Users guide
ECS 1/2/3
COMPASS / GPS Sensor

ECS1/2/3 REV.1.2 10-05-2004
For latest update: www.elproma.com/compass

Contents

1 Introduction

This manual contains information about the operation, calibration and installation of the Electronic Compass Sensor ‘ECS1’, the ‘ECS2’ and the ‘ECS3’.

ECS1 : Solid State Electronic Compass
ECS2 : GPS receiver
ECS3 : Combined Solid State Electronic Compass and GPS receiver.
This manual is for all three types of sensor, all chapters indicate the relevant units.

In this manual we also refer to a display unit called ECI1 or ECI2. These units have been developed especially to show the measured heading and other information the ECS1/2/3 provides. They also support the special calibration commands which the compass needs to calibrate manually after mounting.

1.1 ECS1

- NMEA0183 : The “HDT” message is sent 10 times per second, and the “HDG” message is sent 2 times per second
- Bluetooth : same as NMEA0183
- NMEA2000 : The update rate is 10 times per second

1.2 ECS2

- NMEA0183 : The “$GPGGA” + “$GPGSA” + “$GPGSV” + “$GPRMC” messages are sent 1 time per second
- Bluetooth : same as NMEA0183
- NMEA2000 : The update rate is 10 times per second

1.3 ECS3

- NMEA0183 : The “HDG” message and “$GPGGA” (not at 4800 baud) + “$GPGSA” + “$GPRMC” + “$GPGSV” messages are sent 1 time per second.
- Bluetooth : same as NMEA0183
- NMEA2000 : The update rate is 10 times per second, inclusive basic GPS info

2 Installation

2.1 Choosing a location

2.1.1 ECS1 and ECS3 (Magnetic compass)

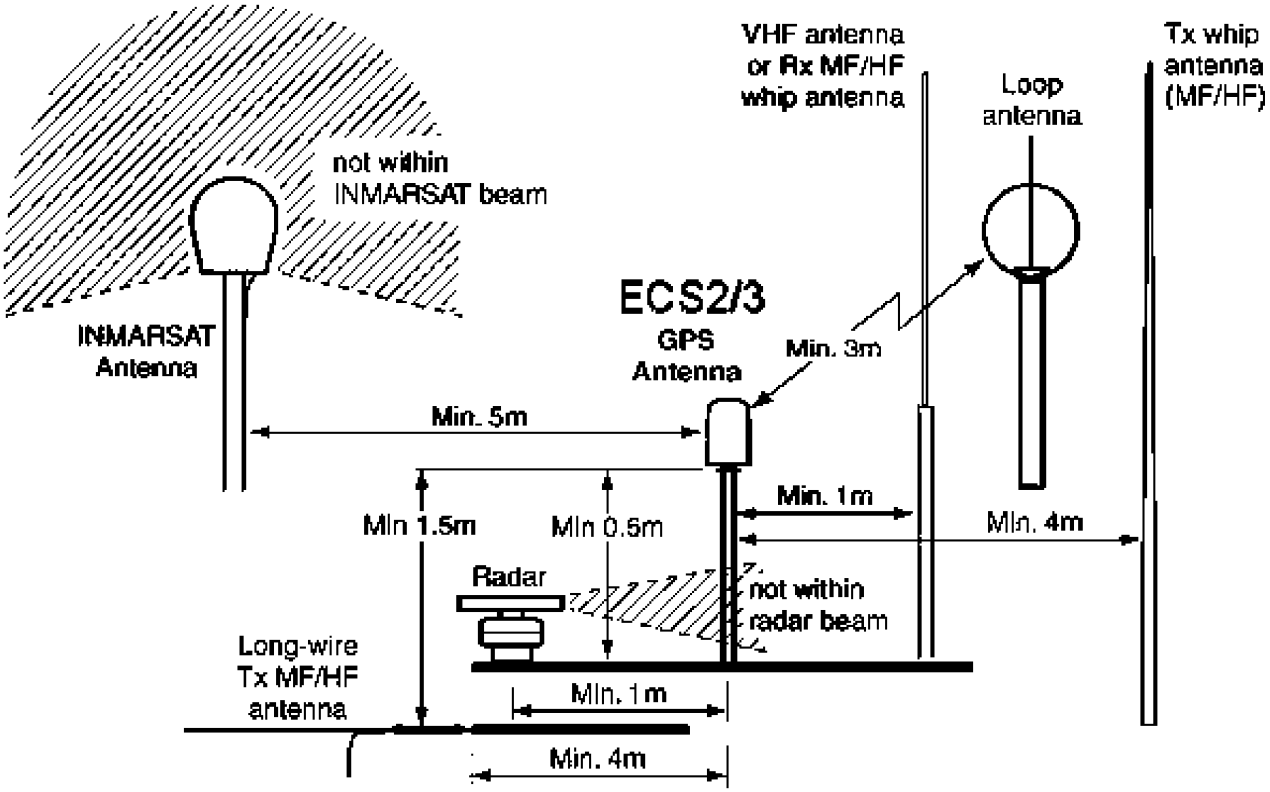
Each compass is calibrated in the factory so the more careful you choose the location for the Compass sensor the better the result will be.
It is very important that the sensor is mounted away from any material that is likely to cause magnetic interference.

