SV8PLUS GPS RECEIVER
INSTRUCTION MANUAL

REVISION: 8/03

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SV8PLUS GPS Receiver

1. Overview

The Trimble Navigation SVeeEight Plus (SV8) is a complete GPS receiver manufactured by Trimble Navigation. The SV8 has been configured by Campbell Scientific, Inc. (CSI) to work with CSI dataloggers.

The SV8 is intended for use with the CR10X, CR23X and newer dataloggers that support P15. Two control ports are required. The CR23X can read standard NEMA strings at 4800 baud and use the RS232 port. The CR510 cannot read the SV8.

The SV8 includes a power cable, communication cable, and mini-magnet mount antenna with a five-meter cable. An optional SV8 mounting bracket, part number 14021, can be purchased with the SV8.

FIGURE 1-1. SV8PLUS

2. Connections

The SV8 has three connections: Power, Communications, GPS antenna. All three cables are supplied with the SV8.

2.1 SV8PLUS Power Cable

The power cable, Campbell part number 14018, has three wires (red, yellow, black) and is terminated in a three-pin plastic connector that mates with the power connector on the receiver. The functions of the cable, and the connections to the datalogger are listed in Table 2-1.

TABLE 2-1. SV8 Power Cable			
Cable Color	**Function**	**Datalogger Connection**	**Comments**
Red	DC Power	12V (if GPS left on always) SW 12V (if GPS not left on)	Requires 9-32V DC, 105 mA @ 9V, 68 mA @ 14V
Black	Ground	GND	
Yellow	Battery Backup	5V	Keeps receiver RAM on, uses ~ 3 uA

2.2 SV8PLUS Serial Communication Cable

The supplied serial communication cable, part number 14019, has three wires. White is GPS transmit, black is GPS receive, clear is ground. The serial cable has a 1k series resistor to limit GPS TXD current. Connect SV8 serial port 2 to the proper datalogger control ports.

The exact connection to the datalogger will depend on control ports used. Connect the GPS TXD to the datalogger RXD, GPS RXD to datalogger TXD, Ground to G, and configure P15 to use RS-232 inverted data at 1200 baud.

Both serial ports on the receiver are RS-232 DCE; after configuration of the receiver, Port 1 is set for RTCM input (4800 baud), no output. Port 2 is configured for TAIP input, NMEA output, 1200 baud. Port 2 is connected to the datalogger; port 1 is not used. The pin out of both serial ports is the same and shown in Table 2-2.

TABLE 2-2. SV8 Serial Ports	
Pin	**Description**
1,4,6,7,8	NC
2	TXD (output)
3	RXD (input)
5	GND
9	1 PPS Out (1 Pulse Per Second open collector output (10 usec) with falling edge synchronized to UTC). The PPS output precedes the NMEA message output.

TABLE 2-3. Serial Communication Cable		
Wire Color	**GPS function**	**Datalogger Connection**
White	GPS TXD	Datalogger RXD
Black	GPS RXD	Datalogger TXD
Clear	GPS GND	Datalogger G

2.3 SV8PLUS Antenna

The GPS antenna must be connected to the SV8 antenna RF connector and the GPS antenna must have a clear view of the sky. Generally the GPS antenna will not work indoors. The GPS antenna connector is a female SMB. The GPS antenna is a five-volt active micropatch with a five-meter cable.

FIGURE 2-1. SV8PLUS, Enclosure, Power Supply

3. GPS Data

The SV8 has several data formats available. The SV8 is configured to output the NEMA $GPGGA time and position string. It is possible to configure the SV8 to output the $GPVTG velocity string, see the appendix for details.

Sample NEMA $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 3-1. NEMA $GPGGA String Definition

Field	Description	
0	$GPGGA	NEMA 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 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.

When P15 is used to read numeric values, fields 1, 2, 4, 6, 7, 8, 9, 11, 13, and 14 are input into sequential input locations. Ten input locations will be used.

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

3.1 Synchronizing GPS Data to Datalogger Program

The NMEA output typically comes at a fixed interval; default is 1/sec. To aid in synchronizing the NMEA output with the datalogger P15 instruction, a TAIP command to enable NMEA output is sent by the P15 instruction that captures the NMEA output. Once the output is captured, another TAIP command is sent via a P15 to disable the NMEA output. This sequence synchronizes the datalogger to the NMEA output. The detailed steps are:

1. If using SW 12V, turn power ON to GPS receiver.

2. Delay one second.

3. Execute P15 which sends TAIP NMEA ON command, and captures NMEA output.

4. Execute P15 which sends TAIP NMEA OFF command.

5. Evaluate NMEA output and decide if it is valid (use GPS Quality Indicator).

6. If NMEA output is valid and using SW 12V, turn power OFF to the GPS receiver.

7. If not valid, leave GPS powered up until valid, checking periodically.

When the SV8 is powered down, the GPS almanac and time can be maintained by supplying five volts to the yellow wire of the power cable. The five-volt backup power allows the receiver to use the previously acquired almanac, ephemeris, and last position information to do a hot or warm start. The amount of time the GPS needs to be left powered on until a GPS fix is acquired is dependent on when the last fix occurred, and if power has been removed or not. The SV8 has three different power up states: cold start, warm start, hot start.

