

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

Submission Title: [VLC wavelength range]

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Re: []

Abstract: [The wavelength range of visible light communication is discussed. Considerations on VLC wavelength range are extracted from the VLC systems demonstrated so far. They include LED infrastructure, visibility, modulation limit, up/down separation, WDM.]

Purpose: [Contribution to IEEE 802.15 SG-VLC]

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VLC wavelength range

2008. 07

Samsung Electronics

Outline

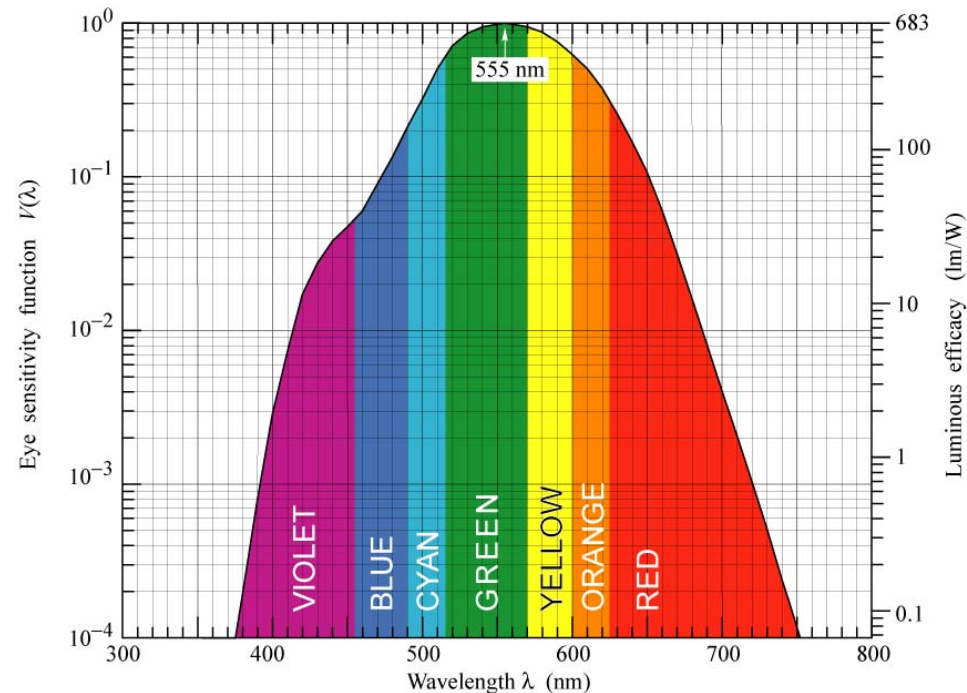
- Why do we discuss on VLC wavelength range?
- Wavelength range reference
 - Illumination industry
 - IrDA
- Considerations on VLC wavelength range
 - Wavelength ranges in VLC demo systems
 - Technical considerations
 - Other considerations
- Summary

Why do we discuss on VLC wavelength range?

- **VLC R&D**
 - Unregulated range over 300 THz
 - Unknown communication characteristics of visible devices
- **VLC standardization**
 - Coexistence/Interoperability with Infrared
 - Consensus on VLC Identity
 - IEEE802.15 VLC PAR

Illumination industry standard

- CIE (Commission Internationale de l'Eclairage)
 - Illumination wavelength range : 380 ~ 780 nm

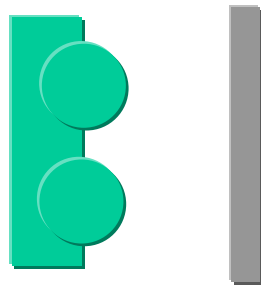


CIE 1978 V(λ) function

Source : www.lightemittingdiodes.org

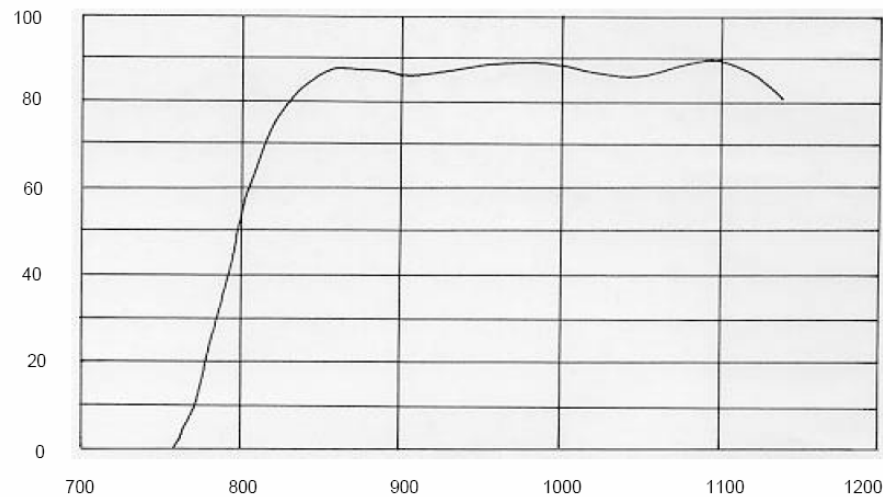
IrDA standard

- Standard : 850 ~ 900 nm
- Product (Vishay TFDU6301)
 - Peak wavelength : 875 ~ 900 nm
 - Spectral bandwidth : 45 nm