- A safe distance from external magnetic interference: 3m/10ft from VHF, RDF, loudspeakers, depth sounders, engines, or power cables carrying heavy current.
- 3m/10ft from Radar and SSB equipment.
- Externally mounted on steel vessels.
- Well protected from physical damage.
- Optimum positioning: As low as possible to minimise effect of pitching and rolling of boat.
- Do not mount the compass near magnets (card compass)

Should there be any doubt about the suitability of mounting the sensor due to magnetic interferance, a hand compass may be used to determine any magnetic deviation at the proposed mounting place.

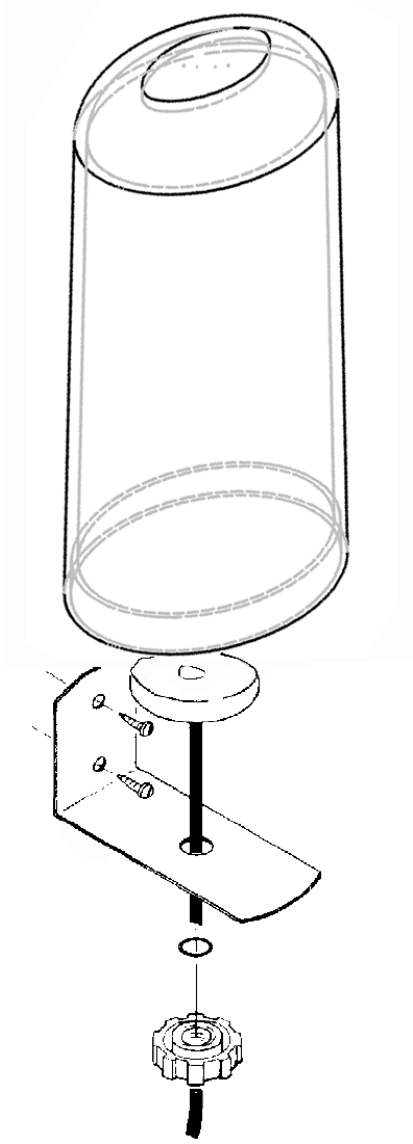
2.1.2 ECS2 and ECS3 (GPS receiver)

The GPS antenna is located in the top of the ECS2/3. Please make sure that the antenna always has an onobstructed view of the sky.

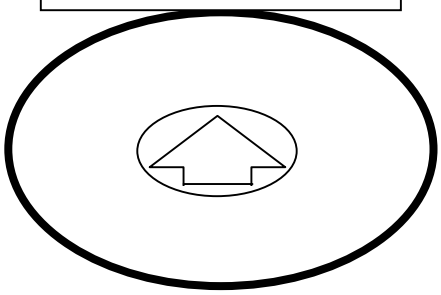


2.2 Mounting

In the package a RVS metal bracket is provided to install the compass.
Loosen the kurled knob and lift the unit, the stem with the cable will slide through the hole of the bracket. Mount the bracket at the desired location. Use only non-magnetic fasteners to secure the bracket.
The arrow on top of the ECS should point to the bow of the vessel.



ECS1/2/3 Top view
Showing arrow



3 Calibration of ECS1 or ECS3

Magnetic deviation, caused by the vessel itself, results in incorrect compass readings. This magnetic deviation can be corrected by means of the calibration procedure.

