Li-Fi (Light-Fidelity): The 5G Technology in Wireless Communication

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Abstract – Light Fidelity or Li-Fi, is an exciting breakthrough in 5G visual light communication systems and the future of wireless Internet access. Li-Fi, i.e. Light Fidelity, is a technology enabling digital content to be broadcast using a light source. By switching a LED on and off several thousand times a second, data can be transmitted in computing language, in 01110… format. The frequencies are not visible to the naked human eye, too fast to have any physiological impact and allow all types of video and audio data to be transferred.

Index Terms – Wireless-Fidelity (Wi-Fi), Light-Fidelity (Li-Fi), Light Emitting Diode (LED), Line of Sight (Los), Visible Light Communication (VLC).

1. INTRODUCTION

Figure 1. Overview of Li-FI

Li-Fi is a term often used to describe high speed VLC in application scenarios where Wi-Fi might also be used. The term Li-Fi is similar to Wi-Fi with the exception that light rather than radio is used for transmission. Li-Fi might be considered as complementary to Wi-Fi. If a user device is placed within a Li-Fi hot spot (i.e. under a Li-Fi light bulb), it might be handed over from the Wi-Fi system to the Li-Fi system and there could be a boost in performance. Li-Fi (Light Fidelity) is a quick and easy optic version of Wi-Fi; it is Depends on Visible Light Communication (VLC). when we talk about VLC we tend to be referring to an illumination source (e.g. a light bulb) which in addition to illumination can send information using the same light signal. So in our terms:

VLC = Illumination + Communication

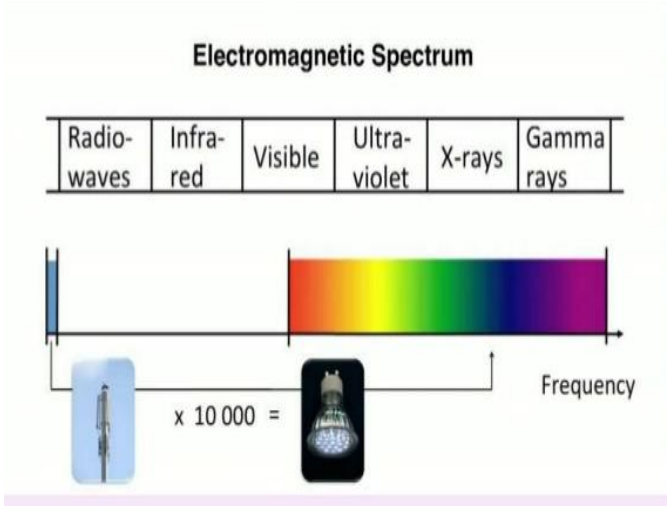

Figure 2. Visible Light Communication

The Li-Fi technology truly began during 1990's in the countries like Germany, Korea, and Japan where Prof. Harald Haas, University of Edinburgh discovered LED's could be retrofitted to send information. Harald Haas continues to wow the world with the potential to use light for communication. At the heart of this technology, a new generation of high-brightness light-emitting diodes. Very simply, if the LED is ON, user can transmit a digital string of 1, if it' s OFF then user can transmit a string of 0. It can be switched ON and OFF very quickly, which gives instant opportunity for transmitting data. It is possible to encode data in the light by varying the rate at which the LED's flicker ON and OFF to pass different strings of 1s and 0s. The modulation is so fast that the human eye doesn't notice. There are over 14 billion light bulbs used across the world, which needs to be replaced with LEDs ones that transmit data.

LED illumination can be used as a communication source by modulating the LED light with the data signal.

Communication system components are:

1. A high brightness white LED which acts as a communication source.
2. Silicon photo diode which shows good response to visible wavelength region.

The LED light appears to be continuous to the human eye due to the fast flickering rate. The high data rate can be achieved by using a high speed LED's and appropriate multiplexing technique. Each LED transmits at different data rate which can be increased by parallel data transmission using LED arrays.

