

Substation Local Area Networks

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Revision History

This Automation Design Instruction (ADI) has been established to document the requirements of substation local area networks, replacing the requirements previously documented in:

ADI 0006 – Substation Communication Systems Amendment No. 0

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1 Purpose

To define the minimum technical requirements for local area network (LAN) communication systems in Endeavour Energy owned transmission, switching, and zone substations.

2 Scope

This document covers communication systems for the purpose of SCADA, protection, and the evolving smart grid within transmission, switching, and zone substations (electrical stations herein). It applies to greenfield sites and major augmentations. For minor augmentations, the extent of applicability of this standard is to be determined by the Secondary Systems and Secondary Design Managers.

The relevant information from the Australian and international standards have been summarised in this document. In the event of inconsistencies and/or conflicts between the requirements outlined within this document and the Australian and/or international standards the requirements within this document shall take precedence.

Wide area network (WAN) communications requirements are defined in ADI0006 – Substation communication systems.

3 References

Internal References
Company Policy 9.2.9 - Electrical Network Telecommunications
Company Policy 9.2.5 - (Network) Network Asset Design
Company Policy 9.7.1 - (Network) Network Asset Construction
Company Procedure GDS 0133 – Enterprise Technology Standards
Earthing Design Instruction EDI 516 - Major substation earthing design, construction and commissioning
Equipment Technical Specification ETS0014 - Control panel fabrication and installation
Substation Design Instruction SDI 505 - Minimum design and construction requirements for transmission and zone substations and switching stations
Substation Design Instruction SDI 526 - Design of Substation Secondary Systems
Substation Design Instruction SDI 531 - Installation of conduits in transmission/zone substations and switching stations
Endeavour Energy Electrical Safety Rules

External References
Work Health and Safety Act 2011
AS 1768:2021 - Lightning protection
AS 11801.1:2019 – Information Technology – Generic cabling for customer premises – General Requirements
AS 11801.3:2019 – Information Technology – Generic cabling for customer premises – Industrial Premises
AS 14763.3:2017 - Telecommunications installations – Implementation and operation of customer premises cabling - Part 3: Testing of optical fibre cabling

IEC 61850:2010 - Communication networks and systems in substations
IEC 61850-9-3 – Precision time protocol profile for power utility Automation
IEEE 1588:2019 - IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
ITU-T G.703:2016 - Physical/electrical characteristics of hierarchical digital interfaces

4 Definitions and Abbreviations

Abbreviation	Meaning
AC (or a.c)	alternating current
ADI	Automation Design Instruction
DC (or d.c.)	direct current
FOBOT	Fibre Optic Breakout Terminal/Tray
FTP	fibre termination point
GPS	Global Positioning System (United States Constellation)
GLONASS	Global Navigation Satellite System (Russian Constellation)
GNSS	Global Navigation Satellite System
GOOSE	Generic Object Oriented Substation Event (IEC 61850 Protocol)
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institution of Electrical and Electronic Engineers
LAN	local area network.
LC	A small form factor snap-in optical fibre connector with a 1.25mm diameter ferrule, having a packing density twice that of SC-PC.
MPO	Multi-fibre push on (connector)
OM3	Optical cable containing 50/125µm graded index multi-mode silica glass fibres, with maximum permissible attenuations of 3.5db/km and 1.5db/km at 850nm and 1300nm respectively
PVC	plasticised polyvinyl chloride
PIU	Process Interface Unit
PRP	Parallel Redundancy Protocol

SUBSTATION LOCAL AREA NETWORKS

PTP	Precision Time Protocol
SAS	substation automation system
SCADA	Supervisory Control and Data Acquisition
SC-PC	A snap-in optical fibre connector known as Subscriber Connector – Physical Contact, with a 2.5mm diameter ferrule.
SDI	Substation Design Instruction
SFP	Small Form-factor Pluggable
ST	An optical fibre connector with a 2.5mm ferrule and a bayonet locking arrangement.
UPVC	plasticised polyvinyl chloride
WAN	wide area network

5 Actions

5.1 Safety

The design, construction, and commissioning of substation local area networks (LAN) shall be carried out in accordance with Endeavour Energy's Health and Safety Management Systems and the Electrical Safety Rules. Systems shall be implemented and maintained to consider the range of human capacity, both physically and mentally, when designing electrical station local area networks.

5.2 System overview

Within Endeavour Energy electrical stations multiple LANs may exist, each with their own purpose and requirements. The scope and individual requirements for each of these LANs are outlined in sections 5.3 and 5.4.

5.3 Station Bus

The Station Bus LAN is utilised for the transmission of control and indication communications between intelligent electronic devices (IEDs) and the substation automation system (SAS). Typical requirements of the Station Bus and its associated equipment are listed in the subsequent sections below.

