PLC Functional Design Specification

E354086-00000-271-078-0003

REV. 02

DOCUMENT APPROVAL PROCESS

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Date	Previous Rev No.	New Rev No.	Details of Revision
10.11.2021	0B	02	As Built

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1 INTRODUCTION

This document details the Functional Design Specification (FDS) for the PLC portion of the Process Control System (PCS) solution for the PCS Upgrade Project. The purpose of this document is to present a functional description of the systems and products to be supplied in compliance with the project Works Information and client User Requirements Specifications.

Modicon M580 ePAC (Ethernet programmable automation controllers) PLCs will be used, in high-availability Hot Standby (HSBY) configurations. Field signals will be interfaced to the PLC via remote IO Racks, using the X80 range of IO modules.

Interface to the OASyS SCADA System will be Modbus TCP communications.

This document is considered a living document and will be updated through the project to 'As-Built' at the end of the project.

1.1 Purpose

The purpose of this specification is to describe the configuration and features of the Modicon M580 HSBY PLC and related PLC hardware and software. The configuration laid out in this specification forms the basis of Engineering design in the PCS Upgrade Project.

1.2 Scope

1.2.1 Requirements Included

This document shall cover:

- Modicon M580 features and operation
- Configuration for the PCS Upgrade Project.
- Functionality of the system and each of the related sub-systems
- Details of all internal and external communication interfaces
- Details of Software and Hardware component make-up identification and details of all interfaces
- General software configuration principles

1.2.2 Requirements Excluded

This specification excludes the following Automation Systems, which are detailed in other project-related Functional Design Specifications:

- OASyS SCADA, including the Liquid Management Suite and Replay functionality
- Sim-Suite Leak Detection System
- HMI Trainer System
- Per Site Software Configurations

1.3 Terms and Definitions

1.3.1 Abbreviations

ACDB	Alarm Configuration Database
API	American Petroleum Institute
AS	PL723 Automation Standard
ASCII	American Standard Code for Information Interchange
CCOTF	Change of Configuration on The Fly
CO	Co-ordinating Officer
DCS	Distributed Control System
DDDT	Device Derived Data Type
DDF	Detected Dangerous Failure
DDS	Detailed Design Specification
DDT	Derived Data Type
DIE	Diesel
DOL	Direct Online
DTM	Device Type Manager
ECP	Effluent Control Panel
EDS	Engineering Design Specification
EIO	Ethernet (Remote) IO
ePAC	Ethernet Programmable Automation Controller
ES	Engineering System
FAST	PLC Fast Task which runs periodically at a pre-determined rate measured in ms
F&G	Fire and Gas
FBD	Function Block Diagram
FC	Flow Computer
FDS	Functional Design Specification
FDT	Field Device Type
FFB	Collective term for EF, EFB and DFB
FRS	Functional Requirements Specification
HART	Highway Addressable Remote Transducer
HMI	Human Machine Interface
HSBY	Hot Standby
I/O	Input/output
IP	Industrial Protocol
IS	Intrinsically Safe
LAN	Local Area Network
MAST	PLC Master Task which runs periodically at a pre-determined rate measured in ms
MCC	Master Control Centre
MDS	Metering System
MIS	Manufacturing Information System
MMS	Machine Monitoring System

MoC	Mode of Control
MoO	Mode of Operation
MTBF	Mean Time Between Failure
MTTF	Mean Time To Failure
MTTR	Mean Time To Replacement
MV	Medium Voltage
NOC	National Operations Centre
OPC	OLE for Process Control
OS	Operating System
P&ID	Piping and Instrumentation Drawing
PCS	Process Control System
PFD	Process Flow Diagram
PID	Proportional, Integral & Derivative Controller
PLC	Programmable Logic Controller
PLC	Programmable Logic Controller
RIO	Remote Input/Outputs
RPI	Request Packet Interval
RSTP	Rapid Spanning Tree Protocol
RTU	Remote Terminal Unit
SCADA	Supervisory, Control and Data Acquisition
SCC	Secondary Control Centre
SFC	Sequential Flow Chart
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SNMP	Simple Network Management Protocol
SO	Station Operator
ST	Structured Text
TBA	To be Advised
TBC	To be Confirmed
TBD	To be Defined
TCP	Transmission Control Protocol
TGS	Tank Gauging System
URS	User Requirements Specification
VSD	Variable Speed Drive
WAN	Wide Area Network

Table 1-1: Abbreviations

1.3.2 Definitions

Adapter	Ethernet/IP device the Publishes data at a set RPI(Request Packet Interval) and sent as multicast messages to Scanner Devices.
Advanced Database Editor (ADE)	An OASyS DNA support and configuration program for editing the real-time database.

Application Software	The software written specifically to perform user requirements for an individual plant when standard software packages cannot be configured to meet the requirements. Application software works with the standard operating software and it does not modify any standard software
Archive	Saving measured values and messages in the operator station to history so the data can be called up over a long period of time
Availability	The probability that a system will perform its designed function when required to do so is expressed as the fraction (or percentage) of time a system or individual module remains on-line and performs as specified during an observation period. It is calculated as follows: A = MTTF/MTBF or A = MTTF/(MTTF + MTTR)
Blocks	Blocks are separate parts of a user control software configuration distinguished by their function, structure, and purpose
CFC	Continuous Function Chart is a high-level graphical language using function blocks for configuring continuous control systems
Control Panel	A standard graphic element that represents, for example, an analogue controller instrument, a hardwired push-button, or a switch, allowing operator monitoring and control of the device, and comprises on one RTDB object.
Display	Graphics which will show the information coming from the RealTime database statically or dynamically.
Engineering Server (ES)	Used for preparation and distribution of software binaries, displays and database changes to the SCADA servers.
Faceplate	A standard graphic element that represents, for example, an analogue controller instrument, a hardwired push-button, or a switch, allowing operator monitoring and control of the device, and comprises of multiple RTDB objects.
Fault Tolerance	The property of a system which permits it to carry out its assigned function even in the presence of one or more faults in its hardware or software components. Fault tolerance is to be achieved automatically without any user intervention
Function Block	A control bock as defined in IEC 1131-3. See also Block
HMI	The graphical interface program for allowing an operator to interact with and control a process
Instance	A copy of a function block, which is used again in the control configuration for a similar application
Ladder Logic (LAD)	Graphical representation of the automation task using relay symbols complying with DIN 19239
MTBF	MTBF is the expected time between failures of a system including time to repair. It is derived in its simplest form as: MTBF = MTTF + MTTR
MTTF	MTTF is the expected time to failure of a system in a population of identical systems

MTTR	MTTR is the statistical average of time taken to identify and repair a fault (including diagnostics)
Mode	Control block operational condition, such as manual, automatic, or cascade
Monitor	Physical device used to show displays.
OPC	Software applications which allow bi-directional data flow between two separate applications. These applications may be running on the same or separate servers. OPC refers to the complete OPC specification
Operator Workstation	Electronic equipment on which the HMI resides, including, at a minimum, PC workstation, a monitor, keyboard, and pointing device used by an operator to monitor and control his assigned process or manufacturing units
Operator / Controller	One who exercises central surveillance and control of the field using SCADA.
Personal Computer (PC)	A workstation or server, typically running MS-Windows when referred to in this way.
PLC	Programmable Logic Controller, used for discrete and continuous control in processing and manufacturing plants
Point	A process variable derived from an input signal or calculated in a process calculation
Process Object	A collection of variables and parameters that performs a control function (e.g. motor, block valve, PID Controller) which may consist of more than one I/O point
Plug and Play	The ability of hardware equipment to automatically identify itself to the system. When the equipment is powered up it is automatically assigned a unique identity without the need to set any dipswitches
Real-time	The inherent property of a system to distribute data such that the users of the data always have the most current data at all times.
Reliability	The probability that when operating under stated environmental conditions, the system will perform continuously, as specified, over a specific time interval
Redundant	A system/subsystem with two modules that provides automatic switchover to a backup in the event of a failure, without loss of a system function
Scanner	Ethernet/IP – A scanner device opens connections and initiates data transfers. This device is typically the subscriber of data. (See Adapter for Publisher)
Screen	Part of the monitor which is shown to arrange displays.
Sequential Function Chart (SFC)	Sequential Function Charts are a high-level graphical configuration language for sequential control applications
Statement List (STL)	Statement List is a textual programming language resembling machine code and complying with IEC 1131-3

Structured Control Language (SCL)	A high-level language complying with IEC 1131-3 and resembling Pascal for programming complex or custom logic tasks within the controller
System Bus	The network used for communication between controllers and HMI servers
System Software	The software components that are required to make the system functional and fit for purpose. System software shall include any firmware, operating software and tools that are supplied as standard items (for example configuration software, operating system and human interface configuration software). Typically, system software is configured to meet user requirements
User Requirements	Those requirements that describe what functions the system must perform to achieve the objectives of operating the physical plant. Typically, the system is configured to meet user requirements
Works	PCS Upgrade Project which includes design, engineering, supply, installation, commissioning and handover of the Process Control, Integrated Custody Metering and Pipeline Monitoring Systems and Deployment to all Crude Oil Pipeline Stations – Main Automation Contract

Table 1-2: Definitions

2 APPLICABLE DOCUMENTS

All documents of the exact revision cited in the Applicable Documents form part of this specification to the extent specified. In the event of conflict between the text of this specification and the documents invoked herein, the text of this specification shall take precedence.

However, nothing in this specification supersedes applicable laws and regulations.

2.1 TPL Applicable Specifications and Standards

No. and Title	Doc. No.	Rev.
[1] PCS Control Module Specification	E354086-00000-271-078-0005	Latest
[2] SCADA Functional Design Specification	E354086-00000-271-078-0018	Latest
[3] Metering FDS	E354086-00000-271-078-0020	Latest
[4] SCADA Configuration Plan	E354086-00000-271-078-0003	Latest
[5] SCADA/PLC Communication Plan	E354086-00000-271-078-0012	Latest
[6] LDS Functional Design Specification	E354086-00000-271-078-0007	Latest
[7] LAN Network Standard	E354086-00000-271-078-0002	Latest
[8] HMI Style Guide	E354086-00000-271-078-0006	Latest
[9] PCS SCADA System Architecture	E354086-00000-271-256-0002	Latest
[10] PLC LAN Architecture Fynnlands Intake Station	E354086-00001-271-256-0001	Latest
[11] PLC LAN Architecture Typical Pump Station	E354086-00000-271-256-0006	Latest
[12] PLC LAN Architecture Typical Booster Station	E354086-00000-271-256-0005	Latest
[13] PLC LAN Architecture Coalbrook	E354086-00017-271-256-0001	Latest
[14] PCS Performance Specification	E354086-00000-271-078-0014	Latest
[15] Software Configuration Management Plan	E354086-00000-271-050-0002	Latest

[16]	Software Lifecycle Plan	E354086-00000-130-050-0001	Latest
[17]	Process Control System URS	TPL-TECH-I-C-SPEC-012	03
[18]	PCS Control Module Standard	TPL-TECH-I-C-SPEC-013	01
[19]	Integrated Metering System URS	TPL-TECH-M-SPEC-011B	04
[20]	Leak Detection System User Requirement Specification	H354086-00000-270-078-0004	0
[21]	Process Control System Automation Standard	PL723	04
[22]	Process Control Network Standard	PL703	2.0
[23]	S600 Floboss Stream FDS	TPL-TECH-I-M-SPEC-016 [4]	04
[24]	S600 Floboss Prover FDS	TPL-TECH-I-M-SPEC-017	04
[25]	TPL Product Codes and Colours Specification	2684358-P-SC0-CS-SP-001(00)	00
[26]	Alarm Philosophy	H354086-00000-270-080-0001 [B]	B
[27]	PLC System Architecture Failure and Recovery Analysis	H354086-00000-271-078-0016	Latest
[28]	PCS Naming Standard	E354086-00000-271-050-0006	Latest
[29]	PLC Coding Standard	E354086-00000-271-050-0004	Latest
[30]	Typical PLC Panel General Arrangement	E354086-00000-271-270-0001	Latest
[31]	Typical PCS Server Panel: All Pump Stations	E354086-00000-271-270-0005	Latest

2.2 Other Applicable Specifications and Standards

The following national and international standards are required to be complied with and shall be read in conjunction with this Specification.

No. and Title	Doc. No.	Rev.

[32]	Standard for Information Technology – Software Lifecycle Processes	IEEE 12207.0	1996
[33]	Electromagnetic compatibility (EMC)- Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	IEC 61000-4-2 (2001-04)	2001-04
[34]	Electromagnetic compatibility (EMC)- Part 4-3: Testing and measurement techniques - Electrostatic discharge immunity test	IEC 61000-4-3 (2002-03)	2002-03
[35]	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Electrical fast transient/burst immunity test	IEC 61000-4-4 (1995-01)	1995-01
[36]	Programmable controllers - Part 3: Programming languages	IEC 61131-3 (1993-03)	1993-03
[37]	Drawing Standards	PL100	03
[38]	Plant & Equipment Tag Numbering Standards	PL101	03
[39]	Equipment, Instrument & Electrical Symbology Standards	PL102	01

2.3 Reference Documentation

The documents included in this section do not form part of the specification, but are included for background and context. Sections and information used within this document have been used in full or in part from these documents of Schneider Electric.

No.		Doc. No.	Rev.
[40]	Modicon X80 Racks and Power Supplies Hardware Reference Manual	EIO000002626 09/2017	09/2017
[41]	Modicon M580 BMENOC0321 Control Network Module Installation and Configuration Guide	NVE24232.01	02/2017
[42]	Modicon M580 Hot Standby System planning guide for frequently used Architectures	NHA58880 09/2017	09/2917
[43]	Modicon M580 Hardware Reference Manual	EIO0000001578.00	10/2013
[44]	Modicon M340 Using Unity Pro – Discrete Input/Output Modules User Manual	35012474.04	05/2010
[45]	Modicon M340 using Unity Pro – Counting Module BMXEHC0800 User Manual	EIO000000318.03	07/2012
[46]	Modicon M340 with Unity Pro – Analog input/output modules User manual	3501197.07	07/2012
[47]	Profibus Remote Master – User Manual	S1A64489.00	04/2010
[48]	Unity Pro Languages and Program Structure Reference Manual	3500614404	06/2006
[49]	Unity Loader V12.0 Readme		V12.0

[50]	Unity Dif – a SoCollaborative Software User Manual	EIO0000001720.00	11/2013
[51]	Power Supplies, Phaseo ABL7, ABL 8 Catalog	June 2018	
[52]	Modicon M580 Remote IO Modules Installation and Configuration Guide	EIO0000001584.02	09/2014
[53]	PlantStruxure General Purpose Library for Unity – Process Components User Guide	EIO0000002093.06	01/2018
[54]	TVDA- "How can I implement an M580 Redundant System?" V2	-	V2 2017
[55]	BMXNRP0200/0201 Fiber Converter module User Guide	EIO0000001108.00	07/2012

3 PLC CONFIGURATION

3.1 PLC System Overview

The Modicon M580 Automation platform is the current flagship model PLC offering from Schneider Electric. The M580 allows two types of architectures – standard application and High-Availability applications. Standard applications comprise of a single BMEP58xxxx processor configuration.

The High Availability configuration is the choice of configuration for the PCS Upgrade Project since downtime cannot be tolerated. This configuration delivers high availability through redundancy. (The availability calculations are documented in the PLC System Architecture Failure and Recovery Analysis document [27]). Two backplanes are configured with identical hardware and software.

The racks which house the Processors are known as the Local Racks. Due to the redundant nature of this configuration, the racks are perceived and operated as one. At any given moment, only one of the CPUs are executing program logic and servicing remote/distributed IO at a time. This is known as the Primary CPU. The other CPU is known as the Standby CPU. Before each scan, the state RAM (the IO image and current values of all of the registers defined in the PLC) of the Primary CPU is copied to the Standby CPU via a dedicated Ethernet Link. This includes date and time data. This means that the Standby CPU always has current system values and is ready to assume control within one scan if the primary CPU stops communicating. Upon specific events, which are described in Section 3.2.9, the Primary and Standby CPUs switch roles i.e. Standby assumes the role of Primary in executing program logic and servicing RIO/DIO.

