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THEORETICAL CONCEPTS AND MATLAB MODELLING OF VLC BASED MIMO SYSTEMS

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Introduction

Highly efficient and long lasting LED lights are replacing standard incandescent and fluorescent lighting technologies. Solid-state LEDs have wide frequency bandwidths enabling them to be switched at very high frequencies. Combining the lighting and switching capabilities of the LED enables a dual functional system, where the primary function is room illumination, and the secondary is to act as an optical transmitter as part of a visible light communication (VLC) system. VLC systems present enormous potential for applications in computer networking, control systems and audio/video streaming.

Research Topics

- Lambertian emissions: line-of-sight (LOS)
- Characterization of LEDs and photodiodes (PD)
- Intensity modulation (IM) schemes: DiPPM, digital offset PPM, NRZ-OOK, duo binary PPM
- Error correction coding techniques: maximum likelihood sequence estimation (MLSE) and Reed–Solomon (RS)
- Channel estimation: channel matrix (H)
- Analogue circuits: PD transimpedance amplifiers (TIA), Matching filters (MF) and channel equalization, LED driver transconductance amplifiers (TCA)

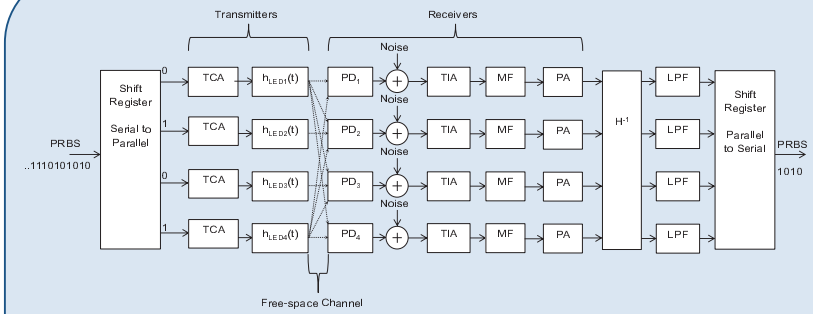


Figure 1 Block diagram of a 4x4 MIMO VLC unidirectional system model

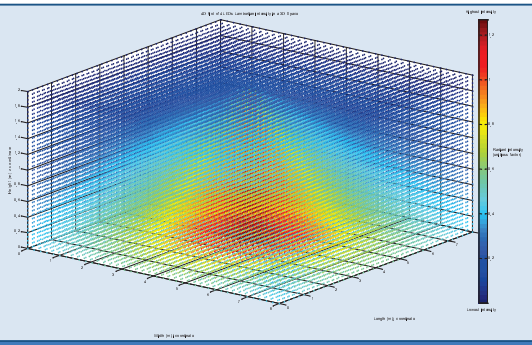
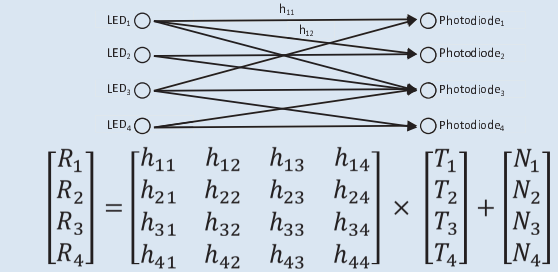


Figure 2 MATLAB simulation: Lambertian intensity (Ro)
2x2 LED array within a 3D space 8m x 8m x 2m



$$\begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ R_4 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} & h_{14} \\ h_{21} & h_{22} & h_{23} & h_{24} \\ h_{31} & h_{32} & h_{33} & h_{34} \\ h_{41} & h_{42} & h_{43} & h_{44} \end{bmatrix} \times \begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \end{bmatrix} + \begin{bmatrix} N_1 \\ N_2 \\ N_3 \\ N_4 \end{bmatrix}$$

Figure 3 4x4 MIMO Channel Matrix/ H Matrix

Aims

- Develop MATLAB based computer models to simulate an indoor, short-range 4x4 MIMO VLC system
- Use LED as optical transmitters in a VLC system
- Generate a block diagram of a 4x4 MIMO VLC unidirectional system model

Results

- Generated a block diagram of a 4x4 MIMO VLC unidirectional system model (Figure 1)
- Coded and tested MATLAB models to simulate a single LED and 2x2 LED array's Lambertian radiant intensity (Figure 2)
- Developed a theoretical strategy for modelling the transmitter, channel, receiver, and MIMO channel estimation (Figure 3)

Conclusions

- Successfully generated a block diagram of a 4x4 MIMO VLC unidirectional system model
- Successfully simulated Lambertian intensity of a single LED and 2x2 LED array within a 3D space using MATLAB, also simulated the path time delays from Tx to Rx
- Work continues to develop MATLAB models