# ACTIVE VOLTAGE CONDITIONER

## Introduction

Voltage sag and short interruptions are power quality phenomena that affect many processes. These disturbances are caused mainly by weather events and result in faults in the distribution network.

Unfortunately, the susceptibility of process line equipment stoppages has increased due to energy efficiency improvement, a smaller footprint of equipment, and improved electronic components. Another vital piece of information is approximately 90% of electronic equipment malfunction is due to voltage sags with up to approximately 10% due to short-term power interruptions in the network.

## Active Voltage Conditioner

The Active Voltage Conditioner (AVC) is an inverter-based system that protects sensitive industrial and commercial loads from voltage disturbances caused by voltage sags. It is a series-connected device with a bypass switchgear. It has an operating efficiency exceeding 98% and provides an extremely fast response.

The 40% AVC is continuously and highly dynamically kept at the target value, and typical voltage sags are easily handled. The 40% AVC corrects three-phase sags with a 40% vector injection. Voltage sags down to 50% remaining, and single-phase sags down to 25% remaining voltage is restored to stay within the +/-10% nominal voltage range.

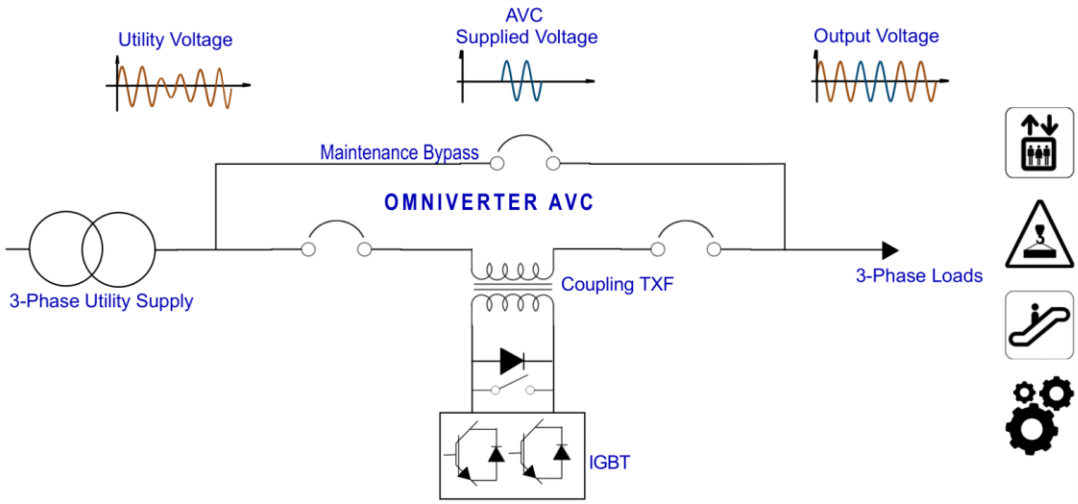


*Figure 1: AVC principle of operation*

## How the AVC Works

The system connects on the utility side of the load. During regular operation, the AVC continuously conditions the voltage. Should the utility supply voltage drop, the AVC will boost the output voltage by injecting voltage vectors to compensate for the missing voltage. The AVC does not protect during power outages. See AVCRTS product offering if outage protection is required.

## Why not use a UPS

Double-conversion UPS equipment was traditionally the best alternative to protect sensitive equipment during a voltage sag or interruption. However, a conventional UPS design is unsuitable for industrial loads with high inrush currents, VFDs with high harmonic currents, or regenerative loads. Therefore, most traditional double-conversion UPS systems are ideal for stable loads such as computer rooms.

The primary purpose of the AVC design is to correct voltage sags for typical industrial loads without the use of battery storage. The AVC is a cost-effective solution that needs little maintenance. It provides continuous voltage regulation and sag protection during voltage sag disturbances.

## Capacity Range

It is not always necessary to protect the entire site from voltage sags—the AVC capacity range from 300kVA to 60MVA. However, from an economic payback perspective, it is recommended to identify loads that need protection. It is then possible to install individual units in line with the specific equipment or processes.

The Medium Voltage AVC is ideal for complete facility protection and ranges up to 60MVA with bypass switchgear. An optional feature is an outdoor enclosure to save valuable indoor floor space.

## Key Features

An essential feature of the unit is its fast response time. For example, the unit corrects a voltage sag or swell within 4 ms. The consequence is that the load will continue to run during the sag or swell event in the supply network.

