CITY OF TULSA WATER AND SEWER DEPARTMENT

SCADA SYSTEM IMPROVEMENTS

AUTOMATION STANDARDS

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PRESENTED TO

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1 PURPOSE – SUMMARY OF INTENT

The Programmable Logic Controller (PLC) Hardware Standards define the preferred hardware, technologies, implementation and related design topics for the selection and design of PLC hardware systems for the City of Tulsa (CoT) Water & Sewer Utility inclusive of Stormwater. The City has selected Schneider Electric as the preferred PLC hardware manufacturer with the requirement that all PLC hardware be compatible with EcoStruxure Automation Expert (EAE).

This document will provide guidance to the CoT stakeholders and design engineers on design decisions required to implement both the near-term and long-term vision as they relate to PLC hardware and the overall Plant Control System (PCS). This document will focus on the selection of Programmable Logic Controller (PLC) Hardware and associated components to be included in process control design. Determination of the exact PLC hardware selections and sizing will be determined using the criteria identified herein.

2 DEFINITIONS – TERMS SPECIFIC TO THE DOCUMENT

Term/Acronym	Definition/Description
dPAC	Distributed Programmable Automation Controller – the EAE runtime target that executes IEC 61499 control applications and manages local/remote I/O.
Soft dPAC / HA Soft dPAC	An EAE runtime instance hosted on an industrial PC (iPC) rather than dedicated Modicon controller hardware. "HA" (High Availability) Soft dPAC is the redundant, software-based version qualified on Harmony P6 and AsRock Industrial iPC platforms (Appendix B).
EAE	EcoStruxure Automation Expert – Schneider Electric's IEC 61499-based engineering, runtime, and lifecycle-management platform.
APP Library	An EAE standard, vendor-maintained application library of pre-built, reusable function blocks and objects, as distinct from a City-specific custom library (Section 6.3).
FB / CAT / CATO	Function Block; Composite Automation Type (an FB composed of multiple facets – logic, HMI, documentation – packaged as one reusable object); Composite Automation Type Object (an instantiated CATO within a project).
ECC	Execution Control Chart – the state-machine diagram documenting a function block's internal event/state logic, provided for each custom FB/CAT/CATO per Section 6.3.
Edge I/O NTS	Modicon Edge I/O NTS – an IP20 distributed I/O system for data aggregation, compatible with the M251dPAC/M262dPAC/M580dPAC, Soft dPAC, and third-party controllers over Modbus TCP or Ethernet/IP.
HMI / EAE-HMI	Human Machine Interface. EAE-HMI is the platform's native, object-oriented visualization application
ISA-101	ISA/IEC standard for Human-Machine Interfaces for Process Automation Systems, covering situational-awareness graphics design (Section 6.7).
Lucity or Central Square EAM	The City of Tulsa's enterprise asset-management system; ICS must maintain compatibility with the City's master tagging convention referenced in Section 6.4.
ICS	Industrial Control Systems
I/O	Input / Output types: DI – Digital Input; DO – Digital Output; AI – Analog Input; AO – Analog Output.

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Term/Acronym	Definition/Description
iPC	Industrial Personal Computer
OIT	Operator Interface Terminal – a panel-mounted display running EAE-HMI or a compatible visualization application.
PCS	Plant Control System
RIO	Remote I/O – I/O logically part of a dPAC's application but physically located apart from the dPAC.
RSTP	Rapid Spanning Tree Protocol
SCADA	Supervisory Control and Data Acquisition
UAO	Universal Automation Organization, UniversalAutomation.org
UPS	Uninterruptible Power Supply
VDC	Volts, Direct Current
VAC	Volts, Alternating Current
WAN / LAN	Wide Area Network (City-provided IP addressing, Section C2) / Local Area Network (Contractor-assigned panel and process-network IP addressing, Section C2).

3 ROLES & RESPONSIBILITIES

The following role definitions provide guidance to clearly identify individuals or groups involved with the design, development, procurement, and configuration of a Plant Control System.

System Integrator – The individual or company responsible for providing equipment, materials, and EAE software services required to meet the intent of the contract documents, including commissioning, testing, training, and application deployment.

Automation/I&C Design Engineer – The individual, whether CoT staff or hired by CoT, responsible for process control system design, including the function block application deployment plan, instrumentation design, tagging coordination, and (where applicable) graphics and historian configuration.

CoT Personnel – ICS, Supervisor, operations, maintenance, IT/OT, and project PM staff who provide the overriding decisions required to deliver a complete EAE-based automation system meeting project needs and the City's long-term goals.

4 DETAILED PROCEDURE

4.1 Requirements for Deviations from Standard

Any intended deviation from these standard guidelines shall be discussed with CoT personnel and approved on a project-by-project basis to ensure methodologies remain aligned with the City's vision. This will provide an opportunity for CoT personnel to consider if updates to the standards document are needed based on any approved deviations.

4.2 Notes for Design Engineer

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On a project-by-project basis, the Automation/I&C Design Engineer, in discussion with CoT personnel, is responsible for evaluating and setting aside items found in this standard that are not pertinent to the current project.

5 CONSIDERATIONS FOR PLANT CONTROL SYSTEM (PCS) DESIGN

Key design decisions must be made by CoT personnel during the design phase of a project to provide guidance to the I&C Design Engineer for the development of the detailed design. The selections made are used to develop plans and specifications to meet the needs of each project while adhering to the long-term goals of the CoT.

The overall complexity of the PCS is based on several criteria, including:

- New or existing construction
- Distribution of dPAC control nodes within the plant
- Networking of equipment
- EAE version and software/licensing scope (Section 6)

5.1 New Construction

A new construction project is either a "Greenfield" plant or the addition of new process areas to an existing plant. Either of these construction projects involves new buildings, processes, PLC control panels, and how they are to be integrated into the overall plant design. There are several key high-level decisions to be made early on in a project that provide guidance.

- How are the PLC CPUs to be distributed (central or distributed)?
- Where would Operator Interfaces be most beneficial to Operators?
- Network topology and media
- Input/Output Module Selection and Wiring

The decisions to the questions above can lead to more detailed questions as the specifics of the project develop. The I&C Design Engineer will work hand in hand with CoT Personnel on these decisions. The I&C Design Engineer should solicit and provide input from/to CoT Personnel during all phases of the design from conceptual to final bid plans and specifications. This can be done through the normal review process at each milestone and additionally using focused workshops.

An example design decision is the voltage selection for discrete input/output modules. The modules come in either 24VDC or 120VAC as the operating voltage of the field contacts that wire to them. The preferred voltage is 24VDC for all new construction. 24 VDC controls provide for less potential shock hazard to maintenance personnel than 120VAC. Since the new process may incorporate some manufacturer supplied equipment that are wired for 120 VAC controls, the PCS will require additional steps such as rewiring power distribution within the panel and/or providing interposing relays transitioning from 120VAC to 24VDC. In lieu of transitioning, the design team may decide to provide 120 VAC modules instead.

5.2 Existing Plant Upgrade

These projects incorporate modifying existing plant process areas through expansion or upgrading of the existing PCS. There are three (3) options for upgrading/replacing existing PLC Hardware and their associated control panels. Each of

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these options allow for the PLC hardware provided to fully meet the intent of the hardware standard or with deviations as agreed upon by the CoT Personnel and I&C Design Engineer.

- Replace entire control panel: Enclosures completely removed due to age, condition, etc. and new panels installed in the same location. There may be scheduling issues with this option.
- Replace only PLC hardware: The panel enclosures remain and the PLC hardware along with other panel desired components are removed and replaced.
- Gut existing panel except for field terminations and add new panels: All panel components except for the Field Terminations are removed from the panel(s). New panels installed nearby, and field wiring extended. The old panel becomes a marshalling panel.

Each plant upgrade project is unique and relies heavily on the availability and accuracy of the existing PCS record drawings. If these drawings do not exist or are not relatively correct, the I&C Design Engineer will have to perform detailed site investigations to assess the age, condition, and functionality of the control system and document this information in the form of reports using photos, sketches and other means. The site investigation report will be used by CoT Personnel and the I&C Design Engineer to determine which of the three options above is the best fit.

5.2 Distribution of Control Nodes (dPACs) within the Plant

Centrally located dPAC(s) with local I/O and distributed remote I/O are recommended for small treatment plants or single-building sites with a total I/O count under approximately 1,000 points. Distributed dPACs, each aggregating the I/O and control logic for its own process area or building, are recommended for large treatment plants with multiple buildings spread across a campus setting. Appendix A provides T-shirt sizing across the current dPAC family (M251, M262, M580, ATV dPAC) to support this decision.

> ***Design Note:*** *Because EAE is software defined it decouples the application from the runtime target, a "central vs. distributed" decision is not permanent. A control node initially deployed to one dPAC can be redeployed to another dPAC, or to an HA Soft dPAC running on a control-room industrial PC without modification to the underlying function block application.*

> ***Design Note:*** *For mission-critical processes, consideration should be given to a HA Soft dPAC pair per Appendix B, both of which run the identical application in lock-step so that a failure of the primary unit causes no loss of application state.*

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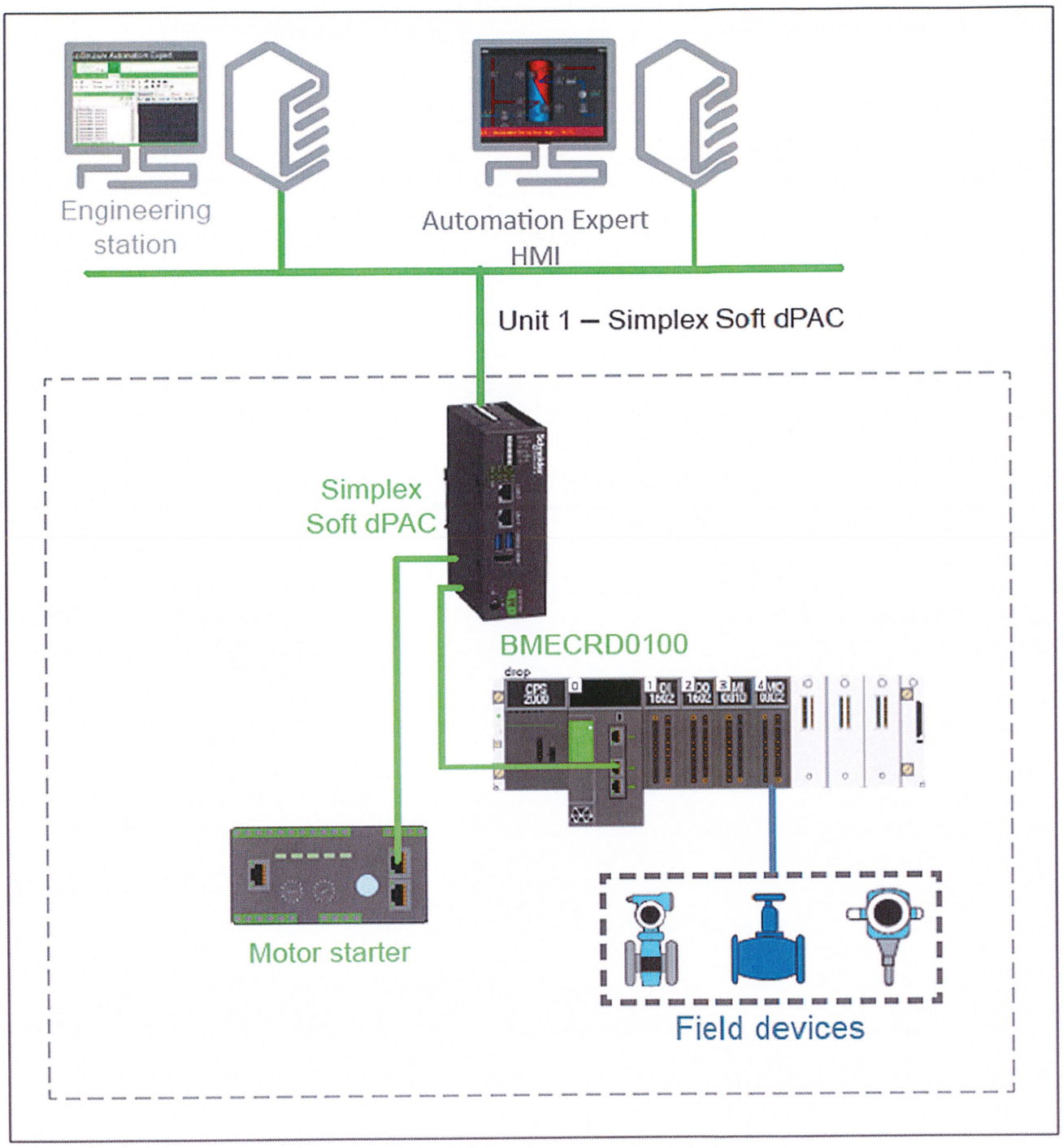


Figure 5-1 Example Centralized Architecture for Small Sites

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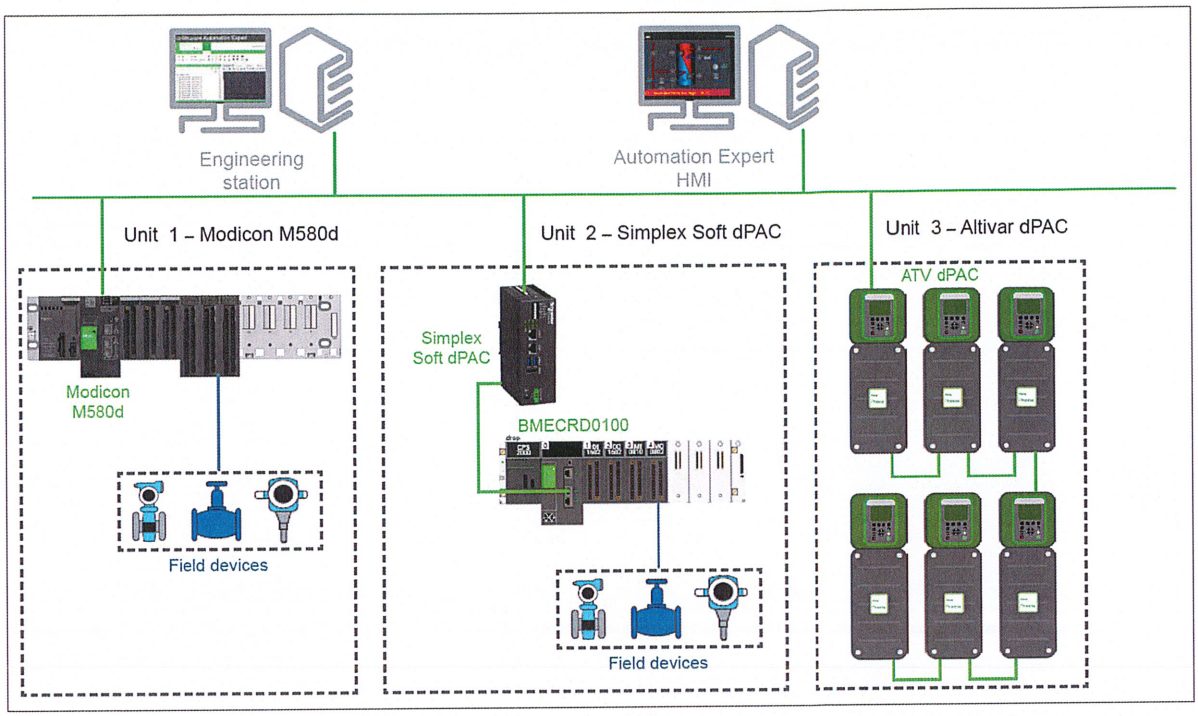