Transmittance (%)

ACRYLICCOLOR NUMBER 2711



Wavelength (nm)

Wavelength ranges in VLC demo systems



Organization	VLCC	VLCC	VLCC
Application	LAN	Audio broadcast	Navigation
Wavelength	R/G/B (down) Ir (up)	R/G/B	R/Y/G
Consideration	Up/down separation Modulation limit	WDM	Traffic infra

Wavelength ranges in VLC demo systems



Organization	Oxford U.	Kopti	VLCC
Application	Audio broadcast	Data broadcast	Optical ID
Wavelength	White	R/G/B	White
Consideration	LED infra	WDM	LED infra

Wavelength ranges in VLC demo systems



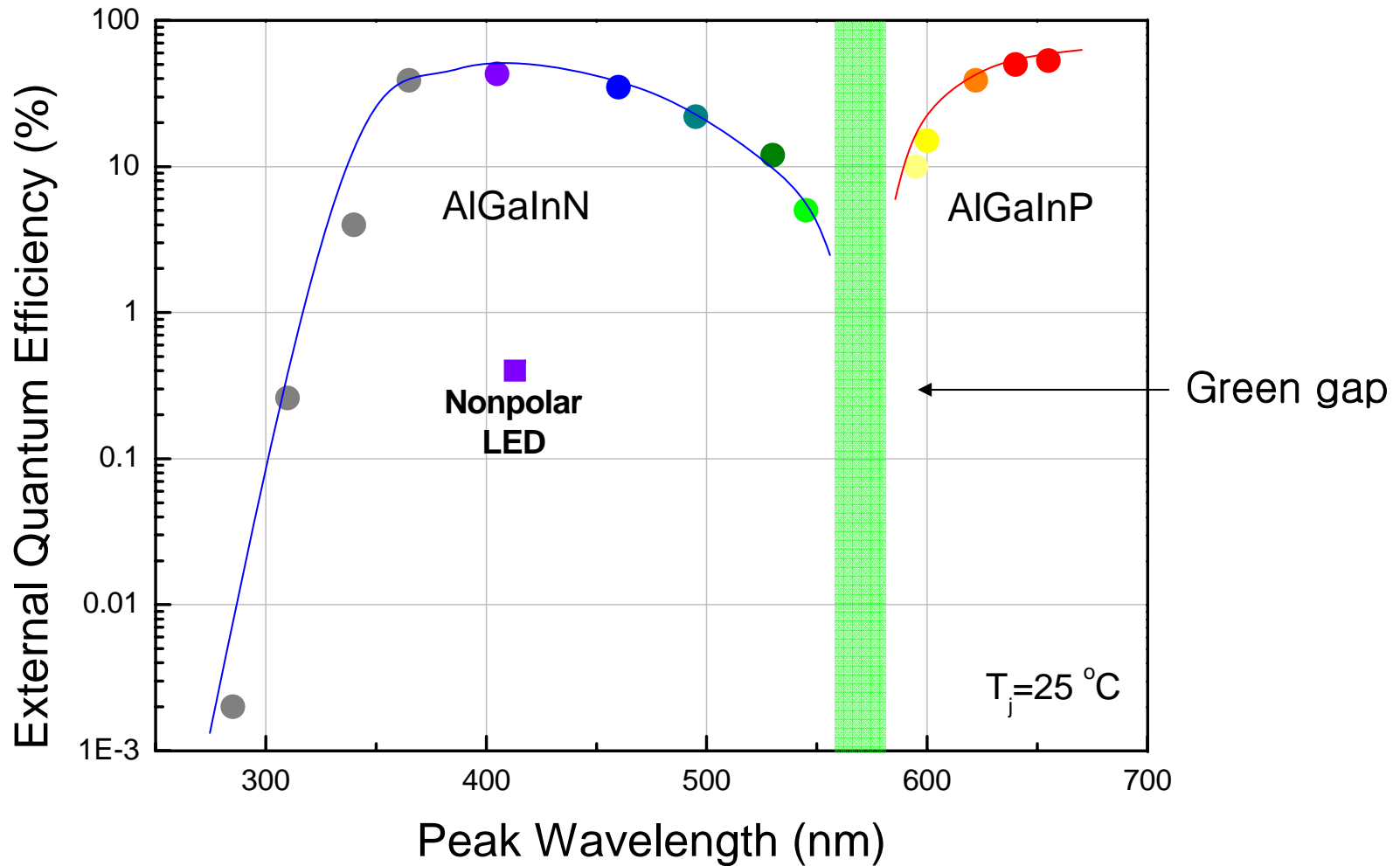
Organization	Samsung	Samsung	Samsung
Application	P2P	Data broadcast	LAN
Wavelength	Red	R/G/B	White (down) Red (up)
Consideration	Visibility Modulation limit	WDM Sign board infra	LED infra Visibility

