Verifying Harmonics & Flicker Test Meters

Overview

The reasons behind the need to test for Harmonics and Flicker on the AC mains supply are presented. A number of problems with the tests are then identified. The York EMC Services HFG01 Harmonics and Flicker verification tool is described and its use outlined. Typical results obtained from the HFG01 are given. The conclusions drawn show the value of this instrument for routine verification of Harmonics and Flicker test systems and the development of the test standards.

Why test

Harmonics

When an electrical apparatus presents a non-linear load to the AC power network it draws reactive power from the supply. Most modern electrical and electronic apparatus use some form of AC to DC power supply within their architecture and it is these supplies that provide the majority of non-linear loads. Contrary to popular belief “Linear” power supplies are no better than switched mode power supplies due to the fact that both topographies draw pulses of current from the AC network during each half cycle of the supply waveform. The amount of reactive power drawn by a given apparatus, for example a domestic television, may be small. However within a typical street there may be 100 or more TVs drawing reactive power from the same supply phase, resulting in a significant amount of reactive current flow. This reactive current is not detected by the domestic tariff meter but has to be generated by the power utilities. This mismatch between the power generated and that used results in a loss of revenue to the utilities.

For 3-phase balanced apparatus, all triplen harmonics drawn (3rd, 9th, 15th etc.) flow only in the neutral conductor causing potential supply problems.

Furthermore, 3-phase unbalance can also be created within a housing scheme, since different streets are supplied on different phases. When a 3-phase system is unbalanced, the unbalance current flows in the Neutral line of a star configuration. Traditionally the neutral line within the feeder had a smaller cross sectional area than the phase conductors, as it only had to carry a residual current. However with proliferation in recent years of electrical and electronic devices containing non linear supplies, a dramatic increase of Neutral current has occurred. This current overloads the Neutral line, causing heating and, in the extreme, has been known to cause burn out of the conductor.

Due to supply line impedances the reactive current manifests itself as distortion of the voltage waveform. If co-located apparatus is sensitive to such voltage distortion an EMC problem exists.

The test for evaluating the harmonic emissions generated by an apparatus is defined within EN (IEC) 61000-3-2 for line currents up to 16A.

Flicker

When an electrical apparatus presents a changing load to the AC power network it draws fluctuating power from the supply. A good example of such an apparatus is a washing machine, since it contains electrical heaters and electric motors both of which draw significant current. As the machine runs through its washing cycle, the load presented to the supply changes as the program progresses. This changing load draws fluctuating current from the supply via the supply wiring which has an impedance. A fluctuating voltage drop is therefore seen across the supply wiring. If the wiring provides power to other electrical apparatus in the locality this fluctuating voltage can affect the function of the co-located apparatus. If the co-located apparatus is incandescent lighting, the fluctuation can manifest itself as a modulation of the light output from the luminaire, i.e. flicker.

The human eye/brain combination is especially sensitive to such light variations particularly via peripheral vision. Flicker Perception is a measure of this sensitivity and is based on the effect of supply variations at different rates when applied to a 60Watt incandescent light bulb. The response of human eye/brain combination is most sensitive to a flicker rate of about 1000 changes per minute (this equating to a square wave at 8.33Hz). In extreme cases this rate can trigger an epileptic fit in vulnerable people.

In order to make measurements of any phenomena one or more parameters have to be defined. In the case of flicker, two flicker indicators have been defined. These are Short Term (PSt) and Long Term (PLt). The short-term indicator is measured over a 10-minute period whilst the long term over a period of up to 2 hours.

The evaluation of flicker is complex and usually requires a special flicker meter. Like harmonic distortion, if co-located apparatus is sensitive to voltage fluctuations an EMC problem exists.

The test for evaluating the voltage fluctuations generated by an apparatus is defined within EN (IEC) 61000-3-3 for line currents up to 16A.

