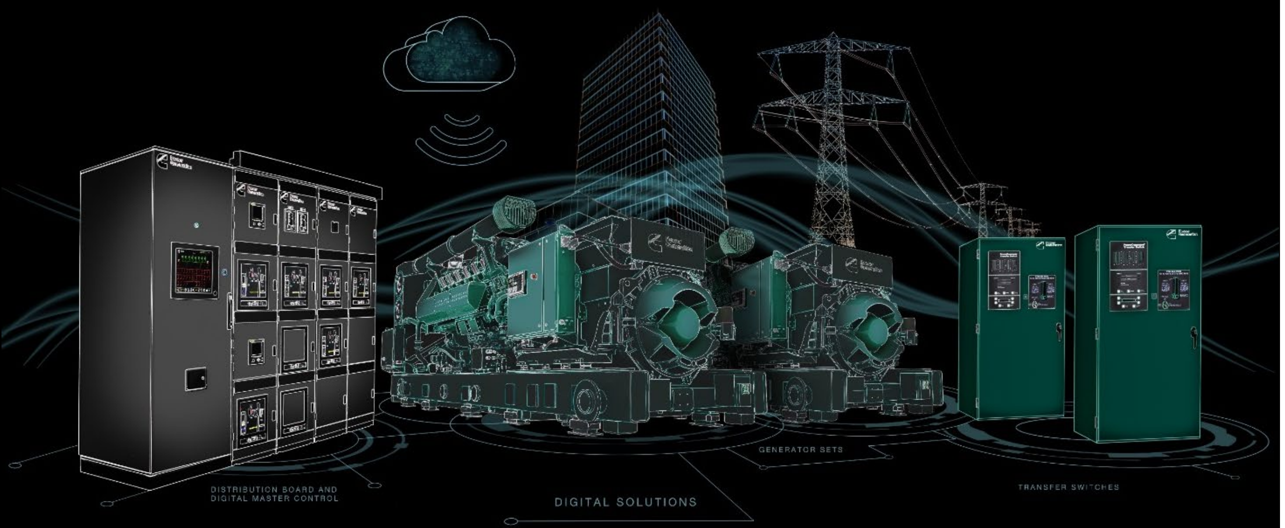

Power
Generation

The Role Of A System Level Control In A Power System

PowerHour webinar series for consulting engineers

Experts you trust. Excellence you count on.

May 21st, 2020 11:00 PDT / 1:00 CDT

(1PDH issued by Cummins)

Public

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- Participants are encouraged to refer to the entire text of all referenced documents. In addition, when it doubt, reach out to the Authority Having Jurisdiction.

Course Objectives

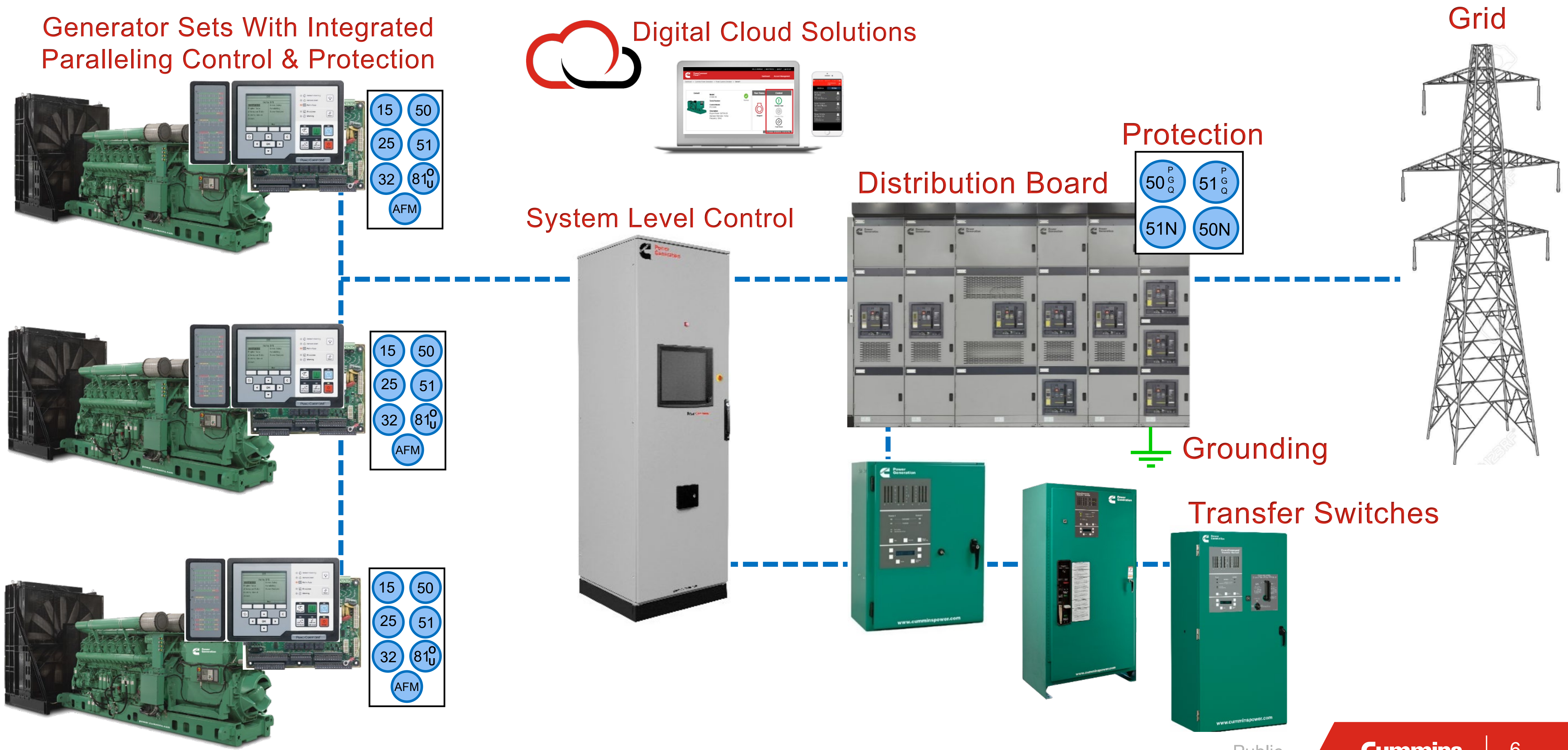
The Role Of A System Level Control In A Power System

This course goes beyond paralleling generator sets and dives into system level design and discusses the role and value of controls at a system level in a power system. Different failures modes are discussed to ensure a safe and reliable power system operation.

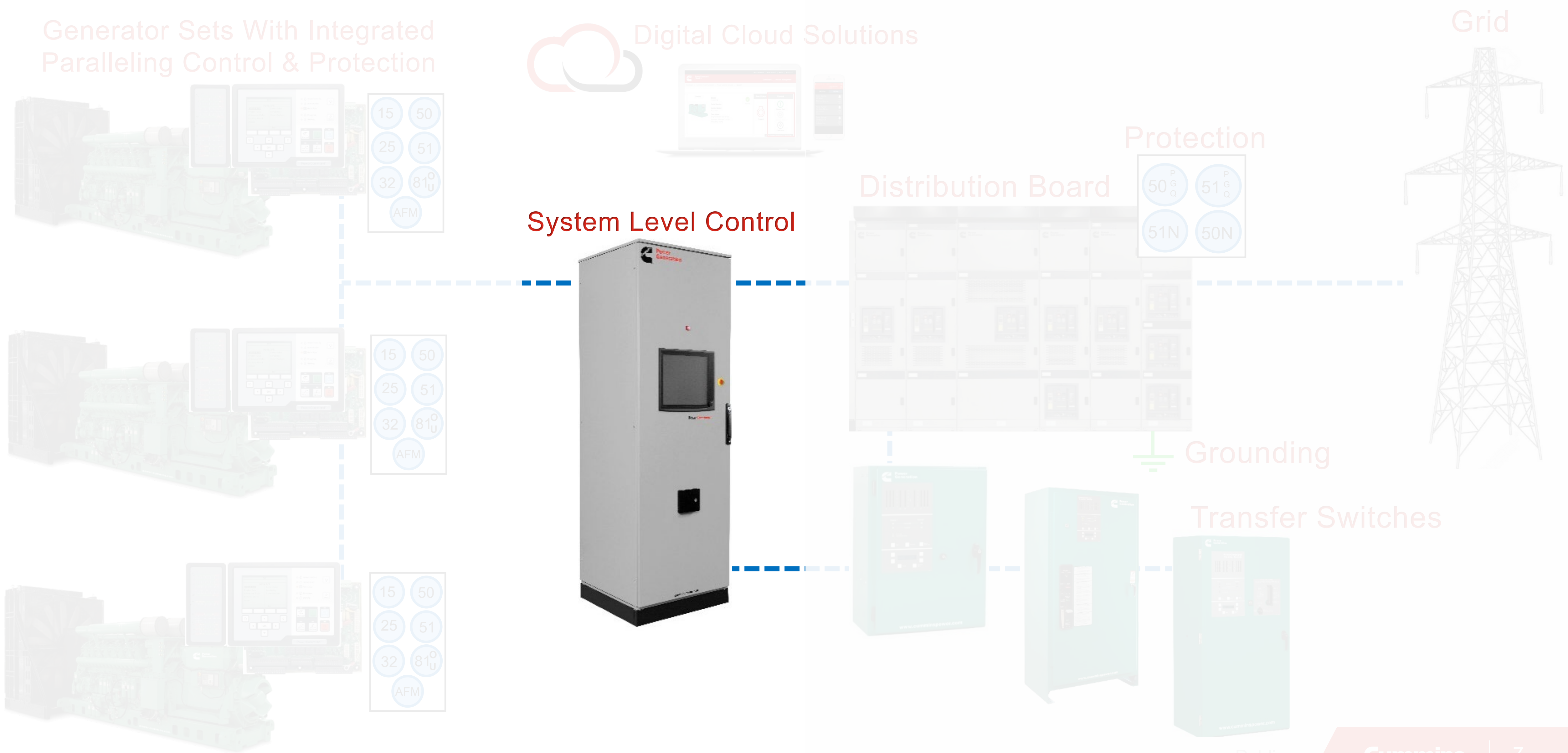
After completing this course, participants will be able to:

- Recognize the common building blocks of a backup power system and their functionalities
- Discuss the functionalities of a system level control and how they fit in a power system
- Describe common failure mode scenarios that must be considered when specifying a system level control for a safe and reliable operation
- Explain the different use case scenarios for system level control to better understand the value it brings to a power system

