OmniSTAR®

The Global Positioning System

2100LR12 OPERATOR'S MANUAL

Release: April 2001

About this manual

This manual has been released by:

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The information in this manual applies to 2100LR12 receivers with

Software version 1.41 (release date August 10, 2000)
DSP (L-Band) version 3.3 (release date August 27, 2000)
ARM (GPS) version 3.7

Specifications are subject to change without notice.

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OmniSTAR Limited Warranty

This warranty applies only to normal usage of the product. It does not apply to units or electronic circuit boards which are defective due to improper installation or handling. Physical damage due to lightning or other electrical discharge and units subjected to fresh or salt water contamination is not covered. OmniSTAR reserves the right not to warrant the product if, upon request, sufficient proof of recommended installation compliance as laid out in this manual is not provided. No other warranties are expressed or implied. No other warranties exist.

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OmniSTAR reserves the right to repair and/or replace, at its option, any part or parts found to be defective, provided such defects, in their opinion, are due to faulty material or workmanship and are not caused by unauthorised or improper repair or abuse, or normal wear. Purchaser shall be responsible for shipping and insurance of the returned product for repair under this warranty. OmniSTAR will pay shipping and insurance for the product's return to purchaser provided that the product returned proves to be defective under this limited warranty.

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OmniSTAR assumes no responsibility for any consequential or incidental losses or damages of any nature with respect to the use of this product.

Table of contents

List of figures

List of tables

1. Introduction

The Global Positioning System (GPS) is a reliable, continuous, all-weather navigation system which is operated by the United States Government. At the time of writing, the space segment of GPS includes a constellation of 28 satellites, which orbit the earth at an altitude of approximately 22.000 km.

These satellites (Space Vehicles or SV's) transmit radio signals containing precise satellite time and position information. By receiving four or more of these signals a 3-dimensional position can be computed.

Although GPS provides an acceptable level of performance for some users, many applications demand a more reliable and precise position than GPS alone can provide. In such cases Differential GPS (DGPS) must be used.

The purpose of DGPS is to minimize the effects of atmospheric and satellite errors on the position determination. In order to achieve this a reference GPS receiver must be installed at a point of known coordinates. This receiver uses the radio signals from each of the GPS satellites which are in view to measure so-called pseudo-ranges to these satellites. Because the exact locations of the satellites and the reference receiver are known, it is then possible to determine the difference between the actual and the expected pseudo-ranges (pseudo-range correction or PRC).

In order to provide compatibility for exchanging this correction data, a standard has been developped by the Radio Technical Commission for Maritime Services Special Committee 104. This standard is commonly known as RTCM SC-104.

When RTCM version 2.0 correction data from the reference receiver is applied to a nearby GPS receiver, the position accuracy will be substantially better than if stand-alone GPS were to be used.

1.1 The OmniSTAR system

The 2100LR12 is one of several DGPS receivers which have been designed to work with the world-wide OmniSTAR service.

The OmniSTAR DGPS system delivers corrections from an array of reference stations which are located all around the world (see figures 2 and 3 on page 3). The RTCM correction data from these reference stations is provided to OmniSTAR's two global Network Control Centres (NCC) , where the corrections are decoded, checked, and repackaged in a highly efficient format for broadcast.

The OmniSTAR data is broadcast over a series of L-band communication satellites. The signal transmitted over each of these satellites contains the corrections from the reference stations in and close to the region in which this satellite can be received.

When a receiver with a valid subscription receives data through one of OmniSTAR's satellite channels it will output a differentially corrected position. The way in which the correction data from each individual reference station will be used in the position calculation depends on the user's OmniSTAR subscription.

1.2 Subscription type

The 2100LR12 supports the following OmniSTAR service:

- Virtual Base Station (VBS), where the data from multiple reference stations is used in the processor software to produce enhanced corrections for the user's location. This service provides optimal position accuracy with a minimum dependence on the user's location. The VBS service can be obtained on a continental, country or regional basis.

Figure 1: OmniSTAR 2100LR12

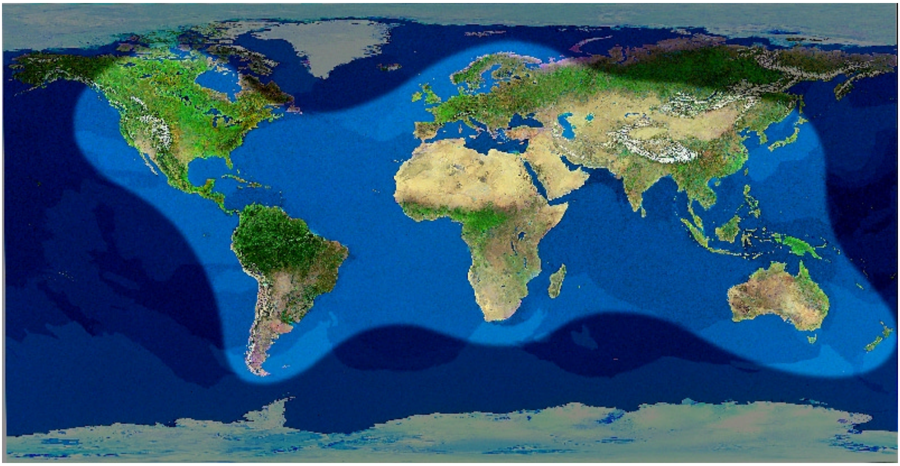


Figure 2: World coverage map for the OmniSTAR service

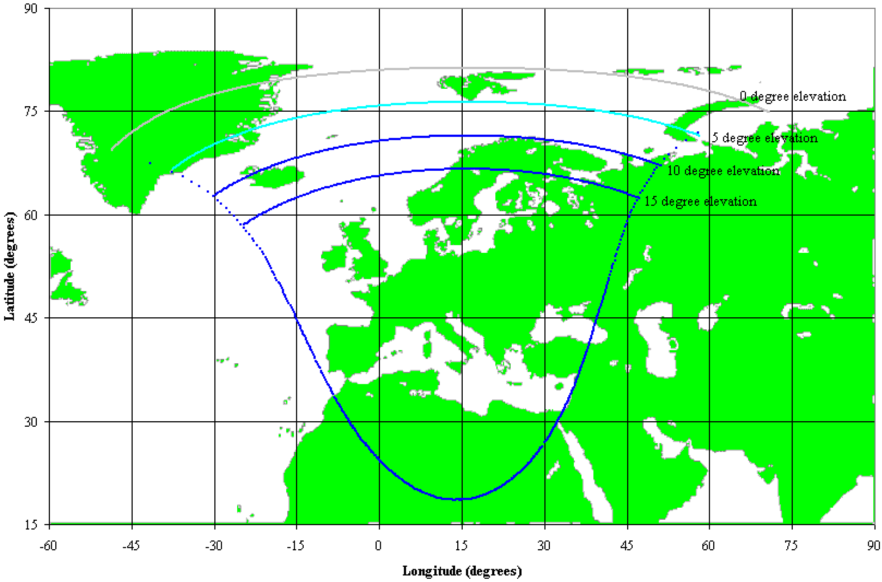


Figure 3: EMS spotbeam for coverage in Europe

2. Factors affecting system performance

The 2100LR12 has proven to be a high-quality positioning device.
The accuracy that the user can obtain depends on several factors, including:

- Number of visible satellites
- Multipath
- Dilution of Precision (DOP)
- Satellite elevations
- Differential correction

2.1 Number of visible satellites

A minimum of four satellites are required to calculate a 3-dimensional position. In general it can be said that every increase in the number of visible satellites will result in an increase in the system's accuracy. As the GPS satellites orbit around the earth the number of visible satellites will change in time. The GPS constellation has been designed so as to provide a minimum of 4 visible satellites at any location at all times. The number of visible satellites can decrease due to blockage by objects such as trees and buildings.