It is not possible to allocate IO to a local Rack on a HSBY configuration. IO is allocated in Remote racks which communicate to the local rack via Ethernet. IO on the M580 range of PLC is generically and collectively referred to as X80 IO.

3.2 Hot Standby Configuration

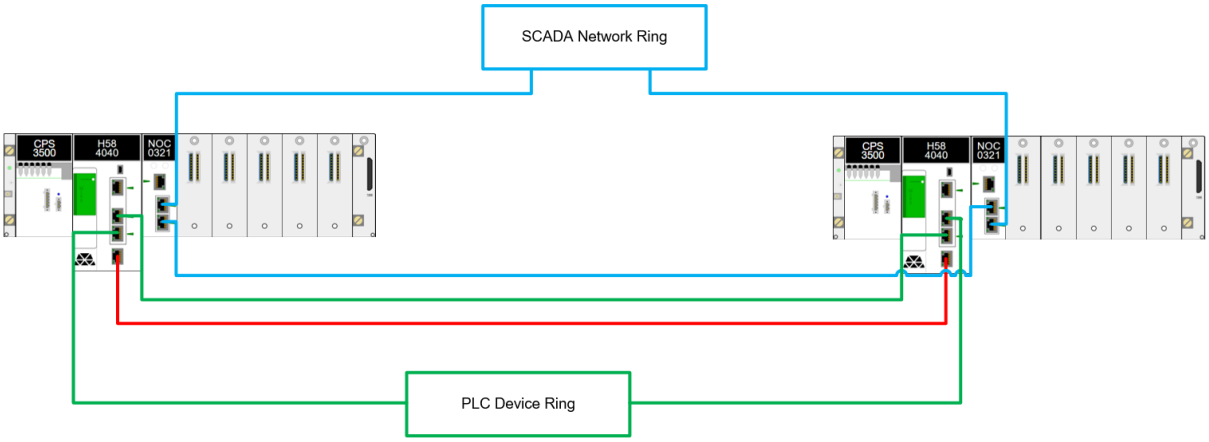


Figure 3-1: Hot Standby Local Racks

3.2.1 M580 Hot Standby Data

Periodic Data Exchanges

The HSBY CPUs perform two periodic data exchanges:

- Before each MAST cycle, the primary CPU transmits to the standby CPU application variables, system status and IO data.
- Periodically, both CPUs exchange the contents of the T_M_ECPU_HSBY DDT. This Derived Data Type is the exclusive interface between the M580 HSBY system and the application running in the CPU.

The T_M_ECPU_HSBY DDT presents three distinct sections:

- *LOCAL_HSBY_STS:* Provides information about the local PLC. Data is both auto-generated by the HSBY system and provided by the application. This data is exchanged with the remote PLC.
- *REMOTE_HSBY_STS:* Provides information about the remote PLC and contains the image of the last received exchange from the counterpart PLC. The validity of this information is represented by the *REMOTE_STS_VALID* flag in the common part of this DDT. NOTE: The structure of both the LOCAL_HSBY_STS and REMOTE_HSBY_STS sections are determined by the HSBY_STS_T data type and are therefore identical. Each is used to describe data relating to one of the two HSBY PLCs.
- A common part of the DDT: Consists of several objects, including status data system control objects and command objects
    - *Status data is provided by the HSBY system as a result of diagnostic checking.*
    - *System control objects enable you to define and control system behaviour.*

- *Command data objects include executable commands that can be used to modify system state.*

Refer to the Modicon M580 Hardware Reference Manual [43] for specific details of the T_M_ECPU_HSBY DDT.

Data Transmitted Each MAST Cycle

Before each MAST task, the primary CPU transmits data to the standby CPU in two ways. The primary CPU uses:

- The Hot Standby link to send application variables, system status and IO data.
- The Ethernet RIO link to send application variables and system status.

When communication is lost on the Hot Standby link, the standby CPU does not receive updated IO data and application variables. If communication is lost for three (3) seconds or more, the standby CPU enters wait state. Wait state is characterised as a condition of neither Primary nor Standby. It is 'waiting' for all preconditions to be met (HSBY Link).

The HSBY link is a crucial component to ensuring High Availability. As such it's status is sent to the SCADA for critical alarming.

3.2.2 PLC Backplane

TPL has standardised on the use of 8 and 4 slot, standard backplanes BMEXBP0800 and BMEXBP0400. These backplanes have also been standardised for Remote IO. One key role of the backplane other than supply power to connected modules, is to provide a communication bus for the modules installed on the rack. This communication bus provides support for XBUS and Ethernet. All standard IO modules support XBUS while special purpose modules such as HART, Weighting modules, Ethernet communication modules etc use Ethernet.

The 8 Slot BMEXBP0800 will be used on all Rack with the exception of MV and Metering panels which will used the 4 slot BMEXBP0400.

3.2.3 Rack Power Supplies

The standard BMXCPS3500 High Power, Power Supply has been standardised on by TPL on all racks. This is an alternating current power supply module with a nominal input voltage range of 100-120VAC/200-240VAC.

3.2.4 CPU - BMEH584040

3.2.4.1 CPU Module Front and Back Views

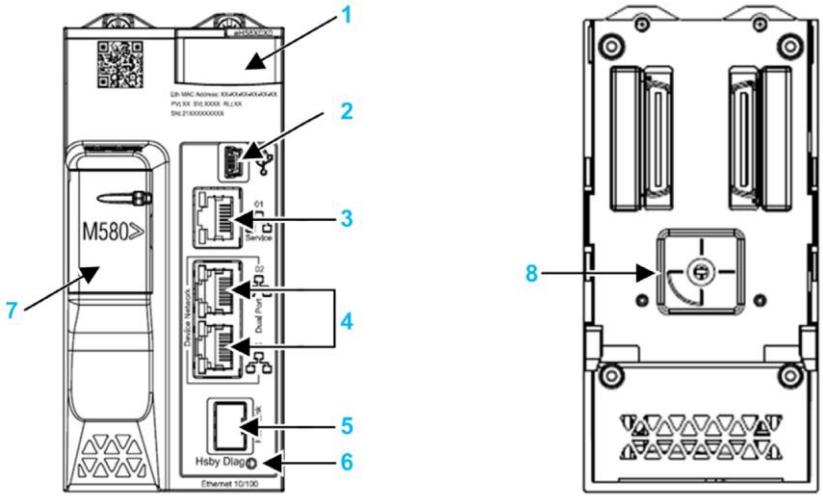


Figure 3-2: CPU module view

1. LED diagnostic display panel
2. Mini-B USB port for module configuration via PC running Unity Pro
3. RJ45 Ethernet service port connector
4. RJ45 connectors that together serve as a dual port to the Ethernet network
5. SFP socket for copper or fibre-optic Hot Standby link connection
6. Hot Standby status link LED
7. SD memory card slot
8. A/B/Clear rotary selector switch, used to designate the PLC as either PLC A or PLC B, or to clear the existing Unity Pro application

The BMEH584040 CPU is used in the PCS Upgrade Project.

Feature	BMEH584040	BMEH584060*
RIO drops (main+ extended racks)	16	31
BMENOC0301/11 Ethernet scanners	4	6
Program (MB)	16	64
Data (MB)	2	Up to 64
Maximum retained data (KB)	2048	4096
Maximum configurable Hot Standby transfer data (KB)	2048	4096
Data Storage (GB)	4	4
Discrete IO	4096	6144
Analogue IO	1024	1536

Table 3-1: CPU Specifications

* CPU available for use on larger sites.

3.2.4.2 CPU Firmware Mismatch

The M580 HSBY system can continue operating when there is a mismatch of firmware version in the primary and standby CPUs, if each CPU firmware can execute the application. This makes it possible to upgrade (or downgrade) CPU firmware without having to stop the operation of the HSBY system.

3.2.4.3 Application Mismatch

The M580 HSBY system cannot operate if the primary and standby CPUs are equipped with fundamentally different applications. In this case, the primary PLC operates as a standalone PLC and the standby PLC enters the stop state.

The HSBY operation is restored by confirming that the applications in both CPUs are the same. Procedures to deal with CPU failure is described in the PLC System Architecture Failure and Recovery Analysis document [27]

3.2.4.4 SD Memory Card

The SD Card is an option which is used on the PCS Upgrade Project for application and data storage. The SD Card is installed in the memory slot on the CPU (Item 7 on Figure 3-2: CPU module view).

The BMXRMS004GPF is a 4GB, Class A SD card which is rated for Industrial use.

Note: The BMXRMS004GPF memory card is formatted specifically for the M580 CPUs. If you use this card with another CPU or tool, the card may not be recognized by the M580.

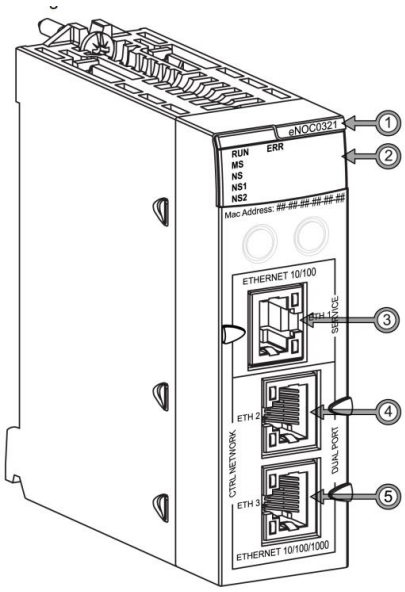
Memory card Characteristics

Global memory size	4 GB
Application backup size	64 MB
Data storage size	3.93 GB
Write/erase cycles (Typical)	100 000
Operating temperature range	-40…+85 °C
File retention time	10 Years
Memory zone for FTP access	Data storage directory only

Table 3-2: Memory Card Specification

3.2.5 BMENOC0321 Control Network Module

The BMENOC0321 is the entry point from the control network (SCADA Network) to a device network (including RIO and distributed equipment) managed by a Modicon M580 PLC. The module provides network transparency and provides a direct Ethernet connection between the control room subnetwork and the automation devices subnetwork.



Legend:

Item	Description	Function
1	module name	BMENOC0321
2	LED array	Observe the LED display *(see page 182)* to diagnose the module.
3	SERVICE port (ETH 1)	Use the RJ45 Ethernet connector for a service port. **NOTE:** Refer to the service port configuration *(see page 108)*.
4	control network port (ETH 2)	These RJ45 control network ports provide: • Ethernet communications (10/100/1000 Mbps) • connections for distributed device communications • cable redundancy through a daisy chain loop architecture
5	control network port (ETH 3)	

Figure 3-3: BMENOC0321 module

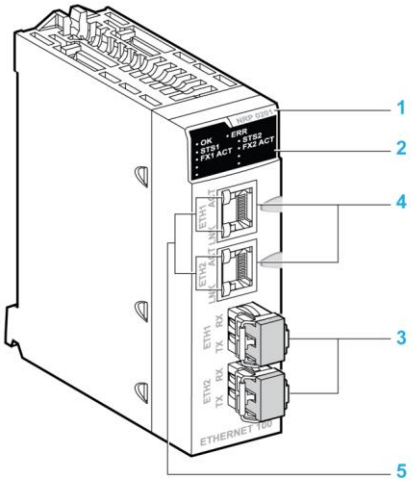
Feature		Maximum Capacity
Client	Simultaneous requests	16
	Message Size	1024 Bytes
Server	Simultaneous requests	32
	Message Size	1024 Bytes

Table 3-3: BMENOC0321 Connection Specification

Refer to the Modicon M580 BMENOC0321 Control Network Installation and Configuration Guide [41] for further information.

3.2.6 BMXNRP0201 Fibre Converter Module

The BMXNRP0201 serves as a Copper to Fibre / Fibre to Copper converter. These modules are used to extend the distance of the network. Coalbrook will be the only site on the PCS Upgrade Project to use these modules. The BMXNRP0201 supports single-mode fibre cable for distances up to 15km. This module serves as a medium converter and has no configuration. Power is supplied to this module via the Backplane.



1 Model number
2 LED display panel
3 Optical port with SFP transceiver for LC-type connector
4 RJ45 Ethernet port
5 **LNK** and **ACT** LED indicators on the RJ45 Ethernet port

Figure 3-4: BMXNRP0201 Single Mode Module

Refer to BMXNRP0200/201 Fiber Converter Module User Guide [55] for further information.

3.2.7 Local Rack Modules

The local rack comprises of (2 Local racks are used for HSBY):

- Backplane – BMEXBP0800 (8 Slot Backplane)
- Power Supply BMXCPS3500
- CPU – BMEH584040
- Hot Standby Link SFP (RJ45 Copper) – 490NAC0100
- Ethernet Communication Module – BMENOC0321
- Fibre Optic (Single Mode) Medium Convertor Module – BMXNRP0201 (The fibre optic module will be used where necessary and may not be present on all sites throughout the Crude Pipeline).

Note: A M580 Hot Standby Local rack:

- Does not support IO modules
- Does not support serial communication modules
- Cannot be Extended

3.2.8 Remote Racks – X80 IO

The HSBY configuration makes use of X80 Remote IO drops which comprises of:

- Backplane – BMEXBP0800 (8 Slot Backplane)
- Power Supply BMXCPS3500
- Ethernet Communication module – BMECRA31210
- Fibre Optic (Single Mode) Medium Convertor Module – BMXNRP0201 (Where necessary)
- Relevant IO Modules: Digital Inputs, Digital Outputs, Analogue Inputs, Analogue Outputs, High Speed Counter

3.2.8.1 BMECRA31210 Communication adapter

The M580 PLC processor has 2 dedicated Device Ethernet ports which are used for connection to multiple X80 remote IO racks.

The BMECRA31210 adapter is used as the interface at each remote rack. This module has the following ports:

Service Port

- Allows the diagnosis of Ethernet device network ports and provides access to external tools and devices (Unity Pro, ConneXium Network Manager, HMI etc.)
- The following modes are supported:
    - Access port (Default): This mode supports Ethernet communication.
    - Port Mirroring: In this mode, data traffic from one of the other 2 ports are copied to this port. This allows a connected management tool to monitor and analyse port traffic.
    - Disable

Device Network Ports

The Device Network copper ports are used to put the drop on the simple daisy chain loop.

They provide:

- Connections for Remote IO communications
- Cable redundancy

The BMECRA31210 adapter exchanges data via an IO Scanner service, which resides in the CPU on the main local rack:

- The input data from the remote IO drop is collected and published to the IO scanner
- The output modules are updated with the date received from the IO scanner
- The protocol used for exchange is Ethernet/IP

- The exchanges are deterministic, which means that the remote IO logic is scanned regularly in a scheduled and predictable manner.

External Features

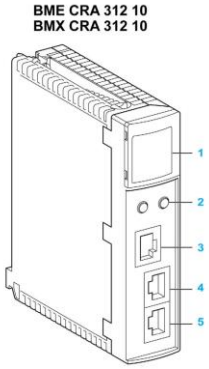


Figure 3-5: BMECRA31210 physical features

1	LED Display
2	Rotary Switches
3	Service Port (ETH 1)
4	Device Network (ETH 2)
5	Device Network (ETH 3)

Network Cable Installation

The network cables are connected in a loop, i.e. A cable leaves the CPU (ETH 3) port and connects to (ETH2) port on the CRA. The (ETH3) port on the CRA is then connected to (ETH 2) on the next CRA module. The final CRA module on the last remote IO drop will have (ETH3) return to the CPU (ETH2).

This configuration forms a Ring connection. The RSTP protocol is implemented to establish redundant communications with at least of the paths active to the CPU.

3.2.9 Switchover Causes

Any one of the following events will cause a switchover:

- The primary PLC has encountered a blocking condition (see Modicon M580 Hardware Reference Manual [43]) and entered the HALT state.
- The primary PLC has detected an unrecoverable hardware or system error.
- The primary PLC has received a STOP command from Unity Pro or the DDDT.
- An application program is being transferred to the primary CPU.
- Primary PLC power is turned off.

