11146

B5 PROTECTION & AUTOMATION

PS1 Practical experiences and new developments of process bus

The Full Digital Substation Success in Vietnam

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Electricity Vietnam (EVN)

Transmission and Distribution Service Operator (TSO & DSO)
Deploy 10 (9 EVN, 1 IPP) full digital substations (IEC 61850 station bus + process bus) despite Covid restriction

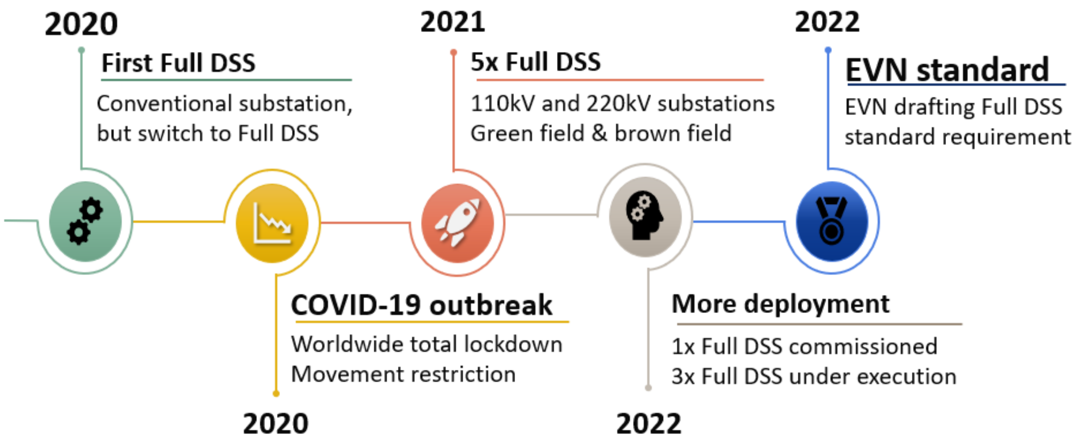
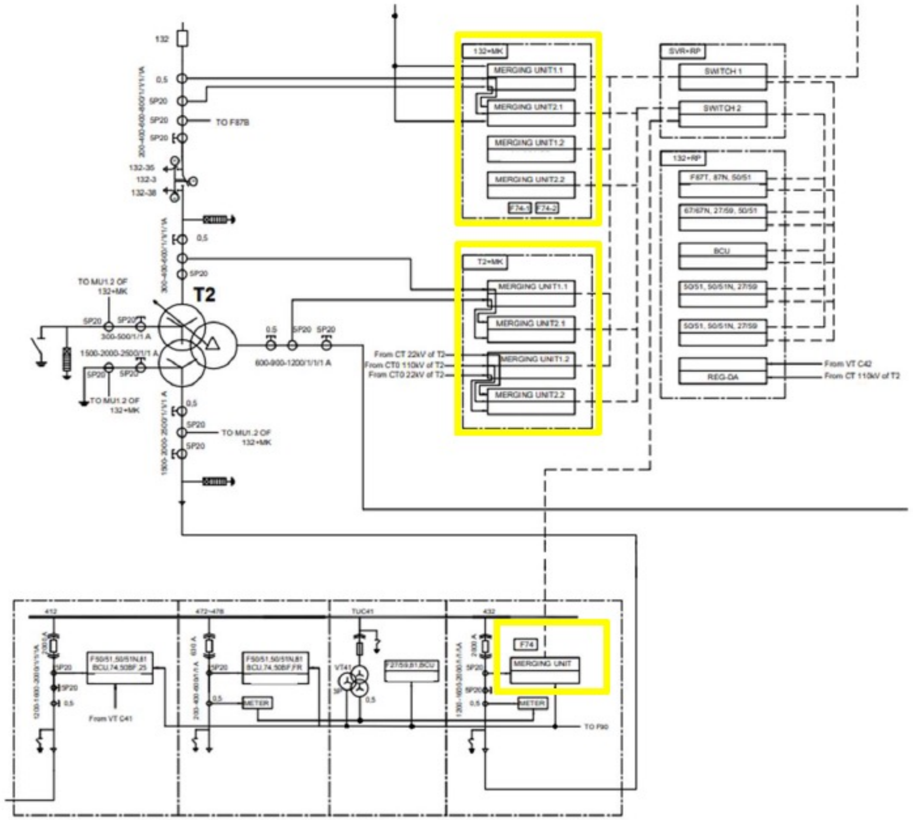


