EDL PROJECT REPORT

VISIBLE LIGHT COMMUNICATION

Group : D18

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Abstract:

The aim of the project is to use visible light to send data and receive the optical signal to decode the message sent. The objective is to achieve as high data rates as possible while eliminating the ambient noise and minimizing the flickering of the light source.
The basic setup for the project includes an LED as the source of light and a photodiode to detect the light signal sent by the LED. The LED is driven by a MOSFET which acts as a driver circuit capable of providing high switching rates. The data to be transmitted can be a text file and it can be read from a terminal or stored in the memory of the Pt-51. The data is modulated using pulse position modulation and fed to the driver circuit and thus sent over the link.
The receiver comprises of a photodiode which detects changes in intensity of light and these are converted to voltage levels which are input to the TIVA board. The demodulation is done by the processor and the output is displayed on the screen.

Aim:

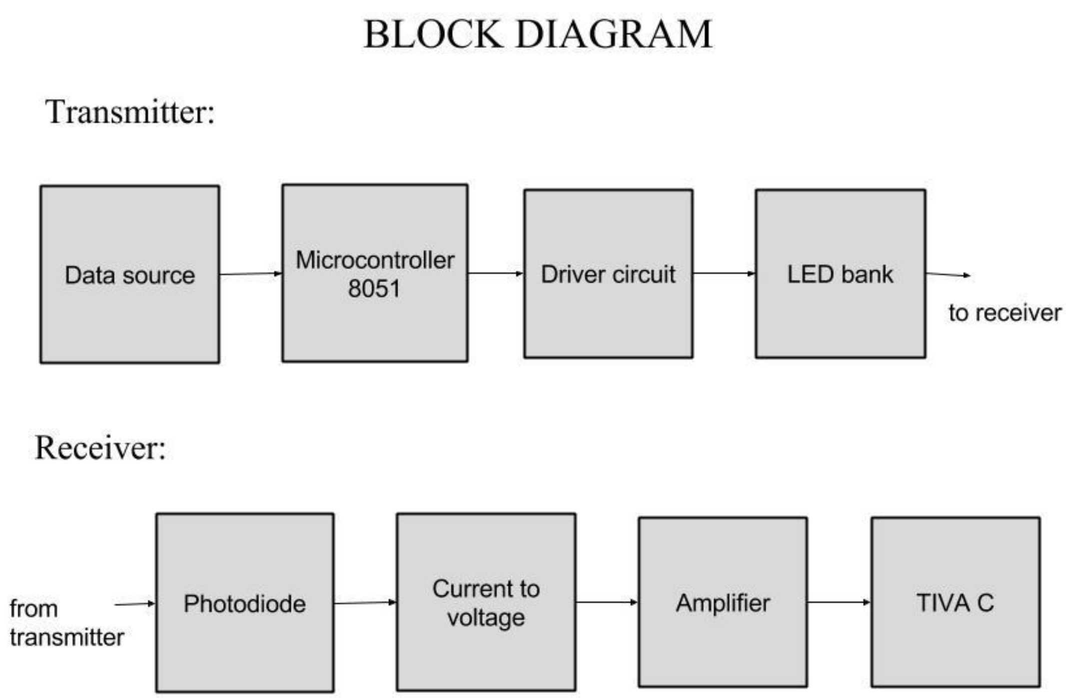
To design a visible light communication system which would be able to send data (such as text) stored in the transmitter's memory using visible light. The data sent using the power LED is to be read and corresponding message to be displayed at the receiving end.

Introduction:

Visible Light Communications is a data communications medium which uses visible light between 400 and 800 THz (780-375 nm). In this method of communication, data is transferred using a light source (usually an LED) and is received by a photodiode on the receiver side. VLC is superior to radio communication in a variety of fields where radio communication can harm the surrounding equipments like in hospitals near MRI, in aircrafts and for underwater communications. This is also proposed as a solution to the RF bandwidth limitations. Li-Fi (Light Fidelity) is an emerging technology that uses visible light communication and could be a complement to RF communication.

