Hemisphere GPS

MBX-4

User Guide

Part No. 875-0188-000 Rev. A1

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference, that may cause undesired operation.

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Hemisphere GPS
7560 East Redfield Road, Suite B
Scottsdale, Arizona 85260
Phone 480.348.9919 Fax 480.348.6370
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GPS

This chapter provides a brief overview of GPS, differential GPS beacon technology, and a description of the MBX-4 receiver, antenna, and mount.

The United States Department of Defense (DoD) operates a reliable, 24 hour a day, all weather Global Positioning System (GPS).

Navstar, the original name given to this geographic positioning and navigation tool, includes a constellation of 24 satellites (plus active spares) orbiting the Earth at an altitude of approximately 13,670 miles (22,000 kilometers).

How it Works

These satellites transmit coded information to GPS users at UHF (1.575 GHz) frequencies that allows user equipment to calculate a range to each satellite. GPS is essentially a timing system - ranges are calculated by timing how long it takes for the GPS signal to reach the user's GPS antenna.

To calculate a geographic position, the GPS receiver uses a complex algorithm incorporating satellite coordinates and ranges to each satellite. Reception of any four or more of these signals allows a GPS receiver to compute 3D coordinates. Tracking of only three satellites reduces the position fix to 2D coordinates (horizontal with fixed vertical).

The GPS receiver calculates its position with respect to the phase center of the GPS antenna.

GPS Services

The positioning accuracy offered by GPS varies depending upon the type of service and equipment available. For security reasons, two GPS services exist: the Standard Positioning Service (SPS) and the Precise Positioning Service (PPS). The US Department of Defense (DoD) reserves the PPS for use by its personnel and authorized partners. The DoD provides the SPS free of charge, worldwide, to all civilian users.

In order to maintain a strategic advantage, the US DoD has a policy to artificially degrades the performance of the SPS. Currently the level of this degradation has been set to zero, however, in years past, this intentional error limited the positioning accuracy of the SPS to 100 meters 95% of the time. This policy is called Selective Availability (SA). Without SA, autonomous positioning accuracy is currently about 10 to 15 m 95% of the time.

For many positioning and navigation applications, an accuracy of 10 to 15 meters is insufficient, and differential positioning techniques must be employed.

Differential GPS

The purpose of differential GPS (DGPS) is to remove the effects of SA (if present), atmospheric errors, timing errors, and satellite orbit errors, while enhancing system integrity.

How it Works

DGPS involves setting up a reference GPS receiver at a point of known coordinates. This receiver makes distance measurements, in real-time, to each of the GPS satellites. The measured ranges include the errors present in the system. The base station receiver calculates what the true range should be without errors, knowing its coordinates and those of each satellite. The difference between the known and measured range for each satellite is the range error. This error is the amount that needs to be removed from each satellite distance measurement in order to correct for errors present in the system.

Real-Time DGPS

The base station transmits the range error corrections to remote receivers in real-time. The remote receiver corrects its satellite range measurements using these differential corrections, yielding a much more accurate position. This is the predominant DGPS strategy used for a majority of real-time applications. Positioning using corrections generated by DGPS radiobeacons will provide a horizontal accuracy of 1 to 5 meters with a 95% confidence. More sophisticated, short-range DGPS systems (10 to 15 km) can achieve centimeter-level accuracy, but are very expensive and often limited to precise survey applications due to technical constraints on their use.

DGPS Format

For manufacturers of GPS equipment, commonality is essential to maximize the utility and compatibility of a product. The governing standard associated with GPS is the Interface Control Document, ICD-GPS-200, maintained by the US DoD. This document provides the message and signal structure information required to access GPS.

Like GPS, DGPS data and broadcast standards exist to ensure compatibility between DGPS networks, and associated hardware and software. The Radio Technical Commission for Maritime Services Special Committee 104 has developed the primary DGPS standard associated with radiobeacon DGPS, designated RTCM SC-104 V2.2.

Various broadcast standards may exist for the beacon networks installed internationally, controlled by their respective operating authority. The United States Coast Guard maintains a broadcast standard that is referenced in the Further Reading section of this manual.

Radiobeacon Range

The broadcasting range of a 300 kHz beacon is dependent upon a number of factors including transmission power, free space loss, ionospheric state, surface conductivity, ambient noise, and atmospheric losses.

The strength of a signal decreases with distance from the transmitting station, due in large part to spreading loss. This loss is a result of the signal's power being distributed over an increasing surface area as the signal radiates away from the transmitting antenna.

The expected range of a broadcast also depends upon the conductivity of the surface over which it travels. A signal will propagate further over a surface with high conductivity than over a surface with low conductivity. Lower conductivity surfaces such as dry, infertile soil,

absorb the power of the transmission more than higher conductivity surfaces, such as sea water or arable land.

A radiobeacon transmission has three components: a direct line of sight wave, a ground wave, and a sky wave. The line of sight wave is not significant beyond visual range of the transmitting tower, and does not have a substantial impact upon signal reception.

The ground wave portion of the signal propagates along the surface of the earth, losing strength due to spreading loss, atmospheric refraction and diffraction, and attenuation by the surface over which it travels (dependent upon conductivity).

The portion of the beacon signal broadcast skywards is known as the sky wave. Depending on its reflectance, the sky wave may bounce off the ionosphere and back to Earth causing reception of the ground wave to fade. Fading occurs when the ground and sky waves interfere with each other. The effect of fading is that reception may fade in and out. However, this problem usually occurs in the evening when the ionosphere becomes more reflective and usually on the edge of coverage areas. Fading is not usually an issue with overlapping coverage areas of beacons and their large overall range.

Atmospheric attenuation plays a minor part in signal transmission range, as it absorbs and scatters the signal. This type of loss is the least significant of those described.

Radiobeacon Reception

Various sources of noise affect beacon reception, and include:

- Engine noise
- Alternator noise
- Noise from Power lines
- DC to AC inverting equipment
- Electric devices such as CRT's electric motors, and solenoids

Noise generated by this type of equipment can mask the beacon signal, reducing or impairing reception. The "Antenna Placement to Optimize Reception" section on page 24 presents an effective procedure to minimize impact of local noise on beacon reception when using this correction service.

Radiobeacon DGPS

Radiobeacons conforming to the standards of the International Association of Lighthouse Authorities broadcast a limited selection of RTCM SC-104 messages, including message types 1, 2, 3, 5, 6, 7, 9, and 16.

- A DGPS beacon will broadcast either Type 1 or Type 9 messages, both of which contain similar information. These two messages contain pseudorange corrections and range rate corrections to each GPS satellite.
- The Type 2 message contains delta differential corrections that are used when the remote receiver is using a different satellite navigation message than used by the base station.
- The Type 3 message contains the position of the beacon's reference station, often accurate to within centimeters with respect to the WGS-84 reference datum.

- The Type 5 message contains GPS constellation health information used for improving tracking performance of a GPS receiver
- The Type 6 message contains null information, and is broadcast so that a beacon receiver demodulating the data from the broadcast does not lose lock when the beacon station has no new data to transmit.
- The Type 7 message contains the radiobeacon almanac information composed of location, frequency, service range, and health information of sister stations for the currently tuned beacon.
- The Type 16 message provides users with a 90 character text string that may contain information regarding the status of the system, weather warnings, etc.

Radiobeacon DGPS is often referred to as a local-area service, as the data broadcast is appropriate for use within the coverage range of the station, and is calculated by a single, local GPS reference station.

Radiobeacon Coverage

Figure 1-1 on page 9 shows the approximate radiobeacon coverage throughout the world. In this figure, light shaded regions note current coverage, with beacon stations symbolized as white circles.

The world beacon networks continue to expand. For current coverage, consult the Hemisphere GPS web site at www.hemispheregps.com.

Figure 1-1. World DGPS Radiobeacon Coverage

Factors Affecting Positioning Accuracy

Many factors affect the positioning accuracy that a user may expect from a DGPS system. The most significant of these influences include:

- Proximity of the remote user to the reference station
- Age of the received differential corrections
- Atmospheric conditions at the beacon and remote user locations
- Satellite geometry, often expressed as a Dilution of Precision (DOP)
- Magnitude of multipath present at the remote station
- Quality of the GPS receiver being used at both the reference and remote stations.

The distance between a remote user and the reference station is often considerable when using 300 kHz DGPS radiobeacons. Broadcast ranges may be as great as 450 km (280 miles) or more, depending primarily upon transmission power and surface conductivity. Consequently, some of the errors associated with GPS at the base station differ somewhat from those at the remote user's location. This spatial decorrelation of errors can result in a relative position offset from the absolute coordinates of the remote receiver. This offset may be as much as one meter for every 100 km (62 miles) between the base station and remote receiver.

