Electricity Distribution

nationalgrid

Company Directive

STANDARD TECHNIQUE: TP1B/1

Loss of Mains Intertripping for EREC G99 and G59 Compliance

Summary

This directive contains requirements for intertripping schemes that are used to meet the requirements of Engineering Recommendations G99 and G59 for loss of mains protection.

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Implementation Date: **September 2023**

Approved by

Carl Ketley-Lowe
Engineering Policy Manager

Date: **21st September 2023**

Target Staff Group	**Staff responsible for the design, recording, commissioning, maintenance and sufficiency assessment of Loss-of-Mains intertripping schemes.**
Impact of Change	**Amber – the changes affect the design and maintenance of National Grid Electricity Distribution' s networks**
Planned Assurance checks	**Author to review ongoing and issued design work for a selection of schemes 6 months after issue.**

IMPLEMENTATION PLAN

Introduction

This directive contains requirements for intertripping schemes that are used to meet the requirements of Engineering Recommendations G99 and G59 for loss of mains protection.

Main Changes

The following changes have been made:

- Clarification has been provided regarding the applicability of loss of mains intertripping.
- Failure mitigation requirements have been relaxed somewhat

Impact of Changes

Target Staff Group	**Staff responsible for the design, recording, commissioning, maintenance and sufficiency assessment of Loss-of-Mains intertripping schemes.**
Impact of Change	**Amber – the changes affect the design and maintenance of National Grid Electricity Distribution' s networks**

Implementation Actions

Managers responsible for members of the Target Staff Group shall ensure that their staff are aware of and comply with the requirements of this new directive.

A briefing presentation is available <here>

A Webinar Session will be conducted by Engineering Policy shortly after implementation of this policy document

Implementation Timetable

Design requirements shall be applied to new schemes from the date of issue. Where design work for a scheme has already begun, the requirements shall be applied in so far as is reasonably practicable. All other requirements are implemented on issue.

REVISION HISTORY

DOCUMENT REVISION & REVIEW TABLE			
Issue	**Date**	**Comments**	**Author**
1	19/09/2023	• Document has been re-formatted • Section 1.0 - Clarification has been provided regarding the applicability of loss of mains intertripping. Power Generating Facilities with a registered capacity of <50MW will normally utilise RoCoF protection (or equivalent) rather than loss of mains intertripping. • Section 1.2 - Flowchart inserted into document • Section 2.0 - New definitions have been included • Clause 5.6 - Failure mitigation requirements have been modified. • Clause 5.7 – Further guidance on duplicating either the hardware or the communication systems for both conventional intertripping and that of loss of mains intertripping.	Daniel Price
0	01/09/2022	• First issue	Steve Quinn

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1.0 INTRODUCTION

1.1 G99 Requirements

EREC G99 normally requires Loss of Mains (LoM) protection for Power Generating Modules operating in long-term parallel mode.

LoM protection is used to detect the loss of incoming supply to generation from the wider network. It disconnects the generation from the distribution network to prevent a network island from forming. This ensures that:

- ESQCR requirements for neutral earthing of distribution networks are met;
- ESQCR requirements for voltage and frequency of supplies to customers are met;
- Circuit breakers are not subjected to out-of-synchronism closure, which could damage the DNO's equipment or the generator's equipment; and
- ESQCR requirements for fault clearance are met where these will not be met by other protection.

EREC G99 prohibits the use of RoCoF protection at power generating facilities (PGFs) with a Registered Capacity exceeding 50MW. It also expects, but does not mandate, LoM intertripping for Type D Power Generating Modules (PGMs) and PGFs with a Registered Capacity below 50MW.

1.2 NGED Approach

In practice, particularly within interconnected networks or networks that can be operated/configured in several different ways, LoM intertripping may be extremely complex and/or expensive to implement. This is recognised in clause 10.4.13 of EREC G99 which states:

For a radial or simple Distribution Network controlled by circuit breakers that would clearly disconnect the entire circuit and associated Power Generating Module for a LoM event an intertripping scheme can be easy to design and install. For meshed or ring Distribution Networks, it can be difficult to define which circuit breakers need to be incorporated in an intertripping scheme to detect a LoM event and the inherent risks associated with a complex system should be considered alongside those associated with a simple, but potentially less discriminatory LoM relay.

