Protection CT and link design layout, and wiring specifications

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51 Huntingwood Drive, Huntingwood NSW 2148
Postal address: PO Box 811 Seven Hills NSW 1730
Phone: 133 718 Fax: (02) 9853 6000
PDI 4003 Protection CT and link design layout, and wiring specifications

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1.0 PURPOSE
To specify the general protection design requirements for the installation and layout of CTs, isolation links, fuses and the associated wiring for Endeavour Energy’s network.

2.0 SCOPE
This standard covers the protection design aspects associated with links, wiring and CT layouts in new substations.

When an existing substation is being augmented or retrofitted, and the new works is clearly differentiated from the existing equipment, this standard shall be used.

Care is required to ensure that conflicts in tripping philosophies or CT connections do not impact on the network security. New designs will need to integrate with existing tripping standards.

It is important that the design of tripping circuit isolation is consistent within each protection scheme or panel.

3.0 REFERENCES
- Company Policy 9.2.2 - Network Protection
- EC1 October 1991 - Electricity Council of NSW Guide to the Maintenance of Protection
- Network Management Plan 2011-2013
- Equipment Technical Specification ETS 0014 – Protection and control panels
- Protection Design Instruction PDI 4002 - Current transformers for protection
- Substation Design Instruction SDI 526 - Control cabling, panels and terminations
- AS/ANZ 60269.2.1:2001 - Supplementary requirements for fuses for use by authorised persons, Section IV

4.0 DEFINITIONS AND ABBREVIATIONS
BBP busbar protection
CB circuit breaker
CT current transformer
DC direct current
LBU local backup
LV low voltage
PDI Protection Design Instruction
Protection circuits Circuits where a failed connection/termination may result in an unwanted protection system trip, or the failure of the protection system to clear a fault.
SDI Substation Design Instruction
UFLS under frequency load shedding
VT voltage transformer
5.0 ACTIONS

5.1 Protection guidelines

Links and fuses shall be provided in protection schemes to provide a means of isolating protection equipment so that it can be safely isolated for work to proceed. Links and fuses are used to isolate equipment to allow maintenance work to be carried out safely and efficiently.

5.2 Battery banks

5.2.1 Protection DC supplies

Where there are two (2) separate battery banks in a substation, there shall be separate protection bus supplies from each battery. One (1) battery bank shall supply the #1 protection scheme and the second battery bank shall supply the #2 protection scheme. The negative terminals of both battery banks shall be connected together by way of a removable link or switch.

Where there is only one (1) battery bank, two (2) separate protection bus supplies shall be made available and used to supply the relevant primary and back-up schemes.

All protection schemes shall have individual fused supplies, which shall be used exclusively for the particular scheme. Also, all schemes shall independently trip the associated CBs through their own trip coil (that is, two protection schemes protecting the same piece of equipment shall not operate the same trip coil).

All protection trip supplies and trip circuits shall be continuously supervised.

5.2.2 Circuit breaker failure and LBU

The term circuit breaker failure is the preferred description in new designs.

5.3 Protection current transformers

Current transformers used to supply protection schemes shall comply with the requirements of PDI 4002.

Current transformers that are not in service shall be short circuited across the full winding and connected to earth on the CT side of the CT links closest to the CT.

5.3.1 Separation of CT circuitry

Separate current transformer cores and secondary wiring shall be used for duplicate protection systems.

5.3.2 Arrangement

As far as practical, current transformers shall be arranged to eliminate blind spots in protection.

Where applicable, the zones seen by current transformers shall overlap. Instrumentation current transformers shall be located within the zone seen by the protection current transformers.

Where current transformers can be located on only one side of a circuit breaker, they shall be situated on the side that is away from the busbar.

It is preferred that the bus section or bus coupler CTs be mounted on the side with the lower bus-section number (for example, for a 2-3 bus-section CB, the CT should be on the bus section #2 side rather than bus section #3 side).

The preferred orientation of the primary polarity marking of a current transformer (nominal P1) is towards the busbar.

For post CTs on a bus section or bus coupler, P1 should be towards the CB.
5.3.3 CT connections

The star point of CT secondaries shall lie inside the protected zone. For example:

- For feeders, the star-point shall be on the line side of the CT secondaries.
- For transformers, the star-point shall be on the CT secondaries nearest the transformer.
- For BBP, the star-point shall be on the busbar side of the CT secondaries.

