

INSTRUCTION MANUAL



GPS16X-HVS GPS Receiver

Revision: 7/10



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GPS16X-HVS GPS Receiver

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GPS16X-HVS GPS Receiver



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

1. Overview

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 all dataloggers.

The CR1000, CR3000, CR800, and CR850 dataloggers use the GPS and serial instructions to read, parse and store GPS data. Although wiring and programming are more complicated, the CR23X, CR5000, and CR9000(X) dataloggers can be used with the GPS16X-HVS. The CR10(X), CR500, CR510, and CR200(X)-series dataloggers are not compatible with the GPS16X-HVS. Information regarding the CR23X, CR5000, and CR9000(X) dataloggers is included in Appendix B and C.

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.

NOTE

To use newer PPS functionality, the datalogger needs to have a newer clock chip. Dataloggers with newer chips are: CR1000M Modules with serial numbers ≥ 20409 ; CR800/CR850s with serial numbers ≥ 7920 ; CR3000s with serial numbers ≥ 3168 .

2. Specifications

2.1 Replacement Parts

CSI part number	Description
17212	GPS16X-HVS magnetic mount

2.2 Specifications

Physical

Color:	Black with white logos
Size:	3.39" (86 mm) diameter, 1.65" (42 mm) high
Weight:	6.4 oz. (181 g) without cable, 11.7 oz. (332 g) with 5 meter cable
Cable:	Black PVC-jacketed, 5 meter, foil-shielded, 8-conductor, 28 AWG

Electrical Characteristics

Input Voltage:	8.0 Vdc to 40 Vdc unregulated
Current:	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 seconds
Warm:	1 second (all data known)
Cold:	45 Seconds (initial position, time and almanac known, ephemeris unknown)
SkySearch:	5 minutes (no data known)

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

Accuracy:	GPS Standard Positioning Service (SPS)
Position:	Less than 15 meters, 95% typical (100 meters with Selective Availability on)
Velocity:	0.1 knot RMS steady state

DGPS (USCG/RTCM)

Position: 3-5 meters, 95% typical
 Velocity: 0.1 knot RMS steady state

DGPS (WAAS)

Position: Less than 3 meters
 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 feet, 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)

Port 1

NMEA 0183 version 2.00 and 3.00

NMEA output sentences GPALM, GPGGA, GPGLL, GPGSA, GPGSV, GPRMC, GPVTG; Garmin proprietary sentences PGRMB, PGRME, PGRMF, PGRMM, PGRMT, PGRMV

NMEA 0183 Output:

Position, velocity and time
 Receiver and satellite status
 Differential Reference Station ID and RTCM Data age
 Geometry and error estimates

NMEA 0183 Inputs:

Initial position, data and time (not required)
 Earth datum and differential mode configuration command, PPS Enable, GPS satellite almanac
 Configurable for binary data output including GPS carrier phase data

Port 2

Real Time Differential Correction input (RTCM SC-104 messages types 1, 3, 3, 7 and 9), no output

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°C to +80°C operational, -40°C to +80°C storage

3. Wiring

The GPS16X-HVS connects directly to a CR800, CR850, CR1000, or CR3000 datalogger (see Figure 2 and Table 3-1). Refer to Appendix B.1 if connecting the receiver to a CR23X. Our CR5000 and CR9000X connect to the receiver via the SC110 and an SDM-SIO4 (see Appendix C).

If the GPS16X-HVS is to be connected to a computer to change the default settings, an SC110 cable is needed (see Appendix A).

TABLE 3-1. Datalogger Wiring		
GPS16X-HVS	Datalogger	Function
Red	12V	Power In
Black	Ground	Power Ground
Yellow	Ground	Power Switch
White	Control Port (RX)	TXD
Gray	Control Port (TX)	PPS
Blue	Ground in operation Send data to receiver for configuration	R _x data
Shield	Ground	Shield



FIGURE 2. CR1000 to GPS16X-HVS Connection

4. 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 for details.

4.1 \$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 4-1. 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 Meters
10	M	M = Meters
11	x.x	Geoidal Separation in Meters
12	M	M = Meters. 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

If the almanac and ephemeris data are not stored in the non-volatile data, GPS acquisition time is less than 5 minutes. If only the ephemeris data are unknown, acquisition time is less than 45 seconds. If all data are known (warm start), GPS acquisition time is less than 15 seconds.

4.2 \$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	

5. CRBasic Programming

This section describes programming a CR800, CR850, CR1000, or CR3000. See Appendix B and C for programming other dataloggers.

