Emergency Power Systems Design

ASCO Power Technologies™

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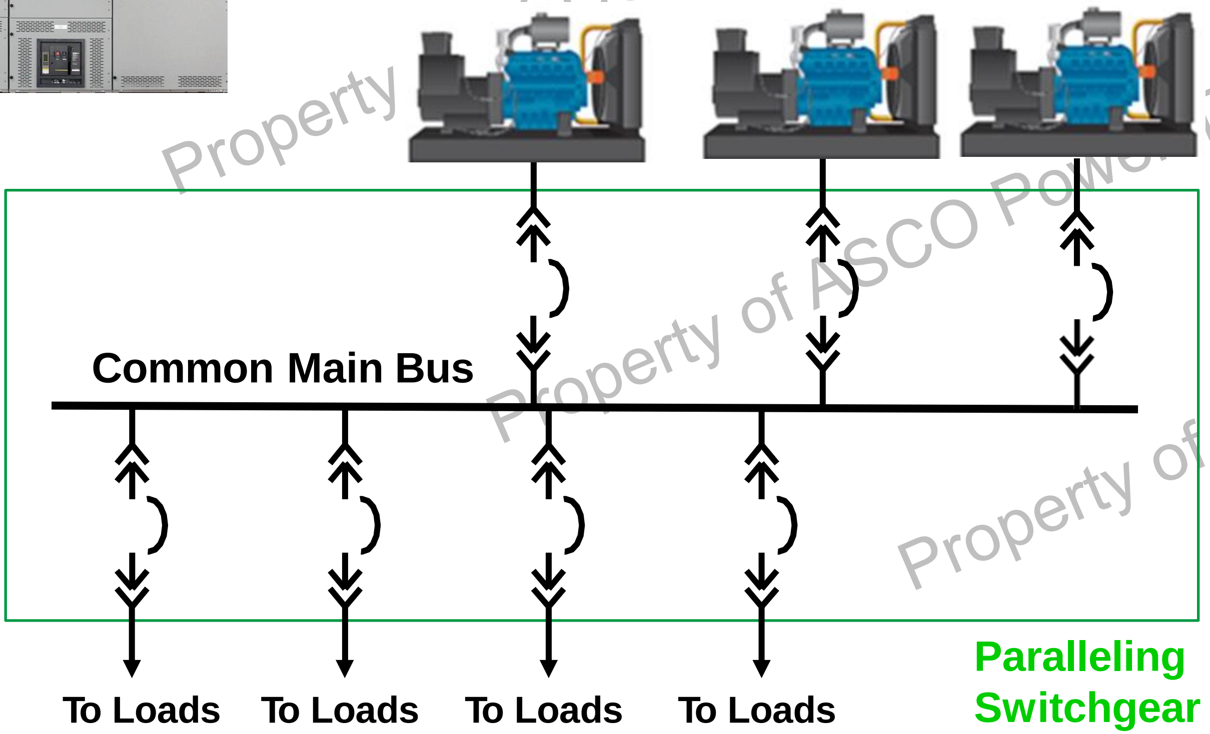
Agenda

1	Applications
2	Network Architecture
3	Generator Controls
4	System Controls
5	System Control Topology & Redundancy
6	DC Power
7	System Load Control & Sequences
8	System Configurations and Modes of Operation

Paralleling Switchgear Design Considerations

Paralleling/Synchronizing Switchgear refers to the controls and equipment required for connection of multiple sources, usually generators to a common bus and/or a Utility Source and the load control necessary for the specific application in the event of a power outage



- **Multiple generators inherently provide redundancy by design vs a single larger generator**
- **Can provide N+1 configuration/capacity for maintainability. Ex: 1 Generator can be down for maintenance with full backup capacity available**
- **System Priority Load Control ensures the most critical loads are connected to backup power when necessary – *Life Safety*, *Critical*, *Equipment***
- **Ensure a high level of reliability and resiliency**
- **Eliminate single points of failure**

Emergency Power Systems - Applications

Healthcare Facility

Water & Wastewater

Data Center

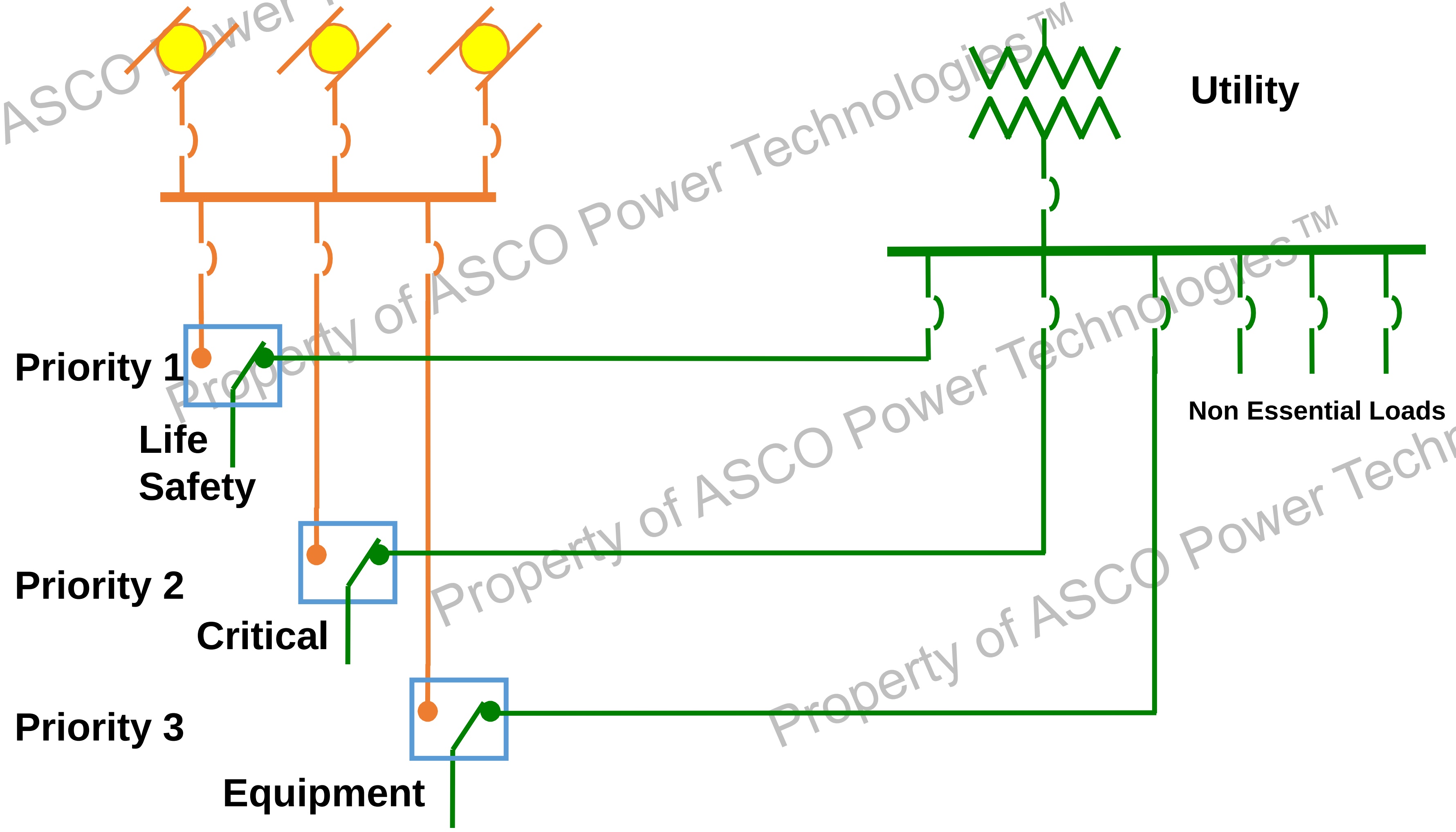
Government Facility

Industrial Buildings

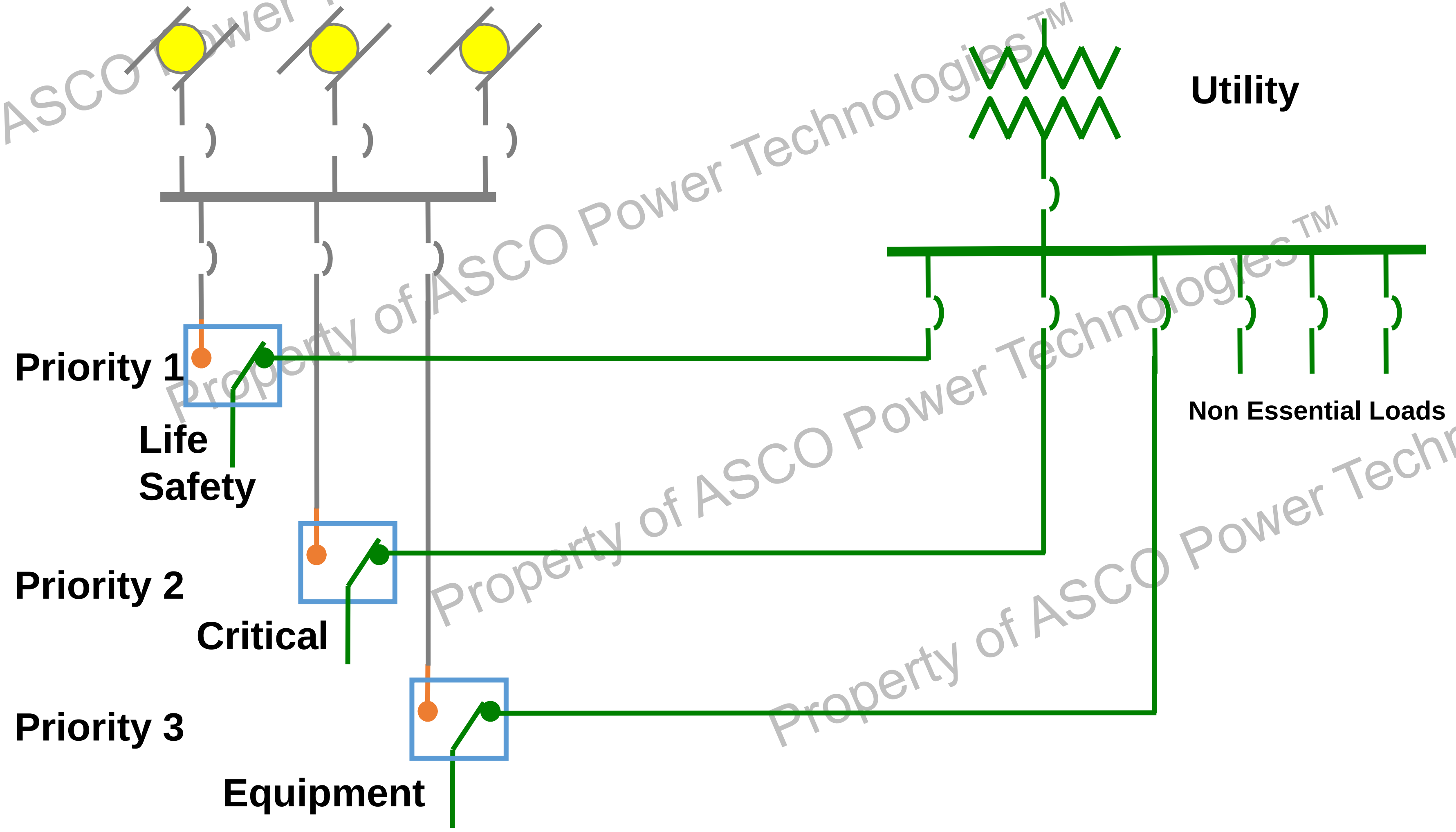
Telecom

24 x 7 x 365 ***Code Driven – NEC, NFPA*** ***Business Driven - $$$***

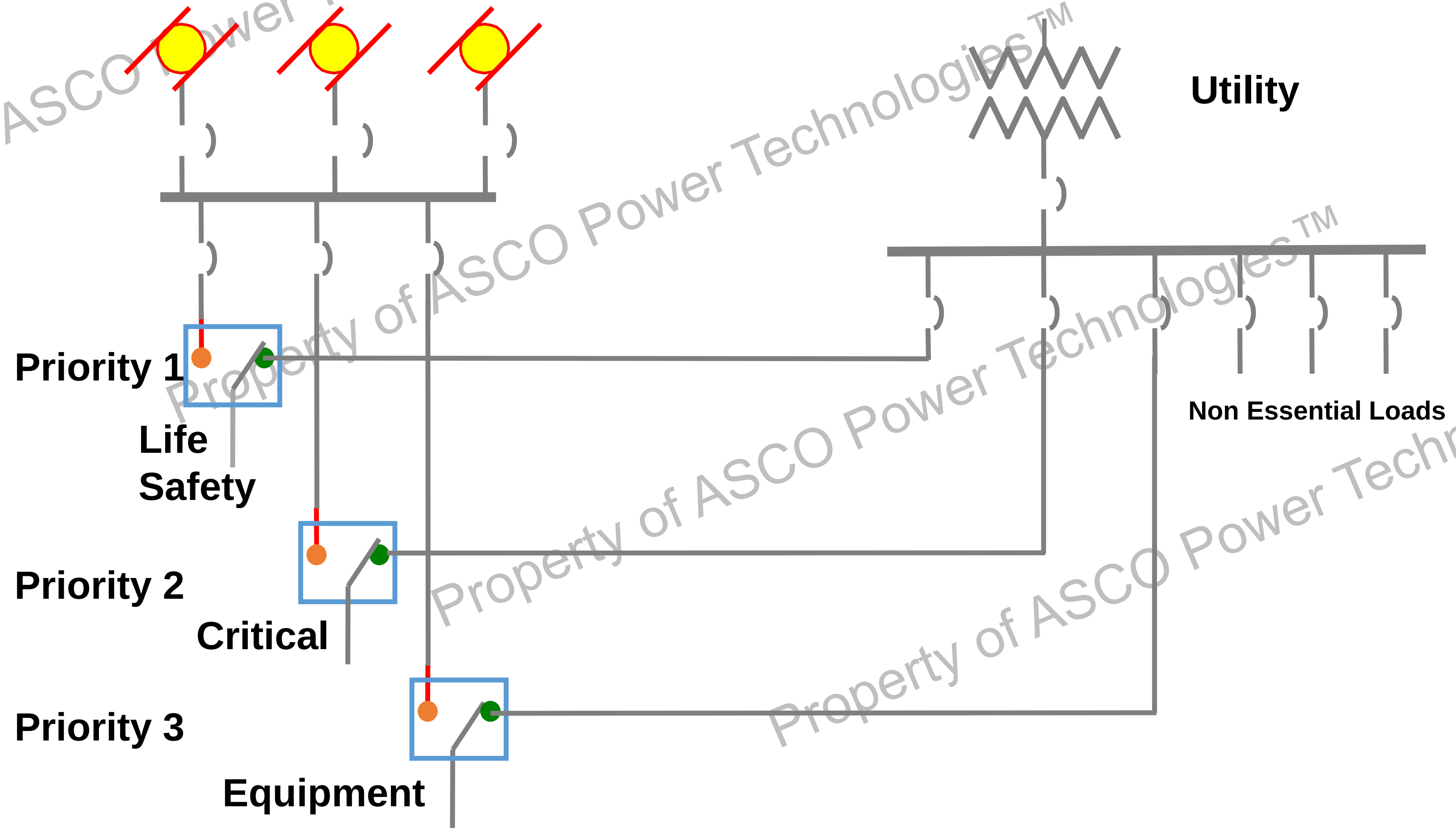
Example Basic Paralleling System SOO- Emergency Standby



