ASCO Power Technologies™

Increasing Maintainability of Backup Power Systems

White Paper 130

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Standby and emergency power systems are installed to provide facilities with reliable sources of backup power whenever outages occur on the normal power source. The following narrative describes how elements of backup power systems can be configured to promote maintainability and regulatory compliance.

THE NEED TO MAINTAIN AND TEST BACKUP POWER SYSTEMS

Comprised of engine-generators, transfer switches, and in multi-generator systems, paralleling switchgear, backup power systems require periodic evaluation and service to provide the highest levels of reliability. To ensure the equipment will be ready for service whenever needed, power devices must be maintained, tested, and documented in accordance with manufacturer recommendations as well as industry standards such as ***NFPA 110 - Standard for Emergency and Standby Power Systems***.

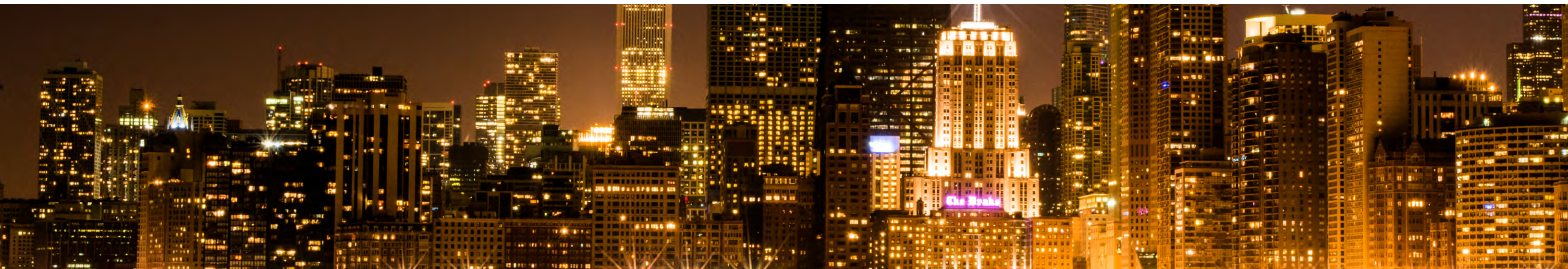
Devices that typically require periodic inspection and service include: (1) the engine-generators that provide backup power; (2) transfer switches that switch loads to generators when they detect unacceptable power on the normal source, then back to the normal source when power is restored; and, (3) in multi-generator systems, paralleling switchgear that synchronizes and connects multiple gensets to a facility's power distribution system. Skipping maintenance can compromise the reliability of these devices. Skipping routine testing leaves facilities without assurance that backup power systems will perform as designed when needed. Either omission can result in a power outage if backup systems fail.

Completing prescribed inspections and maintenance and required testing is the best way to assure the highest levels of power availability. Streamlining maintenance can help ensure that this work gets done. The following sections describe several features and practices that enable and simplify equipment service.

MAINTAINING TRANSFER SWITCHES

Transfer switches of all types require periodic inspection, evaluation, and maintenance. Contactor-type switches utilize sophisticated electromechanical assemblies to open and close the transfer switch contacts for the normal and emergency power sources. Electronic controllers and electrical signaling systems orchestrate their operation. All of these components must be checked to confirm that they are operating properly. Inspecting and servicing transfer switch mechanisms requires that they be depowered. Without adequate forethought, this could require a facility to remove power from the exact loads a critical power system was installed to backup.

A common means of promoting inspection and service of critical power devices is to utilize a transfer switch configured with a bypass for the transfer mechanism, shown in Figure 1. This bypass is itself equipped with a second transfer mechanism that can transfer loads between normal and emergency sources. This allows the facility to depower the primary transfer mechanism for service without interrupting power flow to downstream loads. Isolation features then allow an operator to disconnect the primary transfer mechanism from the rest of the switch. This provides access for visual inspection, test measurements, lubrication and adjustment, component replacement, and replacement of an entire transfer switching mechanism when necessary. NFPA 110 provides guidance on maintaining transfer switches. An overview of the standard is provided in ***Part 1*** and ***Part 2*** of the ASCO Power Technologies document entitled *NFPA 110 Overview*. An example of a *Bypass Isolation Automatic Transfer Switch* with draw-out capability for the primary transfer switch mechanism is shown in Figure 2.



