

Strategies in Light®

MARCH 1-3, 2016

SANTA CLARA CONVENTION CENTER | SANTA CLARA, CA

Progress in driverless LED light engines

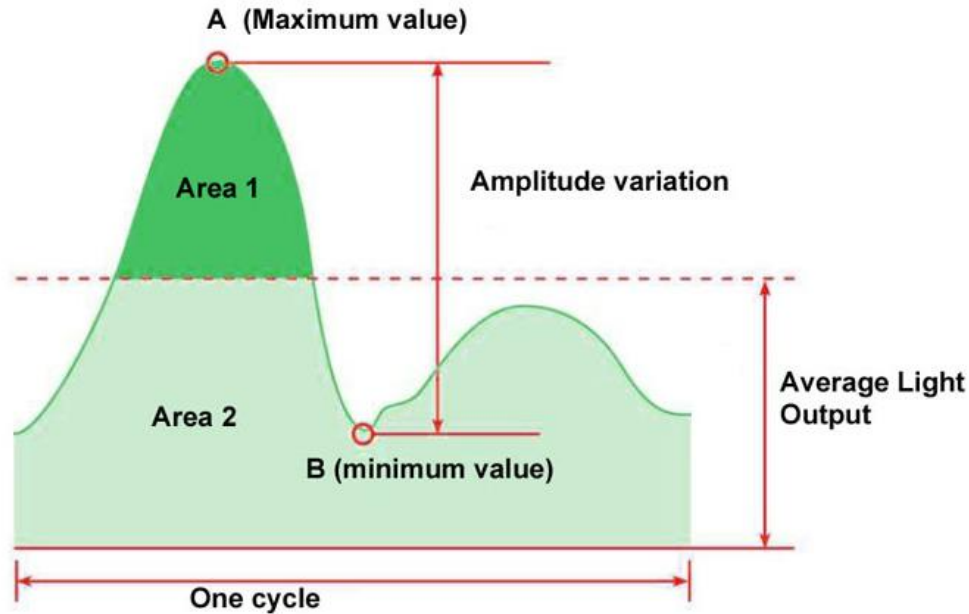
Peter W. Shackle Photalume

Peter W. Shackle is a 25 year veteran of the lighting industry with 57 US patents, mostly in lighting electronics

Progress in driverless LED light engines

- ❑ This presentation will describe a new kind of AC LED light engine with flicker performance improved by 2X from last year
- ❑ Since the presentation is about improved flicker performance flicker measurement methods are explained first

