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The Light-Fidelity Technology

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Abstract—*We know that spectrum is not a rare term for communication engineers. Today, with the quick growth of wireless communications the difficulty of using bandwidth proficiently has become more vital. A number of solutions have been brought up to solve this problem; one of these is the usage of light frequencies for communication. Light fidelity (Li-Fi) is an innovative short range optical wireless communication technology which offers the connectivity within a local networking system, by using LEDs to transfer data depending on light illumination properties.*

Index Terms—*VLC, Light Fidelity, Spectrum Crunch, Modulation Techniques.*

I. INTRODUCTION

Transfering data from one location to another is one of the most important day-to-day activities. The present wireless networks that connect us to the internet are very slow when several devices are connected. As the quantity of devices that access the internet rises, the fixed bandwidth available makes it more and more problematic to enjoy high data rates and link to a protected network. In today's world, everybody like to use their smart phones, laptop to contact each other over Wireless-Fidelity (Wi-Fi) systems, and this technology, is extensively used in all areas like home, public places like airports, cafés by people, also the time usage of wireless systems is increasing exponentially every year; but the capability is going down, due to the restriction of Radio Frequency (RF) resources, so we are going to suffer from this severe problem.

In order to overcome this difficulty in the future, Professor Harald Haas, a professional in optical wireless communications, proposed a excellent and appropriate solution by using light to transmit data, he demonstrated how an Light-Emitting Diodes (LED) bulb with a signal processing technology could stream a quality audio-visual to a computer and he showed that one watt LED light bulb would be sufficient to deliver net connectivity to four devices or computers.

This new innovative technology is known as Light–Fidelity. This technology visible light instead of traditional RF spectrum for communication. "Pure Visible Light Communication" is a private company founded by Professor Harald Haas, to explore the Light-Fidelity technology.

He predicts a future where data for all kind of communication electronic devices like laptops and smart phones are transmitted through the light in a safe way.

In this seminar, we will talk about the limitations of radio spectrum , components, working principle and modulation techniques in Li-Fi. Just like Wi-Fi, Li-Fi is wireless connectivity and makes use of the standard 802.11 protocols; but it uses Infrared and visible light communication (instead of radio frequency waves), which has a lot larger bandwidth. One part of VLC is structured after communication protocols created by the IEEE 802 workgroup. However, the IEEE 802.15.7 standard is obsolete: it fails to recognize the newest technological progresses in the field of optical wireless communications, with the forth bringing of optical orthogonal frequency-division multiplexing (O-OFDM) modulation method for enhancement for data rates, multiple-access and usage ofenergy effectively.

II . **Analysis of Radio Spectrum**

A. Problem with the radio Spectrum

In spite of consistent developments in wireless communication systems, e.g. 3G, 4G, etc.., a imminent crisis is likely occur due to the lack of necessary Radio Frequency (RF) resources, this constraint in bandwidth can't hold up the growing demand for high data rates and the large amounts of communication systems, this is known as "Spectrum Crunch"
Figure 1 shows the, bandwidths between 300 kHz and 4 GHz in Visible light Spectrum.

Even though, bandwidth congestion reduces when we use high frequencies to transmit data, but this not a practice solution, because this part of spectrum requires complex equipments and causes greater cost systems.

B . Visible Light Communication

Definition

VLC is an optical communication technology that uses visible light emissions, these rays are located between [400-800] THz, as optical carrier for data transmission by light. The light is flickered o rapidly that it cannot be detected by naked eye.The usage of any part the visible light or even the infrared portion not visible to human eye, of the electromagnetic spectrum can also be used small or larger transfer of information.

