Eskom	Guideline	Technology

Title: **INTERLOCKING GUIDELINE FOR ESKOM HV YARD SCADA HMI EQUIPMENT**

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Content

Executive Summary

With the advances in Technology being utilised in the SCS and SCADA area within Eskom it has been requested that SCADA HMI's with interlocking functionality be incorporated at all HV Yard Control rooms to assist the operator with their operating. This guideline seeks to give clarity as to how interlocking should be utilised at all HV Yard Control rooms within Eskom and what impact it should have on the safe operation pertaining to the HV Yard by either "Control Centres, Local Operators and Power Station EOD's"

1. Introduction

Eskom has made huge investments in the current substation(s) infrastructure by purchasing and employing expensive production equipment to meet immediate and future business needs. Eskom has not been able to realise full benefits in such equipment investment due to high operational cost incurred as a result of inadvertent erroneous operations, which in turn could result in equipment damage and or human injuries/fatalities. The impact of equipment damage is not only felt by Eskom but also the customers. This is evident on the turnaround time for the replacement of damaged equipment which often goes beyond the expectation due to long lead times required for the sourcing of similar equipment spares.

In light of the above, Eskom requires the concept of integrated-equipment interlocking as the strategy to reduce equipment damages, human injuries/fatalities and hence the operational cost. The interlocking is a concept of applying Boolean equations to establish the HV plant interlock conditions that must be satisfied in order to operate a particular plant device/equipment.

It is recognised that some parts of the Eskom network have already implemented the interlocking concept. This document seeks to provide clarity for Eskom to consider it justifiable, both technically and economically, to implement interlocking at all Eskom sites. It also provides the minimum system requirements for the development and implementation of an interlocking system that will ensure high quality, low risk and technical acceptability.

It should be noted that the interlocking system would not prevent erroneous operations but prohibit any attempt to operate a particular plant device if the interlocking conditions have been violated. Although mechanical interlocks and interlocking at control panels afford additional protection against operating errors, they restrict operating under abnormal circumstances. Time is often a critical factor during abnormal conditions and any hindrances are undesirable. The interlocking should therefore be avoided at control panels and mechanism boxes to permit abnormal operating procedures when necessary.

It should be understood that the interlocking philosophy currently installed within Transmission, is that for every possible operation carried out on the plant a rule exists to verify the operation to be correct. If the operation is verified as being true, the operation will be executed. Thus if no rule exists, the operation will be blocked.

2. Supporting clauses

2.1 Scope

The document covers how interlocking should be installed, how the interface with “Control Centres” should be integrated and what is required to ensure interlocking rules are installed correctly.

2.1.1 Purpose

The purpose of this document is to provide the interlocking guideline to be adopted, for future interlocking applications, on the operating diagrams and Substation Control Systems (SCS) equipment used for controlling and monitoring Transmission High Voltage (HV) plant, namely the SCADA HMI’s used by Transmission, Distribution and/or DCS\HMI’s system used by Generation for control in the HV Yard.

It is not the intention of this document to provide the basis for the re-engineering of the currently operational interlocking systems on Transmission equipment and operating diagrams. The requirements herein stipulated are geared towards future applications of the interlocking system.

2.1.2 Applicability

This guide applies to the following:

- All Transmission Substation Control System equipment (i.e. substation Gateway).
- All Distribution Substation Control System equipment (i.e. substation Gateway).
- All power Station DCS/EOD’s operating Transmission HV Yards
- Contractors undertaking SCS work on behalf of ESKOM Transmission and Generation divisions

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] ISO 9001, Quality Management Systems.

[2] Eskom 240-170000076: SCADA HMI graphic user interface design guide for EHV substations

[3] OPS5016/22-5: “Interlocking of future operating diagrams for the control of high voltage equipment” – W.L Erasmus, Rev 4

