MADHA
Expertise | Empathy | Excellence
ENGINEERING COLLEGE

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

EC8711 EMBEDDED LABORATORY

Semester - 07

LABORATORY MANUAL

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ENGINEERING COLLEGE

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Vision

To excel in providing value based education in the field of Electronics and Communication Engineering, keeping in pace with the latest technical developments through commendable research, to raise the intellectual competence to match global standards and to make significant contributions to the society upholding the ethical standards.

Mission

- ✓ To deliver Quality Technical Education, with an equal emphasis on theoretical and practical aspects.
- ✓ To provide state of the art infrastructure for the students and faculty to upgrade their skills and knowledge.
- ✓ To create an open and conducive environment for faculty and students to carry out research and excel in their field of specialization.
- ✓ To focus especially on innovation and development of technologies that is sustainable and inclusive, and thus benefits all sections of the society.
- ✓ To establish a strong Industry Academic Collaboration for teaching and research, that could foster entrepreneurship and innovation in knowledge exchange.
- ✓ To produce quality Engineers who uphold and advance the integrity, honour and dignity of the engineering.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1. To provide the students with a strong foundation in the required sciences in order to pursue studies in Electronics and Communication Engineering.
2. To gain adequate knowledge to become good professional in electronic and communication engineering associated industries, higher education and research.
3. To develop attitude in lifelong learning, applying and adapting new ideas and technologies as their field evolves.
4. To prepare students to critically analyze existing literature in an area of specialization and ethically develop innovative and research oriented methodologies to solve the problems identified.
5. To inculcate in the students a professional and ethical attitude and an ability to visualize the engineering issues in a broader social context.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Design, develop and analyze electronic systems through application of relevant electronics, mathematics and engineering principles.

PSO2: Design, develop and analyze communication systems through application of fundamentals from communication principles, signal processing, and RF System Design & Electromagnetics.

PSO3: Adapt to emerging electronics and communication technologies and develop innovative solutions for existing and newer problems.

SYLLABUS

EC8711-Embedded Lab **L T P C**
0 0 4 2

Course Objective:

The student should be made to:

- Learn the working of ARM processor
- Understand the Building Blocks of Embedded Systems
- Learn the concept of memory map and memory interface
- Write programs to interface memory, I/Os with processor
- Study the interrupt performance

List of Experiments:

1. Study of ARM evaluation system
2. Interfacing ADC and DAC.
3. Interfacing LED and PWM.
4. Interfacing real time clock and serial port.
5. Interfacing keyboard and LCD.
6. Interfacing EPROM and interrupt.
7. Mailbox.
8. Interrupt performance characteristics of ARM and FPGA.
9. Flashing of LEDS.
10. Interfacing stepper motor and temperature sensor.
11. Implementing zigbee protocol with ARM.

Course Outcome:

At the end of the course, the student should be able to:

- Write programs in ARM for a specific Application
- Interface memory, A/D and D/A convertors with ARM system
- Analyze the performance of interrupt
- Write program for interfacing keyboard, display, motor and sensor.
- Formulate a mini project using embedded system

TOTAL: 60 PERIODS

LIST OF EXPERIMENTS

1. Study of ARM Evaluation System

Aim

To learn about the evolution, core features, general characteristics and applications of ARM processors.

Pre Lab Questions

1. What is an embedded system?
2. Mention the difference between microprocessor and microcontroller.
3. Enumerate the terms object oriented and object based language
4. Define Pipelining.
5. List the basic units of Microprocessor

Theory

The LPC2148 microcontrollers are based on a 32/16 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16- bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

Due to their tiny size and low power consumption, LPC2148 are ideal for applications where miniaturization is a key requirement, such as access control and point- of-sale. A blend of serial communications interfaces ranging from a USB 2.0 Full Speed device, multiple UARTS, SPI, SSP to I2C s and on-chip SRAM of 8 kb up to 40 kb, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for industrial control and medical system**s.**

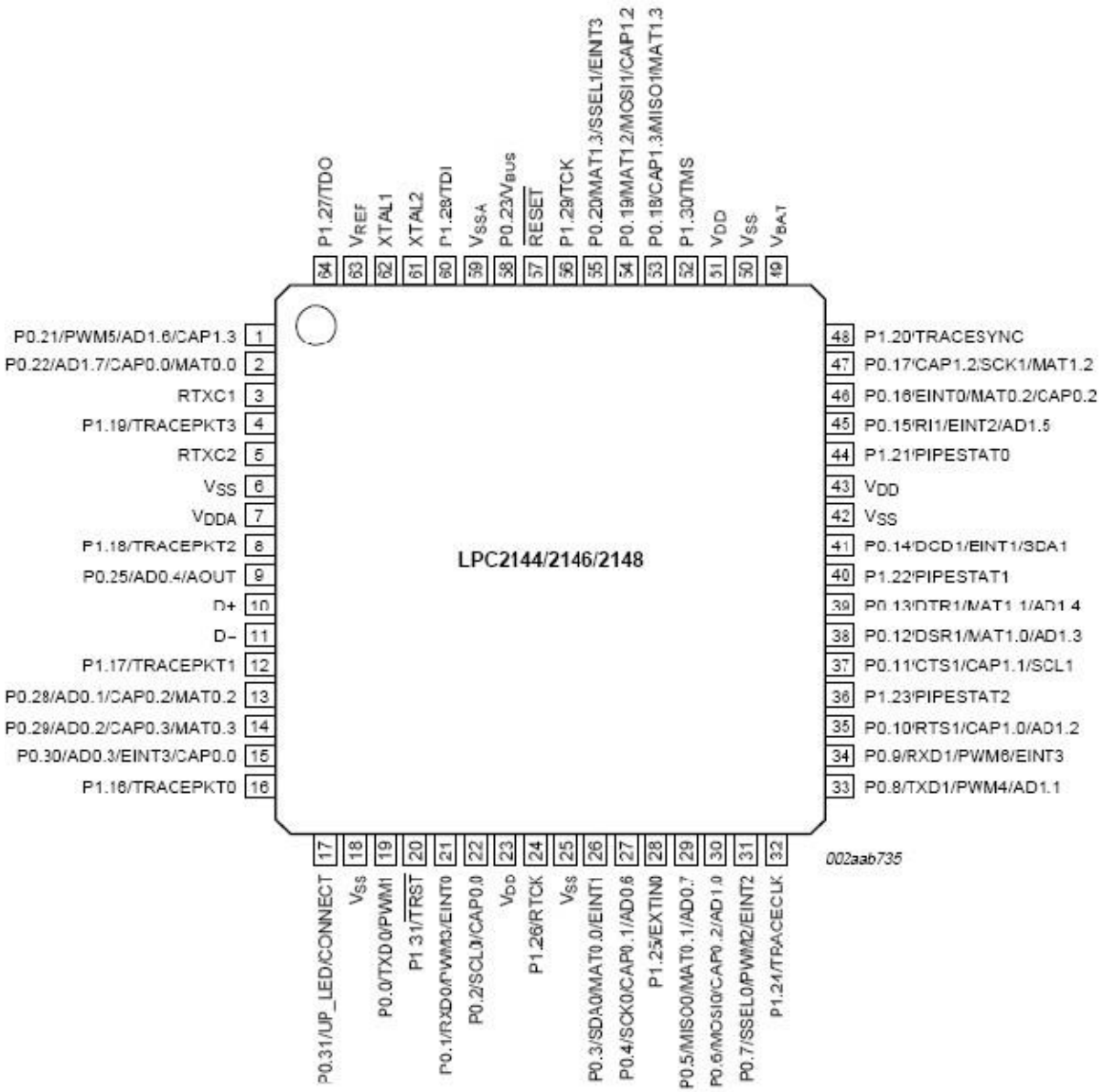
LPC2148 specification

Features:

- 16/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64package.
- 8 to 40 KB of on-chip static RAM and 32 to 512kB of on-chip flash Program memory.
- 128 bit wide interface/accelerator enables high speed 60 MHz operation.
- In-System/In-Application Programming(ISP/IAP)via on-chip boot- loader software. Single flash sector or full chip erase in 400ms and programming of 256 bytes in 1 ms.
- Embedded ICE RT and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high speed tracing of instruction execution.
- USB 2.0 Full Speed compliant Device Controller with 2 kb of endpoint RAM. In addition, the LPC2146/8 provide 8 kb of on-chip RAM accessible to USB by DMA.
- One or two (LPC2141/2 vs. LPC2144/6/8) 10-bit A/D converters provide a
    - total of 6/14 analog inputs, with conversion times as low as 2.44µsper channel.
- Single 10-bit D/A converter provide variable analog output.
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
- Low power real-time clock with independent power and dedicated 32kHz Clock input.
- Multiple serial interfaces including two UARTs (16C550), two Fast I2C -bus (400 kbit/s), SPI and SSP with buffering and variable data length capabilities.
- Vectored interrupt controller with configurable priorities and vector addresses.

- Up to 45 of 5 V tolerant fast general purpose I/O pins in a tinyLQFP64 package.
- Up to nine edge or level sensitive external interrupt pins available.
- 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100µs.
- On-chip integrated oscillator operates with an external crystal in range from 1MHz to 30 MHz and with an external oscillator up to 50MHz.
- Power saving modes include Idle and Power-down.
- Individual enable/disable of peripheral functions as well as peripheral clock scaling for additional power optimization.
- Processor wake-up from Power-down mode via external interrupt, USB, Brown-Out Detect (BOD) or Real-Time Clock(RTC).
- Single power supply chip with Power-On Reset (POR) and BOD circuits:
    - CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %)with 5V tolerant I/O pads.

Pin Configuration:

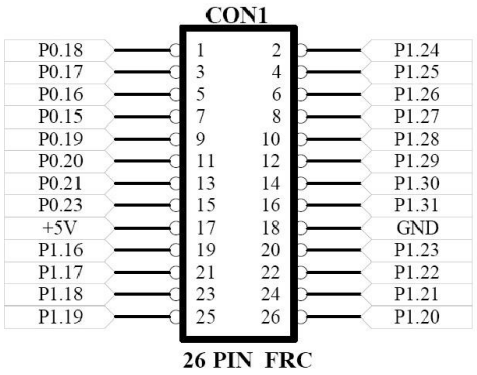


For further studies about LPC2148 specification refer NXP's website to download LPC2148 user manual.

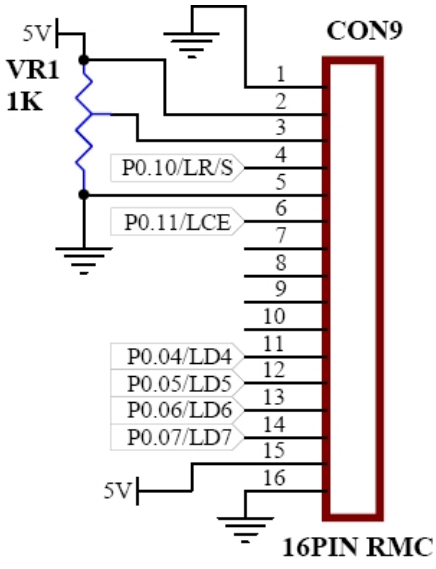
APPENDIX-II: CONNECTORS & CONNECTION DETAILS

Type	Label	Description
26 Pin FRC	CON1	For GPIO
20 Pin FRC	CON2	For JTAG
DB9	CON3	UART0
DB9	CON4	UART1
3 Pin RMC	CON5	PWM output
6 Pin RMC	CON6	ADC input
3 Pin RMC	CON7	DAC output from OPAMP
3 Pin RMC	CON8	Temperature sensor input
16 Pin RMC	CON9	LCD Display
Power jack	C10	Power input
PS2	CON11	Keyboard interface

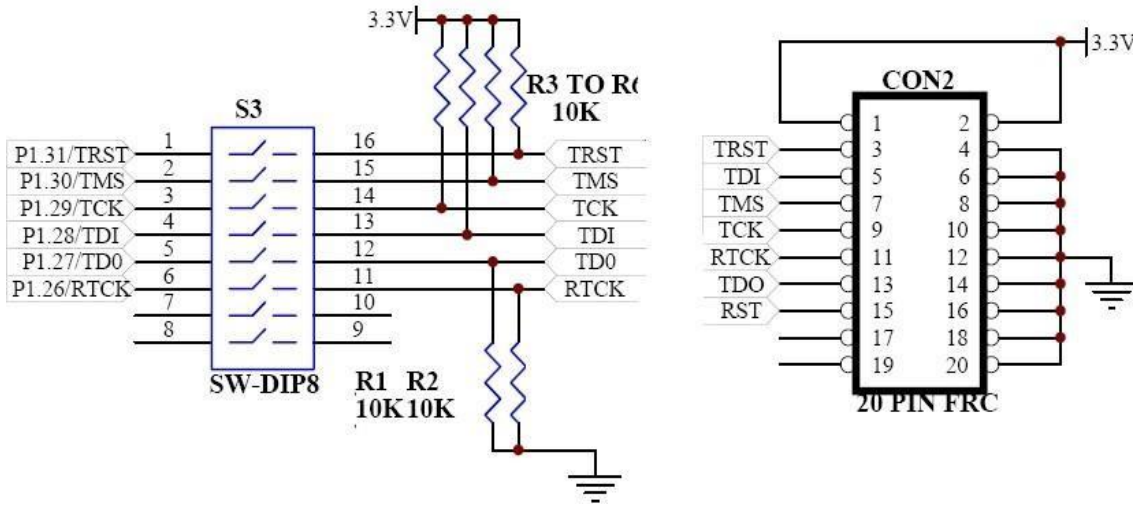
Connections Details for 26 pin FRC:



Connection Details for LCD(16 pin RMC):



Connection Details for JTAG(20 pin FRC):



Post Lab Questions

1. What is the difference between embedded systems and the system in which rtos is running?
2. Discuss about semaphore.
3. What are the instructions used to access the memory in ARM?
4. Mention the characteristics of RISK Instruction.
5. Define Interrupt.

Result

The evolution, core features, general characteristics and the applications of ARM processors has been studied and is evaluated.

2. INTERFACING ADC & DAC

Aim

To develop a C-Language program for reading an on-chip ADC, convert into decimal and to display it in PC and to generate a square wave depending on this ADC reading. The ADC input is connected to any analog sensor/ on board potentiometer.

Pre Lab Questions

1. List the types of ADC and DAC
2. Define resolution.
3. Summarize the features of Conversion time in ADC.
4, What is the function of Sample-and-hold circuits in analog-to digital converters?
5. Why are internal ADCs preferred over external ADCs?

Apparatus & Software Required

1. LPC2148 Development board.
2. KeilμVision5 software.
3. Flash Magic.
4. USB cable.
5. CRO.

Theory

The LPC 2148 has 10-bit successive approximation analog to digital converter. Basic clocking for the A/D converters is provided by the VPB clock. A programmable divider is included in each converter, to scale this clock to the 4.5 MHz (max) clock needed by the successive approximation process. A fully accurate conversion requires 11 of these clocks. The ADC cell can measure the voltage on any of the ADC input signals.

ARM Board has one potentiometer for working with A/D Converter. Potentiometer outputs are in the range of 0V to 3.3V. Switch select in right position for reading the Potentiometer value by ADC.

Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

MAIN ADC TEST

```
/*****************************************************************************/
        /* This is a test program to ADC in theARMLPC2148        developmentboard*/
/*****************************************************************************/

#include<LPC214x.H>                     /* LPC214x definitions*/
#include"ADC_Driver.c"                          /* contains prototypes of driverfunctions*/ #include"lcd.c"
#include <stdio.h>

int main (void)
  {
    unsigned int adc_val;
    unsigned int temp;
    unsigned char buf[4] ={0,0,0,0}; ADCInit();
    lcdinit();
         //wait();
              clrscr(10);
         printstr("ADC Test",0,0); wait();
    while(1)                                    /* Loop forever*/
      {
              adc_val = ADC_ReadChannel();
              temp = (unsigned int)((3*adc_val*100)/1024);
              sprintf(buf,"%d",temp);
              printstr(buf,0,1);

      }


  }

 /*****************************************************************************/
```

LCD.C

```
/*****************************************************************************/

#include <LPC214x.h>

#defineRS               0x00000400 /* P0.10 */
#defineCE               0x00001800 /* P1.11*/
void clrscr(char ch); void
lcdinit(void); void
lcdcmd(char); void
lcddat(char);
void gotoxy(char,char); //x,y ; x-char position(0 - 16) y-line number 0 or1 void
printstr(unsignedchar*,char,char);                              //string,column(x),line(y)
void wait (void);
void split_numbers(unsigned int number);

#define SET1
#define OFF0
unsigned int thousands,hundreds,tens,ones;
```

```
voidwait(void)
{       /* wait function */
int     d;
   for (d = 0; d <100000;d++);                          /* only to delay for LED flashes*/
}


void lcdinit()
{
       IODIR0 |= 0xFFFFFFFF;
            IOCLR0 |= 0X00000FFF;
            lcdcmd(0x28);lcd
       cmd(0x28);
       lcdcmd(0x0c);
       lcdcmd(0x06);
       lcdcmd(0x01);
       lcdcmd(0x0f);
       wait();
}

void gotoxy(char x, char y)
{
       if(y == 0)
              lcdcmd(0x80+x);
       else
              lcdcmd(0xc0+x);

}
void printstr(unsigned char *str, char x, char y)
{
       char i; gotoxy(x,y);
       wait();//(500);
       for(i=0;str[i]!='\0';i++)lcddat(str[i
              ]);

}
void lcdcmd(charcmd)
{
unsigned charLCDDAT;
              LCDDAT = (cmd&0xf0);              //higher nibble
              IOSET0 =LCDDAT;
         IOCLR0 = RS;
              IOSET0 = CE;
         wait();//(100);                                    //enablelcd
              IOCLR0 = CE;
              IOCLR0 = 0X00000FFF;


         LCDDAT = ((cmd<<0x04)&0xf0);                       //lower nibble
              IOSET0 =LCDDAT;
         IOCLR0 = RS;
              IOSET0 = CE;
         wait();//(100);                                    //enablelcd
              IOCLR0 = CE;
              IOCLR0 = 0X00000FFF;

}

void lcddat(char cmd)
```

```
{
    unsigned charLCDDAT;
          LCDDAT = (cmd&0xf0);              //higher nibble
          IOSET0 =LCDDAT;
      IOSET0 = RS;
          IOSET0 = CE;
      wait();//(100);                                   //enablelcd
          IOCLR0 = CE;
          IOCLR0 = 0X00000FFF;

      LCDDAT = ((cmd<<0x04)&0xf0);                      //lower nibble
          IOSET0 =LCDDAT;
      IOSET0 = RS;
          IOSET0 =CE;
      wait();//(100);                                    //enable lcd
          IOCLR0 =CE;
          IOCLR0 = 0X00000FFF;
 }

void clrscr(char ch)
{
      if(ch==0)
      {
            printstr("                              ",0,0);
            gotoxy(0,0);
      }
        else if(ch == 1)
      {
            printstr("                              ",0,1);
            gotoxy(0,1);
      }
      else
      {
              lcdcmd(0x01);
                //delay(100);
      }
}

void split_numbers(unsigned int number)
{
   thousands = (number /1000);
   number %= 1000;
   hundreds = (number / 100);
   number %= 100;
   tens = (number / 10);
   number %= 10;
   ones = number ;
}

void Wait_Msg(void)
{
 lcdcmd(0x01);
 printstr("          Please Wait ", 0,0);
}
void Welcome_Msg(void)
{
 lcdcmd(0x01);
 printstr("          Welcometo          ", 0,0);
 printstr("            SMMICRRO     ", 0,1);
}
```

```
/*****************************************************************/
                        ADC   DRIVER.C
/*****************************************************************/


#include<LPC214x.H>                     /* LPC214x definitions */

Void ADCInit(void)
  {
    PINSEL1|=0x04000000;          /*For Channel AD0.2 is P0.29*/
    IODIR0 |=~(0x04000000);
    AD0CR    |=0x00200204;            /*0x04 selects AD0.2 to mux output, 0x20 makes ADCin operational*/
    AD0GDR;                          /*A read on AD0GDR clears the DONEbit*/
  }

void ADC_StartConversion(void)
  {
     AD0CR |= (1<<24);
  }
void ADC_StopConversion(void)
  {
     AD0CR &= (~ (1<<24));
  }


unsigned int ADC_ReadChannel(void)
  {
//       unsigned int i; unsigned long
     ADC_Val, t;
     ADC_StartConversion();
     while((AD0DR2&0x80000000)==0); /*wait until ADC conversion completes*/
     if(AD0STAT & 0x00000400)
                {
                  //printstr("OVR",0,1);return(
                  0);
                }
     t = AD0DR2;
     ADC_Val = ((t>>6) & 0x000003FF);//(AD0DR2 & 0x000003FF); //((AD0CR>>6) & 0x000003FF);
     //ADC_StopConversion();retur
     n(ADC_Val);
```

ADC PROGRAM PORT DETAILS

ARM	DETAILS
P0.29	ADC0.2
PO.10	RS LCD PIN
P1.11	CE LCD PIN

DAC PROGRAM

```
/*****************************************************************/      DAC.C
/*****************************************************************/
                This is a test program to DAC in the ARM LPC2148 Development board
/*****************************************************************/

#include<LPC214X.H>


void wait_long (void)
{                                       /* wait function*/
   int      d;
   for (d = 0; d <1000000;d++);                              /* only to delay*/
}

int main()
  {
          wait_long();wai
          t_long();
          IODIR0   =   0X00000FFF;
          IODIR1   =   0XFFFF0000;
          IOSET0   =  0XFFFFFFFF;
          IOCLR1 = 0XFFFF0000;
      PINSEL1 |= 0x00080000; //Enablepin0.25                  asDAC
          DACR=0X00017FC0;                  // 000 = 0V (min),7FC = 1.6V,7FF =3.3V(max)
          While (1);
}
```

DAC PROGRAM PORT DETAILS

ARM	DETAILS
P0.25	DAC ENABLE PIN

Post Lab Questions

1. What are the ADC operating modes in LPC2148?
2. What is the function of A/D Status Register
3. Which pin provides a voltage reference level for the D/A converter?
4. What is Burst conversion mode?
5. What is settling time?

Result :

The C-Language program for reading an on-chip ADC, convert into decimal and to display it in PC was written & output is verified with the ADC input is connected to on board potentiometer

The DAC, convert digital data into analog signal& output is verified with the DAC input and the square wave has been generated to display it in CRO.

3. INTERFACING LED & PWM

Aim

To write a C program for Switch & L ED to activate LED's and generate a PWM and to vary the duty cycle .

Pre Lab Questions

1. What happens if the junction temperature of LED is increased?
2. Mention the principle of PWM.
3. What are the materials used to make LED?
4. What are the types of seven segment display.
5. Differentiate LED from LCD.

Apparatus & Software Required

1. LPC2148 Development board.
2. Keil µVision 5 software.
3. Flash Magic.
4. USB cable.
5. CRO .

Theory

The PWM is based on the standard timer block and inherits all of its features, although only the PWM function is pinned out on the LPC2148. The timer is designed to count cycles of the peripheral clock (PCLK) and optionally generate interrupts or perform other actions when specified timer values occur, based on seven match registers. The PWM function is also based on match register events.

Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

```
/*****************************************************************************/
                        SWITCH AND LED PROGRAM
/*****************************************************************************/
/* Description: This program gets DIP switch inputs and switches ON corresponding LED
                                                                        */
/*                  P1.16 to P1.31 are output switch                   */

/*****************************************************************************/

#include<LPC214x.H>

int main()
{

        IO1DIR=0xFFFF0000;                          // P1.16 TO P1.31 OUTPUTPIN

         while(1)
           {
                        IOCLR1 = 0xFFFF0000; // output pin cleared for enable the led
                }
         }
```

SWITCH AND LED PORT DETAILS

ARM	DETAILS
P1.16	S&L ENABLE PIN
P1.17	S&L ENABLE PIN
P1.18	S&L ENABLE PIN
P1.19	S&L ENABLE PIN
P1.20	S&L ENABLE PIN
P1.21	S&L ENABLE PIN
P1.22	S&L ENABLE PIN
P1.23	S&L ENABLE PIN
P1.24	S&L ENABLE PIN
P1.25	S&L ENABLE PIN
P1.26	S&L ENABLE PIN
P1.27	S&L ENABLE PIN
P1.28	S&L ENABLE PIN
P1.29	S&L ENABLE PIN
P1.30	S&L ENABLE PIN
P1.31	S&L ENABLE PIN

```
/*****************************************************************************/
```

PWM.C

```
/*****************************************************************************/
/* Place lcd.c file into following directories C:\Keil\ARM\INC\Philips.*/
/* This program is used to Generate the PWM, Frequency and Duty cycle can be changed*/
*****************************************************************************/

#include<LPC214x.H>

int main(void
{

PINSEL1 |= 0x00000400;//Enablepin0.7          asPWM2
PWMPR           =0x00000100;      //Load prescaler (to vary the frequency can modify here)

PWMPCR=0x00002000;     //PWM channel single edge control, output enabled
PWMMCR = 0x00000003; //On match with timer reset the counter

/* PWMR0 AND PWMR5 Both Value can change the duty cyle ex : PWMR0 = 10 AND PWMR5 = 2*/
PWMMR0 = 0x00000010; //set cycle rate to sixteen ticks
PWMMR5 = 0x00000008; //set rising edge of PWM2 to 2 ticks

PWMLER = 0x00000021; //enable shadow latch for match 0 - 2
PWMTCR = 0x00000002; //Reset counter and prescaler
PWMTCR = 0x00000009; //enable counter and PWM, release counter fromreset
while(1)      // mainloop
 {
 }
}
```

PWM PROGRAM PORT DETAIL

ARM	DETAILS
P0.7	PWM2

Post Lab Questions

1. How do the variations in an average value get affected by PWM period?
2. Name the common formats available for LED display
3. Why are the pulse width modulated outputs required in most of the applications?
4. How do you determine the duty cycle of the waveform ?
5. What is the function of GPIO?

Result

The C code is generated for Switch & LED and output is verified in LED's by Switches
The C code is generated for PWM and to vary the duty cycle and verified in CRO output.

4. INTERFACING REAL TIME CLOCK PROGRAM AND SERIAL PORT

Aim

To develop a C-Language program for reading the RTC, convert into decimal and to display it.

Pre Lab Questions

1. How would you define real time clock?
2. List the applications of real time clock.
3. What is the baud rate of serial port ?
4. Compare serial communication and parallel communication.
5. Enumerate the different modes of communication.

Apparatus & Software Required

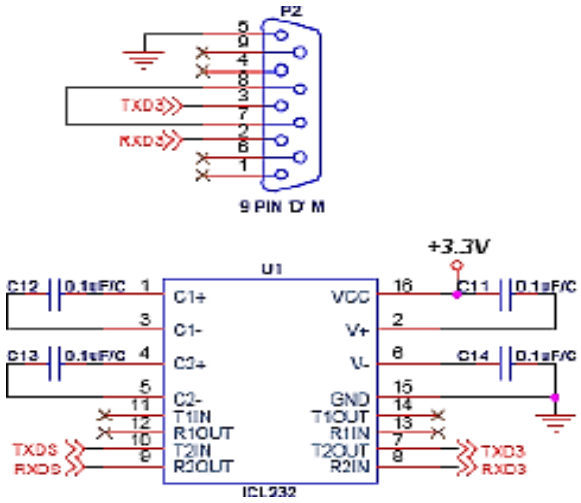
1. LPC2148 Development board.
2. KeilµVision 5 software.
3. Flash Magic.
4. USB cable.
5. RS232 Serial cable.

Theory

The Real Time Clock (RTC) is a set of counters for measuring time when system power is on, and optionally when it is off. It uses little power in Power-down mode. On the LPC2141/2/4/6/8, the RTC can be clocked by a separate 32.768 KHz oscillator, or by a programmable prescale divider based on the VPB clock. Also, the RTC is powered by its own power supply pin,VBAT,which can be connected to a battery or to the same 3.3 V supply used by the rest of the device.

Serial Communication

Serial communication takes a byte of data and transmits the 8 bits in the byte one at a time. The advantage is that a serial port needs only one wire to transmit the 8 bits (while a parallel port needs 8). The disadvantage is that it takes 8 times longer to transmit the data than it would if there were 8 wires. Serial ports lower cable costs and make cables smaller.



Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

```
/*****************************************************************/
```

RTC.C

```
/*****************************************************************/

        /* Place lcd.c file into following directories C:\Keil\ARM\INC\Philips.******/
      /* This program is used to interface the RTC.You can change the date and time*/
     /* If you want. This Program can both Read and write data into RTC.RTC has a*/
   /* Battery backup for continuous Running. ************************************/
                                                    /*
pclk = 30,000,000 Hz
PREINT = (int)(pclk/32768)-1
PREFRAC = pclk - ((PREINT+1) x 32768)
*/
#include<LPC214X.H>
#include<lcd.c>
int main()
{
unsigned int hrs,min,sec;
            wait();
             wait();
             wait();
             wait();
             lcdinit();clrs
             cr(2);
             printstr("SM MICRROSYSTEM",0,0);
             printstr("         ARMDEVKIT  ",0,1);

             VPBDIV = 0x00000002; // VPB bus clock is one half of the processor clock(cclk)

             PREINT = 0x00000392; // Set RTC prescaler for 30MHz Pclk
                                                    // PREINT = (int) (30,000,000/32768(RTC
crystal))-1 = 914
              PREFRAC = 0x00004380;
              CIIR=0x00000001;          // Enable seconds counterinterrupt
              CCR=0x00000001;                  // Start theRTC
            YEAR=2009;           // Year
       MONTH=11;          //Month
       DOM=25;           // Day of month
       DOY=0;           // Day ofyear
           DOW=0;          // Day of week
           HOUR=18;          //Hours
           MIN=30;           // Minutes
           SEC =30;
           printstr("                                    ",0,1);
           while(1)
           {
              gotoxy(0,1);hrs
              = HOUR; min
              = MIN; sec =
              SEC;
              split_numbers(hrs);lcdd
              at(tens+0x30);
              lcddat(ones+0x30);
              lcddat(':');
              split_numbers(min);lcd
              dat(tens+0x30);
```

```
            lcddat(ones+0x30);
            lcddat(':');
            split_numbers(sec);lcdd
            at(tens+0x30);
            lcddat(ones+0x30);
            //lcddat(':');
        }
}
```

RTC PROGRAM PORT DETAILS

PORT	INBUILT

SERIAL PORT PROGRAM

```
/*****************************************************************/
                    /* Uart0 Initialization */

  /* This is a test program to send and receive data via uart0 in theARMLPC2148   */
                          Development board itself
 /*******************************************************************************
#include<LPC214x.H>                     /* LPC214x definitions*/
   #include"uart0.h"                    /* contains prototypes of driverfunctions*/


   int main (void)
    {
      unsigned char *s1;
      initserial();                     /* uart0 initialization */
      send_string("***********************************************");
      send_string("                  SMMicrroSystem               ");
      send_string("                     Tambaram                  ");
      send_string("                      Chennai                  ");
      send_string("***********************************************");
      send_string("");send_string("");
      send_string("This program Echos the string entered byuser."); send_string("So,type
      some strings and press ENTERkey");

      while(1)                          /* Loop forever*/
        {
              s1 = receive_string();
              send_string(s1);
        }

                                                  }
          /*****************************************************************************/
                                    SERIAL PORT PROGRAM

              /*****************************************************************************/
                                    /* Uart1 Initialization */
              /*****************************************************************************/
   #include<lpc214x.h>#inc
   lude<stdio.h>
   #include<stdlib.h>

   #include "uart1_driver.c"



   int main()
   {
   unsigned char *a;
   //unsigned char *w;
   a=malloc(sizeof(100));

   inituart1();
   sendstring1("ABCDEFGHIJKLMNOPQRSTUVWXYZ");
   sendstring1("ABCDEFGHIJKLMNOPQRSTUVWXYZ");
```

```
sendstring1("ABCDEFGHIJKLMNOPQRSTUVWXYZ");
sendstring1("ABCDEFGHIJKLMNOPQRSTUVWXYZ");
sendstring1("ABCDEFGHIJKLMNOPQRSTUVWXYZ");
   /*sendstring1("          *         ");
   sendstring1("          **  ");
   sendstring1("         ***  "); s
   endstring1("        * ***  "); sendstring1(" *
   * * * * ");
   sendstring1(" SM MICRRO ");
   sendstring1(" * * * * * ");
   sendstring1("       * ***  "); sendstring1("
                       ***   ");
   sendstring1("         **   ");
    sendstring1("          *         ");          */

   while(1)
   {
   receivestring1(a);send
   string1(a);

   }
      }
```

SERIAL PROGRAM

PORTDETAILSUART0

ARM	DETAILS
P0.0	TXDO
P0.1	RXDO

UART1

ARM	DETAILS
P0.8	TXD1
P0.9	RXD1

Post Lab Questions

1. What is I2C and how does it work?
2. Summarize the features of I2C in LPC2148 ARM7 microcontroller.
3. Through which port the date and time is displayed in RTC?
4. What is a serial port?
5. **List the registers used to transfer data in serial port.**

Result

The C-Language program for reading RTC and displaying it in LCD was written & output is verified with running the RTC from a default/specified time.

5.INTERFACING KEYBOARD ANDLCD

MATRIX KEYBOARD PROGRAM

Aim

To develop a C-Language program for displaying the Key pressed in the Keypad in the LCD module. The display should come in the desired line and column.

Pre Lab Questions

1. Mention the function of pull up resistor?
2. Outline the keyboard matrix.
3. Summarize the working principal of LCD.
4. What kind of interrupt is generated if a key has to be operated in an interrupt mode?
5. How many rows and columns are present in a 16 x 2 alphanumeric LCD?

Apparatus & Software Required

1. LPC2148 Development board.

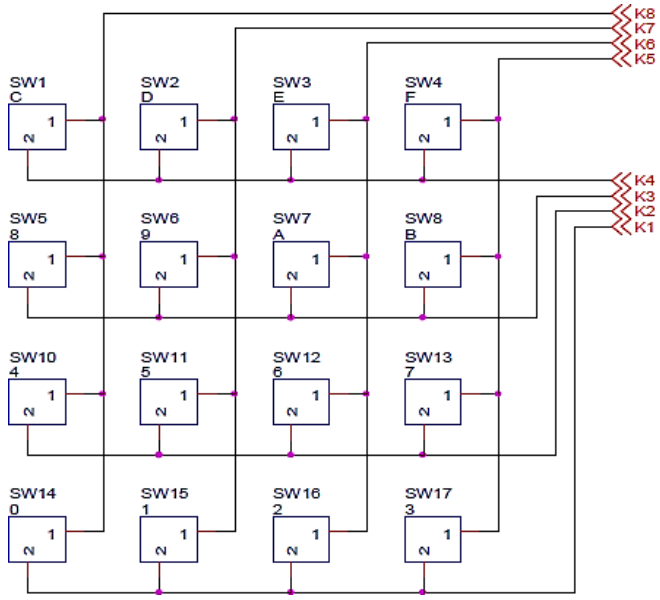
2. KeilµVision5software.

3. Flash Magic.

4. USB cable.

Theory

The Matrix keyboard is used to minimize the number of I/O lines. Normally it is possible to connect only one key or switch with an I/O line. If the number of keys in the system exceeds the more I/O lines are required. To reduce the number of I/O lines the keys are connected in the matrix circuit. Keyboards use a matrix with the rows and columns made up of wires. Each key acts like a switch. When a key is pressed a column wire makes contact with row wire and completes a circuit. For example 16 keys arranged in a matrix circuit uses only 8 I/O lines.



Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

```
/*****************************************************************/
```

MAIN.C

```
/*****************************************************************************/
/* Description: This program gets input from Matrix key board and displays
corresponding */
/*                  Key value in 7segment display. Hence this program demonstratesboth
*/                     7 segment display as well as Matrix keyboard.*/
/*                  P1.16 to P1.23 are inputs from matrix keyboard,*/
/*                  P1.24 to P1.31 are outputs to 7 segmentdisplay
*/
/*****************************************************************************
****/
/*                  ------- matrix key boarddescription----------
*/
/*                  --          --          --          --
*/
/*   row1     --| c |----| d |-- --| e |-- --|F|--                  (SW1,SW2,SW3,SW4)
*/
/*                  --          --          --          --
*/
/*                  --          --          --          --
*/
/*   row2     --| 8 |-- --| 9 |-- --| A |---- |b|--                  (SW5,SW6,SW7,SW8)
*/
/*                  --          --          --          --
*/
/*                  --          --          --          --
*/
/*   row3     --| 4 |-- --| 5 |-- --| 6 |-- --|7|--                   (SW9,SW10,SW11,SW12)
*/
/*                  --          --          --          --
*/
/*                  --          --          --          --
*/
/*   row4     --| 0 |-- --| 1 |-- --| 2 |-- --|3|--                  (SW13,SW14,SW15,SW16)
*/
/*                  --          --          --          --*/
/*****************************************************************************/
#include <LPC214x.h>
#include "mat_7seg.h"
int main()
{
  unsigned int key, last_key, Disp_key;
  init_Matrix_7seg();          // Initialize matrix keyboard and 7segment dispaly
  clearall_7seg();             // clear 7 segmentdisplay
  last_key=0;                           // Initialize this variable to zero
  while(1)
      {
          key=catch_key();          // scan for a valid keypress
          if(key!=0)                        // zero means no key ispressed
          {
            if(key!=last_key)       // check whether the same key is pressed again(assume this as STEP1)
              {
```

```
                    Disp_key=key;              // valid new key is stored in anothervariable
                    last_key=key;           // this variable's value is used forSTEP1
                  }
               }
               //Display_Number(Disp_key);            /*this function is used to display number in
decimalformat*/
               Alpha_Dispay(4,Disp_key);                  /*this function is used to display number in hex format
(single digitonly)*/
            }

}


 /*****************************************************************************/
                              MATRIX SEVEN SEGMENT DRIVER.C
            /*************************************************************/

#include <LPC214x.h>
#include "defs.h"
                                  /*********************************Global
                               variables*****************************************/
                                     unsigned int thousands,hundreds,tens,ones;
     /*****************************************************************************
                                                ******/

     void init_Matrix_7seg(void)
      {
          IODIR1 |= 0xff0f0000; // set 7seg LEDs as output ports and matrix's MSB as
inputs and LSB as outputs
               IODIR0|=S7SEG_ENB;          // set P0.19 to P0.22 as outputs to drive 7segenable
pins
               IOPIN0|=S7SEG_ENB;                  // since we are using active low 7 seg display,the
                                                  enable signals
                                                // should be initially set to HIGH.
      }

/*****************************************************************************
*******/
     unsigned long scan_row(unsigned int row_num)
            {
               //unsigned int row,i;
               unsigned long val;

               IOSET1=ROW_MASK;      //clear the previous scan row output ie make all row opshigh
               switch(row_num)
                 {
                              case 1: IOCLR1 = ROW1;break; // make P1.16 low
                              case 2: IOCLR1 = ROW2;break; // make P1.17 low
                              case 3: IOCLR1 = ROW3;break; // make P1.18 low
                              case 4: IOCLR1 = ROW4;break; // make P1.19 low
                                          //default: row = ERR;
                 }
//             for(i=0;i<=65000;i++);
               val=IOPIN1;                    // read the matrixinputs
               val = ((val >> 20) & 0x0000000F)^0x0000000F; // shift the colum value so that it comes to LSB
                                                                  // XORing is done to take 1's
complement of shifted value.
                                                                                        //
               return(val);
            }
```

```
unsigned int catch_key(void)
  {
        unsigned long v; v =
        scan_row(1);
        switch(v)
          {
            case 1:return(13);
            case 2:return(14);
            case 4:return(15);
            case 8:return(16);
          }
     v = scan_row(2);
        switch(v)
          {
            case  1: return(9);
            case 2:return(10);
            case 4:return(11);
            case 8:return(12);
          }
     v = scan_row(3);
        switch(v)
          {
            case 1:return(5);
            case 2:return(6);
            case 4:return(7);
            case 8:return(8);
          }
     v = scan_row(4);
        switch(v)
          {
            case 1:return(1);
            case 2:return(2);
            case 4:return(3);
            case 8: return(4); default:
            return(0);
          }
      }
/*****************************************************************************************
*****/
    void clearall_7seg(void)
      {
            IOPIN1 &= ~S7SEG_LED; // make all the 7seg led pins toLOW
            IOPIN0|=S7SEG_ENB               // Disable all the 7 segdisplay
      }
/*****************************************************************************************
****/
    void clearDigit_7seg(int digit_num)
      {
            IOPIN0 |= S7SEG_ENB; // clear enables first
            switch(digit_num)
              {
                case 1: {
                              IOPIN0 =   ~DIGI1_ENB;          // now  enable  only  the  digit1
                        break;
                              }
                 case  2:  {
                              IOPIN0 =  ~DIGI2_ENB;          // now  enable  only  the  digit2
                        break;
                              }
                 case  3:  {
                              IOPIN0 =  ~DIGI3_ENB;          // now  enable  only  the  digit3
```

```
                                    break;
                                        }
                    case 4: {
                                IOPIN0=~DIGI4_ENB;              // now enable only the digit4 break;
                                        }
                     }
                    IOPIN1&=~S7SEG_LED;         // make all the 7seg LED pinsLOW
              }
/*****************************************************************************************
*****/
    void Digit_Dispay(int digit_num, unsigned int value)
       {
            clearDigit_7seg(digit_num);switch(
            value)
             {
                    case  0:    IOPIN1  |=   ZERO;break;
                    case  1:    IOPIN1  |=   ONE; break;
                    case  2:    IOPIN1  |=   TWO; break;
                    case  3:    IOPIN1  |=   THREE; break;
                    case  4:    IOPIN1  |=   FOUR; break;
                    case  5:    IOPIN1  |=   FIVE; break;
                    case  6:    IOPIN1  |=   SIX; break;
                    case  7:    IOPIN1  |=   SEVEN; break;
                    case  8:    IOPIN1  |=   EIGHT; break;
                    case  9:    IOPIN1  |=   NINE; break;
                }
          }
/*****************************************************************************************
*****/
    void Alpha_Dispay(int digit_num, unsigned int value)
       {
            clearDigit_7seg(digit_num);switch(
            value)
             {
                    case  1:    IOPIN1  |=   ZERO;break;
                    case  2:    IOPIN1  |=   ONE; break;
                    case  3:    IOPIN1  |=   TWO; break;
                    case  4:    IOPIN1  |=   THREE; break;
                    case  5:    IOPIN1  |=   FOUR; break;
                    case  6:    IOPIN1  |=   FIVE; break;
                    case  7:    IOPIN1  |=   SIX; break;
                    case  8:    IOPIN1  |=   SEVEN; break;
                    case  9:    IOPIN1  |=   EIGHT; break;
                   case10:       IOPIN1 |= NINE; break; case
                   11: IOPIN1 |= AAA; break; case 12:
                   IOPIN1 |= bbb; break; case 13: IOPIN1 |=
                   ccc; break; case 14: IOPIN1 |= ddd; break;
                   case 15: IOPIN1 |= eee; break; case 16:
                   IOPIN1 |= fff;break;
                }
          }
/*****************************************************************************************
******/
    void split_numbers(unsigned int number)
      {
        thousands = (number /1000);
        number %= 1000;
        hundreds = (number / 100);
        number %= 100;
        tens = (number / 10);
        number %= 10;
```

```
        ones = number ;
      }
/*****************************************************************************************
******/
    void Display_Number(unsigned int num)
      {
            unsigned int i;
            if(num <= 9999)
            {
              clearall_7seg();
              split_numbers((unsignedint)num);
              Digit_Dispay(4, ones);
              for(i=0;i<10000;i++);
              Digit_Dispay(3, tens);
              for(i=0;i<10000;i++);
              Digit_Dispay(2,hundreds);
              for(i=0;i<10000;i++);
              Digit_Dispay(1,thousands);
              for(i=0;i<10000;i++);
            }

          }
```

MATRIX SEVEN SEGMENT PROGRAM PORT DETAIL

ARM	DETAILS
P0.19	SEGMENT ENABLE PIN
P0.21	SEGMENT ENABLE PIN
P0.22	SEGMENT ENABLE PIN
P1.16	KEY BOARD INPUT
P1.17	KEY BOARD INPUT
P1.18	KEY BOARD INPUT
P1.19	KEY BOARD INPUT
P1.20	KEY BOARD INPUT
P1.21	KEY BOARD INPUT
P1.22	KEY BOARD INPUT
P1.23	KEY BOARD INPUT
P1.24	OUTPUT SEGMENT
P1.25	OUTPUT SEGMENT
P1.26	OUTPUT SEGMENT
P1.27	OUTPUT SEGMENT
P1.28	OUTPUT SEGMENT
P1.29	OUTPUT SEGMENT
P1.30	OUTPUT SEGMENT

LCD PROGRAM

/***/

LCD.h

/***/

```
void clrscr(char ch);
void lcdinit(void);
void lcdcmd(char);
void lcddat(char);
void gotoxy(char,char); //x,y ; x-char position(0 - 16) y-line number 0 or1
voidprintstr(char*,char,char);                    //string,column(x),line(y)
void wait (void);
void split_numbers(unsigned int number);
void Wait_Msg(void);
void Welcome_Msg(void);
```

/***/

LCD.c

/***/

```
#include <LPC214x.h>

#defineRS            0x00000400     /* P0.10 */
#defineCE            0x00001800     /* P1.11 */

void clrscr(char ch); void
lcdinit(void); void
lcdcmd(char); void
lcddat(char);
void gotoxy(char,char); //x,y ; x-char position(0 - 16) y-line number 0 or1
voidprintstr(char*,char,char);                    //string,column(x),line(y)
void wait (void);
void split_numbers(unsigned int number);

#define SET1
#define OFF0

unsigned int thousands,hundreds,tens,ones;

voidwait(void)            {                                  /* wait function */ int
            d;
   for (d = 0; d <100000;d++);                              /* only to delay for LED flashes*/
}

void lcdinit()
{
       IODIR0 |= 0x0000FFFF;
            IOCLR0 |= 0X00000FFF;
            lcdcmd(0x28);lcd
       cmd(0x28);
       lcdcmd(0x0c);
       lcdcmd(0x06);
       lcdcmd(0x01);
```

```
            lcdcmd(0x0f);wait();
}

void gotoxy(char x, char y)
{
      if(y == 0)
            lcdcmd(0x80+x);
      else
            lcdcmd(0xc0+x);

}

void printstr(char *str, char x, char y)
{
      char i; gotoxy(x,y);
      wait();//(500);
      for(i=0;str[i]!='\0';i++)lcddat(str[i
            ]);

}
void lcdcmd(charcmd)
{
unsigned charLCDDAT;
            LCDDAT = (cmd&0xf0);          //higher nibble
            IOSET0 =LCDDAT;
        IOCLR0 = RS;
            IOSET0 = CE;
        wait();//(100);                                  //enablelcd
            IOCLR0 = CE;
            IOCLR0 = 0X00000FFF;


        LCDDAT = ((cmd<<0x04)&0xf0);                     //lower nibble
            IOSET0 =LCDDAT;
        IOCLR0 = RS;
            IOSET0 = CE;
        wait();//(100);                                  //enablelcd
            IOCLR0 = CE;
            IOCLR0 = 0X00000FFF;

}

void lcddat(char cmd)
{
    unsigned charLCDDAT;
            LCDDAT = (cmd&0xf0);          //higher nibble
            IOSET0 =LCDDAT;
        IOSET0 = RS;
            IOSET0 = CE;
        wait();//(100);                                  //enablelcd
            IOCLR0 = CE;
            IOCLR0 = 0X00000FFF;

        LCDDAT = ((cmd<<0x04)&0xf0);                     //lower nibble
            IOSET0 =LCDDAT;
        IOSET0 = RS;
            IOSET0 = CE;
        wait();//(100);                                  //enablelcd
            IOCLR0 = CE;
```

```
  IOCLR0 = 0X00000FFF;
  }

void clrscr(char ch)
{
        if(ch==0)
        {
                printstr("                                ",0,0);
                gotoxy(0,0);
        }
        else if(ch ==1)
        {
                printstr("                                ",0,1);
                gotoxy(0,1);
        }
        else
        {
                  lcdcmd(0x01);
                    //delay(100);
        }
}

void split_numbers(unsigned int number)
{
    thousands = (number /1000);
    number %= 1000;
    hundreds = (number / 100);
    number %= 100;
    tens = (number / 10);
    number %= 10;
    ones = number ;
}

void Wait_Msg(void)
{
  lcdcmd(0x01);
  printstr("          PLEASEWAIT     ", 0,0);
}
void Welcome_Msg(void)
{
  lcdcmd(0x01);
  printstr("            WELCOMETO ", 0,0);
  printstr("SM MICRRO SYSTEM", 0,1);
}
```

```
/*****************************************************************************/
                                LCDmain.c
/*****************************************************************************/
/* This is a test program to display strings in LCD module in theARMLPC2148Development board itself*/
/*****************************************************************************/
 #include<LPC214x.H>            /* LPC214x definitions*/
#include"lcd.h"                 /* includes lcd driverfuntions*/

int main (void)
  {
    lcdinit();                  /*Initializelcd*/
    Wait_Msg();         /*Display message - "Please Wait"*/ Welcome_Msg();
                        /*Display message - "Welcome to SMMICRRO"*/

    while(1)                    /*LoopForever*/
      {

          }
```

LCD PROGRAM PORT DETAILS

ARM	Details
PO.10	RS LCD PIN
P1.11	CE LCD PIN

Post Lab Questions

1. Outline the operations involved when the key in a 4 x 4 keyboard matrix is being pressed.
2. List the registers used to store the keyboard, display modes and other operations programmed by CPU.
3. What is switch bouncing ? How to prevent it using de-bounce circuit?
4. How to adjust the contrast of the LCD?
5. Which command of an LCD is used to shift the entire display to the right?

Result

The C-Language program for displaying the Key pressed in the Keyboard is displayed in the seven segment display and LCD module and the output was verified on the LCD on the desires line and column/address.

6. INTERFACING EPROM AND INTERRUPT

Aim

To develop a C-Language program to write and read a data in EEPROM and also to analyze its performance with the interrupt

Pre Lab Questions

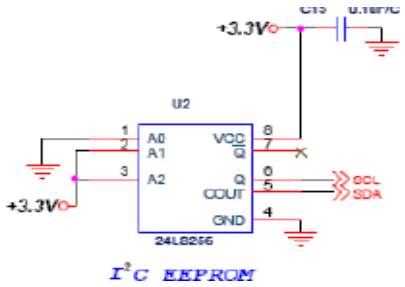
1. What is an edge triggering ?
2. Mention the advantages and disadvantages of level triggering pulse.
3. Differentiate EPROM and ROM.
4. List the different types of Memory devices.
5. Which interrupt is said to be non maskable interrupt , Why?

Apparatus & Software Required

1. LPC2148 Development board.
2. Keil µVision5 software.
3. Flash Magic.
4. USB cable.

Theory

Serial-interface EEPROM's are used in a broad spectrum of consumer, automotive, telecommunication, medical, industrial and PC related markets. Primarily used to store personal preference data and configuration/setup data, Serial EEPROM's are the most flexible type of nonvolatile memory utilized today. Compared to other NVM solutions, Serial EEPROM devices offer a lower pin count, smaller packages, lower voltages, as well as lower powerconsumption.



I²C EEPROM

Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

EPROM PROGRAM

/***/

I2C .C

/***/

```
/* This Program For I2C  Interface */
#include<LPC214x.H>
#include "lcd.c"

void InitI2C (void);
void SendI2C Address(unsigned char Addr_S); void
WriteI2C (unsigned char Data);
void StopI2C (void); void
StartI2C (void);

#define    STA    0x20
#define    SIC    0x08
#define     SI    0x08
#define    STO    0x10
#define   STAC   0x20
#define AA 0x04

void InitI2C (void)
{
    I2C 0CONCLR = 0xFF;
    PINSEL0   |=0x50;          //     Set pinouts as scl andsda
    I2C 0SCLL    =19;          //speed at 100Khz for a VPBClockDivider          = 4 at 12 MHz
    I2C 0SCLH    =19;
    I2C 0CONSET=0x40;          //Active Master Mode on I2C bus
}


void SendI2C Address(unsigned char Addr_S)
{
      while(I2C 0STAT!=0x08);          // Wait for start to becompleted
      I2C 0DAT     =Addr_S;            // Charge slaveAddress
      I2C 0CONCLR = SIC|STAC;          // Clear I2C  interrupt bit to send the data
      while(!( I2C 0CONSET &SI));      // wait till statusavailable
}


unsigned char ReadI2C (void)
{
unsigned char r;
```

```
        I2C 0CONCLR = SIC;
        I2C 0CONSET=0x04;                       // clearSIC;
    while(!(I2C 0CONSET&0x8));                  // wait till statusavailable r=I2C
    0STAT;
        wait();                                 // check forerror
    if (r==0x50){                               // look for "Data byte has been received; ACKhas been returned"
         lcdcmd(0x01);
            printstr("Read Sucess",0,0);
    }

    return I2C 0DAT;
}

void WriteI2C (unsigned char Data)
{
    unsigned char r;
    I2C 0DAT    =Data;                          // ChargeData
    I2C 0CONCLR=0x8;                            // SIC; Clear I2C interrupt bit to send thedata while(!(I2C
    0CONSET&0x8));                              // wait till statusavailable
    r=I2C 0STAT;
    if (r == 0x28)
        {                           // look for "Data byte in S1DAT has been transmitted; ACKhas been received"
       lcdcmd(0x01);
          printstr("Write Sucess",0,0);
    }
}
void StopI2C (void)
{
    I2C 0CONCLR = SIC;
    I2C 0CONSET =
    STO;
    while((I2C 0CONSET&STO));                   // wait for Stopped busI2C
}

void StartI2C (void)
{
     I2C 0CONCLR=0xFF;                          // clear I2C  - included if User forgot to "StopI2C ()"
                                                // else this function would hang.
    I2C 0CONSET=0x40;                           // Active Master Mode on I2C  bus I2C
        0CONSET=0x00000020;                         // Startcondition
}
int main()
{

  unsigned char r;

            wait();
            wait();
            wait();
            wait();
            lcdinit();clrsc
            r(2);
            printstr("SM MICRRO SYSTEM",0,0);
            printstr("          ARMDEVKIT    ",0,1);
       InitI2C ();
            StartI2C ();
            SendI2C Address(0xa0);          // EEPROM device address
       WriteI2C (0);                        // Set the control portvalue
            WriteI2C ('B');
```

```
        StopI2C
        ();wait();
        wait();
        StartI2C ();
        SendI2C Address(0xa0);          // EEPROM device address
    WriteI2C (0);                       // Set the control portvalue
        StopI2C ();
        StartI2C ();
        SendI2C Address(0xa1);          // Start the read
        r=ReadI2C ();                   // read the result
        StopI2C ();
        gotoxy(0,1);
        split_numbers(r);
        lcddat(0x30+hundreds);lcdda
        t(0x30+tens);
        lcddat(0x30+ones); while(1);

  }
/*****************************************************************************************/
```

LCD.C

```
/*****************************************************************************************/

#defineRS           0x00000400    /* P0.10 */
#defineCE           0x00001800    /* P1.11 */
void clrscr(char ch); void
lcdinit(void); void
lcdcmd(char); void
lcddat(char);
void gotoxy(char,char); //x,y ; x-char position(0 - 16) y-line number 0 or1
voidprintstr(char*,char,char);                  //string,column(x),line(y)
void wait (void);
void split_numbers(unsigned int number);
#define SET1
#define OFF0
unsigned int thousands,hundreds,tens,ones;
voidwait(void)          {                       /* wait function */
intd;
  for (d = 0; d <100000;d++);                   /* only to delay for LED flashes*/
}

void lcdinit()
{
    IODIR0 = 0xFFFFFFFF;
      IOCLR0 = 0X00000FFF;
      lcdcmd(0x28);
    lcdcmd(0x28);
    lcdcmd(0x0c);
    lcdcmd(0x06);
    lcdcmd(0x01);
    lcdcmd(0x0f);
    wait();//(1600);
}
```

```
void gotoxy(char x, char y)
{
        if(y == 0)
                lcdcmd(0x80+x);
        else
                lcdcmd(0xc0+x);


}
void printstr(char *str, char x, char y)
{
        char i; gotoxy(x,y);
        wait();//(500);
        for(i=0;str[i]!='\0';i++)lcddat(str[i
                ]);

}
void lcdcmd(charcmd)
{
unsigned charLCDDAT;
                LCDDAT = (cmd&0xf0);                    //higher nibble
                IOSET0 =LCDDAT;
          IOCLR0 = RS;
                IOSET0 = CE;
          wait();//(100);                                       //enablelcd
                IOCLR0 = CE;
                IOCLR0 = 0X00000FFF;


          LCDDAT = ((cmd<<0x04)&0xf0);                  //lower nibble
                IOSET0 =LCDDAT;
          IOCLR0 = RS;
                IOSET0 = CE;
          wait();//(100);                                       //enablelcd
                IOCLR0 = CE;
                IOCLR0 = 0X00000FFF;

}


void lcddat(char cmd)
{
     unsigned charLCDDAT;
                LCDDAT = (cmd&0xf0);                    //higher nibble
                IOSET0 =LCDDAT;
          IOSET0 = RS;
                IOSET0 = CE;
          wait();//(100);                                       //enablelcd
                IOCLR0 = CE;
                IOCLR0 = 0X00000FFF;
          LCDDAT = ((cmd<<0x04)&0xf0);                  //lower nibble
                IOSET0 =LCDDAT;
          IOSET0 = RS;
                IOSET0 = CE;
          wait();//(100);                                       //enablelcd
                IOCLR0 = CE;
                IOCLR0 = 0X00000FFF;
}
void clrscr(char ch)
{
```

```
        if(ch==0)
        {
                printstr("                              ",0,0);
                gotoxy(0,0);
        }
        else if(ch ==1)
        {
                printstr("                              ",0,1);
                gotoxy(0,1);
        }
        else
        {
                lcdcmd(0x01);
                  //delay(100);
        }
}

void split_numbers(unsigned int number)
{
   thousands = (number /1000);
   number %= 1000;
   hundreds = (number / 100);
   number %= 100;
   tens = (number / 10);
   number %= 10;
   ones = number ;
}
```

EPROM (I2C) PROGRAM PORT SETAILS

ARM	DETAILS
PO.10	RS LCD PIN
P1.11	CE LCD PIN
P0.11	SCL
P0.14	SDA

INTERRUPT BUZZER PROGRAM

/***/

ExtDriver.C

/***/

```
#include <LPC214x.h>
  void init_VIC(void)
    {
                /* initialize VIC*/
        VICIntEnClr       =0xffffffff;
        VICVectAddr     =0;
        VICIntSelect =0;
    }


  void ExtInt_ISR(void)irq
  {
    //EXTINT=(1<<2);             /* clear EINT2 flag by writing HIGH to corespondingbit*/
    //IOCLR0 = 0x40000000; /* Trigger the relay*/
              IOCLR1 = 0x400f0000; /* P1.18 Trigger the relay*/
            //IOPIN1 = 0x00000000;
    EXTINT = (1<<2);
    VICVectAddr=0;                      /* Acknowledge Interrupt*/
  }
  void init_Interrupt(void)
        {
                PINSEL0=0x80000000;               // select P0.15 for EINT2
                VICIntEnable = (1<<16);                 // External interrupt 2(EINT2)
                VICVectCntl0=(1<<5)|(16);               // set the VIC control reg for EINT2
                VICVectAddr0 = (unsignedlong)ExtInt_ISR;
                EXTMODE&=~(1<<2);       // set VIC for egdse sensitive forEINT2
//              EXTPOLAR = ~(1<<2); // set VIC for falling edge sensitive forEINT2
            }
  void init_ports(void)
        {
                IODIR0    =    0x40000000;
                IODIR1    =    0x400f0000;
                IOPIN1    =    0xff010000;
                IOSET0 = 0x40000000;
                        IOSET1 = 0x400f0000;

            }
  /*void wait_for_turnoffRelay(void)
        {
                int val;
                val=IOPIN1;                                     // read the ports for key board input
                while((~(val>>20))!=0);                         // wait until 1st key in the matrixkeyboard
is pressed
                IOCLR0=0x00010000;                      // switch off therelay
            }*/
```

```
/*****************************************************************************/
                                XINTR_RELAY.C
/*****************************************************************************/
#include <LPC214x.h>
#include "ext.h"
int main()
 {
    init_VIC();
    init_Interrupt();init_po
    rts();
        while(1)
                {
                   //wait_for_turnoffRelay();
                }
 }
```

INTERRUPT BUZZERPROGRAM

ARM	DETAILS
P1.18	TRIGGER THE RELAY
P0.15	EINT2

Post Lab Questions

1. What will be the initial values in all the cells of an EPROM ?
2. What are the contents of the IE register, when the interrupt of the memory location 0x00 is caused?
3. Why normally LJMP instructions are the topmost lines of the ISR?
4. Enumerate the features of nested interrupt.
5. Illustrate the Master Slave mode.

