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FUNCTIONAL TEST REQUIREMENTS – LOSS OF MAINS RELAYS

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ENA PROTECTION ASSESSMENT – FUNCTIONAL TEST REQUIREMENTS – LOSS OF MAINS RELAYS

FOREWORD

The Energy Networks Association (ENA) has prepared this ENA Technical Specification (TS) 48-6-8 document to cover the functional test requirements for loss of mains relays as defined in the scope. The ENA Protection Assessment Panel use this specification as part of the Phase 2 Assessment Process, where applicable.

Loss of mains protection equipment covered by this Technical Specification shall conform to the latest issues of the relevant International and British Standards listed. This document is intended to amplify and/or clarify the requirements of those Standards, where alternative arrangements are permitted by those Standards and further information is required.

SCOPE

This document details the Energy Networks Association Protection Assessment Panel (PAP) normal functional test requirements for loss of mains relays. It also details the information to be provided to the assessment team by the Manufacturer. It applies to protection equipment intended for use within the UK Electricity Supply Industry, however, individual ENA member Company Specifications will, where appropriate, contain additional requirements to this document.

REFERENCES

The Regulations made under the Health and Safety at Work Act 1974 and the Electricity Act 1989 impose specific duties on the installers and operators of switchgear. These duties apply irrespective of the origin of the equipment. Manufacturers should take account of these requirements in the design of their equipment. Relevant regulations include:

The Electricity at Work Regulations 1989

The Provision and Use of Work Equipment Regulations 1998

The Manual Handling Operations Regulations 1992

The Confined Spaces Regulations 1997

The Construction Design and Management Regulations 1994

The Electricity Safety, Quality and Continuity Regulations 2002

Prior to the functional testing required by this document the manufacturer is required to submit an environmental test statement to the ENA, and these tests shall conform to the following document;

IEC 60255-3 Electrical Relays – Single input energizing quantity measuring relays with dependent or independent time.

IEC 60255-6 Electrical Relays - Measuring relays and protection equipment

IEC 60255-12 Electrical Relays - Directional relays and power relays with two input energizing quantities.

ENA TS 48-4 DC relays associated with a tripping functions in protection systems

ENA TS 48-5 Environmental test requirements for protection relays & systems

1. INFORMATION SUBMITTED FOR ASSESSMENT

To enable the assessment team to become familiar with the equipment under assessment the following information shall be provided by the manufacturer:

1.1. Equipment references (ordering details etc);

1.2. Hardware/firmware version;

1.3. Software version (including software upgrade record);

1.4. Types of protection function (for example Rate of Change of Frequency, Vector Shift, etc);

1.5. Setting ranges of various protection functions;

1.6. Blocking features;

1.7. Operating characteristics of various protection functions

1.8. Operating principles

1.9. Performance specifications (operating times, accuracy, sensitivity, immunity to offset transients, etc);

1.10. Current Transformer requirements (CT class, knee point, burden, core balance)

1.11. Voltage Transformer requirements

1.12. Application guidance (including application diagrams);

1.13. Setting recommendations.

1.14. Recommendations on installation, commissioning and maintenance;

1.15. Customer reference list.

2. TEST REQUIREMENTS

Functional tests listed below are designed to show compliance with manufacturers' claimed operating characteristics and performance specifications and to demonstrate correct performance during different fault scenarios. Based upon the information contained in this document the manufacturer shall submit a Test Plan to the assessment team for approval. This shall detail the tests to be carried out on the equipment and the test result when completed. The number of tests included in the Test Plan may vary but as a minimum it shall include the following steady state and dynamic tests.

2.1. Steady State Tests

2.1.1. Demonstrate the operating characteristics

The following protection elements where present must be tested against claimed operating time accuracy, pick-up setting accuracy and drop-off accuracy and be within the limits specified below:

Under Voltage Settings:

- Relay pick up voltage = setting voltage ± 1%.
- Relay reset voltage must be 105% of the voltage setting.
- Relay operating time = time Setting ± 2.5% or ± 100mS, whichever has the greater magnitude, at a voltages ≤ 0.9 x setting voltage.

Over Voltage Settings:

- Relay pick up voltage = setting voltage ± 1%.
- Relay reset voltage must be 95% voltage setting.
- Relay operating time = time setting ± 2.5% or ± 100mS, whichever has the greater magnitude, at voltages ≥ 1.1 x setting voltage.

Under Frequency Settings:

- Relay operating frequency = setting frequency ± 0.1Hz.
- Relay reset frequency must 101% of the frequency setting.
- Relay operating time = time setting ± 2.5% or ± 100mS, whichever has the greater magnitude, at voltages ≤ 0.9 x setting frequency.

Over Frequency Settings:

- Relay operating frequency = setting frequency ± 0.1Hz
- Relay reset frequency must be 99% of the frequency setting.
- Relay operating time = time setting ± 2.5% or ± 100mS, whichever has the greater magnitude, at voltages ≥ 1.1 x setting frequency.

Vector Shift Settings:

- Relay operating threshold = setting value ± 1 degree.
- Relay operating time ≤ 200mS for a vector shift values ≥1.2 x setting value.

