

2025 Korean Nuclear Society Spring Conference
May 21-23, 2025, JeJu

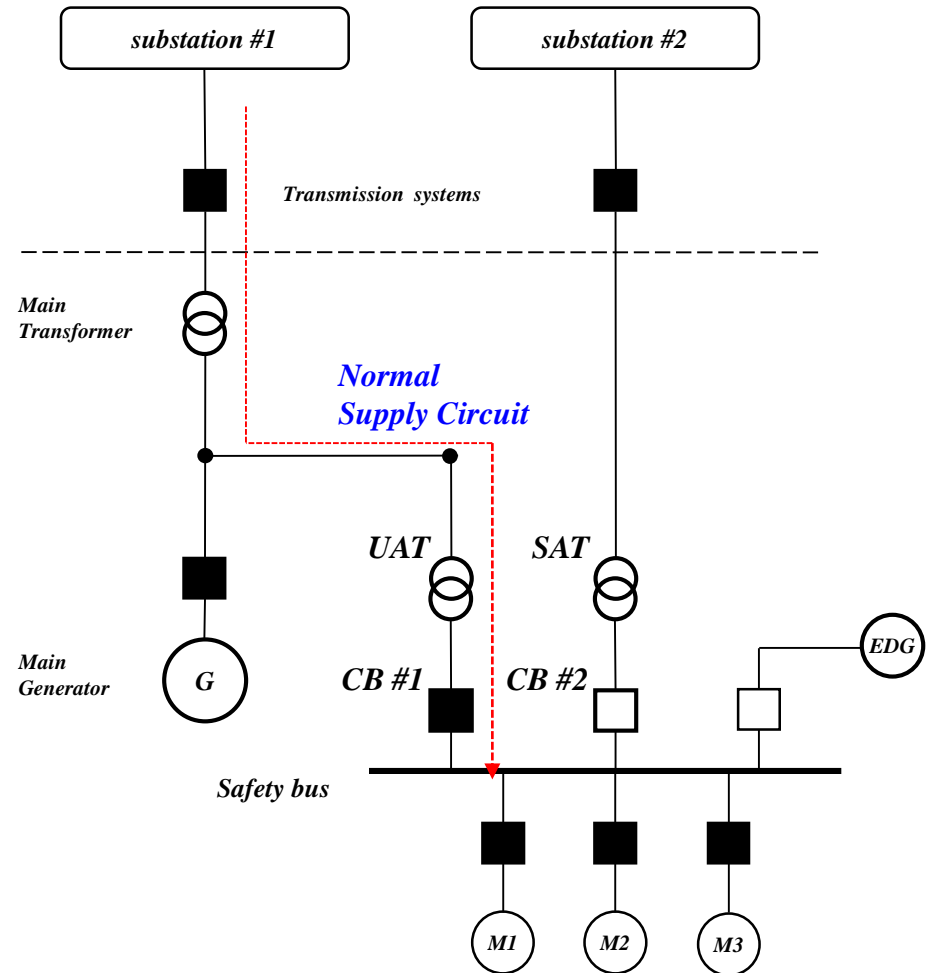
Importance of Power Transfer Design with Bus Protection Logic in Nuclear Power Plants

