

# GPS16X-HVS

GPS Receiver





# Guarantee

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This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

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# PLEASE READ FIRST

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## About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

**Area:** 1 in<sup>2</sup> (square inch) = 645 mm<sup>2</sup>

**Length:** 1 in. (inch) = 25.4 mm  
1 ft (foot) = 304.8 mm  
1 yard = 0.914 m  
1 mile = 1.609 km

**Mass:** 1 oz. (ounce) = 28.35 g  
1 lb (pound weight) = 0.454 kg

**Pressure:** 1 psi (lb/in<sup>2</sup>) = 68.95 mb

**Volume:** 1 UK pint = 568.3 ml  
1 UK gallon = 4.546 litres  
1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a “#” symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

## Recycling information



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.



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# Safety

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DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.** FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at [www.campbellsci.eu](http://www.campbellsci.eu) or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

## General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

## Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

## Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

## Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.





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# GPS16X-HVS GPS Receiver

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## 1. Overview



*FIGURE 1-1. The GPS16X-HVS terminates in pigtails for direct connection to our data loggers*

The GPS16X-HVS is a complete GPS receiver manufactured by Garmin International, Inc. Campbell Scientific configures the GPS16X-HVS to work with our data loggers and modifies its cable so that the cable terminates in pigtails. The pigtails connect directly to the control terminals of our data loggers or with the aid of an A300.

The GPS16X-HVS includes the GPS receiver and antenna in the same housing with one cable for the power supply and communications. The GPS antenna must have a clear view of the sky. Generally, the GPS antenna will not work indoors.

The GPS16X-HVS is a 12-channel GPS receiver that supports FAA Wide Area Augmentation System (WAAS) or RTCM differential GPS. Also supported is the 1 Pulse Per Second (PPS) timing signal. The cable connections provided with the GPS16X-HVS do not support differential GPS correction. The cable can be modified by the user if differential correction is required.

### 1.1 Default Settings

TABLE 1-1 shows the default settings of the GPSX16-HVS.

TABLE 1-1. Default Settings	
Baud Rate	38400 bps
Parity	N (no parity)
Stop Bit	1
Sentences Output	GPGGA, GPRMC
PPS	100 ms

## 1.2 Compatible Data Loggers

### Compatible Contemporary Data Loggers

CR300 Series	CR800 Series	CR6 Series	CR1000X	CR1000	CR3000	CR9000X
✓	✓*	✓	✓	✓*	✓*	✓**

\*If PPS is required, the A300 Power and Signal Converter is needed.

\*\*CPU Card RS-232 port only.

#### NOTE

This manual provides information only for CRBasic data loggers. For retired Edlog data logger support, see an older manual at [www.campbellsci.com/old-manuals](http://www.campbellsci.com/old-manuals).

Except for the CR9000(X), our data loggers use the CRBasic **GPS()** instruction to read the GPS16X-HVS. To use the PPS functionality, some data loggers need an updated clock chip. The clock chip is factory replaced (refer to [Please Read First](#) page for more information). Data loggers with the following serial numbers need an updated chip:

Data Logger	Serial Number
CR1000M	< 20409
CR800 Series	< 7920
CR3000	< 3168

In August 2014, Garmin changed the PPS output signal from 5 V to 3 V. Units with serial numbers greater than 1A4189318 have a 3 V PPS output signal. Because of this, the CR800-series, CR1000, and CR3000 data loggers need the A300 power and signal converter to use the PPS signal output. The A300 is NOT required for the CR6-series, CR1000X, or CR300-series data loggers.

## 1.3 Common Accessories

The following common accessories are described at [www.campbellsci.eu/gps16x-hvs](http://www.campbellsci.eu/gps16x-hvs):

- GPS16X-HVS Magnetic Mount
- CM235 Magnetic Mounting Stand
- A200 Sensor to PC Interface
- A300 Power and Signal Converter
- DB9 Female to Terminal Block with Hood and Hardware Kit

## 2. Precautions

- READ AND UNDERSTAND the [Safety](#) section at the front of this manual.
- When wiring the GPS16X-HVS, connect Ground before connecting 12V.

### 3. Initial Inspection

Upon receipt of the GPS16X-HVS, inspect the packaging and contents for damage. File damage claims with the shipping company.

### 4. QuickStart

A video that describes data logger programming using Short Cut is available at: [www.campbellsci.eu/videos/cr1000x-datalogger-getting-started-program-part-3](http://www.campbellsci.eu/videos/cr1000x-datalogger-getting-started-program-part-3). *Short Cut* is an easy way to program your data logger to measure the GPS16X-HVS and assign data logger wiring terminals. *Short Cut* is available as a download on [www.campbellsci.eu](http://www.campbellsci.eu). It is included in installations of *LoggerNet*, *RTDAQ*, *PC400*, or *PC200W*.

The following procedure also describes using *Short Cut* to measure the GPS16X-HVS.

1. Open *Short Cut* and select to create a new program.
2. Double-click the data logger model.
3. In the **Available Sensors and Devices** type GPS16X-HVS or find the sensor in the **Sensors > Miscellaneous Sensors** folder. Double-click **GPS16X-HVS**. Specify the **Local time offset**, whether to **synchronize datalogger clock to GPS clock**, and the **Maximum time difference allowed between datalogger clock and GPS clock**. You may also change any of the default labels for the returned GPS values.