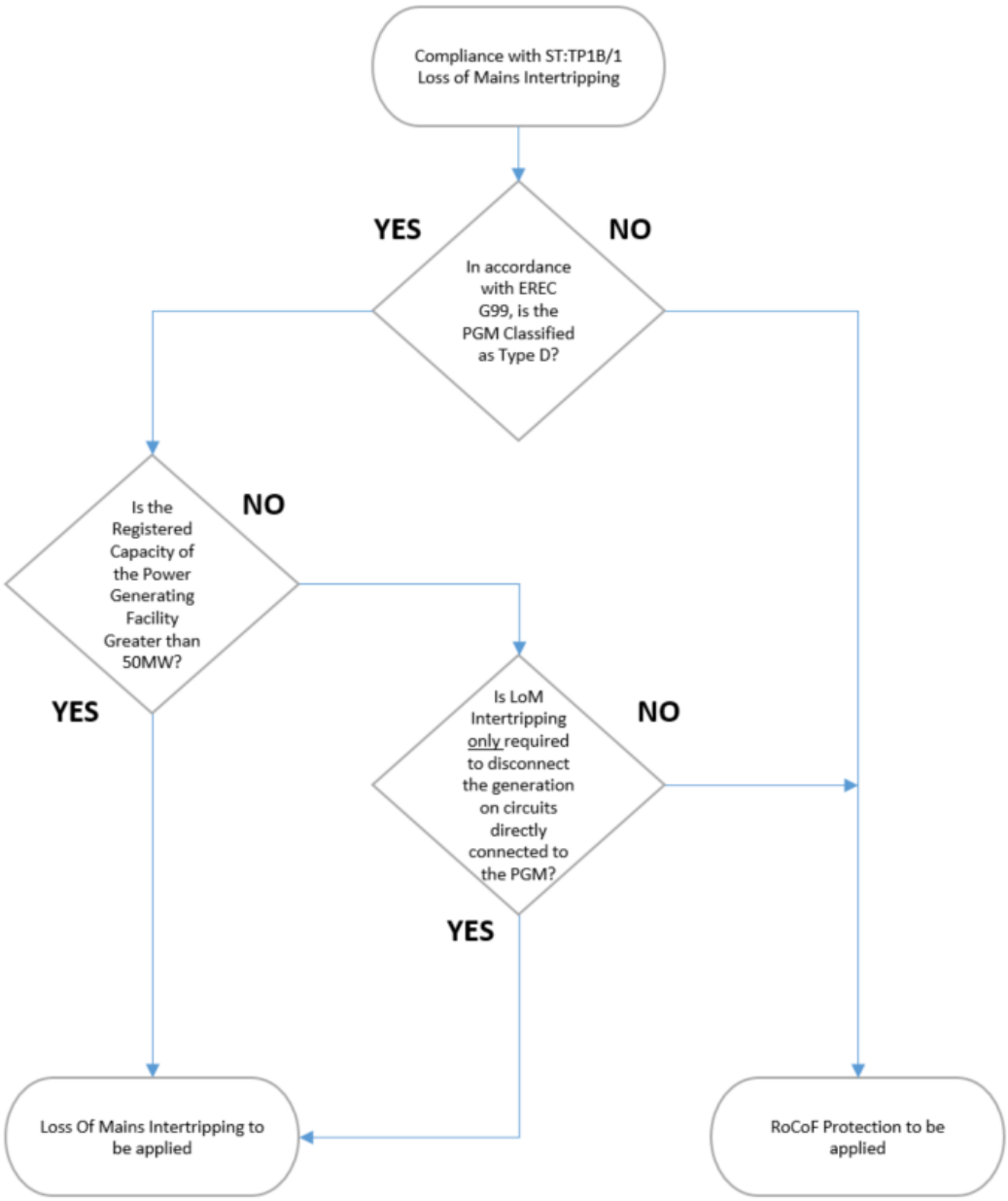
For this reason NGED requires power generating facilities with a registered capacity below 50MW to utilise RoCoF or an alternative passive or active LoM protection rather than LoM intertripping unless LoM Intertripping is relatively simple to install and maintain. In practice this means where Network islanding can be prevented by simply installing LoM intertripping at the circuit(s) directly connected to the <50MW Power Generating Facility then this method should be used in preference to RoCoF etc.

