

Industrial Battery Chargers - From Silicon Controlled to Switch Mode

As we look at each step in the DC power and redundancy equation – from dual AC inputs to multiple interconnected battery strings – the heart of that chain is the battery charger. The charger both converts (or “rectifies”) the AC power to DC power and conditions that power to reliably charge the batteries that power substation protection and control systems such as relays, breakers and switch controls.

Over the years, battery charger technologies have evolved from Mag Amp, to controlled ferro resonant chargers (CFR), to, what is more common today for most industrial settings, a silicon-controlled rectifier (SCR) charger.

When we speak of “silicon” we’re talking about semiconductors converting and controlling the output at the charger versus an electric circuit performing that function. SCR chargers use thyristors to control the phase angle of the power to be rectified, thereby regulating the power on the output.

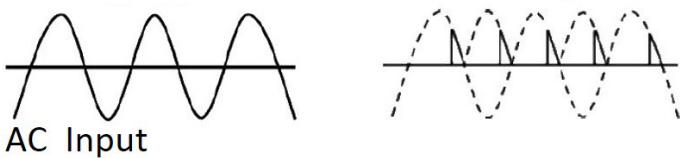


Figure One: “Rectified” AC Power

SCR chargers – sometimes called thyristor chargers - have been the go-to technology for most powersubstation applications where size and weight, efficiency and maintenance are not key factors in the design consideration. With newer technologies, they provide microprocessor control and communications functions as well.

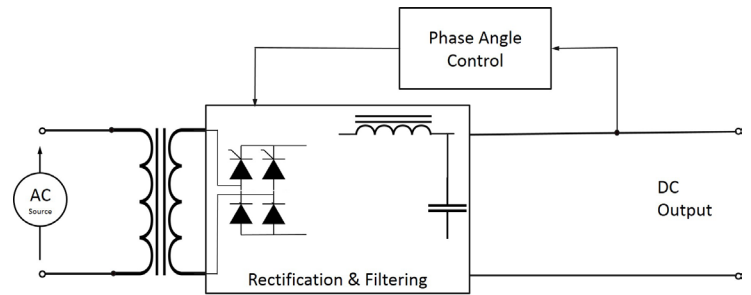


Figure Two: Silicon controlled rectifier (SCR) configuration

SCR chargers do present some challenges with EMI (electromagnetic interference) created by the hard switching SCRs employ. It also requires a larger output filter that eventually requires maintenance or replacement. That replacement needs to be performed by specialized technicians. SCRs are also sensitive to the voltage and frequency input, as power transformation occurs at 50-60Hz in the first stage of the circuit.

There is some issue with SCR chargers generating uneven, or ripple, DC voltages, which can create excess heat. This is less of an issue with traditional vented lead acid (VLA) batteries. But a move toward more environmentally friendly value-regulated lead-acid (VRLA) batteries does raise issues concerning ripple-generated heat and its effect on long-term performance and battery life.

Commercial Switch Mode Battery Chargers

The advent of an alternative charger technology is a switch mode rectifier (SMR), sometimes called a high frequency charger. SMR charger technology has been around for decades and is based on converting the AC power input into a higher frequency using pulse width modulation (PWM) and switching controls, and the use of switching transistors.

This allows for smaller transformers, yielding a smaller, more compact and more power-efficient battery charger.

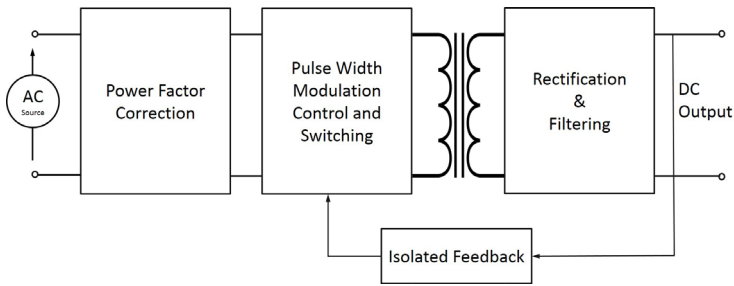


Figure Three: Switch Mode Rectifier (SMR) configuration

SMR chargers offer other performance advantages in terms of faster load/line response. With SMRs the AC power is converted to DC before it is transformed to AC for conversion. This enables a wide input voltage and frequency range and is forgiving of voltage variations or disturbances.

Some versions of SMR chargers handle heat discharge through conductive cooling via heat sinks, making these systems larger. To achieve higher power density, fan-based forced-air cooling is used. To protect the electronics against dust and pollutants in the air, filters may be used. A viable alternative is to use conformally coated circuitry to protect the electronics from dust and environmental contaminants. Newer SMR chargers can also operate in a wide range of harsh environmental conditions and temperature ranges from -40 degrees Celsius (-40 degrees Fahrenheit) to +75 degrees Celsius (+167 degrees Fahrenheit).

The Power of Dual Versus Single Chargers -- Modularity, Maintenance and Reliability

A fundamental difference between SCR and SMR-based chargers is summed up as “one versus many.” Where a SCR charger relies on a single, dedicated power rectification and filtering unit (we’ll call that a “power module”), a SMR charger can be configured with a series of smaller but interconnected charger power modules or “blocks.” If, for example, you have a 60-amp load, a single SCR charger is needed to provide that power at full capacity. A SMR charger might be configured with three 20-amp power units (with an additional fourth power unit for full N+1 back-up)

So, what’s the difference between one large versus three smaller interconnected modules operating in parallel? It’s the triple benefit of maintenance, reliability and redundancy.

In a maintenance operation, a SMR charger power module is hot-swappable, allowing workers to remove one module while, in this example, the other two units both power the load to maintain power rectification and filtering functions. The complete operation can be done without powering down the entire charger system or taking it off-line.

It should also be noted that this field operation can be done by more readily available field operation personnel rather than a highly trained senior electricians skilled in battery charger technology.

From a reliability standpoint, if one modular SMR power unit fails, AC-to-DC power conversion still continues, as the partial load is shared by the other modules. With an SCR charger, if a single unit fails the entire power charging function fails.

SMR chargers also offer less expensive and easy-to-upgrade system redundancy. As described, if one 20-amp SMR power module fails (in our 60-amp example) the other two 20-amp units still carry most of the load.

And to achieve N+1 redundancy, in this same example, a fourth 20-amp power module can readily be added to ensure full power output under a failure or repair situation of one module. Full redundancy N+N can also be achieved, for example, by having six 20-amp modules in the same cabinet with two separate AC inputs, each feeding three modules.

In a corresponding example of a single 60-amp SCR battery recharger, full reliability and redundancy can only be achieved with two individual battery recharges controlled together – doubling the per amp capacity costs and adding both space and maintenance OpEx costs to the substation operation.

Ensuring always-available DC battery power for critical substation systems is an absolute. Adopting new “one-charger redundancy” field-proven switch mode rectifier-based chargers offers utility T&D engineers new options for maintaining reliable, practical and cost-efficient critical power.