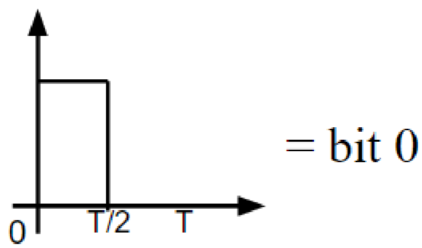
Block diagram and description:

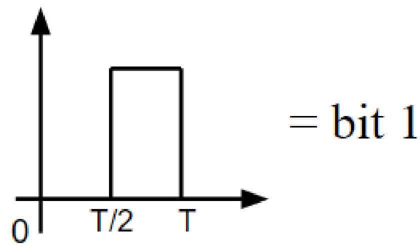
The system comprises of two major components, the transmitter and the receiver. The transmitter and receiver block diagrams are as shown in the following figure and explained below:



Modulation scheme:

The modulation scheme used for transmission of data is Pulse Position Modulation (2-PPM). The bits 0 and 1 would are represented by the waveforms as shown below.





For a bit duration of T, the waveform is high for a duration of T/2 and high for the other T/2, the order depending on whether the bit 0 or the bit 1 is to be represented.

Transmitter module:

The transmitter module consists of Pt-51, which is an 8051 based microcontroller used to modulate the data and accordingly control the LED driving circuit. The text file to be sent is stored in the memory of the microcontroller, which it reads and converts to corresponding bit sequence. Each bit is then modulated using 2-PPM as described earlier and given to the microcontroller's output. The microcontroller first sends out a start byte, then the data, followed by the stop byte. It also generates a special pre-determined sequence, which is sent to enable any receiver to synchronize its clock with the transmitter's clock.

This microcontroller output is then fed to the LED driver circuit, which basically consists of a high speed, large current capacity MOSFET (IRF840), which controls power to the LED bank according to the input received from the microcontroller.

The LED bank consists of two branches of LEDs, each branch containing three 1Watt power LEDs joined in series. The LED bank is designed, so as to take an input voltage of 12V and current of 0.65A when powered on.

Receiver module:

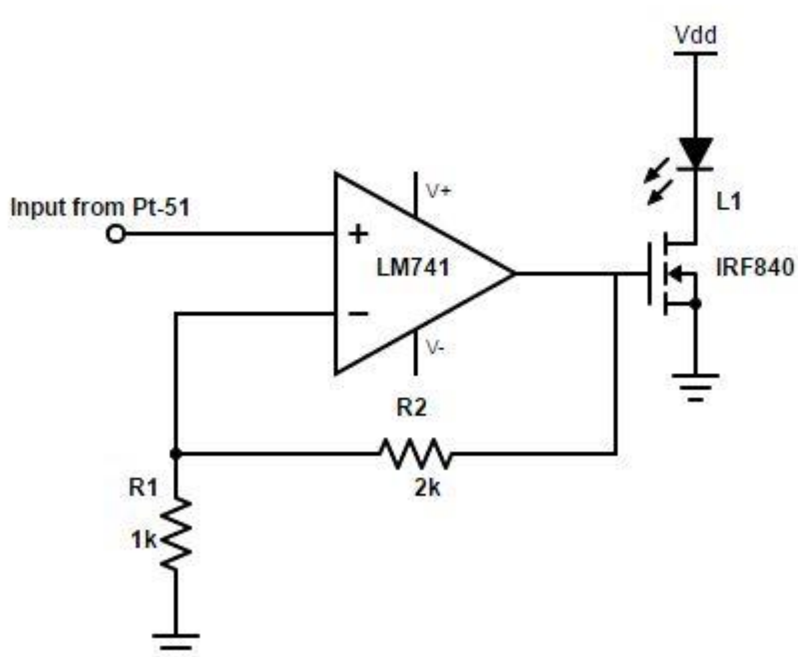
The first component of the receiver is the photo detector circuit, which uses a high speed photodiode (BPW34), to convert the signal received in terms of the light intensity, to corresponding voltage levels. The voltage output of the photo detector circuit is given to the TIVA board to demodulate the signal to obtain the message transmitted.

The demodulation of the received signal is done by detecting the values in the two half parts in a time period and then comparing them on the TIVA board.