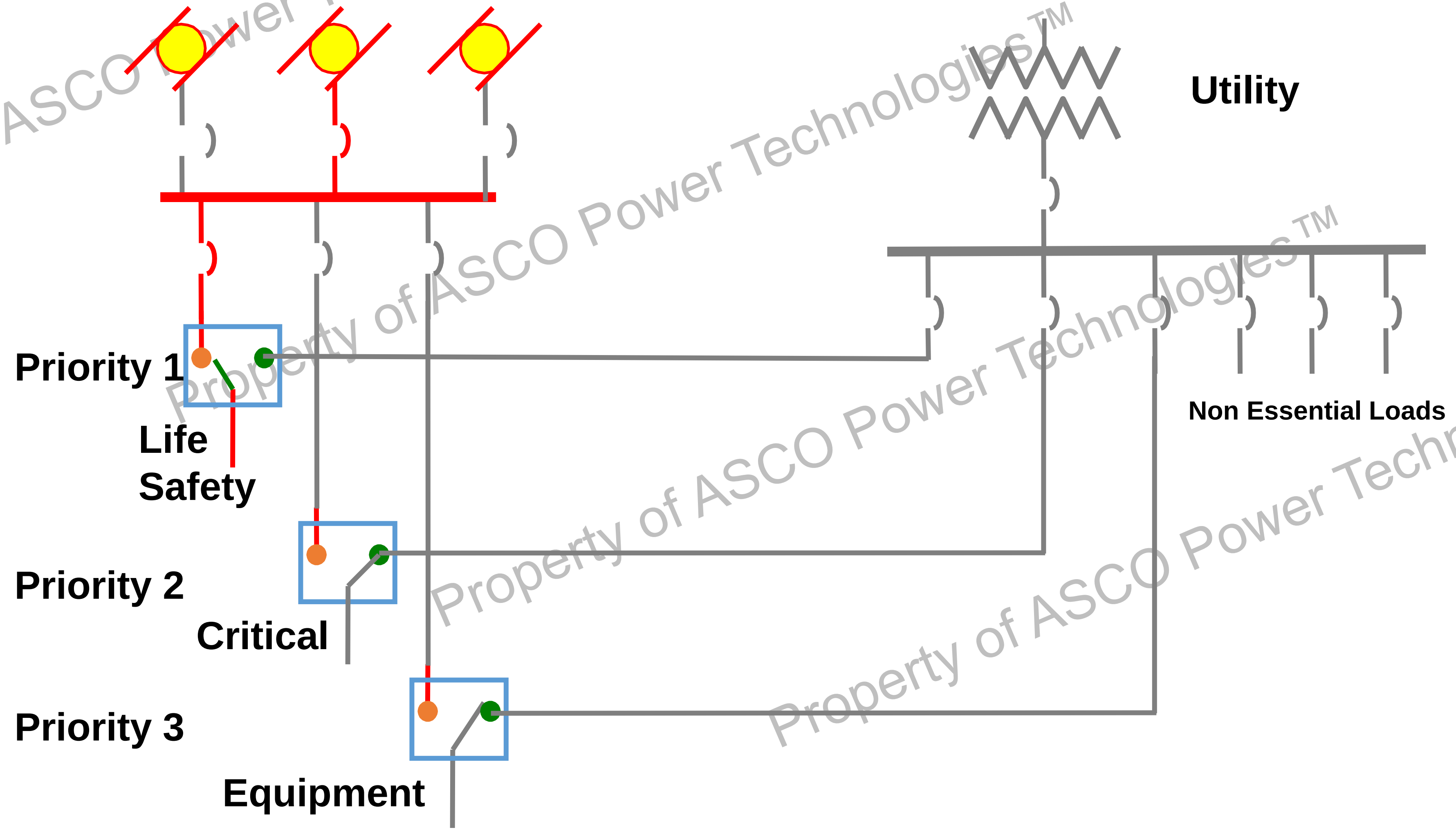
Normal Operation: Utility Available



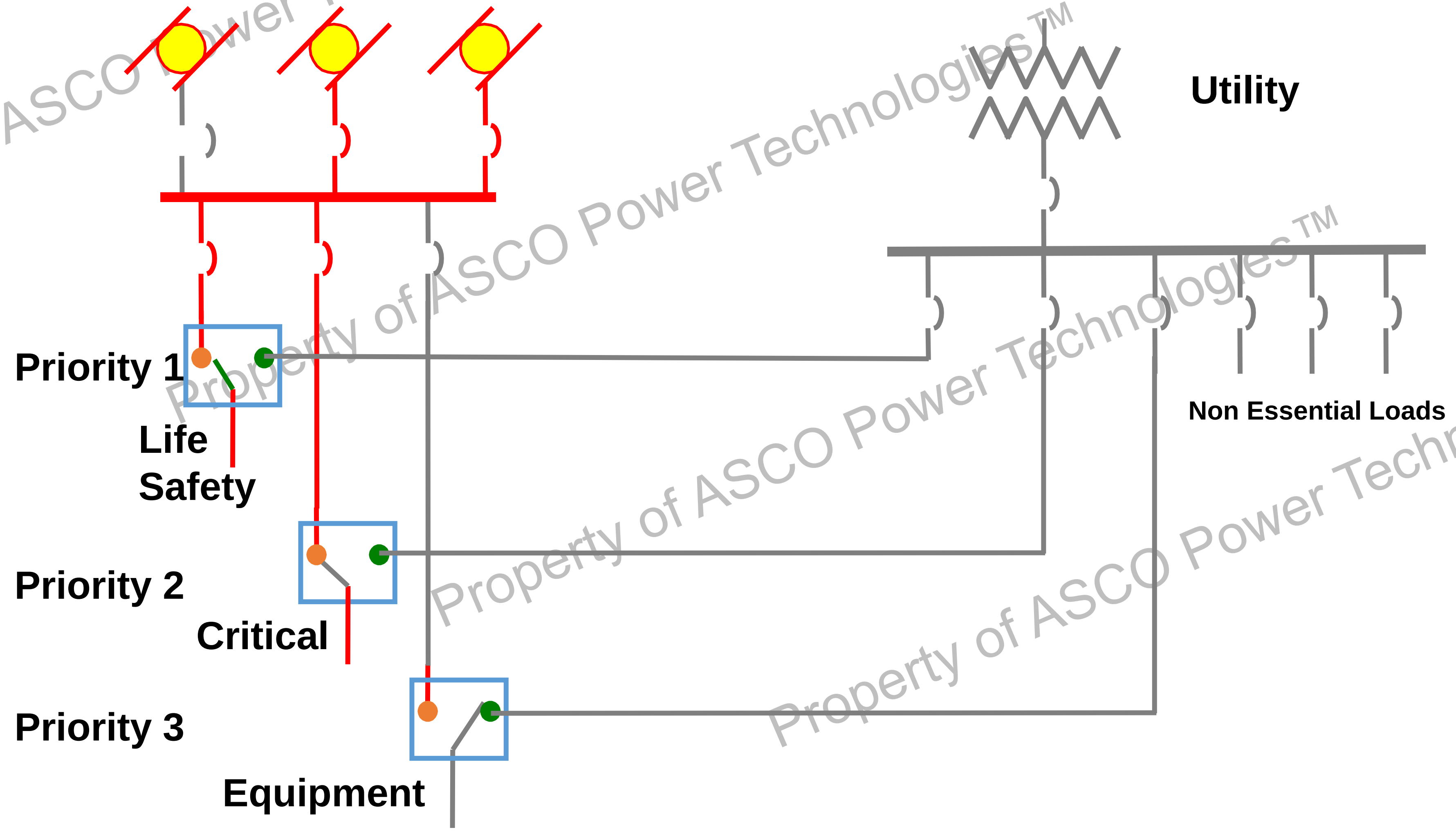
Utility Fails: All 3 Generators Start



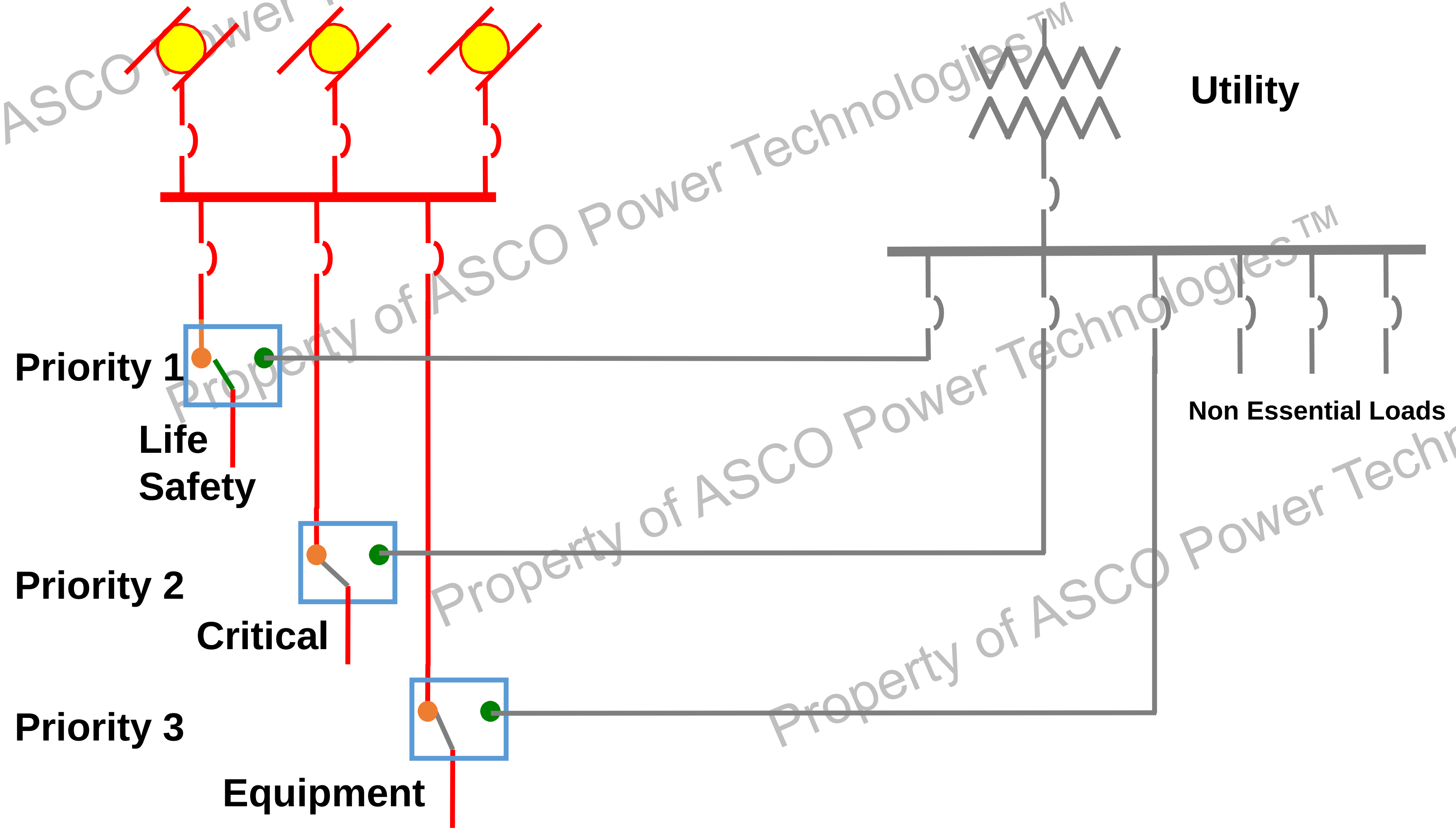
First Generator Online: Priority 1 ATS Transfers



Second Gen Online: Priority 2 ATS Transfers

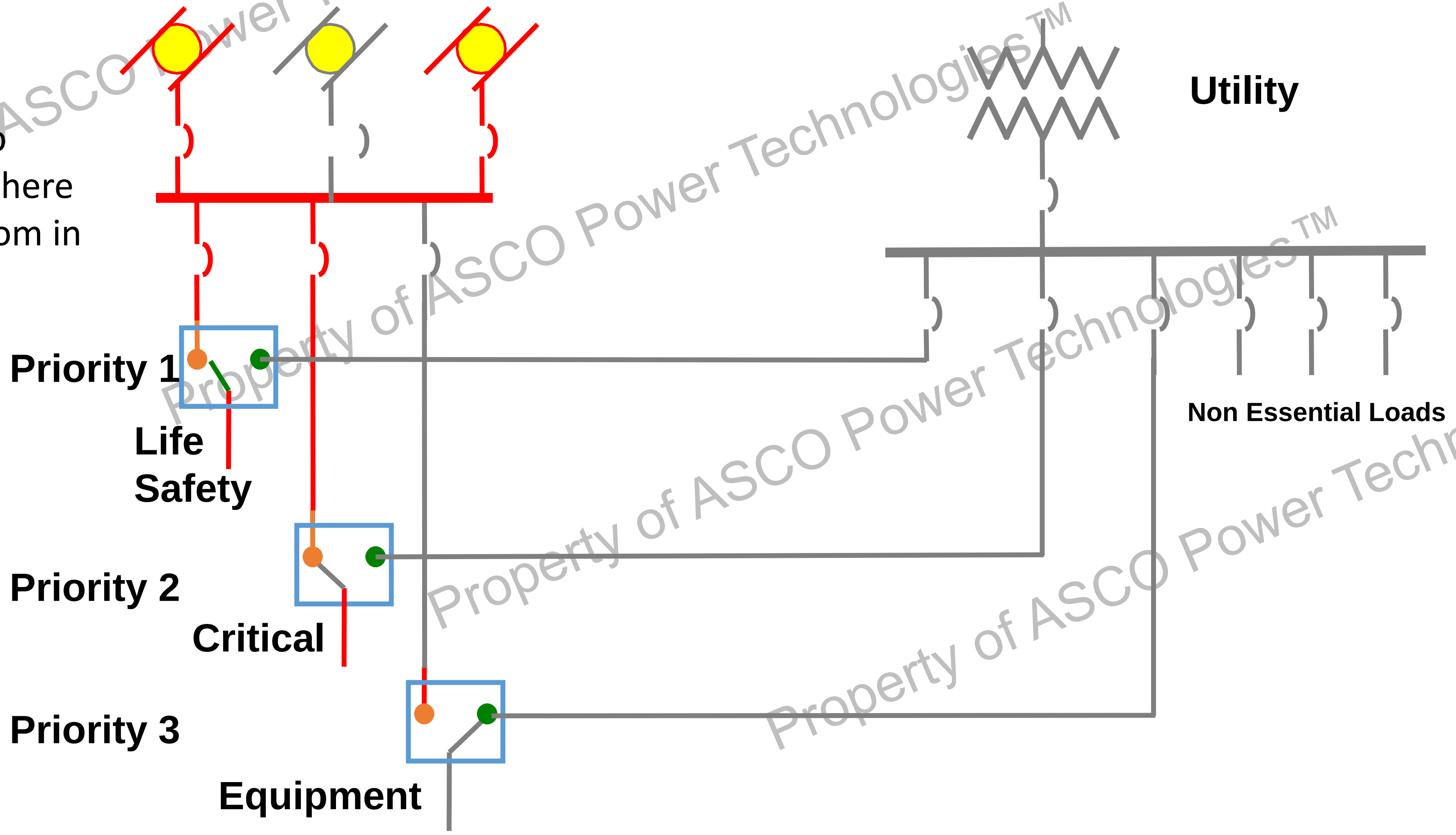


Third Generator Online: Priority 3 ATS Transfers

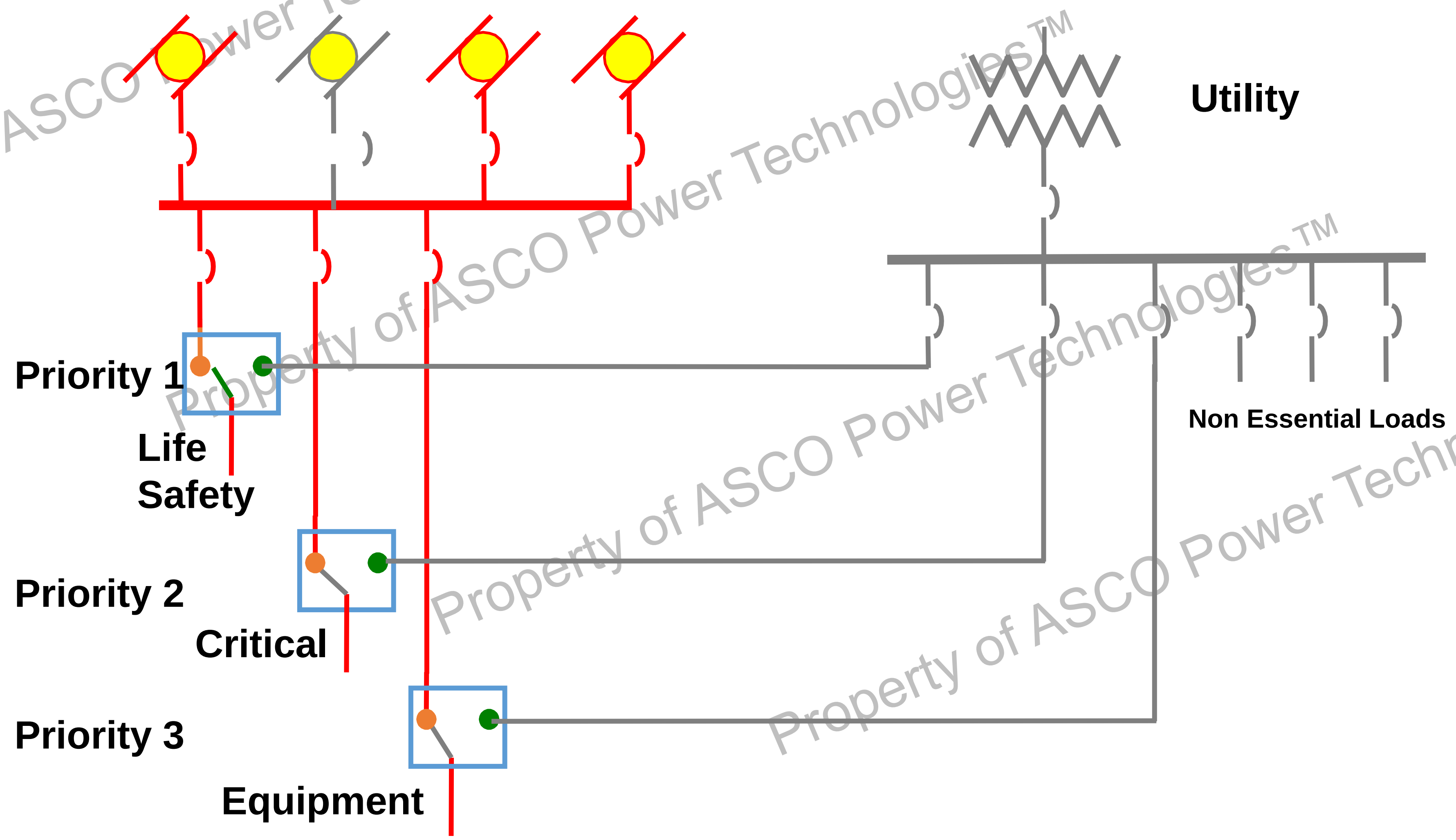


Generator Fails: Priority 3 ATS Sheds

Load latch will keep Priority 3 online if there Is available headroom in the remaining gens

