Honeywell

Safety Manager Module Control Functions

for use with the Triconex TRICON Version 8 systems

SM09-500

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Implementation

Safety Manager TRICON

Safety Manager Module Control Functions

for use with the Triconex TRICON Version 8 systems

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About This Publication

This publication defines the control functions available for the Safety Manager Module used with the Triconex TRICON Version 8 for TDC 3000^{X} Release 500 series. It is a reference manual for process engineers, control system engineers, and application engineers who design and implement data acquisition and control strategies for TDC 3000^{X} Systems with Local Control Networks.

The user should be familiar with the system control functions described in *System Control Functions* in the *Implementation/Startup & Reconfiguration - 2* binder before using this publication.

Detailed descriptions of the parameters mentioned in this publication can be found in the *Safety Manager Module Parameter Reference Dictionary* in this binder, and further background information relative to Safety Manager implementation can be found in *Safety Manager Module Implementation Guidelines* also located in this binder.

This publication supports TDC 3000^{X} software release 500 series.

All references in this manual to "Safety Manager" or "Safety Manager Module" pertain only for use with the Triconex TRICON Version 8 systems.

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Tables

Acronyms

AC .... Alternating Current
AI .... Analog Input
AM .... Application Module
AO .... Analog Output
ASCII .... American Standard Code for Information Interchange
APM .... Advanced Process Manager
DC .... Digital Composite
DC .... Direct Current
DCM .... Data Communication Module
DHP .... Data Hiway Port
DI .... Digital Input
DO .... Digital Output
EICM .... Enhanced Intelligent Communication Module
EIP .... Event-Initiated Processing
EPROM .... Erasable Programmable Read Only Memory
HIM .... Hiway Interface Module
HM .... History Module
HPM .... High-Performance Process Manager
I/O .... Input/Output
IEEE .... Institute of Electrical and Electronic Engineers
LCN .... Local Control Network
LED .... Light Emitting Diode
LM .... Logic Manager
MAN .... Manual
MP .... Main Processor
NCM .... Network Communication Module
N/C .... Normally Closed
NIM .... Network Interface Module
N/O .... Normally Open
OP .... Output
OPER .... Operator
PID .... Proportional, Integral, Derivative
PLC .... Programmable Logic Controller
PM .... Process Manager
PV .... Process Variable
RC .... Resistive, Capacitive
RPM .... Revolutions Per Minute
RTD .... Resistance Temperature Detector
RTU .... Remote Terminal Unit
RXM .... Remote Chassis
SM .... Safety Manager
SMM .... Safety Manager Module
SOE .... Sequence of Events
SP .... Set Point
SRAM .... Static Random Access Memory
TCP/IP .... Transmission Control Protocol/Internet Protocol
TDC .... Total Distributed Control
TMR .... Triple Modular Redundancy
UCN .... Universal Control Network
US .... Universal Station

Parameters

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References

For TDC 3000^X Documentation:

Publication Title	Publication Number	Binder Title	Binder Number
Safety Manager Module Parameter Reference Dictionary	SM09-550	Implementation Safety Manager TRICON	TDC 3074
Safety Manager Module Implementation Guidelines	SM12-500	Implementation Safety Manager TRICON	TDC 3074

For TRICON Documentation:

Document Title	Document Number	Binder Title
TRISTATION MSW User's Manual	9720044-001	TRISTATION MSW User's Manual
TRICON Planning and Installation Guide	9720048-001	TRICON Planning and Installation Guide

Section 1 – Introduction

1.1 Section Overview

About this section

This section contains an overview of the Safety Manager, its key components, and user interfaces. It also provides references to other publications that are useful or necessary during implementation. Topics included in this section are:

1.2 Safety Manager Overview

Background

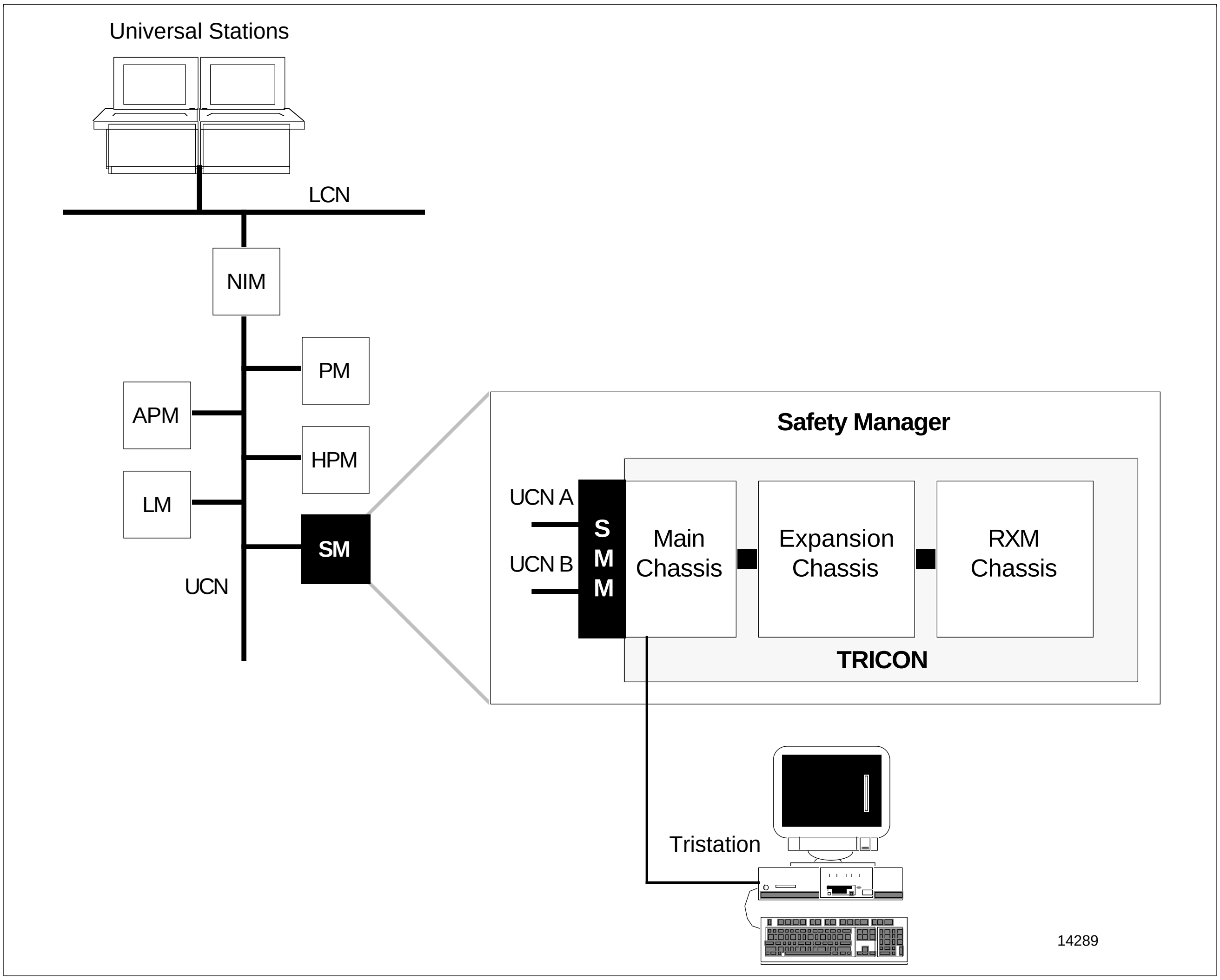
The Safety Manager (SM) is a process-connected device that resides on the TDC 3000X Universal Control Network (UCN) as a peer to the Process Manager (PM) and Logic Manager (LM).

Key components

As illustrated in Figure 1-1, the SM consists of two key components mounted in one or more standard TDC 3000X cabinets:

- TRICON Programmable Logic Controller
  - a triple-redundant PLC and associated subsystems from Triconex Corporation, and
- Safety Manager Module (SMM)
  - a Honeywell option module providing peer-to-peer communications with other process-connected devices residing on the TDC 3000X Universal Control Network.

Figure 1-1 Safety Manager Relationship to the TDC 3000X



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Available chassis

As shown in Figure 1-1, the Safety Manager uses three types of chassis to house the numerous kinds of available plug-in modules. These chassis are:

- Main Chassis
  - housing the main processors, chassis power supplies, communications modules and logical slots for other user-selected modules.
- RXM Chassis
  - used when the I/O bus cabling must exceed 30 meters (100 feet), and
  - housing chassis power supplies, fiber optic repeater/extenders, set of three RXM modules and four other logical slots for I/O and communications modules.
- Expansion Chassis
  - used when the I/O bus cabling does not exceed 30 meters (100 feet),
  - housing the chassis power supplies, and five logical slots for I/O and communications modules.

Human interfaces

As shown in Figure 1-1, two human interfaces are used in conjunction with the Safety Manager:

- Universal Station (US) and Universal Work Station are two configurations of the TDC 3000^X level user interface and are used by
  - process operators to monitor and control the process, respond to alarms, print reports, and to change equipment statuses,
  - process engineers to setup the TDC 3000^X process database, displays, and reports, and to load system software,
  - maintenance technicians to diagnose and maintain both control room and process connected equipment; and
- TRISTATION, used to interface with the TRICON PLC component to
  - configure TRICON and process points to be used with PLC ladder and UCN,
  - create and load the ladder logic control program,
  - diagnose system faults, and
  - force points for loop check-out and maintenance of field devices.

1.3 Safety Manager Module Component

Introduction

The Safety Manager consists of two key components mounted in one or more standard TDC 3000X cabinets:

- the TRICON Programmable Logic Controller
  - a triple-redundant PLC and its associated subsystems from Triconex Corporation, including a
- Safety Manager Module
  - a Honeywell option module to the TRICON providing peer-to-peer communications with other process connected devices residing on the TDC 3000X Universal Control Network.

This subsection provides an overview of the Safety Manager Module component of the Safety Manager.

Frontplate features

As illustrated in Figure 1-2, the SMM's frontplate includes the following major features.

- Diagnostic and Operation LED Indicators, which indicate the
  - primary UCN redundant status,
  - result of self-test diagnostics,
  - status of redundant (spare) partner,
  - UCN cable that is currently carrying message traffic, and
  - UCN transmit or receive status.
- SMM Status Indicator, which displays an alphanumeric code number representing the current operational status of the module or system.
- F-style connectors which provide a link to the redundant Universal Control Network (A and B) via drop cables.
- SMM Debug Port which provides debug capability to Honeywell personnel only.

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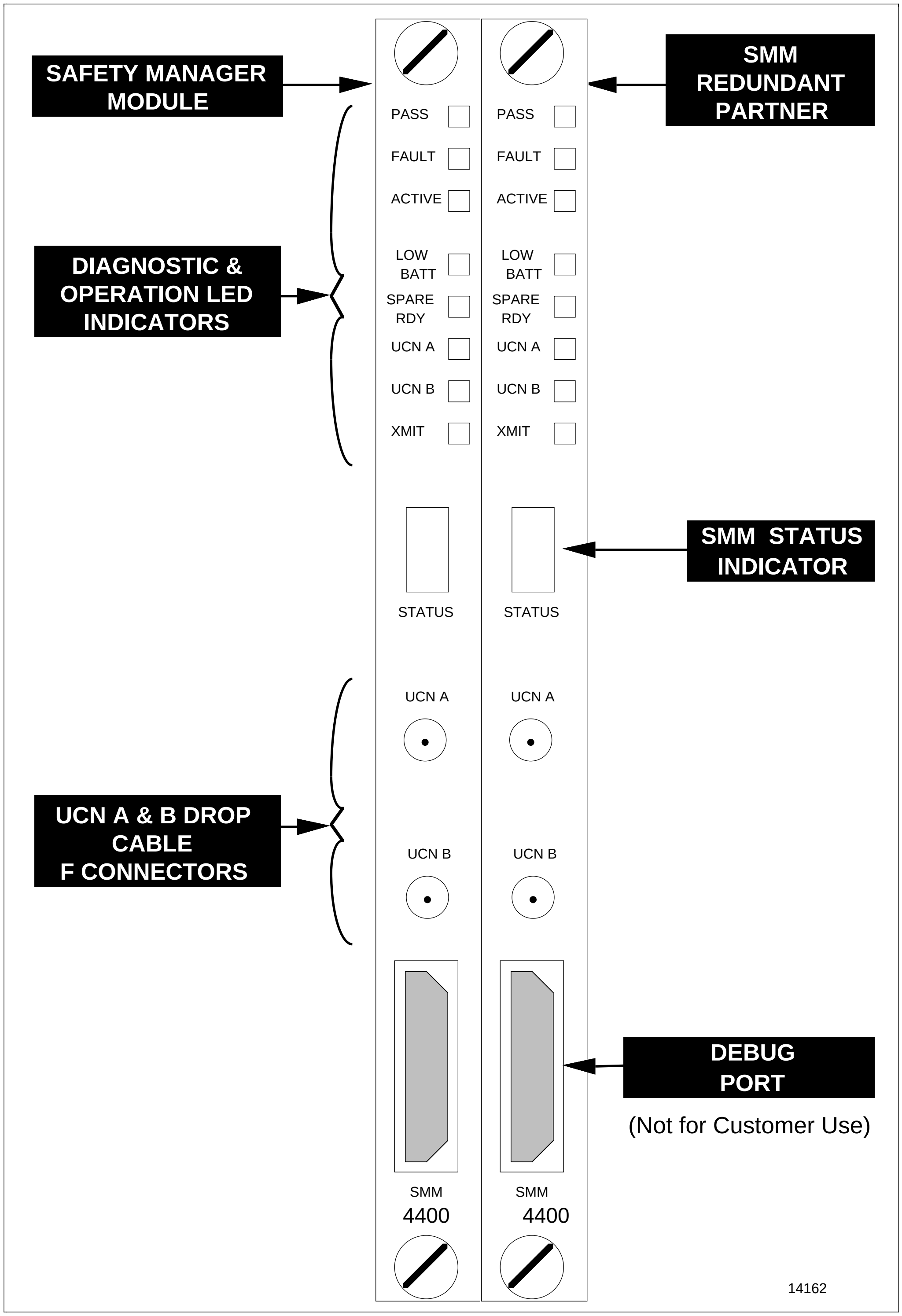
Frontplate, continued

Figure 1-2 Safety Manager Frontplate Features



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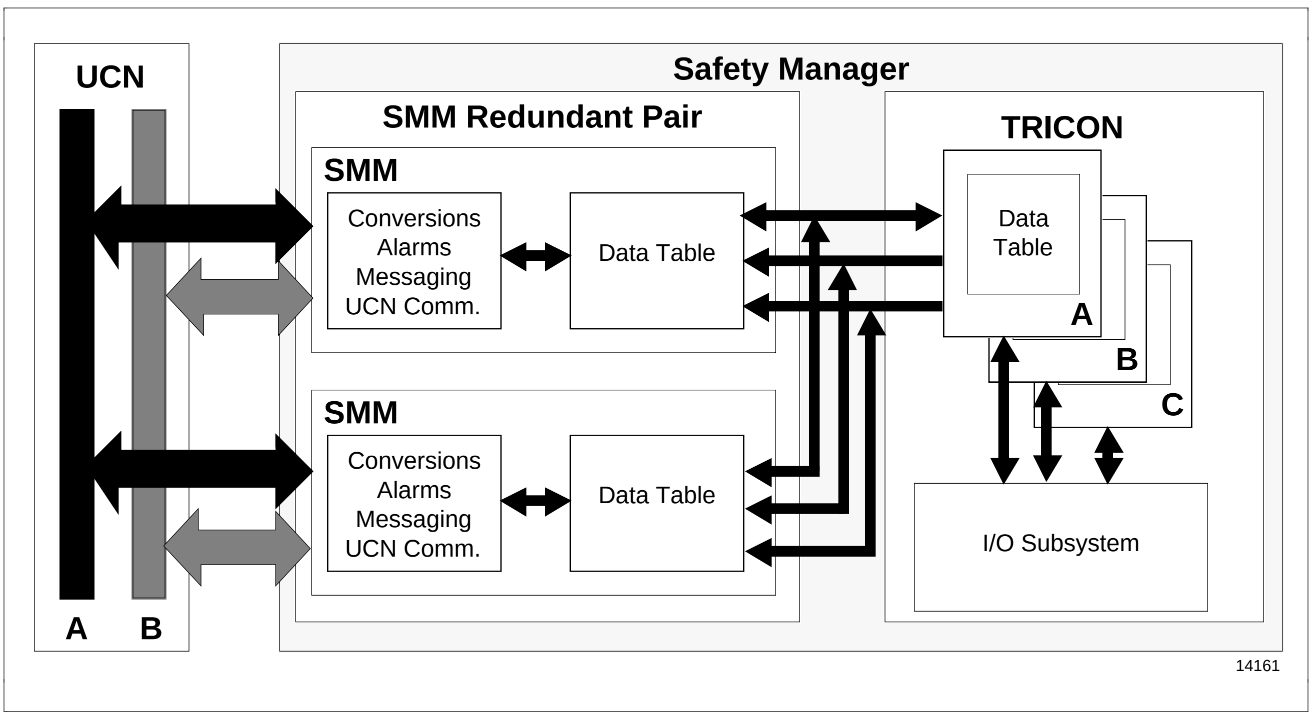
Function

The Safety Manager Module serves as the communications interface between the TRICON and the Universal Control Network. The UCN communication channel is redundant. The SMM's basic functions (as illustrated in Figure 1-3) are to

- exchange data between its own tables and the tables of the TRICON;
- collect and process information from the TRICON and its ladder logic control program
  - convert the information to TDC 3000^{X} data types,
  - perform engineering unit conversions, and alarm handling, annunciation, diagnostic status reporting, peer-to-peer communications, and other UCN functions,
  - pass the converted information to the appropriate devices on the UCN; and
- collect and process information received over the UCN
  - convert the information to the appropriate formats,
  - pass the converted information to the TRICON.

Figure 1-3 SMM Basic Functions



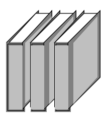
1.4 TRICON Component

Introduction

The Safety Manager consists of two key components mounted in one or more standard TDC 3000^{X} cabinets:

- the TRICON Programmable Logic Controller
  - a triple-redundant PLC and its associated subsystems from Triconex Corporation, including a
- Safety Manager Module
  - a Honeywell option module to the TRICON providing peer-to-peer communications with other process-connected devices residing on the TDC 3000^{X} Universal Control Network.

This subsection provides an overview of the TRICON component of the Safety Manager.



REFERENCE—For detailed information regarding the concepts and functions described in this section, refer to the *TRICON Planning and Installation Guide.*

TMR architecture

The TRICON system is based on an architecture called Triple Modular Redundancy (TMR). In a TMR system three separate system legs collect, process, and output process information. A two-out-of-three voting scheme provides a fault-tolerant, high-reliability safety system. Figure 1-4 illustrates that

- each field input signal is
  - collected by an input module,
  - separated into three individual input legs (A, B, C), and
  - placed on individual I/O busses;
- each of the three main processors (A, B, C)
  - receives the input signal over its directly connected I/O bus,
  - votes the input signals with its two main processor companions over a high-speed interprocessor communications link (TRIBUS),
  - processes the input data by executing its resident copy of the control program, and
  - places any resulting output signals back on its individual I/O bus for transmission to the proper output module(s); and
- the output module
  - receives output signals from each of the three main processors over individual I/O busses,
  - checks (votes upon) the output signal for consistency with the other two output legs, and
  - transmits the output signal to the connected field device.

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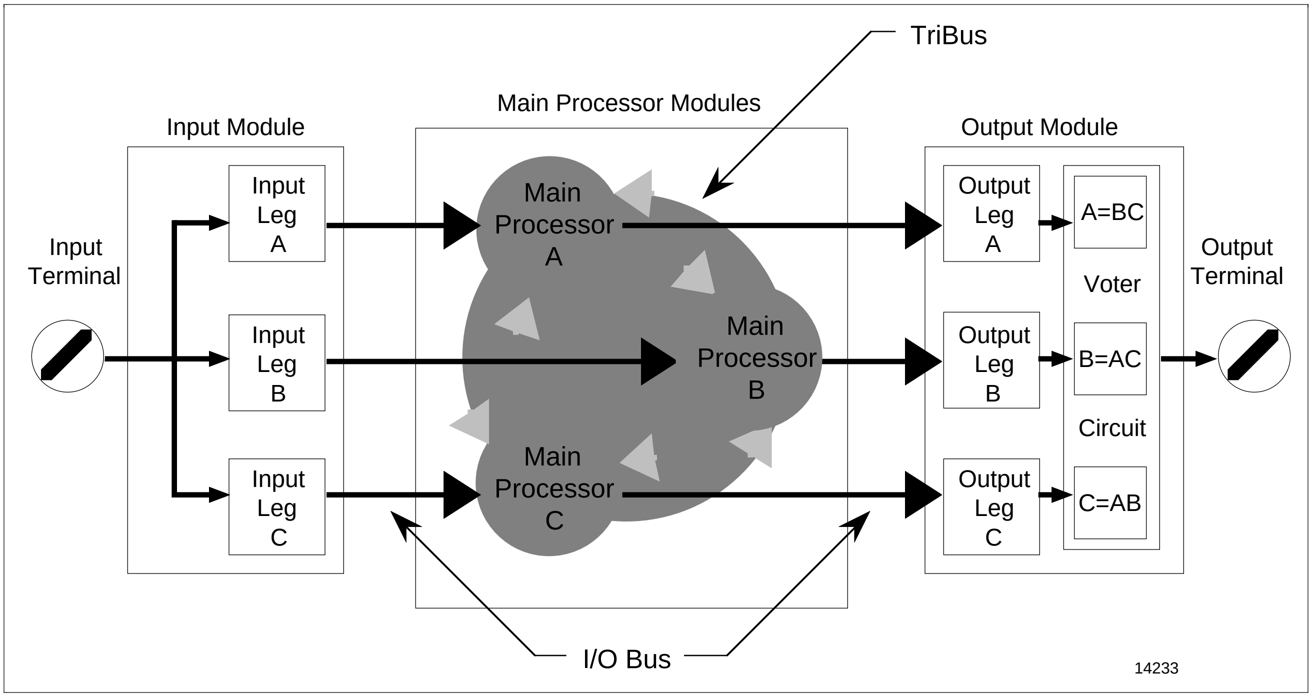
TMR architecture, continued

Figure 1-4 TMR Architecture



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Main processor modules

A TRICON system includes three main processor (MP) modules, each of which

- must be located in the first logical slot in the main chassis to the right of the power supply modules;
- controls a separate leg of the system and operates in parallel with its two partners to
  - collect input data,
  - check the input data's validity with its partners' input data, and
  - provide the validated input data to the control program for processing;
- communicates with
  - the I/O subsystem over a triplicated I/O bus, and
  - its two redundant partners over an isolated 4M baud communications link called, TRIBUS;
- provides 1.5MB of memory including
  - 512KB of EPROM memory for the TRICON operating system,
  - 800KB or 1824KB (dependent on MP model used) of SRAM for user-written control programs, and
  - 224KB of SRAM for use by the operating system;
- includes multiple microprocessors, such as
  - a 32-bit, 25MHz NS32GX32 main microprocessor,
  - an NS32381 math co-processor for floating point number-crunching,
  - a 16MHz, 500K baud 80C31 microprocessor for communication subsystem management, and
  - a 12MHz 8031 microprocessor for I/O subsystem management; and
- executes extensive on-board diagnostics that
  - verify memory,
  - test the main and math co-processors' operation,
  - verify communication with the I/O communication processor, and
  - verify the TriBus and related operations.

Figure 1-5 illustrates the frontplate of a main processor module and its basic memory map.

