LED Lamp Investigation
by
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The lamp that started it all!

Most manufacturers deny a breach of the regulations this one appears to advertise it.

“We are now offering our most popular light fitted with the latest LED technology. Only uses 5w of energy.

This LED model will interfere with DAB broadcasts.”
The keen eyed amongst you will note that many of the following emission sweeps reference EN55022.

While this is technically incorrect (EN55015 references EN55011), for investigative work this has absolutely no bearing on the validity of the results found.

EN55011 Group 1 Class B and EN55022 Class B are, to all intents and purposes, identical.
HALOGEN bulb fitted to floor standing lamp unit (mains powered)
Radiated Emissions

Worst case margin is >12dB below Class B limit.
These emissions were subsequently traced to the 12V smps.
LED bulb1 fitted (Opti-led 3.5W)
Radiated Emissions

Worst case margin is 15.78dB ABOVE Class B limit
LED bulb 2 fitted (Philips 7W)
Radiated Emissions

Worst case margin is 7.11dB ABOVE Class B limit
As a quick comparison, the following Radiated Emissions traces show:

- Halogen bulb (Red line)
- LED 1 Opti-led 3.5W (Cyan line)
- LED 2 Philips 7W (Dark Blue line)
HALOGEN bulb fitted to floor standing lamp unit (mains powered)

Conducted Emissions

Average detector: 9.51dB ABOVE Class B limits
Q-P detector: 8.54dB ABOVE Class B limits
LED bulb1 fitted (Opti-led 3.5W)

Conducted Emissions

Average detector  12.71dB ABOVE Class B limits
Q-P detector 7.57dB ABOVE Class B limits
LED bulb 2 fitted (Philips 7W)
Conducted Emissions

Average detector 15.69dB ABOVE Class B limits
Q-P detector 15.12dB ABOVE Class B limits
Conducted emissions:
- Halogen bulb (Red line)
- LED 1 Opti-led 3.5W (Cyan line)
- LED 2 Philips 7W (Dark Blue line)

The lower frequency emissions were attributed to the smps, but note the large variation between bulb types around 10MHz.
Other LED lighting units (battery powered)
e.g.

All gave “noise floor” emission results
BULB only investigations
(linear 12V psu, 30cm twisted pair)
Radiated emissions:
- Halogen
- LED 1: Opti-led 3.5W
- LED 2: Philips

(Red line)
(Cyan line)
(Dark Blue line)
Components!
In pieces

LED plate only (AC/DC unit removed)

Radiated emissions

As expected – noise floor emissions
Bulb only Conducted Emissions measurement on DC input to bulb (12V\textsubscript{DC} supplied via LISN)

LED bulb 1: Opti-led 3.5W

Average detector: 30.83dB ABOVE Class B limits
Q-P detector: 20.30dB ABOVE Class B limits
Bulb only Conducted Emissions measurement on DC input to bulb ($12V_{DC}$ supplied via LISN)

LED bulb 2: Philips 7W

Average detector 57.74dB ABOVE Class B limits
Q-P detector 61.64dB ABOVE Class B limits

Note: “Overload” detected during readings so linearity not guaranteed.
More Lamps

12V ac/dc

Deltech 4W MR16 12V AC/DC (30W Halogen equiv)

Conducted Emissions

Radiated Emissions
240V ac Lamps

GE 1W (28 lumen) White GU10
230-240V

Conducted Emissions
240V ac Lamps

GE 4W (225 candela) White
GU10 240V

Conducted Emissions
240V ac Lamps

Alpha 1.3W (8W incandescent equiv) GU10 240V

Conducted Emissions
MR11 LED Bulb Conducted Emissions

<table>
<thead>
<tr>
<th>Marker</th>
<th>Measured Frequency (MHz)</th>
<th>Measured Peak (dBuV)</th>
<th>Measured Average (dBuV)</th>
<th>Measured Q-P (dBuV)</th>
<th>Q-P Limit (dBuV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.35289</td>
<td>71.41 *</td>
<td>53.67</td>
<td>69.09 *</td>
<td>58.90</td>
</tr>
<tr>
<td>1</td>
<td>1.4523</td>
<td>74.13 *</td>
<td>57.98 *</td>
<td>73.48 *</td>
<td>56.00</td>
</tr>
</tbody>
</table>

Q-P readings are greater than 17dB ABOVE Class B limit  **FAIL**
MR11 LED Bulb Radiated Emissions
This unit **FAILS** the conducted (Q-P) requirement by 7.37dB (marker #1).