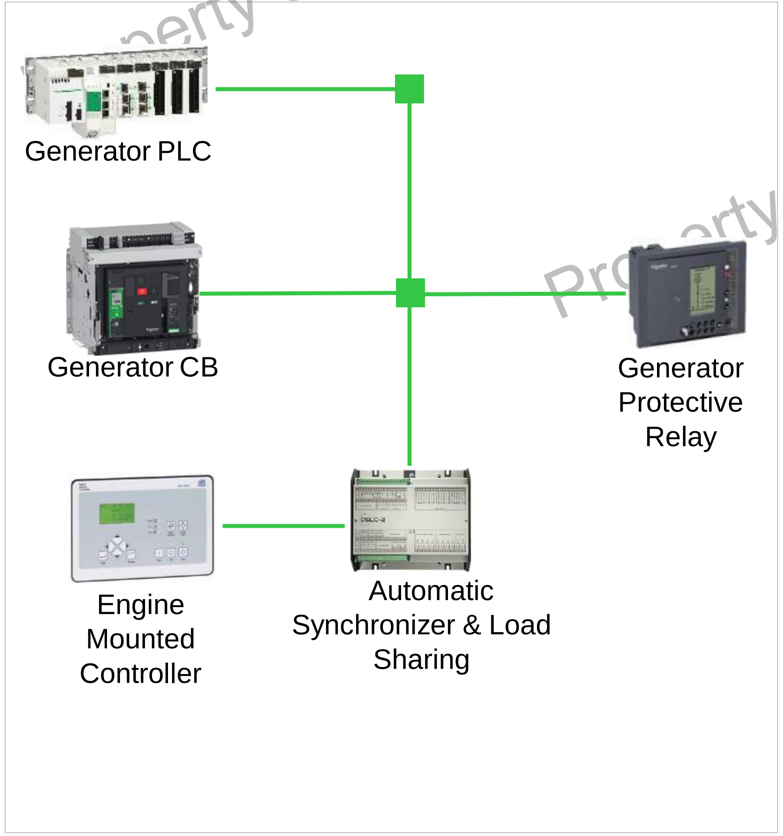


N+1 System Adds Reliability if Generator Fails

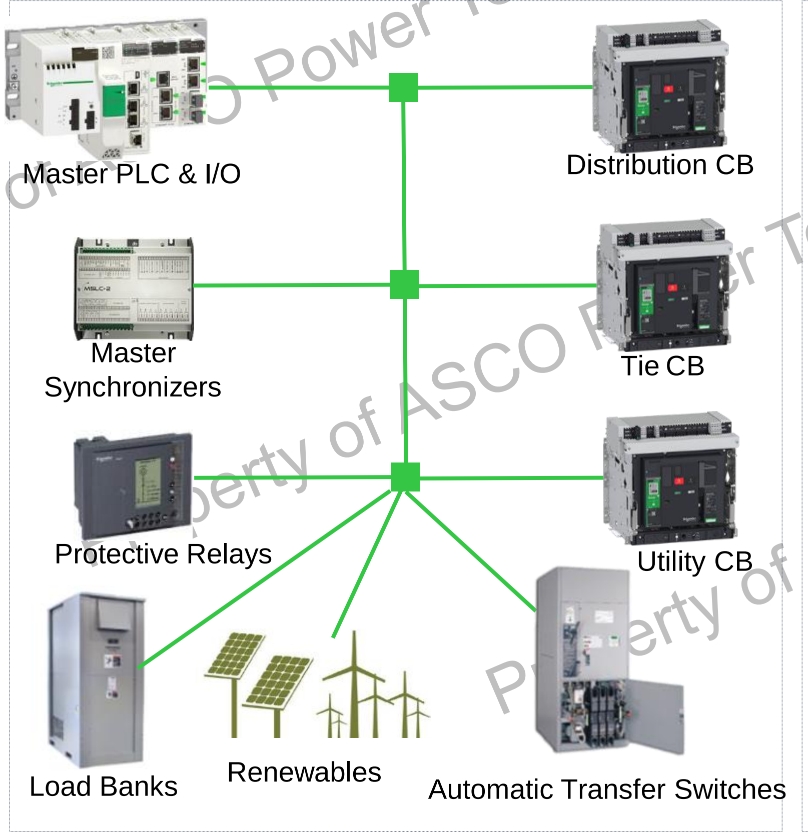


Emergency Paralleling System Network Architecture

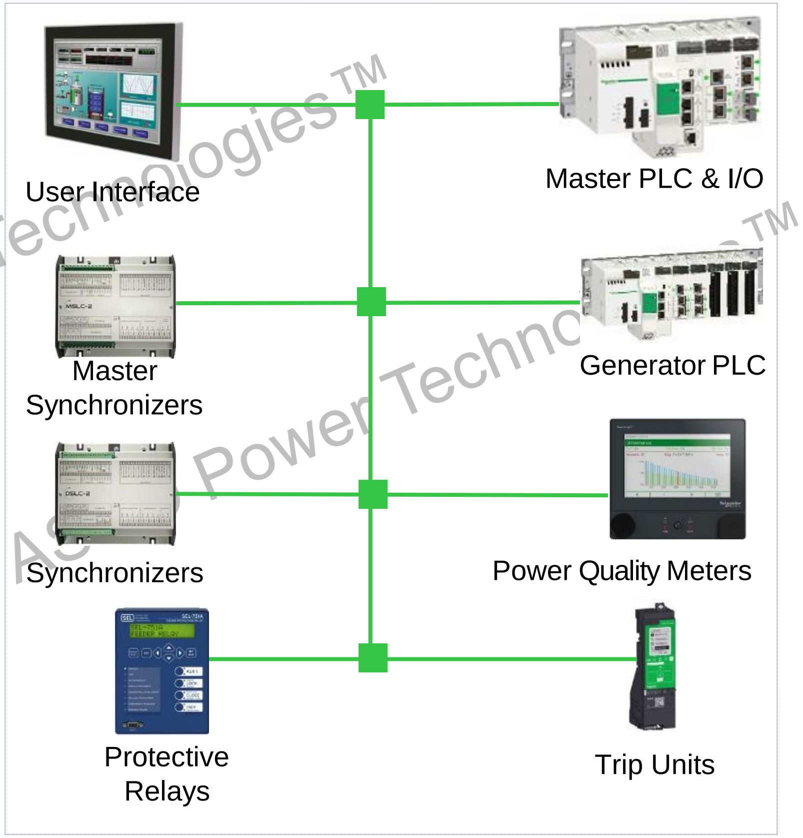
The Generator Control System



The System Master & Load Control System

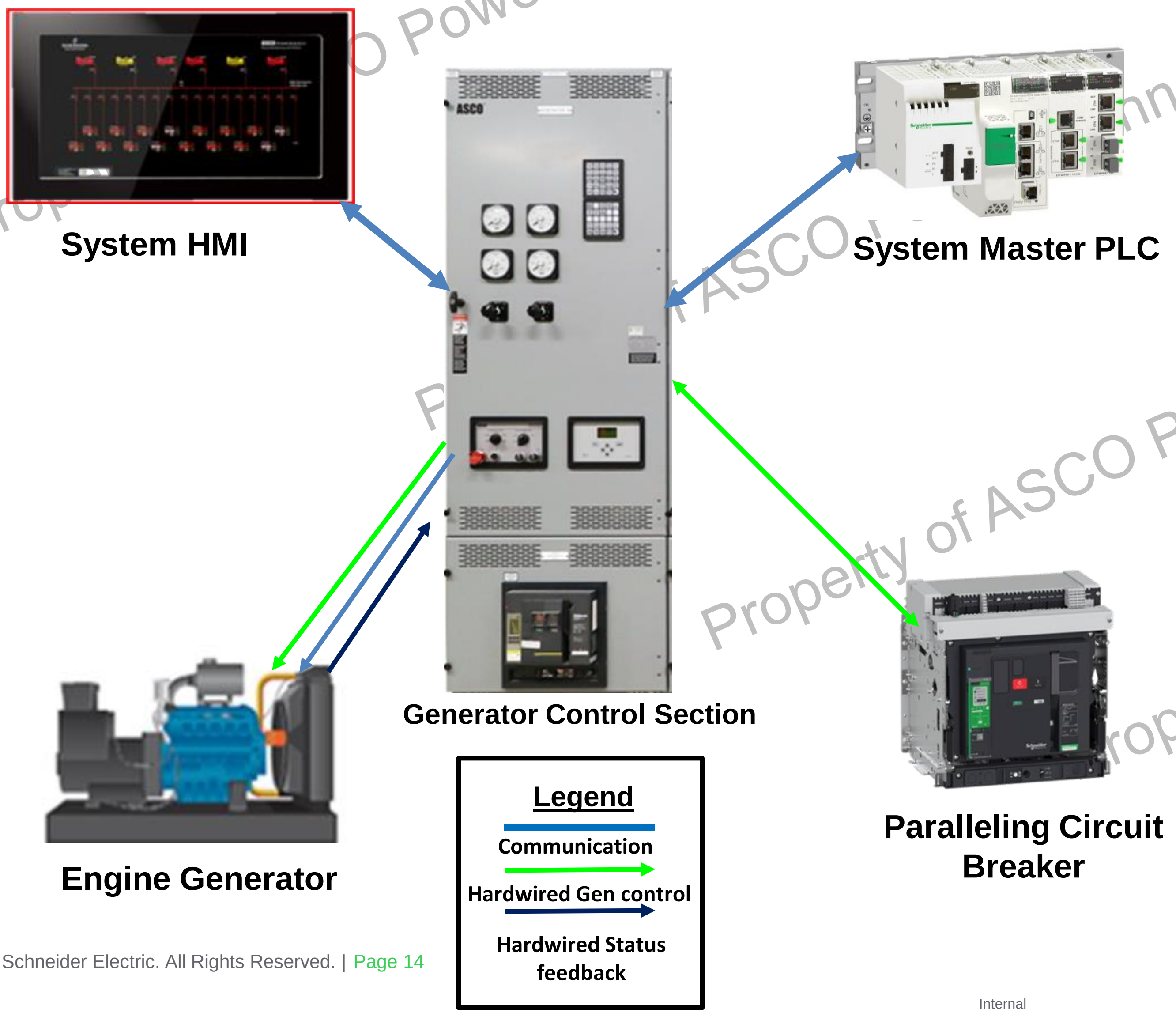


User Management & System Monitoring



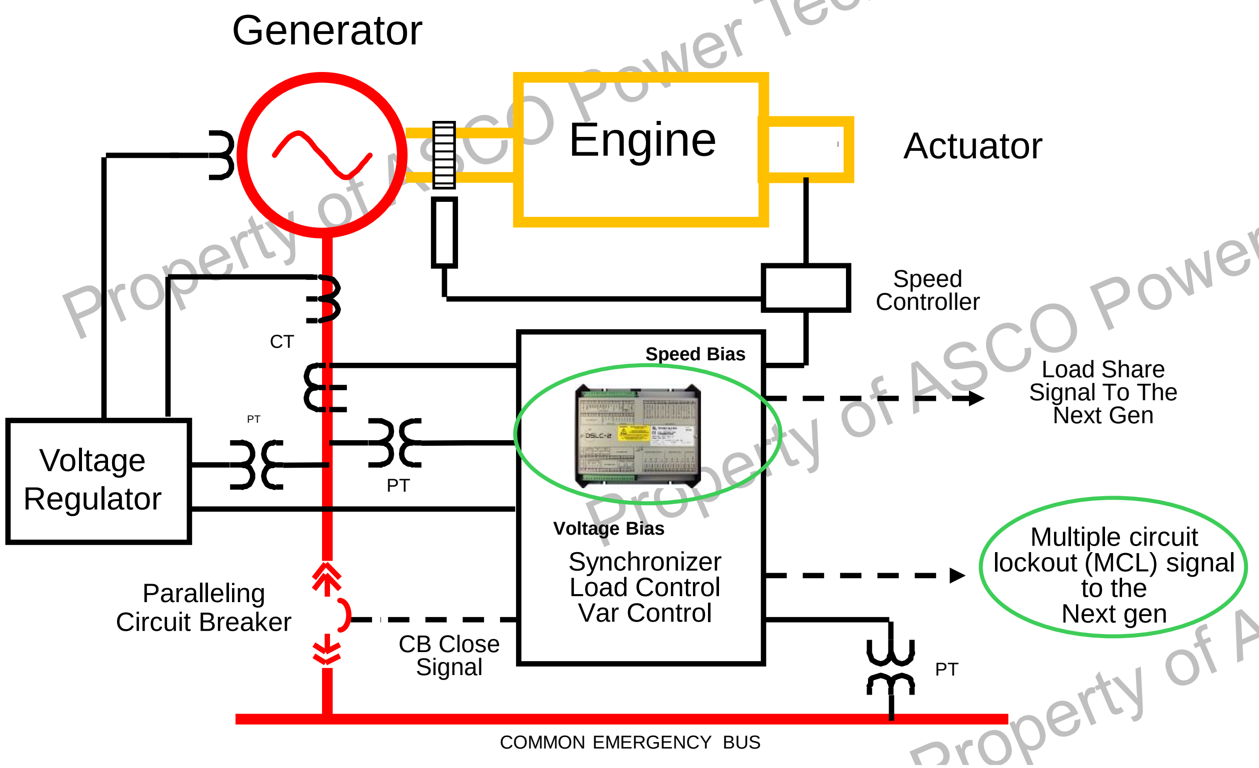
Separate networks allow for easier maintenance, troubleshooting, enhances security & reliability

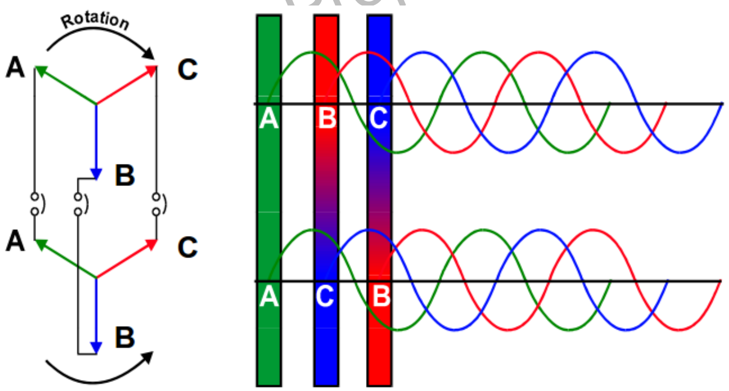
Power Control Systems Generator Controls Architecture



- Dedicated PLC for each generator with independent CPU – Increased Reliability
- Provides Engine start, monitoring, communication and circuit breaker control
- Communicates with System Master PLC
- Control should be independent from the System Master PLC or HMI
- Starts engine independent of System Master PLC
- Independent PLC eliminates reliance on other components and reduces points of failure
- Loss of communication to Master PLC or System HMI does not affect operation of Generator PLC

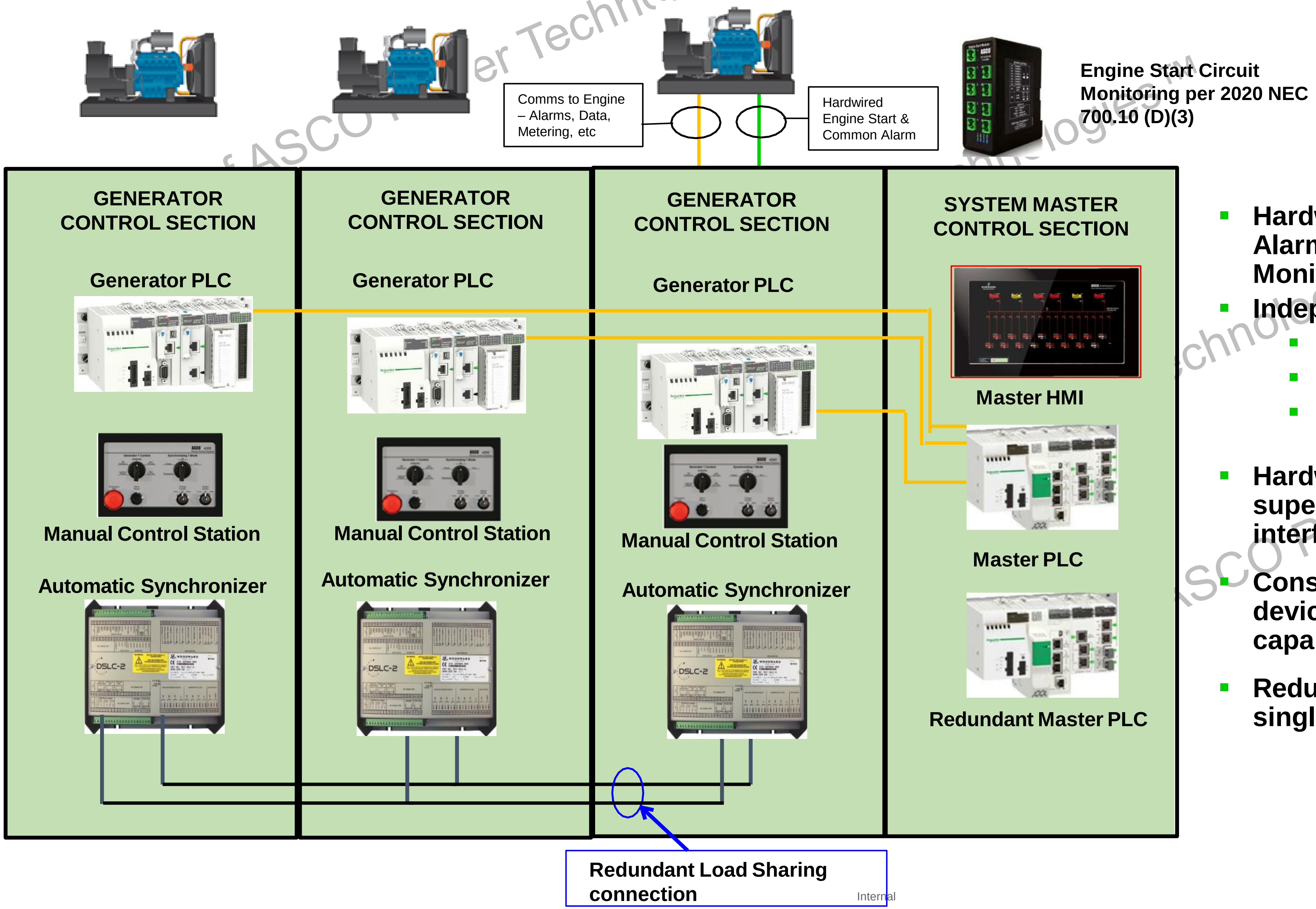
Generator Control Architecture – Automatic Synchronization





- **What is generator synchronization?**
  - **Generator synchronization matches generator speed/frequency with another source (Other generators and/or utility).**
  - **Voltage levels and phase relationships need to be considered.**
- **Why is synchronization needed?**
  - **Controls power surges. Avoids reverse power, overpower and mitigates transients when bringing additional power sources online.**
  - **Reduces electrical stress on generators and switchgear. Helps prevent high currents and breaker wear.**
  - **Reduces mechanical stress on generators and prime movers. Helps prevent bent drive shafts and broken couplings.**
- **What conditions must be met for two sources to be synchronized?**
  1. **The number of phases must be the same.**
  2. **The direction of rotation must be the same.**
  3. **The voltage amplitudes must be closely matched.**
  4. **The frequencies must be closely matched.**
  5. **The phase angles must be closely matched.**

Power Control Systems Generator Controls Architecture



- Hardwired Engine Start and Common Alarm with Engine Start Circuit Monitoring
- Independent Generator PLCs
  - No Reliance on Master PLC
  - Eliminates Point of Failure
  - Engines can be started in absence of Master PLC(s)
- Hardwired Manual Control Station for supervised operation and engine interface
- Consider utilizing synchronizing devices that include a Load Share capability
- Redundant load sharing eliminates a single point of failure

Generator Control Architecture – Hardwired Backup Redundancy

Reduce Single Points of Failure

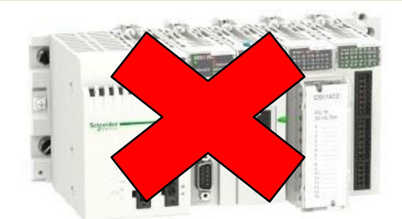
What if a Generator PLC Fails?

Communication to engine and some Status is unavailable

But…..

GENERATOR SECTION

Generator PLC

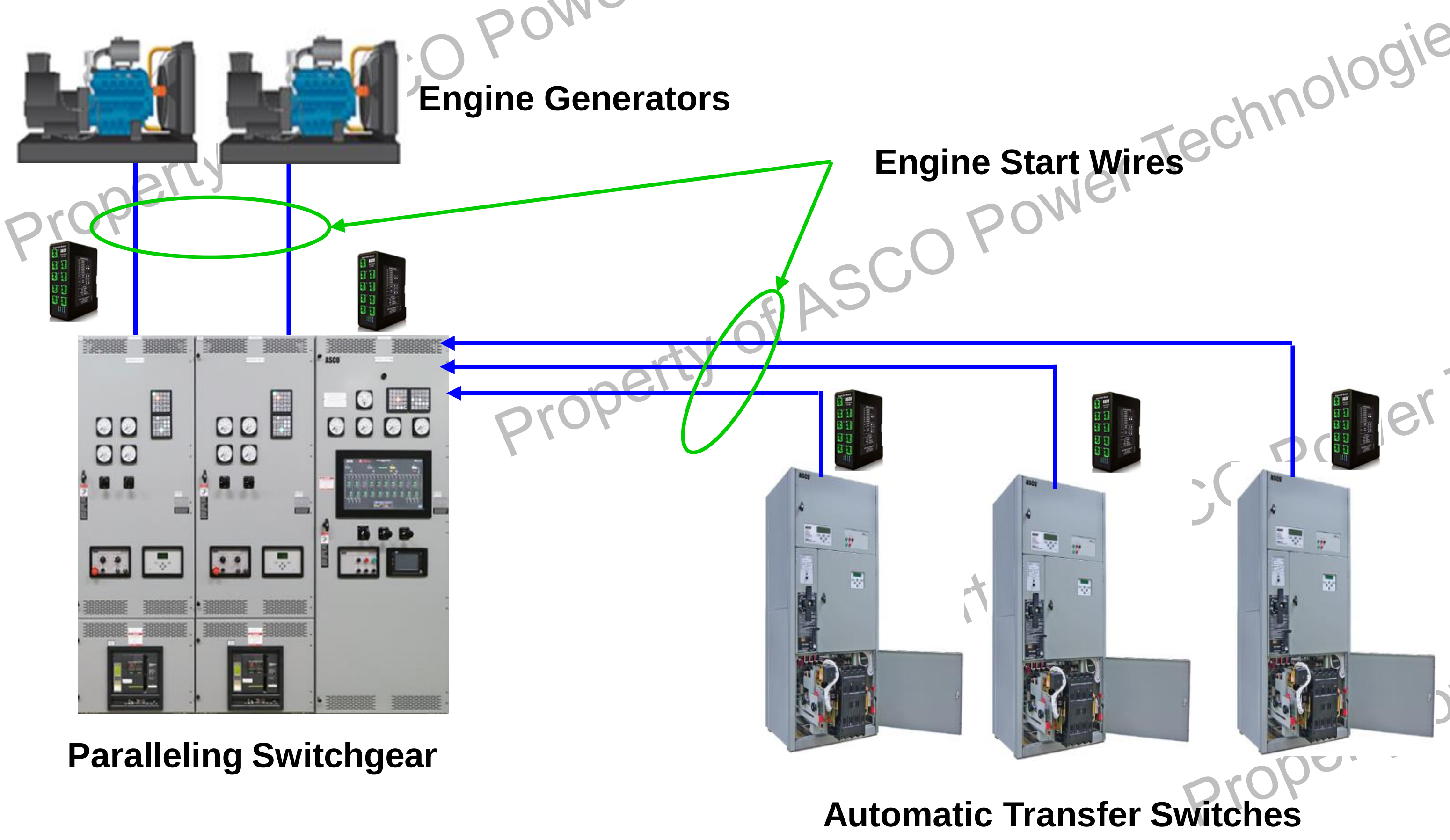


Synchronizer

Manual Control Station

- **Full Automatic Control remains available – Provides Redundancy**
- **Eliminates Single Point of Failure**
- **Provide Engine start, breaker close & trip with *hardwired* backup**
- **Common Shutdown, Engine running, Autostart, breaker status, PLC stopped & control voltage failure status lights are *hardwired***
- **Synchronizer synchronizes oncoming generator and closes breaker connected the it to the bus**
- **No manual intervention required by the operator**
- **Hardwired Engine Control Switches allow operator to start or stop engine manually if needed**

Engine Start Monitoring – 2020 NEC 700.10(D)(3)



ASCO 5101
Engine Start
Monitor

2020 NEC 700.10 (D)(3)

(3) Generator Control Wiring. Control conductors installed between the transfer equipment and the emergency generator shall be kept entirely independent of all other wiring and shall meet the conditions of 700.10(D)(1).

