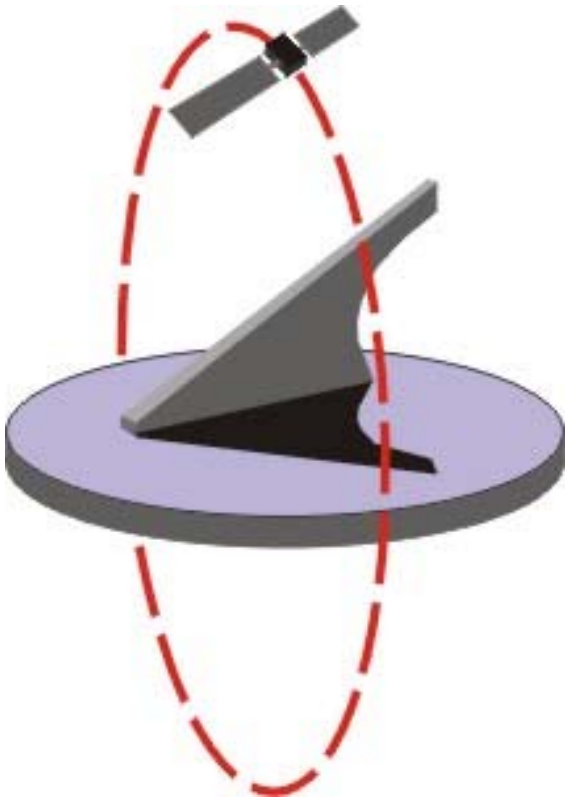
hiprom technologies

1746HP-GPS

USER MANUAL



Rev 3.0 – Sept 2005

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CHAPTER 1 INTRODUCTION

Hiprom Technologies presents a Global Positioning System (GPS) based Time Stamping Input module for the Allen-Bradley SLC (1746- family of PLC's).

The 1746HP-GPS module provides precision time stamped events of both the 16 external inputs and 16 internal PLC bits. In addition the 1746HP-GPS module provides GPS time, position and velocity measurement together with GPS status information.

This document serves to describe the functionality, installation, configuration and use of the module.

CHAPTER 2 MODULE ACCESSORIES

Each 1746HP-GPS package includes the following components:

- **1746HP-GPS module**
- **5m RG58 patch lead with a SMA male and TNC male connector on either end**
- **3.3V active 50Ω hard mount antenna**
- **1746HP-GPS user manual**
- **HTSB bus cable (slave modules)**

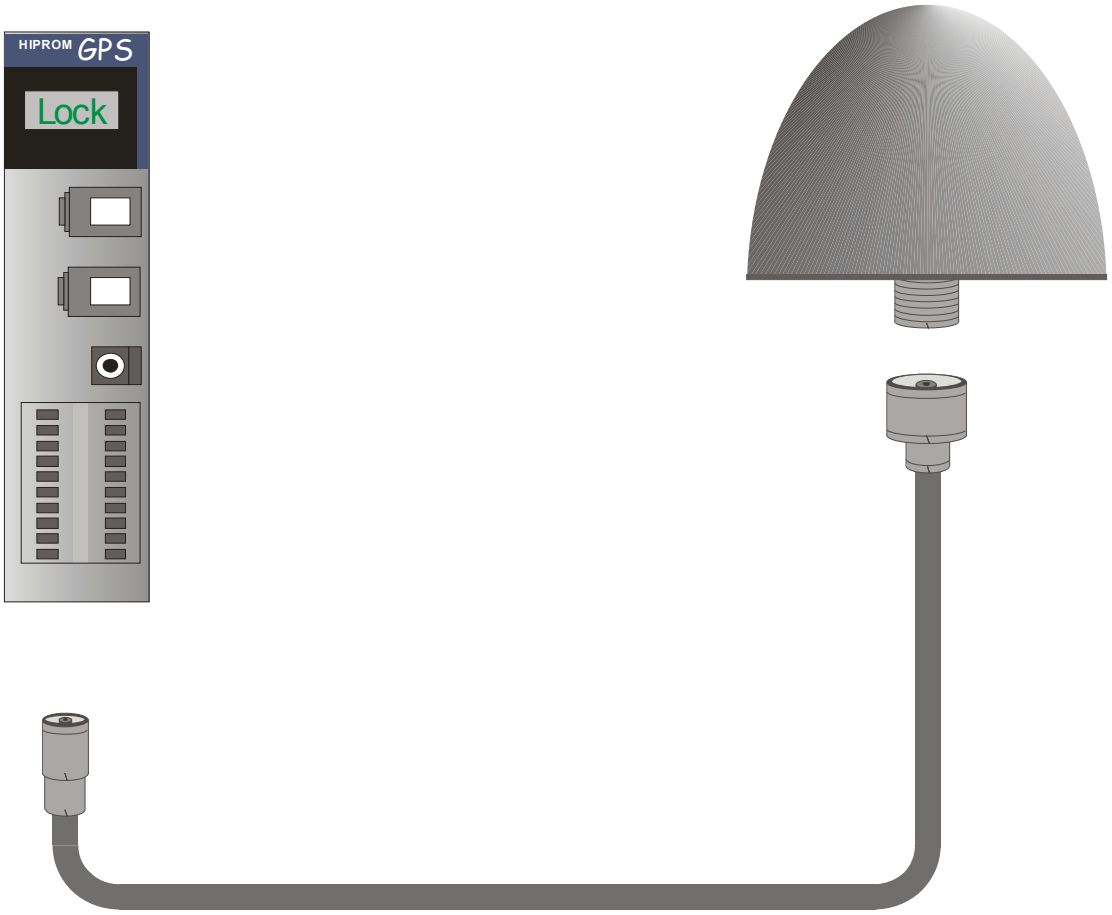


Figure 2.1 : 1746HP-GPS module with antenna and patch-lead

CHAPTER 3 MODULE OPERATION

The 1746HP-GPS module is designed to operate within the Allen-Bradley 1746 backplane. All power required for the module's operation is derived from the 1746 backplane.

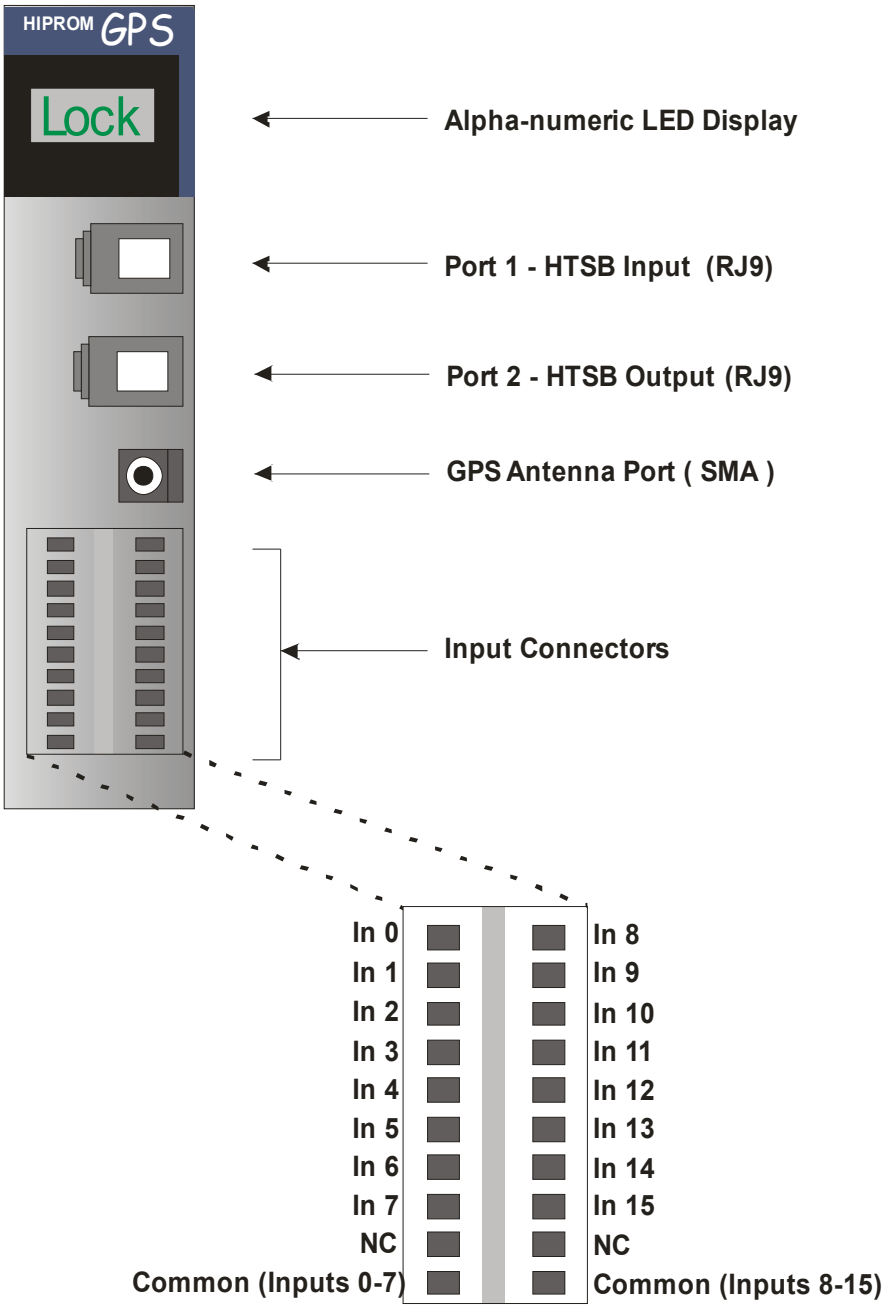


Figure 3.1 : 1746HP-GPS Layout

The 1746HP-GPS module makes use of the Global Position System (GPS) to provide accurate time stamping of PLC and external events.

Events are triggered by a change in either:

- the switching of any of the external 16 digital inputs, (External)
- Or the changing of any of the bits in one of the module's PLC output image registers. (Internal)

External Inputs

The 16 external inputs are arranged in 2 banks of 8 channels each. These banks are electrically independent from each other, having their own commons. The inputs are optically isolated and available in either 24Vd.c. or 110Vd.c.

Digital Filtering

In order to prevent unnecessary events from being triggered due to contact bounce, etc. each external input is digitally filtered. Once an event has triggered on a specific input, that channel is ignored for the duration of the filter constant. This filter constant is common for all 16 channels and can be configured via the module's output image.

Internal Inputs

Events are also triggered by a transition of any one or more of the 16 internal memory bits. These bits occupy word 17 of the module's SLC output image.

Event Processing

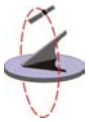
Each event that is triggered is logged to the event buffer within the 1746HP-GPS module. This event buffer -- which can store up to 1000 events -- operates in a first-in-first-out mode.

Each entry in the event buffer stores the following information pertaining to that specific event :

- Event ID
- Date
- Time
- Validity of Time Stamp
- Snapshot of Physical & Memory Inputs
- Trigger Mask (Cause of the Event)

If there is an unread event in the event buffer, then the 1746HP-GPS module notifies the SLC by raising a flag (BRD) located in the module's PLC input image.

The user's PLC software should monitor this flag, and when ready, toggle the NXT bit, in order to read the event.



A 0 to 1 transition of the NXT bit will transfer the next event from the module's buffer into the SLC input image, and will be available to be read by the SLC on the next scan.

Should the event buffer still contain an event, then the BRD flag will remain set and the user software should execute a further transfer. Once the event buffer is empty the BRD flag will be cleared.

Current Date Time

Current date and time information is available directly across the backplane in the input image. The time can be configured to any time zone by setting the UTC offset -- the difference between the required local time standard and GMT. To allow for time zones that are a fraction of an hour from GMT, the time zone offset must be multiplied by 10 before being written to the module.
For example, to select Pacific Standard Time (GMT - 8), set the time zone = -80.

Refer to examples listed in the Appendix.

Current Position & Velocity

Current GPS position and velocity is available in 2 modes :

- Polar: Latitude, Longitude, Altitude
- Cartesian: Earth-Centred Earth-Fixed

The mode can be selected via the ECF flag in the modules output image.

If both co-ordinate systems are required then this bit can be toggled every second. It is important to check the status of the PEC flag to determine the format of the current position before using the data. Similarly, the VEC flag should be examined before reading the velocity data.

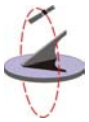
GPS Receiver Status

Certain GPS receiver statuses are made available to the SLC. These include:

- GPS Satellite Lock
- Pulse per Second
- Differential Mode (DGPS)
- Position Dilution of Precision Alarm
- Antenna Status
- Number of Satellites used in fix.

Master / Slave Topology

The precise time-stamping in the module is achieved by synchronization with the GPS satellite system.



The 1746HP-GPS-Master module has an on-board GPS receiver providing time-synchronisation information not only to itself, but also to other adjacent Slaves by means of the HTSB output port. The Master module must be connected to an antenna positioned with an unimpeded view of the sky.

CHAPTER 4 INSTALLING THE MODULE

GPS utilizes a spread spectrum signal in the 1.5GHz range, and thus cannot penetrate conductive or opaque surfaces. Thus the antenna should be mounted in a horizontal position with an unobstructed view of the sky.

Attach the antenna patch lead to the antenna. It is recommended that waterproofing tape be used to seal the connection.

NOTE: Should a longer patch lead be required it is recommended that a GPS signal booster is used. Contact your local Hiprom Technologies distributor for assistance.

Attach the patch lead SMA (male) to the module's SMA (female) connector. It is not recommended that the antenna patch lead exceed a total loss of 10dB at 1.5GHz, as this may increase the time to GPS lock, or in extreme cases, prevent GPS lock from being achieved at all.

