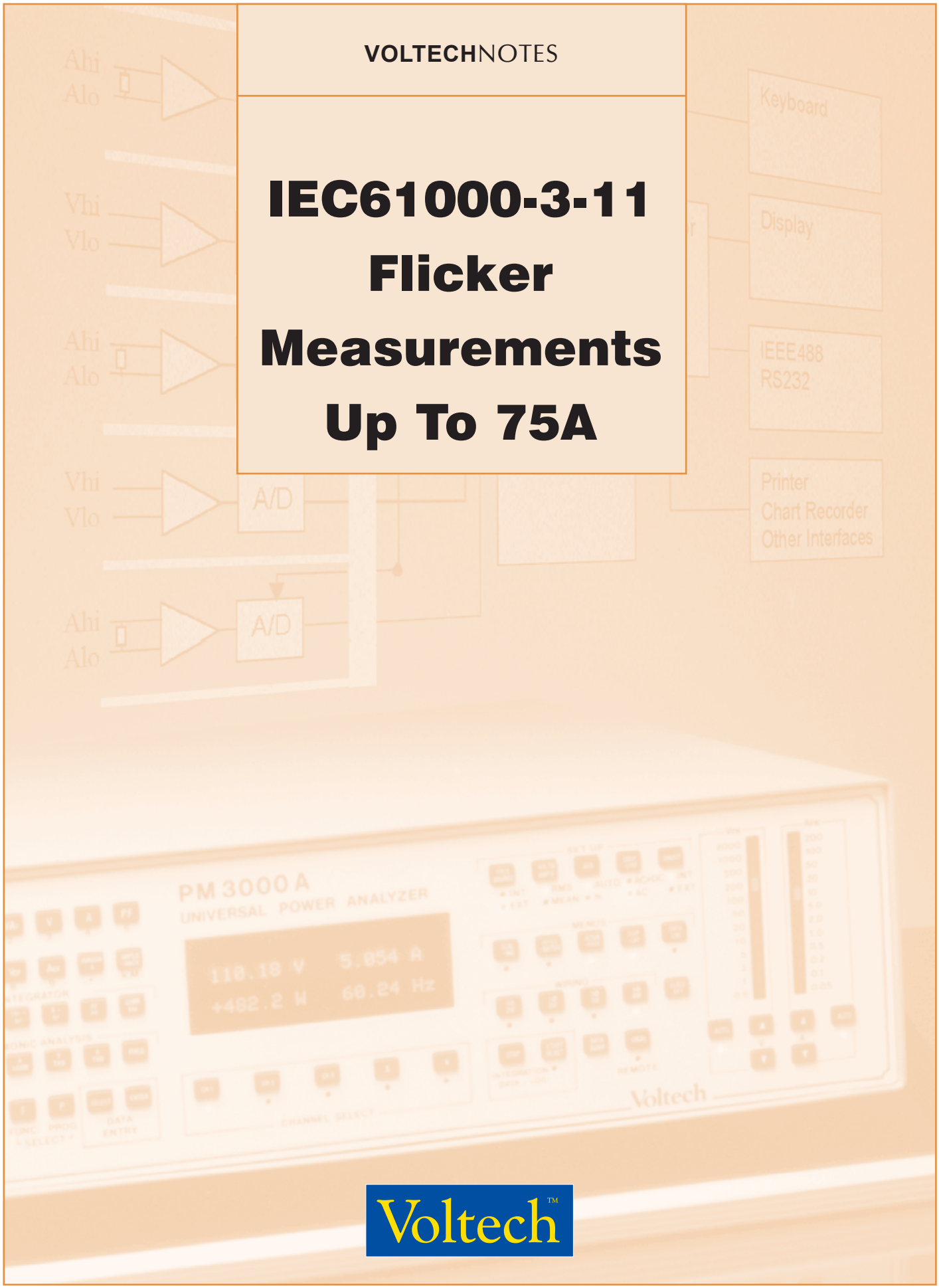
VOLTECHNOTES

IEC61000-3-11 Flicker Measurements Up To 75A



Voltech™

VPN 104-152/1

IEC 61000-3-11
Flicker Measurements Up To 75A

Introduction

The legislative requirement to measure harmonics and flicker on equipment rated up to 16A rms is well known to organizations selling any type of electrical and electronic equipment in the European Community. The IEC Standard 61000-3-11 is a relatively recent addition to the 61000 series of standards and defines testing methods and limits for the flicker and voltage changes for equipment rated up to and including 75A.