The integrity of the generator control wiring shall be ***monitored for broken, disconnected or shorted wires. Loss of integrity of the remote start circuit(s) shall start the generator and annunciate the alarm at an annunciator.***

Power Control Systems - Master Controls

- Provides overall system load control
  - ATS
  - Circuit Breakers
  - Remote Switchgear Lineups
- Implements complex sequences of operation
- Receives outage signal
- Communicates to generator PLCs
- Gathers Data for HMI Display
- Gathers data to interface with BMS or EPMS
- Provides Manual Paralleling Capability
- Monitors System Parameters
- Hardwire critical interfaces
  - Engine Start
  - Load Add/Shed
  - Common Alarm

Legend

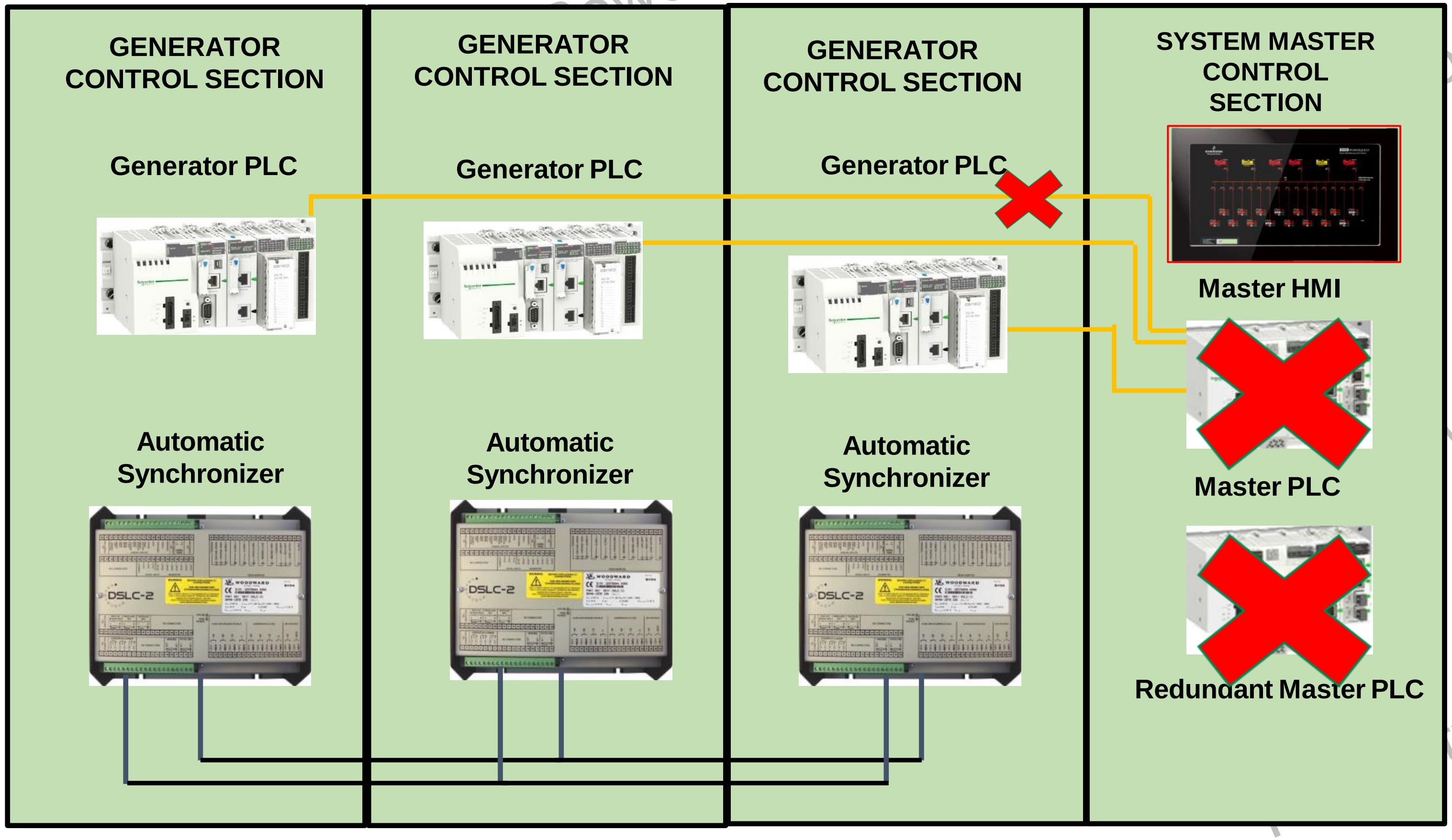
Communication

Hardwired Control

Hardwired Status feedback

Power Control Systems Architecture – System Master Controls

Reduce Single Points of Failure



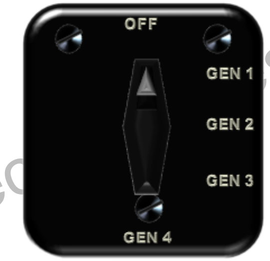
- A single Master PLC failure in a system with redundant Master PLCs results in no loss of automation.
- Generator PLCs are independent of the Master PLC – Loss of Master PLC(s) does not affect Generator PLCs
- Loss of Communication from Master PLC to Generator PLCs does not affect Generator PLCs or Automation
- If both Master PLCs fail independent Generator PLC can *start engines automatically and priority 1 loads are automatically added*

Hard wired manual backup for Load control

Power Control Systems Master Control Architecture – Manual Paralleling

Include hardwired manual paralleling capability

- Eliminates Automatic Synchronizer Single Point of Failure
- Provides a means to manually close the generator breakers in-phase if an automatic synchronizer is not functioning properly – Alternate manual close path
- Manual Paralleling controls are grouped at the Master Control Section
- Controls include a Synchroscope, Selector Switch and Sync Check Relay to assist the operator and prevent out of phase closure
- Completely hard wired, no reliance on automation or touchscreen
- Manual operation not required in front of Generator Circuit Breaker – Arc Flash Consideration



Master Control Station

System Master Controls

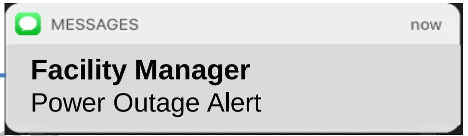
 |

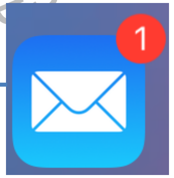
Power Control Systems – User Interface

System Master Controls

Master Control Section

To BMS or BAS System



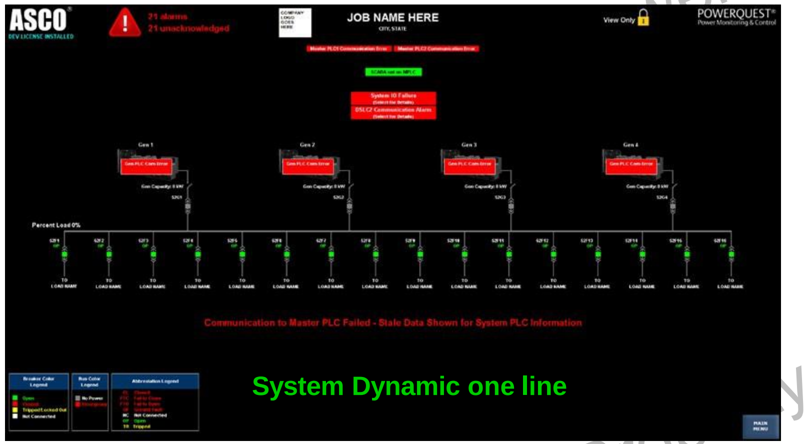


HMI/Operator Interface Terminal

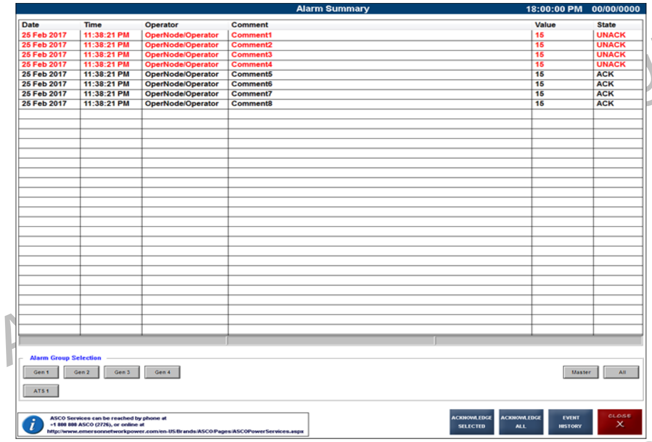
- **Allows Operator to adjust some parameters – Ex: Load Priorities**
- **Allows Operator to perform some control operations – Ex: System Test**
- **Includes System Dynamic One Line**
- **Generator and Total System Metering, Status, Alarms & Shutdowns**
- **Historical Trending**
- **Joint Commission Reporting if required**
- **BMS/EPMS Interface/Gateway**
- **Includes several levels of Password Protection**
- **Email or Text Alarm Notifications**
- ***System Operation should not be dependent on Touchscreen***

User Management & System Monitoring

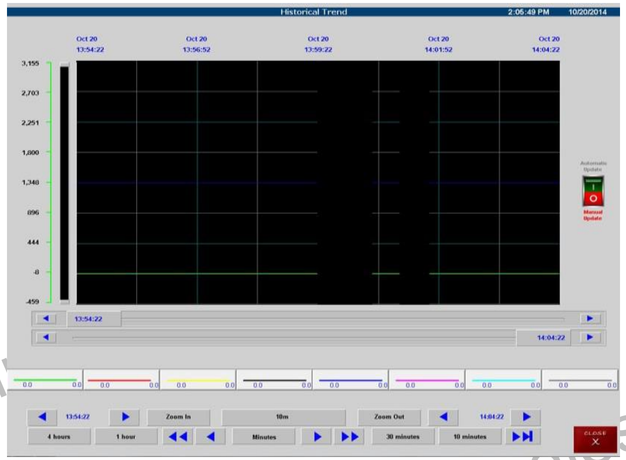
An Operator Interface Panel is Provided for access to User-Adjustable Settings And System Monitoring And Control



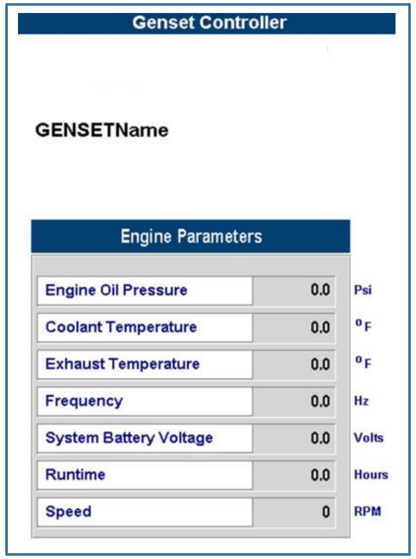
System Dynamic one line



Alarm Summary with date & time stamp

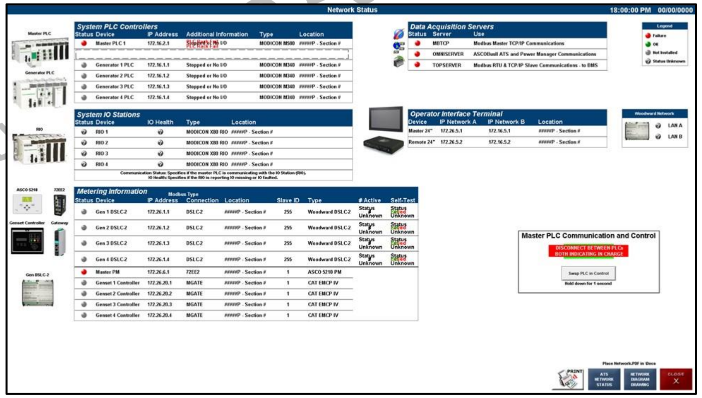


Historical Trending



Engine Monitoring

Generator & System Status



Network Connected device status

Joint Commission Reporting for Healthcare

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Remote Monitoring Stations

24” OIT

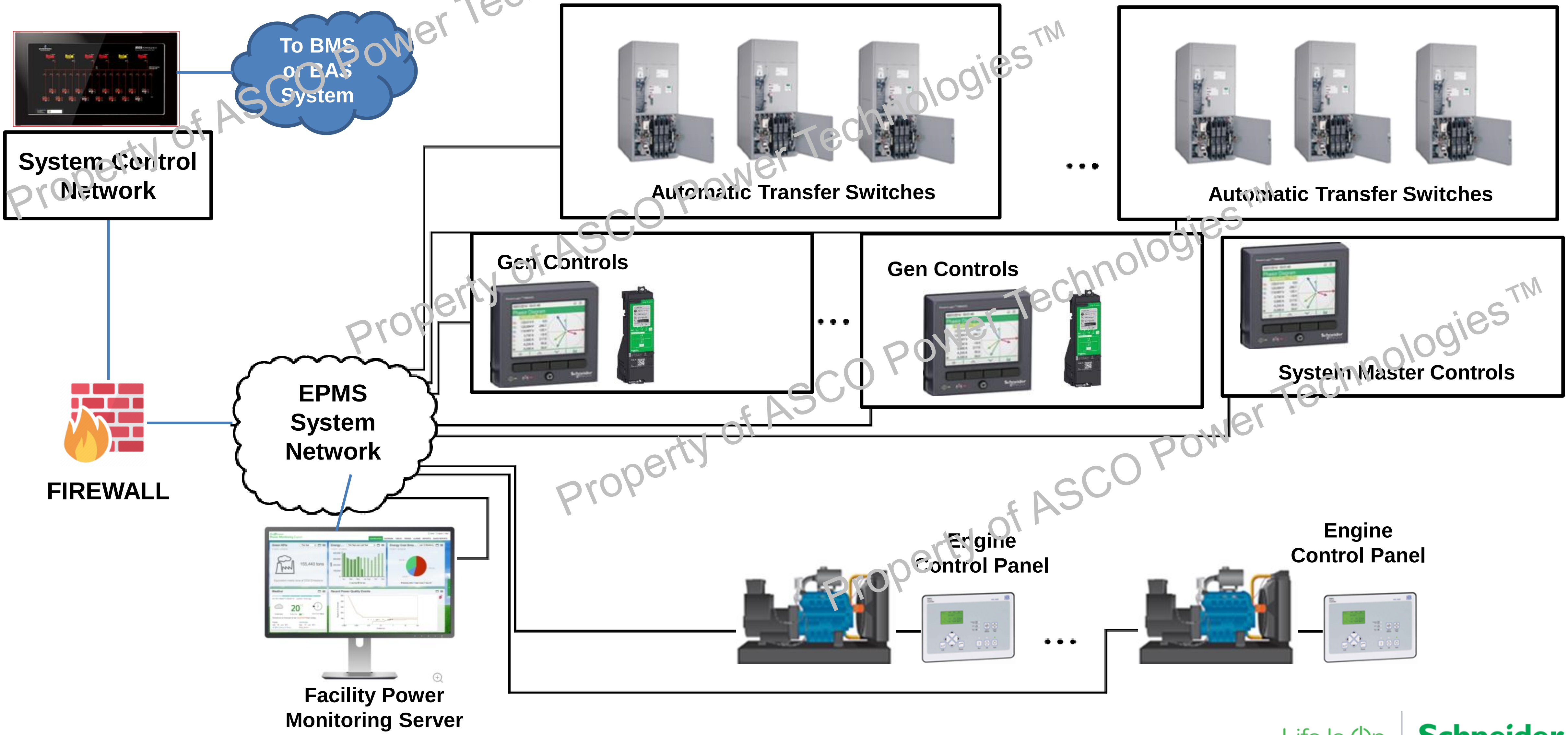
43” OIT

Remote Wall Mount HMI

- **Remote Monitoring – Engines and gear less accessible**
- **Consider Additional Monitoring And Control Nodes To Allow User Interface Outside the Arc Flash Zone**
- **Monitoring and control are the same as the System Master OIT**
- **Connections from System Master Controls via Ethernet, Fiber or *Redundant Fiber***

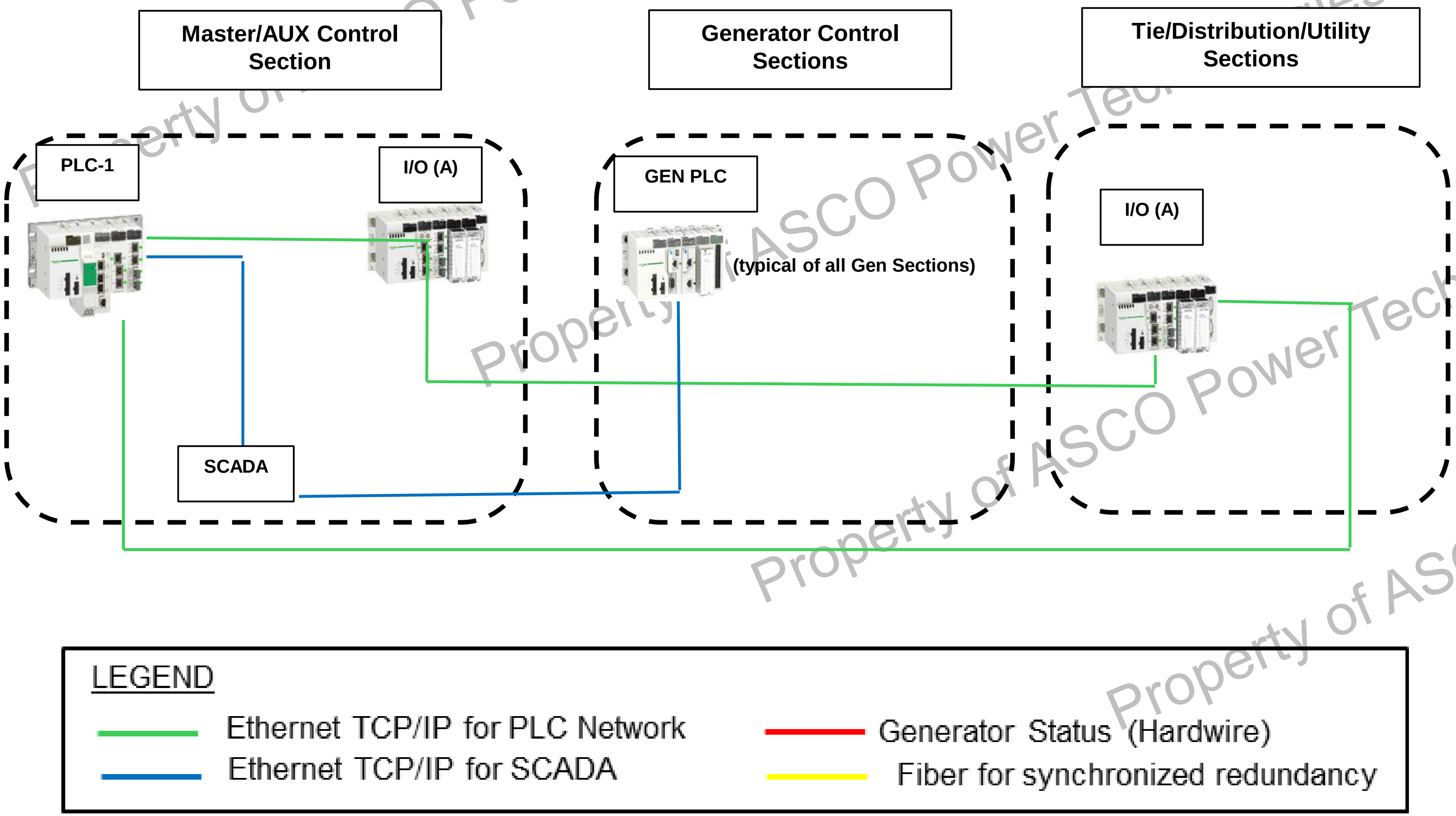
Remote Workstation

Typical EPMS/PCS Network



Paralleling System Control Network

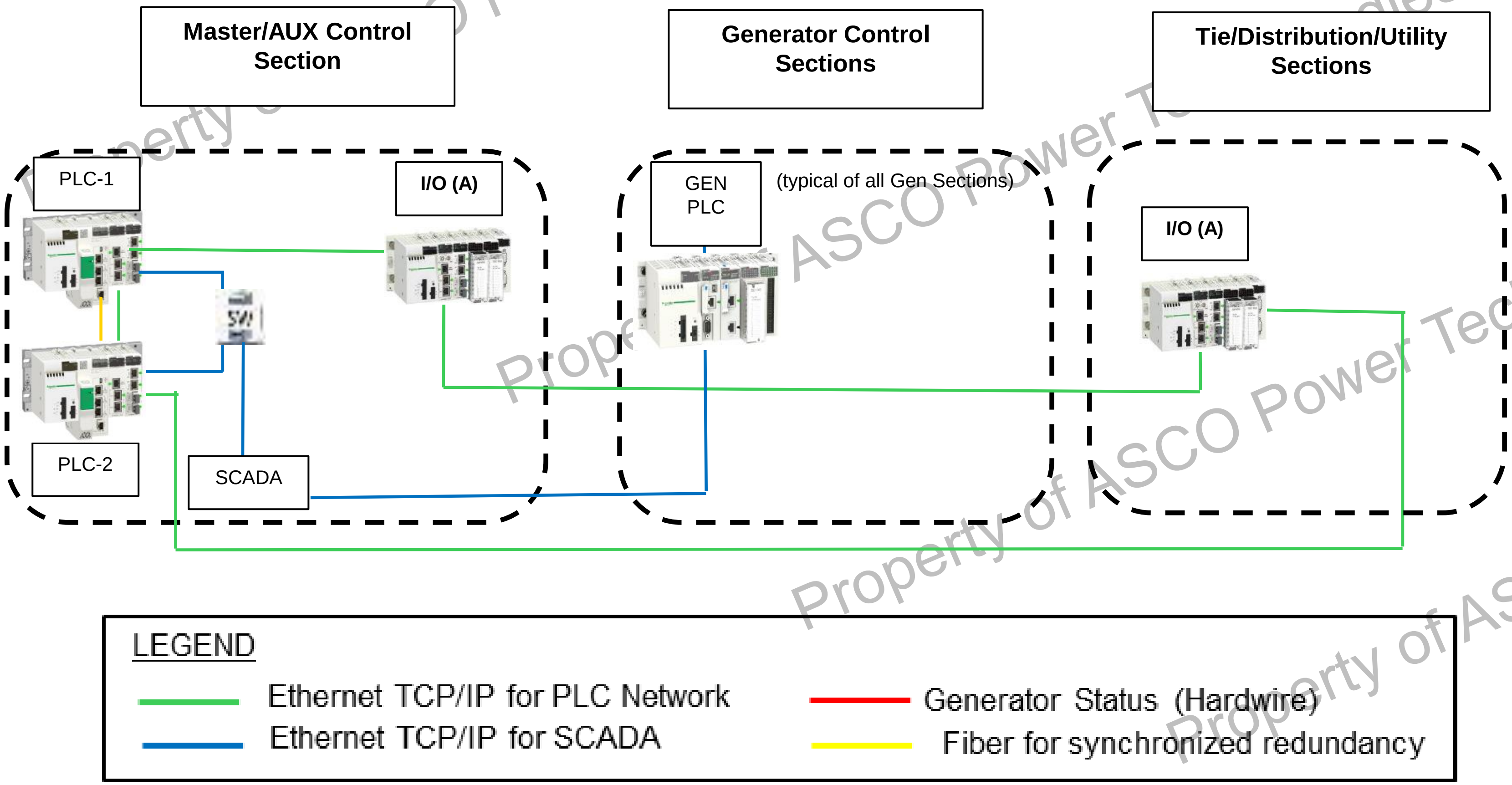
Single PLC, Single I/O, Ring Topology



- **Increased reliability and uptime for critical applications**
- **Minimizes single point of failure with ring configuration**
- **Single points of failure remain with single PLC and single I/O.**

