The Need for Speed - Why Fast Track Digital Substation Deployment?

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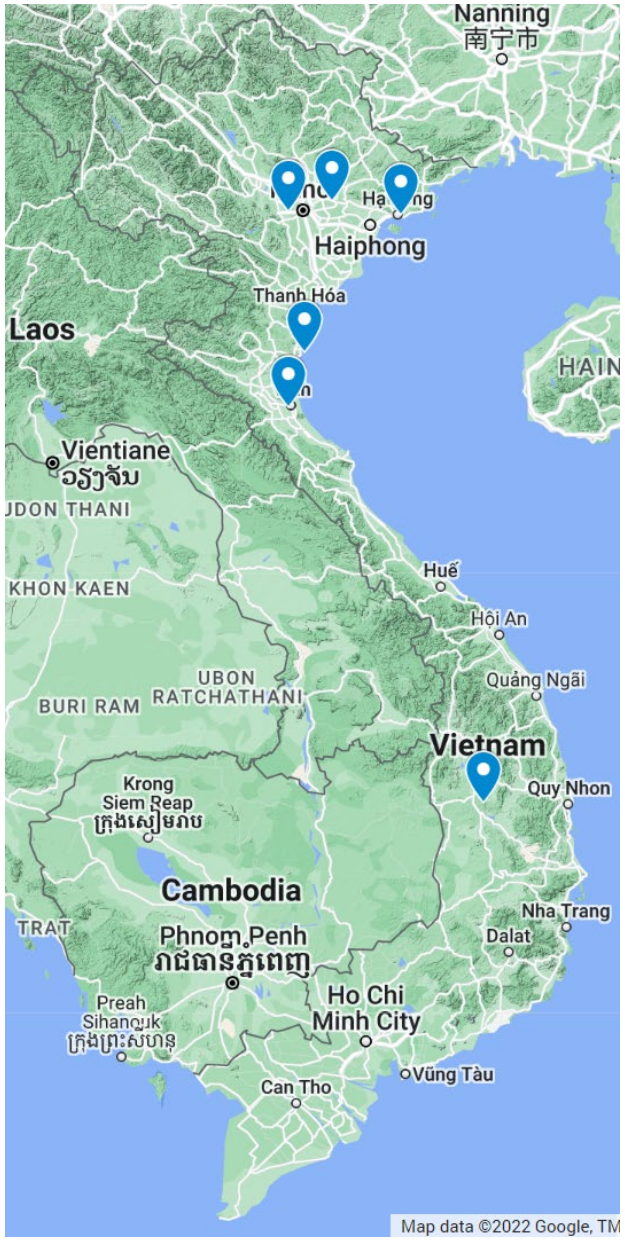
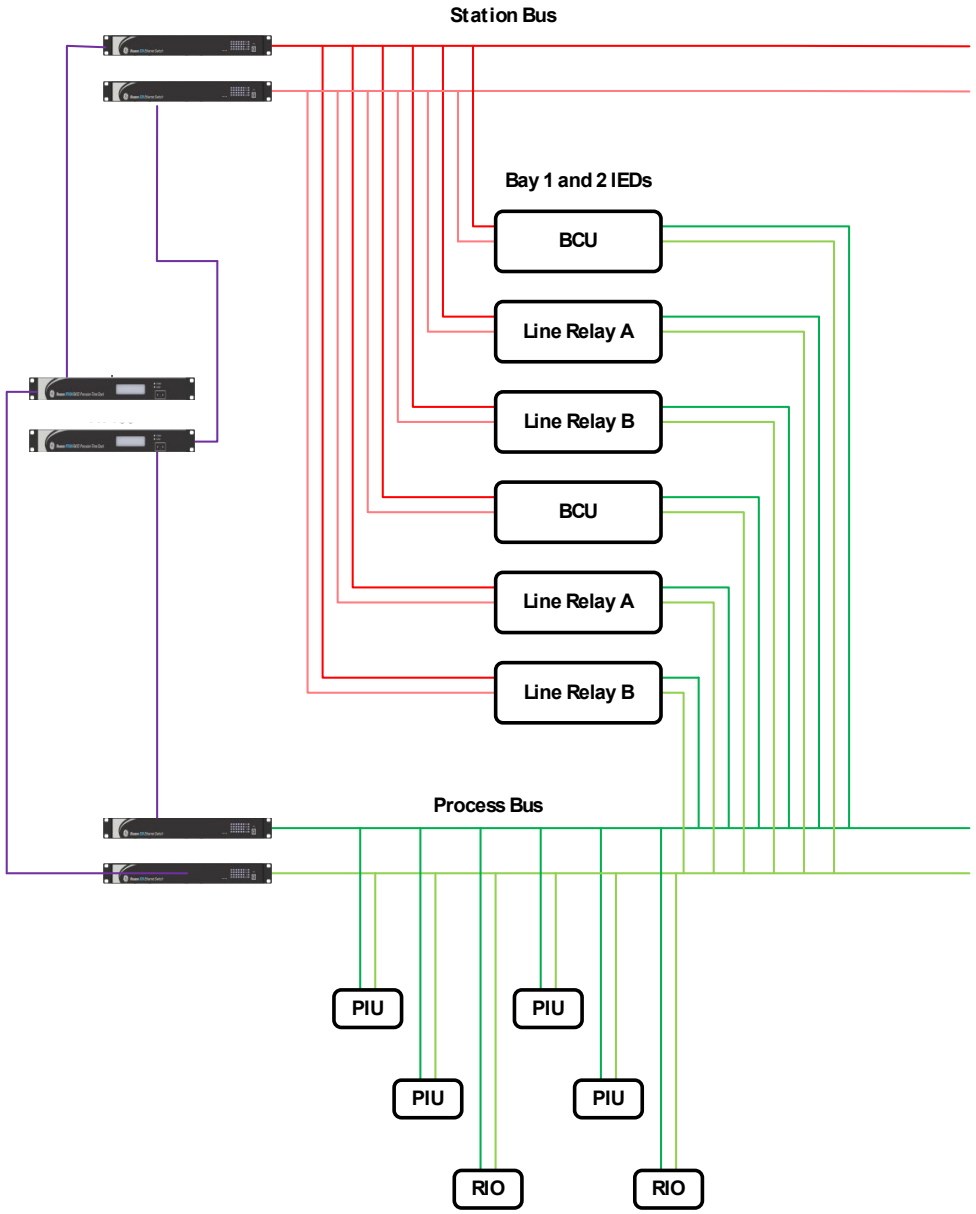
EVN Vietnam



