

LED-TO-CAMERA VLC

System Design of LED-to-Rolling-Shutter-Camera Communication using Color Shift Keying.

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INTRODUCTION

- Radio Frequency (RF) bands are getting crowded.
- Visible Light Communication (VLC) is a solution.
- Data Rate in VLC is limited.
- Using Color Patterns can increase Data Rate in VLC.
- Design Challenges for Rolling Shutter Camera & Color Shift Keying (CSK).

OBJECTIVE

- Propose a System Design for LED-to-Camera Communication.
- Design Challenges Color Shift Keying & Rolling Shutter Camera.

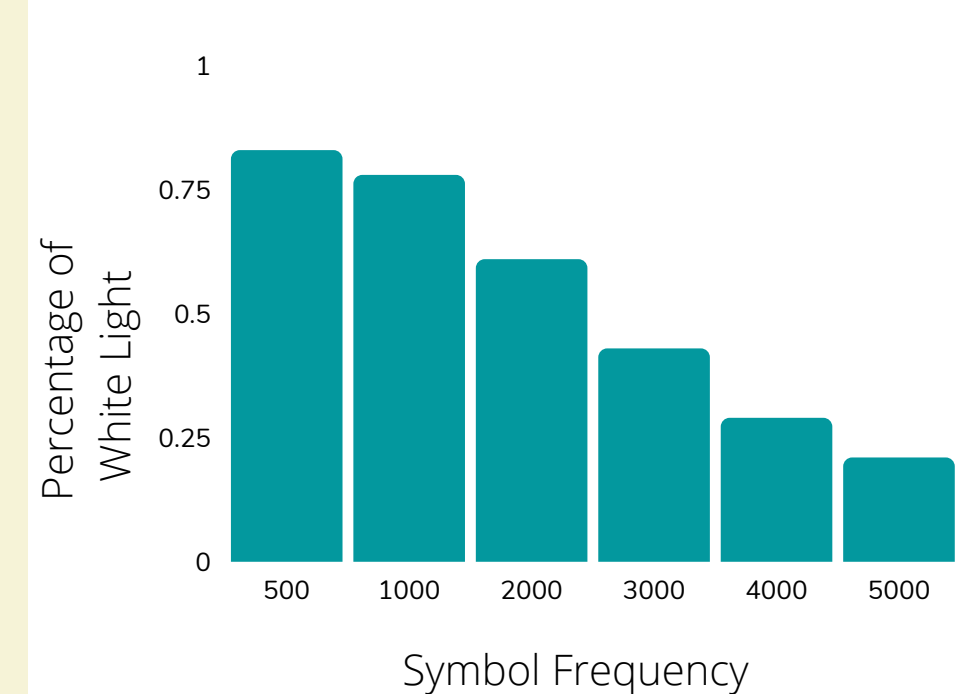
METHODOLOGY

Transmitter: Tri-LED
 Receiver: Rolling Shutter CMOS Image Sensor
 Modulation: 8 Color Shift Keying (8-CSK)

DESIGN CHALLENGES

Avoiding Human Perceivable Color Flickering

- Introduction of White Light Symbols
- Color Sequence Shift Keying (CSSK)

