Enhanced Power System Design For Nuclear Safety & Reliability

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Agenda

- Inadequate Voltage at the Preferred Power Source
- Electrical Faults That Propagate to More Than One Division
- Catastrophic Failure of Onsite Breakers
- Delays in Safety Bus Energization
- Instrument Bus Power Supply Failures
- Plant Trip and Loss offsite Power Caused by External Faults
- Conclusion
- Questions

1. Inadequate Voltage at the Preferred Power Source

- Fast transfer to alternate source fails
- Transformer tap changer failure
- Voltage regulator failure
- Synchronism check relay blocks
- Grid fails to accommodate the loss of a nuclear unit

- **Solutions:**
  - Contracts & Communication with grid operator
  - Shared knowledge on contingencies

Communication

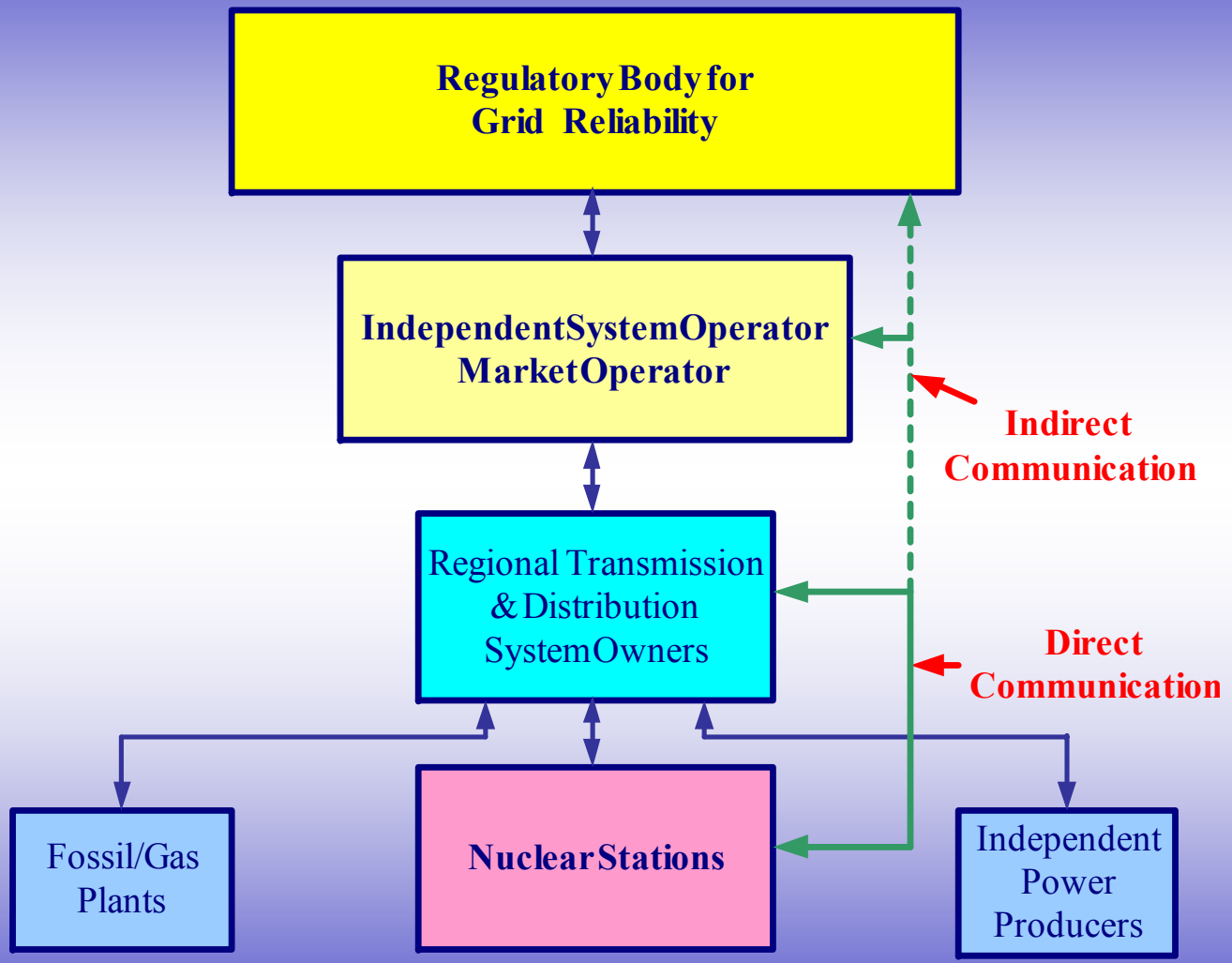
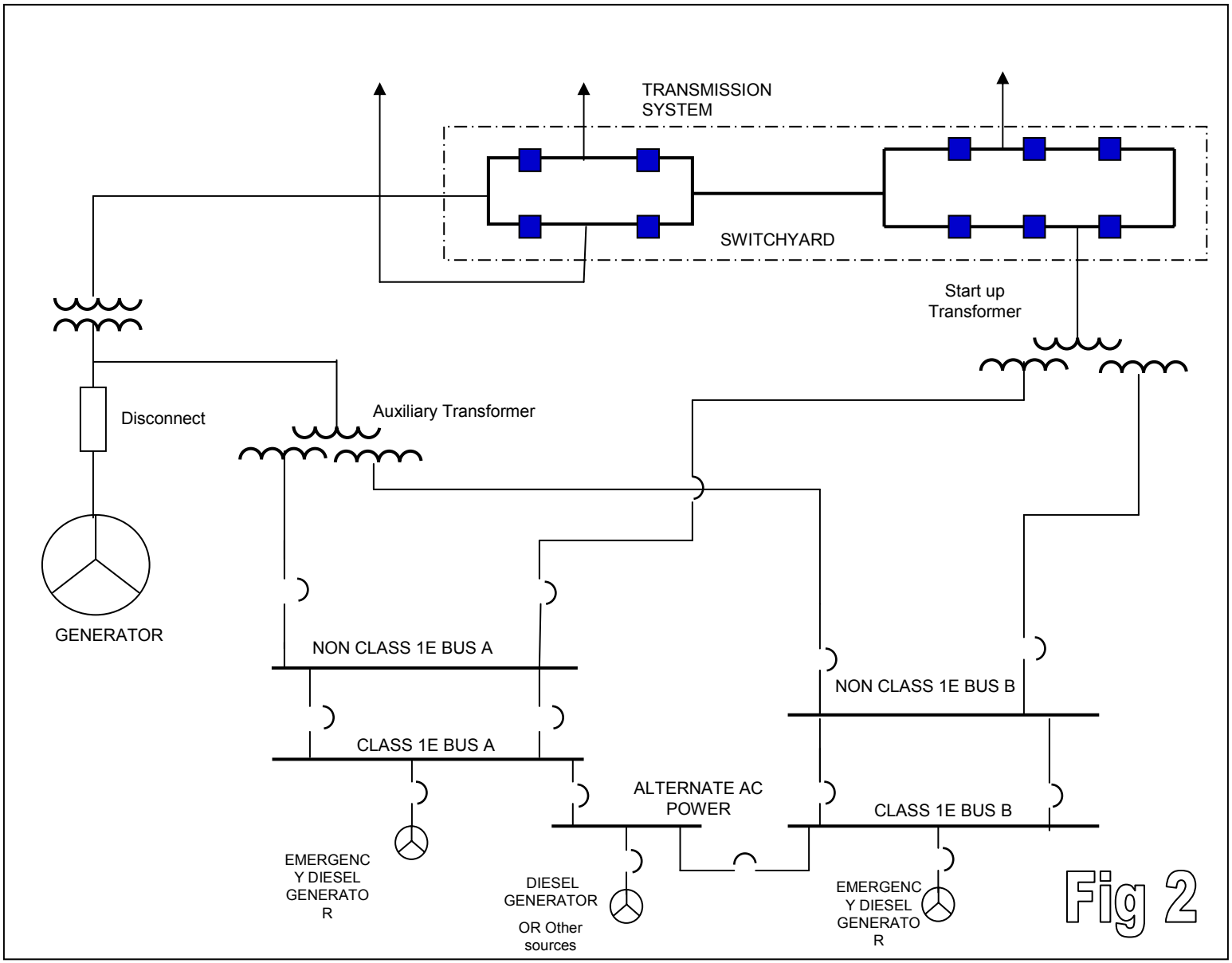


