Updates in International Standards: Harmonics and Flicker

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Updates in International Standards

Introductions, Greetings, Salutations and Disclaimers

Standards for Discussion

Required for CE-Mark

for distribution in EU nations

Many standards for Electromagnetic compatibility

We are concerned with the low-frequency requirements regarding interface with the mains public power supply:

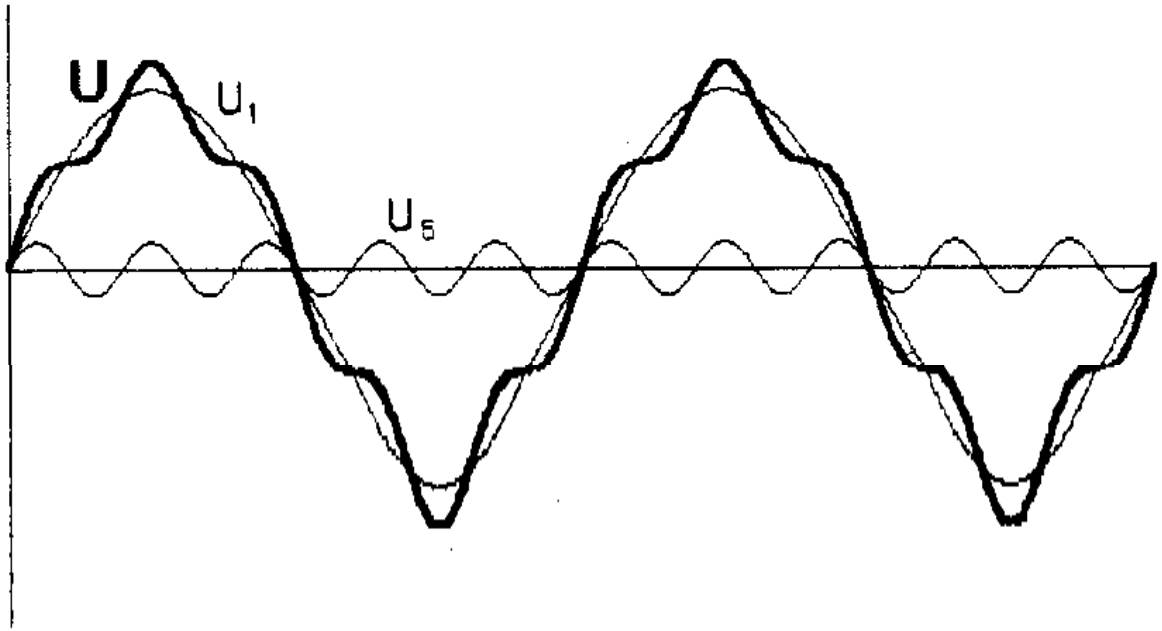
- 61000-3-2 and 61000-3-12 describe limits for harmonics
- 61000-3-3 and 61000-3-11 describe limits for flicker

- 61000-4-7 describes the measuring instrument for harmonics
- 61000-4-15 describes the measuring instrument for flicker

Harmonics

Harmonics

Sinusoidal voltages or currents having frequencies that are whole multiples of the frequency at which the supply system is designed to operate (e.g. 50Hz or 60 Hz)



Example of Fundamental, plus 5th harmonic signal

Courtesy: Mathieu van den Bergh

Harmonics

Causes:

Nonlinear loads; with current and voltage waveforms that are nonsinusoidal or that contain distortions.

These place additional waveforms onto the fundamental waveform, creating multiple frequencies within the normal 50- or 60-Hz sine wave. The multiple frequencies are harmonics of the fundamental frequency.

