Design and performance evaluation of a DSP visible light communication receiver

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Abstract

This paper proposes a new architecture for outdoor low data rate visible light communication applications. Considering the performances of the digital filtering, the proposed architecture considers the usage of digital signal processing (DSP) as an alternative to the analog signal treatment. The key aspects related with the implementation of the VLC receiver are discussed and motivated through simulations.

Introduction

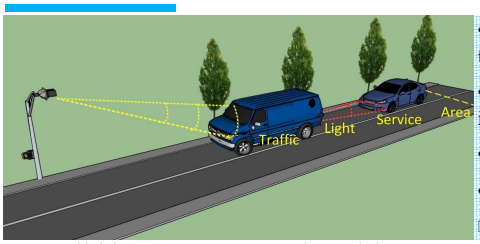

Fig. 1 – Visible light communications usage to enhance vehicle awareness: traffic safety information is transmitted from the transportation infrastructure and propagated from one vehicle to an other.

- Traffic safety and efficiency can be substantially improved by increasing vehicle awareness through wireless Infrastructure to Vehicles (I2V) and Vehicle to Vehicle (V2V) communications.
- LED lighting systems are gradually replacing classical lighting in the automotive industry and in the transportation infrastructure (traffic lights, street lighting).
- LEDs rapid switching capability enables VLC.
- VLC performances could be enhanced by using digital filtering.

⇨ A new architecture of VLC receiver based on DSP is proposed (Fig. 2).

VLC system configuration

The system considers using DSP techniques for signal enhancing.

System configuration:

Simulations are performed to determine the optimal parameters for the system:

- sampling rate (1.167 MHz);
- filter type and order (2nd order Butterworth);
- cutoff frequency (1.5 – 1.75 the modulation frequency);
- triggering (symmetric and adaptive);

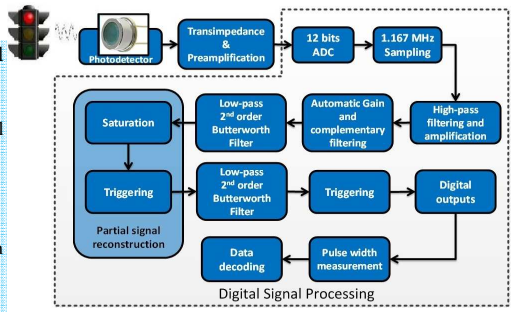

Fig. 2 - Synopsis of VLC system.

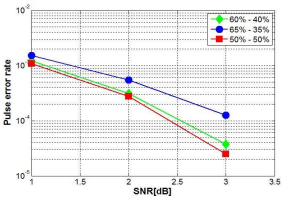

Fig. 7– Threshold selecting.

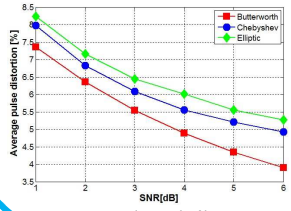

Fig. 3 – Selecting the filter.

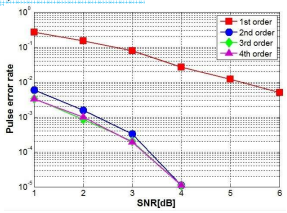

Fig. 4 - Influence of the filter order.

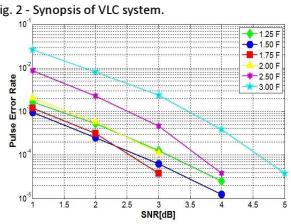

Fig. 5 - Influence of the cutoff frequency.

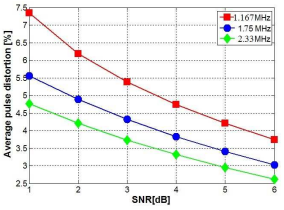

Fig. 6 - Influence of the sampling frequency.

Performance evaluation

- Simulation are performed to evaluate:
  - ✓ the frame error ratio (FER);
  - ✓ the bit error ratio (BER);
  - ✓ the robustness to noise (shot and thermal noise modeled as additive white Gaussian noises);

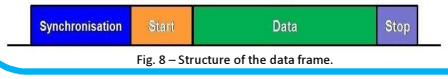

Fig. 8 – Structure of the data frame.

- ***Conditions***:
  - unobstructed line of sight;
  - On Off Keying (OOK) modulation;
  - Manchester coding;
  - frequency 11.67 kHz;
  - asynchronous transmission - a digital data frame has been defined (Fig. 8);
  - short messages of 8 ASCII characters;

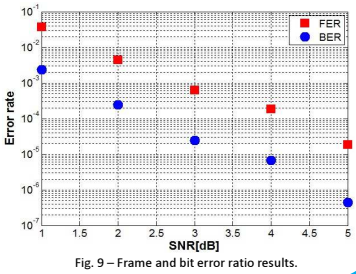

Fig. 9 – Frame and bit error ratio results.

Conclusions

- A new DSP VLC receiver architecture was proposed.
- The simulation results confirmed the suitability of the proposed receiver for VLC, even at low SNR levels.
- Error-correcting codes will further improve the performances.
- Preliminary experimental tests confirmed the performances of the proposed architecture.

Acknowledgments

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