Visible Light Communication System with Ambient Light Cancellation

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Introduction

Power Light Emitting Diodes (LED) are the latest development in the LED technology. They inherent salient features like energy efficiency, convenience of use, long lifetime, high reliability and most importantly they have high speed switching capability. This enables the LEDs to be modulated with high frequency digital data. Once the LED is modulated with digital data, the light emitted through the LED replicates the digital data stream. Our objective is to develop a Visible Light Communication (VLC) system which exploit this methodology to transmit data through visible light.

Procedure

In this work, a VLC system was implemented using power LEDs to suit the indoor lighting systems and the performance of the system is observed under various light conditions. Results show that the system fails when the ambient light effects are severe. Next the proposed methodology is deployed to cancel the ambient light effects. Constant component of the ambient light is cancelled using hardware setup. Further the time varying components of the ambient light are cancelled using signal processing techniques. The proposed methodology was able to mitigate the effects of sunlight variations and various other time varying effects like CFL bulbs.

Design of the VLC System

Figure 1 shows the block diagram of the implemented VLC system.

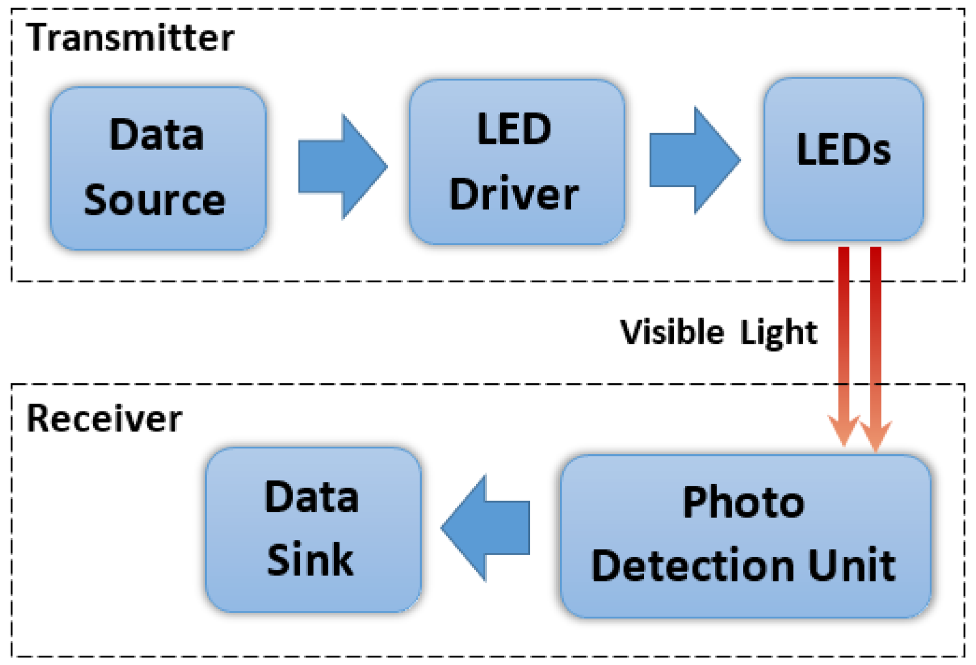

Figure 1: Block Diagram of the VLC System.

Our approach:

- Designing the VLC transmitter and receiver.
- Observe the performance under various environment conditions (Time varying ambient light conditions).
- Propose a method to cancel ambient light effects.

Transmitter

Transmitter converts the digital data signal into variation of light intensity. Data source generates a digital data stream of 0-5 V. An LED driver has implemented to bridge the data source and the LED panel. Current implementation uses the On-Off Keying (OOK) modulation.

Receiver

Receiver of the VLC system has a photo detection unit which converts the variations in light intensity into a voltage signal. Resulting voltage signal is applied to the data sink. Photo detection unit has a photodiode, three amplifications and a comparator to reconstruct the digital signal. Figure 3 shows all the sub modules included in the photo detection unit.

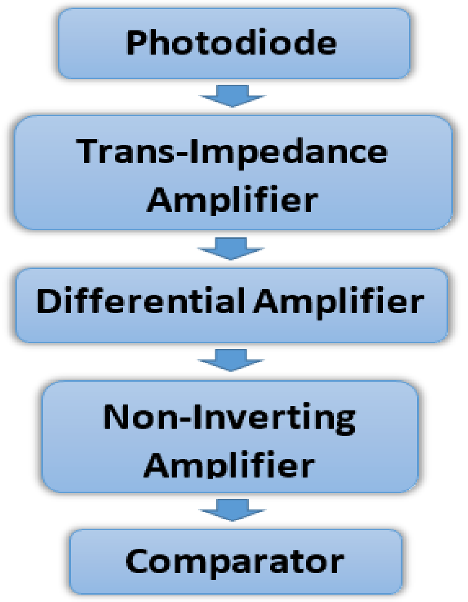

Figure 3: Block Diagram of the Photo Detection Unit.

