

Centralised Protection & Control

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IEC 61850 Global
2019 14-18 October 2019
London, UK



Agenda

Why do we need a Centralised Protection and control system Architecture?

Our approach to Assess, specify and design a Centralised Protection and Control system?

How will we test and maintain our new Centralised Protection and Control systems?

The Centralised Protection and Control system and its benefits

Why do we need a Centralised Protection and control system Architecture?

Measure	Data
End customers	8.3M
Peak demand	16GW
Energy distributed	85TWh
Underground electricity cables	138,000km
Overhead lines	46,000km
Protection relays	45,000
ED1 totex allowance	£6,029M



UK Power Networks metrics

Why do we need a Centralised Protection and control system Architecture?



Growth in DG

- **9.1GW** of DG connected, doubled in the last 5 years
- First Solar / Storage schemes with no subsidy support
- Over **200,000** distributed energy resources



Storage Market

- Over **1GW** of accepted storage offers
- **1000 (18GW)** formal enquiries since July 2015
- Two **50MW** Batteries connected,



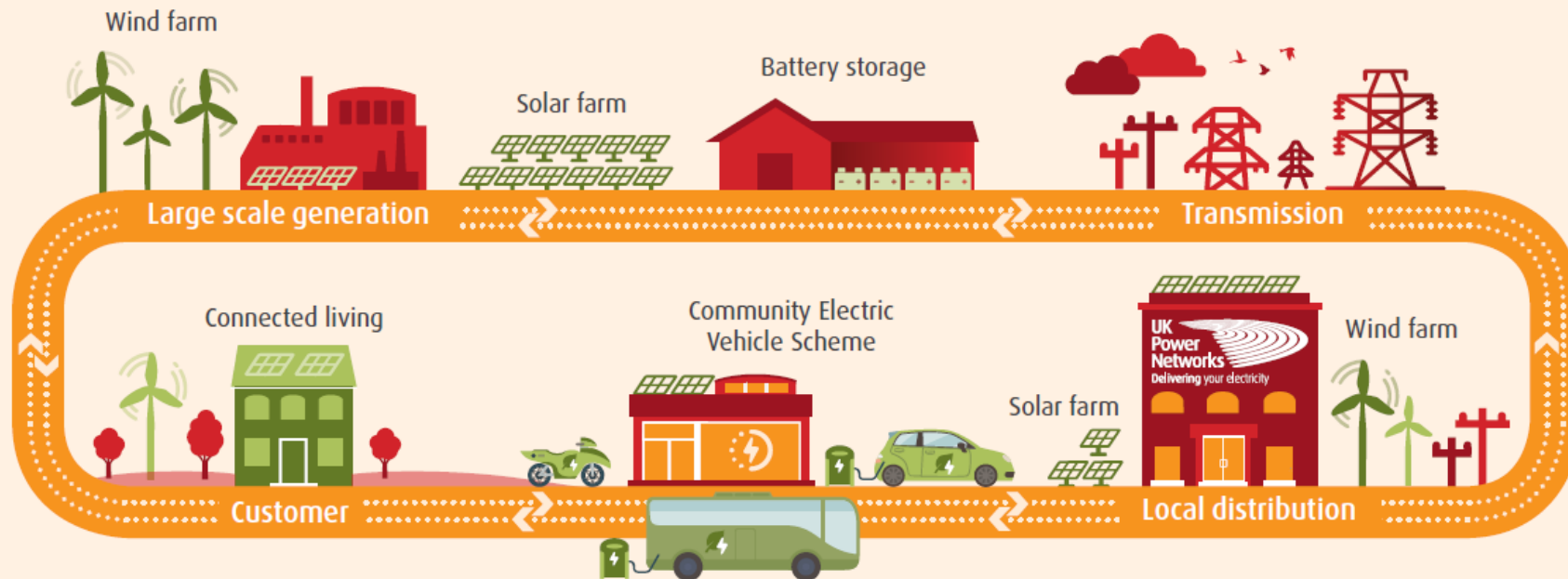
Growth in Electric Vehicles

- Over 300 electric buses in London by 2020
- **195,000** Plug-in vehicles sold in the UK, **31%** on our networks
- UK EV registrations **53%** year on year growth
- Over **19,000** public Charge points

Pace and scale of change continues to increase

Why do we need a Centralised Protection and control system Architecture?

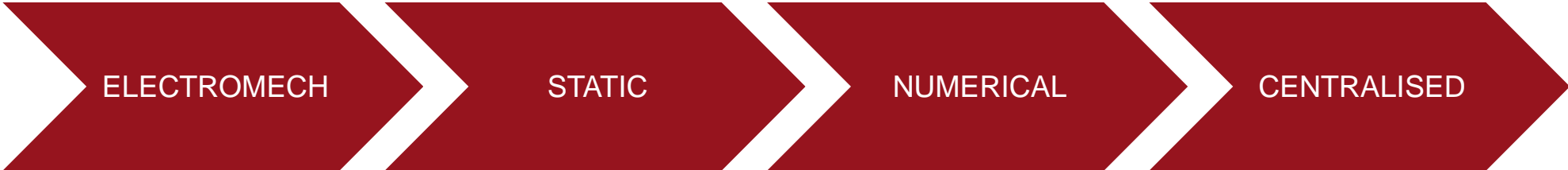
New World



- Large number of generators connected on the distribution network, including behind-the-meter
- Two-way power flows
- Inclusion of renewables (such as, solar PV, wind turbines and biomass) and grid scale battery storage
- Proactive and active customer engagement

No longer the “New World” this is our network

Why do we need a Centralised Protection and control system Architecture?



Protection development timeline

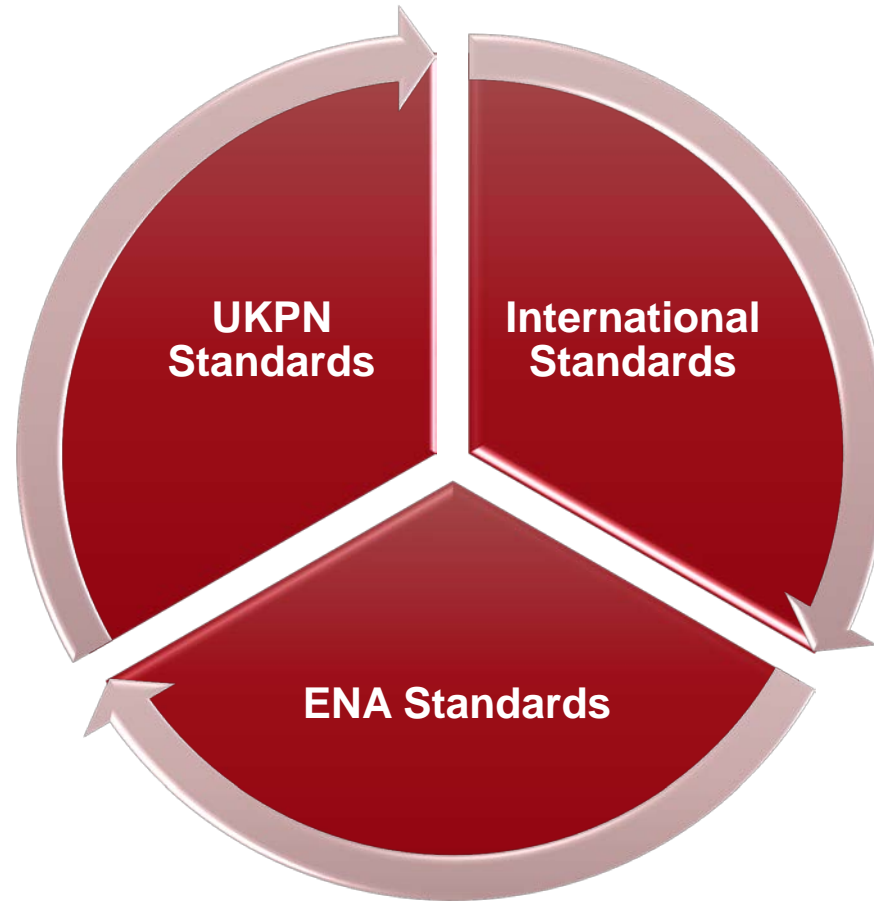
Why do we need a Centralised Protection and control system Architecture?

With the changes in our network we have a much greater need for data rich substations to support smart grid technologies and Asset management

We need a technology that can be deployed rapidly in strategic locations to support our DSO strategy

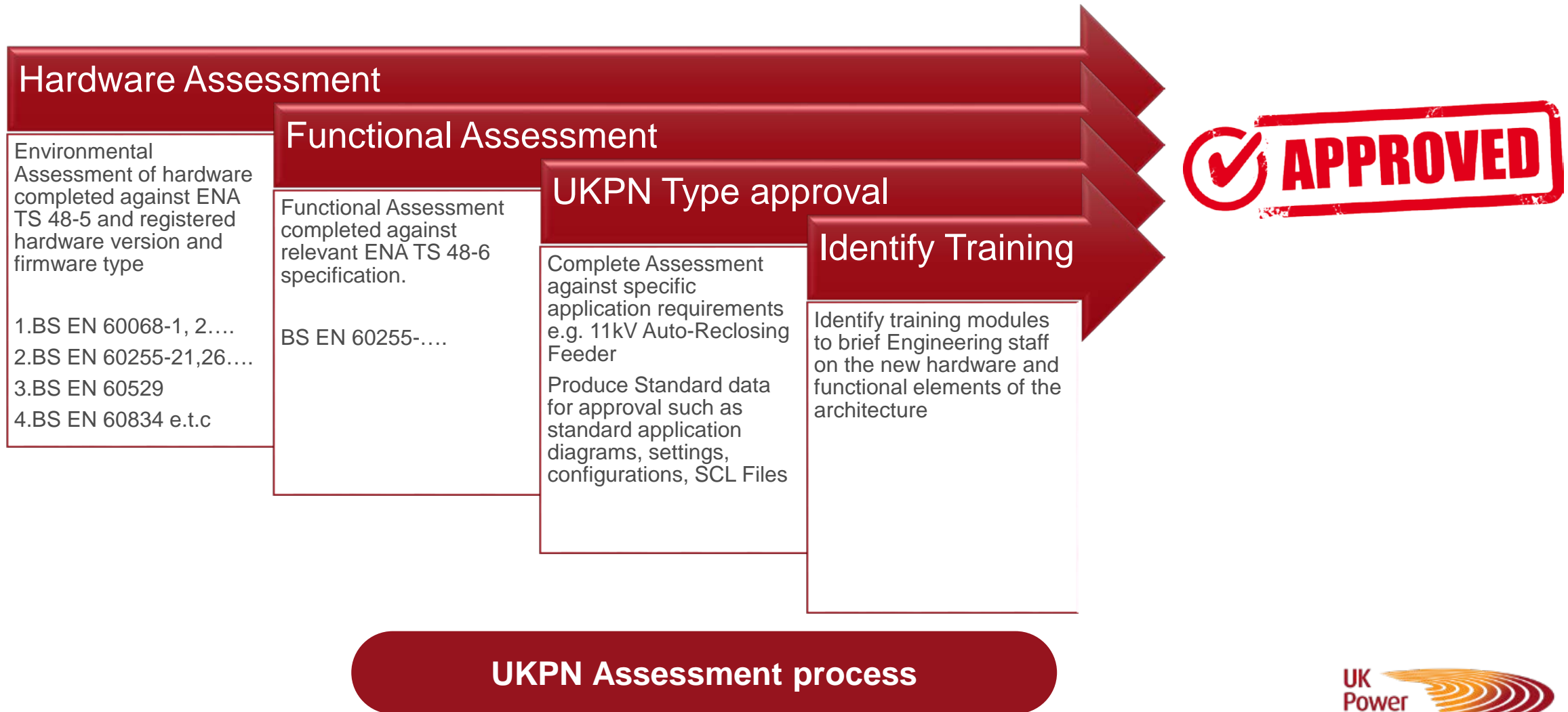
The technology required needs to achieve greater TOTEX cost efficiency than current technologies

Our approach to Assess, specify and design a Centralised Protection and Control system?

