UPS: On the Power Quality Frontline

This is the first part of a yearlong series that will cover the basic power quality, engineering and code issues involved in designing and specifying uninterruptible power supply systems.

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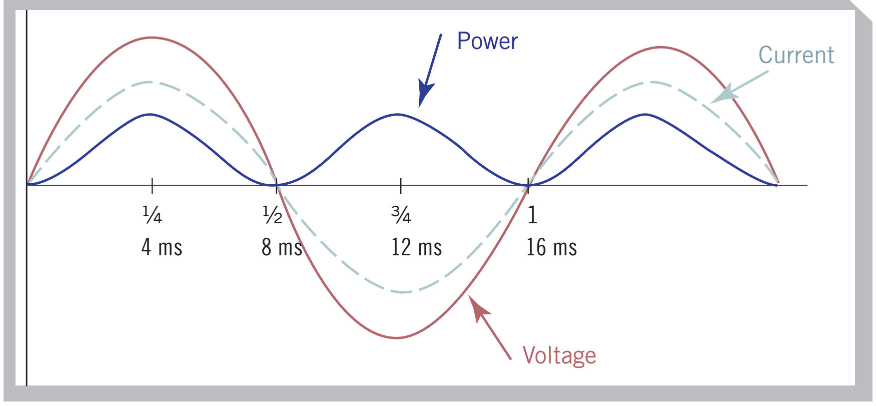
A UPS is typically installed between a power supply and a critical load to prevent power anomalies from affecting that load. UPS can be classified under one of three technologies.

OFF-LINE

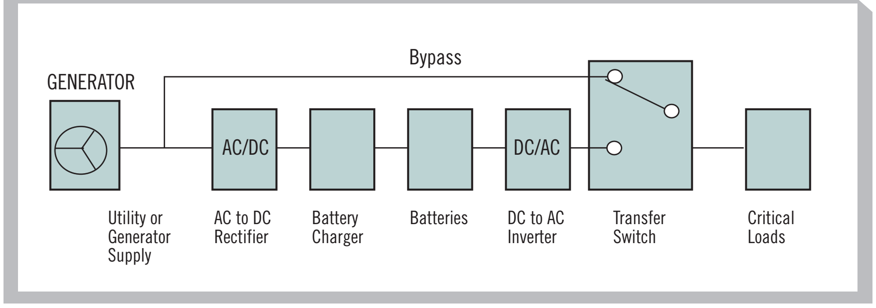
Off-line UPS systems use a transfer switch for a system bypass. They also include a rectifier (to convert AC to DC), a battery charger, a battery and an inverter (to convert DC to AC) as in Figure 2. Off-line UPS are also referred to as standby power supplies (SPS).

The system normally runs in bypass mode—no current running through the rectifier, battery and inverter. When it senses an anomaly, the transfer switch switches position and starts to draw power. In this scenario, protection is

[Figure 1]



[Figure 2]



available only when the serving voltage dips to a predetermined level.

Some off-line UPS come with integrated transient voltage surge suppressors (TVSS), and some have optional built-in power line conditioners to protect against electrical line noise, power brownouts and voltage sags only when the battery is delivering power to the critical loads. In a surge event, a SPS passes overvoltage directly to the critical load until the voltage reaches a predetermined level, typically at 115% to 120% of nominal voltage. It often protects less critical applications.

The time required for the inverter to come online is typically called the switchover time. While some computer manufacturers indicate that their power supplies can handle a switching time of 50 to 100 milliseconds (ms), actual tolerances will vary. Switch mode power supplies should be able to handle a complete outage of supply voltage for up to 20 ms. Most off-line UPS claim a transfer time to battery of about 4 ms or ¼ of a cycle—well within the curve.

SPS offer the least amount of protection and are the least expensive UPS. But systems effectiveness varies.

Additional features can be added to SPS, including line filtering and other line conditioners. A toroidal transformer with a low pass series filter can provide attenuation of both normal and common mode noise.

LINE-INTERACTIVE

A line-interactive UPS is similar in functional topology to the SPS. But the former typically includes buck-and-boost transformer capability, the addition of which adds voltage regulation to the UPS. As input voltage changes from the incoming power source, the tap-changing transformer can modify the output voltage to the desired level. The line-interactive UPS uses a voltage-sensing transfer switch to draw power from the batteries when incoming power is outside of the input voltage range. The tap transformer feature compensates for power surges and sags of 20% to 30% of normal incoming voltage level without requiring the use of the batteries to regulate voltage. This provides a significant reduction in battery use.

Moreover, a line-interactive UPS typically has a few minutes of backup time when fully loaded, which is enough to ride through approximately 85% to 90% of utility power anomalies. In the event of a longer outage, software is available to provide an orderly shut down of the critical loads. In addition, UPS software can monitor and log the status of the power supply, display voltage and current draw and provide alarms for certain error conditions.

A line-interactive UPS provides good protection against high voltage spikes and switching transients.