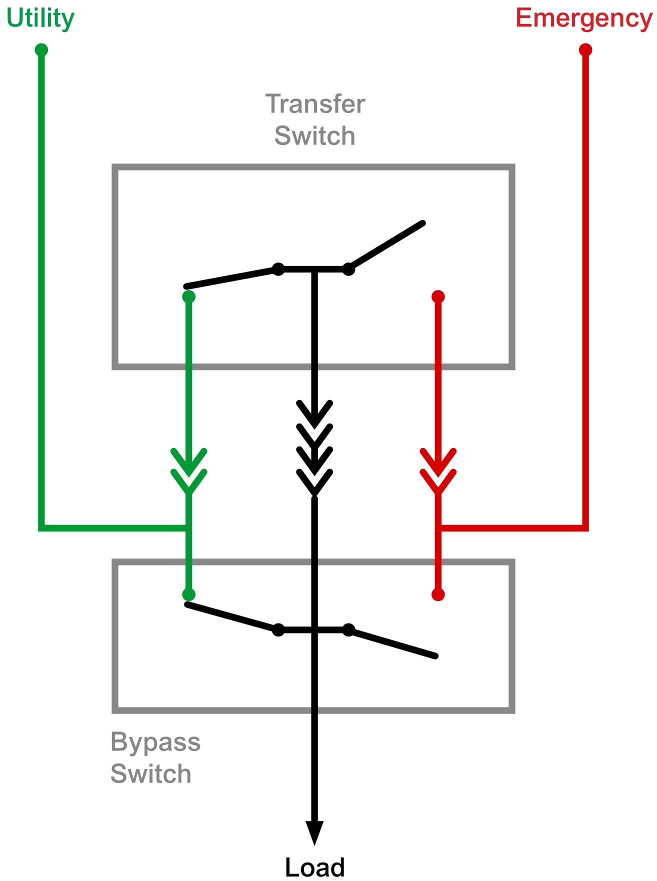


Figure 1: Bypass Isolation Transfer Switch Configuration

Figure 2: Many Bypass Isolation Transfer Switches offer draw-out capability for servicing the primary transfer switch mechanism.

Notably, Article 708.24(D) of the 2020 Edition of the *National Electrical Code*® (NEC®) requires the use of a bypass isolation automatic transfer switch when a facility with a Critical Operations Power System (COPS) is served by a single generator:

> *Bypass Isolation Automatic Transfer Switches.*
>
> *Where loads are supplied by only one automatic transfer switch, the automatic transfer switch shall include a bypass isolation switch to facilitate maintenance as required in 708.6(C) without jeopardizing continuity of power. When the bypass isolation transfer switch is in the bypass mode, either it shall automatically initiate transfer between power sources upon loss of the connected power source or it shall remain actively supervised by a qualified person who can manually initiate a transfer between power sources.*[1]

[1] National Fire Protection Agency. National Electrical Code®. 2020 Edition. Article 708.24(D). https://link.nfpa.org/publications/70/2020/chapters/7/articles/700, accessed April 30, 2021.

MAINTAINING GENERATORS

Like other equipment, engine-generator sets require scheduled inspection and maintenance in accordance with manufacturer recommendations and prevailing codes. Whether this presents particular challenges depends on the configuration of the backup power system. Where there is sufficient generator capacity and redundancy, a facility may be able to carry its emergency load without one of its multiple gensets. Consequently, a service event may have little direct impact if one unit is taken offline for maintenance. But what about facilities with only one generator? Any service event will leave the facility without backup power if an outage occurs on the normal source, typically an electric utility feed.