File Program Tools Help

**Progress**

1. New/Open
2. Datalogger
3. **Sensors**
4. Output Setup
5. Adv. Outputs
6. Output Select

**Available Sensors and Devices**

GP X ☒ Exact Match

- CR1000X Series
  - Sensors
    - GPS16X-HVS GPS Receiver**

**Selected Measurements Available for Output**

Sensor	Measurement
CR1000X Series	
Default	BattV
	PTemp_C

GPS16X-HVS GPS Receiver (Version: 2.0)

**Properties Wiring**

Local time offset (hours) from UTC time (+ = East; - = West of Greenwich, London) 0

☒ Synchronize datalogger clock to GPS clock

Maximum time difference (milliseconds) allowed between datalogger clock and GPS clock 500

Degrees latitude (+ = North; - = South) Latitude\_A degrees

Minutes latitude Latitude\_B minutes

Degrees longitude (+ = East; - = West) Longitude\_A degrees

Minutes longitude Longitude\_B minutes

Speed Speed knots

Course over ground Course degrees

Magnetic variation from true north (+ = East; - = West) MagVar degrees

GPS fix quality FixQual code

Number of satellites used for fix NumSats count

Altitude Altitude meters

Microseconds into second of system clock when PPS rising edge occurs PPS microseconds

Seconds since last GPRMC string SecSinceGPRMC seconds

Count until GPS ready (10 = ready) GPSReady count

Maximum value the clock was changed MaxClockChange milliseconds

Number of times the clock was changed NumClockChange count

4. Click on the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.

The screenshot shows the 'Properties' dialog box for the 'GPS16X-HVS' device, with the 'Wiring' tab selected. The dialog is divided into two main sections: 'GPS16X-HVS' and 'CR1000X Series'. The 'GPS16X-HVS' section contains a table with color-coded wires and their corresponding CR1000X Series terminal names. The 'CR1000X Series' section contains a table with terminal names and their corresponding wire colors. Below the tables, there is a note: 'Click a CR1000X Series terminal name to change a wire's location.' At the bottom of the dialog, there is a section for the 'GPS16X-HVS GPS Receiver' with a small image of the device and a description of its default settings. The 'OK', 'Cancel', and 'Help' buttons are at the bottom right.

GPS16X-HVS	CR1000X Series
Red	12V
Grey	C1
White	C2
Clear	G
Black	G
Yellow	G
Blue	G

Click a CR1000X Series terminal name to change a wire's location.

**GPS16X-HVS GPS Receiver**

This module assumes the GPS16X-HVS is configured with the default settings of 38400 bps baud rate, no parity, one stop bit, GPGLA and GPRMC sentence output, and 100 ms PPS. If the gray TX wire is attached to the U1 terminal of a CR6 or the C1 terminal of a CR1000X, the datalogger will use the PPS signal for improved time synchronization accuracy and precision, otherwise, time will

OK Cancel Help

5. Repeat steps three and four for other sensors. Click **Next**.
6. In **Output Setup**, type the scan rate, meaningful table names, and **Data Output Storage Interval**.

The screenshot shows the 'Output Setup' dialog box. The 'Progress' pane on the left shows the steps: 1. New/Open, 2. Datalogger, 3. Sensors, 4. Output Setup (selected), 5. Adv. Outputs, 6. Output Select, 7. Finish. The 'Wiring' pane shows 'Wiring Diagram' and 'Wiring Text'. The main area of the dialog is titled 'How often should the CR1000X Series measure its sensor(s)?' and has a dropdown set to '5' and a unit dropdown set to 'Seconds'. Below this, there is a section 'Data is processed by the datalogger and then stored in an output table. Two tables are defined by default; up to 10 tables can be added.' with an 'Add New Table' button. The 'Table Name' field is set to 'Daily'. The 'Data Output Storage Interval' section shows '1440' and a unit dropdown set to 'Minutes'. There is a checkbox for 'Advanced Outputs (all tables)'. At the bottom, there is a help icon and a text box explaining the output interval settings. The 'Previous', 'Next', 'Finish', and 'Help' buttons are at the bottom.

File Program Tools Help Tst

**Progress**

1. New/Open
2. Datalogger
3. Sensors
4. **Output Setup**
5. Adv. Outputs
6. Output Select
7. Finish

**Wiring**

Wiring Diagram  
Wiring Text

**How often should the CR1000X Series measure its sensor(s)?** 5 Seconds

Data is processed by the datalogger and then stored in an output table. Two tables are defined by default; up to 10 tables can be added.