3.1 Automatic calibration

The ECS compass has an automatic calibration procedure. Default “Auto Calibration” is “ON”. The compass will calibrate itself everytime two full circles have been made within 1 to max. 4 minutes per circle.
If you have an ECI1 or ECI2 display you can switch this function OFF and use the manual calibration command.

3.2 Manual calibration for ECI1/2 owners

If you own an ECI1 or ECI2 display then you can do the following to start calibration:

To calibrate the ECS1/3 compass you need a calm day and a clear area. Start turning your boat in a large circle at a slow speed. Then select calibrate in the menu and press up and down buttons together for two seconds. Now the display shows the heading and ‘In process’. The time to complete the circle (full 360°) should be at least 1 up to max. 4 minutes. When the calibration was successfull the display shows “Done” and a short beep will be heard. Circles may be clockwise or counterclockwise. If the circle was not in between the time limits, the old calibration is restored and you can see on the display if the circle was too fast or too slow.

Example: -Start turning the boat in a large circle
-goto menu Calibration -> Calibration
-press up and down together for 2 seconds -> In process
-now continue the circle and wait for the ECI1/2 to beep.
The ECI1/2 compass display now shows if the calibration was done or not.

3.3 NMEA calibration commands

The ECS1 and ECS2 units have a few commands to start and to check the calibration. The ECS1 and ECS2 use a baudrate of 4800 baud, no parity, 1 stopbit.
The procedure is :

- Start turning the boat in a large circle The time to complete the circle (full 360°) should be at least 1 up to max. 4 minutes.
- Send the message “Start Calibration” to the ECS
  The ECS sends one “BUSY”message back
  The ECS send “HDG” messages while turning (Unfiltered heading)
- Now continue the circle and wait for the “Done”, “Fast” , “Slow” or “Stop” message.
- If the last received message is “Fast” , “Slow” or “Stop”, the procedure must be repeated, no values have been saved and the old calibration values are restored.

See chapter 4 for all NMEA commands.

4 NMEA0183 commands

4.1 NMEA0183 command structure

The ECS uses standard NMEA0183 messages but also some special commands and messages. The messages are updated one (ECS2,3 “HDG”) or ten (ECS1 “HDT”,”HDG”) times per second. The default used serial setting is 4800 baud, no parity, 1 stopbit.

Compass NMEA message format:
$HCHDG,X.X,Y.Y,v,Z.Z,Q*CC<13><10>

$HCHDT,X.X,T*CC<13><10>

X.X = compass heading.
Y.Y,v = not used
Z.Z = variation
Q = variation available (a) or invalid (v)
T = True heading
CC = Checksum field
<13> = carriage return, <10> = line feed
Checksum = The checksum is the last field in a message and follows the checksum delimiter character “*”. The checksum is the 8-bit exclusive OR (no start or stop bits) of all characters in the message, including “,” delimiters, between but not including the “$” and the “*” delimiters.

GPS NMEA messages:
The general NMEA format consists of an ASCII string commencing with a ‘$’ character and terminating with a <CR><LF> sequence.
NMEA standard messages commence with ‘GP’ then a 3-letter message identifier. The message header is followed by a comma delimited list of fields optionally terminated with a checksum consisting of an asterix ‘*’ and a 2 digit hex value representing the checksum. There is no comma preceding the checksum field. When present, the checksum is calculated as a bytewise exclusive of the characters between the ‘$’ and ‘*’. As an ASCII representation, the number of digits in each number will vary depending on the number and precision, hence the record length will vary. Certain fields may be omitted if they are not used, in which case the field position is reserved using commas to ensure correct interpretation of subsequent fields.

4.2 Compass commands

4.2.1 Start calibration command

$IIELP,CAL,ECS,STRT*CC<13><10> // Start calibration command
Start calibrating, be sure that the vessel is already turning before sending this command.

4.2.2 Stop calibration command

$IIELP,CAL,ECS,STOP*CC<13><10> // Stop calibration command
If for some reason you want to stop calibrating, send this message.

4.2.3 Auto calibration ON command

$IIELP,CAL,ECS,AUTO*CC<13><10> // Auto calibration command
The compass now will calibrate itself everytime two full circles have been made within 1 to max. 4 minutes per circle.

4.2.4 Auto calibration OFF command

$IIELP,CAL,ECS,MANU*CC<13><10> // Stop auto calibration command
Autocalibration Off.