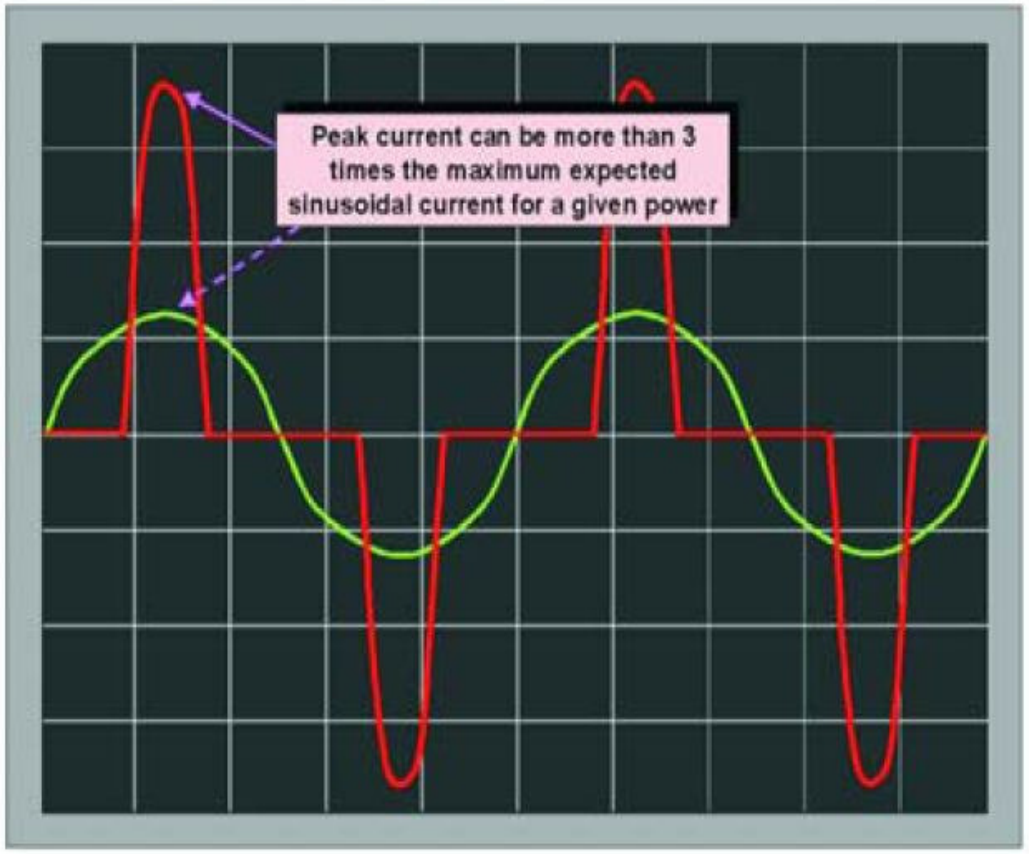
Examples include:

switching mode power supplies, battery chargers, electronic ballasts and variable frequency drives.

Harmonics

The typical rectifier-capacitor ac-dc powe converters used in 'linear' and switch-mode ac-dc power converters to create their unregulated dc voltage rails present a non-linear load to the mains supply. Since they only 'top up' their dc storage capacitors at the peaks of the ac supply waveform, their supply current consumption is discontinuous, non-sine wave, and rich in harmonic currents.

Non-linear currents in a rectifier-capacitor type ac-dc converter



Courtesy: REO

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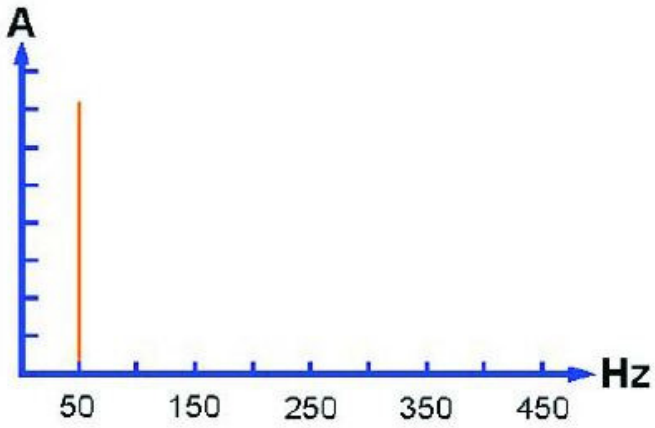
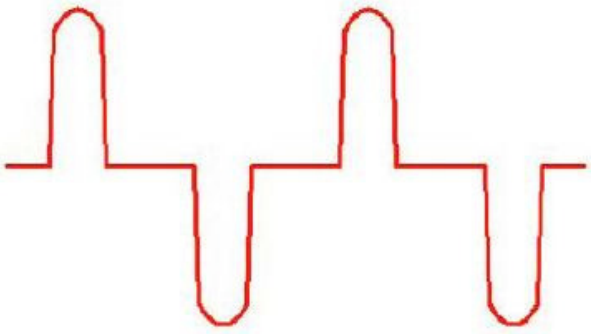
Harmonics