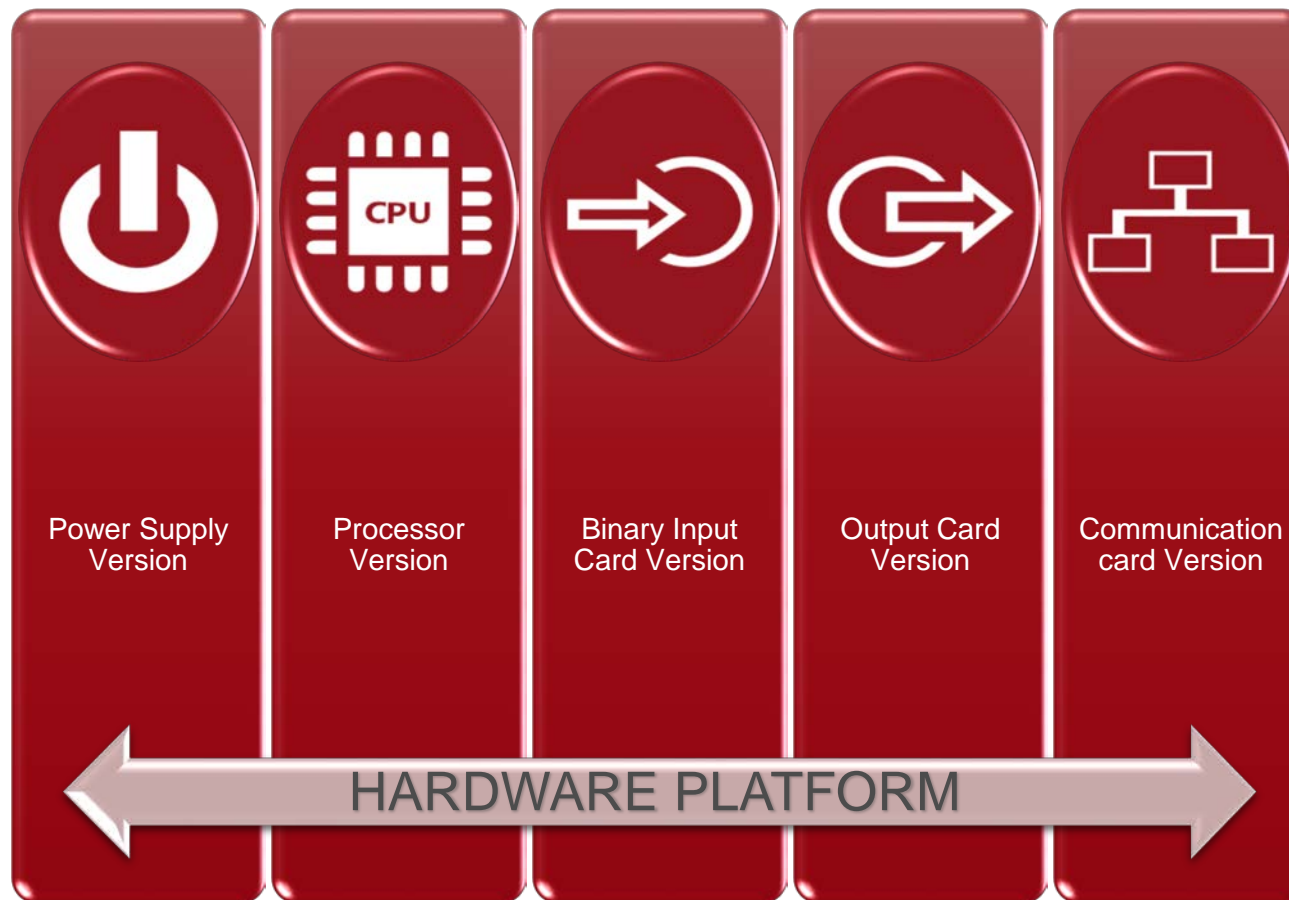


How we started the journey

Our approach to Assess, specify and design a Centralised Protection and Control system?



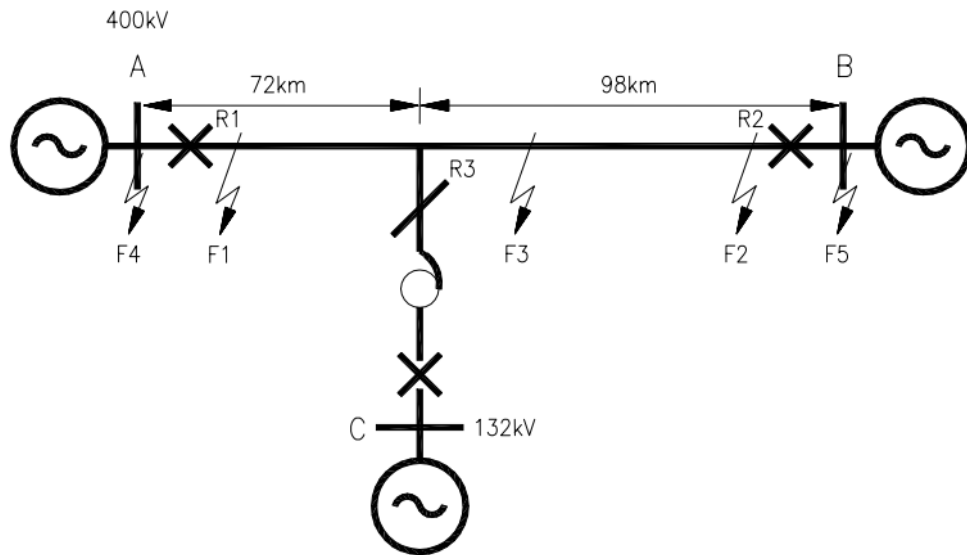
Our approach to Assess, specify and design a Centralised Protection and Control system?



Hardware Assessment

Our approach to Assess, specify and design a Centralised Protection and Control system?

ENA TS 48-6-2 Network Model

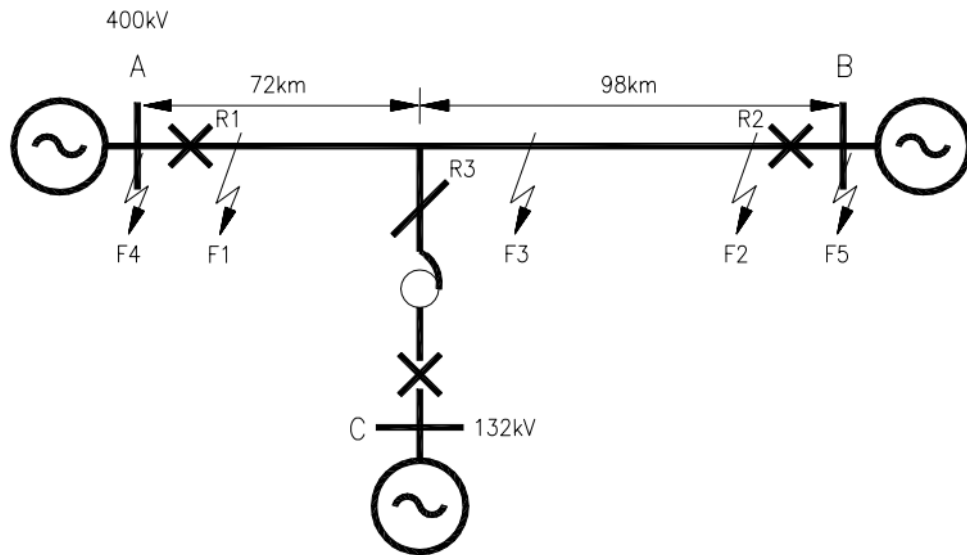


Functional Test	Type
Operating characteristic accuracy	Threshold test
Operating characteristic time	Threshold test
Fault indications	Event capture
Event recording	Event capture
Settings transfer during fault	Data stability

Functional Assessment

Our approach to Assess, specify and design a Centralised Protection and Control system?

ENA TS 48-6-2 Network Model



Test	Type
1Ph-E	Dynamic test
2Ph	Dynamic test
2Ph-E	Dynamic test
3Ph	Dynamic test
Switch onto fault	Dynamic test
Evolving faults	Dynamic test

Total of 107 fault cases

Functional Assessment

Our approach to Assess, specify and design a Centralised Protection and Control system?