Considerations on VLC wavelength range

- LED infrastructure
- Visibility
- Modulation limit
- WDM
- Up/down separation

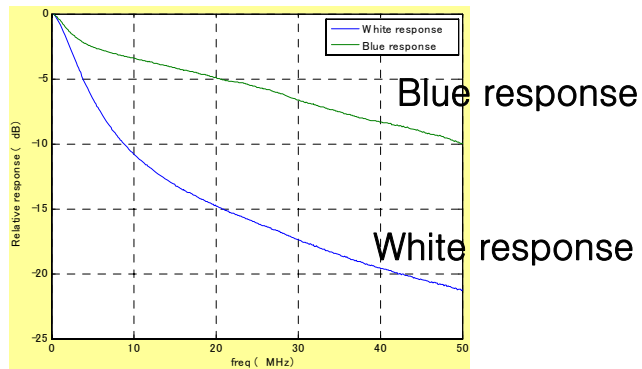
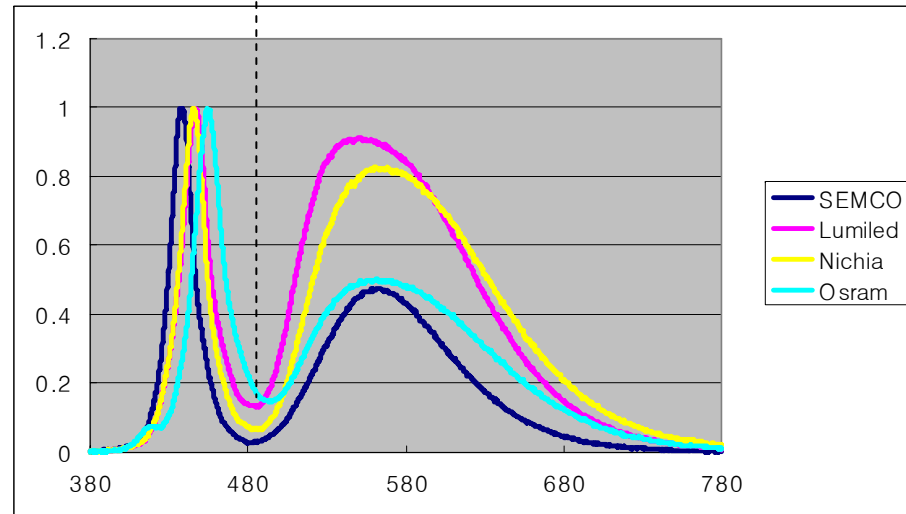
- Coexistence/interoperability with Infrared
- Photodiode
- Link

LED infrastructure – LED efficiency

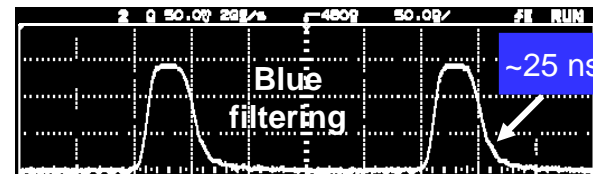
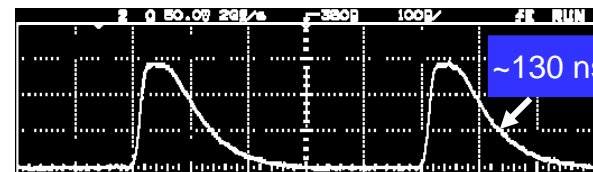