3.2 Cold Start

The term "cold start" describes the performance of a GPS receiver at power-on when no navigation data is available. "Cold" signifies that the receiver does not have a current almanac, satellite ephemeris, initial position, or time. The cold start search algorithm applies to a GPS which has no memory of its previous session (i.e., is powered on without the memory backup circuit connected to a source of DC power). This is the "out-of-the-box" condition of the GPS module as received from the factory. In a cold start condition the receiver automatically selects a set of eight satellites and dedicates an individual tracking channel to each satellite, to search the Doppler range frequency for each satellite in the set. If none of the eight selected satellites is acquired after a pre-determined period of time (time-out), the receiver will select a new search set of eight satellites and will repeat the process, until the first satellite is acquired. As satellites are acquired, the receiver automatically collects ephemeris and almanac data. The GPS uses the knowledge gained from acquiring a specific satellite to eliminate other satellites, those below the horizon, from the search set. This strategy speeds the acquisition of additional satellites required to achieve the first position fix. The cold start search sets are established to ensure that at least three satellites are acquired within the first two time-out periods. As soon as three satellites are found, the receiver will compute an initial position fix. The typical time to first fix is less than two minutes.

A complete system almanac is not required to achieve a first position fix. However, the availability and accuracy of the satellite ephemeris data and the availability of a GPS almanac can substantially shorten the time to first fix.

3.3 Warm Start

In a warm start condition, the receiver has been powered down for at least one hour but has a current almanac and an initial position and time stored in memory. When connected to an external backup battery, the GPS retains the almanac, approximate position, and time to aid in satellite acquisition and reduce the time to first fix.

During a warm start, the GPS identifies the satellites which are expected to be in view, from the system almanac, the initial position and the approximate time. The receiver calculates the elevation and expected Doppler range frequency for each satellite in this expected set and directs the eight tracking channels in a parallel search for these satellites.

The warm start time to first fix, when the receiver has been powered down for more than 60 minutes (i.e. the ephemeris data is old), is usually less than 45 seconds.

3.4 Hot Start

A hot start strategy applies when the GPS has been powered down for less than 60 minutes, and the almanac, position, ephemeris, and time are valid. The hot start search strategy is similar to a warm start, but since the ephemeris data in memory is considered current and valid, the acquisition time is typically less than 20 seconds.

4. Programming

Program instruction 15 (P15) is used to read the NEMA $GPGGA string of GPS data. Each iteration of P15 can either read the numbers or read everything. When reading the numbers, 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. P15 can be used to import everything in the string and convert it to the decimal equivalent. The decimal equivalent method is seldom used, and only when the general area (hemisphere) is not known.

4.1 Program Execution Interval

The datalogger program must allow enough time to turn the SV8 on, wait for the data string, and turn the SV8 off. There are other steps involved, but they don’t take much time. Generally two seconds is the fastest the CR23X will import the GPS data. The CR10X requires three seconds.

4.2 Loading NEMA On and Off Commands

The command used to enable the NEMA output is loaded to input locations. When the NEMA output is enabled, all active NEMA strings are output on a one-second interval. The default state only uses the $GPGGA string.

NEMA on command is: >SPR;NMEA=FO<
NEMA off command is: >SPR;NMEA=FF<

For each NEMA command, use two bulk load commands (P65) to load the ASCII equivalent of each character in consecutive input locations. Appendix E of the datalogger manual is an ASCII table.

TABLE 4-1. NEMA On Command	
ASCII Equivalent	**Character**
62	>
83	S
80	P
82	R
59	;
78	N
77	M
69	E
65	A
61	=
70	F
79	O
60	<

TABLE 4-2. NEMA Off Command	
ASCII Equivalent	**Character**
62	>
83	S
80	P
82	R
59	;
78	N
77	M
69	E
65	A
61	=
70	F
70	F
60	<

4.3 Reading GPS Data

Each read of the GPS data requires three steps. Enable NEMA output, read string, and disable NEMA output. If the SV8 is usually powered down, power must be switched on before sending commands to the transmitter. The SV8 must remain on long enough to acquire a GPS fix before the datalogger can read a valid GPS string.

One P15 command can be used to enable NEMA output and read the data string. Example 4.1 shows P15 with a CR23X to read the NEMA $GPGGA data string.

