

Foot-candles

Our occasional notes on photometry, optics and opto-electronics. **David Gibson** discusses pulsed light sources.

Bicycle rear lamps often use flashing red LEDs. Why do they flash? Is it to save power, or because the LEDs are more efficient when pulsed; or is it, perhaps, because a blinking/strobing light source is better at attracting attention?

Is a flashing light more efficient?

It is well-known that the *apparent* brightness of a fast-pulsed light source is equal to the integrated value of the actual illumination. In other words, if you viewed it through a shutter that opened and closed 100 times a second, and it was open for 30% of the time, then the light would appear to be 30% as bright. This is the principle of *persistence of vision* and is formally expressed in *Talbot's Law* for frequencies greater than about 10Hz.

LEDs

Expressed another way, this says that if were to drive an LED with 100mA pulses on a 20% duty cycle at a frequency high enough for 'persistence of vision' to apply, then (for the same LED efficiency) the apparent brightness would be as if we drove it with 20mA continuously.

Early LEDs were more efficient at converting electrical energy to light energy when driven at a higher current, so a pulsed LED, as in the example above, would actually give a brighter light than a continuously-driven diode. However this is *not* true of modern LEDs, and it is certainly far from true of white LEDs. These have a higher-than-usual series resistance, and are much less efficient at high currents, as the following table, based on the data for Nichia white LEDs shows.

Forward current (mA)	5	10	20	50	100
Forward voltage (V)	3.1	3.3	3.7	4.3	5.2
⇒ Power dissip.(mW)	15.5	33	74	215	520
⇒ Relative power, P	0.2	0.4	1.0	2.9	7.0
Relative luminosity, L	0.3	0.55	1.0	1.9	3.0
⇒ Efficiency, L/P	1.4	1.2	1.0	0.7	0.4

You can see that pulsing this diode at 100mA means that its inherent efficiency is only 40% of the value at 20mA. Several people have recently expressed to me a contrary view to this, but I do not understand the basis for their assertions!

Incandescent Lamps

With incandescent lamps the situation is slightly different. Here, it is not the 'persistence of vision' of the human eye that matters, but the thermal time constant of the filament. Furthermore, the luminous effi-

ciency is not related to the instantaneous current, as it is with an LED, but to the mean current, because the filament is cooler at a lower current, and generates more heat and less light. Again, people discussing this on the Internet have had some strange ideas – that high frequency pulses are somehow inherently less efficient – not so!

Is a flashing light more visible?

The *Blondel-Ray Law* states that at low frequency (< 5Hz) the apparent brilliance of a light source is related to the actual brilliance (during the flash) by the fraction $t/(\alpha+t)$ where t is the duration of the flash and $\alpha \approx 0.2s$. (α depends on various factors that I will not go into).

We can interpret this as follows. If the duration of the flash is very short then its apparent brightness is the brightness we get by averaging the flash over 0.2s. This makes good sense when you consider the photochemical properties of the eye.

Is a flashing light more noticeable?

Of course, 'apparent brightness' is not quite the same thing as 'noticeability' and a rear cycle lamp is visible for the same reason that moving objects stand out against a stationary background.

Suppose you are designing an emergency beacon and the tube is driven with a 50J pulse that lasts for 2ms. You might decide, from the conversion efficiency that this is 2500 lumen-seconds. If the beacon has 360° viewing and a beam height of 45° that is about 0.4 steradians so the inherent brightness is 6250 candela. But, applying the Blondel-Ray law, this is only going to appear to be 62.5 candela – not particularly bright! But this does not take into account the 'noticeability' of a flashing light.

In conclusion: It seems that flashing LEDs do cause a lot of confusion. Someone recently claimed to me that "*blue LEDs were 'hundreds of times' more visible than other colours, especially when pulsed*". On the face of it, this is complete nonsense on both counts, but I'm only quoting from conventional literature. If people really are getting different results then they need get the work verified and published!



Photography News

David Gibson reports on the forthcoming field meeting, and on plans for a BCRA photography group

Photography Field Meeting

For several years now, a joint team from *Underground Photographer* and CREG have organised a cave photography field meeting in May. A similar meeting is planned for **June 10th-11th** at the Dalesbridge Centre in the Yorkshire Dales.

The format will be slightly different to previous years – on Saturday there will be a series of workshops and talks, and on Sunday there will be caving trips and practical photography. The Saturday programme is likely to include discussion on practical techniques, lighting, computer imaging for photos and web sites, and electronic gadgets, as well as the usual slide shows and a photo-salon. Everyone is welcome – both beginners and experts in cave photography, and anyone with an interest in underground imaging.

The Dalesbridge Centre, www.dalesbridge.co.uk has camping facilities. If you want B&B or bunkhouse accommodation at the Centre, you are advised to book it early. If you would like to attend, to help organise the weekend, or to give a talk, **Richard Rushton** will be very pleased to hear from you. Contact him at: **18 Long Meadow, SKIPTON, North Yorkshire, BD23 1BH.** Tel: 01756 794538, or e-mail to richard@yabon.demon.co.uk

BCRA Photography Group

For some years now – since CREG's publication of the first issue of *Underground Photographer* in fact – some of us have been pondering on the idea of a BCRA Special Interest Group for cave photographers. The reason it never got off the ground was that there did not seem to be a pressing need for a 'formal' group. The situation has now changed slightly, and I think that an 'informal' group, with an occasional newsletter might now serve a useful purpose of informing people about cave photography events – in particular, our annual field meeting and the photo competition at the national caving conference.

I could probably have my arm twisted to maintain a mailing list of interested people. I am not intending to start up a 'formal' group, but I could probably manage to issue a small newsletter now and then. If you would like to be put on the mailing list please let me know: **David Gibson, 12 Well House Drive, LEEDS, LS8 4BX.** Tel: 0113 248 1218, or e-mail to david@caves.org.uk

The editors of *UP*, Kym & Paul, have been pre-occupied for some time with family and business problems. We all wish them well and hope that *UP* will make a recovery soon!