Comparison of Analog and Digital based Voice Transmission System for Visible Light Communication

[1]Shweta Sagar[3], Mukti Rawal, [4] Yukti Mutreja
[1, 3, 4] Assistant Professor,
Hmritm (GGSIPU)

[2] Sushil Kumar
[2]School of Engineering and Technology,
Noida International University

Abstract: **In this paper, we present an analog and digital voice transmission system based on Visible Light Communication. The transmitter of the system, consists of Voltage-Frequency conversion circuit. In this system the analog voice signal is transformed into the frequency signal, which is linear with the amplitude of the signals. At the receiver end the voice signal can be demodulated with the help of Frequency –Voltage conversion circuit. Finally the comparison has been studied for analog and digital based voice transmission system for visible light communication. It shows that the input and output waveforms are consistent, the transmitted voice can be received without distortion.**

Index Terms- ***Visible Light Communication (VLC), voice transmission system, Voltage-Frequency conversion, Frequency – Voltage conversion.***

I. INTRODUCTION

Along with the development of Internet of things and popularization of LED, visible light communication (VLC) [1] which is using common LED as the light communication transmission equipment, has aroused great attention of government, researchers and scholars. If we can use LED lighting source as the transmitting device in the museum, exhibition hall, tourist attractions and other places where the guided tours are needed, we can not only achieve the green lighting but also achieve the voice transmission. It is a very good application of VLC technology. When using visible light to transmit voice, digital modulation can be used, and the analog modulation mode can be adopted too [2]. Comparing with digital modulation [3].For the VLC systems, in some occasion where the sound quality is not require non-destructive, such as the interpretation of the tourist attractions which is a reasonable choice to use analog modulation mode [4]. The development of LED enhances the use of visible light communication system and they are used for high data rate transmission. In 1999, pang et al. introduced fast switching LEDs and use of modulation in visible light for communication purpose. In the year 2000 in Japan, white LEDs were utilized for illumination and communication. In 2001, Tw bright labs open-source project Reasonable Optical near Joint Access (RONJA) presented a long range bi-directional optical communication link to transfer the data over light at 10 Mbps over a distance of 1.4 km. In 2003, Visible Light Communication Consortium (VLCC) was established to promote and standardize the VLC technology. By integrating different communication technologies, European Union funded home Gigabit Access project (OMEGA) for developing global standard for home networking. They aimed at delivering gigabit data rates for home users and achieved a data rate of 100 Mbps with the unidirectional VLC link. In 2011, professor Harald Haas demonstrated a high quality real-time video transmission over VLC link at Technology Entertainment Global conference. Kahn and Barry introduced a system for indoor wireless optical applications. In this system, Intensity Modulation with Direct Detection (IM/DD) is employed and a directed Line of sight link has been considered. In an IM/DD system, the data is modulated on optical intensity of transmitted light using an optical modulator. By using rate-adaptive discrete multitone (DMT) modulation and phosphorescent white LED, a 1 Gbps transmission was demonstrated in IEEE photonics journal in 2012.

II. SYSTEM DESCRIPTION

If we adapt analog baseband signal to the light wave amplitude modulation and ensure that LED works in the linear region, the amplitude of the signal will change with the modulation signal, then the receiver will be able to easily recover the voice signal. From the point of view of communication, this method is feasible. However, from the perspective of lighting, it does not meet the practical application because the amplitude of the baseband signal changes significant and it will lead to lamp flickering and cause the human eyes discomfort.

The scheme in this paper is: at the transmitter, the voice analog signal is converted into the frequency signal with different pulse interval according to the amplitude of the baseband signal by the V-F conversion circuit. Then use the frequency signal to drive LED through amplitude modulation (AM). Then, we will get an optical signal with equal amplitude and pulse interval varying with the voice signal amplitude. At the receiver, restoring the baseband signal of the transmitter through the F-V conversion circuit. The block diagram of the voice transmission system based on VLC is shown in Fig. 1.