Regulatory Requirements

For this reason, recent editions of the National Electrical Code® (NEC) have added requirements for this type of situation. For Emergency Systems, Article 700.3(F) of the 2020 NEC requires a means of connection for a temporary generator to ensure that backup power will be available if needed:

> *Temporary Source of Power for Maintenance or Repair of the Alternate Source of Power.*
>
> *If the emergency system relies on a single alternate source of power, which will be disabled for maintenance or repair, the emergency system shall include permanent switching means to connect a portable or temporary alternate source of power, which shall be available for the duration of the maintenance or repair.*[2]

Because they provide a critical public service, facilities with COPS must also provide a connecting means for the same situation.[3] Article 708.20(F)(6) states:

> *Means for Connecting Portable or Vehicle-Mounted Generator.*
>
> *Where the COPS is supplied by a single generator, a means to connect a portable or vehicle-mounted generator shall be provided.*[4]

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[2] Ibid. Article 700.3(F). https://link.nfpa.org/publications/70/2020/chapters/7/articles/700, accessed April 29, 2021.

[3] Critical Operations Power Systems serve facilities whose operations meet a critical public need, such an emergency services, national security, or economic infrastructure.

[4] Ibid. Article 708.20(F)(6). https://link.nfpa.org/publications/70/2020/chapters/7/articles/708#ID000700009001, accessed April 29, 2021.

Figure 3: A quick-connect panel for connecting a temporary generator

The first part of a solution to these requirements is to include a quick connect panel in the design of a backup power system. This enables the connection of a temporary generator to the power distribution system whenever service is scheduled … and provides a supplemental backup solution if a sole generator should ever fail. Figure 3 shows a quick connect panel for connecting a temporary or portable generator. For more information about providing a permanent connection means for supplemental power in COPS facilities, review the ASCO Technical Brief entitled *Temporary Backup Power for Critical Operations Power Systems*.

The second part of the solution involves providing a means to select between a permanent generator and a temporary power source. With certain exceptions, a facility's power distribution system is served by only one power source at any time. As a result, a transfer switch is needed to connect either the facility's permanent generator or the quick connection panel and supplemental generator to the backup power system. Manual transfer switches are well-suited for this application. Using this arrangement, a facility can connect a supplemental generator and set the manual transfer switch to connect it to the backup power distribution system. This isolates a facility's permanent genset to make it available for maintenance and avoids leaving the facility without a source of backup power. A facility can be fitted with a manual transfer switch and a separate connection, or a manual transfer switch with integral quick connects. Figure 4 shows an example.

