



TECHNICAL PERSPECTIVE

Generator Paralleling

INTRODUCTION

Parallel standby power solutions have always offered significant advantages, but implementation has been limited to mission critical applications and large kilowatt projects. This is largely because of panel board constraints including cost, space, issues of single-source responsibility and a high level of complexity. To achieve the benefits of parallel generation without all of those limitations, Generac Power Systems offers a truly integrated solution with its Modular Power System (MPS) product line.

Benefits of Paralleled Generation

Some of the benefits of placing multiple generators in parallel include increased reliability, expandability, flexibility, serviceability and cost effectiveness.

Reliability

The redundancy inherent in parallel power generation provides significantly greater reliability for critical loads. For example, if the reliability of a standby generator is defined at 98%, an N+1 configuration has a reliability of 99.96% and an N+2 configuration has a reliability of 99.999%. In a parallel configuration, if one generator fails, the most critical loads are redistributed among the other units in the system. Given typical applications and load factors, the load requiring the highest degree of reliability is often only a fraction of the total generation capacity. Redundancy is achieved without the addition of costly under-utilized generators.

Expandability

When sizing generators, it is often difficult to adequately plan for anticipated load growth. If load projections are too aggressive, initial capital expenditures may be higher than necessary. If load projections are too low, the facility may be left without reliable standby power or may require expensive generator upgrades. Generac's integrated approach allows generators to be added as needed.

KEY POINTS

- Parallel power solutions offer superior benefits compared to single generator configurations.
- Traditional paralleling solutions have limited application due to cost and complexity.
- Complexity in traditional systems results from the use of four to six micro-controllers per generator.
- An integrated approach to generator paralleling can be as simple, and often more cost effective, than single generator configurations.
- Generac offers integrated paralleling solutions in diesel, natural gas, and bi-fuel configurations.



Figure 1

Flexibility

Utilizing multiple smaller generators instead of a single large unit offers greater location flexibility. The ability to distribute weight over a wider area makes rooftop installations more feasible. A lower profile makes installation in parking garages and other restricted areas possible. Generac's MPS units do not have to be grouped together, so it's possible to take advantage of multiple smaller spaces.

Serviceability

With multiple generators available, individual units can be taken out of service for repair or maintenance without losing standby power for critical circuits. This feature enhances reliability and reduces the need to bring a backup rental generator to the site. Though failures of standby generators are not common, the built-in redundancy of a parallel system provides multiple layers of protection for critical circuits.

High Quality & Cost Effectiveness

The engines used in smaller generators are usually high-volume, over-the-road truck or industrial engines. These high quality engines are very reliable due to the level of tooling and automation utilized in their manufacture. Advanced manufacturing technology, along with market pressures and economies of scale allow these engines to provide the lowest cost per kW in the industry.

Limitations of Traditional Paralleling

Cost

Most parallel power generation is accomplished with equipment from third party vendors that integrate UL 891 dead front panel boards into generator paralleling switchgear. To parallel two generators typically requires one section for each generator and a master control section. The cost can be between \$70,000 and \$90,000, and that's only a fraction of total project cost.

Space

The paralleling panel boards need dedicated floor space inside the building. Each section will typically be 36" wide by 48" deep and 90" tall. A minimum of 3' in front and 3' behind the switchgear cabinets will also be required.

Integration Issues

The installation process normally takes two weeks and an additional two weeks is typically needed for startup and commissioning. This process requires the generator and switchgear technicians to be on-site and rarely goes smoothly.

Traditional Paralleling Control Complexity

The control system in a traditional paralleling solution is extremely complex. Each generator in the system will normally require four to six micro-controllers. These controllers are a combination of analog and digital technology from various manufacturers that are hardwired together. A typical two-generator system will have between nine and fourteen controllers (including the master control section) to manage the speed governor, load-share controller, synchronizer, voltage regulator, genset controller, and protective relay.

Speed Control

Each generator in the system incorporates an electronic governor. The governor controls engine speed and, as a result, generator frequency in what is called isochronous speed control. This works fine for a single engine generator. However, when multiple generators are paralleled, the engine speed is locked into the speed of the other generators in the system. This creates a problem. An engine with a slightly lower speed set point will close its fuel setting and reverse power. Generators do not inherently share load.

