

Capital Delivery
Design Handbook

**APPLICATION GUIDANCE NOTES FOR THE NEW BUILD & ASSET
REPLACEMENT OF TRANSMISSION SYSTEM PROTECTION AND
CONTROL EQUIPMENT**

DH 01

Issue 5

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APPLICATION GUIDANCE NOTES FOR THE NEW BUILD & ASSET REPLACEMENT OF TRANSMISSION SYSTEM PROTECTION AND CONTROL EQUIPMENT

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1. PURPOSE

This design handbook has been compiled to offer guidance to Contractors when preparing Design Intent Documents and completing engineering for all light current replacement, new build and asset replacement work. It is not intended to direct Contractors to a particular solution.

This handbook also intends to clarify areas where National Grid requirements may be unclear.

2. REFERENCES

PS(T)010, Application and Protection Setting Policy for the National Grid UK Transmission System.
PS(T)055, Application & Setting of Systems that Perform Synchronising, DAR, Automatic Plant Isolation and Ferroresonance Quenching.
TGN(E)205, Application & Setting of Systems that Perform Synchronising, DAR, Automatic Plant Isolation and Ferroresonance Quenching.
TS 2.19, Ancillary Light Current Equipment.

3. RESPONSIBILITIES

3.1 Contractor

It is the Contractor's responsibility to produce a design fully compliant to National Grid's technical specifications. This document is intended to give guidance on the implementation and application of these technical specifications.

3.2 National Grid

It is National Grid's responsibility to ensure the Contractor is aware of all the relevant technical standards and to review the design for compliance with these standards and the Substation Design Specification requirements.

4. INTRODUCTION

4.1 Principles

The principles of this Design Handbook are based on designs that deliver TS 2.24 and its associated level three documents. The purpose is to facilitate the effective integration of substation light current functions, IED's, bay and station functions for both asset replacement and "green field" installations into a common vision of National Grid's substation light current architecture.

After the protection equipment fitted to a circuit has been installed, whether on a new installation, a switchgear project or a light current refurbishment project it must be left protected as a minimum to the standards detailed in PS(T)010.

Emphasis will be placed on equipment to be installed pre-outage following a full system FAT and SAT in advance of first circuit access. Engineered solutions are required that maximise multicore cabling pre-outage avoiding the use of redundant equipment as marshalling points.

It should be realised that with the pace of change in the industry, guidance should be sought as to the current status of any equipment list in terms of type registration.

4.2 Specific

4.2.1 Relays & Equipment configuration/setting

Where relays are used that have communications interfaces (e.g. an RS232 interface) the design must allow easy access to the interface whilst the relay is in normal operations mode.

To facilitate the calculation and issue of Protection Settings, relay details (type, range, rating etc.) need to be included or issued, two months after the design freeze stage.

Relay calculations shall be submitted to National Grid at least 20 weeks ahead of the circuit commissioning date to facilitate the issue of Thermal Rating data. All information should be submitted in line with the timescales outlined in UKBP/TP106 & UKBP/TP107.

Prior to the FAT the Contractor shall apply all programmable software logic settings and power system settings to the equipment. The relay settings calculations shall be submitted to and agreed with National Grid prior to the commencement of the FAT. The process for managing numerical relays is detailed in Commissioning Handbook 21, Management of Numerical Protection Schemes.

To facilitate the control system configuration, the Generic Equipment Model (GEM) information should be submitted and agreed prior to the design freeze stage.

4.2.2 Drawings

To clarify and confirm the protection design the following diagrams must either be included within or appended to the Design Intent Document (DID):

- Main Connections and Protection key diagram.
- Drawing showing the distribution of functions within a set of IEDs.

Examples of diagrams which meet the required standard are given in DH11, Single Line and Key Line Diagrams.

4.2.3 Tripping Arrangements

Current practises in tripping arrangements are such that only one self-resetting trip relay per tripping coil/system is used. All functions in a bay solution shall initiate a single trip relay per circuit breaker trip system which shall then be used in the trip circuit, to minimise trip circuit supervision wiring. For protection tripping functions there shall be no more than one trip relay between the protection and the trip coil. This philosophy should be adopted as standard where the scope of work allows.

It is accepted that the tripping arrangements for transformer LV circuit breakers may require transformer trip relays to be operated by HV located (i.e. mesh corner, busbar protection, feeder etc.) trip relays via the transformer dc tripping systems.

4.2.4 Reduced Equipment

Bay solutions using numerical relays shall be employed. Where protection systems include an integral intertrip facility, this shall be used to supplement the standard requirements for the type of connection. Alarm, Indication and Control cabling to the Control function should utilise serial connections where possible. This may be achieved with the use of appropriate protocol converters. The distribution of facilities across equipment in the system shall comply with TS 2.24 and the TS 3.24... series of technical specifications.