TABLE 4-3. P15 for NEMA $GPGGA Data String

Parameter	Data	Description
1	1	Repetitions
2	1 --	Configuration code for RS232 ASCII data at 1200 baud with data buffering turned off. The -- indicates data buffering turned off.
3	1	Delay before sending NEMA on command.
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 TXD). Control port 6 is datalogger RXD. SV8 communication cable: Black wire C5, White wire to C6, gnd.
5	10	Input location where first character of NEMA on command is stored.
6	13	Number of consecutive input locations to send, NEMA on command
7	42	Termination character, 42 is ASCII equivalent of the asterisk
8	120	Maximum number of characters to receive.
9	250	Delay in mS. How long to wait for $GPGGA string
10	40	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. A CR10X can use control ports 1 through 6. Wiring of the communication cable depends on the selection for parameter 4. With a CR23X the black wire is connected to the control port selected in parameter 4, the white wire connects to the next high number control port. With a CR10X, the black wire is connected to the next higher numbered control port than the control port specified in parameter 4. The white wire is connected to one port higher than the black wire.

P15 parameter 5 is the first input location of the block of input locations used to store the NEMA on command. Parameter 6 is how many input locations are used to store the NEMA on command. P15 will start transmitting input locations at the location specified in parameter 5 and send the number of locations specified in parameter 6. After sending the NEMA command, P15 will wait to read data. 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. Ten sequential input locations will be used to store time and position.

Example 4.1 Program Instruction 15 (P15) for CR23X

```
Port Serial I/O (P15)
  1:  1          Reps
  2:  1          -- Configuration Code
  3:  1          Delay (units = 0.01 sec)
  4:  5          Control Ports
  5:  10         Output Loc [ Bulk     ]
  6:  13         No. of Locs to Send
  7:  42         Termination Character
  8:  120        Maximum Characters
  9:  250        Time Out Delay (units = 0.01 sec)
  10: 40         Loc [ Raw_time1 ]
  11: 1          Mult
  12: 0          Offset
```

Example 4.2 Program Instruction 15 (P15) for CR10X

```
8:  Port Serial I/O (P15)
  1:  1          Reps
  2:  1          ASCII/RS-232, 1200 Baud
  3:  1          Delay (units = 0.01 sec)
  4:  1          First Control Port
  5:  10         Output Loc [ Bulk     ]
  6:  13         No. of Locs to Send
  7:  42         Termination Character
  8:  100        Maximum Characters
  9:  150        Time Out Delay (units = 0.01 sec)
  10: 40         Loc [ Raw_time1 ]
  11: 1.0        Mult
  12: 0.0        Offset
```

NOTE Communication cable wiring for: CR23X/Example 4.1: Black to C5, White to C6. CR10X/Example 4.2. Black to C2, White to C3. CR10X, P15 parameter 2, buffering off without indexing.

4.4 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 the same way the NEMA on and off commands are entered in P65 bulk load.

TABLE 4.-4. Filter	
ASCII Equivalent	**Character**
36	$
71	G
80	P
71	G
71	G
65	A

4.5 Disable NEMA Output

To disable NEMA output, P15 is used again to send a command; there is no data to read back. The NEMA off command should be stored in 13 sequential input locations using the P65 bulk load command. P15 should be setup almost the same as before except parameter 5 is a different starting location for the NEMA off command, parameter 8 is set to zero, the time-out is less and parameter 10 is a dummy location because nothing is returned.

4.6 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. The six digits are too large to view. 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 require similar work. Use P45 to write the integer portion of latitude and longitude to new input locations that will hold degrees and minutes. You can parse these further to place degrees in one location and minutes in another. Use P44 to write the fractional portion of latitude and longitude to new input locations. The fractional portion is thousandths of a degree.

If the longitude is parsed to two input locations, the location with degrees and minutes must be stored as high resolution. The other option is to parse the degrees and minutes into separate input locations. For latitudes greater than 69 degrees, take the same steps as with longitude.

The GPS quality number can be used to determine if you have a valid GPS fix and 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 ten 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 FFFFh, 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.

The GPS time can be used to set the datalogger clock. If this is desired, 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.

5. 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.

5.1 GPS Setup and Function

Test NEMA on string, NEMA off string, GPS fix, and serial port function; use a computer, terminal emulator software, a serial port (RS232), and a 9-pin to 9-pin serial cable. The computer and serial port can be the same one used to communicate with the datalogger. The serial cable can be an SC12 cable. Terminal emulation software is pretty common. Hyperterm is supplied as part of Windows ™ and works well. Procomm ™ is another popular software package that works well.

