PACSystems™ RX3i

SEQUENCE OF EVENTS USER MANUAL

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Contents

Chapter 1:   Introduction

Capturing a sequence of events is important in a variety of automation applications. The idea is to set up the target system in such a way as to continuously capture any change in state of selected I/O points throughout the application, store the resultant records into a managed depository, then be in a position to analyze the sequence of events that led up to a trigger situation, such as the inadvertent opening of a valve, or some other unintended operation of the overall system.

Key to capturing intelligible data is synchronizing all devices throughout the system to a common time-base and using a time-base with a degree of resolution that is meaningful for the application. The time-base is used to time-stamp each event recorded. By analyzing the captured sequence of events, the automation designer or system operator can reconstruct the activities that led up to the trigger event, and thereby correct or adjust the operation in order to achieve a more desirable outcome.

With the RX3i Sequence of Events (SoE) architecture shown in Figure 1, all the elements described above are made available.

Figure 1: SoE High-Level Architecture
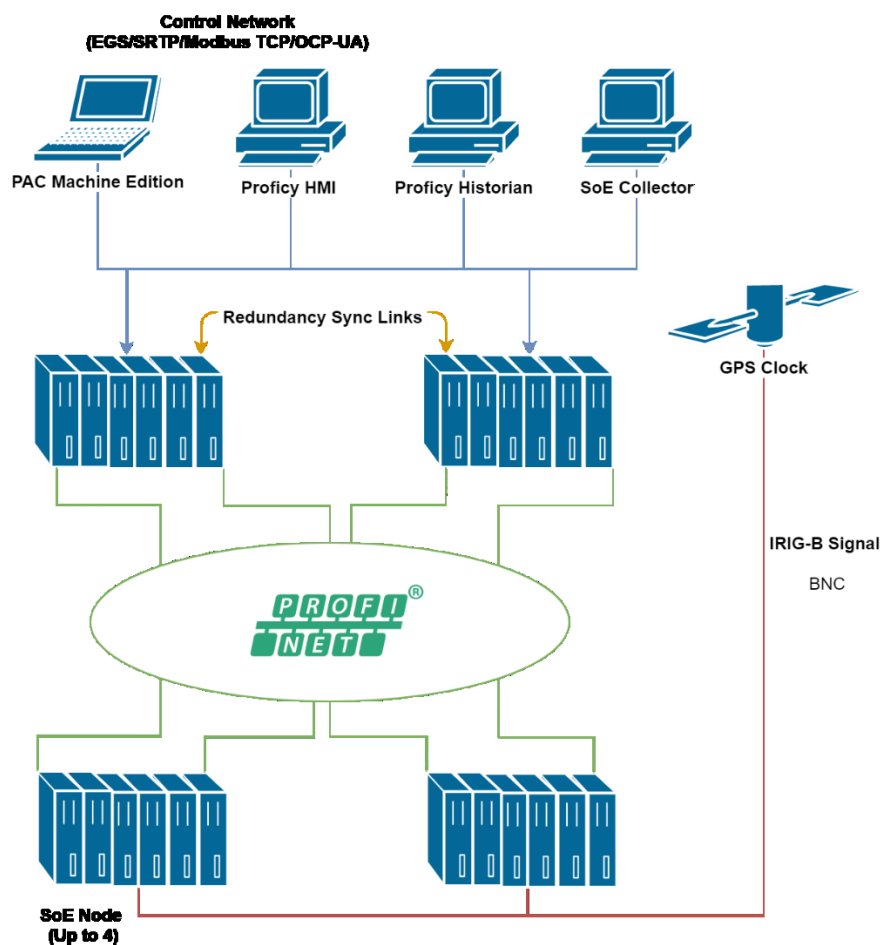
1.1 Key Features

1.1.1 High System Availability

The RX3i solution relies on a system configuration that provides high reliability and is compatible with both redundant and simplex applications. The I/O is connected via the industry-standard PROFINET. The CPUs are interconnected via high-speed links that synchronize the redundant CPUs, if redundancy is used. The computer used to collect the sequence of events records is attached via a high-speed, high-availability Ethernet link.

1.1.2 Time-stamps to 1ms Accuracy

The IRIG-B time reference signal, used to establish a system-wide time-base, is directly connected to High-Speed Counter modules distributed throughout the network via a dedicated signal network.

This solution provides time synchronization of I/O events accurate to 1ms using unmodulated IRIG-B formatted signals.

1.1.3 Components

The CPU which supports the SoE implementation is IC695CPE330.

To implement SoE, the CPE330 controller project folder (in PAC Machine Edition) contains a pair of dedicated C program blocks designed to configure and collect SoE records and provide diagnostic features.

The user defines which I/O points are to be monitored as part of the SoE data collection by means of the CPU registers used to interface with the C Block, and by configuring those points on the input module.

Each CPU is configured to use its embedded PROFINET Controller (PNC). Rack-mounted PROFINET Controllers may not be used to collect SoE records.

Each CPU may be configured for Simplex operation, or for PROFINET Redundancy. If PROFINET Redundancy is configured, the high-speed Redundancy links are provided by a pair of RMX modules (IC695RMX128 or IC695RMX228), two installed in each CPU rack of the Redundant pair.

Each PNC may control up to four PROFINET nodes collecting SoE data. These are designated SoE Nodes in this document. Each SoE node is equipped with an RX3i Advanced PROFINET Scanner Module (PNS101). The PNS101 contains features required in the SoE Application. The PNC is networked to its PNS modules over PROFINET, which may itself be configured for Media Redundancy (MRP mode). The PNC may control additional PROFINET IO Devices (not collecting SoE Data) based on its documented capabilities.

Up to four Discrete Input modules may be installed in any given PNS node. An SoE event is defined as a transition (low-to-high or high-to-low) on any of these inputs, provided they have been configured as an SoE channel to be monitored.

Each PNS can buffer up to 4,000 events in its event queue at a maximum rate of 400 events per second.

The I/O events are time-stamped by the PNS as they are scanned.

The PNS time-stamps are synchronized to the IRIG-B time-base via a High-Speed Counter (HSC) located within the same rack, thus all time-stamps are refenced to a common clock. The IRIG-B/HSC interface is described in Chapter 1:

Each SoE event is compiled into an SoE Record by the supervising PNS module. The SoE Record pinpoints the location of the input channel, the nature of the transition, and a time-stamp.

The SoE records from each of the PNS modules are passed to its networked CPE330 Embedded PNC and are then consolidated by the host CPU. The consolidated record set is placed in CPU reference memory as configured by the user (refer to Chapter 4:).

The Historian/SoE Collector (Cimplicity Historian/SQL database) can read the CPU's SoE Records Buffer using a variety of techniques: SRTP, EGD, etc. The CPU indicates how many records are present in that buffer. The Historian/SoE Collector, after reading these records, indicates to the CPU that they have been read. For details, refer to Section 5.7.

Component Checklist

Item	Catalog #	Description	Qty	Remarks
	IC695CPE330	RX3i CPU with embedded Ethernet	1 or 2	1 for Simplex 2 for Redundancy
RMX	IC695RMX128 or IC695RMX228	Reflexive Memory Module	2 per CPU	Redundancy only: Pair RMX128 with RMX128 or RMX228 with RMX228
PNC	N/A	PROFINET Controller	1 per CPU	Embedded in CPE330
PNS	IC695PNS101	Advanced PROFINET Scanner Module	Up to 4 per PNC	Each PNS controls a node of I/O Modules
HSC	IC695HSC304 or IC695HSC308	RX3i High-Speed Counter Module	1 per PNS	IRIG-B signal is connected to all HSC modules.
I/O Modules	IC694MDL660 or IC694MDL655	RX3i 32-Point 24Vdc Grouped Input Module	Up to 4 per PNS	Input-only module Only the IC694MDL660 and IC694MDL655 support the capture of SoE Events.

Item	Catalog #	Description	Qty	Remarks
I/O Rack	IC695CHSxxx	7-, 12-, 16-Slot RX3i Universal Backplane	1 per SoE Node	
Power Supply	IC695PWRxxx or IC695PSAxxx or IC695PSDxxx	RX3i Power Supply Modules	1 or 2 per rack	Size PS to meet rack current draw requirements
PAC Machine Edition	ME95MBP001	PACSystems Programming & Configuration Tool	1	PAC Machine Edition v9.50 SIM 7 or later[1]. Download from web-site.
HMI /Historian	Customer's choice		1	Historian/SoE Collector
IRIG-B Clock	Arbiter 1084	GPS Satellite Controlled Clock	1	Third-party item.

For PACSystems CPU information, refer to the PACSystems RX3i and RSTi-EP CPU Reference Manual, GFK-2222.

For programming a PACSystems CPU, refer to the PACSystems RX3i and RSTi-EP CPU Programmer's Reference Manual, GFK-2950.

For Ethernet information, refer to the PACSystems RX3i and RSTi-EP TCP/IP Ethernet Communications User Manual, GFK-2224.

For PROFINET information, refer to the PACSystems RX3i & RSTi-EP PROFINET I/O Controller Manual, GFK-2571 and to the PACSystems RX3i PROFINET Scanner Manual, GFK-2737.

For I/O Modules, High-Speed Counters, Power Supplies, I/O Racks and installation details, refer to the PACSystems RX3i System Manual, GFK-2314.

All manuals and software may be downloaded from https://www.emerson.com/Industrial-Automation-Controls/support

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[1] Download & install the GSDML from the firmware update kit for the Advanced PROFINET Scanner (IC695PNS101) (GSDML-V2.3-GEIP-RX3iPNS-20180724.xml or later for MDL660 support, GSDML-V2.3-IntelligentPlatformsLLC-RX3iPNS-20191010.xml or later is required for MDL655 support). The GSDML file impacts the configuration of the PNS101 and of the MDL660/MDL655 and HSC modules associated with the PNS101.

1.2   Glossary of Terms

Term	Explanation
CPU	In the context of this manual, a PACSystems RX3i CPU (specifically model IC695CPE330).
HMI	Human Machine Interface
HSC	High-Speed Counter
IRIG-B	Inter-range instrumentation group time codes, commonly known as IRIG time codes, are standard formats for transferring timing information. Atomic frequency standards and GPS receivers designed for precision timing are often equipped with an IRIG output.
MRP	Media Redundancy Protocol (used in PROFINET communications).
PLC	Programmable Logic Controller (CPE330 provides PLC functionality).
PAC Machine Edition	PAC Machine Edition: A configuration tool used to configure and program PACSystems CPUs.
PNC	PROFINET IO Controller (in the SoE Application, the CPE330 Embedded PROFINET Scanner is used).
PNS	PROFINET IO Scanner: a module which scans I/O modules in an I/O Rack and exchanges I/O data over PROFINET with a PROFINET IO Controller.
PROFINET	Acronym for Process Field Net: an industry technical standard for data communication over Industrial Ethernet.
RMX	Redundancy Memory Xchange module
SoE	Sequence of Events
SoE Node	A remote rack controlled by an IC695PNS101 Advanced PROFINET Scanner and containing the RX3i modules required to support SoE, as defined in Section 2.2.

