

# Selecting SCR Power Controllers to Reduce Heat Control System Panel Costs

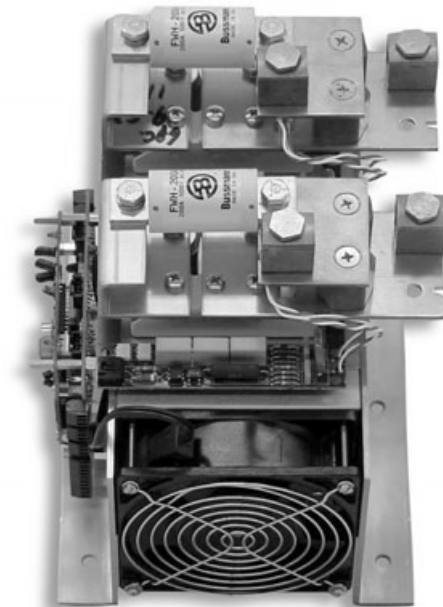
*Michael Hardy, Chromalox*

Whether building control panels for internal use or a paying customer, controlling cost always is a major concern. With fully burdened labor rates as high as \$75 an hour, assembly and installation times must be held to a minimum. Of course, the cost of enclosures, wire, and other parts must also be controlled, and there is always the question of what to make and what to buy as a sub-assembly. These are particularly sensitive issues in the construction of SCR power control panels used for resistive and inductive heaters in ovens, kilns, environmental chambers, furnaces, and other manufacturing applications.

When selecting control panel components, it is important to look for those that reduce assembly time, provide flexible wiring options, and allow smaller enclosures. Careful selection of the SCR power controller used in these panels can significantly reduce the time and hardware costs associated with panel building. In addition, the right choice of SCR power controller can lower maintenance costs, improve ROI, and increase end user satisfaction.

Some of the more important considerations in SCR power controller selection are:

- Electrical Specifications
- Pre-assembled Components
- Physical Size
- Flexible Wiring Options
- Touch-Safe Design
- Fuse and Power Distribution Connections
- Fuse Replacement Cost
- Built-in Controller Protection
- Power Connections and Related Maintenance Issues
- CE Mark
- Options/Plug and Play Considerations
  - SCR detection
  - current limiting
  - soft start
  - zero/gain adjust



- line voltage regulation
- digital communications interface
- retransmitting output drive signal

## **Electrical Specifications**

A power controller must have specifications matched to the application. Major specifications include:

- AC input voltage and number of phases
- SCR control firing method (On/Off, Proportional, and/or Phase Angle)
- Maximum load carrying capacity (Amps)
- Control input (0-10VDC, 4-20mA, etc.)
- Options (such as current limiting, soft start, zero/gain adjust, line voltage regulation, digital communications interface, and retransmit of output drive signal)

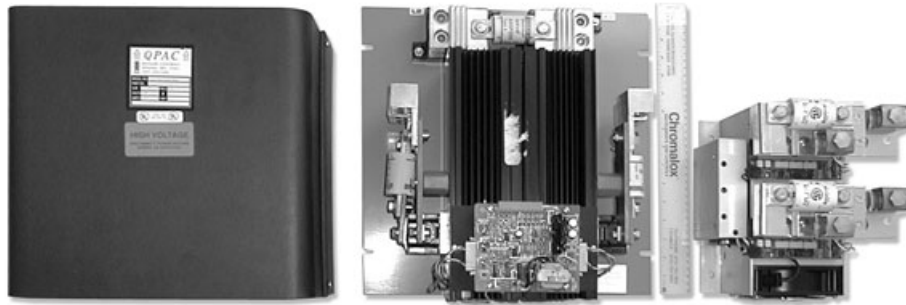
## **Pre-assembled Components**

SCR power controllers come in a wide variety of configurations and options. You can even build one yourself. However, to design and build an SCR controller may not be cost efficient, since packaged systems are readily available in a wide variety of configurations and options. As with any system, installation is faster if the system components come pre-assembled with all the options needed for your application. Commonly, an SCR controller includes the following components:

1. Firing Card – Controls the gating of the SCRs
2. SCRs – Silicon Controlled Rectifiers for load switching
3. Bus Bars – Conduct power from the SCRs to the load connection terminals
4. Current Transformer – For measuring current to detect partial load failures and facilitate soft starting of the load
5. I<sup>2</sup>T Fuses – Fast acting fuse that protects the SCRs
6. MOV Protection – Metal Oxide Varistor circuit that protects the SCRs from excessive transient voltage
7. Heat Sink – Typically, a finned aluminum extrusion on which SCRs are mounted to conduct heat away from them
8. Cooling Fan – Forced convection cooling of the heat sink
9. Connection Lugs – Load connection terminals and grounding lug
10. Mounting – Plate or panel for mounting the SCR assembly in an enclosure

## Physical Size

The SCR power controller is one of the larger components of a heat control system. A power controller with a small footprint reduces panel size requirements, saving cost by allowing use of a smaller enclosure. A compact power controller also increases space for other components and makes assembly easier by giving the installer more space to work in. With the continual shrinkage of semiconductors and other electronic components, you can find 100-amp, single-phase SCR power controllers in package sizes smaller than 0.5 cu. ft.



**The size of SCR power controllers varies greatly. This Chromalox MaxPac unit (right) has a footprint that is at least 30 - 50% smaller than many others with the same power rating.**

## Flexible Wiring Options

A significant challenge in panel building is running the AC power wiring into and out of the SCR controller. Some users want power conductors to enter at the top of the controller and exit at the bottom. Others may want the power to enter and exit on the same side. This depends on how AC power lines enter the control panel enclosure. Because many SCR controllers have fixed power connections and few options on their location, a panel builder or installer may be forced to bend conductors in a U-turn and run them around the inside the panel to meet entry and exit specifications. With high amperage power conductors, this may require such a large bending radius that an oversized enclosure is needed. Besides the wasted space, these wiring practices are time consuming, add component cost, and may increase the enclosure heat rise.

The solution is an SCR power controller with a design that allows power connections in any direction without large radius bends. Typically, this means a controller with bus bar design that acts as an integrated power distribution block, allowing multiple connections in any direction. This type of design also eliminates the need to purchase and wire a separate distribution block, reduces panel construction costs, and lowers installation costs by allowing installers to quickly and easily connect power directly to all circuit legs.

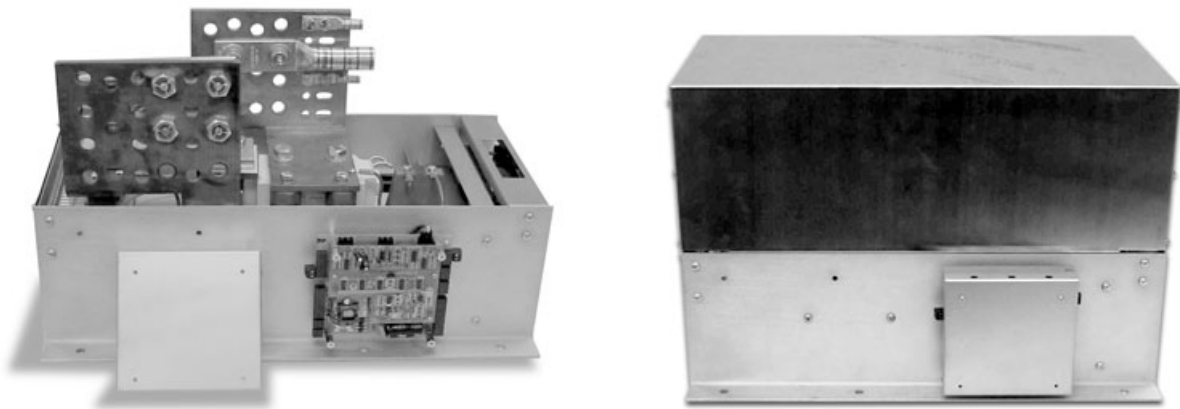
## Touch-Safe Design

Most SCR controllers are open systems that expose the technicians to potentially high voltage parts. It is common practice to install a Plexiglas cover over the power components as a way to add protection, but of course this requires additional labor and materials. Some suppliers provide SCR power controllers in a touch-safe design, which eliminates the need for Plexiglas.

## Fuse and Power Distribution Connections

In some installations, the panel builder must wire the SCR controller to a power distribution block before installing fusing. This step can be avoided if the SCR controller allows sub-circuit power distribution connections right on the output bus bars. Direct cable runs between the controller outputs and fuse blocks reduces both wiring and component costs; remember, sub-circuit terminal blocks can range in price from \$45 to \$120.