2. PROPOSED SYSTEM

The goal of this project is to develop a small, portable yet an intelligent and reliable system for transferring the information wirelessly. It supports for Li-Fi technology. Li-Fi is the emerging area of technology is also known as Visible Light Communications (VLC). It is possible to encode data in the light by varying the rate at which the LEDs flicker on an off to give different strings of 1's Here it consists of two units:

1. Transmitter unit
2. Receiver unit

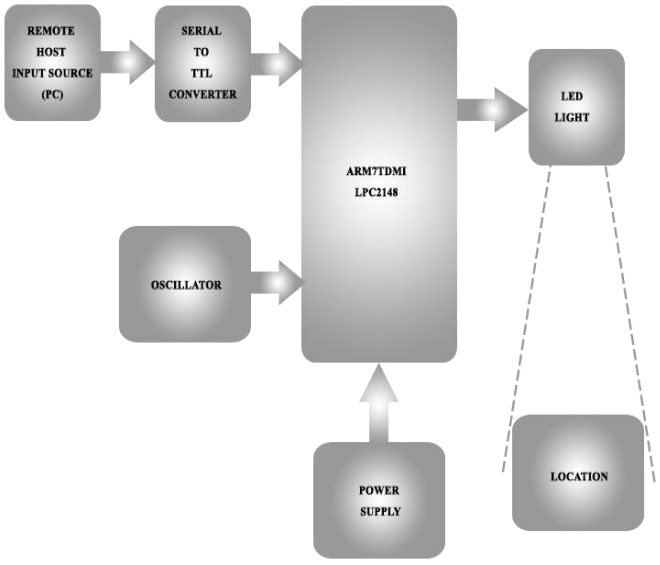

Figure 3. Transmitter of Li-Fi

The Hardware implementation divided into following sections:

- ARM7 LPC2148/38
- MAX 232 (DB 9 Pin Male Connector)
- Li-Fi Sensor(Photodiode)
- Oscillator

The hardware description as follows:

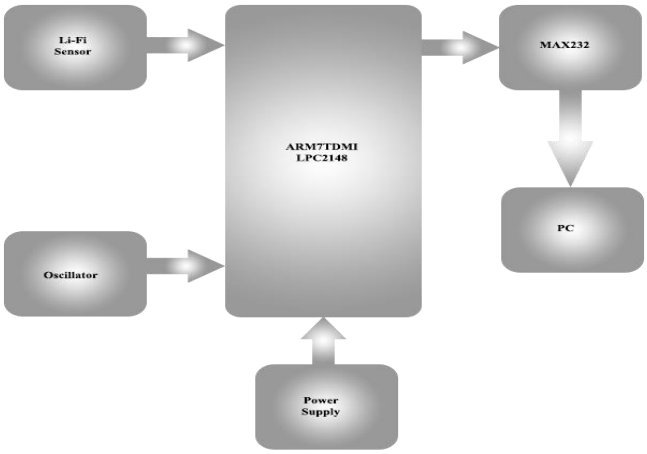

Figure 4. Receiver of Li-Fi

2.1 ARM7 LPC2148/38

LPC2148 is the widely used IC from ARM-7 family. It is manufactured by Philips and it is pre-loaded with many inbuilt peripherals making it more efficient and a reliable option for the beginners as well as high end application developer.

- 8 to 40 kB of on-chip static RAM and 32 to 512 kB of on-chip flash program memory.128 bit wide interface/accelerator enables high speed 60 MHz operation.
- In-System/In-Application Programming (ISP/IAP) via on-chip boot-loader software. Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1ms.

2.2 MAX 232

Usually all the digital ICs work on TTL or CMOS voltage levels which cannot be used to communicate over RS-232 protocol. So a voltage or level converter is needed which can convert TTL to RS232 and RS232 to TTL voltage levels. The most commonly used RS-232 level converter is MAX232. This IC includes charge pump which can generate RS232 voltage levels (-10V and +10V) from 5V power supply. It also includes two receiver and two transmitters and is capable of full-duplex UART/USART communication.

2.3 Li-Fi Sensor(Photodiode)

Silicon photodiodes are semiconductor devices responsive to high-energy particles and photons. Photodiodes operate by absorption of photons or charged particles and generate a flow of current in an external circuit, proportional to the Incident power. Photodiode can be used to detect the presence or absence of minute quantities of light and can be calibrated for extremely accurate measurements from intensities below 1 pW/cm2 to intensities above 100 mW/cm2. Silicon photodiodes are utilized in such diverse applications as spectroscopy, photography, analytical instrumentation, optical

position sensors, beam alignment, surface characterization, laser range finders, optical communications, and medical imaging instruments.