And these systems offer adequate protection as long as the power sags are not occurring on a continuous basis. When they do, the battery system is used frequently and may not be able to recharge for a power outage.

Ferroresonant UPS systems use a saturation transformer that has three windings instead of two. Typically a transfer switch runs the inverter in standby mode. The ferroresonant transformer provides for voltage regulation and wave shaping or filtering of harmonics, and can create output voltage distortion, creating a certain amount of heat due to the inherent inefficiencies of the transformer.

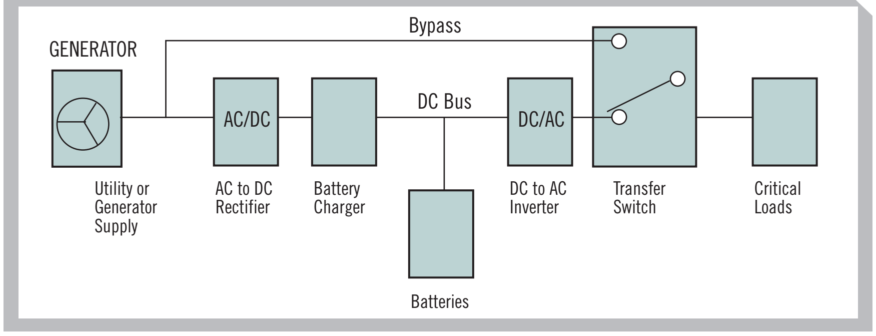
In addition, voltage deviation from the output of a standby generator from block loading or starting can cause problems with the static switch with tracking the waveform. This can cause cycling on the batteries in both standby and line-interactive UPS.

ONLINE DOUBLE-CONVERSION

Online double-conversion UPS provide the highest level of protection for critical loads. These systems use a power circuit and an inverter that changes the incoming AC power into DC power through a rectifier and reconverts the power back to regulated AC through an inverter. This collective double conversion—AC to DC, DC to AC—provides continuous power to the load both for conditioned power and protection from power outages. The batteries on the DC bus are float-charged when in normal operation. Double conversion UPS provide protection and complete electrical isolation from all types of power problems: surges, spikes, transients, sags, line noise, frequency variation, brownouts and blackouts. The major disadvantages of these systems are increased cost, increased power consumption due to losses in the rectifier and inverter, and increased heat.

Double-conversion systems rectify the input power supply, and thus, accommodate swings in supply frequency and continue to operate without going to battery. But a fully online double-conversion system can produce harmonic currents, which results from the UPS drawing power from the upstream source through the rectifier. UPS systems that give off significant amounts of harmonic distortion can cause overheating and havoc to the alternator of your standby generator. Filters and conditioners can reduce this distortion.

[Figure 3]



DELTA CONVERSION MODULES

Delta-conversion technology converts only the power difference between the UPS input and output, and always has the inverter supplying voltage to the load. Consequently, the system is not considered line-interactive. In addition, because only a portion of the load—the delta—is going through the inverter, some do not consider this technology to be truly online double conversion.

Delta conversion has some advantages over traditional double conversion, including approximate unity power factor and 200% overload capability in normal operation.

The power balance point is a node that includes three wires and follows Kirchoff's current law: Currents at a node sum to zero. The three wires are: input power from the delta transformer; output power to the load; and a connection to the main inverter that imports or exports power to the node.

Other advantages of delta-conversion are greater energy efficiency due to only rectifying the "delta" of the load based on Kirchoff current load and approximate unity power factor, i.e., kW = kVA. Also, there is low input harmonic current—less than 5%—and high power factor.

This technology does not change the frequency of the input waveform, which comes into the UPS from the serving utility or the standby generator and will be the frequency of the waveform leaving the UPS to the critical load. Additionally, because the frequency waveform is not modified, one cannot load-bus sync two different systems from two different power sources.

When determining which UPS to use for your critical system, it is important to look for additional criteria, including:

> > The output waveform should be as close to the AC sinusoidal waveform as possible.

> > Inverters should use insulated gate bipolar transistor (IGBT) technology. These devices switch large amounts of current with a small amount of control signal. Some UPS systems utilize silicon-controlled rectifiers (SCR) or bipolar transistor. IGBTs also have faster switching time, higher current capacity, increased tolerance to surges and are more energy efficient.

> > Maintenance manual bypass is essential. Without it, the UPS system acts as a single point of failure. Bypass is further improved if it uses a static transfer switch.

> > On-board monitoring equipment and software is critical. The ability to determine the percent loading, the remaining battery life and the quality of the input power is essential to ensure proper maintenance on a system.

> > Low input harmonic characteristics are important for UPS systems. The lower the input harmonic current, the more generator-friendly your UPS system will be.

> > Customer support and maintenance contracts are important, as these systems are critical pieces of an electrical distribution serving important loads, quick repair and maintenance is essential and is an important criterion in your systems availability. ⒺⓃⒹ