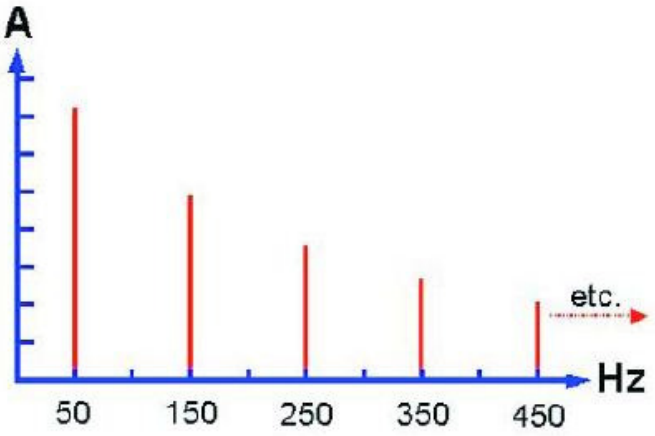
Comparison of waveforms and spectra

A sine-wave current





A typical non-linear current from a single-phase rectifier-capacitor power converter



Courtesy: REO

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Negative consequences of Harmonics:

- Neutral conductor: Overloading due to non-linear load
- Capacitors : Lower Impedance for higher frequencies results in higher thermal loading
- Motors : Additional losses & undesired vibrations
- Switches/breakers: Must be overdimensioned which may result in problems with overload detection
- Transformers: Increased losses due to changes in eddy currents.

Courtesy: Mathieu van den Bergh

Negative consequences of Harmonics:

- Conductors : Skin-effect losses/heating lower transmitted power
- Protection : Fuses melt too soon – electronic breakers do not respond at designed levels
- Electronics : Multiple zero-crossings can cause problems
- General : Additional cost due to filtering & required over-dimensioning of conductors / breakers / transformers.

Courtesy: Mathieu van den Bergh

Recent and Future Standards for Harmonics

Overview of international standards relating to harmonics and flicker.

Emmision				
EN	IEC	DOW	Valid until	OJEU
Harmonic Limits				
~~61000-3-2 Ed. 1.0 with it's ammendments (<16A)~~ Expired!				
~~EN61000-3-2:1995~~	~~IEC61000-3-2:1995~~	~~2001/01/01~~	~~2004/01/01~~	~~Yes~~
~~EN61000-3-2:1995/A1:1998~~	~~IEC61000-3-2:1995/A1:1997~~	~~2001/01/01~~	~~2004/01/01~~	~~Yes~~
~~EN61000-3-2:1995/A2:1998~~	~~IEC61000-3-2:1995/A2:1998~~	~~2001/01/01~~	~~2004/01/01~~	~~Yes~~
~~EN61000-3-2:1995/A14:2000~~		~~2004/01/01~~	~~2004/01/01~~	~~Yes~~
61000-3-2 Ed. 2.0 with it's ammendments (<16A)				
~~EN61000-3-2:2000 (2)~~	~~Modified IEC61000-3-2:2000 (2)~~	~~2008/01/01~~	~~2009/02/01~~	~~Yes~~
~~EN61000-3-2:2000/A2:2005~~	~~IEC61000-3-2:2000/A1:2001 + IEC61000-3-2:2000/A2:2004~~	~~2009/02/01~~		~~Yes~~
EN61000-3-2:2006	IEC61000-3-2:2005	2009/02/01	2012/07/01	Yes
EN61000-3-2:2006/A1:2009	IEC61000-3-2:2005/A1:2008	2012/07/01		Soon
~~EN61000-3-2:2006/prA1 (fragment 7)~~	~~77A/674/FDIS~~			
~~EN61000-3-2:2006/prA1 (fragment 8)~~	~~77A/674/FDIS~~			
EN61000-3-2:2006/A2:2009	IEC61000-7-2:2005/A2:2009	2012/07/01		Soon
61000-3-12 Ed. 2.0 (16-75A)				
EN61000-3-12:2005	IEC61000-3-12:2004	2008/02/01		Yes
	77A/705/CDV (2010/01/08)			