Definition of Flicker index

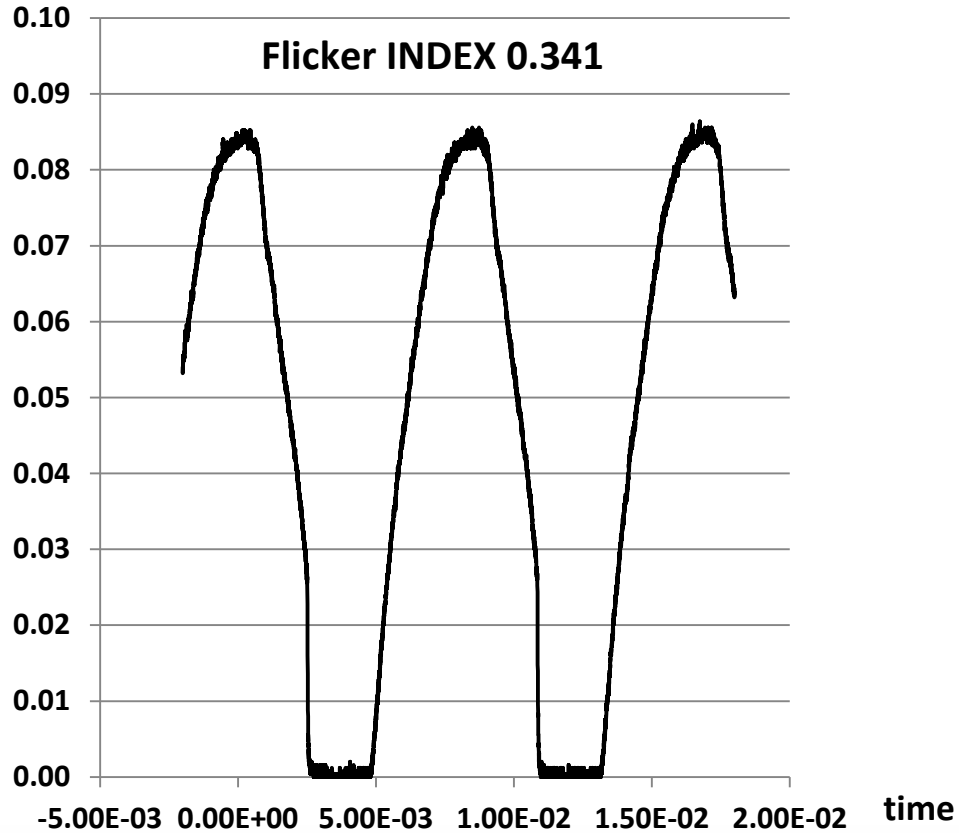


$$\text{PERCENT FLICKER} = 100\% * \frac{A-B}{A+B} \quad \text{FLICKER INDEX} = \frac{\text{AREA 1}}{\text{AREA 1} + \text{AREA 2}}$$

Meaning of flicker index

- For commonplace repetitive light waveforms the maximum (worst) possible is 0.50
- Less is better - 0.0 is perfection
- It is easy to measure – buy a combined photodiode and amplifier for \$8.50