2.4 Oscillator

Oscillations, the heartbeat, are provided using a crystal and are necessary for the system to work.

The LED's are acting as a transmitter unit fitted to the wall/ceiling. This LED's are driven by microcontroller. In the transmitter the modulated information can be collected through LED matrix. The receiver units which consist of Li-Fi sensor demodulate the encoded binary data and generate original data. The receiver unit consist a photo transistor which receives the information from the LED matrix connected to the transmitter. The information is stored in the microcontroller and can be sent to PC using a simple protocol of serial communication and 0's. The modulation is so fast that the human eye doesn't notice. LEDs' ability to transfer information signals over light makes it a very good communication medium. Point-to-point links between handheld terminals rely on there being 'sufficient' alignment be-tween the two ends of the link. Using visible light allows the user to be involved in this, allowing smaller beam divergence, and therefore lower path loss. Communication be-tween two peripherals are described in, and it may be possible to create very high bandwidth links for secure media downloading using similar techniques.

Software Used are as follows:

- Embedded C
- Hex File Format
- Programmer/Burner

3. APLICATIONS OF LI-FI

3.1 Medical Field

For a long time, medical technology has lagged behind the rest of the wireless world. Operating rooms do not allow Wi-Fi over radiation concerns, and there is also that whole lack of dedicated spectrum. While Wi-Fi is in place in many hospitals, interference from cell phones and computers can block signals from monitoring equipment. Li-Fi solves both problems: lights are not only allowed in operating rooms, but tend to be the most glaring (pun intended) fixtures in the room.

3.2 Airlines

Airline Wi-Fi Nothing says captive audience like having to pay for the "service" of dial-up speed Wi-Fi on the plane. And don't get me started on the pricing. The best I've heard so far is that passengers will "soon" be offered a "high-speed like" connection on some airlines. United is planning on speeds as high as 9.8 Mbps per plane. Li-Fi could easily introduce that sort of speed to each seat's reading light.

3.3 Smarter Power Plants

Wi-Fi and many other radiation types are bad for sensitive areas. Like those surrounding power plants. But power plants need fast, inter-connected data systems to monitor things like demand, grid integrity and (in nuclear plants) core temperature. The savings from proper monitoring at a single power plant can add up to hundreds of thousands of dollars.

Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations. Not only would this save money related to currently implemented solutions, but the draw on a power plant's own reserves could be lessened if they haven't yet converted to LED lighting.

3.4 Undersea Awesomeness

Underwater ROVs, those favorites' toys of treasure seekers and James Cameron, operate from large cables that supply their power and allow them to receive signals from their pilots above. ROVs work great, except when the tether isn't long enough to explore an area, or when it gets stuck on something. If their wires were cut and replaced with light -say from a submerged, high-powered lamp-then they would be much freer to explore. They could also use their headlamps to communicate with each other, processing data autonomously and referring findings periodically back to the surface, all the while obtaining their next batch of orders.

3.5 Significantly Lower Power Consumption

Radio masts are very inefficient and require vast sums of power in order to broadcast and in some cases keep them cool enough to operate. LEDs on the other hand use very little power (much less than a fluorescent bulb), meaning Li-Fi also uses very little power. At the same time Li-Fi can also light a room, meaning it can do two jobs for the price of one.

3.6 Education systems

As with the advancement of science the latest technology is the LIFI which is the fastest speed internet access service. So this will leads to the replacement of WIFI at institutions and at companies so that all the people can make use of LIFI with same speed intended in a particular area.

3.7 Reduction in accident numbers

At traffic signals, we can use LIFI in order to communicate with LED lights of the cars by the number of accidents can be reduced. Data can be easily transferred by making use of Li-Fi lamps with the street lamps.

4. RESULTS AND CONCLISION

4.1 Expected Result

Using visible light communication we can transmit the data through light and receive the data at receiver side.

4.2. Conclusion

The possibilities are numerous and can be explored further. If his technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals. One of the shortcomings however is that it only work in direct line of sight.