This technical note describes practical test strategies for making measurements in accordance with the 61000-3-11 standard.

Background

The standard is concerned with limiting voltage changes that are imposed by equipment onto the electricity supply. The term flicker is derived from the fact that a standard filament lamp can be seen to flicker if its supply voltage undergoes momentary changes.

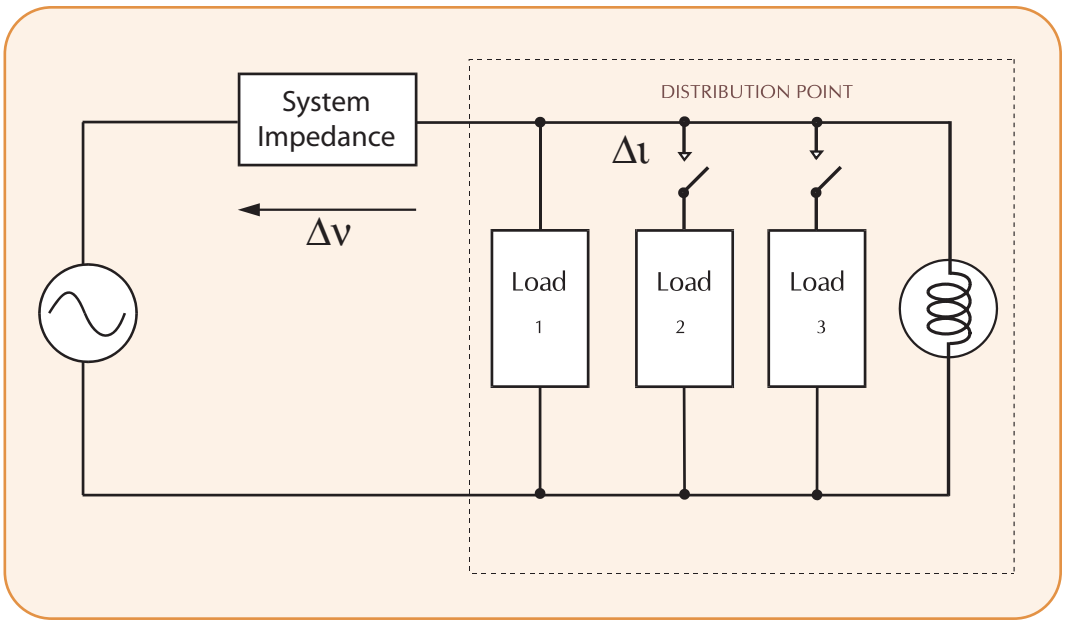


Figure 1. Changing load and lamp on the same supply circuit.

Flicker and voltage changes are measured using a flickermeter. The device under test (D.U.T.) is connected to an ac supply via a series impedance. The flickermeter measures the changes in rms voltage across the D.U.T. every half cycle (10ms @ 50Hz) and applies the weighting filters and statistical methods described by the standard to those changes in order to provide a measurement of flicker.

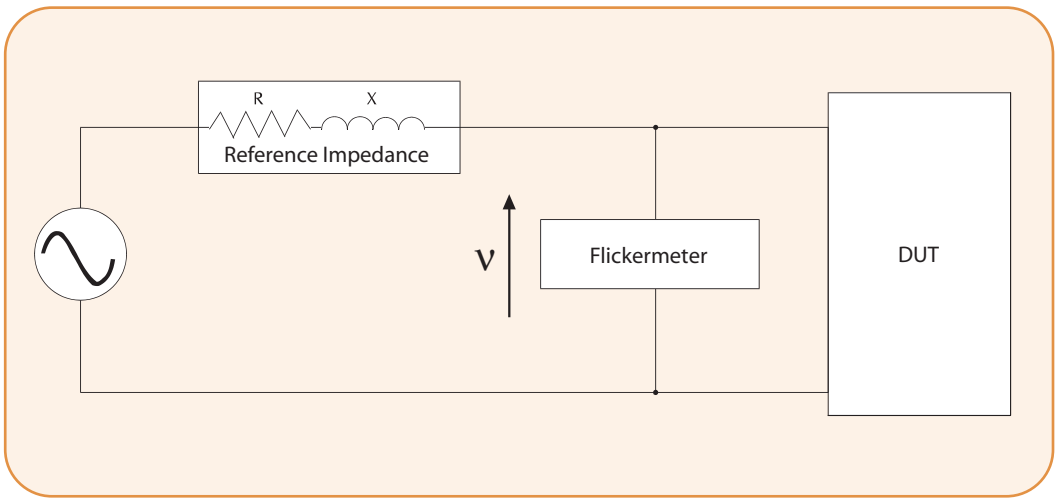


Figure 2. AC source, test impedance, DUT and flickermeter.