4.2.5 Variation command

$IIELP,CAL,ECS,VARI*CC<13><10> // Variation, CC= -45.0 up to 45.0

4.2.6 Align command

$IIELP,CAL,ECS,ALIG*CC<13><10> // Align, CC= -99.0 up to 99.0

4.2.6 Baudrate command

$IIELP,CAL,ECS,BAUD*CC<13><10> // CC= 4800, 9600 or 19200

4.2.7 Firmware version command

$IIELP,CAL,ECS,SFWR*CC<13><10> // return software version

Calibration Response messages:

4.2.8 Done message

$IIELP,CAL,ECS,DONE*CC<13><10>
The calibration circle was fine. New calibration values are now active.

4.2.9 Fast message

$IIELP,CAL,ECS,FAST*CC<13><10>
The calibration circle was too fast, this means less than 1 minute.

4.2.10 Slow message

$IIELP,CAL,ECS,SLOW*CC<13><10>
The calibration circle was too slow, this means more than 4 minutes or the vessel has been in one course too long.

4.2.11 Calibration start message

$IIELP,CAL,ECS,STRT*CC<13><10>
The calibration procedure has started.

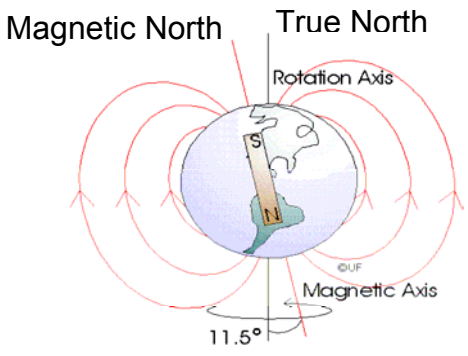
4.2.12 Calibration stopped message

$IIELP,CAL,ECS,STOP*CC<13><10>
The calibration was not successfull, please try again. This can happen when you try to calibrate in heavy wether or near a big metal object (e.g. bridge).

4.3 Variation command

The magnetic field of the earth is the physical quantity to be evaluated by a compass. Figure 1 gives an illustration of the field shape.

The magnetic field strength on the earth varies with location and covers the range from about 20 to 50 A/m. An understanding of the earth´s field shape can be gained, if it is assumed to be generated by a bar magnet within the earth, as pointed out in Figure 1. The magnetic field lines point from the earth´s south pole to its north pole. Fig. 1 indicates, that this is opposite to the physical convention for the poles of a bar magnet (the background is a historical one, in



that a bar magnet´s north pole has been defined as that pole, that points towards north in the earth´s magnetic field). The field lines are perpendicular to the earth surface at the poles and parallel at the equator. Thus, the earth field points downwards in the northern hemisphere and upwards in the southern hemisphere. An important fact is, that the magnetic poles do not coincide with the geographical poles, which are defined by the earth´s axis of rotation. The angle between the magnetic and the rotation axis is about 11.5°.
As a consequence, the magnetic field lines do not exactly point to geographic or "true" north.
The ECS1 and ECS3 compasses have a non volatile memory where the current variation can be stored. This value will be send together with the current heading in the "HDG" message (see chapter 5).

$IIELP,CAL,ECS,VARI,X.X*CC<13><10 // Variation value command
X.X = variation in degrees, -45.0 up to 45.0 max, CC is the checksum (see Chapter 4.1).

4.4 Align command

Align can be used to set the difference between the real magnetic north and the position of the compass. This can be used when it was impossible to mount the compass in the correct direction or to finetune the heading with a reference compass.

$IIELP,CAL,ECS,ALIG,X.X*CC<13><10 // Variation value command
X.X = Align in degrees, -99.00 up to 99.0, CC is the checksum (see Chapter 4.1).

4.5 Baudrate command

The ECS can be set to a different baudrate.

$IIELP,CAL,ECS,BAUD,XXXX*CC<13><10 // Variation value command
XX = 4800 or 9600, CC is the checksum (see Chapter 4.1).
On the ECS2 and ECS3 it is also possible to select 19200.
The compass will echo this command as a message back to make sure that all connected displays will switch to the correct baudrate.

