

A MODEL BASED APPROACH FOR THE CALIBRATION OF IEC STANDARD FLICKERMETERS USING COMPLEX WAVEFORMS

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Abstract

Current methods of calibrating IEC standard flickermeters rely on the known response of a standard flickermeter to basic waveforms. This paper describes an implementation of the IEC standard flickermeter, developed at NPL, in order to assess the response of the flickermeter to more complex waveforms, which are representative of signals that occur in practice.

Introduction

When connected to the mains electricity supply, all appliances draw a certain amount of current. This current causes a voltage drop across the impedance of the electricity supply network. The amount of current drawn varies during the equipment's operating cycle, causing the electricity supply voltage to fluctuate. This voltage fluctuation manifests itself as a flickering of the lights, which can cause severe irritation. The amount of light flicker, and therefore irritation, an appliance can cause is limited by International Standard IEC 61000-3-3 [1].

International Standard IEC 61000-4-15 [2] describes the design specifications of flickermeters, which must be adhered to for the flickermeter to be used for compliance testing, as described in [1]. The response of a flickermeter that meets these specifications is known for two types of waveform, square wave modulated and sine wave modulated mains frequency signals. It is specified in [2], that a flickermeter that conforms to the IEC standard design should give a flicker perceptibility reading (defined below) of 1 for various known modulation depths and modulation frequencies, which depend on the type of modulation.

The fluctuations that occur in practice are considerably more complex than these square and sine wave modulations. Appliances connected to the mains supply draw current in a more erratic manner, resulting in more complex fluctuations. If the regulatory regime to limit light flicker is to be effectively supported, it is therefore necessary to assess the performance of flickermeters under these conditions.

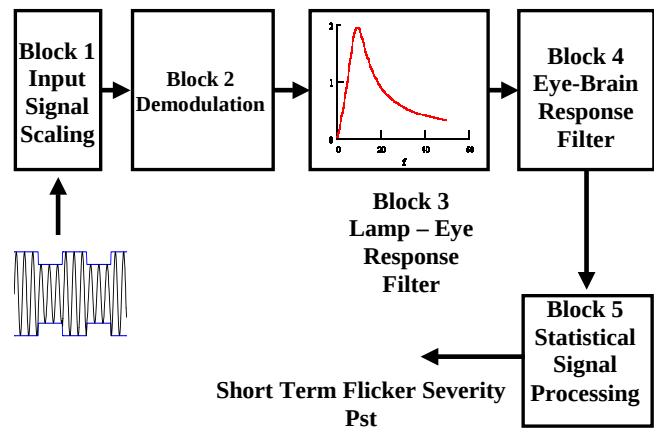
This has led to the development of a model of the IEC standard flickermeter at NPL. Using this model, it is hoped that the response of the IEC standard flickermeter to more complex waveforms can be determined. Once the response of the flickermeter to these waveforms is known, the waveforms can be used to calibrate commercial flickermeters under realistic conditions, by comparing the flicker readings of the model with those of the flickermeter under test. Thus manufacturers and compliance test laboratories will have greater confidence that their equipment correctly measures all types of flicker and not just the two standard types.

Flicker Perceptibility

The short-term flicker perceptibility (PST) is defined as the flicker severity evaluated over a short period of time (usually 10 minutes). A PST reading of 1 is given as the threshold of irritability and any value of PST greater than 1 is deemed too high for the average person to tolerate.

IEC Flickermeter Design Specifications

The IEC 61000-4-15 flickermeter design is broken down into five blocks. A diagram is shown in Figure 1. A description of the NPL implementation of each block



follows.

Figure 1, IEC61000-4-15 Flickermeter Block Diagram

Block 1

An initial measurement is made of the applied RMS voltage and this is used as a reference value to scale the input voltage during a flicker test. During a test the input voltage is divided by the reference value. The RMS value of the input voltage is also calculated every half-cycle of the mains frequency.

Block 2

The output from block 1 is then squared. This block is intended to simulate the behaviour of an incandescent lamp to the input voltage signal.

Block 3

Block 3 consists of a cascade of three filters, which are designed to simulate the response of the eye to input from an incandescent lamp [5]. The first is a first order high pass filter with a 3 dB cut-off frequency of 0.05 Hz. The second is a 6th order low pass Butterworth filter with a 3 dB cut-off frequency of 35 Hz, which is implemented as three cascades of second order filters. The third filter has a transfer function defined in [2], which is implemented as two cascades of second order filters.

Block 4

The output of block 3 is squared and then filtered using a first order low-pass filter with a time constant of 0.3 s. This filter is designed to represent the storage effect in the brain [5]. The output of block 4 is normalised to give a maximum value of 1 during a 10 minute flicker test, when a square wave modulated 50 Hz input signal, with a modulation frequency of 8.8 Hz and a modulation depth of 0.25 %, is applied.

Block 5

The final PST reading is evaluated in this block. A Cumulative Probability Function (CPF) is evaluated by classifying the output of block 4 into a number of bins, which have a logarithmic spacing. This CPF is used to obtain the flicker levels exceeded for various percentages of the test time. The final PST reading is calculated using the equation given in [2]. The PST reading is then multiplied by the ratio of the initial reference voltage level, calculated in Block 1, to the average RMS voltage, evaluated over the flicker test. This ensures that the final flicker reading is scaled to the average voltage, measured throughout the test.

Filter Implementation

The digital coefficients for all the filters are derived from the analogue representation using the bilinear z-transform. All the filters are realised as infinite impulse response filters in cascade form and are implemented in software using the algorithm given in [3].

The time-domain difference equations for each filter can be shown to be identical to those given in [4], which is the implementation on which the specifications given in [2] are based.

Testing the NPL Flickermeter model

The NPL flickermeter model has been tested at the modulation depths and frequencies specified in Table 1 of IEC61000-4-15 and is within -2.5 % and +1.3 % of the required perceptibility reading of 1. This is the expected result as the modulation points were originally calculated based on a different model to that described in the standard [2], as explained in [4]. This accuracy range is given in [5] as the expected deviation from the points given in [2].

Ambiguities in the IEC Standard

There are several factors, not specified in [2], that can have a significant influence on the final output from a flicker test. These include the amount of time allowed to charge the filters before starting a flicker test and the phase of modulation for the square and sine wave modulated test waveforms. The implementation of the suggested logarithmic classification routine in Block 5 is also unspecified and factors such as bin spacing can have a large effect on the results (e.g. changing the number of classes or bins, used to classify the output,

from 1000 to 10000 can change the eventual PST reading by around 0.1 %).

Complex Waveforms

Work is now underway to model and classify waveforms that are likely to occur during compliance tests, which can identify problems with commercial flickermeters that could be overlooked with basic sine and square wave modulated waveforms. It is hoped that this work will lead to improvements in the NPL calibration service, enabling calibrations to be performed under more realistic conditions.

Conclusion

A working model of the IEC standard flickermeter that complies with the requirements given in the standard has been developed. Complex waveforms, which model those that occur in reality and fully test the dynamics of commercial flickermeters, are being developed. These waveforms are to be used in the NPL calibration service, providing greater confidence in the regulatory regime enforced by the IEC standards. However, due to ambiguities in the standard it is difficult to fully verify the correct operation of the model and discussions are underway with members of the relevant standards committee to improve confidence in the model.

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