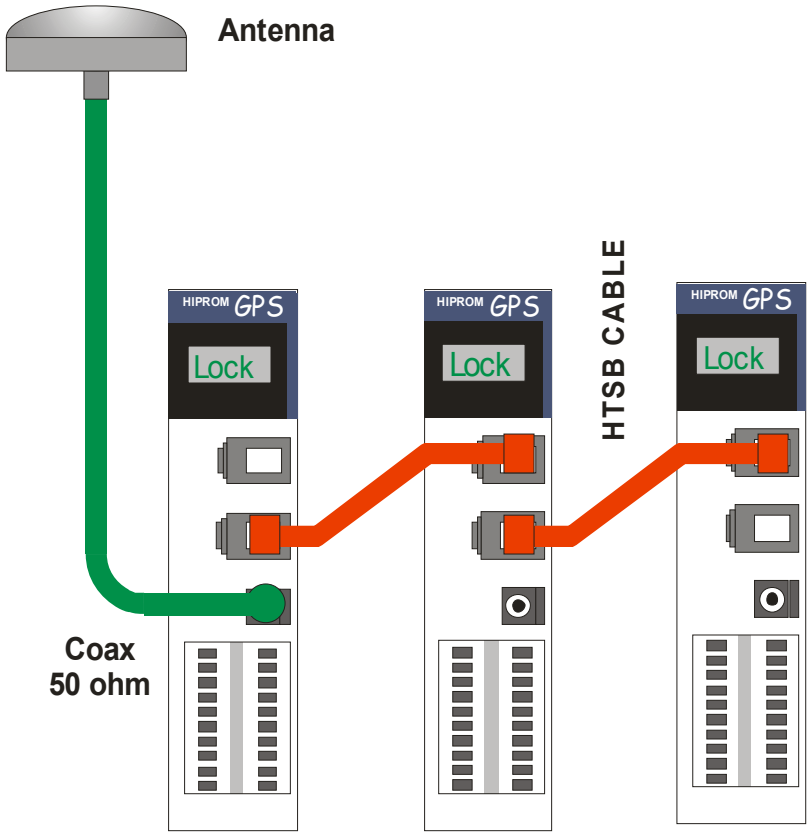


Figure 4.1 : 1746HP-GPS Master / Slave setup

Once the module has been power up for the first time, it will search for satellites from a cold start (i.e no almanac). The module will take approximately 5 minutes to acquire Lock. Once a complete almanac has been downloaded, the time to achieve fix will be reduced to around 45 seconds.

MASTER / SLAVE CONFIGURATION

Slave modules are connected to adjacent Master or other Slave modules by means of an HTSB bus cable (refer to figure 3.1).

All 1746HP-GPS modules are equipped with an HTSB input and output port. Take care to ensure that the HTSB Output port (lower) of the Master module is connected to the HTSB Input port (upper) of the next Slave module. Incorrect connection of the HTSB bus cable could result in permanent damage to the module.

HTSB BUS CABLE

The HTSB cable consists of 4 cores terminated on either side with RJ-9 connectors.

The cable should not exceed 1 meter in length and should not be exposed to high electrical noise environments.

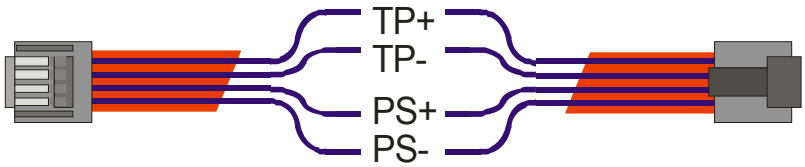


Figure 4.2 : HTSB Bus cable

CHAPTER 5 CONFIGURING THE MODULE

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A direct connection between the controller and the 1746HP-GPS module is required to transfer I/O data to and from the module.

Establishing the Direct Connection

This section describes the procedures necessary to configure the 1746HP-GPS module within the 1746 SLC system.

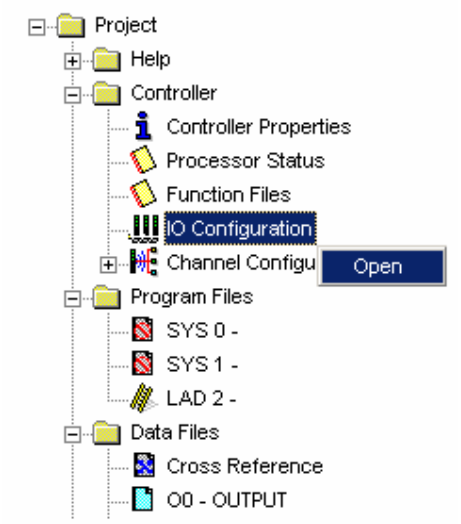


Figure 5.1 : Right-click on I/O Configuration and select Open

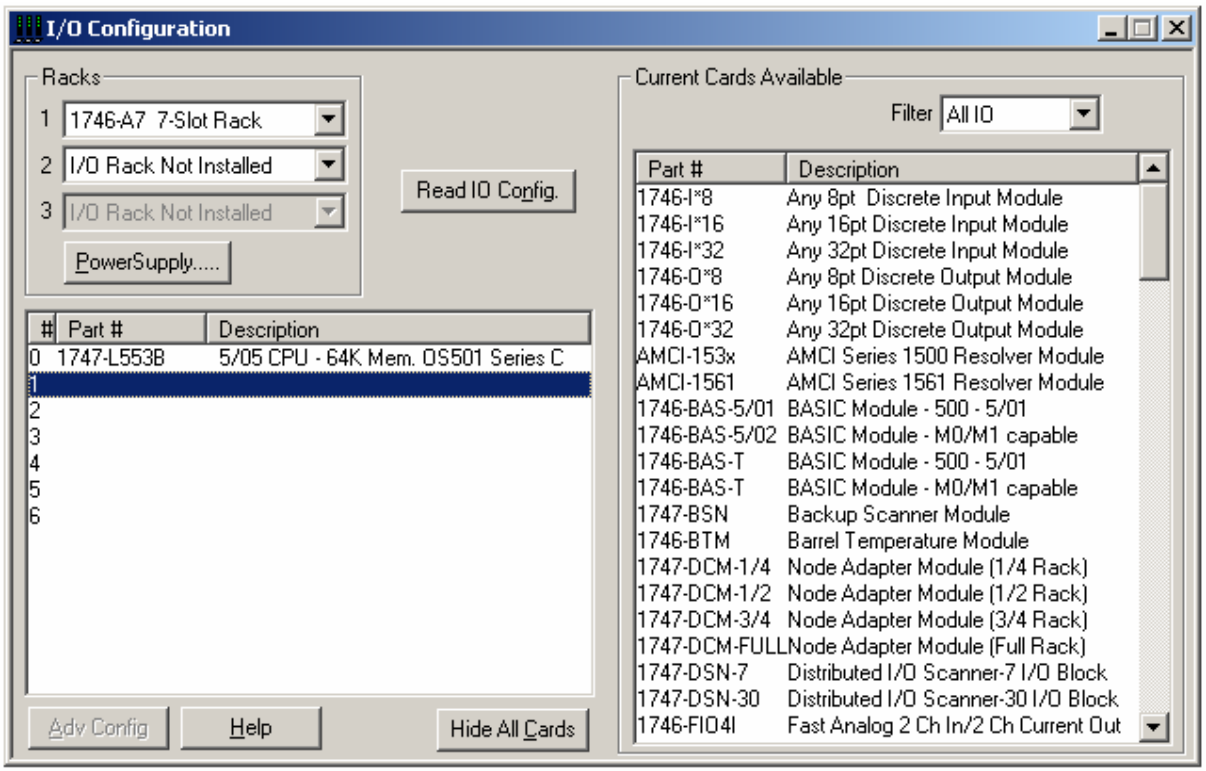


Figure 5.2 : Left-click on Read I/O Config

Before the IO can be read, a connection must be established between RSLogix and the PLC system.

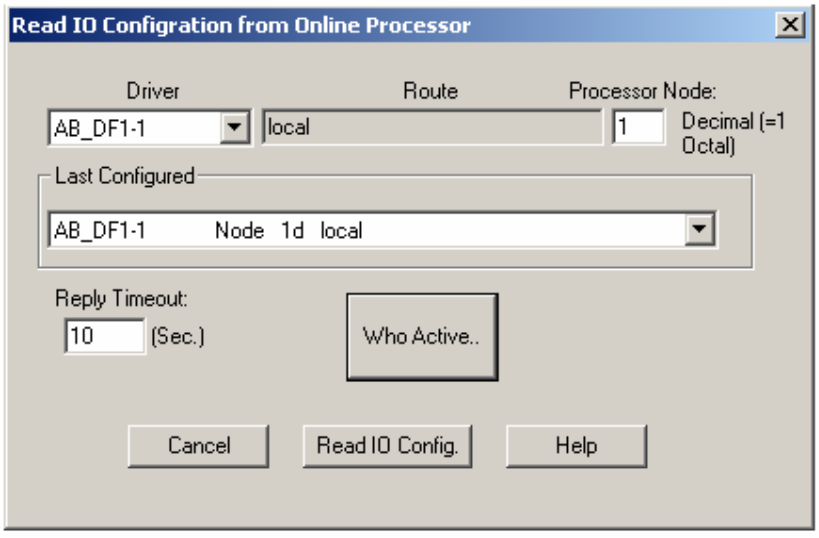


Figure 5.3 : Left-click on Read I/O Config

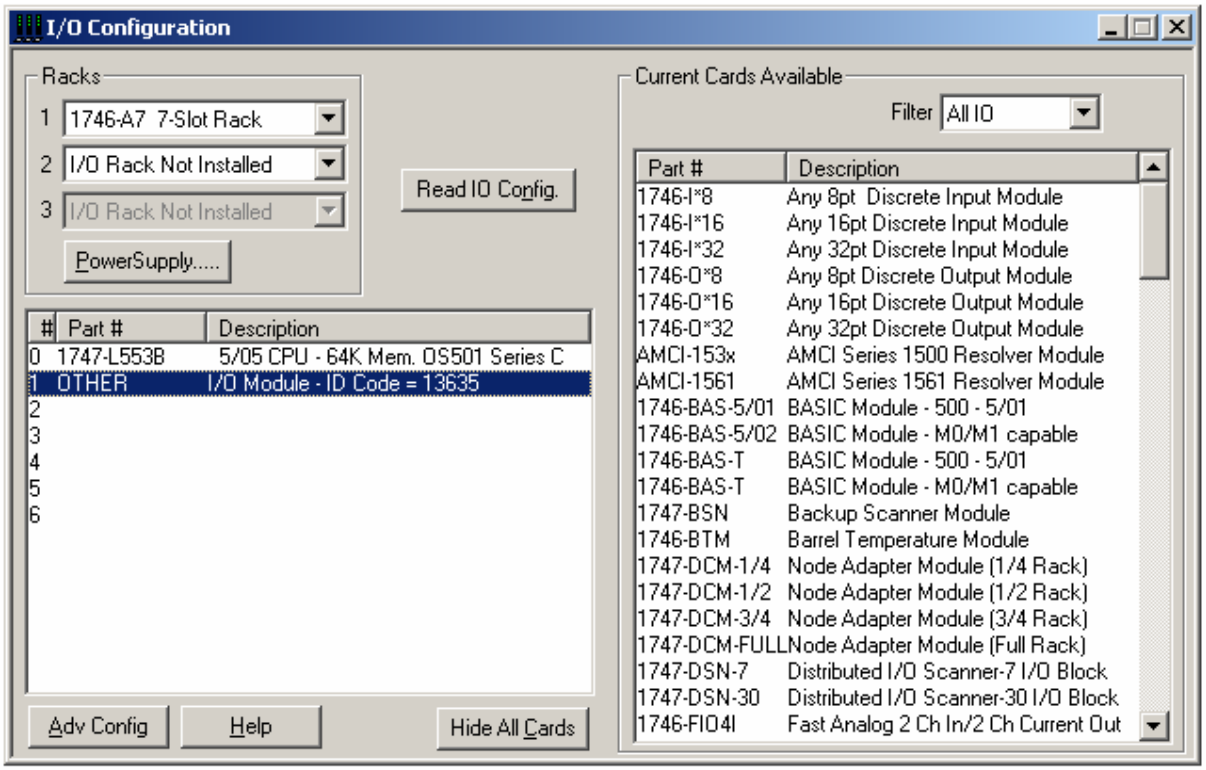


Figure 5.4 : Confirmation that the 1746HP-GPS module has been identified

CHAPTER 6 I/O ADDRESS MAP

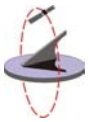
The input and output image of the 1746HP-GPS module is defined in the following sections.