4.6 Software version command

To find out which firmware version is installed use the following command:

$IIELP,CAL,ECS,SFWR*CC<13><10>

The reply will be:

$IIELP,CAL,ECS,SFWR,X.X,Y,Z*CC<13><10> //

X.X: Software version.
Y: 1=ECS1 or
2=ECS2 or
3=ECS3 or
4=LCS
Z: 1=NMEA0183 or
2=NMEA2000 or
3=Bluetooth

4.7 ECS2/3 GPS NMEA commands

4.7.1 $GPGGA (On ECS3 only available with baudrates > 4800)

This message transfers global positioning system fix data. The $GPGGA message structure is shown below:

Field	Format	Min chars	Max chars	Notes
Message ID	$GPGGA	6	6	GGA protocol header.
UTC Time	hhmmss.sss	2,2,2.3	2,2,2.3	Fix time to 1ms accuracy.
Latitude	float	3,2.4	3,2.4	Degrees * 100 + minutes.
N/S Indicator	char	1	1	N=north or S=south
Longitude	float	3,2.4	3,2.4	Degree * 100 + minutes.
E/W indicator	Char	1	1	E=east or W=west
Position Fix Indictor	Int	1	1	0: Fix not available or invalid. 1: GPS SPS mode. Fix available.
Satellites Used	Int	2	2	Number of satellites used to calculate fix.
HDOP	Float	1.1	3.1	Horizontal Dilution of Precision.
MSL Altitude	Float	1.1	5.1	Altitude above mean seal level
Units	Char	1	1	M Stands for “meters”.
Geoid Separation	Int	(0) 1	4	Separation from Geoid, can be blank.
Units	Char	1	1	M Stands for “meters”.
Age of Differential Corrections	int	(0) 1	5	Age in seconds Blank (Null) fields when DGPS is not used.
Diff Reference Corrections	int	4	4	0000.
Checksum	*xx	(0) 3	3	2 digits.
Message terminator	<CR> <LF>	2	2	ASCII 13, ASCII 10.

4.7.2 $GPGSA

This message transfers DOP and active satellites information. The $GPGSA message structure is shown below:

Field	Format	Min chars	Max chars	Notes
Message ID	$GPGSA	6	6	GSA protocol header.
Mode	Char	1	1	M Manual, forced to operate in selected mode. A Automatic switching between modes.
Mode	Int	1	1	1 Fix not available. 2 2D position fix. 3 3D position fix.
Satellites Used	Int	2	2	SV on channel 1.
Satellites Used	Int	2	2	SV on channel 2.
…	.	..	..	..
Satellites Used	Int	2	2	SV on channel 12.
PDOP	Float	1.1	3.1	
HDOP	Float	1.1	3.1	
VDOP	Float	1.1	3.1	
Checksum	*xx	0	3	2 digits
Message terminator	<CR> <LF>	2	2	ASCII 13, ASCII 10

4.7.3 $GPGSV

This message transfers information about satellites in view. The $GPGSV message structure is shown below. Each record contains the information for up to 4 channels, allowing up to 12 satellites in view. In the final record of the sequence the unused channel fields are left blank with commas to indicate that a field has been omitted.

Field	Format	Min chars	Max chars	Notes
Message ID	$GPGSV	6	6	GSA protocol header.
Number of messages	Int	1	1	Number of messages in the message sequence from 1 to 3.
Message number	Int	1	1	Sequence number of this message in current sequence, form 1 to 3.
Satellites in view	Int	1	2	Number of satellites currently in view.
Satellite Id	Int	2	2	Satellite vehicle 1.
Elevation	Int	1	3	Elevation of satellite in degrees.
Azimuth	Int	1	3	Azimuth of satellite in degrees.
SNR	Int	(0) 1	2	Signal to noise ration in dBHz, null if the sv is not in tracking.
Satellite Id	Int	2	2	Satellite vehicle 2.
Elevation	Int	1	3	Elevation of satellite in degrees.
Azimuth	Int	1	3	Azimuth of satellite in degrees.
SNR	Int	(0) 1	2	Signal to noise ration in dBHz, null if the sv is not in tracking.
Satellite Id	Int	2	2	Satellite vehicle 3.
Elevation	Int	1	3	Elevation of satellite in degrees.
Azimuth	Int	1	3	Azimuth of satellite in degrees.
SNR	Int	(0) 1	2	Signal to noise ration in dBHz, null if the sv is not in tracking.
Satellite Id	Int	2	2	Satellite vehicle 4.
Elevation	Int	1	3	Elevation of satellite in degrees.
Azimuth	Int	1	3	Azimuth of satellite in degrees.
SNR	Int	(0) 1	2	Signal to noise ration in dBHz, null if the sv is not in tracking.
Checksum	*xx	(0) 3	3	2 digits.
Message terminator	<CR> <LF>	2	2	ASCII 13, ASCII 10.