Flicker is measured in units of perceptibility, P. The filters of a flickermeter are designed to duplicate the way in which human beings perceive voltage changes when viewed via a filament lamp and the human eye and brain. For example, the most annoying repetition rate for changes is at 8.8Hz, whilst changes at above 35Hz have very little effect.

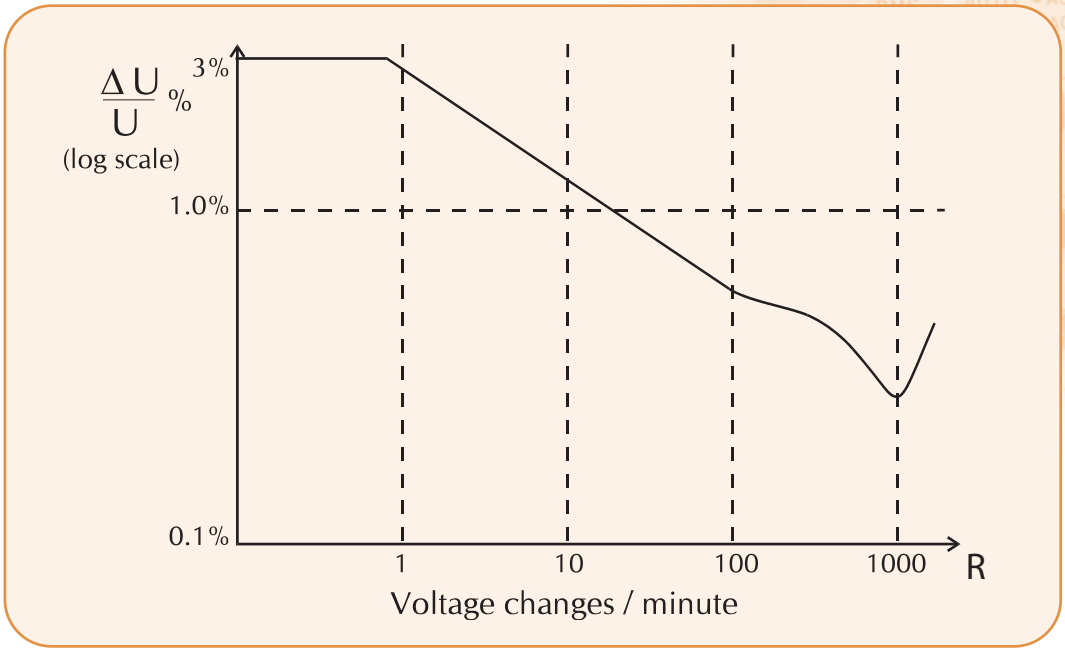


Figure 3. Pst = 1 curve for repetitive rectangular changes.

Relationship to 61000-3-3 (Flicker ≤ 16A)

Equipment rated at up to and including 16A must be tested to 61000-3-3. Equipment that does not meet the requirements of 3-3 may be tested to 3-11 but will then be subject to conditional connection, as described later.

The 61000-3-11 (≤75A) standard uses the same methods, limit types and flicker-meter of 3-3 (≤16A) but recognizes that a high current version of the test impedance must be used.

Compliance Testing to 3-11

This section refers to, and should be read in conjunction with, the 61000-3-11 standard. There are three possible routes to compliance with the 3-11 standard:

1) Clause 6.2.1. Compliance to the requirements of 61000-3-3.
   - Test with a suitable reference impedance. (Reference impedances are discussed later).
   - Factor the results according to the ratio between the actual reference impedance and the ideal.
   - If the results meet the limits of 3-11, then you may declare that the product "meets the technical requirements of IEC 61000-3-3".

   For: Clear result. No concerns over connection impedances. Can use practical test impedance.

   Against: Requires a suitable test impedance. No allowance in the limits for higher current product.

