Diablo Canyon Power Plant Units 1 & 2 Process Protection System Replacement Interface Requirements Specification (IRS), Revision 4 (LAR Reference 29)

Pacific Gas and Electric Company
Diablo Canyon Power Plant
Units 1 & 2

Process Protection System (PPS) Replacement
Interface Requirements Specification

Nuclear Safety-Related

Rev 4

Prepared Sig.	[signature]	Date	8/31/2011
Print Last Name	Hefler	User ID	JWH3
Reviewed Sig.	[signature]	Date	08/31/2011
Print Last Name	Lint	User ID	RAL4
Coord Sig.	[signature]	Date	09/01/2011
Print Last Name	QUINN	User ID	N/A
Approval Sig.	[signature]	Date	9/1/11
Print Last Name	Patterson	User ID	SBP1

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REVISION HISTORY

Revision Number	Affected Pages	Reason for Revision
1	All	Initial Issue
2	1.4.4.8	Added STP I-33
	1.4.5.4	ALS Topical Report is Rev 1
	1.5.2	Revised Tricon PLC description
	1.5.3.1	Deleted STB and COM boards – not used
	1.5.3.2	Clarified ASU capability
	1.5.3.3	Added section and new Figure 1-1 to clarify ALS A and ALS B connections to SSPS
	1.5.5	Revised section to clarify signal characteristics and open RTD detection
	1.5.5.6	Revised TCM communications description
	1.5.7	Added PPS Gateway Computer Scope and CC4 system health HMI unit
	1.5.8	Added Response Time Allocation
	Figure 1-2 through Figure 1-21	1. Clarified PRXM and RRXM chasses notation 2. Reassigned safety-related OOS switches to safety-related PRXM Chassis 3. Replaced Class 2 PS Failure contact inputs to Class 2 RRXM with safety-related + 24 Vdc PS output to safety-related PRXM chassis 4. Removed FW flows from Class 2 RRXM
	Appendix 3.1 (I/O List)	General revision
	2.1.1	Clarified ALS input loop power supply. Clarified PTC Thermistor terminology.
	2.1.2	Deleted reference to Fig 2-2 through Fig 2-4
	2.3.3	Added new section - one-way communications. link from ALS to Maintenance Workstation. Renumbered remaining sections.
	2.3.6.3	Protocol is Ethernet based
	Appendix 3.1 (All sheets)	General revision
	Entire Document	Clarified "Safety-Related" and "Non-Safety-Related" items
	Entire Document	Changed MVDU to Maintenance Workstation
3	1.3.1	Added Electrical Class 1E definition, clarified instrument class definitions.
	1.4.4.9, 1.4.5.5, 1.4.5.6, 1.4.5.7	Added references
	1.5.7	Clarified port aggregator tap description and scope
	1.5.8	ALS response time is 150 ms for temperature channels per ALS comment.
	Figure 1-1 through Figure 1-21	Added loopback from trip switch load side; port aggregator tap is PG&E scope; Figure 1-14, Figure 1-19 corrected typos in descriptions
	Figure 1-22	Updated figure per ALS topical report
	2.1	Clarified I/O power supply requirements and scope
	Figure 2-2	Clarified TE-413A and TE-423 for illustration only.
	2.3 2.7.1	Updated communications
	Figure 2-1 Figure 2-3	Added new figures per ALS coordination meeting 05/17-18/2011

REVISION HISTORY, continued

Revision Number	Affected Pages	Reason for Revision
4	1.5.3.3 Figure 1-1	Updated per ALS design documentation
	1.5.7	Updated isolation per ALS design documentation
	1.5.8	Updated response time per ALS documentation
	Figure 1-2 Figure 1-3 Figure 1-7 Figure 1-8 Figure 1-12 Figure 1-13 Figure 1-17 Figure 1-18	Updated figures to illustrate ALS Line Sense Modules and external Trip Switches
	Figure 1-6 Figure 1-11 Figure 1-16 Figure 1-21	Updated figures to include Class II power supply failure discrete inputs
	Figure 1-22	Corrected class break
	2.1.2	Clarified Triconex AI cards
	Figure 2-1 Figure 2-2	Reformatted
	2.1.5	Added LSM description
	Figure 2-4 Figure 2-5	Added figures
	2.7.2.3	Updated per ALS design documentation
	Global (not marked)	Deleted proprietary information designations

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Contents

Figures

1 Introduction

1.1 Purpose

This document specifies the requirements imposed on the Process Protection System (PPS), its subsystems, and other system components to achieve interfaces among these entities that are required for the PPS to perform its design function.

This document is intended to be revised as the PPS replacement design progresses. Accordingly, various requirements are marked "to be provided by ______," to indicate information that will be supplied later by others.

1.2 Scope

The PPS is comprised of Tricon equipment provided by Invensys/Triconex and Advanced Logic System (ALS) equipment provided by Westinghouse CS Innovations, LLC. This Interface Requirement Specification (IRS) provides: (1) requirements for the interfaces between external field devices such as process transmitters and the Tricon and the ALS; (2) electrical and communication interfaces between the Tricon and ALS and their associated peripheral devices; and (3) other interfacing Diablo Canyon Power Plant (DCPP) systems such as the Plant Process Computer (PPC), Main Annunciator System (MAS), Safety Parameter Display System (SPDS) and the Safety-Related 120 Vac and 125 Vdc Power Systems.

All external interface requirements for each of these systems will be defined.

1.3 Definitions and Acronyms

1.3.1 Definitions

The following definitions are used in this document:

TERM	DEFINITION
Channel	An arrangement of components, modules, and software as required to generate a single protective action signal when required by a generating station condition. A channel loses its identity where single action signals are combined.
Electrical Class 1E [1.4.4.9]	Design Class I electrical systems, components and equipment perform safety-related functions. Instrument Class IA and IB Category 1 devices below are considered to serve Class 1E functions. All other instrument classes are considered to serve non-Class 1E functions.
Instrument Class IA [1.4.4.6]	Instrument Class IA instruments and controls are those that initiate and maintain safe shutdown of the reactor, mitigate the consequences of an accident, or prevent exceeding 10 CFR 100 [1.4.5.2] off-site dose limits.
Instrument Class IB [1.4.4.6]	Instrument Class IB instruments and controls are those that are required for post-accident monitoring of Category 1 and 2 variables in accordance with Regulatory Guide 1.97, Revision 3 [1.4.3.2].
Instrument Class IC [1.4.4.6]	Instrument Class IC instruments and controls have the passive function of maintaining the pressure boundary integrity of PG&E Design Class I piping systems.

TERM	DEFINITION
Instrument Class ID [1.4.4.6]	Instrument Class ID instruments and controls are components that have certain Design Class I attributes, but do not require conformance with all Class IA, IB, or IC requirements.
Instrument Class II [1.4.4.6]	Instrument Class II components are Design Class II devices with non-safety-related functions. However, certain Class II components are subjected to some graded quality assurance requirements.
Protection Set	The physical grouping of process channels with the same channel designation. Each of the four redundant protection sets is provided with a separate and independent power feed and process instrumentation transmitters. Thus, each of the four redundant protection sets is physically and electrically independent from the other sets.

1.3.2 Acronyms

ACRONYM	DEFINITION
ALS	Advanced Logic System
AMSAC	ATWS Mitigation System Actuation Circuitry
ASU	(ALS) Auxiliary Service Unit
ATWS	Anticipated Transient Without Scram
CDD	Conceptual Design Document
CLB	Core Logic Board
COM	Communications Board
DCM	Design Criteria Memorandum
DDE	Dynamic Data Exchange
DCPP	Diablo Canyon Power Plant
DFWCS	Digital Feedwater Control System
FRS	Functional Requirements Specification
I&C	Instrumentation and Controls
IEEE	Institute of Electrical and Electronic Engineers
I/O	Input/Output
IPB	(ALS) Input Board
IRS	Interface Requirements Specification
LLC	Limited Liability Corporation
MAS	Main Annunciator System
NQEL	Nuclear Qualified Equipment List
NR	Narrow Range
NRC (USNRC)	(United States) Nuclear Regulatory Commission
OPB	(ALS) Output Board
OPDT	Overpower Delta T
OTDT	Overtemperature Delta T
PG&E (PGE)	Pacific Gas & Electric Company
PLC	Programmable Logic Controller
PPC	Plant Process Computer
PPS	Process Protection System
PRXM	Primary Remote Expansion Module
PSU	(ALS) Power Supply Unit
RCS	Reactor Cooling System
RNASA/RNASB	Rack Nuclear Auxiliary Safeguards A & B

ACRONYM	DEFINITION
RNP	Rack Nuclear Protection (PPS Racks)
RRXM	Remote RXM
RTD	Resistance Temperature Detector
RXM	Remote Expansion Module
RVLIS	Reactor Vessel Level Indication System
SCM	Software Configuration Management
SPDS	Safety Parameter Display System
SRS	Software Requirements Specification
SSPS	Solid State Protection System
STB	(ALS) Service and Test Board
TCM	Triconex Communication Module
TMR	Triple Modular Redundant
TSAP	TriStation 1131 Application Program
WR	Wide Range

1.4 Referenced Documents

1.4.1 General References and Standards

The following codes, standards, and regulations referenced in this Section are totally or partially applicable to the activities covered by this Specification:

1.4.2 Institute of Electrical and Electronics Engineers (IEEE)

1.4.2.1 IEEE Standard 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations"

1.4.2.2 IEEE Standard 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations"

1.4.3 United States Nuclear Regulatory Commission (USNRC) Regulatory Guides

1.4.3.1 Regulatory Guide 1.75, Rev. 2, "Physical Independence of Electric Systems"

1.4.3.2 Regulatory Guide 1.97, Rev. 3, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident"

1.4.3.3 Regulatory Guide 1.180, Rev. 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems"

1.4.4 Implementing Documents

1.4.4.1 Process Protection System Replacement Conceptual Design Document (CDD)

1.4.4.2 Process Protection System Replacement Functional Requirements Specification (FRS)

1.4.4.3 Process Protection System Replacement System Software Requirements Specification (SRS)

1.4.4.4 SCM-38-01-SR Process Protection System Software Configuration Management (SCM)

1.4.4.5 DCM S-38A, Plant Protection System

1.4.4.6 DCM T-24, DCPP Instrumentation and Controls

1.4.4.7 DCM S-65, 120 VAC System

1.4.4.8 STP I-33, Reactor Trip Time Test Program

1.4.4.9 DCM T-19, Electrical Separation and Isolation

1.4.5 Other References

1.4.5.1 Triconex Corporation Nuclear Qualified Equipment List (NQEL), latest version

1.4.5.2 Title 10 Code of Federal Regulations Part 100, Reactor Site Criteria

1.4.5.3 Letter No. NRC-V10-09-01, J. Polcyn (Invensys) to NRC, "Nuclear Safety-Related Qualification of the Tricon TMR Programmable Logic Controller (PLC) – Update to Qualification Summary Report Submittal and "Application for withholding Proprietary Information from Public Disclosure," dated September 9, 2009

1.4.5.4 Diablo Canyon Power Plant, Unit Nos. 1 and 2 - Safety Evaluation for Topical Report, "Process Protection System Replacement Diversity & Defense-In-Depth Assessment" (TAC Nos. ME4094 And ME4095), dated April 19, 2011 (ADAMS Accession No. ML110480845)

1.4.5.5 6002-00301, CS Innovations ALS Topical Report and Supporting Documents Submittal, July 29, 2010 (ADAMS Accession No. ML102160471)

1.4.5.6 6002-31002, CS Innovations ALS 321 Design Specification

1.4.5.7 9700052-019, Field Terminations Guide for Tricon v9-10 Systems

1.5 Identification

This section identifies the systems, interfacing entities, and other interfaces to which this document applies.

1.5.1 Protection Sets

The PPS consists of sixteen (16) racks (per DCPP Unit) of instrumentation located in the Cable Spreading Rooms (Auxiliary Building, elevation 128). The sixteen racks are divided into four Protection Sets; five racks each for Protection Sets I and II, three racks each for Protection Sets III and IV. Each Protection Set is physically separated and electrically isolated from the other sets. Figure 1-1 illustrates the hardware that comprises the sixteen (16) protection sets.

Protection Set I is comprised of Racks 1 thru 5 (RNP1A, RNP1B, RNP1C, RNP1D, and RNP1E).

Protection Set II is comprised of Racks 6 thru 10 (RNP2A, RNP2B, RNP2C, RNP2D, and RNP2E).

Protection Set III is comprised of Racks 11 thru 13 (RNP3A, RNP3B, and RNP3C).

Protection Set IV is comprised of Racks 14 thru 16 (RNP4A, RNP4B, and RNP4C).

Physical equipment will be assigned to specific PPS racks during detailed design.

The existing Eagle 21 HMI units are located in Racks 5 (RNP1E), 9 (RNP2D), 12 (RNP3B) and 14 (RNP4A). These racks are expected to house the replacement PPS

Maintenance Workstation and communications equipment.

1.5.2 Triconex Tricon Programmable Logic Controllers (PLC)

The Tricon PLC shown in the following figures comprises the Main Chassis and two Remote Expansion Chassis (RXMs), all within a given protection set. The Main Chassis is connected to a "Primary" RXM via triplicated copper I/O expansion bus cables. The Primary RXM (PRXM) is connected to a "Remote" RXM chassis using multimode fiber-optic cables. The Remote RXM (RRXM) chassis allows extending the I/O bus over longer distances than copper cables can support, and to provide electrical isolation for non-safety-related I/O signals, as required.

Refer to the Triconex licensing Topical Report [1.4.5.3] for additional information.

1.5.3 CS Innovations Advanced Logic System (ALS)

1.5.3.1 A typical ALS rack configuration as shown in the following figures contains two sets of the following components (See Reference 1.4.5.5 for additional details):

ALS CLB – Core Logic Board

ALS IPB – Input Board

ALS OPB – Output Board

ALS PSU – Power Supply Unit

1.5.3.2 ALS ASU – Auxiliary Service Unit

The ASU shown in Figure 1-22 is a dedicated piece of test equipment which can be connected to the ALS rack during diagnostics or testing by plant personnel. The ASU provides non-intrusive diagnostic tools that allow plant personnel to access detailed status and configuration information of the system while the system is online. The ASU also provides a post-event analysis information about the system to plant personnel for evaluation of an event after it has occurred.

The ASU can modify setpoints and tuning constants, but cannot alter functional programming (i.e., alter the algorithm) of the CLB..

In the PPS Replacement project, the Maintenance Workstation will perform the functions of the ASU.

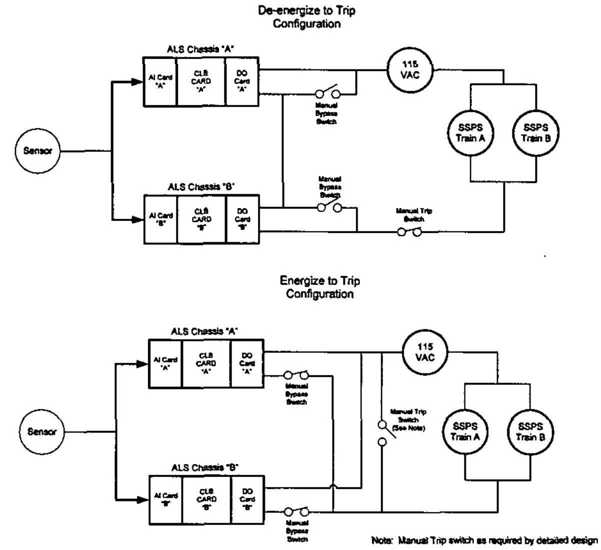
1.5.3.3 The ALS A and ALS B conceptual architecture to provide built-in diversity and defense in depth per the D3 evaluation approved by NRC [1.4.5.4] is illustrated in Figure 1-1. Wiring details are illustrated in Figure 2-4 and Figure 2-5.

The manual bypass switches in Figure 1-1.allow one ALS diversity Group (i.e., ALS-A or ALS-B) to be bypassed and removed from service without tripping the channel. The manual trip switch is used to trip the channel in the unlikely event that both ALS diversity groups are inoperable.

1.5.4 Isolation Devices

The isolation devices shown in Figure 1-3, Figure 1-8, Figure 1-13, and Figure 1-18 are safety-related components powered from the PG&E 120 Vac safety-related power supply. The isolation devices are separate and independent from both the Tricon and the ALS. All isolation devices are 4-20 mA DC input and 4-20 mA DC output. Input and out range information is provided in the I/O List [Appendix 3.1].

Figure 1-1 ALS-A and ALS-B SSPS Diversity Architecture Concept



1.5.5 Safety-Related Signal Conditioning

1.5.5.1 The ALS shall provide signal conditioning and isolation for the Reactor Coolant System (RCS) non-safety-related flow analog output signals with capability to normalize the scaling periodically.

1.5.5.2 The ALS shall provide signal conditioning for the RCS narrow range Resistance Temperature Detector (RTD) safety-related signals to the Overpower Delta Temperature (OPDT) and Overtemperature Delta T (OTDT) reactor trip functions, and for the RCS Wide Range Temperature and Pressurizer Vapor Space Temperature RTD signals.