DOW = Date of withdrawal: The latest date by which national standards conflicting with an EN (and HD for CENELEC) have to be withdrawn
OJEU = Official Journal Of The European Union CD = Committee draft CDV = Committee draft for vote FDIS = Final draft international standard

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Harmonics Equipment Classes

Class A
- Balanced three-phase equipment
- Household appliances except equipment identified as Class D
- Tools excluding portable tools
- Dimmers for incandescent lamps
- Audio equipment

Class B - Portable tools

Class C - Lighting equipment

Class D
- Equipment having a specified power according less than or equal to 600W, of the following types:
- Personal computers and personal computer monitors
- Television receivers

Classification of devices according to EN61000-3-2/A14

Harmonics - Methodology

- In a standardized test, the test sample is fed by a purely sinusoidal and stable voltage from a power source.

- It must be made clear that the measured current harmonics come from the test sample and are not generated from the source.

- The power analyzer then measures the presence or absence of distortion and voltage stability of the source in each analysis window of 10,12 or 16 periods.

Changes

IEC 61000-3-2 A1 Ed.3: EMC Part 3-2:

Limits for harmonic current emissions: equipment input ≤ 16 A / phase

77A/625/FDIS

Distributed on 30 NOV 2007; Voting closed 1 FEB 2008

IEC 61000-3-2 A2 Ed.3: EMC Part 3-2:

Limits for harmonic current emissions: equipment input ≤ 16 A / phase

77A/674/FDIS

Distributed on 14 NOV 2008; Voting closed 16 JAN 2009

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EN61000-4-7

- Harmonic Analyzer
  - 10 period interval (about 200ms)
  - Smoothing
  - Accuracy Class I
- Actual (2009-08-26):
  - EN61000-4-7:2002
  - EN61000-4-7:2002/A1:2009

EN61000-4-7

EN	IEC	DOW	Valid until	OJEU
Harmonics Measurements				
~~61000-4-7 Ed. 1.0 (16 periods)~~ Expired!				
~~EN61000-4-7:1993~~	~~IEC61000-4-7:1991~~	~~1993/12/01~~	~~2005/10/01~~	~~No (1)~~
61000-4-7 Ed. 2.0 (10/12 periods)				
EN61000-4-7:2002	IEC61000-4-7:2002	2005/10/01	2012/03/01	No (1)
EN61000-4-7:2002/A1:2009	IEC61000-4-7:2002/A1:2008	2012/03/01		

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Flicker

IEC 61000-3-3 Ed.2: Electromagnetic compatibility (EMC) - Part 3-3: Limits

Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection

77A/644/FDIS

Distributed on 14 MAR 2008; Voting closed 16 MAY 2008

IEC 61000-3-3 cancels and replaces the first edition published in 1994, amendment 1 (2001) and amendment 2 (2005).

Flicker

EN61000-3-3

Flicker and voltage changes

Flicker is determined by the amplitude and frequency of line voltage fluctuations. Voltage fluctuations in turn occur in the mains network impedance through the repeated sudden current variations of a consumer on the network.

EN61000-3-3

EN	IEC	DOW	Valid until	OJEU
Flicker Limits				
61000-3-3 with it's ammendments (<16A)				
~~EN61000-3-3:1995~~	~~IEC61000-3-3:1994~~	~~2001/01/01~~	~~2004/05/01~~	~~Yes~~
~~EN61000-3-3:1995/A1:2001~~	~~IEC61000-3-3:1994/A1:2001~~	~~2004/05/01~~	~~2008/09/01~~	~~Yes~~
EN61000-3-3:1995/A2:2005	IEC61000-3-3:1994/A2:2005	2008/09/01	2011/09/01	Yes
EN61000-3-3:2008	IEC61000-3-3:2008	2011/09/01		Not yet
61000-3-11 (<75A)				
EN61000-3-11:2000	IEC61000-3-11:2000	2003/11/01		Yes