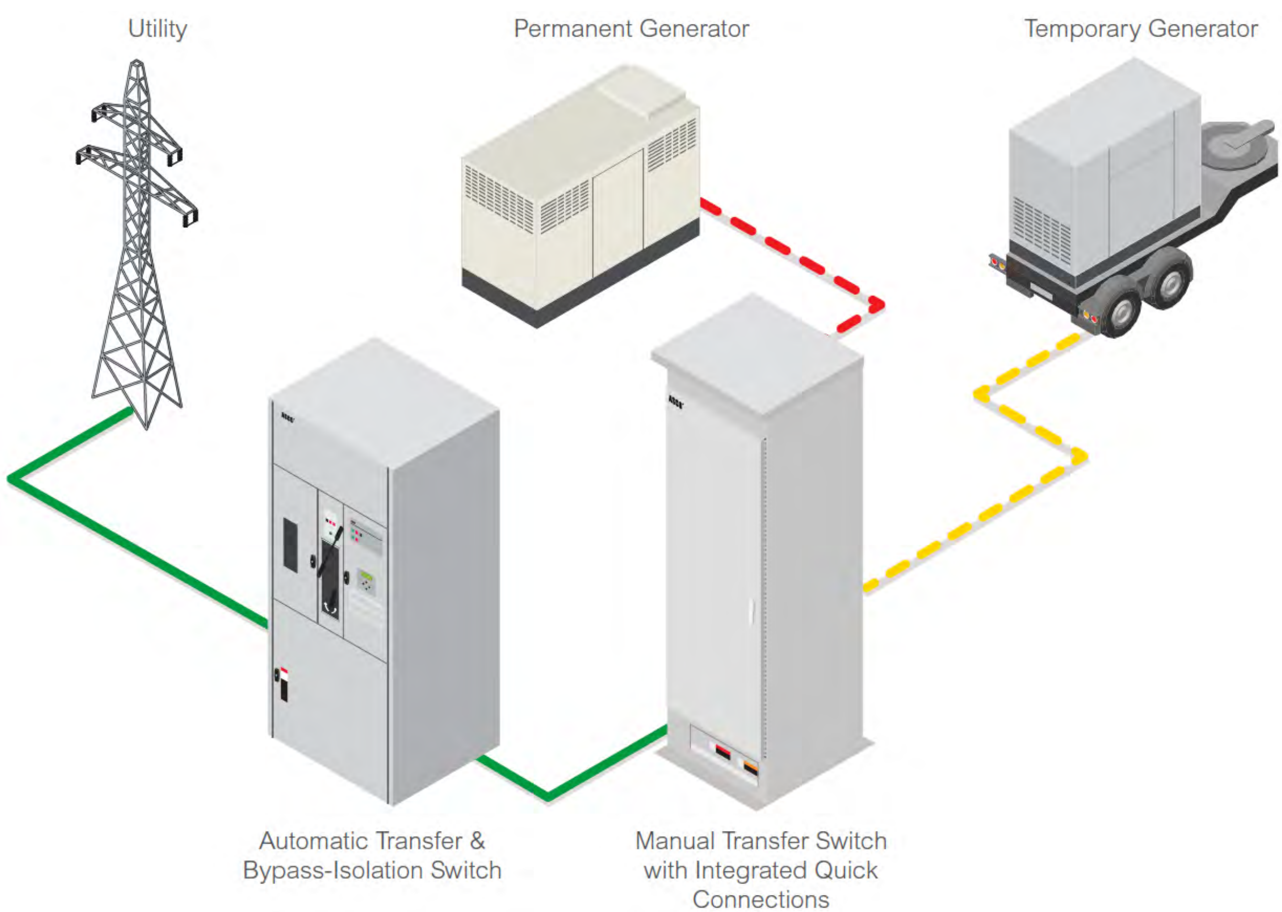

Figure 4: A solution for connecting a temporary generator to a backup power system.

Additional Considerations

The cited NEC requirements make clear that a regulated facility with a single permanent generator must provide a connecting means for a temporary unit so that it will not be without a source of standby or emergency power. But facilities with two or more gensets could find themselves in the same predicament if they cannot supply their entire emergency load without one of their generators. For example, a facility with emergency loads equaling 300 kW might be served by two 200 kW generators. In this instance, taking either genset offline will result in undersupply if backup power is needed during a maintenance event. Some facilities may find that emergency loads have grown since the electrical system was originally designed. Adding a connecting means to these systems can allow the facility to take one unit offline for service and still comply with codes.

Second, adding a temporary connecting means enables a facility to selectively increase power redundancy when needed. For instance, a facility may elect to provide an additional genset when foreseeable operating challenges arise that could heighten the chance that backup power will be needed. One example would be a predicted storm or other natural event that could impact the availability of utility power. Another could be the occurrence of intentional outages, such as multi-day outages occurring in California to mitigate wildfire risks. For more information about this topic, review the ASCO document entitled ***California Power Outages***.