Moreover, fewer high-power connections mean that there are fewer potential hotspots and points of failure. The higher the amperage rating, the more important this becomes. A temperature related insulation failure, resulting in an electrical short, can easily destroy the entire control panel.



Panel builders can eliminate or reduce costs with well-designed SCR power controllers.

- A Plexiglas cover over power components can be eliminated by a touch safe design (right).
- The feed wire is bent and wrapped around the panel. A flexible SCR design simplifies installation by allowing both the Power Feed and Load Feed to go in and out the same side of the controller.
- The SCR power controller is often the largest component in the panel. A smaller form factor saves space and may allow reduction in panel size to reduce costs.
- Sub-circuit power blocks are often part of installation. New SCR power controllers eliminate the need for this step.

## Fuse Replacement Cost

Another benefit of selecting an SCR power controller with a built-in power distribution block is easier division of output circuits into multiple legs. This arrangement is often required in a multi-circuit temperature control system, and may be desirable in many other applications. For example, circuit division allows the use of lower amperage fuses, which are less expensive and more readily available from distributor shelf stock. This reduces your inventory cost and reduces downtime in emergency situations. Over the lifetime of a panel, these cost savings can be significant. A typical 400 amp fuse costs \$117, while a typical 80 amp fuse costs \$33.

## **Built-in Controller Protection**

In addition to fuses that protect the external power circuits and equipment, the user normally wants to protect controller SCRs, which are expensive to replace. Many power controllers include I<sup>2</sup>T fuses (described earlier) and a thermal shutdown feature. In case of thermal overload, it generally is preferable to have advanced warning of impending shutdown, so that steps can be taken to avoid the loss of work-in-process material. Therefore, the protection circuit should provide an LED or software alarm before temperatures reach the automatic shutdown point. Some power controllers only have a thermostatic cutout that shuts down the system without warning.

Another form of protection is a feature that detects a short in the SCR, which can help shorten troubleshooting and down time costs. While this feature is desirable, for reasons of cost it may be omitted for less critical applications. Chromalox, for example, sells this feature as an option in the form of a retrofitable plug-in board. This allows the user to specify only the components needed for a specific application, but upgrade the panel later if its use changes.

## **Power Connections**

To reduce maintenance problems, do not overlook power cable connections. Since controller input and output configurations vary by manufacturer, it is common practice for makers to supply cable lugs that fit their designs. You may find designs that use aluminum lugs, but these should be avoided with copper conductors. The different thermal expansion rates of the two metals can result in the connectors loosening over time. This is especially true for a high power heating system that utilizes on/off control, and will be worse for lugs that have a bolted split-barrel connection to the conductor. The most secure and reliable copper connection is a crimped barrel, tin-plated copper lug. (It is anticipated that Underwriters Laboratories will soon require all-copper connections before issuing a UL product listing.)

Also, a two-hole lug provides the most reliable connection to a power distribution block. A single hole lug is more likely to rotate during installation or if it becomes loose under thermal or mechanical stress. This creates a higher potential for shorts and thermal problems in nearby circuits. A two-hole lug greatly reduces this possibility and helps minimize maintenance costs.

## **CE Mark**

When building power control panels for equipment sold to European markets, a CE mark may be required on all major components to signify compliance with EEC directives. Purchasing an integrated power controller with the CE mark simplifies sourcing and vendor management compared to individual component purchases. Not having those CE marks can eliminate the panel builder from consideration as a supplier, or could require extensive rework on a previously built panel. Since you may not know where a panel will end up, it is advisable to standardize on controllers and other components that have the CE mark.

## Options/Plug and Play Considerations

It is desirable that power controller options be the plug-and-play variety, particularly when they are retrofitable or interface with other control elements (see 'Electrical Specifications – Options...'). Usually, retrofitting optional features to an integrated controller is much simpler than trying to add those features to one you have built yourself from various manufacturers' components. If a plug-in option can be configured by the user, it should still start up automatically with a default configuration. For example, shorted SCR detection in the Chromalox MaxPac series is a plug-in card that has an auto-configuration feature, making it fully plug-and-play.

## About the Author

Michael Hardy is Product Manager for Chromalox Control Panels and Power Control Components. He has three decades of industrial control experience and has been with Chromalox for 14 years as an application engineer.



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