Add New Table

1 Hourly 2 Daily

Table Name: Daily

Delete Table

Data Output Storage Interval: 1440 Minutes

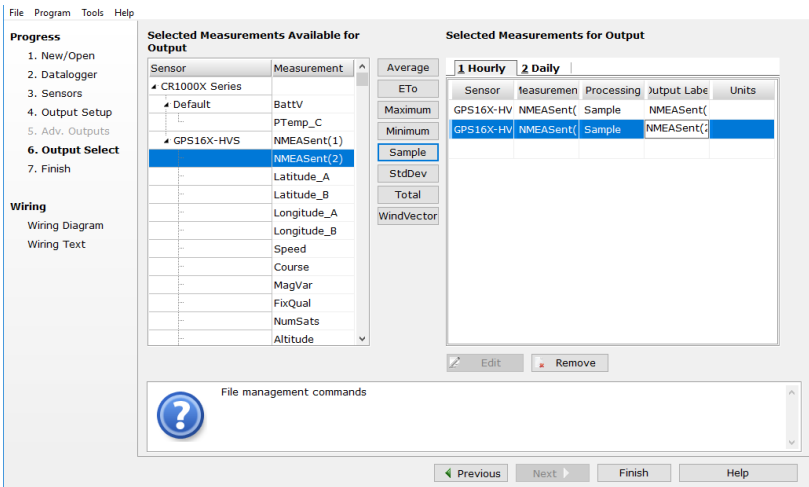
Makes 17280 measurements per output interval based upon the chosen measurement interval of 5 Seconds.

Advanced Outputs (all tables)

Specify how often measurements are to be made and how often outputs are to be stored. Note that multiple output intervals can be specified, one for each output table. By default, an output table is set up to send data to memory based on time. Select the Advanced Output option to send data to memory based on one or more of the following conditions: time, the state of a flag, or the value of a measurement.

Previous Next Finish Help

7. Select the output options.



8. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.
9. If the sensor is connected to the data logger, check the output of the sensor in the data display in *LoggerNet*, *RTDAQ*, *PC400*, or *PC200W* to make sure it is making reasonable measurements.

## 5. Specifications

### Physical

- Size:** 86 mm (3.39 in) diameter, 42 mm (1.65 in) high
- Weight:** 181 g (6.4 oz) without cable, 332 g (11.7 oz) with 5 m cable
- Cable:** PVC-jacketed, 5 m, foil-shielded, 8-conductor, 28 AWG

### Electrical Characteristics

- Input Voltage:** 8.0 VDC to 40 VDC unregulated
- Current Drain:** 65 mA @ 12 VDC

### GPS Receiver

- Sensitivity:** -185 dbW minimum

### GPS Performance

- Receiver:** WAAS enabled; 12 parallel channel GPS receiver continuously tracks and uses up to 12 satellites, 11 if PPS is active

**Acquisition Times (Approximate)**

<b>Reacquisition:</b>	Less than 2 s
<b>Hot:</b>	1 s (all data known)
<b>Warm:</b>	~38 s (initial position, time and almanac known, ephemeris unknown)
<b>Cold:</b>	~45 s

**SkySearch:** 5 min (no data known)

**Sentence Rate:** 1 s default; NMEA 0183 output interval configurable from 1 to 900 s in one second increments

<b>Accuracy:</b>	GPS Standard Positioning Service (SPS)
<b>Position:</b>	Less than 15 m, 95% typical (100 m with selective availability on)
<b>Velocity:</b>	0.1 knot RMS steady state

**DGPS (USCG/RTCM)**

<b>Position:</b>	3-5 m, 95% typical
<b>Velocity:</b>	0.1 knot RMS steady state

**DGPS (WAAS)**

<b>Position:</b>	Less than 3 m
<b>Velocity:</b>	0.1 knot RMS steady state

**PPS Time:**  $\pm 1$  microsecond at rising edge of PPS pulse (subject to selective availability)

**Dynamics:** 999 knots velocity (limited above 60,000 ft, 6g dynamics)

**Interfaces:** True RS-232 output, asynchronous serial input compatible with RS-232 or TTL voltage levels, RS-232 polarity. Selectable baud rates (4800, 9600, 19200, 38400)

**PPS:** 1 Hz pulse, programmable width, 1 microsecond accuracy

**Power Control**

<b>Off:</b>	Open circuit
<b>On:</b>	Ground or pull to low logic level < 0.3 VDC

**Environmental Characteristics**

**Temperature:** -30 to 80 °C operational, -40 to 80 °C storage

## 6. Installation

### 6.1 Wiring

The GPS16X-HVS connects directly to a CR6-series, CR3000, CR1000X, CR800-series, CR300-series, or CR1000 data logger (see TABLE 6-1). However, if PPS is required, the A300 Power and Signal Converter may be required for use with the CR800 series, CR1000, and CR3000. See Section



6.1.1, *Using with an A300* (p. 8). The CR6 series, CR1000X series, and CR300 series do not require the A300.

Use the DB9-Male-to-Terminal-Block interface to connect the GPS16X-HVS to the RS-232 port of the CR9000X CPU card. See TABLE 6-2.

To change the default settings, connect the GPS16X-HVS to a computer. Either use the A200 interface to connect to a computer USB port or the DB9-Female-to-Terminal-Block interface to connect to a computer serial port (see Appendix A, *Changing GPS16X-HVS Settings* (p. A-1)).

TABLE 6-1. Data Logger Wiring		
GPS16X-HVS	Data Logger	Function
Red	12V	Power In
Black	G	Power Ground
Yellow	G or C (control terminal)	Ground or Power Switch
White	C or U configured for Rx <sup>1</sup>	TXD
Grey	C or U configured for Tx or PPS <sup>1</sup>	RXD or PPS
Blue	G	Ground
Shield	⏏	Shield
<sup>1</sup> U terminals are automatically configured by the measurement instruction.		