Set up the software for the correct serial port, 1200 baud, 8 data bits, 1 stop bit and no parity. Flow control should be off. Using the serial cable, connect the SV8 to the computer serial port. Connect to the SV8 port 2. Power up the SV8. The GPS antenna should have a clear view of the sky. Don’t expect the GPS antenna to work indoors. The NEMA on and off strings can be sent as a text file or typed from the keyboard. After the NEMA on command is sent, the $GPGGA string should be displayed once a second. After the NEMA off command, the $GPGGA string should not be updated. Once the NEMA on command is working, 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. Issue the NEMA off command before testing further.

5.2 Datalogger Program and Wiring

Datalogger program testing can't be broken down into small segments. The program testing includes cable testing. The first step is to verify it really does not work. With the SV8 running and the datalogger program running, look at the input location for GPS Quality Number. This location will show a one when the SV8 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 program table runs.

If the SV8 data is not shown in the input locations, check the communication cable wiring. SV8 port 2 to the proper control ports.

If the SV8 data is not correct every program table execution but correct sometimes, check program table execution interval. A slower interval may be required. Also check the P15 time-out. It may need a longer time-out. Also check the P15 maximum number of characters to receive, usually 120 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. On a CR23X, index parameter 2. On a CR10X don't index parameter 2. It is possible to use buffering, but generally buffering should be off.

If further testing of the datalogger program and wiring is required, make several small programs, or control portions of the program with user flags. Test the NEMA on command. With the SV8 properly connected to the datalogger, issue the NEMA on command and then connect the SV8 to the PC. Using the terminal emulation software, you should see the $GPGGA string update once a second. Reconnect the SV8 to the datalogger and test the NEMA off command. Connect to PC to verify the NEMA off command worked.

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 SV8 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.

The datalogger will not pick up valid data until the SV8 has a valid GPS fix, except during a SV8 warm start where time can be read before position is known.