The latency of differential corrections also affects the achievable positioning accuracy at the remote receiver. Latency is a function of the following:

- The time it takes the base station to calculate corrections
- The data rate of the radio link
- The time it takes the signal to reach the user
- The time required for the remote differential receiver to demodulate the signal and communicate it to the GPS receiver.
- Any data loss that occurs through reception problems

Most of these delays require less than a second, though in some instances, depending upon the amount of information being transferred, overall delays of three to five seconds may occur. In the past when SA was “on,” latency was a concern if lock on the differential signal was lost for ten seconds or more. Without the effects of SA, the age of the differential corrections is not as significant, but care should be taken to ensure that their age is kept below a couple minutes by ensuring consistent beacon receiver lock.

To account for latency, a GPS receiver can calculate approximate corrections until new corrections are available. Calculating the differential correction for a new epoch, using old corrections, leads to inaccuracy that grows with time. Accuracy is restored when new corrections become available.

Although ionospheric errors are normally removed through differential positioning, the state of the ionosphere can differ between the base station and remote user over large distances. As the base station calculates corrections based on local ionospheric conditions, they may not completely account for the errors observed at the remote user’s location. This causes part of the spatial decorrelation that may be observed over large distances between base station and remote receivers

The number of satellites visible and their geometry in the sky influences positioning accuracy. The Dilution of Precision (DOP) describes the strength of location and number of satellites in view of the receiver. A low DOP indicates a strong potential for better accuracy than a high DOP. Generally, more satellites visible to both the reference and remote receivers results in a lower DOP. Additionally, if the satellites are evenly spread around the receiver, rather than grouped in a few regions of the sky, a lower DOP (stronger solution) will result.

Satellite signals received by the GPS receiver by a reflection from an object can decrease positioning accuracy. These multipath signals increase the measured range to a satellite as the signal takes a longer route to the GPS antenna. Certain precautions will minimize GPS antenna sensitivity to these reflected signals. Operating away from large reflective structures such as buildings or using special antennas and GPS equipment can help to reduce the impact of multipath. For most consumer-level applications, a small amount of multipath is tolerable.

The quality of a GPS receiver has a dramatic influence on positioning accuracy. Consumer-based GPS products, such as many affordable handheld and fixed-mount receivers, typically operate with an accuracy of 2 to 5 meters horizontally 95% of the time. The accuracy of a particular product depends on the specific receiver's performance characteristics. Higher accuracy GPS receivers are able to achieve up to 1 meter of horizontal accuracy 95% of the time using real-time DGPS transmissions.

MBX-4 Beacon Receiver Information

The MBX-4 receives, and demodulates RTCM SC-104 differential correction data transmitted by 300 kHz DGPS radiobeacons. The MBX-4 house the Hemisphere GPS dual channel SBX-4 beacon receiver engine that features high-performance beacon search algorithms and a highly sensitive, adaptive architecture.

The MBX-4 features:

- Fast acquisition times ensuring that you are up and running quickly
- Low power consumption giving extended battery life
- Automatic and manual tune modes for versatility
- Full NMEA 0183 command protocol for configuration, operation, and monitoring of receiver performance
- Firmware upgrades uploaded through the serial port
- Various baud rates for compatibility with “differential-ready” GPS products
- A 2-line by 16-character display and 3-key control panel for operation of the receiver, and monitoring performance.
- Built-in signal splitter allows output of GPS signal from combination GPS/beacon antenna to a separate GPS receiver

MGL-4 Combined GPS / Magnetic Field Antenna

The MGL-4 combines two individual antennas, an H-field Loop antenna and an L1 GPS patch antenna. Both of these elements are active and draw their power from the MBX-4 beacon receiver.

2: Installation

System Parts List

The following list of standard equipment is included with the beacon receiver system:

- MBX-4 Receiver
- MGL-4 Antenna
- Magnetic mount (threaded stem facilitates a 5/8” thread)
- Reference Manual

Receiver Layout and Connections

The MBX-4 receiver is easily installed, requiring only power, data, antenna, and ground connections. Figure 1-1 illustrates the required receiver cable connections.

Warning!

The MBX-4 receiver provides 10 VDC across the antenna port labeled "ANT." Connection to incompatible devices may result in damage to equipment. No voltage is provided on the GPS port and any voltage applied to this port from an external GPS product is DC-blocked for protection of the MBX-4.

Figure 2-1. Receiver Cable Interface

Installing the Receiver

To ensure optimum receiver performance and ease of operation, you should consider the information presented in the following sections when installing the MBX-4 receiver.

Receiver Placement

When selecting a location to install the receiver, you should ensure that:

- The receiver is within reach of power, data, and antenna cable connections.
- Sufficient room is available at the back of the receiver to connect and disconnect the power, data, antenna, and ground cables if required.
- Once you have installed the receiver, cables will not be bent or pinched as the receiver is tilted up or down.
- You have a clear view and access to the receiver's front panel, to monitor the receiver status, if you require

Environmental Considerations

The MBX-4 is designed to operate within enclosed environments where the temperature remains between -22° F and 158° F (-30° C and +70° C and relative humidity is less than 95 percent. It may be stored between -40° F and +176° F (-40° C and +80° C).

Power Considerations

The MBX-4 possesses a 2-conductor, positive locking, circular power connector and operate with an input voltage between 9 and 40 VDC. For best performance, the supplied power should be continuous and clean. You may use an in-line power filter to minimize power fluctuations resulting from additional electrical accessories connected to the same power supply.

The backlit LCD display of the MBX-4 receiver remains illuminated while power is applied.

Table 2-1 Power Requirements of the MBX-4.

Table 2-1: Power requirements

Receiver	Input voltage	Input current	Input power
MBX-4	9-40 Vdc	210 mA @ 12 VDC	2.5 W

To power the receiver:

1. Connect the red wire of the supplied power cable to DC positive (+).
2. Connect the black wire of the supplied power cable to DC negative (-).
3. Connect the keyed, two-conductor socket connector of the power cable to the receiver's power input connector, labeled PWR.

Both receivers possess reverse polarity protection to prevent damage if the power leads are reversed.

A 1.5 A slow blow fuse, situated in-line of the power cable protects the receiver from power surges. The fuse container should remain accessible after installation.

Warning!

Do not operate the MBX-4 with the 1.5 A fuse bypassed. Such modification will void the product warranty.

Grounding the Receiver

For best performance, connect the ground screw, labelled GND, on the back of the MBX-4 to a counterpoise (artificial) ground. This ground point may be a ground plate on a marine vessel, the chassis of a vehicle. Other grounds may provide acceptable performance. You should minimize the overall length of the ground wires for best performance, if possible.

Connecting the Receiver To External Devices

Both receivers support RS-232C (default) and RS-422 interface levels for communication with differentially capable GPS products. They feature one external bi-directional data port used for transmitting RTCM SC-104 differential correction data to a GPS receiver, and for remote control and querying of the beacon receiver using a terminal device. This data port is located at the back panel of the receiver and is a DB9 socket connector.

Table 2-2 provides pin-assignment information for the data port of the receiver, at the default RS-232 interface level. Table 2-3 provides the pin-assignments for the data port at the RS-422 level.

Table 2-2: Receiver data pin-out, RS-232 interface level

Pin number	Signal	Description
2	Transmit	RTCM SC-104/status output
3	Receive	NMEA Input
5	Signal ground	Signal return

Table 2-3: Receiver data Pin-out, RS 422 interface level

Pin number	Signal	Description
1	Transmit +	RTCM SC-104/status output +
2	Transmit -	RTCM SC-104/status output -
4	Receive	NMEA input -
5	Signal ground	Signal return
7	Receive +	NMEA input +

To establish communications between the beacon receiver and your GPS, you must connect the transmit pin(s) of the beacon receiver to the receive pin(s) of the GPS receiver.

Optionally, you may connect the receive pin(s) of the beacon receiver to the GPS, or communicating device transmit line. This is required for display of GPS information on the MBX-4 LCD display when in BX-E mode, and for tuning of the MBX-4 receiver remotely. You must connect the signal ground (pin 5) of the beacon receiver to the signal ground of the external GPS device.

