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Eco Friendly Video Transmission through Visible Light Communication Using Lighting Control Network

[1]V.Malathy, [2]S.M.Kamali, [3]M.Anand

[1]Assistant Professor, Department of Electronics and Communication Engineering,
S R Engineering College, Warangal
malathyvanniappan@gmail.com

[2]Professor, Department of Electrical and Electronics Engineering,
Mahendra College of Engineering, Salem
kamalinalladurai@gmail.com

[3]Professor, Department of Electronics and Communication Engineering,
Dr M.G.R Educational and Research Institute, Chennai
worldcommunication25@gmail.com

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Abstract
The communication by radio frequency signals has a drawback of less bandwidth and narrow spectrum. This leads to the introduction of Li-Fi. There is a rapid development in the solid state light emitting diode (LED) materials which gave a way for the next generation data communication known as visible light communication (VLC). VLC has a promising future and it acts as a complement to the present RF communication by achieving larger bandwidth and high data rate. At present, the day to day activities is done with lot of LED based lights, which can also be used for communication like fast switching, high power efficiency and safe to human vision. Hence, this project presents about eco-friendly data communication through visible light which consists of the white LEDs that transmit video signals to the receiver. The receiver circuit consists of solar panel connected with the amplifier and speakers to recover back the amplified version of original input signal. Here, we can transmit the video files from transmitter to the receiver using the LED where the video signal is digitized and transmitted. The transmitted signal is received by the photo-detector placed in the receiver.

Keywords: *Light Emitting Diode, Photo Detector and Visible Light Communication.*

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1. Introduction

The radio spectrum is limited. The demand for wireless data transmission keeps increasing. There is a pressing need for new kinds of wireless communication systems. Recently, Visible light communication (VLC) has been proposed as an alternative means of wireless communication. The idea is to modulate LEDs transmitting electromagnetic waves in the visible light frequencies to communicate between devices within the same room. A Li-Fi is a new wireless technology to provide the connectivity within networkenvironment. It provides transmission of data through illumination bysending data through an LED light bulb that varies in intensity faster than the human eye can follow. It is the same idea behind infrared remote controls but the far more powerful device. It can produce data rates faster than 10 megabits per second, whichcan be faster than the average broadband connection. The LED is used in differentareas of everyday life. It can use the lighting capability to transmit the data fromone to another. The massive use of Li-Fi may solve some bottleneck of datatransmission in Wi-Fi technology.

In earlier, the system used RF based communication, so the interference and noise of the signal is high. Power consumption of existing system is high. Installation cost and environmental hazards are high. Further the system gave rise to data like text and audio to be transmitted through visible light from transmitter to receiver through light emitting diodes.

Indoor access to the Internet via VLC technology is becoming an issue and in this sense system planning requires to look at the number of LEDs to be used. This task can be accomplished by looking at different performance metrics. We consider the problem of optimal footprint mapping by taking into account the achievable user rate when handover procedures take place due to user mobility. This problem is equivalent to the optimal LEDs placement. In this regard, it is shown that several parameters influence system performance starting from the data rate of download, the speed of the user in the room as well the handover time. In this context we derive a mathematical tool for VLC network planning and show the performance that can be achieved as a function of different parameters.

The channel capacity and region for both the single-input-single-output (SISO) channel and broadcast channel (BC) in VLCsystems, under the peak optical power, average optical power and electrical power constraints. Under the condition that the input signal is continuous, we develop a closed-form lower bound (termed ABG lower bound) and an upper bound for SISO channel using the entropy power inequality and Lagrangian function method. Moreover, a closed-form achievable rate region (termed ABG region) is derived for the VLC BC. Furthermore, for a multi-LED and multi-user VLC system, we propose an achievable rate expression for each user, and then investigate a VLC BC beamforming design problem by utilizing the obtained closed-form expression. The beamforming design problem is shown to be NP-hard, and we transform this problem into a convex semidefinite program (SDP) by using the semidefinite relaxation (SDR) technique. Finally, numerical results are presented to evaluate the performance of the proposed ABG lower bound/region and the beamforming design.

