**Microsoft DUB13**

Medium Voltage (MV) Coordination Study

**Dub 13 MV Coordination Study**

Project Number 20\_D027

September 2020

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# Executive Summary

This report details the MV coordination study for Microsoft Dub 13 Colo1+Admin and Colo 2. The study in this report will verify that the MV system coordinated up to the Dub06 USS01 MV distribution boards.

## Summary Results

All fault scenarios examined result in fault clearance in acceptable time and with correct discrimination i.e. the minimum number of possible circuits isolated for a fault.

# Introduction

Microsoft Dub13 MV system comprises of three levels of MV distribution.

1. Power Source: MV distribution boards USS01A, USS01B, USS01C located within the main campus substation
2. MV Sub distribution boards UMS01, UMS02, UMS03
3. Ring main units UPM# (5No. in Colo1 and 4No. in Colo2)

There is a MV ring topology for each of the Colo’s. Each Colo has four cells and each cell has a UPM ring main unit. There is a ring main unit for the administration building in Colo1. The proposed MV equipment providers will be Siemens and the existing MV equipment in Dub06 is ABB.

This study is based on the proposed and existing equipment. The MV model has been completed in ETAP modelling software

The ring configuration is an open type system which has an open point in the ring which as shown in Figure 1. Colo2 is identical to Colo1 therefore the MV study has been completed for Colo1 and the Admin only.

# Calculation Input Data

This study was conducted based on the following Dub 13 input data:

* E-H-006 ELECTRICAL COLO 1 AND 2 20kV ONE LINE DIAGRAM
* E-H-009 ELECTRICAL ADMIN OFFICE 415V ONE LINE DIAGRAM
* E-H-011 ELECTRICAL COLO 1, CELL 1 415V ONE LINE DIAGRAM
* E-H-012 ELECTRICAL COLO 1, CELL 2 415V ONE LINE DIAGRAM
* E-H-030 ELECTRICAL GROUNDING ONE LINE DIAGRAM
* Premium Power Dub 6 Rev13 MV Protection Coordination Study
* Premium Power Dub 7 Rev12 MV Protection Coordination Study
* Premium Power Dub 8 Rev09 MV Protection Coordination Study
* Dub06 USS01A/B/C ABB switchgear details received from ABB
* Switchgear Information provided by Siemens
* Cable Information from the MV cable Study
* MV/LV Distribution Transformer Information provided by Siemens
* Cable lengths have been measured from cable containment drawings and underground ducting drawings

### Site Load flow & Protection Coordination Model

Dub 13 Colo1 + Admin and Colo2 will be connected to the existing Dub06 USS01 A, B and C MV distribution boards.

The MV topology is an open ring consisting of:

* 9No. MV Ring main units (UPM\_#) with incoming network switches and outgoing transformer circuit breakers
* 3No. Primary source MV distribution boards (UMS\_#) with incoming MV circuit breakers and outgoing MV circuit breakers
* 3No. Source connection points (USS\_#), these are existing MV distribution boards located within the campus substation.
* At the main substation there is a neutral-earth resistor (NER) which limits the ground fault current to 480A.

The protection and coordination modelling will assess the coordination between the MV circuit breakers along Route 1 and Route 2 for Colo1+Admin and Colo2 (as shown in Figure 1)

The model has been used to determine the settings from the MV protection relay on the site USS#, to the UMS# and UPM# MV distribution boards and the associated ACB on the LV side of the transformer.

The same settings shall be applied to the following transformer MV and LV protection devices since the transformer ratings and loading are the same.

* COLO1-CE1-XFM01
* COLO1-CE2-XFM01
* COLO1-CE3-XFM01
* COLO1-CE4-XFM01
* COLO2-CE4-XFM01
* COLO2-CE2-XFM01
* COLO2-CE3-XFM01
* COLO2-CE4-XFM01

The settings have also been determined for the MV protection relay on UPM# feeder and the associated ACB on the LV side of the ADMIN transformer.

### Site Loading

* All UPM\_FCB are to set to 102Amps for overcurrent. This is based on the full load current from the 3.5MVA transformers at 20kV
* All UMS\_FCB are set to 379A which is based on the full load of the MV ring (9.6MW x 1.25PUE = 12MW + 0.5MW Admin = 12.5MW operating at 20kV with 0.95 power factor

# Protection coordination scenarios

Figure : MV Coordination Routing (see appendix C)

# Protection and Coordination Study

## Philosophy

The upper limits for the site are generally determined by the settings implemented by the Utility but in this case will be the settings on the existing NM1 MV breaker in the USS01A, B, C distribution boards. The lower limit for a particular device is the generally the full load current for that circuit.