REFERENCES

[1] Hadia Abd Elrahman Abdella Ali, Dr.Mohamed Abaker Hussein, "Li-Fi (Light Fidelity): The Future Technology in Wireless Communication," International Journal of Recent Trends in Engineering and Research, 2016, pp. 389–394.
[2] Suriya Begum, Siddharth Konar, Ashhar, "Light Fidelity (Li Fi): A Survey," International Journal of Engineering Sciences & Research Technology, July 2016, pp. 392–402.
[3] Jyoti Rani, Prerna Chauhan, Ritika Tripathi," Li-Fi (Light Fidelity)-The future technology In Wireless communication," International Journal of Applied Engineering Research, Vol.7 No.11 (2012).
[4] Dobroslav Tsonev, Stefan Videv and Harald Haas., "Light Fidelity (Li-Fi): Towards All-Optical Networking," IEEE Commun. Mag., vol. 46, pp. 50–55, Apr. 2008.
[5] Dhakane Vikas Nivrutti, Ravi Ramchandra Nimbalkar, "Light-Fidelity: A Reconnaissance of Future Technology," International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 11,November 2013, pp. 753-756.
[6] **Revathi Ganesan**, "Li-Fi Technology in Wireless Communication," International Journal & Magazine of Engineering, Technology, Management And Research.
[7] Ekta, Ranjeet Kaur, "Light Fidelity (LI-FI)-A Comprehensive Study," International Journal of Computer Science and Mobile Computing, Vol.3 Issue.4, April-2014, pg. 475-481
[8] Azhar, A., Tran, T., and O'Brien, D., "A Gigabit/s Indoor Wireless Transmission Using MIMO-OFDM Visible-Light Communications," IEEE Photonics Technology Letters 25, 171–174 (Jan.15 2013).
[9] Tsonev, D., Sinanovi´c, S., and Haas, H., "Novel Unipolar Orthogonal Frequency Division Multiplexing (U-OFDM) for Optical Wireless," in [Proc. of the Vehicular Technology Conference (VTC Spring)], IEEE, IEEE, Yokohama, Japan (May 6–9 2012).
[10] Khalid, A. M., Cossu, G., Corsini, R., Choudhury, P., and Ciaramella, E., "1-Gb/s Transmission Over a Phosphorescent White LED by Using Rate-Adaptive Discrete Multitone Modulation," IEEE Photonics Journal 4, 1465–1473 (Oct. 2012).
[11] Harald, B., Nikola, S., Dobroslav, T., Stefan, V., and Harald, H., "VLC: Beyond Point-to-Point Communication," IEEE Communications Magazine pre-print available at: http://www.eng.ed.ac.uk/drupal/hxh/publications/ (2014).
[12] Fakidis, J., Tsonev, D., and Haas, H., "A Comparison Between DCO-OFDMA and Synchronous One- dimensional OCDMA for OpticalWireless Communications," in [Proc. of the IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 2013)], IEEE, IEEE, London, UK (Sept. 8–11, 2013).
[13] Lee, S. C. J., Randel, S., Breyer, F., and Koonen, A. M. J., "PAM-DMT for Intensity-Modulated and Direct-Detection Optical Communication Systems," IEEE Photonics Technology Letters 21, 1749–1751 (Dec. 2009).
[14] T. Komine and M. Nakagawa, "Fundamental Analysis for Visible-Light Communication System using LED Lights", IEEE Trans. Consumer Electronics, vol. 50, no. 1, pg. 100-107, Feb. 2004.
[15] William Stallings, "Data and Computer Communications, Eighth Edition, Prentice Hall, 2007
[16] IEEE 802.15.7 Draft D8, "Standard for Short-Range Wireless Optical Communication using Visible Light", 2011.
[17] H. L. Minh et al., "100-Mb/s NRZ Visible Light Communications Using a Post equalized White LED", IEEE Trans. Photon. Technol. Lett., vol. 21, no. 15, pg. 1063-1065, Aug. 2009.
[18] J. Vuc_ic_ et al., "513 Mbit/s Visible Light Communications Link Based on DMT-Modulation of a White LED", IEEE/OSA Journal of Light wave Tech., vol. 28, no. 24, pp. 3512-3518, Dec. 2010.
[19] "Visible-light communication: Tripping the light fantastic: A fast and cheap optical version of Wi-Fi is coming", Economist, dated 28Jan 2012.
[20] Philips Creates Shopping Assistant with LEDs and Smart Phone, IEEE Spectrum, 18 February 2014, Martin LA Monica.

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