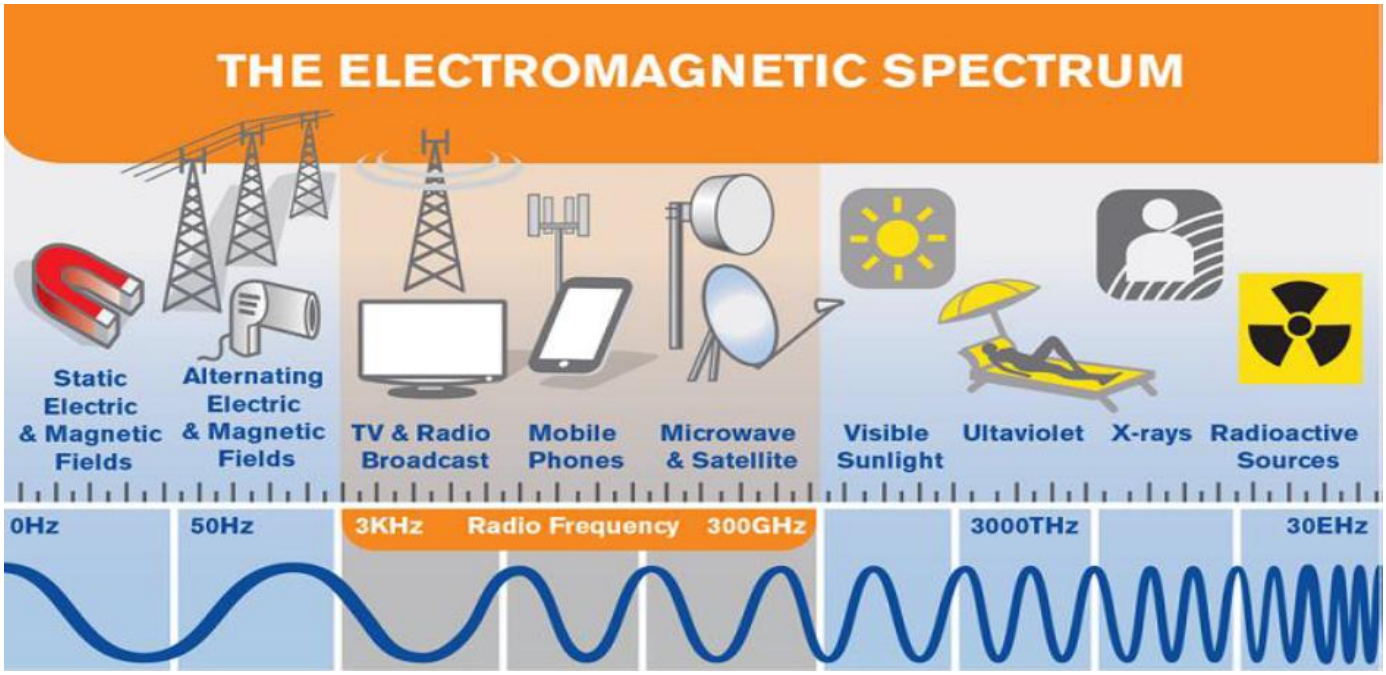


Figure 1:Radio Frequency spectrum.

The Visible Light Communication regularization process is conducted within IEEE wireless private area networks working group (802.15). One of the VLC's features is the wide bandwidth. We can certainly see that usage the optical proportion of spectrum guarantees about 10,000 times better bandwidth compares to the conventional RF frequencies.

C. **Components**

As we see in the previous paragraph, VLC is a communication technique which consists of a transmitter, a receiver and channel for communication. The key components required are:

•High brightness Light-Emitting Diodes (LEDs) or any light sources, which acts as transmitter.
•A silicon photodiode has the roll of a detector and it shows a good response to visible wavelength.
•Communication channel is fiber optics.

D. What is Li-Fi?

Li-Fi is a innovative new technology for a short room range communication wirelessly; which is suitable for data transmission via LEDs by the radiance of the light. It uses the visible light, a part of the electromagnetic spectrum that is still not effectively utilized. Usually, we add to these components some required circuits like a driving equipment and a receiving equipment.
The driving set of equipments contains control circuit and output stage to change the data and make it ready to be sent and the receiving circuit contains a filter to select the required band, amplification stage to deliver the necessary signal.

The encoding of the data into the light is done by modifying the flickering rate of the LEDs, that is on and off to give altered sequences of 1s and 0s. The modulation of the LEDs intensity is done so quickly that it cannot be noticed by the human eye , so the output appears to be constant; also more sophisticated methods could help dramatically raise the Li-Fi data rates such as using array of LEDs, where each LED is used in transmitting a different data stream, and to provide data transmission parallely. Other designs concepts are using combinations of red, green and blue LEDs to modify the light frequency encoding with a different data channel.

E. Working Principle

Li-Fi technology is employed using white LED light bulbs used for illumination by applying current constantly. However, by fast deviations of the power, the light output can be made to fluctuate at tremendously high speeds. If the LED is on, it transmits a digital/binary 1,otherwise it transmits a digital/binary 0. The LEDs is switched on and off rapidly to transmit data that can't be spotted by a human eye.
The LED bulb equipped with a micro-chipset that will do the work of handling the data. The light intensity or strength can be modified to send binary data by minute variations in amplitude.

Figure 2 shows the working principle of Li-Fi technology, for data transfer; it can be done by single LED or by bunch of LEDs. On the receiving part consists of a photo detector, which converts this light into electrical signals and it will give the electric signals to the device linked to it. Voltage regulator and level shifter circuits are used on both sides to transform or preserve a voltage level between transmitter and receiver.