4.2.5 Plant Protection

Preference will be given to the use of modern numerical protection with acceptable diagnostic facilities to allow a 1 out of 1 protection to be applied.

For auto transformers the use of a restricted earth fault using external high impedance components is not required. However where REF is a discrete low impedance algorithm in the overall protection relay then it shall be enabled.

4.2.6 Setting Resistors

Where required circulating current protection Stabilising Resistors shall be replaced with ones of a specific fixed value as determined by the particular application. It is not permissible to use variable resistors.

4.2.7 Commissioning

Commissioning shall be in line with UKBP/TP106. Maximum use of Factory testing should be considered to reduce on-site commissioning time. The proposed commissioning philosophy and methodology shall be included within the DID.

4.2.8 Temporary Protections

The Contractor shall make provision for engineering that will enable temporary commissioning protection to be installed and commissioned. The Contractor must also provide, install and remove when finished with any temporary protections required to meet any Emergency Return To Service (ERTS) requirements and for stage 2 commissioning works.

4.2.9 Circuit Breaker Close & Trip Circuit Wiring

The Contractor must supply calculations and carry out site testing that demonstrates that the circuit breaker close and trip coils will reliably operate with a minimum of 87.5V across the coil. The following points must be taken into consideration:

- The formal calculations which are to be submitted for client review must be listed within the DID. This list should include calculation reports for the CB trip and close circuitry of all existing and new Circuit Breakers which are being worked on.
- Post Design Freeze the Contractor shall submit the calculations for review by National Grid. These calculations should demonstrate that the CB trip and close coils receive sufficient voltage for reliable operation i.e. a minimum of 87.5V. This is under minimum battery conditions at the battery terminals as stated in TS 3.12.4 (93V for dispersed relay rooms and 102V for Central Relay Rooms). The maximum trip and close wiring resistance in series with the trip and close coils will form part of these calculations. This calculation must be from the contact furthest away from the coil being considered.
- During installation and Stage 1 commissioning, SCT 01 and SCT 26 (or the Contractors 'approved' equivalents which must incorporate fully the requirements of SCT 01 & SCT 26) shall be completed in full. This will confirm that the trip and close circuits conform to the proposed design.
- SCT 01 requires a check that the trip coil operates at 87.5Volts using a trip coil tester. These testers are normally used by Asset Management staff during maintenance and the latest ones manufactured by RES Ltd use the Substation battery as a source of supply and have a constant voltage output variable from 5 - 95% of the input voltage. These can be used for setting the source voltage to either 102V or 93V in a safe and controlled manner thus representing the minimum battery state after 6 hours.
- SCT 26 requires a trip to the CB from **ALL** initiating contacts and must be adhered to. It also requires instantaneous volt drop measurements across the trip wiring and trip coil with suitable UV trace recorders or storage scopes connected. This test is at normal battery voltage (125V) but should be repeated at the minimum 6 hour value (93V or 102V) and in both cases the voltage across the trip coil must not be less than 87.5V.
- SCT 26 also refers to Transmission Design Memorandum 3/35 – 'Site Tests to Confirm Satisfactory Operation of Circuit Breaker Trip Coils', and provides guidance on the requirements to be met or which can be accepted for existing installations.
- Recently installed Circuit Breakers compliant with TS2.02, 'Switchgear' are designed with trip coils able to operate in the voltage range 77V – 137.5V. In these cases the calculation can assume a voltage of 77V at the trip coil terminals. i.e. a maximum voltage drop across the cabling of 25V for Centralised systems and 16V for dispersed relay rooms. These values can be used in SCT26 when commissioning circuit breakers compliant to TS2.02. The minimum close coil voltage should be considered to be 87.5V.
- The use of multiple cores within the trip circuitry should be avoided as the trip circuit supervision system cannot detect a single core going open circuit within parallel connected wiring.
- All of the above requirements must be met in the first instance. However, by exception, National Grid may give a dispensation based on TDM 3/35 such that site tests demonstrate the minimum close or trip voltage appearing at the CB close & trip coils should be equal to or greater than the coil minimum reliable operating voltage plus 20%.

- Appendix 4 details trip & close coil burdens of the majority of circuit breakers installed on National Grids electricity transmission system. The Contractor must ensure that the trip, open interposing & close interposing relays have contacts suitably rated to switch the trip and close coil burdens.