Figure 2-2 illustrates this requirement for a GPS receiver operating at the RS-232 communications level:

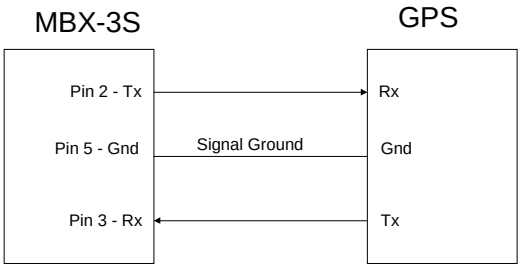

Figure 2-2. Receiver I/O Interface, RS-232

Figure 2-3 illustrates this requirement for a GPS receiver operating at the RS-422 communications level:

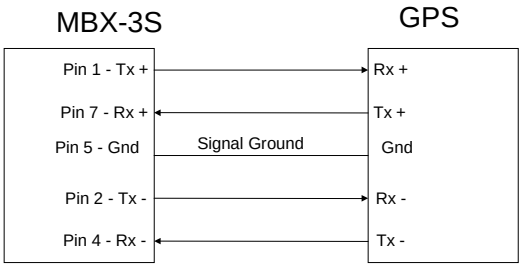

Figure 2-3. Receiver I/O Interface, RS-422

For successful communications, the baud rate of the beacon receiver must be set to match that of the GPS receiver. Refer to the "Change Baud Rate" section on page 51 for instructions set the MBX-4 baud rate using the display and keypad, and the "MBX-4 Port Rate Command ($PCSI,6)" section on page 63 for information to change the baud rate using proprietary NMEA commands.

RS-232 and RS-422 Operation

A majority of GPS receiver products communicates at the RS-232 level, similar to a PC computer. However, there are a number of chart-plotting devices, incorporating GPS capabilities, that operating at the RS-422 interface level. The default communication level of the MBX-4 is RS-232.

To switch from the default RS-232 communication level, you must remove the MBX-4's front and back panels to slide the receiver board out of the case approximately 2 inches (5 centimeters). Always observe proper electrostatic discharge precautions (ESD) when handling the beacon receiver or its components, outside of the enclosure. Such precautions include proper grounding of personnel, tools, and the surface upon which the receiver rests.

You will require a Philip's screwdriver to open the front and back panels of the MBX-4. Once you have removed the front panel screws for the MBX-4, carefully remove the front plate and disconnect the ribbon cables of the display and keypad, taking note of connector orientation when secured. Do not pull on the ribbon cables, hold onto the connector when removing so that strain is not placed on the cable.

When making this modification, do not draw the printed circuit board fully out of the enclosure. Instead, slide the board out no more than two inches before reaching in to reposition the RS-232/RS-422 slide switch. Use of a ball-point pen is recommended when making this adjustment. Figure 2-4 illustrates the location of the RS-232/RS-422 slide switch within the receiver:

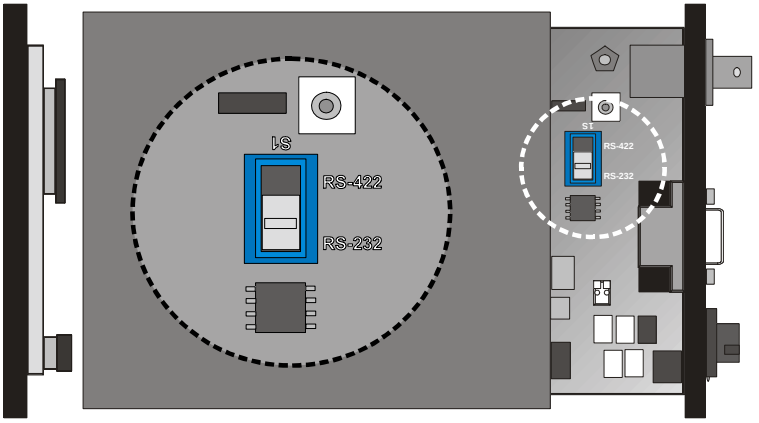

Figure 2-4. RS-232/RS-422 Configuration

With the switch set to the lower position (as viewed in Figure 2-4), the receiver communicates at the RS-232 level. When set to the upper position, the receiver communicates at the RS-422 level. The interface level corresponding to the switch position is silk-screened onto the circuit board for identification.

Warning!

The MBX-4 is an electrostatic sensitive device. Observe proper precautions when handling the receivers during this procedure. Damage caused to the receiver by ESD is not covered under warranty.

Once you have set the slide switch to the desired position, slide the receiver board back into the enclosure. Reconnect the front panel display and keypad ribbon cables. When replacing the front and back plate screws ensure that no cables or components catch between the panels and the housing.

Installing the Antenna

The following sections provide antenna installation details and discusses the internal signal splitter.

Antenna Placement to Optimize Reception

Local noise generated by your vehicle, vessel, or surroundings may affect your beacon system performance. To minimize this impact, you should locate the antenna outside the path of a radar beam, away from any transmitting antennas, and away from any other source of interference such as motors, solenoids, and other electronics.

Your receiver calculates a Signal to Noise Ratio (SNR), measured in dB (Decibels) which indicates the receiver's performance. The SNR is height of the signal above the noise floor. The higher the SNR, the better your receiver is receiving the signal. The optimum antenna location will be a position where your average SNR is highest. You should turn on all accessories that you intend to use during normal operation when locating the best position for the antenna.

The MBX-4 receiver displays the SNR within the Beacon Status menu. You may alternatively issue a NMEA query to the receiver through the serial port to get this information. Normally you will require a PC computer with a terminal program to do this, however, some GPS systems will display the SNR, such as Garmin GPS receivers (you must connect the GPS transmit signal to the receive of the beacon receiver). Hemisphere GPS offers free PC computer controller software for interfacing with Hemisphere GPS beacon receiver equipment, located on the Hemisphere GPS web site at: www.hemispheregps.com, however, this is not normally needed for operation of the MBX-4.

MGL-4 Combined GPS/Beacon Antenna

Install the MGL-4 combined GPS/beacon antenna in a location with a clear, unobstructed view of the sky.

The MGL-4 uses a 1-14-UNS thread for mounting. A magnetic mount with integral 5/8th inch threaded shaft is provided with the MBX-4. For best performance, mount this antenna so that the center of the black gasket is at least 3 inches (8 centimeters) above any ferrous material.

Note: Mount this antenna with a clear, unobstructed view of the sky and 3 inches (8 centimeters) away from any metal surface.

Warning!

Antennas threaded onto a mount should be tightened only by hand. Do not use tools to install the MGL-4 as this may cause damage to the antenna. Damage caused by over tightening is not covered under warranty.

Routing and Securing the Antenna Cable

Hemisphere GPS beacon antennas require a 50 omega impendance antenna extension cable such as RG-58U (up to a maximum of 492 feet (150 meters) in length) for proper operation. in the case of the combined MGL-4, cable losses at the higher GPS frequency (1.575 GHz) restrict the cable length to approximately 32.8 feet (10 meters) (for RG-58U cable), depending on GPS receiver requirements. For more information on cable length, please contact your Hemisphere GPS dealer or Hemisphere GPS technical support.

When choosing a route for the antenna extension cable, consider the following recommendations:

- Avoid running cables in areas of excessive heat.
- Keep antenna cables away from corrosive chemicals.
- Do not run the extension cable through door or window jams.
- Keep the antenna cable away from rotating machinery.
- Do not bend or crimp the antenna extension cable.
- Avoid placing tension on the cable.
- Remove unwanted slack from the antenna extension cable at the receiver end.
- Secure along the cable route using plastic tie wraps.

Warning!

The MBX-4 receiver provides 10 VDC across the antenna port. Connection to incompatible devices may result in damage to equipment. No voltage is provided on the GPS port and any voltage applied to this port from an external GPS product is DC-blocked for protection of the MBX-4.

Warning!

Connect the antenna to the beacon receiver before you apply power to the receiver.

Warning!

Improperly installed cables near machinery can be dangerous.

Magnetic Mount

The magnetic mount, can be used to install the MGL-4 antennas on any ferrous surface such as the roof of a vehicle. It consists of a mounting extension three inches long, attached to a circular metal disk, housing a magnet. A Mylar cover on the bottom of the mount protects the mounting surface from abrasion. (Hemisphere GPS part number.

A three inch diameter zinc plated steel disc and a double sided adhesive foam pad are included with the magnetic mount to attach the magnetic mount to non-ferrous surfaces, such as fiberglass rooftops. For such an installation, remove the protective backing from both sides of the adhesive foam pad, and affix the foam pad to the non-ferrous surface. Place the disc on top of the foam pad. You can then place the magnetic mount securely on the metal plate, and remove as necessary.

