INSTRUCTION MANUAL

GPS16X-HVS GPS Receiver

Revision: 10/17

Guarantee

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.

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Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

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Campbell Scientific Ltd,
80 Hathern Road,
Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141
Fax: +44 (0) 1509 601091

Email: support@campbellsci.co.uk
www.campbellsci.co.uk

PLEASE READ FIRST

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^2 (square inch) = 645 mm^2	**Mass:**	1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	**Pressure:**	1 psi (lb/in^2) = 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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Campbell Scientific Ltd, 80 Hathern Road, Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141 Fax: +44 (0) 1509 601091
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

Precautions

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 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

1. Overview

FIGURE 1-1. The GPS16X-HVS terminates in pigtails for direct connection to our dataloggers

The GPS16X-HVS is a complete GPS receiver manufactured by Garmin International, Inc. Campbell Scientific configures the GPS16X-HVS to work with our dataloggers and modifies its cable so that the cable terminates in pigtails. The pigtails connect directly to the control ports of our dataloggers 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 Dataloggers

Compatible Contemporary Dataloggers

CR300 Series	CR200(X) Series	CR800 Series	CR6 Series	CR1000X Series	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 dataloggers. It is also compatible with some of our retired Edlog dataloggers. For Edlog datalogger support, see an older manual at *www.campbellsci.com/old-manuals*.

Our CR1000X-series, CR6-series, CR300-series, CR800-series, CR1000, and CR3000 dataloggers typically use the CRBasic **GPS()** instruction to read the GPS16X-HVS. To use the PPS functionality, some dataloggers need an updated clock chip. The clock chip is factory replaced (requires an RMA). Dataloggers with the following serial numbers need an updated chip:

Datalogger	Serial Number
CR1000M	< 20409
CR800 Series	< 7920
CR3000	< 3168

In August 2014, Garmin changed the GPS16X-HVS PPS output signal from 5 V to 3 V. Units with serial numbers greater than 1A4189318 have a 3 V PPS output signal. When this new design is used with a CR800-series, CR1000, or CR3000 datalogger, a 3 V to 5 V voltage shifter is required for use with the PPS signal output. The A300 can be used for this purpose. This level shifter is NOT required for the CR6-series datalogger.

1.3 Common Accessories

CSI part number	Description
#17212	GPS16X-HVS magnetic mount
CM235	Magnetic mounting stand
A200	Sensor to PC interface
A300	Power and signal converter
#28840	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

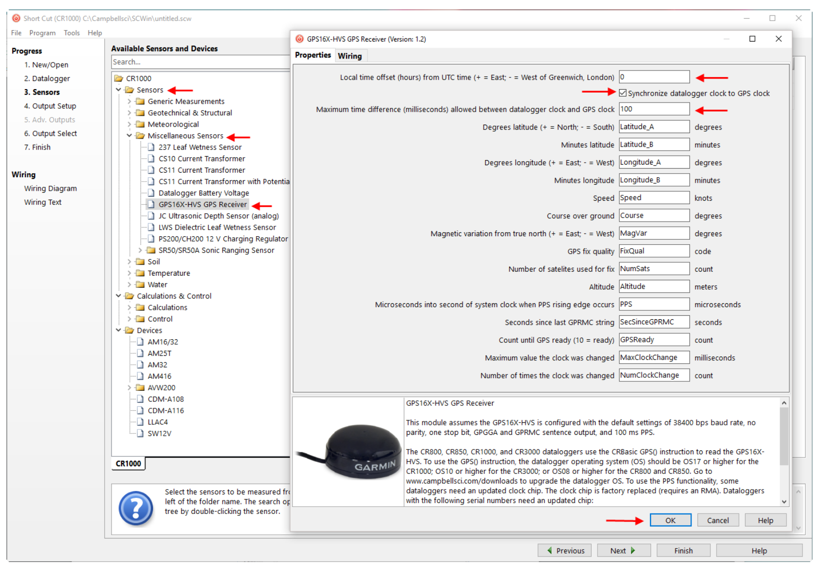
Short Cut is an easy way to program your datalogger to measure the GPS16X-HVS and assign datalogger wiring terminals. *Short Cut* is available as a download on *www.campbellsci.eu*. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