CRBasic is used to write programs for the CR1000, CR3000, CR800, and CR850 dataloggers. These dataloggers use several instructions to read GPS output, which is asynchronous serial data. As shipped from Campbell Scientific, the GPS receiver will output data once a second, 38400 baud, 8 data bits, no parity, and 1 stop bit. Only the GPGGA string is output. See Section 3 for details on the GPGGA string. See Appendix A for specifics on changing the GPS receiver configuration, including using different baud rates.

5.1 GPS Instruction

The GPS instruction is available for our CR800, CR850, 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 and CR850. 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.

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, meters
	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 expects a baud rate of 38,400 bps.
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.
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 GPGLL 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.

5.2 Example Program Using GPS Instruction

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

Program the GPS16X-HVS to use 38.4 kbaud, no parity, 8 data bits, and 1 stop bit

**** Wiring ****

'C7 GPS16X-HVS pulse per second (gray)
 'C8 GPS16X-HVS RS-232 Tx (white)
 'G GPS16X-HVS power control (yellow)
 '12V GPS16X-HVS power (red)
 'G GPS16X-HVS power and RS-232 signal reference (black)
 'G Ground (blue)
 'G Shield (shield)

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 (+ = East; - = West)*

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 *'Elapsed ms since last pulse per second (PPS) from GPS*

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*

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 = m/s

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

Scan (1,Sec,0,0)

GPS (latitude_a,Com4,LOCAL_TIME_OFFSET*3600,0,nmea_sentence(1))

NextScan

EndProg

5.3 Example Program Using Serial Instruction

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.

```
'CR1000 Series Datalogger

Public rawdata 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 rcmagvariation As String
Public rcmage_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 ggchecksum As String

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,ggaltutudeunits,String)
Sample (1,ggageoidsep,String)
Sample (1,ggageoidunits,String)
Sample (1,ggchecksum,String)
EndTable
'Main Program
BeginProg
  Scan (1,Sec,0,0)
    SerialOpen (Com4,38400,0,0,500)
    SerialInBlock (Com4,rawdata,500)
    'parse rmc data
    rmcid=Mid (rawdata,1,6)
    rmcutc=Mid (rawdata,8,6)
    rmcstatus=Mid (rawdata,15,1)
    rmclatitude=Mid (rawdata,17,9)
    rmcin_s_ind =Mid (rawdata,27,1)
    rmclongitude=Mid (rawdata,29,10)
    rmce_w_indicator=Mid (rawdata,40,1)
    rmcsped=Mid (rawdata,42,5)
    rmccourse=Mid (rawdata,48,5)
    rmcutcdate=Mid (rawdata,54,6)
    rmcmagvariation=Mid (rawdata,61,5)
    rmcimage_w =Mid (rawdata,67,1)
    rmcchecksum=Mid (rawdata,68,3)
    'parse gga data
    ggaid=Mid (rawdata,73,6)
    ggautc=Mid (rawdata,80,6)
    ggailatitude=Mid (rawdata,87,9)
    ggan_s_ind=Mid (rawdata,97,1)
    ggalongitude=Mid (rawdata,99,10)
    ggae_w_ind=Mid (rawdata,110,1)
    ggapositionfix=Mid (rawdata,112,1)
    gganumsatellites=Mid (rawdata,114,2)
    ggahdop=Mid (rawdata,117,3)
    ggaaltitude=Mid (rawdata,121,6)
    ggaaltutudeunits=Mid (rawdata,128,1)
    ggageoidsep=Mid (rawdata,130,5)
    ggageoidunits=Mid (rawdata,136,1)
    ggchecksum=Mid (rawdata,139,3)
    CallTable gpsdata
  NextScan
EndProg

```

6. 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.

6.1 GPS Setup and Function

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 9-pin to pigtail cable (SC110/sockets). 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 TM and works. Procomm TM is another communication software package that works well.

Set up the software for the correct serial port, 38.4 kb baud, 8 data bits, 1 stop bit and no parity. Flow control should be none. Using the SC110 cable, 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.

SC110 Cable Connections	
GPS16X Receiver	SC110/Sockets or DB9/Sockets to Pigtails
White	Pin 2
Black and Yellow	Pin 5

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 80 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 = 80 mS
Phaze output Data = off
DGPS Mode = WAAS only
Differential mode = Automatic
Earth Datum Index = NGS 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

An SC110 cable with sockets is required to connect the GPS16S-HVS to a computer. The SC110 consists of two cables—each has a 2-foot (0.6 m) length. Use the cable that has a 9-pin female connector (DCE).