9-150kHz conducted and also 30-300MHz radiated emissions are all well within requirements.
Tim Williams has been carrying out independent investigations on 240V ac lamps and has found all to be compliant for conducted emissions, but have quite different characteristics especially below 150kHz.

We, along with Keith Armstrong, are concerned that we may have a “misunderstanding of the EMC Standards and Regulations” as lamp manufacturers appear to be under the misapprehension that only conducted emissions testing is required and then only for 230/240V units.
The ‘problem’ may be wider than initially thought

The following was discovered by Terry Wells (Virgin Media)
Reported to us via Brian Copsey

Question re: LED Interference with VHF

“I recently installed an LED tri-color and an LED anchor light. Unfortunately, now whenever I have either light on I only hear static on all stations on my VHF, no matter what I do with the squelch. Its no good because its important that I have the tri-color and the VHF working properly at the same time for night sailing. Any suggestions as to what is causing this”? 
We were recently informed by a company, who install studio equipment, that many professional recording studios have banned the use of “energy efficient” lighting, in particular LED lighting!

Dave Bowman of Quantel is “looking into this”!
Summary: The Good

• The LEDs themselves are, as expected, benign and do not emit.

• Available 240V units appear to be compliant (at least above 150kHz).

• If 240V lamps do employ switching circuitry then the technology and/or filtering used appears to be adequate for compliance.

• Low voltage units employing LEDs only (torches, panel indicators, etc.) are no problem.

• Even some low voltage units employing switching circuitry are no problem.
Summary: The Bad

• Some low voltage LED units employing electronic devices (constant current sourcing?) exhibit unacceptable conducted emissions.

• The current trend towards “energy efficient” lighting means that LED usage will become much more widespread.

• These units are often installed as part of a low voltage distribution system which could extend over an entire building.

• Reports seem to show that the lighting industry does not appreciate the need for low voltage device emissions testing.

• Research into better ac/dc converters and constant current devices, along with adequate filtering, is essential.

• Problems are beginning to emerge in areas other than domestic lighting.
Summary: The Ugly

Each household will have, at worst, only one PLT device

But with results such as these:-

What will be the impact on the power distribution network when you consider how many LED lights a household may have?
And this is where our investigation might have stopped. Indeed, we were demonstrating these findings at the EMCUK trade show in October when we suddenly found one of our lamps, which previously was thought to have few emissions, suddenly went way above the limit!

Tracing the problem we noticed that the voltage supply to the bulb had drifted off 12V.

This led us to a whole new line of investigation and by now other people, including Keith Armstrong, had lent us more LED bulbs to look at.
Unbranded LED MT16 6W Radiated Emissions with the voltage set to exactly 11V

Radiated emissions are well under the limit line.
Unbranded LED MT16 6W Radiated Emissions with the voltage set to exactly 12V

No radiated emissions problems at exactly 12V
Unbranded LED MT16 6W Radiated Emissions with the voltage set to exactly 13V

Radiated emissions “slightly” above the limit line!
Unbranded LED MT16 6W Radiated Emissions 11V with comparison overlays for voltages at 12V and 13V

Traces: Dark blue 11V  Cyan 12V  Red 13V
Unbranded LED MT16 6W Conducted Emissions with the voltage set to exactly 11V

No conducted emissions problems at exactly 11V
Unbranded LED MT16 6W Conducted Emissions with the voltage set to exactly 12V

No problems
Unbranded LED MT16 6W Conducted Emissions with the voltage set to exactly 13V

Not quite noise floor!
Unbranded LED MT16 6W Conducted Emissions
11V with comparison overlays for voltages 12V and 13V

Traces: Dark blue 11V   Cyan 12V   Red 13V
Not all LED bulbs exhibit this poor behaviour.

Some are poor at all voltages!
Unbranded 12V/AC DC bulb
Radiated Emissions with comparison voltages

Traces: Dark blue 11V  Cyan 12V  Red 13V
Unbranded 12V/AC DC bulb
Conducted Emissions with comparison voltages

Traces: Dark blue 11V     Cyan 12V     Red 13V
Deltech MR16 5W bulb Radiated Emissions with comparison voltages

Traces: Dark blue 11V  Cyan 12V  Red 13V
Deltech MR16 5W bulb Conducted Emissions with comparison voltages

Traces: Dark blue 11V   Cyan 12V   Red 13V

The frequency where problems occur changes as the supply voltage changes.
LED bulb 2: Philips 7W
Radiated Emissions with comparison voltages