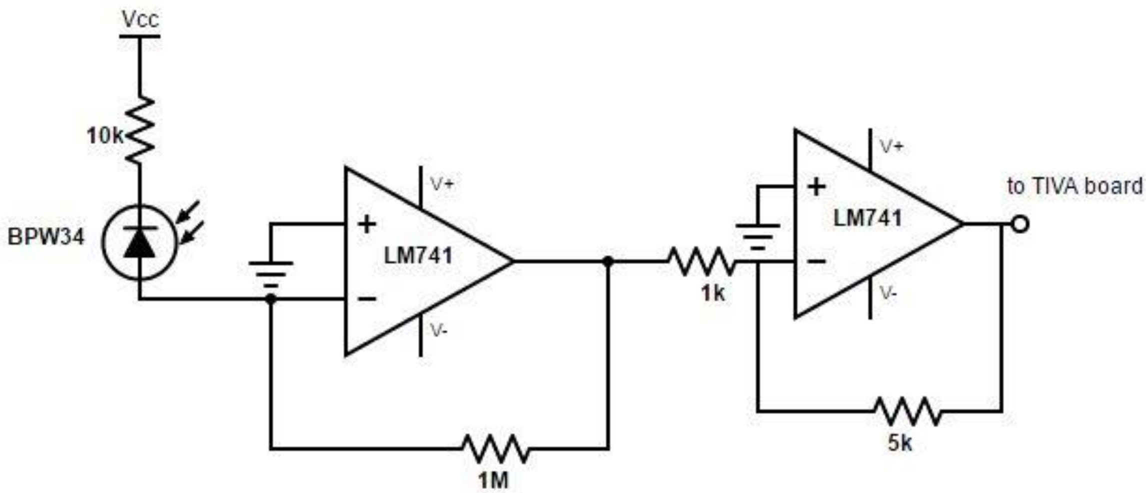
The TIVA board first looks for the special pre-determined sequence, to synchronize its clock, with that of the transmitter. Once synchronization is achieved, a value from the interval t=0 to T/2 and another from the interval t=T/2 to T, and each bit is computed according to which is greater. This technique is extremely robust, as it eliminates the effect of environmental noise even for a noise of variable magnitude.

Circuit diagrams:

Transmitter circuit:



Receiver circuit:



Photographs of units:

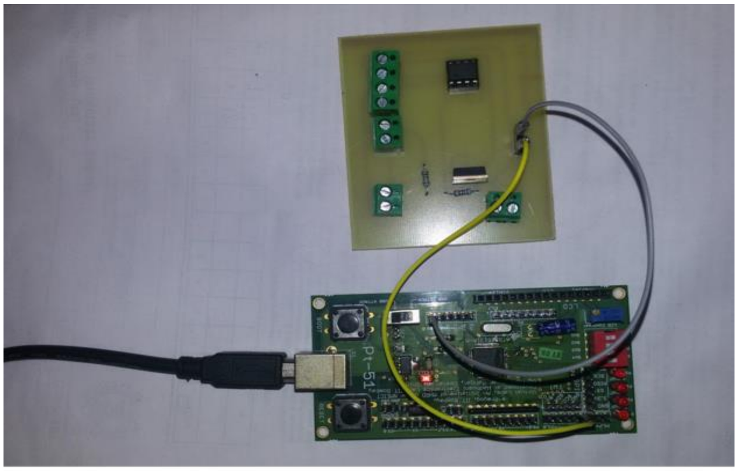


Fig 1:
Transmitter module. The pt-51 output goes to the led driver circuit as shown.

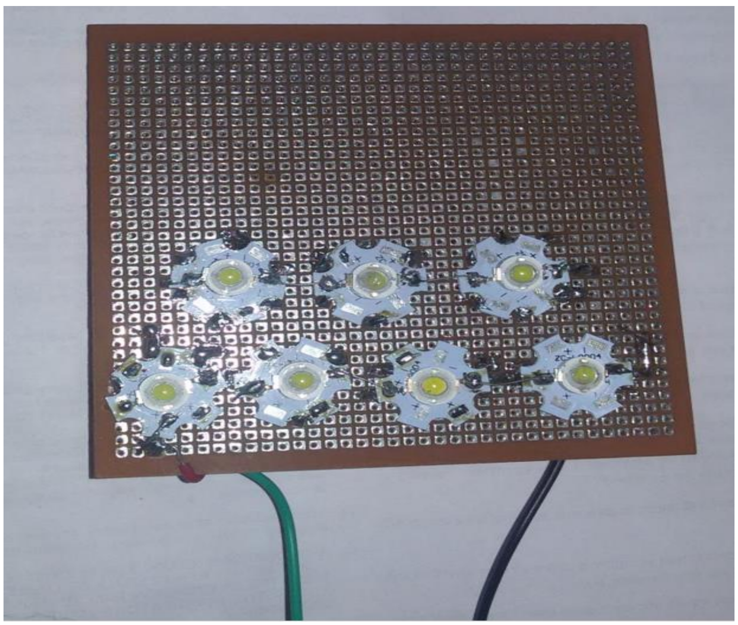


Fig 2:

LED Bank. Each branch has LEDs connected in series, and two such branches connected in parallel.