Acceptable topologies for Station Bus networks are shown in Appendix A, site specific requirements will dictate the level of redundancy required.

5.3.1 Ethernet Station Bus

Copper Ethernet networks are the current standard for Endeavour Energy Station Bus LANs to align with the IED models approved for use. Where Ethernet backbone connections are required throughout the electrical station fibre-optic cables are to be used to minimise risk of electrical interference.

Category 6 cables consisting of unshielded twisted pairs shall be used for copper Ethernet Station Bus. These cables shall be no more than 10m in length and be restricted to use within the equipment cabinets. These cables, if deployed beyond the confines of the equipment cabinet, shall have a screen that is earthed at one end only.

5.3.2 Serial Station Bus

Serial communications for the purpose of connecting IEDs to the SAS are considered legacy and shall not be utilised for project works. For legacy RS485 applications Belden data cable part number 3106A shall be used, the overall cable shall be shielded by a combination of braid and a foil. These cables shall only be run between adjacent cabinets in a bay and shall not be run in the cable basements, either within or outside ducts. Circuits in these instances shall be terminated as specified by the respective end equipment manufacturer.

When significant project work is being performed within an electrical station, for example a SAS upgrade or the rearrangement of serial lines to overcome communication failures any cabling not compliant with the above requirements shall be upgraded. In the case of SAS upgrades an assessment of the effort and funding required to install terminal servers with supporting Ethernet backbone to the SAS shall be carried out to prevent serial cables being non-compliant with the above conditions.

5.3.3 Station Bus network switches

To accommodate the connection of multiple IED's, SAS components a number of network switches may be required within an electrical station. Typically, managed switches are used throughout the LAN as both core and distributed switches. Where the cost of managed distributed switches is prohibitive to the execution of a project dispensation may be granted by the Integration Manager Secondary Systems during a project's detailed design phase.

Station Bus network switches shall have dual power supplies, with both connected to the station DC supply and monitoring within the SAS by either,

- Watchdog contact which will close upon the failure of a switch or individual power supply,

- Communications level monitoring of both power supplies via the SAS.

Only network switches and associated equipment approved by the Secondary Systems team shall be used within Endeavour Energy's electrical stations.

5.3.4 Station Bus topology and redundancy

Typically, the Station Bus within Endeavour Energy's electrical stations are star networks with no active redundancy. Individual project requirements may require various levels of redundancy and topology configurations, where these requirements exist approval shall be sought from the Integration Manager Secondary Systems.

5.4 Process Bus

IEC61850 Digital Substations utilise fibre-optic based Ethernet networks in place of copper wires within the electrical station protection systems. Due to the importance and availability requirements of the protection systems integrity and timeliness a Process Bus network exists physically and logically separate to the Station Bus.

Acceptable topologies for Process Bus networks are shown in Appendix A, site specific requirements will dictate the level of redundancy required.

5.4.1 Process Bus physical medium

All process bus network cabling shall be fibre optic to minimise electrical interference within the electrical station environment and shall be compliant with the requirements of section 5.5 of this standard.

5.4.2 Process Bus network switches

Network switches used in Process Bus Networks shall be IEC 61850-3 compliant and specifically be compliant with Class 2 environmental and performance standards. Each switch shall have dual power supplies connected to the respective protection systems DC supply via independent MCBs. Monitoring of the Process Bus network switch health within the SAS shall be by either,

- Watchdog contact which will close upon the failure of a switch or individual power supply,
- Communications level monitoring of both power supplies via the SAS.

Only network switches and associated equipment approved by the Secondary Systems team shall be used within Endeavour Energy's electrical stations.

5.4.3 Process Bus separation and redundancy

Each PIU cabinet will be connected to both No.1 and No.2 protection system network panels via a dedicated fibre optic cable in a point-point arrangement as per requirements in Table 1. The fibre cable is to be terminated into a mounted FOBOT within the PIU cabinet.

Fibre cables for No. 1 and No. 2 protection systems must follow diverse physical paths and shall not be combined in the same conduit or cable run. Within electrical stations, these cables should be laid out in separate paths to prevent any common points of failure affecting fibres for individual feeders' protection schemes. Additionally, the process bus for Protection No. 1 is segregated from the process bus for Protection No. 2.

5.5 Fibre optic sub-systems

Fibre optic cables are deployed both between the substations (inter-substation, covered by ADI 0006) and within substations (intra-substation, covered by this Standard).

5.5.1 Intra-substation distribution cables

LAN fibre cables within electrical stations must have PVC jackets and a crush resistance of at least 200N/cm. Cables installed outside the control building must also be vermin-proof.