6.1 Input Image

Word	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I:e.0	**NSH**	**EWH**	**PEC**	**VEC**	Rsv	**OVF**	**BRD**	**DTV**	**AER**	**ANT**	**BAT**	**PDP**	**PPS**	**DIF**	**LOC**	**SKY**
I:e.1	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	**SV Count**			
I:e.2	**Milliseconds**															
I:e.3	**Seconds**															
I:e.4	**Minutes**															
I:e.5	**Hours**															
I:e.6	**Day**															
I:e.7	**Month**															
I:e.8	**Latitude -** (Seconds x 100)								**or Position X - (metres x 1)**							
I:e.9	**Latitude -** (Minutes)								**or Position X - (metres / 10,000)**							
I:e.10	**Longitude -** (Seconds x 100)								**or Position Y - (metres x 1)**							
I:e.11	**Longitude -** (Minutes)								**or Position Y - (metres / 10,000)**							
I:e.12	**Altitude -** (meters x 1)								**or Position Z - (metres x 1)**							
I:e.13	**Altitude -** (meters / 10,000)								**or Position Z - (metres / 10,000)**							
I:e.14	**Velocity North** - (m/s x 10)								**or Velocity X - (m/s x 10)**							
I:e.15	**Velocity East** - (m/s x 10)								**or Velocity Y - (m/s x 10)**							
I:e.16	**Velocity Up** - (m/s x 10)								**or Velocity Z - (m/s x 10)**							
I:e.17	**I15**	**I14**	**I13**	**I12**	**I11**	**I10**	**I09**	**I08**	**I07**	**I06**	**I05**	**I04**	**I03**	**I02**	**I01**	**I00**
I:e.18	**Event Buffer Count**															
I:e.19	**Event ID**															
I:e.20	**Event Month**															
I:e.21	**Event Day**															
I:e.22	**Event Hour**															
I:e.23	**Event Minute**															
I:e.24	**Event Second**															
I:e.25	**Event Millisecond**															
I:e.26	**Event Input Status**															
I:e.27	**Event Input Change**															
I:e.28	**Event Memory Status**															
I:e.29	**Event Memory Change**															
I:e.30	**Channel**			**SV PRN**					**SV Signal Strength**							
I:e.31	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv

Figure 6.1 : Connected Input Image

* Rsv = Reserved for future use.

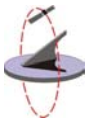


Input Image (Continued)

SKY	**Visible Sky** 0 = Sky not visible or no satellite signals present 1 = Satellite signals available No sky usually indicates that the antenna does not have a clear view of the sky, such as in a building, etc.	**I:e.0/0**
LOC	**Satellite Lock** 0 = Not tracking sufficient satellites to provide positional fix 1 = Sufficient satellites being tracked to provide positional fix Typically, tracking 4 satellites is sufficient to provide lock.	**I:e.0/1**
DIF	**Differential Correction Mode** 0 = No acceptable differential GPS Corrections being received 1 = Acceptable Differential corrections being received and are being used in the position calculations. Differential corrections in the industry standard protocol RTCM-SC104 can be passed to the module via Port-2 (RJ-9) on the front of the module. These correction factors cancel certain inherent errors such as ionospheric delays and thus render a more accur	**I:e.0/2**
PPS	**Pulse per Second** This bit transitions from 0 to 1 precisely every second. The pulse duty cycle is approximately 50%.	**I:e.0/3**
PDP	**PDOP OK** 0 = Position Dilution of Precision is unacceptable 1 = No Position Dilution of Precision present Position Dilution of Precision occurs when although there are sufficient satellites in lock, 2 or more of them appear to occupy similar positions in the sky and thus the number of effective satellites is decreased.	**I:e.0/4**

Input Image (Continued)

BAT	**Battery Backup on Boot** 0 = No battery backup available on boot-up. 1 = Battery backup available on boot-up. Battery backup is enabled by setting the jumper J107 to the ON position. With battery backup enabled the time taken for the GPS module to regain satellite lock is greatly reduced. It is recommended that if the module is not to be used for an extended period that the battery backup be disabled.	**I:e.0/5**
ANT	**Antenna OK** 0 = Antenna Fault 1 = Antenna OK An Antenna fault will occur if the antenna is not present or has been damaged.	**I:e.0/6**
AER	**Antenna Short / Open** 0 = Antenna Open Circuit 1 = Antenna Short Circuit Indicates the type of Antenna fault.	**I:e.0/7**
DTV	**Date / Time Valid** 0 = Date Time Not Valid 1 = Date Time synchronized with GPS	**I:e.0/8**
BRD	**Ready for Event Transfer** 0 = No Events in buffer 1 = One or more events in buffer which are ready for transfer to the Input Image	**I:e.0/9**
OVF	**Buffer Overflow Latch** 0 = Buffer has not overflowed. 1 = Buffer has Overflowed. This Latch will be set when more than 1000 events have been logged to the buffer but not yet transfered to the Input Image. Once the buffer has Overflowed this bit will remain set until an Overflow Latch Clear (CLR) command has been issued.	**I:e.0/10**



Input Image (Continued)

VEC	**Last Velocity Vector in ECEF Mode** 0 = Velocity Update in Northing, Easting and Upward format 1 = Velocity Update in Earth-Centred-Earth-Fixed X,Y,Z format ECEF Mode can be invoked by setting the ECF bit in the output image. (O:e.0/3)	**I:e.0/12**
PEC	**Last Position Vector in ECEF Mode** 0 = Position Update in Latitude, Logtitude and Altitude format 1 = Position Update in Earth-Centred-Earth-Fixed X,Y,Z format ECEF Mode can be invoked by setting the ECF bit in the output image. (O:e.0/3)	**I:e.0/13**
EWH	**Current East / West Hemisphere** 0 = Current position in East hemishere 1 = Current position in West hemisphere This flag is Not valid when in ECEF mode is invoked.	**I:e.0/14**
NSH	**Current North / South Hemisphere** 0 = Current position in North hemishere 1 = Current position in South hemisphere This flag is Not valid when in ECEF mode is invoked.	**I:e.0/15**
SV Count	**Number of Satellites used in GPS Fix** This indicates the number of satellites used in the current GPS position / time fix, as a 4-bit nibble between 0 - 8.	**I:e.1/0** **thru** **I:e.1/3**
Milli-seconds	**Real Time Milliseconds** Current real time Milliseconds (0 - 999)	**I:e.2**
Seconds	**Real Time Seconds** Current real time Seconds (0 - 59)	**I:e.3**
Minutes	**Real Time Minutes** Current Local time Minutes (0 - 59) This is dependent on the configured time zone (O:e.2)	**I:e.4**

Input Image (Continued)

Hours	**Real Time Hours** Current Local time Hours (0 - 23) This is dependent on the configured time zone (O:e.2)	**I:e.5**
Day	**Calendar Day of Month** Current Local Calendar Day (1 - 31) This is dependent on the configured time zone (O:e.2)	**I:e.6**
Month	**Calendar Month** Current Local Calendar Month (1 - 12) This is dependent on the configured time zone (O:e.2)	**I:e.7**
Latitude (PEC = 0)	**Current Position Latitude** Degrees = integer (I:e.9 / 60) Minutes = I:e.9 mod 60 Seconds = I:e.8 / 100 Only Valid if the PEC flag (I:e.0/13) = 0 ***OR***	**I:e.8** **I:e.9**
Position X (PEC = 1)	**Distance from Earth-centre along the X - axis.** **X-Position = (I:e.8 + (I:e.9 x 10,000))** ***in metres*** Position is calculated with respect to the WGS-84 Earth-Centred Earth-Fixed co-ordinate system. The X-axis is defined as the vector with origin at the earth's centre and passing through the intersection of the equator and Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	

Input Image (Continued)

Longitude (PEC = 0)	**Current Position Longitude** Degrees = integer (I:e.11 / 60) Minutes = I:e.11 mod 60 Seconds = I:e.10 / 100 Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Distance from Earth-centre along the Y - axis.** **Y-Position = (I:e.10 + (I:e.11 x 10,000)** ***in metres*** Position is calculated with respect to the WGS-84 Earth-Centred Earth-Fixed co-ordinate system. The Y-axis is defined as the vector with origin at the earth's centre and passing through the equator 90 degrees east of the Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	I:e.10 I:e.11
Position Y (PEC = 1)		
Altitude (PEC = 0)	**Current Position Altiude** **Altitude= (I:e.12 + (I:e.13 x 10,000)** ***in metres*** Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Distance from Earth-centre along the Y - axis.** **Z-Position = (I:e.10 + (I:e.11 x 10,000)** ***in metres*** Position is calculated with respect to the WGS-84 Earth-Centred Earth-Fixed co-ordinate system. The Z-axis is defined as the vector with origin at the earth's centre and passing through the North pole. Only Valid if the PEC flag (I:e.0/13) = 1	I:e.12 I:e.13
Position Z (PEC = 1)		

Input Image (Continued)

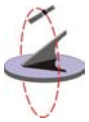
Velocity - North (PEC = 0)	**Current Northerly Velocity** **Velocity North = (I:e.14 / 10) in m/s** A negative value indicates a Southerly direction of movement. Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Speed with respect to the X - axis.** **X-Velocity = (I:e.14 / 10.0)** ***in m/s*** The X-axis is defined as the vector with origin at the earth's centre and passing through the intersection of the equator and Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	**I:e.14**
Velocity - East (PEC = 0)	**Current Easterly Velocity** **Velocity East = (I:e.15 / 10) in m/s** A negative value indicates a Westerly direction of movement. Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Speed with respect to the Y - axis.** **Y-Velocity = (I:e.15 / 10.0)** ***in m/s*** The Y-axis is defined as the vector with origin at the earth's centre and passing through the equator 90 degrees east of the Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	**I:e.15**

Input Image (Continued)

Velocity - Up (PEC = 0)	**Current Upward Velocity** **Velocity East = (I:e.16 / 10) in m/s** A negative value indicates a Downward direction of movement. Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Speed with respect to the Z - axis.** **Z-Velocity = (I:e.15 / 10.0)** ***in m/s*** The Z-axis is defined as the vector with origin at the earth's centre and passing through the North pole. Only Valid if the PEC flag (I:e.0/13) = 1	**I:e.16**
I00 - I15	**Digital Input Status Word**	**I:e.17**
I00	Digital Input 0 Status (After Digital Filtering)	**I:e.17/0**
I01	Digital Input 1 Status (After Digital Filtering)	**I:e.17/1**
I02	Digital Input 2 Status (After Digital Filtering)	**I:e.17/2**
I03	Digital Input 3 Status (After Digital Filtering)	**I:e.17/3**
I04	Digital Input 4 Status (After Digital Filtering)	**I:e.17/4**
I05	Digital Input 5 Status (After Digital Filtering)	**I:e.17/5**
I06	Digital Input 6 Status (After Digital Filtering)	**I:e.17/6**
I07	Digital Input 7 Status (After Digital Filtering)	**I:e.17/7**
I08	Digital Input 8 Status (After Digital Filtering)	**I:e.17/8**
I09	Digital Input 9 Status (After Digital Filtering)	**I:e.17/9**
I10	Digital Input 10 Status (After Digital Filtering)	**I:e.17/10**
I11	Digital Input 11 Status (After Digital Filtering)	**I:e.17/11**
I12	Digital Input 12 Status (After Digital Filtering)	**I:e.17/12**
I13	Digital Input 13 Status (After Digital Filtering)	**I:e.17/13**
I14	Digital Input 14 Status (After Digital Filtering)	**I:e.17/14**
I15	Digital Input 15 Status (After Digital Filtering)	**I:e.17/15**
Buffer Count	**Number of Records in Module Event Buffer**	**I:e.18**

Input Image (Continued)

Event ID	**EventID of the Last Unloaded Event** EventID is a sequential event index, which resets when the module is powered-up or by setting the IDZ flag (O:e.0/4). The index will roll-over to 0 after 9999. If the GPS date and time is invalid when the event was generated, then the EventID will be negative.	**I:e.19**
Event Month	**Month Date Stamp of Last Unloaded Event** Dependent on the time zone configuration at the time of the event.	**I:e.20**
Event Day	**Day Date Stamp of Last Unloaded Event** Dependent on the time zone configuration at the time of the event.	**I:e.21**
Event Hour	**Hour Time Stamp of Last Unloaded Event** Dependent on the time zone configuration at the time of the event.	**I:e.22**
Event Minute	**Minute Time Stamp of Last Unloaded Event** Dependent on the time zone configuration at the time of the event.	**I:e.23**
Event Second	**Second Time Stamp of Last Unloaded Event**	**I:e.24**
Event Milli-second	**Millisecond Time Stamp of Last Unloaded Event**	**I:e.25**
Event Input Status	**Status of the Digital Input Word when Event occured**	**I:e.26**
Event Input Change	**Change Mask of the Digital Input when Event occured** This word indicates which of the Digital Inputs changed (if any), triggering the Event. A zero implies that the Event was noit triggered by the modules digital inputs, i.e. it was triggered by a memory event.	**I:e.27**



Input Image (Continued)

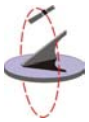
Event Memory Status	**Status of the Memory Output Word (O:e.17) when Event occured**	**I:e.28**
Event Memory Change	**Change Mask of the Memory Output when Event occured** This word indicates which of the memory outputs changed (if any), triggering the Event. A zero implies that the Event was not triggered by the module's memory outputs, i.e. it was triggered by a digital input event.	**I:e.29**
Channel	**GPS Receiver Channel Number** These 3 bits indicate which of the GPS's 8 (0-7) channels' data is being displayed. Because all 8 channels' data is passed with a single word, it is time division multiplexed, showing a different channel every second. The channel number can be used as an indirect addressing pointer, to store the Channel SV PRN and Signal Strengths in the SLC.	**I:e.31/13 - I:e.31/15**
SV PRN	**Satellite Vehicle PRN Identification Number tracked on current channel** Each operational GPS satellite has a unique PRN identification number (0-31). Updated in conjuction with "Channel" described above	**I:e.31/8 - I:e.31/12**
SV Signal Strength	**Satellite Signal Strength on current channel** A measure of the satellite signal strength calculated during signal correlation. Signal Strength in (dbHz x 10) after correlation Updated in conjuction with "Channel" described above	**I:e.31/0 - I:e.31/7**

6.2 Output Image

Word	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
O:e.0	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	Rsv	**IDZ**	**ECF**	**Purg**	**Clr**	**Nxt**
O:e.1	Rsv															
O:e.2	**Time Zone** (Hours x 10)															
O:e.3	**Input Filter** (ms)															
O:e.4	Rsv															
O:e.5	Rsv															
O:e.6	Rsv															
O:e.7	Rsv															
O:e.8	Rsv															
O:e.9	Rsv															
O:e.10	Rsv															
O:e.11	Rsv															
O:e.12	Rsv															
O:e.13	Rsv															
O:e.14	Rsv															
O:e.15	Rsv															
O:e.16	Rsv															
O:e.17	**M15**	**M14**	**M13**	**M12**	**M11**	**M10**	**M09**	**M08**	**M07**	**M06**	**M05**	**M04**	**M03**	**M02**	**M01**	**M00**
O:e.18	Rsv															
O:e.19	Rsv															
O:e.20	Rsv															
O:e.21	Rsv															
O:e.22	Rsv															
O:e.23	Rsv															
O:e.24	Rsv															
O:e.25	Rsv															
O:e.26	Rsv															
O:e.27	Rsv															
O:e.28	Rsv															
O:e.29	Rsv															
O:e.30	Rsv															
O:e.31	Rsv															

Figure 6.2 : Connected Output Image

* Rsv = Reserved for future use.