2.2 Multipath

It is possible for satellite signals to reflect off large nearby objects such as buildings, cars or even the ground, thereby resulting in an erroneous distance measurement. This phenomenon is known as multipath. Multipath can cause significant errors in the position determination and it is therefore important to place the receiver in an environment which is free of large reflective surfaces. It is also recommended to mount the receiver directly onto a surface, while maintaining a clear view of the sky in all directions.

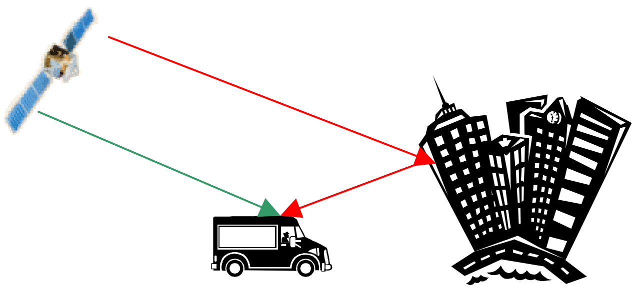


Figure 4: Multipath

2.3 Position Dilution of Precision (DOP)

The Position Dilution of Precision (PDOP) is a measure of the satellite geometry. The lower the PDOP value, the more accurate the GPS position will be. By default the 2100LR12 is configured to output position data as long as the Position Dilution of Precision does not exceed 10.

2.4 Satellite elevations

The signal from a satellite which is low on the horizon will travel a greater distance through the atmosphere. This results in a lower signal strength and a delayed reception, thereby causing erroneous and noisy data. By default the 2100LR12 is configured to ignore any satellites which have an elevation angle lower than 5°.

2.5 Differential corrections

For accurate positioning it is essential that the differential corrections are received. In order to ensure reception of the OmniSTAR satellite signal it must be prevented that the line of sight towards the satellite is blocked by objects such as trees and buildings.

Multipath reflections can cause destructive interference, thereby significally decreasing the signal strength. It is therefore recommended to mount the 2100LR12 directly onto a surface in a reflection free environment.

Although the 2100LR12 has been designed to provide optimal system performance under most circumstances, it is possible, due to the nature of radio communications, that system performance degrades due to local interference sources.

3. Installation

This chapter contains instructions and recommendations for the installation of the 2100LR12.

3.1 System parts list

A shipment usually consists of:

• 2100LR12 receiver	(part nr: REC-2100LR12)
• Combined data/power cable	(part nr: CBL-2100-02)
• This manual	(part nr: MAN-2100-00)
• Command cable (optional)	(part nr: CBL-2100-00)
• Parasol Antenna	(part nr: ANT-SATL-00)
• Antenna Cable 1.2 m Blue	(part nr: CBL-2100-03)
• Toolkit software	(part nr: SOF-2100-00)

3.2 Installing the 2100LR12

In order to provide for a smooth and successful installation, please observe the following instructions and recommendations.

3.2.1 Installation Considerations

- Determine preferred location of each unit prior to beginning installation. Consider cable length, connector attachment space (cable bend radius), stowing excess cable, moisture, chemical corrosion, vibration and heat exposure.

- Before drilling holes, consider using existing hardware and hardware locations. Avoid drilling holes that may damage other equipment (example: structural frame members, electrical cables or fluid lines).

- High vibration and high temperature locations should be avoided whenever possible.

- In applications where vibration exceeds 6 Gs acceleration, shock mounts are required. Refer to Customer support for mounting recommendations.

- Vehicle primary power contains voltages that may be harmful to personnel and equipment. Detach battery cable connector from battery -ve (negative) terminal before attempting connection to any power terminals.

3.2.2 Electrical Grounding Requirements

The 2100LR12 requires a perfect ground to vehicle structure at the negative line in the receiver power input. The L-Band receiver should read zero Ohms to where the battery negative terminal is connected to vehicle ground.

3.2.3 Counter Electromagnetic Force (CEMF)

A potential problem inherent in any installation of electronic systems in a vehicle is Counter Electromagnetic Force (CEMF).
CEMF is caused when relays or solenoids connected to the common vehicle DC power bus are de-energised. The voltage produced may exceed -400 volts.

CEMF is produced by equipment such as the following:

- Differential correction
- Electric Fan Brakes
- Air Conditioners
- Starter relays
- Electric Pump Relays

CEMF is more than sufficient to damage, or cause erratic operation of any electronic system also connected to DC power.
CEMF can be eliminated by installing diodes at the relays and solenoids that cause the CEMF, and more importantly, at the power supply cable connection of the 2100LR12 system. A 47V, 5W, Zener diode (1N5368 or equivalent) should be connected.

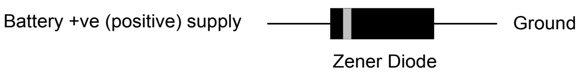


Figure 5: Zener Diode Installation

3.2.4 Cable Installation Considerations

- Cables must be correctly installed for optimum system operation. Therefore, the following should be noted:

- Do not route an L-Band receiver remote antenna cable along with the cabling of any other radio system. This can cause interference between both systems.

- If at all possible, do not run L-Band receiver antenna cables parallel to other radio system cabling closer than 30 centimetres.

- If cables must cross, ensure that they cross at an angle of 90°. This minimises the possibility of interference.

- As far as is practicable, ensure that cables and I/O connectors are unique and fit only in their allocated location.

- Avoid routing cables along-side power generator cabling and other high electrical noise sources. This can cause interference.

- Do not kink or force cables into sharp bends that may damage the cables and cause system failure.

- After installation, ensure that excess cable in looped and clamped or tied safely away from any control cables, fuel lines, hydraulic lines or moving parts.

- When stowing over length cables, form loops not less than 150mm minimum cable bend radius.

- Cable routing must avoid high temperature exposure (e.g. exhaust manifold).

3.2.5 Antenna Location

Antenna position is critical to system performance. The following conditions must be met for optimum system operation:

- 2100LR12 antenna must be mounted at least 1 to 5 metres away from transmitting antennae of any frequency. Closer positioning may cause overloading of receiver RF circuits.

- The 2100LR12 antenna should be mounted at the highest practical point that will give a good view of the horizon and be as near to level as possible.