Figure 1 – Timeline

Typical EVN substation: 1-Line



Outdoor Marshalling Kiosk

Metal-Clad MV Switchgear Application

Architecture

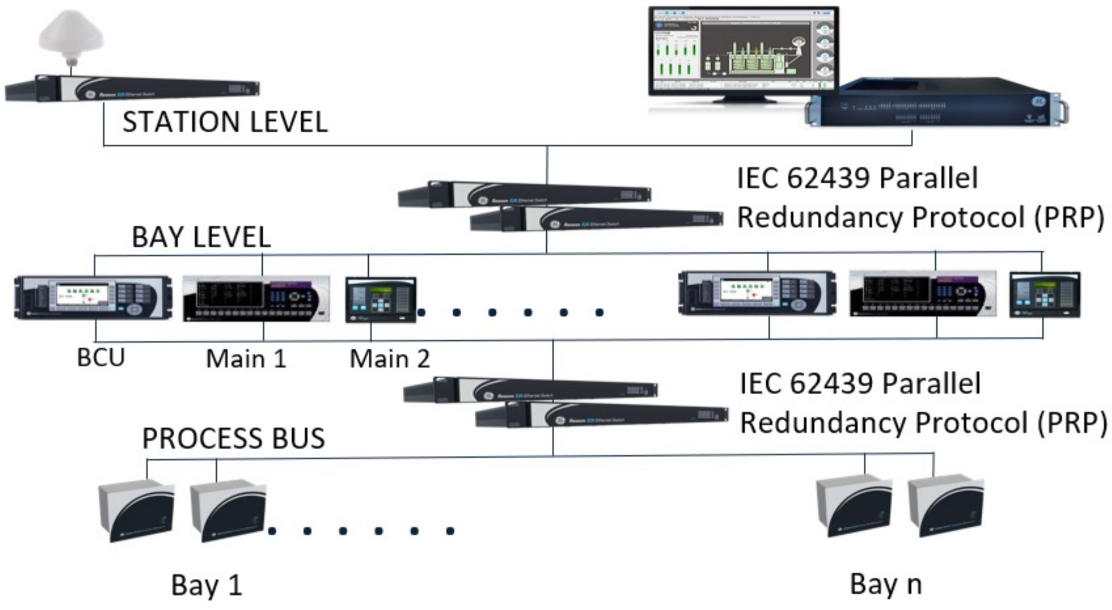
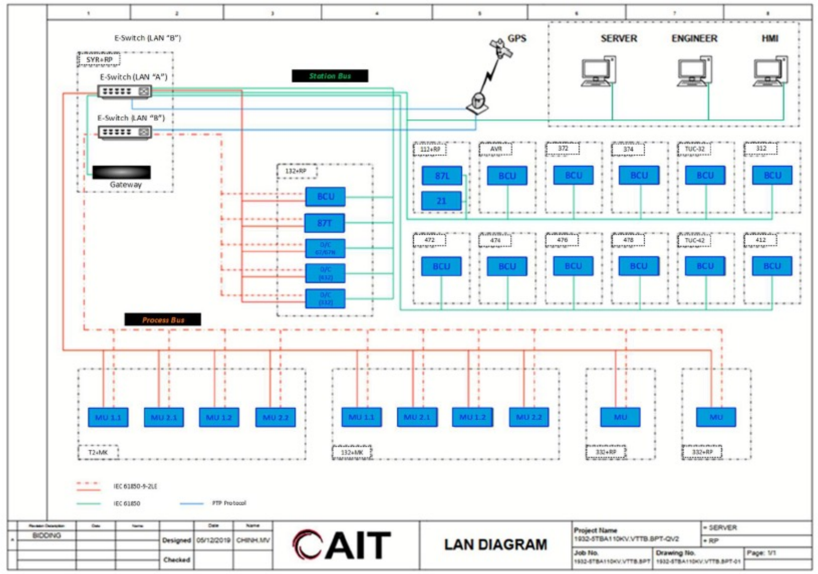