Output Image (Continued)

Nxt	**Next Event Command** A low to high transition on this bit unloads the next event from the buffer and transfers it to the input image. This command will be ignored if there are no events in the buffer.	**O:e.0/0**
Clr	**Clear Buffer Overflow Flag** Setting this bit clears the event buffer overflow flag. This bit should be cleared after use.	**O:e.0/1**
Purg	**Complete Event Buffer Purge** Setting this bit purges the buffer. This bit should be cleared after use.	**O:e.0/2**
ECF	**Select Earth-Centred-Earth-Fixed Mode** Setting this bit causes the module to report position and velocity data in Cartesian co-ordinates. Clearing this bit causes the module to report position and velocity data in Polar co-ordinates.	**O:e.0/3**
Time Zone	**Time Zone Configuration** Used to set the module to report in local time standard. Time zone = UTC Offest * 10 where the UTC Offest is the difference, in hours, between local time and GMT. E.g. For Pacific Standard Time (GMT - 8) set time zone = - 80	**O:e.2**
Input Filter	**Digital Input Filter Configuration** Used to set the digtal input filter duration in milliseconds. Time constant should be between 0 - 255.	**O:e.3**

Output Image (Continued)

M0-M15	**Digital Memory Output Word** Modifying any one of these bits will cause an event to be logged.	O:e.17
M00	Memory Output 0 Trigger	**O:e.17/0**
M01	Memory Output 1 Trigger	**O:e.17/1**
M02	Memory Output 2 Trigger	**O:e.17/2**
M03	Memory Output 3 Trigger	**O:e.17/3**
M04	Memory Output 4 Trigger	**O:e.17/4**
M05	Memory Output 5 Trigger	**O:e.17/5**
M06	Memory Output 6 Trigger	**O:e.17/6**
M07	Memory Output 7 Trigger	**O:e.17/7**
M08	Memory Output 8 Trigger	**O:e.17/8**
M09	Memory Output 9 Trigger	**O:e.17/9**
M10	Memory Output 10 Trigger	**O:e.17/10**
M11	Memory Output 11 Trigger	**O:e.17/11**
M12	Memory Output 12 Trigger	**O:e.17/12**
M13	Memory Output 13 Trigger	**O:e.17/13**
M14	Memory Output 14 Trigger	**O:e.17/14**
M15	Memory Output 15 Trigger	**O:e.17/15**

CHAPTER 7 MODULE STATUS

Status Display

TmOk	**Time Synchronization Ok** The module has successfully time synchronized with the GPS satellite system and has accurate time.
Tm??	**Time Synchronization Failure** The module has lost time synchronization with the GPS satellite system and cannot maintain accurate time.
Tm.?	**Time Synchronization Failure** The module has lost time synchronization with the GPS satellite system and cannot maintain accurate time.
IEvt	**External Input Event Triggered** A change in the status of one or more of the External Inputs has generated an event.
MEvt	**Memory Event Triggered** A change in the status of one or more of the Memory Output Image bits has generated an event.
B n	**Event Buffer Count** where n indicates the number of events in the buffer.
Empt	**Event Buffer Empty** There are zero events in the event buffer.
Full	**Event Buffer Full** There are 1000 events in the event buffer, rendering it unavailable for event logging.
OvFl	**Event Buffer Overflow** An event was generated but could not be logged because the event buffer was already full.
Clr	**Event Buffer Overflow Latch Cleared** The event buffer Overflow Latch has been cleared by the PLC.

Status Display (Continued)

Purg	**Event Buffer Purged** All events in the event buffer have been deleted.
ID Z	**Event ID counter set to Zero** Indicates that the Event ID counter has been manually set to zero.
Init	**Initialization of Module** The module is initialized only on power-up.
FRev	**Firmware Revision** The firmware revision number is displayed on power-up.
EPro	**Event Processor Started** The Event Processor has started and is ready to process memory events. This typically occurs 3 seconds after power-up. Note that External Input Events are immediately available on Power-up of the module, and remain active when the SLC CPU enters program mode.
RmEr	**Internal Memory Failure** RAM check has failed. Check PLC power supply. Contact supplier.
AntO	**GPS Antenna Open-circuit** Indicates the Antenna is not connected or damaged.
AntX	**GPS Antenna Short-circuit** Indicates the Antenna patch-lead is shorted or damaged or the Antenna is damaged.
Sky	**No Sky Available** Indicates the absence of any satellite signals. This usually occurs when the Antenna is placed indoors, or during power-up before Lock is achieved.
Srch	**Satellite Search** Module is attempting to acquire satellites
Cold	**Cold Initialisation Required** Indicates that the module is devoid of internal satellite information. Module will automatically download new almanac & ephemeris data from a satellite.

Status Display (Continued)

Time	**Satellite Time synchronization in Progress** Indicates that the module is receiving satellite signals but has not yet been able to synchronize to GPS time.
Lock	**Satellite Lock** Indicates that sufficient satellites are being tracked to provide position fixing.
PDOP	**Position Dilution of Precision Warning** Position Dilution of Precision occurs when although there are sufficient satellites in lock, 2 or more of them appear to occupy similar positions in the sky and thus the number of effective satellites is decreased.
Trk1	**Tracking only 1 Satellite**
Trk2	**Tracking only 2 Satellites**
Trk3	**Tracking only 3 Satellites**
SBad	**Current Satellite is Bad** The satellite signal currently being acquired is suspect or unusable.

APPENDIX A PLC LADDER EXAMPLE

The ladder example on the following page consists of the following program files :

File 2 - Main

- Calls all other program files

File 3 - Event

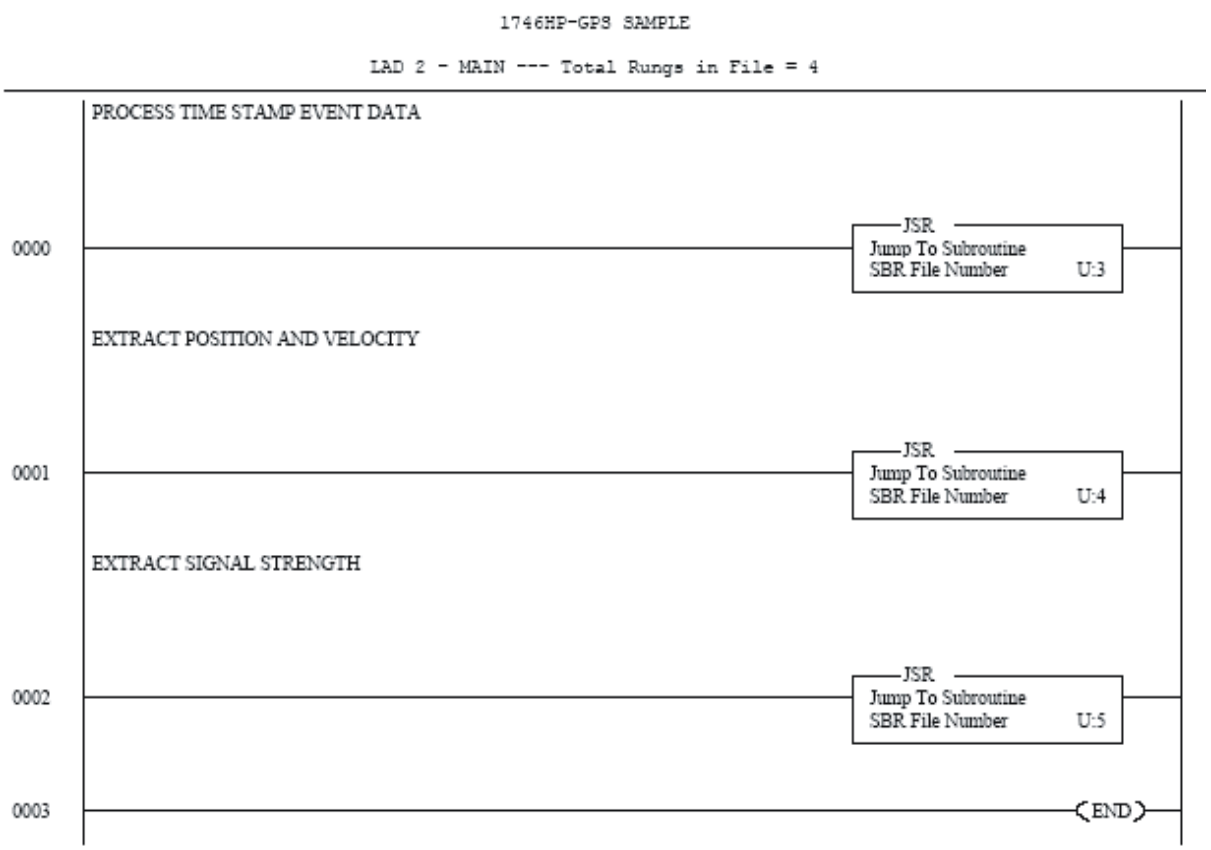
- Configures time zone
- Configures digital filtering time
- Checks for a new event in module's event buffer
- Triggers the event to be unloaded to input image
- Calls file 6 which copies the event into an SLC memory stack