The stem of the magnetic mount is removable from the base and facilitates a 5/8" thread commonly used in the GIS and mapping industry.

Internal Signal Splitter

The MBX-4 receivers feature an internal signal splitter for use with the MGL-4 antenna. The Internal Signal Splitter separates the GPS and beacon signals. The beacon portion of the combined signal is supplied to the internal beacon receiver, while the GPS signal is re-directed out of the receiver through the TNC-S coaxial connector labeled GPS (see Figure 2-6). This feature eliminates the need for a separate GPS antenna or an external splitter box, reducing the amount of cable required for an installation. No voltage is provided through this port and any voltage applied to this port from an external GPS product is DC-blocked for protection of the MBX-4.

Figure 2-5. MBX-4 Internal Signal Splitter Interface

3: MBX-4 Configuration and Operation

Front Display and Keypad

Factory Default Settings

Tune Modes

Display Modes

MBX-4 Menu Systems

MBX-4 Receiver Performance - SNR Reading

Operation of MBX-4 with Garmin GPS

Configuring the Receiver

Front Display and Keypad

The MBX-4 features a 2-line by 16-character LCD and 3-key control panel. The control panel is composed of an up arrow ▲, enter ⓔ, and down arrow ▼ key. These keys allow you to navigate through the intuitive MBX-4 menu system, configuring operating parameters and viewing status information. Figure 3-1 shows the display and keypad of the MBX-4. The top line of the display is the active Focus Line for keypad operations.

Figure 3-1. MBX-4 Display and Keypad

Note - The top line of the MBX-4 display is the Focus Line, denoted by the left and right arrows on either side of the display. The field of interest must be "in focus" for keystrokes to have the desired effect.

Lock Status

The MBX-4 indicates lock status in the upper right hand corner of the display. The lock symbol, illustrated in Figure 3-2, remains in the closed position when the MBX-4 is locked to an RTCM signal, and open, when no broadcast is available for the specified frequency and/or MSK bit rate.

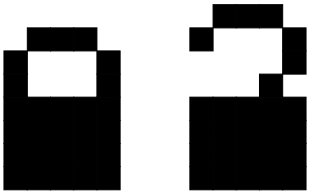

Figure 3-2. MBX-4 Beacon Lock Indicator

Factory Default Settings

Table 3-1 presents the factory default MBX-4 operation settings, while Table 3-2 lists the default communication settings. These operation and port settings are valid upon initial power-up. The MBX-4 maintains any changes made to its operation or port settings for subsequent power-up.

Note: The changes you make to the MBX-4 configuration are saved in memory for subsequent power-up.

Table 3-1: Default MBX-4 Operating Settings

Tune Mode	Display Mode
Automatic	MBX-4

Table 3-2: Default MBX-4 Port Settings

Baud Rate	Data Bits	Parity	Stop Bit	Interface Level
P1-Main: 4800	8	None	1	RS-232C

Tune Modes

The MBX-4 may be operated in either Automatic or Manual Tune Mode. In Automatic Beacon Search (ABS) Mode, the receiver identifies and tunes to the station providing the strongest DGPS signal. In Manual Mode, you specify the frequency to which the receiver will tune.

Refer to Figure 3-4 on page 37, and the "Configuring the Receiver" section on page 51 to switch between Automatic and Manual Tune modes using the display and keypad.

Automatic Beacon Search (ABS) Mode

The MBX-4 receiver operates in Automatic Beacon Search (ABS) mode by default, selecting and tuning to the most appropriate beacon without operator intervention. The MBX-4 uses its two independent channels to identify and lock to DGPS beacons without interrupting the continuous flow of RTCM data to your GPS receiver.

ABS mode is ideal for navigation applications over considerable areas, eliminating the need for operator intervention when travelling from one beacon coverage zone to another.

Global Search - When powered for the first time in ABS mode, the MBX-4 initiates a Global Search, examining each available DGPS beacon frequency, and recording Signal Strength (SS) measurements in units of dBmV/m to the Global Search Table. The receiver uses these measured values to compute an average SS, and noise floor, and to sort the frequencies in descending order of SS. The two channels cooperatively examine the frequencies with the highest SS measurements, above the computed noise floor, to determine the station providing the strongest RTCM signal. The receiver's primary channel locks to the first identified DGPS broadcast, while the second channel continues searching in the background for superior beacon signals. If no signal is available, the MBX-4 will initiate a fresh Global Search, continuing this cycle until it finds a valid beacon.

Background Search - During the Background Search, the second channel examines all frequencies at both the 100 and 200 bps MSK bit rates to identify beacons possessing superior signal quality. If a DGPS broadcast is identified that exhibits a 2 dB greater signal strength than that of the primary station, the receiver will automatically switch to this beacon. No loss of lock occurs on the primary station during the background scan.

The MBX-4 stores the current primary beacon in memory so that it is available upon subsequent power-up. You may force a new Global Search at any time using the proprietary NMEA 0183 command defined in Chapter 5.

Manual Mode

In Manual tune mode, you may select a specific frequency and bit rate for the receiver to tune to, or simply specify the frequency, allowing the MBX-4 to identify the correct MSK bit rate on its own. This mode of operation is most useful when working in an area where you know the frequency though not necessarily the MSK bit rate of the closest beacon.

The MBX-4 also provides the capability to select a beacon by name from the World Beacon Table stored within receiver memory. You can update this table via the MBX-4 serial port, as detailed in Chapter 4.

MBX-4 Display Modes

The MBX-4 operates in one of two modes as described in the following sections.

BX Mode

This is the default mode of receiver operation. In MBX-4 mode, you have display and keypad access to all information related to beacon receiver operation and configuration. The receiver outputs RTCM data through the transmit data line of the serial port, and receives configuration commands and status queries through the data port receive pin.

BX-E Mode

In BX-E, or external GPS input mode, standard NMEA 0183 GPS messages ($GPGGA, $GPVTG, $GPZDA, and $GPGSV) are input from an external GPS receiver, and the position, navigation, and satellite information contained within these messages is displayed by the MBX-4. The MBX-4 continues to output RTCM data to the external GPS device while in this mode. This feature can be very useful when working with a GPS receiver that does not provide a graphical interface.

You may select BX mode from the Options section of the Setup menu, as described in this chapter. Refer to Chapter 2 to connect an external GPS receiver for BX-E operations. Please consult your GPS receiver user's guide for more information on these GPS NMEA messages.

Position Fix Status (BX Mode Only) - When configured for BX mode, the MBX-4 provides an indication of the GPS lock status, as contained within the $GPGGA message string input from the external GPS receiver. This indicator is located in the lower right hand corner of the MBX-4 display. Figure 3-3, describes the three states of GPS lock.

Figure 3-3. BX-E Position Fix Indicator

In the first state, the two parallel vertical lines indicate that no position fix is available. The second state, denoted by the hollow circle between the two parallel vertical lines states that the receiver is tracking four satellites or more, and is computing a position. This indicator is a symbol representing a GPS satellite. The third state, denoted by the solid circle between the two parallel vertical lines indicates that the GPS receiver is computing differentially corrected position solutions.

MBX-4 Menu System

Figure 3-4 illustrates the MBX-4 display and keypad actuated menu system.

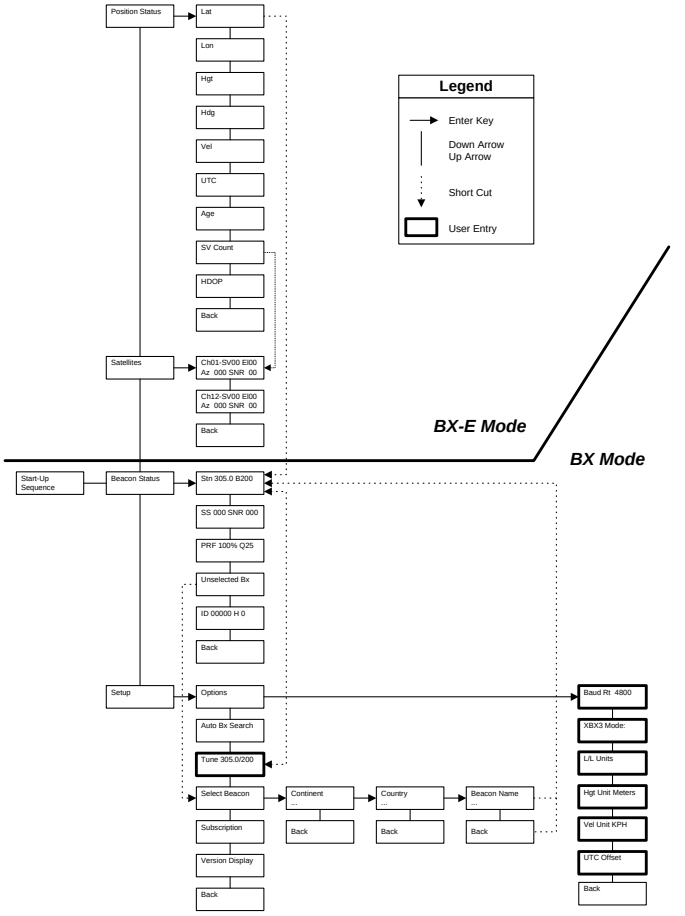

Figure 3-4. MBX-4 Menu System

Start-Up Sequence

When power is applied, the MBX-4 will sequence through four initialization screens. These start up screens include a receiver initialization and memory check, a display test, a splash screen, and a screen displaying the receiver serial number, software version, and the current display mode.