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

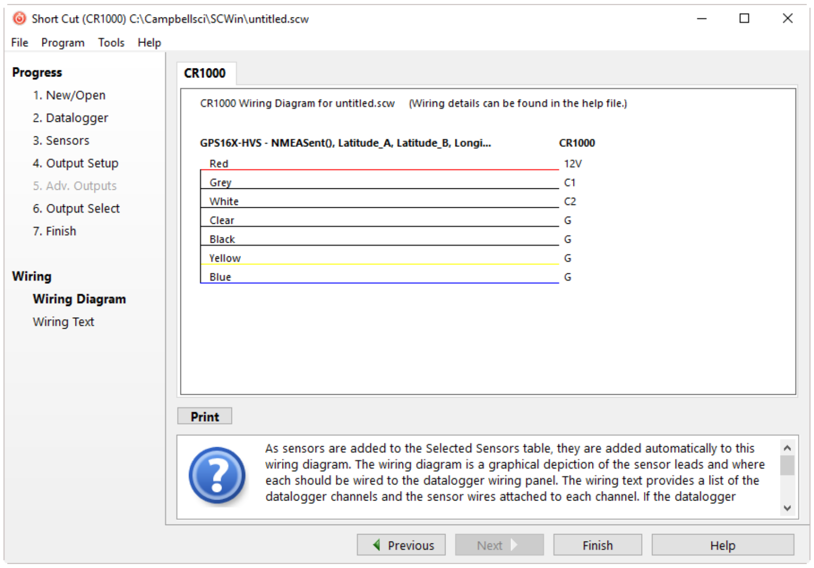
1. Open *Short Cut* and select to create a new program.

2. Double-click the datalogger model.

3. Under the **Available Sensors and Devices** list, select the **Sensors | Miscellaneous Sensors** folder and 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. Press **OK**.



4. After completing the sensor form, click **Wiring Diagram** to see how the GPS16X-HVS is to be wired to the datalogger. The wiring diagram can be printed now or after more sensors are added.



5. Select any other sensors you have, then finish the remaining *Short Cut* steps to complete the program. The remaining steps are outlined in *Short Cut Help*, which is accessed by clicking on **Help | Short Cut Help | Contents | Programming Steps**.

6. If *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* is running on your PC, and the PC to datalogger connection is active, you can click **Finish** in *Short Cut* and you will be prompted to send the program just created to the datalogger.

7. If the GPS16X-HVS is connected to the datalogger, as shown in the wiring diagram in step 4, check the output of the GPS16X-HVS in the datalogger support software data display 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)
- **Reacquisition:** Less than 2 s
- **Hot:** 1 s (all data known)
- **Warm:** ~38 s (initial position, time and almanac known, ephemeris unknown)
- **Cold:** ~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

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

DGPS (USCG/RTCM)
- **Position:** 3-5 m, 95% typical
- **Velocity:** 0.1 knot RMS steady state

DGPS (WAAS)
- **Position:** Less than 3 m
- **Velocity:** 0.1 knot RMS steady state

PPS Time: ±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
- **Off:** Open circuit
- **On:** Ground or pull to low logic level < 0.3 volts

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 CR300-series, CR1000X-series, CR6-series, CR800-series, CR1000, or CR3000 datalogger (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 use of an A300.

The CR9000X only supports the GPS16X-HVS on the RS-232 port of the CPU card. The recommended interface is pn #28841. See TABLE 6-2.

If the GPS16X-HVS is to be connected to a computer to change the default settings, an A200 or pn #28840 interface is needed (see Appendix A, *Changing GPS16X-HVS Settings* *(p. A-1)*).