- The 2100LR12 Receiver must be located along the vehicle centre line to ensure correct data accuracy.

- The receiver has a clear line of sight towards the L-band communication satellite. Since these satellites are located above the equator, they are to the South of Europe at an elevation angle of 20° (Oslo) to 45° (Athens).

3.2.2 Power considerations

Power can be supplied to the 2100LR12 by connecting 9.5 – 40 VDC on the fused power wire. The other power wire should be connected to ground.

Only supply power after the cable has been connected to the 2100LR12, never attach or detach a powered cable to/from the unit.

The power consumption of the 2100LR12 is 400 mA at 12 V.

In order to protect the equipment from power surges a 2 A in-line fuse has been adopted in the positive power wire. Do not run the equipment with the fuse bypassed as this will void warranty.

3.2.3 Mounting

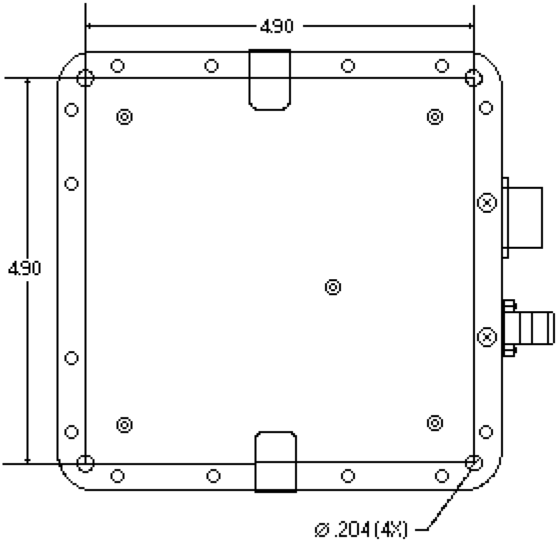


Figure 6: 2100LR12 Mounting Details

1. Determine the proper mounting location(s) for the 2100LR12 receiver.

2. Verify that cables are of sufficient length and routing meets all the conditions listed.

3. Position the 2100LR12 receiver on the desired mounting location.

4. Use the 2100LR12 receiver as a template and mark the drill locations four places for the mounting bolts, then remove the receiver.

5. Drill ¼" holes at the marked locations.

3.2.3 Connecting to external equipment

The 2100LR12 uses the RS232 protocol to communicate with external equipment.

The 2100LR12 is normally shipped for communicating with the following settings:

- 9600 bps
- 8 bits
- No parity
- 1 stop bit
- flowcontrol none

The 2100LR12 is normally configured to output the following NMEA sentences:

- GGA
- GSA
- VTG
- ZDA

Other NMEA sentences are available (see Appendix D).

The standard data cable allows the receiver to output NMEA data. A so-called command cable (part nr: CBL-2100-00) is available as an option for experienced users who need to change settings. Please contact OmniSTAR for more information.

3.3 Start up procedure

Consider the following guidelines before starting to work with the system:

- Normally the receiver software is already set to the user's specific requirements
- Make sure that the 2100LR12 has a clear line of sight to the communication satellite
- Connect the 9 pin sub-D connector to a PC (or other logging device), which has been set to communicate using 9600,8,N,1
- Connect the power cable to an appropriate power supply (9.5 to 40 VDC) which has been turned off
- Turn on the power supply

*When the unit is used for the first time, has not been used for a long period of time, or has been moved a long distance it may take up to **12.5** minutes to start outputting NMEA messages. The outputting of differentially corrected NMEA may take up to **40** minutes under these circumstances.*

3.3.1 LED INDICATORS

The 2100LR12 receiver has 4 LED's that serve as status indicators. These LED's should all be illuminated solid (non-blinking) when the receiver is powered ON and has a valid GPS and differential solution. Otherwise, the LED's can be in various states (blinking, on solid or off). The LED operations are described in the following tables.

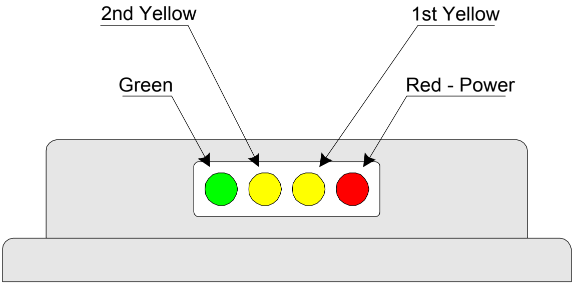


Figure 7: LED Location and Colours

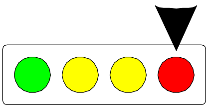
LED	Function
Red LED (Right-hand side) 	This LED should be on solid once power is applied to the receiver. This is the only LED that is not under Computer control.

Table 1: Red LED Function

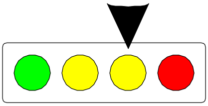
LED	Function
1st Yellow LED 	This LED serves two purposes. • At power-on it will blink 3 to 4 times, once per second, and then go off. If it fails to blink, the L-Band differential processor is likely to have failed. If it does not stop blinking the GPS processor is the likely culprit. • After a minute or so, this LED should go on solid yellow to indicate that GPS has lock. This is true even if differential corrections are not available.

Table 2: 1st Yellow LED Function

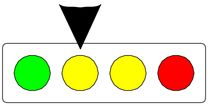
LED	Function
2nd Yellow LED 	This LED can be in several states Off – L-Band differential signal has not been received. • Flickering on and off – the receiver is close to acquiring the L-Band • Blinking at a steady rate – L-Band differential signal has been acquired, but the Bit-Error-Rate is high. Generally, this will not affect performance, but it is a warning of weak signal strength. • On 'Steady' – L-Band differential signal has been acquired and signal strength is good.

Table 3: 2nd Yellow LED Function

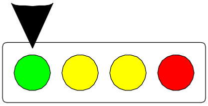
LED	Function
Green LED 	This LED will remain off until a differentially corrected GPS solution is available. It will blink at a steady rate if the solution has not converged to the accuracy specified by the $JLIMIT command and will become solid green after the solution has converged. (The $JLIMIT sets the threshold for the RMS residual error and this error gives a rough indication of expected user accuracy. Note however, that it is not a direct measure of accuracy, factors such as constellation geometry must also be taken into account. The default value for $JLIMIT is 10 meters).

Table 4: Green LED Function

Other Conditions: If at start-up, the two yellow and one green LED's blink in sequence 3 times, then the subscription on the receiver has expired.

3.4 Subscription (re) activation

If the OmniSTAR subscription on your 2100LR12 has not been activated yet, will expire soon or has been expired already, a new subscription can be sent over the satellite link.

The procedure for obtaining a new subscription is:

- Fill in the *OmniSTAR subscription agreement* form (see Appendix F)
- Fax the form to OmniSTAR BV at +31-70-3170919
- At the agreed time of activation make sure your receiver is outside and in a place where it will be able to receive signals from the communication satellite
- Have the receiver switched on at the time of activation

At the time of activation a series of commands containing the new expiry date and other subscription information will be sent over the satellite link to your 2100LR12 receiver.