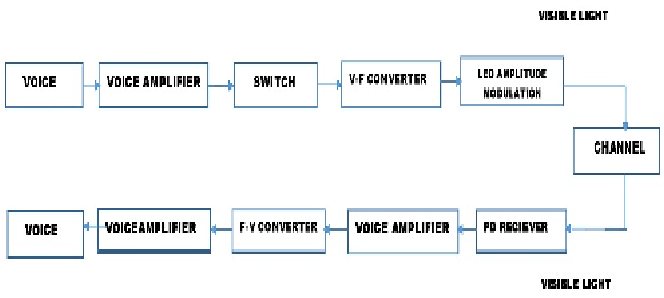

Fig. 1. Block diagram of the voice transmission system based on Visible Light Communication

III. VISIBLE LIGHT COMMUNICATION (VLC) SYSTEM

Visible light communication uses off-the shelf white light emitting diodes (LEDs) used for solid-state lightning (SSL) as signal transmitters and off-the-shelf p-intrinsic-n (PIN) photodiodes (PDs) or avalanche photo-diodes(APDs) as signal receivers[2].This means that VLC enables systems that illuminate and at the same time provide broadband wireless data connectivity. If illumination is not desired in the uplink, infrared (IR) LEDs or indeed RF would be viable solutions. In VLC, the information is carried by the intensity (power) of the light. As a result, the information-carrying signal has to be real valued and strictly positive. Traditional digital modulation schemes for RF communication use complex valued and bipolar signals. Modifications are therefore necessary, and there is a rich body of knowledge on modified multi-carrier modulation techniques such as OFDM for intensity modulation (IM) and direct detection (DD). Data rates of 3.5 GB/s have been reported from a single LED. It has to be noted that VLC is not subject to fast fading effects as the wavelength is significantly smaller than the detector area. While the link-level demonstrations are important steps to prove that VLC is a viable technique to help mitigate spectrum bottleneck in RF communications, it is essential to show that full-fledge optical wireless networks can be developed by using existing lightning infrastructures. This includes MU access techniques, interference coordination. VLC has its own strengths, but also weaknesses. This section summarizes its characteristics, which are overviewed in Table1. These characteristics deserve special attention in designing architectures and protocols for VLC communications and networking.VLC offers several advantages over RF, which are summarized in the left column of Table 1. First, it has unregulated spectrum, specifically from 428 to 750 THz, which provides huge communication bandwidth to deliver license-free extremely high data rate services such as large files and super high definition video transfer. Compared to RF communications, VLC offers hundreds of terahertz of license-free bandwidth, 10,000 times more than the entire RF spectrum up to 30 GHz. Besides the transmission speed, reported at 3.5 Gb/s currently [2], allowed by the huge bandwidth of VLC, the ultra-wide bandwidth is also more robust to multipath fading in various environments. In a 2011 TED talk, Hass successfully demonstrated the transmission speed of 1 Gb/s for HD video streaming. Second, the energy cost for data transmission of VLC is considerably lower than that of RF, which enables it to become a promising candidate for green communication. This is because lighting is on most of the time, so the energy used for communication would be close to zero if data is piggy-backed on illumination. Even if lighting is not on, energy-efficient intensity modulation (IM) techniques would allow data communication [2]. Third, VLC spectrum can be reused densely. Visible light wave, as a media for data transmission, cannot penetrate walls and obstacles. Therefore, the information cannot be received unless a receiver sees a transmitter. As a result, in indoor cases, the coverage of VLC is restricted in one room. This exact property enables dense spatial reusability, because the same spectrum can be reused in other rooms. Fourth, VLC provides high secrecy. Its narrow beam width and line of sight (LOS) constraint protect the communication from eavesdropping.

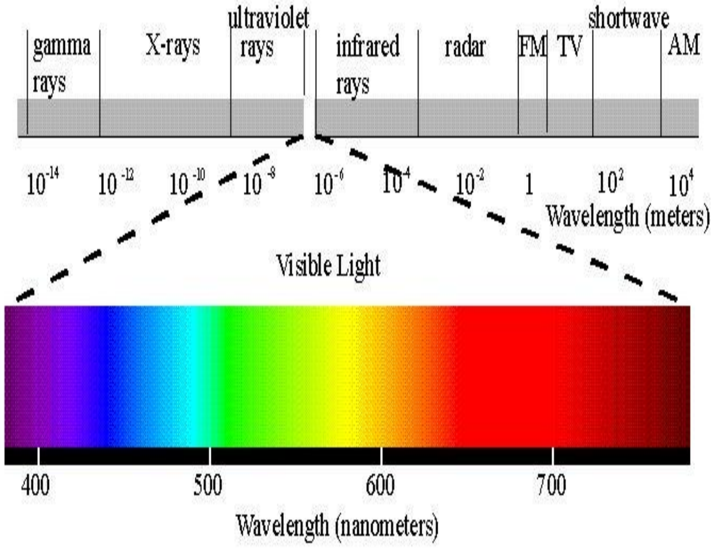

Fig. 2. Comparison between radio waves and visible spectrum.