FIGURE 6-1. CR1000 to GPS16X-HVS connection

**TABLE 6-2. CR9000X Wiring**

<b>GPS16X-HVS</b>	<b>CR9000X</b>	<b>Function</b>
Red	12 V (SDM or 9011 connector)	Power In
Black	Ground (SDM or 9011 connector)*	Power Ground
Yellow	Ground (SDM or 9011 connector)*	Power Switch
White	RS-232 pin 3 (using 28841)	TXD
Grey	RS-232 pin 9 (using 28841)	PPS
Blue	No Connection	N/A
Shield	Ground (SDM or 9011 connector)*	Shield

\*All of the grounds to the RS-232 pin 5 (using the DB9-Male-to-Terminal Block interface). A 5-position terminal connector can be used to facilitate connecting all of the wires into the same terminal.

### 6.1.1 Using with an A300

In 2014, Garmin changed the pulse-per-second (PPS) output of the GPS16X-HVS from 5 V to 3 V. Units with a serial number 1A4189318 or greater have a PPS output of 0 to 3 V. For those units, an A300 is needed to connect the PPS output to a CR800-series, CR3000, or CR1000 data logger. Those data loggers require the PPS line to have a voltage of 3.8 V or greater.

**TABLE 6-3. GPS16X-HVS Wiring to A300 Terminals and Data Logger Terminals**

<b>GPS16X-HVS Wire Colour</b>	<b>GPS16X-HVS Wire Function</b>	<b>A300 Terminal</b>	<b>Data Logger</b>
Red	12 V		<b>12V</b>
Black	Ground	G	
Yellow	Enable		<b>G or C terminal</b>
White	TXD (Output)		<b>C (even) (Rx)</b>
Grey	PPS	3.3V IN	
Blue	Ground		Ground
Shield	Shield		Ground

TABLE 6-4. A300 Cable Wiring to Data Logger Terminals		
A300 Wire Colour	A300 Wire Function	Data Logger
Red	12 V	12V
Black	Ground	G
Green	5 V Signal Input	G
White	5 V Signal Output	C (Tx)

## 6.2 Mounting

The GPS16X-HVS mounts to a mast or crossarm using the CM235 Magnetic Mounting Stand. Typically, the GPS16X-HVS mounts to the CM235 magnetically with the Magnetic Mount. Alternatively, the GPS16X-HVS can be mounted directly to the CM235 using three M4 screws supplied with the 17212 or by the customer.



FIGURE 6-2. GPS16X-HVS mounted using a CM235 Magnetic Mounting Stand

## 7. GPS Data

The GPS16X-HVS has several data formats available. The GPS16X-HVS is configured to output the NMEA \$GPGGA and \$GPRMC time and position string. It is possible to configure the GPS16X-HVS to output other NMEA strings including the \$GPVTG track made good and ground speed string. See [Appendix A](#), *Changing GPS16X-HVS Settings (p. A-1)*, for details.

## 7.1 \$GPGGA Sentence (Position and Time)

Sample NMEA \$GPGGA data string:

\$GPGGA,hhmmss,llll.lll,a,nnnnn.nnn,b,t,uu,v.v,w.w,M,x.x,M,y.y,zzzz\*hh<CR><LF>

TABLE 7-1. NMEA \$GPGGA String Definition		
Field	Description	
0	\$GPGGA	NMEA string identifier
1	hhmmss	UTC of Position: Hours, minutes, seconds
2	llll.lll	Latitude: Degrees, minutes, thousandths of minutes
3	a	N (North) or S (South)
4	nnnnn.nnn	Longitude: Degrees, minutes, thousandths of minutes
5	b	E (East) or W (West)
6	t	GPS Quality Indicator: 0 = No GPS, 1 = GPS, 2 = DGPS
7	uu	Number of Satellites in Use
8	v.v	Horizontal Dilution of Precision (HDOP)
9	w.w	Antenna Altitude in Metres
10	M	M = Metres
11	x.x	Geoidal Separation in Metres
12	M	M = Metres. Geoidal separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level.
13	y.y	Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 Update
14	zzzz	Differential Reference Station ID (0000 to 1023)
15	*	Asterisk, generally used as the termination character
16	hh	Checksum
17	<CR><LF>	Carriage return, line feed characters.

Sample \$GPGGA output strings:

Cold Start

No satellites acquired, Real Time Clock and Almanac invalid:

\$GPGGA,,,,,0,00,,,,,,\*66

Warm Start

No satellites acquired, time from Real Time Clock, almanac valid:

\$GPGGA,235032.0,,,,,0,00,,,,,,\*7D

Warm Start

One satellite in use, time from GPS Real Time Clock (not GPS), no position:

\$GPGGA,183806.0,,,,,0,01,,,,,,\*7D

Valid GPS Fix

Three satellites acquired, time and position valid:

\$GPGGA,005322.0,4147.603,N,11150.978,W,1,03,11.9,00016,M,-016,M,,\*6E

## 7.2 \$GPRMC Sentence (Position and Time)

Example (signal not acquired):

\$GPRMC,235947.000,V,0000.0000,N,00000.0000,E,,,041299,,\*1D

Example (signal acquired):

\$GPRMC,092204.999,A,4250.5589,S,14718.5084,E,0.00,89.68,211200,,\*25

Field	Example	Comments
Sentence ID	\$GPRMC	
UTC Time	092204.999	hhmmss.sss
Status	A	A = Valid, V = Invalid
Latitude	4250.5589	ddmm.mmmm
N/S Indicator	S	N = North, S = South
Longitude	14718.5084	dddmm.mmmm
E/W Indicator	E	E = East, W = West
Speed over ground	0.00	Knots
Course over ground	0.00	Degrees
UTC Date	211200	DDMMYY
Magnetic variation		Degrees
Magnetic variation		E = East, W = West
Checksum	*25	
Terminator	CR/LF	

## 8. CRBasic Programming

This section describes programming a CR6-series, CR3000, CR1000X, CR800-series, CR300-series, CR1000, or CR9000X data logger.

