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

Submission Title: On Study Group Status for Camera Communications
Date Submitted: July 2013
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Re:

Abstract: A short presentation in regards to CamCom

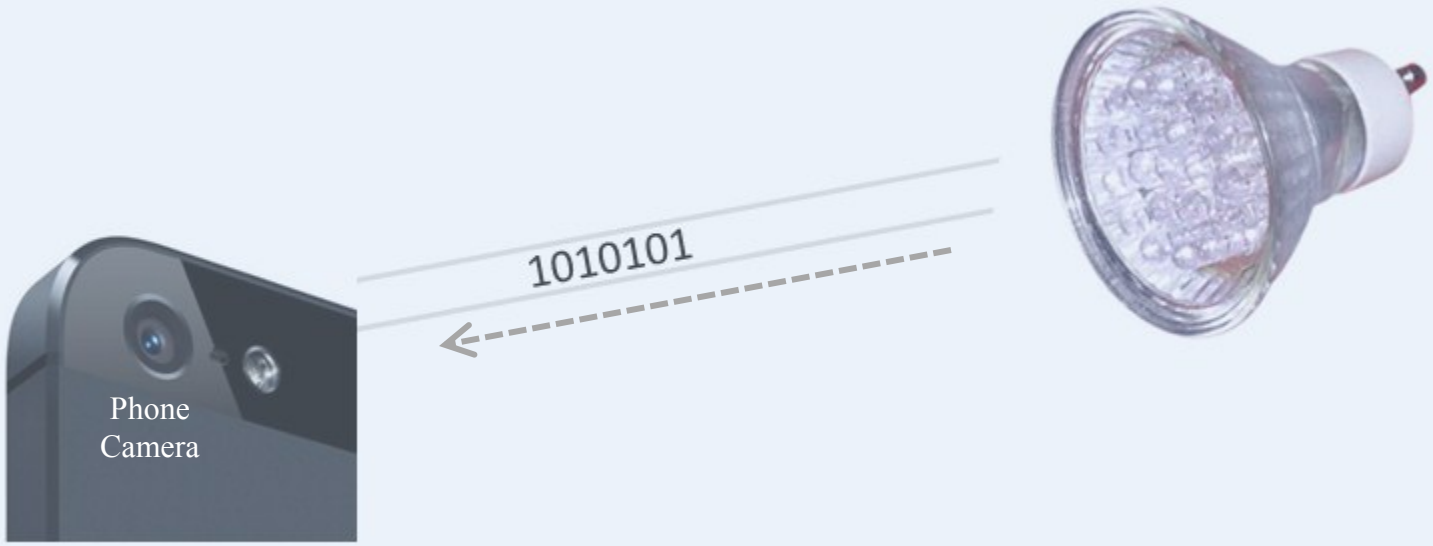
Purpose: Presentation to WNG

Presentation to WNG in anticipation of SG status

There is an emerging interest in the implementation of Visible Light Communications (VLC) for uni-directional, low data rate, short message broadcasts via LEDs using an image sensor as the receiving device. In response, IEEE802.15 LED ID IG is contemplating transitioning from an interest group to a study group focusing on writing a PAR and 5C in regards to camera communications (CamCom).

Camera Communications (CamCom)

A Pragmatic Form of Visible Light Communications

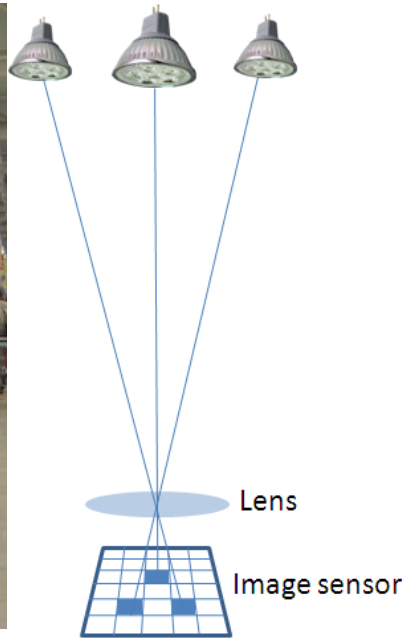


Today we have millions of mobile devices enabled to receive visible light communications via the camera, but we lack standards to describe the modulation format.

This contribution discusses some CamCom topics of interest.

