



Power Conditioning Equipment for Voltage Sag Immunity (Part 1)

By: *Engr. Mohamed Fuad bin Faisal, MIEM, P.Eng*

1.0 The importance of EMC

Electromagnetic Compatibility (EMC) is the branch of electrical sciences which studies the unintentional generation, propagation and reception of electromagnetic energy with reference to the unwanted effects that such energy may induce. The goal of EMC is the correct operation, in the same electromagnetic environment, of different equipment which involves electromagnetic phenomena in their operation.

In order to achieve this objective, EMC pursues different issues: emission issues, in particular, are related to the reduction of unintentional generation of electromagnetic energy and/or to the countermeasures which should be taken in order to avoid the propagation of such an energy towards the external environment, susceptibility or immunity issues, instead, refer to the correct operation of electrical equipment in the presence of electromagnetic disturbances.

Noise mitigation and, hence, electromagnetic compatibility is achieved by addressing both emission and susceptibility issues, i.e., quieting the sources of interference, making the disturbance propagation path less efficient, and making the potentially victim systems less vulnerable.

When the propagation of electromagnetic disturbances in guiding structures, i.e. conductors, transmission lines, wires, cables and printed circuit board (PCB) traces, is by a guided propagation mechanism, conducted emission and susceptibility issues are considered. On the other hand, when open-space propagation of electromagnetic disturbances is addressed, the point of focus becomes radiated emission and susceptibility phenomena.

2.0 EMC compliance for sensitive equipment

EMC is a characteristic of equipment or systems that mutually withstand their

respective electromagnetic emissions. Equipment and systems are always subjected to electromagnetic disturbances, and any electrotechnical equipment is, itself, more or less an electromagnetic disturbance generator.

According to IEC 61000-2-1, EMC is the ability of a device or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. For all electrotechnical equipment, EMC must be considered right from the initial design phase, and the various principles and rules carried on through to manufacturing and installation.

This means that all those involved, from the engineers and architects that design a building to the technicians that wire the electrical cabinets, including the specialists that design the various building networks and the crews that install them, must be concerned with EMC – a discipline aimed at achieving the ‘peaceful’ coexistence of equipment sensitive to electromagnetic disturbances (which may be considered as the ‘victim’) alongside equipment emitting such disturbances (in other words, the ‘source’ of the disturbances).

EMC is now becoming a discipline aimed at improving the coexistence of equipment or systems which may emit electromagnetic disturbances and/or be sensitive to them. There are many alternatives to ensure sensitive equipment and processes meet the EMC requirement for voltage sags as stipulated by IEC 61000-2-4.

Some of the common approaches to improve equipment sensitivity to voltage sags are:

- Adjust the settings on the motor protection circuit to make the parameters less sensitive to voltage sags and voltage unbalance. The proposed delay settings for the voltage and current relay are at least two seconds. The proposed unbalance current setting is between

20-30%, and the voltage unbalance to at least 3% (for motors with service factors of 1.15 or greater). It is also important to disable any feature that will make the chiller shutdown on the dropout of a single cycle of voltage.

- Built-in software programming within the sensitive device. Several small adjustable speed drive models have user programmable automatic restart. Typically, they wait 30-60 seconds for the circuit to stabilise before trying to restart. The number of retries can be programmed; typically, it is set at five retries. This strategy is commonly used in HVAC fans and pumps in an unattended environment. This applies to both sags and momentary interruptions.
- Install power conditioning equipment

3.0 Introduction to Power Conditioning Equipment

To ride through a power quality event, for example, a voltage sag event, the load will need some kind of system that can react within about half a cycle and provide near-normal power for a few seconds until the voltage is fully restored. This requires either a source of stored energy at the site or an alternate source of energy. These devices must either be capable of being switched very quickly or always be on-line. To achieve this condition, one needs to install some form of power-conditioning device. This solution increases in cost with the size and scope of the equipment or circuits being protected. The location to install a power conditioner will also determine the coverage area of protection against voltage sags.

3.1 What is a power conditioner?

The function of a power conditioner is similar to a hair conditioner which softens hair after shampooing and keeps static electricity from causing the hair to stand up. A power conditioner is also similar to a water filter which produces cleaner water.