4.2.10 Use of Opto Coupler Inputs on Modern Relays

Optical coupler inputs are discreet components used extensively within protection equipment to provide fast galvanic isolation for the processing of trip, control commands and switchgear positional status indication. A typical optical coupler input consists of an LED connected to a resistive network and can provide isolation up to 5kV. Optical coupler inputs are inherently low power with fast operation speed. These qualities render them susceptible to the effects of capacitive discharge and capacitive coupling.

TS3.24.4 (August 2000) functionally specifies that optical coupler inputs should be immune to the effects of battery earth faults and capacitive coupling. National Grid acknowledges the fact that the optical coupler inputs on board different manufacturer's equipment offer different levels of immunity, however the restrictions and limitations detailed within this document should be applied universally.

The Contractor must ensure that suitable precautions are taken to ensure that all IED status inputs are not vulnerable to operation by induced voltages and that the requirements of TS 3.24.4, section 4 regarding immunity from mal-operation due to capacitive discharge are fully met.

The following restrictions and limitations should be applied to installations utilising optical coupler inputs:

- The preferred method of switching optical coupler inputs is through double pole switching devices. However it is recognised that this will not be achievable in all applications due to unavailability of initiating contacts or in situations where the negative terminals of the optical coupler inputs are connected internally within the protection relay and presented externally as a single common terminal. Cross site initiations which can directly or indirectly cause a trip have been proven to be problematic, these should be either double pole switched or connected as stated below.
- Where double pole switching is utilised, drain resistors must not be fitted across the contacts switching the negative side of the supply.
- Under no circumstances should cables connecting optical coupler inputs share conductors carrying AC circuits. This means CT, VT or 415V LVAC circuits.
- Without exception 110V DC systems supplying optical coupler inputs should be of the centre tapped earth arrangement.
- Where cross site initiations cannot be connected as above and the initiating contact is on a remote site (with a separate earth mat) to the optical coupler via a long pilot cable, consideration must be given to fitting a high burden (EB2) interposing relay. There are no specific requirements regarding insulation levels other than those specified in TS 2.19.

4.2.11 Terminal Mounting Arrangements

When terminals are used that rely on the adjacent terminal for insulation from live connections (i.e. RSF3s etc.) the mounting arrangements used should prevent a terminal from being inadvertently inverted causing a possible short circuit to the adjacent terminal. In some examples the profile of the mounting rail prevents this possible unwanted risk. i.e. 'Top Hat' profiled rail allows terminals to be mounted both ways whereas 'G' profiled rail does not. This type of rail should be used where possible.

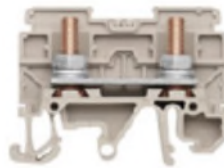
4.2.12 The Provision of Shorting Links & Terminals for Current Transformer AC Wiring

TS 2.19 issue 3 section 1.10 states the following:-

“Current Transformer (CT) terminal blocks housed at the marshalling point closest to the Current Transformer shall facilitate the application of temporary shorting links secured using a nut and washer locking arrangement. Facilities for isolating the short circuited CT shall also be provided at this point. The design shall be such that the integrity of the short and open circuits may be readily confirmed by visual inspection. The terminal block shall be located in an easily accessible position.”

“On high impedance busbar protection schemes only- termination blocks that facilitate the in service shorting and disconnection of circuit current transformers (i.e. isolation and shorting links) shall be provided at the point of connection to the common bus-wiring”.

To implement the TS 2.19 requirements for all CT secondary circuits, with the exception of high impedance busbar protection, terminal blocks of type ST5 or equivalent (see below) shall be used.



These shall also be the means of shorting. This will be by using temporary wire loops with suitable ring crimp terminations to allow connection to each stud. No other means of shorting should be achievable apart from via test blocks at the relay panel.

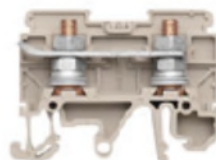
The location of the ST5 terminal blocks must **not** be in the relay panels and shall be at the next interface/marshalling point after the CT terminal box. The following locations are considered suitable:-

- The site circuit marshalling kiosk for sites with a common relay room and no GIS Local Control Cubicle (LCC).
- The GIS LCC for sites provided with such.
- The circuit marshalling rack for sites with a blockhouse.
- Where none of the above can be applied the terminals shall be located at suitable location between the CT and relay panel as close to the CT as possible.

The terminals should include spring washers under the nut to prevent them inadvertently becoming loose.

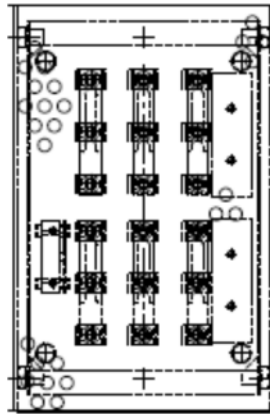
The terminals must be arranged such that connections to take on load readings can be easily applied & they must be mounted so as to be easily accessible by National Grid engineers.