III. **Modulation Techniquess for Li-Fi**

In this paragraph we summarize the digital modulation techniques that are commonly used for Li-Fi. In principle, Li-Fi also depend on electromagnetic radiation for information transmission. Hence, normally used modulation techniques in RF communication can also be used to Li-Fi with essential modifications.

1. Single Carrier Modulation

A. On-off keying (OOK):

On-off keying is the simple form of amplitude-shift keying (ASK) modulation in which digital data is signified in the form of binary one, while its nonappearance for the same duration represented by binary zero. It is analogous to unipolar encoding line code.

B. **Pulse-width modulation** (**PWM**):

An electronic device like a microcontroller can easily work with inputs and outputs. There are only two states, on and off. In the same way, you can use it to control any electrical device on and off by using proper drivers such as transistor, relays, etc. But sometimes you need more than just "on" and "off" control over the device. For example you want to regulate the intensity of a LED or any electronic light source, or the motion of DC motor, then the digital signal (on/off) simply can't do it. form of appearance or nonappearance of a carrier wave.

This condition is very elegantly handled by a technique called Pulse Width Modulation. PWM is the technique used to produce analog signals from a digital device like a Micro Controller Unit. Digital controller is used to create a square wave, a signal switched between on and off. The time duration of "on-time" is called the pulse width. To get fluctuating analog values, you might change or modulate the pulse width. If we continually do this pattern of repetitive eon-off fast enough with an LED for example, the result is as if the signal is a stable voltage in the middle of 0V and 5V controlling the brightness of the LED.PWM communicate the data by encoding the data into the time duration of the pulses. Great number of data can be conveyed within the occurance of each pulse.

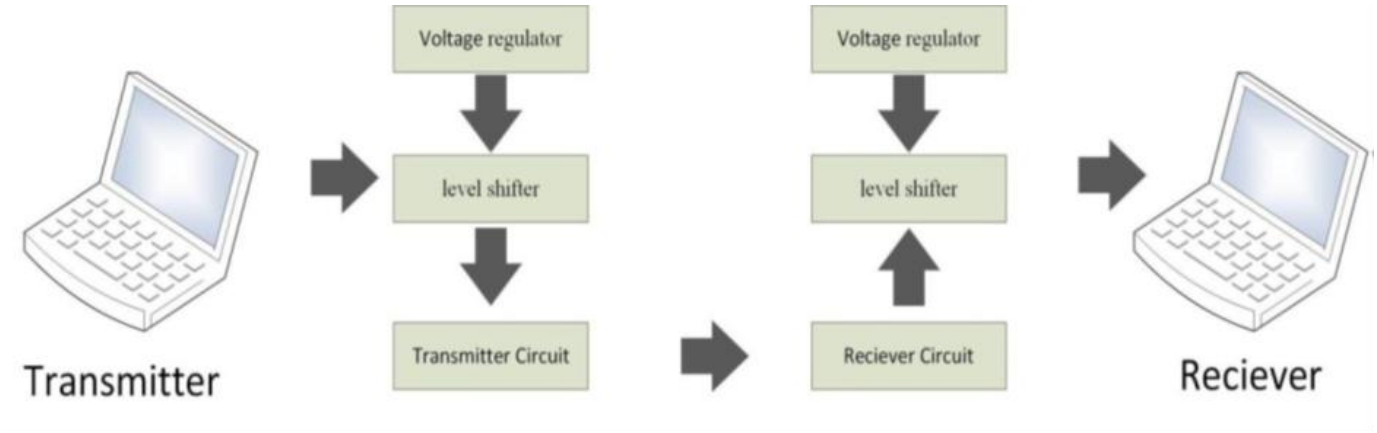


Fig. 2. The working principle of the Li-Fi.

The initiation and decoding is simple but is not very optimum in terms of illumination control and data throughput signifies a digital one, while its non-appearance for the equivalent period signifies a digital zero. It is very simple to initiate and interpret but is not very optimal in terms of radiance control and throughput of data.

