# FINAL YEAR PROJECT REPORT

## (VISIBLE LIGHT COMMUNICATION)

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# VISIBLE LIGHT COMMUNICATION

Project Report submitted to the

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# ABSTRACT

In the recent times wireless communication has taken over most of the communication medium due to which problems regarding bandwidth restraints have started to raise so there is a need to find alternative sources for wireless communication.

Solid state light sources are a perfect candidate for further research on communication basis as it has a very vast untapped bandwidth that we can utilize without any complications or hindrances as all this bandwidth is unrestricted and unlicensed and we can achieve very high speeds using this technology.

# DEDICATION

Dedicated to our kind teachers

**Rauf ali**, **Ali Murtaza** & **Our Parents**

Who enlightened our minds with Knowledge, tried

to include the spirit of hard work and dedication in us

so that we could have a BRIGHT FUTURE in terms

of being good human and turn out to be competent

Engineers with powers to take challenging

ENGINEERING PROBLEMS.

# ACKNOWLEDGEMENTS

Engineering is not only hard work and perseverance; it also involves imagination, motivation and dedication. It is keenness to learn and desire to excel; it is planning and managing; and above all it is activity with insight.

Planning is vital for any project. During our project several problems and glitches of technical nature emerged but by the grace of ALLAH ALMIGHTY, they were overcome and this project was completed in time. In this regard, guidance and suggestions of our Project Advisor **Rauf Ali** proved to be a beacon of light throughout the derivation in which we remained engaged in this project.

We would like to express our appreciation to **All those people** who guided us throughout the project. We also greatly appreciate the efforts of all Lab Assistants in SST.

Finally, we are also grateful to our dear Parents for their love, support and prayers without which we could not have achieved anything.

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# CHAPTER 1: INTRODUCTION TO VISIBLE LIGHT COMMUNICATION

## 1.1 WHAT IS VISIBLE LIGHT COMMUNICATION?

Visible light communication (VLC) is a wireless data communications medium using solid state light sources which in our case is the LED and while the data is being communicated the solid state light sources can be used for illumination purposes.

VLC systems are presently being developed by scientists seeking to create ultra high-speed, high security, biologically friendly communications networks that allow the creation and expansion of seamless computing applications using very large bandwidth high-frequency pulsed light instead of radio waves and microwaves.

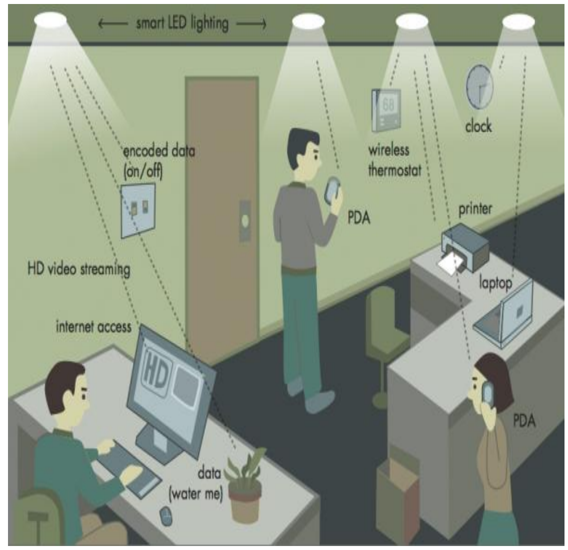



Figure 1: VLC environment

Such systems use modulated light wavelengths emitted (and received) by a variety of suitably adapted standard sources, such as indoor and outdoor lighting, displays, illuminated signs, televisions, computer screens, digital cameras and digital cameras on mobile phones for communication purposes, primarily through the use of Light Emitting Diodes (LEDs).

## 1.2 BRIEF HISTORY:

Here is a timeline development in the field of VLC

**1880:** The first VLC transmission (which was also the first wireless transmission in the world) was sent in Washington D.C. on 3 June 1880 by Scottish born engineer, inventor, scientist and innovator Dr. Alexander Graham Bell and his then assistant, American inventor Charles Sumner Tainter. They used a system they had developed and patented called the Photo phone. Bell stated that it was his greatest achievement, surpassing even his invention of the telephone in terms of importance

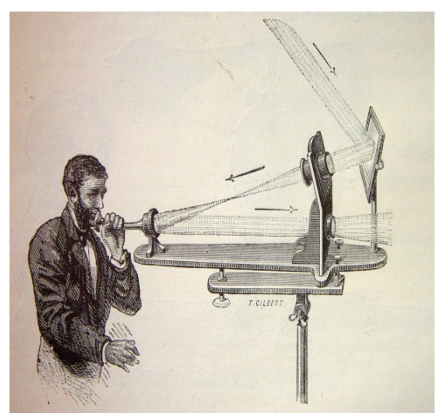


Figure 2: The Photo phone

**1931:** Dr. Sergius P. Grace, of the US Bell Telephone Laboratories, discusses the potential for using light for wireless communications to prevent the danger of eavesdropping by others.

