Voltage Fluctuation/Flicker International Standards and Measurement Techniques: Standard

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While harmonic current is regulated for maintaining the quality of a system power supply, regulations are also imposed on voltage fluctuations/flicker for the purpose of suppressing the flickering of incandescent lamps, malfunctioning of a computer application device, and inrush current of equipment. The limits for voltage fluctuations/flicker are defined by the international standards IEC61000-3-3 and IEC61000-3-11. These are the EMC emission standards that are required for compliance by the CE regulations.

This paper describes the background of the regulations on voltage fluctuations/flicker for electrical and electronic equipment connected to the power supply network. It also provides an overview of the international standards, IEC61000-3-3 and IEC61000-3-11.

1. Background of the regulations

For electrical and electronic equipment used on a daily basis, harmonic currents are limited and voltage fluctuations and flicker are regulated. These limit the change in the current consumption of equipment. Since a power transmission system and power distribution system have some impedance, as the current flowing through them changes, the power supply voltage near a device also changes according to the impedance. Therefore, when an incandescent light bulb is used for lighting, brightness flickering occurs. This flickering and the voltage fluctuation that causes it are known simply as “flicker.”

One of the purposes of the regulations is to prevent this flickering of incandescent lamps.

Recently, environmental protection activities have been promoted and incandescent lamps have been replaced by other lighting equipment. The problems caused by voltage fluctuation that are becoming more noticeable include malfunctions of computers, electronic application equipment using computers, and automatic control devices; the inability of motors to start; output torque dropping; and abnormal vibration and noise in rotating equipment. Regulation of inrush current caused by the power applied while starting up equipment is now subject to IEC voltage fluctuation/flicker measurement.

Table 1. Measurement parameters and limits of IEC61000-3-3 *1)

Parameters	Definitions	Limits
dc	Maximum steady state voltage change during an observation period Percent value divided by the rated voltage	Shall not exceed 3.3%
dmax	Maximum absolute voltage change during an observation period expressed as percent value divided by the rated voltage	Shall not exceed 4% (6% or 7%, depends on conditions)
Tmax	Maximum time duration during the observation period that the voltage deviation d(t) exceeded the limit for dc	Shall not exceed 500 ms
Pst	Short-term flicker severity	Shall not exceed 1
Plt	Long-term flicker severity	Shall not exceed 0.65

This inrush current may cause the power system to be unstable or even cause a power failure in some cases.

In order to prevent these problems, the international standards IEC61000-3-3 and IEC61000-3-11 specify the voltage fluctuation/flicker limits for electrical and electronic equipment that are connected to the system power supply. Also, IEC61000-4-15 defines the requirements for instruments that measure voltage fluctuations and flicker.

2. IEC61000-3-3

IEC61000-3-3 is the international standard that specifies the voltage fluctuations and flicker limits for electrical and electronic equipment of 16A or less per phase. Devices that satisfy the limits can be connected to the power supply network unconditionally.

Table 1 shows the measurement parameters and limit values specified by IEC61000-3-3 and Figure 1 shows the relationship between waveforms and measurement parameters.

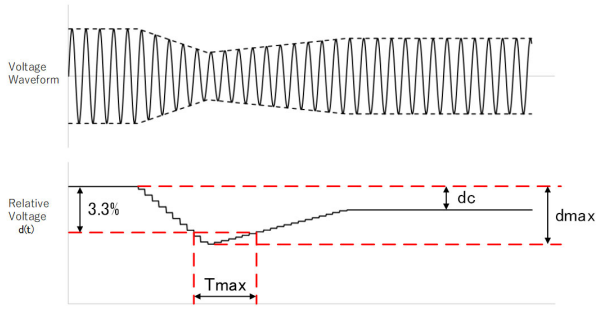

Figure 1. Waveforms and measurement parameters *2)

2-1 Wiring for voltage fluctuation/flicker measurement

Figure 2 shows the wiring for voltage fluctuation and flicker measurement.

This figure is for three-phase devices. For single-phase devices, only L1 and N are connected.

