



Fairford Electronics Soft Starters, G5/4, IEC 61000-3-12 and the Effects of Harmonics and how to alleviate these Problems

G5/4

The document G5/4 is the UK Electricity Council's Engineering Recommendations that installations are recommended to adhere with. These are only recommendations they are not a mandatory requirement. In the majority of countries world wide there should be a similar style recommendation for installations to adhere with. For each individual country investigation should be made if there are any mandatory requirements.

In the UK there are certain levels for Harmonic Voltages in 400V systems laid down in G5/4 for each harmonic, therefore for example for the 5th Harmonic the level of Harmonic Voltage allowed is 4% at the point of common coupling (PCC).

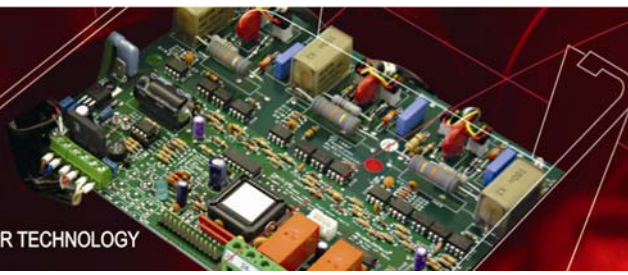
The deciding factor in any installation is how strong the actual supply is and this is determined via the supply power transformer itself and what remedies that have already been put in place to combat against Harmonics. Any measurements for investigating what levels of Voltage distortion are present should be made at the point of common coupling. The harmonic current levels may be high however if for example the supply is very strong it may have a negligible effect upon the level of Voltage distortion.

If the Harmonic Voltage levels are breached then further discussions should be held with Fairford Electronics and the local energy provider. The section following briefly describes the effects of harmonics and explains strategies of how to alleviate them.

IEC 61000-3-12

IEC 61000-3-12 is the new International IEC standard that presents some limits for Harmonics. This looks at admissible individual harmonic current as a percentage for each harmonic current in relation to the short circuit ratio of supply transformer. Without going into too much detail even in the worse case with a transformer with the smallest short circuit ratio specified the admissible individual harmonic current generated by our Soft Starters is within the limits.

Therefore as an example if we take the case of a 7.5kW motor at 16 Amps. Typically the 5th harmonic produces about 25% of 5 Amps current when operating in the Energy Optimising function using our Soft Starter; this equates to 1.25 Amps. Now with the minimal short circuit ratio (worst case) of the supply transformer in the IEC Standard stated, $R_{scc}=33$, the admissible individual harmonic current of the 5th harmonic is 10.7%. At 1.25 Amps is only a percentage of 7.8%, well within the new proposed limits.



The Effects of Harmonics

The presence of harmonic currents implies that harmonic voltages must also exist which will begin to distort the fundamental voltage waveform. In particularly adverse circumstances the voltage distortion is capable of generating high peak voltages leading to premature failure of electronic devices, motor insulation etc.

In 4-wire three phase systems such as building supplies, the three phases of the power system are 120° out of phase. Because of this, provided the 50 Hz phase currents are substantially balanced in the phase conductors, the neutral current will be close to zero. It can be shown mathematically that the neutral current, when only 50 Hz is present, will never exceed the highest loaded phase conductor. Thus, over current any protection installed in the phase conductors automatically protects the neutral conductor.

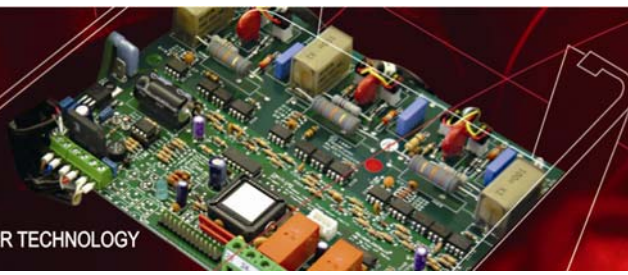
Unfortunately, when harmonic currents are present, this is no longer the case. The third harmonic of each of the three phase conductors is exactly in phase and when these harmonic currents come together in the neutral, rather than cancel, they actually add and it is possible to have more current in the neutral conductor than in the phase conductors. In this situation, the neutral conductors are no longer protected by overload protection in the phase conductors.

