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The Rating of Stabilising and Setting Resistors and Metrosils for High Impedance Differential Protection

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Authorised for Issue by:

Mike Dean
Asset Strategy Manager

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Registered Office
1 - 3 The Strand
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Administrative enquiries regarding this document should be directed to:

Asset Support at Coventry, Telephone: 024 7653 7777

Technical enquiries regarding this document should be directed to:

Contact name: Dr. Indy Sokhey / Alastair Auld
Asset Strategy
Telephone: 024 7653 7777

THE RATING OF STABILISING AND SETTING RESISTORS AND METROSILS FOR HIGH IMPEDANCE DIFFERENTIAL PROTECTION

FOREWORD

This Technical Guidance Note specifies a method of calculating the rating of stabilising and setting resistors for high impedance differential protection. Section 5 gives a procedure for the selection of resistors and metrosils based upon the use of the National Grid computer program, Metcalc. Section 6 gives a procedure for the selection of resistors where either metrosils are not required or access to the Metcalc programme is not available.

1 SCOPE

Stabilising and loading resistors used in high impedance circulating current protection schemes can be subjected to considerable stress during an internal fault due to the high voltages which can be developed by the current transformers. In many cases, metrosils will have to be fitted to prevent such voltages rising to dangerous levels. It is essential that this relay network equipment is adequately rated to ensure that it does not incur damage as this could either result in a failure of the protection to clear the present fault or impair its performance during future faults on the system.

This TGN sets out a procedure for ensuring that a resistor or metrosil has adequate continuous and short-time ratings for its particular application. Factors which affect a resistor's capability are continuous rating, the proportion of a tapped resistor in circuit, the knee-point voltage of the current transformers and the characteristic of the metrosil. Factors which affect the metrosil capability are the relay network resistance, the current flowing into this network and the metrosil continuous rating.

2 REFERENCES

TGN(T) 64 Instantaneous High-Impedance Protection

Transmission Plant Specification (Application) TPS 2.24.3, Protection Setting Policy for National Grid's Transmission System

National Grid Computer Programme, Metcalc, Version 1.0, Sep 2002.

3 DEFINITIONS

3.1 Protection

The provisions for detecting faults or other abnormal conditions in a power system, for enabling fault clearance, for terminating abnormal conditions, and for initiating signals or indications.

Notes:

- (i) The term "protection" is a generic term for protection equipment or protection systems.
- (ii) The term "protection" may be used to describe the protection of a complete power system or the protection of individual plant items in a power system e.g. transformer protection, line protection, generator protection.

3.2 Differential Protection

Protection in which the differential current equals the algebraic sum of the currents flowing into the protected zone.

3.3 High Impedance Differential Protection (IEC Publication 50, 448-14-22)

Current differential protection using a current differential relay whose impedance is high compared with the impedance of the secondary circuit of a saturated current transformer.

3.4 Relay Circuit

The relay circuit consists of the relay(s) together with all the externally mounted components, such as stabilising resistor and linear and non-linear shunt resistors.

3.5 Relay Circuit Current

The minimum value of the current which must flow through the overall relay circuit, including such components as are necessary to produce the desired overall characteristic, to enable the relay to operate.

3.6 Relay Setting Voltage

The minimum value of the voltage which must be applied to the overall relay circuit, including such components as are necessary to produce the desired overall characteristic, to enable the relay to operate.

3.7 Relay Operating Current

The minimum value of the current which must flow through the relay to enable it to operate.

3.8 Relay Operating Voltage

The minimum value of the voltage which must be applied to the relay to enable it to operate.

3.9 Relay Terminals

These are the terminals on the relay to which the internally mounted circuit components are connected. The circuit between these terminals thus excludes any externally mounted components such as series stabilising resistors and linear and non-linear shunt resistors which may be provided.

3.10 Metrosils

“Metrosils” is the trade name of one manufacturer – Micanite and Insulators – for its range of silicon carbide non-linear resistors. Other manufacturers exist and use their own names. However, for the purpose of this document, the term metrosil will be used, it being understood to mean a non-linear resistor of any manufacturer.

4 BASIC CONSIDERATIONS

In applying instantaneous high impedance differential protection, the following shall be taken into account:

- (i) the resistance of all wiring used for connecting the apparatus on site;
- (ii) the characteristics of the current transformers; particularly to ensure that they are of the low-reactance type;
- (iii) the impedance of the protected plant and its rated current;
- (iv) the method of earthing of the power system to which the plant is connected, and, if appropriate, the earthing of the plant, eg whether
 - (a) directly earthed,
 - (b) earthed through a resistor or reactor,
 - (c) earthed through an earthing transformer with or without a resistor or reactor,
 - (d) earthed through a distribution transformer;
- (v) the minimum fault current available within the protected zone;
- (vi) the maximum through fault current;
- (vii) the in-zone primary capacitance current;
- (viii) any high frequency transient currents;
- (ix) the continuous and short term thermal ratings of the components of the protection systems;
- (x) the maximum value of the peak voltages in the secondary circuits during internal fault conditions.

4.1 Resistor Application

Resistors used for this application are wire wound on a tubular ceramic former with or without a vitreous enamelled coating. They should preferably not be tapped and should never be of the continuously variable via slider type and must have a minimum wire size of 43swg.

Continuous rating requirements are dependant upon the type of scheme in which the resistors are being applied. For busbar protection schemes (i.e. two out of two schemes), the resistor must be rated to withstand the voltage developed across the network when it is subject to the continuous current of the switchgear. For other types of schemes, e.g. auto-transformer overall protection (ie one out of one), the continuous rating should not be less than the power dissipated in the resistor when setting voltage is applied to the relay network.

The short-time rating of the resistor should accommodate the voltage developed across the resistor network when an internal fault takes place for a time of 1.0 seconds. (In the past, a 0.5 second rating was considered appropriate, but to meet the requirements of NGTS 1, the higher 1 second rating requirement must now be met).

Rating data for resistors commonly in use in National Grid substations is given in Appendix A.

4.2 Metrosils

Metrosils are manufactured from a mixture of silicon carbide, carbon and a ceramic bonding agent. The mixture is pressed into discs (usually annular) and fired at high temperature. Finally, suitable provision for electrical connections is made.

Metrosils are usually of either 3 inches or 6 inches diameter, and arranged singly or in groups of 3 or 6 (the latter being three parallel pairs).

The continuous rating of a metrosil is a function of its surface area and its short-time rating is a function of its mass and specific heat.

The continuous rating of a 6 inch diameter disc is 20W and that of a 3 inch disc is about 10W. The short-time rating for a metrosil is derived from the formula

$E = m \times s \times \theta$; where

m is the mass in grams
s is the specific heat
 θ is the temperature rise.

With a maximum withstand temperature of 120 degrees C and a specific heat capacity of 0.84, the required short-time (1.0 second) rating is given by

$P = 84 \times m$ Watts.

Rating data for metrosils commonly in use in National Grid substations is given in Appendix A.