1.3   Revisions in this Manual

Rev	Date	Description
C	Marc-2020	Adds support for Sequence of Events capture from IC694MDL655 modules in the PNS101 rack.
B	Sep-2018	Following Emerson's acquisition of this product, changes have been made to apply appropriate branding and registration of the product with required certification agencies. No changes to material, process, form, fit or functionality.
A	Aug - 2018	Release update. Advanced PROFINET Scanner with SoE released as IC695PNS101.
-	Apr-2018	Initial publication (for Beta).

1.4 PACSystems Documentation

A complete Sequence of Events application system incorporates a variety of hardware and software components.

A simple SoE ladder application template, along with C Blocks, and the Diagnostic UDTs referenced later in this document are available for download at the Emerson support website. The latest information can be obtained by searching for the PNS101 Landing Page and following SoE references there.

PACSystems Manuals

PACSystems RX3i and RSTi-EP CPU Reference Manual	GFK-2222
PACSystems RX3i and RSTi-EP CPU Programmer's Reference Manual	GFK-2950
PACSystems RX3i and RSTi-EP TCP/IP Ethernet Communications User Manual	GFK-2224
PACSystems TCP/IP Ethernet Communications Station Manager User Manual	GFK-2225
C Programmer's Toolkit for PACSystems	GFK-2259
PACSystems Memory Xchange Modules User's Manual	GFK-2300
PACSystems Hot Standby CPU Redundancy User Manual	GFK-2308
PACSystems Battery and Energy Pack Manual	GFK-2741
PAC Machine Edition Logic Developer Getting Started	GFK-1918
PACSystems RXi, RX3i and RSTi-EP Controller Secure Deployment Guide	GFK-2830
PACSystems RX3i & RSTi-EP PROFINET I/O Controller Manual	GFK-2571

RX3i Manuals

PACSystems RX3i System Manual	GFK-2314
PACSystems RX3i Ethernet Network Interface Unit User's Manual	GFK-2439
PACSystems RX3i PROFINET Scanner Manual	GFK-2737
PACSystems RX3i Serial Communications Modules User's Manual	GFK-2460
PACSystems RX3i High-Speed Counter Modules User's Manual	GFK-2441

In addition to these manuals, datasheets and product update documents describe individual modules and product revisions. The most recent PACSystems documentation is available on the Emerson support website https://www.emerson.com/Industrial-Automation-Controls/support

Chapter 2:   RX3i Hardware Configuration

Sequence of Events operation is configured by a combination of Hardware Configuration in PAC Machine Edition and SoE/IRIG-B User Memory Map data read by the SoE Application C Block (below in Chapter 4:). This section describes the required Hardware Configuration.

2.1   CPE330 Configuration

The SoE functionality is supported by the CPE330.

In PAC Machine Edition Navigator, configure LAN2 of the CPE330 as a PROFINET Controller, as shown in Figure 2.

Figure 2: CPE330 with Embedded PROFINET Controller
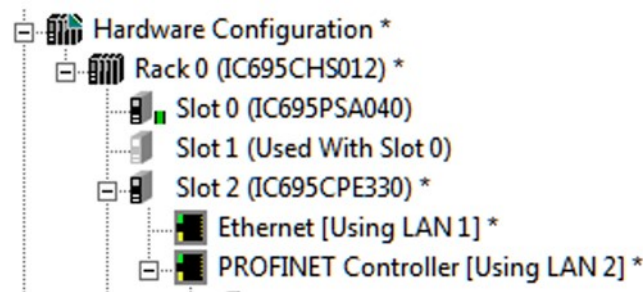
The settings tab Shows LAN2 Mode configured for PROFINET, which is what is required for this application:
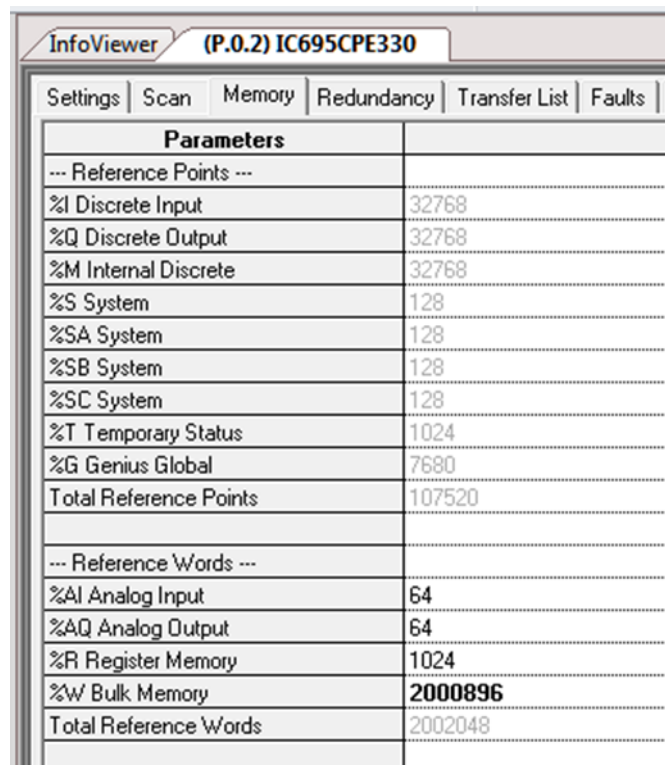
Figure 3: CPE330 Settings Showing LAN2 Mode = PROFINET

Once the PROFINET Controller has been configured, add nodes to the PROFINET network. For SoE, an IC695PNS101 is selected as the module to be added. An example is shown in Figure 2. It displays in PAC Machine Edition as an Advanced PROFINET Scanner. Each PNS101 added will function as the head-end of the RX3i rack containing all the hardware required to support SoE, as discussed in Section 2.2, SoE Node Configuration. Up to four PNS101 modules may be added in this fashion.

SoE functionality requires locating and reserving two blocks of memory; a 151-word User Memory Map area that is specified as one of the input parameters to the SoE Application C Block, and an SoE Records Buffer whose size and location is configured within the User Memory Map. (The SoE Records Buffer size is defined by the number of records specified in element 17 of the SoE Memory Map multiplied by 10 words per record for a size of up to 320,000 words.) Each block may be in any of the Word-type Reference memory areas; i.e. %W, %R, %AI, or %AQ. Reference Memory area sizes are user-configured on the CPE330 Memory tab and must allocate enough memory for the highest memory reference used. Figure 4 shows a configuration which is utilizing %W memory for both the Memory Map and SoE Records Buffer.

Figure 4 CPE330 Memory Configuration

In planning, care should be taken that the Memory Map and SoE Records Buffer do not conflict with memory used by anything else, and if located in the same memory region, do not overlap each other.

2.1.1 Redundant Systems

In a system configured for Hot Standby Redundancy, the Active controller must synchronize it's SoE Records Buffer with the Backup Controller on every sweep. This can contribute significant additional sweep time when the external Historian/SoE Collector is not keeping up with the SoE events being generated, therefore the CPU Watchdog Timer parameter may need to be increased. The worst-case SOE sweep time impact is approximately 120ms. The Watchdog Timeout should be set to at least the normal sweep time + 120ms. For example, if the sweep is normally 100ms with no SoE records buffered internally then the watchdog should be set to at least 220ms (100 + 120 = 220).

Figure 5: Watchdog Timer Configuration

The SoE Records Buffer should be added to the Output Transfer List of the system. The Memory Map area should not be in either of the Transfer Lists. The SoE_App and CPE330 firmware will transfer the portions of the Memory Map area that should be synchronized. Specifically, the CPE330 firmware will maintain the SoE Record Communication Buffer Handshake and SoE Records Buffer update counter. These two registers must not be in either transfer list. If the SoE Records Buffer is incorrectly added to the Input Transfer List, SoE Events placed in the SoE Records Buffer on the sweep before a CPU switchover are lost.

Remote Station Overflow bits are not maintained in a redundant manner. They are set on the Active unit on the first read of records after an overflow has occurred. If it is desired to maintain these accurately on a redundant system, they should be OR'd into a variable from User Logic and that variable should be placed on the Output Transfer List.

Similarly, the Overflow bit (bit 1) of the SoE Status register is set when new data is received on the Active unit that would overflow the buffer. When SoE data is transferred to the backup unit, the overflow condition is not sent. When the Backup unit transitions to the Active unit, it has all the internal events transferred and the ½ full and ¾ full bits will be correctly set based on that internal data, but an overflow bit will not be maintained. If it is necessary to maintain the overflow condition between redundant CPUs, the SoE Status register should be placed on the Output Transfer List.

2.2   SoE Node Configuration

2.2.1   Physical Constraints for Devices in an SoE Node

Each of the RX3i SoE Nodes shown in Figure 1 must conform to the following module placement:

Figure 6: SoE Node (Remote Rack) Module Placement

Once a slot is selected for the PNS module, the input modules used in SoE must be placed contiguously to the right of the PNS Module, as shown in Figure 6. Up to four input modules are permitted per Node. The slot location of the PNS module is passed to the C Block via the Memory map discussed in Chapter 4:

The Power Supply follows rules for its placement per the PACSystems RX3i System Manual, GFK-2314.

The High-Speed Counter is free to use any unoccupied slot. It may not be placed between the PNS module and any of the designated SoE Input Modules. The IRIG-B signal is connected to the HSC, as discussed in Chapter 3:.

Figure 7(below) shows a fully-configured SoE Node, corresponding to that diagrammed in Figure 6 The PNS101 occupies Slot 1. This constrains the MDL660/MDL655 modules to Slot 2 and

higher (contiguously). The Power Supply occupies Slot 0 and the HSC occupies Slot 6. The whole arrangement fits in a 7-slot RX3i backplane.