Figure 2 – Conceptual architecture

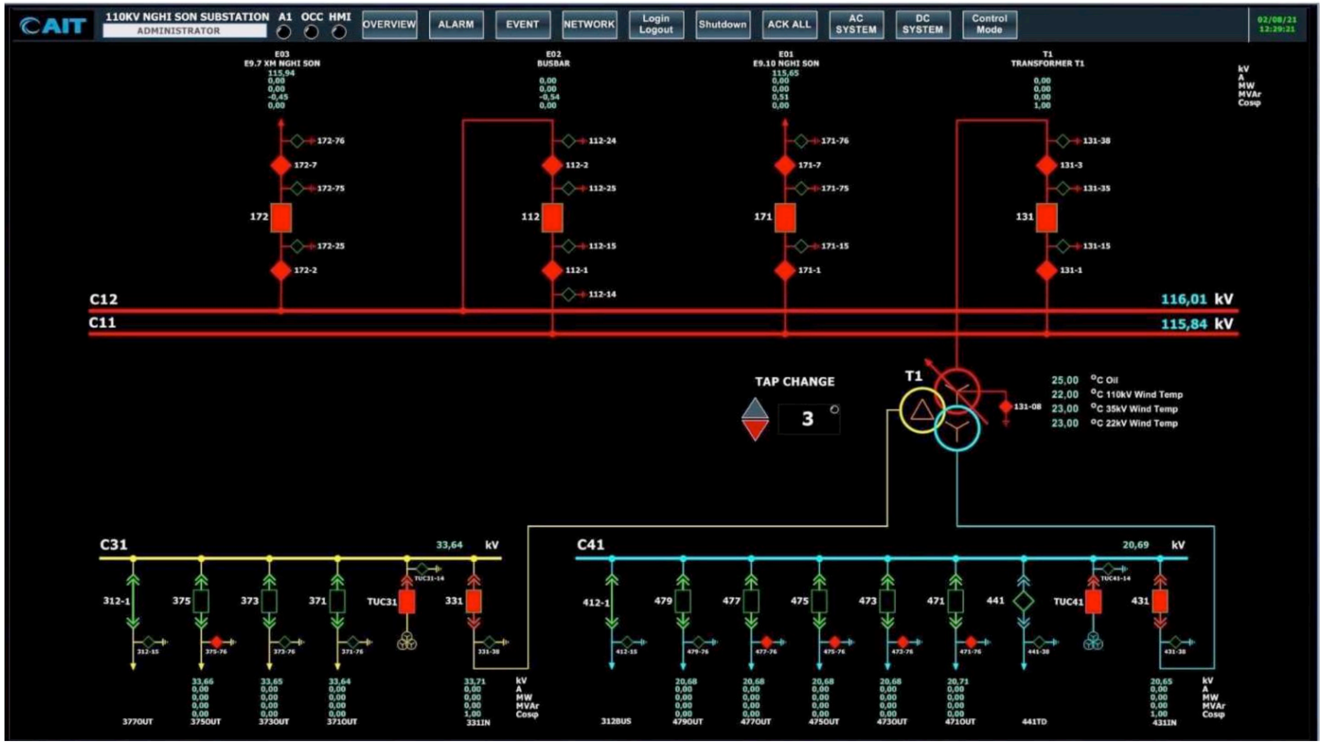
Separate process bus and station bus

IEC 62439 Parallel Redundancy Protocol (PRP) Ethernet



Application Development Concurrent with Lab Scheme Testing

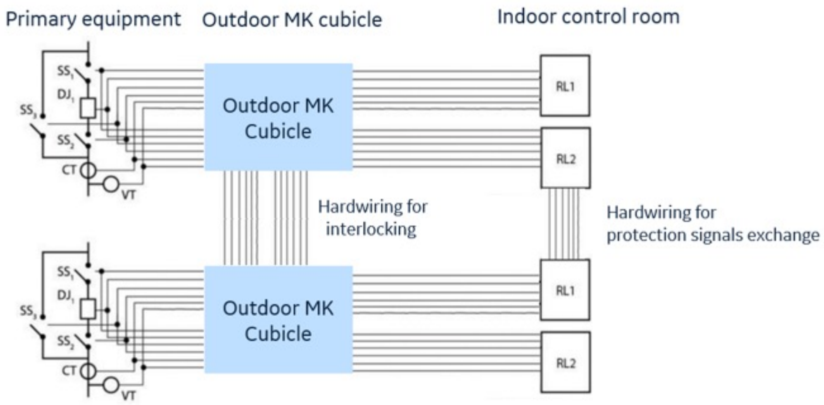
Example EVN Substation: 110kV Nghi Son Full DSS



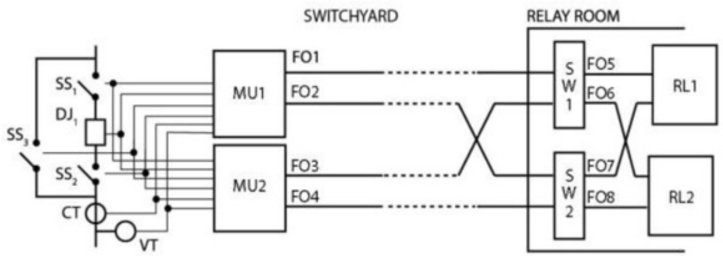
One Line and HMI Example

Subtransmission to Two Primary Distribution Voltages Distribution using Draw Out Metal-Clad Switchgear

PACS operating time



Conventional substation scheme



Digital substation scheme

- PACS performance and reliability must never be compromised but must be equivalent or better than the conventional substation

	Total clearance time including primary breaker trip time (EVN requirement <100ms)	
	Conventional substation (cooper wires + protection relay)	Digital substation (merging unit + protection relay)
Transformer protection	<100ms	<100ms
Distance protection	<100ms	<100ms