Rate of Change of Frequency Settings:

- Relay operating threshold = setting value ± 10mHz/s.
- Relay operating time ≤ 200mS for a rate of change of frequency values ≥1.2 x setting value.

2.1.2. Demonstrate correct performance during on-line data exchange

Tests to show protection elements operating with no increase in operating time when data exchange is taking place during communications with the relay. Retrieval of the relay setting/configuration and fault record with overcurrent and earth fault change tests applied.

Tests to show protection elements operating with no increase in operating time when setting change is taking place during communications with the relay. Relay setting change coinciding with a primary system fault condition.

2.1.3. Demonstrate the accuracy of protection elements

- All protection functions refer to ENATS 48-6-6 where necessary
- Timers
- Blocking logic
- Various PU/DO ratio values

2.1.4. Demonstrate correct operation for the interfaces

- Internal logic configurations required to achieve protection functions
- Input/Output performance during scheme and logic tests
- Fault indications, disturbance and event recording
- All self monitoring functions and supervision alarms
- HMI operation
- Switching of setting groups.

3. PROCEDURE FOR TESTING LOSS OF MAINS (LOM) RELAY PERFORMANCE

3.1. Introduction

The following section describes the testing procedure for LOM relays that can be applied to test the performance of any LOM relay. This includes both sensitivity and stability tests with an indication of when a relay should trip for a LOM event and when it should be expected to ride-through external faults or disturbances. Note that this is not limited to relays with ROCOF functionality; any LOM relay can be tested, in terms of its sensitivity and stability, using the recommended methods and the supplied COMTRADE files.

The transient responses displayed by different non-synchronous machine-based generation technologies are very diverse. Therefore, the described performance benchmarks and supplied COMTRADE files relate only to synchronous machine-based generation connected to both 33kV (30MVA generation) and 11kV (3MVA generation) networks. The LOM protection of networks containing synchronous machines appears to be the most challenging; accordingly, if a relay can “pass” these tests as outlined in this section, then it should be capable of protecting other types of generating technology.

The reason for providing this fixed set of LOM testing scenarios is to provide a benchmark for what the minimum performance should be in order to achieve an acceptable compromise between sensitivity and stability.

3.2. COMTRADE files

A set of COMTRADE files has been has generated from test scenarios (simulations) details of the data used within the simulations are provided in Appendix 2, a new set of COMTRADE files must be generated if the testing scenarios deviate in any way from those already established and used in this document.

The COMTRADE test files follow a simple naming format that can be used to identify their contents. Each file name contains several fields that may indicate the system voltage, generator technology, percentage of imbalance between local load and generation output, nature of power flow, fault type and the percentage of retained voltage across the generator terminals. For sensitivity test files the format is as follows:

X_Y_Z_P

where:

- **X** is the system voltage (11kV or 33kV).
- **Y** is the generator technology (synchronous machine in this case).
- **Z** is the percentage of power imbalance including the direction of power flow.
- **P** is the nature of power imbalance (active or reactive). Not used for 0% imbalance.

In a similar manner, stability test files have the following format:

X_Y_Z_V

where:

- **X** is the system voltage (11kV or 33kV).
- **Y** is the generator technology (synchronous machine in this case).
- **Z** is the type of fault introduced to the network (single, two or three phase).
- **V** is the percentage of retained voltage across the generator terminals.

In the COMTRADE files, the voltage signals are referred to as V1, V2, and V3 for red, yellow and blue phases respectively. The full list of all COMTRADE file names is included in Appendix 1.

3.3. Sensitivity tests

The data generated for this type of test involved recording the voltage at the generator terminals (i.e. at 33kV or 11kV) throughout the test. The test data contains a period (of at least one second) of normal operation prior to islanding. This gives enough time for the LOM algorithm to stabilise which maintains consistency of the obtained results and avoids invalid relay responses.

The LOM event is represented by the opening of a circuit breaker which defines the point of common coupling (PCC) between the local and main grids. Again, the LOM event follows a period of network stability where no faults occur just before LOM. This allows for a worst case scenario when testing the relays. The duration of the LOM event lasts to the end of the simulation.

Several COMTRADE files contain scenarios where a power flow imbalance between the local generation and local load is created prior to LOM in order to test the relays' sensitivity. The generators output prior to LOM is constant at 90% of generator rating for all sensitivity tests. The circuit breaker at the PCC is the where power flow imbalances are measured.

Both active and reactive power flow imbalances have been included in the COMTRADE files and are summarised below:

- Active balance at reactive imbalance at +/- (2.5%, 5% and 10%) of generator rating.
- Reactive balance at reactive imbalance at +/- (2.5, 5% and 10%) of generator rating.
- Active and reactive balance (0% power flow through the PCC).

For the purposes of determining the suitability of a relay under test in terms of its sensitivity to true LOM events, it is required that the LOM relay must be sensitive (i.e. trip) for +/- 10% active and reactive imbalances. The relay is not expected to trip at lower imbalance levels, however, if it does then this is obviously beneficial. However, the results of the sensitivity tests must be analysed in conjunction with the stability tests detailed later in this section when assessing whether a relay is suitable for LOM application.