Multi-mode optical fibre cables are to be installed as per the requirements of Table 1.

Table 1: LAN multi-mode fibre optic cable

LAN	Usage	Fibre Minimum Core count
IEC61850 Process Bus (Per Protection System)	Between Buildings	24
IEC61850 Process Bus (Per Protection System)	Between Panels	12 ¹
External PIU Process Bus (Per protection system)	Between Panel and PIU	12
Station Bus LAN	Between Switches	2
Station Bus LAN	Between Rooms	12

¹ MTP connections are to be used as per section 5.5.4.

5.5.2 Fibre cable installation

Pre-fabricated bends shall be used where appropriate to suit the largest minimum allowable bending radii of enclosed cables. SDI 531 provides detailed instructions on installing underground conduits inside the substation boundary. Communication pits may be installed in lieu of bends in strategic locations to facilitate hauling in additional optical fibre cables in the future.

All fibre optic cables installed indoors within substations (except patch cords) shall be in white conduits or specially marked trays dedicated for optical fibre cables only. Indoor conduits can be smaller than twice the sum of enclosed cable diameters where the cables are installed concurrently with the conduits.

An appropriately sized loop (diameter shall not be less than the minimum specified by the cable manufacturer) of optical fibre cable shall be coiled and secured neatly as set out below to allow future rearrangements. Typical requirements are 3m to 5m long loops, preferably within the cabinet.

5.5.3 Fibre splicing

Optical fibre splicing shall only be carried out using a fusion splicer employing active alignment techniques, preferably active core alignment.

Joining of optical fibre cables for LANs shall be eliminated by design, with preference for point-to-point installations as a means of reducing points of failure.

5.5.4 Fibre termination points (FTPs)

Fibre termination points (FTPs) are used to terminate the individual cores in fibre cables onto sockets. These sockets are readily accessible to allow patching using patch cords. The FTPs are typically installed inside equipment or control panels.

Mechanical Transfer Push-On (MTP) systems are the high-performance version of the Multi-Fibre Push-On (MPO) cabling systems and are the preferred method for inter-panel multi-core fibre distribution over panel mounted FTPs. MTP cassette sockets shall be terminated as LC. Specific colour coding for MPO cabling is not required.

FTPs may be required to align with existing systems or where the length between terminating points prohibits the use of a MTP. Where used, panel mounted FTPs shall have angled SC-PC or LC sockets for terminating at least 12 fibres. Preference shall be given to FTPs capable of being DIN rail or flat panel mounted.

5.5.5 Fibre patch cord specifications

Single-mode and multi-mode patch cords shall have the optical specifications, jacket colours and FTP side connectors set out in the table below.

Application	Optical specification	Jacket colour	FTP side connector
Protection relay to a protection multiplexer (within the substation)	multi-mode OM3 or OM4 50/125µm	Salmon Pink	Aqua connector matching FTP socket (SC-PC or LC connector)
SCADA multi-mode applications	multi-mode OM3 or OM4 50/125µm	Purple	Aqua connector matching FTP socket (SC-PC or LC connector)
IEC61850 Process Bus No.1	multi-mode OM3 or OM4 50/125µm	Green	Aqua connector matching FTP socket (SC-PC or LC connector)
IEC61850 Process Bus No.2	multi-mode OM3 or OM4 50/125µm	Salmon Pink	Aqua connector matching FTP socket (SC-PC or LC connector)
Communications LAN multi-mode applications other than SCADA or protection	multi-mode OM3 or OM4 50/125µm	Aqua	Aqua connector matching FTP socket (SC-PC or LC connector)

Connectors on the equipment side for both single-mode and multi-mode patch cords shall be chosen to suit the respective equipment, LC connectors are preferred.

Patch cord jackets should be two (2) mm in diameter and be made of PVC. Duplex patch cords shall be used for all duplex applications. Simplex patch cords shall be used for simplex applications only.

5.5.6 Patch cord management outside racks and cabinets

Managing fibre optic patch cords outside cabinets shall be through horizontal 100mm x 50mm straight solid raceway ducting with a snap-on cover, suspended over or mounted on the cabinets. Patch cord exit from these ducting into the cabinets shall be by using 50mm round convoluted tubing to meet with the internal ducting.

Accessories recommended by the raceway duct manufacturer shall be used when supporting (mounting/suspending) or joining ducts/tubing at bends and exit points.

5.5.7 Patch cord management inside racks and cabinets

When managing fibre optic patch cords vertically and horizontally on panel walls inside the cabinets, rectangular slotted ducting with a snap-on cover should be used. Slots in the ducting will allow patch cord exit for devices mounted on the panel walls. Patch cords may be run inside corrugated conduit where there is no future need to run additional cords.

