







# OSRAM LED-Driver and Quality of Light

Juni 2017 | Garching  
Light is OSRAM

**OSRAM**

# Light Modulation and Relevant Frequency Bands

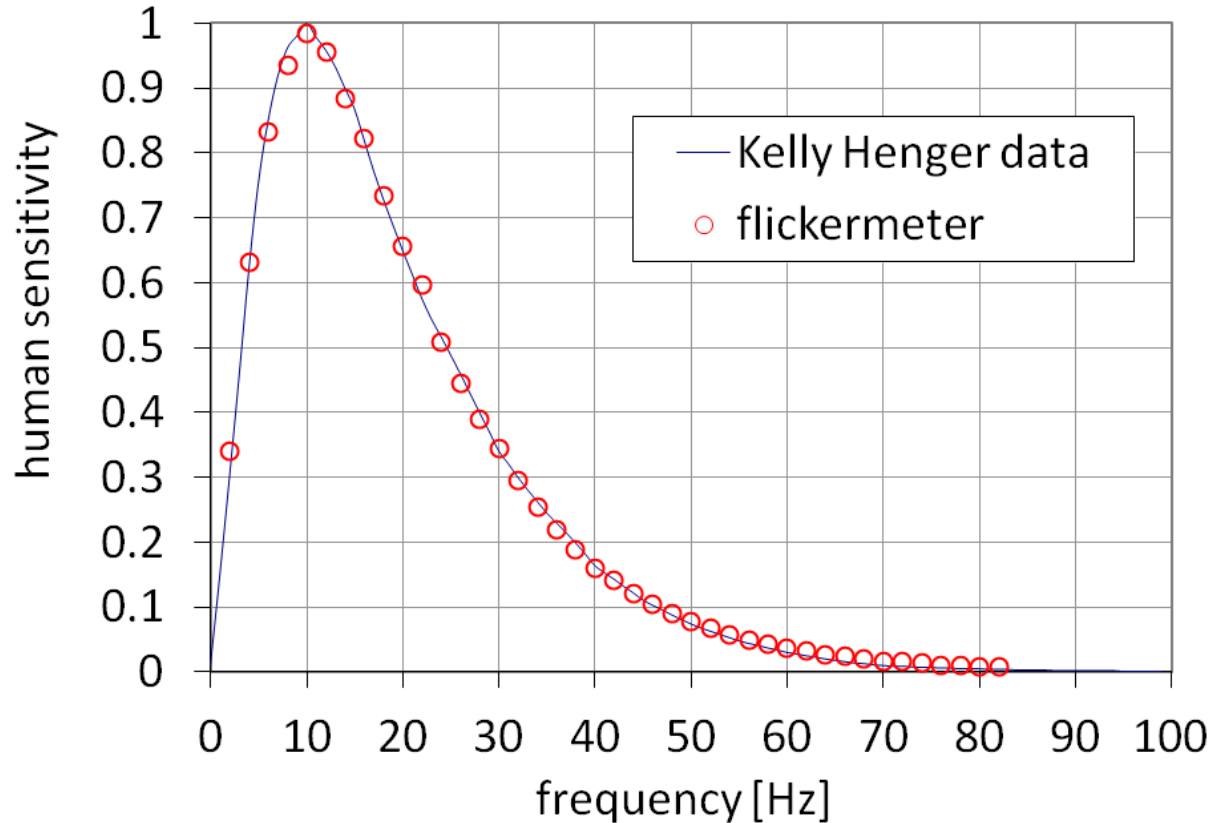
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# Visible Light Flicker

## Measurement according to Kelly-Metric (0...80 Hz)



The perceived **visible light flicker** is the accumulation of **spectrally resolved Light Levels**, weighted by **Kernel Function**

$$FV[S] = \frac{1}{A} \sqrt{\sum_k \mathcal{K}^2(f_k) b_{f_k}^2}$$





The visible light flicker (**Kelly-metric <0.003**) is equivalent and even more strict compared to a  $\mathbf{P}_{st}^{LM}$  flicker-measurement-metric acc. DTR – IEC/TR 61547-1

