Advanced Voltage Stabilisation Technology

6 SEP 2011 | Shimon Limor, CTO, PowerSines

Electric appliances with inductive characteristics, such as refrigerators, air conditioners and compressors are more efficient when the voltage supplied is regulated and stabilised. PowerSines provides a solution for voltage optimisation and regulation that saves up to 18% on inductive loads in commercial facilities. This article will explain the physical principles behind voltage reduction on inductive loads, and will include case studies depicting energy savings using PowerSines ComEC (a universal energy efficiency controller) in leading industrial and commercial applications such as, cooling storages, refrigerated containers, commercial kitchens and supermarkets in the UK.

Voltage Optimisation and Reduction Physical Principles

Electricity Quality and Supply Regulations (EQS) define harmonized supply voltages across Europe at 230V±10%, which is within the range of 207–253V. According to the EQS definitions and the IEC 60038 any electric equipment with the CE mark can be safely operated at this range.

Therefore, utility companies are allowed to increase the voltage level at low-voltage transformers, even at substations, in order to provide an adequate voltage level across existing infrastructures. Increasing the voltage level is the easiest way for utilities to cope with the growing number of electric appliances on the network and the rising demand for electricity. As a result of this increase many types of equipment, originally designed to work on a 220V network, are operated at 230V or more, which in turn shortens their lifetime and causes wasted energy.

PowerSines provides an energy efficient solution using ComEC, an advanced energy controller that regulates and stabilises the supplied voltage level at the facility and extends the electrical equipment lifetime. ComEC guarantees a stable voltage output preset to the user-defined level.

The basic principle for voltage regulation reduces the voltage level from that of the incoming supply to a lower level allowed by EQC regulations. For simple linear resistive loads the voltage supply results in a power reduction according to electric formulae based on Ohms law and defines the relationships between voltage and power:

\[ P = \frac{V^2}{R} \]

Therefore, for loads with resistive characteristics that operate continuously or on a time-based regime, a decrease in power will be directly translated into energy (kWh) reduction:

\[ E = P \times T \]

However, many loads in commercial facilities are not resistive, but rather have inductive or mixed characteristics, such as: refrigeration systems, air conditioners and many others. These types of electric devices include either a single phase or three phase inductive motor.
When inductive motors work at nominal power level they are very efficient (typically >90%); however, in many cases these motors are oversized and are actually operated under partial load conditions. In this regime the inductive motor is inefficient, since the power factor is low and the working current is high – as a result, the motor produces more internal and network losses and emits more heat.

The diagrams below (Figures 1 & 2) show how the motor efficiency and power factor are affected by a partial load profile.

In addition, many inductive motors are designed for 220V networks. When these motors operate at voltage levels higher than 230V they are working in the saturated part of the magnetic hysteresis curve, thus increasing internal losses (iron and copper losses) and becoming less efficient.

Figure 3 depicts a typical magnetic hysteresis curve for AC motors and magnetic saturation when the motor operates at voltages higher than the nominal.
Voltage reduction in the range of allowed voltages brings the following benefits for inductive loads.

1. **Increased efficiency**
   For motors running at loads below the nominal, voltage reduction in the allowed range (up to 20V from the line voltage) will change the motor working point and bring the motor to a more efficient position in the *Load vs. Efficiency* curve, as is shown in Figure 4.

   ![Figure 4. Motor Efficiency vs. Load Curve under reduced supplied voltage](image)

2. **Improved Power Factor**
   A similar improvement can be also detected at the power factor. Increase of power factor will actually reduce the working currents and reduce conduction losses in the facility electric network. See Figure 5.

   ![Figure 5. Power Factor vs. Load Curve under reduced supplied voltage](image)
3. Improved motor operation point at magnetic hysteresis curve

Voltage reduction will move the working point of the motor on magnetic hysteresis curve from a saturated part to a linear one, thus reducing internal losses (specifically iron losses) of the inductive motors.

The improvements described above are applicable for inductive loads that are not controlled by invertors or variable speed drives. Motors that are controlled by invertors or variable speed drives control the power supplied to the motor by high-frequency modulation and frequency control, they are therefore not effected by the supplied voltage level.
Case Study

PowerSines ComEC energy efficiency controllers are installed in a wide range of applications worldwide affording the maximum savings possible. The ComEC advanced voltage control technology ensures that the output voltage level is kept constant at the level pre-set by the user, regardless of input voltage fluctuations. Even more importantly, ComEC continuously monitors input voltage and automatically switches to bypass mode when the input voltage drops too low. These two control mechanisms: voltage stabilisation and built-in bypass, enable utilising the full potential in voltage reduction for savings generation, and eliminate the need for safety margins when the input voltage decreases.

The ComEC systems have been successfully deployed in leading UK cooling storage facilities achieving 11-14% reduction in electric costs. The chart in Figure 7 shows the performance of ComEC 350A implemented at one of the facilities, it is neatly installed after the main circuit breaker, stabilising the voltage for the entire plant. The voltage was reduced from the average level of 240V to an optimised level of 220V. This voltage stabilization and reduction generated savings of 12.3%. These diagrams depict the benefits achieved with voltage stabilisation and reduction of power consumption.

The chart in figure 8 shows an irregular reduction in input voltage supply while the ComEC continues to stabilise the output voltage.

In addition, The PowerSines ComEC system includes a built-in Remote Energy Management System for on-line monitoring and control of ComEC’s operation at distant facilities. The PowerSines Remote EMS seamlessly integrates with ComEC systems and enables the user to analyse online and in real-time electricity allocation and consumption anomalies.

Figure 7. Power consumption changes in ComEC Save and Bypass modes

Figure 8. ComEC stabilises output voltage regardless of input voltage fluctuations
To Conclude
PowerSines ComEC system is an advanced energy controller that reduces the line voltage by up to 20V and stabilizes it at the user defined set point. ComEC continuously supplies a pure sinusoidal voltage waveform to all loads connected, thereby improving active power and energy consumption. In addition, ComEC reduces active currents and reactive energy, which in turn leads to indirect reduction of network losses in the facility and cuts operating expenses. The ComEC system installs quickly on your existing electrical infrastructure and requires zero maintenance.

Figure 9 shows the effect of reduced supplied voltage on electric equipment with inductive characteristics.

Figure 9. Reduced voltage effect on total, active and reactive power vectors