

# Digital control technology enhances power system reliability and performance

## > White paper

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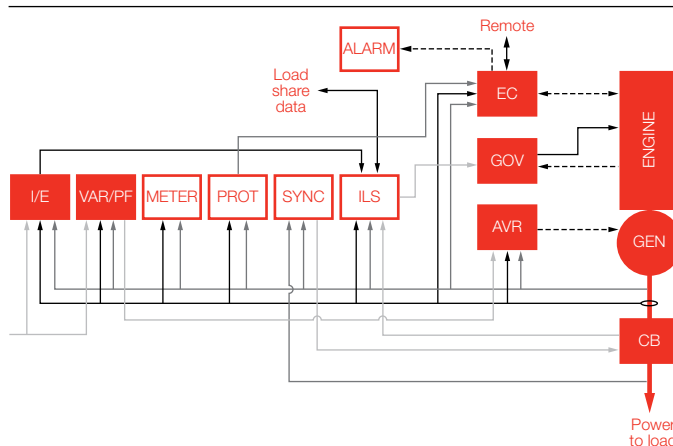
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Traditionally on-site power systems depended on analog control systems to provide reliable service to a facility's electrical loads. Today, reliable, flexible and user-friendly digital control technology is available for every on-site power system. For traditional standby power systems that power only emergency lighting for a small building analog controls may still be adequate. However with larger on-site and standby power systems, critical 24/7 power needs, more complex power distribution systems, and a mix of linear and non-linear loads digital controls provide greater performance capabilities.

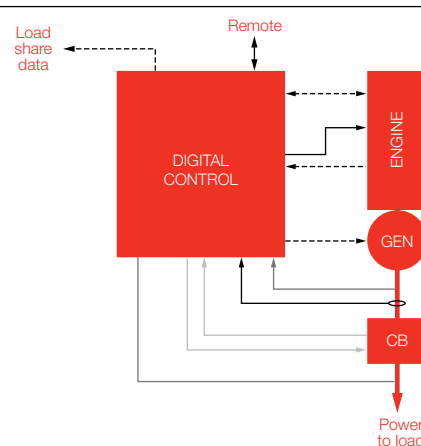
## Analog vs. digital: What's the difference?

Analog devices in power system control are discrete components (resistors, switches, capacitors, coils and relays) that coordinate input and output signals, and perform rudimentary logic for specific control functions. Adjustments to the system usually involve a physical adjustment such as increasing or decreasing the resistance of a variable resistor or substituting modules. Analog control hardware communicates system status and fault conditions with indicator lights, analog meters or alarms.

In modern generating systems, there may be more than 200 typical alarm conditions having to do with the load, the utility, other paralleled generators, the engine or the alternator. As the number of potential status or alarm conditions has grown, analog control systems have not been able to communicate this information to operators effectively.



**FIGURE 1** – This illustrates the various analog components required in a utility paralleling application. Note the number of separate components, wires and connections—all which detract from reliability.



**FIGURE 2** – In a digital environment, all engine, generator and load control functions are combined in a small digital central control unit. Reliability is enhanced because interconnections have been reduced.

A digital control system uses a microprocessor to control input, output and logic functions. System status can be graphically displayed on a computer, and operational adjustments are made through inputs on a keyboard or touch-screen. Changes can be made on the computer screen attached to the power system's master control, or even on a remote computer connected via a local area network or the Internet. Digital systems allow a high degree of control function integration, so one digital control can do the job of several analog controls.

### Reliability

Many power system end-users have learned to depend on their analog control systems, feeling that they understand exactly how they work and how to fix them when they fail to work. If users don't have experience with digital generator sets, transfer switches, or paralleling controls, they may be reluctant to make the change from analog.

This attitude is ironic, since the decision to stay with analog controls actually makes the system less reliable and burdens a facility with controls that are, for all practical purposes, obsolete when they are installed.

Digital generator controls are demonstrably more reliable. For example, digital controls used in the PowerCommand® master control systems for generator sets from Cummins Power Generation, have demonstrated a reliability of 300,000+ hours MTBF (Mean Time Between Failures). Few discrete components in an analog control system can approach that kind of reliability. What's more, in an analog system, all system components need to function properly for the system to operate at all. In contrast, digital systems have built-in

redundancy that significantly improves reliability by allowing the system to function properly even with a component failure in one portion of the control circuit. Reliability is also enhanced because the physical electrical interconnections between logic functions have been eliminated with solid-state digital components.