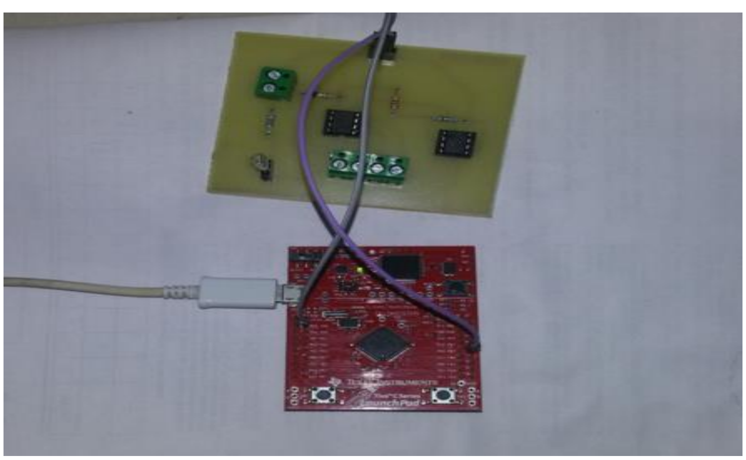


Fig 3:

Receiver module. The output of the photo detector circuit goes to the TIVA board.

Results/Objectives achieved:

Working transmitter module:

We have completed the transmitter code that takes in a piece of text to be sent (stored in memory), breaks it into a stream of characters and modulates them and sends the modulated signal as the output, to drive the LEDs accordingly.

Reducing of flickering of the LEDs for different data:

We have used 2-PPM as the modulation scheme, because of which, the DC value of the transmitted signal remains constant, irrespective of the data being sent, thus reducing the flicker. The LEDs will not remain off for a long time if input is zero continuously.

Receiver module:

The receiver module has most of the processing done in the TIVA board. It receives the voltage signals corresponding to the modulated data, demodulates it and decides the bits that are sent by the transmitter.

Working visible light channel:

The whole setup consisting of a modulator, a light source and detector and a demodulator transmits data at a rate of 100 bits per second accurately and at a rate of 1kbps with some bit error(<5%).

Problems faced:

Filtering limitations for modulation using FSK:

Initially, we tried working with FSK (Frequency Shift Keying) as the modulation scheme but the analog filters had very low accuracy and we weren't getting sharp distinction between peaks using digital filters.

Data rate limitations using RS-232:

The RS-232 module has a limitation that the data rates cannot be tweaked freely and no modulation can be used. For that purpose we switched to using Pt-51 to implement the transmitter part

Long distance transmission:

As the intensity of the light varies inversely with respect to the square of the distance, we need a large number of LEDs to make it work over long distances

Synchronization:

The problem with the receiver part while using the PPM scheme is that there needs to be a proper synchronization between the transmitter and the receiver which is difficult to obtain.

Bit error:

Error in the detection of one bit or detection of an extra zero or one can affect the entire pattern and in turn corrupt the final output.

Flickering:

Flickering of the LEDs causes a problem as it is unacceptable in a regular environment. High data rates are essential to eliminate flickering resulting in a trade-off between flickering and accuracy.

Conclusions:

We conclude that with the designed system, it is possible to achieve data transmission over a distance of upto 40 cm with a data rate of 100 bits per second accurately.

Future work suggestions:

Two way communication:

We could add transmitters and receivers at both ends, which would allow the devices to communicate with feedback. This system can then replace transmission devices such as wifi routers.

Mobile app:

The receiver can be developed using a mobile app, which would use the photo sensor of the cellphone, and process data received, which would make the receiver very compact and eliminate the need to use the receiver hardware and TIVA board.

Internet of things:

With VLC system added to all basic devices such as, air conditioners, refrigerators etc. we can get the devices to communicate with each other, independently, even without being connected to the internet or any common WiFi router. We can also use it for interactive and innovative information transfer in places like museums, schools etc.

References:

Pulse position modulation: http://ee.stanford.edu/~jmk/pubs/dppm.pdf

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BPW34 Photodiode: http://www.vishay.com/docs/81521/bpw34.pdf

IRF840: http://www.vishay.com/docs/91070/91070.pdf
http://intranet.ctism.ufsm.br/gsec/Datasheets/IRF840.pdf