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# Introduction

This document gives a detailed representation of the interlocking logic or rules for the Pinotage 400/132kV substation. These rules need to be approved by Eskom as being correct and serve as a baseline for the substation interlocking system.

# Supporting Clauses

## Scope

The scope of this document is limited to the interlocking rules for use at Pinotage substation.

### Purpose

The purpose of the document is to provide the interlocking rules to be implemented at Pinotage substation.

### Applicability:

This document shall apply to Eskom Transmission Division – Pinotage substation.

## Normative/Informative References

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

### Normative

1. ISO 9001 Quality Management Systems.

### Informative

N/A

## Definitions

### Disclosure Classification

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

## Abbreviations

N/A

## Roles and Responsibilities

PTM&C Engineering shall be responsible for the implementation and tracking of this document.

## Process for monitoring

It is the responsibility of PTM&C Engineering to ensure that all processes are followed correctly during the development of this document.

## Related/Supporting Documents

N/A

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# Interlocking system

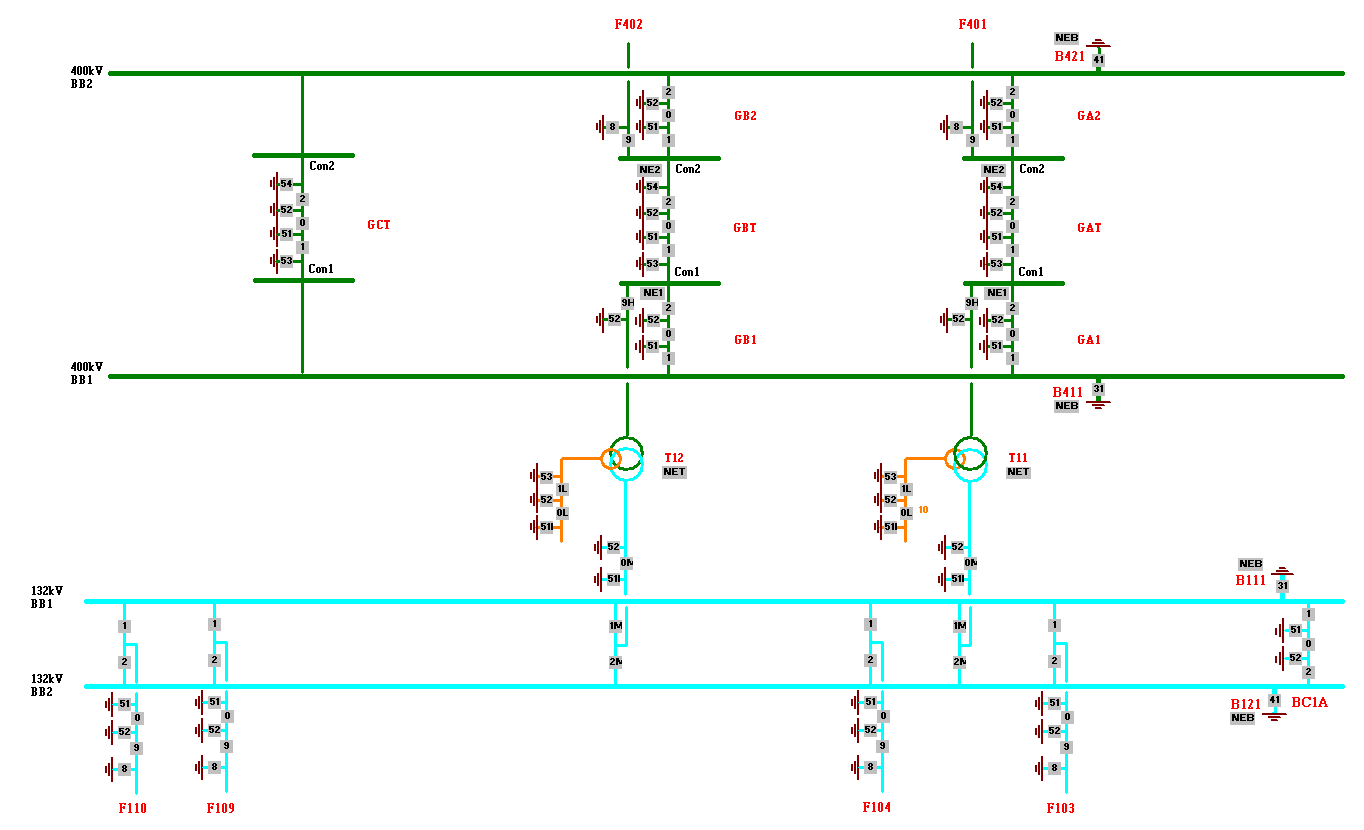


Figure 1: Single Line Interlocking Diagram

## objectives of THE substation interlocking system

The main objectives of a substation interlocking system are as follows:

* To protect human and plant against erroneous operational switching, for example opening and closing of an isolator under load or closing a live piece of equipment on to an earth.
* To ensure that the protection transfer functionality is not jeopardised.
* To only allow for operating as per High Voltage Regulations or substation specific operating procedures.