### 8.1 GPS() Instruction

The **GPS()** instruction is used along with a GPS device to set the data logger clock. This instruction will also provide information such as location (latitude/longitude) and speed, and store NMEA sentences from the GPS device.

#### NOTE

To use the **GPS()** instruction, the data logger operating system (OS) should be OS17 or higher for the CR1000; OS10 or higher for the CR3000; or OS08 or higher for the CR800 series. Go to [www.campbellsci.eu/downloads](http://www.campbellsci.eu/downloads) to upgrade the data logger OS.

The resolution of accuracy for the clock set is typically 10 microseconds. Some older CR3000, CR800-series, and CR1000 data loggers (hardware revision number less than or equal to 007 in RevBoard field in the data logger Status table) have a resolution of 10 milliseconds. The clock set relies on information from the GPRMC sentence. If this sentence is not returned, a clock set will not occur.

By default, the instruction expects the GPS unit to be set up at 38400 baud, outputting the GPRMC and GPGLL sentences once per second. The data logger expects the start of the second to coincide with the rising edge of the PPS signal. If there is no PPS signal or if the required sentences come out at less than once per second, the data logger will not update its clock.

GPS units with lower baud rates can be used with the **GPS()** instruction but the baud rate has to be set for the relevant Com port it is to be connected to either in the data logger settings or by including a **SetStatus()** command after the **BeginProg()** instruction in the program (for example, **SetStatus("BaudrateCOM4",19200)**).

Baud rates of 2400 bps or lower will not work as the GPS unit will not transmit the two GPS sentences once per second reliably. Similar problems can be encountered even at higher baud rates if too many optional GPS strings are selected to be output.

The **GPS()** instruction has the following syntax:

```
GPS(GPSArray,ComPort,TimeOffset,MaxTimeDiff,NMEAStrings)
```

Description of the parameters follows:

*GPSArray*      The *GPSArray* parameter is the variable in which to store the information returned by the GPS. Fifteen values are returned. If this array is not dimensioned to 15, values will be stored to fill the array and no error will be returned. If no values are available, NAN will be returned. The following values are returned by the GPS:

- Array(1) = Latitude, degrees
- Array(2) = Latitude, minutes
- Array(3) = Longitude, degrees
- Array(4) = Longitude, minutes
- Array(5) = Speed over ground, knots
- Array(6) = Course over ground, degrees
- Array(7) = Magnetic variation (positive = East, negative = West)
- Array(8) = Fix Quality (0 = invalid, 1 = GPS, 2 = differential GPS, 6 = estimated)
- Array(9) = Number of Satellites
- Array(10) = Altitude, metres
- Array(11) = Pulse per second (PPS) length, microseconds
- Array(12) = Seconds since last GPRMC sentence
- Array(13) = GPS Ready, 10 = ready
- Array(14) = Maximum clock change, milliseconds (10 msec resolution)
- Array(15) = Clock change count

<i>ComPort</i>	The <i>ComPort</i> parameter is the control terminal pair to which the GPS device is attached. Valid options are COM1 (C1/C2), COM2 (C3/C4), COM3 (C5/C6), and COM4 (C7/C8). Rx is used to read in the NMEA sentences and Tx is used to monitor the PPS from the GPS. This instruction defaults to a baud rate of 38,400 bps. If a different baud rate is required, use the <b>SetStatus()</b> instruction to override the default.
<i>TimeOffset</i>	The <i>TimeOffset</i> parameter is the local time offset, in seconds, from UTC.
<i>MaxTimeDiff</i>	<p>The <i>MaxTimeDiff</i> parameter is the maximum difference in time between the data logger clock and the GPS clock that will be tolerated before the clock is changed. If a negative value is entered, the clock will not be changed.</p> <p>For data loggers prior to hardware revision 08, the <i>MaxTimeDiff</i> parameter should not be set to 0. A minimum value of 20 ms is recommended. With this hardware, when a <b>GPS()</b> instruction is in the program the clock is checked each second (regardless of how often the <b>GPS()</b> instruction is run). The clock is set if any difference is found. This can result in the clock being set each second, resulting in skipped records in the data table(s). This restriction does not apply to hardware revisions 08 or greater.</p>
<i>NMEAStrings</i>	The <i>NMEAStrings</i> parameter is the string array that holds the NMEA sentences. If it exists, the GPRMC sentence will reside in <i>NMEAStrings</i> (1), and the GPGGA sentence will reside in <i>NMEAStrings</i> (2). Any other sentences will reside in subsequent indexes into the array (on a first-in basis). Once an index in the array is used to store a particular sentence, that sentence will always be stored in that location when updates to the sentence are received.