Moon-Young Kim
Korea Institute of Nuclear Safety



Power Transfer in NPPs

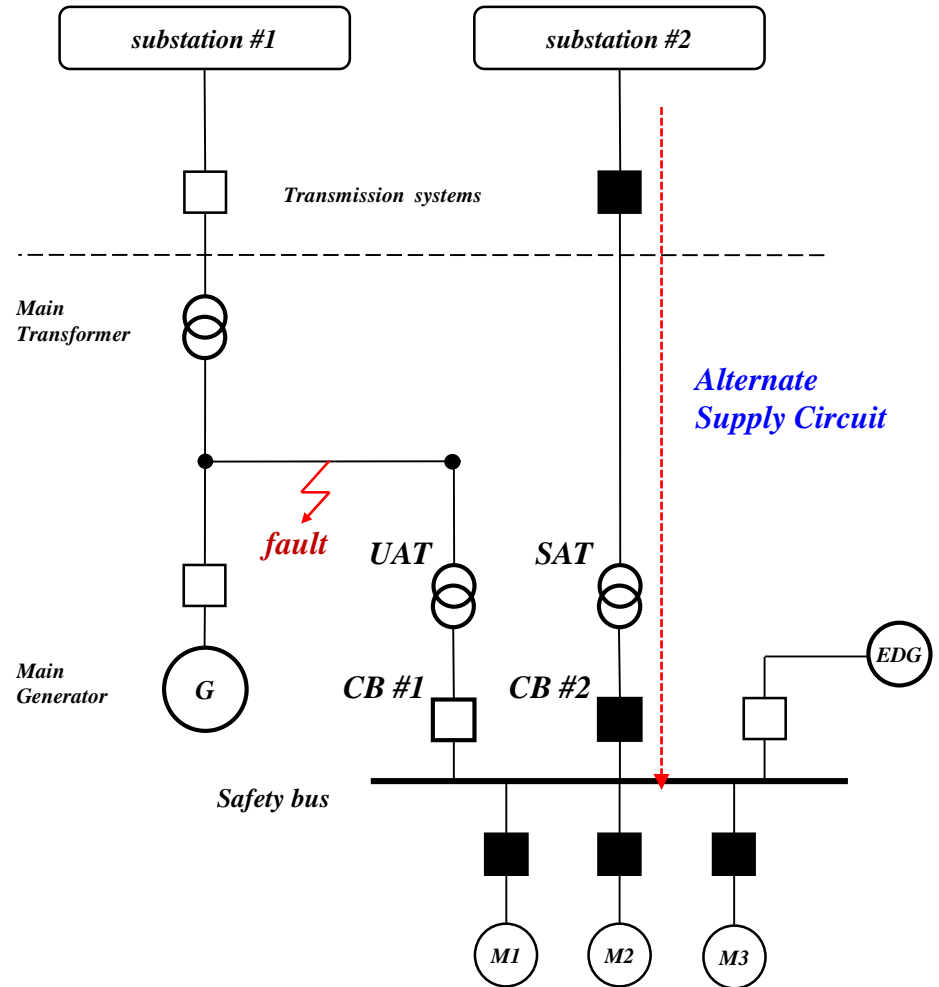
- One of the design methods to supply reliable power to safety bus is the **power transfer** which is to make a **switchover** from *normal power source* to *alternate power source*.
- When main generator is to trip, the safety bus can be supplied from **normal power supply circuit**.
(substation #1)



Power supply systems for the safety bus in NPPs

Power Transfer in NPPs

- If the **normal power supply circuit** is not available due to electrical faults, the safety bus can be supplied from independent **alternate power supply circuit**. (*substation #2*)
- Power supplying from alternate power source can be accomplished by the **power transfer**.
→ fast switchover
CB #1(open) & CB #2(close)

