# The Future Scope: Communicating MC's through Li-Fi with Inverse CRC3 Security

**Ch. Mydhili*, G.Vijaya Lakshmi, P. Paul Divakar**
*Faculty, Dept. of Electronics, Sir C R Reddy College (Autonomous), ELURU, India.*
*mail id: mydhili.chintamaneni91@gmail.com

**Abstract**: Now a day's in wired communication optical fiber communication plays a prominent role in high speed data communication with larger bandwidth. This is achieved by using light as a carrier. But most of the communications use wireless technology for data transmission which uses radio waves. The spectrum is limited due to various sectors of communications. Here comes the solution for this problem. Instead of transmitting light through fiber cable, it is transmitted in free space called Li-Fi Technology. The Li-Fi Technology uses optical transmitter and receiver for data transmission.

In future it will replace Wi-Fi technology. In general processors/controllers use RF, Bluetooth, and Zigbee communications for data transmission. This paper proposes a new method of communication between MC's through Li-Fi Technology with inverse CRC3 Security.

***Keywords***: *MC's, Data Transmission, Inverse CRC3, Li-Fi, Optical Transmitter and Receiver*

## I. INTRODUCTION

In recent years, communication via electronic devices is common. Because of spectrum limitation only small part of it is available for communications. Currently Bluetooth and Zigbee are used for MC communications. The Bluetooth technology manages the communication channel of the wireless part. The Bluetooth modules can transmit and receives the data wirelessly by using two devices. The Bluetooth module can receive and transmits the data from a host system with the help of the host controller interface (HCI). The UART & USB are the most popular host controller interfaces. The Bluetooth is free to use in the wireless communication protocol as the range of the Bluetooth is less than the other wireless communication protocols like Wi-Fi and Zigbee. The Bluetooth operates at the frequency of the 2.4 GHz and also used in many small ranges of applications.

Bluetooth and Zigbee, both operate in the same frequency band of 2.4 GHz and belonging to the same wireless private area network (IEEE 802.15). But even if this is the case, they are not exactly competing technologies. Bluetooth and Zigbee have a maximum network speed of 1Mbps to 250 Mbps respectively; Whereas Li-Fi uses visible light for data transmission. The operating range of visible light is 430–770 THz, theoretical speed is 10Gbps. This Li-Fi uses optical sources like LED and LASER, optical detectors like photo diodes, photo duo diodes etc. Because of these devices the cost of Li-Fi transmitter and receiver is less when compared to above devices.

## II. EXISTING CRC3

A cyclic redundancy check (CRC) is an error-detecting code commonly used in digital networks and storage devices to detect accidental changes to raw data. Blocks of data entering these systems get a short *check value* attached, based on the remainder of a polynomial division of their contents. Division of modulo 2 polynomials is done in exactly the same way as it is for ordinary polynomials, remembering that the coefficients obey modulo2 arithmetic (Half addition). On retrieval, the calculation is repeated and, in the event the check values do not match, corrective action can be taken against data corruption. CRCs can be used for error correction. CRCs are so called because the *check* (data verification) value is a *redundancy* (it expands the message without adding information) and the algorithm is based on *cyclic* codes. CRCs are popular because they are simple to implement in binary hardware, easy to analyze mathematically, and particularly good at detecting common errors caused by noise in transmission channels. Because the check value has a fixed length, the function that generates it is occasionally used as a hash function. The CRC was invented by W. Wesley Peterson in 1961. Polynomial representation of cyclic redundancy check CRC3 is $x^3+x^1+x^0$[9]. In this example, we shall encode 5 bits of message with a 3-bit CRC, with a polynomial $x^3 + x + 1$. The polynomial is written in binary as the coefficients; a 3rd-order polynomial has 4 coefficients ($1x^3 + 0x^2 + 1x + 1$). In this case, the coefficients are 1, 0, 1 and 1. The result of the calculation is 3 bits long. The total code word contains 8 bits. A very important operation in the calculation of CRCs is the calculation of the remainder R(x), given by

$$\text{CRC } R(x) = M(x) - G(x).Q(x) \_\_\_\_\_\_\_\_\_\_ \quad (1)$$

Where R(x) is Reminder polynomial (CRC), M(x) is data polynomial (m bits) appended with no. of bits in G(x) -1 zero's (n bits), G(x) is Generator polynomial (Divisor n+1 bits) and Q(x) is Quotient.