Following initialization, the receiver proceeds directly to the Beacon Status branch of the menu tree. When operating in BX mode, the BX will proceed directly to the Position Status branch of the menu tree.

Beacon Status

The Beacon Status section of the menu tree provides access to information related to the status of the receiver's primary channel.

1	Stn 305.0 B200	¨ Focus Line
2	SS 031 SNR 015	
3	MTP 100 Q 25	
4	Unselected BX	
5	ID 00000 H 1	
6	Back	

Stn

Frequency in kHz to which the MBX-4 is tuned.

B

MSK bit rate in bits per second (bps) at which the MBX-4 is demodulating data.

SS

Signal Strength in dBmV/m - a SS of 20 is 10 mV/m

SNR

Ratio of SS over computed noise floor in dB, refer to Chapter 3 for information

MTP

Message throughput (correct data ³ total data x 100%)

Q

Number of consecutive 30 bit RTCM words received correctly (max Q count = 25).

Unselected

BX

Name of the beacon to which the receiver is tuned. This field is only updated if a specific beacon is selected from the receiver's Global Beacon Table.

ID

Reference station identifier as contained within the RTCM broadcast messages.

H

Health of the transmitting beacon. Table 3-3 defines the various health values.

Table 3-3: Beacon Health Status Values

Health Code	Indication
0 – 5	Reference Station Transmission Broadcast - Monitored
6	Reference Station Transmission Broadcast – Un-monitored
7	Reference Station Not Working

Top Menu

Returns the receiver to the top menu level.

Black

Returns the receiver to the last viewed menu.

Setup

The Setup section of the menu tree provides access to MBX-4 configuration information and sub-menus.

1	Options Search	¨ Focus Line
2	Auto BX	
3	Tune 325.0/200	
4	Select Beacon	
5	Subscription	
6	Version Display	
7	Back	

The Options sub-menu provides access to the following configuration parameters:

1	Baud Rt 4800	¨ Focus Line
2	XBX3 Mode: BX	
3	L/L Unit DM.M	
4	Hgt Unit Meters	
5	Vel Unit KPH	
6	UTC Offset 0	
7	Back	

Baud Rate

P1-MAIN {2400, 4800, 9600 bd}

Baud rate at which the MBX-4 communicates through the bi-directional DB-9S data connector (Pins 2 and 3). Change this parameter to match the baud rate of the external GPS device with which the MBX-4 is communicating.

XBX3 Mode

{BX, BX-E, GBX, GBX-E, GLX}

BXDefault mode of operation. In BX-3 mode, the MBX-4 receiver accepts command and query messages, and outputs RTCM and NMEA status messages through its external communications port.

BX-EMode of operation in which the MBX-4 will display GPS position, navigation, and satellite data as input from an external GPS device. (GGA, VTG, ZDA, GSV NMEA message input required)

GBXNot applicable (only used with GBX Series combination Beacon/ GPS receivers). Do not configure the MBX-4 for this mode of operation.

GBX-ENot applicable (only used with GBX Series combination Beacon/ GPS receivers). Do not configure the MBX-4 for this mode of operation.

GLXMode of operation reserved for Hemisphere GPS LGBX products incorporating GPS, Beacon, and OmniSTAR L-Band receiver technologies. Do not configure the MBX-4 for this mode of operation.

L/L Unit

{DM.M, DMS, DD}

Pressing e with this line in focus allows you set the units of the Lat and Lon parameter displayed in the Position Status section of the menu.

Use the ▲ and ▼ keys to select the desired units, and press ⓔ again to implement the change.

Hgt Unit

{Meters, Feet}

Pressing ⓔ with this line in focus allows you set the units of the Hgt parameter displayed in the Position Status section of the menu, in BX-E mode. Use the▲ and ▼ keys to select the desired units, and press ⓔ again to implement the change.

Vel Unit

{KPH, MPH, k}

Pressing ⓔ with this line in focus allows you set the units of the Vel parameter displayed in the Position Status section of the menu, in BX-E mode. Use the ▲ and ▼ keys to select the desired units (kilometers/hour, miles/hour, or knots), and press ⓔ again to implement the change.

UTC Offset

{-12 to +12 hours}

Pressing ⓔ with this line in focus allows you set the local time offset from UTC allowing the display of local time, in the Position Status section of the menu, in BX-E mode. Use the▲ and ▼ keys to select the desired offset in hours, and press ⓔ again to implement the change.

Back

Returns the MBX-4 to the Setup menu level.

The Setup menu also provides the following configuration and information options.

Auto Bx Search

Pressing ⓔ with this line in focus sets the MBX-4 to ABS mode, erasing the stored Global Search Table and forcing a new Global Search.

Tune 325.0/200

Pressing ⓔ with this line in focus allows you set the beacon frequency and MSK rate to which the receiver should tune. The ▲ and ▼ keys increment the frequency by 500 Hz, with three MSK rate options, 100 bps, 200 bps, and Auto, available for each increment. Select Auto if you know the frequency of the beacon but are uncertain of the correct MSK rate. When the correct frequency and bit rate is displayed, press ⓔ to proceed to the Beacon Status menu.

Select Beacon

This feature allows you to select a particular beacon for a geographical region. Geographic regions are resolved into continent and country. Upon selecting a beacon, the MBX-4 will automatically return to the Beacon Status menu, updating the Stn/B and beacon name fields.

Subscription

The subscription feature allows you to configure the MBX-4 for operation within a Hemisphere GPS proprietary encrypted RTCM broadcast network. To enable this feature, please contact your Hemisphere GPS dealer or Hemisphere GPS Customer Service.

Version Display

Displays the MBX-4 serial number, resident firmware, SBX-4-2 firmware, and receiver diagnostic checksums.

Back

Returns the MBX-4 to the top menu level.

Position Status (BX-E Mode Only)

The Position Status section of the menu tree provides access to BX-E GPS position and navigation status information provided by an external GPS sensor outputting the associated NMEA 0183 GPS message strings.

1	L	a	t			5	1	4	6	.	2	3	4		N
2	L	o	n		1	1	4	0	3	.	1	4	3		W
3	H	g	t		1	0	3	9	.	0				M	
4	H	d	g			1	9	.	7	o	t	r	u	e	
5	V	e	l				2	4	.	4				K	
6	U	T	C		1	1	:	4	7	:	3	6			
7	A	g	e			7	.	0						s	
8	S	V		C	o	u	n	t		0	9				
9	H	D	O	P		1	.	9							
1	B	a	c	k											

¨ Focus Line

Lat

Displays the current latitude in degrees, minutes, decimal minutes (DM.M) as input from an external GPS receiver. This information is parsed from the NMEA $GPGGA message string.

Lon

Displays the current longitude in degrees, minutes, decimal minutes (DM.M) as input from an external GPS receiver. This information is parsed from the NMEA $GPGGA message string.

Hgt

Displays the current height in either meters or feet depending on the units selected, as input from an external GPS receiver (See Chapter 4). This information is parsed from the NMEA $GPGGA message string.

Hdg

Displays the horizontal heading clockwise from True North in degrees. This information is parsed from the NMEA $GPVTG message string.

Vel

Displays the horizontal speed in KPH, MPS, or knots depending on the units selected, as input from an external GPS receiver (See Chapter 4). This information is parsed from the NMEA $GPVTG message string.

UTC

Displays the current UTC Time with local offset as input from an external GPS receiver (See Chapter 4). This information is parsed from the NMEA $GPZDA message string.

Age

Displays the current DGPS age of correction in seconds, as input from an external GPS receiver. This information is parsed from the NMEA $GPGGA message string.