## 8.2 Example Program Using GPS() Instruction

The following wiring and short program provide an example of using the **GPS()** instruction with the Garmin GPS16X-HVS.

**CRBasic Example 8-1. Reading the GPS Using the GPS() Instruction**

```

'Program the GPS16-HVS to use 38.4 kbaud, no parity, 8 data bits, and 1 stop bit
PipeLineMode

Const LOCAL_TIME_OFFSET = -6           'Local time offset relative to UTC time
Dim nmea_sentence(2) As String * 100

Public gps_data(15)
Alias gps_data(1) = latitude_a          'Degrees latitude (+ = North; - = South)
Alias gps_data(2) = latitude_b          'Minutes latitude
Alias gps_data(3) = longitude_a         'Degrass longitude (+ = East; - = West)
Alias gps_data(4) = longitude_b        'Minutes longitude
Alias gps_data(5) = speed               'Speed
Alias gps_data(6) = course              'Course over ground
Alias gps_data(7) = magnetic_variation 'Magnetic variation from true north (+ =
                                        'East; - = West)
Alias gps_data(8) = fix_quality          'GPS fix quality: 0 = invalid, 1 = GPS, 2 =
                                        'differential GPS, 6 = estimated
Alias gps_data(9) = nmbr_satellites      'Number of satellites used for fix
Alias gps_data(10) = altitude            'Antenna altitude
Alias gps_data(11) = pps                 'usec into sec of system clock when PPS
                                        'rising edge occurs, typically 990,000 once
                                        'synced
Alias gps_data(12) = dt_since_gprmc     'Time since last GPRMC string, normally less
                                        'than 1 second
Alias gps_data(13) = gps_ready           'Counts from 0 to 10, 10 = ready
Alias gps_data(14) = max_clock_change   'Maximum value the clock was changed in msec
Alias gps_data(15) = nmbr_clock_change  'Number of times the clock was changed

'Define Units to be used in data file header
Units latitude_a = degrees
Units latitude_b = minutes
Units longitude_a = degrees
Units longitude_b = minutes
Units speed = knots
Units course = degrees
Units magnetic_variation = unitless
Units fix_quality = unitless
Units nmbr_satellites = unitless
Units altitude = m
Units pps = ms
Units dt_since_gprmc = s
Units gps_ready = unitless
Units max_clock_change = ms
Units nmbr_clock_change = samples

BeginProg
  'Use SetStatus prior to scan if baud rate needs to be changed for device
  Scan (1,Sec,0,0)
  GPS (latitude_a,Com4,LOCAL_TIME_OFFSET*3600,100,nmea_sentence(1))
  NextScan
EndProg

```

## 9. Troubleshooting

Testing and evaluation of serial communications is best done by reducing the whole system to small manageable systems. Usually some portions of the whole system are working. The first steps involve finding what is working. During this process, you may find parts of the system that are not working or mistakes that can be easily corrected. Fix each subsystem before testing others.



## 9.1 Testing and Evaluating Serial Communications

### 9.1.1 Through a Direct Connection to the GPS16X-HVS

Test the GPS16X-HVS for proper operation including the baud rate and output string. Use a computer, terminal emulator software, a serial port (RS-232), and a DB9 to Terminal Block Interface. The computer and serial port can be the same as used to communicate with the data logger. Terminal emulation software is common. *Hyperterm* is supplied as part of Windows™ and works. *Procomm*™ is another communication software package that works well.

Set up the software for the correct serial port, 38.4 kbps, 8 data bits, 1 stop bit and no parity. Flow control should be none. Using the DB9-Female-to-Terminal-Block interface, connect the GPS16X-HVS to the computer serial port. Power up the GPS16X-HVS. The GPS antenna should have a clear view of the sky. Don't expect the GPS antenna to work indoors. The \$GPGGA and GPRMC strings should be displayed once a second. Make sure the \$GPGGA string is showing a valid GPS fix. A valid GPS fix will display time, position and have a GPS quality number greater than zero.

DB9-Female-to-Terminal-Block Connections	
GPS16X Receiver	DB9 to Terminal Block Interface
White	Pin 2
Black and Yellow	Pin 5 (shares power ground)

### 9.1.2 Through a Data Logger Connected to the GPS16X-HVS

Serial communication can also be tested using the data logger terminal mode watch command, also known as sniffer mode. To enter sniffer mode:

1. Connect to your data logger in the *Device Configuration Utility* and select the **Terminal** tab. (You can also use the **Terminal Emulator** in *PC200W*, *PC400*, or the *LoggerNet Connect* screen.)
2. Press **Enter** until a *datalogger\_type>* prompt (for example, CR1000X>) appears.
3. Type **W** and press **Enter**.
4. In response, the query **Select:** is presented with a list of available terminals. Enter the port number assigned to the terminal to which the GPS16X-HVS is connected, and press **Enter**.
5. In answer to **Enter timeout (secs):**, type **100** and press **Enter**.
6. In response to the query **ASCII (Y)?**, type **Y** and press **Enter**.
7. Communication between the data logger and GPS16X-HVS is now open for viewing.