Fig 1

2. Electrical Faults That Propagate to More Than One Division

- Cable failure at incoming power to a safety bus in Fig 1 could take out power to both safety buses
- Any uncleared bus failure, delay in clearing a fault in the switchyard or transformer failure could take out offsite power to two trains

- Mitigation
  - Provide separate transformer & breaker for isolating faults within a train for offsite power


TRANSMISSION SYSTEM
SWITCHYARD
Start up Transformer
Disconnect
Auxiliary Transformer
GENERATOR
NON CLASS 1E BUS A
NON CLASS 1E BUS B
CLASS 1E BUS A
ALTERNATE AC POWER
CLASS 1E BUS B
EMERGENCY DIESEL GENERATOR
DIESEL GENERATOR
OR Other sources
EMERGENCY DIESEL GENERATOR
Fig 2

ONE LINE DIAGRAM FOR SINGLE UNIT NUCLEAR STATION

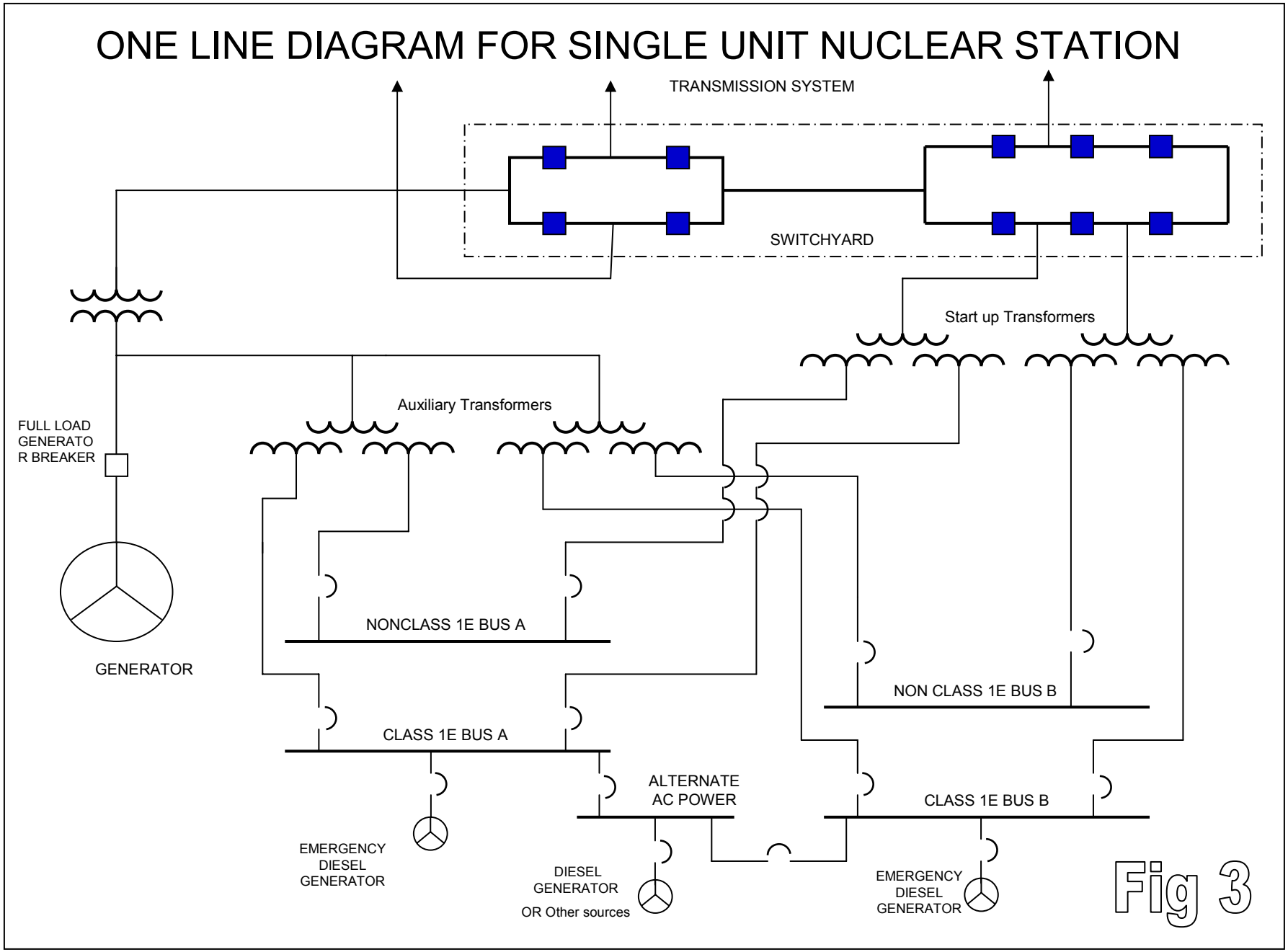


Fig 3

3. Catastrophic Failure of Onsite Breakers

- Interruption of a fault current higher than breaker rating
- Transformer lockout from overloads or protective system
- Breaker closing out-of-phase

- Mitigation
  - Specify breakers for accommodating fault current from all sources including grid
  - Locate breakers at extremities of the buses

4. Delays in Safety Bus Energization

- Following a plant trip, safety bus receives power when fast transfer / slow transfer is completed (See Fig 1)

- Mitigation
  - Instead of a disconnect switch at the generator output, provide a breaker. Grid power will be available immediately following the trip (see Fig 2)
  - Avoids transient torque on running motors

5. Instrument Bus Power Supply Failures

- Failure of inverter,
- Switching failure (Fig 4)
  - Mitigation
    - Provide DC control and DC controls with diesel generator back up
    - Provide DC vital bus with battery back up