The interlocking logic is designed to satisfy the above mentioned requirements.

## Interlocking Conventions

The interlocking logic rules use the Q notation to identify devices. Every type of device has a specific Q number, e.g. a breaker is represented by Q0 and a line isolator by Q7.

NE-inputs (NEB, NET, NE1 and NE2) stipulates that no earth is connected to that specific node from anywhere in the substation when the input is true. An algorithm needs to be used to calculate all possible paths from all earths in the substation to that specific node to determine the state of the input. Breakers should be considered as closed switches, as there should be at least one isolator open for every possible path between any given earth and the node. Switches that are not specifically in the open state (failed or uncertain quality, closed state, transit state or invalid state) should be considered to be closed. This will ensure fail save operation.

**Figure 1**: Single Line Interlocking Diagram, assigns Q numbers to all the relevant devices. **Appendix A** gives the bay abbreviation, Q-number and associated tag name for every device.

Every device that needs to be interlocked has a number of rules. All these rules have to be false for a device to be locked.

Circuit breakers are only locked for the closing command. The interlocking system will therefore never lock the tripping or opening of a breaker. For all the other devices the same rule is used for locking the opening as well as the closing command of the device.

The rules are divided into external and internal conditions. Devices that belong to the same bay as the interlocked device, form part of the internal conditions. Devices that do not belong to the bay form part of the external conditions. In the external conditions the bay of every device used, must be defined as well. The following notation is used to define the bay:

* (~Q51. ~Q52)(F401) meaning Not Q51 AND NOT Q52 of bay F401
* Q2(F401. F402. F403) meaning Q2 of bay F401 AND Q2 of bay F402 AND Q2 of bay F403

An AND-operator must be used for all the external together with all the internal inputs to calculate the not locked state of a specific rule. As all rules need to be false for a device to be locked, an OR-operator must be used for all the rules of a device to calculate the not locked state of that device.

The next section of this document gives a detail representation of the interlocking logic rules for all controllable devices.