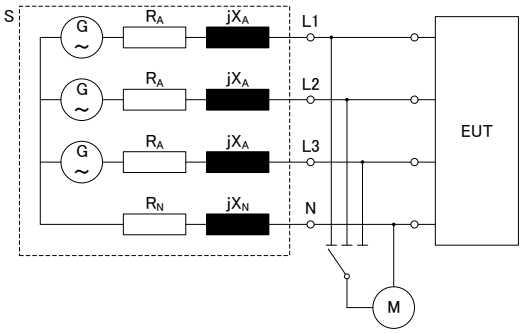

Figure 2. Wiring for voltage fluctuation/flicker measurement (three-phase device) *3)

G Voltage source
EUT Equipment under test
M Measuring instrument
S Power supply consists of voltage generators G and reference impedance Z.

Here, R and jX are referred to as reference impedance, Zref, and simulate the impedance of the system power supply. This impedance makes the change in the power supply current of EUT the change in the power supply voltage, and the measurement parameters in Table 1 are measured by the instrument M. The values of R and jX are specified in the standard as follows. *4)

Three-phase:
$R_A = 0.24\ \Omega$, $jX_A = 0.15\ \Omega$ (50 Hz)
$R_N = 0.16\ \Omega$, $jX_N = 0.10\ \Omega$ (50 Hz)
Single-phase:
$R = R_A + R_N = 0.40\ \Omega$
$jX = jX_A + jX_N = 0.25\ \Omega$ (50 Hz)

2-2 Observation period for measurement

The following time periods are required for the evaluation of short-term and long-term flicker values. *5)

Pst observation period: 10 minutes
Plt observation period: 2 hours
(Pst observation period x 12)

Unless otherwise specified, the above observation periods apply to those of dc, dmax and Tmax.

The observation period needs to include the time in which the largest voltage change over the entire operation cycle of the target device occurs.

2-3 Measurement of dmax caused by manual switching *6)

The change in the power supply voltage caused by the inrush current when the power is turned on often turns out different every time it is measured. Therefore, it is required to measure dmax caused by manual switching separately from the measurement with the observation period in 2-2. The measurement of dmax caused by the manual switching requires 24 one-minute measurements.

The manual switch is turned on at the beginning of the measurement period of one minute and the switch is turned off before the one minute ends. The maximum and minimum values are removed from the results of 24 measurements and the average of the 22 measurements is the dmax caused by manual switching.

3. IEC61000-3-11

IEC61000-3-11 is another international standard that defines the voltage fluctuation and flicker limits. It applies to electrical and electronic equipment whose rated input current per phase is above 16 A, not greater than 75 A and electrical and electronic equipment whose rated input current per phase is less than 16 A, but not meeting the IEC 61000-3-3 limit.

The limits of this standard are the same as those of IEC61000-3-3 and are shown in Table 1.

The difference from IEC61000-3-3 is that IEC61000-3-11 defines three types of connection conditions depending on the condition when the limit values in Table 1 are satisfied.

The first one is that when the requirements of IEC61000-3-3 are satisfied, unconditional connection to the power supply network is possible.

The second is that the maximum permissible system impedance, Zmax, should be specified in the instruction manual and the target device can be connected only to the power receiving points with an impedance lower than that.

The third is that the target device is used only in a premise with a service current capacity of 100 A or more per phase.

Table 2 shows the three connection conditions and requirements.

Table 2. Connection conditions and requirements of IEC61000-3-11 *7)

	Connection conditions	Requirements
1	No conditions	Satisfy requirements of IEC 61000-3-3.
2	Power interface points with maximum allowable system impedance Zmax or less	The impedance Ztest suitable for the test. From the measurement result at this time and the reference impedance Zref specified by Ztest and IEC61000-3-3, the measurement result is converted into the measurement by Zref. If this converted value exceeds the limit value in Table 1, the impedance Zsys for which each converted value falls within the limit value is calculated, and their minimum value is Zmax.
3	Current supply capacity of 100 A or more per phase.	The reference impedance specified in the test for the current supply capacity of 100 A or more, and meet the limit values in Table 1. This reference impedance shall be smaller than the reference impedance of IEC61000-3-3.

Equipment of 16 A or less per phase that does not meet the requirements of IEC61000-3-3 can comply with IEC61000-3-11 under the connection condition 2 or 3 in Table 2.