A typical example of a relatively simple LoM intertripping application is where a <50MW Power Generating Facility is teed into an existing 132kV Transformer Feeder and simply tripping/intertripping the Generator's G99 circuit breaker when 132kV source (Transformer Feeder) circuit breaker has tripped will prevent the risk of Islanding on the Network.

At power generating facilities with a registered capacity of 50MW or above RoCoF shall not be installed and LoM intertripping complying with the requirements of this document shall be used instead.

LoM intertripping detects credible fault outages on the DNO or upstream network that could result in an island forming by monitoring of switchgear statuses and/or protection trip signals. In the event of such an outage, a signal is sent to the Power Generating Facility, causing generator circuit breaker(s) to open to disconnect the Power Generating Module(s) from the distribution network.

Figure 1 Process Map



2.0 DEFINITIONS

Name/Phase	Definition
Generating Unit	Any apparatus that produces electricity. This includes micro-generators and controllable electricity storage devices. *Definition derived from EREC G99. See EREC G99 for full definition.*
Power Generating Facility (PGF)	A facility that converts primary energy into electrical energy and which consists of one or more Power Generating Modules connected to a network at one or more connection points. *Definition taken from EREC G99.*
Power Generating Module (PGM)	Either a Synchronous Power Generating Module or a Power Park Module. *Definition taken from EREC G99*
Power Park Module (PPM)	A Generating Unit or ensemble of Generating Units generating electricity, which is either asynchronously connected to the network or connected through power electronics, and that may be connected through a transformer and that has a single connection point to the distribution network. *Definition derived from EREC G99. See EEC G99 for full definition.*
Radial Feed	A system whereby the connection between the source circuit breaker and that of the feeder or customer circuit breaker is of a single connection point with no alternative current paths
Secured Outage	An outage or combination of outages after which Customer Security, Network Integrity and System Frequency Integrity requirements must be satisfied in design studies. *Further guidance on this definition is provided in POL: SD11.*
Selection Control	A scheme input which can, as part of a switching schedule, be selected to one of two positions to modifying the scheme behaviour. A typical Selection Control will mimic the statuses of disconnectors in a bay, and be selectable between: • Normal, indicating that all series disconnectors and (where present) at least one busbar selector disconnector are closed; and • Outage, indicating that one or more disconnectors has been opened to render the bay open-circuit.

Name/Phase	Definition
System Frequency Integrity	The ability of the GB system to operate within acceptable frequency-related technical limits under both Intact Network and outage conditions. System Frequency Integrity is primarily managed by NGESO, but it can be affected by the operation of NGED's network and customers. This includes but is not limited to: • Low Frequency Demand Disconnection • Interface Protection associated with Power Generating Modules • Changes in net Load caused by protection operation, manual intervention or the operation of Load Management Schemes. *Definition taken from POL: SD11*
Synchronous Power Generating Module	An indivisible set of Generating Units which can generate electrical energy such that the frequency of the generated voltage, the generator speed and the frequency of the network voltage are in a constant ratio and thus in synchronism. *Definition derived from EREC G99. See EREC G99 for full definition.*
Total System	The integrated system of connected Power Generating Modules, Transmission System, Distribution Networks and associated electrical demand. *Definition taken from EREC G99*
Type D	A Power Generating Module with a connection point at or above 110kV and/or with a Registered Capacity of 50MW or greater. *Definition taken from EREC G99. See EREC G99 for definition of Registered Capacity.*

3.0 SCOPE

This directive applies to LoM intertripping schemes required for compliance with ER G59 and G99.

Although providing LoM protection is the responsibility of the generator, where LoM intertripping is required the intertripping scheme shall be designed and owned by NGED. Where a Power Generating Module requiring LoM intertripping is connected to the network of an Other Authorised Distributor (as defined in the Distribution Code) that is in turn connected to NGED's network, the parts of the intertripping scheme relating to NGED's network shall be designed and owned by NGED. The customer or OAD, as applicable, is responsible for ensuring that the generation is disconnected when LoM intertripping operates. The customer or OAD shall utilise an intertripping system that meets the requirements of NGEDs protection standards

The generator's Interface Protection device(s) (for Under Voltage, Over Voltage, Under Frequency, Over Frequency and, where provided, non-intertripping Loss of Mains protection) are outside of the scope of this directive.

Where any difficulty is encountered with the application of this policy, the author shall be notified, who will consider if a variation is appropriate.

