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AN EVALUATION OF VISIBLE LIGHT COMMUNICATION BASED AUDIO TRANSMISSIONUSING LI-FI TECHNOLOGY

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Abstract---In the recent year, visible light communication has the trending research topic due to this speed, efficiency and also it being eco-friendly makes it all the more advantageous. It is gaining popularity in both indoor and outdoor applications. The primary sources of light are found everywhere ranging from the fluorescent lamps to the LED bulbs used at homes. In comparison with the wired fiber transmission, this is preferred because of convenient installation. This paper aims to survey the different algorithms used in the transmission of audio using light and its applications along with its limitations. The techniques and principles are surveyed for the better understanding of compensation of optical noise.

Keywords--- *Visible Light Communication, Indoor and Outdoor, Eco-friendly, Audio transmission*

1.INTRODUCTION

Li-Fi is a high speed and wireless communication technology that allows utilization of light for different purposes and connectivity. Li-Fi enabled LED lights modify illumination levels so that when bulbs are turned on, data is transferred along with the light throughout the room. This modulation is so rapid that even the human eye cannot sense it. Visible light spotlight is a trending technology that creates focused light beam similar to sound beams from a directional speaker. By reflectingoptics to one side, listeners can be hear with sound without chances of eavesdropping. It uses an arrangement of non-linear optics converters and some mathematics. But it is a fact that this is not from conventional loud speaker. This lightdevice comprises of an audio playback module those fires out of earshot ultrasound pulses in very small wavelengths which are similar to that of a narrow column.

2.LITERATURE SURVEY

2.1.Wireless Wavelength Hopping with AWG/Optical Switch Implemented Secure Audio/Digital Signals:

In this circuit wavelength wireless hopping technique is used. The broadband light source is applied in center wavelength of 1550nm. By changing optical switch from off on to state for protecting against interception and interference, group wavelengths λ1-λ8 is converted the transmission path from input port #1 to #3 of AWG.

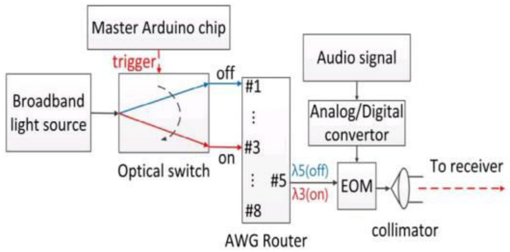

Fig 1.Transmitter circuit

The principle used in this wavelength wireless hopping technique is AWG. By applying the **PRNG** algorithm embedded slave Arduino microprocessor to generate the same triggering binary stream, the proposed received AWG/optical switch-based configuration is created with synchronous varied wavelength hopping pattern as transmitted end. The optical spectrum analyzer (OSA) is used to monitor desired wavelength hopping from λ5=1546.6nm to λ3=1545.0nm while optical switch is trigged from off to on state by a series of binary stream. Similarly, oscilloscope (OSC) is used to monitor whether audio signal of 6.25MHz can be retrieved correctly after synchronous de-wavelength hopping is performed.

Fig 2. Receiver circuit

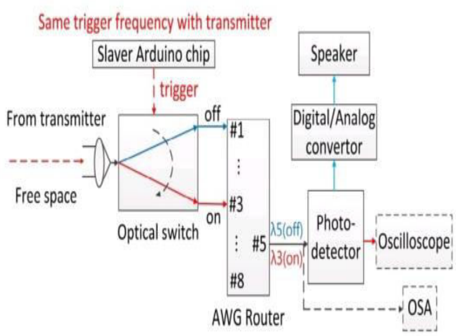

Fig 3.The retrieved audio signal of 6.25MHz with optical switch off (bar) state

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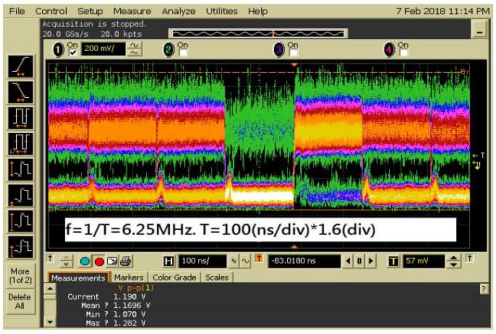
In this experiment, the analog/digital converter is a transmission interface for S/PDIF



(Sony/Philips Digital Interface Format).In current practical experiment, the experimental results showed that desired wavelength is correctly achieved while the optical switch was changed from switch off (bar) state to switch on (cross) state. The audio signal is applied to verify the feasible configuration of wireless wavelength hopping implemented by proposed AWG/optical switch-based scheme.

