Engineering Specification ES396

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Protection in Primary Substations

Contents

Approved for issue by the Technical Policy Panel

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Amendment Summary

Amendment No. Date	Brief Description and Amending Action
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PROTECTION EQUIPMENT IN PRIMARY SUBSTATIONS

1. INTRODUCTION

This specification covers the requirements for protection equipment to be installed at Primary substations on 6.6kV, 11kV and 33kV systems. The existing protection requirements are detailed in a variety of specifications and this specification will reference those other documents as well as detailing future needs.

Historically the protection relays and systems have been specified on standalone panels remote from the switchgear. The advent of modern protection utilising feeder manager relays and modern switchgear have reduced the need for separate panels and it is intended to specify protection mounted on the switchgear whilst maintaining existing protection scheme functionality.

2. SCOPE

This specification covers the requirements for protection equipment to be installed at Primary substations on 6.6kV, 11kV and 33kV systems

3. EXISTING PROTECTION

3.1 General

The existing practice of using remote panels had two functions firstly, it made it easier to specify a number of standard panels for different circuit configurations and requirements and secondly, it also enabled the switching of circuit breakers remotely within the substation. The standard panels were able to be built and installed separately from the switchgear with multicore connection and commissioning done on site. In order to reduce the operator risk of operating oil circuit breakers it was felt that to be able to operate remotely within the substation would be a distinct advantage.

3.2 6.6/11kV

The existing protection for a 6.6kV or 11kV primary switchboard is specified within two documents, ES314 – 11kV switchgear specification and ES337 – 11 and 33kV panel specification. At this voltage level the individual feeders have the protection mounted on the switchgear already (as ES314), so there will be no physical change from that perspective. However, as described later in section 4 it is anticipated that additional functionality can be provided by a modern relay. The bus section and incomers have their protection mounted on separate panels as per ES337, this also includes the general alarms and voltage control panels.

ES314 details the possible variations for the protection requirements on standard feeders, incomers and bus section depending on whether the circuit is underground, overhead, metered, unit or directionally protected. All these variations around the differing protection requirements will still be needed.

3.3 33kV

All protection at 33kV is installed on remote panels with generally one panel per feeder bay. The protection requirements for 33kV are detailed in ES337 – panel specification. The 33kV switchgear specification also details the requirements for the current transformers and general protection items. The overall protection functionality described in these specifications will still be required but it is expected that modern relays will enable the combination of several functions within one unit and that the space savings will enable the protection to be mounted back on the switchgear in some instances.

4. FUTURE PROTECTION REQUIREMENTS

4.1 General

Whilst the use of remote panels has enabled standardisation to a degree it also necessitates a much larger substation floor area as well as adding complexity and increased installation time in the small wiring due to the large number of multicores required between switchgear, panels and outstation. It is expected that in some cases the protective and ancillary functions may be able to be combined within one relay or feeder manager so reducing the space requirements and enabling the protection to be mounted on the switchgear.

The advent of modern vacuum and gas switchgear with arc fault containment has greatly reduced the need to be remote from the switchgear during operation. However in recognising the preference not to be stood in front of the circuit breaker when operating it a requirement for a time delay on closing will be necessary, provided through the protection relay.

4.2 6.6/11kV Feeders

At this voltage level there only tends to be one main protection relay per feeder with standard overcurrent and earth fault functionality. However, there are other protection options for feeders depending on the circuit type and it is anticipated that some of these other functions could be combined within a single protective relay. The typical options at this level are auto-reclosing, sensitive earth fault protection, unit protection where necessary, and directional protection. The preferred relays will be those where the additional functionality mentioned above is (or can be optionally) contained within the same relay.

In addition to the traditional protection functions a typical feeder will also have trip circuit supervision, trip relay, telecontrol interposing relays, auxiliary relays and additional cts to monitor feeder load. Again to minimise equipment and wiring within the switchgear the preferred protection relay will be able to provide some or all of this functionality, subject to the requirements mentioned below.