## Interlocking Logic Description

### 400kV Diameters

|  |  |  |
| --- | --- | --- |
| **GA1 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 0 | NE1(GAT) . NEB(B411) | Q2 . Q1 . ~Q52 . ~Q51 |
|  |  |  |
| 1 |  | ~Q2 . ~Q1 |
|  |  |  |
| **GA1 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 2 | NEB(B411) | ~Q52 . ~Q0 . ~Q51 . ~Q2 |
|  |  |  |
| 3 | NEB(B411) . NE1(GAT) | ~Q52 . ~Q0 . ~Q51 |
|  |  |  |
| **GA1 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 4 | NE1(GAT) | ~Q52 . ~Q0 . ~Q51 . ~Q1 |
|  |  |  |
| 5 | NE1(GAT) . NEB(B411) | ~Q52 . ~Q0 . ~Q51 |
|  |  |  |
| **GA2 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 6 | NE2(GAT) . NEB(B421) | Q1 . Q2 . ~Q51 . ~Q52 |
|  |  |  |
| 7 |  | ~Q1 . ~Q2 |
|  |  |  |
| **GA2 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 8 | NEB(B421) | ~Q51 . ~Q0 . ~Q52 . ~Q1 |
|  |  |  |
| 9 | NEB(B421) . NE2(GAT) | ~Q51 . ~Q0 . ~Q52 |
|  |  |  |
| **GA2 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 10 | NE2(GAT) | ~Q51 . ~Q0 . ~Q52 . ~Q2 |
|  |  |  |
| 11 | NE2(GAT) . NEB(B421) | ~Q51 . ~Q0 . ~Q52 |
|  |  |  |
| **GAT Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 12 |  | Q2 . Q1 . NE2 . NE1 |
|  |  |  |
| 13 |  | ~Q2 . ~Q1 |
|  |  |  |
| **GAT Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 14 |  | ~Q0 . ~Q1 . ~Q52 . ~Q51 . NE2 |
|  |  |  |
| 15 |  | ~Q0 . ~Q52 . ~Q51 . NE2 . NE1 |
| **GAT Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 16 |  | ~Q0 . ~Q52 . ~Q51 . NE1 . ~Q2 |
|  |  |  |
| 17 |  | ~Q0 . ~Q52 . ~Q51 . NE1 . NE2 |
|  |  |  |
| **GB1 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 18 | NE1(GBT) . NEB(B411) | Q2 . Q1 . ~Q52 . ~Q51 |
|  |  |  |
| 19 |  | ~Q2 . ~Q1 |
|  |  |  |
| **GB1 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 20 | NEB(B411) | ~Q52 . ~Q0 . ~Q51 . ~Q2 |
|  |  |  |
| 21 | NEB(B411) . NE1(GBT) | ~Q52 . ~Q0 . ~Q51 |
|  |  |  |
| **GB1 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 22 | NE1(GBT) | ~Q52 . ~Q0 . ~Q51 . ~Q1 |
|  |  |  |
| 23 | NE1(GBT) . NEB(B411) | ~Q52 . ~Q0 . ~Q51 |
|  |  |  |
| **GB2 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 24 | NE2(GBT) . NEB(B421) | Q1 . Q2 . ~Q51 . ~Q52 |
|  |  |  |
| 25 |  | ~Q1 . ~Q2 |
|  |  |  |
| **GB2 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 26 | NEB(B421) | ~Q51 . ~Q0 . ~Q52 . ~Q1 |
|  |  |  |
| 27 | NEB(B421) . NE2(GBT) | ~Q51 . ~Q0 . ~Q52 |
|  |  |  |
| **GB2 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 28 | NE2(GBT) | ~Q51 . ~Q0 . ~Q52 . ~Q2 |
|  |  |  |
| 29 | NE2(GBT) . NEB(B421) | ~Q51 . ~Q0 . ~Q52 |
|  |  |  |
| **GBT Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 30 |  | Q2 . Q1 . NE2 . NE1 |
|  |  |  |
| 31 |  | ~Q2 . ~Q1 |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **GBT Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 32 |  | ~Q0 . ~Q1 . ~Q52 . ~Q51 . NE2 |
|  |  |  |
| 33 |  | ~Q0 . ~Q52 . ~Q51 . NE2 . NE1 |
|  |  |  |
| **GBT Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 34 |  | ~Q0 . ~Q52 . ~Q51 . NE1 . ~Q2 |
|  |  |  |
| 35 |  | ~Q0 . ~Q52 . ~Q51 . NE1 . NE2 |
|  |  |  |
| **GCT Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 36 | NEB(B421 . B411) | Q2 . Q1 |
|  |  |  |
| 37 |  | ~Q2 . ~Q1 |
|  |  |  |
| **GCT Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 38 | NEB(B421) | ~Q0 . ~Q1 . ~Q52 . ~Q51 |
|  |  |  |
| 39 | NEB(B421 . B411) | ~Q0 . ~Q52 . ~Q51 |
|  |  |  |
| **GCT Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 40 | NEB(B411) | ~Q0 . ~Q52 . ~Q51 . ~Q2 |
|  |  |  |
| 41 | NEB(B411 . B421) | ~Q0 . ~Q52 . ~Q51 |
|  |  |  |

### 400kV Feeders

|  |  |  |
| --- | --- | --- |
| **F401 Q9 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 42 | NE2(GAT) . ~Q0(GA2 . GAT) | ~Q8 |
|  |  |  |
| 43 | NE2(GAT) . ~Q0(GA2) . ~Q2(GAT) | ~Q8 |
|  |  |  |
| 44 | NE2(GAT) . ~Q1(GA2) . ~Q0(GAT) | ~Q8 |
|  |  |  |
| 45 | NE2(GAT) . ~Q1(GA2) . ~Q2(GAT) | ~Q8 |
|  |  |  |
| **F402 Q9 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 46 | NE2(GBT) . ~Q0(GB2 . GBT) | ~Q8 |
|  |  |  |
| 47 | NE2(GBT) . ~Q0(GB2) . ~Q2(GBT) | ~Q8 |
|  |  |  |
| 48 | NE2(GBT) . ~Q1(GB2) . ~Q0(GBT) | ~Q8 |
|  |  |  |
| 49 | NE2(GBT) . ~Q1(GB2) . ~Q2(GBT) | ~Q8 |
|  |  |  |