### Overcurrent Protection

Overcurrent protection functions have been implemented with two stages; Long Time Delay and Instantaneous.

Time delays are selected to achieve maximum discrimination with upstream and downstream devices. It must also be ensured that time delays are set adequately low so that both the nominal current rating and short circuit current rating of equipment and cables is not exceeded.

### Earth Fault Protection

The earth fault protection has been implemented with a single Definite Time stage for the USS protection and a Definite Inverse time setting for the UMS panels. Earth fault protection shall allow for possible current transformer inconsistencies and possible spurious earth fault currents.

Pickup current can be set no lower than 10% of the nominal CT rating for this reason to provide an extra safety margin.

### Time Discrimination.

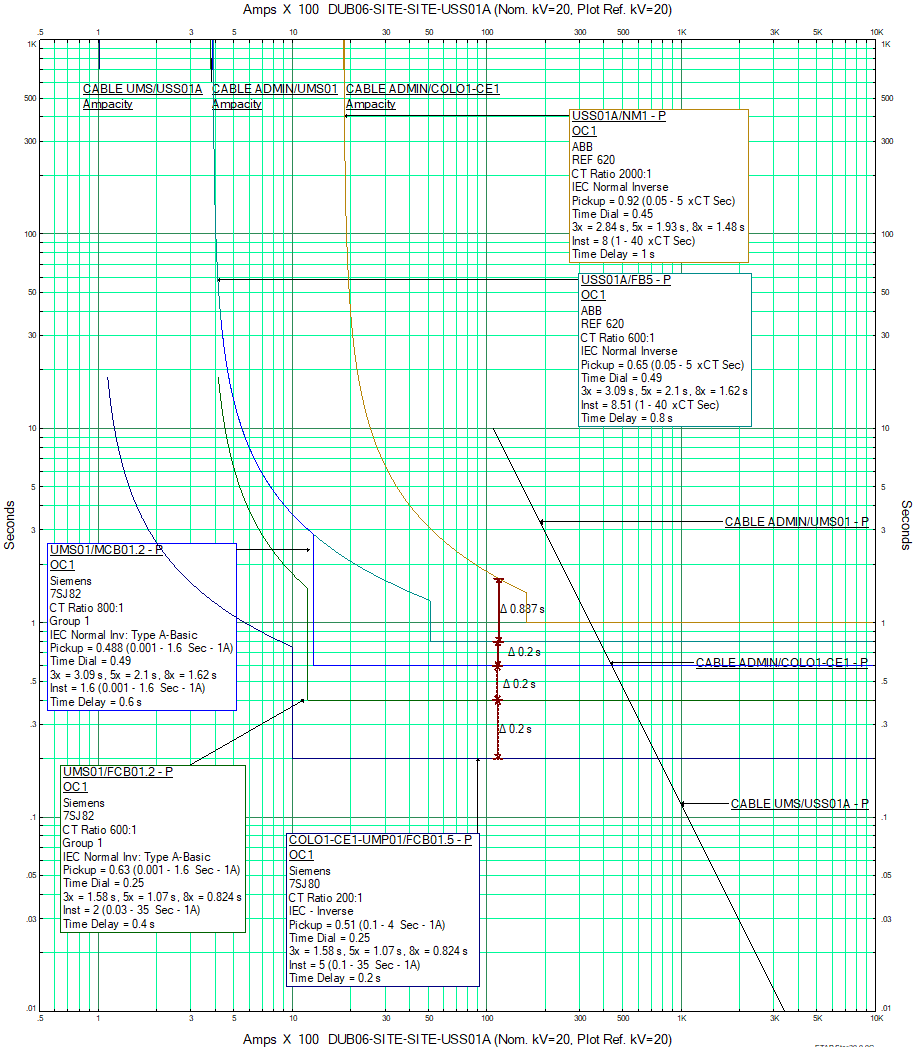
It is proposed to have at least 200 millisecond time difference between adjacent trip curves on the MV network for overcurrent and earth fault curves, where possible. This is to allow the upstream protection relay to detect, act and open on a fault before the next upstream relay and circuit breaker opens.