Figure 7: Fully-Configured SoE Node (Remote Rack)


```
Slot 2 (IC695CPE330) *
   Ethernet [Using LAN 1] *
   PROFINET Controller [Using LAN 2] *
      rx3i-pns (#1) [7-Slot (Slot 1) PACSystems RX3i Advanced PROFINET IO Scanner] *
         Slot  0 (IC695PSD140: Multifunctional 24VDC 40W Power Supply (1-slot)) *
         Slot  1 (7-Slot (Slot 1) PACSystems RX3i Advanced PROFINET IO Scanner) *
         Slot  2 (IC694MDL660: 32 Circuit Input 24 VDC Positive / Negative Logic with SoE) *
            Subslot  1 (Inputs Only with SoE) *
         Slot  3 (IC694MDL660: 32 Circuit Input 24 VDC Positive / Negative Logic with SoE) *
            Subslot  1 (Inputs Only with SoE) *
         Slot  4 (IC694MDL660: 32 Circuit Input 24 VDC Positive / Negative Logic with SoE) *
            Subslot  1 (Inputs Only with SoE) *
         Slot  5 (IC694MDL660: 32 Circuit Input 24 VDC Positive / Negative Logic with SoE) *
            Subslot  1 (Inputs Only with SoE) *
         Slot  6 (IC695HSC308: RX3i High Speed Counter (8 Counters)) *
            Subslot  1 (IC695HSC308: IRIG-B Time Source) *
   Slot 3 (Used With Slot 2)
```

For full details of configuring a PROFINET Controller, refer to the PACSystems RX3i & RSTi-EP PROFINET I/O Controller Manual, GFK-2571.

For full details of configuring a PROFINET Scanner, refer to the to the PACSystems RX3i PROFINET Scanner Manual, GFK-2737.

2.2.2   I/O Mapping for Devices in an SoE Node

As shown in Figure 6, the Input Modules and PNS are constrained to a fixed physical arrangement. Similarly, within each SoE Node, the mapping of those inputs into the host CPU reference memory is fixed relative to one another, as described in this section. If PACS Machine Edition has any problems accepting the planned reference assignments, the user must either change some external reference assignments, or alter the planned reference assignments in PAC Machine Edition.

The base index for each SoE Node is defined in Chapter 4:, SoE/IRIG-B User Memory Map. These assignments are passed to the C-Block.

Notation: since multiple PNS modules may be present in the SoE structure, this document is using PNS(x) to denote the PNS module located in SoE Node x in the Memory Map. Thus PNS(1) represents the PNS in Node 1, PNS(2) represents the PNS located in SoE Node 2, etc. Each PNS(x) has a unique range of map elements associated with it, per Chapter 4:

For PNS(1), the definition is presented in Element (26) and Element (27). Thus,

- if Element (26) is set to 16(dec), the CPU reference memory type is defined as %I;
- if Element (27) = 1001, the starting reference for this SoE Node is %I1001.

| Device	Required/ Optional	Reference Assigned	Number of Bits	Example
PNS(1)	Required	Per Element (26) and Element (27)	32	%I1001 - %I1032
Input Module 1	Required	Next contiguous	32	%I1033-%I1064
Input Module 2	Optional	Next contiguous, if used	32	%I1065-%I1096
Input Module 3	Optional	Next contiguous, if used	32	%I1097-%I1128
Input Module 4	Optional	Next contiguous, if used	32	%I1129-%I1160
HSC (IRIG-B)	Required	None		

The PROFINET Scanner Module also consumes 32 bits of output data. Refer to the PACSystems RX3i PROFINET Scanner Manual, GFK-2737.

2.3 PNS Selection

A PNS is added by right-clicking the CPE330 PROFINET Controller (Figure 7)and selecting Add IO-Device. This opens the PROFINET Device Catalog. Expand the RX3iPNS entry to expose the RX3i PNS101 configuration selections (Figure 8). The revision date is encoded as part of the RX3iPNS entry name. If there are multiple RX3iPNS entries, typically you should select the latest.

When adding a device to the PROFINET network (Figure 8), choose one of the devices with the description Advanced PROFINET IO Scanner. The selection represents the PNS101 module itself, the type of rack in which it will reside, and the slot it will occupy in that SoE Node:

Figure 8: Select Advanced PROFINET IO Scanner from PROFINET Device Catalog
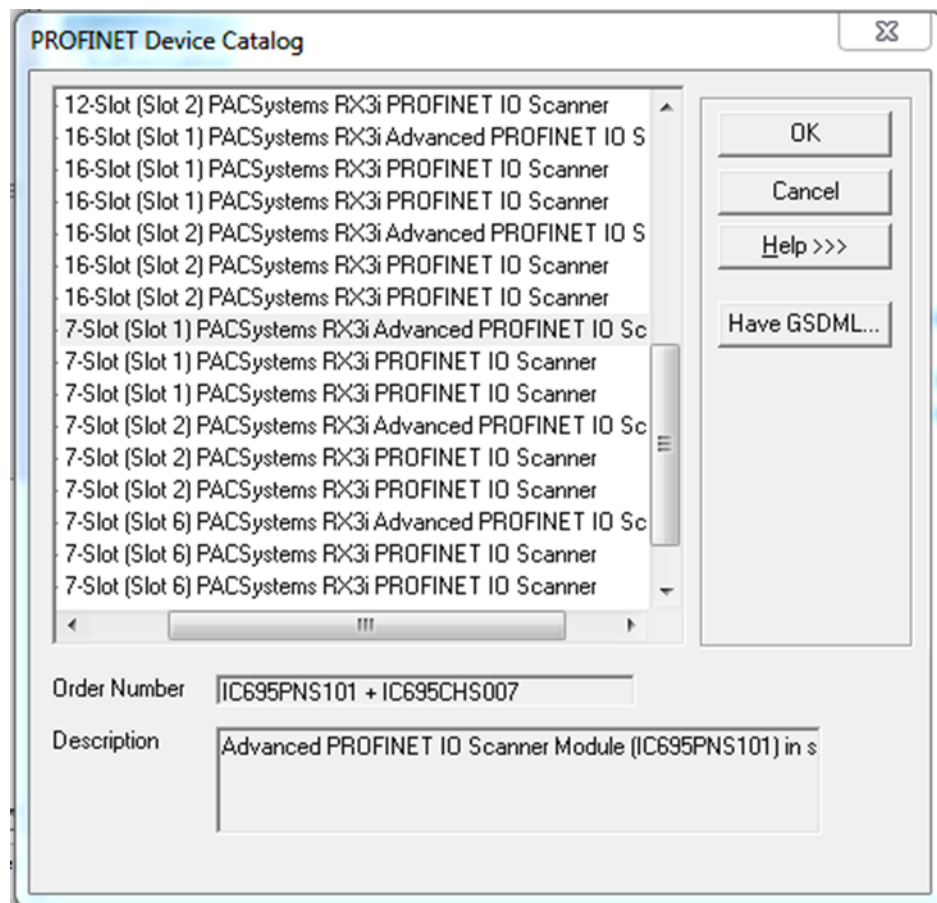
In the event the particular version of Advanced PROFINET IO Scanner is not available, or an updated GSDML file has been made available, click on the Have GSDML button (Figure 8) and browse to the folder containing the new GSDML file, then import that file to the PROFINET Device Catalog. Detailed instructions are provided in the PACSystems RX3i & RSTi-EP PROFINET I/O Controller Manual, GFK-2571.

GSDML files are available for download (as part of the PNS101 firmware update kits) at https://www.emerson.com/Industrial-Automation-Controls/support.

2.4 PNS Configuration

The Update Rate of the PNS scan should be set to either the fastest supported for the overall system (see PROFINET IO controller documentation for the fastest rate supported for the number of nodes in the system) or considering the rate of SoE Records generated. The CPE330 uses the PNS status bits to know if there are any records available to be retrieved. If too many records occur before the update of the PNS status bits, an overflow can occur within the PNS internal queue and events will be lost.

2.4.1   Module Parameters

Figure 9 PNS Module Settings Tab

The Advanced PROFINET Scanner (IC695PNS101) has a parameter in its Module Parameters Tab labeled Max IO Scan of 1ms which defaults to Enabled. When enabled, the Scanner prioritizes the collection of input transitions at a 1ms rate, and internal schedules and settings are adjusted to prioritize the I/O scanning. To support 1ms SoE collection, all limitations must be adhered to and this parameter set to Enabled.

The PNS101 is optimized to support 1ms SoE collection when used with up to four IC694MDL660.IC694MDL655 input modules and one IC695HSC304/308 for IRIG-B time synchronization and the Max IO Scan of 1ms parameter Enabled. Additional general purpose I/O may be incorporated into the PNS101 rack, however, adding general purpose I/O increases the PNS101 IO scan time and the PNS101 may not be able to maintain a 1ms SoE collection rate. For the best performance, general purpose I/O should be in a separate PROFINET Scanner rack and not added to a dedicated PNS101 SoE Node. If general purpose I/O modules are present in the PNS101 SoE node, best-effort SoE collection can be used. In that case, the Max IO Scan of 1ms parameter should be set to Disabled to allow for I/O scans potentially longer than 1ms and correct servicing of the SoE and general purpose of I/O modules in a given PNS101 SoE node. SoE collection will occur at the I/O scan rate of the PNS101 which may be longer than 1ms. In this case, events occurring faster than the PNS101 I/O scan rate may be missed.

2.5   HSC Configuration

Most of the HSC configuration is performed by the SoE C Block. Only one parameter is available when the HSC is chosen to be an IRIG-B Time Source. On the Module Parameters tab, the HSC External Input Voltage threshold is defaulted to 5V to match the voltage range of the IRIG-B clock source output as shown in Figure 10. This may be changed to 12/24V if the IRIG-B clock source provides signaling in that range.

Figure 10: HSC Input Voltage Threshold Configuration
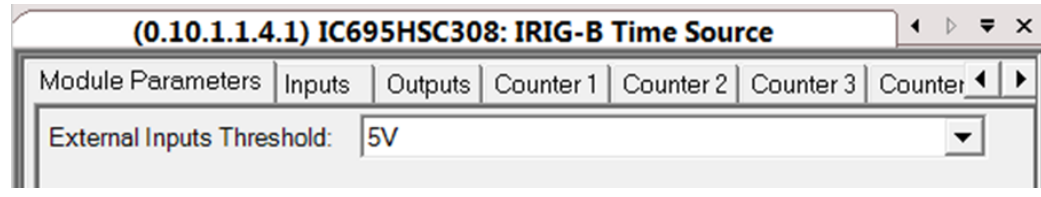
2.6   MDL660 Configuration

Each IC694MDL660 Input Module needs to be configured.

a.   To determine which inputs on the module are being used in the SoE application. Any inputs with SoE enabled (Figure 12) will be monitored for input state transitions. Any such transitions will be logged as an SoE Record. This aspect is discussed in this section.

b.   Note that the status bits normally associated with MDL660 are not allowed in combination with the SoE feature.