1.5.5.3 The ALS shall convert the RTD signals from resistance to temperature. The ALS shall provide capability to update the resistance to temperature conversion coefficients periodically.

Analog temperature signal input and output range information is provided in the I/O List [Appendix 3.1].

1.5.5.4 Temperatures shall be transmitted from the ALS to the Tricon via 4-20 mA analog signals scaled per Appendix 3.1.

1.5.5.5 All temperatures shall be transmitted from the ALS to the Gateway computer via RS-422 signals scaled for the full input range per Appendix 3.1.

1.5.5.6 The ALS shall provide down-scale open RTD protection. If the ALS detects an open or failed RTD, it shall output an analog signal below the Tricon signal failure threshold, which is -5% of span = 3.20 mA per the FRS [3]. If the actual temperature is below the low scale value provided in Appendix 3.1, the ALS shall output the low scale value, or 0% of span = 4.00 mA. This allows the Tricon to provide RTD failure alarming and ensures that the Tricon does not indicate RTD failure when the temperature is below low scale but still functioning correctly, a condition that exists during plant shutdown. In the latter case, the actual temperature shall be available from the ALS via the Gateway computer.

1.5.6 Maintenance Workstation

The non-safety-related Maintenance Workstation shown in Figure 1-22 is used to maintain and configure the Tricon using the TriStation 1131 Developer's Workbench and also to view data from both the Tricon and ALS.

The Tricon will be isolated from the Maintenance Workstation by the qualified safety-related Triconex Communications Module (TCM). Fiber optic cable electrically isolates the Tricon from external non-safety-related devices.

The ALS is configured for one-way communications, broadcasts data to the Maintenance Workstation Dynamic Data Exchange (DDE) server, so that a single Maintenance Workstation may be used to view data from both the ALS and the Tricon in a given protection set.

A Maintenance Workstation may access data only within its own protection set. Communication with other protection sets is not permitted.

1.5.7 Plant Process Computer Gateway and Other Non-Safety-Related Communications Interfaces

The safety-related Tricon and ALS are connected to the non-safety-related PPC and workstation via the Gateway computer shown in Figure 1-22. The Gateway computer will be installed by PG&E in the Process Control System (PCS) replacement project. The ALS Core Logic Board (CLB) provides isolation for the TxB1 and TxB2 one-way EIA-422 communication links to the PPC Gateway and the Maintenance Workstation, respectively. The ALS transmits data to the non-safety-related Gateway computer, which is common to all four protection sets, and to the Maintenance Workstation using serial, unidirectional, one-way communications channels that do not require any handshaking.

The Tricon will be isolated from the Gateway computer by a data isolation device such as the port aggregator network tap shown in Figure 1-22, which permits two-way communications between the Maintenance Workstation belonging to a specific protection set and the Tricon in that protection set, yet allows only one-way communication to the PPC Gateway Computer. The port aggregator tap will be provided by PG&E.

For system health displays, the PPS will share a HMI unit in the Control Room on CC4 that will also be installed by the Process Control System (PCS) replacement project. This HMI unit will obtain PPS data through a connection to the PPS Gateway Computer as shown in Figure 1-22.

1.5.8 Response Time

The reactor trip response time is the time interval from when the monitored parameter exceeds its trip setpoint at the channel sensor, until loss of control rod stationary gripper coil voltage. The ESF response time is the time interval from when the monitored parameter exceeds its trip setpoint until the ESF equipment is capable of performing its safety function. The PPS is allocated a maximum response time of 409 ms [1.4.4.8].

The ALS performs signal conditioning for the narrow range RTD's that support the Overtemperature ΔT (OTDT) and Overpower ΔT (OPDT) reactor trips, and the Tricon performs setpoint calculation and comparison and trip output. Therefore, the PPS time response allocation is shared between the ALS and Tricon portions of the PPS for these functions.

The preliminary worst case (deterministic) OTDT and OPDT PPS response time allocations are as follows:

ALS:	175 ms for RTD processing
Tricon:	200 ms
Contingency:	34 ms

Total PPS Allocation: 409 ms

The vendor shall provide means of verifying the actual response time if the system does not support deterministic methods of calculating worst case response time characteristics.

1.5.9 Accuracy

The FRS specifies existing Eagle 21 accuracy requirements to maintain currently licensed Channel Statistical Allowance (CSA) margins such that no setpoint changes are required. Accuracy allocation between the ALS and Tricon for the RCS temperature parameters will be determined during the detailed design.

Figure 1-2 Replacement PPS Architecture – Set I ALS-A

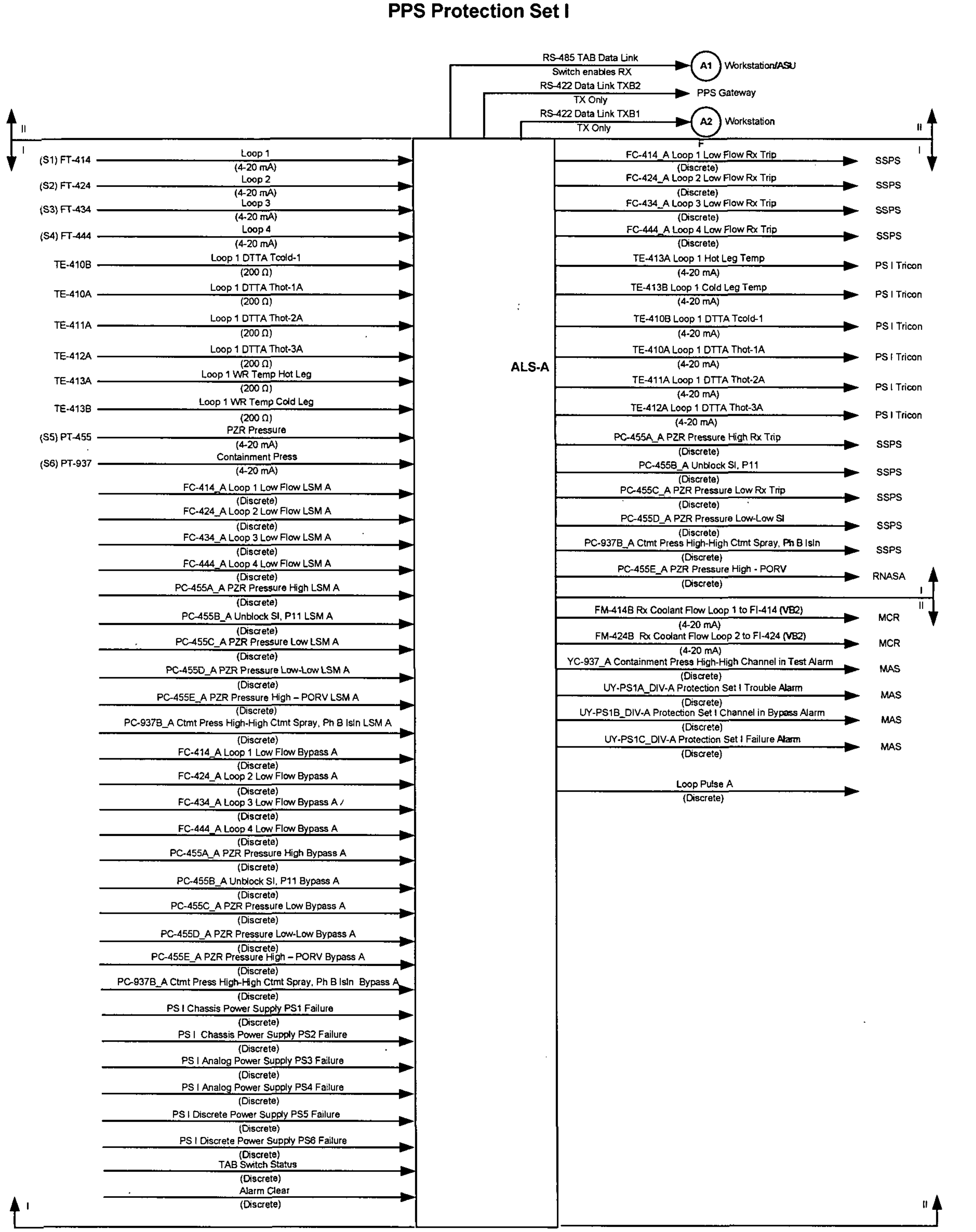


Figure 1-3 Replacement PPS Architecture – Set I ALS-B and Isolation Devices

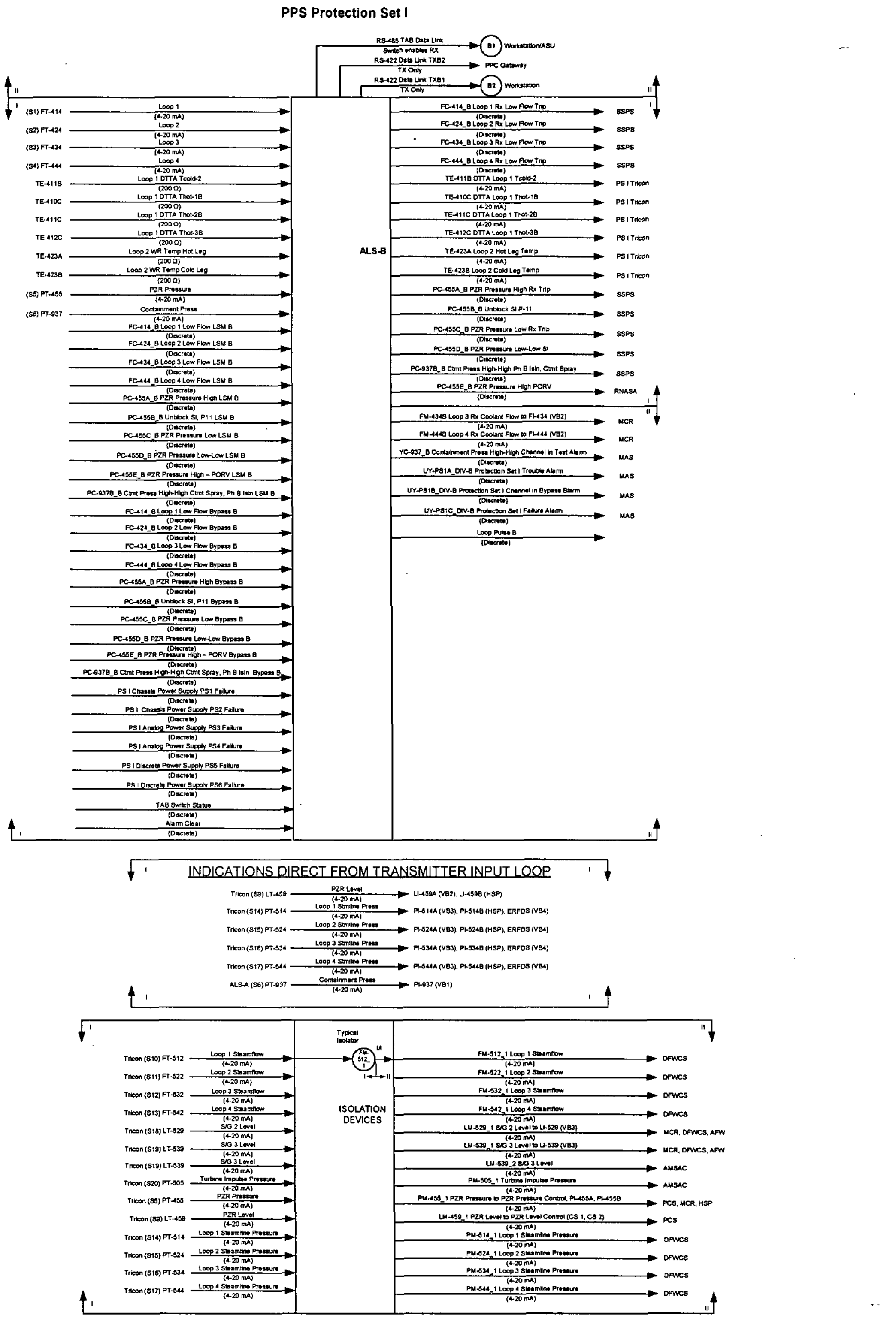


Figure 1-4 Replacement PPS Architecture - Set I Safety-Related Tricon Main Chassis

PPS Protection Set I

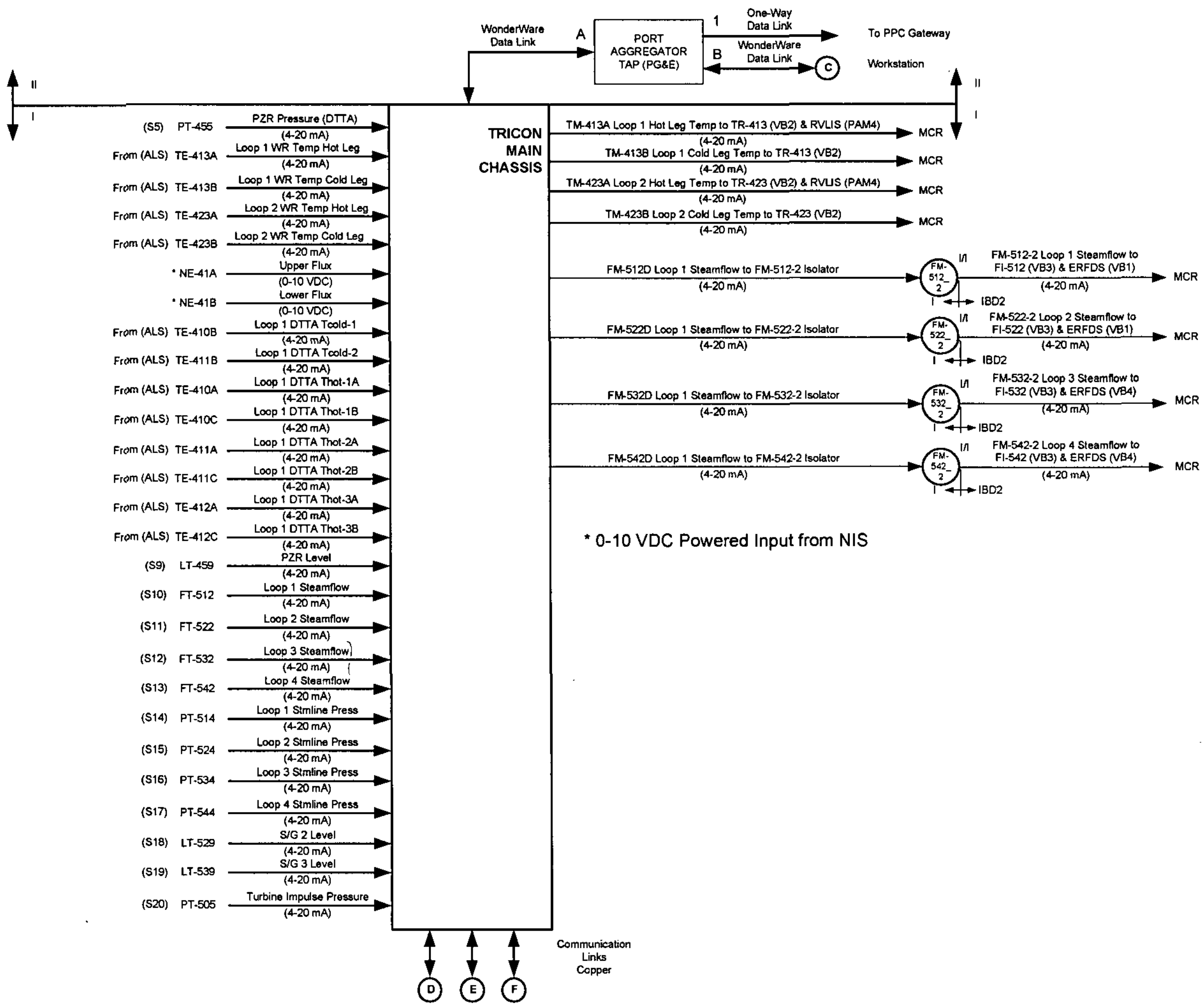


Figure 1-5 Replacement PPS Architecture – Set I Safety-Related Tricon Primary RXM Chassis