If your receiver does not start outputting differential position data within 45 minutes after the activation time, please contact OmniSTAR by phone at +31-70-3170900.

4. Connections

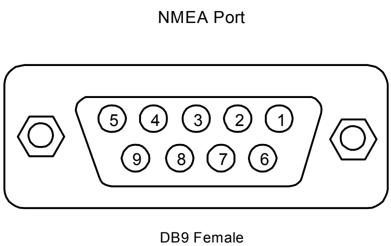
4.1 Electrical Interface Description

The RF connector is a standard TNC 50 Ohm female connector. There are 5V DC present when the unit is powered up to bias the Low Noise Amplifier (LNA) in the remote antenna. Care should be taken not to connect or disconnect while powered up.

The I/O connector is a standard metal eight-pin circular Bendix style connector PT02E-12-8P. The pin-out is defined in Table 5.

Pin No.	Name	Description
A	+ Vin	9.5 to 40V DC, 5W, power input (12V DC, 0.417A)
B	1 PPS	One pulse per second, 1µs width, rising edge aligned, TTL levels
C	Aux. Tx	Auxiliary communication port, transmit line, RS232 levels (**NMEA**)
D	Aux. Rx	Auxiliary communication port, receive line, RS232 levels (**NMEA**)
E	Diag. Tx	Primary communications port, transmit line, RS232 levels. (**Command**)
F	Diag. Rx	Primary communications port, receive (input) line, RS232 levels (**Command**)
G	Mark in	Manual Mark input line, TTL levels, falling edge triggered.
H	Ground	Digital, power and analogue ground

Table 5: Pin-out for I/O Connector



Pin#	Signal
1	N/A
2	DATA OUT*
3	N/A
4	N/A
5	GND
6	N/A
7	N/A
8	N/A
9	N/A

Figure 8: 9 pin sub-D connector on data cable

4.2 Cables

The 2100LR12 is normally shipped with a combined data/power cable and an antenna cable. For experienced users who need to change settings a command cable is available.

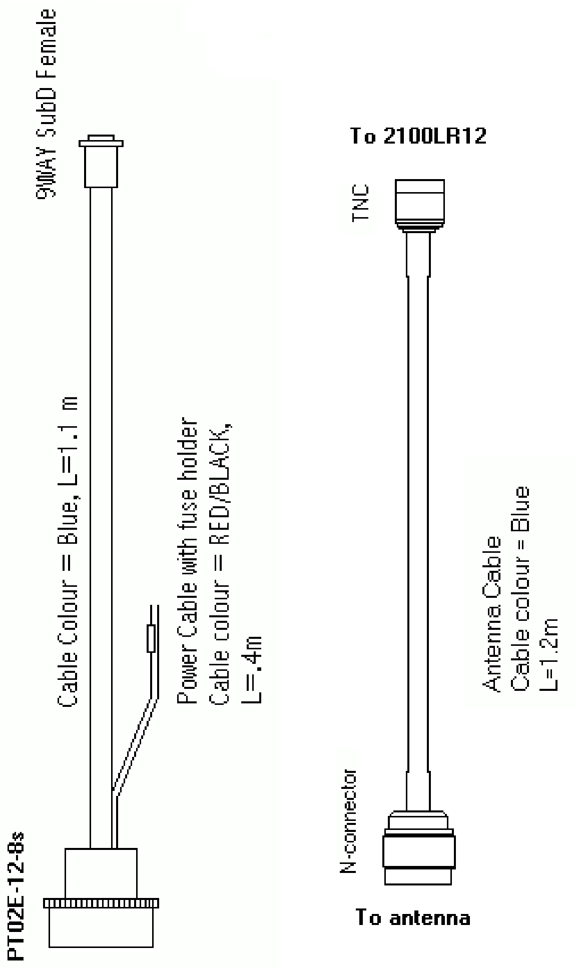


Figure 9: User and Antenna Cable

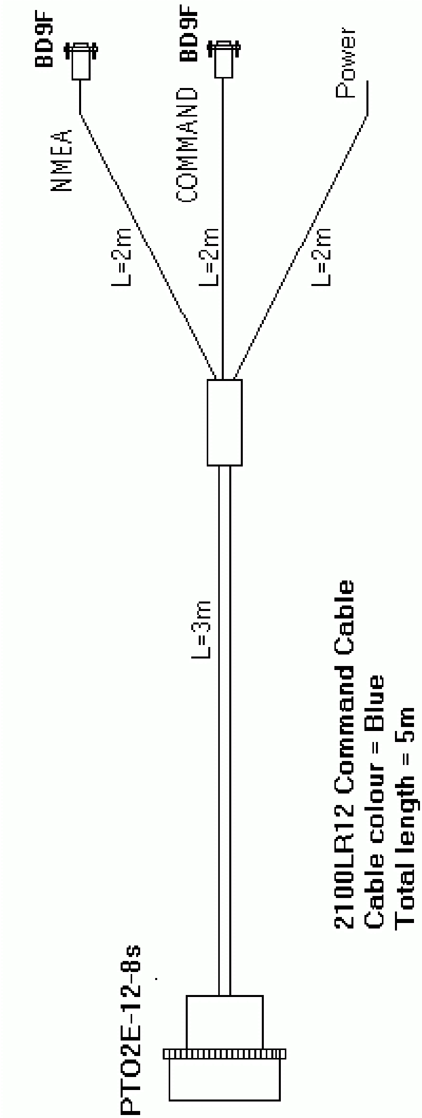


Figure 10: 2100LR12 Command cable

5. Troubleshooting

Use to following diagram to identify and solve problems in the event that the 2100LR12 does not output a differentially corrected position.