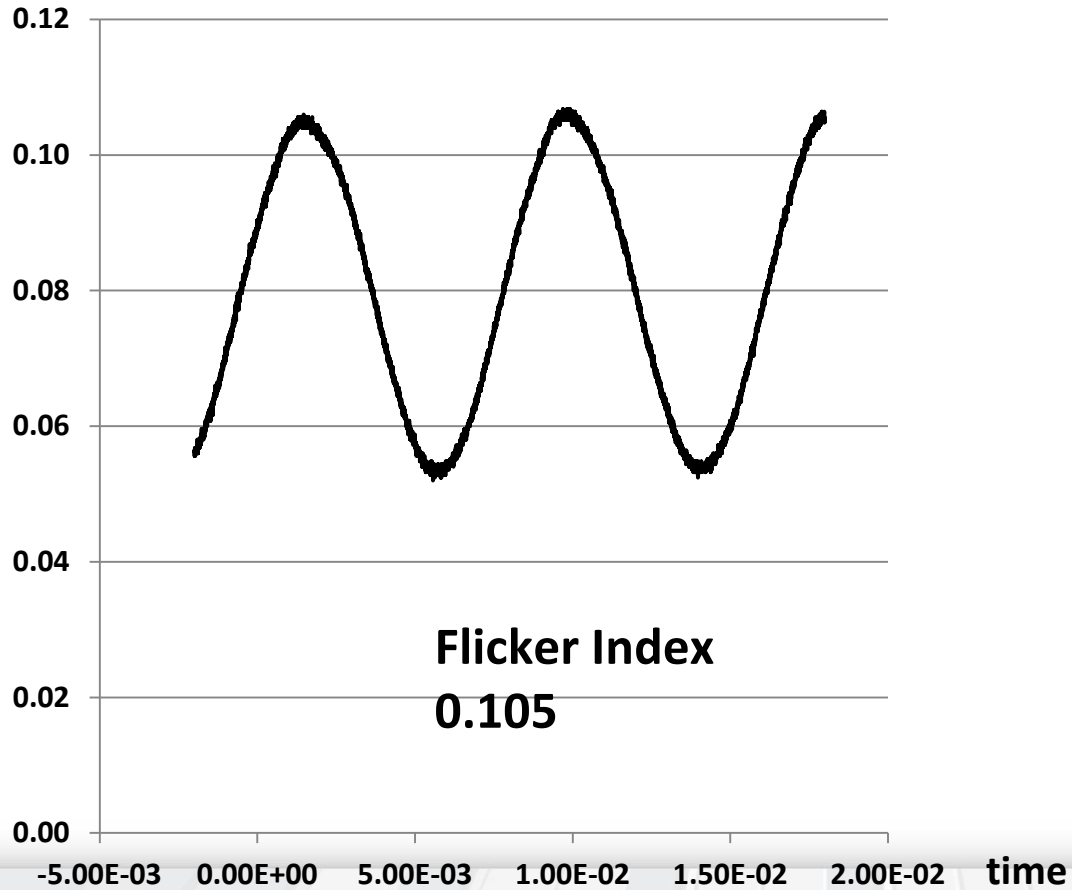
light output from Christmas Light



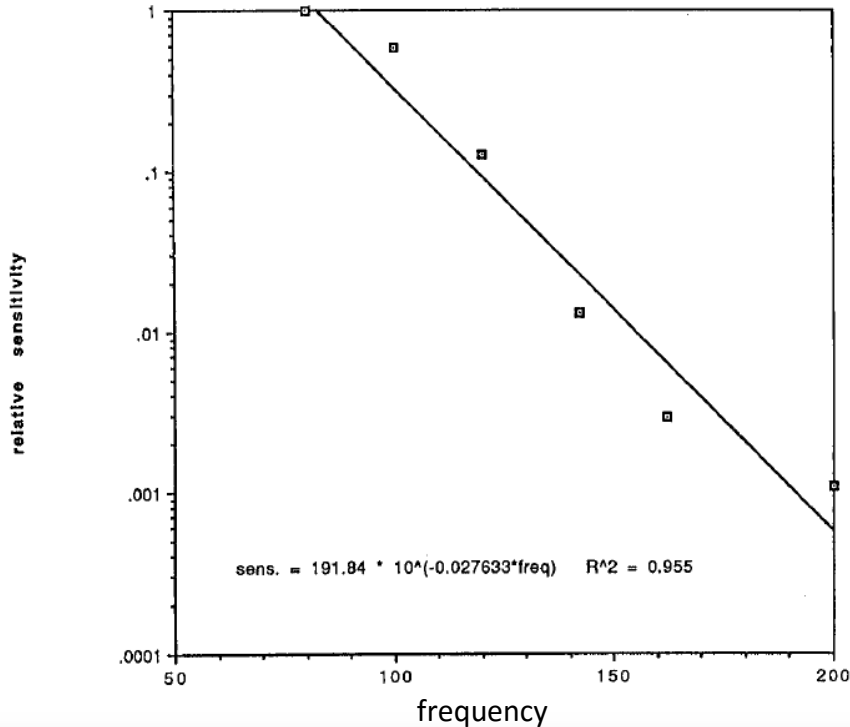
**Flicker
index
examples**

light output from LED Halogen replacement

Flicker index examples



Frequency sensitivity of the human eye



The Berman Experiment, 1991

See also:

A flicker perception metric

D Bodington , A Bierman ,N Narendran

Lighting Research and Technology

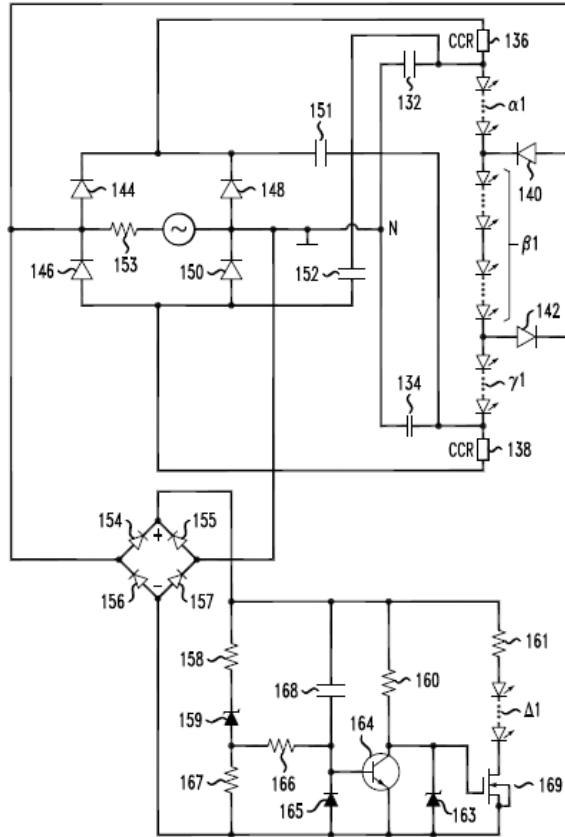
April 13, 2015 1477153515581006

History of flicker in AC LED Light Engines

<u>Year</u>	<u>Flicker index</u>	<u>Source</u>
2011	0.42	Survey by Poplawski and Miller
2015	0.32	Seoul Semiconductor (ACRICH 3)
2016	0.152	This work

Takeaway: The new light engine has dropped the best available flicker index by a factor of two from the previously reported best value.