PPS Protection Set I

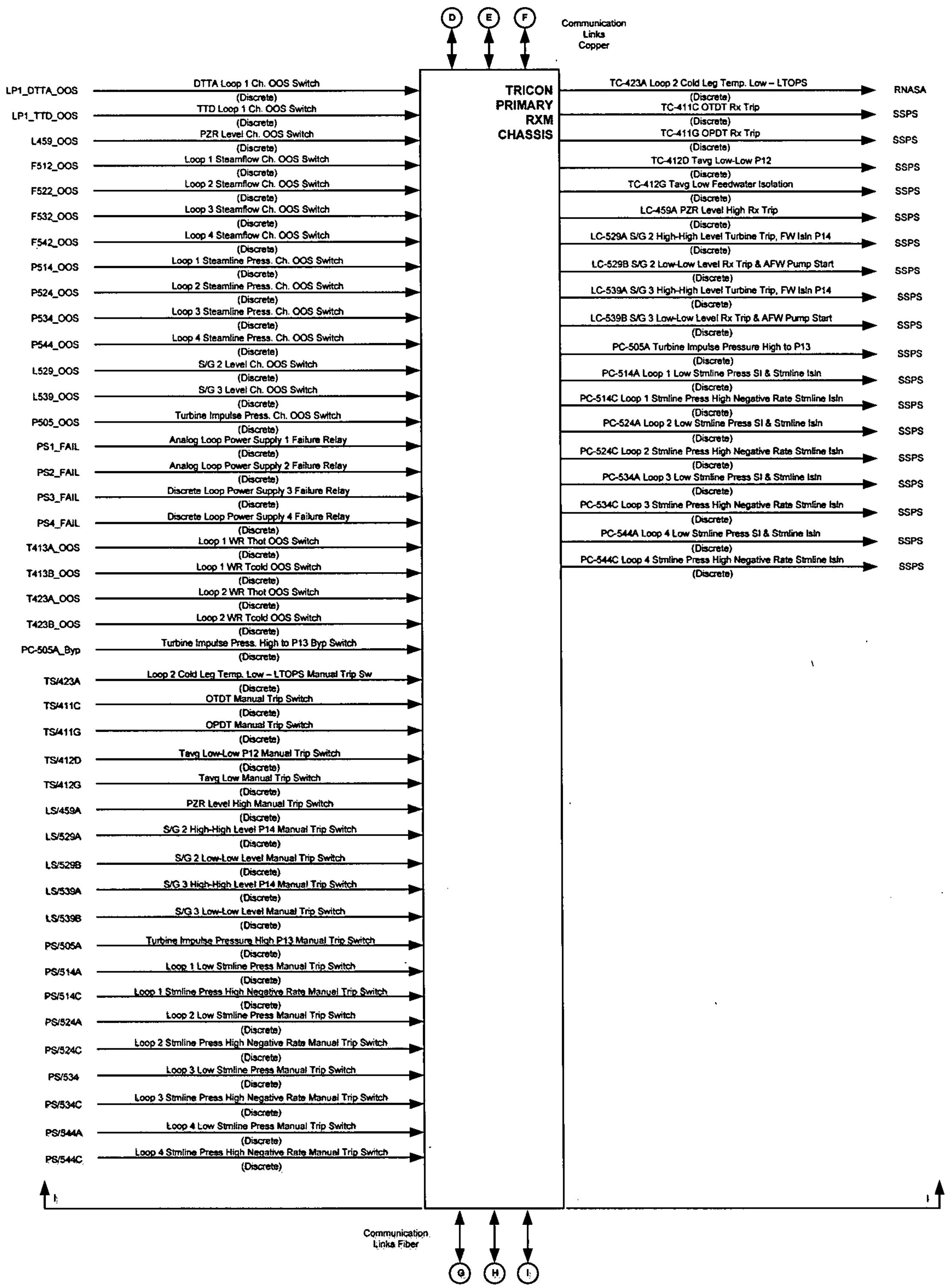


Figure 1-6 Replacement PPS Architecture – Set I Non-Safety-Related Tricon Remote RXM Chassis

PPS Protection Set I

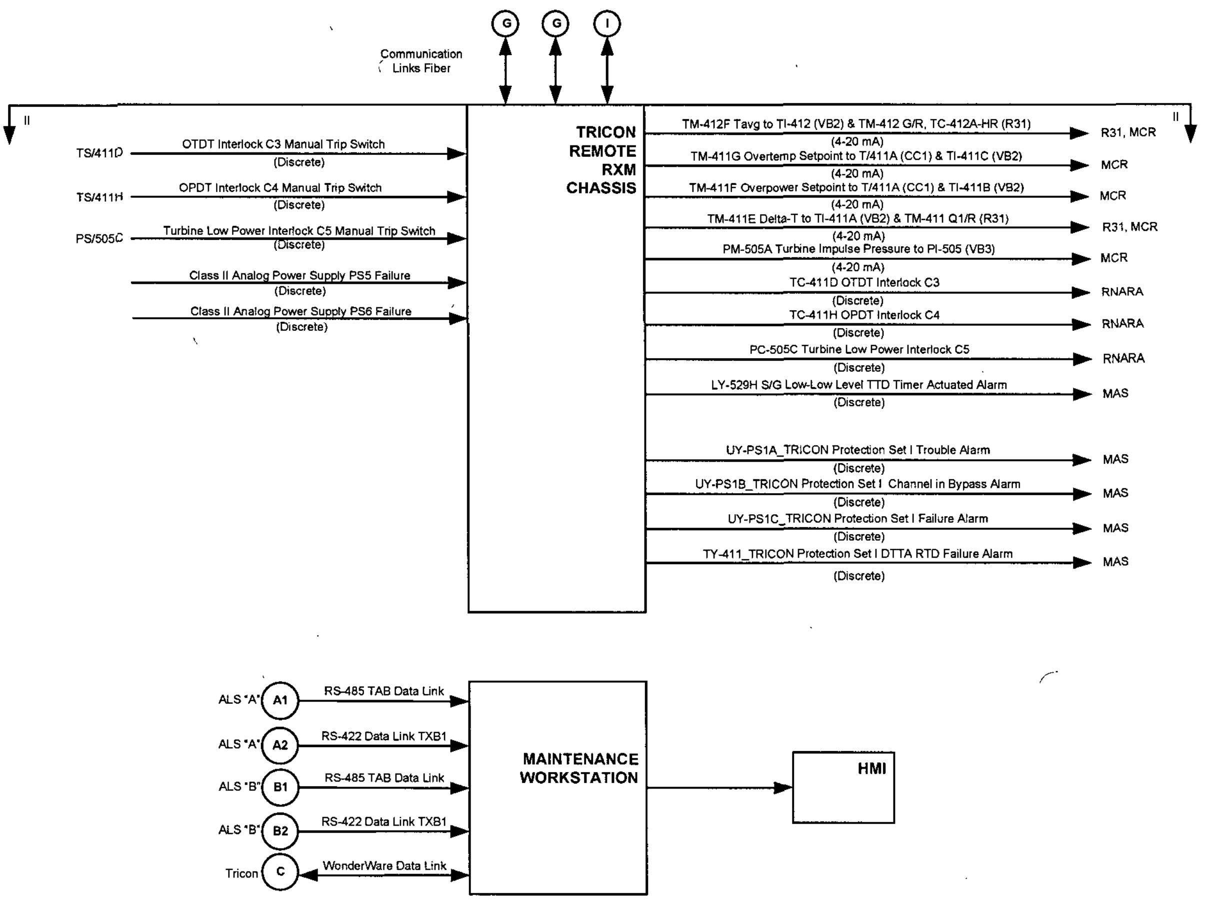


Figure 1-7 Replacement PPS Architecture – Set II ALS-A

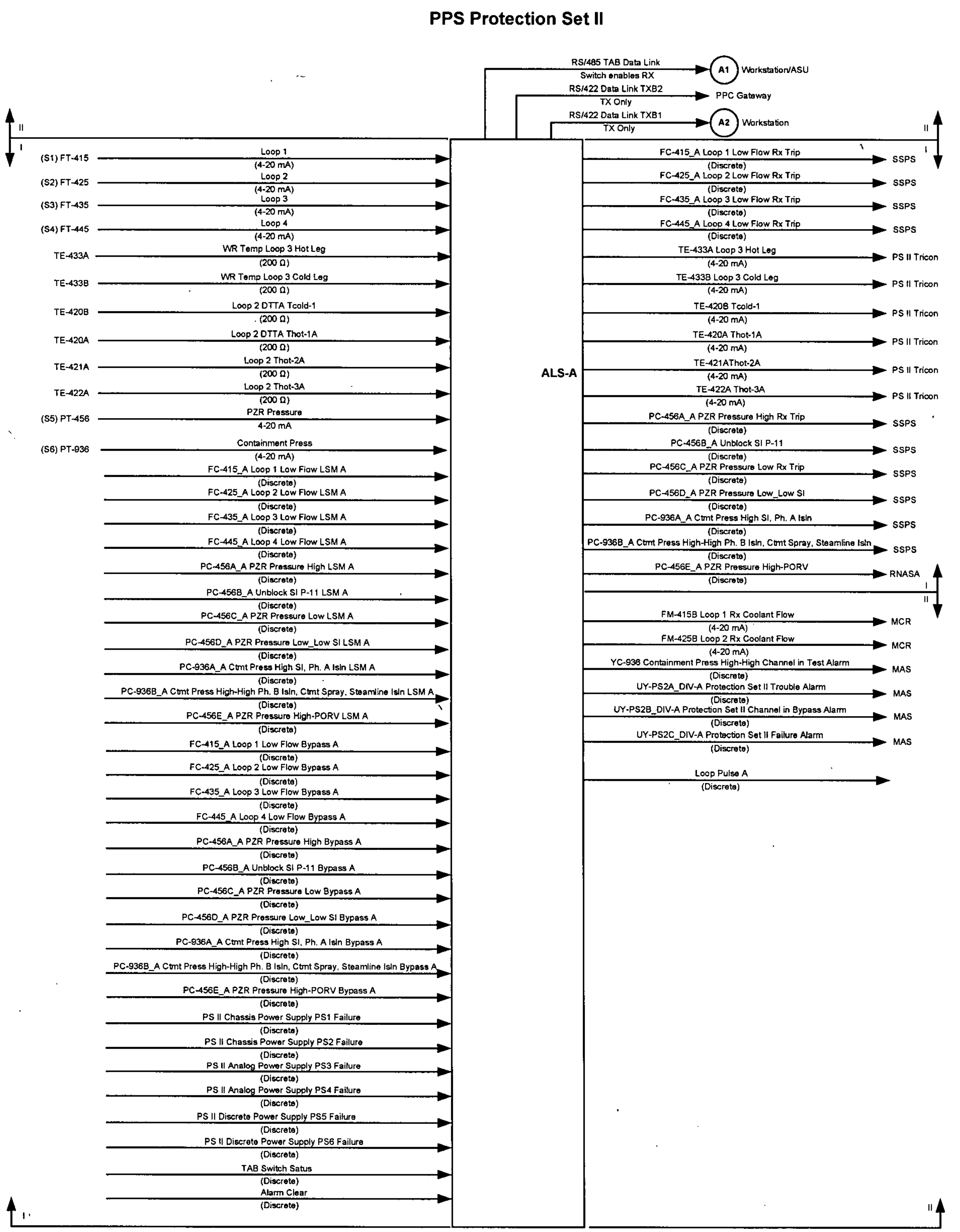


Figure 1-8 Replacement PPS Architecture – Set II ALS-B and Isolation Devices

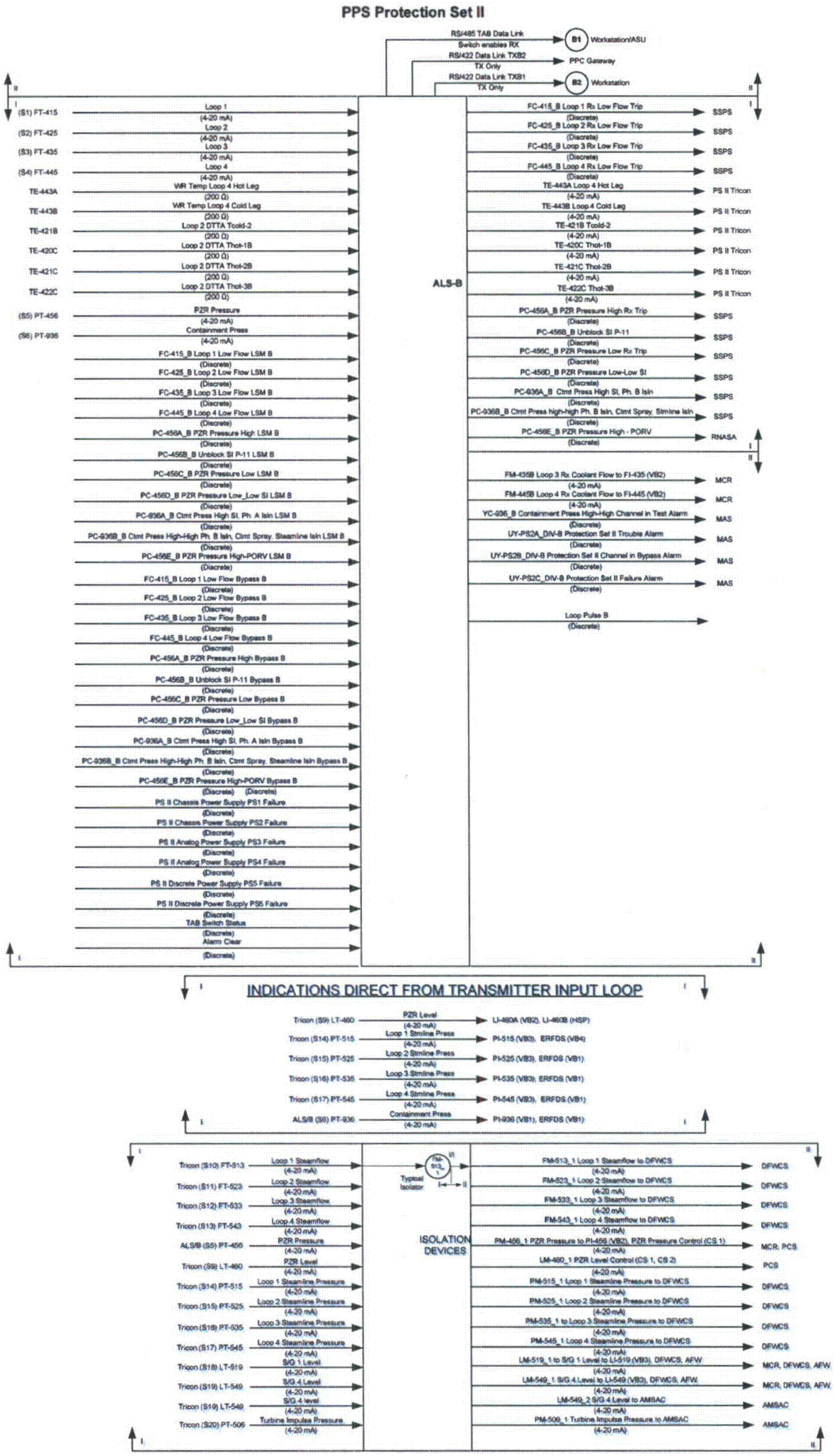


Figure 1-9 Replacement PPS Architecture – Set II Safety-Related Tricon Main Chassis

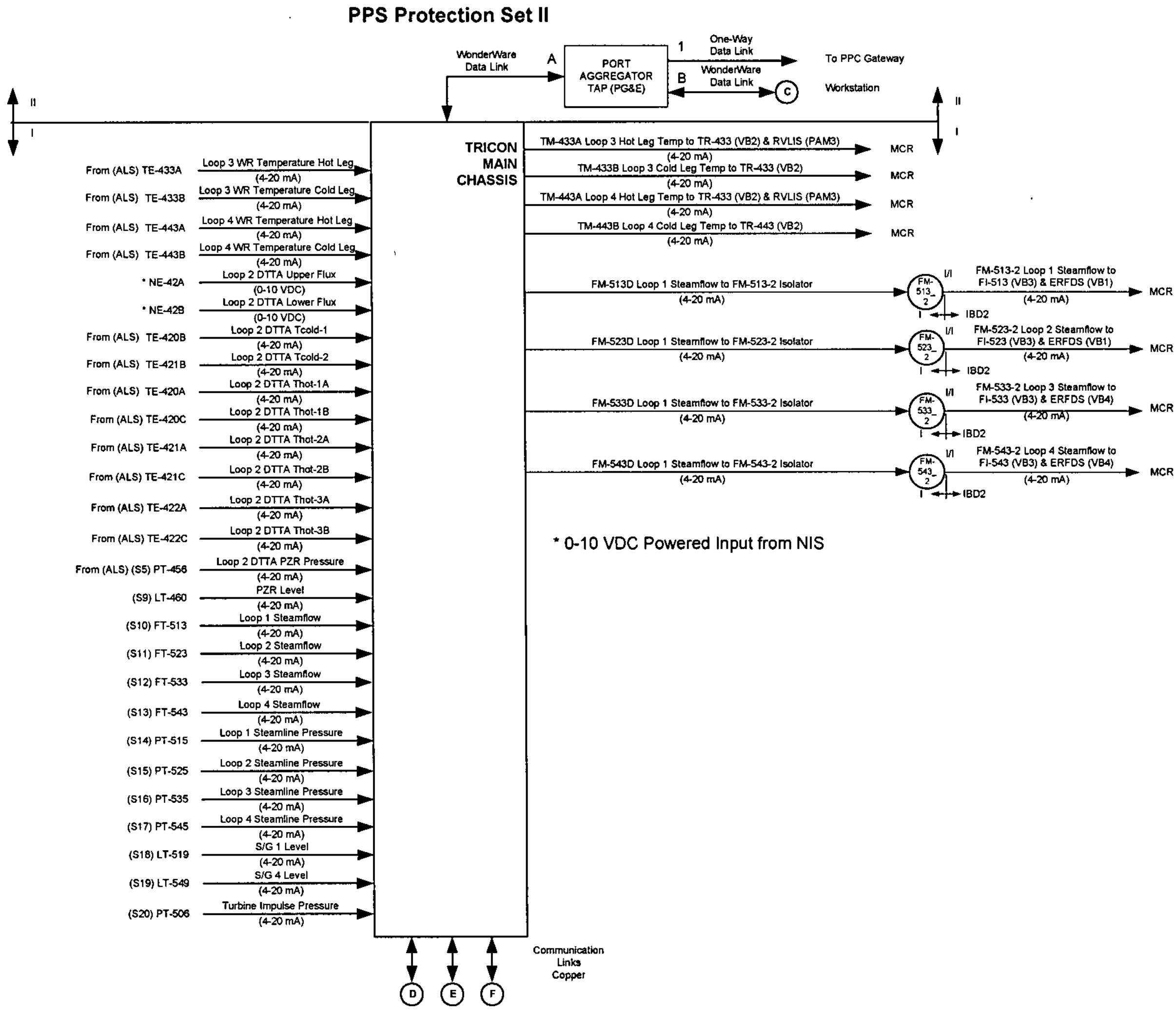


Figure 1-10 Replacement PPS Architecture – Set II Safety-Related Tricon Primary RXM Chassis

