

Industry first SAE J1939 controlled mobile hydraulic AC power generator systems

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ABSTRACT

Smart Power Systems improves mobile power generation by providing electronic control integration into SAE J1939 vehicle multiplexing systems, adding onboard diagnostics with event recording. Electronic control enables precise frequency output by controlling fluid flow through a hydraulic motor, ensuring a constant frequency output. Automated control features protect the system from conditions outside its designed operating parameters that may cause damage. The electronic controlled Multiplexing Interface Module communicates operation parameters in SAE J1939 approved format for integration with vehicle multiplexing. This paper describes the design and features of electronic controlled hydraulic generators, and how the use of SAE J1939 has expanded the functionality of the system while making operation simpler for the user.

INTRODUCTION

Hydraulic generator systems needs range from 5.5kW through 30kW continuous 120VAC/240VAC clean power outputs. Primary usage of these systems is on fire and rescue apparatus, to power perimeter and scene lighting, extrication tool pumps, smoke ejector fans, and various other equipment. Other applications for these systems include pipeline inspection trucks, welding/ service trucks, mobile communications

vehicles, marine, military and other mobile equipment.

Typically hot air recirculation (overheating) reduces generator output power making capability.

To solve the overheating problem, (See Figure 1) exclusive top mount generator design exhausts hot air straight up, eliminating hot air recirculation.



Figure 1: Smart Power® HR Series Top Mount Tray Assembly Tray

Each system includes an efficient hydraulic fluid cooling system to ensure the system temperature remains well below the operating limits of the components. A larger than required cooling system was added to operate in higher ambient temperature environments, while enhancing long-term reliability.

SAE J1939 control enables advanced features such as expanded control, diagnosis, and operator feedback.

Typically hydraulic systems rely on fluid flow (gpm) to maintain frequency and voltage. As hydraulic fluid changes temperature viscosity changes affecting flow rate, which affects voltage output.

In addition, as load (watts) is added to the generator the voltage increases. The hydraulic fluid flow is set to try to compensate but often falls short usually causing low voltage at full rated load. As ambient temperature increases greater losses in efficiency occur creating the following issues:

1. Low voltage
2. Overheating
3. Generator component damage

Improvements by adding electronic control in addition to multiplexing are described herein.

GOALS

Mobile power generation operates with a unique set of requirements including a very limited amount of space, widely varied environmental conditions, and generally a high demand for zero downtime, especially on applications such as the fire and rescue industry.

The goals of the electronic controlled design are:

1. Superior reliability through automated features
2. Low downtime through advanced diagnostics
3. Superior performance through high-technology control and hydraulic fluid cooling systems
4. Ease of use through multiplexing integration
5. Space savings through compact design
6. Reduced installation times

7. Exceed 120°F ambient temperature operation

CONTROL SYSTEM

Since early 2003, all electronic controlled generators have been equipped with a unique proprietary electronic control system that optimizes performance and prevents damage to the generator and vehicle equipment. This includes the addition of a multiplexing interface module, which converts all communication to SAE J1939 for integration to the vehicles centralized multiplexing system.

MULTIPLEXING INTERFACE MODULE

As the electrical complexity of vehicles increases and multiplexing systems become the standard method of wiring, SAE codes for mobile generator systems are developed as the electronic controlled system offered the first opportunity as they didn't exist prior.

Hardware

The electronic controlled Multiplexing Interface Module is a separate component in a NEMA 4 enclosure of the hydraulic generator system, capable of being remote mounted at a location convenient to the multiplexing bus wiring of the vehicle. Two connectors are provided, one providing power, ground and communications, and the other a standard J1939 stub connector. See Figure 2.



Figure 2: Multiplexing Interface Module

The interface module kit comes with a wiring harness 15' in length allowing for mounting anywhere within 15' of the generator tray assembly.

Broadcast Messages

After successfully claiming an address, the module will begin broadcasting its periodic messages. There are two periodic messages, each broadcast once per second. These are "Generator Output" and "Generator Status".

The Generator Output message provides voltage, frequency, current and operating temperature information about the generator. The Generator Status message provides information on whether the generator is running, could be started, the status of hydraulic pressure, the operating mode, number of active alarms, whether an active alarm will cause a shutdown, and the total operating time on the generator. All values are expressed using J1939 standard SLOTS (Scaling, Limit, Offset and Transfer function).

Capability

All information available through the generator's standard electronic control system is available through the J1939 interface. This includes voltage, frequency, current draw on lines 1 and 2, number of hours on generator, number of hours on filter, system temperature, model name, kW output size, system warnings for overheat, overload, cold fluid, low oil, service reminders, display calibration, alarms, shutdowns, overrides, and real-time troubleshooting steps.

Full diagnostics with event recording is also standard, and available through the multiplexing system. This enables the ability to view a record of the total operating history, including but not limited to, highest recorded voltage, highest recorded frequency, highest recorded current, highest recorded temperature, number of over temperature shutdowns, number of over temperature shutdown overrides, hours at over temperature, number of over current faults, hours run at over current, hours on filter, valve faults, fan faults, and temperature sensing faults.