Appendix A. Program Examples

Example A.1 CR10X Program

```
;{CR10X}
;

; CR10X program using P15 instruction with SV8 plus Trimble Navigation
; GPS receiver. Program inputs time and position only.
; The Velocity (GPVTG) string is not used.

; The SV8 is setup to allow the NEMA strings to be
; turned on and off. The logger enables NEMA output,
; reads the data then disables NEMA output.

; The velocity strings (VTG)can be handled the same way.

; Wiring:
; GPS power: Red to 12V, Black to GND, Yellow to 5V.
; Yellow is optional, used to backup SV8 memory.
; GPS RS232: Cable has a 1 KOhm resistor in
; series with the GPS TX line, which is white.
; Wire Black to C2, White to C3, clear to GND.

; Operation:
; Flag 1 high will turn SV8 NEMA GGA string on and get data
; Flag 2 high will turn SV8 NEMA GGA string off
; Input locations used:
; 3 Hours/Minutes
; 4 Seconds
; 5 Lat - Degrees
; 6 Lat - Thousands
; 7 Long - Degrees
; 8 Long - Thousands
; 43 Quality, zero is no GPS signal
; 44 Number of satellites in view
; 46 Altitude in meters

; Check all input locations for valid numbers

; Program requires 250 input locations. Use input location editor (F5) to add input locations.

*Table 1 Program
  01: 5            Execution Interval (seconds)

1:  Batt Voltage (P10)
  1:   1           Loc [ Battery   ]


; Load Command to turn NEMA GGA string on
; >SPR;NMEA=FO<
```

```
2:  Bulk Load (P65)
   1:   62            F ;>
   2:   83            F ;S
   3:   80            F ;P
   4:   82            F ;R
   5:   59            F ;;
   6:   78            F ;N
   7:   77            F ;M
   8:   69            F ;E
   9:   10            Loc [ NEMAon_1  ]

3:  Bulk Load (P65)
   1:   65            F ;A
   2:   61            F ;=
   3:   70            F ;F
   4:   79            F ;O
   5:   60            F ;<
   6:   0.0           F
   7:   0.0           F
   8:   0.0           F
   9:   18            Loc [ NEMAon_9  ]

; Load command to turn NEMA GGA string off
; >SPR;NMEA=FF<
4:  Bulk Load (P65)
   1:   62            F ;>
   2:   83            F ;S
   3:   80            F ;P
   4:   82            F ;R
   5:   59            F ;;
   6:   78            F ;N
   7:   77            F ;M
   8:   69            F ;E
   9:   23            Loc [ NMAoff_1  ]

5:  Bulk Load (P65)
   1:   65            F ;A
   2:   61            F ;=
   3:   70            F ;F
   4:   70            F ;F
   5:   60            F ;<
   6:   0.0           F
   7:   0.0           F
   8:   0.0           F
   9:   31            Loc [ NMAoff_9  ]

; If Flag 1 high, turn on NEMA outputs and receive NEMA string
6:  If Flag/Port (P91)
   1:   11            Do if Flag 1 is High
   2:   30            Then Do
```

```
; Clear GPS Quality input location
7:  Z=F (P30)
   1:   0              F
   2:   0              Exponent of 10
   3:   43             Z Loc [ Quality   ]

; Enable NEMA $GPGGA string, read data
8:  Port Serial I/O (P15)
   1:   1              Reps
   2:   1              ASCII/RS-232, 1200 Baud
   3:   1              Delay (units = 0.01 sec)
   4:   1              First Control Port
   5:   10             Output Loc [ NEMAon_1  ]
   6:   13             No. of Locs to Send
   7:   42             Termination Character
   8:   100            Maximum Characters
   9:   150            Time Out Delay (units = 0.01 sec)
   10:  40             Loc [ Raw_time1 ]
   11:  1.0            Mult
   12:  0.0            Offset

9:  End (P95)

; If Flag 2 high, turn off NEMA outputs
10:  If Flag/Port (P91)
   1:   12             Do if Flag 2 is High
   2:   30             Then Do

11:  Excitation with Delay (P22)
   1:   1              Ex Channel
   2:   50             Delay W/Ex (units = 0.01 sec)
   3:   0000           Delay After Ex (units = 0.01 sec)
   4:   0000           mV Excitation

12:  Port Serial I/O (P15)
   1:   1              Reps
   2:   1              ASCII/RS-232, 1200 Baud
   3:   1              Delay (units = 0.01 sec)
   4:   1              First Control Port
   5:   23             Output Loc [ NMAoff_1  ]
   6:   13             No. of Locs to Send
   7:   42             Termination Character
   8:   0              Maximum Characters
   9:   13             Time Out Delay (units = 0.01 sec)
   10:  60             Loc [ Null      ]
   11:  1.0            Mult
   12:  0.0            Offset

13:  End (P95)
```

```
; Time field is too large to display, these instructions
; break the time into 2 input locations. The first for
; Hours and Minutes (Hour_Min), the second for seconds
14:  Z=X*F (P37)
   1:   40            X Loc [ Raw_time1 ]
   2:   .01           F
   3:   2             Z Loc [ Raw_time2 ]

15:  Z=INT(X) (P45)
   1:   2             X Loc [ Raw_time2 ]
   2:   3             Z Loc [ Hour_Min  ]

16:  Z=FRAC(X) (P44)
   1:   2             X Loc [ Raw_time2 ]
   2:   4             Z Loc [ Seconds   ]

17:  Z=X*F (P37)
   1:   4             X Loc [ Seconds   ]
   2:   100           F
   3:   4             Z Loc [ Seconds   ]

18:  Z=INT(X) (P45)
   1:   4             X Loc [ Seconds   ]
   2:   4             Z Loc [ Seconds   ]

19:  If (X<=>F) (P89)
   1:   4              X Loc [ Seconds   ]
   2:   3             >=
   3:   60            F
   4:   30            Then Do

20:  Z=F (P30)
   1:   0             F
   2:   0             Exponent of 10
   3:   4             Z Loc [ Seconds   ]

21:  End (P95)

; Separate the degrees from the thousands of degrees
; in the Lat and Long.

22:  Z=INT(X) (P45)
   1:   41            X Loc [ Latitude  ]
   2:   5             Z Loc [ Lat_Deg   ]

23:  Z=FRAC(X) (P44)
   1:   41            X Loc [ Latitude  ]
   2:   6             Z Loc [ Lat_Thds  ]

24:  Z=INT(X) (P45)
   1:   42            X Loc [ Longitude ]
   2:   7             Z Loc [ Long_Deg  ]
```

```
25:  Z=FRAC(X) (P44)
   1:   42              X Loc [ Longitude ]
   2:   8               Z Loc [ Long_Thds ]

; Only write data if GPS data is valid
; Note: This method does not work for Averages, Max, Mins, etc.
26:  If (X<=>F) (P89)
   1:   43              X Loc [ Quality   ]
   2:   3               >=
   3:   1               F
   4:   30              Then Do

; Set output flag and write data to Final Storage
; Use High resolution because Longitude can be 5 digits.
27:  Do (P86)
   1:   10              Set Output Flag High (Flag 0)

28:  Real Time (P77)
   1:   0220            Day,Hour/Minute (midnight = 2400)

29:  Resolution (P78)
   1:   1               High Resolution

30:  Sample (P70)
   1:   2               Reps
   2:   3               Loc [ Hour_Min  ]

31:  Sample (P70)
   1:   4               Reps
   2:   5               Loc [ Lat_Deg   ]

32:  Sample (P70)
   1:   6               Reps
   2:   43              Loc [ Quality   ]

33:  End (P95)
```