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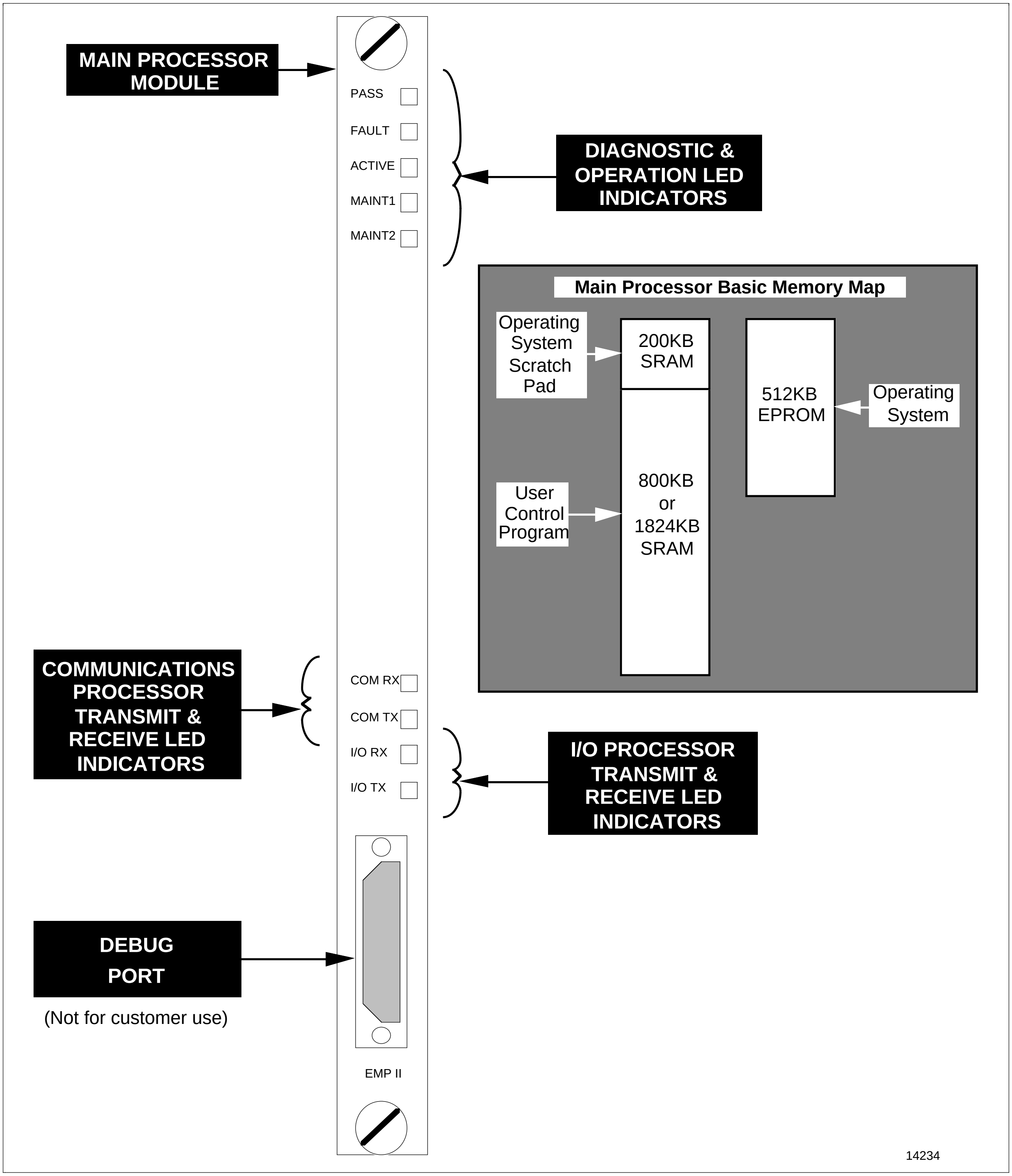
Main processor modules, continued

Figure 1-5 Main Processor Frontplate and Basic Memory Map



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Communication modules

In addition to the Safety Manager Module, the TRICON can be equipped with several other communication modules. These modules provide a means for the TRICON to communicate with external devices such as the TRISTATION and other intelligent devices. Optional communication modules include

- the Data Communications Module (DCM), which
  - provides an IEEE 802.3 communication interface between the TRICON, the TRISTATION, and other host computers, and
  - operates at up to 10M baud;
- the Enhanced Intelligent Communications Module (EICM), which
  - permits the TRICON to communicate with MODBUS hosts and the TRISTATION,
  - provides four serial ports supporting both RTU and ASCII MODBUS modes,
  - supports a total of 57.6K baud with port baud rate options of 1200, 2400, 9600, and 19200, and
  - provides one parallel port supporting Centronics compatible printers;
- the Hiway Interface Module (HIM), which
  - provides a communication interface between the TRICON and the Honeywell TDC 3000X Data Hiway,
  - is functionally the same as four Data Hiway Ports (DHPs),
  - supports a redundant (hot-spare) HIM, and
  - communicates at 250K baud; and
- the Network Communications Module (NCM), which
  - provides an IEEE 802.3 TCP/IP communication interface between the TRICON, the TRISTATION, and other host computers,
  - uses the TRICON System-Access Application Protocol, and
  - operates at 10M baud.

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I/O modules

The TRICON's I/O modules can be thought of as a three module set consisting of

- a field termination module,
- an input or output module, and
- an optional redundant (hot online spare) I/O module.

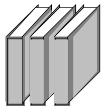
Each I/O set corresponds to one logical chassis slot and is made up of three physical chassis slots as illustrated in Figure 1-8.

The field termination module is used to interface field wiring to the TRICON and is available in both internal and external models. Both types are electrically passive devices and reside in the left-most physical slot. The internal model permits the field wiring to be directly connected to the module and is typically used in high-density applications. With the external model, field wiring is connected to a separate termination panel which is then interfaced to the module through one or more interface cables. Examples of both models are illustrated in Figure 1-6.

A variety of I/O modules are available with the TRICON. Included are

- *digital input modules:* available in a variety of voltage ranges, and TMR or simplex models,
- *digital output modules:* available in a variety of voltage ranges, relay contacts, and TMR or simplex models,
- *analog input modules:* available in a variety of voltage ranges, isolated or non-isolated inputs, and all in TMR models,
- *analog output module:* available in a 4 to 20 mA TMR model, and
- *special function modules:*, including
  - isolated and non-isolated TMR type thermocouple input module, and
  - pulse input module.

The TMR (Triple Modular Redundancy) model types include three incoming, or outgoing, signal legs (A, B, C). The simplex model types provide only a single signal leg and are a less-costly alternative for non-critical application situations.



In addition to the TRICON documentation, refer to Subsection 1.5—*I/O Subsystem* for more information regarding the I/O subsystem and the available I/O modules.

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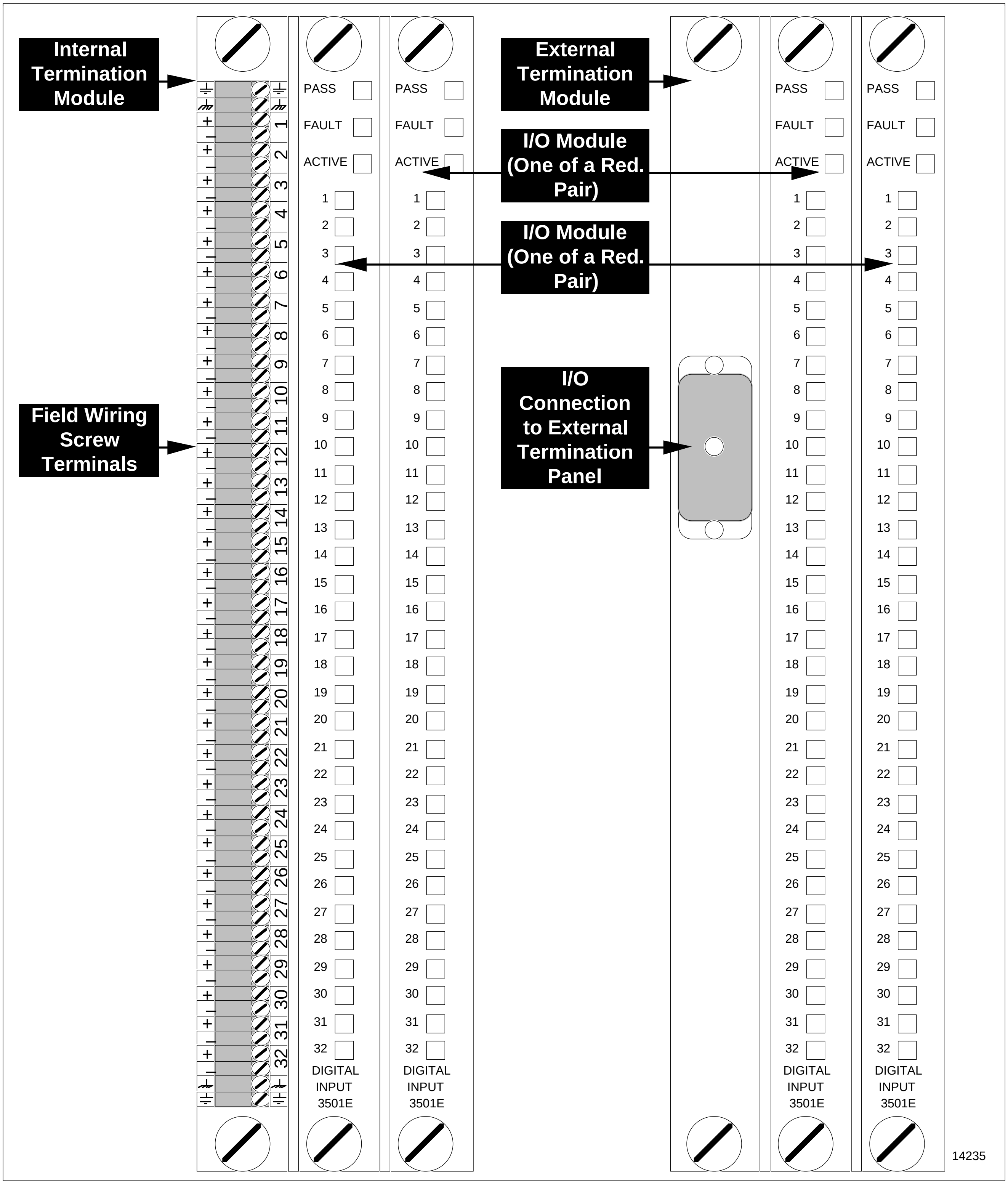
I/O modules, continued

Figure 1-6 I/O Module Set Examples



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Power supply modules

A pair of power supply modules are needed for each chassis to provide dual power redundancy. They are located on the left side of each chassis, one above the other. They come in 115 Vac/Vdc, 24 Vdc, and 230 Vac input voltage ranges. Figure 1-7 illustrates a typical power supply module and its frontplate features, including

- LED diagnostic status indicators:
  - PASS indicating that the modules self-test diagnostics have passed,
  - FAULT indicating that the incoming power has been interrupted or the module has otherwise failed,
  - ALARM indicating an alarm condition exists within the chassis,
  - TEMP indicating the module is over-heating, and
  - BAT LOW, provided in the main chassis compatible models, indicating that the battery used to backup main processor memory is at or below its holding threshold;
- fuse cover
  - 4A for the 115 Vac/Vdc models,
  - 15A for the 24 Vdc models, and
  - 2A for the 230 Vac models;
- signal grounding terminals
  - located on a separate terminal strip, and
  - providing the option of RC network to chassis ground, direct signal ground, and direct chassis ground connections;
- alarm terminals,
  - the normally open (N/O) to ground connection opens when an alarm condition is present, and
  - the normally closed (N/C) to ground connection closes when an alarm is present; and
- input power terminals, providing
  - line (hot), neutral, and chassis ground connections for AC input power, and
  - positive, negative, and chassis ground connections for DC input power.

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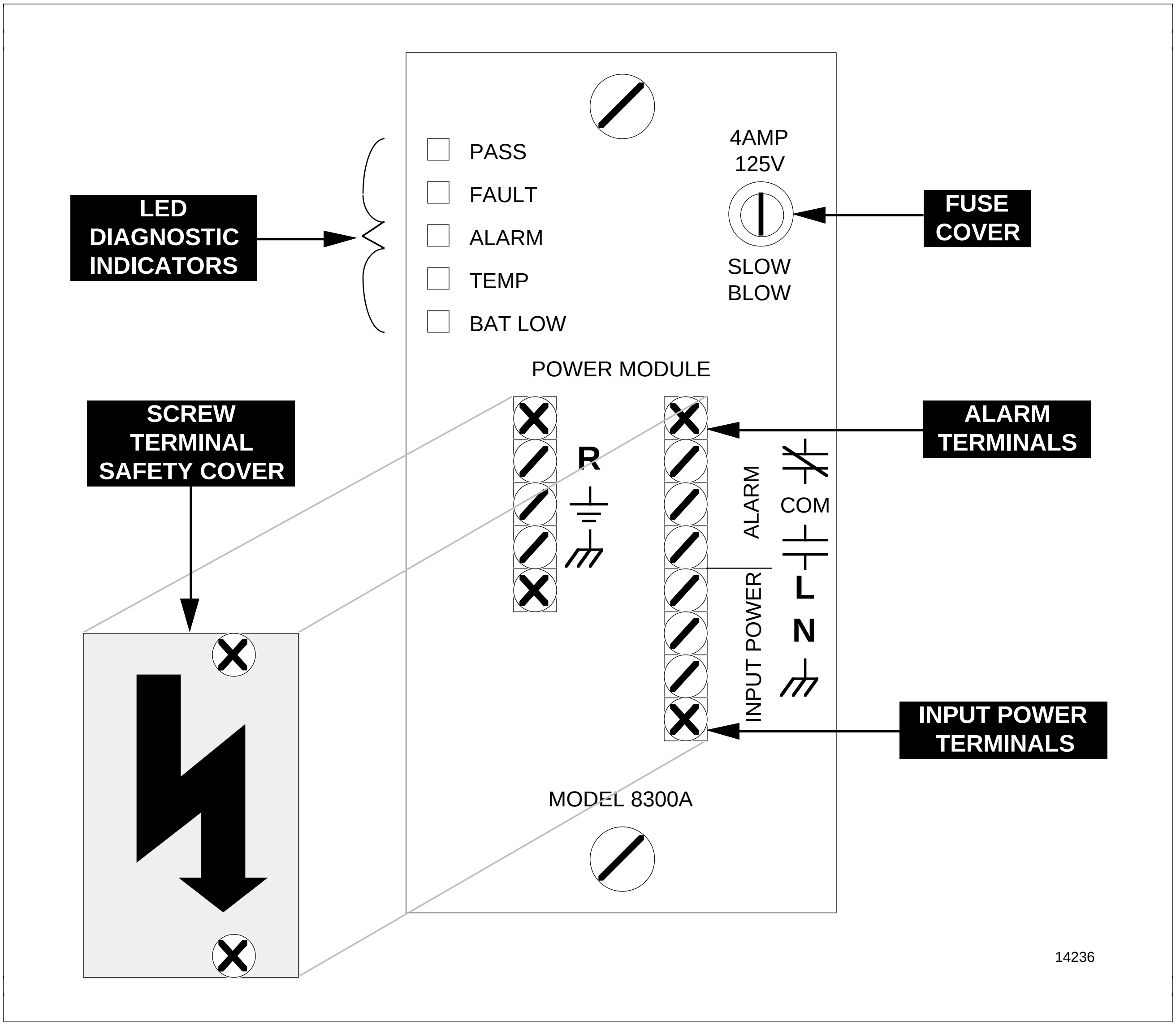
Power supply modules, continued

Figure 1-7 Power Supply Frontplate Features



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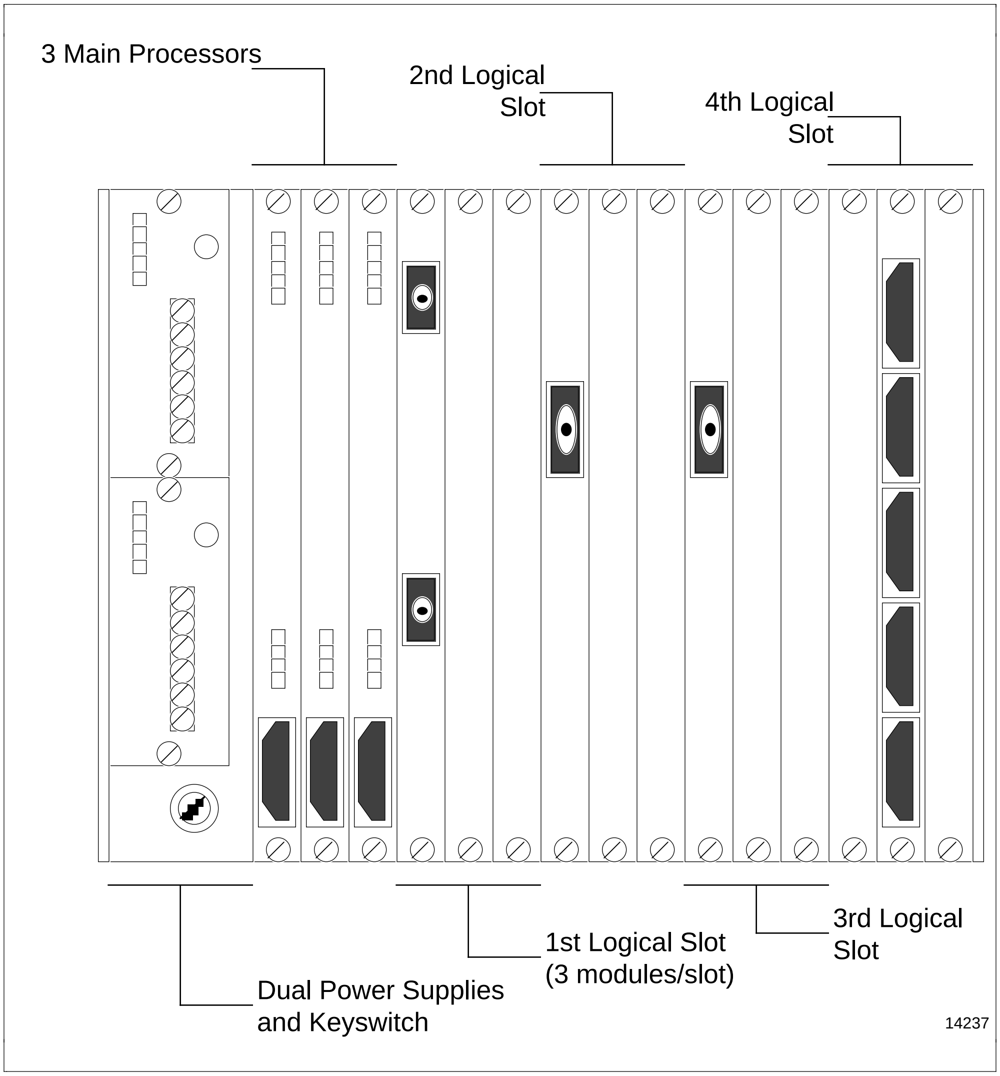
Main chassis configuration

The standard configuration of the Safety Manager's (TRICON's) main chassis appears as illustrated in Figure 1-8 and includes the following:

- dual power supply modules,
- keyswitch for system control,
- three main processor modules, and
- four logical slots, each consisting of three physical spaces for either
  - I/O modules (termination module, left-most space; I/O module, center space; optional hot-spare I/O module, right-most space), or
  - communication modules.

Figure 1-8 Main Chassis Configuration



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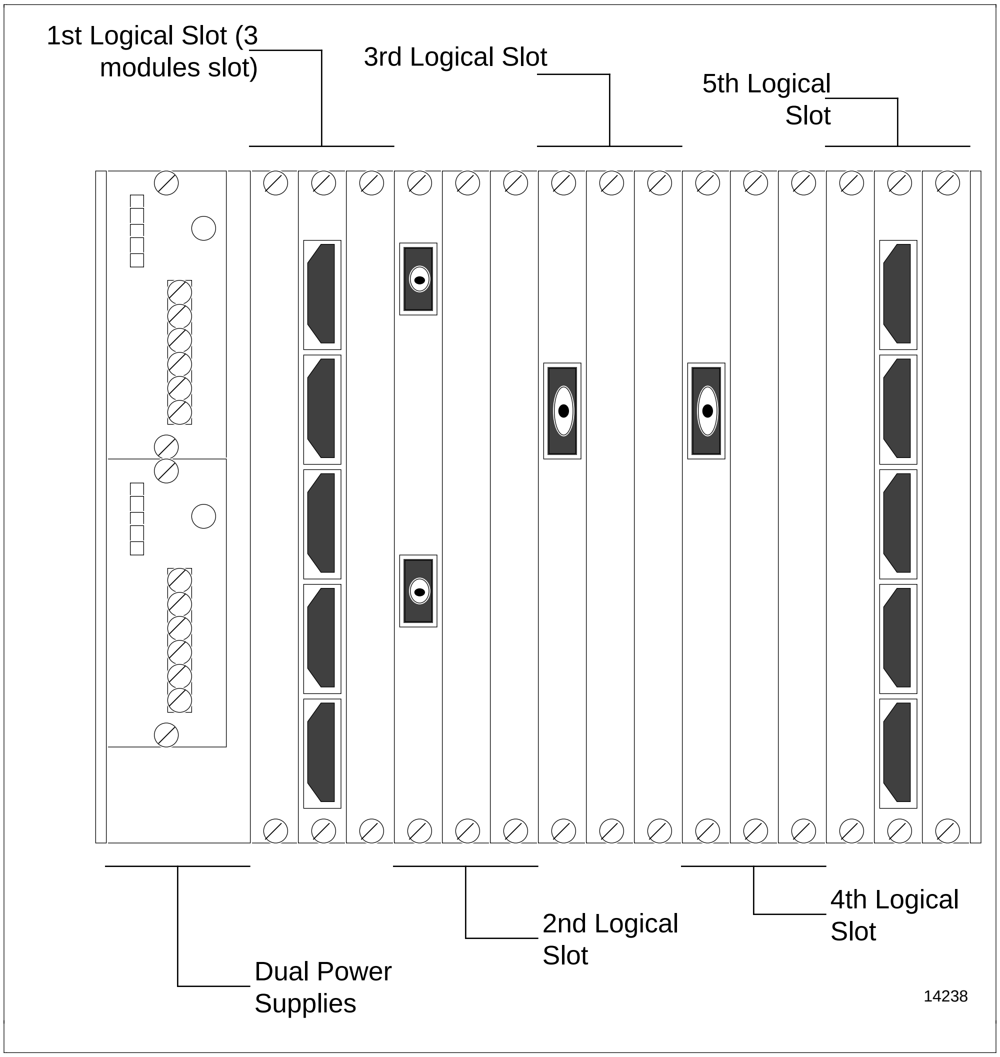
Expansion chassis configuration

The standard configuration of the Safety Manager's (TRICON's) expansion chassis appears as illustrated in Figure 1-9 and includes the following:

- dual power supply modules, and
- five logical slots, each consisting of three physical spaces for I/O modules (termination module, left-most space; I/O module, center space; optional hot-spare I/O module, right-most space).

Figure 1-9 Expansion Chassis Configuration



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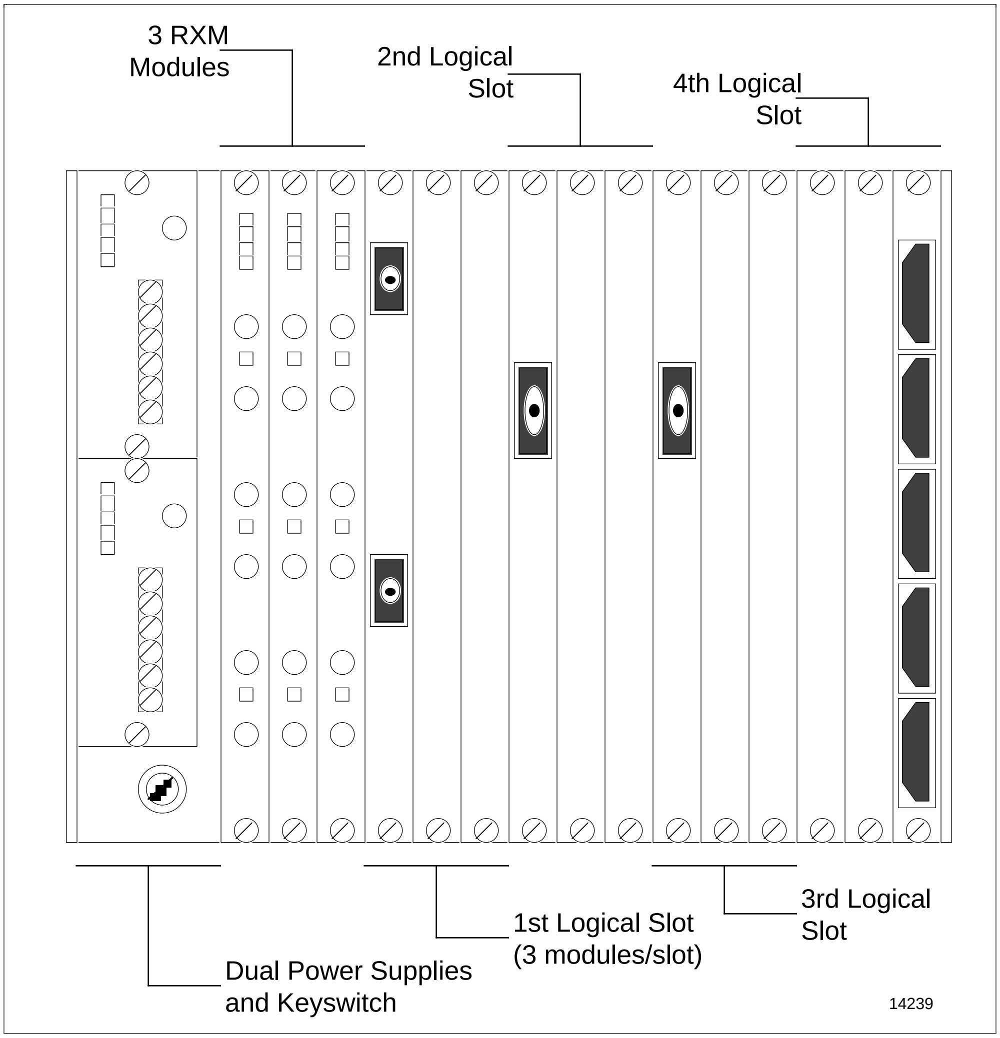
RXM chassis configuration

The standard configuration of the Safety Manager's (TRICON's) RXM chassis appears as illustrated in Figure 1-10 and includes the following:

- dual power supply modules,
- three RXM modules, and
- four logical slots, each consisting of three physical spaces for I/O modules (termination module, left-most space; I/O module, center space; optional hot-spare I/O module, right-most space).

Figure 1-10 RXM Chassis Configuration



1.5 I/O Subsystem

Introduction

The I/O subsystem can consist of two basic configurations.