The New Light Engine



Protection components omitted for clarity except for resistor 153

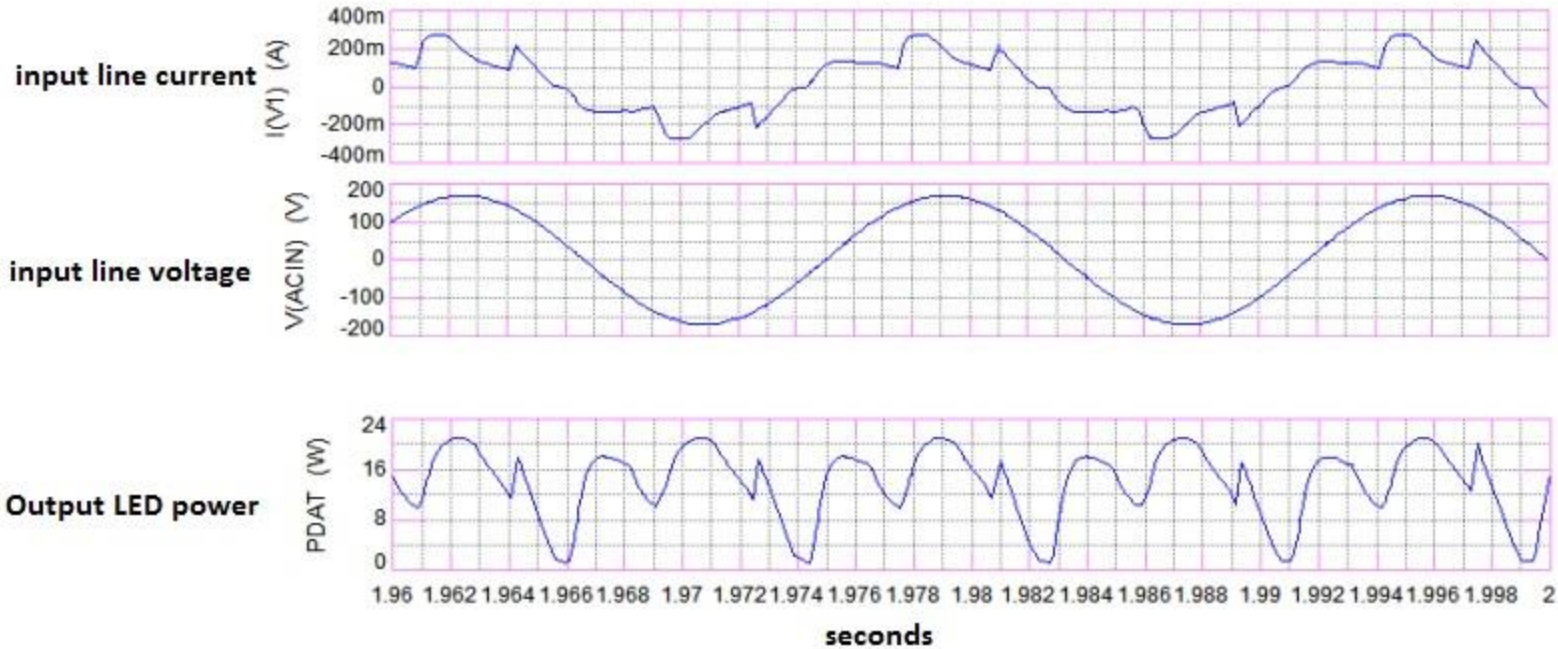
About the New Light Engine

- ❑ It uses no proprietary integrated circuits
- ❑ You can see a detailed explanation in the March 2016 issue of LEDs magazine
- ❑ In extreme summary, small amounts of energy are stored on chip capacitors and released at the right moment to give good power factor and good flicker index simultaneously.
- ❑ It is patent pending and licenses are available.

Performance of the New Light Engine

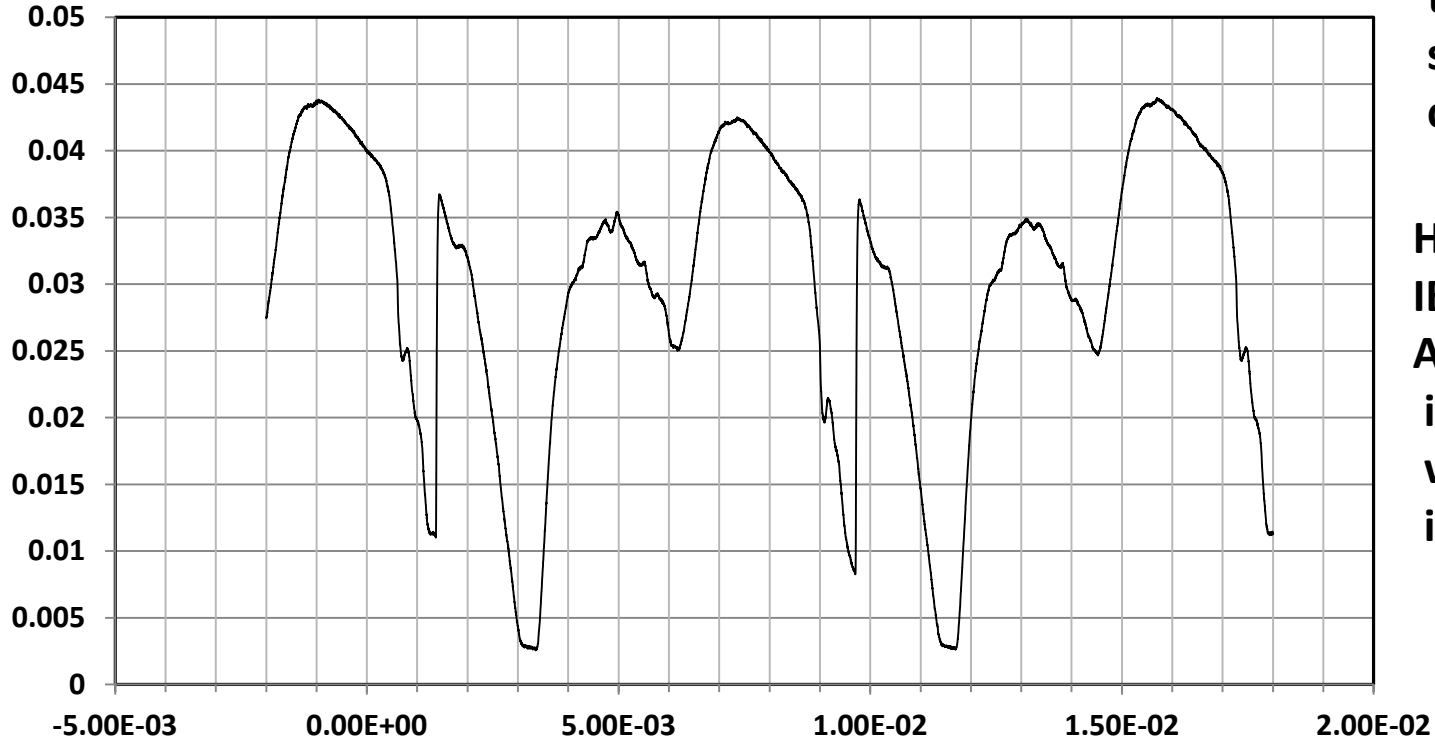
Power factor	0.90
Flicker index	0.152
THD	35%
Electrical efficiency	83%
Dimming range	down to 2.8% with ELV dimmer
Efficacy	120 lumens/W (depends on LEDs chosen)
Input voltage range	108V-132V, 60 Hz
Versions are being designed for 230V, 50 Hz	