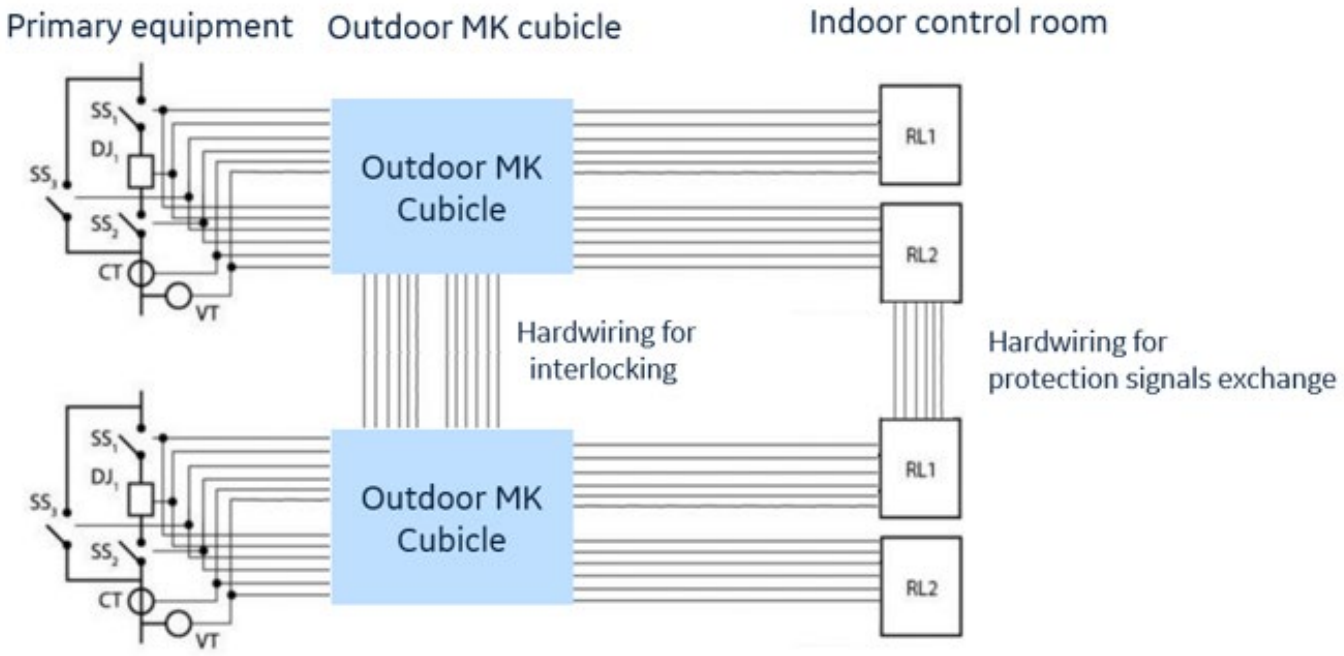
- Electricity Vietnam (EVN)
  - Transmission and Distribution Service Operator (TSO & DSO)
  - Deploy 6 (5 EVN, 1 IPP) full digital substations (IEC 61850 station bus + process bus) despite Covid restriction

