



WHAT YOU NEED TO KNOW ABOUT SCR POWER CONTROLLERS

FUNCTIONS, FEATURES, AND EFFICIENCIES

ABSTRACT

Temperature regulation is required in nearly every manufacturing process, typically for the purposes of material heating, melting, drying, or forming. SCR power controllers, also called silicon controlled rectifiers (SCRs), play a critical role in temperature regulation. Their primary use is to control the flow of electricity from the grid to a heater. This function precisely regulates temperature to produce specific material effects or properties within an industrial furnace, oven, or other thermal processing equipment.

Compared to alternative devices, such as IGBT-based controllers, SCR power controllers provide much greater efficiency—up to 99.5%. SCR power controllers also are used to replace contactors or relays due to the wear-free switching offered by thyristor devices. This characteristic greatly improves reliability and product longevity.

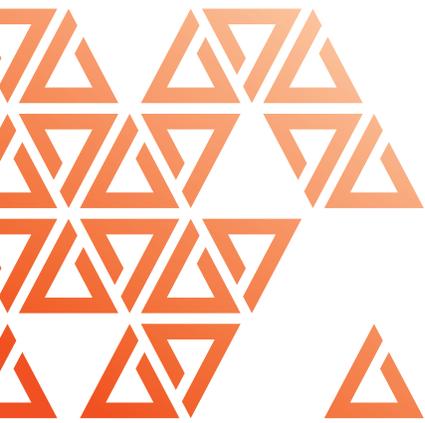


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FUNCTIONALITY

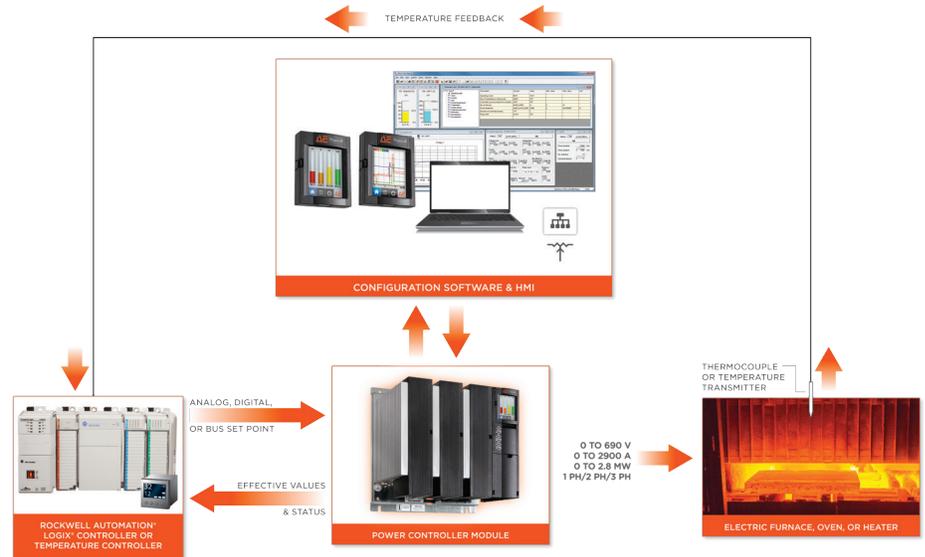


Figure 2. Operation of a power controller module in an industrial heating application

Figure 2 shows a closed-loop system in which the SCR power controller regulates the flow of power from the mains to a furnace, oven, or heater. The temperature sensor or transmitter located within the furnace sends a direct feedback signal to either a Rockwell Automation® Logix® controller or external temperature controller. The Rockwell Automation Logix controller or temperature controller then transmits an analog or digital set point to the SCR power controller. This set point is based on the chamber temperature, control, and PID settings. The SCR power controller uses this set point to regulate the flow of electricity to the heater and achieve a precise, stable temperature inside the furnace. A high-quality SCR power controller can regulate current, voltage, or power output, depending on process requirements and conditions.

KEY FEATURES FOR SCR-BASED THERMAL PROCESSING

SCR power controllers play a critical role in nearly every industrial manufacturing process that uses electrical heating.

Typical industries include:

- › Chemical
- › Industrial furnace
- › Glass and crystal
- › Metals
- › Oil and gas

SCR power controllers ensure high quality and cost efficiency through their high accuracy, flexibility, small footprint, and energy efficiency.