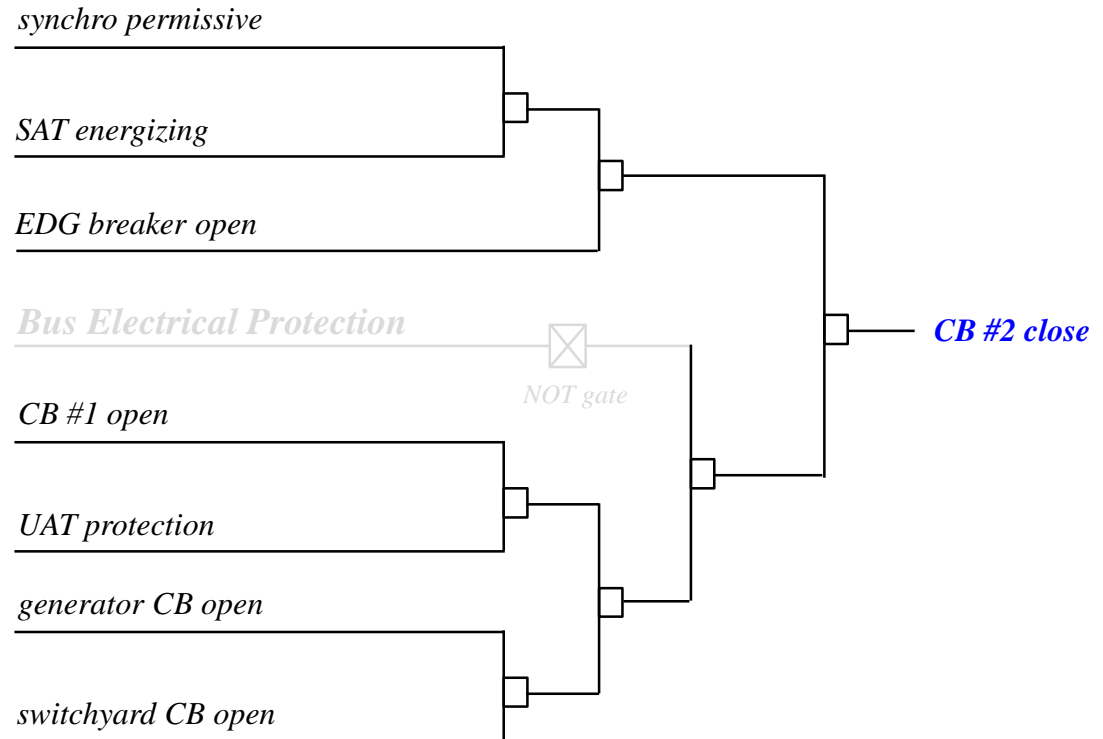


Power supply systems for the safety bus in NPPs

Logic Diagram of Power Transfer

- To accomplish the power transfer, various factors in power transfer design should be considered.

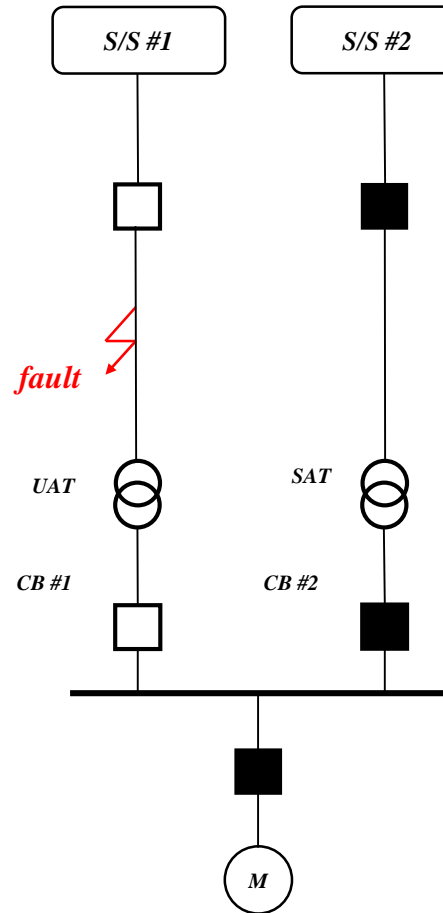
- The successful power transfer which is the all logic completion for *CB #2 close* should be satisfied with various factors as well as *CB #1 open*.