Result

The C-Language program to write and read a data in EEPROM and also to analyze its performance with the interrupt is developed and is verified.

7. MAILBOX

Aim

To develop a ‘C’code to create a mailbox and to understand the RTOS functions.

Pre Lab Questions

1. How does mailbox works in RTOS?
2. What is Semaphore?
3. Differentiate mailbox and queue.
4. List the synchronous and asynchronous modes are there in serial port?
5. Interpret the inter process communication

Apparatus & Software Required

1. LPC2148 Development board.
2. KeilµVision5 software.
3. Flash Magic.
4. USB cable.

.

Theory

Real-time and embedded systems operate in constrained environments in which computer memory and processing power are limited. They often need to provide their services within strict time deadlines to their users and to the surrounding world. It is these memory, speed and timing constraints that dictate the use of real-time operating systems in embedded software.

The "kernel" of a real-time operating system ("RTOS") provides an "abstraction layer" that hides from application software the hardware details of the processor (or set of processors) up on which the application software will run.

In providing this "abstraction layer" the RTOS kernel supplies five main categories of basic services to application software

The most basic category of kernel services is Task Management. This set of services allows application software developers to design their software as a number of separate "chunks" of software -- each handling a distinct topic, a distinct goal, and perhaps its own real-time deadline. Each separate "chunk" of software is called a "task." The main RTOS service in this category is the scheduling of tasks as the embedded system is in operation.

The second category of kernel services is Inter task Communication and Synchronization. These services make it possible for tasks to pass information from one to another, without danger of that information ever being damaged. They also make it possible for tasks to coordinate, so that they can productively cooperate with one another. Without the help of these RTOS services, tasks might well communicate corrupted information or otherwise interfere with each other. Since many embedded systems have stringent timing requirements, most RTOS kernels also provide some basic Timer services, such as task delays and time-outs.

Many (but not all) RTOS kernels provide Dynamic Memory Allocation services. This category of services allows tasks to "borrow" chunks of RAM memory for temporary use in application software. Often these chunks of memory are then passed from task to task, as a means of quickly communicating large amounts of data between tasks. Some very small RTOS kernels that are intended for tightly memory-limited environments, do not offer Dynamic memory allocation.

Many (but not all) RTOS kernels also provide a "Device I/O Supervisor" category of services. These services, if available, provide a uniform framework for organizing and accessing the many hardware device drivers that are typical of an embedded system.

Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

/***/

MAILBOX.C

/***/

```
#include <string.h>
#include <stdio.h>
#include <RTL.h>
#include <LPC214x.H>                        /* LPC214x definitions                  */
#include "config.h"
#include "uart.h" #include
"lcd.h"

OS_TID tsk1;                                /* assigned identification for task 1   */
OS_TID tsk2;                                /* assigned identification for task 2   */


typedefstruct{                              /* Messageobjectstructure               */
   charmsgBuf[MBOX_MSG_BUF_SIZE];
} T_MEAS;

os_mbx_declare(MsgBox,MAILBOX_MEMORY_POOL_CNT); /* Declare an RTXmailbox*/
_declare_box (mpool,sizeof(T_MEAS),MAILBOX_MEMORY_POOL_CNT);/* Dynamic memory pool*/

task void send_task (void);
task void rec_task (void);
void main_menu()
{
      send_string(USE_UART,"\n\r\n\n*********************************************");
      send_string(USE_UART,"\n\r          SM Micrro System,Tambaram,Chennai          ");
      send_string(USE_UART,"\n\r              MailBoxMessageSimulation               ");
      send_string(USE_UART,"\n\r                    MAIN MENU");
      send_string(USE_UART,"\n\r*********************************************");
      send_string(USE_UART,"\n\n\r");
      send_string(USE_UART,"\n\rThis program simulates MailBox IPC mechanism.");
      send_string(USE_UART,"\n\rPlease Follow Below Commands"); send_string(USE_UART,"\n\r - Type any
      string and press enter to send"); send_string(USE_UART,"\n\r                    the
      stringusingmailbox.                    "); send_string(USE_UART,"\n\r-Press   SPACE Key to
      check available MailboxCount"); send_string(USE_UART,"\n\r-Press              ESC Key to reset
      the input string"); send_string(USE_UART,"\n\n\r");
}
/* ---------------------------------------------------------------------------------------------------------
 *    Task1:       RTX Kernel starts this task with os_sys_init(send_task)
 *  ---------------------------------------------------------------------------------------------------------*/
task void send_task (void)
{
      T_MEAS *mptr;
      static unsigned char sInputBuf[MBOX_MSG_BUF_SIZE]; int
      cnt=0;
      char sSndTskBuf[30]; char
      ch;
      int MsgFree = 0;

      tsk1 =os_tsk_self();                  /* get own taskidentificationnumber     */
#ifndefDISABLE_RECV_TASK
      tsk2 = os_tsk_create (rec_task, 0); /* starttask2                             */
#endif /* DISABLE_RECV_TASK*/

      os_mbx_init (MsgBox, sizeof(MsgBox));/* initializethemailbox                 */
      os_dly_wait(5);                       /* Startup delayforMCB21xx              */
          lcdinit();
```

```
        clrscr(10);
      printstr("          MailBox       ",0,0);
      printstr("        Simulation      ",0,1);

#ifndef DISABLE_RECV_TASK
      mptr =_alloc_box(mpool);                    /* Allocate a memory forthemessage          */
      memset(mptr->msgBuf,'\0',MBOX_MSG_BUF_SIZE);
      memcpy ( mptr->msgBuf, STD_MSG1, sizeof(STD_MSG1) );
      os_mbx_send (MsgBox, mptr, 0xffff); /* Send the message to the mailbox*/
      os_dly_wait (100);

      mptr = _alloc_box (mpool);
      memset (mptr->msgBuf,'\0',MBOX_MSG_BUF_SIZE);
      memcpy ( mptr->msgBuf, STD_MSG2, sizeof(STD_MSG2) );
      os_mbx_send (MsgBox, mptr, 0xffff); /* Andsendit.                                */
      os_tsk_pass();                              /*Cooperativemultitasking                  */
      os_dly_wait(100);

      mptr = _alloc_box (mpool);
      memset (mptr->msgBuf,'\0',MBOX_MSG_BUF_SIZE);
      memcpy ( mptr->msgBuf, STD_MSG3, sizeof(STD_MSG3) );
      os_mbx_send (MsgBox, mptr, 0xffff); /* Andsendit.                                */
      os_dly_wait(100);
      #endif /* DISABLE_RECV_TASK */
      memset (sInputBuf,'\0',MBOX_MSG_BUF_SIZE);
      cnt = 0;
      main_menu();w
      hile(1)
      {
            ch = receive(USE_UART);
            if(ch == CARRIAGE_RET && cnt > 0)
            {
send_string(USE_UART,"\n\n\n\r**********SENDING MAILBOX USER MESSAGE**********");
                        MsgFree = os_mbx_check (MsgBox); if
                        (MsgFree != 0)
                        {
                              mptr = _alloc_box (mpool);
                              memset (mptr->msgBuf,'\0',MBOX_MSG_BUF_SIZE);

                                 memcpy ( mptr->msgBuf, sInputBuf, strlen((const char *)sInputBuf) );

*/                            sprintf (sSndTskBuf, "\n\ros_mbx_send byTaskID:%d ",tsk1);

                                 send_string(USE_UART,sSndTskBuf);send
                                 _string(USE_UART,"\n\n\r");

                        }
                        else
                        {
                              os_mbx_send (MsgBox, mptr, 0xffff); /* And send it. os_dly_wait

                              (100);

                        }
#ifdefDISABLE_RECV_TASK       memset (sInputBuf,'\0',MBOX_MSG_BUF_SIZE); cnt
                              = 0;



                                 send_string(USE_UART,"\n\rMailbox is FULL");
                        main_menu();
```

```
#endif /* DISABLE_RECV_TASK */
                }
                else if ( KEY_SPACE == ch)
                {
                        MsgFree = os_mbx_check (MsgBox); if
                        (MsgFree == 0)
                        {
                            send_string(USE_UART,"\n\rMailboxisFULL.....");
                         }
                         else
                         {
                                sprintf (sSndTskBuf, "\n\rMailBox Free Count : %d ", MsgFree);
                                send_string(USE_UART,sSndTskBuf);
                                        send_string(USE_UART,"\n\n\r");
                         }
                                os_dly_wait (100);
                        main_menu();

                }
                else if ( KEY_ESC == ch)
                {
                        cnt = 0;
                        memset (sInputBuf,'\0',MBOX_MSG_BUF_SIZE);
                                                        send_string(USE_UART,"\n\rClearing Buffer
PleaseWait. ..... ");
                                                        os_dly_wait (100);
                        main_menu();
                }
                else if('\0' != ch)
                {

                                sInputBuf[cnt++] = ch;

                                cnt %= MBOX_MSG_BUF_SIZE;
                                if(ch == CARRIAGE_RET &&cnt==1)          //emptystring
                                {
                                        cnt = 0;
                                }
                                else
                                {
                                        putcharr (USE_UART,ch);
                                }

}
        }

//      os_tsk_delete_self();                           /* We are done here, deletethistask                     */
}

#ifndef DISABLE_RECV_TASK
/* ---------------------------------------------------------------------------------------------------------------
 *    Task 2: RTX Kernel starts this task with os_tsk_create (rec_task,0)
 *--------------------------------------------------------------------------------------------------------------*/
task void rec_task (void)
{
   T_MEAS *rptr;
   static char sRxTskBuf[MBOX_MSG_BUF_SIZE];

      for (;;)
      {
            os_mbx_wait (MsgBox, (void **)&rptr, 0xffff); /* wait forthemessage                                  */
            send_string(USE_UART,"\n\n\n\r**********MAILBOXMESSAGE
RECEIVED**********");
```

```
sprintf (sRxTskBuf, "\n\rec_task by Task ID: %d ", tsk2); send_string(USE_UART,sRxTskBuf);

                memset (sRxTskBuf,'\0',MBOX_MSG_BUF_SIZE);
                memcpy ( sRxTskBuf, rptr->msgBuf, strlen(rptr->msgBuf) ); send_string(USE_UART,"\n\n\rReceived Mbox: ");
                send_string(USE_UART,sRxTskBuf);

    send_string(USE_UART,"\n\r*****************************************************");
                _free_box(mpool,rptr);                  /* free memory allocatedformessage          */
                main_menu();
        }
    }
    #endif /* DISABLE_RECV_TASK */

    /* ---------------------------------------------------------------------------------------------------------
     *                Main: Initialize and start RTXKernel
     *--------------------------------------------------------------------------------------------------------*/
    int main (void)
    {
        initserial(USE_UART);                   /* uart0 initialization*/

        _init_box(mpool,sizeof(mpool),          /* initialize the 'mpool'memoryfor          */
                        sizeof(T_MEAS));        /* the memboxdynamicallocation              */
        os_sys_init(send_task);                 /* initialize and starttask1                */
    }

    /* ---------------------------------------------------------------------------------------------------------
     * end of file
     *--------------------------------------------------------------------------------------------------------*/


                        /*****************************************************************/
                                                RTX_CONFIG.C
                        /*****************************************************************/
     /*---------------------------------------------------------------------------------------------------------
     *           RL-ARM -RTX
     *---------------------------------------------------------------------------------------------------------
     *           Name:        RTX_CONFIG.C
     *           Purpose: Configuration of RTX Kernel for NXPLPC21xx
     *           Rev.:        V4.20
     *---------------------------------------------------------------------------------------------------------
     *           This code is part of the RealView Run-TimeLibrary.
     *           Copyright (c) 2004-2011 KEIL - An ARM Company. All rightsreserved.
     *--------------------------------------------------------------------------------------------------------*/


    #include <RTL.h>
    #include<LPC21xx.H>                         /*LPC21xxdefinitions                       */

    /* ---------------------------------------------------------------------------------------------------------
     *           RTX User configuration partBEGIN
     *--------------------------------------------------------------------------------------------------------*/


    //-------- <<< Use Configuration Wizard in Context Menu >>> -----------------
    //
    // <h>TaskConfiguration
    //======================
    //
```

```
//          <o>Number of concurrent running tasks<0-250>
    //       <i> Define max. number of tasks that will run at the sametime.
    //       <i> Default: 6
    #ifndefOS_TASKCNT
    #defineOS_TASKCNT          6
    #endif

    //       <o>Number of tasks with user-provided stack<0-250>
    //       <i> Define the number of tasks that will use a biggerstack.
    //       <i> The memory space for the stack is provided by theuser.
    //       <i> Default: 0
    #ifndefOS_PRIVCNT
    #defineOS_PRIVCNT          0
    #endif
    //       <o>Task stack size [bytes]<20-4096:8><#/4>
    //       <i> Set the stack size for tasks which is assigned by thesystem.
    //       <i> Default: 200
    #ifndefOS_STKSIZE
    #defineOS_STKSIZE          50
    #endif

    // <q>Check for the stackoverflow
    //================================
    // <i> Include the stack checking code for a stack overflow.
    // <i> Note that additional code reduces the RTX performance. #ifndef
    OS_STKCHECK
      #defineOS_STKCHECK       1
    #endif

    // </h>
    // <h>Tick Timer Configuration
    // ============================
    //       <o>Hardware timer <0=> Timer 0 <1=> Timer1
    //       <i> Define the on-chip timer used as a time-base forRTX.
    //       <i> Default: Timer 0
    #ifndefOS_TIMER
    #defineOS_TIMER            1
    #endif

    //       <o>Timer clock value [Hz]<1-1000000000>
    //       <i> Set the timer clock value for selectedtimer.
    //       <i>Default:15000000          (15MHz at 60MHz CCLK and VPBDIV = 4)
    #ifndefOS_CLOCK
      #defineOS_CLOCK          15000000
    #endif

    //       <o>Timer tick value [us]<1-1000000>
    //       <i> Set the timer tick value for selectedtimer.
    //       <i>Default:10000          (10ms)
    #ifndefOS_TICK
      #defineOS_TICK           10000
    #endif

    // </h>

    // <h>SystemConfiguration
    //=======================
    // <e>Round-Robin Taskswitching
    //=============================
    // <i> Enable Round-Robin Task switching. #ifndef
    OS_ROBIN
      #defineOS_ROBIN          1
```

```
#endif

//       <o>Round-Robin Timeout [ticks]<1-1000>
//       <i> Define how long a task will execute before a taskswitch.
//       <i> Default: 5
#ifndefOS_ROBINTOUT
#defineOS_ROBINTOUT      5
#endif

// </e>

//       <o>Number of user timers<0-250>
//       <i> Define max. number of user timers that will run at the sametime.
//       <i>Default:0           (User timersdisabled)
#ifndefOS_TIMERCNT
 #defineOS_TIMERCNT        0
#endif

//       <o>ISR FIFOQueuesize<4=>          4entries        <8=>     8entries
//                                  <12=>12entries          <16=> 16entries
//                                  <24=>24entries          <32=> 32entries
//                                  <48=>48entries          <64=> 64entries
//                                  <96=> 96entries
//       <i> ISR functions store requests to thisbuffer,
//       <i> when they are called from the IRQhandler.
//       <i> Default: 16 entries
#ifndefOS_FIFOSZ
#defineOS_FIFOSZ              16
#endif

// </h>
//------------- <<< end of configuration section >>> -----------------------

// Standard library systemmutexes
//===============================
//     Define max. number system mutexes that are used toprotect
//     the arm standard runtime library. For microlib they are notused.
#ifndefOS_MUTEXCNT
 #defineOS_MUTEXCNT       8
#endif

/* ----------------------------------------------------------------------------------------------------------------------
 *          RTX User configuration partEND
 *---------------------------------------------------------------------------------------------------------------------*/

#if       (OS_TIMER==0)                                          /*Timer0                */
 #defineOS_TID_               4                                  /*    TimerID           */
 #defineTIMx(reg)             T0##reg
#elif (OS_TIMER==1)                                              /*Timer1                */
 #defineOS_TID_               5                                  /*    TimerID           */
 #defineTIMx(reg)             T1##reg
#else
 #error OS_TIMER invalid
#endif

#defineOS_TIM_                (1<<OS_TID_)                       /*    InterruptMask     */
#defineOS_TRV                 ((U32)(((double)OS_CLOCK*(double)OS_TICK)/1E6)-1)
#defineOS_TVAL                TIMx(TC)                           /*    TimerValue        */
#defineOS_TOVF                (TIMx(IR)&1)     /*                OverflowFlag          */
#defineOS_TFIRQ()             VICSoftInt       =OS_TIM_;         /*    Force Interrupt */
#defineOS_TIACK()             TIMx(IR)=1;                        /*    InterruptAck      */ \
```

```
#define   OS_TINIT()      VICSoftIntClr = OS_TIM_;                                    \
                          VICVectAddr      = 0;
                          TIMx(MR0) =OS_TRV;          /*   Initialization   */ \
                          TIMx(MCR) =3;                                            \
                          TIMx(TCR) =1;                                            \
                          VICDefVectAddr = (U32)os_def_interrupt;                  \
                          VICVectAddr15    =(U32)os_clock_interrupt;               \
                          VICVectCntl15    = 0x20 |OS_TID_;
#define   OS_IACK()       VICVectAddr      =0;        /* InterruptAck     */

#define#  OS_LOCK()       VICIntEnClr      =OS_TIM_;  /* Task Lock        */
define    OS_UNLOCK       VICIntEnable     =OS_TIM_;  /* Task Unlock      */
          ()

/* WARNING: Using IDLE mode might cause you troubles while debugging.*/ #define_idle_()
                          PCON =1;


/* ------------------------------------------------------------------------------------------------------
 *           GlobalFunctions
 *-----------------------------------------------------------------------------------------------------*/

/* ---------------------------------------- os_idle_demon ---------------------------------------------*/
task void os_idle_demon (void) {
   /* The idle demon is a system task, running when no other task is ready*/
   /* to run. The 'os_xxx' function calls are not allowed fromthistask.                */


   for (;;) {
   /* HERE: include optional user code to be executed when no task runs.*/
   }
}

/* ---------------------------------------- os_tmr_call -----------------------------------------------*/

void os_tmr_call (U16 info) {
   /* This function is called when the user timer hasexpired.Parameter                 */
   /* 'info' holds the value, defined when the timerwascreated.                        */

   /* HERE: include optional user code to be executed on timeout. */
}


/*----------------------------------------os_error ----------------------------------------------*/

void os_error (U32 err_code){
   /* This function is called when a runtime error is detected. Parameter*/
   /* 'err_code' holds the runtime error code (definedinRTL.H).                        */


   /* HERE: include optional code to be executed on runtime error. */ for (;;);
}
/* ------------------------------------------------------------------------------------------------------
 *           RTX ConfigurationFunctions
 *-----------------------------------------------------------------------------------------------------*/

static void os_def_interrupt(void)irq                    {
   /* Default Interrupt Function: may be called when timer ISR is disabled */ OS_IACK();
}
```

```
#include <RTX_lib.c>

/* ---------------------------------------------------------------------------------------------------------------------
 *  end offile
 *--------------------------------------------------------------------------------------------------------------------*


 /*************************************************************************/
                                        LCD.C
                    /*************************************************************/

#include<LPC214x.H>                     /* LPC214x definitions */
#defineRS           0x00000400      /* P0.10*/
#defineCE           0x00001000      /* P1.11*/

#define SET1
#define OFF0

void lcdcmd(char cmd); void
lcddat(char cmd);
void printstr(unsigned char *str, char x, char y);

voidwait(void)          {                       /* wait function */ int
        d;
   for (d = 0; d <100000;d++);                  /* only to delay for LED flashes*/
}


void lcdinit(void)
{
      IODIR0 |= 0x000014f0;
      lcdcmd(0x28);
      lcdcmd(0x28);
      lcdcmd(0x0c);
      lcdcmd(0x06);
      lcdcmd(0x01);
      lcdcmd(0x0f);
      wait();//(1600);

}

void gotoxy(char x, char y)
{
      if(y == 0)
            lcdcmd(0x80+x);
      else
            lcdcmd(0xc0+x);

}


void printstr(unsigned char *str, char x, char y)
{
      char i; gotoxy(x,y);
      wait();//(500);
      for(i=0;str[i]!='\0';i++)lcddat(str[i
            ]);

}
```

```
void lcdcmd(charcmd)
{
unsigned charLCDDAT;
            LCDDAT = (cmd&0xf0);                    //higher nibble
            IOSET0 |=LCDDAT;
        IOCLR0 |= RS;
            IOSET0 |= CE;
        wait();//(100);                                         //enablelcd
            IOCLR0 |= CE;
            IOCLR0 |= 0X00000FFF;


        LCDDAT = ((cmd<<0x04)&0xf0);                    //lower nibble
            IOSET0 |=LCDDAT;
        IOCLR0 |= RS;
            IOSET0 |= CE;
        wait();//(100);                                         //enablelcd
            IOCLR0 |= CE;
            IOCLR0 |= 0X00000FFF;

}

void lcddat(char cmd)
{
    unsigned char LCDDAT;
            LCDDAT = (cmd&0xf0);                    //higher nibble
            IOSET0 |=LCDDAT;
        IOSET0 |= RS;
            IOSET0 |= CE;
        wait();//(100);                                         //enablelcd
            IOCLR0 |= CE;
            IOCLR0 |= 0X00000FFF;


        LCDDAT = ((cmd<<0x04)&0xf0);                    //lower nibble
            IOSET0 |=LCDDAT;
        IOSET0 |= RS;
            IOSET0 |= CE;
        wait();//(100);                                         //enablelcd
            IOCLR0 |= CE;
            IOCLR0 |= 0X00000FFF;
}


void clrscr(char ch)
{
      if(ch==0)
      {
            printstr("                                ",0,0);
            gotoxy(0,0);
      }
      else if(ch ==1)
      {
            printstr("                                ",0,1);
            gotoxy(0,1);
      }
      else
      {
              lcdcmd(0x01);
                //delay(100);
      }
}
```

```
/*****************************************************************/
                        UART.C
/*****************************************************************/

 /* This file contains driver functions to send and receive data via uart0inthe                    */
                        /* ARM LPC2148 Development board itself */
 /*******************************************************************************/      #include
<LPC214x.H>
#include "config.h"
#define TEMT (1<<6)

void initserial(unsigned char uart)
{
        if(0 == uart)
        {
                PINSEL0=0x00000005;         /* Make pins 19 and 21 to function as TXD0and RXD0
forUART0*/
                U0LCR=0x83;                 /* 8 bits, no Parity, 1Stopbit                    */
                U0FDR=0x00000010;           /* DIVADDVAL = 0; MULVAL = 1*/
                U0DLL=98;                   /* 9600 Baud Rate @ 15MHz VPB Clock; =97.65=98
*/
                U0LCR=0x03;                 /* DLAB = 0*/
                U0IER=0x01;                 /* Enable reciever data availableinterrupt*/

        }
        else
        {
                PINSEL0=0x00050000;         /* Make pins 19 and 21 to function as TXD0and
RXD0 for UART0*/
                U1LCR=0x83;                 /* 8 bits, no Parity, 1Stopbit                    */
                U1FDR=0x00000010;               /* DIVADDVAL = 0; MULVAL = 1*/
                U1DLL=98;                   /* 9600 Baud Rate @ 15MHz VPB Clock; =97.65=98
*/
                U1LCR=0x03;                 /* DLAB = 0*/
                U1IER=0x01;                 /* Enable reciever data availableinterrupt*/


        }
}
void putcharr (unsigned char uart, unsignedcharch)                  /* Writes character to
SerialPort*/
{
        if(0 == uart)
        {
                while (!(U0LSR &TEMT)); U0THR
                =ch;
        }
        else
        {
                while (!(U1LSR &TEMT)); U1THR
                =ch;
        }
}


unsigned char getcharr (unsignedcharuart)                       /* Reads character from
SerialPort*/
{
        if(0 == uart)
        {
                while (!(U0LSR & 0x01));
                return (U0RBR);
```

```
        }
        else
        {
            while (!(U1LSR & 0x01));
            return (U1RBR);
        }
}

char receive(unsigned char uart) /*function for receiving data from sensor (readsbyte by byte & returns value if
exist,else#)                                                    */
{
        if(0 == uart)
        {
                if (U0LSR&0x01)          /* If U0LSR 1st bit contains valid data, thenreturn value ofU0RBR*/
                {
                        return (U0RBR);
                }
                return'\0';                         /* If other than 0 to 9 data is recievedreturn
#*/
        }
        else
        {
                if (U1LSR&0x01)          /* If U0LSR 1st bit contains valid data, thenreturn
value of U0RBR*/
                {
                        return (U1RBR);
                }

                return'\0';                         /* If other than 0 to 9 data is recievedreturn
#*/


        }
}

void send_string(unsigned charuart,char*cpr)                    /* Writes string to serial port*/
{
   while(*cpr != '\0')
   {
      putcharr (uart,*cpr); cpr++;
   }
}

unsigned char* receive_string(unsignedcharuart)                         /* Reads string to serial
port*/
{
   static unsigned char c[30]; unsigned
   char i=0;
   c[i] = getcharr(uart); while(c[i] !=
   CARRIAGE_RET)
     {
        i++;
        c[i] = getcharr(uart);


     }
   c[i] = '\0';
   return(c);
}
```

CONFIG.H

```
/*****************************************************************/
#define          MAILBOX_MEMORY_POOL_CNT16
#define          MBOX_MSG_BUF_SIZE       100
#defineUSE_UART                                          0
/*****************************************************************/
/*            Enable below macro to disable the the recv task to check mailbox full*/
//#define           DISABLE_RECV_TASK
/*****************************************************************/
#define STD_MSG1 "MailBox Test Message 1" #define
STD_MSG2 "MailBox Test Message 2" #define STD_MSG3
"MailBox Test Message3"
#define LINE_FEED 0x0A #define
CARRIAGE_RET    0x0D    #define
KEY_SPACE       0x20       #define
KEY_ESC0x1B
```

MAIL PROGRAM PROGRAM

PORTDETAILS UART0

ARM	DETAILS
P0.0	TXDO
P0.1	RXDO

UART1

ARM	DETAILS
P0.8	TXD1
P0.9	RXD1

LCD PORTDETAILS

ARM	DETAILS
PO.10	RS LCD PIN
P1.11	CE LCD PIN

Post Lab Questions

1. Mention the operations that can be performed on a mailbox.
2. When does the mailbox will get deleted?
3. Illustrate the operation of reading operation from a mailbox.
4. How to configure the mailbox?
5. What is branch prediction?

