Understanding Load Bank Circuits

White Paper

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Load banks promote safe, reliable, and convenient operation and long service life. Knowing the layout and function of control, cooling, and load element circuits is important for understanding load bank operation, selecting load banks for an application, and maintaining load banks. The following sections describe these circuits.

Overview of Load Bank Operation

A load bank receives electricity from a power source, converts it to heat, then ejects this heat from the unit. By consuming power in this way, it places a corresponding load on the power source. To do so, load banks absorb a massive amount of current. A 1000 kW, 480V load bank will continuously absorb more than 1200 amps per phase and will produce 3.4 million British Thermal Units of heat per hour.

Load banks are typically used to (1) stress a power source for testing purposes, such as periodic testing of a generator; (2) affect the operation of the prime mover, such as providing minimum load to prevent the buildup of unburned exhaust residues in the diesel engines of gensets; and/or (3) adjust the power factor of an electrical circuit.

Load banks apply load by directing current through load elements that use resistance or other electrical effects to consume power. Regardless of purpose of operation, any developed heat must be removed from the load bank to avoid overheating. Heat removal is typically accomplished using an electrically powered blower, which ejects hot exhaust out of the load bank.

Essential Load Bank Circuits

Separate circuits are used to operate the load elements, the blower system, and the devices that control them. Figure 1 provides a simplified one-line diagram of the relationship of these circuits. Each is further described in the following sections.

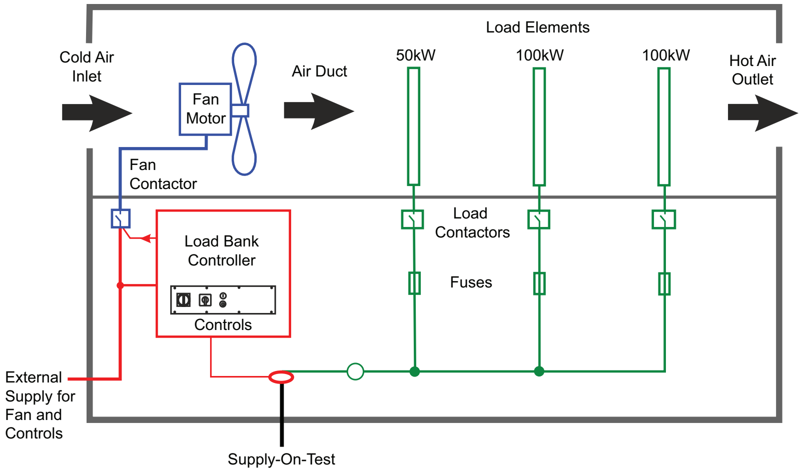

Figure 1: Load Bank One-Line Circuit Diagram

Control Circuit

Basic load bank controls include a master on-off switch as well as switches that control the cooling system and load elements. The load elements are often switched individually using dedicated switches; this enable operators to apply and vary load in a stepwise fashion. Load steps are defined by the capacity of the smallest load element. A load bank with one 50 kW load element and two 100 kW elements affords opportunity to select total loads of 50, 100, 150, 200, or 250 kW, with a resolution of 50 kW. Figure 2 shows a simplified load bank control circuit.

Notably, a load bank control circuit also provides power and signaling for one or more over-temperature sensors and air-fail safety devices. The former are designed to sense over-heating in the load bank, regardless of cause. The latter are switches that close only when they sense air flowing past the load elements; if a switch remains open, power cannot flow to one or more load elements, preventing an overheat condition.

The control circuit requires a single-phase voltage source, typically 120-Volt at 60 hertz or 220-Volt at 50 hertz. This power can be derived from the power source for the load elements using any necessary step-down transformer, or by supplying power from an external single-phase source. If the load bank is configured for dual-voltage operation, a switch will be provided in the control circuit for user to selecting the proper voltage mode.

Typical outdoor load bank with external control wiring housed in a conduit.

