

**Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)**

**Submission Title:** Phosphorescent white LEDs: dependence of colour temperature on driving current

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**Re:** N/A

**Abstract:** The VLC baseline draft advocates variable DC bias currents for dimming when using OOK or CCM modulation. We address the impact of such variability on the radiant colour temperature of phosphorescent white LEDs.

**Purpose:** Helping TG 802.15.7 to assess the impact of driving current on radiant colour integrity.

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# Phosphorescent white LEDs: dependence of colour temperature on driving current

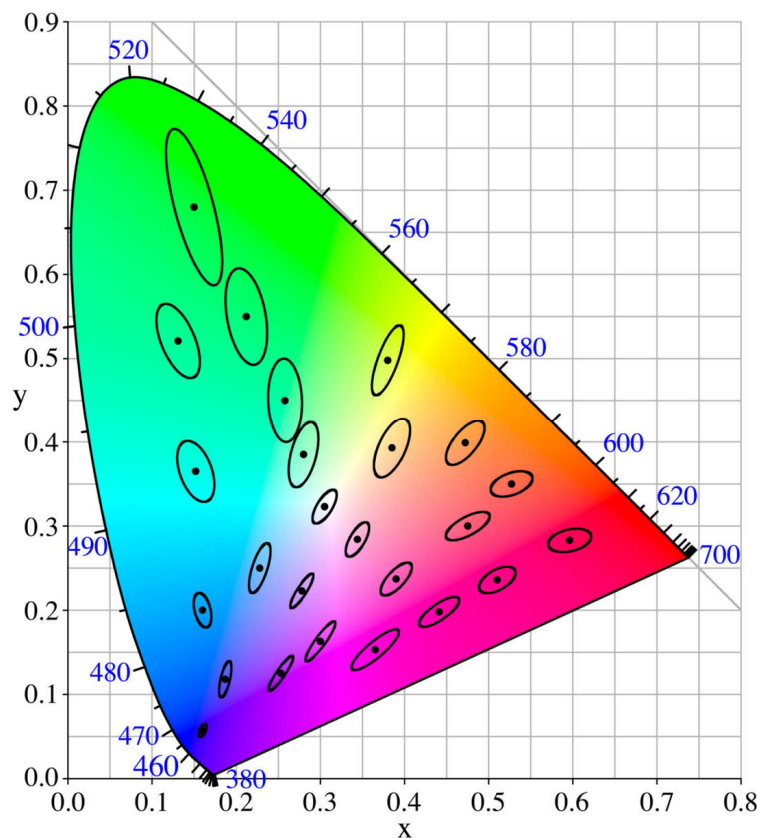
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## Motivation for this contribution

- IEEE 802.15.7, draft D0, relies on amplitude dimming for OOK and CCM modulation
- Common knowledge: colour temperature of LED emission depends on bias current
- For multi-colour LED systems this effect can be compensated for by aid of sensor feedback loops
- Potential issue: colour shift of phosphorescent white LEDs due to amplitude dimming