INCREASING MAINTAINABILITY USING PARALLELING SWITCHGEAR

Adding a generator(s) to a backup power system can increase maintainability. To power 400kW of emergency load, a facility might install two 500 kW gensets. Either unit could handle the entire load. In another example, 900 kW of backup power can be supplied by two 500 kW gensets; installing a third unit provides the required capacity during a generator maintenance service event. These “n+1” configurations mean that one extra generator would always be available to replace an offline unit. For more information on strategies for redundant backup power devices and systems, review the ASCO Power Technologies document entitled ***Power Redundancy Schemes for Data Centers***.

Multi-generator systems such as these typically utilize paralleling switchgear to connect multiple power sources and loads to electrical bus. Tie circuit breakers allow power to flow in either direction between bus segments. A simple segmented bus arrangement is shown in Figure 5.

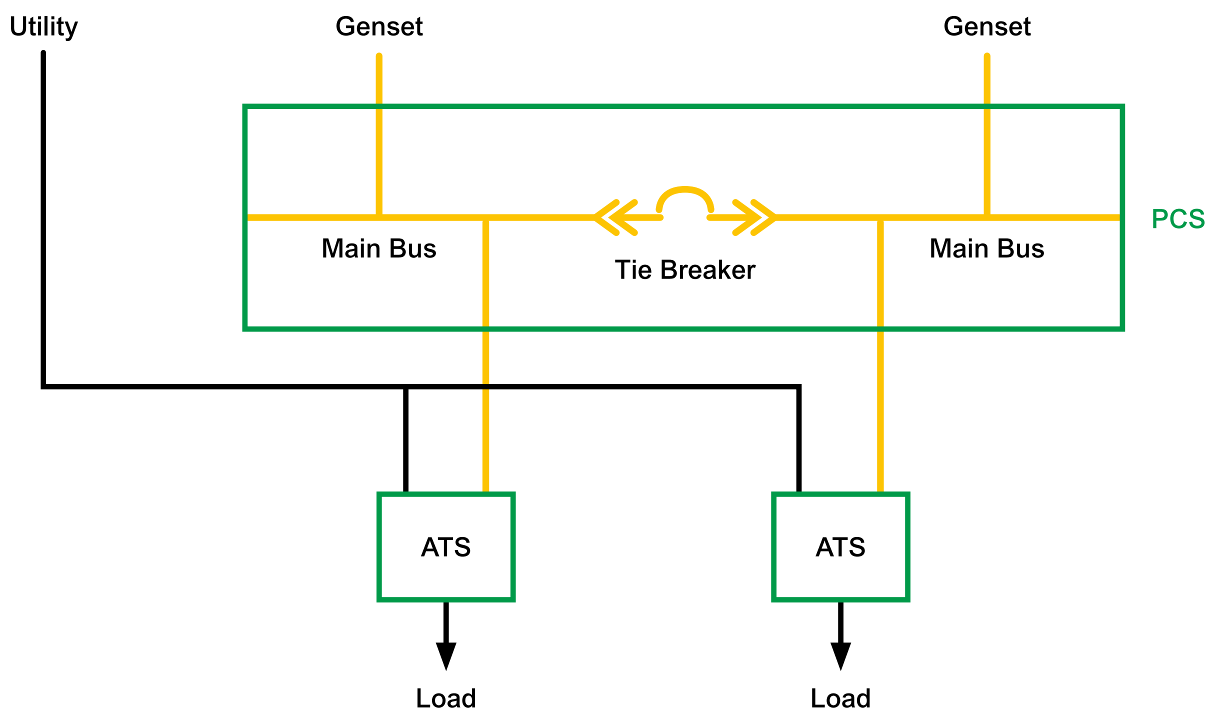

Figure 5: Simple segmented bus with tie breaker

Figure 6 below illustrates a split bus arrangement that can connect a utility feed, another from on-site renewable power sources, and four generators to a power distribution system. This arrangement offers source flexibility, where closing the breaker enables generators from one side to feed loads on both bus segments. Coincidentally, this arrangement can bring backup power to the most critical loads faster than an equivalent single bus system because the first generator on each side to produce acceptable power can be immediately connected to the loads of highest priority.