If you see no communication, the GPS16X-HVS is hooked up incorrectly, is not powered, or does not have the yellow wire tied to ground. If you see readable NMEA strings coming in but many fields are not populated, you most

likely need to go outside to obtain a better signal. If you see “garbage” characters coming in (that is, non-NMEA strings), there is likely a baud rate mismatch.

## **9.2 NMEAStrings Variable Populated, but Clock Not Setting**

Look at the GPSReady variable. It will increment from 0 to 10 when the data logger has received good GPRMC strings and a synchronized PPS signal. Once GPSReady reaches 10, the data logger will begin to use GPS time for clock setting. The 12th value populated in GPSArray indicates elapsed time since a GPRMC string was received and should not exceed 1. If the GPRMC string is being received and GPSReady remains at zero, the PPS signal is not being received by the data logger.

# **Appendix A. Changing GPS16X-HVS Settings**

---

As configured by Campbell Scientific, the GPS16X-HVS will output the NMEA 0183 \$GPGGA and \$GPRMC data strings once a second, the PPS signal is enabled with a duration of 100 milliseconds and the baud rate is set to 38,400 baud.

Special software (SNRSRCFG.EXE) is available from Garmin International for system setup. The GPS16X-HVS user manual available from Garmin International provides technical details beyond the scope of the Campbell Scientific user manual.

Settings used by Campbell Scientific for GPS16X-HVS setup:

GPS Base Model = GPS 16(X)

Fix Mode = Automatic

Baud Rate = 38,400

Dead Reckon Time = 30 sec

NMEA output time = 1 sec

Position pinning = off

NMEA 2.30 mode = off

Power Save Mode = off (Normal mode)

PPS mode = 1 Hz

PPS Length = 100 mS

Phaze output Data = off

DGPS Mode = WAAS only

Differential mode = Automatic

Earth Datum Index = WGS 84

Selected Sentences = GPGGA and GPRMC

Common changes would be baud rate and selected sentences. The NMEA 0183 GPVTG data sentence gives ground speed and direction, which may be required for some applications. Changes can be made with the Garmin software, or with a terminal emulator and the Garmin technical user manual. Contact Garmin International ([www.garmin.com](http://www.garmin.com)) for either resource.

## **A.1 Computer Connections**

Either an A200 interface or a DB9-Female-to-Terminal-Block interface is required to connect the GPS16X-HVS to a computer. The A200 is used to connect to a computer USB port, and the DB9 Female to Terminal Block is used to connect to a computer 9-pin serial port.

### **A.1.1 Using the A200**

#### **A.1.1.1 Driver Installation**

If the A200 has not been previously plugged into your computer, the A200 driver needs to be loaded onto your computer.

**NOTE**

Drivers should be loaded before plugging the A200 into the computer. The A200 drivers can be downloaded, at no charge, from: [www.campbellsci.eu/downloads](http://www.campbellsci.eu/downloads).

**A.1.1.2 Wiring**

One end of the A200 has a terminal block while the other end has a type B female USB port. The terminal block provides 12V, G, TX, and RX terminals for connecting the GPS16X-HVS (see FIGURE A-1 and TABLE A-1).

A data cable ships with the A200. This cable has a USB type-A male connector that attaches to a computer USB port, and a type B male connector that attaches to the A200 USB port.

TABLE A-1. A200 Wiring		
Colour	Sensor Cable Label	A200 Terminal
Red	12V	+12 Vdc
Black	G	G
Yellow	G	G
White	Tx	Tx
Grey	PPS	No Connection
Blue	Rx	Rx
Shield	sig ground	G



FIGURE A-1. A200 Sensor-to-PC Interface

### A.1.1.3 Powering the Sensor

The A200 provides power to the GPS16X-HVS when it is connected to a computer USB port. An internal DC/DC converter boosts the 5 VDC supply from the USB connection to a 12 VDC output that is required to power the sensor.

### A.1.1.4 Determining which COM Port the A200 has been Assigned

When the A200 is loaded, the A200 is assigned a COM port number. Often, the assigned COM port will be the next port number that is free. However, if other devices have been installed in the past (some of which may no longer be plugged in), the A200 may be assigned a higher COM port number.

Often, the assigned COM port will be the next port number that is free. However, if other devices have been installed in the past (some of which may no longer be plugged in), the A200 may be assigned a higher COM port number. To check which COM port has been assigned to the A200, you can monitor the appearance of a new COM port in the list of COM ports offered in your software package, such as *LoggerNet*, before and after the installation, or look in the Windows Device Manager list under the ports section (access via the control panel).

## A.1.2 Using the DB9-Female-to-Terminal-Block Interface

The DB9-Female-to-Terminal-Block interface includes a hood for covering the connections and is only needed for permanent installations. TABLE A-2 shows wiring.

TABLE A-2. DB9-Female-to-Terminal-Block Interface Wiring		
Interface Pin Number	Wire Colour of GPS16X-HVS	Power Supply
Pin 3	Blue	N/A
Pin 2	White	N/A
Pin 5	Shield	N/A
N/A	Red	+12 V
N/A	Black	Ground
N/A	Yellow	Ground



# Appendix B. Serial Programming

Serial programming allows the retrieval of all values of GPRMC and GPGLGA values. The **GPS()** instruction is a subset of the values that are available.