Document

- Overview
- Report
- System under Test**
 - Power system
- Test sets configurations**
 - Configuration 1
 - CMC 356 - MC458V
- Test cases**
 - Test Manager
 - Table 1 tests
 - Table 2 tests
 - Table 3 tests
 - Table 4 tests
 - Table 5 tests
 - Tests: table 6



Table 2 F1		F1 - Fault type	F1 - Inception a...	F1 - Fault resista	Trip test 1(A)	Trip test 2(B)	Time stamp	Comment
1	Passed - settings changed	L1-L2	0.00 °	0.0000 Ω	32.2 ms	31.1 ms	08/07/2019 10:24:39	
2	Passed - settings changed	L1-L2	90.00 °	0.0000 Ω	29.1 ms	27.9 ms	08/07/2019 10:24:44	
3	Passed - settings changed	L1-L2	180.00 °	0.0000 Ω	29.6 ms	29.0 ms	08/07/2019 10:24:48	
4	Passed - settings changed	L1-L2	0.00 °	5.0000 Ω	30.6 ms	29.9 ms	08/07/2019 10:24:53	
5	Passed - settings changed	L1-L2	0.00 °	10.0000 Ω	30.8 ms	29.6 ms	08/07/2019 10:24:58	

Cursors

A: 117.80 ms B: 150.60 ms

B - A = 32.804 ms

TAUNTON VOLTS

V L1-N sec.: 28.800 V < -60.03 °

V L2-N sec.: 28.800 V < -60.03 °

V L3-N sec.: 57.600 V < 119.97 °

TAUNTON CURRENT

I L1 sec.: 0.0000 A < NaN

I L2 sec.: 0.0000 A < NaN

I L3 sec.: 0.0000 A < NaN

INDIAN QUEENS VOLTS

V L1-N sec.: 29.620 V < -51.06 °

V L2-N sec.: 28.720 V < -69.29 °

V L3-N sec.: 57.600 V < 119.97 °

INDIAN QUEENS CURRENT

I L1 sec.: 0.0000 A < NaN

Power system

Relay A - CT A - 3xI

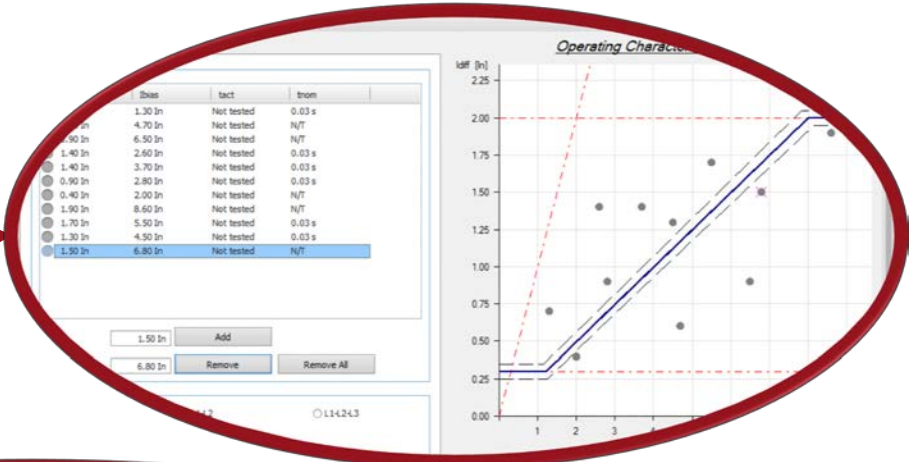
Relay A - Binary outputs

Functional Assessment

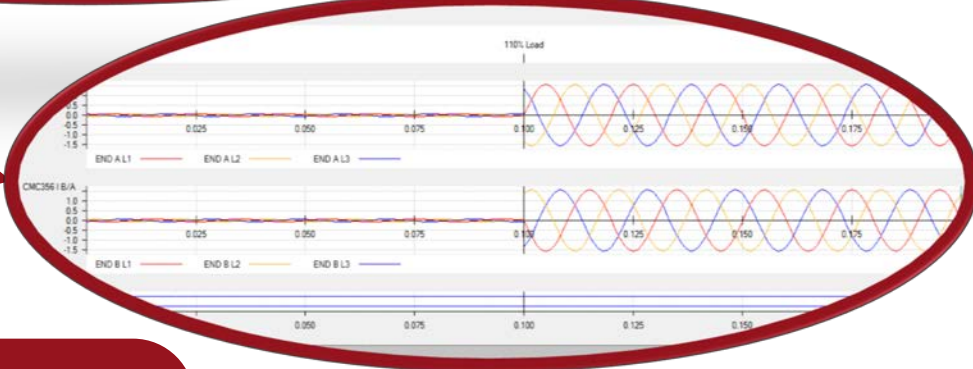
Our approach to Assess, specify and design a Centralised Protection and Control system?

SOLKOR TEST DOCUMENT_v1...

- SOLKOR TEST DOCUMENT_v1.occ
 - Circuit in ENA TS48-6-2
 - Hardware Configuration
 - AuxDC Configuration
 - MEASUREMENTS CHECK
 - Steady State Tests
 - 2.1 Steady State Tests
 - 2.1.1 (shot test) Diff Operating Characteristic
 - 2.1.1 (search test) Diff Operating Characteristic
 - 2.1.2 Diff Trip Time Characteristic
 - 2.1.4 Indications and Recording
 - 2.1.5 Online data exchange
 - Dynamic Tests
 - 2.2 Dynamic Tests
 - 2.2.1 Table 1 results (Ph-E faults)
 - Microsoft Excel Macro-Enabled Worksheet
 - Fault 2
 - Microsoft Excel Macro-Enabled Worksheet
 - Fault 5 Fault 2: 5ms and 40ms
 - Microsoft Excel Macro-Enabled Worksheet
 - 2.2.4 Load Increase 5% to 110%
 - 2.2.4 Line energisation
 - 2.2.1 DIFF STABILITY CHECK?
 - 2.3.3 Comms failure (remove fibre)
 - 2.3.3 Testing comms failure
 - 2.3.3 One relay out (supply off)
 - 2.3.3 Testing one relay out
 - 2.3.4 Protection Star Up after failure
 - Final Comments



	F1 - Inception	F1 - Fault						
	F1 - Fault type	angle [°]	resistance (RF) [Ω]	Trip test 1(A) [s]	Min [s]	Max [s]	Trip	
1 Passed	L1-N	0	0	0.0292	0	0.2	0.0277	
2 Passed	L1-N	90	0	0.029	0	0.2	0.0277	
3 Passed	L1-N	180	0	0.0277999	0	0.2	0.0277	
4 Passed	L1-N	0	10	0.0296	0	0.2	0.0277	
5 Passed	L1-N	0	50	0.0328	0	0.2	0.0277	
6 Passed	L1-N	0	0	0.0304	0	0.2	0.0277	



Functional Assessment

Our approach to Assess, specify and design a Centralised Protection and Control system?

Advantages

Compliance with standards specified can be verified and compared with vendor reports submitted for Assessment

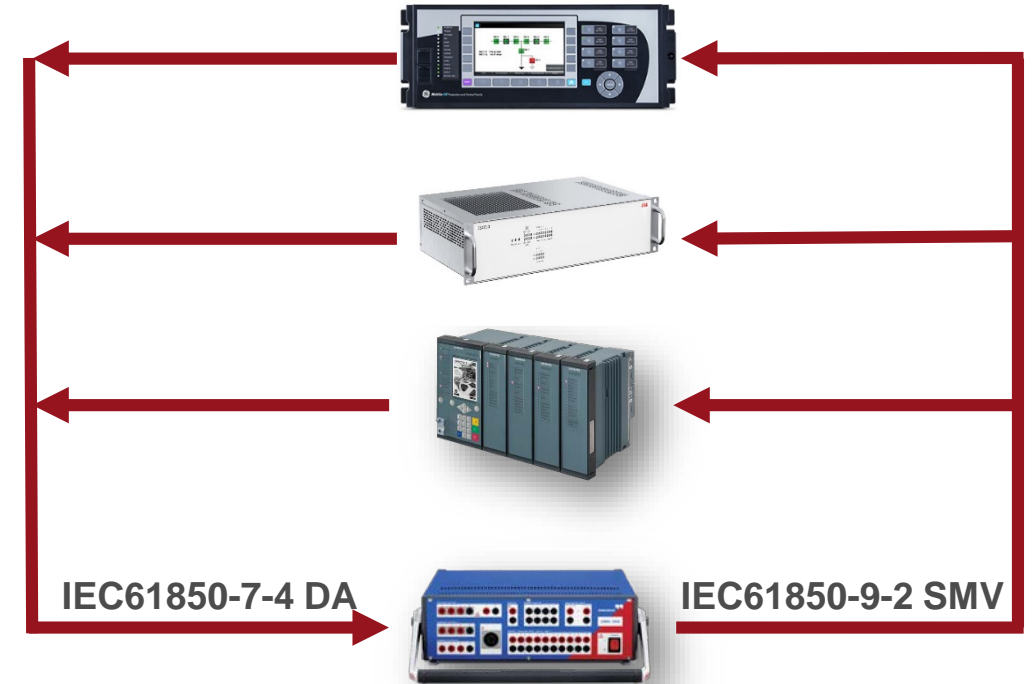
Consistent Assessment method across different vendor assets on the network

Cyber security patches can be verified through regression testing very quickly in a lab environment closing vulnerabilities quickly and efficiently

IEC 61850 data attributes from logical nodes can be confirmed during Assessment phase