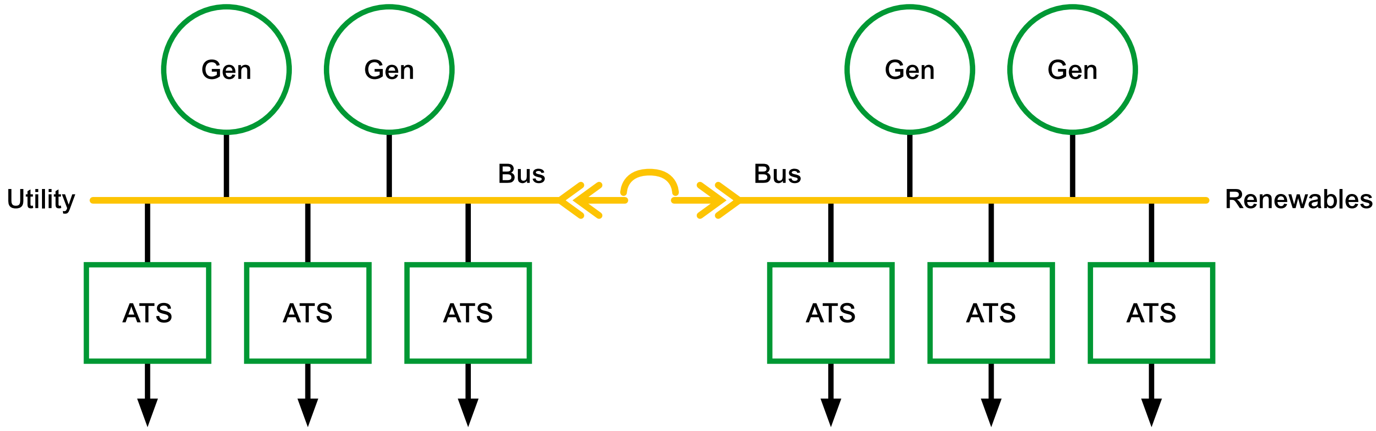

Figure 6: A more complex split bus arrangement

Figure 7 shows a ring bus system. If a bus or tie breaker fails, this system can still carry power from any remaining source to any remaining load.