Problems with the tests

EN61000-3-2

This standard was ratified as EN60555-2 Issue 2 in November 1994 and superceded EN555-2. It was subsequently renumbered before publication as EN61000-3-2 in July 1995. There was then considerable debate as to when 61000-3-2 superceded EN555-2 for demonstrating compliance to 89/336/EEC. This was finally resolved in November 1997 by the EU commission, EMC government experts accepting the view that products outside the scope of EN555-2 need only be tested to EN61000-3-2 from January 2001.

As the standard was applied it became apparent that there were serious problems with it. These revolved around interpretation of the wording of the standard resulting in test equipment manufacturers implementing test software/firmware in different ways. The inevitable outcome of these interpretations was that different results were possible at different test houses.

An independent consultant and United Kingdom Accreditation Service (UKAS) assessor did considerable work to define the problems. The EMC Test Laboratories Association (EMCTLA) then organized a Round Robin in which a standard piece of equipment under test (EUT) was tested at a number of test laboratories. As expected this work showed considerable variation in results particularly when the fluctuating harmonic test was being performed.

It was recognized that all the interpretations of the standard were valid and so UKAS issued a Technical Policy Statement (TPS21). This document required laboratories to provide in the test report the interpretation used by the particular test equipment. This obviously did not solve the problem of different results being obtained at different laboratories and hence a manufacturer could obtain a “pass” at one lab and a “fail” at another.

In an attempt to ease the problem the European standards making body CENELEC drafted amendment A14. After 2 years of “will they, won’t they” A14 was ratified and published in double quick time for immediate implementation on 1 January 2001. This amendment dramatically changed the standard resulting in the majority of apparatus requiring testing to the benign Class A limit. There was a 3-year transitional period during which manufacturers could opt for the standard as was or with A14 applied. This period also allowed the test equipment manufacturers and test laboratories time to update their systems to implement the amendment. Subsequently the standard was issued as EN61000-3-2 (2000), this edition contained all the amendments and became mandatory January 2004.

EN61000-3-3

This standard was ratified as EN60555-3 Issue 2 in July 1994 and superceded EN555-3. It was also renumbered before publication as EN61000-3-3 in July 1995 and became mandatory from January 2001. Amendment A1 was published in June 2001, with a date of cessation of presumption of conformity to 89/336/EEC of 1/5/2004. This amendment made changes to the limits that effectively add an inrush current test at switch on. It is generally agreed within the EMC test community that most apparatus, if not fitted with a soft start, will be non compliant with this test. Again this anomaly has been investigated. The EMCTLA advice to manufacturers was to have the inrush current test performed during the transitional period thus the need for a soft start for the apparatus may be assessed.

From a practical point of view there are problems with the tests required by the standard.

With reference to figure 1 the test relies on a statistical analysis of the measured data within the Flicker meter. The person performing the test therefore relies upon the test equipment manufacturer correctly interpreting the statistics. There are however further influences that have a significant effect on the measurement. The most crucial of these is the standard impedance.

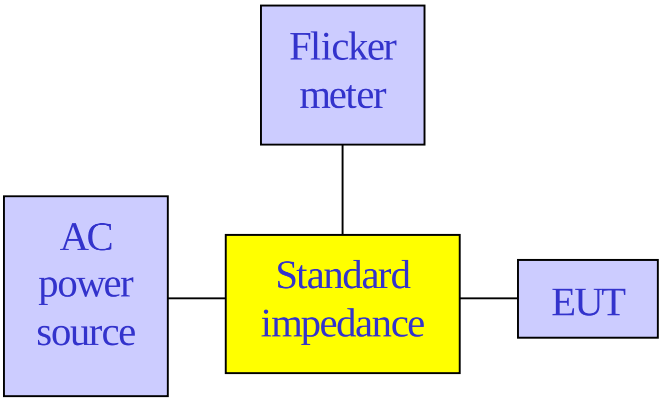

Figure 1—Test set-up

The flicker meter measures the voltage at the input to the EUT and then calculates various parameters from this value. Therefore the absolute accuracy of the impedance is important since the voltage drop across the impedance is directly proportional to its value. There is no tolerance specified, but the uncertainty of the measurement must be no greater than 8%. The nominal value of the impedance is 0.47-ohm, hence minor changes within the system can have significant influence over its actual value.