4.7.4 $GPRMC

This message transfers recommended minimum specific GNSS data. The $GPRMC message format is shown below.

Field	Format	Min chars	Max chars	Notes
Message ID	$GPRMC	6	6	RMC protocol header.
UTC Time	hhmmss.sss	1,2,2.1	2,2,2.3	Fix time to 1ms accuracy.
Status	char	1	1	A Data Valid. V Data invalid.
Latitude	Float	1,2.1	3,2.4	Degrees * 100 + minutes.
N/S Indicator	Char	1	1	N=north or S=south.
Longitude	Float	1,2.1	3,2.4	Degrees * 100 + minutes.
E/W indicator	Char	1	1	E=east or W=west.
Speed over ground	Float	1,1	5.3	Speed over ground in knots.
Course over ground	Float	1.1	3.2	Course over ground in degrees.
Date	ddmmyy	2,2,2	2,2,2	Current date.
Magnetic variation	Blank	(0)	(0)	Not used.
E/W indicator	Blank	(0)	(0)	Not used.
Mode	Char	1	1	A Autonomous
Checksum	*xx	(0) 3	3	2 digits.
Message terminator	<CR> <LF>	2	2	ASCII 13, ASCII 10.

5 ECS1/2/3 Specifications

5.1 Hardware (ECS1/2/3)

Resolution 0.1 deg.
Repeatability : 1°
Tilt compensated : up to 35°
Output error : 2° max.
Output change with tilt : 2° max.
Reverse battery protection
Interface options :

- NMEA 0183 (Standard, 4800 baud, up to 19200 selectable)
- NMEA 2000 (Optional)
- Bluetooth (Class 1)

The interface options are not user installable.

Cable length :	10m.
Power supply :	50mA @ 12V, 30mA @ 24V
Bluetooth current max. :	100mA (extra)
NMEA2000 current max. :	100mA (extra)
Operating temp. Range :	-20 to +50 °C
Storage temp. Range :	-30 to +70 °C
Dimensions :	110 X 110 X 24,5+31,5mm
Weatherproof Sealed:	according to IP66

5.2 GPS (ECS2/3)

Chipset :	NEMERIX
Frequency :	1575.42MHz-Li C/A Code
Protocol :	NMEA 0183
GPS Channel :	16 Channels
Operating Voltage :	12 to 24V
Operating temp. Range :	-20 to +50 °C
Power Consumption :	30mA
Position Accuracy :	3m CEP(50%), 7m DEP(90%)
Cold Start Time :	45 sec.
Warm Start Time :	38 sec.
Hot Start Time :	10 sec.
Reacquisition :	100ms
Update rate :	1Hz
Tracking Sensitivity :	-147dBm

5.3 NMEA0183 commands/messages

Special calibration commands:

$IIELP,CAL,ECS,STRT*CC<13><10> // Start calibration command
$IIELP,CAL,ECS,STOP*CC<13><10> // Stop calibration command
$IIELP,CAL,ECS,AUTO*CC<13><10> // Auto calibration command
$IIELP,CAL,ECS,MANU*CC<13><10> // Disable auto calibration command
$IIELP,CAL,ECS,VARI,X.X*CC<13><10 // Variation value command
$IIELP,CAL,ECS,ALIG,X.X*CC<13><10 // Align value command
$IIELP,CAL,ECS,BAUD,XXXX*CC<13><10 // Baudrate value command
$IIELP,CAL,ECS,SFWR*CC<13><10> // Software version command

Response message:
$IIELP,CAL,ECS,DONE*CC<13><10> // message “Done”
$IIELP,CAL,ECS,FAST*CC<13><10> // message “Fast”
$IIELP,CAL,ECS,SLOW*CC<13><10> // message “Slow”
$IIELP,CAL,ECS,STRT*CC<13><10> // message “Start”
$IIELP,CAL,ECS,STOP*CC<13><10> // message “Stop”
$IIELP,CAL,ECS,SFWR,X.X,Y,Z*CC<13><10> // software version/type/interface

