New Harmonics Standard Makes for Easy Drive Installations

a report by
Mikko Lönnberg

Heating, Ventilation and Air conditioning Market Manager, ABB Oy

Harmonics can prove problematic for building managers, causing disruption and damage, and one of the sources is variable speed drives. A new European standard governs the generation of harmonics by electronic equipment such as drives, which are often used in building services and heating, ventilation and air conditioning (HVAC) applications. This article outlines the options for the building manager regarding what harmonics are, the effects they have and how to potentially avoid them.

Many electronic devices use direct current (DC) internally, with a rectifier converting the alternating current (AC) supplied by the network. Unless the device has an active component, it will not be concerned about the trail of destruction the return path leaves on the network, in the form of additions to the waveform that cannot be used by other devices. These additions represent energy, but because the devices cannot use them, they produce the range of symptoms described earlier. The energy is destructive and it costs money – the user still has to pay for it through the electricity bill, even though the energy is not productive.

Variable speed drives is one source of harmonics. They are used to run motors and therefore they draw a fair amount of current however, they can be isolated for countermeasures more easily than the thousands of fluorescent lights, photocopiers, personal computers (PCs) and other devices that all contribute to harmonics.

The building manager may need to seek permission from the supply utility if a site produces large amounts of harmonics. The AC driver International Electrotechnical Commission/European Standard (IEC/EN) 61000-3-2 has been around for a while and covers a multitude of small electronic equipment. However, for power electronics, a well-defined standard has long been lacking and this is what the new standard, IEC/EN 61000-3-12, is seeking to address. This covers equipment up to 75 amps (A) and will become mandatory in February 2008 for all equipment for installation in the building sector.

For the building services manager or consultant, solving the problem is simply a matter of ensuring that the drives they install in their system conform to the latest product standards regarding harmonics in buildings. Many building services consultants had a concern in the past and will now be relieved to know that there is an easy route to compliance when selecting variable speed drives for their HVAC installations.

Electronic displays and lights flickering, transformers overheating, circuit breakers tripping, fuses blowing spuriously, computers failing and metering giving false readings are all symptoms of harmonics that can be severe and serious problems can result. In addition to these symptoms transformers can overheat and may not be able to supply as planned, cables may get too hot and their insulation can break down. Motors may also overheat or become noisy. Capacitors can overheat or form tuned circuits that resonate.

Solving Harmonics Problems

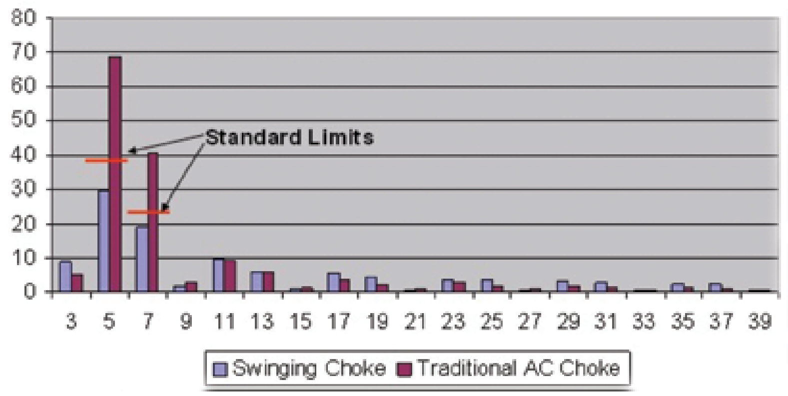
The most likely problem areas are office buildings, which will often have many PCs. Situations where most of the supply capacity is used by electronic equipment such as fluorescent lights, copier machines, drives, converters and uninterruptible power supply (UPS) systems can also be a significant source of harmonics. Sometimes, a separate network for computers, backed by a UPS, ensures a clean power supply.

In general, if the total rectifier loading on a power system that is the current drawn by one or more rectifiers comprises less than 20% of the total load, then harmonics are unlikely to be a problem. There are many sources for harmonic distortion and it can be hard to decide whether to be concerned or not. However, with the new standard, any electrical equipment is covered from the outset.

Traditional techniques used to solve harmonic problems include:

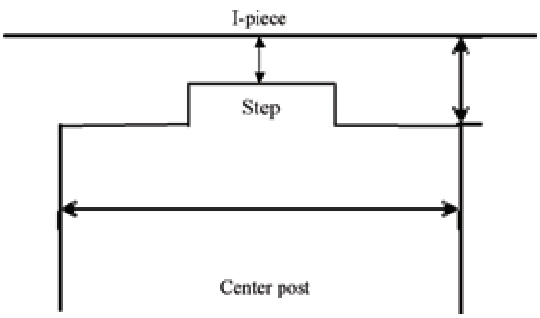
- Connecting the equipment to a point with a

Figure1: Spectrum of DC Swinging Choke and Traditional AC Choke



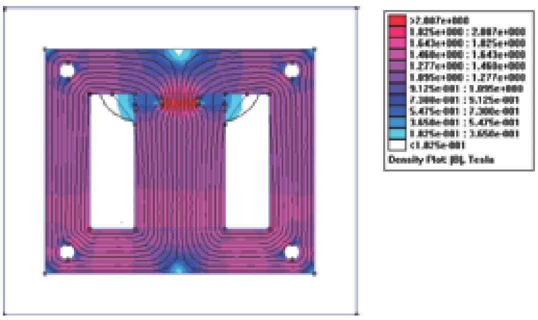
Red lines indicate the limits of IEC/EN 61000-3-12. The red and the blue indicate the actual harmonic mitigation performance of the swinging choke and traditional choke.