The stability of the impedance both long term due to aging and short term due to ambient temperature have to be considered. More important perhaps is the change of impedance, due to self-heating of the components making up the complex impedance. These components can potentially carry 16A and so have to be rated accordingly. Finally the wiring and the non-zero source impedance add to the nominal value of the impedance, increasing the error in the measurement.

Solutions

The need for verification.

With the problems associated with these tests it is beneficial to have a means of verifying the test system. These verifications should enable any gross errors between systems to be spotted and track any drift within a system. Some commercially available systems have an in-built verification capability. If, however, these verifications do not use an independent “reference” then errors may be masked. Use of a “Standard” EUT overcomes the objection to the in-built system. In response to this need York EMC Services designed a standard EUT for its own use. The HFG01 is the result of this in-house development and is now available to the EMC testing community.

The HFG01

Figure 2—Harmonic & Flicker Generator HFG01

The HFG01 provides a simple and quick method of verifying Harmonics and Flicker test systems. It must be stressed that the HFG01 is not intended as an absolute standard for calibration. During development however an HFG01 was measured by NPL. And stable, repeatable results obtained.

The HFG01 modes of operation.

The HFG01 simulates equipment under test (EUT), generating known, repeatable levels of harmonic and flicker disturbance in one of four modes of operation.

In Steady State harmonics (SS) mode, a harmonic-rich current waveform is generated, allowing the harmonic measurement system to be verified. In this mode the generator simulates Class D equipment and produces harmonic levels that will fail the EN/IEC61000-3-2 Class D limits. This mode will pass EN/IEC61000-3-2 Class A limits.
Fluctuating harmonics (FL) mode alternates between two distinct current waveforms over a 10s cycle.

In flicker test mode, a fixed level of mains disturbance is generated at a rate of 8.33Hz or 1Hz. When tested to EN/IEC61000-3-3, the 8.33Hz rate produces a stable Pst value >1, which lies above the limit line. The 1Hz setting produces a Pst value <1, which falls below the same limit.

The instrument is a standalone device and requires no additional equipment. The four modes of operation are user selectable by a front panel rotary switch.

Summary.

The HFG01 is a simple tool for verifying Harmonics and Flicker test systems. Its use will enable test houses and manufacturers with their own Harmonics and Flicker test equipment to verify and maintain the performance of their system.