Figure 11: PAC Machine Edition Navigator Tree View of MDL660 in SoE Node (Remote Rack)
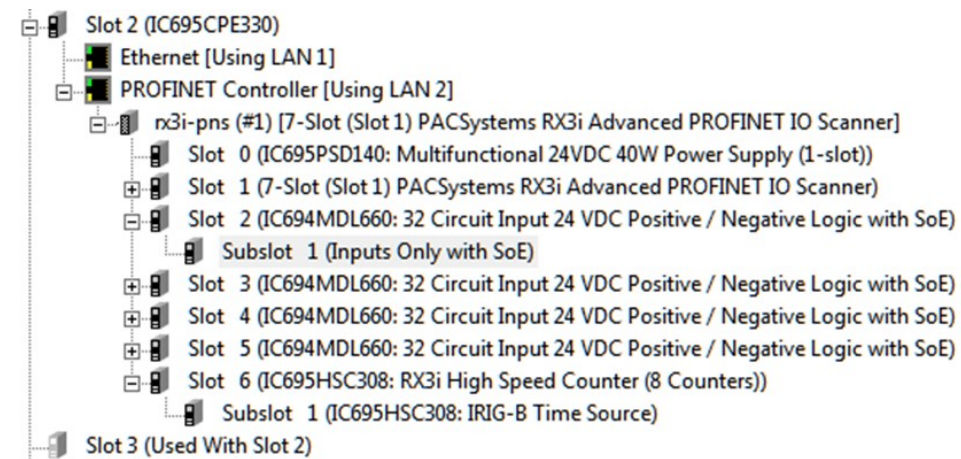
Figure 12: Enable MDL660 Inputs as SoE Channels

The MDL660 has 32 input channels. Any combination may be used as SoE Input Channels, as determined by the selections made on the MDL660 Module Parameters tab (Figure 12).

2.7 MDL655 Configuration

Each IC694MDL655 Input Module needs to be configured.

To determine which inputs on the module are being used in the SoE application. Any inputs with SoE enabled (Figure 13) will be monitored for input state transitions. Any such transitions will be logged as an SoE Record. This aspect is discussed in this section.

Figure 13: PAC Machine Edition Navigator Tree View of MDL655 in SoE Node (Remote Rack)

Figure 14: Enable MDL655 Inputs as SoE Channels
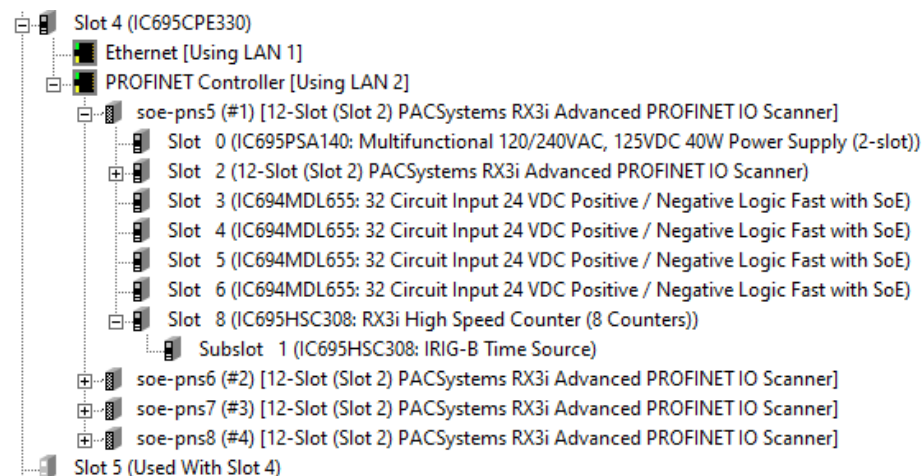

The MDL655 has 32 input channels. Any combination may be used as SoE Input Channels, as determined by the selections made on the MDL655 Module Parameters tab (Figure 16).

Chapter 3:   IRIG-B Set-up & Interface

IRIG-B is a protocol used to encode Global Positioning System (GPS) time into a serial bit stream. The RX3i architecture uses the IRIG-B data stream to synchronize its local clock to that GPS Time. It then uses its locally synchronized clock as the time-source when an SoE event is detected in the RX3i system.

The IRIG-B signal is physically interfaced to the RX3i SoE system via a BNC cable. The BNC signal is connected to a series of High-Speed Counter (HSC) Modules, one located in each SoE Node, as shown in Figure 1. Either an IC695HSC304 or an IC695HSC308 may be used.

The HSC module converts the IRIG-B signal to a digital bitstream that is delivered to the PNS over the backplane. The PNS module interprets the bitstream to resynchronize its internal time base once per second, which it subsequently uses to time-stamp all SoE events in the same rack.

The time-stamped SoE records are stored by the PNS. The PNS then sets an SoE Data Available status bit indication to the CPU. The CPU automatically retrieves the associated SoE records over PROFINET and deposits those records into the memory location previously configured for SoE Records (refer to Chapter 1:)

The limiting factor for overall accuracy of the time-stamp is the 1ms update rate of the inputs on IC694MDL660/IC694MDL655 and the input filter delay of the IC694MDL655. Refer to the PACSystems RX3i System Manual, GFK-2314 for information on how to set the input filter to its lowest value on MDL660. This setting (0) corresponds to the hardware filter of 0.5ms. The purpose of the input filter is to prevent unwanted transitions from external electrical noise that may be present at the SoE Node,

The supported formats of the IRIG 200-04 standard are: B000, B004, B005, B006, and B007. Instruments that use the older IRIG 200-98 standard are also supported in format B000 with IEEE 1344-1995 control function extensions.

The solution can be configured to accept Unmodulated (DC Level) IRIG-B signals. Modulated (1 kHz Carrier) signaling is not supported.

3.1　Connecting the IRIG-B to HSC Input

Attach the BNC cable to the Unmodulated (DC Level) output connector on the IRIG-B hardware, in accordance with your application design.

The IRIG-B Signal is connected to the HSC in each SoE Node on the network via BNC breakout boxes, as indicated in Figure 13 One BNC breakout box is required for each SoE Node in your application.

- Connect the positive signal from the BNC breakout box to Input 1 (Terminal 1) of the HSC.

- Connect the BNC breakout box negative signal to the HSC Common terminal (Terminal 9).

- Do not use any other HSC input for this purpose.

Figure 15: IRIG-B Signal Distribution
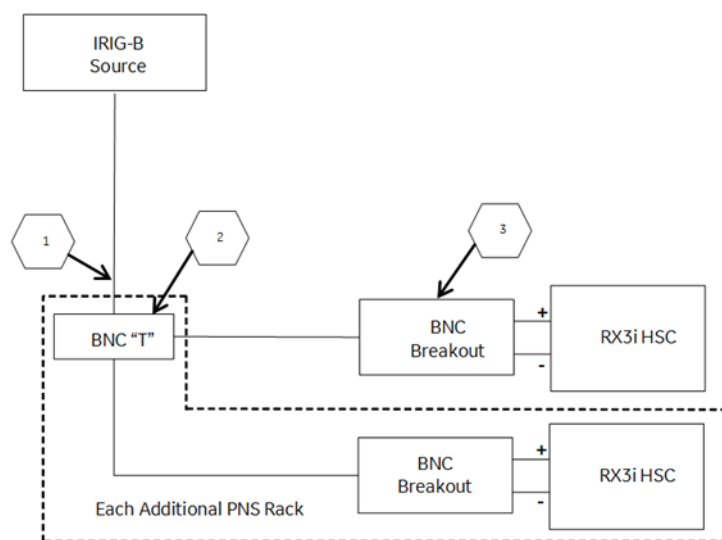
The following table documents the callouts shown in Figure 15. The indicated components are available from multiple sources. The indicated vendor and corresponding components are provided as a reference.

Item	Part Number	Description	Vendor
1	2249-C-XX	RG58 Patch Cable: (XX = length in inches)	Pomona
2	3284	BNC Tee	Pomona
3	4969	BNC Breakout	Pomona

Figure 16: Field Wiring HSC304
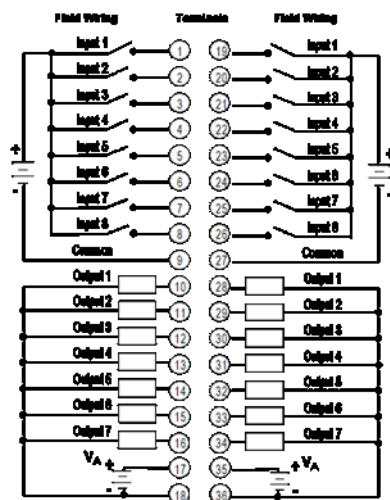
Figure 17: Field Wiring
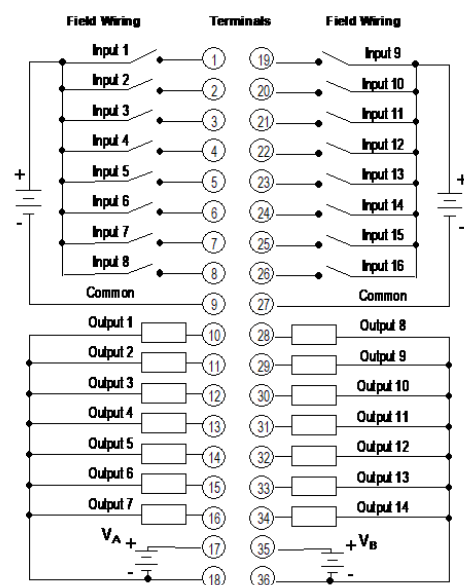
HSC308The HSC module used for interfacing with the IRIG-B signal cannot perform any other functions

Refer to the PACSystems RX3i System Manual, GFK-2314, Chapter 8, for information on HSC304 & HSC308.

3.2   Synchronization of the CPU System Clock

The CPE330 system clock is not synchronized to the IRIG-B signal.

Chapter 4: SoE/IRIG-B User Memory Map

The structure discussed in this chapter is set up in the PLC CPU Memory. It is manipulated by the user in order to interface with the SoE application.

The SoE C-Block accepts an input which defines the base memory location for the structure. Once the base location is set, all elements are relatively located, as shown below.

The SoE User Memory Map consists of three main areas; the Handshake Word (element 1), Status (elements 2 through 11), and Configuration (elements 17 and beyond). The Configuration area defines the size and location of the SoE Records Buffer, and the PNS node(s) providing the event data.