TABLE A-1. SC110's DCE Cable Wiring		
Wire Color of SC110's DCE Cable	Wire Color of GPS16X-HVS	Power Supply
Brown	Blue	N/A
White	White	N/A
Yellow	Shield	N/A
N/A	Red	+12 V
N/A	Black	Ground
N/A	Yellow	Ground

A.2 NMEA Commands for System Setup

Received NMEA strings are commands to the GPS16X-HVS which change some operating parameter. Null fields in the configuration sentence indicate no change. All sentences are terminated with the carriage return and line feed characters (CRLF). The CRLF can occur anywhere in the string. The *hh indicates a checksum which is not required.

TABLE A-2. PGRMC Setup Sentence \$PGRMC,1,2,3,4,5,6,7,8,9,10,11,12,13,14*hhCRLF	
1	Fix mode, A = Automatic, 2 = 2D, 3 = 3D
2	Altitude above or below sea level
3	Earth Datum
4	User Earth datum semi-major axis
5	User Earth datum inverse flattening factor
6	User Earth datum delta x earth centered coordinate
7	User Earth datum delta y earth centered coordinate
8	User Earth datum delta z earth centered coordinate
9	differential mode, A = automatic, D = differential only
10	NMEA 0183 baud rate, 3=4800, 4=9600, 5=19200, 8=38400
11	Velocity filter, 0 = no filter, 1 = Automatic filter, 2-255 = filter time constant
12	PPS mode, 1 = no pps, 2 = 1 Hz
13	PPS pulse length, 0-48 = (n+1)*20 ms. Example: n=4 corresponds to a 100 ms wide pulse width
14	Dead reckoning valid time (1-30 seconds)

PGRMC Notes: All configuration changes take effect after receipt of a valid value except baud rate and PPS mode, which take effect on the next power cycle or an external reset event.

TABLE A-3. PGRMO Output Sentence Enable/Disable \$PGRMO,1,2,*hhCRLF	
1	Target Sentence description (e.g., GPVTG)
2	Target Sentence Mode, where: 0 = disable specified sentence 1 = enable specified sentence 2 = disable all output sentence (except PSLIB) 3 = enable all output sentences (except GPALM) 4 = restore factory default output sentences

PGRMO Notes:

1. If the target sentence mode is 2 (disable all) , 3 (enable all) or 4 (restore defaults), the target sentence description is not checked for validity. In this case, an empty field is allowed (e.g., \$PGRMO,,3), or the mode field may contain from 1 to 5 characters.
2. If the target sentence mode is 0 (disable) or 1 (enable), the target sentence description field must be an identifier for one of the sentences that can be output by the GPS sensor.
3. If either the target sentence mode field or the target sentence description field is not valid, the PGRMO sentence will have no effect.
4. \$PGRMO,GPALM,1 will cause the GPS sensor to transmit all stored almanac information. All other NMEA 0183 sentence transmission will be temporarily suspended.
5. \$PGRMO,,G will cause the COM 1 port to change to GARMIN data Transfer format for the duration of the power cycle. The GARMIN mode is required for GPS 16/17 series product software updates.

TABLE A-4. Supported NMEA 0183 Sentences Order and Size		
Sentence	Default Output	Maximum Characters
GPRMC	Yes	74
GPGGA	Yes	82
GPGSA	Yes	66
GPGSV	Yes	70
PGRME	Yes	35
GPGLL	No	44
GPVTG	No	42
PGRMV	No	32
PGRMF	No	82
PGRMB	Yes	40
PBRMM	Yes	32
PGRMT	Once per minute	50

In Table A-4 default Output indicates NMEA sentences that are GPS16X-HVS defaults. CSI turns off all output except the GPGGA sentence. The time required to output a NMEA sentence can be determined by multiplying the maximum number of characters by 10 then dividing the result by the baud rate. Selected sentences will be transmitted at a periodic rate based on the selected baud rate and the selected output sentences. The sentences will be output contiguously. Regardless of the baud rate, the sentences are reference to the PPS signal immediately preceding the GPRMC sentence, or whichever sentence is output first.