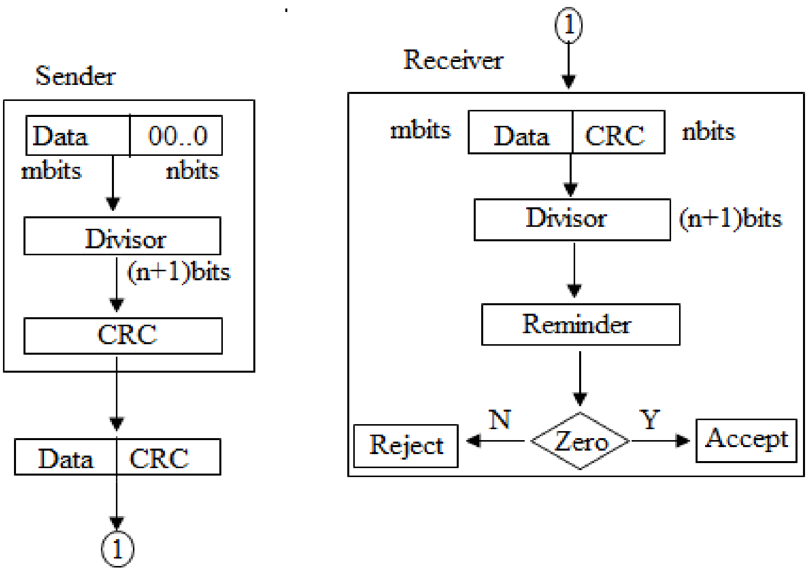


Fig 1 CRC3 Flowchart

Polyomial inputdata with CRC "000"

```
1 0 1 1 ) 1 1 1 1 1 0 0 0 ( 1 1 0 1 0  Q
          1 0 1 1
            1 0 0 1
            1 0 1 1
              0 1 0 0
              0 0 0 0
                1 0 0 0
                1 0 1 1
                  0 1 1 0
                  0 0 0 0
                    1 1 0    R(CRC)
```

Fig 2 CRC3 Calculation

Here 8bit controller is assumed, the raw data is represented in 5bit, polynomial size is 4bit (CRC is 4bit-1bit=3bit length). Therefore the length of code word is 8bit which is register size of assumed controller. This CRC checks error only but not provide any security for the data in Li-Fi communication. As controller assumption limited to 8bit, 5bit is data considered. In general for data transmission ASCII code is considered and for CRC3 with above mentioned polynomial is used. Li-Fi uses OOK (On Off Keying) Modulation for data transmission. The drawback with Li-Fi method is everyone knows about ASCII, CRC3 and a photo detector is enough for receiving data. This increases data misuse and unauthorisation.

Table 1
Data Representation in CRC3

| Raw Data | Data (5bit) | Code Word (in HEX) | Raw Data | Data (5bit) | Code Word (in HEX) | Raw Data | Data (5bit) | Code Word (in HEX) |
|---|---|---|---|---|---|---|---|---|
| A | 00110 | 31 | J | 01111 | 7F | S | 11000 | C4 |
| B | 00111 | 3A | K | 10000 | 81 | T | 11001 | CF |
| C | 01000 | 45 | L | 10001 | 8A | U | 11010 | D2 |
| D | 01001 | 4E | M | 10010 | 97 | V | 11011 | D1 |
| E | 01010 | 53 | N | 10011 | 9C | W | 11100 | E3 |
| F | 01011 | 58 | O | 10100 | A6 | X | 11101 | E8 |
| G | 01100 | 62 | P | 10101 | AD | Y | 11110 | F5 |
| H | 01101 | 69 | Q | 10110 | B0 | Z | 11111 | FE |
| I | 01110 | 74 | R | 10111 | BB | | | |

## III. PROPOSED SYSTEM

The proposed system uses inverse CRC3 method, which enhances the data security in Li-Fi transmission. In this method first CRC3 is performed and then the 3bit CRC is inversed and appended to 5bit data to form 8bit codeword which is shown in Table 2.