By courtesy of SEM

LED infrastructure – Illumination LED spectrum

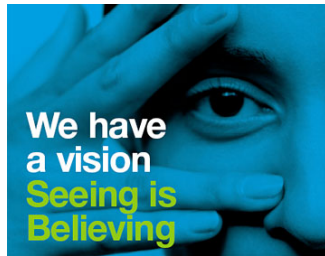


Measured LED small-signal bandwidth

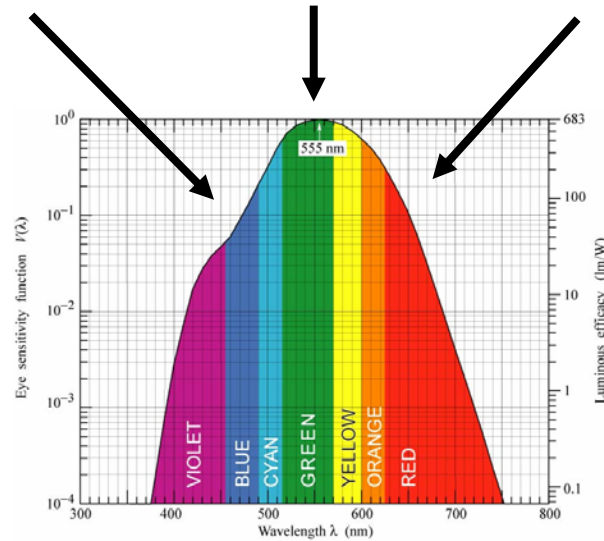
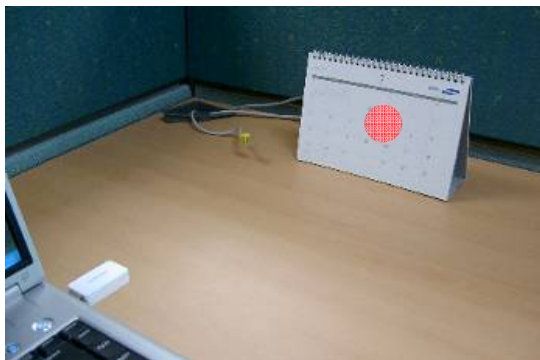
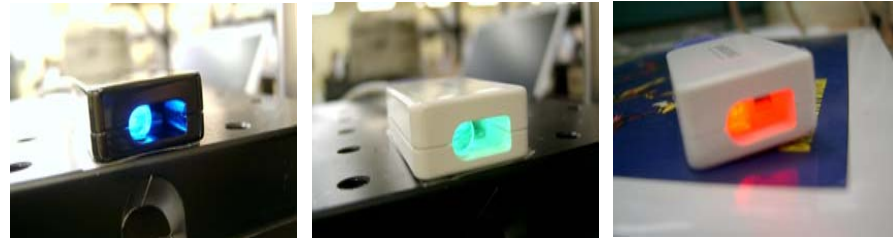