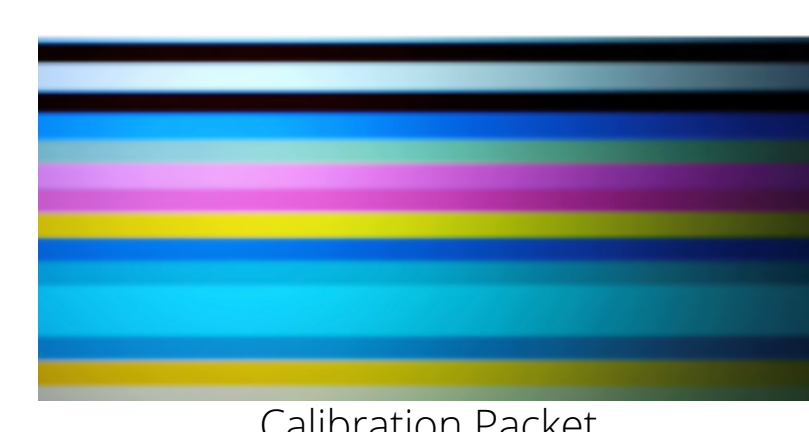
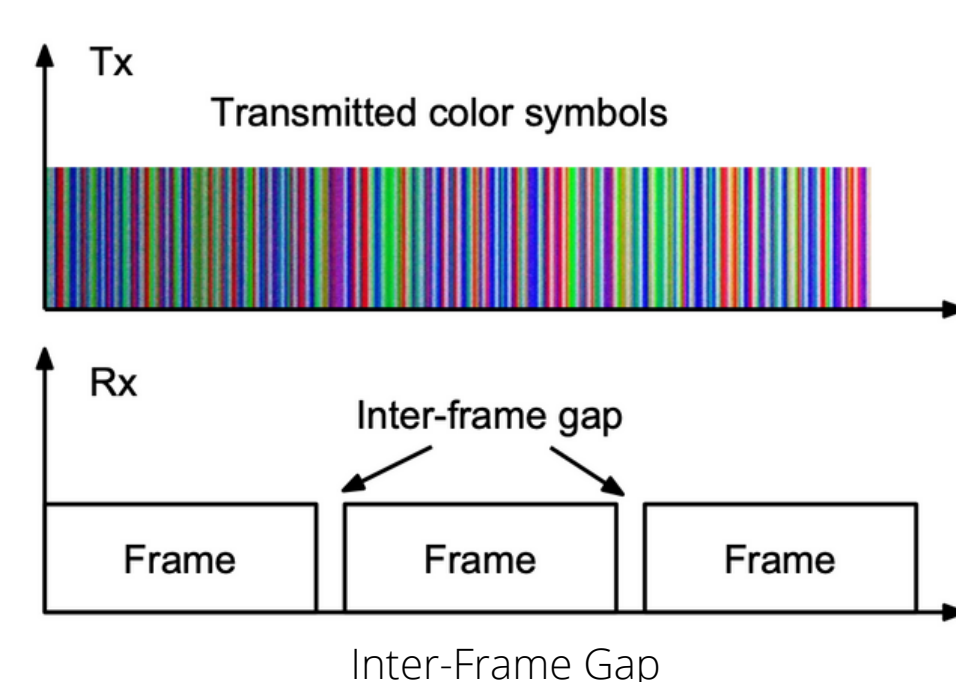
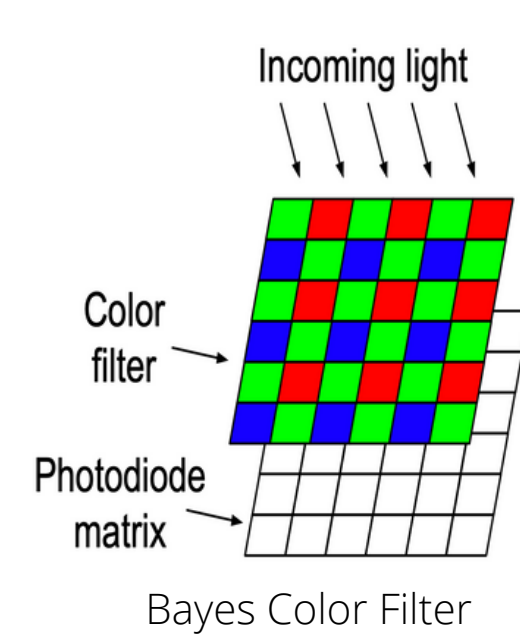
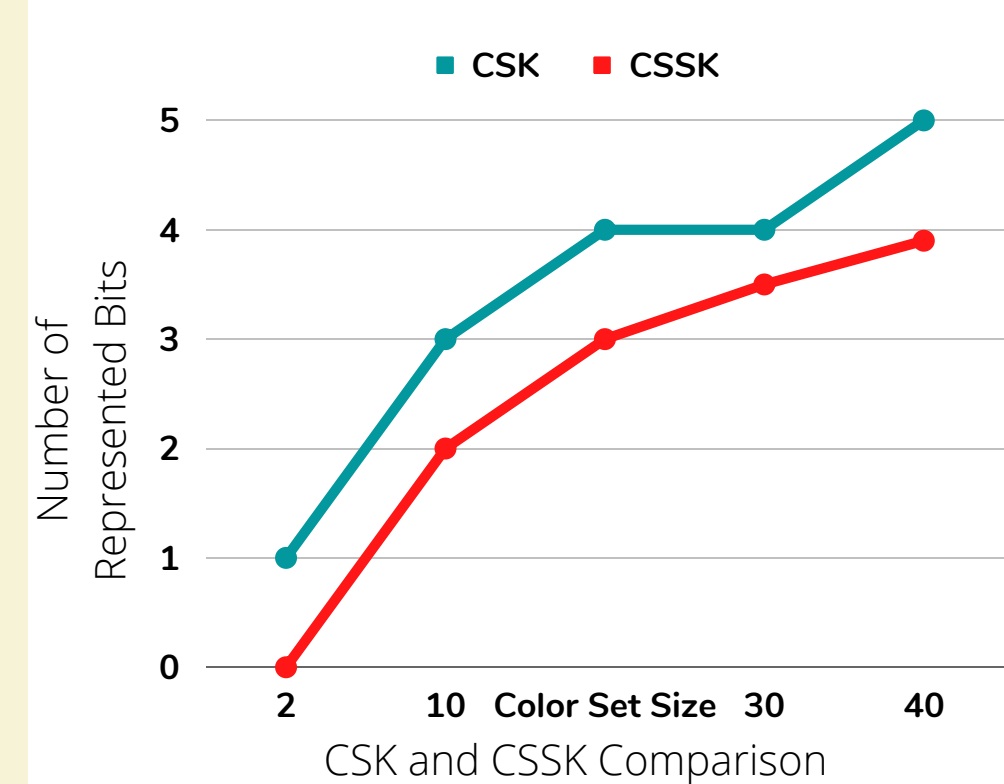