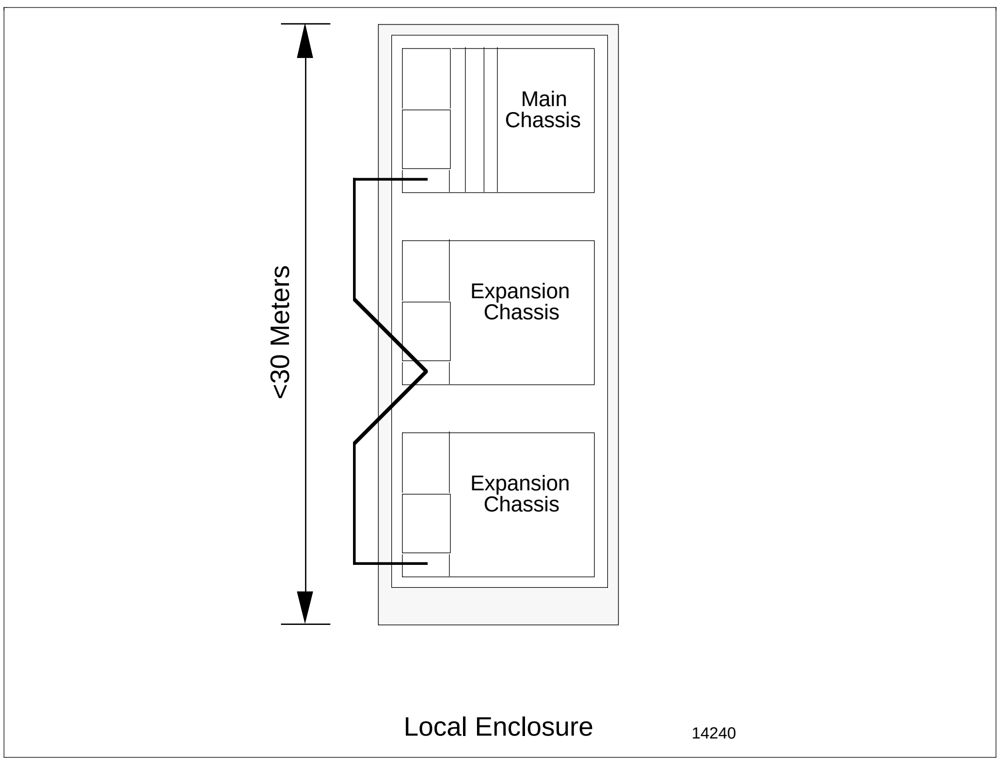
- Local I/O subsystem where
  - only a main chassis is employed, or
  - main chassis and one or more expansion chassis are employed.
- Remote I/O subsystem where
  - RXM chassis located over 30 meters from the main chassis are employed.
  - the main chassis and each RXM chassis may include one or more expansion chassis.

Local I/O subsystem

Figure 1-11 illustrates an example Safety Manager configuration with no remote locations. This example configuration includes

- a single enclosure with
  - one main chassis, and
  - two expansion chassis; and
- an RS485 I/O bus link connecting each chassis.

Figure 1-11 Local I/O Subsystem Configuration Example



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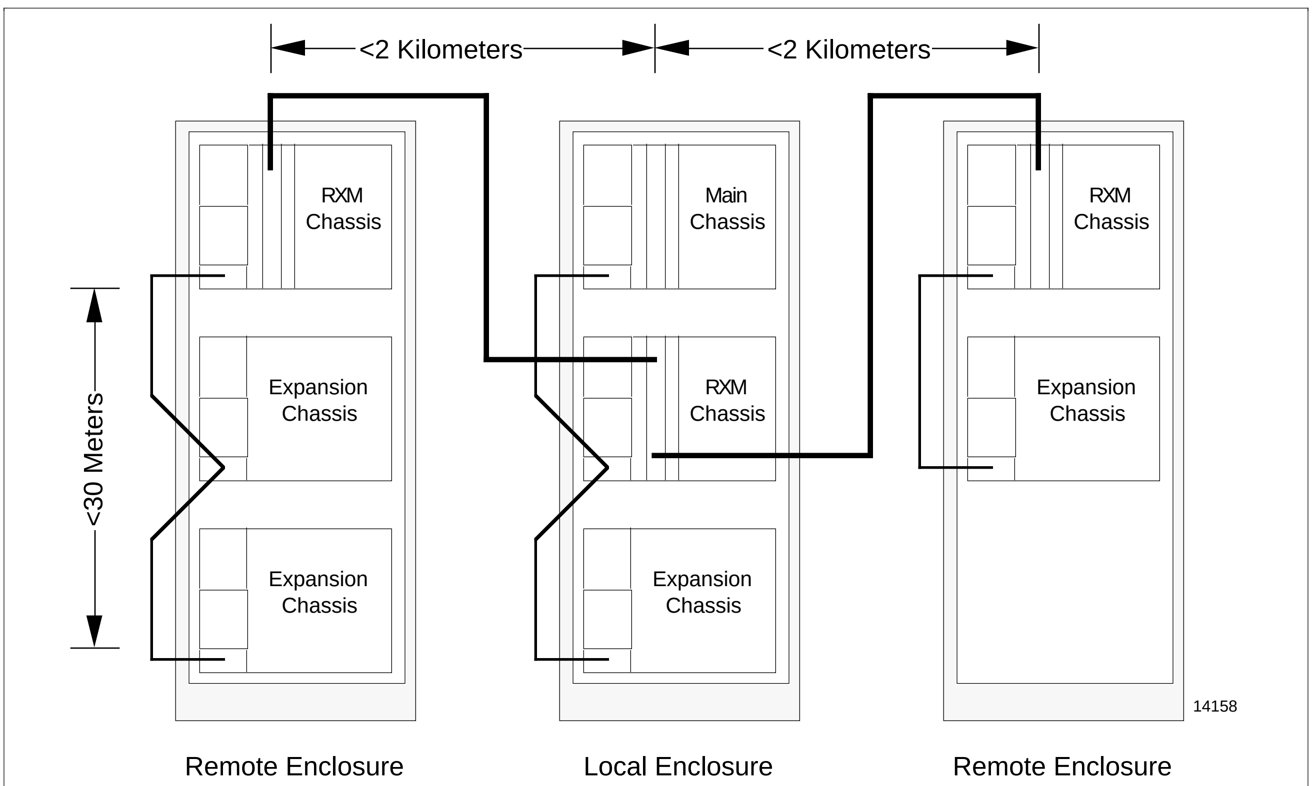
Remote I/O subsystem

Figure 1-12 illustrates an example Safety Manager configuration with two remote locations. This example configuration includes

- a local enclosure with
  - one main chassis,
  - one RXM chassis, and
  - one expansion chassis;
- a remote enclosure with
  - one RXM chassis, and
  - two expansion chassis;
- a second remote enclosure with
  - one RXM chassis, and
  - one expansion chassis;
- three RS485 I/O bus links (one in each enclosure) connecting each location's chassis; and
- two sets of three RXM fiber optic cables linking RXM chassis in the remote locations with the RXM chassis in the local enclosure.

ATTENTION Communications modules, including the SMM, may only be installed in the main chassis (chassis #1) or in an expansion or RXM chassis configured as chassis #2 in the local enclosure.

Figure 1-12 Local and Remote I/O Subsystem Configuration Example



1.6 TRISTATION

Background

The TRICON component of the Safety Manager is programmed, configured, and diagnosed using a personal computer-based human interface known as the TRISTATION. The TRISTATION is used by process engineers and maintenance personnel to

- define the hardware configuration of the TRICON component,
- define program variable tagnames,
- develop, test, and document the control program,
- diagnose system faults within the TRICON component, and
- assign password security.

Functions

The TRISTATION software includes several components or functions. Among them are

- the *Module Configurator* used to define and configure the TRICON hardware,
- the *Dictionary Editor* used to assign tagnames and other information to I/O points and control program elements,
- the *Ladder Editor* used to write the control program,
- the *Setup Manager* used to set control program scan time and to establish communications with the TRICON,
- the *File Manager* used to save and download control programs between the TRISTATION and the TRICON,
- the *Diagnostics* used to display performance statistics of the current control program and fault statuses of the TRICON, and
- the *Program Manager* used to test and monitor a control program in either the emulation or execution mode.

REFERENCE—For additional information regarding the functions, features, and use of the TRISTATION, refer to the *TRISTATION Multi-System Workstation User's Manual* in the TRICON documentation provided with your Safety Manager.

1.7 Universal Station

Background

The Universal Station is the TDC 3000^{X} level human interface used by

- operators to monitor and control the process, respond to alarms, print reports, and to change equipment statuses,
- process engineers to setup the TDC 3000^{X} process database, displays, and reports, and to load the system software, and
- maintenance technicians to diagnose and maintain both control room and process-connected equipment.

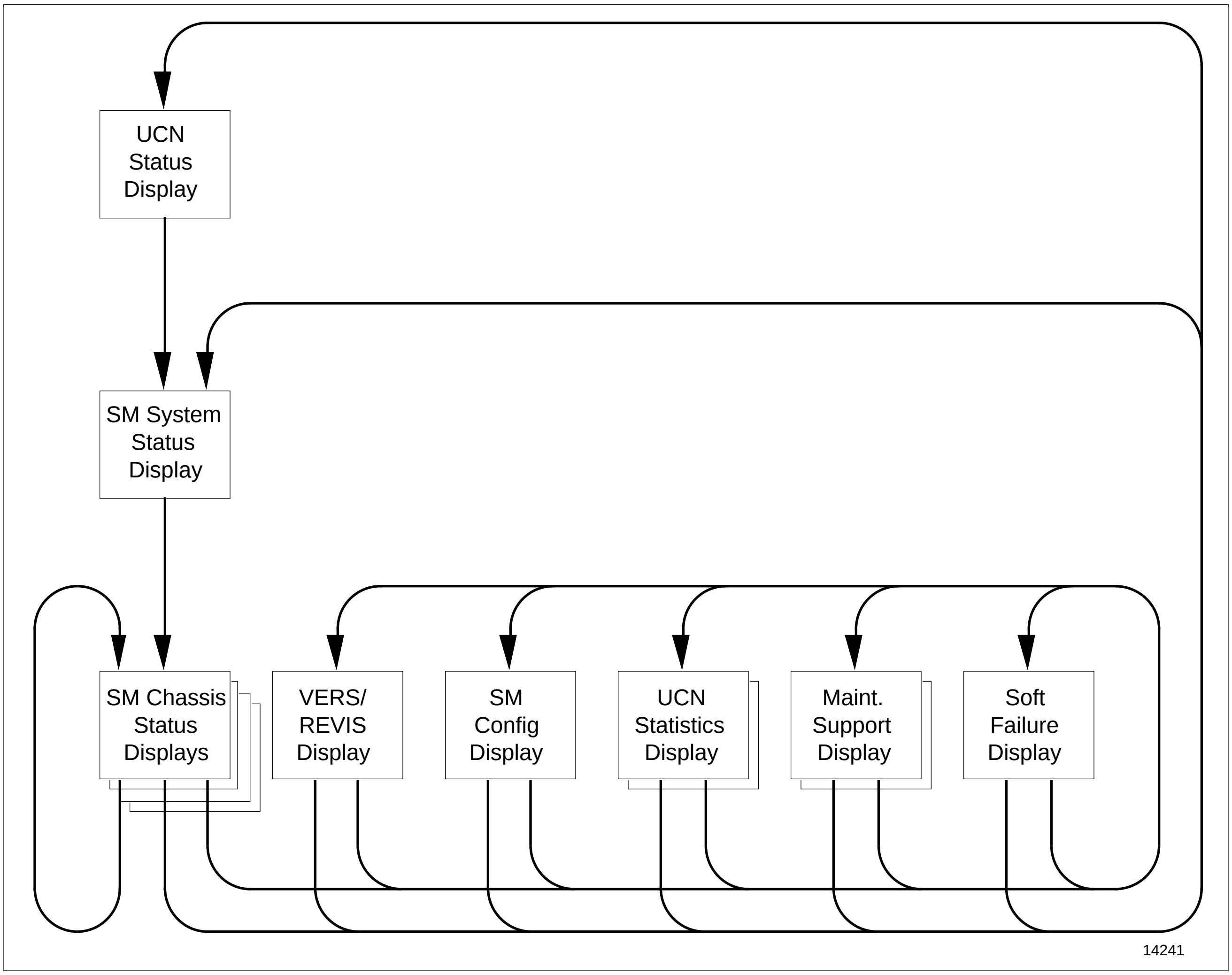
SM standard displays

The standard suite of node status displays associated with the Safety Manager and its data points are consistent with similar displays provided for the Logic Manager and Process Manager family of UCN devices.

Display access scenario

As illustrated in Figure 1-13, access to the US displays associated with Safety Manager status is typical of any other UCN device.

Figure 1-13 Display Access Scenario



Section 2 – TRICON Operational Overview

2.1 Section Overview

About this section

This section provides an overview of the operation of the TRICON component to the Safety Manager system. The information presented here provides an overview of the TRICON PLC's general operating characteristics. It does not discuss this device's operation in detail. Topics included in this section are:

REFERENCE—For additional and detailed information regarding detailed operating characteristics of the TRICON component to the Safety Manager system, refer to the:

- *TRICON Planning and Installation Guide*, and
- *TRISTATION Multi-System Work Station User's Manual.*

2.2 Operational Modes

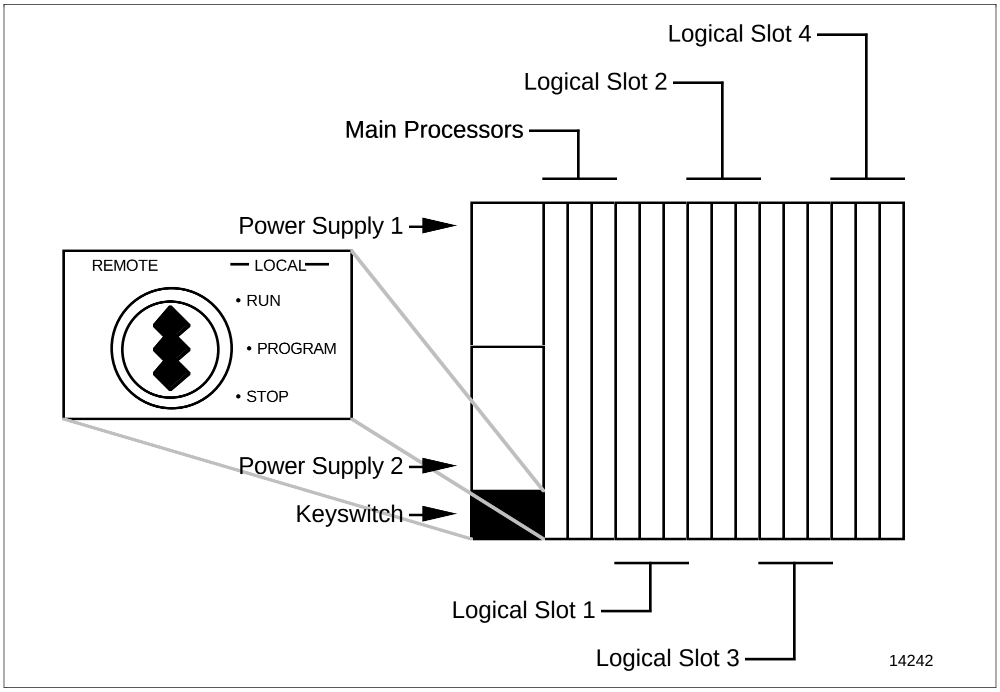
Introduction

The TRICON component features four modes of operation. They are

- Program mode,
- Run mode,
- Remote mode, and
- Stop mode.

A four position keyswitch, located below the power supply modules in the main chassis, is used to select the TRICON's operational mode. The position of the keyswitch can be read from the TRISTATION, the Universal Station, and by application programs. Figure 2-1 illustrates the keyswitch and its location in the main chassis.

Figure 2-1 TRICON Mode Control Keyswitch



Program mode

This mode/keyswitch position enables

- full use of all TRICON features and functions,
- the downloading of control programs from the TRISTATION,
- the editing of control programs from the TRISTATION, and
- time synchronization by the SMM.

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Run mode

This mode/keyswitch position

- enables execution of the control program,
- enables the TRICON to respond to MODBUS master read commands,
- disables the changing of data values from the TRISTATION, Universal Station, or a MODBUS master,
- disables the editing of control programs from the TRISTATION, and
- disables time synchronization by the SMM.

Remote mode

This mode/keyswitch position

- enables execution of the control program,
- enables the changing of data values from the TRISTATION, Universal Station, or a MODBUS master,
- disables the editing of control programs from the TRISTATION, and
- enables time synchronization by the SMM.

ATTENTION Must be logged into security levels 3 or 4 in the Run or Remote modes to edit control programs.

Stop mode

This mode/keyswitch position

- disables execution of the control program,
- disables the collection of input data from the I/O subsystem,
- forces the non-retentive digital data values to zero,
- forces the analog outputs values to zero, and
- freezes retentive output values.

ATTENTION Servicing the TRICON system does not require that it be stopped.

2.3 Control Program

Introduction

The control program runs in the TRICON component of the Safety Manager and is used for data acquisition, local process/discrete control algorithms, and data transmission to the field. The control program is developed using the TRISTATION.

ATTENTION The TRICON's control program should not be confused with control and data acquisition operations performed at the TDC 3000X (or remote to TRICON) level. The Safety Manager Module (SMM) is configured to interface between these two systems so that data and control operations at the TRICON level can be tightly integrated with data acquisition and control operations at the higher TDC 3000X level.

TRISTATION

With regards to the control program, the TRISTATION is used to

- define the hardware configuration of the TRICON component,
- define program variable tagnames,
- develop the
  - relay ladder logic (RLL), and
  - high-level language expression boxes; and
- test, debug, and edit the control program.

Hardware configuration

The TRISTATION's Module Configurator is used to define the physical location and identification of the hardware in the TRICON, including the SMM. This information becomes part of the control program and is downloaded to the TRICON. Upon downloading, the hardware location and identification in the system is checked against the control program's configuration definition. You are immediately notified of any mismatches.

Tagnames

It is not necessary to assign numerical addresses to the control program variables. Instead, the TRISTATION's Dictionary Editor is used to define all program variables (I/O points and program elements) using alphanumeric variable names (tagnames). These tagnames are assigned based on the variable's class and type. In addition to class and type, ten other definition fields exist. Only those definitions pertinent to the selected class and type are entered for a given variable. Table 2-1 defines the 12 variable definition fields.

Continued on next page

Tagnames, continued

Table 2-1 Dictionary Editor's Variable Name Definition Fields

Field	Definition
Class	This field is used to define whether a variable is a • field input point, • field output point, or • internal memory value.
Type	This field is used to define the format of the variables data as • discrete, • integer, or • real.
Name	This field is used to define the seven-character label for the logic control element in the control program. For example: **SVALV17**
Tag	This field is used to define the logic control element's 12-character tagname. For example: **SV-0017** **ATTENTION** The point's TDC 3000X tagname may be used here to simplify the correlation between the TRICON and TDC data.
Description	This field is used to define the 34-character comment that further defines logic control element. For example: **SAFETY VALVE 17-Unit 4-Reactor 2**
Group	This field is used to define an 8-character identifier used to associate individual variables for documentation and analysis purposes.
Chass Slot Point	This field is used to define chassis, slot, and point location where the input or output variable is physically connected to the TRICON.
Power Up	This field is used to define whether a variable is • retentive, or • non-retentive.
DP	This field is used to define the number of decimal places to the right of the decimal point that are to be displayed for a variable type defined as real.

Continued on next page

Tagnames, continued

Table 2-1 Dictionary Editor's Variable Name Definition Fields, Continued

Field	Definition
Alias	This field is used to assign a compatible address to TRICON variables to be accessed by the TDC 3000^{X} or MODBUS host computer through one of the communication modules. **ATTENTION** For points to work properly from TDC 3000^{X}'s point of view, TRICON aliases must be mapped to TDC point's "PLC address" field.
Min/Max Span	This field is used to define the upper and lower limits of the variable in engineering units when converting real values to integers for transmission across MODBUS.
Subtype	This field is used to define whether pulse input module frequency measurements are to be represented as • speed, or • RPMs.

Continued on next page

User memory

The TRICON communicates with the SMM module using alias addresses which represent data elements within the TRICON's memory areas (tables). Three types of areas are used by the TRICON.

- Input tables, which
  - are used to store discrete, integer, and real values, and
  - have its alias addresses automatically assigned by the TRISTATION.
- Output tables, which
  - are used to store discrete, integer, and real values, and
  - have its alias addresses automatically assigned by the TRISTATION.
- Memory tables, which:
  - are used to store discrete, integer, and real values, and
  - you use the TRISTATION to assign alias addresses.

Table 2-2 shows the TRICON memory allocation and the SMM's access rights to this information. Figure 2-2 illustrates a map of the accessible areas of the TRICON's memory.

Table 2-2 TRICON Memory Allocation

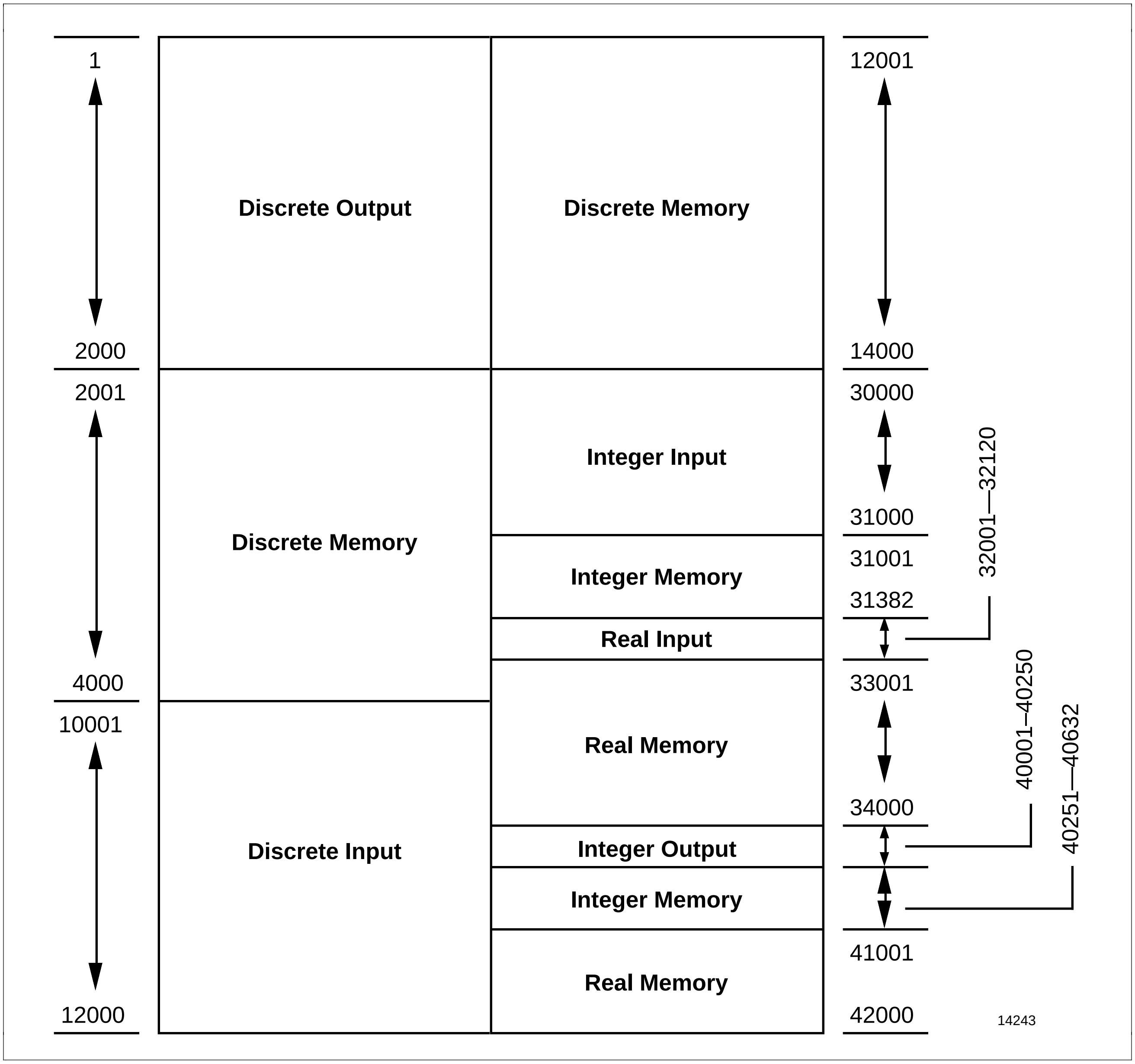
TRICON Alias Range	TRICON Data Type	TRICON Area	SMM Access Rights
1 - 2000	Discrete	Output	Read Only
2001 - 4000*	Discrete	Memory/Output	Read/Write
10001 - 12000*	Discrete	Input	Read Only
12001 - 14000*	Discrete	Memory/Input	Read Only
30001 - 31000	Integer	Input	Read Only
31001 - 31382	Integer	Memory/Input	Read Only
32001 - 32120	Real	Input	Read Only
33001 - 34000	Real	Memory/Input	Read Only
40001 - 40250	Integer	Output	Read Only
40251 - 40632	Integer	Memory/Output	Read/Write
41001 - 42000	Real	Memory/Output	Read/Write

*Alias ranges available for DISOE timestamping.

Continued on next page

User Memory,
continued

Figure 2-2 TRICON Memory Map



2.4 Ladder Logic and Expression Instructions

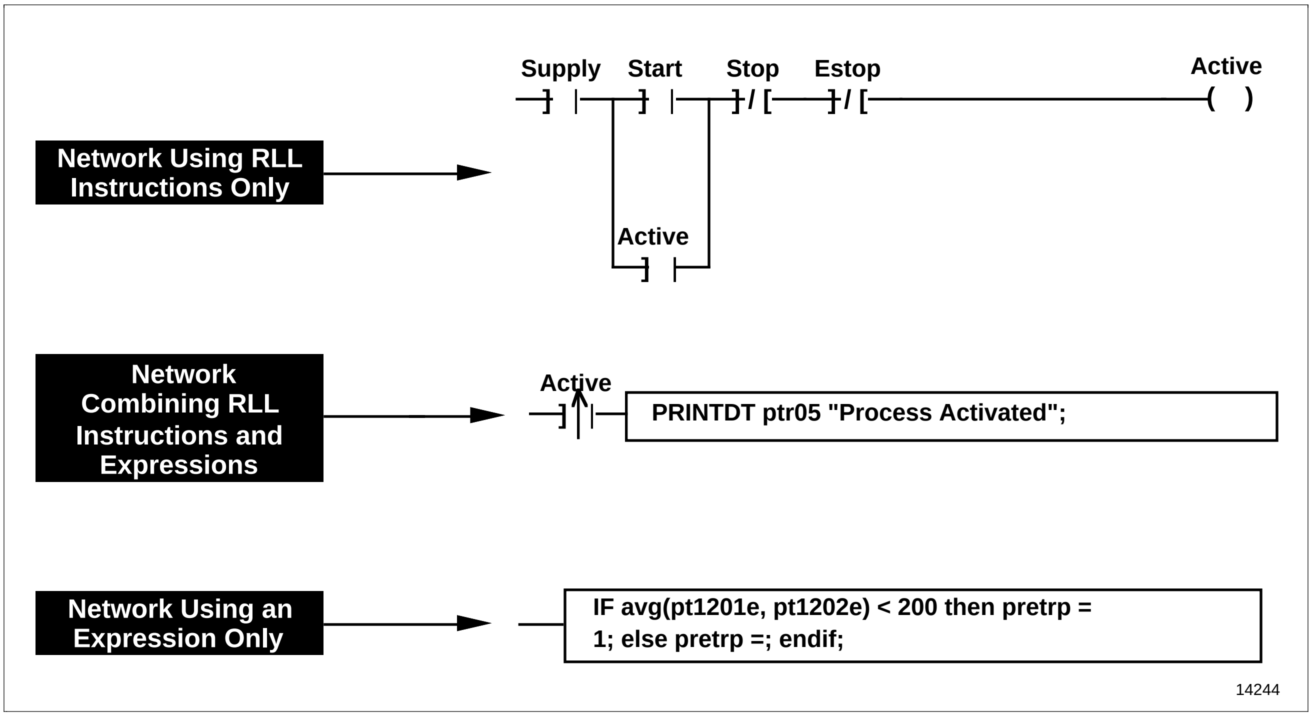
Introduction

The control program is made up of relay ladder logic and high-level language expressions. Both take the form of a ladder diagram as illustrated in Figure 2-3. Notice that both forms are integrated into a simple ladder diagram structure, including the expression which is represented as a single rung or network.