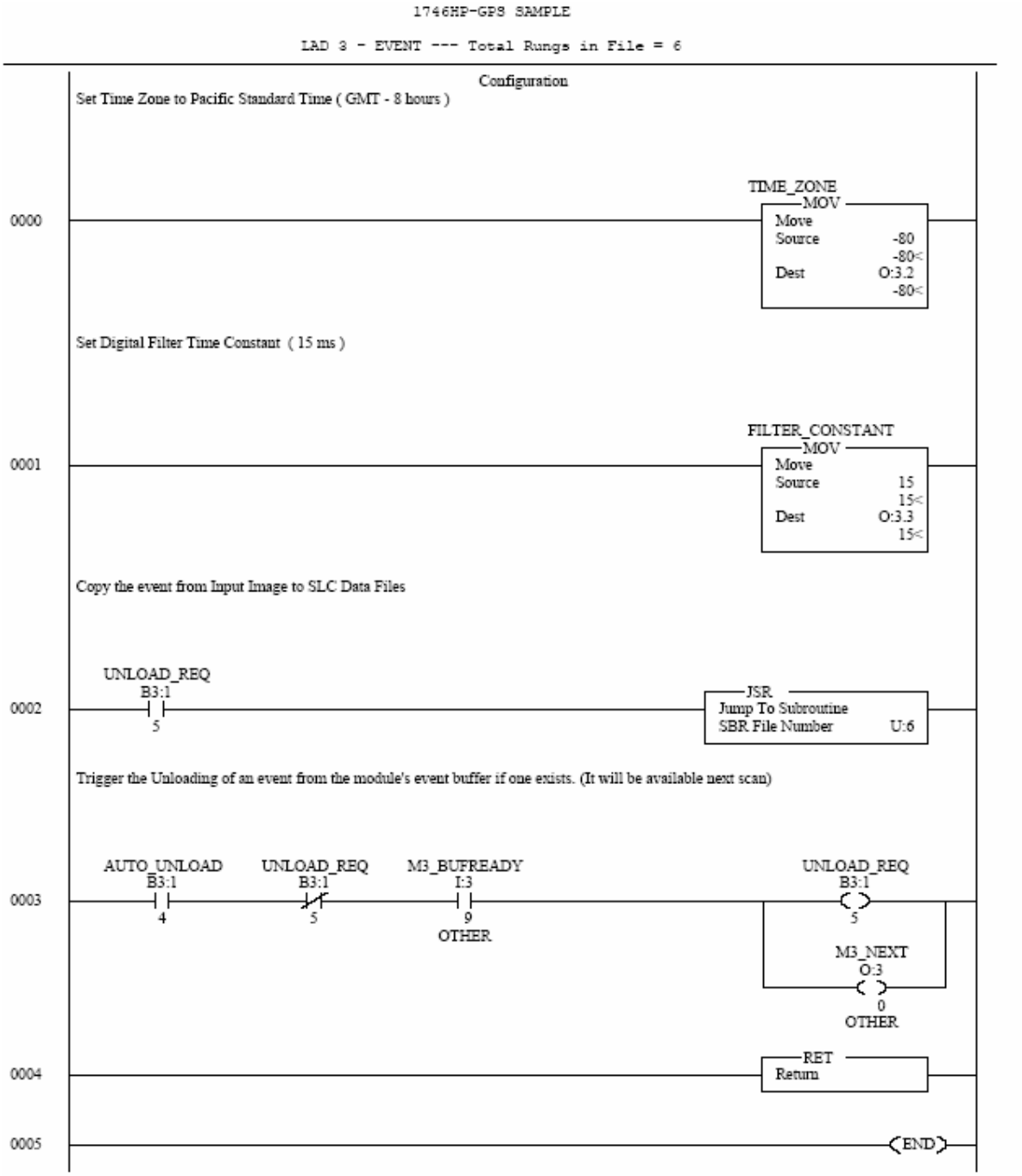
File 4 - Pos_Vel

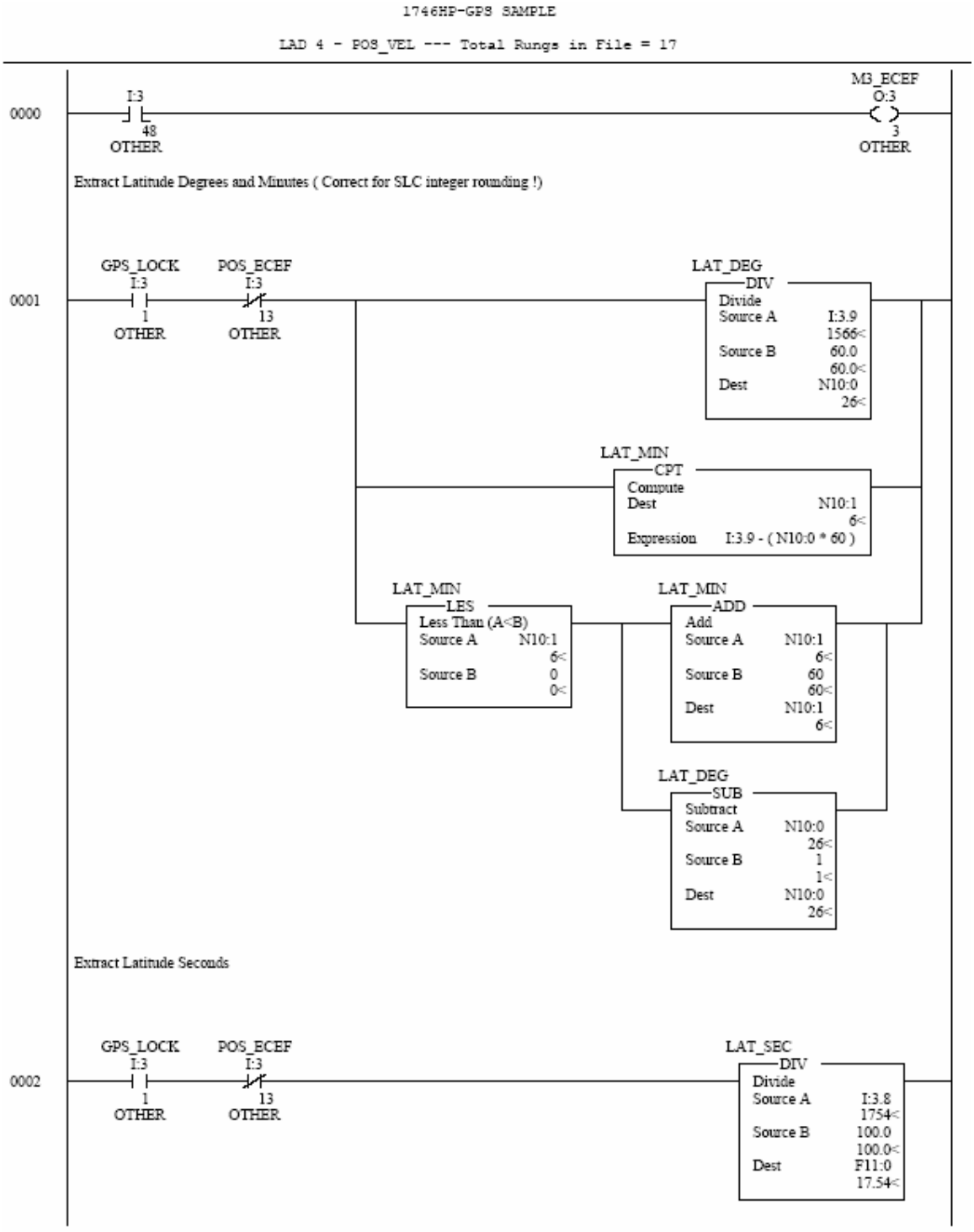
- Extracts Position in either Polar or ECEF
- Extract Velocity in either Polar or ECEF

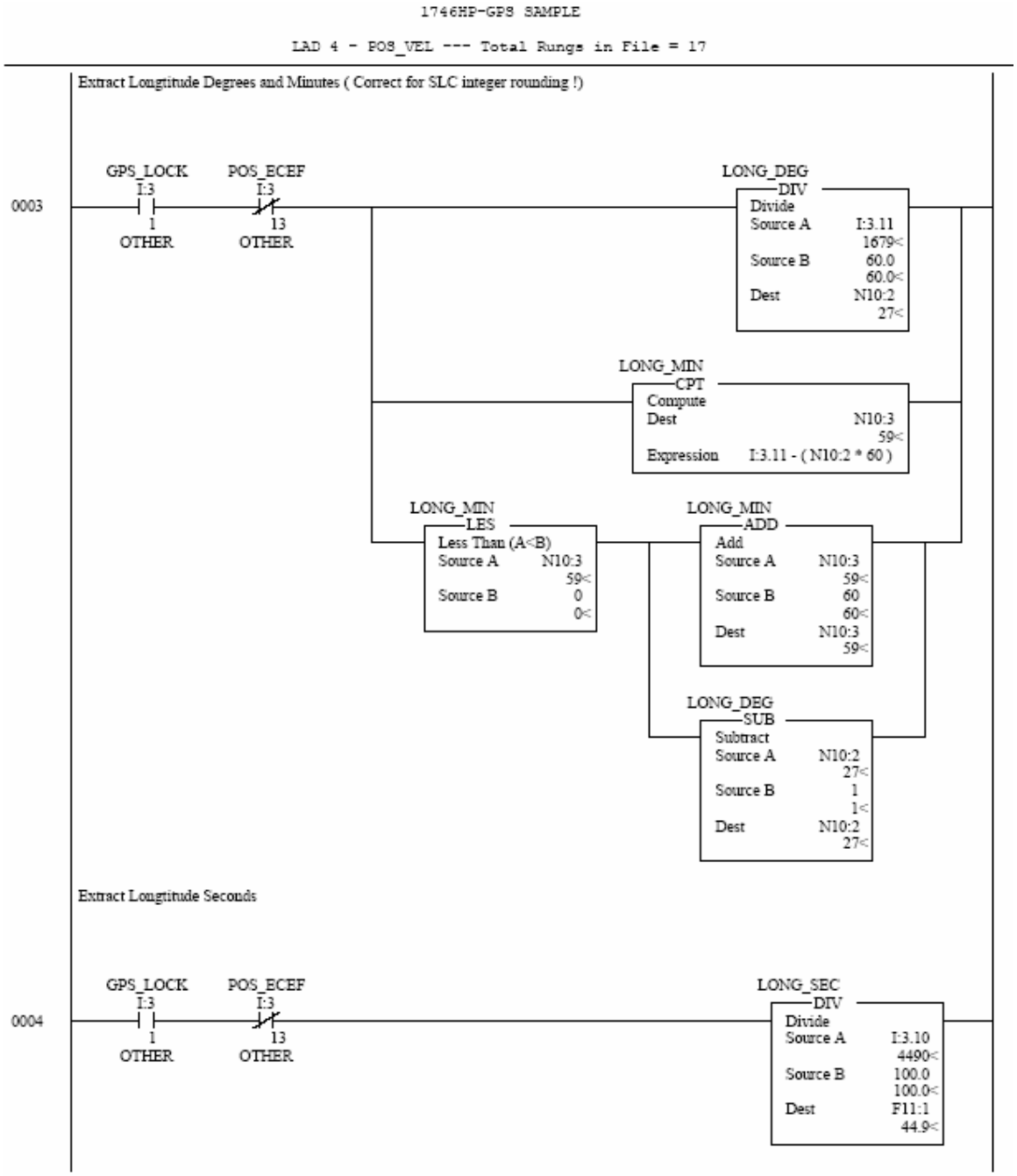
File 5 - Signal

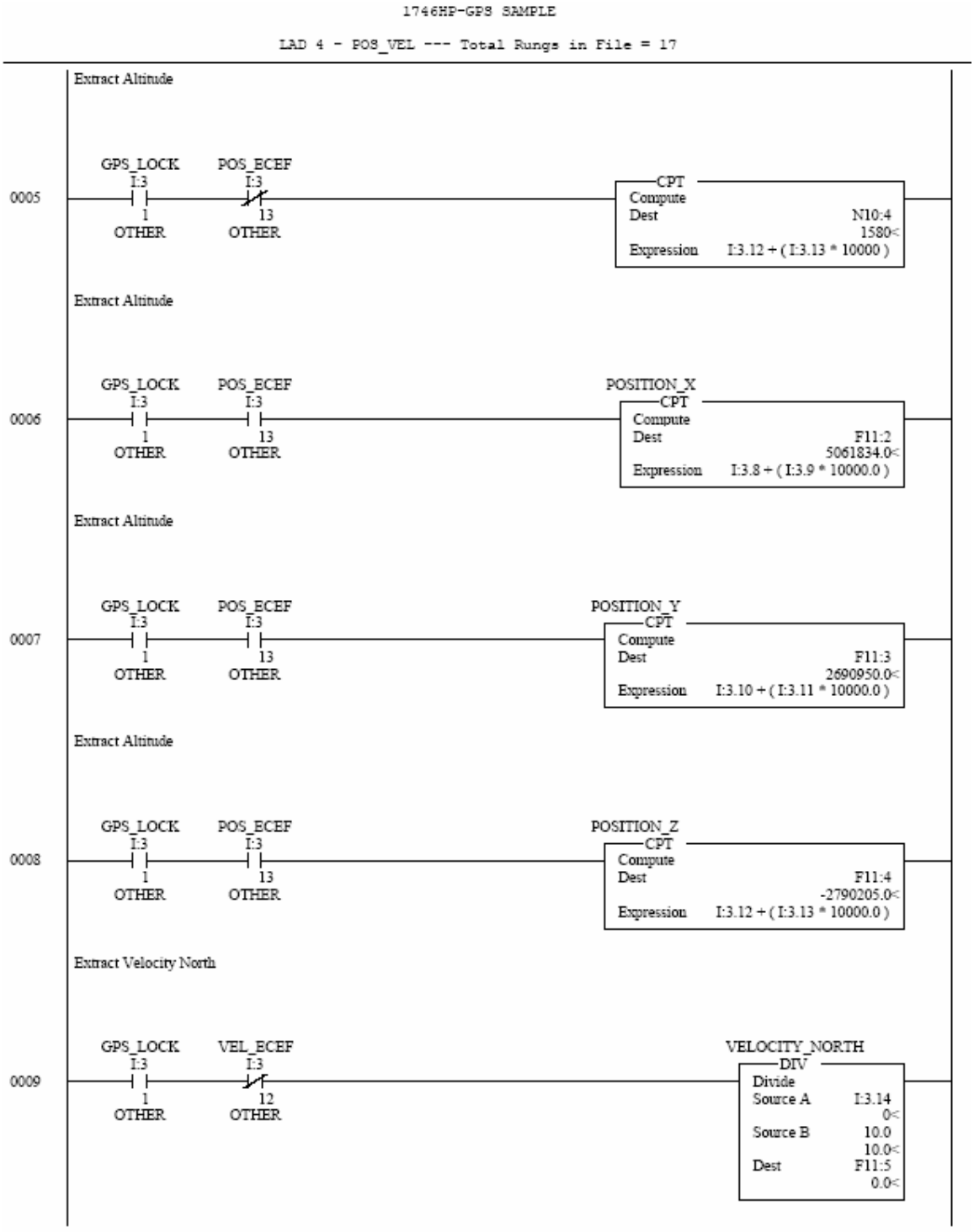
- Extracts the satellite signal strengths for all 8 GPS receiver channels