The main focus of this work is the integration of the communication and power management functions of 80W smart LED module. The luminaire provides high-efficiency programmable ambient lighting and can also act as a networked sensor node to gather a variety of local measurements, which leads to improved safety, comfort and efficiency in future lighting systems. A dimmable LED driver based on the LLC resonant dc-dc converter topology is proposed to implement an emerging communication scheme, VLC. VLC capitalizes on the high switching-speed of LEDs and offers several compelling advantages over conventional RF and wired communication schemes. The digitally controlled LLC converter operates in constant-current burst mode, where the burst is sequenced to independently control the dimming and transmission of data using the Variable Pulse Position Modulation (VPPM) protocol. A receiver circuit is designed to demodulate and decode the visible light signal. The 50 kb/s system is successfully demonstrated on a 308 LED Luminaire with a digitally controlled LLC dc-dc converter.

2. The Proposed Method

The Proposed system is capable of transmitting high quality video signals wirelessly through visible light using PIC 16F877A micro controller with various special features to easily interface hardware and software. The transmitter can transmit video signals at a distance of 10 meters with an acceptable clarity at the receiver side.Distance between transmitter and receiver is increased compared to the existing system.The system can be deployed by having a single transmitter with multiple receivers.The system is capable of producing consistent output on a real time basis.

This system can be used to any kind of environment especially on hospitals and aircrafts where wireless devices are sometimes prohibited. The system transmission can penetrate transparent blockings on the path of light with a small effect on the received signal. Also the data rate is greater than 10Gbps. As Light Waves cannot penetrate through walls,the data cannot be intercepted. This provides secured communication. Speed of data communication can also be increased.