### Transformers

|  |  |  |
| --- | --- | --- |
| **T11 Q9H Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 50 | (NE1 . ~Q0)(GAT) . ~Q0(GA1) . NEB(B111) | ~Q2M . NET |
|  |  |  |
| 51 | (NE1 . ~Q0)(GAT) . ~Q0(GA1) . NEB(B121) | NET . ~Q1M |
|  |  |  |
| 52 | (NE1 . ~Q0)(GAT) . ~Q2(GA1) . NEB(B111) | NET . ~Q2M |
|  |  |  |
| 53 | (NE1 . ~Q0)(GAT) . ~Q2(GA1) . NEB(B121) | NET . ~Q1M |
|  |  |  |
| 54 | (NE1 . ~Q1)(GAT) . ~Q0(GA1) . NEB(B111) | NET . ~Q2M |
|  |  |  |
| 55 | NE1(GAT) . NEB(B121) . ~Q1(GAT) . ~Q0(GA1) | NET . ~Q1M |
|  |  |  |
| 56 | NE1(GAT) . ~Q2(GA1) . ~Q1(GAT) . NEB(B111) | NET . ~Q2M |
|  |  |  |
| 57 | NE1(GAT) . ~Q2(GA1) . ~Q1(GAT) . NEB(B121) | NET . ~Q1M |
|  |  |  |
| 58 | ~Q2(GA1) . ~Q1(GAT) | ~Q1M . ~Q2M |
|  |  |  |
| **T11 Q0M Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 59 | NE1(GAT) . NEB(B111) | Q1M . ~Q2M . NET . Q9H |
|  |  |  |
| 60 | NE1(GAT) . NEB(B121) | ~Q1M . NET . Q2M . Q9H |
|  |  |  |
| 61 |  | ~Q9H . ~Q1M . ~Q2M |
|  |  |  |
| **T11 Q1M Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 62 | NEB(B111) | ~Q9H . ~Q2M . ~Q0M . NET |
|  |  |  |
| 63 | NEB(B111) . NE1(GAT) | ~Q2M . ~Q0M . NET |
|  |  |  |
| 64 | (Q1 . Q0 . Q2)(BC1A) | Q2M |
|  |  |  |
| **T11 Q2M Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 65 | NEB(B121) | ~Q0M . ~Q1M . ~Q9H . NET |
|  |  |  |
| 66 | NEB(B121) . NE1(GAT) | ~Q0M . ~Q1M . NET |
|  |  |  |
| 67 | (Q1 . Q0 . Q2)(BC1A) | Q1M |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **T11 Q0L Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 68 |  | Q1L . NET . ~Q52L . ~Q51L |
|  |  |  |
| 69 |  | ~Q1L . Q52L . Q51L |
|  |  |  |
| 70 |  | ~Q1L . ~Q52L |
|  |  |  |
| **T12 Q9H Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 71 | (NE1 . ~Q0)(GBT) . ~Q0(GB1) . NEB(B111) | ~Q2M . NET |
|  |  |  |
| 72 | (NE1 . ~Q0)(GBT) . ~Q0(GB1) . NEB(B121) | NET . ~Q1M |
|  |  |  |
| 73 | (NE1 . ~Q0)(GBT) . ~Q2(GB1) . NEB(B111) | NET . ~Q2M |
|  |  |  |
| 74 | (NE1 . ~Q0)(GBT) . ~Q2(GB1) . NEB(B121) | NET . ~Q1M |
|  |  |  |
| 75 | (NE1 . ~Q1)(GBT) . ~Q0(GB1) . NEB(B111) | NET . ~Q2M |
|  |  |  |
| 76 | NE1(GBT) . NEB(B121) . ~Q1(GBT) . ~Q0(GB1) | NET . ~Q1M |
|  |  |  |
| 77 | NE1(GBT) . ~Q2(GB1) . ~Q1(GBT) . NEB(B111) | NET . ~Q2M |
|  |  |  |
| 78 | NE1(GBT) . ~Q2(GB1) . ~Q1(GBT) . NEB(B121) | NET . ~Q1M |
|  |  |  |
| 79 | ~Q2(GB1) . ~Q1(GBT) | ~Q1M . ~Q2M |
|  |  |  |
| **T12 Q0M Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 80 | NE1(GBT) . NEB(B111) | Q1M . ~Q2M . NET . Q9H |
|  |  |  |
| 81 | NE1(GBT) . NEB(B121) | ~Q1M . NET . Q2M . Q9H |
|  |  |  |
| 82 |  | ~Q9H . ~Q1M . ~Q2M |
|  |  |  |
| **T12 Q1M Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 83 | NEB(B111) | ~Q9H . ~Q2M . ~Q0M . NET |
|  |  |  |
| 84 | NEB(B111) . NE1(GBT) | ~Q2M . ~Q0M . NET |
|  |  |  |
| 85 | (Q1 . Q0 . Q2)(BC1A) | Q2M |
|  |  |  |
| **T12 Q2M Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 86 | NEB(B121) | ~Q0M . ~Q1M . ~Q9H . NET |
|  |  |  |
| 87 | NEB(B121) . NE1(GBT) | ~Q0M . ~Q1M . NET |
|  |  |  |
| 88 | (Q1 . Q0 . Q2)(BC1A) | Q1M |
| **T12 Q0L Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 89 |  | Q1L . NET . ~Q52L . ~Q51L |
|  |  |  |
| 90 |  | ~Q1L . Q52L . Q51L |
|  |  |  |
| 91 |  | ~Q1L . ~Q52L |
|  |  |  |