Measured impulse response

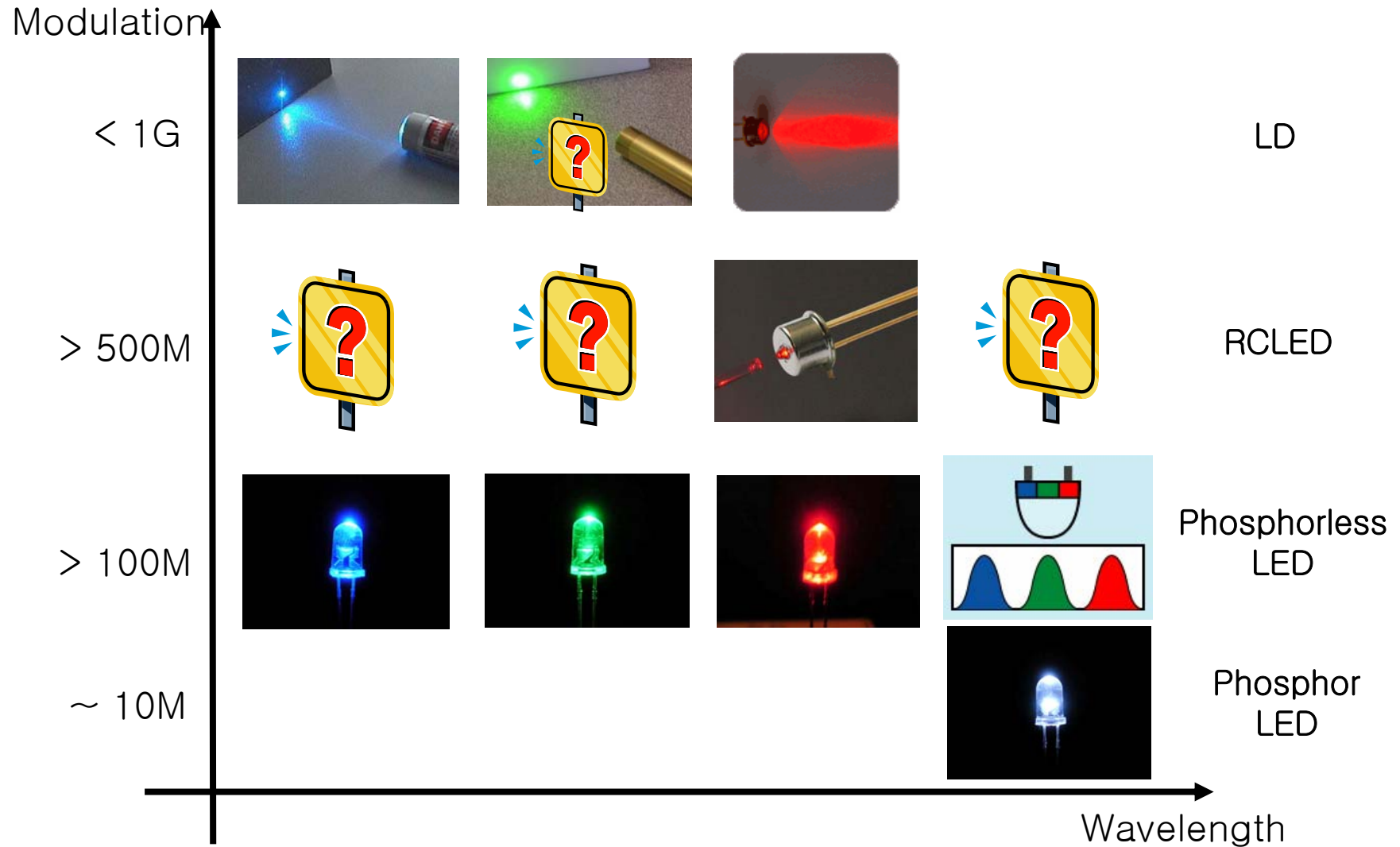
Visibility



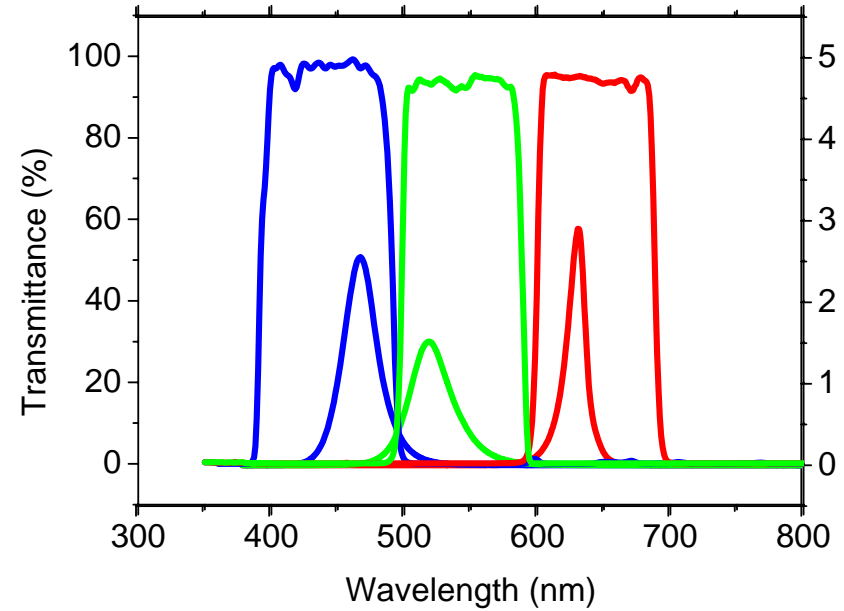
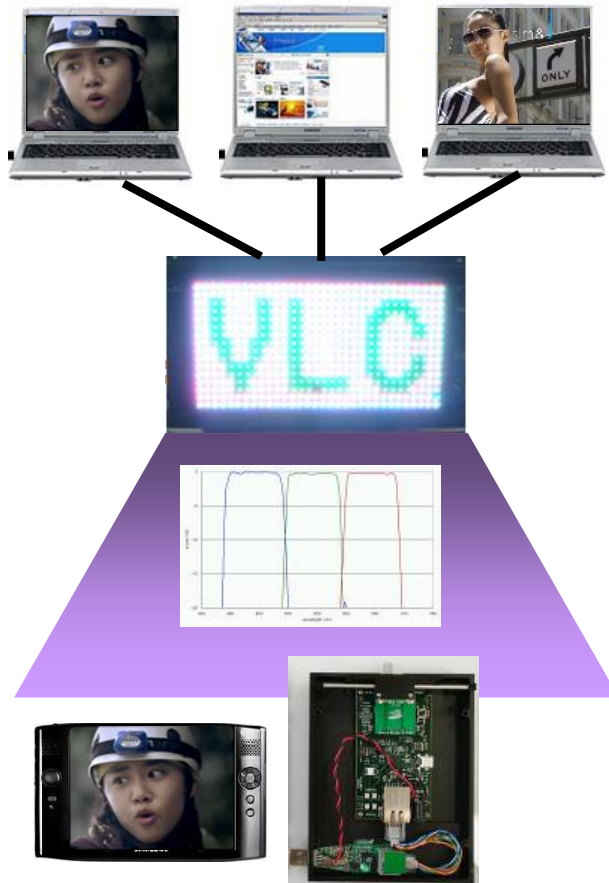
What You See Is What You Send (WYSIWYS)