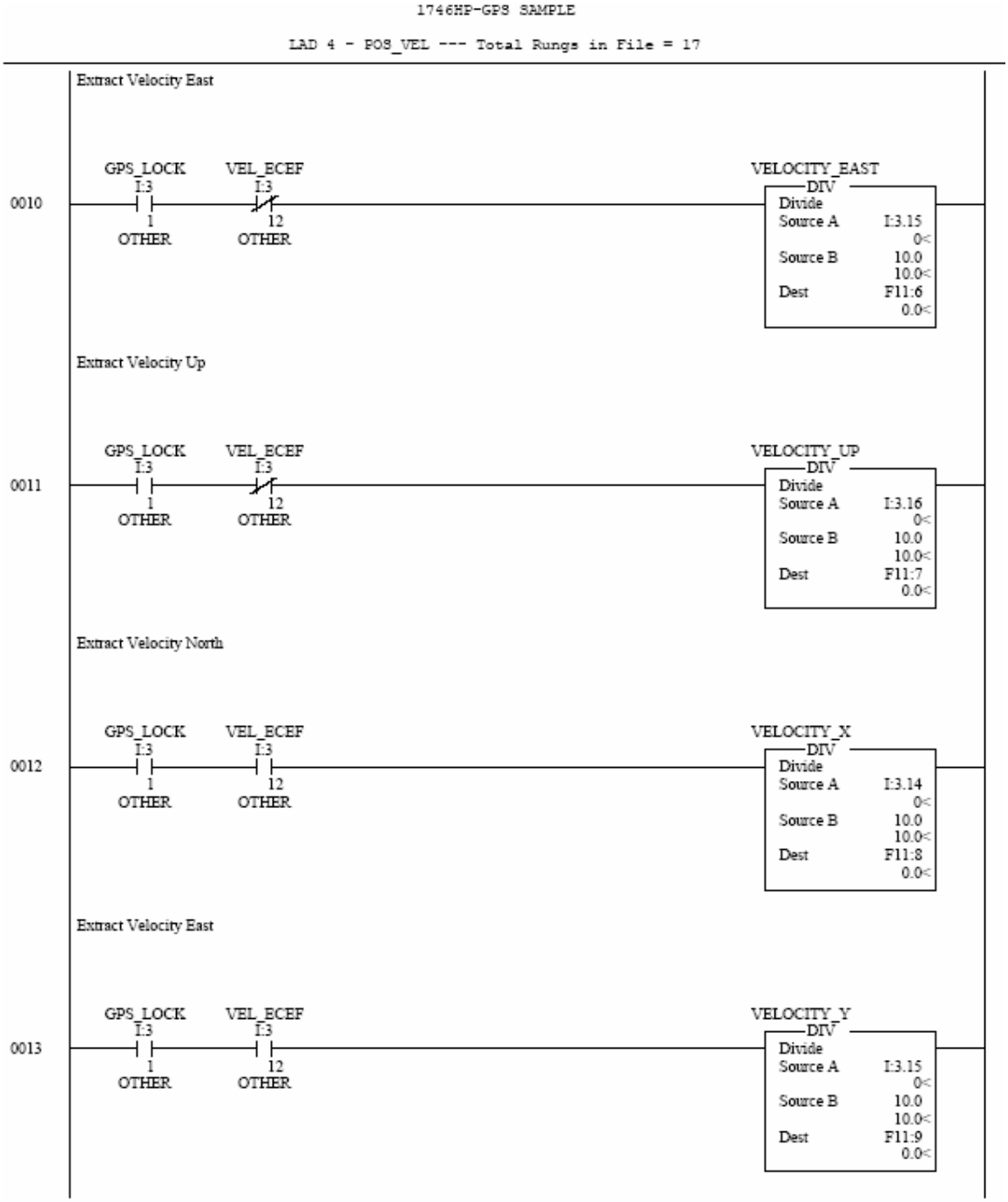

1746HP-GPS SAMPLE
LAD 2 - MAIN --- Total Rungs in File = 4
PROCESS TIME STAMP EVENT DATA
0000
JSR
Jump To Subroutine
SBR File Number U:3
EXTRACT POSITION AND VELOCITY
0001
JSR
Jump To Subroutine
SBR File Number U:4
EXTRACT SIGNAL STRENGTH
0002
JSR
Jump To Subroutine
SBR File Number U:5
0003
END

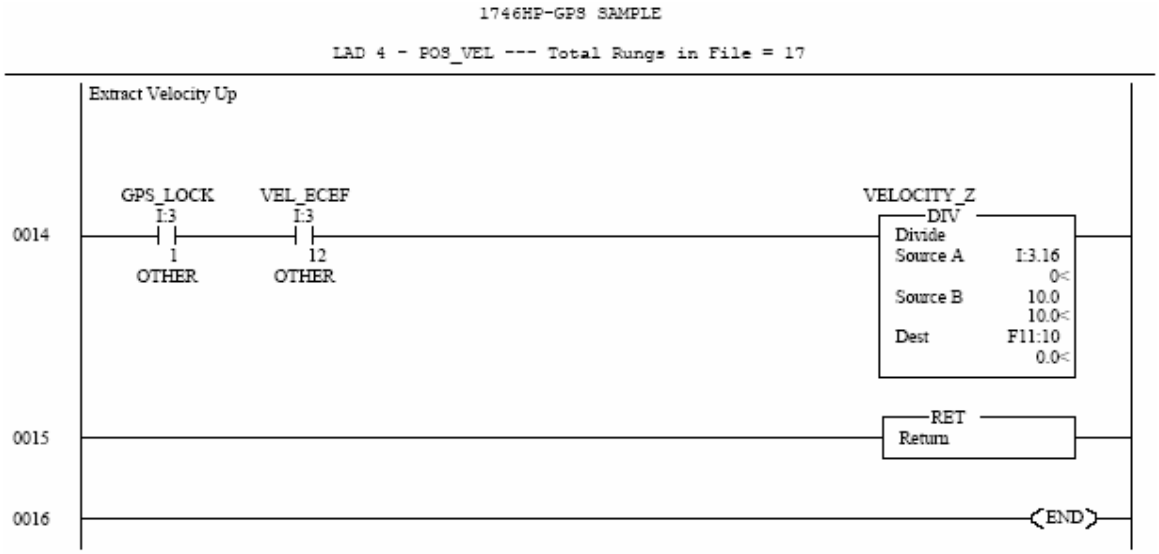

1746HP-GPS SAMPLE
LAD 3 - EVENT --- Total Rungs in File = 6
Configuration
Set Time Zone to Pacific Standard Time (GMT - 8 hours)
TIME_ZONE
MOV
Move
Source -80
-80<
Dest O:3.2
-80<
0000
Set Digital Filter Time Constant (15 ms)
FILTER_CONSTANT
MOV
Move
Source 15
15<
Dest O:3.3
15<
0001
Copy the event from Input Image to SLC Data Files
UNLOAD_REQ
B3:1
5
0002
JSR
Jump To Subroutine
SBR File Number U:6
Trigger the Unloading of an event from the module's event buffer if one exists. (It will be available next scan)
AUTO_UNLOAD
B3:1
4
UNLOAD_REQ
B3:1
5
M3_BUFREADY
I:3
9
OTHER
0003
UNLOAD_REQ
B3:1
5
M3_NEXT
O:3
0
OTHER
RET
Return
0004
END
0005

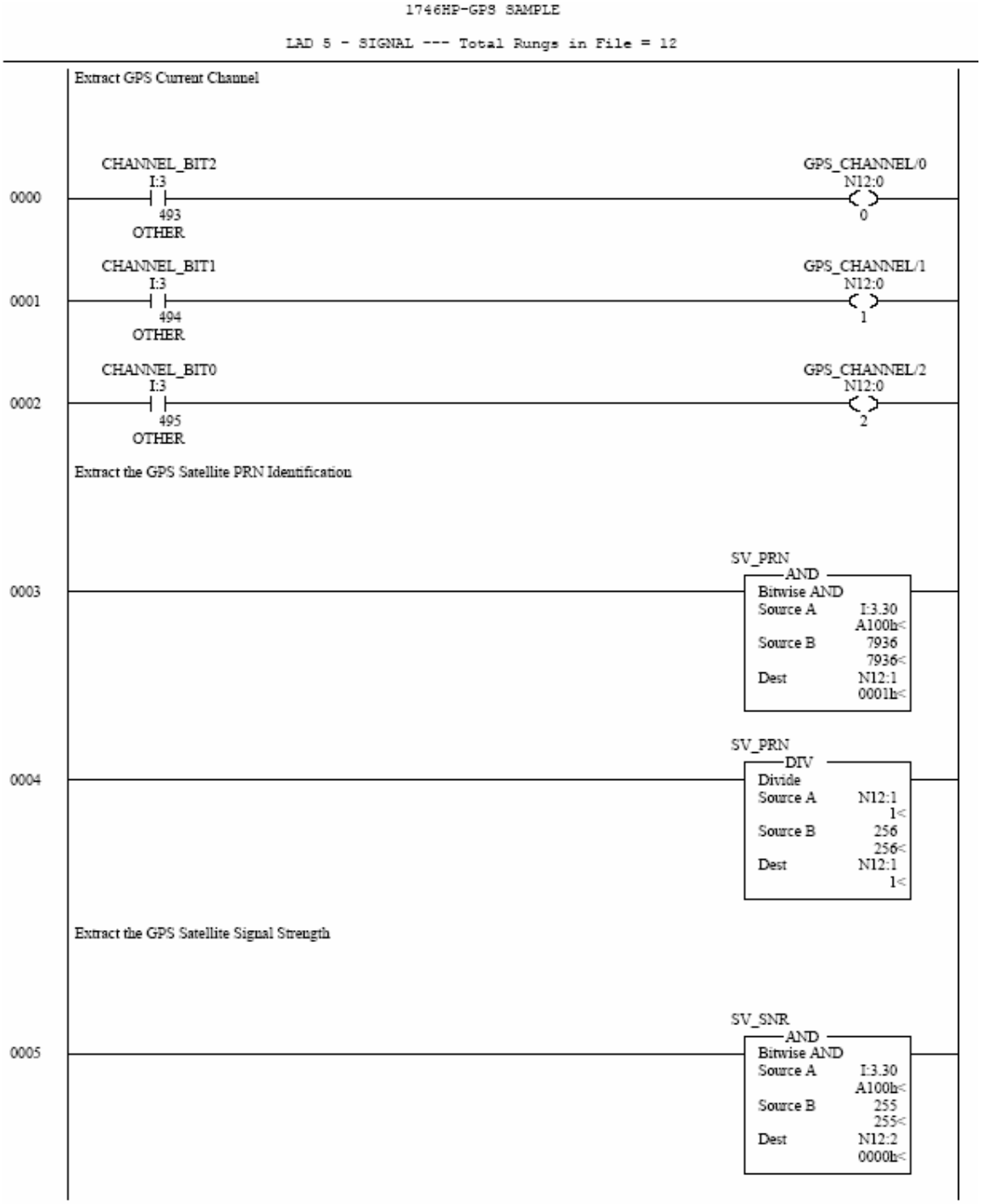

1746HP-GPS SAMPLE
LAD 4 - POS_VEL --- Total Rungs in File = 17
0000
I:3
48
OTHER
M3_ECEF
O:3
3
OTHER
Extract Latitude Degrees and Minutes (Correct for SLC integer rounding !)
0001
GPS_LOCK
I:3
1
OTHER
POS_ECEF
I:3
13
OTHER
LAT_DEG
DIV
Divide
Source A I:3.9 1566<
Source B 60.0 60.0<
Dest N10:0 26<
LAT_MIN
CPT
Compute
Dest N10:1 6<
Expression I:3.9 - (N10:0 * 60)
LAT_MIN
LES
Less Than (A<B)
Source A N10:1 6<
Source B 0 0<
LAT_MIN
ADD
Add
Source A N10:1 6<
Source B 60 60<
Dest N10:1 6<
LAT_DEG
SUB
Subtract
Source A N10:0 26<
Source B 1 1<
Dest N10:0 26<
Extract Latitude Seconds
0002
GPS_LOCK
I:3
1
OTHER
POS_ECEF
I:3
13
OTHER
LAT_SEC
DIV
Divide
Source A I:3.8 1754<
Source B 100.0 100.0<
Dest F11:0 17.54<

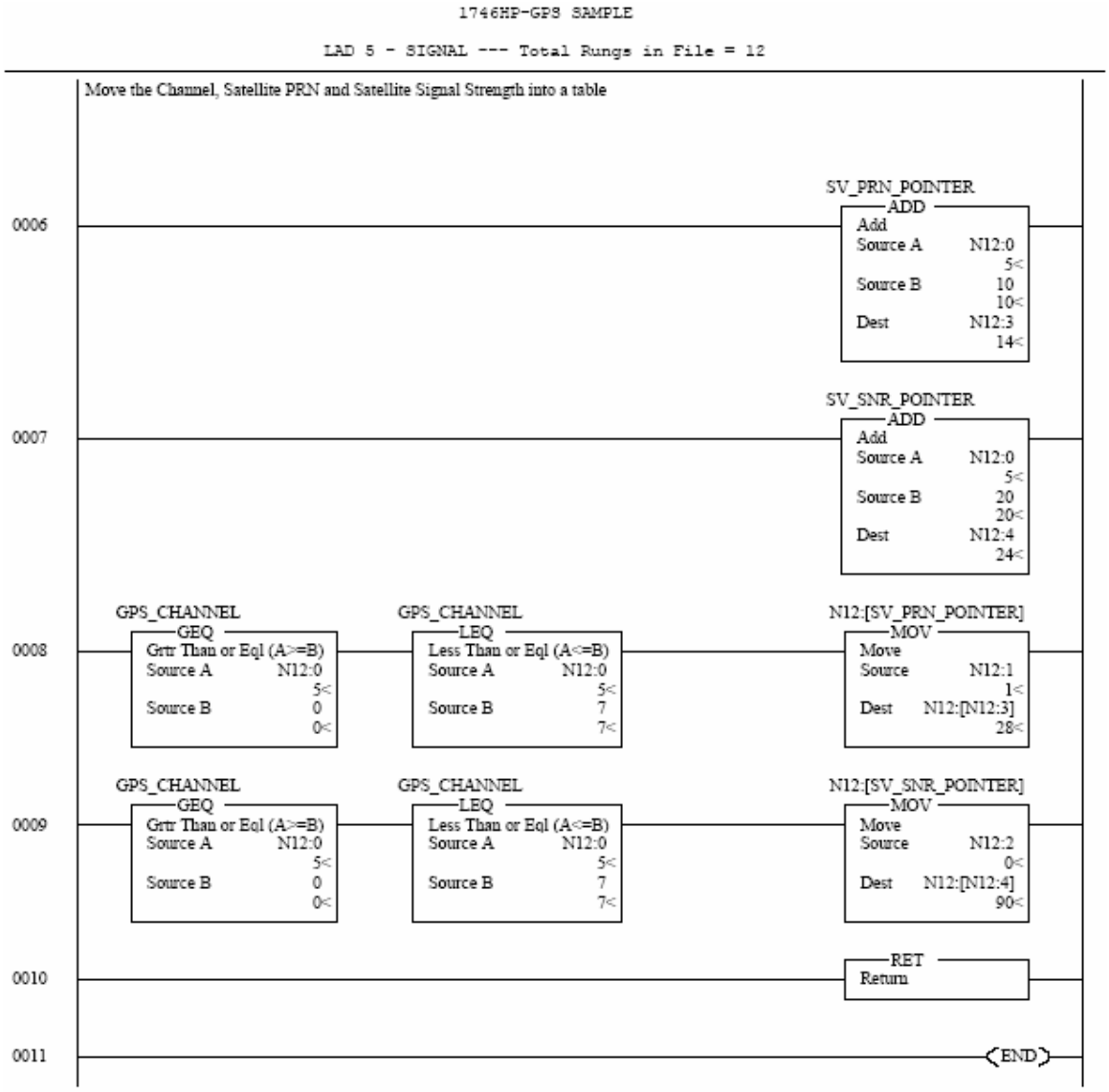

1746HP-GPS SAMPLE
LAD 4 - POS_VEL --- Total Rungs in File = 17
Extract Longtitude Degrees and Minutes (Correct for SLC integer rounding !)
0003
GPS_LOCK
I:3
1
OTHER
POS_ECEF
I:3
13
OTHER
LONG_DEG
DIV
Divide
Source A I:3.11
1679<
Source B 60.0
60.0<
Dest N10:2
27<
LONG_MIN
CPT
Compute
Dest N10:3
59<
Expression I:3.11 - (N10:2 * 60)
LONG_MIN
LES
Less Than (A<B)
Source A N10:3
59<
Source B 0
0<
LONG_MIN
ADD
Add
Source A N10:3
59<
Source B 60
60<
Dest N10:3
59<
LONG_DEG
SUB
Subtract
Source A N10:2
27<
Source B 1
1<
Dest N10:2
27<
Extract Longtitude Seconds
0004
GPS_LOCK
I:3
1
OTHER
POS_ECEF
I:3
13
OTHER
LONG_SEC
DIV
Divide
Source A I:3.10
4490<
Source B 100.0
100.0<
Dest F11:1
44.9<