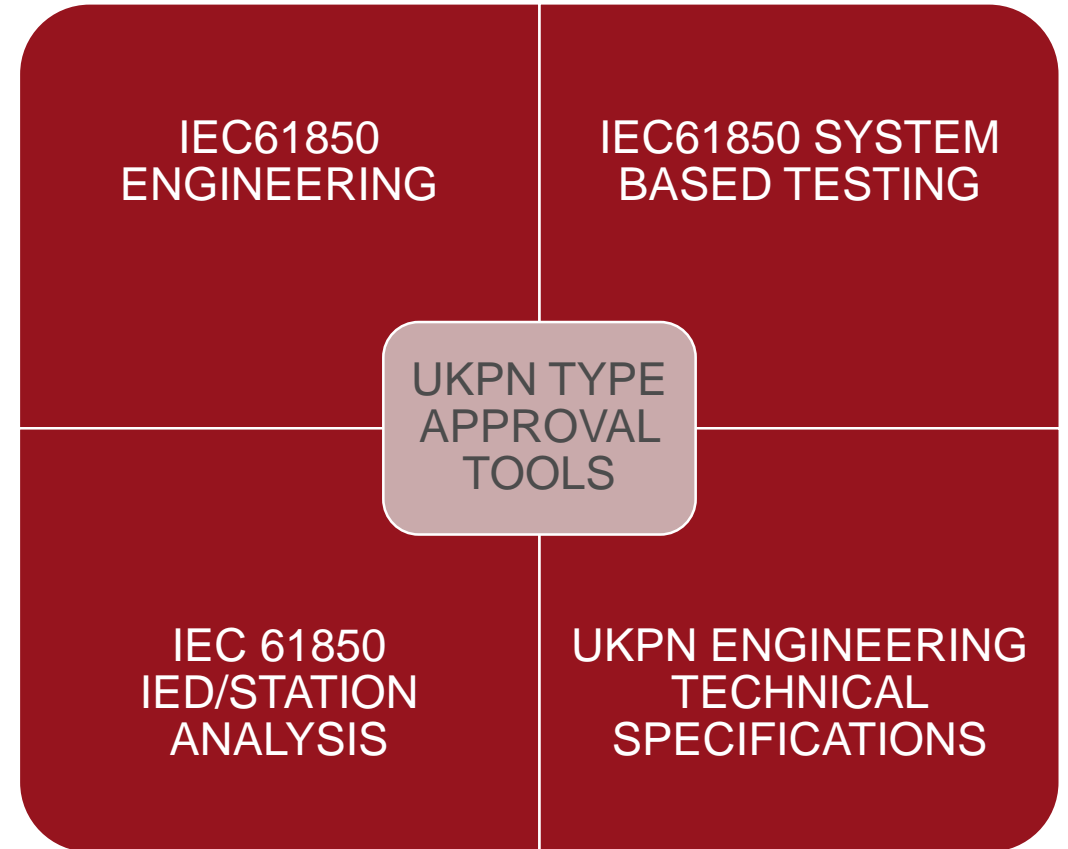
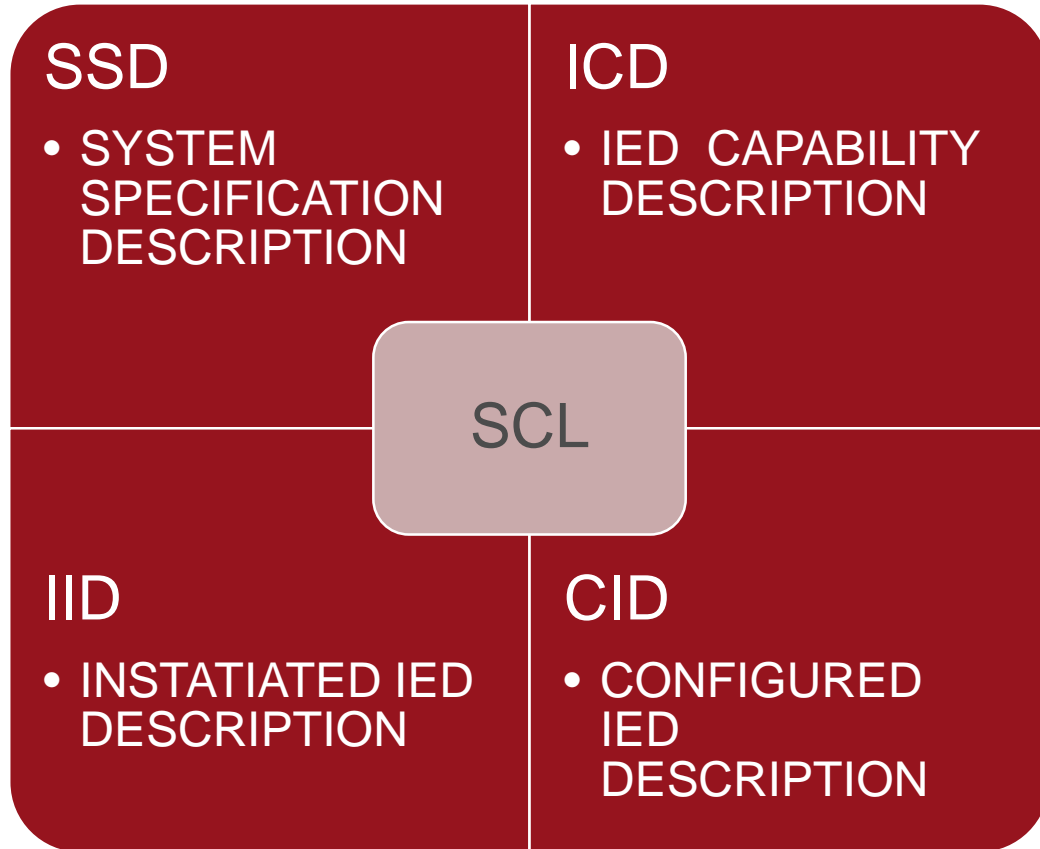
Network model can be easily modified for project specific queries or investigations

New functions or upgrades can be assessed before being deployed on the live network



Functional Assessment

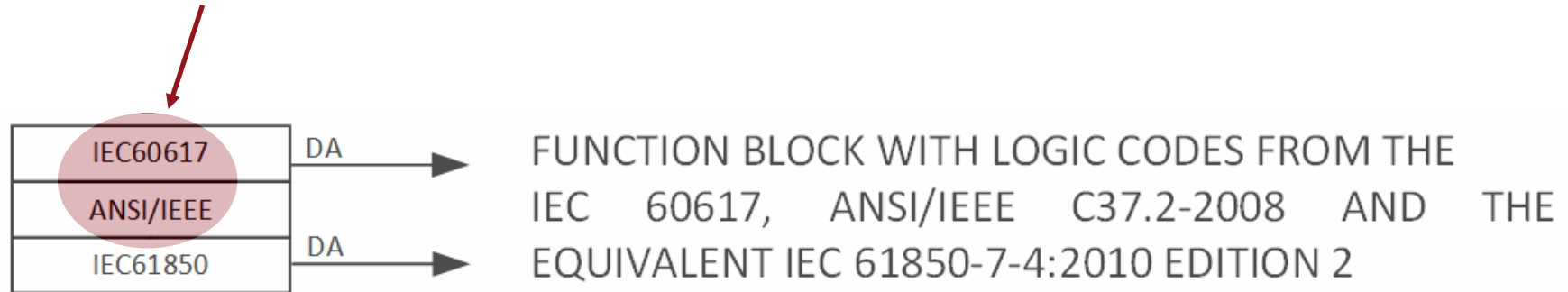
Our approach to Assess, specify and design a Centralised Protection and Control system?



UKPN Type approval

Our approach to Assess, specify and design a Centralised Protection and Control system?

ANSI AND IEC STANDARDS FOR FLEXIBILITY



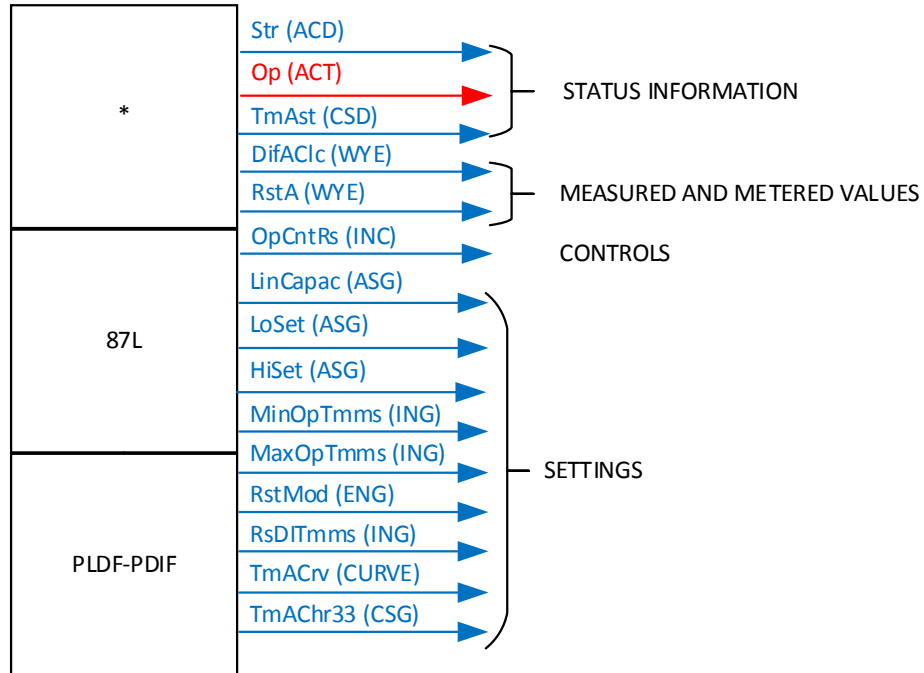
SPECIFIED INLINE WITH IEC61850-7-4:2010 EDITION 2

UKPN Type approval (SSD)

Our approach to Assess, specify and design a Centralised Protection and Control system?