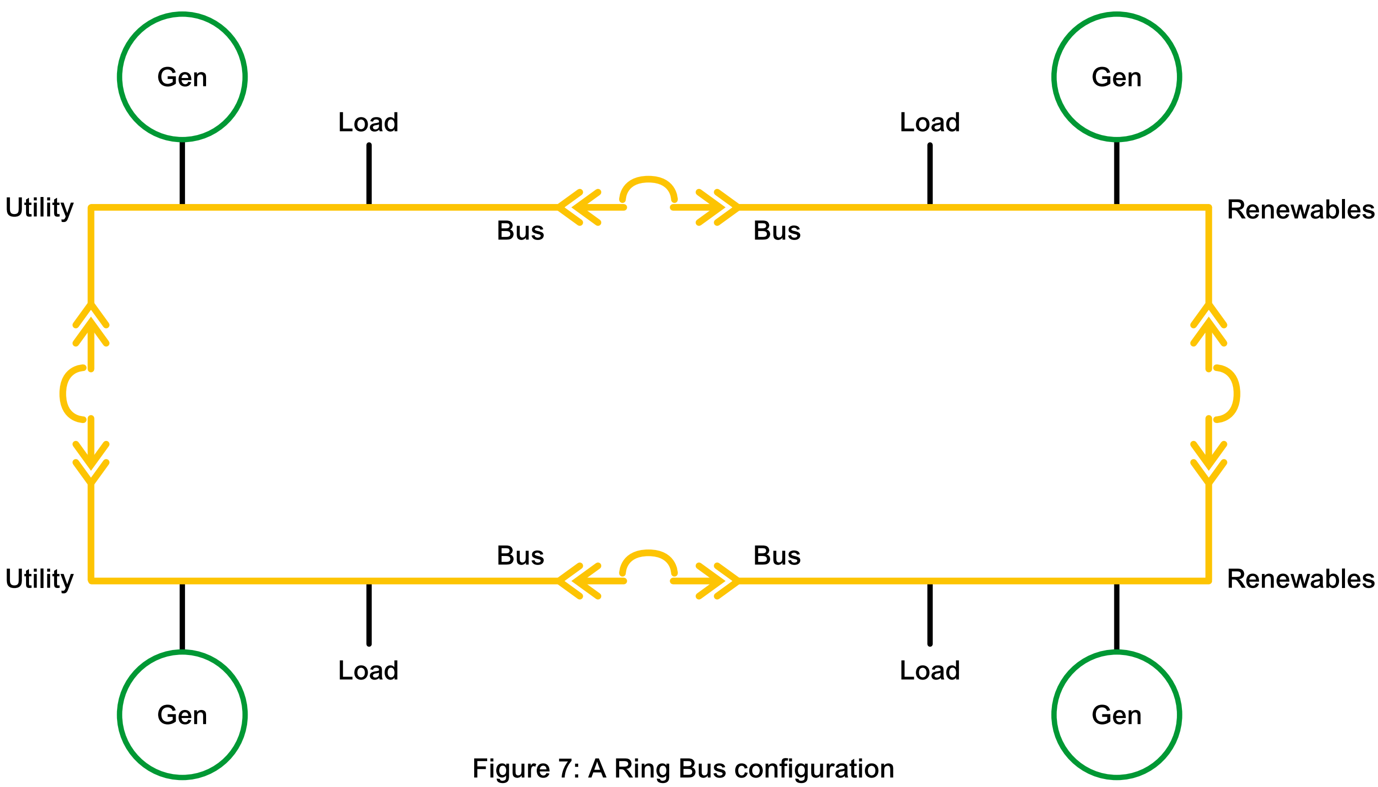

Figure 7: A Ring Bus configuration

Power Control Systems such as these provide high levels of availability, and can be used to supply power to all necessary loads while a generator is offline. These systems are controlled by Programmable Logic Controllers (PLCs), which can require occasional maintenance in the form of software installs to update control sequences, security provisions, and other features.

Paralleling switchgear systems can be fitted with redundant PLCs and Input/Output pathways. Typically installed to provide power system control if a PLC or pathway should become unavailable, redundant control systems nevertheless enable control devices in paralleling switchgear to be taken offline for upgrades or troubleshooting, without interrupting backup power system control. Various levels of PLC and I/O redundancy are available. Figure 8 shows an example of a PCS control system with redundant PLCs and I/O pathways. For more information, review the ASCO document entitled *Redundant Control and Communication for Power Control Systems*.