Example A.2 CR23X Program Example

```
;{CR23X}
;

; CR23X program using P15 instruction with SV8 plus Trimble Navigation
; GPS receiver. Program inputs time and position only.
; The Velocity (GPVTG) string is not used.

; The SV8 is setup to allow the NEMA strings to be
; turned on and off. The logger enables NEMA output,
; reads the data then disables NEMA output.

; The velocity strings (VTG) can be handled the same way.

; GPS serial cable wiring.
; CR23X         SV8          Function
; C5            Black        Transmit from 23X to SV8
; C6            White        Receive from SV8 to 23X
; Gnd           Clear        Ground

; GPS power cable wiring.
; Red to Switched 12 Volts.
; Yellow to 5 Volts, optional backup power.
; Black to Ground.

; Flags
; Flag 1       Turn NEMA string on, get time, lat, long
; Flag 2       Turn NEMA string off
; Flag 3       Turn GPS power on
; Flag 4       Turn NEMA on, get N or S and E or W, Uses Subroutine 1

; Input locations, complete list at end of program:
; 3 Hours/Minutes
; 4 Seconds
; 5 Lat - Degrees
; 6 Lat - Thousands
; 7 Long - Degrees
; 8 Long - Thousands
; 43 Quality, zero is no GPS signal
; 44 Number of satellites in view
; 46 Altitude in meters
; 51 North (78) or South (83)
; 52 East (69) or West (87)

*Table 1 Program
  01: 5             Execution Interval (seconds)

; Turn GPS power on
1:  If Flag/Port (P91)
  1:   13           Do if Flag 3 is High
  2:   49           Turn On Switched 12V
```

```
; Turn GPS power off
2:  If Flag/Port (P91)
   1:   23            Do if Flag 3 is Low
   2:   59            Turn Off Switched 12V

3:  Batt Voltage (P10)
   1:   1             Loc [ Battery   ]

; NEMA on command: >SPR;NMEA=FO<
4:  Bulk Load (P65)
   1:   62            F ;>
   2:   83            F ;S
   3:   80            F ;P
   4:   82            F ;R
   5:   59            F ;;
   6:   78            F ;N
   7:   77            F ;M
   8:   69            F ;E
   9:   10            Loc [ NEMAon_1  ]

5:  Bulk Load (P65)
   1:   65            F ;A
   2:   61            F ;=
   3:   70            F ;F
   4:   79            F ;O
   5:   60            F ;<
   6:   0             F
   7:   0             F
   8:   0             F
   9:   18            Loc [ NEMAon_9  ]

; NEMA off command: >SPR;NMEA=FF<
6:  Bulk Load (P65)
   1:   62            F ;>
   2:   83            F ;S
   3:   80            F ;P
   4:   82            F ;R
   5:   59            F ;;
   6:   78            F ;N
   7:   77            F ;M
   8:   69            F ;E
   9:   23            Loc [ NMAoff_1  ]

7:  Bulk Load (P65)
   1:   65            F ;A
   2:   61            F ;=
   3:   70            F ;F
   4:   70            F ;F
   5:   60            F ;<
   6:   0             F
   7:   0             F
   8:   0             F
   9:   31            Loc [ NMAoff_9  ]
```

```
8:  If Flag/Port (P91)
  1:   11            Do if Flag 1 is High
  2:   30            Then Do

9:  Port Serial I/O (P15)
  1:   1             Reps
  2:   1             -- Configuration Code
  3:   1             Delay (units = 0.01 sec)
  4:   5             Control Ports
  5:   10            Output Loc [ NEMAon_1  ]
  6:   13            No. of Locs to Send
  7:   42            Termination Character
  8:   120           Maximum Characters
  9:   250           Time Out Delay (units = 0.01 sec)
  10:  40            Loc [ Raw_time1 ]
  11:  1             Mult
  12:  0             Offset

10:  Extended Parameters (P63)
  1:   36            Option
  2:   71            Option
  3:   80            Option
  4:   71            Option
  5:   71            Option
  6:   65            Option
  7:   0             Option
  8:   0             Option

11:  End (P95)

12:  If Flag/Port (P91)
  1:   12            Do if Flag 2 is High
  2:   30            Then Do

13:  Port Serial I/O (P15)
  1:   1             Reps
  2:   1             Configuration Code
  3:   1             Delay (units = 0.01 sec)
  4:   5             Control Ports
  5:   23            Output Loc [ NMAoff_1  ]
  6:   13            No. of Locs to Send
  7:   42            Termination Character
  8:   0             Maximum Characters
  9:   13            Time Out Delay (units = 0.01 sec)
  10:  2             Loc [ Raw_Time2 ]
  11:  1             Mult
  12:  0             Offset

14:  End (P95)

15:  Z=X*F (P37)
  1:   40            X Loc [ Raw_time1 ]
  2:   .01           F
  3:   2             Z Loc [ Raw_Time2 ]
```

```
16:  Z=INT(X) (P45)
  1:   2              X Loc [ Raw_Time2 ]
  2:   3              Z Loc [ Hour_Min  ]

17:  Z=FRAC(X) (P44)
  1:   2              X Loc [ Raw_Time2 ]
  2:   4              Z Loc [ Seconds   ]

18:  Z=X*F (P37)
  1:   4              X Loc [ Seconds   ]