TABLE A-5. \$GPGGA Global Positioning System Fix Data \$GPGGA,1,2,3,4,5,6,7,8,9,M,10,M,11,12*hhCRLF	
<1>	UTC time of position fix, hhmmss format
<2>	Latitude, ddmm.mmmm format (leading zeros will be transmitted) (5 digits of precision on GPS 16A)
<3>	Latitude hemisphere, N or S
<4>	Longitude, ddmm.mmmm format (leading zeros will be transmitted) (5 digits of precision on GPS 16A)
<5>	Longitude hemisphere, E or W
<6>	GPS quality indication, 0 = fix not available, 1 = Non-differential GPS fix available, 2 = Differential GPS (DGPS) fix available, 6 = Estimated
<7>	Number of satellites in use, 00 to 12 (leading zeros will be transmitted)
<8>	Horizontal dilution of precision, 0.5 to 99.9
<9>	Antenna height above/below mean sea level, -9999.9 to 99999.9 meters
<10>	Geoidal height, -999.9 to 9999.9 meters
<11>	Differential GPS (RTCM SC-104) data age, number of seconds since last valid RTCM transmission (null if not an RTCM DGPS fix)
<12>	Differential Reference Station ID, 0000 to 1023 (leading zeros will be transmitted, null if not an RTCM DGPS fix)

Appendix B. CR23X Wiring and Programming

B.1 CR23X Connections

Reconfigure the receiver for 1200 baud using Garmin configuration software available on Garmin's website. Refer to Table B-1 to connect the GPS16X-HVS directly to a CR23X datalogger.

TABLE B-1. CR23X Wiring		
GPS16X-HVS	CR23X	Function
Red	12V	Power In
Black	Ground	Power Ground
Yellow	Ground	Power Switch
White	Control Port	TXD
Gray	Control Port	PPS
Blue	Ground in operation Send data to receiver for configuration	R _x data
Shield	Ground	Shield

B.2 Programming

Program instruction 15 (P15) is used to read the NMEA \$GPGGA string of time and position data. Each iteration of P15 can either read the numeric fields or read everything. When reading the numeric fields, such as time, latitude, longitude and elevation, P15 requires non-numeric delimiters between data points. The only available format of GPS data with delimiters is the NMEA 0183 format. Program instruction 15 (P15) reads serial data and discards non-numeric values. All non-numeric values act as delimiters between numbers, and decimal points can also act as delimiters. P15 can be used to import everything in the string, character by character, and convert it to the decimal equivalent. The decimal equivalent method is seldom used, and only when the general area (hemisphere) is not known.

B.2.1 Program Execution Interval

When the PPS signal is used to trigger the read data function (P15), the program table execution interval does not matter. Otherwise the timing between the GPS16X-HVS output and the datalogger read must be considered. Generally the execution interval can not be less than 2 seconds when the PPS signal is not used.

B.2.2 Reading GPS Data

Table B-2 is a sample CR23X P15 instruction for reading NMEA \$GPGGA data string. The second parameter has two dashes indicating data buffering has been turned off. The CR10X does not have the data buffering option.

TABLE B-2. P15 for NMEA \$GPGGA Data String		
Parameter	Data	Description
1	1	Repetitions
2	66 --	Configuration code for RS232 ASCII data at 38400 baud with data buffering turned off. The -- indicates data buffering turned off. Decimal delimiter
3	1	Delay before sending data out
4	05	Control ports. Two digit format AB. A is for handshaking and set to zero. B in this example is control port 5 (datalogger RCV). GPS16X-HVS communication cable: GPS transmit to control port 5 in this example
5	1	Input location where first character to transmit is stored. Note: nothing is actually transmitted
6	0	Number of consecutive input locations to send
7	42	Termination character, 42 is ASCII equivalent of the asterisk
8	100	Maximum number of characters to receive.
9	80	Delay in mS. How long to wait for \$GPGGA string
10	1	Starting input location for time and position data
11	1	Multiplier, always 1.
12	0	Offset, always 0.

P15 parameters 4, 5, and 10 are somewhat variable. When using a CR23X, parameter 4 can be set to 05, 06 or 07 depending on what control ports are used. Wiring of the communication cable depends on the selection for parameter 4. With a CR23X the GPS transmit wire is connected to the control port selected in parameter 4.

P15 is executed when the PPS signal drives control port 8 high. P15 will wait until one of three conditions is met: the time-out listed in parameter 9 has expired, the maximum number of characters in parameter 8 have been read, or the termination character listed in parameter 7 has been read.

P15 parameter 10 is the first input location you wish to store GPS data in. Fifteen sequential input locations will be used to store time and position.

B.2.2.1 CR23X Example of Instruction 15 (P15)

Port Serial I/O (P15)		
1:	1	Reps
2:	66 --	RS-232 ASCII (decimal delimiter), 38400 Baud
3:	1	Delay (units = 0.01 sec)
4:	5	Control Ports
5:	1	Output Loc [Bulk]
6:	0	No. of Locs to Send
7:	42	Termination Character
8:	100	Maximum Characters
9:	80	Time Out Delay (units = 0.01 sec)
10:	1	Loc [Raw_time1]
11:	1	Mult
12:	0	Offset

NOTE

Communication cable wiring for:

CR23X/Example B.2.2.1 — PPS to C8, GPS transmit to C5.