4. Requirements for measurement instruments and power supplies

The measurement methods of the measurement parameters dc, dmax, Tmax, Pst, and Plt are defined in the international standard IEC61000-4-15 Flickermeter-Functional and design specifications. The Block diagram of the flicker meter specified by this international standard is shown in Figure 3.

Among the measurement parameters, dc, dmax and Tmax, which are directly obtained from the half-cycle RMS value, are called “d parameters.” dc and dmax are determined in Block 1 in Figure 3 and Tmax is a sum of the time periods when d(t) obtained in Block 1 exceeds 3.3%. Pst and Plt are the output of Block 5 in Figure 3.

Regarding the AC power source that can be used for measurement, the following requirements are defined in IEC61000-3-3: *8)

(1) Test supply voltage shall be the rated voltage of the equipment, where the target equipment is specified by voltage range, single-phase 230 V or three-phase 400 V.

(2) Test voltage shall be within ±2% of the nominal value.

(3) Frequency shall be 50 Hz ±0.25 Hz.

(4) Total harmonic distortion of supply voltage shall be less than 3%.

(5) Ignore the fluctuation in supply voltage during a test if the Pst value due to the fluctuation is less than 0.4.

When measuring directly with a commercial power supply, verify this condition before and after each test.

When measuring with a stabilized power supply, verify this condition during calibration of the power supply.

5. Conclusion

This paper described the necessity of the regulation on voltage fluctuations/flicker for electrical and electronic equipment and provided an overview of the international standards IEC61000-3-3 and IEC61000-3-11. It is required to satisfy the requirements of these standards to obtain the CE marking.

We hope this article will help the reader to understand the standards when evaluating voltage fluctuations and flicker according to them. The article, “Voltage Fluctuation/Flicker International Standards and Measurement Techniques: Measurement Techniques” that describes measurement techniques may provide a better understanding.

References

・IEC61000-3-3 Ed 3.0: 2013
*1) : 5 Limits
*3) : 6.6 General test conditions Figure 1
*4) : 6.6 General test conditions Figure 1
*5) : 6.5 Observation period
*6) : Annex B Procedure
*8) : 6.3 Test supply voltage
・IEC61000-3-11 Ed 1.0 : 2000
*7) : 4 Requirements
・IEC61000-4-15 Ed 2.0 : 2010
*2) : Annex B Figure B.2
*9) : 4.1 General Figure 2

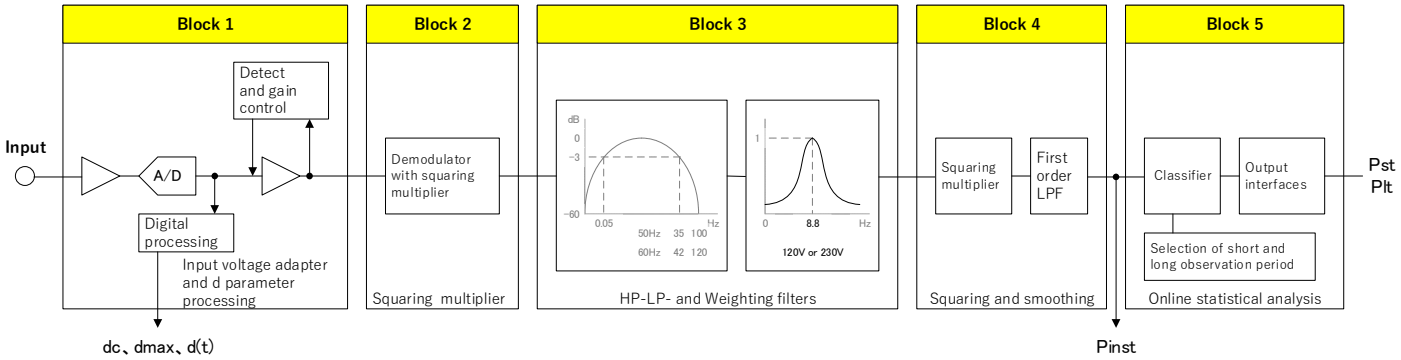

Figure 3. Block diagram of the flicker meter in IEC61000-4-15 *9)

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