Table 1: commissioning testing test result

PACS Reliability

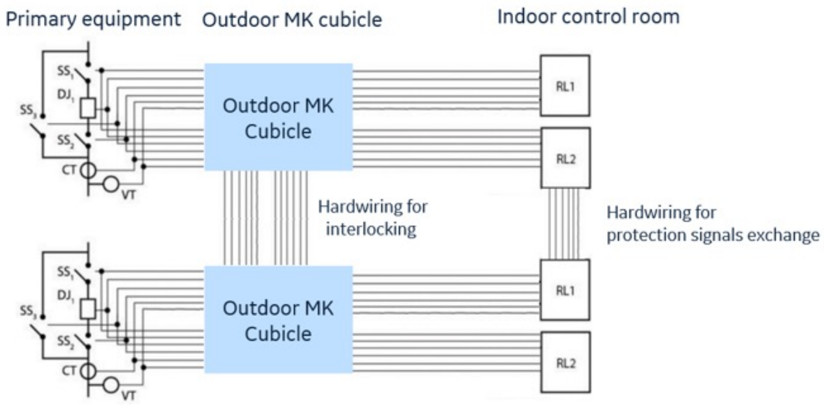
PACS Reliability Study

- Reliability is the Probability of a Device Performing Properly, for a Certain Time Period, Under Given Operating Conditions

$$R_{component} = e^{(-t/MTBF)}$$

Element	MTBF (years)	Reliability
Protection relay	300	0.9967
Merging Unit	300	0.9967
Ethernet Switch	100	0.9900
Copper Cables	100	0.9900
Fiber Optic Cables	100	0.9900

PACS Reliability – Conventional substation

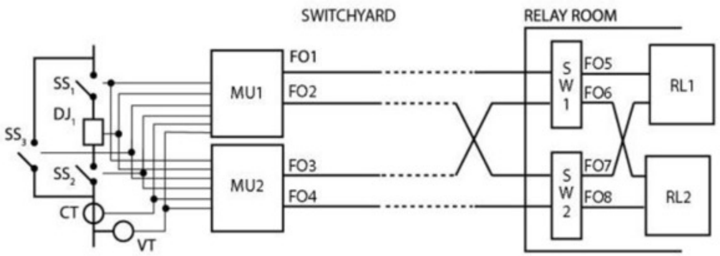


$$R_{component} = e^{(-t/MTBF)}$$

$$R_{conventional} = [1 - (1 - R_{CC1} * R_{RL1})*(1 - R_{CC2} * R_{RL2})]$$

Element	MTBF (years)	Reliability
Protection relay	300	0.9967
Merging Unit	300	0.9967
Ethernet Switch	100	0.9900
Copper Cables	100	0.9900
Fiber Optic Cables	100	0.9900

PACS Reliability – Full digital substation



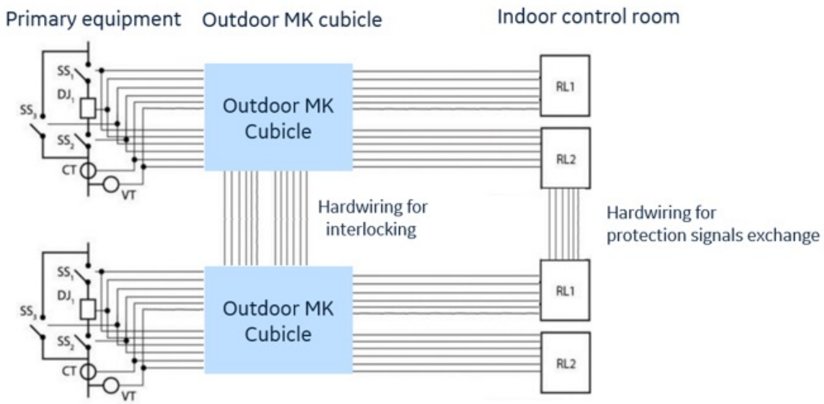
Redundant scheme for every equipment

$$R_{component} = e^{(-t/MTBF)}$$

$$R_{digitalsubstation} = [1 - [1 - [[1 - ((1 - R_{FO1})*(1 - R_{FO3}))]*[1 - ((1 - R_{FO5})*(1 - R_{FO7}))]*R_{SW1}]] * [1 - [[1 - ((1 - R_{FO2})*(1 - R_{FO4}))]*[1 - ((1 - R_{FO6})*(1 - R_{FO8}))]*R_{SW2}]]] * [1 - [(1 - R_{MU1})*(1 - R_{MU2})]] * [1 - [(1 - R_{RL1})*(1 - R_{RL2})]]* [1 - [(1 - R_{FO1})*(1 - R_{FO2})*(1 - R_{MU2})]] *[1 - [(1 - R_{FO3})*(1 - R_{FO4})*(1 - R_{MU1})]]$$

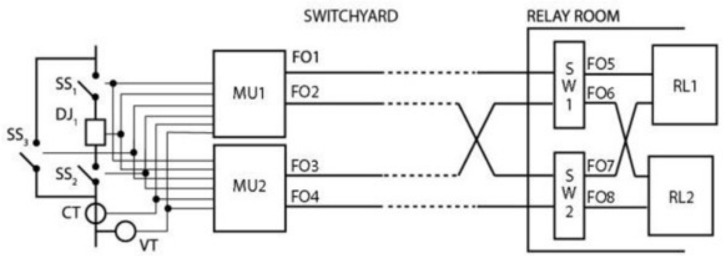
Element	MTBF (years)	Reliability
Protection relay	300	0.9967
Merging Unit	300	0.9967
Ethernet Switch	100	0.9900
Copper Cables	100	0.9900
Fiber Optic Cables	100	0.9900