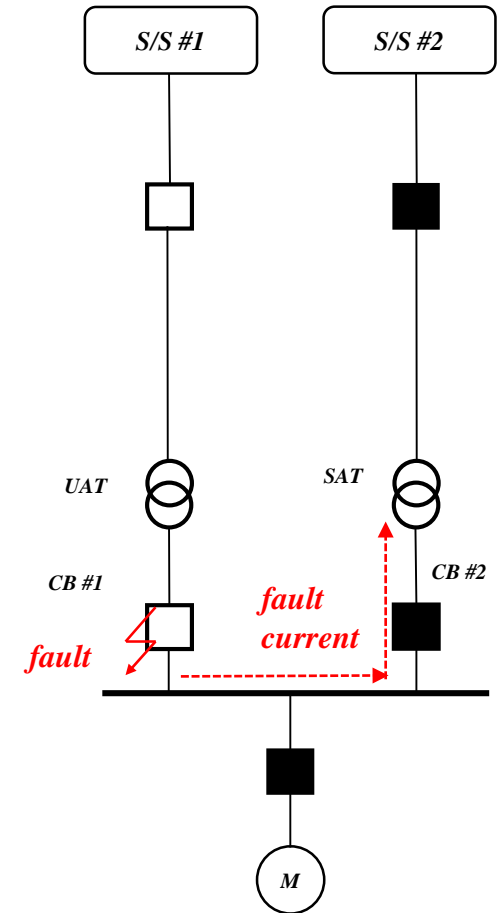
Logic diagram of power transfer

Faults on Circuit Breaker

- In case of typical *faults on feeder*, power transfer can accomplish without influence of faults.
- As for *faults on circuit breaker*, healthy power systems can be electrically connected with the faulted conditions.
- This result in the *propagation of faults* to the healthy power systems including *alternate power supply circuit*.



Fault on feeder

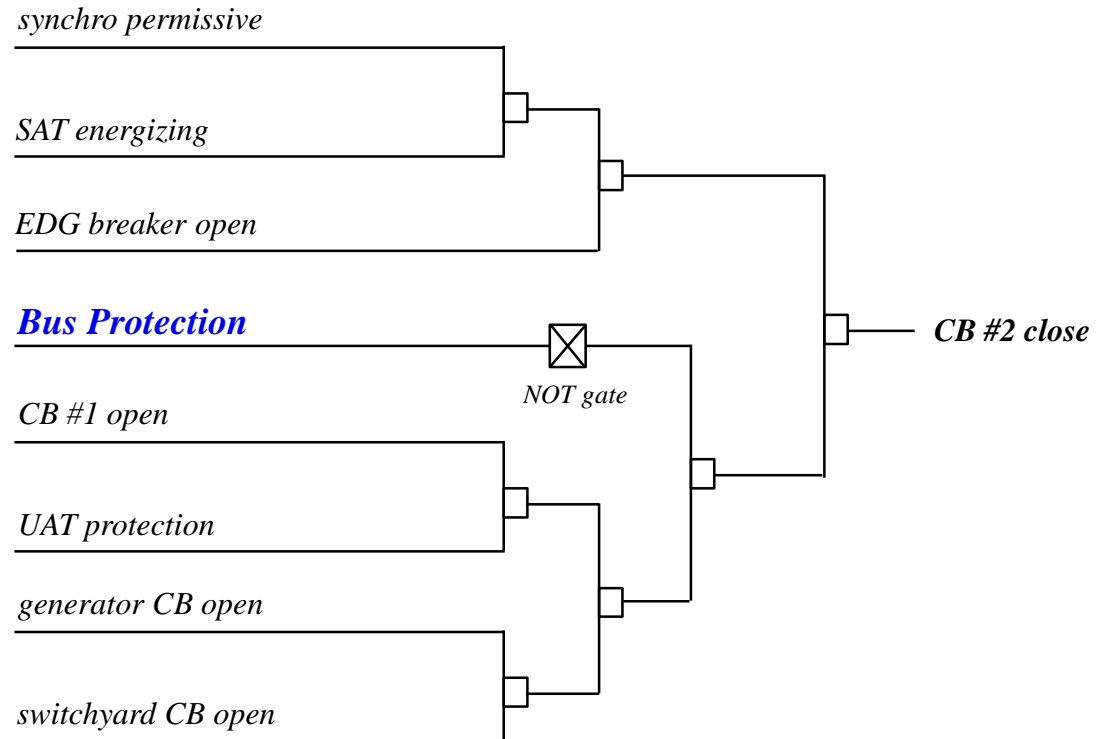


Fault on breaker

Bus Protection in Power Transfer

- Bus Protection logic is a significant factor in power transfer design and can prevent the propagation of the fault.