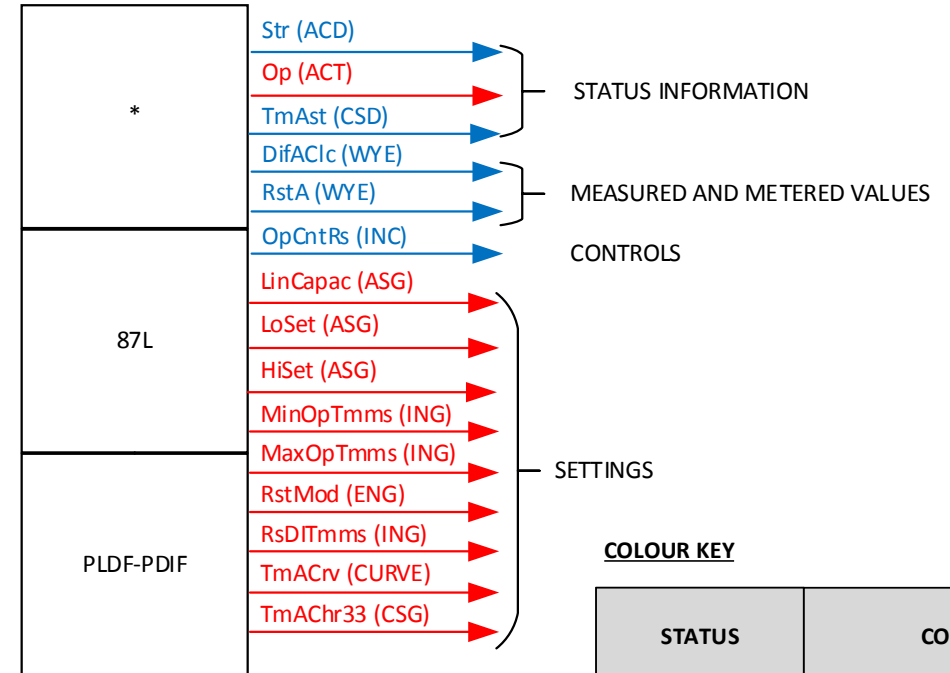
IEC61850-7-4 SPEC

DIFFERENTIAL LINE PROTECTION



UKPN SPEC

DIFFERENTIAL LINE PROTECTION

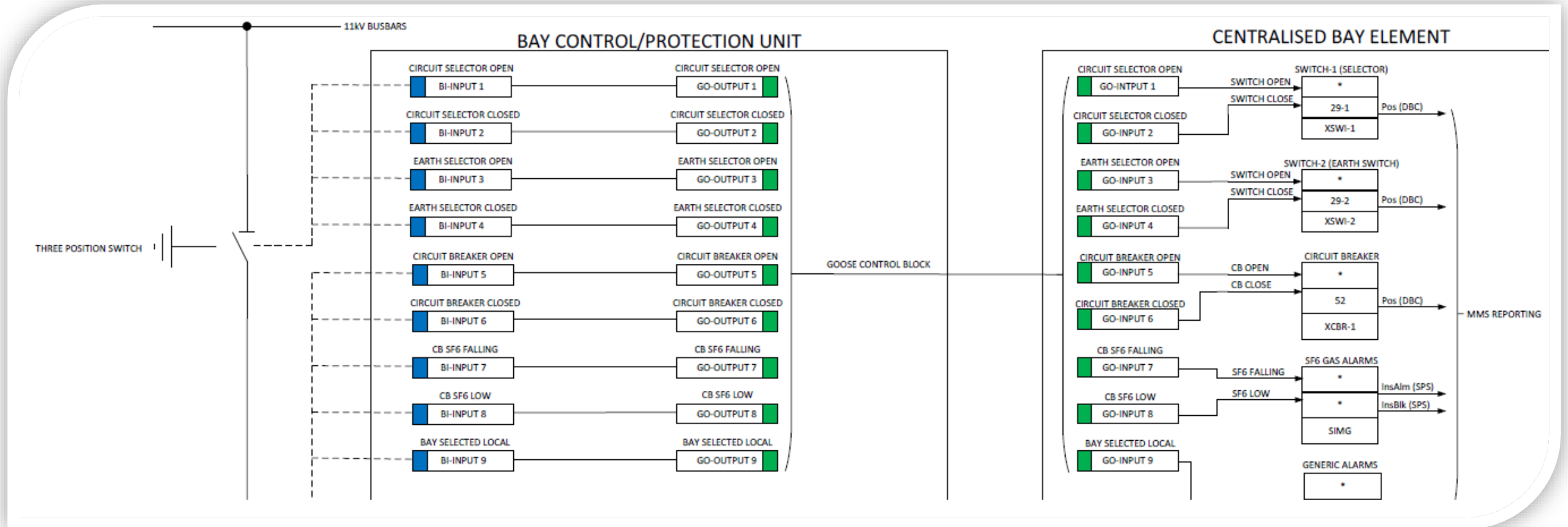


COLOUR KEY

STATUS	COLOUR
MANDATORY	Red
OPTIONAL	Blue
CONDITIONAL	Green

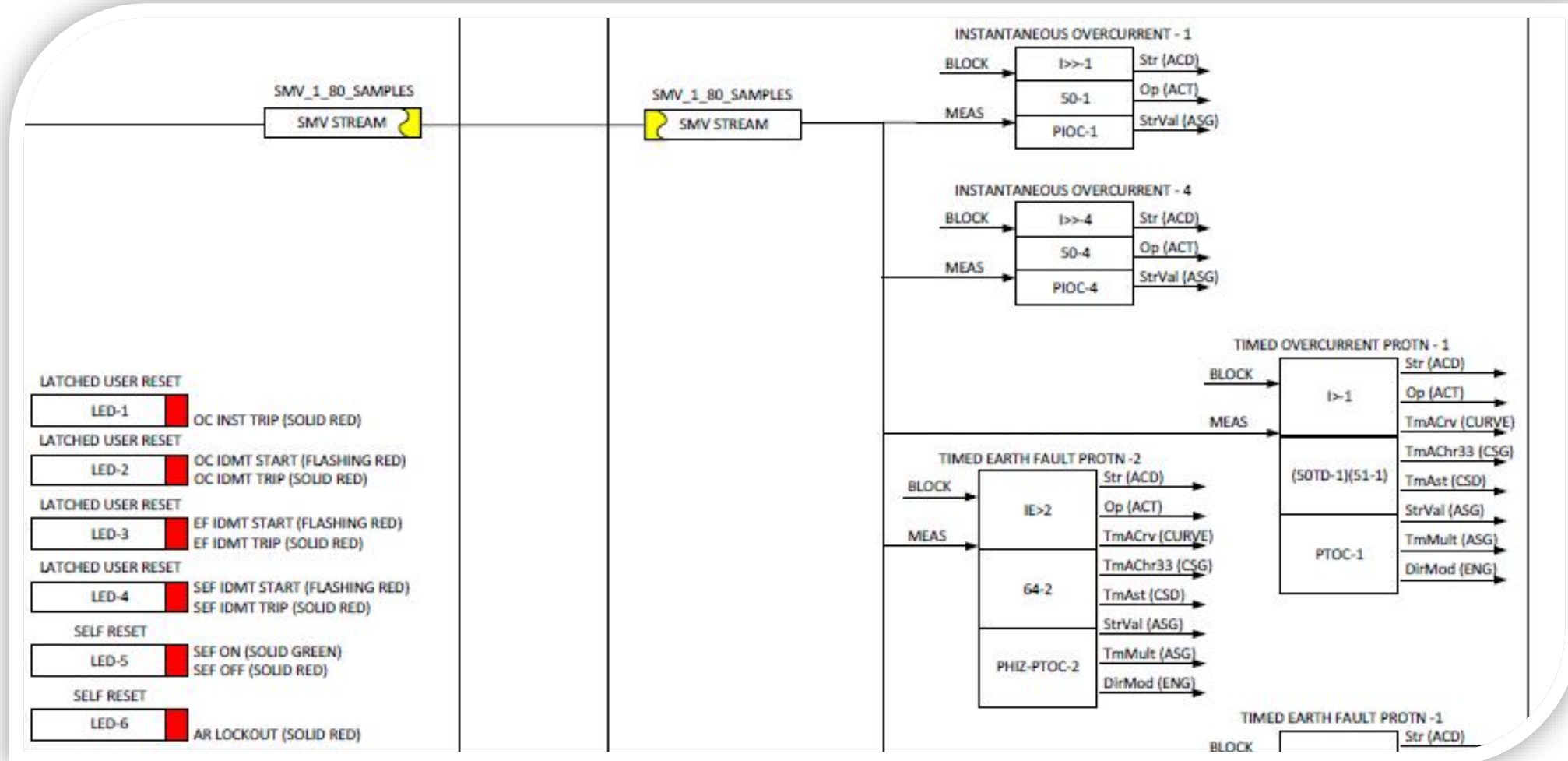
UKPN Type approval (SSD)

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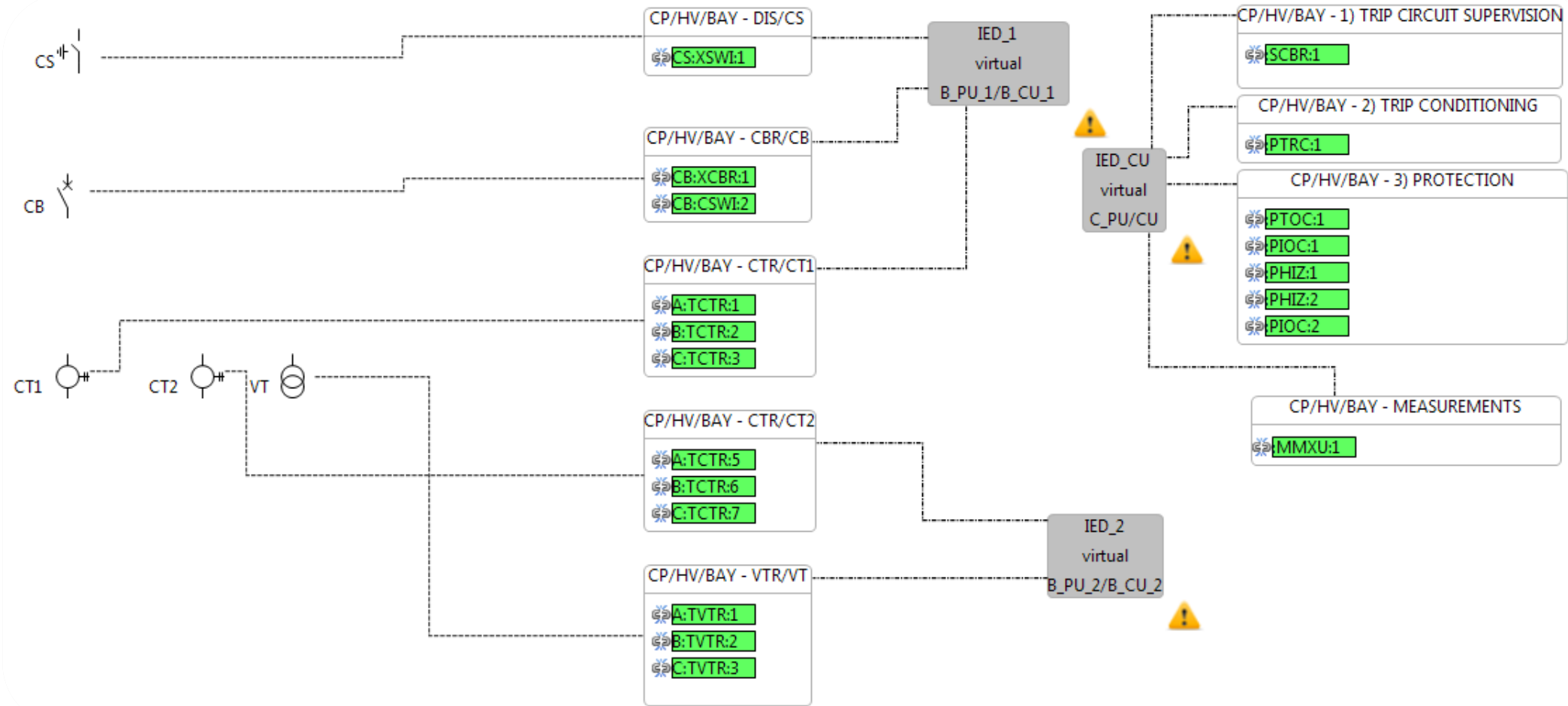
UKPN Type approval (SSD)