Figure 5-2 Example Distributed Architecture for Medium-Large Sites

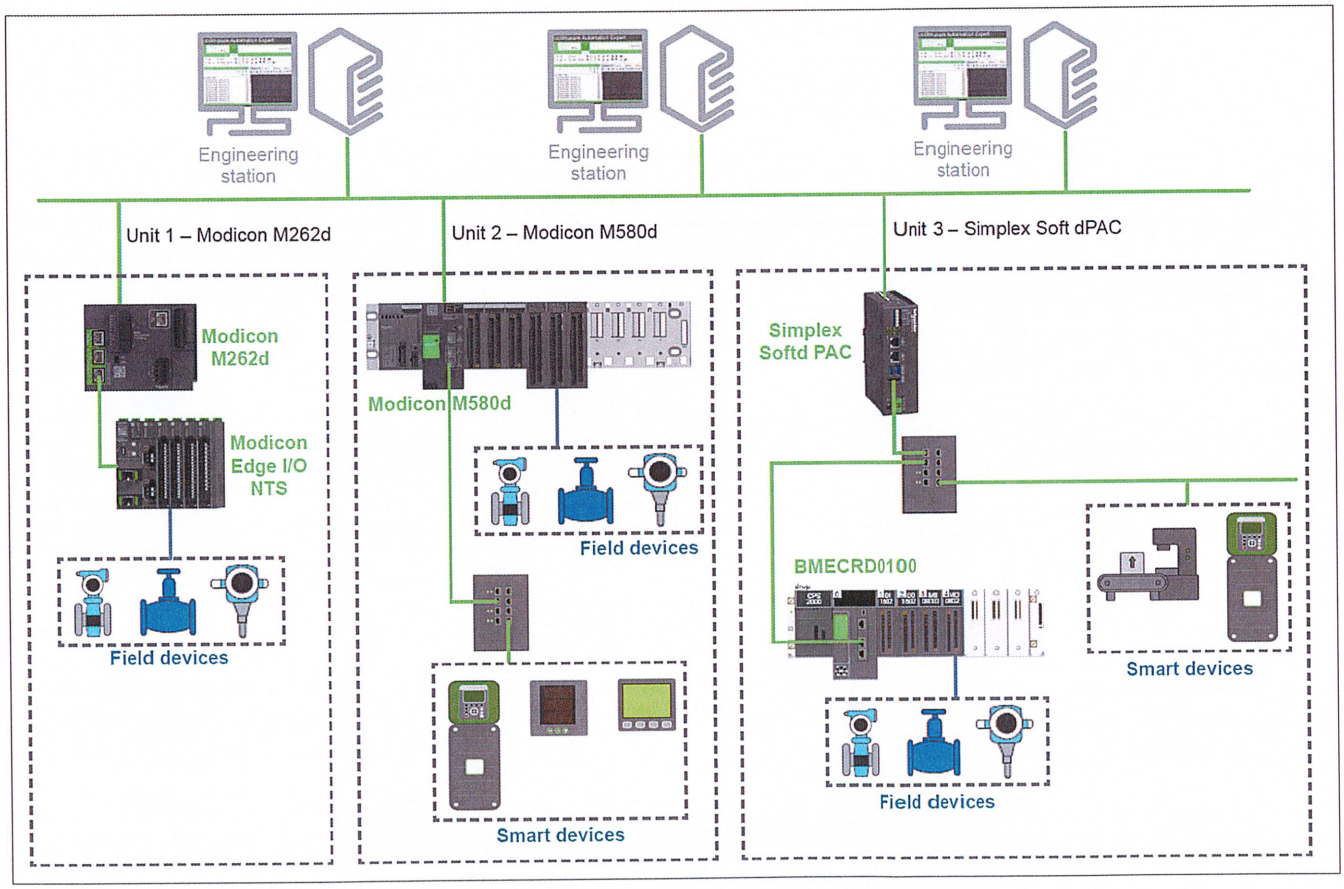


Figure 5-3 Example Distributed Architecture for Medium-Large Sites

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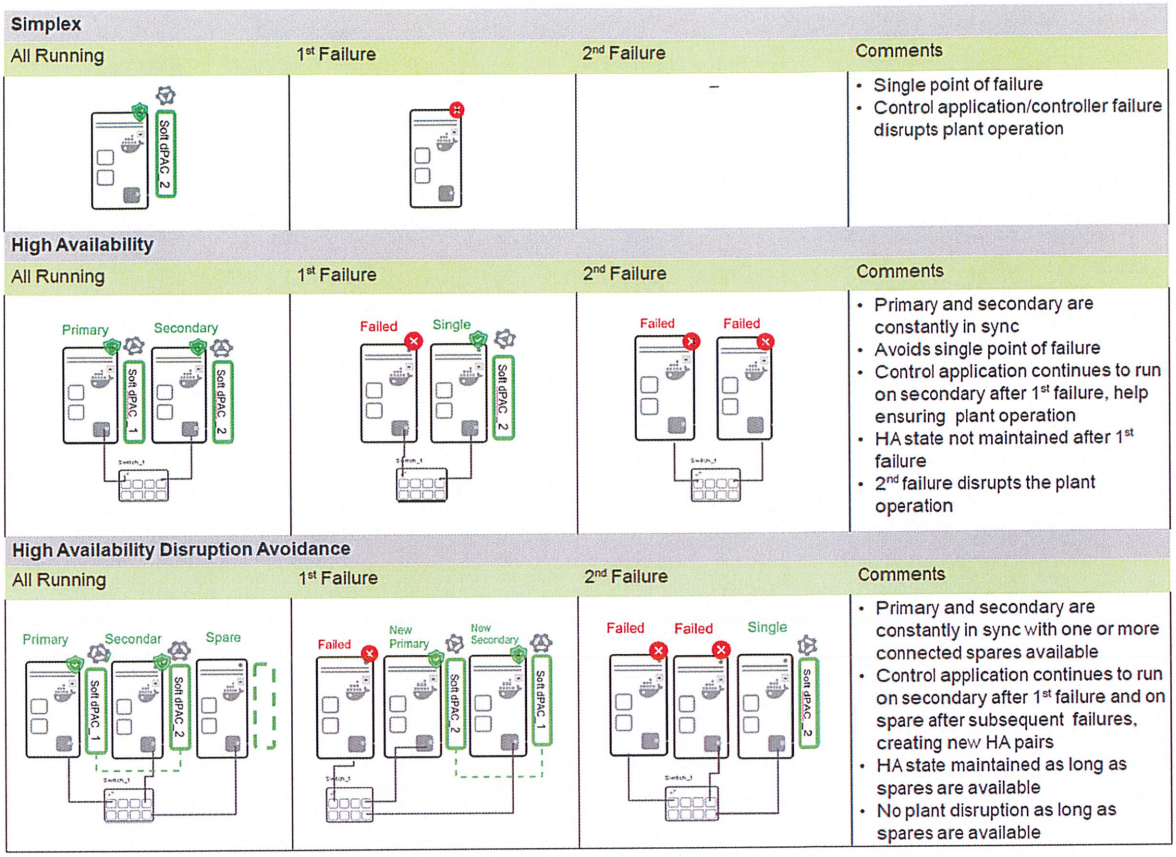


Figure 5-4 Simplex vs High Availability Architectures

Design Note: *At the heart of a high-availability architecture are two iPCs - Preferred Primary and Non-Preferred Primary, with identical hardware configurations, based on Linux software connected via a high-speed (1 Gbps) communication link.*

The Preferred Primary device executes the application program and controls the I/Os located in Modicon X80 drops. The Non-Preferred Primary remains in the background. In the event of a detected error affecting the Primary device, the Standby system switches over automatically, changing over the execution of the application program and control of the I/O to the Standby device with an up-to-date data context. Once the changeover is complete, the Standby device becomes the Primary device while the former Primary device is being cleared from the detected error; when clearance is done, the device reconnects to the standby system and acts as the Standby device. The changeover from Primary to Standby is performed smoothly at the outputs and is completely transparent to the process.

Design Note: *For high-availability applications, two BMXCPSxx02 redundant power supplies can be used on the same rack to increase the availability of power supply. They are supported by 6-slot BMEXBP0602 backplane and 10-slot BMEXBP1002 backplane equipped with dual slots marked CPS1 and CPS2. On CPS1 slot, the power supply is initially set as Primary and on CPS2 slot, as Standby. When power stops being supplied in accordance with expected rate, they switch roles so that power can be continuously delivered.*

See Modicon X80 modules catalog for more details.

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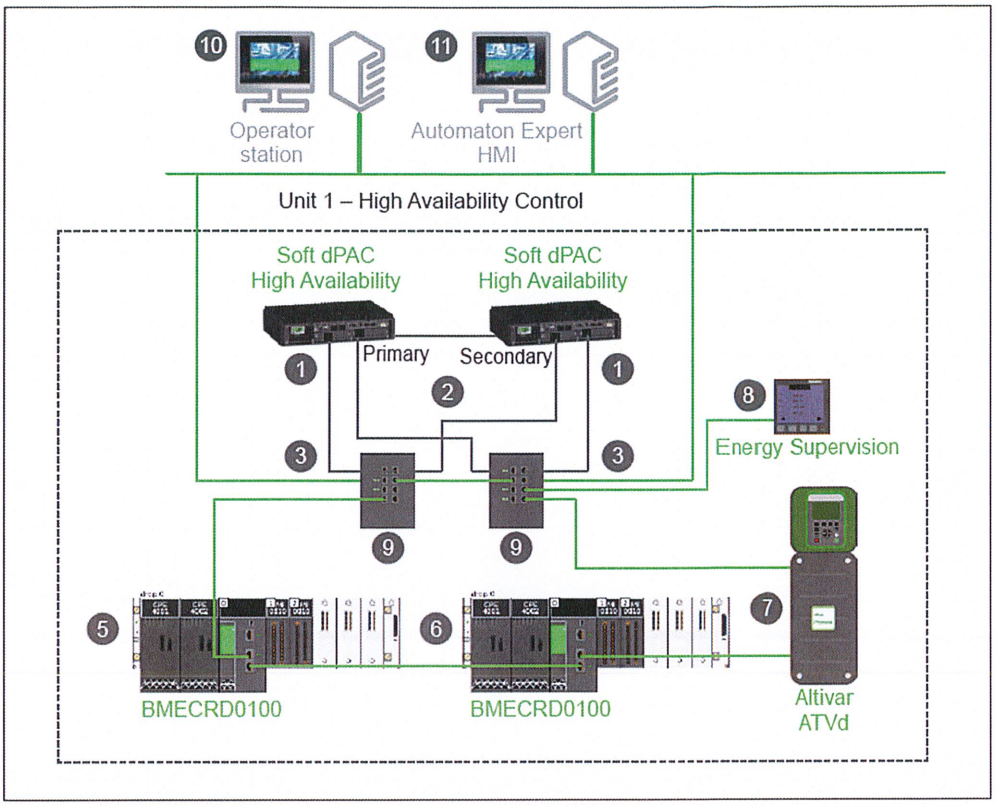
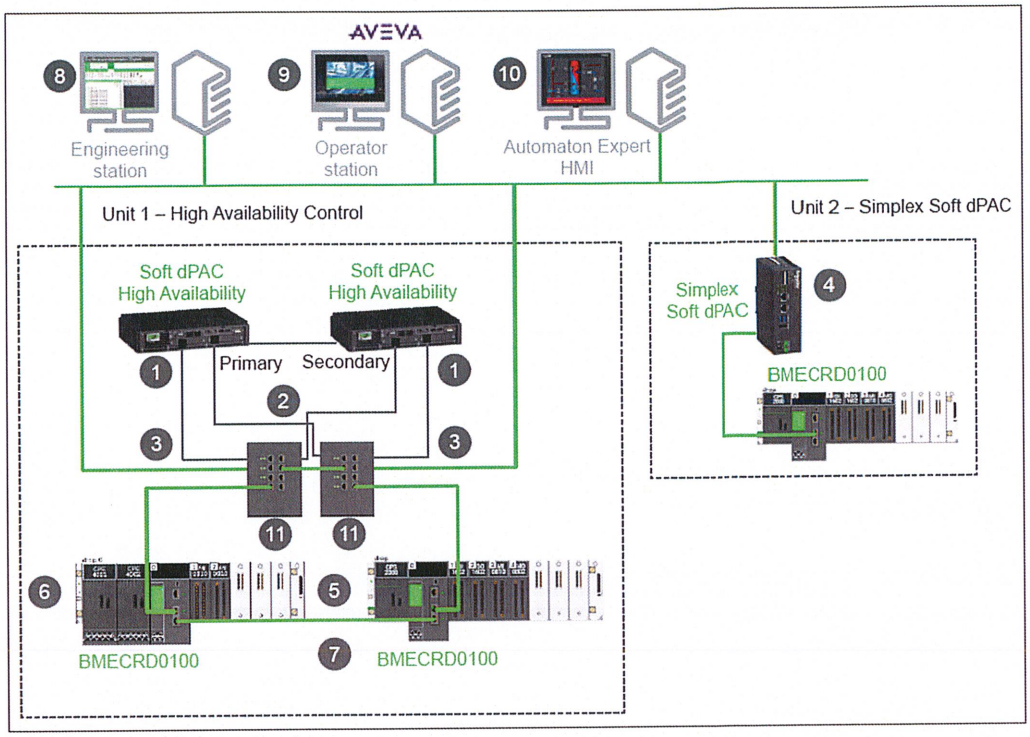


Figure 5-5 Example of High Availability Architectures (HA)

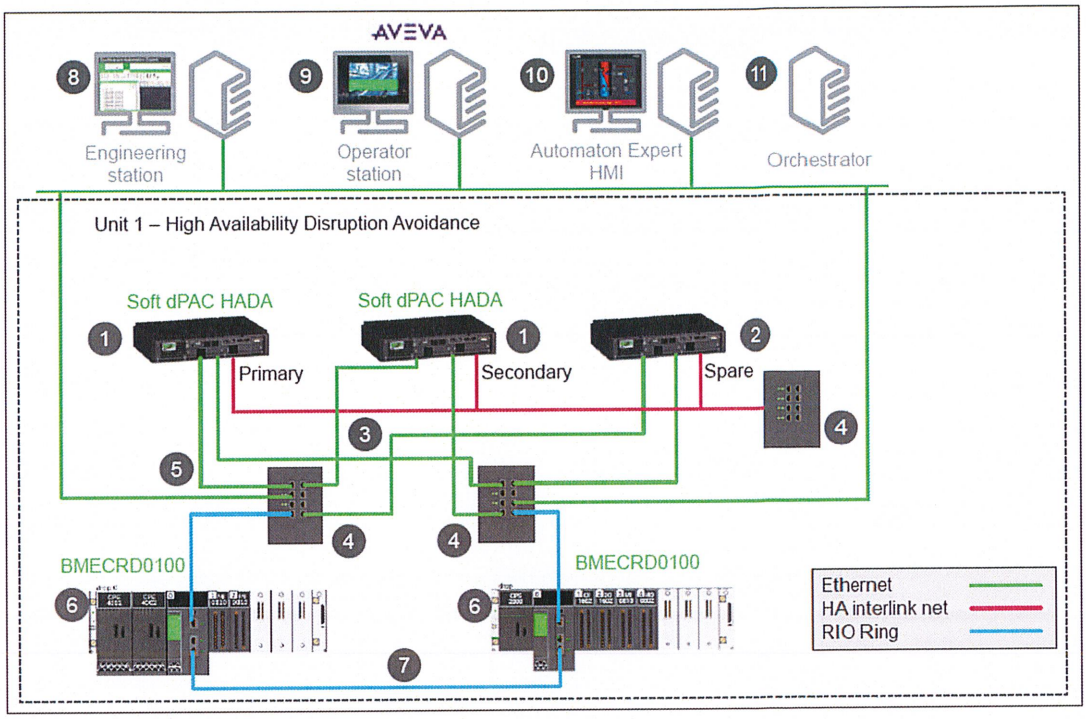
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1. Linux-based *i*PC pair, each hosting an instance of High Availability Soft dPAC
2. HA Interlink: 1GB/s Network Interface Card (NIC)/connection
3. Redundant network: 100MB/s with NIC bonding
4. Linux-based standalone *i*PC, hosting an instance of non-redundant Soft dPAC
5. Non-redundant Modicon X80 I/O drop with BMECRD0100 RIO drop adapter and redundant power supplies
6. Non-redundant Modicon X80 I/O drop with BMECRD0100 RIO drop adapter and redundant power supplies
7. Remote I/O RSTP - enabled ring network
8. Workstation running EcoStruxure Automation Expert Build Time
9. Workstation running AVEVA System Platform (ASP), AVEVA Operation Management Interface (OMI), and AVEVA historian. Communication is over OPC UA
10. Workstation running EcoStruxure Automation Expert Runtime HMI
11. Managed switches, for example, Modicon switch

Figure 5-6 Example of High Availability & Simplex Architectures

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1. Linux-based *i*PC pair, each hosting an instance of High Availability Soft dPAC
2. Linux-based *i*PC spare
3. HADA Interlink network: 1GB/s Network Interface Card (NIC)/connection
4. Managed switch, for example, Modicon switch
5. Redundant network: 100MB/s with NIC bonding
6. Non-redundant Modicon X80 I/O drop with BMECRD0100 RIO drop adapter and redundant power supplies
7. Remote I/O RSTP - enabled ring network
8. Workstation running EcoStruxure Automation Expert Build Time
9. Workstation running AVEVA System Platform (ASP), AVEVA Operation Management Interface (OMI), and AVEVA historian. Communication is over OPC UA
10. Workstation running EcoStruxure Automation Expert Runtime HMI
11. Orchestrator for High Availability Soft dPAC

Figure 5-7 Example of High Availability Disruption Avoidance Architecture (HADA)

5.3 PCS Network Design

For the PCS systems that incorporate the distributed CPU and I/O architecture, the network that interconnects them is of vital importance. The design of the PCS network is influenced by several factors:

- How the physical plant facilities are arranged.
- Number of PLCs across the plant to be interconnected
- Number of manufacturers supplied PLCs
- HMI locations desired throughout the site
- Communications required for remote (off-site) facilities such as Lift Stations
- Availability of proprietary manufacturer remote connections for Warranty maintenance

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The I&C Design Engineer and CoT Personnel will work together to layout the network to meet the intent of the current project, while allowing for easy modifications to accommodate future projects. Over time as the PCS expands and is upgraded, the network must evolve along with the expansion. The design of a PCS network topology should be a Hybrid network. A Hybrid network combines the different topologies (Ring, Star, Mesh, etc.) and allows for maximum flexibility. Refer to Appendix E for topology detail and Appendix C2 for IP addressing responsibility and cabling requirements.

For distributed CPU architectures, the Hybrid network typically consists of a fiber-optic ring backbone between CPU racks, and Star network connections to manufacturer supplied PLC panels or equipment controllers such as variable frequency drives. The ring involves running fiber optic cable from each distributed CPU to the next unit and finally back to the starting CPU. The ring topology requires network switches that allow for ring communications. Within each building/process a star network can be configured using copper CAT6 or fiber optic cabling to interconnect devices within the building to the network switch. A fiber-optic ring backbone between dPAC panels, using Rapid Spanning Tree Protocol (RSTP) for redundancy, is preferred between buildings, with Star connections to manufacturer-supplied panels or VFDs within a building.

For distributed I/O architectures, a Device Level Ring should be used. The fiber optic ring is connected to networks switches and CPUs which are Device Level Ring enabled.

> ***Design Note:*** *The fiber optic backbone (ring) cable enters each control panel and is terminated to a Fiber Optic Patch Panel (FOPP) for distribution. The FOPP should be installed in the control panel. The fiber optic cable used to interconnect panels should be 12 strands, minimum. Two (2) strands are used for CPU communications, and the remainder for other plant systems such as security, fire and spares.*

> ***Design Note:*** *The fiber optic star cable enters each control panel and is terminated to a Fiber Optic Patch Panel (FOPP) for distribution. The FOPP should be installed in the control panel. The fiber optic cable used make a star connection from the CPU panel to manufacturer supplied panels and ethernet based equipment should be four (4) strands, minimum. Two (2) strands are used for CPU communications, and the remainder are spares.*

For remote network communications to off-site facilities there are several choices:

- Radio (Licensed and/or unlicensed) – radio systems need to have "Line-of-sight" or paths with minimal physical obstructions (tall building, trees, etc.) which impede/reduce radio signal strength below the minimum required. A physical radio survey must be done to confirm paths and antenna heights before installation of any permanent infrastructure (cabling, antennas, masts/poles towers). Depending on the survey results, the initial capital costs of this option can be exorbitant to cover the costs of the antenna towers. The operational costs are low compared to the recurring costs seen for other options. Radio transmission can be negatively affected by weather and other nearby radios.

- **Phone/Cable Telemetry –** requires modem to connect to the utility lines. System utilizes the phone/cable utility infrastructure to communicate between sites. Data bandwidth provided by the telcom utilities are not prohibitive for communications between remote pump stations, flow equalization basins, and the plant. There are recurring monthly fees based on data usage that are negotiated with the utility.

- Cellular – requires that cellular service (LTE, 4G and now 5G) is available at the remote location. Cellular antennas are typically small and do not require special installations like radio systems. Data rates are generally low bandwidth and do not require 5G. There are recurring monthly fees based on data usage that are negotiated with your local provider. Due to the low bandwidth restrictions, cellular is only recommended for very small sites such as meter or valve vaults located out in the collection system.

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- **Fiber Optic Cable –** installation of a fiber optic cable network in the service area that connects the remote sites back to the treatment plant. This is usually cost prohibitive, unless a process pipe is also being installed between the two sites. The fiber optic cable can then be installed in the same trench as the pipe.

In some instances, a manufacturer provided control system is provided along with their process equipment, and the manufacturer requires/recommends a remote connection to their control system. This remote connection allows the manufacturer to monitor and/or work on the equipment from their service center. Some manufacturers of highly proprietary equipment require this connection for maintaining the warranty. Third party connections to the plant SCADA system are not allowed. The Engineer should work with the manufacturer to eliminate this connection request.

5.4 Automation Hardware Selection Considerations

In conjunction with the decisions made by CoT Personnel and the I&C Design Engineer for CPU distribution and network topology, the PLC hardware must be chosen. The chosen hardware must seamlessly work with the CPU and the field I/O that will be monitored and controlled. There are several design aspects that require consideration when selecting the PLC hardware:

- Physical and environmental conditions
- Electrical Properties of Input/Output modules
- Wiring and Interface requirements of Input/Output modules

Physical and Environmental

- Enclosure rating: NEMA 4X is the CoT default/minimum for new PCS panels (Appendix D4); a lower rating requires CoT approval for a qualifying indoor electrical-room location.
- Will PLC cabinets require heating and/or cooling? The PLC hardware generally has a temperature range: Standard 32 to 140 Deg. F; Extended - (-4...+158 F).
- Will PLC cabinets be exposed to a corrosive atmosphere? Conformal Coating of the PLC hardware modules should be specified for corrosive or damp/wet areas.