Typical EVN substation

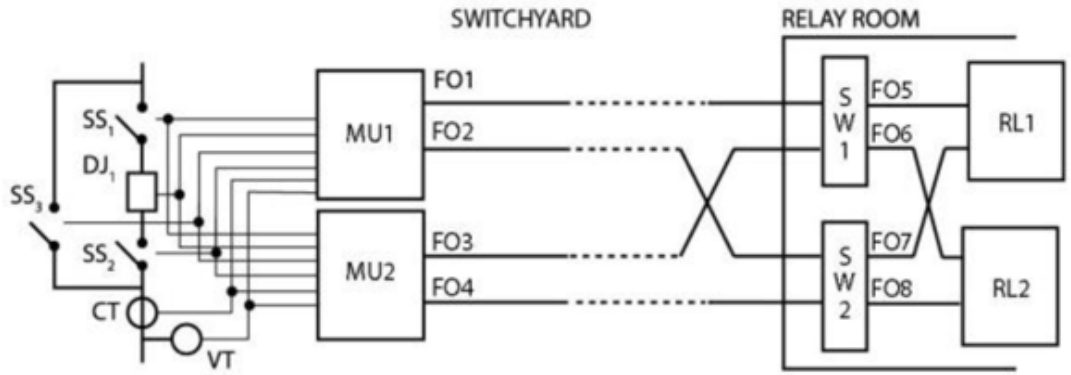


- Separate process bus and station bus
- IEC 62439 Parallel Redundancy Protocol (PRP) Ethernet

