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

Submission Title: [Visibility for VLC on TRD]
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Re: []

Abstract: [Visibility issue of the VLC for TRD is described in this document. Some consideration point of visibility are also presented.]

Purpose: [Contribution to IEEE 802.15.7 TG-VLC]

Visibility for VLC on TRD

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Samsung Electronics

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❖ **Summary**

General Advantageous features of VLC

❖ **There are 2 major advantageous features of VLC**
- LED infrastructure proliferation
- Visibility

❖ **Visibility**
- Intuitive communication
- Fun & Aesthetics
- High Security (Physical layer security)

❖**Visibility considerations of VLC**
- Can be verified by the naked eyes
  - ◆ Unique protocol
- LED choice
  - ◆ Independent from LED Infrastructure (different color and type light source)

* Ref: IEEE802.15 08-0428-00

Visibility

❖ **Definition**

◼ How far or how clearly you can see in particular weather condition

Visibility for Visible Light Comm.

❖ Necessity

- Help the Link alignment (direction)
- Help find the destination (end of light beam)
- Physical security

❖ Visibility on PAR

- **Scope of proposed Standard**: This standard … . The **visible light spectrum** extends from **380 to 780 nm** in wavelength. The standard is capable of delivering data rate sufficient to support audio and video multimedia services and also considers mobility of the **visible link**; … ; and a **MAC layer that accommodates visible links.** ….
- Ref: 15-08-0656-01-0vlc-par-document.pdf

Visibility for Visible Light Comm.

❖ **Requirement**

■■ Visible

◆ PAR: The visible light spectrum extends from 380 to 780 nm in wavelength.

◆ even if the light source range is between 380nm and 780nm, some light around 380nm and 780 nm cannot be seen by the naked eyes.

■■ Continuance of lighting

◆ during the normal communication conditions, the light cannot be recognized.

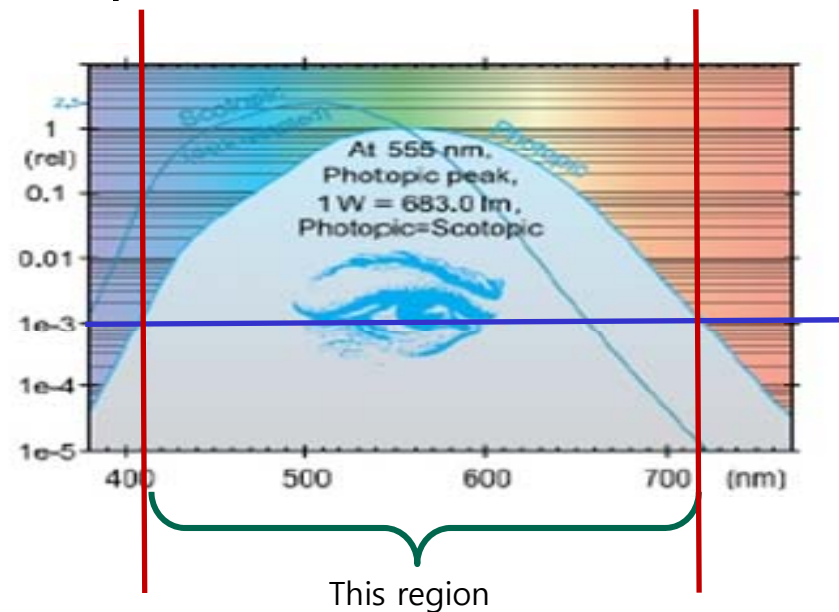◆ light is needed to be ON at least while people can recognize.

■■ Quantitative expression

◆ Can we indicate the light quantity?

Requirement for Visibility

❖ **Visibility**

▪ Need to define the limited wavelength range.

