UPS and generator compatibility in a backup power system

Compiled by TL Martin

To protect your business from the adverse affects of power outages and load shedding requires at least a standby generator or an uninterruptable power supply (UPS) or a combination of the two.

To have a UPS covering critical loads, such as sensitive electrical equipment, backed up by a generator to supply less critical loads and to extend the backup time of the UPS system seems to be the obvious solution in most cases.

In this situation special consideration is needed to ensure that the UPS is compatible with the unique characteristics of the generator. In order to sustain compatibility it would be necessary to match the UPS to the specifications of the generator.

To calculate the size of the generator or the UPS required for a specific application seems to be a fairly straight forward task. This is true when the generator and UPS operate independently of each other. When the application requires that a diesel-electric generator is used in conjunction with a UPS, the sizing and selection of the generator for use with the UPS is complicated by the complex nature of the combined system. In a system where the generator and UPS operate in tandem certain unfavourable conditions may occur that would not normally exist when the UPS and generator operate separately.

Special care in selecting the correct generator should also be considered where a non-linear load such as variable speed drives (VSD's), soft starters and switch mode power supplies are connected to the output of the generator. The non-linear load draws non-sinusoidal current from the source, and along with notching and ringing effects, introduces harmonic distortion to the voltage wave from the source. In theory a cyclical waveform is made up of components consisting of the fundamental sine wave and harmonics that are multiples of the fundamental frequency such as the 3^{rd} and 5^{th} harmonics.

The magnitude of the distortion of the voltage waveform caused by the current drawn from a non-linear load is directly influenced by the source impedance. In power systems where generators are used for backup purposes the source impedance is not an easily defined value because the generator reactance varies with sudden load changes. Therefore the generator subtransient reactance (X"d) and subtransient short circuit time constant (T"d) are key parameters influencing distortion during the short switching period of SCR's.

In order to save on costs, when system calculations are done, the backup equipment (generator sets) are sized to supply critical and emergency loads only. For this reason these generators may have substantially greater subtransient reactance than main source transformers. Thus nonlinear loads may operate fine on utility power, but may react totally different when supplied by a backup generator set.

Harmonic distortion cause excessive heating at the generator and extreme voltage distortion across the system. The selected UPS must be able to clamp down the

distorted waveform, for this reason a UPS system that uses twelve- pulse rectification technology will provide better overall performance in a generator/UPS system than a UPS using six-pulse rectification technology. A UPS using switch-mode rectification technology will be more superior to the UPS using twelve-pulse rectification technology. Some UPS suppliers provide extra filters to reduce the Total Harmonic Distortion (THD) seen by the generator even further.

Harmonics generated by the inverter of the UPS can cause a distorted voltage waveform at the generator. Generators using permanent magnets to derive their own excitation alleviate this problem. Generators using digital voltage regulators and digital excitation controllers provide further protection against the adverse affect of harmonics caused by non-linear loads.

On the other hand this voltage waveform distortion can cause malfunction of generator sets equipped with certain types of voltage regulators, especially Automatic Voltage Regulators (AVR's) that utilize SCR's to switch and control excitation power. When connected to linear loads these AVR's provide good performance, but can fail to operate in situations where the voltage waveform is disrupted by non-linear loads.

Under normal (linear load) conditions, the AVR will sense the voltage on the output of the generator and based on that voltage level, controls the firing of the SCR's in order to control the power to the exciter. Remember a single trigger on the gate of the SCR turns the SCR on while the SCR switches off by self-commutation as the voltage waveform approaches its zero-crossing point and as a result the voltage level on the output drops. When the generator is connected to non-linear loads the "notching" and "ringing" effects of the distorted waveform causes the SCR (in the AVR) to switch off prematurely and the exciter cannot maintain the generator output (less energy is fed to the exciter). The AVR tries to compensate (increasing the voltage level) by switching on the SCR's sooner, but actually overcompensates for the problem causing the output voltage of the generator to oscillate. The AVR voltage variation results in generator terminal voltage fluctuations and subsequently real power pulsations affecting the load connected to the generator set. These power pulsations cause pulsating governor action, and oscillating frequency, which makes the problem even worse.

Due to inherent restrictions (such as rotational inertia and rate of governor response) generators fail to control the frequency in a tight band, which also adversely affects their response to altering loads. The load's reaction to frequency changes must also be considered. Under standard load conditions these relatively small frequency fluctuations are normally tolerable. Since generator and UPS controls are affected by, and react to the frequency fluctuations the affects of these fluctuations are undesirable. These frequency fluctuations could prevent the UPS from synchronizing to bypass.

In order to minimize frequency fluctuation issues it is important that the engine governor and the generator's voltage regulator are selected carefully so that they operate in accord to ensure system stability.

To deliver high quality power under all operating conditions it is necessary that the suppliers of the different technologies make an effort to solve the challenges

associated with the combined systems. This is where a consultant specializing in backup and emergency power requirements adds tremendous value.