Result

The C-Language program to create a mailbox and to understand the about the RTOS functions is developed and is verified.

8. Interrupt Performance Characteristics ofARM andFPGA

Aim

To study about the Interrupt performance characteristics between ARM and FPGA.

Pre Lab Questions

1. Define interrupts.
2. What is FPGA?
3. Difference between ARM and FPGA.
4. What are PROS and CONS for ARM?
5. What is interrupt pipelining?

Apparatus & Software Required

1. LPC2148 Development board.
2. KeilµVision 5software.
3. Flash Magic.
4. USB cable.
5. Xilinx FPGA Spartan6
6. Xilinx ISE Design suite
7. JTAG Cable
8. FRC Cable

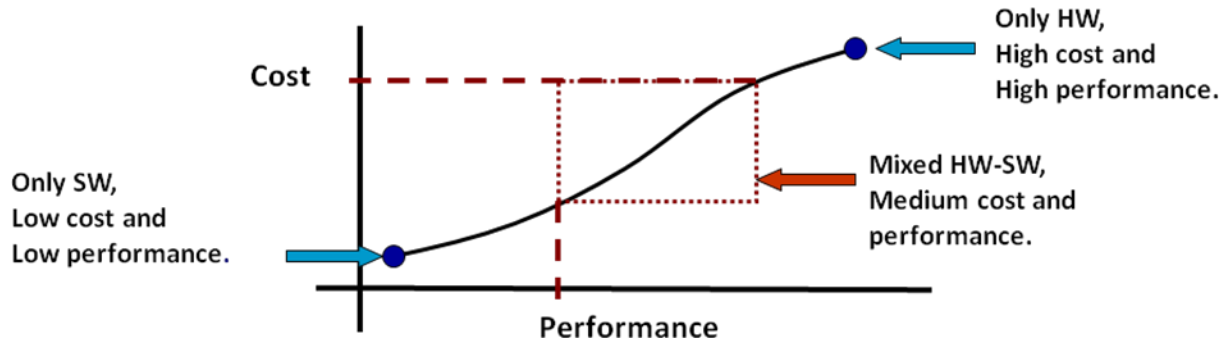
Theory

UART implementation FPGA & ARM7

Why we are doing this experiment?

An embedded system typically consists of both hardware and software. During the design phase of an embedded system the system design Engineer has to choose the components of software and hardware. In a system, implementing a specified logic or algorithm can be done exclusively using software alone or hardware alone.

Implementing a logic or algorithm using only with software involves low cost but delivers only low performance. Implementing the same logic or algorithm only with hardware involves high performance but with low cost.



Hence, from the above graphical analysis it is clear that while designing an embedded system the design engineer must choose a heterogeneous methodology which involves both hardware and software. In this heterogeneous method the engineer has to decide which part of the logic to be implemented in software and which other part to be implemented in software based on performance. So from this experiment a student can learn how to design an embedded system based on performance characteristics.

What is hardware software partitioning on performancecharacteristics?

Choosing the implementation method based on cost is called hardware software portioning on cost characteristics. The design engineer must also consider the performance characteristics like speed, power consumption and reliability while choosing the implementation methodology. Hence deciding which part of our algorithm has to be implemented in software and which other part of the algorithm has to be implemented as hardware based on performance characteristics is called Hardware software partitioning on performance characteristics

Objective of the Experiment:

The aim of this experiment is to implement a UART serial communication algorithm as an embedded system by which to learn hardware-software partitioning based on performance characteristics.

Design of the system:

It is assumed that the reader knows about

i. UART communication protocol
ii. How microprocessor/microcontroller works
iii. What is FPGA and its use
iv. What is ASIC

Software UART	Hardware UART
Advantages: i. Simple to implement ii. Can be easily modified when need arises	Advantages: i. Speed depends only on the FPGA's clocking speed ii. The same design can be manufactured several copies. Hence it is reliable
Disadvantages: i. Complexity of writing code increases when the design involves the operating system. ii. Speed depends on the microprocessor's execution speed and other application code that club with this UART algorithm iii. Since the software code depends on processor architecture, porting the same code in other type of processor needs modifying code again and hence itis not reliable	Disadvantages: i. Designing and writing code in HDL needs good understanding of digital circuit design and a HDL language. Hence complex to implement. ii. The hardware cannot be modified when there is need to upgrade the implemented protocol if it is implemented as ASIC.

Hence, in this experiment we are going to follow the heterogeneous approach to implement the UART algorithm. So it involves both software part and as well as hardware part.

Every protocol has two basic techniques,

i. Data driving logic and

ii. Data packing/ unpackinglogic

Data driving logic:

This involves feeding and obtaining the actual data to be packed to the data packing/ unpacking logic.

Data packing/unpacking logic:

This involves packing the data or unpacking the data and error checking as per the protocol specification.

In this experiment, to design UART communication

a) Data driving logic is implemented in Software. There a son for choosing this logic to be implemented in software is

i) The data is user dependent

ii) Initiating the data transfer is also user dependent

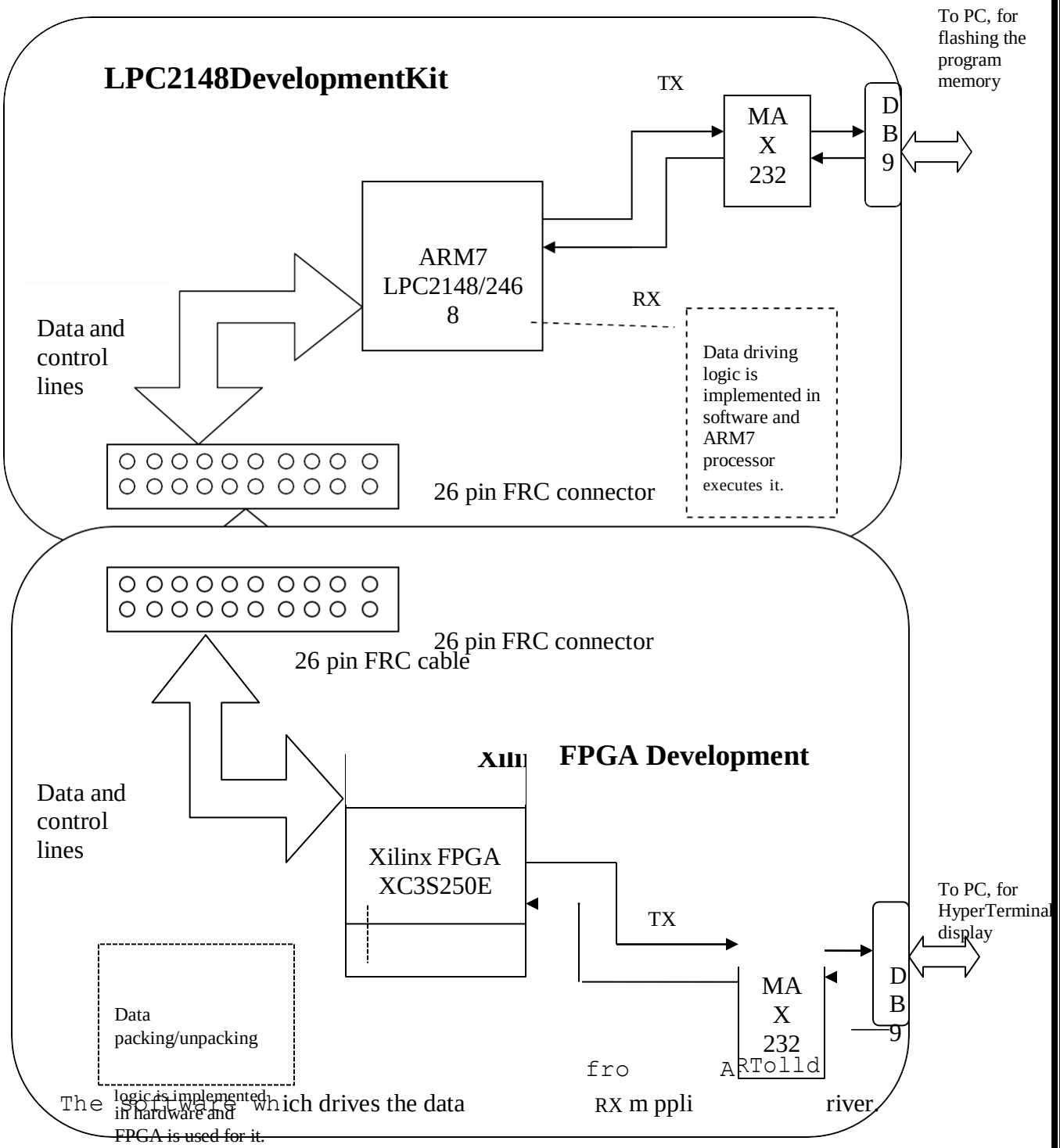
iii) Software design can easily be changed based on the user requirement

b) Data packing/unpacking logic is implemented inhardware. The reason for choosing this logic to be implemented in hardware is

i. Since the protocol specification is fixed one and the packing/ unpacking logic involves designing algorithm for the protocolalone

ii. Data packing/ unpacking speed is high

Pictorial representation:



The software which drives the data RX m ppli river.

Software Part:

1. UART driver i.e. data driving logic is software part in this experiment.
2. This software is written using Embedded Clanguage
3. Keil uVision4 IDE and keil arm compiler is used for compiling the Ccode.
4. Flash Magic tool has been used to download the program in to ARM7 microcontroller.

Hardware part:

1. UART protocol i.e. packing/unpacking logic is hardware part in this experiment.
2. This hardware is designed using Verilog HDLprogram
3. The Model sim IDE is used for simulation to test the functionality of the hardware designed using Verilog HDL
4. Xilinx ISE is used to synthesize the design and to download the synthesized RTL file in to the Xilinx FPGAXC3S250E.

Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

/***/

UART implementation FPGA & ARM7

ARM UART

/***/

```
#include <LPC214x.h>

void init_ios(void)
{
   /*
            P1.16toP1.23          --IN        --      rx data
             P1.24toP1.31          --OUT      --      tx data
             P0.15                 --OUT      --      txcmd
             P0.16                 --IN       --      txdone
             P0.17                 --IN       --      rx_rdy
   */
   IODIR1=0xff000000;          // tx data made as output
   IODIR0=0x00008000;          //      tx cmd made as output
   IOCLR0=0xff008000;          // Default both the outputs toZero
}


void tx_char(unsigned char data)
{
   char tx_done;
   unsigned int i;
   tx_done = ((IOPIN0>>16) & 0x00000001);
              if(tx_done)
                {
                  IOPIN1 &= ~0xff000000; // clr data port
                  IOPIN1|=data<<24;                    // place data on port
                       for(i=0;i<1000;i++);                  //wait
                       IOSET0=1<<15;                                 // enable tx command
                       for(i=0;i<9000;i++);                  //wait
                       IOCLR0=1<<15;                                 // Disable tx command
                       while(!tx_done)
                            tx_done = ((IOPIN0>>16) & 0x00000001);
                }

}
void tx_string(unsigned char* stringg)
{
   while(*stringg != '\0')
     {
        tx_char(*stringg);string
             g++;
     }
   tx_char(0x0a);tx_c
   har(0x0d);
}


int main (void)
  {
   char i;
   init_ios();
   for(i=0;i<100;i++);
```

```
while (1)
        {
          tx_string("SM MICRRO SYSTEM");
        }
    }

/*****************************************************************/
                                FPGA UART
/*****************************************************************/
```

S/GName		Portinarm	Data Direction inFPGA
tx_cmd	--	P0.15	IN
tx_data[0]	--	P1.24	IN
tx_data[1]	--	P1.25	IN
tx_data[2]	--	P1.26	IN
tx_data[3]	--	P1.27	IN
tx_data[4]	--	P1.28	IN
tx_data[5]	--	P1.29	IN
tx_data[6]	--	P1.30	IN
tx_data[7]	--	P1.31	IN
tx_done	--	P0.16	OUT
rx_data[0]	--	P1.16	OUT
rx_data[1]	--	P1.17	OUT
rx_data[2]	--	P1.18	OUT
rx_data[3]	--	P1.19	OUT
rx_data[4]	--	P1.20	OUT
rx_data[5]	--	P1.21	OUT
rx_data[6]	--	P1.22	OUT
rx_data[7]	--	P1.23	OUT
rx_rdy	--	P0.17	OUT

Connector Details

P0.18	- P113	P1.24-	P116	|
Po.17	- P59	P1.25-	P66	|
P0.16	- P112	P1.26-	P91	|
P0.15	- P92	P1.27-	P93	|
P0.19	- P94	P1.28-	P98	|
P0.20	- P97	P1.29-	P106	|
P0.21	- P105	P1.30-	P103	|
P0.23	- P104	P1.31-	P96	|
+5v	-	GND -		|
P1.16	- P135	P1.23-	P134	|
P1.17	- P132	P1.22-	P131	|
P1.18	- P130	P1.21-	P117	|
P1.19	- P139	P1.20-	P126	|

```
*/

module uart_top( clk,
                 rst,tx
                 ,
```

```
                    rx,
                    lcd_rs,
                    lcd_en,
                    //lcd_rw,lcd
                    _dat,
                                        tx_cmd_i,
                                        tx_data_i,tx_
                                        done_o,rx_da
                                        ta_o,rx_rdy_
                                        o
                );

/***********     I/O       Declecration**********/
    input  clk;
    input           rst;
    input           rx;
    output          tx;
    input           tx_cmd_i;
    input     [7:0]tx_data_i;
    output          lcd_rs;
    output          lcd_en;
    //output            lcd_rw;
    output [3:0]lcd_dat; output
                    tx_done_o;
    output [7:0]rx_data_o; output
                    rx_rdy_o;

    /*
        Local Wire and reg decleration for I/Os
    */

    wire u_clk; wire
    tx_done;
    reg [7:0] dat = 8'h31;
    //reg tx_cm;
    //reg [15:0]c1;

    wire [3:0]lcddata_in; wire
    rx_rdy;

    baud        b1(
                    .sys_clk(clk),
                        .sys_rst_l(rst),
                        .baud_clk(u_clk)
                );

    u_xmitt1(       .sys_clk(u_clk),
                        .sys_rst_l(rst),
                        .uart_xmitH(tx),
                        .xmitH(tx_cmd_i),
                        .xmit_dataH(tx_data_i),
                        .xmit_doneH(tx_done_o)
                );

    u_recr1(        .sys_rst_l(rst),
                        .sys_clk(u_clk),
                        .uart_dataH(rx),
                        .rec_dataH(lcddata_in),
                        .rec_readyH( rx_rdy)
                );

    lcd_dis lcd1( .clk(clk),
                    .rs(lcd_rs),
```

```
                    .en(lcd_en),
                    //.rw(lcd_rw),
                    .data(lcd_dat),
                    .wr_sig(rx_rdy),
                    .data_in(lcddata_in)
                  );
/*
always @(posedge u_clk or negedge rst) begin
                    if(~rst)
                                begin
                                    c1 <= 16'd0;
                                    end
                            else
                                begin
                                        c1 <= c1 + 16'd1; if(c1 ==16'd1000)
                                                    tx_cm <= 1'b1; if(c1
                                            ==16'd1010)
                                              begin
                                              tx_cm <= 1'b0; end



      end                                   end
*/


assign rx_data_o = lcddata_in; assignrx_rdy_o
                            =rx_rdy;

endmodule


/*********************************************************************/
                                        FPGA UCF FILE
/*********************************************************************/

#PACE: Start of Constraints generated by PACE #PACE:

Start of PACE I/O Pin Assignments
NET"clk"      LOC="p80"       ;
NET"lcd_dat[0]"  LOC="p2"  ;
NET"lcd_dat[1]"  LOC="p3"  ;
NET"lcd_dat[2]"  LOC="p4"  ;
NET"lcd_dat[3]"  LOC="p5"  ;
NET"lcd_en"  LOC="p16"     ;
NET"lcd_rs"  LOC="p15"     ; NET"rst"
             LOC="p6"      ;
NET"rx"      LOC="p120"       ;
NET "rx_data_o[0]"  LOC   = "p168"  ; NET
"rx_data_o[1]"    LOC    =    "p171"    ;   NET
"rx_data_o[2]"    LOC    =    "p172"    ;   NET
"rx_data_o[3]"    LOC    =    "p177"    ;   NET
"rx_data_o[4]"    LOC    =    "p178"    ;   NET
"rx_data_o[5]"    LOC    =    "p179"    ;   NET
"rx_data_o[6]"    LOC    =    "p180"    ;   NET
"rx_data_o[7]" LOC = "p181";
```

```
NET"rx_rdy_o"        LOC="p200"        ;
NET"tx"       LOC="p119"        ;
NET "tx_cmd_i" LOC = "p197";
NET  "tx_data_i[0]"  LOC  =  "p185"  ; NET
"tx_data_i[1]"    LOC    =    "p186"    ;   NET
"tx_data_i[2]"    LOC    =    "p187"    ;   NET
"tx_data_i[3]"    LOC    =    "p189"    ;   NET
"tx_data_i[4]"    LOC    =    "p190"    ;   NET
"tx_data_i[5]"    LOC    =    "p192"    ;   NET
"tx_data_i[6]"    LOC    =    "p193"    ;   NET
"tx_data_i[7]"    LOC    =    "p196"    ;   NET
"tx_done_o" LOC = "p199";

#PACE: Start of PACE Area Constraints #PACE: Start of

PACE Prohibit Constraints #PACE: End of Constraints

generated by PACE
```

Post Lab Questions

1. What are basically ARM processors?
2. Compare RISC and CISC.
3. How to interface interrupts?
4. Explain the importance of using LPC2148 Development board.
5. List out the applications of ARM.

Result

The C-Language program for Interrupt performance characteristics between ARM and FPGA and its characteristics was studied.

9. Flashing of LEDS

Aim

To develop a 'C' program to make the LED blink (including delay routine). Upon change in the delay program the speed should vary.

Pre Lab Questions

1. What is seven segment displays?
2. Where LEDs are used?
3. What are the different configurations of LED?
4. What is the use of flash magic software?
5. Differentiate LED from LCD.

Apparatus & Software Required

1. LPC2148 Development board.
2. KeilµVision 5 software.
3. Flash Magic.
4. USB cable.

Theory

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.

Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

```
/* This is a test program to make the LEDs L2 and L3 Blink in theARMLPC2148 */
                                    Development board itself
/*****************************************************************************/
#include<LPC214x.H>                                  /* LPC214x definitions*/
voidwait(void)                                       /* wait function*/
{
   int     d;

   for (d = 0; d <1000000;d++);                      /* only to delay for LED flashes*/
}

int main (void)
 {

   IODIR0=0x80002000;                                /* P0.13 and P0.31 defined as Outputs*/

   while(1)                                          /* Loop forever*/
    {
          IOCLR0=0x80002000;                                    /*Active Low outputs makes the
LEDsON*/
       wait ();

          IOSET0=0x80002000;                                    /* High outputs makes the LEDs
OFF*
/
          wait();

    }

 }
```

FLASHING LED PROGRAM PORT DETAILS

ARM	DETAILS
P0.13	LED PIN
P0.31	LED PIN

Post Lab Questions

1. What is the function of GPIO?
2. What are the Pins which are used to connect LEDs?
3. How to identify 'Polarity' of LED?
4. What is a use of Jumper?
5. Which port is used in ARM 7 processor kit?

Result

The C-Language program to make the LED blink was developed and output was verified. Upon change in the delay program the speed variation was verified.

10. INTERFACING STEPPER MOTOR ANDTEMPERATURE SENSOR

Aim

To write C Programs for running stepper motor either in clock- wise or counter-clock- wise and the direction of the rotation of the stepper motor depends on the variation in the temperature sensor.

Pre Lab Questions

1. What is LM35?
2. List the devices used to sense temperature.
3. What is the purpose of a thermocouple?
4. What is signal conditioning?
5. What is the output voltage of a thermocouple?

Apparatus & Software Required

1. LPC2148 Development board.
2. KeilµVision 5software.
3. Flash Magic.
4. USB cable.
5. Stepper Motor.

Theory

Stepper motors, effectively have multiple "toothed" electromagnets arranged around a central metal gear. To make the motor shaft turn, first one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are thus aligned to the first electromagnet, they are slightly offset from the next electromagnet.

So when the next electromagnet is turned on and the first willturn off, the gear rotates slightly to align with the next one and from there the process is repeated. Each of those slight rotations is called a "step." In that way, the motor can be turned to a précised angle. There are two basic arrangements for the electromagnetic coils: bipolar and unipolar.

Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

STEPPER MOTOR PROGRAM

```
/* This is a test program to stepper motor interface in theARMLPC2148                    */
/* developmentboarditself                                                                */
/***************************************************************************************/
#include<LPC214x.H>             /* LPC214x definitions*/

#definestep1            0x00010000      /* P1.16 */
#definestep2            0x00020000      /* P1.17 */


void wait (void)
{                                       /* wait function*/
   int      d;
   for (d = 0; d <10000;d++);                           /* only to delay for LED flashes*/
}

call_stepper_forw()
{
  IOCLR1 = 0X00FF0000;
  IOSET1 = 0X00040000;
//wait();
//wait();
  wait();
  wait();
  IOCLR1 = 0X00FF0000;
  IOSET1 = 0X00060000;
//wait();
//wait();
```

```
  wait();
  wait();
  IOCLR1 = 0X00FF0000;
  IOSET1 = 0X00070000;
//wait();
//wait();
  wait();
  wait();
  IOCLR1 = 0X00FF0000;
  IOSET1 = 0X00050000;
//wait();
//wait();
  wait();
  wait();
}



int main (void)
  {
       IODIR1 |= 0xFFFFFFFF; IOCLR1
            |= 0X00FF0000;
            wait();
    while(1)                        /*LoopForever*/
       {
                call_stepper_forw();
     //              wait();
     //              wait();
                    wait();
                    wait();
                IOCLR1 = 0X00FF0000;
            }
  }
```

STEPPER MOTOR PROGRAM PORT DETAILS

ARM	DETAILS
P1.16	STEP 1
P1.17	STEP 2

TEMPERATURE SENSOR PROGRAM

/***/

MAIN ADC TEST

/***/

```
/* This is a test program to temperature sensor in the ARM LPC2148 developmentboard*/
/*****************************************************************************/
#include<LPC214x.H>                    /* LPC214x definitions*/
#include"ADC_Driver.c"                        /* contains prototypes of driverfunctions*/ #include"lcd.c"
#include <stdio.h>

int main (void)
  {
    unsigned int adc_val;
    unsigned int temp;
    unsigned char buf[4] ={0,0,0,0}; ADCInit();
    lcdinit();
         //wait();
              clrscr(10);
         printstr("ADC Test",0,0); wait();
    while(1)                                /* Loop forever*/
      {
              adc_val = ADC_ReadChannel();
              temp = (unsigned int)((3*adc_val*100)/1024);
              sprintf(buf,"%d",temp);
              printstr(buf,0,1);


      }
  }

/*****************************************************************************************/
                                                    LCD.C
/*****************************************************************************/

 #include <LPC214x.h>

#defineRS              0x00000400     /* P0.10 */
#defineCE              0x00001800     /* P1.11 */


void clrscr(char ch); void
lcdinit(void); void
lcdcmd(char); void
lcddat(char);
void gotoxy(char,char); //x,y ; x-char position(0 - 16) y-line number 0 or1
void printstr(unsignedchar*,char,char);                    //string,column(x),line(y)
void wait (void);
void split_numbers(unsigned int number);

#define SET1
#define OFF0
```

```
unsigned int thousands,hundreds,tens,ones;

voidwait(void)          {                                   /* wait function */
intd;
   for (d = 0; d <100000;d++);                              /* only to delay for LED flashes*/
}

void lcdinit()
{
      IODIR0 |= 0xFFFFFFFF;
          IOCLR0 |= 0X00000FFF;
          lcdcmd(0x28);lcd
      cmd(0x28);
      lcdcmd(0x0c);
      lcdcmd(0x06);
      lcdcmd(0x01);
      lcdcmd(0x0f);
      wait();
}

void gotoxy(char x, char y)
{
      if(y == 0)
            lcdcmd(0x80+x);
      else
            lcdcmd(0xc0+x);


}


void printstr(unsigned char *str, char x, char y)
{
      char i; gotoxy(x,y);
      wait();//(500);
      for(i=0;str[i]!='\0';i++)lcddat(str[i
            ]);

}
void lcdcmd(charcmd)
{
unsigned charLCDDAT;
            LCDDAT = (cmd&0xf0);              //higher nibble
            IOSET0 =LCDDAT;
        IOCLR0 = RS;
            IOSET0 = CE;
        wait();//(100);                                     //enablelcd
            IOCLR0 = CE;
            IOCLR0 = 0X00000FFF;


        LCDDAT = ((cmd<<0x04)&0xf0);                        //lower nibble
            IOSET0 =LCDDAT;
        IOCLR0 = RS;
            IOSET0 = CE;
        wait();//(100);                                     //enablelcd
            IOCLR0 = CE;
            IOCLR0 = 0X00000FFF;
}


void lcddat(char cmd)
```

```
{
        unsigned charLCDDAT;
                LCDDAT = (cmd&0xf0);                    //higher nibble
                IOSET0 =LCDDAT;
           IOSET0 = RS;
                IOSET0 = CE;
           wait();//(100);                                          //enablelcd
                IOCLR0 = CE;
                IOCLR0 = 0X00000FFF;

           LCDDAT = ((cmd<<0x04)&0xf0);                  //lower nibble
                IOSET0 =LCDDAT;
           IOSET0 = RS;
                IOSET0 = CE;
           wait();//(100);                                          //enablelcd
                IOCLR0 = CE;
                IOCLR0 = 0X00000FFF;
     }

    void clrscr(char ch)
    {
          if(ch==0)
          {
                printstr("                                ",0,0);
                gotoxy(0,0);
          }
          else if(ch ==1)
          {
                printstr("                                ",0,1);
                gotoxy(0,1);
          }
          else
          {
                   lcdcmd(0x01);
                     //delay(100);
          }
    }

    void split_numbers(unsigned int number)
    {
       thousands = (number /1000);
       number %= 1000;
       hundreds = (number / 100);
       number %= 100;
       tens = (number / 10);
       number %= 10;
       ones = number ;
    }

    void Wait_Msg(void)
    {
      lcdcmd(0x01);
      printstr("          Please Wait ", 0,0);
    }
    void Welcome_Msg(void)
    {
      lcdcmd(0x01);
      printstr("            Welcometo           ", 0,0);
      printstr("              SMMICRRO     ", 0,1);
    }
```

ADC_DRIVER.C

```
/*****************************************************************/

#include<LPC214x.H>                         /* LPC214x definitions */
Void ADCInit(void)
  {
    PINSEL1|=0x04000000;              /*For Channel AD0.2 is P0.29*/
    IODIR0 |=~(0x04000000);
    AD0CR     |=0x00200204;              /*0x04 selects AD0.2 to mux output, 0x20 makes ADCin operational*/
    AD0GDR;                             /*A read on AD0GDR clears the DONEbit*/
  }
void ADC_StartConversion(void)
  {
      AD0CR |= (1<<24);
  }
void ADC_StopConversion(void)
  {
      AD0CR &= (~(1<<24));
  }

unsigned int ADC_ReadChannel(void)
  {
//        unsigned int i; unsigned long
      ADC_Val, t;
      ADC_StartConversion();
      while((AD0DR2&0x80000000)==0); /*wait until ADC conversion completes*/
      if(AD0STAT & 0x00000400)
                {
                  //printstr("OVR",0,1);return(0);
                }
      t = AD0DR2;
      ADC_Val = ((t>>6) & 0x000003FF);//(AD0DR2 & 0x000003FF); //((AD0CR>>6) & 0x000003FF);
      //ADC_StopConversion();return(
      ADC_Val);
  }.
```

TEMPERATURE SENSOR PROGRAM PORT DETAILS

ARM	DETAILS
P0.29	ADC0.2
PO.10	RS LCD PIN
P1.11	CE LCD PIN

Post Lab Questions

1. Why LM35 is used to Measure Temperature?
2. Compare the difference between LM 34 and LM 35 sensors?
3. What is the operating temperature range in LM35?
4. How many pins are available in LM35?
5. What is the main function of analog pin in LPC 2148?