When managing horizontally run fibre optic patch cords in 19-inch racks, 19-inch rack mountable cable management rails shall be used.

5.5.8 Securing patch cords

Cable ties used for electrical cabling shall not be used with fibre optic patch cords. Materials similar to Velcro™, which eliminate the risk of pressure points, should be used instead.

5.6 Time Synchronisation Requirements – Digital Substations

IEC61850 Digital substations require dedicated time synchronisation GNSS hardware for process and station bus network devices and IEDs. Additionally, all ethernet switches require time synchronisation support via dedicated protocols as specified in 1.1.1.

5.6.1 Satellite Based Time Synchronisation Equipment

IEC 61850 Digital Substation time sources shall include the following required features where they are used to provide time synchronisation to substation networks:

- IEEE 1588 Precision Time Protocol (PTP)
 - PTP profile - C37-238-2017
 - PTP profile - IEC61850-9-3
- NTP¹
 - Primary and Secondary time server configuration
 - Client and Server
- GPS constellation support¹
- GLONASS constellation support¹
- Concurrently track multiple constellations¹
- Constant active tracking of at least 15 satellites¹
- Preferred support for GNSS spoofing detection (where this is not integral to the clock additional hardware may be utilised) ¹
- Real time monitoring data for time synchronisation and satellite tracking
- Minimum 2 fibre optic ethernet ports supporting PTP and NTP¹

¹ - These requirements are not mandatory for the purpose of a redundant clock.

²- Redundant clock shall have master/slave capabilities

5.6.2 Transparent Clock Requirements

IEC 61850 Digital Substation process bus network switches shall include the following required features where they are used to provide time synchronisation to all process bus devices:

- IEEE 1588 Precision Time Protocol (PTP) – Hardware based.
 - PTP profile - C37-238-2017
 - PTP profile - IEC61850-9-3

5.7 Time Synchronisation Requirements – Conventional Substations

Non IEC61850 Digital (Conventional) Substation designs do not require dedicated onsite GNSS hardware. Time synchronisation for conventional substation automation systems (SAS) and protection IEDs must be provided via the at least one of the following methods in order of preference:

- NTP
- SNTP
- DNP3

5.8 Labelling

All copper and optical fibre LAN cables, patch cords, FTPs, and communication equipment shall be clearly labelled as follows:

- Each end of a cable shall be labelled within 300mm of the end of the jacket with a label similar to Panduit M300X050Y7C.
- Where patch lead length exceeds five (5) meters or is installed in raceway ducts or tubing, each end of the patch cord shall be labelled within 100mm of the end of the connector boot with a label similar to Panduit S100X220VAC/ NWSLC-7Y label/sleeve combination.
- Labels on the FTPs/connector sockets shall be on the face plate in a way that clearly identifies the individual socket. The labels should be similar to Panduit UILS8BW.
- Labels on the equipment should preferably be attached on the front face plate. Where labels cannot practicably be placed on the front face plate, alternate locations such as blanking plates shall be chosen to maximise the accessibility and visibility.
- To maximise legibility, labels should be printed or generated by a mechanical device.

5.9 SCADA WAN segregation

Routable WAN links providing remote connectivity must not be connected to the substation SCADA LAN, station bus or process bus networks. Station Bus and Process Bus IED connections shall remain isolated from the WAN other than those dedicated for inter-site protection schemes approved by the Integration Manager Secondary Systems.

5.10 Record keeping

LAN equipment and cabling are to be recorded on the appropriate station drawings and cable schedules as per the requirements of SDI 526 – Design of Substation Secondary Systems.

6 Authorities and Responsibilities

General Manager Safety and Operations has the authority and the responsibility for:

- approving this Standard, including any variations.

Head of System Operations has the authority and responsibility for:

- making recommendations to General Manager Safety and Operations in respect to this instruction.

Secondary Systems Manager has the responsibility for:

- keeping this instruction up to date;
- ensuring that the requirements of this instruction are adhered to in the design and construction of substation communication systems; and
- approving any site-specific variations to the design philosophies and standards specified within this document.

Endeavour Energy employee and/or contractors have the responsibility for:

- ensuring that the requirements of this instruction are met;
- working in accordance with local and statutory requirements;
- ensuring that public safety is not compromised; and
- working in accordance with Endeavour Energy's Electrical Safety Rules.

Regional Transmission Managers have the responsibility for:

- ensuring that Endeavour Energy personnel and/or contractors engaged to perform the work have appropriate authorisations.

7 Document Control

Documentation Content Coordinator: Secondary Systems Manager

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Appendix A.1 Tri-Star network, no PRP