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Transmitter Block Diagram

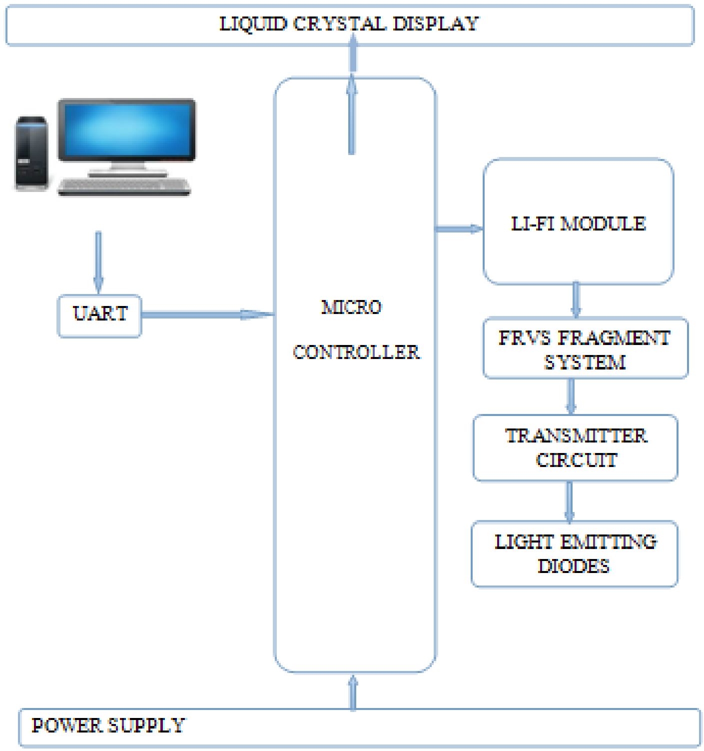

Figure 1: Transmitter

Figure 1: Transmitter

Receiver Block Diagram

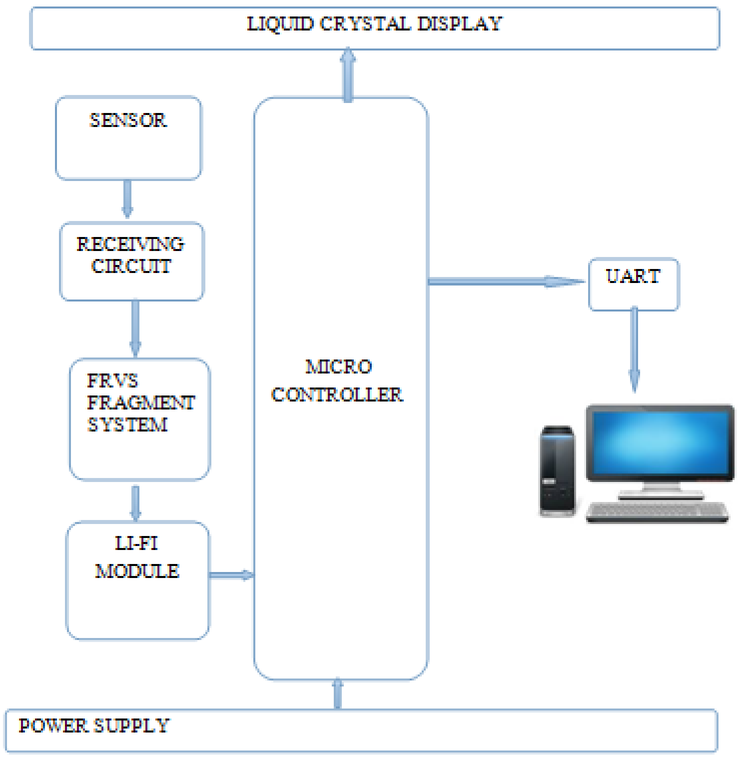

Figure 2:Receiver

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Power supply is given to step down transformer which converts 230volt to 12 volt. Figure 1 shows the Transmitter section. Then the bridge rectifier which consists of 4 diodes is used to convert ac to dc voltage. Regulator IC 7805 separates 12 volt and 5 volt. As per the PCB design 5 volt from IC7805 is given to the controller. Three jumpers of 5volt are used to interface with the sensor if required. 12 volt supply is given to LED. UART is used for serial communication. UART consists of 2 pins, TX and RX that is connected to the 36th and 37th pin of the controller. UART also consists of MAX232 IC. Crystal oscillator is used to process the controller. Potentiometer is used to vary the contrast of LCD. Video from UART is given to the controller and from controller; one of the port C pin is connected to FRVS fragment system. FRVS manages the delay, error, quality of the video. Encoder encodes the data from FRVS and gives as input to LED. Inside the encoder, occurs pulse width modulation and provides digital output. Because of the pulse triggering, LED flickers. Figure 2 shows the receiver section. At the receiver side, the photo receptor obtains the light from LED and gives to FRVS system. Then decodes it and passes to the controller as input. Thus the output is displayed on PC via RS232 cable.

3. Experiments and Discussion

Power Supply

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU as in the Figure 3. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

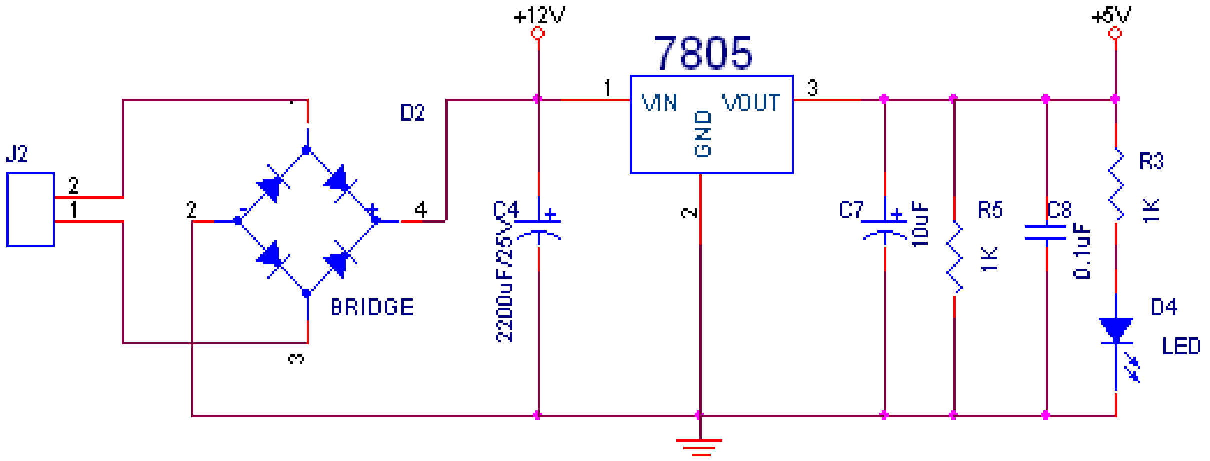

Figure 3:Power Supply

A 230v, 50Hz Single phase AC power supply is given to a step down transformer to get 12v supply. This voltage is converted to DC voltage using a bridge rectifier. The converted pulsating DC voltage is filtered by a 2200µf capacitor and then given to 7805 voltage regulator to obtain constant 5v supply. This 5v supply is given to all the components in the circuit. A RC time constant circuit is added to discharge all the capacitors quickly. To ensure the power supply a LED is connected for indication purpose.