Key Performance Waveforms



Flicker Index of the New light engine

0.152

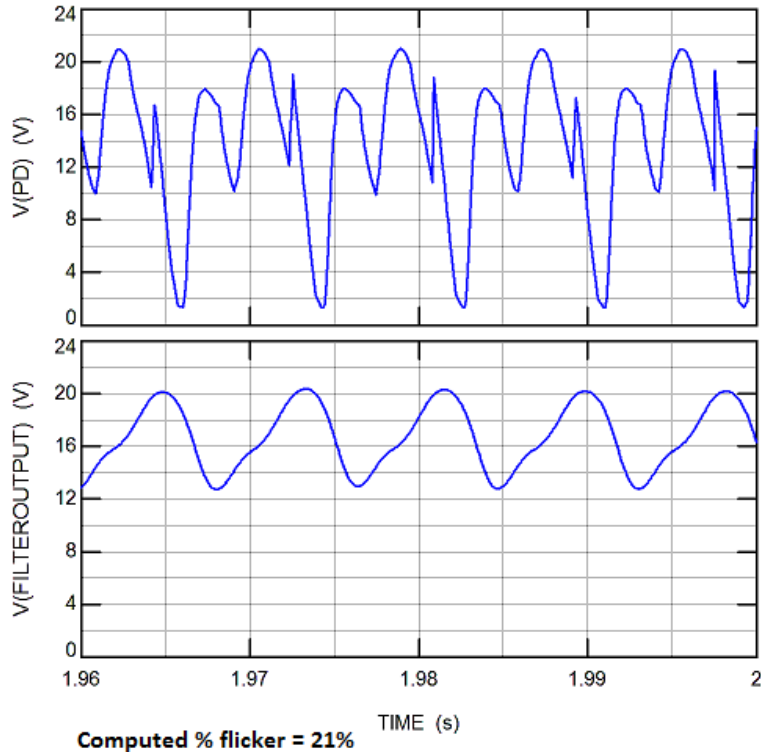


The down spikes are very brief, less than a millisecond so the human eye cannot perceive them

How does this relate to IEEE 1789-2015?

Answer: that standard is limited to sinusoidal waveforms which this is clearly not