## CRBasic Example B-1. Reading the GPS Using Serial Programming

```
'GPS16X-HVS at Campbell Scientific Factory Defaults
Const GPSPort = Com4 'Com port where GPS is connected

Public GGAstring As String * 500
Public RMCstring As String * 500
'rmc variables
Public rmcid As String
Public rmcutc As String
Public rmcstatus As String
Public rmclatitude As String
Public rmcin_s_ind As String
Public rmclongitude As String
Public rmce_w_indicator As String
Public rmcspeed As String
Public rmccourse As String
Public rmcutcdate As String
Public rmcmagvariation As String
Public rmcimage_w As String
Public rmcchecksum As String
'gga variables
Public ggaid As String
Public ggautc As String
Public ggailatitude As String
Public ggan_s_ind As String
Public ggalongitude As String
Public ggae_w_ind As String
Public ggapositionfix As String
Public gganumsatellites As String
Public ggahdop As String
Public ggaaltitude As String
Public ggaaltitudeunits As String
Public ggageoidsep As String
Public ggageoidunits As String
Public ggachecksum As String

Dim NBytesReturned As Long
Dim SubStrings(16) As String * 32, rawdata As String * 500
Dim CalculatedChecksum As Long, ReportedChecksum As Long

DataTable (gpsdata,True,-1)
DataInterval (0,1,Sec,10)
Sample (1,rmcid,String)
Sample (1,rmcutc,String)
Sample (1,rmcstatus,String)
Sample (1,rmclatitude,String)
Sample (1,rmcin_s_ind,String)
Sample (1,rmclongitude,String)
Sample (1,rmcspeed,String)
Sample (1,rmccourse,String)
Sample (1,rmcutcdate,String)
Sample (1,rmcmagvariation,String)
Sample (1,rmcmage_w,String)
Sample (1,rmcchecksum,String)
Sample (1,ggaid,String)
Sample (1,ggautc,String)
Sample (1,ggan_s_ind,String)
Sample (1,ggalongitude,String)
Sample (1,ggae_w_ind,String)
```

```

Sample (1,ggapositionfix,String)
Sample (1,gganumsatellites,String)
Sample (1,ggahdop,String)
Sample (1,ggaltitude,String)
Sample (1,ggaltitudeunits,String)
Sample (1,ggageoidsep,String)
Sample (1,ggageoidunits,String)
Sample (1,ggchecksum,String)
EndTable
'Main Program
BeginProg
  SerialOpen (GPSPort,38400,3,0,1001)
  Scan (1,Sec,0,0)

  SerialInRecord (GPSPort,rawdata,36,0,&h0D0A,NBytesReturned,11)
  CalculatedChecksum = CheckSum (rawdata,9,Len(rawdata) - 3)
  CalculatedChecksum = CalculatedChecksum AND 255
  ReportedChecksum = HexToDec(Right(rawdata,2))
  If CalculatedChecksum = ReportedChecksum Then
    If InStr (1,rawdata,"GPRMC",2) Then
      RMCstring = rawdata
    ElseIf InStr (1,rawdata,"GPGBA",2) Then
      GGAstring = rawdata
    EndIf
  EndIf
  SerialInRecord (GPSPort,rawdata,36,0,&h0D0A,NBytesReturned,11)
  CalculatedChecksum = CheckSum (rawdata,9,Len(rawdata) - 3)
  CalculatedChecksum = CalculatedChecksum AND 255
  ReportedChecksum = HexToDec(Right(rawdata,2))
  If CalculatedChecksum = ReportedChecksum Then
    If InStr (1,rawdata,"GPRMC",2) Then
      RMCstring = rawdata
    ElseIf InStr (1,rawdata,"GPGBA",2) Then
      GGAstring = rawdata
    EndIf
  EndIf

  'parse rmc data
  SplitStr (SubStrings(),RMCstring,"",16,5)
  rmcid = SubStrings(1)
  rmcutc = SubStrings(2)
  rmcstatus = SubStrings(3)
  rmclatitude = SubStrings(4)
  rmcin_s_ind = SubStrings(5)
  rmclongitude = SubStrings(6)
  rmce_w_indicator = SubStrings(7)
  rmcsped = SubStrings(8)
  rmccourse = SubStrings(9)
  rmcutcdate = SubStrings(10)
  rmcmagvariation = SubStrings(11)
  rmcage_w = Left(SubStrings(12),1)
  rmcchecksum = Right(RMCstring,2)

  'parse gga data
  SplitStr (SubStrings(),GGAstring,"",16,5)
  ggaid = SubStrings(1)
  ggautc = SubStrings(2)
  ggailatitude = SubStrings(3)
  ggan_s_ind = SubStrings(4)
  ggalongitude = SubStrings(5)
  ggae_w_ind = SubStrings(6)
  ggapositionfix = SubStrings(7)
  gganumsatellites = SubStrings(8)
  ggahdop = SubStrings(9)
  ggaltitude = SubStrings(10)
  ggaaltitudeunits = SubStrings(11)
  ggageoidsep = SubStrings(12)
  ggageoidunits = Left(SubStrings(13),1)

```



```
ggchecksum=Right(GGAsstring,2)

  CallTable gpsdata
NextScan
EndProg
```



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