Paralleling System Control Network

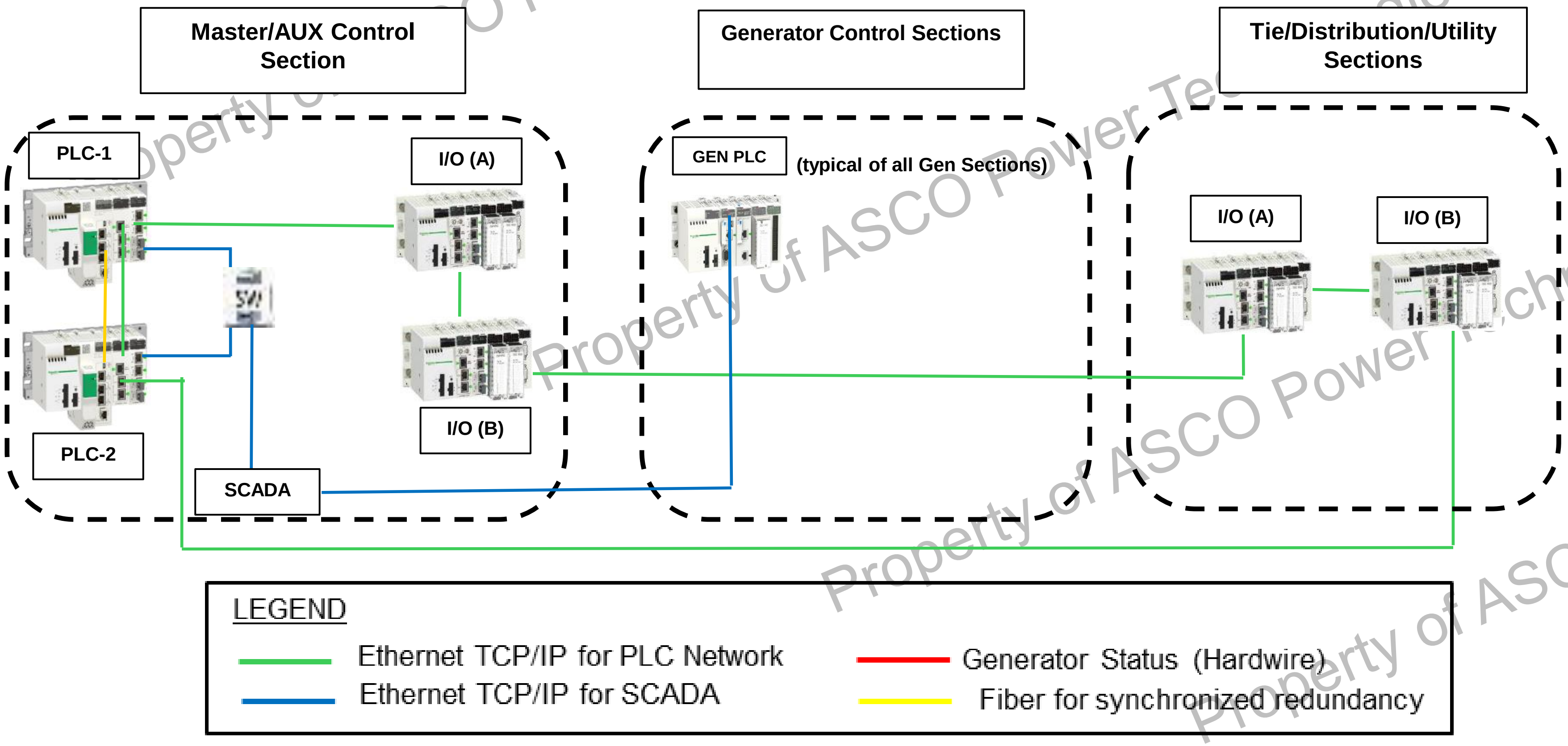
Redundant PLC, Single I/O, Ring Topology



- **Increased reliability and uptime for critical applications**
- **Minimizes single point of failure with redundant master PLC and ring configuration.**
- **Synchronized CPUs provide Bumpless transfer if one PLC fails – No interruption to program & process**
- **Additional layer of reliability & protection for relatively low cost**
- **Optional Redundant I/O**

Paralleling System Control Network

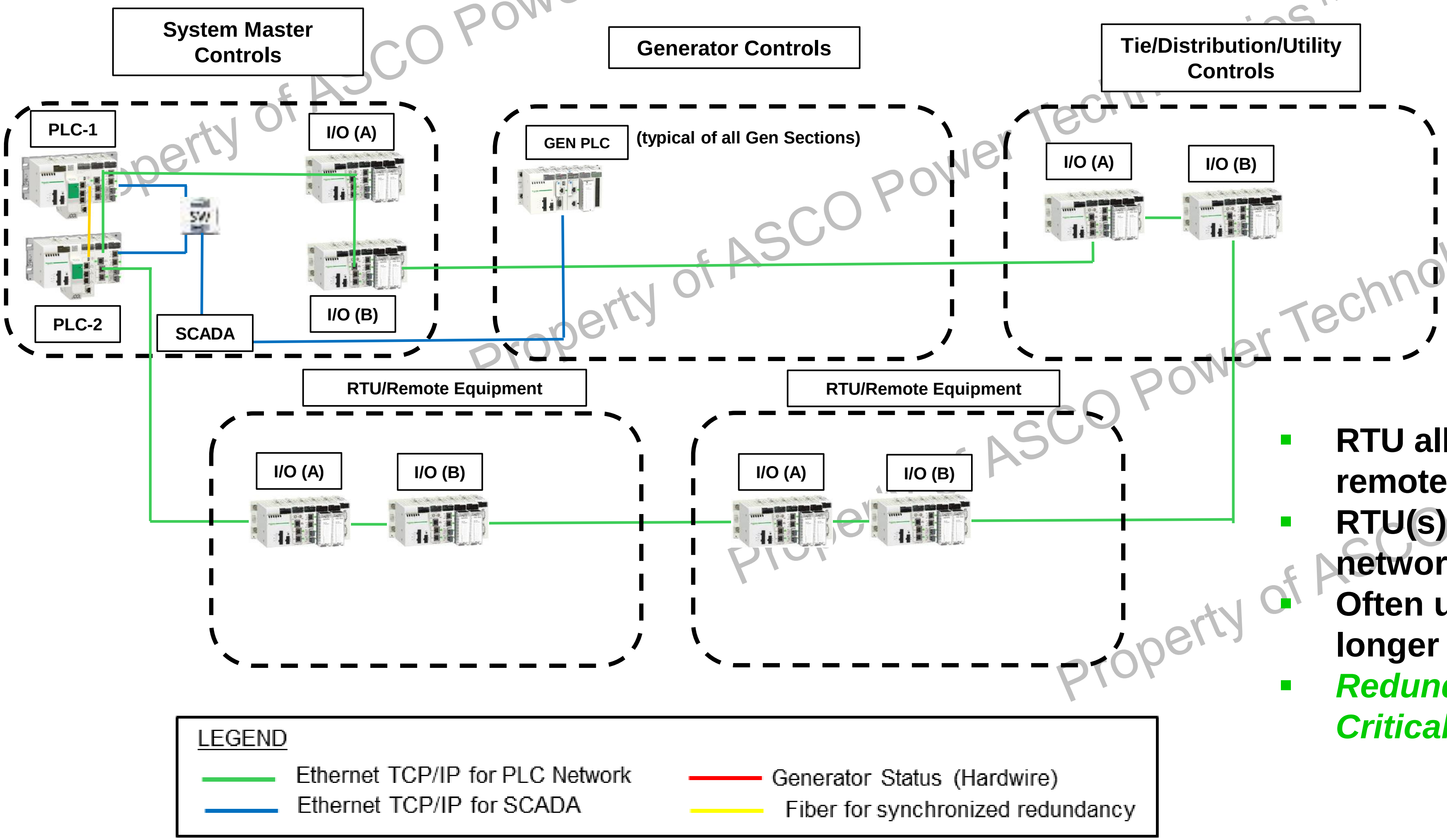
Redundant PLC, Redundant I/O, Ring Topology



- **Increased reliability and uptime for critical applications**
- **Eliminates single point of failure with redundant master PLC, redundant I/O, and ring configuration.**

Paralleling System Control Network

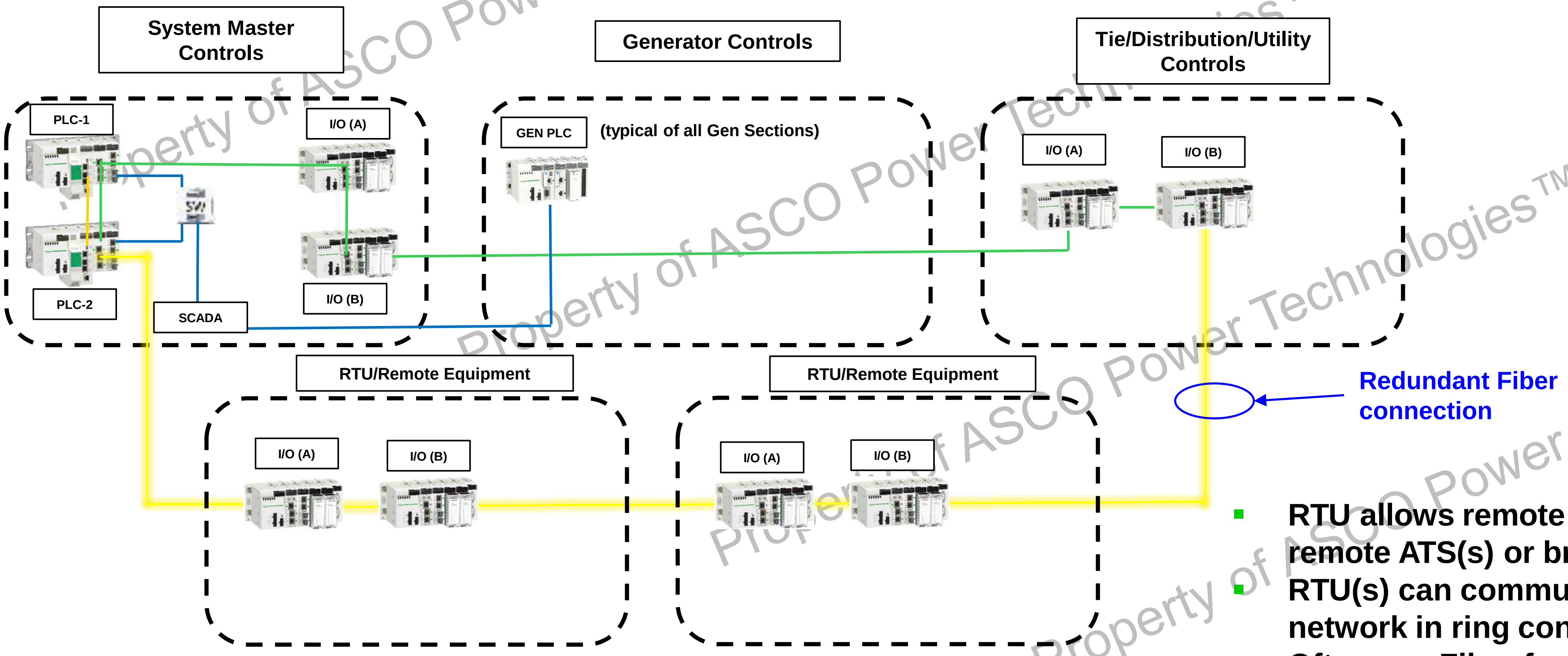
Redundant PLC, Redundant I/O, Ring Topology, Remote IO



- **RTU allows remote I/O to easily control remote ATS(s) or breaker(s)**
- **RTU(s) can communicate back to PLC network in ring configuration**
- **Often use Fiber for the PLC network for longer distances.**
- ***Redundant Fiber common for Mission Critical Applications***

Paralleling System Control Network

Redundant PLC, Redundant I/O, Ring Topology, Remote IO, Redundant Communication Connections



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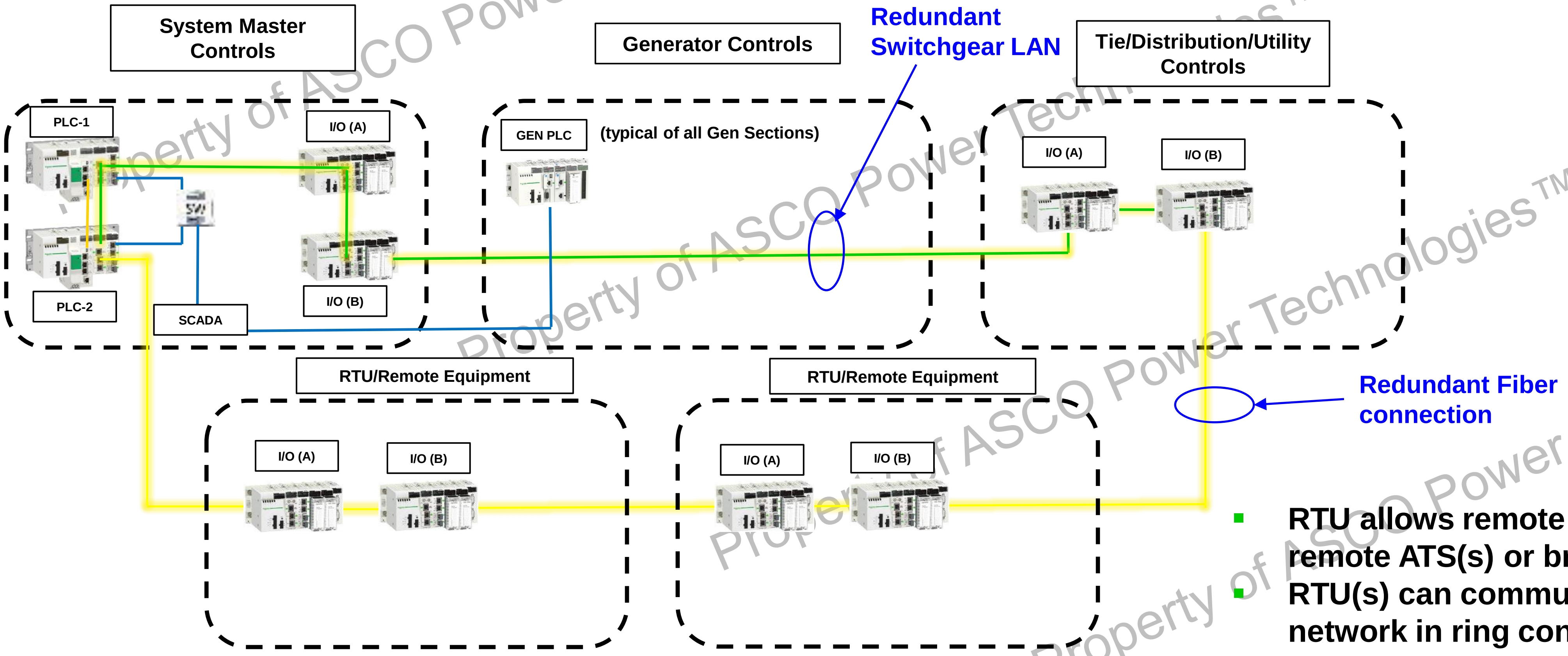
LEGEND

Ethernet TCP/IP for PLC Network (green)	Generator Status (Hardwire) (red)
Ethernet TCP/IP for SCADA (blue)	Fiber for synchronized redundancy (yellow)

Paralleling System Control Network

Redundant PLC, Redundant I/O, Ring Topology, Remote IO, Redundant Communication Connections, Redundant Switchgear LANs



LEGEND

Ethernet TCP/IP for PLC Network	Generator Status (Hardwire)
Ethernet TCP/IP for SCADA	Fiber for synchronized redundancy

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- **RTU(s) can communicate back to PLC network in ring configuration**
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- ***Redundant Fiber common for Mission Critical Applications***

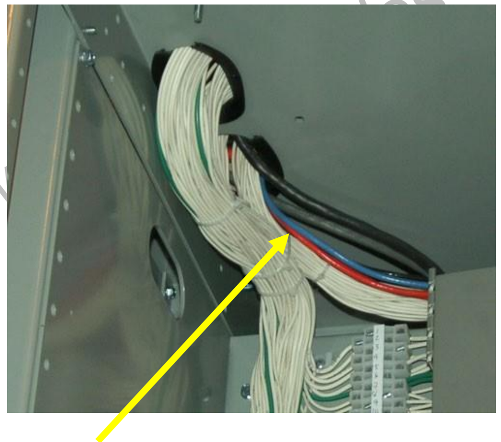
DC Power Considerations

- Reliable DC Power is Required for PLCs, controls, breaker operation
- Engine batteries experience a voltage drop during cranking that can be 24 VDC to less than 12 VDC
- Critical control components cannot function with voltages less than 18VDC. DC-DC convertors and a best battery selector are provided to keep these devices powered up during momentary voltage drops.
- The best battery circuit determines the best available DC voltage from the available battery sources (engine batteries and/or station batteries).
- DC-DC convertors act as a voltage regulator boosting the DC voltage
- A DC Bus Distributes DC power to the Generator and Master Controls
- Mission Critical Systems commonly utilize a combination of 24VDC engine start batteries and a dedicated station battery – 24VDC, 48VDC or 125VDC
- Provide DC – DC Convertors in all Generator and Master Sections
- Redundant Station batteries commonly specified in Mission Critical Applications

Best Battery Selector

DC-DC Convertor

Station Battery System



Red, Blue, Black Wires are DC bus

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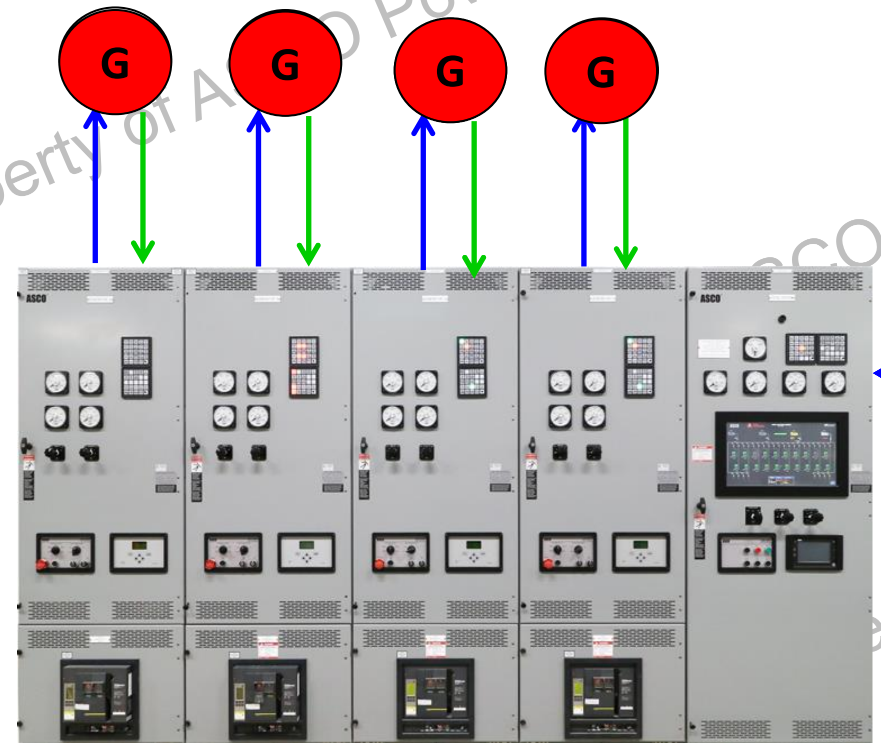
Internal

Power Control System Automatic Priority Load Control

What happens when the lights go out?