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HFG01 Typical Results

Steady State (SS) Simulated Class D EUT

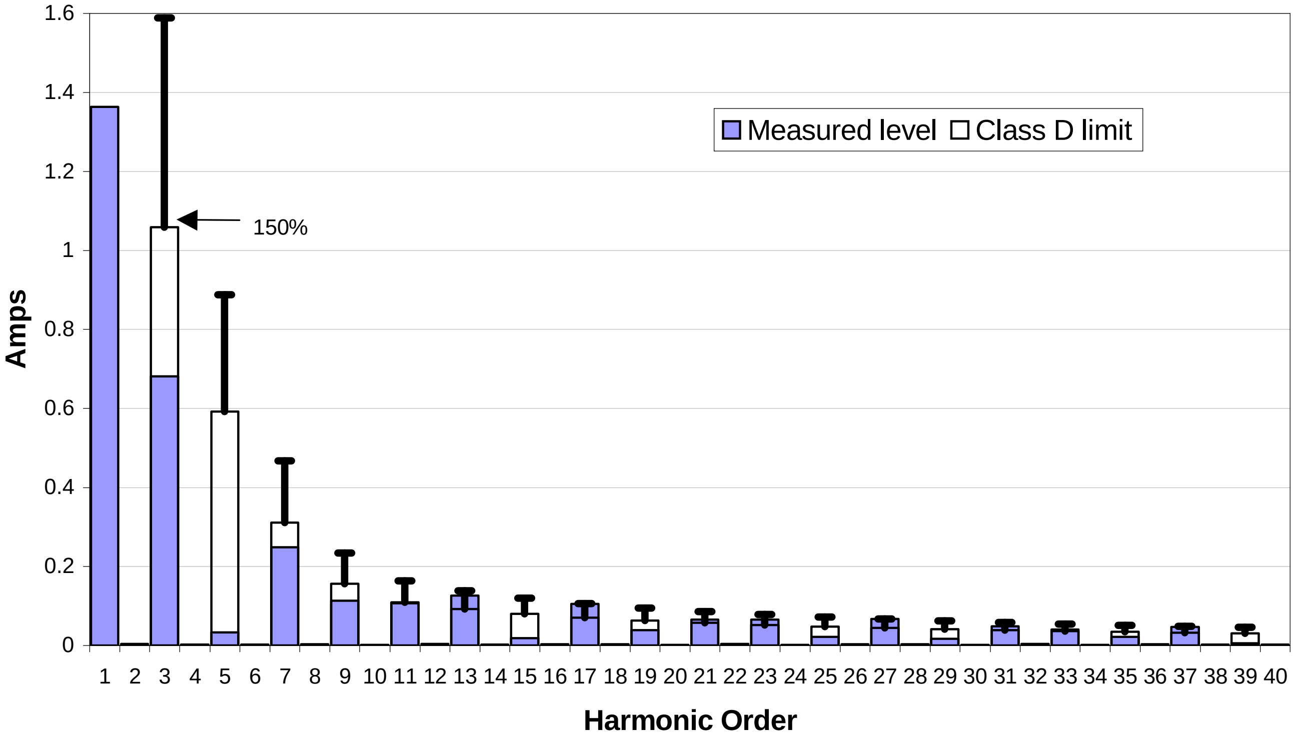

Figure 3—EN61000-3-2 (1995) Class D Fail.
(Harmonic 27 >150%)