B.2.3 Filters

Filters can be used to make sure P15 reads the correct data string. Filters also ensure P15 starts to read the string at the beginning of the string. To use a filter, follow P15 with instruction P63 (extended parameters). P63 is used to define the filter. Enter the desired filter in P63.

TABLE B-3. Filter	
ASCII Equivalent	Character
36	\$
71	G
80	P
71	G
71	G
65	A

B.2.4 Managing the Data

Several of the data values in the \$GPGGA string are too large to view or write to final storage. Some simple math is used to parse the data.

The UTC time is in the format hhmmss where hh is the hours, mm is the minutes and ss is the seconds. Six digits are too many to view with the datalogger display and some software. Add 0.3 to the raw time field. Multiply the raw time input location by 0.01 to reduce the magnitude and place the seconds in the fractional portion of the number. Next use P45 to write the

integer portion (hours/minutes) to a new input location, then use P44 to write the fractional portion to another input location (seconds) and multiply that location by 100. The last step is to use P45 again to take the integer portion of the input location for seconds. The result is hour/minutes in one input location and seconds in another.

The latitude and longitude can be parsed with the P15 instruction when decimal delimiter is on. If P15, parameter 2 is 6x, where the x selects the baud rate, every non-numeric value and decimal point will act as a delimiter. The Degrees and Minutes will be placed in one input location, and the minute fractional portion will be placed in the next input location. The decimal delimiter preserves the resolution of the original measurement.

Further parsing of the latitude and longitude may be necessary. Longitude degrees and minutes can range in value up to 18059, which exceeds the low resolution format of the dataloggers final storage area. Either parse the latitude and longitude degrees and minutes the same way the time was parsed, or store the data in high-resolution format.

The GPS quality number can be used to determine if you have a valid GPS fix and if the datalogger received the data properly. Use P89 to test if the GPS quality number is greater than or equal to one. There is a catch to using the GPS quality number to verify your data. P15 will write to fifteen input locations if everything works correctly. If P15 fails to read the GPS data, only the first input location is written to. The GPS quality number will be unchanged. If P15 fails to read the GPS data, the value displayed in the first input location will be 99999. The datalogger actually stores FFFFFFFFh, a very large number. The time field includes six digits, which can be greater than 99999. This limits the usefulness of the time field as a test for a valid GPS fix. A better approach is to overwrite the GPS quality location with zero before executing P15. Use P30 to overwrite one input location.

If the GPS time is used to set the datalogger clock, the GPS time must be parsed into three input locations: Hour, Minutes, Seconds. P114 is used to set the datalogger clock to match values in input locations. Some time will have passed between the GPS fix and when the program table reaches the P114 instruction. Adjustments can be made by adding a second or two. Be careful about setting seconds to a number greater than 59. You can also correct the UTC time to local time. Table based dataloggers require year, day, hour, minute, and seconds to use P114. Only hour, minutes, and seconds are available from the \$GPGGA string. The PGRFM string includes the month, day and year, but is difficult to use.

B.2.5 Program Discussion

Wiring when using Instruction 15:

Function	Color	Datalogger Connection
Power in	Red	12 volts
Power ground	Black	Ground
Power switch	Yellow	ground
TXD	White	C5
PPS	Gray	C8
Ground	Blue	R _x data for reconfig
Shield	Shield	Ground

The GPS16X-HVS needs to be reconfigured using the Garmin configuration software from the Garmin website for 1200 baud, 8 data bits, 1 stop bit and no parity (see Appendix A). The GPGGA string should be output. The 1 pulse per second signal should be output with a pulse duration of 80 milliseconds.

The code required to read the GPS information and store it to final storage is in Subroutine 98. Subroutine 98 is interrupt driven and triggered when a rising edge is detected on Control port 8. The GPS16X-HVS has a 1 PPS signal which is wired to control port 8. The transmit data line of serial port 1 on the GPS16X-HVS is wired to control port 5. The GPS16X-HVS serial port 2 generally is not used.

When the 1 PPS signal triggers subroutine 98, P15 is executed. P15 is setup to read ASCII serial data. Each data point is separated by a non-numeric character or a decimal point. Fifteen input locations are used as temporary storage for the \$GPGGA string. Table 4-1 explains the \$GPGGA string.