Note that elements (18) and (19) combine to determine where the SoE Records Buffer is to be located. The Memory Map and SoE Records Buffer may be in %W, %R, %AI, or %AQ memory. Adequate memory must be specified in the PAC Machine Edition CPE330 Memory configuration (refer to 2.1 CPE330 Configuration). Care should be taken that the Memory Map and SoE Records Buffer do not conflict with memory used by anything else and, if located in the same memory region, do not overlap.

Element (Word Offset)	Type	Access	Sub-Structure	Function
(1)	WORD	R/W		SoE Record Communication Buffer Handshake
(2)	WORD	R		Overflow Missed Events Counter
(3)	WORD	R		SoE Records Buffer update counter
(4)	WORD	R		SoE Status Flags
(5)	DWORD	R		Informational: Minimum PLC Scan Time (μS)
(7)	DWORD	R		Informational: Current PLC Scan Time (μS)
(9)	DWORD	R		Informational: Maximum PLC Scan Time (μS)
(11)	DWORD	R		Remote Station Overflow bits
(13)	DWORD	R		Reserved
(15)	DWORD	R		Reserved
(17)	WORD	W		Maximum Number of SoE Records Buffered in CPU SoE Records Buffer (Simplex: 1-32,000, Hot Standby Redundancy: 1000-32,000)
(18)	WORD	W		SoE Records Buffer Memory Type (e.g., %W = 196)
(19)	DWORD	W		SoE Records Buffer Memory Index (e.g., Index into %W: use 1001 to represent %W1001)

Element (Word Offset)	Type	Access	Sub-Structure	Function
(21)	WORD	W		Reserved
(22)	WORD	W		SoE Record Export Format (Always 0)
(23)	WORD	W		Number of SoE Nodes (i.e., Number of PNS devices, maximum of 4)
(24)	WORD	W	PNS(1)	PROFINET Device Number[2] of PNS(1)
(25)	WORD	W	PNS(1)	PNS(1) Slot location in SoE Node
(26)	WORD	W	PNS(1)	PNS(1) Status Memory Type (e.g., %I = 16 dec)
(27)	WORD	W	PNS(1)	PNS(1) Status Memory Index (e.g., index into %I)
	Repeat Elements (24) through (27) for each PNS-controlled SoE Node in the system. (max 4 PNS's).			
(36)	WORD	W	PNS(4)	PROFINET Device Number[2] of PNS(4)
(37)	WORD	W	PNS(4)	PNS(4) Slot location in SoE Node
(38)	WORD	W	PNS(4)	PNS(4) Status Memory Type (e.g., %I = 16 dec)
(39)	WORD	W	PNS(4)	PNS(4) Status Memory Index (e.g., index into %I: use 1 to represent %I0001)

The map above is laid out for the maximum four SoE Nodes.

The user also populates some aspects via normal configuration parameters in PAC Machine Edition.

The C-Block validates some of this data and validation is returned in the Configuration/Set-up status (refer to Section 4.2).

Use a DATA INIT Block to configure the SoE application with an FST_EXE contact. Such a DATA INIT block would start at element 17 (Maximum Number of SoE Records Buffered in CPU).

Note: *The SoE Node configuration assumes the input modules (max 4) are installed immediately to the right of the PNS module. For instance, if the PNS module is installed in Slot #1, then the input modules must be installed in Slots #2 through #5, contiguously. Fewer than four input modules are permitted, but they still must be installed in contiguous slots. Index 25 above defines the slot number of the PNS Module, and by extension, the locations of the input modules which it services.*

---

[2] PROFINET Device Number cannot be 0. SoE Record requires 1-127 (7-bit constraint – refer to Appendix A).

4.1 Memory Map Definitions

Element	Sub-Structure	Function	Definition	Range
(1)		SoE Record Communication Buffer Handshake	Read: The number of events that are available in the SoE Records Buffer. Write: The Historian/SoE Collector reciprocates by setting this word to zero each time all content has been copied to the Historian itself.	
(2)		Overflow Missed Events Counter	Number of times the internal buffer overflowed, and events are lost	
(3)		SoE Records Buffer update counter	Incremented by 1 when one or more new events have become available in the SoE Records Buffer since the SoE Record Communication Buffer Handshake word was last cleared. Cleared to 0 on stop to run transition.	
(4)		SoE Status	Bit 1: 1= Internal events buffer overflowed. Cleared on stop to run transition. Bit 1: 0= PLC Reset or new configuration downloaded. Bit 2: PLC restarted (CPU sets bit to 1 following a Stop to Run transition) The HMI/SCADA/Controls system can set Bit 2 to zero to monitor when the PLC is restarted. Bit 3: Reserved Bit 4: 1 = Internal event buffer is ½ full. Cleared when the event count drops below ½ full or stop to run transition. Bit 5: 1 = Internal event buffer is ¾ full. Cleared when the event count drops below ¾ full or stop to run transition. Bit 6 - 16: Reserved	
(5)		Minimum PLC Scan Time (μS)	Informational	
(7)		Current PLC Scan Time (μS)	Informational	
(9)		Maximum PLC Scan Time (μS)	Informational	
(11)		Remote Station Overflow bits	Each bit is set to 1 when there is an overflow (and records are lost) at the remote (PNS) station. The bit remains set until a zero is written to that position. Each bit represents the corresponding PNS configured at Element 24 or later. Bit 0 is the PNS at Element 24, Bit 1, the PNS at Element 28, etc.	
(13)		Reserved		
(15)		Reserved		

Element	Sub-Structure	Function	Definition	Range
(17)		Maximum Number of SoE Records Buffered in CPU	The communication buffer in the CPU is configurable to store up to 32,000 SoE Records. This word indicates the maximum number of SoE Records the host HMI/SCADA/Controls Application Program can poll and collect. By checking the information in the SoE Record Communications Buffer Handshake word (1), the SoE C-Block application in the CPE330 moves the SoE Records from the internal buffer to the SoE Records Buffer. Be aware that the larger the number of SoE Records specified, the larger the impact on the PLC scan time. Each SoE Record is 10 words in size.	1-32,000 For Redundancy, the range is 1,000 – 32,000.
(18)		SoE Records Buffer Memory Type (%W, %R, %AI, or %AQ)	%W = 196 (dec), %R = 8, %AI = 10 (dec), %AQ = 12 (dec)	Using %W is recommended.
(19)		SoE Records Buffer Memory Index (i.e., Index into Memory Type)	Enter 1001 to indicate %W1001, for example.	Range is dependent on memory type and configuration maxima (selected at Index (18) above).
(21)		Reserved		0
(22)		Export Format	This parameter is used to select the SoE Record Format that will be used in the SoE Records Buffer.	Always 0
(23)		Number of SoE Nodes (i.e., Number of PNS devices)		1-4
(24)	PNS(1)	PROFINET Device Number	Range is limited by Export Format	1 - 127
(25)	PNS(1)	Slot occupied by PNS in remote rack (SoE Node)	slot #: 0 = slot 0… up to 0FH=Slot 15	0 - 15
(26)	PNS(1)	PNS Status Memory Type (%I, %Q, %G, %M, %T)	For this memory type / decimal value: %I Discrete input table (Byte mode) 16; %Q Discrete output table (Byte mode) 18; %G Discrete G table 86; %M Discrete M table 76; %T Discrete T table 74	

Element	Sub-Structure	Function	Definition	Range
(27)	PNS(1)	PNS Status Memory Index (e.g. index into %I)	1 represents %I0001	
Repeat elements (24) through (27) for each PNS-controlled SoE Node in the system. Refer to page 23.				

4.2 Configuration/Set-up Status

The status reflected here is generated by the SoE C-Block. It is one word wide. Its location in reference memory is determined by the CPE330 application program. See Rung 5 in the ladder logicbelow (Figure 27).

Status	Description
0	OK
-1	The SoE User Memory Location, supplied as a parameter to the C-Block is null, which is not permitted. (This does not apply to the SoE Status parameter, which may be null).
-2	Memory Type used for the SoE Memory Map is not supported. Supported types are %W, %R, %AI, and %AQ.
-3	The SoE User Memory Location supplied as a parameter to the C Block is set to a Memory Type configured for a memory size of 0.
-4	SoE Memory Map will not fit in the available memory. Either there is insufficient memory configured or the 151-word map is not within the available memory range.
-5	Unsupported SoE record format. Check the contents of the Export Format element in the Memory Map.
-6	Memory Index used for the SoE Records Buffer is zero. All CPU memory is 1-based, e.g. %W0001, etc.
-7	Memory Type used for the SoE Records Buffer is not supported. Supported types are %W, %R, %AI, and %AQ.
-8	SoE Records Buffer, as configured, will not fit in the available memory. There is insufficient memory configured for the specified memory, or it is located such that it does not fit in the range of available memory.
-9	SoE Records Buffer size has been set to default. This happens when the user inputs a size of zero or a value greater than the maximum (32,000). The default value is 50 events. This error code may be ignored; the code is displayed but the C Block call will pass power.
-10	SoE Records Buffer update delay value is not supported and must be set to zero.
-11	SoE Records Buffer starts within the SoE Memory Map area.
-12	SoE Records Buffer overlaps SoE Memory Map area.
-13	Unsupported number of Remote Nodes. Valid values are 1 through 32.
-14	Applying SoE configuration has failed. Ensure the CPE330 firmware version supports the SoE C Block. (Requires CPE330 version 9.60 or later).
-15	Failed to collect SoE Records from the CPU.
-1xx	Invalid Device Number. Error numbers are in the range -101 to -132.

Status	Description
	An unsupported Device Number was specified in the indicated PNS record (1-32). The PNS Device Number must be in the range of 1 – 127.
-2xx	Invalid Remote Node Status Memory Type. Error numbers are in the range -201 to -232. An unsupported reference address memory type was specified in the indicated PNS record (1-32).
-3xx	Invalid Remote Node Status Memory Index. Error numbers are in the range -301 to -332. An invalid reference address was specified in the indicated PNS record (1-32).

4.3 Configuration Errors

Some setup or configuration errors in an SoE system are only detected when the SoE application has been stored and the CPE330 put in run mode. These errors are reported in the CPU Fault Table. The presence of any of these faults indicates the SoE system is not configured correctly and the system will not collect and report all Events.

These errors are caused by incorrect data in one or more of the four-word SoE Node descriptors, starting at element 24 in the User Memory Map (section 4.1 Memory Map Definitions). If one of these errors occurs, review the SoE Node PNS descriptors and correct as necessary. Changes are applied by storing the updated logic and putting the CPU in Run mode.