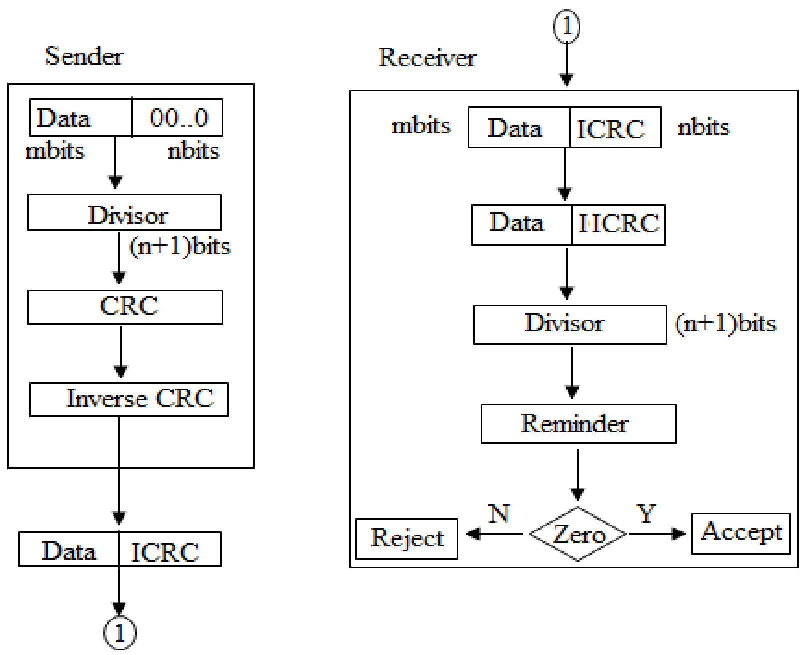


Fig 3 Inverse CRC3 Flowchart

Fig 2 shows CRC3 Calculation for raw data 'Z'. In the same way CRC3 is calculated and tabulated shown in Table 1. In proposed method the CRC “110” is first inverted (“001”) and appended to data bits (shown in Table 2) to form codeword to be transmitted. If any unauthorized person tries to decode the data with normal CRC3 method then it shows error which is illustrated in Fig 5 (b). For existing method, as the reminder is zero which represents no error detected. For the proposed method assume error free transmission, as the CRC is inverted the reminder is non zero which deviates the unauthorized person. So that data transmitted is secured and the original data is only decoded by authorized person.

$$\text{ICRC } R'(x) = (M(x) - G(x).Q(x))' \_\_\_\_\_\_\_\_\_\_ \quad (2)$$

Where $R'(x)$ is Inverse Reminder polynomial (ICRC), M(x) is data polynomial (m bits) appended with no. of bits in G(x) -1 zero’s (n bits), G(x) is Generator polynomial (Divisor n+1 bits) and Q(x) is Quotient. The binary weighted code used for representing data is BCA (*Binary Coded Alphabet*) with the weight shown in equation (3). BCA is similar to BCD the difference is BCD is 4bit, where as BCA is 5bit.

$$\prod_{k=0}^{m-1} 2^{m-(k+1)} + \text{ex6} \_\_\_\_\_\_\_\_\_\_ \quad (3)$$

Five bit weighted code with weight $\prod_{k=0}^{m-1} 2^{m-(k+1)}$ and data starts from 00000 for A, 00110 is added which is known as ex6. Calculation for Inverse CRC3 is shown in flow chart Fig 3. The data is input to PIC MC by using keyboard.