Modulation limit



WDM



Blue : 470 nm(peak), 30 nm(3dB BW)

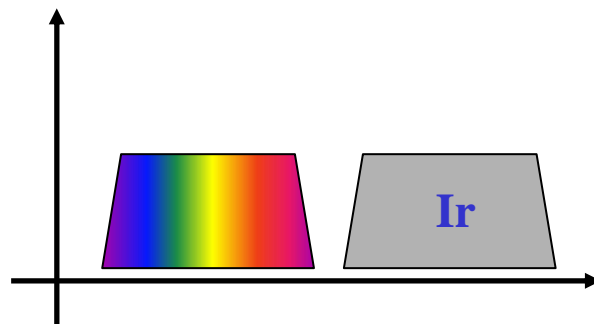
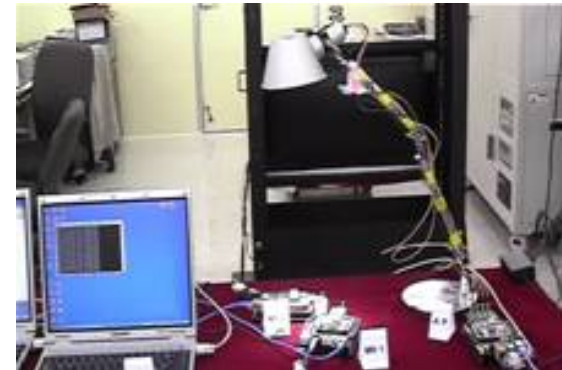
Green : 520 nm(peak), 37 nm(3dB BW)

Red : 630 nm(peak), 17 nm(3dB BW)