# Dub 13 Site Analysis

## Short Circuit Summary Dub 13 MV Study

The results of the short circuit study for the MV system in Dub 13 can be seen in Appendix A

### Colo1 Route 1 – Phase Graph



### Colo1 Route 1 – Description

This graph shows Route 1 from MV Board USS01A to CE1-UPM01. The graphs shows discrimination between the MV circuit breakers has been achieved

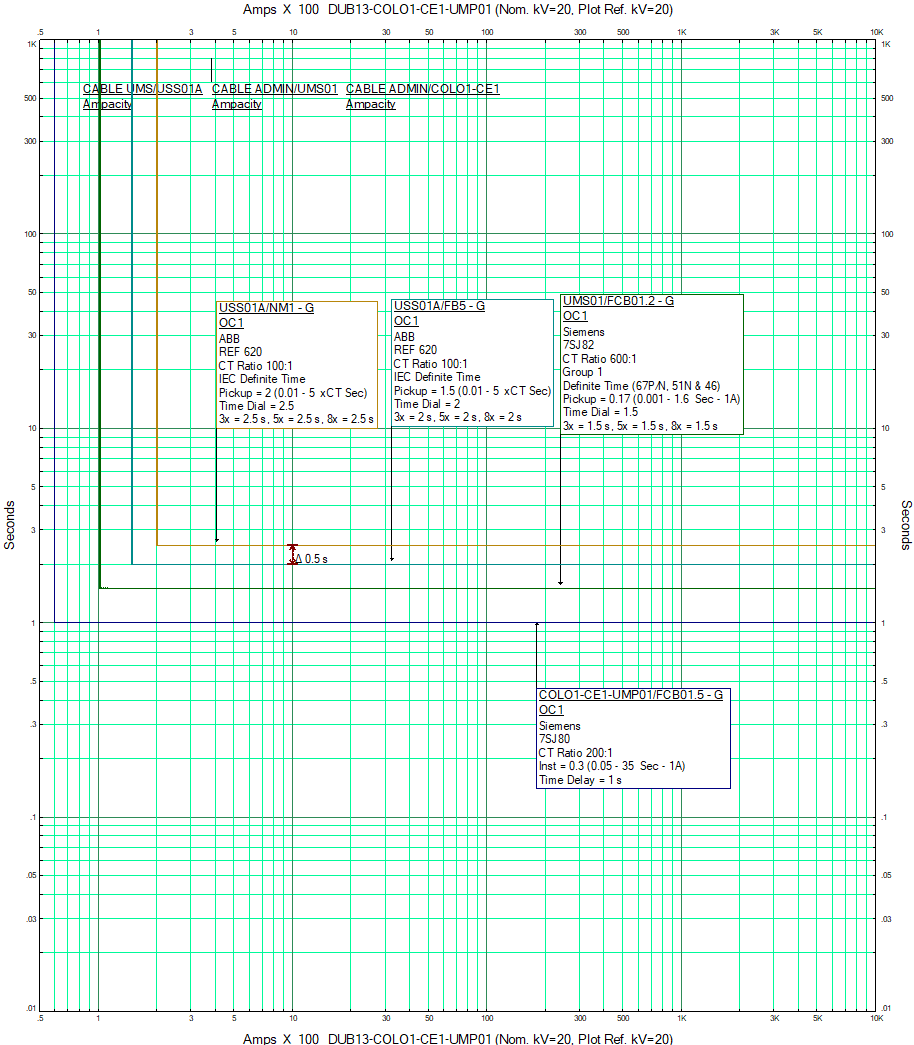
It shows the MV prospective short circuit current of the system at 11.46kA and the maximum PSCC withstand of the MV cables.

The maximum PSCC withstand of the MV cables is behind the MV breaker curve, this shows the MV cable can withstand the fault conditions of the MV system

It should be noted that the main USS01 circuit breaker will not open on instantaneous setting for downstream faults due to the pickup of the instantaneous curve (16kA) being higher than the PSCC.

A minimum time delay of >200m/s at the PSCC has been achieved between inline upstream protective devices i.e. between the UPM and UMS and between the UMS and the USS distribution boards. This is highlighted in the Route 1 Phase Graph