PACS Reliability



Conventional substation scheme

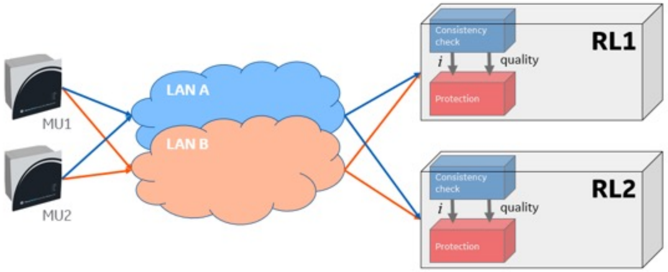
Reliability = $R_{copper\ cables}$ & R_{relay}
= 0.9998

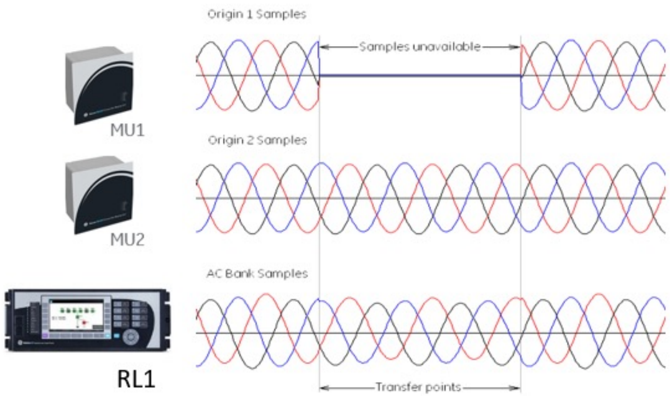


Digital substation scheme

Reliability = $R_{fibre\ cables}$ & R_{relay} & $R_{E\text{-}SW}$ & R_{MU}
= 0.9999

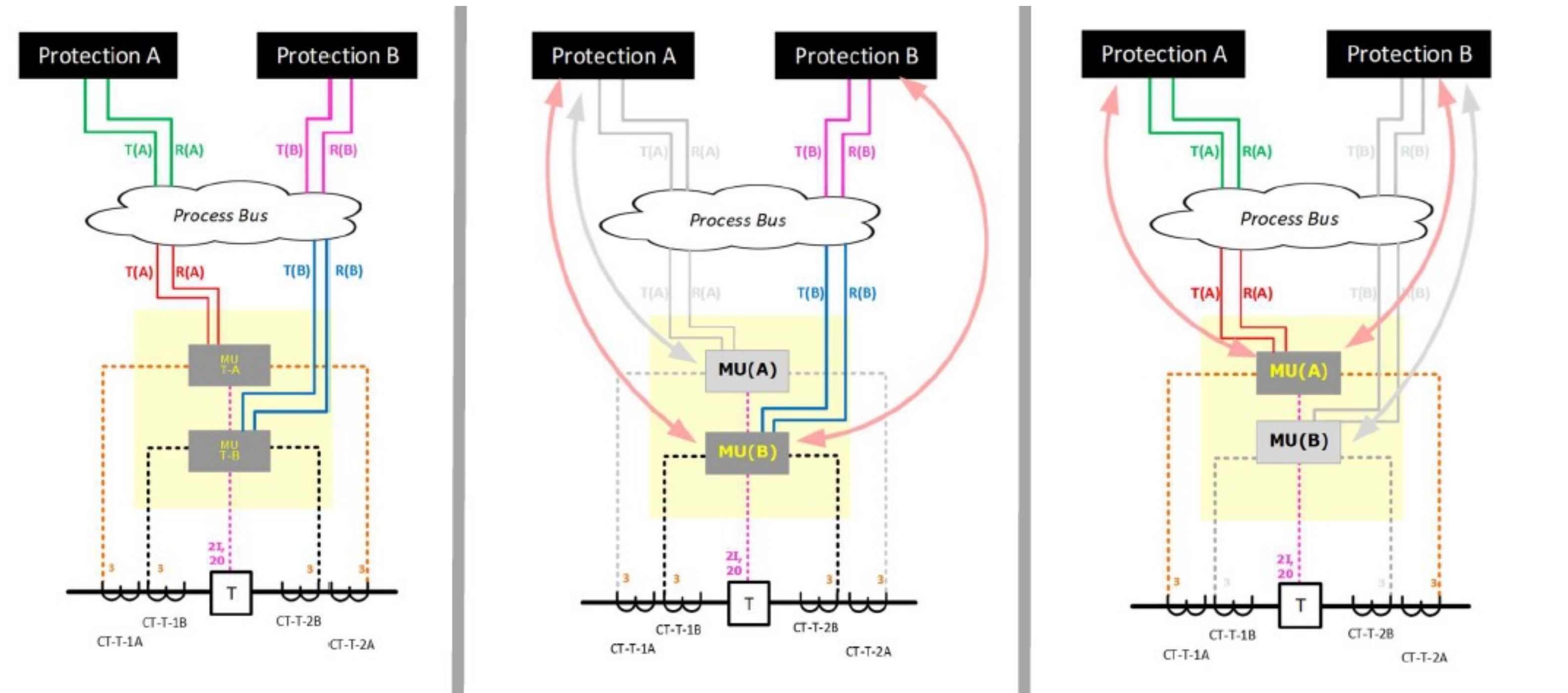
Extra Resiliency in digital substation





- Digital substation has redundant communication scheme
- Protection automatically switches over SVs on the event of failure
- Increases system availability