2) Clause 6.2.2. Declare a maximum system impedance for connection.
   - If the product fails to meet the requirements of 3-3 as above, then calculate the maximum system impedance that may be used when the product is connected for use.
   - This maximum impedance must be declared on the product and in its user manual. It may be necessary to discuss the installation with the electricity supplier.

   For: Can use a practical test impedance.

   Against: Requires a suitable test impedance. Conditional connection.

3) Clause 6.3. Test using a specified impedance. System capacity must be >100A.
   - The test impedances 0.25 + j0.25 (single phase) and 0.15 + j0.15 (three phases) are specified.
   - The limits of 3-11 are applied to the results of testing on the specified impedance.
   - If the limits are met, the product must be marked as suitable for use only

if the service capacity is greater than 100A.

For: Well defined test impedance. Lower impedance means product is more likely to pass than in route 1.

Against: Conditional connection. Modify product or use routes 1 and 2 above if the test fails.

Test Impedance for Flicker Measurements

The test impedance is designed to provide realistic and measurable voltage changes when used to measure flicker, as shown in figure 2.

The impedance is defined to be a complex one, consisting of both resistive and inductive elements. The 61000-3-3 impedance is called Z_{ref} in 61000-3-11 and consists of 0.40 ohms resistive in series with 0.25 ohms inductive at 50Hz.

Z_{ref} = 0.40 + j 0.25

The magnitude of the impedance or $|Z_{ref}| = \sqrt{0.40^2 + 0.25^2} = 0.4717\Omega$

	Single Phase	Three Phase
IEC 61000-3-3 Z_{ref}	0.40 + j0.25	0.24 + j0.15
IEC 61000-3-11		
Clause 6.3 (100A Capacity)	0.25 + j0.25	0.15 + j0.15

Clause 6.2 Impedance

For testing to clause 6.2, either the 3-3 Z_{ref} or a more practical lower impedance may be used. If a lower impedance is to be used, it must meet the following requirements:

1. The voltage drop caused by the D.U.T. "shall be within the range 3% to 5% of the test voltage".
2. The ratio of inductive to resistive components "shall be within the range 0.5 to 0.75".

For example, a product that draws a nominal 30A (single phase) is to be tested.

Now it is possible to calculate, design and construct an impedance for every possible case but it is more convenient to use readily available parts. The Voltech single-phase 61000-3-3 impedance consists of 0.40 ohms resistive in series with 0.25 ohms inductive.

Wiring two impedances in parallel will give a total impedance,

Z_{test} = 0.2 + j0.125 ohms.

$|Z_{test}|$ = 0.236 ohms.

1. Voltage drop.

   30A = 30 x 0.236 = 7.08 V

   Voltage drop (%) = (7.08 / 230) x 100% = 3.08%

   The nominal working current (30A) of the D.U.T. has been used in this calculation to obtain a realistic and practical impedance. The accuracy and resolution of the flickermeter in the Voltech PM3000A power analyzer is in excess of the requirements of the standard, so impedances creating a percentage voltage drop in the region 1 to 3% may also be used with confidence.

2. Ratio of inductive to resistive components = 0.125 / 0.2 = 0.625

   (Using multiples of existing 61000-3-3 impedances will always give the correct ratio).

Connecting Voltech 61000-3-3 Impedances in Parallel

Impedances for 61000-3-11 testing using multiple single-phase impedances:

	Current per phase	Single Phase	$\|Z_{test}\|$	Three Phase
1	< 18.75A	Standard 61000-3-3 impedance	0.4717	3 x item 2
2	18.75 < 37.50A	2x Z_{ref} in parallel 0.200 + j 0.1250	0.2359	3 x item 2
3	37.50 < 56.25A	3x Z_{ref} in parallel 0.133 + j 0.0833	0.1572	3 x item 3

Each Voltech 61000-3-3 reference impedance is carefully constructed to operate within close tolerances over a broad range of currents. Because each impedance is matched and stable, they will parallel and share current well.

The impedance is supplied in a bench instrument case, which is also suitable for rack mounting.

1. Connect the yellow 4mm rear terminal marked 'AC Source, L' on each impedance together and to the L or phase terminal of the AC Source.

2. Connect the yellow 4mm front terminal marked 'D.U.T. L' on each impedance to together and to the L terminal of the D.U.T. It may be convenient to bring this wire out to a suitably rated connector.

3. For flicker testing alone (single phase), the neutral of the DUT can be connected directly back to the N of the AC Source.