As this active conditioning of grid voltage is done simultaneously in all 3 phases, the phase voltages connected to the end-user equipment remain at a user-selectable value (± 10% of the grid voltage) during all loading conditions. Therefore, it is a much faster solution than a tap-changer, and it is possible to set the load voltage higher or lower than the grid voltage (±10%).

Not only is magnitude continuously conditioned, but the phase angle is also corrected between the 3 phases, resulting in voltage unbalance to be near 0% under all conditions of unbalanced grid voltages or unbalanced load currents. Note: The AVC corrects the phase angle first and then the amplitude, all within a ½ cycle.

Even if voltage flicker was significant in the grid, voltage flicker downstream from the grid is improved.

## Typical Applications

Industries with continuous high-value production lines where unplanned production stoppages can be very costly, for example:

- Semiconductor Manufacturing
- Pharmaceutical Manufacturing
- Automotive and robotic processes
- Continuous high-speed and high-value processes
- Processes with regenerative loads

## Case Study Field Measurements

Figure 2 & 3 illustrates the performance of the input and output of an AVC. The load is a rural line feeding sensitive process equipment. Each voltage sag is plotted against the SEMI 47 sag immunity curve. The y-axis is the sag depth, and the x-axis is the time duration of each sag. SEMI 47 sets out limits of voltage sag that the equipment needs to tolerate without creating any process stoppages.

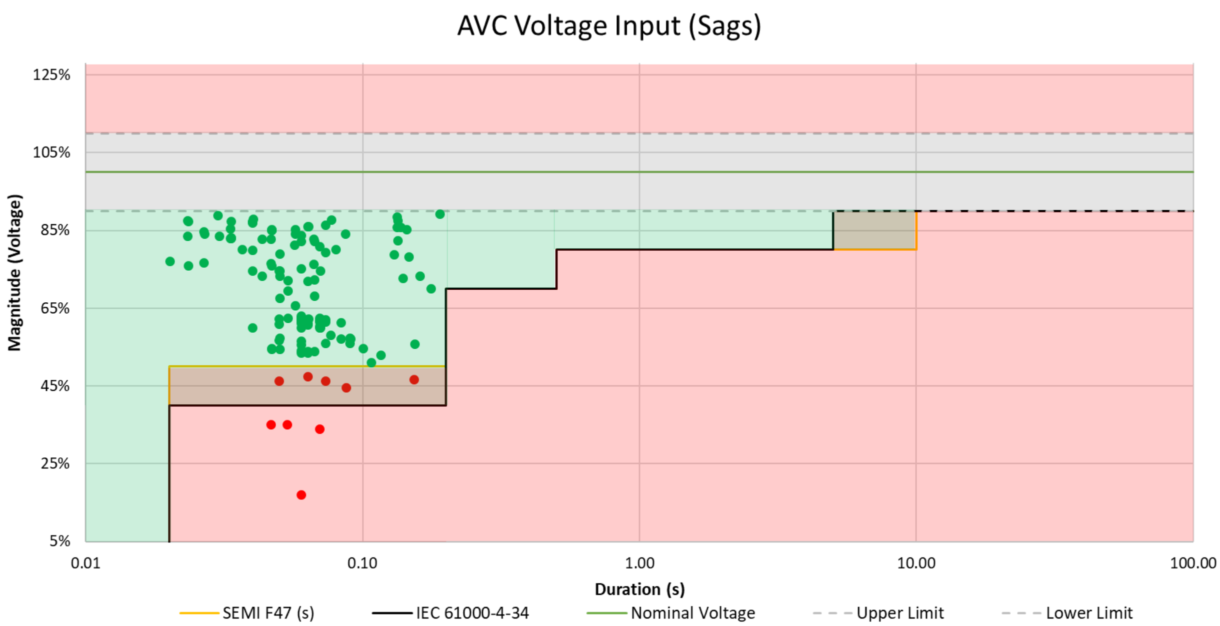


*Figure 2: Input measurement before the sag correction*

The input and output terminals at the AVC were measured using two power quality analyzers. The analyzers were set up to simultaneously capture the event on both devices during voltage sag.

Figure 2 uses a sag diagram to show the 140 sags recorded at the input terminals of the AVC. Nine voltage sags were below the SEMI F47 immunity level, as indicated in red. Figure 3 shows the results measured on the outside of the AVC unit. The AVC significantly improved voltage sags from 116 to 39 sags. The percentage of sag correction is dependent on the severity of the phase shift and magnitude. AVC corrects the phase angle first and then the magnitude within a ½ cycle.