PPS Protection Set II

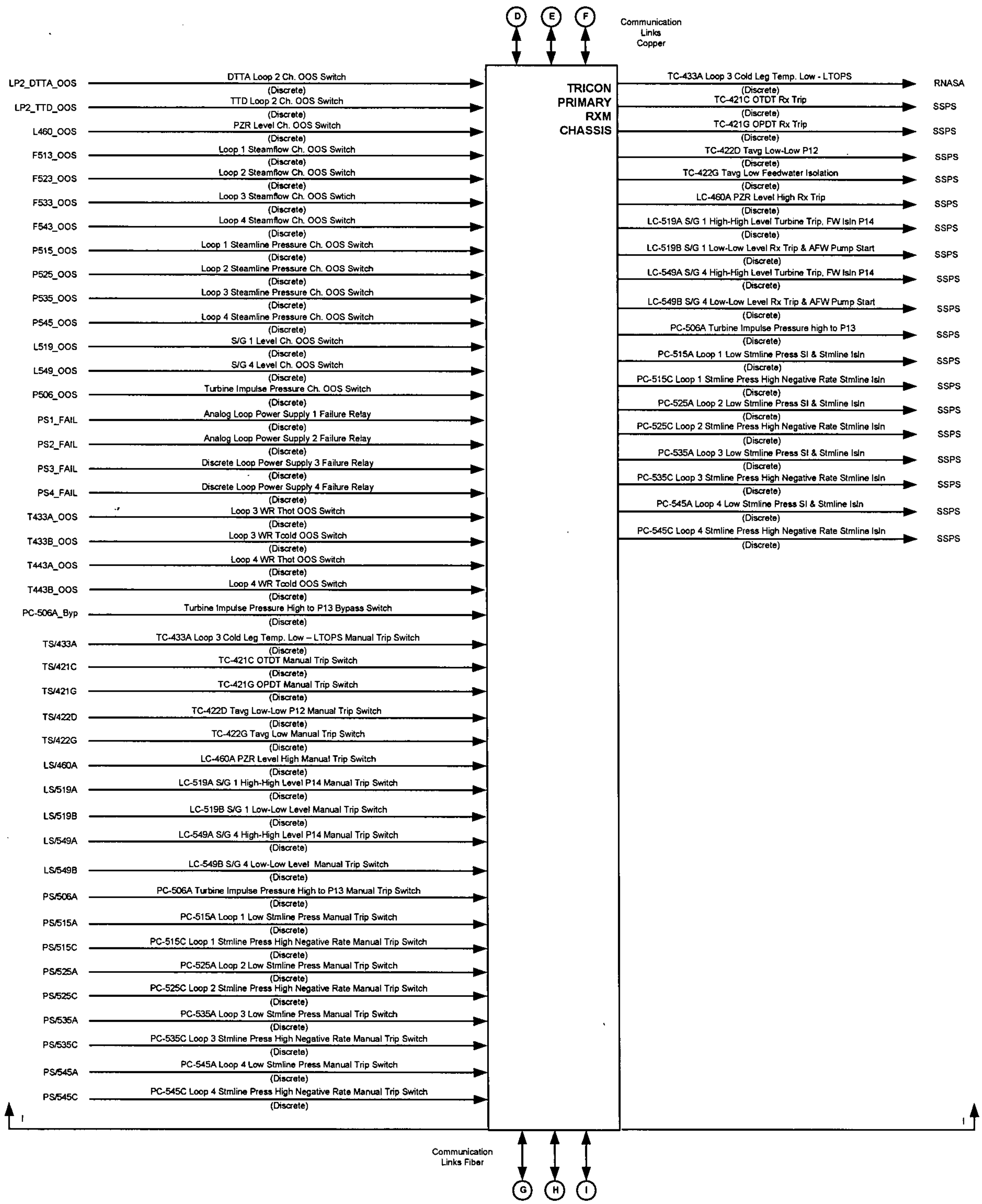


Figure 1-11 Replacement PPS Architecture – Set II Non-Safety-Related Tricon Chassis

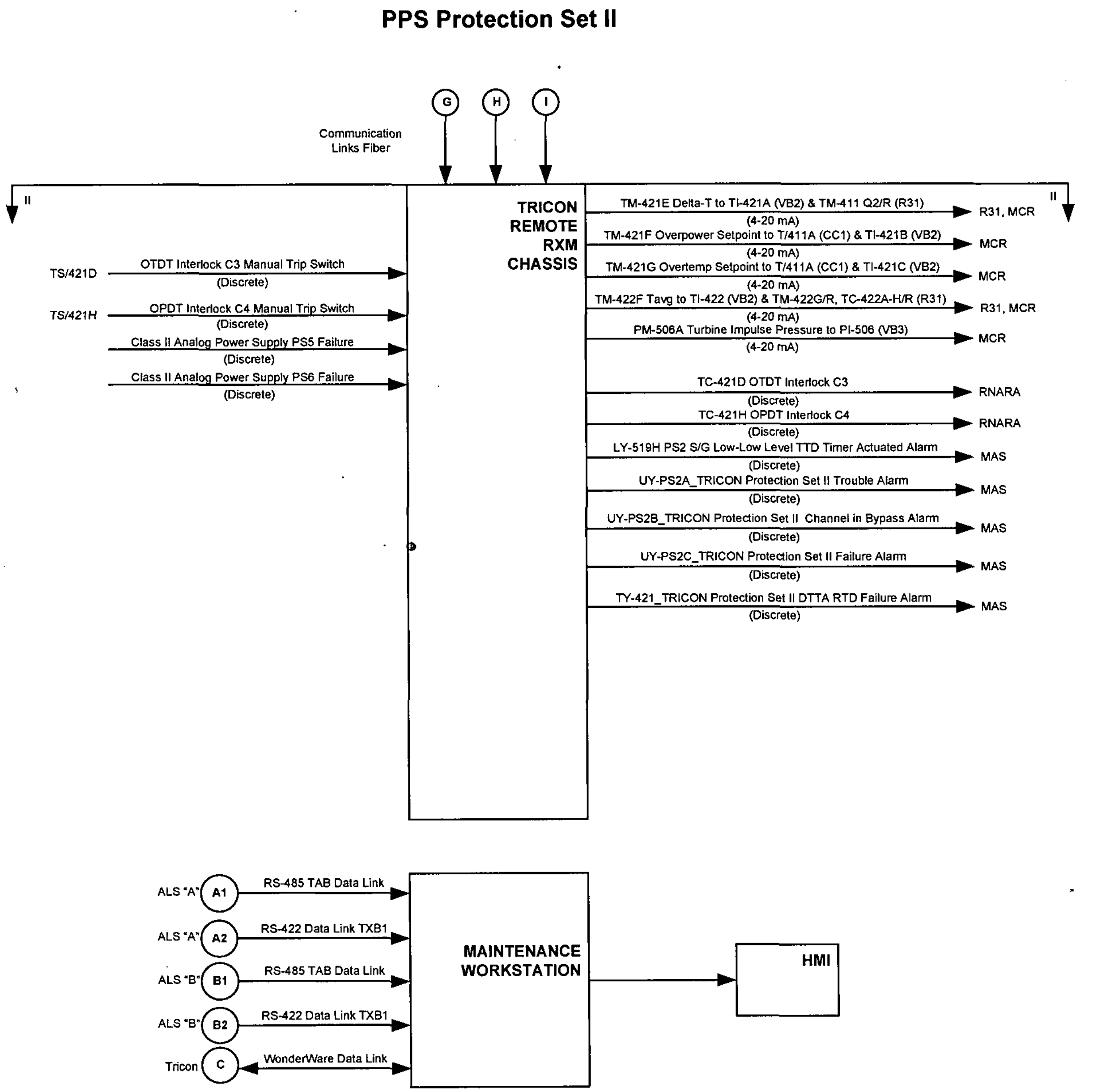


Figure 1-12 Replacement PPS Architecture – Set III ALS-A

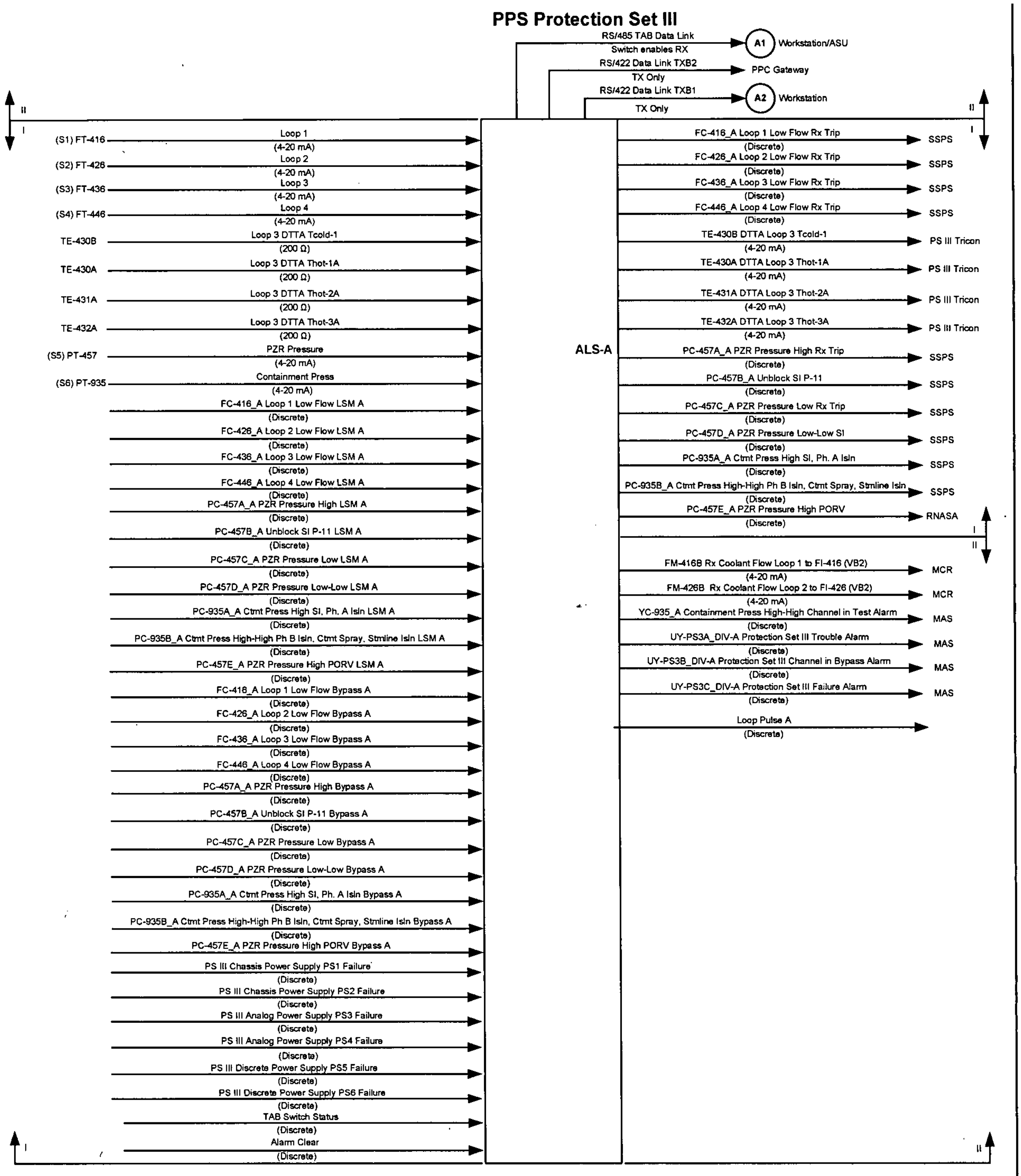


Figure 1-13 Replacement PPS Architecture – Set III ALS-B and Isolation Devices

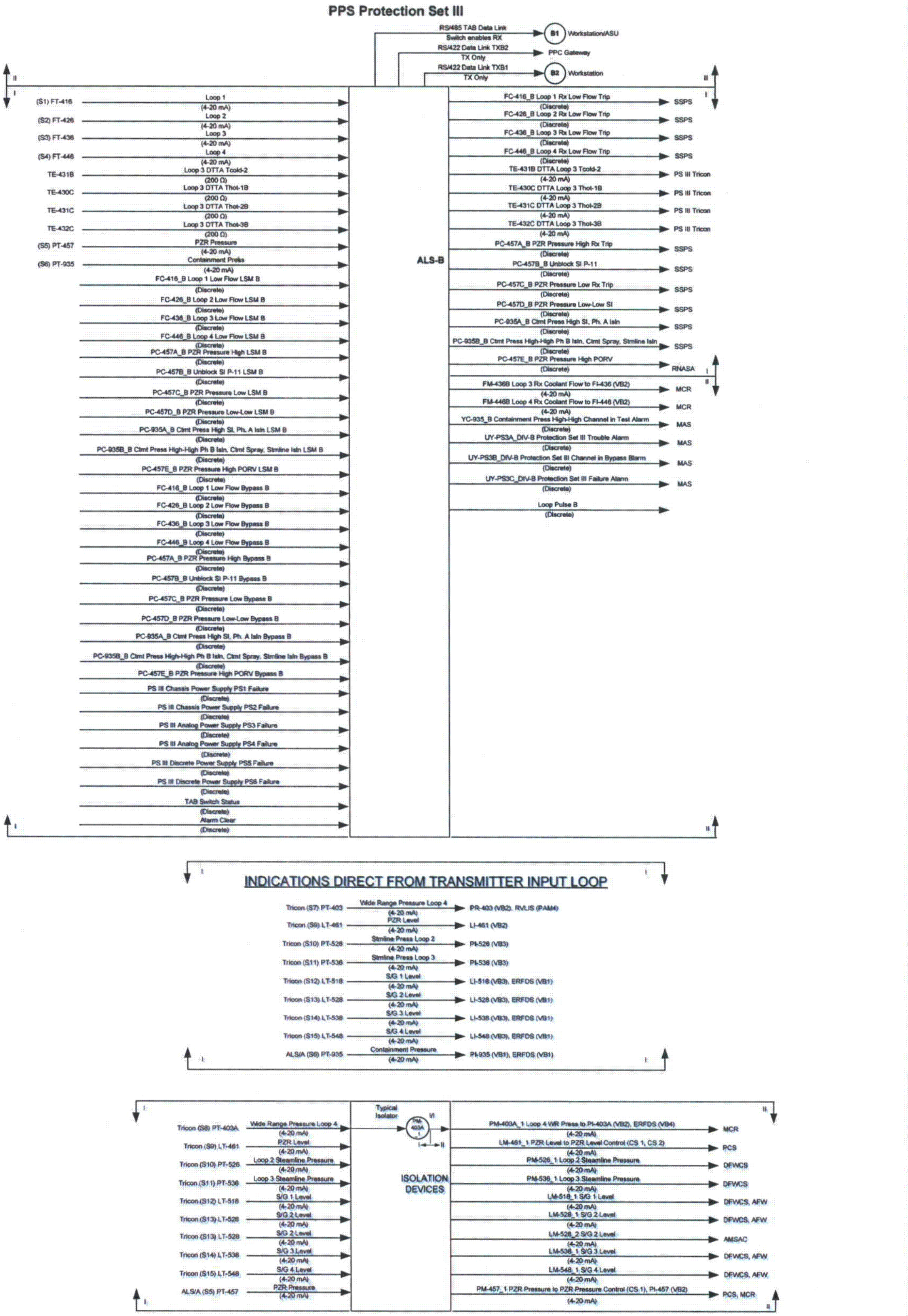


Figure 1-14 Replacement PPS Architecture – Set III Safety-Related Tricon Main Chassis