The standard trip circuit supervision utilised is the H7 scheme from Engineering Recommendation ER S15 incorporating pre-closing supervision, and the protective relay would only be considered for provision of trip circuit supervision if it can provide a full replica of the H7 scheme.

The current UU telecontrol system requires interposing relays with a 500ohm coil and it would be preferable if links from telecontrol could be made direct to the relay's inputs. (For specification of telecontrol interposing relay requirements please see detail in Appendix A). The practicalities of achieving this should be considered in the overall wiring scheme i.e. if it is necessary to use resistors on the inputs can this be done neatly and easily in an existing terminal block for the relay wiring.

In addition to these ancillary relay requirements in order to provide the 'remote'operation facility locally on the breaker it will be necessary to be able to utilise a time delay for closing of the circuit breaker.

In order to consider replacement of the standard trip relay the protection relay should be able to meet the requirements of EATS 48-4, class EB2 and also provide all the necessary auxiliary output contacts.

It is anticipated that the protective relay will be able to monitor standard circuit parameters e.g. amps and volts and that these will be readily available to the telecontrol system.

4.3 6.6/11kV Incomers

The transformer incomers have a larger protection requirement than the feeders and this was one of the reasons why fitting it to a separate panel was required. However, the modern relay functionality may enable sufficient functions to be combined such that the relays can once again be mounted on the switchgear.

A typical incomer will have directional overcurrent and earth fault protection, restricted earth fault, standby earth fault, intertripping, voltage control, and optionally neutral voltage displacement, voltage controlled overcurrent. In addition there will be transformer buchholz and winding temperature alarms and trips. It should be noted that the restricted earth fault scheme will be a high impedance type. The neutral voltage displacement scheme utilises condenser bushings on the 33kV side of the transformer, which are specified as standard on all UU transformers

The same philosophy as stated for feeders will apply for the incomers with regard to trip circuit supervision, trip relays, telecontrol interposing relays and auxiliary relays. If the protective relay can meet the required functionality then these ancillary functions can be combined within the relay.

4.4 33kV Circuits

The standard protection at 33kV incorporates a main and backup protection requirement. The main protection is usually unit protection or, in the case of overhead networks, distance protection. Back up protection is standard IDMT overcurrent and earth fault protection. Further options include balanced earth fault and single shot auto-reclosing. In addition at 33kV a full high impedance busbar protection will also be used.

The philosophy discussed for the 6.6/11kV circuits above is intended to be applied at 33kV but has yet to be applied within UU. The approach taken will use the same considerations as stated for 6.6/11kV and it will be considered acceptable for both main and backup protection to be provided within one relay.

4.5 Signalling Channels for Protection

Where the above sections discuss unit protection or intertripping there is a requirement for a signalling or communications link between the various ends of the protection equipment. Within Electricity North West it should be assumed that all these channels are standard copper pilot cables and the protection will need to be able to work either directly with them or through a suitable interface over the necessary distances. There are very few fibre optic links between substations at this moment and it must not be assumed that any are available.

4.6 Standalone Relay Panels and Diagrams

The current specification for relay panels, ES337, has not been modified to reflect any of the proposals within this specification. This is because it is anticipated that a site will either adopt the modern approach where this can be done satisfactorily or in a few cases, such as replacement of individual panels, there may be a need to utilise the standalone panel approach. This is particularly true of the 33kV system where the combined protection functionality has not yet been trialled at all and will need development work to be completed.

ES337 also lists all the diagrams for UU's standard protection panels. At the present time there are no updated diagrams for the combined protection functionality described in this specification. As soon as diagrams become available these will be listed in ES337 but the Tenderer should always consult UU to check the status of diagrams, as these may be available prior to the update of specifications.

5. COMMUNICATIONS REQUIREMENTS

5.1 Telecontrol Systems

The existing Electricity North West telecontrol system is 20 years old and utilises hard-wired interfaces to the switchgear and protection. Within the switchgear specifications there are requirements for specific interposing relays that are necessary to meet the requirements for telecontrol. There are also hard wired Watt and VAr transducers on the incomers, ring cts used for monitoring feeder amps, voltage transducers, etc. Where a new switchboard is to be installed utilising modern relays the functionality discussed above is required but it has to be remembered that the interface to the existing telecontrol must be met and this can rapidly use up I/O capacity on relays.