X.X: Software version.
Y: 1=ECS1 or
2=ECS2 or
3=ECS3 or
4=LCS
Z: 1=NMEA0183 or
2=NMEA2000 or
3=Bluetooth

GPS messages:
$GPGGA,,,,,,,,, (On ECS3 not available when NMEA0183, 4800 baud is used)
$GPGSV,,,,,,,,,,,
$GPGSA,,,,,,,,,
$GPRMC,,,,,,,

5.4 Bluetooth (optional)

Class-1 compliant:	Up to 100 meter range (free field)
Antenna:	Integrated
Carrier frequency :	2402Mhz to 2480Mhz
Output power:	14dBm typ.
Messages:	NMEA0183 format (see 7.2)

5.5 NMEA2000 (optional)

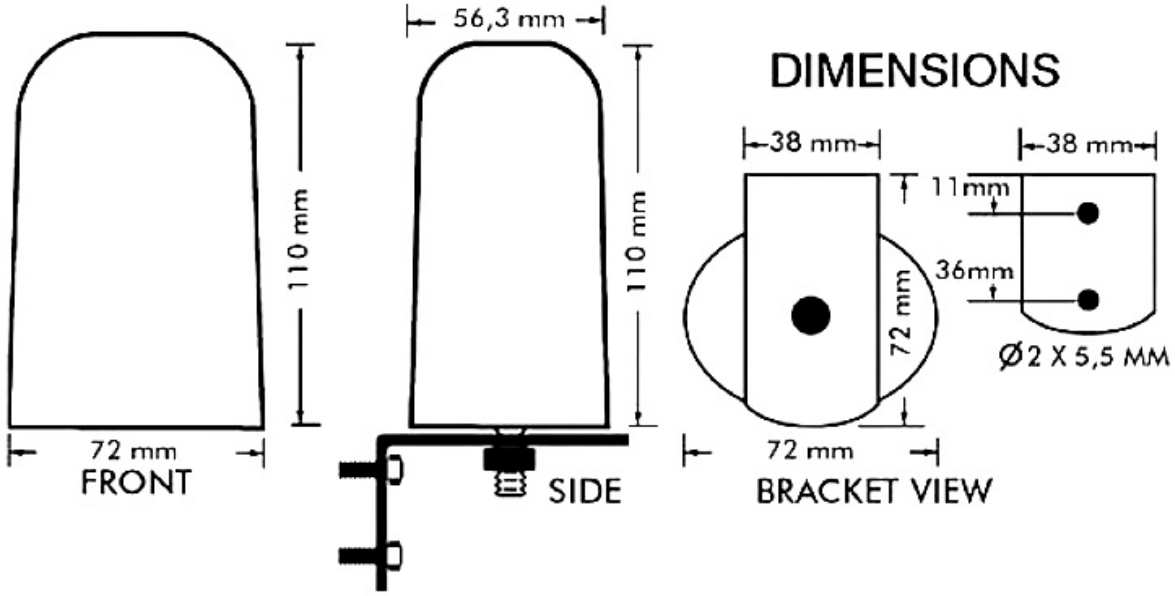
Update rate :	10 cycles per second		
PGN 126208 :	Request/ Command/ Acknowledgment Group function		
PGN 59392 :	Acknowledgment		
PGN 59904 :	Request		
PGN 60160 :	Transport Protocol, Data Transfer		
PGN 60416 :	Transport Protocol, Connection Management		
PGN 60928 :	Address Claim		
PGN 126996 :	Product information		
PGN 126464 :	Transmit/ Receive PGN List Group Function		
PGN 127250 :	1. SID Sequence ID	INT8 unsigned	
	2. Heading Sensor Reading	INT16 unsigned	
	3. Deviation	INT16 signed	Not used
	4. Variation	INT16 unsigned	
	5. Heading sensor reference	2 bits	0=True 1=Magnetic 2=Error 3=Null
	6. Reserved bits	variable	

5.6 Certifications

Maritime Navigational and Radiocommunication Equipment & Systems :	according to IEC 60945
EMC : Conducted/Radiated Emmission :	according to IEC 60945-9
Conducted/Radiated Immunity :	according to IEC 60945-10
Safety : Dangerous voltage, etc. :	according to IEC 60945-12