Figure 1: Examples of hair shampoo/conditioners



Figure 2: Examples of water filters

Power conditioning equipment improves power quality while water filters

improve water quality. Technically, power conditioners include devices that reduce or eliminate the effect of power quality disturbance. Depending on the type of equipment, it conditions the power by improving its quality and reliability at any part of the power system. It can be used to condition the source, transmitter or receiver of the power quality problem. It provides a barrier between electrical disturbances and sensitive electronic equipment.

The location to install power conditioners are shown in Figure 3.

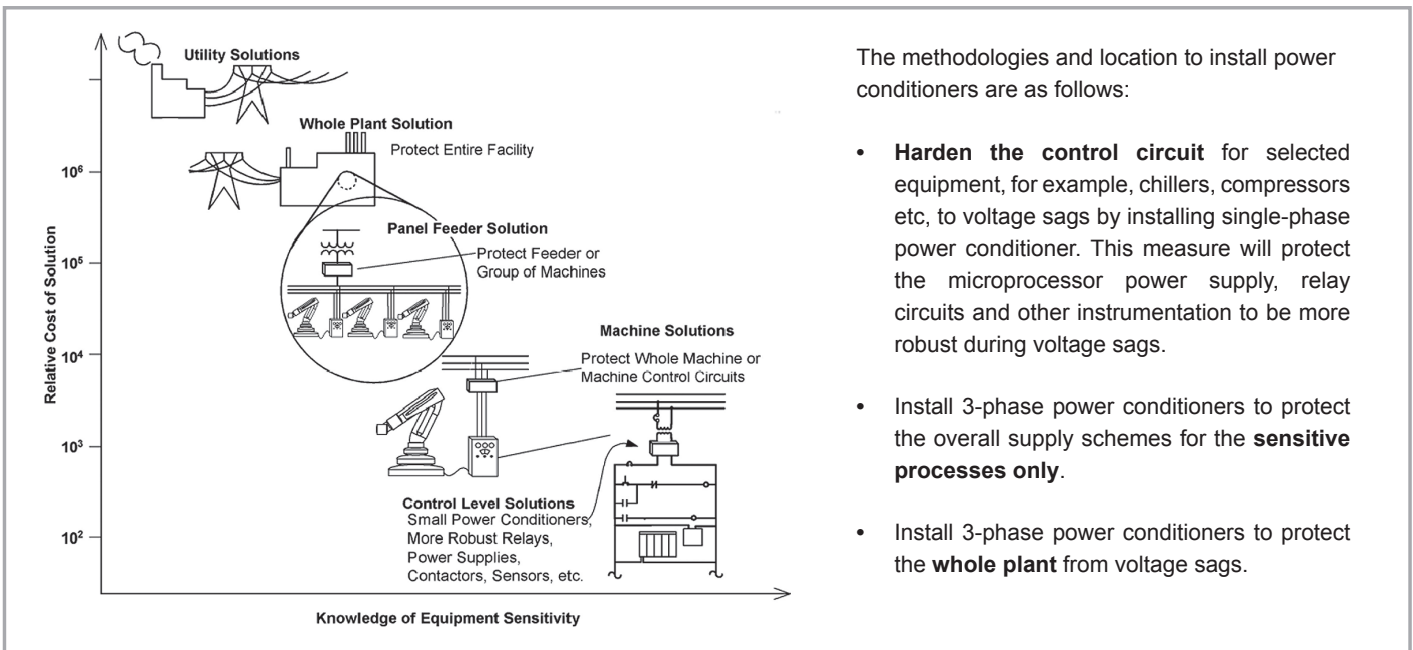
3.2 How does a power conditioner work?

Power conditioning usually involves voltage conditioning because most power quality problems are voltage quality problems. Most devices modify or condition the voltage magnitude or frequency. They employ technology to reduce the effect of transient, voltage sags and steady state voltage change or isolate sensitive equipment from disturbances.

The main types of voltage conditioners include voltage regulators and tap changer of various types, ferromagnetic devices, harmonic filters, solid-state surge suppressors and static VAR compensators. Other types of power conditioners include devices that provide alternative sources of energy. These devices include devices for energy storage or for switching to alternative sources.

Solid state switches provide an alternative source of energy by quickly switching from a power supply feeder to an alternative feeder during a disturbance. Energy storage systems include batteries, capacitors, superconducting magnets and flywheels. All of these technologies will provide some form of isolation to the sensitive loads during occurrences of power quality disturbances.