Power System Building Blocks

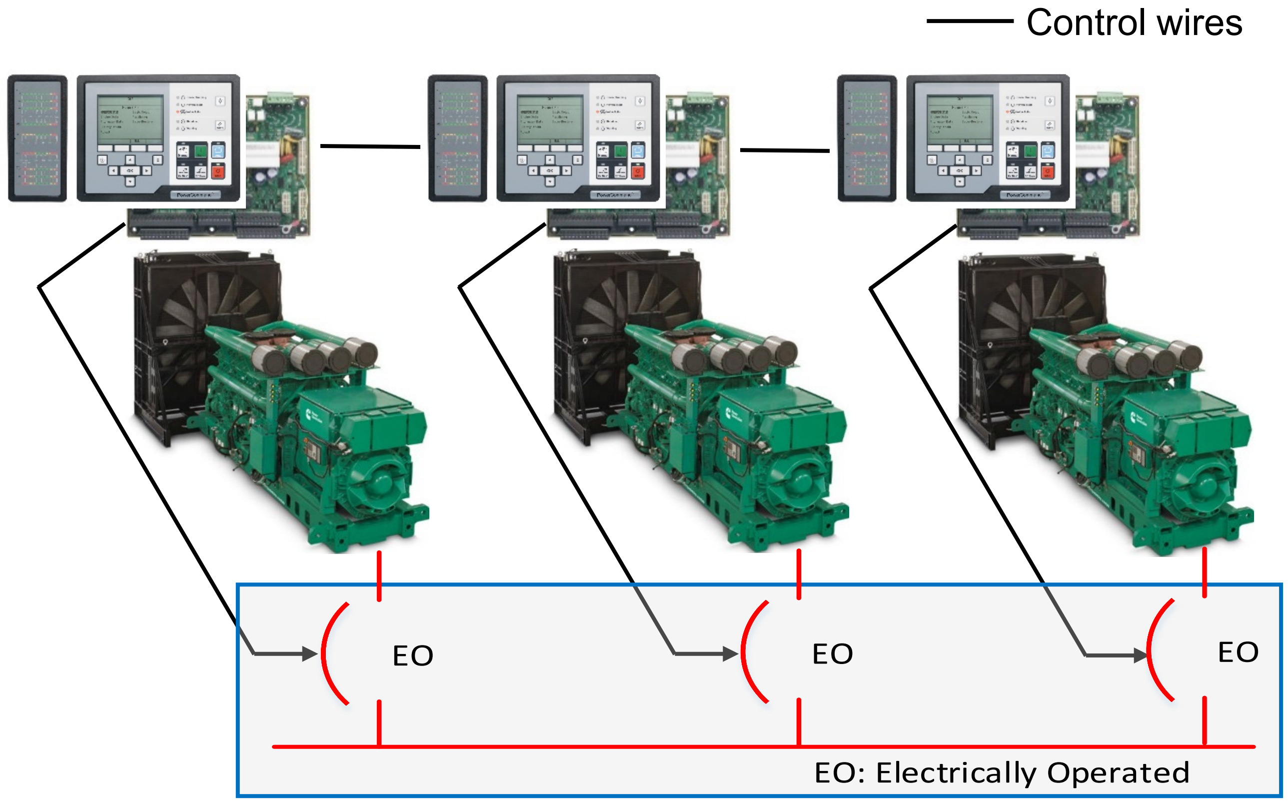


Power System Building Blocks



Integrated Autonomous Paralleling Control

- Paralleling functions are part of the generator set control
  - First start arbitration
  - Synchronizing (Ø, V, Hz)
  - Load sharing (kW and kVAR)
  - Generator set protection
  - Metering and alarms
  - Built-in safe manual paralleling
  - Capacity to load consumption optimization
- Distributed logic architecture
  - No paralleling master
  - Single point of failure eliminated
- Consistent design
  - Easier to learn, operate, and troubleshoot
- Reduced wiring and footprint and more reliable compared with the traditional generator set paralleling



Common point of power connection such as a switchgear or a switchboard

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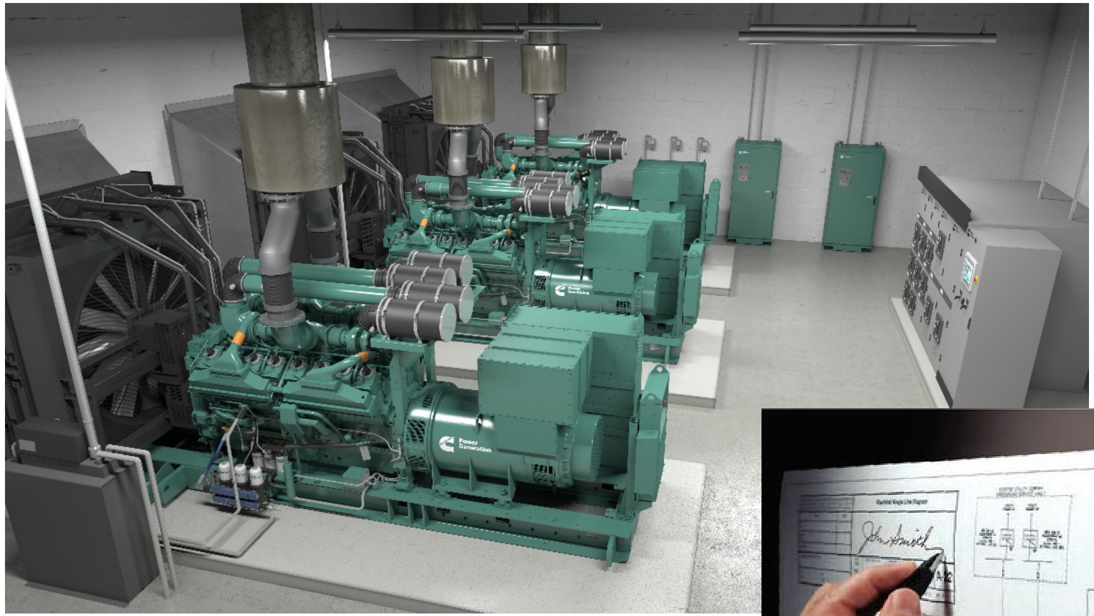
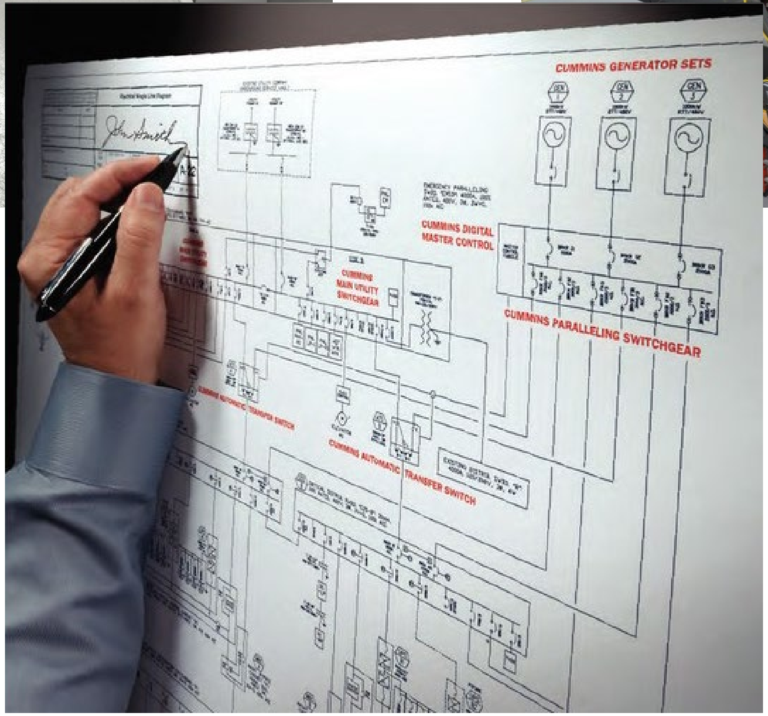
Common point of power connection such as a ...board

Spec Note Each generator set shall be designed to be completely autonomous and capable of providing all specified paralleling functions and performance without any external control.

