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Performance Enhancement of Data Communication through Visible Light Communication Using On Off Keying

***Abstract*— Visible Light Communication (VLC) refers to short-range optical wireless communication using visible light spectrum from 380 to 780nm and it has many advantages such as it can offer speeds up to 10GB/S. The other advancement is that the bandwidth available for visible light communication is 300THz whereas it is below 6GHz on RF communication. VLC transmits data by the intensity modulating optical source, such as light emitting diodes (LEDs) because of its energy efficiency and recent advancement in LED technology with fast nanoseconds switching time. This paper applies On Off keying to achieve a minimum bit error rate during its transmission of digital data when compared to other modulation techniques. The result shows that best performance using OOK, making it an ideal modulation technique for future visible light communication. The methodologies used for stimulation purpose are MATLAB and Lab View.**

***Index Terms*—visible light, white LED, On Off Keying.**

I. INTRODUCTION

Wireless communication is the transfer of information from one point to another point through a wireless medium such as free space. Actually wireless communication is one of the very oldest form of communication. For example,shouting and beating drums does not require any wires or cables to function. Even the very oldest optical communication is wireless i.e. smoke signals are based on the propagation of optical signals along the line-of-sight communication. It started with the work of Maxwell and Hertz, who laid the basis for understanding of the transmission of electromagnetic waves. After that Tesla who demonstrated the transmission of information via the electromagnetic waves. Later radio and television become popular throughout the world. The data is being transmitted from one place to another using electromagnetic waves They can even constitute "mobile communications," .

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II. METHODS OF DATA COMMUNICATION

A number of wireless techniques exist for short-range communication with a goal of delivering wireless connection. Following details provide an overview of some of the standard technologies for short range wireless communication.

A. Infrared Communication:

Infrared Data Association, founded in 1993, is an industry-based group of device manufacturers that developed a standard for transmitting data via infrared light waves[2]. Infrared transmissions are inherently localized and governments do not regulate the infrared portion of the light spectrum.

The standard is normally applicable for short-range and point-to-point communication and is used for providing wireless connectivity for devices that normally would use a cable-oriented solution. It contains some set of protocols including all layers of data transfer, moreover some of the network management capabilities .

The Infrared communication has the following characteristics:

- The operating range is 1 meter that can further be extended to 2 meters.
- Less power consumption.
- Bidirectional communication.
- The data transfer rate ranges from 9600 bits/seconds with primary speed/cost and steps of 115 kB/s and maximum speed up to 4 MB/s.
- By using a Cycle Redundancy Check (CRC) , the data packets are protected

In IrDA, Data protocol does not exist but built in encryption facility, as infrared signal that is emitted is in a narrow cone area and with very little signal strength thus the transmitter should be close to the receiver and aiming at it.

B. Bluetooth communication:

Bluetooth is a high-speed, low-power microwave wireless link technology, intended to exchange data over short distances from fixed and mobile devices, creating personal area networks (PANs)[1]. Bluetooth is omnidirectional one and does not need of line of sight when connected to devices. When Bluetooth enabled devices come within range of other such devices, they immediately exchange address information and create small ad-hoc networks which is known as piconet among each other. Piconets are established dynamically and automatically as Bluetooth enabled devices enter and leave radio proximity.

Bluetooth specifications were developed in 1994 and licensed by the Bluetooth Special Interest Group (SIG) that consists of companies in the areas of communication ,telecommunication and consumer electronics. Bluetooth has following main characteristics:

- Operates in the 2.4 GHz ISM (Industrial Scientific Medical band) .
- Frequency Hop Spread Spectrum (FHSS) is used.
- Uses Gaussian frequency-shift keying (GFSK)
- Able to support up to 7 other devices in a piconet.
- Omnidirectional, non-line of sight transmission.
- Range depends on power.
- Low cost.
- Different data rates.

Bluetooth uses ISM band which is the noisy part of the spectrum; however, the Bluetooth standard has been designed to work smoothly in this noisy, unregulated environment.

A fundamental strength of Bluetooth wireless technology is the ability to simultaneously handle both data and voice transmissions. However, because Bluetooth enabled devices can potentially communicate with so many devices at once and without knowledge of the listener so data security has to be considered.

Bluetooth versus IrDA:

Bluetooth is a Radio technology and has ability to penetrate solid objects and its capability for maximum mobility within the piconet allows data swapping applications that are tricky or unfeasible with Infrared communication. On the other side, as in IrDA communication the signal will not pass through opaque objects, thus making eavesdropping harder and reducing the possibility of interference [7]. Further infrared links are not as susceptible to multi-path fading due to the short carrier wavelength. Bluetooth transmissions are omnidirectional, thus there are no line-of-sight issues as in Infrared communication when the information exchange takes place. Bluetooth has robust security mechanisms which are absent in Infrared communication. On the other side, infrared communication consumes low power compared to Bluetooth and are simpler to implement and generally comes out to be cheaper when compared to Bluetooth solutions.

