# SCR rectifier / charger: how does it work?

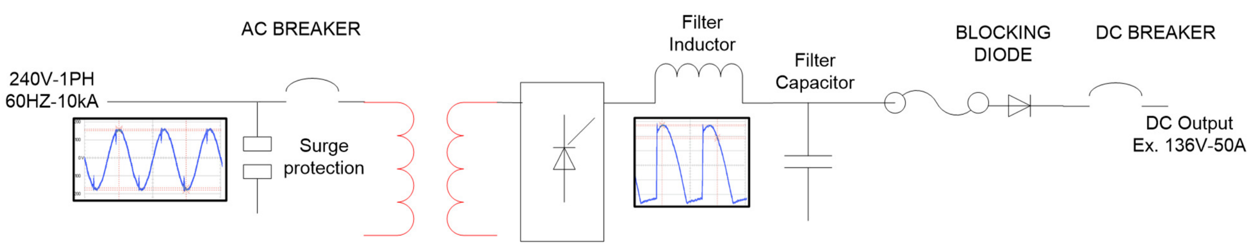
The first Thyristor (SCR) rectifier was introduced back in the 1950's as an upgrade for magnetic amplifiers and ferro-resonant rectifiers. The SCR is 3 terminal semiconductor-controlled rectifier. It can be triggered into conduction mode by firing the gate when the device is in the forward mode. The SCR will stop conducting until the current drops below its minimum holding current. The advantage of using SCR over Mag-amp and ferro designs is mainly the relative smaller size/weight and its line frequency independence providing a better dc regulation capability. Its advantage over the newer high frequency design is the fact it has a single conversion stage (low component counts) and can be easily designed to operate with natural convection cooling to provide medium power range.

6 pulse design is the basic configuration in 3 phase rectification. 12 and pulse rectifiers can easily be configured to provide higher power level with lower dc ripple and better harmonic distortion (THDi) reflected on the input to comply with national electrical standards.

A well-designed SCR rectifier/charger with the right power components, appropriate snubbers and right control circuits is very durable and resilient in high peak demands to provide reliable dc power for 20+ years.

The dc output of the SCR rectifier, like the ferro and mag-amp designs, can be filtered by adding inductors and capacitors (LC, LCLC, etc.) to create a low pass filter and reduce the output ac ripple content. High ripple content can reduce the battery life and may affect the load operation.

## How does it work?




1- Typical SCR single line diagram.

Figure 1 shows a typical single line diagram of a single-phase charger. Sine wave (figure 2) is rectified (figure 3) then chopped (picture 3) at different firing angles depending on the energy level the controller would require to regulate the dc output current and voltage. The firing angles are generally calculated based on the feedback reading values coming from the rectifier output: Vdc, Idc, temperature sensing, etc.

In the following example (figure 4), the 1st sine part is chopped at $\alpha_1$ and the 2nd part at $\alpha_2$. So more energy will be delivered during the 1st part and less in the 2nd part. This occurs 60 times a second in a single-phase charger. In three-phase 6 pulse designs, 3 sinewaves are superimposed with 120° phase shift. To reduce the output ripple, the output can then be filtered by using inductors and capacitors in for example LC or LCLC configurations: ripple can be reduce to 100mVrms or lower to meet battery and load requirements.

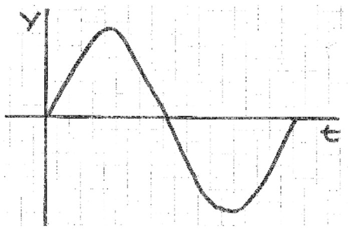


Fig. 2 Typical sinewave

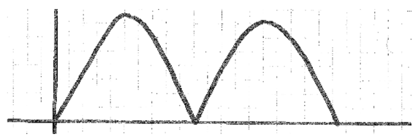


Fig. 3 Typical rectified sinewave

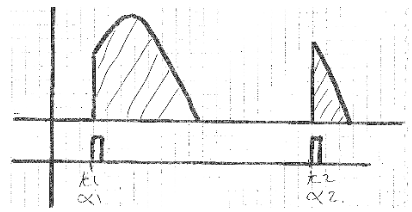


Fig. 4- Typical pulsed dc voltage

When battery is connected to a charger, the output waveform changes. The battery can act as load during charge and as a source during discharge: let's suppose that we have a non-filtered battery charger connected to a 125Vdc battery and a station load. During phases B and D in figure 5 the battery will be recharging. During A, C and E the battery will be contributing in feeding the load since its voltage being higher than the charger's one. So, in each cycle we end up having 2 battery micro-cycles (charge/discharge). This battery micro-cycling contributes into overheating the battery and shortening its useful life. Chargers with higher filtering level, help to extend battery life and reliability.

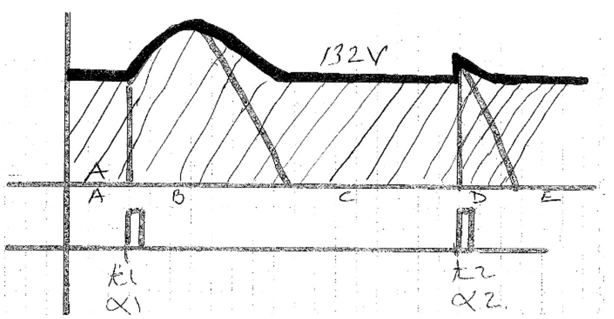



Fig. 5- Typical waveform of a DC system output with connected battery

We recommend using filtered chargers compliant to NEMA PE5 in order to preserve batteries and help to ensure correct dc system operation. You ay also refer to IEEE946 for guidance for dc system designs.

**REFERENCES:**

NEMA PE5: Utility-Type Battery Chargers

IEEE946: IEEE 946-2004 - IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Systems