  2:   100            F
  3:   4              Z Loc [ Seconds   ]

19:  Z=INT(X) (P45)
  1:   4              X Loc [ Seconds   ]
  2:   4              Z Loc [ Seconds   ]

; Parse Latitude and Longitude
20:  Z=INT(X) (P45)
  1:   41             X Loc [ Latitude  ]
  2:   5              Z Loc [ Lat_deg   ]

21:  Z=FRAC(X) (P44)
  1:   41             X Loc [ Latitude  ]
  2:   6              Z Loc [ Lat_thds  ]

22:  Z=INT(X) (P45)
  1:   42             X Loc [ Longitude ]
  2:   7              Z Loc [ Long_deg  ]

23:  Z=FRAC(X) (P44)
  1:   42             X Loc [ Longitude ]
  2:   8              Z Loc [ Long_thds ]

24:  Z=X (P31)
  1:   46             X Loc [ Altitude  ]
  2:   9              Z Loc [ Elevation ]

25:  If (X<=>F) (P89)
  1:   43             X Loc [ Quality   ]
  2:   3              >=
  3:   1              F
  4:   30             Then Do

26:  Do (P86)
  1:   10             Set Output Flag High (Flag 0)

27:  Real Time (P77)
  1:   220            Day,Hour/Minute (midnight = 2400)

28:  Resolution (P78)
  1:   1              High Resolution
```

```
29:  Sample (P70)
  1:  7              Reps
  2:  3              Loc [ Hour_Min  ]

30:  End (P95)

31:  If Flag/Port (P91)
  1:  14             Do if Flag 4 is High
  2:  1              Call Subroutine 1

*Table 2 Program
  01: 0.0000         Execution Interval (seconds)

*Table 3 Subroutines

; Sub 1 will turn on GPGGA output and look for the
; E or W for East or West.
1:  Beginning of Subroutine (P85)
  1:  1              Subroutine 1

; The field for East or West will be the 27th
; character. East = 69, West = 87. North = 78. South = 83.
; North or South is located in the 16th position.
;
2:  Port Serial I/O (P15)
  1:  1              Reps
  2:  21             -- Configuration Code ;RS232, Binary, 1200 baud
  3:  1              Delay (units = 0.01 sec) ;23X does not wait for CTS
  4:  5              Control Ports
  5:  10             Output Loc [ NEMAon_1  ]
  6:  13             No. of Locs to Send
  7:  42             Termination Character
  8:  200            Maximum Characters
  9:  150            Time Out Delay (units = 0.01 sec)
  10: 50             Loc [ _________ ]
  11: 1.0            Mult
  12: 0.0            Offset

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:  44             Option ;,
  8:  0              Option ;,
```

```
; P15 to turn NEMA output off
4:  Port Serial I/O (P15)
   1:   1              Reps
   2:   1              Configuration Code
   3:   1              Delay (units = 0.01 sec)
   4:   5              Control Ports
   5:   23             Output Loc [ NMAoff_1  ]
   6:   13             No. of Locs to Send
   7:   42             Termination Character
   8:   0              Maximum Characters
   9:   13             Time Out Delay (units = 0.01 sec)
   10:  2              Loc [ Raw_Time2 ]
   11:  1              Mult
   12:  0              Offset

5:  Z=X (P31)
   1:   68             X Loc [ Nth_Sth   ]
   2:   51             Z Loc [ N_or_S    ]

6:  Z=X (P31)
   1:   80             X Loc [ Est_Wst   ]
   2:   52             Z Loc [ E_or_W    ]

7:  End (P95)

End Program

-Input Locations-
1 Battery   1 0 1
2 Raw_Time2 1 2 3
3 Hour_Min  1 1 1
4 Seconds   1 3 3
5 Lat_deg   1 0 1
6 Lat_thds  1 0 1
7 Long_deg  1 0 1
8 Long_thds 1 0 1
9 Elevation 1 0 1
10 NEMAon_1  5 2 1
11 NEMAon_2  9 0 1
12 NEMAon_3  9 0 1
13 NEMAon_4  9 0 1
14 NEMAon_5  9 0 1
15 NEMAon_6  9 0 1
16 NEMAon_7  9 0 1
17 NEMAon_8  17 0 1
18 NEMAon_9  5 0 1
19 NEMAon_10 9 0 1
20 NEMAon_11 9 0 1
21 NEMAon_12 9 0 1
22 NEMAon_13 9 0 1
23 NMAoff_1  13 1 2
24 NMAoff_2  9 0 2
25 NMAoff_3  25 0 2
26 NMAoff_4  9 0 1
27 NMAoff_5  9 0 1
28 NMAoff_6  9 0 1
```

```
29 NMAoff_7  9 0 1
30 NMAoff_8  17 0 1
31 NMAoff_9  5 0 1
32 NMAoff_10 9 0 1
33 NMAoff_11 9 0 1
34 NMAoff_12 9 0 1
35 NMAoff_13 9 0 1
36 Bulk_27   9 0 1
37 Bulk_28   9 0 1
38 Bulk_29   17 0 1
39 __________ 0 0 0
40 Raw_time1 1 1 1
41 Latitude  1 3 0
42 Longitude 1 2 0
43 Quality   1 1 0
44 Num_Sats  1 0 0
45 H_D_of_P  1 0 0
46 Altitude  1 1 0
47 GeoidalSP 1 0 0
48 Age       1 0 0
49 Diff      1 0 0
50 __________ 1 0 1
51 N_or_S    1 0 1
52 E_or_W    1 0 1
53 __________ 0 0 0
54 __________ 0 0 0
55 __________ 0 0 0
56 __________ 0 0 0
57 __________ 0 0 0
58 __________ 0 0 0
59 __________ 0 0 0
60 __________ 0 0 0
61 __________ 0 0 0
62 __________ 0 0 0
63 __________ 0 0 0
64 __________ 0 0 0
65 __________ 1 0 0
66 __________ 0 0 0
67 __________ 0 0 0
68 Nth_Sth   1 1 0
69 __________ 0 0 0
70 __________ 0 0 0
71 __________ 0 0 0
72 __________ 0 0 0
73 __________ 0 0 0
74 __________ 0 0 0
75 __________ 0 0 0
76 __________ 1 0 0
77 __________ 0 0 0
78 __________ 0 0 0
79 __________ 0 0 0
80 Est_Wst   1 1 0
```