The CT earth link shall be of type STL5 (see below) or equivalent and shall be located at the relay panel.



For High Impedance Busbar Protection the shorting links provided shall be of a type consistent with the existing installation. However an example of the minimum standard for a typical circuit is shown

below. The location of the links shall be preferably on the front of the busbar protection relay panel, although the LCC is another option, where this is provided.



4.2.13 Use of LEDs on IED's

The majority of IEDs have a number of configurable indication/alarm LEDs located on their front panels. To avoid confusion these LEDs must be configured as follows:

Green LEDs: Normal Operation (i.e. equipment in service).

Red LEDs: Abnormal condition (i.e. operate/trip indication or faulty alarm).

4.2.14 Ferruling & Wire Colouring

All ferrules should be coloured white with black lettering, with the exception of CT & VT wiring which should be as specified in TS 2.19.

Wiring insulation should generally be coloured as specified in TS 2.19. In addition supply wiring colours not specified in TS 2.19 should be as follows:

- 110V dc supply wiring should be BROWN (+ve) and GREY (-ve).
- 48V dc (positive earthed) supply wiring should be BLUE (+ve) and GREY (-ve).
- 110V ac supply wiring should be BLUE (L1) and BLACK (L2) where a centre tapped supply is used.

5. RELAY EQUIPMENT BUILDINGS AND GENERAL SITE ARRANGEMENTS

5.1 Buildings

All existing relay equipment buildings are in reasonable condition. Some substations employ a centralised relay room with others utilising dispersed type relay rooms. In both cases there are varying amounts of spare capacity for new equipment, the exact amount of space should be determined by surveying the buildings during the **Network Development Process (NDP) stages 4.3 & 4.4 IP3 stage**.

Any new buildings must meet the requirements of DH15; 400kV and 275kV Gas Insulated Switchgear (GIS) and Air Insulated Switchgear (AIS) Substation Buildings

5.2 Design Principles

Where possible pre-outage work must be maximised by installing equipment and cabling and completing site functional testing prior to commencement of the outage.

On existing sites this can be effected by use of existing relay room spare capacity where possible. If no spare capacity exists consideration should be given to utilising other spare accommodation on site, relay room extensions or a pre-fabricated / portable relay room.

Guidance will be given, if required during the ~~IP2 & IP3 development stages~~ NDP stages 4.3 & 4.4 although equipment location will depend upon current and future proposed works.

For Asset Replacement the total replacement of light current equipment will require new relay equipment accommodation with cabling direct to the plant marshalling kiosks.

Piecemeal replacement may reuse existing accommodation and cables but the extent of reuse will depend on outage and Emergency Return to Service (ERTS) time constraints.

5.2.1 Asset Replacement within Dispersed Relay Rooms

At sites with dispersed relay rooms, a total replacement of protection and control equipment using a 19" mounting arrangement is preferred. New swing rack cubicles meeting the requirements of TS 2.19 should replace existing swing frames. Existing terminal marshalling racks should be retained and refurbished where old larger terminal blocks are used. Modern terminal blocks are smaller and will increase the space for additional terminations.

Any distributed high impedance busbar protection relays should be retained unchanged along with back tripping relays where possible.

The re-use of any existing modern electronic relays will be highlighted in the enquiry document.

5.2.2 Asset Replacement within Centralised Relay Rooms

At sites with a centralised relay room, a total replacement of protection and control equipment using a 19" mounting arrangement is preferred. New swing frame cubicles meeting the requirements of TS 2.19 should replace existing TPS 5/12 swing frames. Where it is not cost effective or there are outage constraints then to avoid re-cabling, arrangement can be made to re-use the existing back boxes. In this case retain the terminal marshalling racks and refurbish where old larger terminal blocks are used. Modern terminal blocks are smaller and will increase the space for additional terminations.

Where relay panels are removed their associated back boxes must be cleared of all terminals, wiring and cabling. Redundant back boxes must not be used as marshalling points.

The re-use of any existing modern electronic or numeric relays must be highlighted in the DID.

5.2.3 Cabling

Over filling the existing cable trenches should be avoided. New cables should not prevent the removal of redundant cables in the future. Also, redundant cables should be removed from the cable trenches inside buildings and within 10 metres of building entries and marshalling kiosks and other plant termination points.

For Asset Replacement the condition of any multicore cables must be assessed to ensure they are suitable for re use. In particular where cables are clamped or cleated the area around and under the clamp or cleat must be inspected to ensure there is no damage to the cable. Cables that have V.I.R. insulation or those that are unsuitable and/or unsound should be replaced.