### 132kV Feeders

|  |  |  |
| --- | --- | --- |
| **F103 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 92 | NEB(B111) | Q1 . ~Q2 . Q9 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 93 | NEB(B121) | Q9 . ~Q1 . Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 94 |  | ~Q1 . ~Q2 . ~Q9 |
|  |  |  |
| **F103 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 95 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q9 |
|  |  |  |
| 96 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 97 | (Q1 . Q0 . Q2)(BC1A) | Q2 |
|  |  |  |
| **F103 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 98 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q9 |
|  |  |  |
| 99 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q8 |
|  |  |  |
| 100 | (Q1 . Q0 . Q2)(BC1A) | Q1 |
|  |  |  |
| **F103 Q9 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 101 |  | ~Q0 . ~Q1 . ~Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 102 | NEB(B111) | ~Q0 . ~Q2 . ~Q8 . ~Q51 . ~Q52 |
|  |  |  |
| 103 | NEB(B121) | ~Q0 . ~Q1 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 104 | NEB(B121 . B111) | ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| **F104 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 105 | NEB(B111) | Q1 . ~Q2 . Q9 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 106 | NEB(B121) | Q9 . ~Q1 . Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 107 |  | ~Q1 . ~Q2 . ~Q9 |
|  |  |  |
| **F104 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 108 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q9 |
|  |  |  |
| 109 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 110 | (Q1 . Q0 . Q2)(BC1A) | Q2 |
| **F104 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 111 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q9 |
|  |  |  |
| 112 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q8 |
|  |  |  |
| 113 | (Q1 . Q0 . Q2)(BC1A) | Q1 |
|  |  |  |
| **F104 Q9 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 114 |  | ~Q0 . ~Q1 . ~Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 115 | NEB(B111) | ~Q0 . ~Q2 . ~Q8 . ~Q51 . ~Q52 |
|  |  |  |
| 116 | NEB(B121) | ~Q0 . ~Q1 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 117 | NEB(B121 . B111) | ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| **F109 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 118 | NEB(B111) | Q1 . ~Q2 . Q9 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 119 | NEB(B121) | Q9 . ~Q1 . Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 120 |  | ~Q1 . ~Q2 . ~Q9 |
|  |  |  |
| **F109 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 121 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q9 |
|  |  |  |
| 122 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 123 | (Q1 . Q0 . Q2)(BC1A) | Q2 |
|  |  |  |
| **F109 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 124 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q9 |
|  |  |  |
| 125 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q8 |
|  |  |  |
| 126 | (Q1 . Q0 . Q2)(BC1A) | Q1 |
|  |  |  |
| **F109 Q9 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 127 |  | ~Q0 . ~Q1 . ~Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 128 | NEB(B111) | ~Q0 . ~Q2 . ~Q8 . ~Q51 . ~Q52 |
|  |  |  |
| 129 | NEB(B121) | ~Q0 . ~Q1 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 130 | NEB(B121 . B111) | ~Q0 . ~Q51 . ~Q52 . ~Q8 |
| **F110 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 131 | NEB(B111) | Q1 . ~Q2 . Q9 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 132 | NEB(B121) | Q9 . ~Q1 . Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 133 |  | ~Q1 . ~Q2 . ~Q9 |
|  |  |  |
| **F110 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 134 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q9 |
|  |  |  |
| 135 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 136 | (Q1 . Q0 . Q2)(BC1A) | Q2 |
|  |  |  |
| **F110 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 137 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q9 |
|  |  |  |
| 138 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q8 |
|  |  |  |
| 139 | (Q1 . Q0 . Q2)(BC1A) | Q1 |
|  |  |  |
| **F110 Q9 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 140 |  | ~Q0 . ~Q1 . ~Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 141 | NEB(B111) | ~Q0 . ~Q2 . ~Q8 . ~Q51 . ~Q52 |
|  |  |  |
| 142 | NEB(B121) | ~Q0 . ~Q1 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 143 | NEB(B121 . B111) | ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |

**Feeder 7 – Steenbras**

|  |  |  |
| --- | --- | --- |
| **F107 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 1 | NEB(B111) | Q1 . ~Q2 . Q9 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 2 | NEB(B121) | Q9 . ~Q1 . Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 3 |  | ~Q1 . ~Q2 . ~Q9 |
|  |  |  |
| **F107 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 4 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q9 |
|  |  |  |
| 5 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 6 | (Q1 . Q0 . Q2)(BC1A) | Q2 |
|  |  |  |
| **F107 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 7 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q9 |
|  |  |  |
| 8 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q8 |
|  |  |  |
| 9 | (Q1 . Q0 . Q2)(BC1A) | Q1 |
|  |  |  |
| **F107 Q9 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 10 |  | ~Q0 . ~Q1 . ~Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 11 | NEB(B111) | ~Q0 . ~Q2 . ~Q8 . ~Q51 . ~Q52 |
|  |  |  |
| 12 | NEB(B121) | ~Q0 . ~Q1 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 13 | NEB(B121 . B111) | ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |

**Feeder 8 – Mitchells Plain**

|  |  |  |
| --- | --- | --- |
| **F108 Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 14 | NEB(B111) | Q1 . ~Q2 . Q9 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 15 | NEB(B121) | Q9 . ~Q1 . Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 16 |  | ~Q1 . ~Q2 . ~Q9 |
|  |  |  |
| **F108 Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 17 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q9 |
|  |  |  |
| 18 | NEB(B111) | ~Q2 . ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 19 | (Q1 . Q0 . Q2)(BC1A) | Q2 |
|  |  |  |
| **F108 Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 20 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q9 |
|  |  |  |
| 21 | NEB(B121) | ~Q0 . ~Q51 . ~Q52 . ~Q1 . ~Q8 |
|  |  |  |
| 22 | (Q1 . Q0 . Q2)(BC1A) | Q1 |
|  |  |  |
| **F108 Q9 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 23 |  | ~Q0 . ~Q1 . ~Q2 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 24 | NEB(B111) | ~Q0 . ~Q2 . ~Q8 . ~Q51 . ~Q52 |
|  |  |  |
| 25 | NEB(B121) | ~Q0 . ~Q1 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |
| 26 | NEB(B121 . B111) | ~Q0 . ~Q51 . ~Q52 . ~Q8 |
|  |  |  |

### 132kV Bus Coupler

|  |  |  |
| --- | --- | --- |
| **BC1A Q0 Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 144 | NEB(B111 . B121) | Q1 . Q2 |
|  |  |  |
| 145 |  | ~Q1 . ~Q2 |
|  |  |  |
| **BC1A Q1 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 146 | NEB(B111) | ~Q2 . ~Q51 . ~Q52 . ~Q0 |
|  |  |  |
| 147 | NEB(B111 . B121) | ~Q51 . ~Q52 . ~Q0 |
|  |  |  |
| **BC1A Q2 Open and Close** | |  |
| **EQTN** | **EXTERNAL CONDITIONS** | **INTERNAL CONDITIONS** |
| 148 | NEB(B121) | ~Q51 . ~Q52 . ~Q0 . ~Q1 |
|  |  |  |
| 149 | NEB(B121 . B111) | ~Q51 . ~Q52 . ~Q0 |

# Revisions

| Date | Rev. | Compiler | Remarks |
| --- | --- | --- | --- |
| Nov 2017 | 1.0 | TC du Plessis | First Release |