4.0 SCHEME BEHAVIOUR

LoM intertripping schemes shall be designed to disconnect the Power Generating Module(s) from NGED's network for Secured Outages that would result in loss of synchronising path from the Total System to the Power Generating Module(s).

Note: A boundary across which three or more independent circuits operate in parallel will not typically have Secured Outages which result in the loss of synchronising path across the boundary, but due account should be taken of factors including:

- *The disposition of circuits onto busbars;*
- *Split running to mitigate constraints such as fault level; and*
- *The behaviour of load management schemes.*

The scheme may omit arranged outages for which the Power Generating Module(s) are disconnected from NGED's network before the outage is taken.

The scheme design shall, in so far as is reasonably practicable, take account of credible future changes in running arrangements.

The designer of the scheme behaviour shall document the necessary inputs and combinatorial logic in an unambiguous format (e.g. logic diagram, logic equation or logic table) for use by the designer of the scheme configuration.

The Electricity System Operator (ESO) may wish to trigger NGED's LoM intertripping for circumstances arising on NGETs network. Any such requirements shall be agreed within the bilateral agreement between ESO and NGED.

4.1 Sufficiency Assessment

The sufficiency of the scheme shall be proved by calculating its behaviour for each pertinent Secured Outage to confirm that either:

- The Power Generating Module(s) retain a synchronising path to the Total System;
- The Power Generating Module(s) are disconnected from NGED's network in response to a switching instruction before the outage is taken; or
- The scheme identifies the loss of the synchronising path to the Total System and disconnects the Power Generating Module(s) from NGED's network.

The impact of switching instructions and Load Management Schemes shall be taken into account when determining the network topology for each Secured Outage.

If a load-flow program is used to assist in sufficiency assessment, the user shall determine whether the program includes functionality that automatically disconnects islanded generation. If it does, the user shall take steps to ensure that it is the LoM intertripping scheme rather than the load-flow program functionality that disconnects islanded generation in simulations. If in doubt, a network modelling and analysis specialist should be consulted.

Note: Siemens PSSE's TREE routine disconnects all buses and branches that do not have an in-service path to at least one Type 3 (swing/slack) bus. This routine is run automatically for each outage in PSSE's contingency analysis routines. It will disconnect islanded generation regardless of the presence (or absence) of a LoM intertripping scheme.

5.0 SCHEME CONFIGURATION

5.1 Inputs

The scheme may be triggered by one or more of:

- Circuit breaker secondary contacts
- Disconnector secondary contacts
- Protection trip signals
- Signals from associated LoM intertripping schemes on upstream transmission or distribution networks

Where protection trip signals are used, the designer shall ensure that all protection schemes that can trip a circuit breaker (e.g. backup protection and busbar protection) are considered in addition to circuit main protection.

Where the status of a manually operated (whether local, remote or supervisory) disconnector is required, Selection Controls may be used in lieu of disconnector secondary contacts. These Selection Controls shall be made available as both:

- Supervisory controls with status indication on the Network Management System; and
- Local push buttons with status indicator lamps on site.

Note: the use of Selection Controls can reduce the design and commissioning complexity of a scheme, at the expense of increased operational complexity. Where their use is proposed, the Control Centre should be consulted on their operational implications.

5.2 Communications Links

Each communications link shall either:

- Meet at least Category 3 of POL:TP20; or
- Be a NGED-owned metallic pilot pair.

Regardless of the type of communications link used:

- Intertripping relays shall be approved in EE SPEC: 98 for function IT and incorporate pilot supervision; and

- The requirements of POL: TP20 for separation and segregation of communications links shall be achieved if reasonably practicable.

This does not preclude the use of SCADA facilities for supervisory operation of Selection Control.

5.3 Combinatorial Logic

Combinatorial logic may be implemented using one or more of:

- Series and parallel connection of input contacts;

- Auxiliary relays approved in EE SPEC: 136; and

- Numerical relays approved in EE SPEC: 98 with appropriate programmable logic elements. A numerical relay may be used for both combinatorial logic and intertripping. Where existing approved relays are not suitable, alternative devices may be submitted to Engineering Policy for evaluation in accordance with POL: TP25.

Combinatorial logic may be distributed across the sites at which inputs and outputs are located. Logic elements should be local to their inputs where reasonably practicable, to minimise the number of intertripping channels required and to facilitate testing. Initially apply curtailment using the highest sensitivity factors with the lowest pre-event limits.