For new installations consideration must also be given to segregation of signals between multicore cables. As a minimum the following signals should be allocated to separate cables:

- 240/415V AC supplies.
- 110V DC supplies.
- 48V DC supplies.
- First and second supplies must also be run in separate cables.
- CT connections.

- VT connections.
- DC trip, alarm, control, & interlocking signals can be allocated to the same cable but first and second tripping systems must be run in separate cables.
- Transducer mA output signals. These must also be allocated to screened twisted pair cable.

Where signals are being sent between different sites, for example between the HV and LV sides of transformers the first and second trip systems must be allocated to separate cables. Ideally these cables should be physically separated by at least 5 meters to prevent accidental damage to both and be run in separate ducts/trenches from any parallel power cables.

For Asset Replacement works where existing cross site cables are commonly reused consideration must be given to segregating the following signals between multicore cables:

1. Cores being used for CT & VT connections must be in separate cables from cores being used to energise IED status inputs using optical couplers.
2. Cores used for first and second protection systems should be in separate cables.
3. Ideally cores carrying CT/VT connections should be in separate cables from those carrying DC & tripping supplies.
4. 415V AC supplies should be run in dedicated cables.

Item 1 is considered to be mandatory. If there are sufficient spare cores available in the existing cables the opportunity should be taken to segregate functions across the multicore cables as per items 2, 3 & 4 with item 2 being given the highest priority.

Occasionally contractors may have difficulties in obtaining multicore cable with cores covered with white coloured insulation. This has been found to be particularly the case with multicore cables with cores of 10mm² or larger. Where this is the case the coloured cores must be covered with white coloured sleeving where the outside insulation/armouring has been stripped away. The cores must be suitably numbered and continuity tested after the sleeving has been applied.

As multicore cables of 6mm² and below are readily available with white insulated cores it is not permissible to use these sizes with coloured cores for cabling/wiring that requires white coloured cores.

Fibre Optic interconnections, supplied by the Contractor, are preferred between dispersed equipment locations to provide electrical isolation and noise immunity.

Fibre optic cabling shall be installed and protected to the applicable TS.

5.2.4 Cubicle Illumination Supplies

TS 2.19, Issue 3, Part 1 section 1 states that the use of auxiliary supplies above 110V (ac) should be avoided. The preferred voltage for auxiliary ac circuits is 110V sourced from a centre tap earthed transformer.

This conflicts with section 1.4 of the same document which states that cubicle lighting shall be supplied from a 230V (ac) single phase supply incorporating earth leakage protection.

For new substations & dispersed relay rooms cubicle illumination circuits should comply with the requirements in TS 2.19 section 1 to use a 110V (ac) supply. 230V (ac) supplies must not be used for cubicle illumination circuits for all new equipment cubicles.

National Grid preference is to use 110V (ac) for heating supplies on new equipment. However it is accepted that where a large number of heaters may have to be connected to one supply (for example all the kiosks/panels on outdoor sites) 230V (ac) supplies may have to be used to keep the loadings and ratings down to reasonable levels.

~~For Asset Replacement works these requirements must be discussed with the P & C Design Assurance Engineer to determine the most suitable cubicle illumination supply voltage.~~

Cubicle lighting shall be 110V in all new panel installations. Where existing panels are to be retained with new front sheets, or block house Z-frame racks are being retained, existing lighting arrangements need not be modified.

For all solutions below, the use of 'bulk-head' lighting is to be discouraged and more innovative lighting solutions such as 110v (dc) LED lighting are encouraged, these solutions should not make the procurement of replacement bulbs difficult.

Centralised Relay Room

- A new 110V (ac) supply will be added to the existing LVAC board, sufficiently rated for the new and future panel capacity. A new 110V (ac) feed will be run through the existing wall boxes, as far as is reasonable for new and future installations. The future requirements will be assessed as part of the initial site visit carried out at the start of a new project in discussion with the P&C Design Assurance Engineer and the ETAM Operations site representative.
- The new 110V (ac) supply will be dependent on the age of the LVAC board. Where the LVAC board is of such a design as to install a new 110V plug in type module, then this will be installed. Where the LVAC board is of a more traditional vintage, a spare 230V way will be used to supply a 230/110V (ac) transformer, located as close as possible to the spare supply, in a wall mounted enclosure with sub distribution ways.
- Where an existing cable is to be re-used for the 110V (ac) supply, the contractor must confirm that an acceptable volt drop, for the distance from the LVAC board to the supply point, can be achieved. Where it is not possible to maintain a minimum volt drop across the cable, a new larger cable shall be installed.
- A radial or ring supply may be used for the lighting installation.
- Where an existing panel suite is lit from a single switch at the end of one panel and this panel is to be removed, the switch shall be re-located to the associated wall box where practicable.