Electrical Properties

Since the PLC I/O modules interface directly with the process control equipment (motors, valves, instrumentation, etc.) consideration must be given to voltages and currents that will be seen by the hardware. The selection of the PLC Hardware components will be dependent on the voltages and currents present in the field. The main item that drives selection for discrete I/O is the voltage provided or seen by the PLC hardware. Below are recommendations for discrete I/O hardware voltages. Refer to Appendices A, B, and C for the additional options compatible with the UAO runtime.

- PLC Power supplies: 24 VDC is preferred for all new construction. Although 24 VDC is recommended for upgrades also, existing panels may not have DC available and no space for additional power supplies. In this case, the selection of a 120VAC unit would be required.
- Discrete Input modules: 24VDC is the preferred voltage for all new construction. Limiting the voltage seen in the panel, allows for CoT Personnel to work safely on the panel and PLC hardware without the need for special arc flash precautions and personal protective equipment. For upgrades to existing processes, the field equipment that is not upgraded may be wired for 120VAC. In this case, 120 VAC I/O modules would be selected to accommodate this existing wiring.

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- Discrete Output modules: There are several types of output modules – relay, isolated and nonisolated. The relay type modules are the preferred option. Relay modules have a dry-contact output that has no specific voltage provided. The relay contacts allow for these modules to interact with either 24 VDC or 120 VAC systems without the need for interposing equipment.

The main item that drives selection for Analog I/O is whether voltage or current is provided or seen by the PLC hardware. Below are recommendations for analog I/O hardware.

- Analog Input modules: these modules come as either current (4-20mA) or voltage (1-5 VDC, 0- 10VDC) inputs. The 4-20mA current version is preferred, since the majority of field devices provide current outputs.
- Analog Output modules: these modules come as either current (4-20mA) or voltage (1-5 VDC, 0- 10VDC) outputs. The 4-20mA current version is preferred since the majority of field devices are current driven.

Process equipment may have instruments that provide signaling different from what is specified above. A common example in the water and wastewater treatment process is temperature monitoring using RTD or thermocouples. The PLC has the capability to directly accept some of these different signals, removing the need for a third-party controller. These specialty IO modules include a wide variety of choices including thermocouple and RTD modules.

Wiring and Interface

Beyond the characteristics of the PLC hardware modules themselves, how they are wired to the field devices and laid out in the panel are important to the overall integrity and safety of the system. The recommended practices for each module are described below. Refer to Appendix G for wiring and panel layout examples.

All field wiring should be terminated to subplate mounted terminal blocks inside the control panel and not directly to the PLC IO modules. Terminal blocks shall be individually numbered, colored and grouped per input type. Inside the control panel, analog and discrete wiring shall be run in separate wire ducts, to the extent possible, and when necessary cross at 90-degree angles. Terminal block shall accept a minimum of (2) #14 wires and be rated for a minimum of 300VAC/VDC.

- Discrete Input modules: Each individual module shall have the module power feed fused. Discrete inputs from a single piece of equipment shall be grouped together on the same module. A single fuse shall be installed on the panel power feed to the process equipment's discrete input field contacts. Fuse holders should have a Blown Fuse indicator light for ease of troubleshooting.
- Discrete Output Module: Each individual module shall have the module power feed fused, if necessary. Install a fuse on the source voltage for each relay output. The relay output contacts are rated for 2 amps. If the control circuit incorporating this relay contact will draw more than 1.5 amps, an interposing relay should be provided. If an isolated or non-isolated module (utilizing transistor outputs) is used instead of the recommended relay output, it is strongly recommended that each individual output whether 24VDC or 120 VAC have an interposing relay wired to it. The interposing relay provides both a level of electrical isolation between the transistor output and the field device to prevent back-feeding of potential harmful voltage, and provide the additional current carrying capacity for the control circuit that a transistor does not provide. Interposing relays shall be double pull double throw, and 120VAC or 24VDC depending on the panel power available. 24 VDC is recommend.
- Analog Input module: Each individual input shall have a surge protection device wired in series with the current input. Alternatively, as a less expensive option, fuses can be installed instead of the surge protection device. The

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surge protection device is recommended as it can withstand multiple surges and maintain the loop operating while continuing to protect the PLC. For the fuse, once it is blown the loop is interrupted until it is replaced.

- Analog Output module: Each individual output shall have a surge protection device wired in series with the output. Alternatively, as a less expensive option, fuses can be installed instead of the surge protection device. The surge protection device is recommended as it can withstand multiple surges and maintain the loop operating while continuing to protect the PLC. For the fuse, once it is blown the loop is interrupted until it is replaced.

6 EAE SOFTWARE PLATFORM STANDARDS

6.1 Software Version and Compatibility

All software and hardware specified under this standard shall be compatible with EcoStruxure Automation Expert v26.0 and later. Where a feature referenced in this standard (for example, the v26.0 lift station library referenced in Section 7) is not yet available in the currently installed EAE version at a given site, the Automation/I&C Design Engineer shall coordinate with CoT to confirm the upgrade path before relying on that feature in the design.

6.2 Consultant Resources — Help and Training

The following resources shall be provided to consultants and system integrators working under this standard:

- https://youtube.com/playlist?list=PLa7UGrWOTyjkvGehn-WZtJ9Aif36xTemR&si=SBg2jMJI3OOlOyFI• **EAE explanation videos (YouTube playlist):** https://youtube.com/playlist?list=PLa7UGrWOTyjkvGehn-WZtJ9Aif36xTemR&si=SBg2jMJI3OOlOyFI
- https://www.se.com/us/en/product-range/223435768-modicon-edge-i-o-nts/#products• **Modicon Edge I/O NTS product information:** https://www.se.com/us/en/product-range/223435768-modicon-edge-i-o-nts/#products
- https://product-help.se.com/EcoStruxure%20Automation%20Expert/25.0?theme=EcoStruxure%20Automation%20Expert• **EcoStruxure Automation Expert product help — v25.0:** https://product-help.se.com/EcoStruxure%20Automation%20Expert/25.0?theme=EcoStruxure%20Automation%20Expert *(v26.0 link: open item — to be added once published; use the v25.0 reference above in the interim, and confirm version-specific deltas against the v26.0 release notes.)*
- IEC 61499 training: create a free MySchneider account, then use it to access Schneider's partner training portal for the "Industrial Automation using EcoStruxure Automation Expert" eLearning course.
- https://www.se.com/myschneider/onboarding?app=mySchneiderWeb• **MySchneider account creation:** https://www.se.com/myschneider/onboarding?app=mySchneiderWeb
- https://www.se.com/myschneider/partners?alink=https://schneider-electric.csod.com/LMS/LoDetails/DetailsLo.aspx?loid=d4c7f5e8-0bdc-4449-a0b9-e2baddcc6c40• **IEC 61499 / EAE eLearning (via MySchneider partner portal):** https://www.se.com/myschneider/partners?alink=https://schneider-electric.csod.com/LMS/LoDetails/DetailsLo.aspx?loid=d4c7f5e8-0bdc-4449-a0b9-e2baddcc6c40

Public

- https://drive.google.com/drive/folders/1OBPtgCPV6nSFE9ltHOl4BsINNMSSBPzy?usp=drive_link• **Full demo projects ("Demo Projects" folder):** https://drive.google.com/drive/folders/1OBPtgCPV6nSFE9ltHOl4BsINNMSSBPzy?usp=drive_link

6.3 Consultant Resources — EAE Qualification

Schneider Electric will help any interested parties learn and qualify to use EAE. If interested, reach out to your local Schneider rep or Nathan.Henderson@SE.com. Nathan is the System Integrator development lead in the Schneider EAE team.

- Training will consist of
    - 2-day intro workshop
    - Online VILT Training
    - 5-day Masterclass
- System Integrators will be officially badged by Schneider electric as EAE certified once they have at least 2 employees complete the VILT training and they've executed an EAE project.

6.4 Control Logic and Library Standards

Control logic shall be built primarily from standard EAE APP libraries; the City of Tulsa custom library shall supply any CoT-specific standardization not covered by the standard libraries.

> ***Open item:*** *The CoT custom library is under active development (Schneider Electric point of contact: Aayush Patel). Once established, project submittals shall include a PDF of the Execution Control Chart (ECC) for each custom Function Block (FB), Composite Automation Type (CAT), and Composite Automation Type Object (CATO) used, as part of the design deliverable set.*

No essential process logic shall reside at the HMI/graphics layer — control decisions belong in the dPAC/control-node application, not in display scripting. This principle applies even where the control application and HMI are engineered within the same EAE project, since keeping logic out of the graphics layer preserves a single, auditable location for process behavior regardless of platform.

The current list of acceptable libraries to be used is:

Library Name	Short Description	Extended Description
Runtime.Base	Standard blocks	This library contains the basic function blocks to be used for runtime management, arithmetic functions, logic functions, format conversion, event management, etc.
NTS EdgeIO library	Edge I/O Integration	-
SE.App2Base	Elementary blocks of the application	Library with application CATs covering basic application functions like alarms, conditions, owners, and signal conditioning that are used by other application CATs like the ones from SE.App2CommonProcess.
SE.App2CommonProcess	Common process application	Library with application CATs to address common process assets or functions like digital I/O, analog I/O, motors, valves, flow control, etc. These types of object can be used in any industrial application as well as in process control in manufacturing applications.

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SE.App2Conveying	Conveying application	Library with application CATs to address common equipment such as conveyors, sorters, transfer tables, and turntables, typically used in logistic hubs and distribution centers.
SE.App2LiquidFood	Liquid and food (CPG)	Library with application CATs to address Liquid and Food applications with mix proof valves; transfer of materials and liquids from a source to a destination; and equipment status function is a crucial component within a system that monitors and reports the operational condition of various equipment.
SE.App2MMM	Mining, Mineral and Metals application	Library with the Group Control application CAT to manage and control multiple devices as a group, simplifying the process of coordinating and supervising various elements within a system.
SE.App2BMS	Building management system application	Library with objects targeting HVAC system and air handling unit to suit building management system applications.
SE.App2SingleLinePowerMonitoring	Low and medium power monitoring application	Library with application CATs with common functions for electrical objects such as busbars, sources, infeeds, and loads that can be connected to energy management hardware CATs.
SE.App2WWW	State management	Library with application CATs used to monitor and manage control sequences like aeration and dual media filter for Water and Wastewater applications.
SE.App2StateManagement	State management	Library with application CATs to provide state management functionality for generic application (State Manager) as well as ISA-88 based application (Phase Manager). Phase Manager also includes a phase logical interface that accepts commands from external batching interfaces such as AVEVA Batch Management and returns the Phase Manager status.
SE.AppSequence	Sequence Control	Library with a set of application CATs that allows you to create sequential control algorithms with steps and transitions to command control modules. This library works with both SE.AppCommonProcess and t.App2CommonProcess.
SE.DPAC	dPAC hardware controllers	Library containing the dPAC device types
AVEVA.IndustrialGraphicsLibrary	Industrial graphics library	Industrial Graphics are vector-based graphics that can be scaled, animated, embedded into application objects, and deployed. The library contains common industrial equipment. You can modify graphics or add graphics to the library by creating new graphics using the Industrial Graphic Editor.
SE.EAEPortal	AVEVA System Platform Device type	The AVEVA System Platform device type is required by Asset Link for establishing communication and creating the application objects automatically in AVEVA System Platform
SE.FieldDevice	Field device hardware CATs	This library has ready-to-use hardware CATs for motor control, energy management, machine safety, and weighing from Schneider Electric, allowing dPAC communication with these devices by Modbus TCP, Modbus RTU, or EtherNet/IP depending on the device.
SE.HwCommon	Common hardware CAT functions	Library of functions used by the various hardware CAT libraries
SE.IoATV	Variable speed drive I/O services for ATV dPAC	Library of hardware CATs for Altivar I/O (local and modules) used for the Altivar dPAC module hardware configuration
SE.IoNet	UDP gateway	Library of hardware CATs to enable UDP communication

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SE.IoTMx	TM I/O services for M251d/M262d	Library of hardware CATs for TM3 I/O modules used for M251d and M262d hardware configuration
SE.IoX80	X80 I/O services for M580d/CRd	Library of hardware CATs for X80 I/O modules used for M580d/CRd hardware configuration
SE.ModEdgeIONTS	Edge I/O NTS services for Simplex Linux Soft dPAC	Library of hardware CATs for Modicon Edge I/O NTS
SE.ModbusGateway	Standard Modbus gateway	Library of hardware CATs to enable Modbus TCP communication with import of data description file
SE.Standard	EcoStruxure Automation Expert HMI device type	Library with EcoStruxure Automation Expert HMI device type
Standard.IoEtherNetIP	Standard Ethernet IP scanner functions	Library of hardware CATs used for EIP scanner configuration (Implicit use by the EcoStruxure Automation Expert system when using the EIP scanner and also to add custom EIP connections)
Standard.IoModbus	Standard Modbus functions	Library of hardware CATs to enable Modbus client communication
Standard.IoModbusSlave	Standard Modbus server functions	Library of hardware CATs to enable Modbus server communication
Standard.OPCUAClient	Standard OPC UA client functions	Functions to enable OPC UA client connection, monitor, read, and write data
Standard.EtherCAT	Standard EtherCAT functions	Library for configuring hardware CATs on EtherCAT main device and subdevices to enable communication.
Standard.IoPROFINET	Standard PROFINET functions for I/O Controller and I/O device	Library of hardware CATs and function blocks used to enable PROFINET I/O controller and I/O device roles.

6.5 Tagging

Tag-naming convention is outside the scope of this hardware/software standard. Tagging shall follow the City's Lucity asset-management standard; EAE shall be configured to auto-populate the function and type portions of the tag from its object model rather than requiring them to be manually re-keyed for each instance.

- Water Pollution Control (WPC) side: per the WPC tagging Excel convention (provided separately by CoT).
- Water side: per the existing Mohawk-facility documentation, as previously provided for the Spavinaw project.
- ABJ tagging standards apply where in effect; Automation/I&C Design Engineer shall request the current copy from CoT if not already on hand.

6.6 Historian (Tier 1 — EAE Archive)

EAE Archive is the Tier 1 historian and shall be used on all standard projects. By default, all instrumentation points and calculated process setpoints shall be trended at a 5-second interval; this default may be reviewed and adjusted by CoT ICS team as conditions dictate (e.g., reduced for slow-changing points to manage storage, or increased for loop-tuning studies).

IPC and storage sizing guidance

Public

- Size the Archive host IPC's processor and RAM to the project's total tag count and trend interval, consistent with the HA Soft dPAC sizing guidance in Appendix B (multi-core x86, ECC RAM recommended).
- Size local storage using: tag count × trend rate × bytes/sample × retention period, with margin for alarm/event journaling in addition to trend data; confirm current per-tag storage estimates against the EAE Archive sizing guidance in the product help (Section 6.2) at time of design, since compression and per-sample overhead vary by release.
- Provide redundant storage (RAID or equivalent) on any Archive host serving as the plant's system-of-record historian, and define a backup/retention schedule consistent with CoT IT data-retention policy.

6.7 Historian (Tier 2 — PI)

OSIsoft/AVEVA PI Historian integration is Tier 2 and is generally outside the scope of most projects. Where a specific project scope calls for PI integration, this shall be identified during the basis-of-design phase, since it introduces an additional data path (EAE Archive/OPC UA to PI) requiring coordination with CoT IT.

6.8 Graphics Standards

For lift stations and pump stations, new graphics shall be built natively in EAE v26 EAE-HMI rather than AVEVA System Platform/InTouch, since EAE-HMI removes the extra buildtime hop and the Asset Link for AVEVA OMI translation step that a split EAE/AVEVA architecture requires.

> ***Open item:*** *Sites with existing AVEVA InTouch/System Platform graphics need a defined transition strategy rather than a blanket rule. Options to evaluate per project: (a) full graphics rebuild in EAE-HMI at the time of the automation upgrade; (b) hybrid operation, with EAE Archive/OPC UA feeding AVEVA System Platform for a defined transition period; or (c) continued AVEVA OMI generation via Asset Link, where EAE remains the control layer but System Platform remains the plant-wide SCADA client. Under option (c), OMI generation would continue to be used; under (a) or a site-wide EAE-graphics decision, OMI generation would not be needed for that site. CoT shall decide, on a per-facility basis (e.g., whether Spavinaw Dam is built graphics-native in EAE or remains on the AVEVA path), and document that decision in the project basis-of-design.*

Graphics shall follow ISA-101 (Human-Machine Interfaces for Process Automation Systems) situational-awareness principles: low-saturation, low-contrast backgrounds; color and animation reserved for abnormal/alarm conditions rather than used decoratively; hierarchical navigation from a plant-level overview down to loop/equipment-level detail; and a consistent symbol library across displays.

Provide pop-up faceplate boxes that allow instrument-technician-level users to calibrate or adjust field devices directly from the HMI, without requiring access to the underlying control logic.

For larger sites, consult with the CoT ICS team to determine whether to use the native EAE-HMI or AVEVA System Platform graphics.

6.9 Users and Security Levels

Provide a 15-level user security model. The table below is the CoT default starting point; CoT and the Automation/I&C Design Engineer shall confirm role names and permissions per project and may consolidate levels where a smaller facility does not need the full 15-tier granularity.

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Level	Role (default)	Typical Permissions
1	Guest / View Only	View displays and trends; no control, no alarm actions
2	Operator – View & Acknowledge	Level 1, plus alarm acknowledgment
3	Operator – Standard	Level 2, plus manual start/stop within permitted equipment groups
4	Operator – Senior	Level 3, plus setpoint adjustment within engineered limits
5	Shift Supervisor	Level 4, plus alarm silence/reset and mode changes (Auto/Manual)
6	Maintenance – Mechanical	Equipment out-of-service tagging, maintenance-mode overrides
7	Maintenance – Electrical	Level 6, plus MCC/VFD parameter view
8	Maintenance – Instrument Technician	Field device calibration pop-ups (Section 6.7); no logic access
9	Process Engineer – View	Full read access to logic, tuning parameters, and historian configuration
10	Process Engineer – Tuning	Level 9, plus PID/setpoint tuning parameter write access
11	Controls Engineer – Read	Read access to EAE application logic and CATs/CATOs
12	Controls Engineer – Write	Logic edit and download; requires change-control per Section 4.1
13	System Integrator / Commissioning	Temporary elevated access during commissioning; time-limited account
14	IT/OT Network Administrator	Network, switch, firewall, and UPS communications configuration
15	System Administrator	Full platform administration, including user/security-level management

6.10 Licensing

Every project delivered under this standard MUST include all relevant software licenses required for a complete, operable system, itemized as a licensing bill-of-materials in the project submittal:

- EAE Professional perpetual license(s) – sized per concurrent engineering seat
- EAE Application runtime license– sized per total I/O count of the system as applicable to the project scope

Existing system upgrades may already contain the required licenses. Consult with the CoT ICS Team to determine if a new license is required.

Public

7 EXAMPLE PROGRAM — PUMP / LIFT STATION FUNCTIONAL DESCRIPTION

This section provides a standard, anonymized functional description (control narrative) for pump and lift station control for use as the starting point on new lift/pump station work. Tag names below (Pump 1, Level 1, etc.) are generic placeholders per Section 6.4 and shall be replaced with project tags per the Lucity-based tagging convention — they are not to be carried into design as-is.