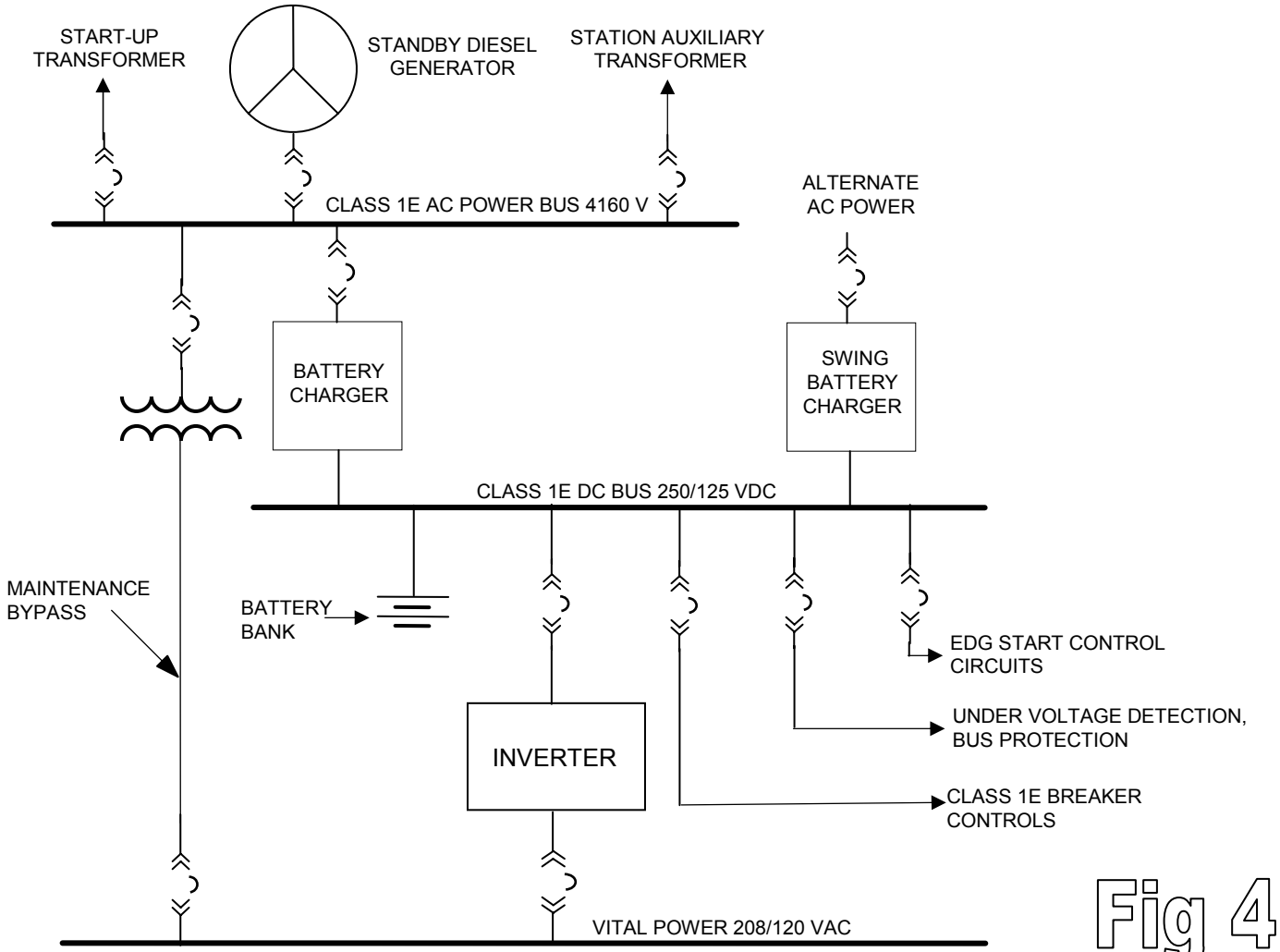

START-UP
TRANSFORMER
STANDBY DIESEL
GENERATOR
STATION AUXILIARY
TRANSFORMER
CLASS 1E AC POWER BUS 4160 V
ALTERNATE
AC POWER
BATTERY
CHARGER
SWING
BATTERY
CHARGER
CLASS 1E DC BUS 250/125 VDC
MAINTENANCE
BYPASS
BATTERY
BANK
EDG START CONTROL
CIRCUITS
UNDER VOLTAGE DETECTION,
BUS PROTECTION
INVERTER
CLASS 1E BREAKER
CONTROLS
VITAL POWER 208/120 VAC

Fig 4

6. Plant Trip and Loss of Offsite Power Caused by External Faults

- Stuck breaker protection
- Longer time to clear distant faults
- Automatic reclosing of the breaker on to the faulted feeder

- Mitigation
  - Increase protection at the cost of availability
  - Remove Aut0 reclosing of breakers
  - Reduce time for isolating NPP switchyard
  - Add ground fault detection and isolation in every segment of NPP switchyard

Summary

- Design enhancements can improve
  - Availability for safety buses
  - Reduce plant trips
  - Availability of instrument/vital buses

Questions