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Data Transmission between Two Laptops Using Optical Source

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ABSTRACT: When laser were first invented, they were called a solution looking for a problem. Everyone thought they were as cool as Bose-Einstein condensate, but no one quite knew what to do with these devices that could produce a highly focused beam of light. Today, lasers have become one of the world's most important technologies, used in industries ranging from information technology to telecommunications, medicine, consumer electronics, law enforcement, military equipment, entertainment and manufacturing. In terms of information speed and density, light could outperform radio. Light wavelengths are packed much tightly and they transmit more information per second, and with a stronger signal than sound waves. In communications, laser have been used for years. We transfer information through laser whether by reading CDs and DVDs every day, scanning bar codes at checkout lines or tapping the fiber optic backbone of phone or Internet services. On the horizon over vast distances, through air or space, with little data loss that will allow high throughput point-to-point communication.

KEYWORDS: Arduino, transmitter, receiver, DTMF

I. INTRODUCTION

The implemented prototype incorporates various electronic circuits which are designed in such a way that streamlined concepts of communication systems shall attribute to its functionality. The circuit consists of a transmitter and receiver section followed by a laser modulator encoders and decoders are used to convert the transmitted and received data in a user friendly form. Various optical sources have been considered such as optical fibers, LEDs and junction lasers. The proposed study concluded laser as the best optical source for the transmission of information over the wireless media.
Example: If a PC A wants to send a character ‘Z’ to PC B the encoder attached to the transmitter section takes the data in the ASCII form and convert it into binary. The data is further transmitted to the receiver via modulator which helps in reducing the transmission losses to the receiver. Decoder attached to the reception device converts the binary data received and display it to the serial port of the PC -B.

II. TECHNICAL SPECIFICATIONS

The implemented circuit consists of the following electronic devices:
TRANSMITTER SECTION:
The transmitter section consists of a 32 bit microcontroller atmega 328P which is embedded on an open source Arduino board, laser has been used as an optical source which is used to transfer data followed by an encoder.
The data which has to transmit is encoded in the following line scheme: MANCHESTER FORMAT.

Transmitter:keypad, microphone, some transistors and an op-amp with attached laser light to transmit the amplified signals is available in the transmitter.

Receiver: It is having microcontroller AT89c52 as the main part and a DTMF Decoder is there to convert light signal into corresponding frequencies. LCD and speaker are also available for getting output.

Power Supply: It favors regulated voltage and 7805 Regulator IC is most suitable here.

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Resistor both fixed and variable resistor are used here. Generally 1k, 10k and 470ohm are values of fixed resistors and 1Mohm is the value of variable resistor..

Photodiode: the laser light signal is received here and also the received signal into electrical equivalent is converted.

DTMF Decoder: It decodes the DTMF signal into BCD numbers.
Microcontroller chip: the processing unit of whole prototype.