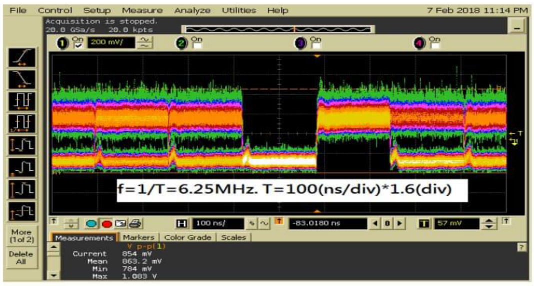


Fig 4.The retrieved audio signal of 6.25MHz with optical switch on (cross) state

The audio signal of 6.25MHz is correctly retrieved when optical switch was changed from switch off (bar) to switch on (cross) state triggered by PRNG algorithm. In order to further verify higher transmission rate for expanding multimedia application of proposed wireless wavelength hopping scheme, a digital sequence (start bitrandom payload-stop bit) were created by pattern generator
The experimental results showed that the desired digital signal of 100 MHz was obtained with exceeding peak-to-peak value of 200mV.Furthermore, the un-authorized effect of same scheme will be evaluated to analyze wireless security of proposed AWG/optical switch-based wavelength hopping.

2.2. A Circuit for Robust Visible Light Communication Systems in Indoor Environment

The proposed design of AFE block circuit for indoor VLC is framed. This system consists of the Trans-impedance Amplifier (TIA), Non-inverting amplifier, DC gain buffer & Differential amplifier to replace the capacitor block in [7], high-pass filter (HPF) with 10 Hz of cut-off frequency (fc) & notch filter with 100 Hz of fc to replace HPF with 50 kHz in, Automatic Gain Controller IC, and the last stage is amplitude signal adjuster. All of blocks are built by Op-Amps configuration. This paper only discusses the circuit for robust VLC from other light sources.

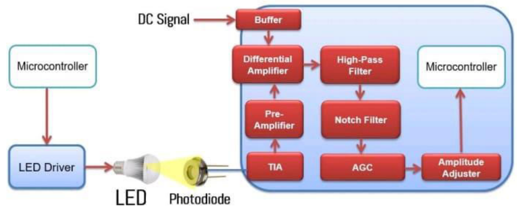


Fig.5 Proposed AFE circuit for robust indoor VLC system.

In this circuit, we used SP-8ML Kodenshi PIN photodiode [8]. This photodiode has wavelength = 450 nm to 1050 nm, thus it can detect visible light and infrared as well with 900 nm of peak wavelength sensitivity. It has ~1 µs of rising time and falling time.

2.2.1. TIA Circuit:

AFE receiver circuit is TIA (Op-amp U1) that has function to convert photocurrent (I_{pd}) of D1 to the voltage. The TIA output voltage is: $v1 = IR1 *R1$, while I_{pd} is equal to the current that flows on R1, thus $v1$ can be expressed as $1 = IPD*R1$ .The available resistor value of 56 kΩ for R1 is

$R1 = \frac{Voutsaturation}{Maximum(I_{pd})}$ (1)

2.2.2. Pre-Amplifier Circuit:

The photo detector not only generates the current from the light deriving from the LED transmitter but also from the ambient light source. This ambient light is undesirable things on the VLC system; hence it should be filtered out in order not to interfere the system performance. The maximum of TIA output voltage can be expressed as

$V1\ max = (Iinf + Iamb)\ R1$ (2)

$V1\ max$ =0.85 v (3)

The maximum gain signal from the ambient light (V2 max) is set at least 0.5 VDC below VSat as visualized

?2 max =3.5 v (4)

Voltage gain value can be calculated by considering v1 and v2. We get

AV= 4.12 (5)

2.2.3. DC-offset Remover:

Differential amplifier is used to subtract the received signal ($v3$) from the DC signal ($v2$) .The RV1 potentiometer should be adjusted at least to meet the conditions as follows: $v2\ min - vadj \leq -0.4\ V$.