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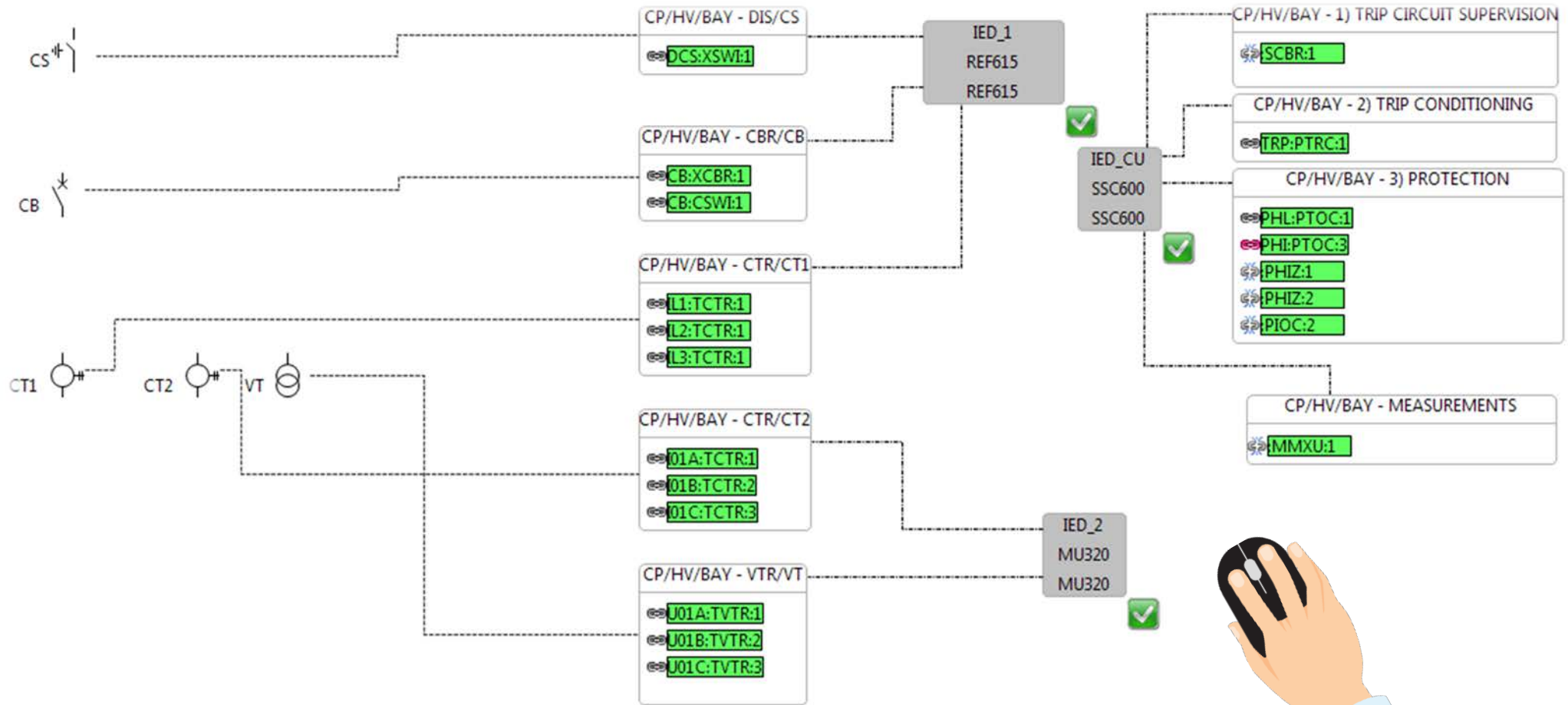
UKPN Type approval (SSD)

Our approach to Assess, specify and design a Centralised Protection and Control system?



UKPN Type approval (SSD)

Our approach to Assess, specify and design a Centralised Protection and Control system?



UKPN Type approval

Our approach to Assess, specify and design a Centralised Protection and Control system?

UPDATE UKPN STANDARD LIBRARY



PUBLISH ENGINEERING APPROVAL

UK Power Networks logo

Document Number: EAS 05-0031
Version: 1.0
Date: 16/07/2019

ENGINEERING APPROVAL STANDARD

EAS 05-0031

IEC61850 : SIEMENS SIPROTEC 5 7SJ85

Network(s): EPN, LPN, SPN, Private Networks

Summary: This equipment approval standard IEC 61850 Application Engineering, Standard configurations and setting information

Author: Colin Scoble **Date:** 16/07/2019

Approver: Paul Williams **Date:** 16/07/2019

ARCHIVE Assessment REPORTS

SOLKOR TEST DOCUMENT_v1... x

- SOLKOR TEST DOCUMENT_v1.occ
 - Circuit in ENA TS48-6-2
 - Hardware Configuration
 - AuxDC Configuration
 - MEASUREMENTS CHECK
 - Steady State Tests
 - 2.1 Steady State Tests
 - 2.1.1 (shot test) Diff Operating Characteristic
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 - 2.1.2 Diff Trip Time Characteristic

UKPN Type approval

How will we test and maintain our new Centralised Protection and Control systems?

ONLY MAINTAIN WHEN SYSTEM TELLS YOU



CYBER SECURITY PATCH

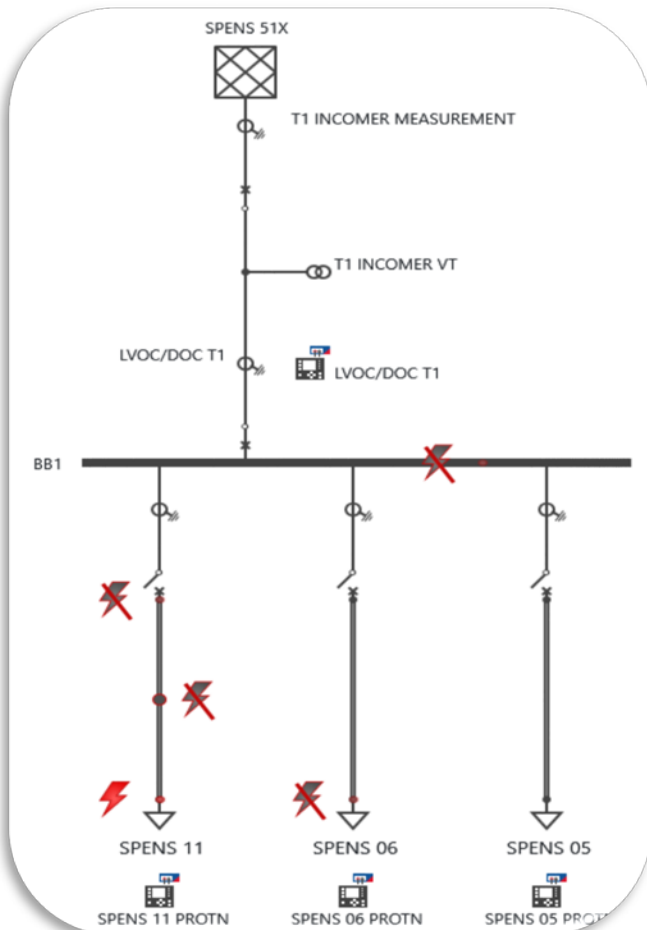


UPGRADES



How will we test and maintain our new Centralised Protection and Control systems?

SYSTEM TEST MODEL



INJECTED QUANTITIES

▲ FAULT INFEEED			
I L1 prim.:	1.9051 kA	∠	-20.99 °
I L2 prim.:	1.8594 kA	∠	161.18 °
I L3 prim.:	84.630 A	∠	102.75 °
▲ ROUGH BALANCE			
V L1-N prim.:	15.996 kV	∠	-22.29 °
V L2-N prim.:	11.836 kV	∠	-118.26 °
V L3-N prim.:	18.884 kV	∠	119.15 °
I L1 prim.:	1.9051 kA	∠	-20.99 °
I L2 prim.:	1.8594 kA	∠	161.18 °
I L3 prim.:	84.630 A	∠	102.75 °
▲ FEEDER RELAY			
V L1-N prim.:	NaN	∠	NaN
V L2-N prim.:	NaN	∠	NaN
V L3-N prim.:	NaN	∠	NaN
I L1 prim.:	1.9051 kA	∠	-20.99 °
I L2 prim.:	1.8594 kA	∠	161.18 °
I L3 prim.:	84.630 A	∠	102.75 °

NETWORK PARAMETERS

Line 1

Name:

Show label

Nominal current:

Length:

Line impedances:

Z1:

Z0:

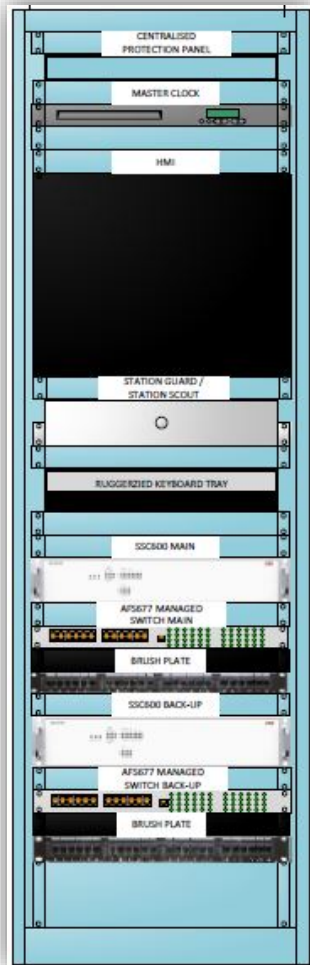
Line protection orientation:

Enable mutual coupling:

Enable capacitance:

