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LI- FI :A New Era for Very High Speed Data Transmission Through Leds

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Abstract: **The terrific increase in data traffic nowadays, the maximum speed is getting reduced because of the scarcity of Radio Frequency(RF) range available in Radio Spectrum. Although Frequency reuse is used for the effective usage of Radio Spectrum, the efficiency is very less. To overcome this drawback a new concept known as Light Fidelity(LI-FI) which was introduced by Professor Harald Haas, in University of Edinburgh, where he proved that very high speed transmission of data is possible through light using Light Emitting Diodes(LEDs), which varies in intensity faster than the human eye can detect. More sophisticated techniques could increase Visible Light Communication(VLC) data rates. We have proposed a concept where the portable LI-FI is possible to transmit and receive data at very high speed. The LI-FI is safer, cleaner and greener technology which is more efficient too for the future generations to create more value added services in this area.**

Keywords: LI-FI – Light fidelity, WI-FI- wireless fidelity, LOS- Line of sight, VLC- Visible light communication, OOK- OnOff keying, RF- Radio frequency, LED- Light emitting diode. PPM- pulse position modulation

I. INTRODUCTION

Data traffic and number of users are getting increased day by day, but we do not have more frequency range in

our RF spectrum. The global mobile data traffic are increasing rapidly [10] as shown in fig 1.

So, what will be the remedy to overcome this acute problem of RF spectrum shortage?? The answer is using of LEDs which will transmit the data at the speed of light and they are more energy efficient, safer than a normal incandescent light.

Fig 1: Global Mobile Data Traffic

These LEDs are designed in such a way that they turn ON and OFF within nanoseconds which an human eye cannot detect it. The 'OFF' represents digital output '0'and 'ÓN' represents digital output '1'as in fig2. This operation of 'ON' and 'ÓFF' are done by a process called On Off Keying(OOK)[1].

Fig2: LED which transmits data.

This concept of transmitting data containing 0s and 1s in the form of 'ÓFF and ON' of light using LEDS at a very high speed is known as LI-FI. This is shown in fig3 below. This is found by Professor Harald Haas, in University of Edinburgh. It is observed that the speed of LI-FI will be more than 10Gbps,which is capable of downloading a HD film in 30 seconds[2].

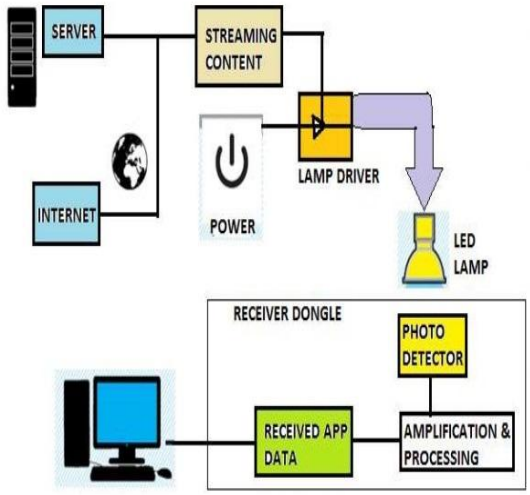

Fig3: Basic working model of LI-FI.

The visible light spectrum is ~10,000 times larger than the RF spectrum range as depicted in fig4.

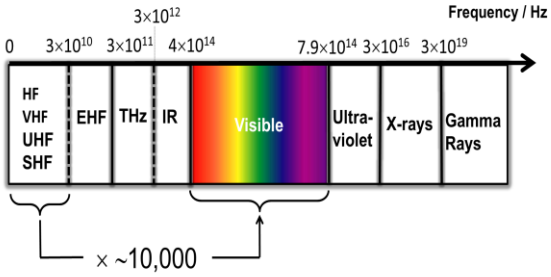

Fig4:Comparison between light spectrum and RF Spectrum

Since the light spectrum is very large than the RF spectrum we can transmit data faster and at a less cost.

II.EXISTING SYSTEM:

It is quite obvious to think that why we need LI-FI when we have our own existing system WI-FI. WI-FI is used as an hotspot having certain working range say about 100 meters per access point. Although Frequency Reuse is beneficial for increasing the range of coverage in RF spectrum there are many disadvantages in WI-FI such as,

1. One WI-FI access point can cover maximum area of 100 meter range only.
2. To increase range we have to deploy additional access points for every 100 meters and the access points are to be physically integrated with each other using RJ45 category cable which are costly.
3. For reuse of RF spectrum care is to be taken to select the adjacent channels in such a way that they do not interfere with each other.
4. One of the major disadvantage is decrease in speed when number of simultaneous accesses is effected (Shared access). To avoid this we have to opt for Dedicatedaccess but the cost is more.