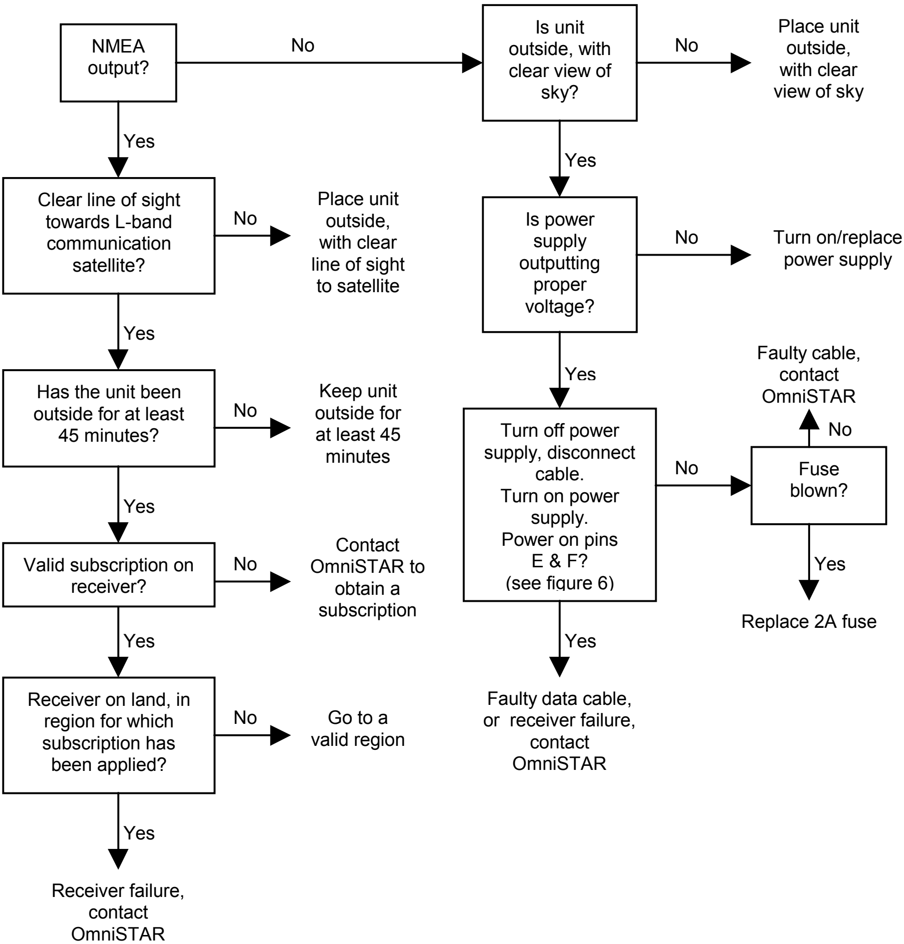


Figure 11: Troubleshooting

5.1 Contacting OmniSTAR

If you encounter a technical problem during installation or system operation, please contact OmniSTAR at +31-70-3170900.

Appendix A, Receiver Commands

Note The word(s) contained in brackets [ ] in the 'Command' column in the following pages indicate(s) an optional addition to the particular command line. They may be omitted or added (without the brackets) however the user sees fit.

Note Configuration changes are not saved between power cycles unless the $JSAVE command is issued.
The $JFREQ and the $4STRING commands are exceptions. They are automatically saved after issuing.

Command	Description and Allowed Values	Example	Reply
$JBIN,msg,r[,OTHER]	Turn On/Off binary message. R = 0, 0.2, 1 or 5Hz (0 turns message off). Msg = 1, 2, 97, 98 or 99 (more may be added. Msg 97, 98 and 99 only support 1Hz). Use the keyword 'OTHER' to configure to the other port).	Turn on 99 at 1Hz. $JBIN, 99, 1.	$>Binary message 99 will begin outputting every second. (See 'Appendix - Binary Message Type 99' for further details).

Table 6: 2100LR12 L-Band Receiver Commands

Command	Description and Allowed Values	Example	Reply
$JASC, GP[GGA, GLL, VTG, GSV, RMC, GSA, ZDA,GST], r, [OTHER]	Turn On/Off NMEA msg x at rate r. R = 0, 0.2, 1 or 5Hz (0 turns message off). Options supported are: $JASC, GPGGA, r $JASC, GPGLL, r $JASC, GPVTG, r $JASC, GPGSV, r * $JASC, GPRMC, r $JASC, GPGSA, r * $JASC, GPZDA, r $JASC, GPGST, r ** Options with * only available at 0.2Hz or 1Hz. Optional with ** only available at 1Hz. (Use the keyword ‘OTHER’ to configure to the other port).	Turn on GGA. $JASC, GPGGA, 1	$> NMEA string GGA will begin outputting every second.

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$J4STRING[,r][,OTHER]	Configure port to output NMEA strings: GPGGA, GPVTG, GPGSA, and GPZDA. The output rate of each string is 1Hz and all other strings on the port are turned off. Makes the change permanent (i.e. saves configuration). r = 4800, 9600 (if r is omitted, the rate defaults to 4800). (Use the keyword 'OTHER' to configure to the other port).	Configure other port to output 4 Strings of NMEA at 4800 baud. $J4STRING, OTHER	$> $> NMEA strings GGA, VTG, GSA and ZDA, will begin outputting at 4800 BAUD every second from the other port.

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JASC,RTCM,r[,OTHER]	Turn On/Off RTCM msg r. r = 0, 0.2 or 1 (0 turns message off). (Use the keyword 'OTHER' to configure to the other port).	Turn on RTCM. $JASC,RTCM,1	$> RTCM message will begin outputting.
$JASC,Dx,r[,OTHER]	Turn on/off Diagnostics message x. r = 0 or 1 Hz. x = 1 (more may be added). (Use the keyword 'OTHER' to configure to the other port).	Turn on diag I. $JASC,DI,1	$> Diagnostic message 1 will begin outputting every second (see Format for reply to $JASC, D1,1 command).

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JASC,MSG,r[,OTHER]	Configure to turn On/Off general text messages (these begin with $RMSG). r = 0 for Off r = I for On (Use the keyword 'OTHER' to configure to the other port).	Turn text messages on. $JASC,MSG, 1	$> Text Messages will begin outputting for any direct text messages being broadcast over the network.

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JAIR,m	Turn on air mode so that receiver responds better to higher dynamics and signal fades. m = 0 turn off air mode m = I turn on air mode Note, this comes on automatically once the speed exceeds 30m/s, unless it has been deliberately turned off.	Turn on air-mode. $JAIR, 1	$>Air Mode: ON

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JCMODE,m,[OTHER]	Configure port to accept RTCM. m = 0 port accepts normal commands. m = I port accepts RTCM and will ignore other commands.	Configure other port to accept RTCM. $JCMODE,1,0THER	$>
$JOFF[,OTHER]	Turn off all messages except the $JASC,MSG (those beginning with $RMSG) (Use the keyword 'OTHER' to configure to the other port).	Shut off all messages that are output to other port. $JOFF,OTHER	$>
$JSAVE	Save the current configuration (make permanent).	Save setting changes. $JSAVE	$> Saving Configuration. Please Wait $> Save Complete

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JSHOW	Show the current configuration.	Show status of port and receiver configurations $JSHOW	$>JSHOW,data (see Format for reply to $JSHOW command)
$JBAUD,r	Configure the baud rate. r = 4800, 9600 and 19200 (Use the keyword 'OTHER' to configure to the other port).	Configure other port at 4800 baud. $JBAUD,4800,OTHER	$>

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JALT,c,v	Configure altitude aiding. c = NEVER, ALWAYS,SOMETIMES If c = ALWAYS, v = altitude in meters. If c = SOMETIMES, v =PDOP threshold. Default = NEVER. If c = NEVER, v is ignored.	Use altitude aiding at PDOP=4.0 $JALT,SOMETIMES,4.0	$> (Uses Altitude aiding if PDOP>4.0)

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JLIMIT,v	Set residual threshold for Green LED. 'v' ranges from 1.0 to 50.0 meters. You must have differential and the rms pseudo-range residual less than v before the green LED becomes solid (non-blinking). Default = 10.0.	Set green LED threshold to 2 meters. $JLIMIT,2.0	$>
$JMASK, e	Configure elevation mask e = 0, 1, 2, ... 60 degrees. Default = 0.0	Use 5-degree mask. $JMASK,5	$>