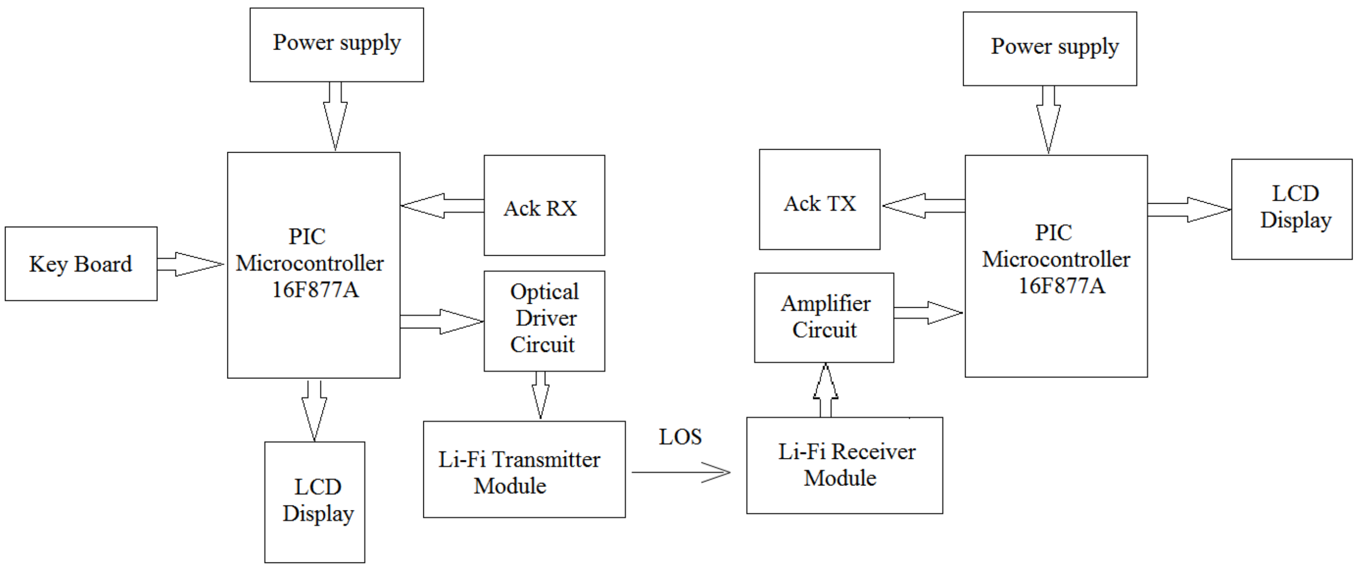


Fig 4 Block Diagram of Proposed System

The entered data is encoded into 8bit which is shown in Table 2, the hex code is transmitted via Li-Fi transmitter (LED or LASER). Li-Fi modulation scheme used is OOK modulation in which high pulse represents ‘1’ and low pulse represents ‘0’. Start and Stop bits are added to data as we are using UART communication. At the receiver end the Li-Fi receiver (PD or Solar) receives the data in such a way that high pulse represents ‘1’ and low pulse represents ‘0’. The OOK modulated signal is amplified and then fed to PIC MC. PIC MC decodes the data according to the Table 2. The data transmitted and received are displayed on 16X2 LCD’s placed at both sides of transmitter and receiver. The block diagram for Transmitter and Receiver is shown in Fig 4.

1 0 1 1 ) 1 1 1 1 1 1 1 0 ( 1 1 0 1 0 Q　　1 0 1 1 ) 1 1 1 1 1 0 0 1 ( 1 1 0 1 0 Q
1 0 1 1　　1 0 1 1

```
1 0 0 1
1 0 1 1
------------
  0 1 0 1
  0 0 0 0
------------
    1 0 1 1
    1 0 1 1
--------------
      0 0 0 0
      0 0 0 0
--------------
        0 0 0   R
```

Fig 5(a) Realization of existing method.

```
1 0 0 1
1 0 1 1
------------
  0 1 0 0
  0 0 0 0
------------
    1 0 0 0
    1 0 1 1
--------------
      0 1 1 1
      0 0 0 0
--------------
        1 1 1   R
```

Fig 5(b) Non Zero reminder for proposed method.