PPS Protection Set III

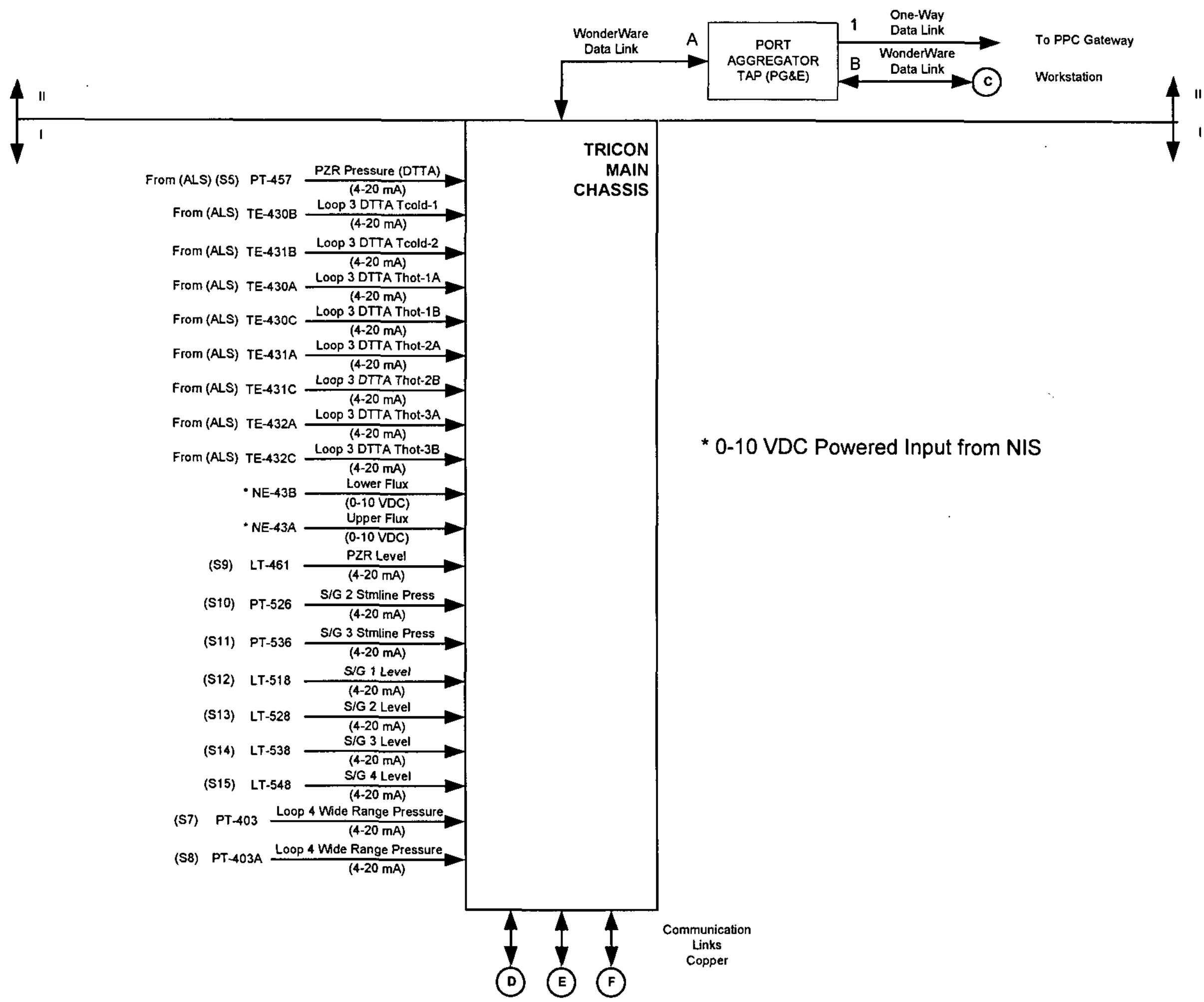


Figure 1-15 Replacement PPS Architecture – Set III Safety-Related Tricon Primary RXM Chassis

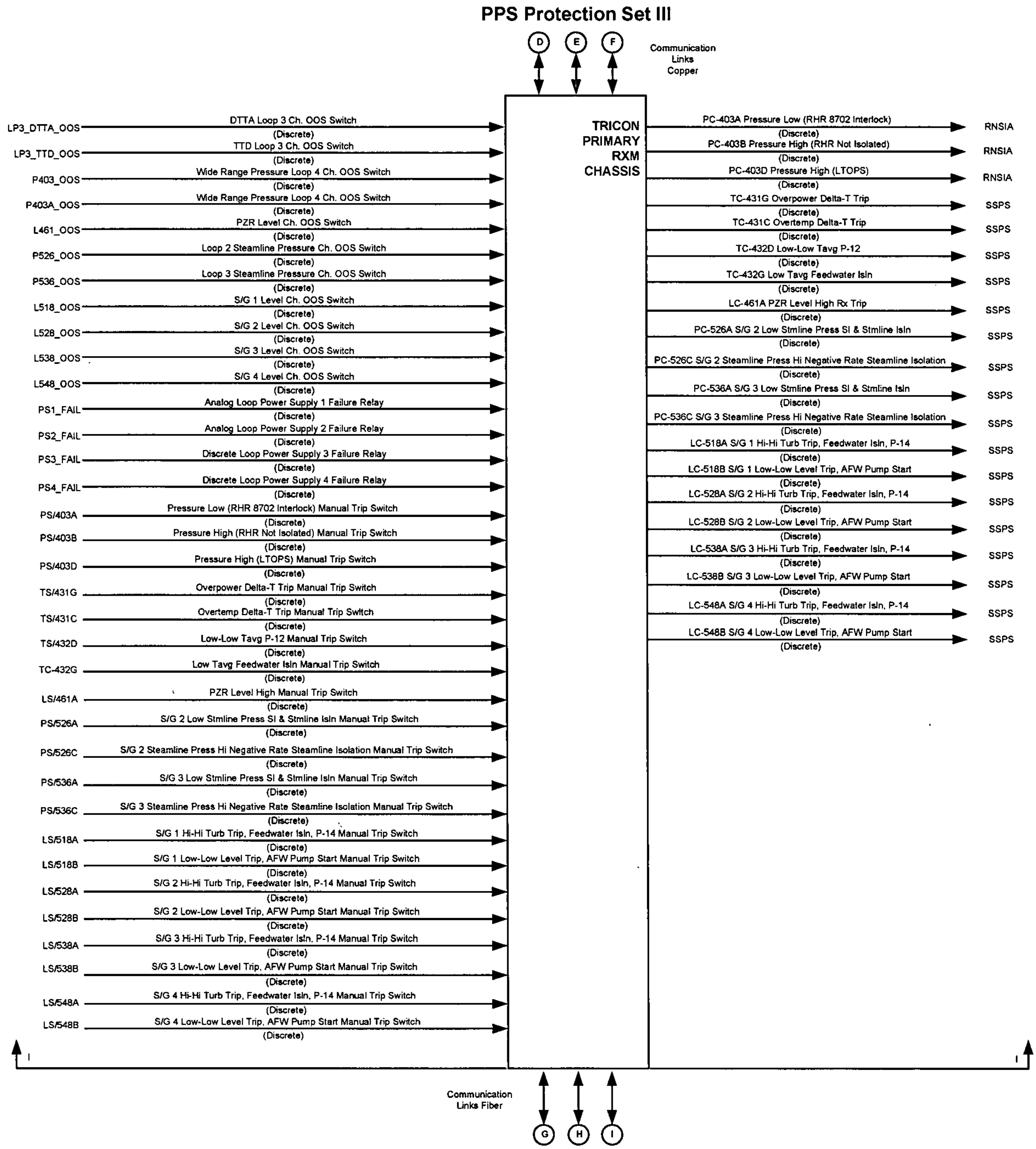


Figure 1-16 Replacement PPS Architecture – Set III Non-Safety-Related Tricon Chassis

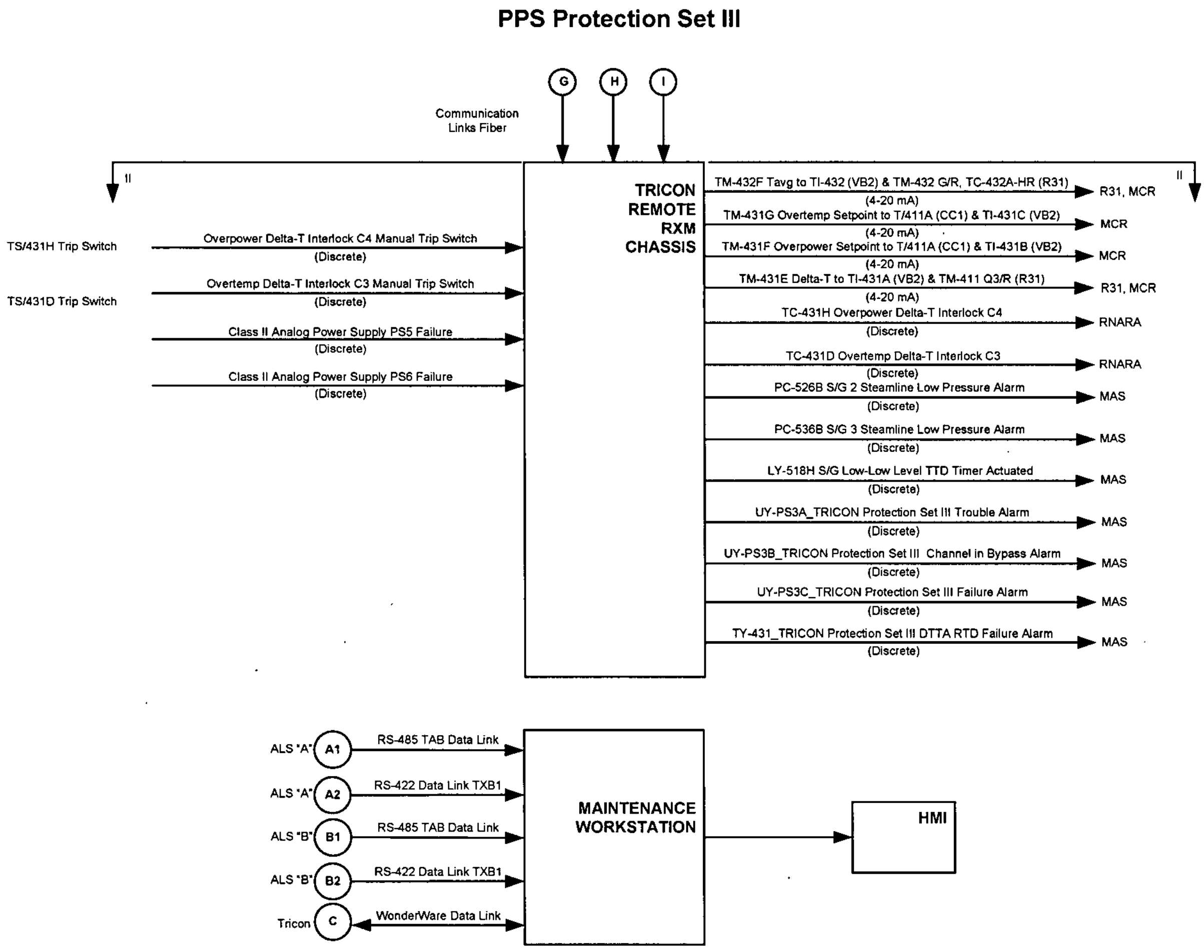


Figure 1-17 Replacement PPS Architecture – Set IV ALS-A

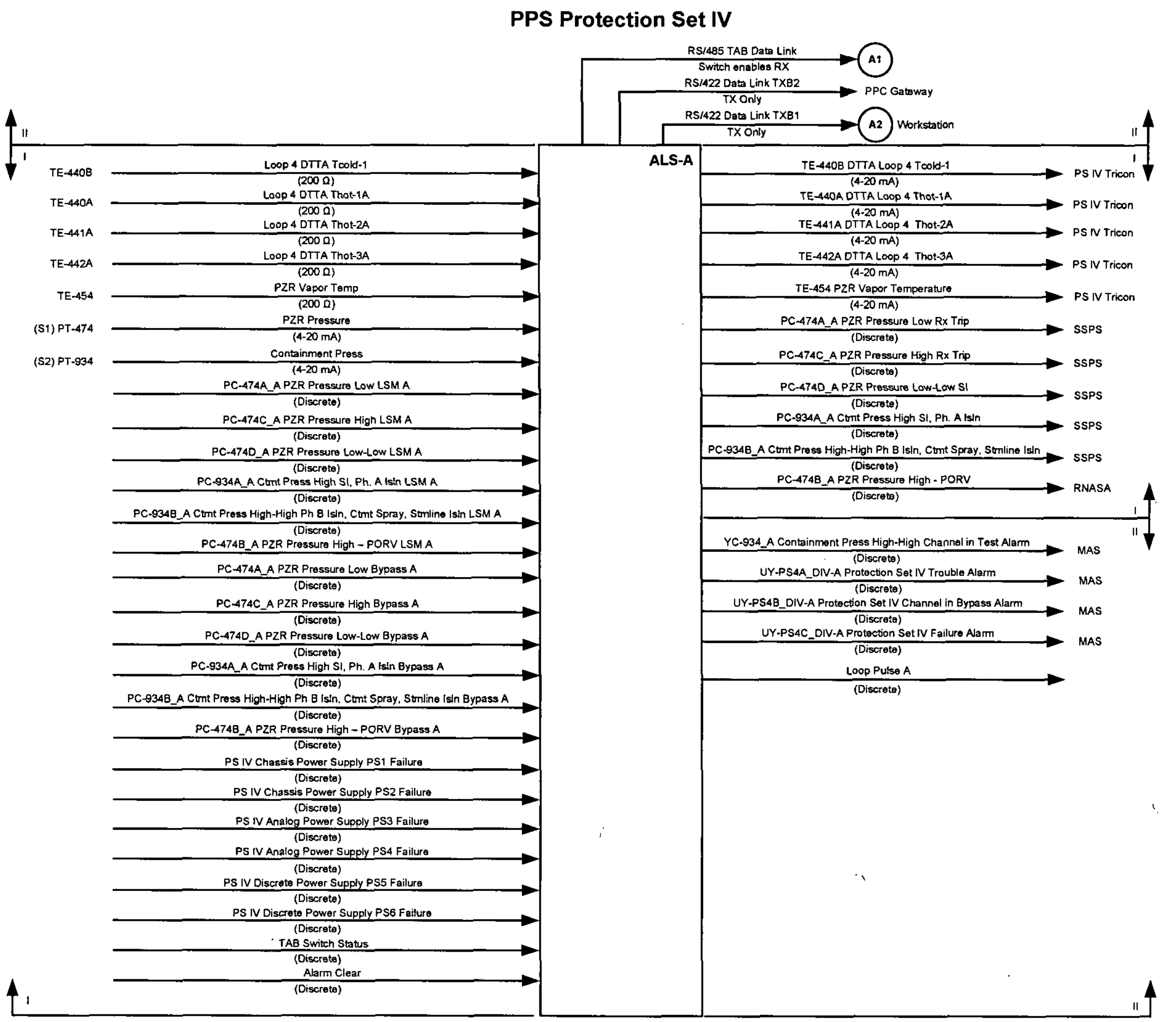


Figure 1-18 Replacement PPS Architecture – Set IV ALS-B and Isolation Devices

PPS Protection Set IV

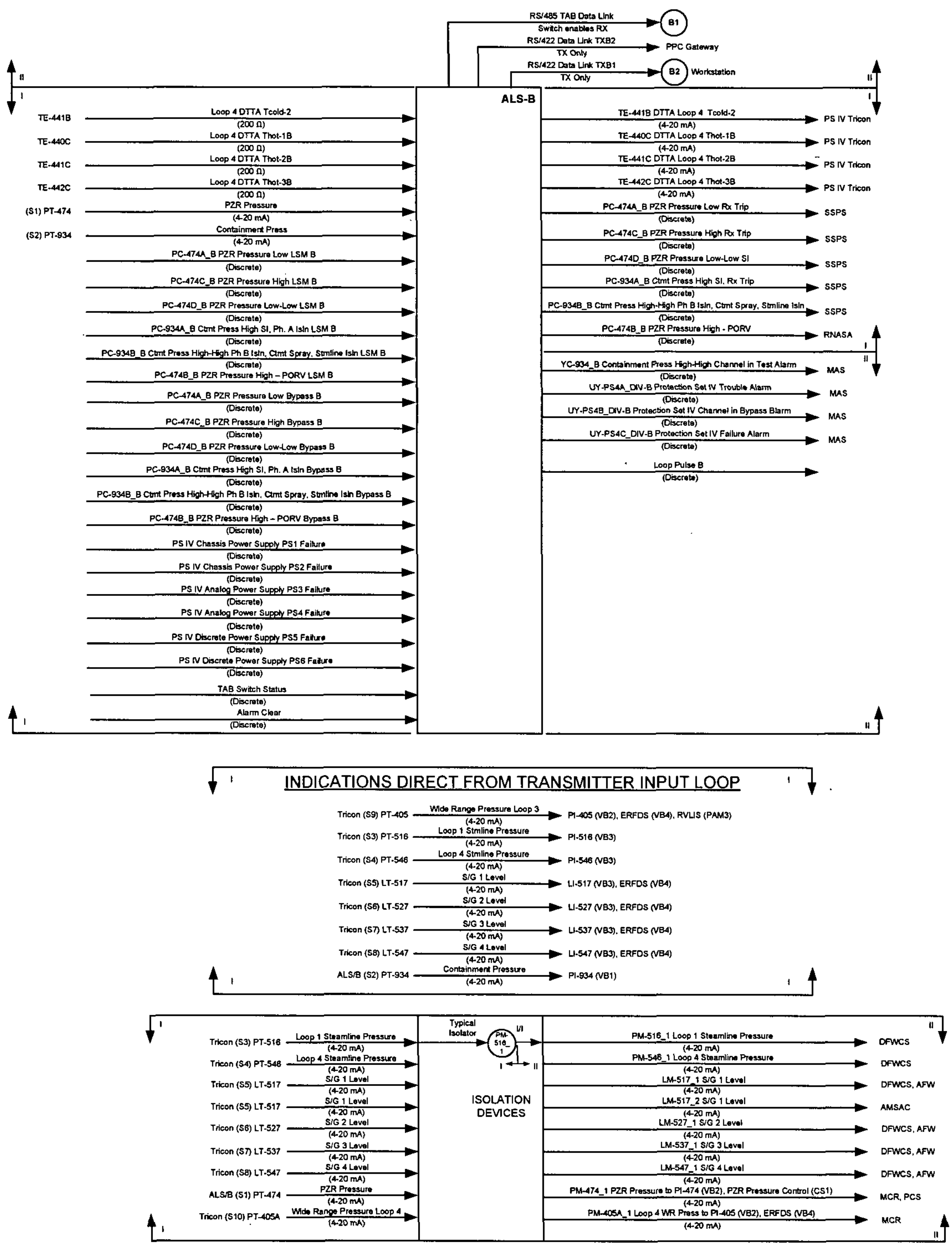


Figure 1-19 Replacement PPS Architecture – Set IV Safety-Related Tricon Main Chassis