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JRESET[,ALL]	Reset configuration to default and makes this permanent. Equivalent to SLIMIT, 10 $JMASK,5 $JALT,NEVER,0 $JOFF $JAIR,0 $JFREQ,0 and $JOFF,OTHER, followed by a $JSAVE. If ALL is included, also resets ALMANAC and clears spot beams to defaults.	Clear only the user configuration. $JRESET	$> Saving Configuration. Please Wait $> Save Complete
$JI	Display receiver unit number, fleet, hardware version, production date code, subscription begin date, subscription expiration date, ARM and DSP software version	Show Receiver information $JI	$>JI, 810 123, 1,3,2502 1 998,01/06/1980,06/30/1 999,2.4,20

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JT	Display receiver type (e.g. 2100LR12).	Show receiver type $JT	$>JT,SLXg
$JK	Display subscription expiration date.	Show current expiration. $JK	$>JK,12/31/1999
$JPOS,Lat,Lon	Set your current location to be used at start-up until a new location is found. Good for first-time start-ups in new spot beam.	$JPOS,33.11,-111.25	$>
$JLBEAM	Display current spot beams.	Show spot beam information. $JLBEAM	$>JLBEAM, Information (see Format for reply to $JLBEAM command).

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JFREQ,Frequency in KHz,Symbol Rate	Force differential frequency and symbol rate to these values and stop using spot beam tables. A frequency value of 0 will re-enable use of spot beam tables.	$JFREQ,1551489,1200	$>
$JDCO,v	Set the frequency offset of the TCXO (at L1) stored in the ARM. Here, v is a double in Hz. It is only used if the ARM does not have a nav solution.	Zero the TCXO value $JDCO,0.0.	$> Message if GPS is already acquired: $>GPS Already has lock.

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JOMS	Display OmniSTAR Subscription Information. $>JOMS,Opt,Source,Type,AccrReductionStartDate,EndDate,HourGlass,ExtentionTime, LinkVector,Software Version.	Show raw subscription information: $JOMS	$>JOMS,DRY,ALL,VBS,0,01/06/1980,06/30/1999,0,0, 1E00, 1.19 (see Format for reply to $JOMS command).

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Command	Description and Allowed Values	Example	Reply
$JOMR	Display Subscription Region Information. This command will respond with a set of Lat and Lon in radians and a radius distance in meters. The receiver will work in the radius of a specified area if an inclusion zone is given (positive radius value) and will not work within the radius of the specified area if an exclusion zone is given (negative radius value).	Show subscription region information. $JOMR	$>JOMR, 1,0.994787, -1.605694,4500000.000 $>JOMR,2,0.000000,0.000000,0.000000 $>JOMR,3,0.000000,0.000000,0.000000 $>JOMR,4,0.000000,0.000000,0.000000 $>JOMR,5,0.000000,0.000000,0.000000 (see Format for reply to $JOMR command).

Table 6: 2100LR12 L-Band Receiver Commands (contd.)

Appendix B - Specifications

Table 7: 2100LR12 specifications

OmniSTAR Engine	
Frequency Range	1525 – 1559 MHz

GPS Engine	
Frequency	1575.42 MHz
Channels	12 parallel tracking

Serial Interface	
Serial Protocol	RS232
Connector (receiver end)	Mil Spec Bulk Head, PT02E-12-8p
Connector (user end)	9 pin sub-D
Baud rate	4800, 9600, 19200 default = 9600,8,N,1
Data output	NMEA (RTCM optional)
Data rate	1 Hz, 5Hz

Power Specifications	
Power supply	9.5 – 40 VDC
Power consumption	400 mA at 12 V

Environmental Specifications	
Operating Temperature	-34°C to 72°C
Storage Temperature	-50°C to 85°C
Humidity	100% condensing
Vibration	10mm Displacement, 10 – 17 Hz 6 Gs to 2000 Hz, Operating
Shock	MIL-STD-202F, Methode 213, Procedure J
Dust	MIL-STD-810E, Method 510.3, Procedure I MIL-STD-202F, Method 101
Salt Fog	Condition II (5% Solution for 48 hours)
Acceleration	4G

Physical Characteristics	
Weight	750 gram
Dimensions	l x w x h 140 x 140 x 40
Finish	White epoxy (corrosion resistant)

Approvals
CE Marking

Appendix C – List of communication satellites

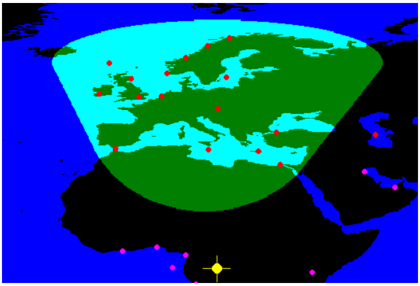
List of communication satellites

The following table presents a list of L-band communication satellites, which will enable you to use your 3100LM over the entire world (depending on your subscription type you might only be entitled to a restricted area).

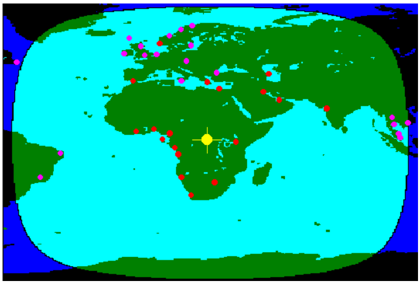
Table 8: Worldwide satellite frequencies and symbol rates

Satellite Channel	Frequency (MHz)	Symbol Rate
Eik EMS	1531.2300	2438
EA-SAT	1535.1525	2438
AP-SAT	1535.1375	2438
AM-SAT	1535.1375	2438
OPTUS	1558.5100	2436
AMSC East	1556.8250	2436
AMSC Centre	1554.4970	2436
AMSC West	1551.4890	2436

The position (marker) and coverage-area of each satellite are displayed in the following figures. The AMSC satellite coverage-area's are in one figure.