> ***Design Note:*** *EAE v26.0 includes a lift station APP library. Per Section 6.3, that library shall be used as the base for the logic described below, supplemented with CoT custom FBs/CATs only where the standard library does not cover a City-specific requirement. Confirm current library scope against the v26.0 release notes (Section 6.2) at time of design.*

7.1 Station Configurations

This functional description covers three station sizes, each following the same control philosophy: 2-pump, 3-pump, and 4-pump duplex/triplex/quadruplex configurations, each pump driven by a dedicated VFD.

7.2 Instrumentation

Tag (generic)	Description
LIT-1	Wet well level transmitter (primary, e.g., submersible or ultrasonic)
LSHH-1 / LSLL-1	Wet well high-high / low-low level float switches (backup to LIT-1)
PIT-1	Common discharge header pressure transmitter
FIT-1	Common discharge header flow meter (optional, project-dependent)
Pump 1–4	Pump run status, fault status, seal-fail status, motor-overtemp status, run-hours, starts count (per pump, VFD-driven)
VFD 1–4	VFD fault, VFD speed feedback, VFD ready/run status (per pump)

7.3 Modes of Operation

Each pump provides a panel-mounted Hand-Off-Auto (HOA) selector per Appendix G4. In Hand, the pump runs at a fixed operator-set speed under local control, bypassing station sequencing. In Off, the pump is disabled from both local and automatic control. In Auto, the pump is available to the automatic lead-lag sequencing described below. A software-level Auto/Manual mode is also provided at the HMI for each active control loop (level or pressure), allowing an operator to hold a manual speed output without removing a pump from Auto at the HOA switch.

7.4 Lead-Lag(-Lag2-Lag3) Rotation

Pumps available in Auto are assigned Lead, Lag 1, Lag 2, and Lag 3 roles (as applicable to the station's pump count). Role assignment rotates on each stop of the lead pump, or after an elapsed run-time or start-count threshold is reached (whichever the City selects as the alternation criterion), so that wear is equalized across all available pumps over time. A pump that is faulted or placed in Hand/Off is automatically skipped in the rotation and does not receive a lead/lag role until it is returned to Auto and its fault is cleared.

7.5 Level-Based Control

Where the station is configured for wet-well level control, a PID loop drives the lead pump's VFD speed to hold LIT-1 at the station's level setpoint. As inflow increases and the lead pump reaches maximum speed without achieving

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setpoint, Lag 1 is staged in; if level continues to rise, Lag 2 and Lag 3 (where present) stage in similarly. As level falls, lag pumps are destaged in reverse order, and the remaining pump(s) decelerate toward minimum speed before the last pump stops, all subject to the minimum run-time and anti-cycling protections in Section 7.7.

7.6 Pressure-Based Control

Where the station is configured for discharge pressure control (e.g., a station feeding directly into a pressurized distribution or force-main network rather than gravity-fed downstream capacity), the same lead-lag staging logic applies, but the PID loop instead drives lead-pump VFD speed to hold PIT-1 at the station's discharge pressure setpoint, staging and destaging lag pumps as needed to maintain pressure under varying demand.

7.7 Permissives, Interlocks, and Protections

- A pump shall not start if its seal-fail, motor-overtemp, or VFD-fault status is active.
- LSHH-1 (high-high level) shall force all available pumps to run at full speed regardless of the active PID mode, overriding normal staging logic, until level falls below the high-high setpoint.
- LSLL-1 (low-low level) shall stop all pumps to prevent dry running, regardless of demand, until level rises above the low-low setpoint.
- Minimum run-time and minimum off-time timers shall be applied per pump to prevent short-cycling during staging/destaging.
- Loss of LIT-1 (or PIT-1, as applicable to the active control mode) shall transfer control to the backup float switches (or a fixed backup pressure band) and raise an instrument-fail alarm, rather than allowing an uncontrolled PID output.

7.8 Alarms

- Wet well high-high / low-low level
- Pump fail to start / fail to stop, per pump
- Seal-fail, per pump
- Motor overtemperature, per pump
- VFD fault, per pump
- Instrument fail (LIT-1, PIT-1, FIT-1)
- Loss of communication (dPAC, network, or HMI)
- Primary power failure / on generator or UPS battery (per Appendix D2/D3 transfer scheme)

7.9 Historian Points

All points listed in Sections 7.2 and 7.8, plus PID setpoint(s) and calculated lead-pump speed output, shall be trended at the Section 6.5 default 1-second interval, with retention and interval subject to review by CoT ICS Team.

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APPENDIX A — dPAC HARDWARE FAMILY

This appendix outlines the current Schneider Electric Modicon dPAC family available under this standard: ATV dPAC, M251dPAC, M262dPAC, M580dPAC, Harmony BX1, Harmony P6. Confirm exact catalog numbers against the current Schneider Electric EAE hardware reference at time of design, as EAE hardware compatibility is expanded periodically.

Recommended/Preferred selections based on the design decisions discussed in the standard are in BOLD.

> ***Design Note:*** *This appendix is intended to expand over time rather than serve as an exhaustive hardware list. As new dPAC form factors are released within the EAE ecosystem, the Automation/I&C Design Engineer shall evaluate them against the T-shirt-sizing framework below and this standard shall be updated accordingly.*

A0 T-Shirt Sizing Overview

dPAC	Class	Typical I/O Range	Relative Scan Speed	Redundancy	Typical Application
ATV dPAC	XS	Drive I/O only (embedded)	Fast (drive-local)	No	Distributed VFD control or small modular machines
M251	S	Up to ~500 I/O	Standard	No	Small single-building site, e.g., a regional lift station or small modular machines
M262	S/M	Up to ~500 I/O	Fast	No	Small single-building site, e.g., a regional lift station or performance modular machines
M580	S/M/L	Up to several thousand I/O, expandable via RIO	High	No	Small/Medium distributed treatment plant with real time applications
SoftdPAC (Windows OS)	S/M/L	Up to several thousand I/O, expandable via RIO	High	No	Non real time applications
SoftdPAC (Linux OS)	S/M/L	Up to several thousand I/O, expandable via RIO	High	No	Large distributed treatment plant with real time applications
Soft dPAC HA	S/M/L	Up to several thousand I/O, expandable via RIO	High	Yes	Large distributed treatment plant with redundant real time applications

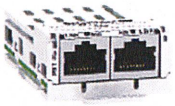
A1 ATV dPAC (Drive-Embedded)

The ATV dPAC is a slide-in dPAC module for the ATV600, ATV900, and ATV340 variable frequency drive families, embedding a control node directly within the drive. For any drive within the ATV600, ATV900, and ATV340 families, the ATV dPAC will be installed.

Public



Altivar Process drives slots



VW3A3530D

The ATV dPAC module is distributed controller solution platform, with 12 MB memory for programs and data. It is intended to be used as a slide-in option for ATV600, ATV900, and ATV340 variable speed drive (VSD) families(1). The Altivar ATV dPAC module is powered by the drive and provides dual Ethernet sockets for connection to peer controllers, distributed I/O, or remote secondary devices.

Product references:

- **VW3A3530D:** Altivar ATV dPAC module
- **VW3A1111:** Graphic display terminal

The VW3A3530D dedicated controller has no embedded I/O. However, all standard I/O on the respective Altivar Process and Altivar Machine drives can be used and extended with I/O modules:

- Up to 23 discrete I/O
- Up to 7 analog I/O
- Encoder interfaces (ATV900 and ATV340)
- Safety modules (ATV900 and ATV340)

It is possible to control up to 8 Modbus TCP devices, such as Altivar drives and soft starters, TeSys motor starters, remote I/O using a TM3BCEIP bus coupler, PowerLogic meters, or Harmony Hub wireless sensors.

A2 Modicon M251 dPAC

A cost-optimized, low-footprint distributed controller based on the machine-specialized Modicon M251 Logic Controller platform. The Modicon M251 dPAC provides a single Ethernet port for fieldbus, switched dual Ethernet ports for peer communications, and supports the field-proven TM3 I/O system(1).

Public



TM251MDESE

Product reference:

- **TM251MDESE:** Modicon M251 dPAC

The TM251MDESE controller has no embedded I/O; it supports Modicon TM3 I/O expansion modules:

- Up to 112 discrete I/O channels(2)
- Up to 112 analog I/O channels(2)
- Up to 14 Modicon TM3 expansion modules (7 local modules + 7 remote modules) with Modicon TM3 bus expansion modules (transmitter module and receiver module)

It is possible to control up to 4 TeSys U and TeSys D motor starters by connecting a TM3XTYS4 TM3 module to the Modicon M251 dPAC

A3 Modicon M262 dPAC

This is the controller for performance machines. It is powered with a non-isolated 24 V DC power supply, has a built-in overload protection, embeds a dual-core processor and a 256 MB memory capacity and supports RSTP protocol.



TM262L01MDESE8T

Product reference:

- **TM262L01MDESE8T:** Modicon M262 dPAC

The TM262L01MDESE8T controller has no embedded I/O; it supports Modicon TM3 I/O and Modicon Edge I/O NTS expansion modules:

- Up to 3,000 discrete I/O channels
- Up to 875 analog I/O channels
- Up to 16 Islands with a maximum of 32 modules each.

Public

It is possible to control up to 4 TeSys U and TeSys D motor starters by connecting a TM3XTYS4 TM3 module to the Modicon M262 dPAC.

A4 Modicon M580 dPAC — X80 I/O / Edge I/O NTS

A distributed field controller with up to 64 MB ECC RAM for programs and data. The Modicon M580 dPAC supports the robust, high-performance Modicon X80 I/O catalog(1) and is available in standard and conformal coated versions.



BMED581020

Product references:

- **BMED581020:** Modicon M580 dPAC (standard)
- **BMED581020C:** Modicon M580 dPAC (conformal coated)

BMED581020 and BMED581020C controllers support:

- Up to 1,408 discrete I/O channels(2)
- Up to 352 analog I/O channels(2)
- Up to 4 racks of local I/O

A5 Soft dPAC (Windows OS)

Soft dPAC represents an open, software-based controller built on a containerized version of the shared-source UAO runtime engine, designed to execute control and compute applications and interact with field devices. The hardware-agnostic nature of Soft dPAC enables deployment across a wide range of hardware platforms, such as edge controllers, servers, workstations, industrial PCs, and microcomputers that meet the required system specifications.

For Windows, one Soft dPAC instance can be installed per host machine Windows Soft dPAC is used for non-real time control applications

A6 Soft dPAC (Linux OS)

Soft dPAC represents an open, software-based controller built on a containerized version of the shared-source UAO runtime engine, designed to execute control and compute applications and interact with field devices. The hardware-agnostic nature of Soft dPAC enables deployment across a wide range of hardware platforms, such as edge controllers, servers, workstations, industrial PCs, and microcomputers that meet the required system specifications.

Public

The Linux Soft dPAC is ideal for real-time control when installed in conjunction with a Linux real-time patch. In a Linux environment, multiple instances of Soft dPAC can be seamlessly installed on a single host machine, allowing tasks like line expansions to be completed without disrupting ongoing processes. This capability minimizes downtime, thereby enhancing productivity and customer service.

Soft dPAC is compatible with Modicon Edge I/O NTS, TM3 I/O, X80 I/O modules, and third-party I/O modules. For Modicon X80 I/O, a dedicated module is required, which provides comprehensive compatibility and functionality within industrial automation setups.

Compatible Hardware:

Name	Reference Number
Harmony BX1	
Harmony P6	
ASRock iEP-5000G	

A7 Soft dPAC HA (Linux OS)

High Availability Soft dPAC (HA Soft dPAC) represents an open, software-based high availability solution engineered to maintain uptime upon a failure, offering resilience against hardware, software, or network failures. This capability effectively minimizes process downtime, making it ideal for demanding applications where uninterrupted process flows are critical. The integration of the high-availability solution with EcoStruxure Automation Expert software plays a pivotal role in enhancing productivity by significantly reducing process downtime.

High Availability Soft dPAC is a versatile edge controller compatible with a variety of hardware options, such as the Schneider Electric Harmony Performance Edge Controller, Automation Processor AP310 and third-party edge controllers such as ASRockTM industrial IoT controller. For compatibility with other hardware options, please contact your Schneider Electric representative for further details.

Moreover, High Availability Soft dPAC seamlessly integrates with Modicon X80 IOs using the BMECRD0100 Remote I/O module, which provides comprehensive compatibility and functionality within industrial automation setups.

Name	Reference Number
Harmony P6	
ASRock iEP-5000G	

A8 Roadmap / Emerging Options

Open item: *Additional simplex and HA-qualified hardware platforms are added periodically by Schneider Electric. The Automation/I&C Design Engineer shall confirm the current qualified-hardware list against the EAE Software-Defined Automation hardware reference at time of design, and shall flag any platform that is under evaluation or announced but not yet formally qualified as not-for-use on CoT projects until it appears on that qualified list.*

Public

APPENDIX C — I/O, NETWORK & GATEWAY HARDWARE

C1 Simplex Architecture I/O

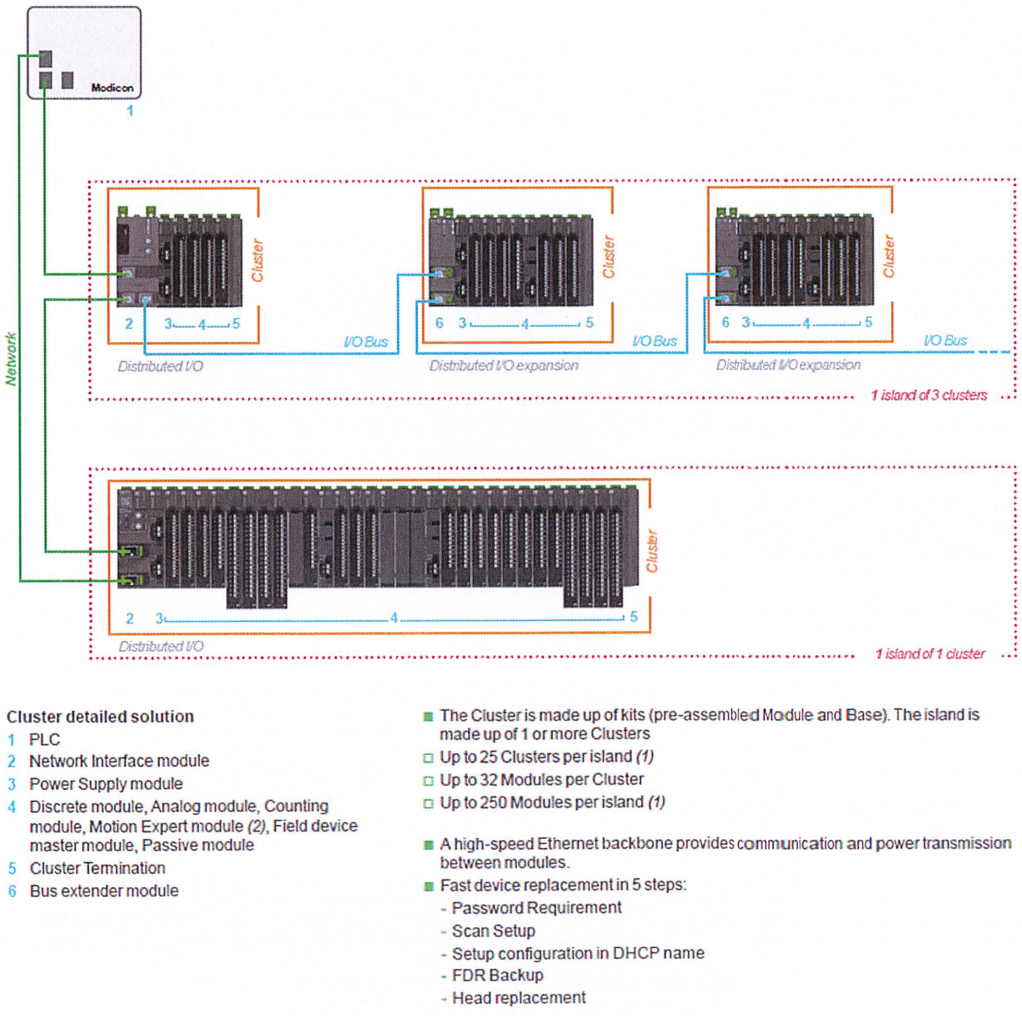
Modicon Edge I/O NTS

The Modicon Edge I/O NTS family is a distributed, DIN-rail mounted I/O system delivered as pre-assembled kits (a Base plus a functional module). Modules snap onto a Base that provides mounting, backplane data transmission, and field-device power. Up to 32 modules form a Cluster; up to 25 Clusters (250 modules) form an Island (planned commercialization), communicating back to the host controller (e.g., Modicon M241/M251/M262, M580, M340, or third-party PLC) over EtherNet/IP or Modbus TCP.

Design Note: Edge I/O NTS is offered in a Standard version (-20 to +60°C) and a Hardened version (-40 to +70°C, conformal coated). Hardened modules are functionally interchangeable with Standard modules and are recommended for unconditioned electrical rooms or corrosive/damp environments.

Recommended/Preferred selections based on the design decisions discussed in the standard are in BOLD.

> ***Design Note:*** *Edge I/O NTS module rollout is ongoing (modules and features are being deployed progressively). Confirm current module availability against the current release notes at time of design before committing a project design to a specific Edge I/O NTS module.*



Cluster detailed solution

1 PLC
2 Network Interface module
3 Power Supply module
4 Discrete module, Analog module, Counting module, Motion Expert module *(2)*, Field device master module, Passive module
5 Cluster Termination
6 Bus extender module

- The Cluster is made up of kits (pre-assembled Module and Base). The island is made up of 1 or more Clusters
- Up to 25 Clusters per island *(1)*
- Up to 32 Modules per Cluster
- Up to 250 Modules per island *(1)*

- A high-speed Ethernet backbone provides communication and power transmission between modules.
- Fast device replacement in 5 steps:
  - Password Requirement
  - Scan Setup
  - Setup configuration in DHCP name
  - FDR Backup
  - Head replacement

Figure C-1 Typical Modicon Edge I/O NTS Clusters

Public

C1.1 Network Interface Module (NIM)

The Network Interface Module is the head of a Cluster/Island and connects the Edge I/O NTS system to the plant network. It is required at the start of every Island.

Table C1-1 Network Interface Modules

Model	Description
NTSNEC1200K	**Network Interface Module + Base + Termination, EtherNet/IP + Modbus TCP + USB 2.0, Standard (-20 to +60°C)**
NTSNEC1200HK	Network Interface Module + Base + Termination, EtherNet/IP + Modbus TCP + USB 2.0, Hardened (-40 to +70°C)

- Ethernet Ports: (2) RJ45, switched, isolated
- Ethernet/IP (adaptor) and Modbus TCP (server); Sercos III support planned
- Data rate: 10/100 Mbit/s, full duplex, autonegotiation
- Network topology: Daisy chain, Star, or Ring (using RSTP)
- Embedded web server and OPC UA server (explicit only)
- USB Type-C commissioning port for configuration and firmware upload
- Embedded cybersecurity: Secure Boot, embedded TPM, TLS 1.2, SCEP client, configurable cybersecurity rotary switch
- Addresses up to 32 I/O kits per Cluster; up to 250 modules per Island (planned commercialization)

C1.2 Power Supply Modules

Every Cluster requires a Power Supply module immediately following the Network Interface Module (or a Bus Extender). Two power supply types are offered: one distributes both Bus and Field power, the other adds Field power only to extend current capacity within a Cluster.