Table 2
Data Representation in Inverse CRC3

| Raw Data | Data (5bit) | Code Word (in HEX) | Raw Data | Data (5bit) | Code Word (in HEX) | Raw Data | Data (5bit) | Code Word (in HEX) |
|---|---|---|---|---|---|---|---|---|
| A | 00110 | 36 | J | 01111 | 78 | S | 11000 | C3 |
| B | 00111 | 3D | K | 10000 | 86 | T | 11001 | C8 |
| C | 01000 | 42 | L | 10001 | 8D | U | 11010 | D5 |
| D | 01001 | 49 | M | 10010 | 90 | V | 11011 | DE |
| E | 01010 | 54 | N | 10011 | 9B | W | 11100 | E4 |
| F | 01011 | 5F | O | 10100 | A1 | X | 11101 | EF |
| G | 01100 | 65 | P | 10101 | AA | Y | 11110 | F2 |
| H | 01101 | 6E | Q | 10110 | B7 | Z | 11111 | F9 |
| I | 01110 | 73 | R | 10111 | BC | | | |

The PIC16F877A is a CMOS flash-based 8-bit microcontroller, which has operating frequency of 20 MHz. It takes 200 ns to execute an instruction cycle. Here a 40 pin PIC16F877A is used. Its main function is to transmit data serially. The main criteria for UART communication is its baud rate. Both the devices Rx/Tx should be set to same baud rate for successful communication. UART associated registers in PIC16F877A are TXSTA Register (Transmit Status And Control Register), RCSTA Register (Receive Status And Control Register), SPBRG Register (USART Baud Rate Generator), TXREG Register (USART Transmit Register. Holds the data to be transmitted on UART), RCREG Register (USART Transmit Register. Holds the data received from UART). SYNC in TXSTA register is USART Mode Select bit for Synchronous mode it is 1, for Asynchronous mode it is 0. SPEN in RCSTA register is Serial Port Enable bit 1 for Serial port enabled (configures RC7/RX/DT and RC6/TX/CK pins as serial port pins), 0 for Serial port disabled. CREN in RCSTA register is Continuous Receive Enable bit in Asynchronous mode. To Enable continuous receive it is set to 1, to Disable continuous receive it is set to 0. Value in SPBRG is calculated by using the following equation.

$$\text{Baud Rate} = \text{Fosc} / (16\ (\text{SPBRG} + 1))$$

BRGH = 1 High Speed SPBRG = (Fosc / (16 * Baud Rate)) -1, BRGH = 0 Low Speed SPBRG = (Fosc / (64 * Baud Rate))-1. The desired Baud rate is 9600 bps. Crystal frequency (Fosc) is 20 MHz. This gives SPBRG as 129 (81 H) which is loaded in it. Any change in crystal frequency/Baud rate changes this value as per the above equation. It may be advantageous to use the high Baud Rate (BRGH = 1) even for slower baud clocks. This is because the FOSC/(16 (X + 1)) equation can reduce the Baud Rate error in some cases.

→Steps to Send Char

1. Wait till the previous char is transmitted. TXIF will be set when the TXREG is empty.
2. Clear the TXIF for next cycle.
3. Load the new char to be transmitted into TXREG.
4. If Ack RX receives negative acknowledgment then the data is retransmitted.
5. An obstacle detector is arranged at transmitter side in such a way that it receive reflected signal from obstacle, the transmitter sends recent 3 characters to reduce errors.

→Steps to Receive Char

1. Wait till the Data is received. RCIF will be set once the data is received in RCREG register.
2. Clear the receiver flag (RCIF) for next cycle.
3. Copy/Read the received data from RCREG register.
4. Received data is checked with the code word; if not match a hand shaking signal is sent to transmitter by using Ack TX.
5. So that the data is retransmitted.
6. The transmitter sends special command so that the RX understands that recent 3 characters are retransmitting.

→Pseudo code to TX and RX data:

```
void UART_TxChar(char ch)
{
while(TXIF==0); // Wait till the transmitter register becomes empty
TXIF=0; // Clear transmitter flag
TXREG=ch; // load the char to be transmitted into transmit reg
}

char UART_RxChar()
{
while(RCIF==0); // Wait till the data is received
RCIF=0; // Clear receiver flag
return(RCREG); // Return the received data to calling function
}
```