- The following events simultaneously occur:
  - The primary PLC loses communication to all RIO drops.
  - The Hot Standby link is healthy.
  - The standby PLC maintains communication with at least one RIO drop.
- The DDDT CMD_SWAP command is executed by either program logic, or an animation table Force Command.
- Clicking the HSBY Swap button in the Task tab of the CPU Animation window in Unity Pro
- BMENOC0321 Failure or communication loss on this card. This switchover is not executed by the CPU but rather by user code. Therefore, this switch will be executed within the 50-100ms. The code has been written in alignment with the TVDA (Tested, Validated and Documented Architecture – From Schneider Electric). [54]

3.2.10 Switchover Execution Time

If both the primary PLC and standby PLC are operating normally, the Hot Standby system detects a switchover causal event within 15 ms. The time to complete a switchover can vary from the maximum detection time of 15 ms, up to one MAST cycle.

After the switchover, the former standby PLC becomes the primary. In the worst case, the new primary PLC operates with data of scan cycle N, while the outputs have received (from the former primary PLC) data of scan cycle N+1. The new primary PLC re-evaluates outputs beginning with scan N+1.

Because the Hot Standby switchover evaluation occurs during the MAST task, some FAST task program execution may be skipped.

3.2.11 Switchover effect on the Main IP Address Assignments

Distributed equipment uses the **Main IP address** setting to communicate over an Ethernet network with the primary CPU. On switchover the **Main IP address** setting is automatically transferred from the former primary CPU to the former standby – now the new primary CPU. Similarly, on switchover the **Main IP address + 1** setting is automatically transferred from the former standby CPU to the new standby.

In this way, the configured links between the distributed equipment and the primary CPU do not need to be edited in the event of a switchover.

This switchover has the same effect on the BMENOC0321 module. These IP addresses are also transferred across thereby ensuring an active connection to the SCADA system.

3.2.12 Switchover Effect on Remote Outputs

For Remote IO drops, the switchover is bumpless: the state of outputs is not affected by the switchover. During Hot Standby operations, each PLC maintains an independent, redundant owner connection with each RIO drop. Each PLC makes this connection via IP address A or IP address B, depending on the A/B/Clear rotary switch (Section 3.2.4.1) designation for its CPU.

When a switchover occurs, the new primary PLC continues to communicate with I/O via its pre-existing redundant owner connection.

NOTE: The switchover may not be bumpless with respect to distributed equipment outputs. Distributed IO include any device outside the Main IO Ring being scanned on Ethernet, such as the ACS1000 VSD or other devices on Modbus Serial which are serviced thought an Ethernet to Serial gateway. This is normally resolved on the end device configuration Hold Time. Setting the Hold time such that in the event of a communication interruption, the outputs are held in state.

3.2.13 Change of Configuration on the Fly (CCOTF)

All M580 BMEH58x040 CPUs support CCOTF. CCOTF allows modifications of a Hot Standby primary PLC configuration in RUN mode without causing a stoppage of the system due to the necessity of a Full configuration download. The changes that can be made in the primary PLC are as follows:

- Add a discrete or analogue module in a free slot.
- Delete a discrete or analogue module.
- Modify the configuration and adjustment parameters of a module.

The changes that can be made in an Ethernet RIO drop are as follows:

- Add and X80 Remote IO drop.
- Add a discrete or analogue module in a free slot.
- Delete a discrete or analogue module.
- Modify the configuration and adjustment parameters of a module.

3.2.14 Diagnostics

All hardware related faults which provide LED indication at each module is accessible through the user code of the PLC. Faults such as: IO module, channel, remote link, etc appear in bit format (Boolean Logic 1 or 0 which represents 'Fault' or 'Healthy').

All IO modules and rack information will be packed to words and passed to the SCADA for display. The method of display is to be decided by AVEVA to align with Baseline displays.

3.2.14.1 IO Module LED Diagnostics

Each IO module is equipped with a display of LEDs on the front panel. This centralises the module information necessary for control diagnostics and maintenance.

Depending on the module, the nature of the indication will differ. Digital modules indicate the logic state of each channel, while analogue modules would indicate channel 'health' state. Each module has a Red LED indicating a fault.

This panel serves as a local form of diagnostics. All of the information present on this panel is available at a software level for access through Unity Pro and packed for SCADA display.

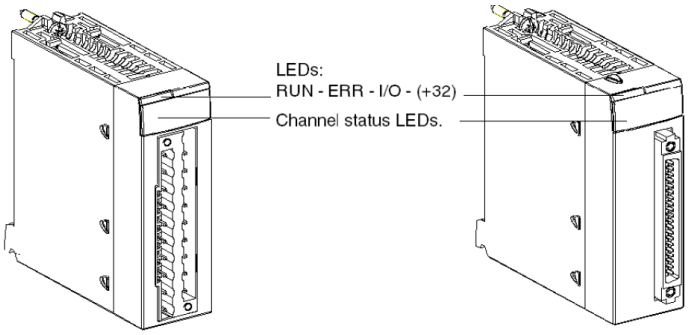


Figure 3-6: General Module LED indication

3.2.14.2 CPU LED Panel

The front face of the BMEH584040 HSBY CPU uses the following LED panel to diagnose the state of the HSBY system.

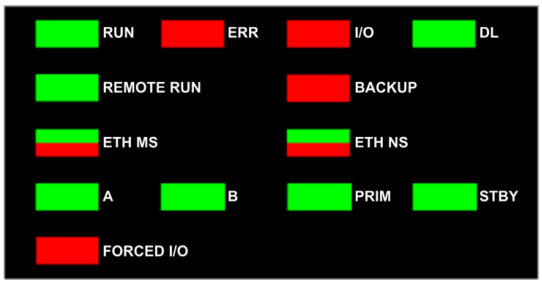


Figure 3-7: CPU LED Panel

The purpose of this LED panel is to provide a first level, quick diagnostics for the system or module in specific.

LED	Description
A	• **ON** (green) indicates: ❍ The local CPU A/B/Clear rotary switch *(see page 21)* is set to “A” , and ❍ The remote CPU A/B/Clear rotary switch is set to “B”. • **BLINKING** (green) indicates: ❍ If LED B is **OFF**: - The local CPU A/B/Clear rotary switch is set to “A” , and - The remote CPU A/B/Clear rotary switch is also set to “A”. ❍ If LED B is also **BLINKING** green: - The local CPU A/B/Clear rotary switch is set to “Clear”. • **OFF**: Indicates local CPU A/B/Clear rotary switch is not set to “A” or to “Clear”.

LED	Description
B	• **ON** (green) indicates: ❍ The local CPU A/B/Clear rotary switch is set to “B” , and ❍ The remote CPU A/B/Clear rotary switch is set to “A”. • **BLINKING** (green) indicates: ❍ If LED A is **OFF**: - The local CPU A/B/Clear rotary switch is set to “B” , and - The remote CPU A/B/Clear rotary switch is also set to “B”. ❍ If LED A is also **BLINKING** green: - The local CPU A/B/Clear rotary switch is set to “Clear.” • **OFF**: Indicates local CPU A/B/Clear rotary switch is not set to “B” or “Clear”.
REMOTE RUN	Indicates the RUN status of the remote PAC: • **ON**: (green): The remote PAC is in RUN state. • **BLINKING**: (green): The remote PAC is in STOP state. • **OFF**: The local PAC cannot read the state of the remote PAC. Both the Hot Standby link and the Ethernet RIO link are lost.
PRIM	Indicates the primary status of the PAC: • **ON** (green) The local PAC is primary, but the remote PAC is not in standby state. • **BLINKING**: The local PAC is in wait state; the STBY LED is also **BLINKING**. • **OFF**: The local PAC is not primary. **NOTE:** • If CPU is in RUN mode and both PRIM and STBY LEDs are **OFF**, CPU is in wait state. • If both CPUs are in RUN mode, and one CPU is primary and the other CPU is in wait state: - On Primary: PRIM LED is ON, STBY LED is BLINK. - On Wait: PRIM LED is OFF, STBY LED is BLINK
STBY	Indicates the standby status of the PAC: • **ON** (green): Indicates the PAC is in standby state. • **BLINKING** (green) indicates either: ❍ The local PAC is primary, but the remote PAC is not in standby state. ❍ The local PAC is in wait state; the PRIM LED is also **BLINKING**. • **OFF**: Indicates local PAC is not in standby state. **NOTE:** • If CPU is in RUN mode and both PRIM and STBY LEDs are **BLINKING**, the CPU is in wait state. • If one CPU is primary and the other CPU is in wait state: - On Primary: PRIM LED is **ON**, STBY LED is **BLINKING**. - On Wait: PRIM LED is **OFF**, STBY LED is **BLINKING**.

Table 3-8: CPU LED Panel

3.2.14.3 Diagnostics via Unity Pro

Using the integrated diagnostics in Unity Pro, the local diagnostics on the module front panel are complemented by system diagnostics based on predefined screens at global hardware configuration level, module level and channel level.

3.2.14.4 Remote diagnostics

Remote diagnostics using a web browser is made possible with the standard web server integrated in the Modicon X80 IO platform (Processor Ethernet port or BMENOC0321 module) using the "ready-to-use" Rack Viewer function. Due to the transparency of Ethernet, it is possible for the MCC engineering station to connect to any PLC CPU across the Pipeline to view diagnostics. There is no transparency however to the X80 IO due to the segregation of the Device network (IO Ring). Diagnostics from IO devices are accessible through the CPU.

3.2.14.5 PLC Diagnostics sent to SCADA

The following signals will be interfaced between PLC and SCADA. To be reviewed during phase 2.

CPU	Redundancy status / Backup path available
	CPU Fault/Stopped
	Hot/Standby status
Field PSU	Device Fault
Remote Racks	Drop Status
X80 IO Modules	Module status
Remote Communication Module(CRA)	Module Status
	Port Status
	Ethernet Backplane Status
BMENOC321 (SCADA Communication)	Module Status on Active module
	Port Status on Active module

3.3 Performance

3.3.1 Controller Performance

The minimum MAST task and FAST task are calculated by the following formulae:

- (# of RIO drops using MAST task) /1.5
- (#of RIO drops using FAST task / 1.5)
- (# of RIO drops using MAST task) / (MAST cycle time) + (# of RIO drops using FAST task) / (FAST cycle time) < 1.5

MAST Task

The estimated maximum drops to be used on any given site of the Crude PCS Upgrade Project is sixteen (16).

Therefore, the minimum MAST task cycle time could be, (16) / 1.5 = **10.667ms** for the MAST task. Despite the possibility of setting a such a fast scan rate, it is estimated that the MAST task will be set to **50ms** to cater for Application Response Time (Section 3.3.2). Due to difference in size of applications and the need to keep the CPU load less than 60%, the Mast Task will be set to 50ms as a start. Once the site application has been developed, and assessment will be made on the CPU loading. If the loading is above 60%, increments of 25ms will be added in bringing down the CPU Loading up to a maximum of 200ms.

FAST Task

Where high speed sensing is required, e.g. Pig detection, a Fast Task is used. The Fast Task will be set to 5ms.

Configuration requirement set out in Modicon M580 Hot Standby System Planning Guide [42].

(16 / 50) + (2 / 5) = 0.72. This result is less than (<) the guideline requirement of 1.5

3.3.2 Application Response Time

Each Ethernet RIO input signal packet travels from a Remote IO drop to the CPU and the CPU sends an output signal back to the RIO drop. The time it takes for the CPU to receive the input signal and effect a change in the output module based on the input is called Application Response Time (ART).

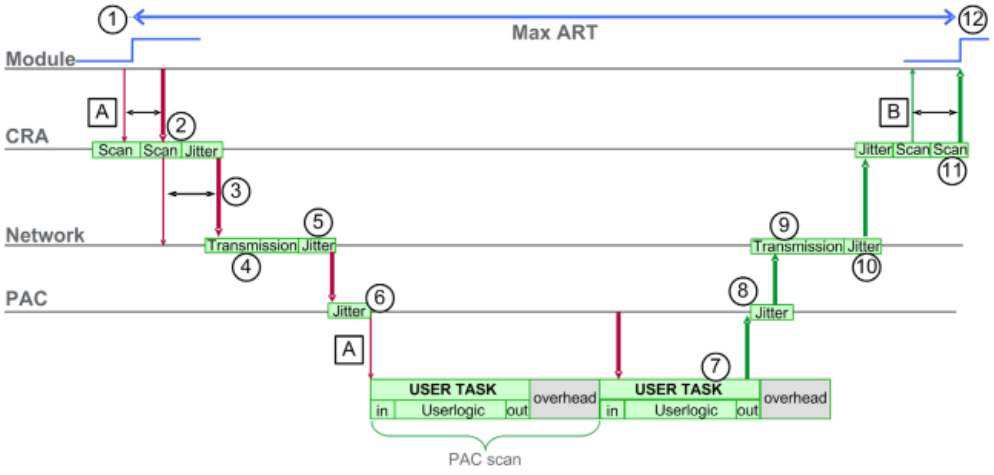


Figure 3-9: Maximum Application Response Time

A	Missed input scan	6	CPU input jitter
B	Missed output scan	7	Operation of application logic (1 Scan)
1	Input turns ON	8	CPU output jitter
2	CRA drop processing time	9	Network delay

3	CRA input Request Packet Interval(RPI) rate	10	Network jitter
4	Network delay	11	CRA drop processing time
5	Network jitter	12	Output applied

Table 3-4: Maximum Application Response time Cycle

To estimate the maximum ART for the Crude PCS Upgrade Project, the following information is used:

- CRA->Scanner RPI
- 2*CPU_Scan (PLC Scan)
- 8.8ms (A constant value representing maximum CRA processing time).

The Estimated Maximum ART for a given station with a periodic scan of 50ms:

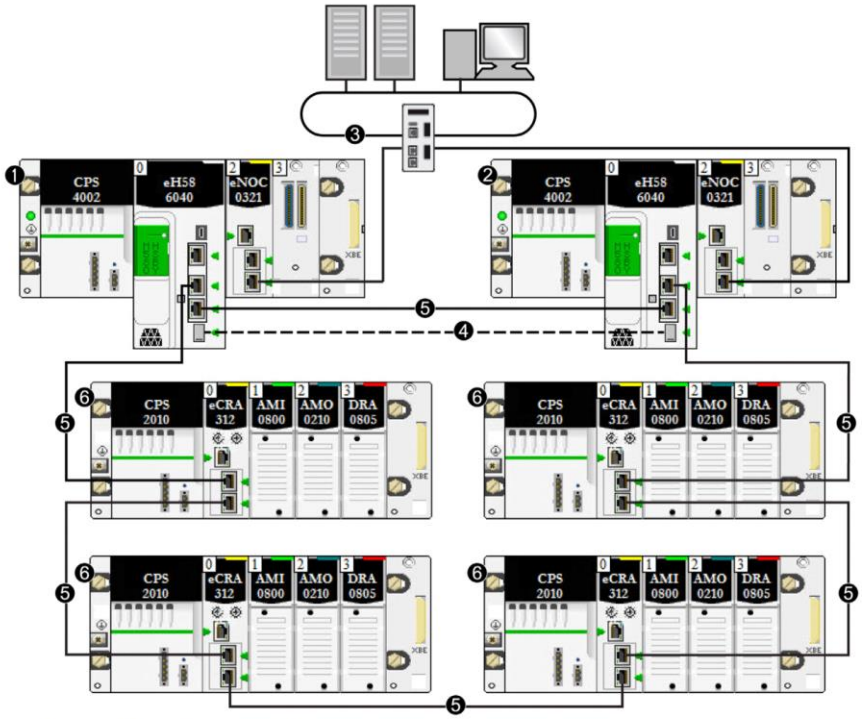
CRA_RPI(25ms) + (2*50ms) + 8.8ms = **133.8ms**

3.3.3 Availability

For PLC System Availability calculations, please refer to PLC System Architecture Failure and Recovery Analysis document [27].