6 Overall dimensions

6.1 Outside dimensions

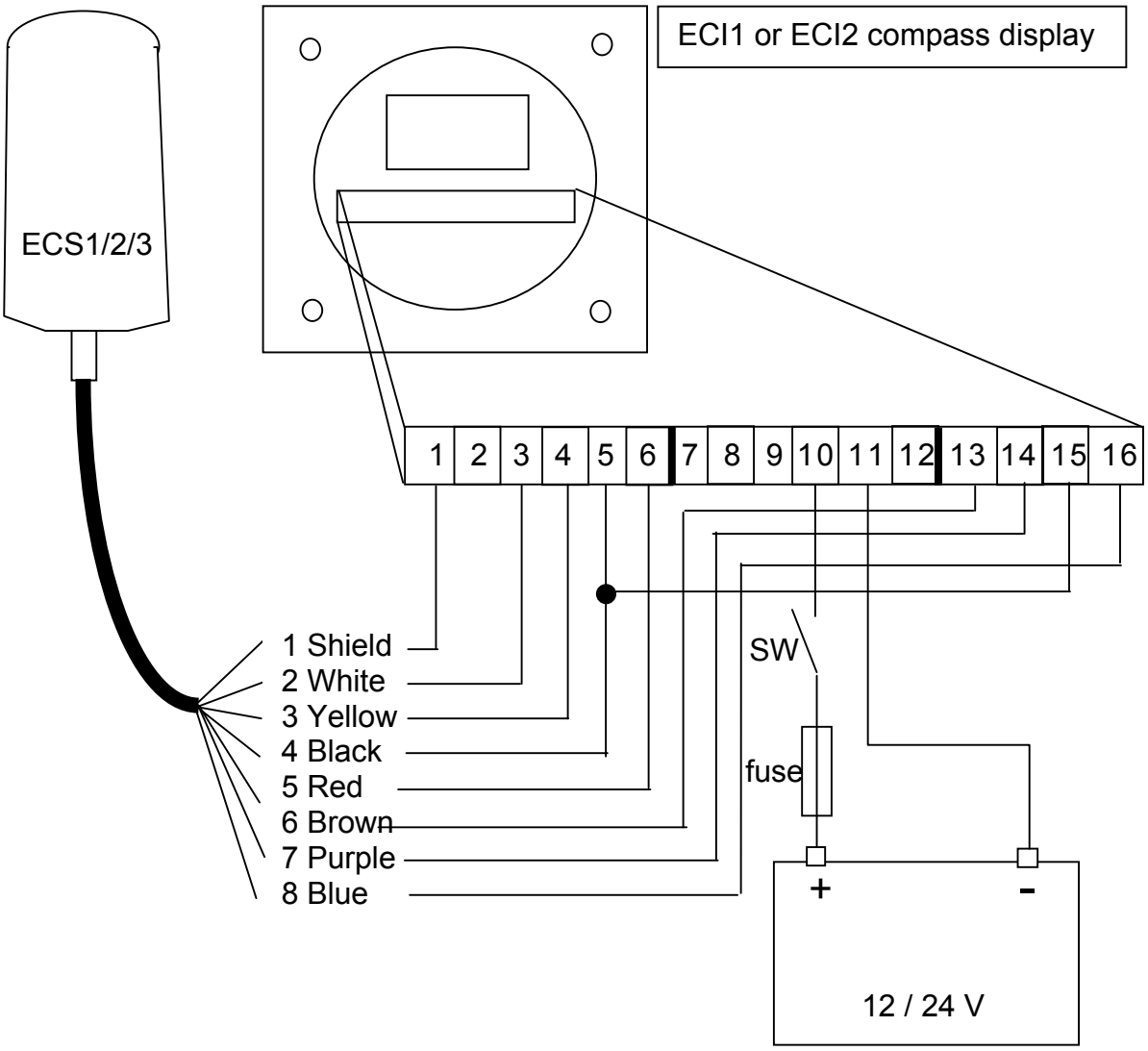


7 Wiring diagrams

7.1 pin assignments

Wire number	Color	description
1		
2	White	NMEA2000-2 (optional)
3	Yellow	NMEA2000-1 (optional)
4	Black	GND
5	Red	+12/24V Power input
6	Brown	NMEA0183-IN-
7	Purple	NMEA0183-IN+
8	Blue	NMEA0183-out (in combination with GND)

7.2 Connecting the ECI1 or ECI2 display



Specifications are subject to change without notice.
Please check www.elproma.com/compass for the most recent documentation.