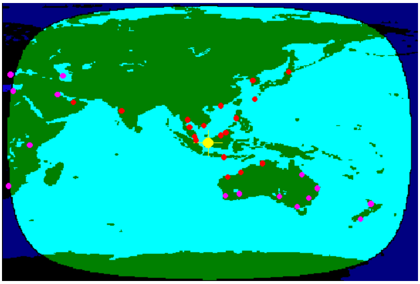


Eik EMS

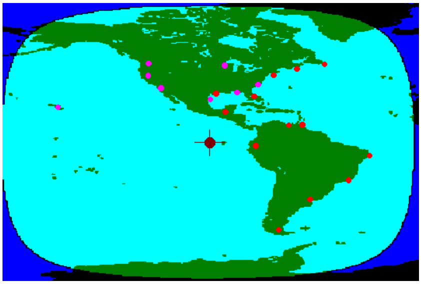


EA-SAT

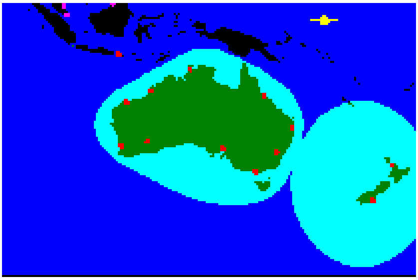
Figure 12: Location and coverage area per satellite



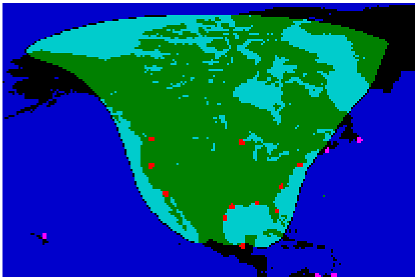
AP-SAT



AM-SAT



OPTUS



AMSC

Figure 13: Location and coverage area per satellite

Appendix D – List of reference stations

The following tables present the current list of reference stations, which are broadcast over communication satellites used by OmniSTAR. The list of reference stations change regularly to improve the network.

Table 9: Reference stations on EMS

Nr	Station	ID	Data
1	Tromso, Norway	690	YES
2	Orlandet, Norway	630	YES
3	Torshavn, Faroes	620	YES
4	Rogaland, Norway	580	YES
5	Aberdeen, Scotland	571	YES
6	Shannon, Ireland	530	YES
7	Leidschendam, The Netherlands	521	YES
8	Toulouse, France	431	YES
9	Vienna, Austria	480	YES
10	Istanbul, Turkey	410	YES
11	Baku, Azerbaijan	400	YES
12	Faro, Portugal	371	YES
13	Malta	351	YES
14	Crete, Greece	340	YES
15	Alexandria, Egypt	310	YES
16	Bodo, Norway	122	YES
17	Visby, Sweden	229	YES
	Ny Alesund, Spitsbergen	101	NO
	Vardo, Norway	114	NO
	Trondheim, Norway	126	NO

Table 10: Reference stations on EA-SAT

Nr	Station	ID	Data
1	Cape Town, South Africa	335	YES
2	Johannesburg, South Africa	262	YES
3	Walvis Bay, Namibia	235	YES
4	Luanda, Angola	095	YES
5	Pointe-Noire, Congo	045	YES
6	Nairobi, Kenia	015	YES
7	Sao Tome	011	YES
8	Douala, Cameroon	043	YES
9	Abidjan, Ivory Coast	050	YES
10	Lagos, Nigeria	060	YES
11	Blantyre, Malawi	155	YES
13	Abu Dhabi, UAE	016	YES
14	Kuwait	290	YES
15	Alexandria, Egypt	310	YES
16	Crete, Greece	340	YES
17	Las Palmas, Canaries	280	YES
18	Orlandet, Norway	630	YES
19	Rogaland, Norway	580	YES
22	Faro, Portugal	371	YES
23	Baku, Azerbaijan	400	YES
24	Durban, South Africa	305	YES
	Rio de Janeiro, Brazil	226	NO
	Rio de Janeiro, Brazil	225	NO
	Mumbai-Arvi, India	191	NO

Table 11: Reference stations on AP-Sat

Nr	Station	ID	Data
2	Karratha, Australia	215	YES
3	Darwin, Australia	125	YES
4	Broome, Australia	185	YES
9	Okinawa, Japan	261	YES
10	Singapore	010	yes
11	Miri, Malaysia	042	YES
12	Vung Tua, Vietnam	012	YES
13	Hong Kong	220	YES
14	Seoul, S. Korea	370	YES
15	Kota Kinabalu, Malaysia	061	YES
16	Bali, Indonesia	096	YES
17	Mumbai-Arvi, India	191	YES
19	Subic Bay, Phillipines	151	YES
20	Kuwait	290	YES
21	Abu Dhabi, UAE	016	YES
23	Kuantan, Malaysia	041	YES
24	Satun, Thailand	018	YES
25	Bangkok, Thailand	141	YES
27	Sapporo, Japan	430	YES

Table 12: Reference stations on AM-Sat

Nr	Station	ID	Data
1	Houston, Texas	100	YES
2	Cocoa Beach, Florida	120	YES
3	Long Island, New York	333	YES
4	Carmen, Mexico	110	YES
5	Punta Arenas, Chile	210	YES
6	Guayaquil, Ecuador	202	YES
7	Rio de Janeiro, Brazil	225	YES
8	St. Johns, Newfoundland	470	YES
9	Dartmouth, Nova Scotia	440	YES
10	Recife, Brazil	075	YES
11	Port Of Spain, Trinidad	111	YES
12	Caracas, Venezuela	112	YES
13	Buenos Aires	345	YES

Table 13: Reference stations on Optus

Nr	Station	ID	Data
1	Perth, Australia	325	YES
2	Karratha, Australia	215	YES
3	Darwin, Australia	125	YES
4	Townsville, Australia	195	YES
5	Brisbane, Australia	275	YES
6	Melbourne, Australia	385	YES
7	Pt Augusta, Australia	326	YES
8	Kalgoorlie, Australia	315	YES
9	Cobar, Australia	316	YES
16	Bali, Indonesia	096	YES
18	Bathurst, Australia	336	YES
22	Auckland. NZ	022	YES
26	Dunedin, NZ	026	YES
31	Broome, Australia	185	YES

Table 14: Reference stations on AMSC

Nr	Station	ID	Data
1	San Diego, Ca, USA	140	YES
2	Everrett, Wa, USA	555	YES
3	Mercedes, Tx, USA	160	YES
4	Houston, Tx, USA	100	YES
5	Pensacola, Fl, USA	150	YES
6	Cocoa Beach, FL, USA	120	YES
7	Fayetteville, NC, USA	130	YES
8	Long Island, NY, USA	333	YES
9	Duluth, Mn, USA	491	YES
10	Redding, Ca, USA	180	YES
11	Carmen, Mexico	110	YES

Appendix E - NMEA 0183

E.1 NMEA introduction

NMEA 0183 is an interface protocol created by the National Marine Electronics Association. The latest release of NMEA 0183 is Version 2.2. This protocol was originally established to allow marine navigation equipment to share information. NMEA 0183 is a simple, yet comprehensive ASCII protocol, which defines both the communication interface and the data format.

E.2 NMEA 0183 message options

The OmniSTAR 2100LR12 is normally configured to output the GGA, GSA and VTG NMEA 0183 sentences (GGA, GSA, RMC for John Deere customers). Sentences can be added or removed at the customer's request. The output rate is normally configured at a 1-second interval.

Table 15: NMEA 0183 message options

Message Sentence	Description
GGA	GPS Fix Data
GLL	Geographic Position – Latitude/Longitude
GSA	GPS DOP and Active Satellites
GSV	Satellite Information
RMC	Recommended Minimum Configuration
GST	GPS pseudorange noise statistics
VTG	Track Made Good and Ground Speed
ZDA	Time and Date

E.3 NMEA 0183 message format

NMEA 0183 allows a single source (talker) to transmit serial data over a single twisted wire pair to one or more receivers (listeners). The NMEA 0183 protocol covers a broad array of navigational data. This is separated into discrete messages, which convey a specific set of information. The NMEA 0183 message structure is outlined below.

