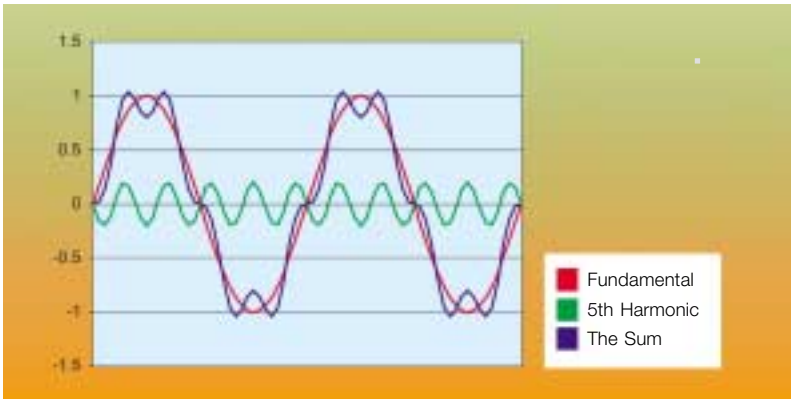
Reducing harmonics caused by variable speed drives

FACT FILE

TD2 EN REVC 2003

Technical Notes



The distorted current or voltage waveform is the sum of the fundamental (e.g. 50 Hz) wave and harmonic (250 Hz in this example) wave.

What is harmonics?

Harmonic distortion is a form of electrical pollution that can cause problems if the sum of the harmonic currents increases above certain limits. A harmonic current is one with a frequency at a multiple of the fundamental frequency, for instance a 250 Hz current on a 50 Hz network is the 5th harmonic. The 250 Hz current represents energy that cannot be used by devices on the network. It will therefore convert to heat.

What is the effect of harmonics?

Harmonics may cause cables to overheat, damaging their insulation. Motors may also overheat or become noisy and torque oscillations in the rotor can lead to mechanical resonance and vibration. Capacitors overheat with, in the most severe cases, the risk of explosion as the dielectric breaks down. Electronic displays and lighting may flicker, circuit breakers can trip, computers fail and meters give false readings.

How are harmonic currents created?

Harmonic currents and voltages are created by non-linear loads connected on the power distribution system. All power electronic converters used in different types of electronic systems can increase harmonic disturbances by injecting harmonic currents directly into the grid. Common non-linear loads include motor starters, variable speed drives, computers and other electronic devices, electronic lighting, welding supplies and uninterruptible power supplies.

How can the effect of variable speed drives be reduced?

Harmonics can be reduced either by modifications to the drive system or by using external filtering. The current harmonics depend on the drive construction and load.

Factors that increase current harmonics include:

- Large motor compared to the supply transformer
- Higher motor load

Factors that decrease current harmonics include:

- Greater DC or AC inductance
- Higher number of pulses in the rectifier

Factors that decrease voltage harmonics caused by the harmonic currents:

- Larger transformer
- Lower transformer impedance
- Higher short circuit capacity of supply

Harmonics is a consequence of the use of power electronics. It is the responsibility of the end user to ensure that harmonics are reduced to a level that does not disturb other devices on the network; users injecting harmonic currents into the network can even be fined by their utility company. ABB provides a full range of products and services to help users combat harmonics.

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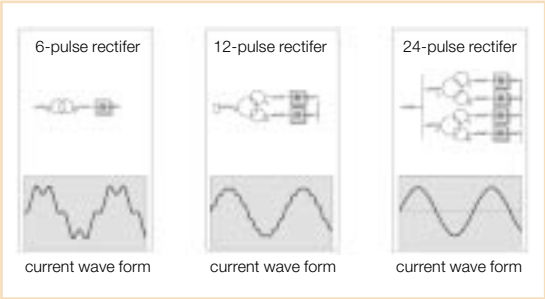
Using 6-pulse, 12-pulse or 24-pulse rectifier

The most common rectifier circuit in three-phase PWM-drives is the six-pulse diode bridge. This rectifier is rugged, robust and cheap, but the input current contains high amounts of low order harmonics.

The twelve-pulse diode bridge is formed by connecting two six-pulse rectifiers in parallel to feed the same dc-bus. This gives a smoother current waveform than the single six-pulse bridge. A drawback of this arrangement is that a special transformer is required, which adds to the cost of the drive. A 24-pulse rectifier is formed similarly by connecting four six-pulse rectifiers.



Harmonics in-line current with different rectifier constructions.

Using an IGBT bridge

An active IGBT (Integrated Gate Bipolar Thyristor) inverter can be used to rectify the incoming AC power. This allows the power factor to be maintained close to unity as the IGBT is actively modulated to reduce harmonic overtones.

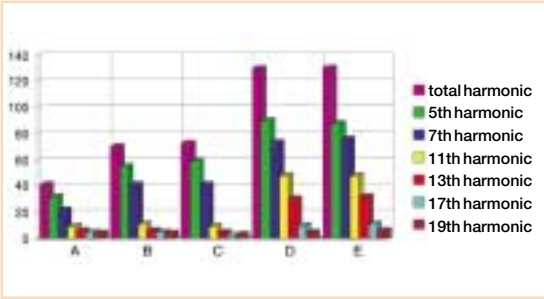
The main benefits are:

- Safe function during mains supply loss
- Accurate control across the range in rectification and regeneration mode
- Possibility to generate reactive power
- Nearly sinusoidal supply current with low harmonic content. The IGBT has very low harmonics at low frequencies, but somewhat higher at higher frequencies
- Voltage boost capability. Should the supply voltage fall, the DC voltage can be boosted to keep the motor voltage higher than the supply voltage.

The main drawback is the high cost of the IGBT bridge and extra filtering needed.

Using larger DC or AC inductor

Results from laboratory tests with drive units from different manufacturers are shown in the chart below. Drive A with large DC inductor has the lowest harmonic current distortion. Drives with no inductor installed have the highest distortion.



Harmonic current with different DC inductances.

External active filter

The active filter compensates the harmonics generated by nonlinear loads by generating the same harmonic components in the opposite phase. External active filters are most suited to multiple small drives.

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