Traces: Dark blue 11V    Cyan 12V    Red 13V
LED bulb 2: Philips 7W
Conducted Emissions with comparison voltages

Traces:  Dark blue 11V     Cyan 12V     Red 13V
The critical voltage isn’t always the same!
LED 3: Unbranded MR16 4W
Radiated Emissions with comparison voltages

Traces: Dark blue 11V   Cyan 12V   Red 13V
LED 1: Unbranded MT16 6W Radiated Emissions
11V with comparison overlays for voltages at 12V and 13V

Traces: Dark blue 11V  Cyan 12V  Red 13V
Does using AC voltages make a difference?
Unbranded LED MT16 6W Conducted Emissions with the voltage set to exactly 9V

Radiated emissions are also well under the limit line.
Unbranded LED MT16 6W Conducted Emissions with the voltage set to exactly 10V
Unbranded LED MT16 6W Conducted Emissions with the voltage set to exactly 15V
Unbranded LED MT16 6W Conducted Emissions
with the comparison voltages 9V, 10V, 15V

Traces: Red 9V    Cyan 10V    Dark blue 15V
LED 2: Philips 7W
Conducted Emissions 2V AC (Lamp just on)
LED 2: Philips 7W
Conducted Emissions 12V AC (rated voltage)
LED 2: Philips 7W
Conducted Emissions 15V AC (rated voltage)
LED 2: Philips 7W
Conducted Emissions 15V AC with comparison overlays

Traces: Red 2V   Cyan 12V   Dark blue 15V
LED 3: Unbranded MT16 4W
Conducted Emissions 8V AC
LED 3: Unbranded MT16 4W
Conducted Emissions 9V AC
LED 3: Unbranded MT16 4W
Conducted Emissions 15V AC
LED 3: Unbranded MT16 4W
Conducted Emissions 15V AC with comparison overlays

Traces: Red 8V  Cyan 9V  Dark blue 15V
Keith Armstrong’s bulb (Philips 4W)
Conducted Emissions 8V AC
Keith Armstrong’s bulb (Philips 4W)
Conducted Emissions 9V AC
Keith Armstrong’s bulb (Philips 4W)
Conducted Emissions 12V AC
Keith Armstrong’s bulb (Philips 4W)
Conducted Emissions 15V AC
Keith Armstrong’s bulb (Philips 4W)
Conducted Emissions 15V AC with overlays

Traces: Black (noise floor) 8V  Red 9V  Cyan 12V  Dark blue 15V
Timeline of an EMC Complaint
Comments paraphrased from phone conversations with an LED complainant

The order of enquiries made by an EMC complainant with each group suggesting the next one.

• Which? The consumer association: “Come back when you have a story”
• Ofcom: “Not our pigeon. Try…”
• Consumer Direct: “Sorry. Not our area of expertise. Try…”
• British Standards Institute (who first suggested Trading Standards): “Why not try …”
• UKAS: “Why us? Try…”
• Nemko Ltd: “You need an expert. Try…”
• TUV: “We’re a test house. We don’t investigate complaints why not try…”
• Hursley “We were recently at a presentation by Peter Metcalfe on just this topic. Try …”
• METECC: We carried out investigative work followed by extensive discussion which resulted in the following …
The follow-up:

- **Consumer Direct**: “Said they had logged the call and passed it to Trading Standards”

- **Trading Standards (Devon)**: “Said they were under no obligation to contact me back. They also said that they do not take complaints from consumers, who should contact Consumer Direct. The Consumer Direct website says how to complain to a company but not how to complain about a company”

- **BBC**: “BBC Reception Helpdesk tells me that they passed my concerns to the BBC Distribution Team (whatever that is) who will get back to me. But they have no timescale to do so.

- **Ofcom (again)**: Received the infamous quote
  “Interference issues that affect broadcast transmissions are not our responsibility. This is now the responsibility of the BBC”

- **Which?**: “They are well behind with answering queries so ...”

- **Given that all the original complaint started on 19th August, my complainant is beginning to feel that no one in authority is really bothered.**
Subsequent to the original presentation of this piece, METECC have been informed of the following official OFCOM/BBC position:

“OFCOM have passed over all responsibility for investigation of radio interference matters to the BBC but have retained all aspects for prosecution”.
So – the situation is that:-

• One body has the remit to investigate but not prosecute

• One body has the remit to prosecute but not investigate

What a pity the two bodies do not give the impression that they are talking to each other!
You may think that this is a joke

But that is exactly what has been happening.
Thank you for your attention

Please feel free to contact us to discuss this further.

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