**2001**: The Reasonable Optical Near Joint Access (RONJA) Free Space Optics device from the Czech Republic became the first device to transmit 10 Mbps wirelessly using beams of light. The range of the basic configuration, which can be extended, is 0.87 miles (1.4 kilometers).

**2002:** Dr. Stefan Spaarmann develops a VLC system but cannot find a company to fund the building of a prototype.

**2003:** The Visible Light Communications Consortium (VLCC) is established between major Japanese companies to develop, plan, research and standardize Japan's own visible light communication systems. Its brief is to develop, test, investigate, plan and standardize ubiquitous high-speed biologically-friendly VLC LED systems.

**2004**: The Visible-Light Communications Consortium demonstrated at CEATEC Japan 2004 how LED-light systems can be used for high-speed transmission of data to handheld and vehicle-borne computing devices.

**2005:** Japan's Ministry of Land trials VLC communications technology to transmit information to mobile phones in the Departure Lounge of Kansai Airport. Throughput estimated at 10 Kbps from fluorescent light units and several Mbps from a light emitting diode (LED) unit.

**2007:** VLC developed by NEC was showcased by Fuji Television at the International Broadcast Equipment Exhibition (Inter BEE) 2007 in Japan. In that demonstration a LED-backlit LCD television operated whilst transmitting information to a PDA via light. The device also enabled the information to be sent securely to chosen individuals.

**2007:** The standardization work undertaken by VLCC leads to the creation of the Japan Electronics and Information Technology Industries Association's JEITA standards (2007) for a "visible light ID system". VLCC is also involved in preparing and publicizing proposals for safe visible light communication technology standards for a variety of applications and fields of industry.

**2008:** EU-funded OMEGA project seeks to develop global standards for home networks, including the use of optical wireless using infrared and VLC technology.

**2008:** A joint-cooperative agreement covering complimentary research and development to advance the communications technology industry is announced between VLCC and the international Infrared Data Association (IrDA) that is responsible for developing and establishing global specification standards for low-cost infrared technology for wireless connectivity.

That agreement allows both organizations to undertake vital complimentary research, combining widely-used mobile phone IrDA technology and new visible light communication technology, to further refine and develop existing and proposed commercial applications of the optoelectronic spectrum, using infrared and visible light frequencies, for items such as cameras, cars, indicator lights, indoor lighting, mobile phones, printers, toll booths, traffic signals and monitor displays. It is expected that such work will create a new standard of user-friendly, and potentially more biologically-friendly, technological communications.

**2009:** A result of the joint cooperative agreement between VLCC and the IrDA, VLCC issue their first Specification Standard which incorporates and expands upon core IrDA specification and defined spectrum to allow for the use of visible light wavelengths. By modifying the IrDA specification, existing IrDA optical modules can - *with only minor alteration* - be utilized for VLCC data-transmission. As a result, this specification change will lead to reduced development costs when the IrDA specification is used widely in portable technology.

**2009:** Research continuing in Japan to increase viable communication distances for VLC to hundreds of meters. Such work will allow the transmission of information by light from billboards, and from new generations of traffic lights to automobiles and trains.

**2009:** German scientist, Dr. Stefan Spaarmann, states that the problem of light smog can be avoided through the inclusion of the transmission signals within the optical surrounding signals (as with natural sight). He stresses the importance of mimicking nature.

**2010:** The data transmission speeds of VLC systems are shown to be rapidly improving, with a frequency-modulated white LED being shown by Siemens researchers and the Heinrich Hertz Institute in Berlin to be capable of transmitting information over 5 meters at a rate of 500 Mbps, significantly faster than present Wi-Fi technologies (that can operate at rates of up to 150 Mbps). The same researchers were also able to demonstrate that a system using up to 5 LEDs could transfer data over greater distances at 100 Mbps with direct line of sight. Reduced levels of transmission would have occurred using diffused light from walls outside of line of sight.

VLC data transfer is generally far more secure than conventional wireless local area network (WLAN) links, as it is indicated that only photoreceptors directly within the transmitted cone of light can receive information, thereby making it apparently 'impervious to interception'.