TABLE 6-1. Datalogger Wiring

GPS16X-HVS	Datalogger	Function
Red	12V	Power In
Black	Ground	Power Ground
Yellow	Ground or Control Port for On/Off control	Power Switch
White	Control Port (Rx)	TXD
Grey	Control Port (Tx)	PPS
Blue	Ground or Control Port (Tx) for datalogger-based configuration	R_x data
Shield	Ground	Shield

FIGURE 6-1. CR1000 to GPS16X-HVS connection

TABLE 6-2. CR9000X Wiring		
GPS16X-HVS	**CR9000X**	**Function**
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	R_x Data
Shield	Ground (SDM or 9011 connector)*	Shield

*All of the grounds should also be tied to the RS-232 pin 5 (using pn #28841). A pn #27373 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, CR1000, or CR3000 datalogger. Those dataloggers require the PPS line to have a voltage of 3.8 V or greater.

TABLE 6-3. GPS16X-HVS Wiring to A300 Terminals and Datalogger Terminals

GPS16X-HVS Wire Colour	GPS16X-HVS Wire Function	A300 Terminal	Datalogger
Red	12 V		12V
Black	Ground	G	
Yellow	Enable		Ground (or Control Port)
White	TXD (Output)		Control Port (Rx)
Grey	PPS	3.3V IN	
Blue	RXD (Input)		Ground
Shield	Shield		Ground

TABLE 6-4. A300 Cable Wiring to Datalogger Terminals

A300 Wire Colour	A300 Wire Function	Datalogger
Red	12 V	12V
Black	Ground	Ground
Green	5 V Signal Input	Ground
White	5 V Signal Output	Control Port (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 addition of the #17212 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	1111.111	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 CR1000X-series, CR300-series, CR6-series, CR800-series, CR1000, CR3000, or CR9000X datalogger.

NOTE This manual provides information only for CRBasic dataloggers. It is also compatible with some of our retired Edlog dataloggers. For Edlog datalogger support, see an older manual at *www.campbellsci.com/old-manuals*.

8.1 GPS() Instruction

The **GPS()** instruction is available for our CR6-series, CR800-series, CR1000, and CR3000 dataloggers. It is used along with a GPS device to set the datalogger's 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 datalogger 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.com/downloads* to upgrade the datalogger OS.

The resolution of accuracy for the clock set is 10 microseconds if the datalogger has a hardware revision number greater than 007 (RevBoard field in the datalogger's Status table). Otherwise, resolution is 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 GPGGA sentences once per second. The datalogger 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 datalogger 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 datalogger settings or by including a **SetStatus()** command after the **BeginProg()** instruction in the program (e.g., **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

ComPort The *ComPort* parameter is the control port 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 **SetStatus()** instruction to override the default.

TimeOffset The *TimeOffset* parameter is the local time offset, in seconds, from UTC.

MaxTimeDiff The *MaxTimeDiff* parameter is the maximum difference in time between the datalogger 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.

For dataloggers prior to hardware revision 08, the *MaxTimeDiff* parameter should not be set to 0. A minimum value of 20 ms is recommended. With this hardware, when a **GPS()** instruction is in the program the clock is checked each second (regardless of how often the **GPS()** 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.

NMEAStrings The *NMEAStrings* parameter is the string array that holds the NMEA sentences. If it exists, the GPRMC sentence will reside in NMEAStrings(1), and the GPGGA sentence will reside in NMEAStrings(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 * 90

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       'Degress 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 (pn #28840). The computer and serial port can be the same as used to communicate with the datalogger. 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 #28840, 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.

#28840 Connections	
GPS16X Receiver	**28840 DB9 to Terminal Block Interface**
White	Pin 2
Black and Yellow	Pin 5 (shares power ground)

9.1.2 Through a Datalogger Connected to the GPS16X-HVS

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

1. Connect to your datalogger 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 ports. 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 datalogger 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 datalogger has received good GPRMC strings and a synchronized PPS signal. Once GPSReady reaches 10, the datalogger 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 datalogger.

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) for either resource.