Extra Resiliency in digital substation

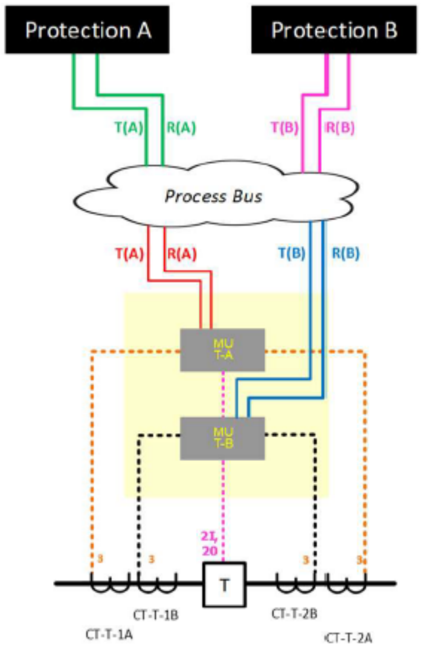


Normal: Both MUs Functional

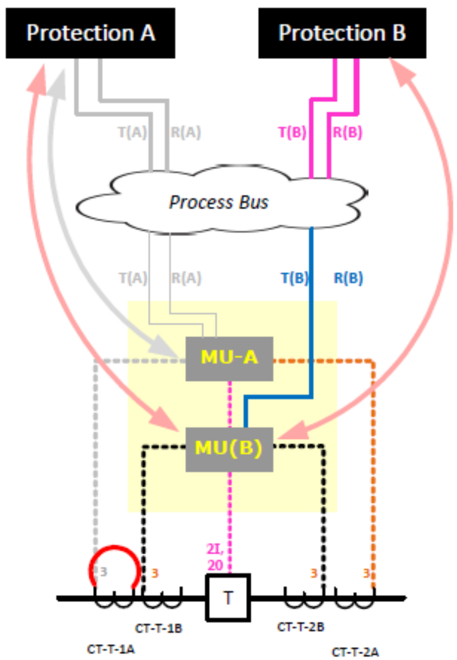
N-1: MU(A) Fails, MU(B) Functional

N-1: MU(B) Fails, MU(A) Functional

Extra Resiliency in digital substation



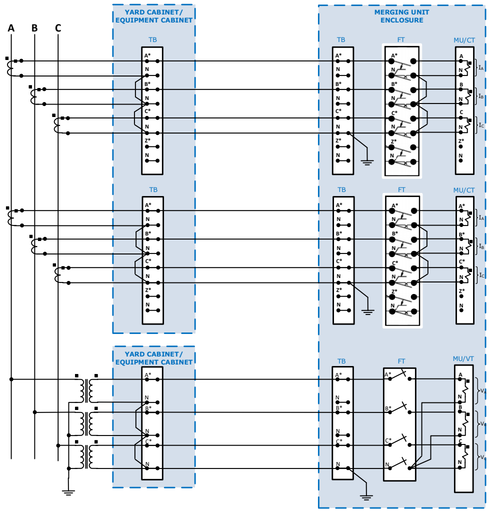
Normal: All CTs Functional



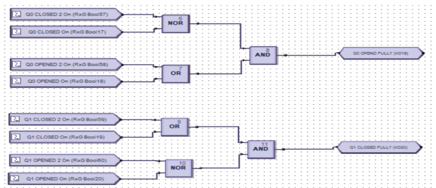
N-1: CT for MU(A) Shorts,
MU(B) CTs Functional

Standardisation & sw interlocking

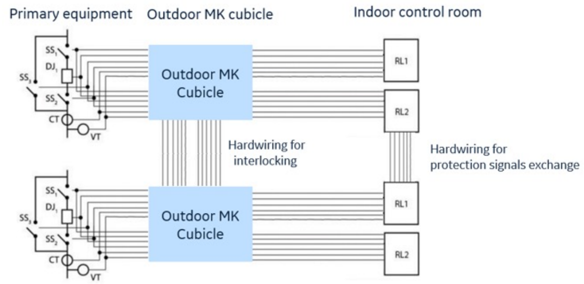
- Bay design standardisation
- Less drawing
- Interlocking by configuration
- Less trip to the substation because monitoring status remotely
- achieve “Un-manned substation” goal