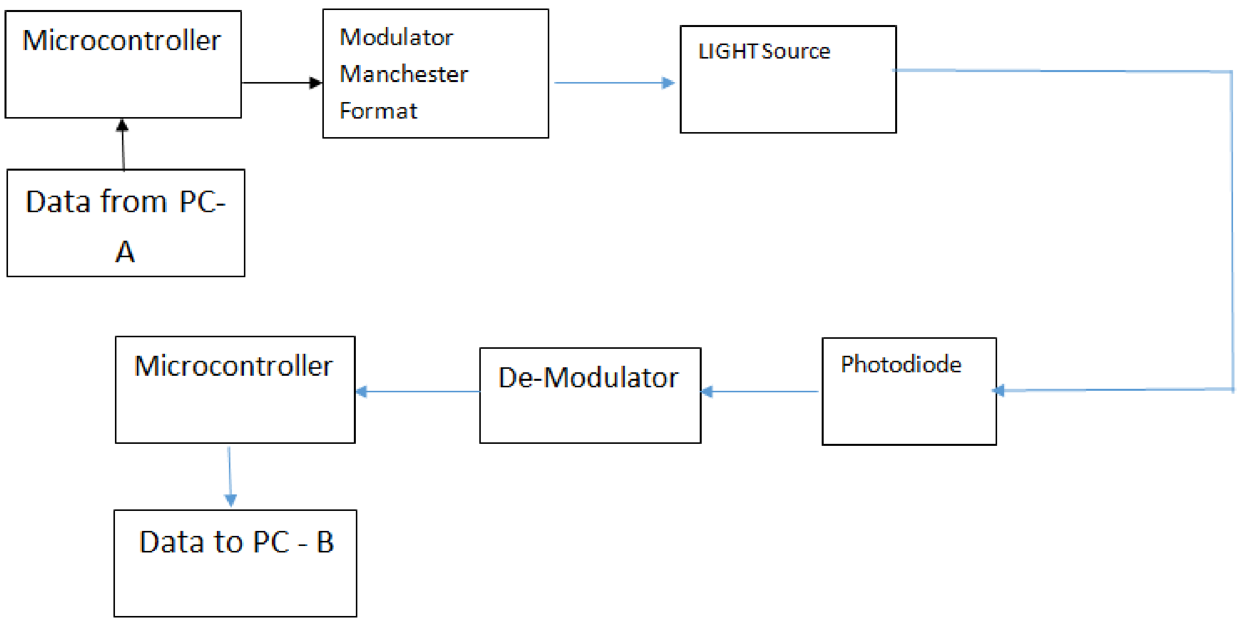
LCD and Speaker: used for getting the desired output.

Inverting Buffer: it acts as an isolator between the controller and the rest of the circuits,when used in the input section.It increases the current drive capability,when used in the output section.

DTMF: when a button is pressed in the telephone set keypad, a connection is made that generates a resultant signal of two tones at the same time. These two tones are taken from a row frequency and a column frequency. The resultant frequency signal is called "Dual Tone Multiple Frequency". These tones are identical and unique. A DTMF signal is the algebraic sum of two different audio frequencies, and can be expressed as follows:
sf(t) = A0sin(2*Π*fa*t) + B0sin(2*Π*fb*t).

III. DESIGN APPROACH AND DETAILS

The following circuit model shows the overall working of the communication system



The above block diagram represents the basic functional units involved in our proposed model. The process involved can be summarized as-
Step1: Data “Hello world” has to be transmitted from Laptop A to Laptop B.
Step2: Laptop A is connected to transmitter and Laptop B is connected to the proposed receiver model.

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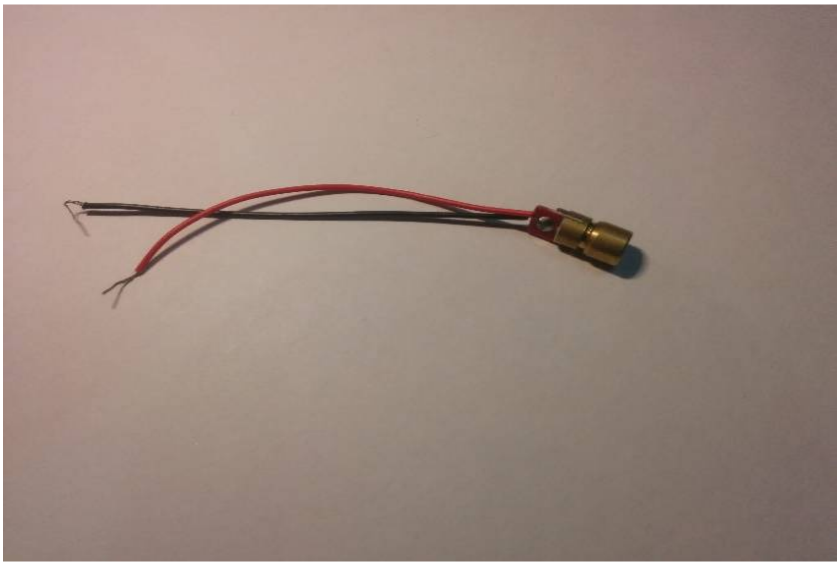
Step3: The data which has to be transmitted is converted in its equivalent ASCII code and furtherly converted into binary format and hence the data is ready to be transmitted. The opposite process is involved in the receiver section in order to receive the data.
Step4: The data has been coded in Manchester format because it is more efficient than RZ and NRZ formats.
Step5: The data is then sent to the receiver and process of decoding and decryption has been involved.
Serial Monitors of both the transmitter and receiver systems has to be used to view the transmitted and received data.