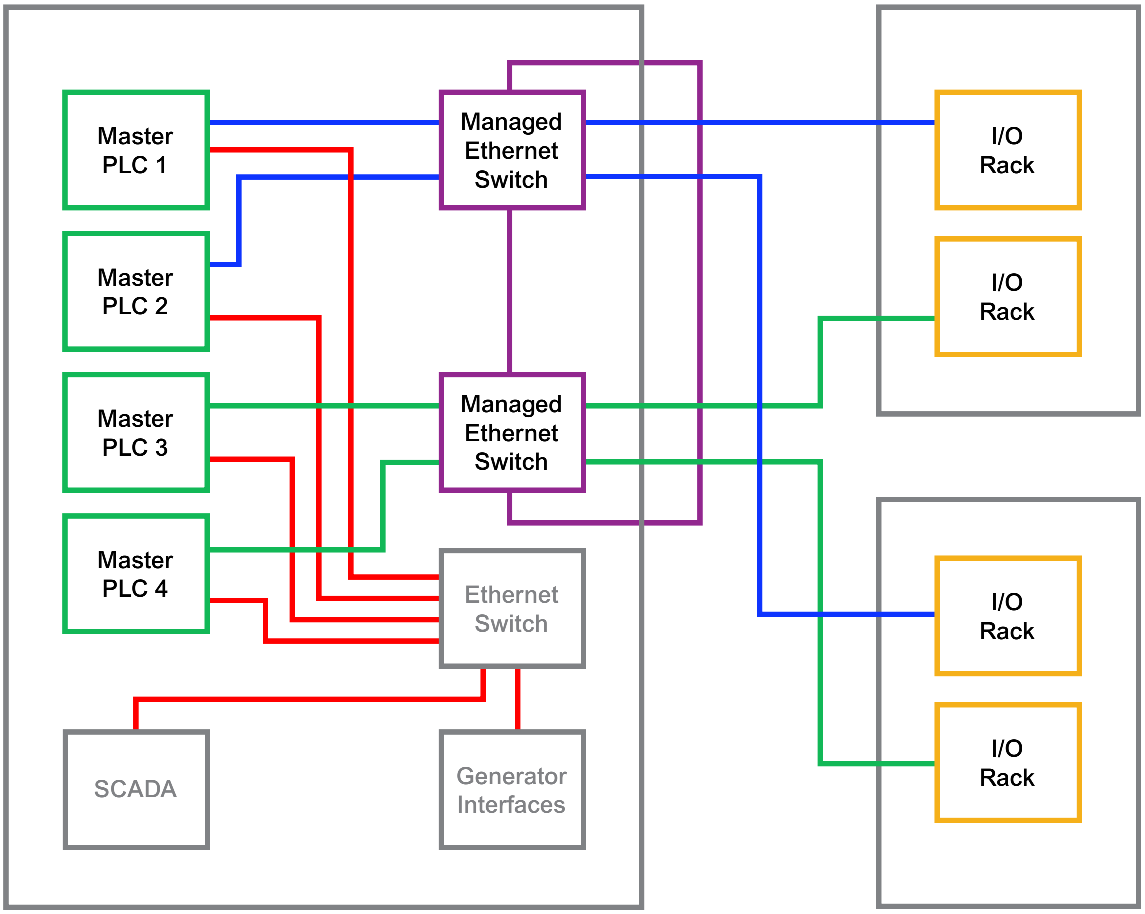

Figure 8. A paralleling switchgear control system with redundant PLCs and redundant I/O pathways.

SUMMARY

Emergency and standby power systems require periodic evaluation and service to provide the highest levels of reliability, and to comply with codes and standards. Because skipping maintenance and testing can result in a power outage if backup systems fail, it is important to streamline maintenance to maximize readiness for use during outages of normal power.

Devices requiring maintenance include engine-generators, transfer switches, and, in multi-generator systems, paralleling switchgear. A common way to promote the inspection and service of transfer devices is to utilize bypass isolation automatic transfer switches that allow current to be routed through a secondary transfer mechanism. This enables the primary mechanism to be depowered, inspected, and serviced without disrupting power to loads. Adding a connecting means such as a quick connect panel enables connection of a temporary generator that can be relied on while a permanent generator is serviced. This also requires the use of a permanent switching means for connecting the backup power distribution system to either the facility's permanent generator or a temporary unit. This arrangement is required when regulated facilities have only a single generator. Connection panels for this purpose are available as stand-alone units or integrated into manual transfer switches.

For paralleling switchgear and power control systems, maintainability is enhanced by enabling a system's multiple power sources to connect with any of its loads. With "n+1" or more generators, a backup power system can carry the emergency load when one generator is offline for maintenance. Adding segmented bus using tie circuit breakers adds source flexibility, and ring bus configurations allow the connection of any remaining source to any remaining load when a generator, tie breaker, or bus segment is unavailable. Redundant switchgear controllers and I/O circuits provide continued control if one element of the power control system is taken offline for upgrade or troubleshooting.

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