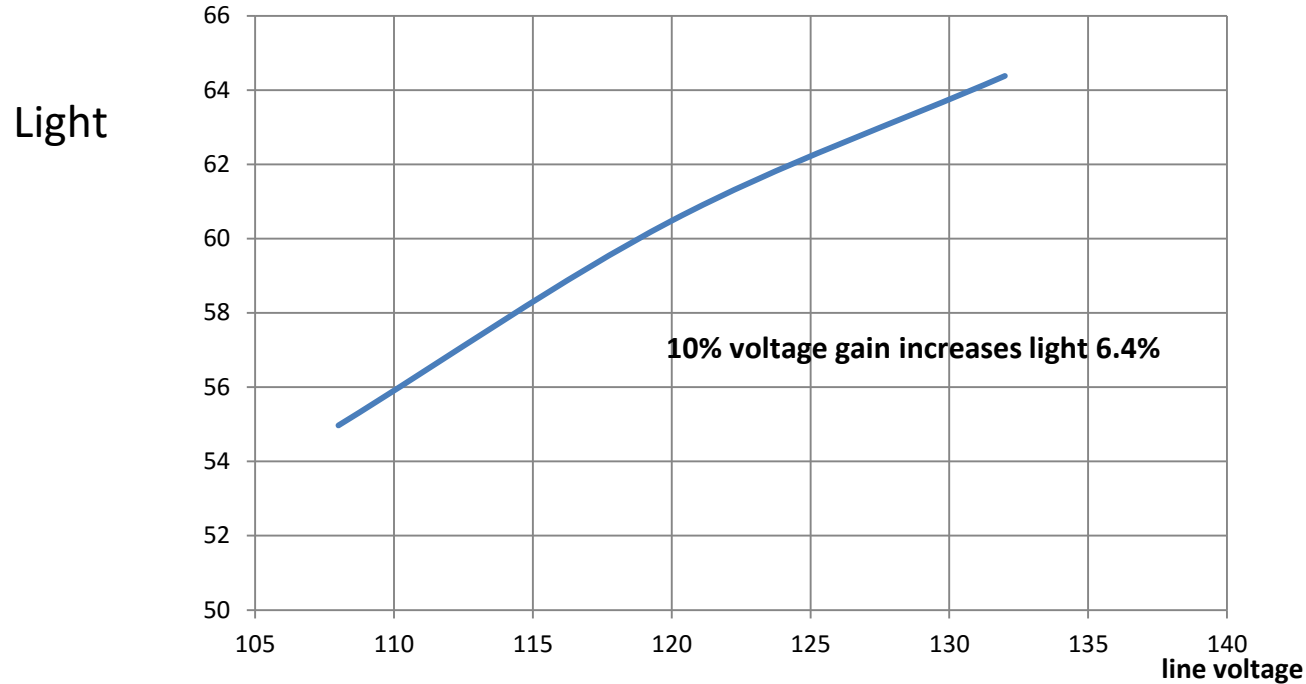
Applying 200 Hz LP filter



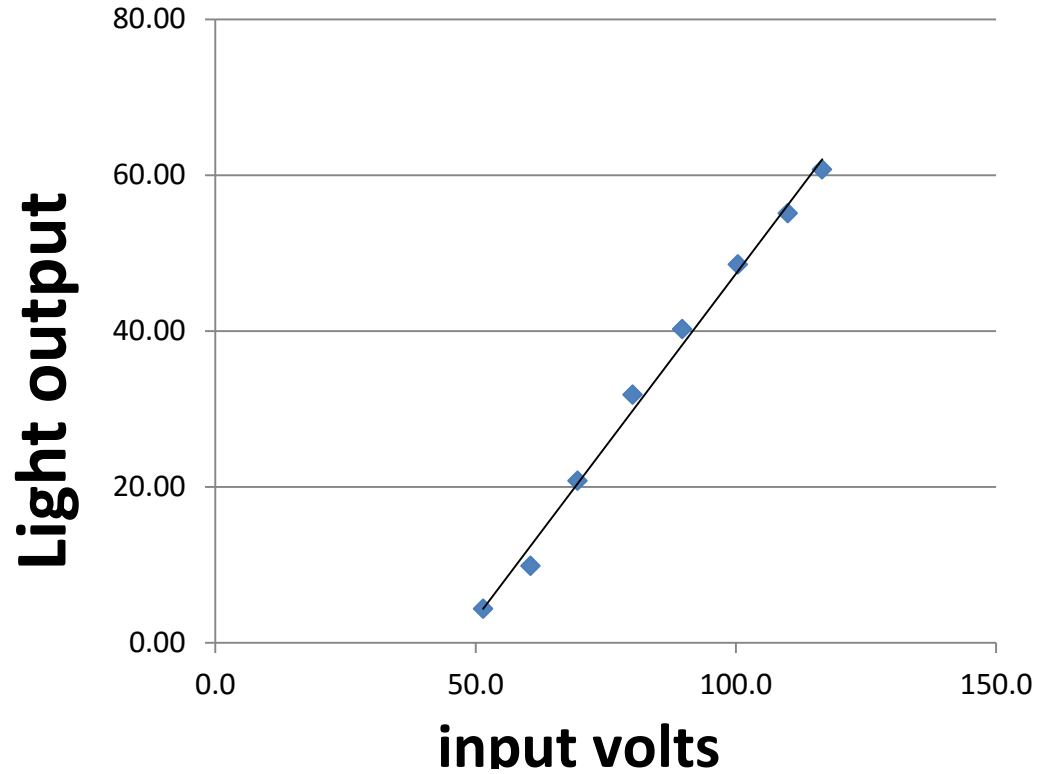
There have been proposals to apply a limit of 30% at 200 Hz to percentage flicker under California Title 24.

