

National Grid
Commissioning
Handbook
Procedure 21

Management of Numerical Protection Schemes

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1 PURPOSE

The purpose of this procedure is to define a quality management process for the management of setting, testing and commissioning multifunction numerical protections. It defines the minimum level of controls to prevent the incorrect application of one of these devices.

This document is intended to supplement the relay settings process outlined in UKBP/TP107 Protection & Control Relay Settings and the commissioning process outlined in UKBP/TP106 Equipment Commissioning & Decommissioning. It is intended for use by National Grid and Contractor Commissioning and Settings Engineers respectively.

2 GENERAL OVERVIEW

Numerical or Multifunction protection relays can be configured or programmed to carry out a variety of functions in many different ways. This Commissioning Handbook details the procedural requirements to be employed to ensure that these relays are correctly applied and configured. The processes detailed cover the work primarily concerned with the project design and installation process, i.e. after type registration has been achieved. The management of numerical relays to be installed on the transmission system comprises four main stages:

- i. Type Registration.
- ii. Scheme design and relay configuration.
- iii. Factory Acceptance Tests (FAT).
- iv. Stage 1 Commissioning Tests

Details are also outlined for the management of in service relay settings changes initiated either by National Grid or a Contractor.

This procedure does not generally apply to Substation Control System database management, these are managed by the processes outlined in UKBP/TP127, Lifetime Management of Substation Control Systems. However if an SCS bay controller incorporates any protection tripping functions or control logic such as synchronising, DAR, auto close, interlocking etc. it must be managed using this handbook.

Each design stage is outlined below within this handbook. Management Control schedules are detailed in :-

Appendix 1 to control the configuration and application of settings to numerical relays.

Appendix 2 outlines National Grid's requirements for the testing to be carried out during FAT's to ensure the correct application of numerical relay configurations and settings.

Appendix 3 details the testing requirements prescribed for Type Registration, Factory Acceptance Tests, Stage 1 and Stage 2 commissioning tests.

This document summarises National Grid's minimum requirements for testing Numerical Protections during the construction process. Although the scope of this document does not include Type Registration these tests are included for completeness.

Appendix 4 defines the cross-checking required to confirm the correctness of the setting sheet prior to issue to site.

3 TYPE REGISTRATION

3.1 Process

Type Registration is the process National Grid uses to verify equipment is suitable for application on the Transmission System. Older equipment was registered as individual relays, newer equipment will be registered as Standard Bay Solutions (SBS). The latter comprise a number of individual relays, each configured to carry out specific functions within the Standard Bay Solution. It should be noted that the specific relay configuration is only applicable to a particular SBS, if it is to be used in another SBS or even as a standalone product it must be re registered for that

particular application.

The National Grid Type Registration process is described in fuller detail within UKBP/TP183, Guidance on Type Registration Procedure.

3.2 Documentation

When a Standard Bay Solution has been type registered the following documents relevant to the process described in this Commissioning Handbook form part of the suite of type registration deliverables:

- i. Standard Circuit Diagrams for that application.
- ii. A Settings Guidance Document including a Master Relay Setting Sheets for each relay. This should give details on calculating the settings and detail the fixed settings and the variable circuit specific power system settings. Further details are given in DH02, Guidance on the Preparation & Format of Relay Settings Guidance Documents.
- iii. Relay Configuration Files for each relay within a SBS.
- iv. The reference of the firmware installed on the relays subjected to type registration tests.
- v. Site Commissioning Test (SCT) schedule for the relays.
- vi. Generic Equipment Model (GEM) for each solution. This gives the SCS facilities required for each SBS.

The above are all produced during the Type Registration process and the parent copies are held and controlled by the contractor once Type Registration is achieved. During this process the National Grid Type Registration Engineer will verify this information as well as the test results carried out during testing to prove the relay configuration.

If Type Registration is not achieved the equipment cannot be accepted for service on the Electricity Transmission System unless a formal derogation has been received from the Asset Policy Manager.

4 SCHEME DESIGN & RELAY CONFIGURATION

4.1 Scheme Design

The engineering for a specific application is to be carried out as follows:

- i. Within the Design Intent Document (DID) the contractor will identify the Standard Bay Solution being used, the equipment within it and the protection functions used within each component box. Also included within the DID should be a Protection Keyline Diagram in line with DH11, Single Line and Keyline Diagrams.
- ii. Once the high level design has been agreed within the DID the contractor will commence the detailed engineering work. This will be carried out by starting with the type registered circuit diagrams for the SBS and customising them to meet a particular application and to interface with existing equipment. As part of this process they will consider the protection functions required as highlighted in the DID and produce the diagrams accordingly.