Five basic categories of instructions are available:

- contacts,
- coils,
- math operators,
- process control functions, and
- fire and gas functions.

Figure 2-3 TRICON Relay Ladder Logic Example



Contacts

Two classes of contacts are available:

- standard contacts, which represent a single parameter used as a discrete (ON/OFF) input or memory state, and
- relational contacts, which perform a comparison on two real or integer values.

Table 2-3 lists and defines the TRICON's contact instructions.

Continued on next page

Contacts, continued

Table 2-3 Contact Type Relay Ladder Logic Instructions

Step	Action
—] [—	Normally Open Contact • Passes logical power when ON/True.
—]/[—	Normally Closed Contact • Passes logical power when OFF/False.
—]↑[—	Transition On Contact • Passes logical power for one scan when its state has changed from OFF/False to ON/True.
—]↓[—	Transition Off Contact • Passes logical power for one scan when its state has changed from ON/True to OFF/False.
Prmtr–1 ——] = = [—— **Prmtr–2**	Equal To Contact • Passes logical power when Parameter–1 is equal to Parameter–2.
Prmtr–1 ——] <> [—— **Prmtr–2**	Not Equal To Contact • Passes logical power when Parameter–1 is not equal to Parameter–2.
Prmtr–1 ——] < [—— **Prmtr–2**	Less Than Contact • Passes logical power when Parameter–1 is less than Parameter–2.
Prmtr–1 ——] > [—— **Prmtr–2**	Greater Than Contact • Passes logical power when Parameter–1 is greater than Parameter–2.
Prmtr–1 ——] <= [—— **Prmtr–2**	Less Than or Equal To Contact • Passes logical power when Parameter–1 is less than or equal to Parameter–2.
Prmtr–1 ——] >= [—— **Prmtr–2**	Greater Than or Equal To Contact • Passes logical power when Parameter–1 is greater than or equal to Parameter–2.

Continued on next page

Coils

Two classes of coils are available:

- standard coils, which may represent a single parameter coil used to represent a discrete (ON/OFF) output/memory state or other similar function, and
- complex coils, which are two- or three-parameter coils used for timers, counters, delays, and other similar functions.

Table 2-4 lists and defines the TRICON's coil instructions.

Table 2-4 Coil Type Relay Ladder Logic Instructions

Step	Action
Name —( )	Standard Output Coil • Turns ON/True when it receives logical power.
Name —(NOT)	Not Output Coil • Turns ON/True when it is not receiving logical power.
Name —(LCH)	Latch Coil • Turns ON/True when it receives logical power, and remains on until reset by the reset coil.
Name —(TGL)	Toggle Coil • Changes ON/OFF (True/False) state each time it receives logical power.
Name —(RST)	Reset Coil • Resets the designated coil to its normal (unenergized) state.
Label —(GOTO)	GOTO Coil • Directs the control program execution scan to go to the network specified by the label.
Name —(END)	End Coil • Identifies the end of the control program.
Name —(TMR) Timer Accumulator	Timer Coil • Is set in milliseconds. • Increments the accumulator to the timer value when receiving logical power. • Turns ON/True when the accumulator equals or is greater than the timer value.

Continued on next page

Coils, continued

Table 2-4 Coil Type Relay Ladder Logic Instructions, Continued

Step	Action
Name —(CTU) Preset Accumulator	Up Counter Coil • Is set in milliseconds. • Increments the accumulator by one when logical power transitions from OFF/False to ON/True. • Turns ON/True when the accumulator equals or is greater than the preset value.
Name —(CTD) Preset Accumulator	Down Counter Coil • Is set in milliseconds. • Decrements the accumulator by one when logical power transitions from OFF/False to ON/True. • Turns ON/True when the accumulator equals or is greater than the preset value.
Name —(PLS) Duration	Pulse Coil • Turns ON/True for the time specified in duration whenever it is transitioned from OFF/False to ON/True.
Name —(BNK) ON Period OFF Period	Blink Coil • Turns ON/True and OFF/False for the individual times specified in period whenever it is receiving logical power.
Name —(TDD) Interval	Time Delay De-Energize Coil • Turns ON/True whenever it receives logical power. • Turns OFF/False after the time period in interval has elapsed.
Name —(TDE) Preset Accumulator	Time Delay Energize Coil • Turns ON/True a period of time (specified in interval) after it receives logical power.

Continued on next page

Math operators

An extensive variety of math operators are available for use in expressions. Table 2-5 lists and defines the TRICON's math instructions.

Table 2-5 Math Operators

Step	Action
+	Performs basic algebraic addition on integer and real numbers.
–	Performs basic algebraic subtraction on integer and real numbers.
*	Performs basic algebraic multiplication on integer and real numbers.
/	Performs basic algebraic division on integer and real numbers.
=	Assigns the integer or real value on the symbol's left to the variable name on the symbol's right.
MOD	Performs a modulo operation where the division of two integers produces a remainder.
SHL	Performs a shift-left operation where the bits of an integer value are shifted the specified number of places left.
SHR	Performs a shift-right operation where the bits of an integer value are shifted the specified number of places right.
&	Performs a logical AND operation, bit-by-bit, on two 32-bit integer values.
^	Performs a logical Exclusive OR operation, bit-by-bit, on two 32-bit integer values.
|	Performs a logical OR operation, bit-by-bit, on two 32-bit integer values.
~	Performs a one's complement operation on a specified 32-bit integer value (i.e., converts each zero-bit to a one-bit and each one-bit to a zero-bit).
-	Performs a positive to negative conversion operation on a specified integer or real value.
**	Raises an integer or real value to the power specified to the left of the symbol.
SQRT	Produces the square root of a specified integer or real value.
EXP	Produces the natural exponent of a specified real value.
LN	Produces the natural logarithm of a specified real value.

Continued on next page

Math operators, continued

Table 2-5 Math Operators, Continued

Step	Action
LOG	Produces the common logarithm of a specified real value.
SIN	Produces the trigonometric sine of a specified real value.
COS	Produces the trigonometric cosine of a specified real value.
TAN	Produces the trigonometric tangent of a specified real value.
ABS	Produces the absolute value of a specified integer or real value.
CEIL	Produces the highest integer value that is less than or equal to a specified real value.
FLOOR	Produces the lowest integer value that is less than or equal to a specified real value.
PACK16	Performs a packing operation where the specified 16 discrete bits become the lower order 16-bits of a 32-bit integer word (value).
UNPACK16	Performs an unpacking operation where the lower order 16-bits of a 32-bit integer word (value) are unpacked in 16 discrete bits.
IF-THEN-ELSE	Performs a conditional execution of the specified operation on variables within an expression box.

Process control functions

An extensive variety of specialized process control functions are available for use in expressions. Table 2-6 lists and defines the TRICON's process control instructions.

Table 2-6 Process Control Functions

Step	Action
HISEL	Performs a high-select operation where the highest real value from a list of variables is selected.
LOSEL	Performs a low-select operation where the lowest real value from a list of variables is selected.
MEDSEL	Performs a median-select operation where the median real value from a list of variables is selected.
AVG	Produces the average real value of a list of variables.

Continued on next page

Process control functions, continued

Table 2-6 Process Control Functions, Continued

Step	Action
PERDEV	Produces a measured ratio real value by calculating the difference between to specified values and then divides the difference by their possible span. • If the measured ratio is ≤ span, then a discrete value of 1 (ON/True) is produced. • If the measured ratio is > span, then a discrete value of 0 (OFF/False) is produced.
XofN	Produces an ON/True state if the values of X and N exceed a specified limit.
AIN	Performs a conversion operation where an analog input value is converted to a scaled real value.
AOUT	Performs a conversion operation where a scaled real value is converted to a analog output value.
TCJConv	Performs a conversion operation where an analog signal value is converted into a Type J thermocouple input value in degrees C.
TCKConv	Performs a conversion operation where an analog signal value is converted into a Type K thermocouple input value in degrees C.
SCALE	Performs a rescale operation where an input value is converted from one type of engineering unit to another.
CLAMP	Performs a clamping operation where the dynamic range of an input value is limited to a specified high and low limit.
PID	Performs proportional, integral, derivative control.
LEADLAG	Produces a real value by computing the lead-lag for two values.
EXPFLTR	Performs an exponential filtering operation of a value to smooth a noisy input.
INTGTOR	Performs an integration operation on a specified input value producing a real value.
TSCHED	Performs a scheduling operation to control the execution of specific routines to some specified time intervals.
CSCHED	Performs a scheduling operation to control the execution of specific routines to some number of specified scans.

Continued on next page

Fire and gas functions

An extensive variety of specialized process control functions are available for use in expressions. Table 2-7 lists and defines the TRICON's process control instructions.

Table 2-7 Fire and Gas Functions

Step	Action
ALRMCOIN	Performs a set-coincidence-alarm operation if a requested number of inputs are in alarm.
GASINIT	Performs initialization operations on various types of gas detectors.
GASDETR	Performs processing of gas-detector analog inputs and generates alarms.
LINEINIT	Performs initialization operations on various types of line monitors.
LINEMNTR	Performs processing of contact inputs and generates contact status and loop-fault alarms.
LOOPINIT	Performs initialization operations on various types of loop detectors (smoke, flame, heat, etc.).
LOOPDETR	Performs processing of loop detector inputs (smoke, flame, heat, etc.) and generates alarms.

Section 3 – SMM Data Point Overview

3.1 Section Overview

About this section

This section contains an overview of the data point types available in the Safety Manager Module (SMM) component of the Safety Manager system. Topics included in this section are:

3.2 Summary of SM Data Point Types

Data point types

Table 3-1 lists and describes the various TDC 3000^X data point types available in the Safety Manager.

Table 3-1 Safety Manager TDC 3000^X Data Point Types

Point Type	Description
Digital Input	Single-bit input from TRICON.
Digital Output	Single-bit output to TRICON (with read back).
Digital Composite	Multiple digital I/O point • can have 0–2 inputs and 0–3 outputs, and • is typically used for motor control.
Analog Input	Real value from the TRICON—may originate from the TRICON as • a raw process input from an analog input module, or • a value supplied by the ladder logic control program
Analog Output	Real value output to a TRICON (with read back) • analog output module, or • a memory location for use by the control program.
Logic	Transfers data between the UCN and TRICON connections. It • supports peer-to-peer communications, and • is also known as a *Linkage Point*.
Flag	A 2-state point for storing a Boolean value.
Numeric	A point for storage of an integer value.
Timer	Provides timekeeping functions through an interface to the TRICON timer capabilities.

Continued on next page

Data point processing

Data being transferred between the SMM and TRICON components will be updated on a 0.5-second cycle.

Data points are scanned in the following order:

1. analog input points,
2. digital input points,
3. digital composite points,
4. logic points,
5. timer points,
6. flag points (first 512 only),
7. analog output points, and
8. digital output points.

ATTENTION Please note the following characteristics regarding data point processing.

- You cannot configure or alter the order of point processing.
- Do not confuse the SMM scan with the TRICON control program scan, as these two processes are completely independent and run asynchronously to each other.
- All UCN and Safety Manager input information will be prefetched prior to their respective processing scan cycles. Additionally,
  - if this prefetch operation is not completed prior to normal scan, the cycle "slips" and data is retrieved on the next scan cycle,
  - an excessive number of such scan cycle "slips" will result in a failure, and
  - all UCN and SM database output data will be post-stored for verification at a later scan cycle.

3.3 Data Point Mix

Point capacity

As part of configuring the SM, you select how many of each point type is to be implemented. Each point type has an absolute maximum limit per Safety Manager system as shown in Table 3-2. The SM points must be configured while the Safety Manager Module (SMM) is in the IDLE state.

Table 3-2 Data Point Capacity

Point Type	Maximum Number of Points	Processing Units per Point
Analog Input	1000	10.2
Analog Output	1000	8.5
Digital Input	2000	2.5
Digital Output	2000	1.2
Digital Composite	652	11.1
Timer	1500	3.1
Logic	30	200

ATTENTION The 0.5 second scan rates will tend to lower the maximum number of points.

Continued on next page

Determining point mix

Typically, you will configure a mix of different types of points. To assure that scanning of all configured points is achieved within the scheduled scan cycle, a per-point weighting system has been established.

Each SMM data point type has been assigned a unique weight, or point processing unit value. To determine the validity of your intended point mix, follow the procedure described in Table 3-3.

Table 3-4 provides a blank point mix worksheet for your convenience. The page containing Table 3-4 may be reproduced for use as a configuration worksheet.

ATTENTION Flag and numeric points use a fixed amount of processing overhead and therefore are not required to be calculated into the point mix determination. You can configure as many as 2000 flag points and as many as 1000 numeric points.

Table 3-3 Point Mix Validity Test Procedure

Step	Action	Result
1	Multiply the intended number of each type of data point in a system by its point processing unit value.	Produces the weighted value of each point type.
2	Add the products produced in Step 1.	Produces the total weighted value of all point types.
3	Test the validity of your point mix.	If the point processing total is less than or equal to 6000, then the total number of data points is valid.

Continued on next page

Point mix worksheet

Use Table 3-4 to determine the validity of your intended point mix. Follow the procedure described in Table 3-3 to complete this worksheet.

Table 3-4 Point Mix Worksheet

Point Type	Maximum Allowable Point Count	Processing Unit Value Per Point	X	Number or Points Desired	=	Total Point Processing Units
Digital Input 0.5 sec. digital scan	2000	2.5	X	_______	=	__________
1.0 sec. digital scan		1.25	X	_______	=	__________
Digital Output 0.5 sec. digital scan	2000	1.2	X	_______	=	__________
1.0 sec. digital scan		0.6	X	_______	=	__________
Digital Composite 0.5 sec. or 1.0 sec. digital scan	652	11.1	X	_______	=	__________
Analog Input 0.5 sec. analog scan	600	10.5	X	_______	=	__________
1.0 sec. analog scan	1000	5.25	X	_______	=	__________
Analog Output 0.5-sec. analog scan	1000	8.5	X	_______	=	__________
1.0 sec. analog scan		4.25	X	_______	=	__________
Logic 0.5 sec. or 1.0 sec. digital scan	30	200	X	_______	=	__________
Timer 0.5 sec. or 1.0 sec. digital scan	1500	3.1	X	_______	=	__________

POINT PROCESSING TOTAL __________

ATTENTION ***Please note the following:***

- 0.5 sec. digital scan when scanrate = AR1DT2 or AR2DT2.
  1.0 sec. digital scan when scanrate = AR1DT1.
  0.5 sec. analog scan when scanrate = AR2DT2.
  1.0 sec. analog scan when scanrate = AR1DT2 or AR1DT1.
- Point Processing total must be 6000 or less to be valid.
- Flag and numeric points use a fixed amount of processing overhead (PU = 0) and therefore are not required to be calculated into the point mix determination. You can configure as many as
  - 2000 flag points and
  - 1000 numeric points

ATTENTION

- This page may be reproduced for use as a configuration worksheet.
- LC overruns will occur if you are operating at or near 500 ms. To avoid this, the Logic Controller scan time should be less than the SMM scan time.

Continued on next page

Point mix worksheet example

Table 3-5 provides an example of an acceptable point mix that falls within the Safety Manager Module point processing unit limit of 6000.

Table 3-5 Point Mix Worksheet Example

Point Type	Maximum Allowable Point Count	Processing Unit Value Per Point	X	Number or Points Desired	=	Total Point Processing Units
Digital Input 0.5 sec. digital scan	2000	2.5	X	*550*	=	*1375*
1.0 sec. digital scan		1.25	X	_______	=	__________
Digital Output 0.5 sec. digital scan	2000	1.2	X	*410*	=	*492*
1.0 sec. digital scan		0.6	X	_______	=	__________
Digital Composite 0.5 sec. or 1.0 sec. digital scan	652	11.1	X	*55*	=	*610.5*
Analog Input 0.5-sec. analog scan	600	10.5	X	_______	=	__________
1.0 sec. analog scan	1000	5.25	X	*30*	=	*157.5*
Analog Output 0.5-sec. analog scan	1000	8.5	X	_______	=	__________
1.0 sec. analog scan		4.25	X	*20*	=	*85*
Logic 0.5 sec. or 1.0 sec. digital scan	30	200	X	*4*	=	*800*
Timer 0.5 sec. or 1.0 sec. digital scan	1500	3.1	X	*26*	=	*80.6*
				POINT PROCESSING TOTAL		3600.6

ATTENTION Please note the following:

- 0.5 sec. digital scan when scanrate = AR1DT2 or AR2DT2.
  1.0 sec. digital scan when scanrate = AR1DT1.
  0.5 sec. analog scan when scanrate = AR2DT2.
  1.0 sec. analog scan when scanrate = AR1DT2 or AR1DT1.
- Point Processing total must be 6000 or less to be valid.
- Flag and numeric points use a fixed amount of processing overhead (PU = 0) and therefore are not required to be calculated into the point mix determination. You can configure as many as
  - 2000 flag points and
  - 1000 numeric points

3.4 Execution States

Introduction

A loaded data point (with the exception of flag and numeric data points which are scanned even when the SMM is in the idle mode) is in one of two execution states—active or inactive—at all times.

Active state

When in the active state, the point is being processed by the Safety Manager.

Inactive state

When in the inactive state, the point is not being processed. Note that

- a new or changed point will initially be placed in the inactive state when being loaded into the SM database, and
- a point must be placed in this state before changes to its configuration can be made.

Displaying execution states

From the Universal Station's Group and Detail displays you can determine which state a point is in. From the Detail display, the operator can also change the point's state by selecting the parameter *Point Execution Status*, PTEXCST.

3.5 Database Relationships

Introduction

All parameters associated with the SM data points are maintained in tables within the Safety Manager Module, based on TDC 3000[X] *Tag.Parameter* assignments. For purposes of data transfer between the SMM and the TRICON, TRICON alias addresses must be specified during data point configuration.

ATTENTION The ladder logic control program within the TRICON has primary control over the processing of data written into and read out of its memory. Consequently, configuration of the SM data points must be coordinated with the control program if unexpected results at the Universal Station are to be avoided.

For a detailed description of the interface for each type of data point, refer to Section 4—*Data Point Detailed Descriptions*.

Databases

Both the SMM and the TRICON have memory tables where the database of process information is stored and accessed. Figure 3-1 illustrates the relationship of these tables which are

- the transfer table
  - located in the SMM, and
  - used as a temporary storage/transfer buffer between the TDC 3000[X] and the TRICON; and
- the memory table
  - located in the TRICON,
  - providing 40000 memory locations, and
  - used as a storage/transfer buffer between the SMM and the control program, and by the control program for data storage.

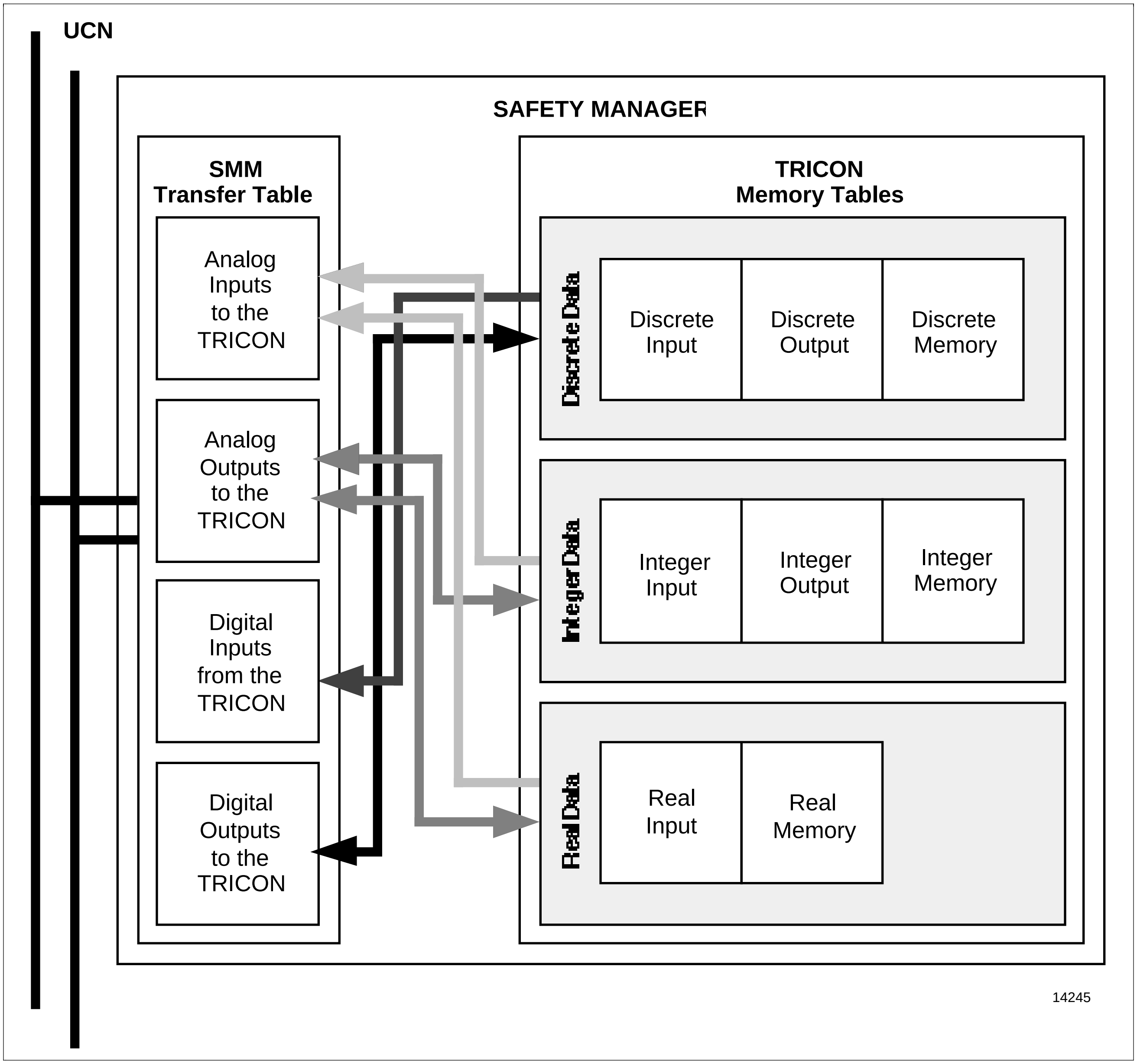
ATTENTION Please note the following.

- SMM outputs cannot be directly mapped to the TRICON outputs. SMM outputs are mapped to the TRICON discrete memory. The control program, running in the TRICON, is responsible for reading these output states from memory, processing them, and effecting any real-world output control. This limitation is essential to maintaining the integrity of the safety shutdown system.
- Programmable Logic Controllers (PLCs), such as the TRICON, commonly refer to ON/OFF states as discrete. Digital is normally reserved to indicate a specific range of signal levels. In Figure 3-1, digital and discrete are synonymous.

Continued on next page

Databases, continued

Figure 3-1 Database Relationships



ATTENTION AO, DC, and DO points “read back” to provide “current status” information.

Continued on next page

TRICON memory tables

The TRICON memory tables (areas) can be thought of in three separate categories.

- *Discrete data tables,* where
  - Discrete (digital) inputs are scanned by the TRICON and posted in the discrete input data range (alias addresses 10001 to 12000) of its memory table. This data is then available for transfer to the SMM.
  - Discrete (digital) outputs, which are the result of TRICON control program processing, are posted in the discrete output data range (alias addresses 1 to 2000) of its memory table. This data is concurrently sent to the TRICON's discrete output modules.
  - Discrete (digital) memory locations that can be thought of as internal coils (alias addresses 2001 to 4000, and 12001 to 14000) which are not directly related to real-world inputs or outputs. This data can be the result of TRICON control program processing, or received from the SMM's transfer table.
- *Integer data tables,* where
  - Integer input values are collected from the TRICON's I/O subsystem and posted in the integer input data range (alias addresses 30001 to 31000) of its memory table.
  - Integer output values, which are the result of TRICON control program processing, are posted in the discrete output data range (alias addresses 40001 to 40250) of its memory table. This data is sent to the TRICON's output modules on demand.
  - Integer memory locations can be thought of as internal registers (alias addresses 40251 to 40632) which are not directly related to real-world data word outputs. This data can be the result of TRICON control program processing, or received from the SMM's transfer table.
- *Real data tables,* where
  - Real (floating point) input values are collected from the TRICON's I/O subsystem and posted in the integer input data range (alias addresses 30001 to 31000) of its memory table.
  - Real (floating point) output values, which are the result of TRICON control program processing, are posted in the discrete output data range (alias addresses 1 to 2000) of its memory table. This data is sent to the TRICON's output modules on demand.
  - Real (floating point) memory locations can be thought of as internal registers (alias addresses 41001 to 42000) which are not directly related to real-world data word outputs. This data can be the result of TRICON control program processing, or received from the SMM's transfer table.