## IV. RESULTS

The data is encoded using ICRC3. When the receiver module is brought in line of sight to the transmitter, then it starts receiving data when transmitted. First “FF” followed by “00” is transmitted using Li-Fi Transmitter to check whether the receiver is ready or not to receive the data. In receiver module after receiving “FF” followed by “00” then receiver send a handshaking signal using Ack. If Ack is positive then the transmitter sends data to be transmitted. Timing diagram for PIC USART Asynchronous Transmission is shown in Fig 6. As OOK modulation is used, for ‘1’ high pulse is used, for ‘0’ low pulse is used for both transmission and reception. The Li-Fi modulator turns on and off according to the encoded data. Timing diagram for PIC USART Asynchronous Reception is shown in Fig 7. The data is encoded and decoded according to the Table 2. The encoded data “42” is send via Li-Fi transmitter for transmitting ‘C’, ASCII value of ‘C’ is send to Tx LCD as it understands ASCII only. At the receiver side the data received is “42”, decoded as ‘C’ and ASCII value of ‘C’ is send to Rx LCD. The letter ‘C’ is displayed on both TX and RX LCD’s. shown in Fig 8.

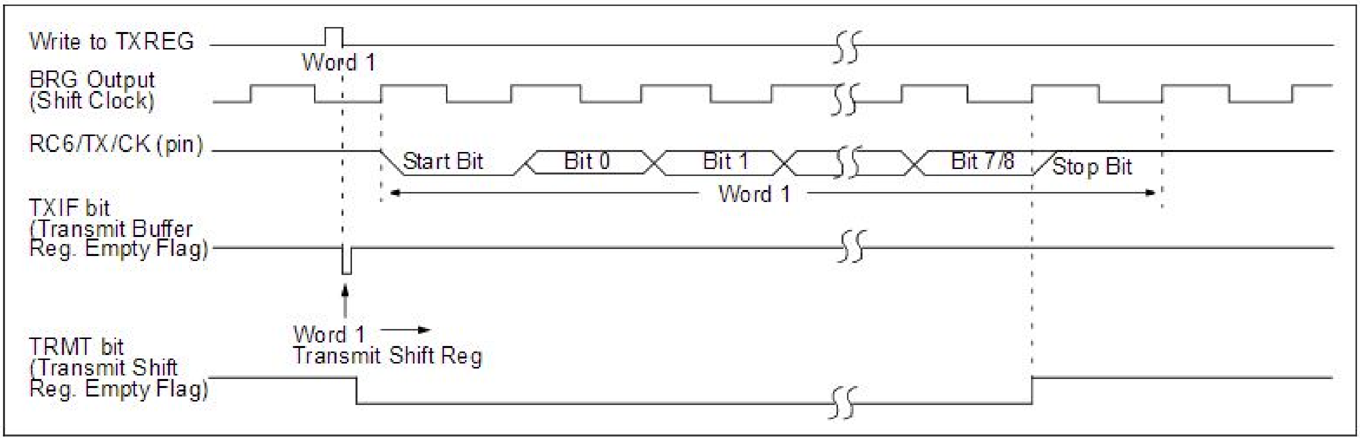


Fig 6 Timing diagram for PIC USART Asynchronous Transmission

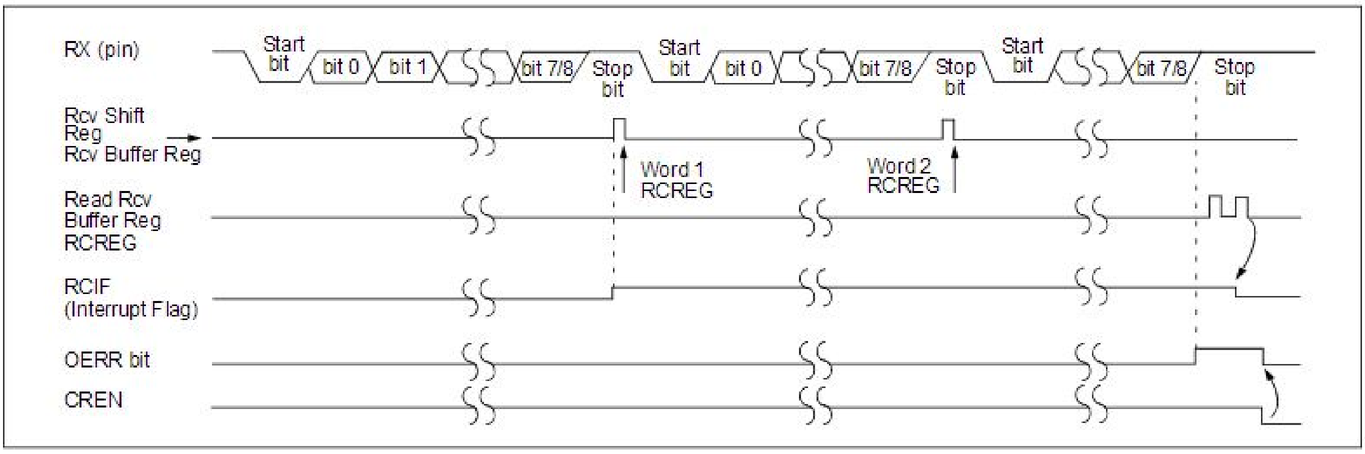


Fig 7 Timing diagram for PIC USART Asynchronous Reception


Fig 8 The letter ‘C’ is displayed on both TX and RX LCD’s.

## V. CONCLUSION

This technology is still under research and surely it will be a breakthrough in communication. It assures Data speed of100gbps which is entirely greater than radio waves. The scope of this Li-Fi technology is ultimately greater. As Li-Fi provides secured, low cost, easy data transmission and provides reliable communication, It can be used in industrial, medical, military applications. Li-Fi is still in its beginning stages, but improvements are being made rapidly, and soon this technology will be able to be used in our daily lives. It is intended that this research will provide the starting steps for further study .In spite of the research problems it is our belief that the VLC system will become one of the most promising technologies for the future generation in optical wireless communication.