4. Ensure each item is correctly earthed and use suitably rated connectors and wire.

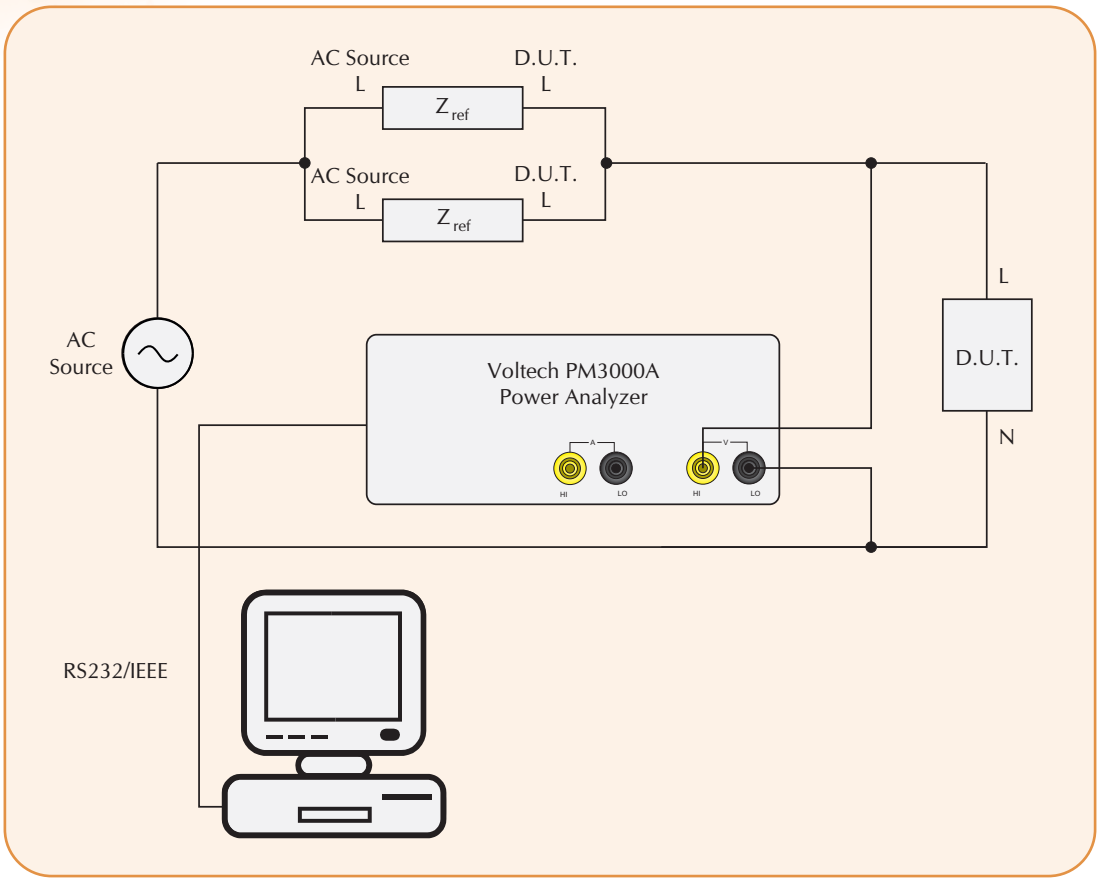


Figure 4. 37.5A Single-phase flicker test system using two Voltech impedances.

Measuring The Impedance

The impedances discussed here are relatively small, and connectors and lead lengths may have a significant impact on the overall impedance. One advantage of the clause 6.2 method of testing is that the impedance does not have to be a specific value, although it is very important to know what it is.

To measure the impedance:

1. Connect one channel of the PM3000A power analyzer to measure the voltage across the impedance and the current through it.

   Ensure that all the leads from the source up to the connection point of the D.U.T. are included within the voltage connections. To measure current in excess of 30A, use a current transformer such as the Voltech CT1000.

2. Apply a nominal load, preferably a simple resistive load.

3. Display the impedance on the PM3000A by pressing the [IMPEDANCE] and then the [FUND] keys on the front panel of the analyzer.