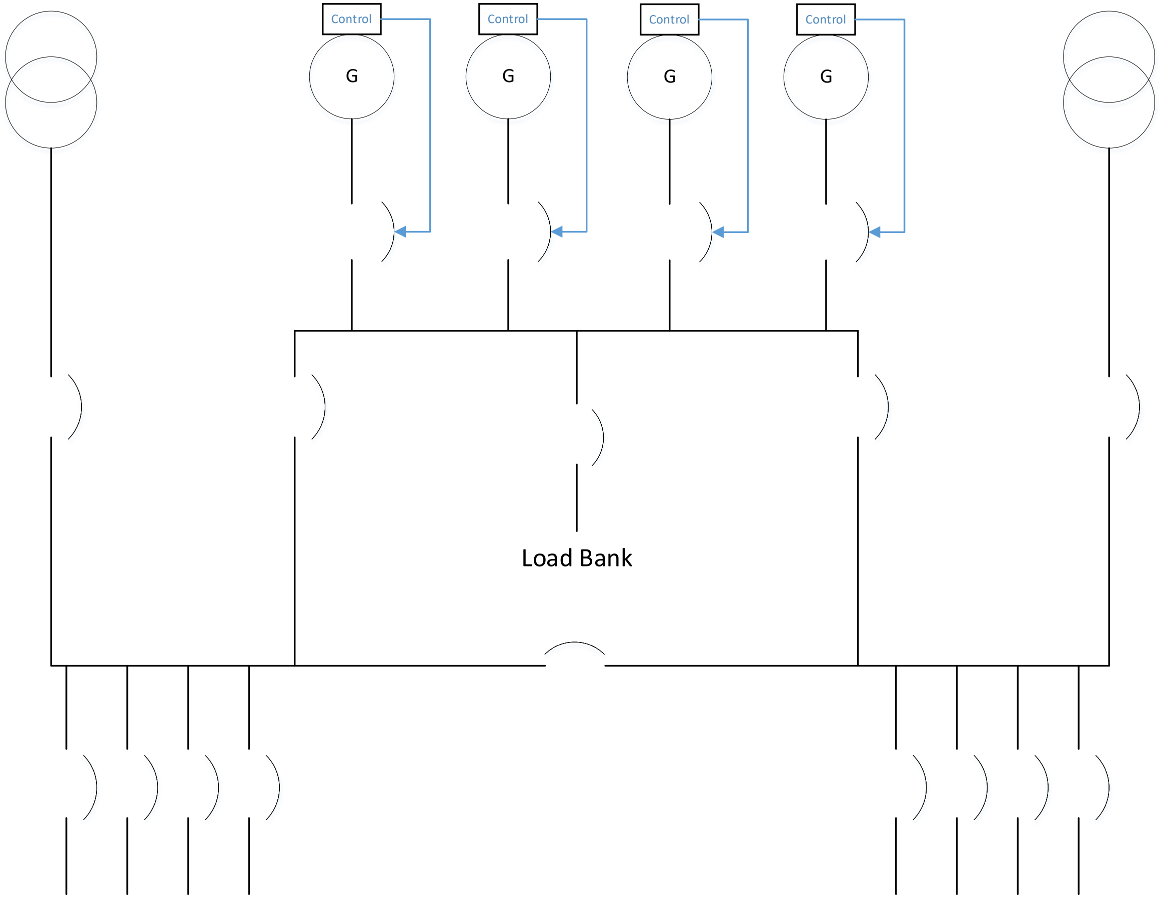
Power System Design





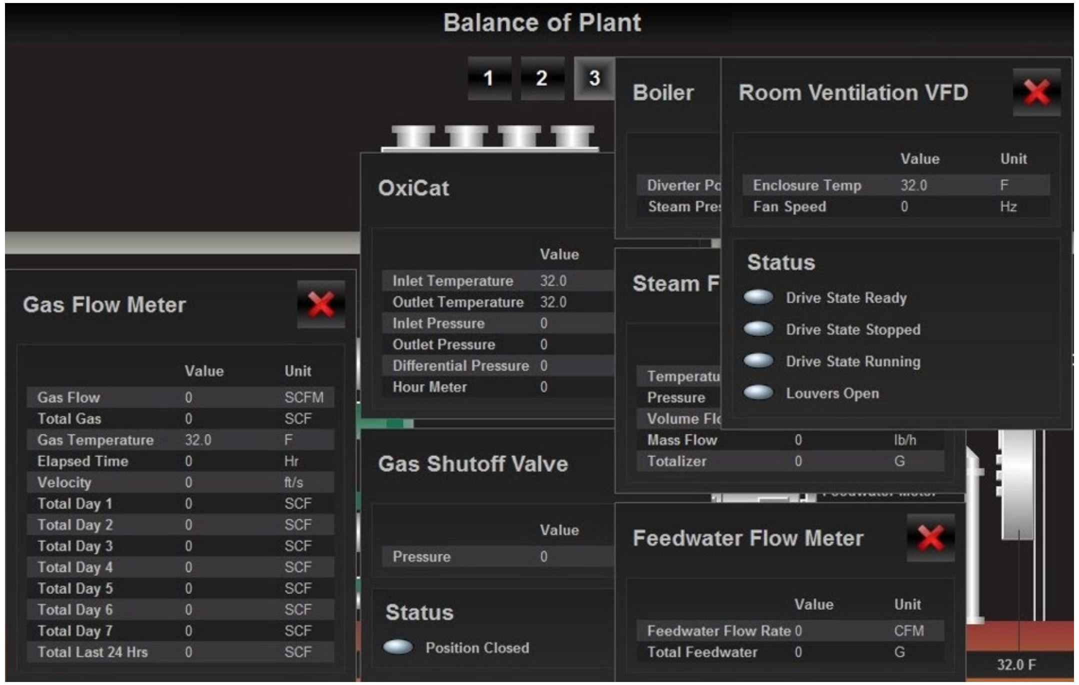
Beyond Paralleling Generator Sets

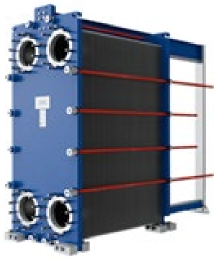
- A power system might be comprised of one or multiple:
  - Paralleling generator sets
  - Utility feeds
  - Generator main breakers
  - Tie breakers
  - Load buses and load control
  - Load banks



Beyond Paralleling Generator Sets

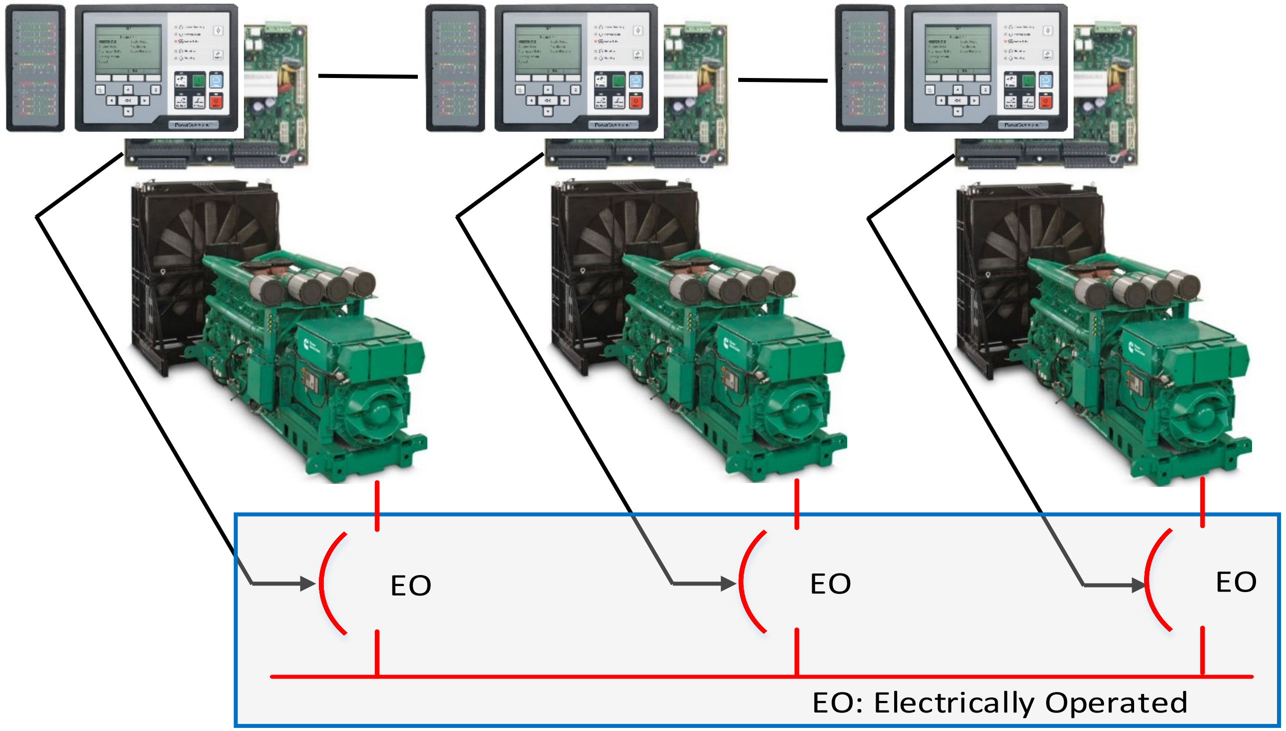
- There might be a need to:
    - Manage and parallel with renewables
    - Manage and control a CHP system
    - Manage and control balance of plant
    - Perform extended utility paralleling
        - Peake-shave or base load

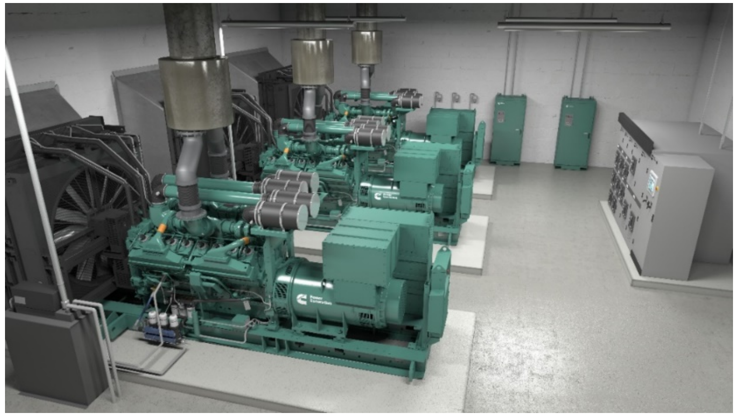


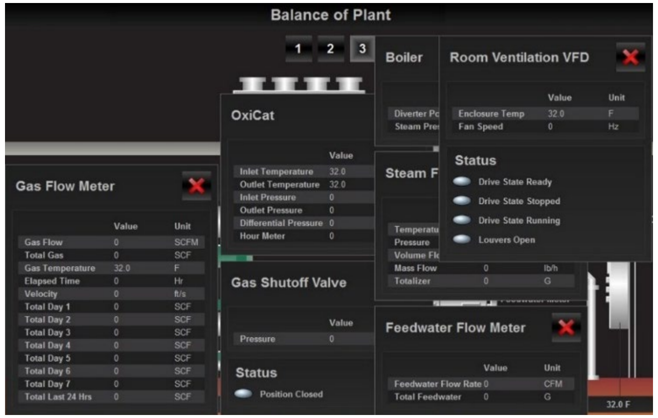


Beyond Paralleling Generator Sets

- Generator set paralleling is accomplished via onboard control
- What about the other parts of the system?
- A set of detailed instructions (known as the sequence of operation) is needed to control this power system and route power from sources to loads with high degree of reliability and handle failure modes







Sequence Of Operation

- It is the most important design aspect of any system. It describes:
  - The system behavior under normal conditions
  - The system behavior when normal power is lost
  - Different paths of routing power from sources to loads
  - Handling failure modes
  - Load control (add/shed)
  - System tests with or without load
  - Automatic load bank control
- The sequence of operation is carried out by the system level controller


Power Generation

Sequence of Operation

Dual Transfer Pair

PowerCommand® Paralleling Switchgear

Revision 1.0

Sequence Of Operation

8.4 52-UM Breaker Failure (Auto - Soft Closed Transition)

8.4.1 52-UM Breaker Fail to Open during Loss of Utility Source

The system follows the sequence described in Auto – Open Transition *52-UM Breaker Fail to Open during Single Loss of Utility Source.*

8.4.2 52-UM Breaker Fail to Open Reset

1. The operator clears the fault on the 52-UM breaker and resets the alarm on the DMC.
2. If the utility source is not available, the system follows the sequence described in *Loss of Single Utility Source (Auto – Open or Auto – Soft Closed Transition).*

8.4.3 52-UM Breaker Fail to Open during Test with Load

1. The system is commanded to enter into Test with Load.
2. The DMC sends a start signal to the generator sets.
3. The Min. Capacity to Connect timer starts.
4. The generator sets start automatically and independently, and accelerate to rated voltage and frequency.
5. The first generator set closes to the bus as dictated by the First Start System.
6. The remaining generator sets synchronize to the Genbus and close their respective generator set breakers when synchronization conditions are met within their PCCs.
7. The Transfer Delay starts in the DMC when the Min. Capacity to Connect is reached. (Transfer Delay stops and resets if the capacity drops below the setpoint.)
8. When the Transfer Delay expires, the master synchronizer is enabled between the utility source and the Genbus to synchronize the generator sets to the utility source.
9. The DMC verifies that Min. Capacity to Connect is true and the DMC commands the 52-GM breaker to close. The 52-GM breaker closes and Min. Capacity to Connect timer stops and resets.
10. The generator sets start to ramp up.
11. When the load across the 52-UM breaker is below the Unload kW threshold, the DMC commands the 52-UM breaker to open. The 52-UM breaker fails to open.
12. The "52-UM Fail to Open" alarm is registered on DMC.
13. The system is removed from Test with Load.
14. The generator sets ramp down.
15. When the load across the 52-GM breaker is below the Unload kW threshold, the DMC commands the 52-GM breaker to open. The 52-GM breaker opens.
16. If the other transfer pair requires the generator set source, the system continues the transfer to the generator set source on the other Loadbus. The DMC removes the start signals from the generator sets if there is no demand for the generator set source.

8.4.4 52-UM Breaker Fail to Open Reset

1. The operator clears the fault on the 52-UM breaker and resets the alarm on the DMC.
2. The system is in *Normal Standby Conditions* and does not reenter Test with Load

