



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



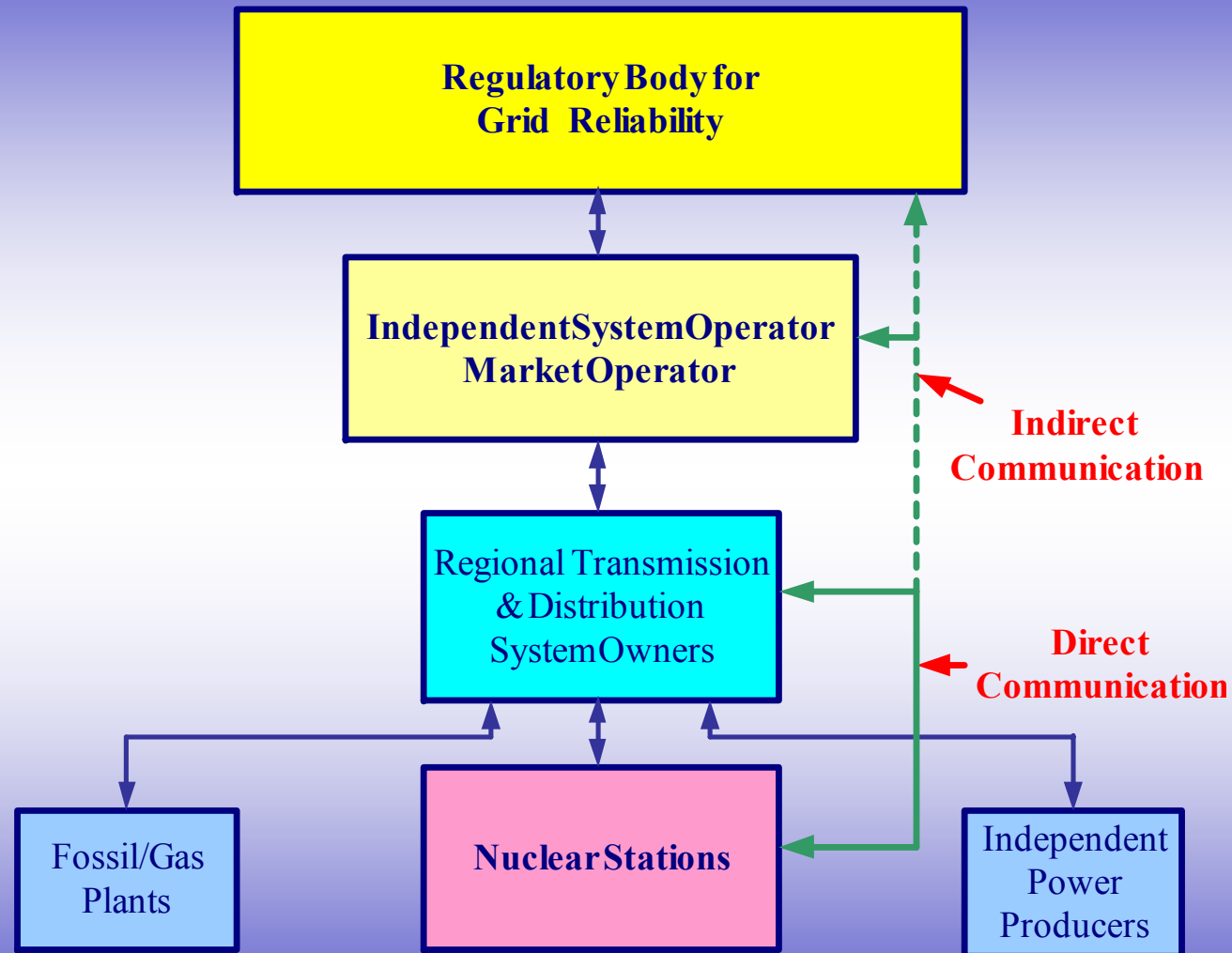
1. Inadequate Voltage at the Preferred Power Source