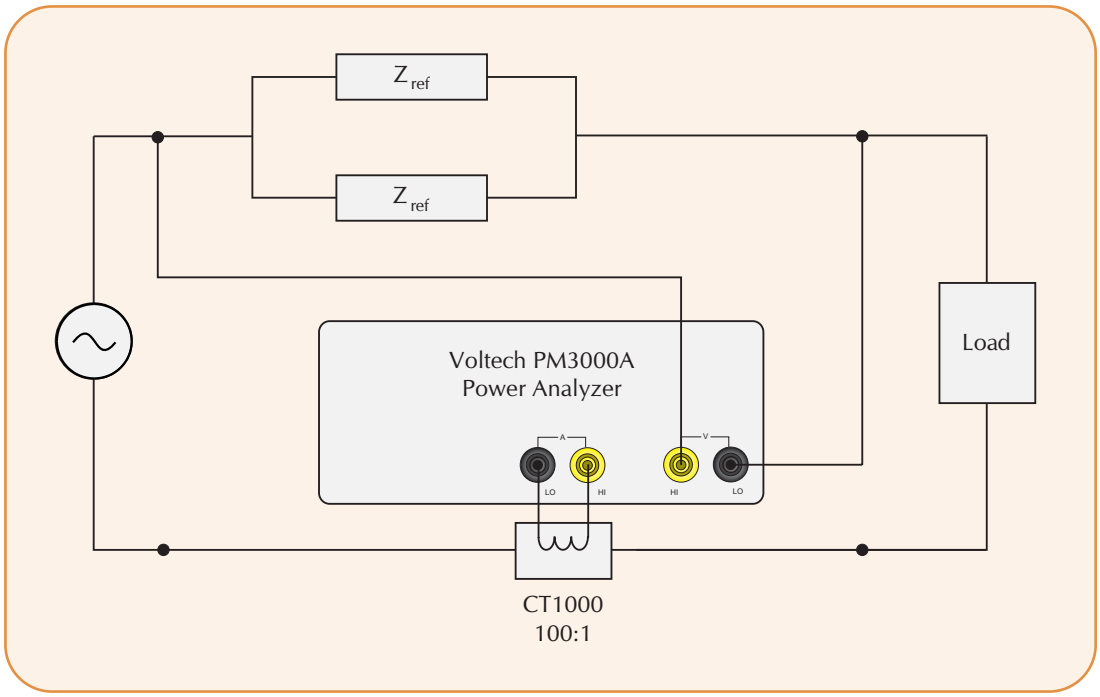


Figure 5. Measuring the flicker impedance on a PM3000A.

Test Method

Set up the AC Source, impedance, power analyzer and D.U.T. as described earlier.

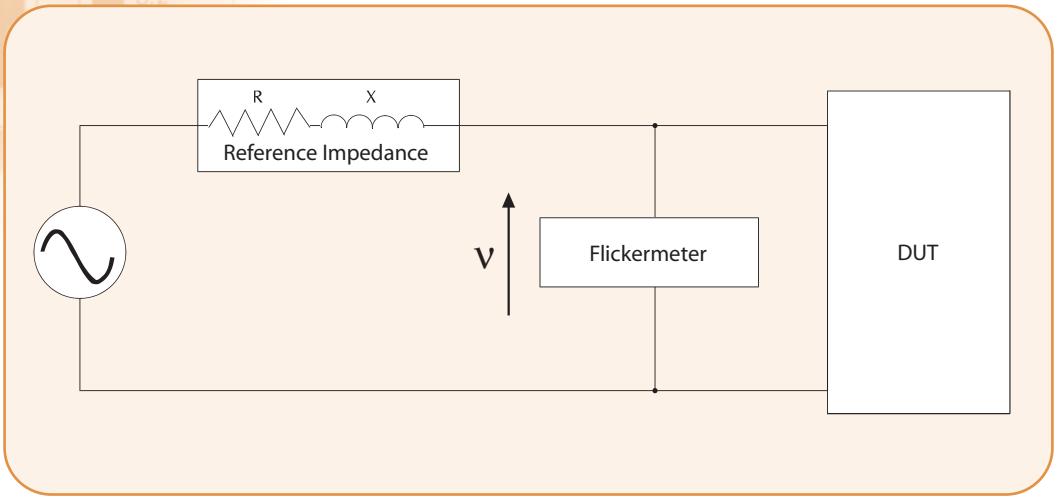


Figure 6. Compliance flicker testing.

Clause 6.3. Test

The reference impedance must be 0.25 + j0.25 (single phase) or 0.1 + j0.1 (three phase, per phase).

1) Check the value of the impedance using the procedure described earlier.