▪ For example

This region

∗ CIE Photopic and Scotopic sensitivity curves

∗ Ref: 15-09-0159-00-0007-considerations-for-getting-a-delicate-vlc-application-summary.pdf
Light Measurement Handbook 1998 by Alex Ryer, International Light Inc.
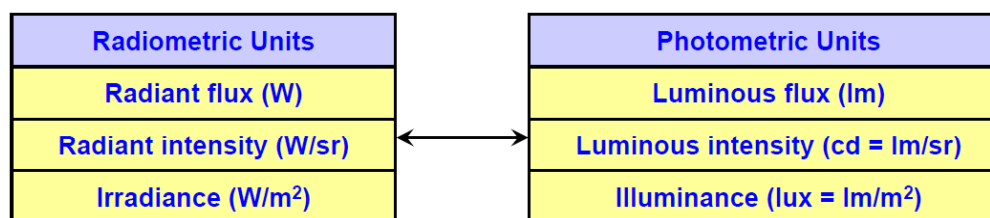
Requirement for Visibility

❖ **Continuance of lighting**

▪ During the communication, keep the light on

▪ Basic steps for normal communication process

◆ Try to align (Device discovery, negotiation, connection)

■ Visible guiding for user alignment

■ User can verify the end of the light beam

◆ Normal data transferring

◆ Unexpectedly interrupted, disconnected, interfered.

■ Visible link failure indication for intuitive usage

◆ Completed, disconnected

Requirement for Visibility

❖ Quantitative expression

▬ The light can be characterized by radiometric or photometric unit (∗1)

Radiometric Units
Radiant flux (W)
Radiant intensity (W/sr)
Irradiance (W/m^2)

Photometric Units
Luminous flux (lm)
Luminous intensity (cd = lm/sr)
Illuminance (lux = lm/m^2)

- ■ The radiometry is the science of measurement of radiant energy (including visible light) in terms of absolute power

- ■ Photometry is the science of measurement of light, in terms of its perceived brightness to the human eye, rather than absolute power.(∗2)

▬ However, it's not easy to decide the criteria or set the standard.

(∗1) Ref: 15-09-0159-00-0007-considerations-for-getting-a-delicate-vlc-application-summary.pdf
(∗2) www.wikipedia.org

Requirement for Visibility

❖ **Other consideration for Visibility**

▪ Divergence angle

▪ Reflectance of reflector

▪ Distance (Transmission Range)

▪ Appropriate power consumption

Other consideration

❖ **Illumination system**

■ Depending on use case, like using the lighting system, some applicatoin doesn't need to worry about visibility.

❖ **Long range use case**

■ difficult to keep the visibility due to the long distance

■ difficult to see the light beam

■ Power consumption

■ It's not easy to apply for all long range use cases.

Visibility & Application

Device Application Classes (Based on Appl. Sum. Doc)			
A. **Short Range** Infra to Mobile/Vehicle	A.1. Infra to **Mobile** (Uni/Bi)	Partially, for mobile device	
	A.2. Infra to Vehicle (Uni/Bi)	No need	
B. Long Range Infra to Mobile/Vehicle	B.1. Infra to **Mobile** (Uni/Bi)	Partially, for mobile device	Depends on distance
	B.2. Infra to Vehicle (Uni/Bi)	No need	
C. **Short Range** Mobile/Vehicle to Mobile/Vehicle	C.1. **Mobile to Mobile (Uni/Bi)**	Need	
	C.2. **Mobile** to Vehicle (Uni/Bi)	Partially, for mobile device	(Appl. Not contributed)
	C.3. Vehicle to Vehicle (Uni/Bi)	No need	
D. Long Range Mobile/Vehicle to Mobile/Vehicle	D.1. **Mobile to Mobile** (Uni/Bi)	Need	Depends on distance
	D.2. **Mobile** to Vehicle (Uni/Bi)	Partially, for mobile device	Depends on distance (Appl. Not contributed)
	D.3. Vehicle to Vehicle (Uni/Bi)	No need	

* Ref.: 15-09-0125-06-0007-vlc-application-definitions-and-summary
15-08-0218-00-0007-vlc-device-classification-and-mobility-considerations

Summary

❖ **VLC's feature and definition of Visibility**

❖ **Define the visibility for VLC**

❖ **Requirements & considerations**

▪ Keep the visibility during the communication

▪ Visibility (wavelength range & continuance of lighting)

❖ **Visibility & Application**

▪ Short distance

▪ Mobile to mobile (or for mobile devices)