A fuse on the line side of the incoming power source protects the control circuit. When a control power on-off switch is closed, a control power indicator illuminates to show that power is present. After control power becomes available, an operator starts the cooling system using the blower start switch. After the blower provides proper airflow velocity, one or more internal differential air pressure switches detect airflow and close to place voltage on the load circuits. If proper airflow is not detected, the air switch will not close and an “air fail” indicator will illuminate.

A Master Load Switch is commonly provided to control the overall function of the specific load elements or element groups switches. This switch can be used to safely drop all applied load, or as a convenient means for providing full or “bulk” load to power source. Load Step Switches engage individual elements to provide the desired amount of load.

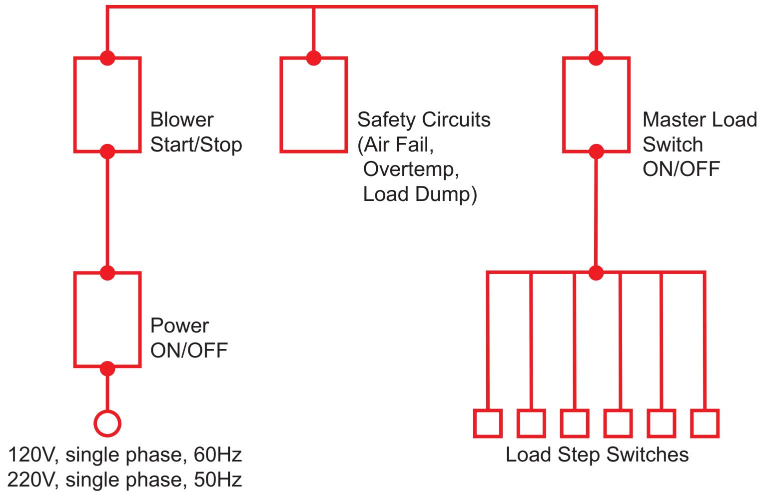

Figure 2: Example Load Bank Control Circuit

Digital metering is standard on many portable load banks, and power for meters is derived from the control circuit. The three-phase load voltage is measured directly on the main input bus. In applications served by digital control equipment, the measurements can be monitored, recorded, and subsequently evaluated.

If a load bank is designed for continuous outdoor use, one or more strip heaters are typically installed inside its enclosure to limit condensation and avoid freezing conditions. When heaters are present, an additional circuit is provided to power them. A temperature switch activates the circuit when temperature decreases below a minimum temperature set point, often 32°F.

Cooling Circuit

The cooling circuit provides the required components for proper cooling fan operation. These components include a motor starter contactor, three-phase fuse protection, and a device to protect from motor overload.

When an operator closes the Blower Start Switch, the motor starter contactor closes to send voltage to the motor. If phase conductors are correctly installed, the motor will turn in the proper direction, creating positive airflow and closing the air fail switch. Upon closure, the air fail switch completes the circuit, enabling load application. If the phase conductors are incorrectly installed, the motor will turn the opposite direction creating a negative air differential that keeps the air switch open. If air flow slows sufficiently or ceases during load bank operation, the air fail switch opens to remove load from the circuit-under-test.

Power for the cooling circuit can be derived from either an external source or internally from load bank bus bars. Some manufactures offer an optional control power transformer for the cooling circuit, which converts three-phase blower power to 120 VAC, single phase. This arrangement eliminates the need to provide dedicated cooling circuit power to permanently installed load banks.

Load Element Circuit

Load Element Circuits typically include an input power buss, branch circuit fuse, and individual contactors for the load elements that comprise each load step. The main voltage input is connected to bus bars or to quick-connect receptacles. Fuses for each load element group limit current damage from phase-to-phase short circuit currents. The control circuit sends current through the individual load circuits to the coil of their respective contactors. After the coils are energized, the contactor will close to load each circuit. Operators typically apply load in stepwise fashion.