Note that all Fault Extra Data is in hexadecimal format.

4.3.1 Invalid Device Number (Error Code 662)

The fault shown below is the result of providing an SoE Node Profinet Device Number that does not exist in the hardware configuration of the PAC Machine Edition project.

Figure 18: PLC Fault Table

Figure 19: PACSAnalyzer Output

In the above example PROFINET Device Number 3 as indicated in the fault extra data (9th byte) has been specified for an SoE Node but does not exist in the hardware configuration of the PAC Machine Edition project. Determine the correct PNS Device Number in the hardware configuration for the project, find the corresponding SoE Node descriptor and replace with the correct value.

4.3.2   Collector Access Denied (Error Code 663)

The fault shown below may occur if a collector record request has been refused by an SoE Node. The ninth byte of the Fault Extra Data is the SoE Node descriptor index in the Memory Map (section 4.1 Memory Map Definitions) for the device being accessed when the failure occurred. In the example below the error occurred while accessing SoE Node defined by the descriptor at index 0, i.e. the descriptor starting at element 24. Verify that the correct slot location has been specified in the SoE Node descriptor.

Figure 20: PLC Fault Table

Controller Fault Table (Displaying 1 of 1 faults, 0 Overflowed)		
Loc	**Fault Description**	
0.2	Non-critical CPU software event	
	Error Code	Group	Action
	663	140	1:Informational
	Fault Extra Data:		06 13 04 a3 81 4e 00 13 00 00 00 00 00 00 00 00 00 00

Figure 21: PACSAnalyzer Output

```
############################  PLC FAULT TABLE  #############################

Last cleared: 08-10-2018 10:54:57
Displaying 1 of 1 faults (0 overflowed), in time descending order.

  1. Location: 0.2    Date/Time: 08-10-2018 11:34:42.303
     Group:140   INFO_CPU_SOFTWR - CPU software event
     Error Code:663    Action:1    Task Num:3
     Extra Data: 06 13 04 a2 81 4e 00 13 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
           ASCII:  .  .  .  .  .  N  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
```

Chapter 5: Operation

5.1 Functions of the C Program Blocks

Two C Block programs are supplied with the SoE application: SoE_App and IRIG_Diag. Both are non-modifiable programs developed by Emerson. The main functions of the C Blocks are:

a. To initialize and configure SoE operation based on the user's input as set out in the User Memory Map (Chapter 1:

b. To pass that configuration to the CPE330 firmware.

c. To trigger the collection of an SoE record from a Remote Node by means of a Special SVC_REQ.

d. To provide diagnostics for the overall SoE Application.

Locate and select the C Program Block in PAC Machine Edition Navigator:

Figure 22: SoE C Program Block Viewed in PAC Machine Edition Navigator
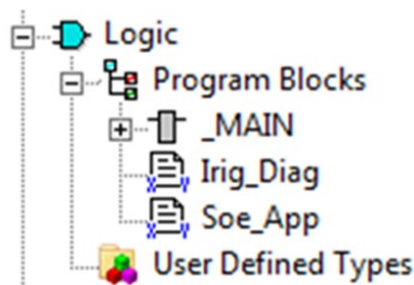
In the PAC Machine Edition Inspector, right click in the empty box to the right of the Parameters entry, then click on the ellipses (…) in order to access the parameters for the C Program Block:

Figure 23: Access the Parameters for C Program Block
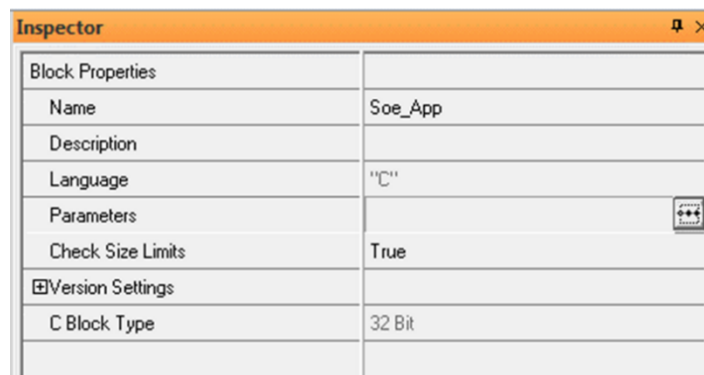
5.1.1 Set up the Input and Output Parameters for the C Program Block

The SoE_App C Program Block requires one input parameter and supplies two output parameters:

1. INPUT - SoE User Memory Location (WORD). This parameter is pointing to the base of the SoE User Memory Map discussed in Chapter 1:. Enter a memory reference such as %W0001. Note that the corresponding memory area cannot be used for any other purpose once assigned to the SoE Application.

2. OUTPUT - Configuration Status (INT). The C-Block uses this parameter to indicate the status of the SoE application operations, per section 4.2. Zero indicates OK. Negative values indicate various error conditions. This parameter may be null, but null is not recommended, as status information would not then be relayed to the user.

3. OUTPUT – SoE C-Block Version: for information only. Should any interfaces change over time, they may be traced to this item.

Figure 24: C Program Block Input Parameters

Figure 25: C Program Block Output Parameters

5.1.2   Install Ladder Logic in Support of C-Block

Once the User Memory Map (refer to Chapter 4:) and the Input and Output Parameters discussed above have been set up, install ladder logic (or equivalent) to initialize the SoE execution, using a Data Init Function Block, as shown in Figure 26 (rung 3). The Data Init function is used to populate user configuration data in the SoE Memory Map that begins at Element 17. This should be executed only once.

Figure 26: Data Init Function Block for SoE_App Set-up (Rung 3)
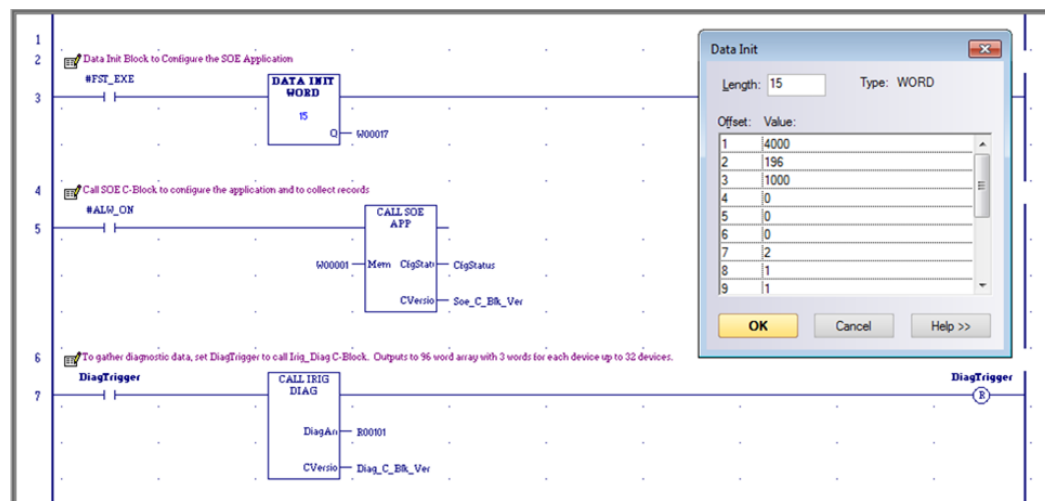
The first word of the SoE User Memory Map is the SoE Record Communications Buffer Handshake word. The C Block updates this word with the number of Events that have been copied to the SoE Records Buffer. When the buffer is populated, no more events are written. Writing zero to this word causes the Controller to start re-filling the capture buffer from the start.

The next 6 parameters provide SoE status information and are updated continuously while the C Block is being executed.

The parameters starting at word 17 provide SoE configuration data to the Controller. These are read by the SoE C Block and updated to the CPE330 on stop-to-run transitions only.

Following initialization, the C Program Block is called on every subsequent Logic Scan.

Figure 27: Calling SoE_App C Program Block from Main Program (Rung 5)
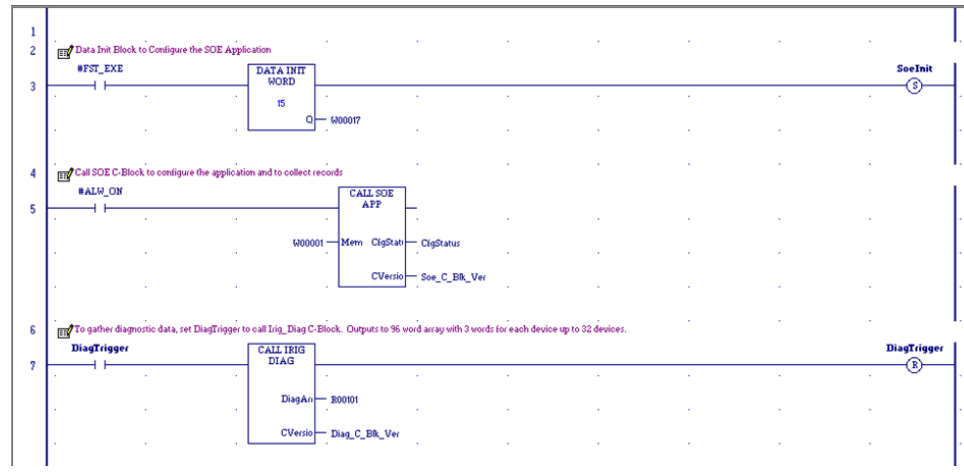
5.2 Functions of the Input Modules (MDL660/MDL655)

The input module MDL660 or MDL655 is scanned in the normal way by the PROFINET Scanner (PNS) located in the same rack. For those inputs which have been designated as SoE Channels (refer to Section 2.6, MDL660 Configuration or Section 2.7 MDL655 Configuration), an SoE event is logged whenever a transition is detected on a corresponding input.

5.3 Functions of the High-Speed Counter (HSC)

Each High-Speed Counter Module converts the GPS Time IRIG-B data stream to a digital data stream to be interpreted by the PNS.

Note that the functionality of the HSC is constrained by the GSMDL file used in this application. Only the IRIG-B input is operational.

5.4 Functions of the Advanced PROFINET Scanner (PNS101)

The PROFINET Scanner executes several functions:

a. Interprets the data stream from the HSC to synchronize the SoE Node time-base once per second.

b. Read inputs from the IC694MDL660's or IC694MDL655's in the rack. If the PNS is configured for a Max IO Scan of 1ms, then priority is given to reading the MDL660/MDL655's every 1ms so events can be recognized every ms.

c. Based on the configuration received during initialization, it analyzes the inputs from the SoE-enabled channels of the MDL660/MDL655 modules located in the same rack

and generates an SoE time-stamped record whenever a transition is detected on one of those channels.

d. Once PNS101 is initialized, config received and is ready to record events, any input that is already in a high state will be recorded as a new event.

e. It generates an IRIG-B time processing status.

f. In response to periodic requests from its host CPU, the PNS passes the SoE records to its host over the PROFINET bus.