### Colo1 Route 1 – Earth Fault Graph

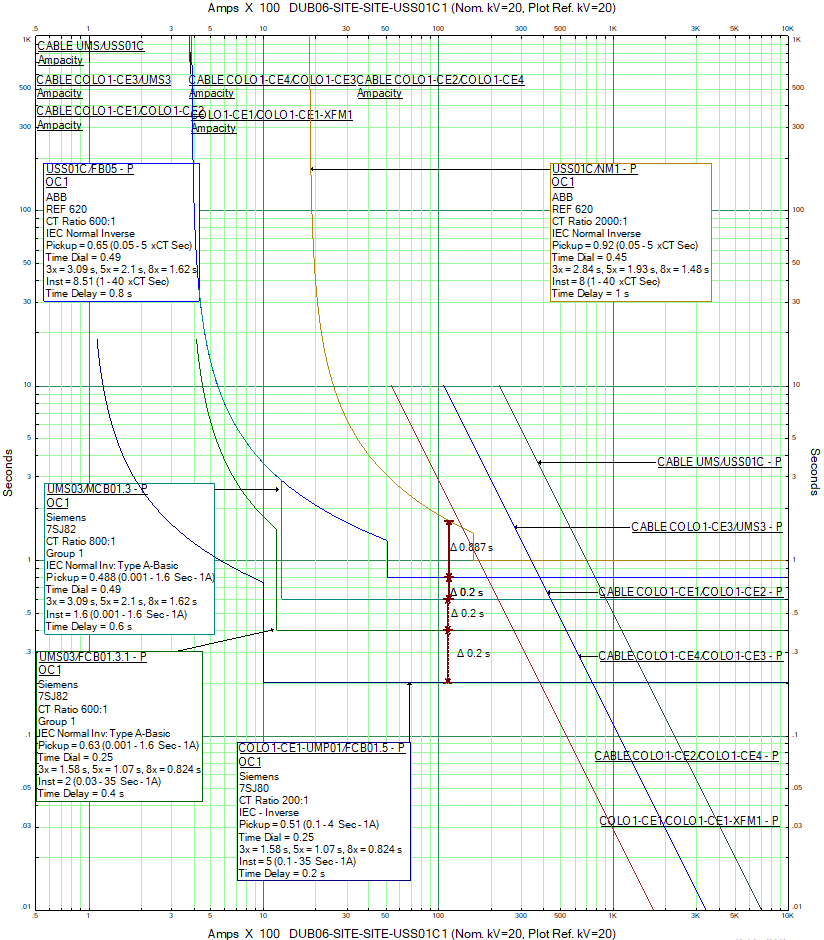


### Colo1 Route 1 – Earth Fault Description

This graph shows the MV circuit breakers operating in earth fault. The graph shows that under an earth fault there is discrimination between the MV circuit breakers

500ms grading was achieved between the USS, UMS and UPM.

### Colo1 Route 2 – Phase Graph



### Colo1 Route 2 – Description

This graph shows Route 2 from MV Board USS01C to UPM01 Colo1-CE1. The graphs shows discrimination between the MV circuit breakers has been achieved

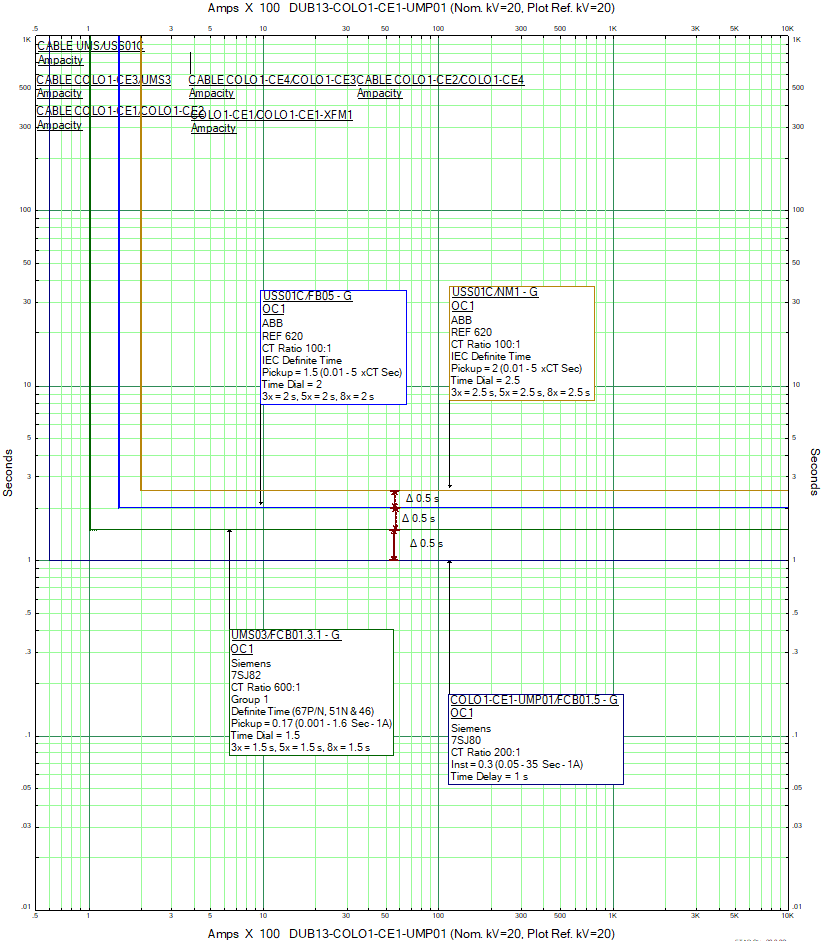
It shows the MV prospective short circuit current of the system at 11.65kA and the maximum PSCC withstand of the MV cables.