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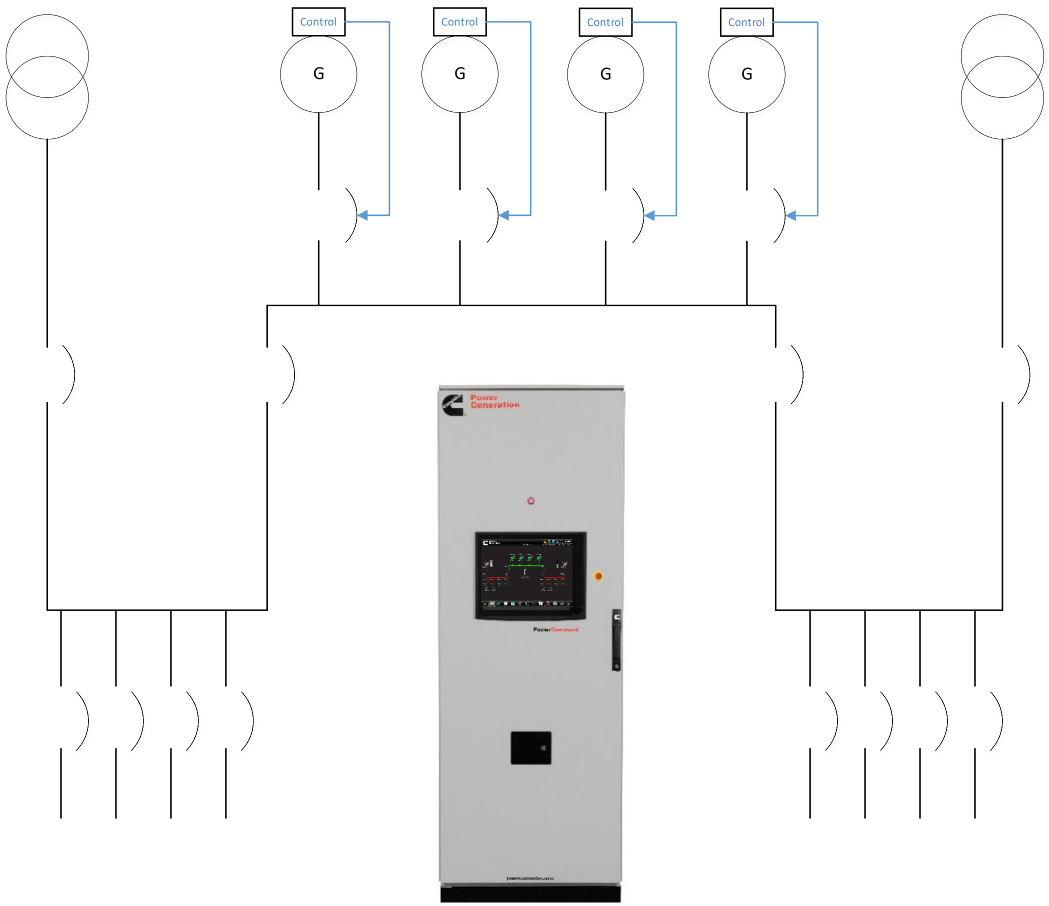
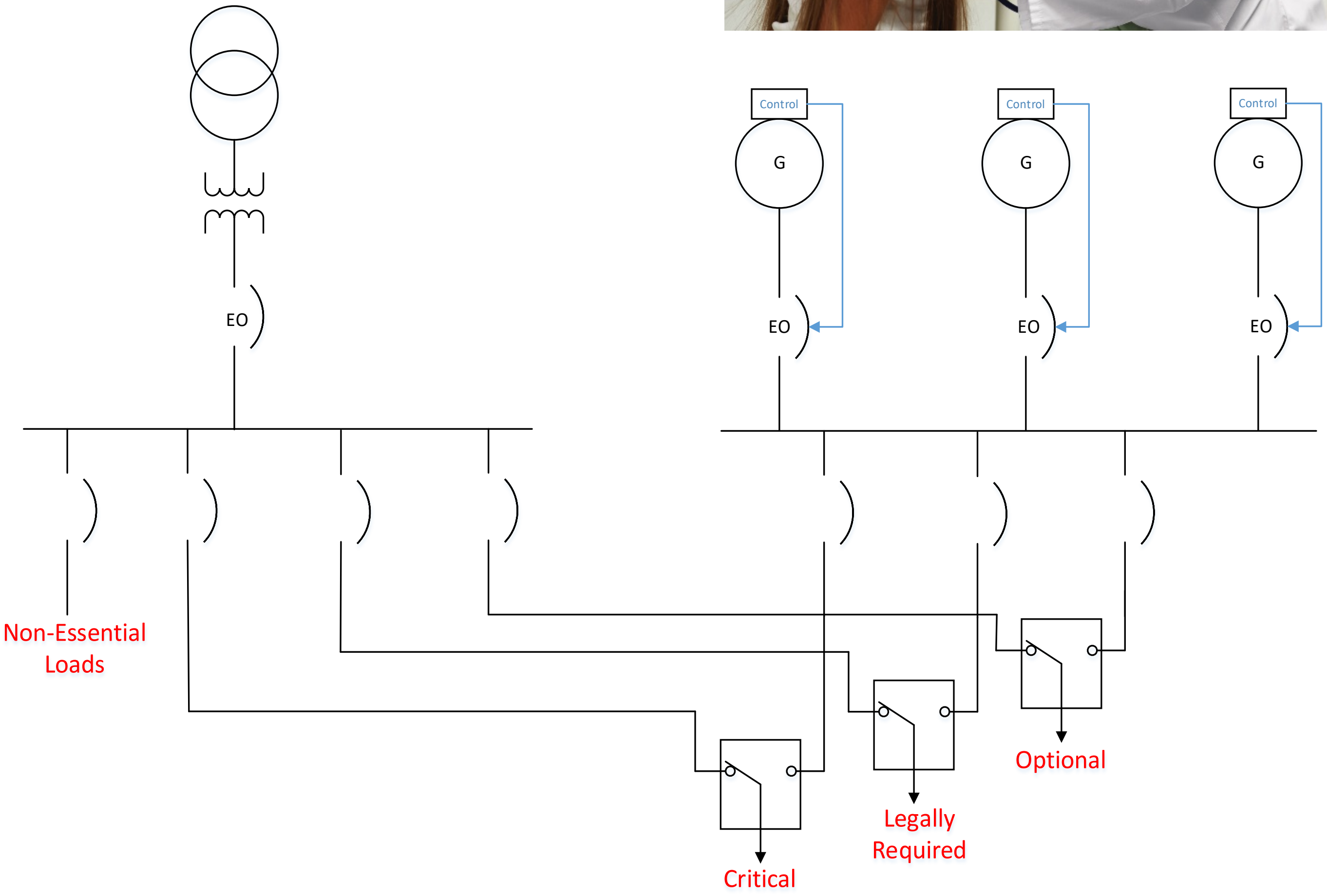
System Level Control Considerations

- Acts as a supervisor to monitor the entire operation and health of the power system
- Executes the sequence of operation and handles key system operation failure modes
- Controls different system breakers:
  - Utility main breakers
  - Generator main breakers
  - Tie breakers
- Handles load control (add/shed) of downstream feeders and transfer switches
- Enables system testing with automatic loadbank control
- Provides reports, alarms, and data trending



System Level Control
Healthcare

- Single-line diagram with critical information
- Automatic load control (add/shed)
- Automatic and manual system control
- System information:
  - Generator set data
  - Transfer switch data
  - Generator and transfer switch test
  - Compliance Reports (NFPA110)
  - Metering data
  - Event log
  - Alarms



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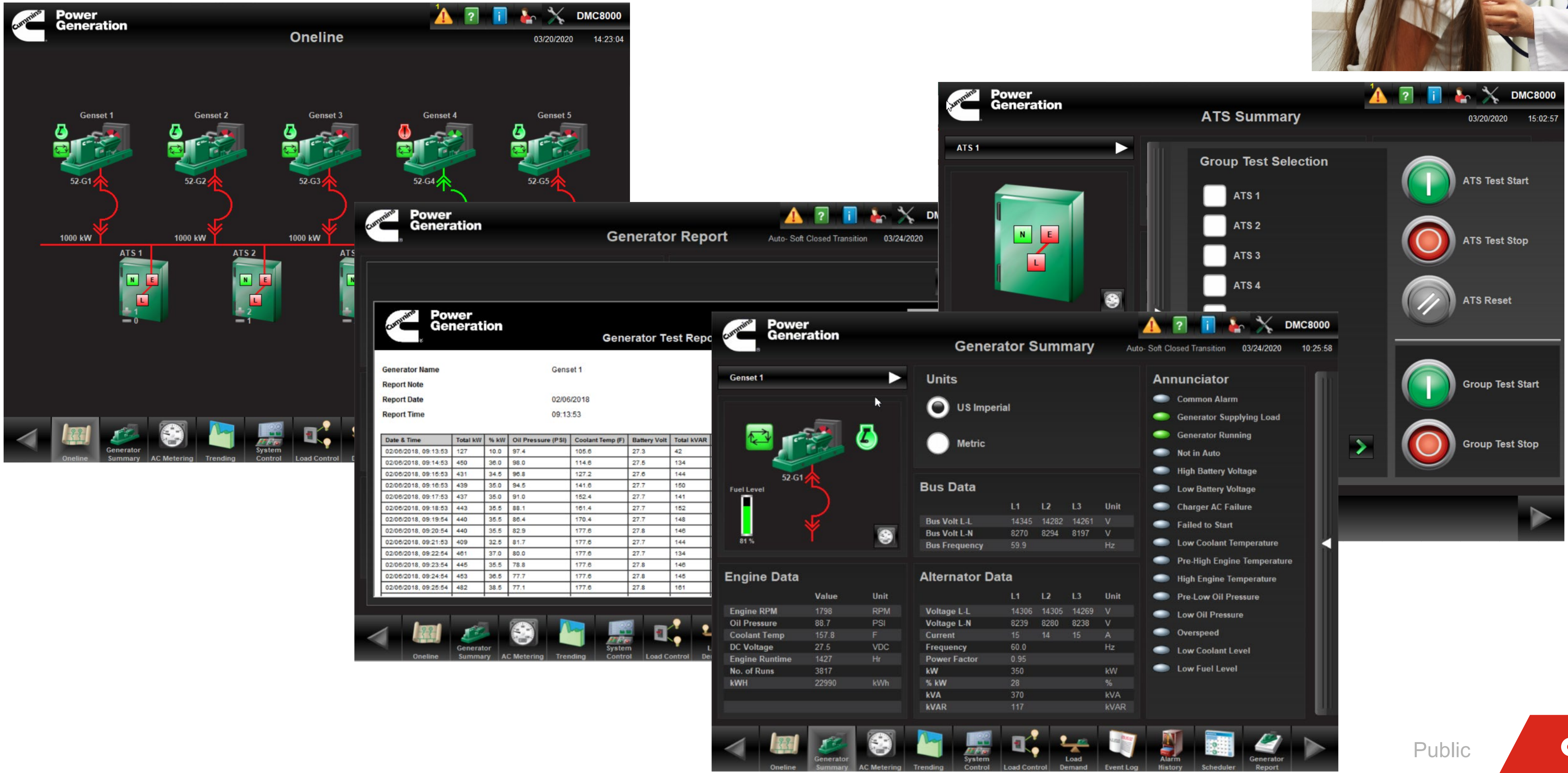
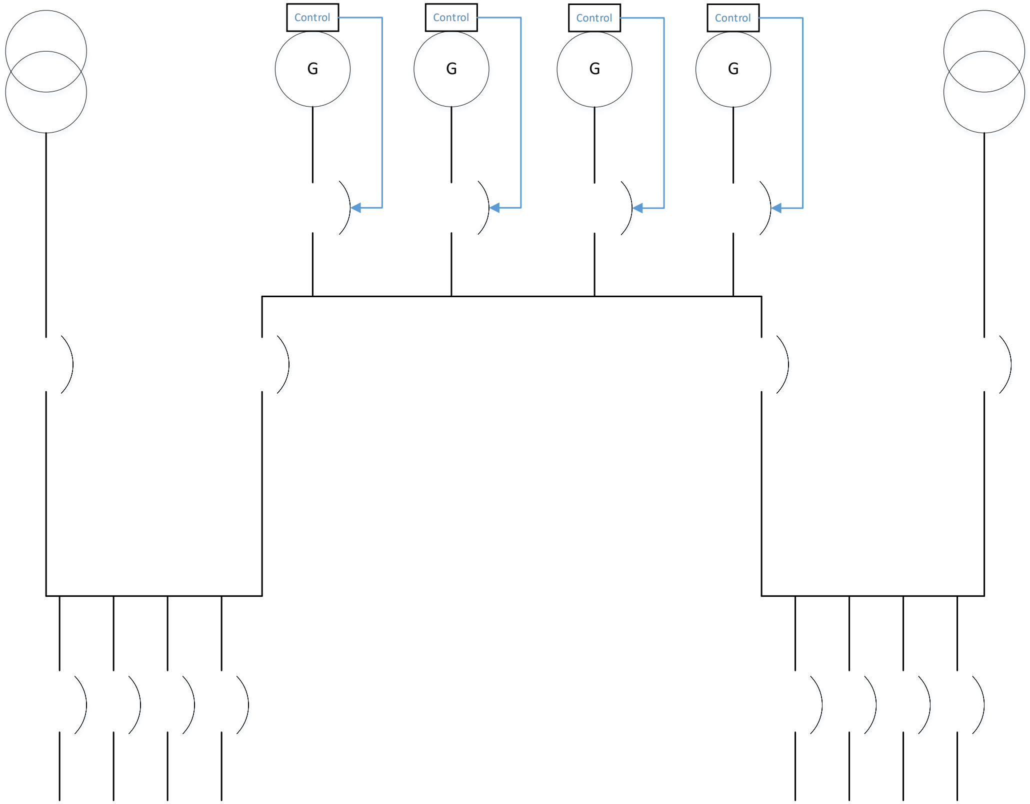