## ACKNOWLEDGEMENT

It is worth full mentioning for me that each of the members mentioned in this article has provides me their precious time. We would like to thank our supervisor Dr. P. Paul Divakar for the guidance and encouragement they rendered us during the course of this research. We are sincerely grateful to them for sharing their views on a number of issues related to this work. And then finally we were able to publish our work.

## REFERENCES

[1] Punith P. Salian, Sachidananda Prabhu, Preetham Amin, Sumanth K.Naik, Dr. M.K. Parashuram,”Visible Light Communication”,Texas Instruments India Educators' Conference, 978-0-7695- 146-3/13 $26.00 © 2013 IEEE

[2] Zashi P. Choudhari,Satish R. Devane,” High sensitivity universal Lifi receiver for enhance data communication” 2016 Online International Conference on Green Engineering and Technologies (IC-GET) 978-1-5090-4556-3/16/$31.00 ©2016 IEEE

[3] Luis Bica Oliveira, Nuno Paulino, João P.Oliveira,Rui Santos, Nuno Pereira, João Goes, Undergraduate Electronics Projects Based on the Design of an Optical Wireless Audio Transmission System 0018-9359 © 2016 IEEE.

[4] Mohit Sanjeev Kumar, Gujar Shrikant, Velankar Arun Chavan”Realtime audio streaming using visible light communication Inventive Computation Technologies (ICICT), International Conference 16620571@IEEE

[5] D. Tsonev, S. Videv and H. Haas "Light Fidelity (Li-Fi): Towards All-Optical Networking", Institute for Digital Communications, Li-Fi R&D Centre, The University of Edinburgh, EH9 3JL, Edinburgh, UK.

[6] T.Komine and M.Nakagawa, ”Fundamental analysis for visible light communication systems using LED Lights,” IEEE Trans. Consumer Electronics, vol. 59, no.1, Feb, 2004.

[7] M.Kavehrad, “Sustainable Energy Efficient Wireless Applications Using Light,” IEEE Commun. Mag., vol. 48, no. 12, Dec. 2010, pp. 66- 73.

[8] P.Amirshahi, M. Kavehrad, “Broadband Access over Medium and Low Voltage Powerlines and use of White Light Emitting Diodes for Indoor Communications,” IEEE Consumer.

[9] Cyclic redundancy check https://en.wikipedia.org/wiki/Cyclic_redundancy_check