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**Construction
Design Handbook**

**GUIDANCE ON POLICY APPLICATION
&
SETTING OF SUPERGRID TRANSFORMER BACKUP PROTECTION**

DH 05

Issue 1

Authorised by:

Keith Hawker

Technical Assurance Manager

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GUIDANCE ON POLICY APPLICATION AND SETTING OF SUPERGRID TRANSFORMER BACKUP PROTECTION

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1. PURPOSE AND SCOPE

The purpose of this handbook is to provide guidance on setting of Supergrid Transformer backup protection settings at National Grid 400kV and 275kV Substations. The application and setting policy for protection of the most commonly occurring National Grid UK Electricity transmission arrangements is laid down in PS(T) 010. This design handbook provides guidance on setting calculation for protection arrangements as specified in PS(T) 010 and those either not covered under PS(T) 010, or where settings deferring from the policy need to be applied to ensure co-ordination of grading.

2. REFERENCES

The following documentation should be read in conjunction with this design handbook.

PS(T) 010 Issue 1 – Application and Setting of Protection

TGN(E) 184 Issue 2 – Technical Guidance Note Application and Setting of Protection

PS(T) 044 Issue 1– Backup Protection Grading Across National Grid Transco/Distribution Network Operator Interfaces

TGN(E) 203 Issue 1 – Backup Protection Grading Across National Grid Transco/Distribution Network Operator Interfaces

DH07 Design Handbook – Bus Section and Bus Coupler Overcurrent

3. RESPONSIBILITIES

National Grid Suppliers and Consultants undertaking setting calculation work are expected to follow the guidance given in this design handbook. The Setting Engineer (Supplier) and Setting Engineer (National Grid) as defined in TP107 are responsible for the calculation and correct application of appropriate relay settings to protect the power system.

It is recognised that this design handbook does not cover the backup protection setting guidance for all Supergrid installations/arrangements found on the National Grid's system, therefore, for transmission arrangements not covered in this document, the principles discussed may still be applicable in determining appropriate settings. For any Supergrid backup calculations that are not covered within this document, advice should be sought from the appropriate Settings Engineer (National Grid).

4. SETTING REQUIREMENTS FOR SUPERGRID TRANSFORMERS

The following sections offer guidance and examples for the settings of 400/275kV auto transformers, Supergrid/132kV auto transformers and Supergrid/66kV or lower double wound transformers.

4.1. SETTING REQUIREMENTS FOR 400/275kV AUTO TRANSFORMERS

This section gives guidance and application of the settings as per PS(T)010 section 2.4.1.

For guidance, the example chosen is a 400/275kV SGT rating of 750MVA & PPS X of 2.6% on 100MVA base. This example is used for each backup setting of the 400/275kV SGT as detailed in the following sections.

4.1.1. 400/275kV High Set Overcurrent/ HV 3 Phase Overcurrent

PS(T)010 gives an option of 3 Phase Overcurrent or HSOC. The HV 3 Phase Overcurrent option is not specified within the current policy/technical specifications and may only be found on some existing installations. As only a limited number of installations where this application is used, it is not covered in this handbook.

The purpose of the HSOC protection is to give high speed instantaneous protection to upper parts of the transformer HV winding and depending on CT location, protection for bushing faults. It must not operate for faults on the LV of the transformer.

PS(T)010 states that the HV HSOC is to operate for HV faults but not for LV faults. To achieve this the current setting :-
Shall not be less than 150% of the fault current fed to a 3 phase fault on the transformer LV terminals under maximum plant conditions.

And

Shall not be greater than 50% of the fault current fed to a Phase to Phase fault on the transformer HV bushing under minimum plant conditions.

Example.

(i) Calculation of Minimum current setting

Fault level data Winter Max Sub-transient 3 Phase fault level = 39.7kA

In feed via SGT = 2.4kA

Fault level available at Substation after subtracting SGT infeed = 37.3.kA

This relates to a source impedance of 0.39% on 100MVA

Total impedance from HV to LV = $0.39 + 2.6 = 2.99\%$

Fault MVA to LV terminals = 3344MVA.

From policy, setting must not be less than 150% of 3344MVA = 5016MVA.

NB. Use the fault level data Sub-transient figures as the HSOC will operate within the Sub-transient time.

(ii) Calculation of Maximum current setting

Fault level data Summer Min Sub-transient 3 Phase fault level = 35kA

In feed via SGT = 2.1kA

Fault level after subtracting SGT infeed = 32.9kA

3 Phase fault level at HV terminals = 22793MVA

Phase to Phase fault level to HV terminals = $22793 \times \sqrt{3}/2$ MVA = 19739MVA

Policy requires setting not to be greater than 50% of the Phase to Phase fault level available at the HV bushing, thus setting must not be greater than 9869MVA

From the above, the setting must be between 5016MVA – 9869MVA. The policy states that where a large range exists, the setting must be chosen to give the maximum sensitivity, thus choose next suitable setting above 5016MVA :-

5016MVA relates to 7240A at 400kV, 7400A is a suitable setting.

4.1.2. 2 Stage HV 3 Phase Overcurrent.

The purpose of this setting is to give backup protection to uncleared faults to circuits on the LV of the transformer – stage 1 and to give backup to the transformer protection to uncleared faults on the transformer – stage 2.

Stage 1

(i) Current setting – 200% of rated HV winding.

Thus in this example $2 \times 750\text{MVA} = 1500\text{MVA}$ setting.