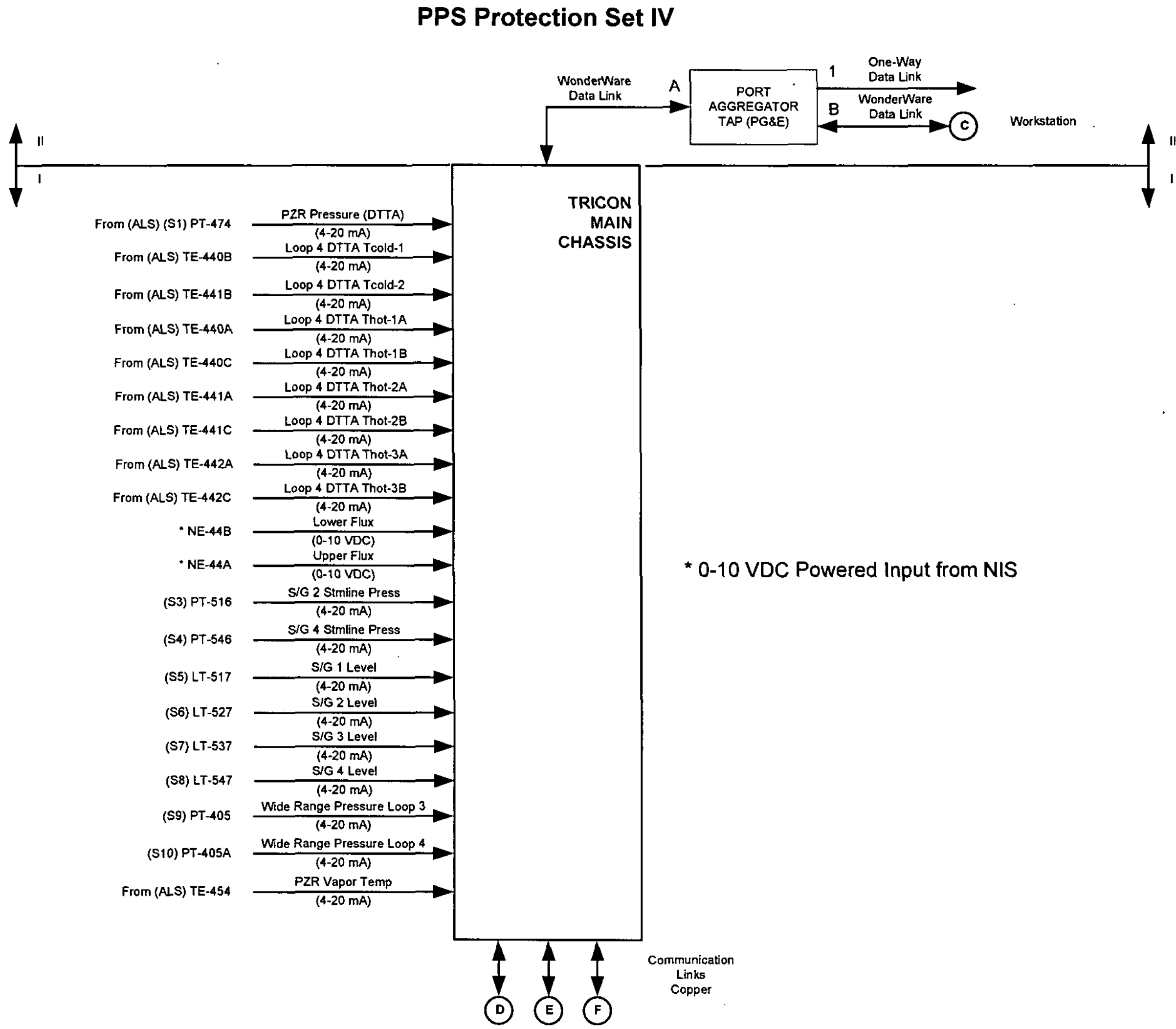


Figure 1-20 Replacement PPS Architecture – Set IV Safety-Related Tricon Primary RXM Chassis

PPS Protection Set IV

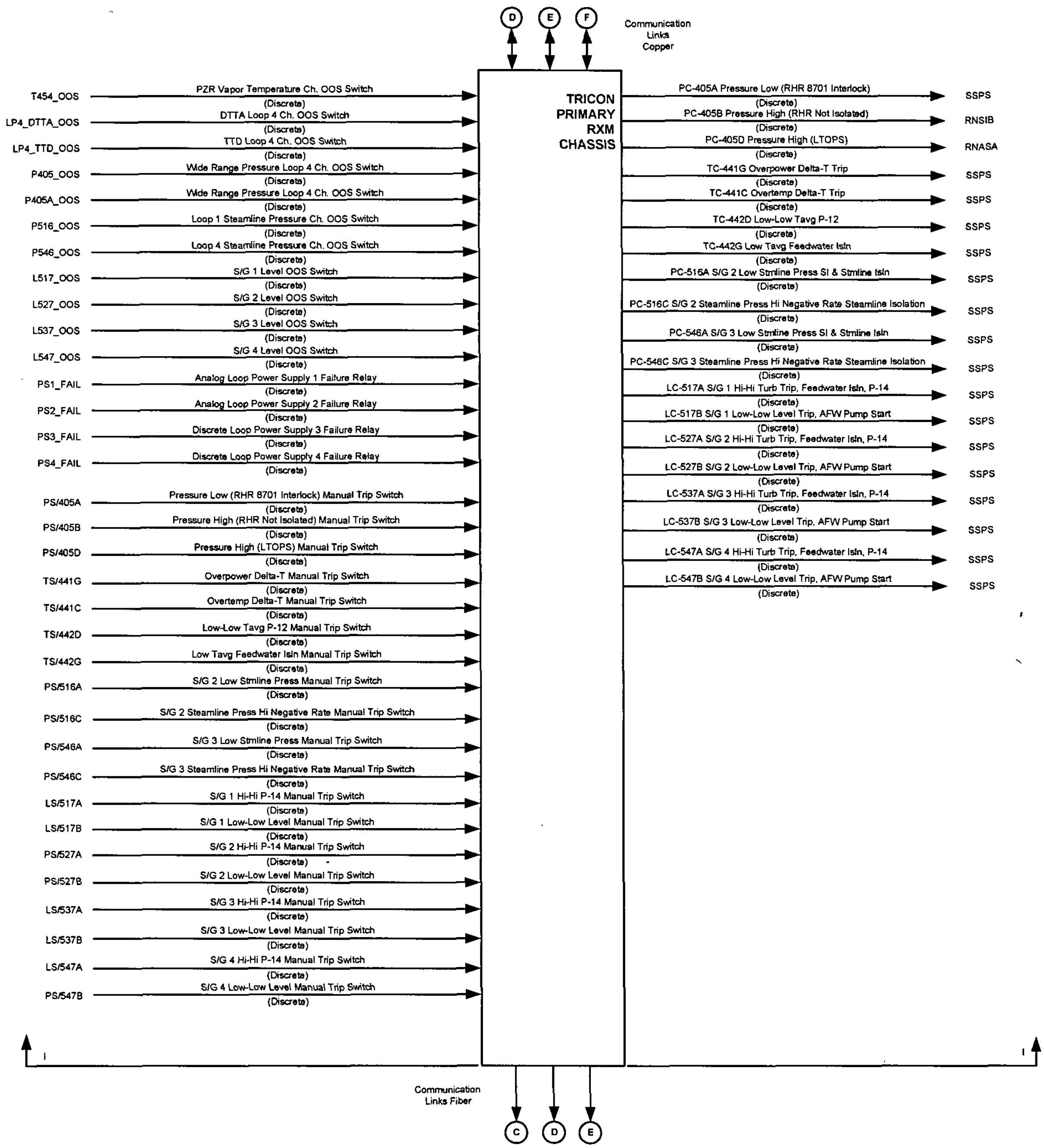


Figure 1-21 Replacement PPS Architecture – Set IV Non-Safety-Related Tricon Chassis

PPS Protection Set IV

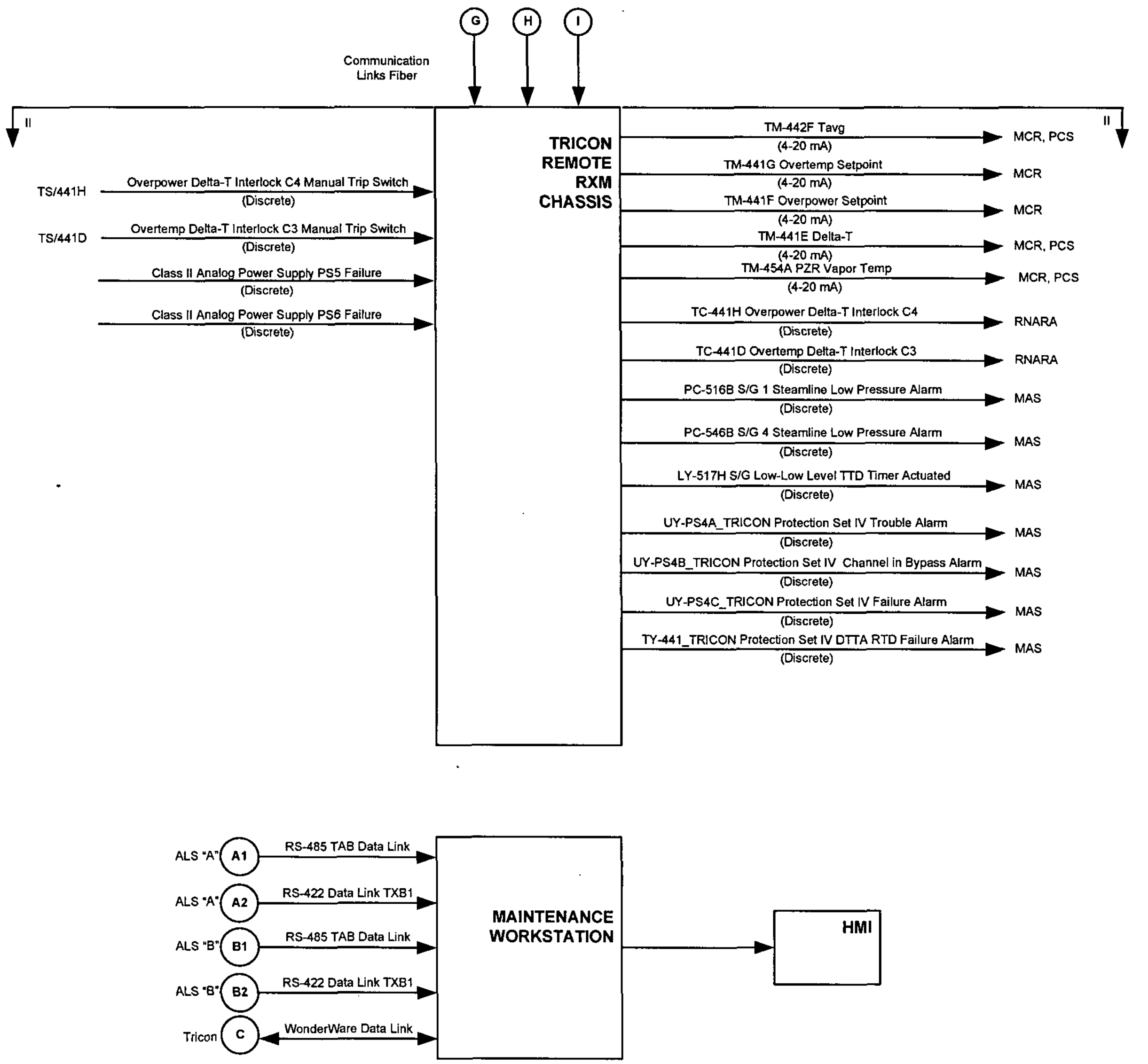
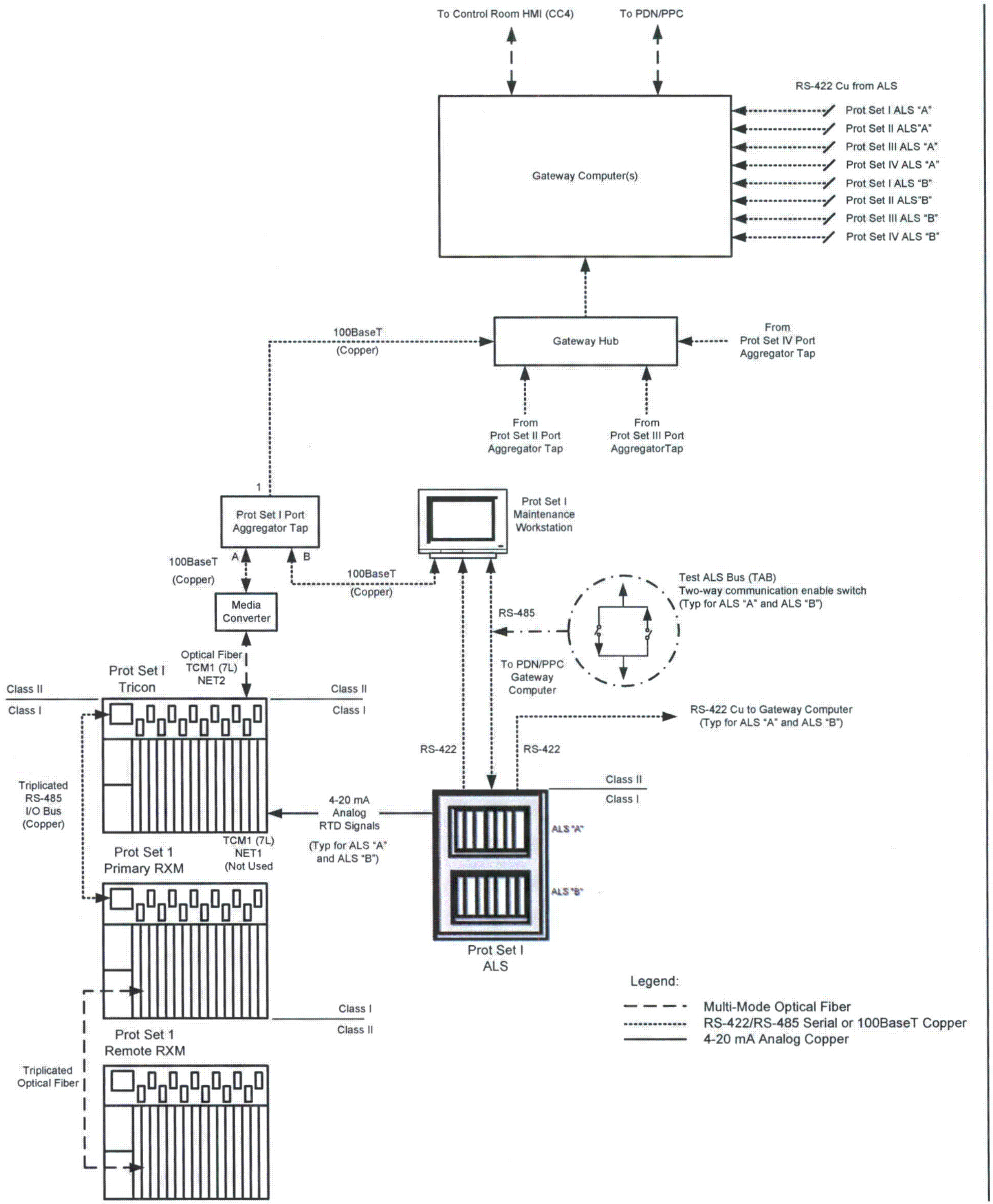


Figure 1-22 Replacement PPS Non-Safety-Related Communications Architecture



2 Interface Requirements

This section specifies the requirements imposed on the systems, subsystems, configuration items, or other system components to achieve required interfaces among these entities.