System Level Control
Water/Waste Water

- Single-line diagram with critical information
- Routing power from different sources to loads
- Utility main and generator main control
- Utility paralleling (if in scope)
- Handling failure modes
- Automatic load control (add/shed)
- Automatic and manual system control
- System information:
  - Trending
  - Metering data



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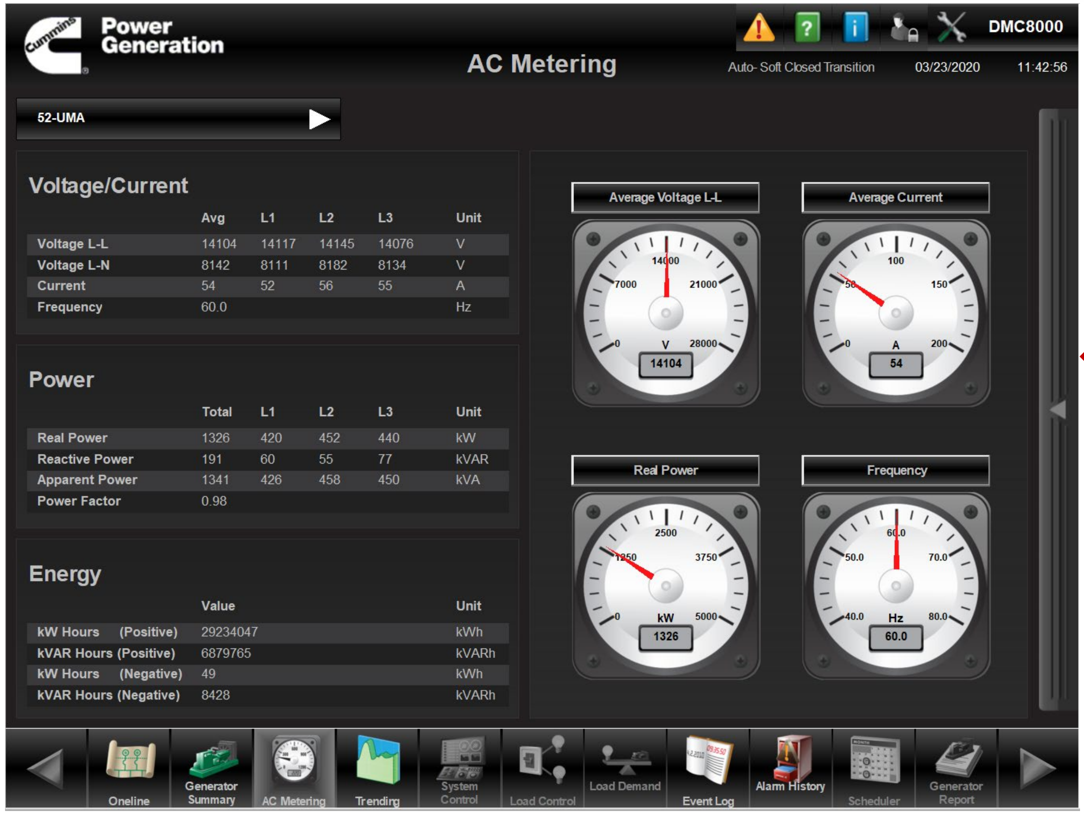
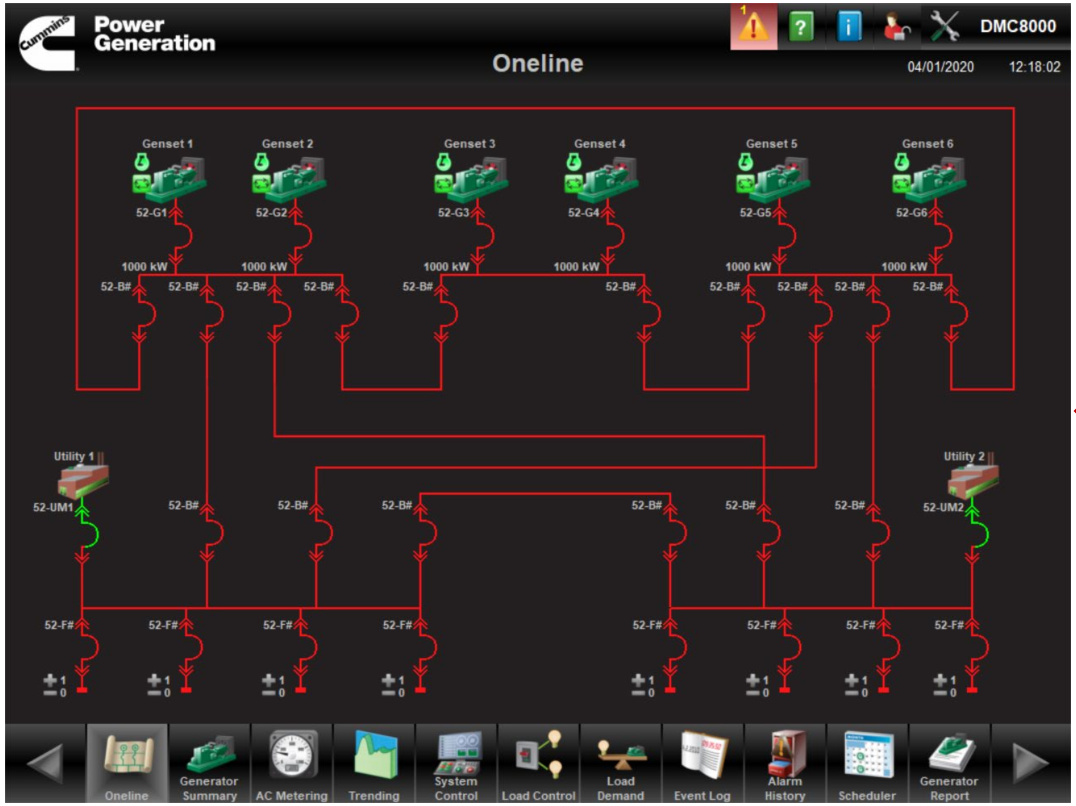


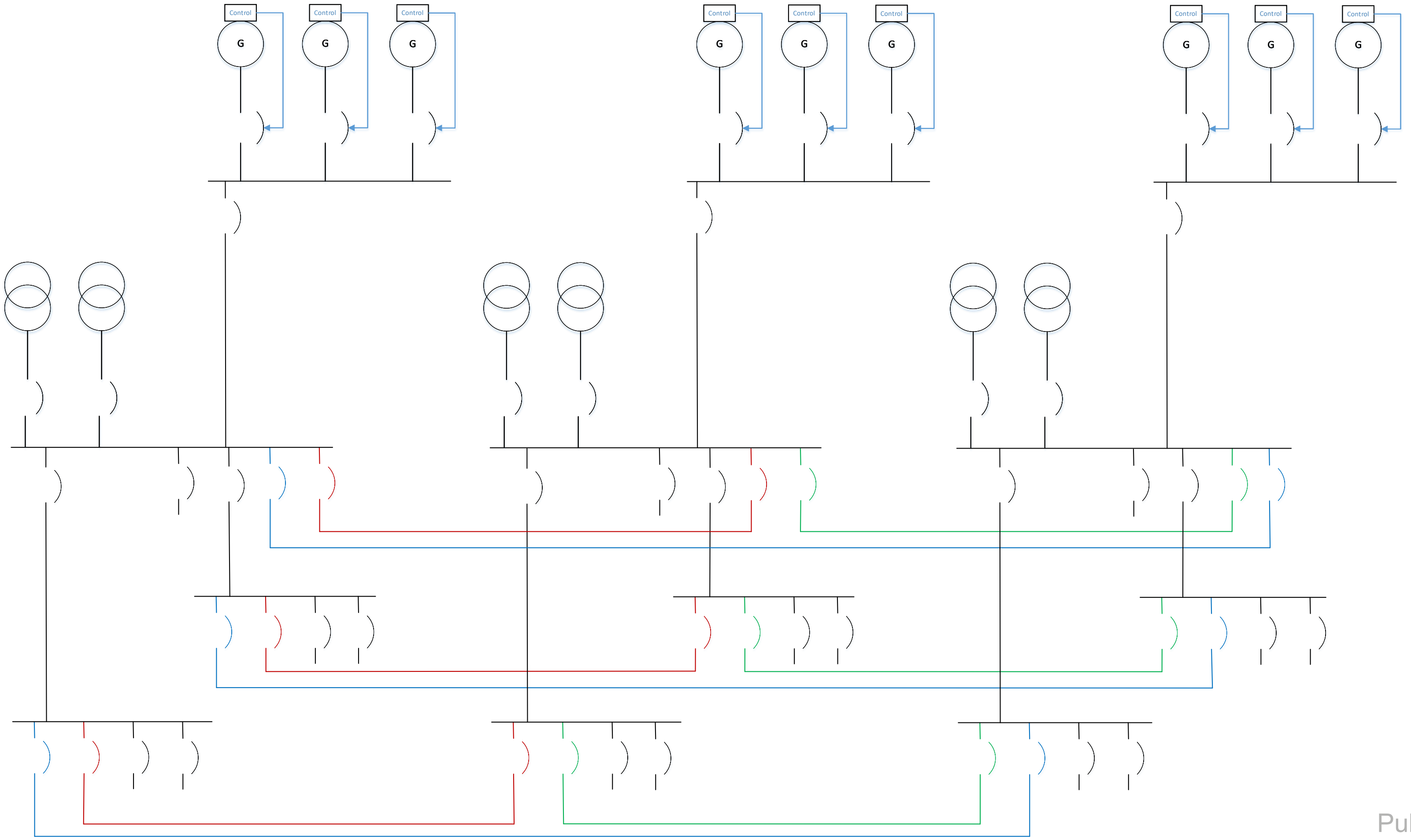
System Level Control
Data Centers

- Single-line diagram with critical information
- Routing power from different sources to loads
- Multi-breaker control:
  - Utility mains
  - Generator mains
  - Ties
- Utility paralleling (if in scope)
- Bypassing buses & breakers for maintenance
- Handling failure modes
- Automatic and manual system control
- System information