Implementation

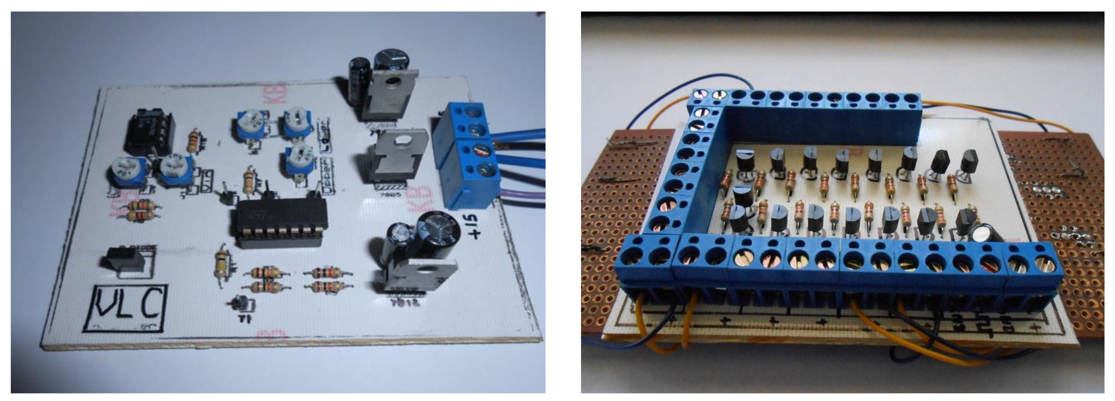

Figure 2: Implemented Transmitter and Receiver Circuits.

BER Evaluation

$$\text{BER(Bit Error Rate)} = \frac{\text{No. of error bits}}{\text{No. of total bits}}$$

BER expresses the ratio of number of error bits to total number of bits. BER of the system was calculated with transmitter-receiver distance. Figure 4 shows the results of BER calculations.

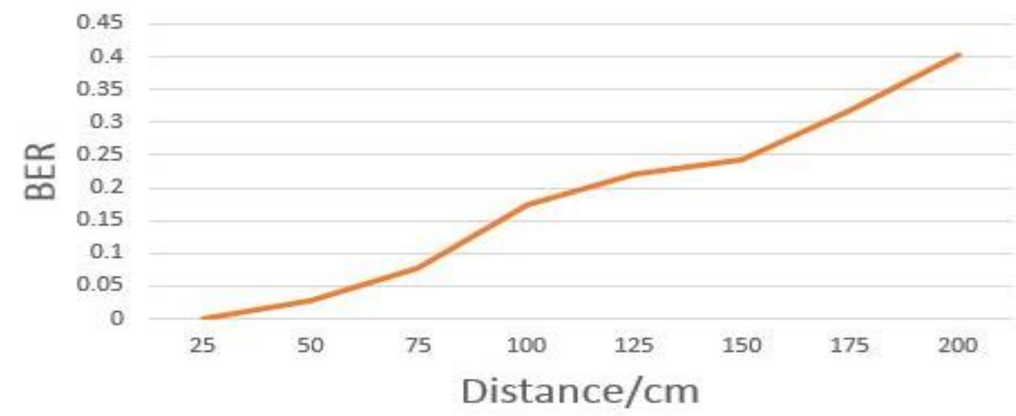

Figure 4: BER with Transmitter-Receiver Distance.

Noise Cancellation Algorithm

Algorithm addresses the time varying light effects. First the algorithm gets a predefined number of samples. Number of samples depends on the processing speed and sampling frequency. Processing unit should be able to process the set of samples before next set arrives. Next a median filter is applied to suppress the spikes in the received signal. Then the signal is sent through a moving average filter to remove the high frequency noise components. Again a median filter is applied to further reduce the spikes. Finally the minimum value of the *N* samples is obtained and it is subtracted from all the samples to remove the DC offset. Figure 5 shows the steps of the algorithm.