2.1 Process Interface Requirements

Appendix 3.1 describes process inputs and outputs for the PPS replacement project. The I/O list contains the following information for each protection set. As noted below, some I/O list information is outside the scope of this interface specification.

2.1.1 I/O Power Supplies

The Triconex qualification requires that separate power supplies be used for analog and digital I/O.

1. All Tricon discrete inputs and outputs will be powered in accordance with the requirements provided in the I/O list.
2. The Containment Pressure Bypass switch inputs to the ALS will be dry contacts wetted by 48 Vdc supplied by PG&E.
3. The Pressurizer pressure loops are shared among the ALS, Tricon, and the control system, via Moore Isolator modules, and will be powered the Tricon ETP as shown in Figure 2-2.
4. Where the analog input signal source is a process transmitter, bounding loop resistances per the I/O list are as follows:
   a) Max resistance < 750 ohms
   b) Min resistance > 200 ohms
5. PG&E will provide 24-45 Vdc adjustable power supplies which will accommodate the above bounding loop resistance values. Analog loop power supply voltage should not exceed 40 Vdc, and may be as low as 24 Vdc based on the following considerations and assumptions:
   a) Rosemount 1154 and 1154 Series H
      1) Max qualified power supply voltage: 45 Vdc
      2) Max Design loop resistance at 45 Vdc input : 1575 ohms
      3) Min Design loop resistance at 45 Vdc input: 500 ohms
      4) Max Design loop resistance at 24 Vdc input: Approx 700 Ohms
      5) Min Design loop resistance at 24 Vdc input: 0 Ohms
   b) Rosemount 1153 Series B&D Output Code P
      1) Max qualified power supply voltage: 40 Vdc
      2) Max Design loop resistance at 40 Vdc input : 1325 ohms
      3) Min Design loop resistance at 40 Vdc input: 500 ohms
      4) Max Design loop resistance at 24 Vdc input: Approx 600 Ohms
      5) Min Design loop resistance at 24 Vdc input: 0 Ohms

c) Rosemount 1153 Series B&D Output Code R
   1) Max qualified power supply voltage: 45 Vdc
   2) Max Design loop resistance at 45 Vdc input : 1575 ohms
   3) Min Design loop resistance at 45 Vdc input: 500 Ohms
   4) Max Design Loop Resistance at 24 Vdc input: Approx 700 ohms
   5) Min Design Loop Resistance at 24 Vdc input: 0 ohms

d) Barton 763 max power supply voltage: 50 Vdc
e) Barton 763 Max loop resistance at 40 Vdc input: Approx 1250 ohms
f) Barton 763 Min loop resistance at 40 Vdc input: Approx 190 ohms
g) Triconex 3805N Analog Output module OVP: 42.5 Vdc
h) ALS input resistance is 220 ohms [Figure 2-2] when both "A" and "B" 302 boards are in the circuit.
i) Triconex 9792-610N Reg Guide 1.180 FTP Max 48 Vdc (Approx input resistance: (250 + 1/(1/250 + 1/3300)) ~ 482 ohms)
j) Input and output loop resistances as shown in Appendix 3.1 based on Triconex resistance above and:
   - Moore CPT isolator input 4-20 mA into 20 ohms
   - Westinghouse VX-252 indicator: 5 ohms (including estimated wire resistance)
   - ERFDS: 50 ohms
   - RVLIS: 250 ohms

k) ALS 4-20 mA analog outputs are powered by the ALS. Therefore, temperature inputs to the Tricon will not use the Positive Temperature Coefficient (PTC) thermistor for loop overcurrent protection and the input resistance for Tricon temperature inputs is 250 ohms.

6. Analog outputs will be powered by 24 Vdc.

2.1.2 Analog Inputs

Figure 2-1, Figure 2-2, Figure 2-3 illustrate typical PPS analog input signal wiring [1.4.5.6, 1.4.5.7]:

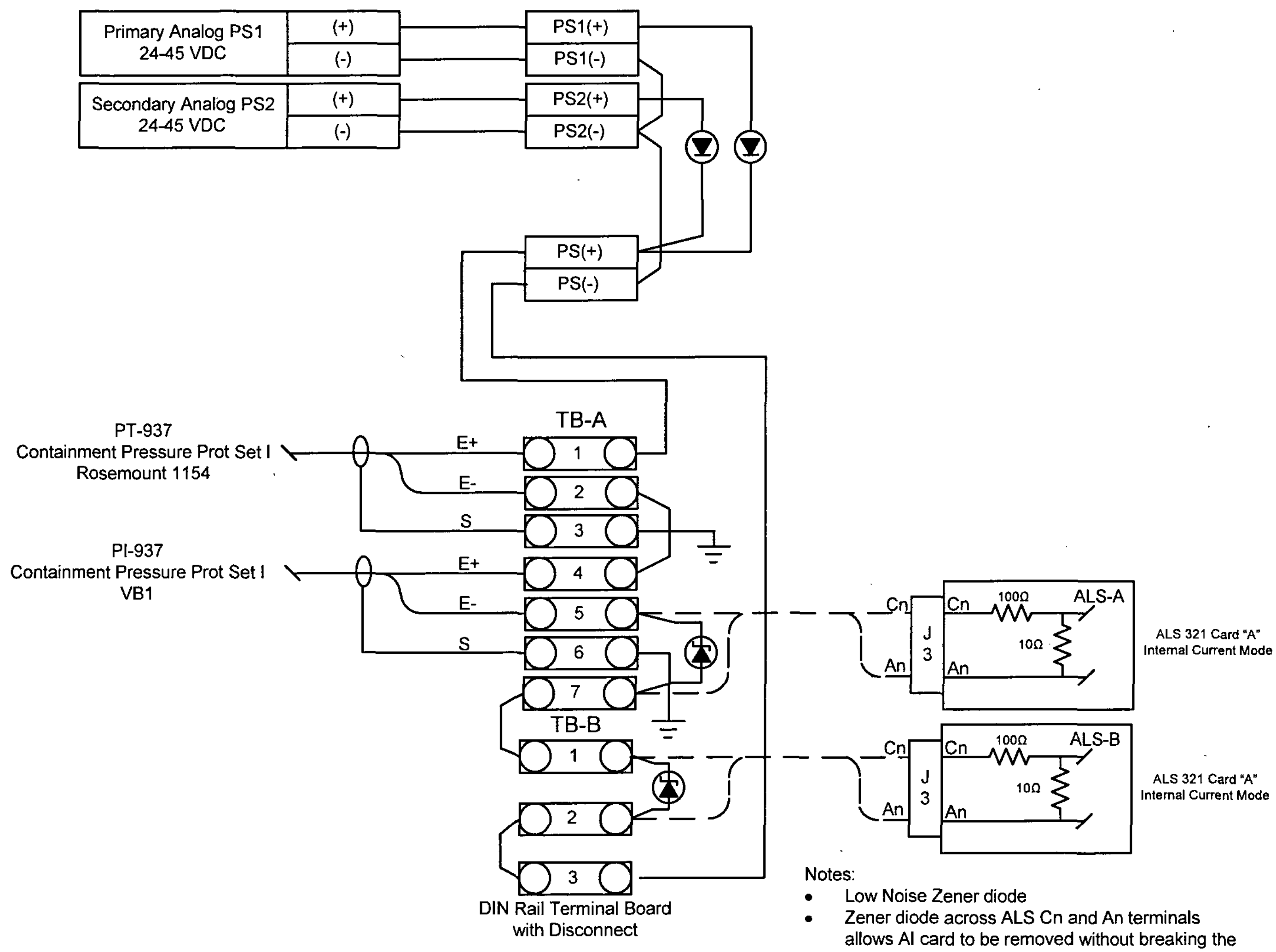
1. PT-455 signal shared among Tricon (DTTA functions), ALS-A, ALS-B and an isolation device
2. LT-459 signal shared among Tricon, Control Board indicators and an isolation device
3. PT-505 signal shared among the Tricon, and an isolation device
4. TE-413A and TE-423A signals are conditioned by ALS-A and ALS-B, respectively before they are input to the Tricon. These signals are shown in Figure 2-2 only to illustrate typical wiring for analog signals that are powered externally to the Tricon ETP. The DCPP PPS Nuclear Instrumentation (NI) input channels will utilize a different AI card (3703EN) from the AI card (3721N) used for other Tricon analog inputs and will NOT be connected to the same ETP.
5. Tricon AI cards 3721 (where used) and 3721N will be configured for 14-bit resolution.
6. Tricon AI cards 3703E (where used) and 3703EN will utilize the default 12-bit resolution.

Signals from redundant field devices shall be processed on separate input boards.

I/O List Items 7-8 and 14 are outside the scope of this specification

1. Input loop impedance: Impedance in Ohms of the instrument loop driving the analog input
2. Instrument Tag: Instrument Number as shown on the associated Instrument Schematic Diagram
3. Signal Type: Electrical signal level of the instrument loop driving the analog input; typically 4-20 mA DC or 1-5 VDC.
4. All 4-20 mA analog signals are powered from power supplies located within the PPS cabinets, except for the 0-10 VDC signals from the Nuclear Instrumentation System (NIS)
5. Inst. Classification: Instrument Safety Classification in accordance with DCPP Design Criteria Memorandum (DCM) T-24 [1.4.4.6]
6. Termination Rack: Protection Set to which the field wiring is connected.
7. Terminal Board: Terminal board located within the Termination Rack
8. Cal. Range: Instrument scale low and high corresponding to the analog signal; e.g., 0-100.
9. EU: Engineering Units into which the input channel is to be converted; e.g., psig.
10. Processor: (a) Tricon; (b) ALS (Referred to as "Diverse A", "Diverse B"); (c) Dedicated Isolation Device
11. Chassis
    (a) Tricon Main Chassis or Expansion Chassis in which the I/O Board is located
    (b) ALS: To be provided later by vendor
    (c) Isolation Device: Moore Industries CPT
12. Slot
    (a) I/O Board location within the Tricon Main Chassis or Expansion Chassis: To be provided later by Vendor Triconex
    (b) ALS: To be provided later by vendor
    (c) Isolation Device: To be provided later by vendor
13. Channel (Ch)
    (a) Location on the I/O Board within the Tricon Main Chassis or Expansion Chassis : To be provided later by Vendor Triconex
    (b) ALS: To be provided later by vendor
    (c) Isolation Device: To be provided later by vendor
14. Tagname
    (a) Tricon: TSAP Application name for the point
    (b) ALS: To be provided later by vendor
    (c) Isolation Device: N/A
15. PPC Tag: Existing Plant Process Computer I/O designation for this point
16. Channel Function: Description

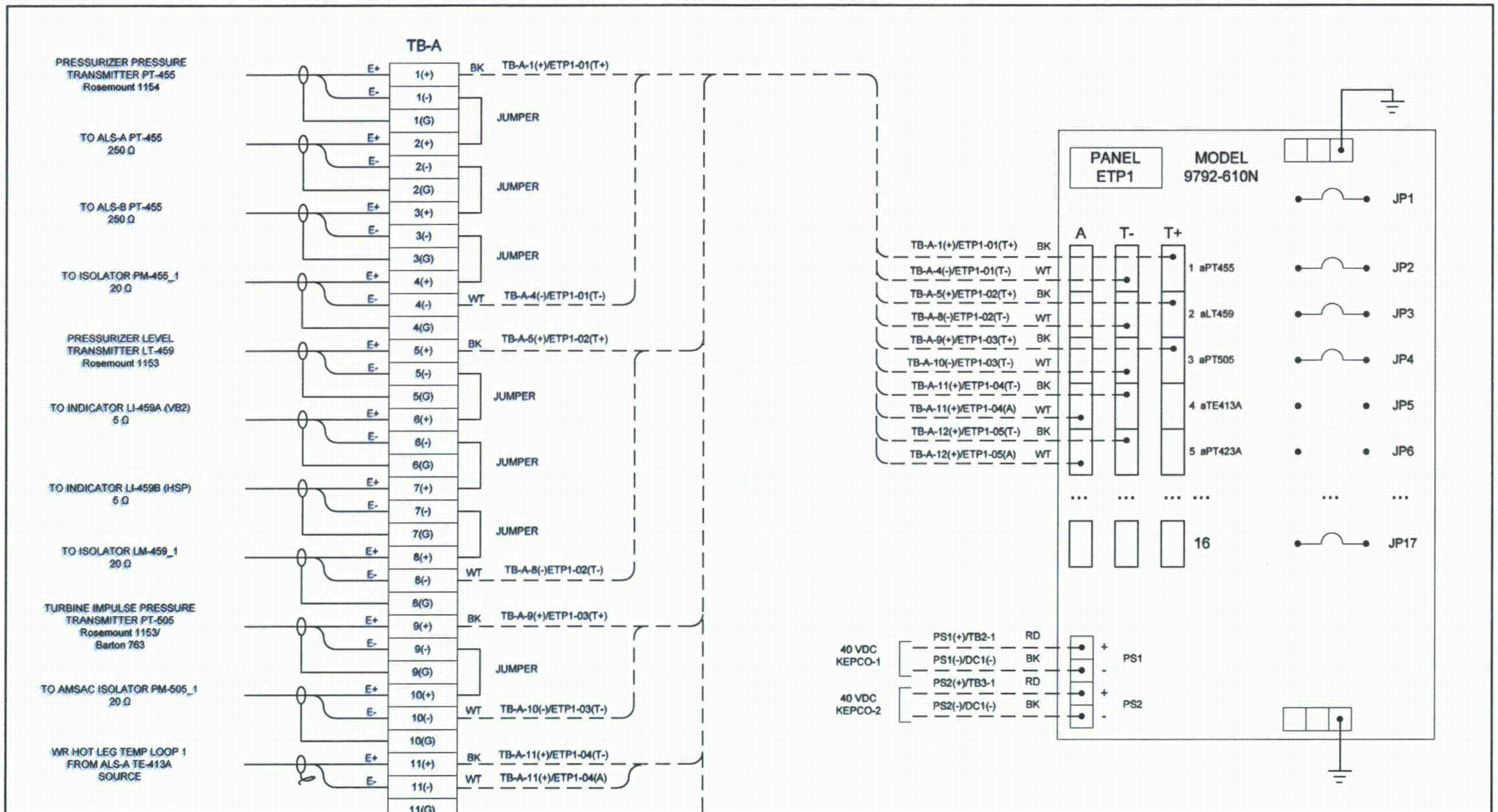
Figure 2-1 Typical ALS Analog Input Wiring



Notes:

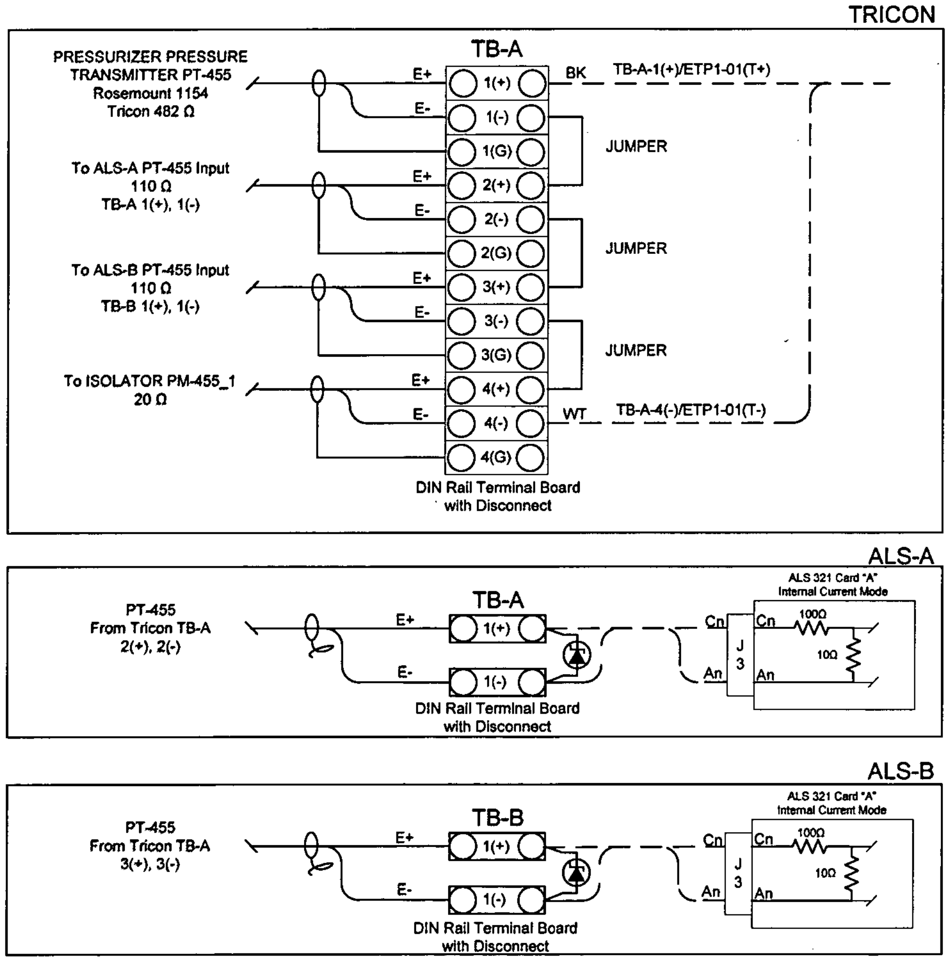
- Low Noise Zener diode
- Zener diode across ALS Cn and An terminals allows AI card to be removed without breaking the 4-20 mA field circuit.