5.4 Outputs

The scheme shall trip one or more generator-owned circuit breakers to fully disconnect all Power Generating Modules from the distribution network. It shall operate without deliberate time delay, and at least 500ms before any auto-reclose or auto-close scheme could reconnect the Power Generating Module(s) to the wider network for Secured Outage Conditions.

The trip output from the scheme shall be presented to the customer as a normally-open volt-free contact marked LoM Intertrip at the interface substation. Outputs shall be presented to the customer in the Connection Control Interface Panel.

The LoM Intertrip contact shall remain closed until a synchronising path has been re-established between the interface substation and the Total System. The Power Generating Module(s) shall not be reconnected to the distribution network until after the LoM Intertrip contact has opened.

The trip output from the scheme shall be enunciated in the Control Centre as an unambiguously described high-priority alarm that unambiguously indicates that a Loss of Mains intertripping scheme has operated.

5.5 Test Facilities

The scheme shall incorporate sufficient facilities (e.g. test blocks, links, switches and buttons) to facilitate the commissioning test requirements in clause 7.1 and maintenance test requirements in clause 8.1.

Note: LoM intertripping is typically requires inputs from multiple interdependent circuits. Since it would not be reasonably practicable to take simultaneous outages of all circuits for testing, it will typically be necessary to test the scheme as a series of overlapping subassemblies.

5.6 Failure Mitigation

Detectable LoM intertripping scheme failures (including but not limited to communications failure alarms, relay/controller watchdog alarms and battery system alarms) shall be enunciated in the Control Centre as an unambiguously described high priority alarm.

In addition, a second normally-open volt-free contact marked LoM Scheme Failure Alarm shall be presented to the customer at the interface substation to indicate detectable scheme failure.

In the event of a detectable scheme failure, so long as all of the following criteria are met, the customer may choose whether or not to disconnect:

- There are no secured outage conditions that would leave the network energised without an earthed neutral
- Neutral voltage displacement protection is fitted at the connection voltage where the customer's power generating facility is connected to NGED's network at:
    - at 66kV or 33kV, or
    - at 11kV or 6.6kV where the export capacity is 500kW or higher
- All auto-reclose and auto-close schemes that could reconnect Power Generating Module(s) to the wider network for secure outage conditions are configured to prevent reclosing against an out-of-sync network.

In all other cases the customer shall immediately disconnect their generation when they receive the LoM Scheme Failure Alarm.

Note, where the customer is allowed to choose whether to disconnect their generation or not on receipt of a LoM Scheme Failure Alarm, the conditions that can cause this contact to close shall be explained to the customer to assist their risk assessment.

5.6.1 System Frequency Integrity

The aggregate export capacity of all Power Generating Modules connected to a LoM intertripping scheme or to multiple schemes that share components shall not exceed the System Frequency Integrity limits in POL:SD2, POL:SD3 and POL:SD4.

5.7 Labelling and integration with other schemes

Scheme panels and devices shall be clearly labelled with the name and purpose of the scheme. To avoid confusion with other forms of intertripping, the term Loss of Mains Intertrip shall be used on labels. Wiring shall be ferruled in accordance with ENA TS 50-19.

Where a Power Generating Facility requires both a LoM intertrip in accordance with this directive and an operational intertrip in accordance with ST: SD11A, both may be integrated as a single scheme meeting the requirements of both directives.

In some cases, conventional protection intertripping may satisfy the requirements/functionality for LoM Intertripping. Where this is the case, the same hardware and intertripping communication channel may be used for both functions. Where the requirements/functionality for the protection intertripping and LoM intertripping differ then a separate communication channel shall be used. These communication channels may share the same communication bearer. Refer to POL: TP20 for further guidance.

LoM intertripping schemes for multiple Power Generating Facilities may share components.

6.0 SCHEME RECORDS

Schemes shall be recorded in accordance with POL: TP10. To avoid confusion with other forms of intertripping, the term Loss of Mains Intertrip shall be used in records.