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Point loading and checkpointing

The SMM database, like those for most other TDC 3000X devices, consists of two basic sets of data:

- program instructions (fixed for each release of software), and
- variable configuration data
  - box-related data (applies to entire device), and
  - point data.

Whenever an SM (or other device) is activated—for the first time or after being powered down for any reason—its SMM program instructions must be loaded from the History Module or removable media. A simple operating procedure is provided for this purpose. Once loaded, the configuration remains intact unless a failure or power-down occurs.

Device or point data is unique for each device or point. Some of this type of data can change or be changed by the operator at any time. For this reason, a provision is made to automatically save, or checkpoint the data on a periodic basis. A manual save can also be requested by the operator at any time. If the data is then lost from device memory due to a failure, it can be restored from the checkpointed database.

For additional details regarding point loading and checkpointing, refer to the publication SM11-500—*Safety Manager Module Implementation Guidelines.*

3.6 Point Form

Introduction

Within the TDC 3000X system, certain process-related information is grouped together and given a name for purposes of identification. For example, all data pertinent to an input from the process (value, limits, engineering units, etc.) is stored in a database file and assigned a unique point tag name that enables the system to access all or part of that point's data whenever required.

Point form purpose

To implement many control strategies using Logic Managers, Process Managers, or Safety Managers, the data from several data points must be linked together during the point configuration process. For example, a regulatory control loop might consist of an analog input from the TRICON (a sophisticated calculation accomplished by an Application Module), and an output through the TRICON. The operator, however, needs only one interface to this control loop, not three.

To provide for this situation, the Safety Manager, like the Logic and Process Managers, supplies a configurable parameter called PNTFORM (point form) that allows you to define which points are to be used as the primary operator interface for point data. The PNTFORM parameter provides the user with two choices for point form: Full and Component.

Full point form

Points used for the primary operator interface are configured as having full point form, which includes descriptor data and alarm-related parameters.

Component point form

Points that are configured as having component point form do not require descriptor data and alarm-related parameters. This type of information is suppressed for component points. The component point form should be used for points that:

- provide inputs to the full point,
- handle the outputs from the full point, and
- are used as part of the full point that has been designated a primary operator interface point.

ATTENTION

The maximum number of points per Network Interface Module (NIM) is 8000. Both full and component points should be counted when checking against this limit.

CAUTION

After initially configuring the database, do a demand checkpoint (SAVE DATA) to checkpoint the configured data.

If the database is not loaded from the checkpoint, then during a cold start-up all the point's parameters are set to their default condition. In the case of the full/component selection, a point configured as full could be defaulted to the component type if the database has not been reloaded from the checkpoint.

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Motor control example

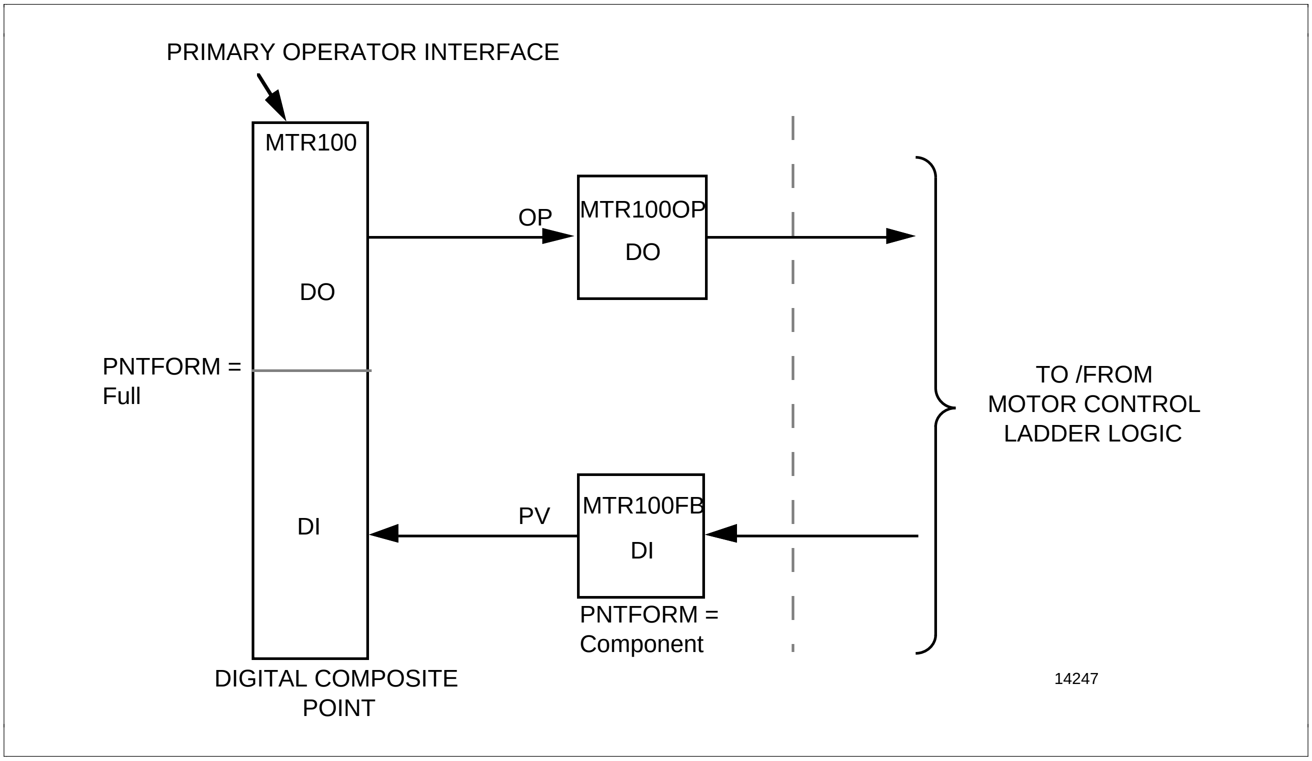
Figure 3-2 illustrates an example application of the full and component point forms.

In this example

- a single-output single-input digital composite point (MTR100) that interfaces a motor control circuit through digital output (DO) point MTR100OP, and digital input (DI) point MTR100FB,
- MTR100 is the primary operator interface and would be configured as a full point,
- MTR100OP and MTR100FB are parts of MTR100 and would be configured as component points, and
- assigning tag names for the standard digital input point and digital output point is optional.

  These points can be alternatively referenced, using the hardware reference addresses that would be assigned as the source and destination on the configuration form for the digital composite point.

Figure 3-2 Motor Control Example Using the Full and Component Point Forms



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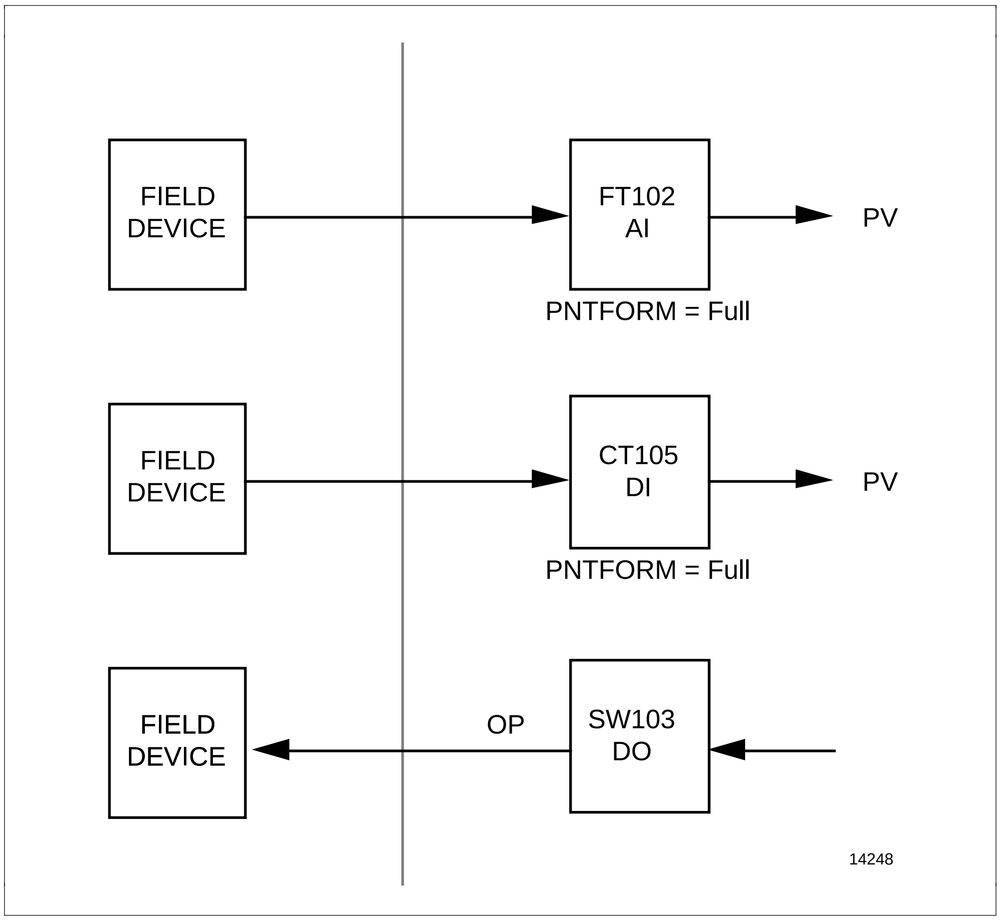
Stand-alone points example

Figure 3-3 illustrates an example application of the full and component point forms.

In this example

- three types of stand-alone points have been configured,
- FT102 and CT105 are analog and digital input points respectively, and could be used for data acquisition where they would be configured as full points, and
- point SW103 is a stand-alone digital output (DO).

Figure 3-3 Stand-Alone Example Using the Full and Component Point Forms



3.7 Alarming

Introduction

As with other UCN-based devices, common alarming functions can be configured for Safety Manager points. Alarm detection and reporting for a point can be configured only if the full point form is specified.

Priorities

For each point, a separate alarm priority can be specified for each alarm (for example, PV high alarm can be low priority but PV high high alarm can be emergency). Alarm priority configuration information is maintained by the NIM. The following alarm priorities are supported for SM points:

- Emergency,
- High,
- Low,
- Journal, and
- NoAction.

Enable status

Alarm enable status is applicable to full point forms and allow you to enable, disable, and inhibit alarms. This function is accomplished through the ALENBST parameter. The alarm enable status function is resident in the NIM.

Contact cutout

The main purpose of the contact cutout function is to prevent a proliferation of alarms from being reported to the operator. This function can be used to cut out alarms on a point when they are generated because of alarm conditions that have been detected at other points. Contact cutout is provided for all the point types in the SM and is implemented through the CONTCUT parameter. When the contact cutout state is ON, the alarms at the point are cut out; any new alarm detected is not reported on the Alarm Summary display of the Universal Station. The alarms continue to be reported to the journals and to the AM or CM60 for event-initiated processing (EIP).

3.8 Red Tagging

Introduction

A point can be red tagged to indicate that it requires maintenance.

Red tagging

This is accomplished by setting the REDTAG parameter to ON. Typically, the operator sets the output of the point to a desired safe value before putting on the red tag. Once red tagged,

- the point mode, mode attribute, external mode switching state, and output cannot be changed, and
- the point can be reconfigured or deleted if the red tag is ON.

Red tagging is supported for the digital output, analog output, and digital composite point types. A point must be configured for the full point form in order to be red tagged.

Mode and mode attribute

Before a point can be red tagged, the point's

- mode must be changed to MAN,
- mode attribute must be changed to OPER, and
- external mode switching state, if configured, must be disabled.

ATTENTION To red tag a digital composite point, the output of the point must not be configured for the momentary state.

Section 4 – Data Point Detailed Description

4.1 Overview

About this section

This section describes in detail each of the operator-displayable data point types, including their major parameters, and how the points relate to the TRICON (ladder logic) database. Topics included in this section are:

4.2 Analog Input Point

Background

The analog input point converts raw TRICON numbers into engineering units for use by the rest of the TDC 3000X system.

Data flow

Analog input values from the field can be collected from the TRICON via its ladder logic control program.

The ladder logic control program

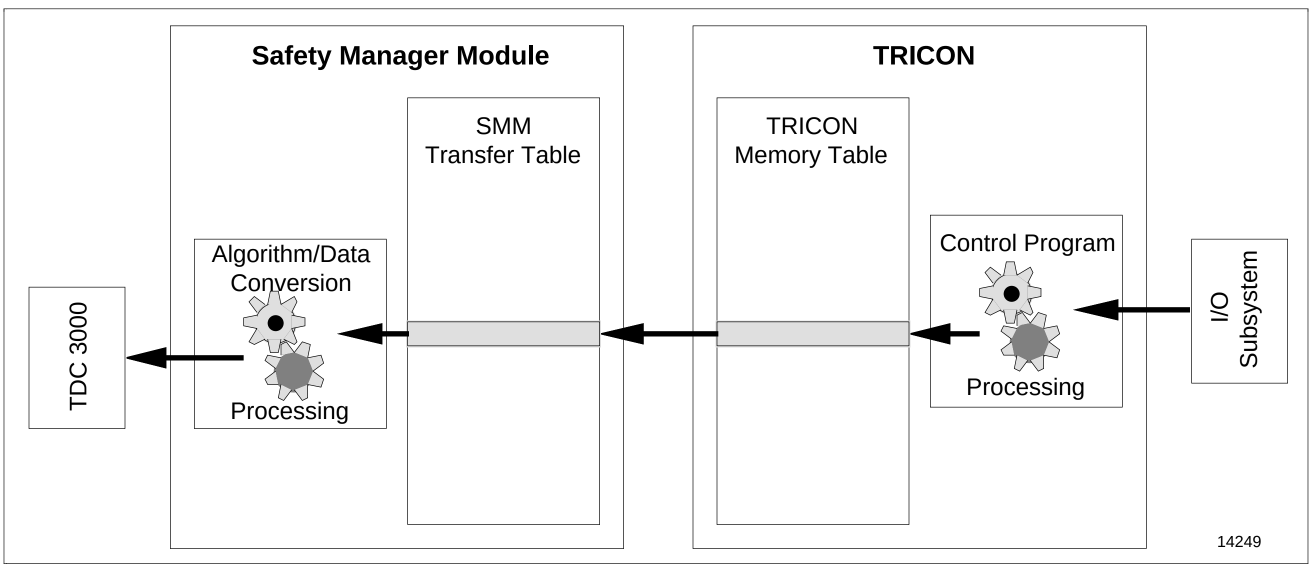
- directs the TRICON to collect the analog input value from specified real I/O addresses, and
- stores the collected value in its data storage area (memory).

The SMM

- accesses the specified location where the desired analog input value has been stored using the TRICON's alias address, and
- transfers the most recently collected value of the desired analog input from the TRICON's memory table to its own memory (transfer) table.

Figure 4-1 illustrates these data flow paths between the TRICON and the SMM.

Figure 4-1 Analog Input Point Data Flow



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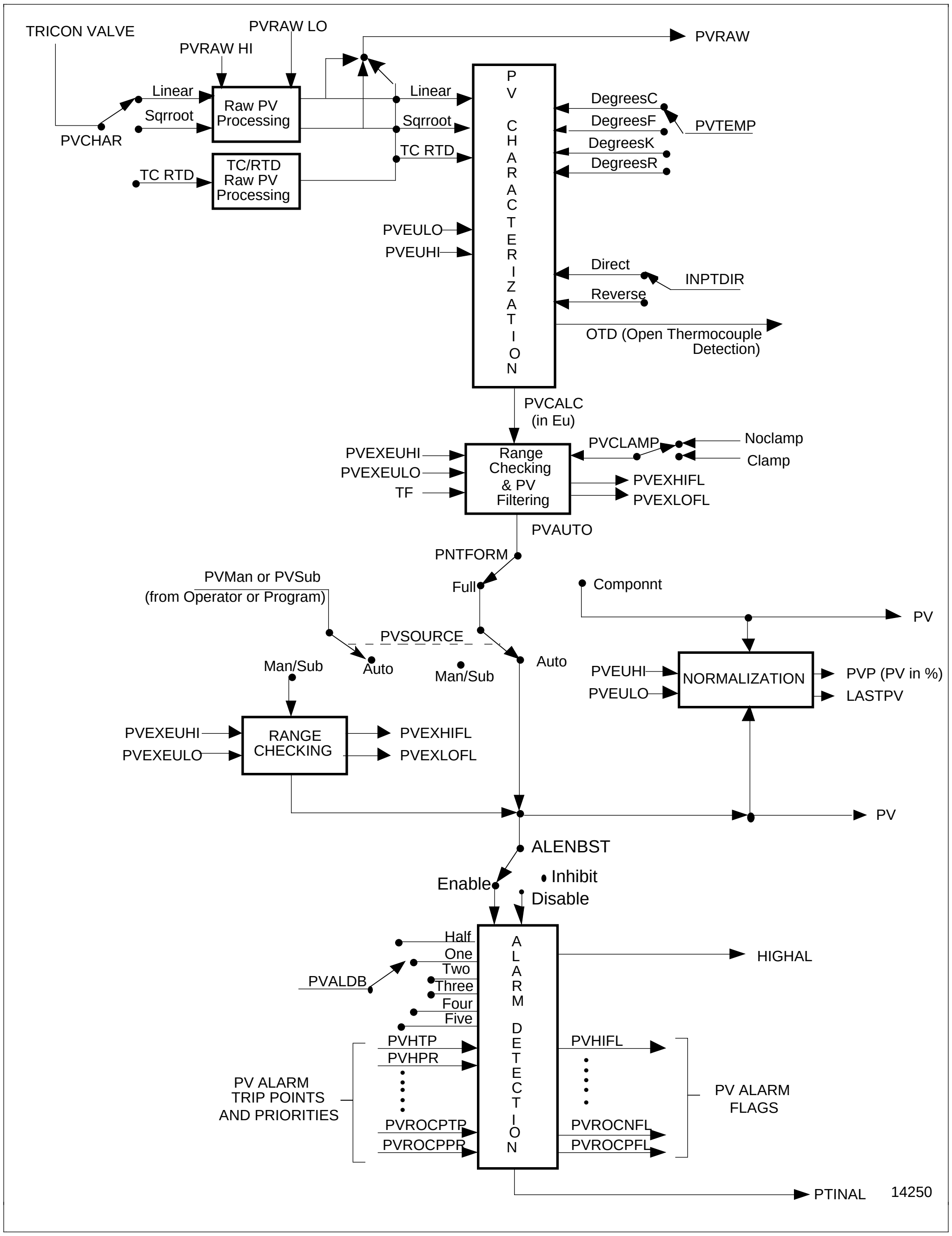
Point processing

Upon receiving the raw AI value from the TRICON, the SMM performs

- PV characterization,
- range checking and PV filtering,
- PV source selection, and
- alarm detection.

Figure 4-2 illustrates the processing functions and associated parameters.

Figure 4-2 AI Point Processing, Functional Diagram



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Format and collection rate

The parameter PVFLTOPT is configured to designate whether the analog input value received from the TRICON is formatted as

- integer, or
- floating point (real).

The Safety Manager can be configured to update analog inputs on either a 1-second or 1/2-second cycle.

Raw PV processing

If PVCHAR is LINEAR or SQRROOT, the value read from the TRICON is converted to a percent (0 to 100%) using the equation:

$$\text{PVRAW} = \frac{\text{TRICON Value - PVRAWLO}}{\text{PVRAWHI - PVRAWLO}} * 100$$

If PVCHAR is TC-RTD, the value read from the TRICON is converted to a percent (0 to 100%) using the equation:

$$\text{PVRAW} = \frac{\frac{\text{TRICON Value}}{8} - \text{PVEULO}}{\text{PVEUHI - PVEULO}} * 100$$

ATTENTION PVCALC is $\frac{\text{TRICON Value}}{8}$ when PVCHAR is TC-RTD.

PV characterization

The PVRAW signal received from the TRICON is a percentage of the source range. It is characterized based on the entries made for the PVCHAR, PVTEMP, and INPTDIR parameters. This value is converted to engineering units by the SMM. The engineering unit conversions that can be selected include

- linear,
- square root,
- thermal, and
- slidewire.

Linear Conversion

When linear conversion is selected, the PV value is converted to a floating point number. The output value of the linear conversion is PVCALC. The state of the input direction parameter (INPTDIR) is taken into consideration during the calculation of PVCALC as described in Table 4-1.

Table 4-1 Input Direct Affect on Linear Conversion Equations

If INPTDIR is…	THEN …
Direct	$\text{PVCALC} = \frac{\text{PVRAW}}{100} * (\text{PVEUHI - PVEULO}) + \text{PVEULO}$
Reverse	$\text{PVCALC} = \text{PVEUHI} - \frac{\text{PVRAW}}{100} * (\text{PVEUHI - PVEULO})$

Continued on next page

PV characterization, continued

Square Root Conversion

The square root calculation is applied to the PVRAW input such that 100% of span = 1.0. The square root value is then converted to engineering units based on the configured PV engineering-unit range values (e.g., square root of 100% = 100%; square root of 50% = 70.71%). The output value of the square root conversion is PVCALC, which is calculated based on the state of the input direction parameter (INPTDIR) as described in Table 4-2.

Table 4-2 Input Direct Affect on Square Root Conversion Equations

If INPTDIR is…	THEN …
Direct	$PVCALC = \frac{\sqrt{PVRAW}}{100} * (PVEUHI - PVEULO) + PVEULO$
Reverse	$PVCALC = PVEUHI - \frac{\sqrt{- PVRAW}}{100} * (PVEUHI - PVEULO)$

ATTENTION Thermocouple and RTD extended range parameters (PVEXEULO and PVEXEUHI) are configured by the user.

PV range checking and filtering

PV range checking ensures that the PVCALC output of PV characterization is within the limits defined by parameters PVEXEULO and PVEXEUHI. PV range checking (limits defined by parameters PVEUHI and PVEULO) and filtering characteristics to consider with the analog input point include the following.

- If either of the PVEUHI/LO limits is violated and clamping has not been specified, the output of the range check is set to BadPV.
- If either of the PVEUHI/LO limits is violated and clamping has been specified, the output of the range check is clamped.
- If the range-checked and filtered value is less than the value specified by the user-configured LOCUTOFF parameter, the final output called PVAUTO is forced to PVEULO.

First-order filtering is performed on PVCALC, as specified by the user through parameter TF (filter lag time).

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PV source selection

The PVSOURCE parameter allows the user to select the source of the PV for this data point. The PV can be provided by the range checking and filtering circuit (when PVSOURCE is Auto), or it can be a manually entered PV (when PVSOURCE is Man or Sub).

In addition, the PV source option parameter (PVSRCOPT) determines whether it is permissible to change the PV source to a source other than Auto. PVSRCOPT has two states: OnlyAuto and All. The All state allows the PV to be manually entered for this data point.

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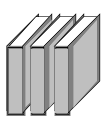
Alarming

The analog input data point compares the PV to threshold values and records the alarms in the database of the data point. The alarms are then reported by the SMM. Table 4-3 lists the parameters that are associated with alarming in the analog input point.

Table 4-3 Analog Input Point Associated Alarm Parameters

Parameter	Definition
ALENBST	Alarm Enable Status
BADPVFL	Bad PV Flag
BADPVPR	Bad PV Alarm Priority
CONTCUT	Contact Cut Out
EIPPCODE	Event-Initiated Processing Point Identifier
HIGHAL	Highest Alarm Detected
HIGHALPR	Highest Level Alarm’s Priority
PTINAL	Point in Alarm Indicator
PVALDB	PV Alarm Deadband as a Percent of Full Range
PVEXHIFL	PV Extended High Range Violation
PVEXLOFL	PV Extended Low Range Violation
PVHIFL	PV High Alarm Flag
PVHIPR	PV High Alarm Priority
PVHITP	PV High Alarm Trip Point
PVLOFL	PV Low Alarm Flag
PVLOPR	PV Low Alarm Priority
PVLOTP	PV Low Alarm Trip Point



Refer to the SM09-550—*Safety Manager Module Parameter Reference Dictionary* for detailed definitions of these parameters.

4.3 Analog Output Point

Background

The analog output point is written from the SMM to the TRICON's

- I/O system:
  - analog output module,
  - via an address in its real I/O range; or
- data register table.