IV. OPTICAL COMPONENT USED

A)LASER Module:
Light power: 5mW Transmit power
Supply Voltage: 5V
DC Operating Current: 40mA
Operating temperature: -36 ~ 65
Storage temperature: -36 ~ 65
Driving mode: APC Single Weight



Laser is one of the most important component used in this project. LED's are also one of the optical source but it cannot be used in this case because of the following reasons
LED light is quite diffuse, and even at high power, doesn't tend to penetrate very deeply. Lasers, on the other hand, because they concentrate the light so well, tend to penetrate much more effectively. Coherent light can be transmitted over much greater distances than incoherent light. This is why lasers are used in fiber optic communication systems. The coherent light can be transmitted hundreds, even thousands of miles through fiber optic cables without much loss.
Lasers, on the other hand, are monochromatic. This means that all the light produced by a laser is a single, specific wavelength. LEDs also tend to produce monochromatic, or nearly monochromatic light. In acupuncture, the color selected to use is based on the effect hoped to achieve. The red colors tend to be tonifying, while blue colors tend to sedate.

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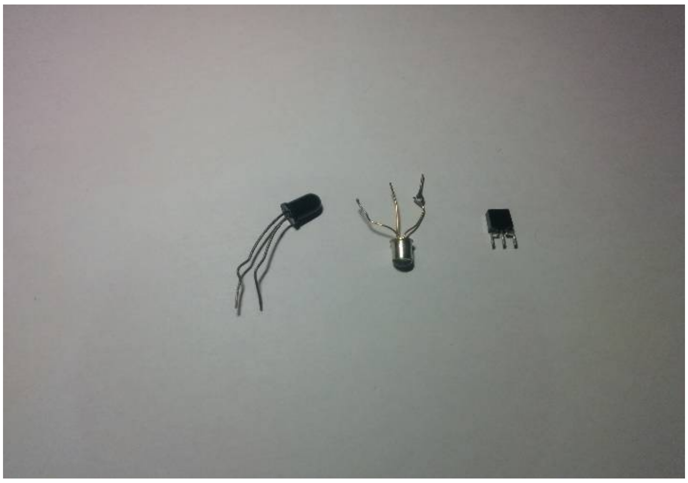
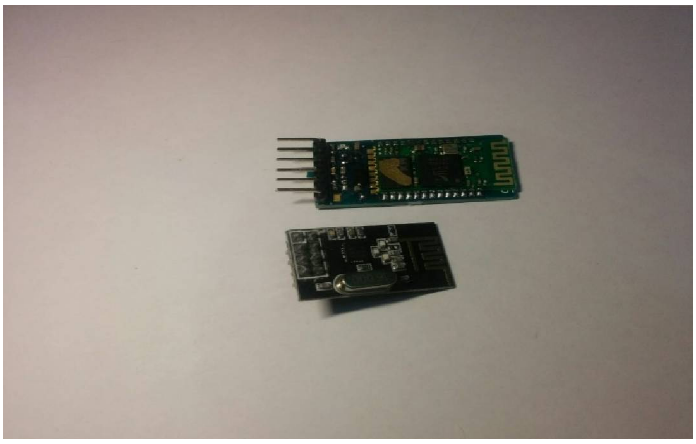
B) Photodiode:

It is used in receiving the laser light signal and also converting the received signal into electrical equivalent. A photodiode is a semiconductor device. It converts lightinto current. When photons are absorbed in the photodiode current is generated. When no light is present, a small amount of current is also produced. Photodiodes contain optical filters, built-in lenses, and large or small surface areas.