5.4.1   Input Status Bits

The PROFINET Scanner's 32 bits of input status provide information about the scanner. All status bits are active high. Bit 1 is the least significant bit.

Status Bits	Name	Description
1	Module OK	Indicates the health of the module. A value of 0 indicates the module is powering up or has failed. A value of 1 indicates the module is functioning properly
2	Reserved	Set to 0
3	Port1 Link Up	1 = port is connected to another device and is communicating. 0 = port is not connected to another device, or the port has some sort of error preventing communications.
4	Port2 Link Up	
5	Port3 Link Up	
6	Port4 Link Up	
7-10	Reserved	Set to 0
11	MRP Enabled	Indicates whether MRP has been enabled or not. A value of 0 indicates that MRP is not enabled. A value of 1 indicates that MRP is enabled.
12	MRP Role	Always 0. PNS only supports MRP Client.
13	PNS Synchronized	PNS101 is synchronized to the GPS global time.
14	SoE Events Available	SoE Events available
15-32	Reserved	Set to 0

The PNS Synchronized status indicates that the PNS has synchronized its clock to the GPS global time. Clock synchronization may require if 90 seconds after power-up. Any records captured before synchronization will have 1970 as the year and other timestamp values will not be referenced to the GPS global time. This status is echoed in the corresponding output data of the SoE Diagnostic Block. The SoE Events Available status indicates that the PNS has captured events available to be read by the PLC. This is an indication to the SoE Application to request event data from the PNS.

5.5   Functions of the PROFINET Controller (PNC)

In addition to its role as a normal PROFINET Bus Controller, the CPE330 Embedded PNC retrieves SoE data from all the configured SoE Nodes and interfaces with its host PACSystems Controller (CPE330).

During initialization, it passes configuration information to each PROFINET Scanner, as appropriate for that PNS101.

5.6   Functions of the CPE330

The CPE330 interfaces with the C Program Block and with the Embedded PROFINET Controller (PNC).

  a. It processes the Configuration represented in the User Memory Map (Chapter 1:and passes that configuration information to the PNC, which in turn, passes segments to each PNS, as appropriate.

  b. Based on PNS Status information, it initiates the collection of SoE records from each SoE Node via the PNC and accumulates them for retrieval by the Historian/SoE Collector.

  c. Whenever the SoE Communication Buffer Handshake Word is zero, the CPU transfers SoE Records from the internal SoE Records Buffer to the Communication Buffer in accordance with the user-supplied configuration (Chapter 1:).

  d. The CPU monitors whether the internal SoE Records Buffer is full. In response to a full condition, the more recent SoE records are lost and a diagnostic is produced (Chapter 6:).

5.7   Functions of a Historian/SoE Collector

A Historian/SoE Collector interfaces with the CPE330 using an agreed protocol, such as SRTP, EGD.

  a. Whenever the SoE Record Communications Buffer Handshake Word is non-zero, the Historian/SoE Collector reads the contents of the SoE Records Buffer from the CPE330 for that number of records.

  b. Once all records have been transferred from the SoE Records Buffer, the Historian/SoE Collector needs to set the SoE Record Communications Handshake Word to zero, as that action tells the CPE330 that the buffer is available for update again.

  c. The Historian/SoE Collector retains all SoE records collected in this fashion, in conformance with rules established by its operator.

  d. The Historian/SoE Collector then performs further SoE record analysis, as programmed by its operator.

5.8 Performance Considerations

For both Simplex and Redundant operation, each RX3i PNS101 device and each MDL module in the PNS rack will contribute time to IO Scan sweep impact. The IO scan sweep impact is the same as non-SOE RX3i PNS001 devices and modules.

For Simplex (non-redundant) SOE operation, the SOE Application C-block has a logic execution time that impacts CPU sweep time.

The SOE_Application logic execution time can be estimated as follows:

SOE_ Application Idle call: 0.02ms

SOE_ Application Update call: 0.75ms per 1000 events added to SoE Records Buffer

An Idle call occurs when the app is either waiting for the next SoE Record Communication Buffer Handshake or there are no events in the internal buffer to move to the SoE Records Buffer. An Update call occurs when the SOE Application updates the SoE Records Buffer with new events.

The following formula estimates the SOE Application logic execution time for SoE Records Buffer Update calls of at least 1000 events or more:

SoeAppExeTimeMilliseconds = (eventCnt * 0.00075)

Since the maximum SoE Records Buffer event size is 32000, the worst case SOE Application logic execution time is approximately 24ms. The worst-case logic execution impact can be reduced by configuring the SoE Records Buffer for a smaller size. In most cases, the SOE Application will be called in the Idle state so a minimal execution time will occur, but periodically the SoE Records Buffer will be updated and that will result in a larger execution time for that sweep.

For redundant SOE operation, the synchronization of buffered events from Active to Backup is the primary contributor to sweep time. This sweep impact is dynamic and can change from sweep-to-sweep depending on the number of events in the Internal buffer (not the SoE Records Buffer in user memory). To keep the sweep impact to a minimum, the external Historian/SOE Collector should empty the SoE Records Buffer at regular intervals and at a rate that keeps up with the SOE event generation rate.

There can be additional sweep time impact due to the SoE Records Buffer data in the Transfer List and the SOE_ Application C-Block execution time. For the SoE Records Buffer data in the Transfer List, the sweep impact is constant each sweep. The sweep impact can be minimized by using a smaller SoE RecordsBuffer. Allowed redundant SoE Records Buffer sizes are between 1000 and 32000, so a size closer to 1000 will reduce the Transfer List sync time. For the SOE_ Application C-Block, the logic execution times are equal to the simplex/non-redundant times. However, when the SOE_ Application moves events from the internal buffer to the SoE Records Buffer the sweep time will likely be reduced because the impact due to synchronizing events in the internal buffer is greater than the SOE_ Application logic execution time to move events to the SoE Records Buffer.

Below are typical sweep time impacts for SOE events in the internal buffer:

For 1 event queued -> 0.5ms

For first 1000 events -> 2.0ms

For each additional 1000 events -> 0.85ms per 1000.

The internal buffer's redundant synchronization is more efficient for larger event sizes. Below is an equation to estimate the sweep impact for internal buffer event counts over 1000.

BufferSyncMilliseconds = ((eventCnt-1000) * 0.00085) + 2.0

If the SOE internal buffer fills to its max size of 128000, then the sweep impact is approximately 110ms. Note, this formula is only approximate. There is variation in the sweep impact depending on how the events are queued and how many are queued. For example, if one PNS queues 8 events this may have less impact than 8 different PNS devices each queuing 1 event to the internal buffer. This calculation is an estimate only.

Chapter 6: Diagnostics

The SoE system drops the more recent events once the Internal Events Buffer overflows. There are indications that the buffer has overflowed in the memory map. Refer to the SoE Status Byte, bit 1 (Section 4.1, Memory Map Definitions). Each SoE Node also has an Overflow bit in the Remote Station Overflow bits status register.

The IRIG_Diag C-Block is used to collect diagnostic info from the configured SoE devices.

The SoE Application provides a User Defined Type (UDT) for monitoring the diagnostic data collected by the Diagnostic block. The IRIG Diag Data UDT can be applied to the Diagnostic C Block by expanding the UDT node in the PAC Machine Edition Navigator pane and dragging the IRIG_DIAG_DATA element to the first output of Diagnostic C Block.

Figure 28:
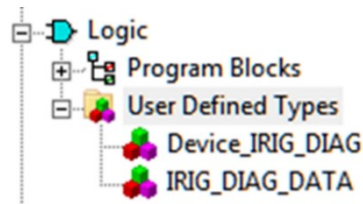
6.1   Configuring the SoE Diagnostic Block

There are no input parameters for this C-Block.

The screenshots below show two methods of setting up the Irig_Diag C-Block Output parameters:

- Figure 29: IRIG-B Diagnostics Output Parameters (UDT)shows a configuration using a UDT for the DiagArray output.

- Figure 30 shows a configuration using a WORD array output.

Figure 29: IRIG-B Diagnostics Output Parameters (UDT)

Figure 30: IRIG-B Diagnostics Output Parameters (Words)
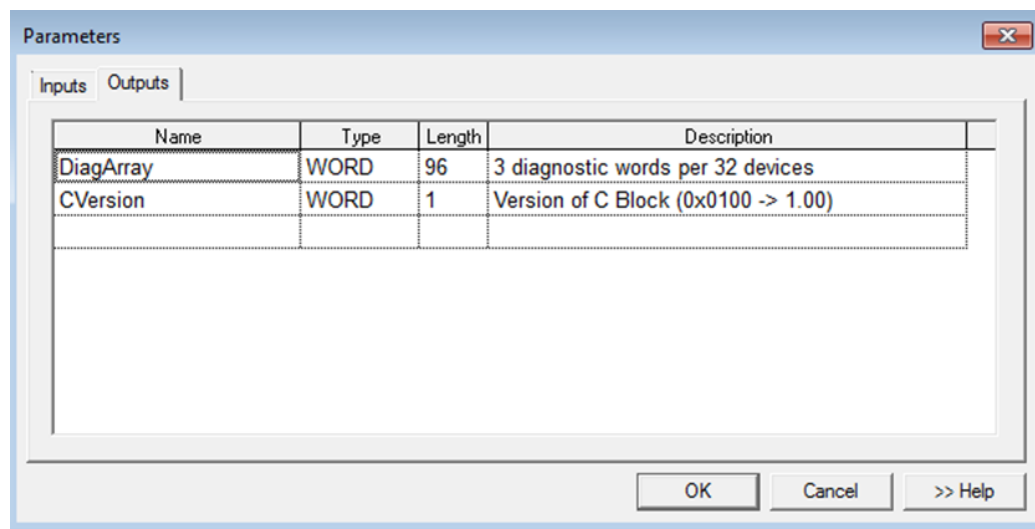
6.2   Monitoring SoE Diagnostics

The IRIG-B diagnostics cannot be run on the first PLC scan, since the first scan is used to configure the SoE system. The diagnostics application requires that the SoE system be configured before it can query the PNS for diagnostic data. Any subsequent execution can run the diagnostics, as shown in Figure 31.