Later, the differential amplifier voltage gain should be able to ensure that the low-level of $v3$ can reach to – 4 VDC, that is a negative saturation voltage. Let we put R5 = R7 = Rf and R4 = R6 = Rg, hence the value of Rg and Rf can be found as

$$V3 = (V2\ min - V3\ ) * Rf/Rg \qquad (6)$$

2.2.4. Optical Interference Light Filter:

The next circuit after HPF is notch filter, its function is to pass all frequencies but attenuates those in a specific range to deficient levels. The type of designed notch filter is Twin-T it has high-Q and simple topology. Hence, we determine the notch filter with fc = 100 Hz.

2.2.5. AGC and Amplitude Signal Adjuster:

The output of notch filter circuit is then connected to the commercial IC LM13700 that configured as AGC circuit, the detailed discussion of AGC using LM13700 is reported at [910]. The range of AGC output is about +5 to -5 VDC.

2.2.6.Circuit Simulation:

To simulate AFE receiver circuit, we perform on SPICE® PROTEUS software. It can be noted that there are attenuating signal at frequencies below 10 Hz caused by HPF circuit and specify at ~100 Hz in consequence of notch filter circuit. Therefore, the designed filter circuits can work as expected. The effective bandwidth of AFE receiver is about 1 to 50 kHz.

2.2.7.Result:

An AFE receiver for robust VLC system against AC optical noise interference and DC ambient light has been designed and tested based on simulation. For proof-of-concept purpose, we also examined the AFE. Our proposed circuit consists of TIA, Pre-amplifier, DC gain buffer, Differential amplifier, HPF, Notch filter, AGC, and the last stage is amplitude level adjuster.

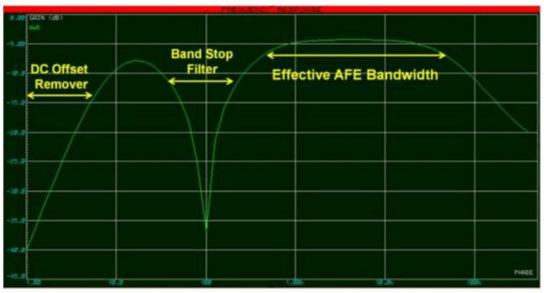


Fig 6. Notch filter circuit

2.3. A Voice Transmission System Based on Visible Light Communication:

Along with the development of Internet of things and popularization of LED lighting technology, visible light communication (VLC) is employed. In the transmitter side 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.

At the transmitter, we can get the voice signal from the mobile device or computer through an audio socket. Then through the amplifier circuit and the level conversion circuit, the voltage level is converted to fit the need of the V-F conversion circuit. Then the V-F conversion circuit converts the analog voice signal into a square wave signal which of the frequency changes with the amplitude of the baseband signal. Amplitude modulation circuit uses square wave signal to drive the LED and the electrical signal is covered into light intensity with different frequency

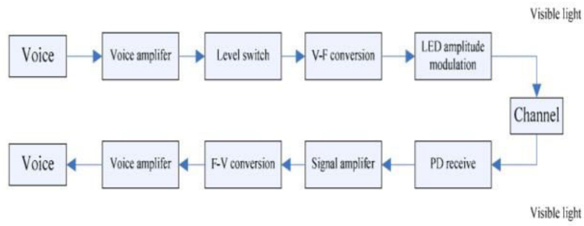


Fig 7. Block diagram of the voice transmission system based on VLC

At the receiver, the PD photoelectric conversion circuit converts the optical signal into electrical signal. The F-V conversion circuit converts the signal into an voice signal that changes with different frequency. A voice amplifier circuit amplifies the audio signal to a level that can push the headphones or speakers. The blue line expresses the input sinusoidal signal, the green line stands for the output waveform of the VF conversion circuit. the higher the amplitude of the input signal, the higher the frequency of the output signal after the V-F converted. At the same time, the lower the amplitude of the signal, the lower the frequency of the signal after V-F converted.

If the waveform of the input voice and the output voice are similar and we also can hear the voice at the receiver by the headphones or speakers. And the system can achieve the function of voice transmission based on VLC.