Digital substation: Standard wiring at merging unit

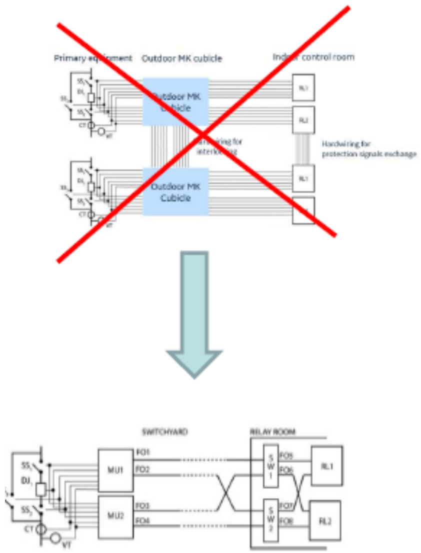


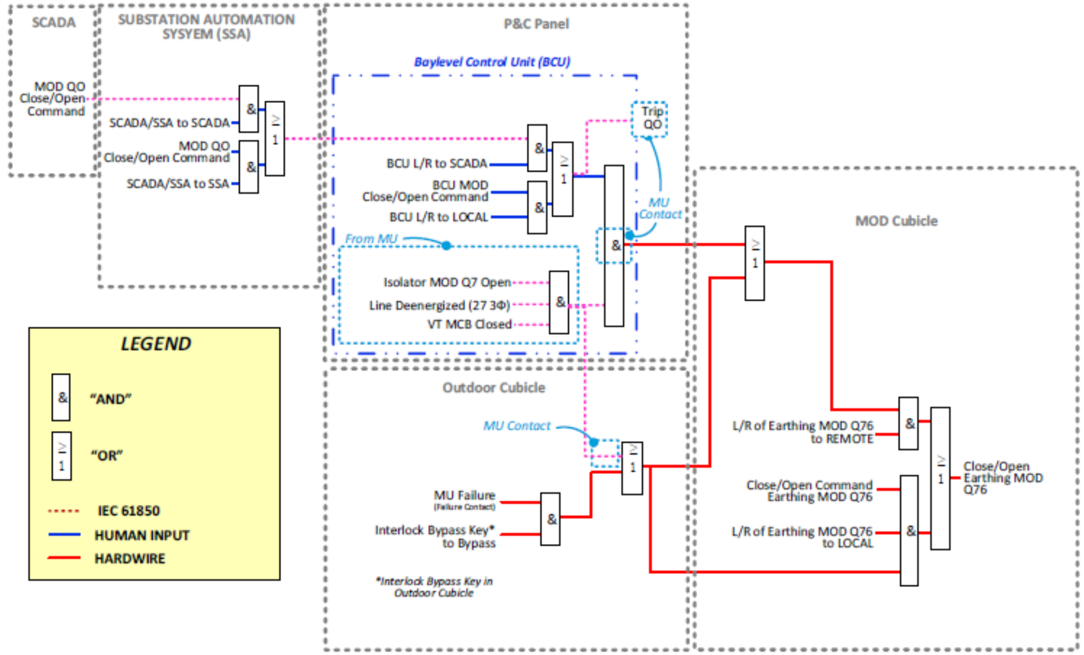
Digital substation: Interlocking by configuration

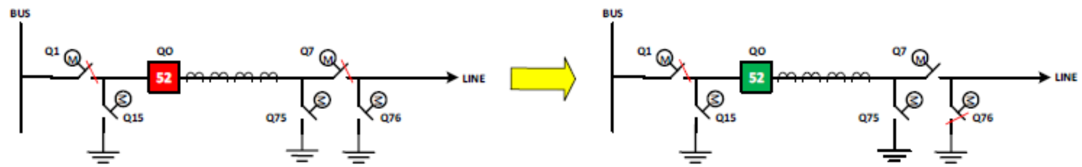


Conventional substation (interlocking by hardwiring)