A.1 Computer Connections

Either an A200 interface or pn #28840 interface is required to connect the GPS16X-HVS to a computer. The A200 is used to connect to a computer USB port, and the #28840 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 PC, the A200 driver needs to be loaded onto your PC.

NOTE Drivers should be loaded before plugging the A200 into the PC. The A200 drivers can be downloaded, at no charge, from: *www.campbellsci.com/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, CSI part number #17648, ships with the A200. This cable has a USB type-A male connector that attaches to a PC's USB port, and a type B male connector that attaches to the A200's USB port.

TABLE A-1. A200 Wiring

Colour	Sensor Cable Label	A200 Terminal
Red	12V	+12Vdc
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 PC's 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 (e.g., *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 28840 Interface

The 28840 interface connects a DB9 female connector to a terminal block. The kit includes a hood for covering the connections and is only needed for permanent installations. TABLE A-2 shows wiring.

TABLE A-2. 28840 Interface Wiring

Pin Number on #28840	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 GPGGA 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 rmcmage_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 ggaaltutudeunits 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,ggaaltitude,String)
  Sample (1,ggaaltutudeunits,String)
  Sample (1,ggageoidsep,String)
  Sample (1,ggageoidunits,String)
  Sample (1,ggachecksum,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,"GPGGA",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,"GPGGA",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)
    rmcspeed=SubStrings(8)
    rmccourse=SubStrings(9)
    rmcutcdate=SubStrings(10)
    rmcmagvariation=SubStrings(11)
    rmcmage_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)
    ggaaltitude=SubStrings(10)
    ggaaltutudeunits=SubStrings(11)
    ggageoidsep=SubStrings(12)
    ggageoidunits=Left(SubStrings(13),1)
```

```
    ggachecksum=Right(GGAstring,2)

    CallTable gpsdata
  NextScan
EndProg
```

Campbell Scientific Companies

Campbell Scientific, Inc.
815 West 1800 North
Logan, Utah 84321
UNITED STATES
www.campbellsci.com • info@campbellsci.com

Campbell Scientific Canada Corp.
14532 – 131 Avenue NW
Edmonton AB T5L 4X4
CANADA
www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Africa Pty. Ltd.
PO Box 2450
Somerset West 7129
SOUTH AFRICA
www.campbellsci.co.za • cleroux@csafrica.co.za

Campbell Scientific Centro Caribe S.A.
300 N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA
www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Southeast Asia Co., Ltd.
877/22 Nirvana@Work, Rama 9 Road
Suan Luang Subdistrict, Suan Luang District
Bangkok 10250
THAILAND
www.campbellsci.asia • info@campbellsci.asia

Campbell Scientific Ltd.
Campbell Park
80 Hathern Road
Shepshed, Loughborough LE12 9GX
UNITED KINGDOM
www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Australia Pty. Ltd.
PO Box 8108
Garbutt Post Shop QLD 4814
AUSTRALIA
www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific Ltd.
3 Avenue de la Division Leclerc
92160 ANTONY
FRANCE
www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific (Beijing) Co., Ltd.
8B16, Floor 8 Tower B, Hanwei Plaza
7 Guanghua Road
Chaoyang, Beijing 100004
P.R. CHINA
www.campbellsci.com • info@campbellsci.com.cn

Campbell Scientific Ltd.
Fahrenheitstraße 13
28359 Bremen
GERMANY
www.campbellsci.de • info@campbellsci.de

Campbell Scientific do Brasil Ltda.
Rua Apinagés, nbr. 2018 ─ Perdizes
CEP: 01258-00 ─ São Paulo ─ SP
BRASIL
www.campbellsci.com.br • vendas@campbellsci.com.br

Campbell Scientific Spain, S. L.
Avda. Pompeu Fabra 7-9, local 1
08024 Barcelona
SPAIN
www.campbellsci.es • info@campbellsci.es

Please visit www.campbellsci.com to obtain contact information for your local US or international representative.