The Centralised Protection and Control system and its benefits

GENERAL ARRANGEMENT DESIGN



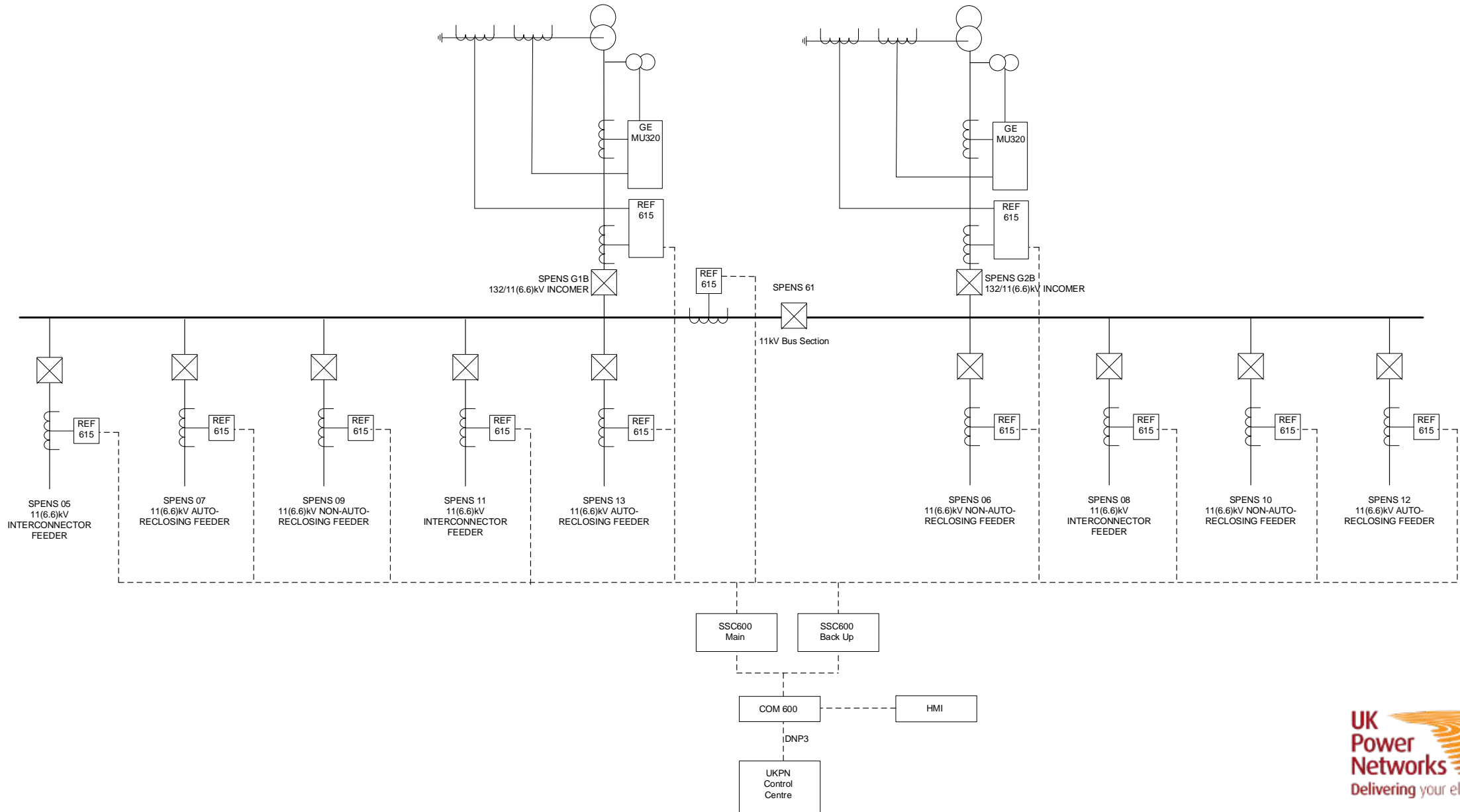
CENTRALISED PROTECTION CUBICLE



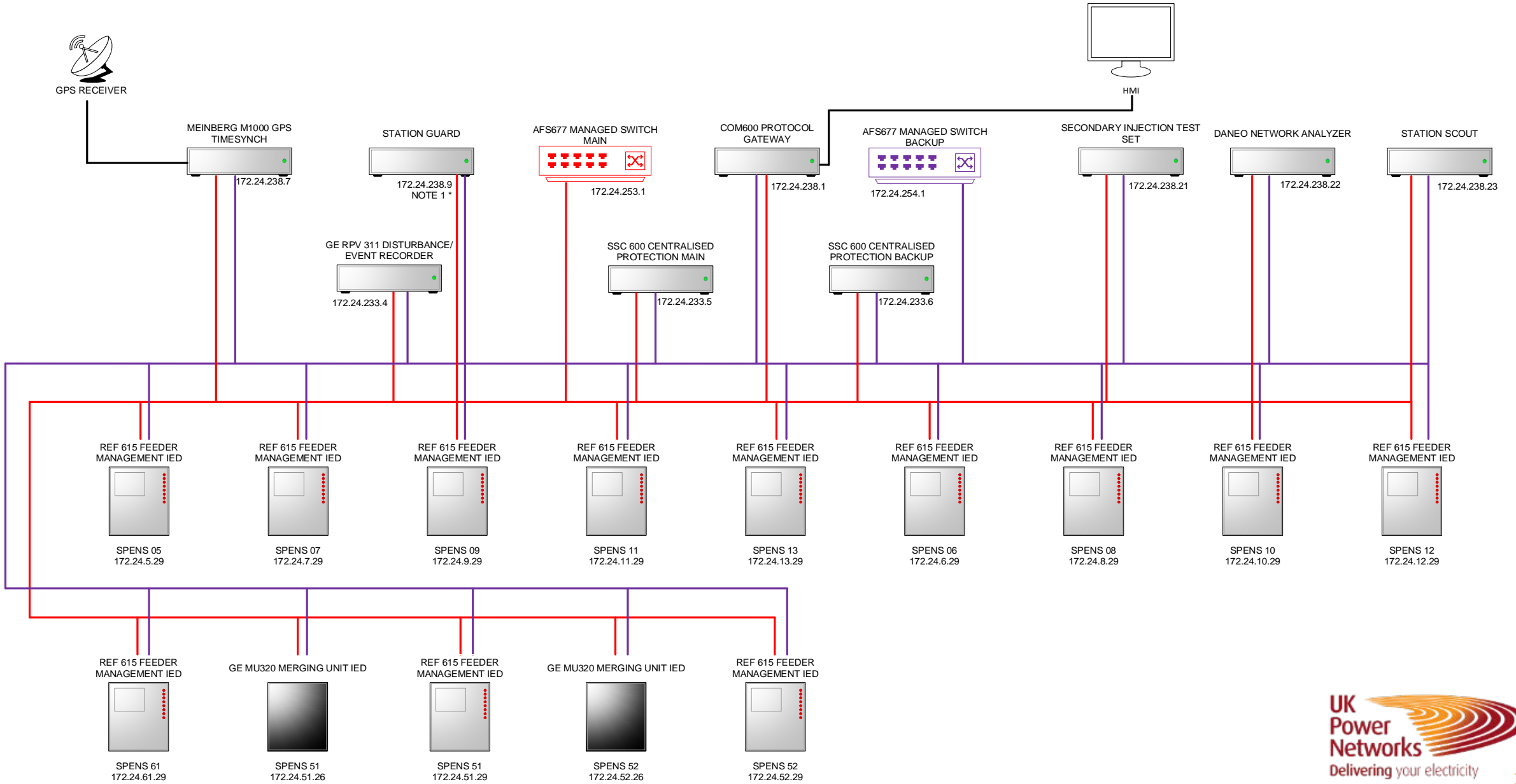
RETROFIT SWITCHGEAR



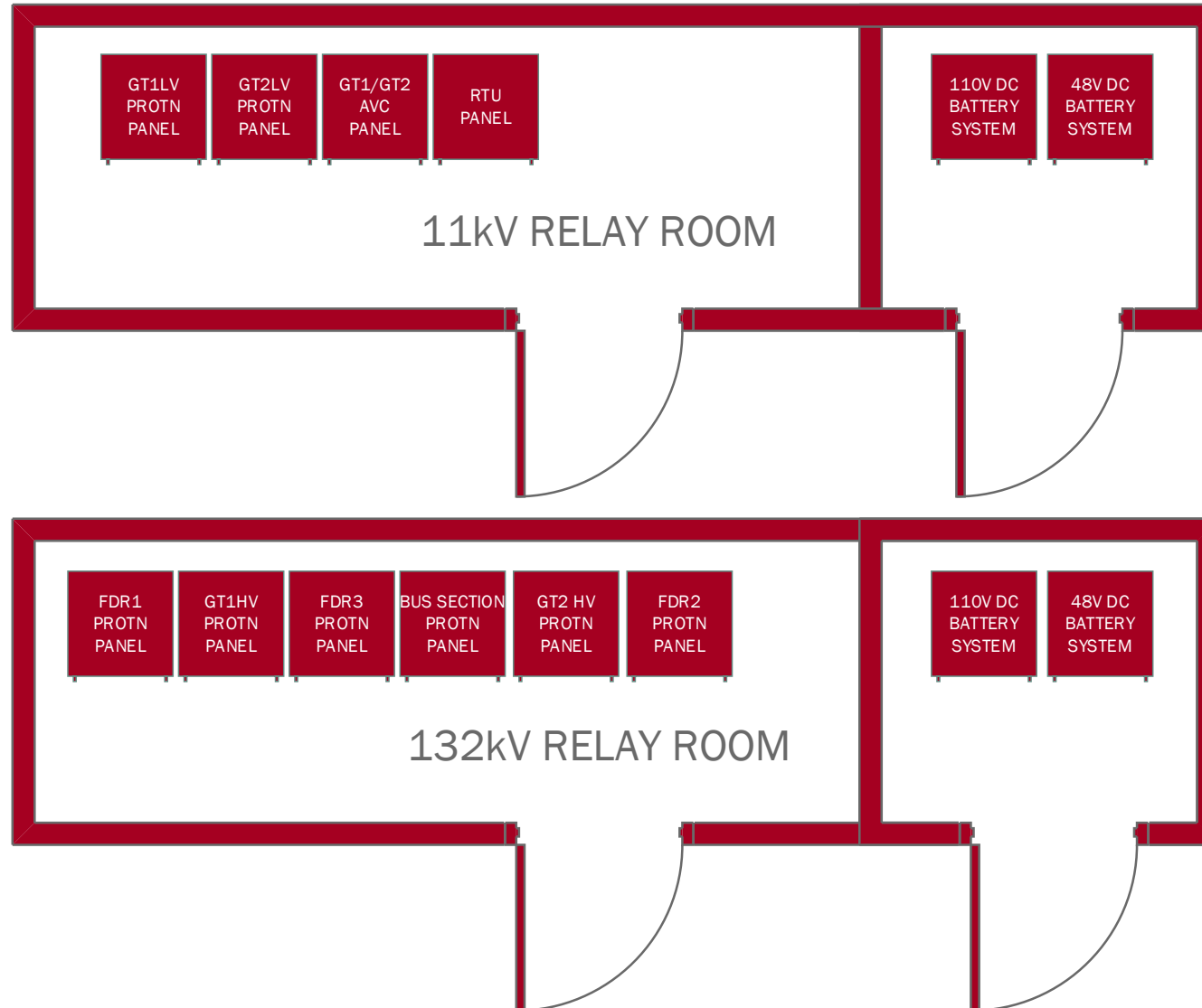
The Centralised Protection and Control system and its benefits