**2010:** Demonstration undertaken successfully in Japan showing the combination of VLC with indoor Global Positioning System (GPS).

**2010:** The Center for Ubiquitous Communication by Light (UC-Light) at the University of California seeks to develop VLC technology further to allow communication between a wide variety of electronic products, such as high definition televisions, information kiosks, personal computers (PCs), personal digital assistants (PDAs) and Smartphone.

## 1.3 WHY USE VLC:

First of all VLC provides us with ample bandwidth which is right now quite restricted in the other mediums due to excess usage.Secondly it can give us very high data rates of upto 500 Mbit/s. one of the prime reason to use VLC as a communication medium is that all the basic infrastructure already exists as we use light in almost everywhere which means low initial cost.

These are but some of the many reason why VLC is now qualifying as a wireless medium and billions of dollars are being poured in for further research in this field

## 1.4 COMPAIRING VLC WITH SOME OTHER SOURCES:

As we all know vlc is a very recent addition to the wireless medium so it is only fit to compare it with some of the existing and well used mediums to know its worth.

### 1.4.1 COMPARISON OF VLC WITH RF:

At present the multiple uses in buildings of the three independent WLAN frequency bands can often compromise information networks. This is a problem that the adoption of VLC technologies could help resolve by providing alternative bandwidths.

Additionally, whilst the use of radiofrequency/microwave communications devices is becoming increasingly widespread, research indicates that some emissions and intensities may also interfere with sensitive electronic equipment (*such as used in hospitals, some factories and on aircraft*), cause health problems and/or biological damage.

With sufficient development, it may prove possible for VLC to avoid such problems, and become a biologically friendly environmental asset. As it appears likely that VLC will not interfere with sensitive electrical equipment it could, in principle, be used in locations where current communications technology is often prohibited and where strong data security is required. An additional incentive at present is that, whilst free usage of radio wave and microwave wireless communications is restricted by law, VLC technologies do not, as yet, require licenses.

### 1.4.2 COMPARISON OF VLC WITH IR:

Infrared devices are often used for data-transmission in devices such as notebook computers, television remote controls and even some newer mobile phones. To date the Infrared Data Association (IrDA) has standardized over 30 specifications that are widely implemented for cordless phones, printers, televisions and other devices. Its 2008 market-report indicated a prolific increase of IrDA infrared enabled devices, of which over 1 billion units have been shipped to date, and that demand for such units was likely to increase greatly, particularly with the development of IrSimple version 1.0 and technological advances used for Giga-IR.

Whilst visible light from LED systems and infrared emissions share similar frequency ranges, it is acknowledged that there are potential visual safety problems with using infrared for high rates of data transmission due to both the large energy emissions it would create and its invisibility, making suitably developed LED light data transmission a safer option for human eyes.

## 1.5 MARITS AND DEMARITS:

### 1.5.1 MARITS OF VLC:

These are some of the few reasons why we should further research visible light as means of transfer medium

***Human Safety:*** VLC poses no health hazards to human body. Thus, the transmission power can be kept high if needed.

***High Data Rates***: VLC inherits high data rates from optical communications. Thus, it can be used for very high speed wireless communications.

***Bandwidth:*** Visible light communications exploits the visible region of electromagnetic spectrum. Thus it offers much larger frequency band ( 300 THz) compared to that available in RF communications ( 300GHz).

***Ubiquitous Nature:*** We have a well-established lighting infrastructure throughout the world. In addition to it, LED based lighting devices are getting widespread acceptance round the globe. Since VLC uses the already available visible light sources for wireless communications, so it is expected to become a ubiquitous technology in near future.

***Security:*** As VLC involves line of sight communication, so it is impossible to tap the communication without breaking the link. So it offers a very secure communication and can be used in high security military areas where RF communication is prone to eavesdropping.

***Visibility:*** It is aesthetically pleasing to see data being communicated by colored lights. Thus, VLC is also used in many entertainment related activities like silent concerts, decoration systems, etc.

***Unlicensed Spectrum:*** As VLC uses the visible region of electromagnetic spectrum, so it is free of cost. Contrary to it, the RF communication band is regulated.

### 1.5.2 DEMARITS OF VLC:

***Line of sight communication:*** The greatest disadvantage of VLC is that it must be a line of sight communication due o which when that line of sight is removed the medium will be broken and the transmission stopped

***Short range:*** This technology is basically designed for short range communication to increase the range more high power light sources and even more powerful receivers have to be used thus exponentially increasing the cost

***Prone to interference:*** VLC is more prone to interference from other illumination devices

## 1.6 APPLICATIONS:

This form of data transfer is called VLC (Visible Light Communication) and has a variety of potential applications. In homes and businesses for example, it could be a valuable addition to established WLAN technology. Wireless networks are increasingly being compromised by the fact that in many buildings the three separate WLAN frequency bands coexist, which leads to collisions among data packets. In a situation like this, visible light offers a perfect alternative.