The maximum PSCC withstand of the MV cables is behind the MV breaker curve, this shows the MV cable can withstand the fault conditions of the MV system

It should be noted that the main USS01 circuit breaker will not open on instantaneous setting for downstream faults due to the pickup of the instantaneous curve (16kA) being higher than the PSCC.

A minimum time delay of >200m/s at the PSCC has been achieved between inline upstream protective devices i.e. between the UPM and UMS and between the UMS and the USS distribution boards. This is highlighted in the Route 2 Phase Graph

### Colo1 Route 2 – Earth Fault Graph



### Colo1 Route 2 – Earth Fault Description

This graph shows the MV circuit breakers operating in earth fault. The graph shows that under an earth fault there is discrimination between the MV circuit breakers.

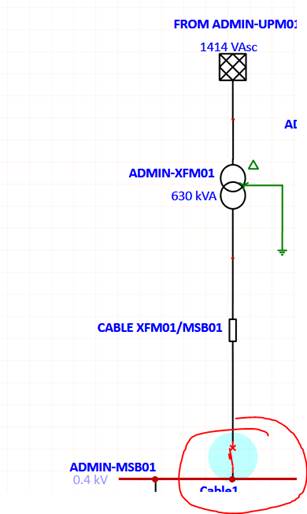
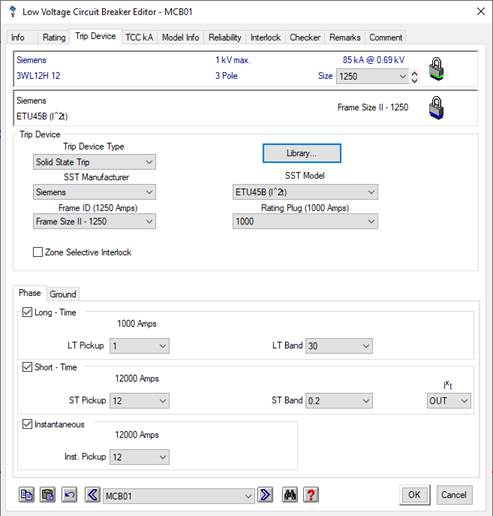
500ms grading was achieved between the USS, UMS and UPM.

### LV and MV Setting Coordination

### LV Single Line Drawing E-H-009

Below is taken from the Admin E-H-009 LV study, it shows the first LV circuit breaker after the MV/LV transformer.

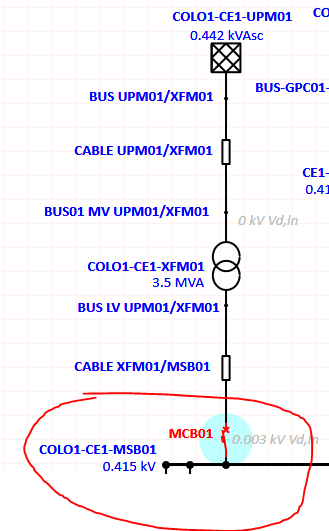
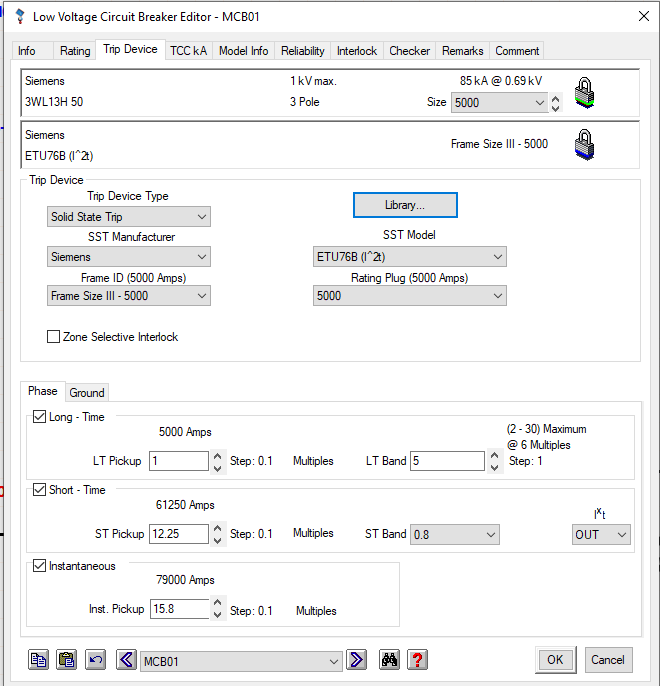
The LV breaker instantaneous pickup is set to 0.01seconds. The transformer instantaneous protection is set to 0.20 seconds. Therefore, there would be discrimination between the MV and LV protection with the LV breakers tripping first.