The harmonic currents also create heat. The heating effect over a period of time will raise the temperature of the neutral conductor. Further, the rise in temperature can overheat the surrounding conductors and cause insulation failure. These currents will also be present the supply transformer neutrals feeding the power network. This is the most obvious symptom of harmonics problems; overheating neutral conductors and transformers. Other symptoms include:

- Nuisance tripping of circuit breakers
- Malfunction of UPS systems and generator systems
- Metering problems
- Computer malfunctions
- Overvoltage problems due to standing waves on the supply network.

What can be done to alleviate these problems?

Several remedies are available to address these symptoms:-



1. Oversizing Neutral Conductors

Particularly in buildings with large amounts of 1-phase distorting equipment such as PC's etc, which employ three phase circuits with shared neutrals, it is common to oversize the neutral conductor up to 200% when the load consists of sizeable non-linear loads. In feeders that have a large amount of non-linear load, the feeder neutral conductor and distribution board busbar should also be oversized.

2. Using Separate Neutral Conductors

On three phase branch circuits, another approach is to not combine neutrals, but to run separate neutral conductors for each phase conductor. This increases the copper use by 33%. While this successfully eliminates the addition of the harmonic currents on the branch circuit neutrals, the distribution board neutral busbar and feeder neutral conductor still must be oversized.

3. Oversizing Transformers and Generators

The oversizing of equipment for increased thermal capacity for transformers and generators that serve harmonics producing loads is a possibility although this approach is much disliked by the energy providers. A more intelligent approach would be to increase the short-circuit ratio at the point of common coupling to the supply

4. Special Transformers

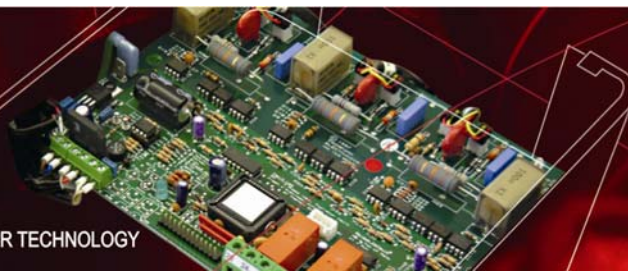
There are several special types of transformer connection that can cancel harmonics. For example, the traditional delta-star transformer connection will trap all the triplen harmonics (third, ninth, fifteenth, twenty-first, etc.) in the delta. Additional special winding connections such as the zigzag connection can be used to cancel other harmonics on balanced loads. These special transformers are often specified for buildings with well-balanced harmonic producing loads.

5. Filtering

There are two types of filter used to eliminate harmonics, active and passive. Where the harmonic load is relatively static and not likely to be changed, a passive filter or input choke, consisting of a circuit tuned to the specific frequency or frequencies being suppressed, can be placed in the phase connections to the load to reduce the harmonics to an acceptable level. These filters, because of the low frequencies involved, can be quite cumbersome and require a considerable amount of space. Further, if the impedance of the choke causes a voltage drop of more than 5%, motors controlled by VSD's may not deliver their full torque output. Due to the inflexibility of input chokes, many installers are now considering active filters that employ capacitors to 'fill-in' the missing parts of the waveform. Where loads are subject to large variations, active filtering offers the only practical alternative however; these filters are presently relatively expensive.



INNOVATION IN SOFT STARTER TECHNOLOGY

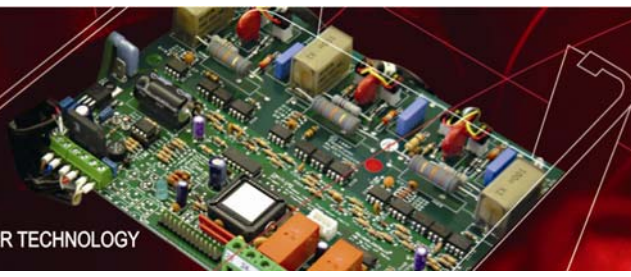


6. Specially Designed Equipment with Low Harmonic Content

Where new installations are concerned, it may be prudent to consider purchasing equipment that has an inherently low harmonic content as it operates. Particularly where high-power VSD's are to be connected to a relatively weak supply, the use of controllers with a built-in phase shifting zigzag transformer combined with a 12-pulse diode-rectifier bridge will produce a substantial reduction in the low-order (5th, 7th, etc.) harmonic levels.



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