On a more practical level, the number-one reason standby generators fail to start is due to dead starting batteries. Over 80% of all starting failures are from this cause. This shouldn't surprise anyone, because the same thing happens in our own cars. In order to test a battery, whether it is in your car, or on a generator set, a service technician needs to test the battery using a load bank. Basically, the load is applied, and output voltage is observed at the same time. If the voltage drops too low, too fast, the battery should be replaced. Digital power system controls have a function which detects a weak battery. With this function, battery voltage is monitored under load while the engine is cranking. If the battery voltage drops too far for too long, a weak battery alarm is sounded.

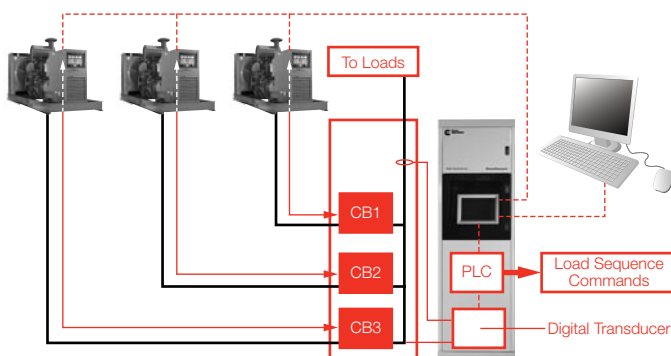
### System integration

One of the primary advantages of digital controls is their seamless integration of the functional components of power systems. For example, the status of all components and values in a complex power system can be viewed and controlled from a central or remote computer screen. In addition, electro-mechanical equipment (modern gas and diesel engines, alternators, transfer switches) can also be monitored and integrated into the control strategy.

This ability of digital systems to integrate diverse functions is especially important in modern emissions-controlled diesel engines. Integrating engine control functions (fuel rate and injection timing) with fluctuations in generator load is critical for minimizing exhaust emissions from diesel engines. In fully integrated digital systems as found on PowerCommand® generator sets, these functions are combined in the digital master controller and not isolated in a separate engine governor. The result is better engine performance under varying loads, reduced exhaust emissions, and more stable output frequency and voltage.

The ability of a digital control system to perform logic functions is also crucial in reducing exhaust emissions while starting the generator set. In most generator sets, the engine speed control system does not "know" that the generator set is in a starting mode. Consequently, the control has a tendency to over-fuel the engine during startup, resulting in a cloud of black smoke from

#### Digital System Architecture



**FIGURE 3** – Digital paralleling control systems only require one digital master controller, regardless of the number of paralleled generator sets. This reduces the “footprint” of the control modules in addition to centralizing information and control into one input / output device.

Digital Control Technology is featured in PowerCommand® power systems from Cummins Power Generation. Unlike other manufacturers', Cummins microprocessor-based generator set controls are designed as a single system, not components of a larger system. This single integrated control system can directly operate the engine fuel system,

directly control the alternator excitation system and provide other control functions that increase reliability. Digital controls are part of PowerCommand power systems — combining generator, transfer and controls technologies into the only pre-integrated system designed by one manufacturer.

the exhaust. This occurs because as power is applied to the governor control, it senses that the engine is a long way from proper speed, so it applies the highest possible fuel rate in order to quickly get the engine to proper speed.

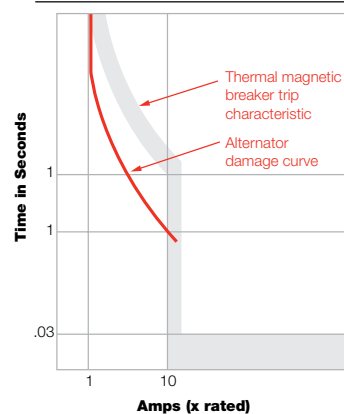
With a digitally based system, the control “knows” that the engine is in a starting mode, so it does not immediately try to accelerate the engine to rated speed. Instead, when the engine starts cranking, it checks for engine rotation, and then provides enough fuel to accelerate the engine gradually to rated speed. This practically eliminates black smoke upon starting. Finally, since a digital control “knows” what the engine temperature is, it can adjust the governor settings based on temperature, making the engine more stable on starting and more responsive as it warms up.