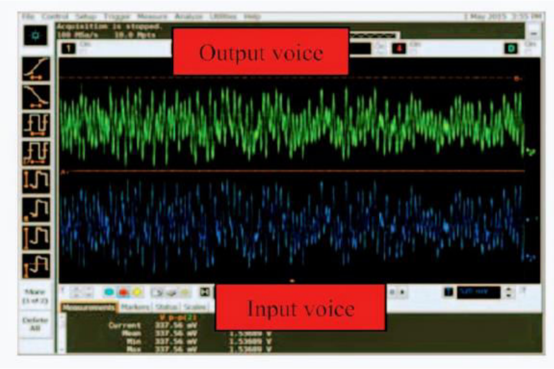
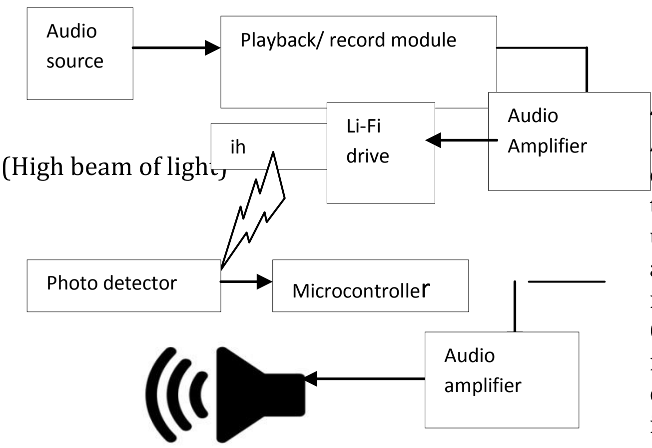


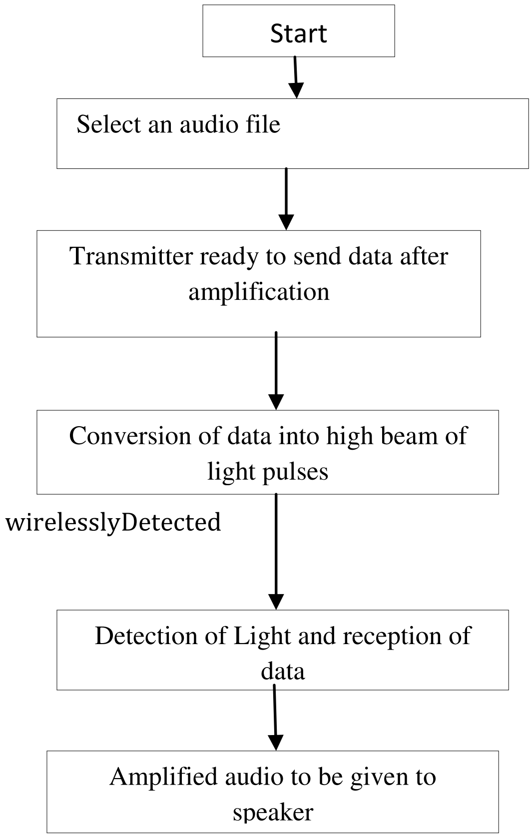
Fig 8. Voice input and output signal

Result:
In the above surveyed paper, an analog voice transmission system based on VLC technology is designed and tested. The results show that the design is reasonable and the sound is clear without distortion. It can meet the requirements of undemanding voice transmission in VLC project and has a very good use value in some occasion.

3.PROPOSED METHODOLOGY



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 At the receiver side, photo detector 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.



4.CONCLUSION

Among the papers that we have studied the essential notes in AWG wavelengthhopping is that audio or digital signals can be identified by using Pseudo Random NoiseGenerator (PRNG) algorithm and it is free from interception and interference. In indoorenvironment Visible Light Communication (VLC) system has high robustness ability of light inindoor than outdoor. Based on stimulation, AC optical noise interference and DC ambient light was designed and tested against the robustness of VLC system. In this Analog Front End (AFE) Receiver is to integrate the unnecessary signals caused by the optical noise. Based on VLC voice transmission, this paper has done the work onanalog voice transmission, and testing the waveform signal is taken by Agilent MSO9104oscilloscope and headphones are used to play the music. Finally this setup gives the clear anddistortion free output. And for improvement we can introduce Li-Fi which is a high speedwireless communication system. In RF based communication, interference and noise level ishigh. By using Li-Fi we can overcome these issues.

5.FUTURE ENHANCEMENT

Future work is based on wireless audio transmission using Li-Fitechnique. In this process voice communication is through Visible Light using LED. The lightsignal from LED varies according with the intensity of input voice signal. It can be done by using PIC16F8774 controller and Li-Fi modules and it can be applicable in RF restricted areassuch as hospital automation, petro chemical industries, power plant museum etc. hence it is muchbetter than Wi-Fi for more sensitive places.

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