Threshold Level \*)  
 $FV_{Th} \leq 0.003 = 0.3\%$

\*) suggested in literature: U. Henger: Investigations for the development of measurement equipment to determine the flicker factor. 7 th Lichttechn. Gemeinschaftstag. Pp. 251-256 Baden b. Wien, May 13-16, 1986

# Light Modulation and Relevant Frequency Bands

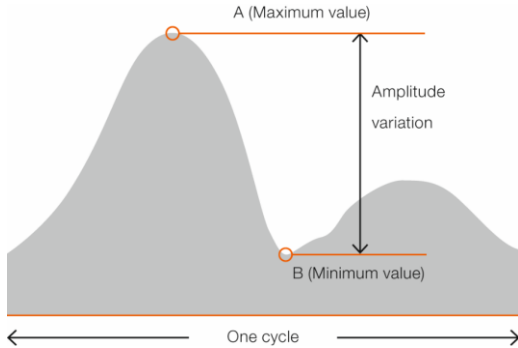
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# Stroboscopic Effects

## Modulation (100 Hz) of different control gears



$$\text{Light modulation} = \frac{\phi_{\max} - \phi_{\min}}{\phi_{\max} + \phi_{\min}}$$

(where  $\phi$  is luminous flux)

**Modulation as well called MD:**  
**Modulation Depth = Percent Flicker**

In practice, many drivers **deliver a high content of 100 Hz modulation.**

Compared to traditional fluorescent light sources, **LEDs instantaneously translate their operating current into light, without much smoothing effects.** Simple, cost effective circuit designs can lead to a lower quality of light.

The light modulation depth can be derived by the current modulation depth.

Ripple current ~ light modulation

### Fluorescent lamp ECG: QUICKTRONIC

### LED driver: OPTOTRONIC

QTI DALI/QTI...DIM	< 10%	OTi DALI	1...3% SELV, 1 % non-isolated
QTP OPTIMAL	< 10%	OTi	< 10%
QT FIT	< 10%	OT FIT	5%
Magnetic gear	25...35%	OTe	20...35%

\*Strongly depends on the LED module

# Stroboscopic Effects

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## Measurement for Light Modulation/Ripple current

The light modulation depth is equivalent (nearly the same value) to the modulation depth of the driver output current.

$$\text{Light modulation} = \frac{\phi_{\max} - \phi_{\min}}{\phi_{\max} + \phi_{\min}} \quad \blacktriangleright \quad \text{LF ripple current} = \frac{I_{\text{LFmax}} - I_{\text{LFmin}}}{I_{\text{LFmax}} + I_{\text{LFmin}}}$$

(where  $\phi$  is luminous flux)





LF = Low Frequency (<2 kHz)

## Light Modulation as well called MD: Modulation Depth = Percent Flicker

Currently, various organisations such as CIE, IEEE or NEMA are discussing very diverse metrics ( $P_{\text{st}}^{\text{LM}}$ , SVM, Flicker index, MD). **Current discussions in CIE, ZVEI and Lighting Europe indicate a preference for the  $P_{\text{st}}^{\text{LM}}$  and SVM metrics.**

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# Camera – Application (smartphone and surveillance cameras)



CCD and CMOS sensors with rolling shutter or global shutter technology

- Rolling frame technology is key to image distortion, used in most common applications
- Affected frequency band **25 Hz ... 10 kHz**
- Severity of image distortion depends on illumination, camera settings, scene and viewer awareness

Limit for modulation depends also on illumination, camera settings, scene- and viewer awareness