Some Use Cases

Line of Sight Marketing



Indoor Location

Provides low cost, beneficial, augmented reality user experience

VLC has a complex ecosystem:

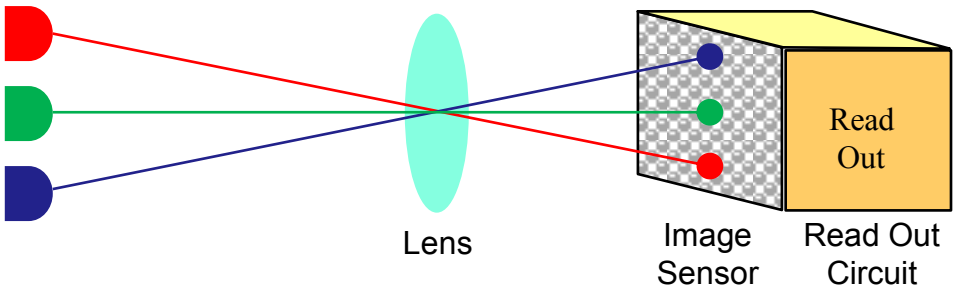
- **hinders technology adoption**
- **simultaneously building out both sides of this ecosystem is difficult**
- **unlike WiFi, no single source vendor**

A receive side APP solution enables:

- **no phone hardware modifications**
- **simplified ecosystem build out**
- **millions of potential receivers**
- **entice VLC enabled LED sources**

Standards Will Be Necessary!

But first some basics about electronic cameras



Camera basic components

- Lens … spatially separates sources
- Image Sensor … array of photodiode pixels
- Readout Circuit … convert pixel signal to digital data

Cameras differ on how the pixels are exposed

- Global Shutter … simultaneously expose all the pixels per frame
- Rolling Shutter … time sequentially expose each row of pixels per frame

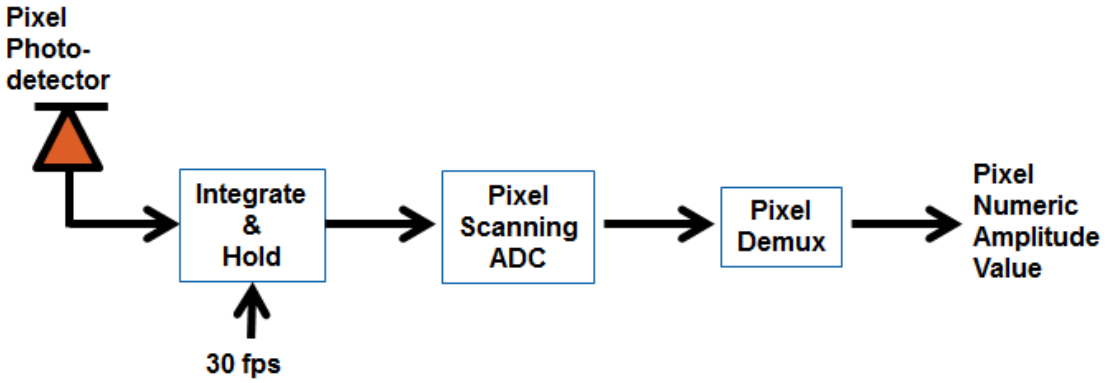


image sensor model: 2 dimensional lightwave-to-digital converter

Sampling rate depends upon how the image sensor does the exposure

- Undersampling (Undersampled Frequency Shift ON-OFF Keying)

- Nyquist Sampling (Picapicamera)

- Rolling Shutter Sampling

Because of camera lens properties, spatial separation of multiple sources is possible enabling MIMO transmission.

Example LED Signage

This LED sign has 321 LEDs …

- each LED illuminates a unique pixel in the image sensor
- each LED can transmit a unique data stream
- 321 x 321 MIMO !!!

With multiple methods to realize CamCom …

… standards will be necessary

1. A SG → TG will explore multiple use cases
2. A SG → TG will discuss multiple modulation formats
3. A SG → TG will facilitate complex ecosystem adoption
   - via smartphone app
   - via MIMO modulated LED lights

Some public demos available on the web

1. Under-sampled Frequency Shifted ON-OFF Keying (UFSOOK) (*Intel Labs*)

http://www.youtube.com/watch?v=K0xsZqTRXes

2. Nyquist Sampled Picapicamera (*Casio*)

http://www.youtube.com/watch?v=t27x1sztArE

3. Rolling Shutter Sampling (*PureVLC*)

http://www.youtube.com/watch?v=IaxD4SF3jsA

The LED interest group believes it is ready to transition to a study group to write a PAR and 5C leading towards the formation of a task group focused on writing a standard for camera communication (CamCom).

Appendix

Proposed Schedule of Events Leading to Task Group Status

July 2013	Aug 2013	Sept 2013	Oct 2013	Nov 2013	Dec 2013
Determine if the group wants to pursue proactive behavior leading to CamCom TG status		Meet in Nanjing or do conference calls on PAR & 5C? Conference calls more efficient?	Conference Call on PAR & 5C. (import to show due diligence)	1. 802 tutorial 2. WG SG Motion 3. EC approval	

Jan 2014	Feb 2014	Mar 2014	Apr 2014	May 2014	June 2014
- 1st SG Meeting - Issue call for participation & applications - draft PAR & 5C	Conference Call on PAR & 5C	Submittal of PAR & 5C to SA	SA Approval	1st TG meeting	