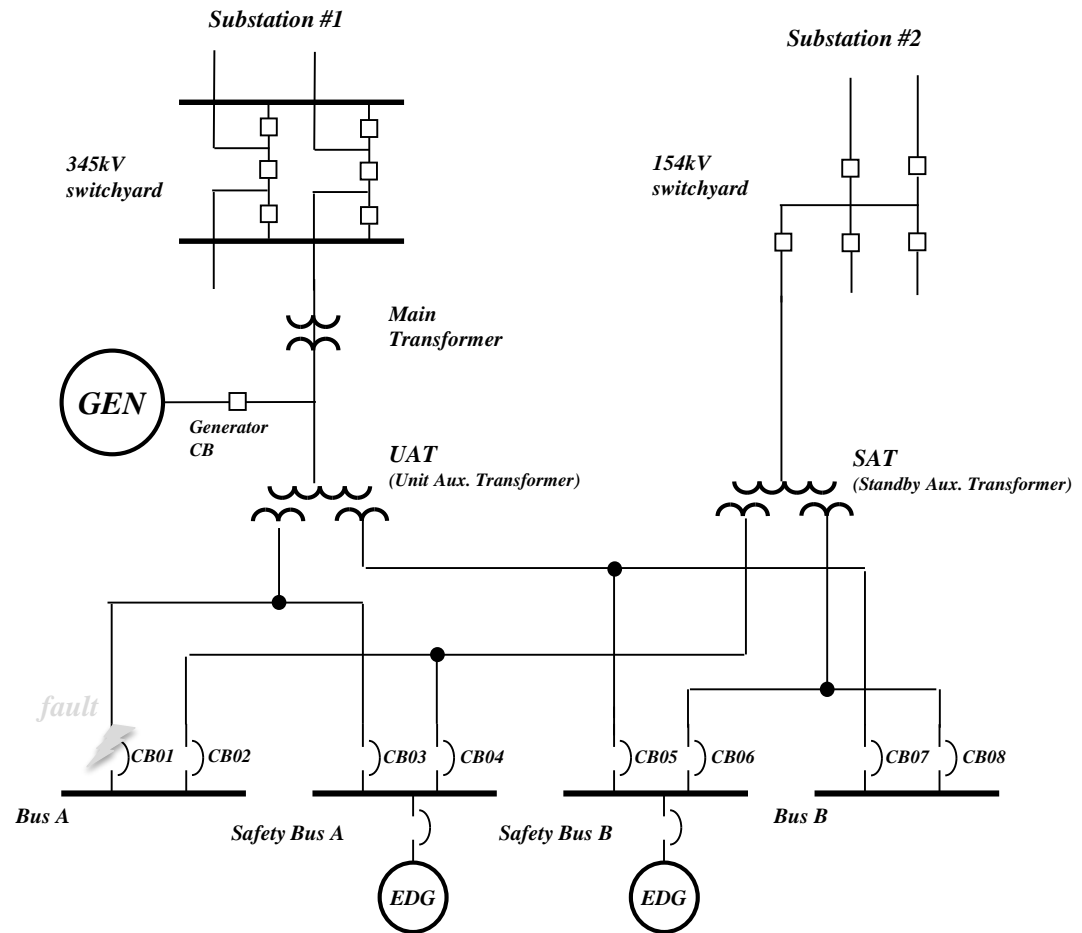
- It is important to reflect bus protection in power transfer to prevent propagation of faults



Logic diagram of power transfer

Event Case in NPP

- Recent nuclear incident resulted in loss of all offsite power, EDG automatic starting and reactor trip is verified due to the absence of bus protection in power transfer.
- Configuration of power system for nuclear power plant is simplified.