In Shared access, the number of people use the broadband simultaneously and hence 'Throughput' decreases. In Dedicated access configuration will be done in such a way that every person gets the allocated maximum throughput irrespective of simultaneous access but the cost of Dedicated access is very high.

To sum up the disadvantages of WI-FI:

- Multiple RF chains are used which is expensive.
- Need of Inter Antenna Synchronisation (IAS).
- It creates Inter Channel Interference which causes many problems[5].
- Physical wiring involvement is more which is costlier.
- Throughput decreases in a particular area where WI-FI is used by number of persons because of Shared access concept.
- Security in WI-FI is very less since they can penetrate through walls which can be hacked easily.
- The efficiency is very low since 95% of the power is used for cooling the base stations, etc.

III.PROPOSED SYSTEM:

The above mentioned drawbacks are eradicated by the process known as LI-FI. VLC is blooming in recent days. In this system transferring of data is by "DATA THROUGH ILLUMINATION" [1], where the light coming out from specially designed LEDs will emit the light with respect of intensity which contains the data in it.

A. LED:

The main component in LI-FI that we use in transmission of data is through LEDS. The normal size of LED available in the market is of 1mm² which cannot be used for transmitting data, so special type of LEDs are used for data transmission purpose and they have size of 1μm², which is very small and blinks at very high rate than a normalLED. If there are going to be a grid of LEDsthen we can imagine how fast the data speed would be. Coloured LEDs such as red, green, blue are available and any such type of LED can be used for data transmission. Researchers in Heirrier Hertz Institution, Germany have proved data rates over 500 Mbps using standard white light [2].

B. Working Principle:

The LED plays an important role in LI-FI concept. The LI-FI is both Uni-Directional and Bi-Directional in nature and initially it was considered that it will work in LOS only but this has been disproved by professor Harald Haas in May 2014, in University of Edinburgh, and hence it can work in Non LOS [13] pattern also.

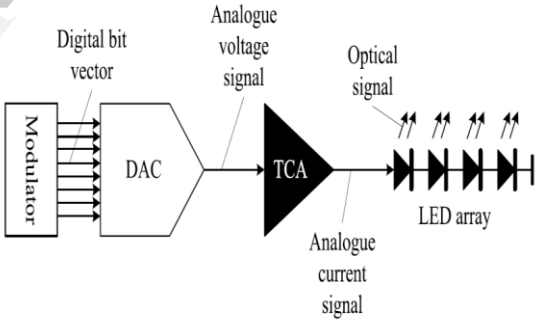

Fig 5: Block Diagram of LI-FI

The components which are used to transmit data through light are [11]:

- Modulator
- DAC
- TCA
- LED

a) MODULATOR:

LI-FI communication is modelled after communication protocols established by IEEE802 work group. This standard defines the physical layer (PHY) and media access control (MAC) layer. This standard is able to deliver enough data rates to transmit audio, video and multimedia services. The standard defines three PHY layer with different rates.

- The PHY-I was established for outdoor application and works from 11.67 Kbps to 267.6Kbps.[5]
- The PHY-II layer allows reaching data rates from 1.25Mbps to 96Mbps[5].
- The PHY-III is used for many emission sources with a particular modulation method called Color Shift Keying (CSK). PHY-II can deliver rates from 12Mbps to 96Mbps.[5]

The modulation formats for PHY-I and PHY-II are the coding OOK and Variable Pulse Position Modulation (VPPM). The Manchester coding used for the PHY-I and PHY-II layers include the clock inside the transmitted data by representing a logic 0 with a OOK symbol "01"and a logic 1 with a OOK symbol "10", all with a continue component. This is an important component because the continue component allows avoiding the light extinction in case of an extended line of logic 0.

b) DAC:

The output of the modulator is digital bit vector which passes through Digital to Analog Converter (DAC) to convert the digital data into analog voltage signals.

c) TCA:

The analog voltage signal will pass thorough TCA(Transconductance Current Amplifier) and will be converted into analog current signal.

The TCA consist of a Metal Oxide Semiconductor Field Effect Transistor(MOSFET) and a resistor. The MOSFET is common source type where the source is the input to the resistor and the drain is the output and the gate acts as a control signal point. The MOSFET act as a switch to sense signals, the resistor is used for controlling the current .

The transconductance of theMOSFET is given by

$gm = \partial ID / \partial Vgs$

To increase the intensity of light passing through it, the grid biased voltage VG must be low and so ID will increase. So the intensity can be varied by varying VG. The efficiency of TCA can be determined by the ratio of output toinput. By the above mentioned process we get the transmission of data at very fast rate. As the analog current varies, the intensity of LED also varies so the distance of the travelling of light varies.