Inter-Frame Data Loss

- Inter-Frame Gap between Frames
- Reed-Solomon Coding (RS Coding)

Receiver Diversity

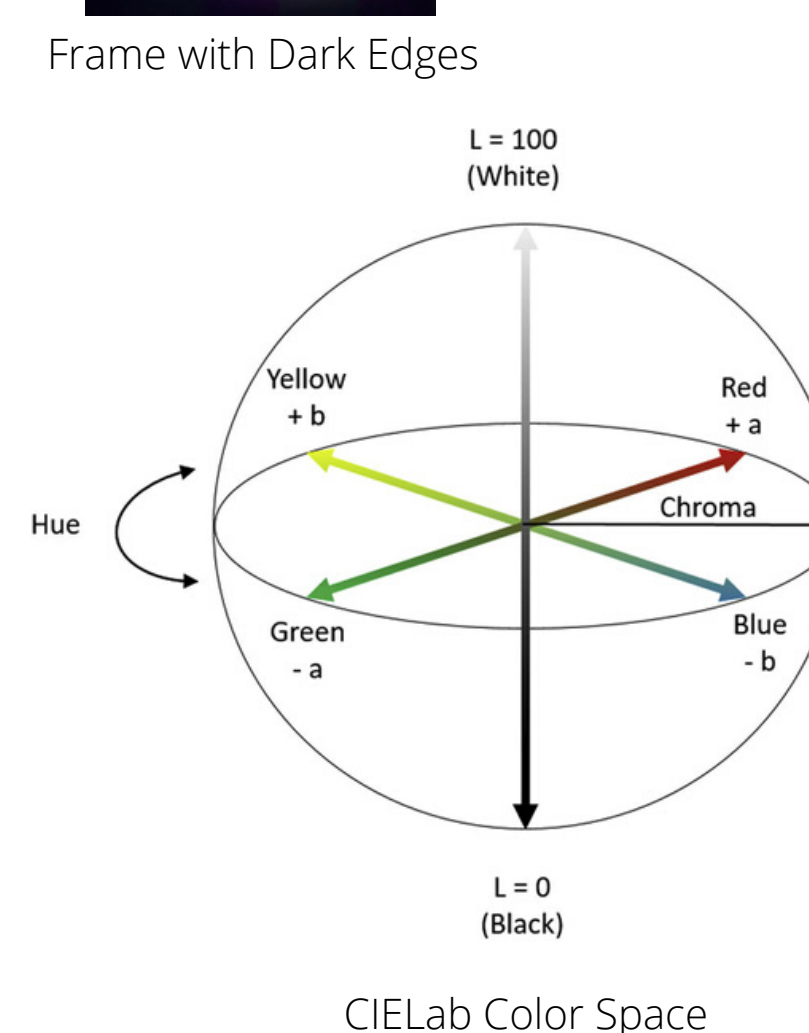
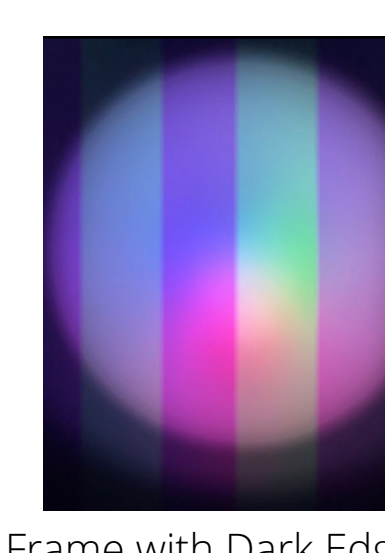
- Color Filter in front of Photodiodes
- Calibration Packets