### Reduced space requirements

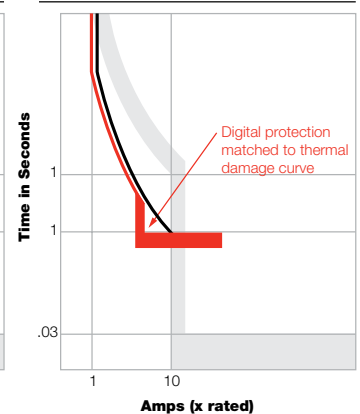
The move to solid-state electronics and digital technology is not only more effective from a performance and reliability point of view, it is highly beneficial from a space-saving point of view. Depending on the application, digital power system controls can save from 25 percent to 40 percent in valuable mechanical room floor space. Digital controls are also more environmentally rugged than analog, allowing many control systems to be located with the generator set rather than being isolated in a separate dust- and vibration-free room. The result is that digital systems occupy less floor space and require less environmental protection. These factors also help simplify installation, commissioning, and reduce maintenance and repair.

### Digital systems provide superior protection

Analog devices, such as circuit breakers, provide protection for simple power systems by sensing overloads and opening to protect wiring and, in general, the generator set. However, analog circuit breakers



**FIGURE 4** – When an overload occurs, conventional thermal magnetic circuit breakers cannot respond to the alternator thermal damage curve. They can only trip when a certain maximum current flow has been exceeded. This results in excessive heat buildup in the alternator during overloads.



**FIGURE 5** – Digital sensing and protection is matched to the damage curve and trips the system before excessive heat can build. Although solid-state breakers can be adjusted to closely match an alternator damage curve, some regions of operation may still exceed the capability. A PowerCommand digital control uses a trip characteristic that approximates the damage curve, providing a complete range of protection.

### About the author



Jim Iverson is a senior applications engineer for Cummins Power Generation, with an M.S. in Engineering Science, and a B.S. in Electrical Engineering. Since 1976, he has managed Transfer Switch Design, Systems Engineering, Switchgear &

Controls, and Technical Marketing & Sales. Jim provides technical direction to Commercial Marketing & Sales, contributes to domestic industry codes and standards development, offers sales and service training, offers technical input for published literature and software, publishes technical papers on industry topics, and provides application engineering support to customers.

do not do a good job of protecting the alternator as required by electrical codes. Excessive current in the alternator (due to even brief overloads) creates heat, which shortens insulation life and can lead to alternator failure. Molded case circuit breakers (MCCB) offer little protection against alternator overloads and heat buildup (see FIGURES 4 and 5).

### In the event of a power failure

While today's power grid is actually more reliable than it has ever been, the cost to end-users of a power failure has steadily increased, making any power failure of any duration unacceptable. If the reliability of the standby power system is compromised because of obsolete analog technology, then the financial risk of a power outage goes up. However, digitally controlled power systems reduce an end-users' financial risk by improving reliability.

### Easy access to information

Just as digital computers have exponentially increased our access to information, digital control systems have increased our access to real-time and historical power system operating information. Once information is inserted into a microprocessor-based control system, there are numerous options for making that information available in many parts of the facility—or even remotely. Building Automation Systems, communication systems, security, and safety systems can all make use of the

information from the power system's digital control system. The availability of information makes it easier to manage a facility efficiently and economically.

Unlike analog systems, digital control systems provide real-time status of all major components within the system. Engine oil and coolant levels and temperatures; battery charge status; fuel levels; and the status of every transfer switch in the power distribution system—are all available on a computer screen on the digital master control in the control room, or even on a secure remote terminal connected via the Internet. With analog systems, for example, the status of transfer switches can only be known by individual physical inspection of each switch—an antiquated approach that involves more labor and time and increases costs.

### Conclusions

Digital controls for power systems offer significant advantages over traditional analog control systems. These advantages include higher system reliability, lower system life-cycle costs, smaller size, greater operational flexibility, longer equipment life, real-time and historical operating information, easier maintenance, easy system changes through software, remote monitoring and control, and better emissions control.

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