IV.TRANSCEVER BUILDING BLOCKS:

In the transmitter a digital input is first converted into analog signal using ADC where these signal are transmitted using the non-linear LEDs and the air acts as a channel and at the receiving end this analog signals are then converted into corresponding digital signals using a DAC and we will get the perfect output [12] as shown in fig 6.

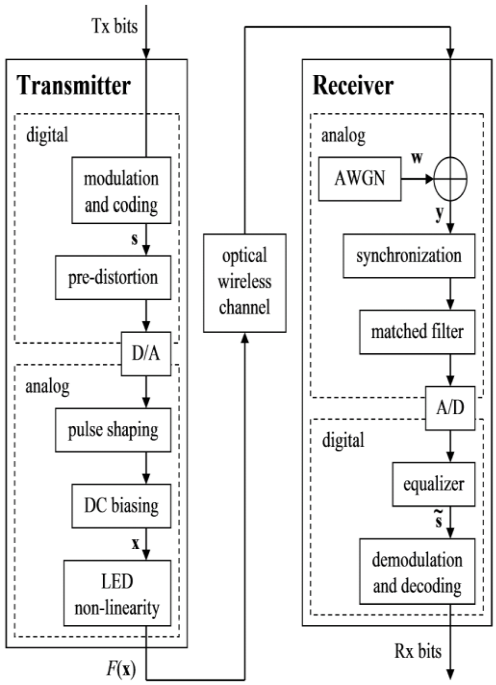

Fig 6: Transceiver Blocks

1. *Transmitter:*

a)MODULATION AND CODING:

In transmitter the bits to be transmitted are in digital format where they are modulated by Amplitude Shift Keying (ASK) and Pulse Position Modulation(PPM) method. The keying that is used is OOK. The Manchester coding is used for effective transmission of data.

For optical Multiple Input Multiple Output (MIMO) Systems, Spatial Modulation (SM)[3,6] and Space Shift Keying (SSK) [4,7]are used to modulate. In SM the interference are reduced, this is more efficient than the frequency reuse concept since the cost of various RF antennas which placed in many places are very high in cost. In SM we transmit two signals at a same instant one representing the spatial symbol and another signal is Quadrature Phase Shift Keying (QPSK) signals. The signal transmitted in SM process are only for analog signals and the SSK does the same job as the SM does but this uses the digital signals for transmissions.

b) PRE-DISTORTION:

The output from the modulator and the coding is then passed through the pre-distortion channel which is used for nonlinearity compensation and regulates the input so that the signal will not get distorted.

c) DAC:

Now the signal is sent into the DAC where the digital signal is converted into analog equivalent so that it can be transmitted through light a special type of DAC are used.[9]

d) PULSESHAPING:

The signals from DAC are then reshaped properly using pulse shaped filters which are used to reshape the actual analog signal.

e) DC BIASING:

A DC voltage is supplied to this signal. By varying the DC supply as mentioned above it is possible to vary the intensity of light. So DC supply perform an important role in data transmission. The principle involved in this is called IM (Intensity Modulation).

f) LED NONLINEARITY:

Then we use the LEDs which are nonlinear in nature where the light emitted by LEDs get reflected from any place in a room.The output from this LEDs are given by F(x).

2. Optical Wireless channel

The optical wireless channel is the medium though which the data are transmitted from transmitter to receiver and the medium that is used here is AIR.Mathematically they are given as h(t).

3. Receiver:

a) AWGN:

In the receiving end the light from nonlinear LEDs which are convoluted with the channel are mixed with AWGN (Additive White Gaussian Noise). The basic flow diagram is shown below

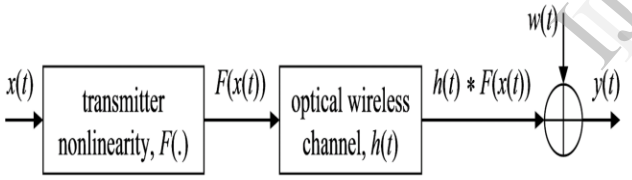

Fig7: Working principle of AWGN

The light coming out of LEDS from the transmission end is given by F(x) and convoluted with the optical wireless channel h(t) and this contains many noise to cancel it out in the receiver end we use AWGN.