Rectifier

A rectifier is an electrical device that converts alternating current to direct current or at least to current with only positive value, a process known as rectification. Rectifiers are used as components of power supplies and as detectors of radio signals.

Voltage Regulator

Features

The output current is up to 1A. It gives thermal overload protection and short circuit protection.

PIC16F877A Microcontroller

A microcontroller is a smallcomputer on a single integrated circuit consisting of a relatively simple CPU combined with support functions such as a crystal oscillator, timers and etc. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls office machines, appliances, power tools, and toys.

Liquid Crystal Display

The familiar character based LCDs are based on Hitachi'sHD44780 controller or others which are compatible with HD44580.

Universal Asynchronous Receiver/Transmitter

A universal asynchronous receiver/transmitter is a type of "asynchronous receiver/transmitter", a piece of computer hardware that translates data between parallel and serial forms. UARTs are commonly used in conjunction with other communication standards such as EIA RS-232. UART is usually an individual (or part of an) integrated circuit used for serial communications over a computer or peripheral device serial port. UARTs are now commonly included in microcontrollers. A dual UART or DUART combines two UARTs into a single chip. Many modern ICs now come with a UART that can also communicate synchronously; these devices are called USARTs.

The UART controller is the key component of the serial communications subsystem of a computer. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires. A UART is used to convert the transmitted information between its sequential and parallel form at each end of the link. Each UART contains a shift register which is the fundamental method of conversion between serial and parallel forms.

MAX232

The MAX232 is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals.

The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case.

The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V.

Sensor

Photo Detectors

A photo detector operates by converting light signals that hit the junction to a voltage or current. The junction uses an illumination window with an anti-reflect coating to absorb the light photons. The result of the absorption of photons is the creation of electron-hole pairs in the depletion region. Examples of photo detectors are photodiodes and phototransistors.

Photo detectors are used primarily as an optical receiver to convert light into electricity. The principle that applies to photo detectors is the photoelectric effect. The photo electric effect is the effect of light on a surface of metal in a vacuum. The electrons are ejected from the surface. Photo detectors are commonly used as safety devices in homes in the form of a smoke detector, also in conjunction with other optical devices to form security systems.

Photodiodes

A photodiode is based on a junction of oppositely doped regions (pn junction) in a sample of semiconductor. This creates a region depleted of charge carriers that results in high impedance. The high impedance allows the construction of detectors using silicon and germanium to operate with high sensitivity at low temperatures. The photodiode functions using an illumination window, which allows the use of light as an external input. Since light is used as an input, the diode is operated under reverse bias conditions. Under the reverse bias condition the current through the junction is zero when no light is present. When there is no light, reverse current will be zero. When the light increases, reverse current increases linearly.This allows the diode to be used as a switch or relay when sufficient light is present.

Photodiodes are mainly made from gallium arsenide. Gallium arsenide can produce electron-hole pairs without the slowly moving phonons; this allows faster switching between on and off states and GaAs also is more sensitive to the light intensity. Once charge carriers are produced in the diode material, the carriers reach the junction by diffusion. Important parameters for the photodiode include quantum efficiency, current and capacitance.

Light Emitting Diode

A light-emitting diode (LED) is an electronic light source. The modern LEDs are available across the visible, ultraviolet and infra red wavelengths, with very high brightness.

LEDs are based on the semiconductor diode. When the diode is forward biased (switched on), electrons are able to recombine with holes and energy is released in the form of light. This effect is called electroluminescence and the color of the light is determined by the energy gap of the semiconductor. The LED is usually small in area (less than 1 mm2) with integrated optical components to shape its radiation pattern and assist in reflection.

LEDs present many advantages over traditional light sources including lower energy consumption, longer lifetime, improved robustness, smaller size and faster switching. However, they are relatively expensive and require more precise current and heat management than traditional light sources.

Applications of LEDs are diverse. They are used as low-energy indicators but also for replacements for traditional light sources in general lighting and automotive lighting. The compact size of LEDs has allowed new text and video displays and sensors to be

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developed, while their high switching rates are useful in communications technology.