Figure 2: The Swinging Choke



An example of the form of the air gap.

Figure 3: Simulated Magnetic Flux Density in the Swinging Choke



low impedance – this involves connecting distorting loads to main bus bars rather than downstream of long cables that are typically shared with other equipment.

- Using drives with a higher pulse number (12–pulse or higher) – standard three-phase drives use six –pulse rectifiers; however, a 12–pulse rectifier eliminates crucial higher harmonics. A 12–pulse rectifier is formed by connecting two six –pulse rectifiers in parallel to feed a common DC bus. The transformer secondaries are in 30º phase shift, so that some of the harmonics are in opposite phase and so cancel each other out. The drawbacks include the special transformer that needs to be used, as well as a more expensive drive.

- Using three–phase drives where possible – harmonic current for a three-phase drive of given power rating is about 30% of that for a single-phase drive and there is no neutral current.

- Using additional inductance – series inductance, in the form of a coil or transformer, at the drive input gives a useful reduction in harmonic current. Some drive manufacturers include this in the design, while in other cases it can be purchased as an additional component, which must then be correctly sized and installed.

- Using a drive with an active input stage – these give exceptionally low harmonic content due a controlled supply unit and built-in filtering. They do not typically require a special transformer, but the cost of these drives is higher than for standard units.

- Using a harmonic filter – a harmonic filter can be used as a last resort. This will give the desired results but it also tends to be the most expensive solution. Harmonic filters are electronic circuits designed to block the passage of particular harmonic frequencies. They can be very effective, but a specialist supplier needs to be consulted. Active harmonic filters are also available. These avoid many of the difficulties of passive filters.

Enter IEC/EN 61000-3-12

Electricity authorities impose regulations to protect other electricity consumers from the effects of harmonics effects. These specify a level of voltage distortion that can be tolerated by correctly designed equipment and is expressed in terms of a total harmonic distortion (THD). This is measured at the point of common coupling (PCC) with other power consumers. In Europe, this is the 400V three–phase transformer.

Things are simpler if a product conforms to a relevant harmonic standard. The standard now being introduced, IEC/EN 61000-3-2, is a European harmonised product standard that governs the level of harmonic currents injected into the public supply system. Drives used in public low voltage networks, i.e. residential, commercial or light industrial buildings, are governed by this standard.

The standard EN 61000-3-12 applies to particular products, such as an individual drive from a specific manufacturer. Ensuring the drive is approved to this standard and the manufacturer's statement of fulfilment is available, the building manager can be confident that the harmonics will not cause a problem. The limits in this international standard are applicable to electrical and electronic equipment with a rated input current exceeding 16A and up to and including 75A per phase. In kW terms, this means from 7.5 to 37kW in a three-phase system.

Partial Loads

EN 61000-3-12 only restricts the amount of harmonics at nominal load but says nothing about restrictions on harmonics at partial load, where the drive is driving the motor at below its maximum speed, such as in variable air volume (VAV) systems. All devices connected to the supply system do not operate at nominal load all the time, especially if they are variable speed drives. In rectifiers with conventional inductance capacitance (LC) filters, the harmonic increases rapidly as the load decreases.

The amplitude of the harmonic currents also decreases but not as much as the fundamental waveform. If it is possible to reduce harmonics at partial load, the harmonics in the whole supply system decreases.

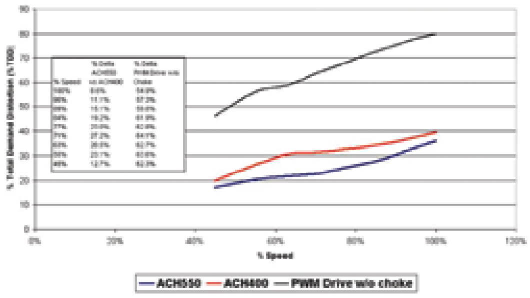
One solution offered by ABB is a swinging choke, which adjusts itself according to the load circumstances. The size and weight of the swinging choke is the same as for a conventional choke and it gives the same performance as a conventional choke at full speed. It differs from a normal choke because its inductance changes according to the current going through it (see *Figures 2* and *3*).

Since devices operating with a variable speed drive operate at partial load much of the time, reducing harmonics at partial load can lead to remarkable savings in transformer heat losses. This in turn can lead to significant cost savings and reduce flickering and heating of cables. The swinging choke design reduces harmonics, especially at partial load for a total reduction of up to 25%, compared with traditional choke designs.

The main objective of using a swinging choke in the frequency converter is to reduce the line current harmonics at partial load (see *Figure 4*). There are further benefits of a swinging choke however, it produces a slowly rising waveform with a low peak voltage, potentially giving longer life to motors by protecting the motor insulation.

In addition to being more effective than other solutions, the swinging choke does not increase the physical size or losses of the drive, and, as the great majority of energy saving drives are run at substantially reduced power for the majority of their lives, the swinging choke can be a great help.

Figure 4: ACH550 Swinging Choke: %TDD versus %Speed for Variable Torque Load



Fifty-five per cent less harmonics at full load, and better than 64% less harmonics at partial loads. (HVAC drives spend most of their operating hours at partial loads.)