ACCURACY AND REPEATABILITY

Variations in mains voltage and heating-element resistance are common issues that impair the accuracy of temperature regulation. The mains voltage can vary up to and even beyond $\pm 10\%$, resulting in temperature fluctuations. SCR power controllers compensate for mains voltage fluctuations by employing RMS voltage regulation. An SCR's voltage regulation mode adjusts the firing angle (phase angle) or duty cycle (zero cross) of the SCR output to maintain a constant voltage output proportional to the set point. Variations in heating-element resistance are due to aging, temperature coefficients, and/or other materials characteristics. SCR power controllers can compensate for these variations by regulating the RMS output current. When both true RMS current and true RMS voltage regulation are employed, the

SCR power controller is said to be in power regulation mode. Power regulation allows the SCR power controller to regulate true power independent of variations in the mains voltage or heater resistance. Power regulation is the most accurate means of regulating temperature and promotes the highest level of process repeatability.

CONFIGURABILITY AND FLEXIBILITY

SCR power controllers that provide a wide range of operation modes and communication options enable optimal performance and easy integration into any process.

For systems with Rockwell Automation Logix® controllers using digital set points to communicate with the SCR power controller, typical field bus protocols include:

- › Ethernet/IP®
- › DeviceNet®
- › Profibus® DPV1
- › PROFINET®
- › Modbus® TCP
- › Modbus® RTU
- › CANopen®

In particular, Ethernet/IP®-connected SCR power controllers enable system streamlining, with fewer components and advanced data collection. Reduction of cable and communication card count lowers cost and reduces potential points of failure. Shorter cable length also augments efficiency for reduced power consumption.

FOOTPRINT

SCR power controllers must be small in order to fit the tight quarters of industrial manufacturing systems. The most advanced SCR power controllers offer a small footprint—without sacrificing functionality.

ENERGY EFFICIENCY

Both the public and industrial sectors have seen a dramatic increase in energy costs in recent years. The latest production technologies offer high efficiency to reduce overall capital and operating expenditures, especially in energy-intensive applications.

At 99.5% efficiency, SCR power controllers offer a distinct advantage over alternative devices such as IGBT-based power supplies and converters. Furthermore, modern SCR power controllers offer multiple firing modes, enabling users to select the best control method for their application. Firing modes can be selected based on technical requirements, such as minimizing THD or maximizing power resolution. Advanced control methodologies such as mains load optimization can be used to reduce peak load demand of multiple SCR units, resulting in lower energy rates.



Phase-angle (VAR) mode is very commonly used in heat applications due to its precise resolution of power. However, phase-angle mode is also known for generating excessive harmonics and low power factor, and in some cases can directly interfere with the operation of other equipment. Digital SCR power controllers with advanced features may offer the following alternatives:

- › Zero-cross mode (TAKT) is a full-wave switching operation mode that creates virtually no harmonics and is standard in many heating applications. The ability to “cut the first half-wave” also enables this mode to drive transformer-coupled loads while minimizing inrush current. For multiple-zone applications operating in zero-cross mode, automatic digital mains load optimization (dASM) reduces peak load demand and THDi.
- › Voltage sequence control (VSC), the “autotap” operating mode, provides phase-angle mode’s fast response, high control dynamic, and high control resolution per cycle—without the disadvantages of harmonics and noise. This mode is used for single or multiple transformer-coupled heating zones.
- › VT mode combines zero-cross and phase-angle firing, and is frequently used for applications with low thermal inertia, such as infrared and single-phase applications, that are not transformer-coupled. VT mode makes use of the advantages of both zero-cross and phase-angle modes, and, in addition, provides mains load optimization (SVT) for multiple-zone applications.
- › MoSi mode is used for heating resistors with very low cold resistance and high thermal inertia. It delivers the advantages of zero-cross mode to applications that require pre-heating in phase-angle firing for each production cycle. In applications with high hot/cold resistance ratios, the SCR power controller can automatically ramp up to the required temperature in phase-angle mode and then switch automatically to zero-cross mode to maintain that temperature.