C. RF communication

RF itself has become common with wireless and high-frequency signals, describing from AM radio between 535 kHz and 1605 kHz to computer local area networks (LANs) at ISM band 2.4 GHz. Although, RF has traditionally defined frequencies from a few kHz to 1 GHz. If we consider microwave frequencies as RF, this range extend to 300 GHz. RF communication works by creating electromagnetic waves at a source and being able to pick up those electromagnetic waves at the receiver side. These electromagnetic waves travel through the air at near the light speed. The wavelength of an electromagnetic signal is inversely proportional to the frequency;. In general, signals with longer wavelengths travel at a greater distance and penetrate around objects better than signals with shorter wavelengths. A major drawback is that exists it in RF communication is interference.

Comparison between Bluetooth, IrDA, RF

	Bluetooth	IrDA	RF
Communication Range	10cm-100m	Up to at least 1m	In the range of Kms
Connection Type, Direction	Multipoint, Omnidirectional	Point-to-point, narrow angle(30 degrees)	Omni-directional
Maximum data rate	24 Mbps	4 Mbps	1-2 Mbps
Security	Authentication and encryption	Physical limitation offer some built-in protection	Encryption
Cost	More	Low	More

Because of the barriers in the present scenario, scientists started to search for new ways of communication and they found Visible Light Communication (VLC).

III. AN ALTERNATIVE COMMUNICATION TECHNOLOGY-VLC

Visible Light Communication (VLC) refers to short-range optical wireless communication using the visible light spectrum from 380 to 780nm. VLC transmits data by intensity modulating optical sources, such as light emitting diodes (LEDs) and laser diodes which are fasten than the persistence of the human eye. There has been renewed interest in visible light optical communication due to widespread deployment of LEDs for energy efficiency and recent advancements in LED technology with fast nanosecond switching times. Traditional radio frequency (RF) communication below 6 GHz is rapidly running out of spectrum bandwidth for high data-rate communication. With ~300 THz of bandwidth available for VLC, multi-gigabit-per second data rates could be provided over short distances.

IV. LED VISIBLE LIGHT COMMUNICATION

LED (Light Emitting Diode) Visible Light Communication systems are recognized as creating a possible valuable addition to future generation which have the ability to utilize light for the purpose of advanced technological communication at ultra-high speed surpassing that of current wireless systems. If it is exploited correctly, the possibility exists than many of the problems associated with present day infrared, Bluetooth and radio wave could be at least moderately resolved, and a more biologically friendly system made available to industries and the general public. The main reasons for using LED are followed :

- High usage of bandwidth.
- Eavesdropping is avoided.
- Heat generation is minimized.
- The transmitter and receiver circuit is very simple and it is not expensive.
- Eco-friendly.
- Long life expectancy.

A further advantage is that VLC systems can transmit data more securely over short distances than other communication devices whose signals can be easily detected outside the rooms and buildings they originate in. In the following section, the paper describes the modulation method and their benefits for flickering.

V. MODULATION TECHNIQUE IN VLC

In the modulation process, the baseband signals constitute the modulating signal and the high-frequency carrier signal is a sine waveform. There are three basic ways of modulating a sinusoidal carrier wave. For binary digital modulation, they are called , binary frequency-shift keying (BFSK) , binary phase shift keying (BPSK) and binary amplitude-shift keying (BASK).

A. Amplitude Shift Keying

Amplitude-shift keying (ASK) is a form of modulation that represents digital data as variations in the amplitude of a carrier wave. The ASK technique is also commonly used to transmit digital data over opticalfibrer. For transmission through LED, binary 1 is represented by a short pulse of light and binary 0 by the absence of light. Normally transmission through LASER will have a fixed "bias" current that causes the device to emit a very low light level. binary 0 is represented by a low level, while a binary 1 is represented by a higher level. When the amplitude of the carrier wave is switched or keyed by the baseband signal, this process is said to be On Off Keying (OOK)

B. OOK VS FSK Considerations

As the number of short range devices (SRD's) is increasing day by day, the need for removing interference by competing other SRD's or some other wireless services has increased drastically over the last few years. It is getting more and more important for SRD's to have the potential of reusing the same spectrum shared by some other SRD's. To share the same spectrum, radio receivers at the transmission side must ignore co-channel interfering signals that are usually weaker than the desired signal. The receiver which exhibits this characteristic is normally referred to as the "capture effect". Usually FM or FSK receivers will have this capture effect and is not normally associated with OOK/ASK receivers.

Also, the important consideration is the bandwidth needed to transmit data with OOK modulation with that of FSK modulation. In the case of FSK, using the minimum consideration for good noise performance, the bandwidth needed for FSK transmission is 1.5 times that required for OOK. This is a very important consideration in the new limited bandwidth ETSI SRD bands at 868 MHz

The OOK transmitters simple circuit is also importantly equal. One should use either the stabilized oscillator circuit in the transmitter side or a buffer amplifier on its output side and is simply turned on and off in order synchronization with the data to be transmitted. The major advantage of using OOK modulation is that least a 50% reduction in battery current drain when compared to current consumed by an FSK/FM transmitter. Because the FSK/FM transmitter must be on 100% of the time when data is being transferred. The accurate control of both the center frequency as well as frequency deviation plays a major role while implementing FSK transmitters. For the required implementation a frequency synthesizer and a bulk crystal for stability purpose is required. While taking many of the SRD applications, such as monitoring of tire pressure, sudden temperature changes over temperature extremes (-40 to +85 degrees C) as well as severe shock and vibration. Bulk crystals are generally complex. To operate over large temperature ranges,they usually require compensation in the oscillator circuit. On the opposite side, using a SAW resonator and a simple oscillator circuit, an OOK transmitter can be implemented. The SAW resonator is easily capable of handling the temperature, shock and vibration extremes of such applications. Accurate frequency control is necessry for proper implementation of FSK receiver implementation, so a frequency synthesizer and bulk crystal must be used. In addition to that, another accurate frequency reference for the discriminator or phase locked loop is required for the demodulation of transmitted FSK signal. For OOK receivers,this is not the case.