Manchester Modulator – Top
Manchester – Demodulator – Bottom



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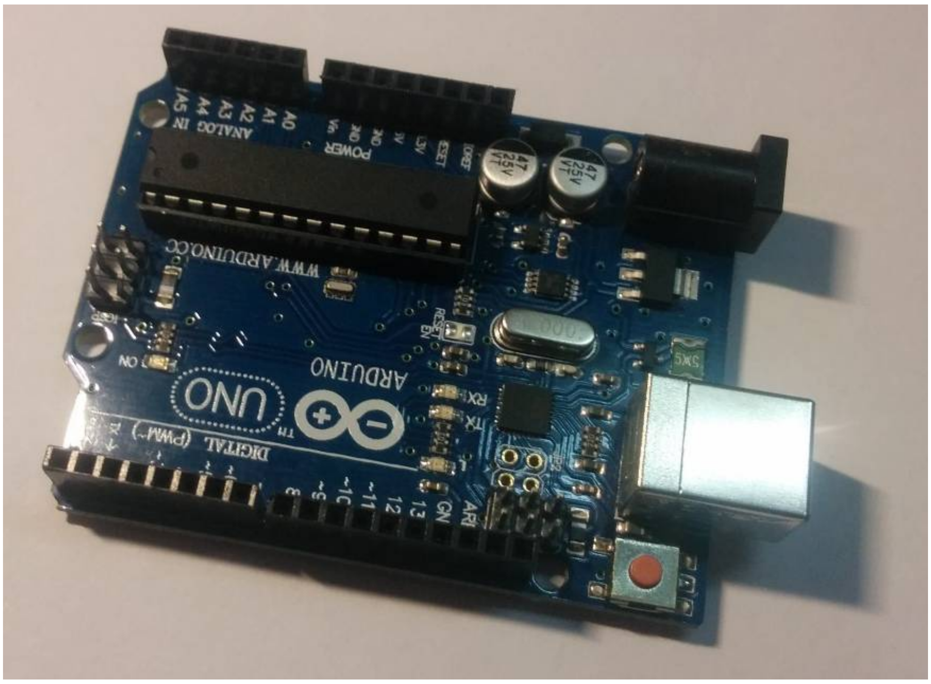
Arduino UNO Microcontroller RD3



V. CODES

5.1 Code (Arduino) Transmitter:

```
#include <TimerOne.h>
#include <util/atomic.h>
#include<string.h>
#define SYMBOL_PERIOD 500
#define WORD_LENGTH 10
#define SYNC_SYMBOL 0xD5
#define ETX 0x03
#define STX 0x02
#define OUT_LED() DDRB |= (1 << 5);
#define SET_LED() PORTB |= (1 << 5)
#define CLR_LED() PORTB &= ~(1 << 5)
unsigned char frame_buffer [38] ; //buffer for frame
char frame_index = -1; // index in frame
char frame_size = -1  ; // size of the frame to be sent
unsigned char bit_counter = 0 ;
unsigned short data_word = 0 ;  //8bit data + start + stop
unsigned char half_bit = 0 ;
unsigned long int manchester_data ;
void to_manchester(unsigned char data, unsigned long int * data_manchester){
  unsigned int i ;
 (*data_manchester) = 0x02 ; // STOP symbol
 (*data_manchester) = (*data_manchester) << 2 ;
  for(i = 0 ; i < 8; i ++){
```