FINAL SYSTEM

Demodulation Method

1. Convert to CIELab Space
2. Finding the Color Bands
3. Symbol Matching

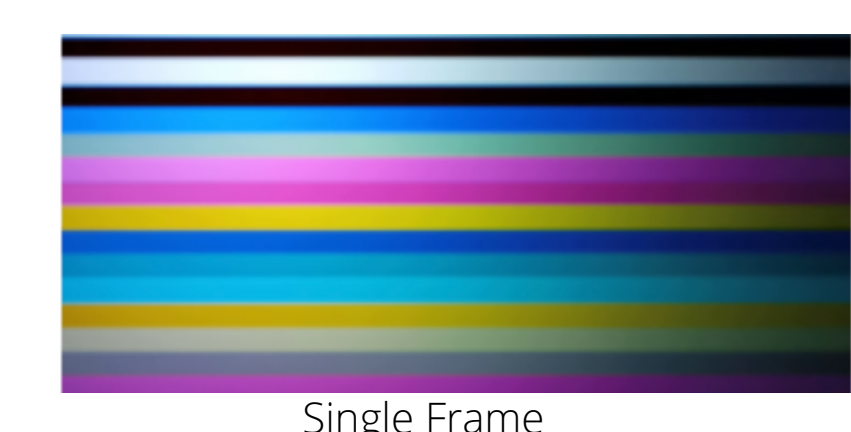


Transmitter:

- White Light Symbols in Calibration Packets change color.
- Use a Diffuser to Distribute Light evenly.
- Darkroom to reduce Ambient Lighting.

Receiver:

- Use a Tripod to hold the Camera Steady.
- Exposure Time of the Camera < Symbol Period.
- Too much Inter-Symbol Interference during Multiple Frames.



CONCLUSION

- Propose a System Design for LED-to-Rolling-Shutter-Camera Communication using Off-the-Shelf Hardware Components.
- Inter-Symbol Interference is Main Limiting Factor of Data Rate when using CSK.

RELATED LITERATURE

P. Hu, P. H. Pathak, X. Feng, H. Fu and P. Mohapatra, "ColorBars: Increasing data rate of LED-to-camera communication using color shift keying", Proc. 11th ACMConf. Emerg. Netw. Exp. Technol., pp. 1-13, Dec. 2015
 H. Ye, Q. Wang. "SpiderWeb: Enabling Through-Screen Visible Light Communication", Proc. 19th ACMConf. Embed. Netw. Sens. Sys. pp. 316-328, Nov. 2021
 Ly, B., Dyer, E., Feig, J., Chien, A., and Bino, S. (2020). Research techniques made simple: Cutaneous colorimetry: A reliable technique for objective skin color measurement. 2020