# Development team

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

* TC du Plessis
* K Thebus

1. : Q-number Assignment

| **Bay** | **Q-Number** | **Tag Name** |
| --- | --- | --- |
| B411 | 31 | Bb411\_ES |
| B411 | NEB | Bb411\_No\_Earth\_Connected\_To\_BB |
|  |  |  |
| B421 | 41 | Bb421\_ES |
| B421 | NEB | Bb421\_No\_Earth\_Connected\_To\_BB |
|  |  |  |
| GA1 | 0 | GA1\_Bkr |
| GA1 | 1 | GA1\_BB1\_Isol |
| GA1 | 2 | GA1\_BB2\_Side\_Isol |
| GA1 | 51 | GA1\_Bkr\_ES\_BB1\_Side |
| GA1 | 52 | GA1\_Bkr\_ES\_BB2\_Side |
|  |  |  |
| GA2 | 0 | GA2\_Bkr |
| GA2 | 1 | GA2\_BB1\_Side\_Isol |
| GA2 | 2 | GA2\_BB2\_Isol |
| GA2 | 51 | GA2\_Bkr\_ES\_BB1\_Side |
| GA2 | 52 | GA2\_Bkr\_ES\_BB2\_Side |
|  |  |  |
| GAT | 0 | GAT\_Bkr |
| GAT | 1 | GAT\_BB1\_Side\_Isol |
| GAT | 2 | GAT\_BB2\_Side\_Isol |
| GAT | 51 | GAT\_Bkr\_ES\_BB1\_Side |
| GAT | 52 | GAT\_Bkr\_ES\_BB2\_Side |
| GAT | 53 | GAT\_Conn\_1\_ES |
| GAT | 54 | GAT\_Conn\_2\_ES |
| GAT | NE1 | GAT\_No\_Earth\_Connected\_To\_Conn\_1 |
| GAT | NE2 | GAT\_No\_Earth\_Connected\_To\_Conn\_2 |
|  |  |  |
| GB1 | 0 | GB1\_Bkr |
| GB1 | 1 | GB1\_BB1\_Isol |
| GB1 | 2 | GB1\_BB2\_Side\_Isol |
| GB1 | 51 | GB1\_Bkr\_ES\_BB1\_Side |
| GB1 | 52 | GB1\_Bkr\_ES\_BB2\_Side |
|  |  |  |
| GB2 | 0 | GB2\_Bkr |
| GB2 | 1 | GB2\_BB1\_Side\_Isol |
| GB2 | 2 | GB2\_BB2\_Isol |
| GB2 | 51 | GB2\_Bkr\_ES\_BB1\_Side |
| GB2 | 52 | GB2\_Bkr\_ES\_BB2\_Side |
|  |  |  |
| GBT | 0 | GBT\_Bkr |
| GBT | 1 | GBT\_BB1\_Side\_Isol |
| GBT | 2 | GBT\_BB2\_Side\_Isol |
| GBT | 51 | GBT\_Bkr\_ES\_BB1\_Side |
| GBT | 52 | GBT\_Bkr\_ES\_BB2\_Side |
| GBT | 53 | GBT\_Conn\_1\_ES |
| GBT | 54 | GBT\_Conn\_2\_ES |
| GBT | NE1 | GBT\_No\_Earth\_Connected\_To\_Conn\_1 |
| GBT | NE2 | GBT\_No\_Earth\_Connected\_To\_Conn\_2 |
|  |  |  |
| GCT | 0 | GCT\_Bkr |
| GCT | 1 | GCT\_BB1\_Isol |
| GCT | 2 | GCT\_BB2\_Isol |
| GCT | 51 | GCT\_Bkr\_ES\_BB1\_Side |
| GCT | 52 | GCT\_Bkr\_ES\_BB2\_Side |
| GCT | 53 | GCT\_Conn\_1\_ES |
| GCT | 54 | GCT\_Conn\_2\_ES |
|  |  |  |
| F401 | 8 | Fd401\_Line\_ES |
| F401 | 9 | Fd401\_Line\_Isol |
|  |  |  |
| F402 | 8 | Fd402\_Line\_ES |
| F402 | 9 | Fd402\_Line\_Isol |
|  |  |  |
| T11 | 0L | Tr\_11\_LV\_Bkr |
| T11 | 0M | Tr\_11\_NV\_Bkr |
| T11 | 1L | Tr\_11\_LV\_BB1\_Isol |
| T11 | 1M | Tr\_11\_MV\_BB1\_Isol |