### LV Single Line Drawing E-H-011

Below is taken from the Admin E-H-011 LV study, it shows the first LV circuit breaker after the MV/LV transformer.

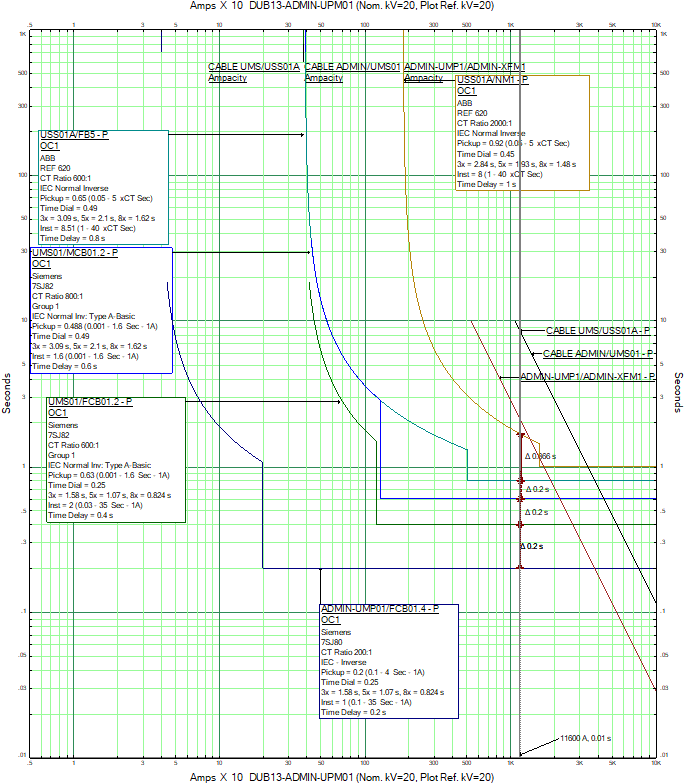
The LV breaker instantaneous pickup is set to 0.01 seconds. The transformer instantaneous protection is set to 0.20 seconds. Therefore, there would be discrimination between the MV and LV protection with the LV breakers tripping first.



### Colo2 Route 1 and 2

Colo2 Routes 1 and 2 will be the same principle and settings as for Colo 1. The full list of settings can be found in Appendix B of this report.

### Admin Route 1 – Phase Graph



### Admin Route 1 – Description

This graph shows Route 1 from MV Board USS01A to Admin-UPM01. The graphs shows discrimination between the MV circuit breakers has been achieved

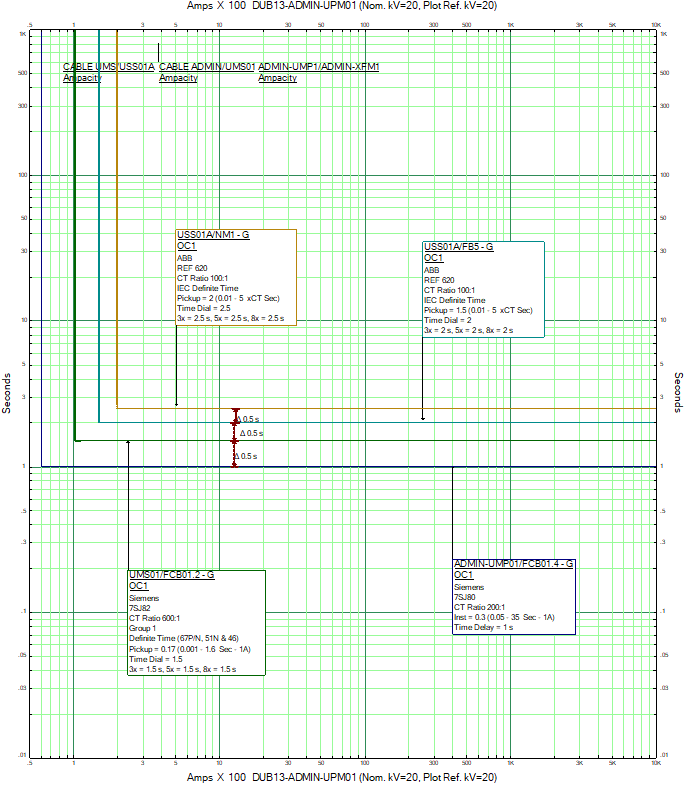
It show the MV prospective short circuit current of the system at 11.60kA and the maximum PSCC withstand of the MV cables.

The maximum PSCC withstand of the MV cables is behind the MV breaker curve, this shows the MV cable can withstand the fault conditions of the MV system

It should be noted that the main USS01 circuit breaker will not open on instantaneous setting for downstream faults due to the pickup of the instantaneous curve (16kA) being higher than the PSCC.