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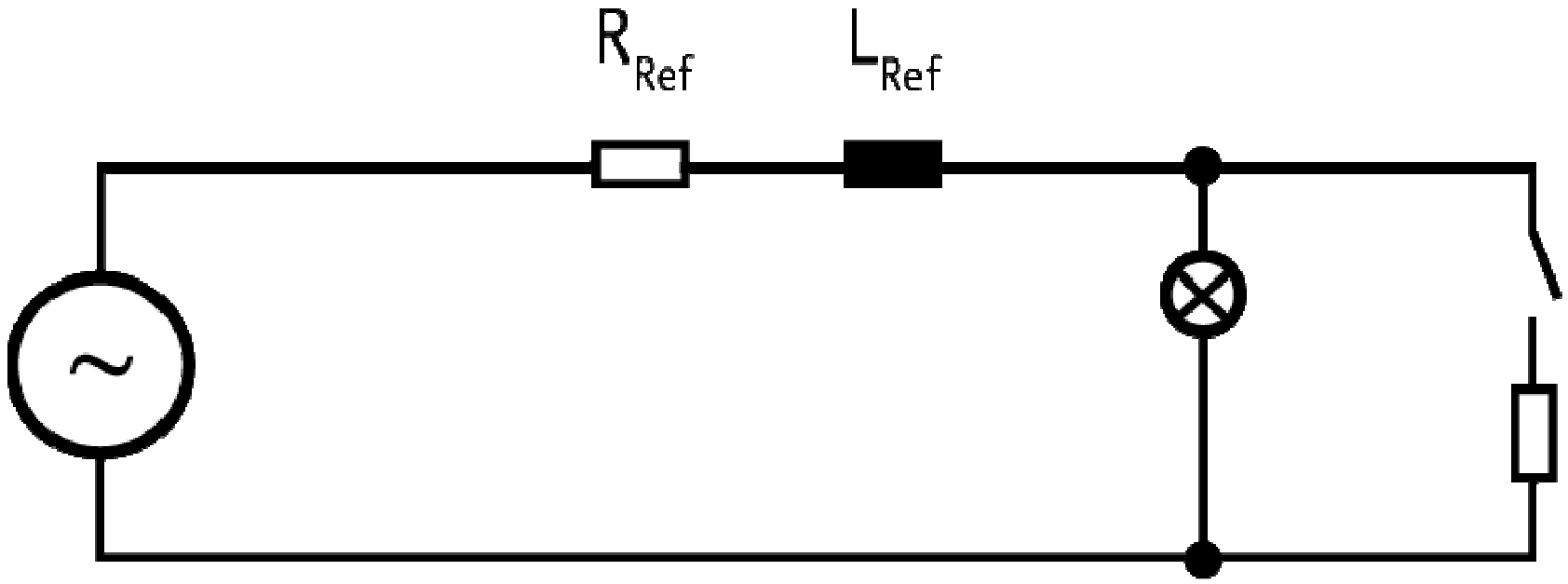
Flicker Background