Figure 2-2 Typical Tricon Analog Input Wiring



Note:
TE-413A and TE-423A signals are conditioned by the ALS before they are input to the Tricon. These signals are shown here ONLY to illustrate typical wiring for analog signals that are powered externally to the Tricon ETP. The DCPP PPS temperature input channels will utilize a different AI card (3703EN) from the AI card (3721N) used for pressure (or other) Tricon analog inputs and will NOT be connected to the same ETP.

Figure 2-3 Tricon/ALS PT-455 Interface Wiring



Notes:

- Low Noise Zener diode
- Zener diode across 1(+) and 1(-) terminals allows AI card to be removed without breaking the 4-20 mA field circuit.

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2.1.3 Discrete Inputs

Signals from redundant field devices shall be processed on separate input boards.

I/O List Item 9 is outside the scope of this specification

1 Instrument Tag: Same as above
2 Signal Type: Electrical signal level driving the discrete input; per I/O List
3 Inst. Classification: Same as above
4 Termination Rack: Same as above
5 Terminal Board: Same as above
6 Processor: Same as above
7 Slot: Same as above
8 Channel (Ch): Same as above
9 Tagname: Same as above
10 Channel Function: Same as above

2.1.4 Analog Outputs

I/O List Items 8-9 and 12-13 are outside the scope of this specification

1 Output Loop Impedance: Impedance in Ohms of the instrument loop being driven by the analog output
2 Instrument Tag: Same as above
3 Signal Type: Electrical signal level of the instrument loop being driven by the analog output; typically 4-20 mA DC
4 Inst. Classification: Same as above
5 Termination Rack: Same as above
6 Terminal Board: Same as above
7 Processor: Same as above
8 Cal. Range: Same as above
9 EU: Same as above
10 Chassis: Same as above
11 Slot: Same as above
12 Channel (Ch): Same as above
13 Tagname: Same as above
14 PPC Tag: Same as above
15 Channel Function: Same as above

2.1.5 Discrete Outputs

Figure 2-4 and Figure 2-5 illustrate typical ALS discrete output signal wiring that implements the diversity architecture [Figure 1-1] using a Line Sense Module to provide a hardwired OR configuration between Diversity Groups ALS-A and ALS-B and to enable the ALS to perform continuous error checks for detecting the following conditions:

- Failure to Trip on Demand
- Trip without Demand
- Failure to Bypass
- Illegal Bypass

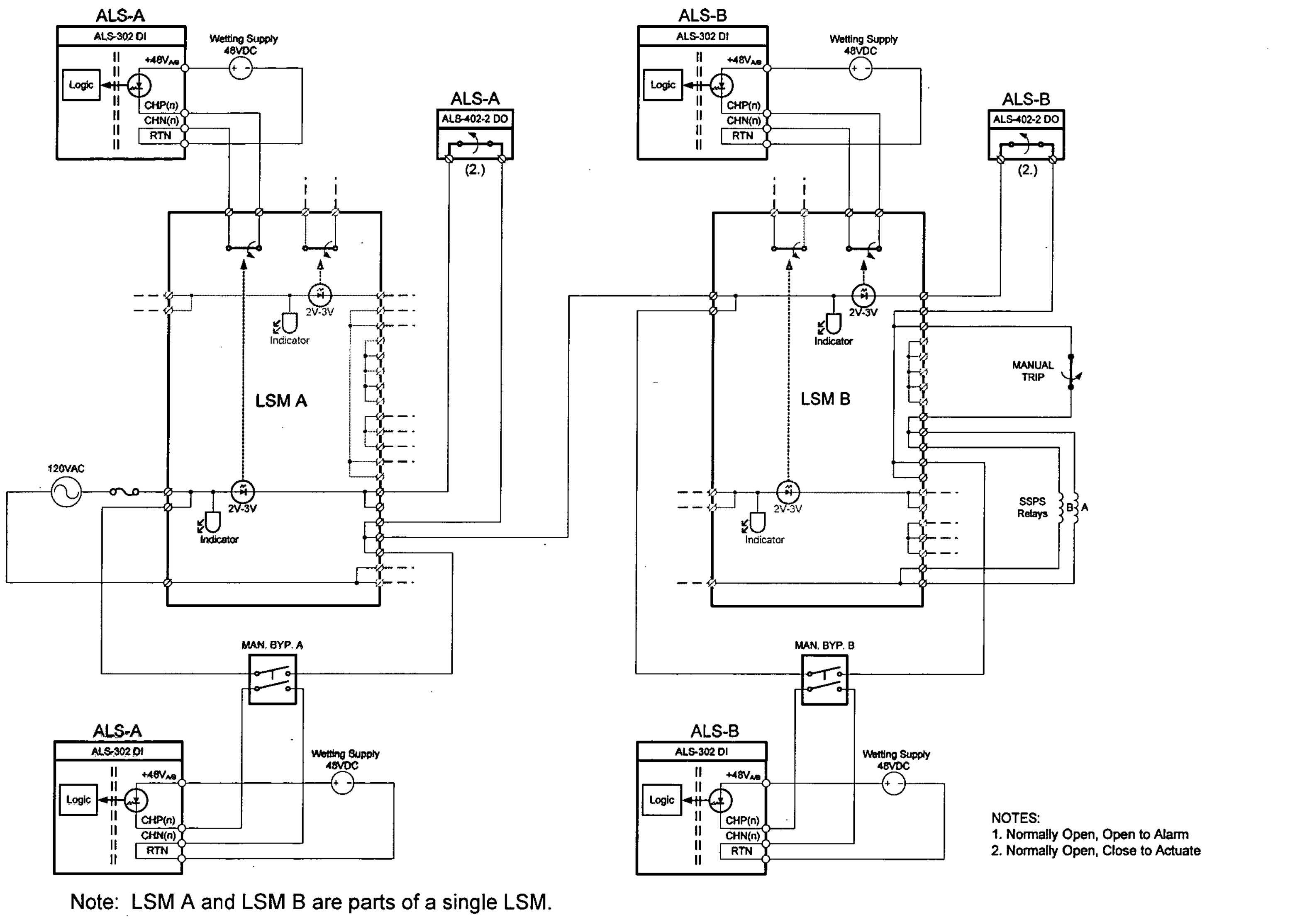
Configuration of the LSM for use in an Energize to Trip (ETT) or Deenergize to Trip (DTT) circuit is done through field wiring terminations on the LSM and does not require any modification of any electrical properties of the LSM itself. Thus, a single LSM can be used in an ETT or DTT circuit without the need to electrically configure the module for the trip circuit type before use. This allows a single part number to be used to provide spares for both ETT and DTT circuit configurations.

Refer to the ALS Design Specification [1.4.5.6] for additional information regarding the LSM and field wiring interface.

I/O List Item 10 is outside the scope of this specification

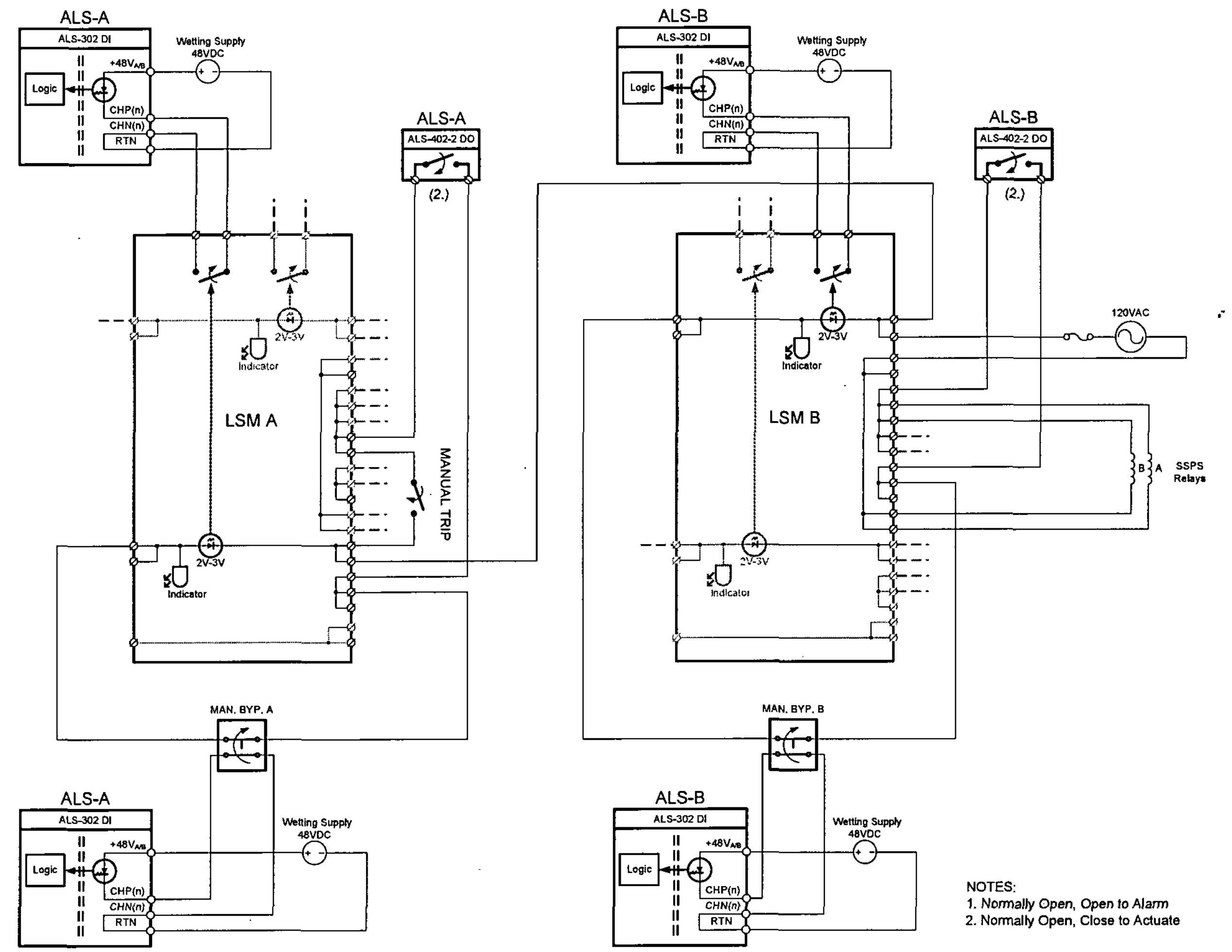
1 Instrument Tag: Instrument Number as shown on the associated Instrument Schematic Diagram
2 Inst. Classification: Same as above
3 Interrogation Voltage: Electrical signal level of the instrument loop driving the discrete output; per the I/O list. Power source is shown on the FRS figures.
4 Termination Rack: Same as above
5 Terminal Board: Same as above
6 Processor: Same as above
7 Chassis: Same as above
8 Slot: Same as above
9 Channel (Ch): Same as above
10 Tagname: Same as above
11 Channel Function: Same as above

Figure 2-4 ALS-A and ALS-B SSPS Connections (Deenergize to Trip Configuration)



Note: LSM A and LSM B are parts of a single LSM.

Figure 2-5 ALS-A and ALS-B SSPS Connections (Energize to Trip Configuration)



Note: LSM A and LSM B are parts of a single LSM.

2.2 Safety-Related ALS/Tricon Interface Requirements

1 Shared inputs (Power source shown in I/O List)
2 ALS Temperature channel inputs to Tricon

All 4-20 mA analog signals

2.3 Data Communication Interface Requirements

Refer to Figure 1-22.

2.3.1 Non-Safety-Related Communications from Tricon to Port Aggregator Tap (2-way)

2.3.1.1 Hardware: Net Optics PA-CU 10/100BaseT Port Aggregator Tap supplied by PG&E

2.3.1.2 Media: Optical Fiber from TCM + 10/100baseT Ethernet Media Converter to port aggregator. Supplied by Triconex.

2.3.1.3 Data Interface Protocol: Triconex Standard Ethernet

2.3.2 Non-Safety-Related Communications from Port Aggregator Tap to Maintenance Workstation (2-way)

2.3.2.1 Hardware: Net Optics PA-CU 10/100BaseT Port Aggregator Tap Supplied by Triconex.

2.3.2.2 Media: 10/100baseT Ethernet

2.3.2.3 Data Interface Protocol: Triconex Standard

2.3.3 Non-Safety-Related Data Communications from ALS to Maintenance Workstation (1-way)

2.3.3.1 Description: Core Logic Board communication channel TXB1

2.3.3.2 Media: RS-422 twisted pair copper to maintenance workstation

2.3.3.3 Data Interface Protocol: ALS TXB1/TXB2 Standard

2.3.4 Non-Safety-Related Communications from ALS Test ALS Bus (TAB) to Maintenance Workstation (1- or 2-way as determined by switch position)

2.3.4.1 Description: TAB interface with ALS chassis

2.3.4.2 Media: (To be provided later by vendor ALS)

2.3.4.3 Data Interface Protocol: ALS TAB Standard

2.3.5 Non-Safety-Related Communications from ALS to Gateway computer (One-way)

2.3.5.1 Description: Core Logic Board communication channel TXB2

2.3.5.2 Media: RS-422 twisted pair copper to Gateway computer

2.3.5.3 Data Interface Protocol: ALS TXB1/TXB2 Standard

2.3.6 Non-Safety-Related Communications from Network Aggregator Tap to Gateway computer (One-way)

2.3.6.1 Hardware: Net Optics PA-CU 10/100BaseT Port Aggregator Tap supplied by PG&E

2.3.6.2 Media: 10/100baseT Ethernet + network hub supplied by PG&E

2.3.6.3 Data Interface Protocol: Ethernet-based.

2.4 System I/O Power Requirements

2.4.1 Tricon

[To be provided later by vendor Triconex]

2.4.2 ALS

[To be provided later by vendor ALS]

2.5 Instrument Power Supply Locations

[To be provided later by PG&E]

2.6 System Power Sources Provided by PG&E

2.6.1 The following power sources are available for the Process Protection System:

2.6.1.1 120 Vac vital instrument power [1.4.4.7]:

Voltage:	120V ±10% [DC 6010908-397]
Frequency:	60 HZ ±5% [DC 6010908-397]

2.6.1.2 Non-safety-related 120 Vac utility power

2.6.2 Harmonic Distortion Limitations

PG&E practices power supply quality monitoring. As-found and as-left Total Harmonic Distortion (THD) measurements will be performed on power supply at PPS 120 Vac power supply input terminals before and after installation of equipment powered from the 120 Vac vital instrument power supply. Refer to USNRC Reg Guide 1.180 [1.4.3.3].

2.7 Workstations

2.7.1 Maintenance Workstation

The Maintenance Workstation shall allow processing and display of information from both Triconex and ALS portions of the PPS. Wonderware Intouch application shall interface (2-way) with the Tricon and display information from both Tricon and ALS (1-way).

2.7.1.1 Description (To be provided later by PG&E)

2.7.1.2 Hardware (To be provided later by PG&E

2.7.1.3 Data Interface Protocol: WonderWare InTouch

2.7.2 Auxiliary Service Unit

Software application shall be provided by Vendor ALS to run on Maintenance Workstation.

2.7.2.1 Description (To be provided later by PG&E)

2.7.2.2 Hardware (To be provided later by PG&E)

2.7.2.3 Data Interface Protocol: ALS TAB standard

3 Appendices

3.1 Process Protection System I/O List