In this article, the focus will be on the use of power conditioning equipment in improving equipment immunity to voltage sags. The choice of a power conditioning equipment by a customer will depend on



The methodologies and location to install power conditioners are as follows:

- **Harden the control circuit** for selected equipment, for example, chillers, compressors etc, to voltage sags by installing single-phase power conditioner. This measure will protect the microprocessor power supply, relay circuits and other instrumentation to be more robust during voltage sags.
- Install 3-phase power conditioners to protect the overall supply schemes for the **sensitive processes only**.
- Install 3-phase power conditioners to protect the **whole plant** from voltage sags.

Figure 3: Location to install power conditioners

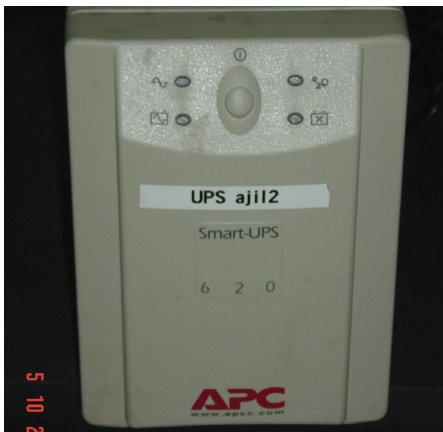


Figure 4: Uninterruptible Power Supply (UPS)

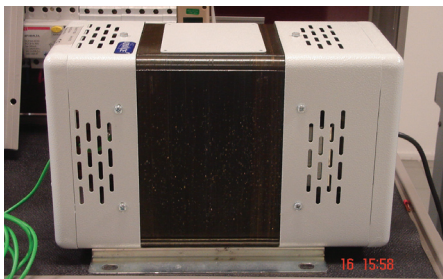


Figure 5: Constant Voltage Transformer (CVT)

power conditioners in several articles starting with the power conditioners recommended for control level solutions (refer to Figure 3).

4.0 Single-phase power conditioners for control level protection

4.1 Uninterruptible Power Supply

Installing an uninterruptible power supply (UPS) on a computer, programmable logic control (PLC) or controls to switch to battery during a voltage sag or interruption will minimise process interruption. The downside to this approach is the battery. As an example, lead acid batteries have the following disadvantages: a) generates hydrogen gas, must be ventilated, b) battery lead is a hazardous waste, and c) battery life is limited and decreases rapidly when cycled often. An advantage is that the UPS will ride through not only sags, but also momentary and extended interruptions (0% voltage) up to the limit of the battery capacity, about 5-10 minutes.

4.2 Constant Voltage Transformer

Most voltage-sag solutions can be handled by ferroresonant transformers. These power conditioners are also known as constant-voltage transformers (CVTs). CVTs are ideally suited for constant, low-power loads. Unlike conventional transformers, the CVT allows the core to become saturated with magnetic flux, which maintains a relatively constant

output voltage during input voltage variations such as under voltages, over voltages and harmonic distortion.

Installing a ferroresonant transformer (CVT) on a computer, programmable logic control (PLC) or controls will provide sag ride through capability. They also provide the filtering of transients. A CVT will not ride through a momentary or sustained interruption. They have no moving parts, no battery and are very reliable. Another consideration when sizing a CVT is the load characteristic. A CVT must be sized for the maximum load.

When the transformer is overloaded, the voltage will decrease and collapse to zero at approximately 150% of loading. Therefore, if the load profile includes an inrush current or a starting motor, the transformer must be sized for this transient load, not the steady-state load. CVTs provide voltage sag ride-through of 25% voltage for one second and also filter spikes, but they are not able to protect against interruptions, either momentary or sustained. CVTs are often used for relatively constant, low-power loads, and have the advantage of lower operating and maintenance costs than UPS, because the former do not require batteries. ■

To be continued in the next article (Part 2). The next article will focus on other single phase power conditioners for example the DPI, VDC, DYSC etc.

the technical and economic considerations. A general and neutral assessment will be given on each of the available power conditioning equipment in Malaysia. I believe this information will enable customers to make the right choice in the purchase and installation of the equipment. Due to the limitations of writing space, I will present the description of all the