Digital Substation Standardisation

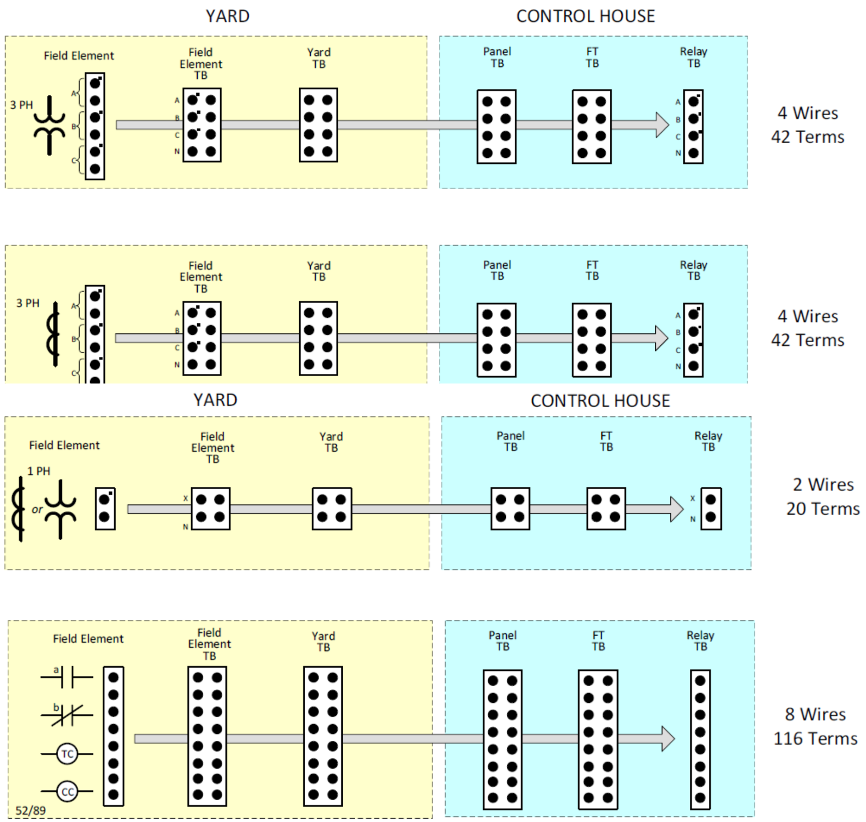




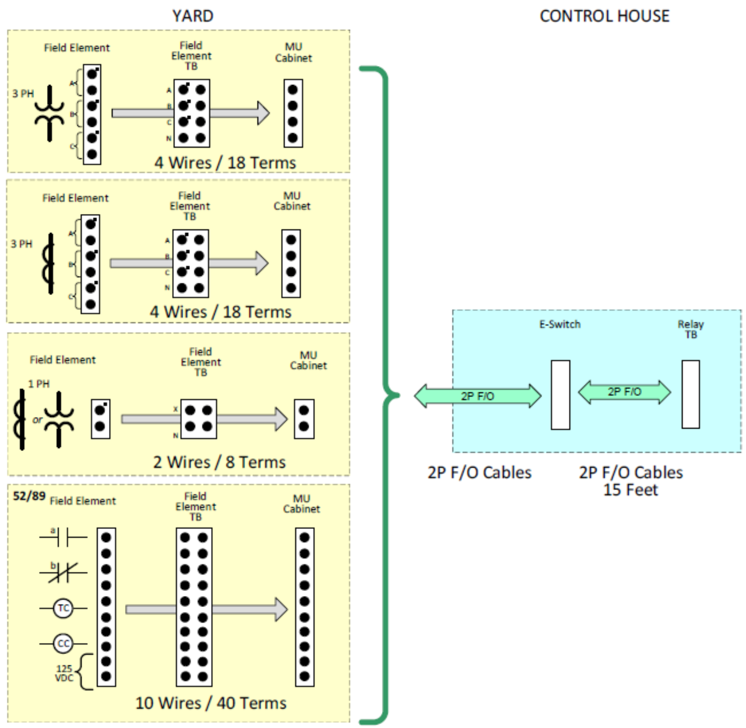


Cabling and Terminations

Conventional substation



Full digital substation



Footprint reduction

- Less wiring
- Less termination
- Easier for bay extension
- Less footprint

Station Name	Conventional Substation	Digital Substation
110KV Nghi Son	3 months (Outdoor Cubicle -1 month, Cabling -1 month)	2 weeks

Figure 8: Outdoor cable at a typical conventional substation vs Outdoor cable at 110KV Nghi Son Digital substation

Figure 9: Protection panel at a typical conventional substation vs protection panel at 110KV Nghi Son Digital substation

Comparison with TransGrid Australia Full DSS

K Hinkley& C Mistry, "First Digital Substation in TransGrid – Australia: A Journey, Business Case, Lessons (DPSP 2018)"

Comparison	First digital substation in TransGrid Australia	The average of Full DSs implemented in Vietnamese TSO
Engineering and deployment time	-	Up to -83% reduction
Copper cables and cable trenches	-95% volume reduction	-30%-40% in copper cable -40% termination (compared to a typical conventional substation in Vietnam)
Control Relay Panel footprint	-80% reduction	No change
System Drawings	-90% reduction	-20% reduction (compared to a typical conventional substation in Vietnam)
Size of the Secondary Building	-80% reduction	No change
Commissioning of substations (Labour)	-50% reduction	-10% reduction
Simplified maintenance	Yes	Yes
Project cost	-30% reduction	-30% labour reduction +10% project cost

Conclusions

- To greenlight the 10 digital substations' rapid deployment, conventional substation and digital substation reliability analysis was conducted.
- The digital substation shows that it has advantage and comparable reliability in protection and control (PAC) scheme compared to a conventional substation.
- Based on 10 projects, digital substation standardised engineering was proven to reduce the deployment time.
- Offers benefits in terms of CAPEX and installation, reduction in engineering drawings, remote monitoring, achieve "Un-manned substation" goal
- Also realised other well proven digital substation benefits such as, massive copper wiring reduction, cable termination reduction, space footprint reduction
- The rapid deployment of digital substation is feasible, EVNNPC achieved the need of speed