- 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



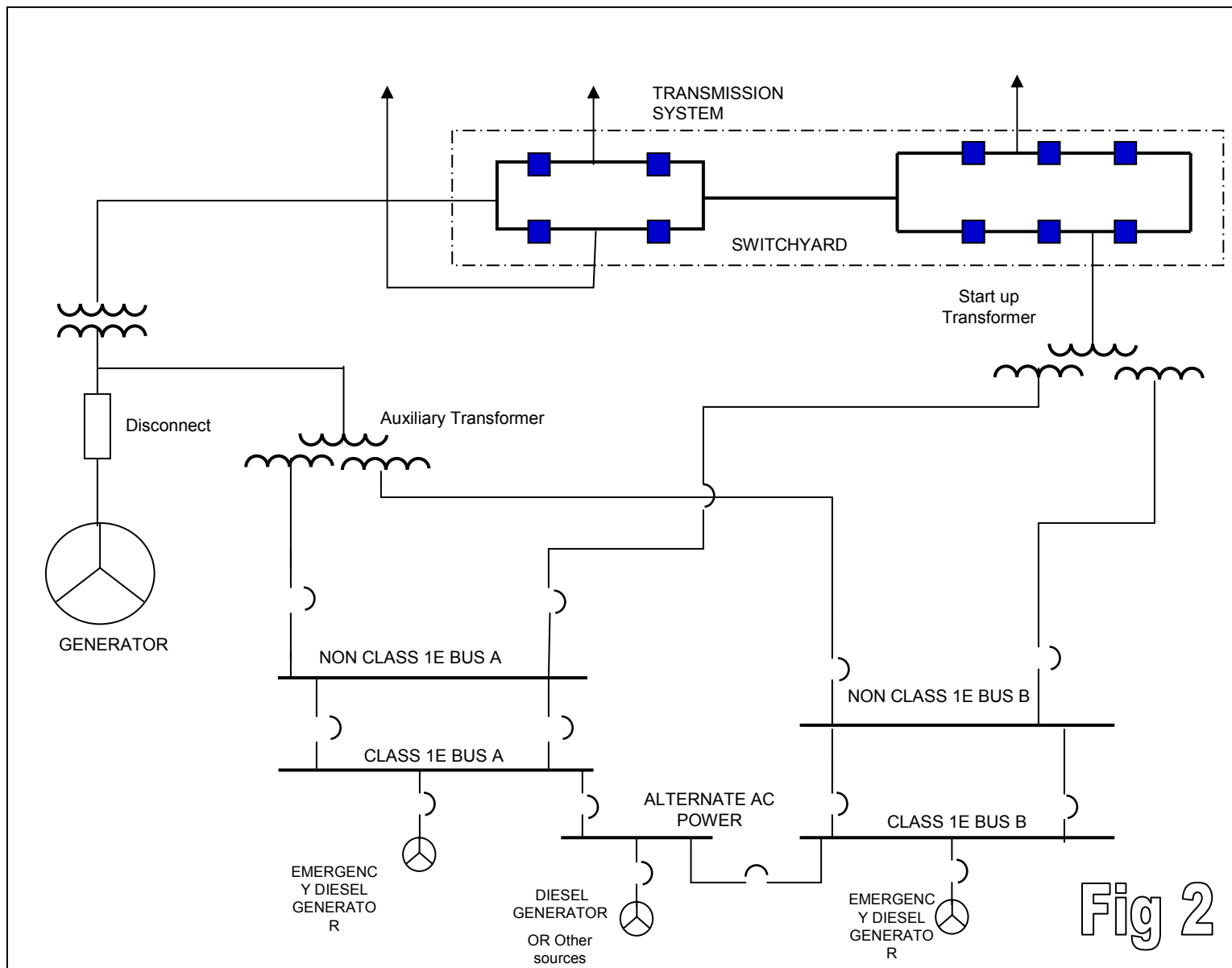
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Fig 1