For low impedance BBP schemes where the CT is shared with the feeder/transformer protection, the star point shall be away from the busbar side on all CT secondaries including the bus section / bus coupler breaker CTs.

In existing substations, the conventions in this clause shall be followed if practical.

5.3.4 Earthing of secondary wiring

All current transformer secondary circuits shall be connected to earth with no more than one (1) earth connection to each set of connected current transformers.

The earth connection shall be made on the current transformer side of the first link that can be isolated, except for high impedance busbar protection schemes, where the earth connection shall be on the summation busbar neutral.

Wherever possible, the earth connection shall be made through a dedicated link that can be used to isolate the earth connection for testing and fault finding.

CT earth connections shall be made to the following arrangements:

- Star-connected secondaries shall be earthed at the star-point.
- Delta connected secondaries shall be earthed at white phase.
- Differential circuits with star and delta secondaries shall be earthed at the star-point.

Differential circuits with only delta secondaries shall be earthed at white phase of the set of lower primary voltage current transformers.

Where frame leakage protection is used, CT earth connections shall be as set out in the following diagram.
5.4 Voltage transformers

Voltage transformers are similar to small power transformers, but are designed for controlled ratio accuracy over the specified range of output. It is usual that common protection and indication voltage transformers are used for a given bus.

They can be protected by fuses on the primary, up to 66kV, but must always be protected on the secondary side to protect against secondary short circuit currents.

Note: Voltage transformers should never be shorted at the secondary terminals.

Where VTs are supplied with two (2) secondary windings, the #1 protection scheme and #2 protection scheme shall use different windings.

5.4.1 Earthing

Three phase star-star connected voltage transformers are the most commonly used in the network. The primary and secondary windings shall be earthed at the star point, except for the following two (2) situations:

- In existing substations where changing to this earthing arrangement is not practical
- Where metering requires an earth on white phase polarity.

5.4.2 Isolation

When isolating a protection scheme from a voltage transformer supply, it is important to remember that voltage transformers usually supply other schemes or instruments. Therefore, care must be taken to isolate only the relevant scheme.
5.5 Protection links

Links and protection fuses are required in protection circuits to provide isolation and testing points. The number of links used should be kept to a minimum.

5.5.1 Fuse and link type

The preferred fuse to be used is a totally enclosed fuse holder, which complies with the specifications of AS/ANZ 60269.2.1:2001 for fuse links with offset contacts, class gG.

The grading requirements for a fuse, in a protection circuit, shall be provided by the Protection section.

The preferred protection link to be used is an M5 three (3) stud link made by EUGAQUIP.

The colour of the link will depend on its function, as follows:

- **BLACK** CT circuits (including pilot wire AC circuits).
- **WHITE** VT circuits between the VT and the protection relay.
- **GREY** DC circuits for protection trip isolation.
- **RED** DC circuits for trip isolation of signals that could trip in-service equipment

Red coloured links shall be used only to isolate the outgoing wires to another protection scheme that is likely to unintentionally trip in-service equipment during maintenance activities.

Some examples of applications where RED links shall be used are

- CB fail trip output
- CB fail start output
- Low SF6 trip to busbar protection schemes (including frame leakage)

In some situations, such as in VT marshalling kiosks and in pilot kiosks, a solid copper link is inserted in a LV fuse carrier for isolation purposes. To differentiate between a fuse and a link in totally enclosed fuse holders, the following colour convention will be used:

- Fuses - **BLACK** fuse holders.
- Links - **WHITE** fuse holders.

5.5.2 Order of links and fuses

Protection circuit links or fuses are to be grouped in the following sequence, from left to right, as viewed from the front of the panel:

- DC trip outputs
- DC local trips
- DC trip inputs
- Pilot wire AC links
- CT links
- VT links
- DC supplies (see note below).

Links associated with #1 and #2 protections are to be segregated if mounted on the same panel.

**Note:** DC supplies shall have the positive (+ve) supplies grouped together and negative (-ve) supplies grouped together.

5.5.3 Special arrangement for BBP, UFLS, and 11kV capacitor bank tripping

Where a clean contact arrangement is used to bring a control (trip) positive (+ve) and a trip output into a protection scheme, these two (2) links shall be grouped in pairs.

