Energy - Docket Optical System

From: Wilkins, Arnold J <arnold@essex.ac.uk>
Sent: Wednesday, February 04, 2015 2:18 AM
To: Energy - Docket Optical System
Cc: Shirakh, Maziar@Energy; Lee, Simon@Energy; Jon McHugh; McGaraghan, Michael (mmcgaraghan@energy-solution.com)
Subject: 14-BSTD-01
Attachments: Screen Shot 2015-02-04 at 09.47.26.png

Dear Madam/Sir

2016 Building Standards Update

I have researched the effects of lighting flicker on headache and ocular motor control for the last 30 years. The standards that you are proposing are nowhere near stringent enough to reduce the symptoms induced by flicker. It is a major innovation, however, to insist on the measurement of flicker, and it can only be hoped that over time the criteria will become more stringent.

Under worst case conditions, flicker can be seen by most observers at frequencies of about 2kHz. The perception can be made during a saccade, when the eye is moving extremely rapidly, and any intermittent illumination becomes a spatial illumination of the retina during the flight of the eye. It turns out that the conditions under which flicker is visible (as pattern) during a saccade closely resemble those at which symptoms are generally reported. There is evidence that (at least at 100Hz) flicker disturbs the control of eye movements. This may be because it is known to cause phase-locked firing of neurons in brain regions responsible for the timing of eye movement.

The attached graph shows the no-effect region for flicker expressed as a joint function of flicker frequency and modulation depth. The curve does justice to the available evidence from several studies of the stroboscopic effect (the intermittent appearance of a moving object under flickering illumination) and the phantom array (the appearance of pattern during a saccade). These studies used a variety of waveform shapes, and yet the characterisation of flicker in terms of percent modulation provides a reasonable fit. It is acknowledged that this approach takes insufficient account of the effects of waveform shape and it is hoped that in the future it will be possible to use the attached curve together with waveform characterisation in terms of Fourier components. The curve has been published in an article by Prof Brad Lehrman (Northeastern U) and myself in IEEE Power Electronics Vol 1 No 3 Sept 2014, and it forms the basis of the forthcoming IEEE1789 standard.

Sincerely,
Arnold Wilkins

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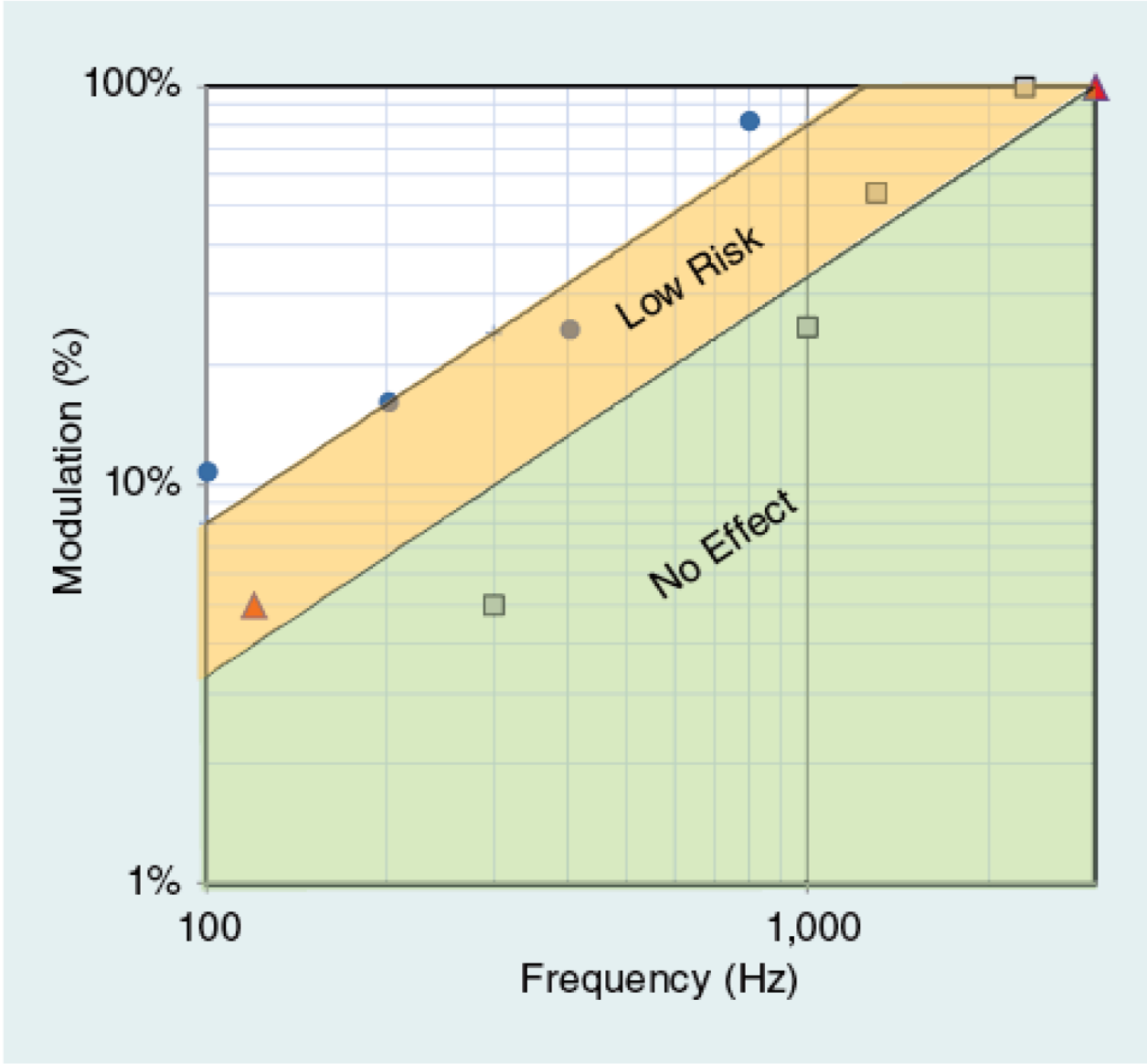

FIG 6 The low-risk (orange) and no-observable-effect (green) regions for flicker as a function of the frequency and modulation percentage. The line Mod% $= 0.0333^{*} f_{\text{Flicker}}$ separates the no-observable-effect and low-risk regions, and the upper margin of the low-risk region is given by the line Mod% $= 0.08^{*} f_{\text{Flicker}}$. (Data taken from Figure 3 of [14] and [15].)