The input locations used for the \$GPGGA string are:

- 1) Raw_Time, Time in hours, minutes, and seconds
- 2) LatDegMin, Latitude degrees and minutes
- 3) Lat_Frac, Latitude fractions of minute
- 4) LngDegMin, Longitude degrees and minutes
- 5) Lng_Frac, Longitude fractions of minute
- 6) Quality, GPS quality indicator
- 7) NumSats, Number of satellites in use
- 8) HDPWhole, Horizontal Dilution of Precision
- 9) HDPFrac, Horizontal Dilution of Precision, tenths
- 10) Elevation, Elevation in meters
- 11) Geoidal, Geoidal separation in meters
- 12) Geoidalth, Geoidal separation in meters, tenths
- 13) Age, Age of differential GPS data
- 14) Agetenth, Age of differential GPS data, tenths
- 15) DiffID, Differential reference station ID

Additional input locations used in the example program are:

- 18) Orig_TM, Copy of original time
- 19) Int1, Place holder for math
- 20) Hours, formatted hours
- 21) Minutes, formatted minutes
- 22) Seconds, formatted seconds
- 23) remainder, place holder for math

Before writing any datalogger code, it's best to enter all the input locations needed. In Edlog, open the input location editor (F5) and enter names for the input locations listed above. When an input location is needed, use the input location pick list (F6).

B.2.5.1 CR23X Example Program

```

;{CR23X}
;

*Table 1 Program
01: 60          Execution Interval (seconds)

; Instruction to eliminate warning about unused subroutine, not needed
1: If Flag/Port (P91)
1: 11          Do if Flag 1 is High
2: 98          Call Subroutine 98

*Table 2 Program
02: 0.0000      Execution Interval (seconds)

*Table 3 Subroutines

1: Beginning of Subroutine (P85)
1: 98          Subroutine 98

;--- read serial data non-buffered
2: Port Serial I/O (P15)
1: 1           Reps
2: 66 --       RS-232 ASCII (decimal delimiter), 38400 Baud
3: 1           Delay (0.01 sec units) before TX
4: 5           No RTS/DTR, C5 TXD/RXD
5: 1           Start Loc for TX [ Raw_Time ]
6: 0           Number of Locs to TX
7: 42          Termination Character for RX
8: 100         RX Buffer Size or Max Chars to RX if Par 2 indexed (--)
9: 80          Time Out for CTS (TX) and/or RX (0.01 sec units)
10: 1          Start Loc for RX [ Raw_Time ]
11: 1.0        Mult for RX
12: 0.0        Offset for RX

;--- filter for $GPGGA
3: Extended Parameters (P63)
1: 36          Option ;$
2: 71          Option ;G
3: 80          Option ;P
4: 71          Option ;G
5: 71          Option ;G
6: 65          Option ;A
7: 0           Option
8: 0           Option

; Test for valid GPS fix and string read
4: If (X<=>F) (P89)
1: 6           X Loc [ Quality ]
2: 3           >=
3: 1           F
4: 30          Then Do

```

```

; Make a copy of time
5: Z=X (P31)
   1: 1      X Loc [ Raw_Time ]
   2: 18     Z Loc [ Orig_TM ]

; Add 0.45 to time stamp to eliminate complications with
; floating point math, P44, and P45
6: Z=X+F (P34)
   1: 18     X Loc [ Orig_TM ]
   2: 0.45    F
   3: 18     Z Loc [ Orig_TM ]

; Move minutes and seconds right of decimal
7: Z=X*F (P37)
   1: 18     X Loc [ Orig_TM ]
   2: .0001   F
   3: 19     Z Loc [ Int1 ]

; Pluck off hours
8: Z=INT(X) (P45)
   1: 19     X Loc [ Int1 ]
   2: 20     Z Loc [ Hours ]

; Subtract hours out
9: Z=X-Y (P35)
   1: 19     X Loc [ Int1 ]
   2: 20     Y Loc [ Hours ]
   3: 19     Z Loc [ Int1 ]

; Move decimal left 2 places
10: Z=X*F (P37)
   1: 19     X Loc [ Int1 ]
   2: 100     F
   3: 19     Z Loc [ Int1 ]

; Pluck off minutes
11: Z=INT(X) (P45)
   1: 19     X Loc [ Int1 ]
   2: 21     Z Loc [ Minutes ]

; Subtract out minutes
12: Z=X-Y (P35)
   1: 19     X Loc [ Int1 ]
   2: 21     Y Loc [ Minutes ]
   3: 19     Z Loc [ Int1 ]

; Move decimal left 2 places
13: Z=X*F (P37)
   1: 19     X Loc [ Int1 ]
   2: 100     F
   3: 19     Z Loc [ Int1 ]

; Pluck of seconds
14: Z=INT(X) (P45)
   1: 19     X Loc [ Int1 ]
   2: 22     Z Loc [ Seconds ]