C. OOK VS FSK Sensitivity

Optimum sensitivity for either an OOK or an FSK receiver is obtained using a coherent or synchronous demodulator. Phase locked loop (PLL) demodulator for either OOK or FSK is used for implementation purpose. For the purpose of the demodulated FSK data, the tuning voltage for the VCO (locked to the RF carrier) in the PLL can be used . By inserting the output of the VCO as one input to a multiplier and the RF carrier as the other input,OOK modulation is demodulated. The output of the multiplier is twice the input frequency and the desired OOK data is the DC term. By applying the incoming RF signal to both input ports of a multiplier, a pseudo-synchronous OOK demodulator, with little or no degradation can be implemented simply. Comparing to the PLL approach, this type of OOK demodulator is much simpler to implement.

The easiest way to compare the sensitivity or the range of OOK and FSK radio receivers is to compute the bit error rate of the receiver versus the signal to noise ratio of the incoming input signal.

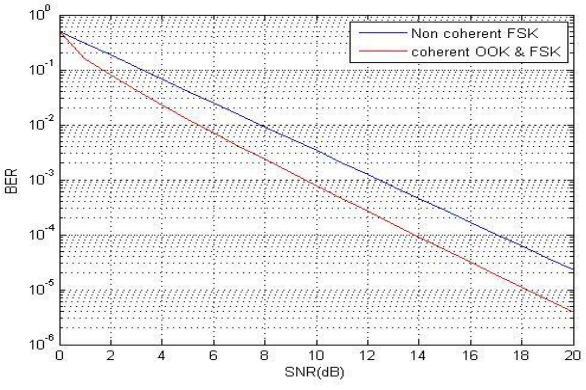

Figure 1
Simulation of Error Probability versus Signal to Noise Ratio for OOK and FSK in MATLAB

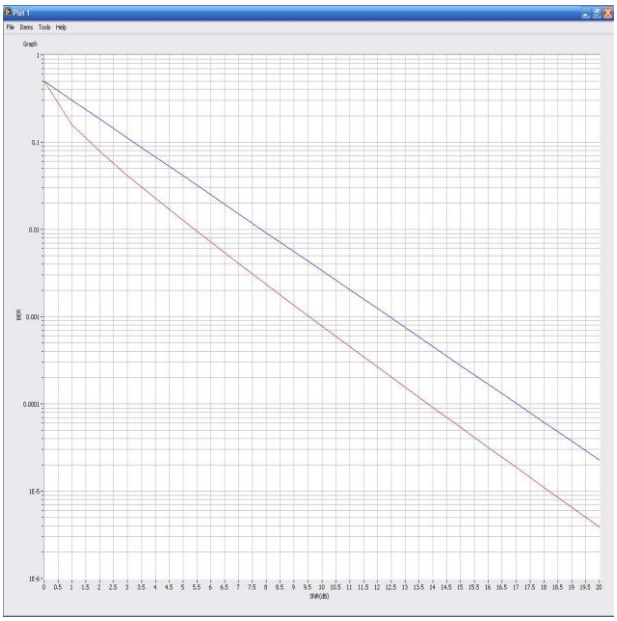

Figure 2

Simulation of Error Probability versus Signal to Noise Ratio for OOK and FSK in LABVIEW

Referring to Figure 1 and Figure 2, the non-coherent FSK example is approximately 1 dB poorer than coherent OOK and FSK. The majority of the FSK receivers used by the industry are non-coherent, using a frequency discriminator with a low frequency resonator as the frequency reference. From these plots, we find that the coherent OOK receiver, as exemplified by the receiver of Figure 1, exhibits a lower probability of error versus signal to noise ratio than the majority of the FSK receivers implemented. The probability of error versus signal to noise ratio for the coherent OOK receiver is identical to that for the coherent FSK receiver. Thus, we conclude there is no sensitivity or range advantage to implementing the more complicated FSK radio link rather than a simple OOK radio link.

II. CONCLUSION

The simplicity of OOK has been the main drive for its application in millions of SRD's in the past. It has been shown in this paper when properly implemented OOK modulation links can compete the FSK modulation links in all areas when its simplicity is assured. A properly implemented OOK receiver is the RFM receiver is the best example of the its simplicity and its performance is outlined in this paper. Also, VLC is the best system for ecological and human health perspective and can use the established retro system including lighting facility as well as power lines. This system is also free from current radio regulation.

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