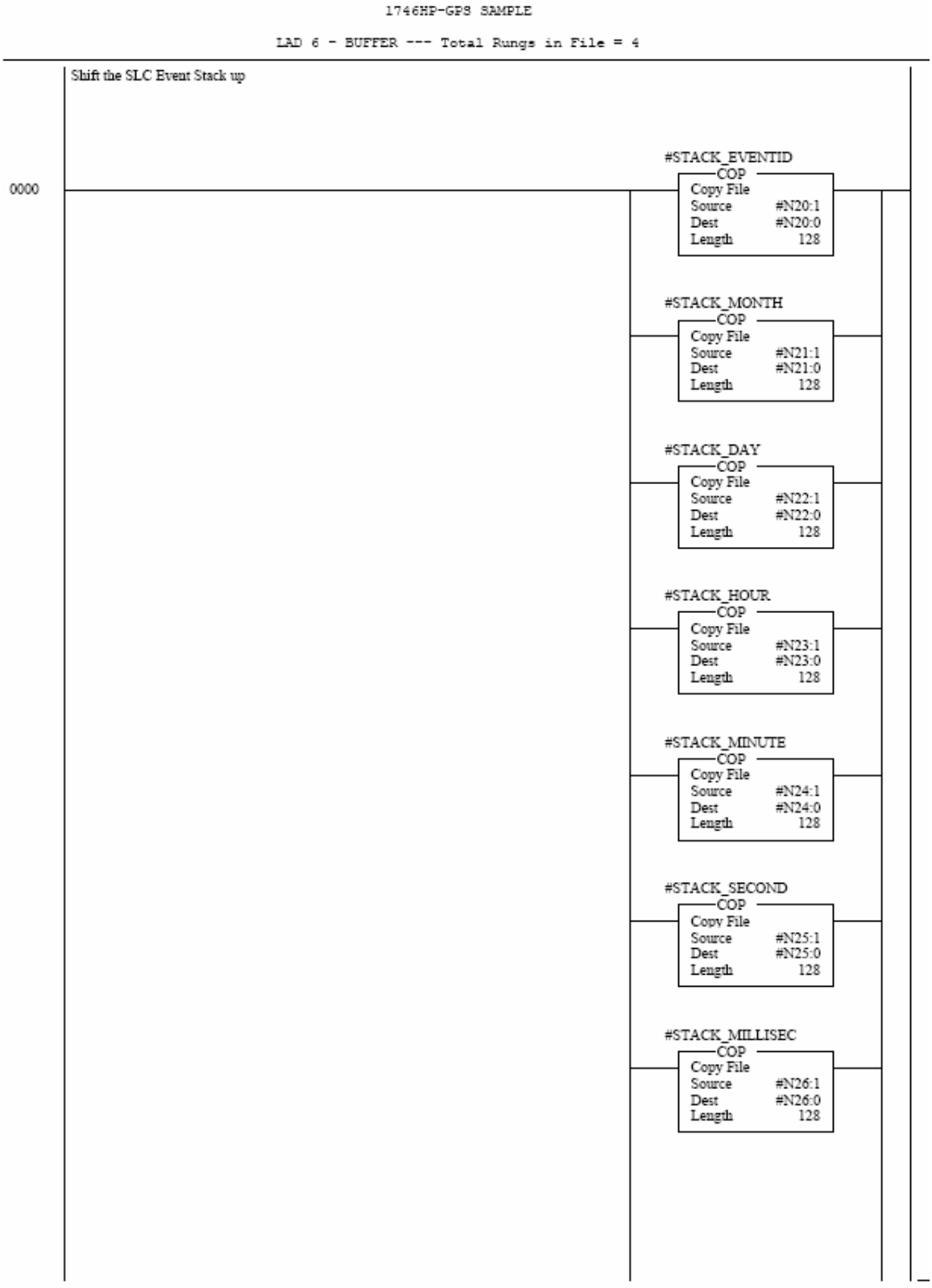

1746HP-GPS SAMPLE
LAD 4 - POS_VEL --- Total Rungs in File = 17
Extract Altitude
0005
GPS_LOCK I:3 1 OTHER
POS_ECEF I:3 13 OTHER
CPT
Compute
Dest N10:4 1580<
Expression I:3.12 + (I:3.13 * 10000)
Extract Altitude
0006
GPS_LOCK I:3 1 OTHER
POS_ECEF I:3 13 OTHER
POSITION_X
CPT
Compute
Dest F11:2 5061834.0<
Expression I:3.8 + (I:3.9 * 10000.0)
Extract Altitude
0007
GPS_LOCK I:3 1 OTHER
POS_ECEF I:3 13 OTHER
POSITION_Y
CPT
Compute
Dest F11:3 2690950.0<
Expression I:3.10 + (I:3.11 * 10000.0)
Extract Altitude
0008
GPS_LOCK I:3 1 OTHER
POS_ECEF I:3 13 OTHER
POSITION_Z
CPT
Compute
Dest F11:4 -2790205.0<
Expression I:3.12 + (I:3.13 * 10000.0)
Extract Velocity North
0009
GPS_LOCK I:3 1 OTHER
VEL_ECEF I:3 12 OTHER
VELOCITY_NORTH
DIV
Divide
Source A I:3.14 0<
Source B 10.0 10.0<
Dest F11:5 0.0<


1746HP-GPS SAMPLE
LAD 4 - POS_VEL --- Total Rungs in File = 17
Extract Velocity East
0010
GPS_LOCK
I:3
1
OTHER
VEL_ECEF
I:3
12
OTHER
VELOCITY_EAST
DIV
Divide
Source A I:3.15
0<
Source B 10.0
10.0<
Dest F11:6
0.0<
Extract Velocity Up
0011
GPS_LOCK
I:3
1
OTHER
VEL_ECEF
I:3
12
OTHER
VELOCITY_UP
DIV
Divide
Source A I:3.16
0<
Source B 10.0
10.0<
Dest F11:7
0.0<
Extract Velocity North
0012
GPS_LOCK
I:3
1
OTHER
VEL_ECEF
I:3
12
OTHER
VELOCITY_X
DIV
Divide
Source A I:3.14
0<
Source B 10.0
10.0<
Dest F11:8
0.0<
Extract Velocity East
0013
GPS_LOCK
I:3
1
OTHER
VEL_ECEF
I:3
12
OTHER
VELOCITY_Y
DIV
Divide
Source A I:3.15
0<
Source B 10.0
10.0<
Dest F11:9
0.0<


1746HP-GPS SAMPLE
LAD 4 - POS_VEL --- Total Rungs in File = 17
Extract Velocity Up
0014
GPS_LOCK
I:3
1
OTHER
VEL_ECEF
I:3
12
OTHER
VELOCITY_Z
DIV
Divide
Source A
I:3.16
0<
Source B
10.0
10.0<
Dest
F11:10
0.0<
0015
RET
Return
0016
END

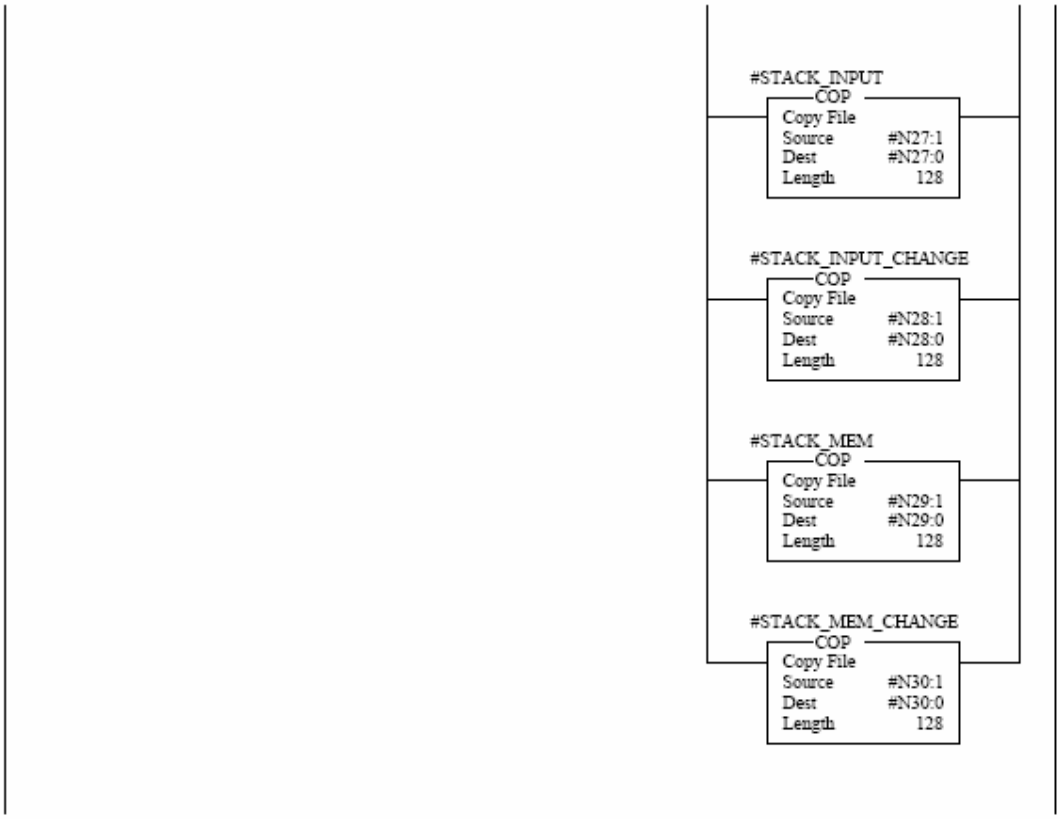

1746HP-GPS SAMPLE
LAD 5 - SIGNAL --- Total Rungs in File = 12
Extract GPS Current Channel
CHANNEL_BIT2
I:3
493
OTHER
GPS_CHANNEL/0
N12:0
0
0000
CHANNEL_BIT1
I:3
494
OTHER
GPS_CHANNEL/1
N12:0
1
0001
CHANNEL_BIT0
I:3
495
OTHER
GPS_CHANNEL/2
N12:0
2
0002
Extract the GPS Satellite PRN Identification
SV_PRN
AND
Bitwise AND
Source A I:3.30 A100h<
Source B 7936 7936<
Dest N12:1 0001h<
0003
SV_PRN
DIV
Divide
Source A N12:1 1<
Source B 256 256<
Dest N12:1 1<
0004
Extract the GPS Satellite Signal Strength
SV_SNR
AND
Bitwise AND
Source A I:3.30 A100h<
Source B 255 255<
Dest N12:2 0000h<
0005

