

6th International LED professional Symposium + Expo Sept 20-22, 2016 | Bregenz



Theory and Practical Measurement Results of Modulated Light

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Compact Flicker Degree CFD





Introduction

□ Ideal *illuminating* (artificial) light...

 \Box ... w/o modulation (like the sun)...

 \Box ... is a cost issue

□ Contrary: Informative artificial light...

- □... has the information modulated.
- Any kind of screens
- D- Special-effect lighting
- □... wants effects on humans
- □... may exceed humans compatibleness









Introduction



Protection is required

- Proper measuring method
- □ Set limits by standards
- Design appropriate light controls

Proper measuring considers

- □ Alternating to continuous amplitude ratio
- □ All frequencies
- □ Frequency-dependent weighting
- □ Static and moving situations

However: Intensity and duration are important.



Introduction



□ Solution: CFD (Compact Flicker Degree)

□ Suitable method for any light source.

Evaluated with **700** light sources.

□ CFD applied on any light source

Incandescent bulbs

Screens

□ Fluorescent tubes

LED illuminants





Measurement Hardware





- V-Lambda Photodiode
- Variable Transimpedance Amplifier
- Anti-aliasing Low-pass Filter
- Analog-to-Digital Converter
- □ CPU either simple...
- □ ...or powerful.



Contrast methods
Simple amplitude calculations

Methods using area calculation
Flicker index

Disadvantages:

- □Only amplitude ratios
- □ Frequency independent
- $\Box \rightarrow$ Simple, but not very useful.







Signal decomposing

Periodic signals turn into frequency components.

□ All frequencies describe non-sinusoidal waveforms.

Frequency-dependent weighting

- $\hfill \square \dots$ according to human perception.
- Perception range while rested,
- Derception range while moving,
- $\Box \rightarrow$ Different weighting characteristics.









Measurement Frequency-domain





□ Frequency weighting curves

□ Kelly (1961), Henger (1986): f_T = 75 Hz; 5%f_T @ 120 Hz

□ ASSIST (2013..2015): f_T = 75 Hz; 5%f_T @ 120 Hz

CFD (2016): 2 parts subdivision: $f_T = 110Hz$; 5% f_T @ 2000 Hz



□ ASSIST...

- $\Box RMS \rightarrow Metric value...$
- Detection probability assessment.

Jeita...

- □ Frequency weighting similar to ASSIST...
- □ Max. weighted

Frequencies above 90 Hz are not considered.



Measurement Frequency-domain result



 $\Box CFD$ $\Box RMS \rightarrow Metric value as \%.$

CFD assessment

- □ 0 < CFD < 1%
- □ 1% < CFD < 10% **Low**
- □ 10% < CFD < 25% **Acceptable**
- □ 25% < CFD < 50% **Moderate**
- □ 50% < CFD < 75% **Strong**

□ CFD > 75% **Extreme**





Frequency-dependent thresholds







Measuring system







Measuring system results...



□ Light modulation report □CFD as % and rating.

Graphics Waveform, FFT analysis

Intermediate data

 Unweighted peak frequencies
 Simple amplitude calculations
 Results acc. to Jeita, IES: RP-16-10, ASSIST, CA-T24-JA10

Light Elisker Teat								
X_Gluehbirne_IncHalo_E27_T-Birne_700Lm_42W_mains 2016-05-02:								
1200 CFD=6	.9%: good	@100Hz; %F	1=13.2%; F	lidx=0.04	0; UL12.7	8	_	
1100		\wedge	/	\sim	/~			
1000				\rightarrow				\rightarrow
900 Avg: 8	3.03%							
800	\sim		\sim			\sim		\sim
700								
700								
600								
500								
400								
300								
200								
200								
100								
flux Ver time/m		10	20		30		40	dark_
4.03	,	10	20				10	
Test item: X_Gluehbirne_IncHalo_E27_T-Birne_700Lm_42W_mains Date: 2016-05-02 Time: 07:46:47 Report file: R88R3 Test conditions: Test item power supply frequency = 50.0 Hz AC Samples = 500004 (using dynamic noise filter) Sample frequency = 500000 Hz Sampling duration = 1000.01 ms FFT: Blackman-Nuttall; Resolution = 1.00 Hz Test results: Compact flicker degree (frequency based): CFD weightened peak frequencies (related to DC=1.0):								
Der Lichtpete	nourne_incH r http://	aio_E27_1-E derlichtpeter	de/	n_42W_Re	роп	30.08.2016		Seite 2 von 3





Incandescent bulb







TV screen interlaced







Fluorescent tube with MB













SSL with insufficient EB, dimmed



→ Imagine:

20% of 170 dimmable SSL surveyed by Der Lichtpeter show this kind of light emission!



PWM dimmed LED (12V)











Lessons Learned



□ Light modulation measurement requires...

- □ Sampling >20 kHz & capturing for 1s.
- □ FFT with 1 Hz resolution.
- □ Wide range frequency weighting.
- □ A single easy-to-use output value.

□ The Compact Flicker Degree <u>CFD</u>...

- □... by **Der Lichtpeter**: 1st universal measuring method acc. to human's health for electrical light sources.
- □... mandatory in the technical data.
- \Box ... the only method eligible for standard limits.
- You are safe with the measurement service by
 Der Lichtpeter.





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Thank you for your attention.

Your Questions please...

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