Power system configuration for event case

Analysis of Event Case

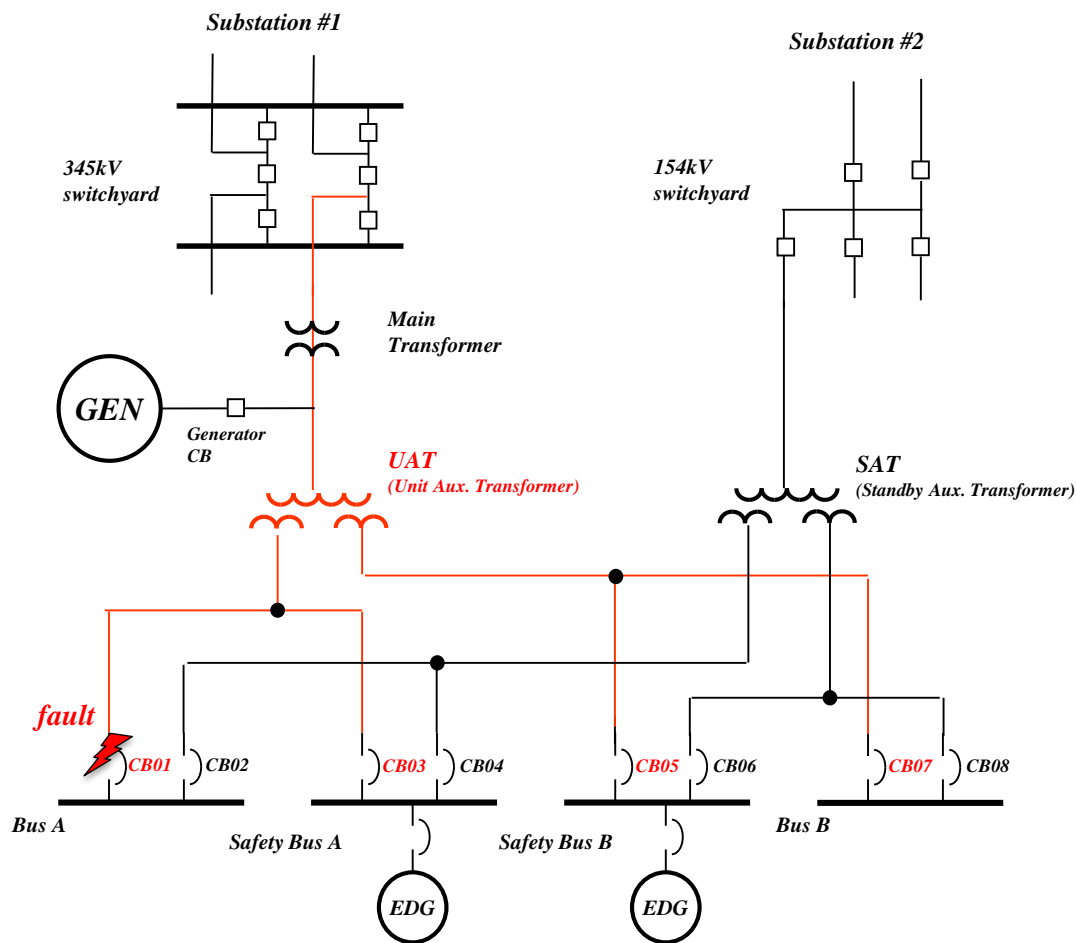
➤ K-NPP : on June 3, 2022, 100% full power operating

① initiating **arcing fault** on incoming **breaker of bus A** due to misaligned breaker contact

② generating **protection signal** (overcurrent protection) for **UAT**

③ **opening** all corresponding circuit breakers(**CB01, CB03, CB05, CB07**) related to UAT