Table C1-2 Power Supply Modules

Model	Description
NTSPFB1002HK	**Bus + Field Power Supply Module + Base, 24 VDC, 3.5 A Bus / 10.5 A Field, Hardened**
NTSPFD1002HK	**Field Power Supply Module + Base, 24 VDC, 10.5 A Field, automatic disjunction, Hardened**

- Input voltage: 24 VDC (19.2...30 VDC)
- Overvoltage, undervoltage, overload, short-circuit, and reverse-polarity protection for Bus and/or Field
- Hot-swap capable
- NTSPFD1002HK includes automatic disjunction; add when more than 10 A is required or to segment the Cluster
- Redundant power supply architecture planned for commercialization

C1.3 Analog Input Modules

These modules come as Voltage/Current, Current-only, or Temperature (RTD/Thermocouple/Thermistor) inputs. The Voltage/Current version is preferred for general process signals since it can be field-configured per channel; the Current (4-20 mA) version is preferred where HART communication is required.

Table C1-3 Analog Input Modules

Public

Model	Description
NTSAMI0210K	**2-Channel (isolated), Voltage/Current, ±10 VDC/0-10 VDC/±5 VDC/0-5 VDC/1-5 VDC, ±20 mA/0-20 mA/4-20 mA, HART tolerance, Standard**
NTSAMI0400K	**4-Channel, Voltage/Current, same ranges as above, Standard**
NTSAMI0420K	4-Channel Differential, Voltage/Current, Standard
NTSAMI0800K	8-Channel, Voltage/Current, 1-2-wire, Standard
NTSAHI0412XHK	4-Channel (isolated), Current 4-20 mA, HART communication, Hardened
NTSACI0802XK	8-Channel, Current ±20 mA/4-20 mA, HART tolerance, Standard
NTSART0214K	2-Channel (isolated), Temperature: Thermocouple J/K/R/S/B/T/N/E/C/L/U, RTD, mV, Resistance, Standard
NTSART0404K	4-Channel, Temperature (Thermocouple/RTD/mV/Resistance), Standard
NTSART0603K	6-Channel, Temperature: Thermistor PTC/NTC, RTD, Standard

- Resolution: 15 bits + sign (16 bits with overflow for Temperature modules)
- Removable spring or screw terminal blocks (ordered separately)
- Built-in HART tolerance is available on most channels; dedicated HART communication is available on the 4-channel isolated current module (NTSAHI0412XHK)
- Overvoltage/over-current and mis-wiring protection per channel; broken-wire, underflow/overflow, and internal field-power diagnostics per channel
- Hot-swap capability; IP20 degree of protection

C1.4 Analog Output Modules

Table C1-4 Analog Output Modules

Model	Description
NTSAMO0210K	**2-Channel (isolated), Voltage/Current, ±10 VDC/0-10 VDC/±5 VDC/0-5 VDC/1-5 VDC, ±20 mA/0-20 mA/4-20 mA, HART tolerance, Standard**
NTSAMO0400K	**4-Channel, Voltage/Current, 0-20 mA/4-20 mA, HART tolerance, Standard**
NTSAHO0212HK	2-Channel (isolated), Current 4-20 mA, HART communication, Hardened

- Resolution: 15 bits + sign (16 bits on NTSAHO0212HK)
- Short-circuit and overvoltage (30 V) output protection
- Removable spring or screw terminal blocks (ordered separately)
- Underflow, overflow, broken-wire, short-circuit, DAC, and internal field-power diagnostics per channel

C1.5 Analog Combo Module

Table C1-5 Analog Combo Module

Model	Description
NTSAMM0600K	**4 Analog Inputs (Voltage ±10 V/0-10 V/±5 V/0-5 V, Current ±20 mA/4-20 mA) + 2 Analog Outputs (Voltage ±10/0-10 VDC, Current 0-20 mA/4-20 mA), Standard**

- Combines inputs and outputs on a single module (1 slot / 15 mm width) to reduce panel footprint
- 3-way isolation between input group, output group, and bus
- 16-bit max resolution on inputs, 13-bit max resolution on outputs

Public

C1.6 Digital Input Modules

24 VDC sink-logic modules are preferred for all new construction, consistent with the discrete I/O voltage guidance in Section 5.4 of this standard. 100-240 VAC modules are available for upgrades where existing field wiring is AC.

Table C1-6 Digital Input Modules

Model	Description
NTSDDI0602K	**6-Channel, 24 VDC, Sink, 1-2-3-wire, Standard**
NTSDDI0802XK	**8-Channel, 24 VDC, Sink, 1-2-wire, Standard**
NTSDDI1602K	**16-Channel, 24 VDC, Sink, 1-wire, Standard**
NTSDDI1642K	16-Channel, 24 VDC, Source, 1-wire, Standard
NTSDAI0403HK	4-Channel, 24 VAC or 48 VAC/DC (configurable), Hardened
NTSDAI0215HK	2-Channel (isolated), 100-240 VAC, Hardened
NTSDAI0404HK	4-Channel, 100-240 VAC, Hardened
NTSDAI0804K	8-Channel, 100-120 VAC, Standard

- Input current: 2.5 mA typical (24 VDC modules)
- Overvoltage protection, reverse-polarity protection, and sensor power-supply over-current protection (model dependent)
- Power-supply and sensor power-supply diagnostics per channel
- 1500 VAC isolation between channels/bus and channels/earth ground (3000 VAC on AC modules)
- Synchronization capability on select 24 VDC models for time-stamped I/O

C1.7 Digital Output Modules

Transistor (source) output modules are recommended for 24 VDC control circuits. Relay modules provide a dry contact suitable for interfacing to either 24 VDC or 120-250 VAC circuits without interposing relays, consistent with Section 5.4 guidance.

Table C1-7 Digital Output Modules

Model	Description
NTSDDO0402K	**4-Channel, 24 VDC Transistor Source, 1-2-3-wire, Standard**
NTSDDO0602K	**6-Channel, 24 VDC Transistor Source, 1-2-3-wire, Standard**
NTSDDO0802K	**8-Channel, 24 VDC Transistor Source, 1-wire, Standard**
NTSDDO1602K	**16-Channel, 24 VDC Transistor Source, 1-wire, Standard**
NTSDRC0215K	**2-Channel (Form C, NO/NC), Relay, 24-250 VAC, Standard**
NTSDRC0415K	4-Channel (Form C, NO/NC), Relay, 24-250 VAC, Standard
NTSDRA0615K	6-Channel (Form A, NO), Relay, 120 VDC/230 VAC, Standard
NTSDAO0205K	2-Channel, Triac, 80-264 VAC, Standard
NTSDAO0415K	4-Channel, Triac, 80-264 VAC, Standard

- Transistor outputs: 0.5-2 A per channel; relay outputs: up to 5 A max. per output (30 VDC/250 VAC resistive)

Public

- Transient voltage suppression, short-circuit, and overload/thermal protection per channel on transistor modules
- Power-supply, short-circuit/over-current, and (on select models) broken-wire and read-back diagnostics per channel
- Field power supplied from the module's own 24 VDC Field bus, or from an external supply on relay/triac models

C1.8 Specialty Modules

Specialty modules add high-speed counting, motion, and field-device (serial/IO-Link) master functions directly within the I/O island, eliminating the need for a separate gateway.

C1.8.1 Counting Modules (Incremental High-Speed Counter)

Table C1-8 Counting Modules

Model	Description
NTSEHC0100K	**1-Channel HSC, 250 kHz, 6 discrete inputs (24 VDC), Standard**
NTSEHC0220K	**2-Channel HSC, 250 kHz, 12 discrete inputs / 8 discrete outputs (24 VDC), Standard**
NTSEHC0120HK	1-Channel HSC, 250 kHz, 6 discrete inputs / 4 discrete outputs (24 VDC), Hardened

- Supports simple counting, single/dual counting, frequency meter, ratio meter, period meter, or PWM output functions per channel
- Integrated reflex output for position control, speed control, flow measurement, level control, part counting, or defect detection
- Over-voltage input protection; short-circuit output protection (model dependent)

C1.8.2 Motion Expert Modules (Planned Commercialization)

Motion Expert modules control 1 to 8 axes over a Sercos III link to servo drives/motors (e.g., Modicon M660) and support Encoder, CAM, Encoder generator, Fast I/Os, and Pulse train output functions. Availability: planned commercialization; consult the Modicon PLC Configurator for current status before specifying.

C1.8.3 Field Device Master Modules

Table C1-9 Field Device Master Modules

Model	Description
NTSFMB0120K	**1-Channel Serial RS-485, Modbus RTU/ASCII Client, 115 kbps, Standard**
NTSFMB0120HK	1-Channel Serial RS-485, Modbus RTU/ASCII Client, 115 kbps, Hardened
NTSFIO0400K	4-Channel IO-Link Master (IEC 61131-9 V1.1), configurable discrete I/O, Standard

- Serial module: IO Scanner Device mode, addresses up to 32 Modbus devices, 1200 m max. cable length
- IO-Link module: up to 4 IO-Link devices per channel (3/4-wire, Class A), 20 m max. cable length, C/Q signal in IO-Link master mode
- Both isolated from the backplane bus; thermal, short-circuit, and over-current protection (IO-Link module)

C1.9 Passive Modules

Passive modules manage electrical distribution or reserve physical space for future expansion; they perform no control or I/O function.

Table C1-10 Passive Modules

Public

Model	Description
NTSPCM0016HK	Common Distribution, 16x 0 VDC commons, Hardened
NTSPCM1600HK	Common Distribution, 16x 24 VDC commons, with one electronic fuse, Hardened
NTSPCM0808HK	Common Distribution, 8x 0 VDC + 8x 24 VDC commons, with one electronic fuse, Hardened
NTSDMY0100HK	Dummy Module, 1-slot (15 mm width), Hardened
NTSDMY0200HK	Dummy Module, 2-slot (30 mm width), Hardened

- Common Distribution modules centralize power distribution with overvoltage, undervoltage, overload, short-circuit, reverse-polarity, and inrush-current protection (24 VDC commons)
- Dummy modules replicate the physical form/connection interface of a real module without performing any control function — used to reserve a slot for planned future I/O
- All Passive modules are offered in Hardened version only (-40 to +70°C)

C1.10 Terminal Blocks and Bases

All field wiring terminates to a removable terminal block ordered separately from the module/Base kit, consistent with the subplate-terminal-block wiring practice described in Section 5.4 of this standard. Terminal blocks are available in Screw or Spring versions, with or without a hinged protective cover, in 2, 12, or 18-point configurations at 3.81 mm or 5 mm pitch depending on the module.

- Spring terminal blocks are recommended for tool-free, vibration-resistant connections and to eliminate periodic re-tightening
- Screw terminal blocks are acceptable where local practice requires them
- A protective cover (ordered separately, sold in sets) is recommended for terminal blocks in areas accessible to personnel
- Bases (NTSXBA01xxH / NTSXBA02xxH / NTSXBA0301H) are ordered as spares only — new construction obtains the Base pre-assembled with the functional module as a kit

Design Note: Model numbers shown above reflect the December 2024 Modicon Edge I/O NTS catalog (Schneider Electric, ref. DIA3ED2240601EN). Items marked "Available soon" or "Planned commercialization" in the source catalog should be re-verified against the current Modicon PLC Configurator or myschneider.se.com prior to specifying on a project.

C2 High Availability Architecture I/O

Modicon X80 I/O

X80 modules mount in a rack (backplane) alongside the CPU, power supply, and communication modules. Racks are available as X-bus only (legacy) or dual Ethernet + X-bus (for Modicon M580). Up to 8 racks can be daisy-chained per station depending on CPU model. Standard operating range is 0–60°C; Ruggedized ("H"/"T"/"C" suffix) versions extend to -25...+70°C with conformal coating for harsh environments.

C2.1 Racks

Table C2-1 Racks

Model	Description
BMXXBP0400	X-bus rack, 4 slots, Standard

Public

Model	Description
BMXXBP0600	X-bus rack, 6 slots, Standard
BMXXBP0800	X-bus rack, 8 slots, Standard
BMXXBP1200	X-bus rack, 12 slots, Standard
BMEXBP0400	Ethernet + X-bus rack, 4 Ethernet/4 X-bus slots, Standard
BMEXBP0800	**Ethernet + X-bus rack, 8 Ethernet/8 X-bus slots, Standard**
BMEXBP1200	**Ethernet + X-bus rack, 8 Ethernet + X-bus/4 X-bus-only slots, Standard**
BMEXBP0602	**Dual power supply rack, 6 slots (redundant PS only)**
BMEXBP1002	**Dual power supply rack, 10 slots (redundant PS only)**
BMXXBE1000	Rack expansion module (for multi-rack daisy chain)

Features:

- X-bus racks distribute power/data and support hot-swap of installed modules
- Ethernet + X-bus racks embed an Ethernet switch; not all slots have Ethernet connectivity
- Up to 2 racks (BMXP341000), 4 racks (BMXP342xxx or BMEP581/2xxx), or 8 racks (BMEP583/4/5/6x0xx) depending on CPU
- Multi-rack (expansion) configurations require a BMXXBE1000 rack expansion module + BMXXBCxx0K X-bus cordset per rack, plus a TSXTLYEX line terminator at each end of the daisy chain
- Racks mount on a panel/plate or DIN rail; ground terminal and shielding connection points included

C2.2 Power Supply Modules

Table C2-2 Power Supply Modules

Model	Description
BMXCPS2010	**24 VDC isolated power supply, 17 W**
BMXCPS3020	**24...48 VDC isolated power supply, 32 W**
BMXCPS4022	**24...48 VDC redundant power supply, 40 W**
BMXCPS3540T	100...150 VDC power supply, 36 W, extended temp (-25 to +70°C)
BMXCPS3522	100...150 VDC redundant power supply, 40 W
BMXCPS2000	100...240 VAC power supply, 20 W
BMXCPS3500	100...240 VAC power supply, 36 W
BMXCPS4002	100...240 VAC redundant power supply, 40 W

Features:

- Each rack (BMEXBPxx00/BMXXBPxx00) requires one power supply; dual-PS racks (BMEXBPxx02) require BMXCPSxxx2 redundant units only

Public

- Alarm relay (volt-free contact) reports blocking faults, incorrect rack voltage, or loss of supply
- Front-panel RESET pushbutton triggers a cold-start of the processor and rack modules
- BMXCPS2000/3500/3540T include an integrated 24 VDC sensor supply (0.45 A or 0.9 A available)
- Redundant models (CPSxxx2) auto-switch master/slave role if the active supply cannot deliver full current

C2.3 Digital Input Modules

Table C2-3 Digital Input Modules

Model	Description
BMXDDI1602	**16-Channel, 24 VDC, positive logic (sink), Type 3, 20-way terminal block**
BMXDAI1602	**16-Channel, 24 VDC/VAC, positive/negative logic, Non-type**
BMXDDI1603	16-Channel, 48 VDC, positive logic, Type 1
BMXDDI1604T	16-Channel, 125 VDC, positive logic, extended temp
BMXDAI1603	16-Channel, 48 VAC, Type 3
BMXDAI1604	16-Channel, 100-120 VAC, Type 3
BMXDAI0814	8-Channel (isolated), 100-120 VAC, Type 3
BMXDAI0805	8-Channel, 200-240 VAC, Type 2
BMXDAI1614	16-Channel (isolated), 100-120 VAC, Type 1, 40-way terminal block
BMXDAI16142	16-Channel (isolated), 100-120 VAC, 60 Hz optimized
BMXDAI1615	16-Channel (isolated), 200-240 VAC, Type 1
BMXDDI3202K	**32-Channel high-density, 24 VDC, Type 1, one 40-way connector**
BMXDDI3232	32-Channel, 12/24 VDC, Type 3, 40-way terminal block
BMXDDI3203	32-Channel, 48 VDC, Type 3
BMXDDI6402K	**64-Channel high-density, 24 VDC, Non-type, two 40-way connectors**

Features:

- Positive (sink) or negative (source) logic depending on model; 2-wire/3-wire PNP or NPN sensor compatibility per IEC/EN 60947-5-2
- Group-fused inputs (0.25–0.5 A fast-blow fuse per channel or group depending on model)
- Hot-swap capable; channels grouped into blocks of 4/8/16 assignable to master or fast application tasks
- 40-way connector modules (32/64-channel) use preassembled cordsets (BMXFCWxx1/xx3) rather than removable terminal blocks
- Diagnostics available via EcoStruxure Control Expert or the embedded Rack Viewer web interface

C2.4 Digital Output Modules

Table C2-4 Digital Output Modules

Public

Model	Description
BMXDDO1602	**16-Channel, 24 VDC transistor, positive logic**
BMXDDO1612	**16-Channel, 24 VDC transistor, negative logic**
BMXDDO3202K	**32-Channel high-density, 24 VDC transistor, one 40-way connector**
BMXDDO6402K	**64-Channel high-density, 24 VDC transistor, two 40-way connectors**
BMXDAO1605	16-Channel, 100-240 VAC triac (4 groups of 4)
BMXDAO1615	16-Channel (isolated), 24-240 VAC triac
BMXDRA0804T	8-Channel (isolated) relay, 100-150 VDC, extended temp
BMXDRA0805	**8-Channel (isolated) relay, 24 VDC/24-240 VAC**
BMXDRA0815	8-Channel (isolated) relay, 24-125 VDC/24-240 VAC
BMXDRA1605	**16-Channel relay (2×8), 24 VDC/24-240 VAC**
BMXDRC0805	8-Channel (isolated) relay, NO+NC contacts, 5-125 VDC/24-240 VAC

Features:

- Transistor outputs: configurable output fallback (state 0/1 or maintain) on PLC stop; overload, short-circuit, reverse-polarity, and inductive-overvoltage protected
- Relay outputs: use an RC snubber or ZNO surge limiter (AC) or discharge diode (DC) across each output for inductive load protection
- Group-fused outputs (0.5–12 A fast-blow fuse depending on model and channel grouping)
- 32/64-channel high-density modules connect via 40-way connector + preassembled cordset, compatible with TeSys Quickfit via LU9G02 splitter modules

C2.5 Digital Mixed I/O Modules

Table C2-5 Digital Mixed I/O Modules

Model	Description
BMXDDM16022	8 In / 8 Out, 24 VDC transistor, positive logic
BMXDDM16025	8 In / 8 Out, 24 VDC in / 24-240 VAC relay out
BMXDDM3202K	**16 In / 16 Out, 24 VDC transistor, one 40-way connector**

Features:

- Combines inputs and outputs on a single module to reduce slot count
- Output paralleling supported (up to 2 outputs on BMXDDM16022, up to 3 on BMXDDM3202K)
- Same configurable fallback and diagnostic capability as standalone DI/DO modules

C2.6 Analog Input Modules

Public

Table C2-6 Analog Input Modules

Model	Description
BMXAMI0410	4-Channel (isolated), Voltage/Current, 16-bit, high-speed
BMXAMI0800	8-Channel (non-isolated), Voltage/Current, 15-bit + sign
BMXAMI0810	**8-Channel (isolated), Voltage/Current, 15-bit + sign**
BMXART0414	4-Channel (isolated), Thermocouple/RTD/mV/Resistance, 15-bit + sign
BMXART0814	**8-Channel (isolated), Thermocouple/RTD/mV/Resistance, 15-bit + sign**

Features:

- BMXAMI0410/0800/0810: Voltage ranges ±10V/0-10V/0-5V/1-5V/±5V; Current 0-20mA/4-20mA (±20mA on BMXAMI0410)
- BMXART0414/0814: multi-range per channel — thermocouple types B/E/J/K/L/N/R/S/T/U, RTD types Pt100/JPt100/Pt1000/JPt1000/Ni100/Ni1000/Cu10, 2/3/4-wire resistance (400Ω/4000Ω), or low-level voltage (±40mV...±1.28V)
- Isolation: 750 VDC between channels (300 VDC on BMXAMI0800), 1400 VDC channel-to-bus/ground
- Compatible with Modicon Telefast ABE7 sub-bases (ABE7CPA410/412/02/03/31/31E) for screw-terminal field wiring

C2.7 Analog Output Modules

Table C2-7 Analog Output Modules

Model	Description
BMXAMO0210	2-Channel (isolated), Voltage/Current, 16-bit
BMXAMO0410	**4-Channel (isolated), Voltage/Current, 15-bit + sign**
BMXAMO0802	8-Channel (non-isolated), Current only, 15-bit + sign

Features:

- Voltage ±10V; Current 0-20mA/4-20mA depending on model
- Conversion time ≤1 ms (BMXAMO0210/0802) or ≤4 ms (BMXAMO0410)
- Compatible with Modicon Telefast ABE7CPA21 (2/4-channel) or ABE7CPA02 (8-channel) sub-bases

C2.8 Analog Mixed I/O Module

Table C2-8 Analog Mixed I/O Module

Model	Description
BMXAMM0600	4 In / 2 Out (non-isolated), Voltage/Current, 12-14 bit

Features:

Public

- Inputs: ±10V/0-10V/0-5V/1-5V or 0-20mA/4-20mA; Outputs: ±10V or 0-20mA/4-20mA
- Isolation between input and output groups: 750 VDC
- Single 20-way terminal block connection

C2.9 HART Analog I/O Modules (Specialty)

Table C2-9 HART Analog I/O Modules

Model	Description
BMEAHI0812	8-Channel (isolated), HART analog input, 4-20 mA, 15-bit + sign
BMEAHO0412	4-Channel (isolated), HART analog output, 4-20 mA, 15-bit + sign

Features:

- Requires an Ethernet + X-bus backplane (BMEXBPxx00); installs only in the main local rack or a BMECRA31210 RIO drop — not supported in expansion racks
- HART field device compliance: V5, V6, V7; point-to-point 2-wire/4-wire device support with HART I/O mapping to the CPU
- Compatible with Modicon Telefast ABE7CPA02/03/31 (inputs) or ABE7CPA21 (outputs) sub-bases

C2.10 Expert and Communication Modules

Table C2-10 Expert Modules (referenced from platform compatibility list; consult the dedicated Expert Modules chapter of the X80 catalog for full specifications)

Model	Description
BMXEHC0200 / BMXEHC0800	Counter module (2 or 8 channel)
BMXEAE0300	SSI encoder interface module
BMXERT1604T/H	Time-stamping module
BMXMSP0200	Motion control module
BMXETM0200H	Frequency input module
PMESWT0100	Weighing module (Technology Partner Program)

Table C2-11 Communication Modules (same caveat as above)

Model	Description
BMXNOM0200	Serial link (RTU) module
BMXEIA0100	AS-Interface master module
BMECXM0100	CANopen master module
PMEPXM0100	PROFIBUS DP master module

Public

Model	Description
BMXNRP0200 / 0201	Fiber converter module
BMENOS0300	Ethernet switch module

Note: *Full technical detail (ranges, isolation, wiring) for Expert and Communication modules was not present in the catalog pages retrieved for this appendix. Pull the "Expert modules" and "Communication modules" chapters (catalog pages 6/x and 8/x) before finalizing a spec that uses these.*

C2.11 Terminal Blocks and Accessories

Features:

- 20-way terminal blocks: Caged (BMXFTB2000), Screw clamp (BMXFTB2010), Spring (BMXFTB2020)
- 28-way terminal blocks (for BMXAMI0800/0810): Caged (BMXFTB2800), Spring (BMXFTB2820)
- 40-way terminal blocks: Caged (BMXFTB4000), Spring (BMXFTB4020)
- Preassembled cordsets available with flying leads (BMXFTWxxx/BMXFCWxxx) or HE10 connectors for Modicon Telefast ABE7 sub-bases (BMXFCCxxx)
- Shielding connection kit (BMXXSPxx00) recommended under the rack for analog/counter/motion cordsets

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Design Note: Model numbers above reflect the March 2022 Modicon X80 catalog (DIA6ED2131203EN, v16). Verify against the current catalog on se.com before finalizing a spec, and pull the Safety (Chapter 5) and Severe-Environment (Chapter 9) sections separately if the project requires functional-safety I/O or ruggedized/coated modules.

C3 Network Interface Cards, Switches, and IP Addressing

Dual- or triple-NIC requirements apply per the redundant/HA configurations in Appendix B1. RSTP-managed switches are required for ring segments per Appendix E.

IP addressing responsibility

The City of Tulsa (CoT) IT department shall assign and provide all Wide Area Network (WAN)-facing IP addresses. The Contractor/System Integrator shall assign Local Area Network (LAN)-side (panel and process-network) IP addresses, in coordination with and subject to approval by CoT IT/OT staff, to avoid address-space conflicts across the plant-wide network.

Cable end requirements

- Shielded RJ45 terminations for standard panel and building-interior runs
- M12 (or equivalent sealed) connectors for wet, washdown, or vibration-prone field locations
- Minimum bend radius per cable manufacturer's data sheet, maintained through all conduit transitions
- Both ends of every cable labeled with the circuit/port identifier shown on the network architecture drawing (Appendix G1)

C4 Gateways / Protocol Translators

Public

For legacy fieldbus (Profibus, DeviceNet, Foundation Fieldbus) or serial Modbus devices that cannot be brought natively into EAE's supported protocol set (Modbus TCP, Ethernet/IP, OPC UA), a protocol translator/gateway shall be provided. Gateway selection is subject to CoT approval on a per-project basis, and the gateway must expose data to EAE over one of its natively supported protocols rather than requiring a proprietary driver installation on the dPAC.

Public

APPENDIX D — ANCILLARY EQUIPMENT

D1 Operator Interface Terminals (OIT) / EAE-HMI

An industrial panel PC running EAE-HMI natively (Harmony P6, Appendix B2) is preferred for plant and control-room OIT locations, since EAE-HMI is fully integrated with the control application. Where a dedicated touch-panel HMI is more appropriate (e.g., a compact panel mounted on a small lift-station enclosure), a Harmony ST6-series touch panel (Appendix B4) running EAE-HMI Client is acceptable.

D2 Uninterruptible Power Supplies (UPS)

A UPS is required for all dPAC-based control panels, sized to provide a minimum of 30 minutes of backup power at full load with at least 25% reserve capacity for future expansion, powering the dPAC, operator interfaces, and network equipment only (not I/O, panel equipment, or field instruments).

- Manufacturer: APC by Schneider Electric, with a network/communication card installed for UPS status monitoring within the EAE application (battery status, remaining battery life, on-battery/on-bypass state).

SMX750C	Smaller UPS unit
SRT1500XLA	Larger UPS unit
SBP1500RM	Bypass for either 750 or 1500 unit
AP9641	Network Management Cards

- Mounting: free-standing, floor- or panel-bottom-mounted. Do NOT specify a door-mounted or 19" rack-mounted UPS within the enclosure.
- Topology: single-conversion (line-interactive / standby) design, NOT double-conversion (dual-inverter) design, so that an internal UPS fault causes the unit to fail closed — passing utility power through to the load — rather than dropping the load.

D3 Network Switches

Where drives, PLCs, HMIs, and other Ethernet-based devices are networked per Section 5.3, the Utility standardizes on managed switches for all plant and pump station Ethernet infrastructure. Unmanaged switches are not permitted for any application other than a single, non-critical, temporary drop (see Section 5.5.3).

5.5.1 Managed Switch Family Selection

Modicon managed switches are available in two general tiers, both DIN-rail mounted and designed for panel installation:

Table 5-2 Modicon Managed Switch Families

Family	Typical Reference Prefix	Capability	Application
Standard or Extended Managed Switch	MCSESM	All Basic Managed features plus HIPER-Ring, redundant ring coupling, modular/combo copper-fiber port configurations, extended temperature range, redundant power inputs	Treatment plant backbone, multi-building campuses, and any application forming part of

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Family	Typical Reference Prefix	Capability	Application
			the plant's fiber ring backbone

The Extended Managed (TCSESM) family is the Utility's preferred default for any switch forming part of a ring backbone or serving more than a small handful of devices, given its support for redundant ring protocols and combination copper/fiber port configurations that allow a single switch to serve both local copper-connected devices and the fiber backbone uplink.

Allowable Alternatives include:

Cisco IE3500 series switches

Allen-Bradley Stratix 5700 series switches

Phoenix Contact managed switches

5.5.2 Required Managed Switch Features

At a minimum, managed switches furnished under this standard shall provide:

- Ring protocol support – Rapid Spanning Tree Protocol (RSTP) at a minimum, with HIPER-Ring or an equivalent proprietary fast-recovery ring protocol on any switch installed in the fiber optic ring backbone described in the Utility's PLC Hardware Standard
- IGMP snooping – to prevent multicast traffic (e.g., EtherNet/IP Class 1 I/O) from being flooded to every port and degrading network performance as the system grows
- VLAN support – to allow logical segregation of control traffic from other plant systems (e.g., security, building automation) sharing common physical infrastructure
- Port security / port mirroring – to restrict unauthorized device connection at field panels and to support network troubleshooting without disrupting production traffic
- SNMP and web/CLI-based configuration and diagnostics – to allow the switch to be polled by the Utility's network monitoring system and to standardize commissioning across the fleet of stations
- Redundant, diverse-source 24VDC power inputs – each switch shall be powered from two independent sources (e.g., the panel's primary 24VDC supply and a secondary/UPS-backed supply) wired to the switch's redundant power terminals, consistent with the Utility's PLC Hardware Standard UPS provisions
- Operating temperature range suited to the installation location – standard range is adequate for conditioned electrical rooms; the extended temperature version shall be specified for unconditioned process buildings or enclosures subject to wide ambient swings

Design Note: *Device Level Ring (DLR), described in the Utility's PLC Hardware Standard and referenced in Section 5.3 of this document, is a device-embedded ring protocol supported directly by dual-Ethernet-port PLCs and drives; it is distinct from a switch-level ring protocol such as RSTP or HIPER-Ring. A managed switch is not itself a DLR node – where a segment of the network consists solely of DLR-capable drives and PLCs, those devices may form their own DLR ring without an intervening switch, while the switch-based backbone connecting that ring back to the rest of the plant network uses RSTP/HIPER-Ring. The Design Engineer shall clearly distinguish the two ring types on the network topology drawing to avoid confusion during commissioning and troubleshooting.*

5.5.3 Port Allocation, Spares, and Cybersecurity

- Managed switches shall be sized with a minimum of 20% spare ports (rounded up), or one spare port, whichever is greater, to accommodate future devices without a switch replacement.

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- All unused switch ports shall be administratively disabled in the switch configuration (not merely left physically unconnected) to reduce the network's attack surface, consistent with the manufacturer's recommended cybersecurity best practices.
- Default switch passwords and default SNMP community strings shall be changed from the factory default at commissioning, and switch firmware shall be updated to the current released version prior to system acceptance.
- An unmanaged Modicon switch (TCSESU family) may be used only for a single, non-critical, low-port-count drop off an existing managed switch (e.g., a temporary laptop connection point or a single non-critical OIT) and shall never be installed as part of the plant's ring backbone or as the sole connection point for a critical drive or PLC.

D4 UPS Transfer Scheme

The panel accepts a 120-volt, single-phase feed from plant power, which directly feeds non-essential items (fan, heater, field instruments), a fused status input to the dPAC, and the UPS. The UPS provides power to the dPAC, HMI, and networking equipment only. A contactor monitors UPS power availability and provides both a dPAC status input and switchover contacts, so that loss of UPS power automatically transfers the dPAC and networking equipment to plant power, and restoration of UPS power switches back automatically. This allows the system to distinguish plant-power-only, UPS-only, both-available, and both-failed (Loss of Communication alarm) conditions. A push-to-test indicator light and a BYPASS-UPS selector switch shall be provided per the wiring practice in Appendix F, and the UPS communications card (Appendix D2) shall expose remaining battery life and fault status directly to the EAE application.

D5 Enclosure Rating

NEMA 4X, stainless steel, free-standing enclosures are the CoT default and minimum requirement for new PCS panels under this standard, regardless of indoor/outdoor location, unless CoT specifically approves a lower rating (e.g., NEMA 12) for a qualifying indoor electrical-room installation.

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APPENDIX E — NETWORK TOPOLOGIES

- **Ring –** physical media forms a ring with each dPAC/switch connected to it; a single break does not interrupt communications.
- **Star –** hub-and-spokes; loss of the hub causes all connected devices to lose communications.
- **Linear/Bus –** devices connected via a common trunk line; limited length and device count, and a single trunk fault can take down the whole segment.
- **Mesh –** radio-based systems, where radios seek alternative paths if a unit goes down.
- **Hybrid –** any combination of the above, and the preferred topology for this standard.

Rapid Spanning Tree Protocol (RSTP)

RSTP (IEEE 802.1w) is the standards-based ring-redundancy protocol used across the Modicon/EAE platform — the EAE-ecosystem equivalent of the Rockwell-proprietary Device Level Ring (DLR) protocol on the retired platform. For mission-critical segments requiring bumpless (zero-loss) failover rather than RSTP's brief reconvergence time, evaluate PRP or HSR network architectures on select M580 dPAC and switch hardware.

Network Transmission Media

Fiber-optic cable (single-mode, 4 strands minimum, per building/segment as detailed on project drawings) is preferred between buildings. Copper CAT6 (or better) is preferred for short runs within a building. Radio and cellular remain available for remote/off-site facilities per the same considerations — physical survey for radio line-of-sight, recurring data fees for cellular — documented in the prior revision of this standard.

Communications Protocol

Ethernet TCP/IP is the preferred transport for all communications. Modbus TCP and Ethernet/IP are both supported for device-level polling of third-party equipment; OPC UA is natively supported by EAE for secure, standards-based integration with SCADA, historian, and IT-level systems.

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APPENDIX F — SCHEMATICS AND WIRING PRACTICE

Project-specific panel layout and wiring diagrams shall follow the practices below, using the TM3/X80/Edge I/O NTS modules recommended in Appendices A and C. See Appendix G for the typical drawing set and an anonymized example panel layout.

F1 Panel Layouts

The front panel provides the OIT/EAE-HMI, a folding shelf mounted on the door front for a service laptop, and a power outlet with Ethernet and USB service ports for commissioning and troubleshooting. The back panel is organized top-to-bottom as: dPAC rack(s) with I/O modules across the top; UPS (free-standing at the panel bottom per Appendix D2) and DIN-rail power supplies at mid-height; and terminal block wireways across the lower two-thirds of the panel, with discrete and analog terminal blocks grouped and separated per Appendix F2/F3.

F2 Digital Input/Output Wiring

- Digital input modules: field contacts wire to individually fused terminal block positions before reaching the module, with empty fuse positions provided for spares. Digital output modules: relay-output (isolated) modules are the default selection; loads requiring across-the-line motor starters or other non-digital control circuits shall be wired through an interposing relay rather than directly from the output module.

F3 Analog Input/Output Wiring

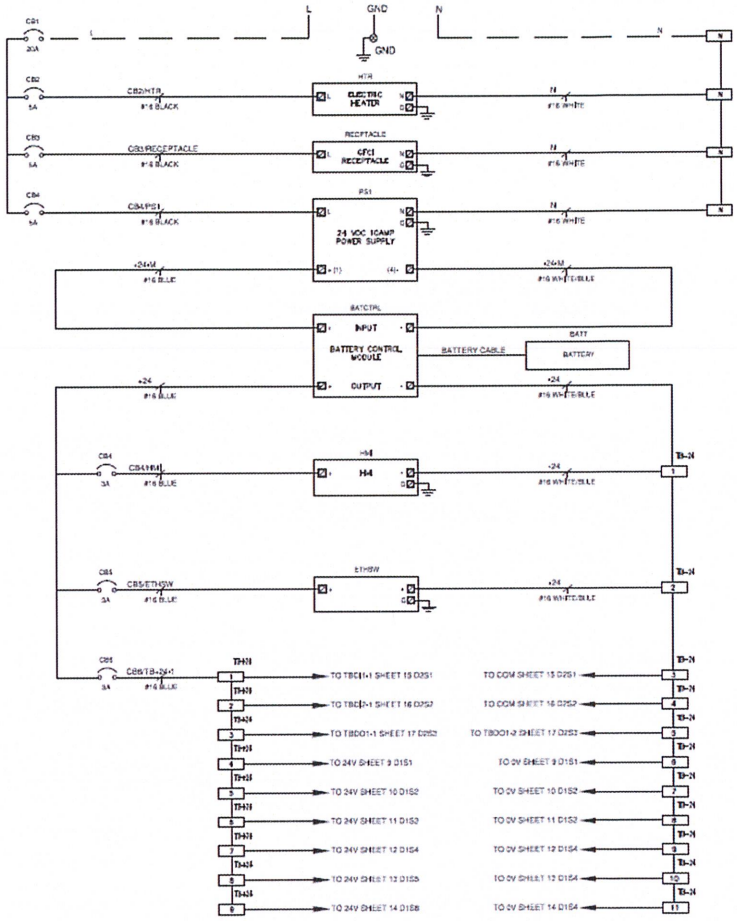
- Analog input modules: loop-powered field transmitters wire through a surge protection device (or fuse) at each channel before reaching the module's input terminals, with the module's current/voltage common grounded at a single point to avoid ground loops; each terminal is labeled with the instrument tag name per Section 6.4. Analog output modules: each output channel wires through a surge protection device (or fuse) in series with the output before reaching the field device, with empty fuse positions provided for spares.