Block Houses / Portable Relay Rooms

- A 230/110V (ac) transformer will be installed as close as is practicable to the distribution fuse board where an 110V (ac) supply will be distributed to the PMF and onto the new panels via ring or radial supply.
- The new transformer shall be sufficiently rated to cater for complete replacement of all protections with swing frame panels, plus addition for other future normally lit cubicles in the block house (i.e. bay controllers).

6. FEEDER PROTECTION

6.1 Feeder Main Protection

6.1.1 Design Principles

All new feeder main protection equipment must be TS 2.24 designed equipment with 125VDC supplies. Any existing modern electronic relays that are replaced and considered serviceable should be recovered and returned to National Grid stores to support the availability of the system. Guidance will be given during the design stage of the contract as to any EMI's (TDC's) that may be relevant to the latest equipment.

Feeder protection should be installed in line with PS(T)010, Application & Protection Setting Policy for the National Grid UK Transmission System.

TS 2.19, Ancillary Light Current Equipment, Issue 3, Clause 1.4 permits differing protection systems to be housed within the same relay panel. This however, does not apply to First & Second Feeder Main Protection systems which must be housed within **different** panels. It is permissible to house other systems in the same panel as Main Protection systems, for example Circuit Breaker Units, Backup Protection, Control facilities etc.

Remote (ENCC or SCP) protection IN/OUT switching is not required on new installations unless required as a function of unlocking a protection as a result of communication failures. On existing SCS only installations where protection IN/OUT switching is present these facilities should be migrated to the new SCS. It shall only be added to protections that require communications unlocking functionality. However each main protection should be fitted with a test / normal switch to enable all it's outputs to be isolated.

The connections to the National Grid operational telecoms network should be as outlined in Appendix 5.

6.1.2 Non Unit blocked overreach distance protection

Where a non-unit blocking overreach scheme is installed in the event of blocking channel failure the protection should automatically revert to plain distance. No blocking In/Out controls are required in this instance.

An additional alarm should be raised from each end IED (1837 1ST BLOCK CHNL or 1859 2nd BLOCK CHNL Flty/Hlthy).

6.1.3 Zone 2 override

A switchable facility allowing for instantaneous zone 2 reach to be selected shall be provided on all plain distance protections on all bay solutions.

This shall be named "Zone 2 Override" and shall allow DAR in all cases. The requirement can be met by either reducing the Zone 2 timer to zero or by extending the zone 1 reach to equal the normal zone 2 reach setting. In both cases DAR must remain active.

In/Out switching of the Zone 2 Override facility shall be provided remotely from the ENCC and the substation HMI, both via the SCS. This must be a double point control with a single point indication. The indication state is HIGH (i.e. = 1) when the Zone 2 override facility is switched IN. The Contractor must not assume inversion of the indication state can be implemented in the substation SCS as older systems cannot provide this facility.

6.1.4 GPS Timed Differential Protection

Separate GPS clocks and aerals should be provided for each GPS timed differential protection supplied. It is not permissible for relays located on different circuits to share the timing signal from one clock. Where a double unit protection arrangement is provided on a circuit each unit protection must have it's own clock.

The location of GPS aerals shall be verified by a GPS survey. Installed equipment shall be monitored for a period of not less than one month to confirm GPS integrity.