**OSRAM-recommendation\*: MD < 10 %  
cameraproof/camerafriendly**

\* For indoor application

**10 % modulation depth**

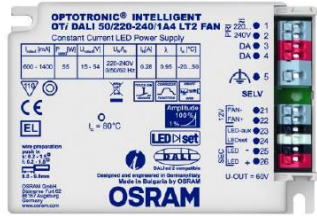


**20 % modulation depth**





# OSRAM-LED-Driver Light Modulation



Visible light flicker



0...80Hz

Regarding Stroboscopic Application suitable



80 Hz...2 kHz

Suitable for Camera applications



25 Hz...10kHz

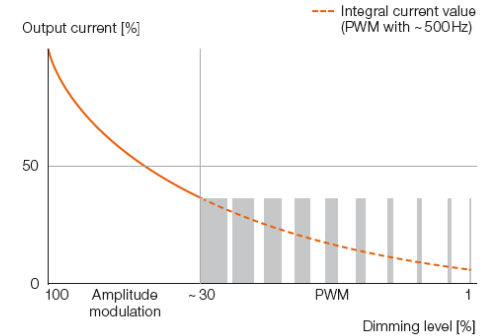
Barcodescanners applications



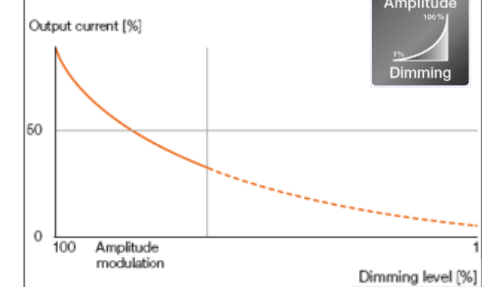
> 10 KHz...100 kHz

Produktgruppe	Dimming technology	SELV/...	Modulation Depth 100 Hz in %	Visible light flicker	Regarding Stroboscopic Application suitable	Suitable for Camera applications	Barcodescanners applications
OTi DALI linear	HD	SELV	<1	No visible light flicker	Good / DoA	Good / DoA	No influence on CCD-Barcode scanners known***
OTi DALI linear (G3) *	AD	Non isolated	<1		Good	Good	
OT FIT linear (G2)		SELV	<5		Good	Good	
OT FIT LT2 linear		Non isolated	<1		Good	Good	
OT FIT linear		Non-isolated	<10		Good	Good	
OTi DALI Compact (G2)	AD	SELV	<2		DoA	DoA	
OTe PC Compact	PC	SELV	25 or <35		Good	Good	
OT FIT Compact		SELV	<1**...5		Satisfying	Satisfying	
OTe Compact		SELV	20, 25 or 30		DoA	DoA	
ELEMENT		SELV	<40		Good	Good	
OT Outdoor ON/OFF		Non-isolated	< 30	DoA	DoA		
OT 4DIMLT2 E	AD	SELV/ double isolated	<3-15	Good	Good		
OT 2DIMLT2 P	AD	SELV / d. isol.	<30	DoA	DoA		

Hybrid dimming



Amplitude dimming



\* G3 pure AM-Dimming from Aug. 17 on

\*\* 1 % OT FIT LT2 CS

\*\*\* detailed tests on Laser-scanners in preparation

DoA = Depending on Application

# OSRAM AC Light Engines

## Light Modulation



Visible light flicker



Suitable for applications with stroboscopic effects



Suitable for Camera applications



Barcodescanners applications



Produktgruppe	Voltage	Modulation Depth 100 Hz in %	0...80Hz	80 Hz...2 kHz	25 Hz...10kHz	> 10 KHz...100 kHz
PL-Coin AC 50	220-240 V	typ. 30 %	No visible light flicker	Good	DoA	No influence on CCD-Barcode scanners known**
PL-Coin AC 111	220-240 V	typ. 30 %		DoA		
PL-Core AC	220-240 V	typ. 99 %		DoA		
PL-Core AC PRO	220-240 V	typ. 35 %		DoA		
PL-Cube AC 1100	220-240 V	typ. 18 %		DoA		
PL-Cube AC 2000	220-240 V	typ. 25 %		DoA		
PL-Cube AC 3000	220-240 V	typ. 25 %		DoA		
PL-Flat AC	220-240 V	typ. 25 %		DoA		
PL-Flat AC DALI	220-240 V	typ. 25 %		DoA		
PL-Flat AC HF	220-240 V	typ. 25 %		DoA		
PL-Flat AC 4000	220-240 V	typ. 37 %		DoA		