4.2 Unused Functionality

The National Grid Type Registered SBS is configured with all possible functionality that may be required. Typically in actual applications some of this functionality is not needed.

Protection functionality can be considered as any functionality which, when activated or operated results in the tripping or transfer tripping of one or more circuit breakers. Experience has demonstrated there is a requirement to, as far as practicable, render inoperative any unused protection functionality. There is also a requirement to minimise, as far as practicable, any deviations from the Type Registered Standard Bay Solution thus maintaining the full suite of functionality offered by the solution and eliminating the need to apply change control systems and associated negative tests.

Protection functionality can be considered as being one or a combination of, two classes either generic or customised. The generic class of protection functionality is standard within the relay's configuration menu whereas the customised class of protection functionality is custom built within the relay's programmable logic for a specific application. A typical example of the generic class of protection functionality is overcurrent protection within a differential protection relay and an example of a customised class of protection functionality is when the overcurrent is enabled through the initiation of a digital input(s) as in the case of stub protection. The preference is that all protection functionality whether generic, customised or a combination of both classes is provided with software switches to enable or disable the functionality as required. The status of the software switches should be recorded within the engineering documentation and the relay settings calculations. The relay setting sheets (MARS) state the functions in use in line with the requirements of UKBP/TP107. The software switch should be the sole means by which protection functionality is either enabled or disabled. **During checking of the setting sheets either at the FAT or at site if it is difficult to identify unused functionality from the relay display it may be necessary to interrogate the relay using a laptop running the appropriate software to confirm if the functionality is active or not.**

It is recognised that there are circumstances when a protection function is selected for a particular application but does not utilise all the inputs associated with it. An example could be a circuit breaker IED, within which Delayed Auto Reclose (DAR) has been selected, but because of the particular primary circuit arrangements there is no ferroresonance detection required for the particular application. In this case a software switch would be selected to enable DAR, the DAR initiation contacts would be connected but the ferroresonance detected input would remain unconnected downstream of the cubicle terminal

In these instances engineering records and drawings should be clear and unambiguous, with terms such as "Spare" or "Not Used" avoided. The drawings should record the relay's ferroresonance detected input as being connected to the cubicle terminal but with no field connection shown, thereby indicating the input is active within the configuration. Unused opto isolator inputs must remain unconnected to site wiring beyond the terminals in the relay panel or back boxes to avoid operation due to electromagnetic induction.

It is further recognised that there are instances where within certain protection functions there may be a requirement to maintain inputs in constant high (logic 1) or low (logic 0) state. An example of such an instance is a multiple node connections protection, with nodes unconnected, which necessitates a requirement to modify the topology by simulating switchgear open positions. This is achieved by connecting the supply positive directly to the switchgear open status digital input. In these instances, drawings should clearly show the connection together with a supporting explanatory note.

Relay outputs associated with disabled or unused functionality should remain configured within the relay logic in the SBS but must not be connected to the site wiring to avoid any inadvertent operation of external equipment. As with unused inputs, engineering records and drawings should be clear and unambiguous, with terms such as "Spare" or "Not Used" avoided. If the output is connected to the cubicle terminals the drawings should record the relay's output as being connected but with no field connection shown, thereby indicating the output is active within the configuration.

4.3 Relay Settings

The Contractor will calculate & determine the settings to be applied to the relay according to the settings guidance document produced at Type Registration. The requirements for the settings guidance document are shown in DH02, Guidance on the Preparation and Format of Setting Guidance Documents. These will be submitted to National Grid for review and comment as required by UKBP/TP107.

Where any functionality is unused, even though it is not connected, any settable values within that functionality must be set to maximum to minimise the risk of operation should the function be inadvertently connected or selected within the relay. Within the type registered file for the SBS (referred to as File 'X' in UKBP/TP107) the default value of any variable settings within the SBS should be set to maximum.

Appendix 4 defines the level of cross-checking to be carried out when preparing the relay settings sheet. Such cross-checking must be against the Type Registered suite of documentation and the circuit specific documentation. Where a SBS is undergoing type registration the Commissioning Officer, Settings Engineers and Type Registration Engineers must liaise to agree suitable settings for the circuit specific application.

4.4 Relay Configuration

National Grids aspiration is that the functionality within a SBS must not be changed from the type registered solution. However it is accepted on occasion minor changes may have to be made to a type registered SBS configuration to fit a specific application. Depending on the changes the SBS may have to undergo further type registration. Guidance on allowable changes are as follows:

The following changes may be made to a type registered solution, provided they are validated by National Grid Technical Assurance:

- i. Disabling of unused functionality (as described in section 4.2).
- ii. Changing of the sense of a contact initiating an input to an IED (where allowable by the configuration logic).
- iii. Adding any alarm (non – tripping) functionality.