Figure 31: SoE Diagnostic Monitoring
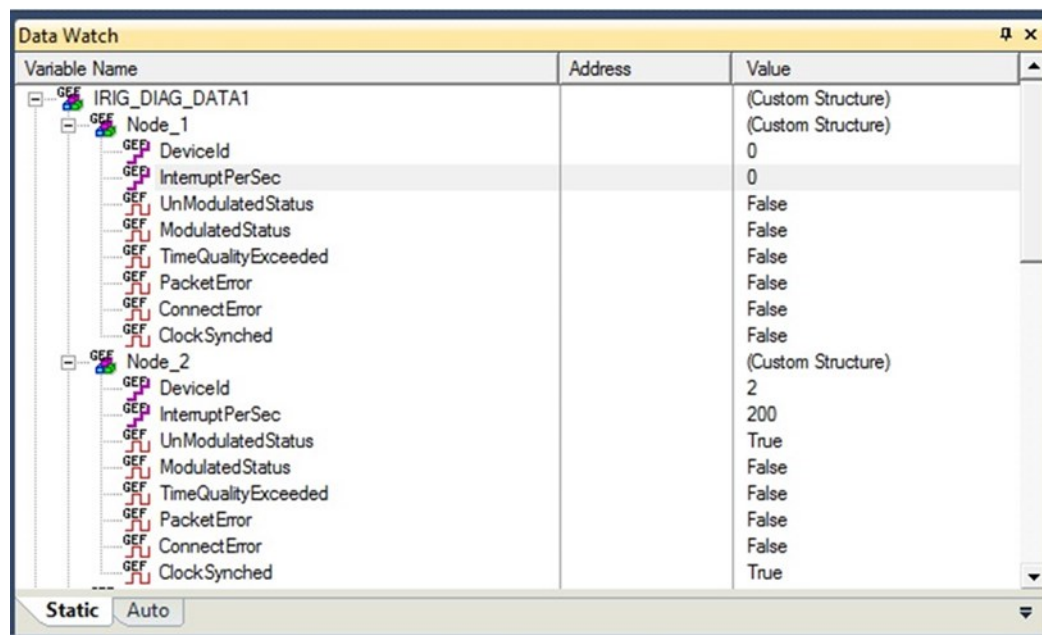
6.2.1   SoE Diagnostic Definitions

|	
Device Id	PNS device ID
Interrupt Per Sec	Set to the number of IRIG-B interrupts the PNS is detecting
Un Modulated Status	Set to true if the correct number of interrupts are seen for an unmodulated IRIG-B signal
Modulated Status	Set to true if the correct number of interrupts are seen for a modulated IRIG-B signal
Time Quality Exceeded	Set to true if IRIG-B packet IEEE-1344 extension time quality value is above 6
Packet Error	Set to true if last IRIG-B packet had and error of some kind
Connect Error	Set to true if no IRIG-B interrupts seen in the last second
Clock Synched	Set to true if the PNS has synchronized its internal clock to match the IRIG-B clock

Appendix A : SoE Record Format

The SoE record structure provides very specific information about the physical location of the SoE event and the nature of the event (i.e., which channel in what SoE Node detected the event, whether the channel transitioned from low-to-high or from high-to-low, and the associated time-stamp and its validity). The SoE record provides complete details for the SoE collection tools.

Word 1 is the most significant word. Word 10 is the least significant word.

Word#	Field	Description	Range
1	YYYY	Year	2000 - 2099
2	MM	Month	1 - 12
3	DD	Day	1 - 31
4	HH	Hour	0 - 23
5	MM	Minute	0 - 59
6	MS	Millisecond	0 - 59999
7	Event Location	Event Location formatted as DDDD DDDS SSSC CCCC (see Figure 32 below).	0 - 65535
8	Channel Event Count	Number of SoE events for this channel since the PACSystems controller powered up. *Note:* *PNS does not stop collecting. This count resets only upon overflow, whenever the downloaded PNS configuration is updated with a different configuration, or when the PNS is power-cycled.*	0 - 65535
9	Station Event Count	Number of SoE events for ALL configured channels since the PACSystems Controller powered up.	0 - 65535
10	Event Status/ Channel Transition	Event Status formatted as xxxx xxxV xxxx xxxT (see Figure 33 below)	V = 0/1 T = 0/1

A-1 Decoding Event Location

Figure 32: Decoding Event Location
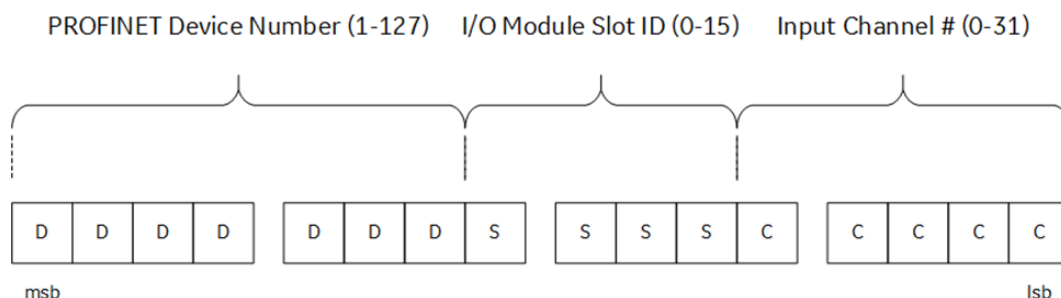
The most significant seven bits, denoted by DDDDDDD above represent the PROFINET Device Number of the PNS Module from which the event was generated. Note that zero is not a permitted value, and that Device Numbers in excess of 127 are not supported by the 7-bit format. Thus, all PNS modules used in this SoE application need to use a unique PROFINET Device Number in the range 1-127.

The next four bits, denoted by SSSS above, represent the slot number occupied by I/O Module which detected the SoE event. Refer to Section2.2, SoE Node Configuration for the constraints placed on the relative location of the PNS Module and the Input modules which support SoE. Both the PNS with the Device ID indicated in the seven most significant bits and the I/O module represented here by SSSS reside in the same RX3i I/O Rack.

The lowest five bits, denoted by CCCCC above, represent the specific I/O Channel which detected the SoE event. The Channel Number is associated with the input module located at slot SSSS.

A-2 Decoding Event Status

Figure 33: Decoding Event Status
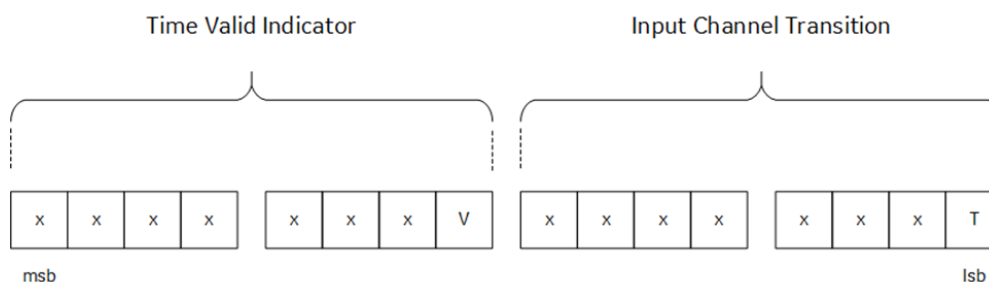
Only two bits in the Events Status Word are used:

V, when returning 1, indicates that the IRIG-B based time-stamp is valid. 0 indicates not valid.

T indicates the direction of transition for the indicated SoE channel (refer to Figure 32).

T = 0 indicates 1➔ 0 transition for that channel;

T = 1 indicates 0➔ 1 transition.

> *Note:* those bits indicated as "x" are reserved for future use and should not be assumed to be zero.

A-3 Translation between Emerson SoE Record and corresponding IO Reference Location

This translation requires that the SoE Node is configured as described in 2.2 SoE Node Configuration. The PNS and Input modules are located sequentially in the backplane of the SoE Node, with no other interposed modules and the %I memory references for all SoE Node inputs in this rack are configured to be sequential as well.

%Ixxxx = Channel_Number + (Input_Module_Slot - Starting Slot) * 32 + Number_Offset

Where:

Channel_Number is derived from Word 7 in the Emerson SoE record (0-31)

Input_Module_Slot is derived from Word 7 in the Emerson SoE record

Starting Slot is the slot occupied by the PNS

Number_Offset is the start of %I memory the user configured for the PNS

Example:

For Channel 5 of the I/O Module located in Slot 4, with the PNS in Slot 1, and the user defining %I1001 as the starting location of the memory map:

xxxx = 5 + (4 - 1) * 32 + 1001

= 5 + 96 + 1001

= 1102

Thus, %I1102 represents the state of Channel 5 in this Input module.

Appendix B : SoE Record Format 2

Word 1 is the most significant word. Word 6 is the least significant word.

Word#	Lo/Hi Byte	Field	Description	Range
1	both	Group	Group Number – Reserved, always 8	8
2	High	DD	Day	1-31
	Low	HH	Hour	0 - 23
3	High	MM	Minute	0 - 59
	Low	SS	Second	0 - 59
4	both	MS	Millisecond	0 - 999
5	both	Point Address	Reference Address in PLC Memory (%Ixxxx)	0 - 65535
6	both	Channel Transition	Transition formatted as xxxx xxxx xxxx xxxT (see Figure 33 above, T-bit only)	T = 0/1

Appendix C : Duplication of Events

The SoE implementation attempts to minimize or eliminate the possibility of duplicated events, but there are some situations where duplication of events may still occur.

If a PNS sends SoE records to the CPU, but the PNS becomes disconnected before the CPU acknowledges the events. Then the events will remain in the PNS device's event queue. When the PNS device connection is later reestablished, the events previously sent to the CPU may be repeated.

In a redundant system with SoE, Active status may switch between Primary and Secondary units along with the Redundant IP assignment. If the external Historian/SoE Collector sets the SoE Record Communication Buffer Handshake word to 0 just before a switch of Active units, then the updated SoE Record Communication Buffer Handshake value may not get transferred to the new Active unit. When the Redundant IP moves to the new Active unit, the Historian/SoE Collector will see the SoE Record Communication Buffer Handshake at its previous value and not cleared to 0. Thus, the Historian/SoE Collector may interpret this as new events, but these records are really the same events it previously consumed. This situation can be avoided if the Historian/SoE Collector takes the extra step of also checking the SoE Records Buffer update counter. If the update counter is the same value as the previously consumed events, then the Historian/SoE Collector could write the SoE Record Communication Buffer Handshake to 0 again and wait for a non-zero value.

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