EN61000-3-2 (2000) Class D Fail
Some odd harmonic averages are above the limit

Fluctuating Harmonics(FL) Alternating between Class A and D

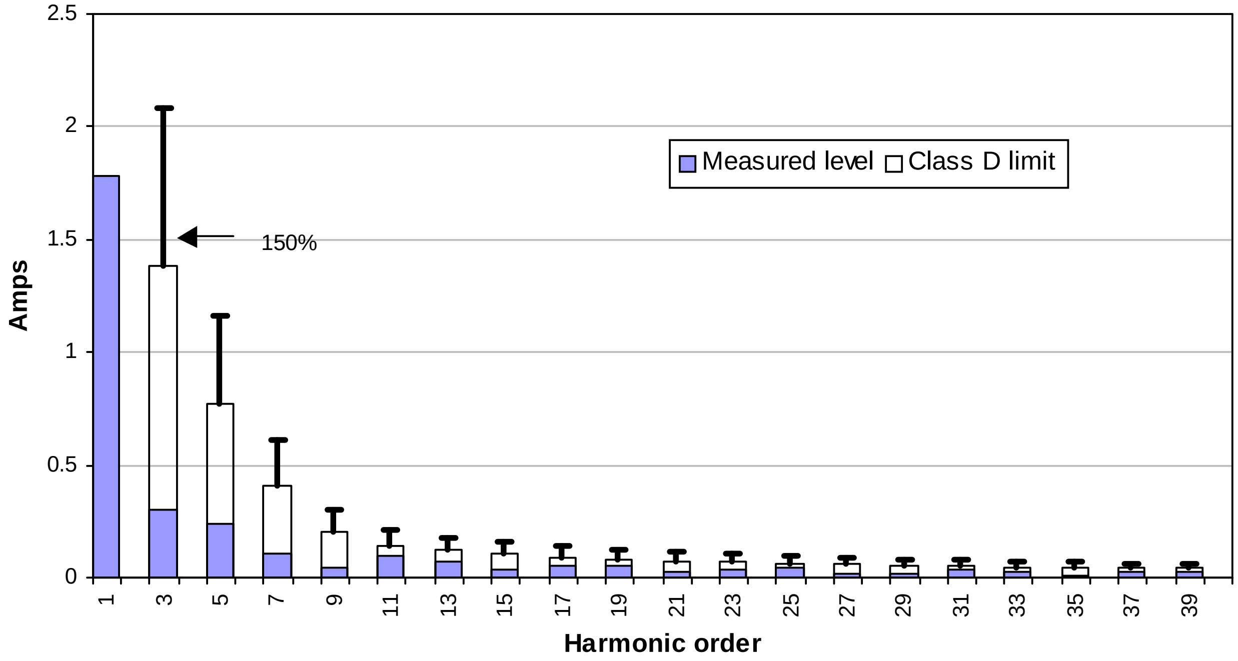

Figure 4—High State (Class A)

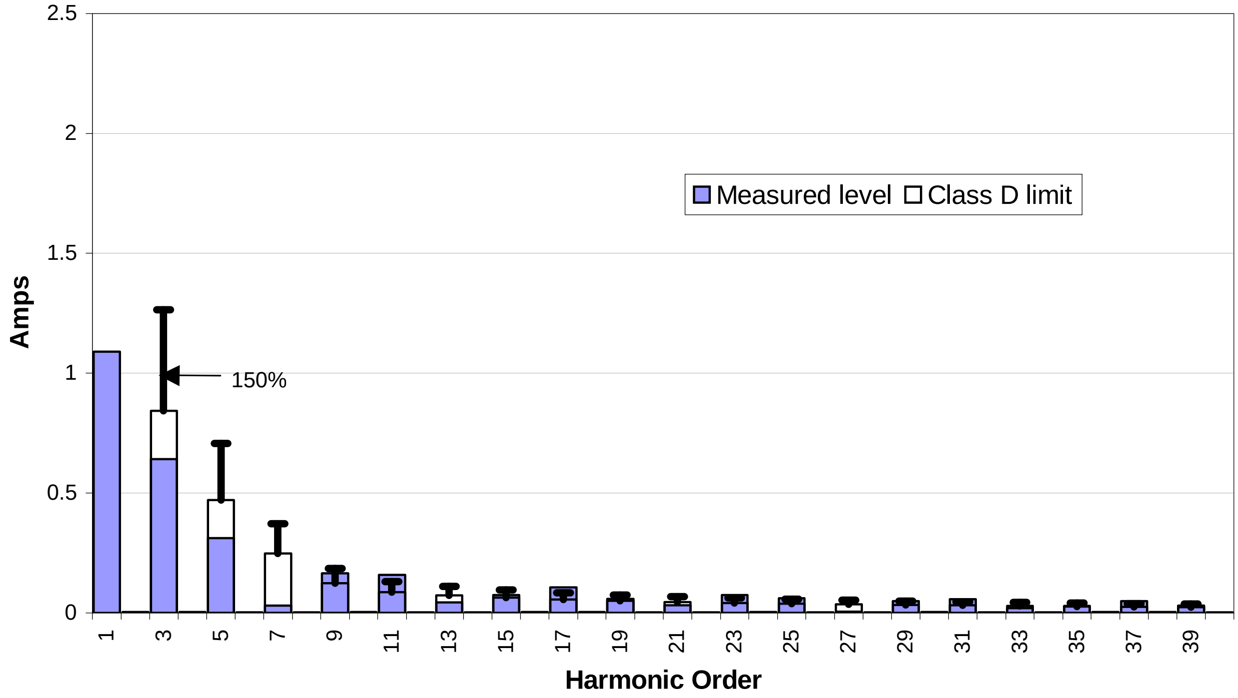

Figure 5—Low state (Class D)
EN61000-3-2 (2000) Class D Pass
EN61000-3-2 (1995) Class D Fail