2.2.2 Informative

[4] Eskom 240-52552944: Interlocking Rules for Network Switching

[5] Eskom 240-114967625: Operating Regulation for High Voltage Systems

2.3 Definitions

2.3.1 General

Definition	Description
Bay Processor	An RTU dedicated to the supervisory needs of a single Protection Scheme
DCS	Distributed Control System (DCS) is a control system method that is spread, or distributed, among several different unit processes in a plant.
HMI Bay Control Enabled	HMI is enabled for the EA to control plant on a per bay basis at the substation.
Master Station	Remote control centres including National Control Centre, Standby National Control, Regional Control Centres, Power Station Electrical Operating Desk and the Substation HMIs.
Operating Diagram	Operating Diagram (displayed on an Operating Device) means the diagram in a control centre, or in a power station control room indicating the operating position and state of all apparatus.
Operating Device	Mimic Panel or SCADA Human Machine Interface (HMI) at a Power Station or Substation Control Room
SCADA HMI	The human interface used for the operation and monitoring of the Substation.
SCS	Substation Control System. An integrated and co-ordinated system that performs the tasks of SCADA, substation automation and offers a single point of control, monitoring and alarm annunciation (HMI) to the substation operator.
Shall	Means that these requirements are non-negotiable and are to be provided.
Stray voltage	The presence of electrical potential on a line or an apparatus relative to a grounded object that ideally should not have a voltage difference between the two objects.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
DCS	Distributed Control System
EOD	Electrical Operating Desk
GIS	Gas Insulated Switchgear
HMI	Human Machine Interface
HV	High Voltage
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Accusation
SCS	Substation Control System
TOC	Transmission Operating Centre

2.5 Roles and responsibilities

It will be the responsibility of the relevant project stakeholders to ensure interlocking is considered during project scoping stage and where applicable, is installed or installed interlocking updated to reflect current equipment status.

2.6 Process for monitoring

Changes in interlocking requirements between SCADA HMI's and HV Yards, as well as change in technology shall be monitored and if necessary, this guideline document shall be revised.

2.7 Related/supporting documents

Not applicable.

3. Requirements for the Provision of Interlocks

3.1 Fundamental Requirements

The interlocking system in all applications described within the scope of this philosophy document is required to satisfy three basic requirements:

1) To protect humans and plant against erroneous operational switching.

2) To protect humans and plant when switching conditions are unsafe.

3) To help ensure National Grid stability.

Erroneous operational switching conditions may be described as follows:

- Opening/closing of an isolator on load.
- Closing a breaker or isolator and energising an earthed circuit.
- Energising or de-energising of an unearthed line via an isolator. E.g. energising line capacitance (charging current) or de-energising stray voltage present on a line.
- Operations related to Transfer functionality.

It must be noted that the diversion of current, as would occur when selecting a circuit from one busbar to another, is not considered as opening an isolator on load.

Unsafe switching conditions refer to the state of the HV plant at the particular point in time, e.g. switching 765 kV GIS while a low SF6 Gas alarm is activated

3.1.1 General Requirements

a) All Eskom HV Yards at sub stations shall implement interlocking for the SCADA HMI where all operation of the HV Yard/Plant should be carried out from. *Eskom should update its HV Yard Operating Philosophy to included operation from the SCADA HMI only*.

b) It is ***strongly recommended*** that Power stations, which have never been "out-of-service" for prolonged periods, should implement interlocking to the Operating Diagram on the Operating SCADA Device if it is used for supervisory control of Transmission HV plant. The Power Station will be subjected to interlocking implemented on the Transmission substation gateway.

c) Previously "out-of-service" Power stations, intending to control Transmission HV plant, shall implement the interlocking in the operating diagrams of the SCADA system.

d) All interlocking systems shall be fail-safe(i.e. should the interlocking system fail, all switching operations shall be blocked)

e) Interlocking will be applied on the Gateway and all Master Stations will be subject to verification by these interlocking rules before a "secure control" is issued.

f) An indication to be sent to all Masters for each bay that is interlocked as well as a general station level interlock indication.

g) An interlock override control is to be made available which may be sent to override the entire substation interlocking for a pre-configured period of time. The override control must be logged by master station which is requesting the interlock override. The gateway must also log which master sent the override control.

h) An indication must be sent to the Master Stations indicating that the interlocking at the substation has been "Overridden"

i) Provision of a mechanism to enable the HMI to allow the authorised person to operate plant on a per bay basis and should be implemented within the substation SCADA HMI System where this is indicated to the Master Stations. A control sent from the substation SCADA HMI to the gateway must set a bit which indicates "HMI Bay Control Enabled" by the substation SCADA HMI effectively blocking all other Master Stations from controlling the plant on the particular bay.

j) At any point in time a circuit breaker must be able to be opened directly from the Substation SCADA HMI detail page, control panel or supervisory circuit, or indirectly via a protection circuit.