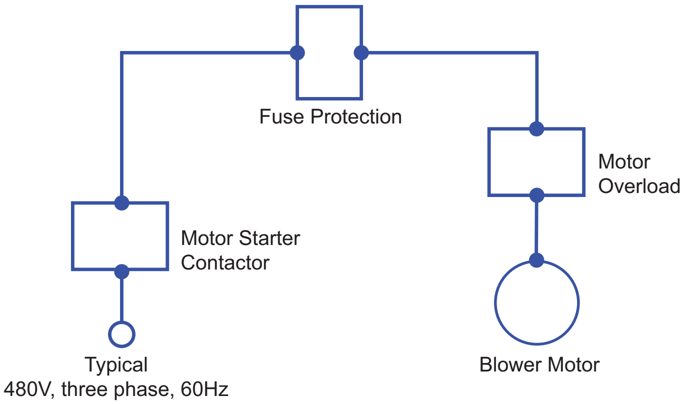

Figure 3: Example Cooling Circuit

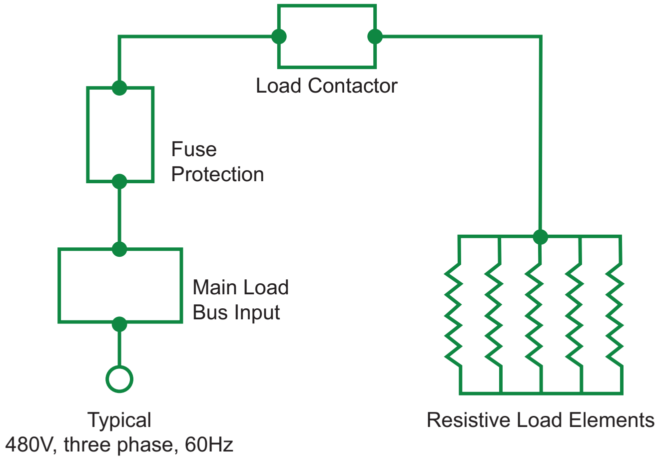

Figure 4: Example Load Element Circuit

The relationship of the control, cooling, and load element circuits is reinforced by review of typical load bank shut down sequences. After a load test is complete, the control circuit is used to shut down the load bank. Load is removed from the power source by placing switches for individual load steps in the “Off” position. This removes control voltage from the coils, de-energizing contactors serving each load element. The entire load system is then shut down using the Master Load Switch and operating a Blower Stop Switch. Most load banks do not require a cool-down period prior to shut down. However, it is good practice to first run blowers to remove residual heat.

Manual and Digital Load Bank Controls

Manufacturers offer control and communication systems that enable local or remote digital monitoring and control of load banks. These systems enable operation using proprietary control devices that interface with load banks, backup power systems, and facility infrastructure. The Avtron SIGMA control system, the Avtron Critical Power Management System, and Schneider Electric EcoStruxture solutions provide insight and control for load banks, critical power systems, and facility power management systems. In addition, many load banks and controls systems can interface directly with third-party power and building management systems.

Summary

Load banks are typically used to test power sources, provide required load to engines, or adjust power factor. To do so, load elements must absorb current. The resulting heat is ejected from the load bank by a blower system. Load Element Circuits and Cooling Circuits deliver power to operate the load banks, and a Control Circuit directs their operation. These are the three primary circuits in load banks.

Control circuits provide for overall control of the equipment. They provide dedicated on-off switching for load elements to enable operators to adjust load amounts. They also include devices that monitor airflow and temperature. They shut down load elements if airflow is compromised or overheating is detected. Likewise, a cooling circuit is required to power the fans that dissipate load bank heat, and load circuits apply electricity from a power source to the load elements. Digital control systems can automate the operations of this equipment, which can support both proprietary and third-party monitoring systems to enhance control and assessment of power systems operations, events, and conditions.

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