3.4 System Architecture

3.4.1 Ring Topology with HSBY



1 primary local rack with primary CPU
2 standby local rack with standby CPU
3 control network connected to a BMENOC0321 module on the local rack to provide transparency between the device network and the control network
4 Hot Standby communication link
5 RIO main ring
6 (e)X80 RIO drop

Figure 3-10: Typical Remote IO Ring Topology

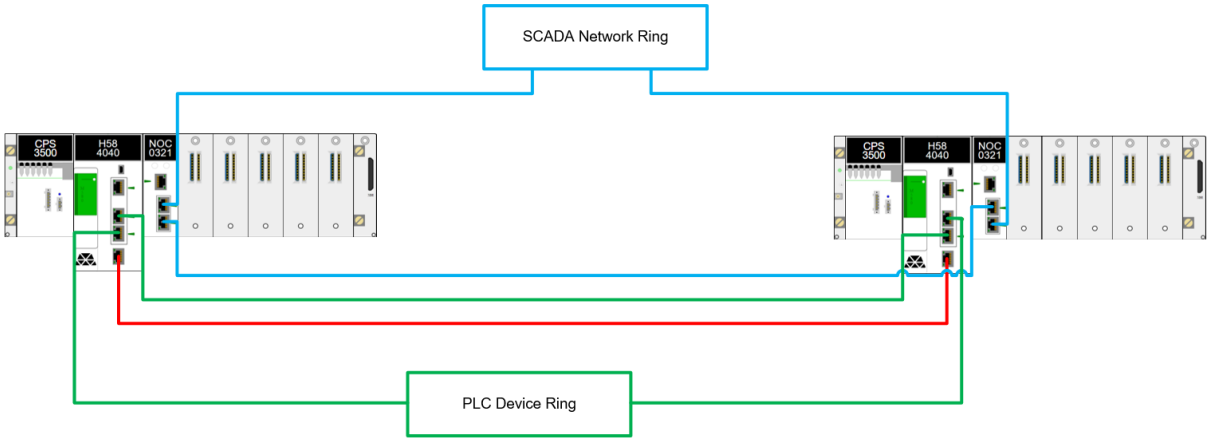


Figure 3-11: TPL System Typical

3.4.2 On-Site Engineering Stations

Unity Pro software (one licence) is installed on the Engineering Server at the NOC, and on the Production Host virtual servers on the local stations (one licence per site). A Facility Licence is provided (100 Licences).

3.4.3 X80 Remote IO

3.4.3.1 IO Assignment and Grouping Philosophy

The Following IO modules will be used where necessary:

- Digital input modules
- Digital output modules
- Analogue input modules
- Analogue output modules
- High speed counter module

On average, 25% additional IO is added for spare capacity. Spare slots are also ensured to provide capacity for future expansion.

Each mainline pump set IO will be allocated to separate racks where possible.

Devices will be ordered on a card in device group order and then sequential tag order, where possible.

3.4.3.2 Digital Inputs

BMXDDI3202k

The 32channel modules standardised on for the Crude PCS Upgrade Project is the BMXDDI3202k. The IO modules are housed in plastic cases which provide IP20 protection for all the electronic parts.

The diagram below shows a 40-pin discrete module.

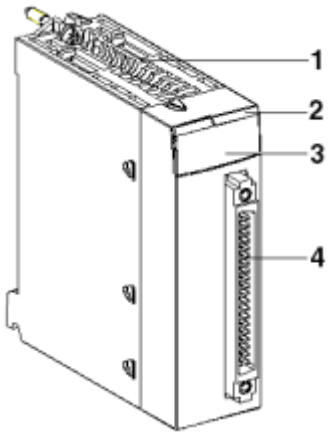


Figure 3-12: 32 Channel Digital Input/Output Module

Number	Description
1	Rigid structure which supports and protects the electronic card.
2	Module reference label **Note**: A label is also visible on the right-hand side of the module.
3	Channel status display panel.
4	40-pin connector, used to connector sensors or pre-actuators.

Table 3-13: Description of 32 Channel Digital Input Module

3.4.3.2.1 Specifications

BMXDDI3202k	
Number of channels	32 Digital Inputs
Range	24VDC
Insulation	Inputs opto-isolated per group of 16 channels
IEC61131-2 compliance	Type 3
Logic	Positive (sink)
Proximity sensor compatibility	2-wire DC and 3-wire PNP proximity sensor (IEC 947-5-2 standard compliant)
Response time	4 ms, 7 ms(Max)
Type of Interface	Connection via 40-way connector with preassembled cord sets
Protection of inputs	Requirement: External 1x 0.5A fast blow fuse per group
Reverse polarity protection	Yes
Isolation	Isolation 500VDC between groups of channels

Table 3-14: Basic Specifications of BMXDDI3202k

BMXDDI1602

The 16channel Digital Input modules standardised on for the Crude PCS Upgrade Project is the BMXDDI1602. These IO modules are housed in plastic cases which provide IP20 protection for all the electronic parts.

The diagram below shows a 20-pin discrete module and 20-pin terminal block. Screw terminals are used throughout all connections.

BMXDDI1602	
	Inputs
Number of channels	16 Digital Inputs
Range	24VDC
Isolation	16 Optically Isolated inputs and 1 common
IEC61131-2 compliance	Type 3
Logic	Positive (Sink)
Proximity sensor compatibility	2-wire DC and 3-wire PNP proximity sensor (IEC 947-5-2 standard compliant)
Response time	4 ms, 7 ms(Max)
Type of Interface	Connection via removable 20-way terminal block
Protection	Requirement: External 1x 0.5A fast blow fuse per group
Reverse polarity protection	Yes
Isolation	500VDC between groups of inputs and outputs

3.4.3.2.2 Module Density

32 channel modules have been standardised on by TPL for all input modules located in the PLC, Metering and LV Panels. 16 channel modules are used in the MV panels where space constraints exist.

32 channel modules have been selected in order to standardise on 40pin connectors and Telefast base units.

3.4.3.2.3 Wiring connections

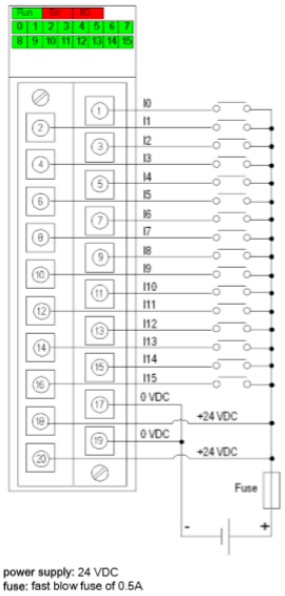


Figure 3-15: Wiring Connection DDI1602

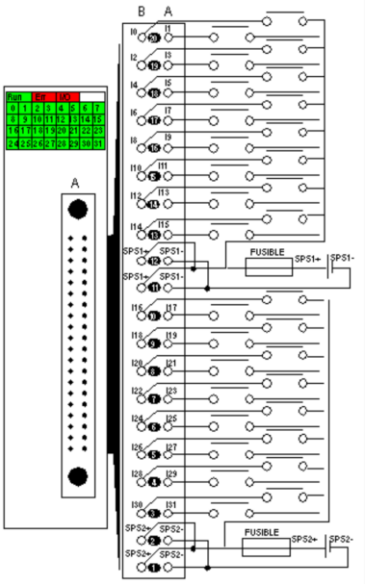


Figure 3-16: Wiring Connection DDI3202k

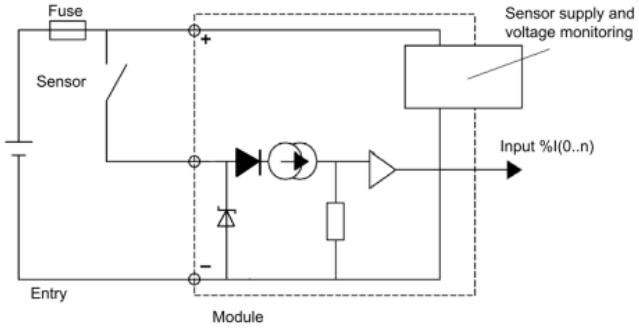


Figure 3-17: Input Circuit Diagram for DDI1602 and DDI3202k

3.4.3.2.4 TELEFAST ABE7 Terminal Blocks General Description

The TELEFAST system is a group of products which enables discrete input modules to be quickly connected to operational components.

The specific model of TELEFAST ABE7 Terminal Block for the PCS Upgrade Project is to be proposed below have been chosen.

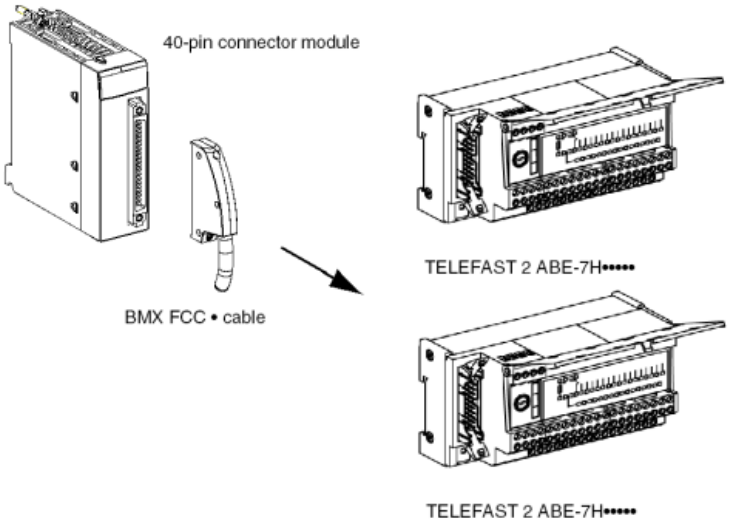
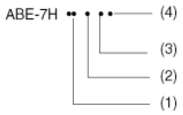


Figure 3-18: 40-pin connector to TELEFAST Block

The principle for identifying the connection interface bases for 8/12/16-channel discrete IO is as follows:



Number	Description
(1)	**08** = 8-channel base **12** = 12-channel base **16** = 16-channel base
(2)	Primary function: • **R** = simple connection • **S** = isolator/channel • **F** = fuse/channel
(3)	**1** = with 1 screw terminal per channel on 1 level **2** = with 2 screw terminals per channel on 2 levels **3** = with 3 screw terminals per channel on 3 levels **4** = with 2 screw terminals per channel on 1 level **5** = with 1 screw terminal per channel on 2 levels
(4)	**0 or even number** = without LED display per channel **odd number** = with LED display per channel

Figure 3-19: TELEFAST Block Identification

ABE-7H16S21

The ABE-7H16S21 is proposed for Digital Inputs on the Crude PCS Upgrade Project. This base offers 16 inputs with an isolator and LED per channel.

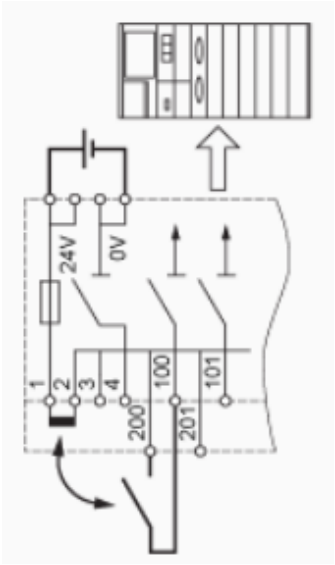


Figure 3-20: ABE-7H16S21 Connections

3.4.3.2.5 Intrinsically Safe (IS) and Non-Intrinsically Safe (Non-IS)

IS and Non-IS IO have been combined. Further information to follow beyond the FEED phase.

3.4.3.3 Digital Outputs

BMXDD03202k

The 32channel modules standardised on for the Crude PCS Upgrade Project is the BMXDD03202K. The IO modules are housed in plastic cases which provide IP20 protection for all the electronic parts.

The diagram below shows a 40-pin discrete module.

BMXDDO1602

16 channel Digital Output modules BMXDDI1602 are used in the MV panels due to space constraints as described above.

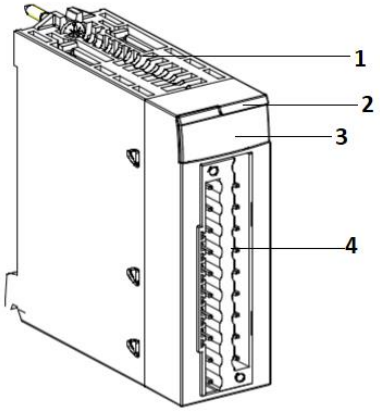


Figure 3-21: 16 Channel Digital Module

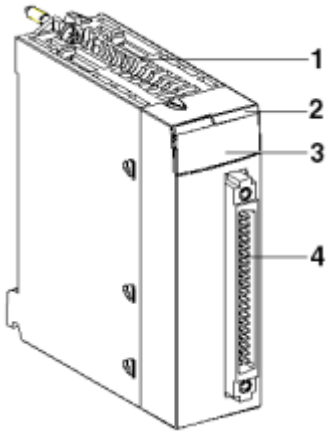


Figure 3-22: 32 Channel Digital Module

Number	Description
1	Rigid structure which supports and protects the electronic card
2	Module reference label **Note**: A label is also visible on the right-hand side of the module.
3	Channel status display panel
4	40-pin connector, used to connector sensors or pre-actuators

Table 3-23: Description of Channel Digital Output Module

3.4.3.3.1 Specifications

BMXDDO1602	
Number of channels	16 Outputs
Range	24VDC
Insulation	Outputs insulated per group of 16 channels
Current	0.5A
Logic	Positive
Overload protection	Outputs protected against short-circuits and overloads with automatic or controlled reactivation and fast electromagnet demagnetisation circuit.
Response time	1.2ms
Type of Interface	1 x removable 20-pin terminal block
Protection of outputs	Requirement: External 1x 6.3A fast blow fuse.
Protection of DC outputs	Active transistor outputs can withstand overloads, short-circuits, reverse polarity and inductive over-voltage.
Isolation	500VDC between groups of channels

Table 3-24: Basic Specifications of BMXDDO1602

BMXDDO3202K	
Number of channels	32 Outputs
Range	24VDC
Insulation	Outputs insulated per group of 16 channels
Current	0.1A
Logic	Positive

Overload protection	Outputs protected against short-circuits and overloads with automatic or controlled reactivation and fast electromagnet demagnetisation circuit.
Response time	1.2ms
Type of Interface	1 x 40-pin connector
Protection of outputs	Requirement: External 1x 2A fast blow fuse per group of 16.
Protection of DC outputs	Active transistor outputs can withstand overloads, short-circuits, reverse polarity and inductive over-voltage.
Isolation	500VDC between groups of channels

Table 3-25: Basic Specifications of BMXDDO3202K

3.4.3.3.2 Module Density

32 channel modules have been standardised on by TPL for all output modules located in the PLC, Metering and LV panels. 16 channel modules are used in the MV panels where space constraints exist.

32 channel modules have been selected in order to standardise on 40pin connectors and Telefast base units.

3.4.3.3.3 Wiring connections

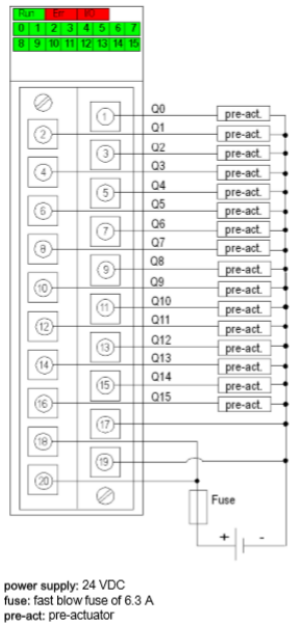


Figure 3-26: Wiring connection of BMXDDO1602

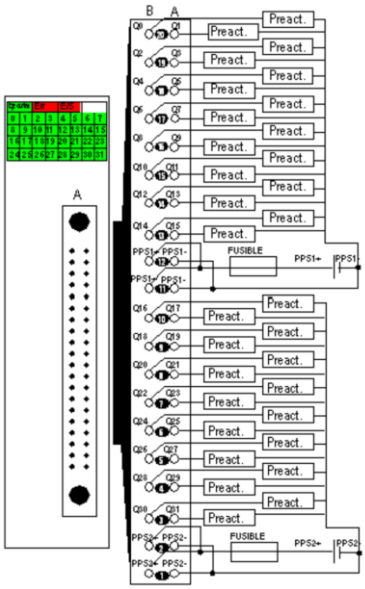


Figure 3-27: Wiring connection of BMXDDO3202

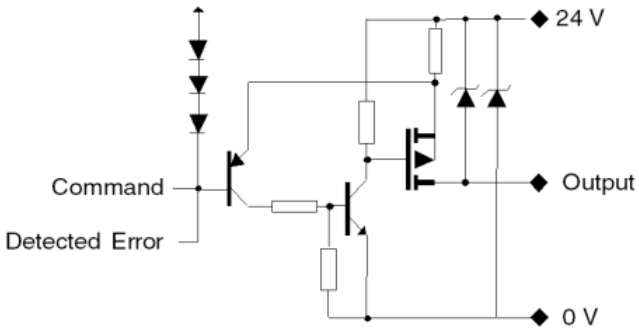


Figure 3-28: Output Circuit Diagram of BMXDDO1602 and BMXDDO3202

3.4.3.3.4 Telefast ABE7 Terminal Blocks – ABE-7P16T210

The ABE-7P16T210 is proposed for Digital Outputs on the Crude PCS Upgrade Project. This base offers one LED indication per potential free contact (N.O.). The output contacts are potential free with a common per channel. This base supports the use of a combination of electro-mechanical and solid-state relays. The standard mechanical relays offering a 5A rating on the contact is to be used.