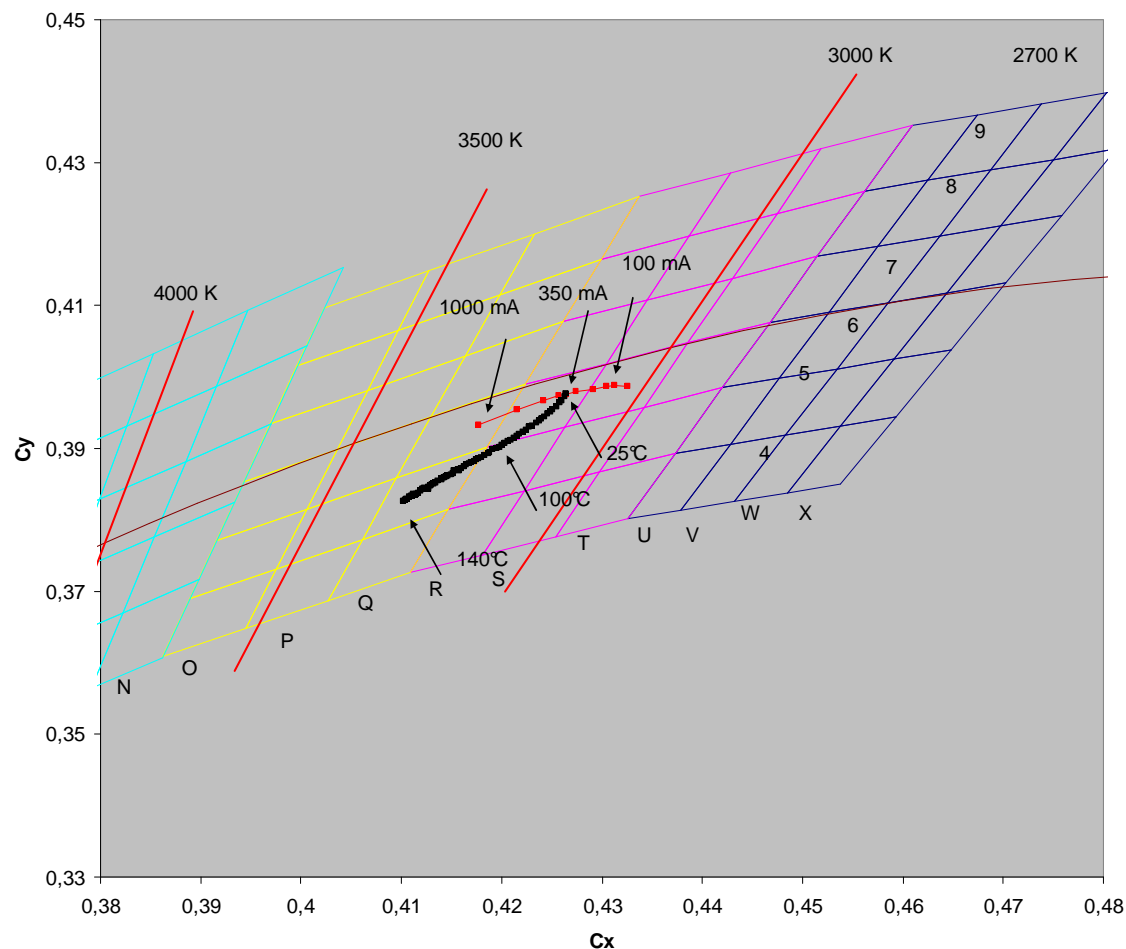
# Mini-tutorial up front: MacAdam ellipse



Source: Wikimedia Commons, GNU Free Documentation License, Version 1.2; Notice: Ellipses ten times their actual size

- Each colour uniquely defined by CIE coordinates  $x$  and  $y$
- Question: what colours are indistinguishable?
- Answer: colours viewed spatially next to each other that lie within MacAdam ellipse cannot be distinguished by naked eye [MacAdam, 1942]
- Colours within ~ three times larger ellipses are not regarded as disturbing the inexperienced observer (working knowledge of lighting OEMs)
- Just FYI: 5 x Mac Adam ellipses lamp-to-lamp difference accepted for fluorescent lamps [IEC, 2002]

# Colour-temperature measurement of phosphorescent white LED



- LED: Golden Dragon Plus
- Typical bias current: 350-700 mA
- Distance between two Grid lines: ~ 3 x Mac Adams threshold value, viz. indistinguishable
- Solid line: change of radiant colour as a function of LED chip temperature
- Red line: change of radiant colour as function of DC bias current

# Discussion

- Fast modulation of bias current ( $> 120$  Hz): eye perceives average colour → Expect no discernible colour change due to ac component of VLC modulation
- However, changing bias current during, e.g., idle periods, can result in perceivable colour changes
- Our recommendation:
  - Briefly discuss phenomenon in standard appendix
  - Leave decision about whether colour change tolerable up to OEM and do not make it an integral part of IEEE 802.15.7 standard

## References

- IEC, “Double-capped fluorescent lamps - Performance specifications,” IEC 60081, ed. 5.1, 2002
- D. L. MacAdam, "Visual sensitivities to color differences in daylight," JOSA 32 (5): 247–274, 1942.