- Changing current causes changing voltage which causes changing light



- Reference impedance

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Flicker

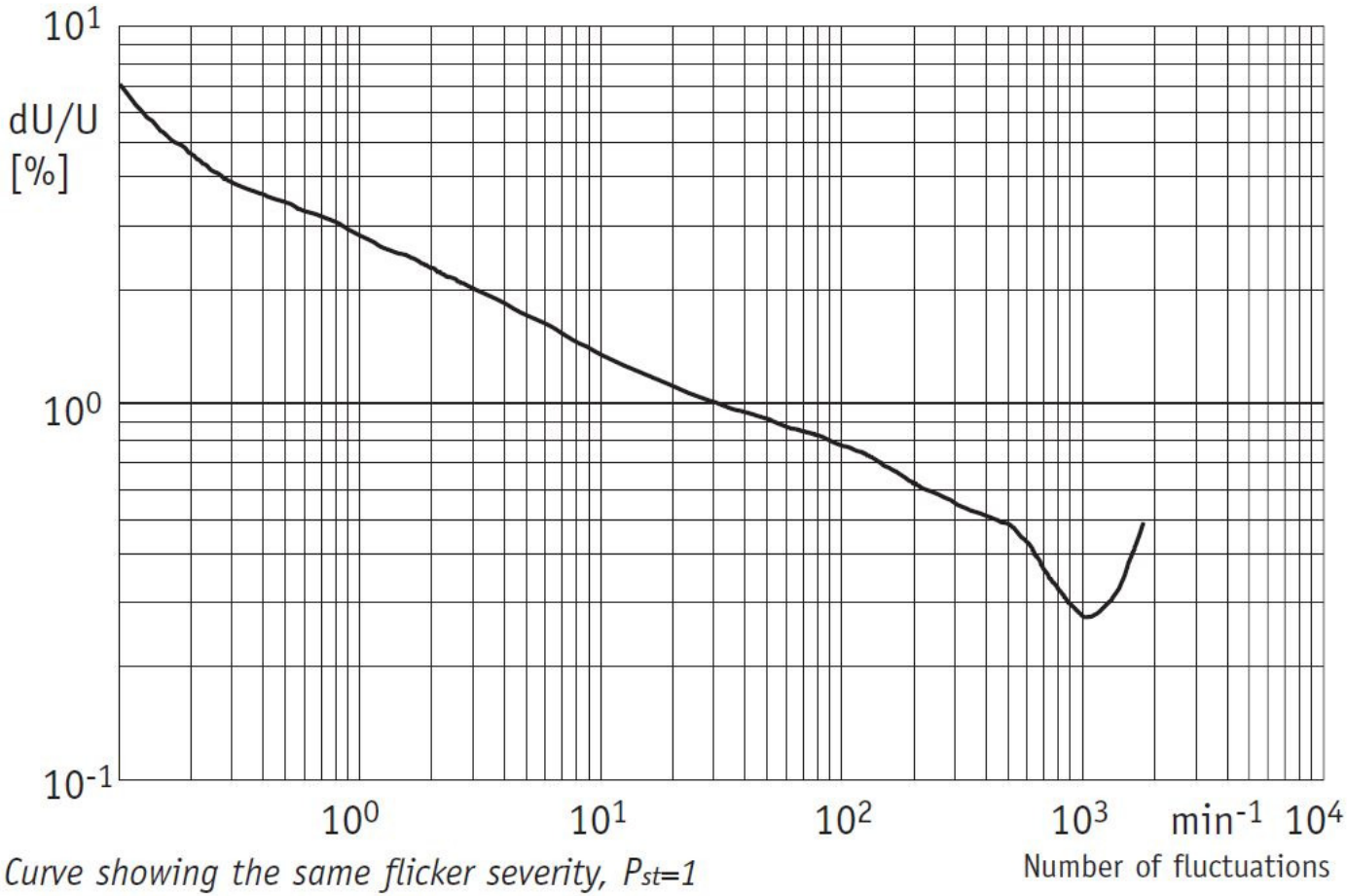
Measurement:

In order to obtain comparable measured results, a standardized mains network impedance must be inserted between the infeed source and the test sample when measuring flicker.

EN61000-3-3

- Flicker <= 16A per phase:
  - $P_{st} < 1.0$, $P_{lt} < 0.6$
  - $d_c < 3.3\%$, $d_{max} < 4\%$-7% depending on device
  - $d(t) > 3.3\%$ only < 500ms
- Actual (2009-08-26):
  - EN61000-3-3:1995/A2:2005
  - EN61000-3-3:2008
- Reference impedance
  - $(0.24 + j\ 0.15)\Omega$ in line
  - $(0.16 + j\ 0.10)\ \Omega$ in neutral

Flicker Perception



Curve showing the same flicker severity, $P_{st}=1$

@ 1058 fluctuations per minute (approx. 8.8 Hz) human sensitivity for flicker phenomena is greatest (Pst=1 is lowest). EN61000-3-3 also defines limits for the maximum voltage change allowable in appliances for initial and sustained operation.