A. Pulse Position Modulation (PPM)

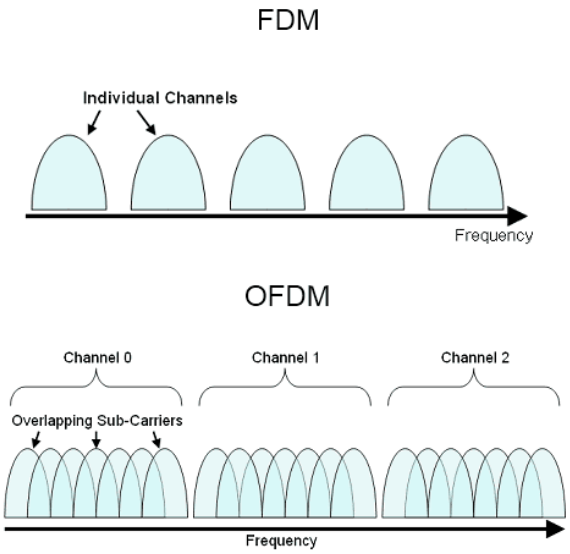
Pulse Position Modulation(PPM) is a method for the modulation of electric signal in which N data bits are encoded by transmitting a single pulse in one of possible necessary time-shifts. The working of PPM is by sending electrical, or optical pulses to a device in order to communicate . It requires both devices to be in same clock synchronization so that when a series of pulses is sent, the device decodes the information on grounds of when the pulses were broadcasted.

In a alternative way, the other form of PPM known as differential pulse position modulation, lets all signals to be encoded grounding upon on the time difference between broadcast times, such as repetition every T seconds.The difference in arrival time period has to be noticed by the receiving devices. It is often used in optical communication, such as fiber optics, in

which there is a very small multi-pathway interference. PPM is specially used to transfers digital signals and cannot be used with analog systems. File transferring is not effective with this form of modulation technique.

2. Multi-Carrier Modulation

Multi-carrier modulation (MCM) is a method of transmiting data by slicing it into several modules, and sending each of these modules over distinct carrier signals. The individual carriers have thin bandwidth, but the combined signal can have broad bandwidth. Relative protection to fading caused by communication over more than one path at a time is an benefit, and also less vulnerabe than single-carrier systems to intervention initiated by noise impulses, and heightened resistance to inter-symbol intrusion. Under borderline situations synchronizing the carriers are little bit challenging, and a relatively strict necessity is that amplification be linear.



A. **Orthogonal Frequency Division Multiplexing (OFDM)**

OFDM is a technique of encoding information on a number of carrier frequencies. A huge amount of narrowly spaced orthogonal sub-carrier signals are used to shift data on numerous parallel data streams or channels. Every sub-carrier is modulated with a conventional scheme (such as phase shift keying) at a least symbol rate, continuing total data rates similar to old-fashioned single-carrier modulation strategy in the equivalent bandwidth. In OFDM, parallel data streams are transmitted concurrently through a gathering of orthogonal subcarriers and complex equalization can be omitted. If the number of orthogonal subcarriers is chosen so that the bandwidth of the modulated signal is smaller than the coherence bandwidth of the optical channel, each sub- channel can be considered as a flat fading channel. Techniques already developed for flat fading channels can therefore be applied.

3. Li-Fi Specific Modulation

Li-Fi transmissions are usually intended not only for wireless transfer of messages but also for illumination, which can be realized either by using blue LEDs with yellow phosphorus layer or by color combinations through colored LEDs. Luminaires with multicolored LEDs can deliver furtherpotentials for signal modulation and recognition in Li-Fi systems. Color shift keying (CSK) is a scheme in IEEE 802.15.7 , where signals are encoded into color intensities emitted by red, green and blue (RGB) LEDs. In CSK, received bits are mapped on to the instantaneous chromaticities of the colored LEDs

while preserving a constant average perceived color. There are lot of advantages of CSK over conventional schemes.Since a constant radiant fluctuation is guaranteed, there would be no twinkling effect over all frequencies.

IV . Conclusion

The opportunities are abundant and can be learnt further because the idea of Li-Fi is currently drawing a lot of eye-balls because it offers a candid and very effectual and alternative way to radio based wireless transmission. It has a good chance to replace the conventional Wi-Fi because as an ever growing population is using wireless internet, the airwaves are becoming gradually more congested, making it very much problematic to get a reliable high-speed signal. In the upcoming years, data for PCs, phones can be transferred through light used in the room by using Li- Fi. Technology researchers are trying to create micron sized LED which are able to fluctuate around thousand times faster than larger LED. If this technology can be put into real practical use, every bulb can be used as a Wi-Fi hotspot to transfer data and we will advance toward the cleaner, safer and brighter future. This idea promises to resolve issues such as the scarcity of radio-frequency bandwidth and root out the drawbacks of Wi-Fi. This would be an innovative solution which can be used all indoor places, like homes,taxis,airports and the congestion in radio waves can be reduced.

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