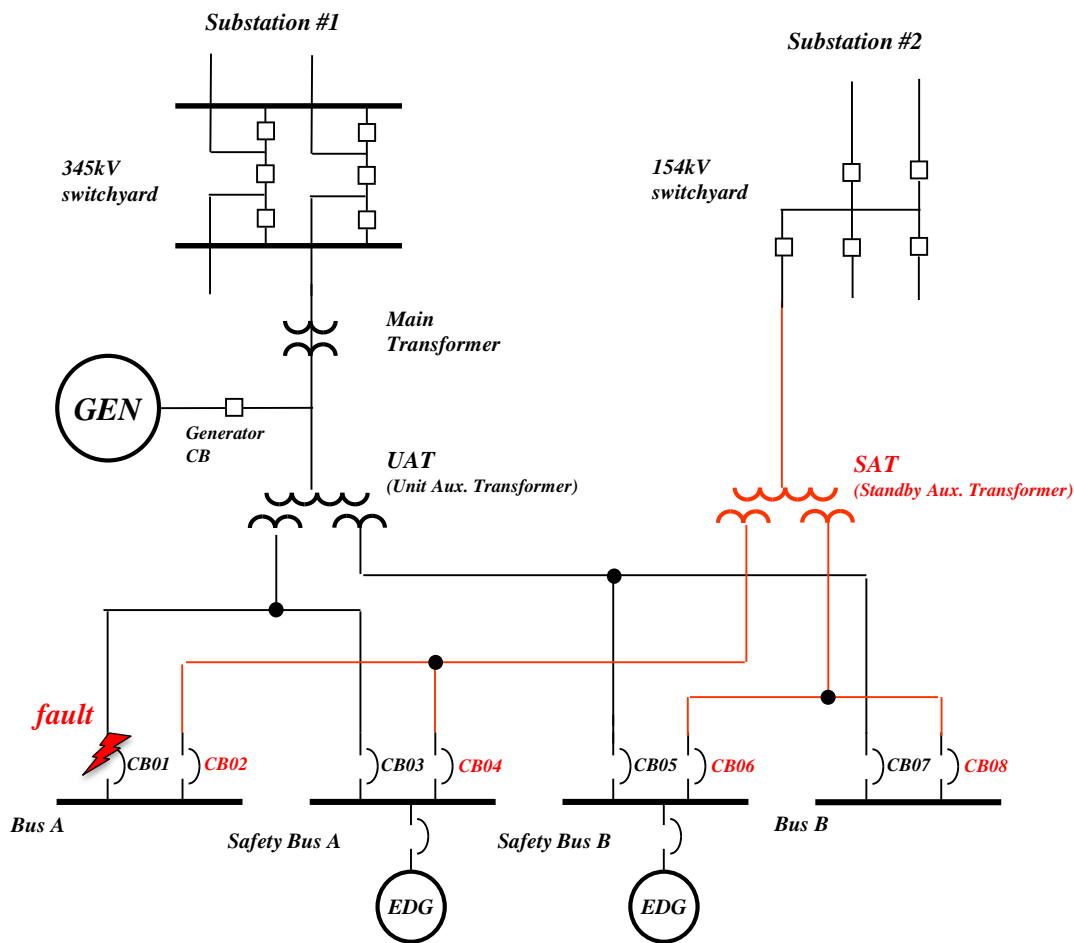
④ **power transferred** from UAT to SAT



Power system configuration for event case

Analysis of Event Case

- ⑤ propagating fault current to SAT because the arcing fault on breaker of bus A still sustained
- ⑥ generating protection signal (overcurrent protection) for SAT
- ⑦ opening all corresponding circuit breakers(CB02, CB04, CB06, CB08) related to SAT
- ⑧ loss of all offsite power and all EDG automatic starting

