, and velocity information with an error of less than 5 meters per second. Because the system is so accurate, the U.S. Government may activate Selective Availability (SA) to maintain optimum military effectiveness. Selective Availability inserts random errors into the system and reduces the GPS C/A-code accuracy to 100 meters.

The effect of SA can be overcome by using a technique called Differential GPS (DGPS), which increases overall accuracy. With DGPS, a GPS receiver is placed at a known location. Positioning information from that unit is used to calculate corrections, which are then communicated to other GPS receivers in the area. Submeter accuracy can be obtained with DGPS and post-processing calculations in static positioning.

DIFFERENTIAL THEORY

Differential positioning is a technique that allows you to overcome the effects of environmental errors and Selective Availability (SA) on the GPS signals to produce a highly accurate position fix. This is done by determining the amount of the positioning error and applying it to position fixes that were computed from collected data.

As used in most marine applications, corrections are determined and broadcast from on-shore GPS receiver sites. In the United States, these sites are beacons that are operated by the U.S. Coast Guard. The on-board GPS receiver requires a separate DGPS receiver to receive the broadcast corrections, demodulate them, and send the corrections to the GPS receiver. (DGPS receivers are also known as MSK, or minimum shift key, receivers and as Differential Radio Beacon Receivers.)

In terrestrial systems, such as AVL (Automatic Vehicle Location), the corrections can be supplied to the GPS receiver through a mobile data network or any other existing data-communication structures.

Typically, the horizontal accuracy of a single position fix from a GPS receiver is 15 meters RMS (root-mean-square) or better. If the distribution of fixes around the true position is circular normal with zero mean, an accuracy of 15 meters RMS implies that about 63% of the fixes obtained during a session are within 15 meters of the true position.

In addition, accuracy is affected by positioning errors. There are two types of positioning errors; correctable and non-correctable. Correctable errors are the errors that are essentially the same for two GPS receivers in the same area; correctable errors can be removed by using differential. Non-correctable errors cannot be correlated between two GPS receivers in the same area.

Correctable Errors

Sources of correctable errors include satellite clock, ephemeris data, and ionospheric and tropospheric delay. When implemented, Selective Availability can also cause a correctable positioning error.

Clock errors and ephemeris errors originate with the GPS satellite. A clock error is a slowly changing error that appears as a bias on the pseudorange measurement made by a receiver. An ephemeris error is a residual error in the data used by a receiver to locate a satellite in space.

Ionospheric delay errors and tropospheric delay errors are caused by atmospheric conditions. Ionospheric delay is caused by the density of electrons in the ionosphere along the signal path. (The ionosphere is the upper portion of the earth's atmosphere.) A tropospheric delay occurs when the GPS signal travels through the troposphere, or the lower portion of the earth's atmosphere. Tropospheric delay is related to humidity, temperature, and pressure along the signal path. Usually, a tropospheric delay is smaller than an ionospheric delay. These delays increase when satellite signals must travel longer distances through the atmosphere, and can become quite large with low-elevation satellites.

Another correctable error is caused by Selective Availability (SA). SA is used by the United States Department of Defense to introduce errors into the Standard Positioning Service (SPS) GPS signals to degrade fix accuracy. The is done to maintain optimum military effectiveness by U.S. and allied forces.

All of the error sources mentioned above have an important characteristic in common; the amount and direction of the error at any given time does not change rapidly. Therefore, two GPS receivers that are sufficiently close together and are using the same satellites will observe the same fix error, and the size of the fix error can be determined.

Non-Correctable Errors

Non-correctable errors cannot be correlated between two GPS receivers that are located in the same general area. Sources of non-correctable errors include receiver noise, which is unavoidably inherent in any receiver, and multipath errors, which are environmental. Multipath errors are caused by the receiver antenna "seeing" reflections of signals that have bounced off of surrounding objects. Neither error can be eliminated with differential, but they can be reduced substantially with position fix averaging.

DGPS

DGPS uses a GPS receiver at a control point whose position is known. This is *the control unit. The control unit* collects data and computes a position fix, which is compared with the known coordinates of the control point. The difference is the positioning error, which is converted to signal corrections for use by the remote receiver.

It is assumed that this correction will be the same for other GPS receivers that are in the same area and are using the same satellite set for positioning. If the correction is communicated to other receivers in the area, the positioning error can be removed from position fixes calculated by these receivers.

When used in most maritime applications, the use of DPGS requires a GPS receiver and a separate differential radio beacon receiver. The radio beacon site is the control position; a GPS receiver at the radio beacon site continuously tracks all visible satellites, and computes and broadcasts corrections for those satellites. In the United States, the beacons are operated by the U.S. Coast Guard.

The marine DGPS user requires only a GPS receiver and a compatible differential radio beacon receiver. The differential radio beacon receiver accepts and demodulates the broadcast corrections, which are then relayed to the GPS receiver. The GPS receiver applies the corrections to the position fixes it computes, and displays a differentially corrected position fix.

WHO USES GPS

GPS C/A-code receivers provide positioning, velocity, and navigation information for the marine, military, and exploration/surveying markets. Currently, GPS is being used in a variety of tasks, including charting and mapping, plotting courses, navigating from point to point, surveying, tracking vehicle movement, and locating previously identified sites.

GPS INFORMATION SOURCES

There are several places where you can find further information about GPS and the status of the satellites.

Civil GPS Information Center

The Civil GPS Information Center (GPSIC) in Virginia was established to accommodate the needs of the large worldwide civil GPS user community. It is operated and maintained by the United States Coast Guard for the Department of Transportation. The primary function of the GPSIC is to provide information to and serve as the point of contact for civil GPS users. The GPSIC has general GPS literature available free upon request. The Center also maintains up-to-date almanac data and Operational Advisory Broadcasts containing current constellation status and planned satellite outages.

There are three ways to quickly obtain current information from the GPSIC:

1. 24-hour recorded phone message at (703) 313-5905
2. Computer bulletin board
   Parameters: 8 data bits, 1 stop bit, no parity
   (703) 313-5910
3. 24-hour live information at phone (703) 313-5900

GPS Computer Bulletin Board at Holloman

The information provided by this bulletin board includes advisories and almanacs. Communication parameters: full duplex, 8-bit data words, no parity, and one stop bit OR full duplex, 7-bit words, odd or even parity, and one stop bit. The former configuration is preferred as it supports X-modem and Y-modem error checking.

Modem speed 1200 (preferred) or 300: call (505) 679-1525

Live system operator: call (505) 679-1784

Government Documents

The U.S. Government has several documents relating to GPS that are of a more technical nature than the documents provided by GPSIC. In particular, NavStar GPS Space Segment/Navigation User Interface, number ICD200, may be very useful.

These documents are available from several sources, including:

Global Engineering Documents
2805 McGaw Ave.
P.O. Box 195439
Irvine, CA 92714 USA
Tel: (714) 979-8135 or (800) 854-7179 (local area only)
Fax: (714) 979-7238

Navtech Seminars Incorporated

Navtech Seminars offers informative seminars and has a broad selection of GPS literature available for purchase. This is a good source to contact if you need in-depth information about GPS and how it works.

Navtech Seminars, Incorporated
2775 S. Quincy Street, Suite 610
Arlington, Virginia 22206-2204 USA
Tel: 703-931-0500
Fax: 703-931-0503

RTCM Documentation

Information on broadcast differential and the RTCM format is available from:

Radio Technical Commission for Maritime Services
P.O. Box 19087
Washington, D.C. 20036 USA