Load Balancing

Each generator incorporates a load-share controller that constantly adjusts the governor's speed reference for its engine. This system balances load between the generators but from a control loop standpoint, it is inherently unstable. Think of it as trying to balance a marble on the outside of a bowl by tipping the bowl left and right.

Synchronizing

The third controller is an auto synchronizer. This controller matches the sine wave of the generator with the sine wave of the generator bus and issues the command to close the breaker tying them together.

Voltage Regulation

The fourth controller normally controls alternator voltage for a single generator. However, when multiple alternators are paralleled, the voltage is locked into the voltage of the other units in the system. Again, this can present a problem. An alternator with a slightly higher voltage set point will integrate its excitation setting open until it is carrying the entire system's kVAR load. Generators don't inherently share kVAR, so the regulators are interconnected in a system called reactive cross current. This system adjusts the voltage regulator references using inputs from current transformers that are all connected in series. The weakness of this traditional approach is that it requires everything to work perfectly. Unfortunately, reactive cross current systems tend to be sensitive to electrical noise.

Genset Control Protection

The fifth and sixth controllers are typically the genset controller and a protective relay. The genset controller monitors various engine and alternator parameters and provides alarming per NFPA 110 requirements. The protective relay typically performs sync check, voltage and frequency, and reverse power functions.

System Master Control

To coordinate the operation of all of these controllers and provide a consolidated point of communication and control, a PLC is used as the system master control. This implementation requires significant wiring (typically 30 to 40 wires per generator) and custom-designed software. The end result is a system that is difficult to install, difficult to commission, and difficult to repair.

Manual Control

To enhance the reliability of traditional parallel systems, the panel boards are often wired with a manual operation mode for when things go wrong. In manual mode, the load share lines and cross current lines are opened and the control loops are typically placed in an inherently more stable control mode (droop). It should be noted that even in manual control mode, any given generator still requires four mission critical controllers to function: governor, regulator, genset controller, and protective relay.

The Integrated Approach to Paralleling

Integrated Digital Control

Generac's integrated approach to paralleling starts with utilizing one digital controller per generator to control all functions: speed governing, voltage regulation, genset alarm and monitoring, synchronizing, load sharing, and protection. No more hardwiring multiple controllers together. No more difficult calibration processes. No more inherently unstable control loops. No more pulling I/O points back to the master PLC just to secure basic supervisory monitoring capabilities.