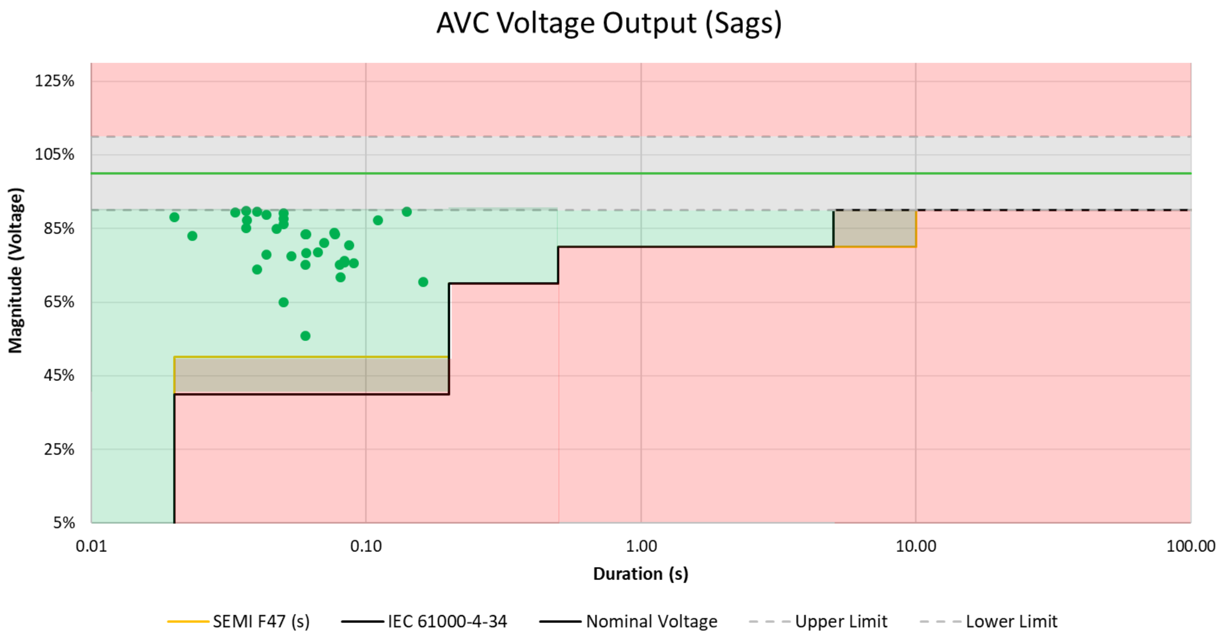


*Figure 3: Output measurement after the sag correction*

Figure 4 confirms how well and fast the voltage sag from the grid is corrected. The y-axis is the voltage level, and the x-axis is the time duration.