```

```

; Write data to final storage every time there is
; a valid read of GPS data
15: Do (P86)
    1: 10          Set Output Flag High (Flag 0)

16: Set Active Storage Area (P80)^18796
    1: 1          Final Storage Area 1
    2: 101        Array ID

; Write datalogger based time stamp
17: Real Time (P77) ^27570
    1: 0011       Hour/Minute,Seconds (midnight = 0000)

; Write GPS based time stamp
18: Sample (P70) ^6080
    1: 3          Reps
    2: 20         Loc [ Hours  ]

; Set resolution to high for latitude and Longitude
19: Resolution (P78)
    1: 1          High Resolution

20: Sample (P70) ^20303
    1: 4          Reps
    2: 2          Loc [ LatDegMin ]

; Write elevation in meters
21: Sample (P70) ^32246
    1: 1          Reps
    2: 10         Loc [ Elevation ]

; Set resolution low
22: Resolution (P78)
    1: 0          Low Resolution

; Write the number of satellites in view
23: Sample (P70) ^1910
    1: 1          Reps
    2: 7          Loc [ NumSats  ]

; Reset the the GPS quality number
24: Z=F x 10^n (P30)
    1: -1         F
    2: 00         n, Exponent of 10
    3: 6          Z Loc [ Quality ]

25: End (P95)

26: End (P95)

End Program

```

B.3 Troubleshooting

The first step is to verify the GPS16X outputs with a terminal program (see Section 6.1). The second step is to verify that it really does not work. With the GPS16X-HVS running and the datalogger program running, look at the input location for GPS Quality Number. This location will show a one when the GPS16X-HVS output is picked up by the datalogger. The input location for parsed time and position are good locations to check. The location for seconds should update every time the GPS data is updated.

If the GPS time and position data are not shown in the input locations, check the communication cable wiring.

If the GPS16X-HVS data is not correct every program table execution but correct sometimes, check the P15 time-out. It may need a longer time-out. Also check the P15 maximum number of characters to receive, usually 100 is enough. Check the P15 termination character; it should be set to 42 (*). The termination character should also work if set to 13 or 10. Also check the buffering and filter. Buffering should be turned off by indexing parameter 2.

For P15 to properly read the \$GPGGA string, P15 must be executing while the \$GPGGA string starts and finishes. The P15 time-out needs to be long enough to pick up the string. The string is output once a second. If P15 starts to execute while the GPS16X-HVS is sending the string, P15 must wait until the string is sent again plus the amount of time it takes to send the string. It shouldn't need more than 1.5 seconds. P15 time-out is in units of 0.01 seconds, 100 = 1 second. A longer time-out will force the datalogger to wait until the time-out has expired or the termination character is received or the maximum number of characters are received. If the data in input locations seem to move from the proper input location to another input location, P15 is stopping before the entire string has been read. An example is latitude being displayed in the time field, then in the latitude field. P15 works best when P15 quits reading data because the termination character has been read. Using the PPS to trigger subroutine 98 is the best way to start P15 just before the GPS16X-HVS sends the \$GPGGA string. If the PPS signal pulls C8 high while the datalogger is in the middle of executing an instruction, it may not be able to run subroutine 98 before the \$GPGGA string has started, which will cause the datalogger to miss the data string. Turning on the data buffering may remedy the problem. Lengthening the serial time-out to allow P15 to execute for 2 cycles of NMEA output may help. Otherwise the SDM-SIO4 may be required or the datalogger program will need to be simplified.

The datalogger will not pick up valid data until the GPS16X-HVS has a valid GPS fix, except during a GPS16X-HVS warm start where time can be read before position is known. Don't spend a lot of time trouble shooting a phantom problem just because the GPS receiver does not have a valid GPS fix.

Appendix C. Using an SDM-SIO4

C.1 SDM-SIO4 Connections

An SDM-SIO4 should be used if measuring the GPS16X-HVS with a CR5000 or CR9000X datalogger. An SC110 cable is required to connect the GPS16X-HVS to an SDM-SIO4. The SC110 consists of two cables. Use the cable that terminates in a 9-pin male connector (DTE). The stripped and tinned leads of that cable attach to the GPS16X-HVS (see Table C-1).