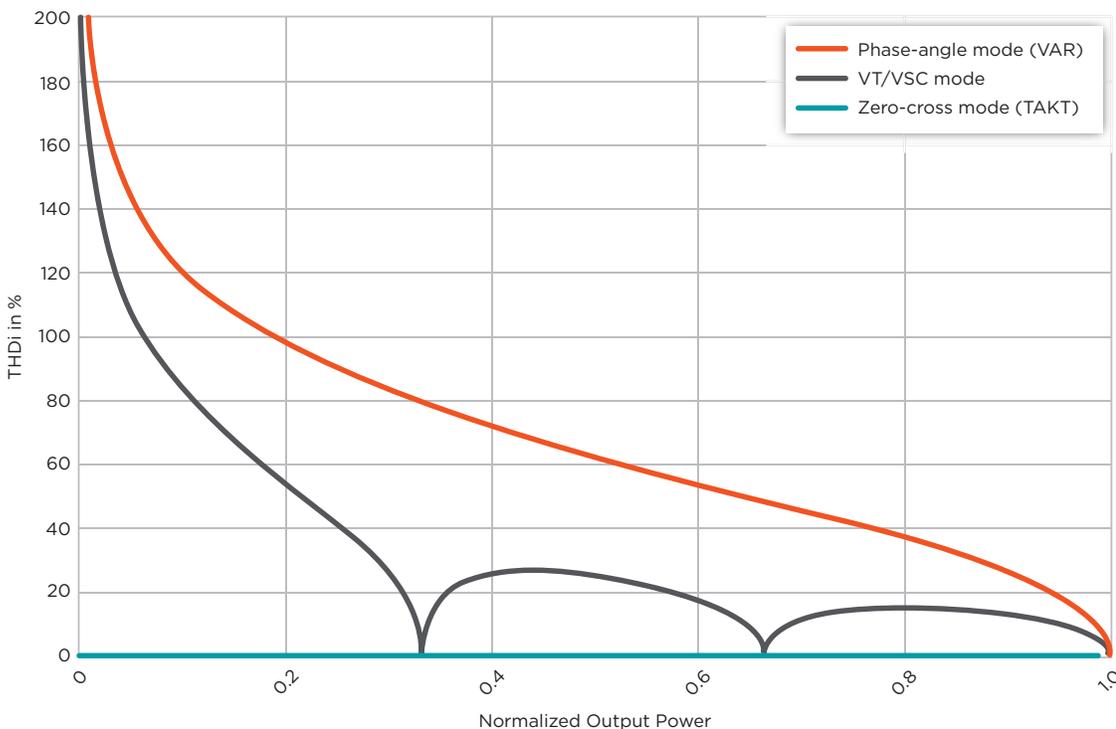


Figure 3. THDi reduction with VT, VSC, and TAKT firing modes

ECONOMIC EFFICIENCY

SCR power controller connectivity options and energy efficiency provide many opportunities to reduce cost.

COMPREHENSIVE CONNECTIVITY OPTIONS

SCR power controllers expand the potential for cost savings by offering a comprehensive range of connectivity options. For example, Ethernet/IP connectivity can reduce component count, enabling the use of fewer cables and communication cards. This translates into significant savings:

- › Ethernet/IP eliminates unnecessary analog equipment and accessories. For example, most SCR power control modules have built-in current and voltage transformers. This makes the requirement for external equipment—such as voltmeters—unnecessary. Instead, current and voltage parameters can be sent directly to an HMI, Rockwell Automation Logix controller, or Panel View screen. Further, multiple heating zones can be monitored, configured, and/or controlled by a single access point.
- › Ethernet/IP provides a higher level of digital control, resulting in greater accuracy and higher reliability for your industrial heat process. Increased uptime and higher yield are also likely benefits. In addition, the Ethernet/IP connectivity allows easy integration with other control interfaces—streamlining the development process.
- › Replacement of obsolete analog SCR units with advanced digital SCR units provides a low-cost option for enhancing immediate performance and functionality, with the option of upgrading to higher-level bus communications/control systems at a later time. Applications with previously no communication options can be easily upgraded to include Ethernet/IP (or other communications) with the addition of a bus module. This gives your original design new life—with greater functionality that can be expanded when you are ready to move in that direction.

Traditional network card solutions (Figure 4, left) require one communication card for each SCR power controller. At a cost of approximately \$200 per card, this adds up to \$1600 per eight SCR power controllers. In comparison, the Ethernet bus module solution shown in Figure 4 (right) requires only one bus module, at a list price of \$539, for a potential savings of as much as \$1061.