| T11 | 2M | Tr\_11\_MV\_BB2\_Isol |
| T11 | 51L | Tr\_11\_LV\_Bkr\_ES\_Cable\_Side |
| T11 | 51M | Tr\_11\_MV\_Bkr\_ES\_BB\_Side |
| T11 | 52H | Tr\_11\_HV\_Trfr\_ES |
| T11 | 52L | Tr\_11\_LV\_Bkr\_ES\_Trfr\_Side |
| T11 | 52M | Tr\_11\_MV\_Bkr\_ES\_Trfr\_Side |
| T11 | 53L | Tr\_11\_LV\_Trfr\_ES |
| T11 | 9H | Tr\_11\_Trfr\_Isol |
| T11 | NET | Tr\_11\_No\_Earth\_Connected\_To\_Trfr |
|  |  |  |
| T12 | 0L | Tr\_12\_LV\_Bkr |
| T12 | 0M | Tr\_12\_NV\_Bkr |
| T12 | 1L | Tr\_12\_LV\_BB1\_Isol |
| T12 | 1M | Tr\_12\_MV\_BB1\_Isol |
| T12 | 2M | Tr\_12\_MV\_BB2\_Isol |
| T12 | 51L | Tr\_12\_LV\_Bkr\_ES\_Cable\_Side |
| T12 | 51M | Tr\_12\_MV\_Bkr\_ES\_BB\_Side |
| T12 | 52H | Tr\_12\_HV\_Trfr\_ES |
| T12 | 52L | Tr\_12\_LV\_Bkr\_ES\_Trfr\_Side |
| T12 | 52M | Tr\_12\_MV\_Bkr\_ES\_Trfr\_Side |
| T12 | 53L | Tr\_12\_LV\_Trfr\_ES |
| T12 | 9H | Tr\_12\_Trfr\_Isol |
| T12 | NET | Tr\_12\_No\_Earth\_Connected\_To\_Trfr |
|  |  |  |
| B111 | 31 | Bb111\_ES |
| B111 | NEB | Bb111\_No\_Earth\_Connected\_To\_BB |
|  |  |  |
| B121 | 41 | Bb121\_ES |
| B121 | NEB | Bb121\_No\_Earth\_Connected\_To\_BB |
|  |  |  |
| F103 | 0 | Fd103\_Bkr |
| F103 | 1 | Fd103\_BB1\_Isol |
| F103 | 2 | Fd103\_BB2\_Isol |
| F103 | 8 | Fd103\_Line\_ES |
| F103 | 9 | Fd103\_Line\_Isol |
| F103 | 51 | Fd103\_Bkr\_ES\_BB\_Side |
| F103 | 52 | Fd103\_Bkr\_ES\_Line\_Side |
|  |  |  |
| F104 | 0 | Fd104\_Bkr |
| F104 | 1 | Fd104\_BB1\_Isol |
| F104 | 2 | Fd104\_BB2\_Isol |
| F104 | 8 | Fd104\_Line\_ES |
| F104 | 9 | Fd104\_Line\_Isol |
| F104 | 51 | Fd104\_Bkr\_ES\_BB\_Side |
| F104 | 52 | Fd104\_Bkr\_ES\_Line\_Side |
|  |  |  |
| F109 | 0 | Fd109\_Bkr |
| F109 | 1 | Fd109\_BB1\_Isol |
| F109 | 2 | Fd109\_BB2\_Isol |
| F109 | 8 | Fd109\_Line\_ES |
| F109 | 9 | Fd109\_Line\_Isol |
| F109 | 51 | Fd109\_Bkr\_ES\_BB\_Side |
| F109 | 52 | Fd109\_Bkr\_ES\_Line\_Side |
|  |  |  |
| F110 | 0 | Fd110\_Bkr |
| F110 | 1 | Fd110\_BB1\_Isol |
| F110 | 2 | Fd110\_BB2\_Isol |
| F110 | 8 | Fd110\_Line\_ES |
| F110 | 9 | Fd110\_Line\_Isol |
| F110 | 51 | Fd110\_Bkr\_ES\_BB\_Side |
| F110 | 52 | Fd110\_Bkr\_ES\_Line\_Side |
|  |  |  |
| BC1A | 0 | Bc\_1A\_Bkr |
| BC1A | 1 | Bc\_1A\_BB1\_Isol |
| BC1A | 2 | Bc\_1A\_BB2\_Isol |
| BC1A | 51 | Bc\_1A\_Bkr\_ES\_BB1\_Side |
| BC1A | 52 | Bc\_1A\_Bkr\_ES\_BB2\_Side |
|  |  |  |