Utility Power



Effected ATS(s) send start signal to System Master Controls

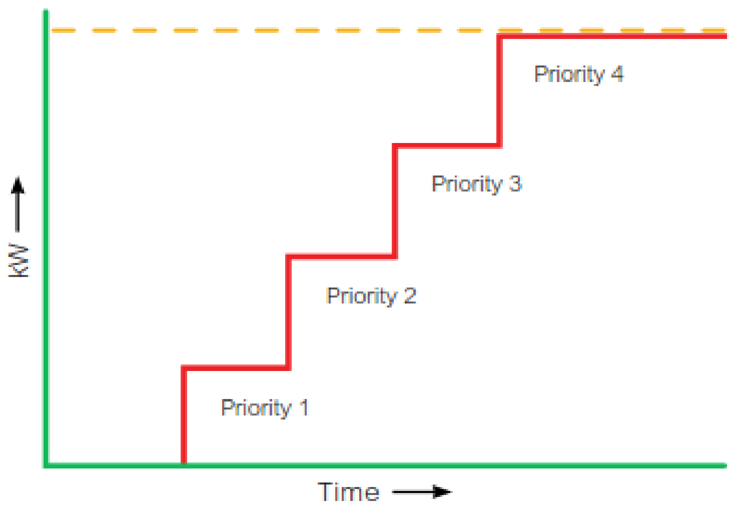
Power Control System

System Master Controls signal Generator Section Controls to start all engines

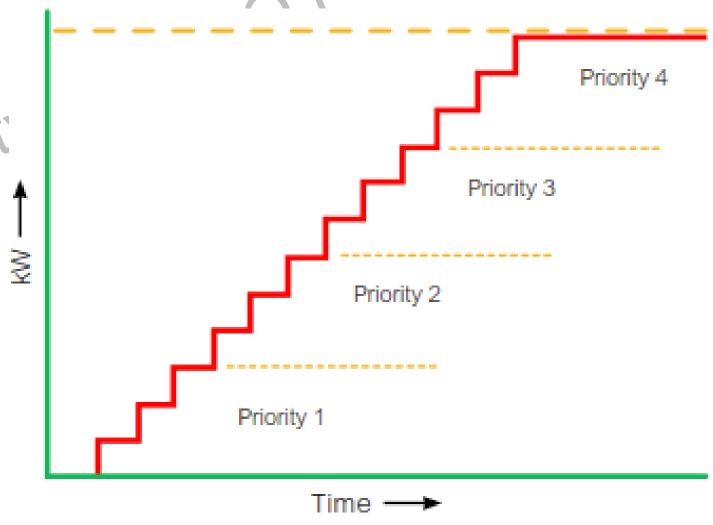
Automatic Transfer Switches

Power Control Systems Automatic Priority Load Control

- What happens next?
- All loads can't be connected immediately
- Loads are connected to the emergency bus as the system connects generators
- The System Controls signal loads (ATS or CB) to connect to the emergency bus in priority order – User adjustable in Master OIT
- Load can be added in priority blocks
- Or in steps



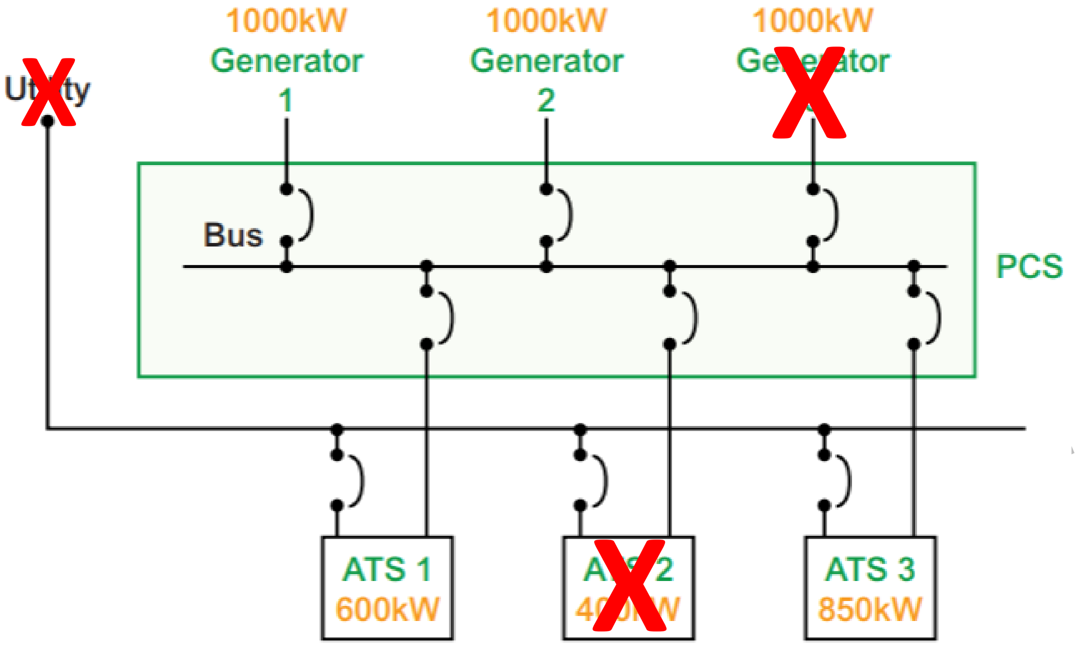
Block Load Control



Step Load Control

Power Control Systems Automatic Priority Load Control Features

- **What happens if an engine fails?**
- **It depends**
- **Traditionally power systems will shed the lowest priority load block**
- **Current power system designs do nothing unless they have to**
- **Systems can provide a *"load latch"* function that compares remaining capacity to real time kW demand of online loads**
- **If sufficient capacity remains *loads will remain online* preventing unnecessary disconnection and re-connection of loads**

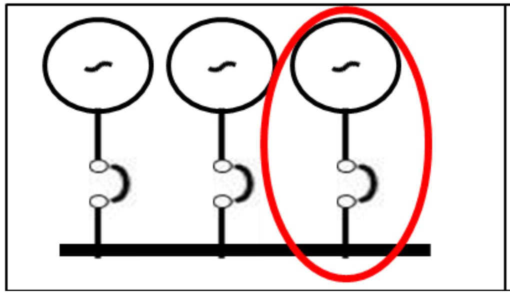


Power Control Systems- Automatic Priority Load Control Features

System Master Controls account for changes or failures in System configuration

Load Demand

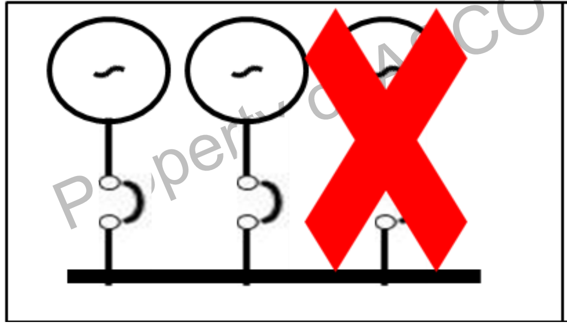
- Maximizes the efficient use of standby generator capacity by adding or removing generators according to demand
- Calculates kW Demand On The Emergency Bus
- Disconnects Unnecessary Generators And Allows A Cooldown Period
- *Highly specified feature*



Operates When Excess Capacity is Available

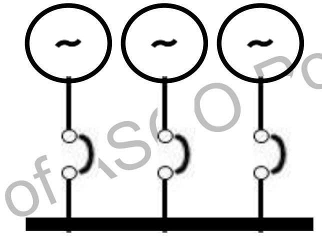
Bus Optimization Feature

- Controls the number of load blocks connected to the System
- Maximizes Load Connected to the system
- Calculates if the next Load Block can be connected
- *Specify more often*



Operates When A Generator Fails

Power Control Systems Load Control – Bus Optimization Feature



Each Generator Is 1000kW

Connected to Utility | Connected to Emergency | De-energized

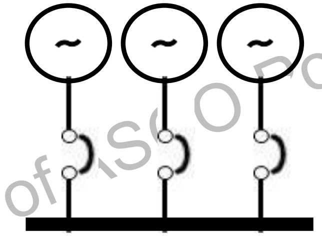
Priority 1	Priority 2	Priority 3
ATS 101	ATS 201	ATS 301
ATS 102	ATS 202	ATS 302
ATS 103	ATS 203	ATS 303
ATS 104	ATS 204	ATS 304
ATS 105	ATS 205	ATS 305
ATS 106	ATS 206	ATS 306
ATS 107	ATS 207	ATS 307
ATS 108	ATS 208	ATS 308
800kW	800kW	800kW

Total Demand on Emergency System: 0kW

Bus Optimization Example

- Bus Optimization is Set to Allow Connection of 90% of Capacity
- For this Example, Each Load is 100kW
- The Utility Source is Available
- All ATSs are Connected to the Utility Source

Power Control Systems Load Control – Bus Optimization Feature



Each Generator Is Signaled to Start

Connected to Utility | Connected to Emergency | De-energized

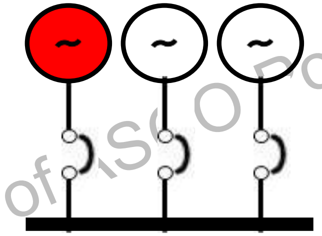
Priority 1	Priority 2	Priority 3
ATS 101	ATS 201	ATS 301
ATS 102	ATS 202	ATS 302
ATS 103	ATS 203	ATS 303
ATS 104	ATS 204	ATS 304
ATS 105	ATS 205	ATS 305
ATS 106	ATS 206	ATS 306
ATS 107	ATS 207	ATS 307
ATS 108	ATS 208	ATS 308
0kW	0kW	0kW

Total Demand on Emergency System: 0kW

Bus Optimization Example

- The Utility Source Fails and All ATSs are De-Energized
- All ATSs Issue a Start Signal to the Emergency Power System
- The Critical Load is Energized by the UPS

Power Control Systems Load Control – Bus Optimization Feature



The 1st Generator Is Connected to the Bus

Connected to Utility | Connected to Emergency | De-energized

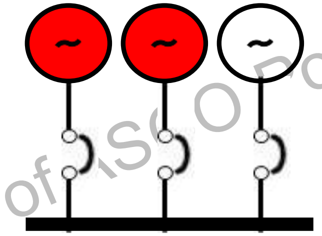
Priority 1	Priority 2	Priority 3
ATS 101	ATS 201	ATS 301
ATS 102	ATS 202	ATS 302
ATS 103	ATS 203	ATS 303
ATS 104	ATS 204	ATS 304
ATS 105	ATS 205	ATS 305
ATS 106	ATS 206	ATS 306
ATS 107	ATS 207	ATS 307
ATS 108	ATS 208	ATS 308
800kW	0kW	0kW

Total Demand on Emergency System: 800kW

Bus Optimization Example

- The First Generator Connects to the Bus
- The Priority 1 ATSs are Allowed to Transfer to Emergency
- All Other ATSs are Inhibited

Power Control Systems Load Control – Bus Optimization Feature



The 2nd Generator Is Connected to the Bus

Connected to Utility | Connected to Emergency | De-energized

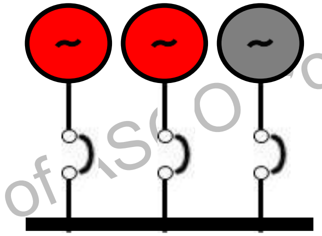
Priority 1	Priority 2	Priority 3
ATS 101	ATS 201	ATS 301
ATS 102	ATS 202	ATS 302
ATS 103	ATS 203	ATS 303
ATS 104	ATS 204	ATS 304
ATS 105	ATS 205	ATS 305
ATS 106	ATS 206	ATS 306
ATS 107	ATS 207	ATS 307
ATS 108	ATS 208	ATS 308
800kW	800kW	0kW

Total Demand on Emergency System: 1600kW

Bus Optimization Example

- The Second Generator Connects to the Bus
- The Priority 2 ATSs are Allowed to Transfer to Emergency
- All Other ATSs are Inhibited

Power Control Systems Load Control – Bus Optimization Feature



The 3rd Generator Fails to Connect to the Bus

Priority 1	Priority 2	Priority 3
ATS 101	ATS 201	ATS 301
ATS 102	ATS 202	ATS 302
ATS 103	ATS 203	ATS 303
ATS 104	ATS 204	ATS 304
ATS 105	ATS 205	ATS 305
ATS 106	ATS 206	ATS 306
ATS 107	ATS 207	ATS 307
ATS 108	ATS 208	ATS 308
800kW	800kW	0kW

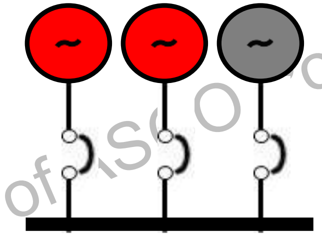
Connected to Utility — Connected to Emergency — De-energized

Total Demand on Emergency System: 1600kW

Bus Optimization Example

- The 3rd Generator Fails to Connect to the Bus
- The Priority 3 ATSs Remain Inhibited from Transferring to the Emergency Source and Remain De-Energized

Power Control Systems Load Control – Bus Optimization Feature



Bus Optimization Begins

Connected to Utility | Connected to Emergency | De-energized

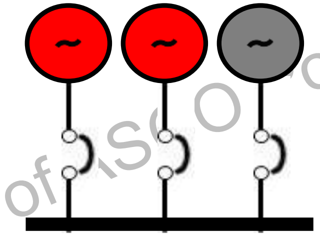
Priority 1	Priority 2	Priority 3
ATS 101	ATS 201	ATS 301
ATS 102	ATS 202	ATS 302
ATS 103	ATS 203	ATS 303
ATS 104	ATS 204	ATS 304
ATS 105	ATS 205	ATS 305
ATS 106	ATS 206	ATS 306
ATS 107	ATS 207	ATS 307
ATS 108	ATS 208	ATS 308
800kW	800kW	200kW

Total Demand on Emergency System: 1800kW

Bus Optimization Example

- After a Time Delay Expires, Bus Optimization Begins
- The System is Programmed to Allow Connection of 1800kW (previously set to 90% of online capacity)
- (2) Additional ATSs are Allowed to Connect to the Bus

Power Control Systems Load Control – Bus Optimization Feature



Bus Optimization Begins

Connected to Utility | Connected to Emergency | De-energized

Priority 1	Priority 2	Priority 3
ATS 101	ATS 201	ATS 301
ATS 102	ATS 202	ATS 302
ATS 103	ATS 203	ATS 303
ATS 104	ATS 204	ATS 304
ATS 105	ATS 205	ATS 305
ATS 106	ATS 206	ATS 306
ATS 107	ATS 207	ATS 307
ATS 108	ATS 208	ATS 308
400kW	700kW	700kW

Total Demand on Emergency System: 1800kW

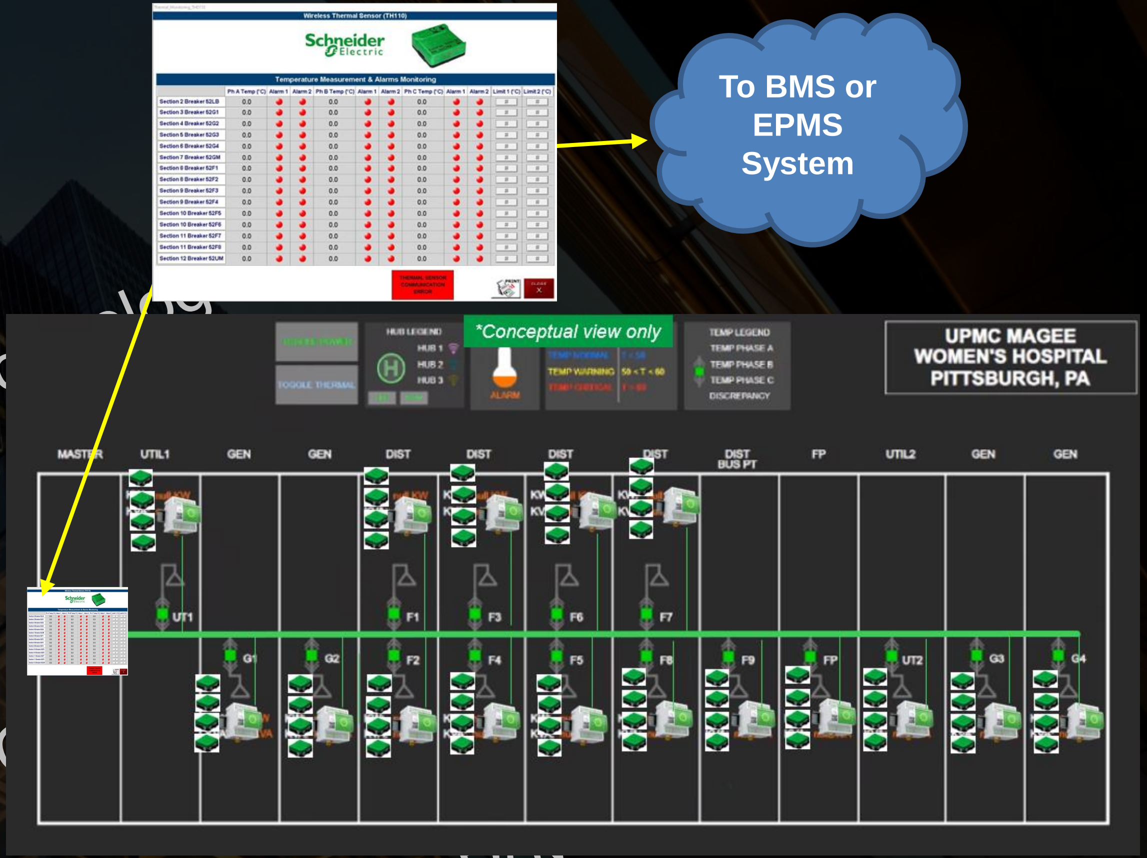
Dynamic Bus Optimization

- **Dynamic Bus Optimization Measures real time load kW of each ATS**
- **ALL ATSs are Allowed to Connect to the Bus even with a generator failure**

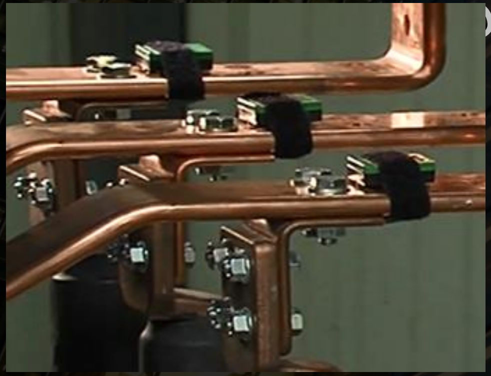
- ***Dynamic Bus Optimization Measures real time load kW and reconnects loads***
- ***Bus Optimization features are typically under specified***