PACS performance



Conventional substation scheme



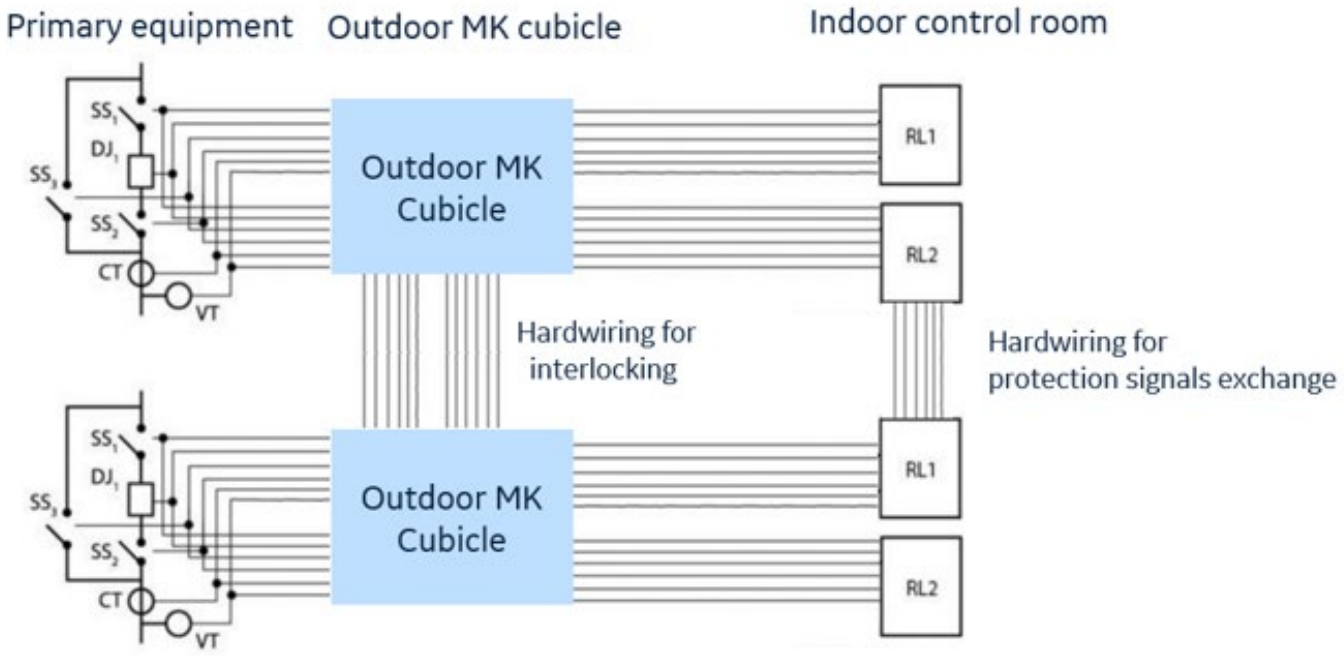
Digital substation scheme

- EVN requirement
- Digital substation should provide equivalent or better performance
  - PACS Performance

	Total clearance time including primary breaker trip time (EVN requirement <100ms)	
	Conventional substation (copper 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 (Conventional substation)



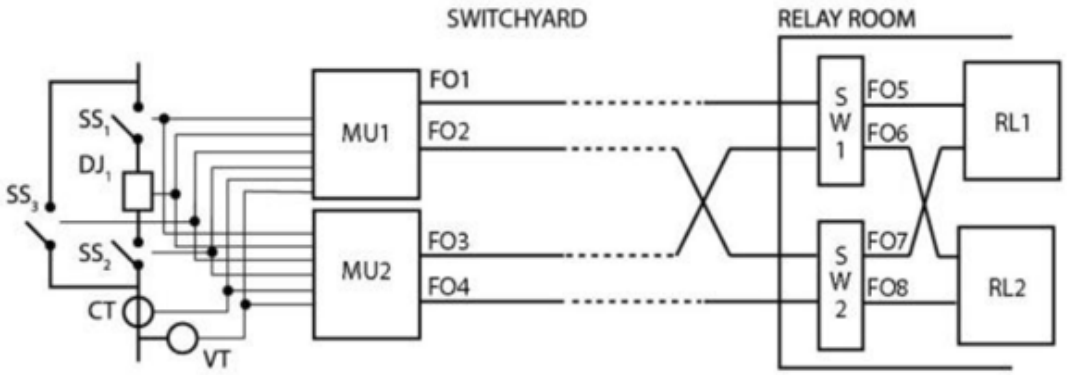
Conventional substation scheme

- EVN requirement
- PACS reliability study
  - Reliability is that it is the probability of a device performing its function properly, for a certain period of time, under given operating conditions