k) Interlocking rules should be calculated in "real time" and must take the entire substation statuses into consideration before and operation commences or is executed. To achieve this functionality a "mechanism" should be implemented to ensure that there are no applied earths within the entire substation that are connected electrically to the plant/apparatus being operated.

l) Earth switches are not remotely operated from Substation SCADA HMI detail pages, but manually applied at the earth point. Their operation is therefore not interlocked on the Substation SCADA HMI detail page. There is normally mechanical interlocking between earth switches and their associated isolators, as well as locking facilities.

m) The SCADA Human Machine Interface (HMI) required for local control and monitoring of Eskom HV plant via the SCS equipment, will have a mechanism provided in the SCADA HMI software to assist the operator in identifying the equipment responsible for the interlock conditions violation, when it occurs.

n) Any HV Plant removed from operation for maintenance or any case where the Secondary plant equipment status is offline or unavailable, resulting in the Substation being interlocked, will need a procedure/program, to allow for hand dressing of these points by the operator, thus allowing for normal operation of the rest of the HV Plant. Once the plant has been restored, the hand dressed point should be removed by the authorised person and the active "real time" information be displayed.

o) While interlocking is provided, casual attitude towards operating based on the belief that the interlocking prevents operating errors, should be avoided and detailed training on the SCADA HMI must be provided to arrest these attitudes.

p) Certain equipment, such as the GIS, which has interlocking as an integral part of the design must be taken into account during system development.

q) No operational interlocking shall be applied on control circuits within equipment mechanism boxes other than the essential interlocking provided to protect the equipment.

r) Eskom ***should investigate a method of monitoring portable earths***, which can be used in the interlocking system, and as such reduce erroneous operational switching in the HV Yard.

3.2 System Development Requirements

The following requirements shall only be applicable to all Eskom Substation SCADA HMI detail pages and SCS equipment requiring interlocking.

a) A mere application of standard “off-the-shelf” technology solution for the provision of Interlocking is not recommended. This is due to the high risk of possible interference with other resident systems and the fact that the interlocking conditions are peculiar to a specific application environment.

3.3 Design Requirements

As a minimum, the interlocking system design shall take cognisance of the following:

a) The normal transfer or bypass operation procedures.

b) The normal link-over procedure to take a busbar out of service.

c) Normal switching/linking routines for energising, loading and de-loading circuits.

d) The opening of any breaker at any time or at any point during an operating procedure.

3.4 System Integration Requirements

The interlocking system shall be part of the Substation Control Systems. As a minimum, the system shall not:

a) Degrade or compromise the integrity of the SCS equipment as well as that of the entire Transmission Network.

b) Interfere with the normal operation and function of other installed technology systems to which the SCS equipment is interfaced.

Affect adjacent functions in the environment to which it is to exist and operate.

3.5 Provision of Overwrite Mechanism

Provision for an override of the interlocking system shall be required as the interlocking module would be resident in the gateway. ***National Control Centre and TOC Control Centre*** will be interlocked via the Gateway and during abnormal conditions should be able to override the interlocking if required to operate plant.

3.6 Documentation Requirements

All system documentation pertaining to interlocking shall be stored safely and appropriately for future references. This includes the following:

- Requirements Analysis Report.
- Systems Design Alternatives Report.
- Technical specification.

- Application Philosophy.
- System Design & Detailed System Design documentation.
- Interlocking guidelines and Boolean rules.
- Factory Acceptance Testing (FAT) specification.
- Site Acceptance Testing (SAT) documentation.
- Manuals etc.

The following deliverables will be required per Sub Station

- Interlocking Rules.
- SCADA HMI configuration.
- Commissioning documentation.
- Handover certification.
- Training material and Attendance register.

3.7 Matters on Which this Guideline Is Silent

It is strongly recommended that matters on which this guideline is silent should be discussed with all the relevant stakeholders

- Technology Custodians.
- Grid and System Operators.
- Primary and Secondary Plant Managers

4. Authorization

This document has been seen and accepted by:

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5. Revisions

Date	Rev	Compiler	Remarks
July 2020	2	TC Visser	Document expired. Definitions table expanded. The following sections were updated (mainly correcting terminology): 1, 2.1.2, 3.1.1 and 3.2.
Feb 2014	1	QG Labuschagne	Interlocking Guideline Required for installation of SCADA HMI's in HV Yards

6. Development team

The following people were involved in the development of this document:

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7. Acknowledgements

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