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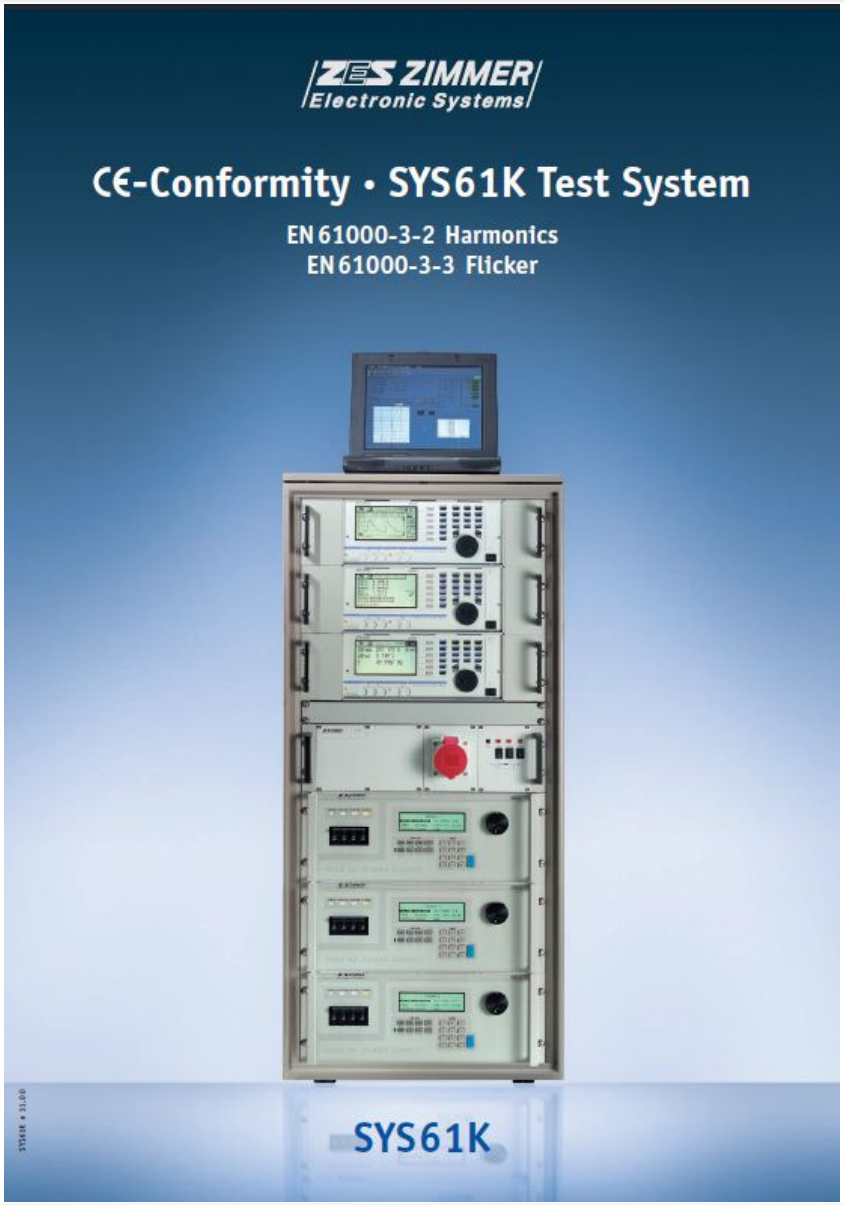
Flicker: Test Procedures Specified

- Cookers
- Hotplates
- Baking Ovens
- Grills
- Microwave Ovens
- Lighting
- Washing Machines / Dryers
- Refrigerators
- Copy Machines / Laser Printers
- Vacuum Cleaners
- Mixers
- Portable Tools
- Amplifiers
- Welding Tools
- Televisions

EN61000-4-15

- Flickermeter Standards
- Actual (2009-08-26):
  - EN61000-4-15:1998/A1:2003
  - 77A/687/CDV (2009-08-07)
- **Soon: IEC61000-4-15:2010**
- 77A/722/FDIS

Flickermeter



Thank you for your attention.

Questions?