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

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

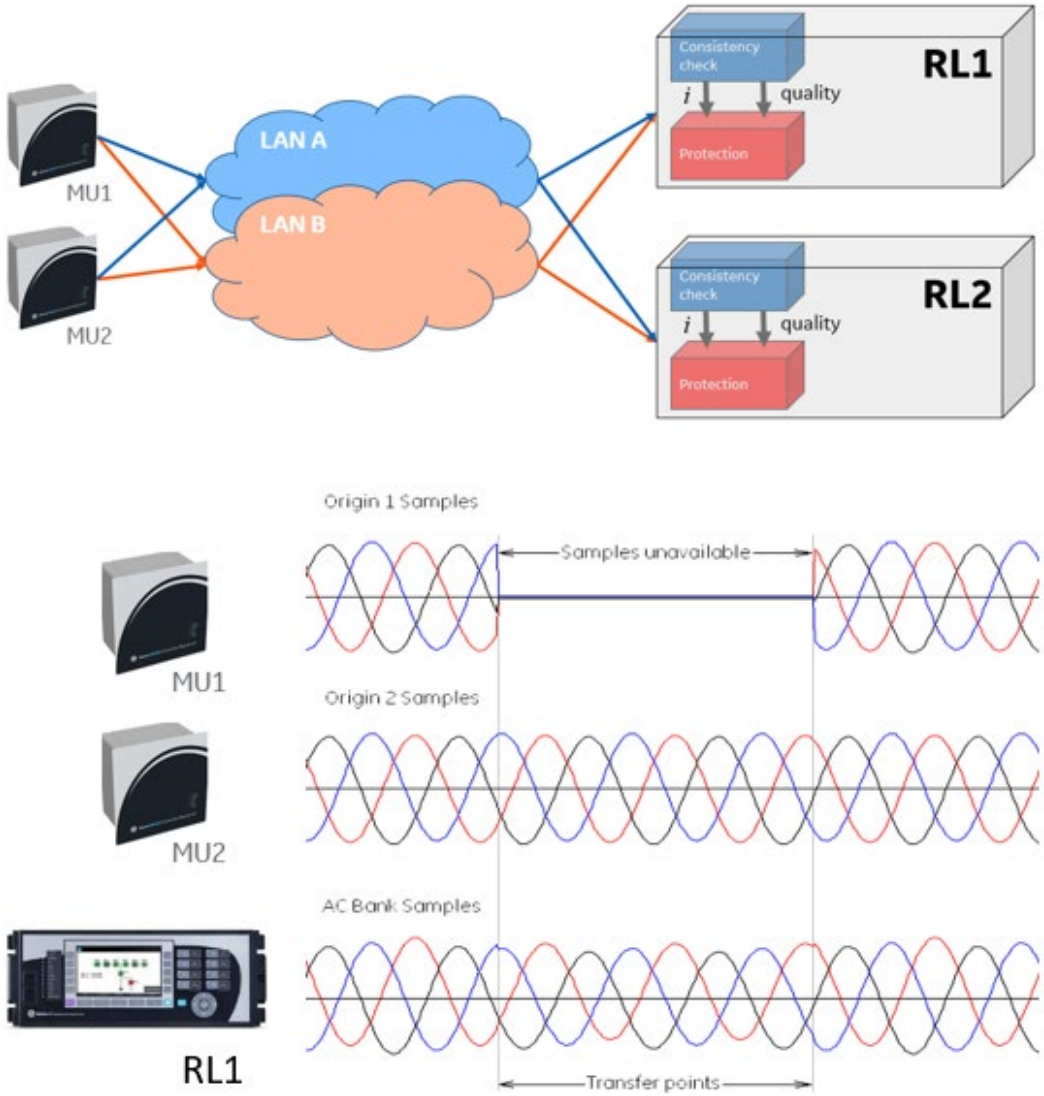
PACS reliability (Digital substation)