5.2 Future Telecontrol

The existing telecontrol system is in the process of being replaced but no outstations have yet been put onto the system. This will be a gradual changeover over the next few years with the program beginning in 2003. The new outstations to be installed at every Grid and Primary substation will utilise modern serial communications to IEC standards, IEC 870-5-101 for telecontrol communications upstream and IEC 870-5-103 for downstream communications to relays and other IEDs. With the installation of the new outstations there will be the opportunity to utilise the communications from modern relays and minimise the amount of small wiring required. The new telecontrol outstation will have modem facilities within it and the capability for engineers to access protection relays.

5.3 Protection Relay Communication Requirements

If Electricity North West specify the use of a new outstation then manufacturers will be expected to offer a scheme that makes full use of the communications available. It is expected that the relay will utilise a standard protocol, preference will be given to those utilising IEC 870-5-103. The substation will have a communications link between the telecontrol outstation and the relays, this shall be wire or fibre optic link in an appropriate configuration as offered by the manufacturer, preference will be given to those systems which offer greater resilience and flexibility in the substation environment.

Access to all relays via a laptop should be available at a common point in the substation, utilising standard communication cables/connectors i.e. not having to wire in the back of a panel. This access will also be available externally utilising either the modem in the telecontrol outstation or a separate modem directly connected to the relay communications. As well as access to all relays at a single point there will be access to each individual relay from a front access port to enable easy configuration, setting and interrogation of the device utilising standard readily available connectors/leads.

6. DOCUMENTS REFERENCED

6.1 ER S15 – Standard Schematic Diagrams

6.2 EATS 48-4 – DC Relays associated with a Tripping Function in Protection Systems

6.3 IEC 870–5–101 – Companion standard for basic telecontrol tasks

6.4 IEC 870–5–103 – Companion standard for the informative interface of protective equipment

6.5 ES337 – Specification for 19” Rack Control and Relay Panels for use in BSP and Primary Substations

6.6 ES314 – 12kV and 7.2kV 20kA Switchgear

7. KEYWORDS

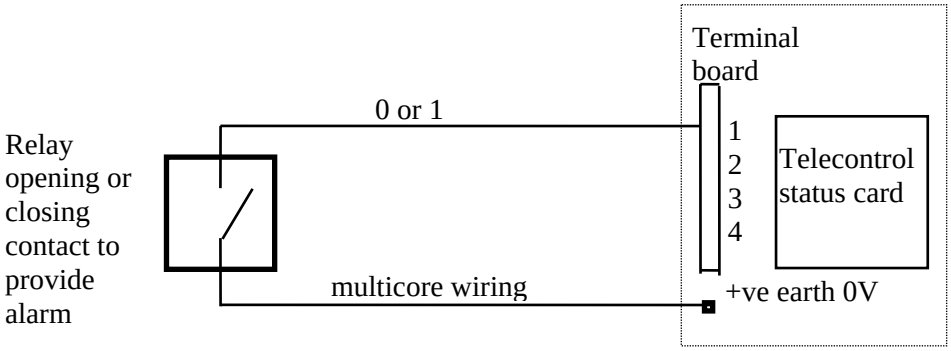
Protection, Panel

APPENDIX A

SPECIFICATION FOR HARDWARE INTERFACE REQUIREMENTS TO SCADA SYSTEM

A1. STATUS (ALARMS AND INDICATIONS)

An alarm condition or change of state needs a relay contact to open or close in order to initiate the Telecontrol system to generate an alarm. The Telecontrol will generate an alarm when an earth is connected or disconnected to the terminal connector as shown below.