A network using VLC also prevents wireless "squatting", where a person logs into a secure (if they break the password) or unsecure network and steals bandwidth. In a VLC network, only the photo detectors that are positioned directly within the light cone are able to receive data. Further use of VLC technology would be in factory and medical environments, where in certain areas radio transmissions are impossible or very limited. This is fascinating stuff, and the opportunities are nearly endless. Some other applications include

### 1.6.1 UNDERWATER COMMUNICATIONS

RF does not work underwater but visible light can support high speed data transmission over short distances in this environment. This could enable divers and underwater vehicles to talk to each other.

### 1.6.2 AVIATION

Radio is undesirable in passenger compartments of aircraft. LEDs are already used for illumination and can also be used instead of wires to provide media services to passengers. This reduces the aircraft construction costs and its weight.

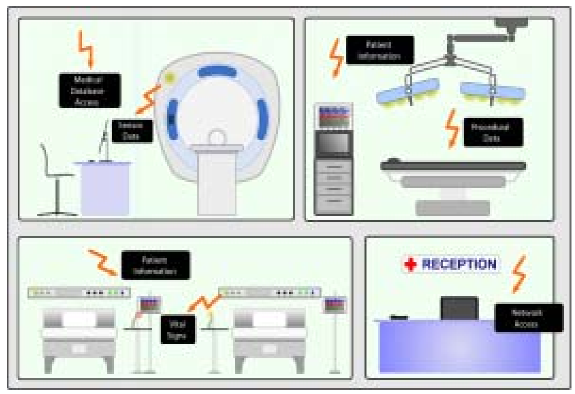


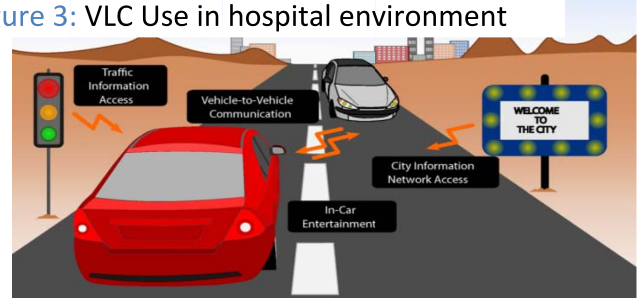

Figure 3: VLC Use in hospital environment

### 1.6.3 HOSPITALS & HEALTHCARE

There are advantages for using VLC in hospitals and in healthcare. Mobile phones and Wi-Fi’s are undesirable in certain parts of hospitals, especially around MRI scanners and in operating theatres.

### 1.6.4 MOBILE CONNECTIVITY

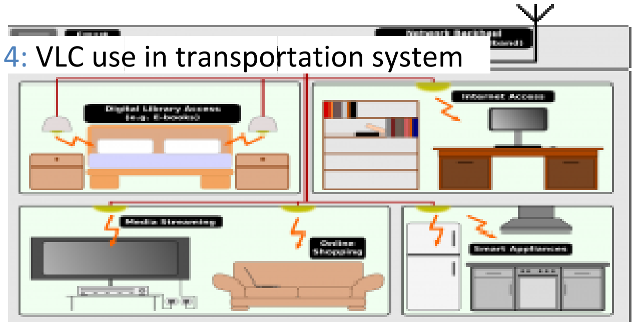
By pointing a visible light at another device you can create a very high speed data link with inherent security. This overcomes the problems of having to pair or connect and provides a much higher data rate than Bluetooth or Wi-Fi.




### 1.6.5 VEHICLE & TRANSPORTATION

Many cars already use LED lamps. Traffic signage, traffic lights, and street lamps are adopting the LED technology too, so there are massive applications opportunities here.

Figure 4: VLC use in transportation system




### 1.6.6 SMART LIGHTING

Smart buildings require smart lighting. Smart lighting with VLC provides the infrastructure for illumination, control and communications and will greatly reduce wiring and energy consumption within a building.

Figure 5: Smart lighting system

### 1.6.7 Wi-Fi SPECTRUM RELIEF

Wi-Fi's have got faster over but cannot keep up with demand for wireless data. VLC can provide data rates greatly in excess of current Wi-Fi and this can be done at low cost since the RF components and antenna system have been eliminated.