6.1 Specific Requirements

The scheme record shall include:

- A logic diagram unambiguously documenting the scheme logic represented as logic gates, with: the geographic location of subsystems clearly identified. The nature of all communications links shall be clearly marked, including the identities of communications bearers where these may be shared with other schemes.
- An operating procedure to be included in the operating instructions submitted to the Control Centre for the applicable area of network. This shall clearly state:
    - How to operate Selection Controls in response to arranged outages;
    - Any potential running arrangements that are not catered for by the scheme and so must not be entered into with the Power Generating Module(s) synchronised;
    - How the scheme is expected to behave in the event of detectable scheme failures such as loss of communications or a relay watchdog alarm; and
    - The extent to which any components such as relays or communications bearers are shared with protection or load management schemes.

Any potential running arrangements that are not catered for by the scheme and so must not be entered into with the Power Generating Module(s) synchronised must be clearly indicated in NGED’s connection agreement with the customer.

7.0 COMMISSIONING

Schemes shall be commissioned in accordance with POL: TP11 and ST: TP11A.

7.1 Test Requirements

Where it is not reasonably practicable to take outages to test the scheme as a whole, the commissioning engineer may test the scheme as a series of overlapping subassemblies.

7.1.1 Inputs

The correct operation of each switchgear status input shall be proved by operation of the associated primary switchgear.

The correct operation of each protection trip input shall be proved by operation of the associated protection relay or trip relay.

The correct operation of each Selection Control shall be proved be operation of both local and supervisory controls.

7.1.2 Communications Links

All communications links shall be tested to prove correct behaviour.

7.1.3 Combinatorial Logic

The full scheme logic shall be tested comprehensively by signal injection to prove correct behaviour. If this test is carried out off-site prior to installation, then a representative sample of logic tests shall be carried out following installation to confirm the validity of off-site tests.

7.1.4 Outputs

The NGED commissioning engineer shall witness the customer demonstrating their circuit breaker(s) correctly responding to a signal from the scheme.

8.0 MAINTENANCE

Schemes shall be maintained in accordance with POL: TP12 and POL: SP2.

8.1 Test Requirements

Where it is not reasonably practicable to take outages to test the scheme as a whole, the maintenance engineer may test the scheme as a series of overlapping subassemblies.

Note: It is recognised that the maintenance testing of overlapping subassemblies may be carried out at different times under different outages.

8.1.1 Inputs

The correct operation of each switchgear status input shall be proved by operation of the primary switchgear. This test may be aligned to the maintenance cycle of the associated primary switchgear instead of the LoM scheme to suit operational requirements.

The correct operation of each protection trip input shall be proved by operation of the associated protection relay or trip relay. This test may be aligned to the maintenance cycle of the associated protection scheme instead of the LoM scheme to suit operational requirements.
The correct operation of each Selection Control shall be proved be operation of both local and supervisory controls.

8.1.2 Communications Links

All communications links shall be tested to prove correct behaviour.

8.1.3 Combinatorial Logic

A representative sample of logic tests shall be carried out by signal injection to confirm correct behaviour.

8.1.4 Outputs

The NGED maintenance engineer shall witness the customer demonstrating their circuit breaker(s) correctly responding to a signal from the scheme.

9.0 MITIGATION OF FUTURE NETWORK CHANGES

There is a risk that changes to the design or running arrangements of the network could render a scheme incapable of meeting the requirements of this directive.

9.1 Ongoing Sufficiency Assessment

The sufficiency and applicability of the scheme logic in the context of network changes shall be confirmed by the methods given in 4.1 (Sufficiency Assessment):

- During the design of any material modification to the applicable area of network; and
- Not less than once every two years as part of the periodic assessment of the network.

9.2 Reporting and Resolution of Deficiencies

Any deficiencies identified by Ongoing Sufficiency Assessment shall be:

- Reported immediately to the Control Centre, who shall be responsible for operational mitigation; and
- Reported to Primary System Design for redesign and modification/reimplementation to meet the requirements of this directive.

APPENDIX A: SUPERSEDED DOCUMENTATION

This document supersedes ST: TP1B/0 dated August 2022 which has now been withdrawn

APPENDIX B: RECORD OF COMMENT DURING CONSULTATION

Comments – ST: TP1B/1

APPENDIX C: ANCILLARY DOCUMENTATION

- EREC G99
- EREC G59
- ENA TS 50-19

APPENDIX D: KEY WORDS

G99, G59, Intertrip, LoM, Loss of Mains, Loss-of-Mains, Synchronise, Synchronising, Island, Islanding.