Note: Solid State relays are optional but not recommended which provide a 2A rating on the contact.

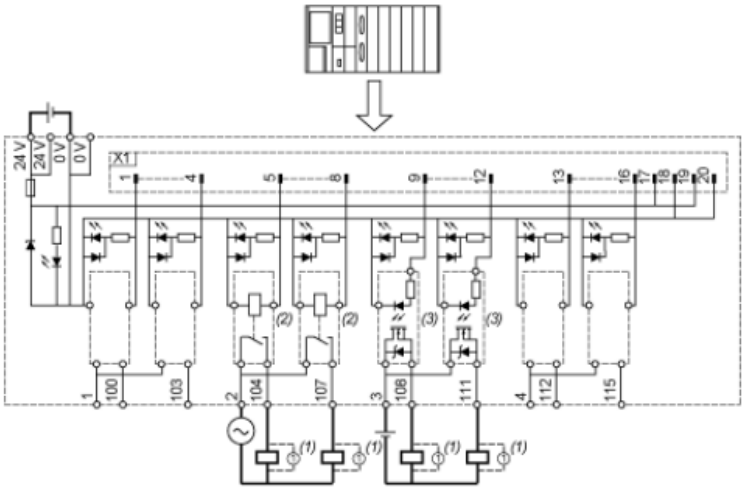


Figure 3-29: Wiring connection of ABE7P16T210

3.4.3.3.5 Intrinsically Safe (IS) and Non-Intrinsically Safe (Non-IS)

IS and Non-IS IO have been combined. All IS IO will use Barriers as specified in section 3.4.6.

3.4.3.4 High Speed Counter module

The BMCEHC0800 counting module is a standard format module that enable pulses from a sensor to be counted at a maximum frequency of 10kHz.

The sensors used on each channel may be:

- 24VDC two-wire proximity sensors
- 24VDC three-wire proximity sensors
- Incremental signal encoders with 10/30 VDC output and push-pull outputs.

3.4.3.4.1 Specifications

BMXEHC0800	
Module Type	8 Channel High Speed Counter
Counter size	16 bits
Maximum frequency at counting inputs	10kHz
Number of inputs per counting channel	2 inputs in single mode 3 inputs in special dual phase mode
Input Compatibility	2-wire/3-wire proximity sensor 19.2..30VDC
Input Voltage	24VDC Type 3
Cycle Time	5ms
Isolation	1500V for 60s

Table 3-30: Basic Specifications of BMXEHC0800

3.4.3.4.2 Module Density

The BMXEHC0800 8 Channel high speed counter module has been standardised for use on the Crude PSC Upgrade Project where needed. This module supports inputs up to a maximum of 10kHz.

3.4.3.4.3 Wiring connections

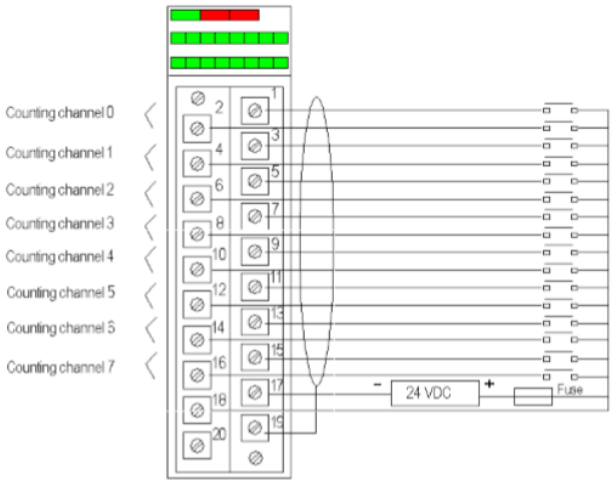


Figure 3-31: Typical wiring connection of BMXEHC0800

3.4.3.4.4 Removable Terminal Blocks

Screw clamp terminals are used on the BMXEHC0800 module.

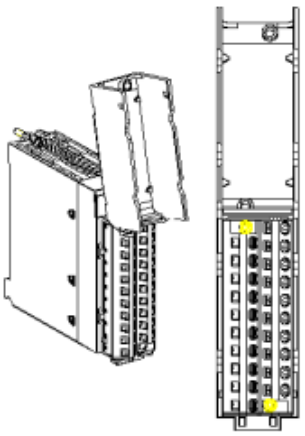
		Screw clamp terminal blocks
Illustration		
Number of wires		1 or 2
Wire gauge	**min**	AWG 22 (0.34 mm^2)
	max	AWG 15 (1.5 mm^2)

Figure 3-32: Screw Clamp Terminal Blocks

3.4.3.4.5 Telefast ABE7 Terminal Blocks

Telefast ABE7 terminal blocks are not available on High speed counter modules. Signals will be wired to terminal rails using SAKR 2.5 knife-edge Terminals.

3.4.3.5 Analogue Inputs

The BMXAMI0810 is a high density analogue input module with 8 isolated channels. This module is used in conjunction with sensors or transmitters; it performs monitoring, measurement and continuous process control functions.

This module offers the following range for each input according to the selection made during configuration:

- +/- 10 V
- 0..10 V
- 0..5 V / 0..20 mA
- 1..5 V / 4..20 mA
- +/- 5 V / +/-20mA

3.4.3.5.1 Specifications

BMXAMI0810	
Module Type	8 High level isolated fast inputs
Nature of inputs	Voltage/Current (250Ω internally protected resisters)
Display Resolution	15 bit +Sign
Acquisition cycle time:	9ms for 8 Channels
Fast (periodic acquisition for the declared channels used)	1ms + 1ms x number of channels used
Default (periodic acquisition for all channels)	9ms
Isolation	Between Channels: 300VDC Between Channel and Bus: 1400VDC Between Channel and Ground: 1400VDC
Wire-break detection	Yes
Short-circuit protection	Yes

Reverse polarity protection	Yes
Total Error	+/- 0.1%
Max load impedance	250Ω

Table 3-33: Basic Specifications of BMXAMI0810

3.4.3.5.2 Module Density

The BMXAMI0810 is an 8 Channel module that has been standardised on by TPL for use on the Crude PSC Upgrade Project where needed.

3.4.3.5.3 Wiring connections

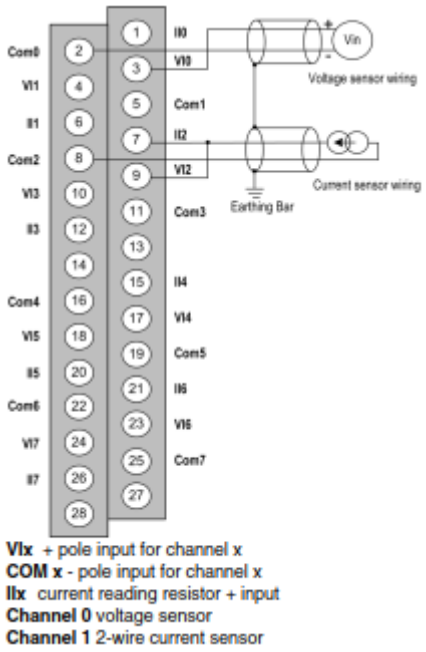
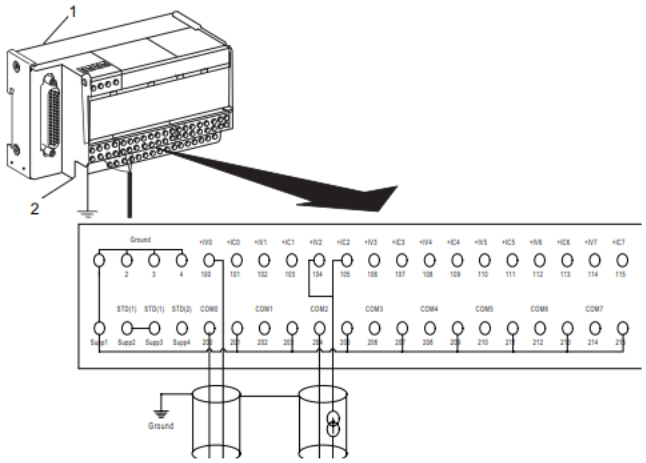


Figure 3-34: Wiring connections of BMXAMI0810

3.4.3.5.4 Telefast ABE7 Terminal Blocks



1 Telefast ABE-7CPA02
2 The grounding of cables is facilited using the ABE-7BV10 accessory
3 Shield wiring to the ground
4 To voltage sensors
5 To current sensors

Figure 3-35: Wiring connections of ABE-7CPA02

The ABE7CPA02 Telefast base unit is used for analogue inputs modules. This module allows connection on a screw terminal block of 8 current/voltage IO.

3.4.3.5.5 Intrinsically Safe (IS) and Non-Intrinsically Safe (Non-IS)

IS and Non-IS IO have been combined. Further information to follow beyond the FEED phase.

3.4.3.6 Analogue Outputs

The BMXAMO0410 has been standardised on for the PCS Upgrade project for all analogue outputs. The BMXAMO0410 is a high density analogue output module fitted with four isolated channels. It offers the following ranges for each output:

- Voltage: +/- 10 V
- 0..20 mA
- 4..20 mA

3.4.3.6.1 Specifications

BMXAMO0410	
Module Type	4 High level Fast Outputs
Nature of inputs	Voltage or Current configured by software:

	+/- 10V 0-20mA 4-20mA
Digital/Analogue convertor resolution	15Bit +Sign
Output refresh time	1ms
Types of Protection	From short circuits and overloads (Voltage output) Wirebreak indication
Isolation	Between Channels: 750VDC Between Channel and Bus: 1400VDC Between Channel and Ground: 1400VDC
Measurement error	<=0.25% of full scale 0..60°C 0.1% of full scale 25°C
Load impedance ohmic	>=1000 Ohm +/-10V <= 500 0..20mA <= 500 4..20mA
Total Error	+/- 0.18% Current

Table 3-36: Basic Specifications of BMXAMO0410

3.4.3.6.2 Module Density

The BMXAMO0410 is a 4 Channel module that has been standardised on by TPL for use on the PSC Upgrade Project where needed.

3.4.3.6.3 Wiring connections

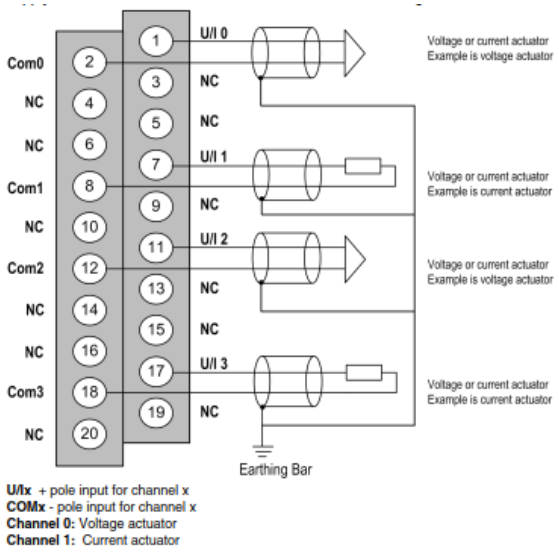


Figure 3-37: Wiring connections of BMXAMO0410

3.4.3.6.3.1 Telefast ABE7 Terminal Blocks

The ABE7CPA21 Telefast base unit with the cable BMXFCA 150/300/500 is used for analogue outputs modules. This module allows connection on a screw terminal block of 8 current/voltage IO.

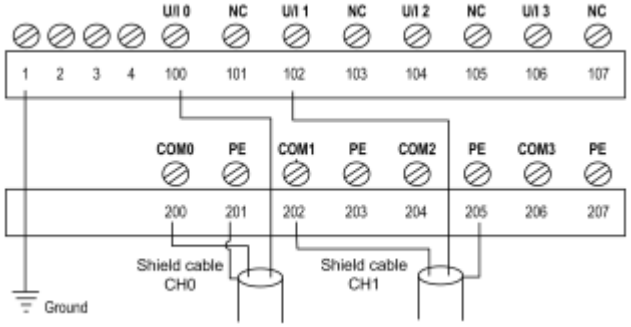


Figure 3-38: Wiring connections of ABE-7CPA21

3.4.3.6.3.2 Intrinsically Safe (IS) and Non-Intrinsically Safe (Non-IS)

IS and Non-IS IO have been combined. Refer to section 3.4.6 for selected Barriers.

3.4.4 Fynnlands Site

The Fynnlands site will be the only site on the PCS Upgrade Project with an initial installation comprising of 'Hardened' PLC Hardware.

Hardened equipment is the ruggedized version of standard equipment that can operate in extended temperature ranges and in dirty or corrosive environments. There are hardened versions of several of the CPUs, backplanes, and power supplies, as well as other components, in the M580 system. These components are listed below in Table 3-39.

The standard temperature range for M580 equipment is 0...60 °C. Hardened equipment can operate at extended temperature range: –25...70 °C.

These modules are interchangeable with standard modules without the need for any form of configuration changes.

BMEH584040C	M580 CPU redundant family 40 with remote and distributed I/O - Coated
BMECRA31210C	X80 Performance Ethernet Drop adapter, Ethernet Backpane - Coated
BMENOC0321C	M580 I/O Scanner Module, IP Forwarding, Ethernet/IP & Modbus TCP, 3 ports - Coated
BMEXBP0400H	PLC 4 slots Ethernet backplane hardened
BMEXBP0800H	PLC 8 slots Ethernet backplane hardened

BMXAMI0810H	X80 Analog Input Module, High Speed, 8 channels, isolated - Hardened
BMXAMO410H	X80 Analog Output Module, 4 channels, isolated - Hardened
BMXCPS3500H	X80 AC Power Supply Module, 100…240 V AC, 36W - Hardened
BMXDDI1602H	X80 Digital Input Module, 16 channels, 24 V DC, Positive (sink) - Hardened
BMXDDI3202KH	X80 Digital Input Module, 32 channels, 24 V DC, Positive (sink) - Hardened
BMXDDO1602H	X80 Digital Output Module, 16 channels, 24 V DC, Positive - Hardened
BMXDDO3202KC	X80 Digital Output Module, 32 channels, 24 V DC, Positive - Coated

Table 3-39: Hardended / Conformally Coated Modules

3.4.5 Field Power Supplies

The Phaseo Universal electronic switch mode power supply for Schneider Electric is designed to provide the DC voltage necessary for the PLC automation systems described above.

The ABL8RP Universal range will be used and sized accordingly during detail engineering.

		Secondary			
Part Number	**Input Voltage**	**Output Voltage**	**Nominal Power**	**Nominal Current**	**Conforming Standard**
ABL8RPM24200	100…120V AC 200…500V AC (Single Phase) -15%, +10% 50/60Hz	24…28VDC	480W	20A	IEC/EN 61000-3-2

Phaseo ABL8RP/ABL8WP (Universal)

Figure 3-40: Phaseo ABL8RP Power Supply.

Redundancy Module for Power Supplies

Redundancy of power supplies is offered with the use of the ABL8RED24400. This unit allows the paralleling and redundancy of two of the power supplies specified above to ensure uninterrupted operation of the application excluding AC line failure and application overloads.