TABLE C-1. SC110's Cable Wiring		
Wire Color of SC110's Cable	Wire Color of GPS16X-HVS	Power Supply
Brown	Gray	N/A
White	White	N/A
Yellow	Shield	N/A
N/A	Red	+12 V
N/A	Black	Power Ground

C.2 CR9000X Example Program

```
'NMEA_GGA_Sio4_030805MGW1.CR9
' This program acquires NMEA GGA data from a GPS receiver using the SDM-SIO4.
'
' Notes:
' (1) Data is acquired from NMEA0183 $GPGGA string:
'   Sio4Fields: GGAFields: Definitions:
'   f1         GGA(Field1)  GGA.UTC_Time of position
'   f2,f3      GGA(Field2)  Latitude
'   f4,        GGA(Field3)  North or South indication letter
'   f5,f6      GGA(Field4)  Longitude
'   f7         GGA(Field5)  East or West indication letter
'   f8         GGA(Field6)  GPS quality,0=NoGPS,1=GPS,2DGPS
'   f9         GGA(Field7)  Number of satellites in use
'   f10        GGA(Field8)  HDOP, Horizontal Dilution Of Precision
'   f11        GGA(Field9)  Antenna altitude in Meters
'   GGA(Field10)
'   GGA(Field11) Geoidal separation in Meters
'   GGA(Field12)
'   GGA(Field13) Age of differential GPS data
'   GGA(Field14) Differential reference station
' (2) SIO4 programming:
'   fltst 1 "t[$GPGGA,]xFt[,]Dt[,]Dt[,]b1t[,]Dt[,]Dt[,]b1t[,]Ft[,]Ft[,]Ft[,]FX"
'
' Const OneRep=1
' Const NoValues=0
' Const OneValue=1
```

```

Const ElevenGGAValues=11
'..
Const UnityMultiplier=1.0
Const NoOffset=0.0
'..
Const Sio4Address0=0
Const Port2=2
'..
'SDM-Sio4 command codes:
Const UnusedParameter = 0000
Const PollForData0001 = 0001
Const SendDataToLgr = 0004
Const Sio4COMSetUpCmd = 2049
Const StartRxFilter = 2054
Const Port2ComCode = 9147 '9=NoHandshaking; 1=1StopBitNoParity; 4=8DataBits; 7=19200Baud
Const RxFilt9001 = 9001 'Command parameter for user defined fltst #1.
Dim DataPoll,NotUsed
'..
Public RawGGADData(ElevenGGAValues)
Alias RawGGADData(1)=GGA.UTC.Time
Alias RawGGADData(2)=Latt_Int : Units Latt_Int=Deg
Alias RawGGADData(3)=Latt_Frac : Units Latt_Frac=Deg
Alias RawGGADData(4)=LattH_NS
Alias RawGGADData(5)=Longit_Int : Units Longit_Int=Deg
Alias RawGGADData(6)=Longit_Frac : Units Longit_Int=Deg
Alias RawGGADData(7)=LongH_EW
Alias RawGGADData(8)=GPSQuality
Alias RawGGADData(9)=Satellites
Alias RawGGADData(10)=HDOP
Alias RawGGADData(11)=Altitude : Units Altitude=Meters
'..
DataTable(GPSData,True,-1)
DataInterval(0,0,0,0)
Sample(ElevenGGAValues,RawGGADData(),IEEE4)
EndTable
'..
BeginProg
'.....
'Configure SDM-Sio4 Port#2 for communications with GPS port:

SDMSIO4(NotUsed,OneRep,Sio4Address0,Port2,Sio4COMSetUpCmd,Port2ComCode,UnusedParameter,NoValues,UnityMultiplier,NoOffset)
    Delay(100,mSec)
'.....
'Start GGA data filter on SDM-Sio4 port:

SDMSIO4(NotUsed,OneRep,Sio4Address0,Port2,StartRxFilter,RxFilt9001,UnusedParameter,NoValues,UnityMultiplier,NoOffset)
    Delay(20,mSec)
'.....
Scan(50,mSec,0,0) 'Main Scan:
'..

SDMSIO4(DataPoll,OneRep,Sio4Address0,Port2,PollForData0001,UnusedParameter,UnusedParameter,OneValue,UnityMultiplier,NoOffset)
    If DataPoll>0 Then

```



```
    Delay(10,mSec)

SDMSIO4(RawGGADData(),OneRep,Sio4Address0,Port2,SendDataToLgr,UnusedParameter,UnusedParameter,Ele
venGGAVvalues,UnityMultiplier,NoOffset)
    Delay(10,mSec)
    CallTable(GPSData)
    EndIf
'..
NextScan
'
EndProg
```


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