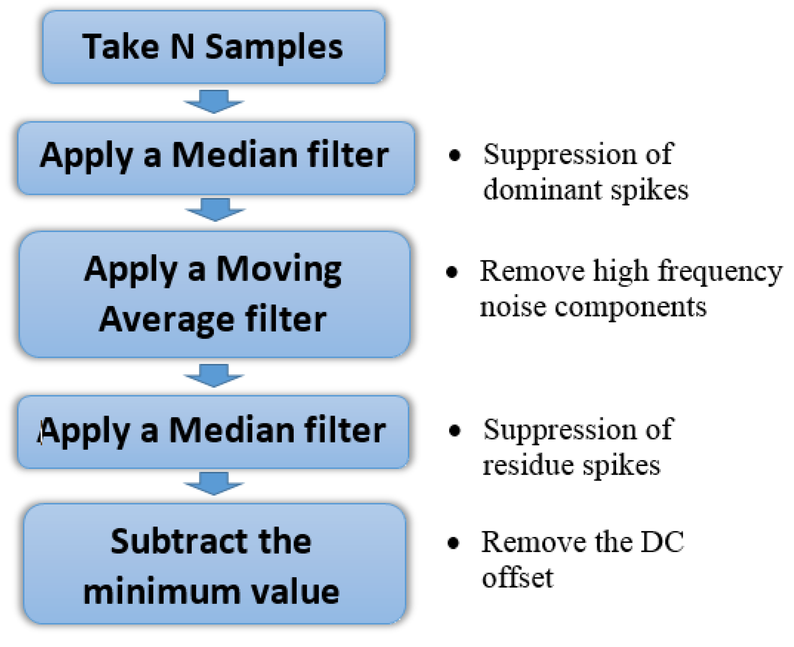

Figure 5: Flow Chart of the Algorithm.

Results

Algorithm was deployed to process the signals which were affected by time varying ambient light effects. Following observations were taken by operating the system at 10 kHz and sampling the output of the receiver at 400 kHz.

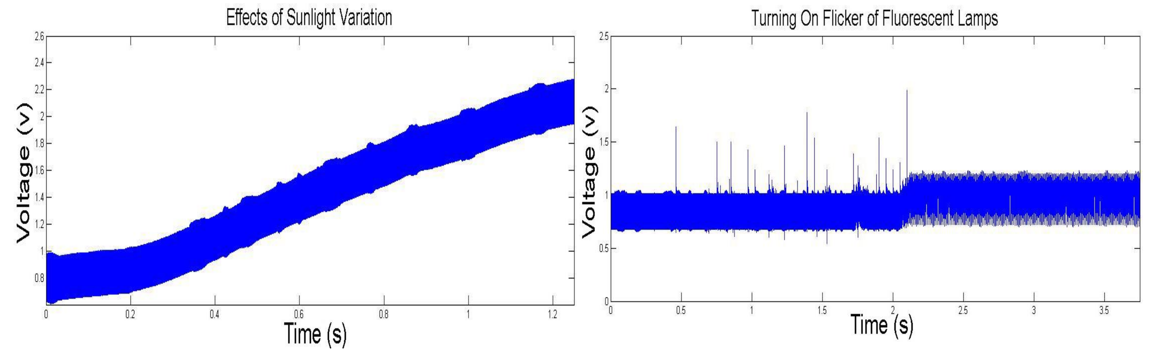

Figure 6: Effects of Sunlight Variation and Turning on Fluorescent Lamps.

Figure 7 shows the results after applying the noise cancellation algorithm

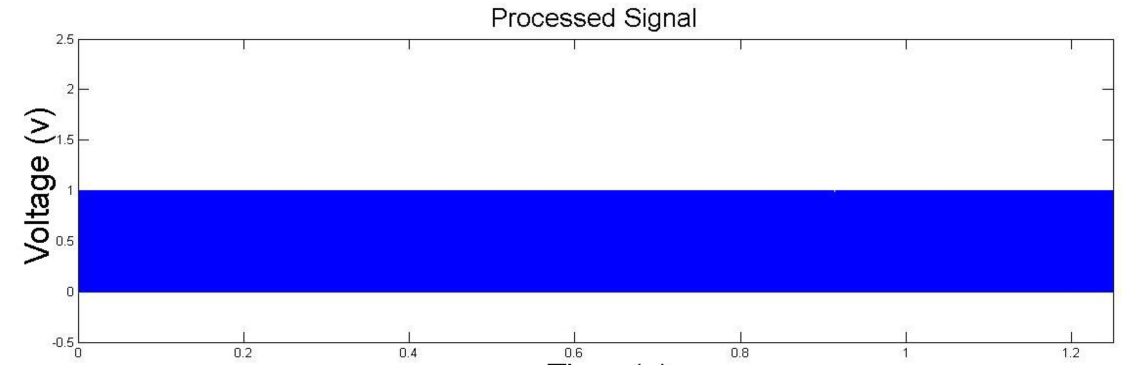

Figure 7: Resulting Signal after Applying the Ambient Light Cancellation Algorithm.

Conclusion

- Implemented system works perfectly up to 100 kHz at a distance of 2m.
- Performance of the system is largely affected by the ambient light sources like the sunlight and CFL bulbs.
- BER measurements obtained before and after applying the proposed cancellation algorithm, showed a significant improvement in the performance of the VLC system.

References

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