Figure 3-41: ABL8RED24400 Redundant Power Supply Module

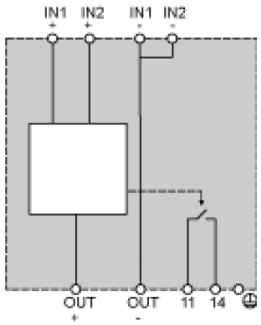


Figure 3-42: ABL8RED24400 Wiring diagram

3.4.6 Galvanic Isolators

TPL has standardised on Pepperl+Fuchs Galvanic isolators for all IS loops as follows:

- Analogues: HiD2022 (Dual Channel)
- Digitals: HiD2844 (Switch Amplifier - 4 Channel Isolator)
- Metering Panel: Zener: Z-961 (2 Channel)
- PLC Panels: Zener: Z779 (2 Channel)
- Blanks: HiD2000(Blank Place Holders)
- Termination Board(Backplane) 8 Slot: HiDTB08-SCT-99C-SC-RA
- Transmitter Power Supply: KFD2-CRG2-Ex1.D

Optional Modules

- HiATB01-HART-2X16: HART communication board for 2-channel module
- HiDMux2700: HART multiplexer master
- HiACA-UNI-FLK34-*M* : HART connection cable

3.4.7 Panel Specifications

Panel Specification – refer to Panel Specification document [30] and [31]

3.4.8 PLC & LAN Architectures

3.4.8.1 Typical Pump Station Architecture

Refer to the PLC LAN Architecture Typical Pump Station drawing[11].

3.4.8.2 Typical Booster Station Architecture

Refer to the PLC LAN Architecture Typical Booster Station drawing [12] to be referenced.

3.4.8.3 Fynnlands Station Architecture

Refer to the PLC LAN Architecture Fynnlands Intake Station drawing [10].

3.4.8.4 Coalbrook Architecture

Refer to the PLC LAN Architecture Coalbrook drawing [13].

3.4.9 Communication and System Interfaces

The following interfaces are excluded from the PLC system:

- MIS
- Existing ATMOS PIPE LDS
- Bentley Nevada MMS System 1

Refer to SCADA FDS for further information.

3.4.9.1 Interfaces

3.4.9.1.1 Interface 1: OASyS SCADA

The interface between the OASyS SCADA system and the PLC system is described within the document SCADA/PLC Communication Plan [5]

3.4.9.1.2 Interface 3: Metering

For details on the Metering interface, refer to the Metering FDS [3].

3.4.9.1.3 Interface 4: Fire and Gas

The Fire System(s) are controlled locally from the Fire Panels located on site. Limited interfacing is provided between the Fire System/s and the Process Control System for alarming purposes only.

Two types of interface exist to Fire & Gas systems installed on TPL sites:

1. Hardwired Interface of signals direct to PLCs installed in the respective PLC Panels
2. Communications interface to Det-Tronics Fire and Gas systems over Modbus 422/485.

3.4.9.1.4 Interface 5: ABB ACS1000 MV Variable Speed Drive

The present interface to the ABB ACS1000 MV VSD is via Profibus DP. Profibus DP communication is possible on the M580 PLC as described in section 3.5.10.2.

Profibus is possible with the ACS1000 via the NPBA-12 module supplied by ABB. The NPBA12 module is a profibus slave which interfaces with the drive via a optical fibre connection. With the use of this module, it is possible to:

- Monitor the drive
  - Read and adjust drive parameter values
  - Read status information and actual values from the drive
  - Read and clear the contents of the fault log and save it to a file
- Control the Drive
  - Give control commands (Start, Stop, Run enable, etc) to the drive

- Feed a motor speed to the drive
- Reset a drive fault

Figure 3-43: ABB NBA-12 Profibus interface module

3.4.9.1.5 Interface 6: Bentley Nevada Machine Monitoring System

The interface between the Bentley Nevada 3500 Rack to PLC and from the PLC to System 1 server is RS422. This is not supported by the current hardware and the use of a convertor will need to be investigated in future.

3.4.9.1.6 Interface 7: Tank Gauging System Heads

Communications interface directly to the Tank Gauging System over Modbus 485. TPL currently has an installed base of:

- Rosemount Raptor Radar Level Tank Gauging system, comprising of 5900S Radar Level Gauge, 2240S Temperature sensor, and 2410 Tank Hub.
- SAAB/Rosemount RTG3950 Tank Gauging System.

3.4.9.1.7 Interface 8: UPS Interface

Hardwired Interface of two UPS volt-free contacts will be required: one to initiate server/workstation shutdown, and another to alarm a UPS fault.

3.4.9.1.8 Interface 9: Safety Instrumented Systems

Two Safety instrumented functions have been identified within TPL Pipeline infrastructure viz:

- Tank overfill protection

- Line over-pressure protection

Safety protection will be implemented using a stand-alone Pepperl+Fuchs KFD2-CRG2-EX1.D trip amplifier relay. This relay is rated SIL 2 and has the following functionality:

- IS rated 4-20mA input
- 4-20mA output repeated to the PLC for indication purposes
- 2 Programmable relay outputs. One for trip function and other for PLC indication and alarming.

For details on SIL FMEDA assessment refer to PNF document FS-013PF20B, 7 Oct 2008.

In addition, the Weidmüller SCS 24VDC P1SIL3DS M safety relay will be used in the MV panels to trip the electrical circuit.

3.4.9.2 Profibus Remote Master

The ABB ACS1000 MV Drive currently utilise Profibus for communication.

The Modicon M580 incorporates the Profibus protocol by means of a gateway device: Profibus Remote Master (PRM).

The PRM is a standalone module designed to provide Profibus DPV0 and DPV1 master capability to the M580 PLC range amongst others. It is integrated in the PLC architecture as a Modbus TCP slave.

The Profibus configuration is done using the FDT/DTM technology.

The PRM module can be mounted standalone on DIN rail, grid or panel.

Key features of the PRM module:

- Provides transparent access from Unity Pro to the Profibus devices.
- Profibus DPV0 and DPV1 Master
- Up to 125 Profibus devices with a total of less than 4Kbytes input data and 4Kbytes output data.
- 2 Ethernet ports with an embedded switch
- Fast Device Replacement (FDR)

Figure 3-44: Profibus Remote Master

3.4.9.3 Modbus Serial

The BMXNOM0200 Serial link module is used for Modbus serial communication on the PCS upgrade project.

The BMXNOM0200 module provides 2-way asynchronous serial communication. Modbus Serial (master or slave) and Character Mode communications is supported. This module is a simple-format, dedicated module which is installed on the Remote IO rack. Two modules can be installed on a remote drop. A card will be installed on the Remote Drop closest to where it is needed. Multiple cards may be need on a site based on the number of device that need connection.

Figure 3-45: BMXNOM0200 Modbus Serial Module

3.4.10 Time Synchronization

The PLC will be synchronised to the local Domain Controller as a primary. Secondary will be the MCC Domain Controller.

Time synchronization is described in detail in the SCADA Functional Design Specification document [2].

4 SOFTWARE

4.1 Unity Pro

4.1.1 Programming Platform

Unity Pro (now known as EcoStruxure Control Expert) is the programming platform used to configure and program and the Modicon M580 PLC.

The XL package is used on the PCS upgrade project as it is required to configure and program the M580 HSBY system.

General Program Structure

Central to the Unity Pro application is the Project Browser. The project browser is used for navigation, displaying and organising all project parameters. The view can be shown either as structural (topological) view and/or functional view.

TPL programs will be structured using 1 MAST (50ms) task. The MAST task will contain all of the necessary sections for control of the specific site. Each section will belong to a Functional group. Many associated sections can belong to one Functional Group. For example, a Launcher Functional Group may have multiple sections of code. Details on the Functional Groups will be determined during the Development phase of the project.

In addition to the MAST TASK, a single FAST (5ms) task is configured. The sections within the FAST task are related to functions that require a faster response time, e.g. Pig Detection.

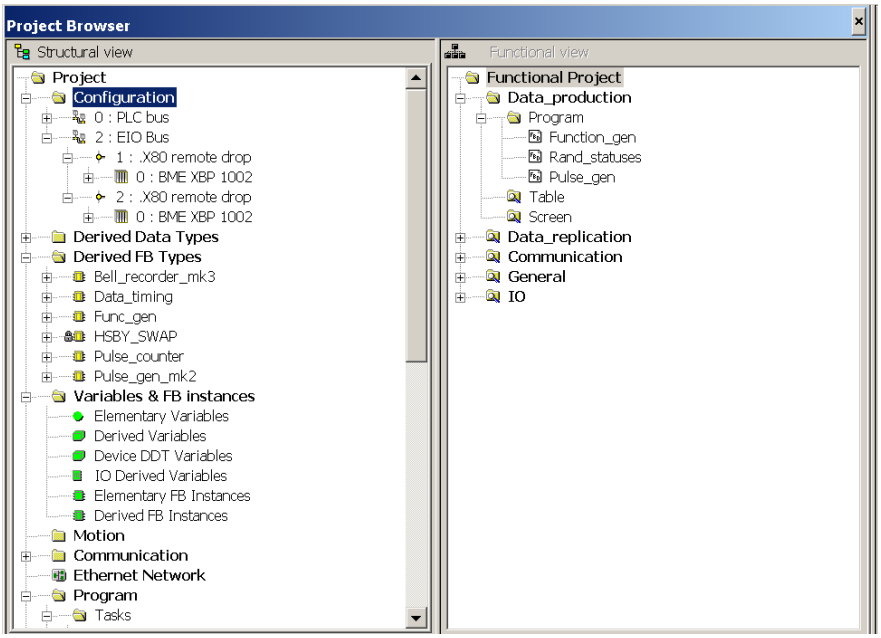


Figure 4-1: Unity Pro – Example of Structural and Functional View

Structural View

The project browser offers the following features in the structural view:

- Creation and deletion of elements
- The section symbol shows the section programming language and if it is protected
- View the element properties
- Creation of user directions
- Launching the different editors
- Start the import/export function

Functional View

The project browser offers the following features in functional view:

- Creation of functional modules
- Insertion of sections, animation tables etc. using Drag and Drop from the structural view.
- Creation of sections
- View the elements properties
- Launching the different editors
- The section symbols show the section programming language and other attributes.

4.1.2 Identification Standards

4.1.2.1 Project Name

Every PLC project in the PCS Upgrade Project will be configured using the site name within the Unity Pro application hierarchy for the purpose of uniquely identifying software applications. This is independent of the chosen file naming standard. Naming conventions are defined in PCS Naming Standards Document[28]

4.1.2.2 Station Revision Management.

The second section of every PLC application will be a **ST** type. This section will not be a functional section but rather, will be used as a comment space for Station Revision tracking. Changes made to the application are to be commented on with Date/Time and details of the change.

4.1.2.3 Remote Rack Labelling

Remote racks within the EIO software configuration are labelled in alignment with Architecture drawings and Panel Labelling.

4.1.2.3.1 Panel Numbers are labelled as follows:

Panel Identifier: =aaPPPxx

Location Identifier: +aaPPPxx

where

aa = Station Number (e.g. CBK = 17)

PPP = PLC for PLC Panel, MET for Metering Panel, VSD for VSD Panel, RR for Remote IO tier in remote rooms, RL for Remote IO cubicle/tier in LV Panel, RM for Remote IO cubicle in MV Panel

xx = Unique No, integer from 1 to 9.

4.1.2.3.2 PLC CPU Hot/Standby racks

The Host Standby Racks will be labelled 'PLCxy'

Individual slots within the Host Standby Racks will be labelled: PLCxyz

where

x = PLC No, integer from 1 to 9

y= Rack drop no, alpha from A to Z. (There will only be two racks - A and B for Host Standby Racks)

z = Slot No, integer from 0 to 7 (8 slot backplanes are used). Slots are numbered sequentially, starting from zero.

4.1.2.3.3 Remote IO racks

Remote IO Racks will be labelled: Ruxyz

where

u = P for PLC Panels, F for Metering Panels, L for LV Panels and M for MV Panels

x = PLC No, integer from 1 to 9

y = Rack drop no, alpha from A to Z. Drops are labelled sequentially in each panel, starting from A.

z = Slot No, integer from 0 to 7 (8 slot backplanes are used). Slots are numbered sequentially, starting from zero.

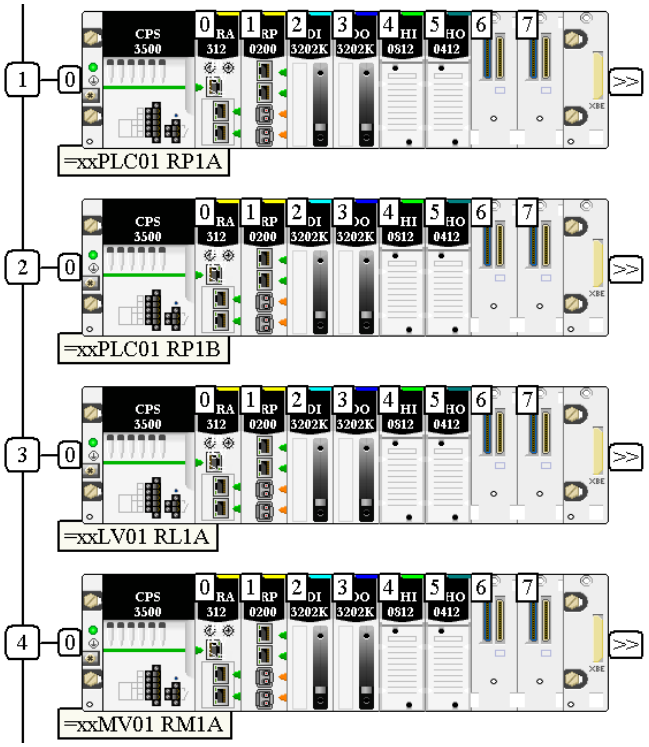


Figure 4-2: Remote Rack configuration and labelling

4.1.3 Software Naming Standard

Refer to Software Naming standards document [28]

4.1.4 Unity Pro Programming Languages

Unity Pro supports all of the IEC61131-3 application languages for the M580 HSBY CPUs. Each language has its place and strengths. As such, not all languages will be used with on the PCS Upgrade Project. All PLCs will be programmed using a combination of FBD, ST and SFC. The majority of code will implement FBD.

Application language / library	Hot Standby CPU	
	BMEH582040	BMEH584040 / BMEH586040
Function Block Diagram (FBD)	X	X
Ladder Diagram (LD)	X	X
Structured Text (ST)	X	X
Instruction List (IL)	X	X
Sequential Function Chart (SFC)	X	X
Derived Function Block (DFB)	X	X
Elementary Function (EF)	X	X
Elementary Function Block (EFB)	X	X
Ladder Logic 984 (LL984)	–	X
PL7 - Standard Function Block (SFB)	–	–
X: Supported –: Not supported		

Table 4-1: M580 Supported Programming Languages

4.1.4.1 Function Block Diagram

Function Block Diagram (FBD) is the chosen standard for programming of all PLCs. All sections within a PLC program will use on FBD with exception of Sequences and Hardcoded settings. These use SFC and ST respectively. Smaller sequences could use Sequencing FBD and will be decided based on the requirements and prescription from the PLC Coding Standards Document [29]. The FBD editor is used to provide a graphical programming interface:

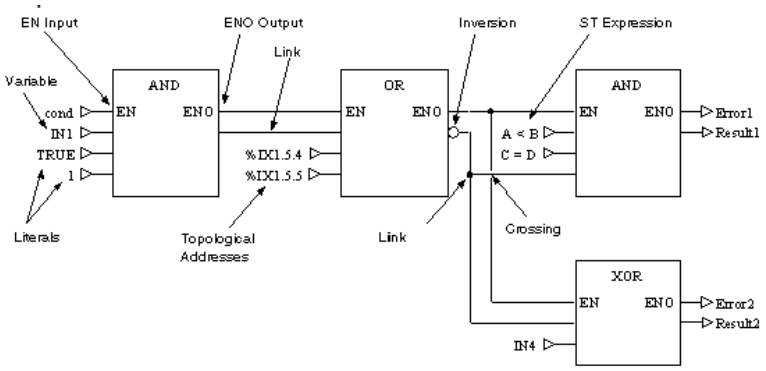


Figure 4-2: Example of FBD representation

The objects of the FBD programming language help to divide a section into a number of:

- Elementary Functions (EFs)
- Elementary Function Blocks (EFBs)
- Derived Function Blocks (DFBs)
- Procedures

- Subroutine calls
- Jumps
- Links
- Actual Parameters
- Text Objects to comment the logic

4.1.4.2 Structured Text

The Structured Text language is also used within the PCS Upgrade Project. The use of this language is generally limited to within sections of DFBs however, Hardcoded limits, settings or parameters that do not change frequently will also use the ST language at MAST task section level. Structured Text is especially used for mathematical calculation and for processing repetitive instructions (Loops).