A minimum time delay of >200m/s at the PSCC has been achieved between inline upstream protective devices i.e. between the Admin UPM and UMS and between the UMS and the USS distribution boards. This is highlighted in the Admin Route 1 Phase Graph

### Admin Route 1 – Earth Fault Graph

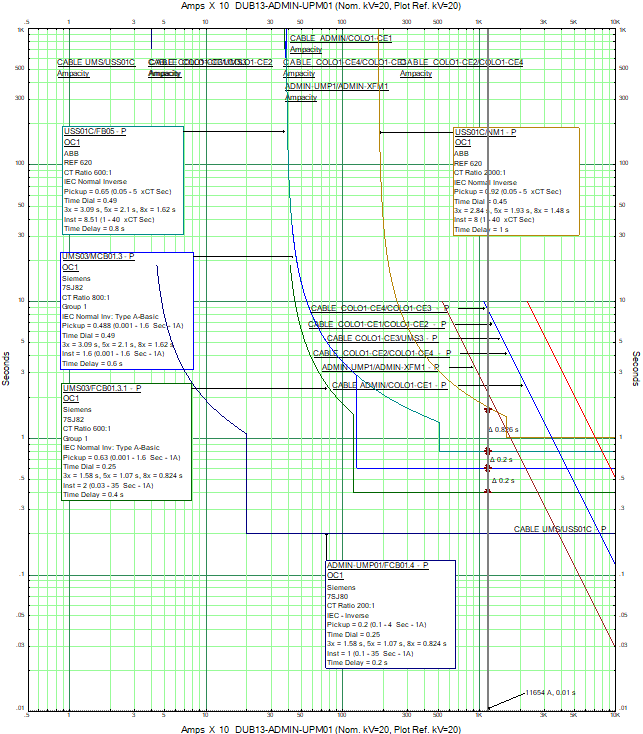


### Admin Route 1 – Earth Fault Description

This graph shows the MV circuit breakers operating in earth fault . The graph shows that under an earth fault there is discrimination between the MV circuit breakers.

500ms grading was achieved between the USS, UMS and UPM.

### Admin Route 2 – Phase Graph



### Admin Route 2 – Description

This graph shows Route 1 from MV Board USS01C to Admin-UPM01. The graphs shows discrimination between the MV circuit breakers has been achieved

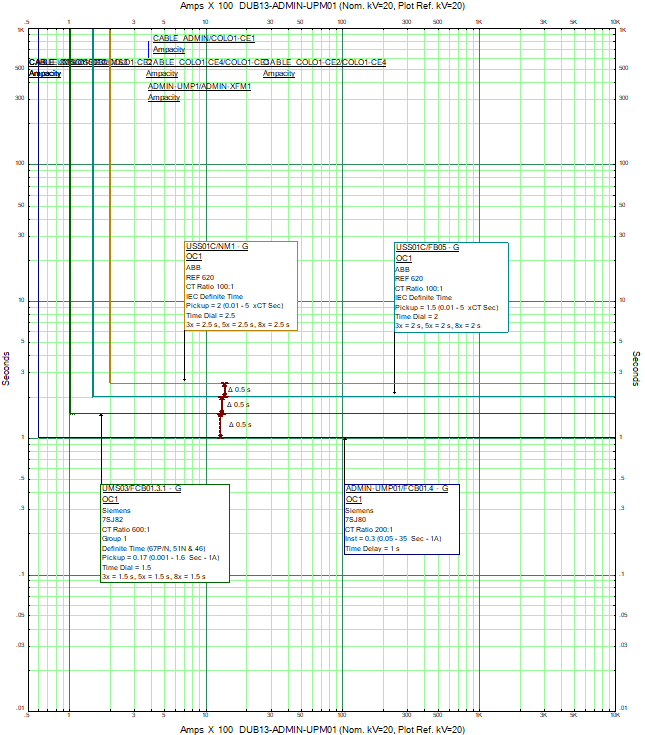
It show the MV prospective short circuit current of the system at 11.66kA and the maximum PSCC withstand of the MV cables.

The maximum PSCC withstand of the MV cables is behind the MV breaker curve, this shows the MV cable can withstand the fault conditions of the MV system

It should be noted that the main USS01 circuit breaker will not open on instantaneous setting for downstream faults due to the pickup of the instantaneous curve (16kA) being higher than the PSCC.