2) Run the test (P_{st} or P_{lt}) depending on the cycle of operation of the D.U.T. and apply the limits in clause 5 of 61000-3-11.

Clause 6.2. Test

Use a reference impedance as described in the earlier table.

1) Check the value of the impedance using the procedure described earlier.

2) Calculate the magnitude of the impedance.

$$Z_{test} = \sqrt{\left(Z_{real}^2 + Z_{imag}^2\right)}$$

3) Run the test (P_{st} or P_{lt}) depending on the cycle of operation of the D.U.T.

4) Modify the results according to the ratio of Z_{ref} to Z_{test}.

Z_{ref} = 0.4717Ω

$$d_c = d_{c\ test} x \frac{Z_{ref}}{Z_{test}}$$

$$d_{\max} = d_{\max\ test} x \frac{Z_{ref}}{Z_{test}}$$

$$P_{st} = P_{st\ test} x \frac{Z_{ref}}{Z_{test}}$$

$$P_{lt} = P_{lt\ test} x \frac{Z_{ref}}{Z_{test}}$$

5) Compare these modified results to the limits of clause 5 of 61000-3-11. If the limits are met, then the product "meets the technical requirements of IEC61000-3-3".

6) If the limits are NOT met, then calculate the maximum permissible system impedance, Z_{sys}, according to the following procedure:

$$Z_{sys1} = Z_{ref} x \frac{d_{\max\ limit}}{d_{\max}}$$

$$Z_{sys2} = Z_{ref} x \frac{3.3\%}{d_c}$$

$$Z_{sys3} = Z_{ref} (P_{st})^{\frac{3}{2}}$$

$$Z_{sys4} = Z_{ref} \left(\frac{0.65}{P_{lt}} \right)^{\frac{3}{2}}$$

The minimum of these values is Z_{max}.

7) The product may be connected, if the system impedance is less than Z_{max}. This is declared in the product's user manual and may have to be determined by the user in consultation with their electricity supplier.

Pre-compliance Testing

The full compliance testing methods described above use equipment and techniques that are in strict accordance with the requirements of the standard. Full compliance techniques are used by test houses and larger organizations to provide traceable certification that the tested equipment meets the standard.

Pre-compliance testing is often used during product design and development phases to provide useful measurements using a less expensive test environment. The Voltech PM3000A may be used without a reference impedance to provide very accurate pre-compliance measurements.

The PM3000A is connected as shown below. Changes in current are measured continuously every 1/2 cycle and converted, using vector mathematics, to the voltage change that would be seen across the physical impedance, if it was present. (Note: this method is quite different to simulating the impedance by programming the output impedance of an AC source. The PM3000A will make accurate dynamic measurements which the AC source control loop cannot duplicate.)