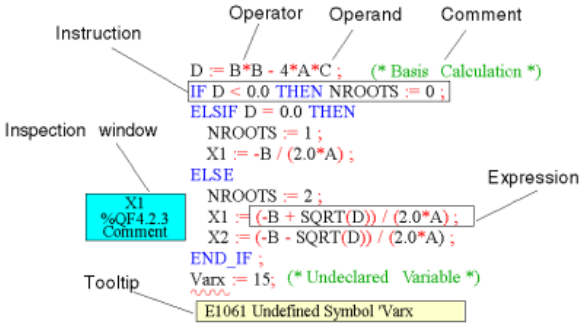


Figure 4-3: ST representation

4.1.4.3 Sequential Function Chart (SFC)

SFC will be used to control all sequences required in the PCS Upgrade Project. Sequences are typically initiated/commanded from the SCADA or instances within code.

Sequential control is created in Unity Pro from SFC sections (top level), transition sections and action sections.

The SFC sections are only allowed in the Master Task of the project. SFC sections cannot be used in other tasks or DFBs.

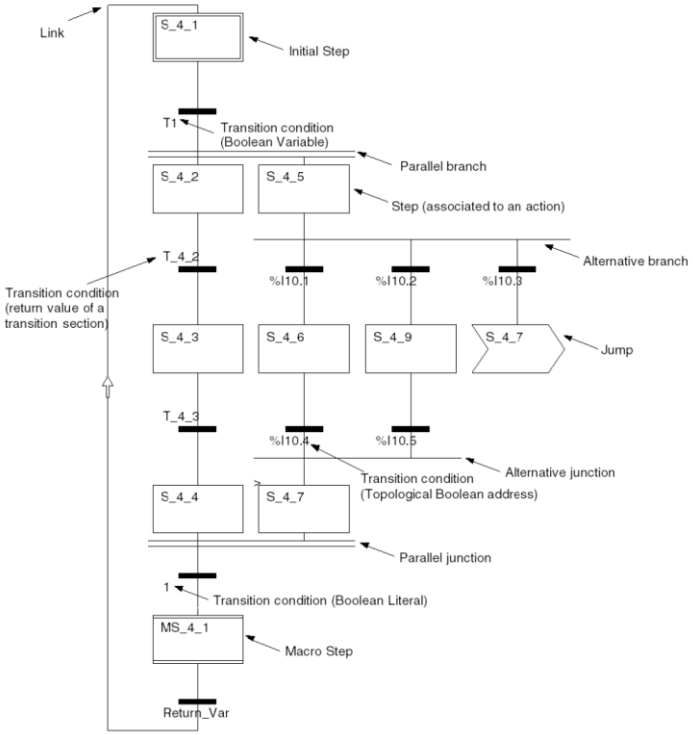


Figure 4-4: SFC representation

4.1.5 Software Coding Standards

An object-oriented methodology is used in the PLC software standard allowing flexible sizing of the system (from smaller booster pumps sites to larger delivery stations), reduced fault finding time and improved ease of device addition.

Function blocks are designed in a manner that the functions they implement are cumulative. This way, specific 'optional service' functionality can be added on to many 'core service' functions.

For example, three function blocks are connected to each other to provide the necessary functions to set up an on-off motor with interlocking and maintenance. A "Control" block (Core service) provides on-off motor functionality. An "Interlock" block (optional service) can be integrated to achieve interlocking functionality. In addition a "Device Maintenance" block (optional service) can be integrated to add maintenance functionality (number of operation and run hours). A Valve "Control" block (Core service) could also achieve interlocking and maintenance properties using this approach.

4.1.6 Derived Function Blocks

A Derived Function Block(DFB) is a type of function block that is defined by the user. TPL DFB blocks are developed using the following languages:

- Function Block Diagram (FBD)
- Structured Text (ST)

The use of DFB types in application code makes it possible to:

- Simplify the design and entry of the of program
- Make the program easier to read
- Make it easier to debug
- Reduce the amount of code generated
- Test and validate functionality
- Reuse proven functionality throughout code

Control Modules as described in the PCS Control Module Specification [15] make use of DBFs.

4.1.6.1 Derived Function block construction

All Derived function blocks are constructed in a similar format. Based on the functionality of the block, the process sections could vary slightly.

Section Name	Language	Description
Revision	ST	Section used to track revision control of the block. In addition to providing a text space to document revision history, an output pin of String type is used to display the revision number when connected to the PLC.
Unpack	FBD	Section used to unpack data coming in to the block via the SCADA DDT or other DDT
Input_map	ST	Section used to map and route between physical input image coming in to the block, with internally simulated feedback signals.
Process	FBD	Section(s) to implement the specific function of this block. All code needs to be put in to one section. Multiple sections could be used to fulfil a process function.
Status	FBD	Section used to manage statuses generated by the block
Simulation	ST/FBD	Section used to perform a simulation of behaviour. Typically field inputs are substituted with simulated field inputs such that the Process code is executed as if in the field.
Pack	FBD	Section is used to pack status information to SCADA DDT and information DDT. Outputs are also driven in this part of code.

Table 4-5: Typical DFB construction

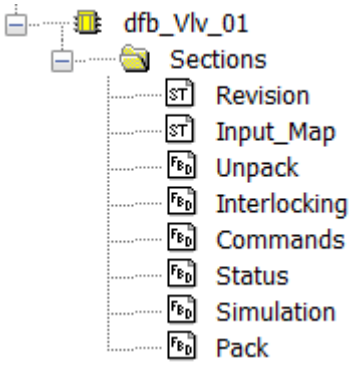


Figure 4-6: Example DFB construction

Note: All DFBs which are placed in simulation mode will have the Input map selected to use internal simulated feedbacks (and not Field IO). This is not true with outputs, i.e. ALL output functions will be driven as per DFB Block function. It is therefore imperative to ensure that NO DFB is placed in simulation mode on ANY active plant (e.g. Valve open/close outputs will be driven if a valve block is in simulation mode with simulated feedback). This is the reason the Sim_En (Used to enable simulation mode) is placed as a Pin at the bottom of the DFBs. It can be seen at a glance that this Pin should have system variable: sys.Simulation_Enabled which is RED (Logic Low).

Simulation Enable/Disable is applied to all blocks that support simulation. This originates from dfb_Sys_01.

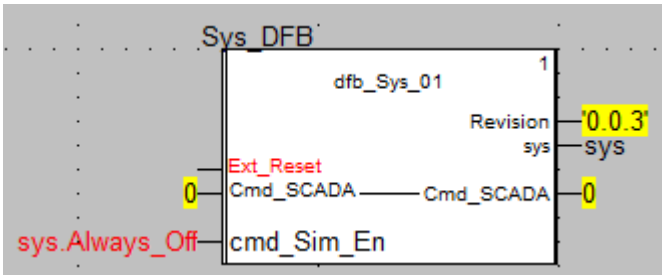


Figure 4-7: System Bits – Simulation Disabled on Active Plant

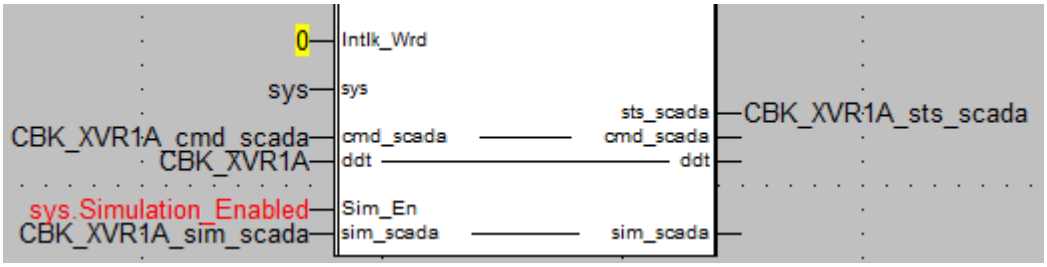


Figure 4-8: Example of Simulation forced Off on Active Plant

4.1.6.2 Function Block Interface

The Derived Function blocks for TPL provide an interface that allows them to be configured, monitored and controlled from the SCADA system (Continuous and/or sequential control).

The following interfaces are provided:

- Basic Configuration
- Continuous Control
- Sequential Control
- States and Monitoring

Basic Configuration

DFB input pins are usually connected to static data and recognized in engineering time (for example, input channel range or limit switch enabling on an on-off device.) These are deemed fixed/hardcoded settings.

Continuous Control

DFB input and output pins:

- Allows receiving commands from other blocks or SCADA
- Provide block status to other blocks to enable functions, detect events (example: High-level), interlocking, configure limits and parameters etc.

Sequential Control

SC public and structured variables publishes the block status and allows its control from the control sequences.

States and Monitoring (DDT)

Depending on their types, the blocks feature up to 2 input/output pins that need to be connected to variables used to pass data to other blocks. In addition, these variables allow the commands and parameters received from the SCADA to be managed.

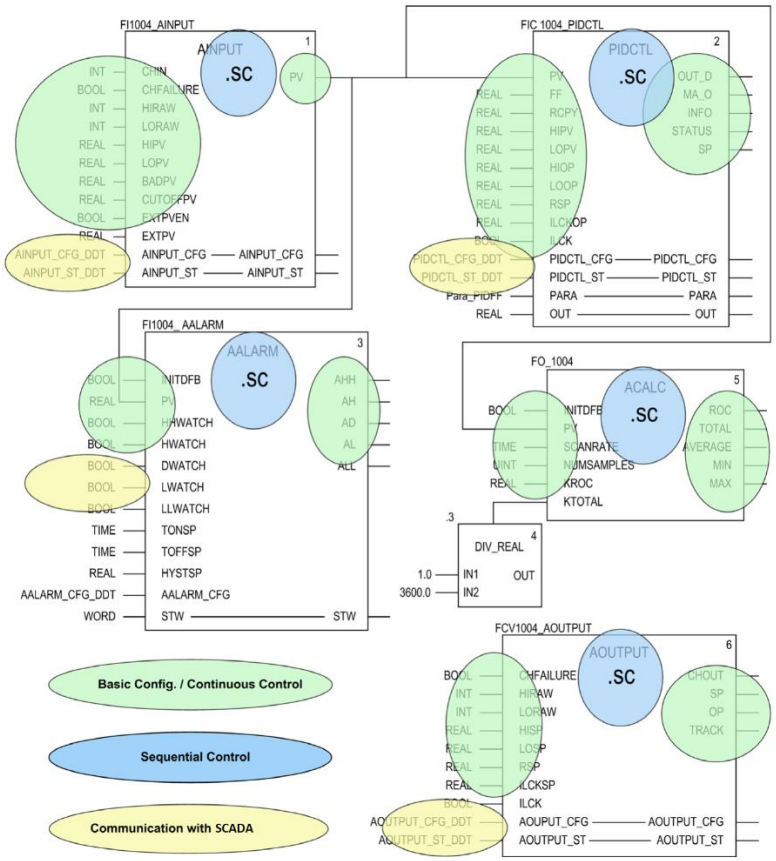


Figure 4-9: Modularity of DFBs

4.1.7 Derived Data Types

A Derived Data Type is a set/structure of elements, typically standard data types such as REAL, INT, BOOL etc, that are constructed by a user in a logical structure. This is used to group data relating to (e.g. a Valve or DOL Motor Block).

Aside from just logical grouping of information pertaining to Control Modules, DDTs are used to pass data between blocks.

Below is an example of a DDT comprising multiple different primary data types:

Name	Type
Scada_info	<Struct>
Sine_wave	REAL
Saw_wave	DINT
Square_wave	INT
Rand_statuses	WORD
PLC_cmd_word	WORD
PLC_cmd_mirror	WORD
SCADA_cmd_word	WORD
SCADA_cmd_mirror	WORD

Figure 4-10: Example of DDT Structure

4.1.8 Libraries

4.1.8.1 Unity Pro Function Block Libraries

The table below details all libraries and common functions that will be used in the PCS Upgrade Project. By default, all of these libraries are installed with Unity Pro. The library serves as a logical grouping of related functions.

Library	Function	Description
Base Library		
	ABS	Absolute
	ADD	Mathematical Addition
	AND	Boolean AND function
	AVE	Mathematical Average operation
	BIT_TO_WORD	Convert 16 Boolean values to Word (Word Packing)
	BYTE_AS_WORD	Type conversion - Lower and Upper byte to word conversion
	CTD	Down Counter
	CTU	Up Counter
	DINT_TO_INT	Type conversion – Double (32Bit) Integer to Single(16Bit) Integer
	DINT_TO_REAL	Type conversion – Double (32Bit) Integer to Floating Point IEEE 754 Standard
	DIV	Mathematical Division operation
	EQ	Comparison - Equal
	EXTRACT	Function that copies a source table to a destination table
	F_TRIG	Boolean Edge detection on the Falling Edge
	GE	Comparison - Greater Than or Equal
	GT	Comparison - Greater Than
	INT_TO_DINT	Type conversion - Single(16Bit) Integer to Double (32 Bit) Integer
	INT_TO_REAL	Type conversion - Single(16Bit) Integer to Floating Point IEEE 754 Standard
	LE	Comparison - Less Than or Equal
	LIMIT	Function to pass a value through provided it is within a Lower and Upper boundary(Limit)
	LT	Comparison - Less Than
	MAX	Function returns the largest value (of a group of inputs) to the output
	MOVE	Function assigns the input value to the output
	MUL	Mathematical Multiplication operation

	NE	Comparison - Not Equal
	OR	Boolean OR function
	PID	Function carries out PID type regulation on an integer type
	R_TRIG	Boolean Edge detection on the Rising Edge
	REAL_TO_DINT	Type conversion - Floating Point IEEE 754 to Double(32Bit) Integer
	REAL_TO_INT	Type conversion - Floating Point IEEE 754 to Single(16Bit) Integer
	RS	Reset/Set latch with Reset Dominant
	SEL	Function used for Binary Selection between two values
	SUB	Mathematical Subtraction operation
	TOF	Off delay timer
	TON	On delay timer
	TP	Function used to generate a pulse with a given duration
	WORD_TO_BIT	Convert Word to 16 Boolean values (Bit Stripping)
Communication Library		
	ADDM	Function converts a string to an address that other function blocks can use to read/write data
	READ_VAR	Function used to read Modbus registers from a source defined by ADDM block
	Write_VAR	Function used to write Modbus registers to a destination defined by ADDM block
Cont_Ctl Library		
	HYST	Function to apply a Hysteresis
	LAG_FILTER	This function represents a delay element of 1st order
	RAMP	Function applies a constant change from an initial value to a target value
	SCALING	Function used to change the value range of numerical variables

Table 4-11: PCS Upgrade Project Used Libraries

4.1.8.2 Derived Libraries

Derived libraries are a collection of specific functions(DFBs) that are created for the project. These libraries are fully open for monitoring and modification. Care should be exercised when making any modification to derived libraries as the implication of a change to a library will extend to all used instances of that library. For this reason, it is advisable to keep them in a

locked format with READ-ONLY attributes. The password should be kept by Senior MC&I Personnel.

Further details of Derived Libraries are described in the PCS Control Module Specification Document.

PSX GPL(General Purpose Library) for Unity Pro

The GLP Library for Unity Pro software provides function blocks (EFBs and DFBs) that are pre-configured and tested by Schneider Electric. These blocks are designed for automating a large variety of processes.

Tabulated below are possible function to be used on the PCS Upgrade Project. The following functionality has been tested by Schneider Electric and could reduce the development time in providing for these specific functions.