Continuous Thermal Monitoring™

- Typically, NFPA 70E IR scans are performed once a year to check cable issues that can cause electrical fires
- Any issues between annual scans won't be detected and the risk remains until the next check up a calendar year later
- Continuous thermal monitoring enables early detection of conditions that could cause fires
- Monitors 24x7x365 and immediately notifies the facility manager and operators of potential dangers
- With optional expert advisor services, optimize maintenance through more streamlined maintenance planning and scheduling



WITHOUT thermal monitoring



WITH thermal monitoring

Power Control Systems – Seismic Certification

SEISMIC CERTIFIED

ASCO Low Voltage Switchgear & Control Products - 300, 4000, 7000 Series

The Schneider Electric equipment referenced in this Certificate of Compliance has been qualified to the requirements of the listed regional building codes and/or seismic design standards identified below. This certification is based on tri-axial shake-table test results conducted in accordance with globally recognized equipment test protocols. Assessment of earthquake demands (EDS-equipment demand spectrum) and equipment seismic capacity (ECS-equipment capacity spectrum) follows the guidelines contained in ISO 3010 and ISO 13033 respectively. Earthquake demand at location of equipment installation must be less than equipment capacity shown in ECS table to validate seismic conformance.[1]

Product Category: Switchgear, Low Voltage
Product Mounting: Rigid Floor Mount
Product Model: Power Control Systems (PCS); Series 300, 4000, 7000; 2000A-10,000A
Product Type: NEMA Enclosure Types 1 and 3R, 2000A - 10,000A

Listing of Regional Codes/Standards			Assumed Maximum Demands (EDS)[2] for Regional Codes/Standards						Tested Product Capacity (ECS)[3] for Regional Codes/Standards					
Country / Region	Code Identification	Exceedance Probability	Hazard Level Ground	EDS Horz A_{FLX-H} Ground	EDS Horz A_{RIG-H} Ground	Hazard Level Roof	EDS Horz A_{FLX-H} Roof	EDS Horz A_{RIG-H} Roof	Hazard Level Ground	ECS Horz A_{FLX-H} Ground	ECS Horz A_{RIG-H} Ground	Hazard Level Roof	ECS Horz A_{FLX-H} Roof	ECS Horz A_{RIG-H} Roof
Argentina	INPRES-CIRSOC103	10% in 50 yrs	Zone 4	1.05	0.35	Zone 4	1.89	1.05	Zone 4	2.52	0.84	Zone 4	3.56	1.98
Australia	AS 1170.4-2007	10% in 50 yrs	Z = 0.6	2.21	0.78	Z = 0.22	1.46	0.86	Z = 0.6	2.52	0.89	Z = 0.22	3.56	2.09
Canada*	2020 NBCC	2% in 50 yrs	S_a = 2.00	2.00	0.81	S_a = 2.00	3.20	2.42	S_a = 2.54	2.54	1.02	S_a = 2.05	3.28	2.48
Chile	NCh 433.Of1996	10% in 50 yrs	Zone 3	1.61	0.52	Zone 3	2.89	1.56	Zone 3	2.52	0.82	Zone 3	3.56	1.92
China	GB 50011-2010 (2016)	2% in 50 yrs	α_{Max} = 1.4	1.40	0.63	α_{Max} = 1.4	2.52	1.89	α_{Max} = 1.4	2.52	1.14	α_{Max} = 1.4	3.26	2.45
Colombia	NSR-10 Título A	10% in 50 yrs	A_a = 0.5	1.25	0.50	A_a = 0.5	2.25	1.50	A_a = 0.5	2.52	1.01	A_a = 0.5	3.56	2.37
Europe	Eurocode 8 EN1998-1	10% in 50 yrs	a_{Gr} = 0.5	2.25	0.90	a_{Gr} = 0.4	3.24	2.16	a_{Gr} = 0.5	2.52	1.01	a_{Gr} = 0.4	3.56	2.37
India	IS 1893 (Part 1) : 2016	10% in 50 yrs	Z = 0.36	0.90	0.36	Z = 0.36	1.62	1.08	Z = 0.36	2.52	1.01	Z = 0.36	3.56	2.37
Indonesia	SNI 1726:2019	2% in 50 yrs	S_S = 2.5	2.00	0.80	S_S = 2.25	3.24	2.16	S_S = 2.5	2.52	1.01	S_S = 2.25	3.56	2.37
Japan	Building Standard Law	10% in 50 yrs	Zone A	1.22	0.49	Zone A	2.20	1.47	Zone A	2.52	1.01	Zone A	3.56	2.37
Mexico	CFE MDOC-15	10% in 50 yrs	a_0^r = 490	2.32	0.80	a_0^r = 299	3.42	1.97	a_0^r = 490	2.52	0.87	a_0^r = 299	3.56	2.04
New Zealand	NZS 1170.5:2004+A1	10% in 50 yrs	Z = 0.6	1.80	0.80	Z = 0.6	3.24	2.39	Z = 0.6	2.52	1.12	Z = 0.6	3.30	2.44
Peru	N.T.E. - E.030	10% in 50 yrs	Zone 4	1.24	0.50	Zone 4	2.23	1.49	Zone 4	2.52	1.01	Zone 4	3.56	2.37
Russia	СП 14.13330.2018	10% in 50 yrs	MSK 10	2.04	0.82	MSK 9	1.84	1.22	MSK 10	2.52	1.01	MSK 9	3.56	2.37
Taiwan	CPA 2011 Seismic Design Code	10% in 50 yrs	S_S^D = 0.8	1.20	0.48	S_S^D = 0.8	2.16	1.44	S_S^D = 0.8	2.52	1.01	S_S^D = 0.8	3.56	2.37
Turkey	TBEC-2018	10% in 50 yrs	S_S = 2.005	2.41	0.96	S_S = 1.5	3.24	2.16	S_S = 2.005	2.52	1.01	S_S = 1.5	3.56	2.37
United States*	2018 IBC / ASCE 7-16	2% in 50 yrs	S_{DS} = 2.00	2.00	0.80	S_{DS} = 2.00	3.20	2.40	S_{DS} = 2.54	2.54	1.01	S_{DS} = 2.07	3.30	2.48

*EDS and ECS are defined at frequency points f_1 = 0.1 Hz, f_2 = 1.3 Hz, f_3 = 8.3 Hz, f_4 = 33.3 Hz with $BA_{FLX}|_{MAX}$ = 1.6 in accordance with AC156 test protocol

Equipment Importance Factor[4]: $I_e > 1.0$ for applications in essential buildings and critical infrastructure where post-earthquake equipment functionality is required.
Installation Restrictions[5]: Equipment ECS must exceed EDS at install location and be anchored per manufacturer's Instruction Bulletin to validate certification.

Schneider Electric

Page 1 of 3 Certificate Number: O-01000000

Seismic Certificate of Compliance

- **IBC is current seismic certification**
- **IBC certification *requires* shake table testing**
- **IBC replaced UBC in 2000**
- **Specify IBC seismic label if seismic certification is required**
- **Applies to Low & Medium Voltage Switchgear**

ASCO Power Technologies™ Schneider Electric

Seismic Certified

Product Name: 4000, and 7000 Series
Product Type: Low Voltage Switchgear and Controls
Equipment Rating: Up to 600VAC
Seismic Performance Characteristics: S_{DS} (g) = 2.50 z/h ≤ 1.0 I_p = 1.5
Manufacturer's Identification Number: See Product Nameplate for Manufacturer's Serial Number

OSHPD Special Seismic Certification Preapproval: OSP-0070-10
International Building Code (IBC)
California Building Code (CBC)

Scan for Certificate

Scan QR code for Seismic Certificate

Seismic Equipment Label

Arc Flash Considerations

NEC Specified Methods – Article 240.87(B)

"One of the following means shall be provided *and shall be set to operate at less than the available arcing current*"

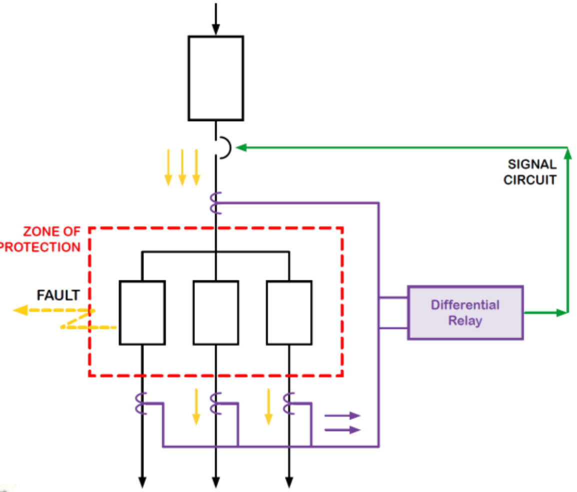
- Energy-Reducing maintenance switching with local status indication
- Energy Reducing active arc flash mitigation
- Differential Relaying
- Zone Selective Interlocking
- An Instantaneous trip that is less than the available arc current
- An Instantaneous override that is less than the available arcing current – *Temporary Adjustment of the Instantaneous trip setting to achieve arc energy reduction shall not be permitted*
- An approved equivalent means

2020 NEC added *Article 240.87(C) – Performance testing* requiring:

1. *Documents that show the implemented arc reduction method operates below the arcing current.*
2. *Documented field tests that prove the installed method performs as intended.*

Circuit Breakers with ERMS switches

Protective Relaying with arc protection capability



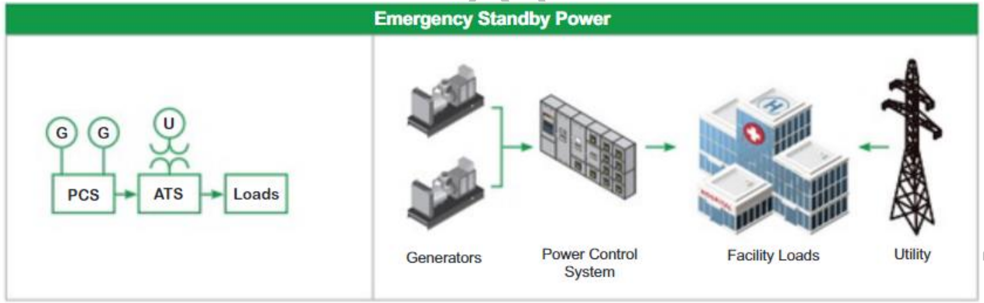
Differential Relaying

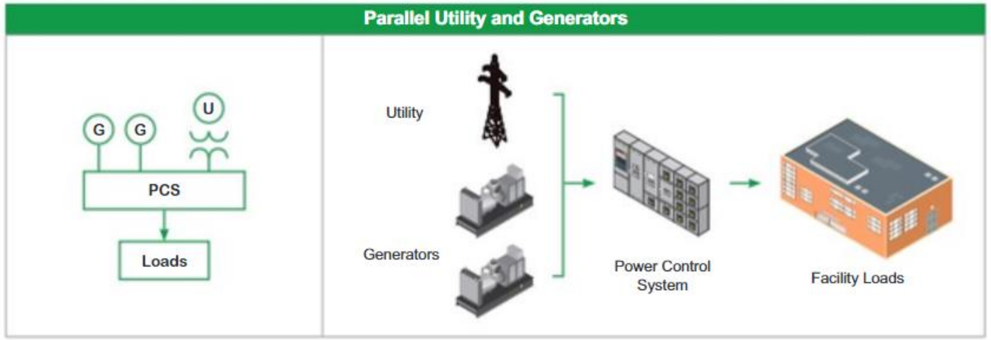
Arc Resistant Switchgear

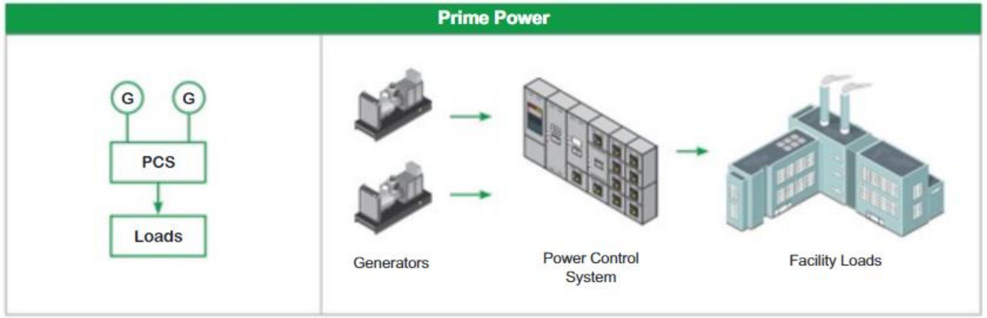
Does not meet NEC Requirement

Paralleling Switchgear Design Considerations

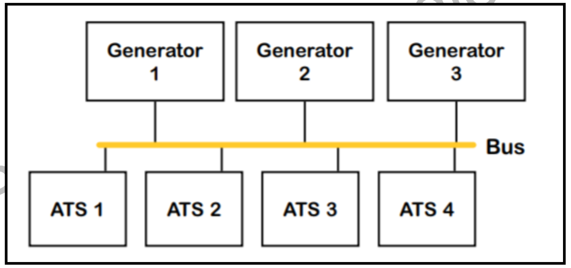
Multiple Operational Modes





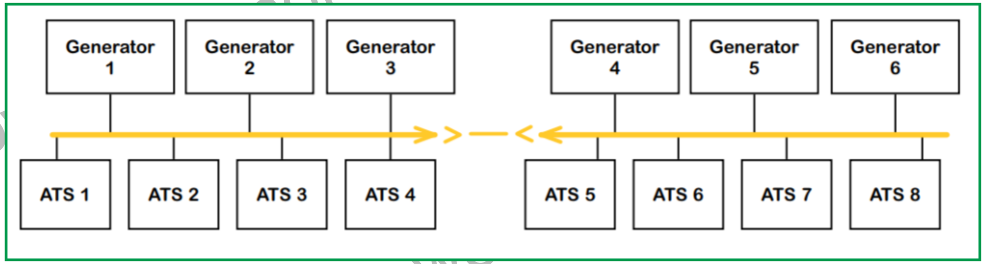


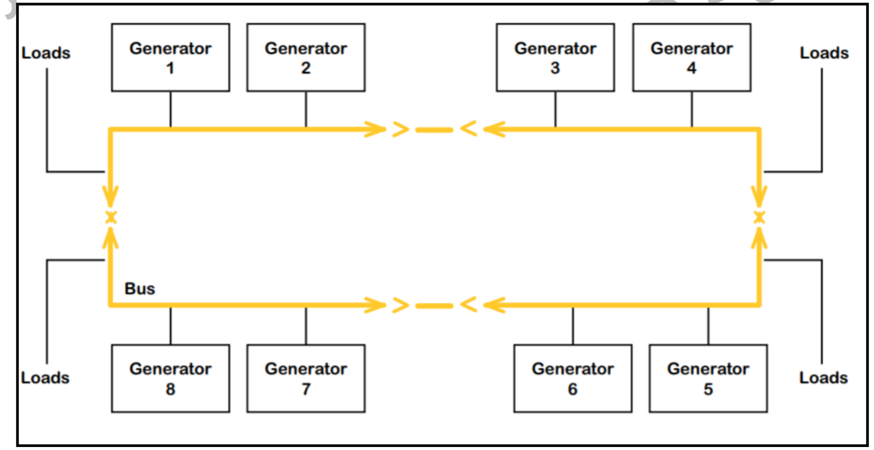
In Customizable bus configurations



Single Common Bus

Segmented Bus





Ring Bus

Power System Modes of Operation

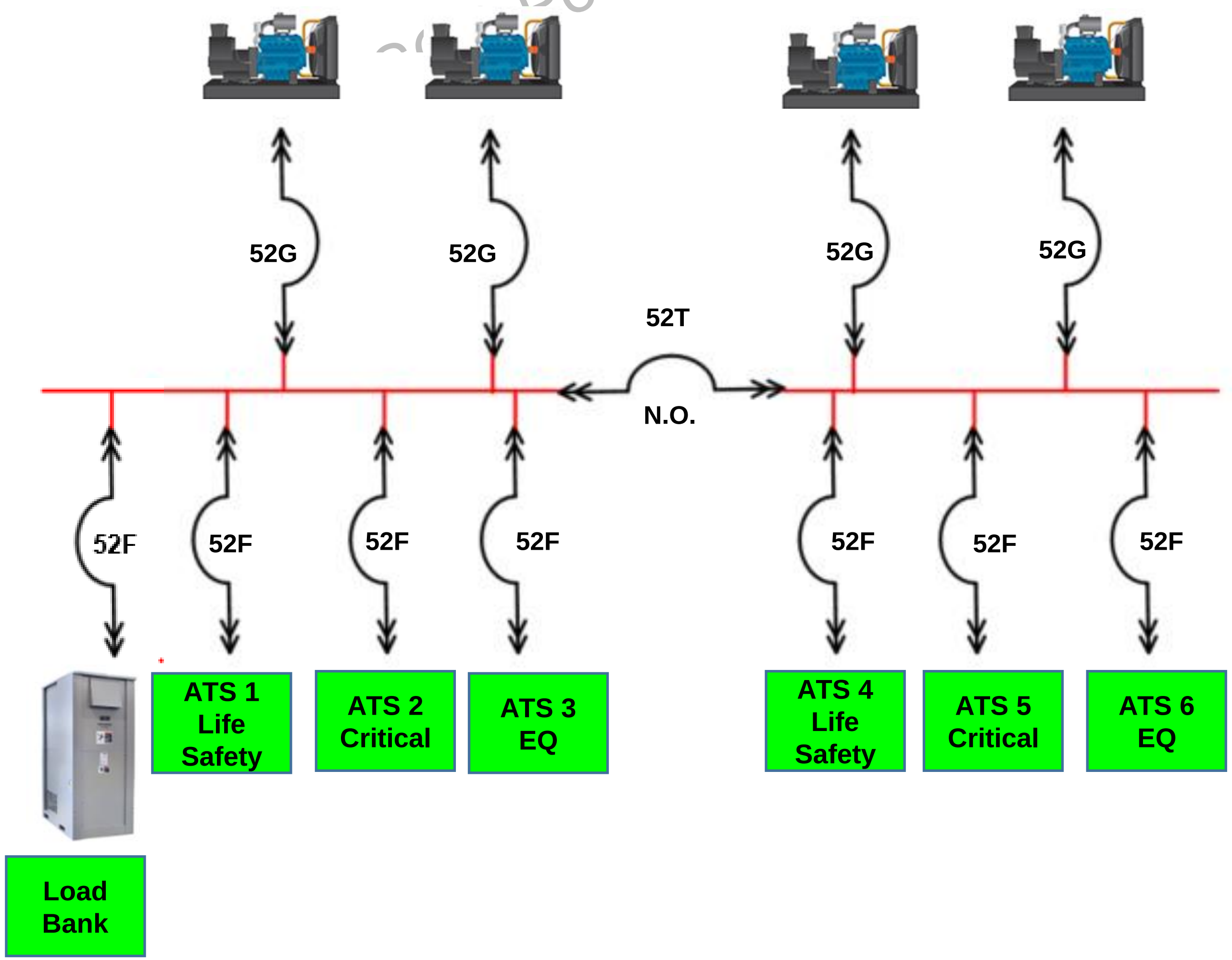
- Open transition is the transfer of load from one power source to another power source by interrupting one power source before the other power source can feed the load (Break before Make).

- Closed Transition is the transfer of load between two power sources without interruption of power (Make before Break). Typically, closed transition is 100ms or less. Closed transition is typically used on retransfers to utility power or during transfer tests of emergency equipment so that load is not interrupted.

- Closed Transition/Soft-load like closed transition, soft-load transition parallels two power sources. In this mode the sources can be paralleled for extended periods. This method is used to decrease loading on the original source while increasing loading on the alternate source.