Close represents a binary 1 and open represents a binary 0

A1.1 Specification for status inputs

Nominal Input Resistance	10k Ohms
Operating Voltage Range	42 - 58V
Max. non-damage supply	66V
Nominal Operating Voltage	50V
Max. Input Current @ 50V	5.2mA

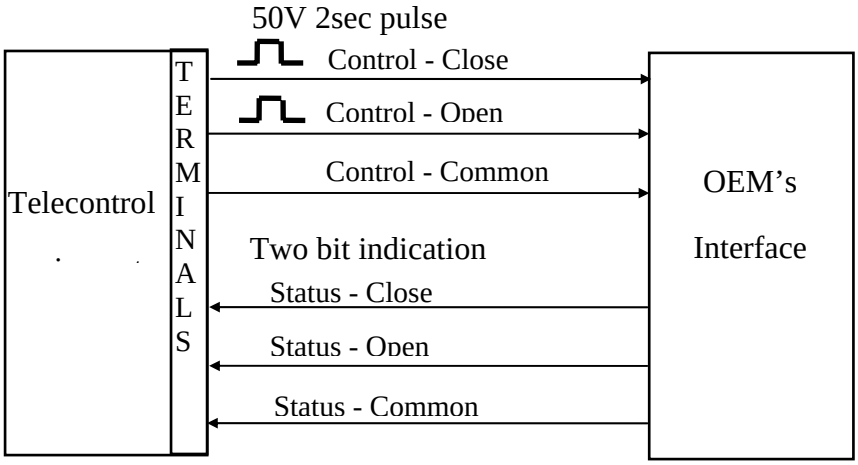
A2 CONTROL OUTPUT

On carrying out any control, whether it be open or close, the Telecontrol Outstation requires to detect a relay coil or equivalent of 500 Ohms. If successful the Telecontrol will generate a 2 second, 50 Volt actuate pulse to operate the relay. A separate multicore pair is used for the open and the close controls, although one leg can be commoned.

Status indications should be received back into the Telecontrol Outstation (as shown below) within a time period of upto 80 seconds and should consist of a two bit indication of transition from one state to the other, i.e. binary 01 or 10 depending upon whether the equipment is in an open or closed state. Both open and close status indications must show a transition , however if an indication is returned as 11 or 00 then an in transition alarm will occur which is an error condition.

A2.1 Specification for control outputs:

Output Voltage	50 Volts
Pulse duration	2 Seconds
Coil Impedance	500 Ohms



A2.2 Example of Carrying Out an Open Control

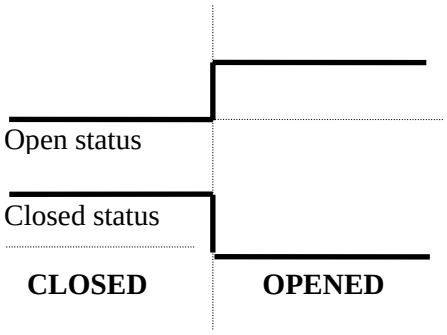
A two second 50V pulse would be sent to the OEM's equipment to initiate a control open.

This would open the switching device and return two status bits to the Telecontrol equipment within 80 seconds i.e. status open as a closed contact and the status dosed as an open contact.

These status indications would update the Telecontrol system indicating that the control was successful,

A2.3 Example To Indicate A Change Of State

If a Circuit Breaker is originally in the closed state and changes state to open in order to clear a fault condition, the status closed and status open indications would change from their original steady state to a new steady state as shown below



APPENDIX B

PROTECTION REQUIREMENTS

B1 6.6/11KV FEEDERS

IDMT Overcurrent and Earth Fault Relay

Trip Circuit Supervision, H7 Scheme

Busbar blocking scheme

Optional:

Auto-Reclose

Sensitive Earth Fault

Unit Protection

Directional overcurrent and earth fault

B2 6.6/11KV INCOMERS

Directional overcurrent and earth fault relay

Restricted Earth Fault

Standby Earth fault

Busbar blocking scheme

Intertripping (where pilots available)

Neutral Voltage Displacement (for overhead 33kV feeders)

Transformer voltage control

B3 33KV CIRCUITS

Unit protection

Distance protection (for overhead feeders)

IDMT overcurrent and earth fault

Busbar Protection (High impedance)

Optional:

Balanced earth fault

Auto-reclose

Directional overcurrent and earth fault

Intertripping