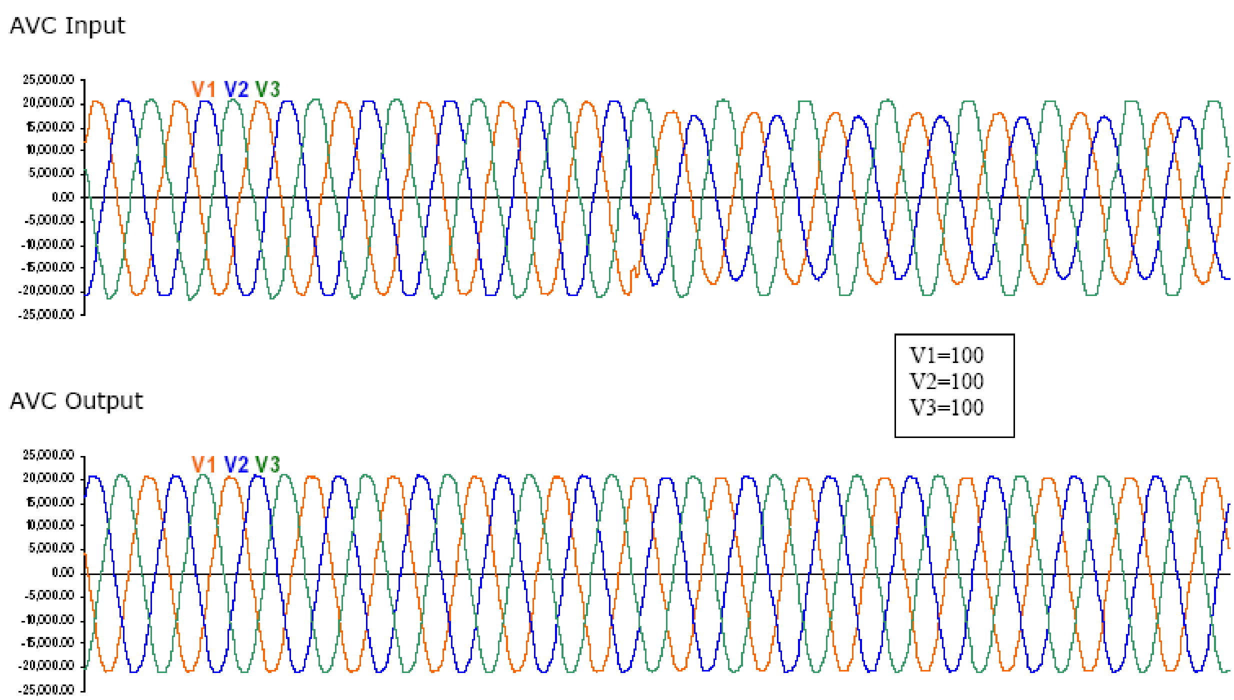


*Figure 4: Voltage waveforms at the grid and end-user equipment after being mitigated by an AVC*

Voltage magnitude regulation is significantly improved, as shown in Figure 5.

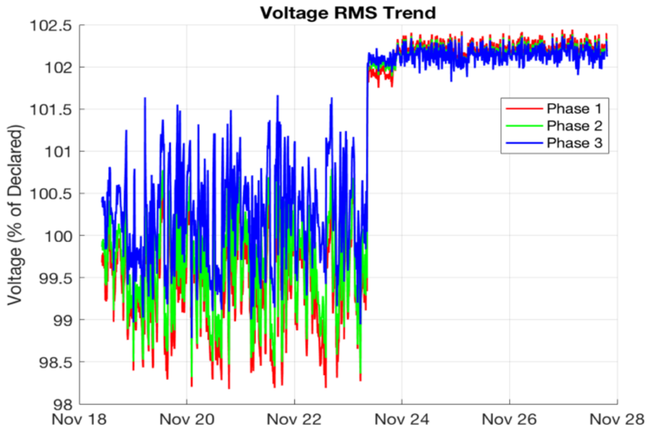


*Figure 5: Voltage magnitude regulation by the AVC*

Lastly, voltage unbalance (asymmetry) benefits from the magnitude and phase angle displacement, shown in Figure 6.

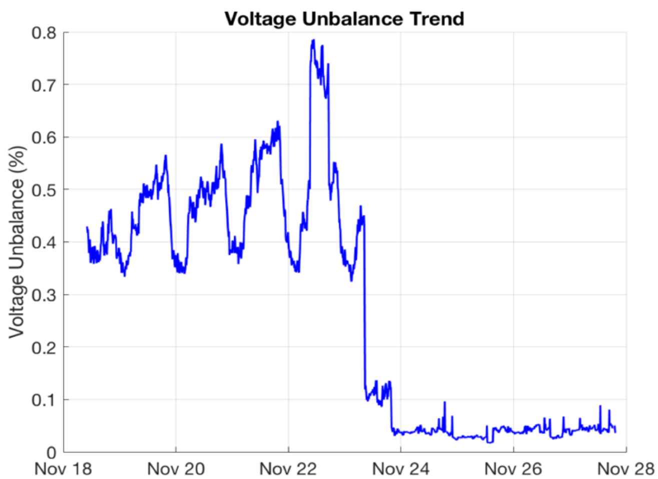


*Figure 6: Voltage unbalance mitigation by the AVC*

## WHERE TO FIND SOLUTIONS FOR ACTIVE VOLTAGE CONDITIONING?

Omniverter voltage conditioning ranges are used by the leading pharmaceutical, semiconductor, high-speed manufacturing, robotic and automated warehouses, water treatment plants, and many more. Visit www.omniverter.com for a comprehensive set of solutions to support the end-user of electricity in all power quality-related concerns.

They are available for discussion on detailed technical specifications of voltage sag/swell mitigation, harmonic filtering, fast reactive power compensation, and high-frequency filtering.