A minimum time delay of >200m/s at the PSCC has been achieved between inline upstream protective devices i.e. between the Admin UPM and UMS and between the UMS and the USS distribution boards. This is highlighted in the Admin Route 2 Phase Graph

### Admin Route 2 – Earth Fault Graph

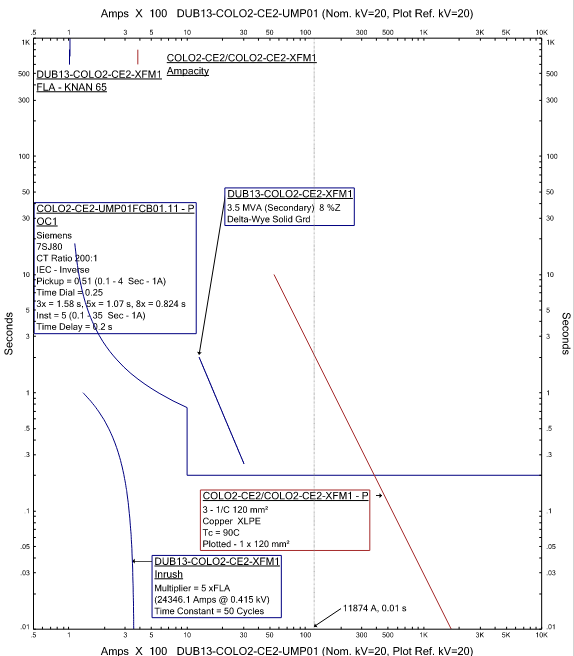


### Admin Route 2 – Earth Fault Description

This graph shows the MV circuit breakers operating in earth fault. The graph shows that under an earth fault there is discrimination between the MV breakers

500ms grading was achieved between the USS, UMS and UPM.

### Colo Transformer Protection



TRANSFORMER DAMAGE CURVE

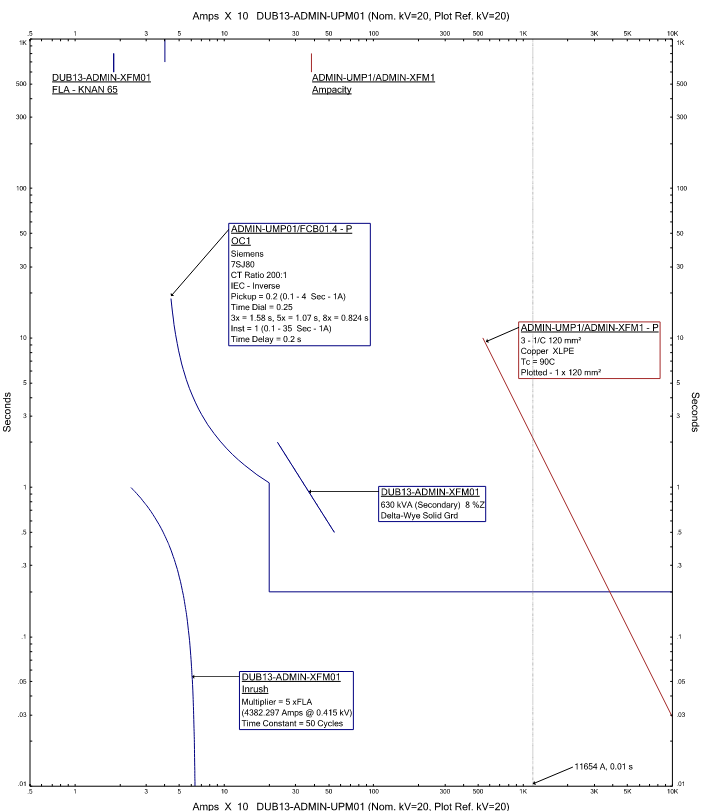
### Colo Transformer Protection – Description

This graph shows the typical cell transformer inrush current and the upstream MV circuit breaker and protection relay. It shows the inrush current of the transformer which is below the circuit breaker operating current.

The inrush current for the transformer has been based on inrush data from Siemens for the specific transformer proposed for Dub 13 It shows the MV cable short circuit capacity which is greater than the PSCC of the system, and protected by the protection curve.

The transformer damage curve is located below the PSCC of the network but is located behind the protection curve of the relay. The transformer will therefore be protected from damage under fault conditions.

### Admin Transformer Protection



TRANSFORMER DAMAGE CURVE

### Admin Transformer Protection – Description

This graph shows the typical cell transformer inrush current and the upstream MV circuit breaker and protection relay. It shows the inrush current of the transformer which is below the circuit breaker operating current.

The inrush current for the transformer has been based on inrush data from Siemens for the specific transformer proposed for Dub 13

It shows the MV cable short circuit capacity which is greater than the PSCC of the system, and protected by the protection curve.

The transformer damage curve is located below the PSCC of the network but is located behind the protection curve of the relay. The transformer will therefore be protected from damage under fault conditions.

# Appendix A – Short Circuit Study Results

# Appendix B – MV Relay Settings

# Appendix C – MV Routing Drawing