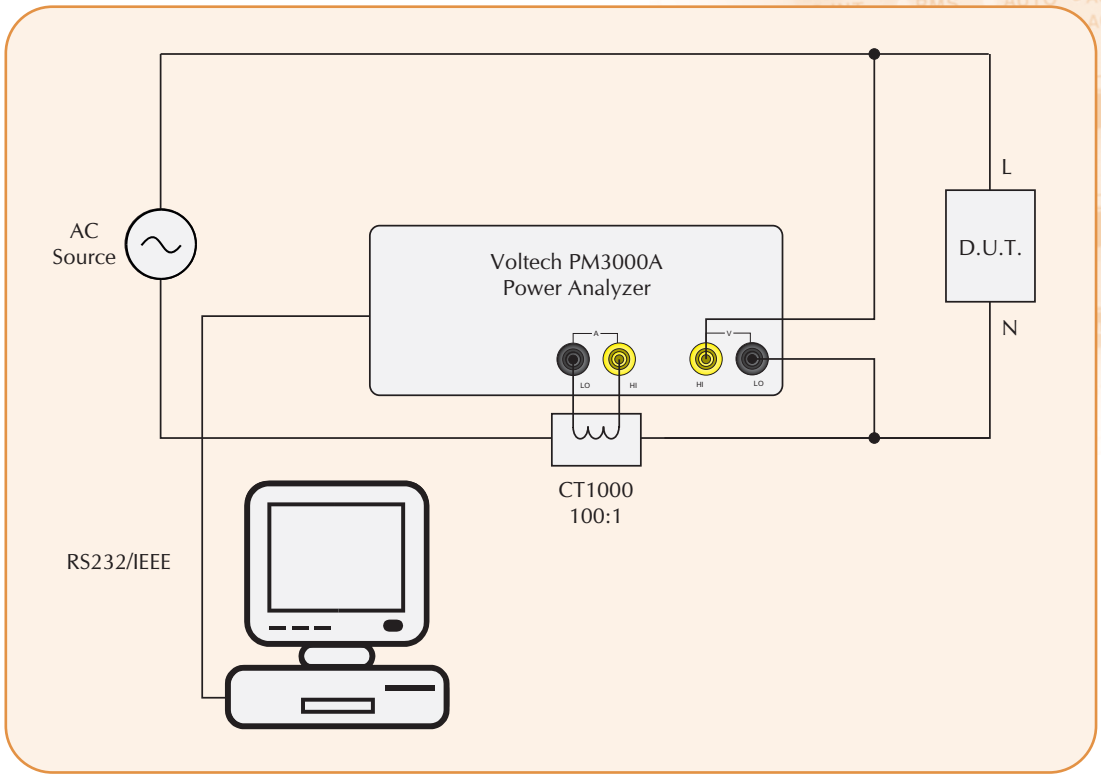


Figure 7. Pre-compliance flicker testing.

The impedance to be used in the calculation is simply entered in to the Voltech PC software.

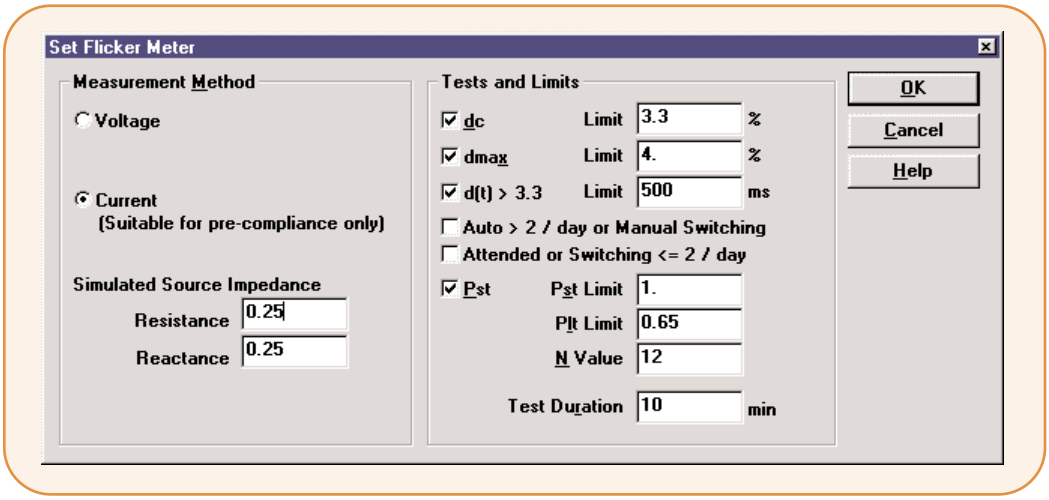


Figure 8. Voltech IEC software.

The test can then be run and limits applied as described in the previous section.

Conclusions

Products rated at up to 75A per phase for connection within the European Community should comply with the requirements of IEC61000-3-11. The requirements are very similar to those of IEC61000-3-3 which is the standard that applies to equipment rated at up to 16A. The test impedance may be lower than that of 61000-3-3 and must be rated to carry the increased load current.

61000-3-3 impedances may be connected in parallel to create impedances for 61000-3-11 testing though it is very important to measure the resulting impedance accurately.

The Voltech PM3000A and its associated PC Software may be used to make 61000-3-11 compliance measurements using the guidance given in this technical note.

Voltech IEC61000-3-3 impedances are ideal for creating 61000-3-11 impedances because of their close tolerances.

The Voltech PM3000A will make accurate measurements of 61000-3-11 impedances to ensure compliance.

The PM3000A can also be used to make very accurate pre-compliance measurements without a physical reference impedance.

References

1. This technical note is written as a guide to implementing the following standard and must be read in conjunction with it. In case of doubt, always refer to the latest available version of the relevant standard.

IEC61000-3-11:2000 Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current ≤ 75A and subject to conditional connection. Available from the IEC at www.iec.ch.

2. The Voltech IEC Software. This PC software includes extensive reference and background material to the IEC harmonics and flicker standards. Available free of charge from www.voltech.com.

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