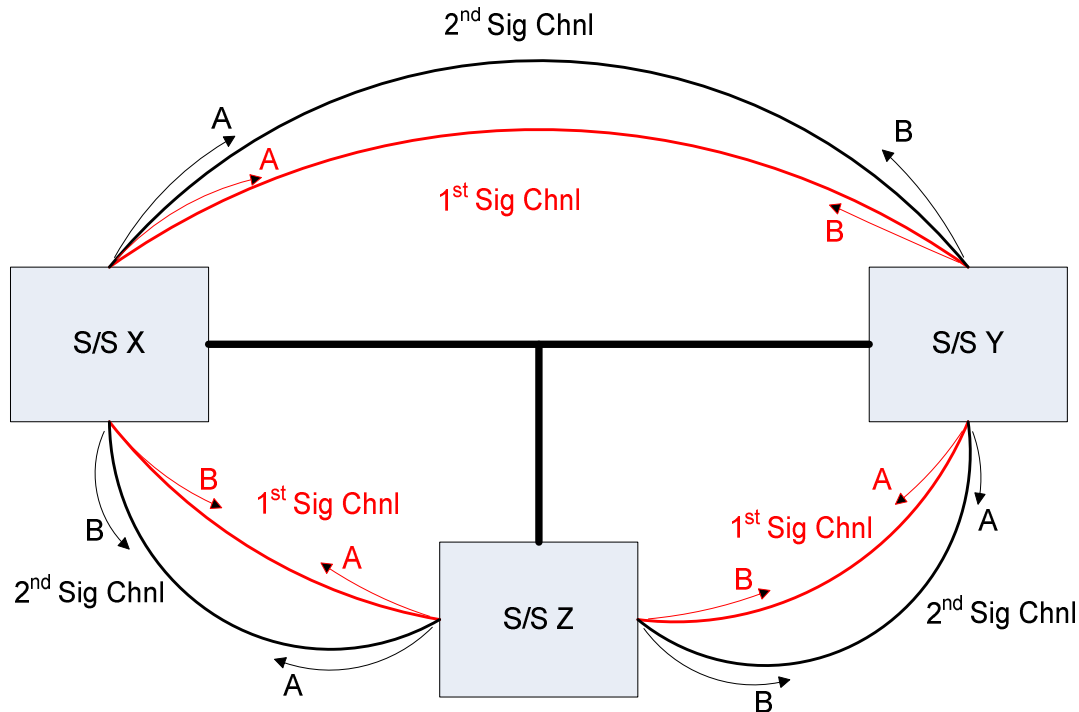
The separation distance between individual GPS aerals should preferably be 5 meters with an absolute minimum distance of 3 meters if there are difficulties in mounting/locating the aerals.

To minimise issues due to induced voltages GPS aerals must not be mounted on blockhouses adjacent to EHV plant in switchyards, it is preferable to mount them on the common facilities/services buildings.

All aerals and associated receivers shall be clearly labelled with the circuit and function being supported. In addition the aerial installation must be suitably guarded to prevent interference by personnel.

6.1.5 Three Ended Differential Protection & Blocked Distance Protection Requirements

The following summarises National Grid's requirements in respect of the communications circuit functionality of 3 ended Differential and Blocked Distance Protection schemes. A simple diagram showing the primary circuit and associated signalling channels/paths is shown below:



1st Sig Chnls carry current data & 1st I/T (FP1)

2nd Sig Chnls carry Blkg Signals & 2nd I/T (FP2)

Each relay generates data which is transmitted to remote ends via two paths A and B, path A to one remote end and path B to other remote end. A and B above are arbitrary

Feeder Protection 1 (Differential)

All signalling channels in service

Under normal circumstances (all signalling channels in service), all ends receive current information from the two remote ends (all ends are in effect Master Ends) and are able to execute correctly, the differential algorithm. Under internal fault conditions each end initiates a local trip and also initiates:

1. An internal PTT signal to both remote ends ensuring all end protections operate and raise appropriate (Protection Operated) alarms. This internal PTT is part of the differential algorithm.
2. An unconditional DTT (intertrip) to both remote ends (via both FP1 and FP 2 I/Ts) ensuring remote end tripping via intertrip.

In the above diagram, current data is sent from end X to end Y via path 'A' and from end X to end Z via path 'B'.

One signalling channel faulty

When one signalling channel has failed (say Z-Y 1st Sig Channel) the following sequence takes place during an internal fault.

End X sends current data to end Y (via path 'A'), and to end Z (via path 'B'), but ends Z and Y can send current data to end X only, via paths 'A' and 'B' respectively. Thus only end X has current data from all three ends and only end X can then operate as Master, executing the differential algorithm and initiating a local trip. End X also initiates an internal 'protection' PTT to both remote ends. In this way the 1st M Protection will operate at all ends and raise the appropriate alarms. Operation of the 1st Main Protection at all ends will result in the sending of a DTT (Intertrip) to remote ends – with Z-Y 1st Sig Chnl faulty as in this example, Z to Y 1st I/T will be cascaded via X, and similarly Y to Z 1st I/T will be cascaded via X. In addition to the DTT initiated via the FP1, DTTs will also be initiated via FP2.

The loss of the Y-Z signalling channel results in only '1st Sig Chnl' faulty alarms at end Y (for leg Z) and at end Z (for leg Y). These alarms will be logged locally and sent to ENCC.

Two signalling channels faulty

In this event, relay logic will determine that two 1st Sig channels have failed, protection relays at all ends will be 'locked' and 1st M Protection faulty and 1st I/T faulty alarms (per leg) will be raised locally (at all ends) and at ENCC.

Feeder Protection 2 (2nd Main Prot – Blocked Distance)

All signalling channels in service.