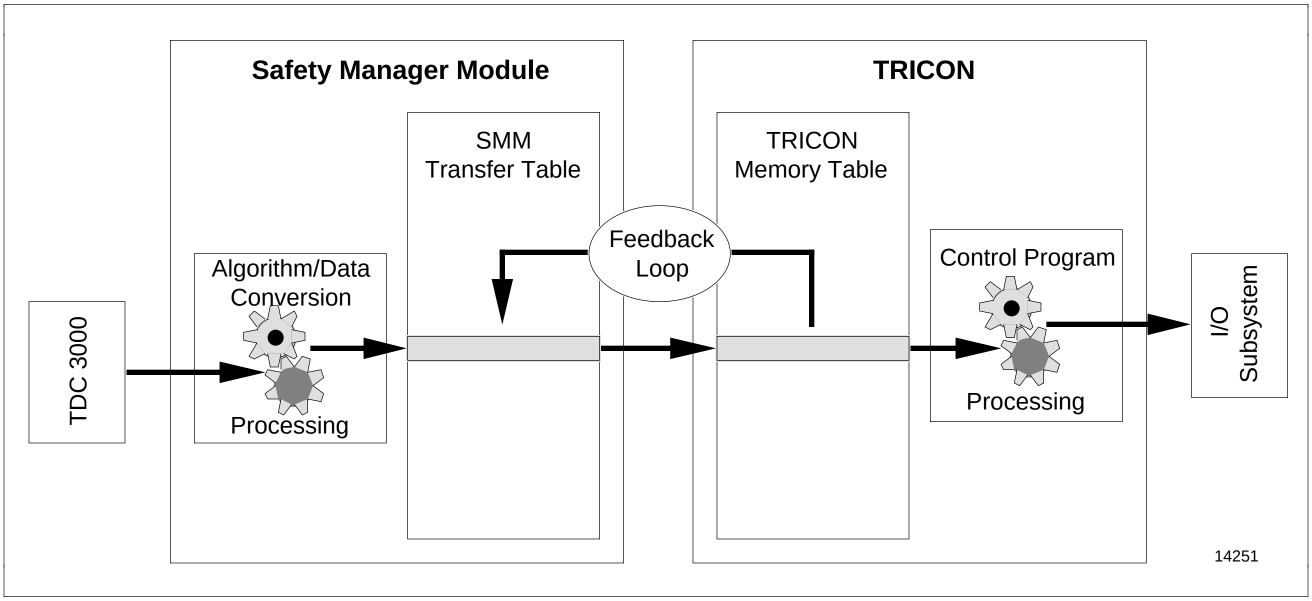
Data flow

Figure 4-3 illustrates the operation of the analog output point transfer to the TRICON's I/O system. The operation is as follows:

- the analog output point data, carrying an alias address corresponding to an analog output module point, is transferred to the TRICON's memory table,
- this information is processed by the TRICON control program which passes the associated data value directly to a holding register in the specified analog output module, and
- the analog output module then
  - converts this digital value to the appropriate analog signal, and
  - transmits this signal to the analog field device connected to that point/address.

Analog output points transferred to the TRICON's memory table can be configured to feedback to the SMM every 1-second or 1/2-second.

Figure 4-3 Analog Output Paths between the SMM and the TRICON's I/O System



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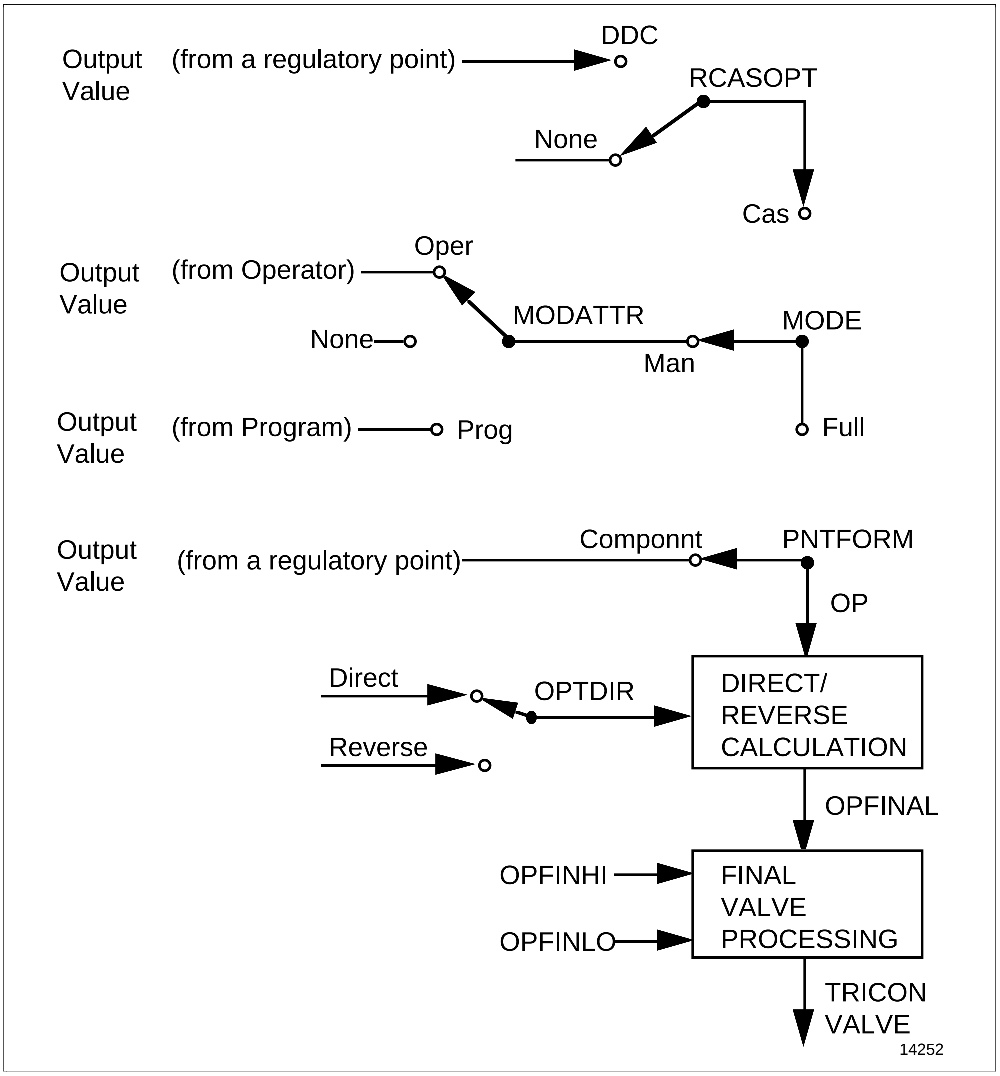
Point processing

Figure 4-4 illustrates the SMM processing functions that are associated with an analog output point, and can be configured via parameters.

Figure 4-4 AO Point Processing, Functional Diagram



Direct/reverse output

The OPTDIR parameter allows you to specify whether the output of the data point is

- direct acting, where
  - minimum value = 0%, and
  - maximum value = 100%; or
- reverse acting, where
  - minimum value = 100%, and
  - maximum value = 0%

4.4 Final Value Processing

Final value processing

The value written to the TRICON is calculated using one of the following equations:

Direct: $$\frac{OPFINAL}{100} * (OPFINHI\ OPFINLO) + OPFINLO$$

Reverse: $$\frac{100 - OPFINAL}{100} * (OPFINHI - OPFINLO) + OPFINLO$$

Data conversion

Not illustrated in Figure 4-4 is the data conversion option. This conversion option allows the user to specify the type of output to be supplied to the TRICON:

- integer, or
- floating point (real).

It is implemented by setting PVFLTOPT parameter to the appropriate format.

4.5 Digital Composite Point

Background

The digital composite (DC) point is a multi-input/multi-output point that provides an interface to a load control algorithm in the TRICON. The TRICON, in turn, controls a target field device, such as a motor. The Safety Manager interface allows the operator at a Universal Station to monitor and make inputs to the control scheme through Group, Detail, and Graphic displays much like those supported by Process Manager DC points.

CAUTION The appropriate algorithm must be programmed into the TRICON for the typical DC point to function. The SMM accesses the TRICON points needed to make the DC point's multiple input/output display available to the operator.

Functions performed by the DC point include:

- Commanded states, provided by the operator or a program, pass to the point's outputs for use by the TRICON.
- Interlock overrides reflect an override operation built into the ladder logic.
- The state of selected TRICON outputs are provided to the Universal Station
  - allowing the TRICON's ladder logic to alter the state of its field output(s) so that it differs from the commanded state, and
  - making operators aware when the actual output state to the field is not the same as the commanded state.
- TRICON points, local digital inputs, or flags are monitored through feedback inputs. The resulting inputs are checked against the commanded state for Off Normal, Command Disagree, or Uncommanded Change, and alarmed as necessary.
- The status of a LOCAL/MANUAL input from the TRICON is monitored. No alarming or control is provided.

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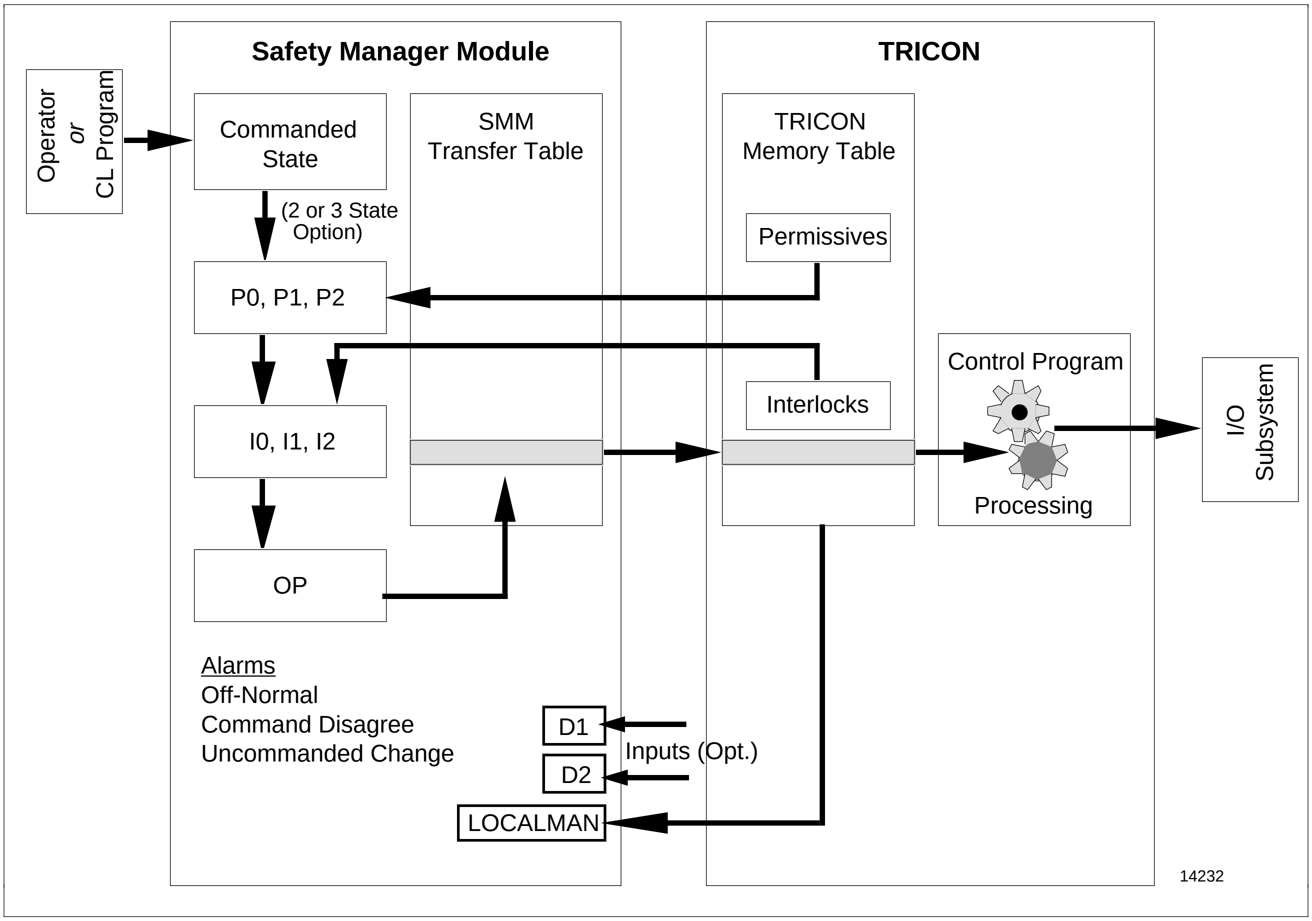
Data flow

Figure 4-5 illustrates typical DC point data flow between the SMM and TRICON.

Figure 4-5 Typical Data Flow of a Digital Composite Point Outputs



Status representation

Figure 4-6 illustrates how DC points are depicted in a Universal Station's Group display. In the display, each state is represented by a separate box. The State 0 box is the middle box, the State 1 box is the upper box, and State 2 box is the lower box. (The State 2 box does not appear if the point has been configured for two states where parameter NOSTATES = 2.)

ATTENTION State changes read back from the TRICON, and their indications on the Group or Detail displays may take a few moments, after the command to change is issued. This short delay can be attributed to

- any normal lag time required for the controlled field device to change states,
- the scan time for the TRICON's ladder logic control program to read the change from the field, and
- the communications time required for transferring data from the TRICON, through the SMM, UCN, NIM, LCN, etc.

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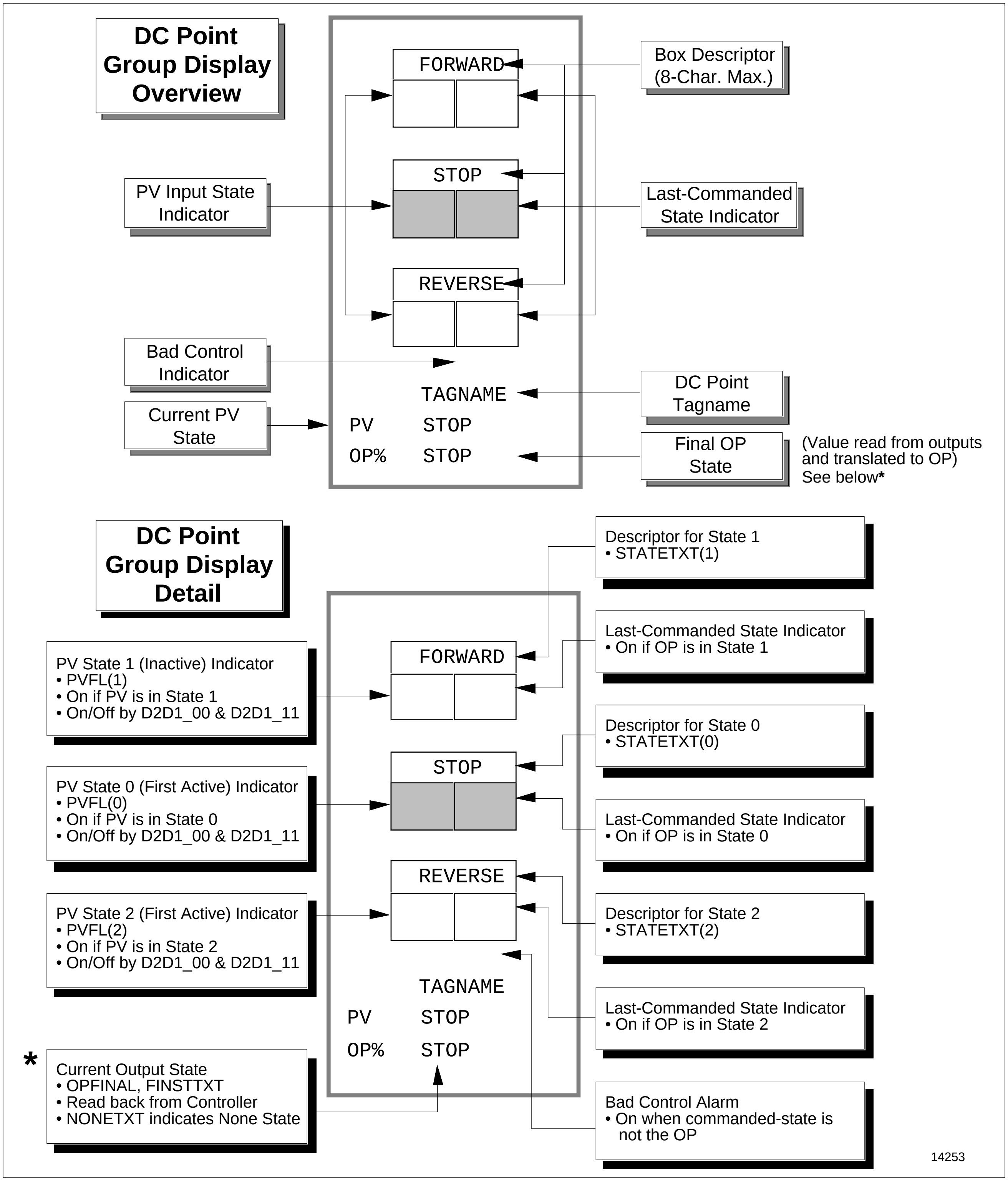
Status representation, continued

Figure 4-6 DC Point Group Display



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Point states

Normal States

DC points can have two or three normal states that allow the data point to interface with devices that have two or three operational states. The normal states of a DC point are defined in Table 4-4.

Table 4-4 Normal Digital Composite Point State Definitions

State	Definition
1	First active state.
0	Inactive (middle) state.
2	Second active state. **ATTENTION** Applicable only when the entry for the NOSTATES parameter is 3, signifying that the data point has three states.

Momentary States

DC points can be configured as being momentary by using the MOMSTATE parameter. In the momentary state the point acts like a doorbell (state remains active as long as a switch is pressed). The momentary states of a DC point are defined in Table 4-5.

Table 4-5 Momentary Digital Composite Point State Definitions

State	Definition
Mom_1	State 1 is momentary. • When released from this state, it jumps back to State 0.
Mom_0	State 0 is momentary. • When released from this state, it jumps back to State 1. • Mom_0 can be selected only if the NOSTATES parameter = 2.
Mom_2	State 2 is momentary. • When released from this state, it jumps back to State 0. • Mom_2 can be selected only if NOSTATES parameter = 3.
Mom_1_2	States 1 and 2 are momentary. • When released from any one of these states, it jumps back to State 0. • Mom_1_2 can be selected only if NOSTATES parameter = 3.

Continued on next page

Point states, continued

Moving/Bad States
The digital composite data point has two states that represent the conditions when the current state of the device is "bad" (indeterminate) or the current state is "moving" (from one state to another). The moving/bad state descriptor is located below the State 2 box on the display.

- The Bad State (BADPVTXT parameter) can result when the PV input signals from the process are in an inconsistent state.
  - *For example:* Limit switches on a valve indicating open and closed are both simultaneously on.
- The Moving State (MOVPVTXT) is encountered when the device is in transition from one state to another.
  - *For example:* A slow moving valve is changing from the open state to the closed state.

The BADPVTXT and MOVPVTXT parameter descriptors are configured once for each SM box data point and then are used for all digital composite points in the same SM.

None State
Users can create an optional None state for a Digital Composite point by configuring On in parameter NONECONF. The none state operates as described in Table 4-6.

Table 4-6 Digital Composite Point None State Operation

IF the none state read back from the TRICON...	THEN …
does not match the commanded state in OP	a bad control alarm is not generated.

Users can specify an output state (or a pattern of states if there is more than one output) which does not generate a bad control alarm, even though it differs from the commanded state.

OPFINAL
OPFINAL contains the current state reflector in the actual outputs. The output values are first read from the TRICON and then compared to the STx-OPy parameters for a match.

IF the outputs match the...	THEN OPFINAL…
STx-OPy for current state in OPFINAL (assuming OPFINAL is not BAD)	does not change.
ST0-OPy	is set to STATE0.
ST1-OPy	is set to STATE1.
ST2-OPy	is set to STATE2.
NONE-OPy and NONECONF is on	is set to NONESTATE, otherwise OPFINAL is set to BAD state.

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Mode attributes

DC points support only the manual (MAN) mode with mode attributes (specified by parameter NMODATTR) of operator and program. Table 4-7 defines how the commanded state is provided.

Table 4-7 Digital Composite Point Mode Attribute Operation

IF mode attribute is …	THEN …
Operator	only the Universal Station operator can provide the commanded output state.
Program	only user programs (continuous or discontinuous) can provide the commanded output state.

The operator mode attribute flag (OPRATRFL) is also provided for potential use by the interlocking logic.

The MODEPERM parameter is provided to optionally prevent the operator (as opposed to the supervisor or engineer) at the Universal Station from changing the mode attribute.

Interlocks

Two kinds of interlocks, permissives and overrides, can be programmed in the ladder logic control program for controlling the DC points associated real-world TRICON output(s). When they are so programmed, their positions (ON, OFF) are communicated to the SMM. Table 4-8 defines to what state the commanded state is forced.

Permissive Interlocks

The permissive interlock parameters P0-P2 determine whether the operator and user programs are allowed to change the output of a DC point to a specific state. A permissive interlock can be provided for each of the three states. Permissive interlocks themselves never cause the output to change.

For the commanded output to be changed to the desired state, the corresponding permissive interlock parameter must be set to ON. The permissive interlock parameters P0, P1, and P2 are normally set to ON, thereby allowing permission for all states. These parameters must be individually set to OFF by the TRICON's ladder logic to prevent access to the corresponding commanded output state.

Override Interlock

The override interlock parameters I0-I2 are read in from the TRICON's memory and force the commanded output (OP) to a specific state regardless of the condition of the permissive interlocks. The operator and user programs cannot change the output state when any override interlock is ON. An override interlock can be provided for each of the three output states. Note that the actual outputs to the process are supplied only by command from the ladder logic control program.

Continued on next page

Interlocks, continued

Table 4-8 Digital Composite Point Override Interlock Operation

IF override interlock …	THEN …
I0 is set to ON by the ladder logic control program	the commanded output state is forced to State 0 (regardless of the condition of parameters I1 and I2).
I0 is set to OFF and I1 is set to ON by the ladder logic control program	the commanded output is forced to State 1 (regardless of parameter I2).
I0 and I1 are set to OFF, and I2 is set to ON by the ladder logic control program	the commanded output is forced to State 2.
I0, I1, and I2 are all set to OFF by the ladder logic control program	the last value of the commanded output is maintained until changed by the operator, program, or another override interlock.

Override interlock parameters I0-I2 are normally set to OFF, disabling all the override interlocks. They must be set to ON (by the ladder logic control program) to force OP only (not the outputs) to go to any specific state.

ATTENTION On the SM, the override interlocks only change OP, not the outputs. (This must be programmed in the TRICON ladder program.)

Digital outputs

Digital outputs for the digital composite point can be configured as either latched or momentary. Momentary outputs use the MOMSTATE parameter.

Commanded State (OP)

The command to go to a specific state normally results in the output to the field device going to the commanded state. (The TRICON can alter output state to the field device.) The OP parameter in the DC point contains the descriptor for the commanded state. The descriptor is configured in parameters STATETXT(0) through STATETXT(3). The OP parameter is available for configuration only if the number of digital output connections (NODOPTS) is configured to be greater than zero.

Up to nine Boolean parameters of the form STx_OPy (where x = 0, 1, or 3 for the state number and y = 1, 2, or 3 for the output number) allow the user to specify the normal state values that are to be stored by the output connections. For each of the three commanded states per output connection, the user must define the value (ON or OFF) of the state.

For the None state, the output values for the three possible outputs are configured in parameters NONE_OP1 through NONE_OP3.

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Digital outputs, continued

Output Connections

The destinations of the outputs (and the output types) from a DC point are specified by the user through the DODSTN(1)-DODSTN(3) parameters. Destinations that can be specified include

- TRICON connection,
- SO parameter of a digital output point within the same SMM,
- PVFL parameter of a local flag point, and
- SM box flag.

Table 4-9 describes the procedures for assigning DC output point connections.

Table 4-9 Digital Composite Point Output Connections

To assign DC output point to …	THEN …
a TRICON connection	enter the following information for the respective DODSTN(n) output connection parameter ... **!LCxxxxx** where **!LCxxxxx** is the address of the point as programmed in the TRICON.
a local digital output point	enter the following information for the respective DODSTN(n) output connection parameter ... **Tagname.SO** where the **tagname** is the 8-character name assigned to the data point through the NAME parameter and **SO** signifies the writeable status command of the digital output point.
a local flag point	enter the following information for the respective DODSTN(n) output connection parameter ... **Tagname.PVFL** where the **tagname** is the 8-character name assigned to the data point through the NAME parameter and **PVFL** signifies the PV flag.
an SM box PV flag in the same SM box	enter the following information for the respective DODSTN(n) output connection parameter ... **!BOX.FL(nnnn)** *-or-* **$NMhhBxx.FL(nnnn)** where **!BOX** specifies the same SM device where the DC point resides, **nnnn** is the flag number having a range of 1 to 2000, **hh** is the SM’s UCN network number, and **xx** is the SM’s UCN address.

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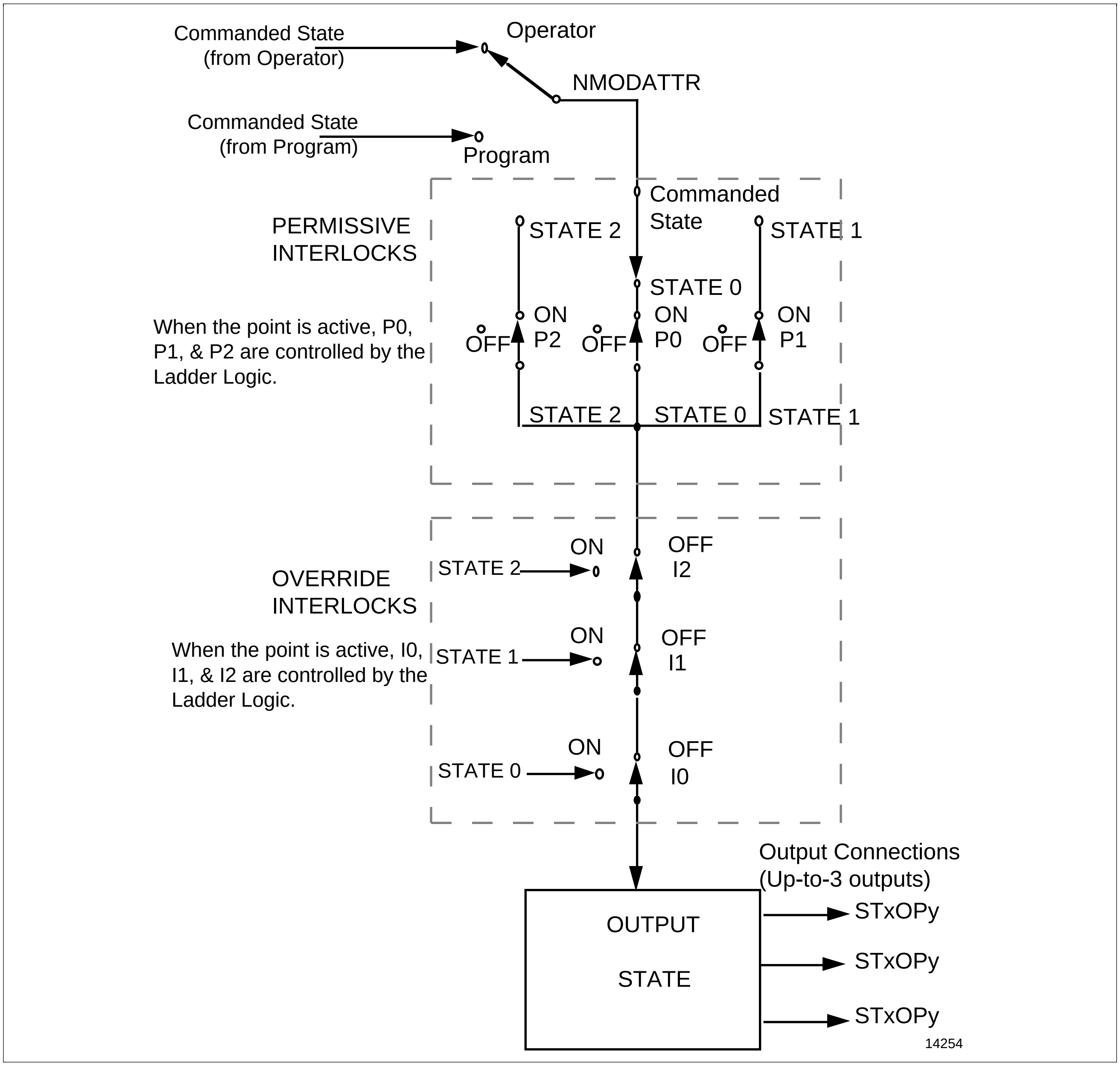
Digital outputs, continued

DC Output Point Processing

Figure 4-7 provides a functional diagram of the processing of a DC output point.