LI FI module

LI-FI –communication

Light as a Transmission Medium

Using light as a communication tool, for example in beacons and lighthouses, has a long tradition. With a speed of approximately 300,000 km / s, light is the fastest known transmission medium. Technologically, everyone is aware of optical signals used in the television remote control. Even when radiation is emitted in infrared (IR), outside our visible spectrum, the transmission of data is based on the same physical laws as those for the so-called VLC using visible light.So far, optical wireless communication has prevailed above all only in special applications, with radio transmission technologies dominating the broader market of wireless data communication. Due to the ever-growing amount of data to be transmitted, radio-based wireless communication is increasingly reaching its limits. In addition to the limited bandwidth availability of radio systems, the so-called "Frequency Crunch" problem, implementation costs are growing exponentially with increasing transmission frequencies.Therefore, optical wireless communication known as Li-Fi (Light Fidelity) is experiencing a renaissance due to high data rates, relatively low production costs and the possibility to communicate in real time. Hence, light as a transmission medium willplay an increasingly important role in both the industrial as well as in the consumer sectors.

The advantages of Li-Fi technology are: Fast (Low latency), Accessible (No cables), Secure (Line-of-Sight), Tiny (Small), Lowcost, Interference-free, Global (No spectrum license fees), High-speed (10 times faster than other wireless systems) and Timely (Up-to-date technology).

LI-FI Hotspot

The Li-Fi-Hotspot developed at Fraunhofer IPMS allows for the installation of a private, high-speed network without imposing cables.The system offers high data rates of up to 1 Gbps, robustness, low energy consumption, data security as well as networking capability over a distance of up to 30 meters and its small size is easily aligned and inexpensive to install.The data exchange is limited to a defined area and therefore does not interfere with other Hotspots nearby, making it possible to use the full bandwidth of each Li-Fi link.

Li-Fi-broadcasting modules senddata in one direction. The technology developed at Fraunhofer IPMS offers the possibility of a real-time capable and bi-directional,full duplex communication.Due to low latency, a Li-Fi communication channel is very well suited for machine-to-machine interaction. It is therefore possible to synchronize sensor and actuator data and thus avoid collisions or coordinate complex interactions between robot arms or different subsystems.Li-Fi solutions developed at Fraunhofer IPMS also allow the expansion of existing infrastructure free of costly installation through an independent communication channel. This is especially beneficial in areas where conventional technologies arealready in use by other applications or the use of radio systems is impossible due to strong electromagnetic interactions.

The electrical interface communication for the Li-Fi module can be individually adapted to the given requirements of an already existing communication network, like Ethernet, Gigabit Ether-net, RS422 and RS232.

Security

The main disadvantage of optical wireless data transmission is the necessary line of sight. Data can only be accessed by the direct introduction of a receiver in the transmission channel. Such an intrusion would, with high probability, be noticed al-lowing for a swift response to such an event. Therefore, Li-Fi communication combines the flexibility of wireless communication technology with the security of traditional cable-wired solutions. Due to the potentially high net data rates, connections must often be held only for a short time, for example when downloading new firmware or uploading sensor data.

LI-FI Board-To-Board Communication

High-frequency signals are commonly transmitted between two circuit boards via HF connectors. Higher data rates require complex connector constructions in order to reliably send signals. The Fraunhofer IPMS is designing Li-Fi modules to replace vulnerable HF connectors on printed circuit boards and thus ensure reliable board-to-board communication.

This allows for higher flexibility with respect to interchangeability and installation of board modules. Furthermore, completely new opportunities arise for the form factor and miniaturization of systems and the galvanic decoupling of subsystems.

FRVS Fragment System

The fragment system is the tendency of a file system to lay out the contents of files non-contiguously to allow in-place modification of their contents. It increases the disc head moment which are known to hinder throughput. When a file system is first initiated on a partition, it contains only few small internal structures. This mean that file system is able to place newly created files anywhere on the partition. When the operating system and the application are installed or archives are unpacked separate files end up occurring sequentially so related files are positioned close to each other. As existing files are deleted or truncated, new regions of free space are created. When existing files are appended to, it is often impossible to resume the write exactly where the file used to end, another file may be already allocated there thus a new fragment must be allocated. As time goes on, and the same factors are continuously present, free spaces as well as frequently appended files tend to fragment more. Shorter regions of free space also mean that file system is no longer able to allocate new files contiguously, and as to break them into fragment. This is especially true when the file system becomes full and large contiguous regions of free space are unavailable.