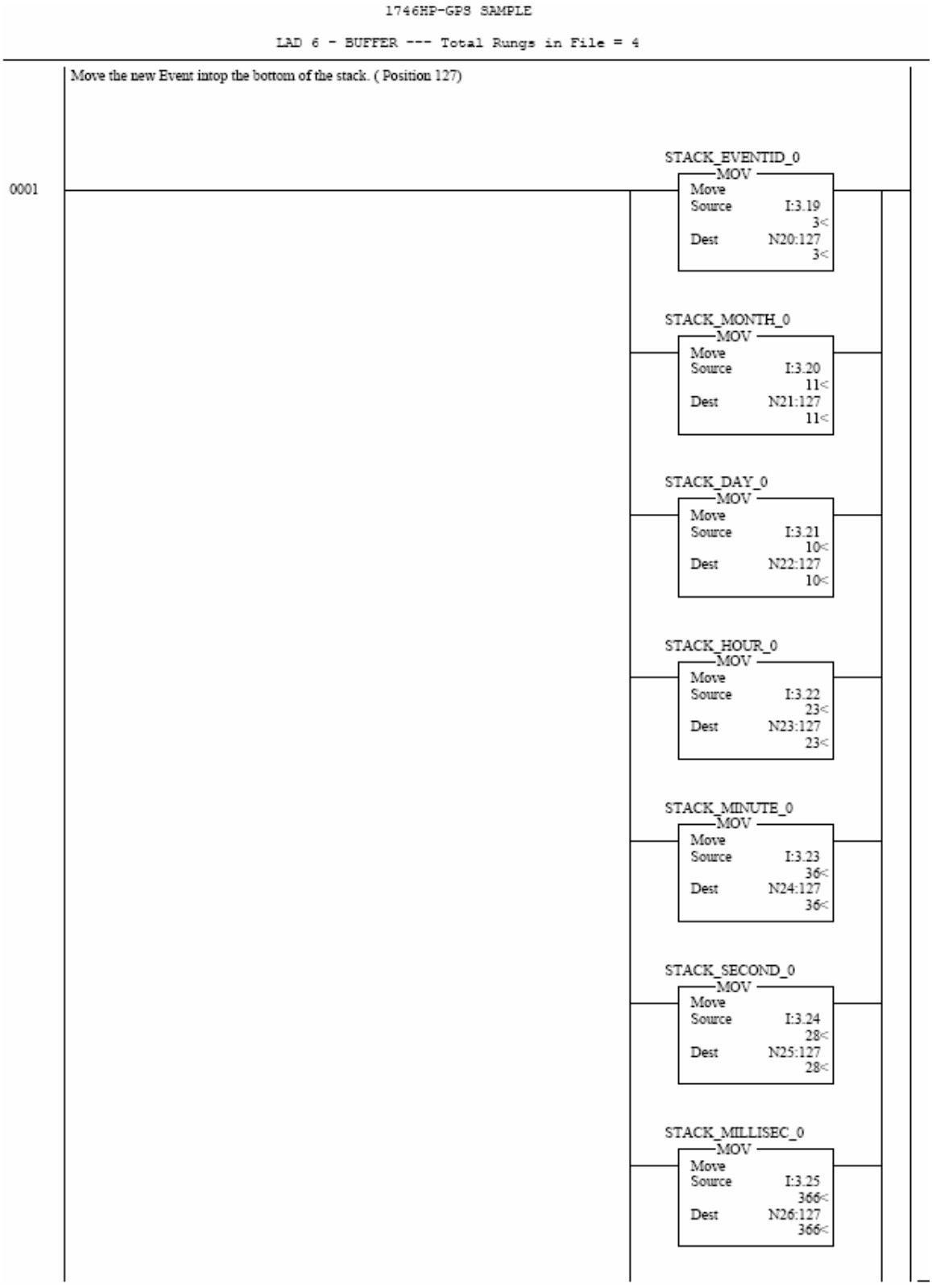

1746HP-GPS SAMPLE
LAD 5 - SIGNAL --- Total Rungs in File = 12
Move the Channel, Satellite PRN and Satellite Signal Strength into a table
0006
SV_PRN_POINTER
ADD
Add
Source A N12:0 5<
Source B 10 10<
Dest N12:3 14<
0007
SV_SNR_POINTER
ADD
Add
Source A N12:0 5<
Source B 20 20<
Dest N12:4 24<
0008
GPS_CHANNEL
GEQ
Grtr Than or Eql (A>=B)
Source A N12:0 5<
Source B 0 0<
GPS_CHANNEL
LEQ
Less Than or Eql (A<=B)
Source A N12:0 5<
Source B 7 7<
N12:[SV_PRN_POINTER]
MOV
Move
Source N12:1 1<
Dest N12:[N12:3] 28<
0009
GPS_CHANNEL
GEQ
Grtr Than or Eql (A>=B)
Source A N12:0 5<
Source B 0 0<
GPS_CHANNEL
LEQ
Less Than or Eql (A<=B)
Source A N12:0 5<
Source B 7 7<
N12:[SV_SNR_POINTER]
MOV
Move
Source N12:2 0<
Dest N12:[N12:4] 90<
0010
RET
Return
0011
END

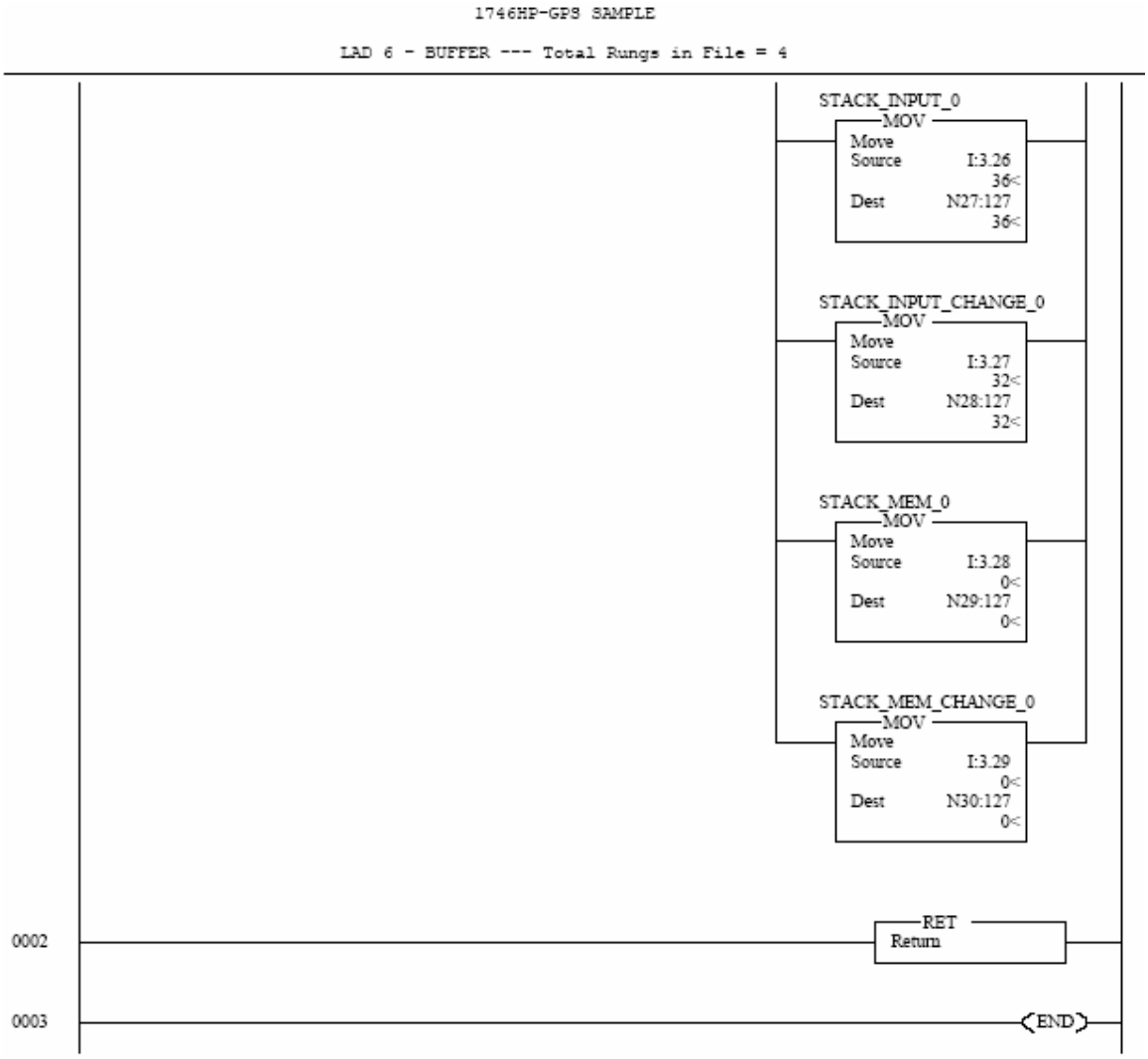

1746HP-GPS SAMPLE
LAD 6 - BUFFER --- Total Rungs in File = 4
Shift the SLC Event Stack up
0000
#STACK_EVENTID
COP
Copy File
Source #N20:1
Dest #N20:0
Length 128
#STACK_MONTH
COP
Copy File
Source #N21:1
Dest #N21:0
Length 128
#STACK_DAY
COP
Copy File
Source #N22:1
Dest #N22:0
Length 128
#STACK_HOUR
COP
Copy File
Source #N23:1
Dest #N23:0
Length 128
#STACK_MINUTE
COP
Copy File
Source #N24:1
Dest #N24:0
Length 128
#STACK_SECOND
COP
Copy File
Source #N25:1
Dest #N25:0
Length 128
#STACK_MILLISEC
COP
Copy File
Source #N26:1
Dest #N26:0
Length 128

1746HP-GPS SAMPLE

LAD 6 - BUFFER --- Total Rungs in File = 4




1746HP-GPS SAMPLE
LAD 6 - BUFFER --- Total Rungs in File = 4
Move the new Event intop the bottom of the stack. (Position 127)
0001
STACK_EVENTID_0
MOV
Move
Source I:3.19 3<
Dest N20:127 3<
STACK_MONTH_0
MOV
Move
Source I:3.20 11<
Dest N21:127 11<
STACK_DAY_0
MOV
Move
Source I:3.21 10<
Dest N22:127 10<
STACK_HOUR_0
MOV
Move
Source I:3.22 23<
Dest N23:127 23<
STACK_MINUTE_0
MOV
Move
Source I:3.23 36<
Dest N24:127 36<
STACK_SECOND_0
MOV
Move
Source I:3.24 28<
Dest N25:127 28<
STACK_MILLISEC_0
MOV
Move
Source I:3.25 366<
Dest N26:127 366<


1746HP-GPS SAMPLE
LAD 6 - BUFFER --- Total Rungs in File = 4
STACK_INPUT_0
MOV
Move
Source I:3.26
36<
Dest N27:127
36<
STACK_INPUT_CHANGE_0
MOV
Move
Source I:3.27
32<
Dest N28:127
32<
STACK_MEM_0
MOV
Move
Source I:3.28
0<
Dest N29:127
0<
STACK_MEM_CHANGE_0
MOV
Move
Source I:3.29
0<
Dest N30:127
0<
0002
RET
Return
0003
END

APPENDIX B SPECIFICATIONS

Parameter	Specification
General	
Module Location	Any Slot
Electrical	
Backplane Current	515mA @ 5.1V
	3mA @ 24V
Schedules Connection Paramters	
RPI	0.2ms to 750ms
GPS Receiver Specification	
General	L1 frequency (1575.42 MHz), C/A code (Standard
	Positioning Service), 8-channel, continuous tracking receiver,
	32 correlators
Accuracy Horizontal	<6 meters (50%), <9 meters (90%)
Altitude	<11 meters (50%), <18 meters (90%)
Velocity	0.06 m/sec
Time	±95 ns or 1 RPI
Hot Start	<14 sec. (50%), <18 sec. (90%)
Warm Start	<38 sec. (50%), <45 sec. (90%)
Cold Start	<90 sec. (50%), <170 sec. (90%)
Antenna	
Antenna Connector	SMA female connector
Frequency Range	1575.42 MHz ± 1.023 MHz
Polarization	Right-hand circular polarization (RHCP)
Output Impedance	50Ω
VSWR	2.0 maximum
Axial Ratio	90°: 4.0 dB maximum; 10°: 6 dB maximum
Gain	35 dB ± 3 Db
Out of Band Rejection	fo: 1575.42 MHz
	fo ± 20 MHz : 7dB min
	fo ± 30 MHz : 12dB min
	fo ± 40 MHz : 20dB min
	fo ± 100 MHz : 100dB min
Azimuth Coverage	360° (omni-directional)
Elevation Coverage	0° to 90° elevation (hemispherical)
Antenna Patch Lead	
Coax Type	RG-58
Impedance	50Ω

APPENDIX C GLOSSARY

Communications format
Format that defines the type of information transferred between an I/O module and its owner controller. This format also defines the tags created for each /O module

Coordinated System Time (CST)
Timer value which is kept synchronized for all modules within a single ControlBus chassis. The CST is a 64 bit number with μs resolution.
Coordinated System Time (CST)

Download
The process of transferring the contents of a project on the workstation into the controller

Earth-Centered-Earth-Fixed (ECEF) coordinates
Cartesian coordinate system where the X direction is the intersection of the prime meridian (Greenwich) with the equator. The vectors rotate with the earth. Z is the direction of the spin axis, with positive through the north pole.

GPS (Global Positioning System)
A constellation of 24 radio navigation (not communication) satellites which transmit signals used (by GPS receivers) to determine precise location (position, velocity, and time) solutions. GPS signals are available world-wide, 24 hours a day, in all weather conditions. This system also includes 5 monitor ground stations, 1 master control ground station, and 3 upload ground stations.

GPS Antenna
An antenna designed to receive GPS radio navigation signals. These antennas typically comprise a Low Noise Amplifier (LNA) and are known as active, and thus require DC power.

GPS Processor
An electronic device that interprets the GPS radio navigation signals (received by a GPS antenna) and determines a location solution.

GPS Receiver
The combination of a GPS antenna and a GPS processor.

Owner controller
The controller that creates and stores the primary configuration and communication connection to a module

PDOP Position Dilution of Precision.
PDOP is a unitless figure of merit that describes how an uncertainty in pseudo-range affects position solutions.

PRN Pseudo-random noise.
Each GPS satellite generates its own distinctive PRN code, which is modulated onto each carrier. The PRN code serves as identification of the satellite, as a timing signal, and as a subcarrier for the navigation data.

Producer/consumer
Intelligent data exchange system devices in which the GPS module produces data without having been polled first.

Removal and insertion under power (RIUP)
ControlLogix feature that allows a user to install or remove a module or RTB while power is applied.

Requested packet interval (RPI)
A configurable parameter which defines when the module will multicast data

Service
A system feature that is performed on user demand

Signal to noise ratio
A measure of the relative power levels of a communication signal and noise on a data line. SNR is expressed in decibels (dB).

SV
Space Vehicle (GPS satellite).

Tag
A named area of the controller's memory where data is stored like a variable

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