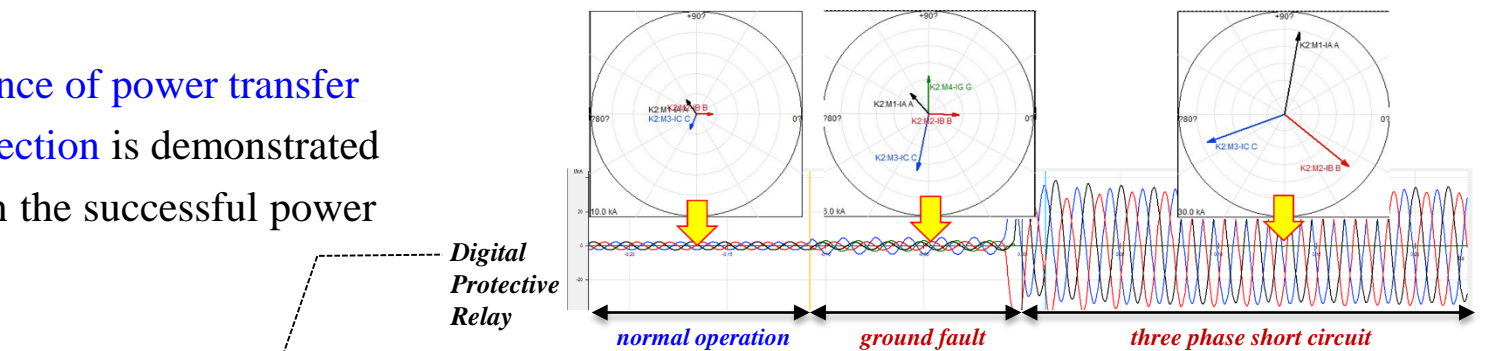


Power system configuration for event case

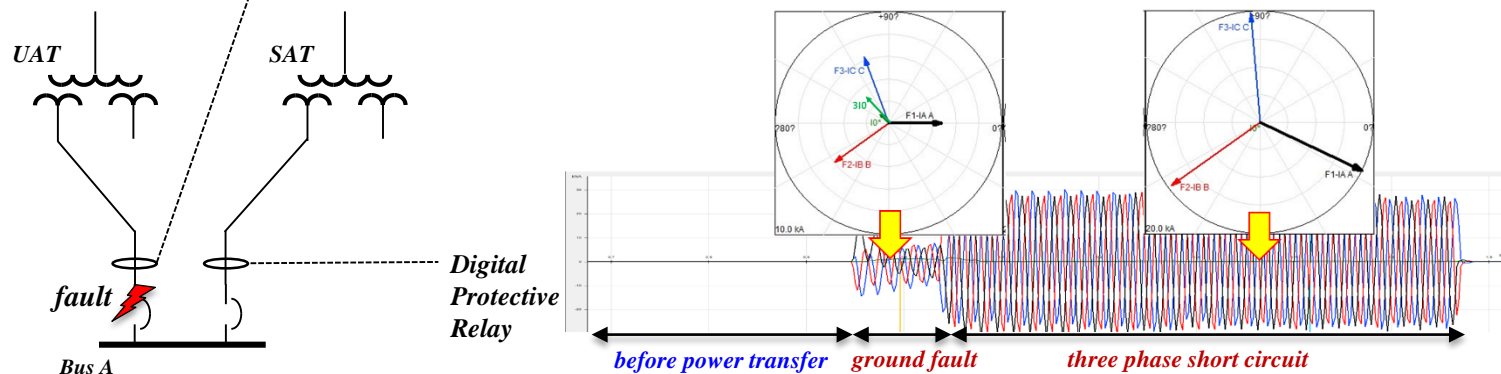
Analysis of Event Case

- Results analysis is conducted from fault current data of faulted bus.
- The significance of power transfer with bus protection is demonstrated to accomplish the successful power transfer.

Waveform and phasor diagram of fault current on bus A



(a) fault data from UAT side digital protective relay



(b) fault data from SAT side digital protective relay