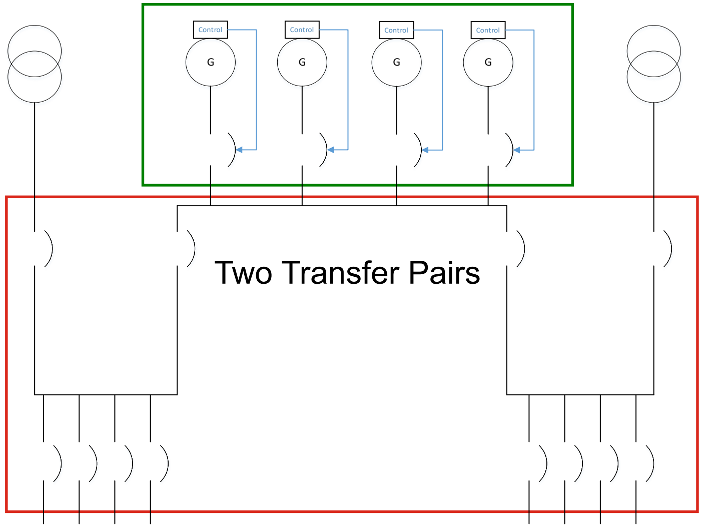


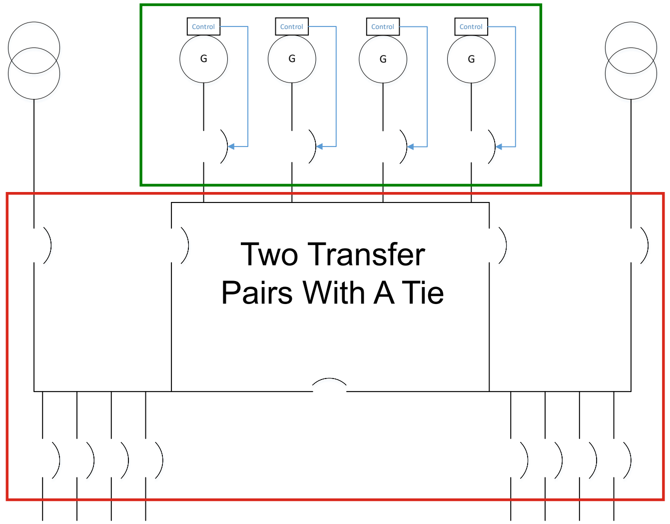
System Level Control

Complex Systems

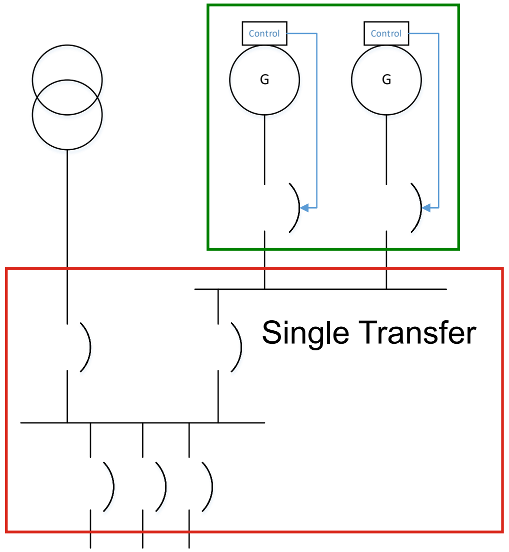


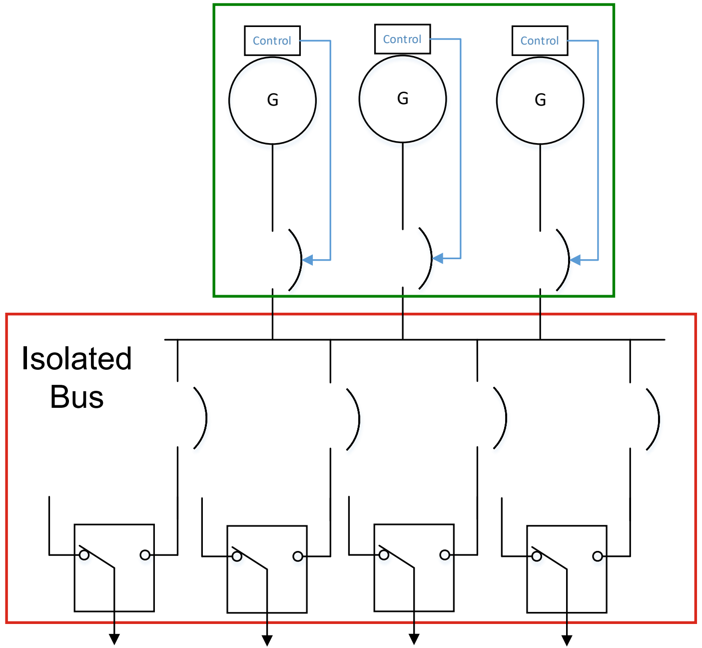
Generator Paralleling Vs. System Level Control





Generator Paralleling Control





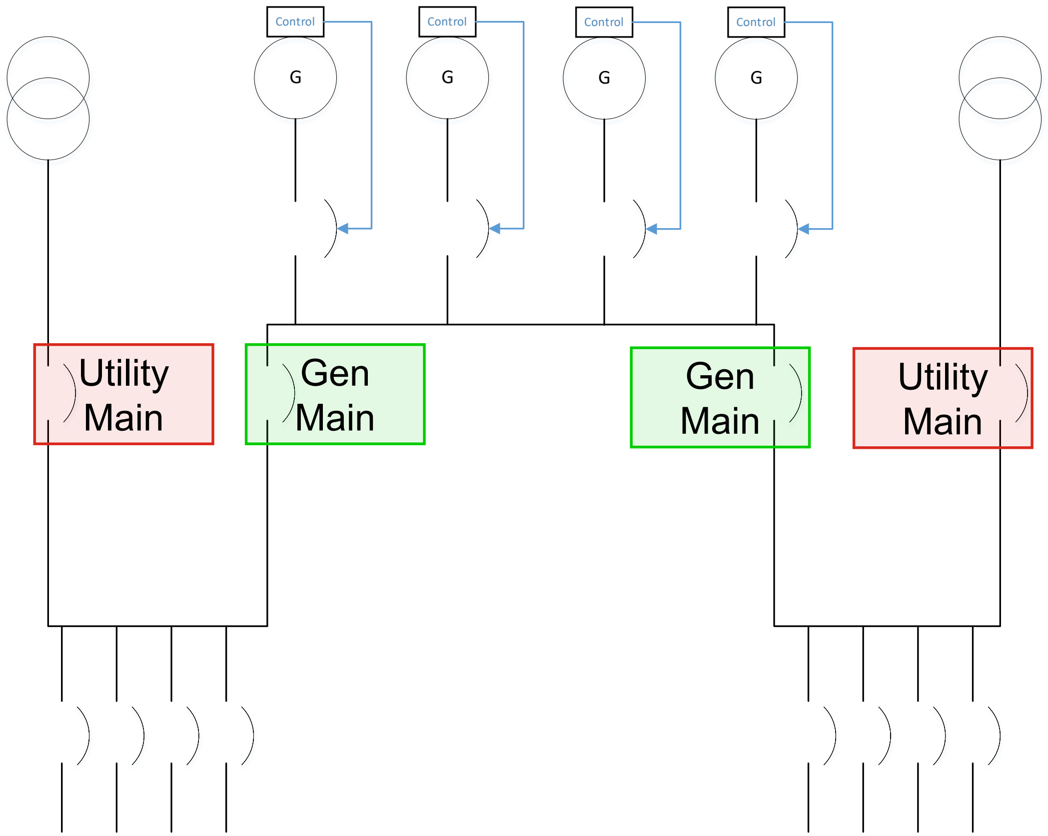
System Level Control

System Level Control Dependability

- Failure of the system level control shall not jeopardize the overall power system reliability
- Some of the components that can fail:
  - HMI (screen)
  - PLC
  - Networking devices: I/O cards, communication
- Failures must be analyzed and mitigated so the system fails gracefully
  - With HMI failure, the system should be able to transfer power
  - Continuous system diagnostics of controller, network, and I/O cards
- The system shall allow for manual operation
  - System breakers can be operated manually if needed
  - Generators can be started manually
  - Generators can be paralleled manually through their local control/HMI

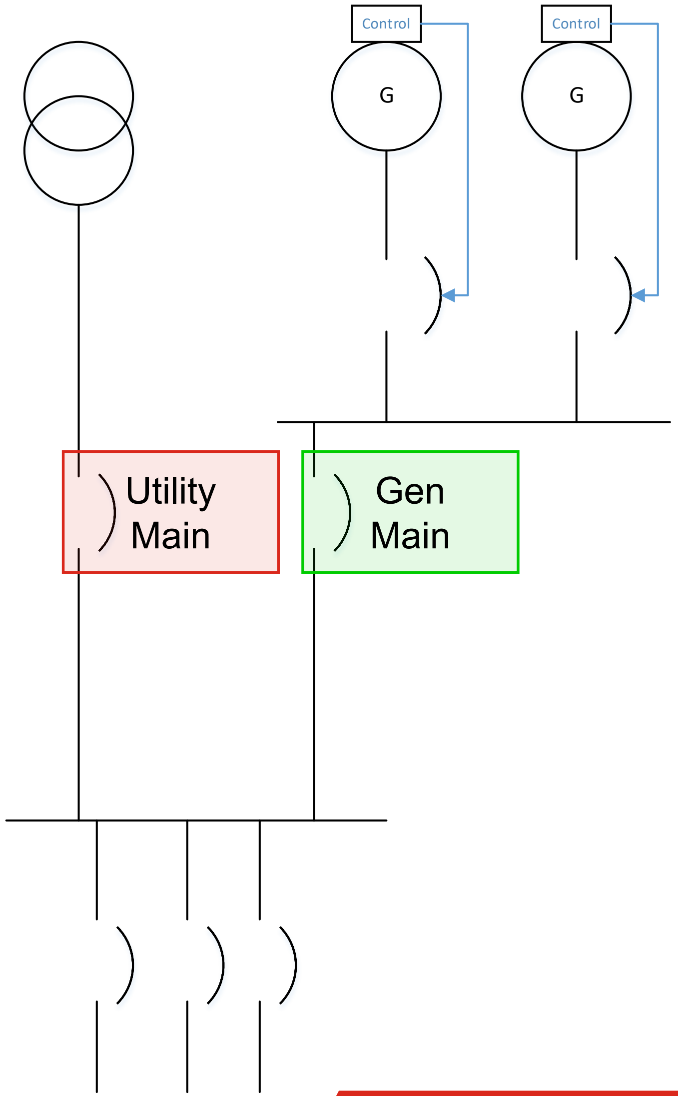
Sequence Of Operation Dependability

- Some examples of breaker failure modes scenarios:
  - Utility main fails to open on loss of normal power
  - Utility main fails to close on return of normal power
  - Gen main fails to open on return of normal power
  - Gen main fails to close on loss of normal power
- The sequence of operation must include mitigated failure modes scenarios to ensure a safe and reliable operation



Deeper Look Into Control Robustness

- Some manufacturers look deeper into system safety and reliability
- For example, utility main/gen main breaker states are:
  - Open
  - Closed
  - Tripped
  - Unknown
- If the status is unknown, then how does the system behave during a power transfer?
- What about unexpected events such as manually operating a breaker or racking out a utility main breaker while the system is in Auto?
- Failures must be analyzed and mitigated for safe and reliable operations