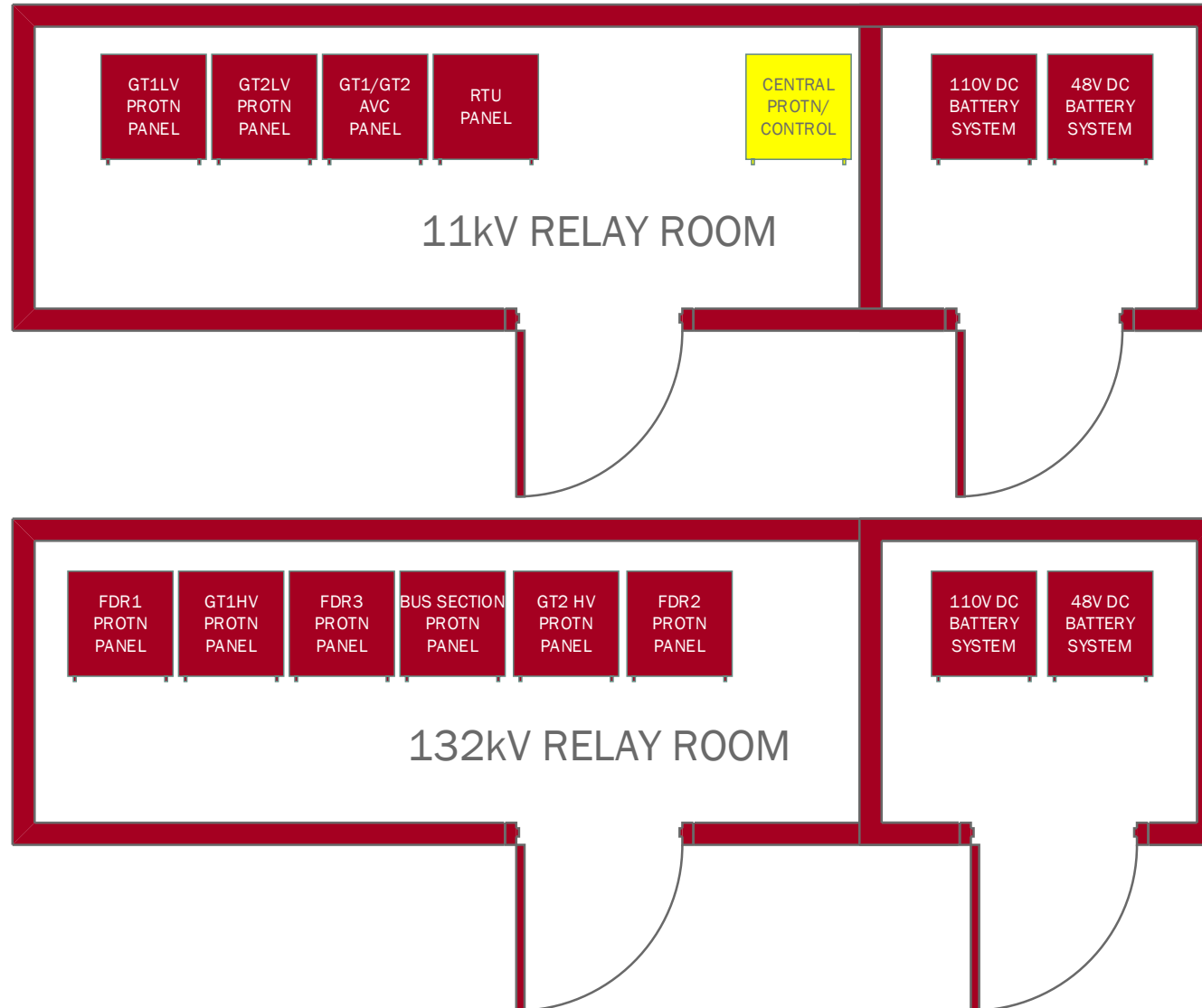
The Centralised Protection and Control system and its benefits



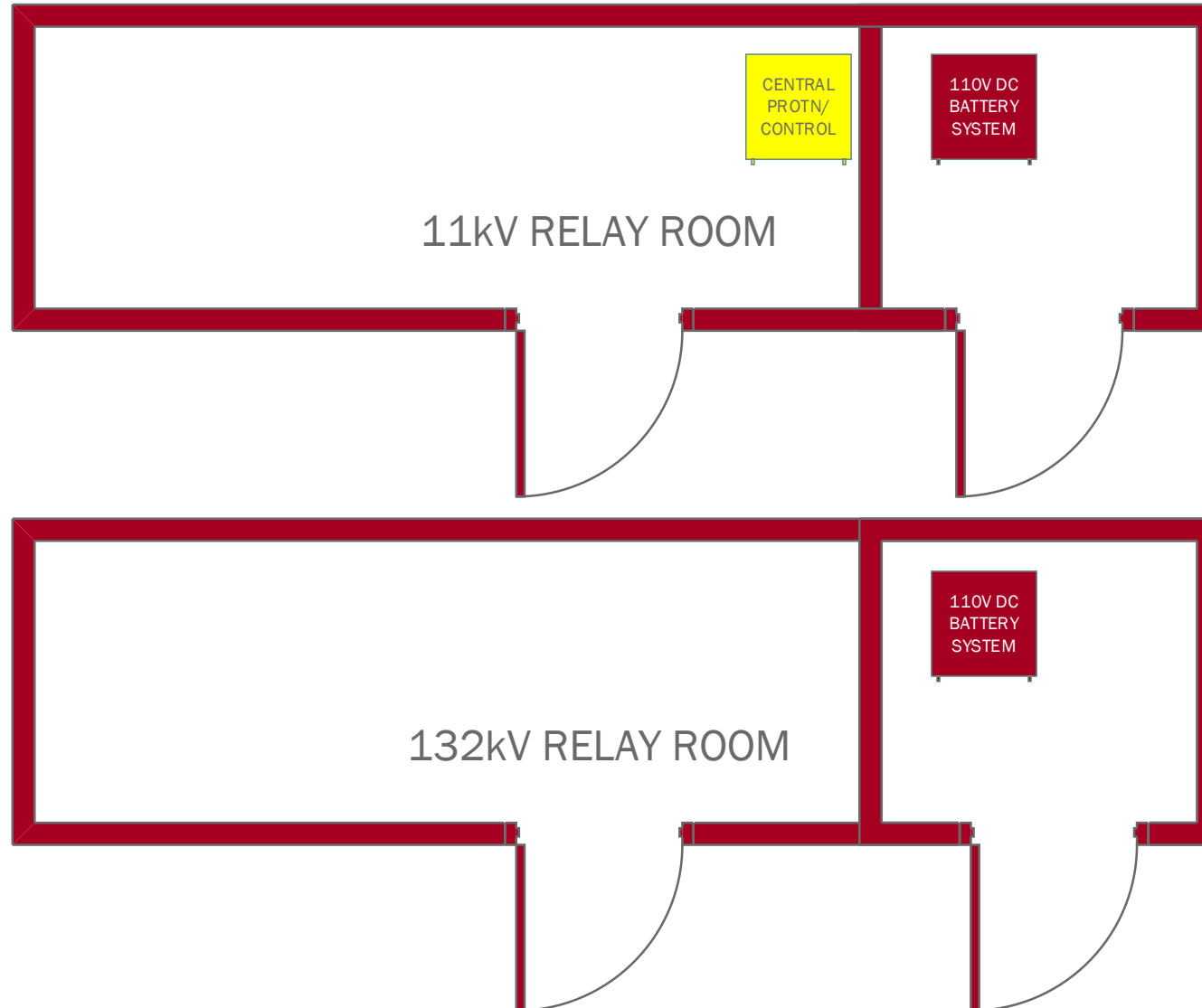
The Centralised Protection and Control system and its benefits



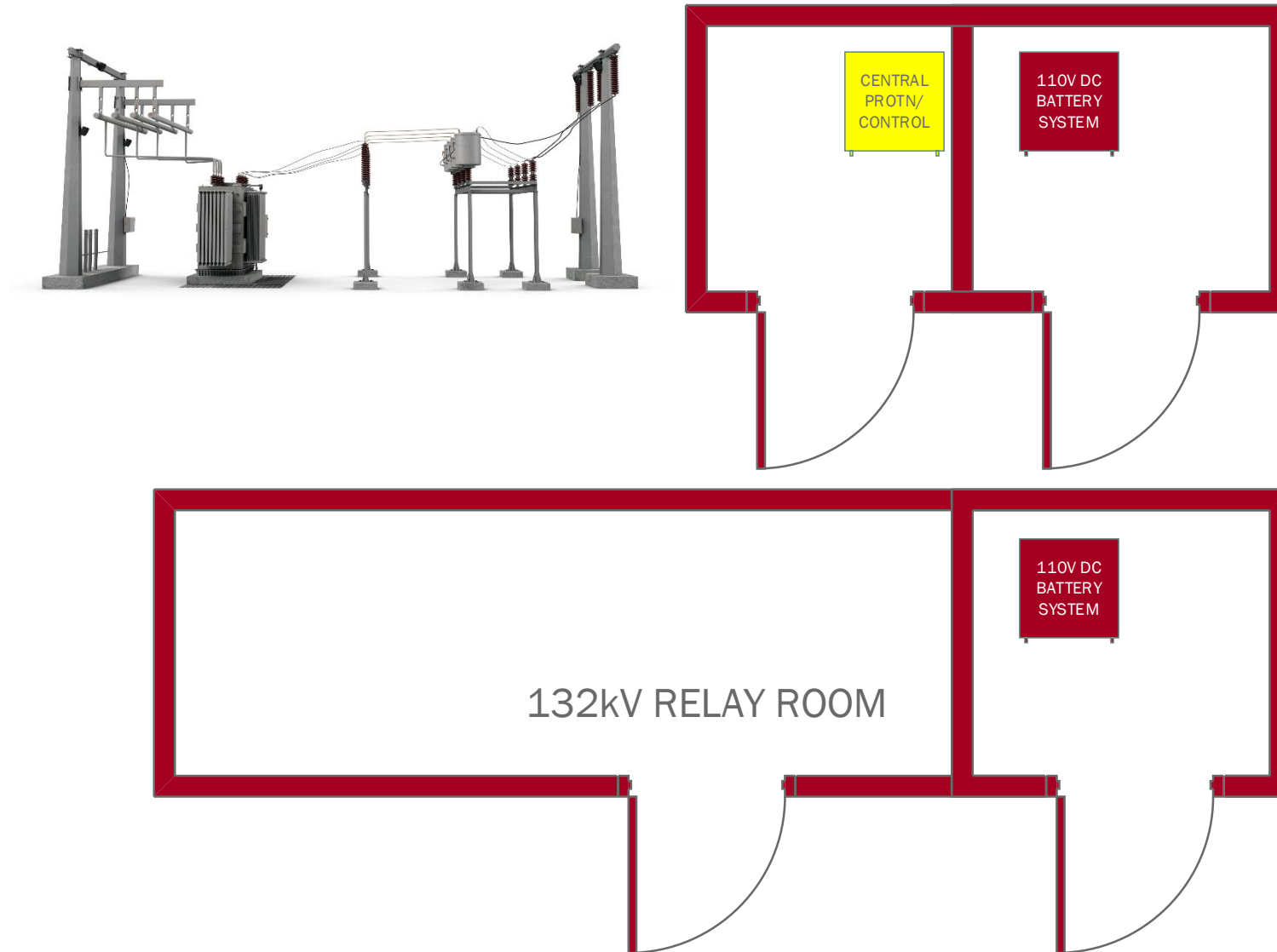
The Centralised Protection and Control system and its benefits



The Centralised Protection and Control system and its benefits



The Centralised Protection and Control system and its benefits



NIA PROJECT - UNIFIED PROTECTION PROJECT

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Conclusions

A new strategy on how we Assess a centralised protection and control system was required. This included an opportunity to align our specifications to the latest standards and communicate clearly to vendors

We identified opportunities to drastically reduce our substation footprint and reduce Engineering, Commissioning and maintenance time providing TOTEX cost efficiency benefits

Greater opportunities to complete full system testing prior to circuit transfers which reduces network risk and outage durations

Look to obtain additional funding in RII0-ED2 (2023-2031) period to accelerate deployment of these systems

Thank you Questions?