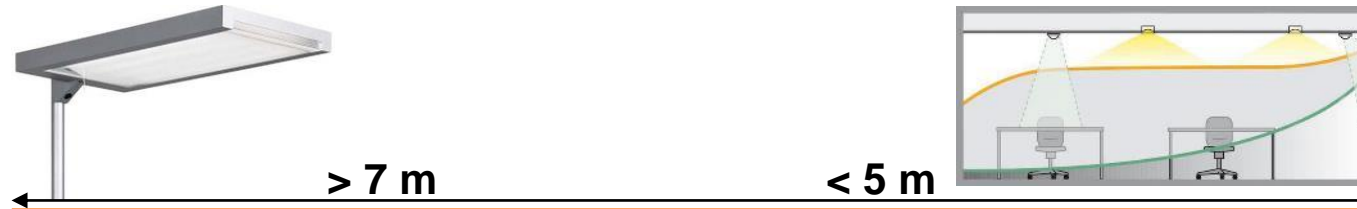
\* during PWM-dimming in lower dimming position

\*\* detailed tests on Laser scanners in preparation

**DoA = Depending on Application**

# Hybrid-Dimming in office applications (AM/PWM (460 Hz) - Dimming)

## Office Application with daylight



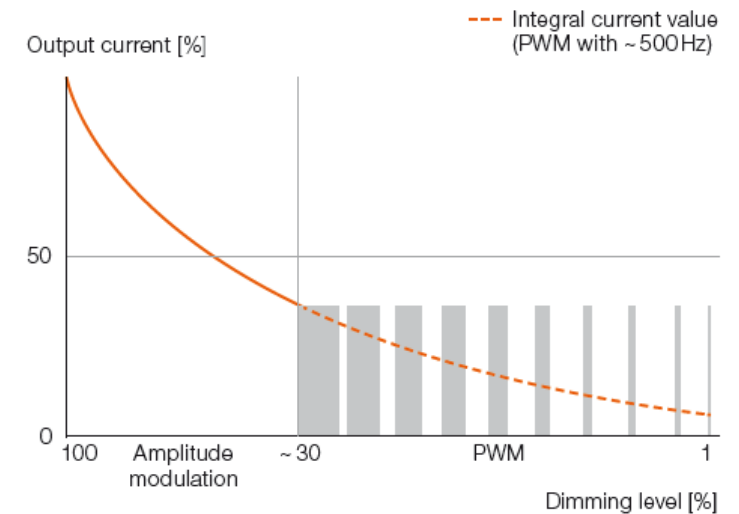
LED-Light

	AM-Dimming	PWM-Dimming	PWM-Dimming
Dimming level	30..100% AM-Dimming	1...30 % PWM (460 Hz)	1 ...5 % PWM (460 Hz)
Driver Modulation	5-10 %	100%	100%
Daylight Share	< 2%	> 80%	99%
<b>Total Light Modulation</b>	<b>5-10%</b>	<b>20 %</b>	<b>&lt; 5 %</b>

### Benefit:

Stable color quality dimming with moderate light modulation

### Hybrid dimming



# Impact on human beings: Low light modulation has a positive impact and influence on human well being

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Using ECGs and LED-Drivers with **Low light modulation has a positive impact on the working environment.** In general, heavy flickering at low frequencies should be avoided. It is known that a small subgroup of epilepsy patients is light-sensitive and reacts to flickering light. By increasing the frequency of light modulation, the risk of these reactions decreases dramatically. According to scientific publications, **above 70 Hz, no reaction of epilepsy patients to flicker in general lighting application has been noted.**

Even at **frequencies up to 400 Hz** negative effects on human well being can not be fully ruled out.

In this frequency range scientific experts suggest to minimize light modulation depths.

**No study** has shown **adverse effects** at modulation frequencies **above 400 Hz.**

**Thank you.**