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```
    if(data & 0x80) (*data_manchester) |=  0x02  ; // data LSB first
    else (*data_manchester) |= 0x01 ;
    (*data_manchester) = (*data_manchester) << 2 ;
    data = data << 1 ; // to next bit
  }
  (*data_manchester) |= 0x01 ; //START symbol
}
void emit_half_bit(){
     if(manchester_data & 0x01){
       SET_LED();
     }else{
       CLR_LED();
     }
     bit_counter -- ;
     manchester_data = (manchester_data >> 1);
     if(bit_counter == 0){
       //is there still bytes to send in the frame ?
       manchester_data = 0xAAAAAAAA ; // keep sending ones if nothing to send
       if(frame_index >= 0 ){
         if(frame_index < frame_size){
           to_manchester(frame_buffer[frame_index], &manchester_data);
           frame_index ++ ;
         }else{
           frame_index = -1 ;
           frame_size = -1 ;
         }
       }
       bit_counter = WORD_LENGTH * 2 ;
       Serial.println(manchester_data, BIN);
     }
}
void init_frame(unsigned char * frame){
  memset(frame, 0xAA, 3);
  frame[3] = SYNC_SYMBOL ;
  frame[4] = STX;
  frame_index = -1 ;
  frame_size = -1 ;
}
int create_frame(char * data, int data_size, unsigned char * frame){
  memcpy(&(frame[5]), data, data_size);
  frame[5+data_size] = ETX;
  return 1 ;
}
int write(char * data, int data_size){
  if(frame_index >=  0) return -1 ;
  if(data_size > 32) return -1 ;
  create_frame(data, data_size,frame_buffer);
  ATOMIC_BLOCK(ATOMIC_RESTORESTATE){
    frame_index = 0 ;
    frame_size = data_size + 6 ;
  }
```

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```
  return 0 ;
}
int transmitter_available(){
  if(frame_index >=  0) return 0 ;
  return 1 ;
}

void init_emitter(){
  manchester_data = 0xFFFFFFFF ;
  bit_counter = WORD_LENGTH * 2 ;
}
void setup() {
  // initialize serial communication at 115200 bits per second:
  Serial.begin(115200);
  OUT_LED();
  init_frame(frame_buffer);
  init_emitter();
  Timer1.initialize(SYMBOL_PERIOD); //1200 bauds
  Timer1.attachInterrupt(emit_half_bit);
}
char *msg="Hello";

String arq;
//char *msg2;
char com_buffer [32] ;
char com_buffer_nb_bytes = 0 ;
void loop() {

  Serial.println("Enter : ");
  //for(int jj=0;jj<5;jj++)
  while(Serial.available());

  arq=Serial.readString();
  //while(arq=="");
  msg=&arq[0];
  #ifdef TRANSMIT_SERIAL
  if(Serial.available() && transmitter_available()){ //constructing the data frame only if transmitter is ready to transmit
    char c = Serial.read();
    com_buffer[com_buffer_nb_bytes] = c ;
    com_buffer_nb_bytes ++ ;
    if(com_buffer_nb_bytes >= 32 || c == '\n'){
      if(write(com_buffer, com_buffer_nb_bytes) < 0){
        Serial.println("Transmitter is busy");
      }else{
        com_buffer_nb_bytes = 0 ;
      }
    }
  }
  delay(10);
  #else
    static int i = 0 ;
```

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```
   memcpy(com_buffer, msg, 11);
   com_buffer[11] = i + '0' ;
   if(write(com_buffer, 12) < 0){
     delay(10);
   }else{
     i ++ ;
     if(i > 9) i = 0 ;
   }
  #endif
}
```

5.2- Code (Arduino) Receiver:

```
#include <TimerOne.h>
#include "receiver_types.h"
#define INT_REF
#define SENSOR_PIN 3
#define SYMBOL_PERIOD 500
#define SAMPLE_PER_SYMBOL 4
#define WORD_LENGTH 10 // a byte is encoded as a 10-bit value with start and stop bits
#define SYNC_SYMBOL 0xD5 // this symbol breaks the premanble of the frame
#define ETX 0x03 // End of frame symbol
#define STX 0x02 //Start or frame symbol
char frame_buffer[38] ;
int frame_index  = -1 ;
int frame_size = -1 ;
unsigned int signal_mean = 0 ;
unsigned long acc_sum = 0 ; //used to compute the signal mean value
unsigned int acc_counter = 0 ;
long shift_reg = 0;
void ADC_setup(){
  ADCSRA =  bit (ADEN);                      // turn ADC on
  ADCSRA |= bit (ADPS0) |  bit (ADPS1) | bit (ADPS2);  // Prescaler of 128
  #ifdef INT_REF
  ADMUX  =  bit (REFS0) | bit (REFS1);    // internal 1.1v reference
  #else
  ADMUX  =  bit (REFS0) ;   // external 5v reference
  #endif
}

void ADC_start_conversion(int adc_pin){
  ADMUX &= ~(0x07) ; //clearing enabled channels
  ADMUX  |= (adc_pin & 0x07) ;    // AVcc and select input port
  bitSet (ADCSRA, ADSC) ;
}
int ADC_read_conversion(){
 while(bit_is_set(ADCSRA, ADSC));
 return ADC ;
}
#define START_SYMBOL 0x02
```