All changes must be fully proven at a FAT.

The following changes cannot be made to a bay solution without reference to both a Technical Assurance and a Type Registration engineer for validation:

- i. The addition of any new functionality to an IED or SBS.
- ii. The modification of any tripping functionality or logic from the generic SBS solution.
- iii. The removal of any functionality (as opposed to switching it off) from an IED or SBS.
- iv. The changing of the hardware or firmware versions within any IED.

The type registration tests may need to be repeated to confirm the suitability of the SBS after these changes.

5 FACTORY ACCEPTANCE TEST (FAT)

It is a mandatory requirement that all Standard Bay Solutions and all numerical protections with configurable logic are subject to a Factory Acceptance Test. National Grid reserves the right for the Commissioning Officer to witness all or part of the FAT and only in exceptional circumstances will not do so. At the end of the FAT all documentation must be available for inspection and acceptance by the National Grid Commissioning Officer.

Appendix 2 outlines National Grid's detailed requirements for Factory Acceptance Testing.

5.1 Details of Factory Acceptance Test

Two types of FAT are generally carried out:

- i. A type registration FAT, which is carried out once to validate the SBS against National Grid Technical Specifications and Policies. This also includes reviewing any relevant type test documentation and the self certification evidence submitted to the National Grid type registration engineer.
- ii. A circuit specific FAT which is carried out to validate the circuit specific application against the type registered SBS. This includes proving the configuration by validating the differences between the circuit specific and type registered solution by file comparison, confirming the correct settings are applied and checking the tripping logic is correct for a particular application.

5.2 Documentation

The proposed FAT test schedules and procedure must be submitted to the Commissioning Officer 4 weeks prior to the commencement of the testing. In addition, the following agreed documentation must be available for inspection immediately prior to commencement of the FAT:

- i. Details of the comparison results between the type registered and the circuit specific IED configurations.
- ii. Design Intent Document (DID) for the circuit being tested.
- iii. Standard Application Circuit Diagrams for the SBS being tested.
- iv. Application specific Circuit Diagrams for the circuit being tested.
- v. Type Registered Configuration and relay firmware details of the SBS being tested.
- vi. Protection Setting Calculations and relay settings for the circuit being tested.
- vii. Factory Acceptance Test procedure and test schedules for the equipment being tested.

The actual circuit specific settings must be applied to the relay prior to the commencement of the FAT. It is not permissible to carry out a FAT with typical settings.

5.3 Multi – Function Relay Management Control Schedule

Prior to the commencement of the FAT a Multi-Function Relay Management Control Schedule should be prepared for each IED under test by the contractor. The contractor must use schedules as shown in **Appendix 1**.

This document details the type registration information, the details of the relay used during the FAT and the relay commissioned on site. National Grid's preference is for the FAT to be carried out on the actual equipment being commissioned, however it is recognised that the relay used for the FAT may not necessarily be the one that is commissioned on site so it is critical that these details are correctly recorded to provide an audit trail.

Where an SCS bay unit has logic such as interlocking, synchronising, DAR, ATCC or Auto Close which performs an automatic function it is expected that a Management Control Schedule will be completed for each bay unit.

One of these documents is required for each relay and they will accompany the relay to site and on completion of the Stage 1 Commissioning Tests should be filed with the SCT sheets in the Commissioning File to form part of the final commissioning records.

National Grid view this as a crucial part of the audit trail for the management of configurations for multi-function numerical protections.

5.4 Factory Acceptance Test Procedure

It is expected that each individual contractor will produce their own FAT procedure according to the requirements of the equipment being tested, their own internal Quality Procedures and organisation. National Grid expect these documents to be based upon the standard requirements below.

The FAT should comprise the following stages:

- i. A Confirmation check between the Type Registered SBS standard application and actual circuit diagrams for the circuit under test. This is to highlight any differences from the standard diagram.
- ii. A confirmation check between the type registered settings configuration file and the proposed configuration file should be carried out, using the configuration software to highlight any differences between the files. These differences should then be explained and documented. Emphasis should be placed on how the changes to the configuration have been controlled.
- iii. A range of tests should then be carried out to prove the design of the configuration meets the required functionality. Any differences between the SBS and the actual solution (which should be minor) should particularly be tested to confirm they meet the desired requirements and have not affected the functionality of the rest of the solution.