Public

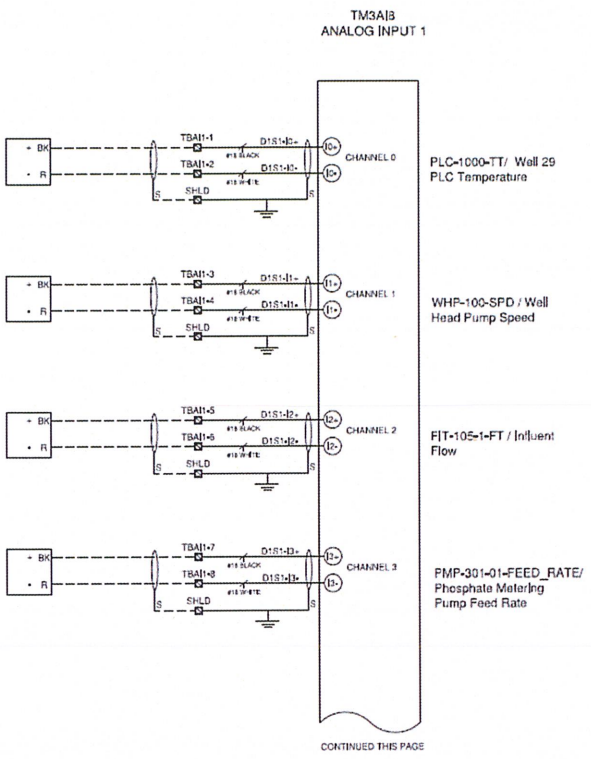
APPENDIX G — DRAWINGS

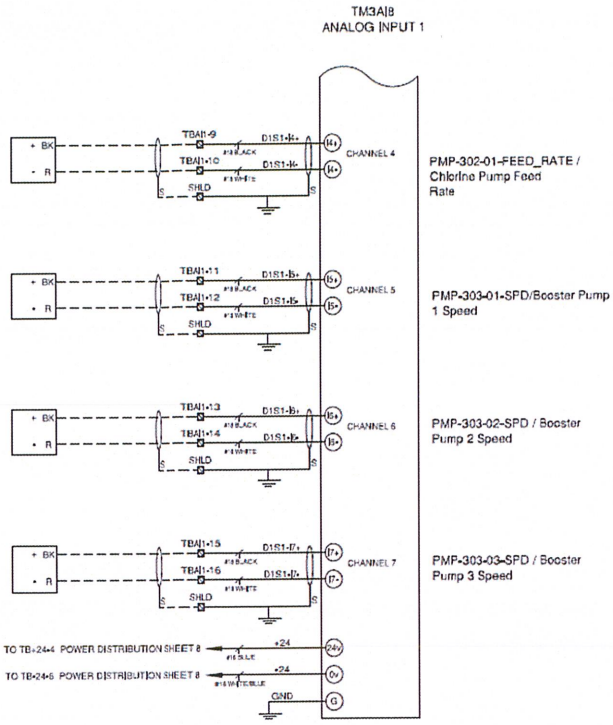
This appendix defines the typical drawing set for a pump/lift station project and provides anonymized examples. All example drawings use generic tags (Pump 1, Pump 2, Level 1, Pressure 1, etc.) and contain no site-specific or designer-specific identifying information, consistent with Section 6.4.

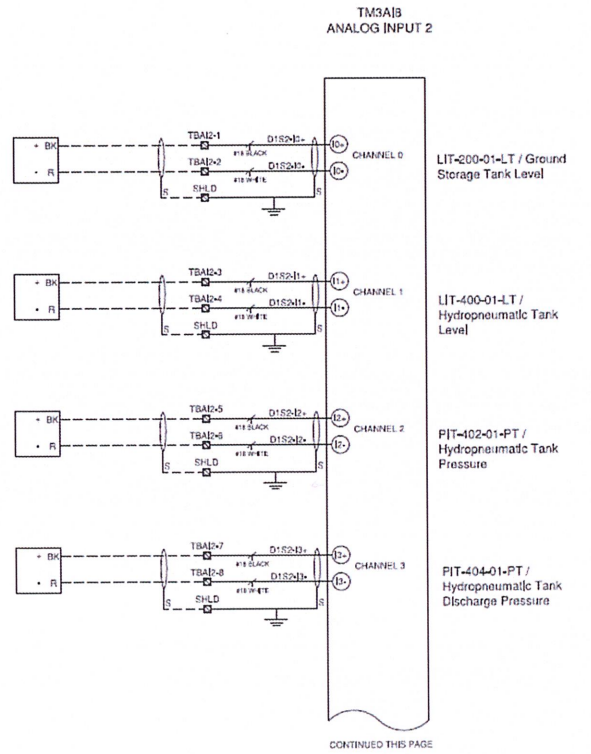
G1 Example P&ID

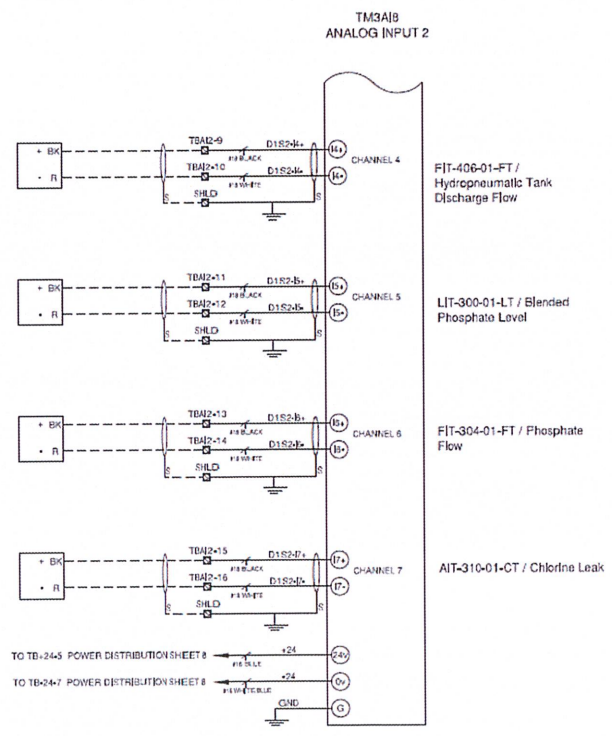


Public


TM3AI8
ANALOG INPUT 1
+ BK
- R
TBAI1-1
TBAI1-2
SHLD
D1S1-I0+
D1S1-I0-
CHANNEL 0
PLC-1000-TT/ Well 29 PLC Temperature
TBAI1-3
TBAI1-4
D1S1-I1+
D1S1-I1-
CHANNEL 1
WHP-100-SPD / Well Head Pump Speed
TBAI1-5
TBAI1-6
D1S1-I2+
D1S1-I2-
CHANNEL 2
FIT-105-1-FT / Influent Flow
TBAI1-7
TBAI1-8
D1S1-I3+
D1S1-I3-
CHANNEL 3
PMP-301-01-FEED_RATE/ Phosphate Metering Pump Feed Rate
CONTINUED THIS PAGE

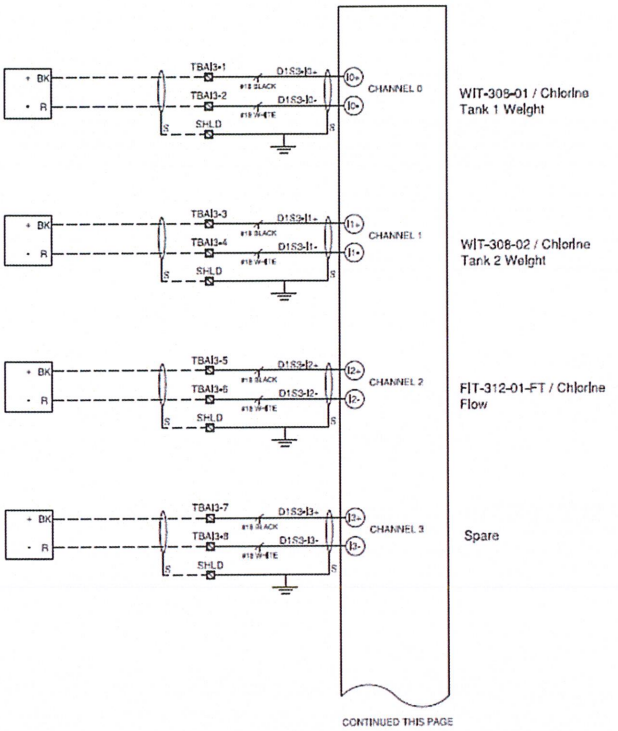

TM3AI8
ANALOG INPUT 1
+ BK
- R
TBAI1-9
TBAI1-10
SHLD
D1S1-I4+
D1S1-I4-
CHANNEL 4
PMP-302-01-FEED_RATE / Chlorine Pump Feed Rate
TBAI1-11
TBAI1-12
D1S1-I5+
D1S1-I5-
CHANNEL 5
PMP-303-01-SPD/Booster Pump 1 Speed
TBAI1-13
TBAI1-14
D1S1-I6+
D1S1-I6-
CHANNEL 6
PMP-303-02-SPD / Booster Pump 2 Speed
TBAI1-15
TBAI1-16
D1S1-I7+
D1S1-I7-
CHANNEL 7
PMP-303-03-SPD / Booster Pump 3 Speed
TO TB+24-4 POWER DISTRIBUTION SHEET 8
TO TB+24-6 POWER DISTRIBUTION SHEET 8
+24
0v
GND


TM3AI8
ANALOG INPUT 2
+ BK
- R
TBAI2-1
TBAI2-2
SHLD
D1S2-I0+
D1S2-I0-
CHANNEL 0
LIT-200-01-LT / Ground Storage Tank Level
TBAI2-3
TBAI2-4
D1S2-I1+
D1S2-I1-
CHANNEL 1
LIT-400-01-LT / Hydropneumatic Tank Level
TBAI2-5
TBAI2-6
D1S2-I2+
D1S2-I2-
CHANNEL 2
PIT-402-01-PT / Hydropneumatic Tank Pressure
TBAI2-7
TBAI2-8
D1S2-I3+
D1S2-I3-
CHANNEL 3
PIT-404-01-PT / Hydropneumatic Tank Discharge Pressure
CONTINUED THIS PAGE


TM3AI8
ANALOG INPUT 2
+ BK
- R
TBAI2-9
TBAI2-10
SHLD
D1S2-I4+
D1S2-I4-
CHANNEL 4
FIT-406-01-FT / Hydropneumatic Tank Discharge Flow
TBAI2-11
TBAI2-12
D1S2-I5+
D1S2-I5-
CHANNEL 5
LIT-300-01-LT / Blended Phosphate Level
TBAI2-13
TBAI2-14
D1S2-I6+
D1S2-I6-
CHANNEL 6
FIT-304-01-FT / Phosphate Flow
TBAI2-15
TBAI2-16
D1S2-I7+
D1S2-I7-
CHANNEL 7
AIT-310-01-CT / Chlorine Leak
TO TB+24-5 POWER DISTRIBUTION SHEET 8
TO TB+24-7 POWER DISTRIBUTION SHEET 8
+24
0v
GND

Public

TM3AI8
ANALOG INPUT 3



WIT-308-01 / Chlorine Tank 1 Weight

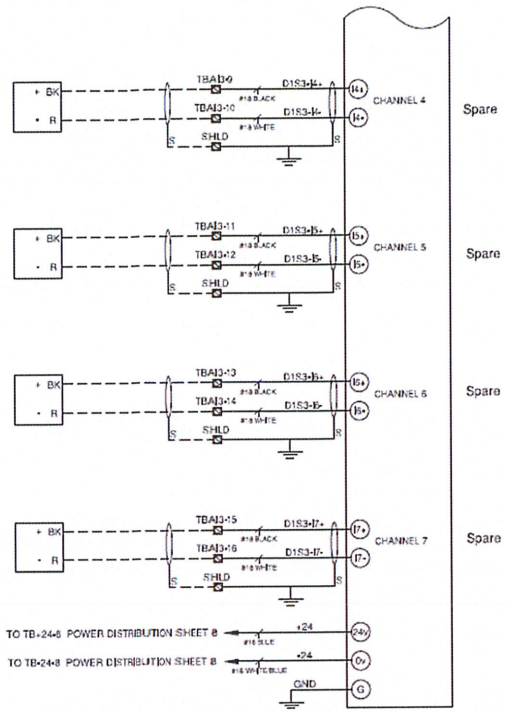
WIT-308-02 / Chlorine Tank 2 Weight

FIT-312-01-FT / Chlorine Flow

Spare

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TM3AI8
ANALOG INPUT 3



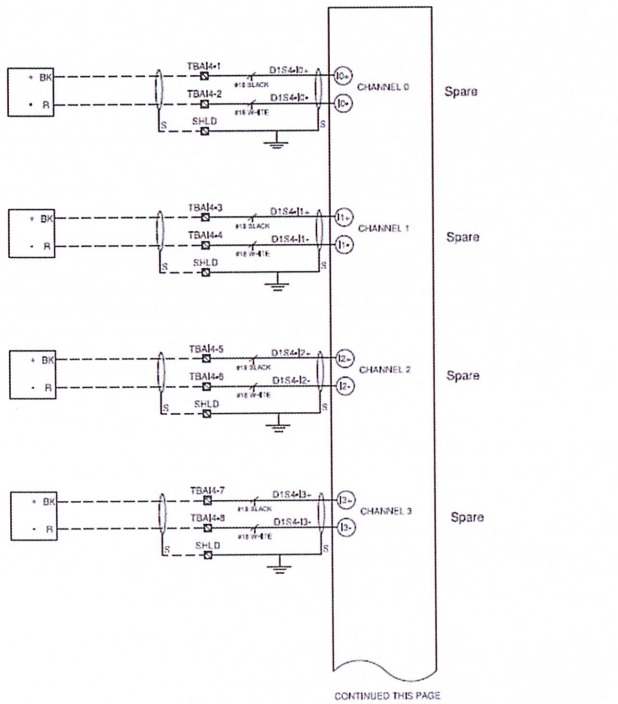
Spare

Spare

Spare

Spare

TM3AI8
ANALOG INPUT 4



Spare

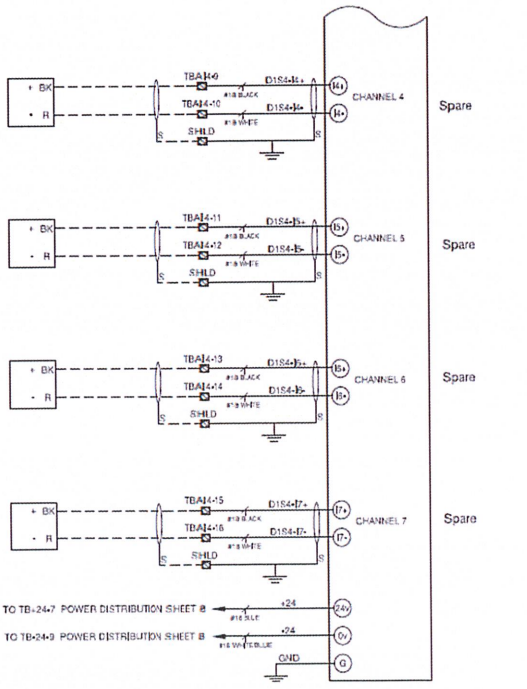
Spare

Spare

Spare

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TM3AI8
ANALOG INPUT 4



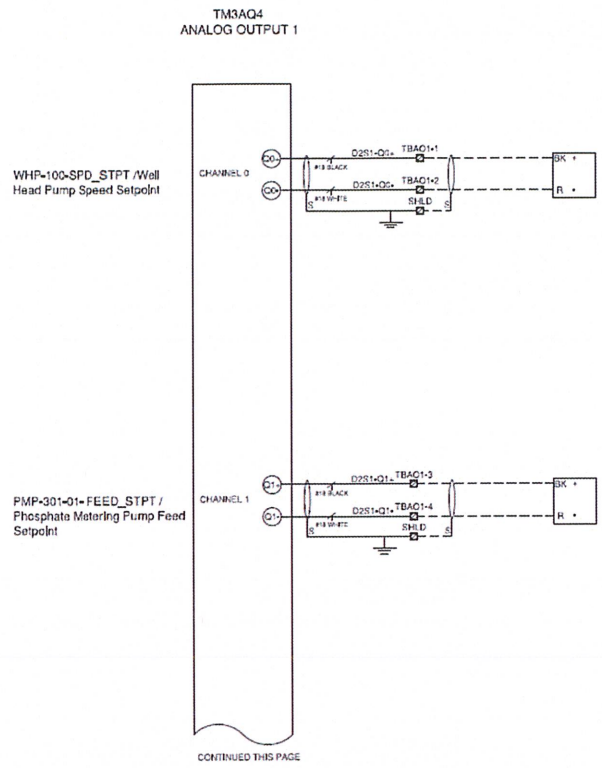
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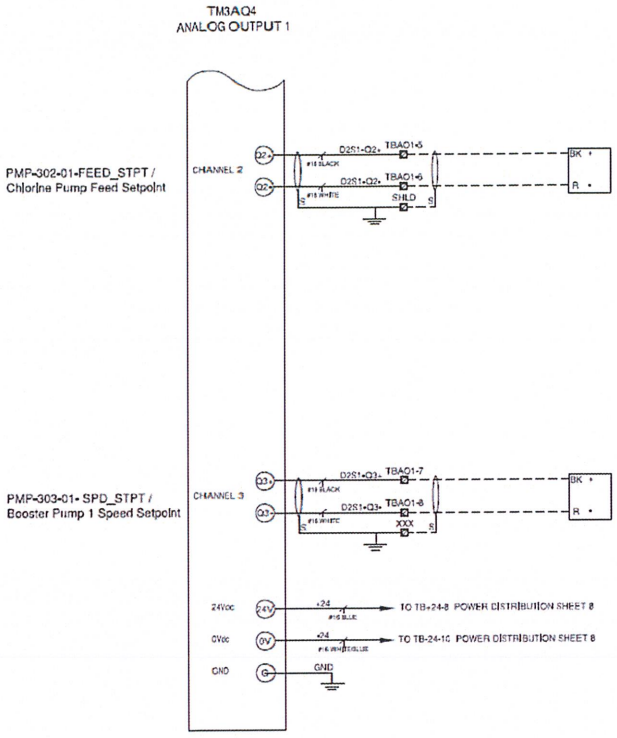
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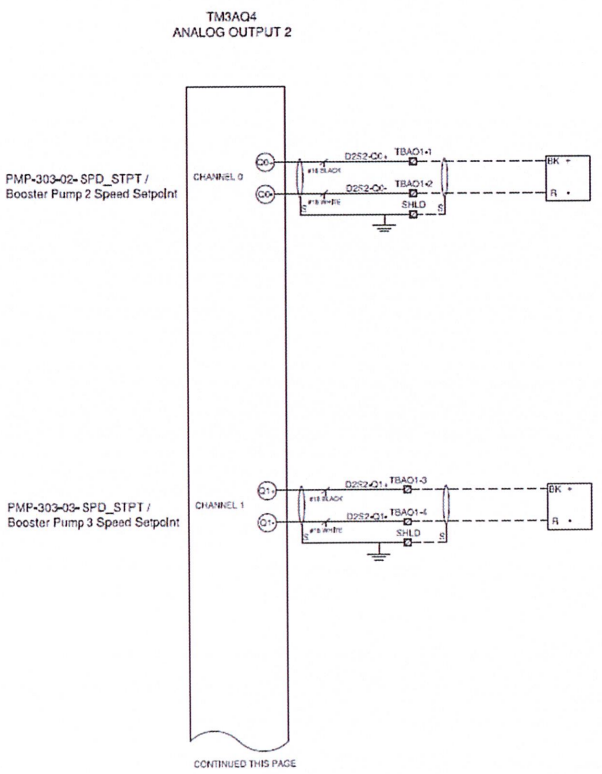
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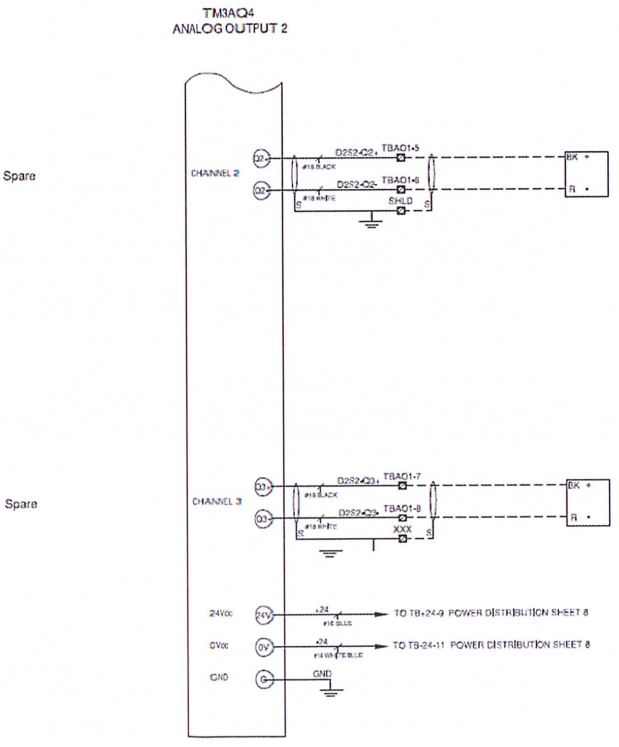
Spare