In the event of an external fault the appropriate end(s) will send a blocking signal to the two remote ends. Eg, for a fault 'behind' Z, the relay at end Z will send a blocking signal to X (via path 'A') and to end Y (via path 'B') and no ends will trip. The Blocking Signals may also be sent via the alternative path eg in this example end Z may also send a blocking signal to X via Y (Z to Y via path B and then Y to X via path A).

One signalling channel faulty

When one signalling channel has failed (say Z-Y 2nd Sig Channel) the following two options are possible during an external fault.

Chain Mode configured.

In the event of an external fault behind Z, end Z will send a blocking signal to end X (via path 'A') and end X will then pass on this blocking signal to end Y (via path A). In this way both remote ends receive a blocking signal and no ends will trip. Before chain mode is configured it should be confirmed the total signalling time from any one end to a remote end via an intermediate end to (i.e. the blocking signal is 'passed on') is less than the Permissive Trip Timer (Tp) setting. Total signalling time is the sum of the two signal propagation times (6ms each is the 'guaranteed' time) plus any delays introduced by the relays. With a Tp delay typically of 40ms this should be achievable with an adequate safety margin.

In these circumstances the failure of say Y-Z 2nd Signalling Channel will raise only a 2nd Sig Chnl faulty alarm locally and at ENCC. The 2nd I/T is maintained from Y to Z via pass on at X.

Loss of two 2nd signalling channels should be detected by the relays causing the circuit protection scheme (relays at all ends) to revert to Plain Mode and 2nd Block Channel fail and 2nd I/T fail alarms to be raised locally and at ENCC alerting staff to the fact that Block Mode has been disabled and (2nd) intertripping has been lost. These Block Channel and I/T fail alarms should be achieved, if possible, by the logical combining of the two discrete channel fail alarms. If it is not possible to achieve this, both 2nd Sig Chnl fail alarms (from all applicable ends) should be raised locally and at ENCC and notes should be provided on circuit Protection Schedules, describing the effect of the loss of two signalling channels.

Chain Mode not configured

In this case loss of any one Signalling Channel causes the Block Mode to be switched out of service at all ends and thus the circuit protection scheme to revert to Plain Mode. Loss of any one signalling channel would this time raise (for the affected leg if discrete channel alarming is possible) 2nd Block Channel fail and 2nd I/T faulty (only if the 2nd intertrip is not passed on via X) alarms alerting ENCC to the fact that the protection has reverted to Plain Mode. Notes on circuit Protection Schedules should be provided to ensure that ENCC staff understand the impact of the loss of the single signalling channel.

Loss of a further 2nd signalling channel would be raised in the same way as the first loss for the 2nd Main Prot (Block Chnl and I/T - different leg).

Chain Mode is preferred as this maintains Blocking functionality in the event of the failure of a single signalling channel.

Reference should be made to GEMs and/or the MAL for precise local and ENCC alarm legends

6.1.6 Fibre Optic – X21 Converters

Where fibre optic – X21 converters are used for the main protection communications the dc supplies for the converters must be sourced directly from the dc distribution boards. Separate supplies are required for the first and second main protections. The 'grasshopper' fuses in existing telecoms cubicles must not be used. Each fibre optic – X21 converter dc supply should be provided with a dedicated MCB and alarmed for a supply failure.

6.2 Feeder Intertripping & Protection Signalling

6.2.1 Design Principles

Where possible all new equipment should use integrated intertripping and protection signalling facilities within the feeder main protection relays. When any dedicated intertrip equipment, protection-signalling equipment and associated interfaces are required they should utilise digital rather than analogue circuits. Fibre Optic cabling must be used for cross-site transmission where possible. The fibre optic interface unit will must be located as close to the ~~Vodafone Cable & Wireless (C & W)~~ service as possible.

Test facilities shall be provided in line with the TS requirements.

Note:

- Transformer disconnectors operating in the fault interfering mode require current and voltage interlocks to be fitted following the addition of a second intertrip channel.
- Power Line Carrier (PLC) intertripping equipment should be located adjacent to the circuit relay panels. Stand-alone intertripping equipment that connects to the ~~Vodafone C & W~~ service should be located in the telecommunications room.
- If the carrier equipment is not to be used consideration on the method and cost of removal should be highlighted during the design stage.
- Operating frequencies and codes for dedicated intertripping equipment need to be confirmed with National Grid.

6.3 Feeder Common Protection

6.3.1 Design Principles

New feeder common protection functions should be integrated within the overall feeder bay solution.

For asset replacement the existing feeder common protections (e.g.: system back-up, trip relay reset, overload and phases unbalanced alarms etc.) are generally a mix of original electro