Result

The C-Language program for running stepper motor either in clock-wise or counter-clock-wise Depending on the temperature is developed in the sensor LM35 and the output is verified in LCD.

11. Implementing zigbee protocol with ARM

Aim

To write C Programs for Zigbee Protocol and verify the communication between Xbee Module Transmitter and Receiver.

Pre Lab Questions

1. What are the applications of zigbee protocol?
2. Why Zigbee based is preferred for wireless communication?
3. What is the function of a scheduler?
4. What is the main function of voltage convertors in UART?
5. List the advantages of using Zigbee protocol.

Apparatus & Software Required

1. LPC2148 Development board.
2. KeilµVision 5software.
3. Flash Magic.
4. USB cable.
5. Zigbee Module Tx and Rx.

Theory

The X Bee/X Bee-PRO ZNet 2.5 (formerly known as Series 2 and Series 2 PRO) RF Modules were directed to operate within the ZigBee protocol. The modules provide reliable delivery of data between remote devices. Zigbee is the communication protocol like wifi and Bluetooth. Xbee is the module using Zigbee protocol

Some of its features are:

- ZigBee is targeted at radio-frequency (RF) applications
- Low data rate, long battery life, and secure networking
- Transmission range is between 10 and 75 meters (33~246 feet)
- The addressing space allows of extreme node density—
  up to 18,450,000,000,000,000,000 devices (64 bit IEEE address)

- Using local addressing, simple networks of more than 65,000 nodes can be configured, with reduced address overhead
- The radios use direct-sequence spread spectrum coding, which is managed by the digital stream into the modulator.
- To ensure reliable data transmission

- Binary phase shift keying (BPSK) in the 868/915 MHz

- Offset quadrature phase shift keying (O-QPSK) at 2.4 GHz

Procedure

1. Follow the steps to create a New project
2. Type the below code and save it with the name (anyname.c)
3. Follow the steps to create a New Project to compile and build the program
4. Follow the procedures in to download your Hex code to processor using Flash Magic Software.

/***/

ARM TRANSMITTER
PROGRAMLCD.C

/***/

```
#include <LPC214x.h>
#include "lcd.h"
#defineRS              0x00000400      /* P0.10 */
#defineCE              0x00001800      /* P1.11 */

/*void clrscr(char ch); void
lcdinit(void);
voidlcdcmd(char);
voidlcddat(char);
void gotoxy(char,char); //x,y ; x-char position(0 - 16) y-line number 0 or1
voidprintstr(char*,char,char);                          //string,column(x),line(y)
void wait (void);
void split_numbers(unsigned int number);*/

#define SET1
#define OFF0

unsigned int thousands,hundreds,tens,ones; void wait

(void)
{                                       /* wait function*/
   int      d;
   for (d = 0; d <100000;d++);                                  /* only to delay for LED flashes*/
}


void lcdinit()
{
        IODIR0 |= 0xFFFFFFFF;
            IOCLR0 |= 0X00000FFF;
            lcdcmd(0x28);lcd
        cmd(0x28);
        lcdcmd(0x0c);
        lcdcmd(0x06);
        lcdcmd(0x01);
        lcdcmd(0x0f);
        wait();
}


void gotoxy(char x, char y)
{
        if(y == 0)
                lcdcmd(0x80+x);
        else
                lcdcmd(0xc0+x);


}


void printstr(char *str, char x, char y)
{
        char i; gotoxy(x,y);
        wait();//(500);
        for(i=0;str[i]!='\0';i++)
```

```
lcddat(str[i]);

}
void lcdcmd(charcmd)
{
unsigned charLCDDAT;
        LCDDAT = (cmd&0xf0);            //higher nibble
        IOSET0 =LCDDAT;
    IOCLR0 = RS;
        IOSET0 = CE;
    wait();                                                         //(100);
                                                                    //enable lcd
        IOCLR0 = CE;
        IOCLR0 = 0X00000FFF;


    LCDDAT = ((cmd<<0x04)&0xf0);                //lower nibble
        IOSET0 =LCDDAT;
    IOCLR0 = RS;
        IOSET0 = CE;
    wait();//(100);                                             //enablelcd
        IOCLR0 = CE;
        IOCLR0 = 0X00000FFF;


}
void lcddat(char cmd)
{
  unsigned charLCDDAT;
        LCDDAT = (cmd&0xf0);            //higher nibble
        IOSET0 =LCDDAT;
    IOSET0 = RS;
        IOSET0 = CE;
    wait();//(100);                                             //enablelcd
        IOCLR0 = CE;
        IOCLR0 = 0X00000FFF;


    LCDDAT = ((cmd<<0x04)&0xf0);                //lower nibble
        IOSET0 =LCDDAT;
    IOSET0 = RS;
        IOSET0 = CE;
    wait();//(100);                                             //enablelcd
        IOCLR0 = CE;
        IOCLR0 = 0X00000FFF;
 }
void clrscr(char ch)
{
    if(ch==0)
    {
        printstr("                          ",0,0);
        gotoxy(0,0);
    }
    else if(ch ==1)
    {
        printstr("                          ",0,1);
        gotoxy(0,1);
    }
    else
    {
          lcdcmd(0x01);
            //delay(100);
    }
```

```
}

    void split_numbers(unsigned int number)
    {
       thousands = (number /1000);
       number %= 1000;
       hundreds = (number / 100);
       number %= 100;
       tens = (number / 10);
       number %= 10;
       ones = number ;
    }

    void Wait_Msg(void)
    {
      lcdcmd(0x01);
      printstr("          Please Wait ", 0,0);
    }
    void Welcome_Msg(void)
    {
      lcdcmd(0x01);
      printstr("            Welcometo          ", 0,0);
      printstr("              SMMICRRO      ", 0,1);
    }

     /*****************************************************************************************/
                                                  LCD.h
           /*****************************************************************************************/

    void clrscr(char ch); void
    lcdinit(void); void
    lcdcmd(char); void
    lcddat(char);
    void gotoxy(char,char); //x,y ; x-char position(0 - 16) y-line number 0 or1
    voidprintstr(char*,char,char);                    //string,column(x),line(y)
    void wait (void);
    void split_numbers(unsigned int number); void
    Wait_Msg(void);
    void Welcome_Msg(void);

                              /*************************************************************/
                                                  UART_1.C
                          /*************************************************************/

    #include <LPC214X.H>
    #include "lcd.c"

    #define TEMT0X40

    void uart_1(void);
    voiddelay(void);
    void putcharr (unsignedcharch);                          /* Writes character to Serial Port*/
    void tx_string(charstr);

    int main(void)
    {
                uart_1();
                lcdinit();dela
                y();
                delay();
```

```
        delay();
            delay();
            printstr("SM MICRRO SYSTEM",0,0);
            while(1)
            {
                        tx_string('C');

                        gotoxy(7,1);
                        lcddat('C');delay
                        ();
                        delay();
                        delay();
                        delay();
                        while(1);
            }
}

void uart_1(void)
{
            PINSEL0 = 0x00050000;
            U1LCR = 0x83;
            U1FDR = 0x00000010;
            U1DLL = 98;
            U1LCR = 0x03;
            U1IER = 0x01;
}
void delay(void)
{
   int      d;
   for (d = 0; d <100000;d++);                    /* only to delay for LED flashes*/
}

void tx_string(char str)
{
            putcharr(str);
}
void putcharr (unsignedcharch)                    /* Writes character to SerialPort*/
{
       while (!(U1LSR&TEMT));                                  /* U1LSR --> Statusregister
*/
            U1THR = ch;
}
```

/***/

ARM RECEIVERPROGRAM

/***/

```
#include <LPC214X.H>
#include "lcd.c"
void uart_1(void); void
delay(void);
unsigned chargetcharr(void);                      /* Reads character from SerialPort*/

int main(void)
{
char rx_data;
            uart_1();
            lcdinit();
            printstr("SM MICRRO SYSTEM",0,0);
            while(1)
            {
```

```
                rx_data=getcharr();                    /* Reads character fromSerial
Port*/
                gotoxy(7,1);
                lcddat(rx_data);
        }
}

voiduart_1(void)  /* UART Installation*/
{
        PINSEL0 = 0x00050000;
        U1LCR = 0x83;
        U1FDR = 0x00000010;
        U1DLL = 98;
        U1LCR = 0x03;
        U1IER = 0x01;
}
void delay(void)
{
   int     d;
   for (d = 0; d <100000;d++);              /* only to delay for LED flashes*/
}
unsigned chargetcharr(void)                 /* Reads character from SerialPort*/
  {
   while (!(U1LSR & 0x01));
   return (U1RBR);
}
```

Implementing zigbee protocol with ARM PROGRAMS PORTDETAIL

TRANSMITTER PROGRAM

ARM	Details
P0.8	TXD1
P0.9	RXD1
P0.10	RS LCD PIN
P1.11	CE LCD PIN

RECEIVER PROGRAM

ARM	Details
P0.8	TXD1
P0.9	RXD1
P0.10	RS LCD PIN
P1.11	CE LCD PIN

Post Lab Questions

1. How to verify the communication between Transmitter and Receiver?
2. Which module is using Zigbee protocol?
3. How many UART ports available in LPC2148?
4. Write the two modes of communication are used in a ZigBee network.
5. Mention the transmission range for Zigbee protocol.

Result

The C-Language program for Zigbee Protocol is written and the communication between Xbee Module Transmitter and Receiver is verified.

12. SIMULATION USING PROTEUS SOFTWARE –AN INTRODUCTION

Aim

To simulate a multivibrator using Proteus Software and check its functionality by verifying its output with an simulated LED.

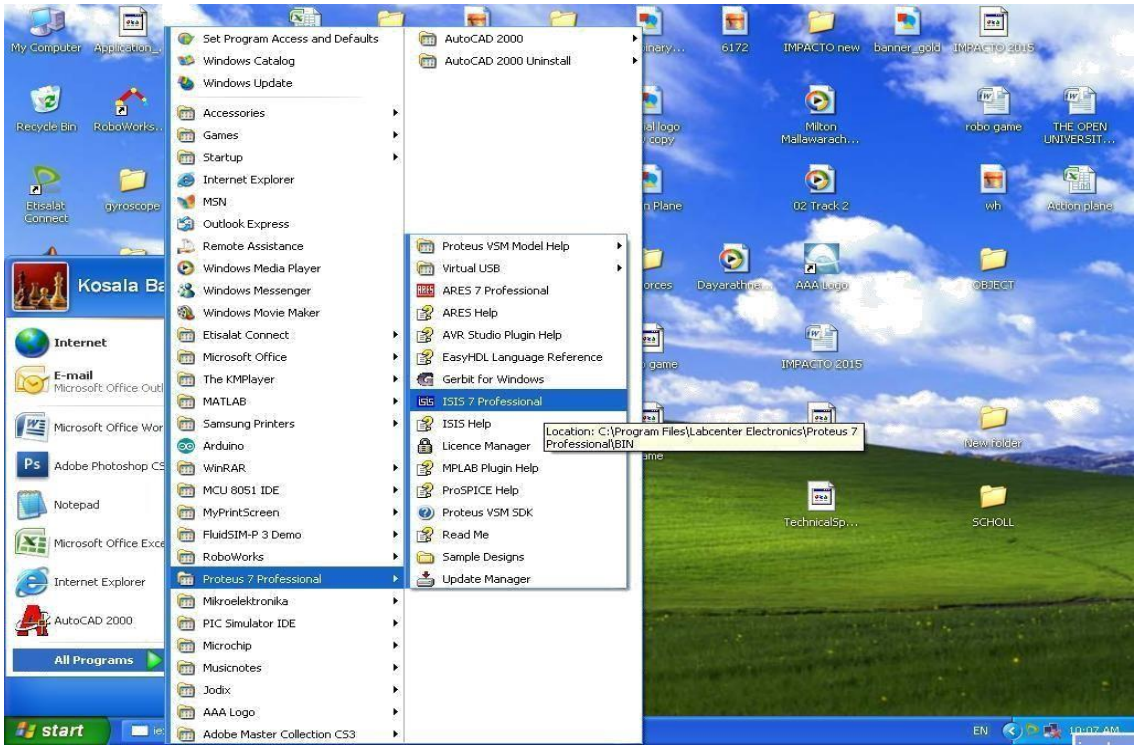
Pre Lab Questions

1. What is the need for a simulationtool?
2. What is Proteus Software?
3. List the feature of Proteus Software?
4. List some of the design tools in proteus software?
5. Give any 3 gadgets available in the proteus software?

Procedure

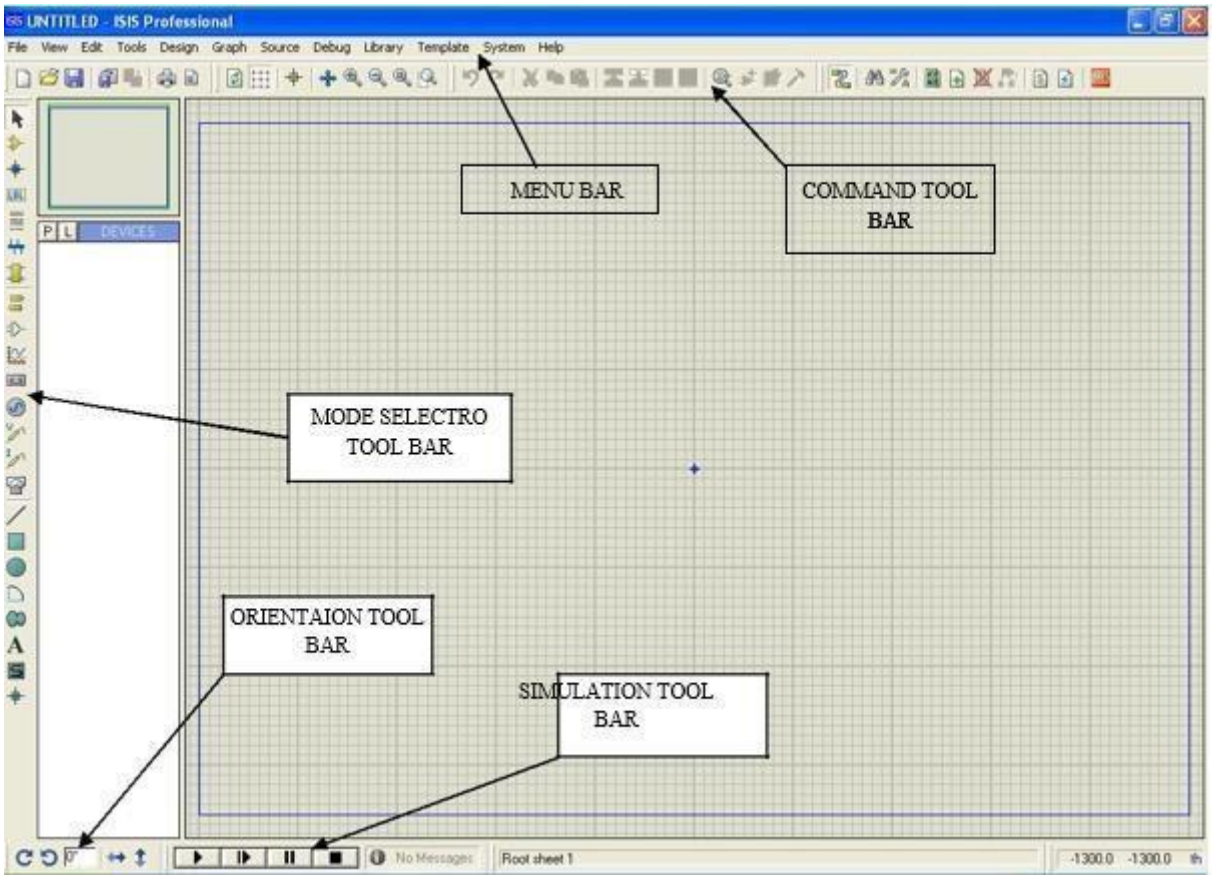
Step1:

Start → All Programs → Proteus xx Professional → ISIS xxProfessional



Note:

- **Identify the components**



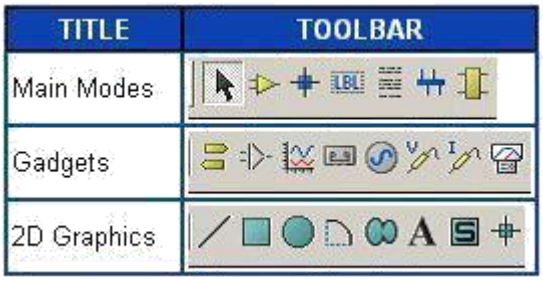
The MenuBar

TheToolbars

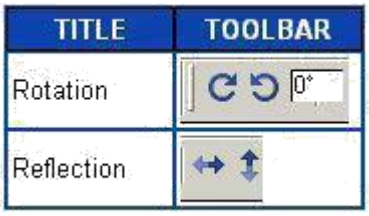
Command Toolbars

TITLE	TOOLBAR
File / Print Commands	
Display Commands	
Editing Commands	
Design Tools	

Mode Selector Toolbar



Orientation Toolbar



Simulation Toolbar

Construct the following multivibrator circuit using analog and digital components and simulate it,

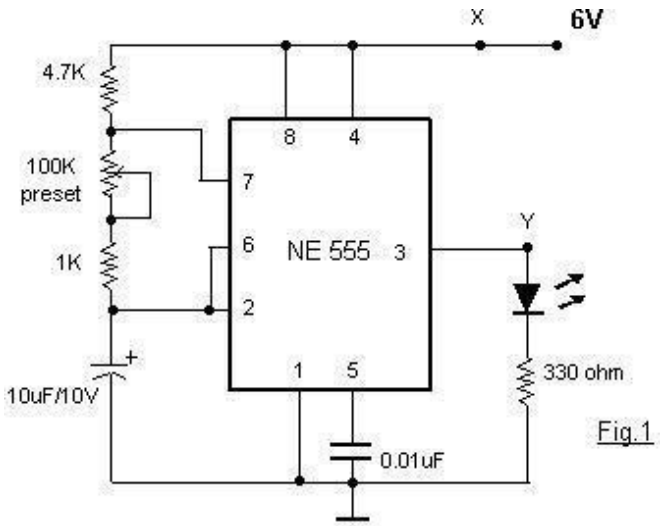


Fig.1

The Components needed are,

Resistors 4.7kΩ ,1kΩ 330Ω , 100k (variable resistor)

Capacitors 10uF ,0.01uF

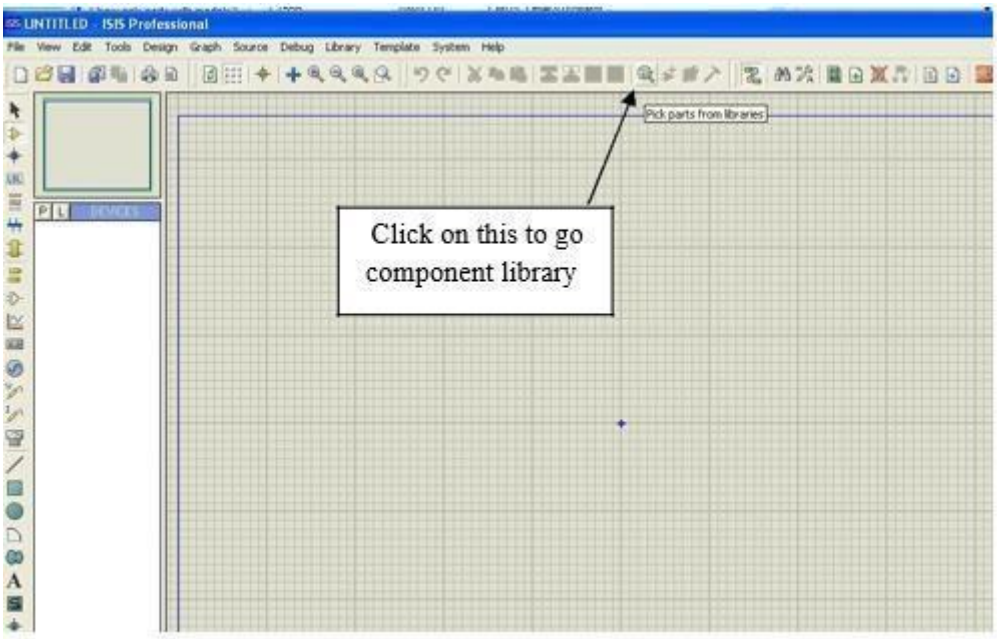
IC NE555

LED

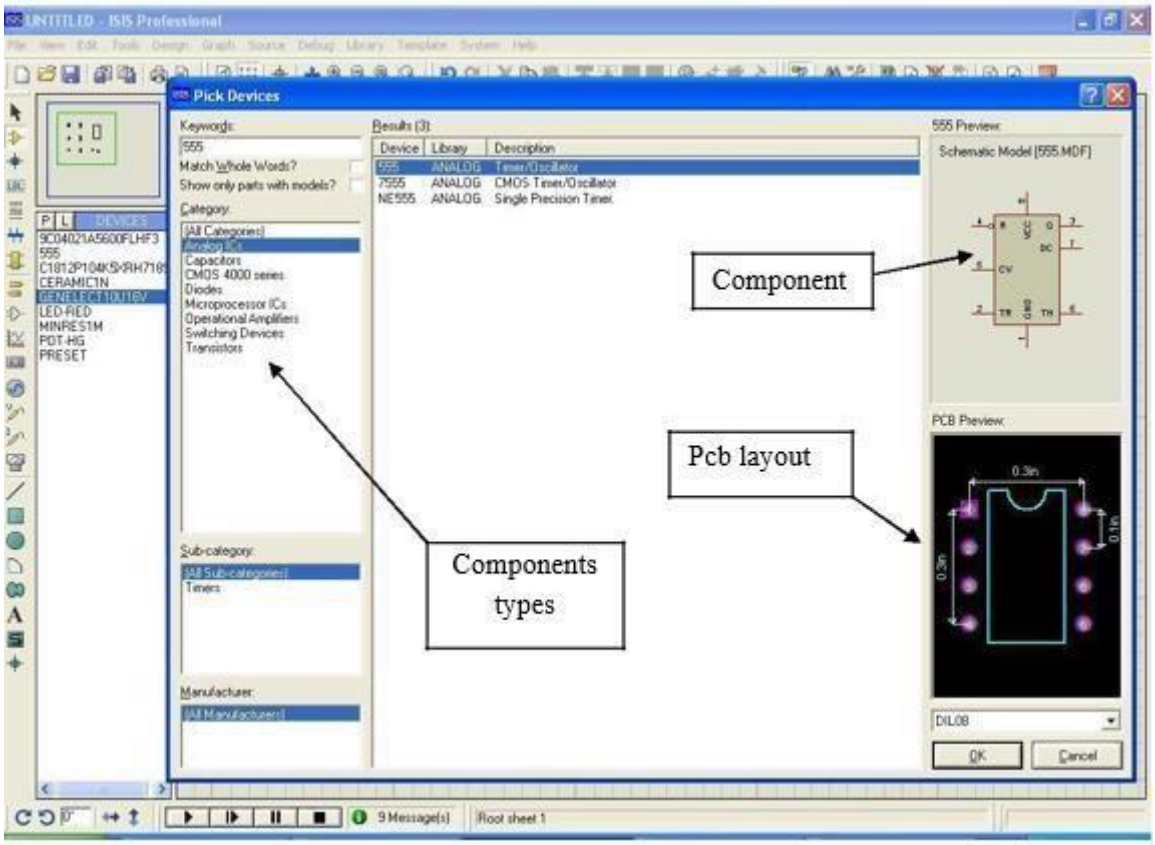
Power supply

Step 2:

Choose required components from the component library in editingcommands.

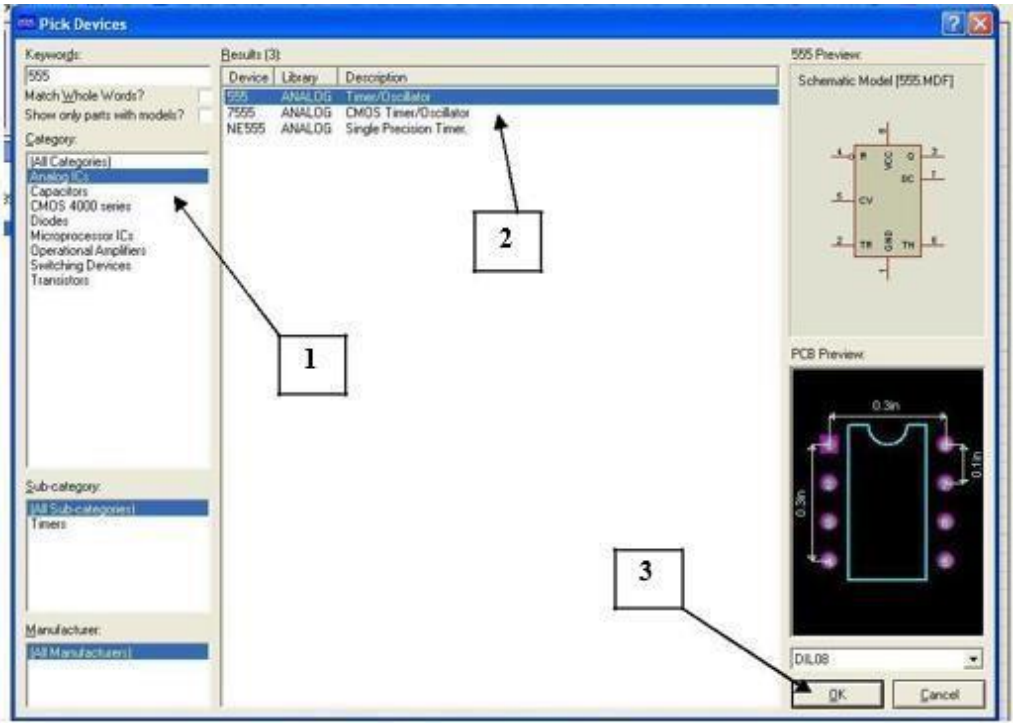


Then the component library window will appear

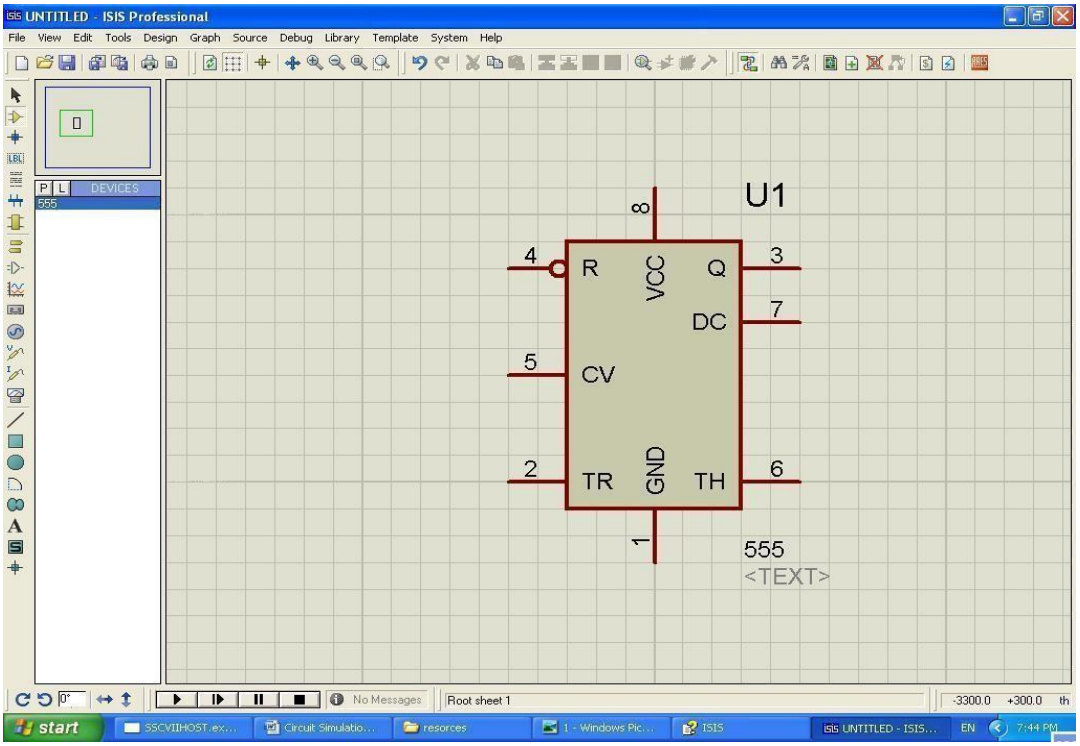


Step 3

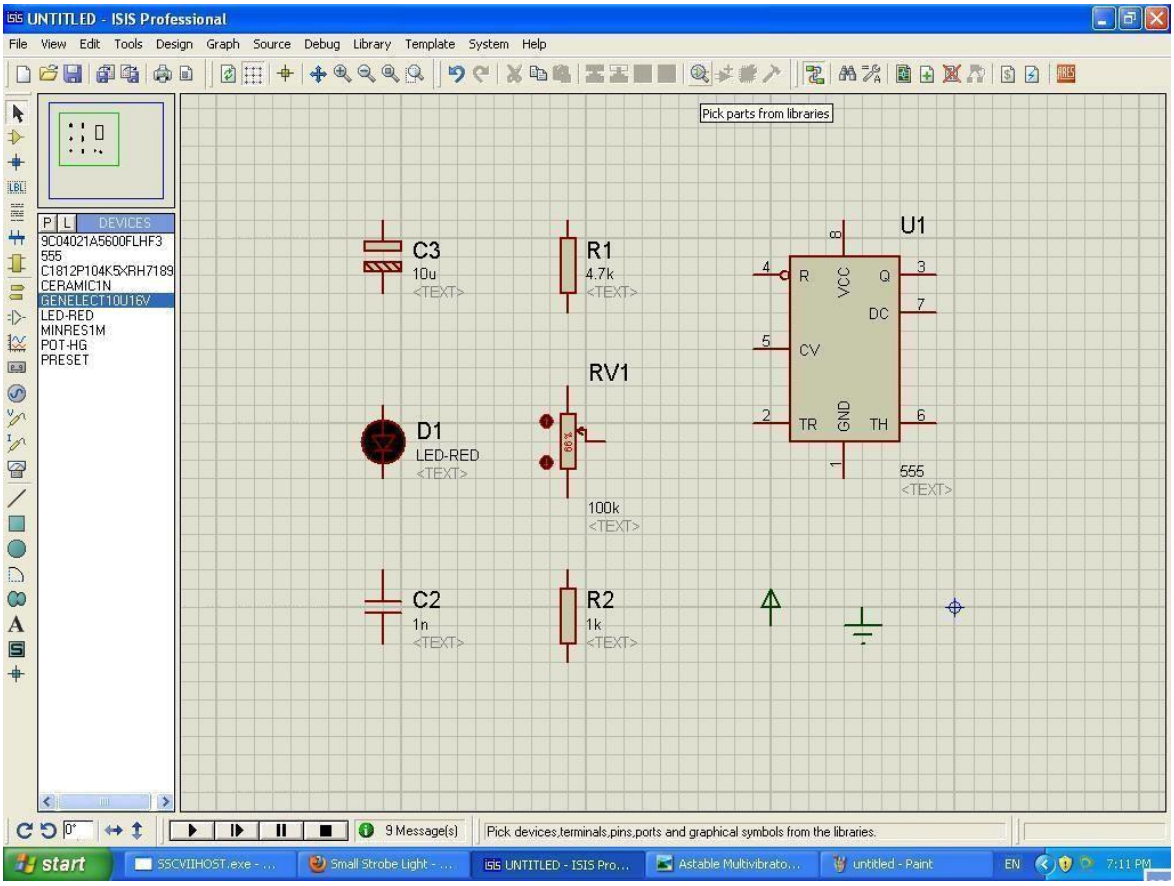
Then choose the all require components and put into the main window.