```
#define STOP_SYMBOL 0x01
#define START_STOP_MASK  ((STOP_SYMBOL << 20) | (START_SYMBOL << 18) | STOP_SYMBOL)
#define SYNC_SYMBOL_MANCHESTER  (0x6665)
inline int is_a_word (long  * manchester_word, int time_from_last_sync, unsigned int * detected_word){
    if(time_from_last_sync >= 20  || frame_state == IDLE){ // we received enough bits to test the sync
      if(((*manchester_word) & START_STOP_MASK) == (START_STOP_MASK)){ // testing first position
        (*detected_word) = ((*manchester_word) >> 2) & 0xFFFF;
        if(frame_state == IDLE){
          if((*detected_word) == SYNC_SYMBOL_MANCHESTER) return 2 ;
        }
        return 1 ;
            }else if(frame_state != IDLE && time_from_last_sync == 20){
       (*detected_word)= ((*manchester_word) >> 2) & 0xFFFF;
       return 1 ;
      }
     }
    return 0 ;
}
inline int insert_edge ( long  * manchester_word, char edge, int edge_period, int * time_from_last_sync, unsigned int * detected_word){
  int new_word = 0 ;
  int is_a_word_value = 0 ;
  int sync_word_detect = 0 ;
  if( ((*manchester_word) & 0x01) != edge ){ //mak sure we don't have same edge ...
     if(edge_period > (SAMPLE_PER_SYMBOL+1)){
       unsigned char last_bit = (*manchester_word) & 0x01 ;
       (*manchester_word) = ((*manchester_word) << 1) | last_bit ; // signal was steady for longer than a single symbol,
       (*time_from_last_sync) += 1 ;
       is_a_word_value = is_a_word(manchester_word, (*time_from_last_sync), detected_word);
       if(is_a_word_value > 0){ //found start stop framing
         new_word = 1 ;
        (*time_from_last_sync) =  0 ;
        if(is_a_word_value > 1) sync_word_detect = 1 ; //we detected framing and sync word in manchester format
       }
     }
     //storing edge value in word
     if(edge < 0){
      (*manchester_word) = ( (*manchester_word) << 1) | 0x00 ; // signal goes down
     }else{
      (*manchester_word) = ( (*manchester_word) << 1) | 0x01 ; // signal goes up
     }
     (*time_from_last_sync) += 1 ;
     is_a_word_value = is_a_word(manchester_word, (*time_from_last_sync), detected_word);
     if(sync_word_detect == 0 && is_a_word_value > 0){ //if sync word was detected at previous position, don't take word detection into account
      new_word = 1 ;
      (*time_from_last_sync) =  0 ;
     }
    }else{
     new_word = -1 ;
```

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```
        }
        return new_word ;
}
#define EDGE_THRESHOLD 4
int oldValue = 0 ;
int steady_count = 0 ;
int dist_last_sync = 0 ;
unsigned int detected_word = 0;
int new_word = 0;
char old_edge_val = 0 ;
void sample_signal_edge(){
  char edge_val ;
  //int sensorValue = analogRead(SENSOR_PIN); // this is too slow and should be replaced with interrupt-driven ADC
  int sensorValue  = ADC_read_conversion(); // read result of previously triggered conversion
  ADC_start_conversion(SENSOR_PIN); // start a conversion for next loop
  #ifndef DEBUG
  #ifdef DEBUG_ANALOG
  Serial.println(sensorValue, DEC);
  #endif
  #endif
  if((sensorValue - oldValue) > EDGE_THRESHOLD) edge_val = 1 ;
  else if((oldValue - sensorValue) > EDGE_THRESHOLD) edge_val = -1;
  else edge_val = 0 ;
  oldValue = sensorValue ;
  if(edge_val == 0 || edge_val == old_edge_val || (edge_val != old_edge_val && steady_count < 2)){
    if( steady_count < (4 * SAMPLE_PER_SYMBOL)){
      steady_count ++ ;
    }
  }else{
        new_word = insert_edge(&shift_reg, edge_val, steady_count, &(dist_last_sync), &detected_word);
        if(dist_last_sync > (8*SAMPLE_PER_SYMBOL)){
          dist_last_sync = 32 ;
        }
        //if(new_word >= 0){
          steady_count = 0 ;
        //}
      }
      old_edge_val = edge_val ;
}
int add_byte_to_frame(char * frame_buffer, int * frame_index, int * frame_size, enum receiver_state * frame_state
,unsigned char data){
  if(data == SYNC_SYMBOL/* && (*frame_index) < 0*/){
    (*frame_index) = 0 ;
    (*frame_size) = 0 ;
    (*frame_state) = SYNC ;
    //Serial.println("SYNC");
    return 0 ;
  }
  if((*frame_state) != IDLE){ //synced
  frame_buffer[*frame_index] = data ;
  (*frame_index) ++ ;
```