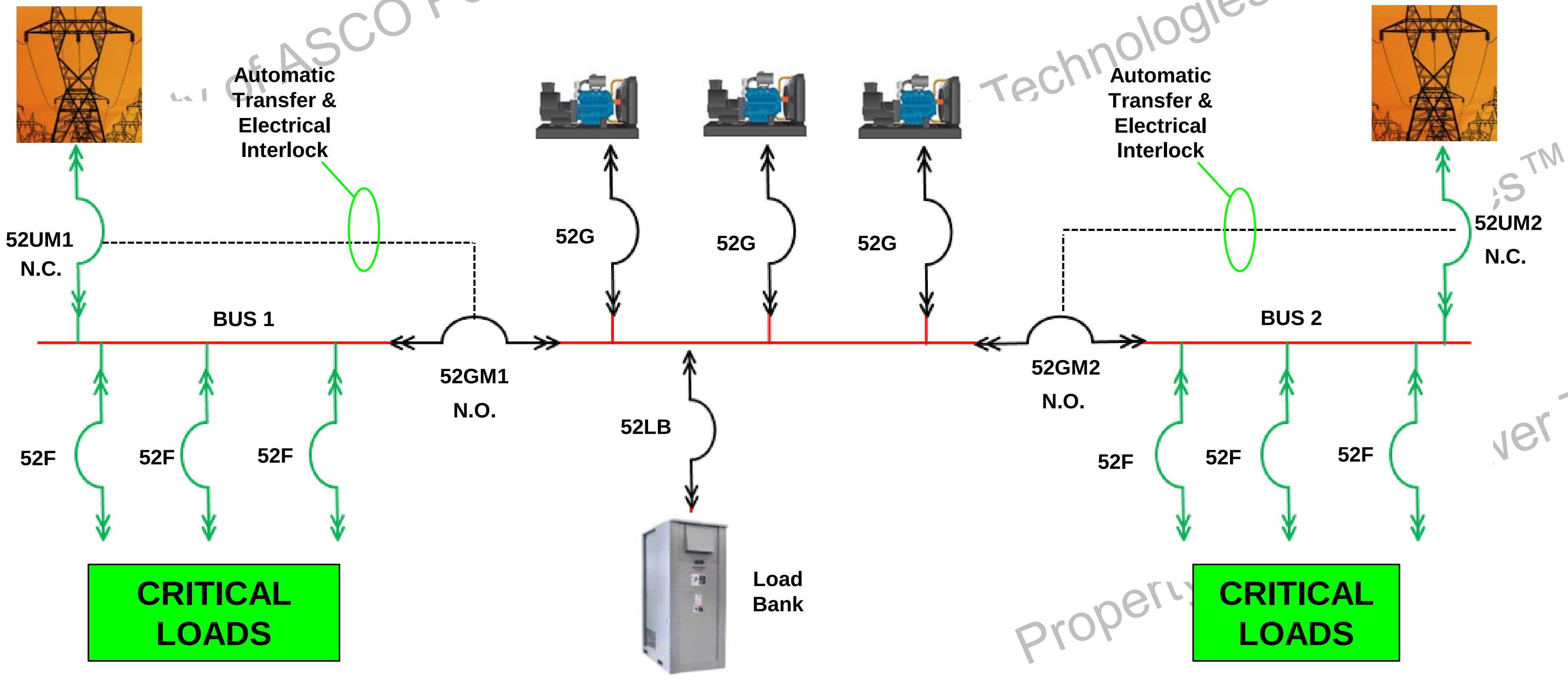
- Extended Parallel with Utility is the connection of the normal (utility) power source with another power source (Generator Paralleling Switchgear) for an extended period of time - hours, days, etc. Used for peak shaving, curtailment, storm modes, etc.

Segmented Bus Configuration



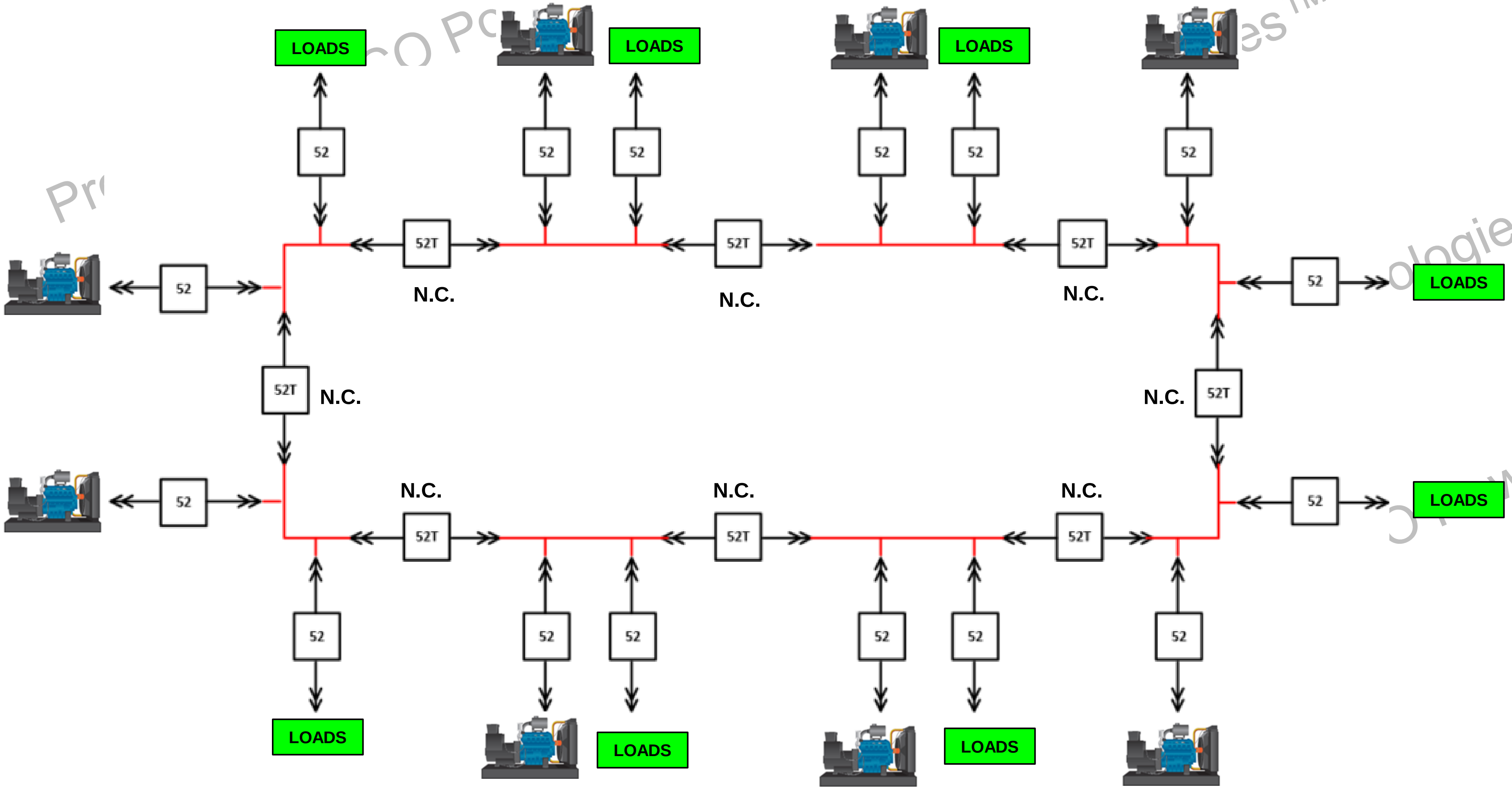
- Concurrently connect generators to isolated segments to bring multiple gensets online within the 10 second timeframe required for critical power applications NEC 517.32-34
- Distribute remaining generation capacity to the loads on each bus when segments are tied together – this increases overall capacity to maximize availability if a generator fails
- Isolate faults if one bus is lost, keeping the remainder of the facility powered
- Can shut down one section completely for maintenance.
- Requires synchronization across tie breaker and voltage sensing on each segment
- More Complex Sequence
- Consider tie breaker failure modes – Ex: Tie fails to automatically close

Main – Tie - Tie – Main Configuration



- Provides Redundancy via separate utility feeds
- Allows for maintenance
- Open & Closed transition, Soft Load or Extended Parallel With Utility Operation
- Load Control via Electrically Operated Circuit Breakers
- More complex sequence of operation
- Requires additional components for utility breakers and parallel with utility operation
- Utility Main and Gen Main act as transfer pairs – Electrically Interlocked
- Consider main breaker failure modes
- Utility Breaker 52UM fail to open inhibits transfer to its respective bus
- Load Bank on Gen Bus

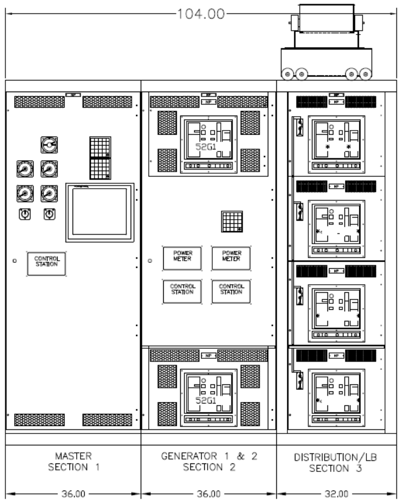
Ring Bus Configuration

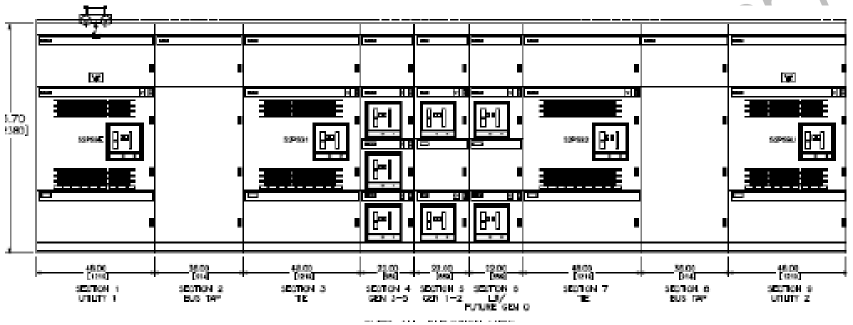


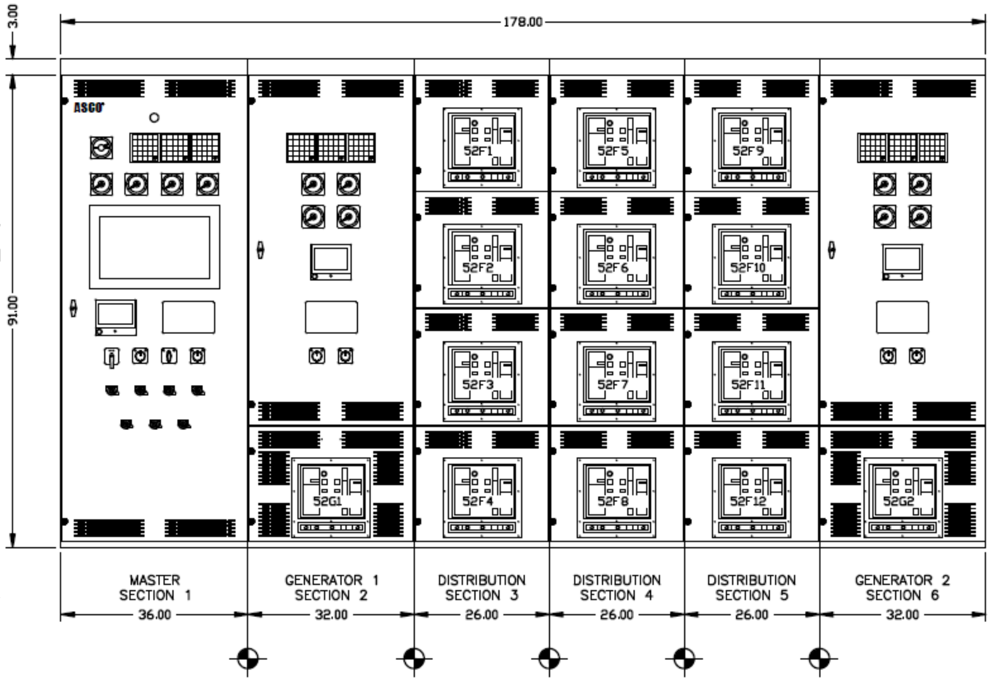
- **High Reliability**
- **Two available paths to supply critical loads**
- **Isolate faults via bus differential if one bus is lost, keeping the remainder of the facility powered**
- **Can shut down one section completely for maintenance.**
- **Typically used in Medium Voltage Applications with large power requirements – Ex: Data Center**
- **Complex Sequence – Typically Soft Load Parallel with utility operation**
- **Multiple Configurations – N+1, N+2, etc**

Footprint Support

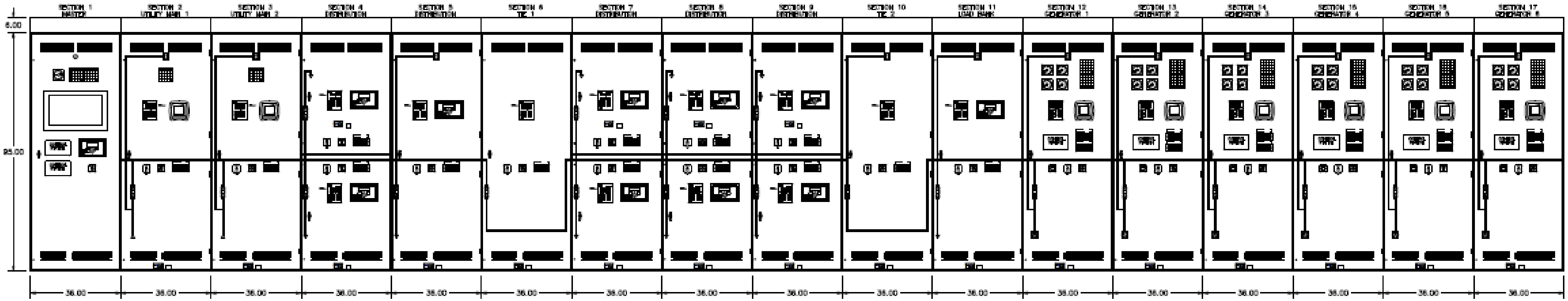
Many variables can affect the switchgear sizing







ELEVATION VIEW



OVER-ALL FRONT DOOR VIEW

Power System Sequence of Operation

SECTION 26 13 24, PAGE 1

MEDIUM VOLTAGE SWITCHGEAR

SECTION 26 13 24 – MEDIUM VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provide pricing and documentation per the instruction within the Request for Proposal (RFP) associated with this specification section. Alternate bids are described in Part 4 of this document.

B. Drawings and general provisions of the Contract, including General Conditions and Division 1 Specification Sections, apply to this and other Sections of Division 26.

1.2 SUMMARY

A. Provide an overall price ("base bid") for the complete equipment package specified; complete with all accessories and services specified and required in the RFP document.

Base Bid	Description	Quantity
Complete Package	Provide 12.0kV Medium Voltage Indoor Switchgear as shown on the drawings.	As Noted in RFP
Complete Package	Provide 12.0kV Medium Voltage Outdoor Switchgear as shown on the drawings.	As Noted in RFP

B. Equipment Supplier shall be responsible for the following:

1. Switchgear specified under this section shall consist of 15kV, indoor and outdoor metal-clad, switchgear lineups associated with the main distribution utility and generator power. The equipment will be placed on "skids" to minimize installation requirements in the field. These Switchgear lineups are designated as follows:

a. "SMV-AX", "SMV-BX", "SMV-AY", and "SMV-BY" contain the utility/generator transfer pairs and load distribution feeder breakers as indicated on the drawings. This equipment will be NEMA 1 type construction and will be controlled by the main PLC for the electrical infrastructure.

b. "SMV-GPX" and "SMV-GPY" is the generator paralleling switchgear and contain the generator distribution for the electrical system. This equipment will be NEMA 3R type construction and houses the paralleling controls of the system.

c. There will be a Remote Annunciating Panel (RCP) located inside the building. The RCP shall house a touchscreen that will allow an operator to remotely monitor and control the medium voltage infrastructure.

d. The medium voltage infrastructure equipment described herein is designed to automatically control the utility service feeders and (16)-3500KW standby generators to provide critical, essential and house power to the data center facility.

e. Provide all the required settings, logic and functionality required for the protective relaying. Equipment supplier will be required to have this completed prior to shipment. All protective settings shall be provided by the engineer.

ISSUED FOR OFE PRICING – REVIEW DATE: 01/31/2020

Project Specification

SECTION 26 13 24, PAGE 1

MEDIUM VOLTAGE SWITCHGEAR – APPENDIX A

Appendix A

SEQUENCE OF OPERATION

Table of Contents

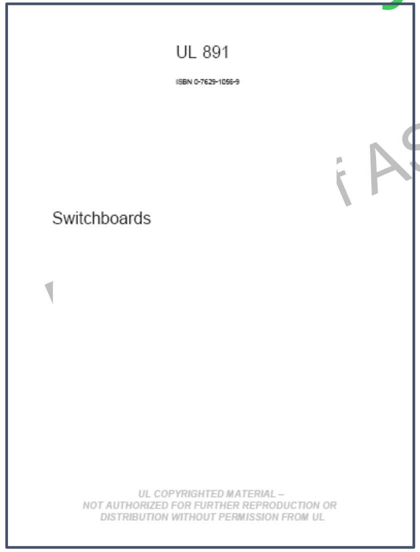
ISSUED FOR OFE PRICING – REVIEW DATE: 01/31/2020

Project Specific Sequence of Operation

- **Project Specific Sequence of Operation**
- **Most critical element of system design**
- **Can impact equipment/component selection**
- **Can affect system short circuit rating**
- **Can impact pricing/bid leveling**
- **Eliminate Single points of failure**
- **More efficient Startup/Commissioning process**
- **Consider failure modes – Ex: What happens if a Generator or Tie Circuit Breaker fails to close (or open)**

Life Is On | Schneider Electric

Power Systems Low Voltage Standards


UL 891

Switchboards

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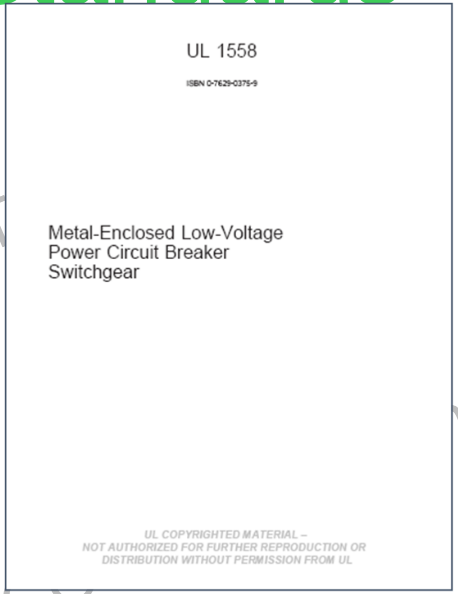
DISTRIBUTION WITHOUT PERMISSION FROM UL


UL 1558

Metal-Enclosed Low-Voltage
Power Circuit Breaker
Switchgear

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- **Based on NEMA Standards – Dead Front Switchboard Construction in accordance with NEC**
- **Molded Case, Panelboards, Insulated case breakers as defined in UL 489 allowed**
- **Fusible Switches allowed**
- **ANSI Rated Breakers as defined by ANSI 37.16, ANSI 37.13 and UL1066**
- **3 cycle short circuit rating/test**
- **No barriers or compartmentalization required**
- **Typical AIC ratings - 42KAIC, 50KAIC, 65KAIC, 100KAIC 150KAIC, 200KAIC**
- **Defines an interrupting current rating for the breaker**

- **Based on ANSI Standard C37.20.1 for Metal Enclosed Low Voltage Circuit Breaker switchgear**
- **Drawout Power circuit breakers as defined in UL 1066 and ANSI are the only type allowed**
- **4 cycle short circuit rating/test, 30 or optional 60 cycle short time test**
- **Heat Rise Test**
- **Complete breaker compartmentalization required**
- **Typical AIC ratings - 65KAIC, 85KAIC, 100KAIC, 200KAIC**
- **Defines an interrupting current rating and short time rating (30 cycle rating) for circuit breakers**

Power Systems Medium Voltage Standards – ANSI 37.20.2

Common in Mission Critical Applications due to safety and maintenance features

- **Drawout circuit breaker**
- **Compartmentalized construction with Grounded metal barriers**
- **Instrument/control compartment isolated from primary voltage**
- **Automatic shutters**
- **Insulated bus**
- **Drawout/Disconnect type voltage transformers Control power transformers (CPT) and voltage transformers (VT)**
- **Grounded breaker truck in and between test/disconnected and connected positions**
- **Voltages range 5kV class to 38kV class**
- **Arc Resistant per ANSI 37.20.7**