1. Select “Analog ICs” inCategory
2. Then select “555 ANALOGTIME/OSCILATOR”
3. Next click onOK
4. Finally component put into mainwindow

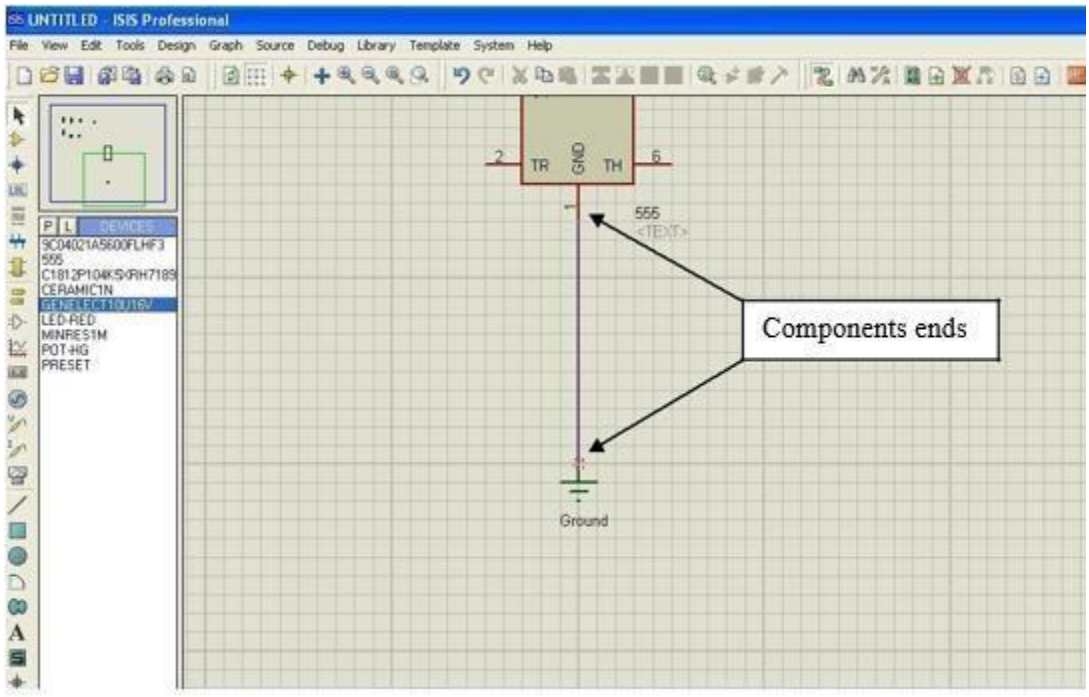


Following the same procedure, place all the required components to main window

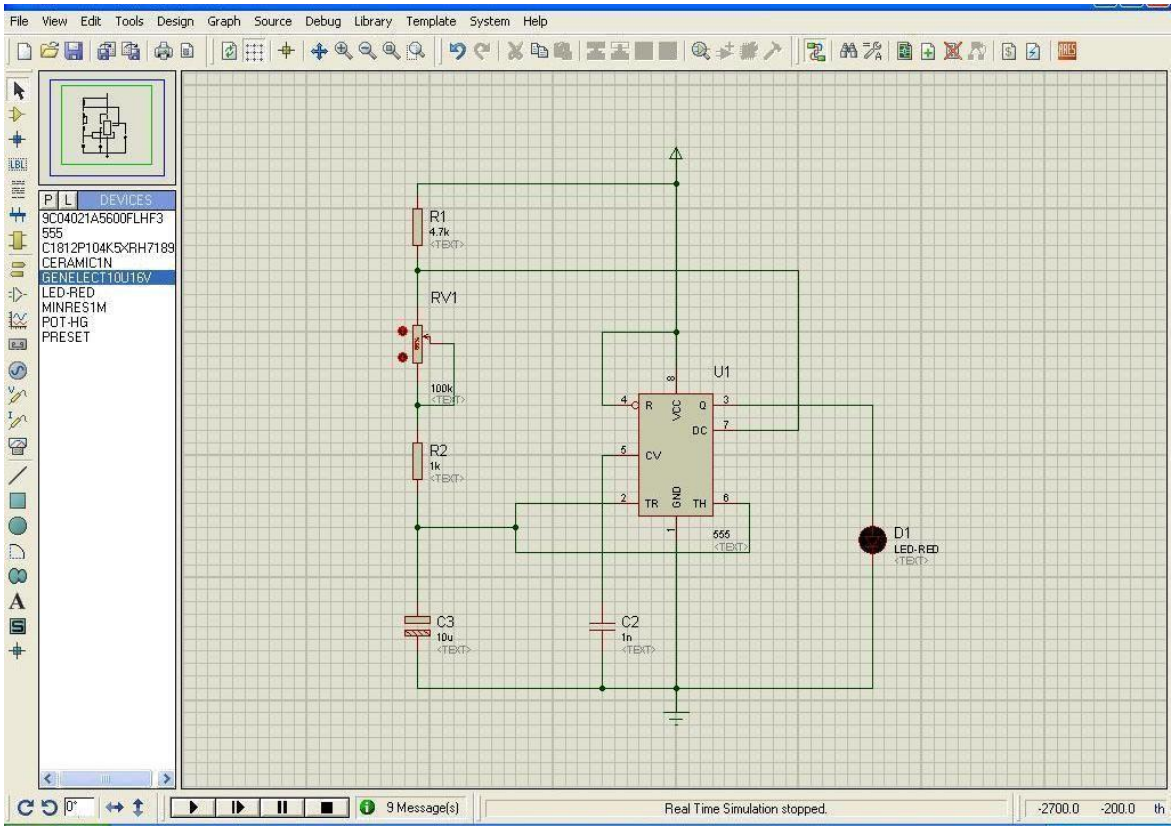


Step 4

Connect all the components as the above circuit diagram by using connecting lines. We can get connecting lines by selectingendsofthecomponentsasshowsinfollowingfigure.

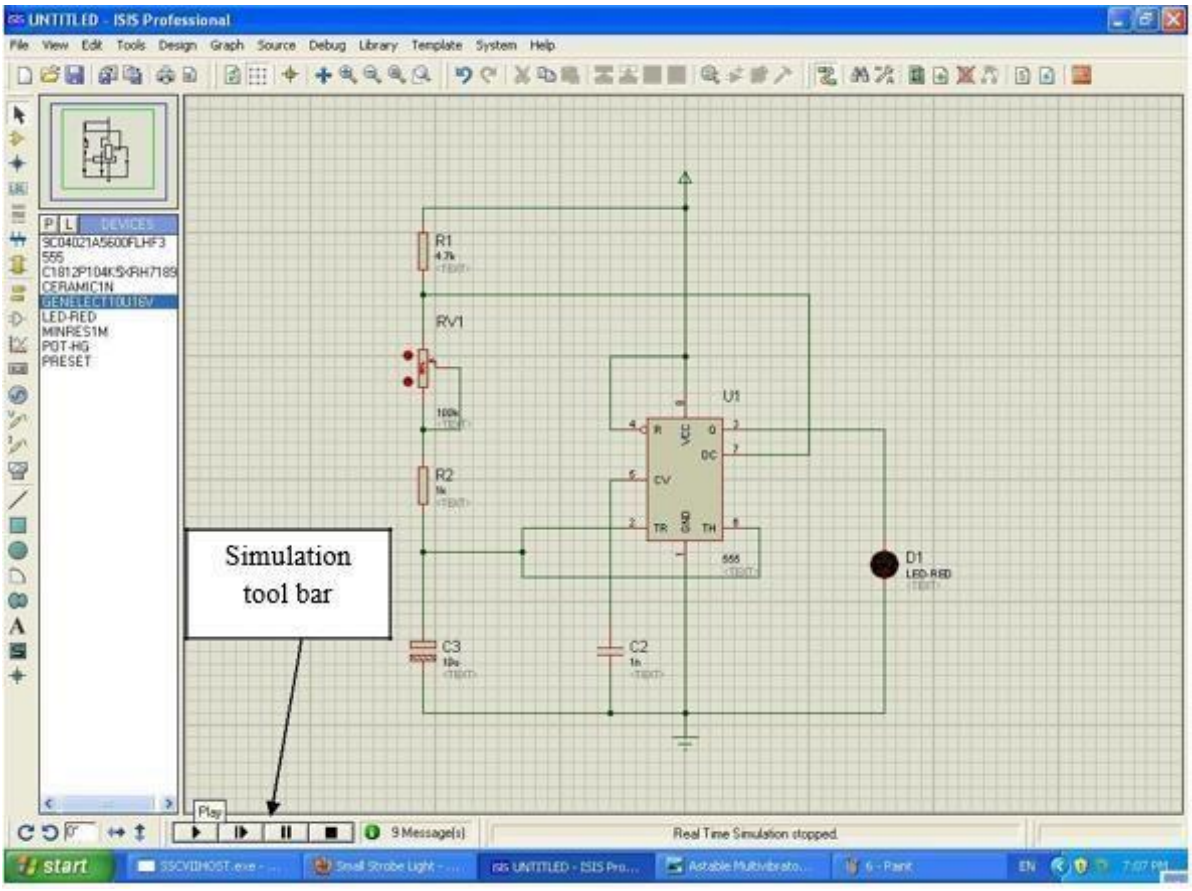


Then complete the circuit using connecting lines as following figure…..



Step 5

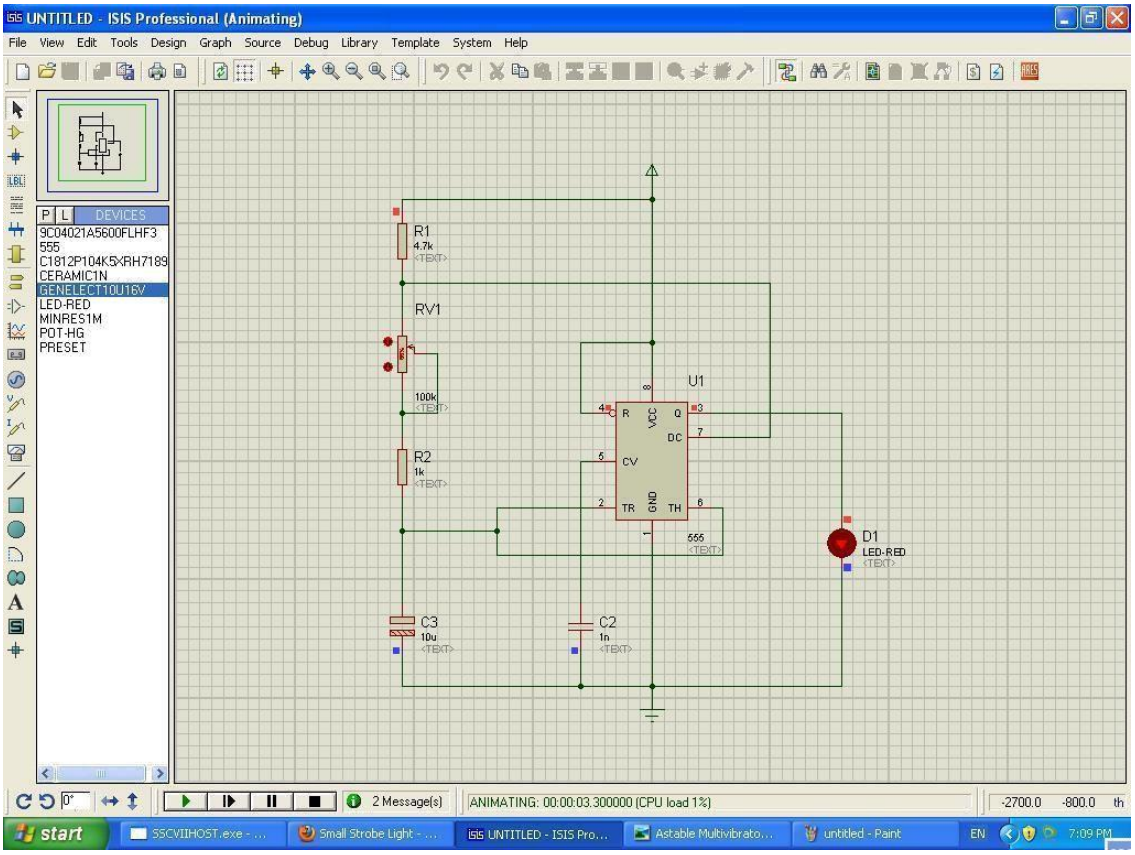
Now make sure all the components correctly connected. Then go the simulation tool bar.



To start the simulation click on play button. 

Then start the simulation if there are any errors the simulation must be fail and give error messages.

Check the output by inspecting the status of the LED.



Post Lab Questions

1. What is mode selector tool bar
2. What is orientation tool bar
3. What is the need for simulation tool bar?
4. What is the frequency of the output obtained in simulation?
5. What is the name of the library under which 555IC is located?

Result

Thus the Multivibrator is simulated using Proteus Software and the output is observed.

13. SIMULATION OF CALCULATOR USING 8051 MICROCONTROLLER IN PROTEUS SOFTWARE

Aim

To simulate a simple calculator using 8051microcontroller in Proteus Software.

Pre Lab Questions

1. List some of the microprocessor supported by proteus software
2. List the required arithmetic operations to be performed by the calculator?
3. Write down the features of 8051 microcontroller
4. What is the difference between microprocessor and microcontroller?
5. What is the size of the data bus in 8051 microcontroller?

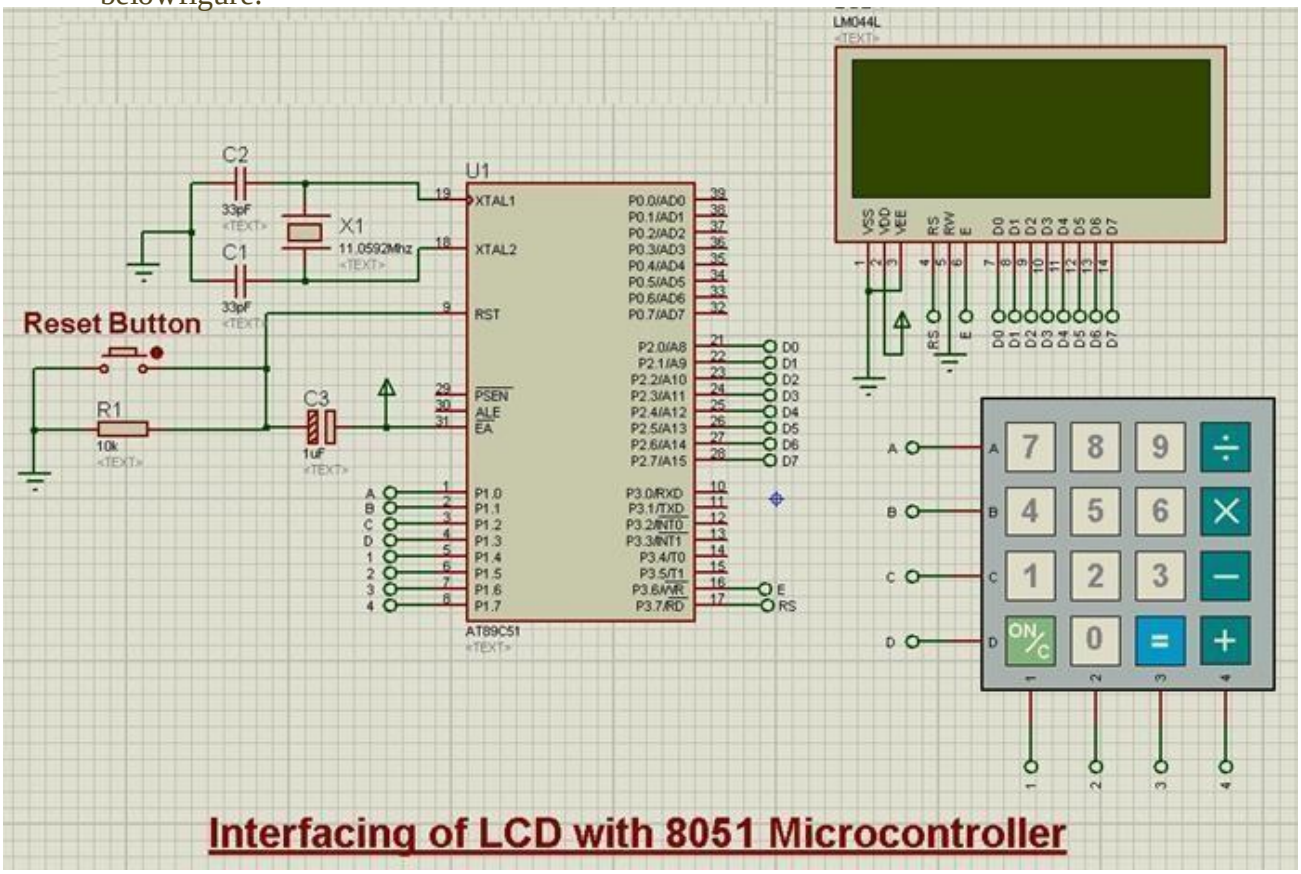
Procedure

The calculator we are going to design is quite basic calculator, it will only perform 4 tasks, which are as follows:

- When you press the **(+)** button then it will add the two digits. For example, you want to add 2 and 3 then you need to press **2 + 2 =** these four buttons in sequence and when you press the = button it will automatically will give you the sum.
- When you press **(-)** button it will subtract the two digits like **3 – 2 =** and it will give you the result.
- When you press **(x)** button it will multiply the two digits.
- When you press the **(/)** button it will simply divide the two digits.
- Whenever you press the **(=)** button, it will give you the output
- depending on the function you used before and if you press (=) in the start then it will give "Wrong Input".
- Finally,there's**(ON/C)**button on the Calculator, when you press this it will simply reset the code and will clear theLCD.
- So,that'show this calculator is goanna work. More over, it will always reset when you try to calculate new value.
- As its a simple calculator, so its only limited to 1 digit, means it will only apply the operation on single digit input like 2+3 but it won't work on more than 1 digit like 12 +13.
- After that, we will do the coding part for calculator with 8051 Microcontroller.
- So, now let's get started with Proteus Simulation.

ProteusSimulation

- TheProteusSimulationofthisCalculatorwith8051 Microcontroller and is shown in belowfigure:



ProgrammingCode

```
1       while(1)
2           {
3              //getnumb1
4              key =get_key();
5              writecmd(0x01);                  //cleardisplay
6           writedata(key);                  //Echo the key pressed toLCD
7           num1=get_num(key);               //Get int number from char value, it checksfor
8
9       wrong input as well
10          if(num1!=Error)                  //if correct input then proceed,num1==Error
11      means wrong input
12          {
13                  //getfunction
14                  key =get_key();
15                  writedata(key);                          //Echo the key pressed toLCD
16                  func=get_func(key);                      //it checks for wrong func 17
18                  if(func!='e')                            //if correct input thenproceed,
19      func=='e' means wrong input 20
        {
21                          //getnumb2
22                          key =get_key();
23                          writedata(key);                      //Echo the key pressed toLCD
24                          num2=get_num(key);                   //Get int number fromchar
25      value, it checks for wrong input as well 26
27                          if(num2!=Error)                      //if correct inputthen
28      proceed, num2==Error means wronginput
```

```
29                              {
30                                      //get equal sign key =
31                                      get_key();
32                                      writedata(key);                 //Echo the key pressed to LCD if(key=='=')
33
34                                                                      //if = is pressedthen
35      proceed
36                                      {
37                                              switch(func)                    //switch onfunction
38                                              {
39                                              case '+': disp_num(num1+num2); break; case '-':
40                                              disp_num(num1-num2);    break;  case    'x':
41                                              disp_num(num1*num2);    break;  case    '/':
42                                              disp_num(num1/num2); break;
43                                              }
44                                      }
45                                      else                                    //key other then=

46      here means error wronginput 47  {
48
                                                Displaywrong
                                                if(key=='C')                    //if clear screenis
49      pressed then clear screen andreset
                                                        writecmd(0x01);         //Clear Screen DispError(0);
                                                  else
                                                                                //Displaywrong
        input error
                                        }
                                }
                        }
                    }
                }
```

- As you can see in the above function, first check for thefirst keypress.
- When you pressed the first key on keypad then I get this key and converter it tointeger.
- AfterthatIwaitedforthenextkeywhichmustbesomeoperation keylike+– Xor/otherwiseitwillgeneratetheerrormessage.
- After that code is waiting for the third key which should be somenumericaldigitandthenItconvertsittointegeragainand if you entered some invalid key then it will generate theerror.
- Finally waiting for the = sign. When you press the = sign it will automatically perform the required operation which Iplaced in the switch caseloop.
- It will calculate the value and then print out the result and onnextkeypressitwillfirstclearthescreenandthengetthe value and willcontinue.
- Below is the detailed code for the project withcomments

```
1       #include<reg51.h>
2       #include<string.h>3
4       //DefineMacros
5       #defineError        13      // Any value other than 0 to 9 is good here 6
7       //Functiondeclarations
8       voidcct_init(void);
9       voiddelay(int);
10      voidlcdinit(void);
```

```
11      voidwritecmd(int);
12      voidwritedata(char);
13      voidwriteline(char[]);
14      voidReturnHome(void);
15      charREAD_SWITCHES(void);
16      charget_key(void);
17      intget_num(char);
18      charget_func(char);
19      voidDispError(int);
20      voiddisp_num(int);
21      void WebsiteLogo();
22      22
23      /
24      //Pindescription
25      /*
26      P2 is databus
27      P3.7 isRS
28      P3.6 isE
29      P1.0 to P1.3 are keypad rowoutputs
30      P1.4 to P1.7 are keypad column inputs 31
        */
32      //*********************
33      // DefinePins
34      //*********************
35        sbit RowA = P1^0;       //RowA
36        sbit RowB = P1^1;       //RowB
37        sbit RowC = P1^2;       //RowC
38        sbit RowD = P1^3;       //RowD
39
40        sbit C1   = P1^4;       //Column1
41        sbit C2   = P1^5;       //Column2
42        sbit C3   = P1^6;       //Column3
43        sbit C4   = P1^7;       //Column4
44
45        sbit E    = P3^6;       //E pin for LCD
46        sbit RS   = P3^7;       //RS pin for LCD
47
48    //*************************************************************
49    // Mainprogram
50    //
51    intmain(void)
52    {
53        charkey;                          //key char for keeping record ofpressed
54    key
55        int num1=0;                       //Firstnumber
56        char func='+';                    //Function to be performed amongtwo
57    numbers
58        int num2=0;                       //Second number 59
60        cct_init();                       //Make input and output pins asrequired
61        lcdinit();                        //InitilizeLCD
62        WebsiteLogo();
63        while(1)
64        {
65          WebsiteLogo();
66          //getnumb1
67          key =get_key();
68          writecmd(0x01);                 //cleardisplay
69        WebsiteLogo();
70        writedata(key);                   //Echo the key pressed toLCD
71        num1=get_num(key);                //Get int number from char value, itchecks
72    for wrong input as well 73
74        if(num1!=Error)                   //if correct input then proceed,num1==Error
75    means wrong input 76
          {
77              //getfunction
78              key =get_key();
79              writedata(key);                         //Echo the key pressed toLCD
80              func=get_func(key);                     //it checks for wrong func 81
```

```
82                  if(func!='e')                       //if correct input thenproceed,
83          func=='e' means wrong input
84                  {
85                          //get numb2
86                          key = get_key();
87                          writedata(key);             //Echo the key pressed toLCD
88                          num2=get_num(key);          //Get int number fromchar
89          value, it checks for wrong input as well
90
91                          if(num2!=Error)             //if correct inputthen
92          proceed, num2==Error means wrong input
93                          {
94                                  //get equal sign
95                                  key = get_key();
96                                  writedata(key);         //Echo the key pressedto
97          LCD
98
99                                  if(key=='=')            //if = is pressedthen
100         proceed
101                                 {
102                                         switch(func)        //switch onfunction
103                                         {
104                                         case '+': disp_num(num1+num2); break;
105                                         case '-': disp_num(num1-num2); break;
106                                         case 'x': disp_num(num1*num2); break;
107                                         case '/': disp_num(num1/num2); break;
108                                         }
109                                 }
110                                 else                        //key other then=
111         here means error wrong input
112                                 {
113                                         if(key=='C')        //if clear screenis
114         pressed then clear screen and reset
115                                         {
116                                             writecmd(0x01);     //Clear Screen
117                                                 WebsiteLogo();
118                                         }
119                                         else
120                                         {
121                                                 DispError(0);           //Display     wrong
122           input     error
123                                                     WebsiteLogo();
124                                         }
125                                 }
126                         }
127                 }
128             }
129         }
130         }
131
132         void WebsiteLogo()
133         {
134             writecmd(0x95);
135             writedata('w');                                 //write
136             writedata('w');                                 //write
137             writedata('w');                                 //write
138             writedata('.');                                 //write
139             writedata('T');                                 //write
140             writedata('h');                                 //write
141             writedata('e');                                 //write
142             writedata('E');                                 //write
143             writedata('n');                                 //write
144             writedata('g');                                 //write
145             writedata('i');                                 //write
146             writedata('n');                                 //write
147             writedata('e');                                 //write
148             writedata('e');                                 //write
149             writedata('r');                                 //write
150             writedata('i');                                 //write
151             writedata('n');                                 //write
152             writedata('g');                                 //write
```

```
153
154             writecmd(0xd8);
155
156             writedata('P');                                         //write
157             writedata('r');                                         //write
158             writedata('o');                                         //write
159             writedata('j');                                         //write
160             writedata('e');                                         //write
161             writedata('c');                                         //write
162             writedata('t');                                         //write
163             writedata('s');                                         //write
164             writedata('.');                                         //write
165             writedata('c');                                         //write
166             writedata('o');                                         //write
167             writedata('m');                                         //write
168             writecmd(0x80);
169         }
170
171         voidcct_init(void)
172         {
173           P0=0x00;          //notused
174           P1=0xf0;          //used for generating outputs and taking inputs fromKeypad
175           P2=0x00;          //used as data port forLCD
176           P3=0x00;          //used for RS andE
177         }
178
179         void delay(inta)
180         {
181             inti;
182             for(i=0;i<a;i++);               //nullstatement
183         }
184
185         void writedata(chart)
186         {
187             RS=1;                           // This isdata
188             P2=t;                           //Datatransfer
189             E   =1;                           //  => E  = 1
190             delay(150);
191             E   =0;                           //  => E  = 0
192             delay(150);
193         }
194
195
196         void writecmd(int         z)
197         {
198             RS = 0;                         //    This   is command
199             P2=z;                           //Datatransfer
200             E   =1;                         // => E =1
201             delay(150);
202             E   =0;                         // => E =0
203             delay(150);
204         }
205
206         void lcdinit(void)
207         {
208            ////////////// Reset process from datasheet /////////
209                 delay(15000);
210              writecmd(0x30);
211                 delay(4500);
212              writecmd(0x30);
213                 delay(300);
214              writecmd(0x30);
215                 delay(650);
216            ////////////////////////////////////////////////////
217              writecmd(0x38);            //functionset
218              writecmd(0x0c);            //display on,cursor off,blinkoff
219              writecmd(0x01);            //cleardisplay
220              writecmd(0x06);            //entry mode, setincrement
221         }
222         voidReturnHome(void)                /* Return to 0 cursor location*/
```

```
223
224     {
225         writecmd(0x02);
226         delay(1500);
227         WebsiteLogo();
228     }
229
230     void writeline(char Line[])
231     {
232         int i;
233         for(i=0;i<strlen(Line);i++)
234         {
235                 writedata(Line[i]);                 /* Write Character*/
236         }
237
238         ReturnHome();                   /* Return to 0 cursor position*/
239     }
240
241     char READ_SWITCHES(void)
242     {
243       RowA =   0;  RowB    = 1; RowC = 1; RowD    = 1;                  //Test Row A
244
245       if (C1   ==  0) {     delay(10000); while    (C1==0);    return '7'; }
246       if (C2   ==  0) {     delay(10000); while    (C2==0);    return '8'; }
247       if (C3   ==  0) {     delay(10000); while    (C3==0);    return '9'; }
248       if (C4   ==  0) {     delay(10000); while    (C4==0);    return '/'; }
249
250       RowA =   1;  RowB    = 0; RowC = 1; RowD    = 1;                  //Test Row B
251       if (C1   ==  0) {     delay(10000); while    (C1==0);    return '4'; }
252       if (C2   ==  0) {     delay(10000); while    (C2==0);    return '5'; }
253       if (C3   ==  0) {     delay(10000); while    (C3==0);    return '6'; }
254       if (C4   ==  0) {     delay(10000); while    (C4==0);    return 'x'; }
255
256
257       RowA =   1;  RowB    = 1; RowC = 0; RowD    = 1;                  //Test Row C
258
259       if (C1   ==  0) {     delay(10000); while    (C1==0);    return '1'; }
260       if (C2   ==  0) {     delay(10000); while    (C2==0);    return '2'; }
261       if (C3   ==  0) {     delay(10000); while    (C3==0);    return '3'; }
262       if (C4   ==  0) {     delay(10000); while    (C4==0);    return '-'; }
263
264       RowA =   1;  RowB    = 1; RowC = 1; RowD    = 0;                  //Test Row D
265
266       if (C1   ==  0) {     delay(10000); while    (C1==0);    return 'C'; }
267       if (C2   ==  0) {     delay(10000); while    (C2==0);    return '0'; }
268       if (C3   ==  0) {     delay(10000); while    (C3==0);    return '='; }
269       if (C4   ==  0) {     delay(10000); while    (C4==0);    return '+'; }
270
271       return'n';                              // Means no key has beenpressed
272     }
273
274     charget_key(void)                         //get key fromuser
275     {
276       char key='n';                           //assume no key pressed 277
278       while(key=='n')                         //wait untill a key ispressed
279               key=READ_SWITCHES();            //scan the keys again and again 280
281       returnkey;                              //when key pressed then return itsvalue
282     }
283
284     int get_num(char ch)                      //convert char into int
285     {
286       switch(ch)
287       {
288               case '0': return 0; break;
289               case '1': return 1; break;
290               case '2': return 2; break;
291               case '3': return 3; break;
292               case '4': return 4; break;
293               case '5': return 5; break;
294               case '6': return 6; break;
```