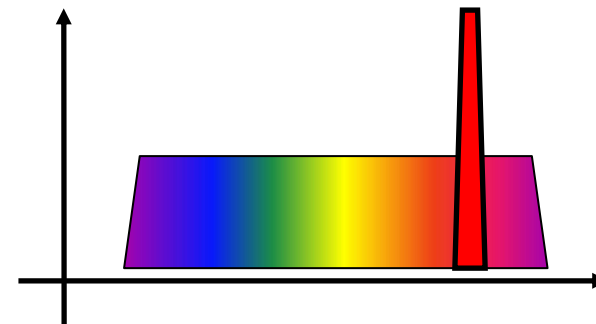
LED : 3 ~ 4 channel

RCLED : 30 ~ 40 channel

Up/down separation

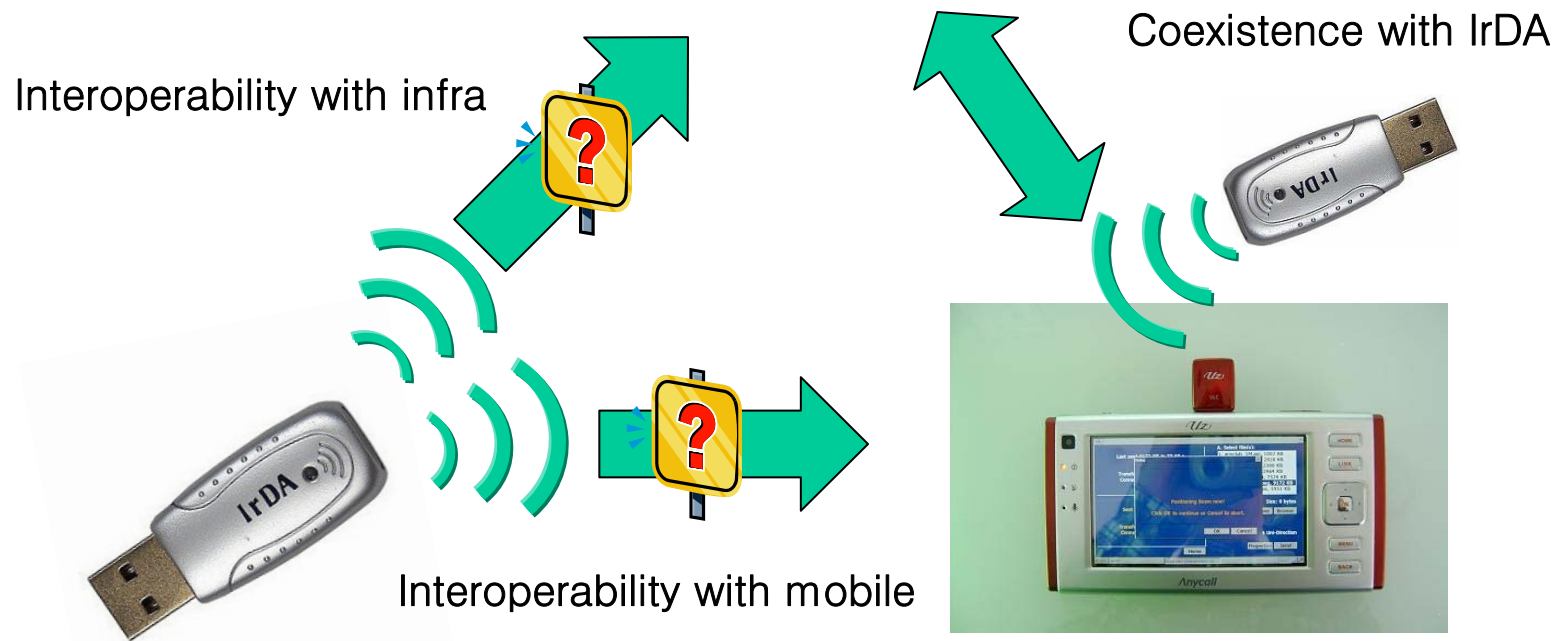


Visible band
Infrared band

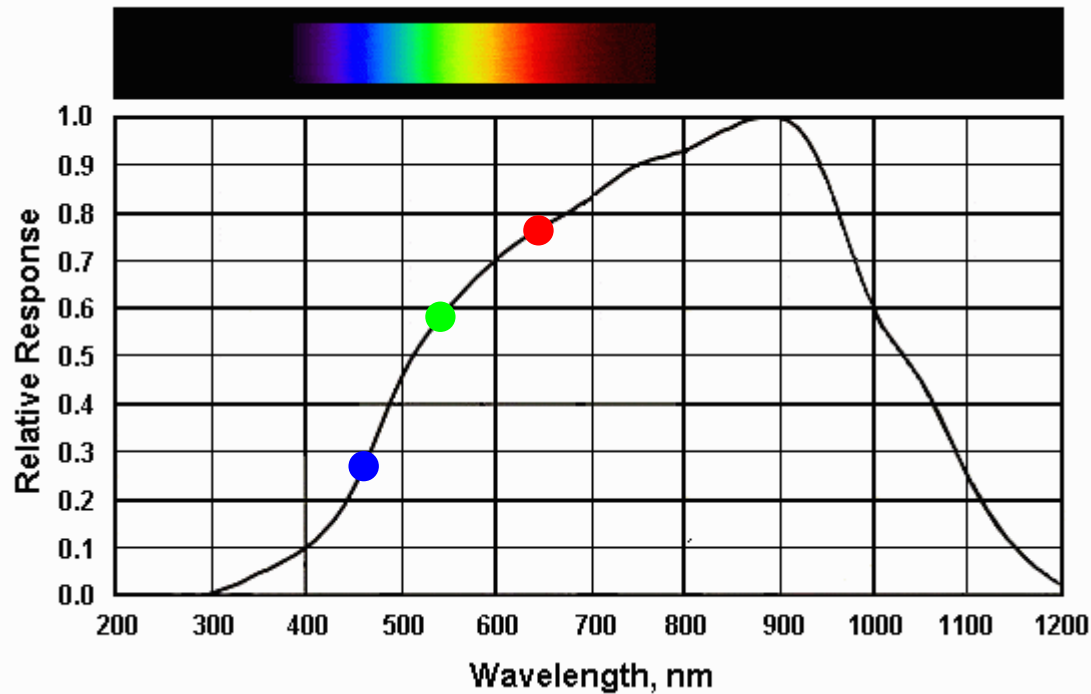


Visible broadband
Visible narrowband

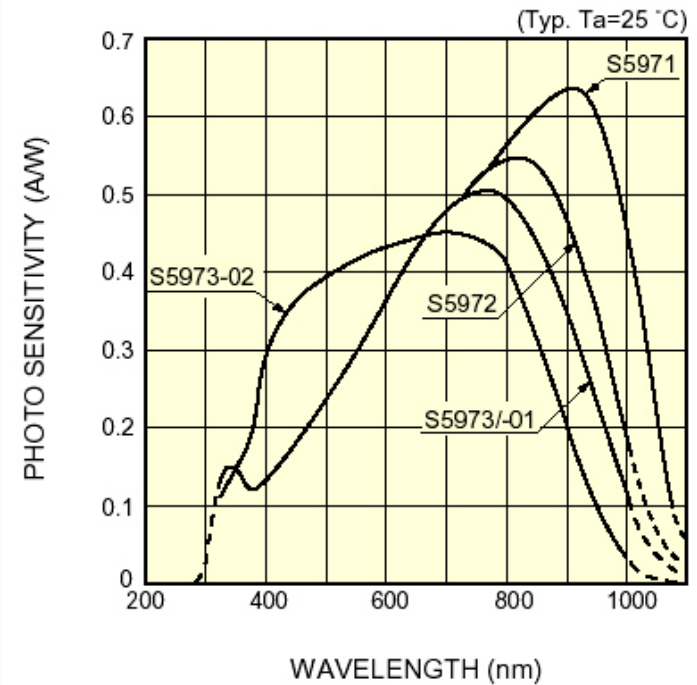
Coexistence/Interoperability with IrDA



Silicon PD spectral response



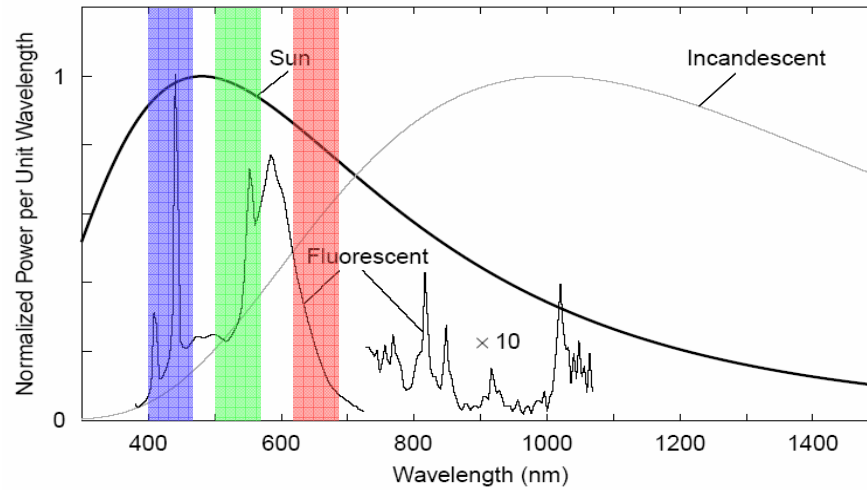
~4 dB Responsivity variation from Blue to Red