STANDARD DISPLAY AND FEATURES

All systems are available without the multiplexing interface module for users who do not have or desire a fully multiplexed vehicle.

Command and Control Center

The user interface display is the Command and Control Center (CCC), which is included even with systems equipped with the multiplexing interface module. On fire and rescue apparatus, the National Fire Protection Association (NFPA) requires a display within sight of the distribution panel and the small size and low cost of the standard CCC make it a much more suitable display than adding another full multiplexing display at this location.

The CCC is ruggedized for the environment and features compact size, sealed, and 100% solid state design. Smart Touch® non-contact switching eliminates failures caused by water, mechanical damage and operational problems caused by bulky gloves. See Figure 3. Multiple displays can be connected to the system using a simple Y-splitter and additional wiring harness.



Figure 3: Standard Command and Control Center Display

Electronic Control Unit

The Electronic Control Unit, or ECU is located in the tray assembly, and is the brains of the system. The ECU not only optimizes performance to ensure cleaner frequency output, but also automates generator functions to prevent damage to the generator and vehicle equipment. This

protection starts from the second you press the “On” button, by slowly increasing the fluid flow to the hydraulic motor, then regulating it to maintain exactly 60Hz. This “soft-start” feature, as it is commonly referred to, eliminates shock to the generator components as well as the vehicle powertrain. The exact frequency regulation allows use of more sensitive equipment such as battery chargers, communication equipment and computers, without fear of damage.

Once the system is running, the ECU continuously monitors all aspects of the generator ensuring it is not run with excessively cold fluid temperatures, which can cause damaging electrical spikes, excessively hot fluid temperatures, which can cause pump and motor damage due to insufficient lubrication, or with too much load, which can cause damage to the electrical system and vehicle wiring. The system will also ensure the generator is not run with low fluid levels, or any other conditions that could lead to premature failure. Service reminders instruct the user when the hydraulic fluid filter needs replacement, and as the only service required, ensures preventative maintenance is not overlooked.

USER ADVANTAGES WITH J1939 MULTIPLEXING

While all of the features required for a highly reliable and fully functional generator system are provided with the standard generator package, many features are highlighted or added through the use of the multiplexing interface module.

Easy Operation

Whether using the standard CCC display or a vehicle multiplexing display, turning the generator on and off is a simple one-touch operation. Beyond that however, the additional buttons and display space of a multiplexing display such as Weldon’s V-MUX Vista III Interface Module/Display enable even easier operation and additional display capabilities that become difficult with the limitations of an LED readout.

As an example, accessing the diagnostics through the CCC requires a unique 5-step sequence using the 2 touch pad buttons. While not difficult, the multiplexing display can reduce that to a one-touch step. In addition, accessing the generators option menu requires the operator to hold the

mode button for ten seconds. Again, not a difficult task, but due to the additional buttons available on a multiplexing display, can be reduced to a one-touch step. See Figure 4 for an example of how the buttons can be laid out on a multiplexing display.



Figure 4: Generator Screen on Multiplexing Display

Graphical Interface

All generator operating information is available through the CCC display, but the full color screen of a multiplexing display adds additional capability which can provide the user with a full understanding of the current condition of the generator.

For example, if the generator’s load on line 1 is currently 41 amps, it will be displayed in the “AMPS LINE 1” block on the CCC. However, if the system is rated to 10,000 watts, the user may not realize that they only have 1 amp left before reaching full rated capacity. On the multiplexing display, that same 41 amp readout can be shown over a bar graph showing how much of the rated load was being used, and another readout specifically stating that the generator was currently operating at 98% of its full rated load. See Figure 4.

Plain English Messages

Again, while all information is provided through the CCC, it may not be as understandable to a user who is unfamiliar with the operation of the system. A hot oil condition will be displayed by the CCC as "OIL HOT 185°F". See Figure 5.



Figure 5: Command and Control Center Overtemperature Readout

That same warning displayed on a multiplexing display has the additional space to read, "WARNING - System Overtemperature", and even continues with real-time troubleshooting steps the user can take to remedy the problem. See Figure 6. This additional information can mean the difference between having electrical power, and not having electrical power, and in the fire-rescue industry, can mean life and death.



Figure 6: Generator Overtemperature Warning on Multiplexing Display

CONCLUSION

With the additional system enhancement provided by J1939, combined with solid-state electronic control, new benefits become possible, including:

- 1) Making the system extremely user friendly
- 2) Reducing the requirement for additional training
- 3) Significant increase in reliability
- 4) Reduction of vehicle down time
- 5) Complete diagnostics with real time troubleshooting
- 6) User selectable voltage and frequency control

The ease of operation and plain English display offered through the multiplexing system provides full access to information, overcoming the complications inherent in non-electronic controlled systems. As the fire/rescue industry looks for reductions in operation costs, training, and maintenance, and looks for reliability; multiplexed systems have the capability to reduce the annual costs.

REFERENCES

1. SAE J1939 – Recommended Practice for a Serial Control and Communications Vehicle Network
2. SAE J1939-75 - Application Layer - Generator Sets and Industrial
3. NFPA 1901 – Standard for Automotive Fire Apparatus