Post Lab Questions

1. What is the need for LCD in the project?
2. What is the need for ADC in the Project?
3. What are the arithmetic operations done in the simulation?
4. What is the need for RESET button in the project?
5. What is the operating frequency of the microcontroller?

Result

Thus the calculator was simulated using8051microcontroller in Proteus Software.

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

EC8711 EMBEDDED LABORATORY

Semester - 07

LABORATORY MANUAL

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Vision

To excel in providing value based education in the field of Electronics and Communication Engineering, keeping in pace with the latest technical developments through commendable research, to raise the intellectual competence to match global standards and to make significant contributions to the society upholding the ethical standards.

Mission

- ✓ To deliver Quality Technical Education, with an equal emphasis on theoretical and practical aspects.
- ✓ To provide state of the art infrastructure for the students and faculty to upgrade their skills and knowledge.
- ✓ To create an open and conducive environment for faculty and students to carry out research and excel in their field of specialization.
- ✓ To focus especially on innovation and development of technologies that is sustainable and inclusive, and thus benefits all sections of the society.
- ✓ To establish a strong Industry Academic Collaboration for teaching and research, that could foster entrepreneurship and innovation in knowledge exchange.
- ✓ To produce quality Engineers who uphold and advance the integrity, honour and dignity of the engineering.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1. To provide the students with a strong foundation in the required sciences in order to pursue studies in Electronics and Communication Engineering.
2. To gain adequate knowledge to become good professional in electronic and communication engineering associated industries, higher education and research.
3. To develop attitude in lifelong learning, applying and adapting new ideas and technologies as their field evolves.
4. To prepare students to critically analyze existing literature in an area of specialization and ethically develop innovative and research oriented methodologies to solve the problems identified.
5. To inculcate in the students a professional and ethical attitude and an ability to visualize the engineering issues in a broader social context.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Design, develop and analyze electronic systems through application of relevant electronics, mathematics and engineering principles.

PSO2: Design, develop and analyze communication systems through application of fundamentals from communication principles, signal processing, and RF System Design & Electromagnetics.

PSO3: Adapt to emerging electronics and communication technologies and develop innovative solutions for existing and newer problems.

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

VII SEM – E.C.E.

EC 8761- ADVANCED COMMUNICATION LABORATORY

CYCLE I

1. Measurement of connector, bending and fiber attenuation losses
2. Numerical Aperture and Mode Characteristics of fibers
3. DC Characteristics of LED and PIN Photo diode
4. i) Fiber optic Analog Characterization- frequency response(analog)

   ii) Fiber optic Digital Link Characterization -eye diagram and BER (digital)
5. Wireless Channel Simulation including fading and Doppler effects

CYCLE II

6. Simulation of Channel estimation, Synchronization& Equalization techniques
7. Analyzing Impact of Pulse Shaping and Matched filtering using MATLAB.
8. OFDM Signal Transmission and Reception using MATLAB.
9. VSWR and Impedance Measurement and Impedance Matching.
10. Characterization of Directional couplers, Isolators and Circulators.
11. Gunn diode Characteristics

EXP. NO: 1
DATE:

MEASUREMENT OF CONNECTOR, BENDING AND FIBER ATTENUATION LOSSES

AIM:

To measure the bending and connector and fiber attenuation losses of optical fibers.

APPARATUS REQUIRED:

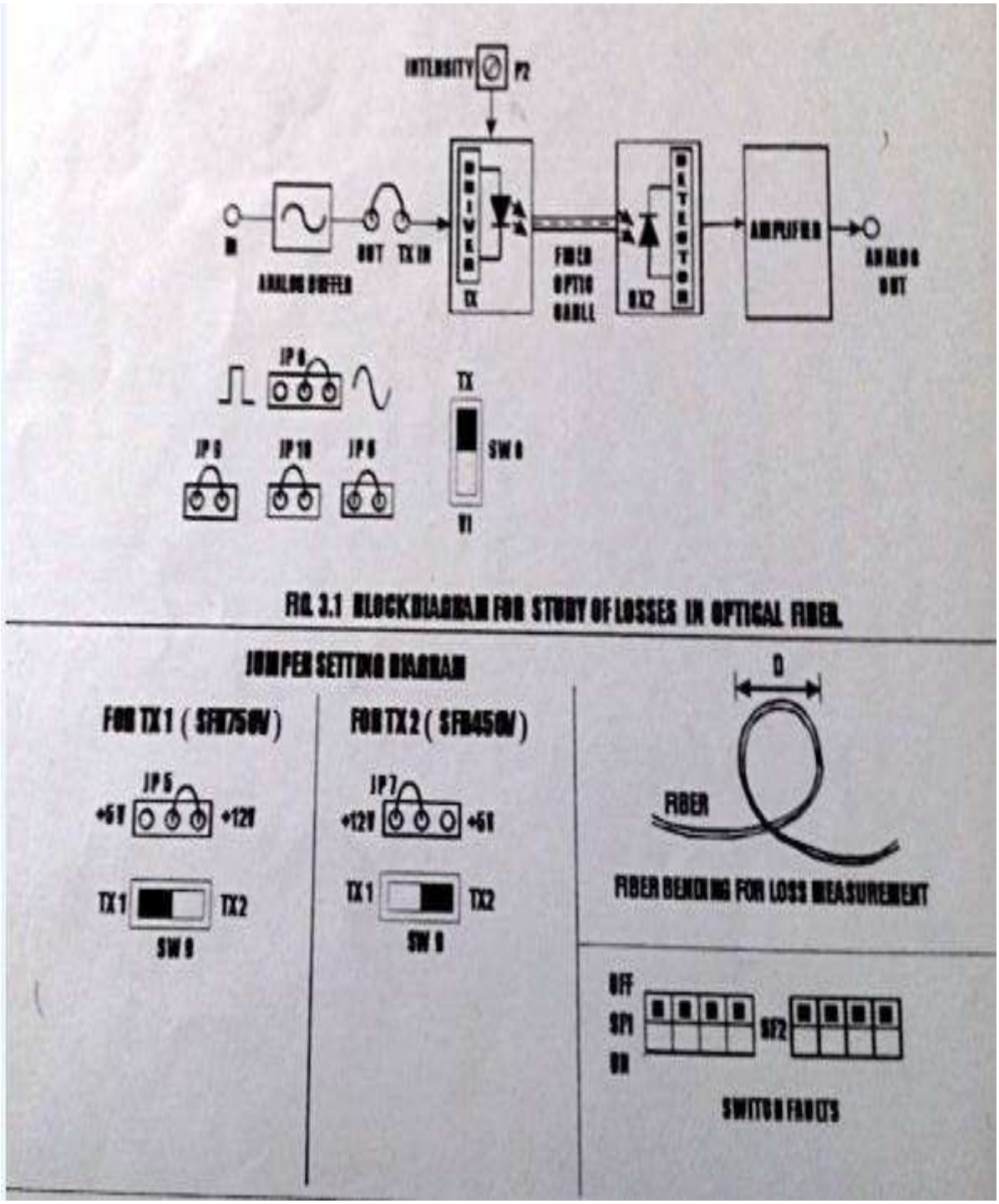
Sl.No	Equipments	Quantity
1.	Power Supply	1
2.	Link B kit	1
3.	1 & 3 Meter Fiber cable	1

THEORY:

Optical fibers are available in different variety of materials. These materials are usually selected by taking into account their absorption characteristics for different wavelengths of light. In case of optical fiber, since the signal is transmitted in the form of light, which is completely different in nature as that of elections, one has to consider the interaction of matter with the radiation to study the losses in fiber.

Losses are introduced in fiber due to various reasons. As light propagates from one end of fiber to another end, part of it is absorbed in the material exhibiting absorption loss. Also part of the light is reflected back of in some other directions from the impurity particles present in the material contributing to the loss of the signal at the other end of the fiber.

In general terms it is known as propagation loss. Plastic fibers have higher loss of the order of 180 dB/Km. whenever the condition for angle of incidence of the incident light is violated the losses are introduced due to reflection of light. This occurs when fiber is subjected to bending. Lower the radius of curvature more is the loss. Another losses are due to the coupling of fiber at LED & photo detector ends with fibers.



MEASUREMENT OF CONNECTION LOSS

PROCEDURE:

1. Connections are made as per circuit diagram.
2. Slightly unscrew the cab of IR LED 450V (960nm) from kit1. Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap and assure that the fiber is properly fixed. Now tighten the cap by screwing back.

3. Connect the power supply cables with proper polarity to Transmitter kit and lit 2. While connecting this, ensure that the power supply is OFF.
4. Connect the on board signal generator between the AMP I/P and GND posts in Transmitter kit to feed the analog to the amplifier.
5. Keep the signal generator in sine wave mode and select the frequency =1 KHz with amplitude =2V p-p.
6. Switch on the power supply.
7. Check the output signal of the amplifier at the post AMP O/P in Transmitter kit.
8. Now rotate the Optical Power Control Pot P1 located below power supply connector in kit1 in anticlock wise direction. This ensures minimum current flow through LED.
9. Short the following posts in kit1 with the links provided.

   A. +9V and +9V – This ensures supply to the transmitter

   B. AMP O/P and TRANSMITTER I/P.

10. Connect the other end of the fiber to detector SFH 250V (Analog Detector) in kit2 very carefully as per the instructions in step 1.
11. Ensure that the jumper located just above IC U1 I Receiver kit is shorted to pins 2 and 3. Shorting of the jumper allows connection of PIN photodiode to the transimpedance amplifier input.
12. Observe the output signal from the detector at AC OUTPUT post in kit2 on CRO. Adjust Optical Power Control pot P1 in kit1. You should get the reproduction of the original transmitted signal. Also adjust the amplitude of received signal as that of the transmitted one. Mark this amplitude level as V_1.
13. Now move the position of connecting fibers for 1 cm length from the source.
14. Switch on the power supply and signal generator.
15. Observe the output signal from the detector at AC OUTPUT post in Receiver kit on CRO.
16. Now again move the connecting position of the fiber 2 cm away from fiber source . Measure the amplitude level at the receiver side again.
17. Plot the graph connecting distance versus output amplitude.

TABULATION

Connecting distance (mm)	**Input Amplitude V**	**Output Amplitude V**

MEASUREMENT OF BENDING LOSSES:

PROCEDURE:

1. Repeat all the steps from. 1 to 11 as above.
2. Bend the fiber in loop. Measure the amplitude of the received signal.
3. Keep reducing the diameter to about 1-2 cm & take corresponding output voltage readings. (Do not reduce loop diameter less than 2 cm.)
4. Plot a graph of the received signal amplitude versus the loop diameter.

TABULATION:

Bending Radius	Input Amplitude	Output Amplitude

RESULT:

Thus the Connector loss and bending loss are measured.

EXP. NO: 2A NUMERICAL APERATURE OF OPTICAL FIBER
DATE:

AIM:

To measure the numerical aperture of the plastic fiber provided with the kit using 660nm wavelength LED.

APPARATUS REQUIRED:

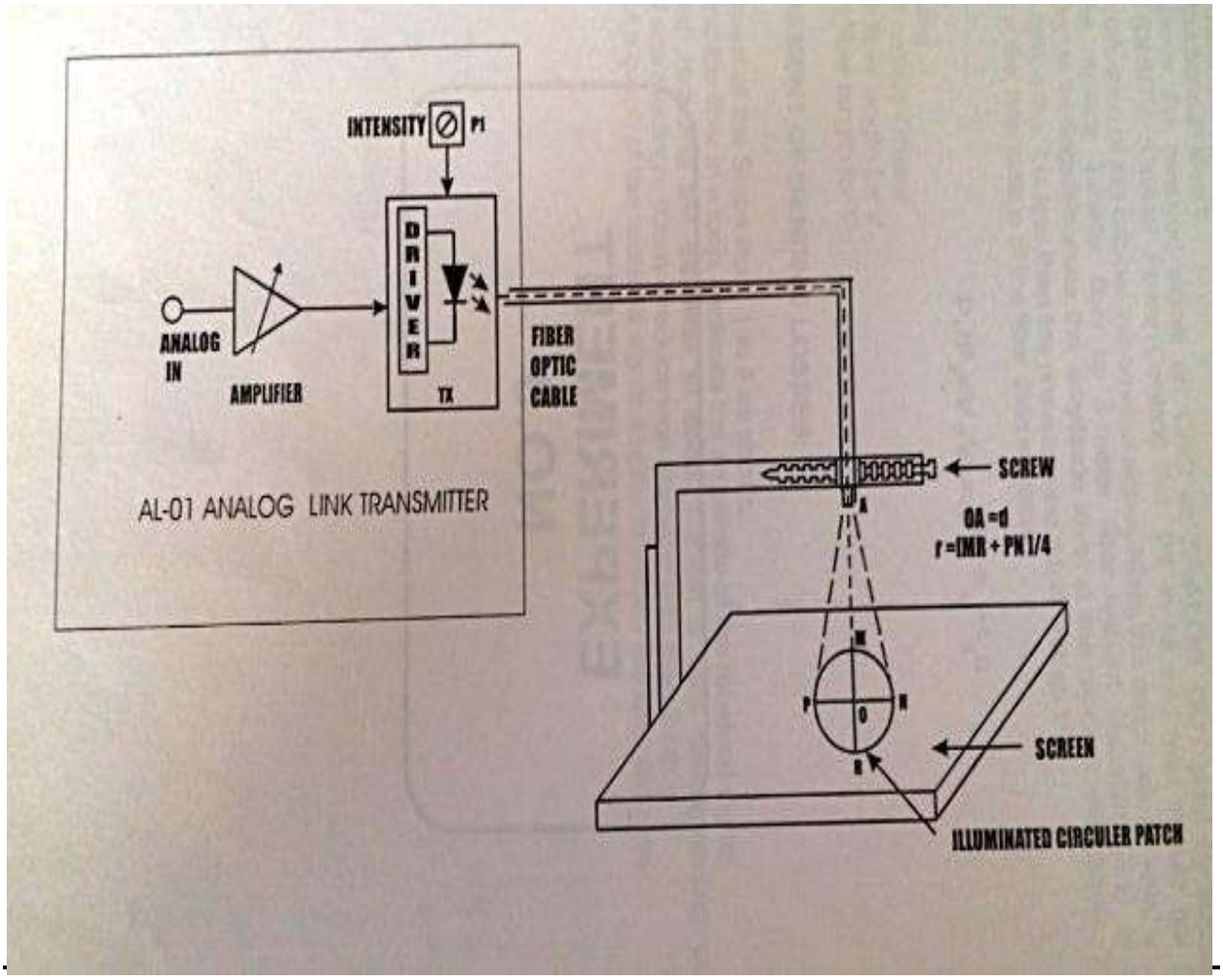
Sl.No	Equipments	Quantity
1.	Power Supply	1
2.	AL-01 KIT	1
3.	1-meter fiber cable	1
4.	NA JIG	1
5.	Ruler	1

THEORY:

Numerical aperture refers to the maximum angel at which the light incident on the fiber end is totally internally reflected and is transmitted properly along the fiber. The cone formed by the rotation of this angle along the axis of the fiber is the cone of acceptance on the fiber. The light ray should strike the fiber end within its cone of acceptance; else it is refracted out of the fiber core.

Considerations in Measurement:

1. It is very important that the optical source should be properly aligned with the cable & the distance from the launched point & the cable the property selected to ensure that the maximum amount of optical power is transferred to the cable.
2. This experiment is best performed in a less illuminated room.



Numerical aperture measurement in optical fiber

PROCEDURE:

1. Connections are made as per circuit diagram.
2. Slightly unscrew the cap of LED SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap. Now tighten the cap by screwing it back
3. Now short the jumpers as show in the jumper diagram
4. Connect the power cord to the kit & switch on the power supply.
5. Insert the other end of the fiber into the numerical aperture measurement jig. Hold the white sheet facing the fiber. Adjust the fiber that the cut face is perpendicular to the axis of the fiber.
6. Keep the distance of about 10nm between the fiber tip and the screen. Gently tighten the screw and thus fix the fiber in the place.
7. Now observe the illuminated circular patch of light on the screen.
8. Measure exactly the distance **d** and also the vertical horizontal diameters MR and PN.

9. Mean radius is calculated using the following formula. r **= (MR + PN) / 4.**

10. Find the numerical aperture of the fiber using the formula.

$$\mathbf{NA = \sin\theta_{max} = r / \sqrt{d^2 + r^2}}$$

Where $\theta_{maxm}$is the maximum angle at which the light incident is properly transmitted through the fiber.

TABULATION:

Sl.No	**Distance d(mm)**	**MR (mm)**	**NP (mm)**	**r = (MR+NP)/4 (mm)**	**Numerical Aperture = r/(r^2+d^2)**	**Θ_{max} = Sin^{-1}(NA)**

RESULT

Thus the numerical aperture of the given fiber optic is measured.

EXP.NO:2B MODE CHARACTERISTICS OF OPTICAL FIBER

DATE:

AIM:

To study the mode characteristics of fiber optic cable and observe the lower order Linearly Polarized (LP) modes.

APPARATUS REQUIRED:

1. LASER Source (633 nm – 1mW)
2. Source to Fiber Coupler
3. Single Mode Fiber
4. Fiber Holding Stand
5. Opaque Screen

THEORY :

The central spot carries 95% of the intensity for laser beams with Gaussian profile. I = Ioe-2(r / w) ^2 where e = 2.718 is the base of the natural logarithm. An accepted definition of a radius of a Gaussian beam is the distance at which the beam intensity has dropped to 1/e2 = 0.135 times its peak value Io. This radius is called spot size. The spot diameter is w.

Spot Diameter (d) micron = Focal length of the Lens (f) mm x Laser beam full divergence angle (DA) mrad.

In order to achieve maximum coupling efficiency, the fiber core diameter has to be bigger than the spot diameter.

NA_{rays} = Laser Beam Diameter (B.D.)

2 x Lens Focal Length (f)

The source coupler is comprised of two base plates. One of the base plates contains a focusing lens and a female connector receptacle. The other base plate is attached onto the laser. An O-ring is sandwiched between the base plates. Threaded screws interconnect the two base plates. A screw driver to alter the angular orientation of one base plate relative to the other can then adjust the screws.

The number of modes propagating through the fiber depends on V-number. If the fiber whose V-number is less than 2.045, it allows to propagate single mode through it, so it is called as Single Mode fiber. For a Multimode fiber, V-number is slightly greater than 2.045 but the number of allowed modes is small enough so that they may be individually identified when the output of the fiber is examined.

When V < 2.045, then only a single mode may propagate in the fiber waveguide. This mode is HE_{11} mode or LP_{01} – Linearly Polarized mode.

When V > 2.045, other modes may propagate, when V is slightly greater than 2.045 i.e. V = 4.91 then 4 Linearly Polarized modes will propagate through fiber.

PROCEDURE

1. Keep optical bread board onto original and flat table surface, so that it will not toggle.
2. Fix the pre-fitted cylindrical head of the He-Ne laser source on to the surface of the bread board from the bottom side with the help of Allen screws provided with it. Confirm the rigid ness of the mount.
3. Fix the laser to the fiber coupler mount on to the bread board with base plate orientation of it towards He-Ne laser exit.
4. Turn on the He-Ne laser and locate the beam spot on the central portion of the laser-fiber coupling lens assembly by adjusting the vertical and horizontal travel arrangement provided with the mount. Tighten the screws of the vertical and horizontal slots.
5. Now look for the back reflection of the He-Ne laser spot from the rod lens of the coupler. In case if you found the back spot, away from the exit of the cylindrical laser head of the laser, adjust the back-reflected spot going back in exit hole by slowly moving the four screws provided for the laser mount.
6. Confirm the central alignment of the laser beam at the exit of the laser fiber coupler by putting a white card sheet and zooming the spot on to it. In case the spot is found of center, adjust it to the center by slightly moving the screws of the laser mount.
7. Put the multimode optical patch cord on to the laser fiber coupler exit and fix the other end of the fiber in the fiber holding stand by moving the grub screws provided with the holder.
8. Notice the bright laser beam spot coming out of the fiber. Adjust the height of exit tip of the fiber to about 50mm. Min. from the white sheet of the paper.
9. Observe the bright round shape circular spot with laser speckle pattern on to the screen. Multimode pattern can be refined by screws provided with laser-fiber coupler. Slightly adjusting or moving the screws on the laser mount, view the change in pattern of this multimode spot.
10. After observing the multimode pattern, change multimode fiber optic patch cord with single mode fiber patch cord.
11. For single mode patch cord, the blur pattern of the various single mode

patterns will appear on the screen. That is, single circular two lobes, three lobes and four lobes patterns can be very well observed by slightly adjusting the Allen screws of the laser-fiber coupler.

OBSERVATION & CALCULATION :

Parameter of given fiber are,

A = 4.5μm (core radius), N.A = 0.11, λ = 633nm

V = 2 π x A x N.A / λ = 4.91

From fig. shows only 4 LP modes propagates.

Total number of modes = $V^2 / 2 = 4.91^2 / 2 = 12$

RESULT

Thus the mode characteristics of fiber optic cable are studied and the lower order Linearly Polarized modes are observed

EXP. NO: 3 DC CHARACTERISTICS OF LED AND PIN PHOTODETECTOR
DATE:

AIM

To determine the characteristics of fiber optic LED and Photo detector.

APPARATUS REQUIRED:

Sl.No	Equipments	Quantity
1.	Power Supply	1
2.	Link B Kit	1
3.	20 MHz Dual Trace Oscilloscope	1
4.	Volt Meter	1
5.	Ammeter	1
6.	Jumper to crocodile wires.	1

THEORY:

In optical fiber communication system, electrical signal is first converted into optical signal with the help of E / O conversion device as LED. After this optical signal is transmitted through optical fiber, it is retrieved in its original electrical form with the help O / E conversion device as photo detector.

Different technologies employed in chip fabrication lead to significant version in parameters for the various emitter diodes. All the emitters distinguish themselves in offering high output power coupled into the plastic fiber. Data sheets for LEDs usually specify electrical and optical characteristics, out of which are important peak wavelength of emission, conversion efficiency (usually specified in terms of power launched in optical fiber for specified forward current), optical rise and fall lies which put the limitation on operating frequency, maximum forward current through Led and typical forward voltages across LED.

Photo detectors usually comes in variety of forms like photoconductive, photovoltaic, transistor type output and diode type output. Here also characteristics to be taken into account are response time of the detector which puts the limitation on the operating frequency, wavelength sensitivity and responsivity.