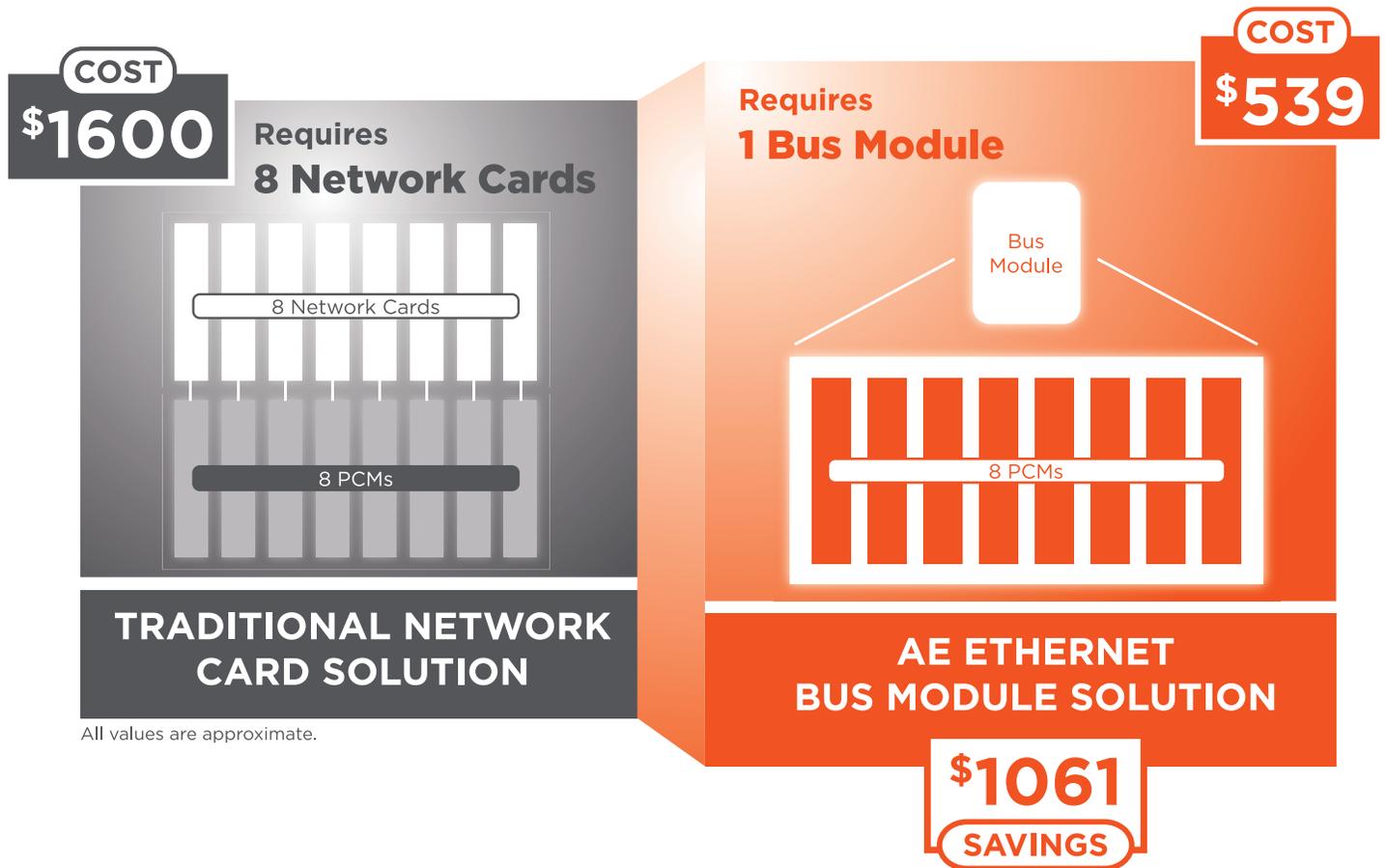


Figure 4. The Ethernet bus module solution (right) offers a potential savings of up to \$1061 USD.

In addition to reduced bus card count, this Ethernet bus module provides the following benefits:

- › Reduced setup time and cost—These can be reduced by as much as 40%.
- › Reduced wiring cost—A single cable connects the Rockwell Automation Logix controller to the bus module.
- › Reduced repair cost—Fewer components and connections means fewer potential points of failure.
- › Reduced upgrade cost—Easy connectivity saves time and money for upgrades.

ENERGY EFFICIENCY

The inherent efficiency of SCR power controller technology also offers specific cost advantages. At 99.5% efficiency, SCR power controllers save energy simply due to their extremely low power losses (heat load) compared to switch-mode power supplies. The low loss designs can operate in ambient temperatures up to 55°C (131°F) (using de-rated SCRs), reducing the need for air conditioning and other associated costs.

Furthermore, many utilities charge a penalty if a certain power factor, typically 0.9, is not met. SCR power controllers with MoSi, VT, zero cross/TAKT (transformer or direct loads), mains load optimization, or other digital features can save thousands of dollars annually in energy costs by improving power factor and reducing peak kVA.

CONCLUSION

The modern digital SCR power controller offers many options to intelligently manage electrical energy used in industrial furnaces, ovens, or other thermal processes. Digital SCRs offer far more capabilities in power regulation, diagnostics, flexibility, and bus connectivity than their analog predecessors. These capabilities have been proven to greatly improve thermal processes through enhanced quality, increased throughput, and reduced energy costs. Small footprint and ease of use are additional benefits of digital SCRs. Making informed decisions about this critical component in your thermal process can be a key advantage to address rising energy costs, demand for higher throughput, and improved quality.

For international contact information, visit advanced-energy.com

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