SV Count

Displays the current number of satellites being used by the GPS receiver in computing its position. If this value is 4 or greater, then the computed position is 3D, and includes a valid height solution. If less than four, then the solution is 2D, holding the height parameter constant at either 0, or its last measured value.

HDOP

Displays the Horizontal Dilution of Precision (HDOP). This information is parsed from the NMEA $GPGGA message string.

Back

Returns the MBX-4 to the top menu level.

Satellites (BX-E Mode Only)

The Satellites section of the menu tree provides access to BX-E GPS satellite information provided by an external GPS sensor. Pressing the ▲ and ▼ keys allows you to scroll through the available GPS receiver channels, numbered Ch01 through Ch12.

1	Ch01-SV15 EL 09	¨ Focus Line
2	Az 154 SNR 41	
3	Back	

Ch01

Displays the external GPS receiver channel (01-12) for which the satellite information provided is valid. This information is parsed from the NMEA $GPGSV or $PASHS,SAT message strings.

SV12

Displays the GPS satellite SV number tracked by channel "XX" of the external GPS receiver. This information is parsed from the NMEA $GPGSV or $PASHS,SAT message strings.

El

Displays the elevation angle (0× - horizon to 90×- vertical) of the SV relative to the external GPS receiver antenna. This information is parsed from the NMEA $GPGSV or $PASHS,SAT message strings.

Az

Displays the azimuth angle (0× = 360× = North) of the SV relative to the external GPS receiver antenna. This information is parsed from the NMEA $GPGSV or $PASHS,SAT message strings.

SNR

Displays the signal to noise ratio of the satellite signal measured by the external GPS receiver. This information is parsed from the NMEA $GPGSV or $PASHS,SAT message strings.

Back

Returns the MBX-4 to the top menu level.

Menu System Shortcuts

There are a number of shortcuts present within the MBX-4's menu system that may allow you to navigate through it more efficiently. A shortcut allows you to move from one menu directly to separate menu without having to choose the Back menu item.

When Stn/B of the Beacon Status menu is in focus, you may press ⓔ to proceed directly to the Tune command line of the Setup menu. You may then press ⓔ again to change the frequency and bit rate to which the receiver is tuned using the ▲ and ▼ keys. When the correct frequency and bit rate are displayed, press ⓔ a third time to tune the receiver and return to the Beacon Status menu.

When Unselected BX of the Beacon Status menu, is in focus, you may press ⓔ to proceed directly to the Select Beacon menu item of the Setup menu. You may then press ⓔ again to select a specific beacon by geographic region by name using the ▲, ▼ and ⓔ keys. When the

correct beacon name is displayed, press ⓔ to tune the receiver and return to the Beacon Status menu.

In BX-E mode, when Lat of the Position Status is in focus, you may press ⓔ to proceed directly to the Beacon Status menu, allowing you to monitor beacon receiver performance quickly.

In BX-E mode, when, SV Count is in focus, you may press ⓔ to proceed directly to the Satellites status menu.

MBX-4 Receiver Performance - SNR Reading

The Signal to Noise Ratio (SNR) best describes beacon receiver performance. The SNR is the height of the signal above the noise floor. The higher the SNR, the better the MBX-4 is receiving the signal. You can easily monitor the SNR in the Beacon Status menu. You may also monitor the SNR by interfacing to a PC computer running a terminal program using the $GPCRQ NMEA sentence discussed in Chapter 4 - NMEA 0183 Interface.

Table 3-4 describes the general quality of reception with respect to the SNR reading of the MBX-4.

Table 3-4: Receiver Performance - SNR Reading

SNR	Reception Description	Data Throughput
>25	Excellent	100% data throughput
20 to 25	Very Good	100% data throughput
15 to 20	Good	Good data throughput up to 100%
10 to 15	Stable	Moderate to good data throughput
7 to 10	Intermittent	Low data throughput
<7	No Lock	No data throughput

Operation of MBX-4 with Garmin GPS

You may use either the Garmin GPS (if beacon interface is supported) or the MBX-4 menu system for tuning and monitoring performance. The MBX-4 will display more information relating to performance than that of the Garmin receiver, including signal strength (SS), message throughput (MTP), station ID, and station health. However, the Garmin may display distance to the beacon, dependent upon the transmission of beacon station coordinates within the RTCM Type 3 message.

When interfacing a Garmin GPS receiver with the MBX-4, set the input/output protocols to RTCM/NMEA and change the baud rate of the Garmin to 4800.

Configuring the Receiver

The following subsections provide detailed instructions to configure important operating parameters of the MBX-4.

Change Baud Rate

To modify the baud rate of the MBX-4 data port (Refer to Figure 3-4):

- Navigate to Options in the Setup menu and press ⓔ.
- Observe the current Baud Rt setting. If incorrect, press ⓔ.
- Scroll with the ▲ or ▼ keys to the correct baud rate {2400, 4800, or 9600} and press ⓔ.

Change Frequency and MSK Rate

To modify the frequency and MSK rate to which the receiver is manually tuned (Refer to Figure 3-4):

- Navigate to Tune in the Setup menu and press ⓔ.
- Scroll with the ▲ or ▼ keys until the desired Frequency and MSK Rate are displayed and press ⓔ {283.5/100 to Auto/Auto}.

Select a Beacon By Name

To tune to a specific beacon by name (Refer to Figure 3-4):

- Navigate to the Select Beacon in the Setup menu and press ⓔ.

- Scroll with the ▲ or ▼ keys until the desired continent is displayed then press ⓔ.
- Scroll with the ▲ or ▼ keys until the desired country is displayed then press ⓔ.
- Scroll with the ▲ or ▼ keys until the name of the specific beacon is displayed then press ⓔ.

Set to Automatic Beacon Search Mode

To set the receiver to ABS mode (Refer to Figure 3-4):

- Navigate to Auto Bx Search in the Setup menu and press ⓔ.

-or-

- Navigate to Tune in the Setup menu and press ⓔ.
- Scroll with the ▲ or ▼ keys until Auto/Auto is displayed and press ⓔ.

The previous method erases any previous search information, while the later method does not.

Change Display Mode

To change display mode (Refer to Figure 3-4):

- Navigate to Options in the Setup menu and press ⓔ.
- Scroll with the ▲ or ▼ keys until XBX3 Mode is displayed and press ⓔ.

- Scroll with the ▲ or ▼ keys to the correct mode {BX or BX-E} and press ⓔ.

4: NMEA 0183 Interface

Interface Protocols

NMEA 0183 Commands

NMEA 0183 Queries

Interface Protocols

The MBX-4 receiver supports the following data, command, and status protocols:

- RTCM SC-104 differential GPS message protocol
- NMEA 0183 standard command and status message protocol
- NMEA 0183 proprietary command and status message protocol

Description of NMEA 0183

The RTCM SC-104 message standard discussed in the DGPS Format section on page 5, contains no provision for the transmission or reception of receiver control and status information. To implement these functions, the MBX-4 is capable of processing a subset of standard NMEA 0183 messages, along with a selection of proprietary NMEA 0183 formatted messages.

NMEA 0183 is a communication standard established by the marine industry. It has found use in a variety of marine electronics devices, including ship-borne radar systems, Loran-C navigation devices, and more recently GPS. The National Marine Electronic Association has developed a significant number of messages specifically for use with GPS.

The National Marine Electronics Association publishes updates to the NMEA 0183 standard. The latest version is available by contacting:

National Marine Electronics Association

NMEA Executive Director

P. O. Box 50040, Mobile, Alabama 36605, USA

Tel (205) 473-1793Fax (205) 473-1669

NMEA Message Elements

All NMEA 0183 messages possess a common structure, including a message header, data fields, and a terminating carriage return and line feed.

Example:$GPYYY,xxx,xxx,xxx...<CR><LF>

Table 4-1: NMEA Message Elements

Element	Description
$GP	Message Identifier Indicating a GPS Related Message
YYY	Type of GPS Message
Xxx	Variable Length Message Fields
<CR>	Carriage Return
<LF>	Line Feed

Null fields occur when no information is available for a field.

To issue NMEA commands, use a program with a terminal utility running on a PC computer. You may type these commands into the terminal window once you have matched the communication parameters between the terminal program and the receiver. You must ensure that when you press the Enter key on your PC to send a command, it represents both a carriage return <CR> and line feed <LF>. If a NMEA command is not working, this terminal facility option may not be set correctly. Please contact your dealer, or Hemisphere GPS Technical Service for more information.