Digital substation scheme

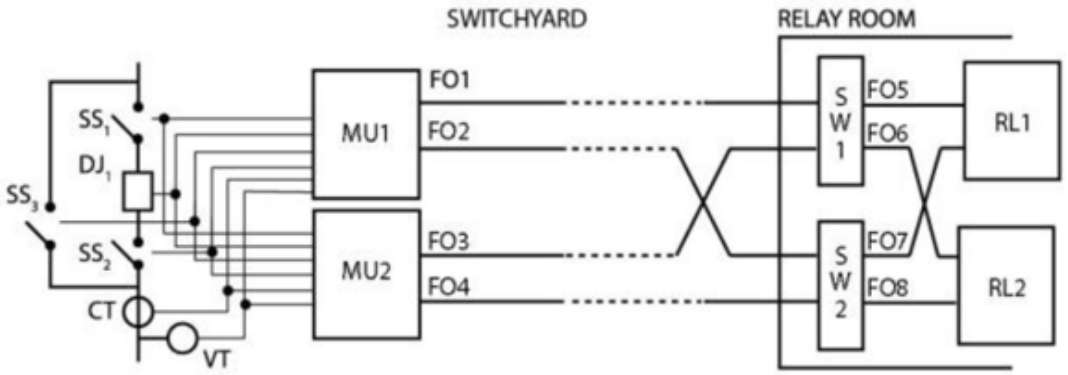
- Digital substation reliability
  - Merging unit
  - Fiber optic
  - Ethernet switch
  - Protection relay

Digital substation offers flexibility



- Digital substation has redundant communication scheme
- Digital architecture allows automatically switch over on the event of failure and increases system availability

PACS reliability (Digital substation)