Hardware Connections

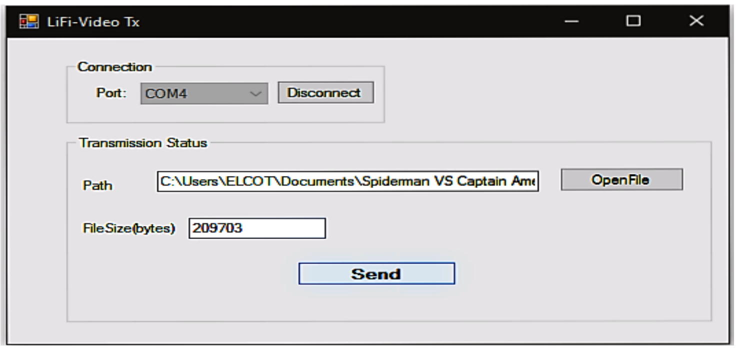
PIC 16F877A is connected to the Pic kit 2 via the protoboard. The information needed to connect the PIC to the Pic kit 2 programmeris called In-Circuit Serial Programming (ICSP) because the programmer can be attached to PIC while the PIC is running.PIC can be reprogrammed without removing it from the protoboard. 4MHz crystals are used so the mode should be “XT”. The capacitors should be 15-30 pF. Pic kit 2 is connected to the computer using the USB 2.0 port. LED is connected to port RB0. The long lead of the LED should be connected to RB0 and the short lead to ground. 5v and ground from the Pic kit 2 to supply power and ground for PIC and LED are used. The crystal is connected to OSC1 and OSC2. VPP/MCLR Pin is used to reset the PIC. Reset is 0v and the PIC is run by 5v. By connecting this to the PIC’s MCLR pin, the MPLAB software can control this pin. MCLR has an overbar and the pin is enabled with a low voltage. So a low voltage resets the PIC and a high voltage allows the PIC to run. VDD is the voltage source for the PIC. This can be controlled by the MPLAB software. VSS is ground. PGD is used to program the PIC. It is the data connection. PGC is used to program the PIC. It is the clock signal and connected to the protoboard. The outputs from the protoboard are connected to the different pins of the PIC.

Programming the Pic

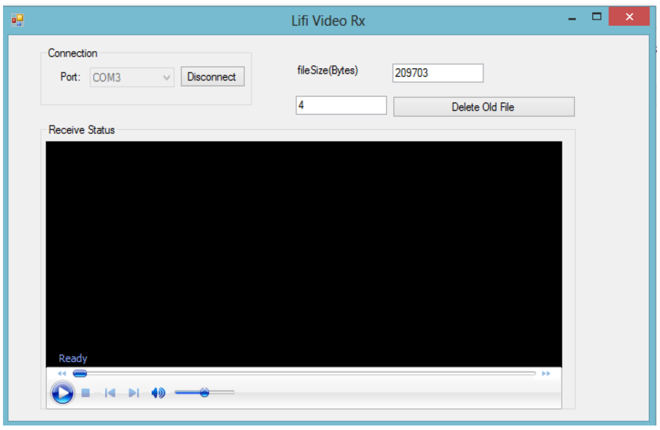
Programming can be done using the programmer menu in MPLAB. Pickit 2 will be selected as the programmer. Then connect is given. This will check if the Pickit 2 and the PIC are connected properly. Then “Program” will download the program into the PIC. The programming is verified whether it was successful. At this point, the PIC may not run because it may be in Reset mode. Reset is released. This changes the MCLR value to high, disabling it and allowing the PIC to run. To reset the PIC, Hold is selected in Reset. The LED will be blinking.

4. Results

Transmitter



Receiver



5. Conclusion

The concept of Li-Fi is currently attracting a great deal of interest. It offers a genuine and very efficient alternative to radio-based wireless. As there is a rapid growth in population, the number of devices accessing wireless transmission and the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. Li-Fi may solve issues such as the shortage of radiofrequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals.

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