Figure 4-7 DC Output Point Processing, Functional Diagram



ATTENTION The following statements are true.

- When override interlocks change, only OP is changed not the outputs.
- When a commanded state from outside comes in, the override interlock values are checked to verify that the state can be changed. (All override interlocks must be OFF.)
- There is no feedback loop from override interlocks to the outputs.

Continued on next page

Digital outputs, continued

Multiple Output Processing

Parameter NODOPTS can be configured to specify one, two, or three SMM outputs from a DC point, all of which reflect the commanded output state in OP. These outputs can be connected to several destinations, including destinations in the TRICON. Where there is more than one TRICON output, the SMM compares each read-back output with OP, and reports the first match in OPFINAL. If no match is found, a bad control alarm is generated.

Digital inputs

When configuring digital inputs of the DC data point, the user can specify

- the input connections,
- PV states,
- PV source and options,
- alarming, and
- change-of-state events.

The input portion of a DC point can be configured only if the user has entered 1 or 2 for the Number-of-Digital-Inputs parameter (NODINPTS).

Current Input State (PV)

The DC point allows the user the flexibility to assign the states of the PV for each possible combination of digital inputs, so that the states correspond to the different applications in which this point type can be used. The PV parameter represents the current state of the interfaced device and is derived from inputs D1 and D2 that can be feedback signals from the process. Separate parameters are used to configure a single-input point and a dual-input point.

Table 4-10 describes the characteristics associated with single- and dual-point input parameters.

Continued on next page

Digital inputs, continued

Table 4-10 DC Point Single and Dual Digital Input Parameter Characteristics

Point Use	Comment	Assigned Conditions
Single-Point	One input parameter (D1). • Two possible PV states: – PVstate0 – PVstate1. • Assigned to either one of two input conditions.	D1 = 1 • D1 is ON; parameter D1_1 D1 = 0 • D1 is OFF; parameter D1_0
	ATTENTION You need only to assign PVstate0 or PVstate1 to parameter D_1; the system automatically assigns the remaining PV state to parameter D1_0.	
Dual-Point	Two input parameters (D2 and D1). • Four possible combinations of input conditions. • User can assign any one of five PV states: – Pvstate1 – Pvstate0 – Pvstate2 – MovPV – BadPV	D2D1 = 00 • D2 is OFF, D1 is OFF; parameter D2D1_00 D2D1 = 01 • D2 is OFF, D1 is ON; parameter D2D1_01 D2D1 = 10 • D2 is ON, D1 is OFF; parameter D2D1_10 D2D1 = 11 • D1 is ON, D2 is ON; parameter D2D1_11
	ATTENTION PVstates1, 0, and 2 cause the PV indicator to be lit in the respective state box on the Group display when the assigned D2D1 input conditions are satisfied. The MovPV and BadPV states cause the respective MOVPVTXT or BADPVTXT descriptor to appear below the state boxes on the Group display.	

ATTENTION Inputs to a digital composite point are usually the PVs from digital input points. Digital input points should be configured as component points that force the input direction to be direct (as opposed to reverse). The actual direct/reverse action can be configured by assigning the appropriate PV state to the input.

Continued on next page

Digital inputs, continued

PV Source

The PV source parameter (PVSOURCE) determines the source of the current PV state for the digital input portion of the digital composite data point. Table 4-11 lists the possible sources of the current PV state.

Table 4-11 Current PV Source States

Source	Description
Man (Manual)	Current PV state is provided by the operator from the Universal Station.
Auto (Automatic)	Current PV state is derived from Input 1 (D1) and Input 2 (D2).
Track	Current PV state is the commanded output state.
Sub (Substituted)	Current PV state is provided by a user program.

During configuration, the user can specify the PV sources to be used for this data point. Parameter PVSRCOPT allows the user to select the PV source as being only AUTO, or to select all the PV sources in the above listing as allowable sources of the PV.

Input Connections

The inputs to a DC point are specified by the user through digital input-source parameters DISRC(1)-DISRC(2). The status of Input 1 is represented by parameter D1; Input 2 is represented by parameter D2. Input 2 can be configured only when the entry for the number-of-digital-inputs parameter (NODINPTS) is 2. These inputs are designated as Input 1 and Input 2, and can be obtained from

- TRICON connection,
- SO parameter of a digital output point within the same SMM,
- local digital input or flag points, and
- SM box flag PV.

The input sources must be in the same SM box as the DC point being configured.

Continued on next page

Digital inputs, continued

Table 4-12 describes the procedures for assigning DC input point connections.

Table 4-12 Digital Composite Point Input Connections

To assign …	THEN …
the PV of a digital input point from the TRICON to the PV input of a DC point	enter the following information for the respective DISRC(n) input connection parameter ... **!LCxxxxx** where **!LCxxxxx** is the address of the point as programmed in the TRICON.
a local digital input to the PV of a DC point	enter the following information for the respective DISRC(n) output connection parameter ... **Tagname.PVFL** where the **tagname** is the 8-character name assigned to the logic slot providing the output and **PVFL** signifies the PV flag.
a local digital output point	enter the following information for the respective DODSTN(n) output connection parameter ... **Tagname.SO** where the **tagname** is the 8-character name assigned to the data point through the NAME parameter and **SO** signifies the writeable status command of the digital output point.
an SM box PV flag to the input of a DC point	enter the following information for the respective DISRC(n) output connection parameter ... **Tagname.PVFL** *-or-* **!BOX.FL(nnnn)** *-or-* **$NMhhBxx.FL(nnnn)** where the **Tagname** is the 8-character name assigned to the box PV flag, **PVFL** signifies the PV flag, **!BOX** specifies the same SM device where the DC point resides, **nnnn** is the flag number having a range of 1 to 1024, **hh** is the SM's UCN network number, and **xx** is the SM's UCN address.

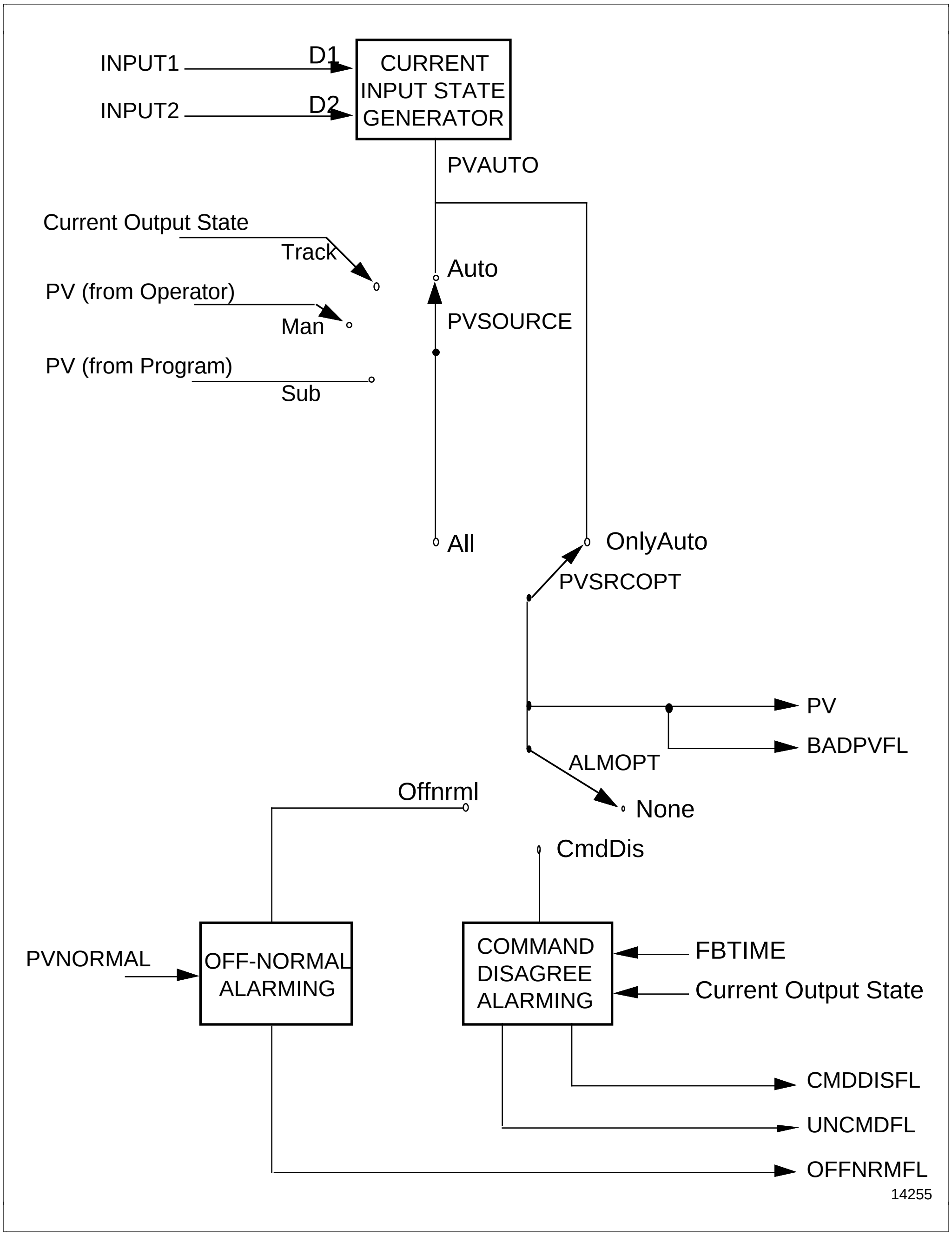
Continued on next page

Digital inputs, continued

DC Input Point Processing

Figure 4-8 provides a functional diagram illustrating the processing of a DC input point.

Figure 4-8 DC Input Point Processing, Functional Diagram



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Alarming

A DC point can be configured to detect and report command disagree, uncommanded change, or off-normal alarms through the use of the ALMOPT parameter. Also provided is the option of specifying no alarming for the data point. These alarm options can be configured only if the digital composite point is configured to have inputs, or inputs and outputs.

Command Disagree and Uncommanded Change

This type of alarming is selected by entering CmdDis for the ALMOPT parameter. When the commanded-output state is changed and the actual input PV state does not change accordingly within a predefined feedback time, a command disagree alarm is generated. The feedback time (1 to 1000 seconds) is specified by the FBTIME parameter.

This alarm condition returns to normal when the input PV state and the commanded-output state are the same. If the commanded state is momentary, no alarm is generated. For example, a motor may have two PV states (RUN and STOP), but there may be three commanded output states (RUN, STOP, and JOG) where JOG is defined as a momentary state. Command disagree alarming is performed for only the RUN and STOP commanded output states.

If a change does not occur in the commanded output state but the input PV state changes (and the PV is not bad), an uncommanded-change alarm is generated. This alarm condition returns to normal when the input PV state and the commanded state are the same. If the point state has been configured as being momentary, this type of alarm is not applicable.

Off-Normal

Detection of off-normal alarms is configured by entering Offnorml for the ALMOPT parameter. The normal state of the PV input is defined by the user through the PVNORMAL parameter. When the PV input state is different from the state specified by the PVNORMAL parameter, the off-normal alarm is generated. The alarm condition returns to normal when the PV input state and the specified PV normal state are the same.

Change-of-State Events

Any transitions in the PV input state can be reported as events for journaling and for causing the event-initiated processing of points in the Application Module (AM). It is configured by entering EIP for the Event-Report-Option parameter EVTOPT. The user must enter the tag name of the AM or CM point using the EIPPCODE parameter. If only journaling is required, the EIPPCODE parameter can be set to a null tag name.

Continued on next page

Alarming, continued

Bad Control Alarm

A bad control alarm indicates that the TRICON output state does not match the commanded state in the OP parameter. After a change in the output is commanded by an operator at a Universal Station or by a user-written program, the SMM defers the calculation of the read back status from the TRICON for one control program scan to allow the TRICON to update its output to the field. The SMM compares each of the one, two, or three outputs with OP, and reports the first match in OPFINAL. A Bad Control alarm (BADCTLFL = On) is generated if no match is found on any output. This causes the bad control indicator (Figure 4-6) to appear on the Group or Detail display for the point.

Local manual indication

Field devices that are interfaced by a DC point often have a local HAND/OFF/AUTO switch (often called HAND/OFF/REMOTE). Unless this switch is in the AUTO position, the SM may not have any control over that device. The user can optionally feedback the switch position into the SM to obtain some display indication for the Universal Station operator. This indication is provided by the word LOCALMAN appearing at the bottom of the DC point on a Group display.

When in local manual, any changes to the output by the operator, user programs, or override interlocks are typically prohibited (assuming the TRICON is programmed accordingly). The override interlocks should be programmed to take effect as soon as the local manual condition is cleared. To support HAND/OFF/AUTO switches, a Boolean flag called LOCALMAN is provided for connection to the TRICON. The ON state indicates that the switch is not in AUTO position.

CAUTION Be aware of the importance of assuring compatibility of the ladder logic control programming with the connections established for the Safety Manager's DC point.

4.6 Digital Input Point

Background

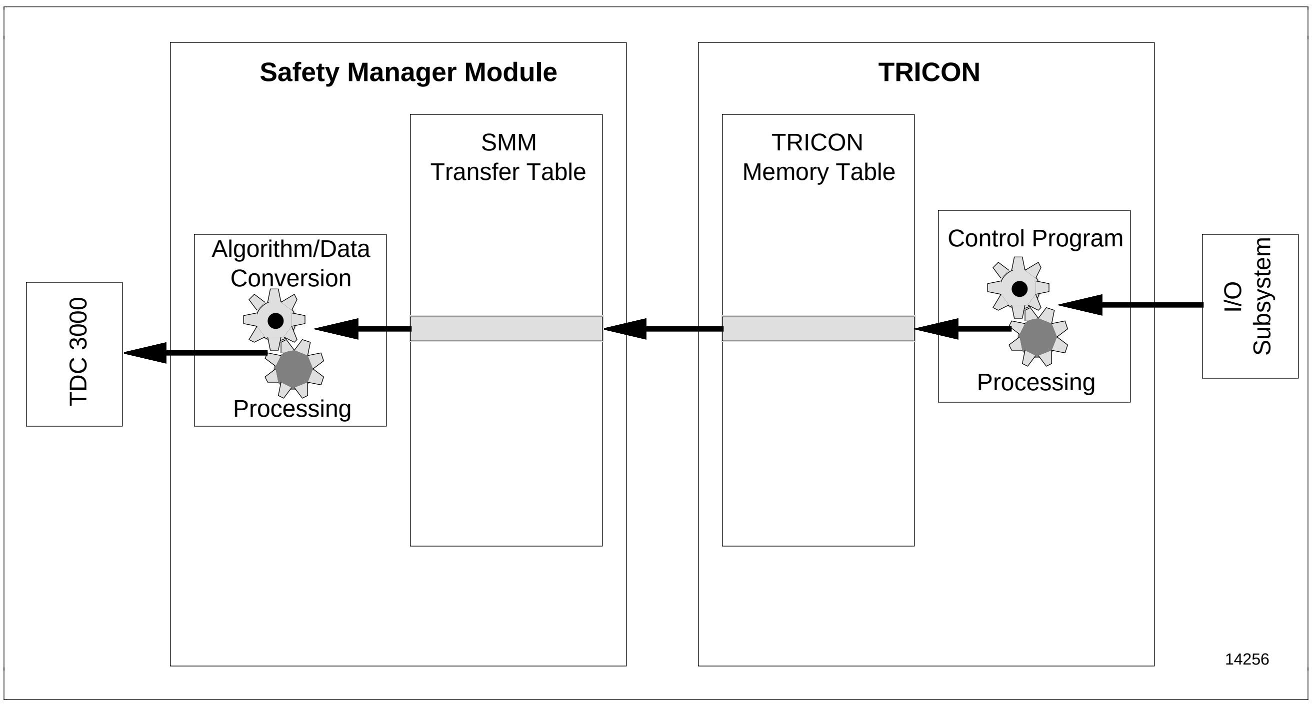
A digital input point converts raw TRICON discrete I/O status into UCN-compatible Boolean formats and performs Off Normal alarming. It represents any single TRICON discrete I/O status point.

Data flow

Figure 4-9 illustrates the operation of the digital input point. The operation is as follows:

- data from discrete input modules are scanned by the TRICON placed in the discrete input memory Table area,
- using the appropriate alias address, the SMM transfers this information to its Transfer Table, then
- this information is processed and passed on to the TDC 3000^{X} as necessary.

Figure 4-9 Typical Data Flow of a Digital Input Point



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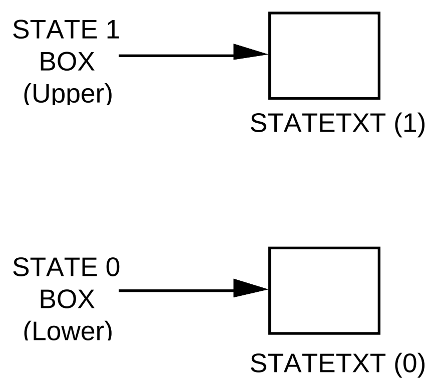
Status representation

The current state of the PV input is represented on the Universal Station Group and Detail displays as two boxes, as shown in Figure 4-10. The boxes are lit or extinguished depending on the current state of PVRAW and the input direction as configured through the INPTDIR parameter, as shown in the chart in Figure 4-10.

Figure 4-10 DI Point US Status Representation



PVRAW State	INPTDIR = Direct	INPTDIR = Reverse
ON	PV = ON. State 1 Box is lit. State 0 Box is extinguished.	PV = OFF. State 0 Box is lit. State 1 Box is extinguished.
OFF	PV = OFF. State 0 Box is lit. State 1 Box is extinguished.	PV = ON. State 1 Box is lit. State 0 Box is extinguished.

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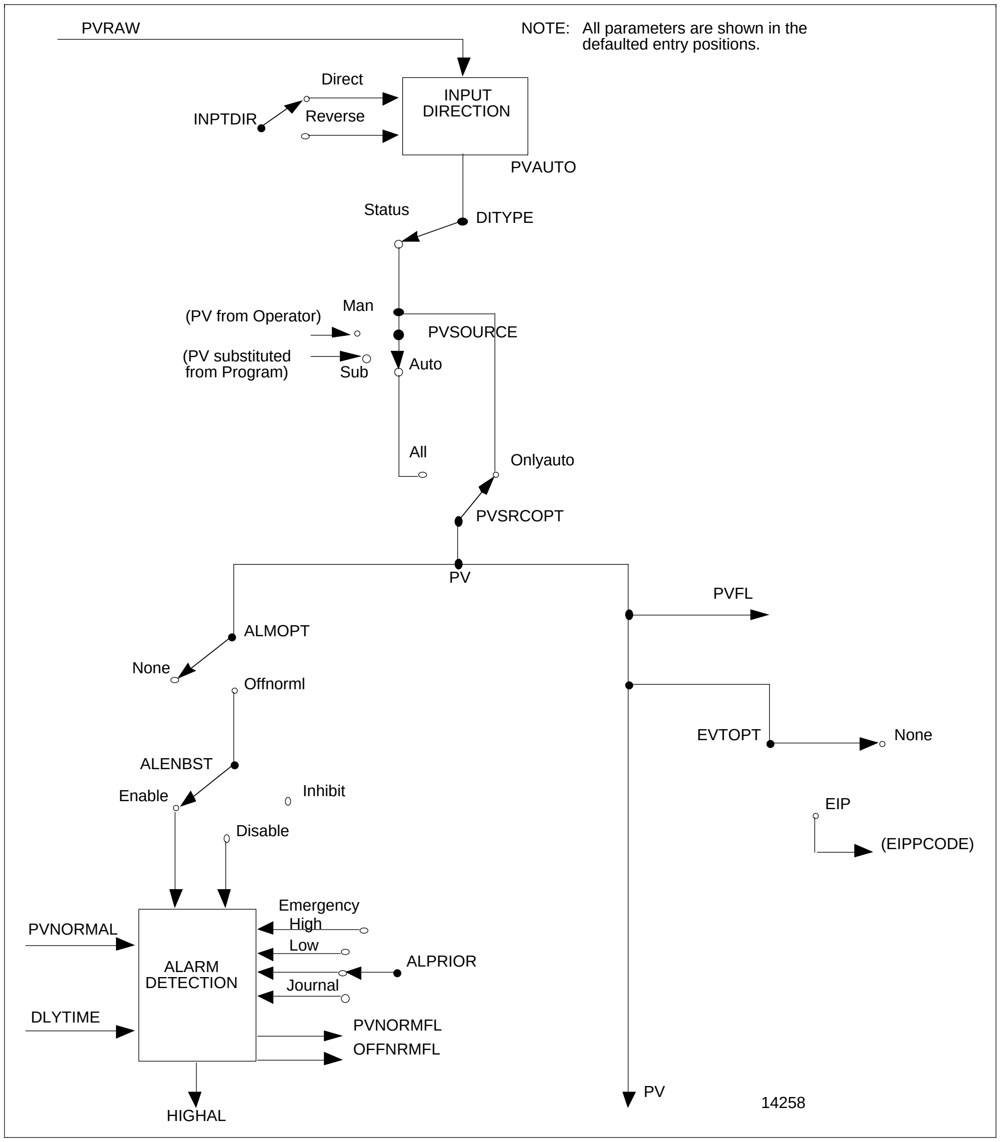
Point processing

Processing performed on a digital input point is illustrated in Figure 4-11. The PVAUTO value represents the state of the input signal after the direct/reverse conversion is performed. The digital input point can be configured for PV source selection, detection of off-normal alarms, and for reporting any PV state changes to the system

Figure 4-11 DI Output Point Processing, Functional Diagram



PV source selection

The PV source parameter (PVSOURCE) option determines the source of the PV for a digital input point. The source can be the PV input from the TRICON (PVauto), the PV state entered by the operator (PVman), or it can be supplied by a user program (PVsub). If PVSOURCE is PVauto, PV tracks PVRAW.

Continued on next page

Off-normal alarming

Enabling, Disabling, and Inhibiting Off-Normal Alarms

The ALENBST parameter allows the operator to enable (permit), disable, or inhibit the off-normal alarm. Disabling the alarm still allows the alarm to be listed on the Alarm Summary display. Inhibiting the alarm prevents the current PV state from being compared to the configured normal state.

Off-Normal Alarming and PV Change Reporting

Off-normal alarming can be selected for the digital input point through the ALMOPT parameter. An off-normal alarm is generated when the input PV state is different than the configured normal (desired) state for the point, as specified by the PVNORMAL parameter. The priority of the off-normal alarm is determined through the ALPRIOR parameter.

Additionally, all PV state changes can be historized as determined by HM volume configuration.

Alarm Delay

When off-normal alarming has been configured and an off-normal alarm is detected, the event is reported to the system. Further off-normal alarms for the same data point are not reported until the time delay (0 to 60 seconds as specified by the DLYTIME parameter) expires. When the time delay expires, the time delay function is disabled and the off-normal alarm for the data point can again be reported

Change of state alarming

The PVCHGDLY parameter defines, in seconds, the preset value for the PV change delay function which, in conjunction with PVCHGTMR, throttles timestamped event collection.

Event reporting

The EVTOPT parameter for the digital input allows the user to

- optionally specify the tagname (EIPPCODE) of a data point in the system that is to be notified when the PV changes state, and/or
- specify that a time stamp be added to the reported PV state change.

For a status input point, EVTOPT has the four possible entries: None, EIP, SOE, and EIPSOE. EIP specifies that the user supply the tagname of the data point in the system that is to receive the PV state change, while SOE specifies that a timestamp is added to the PV state change to establish a sequence of events.

Sequence of events (SOE)

During each scan of a control program, the TRICON examines selected discrete variables for state changes (known as events) and timestamps any found to have changed. SOE block configuration allows you to specify which discrete aliased variables defined in the control program are to be monitored by the TRICON for state changes.

ATTENTION In order to configure a DI point for SOE, the point must be configured to a digital input or digital memory alias (2001-4000, 10001-12000, 12001-14000).

4.7 Digital Output Point

Background

The digital output point is written from the SMM to the TRICON's

- I/O status table, or
- data register table.