$IDMSG,D1,D2,D3,D4,……..,Dn*CS[CR][LF]

"$"	The "$" signifies the start of message.
ID	The Talker identification is a two letter mnemonic which describes the source of the navigation information. The GP identification signifies a GPS source.
MSG	The message identification is a three letter mnemonic which describes the message content and the number and order of the data fields.
","	Commas serve as deliminators for the data fields.
Dn	Each message contains multiple data fields (Dn) which are delimited by commas.
"*"	The asterisk serves as a checksum delimiter.
CS	The checksum field contains two ASCII characters which indicate the hexadecimal value of the checksum.
[CR][LF]	The carriage return [CR] and line feed [LF] combination terminate the message.

NMEA messages vary in length, but each message is limited to 79 characters or less. This length limitation excludes the "$" and the [CR] [LF]. The data field block, including delimiters, is limited to 74 characters or less.

E.4 NMEA 0183 sentences

In this section each message is described in more detail.

E.4.1 GGA – GPS Fix Data

The GGA message includes time, position and fix related data for the GPS receiver.

GGA,hhmmss.ss,ddmm.mmmmm,s,dddmm.mmmmm,s,q,n,uu,pp.p,±aaaaa.aa,M,
±xxxx.xx,M,sss,aaaa

Table 16: Description of the GGA message

Field Number	Description
1	UTC of Position
2,3	Latitude in degrees (d) and minutes(m), N (North) or S (South).
4,5	Longitude in degrees (d) and minutes(m), E(East) or W (West).
6	GPS Quality Indicator: 0=No GPS, 1=GPS, 2=DGPS.
7	Number of Satellites in Use.
8	Horizontal Dilution of Precision (HDOP).
9,10	Antenna Altitude in Meters, M = Meters.
11,12	Geodial Separation in Meters, M = Meters. *
13	Age of Differential GPS Data. **
14	Differential Reference Station ID (0000 – 1023)

NOTES:
* Geodial Separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level (MSL), or when expressed in a formula:

$$\mathbf{Height_{MSL} = Height_{Ellipsoid} - Height_{Geoid}}$$

** Time in seconds since the last RTCM SC-104 message type 1 or type 3 update.

E.4.2 GLL – Geographic Position – Latitude/Longitude

The GLL message contains the latitude and longitude of the present position, the time of the position fix and the status.

GLL,ddmm.mmmmm,s,dddmm.mmmmm,s,hhmmss.ss,A

Table 17: Description of the GLL message

Field Number	Description
1,2	Latitude in degrees (d) and minutes(m), N (North) or S (South).
3,4	Longitude in degrees (d) and minutes(m), E (East) or W (West).
5	UTC of Position.
6	Status: A = Valid, V = Invalid.

E.4.3 GSA – GPS DOP and Active Satellites

The GSA message indicates the GPS receivers operating mode and lists the satellites used for navigation and the DOP values of the position solution.

GSA,a,m,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,pp.p,hh.h,vv.v

Table 18: Description of the GSA message

Field Number	Description
1	Mode: M = Manual, A = Automatic.
2	Current Mode 1 = Fix not available, 2 = 2D fix, 3 = 3D fix.
3 to 14	PRN numbers of the satellites used in the position solution. *
15	Position Dilution of Precision (PDOP).
16	Horizontal Dilution of Precision (HDOP).
17	Vertical Dilution of Precision (VDOP)

NOTES:
* When less than 12 satellites are used, the unused fields are null.

E.4.4 GSV – Satellite Information

The GSV message contains GPS satellite information. Null fields occur where no data is available due to the number of tracked satellites.

GSV,t,m,n,ii,ee,aaa,ss,…,ii,ee,aaa,ss

Table 19: Description of the GSV message

Field Number	Description
1	Total number of messages
2	Message number (1-3)
3	Total number of satellites in view
4,8,..	Satellite number
5,9,..	Elevation in degrees (0-90)
6,10,..	Azimuth (true) in degrees (0-359)
7,11,..	SNR (0-99 dB)

E.4.5 RMC – Recommended Minimum Configuration

The RMC message contains the recommended minimum GPS data.

RMC,hhmmss.ss,a,ddmm.mm,n,ddddmm.mmm,w,z.z,y.y,ddmmyy,d.d,v

Table 20: Description of the RMC message

Field Number	Description
1	UTC of position
2	Status (A = valid, V = invalid)
3,4	Latitude in degrees (d) and minutes(m), N (North) or S (South).
5,6	Longitude in degrees (d) and minutes(m), E (East) or W (West).
7	Ground speed in knots
8	Track made good, referenced to true north
9	UTC date of position fix in day, month, year
10	Magnetic variation in degrees
11	Variation sense (East/West)

E.4.6 VTG – Track Made Good and Ground Speed

The VTG message conveys the actual track made good (COG) and the speed relative to the ground (SOG).

VTG,ttt.tt,T,ttt.tt,M,ggg.gg,N,ggg.gg,K

Table 21: Description of the VTG message

Field Number	Description
1,2	Track Made Good in Degrees True.
3,4	Track Made Good in Degrees Magnetic.
5,6	Speed Over the Ground in Knots.
7,8	Speed Over the Ground in Kilometer's per Hour.

E.4.7 ZDA – Time and Date

The ZDA message contains UTC, the day, the month and the year of the local time zone.

ZDA,hhmmss.ss,dd,mm,yyyy,shh,mm

Table 22: Description of the ZDA message

Field Number	Description
1	UTC.
2	Day (0 – 31).
3	Month (0 – 12).
4	Year.
5	Local Zone Description Hours (± 13 Hours). *
6	Local Zone Description Minutes.

NOTES:
* Local zone description is the number of whole hours added to local time to obtain UTC. The zone description is always negative for eastern longitudes. A GPS receiver cannot independently identify the local time zone offsets.

E.4.8 GST – GPS pseudorange noise statistics

This message is used to support receiver autonomous integrety monitoring (RAOM). Pseudorange measurement noise statistics can be translated in the position domain in order to give statistical measures of the quality of the position solution.

GGA,hhmmss.x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x*hh

Table 23: Description of the GST message

Field Number	Description
1	UTC time of the GGA fix associated with this sentence
2	RMS value of the standard deviation of the range inputs to the navigation process. Range inputs include pseudoranges and DGPS corrections
3	Standard deviation of semi-major axis of error ellipse, meters
4	Standard deviation of semi-minor axis of error ellipse, meters
5	Orientation of semi-major axis of error ellipse (degrees from true north)
6	Standard deviation of latitude error, meters
7	Standard deviation of longitude error, meters
8	Standard deviation of altitude error, meters

Appendix F – OmniSTAR subscription agreement form

The next page contains the form which is necessary to apply for a new OmniSTAR subscription for your 2100LR12 receiver.