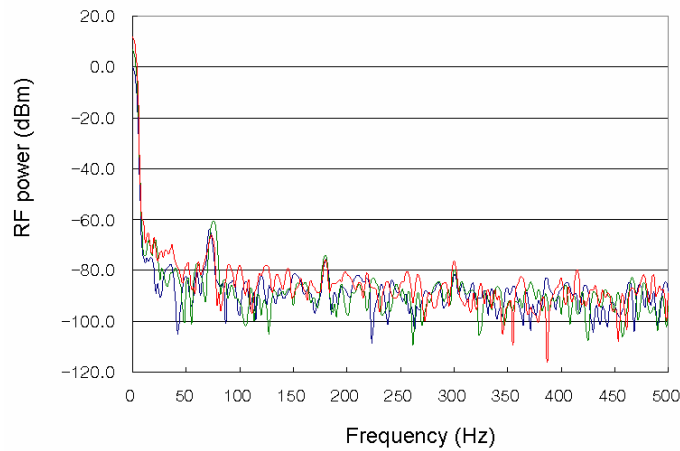
Silicon PD variants
(www.hamamatsu.com)

VLC link

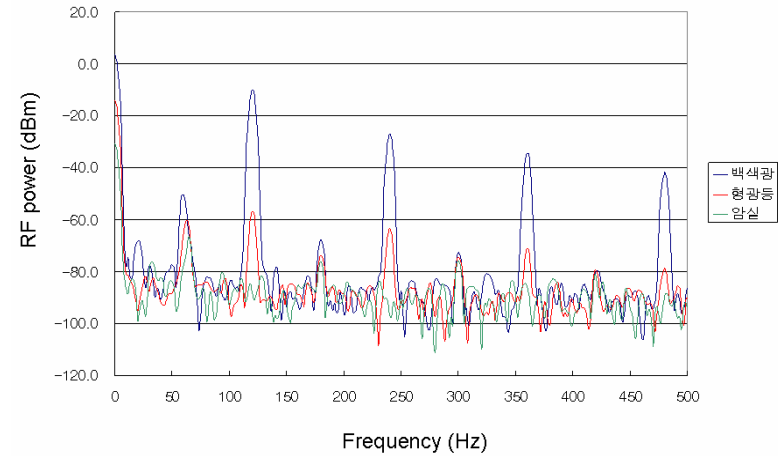
Optical Spectrum



RF Spectrum



[SUN]



[Fluorescent]

SUMMARY

- **Technical considerations on VLC wavelength range**
 - LED Infra
 - Visibility
 - Modulation limit
 - WDM
 - Up/down separation

- **Standardization issue**
 - Consensus on VLC wavelength range
 - Common range or ranges for applications
 - WDM channel
 - Coexistence / Interoperability with IrDA