Appendix B. SV8 Configuration

For a detailed account of everything you would want to know about the Trimble SV8 GPS module, and its three protocols (TSIP, Trimble Standard Interface Protocol, TAIP, Trimble Standard ASCII Protocol, and NMEA 0183, National Marine Electronics Association), see Trimble Navigation System Designer Reference Manual. The reference manual is available from the Trimble Navigation web page.

When the GPS module is configured, most parameters are left at their default settings. The changes affect the protocols used, the automatic output packets, and the serial port baud rate.

In order to obtain velocity information, the NMEA VTG output should be enabled instead of the GGA output. To enable VTG, a TSIP command (TSIP command packet 7A) is sent via P15, then the NMEA ON command is sent (via P15). This command packet is documented in the Trimble TSIP documentation. The command packets to use are below (all values hexadecimal, but would be entered in P63 bulk load as decimal equivalent):

Enable VTG Output:	10 7A 00 01 00 00 00 04 10 03
Enable GGA Output:	10 7A 00 01 00 00 00 01 10 03
Enable VTG and GGA:	10 7A 00 01 00 00 00 05 10 03

These should be done separately so the terminating character (*) is detected with each string.

GPS_INIT_TSIP File Contents:

10 BC 01 07 07 03 00 00 00 03 01 00 10 03	;TSIP command BC to set Port 2 to 9600 baud,
	;TAIP and TSIP input protocol,
	;TAIP output protocol
10 BC 00 06 06 03 00 00 00 08 00 00 10 03	;TSIP command BC to set Port 1 to 4800 baud,
	;RTCM input protocol, no output
10 7A 00 01 00 00 00 01 10 03	;TSIP command 7A to configure NMEA
	;output for 1/sec rate, and GGA output only
10 8E 40 14 11 00 00 00 00 00 00 00 00 10 03	;TSIP command 8E-40 to configure TAIP
	;output configuration
10 BC 01 04 04 03 00 00 00 03 01 00 10 03	;TSIP command BC to Set Port 2 to 1200 baud
	;TAIP and TSIP input protocol,
	;TAIP output protocol

GPS_INIT_TAIP File Contents:

3E 53 50 52 3B 54 53 49 50 3D 46 49 3C	;TAIP command to Set Protocol for Port 2
	;to TSIP for input

Here is ASCII version of above TAIP command:
>SPR;TSIP=FI<

The rest of the file is identical to GPS_INIT_TSIP.

MODE_SAVE File Contents:

3E 53 52 54 53 41 56 45 5F 43 4F 4E 46 49 47 3C	;TAIP command to save configuration in ;EEPROM

Here is ASCII version of above TAIP command:
>SRTSAVE_CONFIG<