IV. LIGHT FIDELITY (Li-Fi)

Li-Fi is a fast and cheap optical version of Wi-Fi, which is based on Visible Light Communication. VLC is a data communication medium using visible light between 400 THz (780 nm) to 800 THz (375 nm) as optical carrier for data transmission and illumination. Li-Fi is basically implemented using white LED light source on the downlink transmitter side. This variation can be used to transfer high speed data. Generally, these kind of devices are employed by applying constant current. Optical output can vary at high speed with the help of subtle and fast variations of current.

Data can be encoded in the light to generate a new data stream by varying the flickering rate, to be clearer, by modulating the LED light with the data signal, the LED illumination can be used as a communication source. This is a whole new spectrum of possibilities as compared to the radio waves spectrum and is 10000 times more in size. Visible light is not injurious to vision and are a mandatory part of an infrastructure, therefore abundantly available and easily accessible. Comparing the number of radio cellular base stations (1.4 million) to the number of light bulbs (14 billion) installed already the ratio is coincidently same i.e. 1:10000.

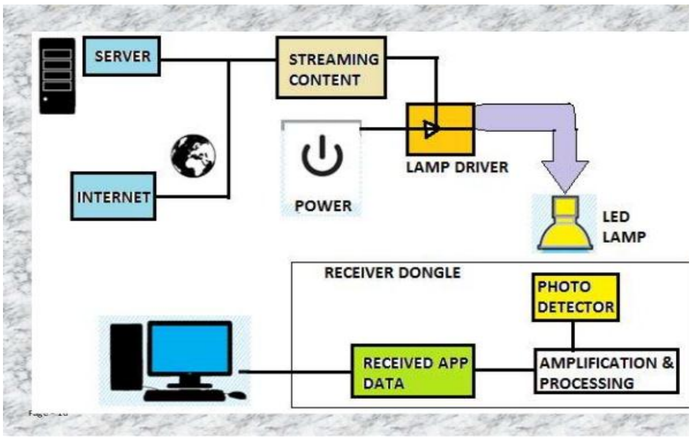

Fig. 3. Block diagram of Li-Fi system [6]

V. DESIGNING & WORKING PRINCIPLE OF VLC SYSTEM

The Standard Operating Procedure (SOP) of data communication through the visible light on the transmitter side keypad is used as the input signal. The microcontroller receives the signal from the keypad and generates two outputs and gives that signal to the microcontroller Encoder. The encoder will generate one tone and one frequency for every pressed key. That frequency is amplified by the amplifier circuits and fed into the power LED. At the receiver side light dependant resister will receive the light signal and correspondingly generate an electrical signal proportional to it. This electrical signal is processed by a demodulator circuit and the output of decoder is then fed to a microcontroller and the microcontroller activates the corresponding load for the pressed key. In the process of voice communication through the visible light on the transmitter side voice is used as the input signal. This signal is converted to an electrical signal through a condenser or microphone. This electrical signal is amplified by the amplifier circuits and fed into the power LED. The light signal from the LED varies according to the intensity of the voice signal. The louder is voice the glow of the LED will be more. At the receiver side light dependant resister will receive the light signal and correspondingly generate an electrical signal proportional to it. This electrical signal is processed by a demodulator circuit which is then fed to a speaker and it produces the audio signal which was at the input of the transmitter side. It became evident that work should be done to look into the possibility of designing a new model that can fit the present and future infrastructure for indoor applications after having gone through the review of the literature. It offers a genuine and very efficient alternative to radio-based wireless. As there is a rapid growth in population, hence the number of devices accessing wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a high-speed and reliable signal.

VI. CONCLUSION

LED-based VLC has provided the Fundamental solutions to develop Li-Fi atto cell networks that are capable of achieving magnitudes of higher data rates per unit area compared to state-of-the-art RF small cell solutions. A key factor enabling this is the radical reduction of cell sizes, and this is possible by using the existing infrastructures through the combination of LED lighting and wireless data networking. The new wireless Li-Fi networking paradigm offers performance enhancements that are sought from the 5th Generation (5 G) and at the same time due to the ubiquitous use of LEDs, this will provide an infrastructure for the emerging IoT. Some short-range communication technologies, such as Wi-Fi, femtocell, VLC and mm-wave communication technologies can be seen as promising candidates to provide high-quality and high-data-rate services to indoor users while at the same time reducing the pressure on outdoor BSs. The implementation of the amplifier helps to improve the signal quality and range of the audio signal. It can be seen that the distance between the transmitter and the receiver can influence the performance of the system. For longer distance, the signal strength degraded and so loss increased. A maximum distance of 50 cm can be achieved for this system with low noise considering ideal conditions.

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