Hemisphere GPS' DGPS Command Center

If you are using Hemisphere GPS' DGPS Command Center program, the terminal window allows you to issue NMEA commands or queries to the MBX-4, each sentence is appended automatically with a <CR> <LF> when the send button is depressed. This software utility is available for download from Hemisphere GPS' Web site at: www.hemispheregps.com.

MBX-S Supported Messages

The MBX-4 supports the NMEA commands and queries listed in Table 4-2.

Table 4-2: MBX-4 Supported NMEA Messages

Message Description	Description
Commands	
$GPMSK (Full Manual Tune)	Sets the receiver into Full Manual Tune Mode
$GPMSK (Partial Manual Tune)	Sets the receiver into Partial Manual Tune Mode
$GPMSK (ABS Mode)	Sets the receiver into Automatic Beacon Search Mode
$PCSI,4 (Proprietary)	Erases the Global Search table forcing a new search
$PCSI,5 (Proprietary)	Reserved (Factory use only)
$PCSI,6 (Proprietary)	Sets the internal and external MBX-4 baud rates
$PCSI,7 (Proprietary)	Sets the display mode of the MBX-4 receiver
$PSLIB (Proprietary)	Sets the frequency and MSK bit rate of the MBX-4
Queries	
$GPCRQ Operation Query	Queries the receiver for operation parameters
$GPCRQ Performance Query	Queries the receiver for performance parameters
$PCSI,0 (Proprietary)	Lists available proprietary $PCSI commands and queries
$PCSI,1 (Proprietary)	Reserved
$PCSI,2 (Proprietary)	Reserved
$PCSI,3 (Proprietary)	Reserved

Response Message

The MBX-4 will issue a NMEA formatted acknowledgment response message upon receiving a selection of NMEA formatted command or query messages. The intent of this message is to confirm that communication exists between the beacon receiver and the terminal device.

Descriptions of the response messages specific to each command and query are provided below the related command in the following sections. N/A indicates that the receiver does not provide a response for that particular message.

NMEA 0183 Commands

This section discusses the standard and proprietary NMEA 0183 commands accepted by the MBX-4 receiver.

Standard Commands

The following subsections describe the selection of valid standard NMEA-0183 commands, and their responses.

Full Manual Tune Command ($GPMSK) - This command instructs the MBX-4 to tune to a specified frequency and MSK Rate. It has the following form:

$GPMSK,fff.f,M,ddd,M,n<CR><LF>

MBX-4 Response:

$PCSI,ACK,GPMSK,fff.f,M,ddd,M,n<CR><LF>

In this message, fff.f is the frequency in kHz, and M designates manual frequency selection. The ddd field represents the desired MSK bit rate in bits per second (100, 200 bps, or non-standard), and the second M designates manual MSK rate. The n parameter is the period of the performance status message output by the receiver (0 to 100 seconds). When power is cycled, the status output interval resets to zero.

The status message output by the MBX-4, as initiated using this command, is the CRMSS message response discussed in Chapter 4.

Note - If the "n" field in this message is non-zero, the status data message output by the MBX-4 may interrupt the flow of RTCM messages to the GPS receiver.

Partial Manual Tune Command ($GPMSK) - This command instructs the MBX-4 to tune to a specified frequency and automatically select the correct MSK rate. It has the following form:

$GPMSK,fff.f,M,,A,n<CR><LF

MBX-4 Response:

$PCSI,ACK,GPMSK,fff.f,M,,A,n<CR><LF>

In this message, fff.f is the frequency in kHz, and M designates manual frequency selection. The A field designates automatic MSK rate. Then parameter is the period of the performance status message, as output by the MBX-4 (0 to 100 seconds). When power is cycled, the status output interval resets to zero.

Again, the status output is the CRMSS message response, discussed in Chapter 4.

Note: If the "n" field in this message is non-zero, the status data message output by the MBX-4 may interrupt the flow of RTCM messages to the GPS receiver.

Automatic Beacon Search Command ($GPMSK) - This command initiates the MBX-4 automatic mode of operation in which the receiver operates without operator intervention, selecting the most appropriate beacon station. This command has the following format:

$GPMSK,,A,,A,n<CR><LF>

MBX-4 Response:

$PCSI,ACK,GPMSK,,A,,A,0<CR><LF>

In this message, the first A designates automatic frequency selection, and the second A designates automatic MSK rate. The n parameter is the output period of the performance status message from the receiver

(0 to 100 seconds). When power is cycled, the status output interval resets to zero.

CRMSS is the MBX-4 performance status message, output every n seconds, and is discussed in Chapter 4.

The MBX-4 provides the above response to this $GPMSK message, and immediately tunes to the optimum beacon station, provided a valid beacon almanac is present in receiver memory. Without a valid almanac, the beacon receiver will perform a Global Search to identify candidate stations in the area.

Note: If the "n" field in this message is non-zero, the status data message output by the MBX-4 may interrupt the flow of RTCM messages to the GPS receiver.

Proprietary Commands

The following subsections describe the selection of Hemisphere GPS proprietary NMEA-0183 formatted commands, and their responses.

Wipe Search Command ($PCSI,4) - The Wipe Search command instructs the MBX-4 to erase all parameters within the beacon almanac and to initiate a new Global Search to identify the beacon signals available for a particular area. The command has the following form:

$PCSI,4<CR><LF>

MBX-4 Response:

$PCSI,ACK,4<CR><LF>

When this command has been issued in Manual Tune mode, the receiver will initiate a new Global Search when commanded to Automatic Tune mode. If the receiver is operating in its Automatic Background Search mode, a new Global Search will begin immediately.

MBX-4 Port Rate Command ($PCSI,6) - This proprietary $PCSI command sets the communication baud rates of the one external (P1-Main) and three internal (P2-GPS, P3-DGPB, P4-DGPA) MBX-4 micro-controller ports. The command has the following form:

$PCSI,6,r1,r2,r3,r4<CR><LF>

MBX-4 Response:

$PCSI,ACK,6, r1,r2,r3,r4

$PCSI,6,P1@r1,P2@r2,P3@r3,P4@r4

In this message, rx designates the MBX-4 communications port baud rate, for the one external and three internal MBX-4 host communication ports, <P1>, <P2>, <P3>, and <P4>. Baud rates r1, r2, r3, and r4 are selected from Table 4-3.

Warning!

Only <P1> is applicable to regular MBX-4 operations. Leave all others, <P2>, <P3>, and <P4> at their factory pre-configured values as defined in Table 4-4.

Table 4-3: MBX-4 Baud Rates

rx, x = 1 to 4
2400
4800
9600

Table 4-4: MBX-4 Factory Pre-Configured Baud Rates

Port	Baud Rate
P1-Main	4800
P2-GPS	4800
P3-DGPB	4800
P4-DGPA	4800

MBX-4 Display Mode ($PCSI,7) - The Display Mode command sets the MBX-4 mode of operation as detailed in the "NMEA Message Elements" section on page 64.

$PCSI,7,m<CR><LF>

MBX-4 Response:

$PCSI,ACK,7,m

In this message, m designates the MBX-4 display mode, and may be selected from the Table 4-6.

Table 4-5: MBX-4 Display Modes

m	Mode
1	BX
2	GBX
4	GBX-E
8	BX-E

Note - Only BX and BX-E modes of operation are applicable to the MBX-4 receiver. The receiver's power must be cycled for the change to occur.

Tune Command ($PSLIB) - A majority of Garmin hand-held and fixed-mount GPS receivers output this non-standard command from the BEACON RCVR feature of the INTERFACE menu. It instructs both the connected beacon receiver to tune to the specified frequency and MSK Rate. The command has the following form:

$PSLIB,fff.f,ddd<CR><LF>

MBX-4 Response:

N/A

In this message, fff.f is the frequency in kHz (283.5-325 kHz; 0 - Auto). The ddd field represents the desired MSK bit rate in bits per second (100, 200 bps; 0 - Auto).

NMEA 0183 Queries

This section discusses the standard and proprietary NMEA 0183 queries accepted by the MBX-4 receiver.

Standard Queries

The following subsections describe the selection of valid standard NMEA-0183 queries, and their responses.

Receiver Operating Status Query ($GPCRQ) - This standard NMEA query prompts the MBX-4 receivers for their operational status. It has the following format:

$GPCRQ,MSK<CR><LF>

MBX-4 Response:

$CRMSK,fff.f,X,ddd,Y,n*CS

When queried for their operational status, both receivers will return this NMEA response where fff.f is the current frequency in kHz, X is the tune mode (A = automatic and M = manual), ddd is the MSK bit rate, Y is the MSK mode (A = automatic and M = manual), and n is the output period of the CRMSS performance status message. The *CS field is the checksum that terminates the NMEA response.