Family	Function	Description
Signal Processing		
	AISignalCond1	Analogue input signal conditioning
	AISignalCond1	Analogue output signal conditioning
	CounterSignalCondUInt	Counter Signal conditioning
	DISignalCond1	Digital input signal conditioning
	DOSIGNALCOND	Digital output signal conditioning
	ACALC	Analogue calculations (ROC)
	AALARM	Analogue limit levels
	AINPUT1	Configurable-range analogue inputs
	TOTAL	Totalizer
On/Off device control		
	DEVCTL	On-off device control
	DEVMNT	On-off device maintenance
Process Control	ARAMP	Ramp functionality
	PIDCTL	PID controller
Sequential control	SEQCTL1	Advanced sequential control
	SEQPARxx	Sequential parameter management
Auxiliary functions	ASELECT	Analogue signal selector
	CONDSUM	Summary of conditions
	CONDSUM1	Interlock condition summary

Table 4-12: GPL – Functions to be used

4.1.8.3 Management of Libraries

During the development phase, a User project will be created for the development and management of the specific Library of DFBs. This will be a common and multi-owner project within EOH. At any given time, a single block will have only one owner who will be responsible for creating/modifying/updating and documenting those blocks.

All of the blocks created during the development and testing phase will reside in this project. A family of library blocks will then be created for import into the Site instances of Unity Pro.

4.1.9 Security

Unity Pro security is set up on the PC on which Unity is installed and not the project. A log file can be used to keep a chronological record of the various operations carried out by users with access to the software.

Super user (Supervisor)

The super user is the only person with rights to manage access security for the software. The super user defines the list including the names of users who can access the software and their access rights.

During installation of Unity Pro, only the super user can access the security configuration without any limitation of rights (without a password). NOTE: The user name reserved for the super use is Supervisor

The super user has the following rights:

- Create or modify the user list
- Create or modify user profiles
- Disable one or more users
- Modify the rules for software access security
- Modify his/her password
- Reset user passwords

Users

Software users are defined in the list of users by the super user, if Unity Pro Access Security is active. If tour name is in the user list, you can access a software instance by entering your name (exactly as it appears on the list) and your password.

A user has the following rights:

- Access the rights defined by his/her user profile in read mode
- Modify his/her password

User Profile

The profile for a user comprises all of his/her access rights. It is defined by a name (2 to 16 characters), an optional comment (maximum of 256 characters) and a list of access rights. Unity Pro provides 5 preconfigured user profiles that cannot be modified. To complete this list, the super user can create all the personalised profiles that he/she requires.

Profile	Description
ReadOnly	The user can only access the project in read mode, except for the PLC address, which can be modified. He/she can also copy or download the project.
Operate	The user has the same rights as with a **ReadOnly** profile, with the added possibility of modifying execution parameters (constants, initial values, task cycle times, etc.)
Adjust	The user has the same rights as with an **Operate** profile, with the added possibility of uploading a project (transfer to the PLC) and modifying the PLC operating mode (Run, Stop, …)
Debug	The user has the same rights as with and **Adjust** profile with the added possibility of using the debugging tools.
Program	The user has the same rights as with a **Debug** profile, with the added possibility of modifying the program.
Disabled	User cannot access the project.

Table 4-13: User Rights

4.2 Unity Simulator

Unity Pro has a built in PLC Simulator which simulates (emulates) the logic execution behaviour of a PLC. This allows the ability to connect, download and run user applications in the same runtime/animated environment as when connected to a real PLC. Saved State RAM (which contain setpoint, logic states etc) can be also be transferred to and from the simulator as with a real PLC

The primary purpose of the simulator is to debug Unity applications, however due to the nature and requirement of the HMI Trainer, the PLC Simulator will be a convenient self-contained solution.

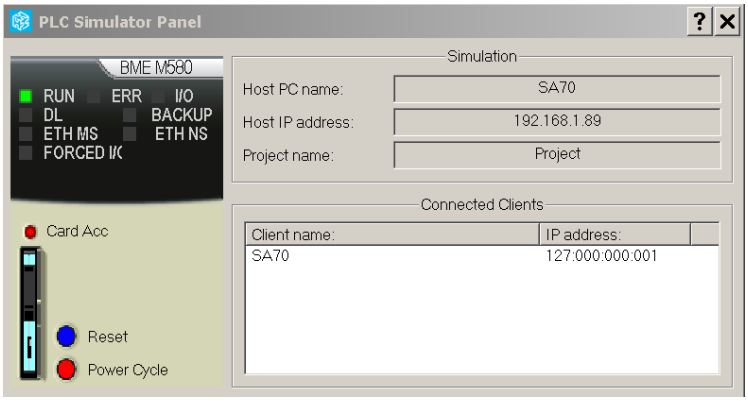


Figure 4-14: Unity Pro Simulator

Note: The simulator does not provide simulation for any PLC initiated explicit communication to external slave devices. The simulator is unable to connect to IO (local or remote). No inter-PLC communication is possible with the simulator. The Simulator however is able to serve SCADA client requests, therefore is able to perform full SCADA interactions.

4.2.1 Software Testing

The Unity Simulator will be used by the Development Software Engineers for general software testing during development. Once the given piece of software is complete, it will then be thoroughly tested by another Software Engineer on a real PLC as per pre-defined and approved test procedures. Control modules and DFB functions are easily simulated using animation tables to 'force' inputs and setpoints from the Unity Pro environment.

For larger, full scale simulation testing, visual testing interfaces (Analogue/parameter setpoints, digital writes etc) will be built in OASyS DNA HMI . This toolkit has the ability to connect to the PLC via Modbus TCP will be used to provide a graphic interface for testing and supervision purposes.

4.3 Unity Loader

Unity Loader is a utility software to exchange data with Unity Modicon PLCs. This software does not require a licence and can be used with all Unity enabled PLCs. Unity Loader offers the following features:

- Firmware download to CPUs.
- Firmware download to X80 modules that embed a firmware (Ethernet, analogue HART, motion).
- Download / upload of project information
    - Program
    - Variables
    - User files on the memory card (if installed)

4.4 Version Control

The following sections list the tools available for version control. The application version and library version number will be transferred to the SCADA system and displayed on the diagnostics page. Refer to the Software Configuration Management Plan for project specific version control.

4.4.1 Application Version

The standard version control provided by Unity Pro is utilised in tracking application versions. Unity Pro structures application version as: Major.Minor.Build. A time stamp is also provided of the last Build.

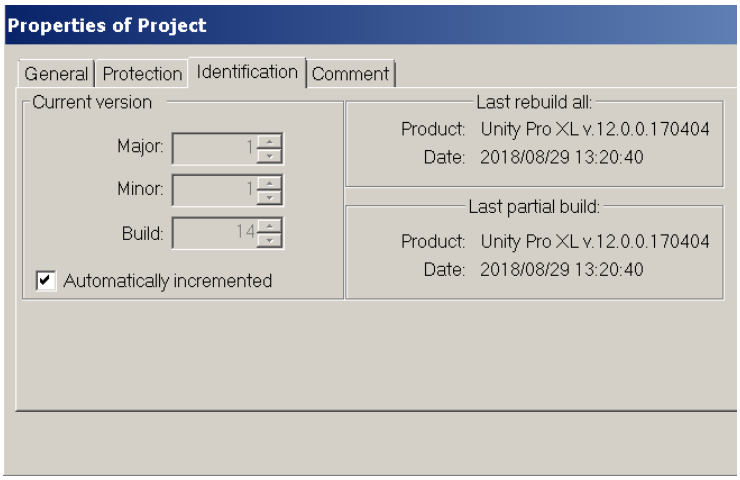


Figure 4-15: Application Version

The application version information along with other information is available in user code which will be passed to the SCADA system.

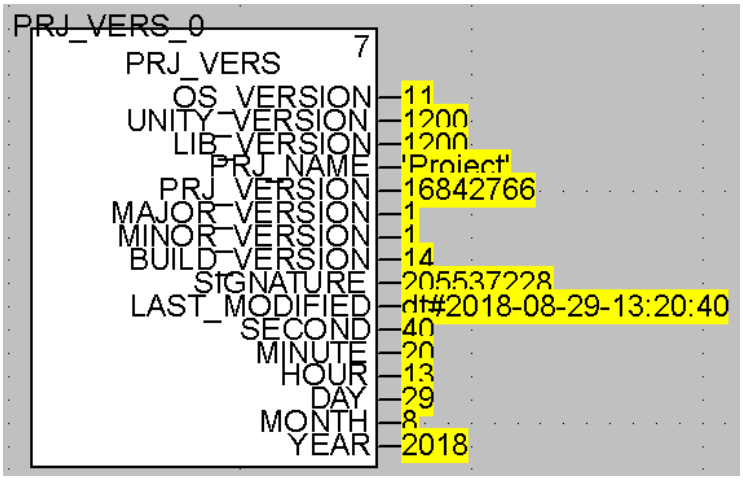


Figure 4-16: Application Version for SCADA display

Application versions prompted when a Download or Upload is commanded.

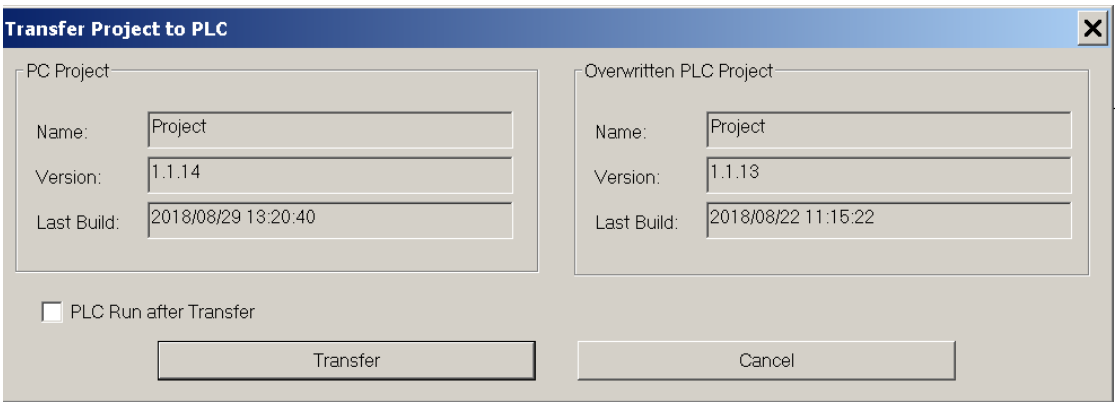


Figure 4-17: Version Compare

4.4.2 Library Version

The Standard library version provided by Unity Pro is aligned with Version of Software being used. Unity Version 13 and as such, Libset V13.0 is used on the Crude PCS Upgrade Project. These versions and control of these versions are done by Schneider Electric.

At an application level, it is possible to remain on a given library set. Therefore it is possible to upgrade a version of Unity Pro, and keep the previous version of Library.

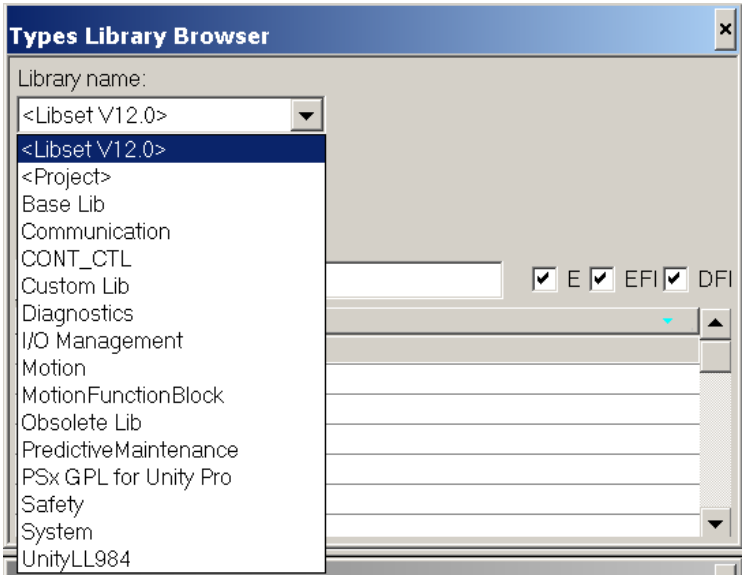


Figure 4-18: Library Version

4.4.3 Standard Block Versions

Below is an example of a EFB out of the library: Libset V12.0

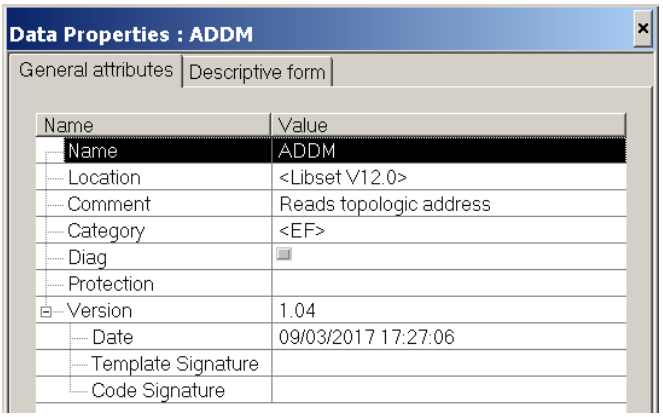


Figure 4-19: Standard Block Version

4.4.4 Derived Function Block Version

DBFs, being user created, are managed by the development team of EOH and Maintained by the TPL team. The first section of code within all DFBs is a **ST** section called *Revision. The TPL library version number will be incremented on any change to DFBs within that library.* The revision control of therefore documented locally within the block.

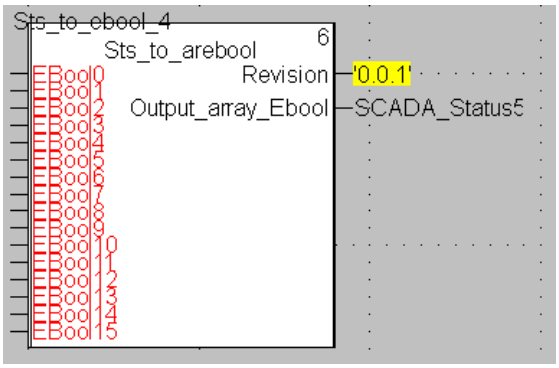


Figure 4-20: DFB Version

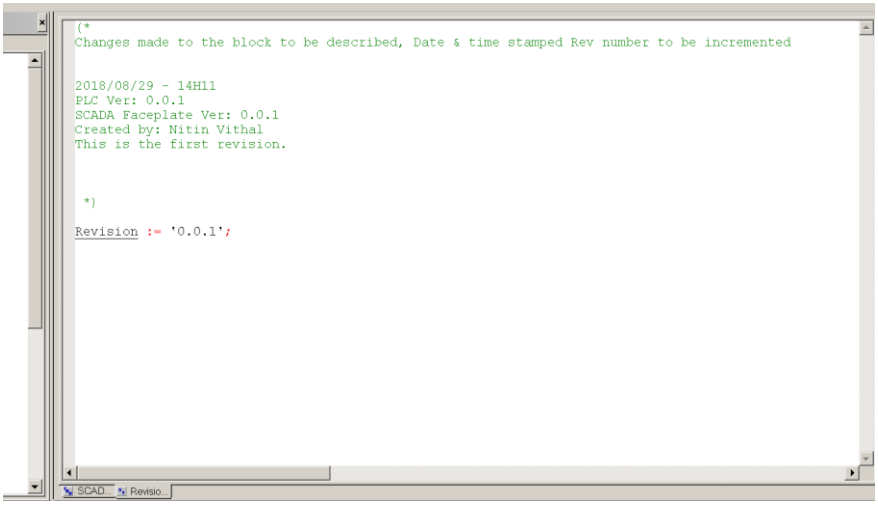


Figure 4-21: DFB Version management

4.4.5 Unity Dif Software Tool

Unity Dif is a comparison software the compares the Unity Pro project files and displays the differences graphically with a similar look and feed of Unity Pro. This enables the user to understand the project differences easily. The result of the comparison is displayed in the Unity Dif main window, which can be printed/saved as *.pdf or *.txt format.

The software provides differences of the following sections after comparison:

- PLC configuration (Hardware and network)
- Derived Data Types
- Derived FB Types
- Variables and FB Instance
- Motion
- Communication
- Programs
- Animation Tables
- Operator Screens
- DTM Catalogue
- Project Settings

The use of Unity DIF adds value from a maintenance perspective, providing TPL personnel to analyse if/and what changes have been made to specific site applications.