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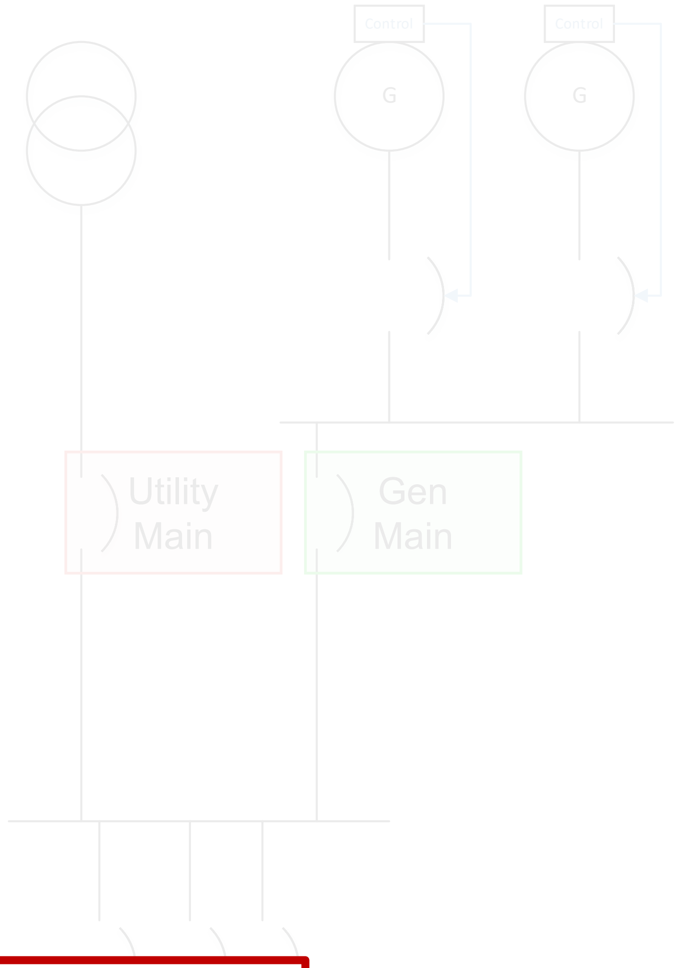
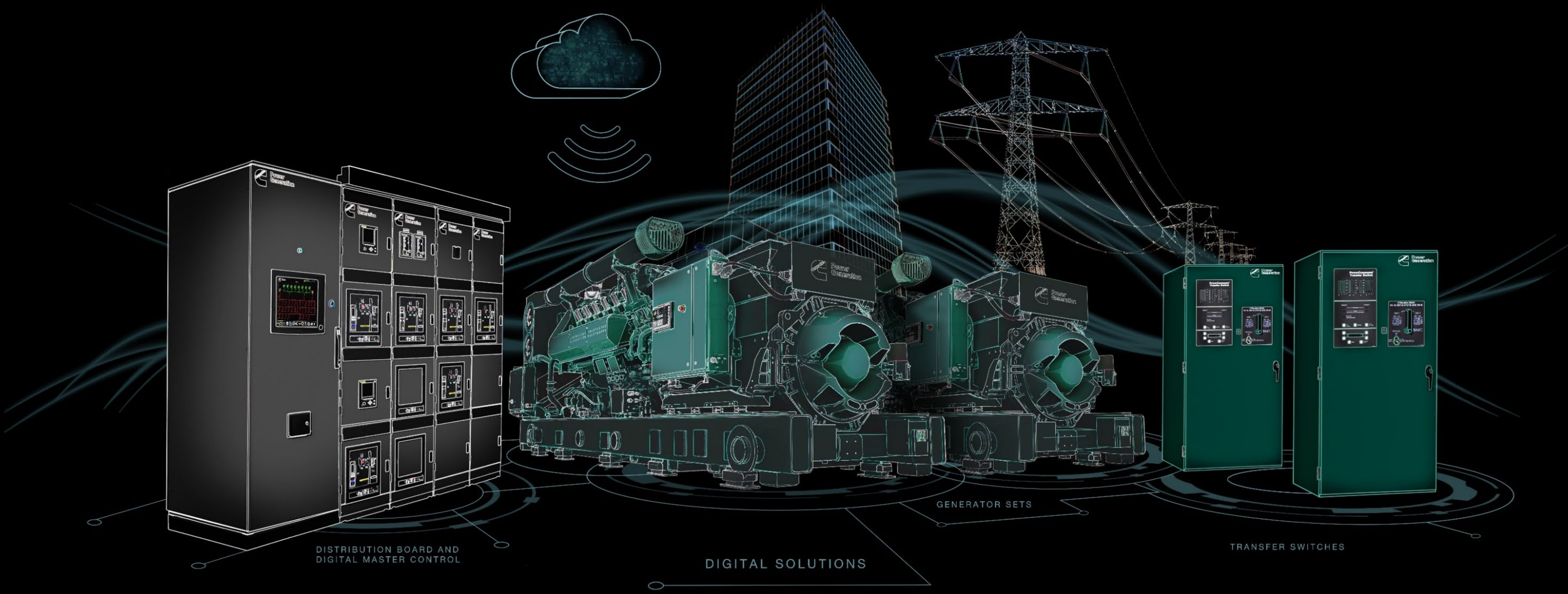


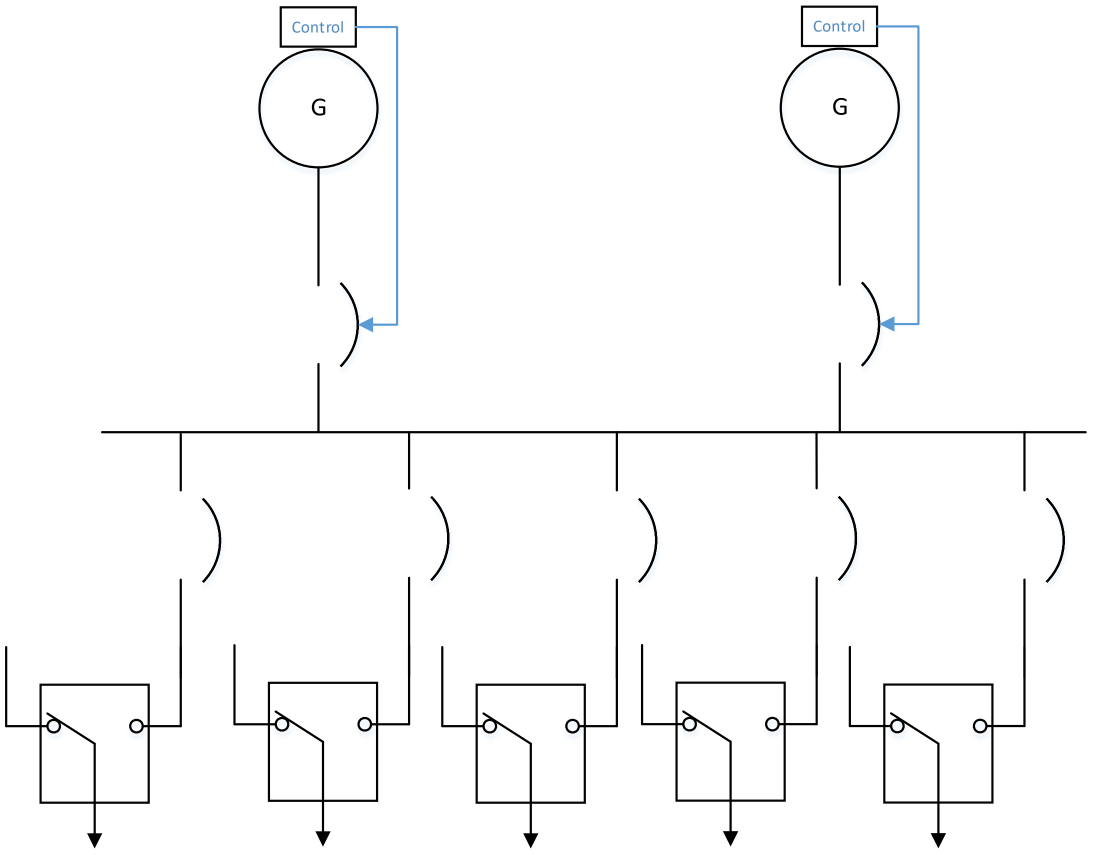
Spec Note Specify a system level control with analyzed and mitigated failures modes to monitor and control the operation of the entire power system.

Use Case Scenarios



Isolated Bus – Hospital

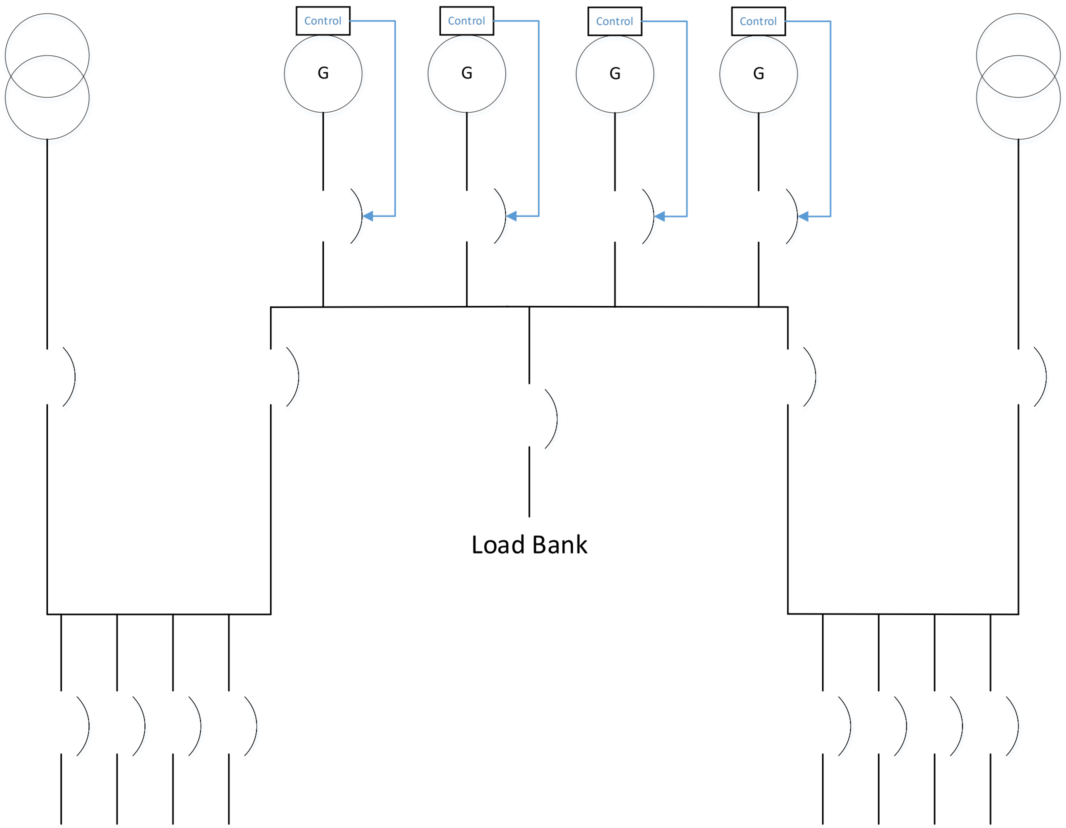
- 480VAC system consists of two 1500kW generator sets and 31 transfer switches
- Operator interface
- Load control (add/shed)
- Solution:
  - Distribution board with all EO* breakers
  - Generator sets with integrated paralleling control
  - System level control