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



ONE LINE DIAGRAM FOR SINGLE UNIT NUCLEAR STATION

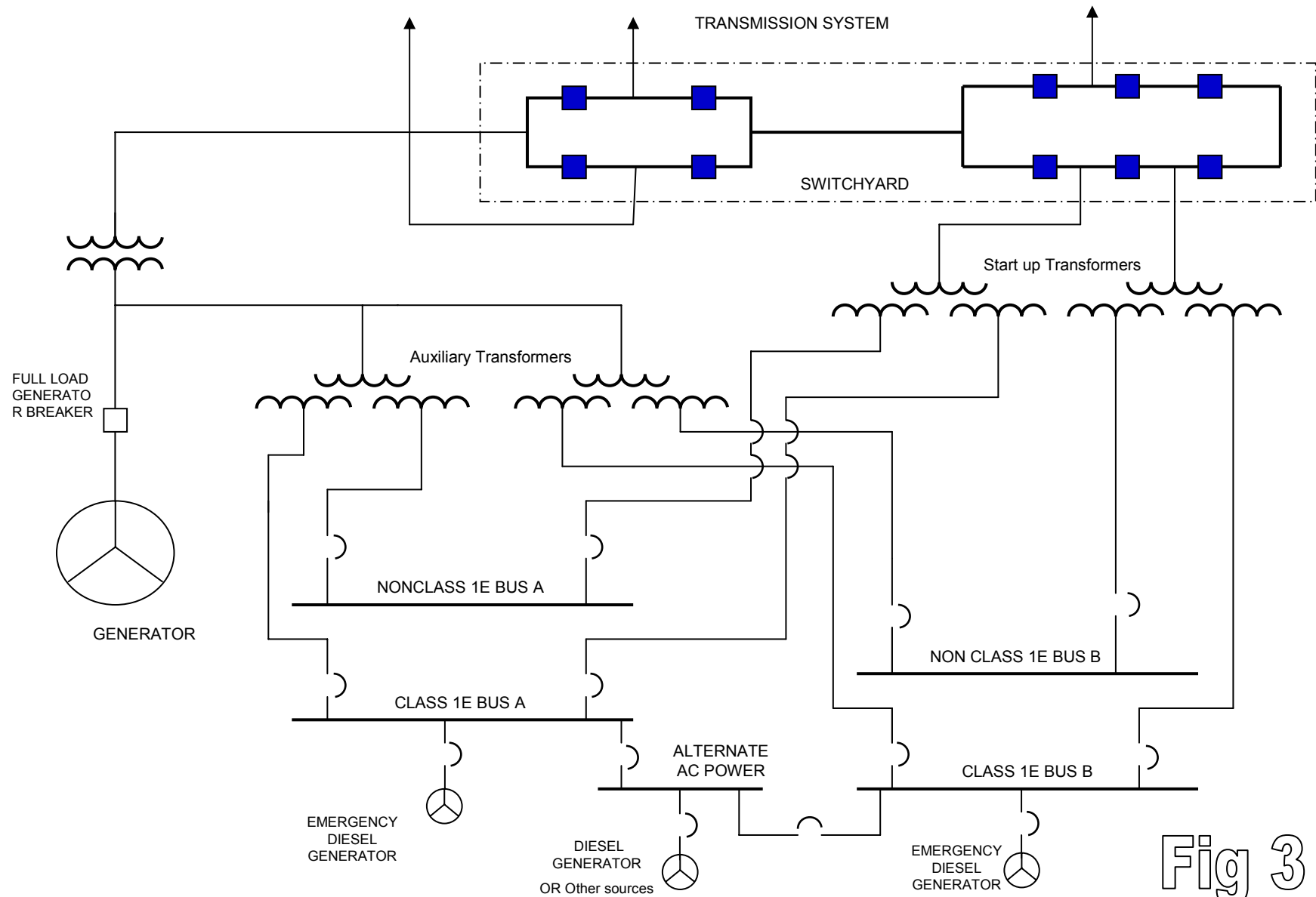


Fig 3



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