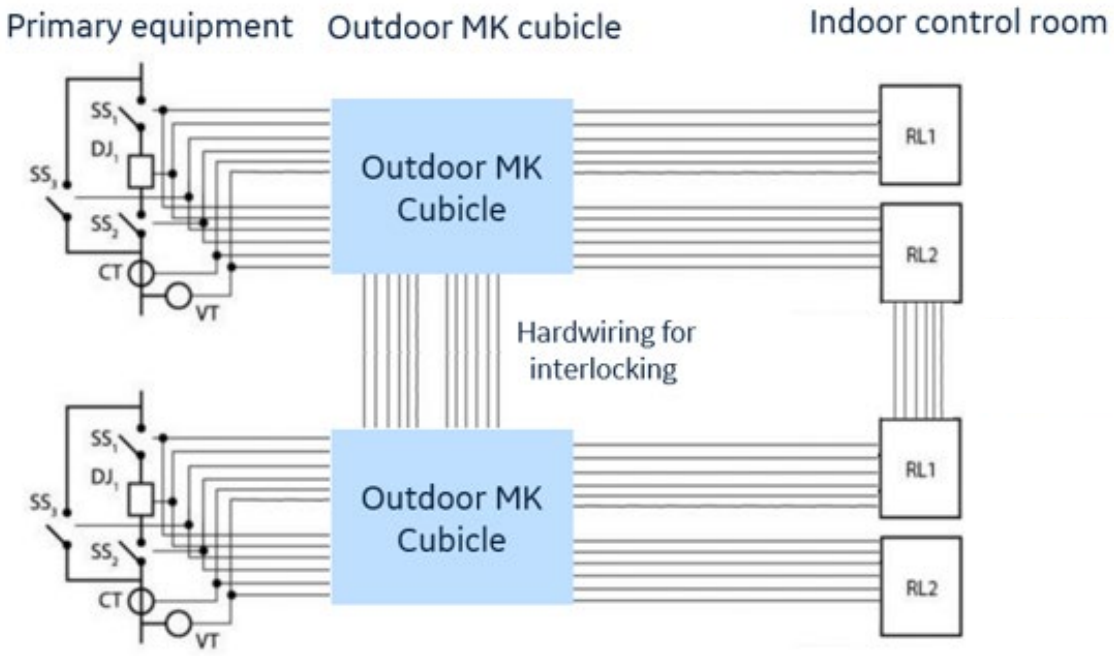


Digital substation scheme

- Digital substation reliability
  - Redundant scheme for every equipment

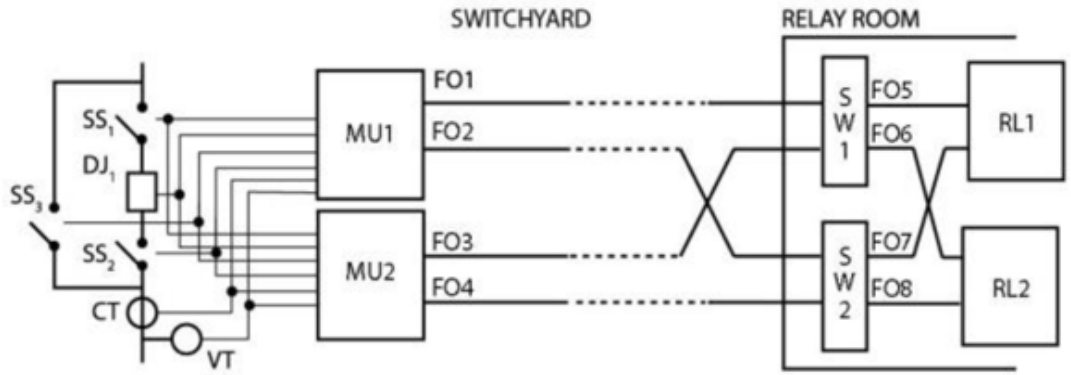
$$R_{digitalsubstation} = [1 - [1 - [[1 - ((1 - R_{FO1})*(1 - R_{FO3}))]*[1 - ((1 - R_{FO5})*(1 - R_{FO7}))]*R_{SW1}]] *$$
$$[1 - [[1 - ((1 - R_{FO2})*(1 - R_{FO4}))]*[1 - ((1 - R_{FO6})*(1 - R_{FO8}))]*R_{SW2}]]] *$$
$$[1 - [(1 - R_{MU1})*(1 - R_{MU2})]] * [1 - [(1 - R_{RL1})*(1 - R_{RL2})]]*$$
$$[1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

PACS reliability outcome



Conventional substation scheme

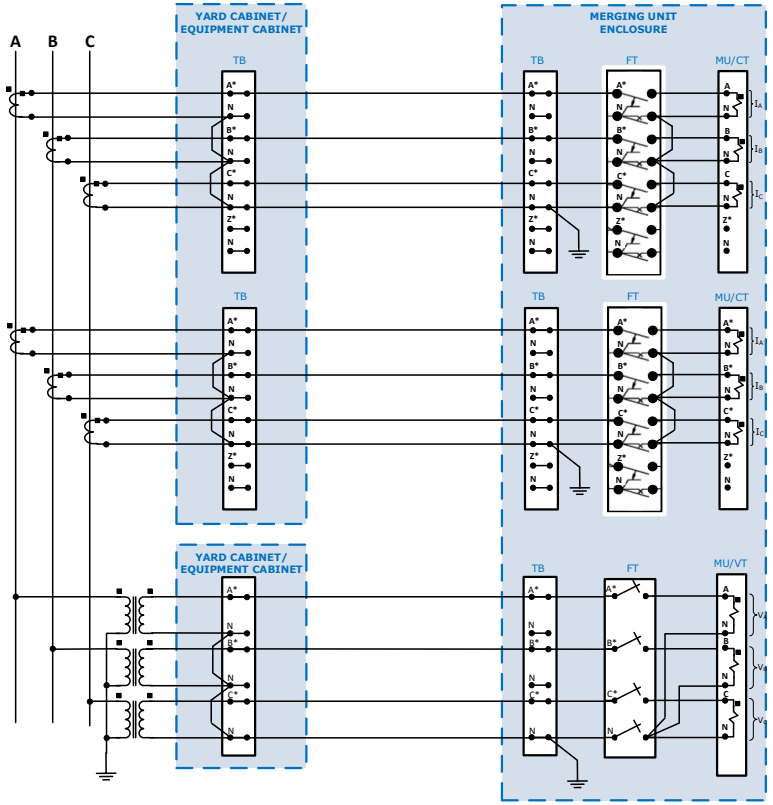
- $R_{Conventional\ Substation} = 0.9998$