'Additive' since it is added to any noise which are intrinsic to information system. 'White' shows uniformpower across the frequency band for information system. 'Gaussian' because it has normal distribution in time domain with an average time domain value of zero.

b) SYNCHORONISATION:

It is used for the purpose of making the received data signal with respect to transmitted signal in time domain. This is the key process in this whole circuit since any non synchronisation occurs the perfect data will not be recived.

c) MATCHED FILTER:

Multitone Lasers emit their light in short pulses. Sensitive detection of these emissions for communication can be accomplished by using appropriate filtering at the optical frequencies for detection and RF amplification. We use Matched Filtering for these signals.

d) ADC:

The analog signals in the receiving end now are converted into digital signals for the machine to understand.

e) EQUALIZER:

Normally in channel portion high frequency range will get high attenuation and low frequency will get low attenuation. This will create unbalance in the receiver output hence to avoid this problem we use equaliser which gives low attenuation for high frequency and high attenuation for low frequency. Thus at the output of the equaliser constant output level for entire frequency range is achieved.

f) DEMODULATION AND DECODING:

The output of the equalizer which is in analog frequency format is to be treated to get back the original Digital bits which are transmitted by the transmitter. This process of retrieving the original digital bits is done by Demodulator. Proper decoding is done by the decoder since Manchester coding was done at the transmitting end. After these two processes we will get the original digital bit signals.

V. FEATURES AND BENEFITS:

- The main problem of existing system is that the throughput decreases as the number of persons increases in a particular connectivity whereas in proposed LI-FI system the throughput remains same for all the connectivity irrespective of number of simultaneous access at a lesser cost.
- LI-FI will work both in LOS as well as Non LOS.[13]
- The frequency spectrum of light is 10,000 times greater than RF spectrum.
- The inter data traffic is reduced very much when we use light to transmit data.
- No spectrum license is required.
- No RF interference for light.
- This type of light which transmit data will not interfere with continuous light (eg. Sunlight, incandescent light).

VI. PERFORMANCE ANALYSIS:

1. TABLE NO 1

Characteristics	WI-FI	LI-FI
Frequency	2.4Ghz to 5Ghz	400 Thz to 800 Thz.
Range	100 meters	Based on LED light intensity
Data transfer rate	11Mbps	>1Gbps
Power consumption	Medium	Low
Security	Minimum secured	Highly secured
Usage Location	Within range of W-LAN infrastructure, usually inside a building	Where ever light is available public places, home, office, road, etc..

VII. FUTURE ENHANCEMENT OF THE PROPOSED SYSTEM:

1) We have proposed a Portable LI-FI which can be brought to existence using the above said principles, with this we can transmit and receive data at very high speed rate. This can be used in a smart phone which has a photo detector in it. Consider a series of LEDs in the smart mobile nearer to the light detector and as how a WI-FI option is provided in the mobile, if an option known as LI-FI is present, if we turn it ON theLEDs which are placed nearer to the light detectorwhich is working as a normal LED on the phone will start acting as a portable LI-FI where these LEDs will do the operations as mentioned above and the photo detector which is in the mobile will sense it and data will be transmitted in which ever place we are.

2)In mining areas where RF signals cannot be used for communication purpose, the light can be used. A special type of LI-FI can be designed which will be very much useful for the people outside the mining area to communicate with people inside the mining area.

VIII. APPLICATIONS OF LI-FI:

1. LIVE LONGER:

One of the drawbacks in RF spectrum is that, it is not allowed in some operational rooms where similar RF spectrumare used as it can interfere with the monitoring equipment's, where as light will not interfere with those equipment's [2].

2. AWESOMENESS UNDER THE WATER:

The RF cannot penetrate inthe water,whereas light can penetrate in the water. We can use light which is used by the Scuba divers, under water machines to send and receive the information who are above the sea level. Even the submarine can transmit and receive the information from the ships that are above it.

3. FLY HAPPILY:

In airlines, which are EMI sensitive environment we all know that equipment's which use RF spectra cannot be used. We can use LI-FI communication which uses light which will not interfere with airlines RF spectrum. Privacy is ensured since secrecy between channels are strictly ensured with light transmission[2].

4. HOME SWEET HOME:

In home when more persons are using WI-FI at thesame time, throughput per person decreases. By using LI-FI, the throughput can be maintained constant as a resultthe speed will be very high for individual persons.

IX. CONCLUSION:

LI-FIwill resolve many issues which are not possible to be provided by RF spectrum such as:

1. Compensating the shortage of RF spectrum.
2. Providing huge bandwidth.
3. Allowing browsing of internet by large number of persons at a very high speed and data rates giving equal amount of throughput to all persons.

If this LI-FI technology is put into commercial usage, every LED bulb can be used as a LI-FI hotspot to transmit data on wireless mode which will pave way for a Cleaner, Greener, Safer and Bright future for fast data communication.

VLC, which aims to connect the two - communications and light. They have an approach that could be an alternative to radiofrequency spectrum,as there are worries about "running out of gas" because demand grows forspace. "We talk aboutthe Internet of Things where every device is interconnected, but without more bandwidth it will be impossible to provide all reliable communication to all of these 'things'.

To effectively achieve the above, LI-FI will be the only best answer in the future upcoming days.

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