*EO: Electrically Operated

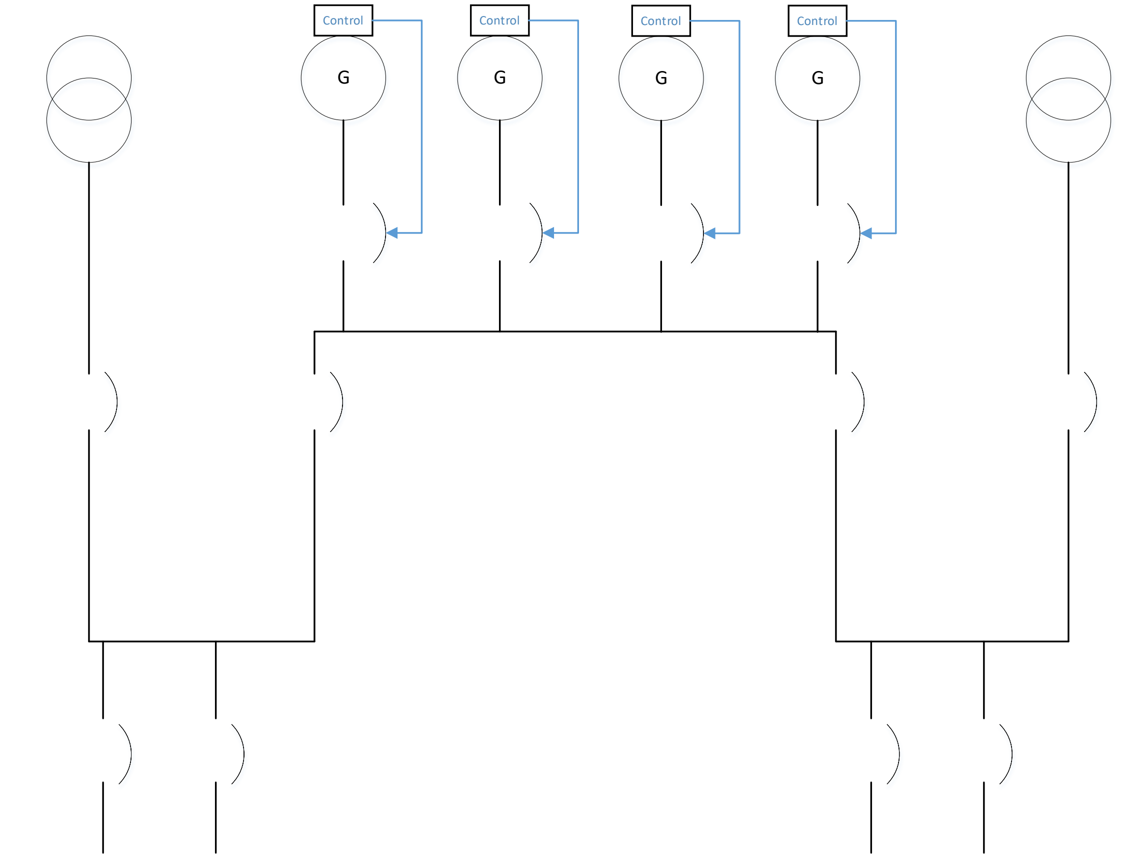
Dual Utilities – Water/Waste Water

- 13.8kV system consists of dual utilities and four 1MW generator sets
- Open/closed transition and extended paralleling
- Eight loads to control (add/shed)
- One loadbank control
- Solution:
    - Distribution board with all EO breakers
    - Generator sets with integrated paralleling control
    - System level control



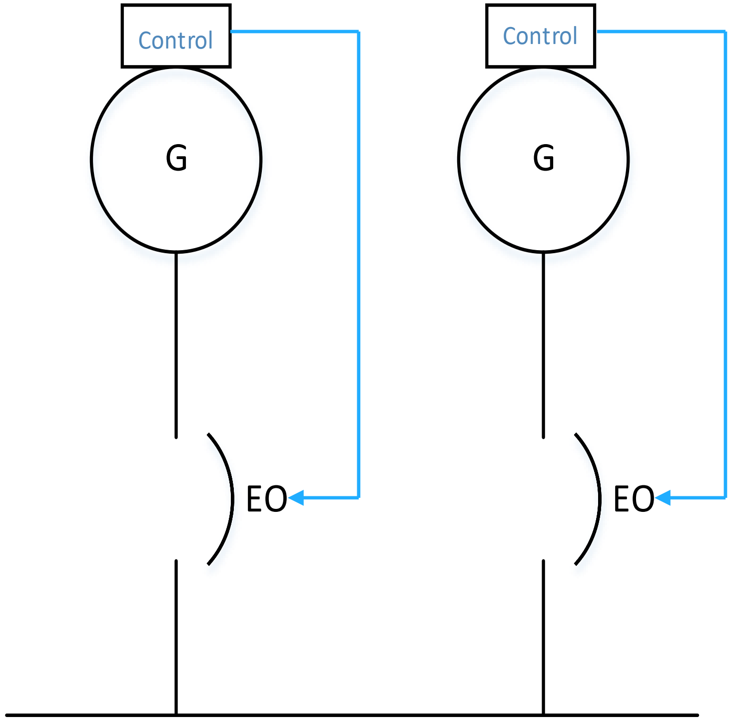
Dual Utilities – Redundant PLC

- 4.16kV system consists of two utilities and four 1250kW generator sets in a dual transfer pair topology
- Open/soft closed transition
- Four loads to control (add/shed)
- Redundant PLC
- Solution:
  - Switchgear with all EO breakers
  - Generator sets with integrated paralleling control
  - System level control



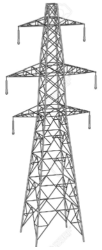
Isolated Bus – Warehouse

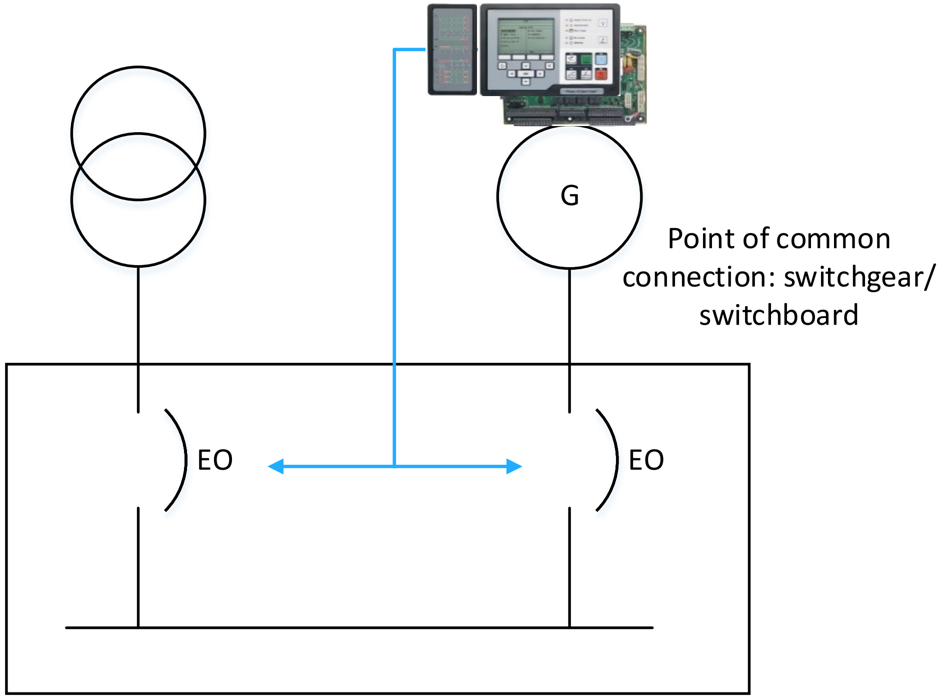
- 480VAC system and parallel two 1000kW generator sets
- Solution:
  - Two generator sets with integrated paralleling control
  - Point of common power connection:
    - Switchboard with two EO breakers



Single Utility/Generator – Grocery Store

- One utility and one generator set
- Open/Closed transition and extended paralleling with the utility
- Solution:
  - Switchboard with two EO breakers
  - Controller to perform the sequence of operation, e.g. generator set controller
  - Utility breaker protection: sync check, reverse power, over/under frequency, e.g. SEL 751





Course Summary

The Role Of A System Level Control In A Power System

- Recognize the common building blocks of a backup power system and their functionalities
- Discuss the functionalities of a system level control and how they fit in a power system
- Describe common failure mode scenarios that must be considered when specifying a system level control for a safe and reliable operation
- Explain the different use case scenarios for system level control to better understand the value it brings to a power system

Summary:

- Write specifications based on functions and performance
- Specify integrated paralleling and protection control for the generator set paralleling aspect
- Specify system level controls with analyzed and mitigated failure modes for controlling and monitoring the power system
- Ask the OEM to provide sequence of operation with mitigated failure modes for the power system control
- Work with a reputable power system provider who fully understands the power system design space

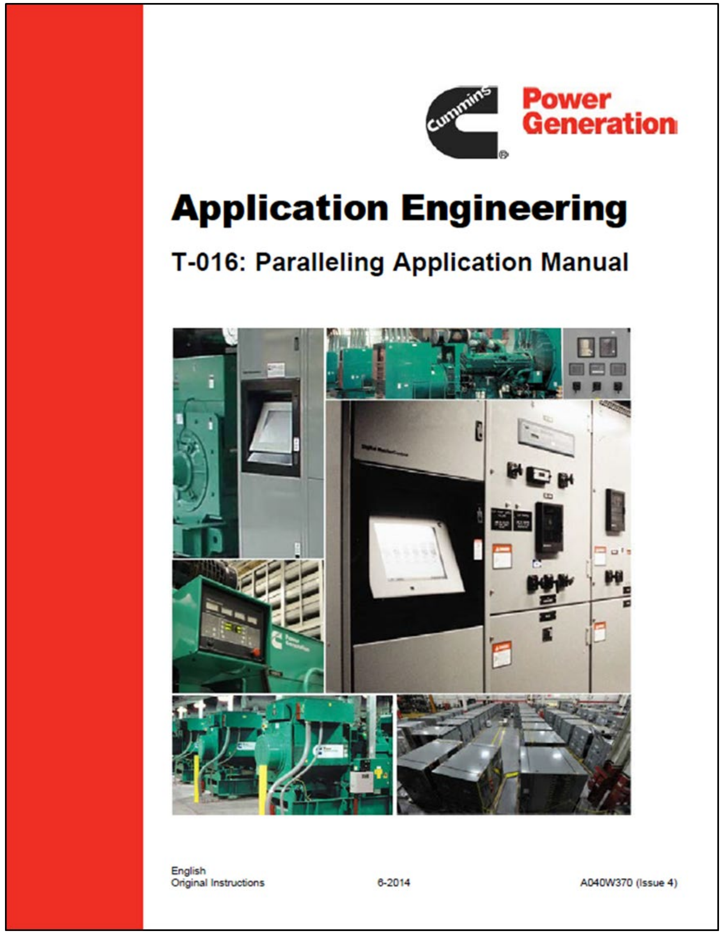
Additional Resources

Cummins Resources & White Papers

- T-016: Paralleling Application Manual
- Digital Control Technology Enhances Power System Reliability and Performance
- Considerations When Paralleling Generating Sets
- Minimizing fuel consumption and increasing longevity for paralleled generator sets
- Design considerations for generator set mounted paralleling breakers

Cummins PowerHour On-Demand Webinars

- Paralleling Power System Design Considerations and System Level Control
- Functions and Features of Generator Set Control Based Paralleling



Q&A

Please type your questions, comments and feedback in the **Zoom Q&A** window.

After the PowerHour, a complete list of questions and answers will be published on powersuite.cummins.com.

Please complete the brief survey before exiting the webinar!

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Closing

Watch out for a follow-up email including:

- A link to the webinar recording and copy of the presentation
- A certificate issuing one professional development hour (1 PDH)

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June 11th Ensuring Power System Reliability through Service Specifications

Please contact Michael Sanford if you have any questions related to the PowerHour webinar (michael.sanford@cummins.com)

Q+A


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