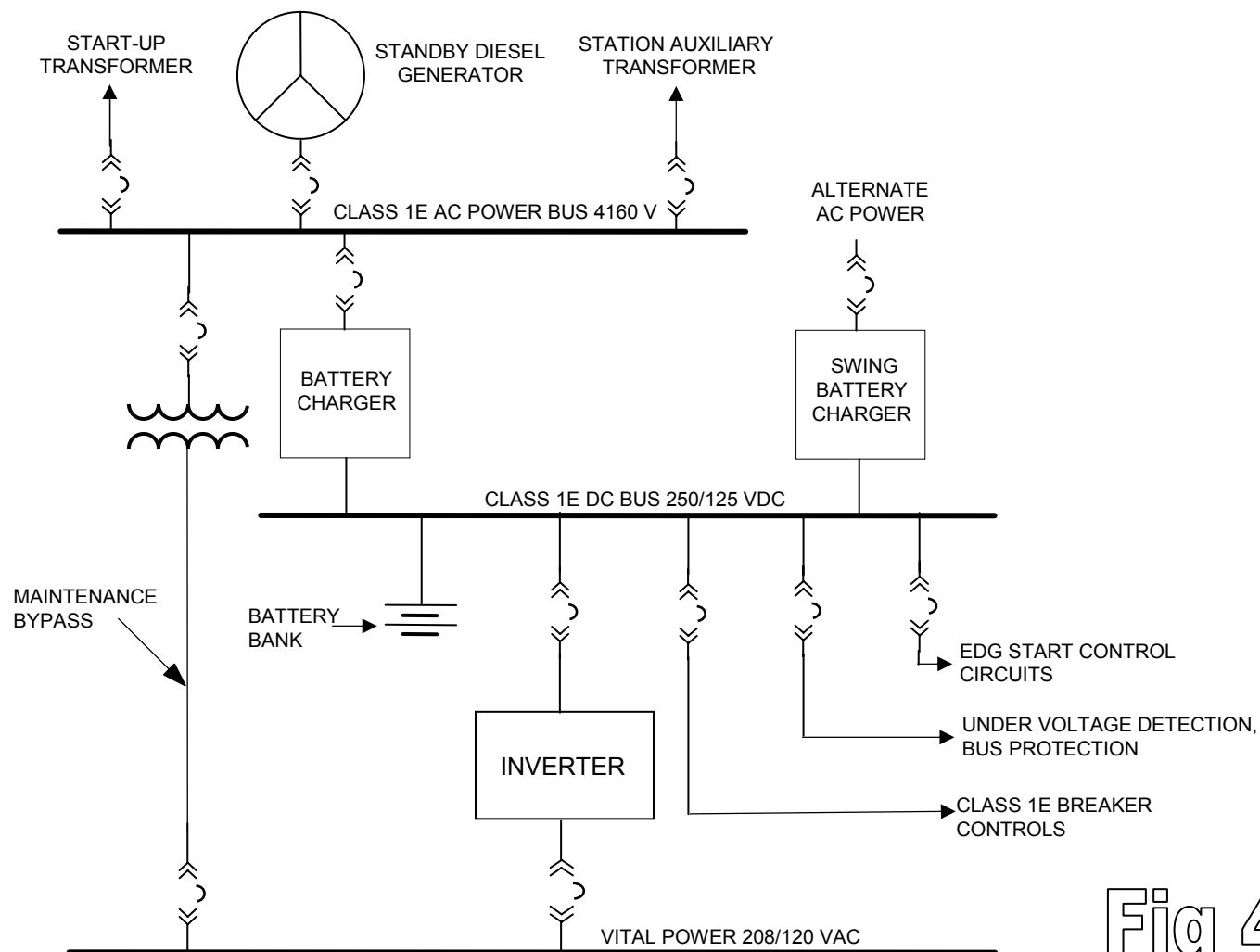


Fig 4



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 Auto 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

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