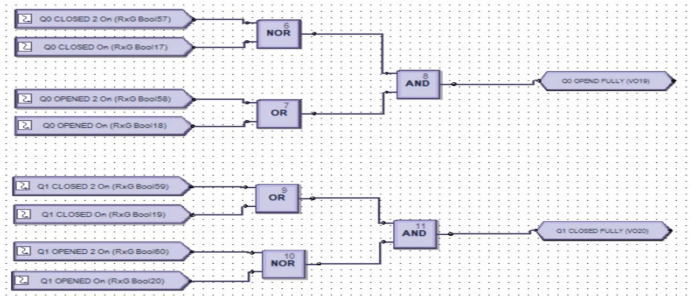
Digital substation scheme

- $R_{Digital\ Substation} = 0.9999$

Digital substation standardization

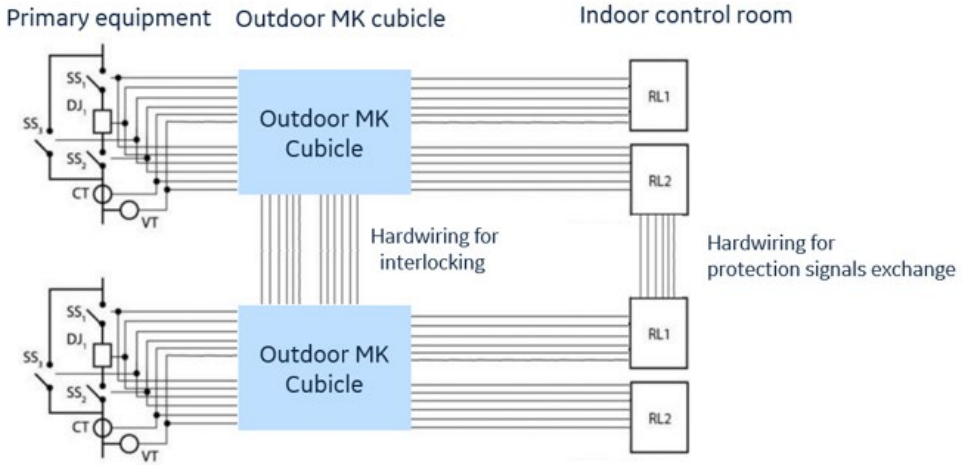


Digital substation: Standard wiring at merging unit



Digital substation: Interlocking by configuration

- Bay design standardization
- Less drawing
- Interlocking by configuration
- 67% reduction in Engineering time
- Less trip to the substation because monitoring status remotely



Conventional substation (interlocking by hardwiring)

Additional Benefits

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

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

Lesson learned from 6 digital substations

- Engineers need to specialist in networking & time synch
  - IEEE 1588v2 PTP + IEC 62439-3 Parallel Redundancy Protocol (PRP)
  - 100ns accuracy or better
  - Setup up demo with actual equipment and scheme testing in the lab
- Busbar protection and transformer protection need higher bandwidth communication (e.g. 1Gbps Ethernet network)
- < CAPEX
  - Cooper wiring reduction
  - Time = $$$ money
  - Standardized design, less engineering drawings
  - Faster installation, less human mistakes
  - 67% reduction in engineering time
- < OPEX
  - Monitor live status and metering remotely
  - Interlocking by configuration
  - Less trip to substation
  - Achieve “Un-manned substation” goal

Conclusions

- Majority of utilities focus on lab testing and deploy pilot projects for proof of concept and monitor the performance
- EVN is steps ahead and successfully deployed and commissioned 6 digital substations in 2 years, especially during the challenging covid time
- Return on experience
  - PACS offers equivalent performance
  - PACS has slightly higher reliability and offers flexibility
  - Standardization design can expedite deployment
  - Massive copper wiring reduction, cable termination reduction
  - Space footprint reduction

Questions