These links shall be grouped separately from other links, with at least one (1) link width separation between each pair of links.
On schemes where two (2) signals (for example CB trip and intertrip) are initiated from a pair of contacts with a common terminal, the three (3) links shall be grouped together.

5.5.4 Mounting of links and fuses

Links are to be mounted so that the sliding section, if loosened, will fall to a closed position. Links and fuses shall be mounted in a horizontal row at locations specified below:

- Centre of panel for full height panels.
- Top of panel for bottom half panels.
- Bottom of panel for top half panels.

5.5.5 Connection to links and fuses

The following convention is to be adopted for connection of wiring to links and fuses.

5.5.5.1 CT and VT circuits

Connections closest to associated CTs and VTs shall be wired to the bottom of the link. Connections to the relay are to be wired to the top of the link.

5.5.5.2 DC circuits

There are two (2) basic principles for the connection of equipment wiring to DC links, as set out below. If there is a conflict between them, principle 1 takes preference.

1. Connections to and from adjacent panels, or coming into the panel from other equipment shall be wired to the bottom of the link, with connections to associated relays wired to the top of the link (that is, the bottom of the link has the external connection).

2. Connections between relays internal to the panel shall be wired with the initiating relay wiring at the top of the link, while the receiving relay wiring is to be connected to the bottom of the link (that is, the trip is down the link).

5.5.6 Labelling of links and fuses

Each link or fuse shall be clearly labelled with a description that unambiguously describes the function. The label shall be fixed in such a position that there is no confusion as to the link or fuse with which it is associated. Wherever possible, standard Endeavour Energy labelling shall be used.

5.5.7 Location of links in protection circuits

Sufficient links are required to provide isolation of protection relays and tripping circuits for:

- Protection testing and fault finding purposes.
- Special in-service conditions where part of the protection scheme may need to be made non-operational.
- Connection of temporary protection.

Note: A separate set of isolating links shall be provided for each individual set of protection CTs used. This allows for the separate isolation of any three phase set of CTs from the scheme they supply. This especially applies to high impedance BBP schemes.

5.5.8 Rating of protection panel tripping supply fuse

The local trip positive fuse on the protection panel is to be a 20 Amp HRC fuse.

The 20A fuse provides short circuit protection only. As the protection scheme is a controlled load, the fuse does not need to provide overload protection.
5.6 Protection wiring and terminations

All protection circuit wiring and terminations shall comply with the requirements of SDI 526 and ETS 0014 except as set out below.

5.6.1 Protection wiring sizes

CT wiring shall be a minimum of 2.5mm² for indoor substations, and 4.0mm² for outdoor switchyards.

Note: In order to prevent over burdening of CTs due to excessive cable lengths, the CT wiring size shall be increased where required.

5.6.2 CT star point wiring

Where protection CTs are connected in star configuration, the star-point shall not be made by the use of a solid straight shorting bar across the terminals. Rather, the star-point shall be made by the use of wire jumpers.

5.6.3 Protection circuit wiring terminations

The termination shall be of a design that if the screw or nut is loose, the termination will remain captured in the terminal.

All terminations shall follow the manufacturer’s designs and recommendations.

All terminations that can accept ring (full circle) terminations shall have the correct size and design terminating ring lug fitted.

All terminations should be bolted or screwed, and include a locking washer (for example spring, cup or dome shaped washer), or other similar arrangement that prevents loosening of the connection.

Open ended terminals (such as spade, fork or non-solid circle) and push-on connection terminals (such as stove or automotive) shall not be used in protection circuits, except in circuit breaker terminations that are monitored by a trip circuit supervision relay.

6.0 AUTHORITIES AND RESPONSIBILITIES

The Chief Engineer has the authority and responsibility for approving this Standard.

The Manager Secondary Systems has the authority and responsibility for making recommendations to the Chief Engineer in respect to this instruction.

The Secondary Systems Development Manager has the authority and responsibility for the development and maintenance of this protection Standard.

All persons involved in the design of Endeavour Energy’s protection schemes have the responsibility for ensuring that the design of protection schemes comply with this Standard.

All persons involved in the commissioning of Endeavour Energy’s protection equipment have the responsibility for ensuring that this design Standard is implemented.

7.0 DOCUMENT CONTROL

Documentation content coordinator: Protection Development Coordinator

Documentation process coordinator: Branch Process Coordinator