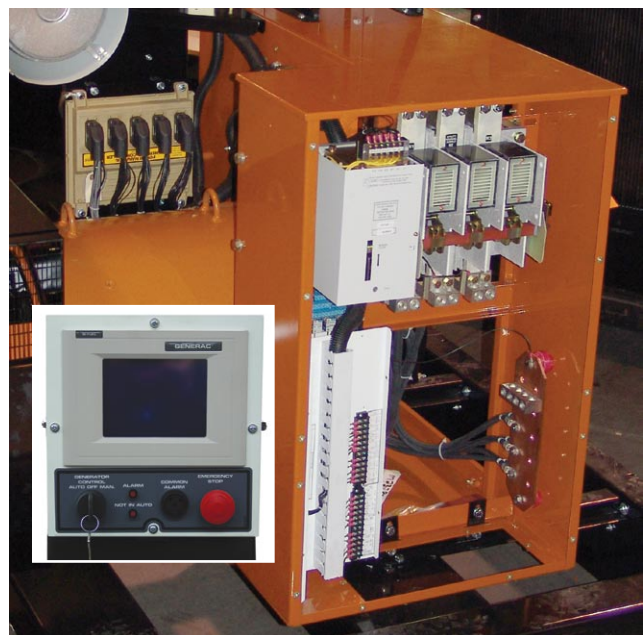
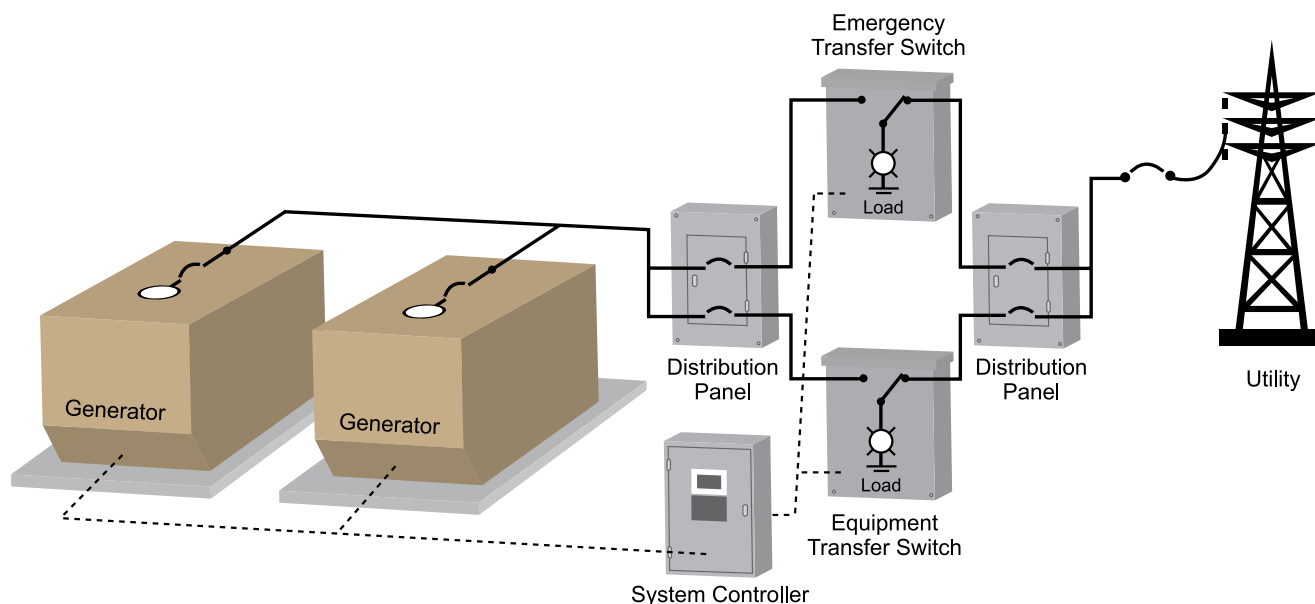


Figure 2

Using one digital controller per generator significantly enhances system performance and reliability. Inherently unstable load sharing methods are replaced with stable control loops. Synchronizing processes are greatly enhanced. Troubleshooting becomes a simple process of monitoring inputs and outputs using a laptop computer. Repairs that took hours or days are reduced to minutes by keeping a spare controller on site. The simple plug and play design makes replacing the controller fast and easy (Figure 2).



Integrated Paralleling Switch

Generac's MPS design also eliminates the cost and space requirements of external panel boards by integrating the paralleling switch function into the generator connection box. In a traditional system, the paralleling switch is a motor operated breaker located in a large metal cabinet, and connected to a bus bar. In the Generac system, it is a high cycle rated contactor specifically designed for switching power circuits. The paralleling switch is mounted and wired directly to the generator, then cabled to a common point — typically a generator distribution panel (Figure 3).

Integrated Master Control

The Generac design also uses an integrated system controller for coordination of starting and stopping the generators, priority loading, load-shedding and data collection for supervisory control by building management systems. Virtually all communication to the system controller is digital versus the hardwiring required in many traditional systems. In addition,

the Generac system controller does not have to perform relay logic to sequence multiple generator controllers. The end result is a design consisting of fewer components that is easy to install, easy to commission, and easy to repair.

CONCLUSION

By designing its Modular Power System gensets specifically for parallel applications, Generac has resolved the cost, complexity and single-source issues that have kept users from reaping the benefits of parallel power generation. Generac's use of advanced digital controller technology in each generator eliminates large, expensive switchgear and simplifies installation, commissioning and service while improving system communication and reliability.

With Generac MPS, all of the benefits of parallel generation are available at a price that can be significantly lower than a large, single engine genset.

DEALER INFORMATION

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