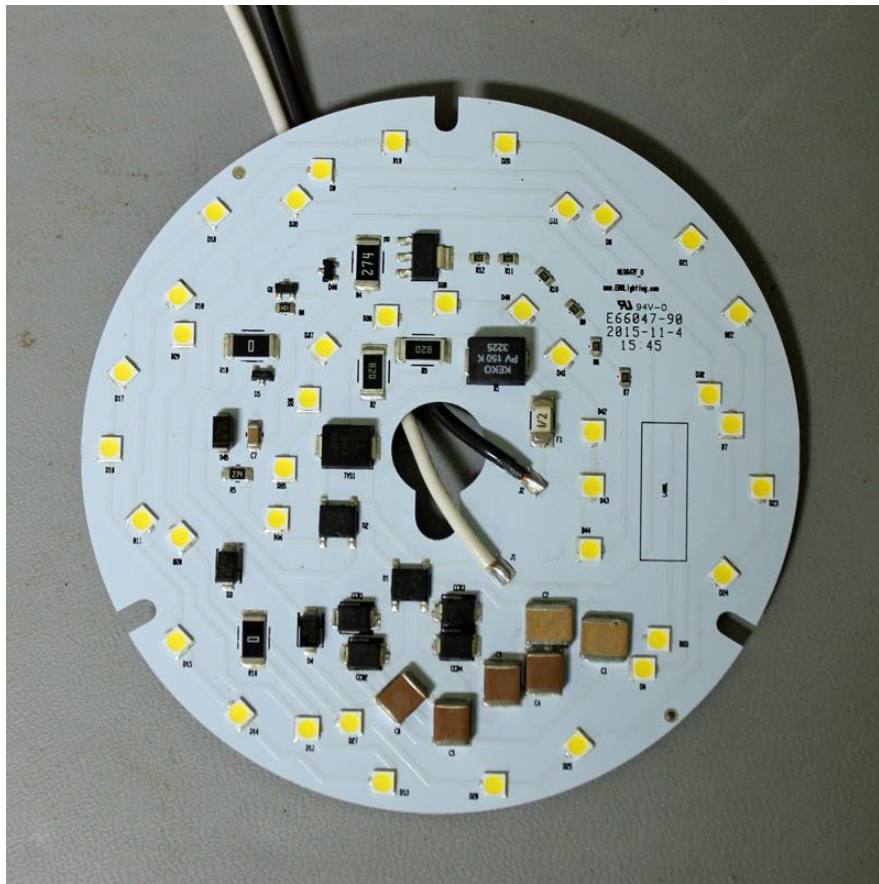
The New light engine has 21% flicker when a 200 Hz filter is applied and thus meets this requirement.

Variation of light output with voltage



Dimming performance with a trailing edge dimmer





An example of one of the New Light Engines

With acknowledgments to ERG
Lighting of Endicott New York

Summary and Conclusions

- ❑ This meeting is the first public announcement of a new kind of AC LED light engine .
- ❑ The flicker index has been reduced by a factor of 2 compared to the previous best performance available
- ❑ As perceived by the human eye, the performance is better than would be expected from the numbers because the imperfections are at very high frequencies.
- ❑ The product dims down to 3% with a trailing edge dimmer, but more sophisticated dimming remains to be engineered
- ❑ Questions?