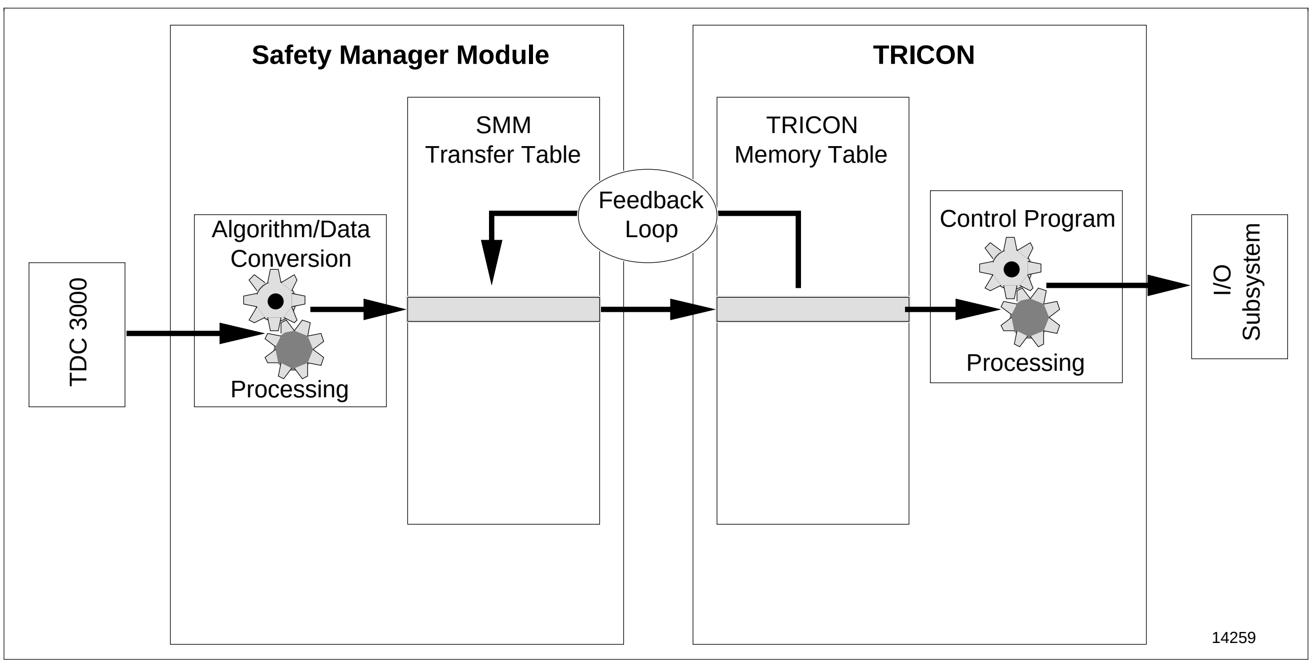
Data flow

Figure 4-12 illustrates the operation of the digital output point transfer to the TRICON's I/O status table. The operation is as follows:

- the digital output point is written into the selected alias address within the TRICON's discrete output memory table area by the SMM,
- this data is processed by the TRICON control program and transferred to the appropriate discrete output module in the TRICON I/O subsystem, and
- this data is also fed back to the SMM every 1/2 second where it is
  - converted back to UCN formats, and
  - stored as the "current status" for that point.

ATTENTION To avoid the appearance of toggling, one TRICON scan is skipped before again processing the raw input data.

Figure 4-12 Digital Output Paths between the SMM and the TRICON's I/O Status Table



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Control options

Depending on the output connection, the digital output can be controlled from
- a digital composite point output,
- a logic slot output, or
- a regulatory control point from a PM.

Output latch function

The output latch function is obtained by linking digital composite point output connections to the SO parameter.

Logic slot control considerations

If SO is received from a logic slot, the SO output of the digital output point tracks the SO output provided by the logic slot.

4.8 Flag Point

Background

A flag data point is a 2-state (ON and OFF) point that is used for storing a Boolean value. The point's state (data) can be supplied by

- the operator,
- an output connection from another SM point,
- another box (SM, PM, APM, etc.) on the same UCN,
- the TRICON, or
- a node on the LCN.

Data flow

Figure 4-13 illustrates the flag point's associated data flow between the SMM and the TRICON.

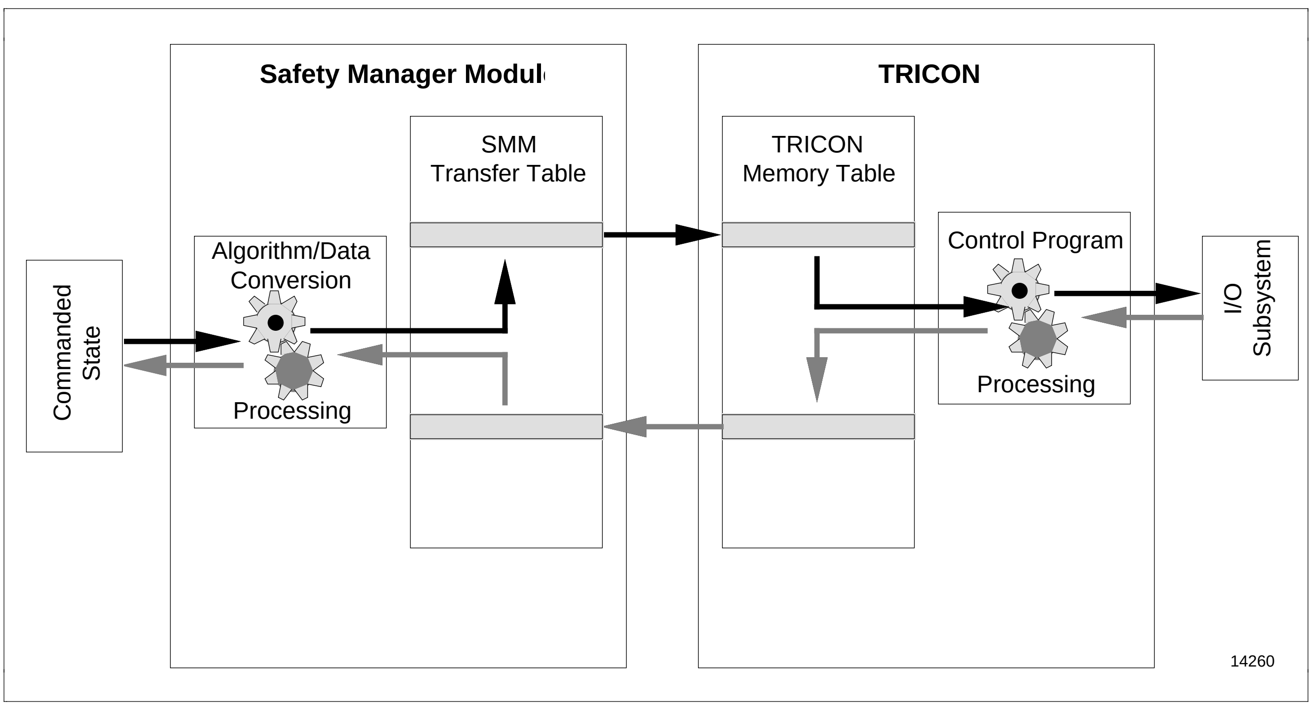
The flag point's state can change whenever it is accessed by other system functions, such as an operator or a user-written program.

Writes

- to the TRICON from the SMM occur at every TRICON scan cycle, and
- to the SMM from the TRICON occur every 1/2 second.

The parameter values of numeric points can change whenever they are accessed by a system activity, such as by an operator or a system program.

Figure 4-13 Flag Point Data Flow



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Point processing

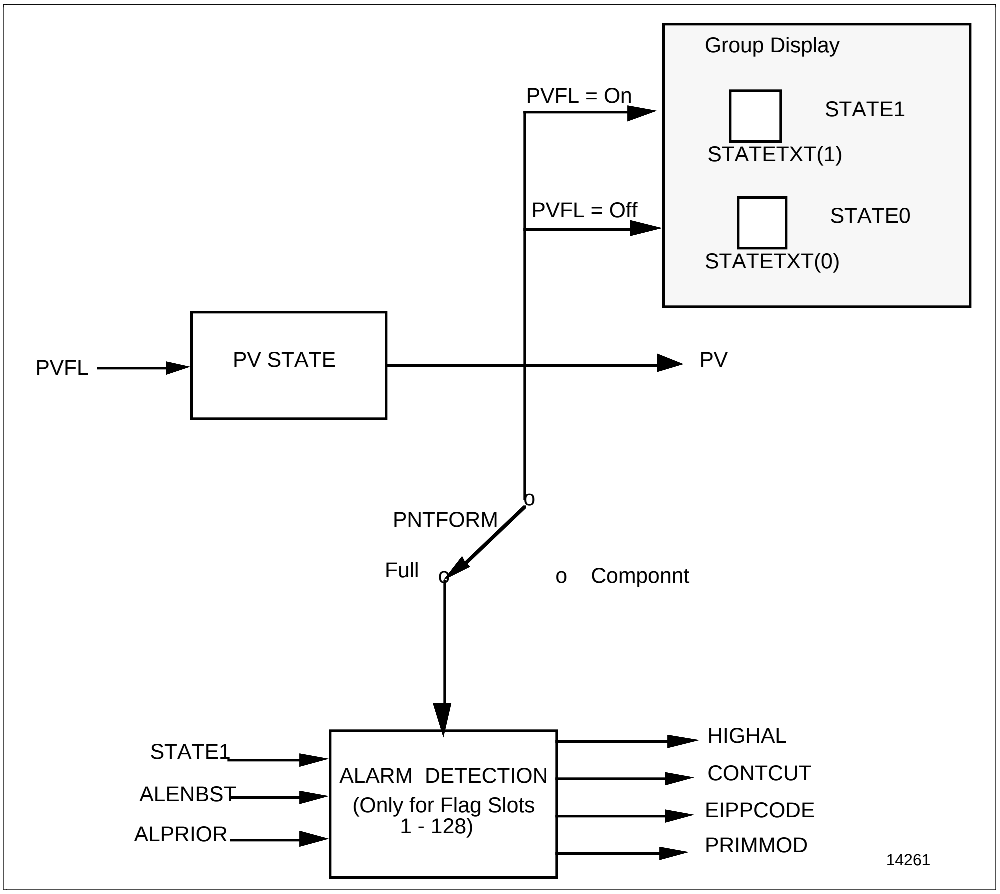
The input to the flag point is provided by parameter PVFL, which can be ON or OFF. PVFL will set the flag point PV state to the same state as PVFL. The PV is then available as an output from the flag point and its current state can be accessed by other points in the SM and in the system.

PVFL will also light the STATE1 and STATE0 boxes on the Universal Station displays, depending on its state. If PVFL is ON, the STATE1 (upper) box will be lit; if PVFL is OFF, the STATE0 (lower) box will be lit.

Flag points can be configured as full or component points as determined through the PNTFORM parameter.

Figure 4-14 illustrates the SMM processing associated with the flag point.

Figure 4-14 Flag Point Processing, Functional Diagram



Alarming

The first 512 flag points (slots) can be configured for off-normal alarming. An alarm will be generated when the PV of the flag point is changed from STATE0 (OFF) to STATE1 (ON).

Alarming is available only if the flag point has been configured as a full point.

4.9 Logic Point

Background

The function of the logic point is limited to the transfer of data between UCN and SM connections, any pairing of which is acceptable. Data types can be

- Boolean,
- Unsigned Integer,
- Signed Integer,
- Real,
- Enumeration, or
- Self-defining enumeration

The logic point has, therefore, sometimes been referred to as the “linkage point,” and is the basis for the SMM’s application-level support of peer-to-peer communications.

Configuration

Each linkage point accommodates 12 input connections and 12 output connections, with a total maximum of 50 connections scheduled for processing during any single scan cycle.

Input connections

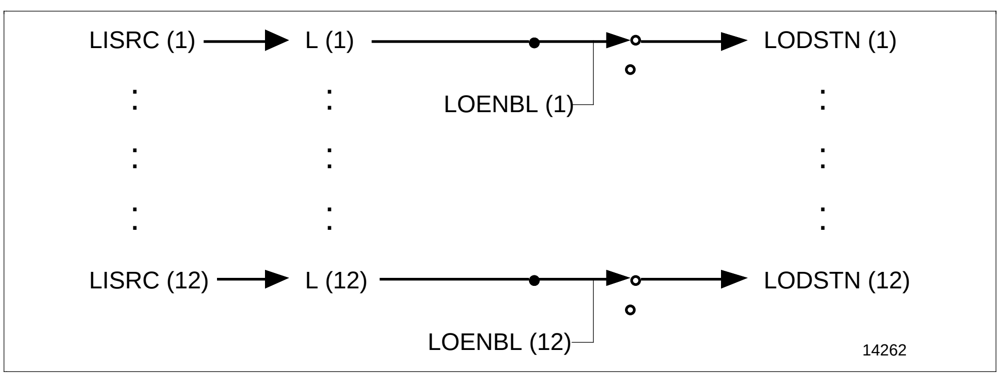
You assign inputs to the logic point during configuration by using logic input connections. You can specify up to 12 inputs to be assigned to linkage-slot inputs L(1) to L(12), as shown in Figure 4-15. The logic input connections are specified through the LISRC parameter.

The inputs to the logic slot can be obtained from

- any Boolean, integer, unsigned integer, enumeration, self-defining enumeration, or real parameter within this SMM, or in another UCN node, using the "Tagname.Parameter" format.

  ATTENTION Integer, unsigned integer, enumeration, or self-defining enumeration parameters are automatically converted to real values.
- an address (!LCxxxxx) in the TRICON.

Figure 4-15 Logic Point Input Connections



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Input errors

Two types of errors can occur in regards to logic point inputs.

- A communication error occurs as the result of a failed device.
- A configuration error occurs when the point mix in that SM has been changed such that the specified point no longer exists.

In order for the routine to be able to continue in spite of a configuration error, the following special features are provided:

- Bad Boolean inputs—If a Boolean input is not successfully fetched, its value is defaulted, based on the logic-input-bad-handling-option parameter (LIBADOPT) as listed in Table 4-13.
- Bad real inputs—If a real input cannot be successfully fetched, its value is defaulted to NaN (Not a Number) and no value is set to the output.

Table 4-13 Logic Input Point Bad Handling Option Parameters

State	Action
ON	The ON state is substituted for the unsuccessful input.
OFF	The OFF state is substituted for the unsuccessful input.
HOLD	The previous value (the last successfully fetched value) is substituted for the unsuccessful input. On start-up, the previous value is defaulted to the OFF state.

Output connections

Logic output connections are used to write the values of local parameters of a respective logic slot to the configured destinations. Up to 12 output connections can be configured for each logic slot. The destinations are specified by the parameter LODSTN by using the "Tagname.Parameter" format, the UCN hardware reference address format, or the TRICON address. Each destination address is tied to the input bearing the same number (LODSTN(1) to L1, LODSTN(2) to L2, etc.).

The logic output connection can write the selected local parameters of a logic slot to

- any Boolean or real parameter in this SMM, or another UCN node,
- an address in the TRICON, and

values written to integer TRICON addresses will be converted to integer first.

Associated with each output connection is a logic output enable flag, LOENBL(n), which is always a TRICON address (!LCxxxxx). The TRICON parameter pointed to by LOENBL(n) must be ON for the corresponding output connection to write to the specified destination. The default value of -1 represents the ON state.

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Generic descriptors

Up to 12 user-defined generic descriptors are provided with each logic slot for identifying external inputs (L1, L2, etc.) with custom names to be shown on Universal Station displays. The actual number of descriptors used is determined by the NODESC parameter for this linkage slot. The corresponding 8-character descriptor is defined by GENDESC(n).

4.10 Numeric Point

Background

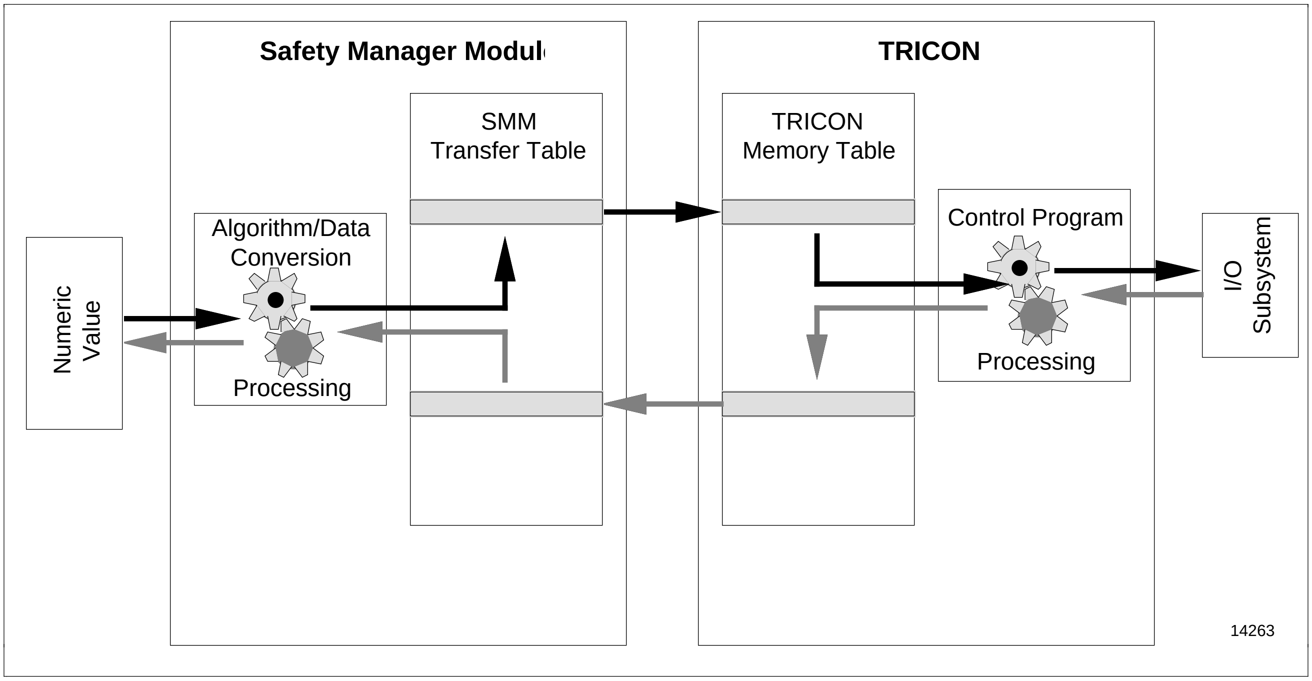
Numeric data points are used to store integer values, such as

- operator entries,
- accumulations, or
- intermediate results of program calculations.

Data flow

Figure 4-16 illustrates the numeric point's associated data flow between the SMM and the TRICON.

Figure 4-16 Number Point Data Flow



Point processing

Numeric points can be configured as either full or component points. They are accessible to routines in

- the same SM,
- any other box (SM, PM, APM, etc.) on the same UCN,
- the TRICON, or
- any node on the LCN.

The parameter values of numeric points can change whenever they are accessed by a system activity, such as by an operator or a system program.

Writes

- to the TRICON from the SMM occur at every TRICON scan cycle, and
- to the SMM from the TRICON occur every 1/2 second.

4.11 Timer Point

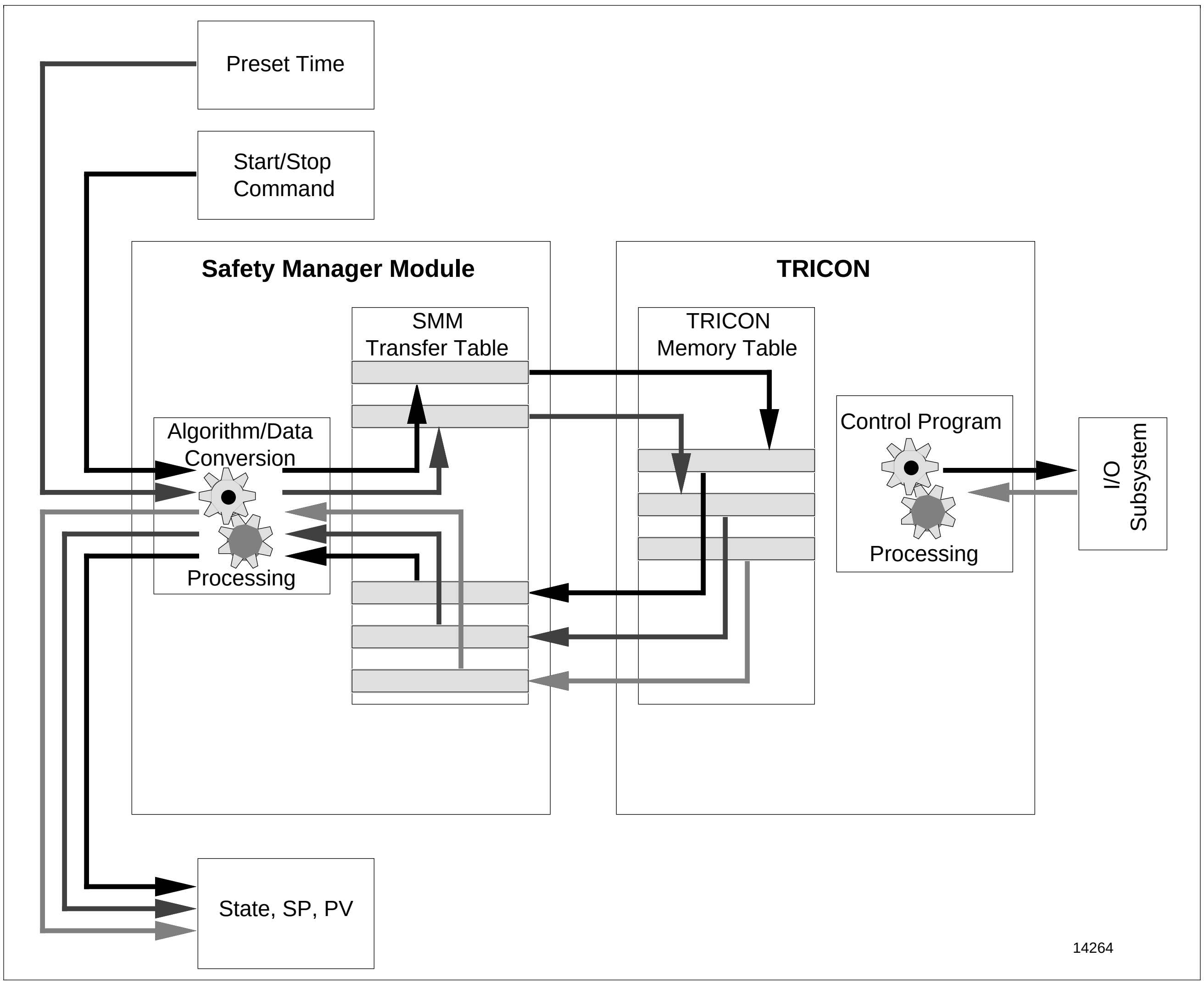
Background

The timer data point provides for automatic timekeeping in the Safety Manager. This type of data point keeps track of the elapsed time after the timer has been started (by the operator or by a program), and provides an indication when the elapsed time has reached the predefined limit.

Data flow

Figure 4-17 illustrates the timer point's associated data flow between the SMM and the TRICON.

Figure 4-17 Timer Point Data Flow



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Point processing

Timer points can be configured as either full or component points. They are accessible to routines in

- the same SM,
- any other box (SM, PM, APM, etc.) on the same UCN,
- the TRICON, or
- any node on the LCN.

The preset length of time that the timer point is to run, in seconds or minutes, is determined by the value recorded in the SP parameter. The SP parameter is loaded with the preset time value from an operator at a Universal Station, or a program.

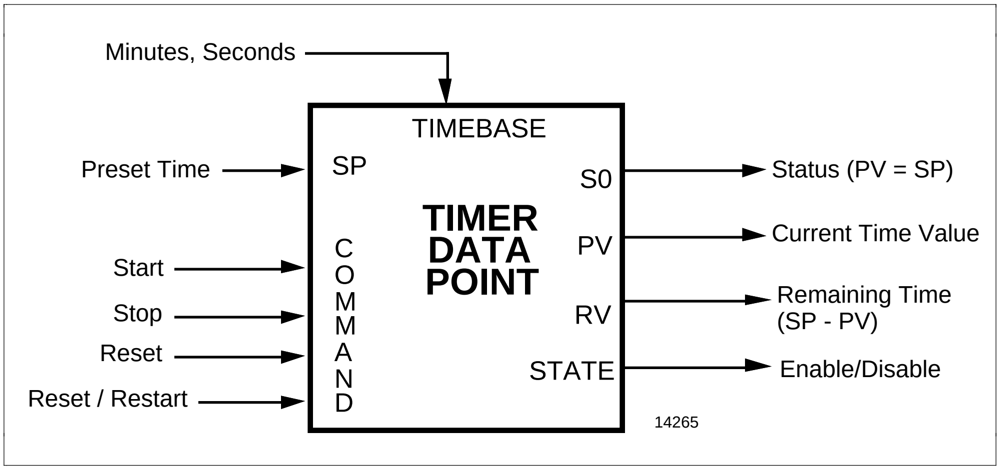
This value is frozen for one SMM cycle (1/2 second) to assure transfer to the TRICON. Once the preset value is entered, the timer is started by setting the COMMAND parameter to Start. The timer can also be stopped, reset, or reset and restarted through the COMMAND parameter.

The time value in PV starts at zero and increments toward the preset time value. The RV parameter indicates the time remaining until the timer reaches its limit (SP - PV). When PV = SP, the status parameter S0 is set to ON indicating the time limit has been reached. The values in PV and SP can range from 0 to 2147483.647 seconds or 0 to 35791.39 minutes, in accordance with the TRICON program. (The parameter TIMEBASE cannot be changed from the Universal Station.)

ATTENTION The timer point in an SMM does not itself perform the timer function. The timer function is performed by ladder logic control programming in the TRICON.

Figure 4-18 illustrates the SMM processing associated with the timer point.

Figure 4-18 Flag Point Processing, Functional Diagram



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