Public

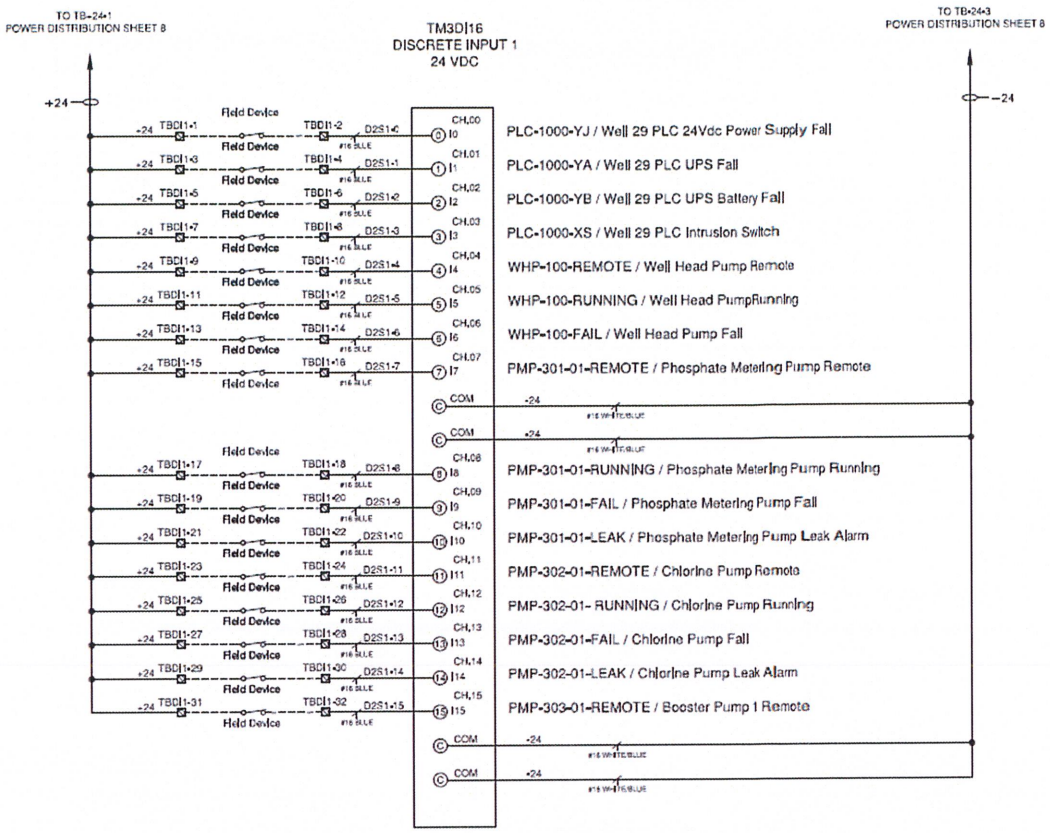

TM3AQ4
ANALOG OUTPUT 1
WHP-100-SPD_STPT /Well Head Pump Speed Setpoint
PMP-301-01-FEED_STPT / Phosphate Metering Pump Feed Setpoint
CHANNEL 0
CHANNEL 1
TBAO1-1
TBAO1-2
TBAO1-3
TBAO1-4
SHLD
BK
R
CONTINUED THIS PAGE

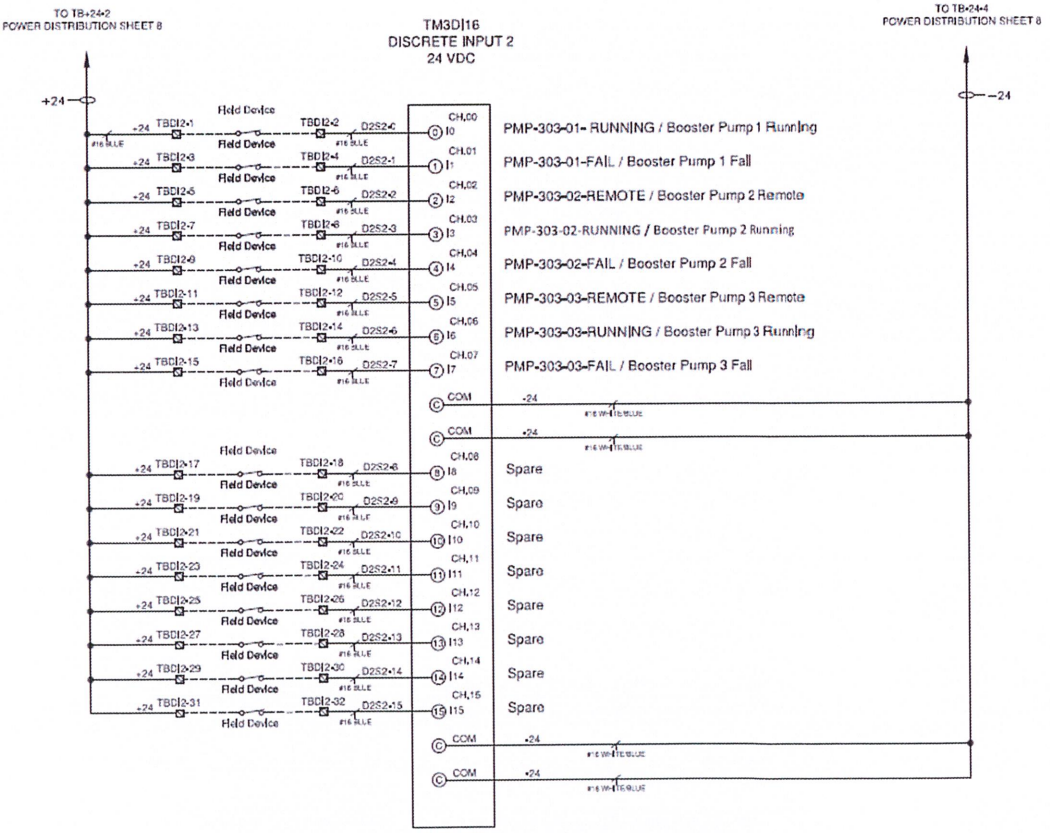

TM3AQ4
ANALOG OUTPUT 1
PMP-302-01-FEED_STPT / Chlorine Pump Feed Setpoint
PMP-303-01-SPD_STPT / Booster Pump 1 Speed Setpoint
CHANNEL 2
CHANNEL 3
TBAO1-5
TBAO1-6
TBAO1-7
TBAO1-8
SHLD
XXX
24Vdc
0Vdc
GND
TO TB+24-8 POWER DISTRIBUTION SHEET 8
TO TB-24-10 POWER DISTRIBUTION SHEET 8


TM3AQ4
ANALOG OUTPUT 2
PMP-303-02-SPD_STPT / Booster Pump 2 Speed Setpoint
PMP-303-03-SPD_STPT / Booster Pump 3 Speed Setpoint
CHANNEL 0
CHANNEL 1
TBAO1-1
TBAO1-2
TBAO1-3
TBAO1-4
SHLD
BK
R
CONTINUED THIS PAGE

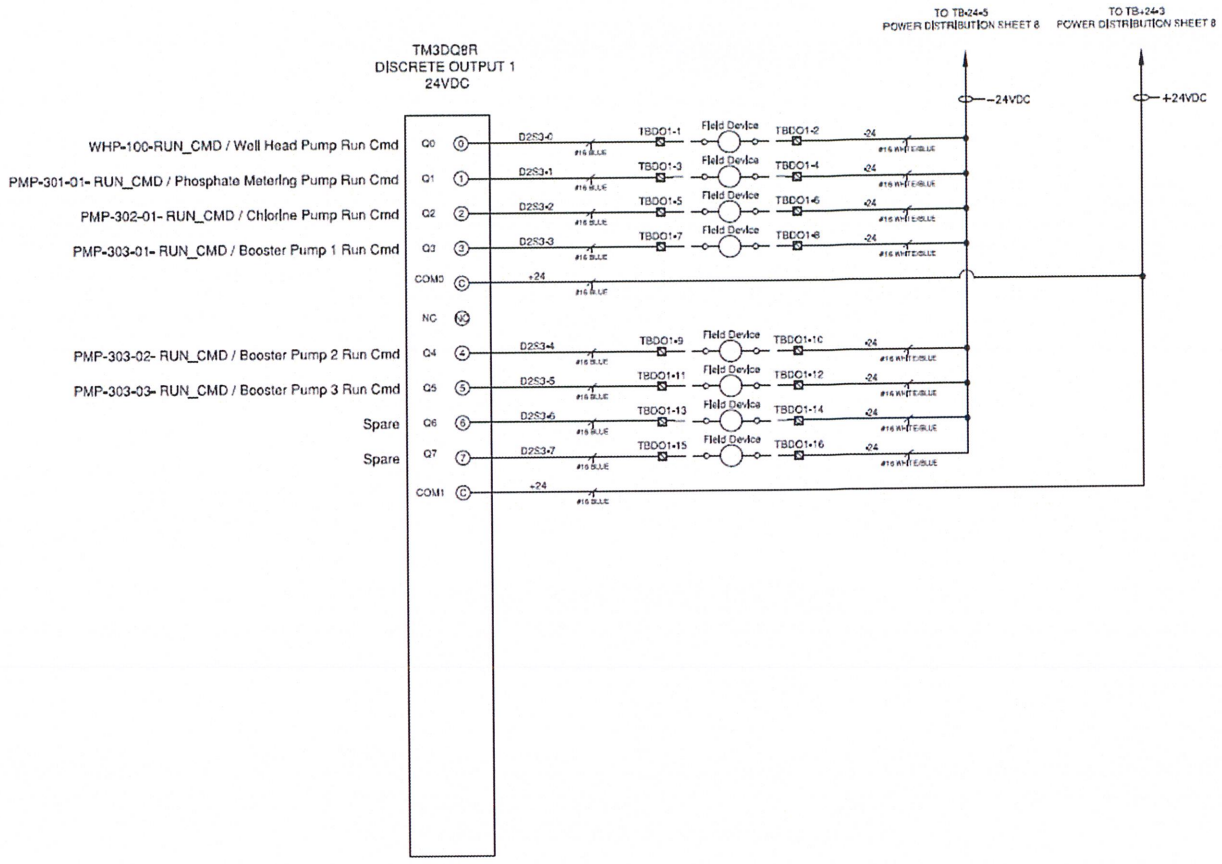

TM3AQ4
ANALOG OUTPUT 2
Spare
Spare
CHANNEL 2
CHANNEL 3
TBAO1-5
TBAO1-6
TBAO1-7
TBAO1-8
SHLD
XXX
24Vdc
0Vdc
GND
TO TB+24-9 POWER DISTRIBUTION SHEET 8
TO TB-24-11 POWER DISTRIBUTION SHEET 8

Public


TO TB-24-1
POWER DISTRIBUTION SHEET 8
TM3DI16
DISCRETE INPUT 1
24 VDC
TO TB-24-3
POWER DISTRIBUTION SHEET 8
+24
-24
Field Device
CH,00 I0 PLC-1000-YJ / Well 29 PLC 24Vdc Power Supply Fail
CH,01 I1 PLC-1000-YA / Well 29 PLC UPS Fail
CH,02 I2 PLC-1000-YB / Well 29 PLC UPS Battery Fail
CH,03 I3 PLC-1000-XS / Well 29 PLC Intrusion Switch
CH,04 I4 WHP-100-REMOTE / Well Head Pump Remote
CH,05 I5 WHP-100-RUNNING / Well Head PumpRunning
CH,06 I6 WHP-100-FAIL / Well Head Pump Fail
CH,07 I7 PMP-301-01-REMOTE / Phosphate Metering Pump Remote
COM -24
COM +24
CH,08 I8 PMP-301-01-RUNNING / Phosphate Metering Pump Running
CH,09 I9 PMP-301-01-FAIL / Phosphate Metering Pump Fail
CH,10 I10 PMP-301-01-LEAK / Phosphate Metering Pump Leak Alarm
CH,11 I11 PMP-302-01-REMOTE / Chlorine Pump Remote
CH,12 I12 PMP-302-01- RUNNING / Chlorine Pump Running
CH,13 I13 PMP-302-01-FAIL / Chlorine Pump Fail
CH,14 I14 PMP-302-01-LEAK / Chlorine Pump Leak Alarm
CH,15 I15 PMP-303-01-REMOTE / Booster Pump 1 Remote
COM -24
COM +24

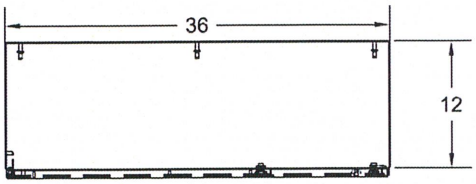

TO TB+24-2
POWER DISTRIBUTION SHEET 8
TM3DI16
DISCRETE INPUT 2
24 VDC
TO TB-24-4
POWER DISTRIBUTION SHEET 8
+24
-24
Field Device
CH,00 I0 PMP-303-01- RUNNING / Booster Pump 1 Running
CH,01 I1 PMP-303-01-FAIL / Booster Pump 1 Fail
CH,02 I2 PMP-303-02-REMOTE / Booster Pump 2 Remote
CH,03 I3 PMP-303-02-RUNNING / Booster Pump 2 Running
CH,04 I4 PMP-303-02-FAIL / Booster Pump 2 Fail
CH,05 I5 PMP-303-03-REMOTE / Booster Pump 3 Remote
CH,06 I6 PMP-303-03-RUNNING / Booster Pump 3 Running
CH,07 I7 PMP-303-03-FAIL / Booster Pump 3 Fail
COM -24
COM +24
CH,08 I8 Spare
CH,09 I9 Spare
CH,10 I10 Spare
CH,11 I11 Spare
CH,12 I12 Spare
CH,13 I13 Spare
CH,14 I14 Spare
CH,15 I15 Spare
COM +24
COM +24

Public

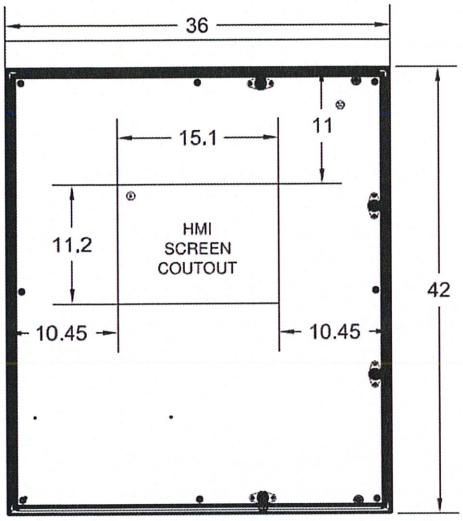

TO TB+24+5
POWER DISTRIBUTION SHEET 8
TO TB+24+3
POWER DISTRIBUTION SHEET 8
TM3DQ8R
DISCRETE OUTPUT 1
24VDC
-24VDC
+24VDC
WHP-100-RUN_CMD / Well Head Pump Run Cmd
PMP-301-01- RUN_CMD / Phosphate Metering Pump Run Cmd
PMP-302-01- RUN_CMD / Chlorine Pump Run Cmd
PMP-303-01- RUN_CMD / Booster Pump 1 Run Cmd
PMP-303-02- RUN_CMD / Booster Pump 2 Run Cmd
PMP-303-03- RUN_CMD / Booster Pump 3 Run Cmd
Spare
Spare
Q0
Q1
Q2
Q3
COM0
NC
Q4
Q5
Q6
Q7
COM1
D2S3-0
D2S3-1
D2S3-2
D2S3-3
D2S3-4
D2S3-5
D2S3-6
D2S3-7
TBDO1-1
TBDO1-2
TBDO1-3
TBDO1-4
TBDO1-5
TBDO1-6
TBDO1-7
TBDO1-8
TBDO1-9
TBDO1-10
TBDO1-11
TBDO1-12
TBDO1-13
TBDO1-14
TBDO1-15
TBDO1-16
Field Device
+24
-24
#16 BLUE
#16 WHITE/BLUE

Public

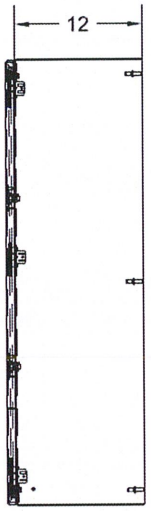
G2 Example Panel Layout



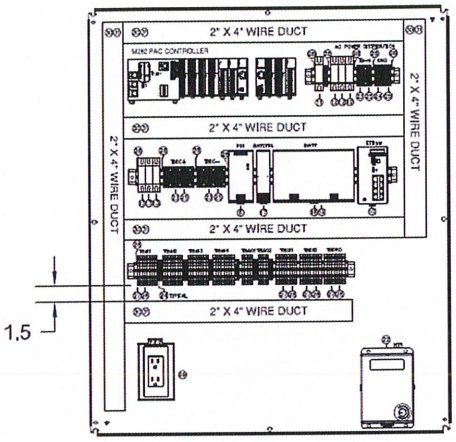
Top View



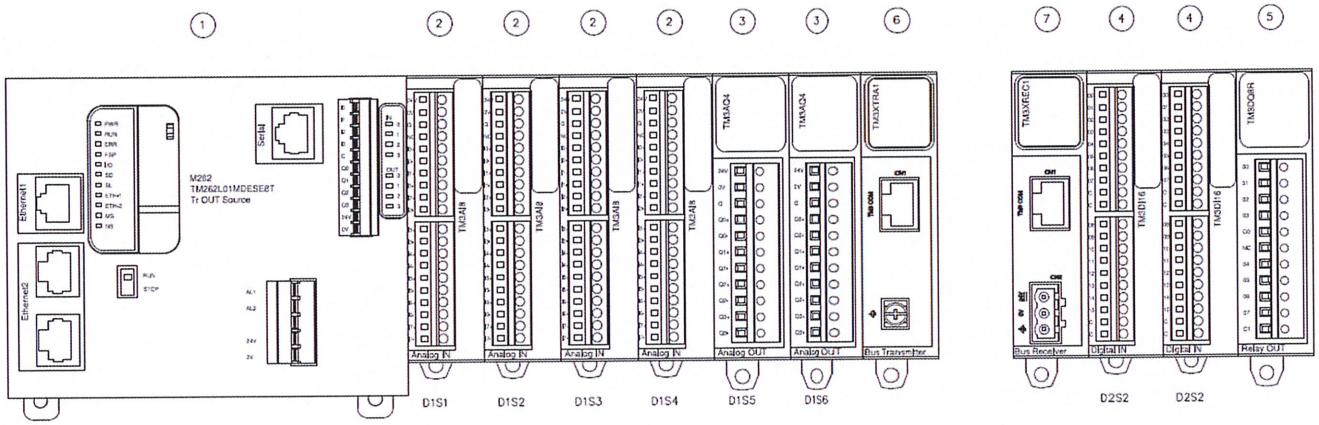
Front View



Side View



Back Plane



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