Receiver Performance Status Query ($GPCRQ) - This standard NMEA query prompts the MBX-4 receiver for their performance status:

$GPCRQ,MSS<CR><LF>

MBX-4 Response:

$CRMSS,xx,yy,fff.f,ddd*CS

Both receivers will return this NMEA response when queried for its performance status. The xx field is the signal strength in dBmV/m, yy is the signal to noise ratio in dB, fff.f is the current frequency in kHz, and ddd is the corresponding MSK bit rate in bps. The *CS termination is the checksum that terminates the response message.

Proprietary Queries

The following subsections describe the selection of valid Hemisphere GPS proprietary NMEA-0183 queries, and their responses.

Receiver Help Query ($PCSI,0) - This command queries the MBX-4 receiver for a list of valid proprietary $PCSI commands:

$PCSI,0<CR><LF>

MBX-4 Response:

$PCSI,0
$PCSI,ACK,0
$PCSI,P012-0,010
$PCSI,0 ->HELP Msg
$PCSI,1 ->Reserved
$PCSI,2 ->Reserved
$PCSI,3 ->Reserved
$PCSI,4 ->Wipe Search
$PCSI,5 ->GPS<>SBX3a Port Rate,<P4>
$PCSI,6 ->XBX3 Port Rates,<P1>,<P2>,<P3>,<P4>

$PCSI,7 ->XBX3 Mode

Note: The $PCSI,5 command is reserved for factory configuration of the MBX-4 and its internal components, and should not be used in the field.

5: Troubleshooting

Troubleshooting

Use the following checklists to troubleshoot anomalous MBX-4 receiver operation. Table 5-1 provides a problem symptom, followed by a list of possible solutions for troubleshooting operation of the MBX-4 receiver.

Table 5-1: MBX-4 Troubleshooting

Symptom	Possible Solution
Receiver fails to power	Verify polarity of power leads Check 1.5 A in-line power cable fuse Check integrity of power cable connections Check power source output voltage (9-40 VDC) Check current restrictions imposed by power source (maximum > 0.5 A)
No data from MBX-4	Check receiver power status (display illuminated?) Verify that MBX-4 is locked to a valid beacon (Lock symbol engaged) Check integrity of power, antenna, and data cable connections Receiver in MBX-4 or MBX-E mode only?
Random data from MBX-4	Check transmitting beacon status Verify baud rate settings of MBX-4 and terminal device (MBX-4 default baud rate = 4800 bd)
No signal lock	Check antenna connections Verify MSK rate is set correctly or choose Auto MSK rate (100 200, or Auto) Verify frequency of transmitting beacon, or choose Auto Bx Search Check MBA-3 antenna ground Verify MBX-4 antenna port output voltage (10 VDC) Verify 10 VDC across antenna cable connector

Table 5-1: MBX-4 Troubleshooting

Low SNR	Check integrity of antenna connections Check MBA-3 antenna ground Select alternate antenna position
Non-differential GPS output	Verify MBX-4 lock status Verify matched MBX-4 output and GPS RTCM input baud rates Verify GPS receiver RTCM compatibility Verify GPS receiver DGPS configuration Verify pin connectivity between MBX-4 and GPS receiver Verify communication parameter settings (8 data bits - No parity - 1 stop bit) Verify communication levels of MBX-4 and GPS receiver are matched ((RS-232C vs RS-422) Verify data cable connections
No MBX-4 response to NMEA commands and queries	Verify baud rate settings of MBX-4 and terminal device (MBX-4 default baud rate = 4800 bd) Verify communication parameter settings (8 data bits - No parity - 1 stop bit) Check integrity of data cable connections Verify pin connectivity between MBX-4 and terminal device Ensure receiver is in MBX-4 mode

Appendices

Appendix A - Specifications

This appendix provides the operational, mechanical, electrical, physical, and environmental specifications for the following Hemisphere GPS products:

- MBX-4 Beacon Receiver
- MGL-4 Combination Antenna
- Internal Antenna Signal Splitter

Table A-1: MBX-4 Beacon Receiver Specifications

Operational Specifications	
Item	**Specification**
Frequency Range	283.5 - 325 kHz
Channels	2
Input Sensitivity	2.5 mV/m for 10 dB SNR @ 100 bps MSK Rate
Acquisition Time	< 1 Second Typical
MSK Bit Rate	100, 200, or Automatic
Frequency Selection	Manual or Automatic
Frequency Offset	± 5 Hz
Dynamic Range	100 dB
Adjacent Channel Rejection	60 dB @ f_0 ± 500 Hz
Decoding	RTCM 6/8
Demodulation	MSK

Serial Interface Specifications	
Item	**Specification**
Interface Levels	RS-232C and RS-422
Data Connector	DB9 Socket

Data Port Baud Rate	2400, 4800, or 9600 Baud
Data Output Format	RTCM SC-104, NMEA 0183
Data Input Protocol	NMEA 0183

Power Specifications	
Item	**Specification**
Input Voltage	9-40 VDC
Input Current	210 mA @ 12 VDC
Power Consumption	2.5 W
Power Connector	Circular 2-pin Locking Plug

Mechanical Characteristics	
Item	**Specification**
Display	2-line, 16-character LCD
Keypad	3-switch membrane
Enclosure	Extruded Aluminum with Aluminum Front and Back Plates.
Length	150 mm (5.9”)
Width	125 mm (4.9”)
Height	51 mm (2.0”)
Weight	0.64 kg (1.4 lb)
Antenna Connector	BNC Socket
Optional GPS Signal Output Connector	TNC Socket

Environmental Specifications	
Item	**Specification**
Storage Temperature	-40×C to 80×
Operating Temperature	-30×C to 70×C

Humidity	95% Non-Condensing

Table A-2: MGL-4 Combination Loop / GPS Antenna Specifications

Operational Specifications	
Item	**Specification**
Frequency Range, Beacon	283.5 - 325 kHz
LNA Gain, Beacon	34 dB
Pre-Amplifier, Beacon	Integral Low Noise Amplifier
Frequency Range, GPS	1.575 GHz (L1)
LNA Gain, GPS	Various available

Power Specifications	
Item	**Specification**
Input Voltage	4.9-13 VDC supplied by receiver
Input Current	50-60 mA

Mechanical Characteristics	
Item	**Specification**
Enclosure	PVC Plastic
Mounting Thread	1-14-UNS-2B
Length	128 mm (5.06”)
Width	128 mm (5.06”)
Height	84 mm (3.33”)
Weight	450 g (1.0 lb)
Antenna Connector	TNC-S
Antenna Extension Cable	RG-58U, < 15 m (45 ft) in Length

Environmental Specifications	
Item	**Specification**
Storage Temperature	-40×C to 80×C
Operating Temperature	-30×C to 70×C
Humidity	100% Condensing

Table A-3: Internal Signal Splitter Specifications

Item	Specification
BCN Port - GPS Frequency Insertion Loss	35 dB nominal, >25 dB min.
BCN Port - Beacon Insertion Loss	0.2 dB nominal, 0.4 dB max.
GPS Port - GPS Frequency	3.5 dB nominal, <5 dB max.
GPS Port - Beacon Frequency	70 dB typical, 58 dB min.

Appendix B - Beacon Information

Hemisphere GPS maintains a listing of DGPS radiobeacons worldwide that is available on the Internet from the Hemisphere GPS home page:

www.hemispheregps.com

This listing contains the following information regarding currently operating beacons and potential new sites:

- Station name
- Frequency
- MSK rate
- Location
- Transmitting ID
- Reference station ID
- Field Strength
- Operating notes

Further Reading

National Marine Electronics Association, National Marine Electronics Association (NMEA 0183) Standard for Interfacing Marine Electronic Devices, Version 2.1, October 15, NMEA 1995, PO Box 50040, Mobile Alabama, 36605 USA

Radio Technical Commission for Maritime Services, RTCM Recommended Standards for Differential NAVSTAR GPS Service, Version 2.2, Developed by Special Committee No. 104, RTCM 1998, 1800 Diagonal Rd, Suite 600, Alexandria, VA, 22314-2840 USA, Tel: +1-703-684-4481, Fax: +1-703-836-4429

US Department of Transportation, United States Coast Guard, Broadcast Standard for the USCG DGPS Navigation Service, COMDTINST M16577.1, April, 1993, 2100 Second St. SW, Washington, D.C., 20593-0001, USA

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