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```
    if(data == STX){
     //Serial.println("START");
     (*frame_state) = START ;
      return 0 ;
    }else if(data == ETX){
     //Serial.println("END");
     (*frame_size) = (*frame_index) ;
     (*frame_index) = -1 ;
     (*frame_state) = IDLE ;
     //Serial.println("END");
      return 1 ;
    }else if((*frame_index) >= 38
     (*frame_index) = -1 ;
     (*frame_size) = -1 ;
     (*frame_state) = IDLE ;
     return -1 ;
    }else{
     (*frame_state) = DATA ;
    }
    return 0 ;
  }
  return -1 ;
}

// the setup routine runs once when you press reset:
void setup() {
  // initialize serial communication at 115200 bits per second:
  int i;
  Serial.begin(115200);
  Serial.println("Start of receiver program");
  ADC_setup();
  ADC_start_conversion(SENSOR_PIN);
  //analogReference(INTERNAL);
  Timer1.initialize(SYMBOL_PERIOD/SAMPLE_PER_SYMBOL); //1200 bauds oversampled by factor 4
  Timer1.attachInterrupt(sample_signal_edge);

}
void loop() {
  int i;
  unsigned char received_data;
  char received_data_print ;
  int nb_shift ;
  int byte_added = 0 ;
  if(new_word == 1){
    received_data = 0 ;
    for(i = 0 ; i < 16 ; i = i + 2){ //decoding Manchester
             received_data = received_data << 1 ;
             if(((detected_word >> i) & 0x03) == 0x01){
                 received_data |= 0x01 ;
             }else{
                 received_data &= ~0x01 ;
```

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```
        }
    }
    received_data = received_data & 0xFF ;
    #ifdef DEBUG
      Serial.print(received_data & 0xFF, HEX);
      Serial.print(", ");
      Serial.println((char) received_data);
    #endif
    new_word = 0 ;
    if((byte_added = add_byte_to_frame(frame_buffer, &frame_index, &frame_size, &frame_state,received_data)) >
0){
      frame_buffer[frame_size-1] = '\0';
      Serial.println(&(frame_buffer[1]));
    }
    //if(frame_state != IDLE) Serial.println(received_data, HEX);
```

VI. CONCLUSION

Main advantages using laser light over RF communication and fiber optics are high transmission security, quick link setup, high bit rate and low bit error rate Text files can be sent by speed of 9600 bits per second. This model is used widely by Metropolitan area network now. Automatic Alignment System can be achieved using this method in future.This technology requires no FCC licensing. This low cost device is capable of 115.2 kbps speed and distance of 500 m and is ideal for applications where round the clock monitoring is necessary.

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