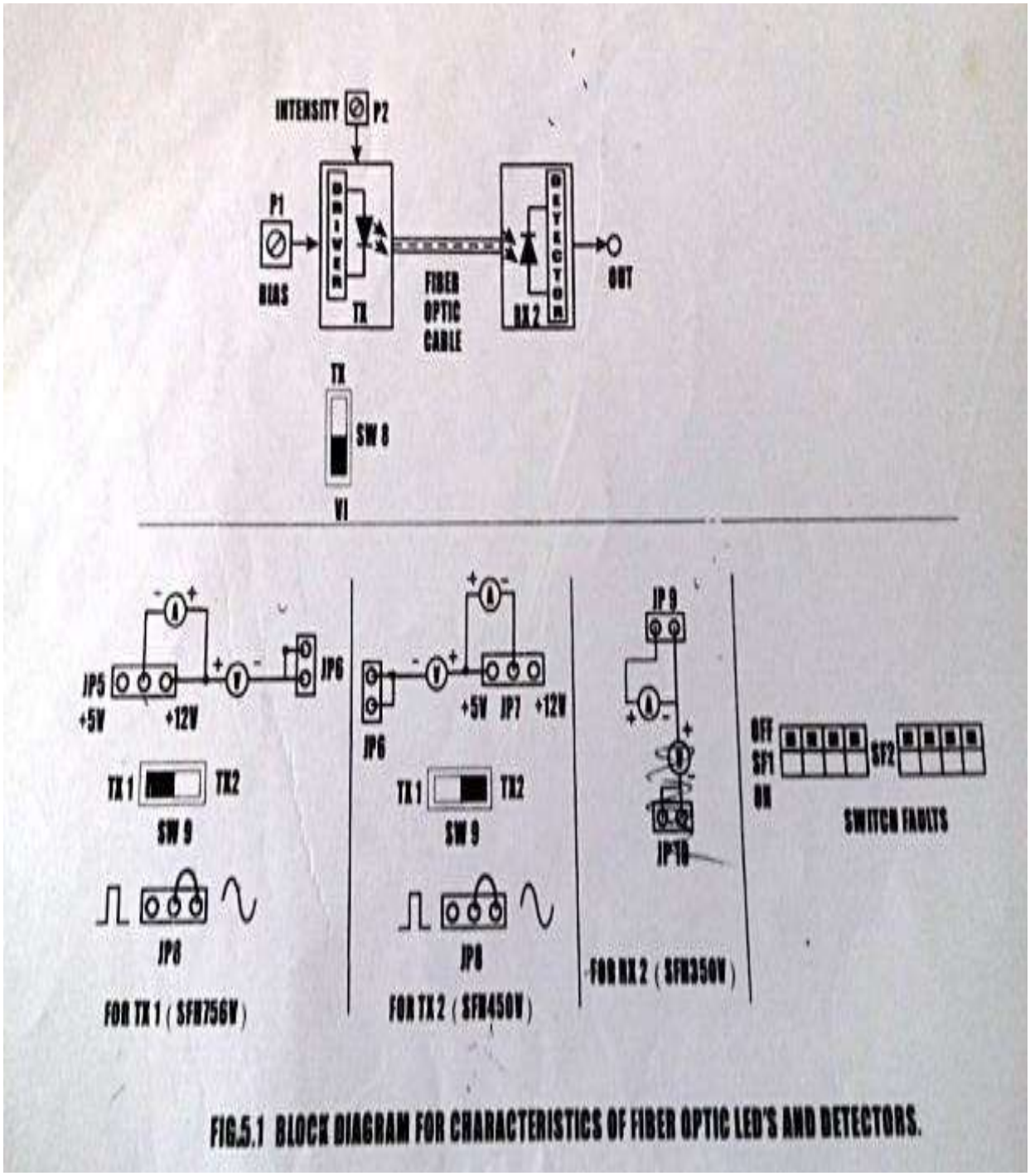


FIG.5.1 BLOCK DIAGRAM FOR CHARACTERISTICS OF FIBER OPTIC LED'S AND DETECTORS.

PROCEDURE:

1. Connections are made as per circuit diagram.
2. Confirm that the power switch is in OFF position.
3. Make the jumper settings as shown in the jumper diagram.
4. Insert the jumper connecting wires (Provided along with the kit) in jumpers JP 17 and JP 16 at positions shown in the diagram.

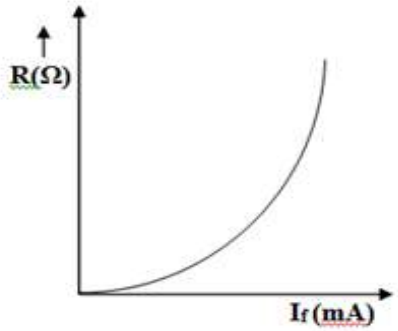
5. Connect the current-meter and volt-meter with the jumper wires connected to JP 17 and JP 16 as shown in the diagram.
6. Keep the potentiometer Pr10 in its maximum position (anti-clockwise rotation) and Pr9 in its minimum position (clockwise rotation). Pr 10 is used to control current flowing through the LED and Pr 9 is used to vary the amplitude of the received signal at phototransistor.
7. To get the IV characteristics of LED, rotate slowly and measure forward current and corresponding forward voltage. Take number of such readings for various current values and plot IV characteristics graph for the Led.
8. For each reading taken above, find out the power which is product of I and V. This is the electrical power coupled into plastic fiber when forward current was 10 mA as 200µW of optical energy. Hence the efficiency of the LED comes out to be approx. 1.15%.
9. With this efficiency assumed, find out optical power coupled into plastic optical fiber for each of the reading in step 7. Plot the graph of forward current v/s output optical power of the LED.
10. Data sheets for the phototransistor detector specified responsivity as 0.8 mA for 10 µW of incident optical energy. In our experimental kit, when Pr9 is at its minimum position, 100Ω of resistance is in series of emitter and ground of phototransistor.
11. Connect the 30 cm optical fiber cable supplied with kit between LED SFH576V (660nm) and phototransistor SFH350V (Analog Detector).
12. From the transfer characteristics obtained in step 8, launched known optical energy into plastic fiber and measure output voltage at ANALOG OUTPUT terminal. Find out the current flowing through phototransistor with this voltage value and 100Ω of resistance.
13. Repeat step 11 for various launched optical energy values and plot the graph for the responsivity of phototransistor. Find out the portion where detector response is linear.

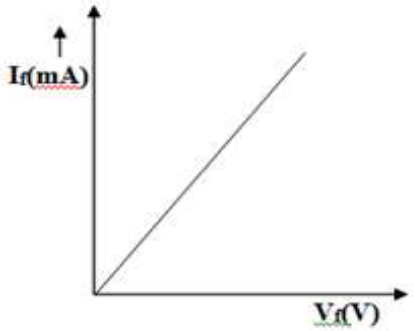
V-I CHARACTERISTIC OF FIBER OPTIC LED & DETECTOR

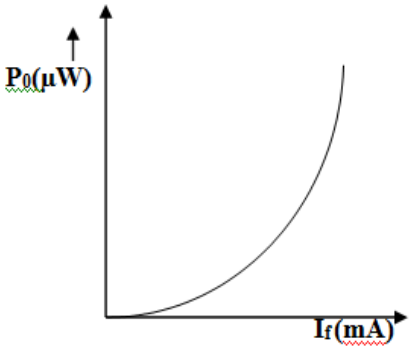
Vf (V)	**If (mA)**	**Pi (mW)**	**Po (µW)**	**V (V)**	**I (mA)**	**R**

Vf = Forward voltage of LED
If = Forward current of LED Pi = V * I(Electrical Power)
Po = Pi*1.615% (Optical power of LED 756)
V = Output voltage of SFH 350
I = V/R = V/100 ohm (O/P Current)
R = 0.8mA*PO / 10µw (Responsivity)

MODEL GRAPH:







RESULT:

Thus the LED and photo diode characteristic has been verified and output is calculated and graph is plotted.

EXP.NO: 4A FIBER OPTIC ANALOG LINK CHARACTERIZATION
DATE:

AIM

To establish 950 nm Fiber Optic Analog Link and find its frequency response.

APPARATUS REQUIRED

Sl.No	Equipments	Quantity
1.	Power Supply	1
2.	Kit 4	1
3.	20 MKz Dual Trace Oscilloscope	1
4.	1 Meter Fiber Cable	1

THEORY:

Fiber Optic Analog Links can be used for transmission of digital as well as analog signals. Basically, a fiber optic link contains three main elements, a transmitter, an optical fiber & a receiver. The transmitter module takes the input signal in electrical form & then transforms it into optical (light) energy containing the same information. The optical fiber is the medium, which carries this energy to the receiver. At the receiver, light the converted back into electrical form with the same pattern an originally fed to the transmitter.

PROCEDURE:

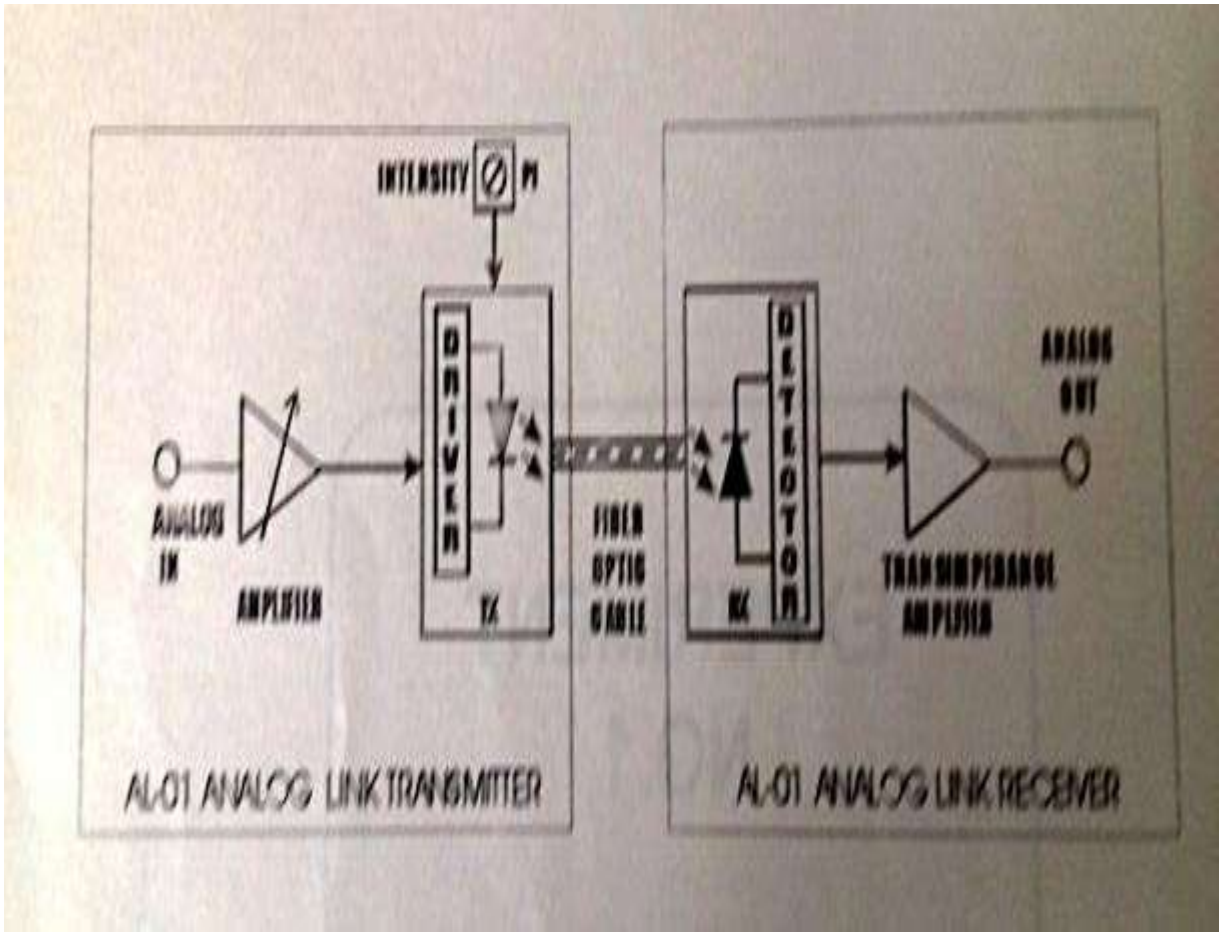
1. Connections are made as per circuit diagram.
2. Slightly unscrew the cap of IRLED SFH 450V (950nm) from Transmitter kit. Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap and and assure that the fiber is properly fixed. Now tighten the cap by screwing it back.
3. Connect the power supply cables with proper polarity to Transmitter kit and Receiver kit. While connecting this, ensure that the power supply if OFF.
4. Connect the 1KHz on board sine wave to the AMP I/P posts in Transmitter kit to feed the analog signal to the amplifier.
5. Keep the signal generator in sine wave and select the frequency of 1 switch with amplitude of 1V p-p.
6. Switch on the power supply
7. Check the output signal of the amplifier at the post AMP O/P in Transmitter kit.

8. Now rotate the Optical Power Control pot P1 located below power supply connector in Transmitter kit in anticlockwise direction. This ensures minimum current flow through LED.
9. Short the following posts in kit1 with the links provided.

    a. +9V and +9V – This ensures supply to the transmitter

    b. AMP O/P and TRANSMITTER I/P.

    Connect the other end of the fiber to detector SFH 250V (Analog Detector) in kit2 very carefully as per the instructions in step 1.
10. Ensure that the jumper located just above IC U1 I Receiver kit is shorted to pins 2 and 3. Shorting of the jumper allows connection of PIN photodiode to the trans impedance amplifier stage.
11. Observe the output signal from the detector at DETECTOR O/P post on CRO by adjusting Optical Power Control pot P1 in kit1 and you should get the reproduction of the original transmitted signal.
    NOTE: Same output signal is available at post AC O/P in Receiver kit without any DC Component.
12. To measure the analog bandwidth of the link, keep the same connections and amplitude of the received signal for each frequency reading.
13. Plot a graph of Gain/Frequency. Measure the frequency range for which the response if flat.



TABULATION:

Frequency	Input amplitude	Output amplitude

RESULT:

Thus the analog link has been established and the frequency response is determined.

EXP.NO: 4B FIBER OPTIC DIGITAL LINK CHARACTERIZATION
DATE:

AIM:

To establish 950 nm fiber optic digital link and to transmit the digital signal through optical fiber and to study eye pattern using fiber optic link

APPARATUS REQUIRED:

Sl.No	Equipments	Quantity
1.	Power Supply	1
2.	Link-B kit	1
3.	20 MHz Dual Trace Oscilloscope	1
4.	1 MHz Function Generator	1
5.	1m Fiber Cable	1

THEORY

EYE PATTERN

The eye-pattern technique is a simple but powerful measurement method of assessing the data-handling ability of a digital transmission system. This method has been used extensively for evaluating the performance of wire systems and can also be applied to optical fiber data links. The eye-pattern measurements are made in the time domain and allow the effects of waveform distortion to be shown immediately on an oscilloscope.

A great deal of system performance information can be deduced from the eye-pattern display. To interpret the eye pattern, follow the procedure ahead

PROCEDURE:

1. Make the connections as shown in fig.12.1. Connect the power supply cables with proper polarity to Link-B kit. While connecting this, ensure that the power supply is OFF.
2. Keep switch SW7 as shown in fig.12.1 to generate PRBS signal.
3. Keep switch SW8 towards TX position.
4. Keep switch SW9 towards TX1 position.
5. Keep switch SW10 to EYE PATTERN position.

6. Select PRBS generator clock at 32 KHz by keeping jumper JP4 at 32k position.
7. Keep jumper JP5 towards +5V position.
8. Keep jumper JP6 shorted.
9. Keep jumper JP8 towards TTL position.
10. Switch ON the power supply
11. Connect the post DATA OUT of PRBS Generator to the IN post of digital buffer.
12. Connect OUT post of digital buffer. to TX IN post
13. Slightly unscrew the cap of LED SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the one-meter fiber into the cap. Now tighten the cap by screwing it back.
14. Slightly unscrew the cap of RX1 photo transistor with TTL logic output SFH551V. Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber into the cap by screwing it back.
15. Connect CLK OUT of PRBS Generator to EXT, TRIG of oscilloscope.
16. Connect detected signal TTL OUT to vertical channel Y input of oscilloscope. Then observe EYE PATTERN by selecting EXT. TRIG KNOB on oscilloscope as shown in Fig.12.2. Observe the Eye pattern for different clock frequencies. As clock frequency increases the EYE opening becomes smaller.

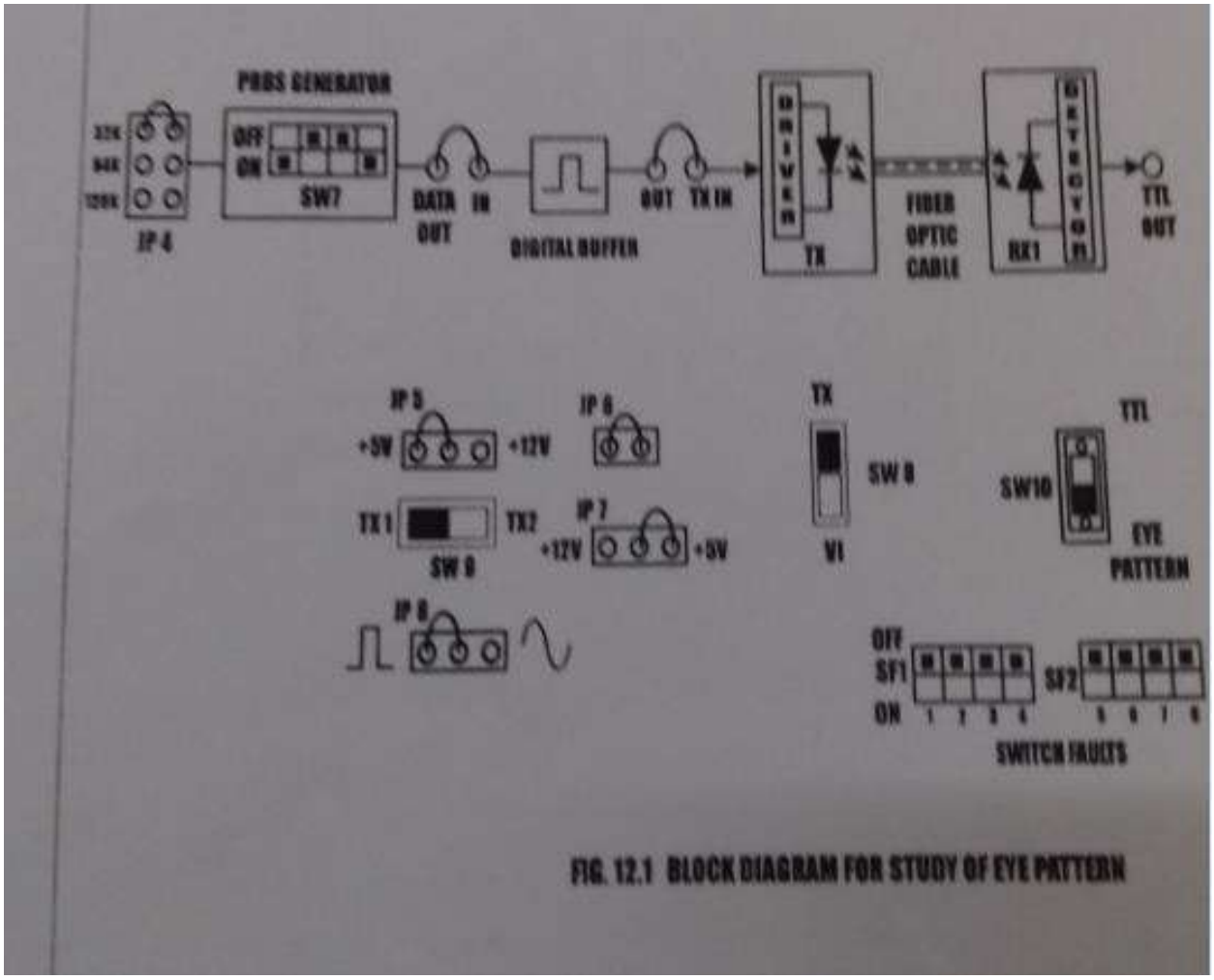


FIG. 12.1 BLOCK DIAGRAM FOR STUDY OF EYE PATTERN

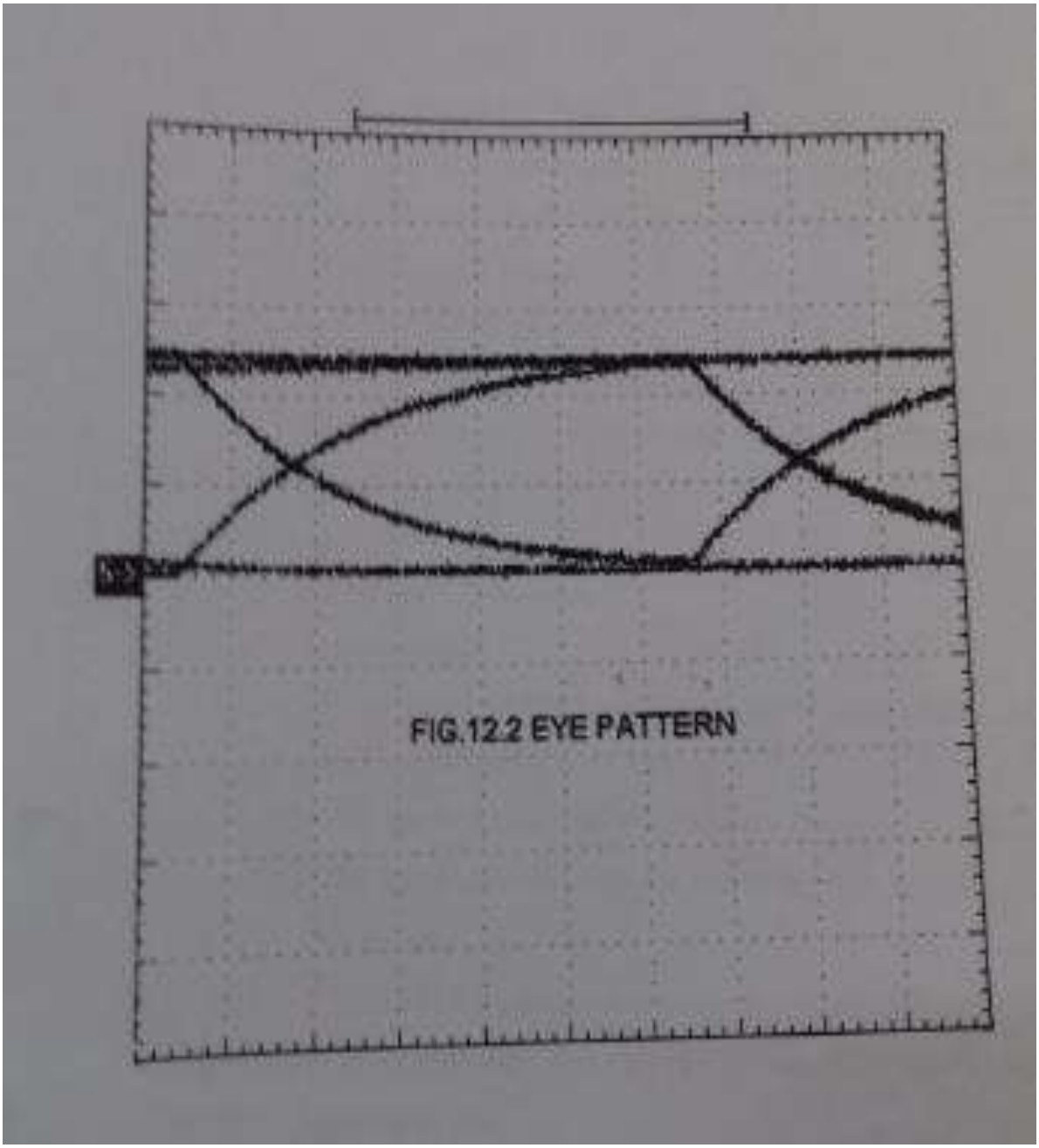


FIG.12.2 EYE PATTERN

RESULT:

Thus the fiber optic digital link has been established also the eye pattern is obtained.

EXP. NO: 4C DETERMINATION OF BIT ERROR RATE USING DIGITAL LINK
DATE:

AIM:

To establish 950 nm fiber optic digital link and to transmit the digital signal through optical fiber to determine the bit error rate.

APPARATUS REQUIRED:

Sl.No	Equipments	Quantity
1.	Power Supply	1
2.	Link-B kit	1
3.	20 MHz Dual Trace Oscilloscope	1
4.	1 MHz Function Generator	1
5.	1m Fiber Cable	1

THEORY:

Bit Error rate

In telecommunication transmission, the bit error rate (BER) is a ratio of bits that have errors related to the total number of bits received in a transmission. The BER is an indication of how often a packet or other data unit has to be retransmitted because of an error. Too high BER may indicate that a slower data rate would actually improve overall transmission time for a given amount of transmitted data since the BER might be reduced, lowering the number of packets that had to be present.

Measuring bit error rate:

A BERT (bit error rate tester) is a procedure or device that measure the BER for a given transmission .The BER or quality of the digital link is calculated from the number of bits received in error divided by the number of bits transmitted.

$$BER = \frac{Bits\ in\ Error}{Total\ bits\ transmitted}$$

Using the bench setup, this is easily measured by means of a comparator in which the transmitted bits are matched in an XOR gate with the received bits. Figure shows the schematic of the device used for the following measurements.

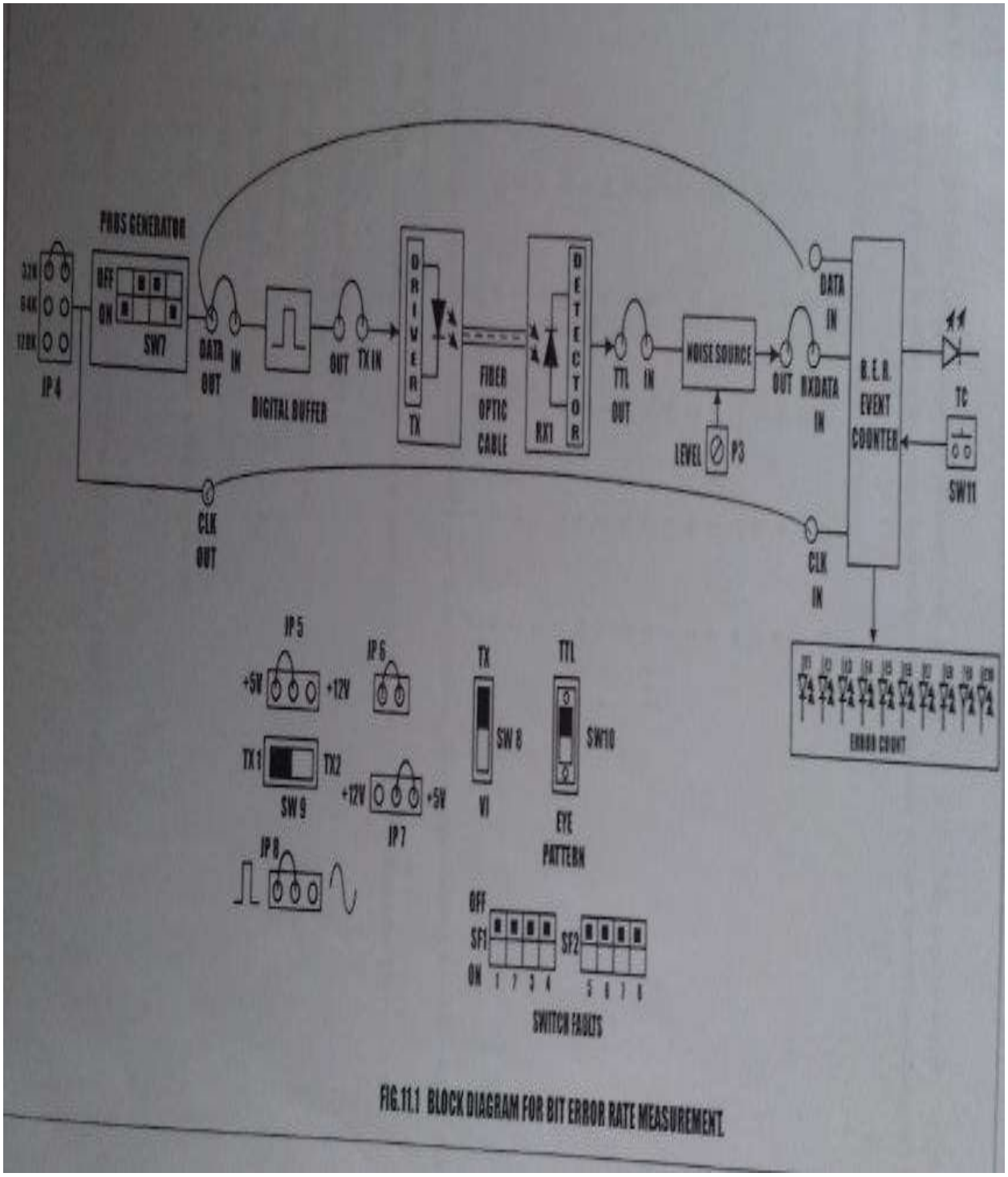


FIG.11.1 BLOCK DIAGRAM FOR BIT ERROR RATE MEASUREMENT

If the bits are alike at the XOR gate input, when clocked in from the D flip flop, the output is low. If they are different, the XOR output goes high, causing an event count. The event counter can be set for various time periods. the more accurate is the count.

A random character generator and white noise source should be used for these measurements. The number of bit error is dependent upon the amount of noise entering the system. White noise or background noise has an average or RMS value that is exceeded periodically by peaks that rise many times that level. These peaks exist for a very short period of time.

When the peak equals or exceeds the signal level that is noise energy =bit energy , there is a

50/50 chance of error. The peak time periods can be calculated statically from the error function. In LinkB , PRBS sequence is generated by using a 4 bit right shift register whose feedback is completed by the XOR gate. Let initially 1001 be the 4 bit switch setting on the SW7.

Clock states	**D1**	**D2**	**D3**	**D4**	
			A	**B**	**C**
1	1	0	0	1	1
2	1	1	0	0	0
3	0	1	1	0	1
4	1	0	1	1	0
5	0	1	0	1	1
6	1	0	1	0	1
7	1	1	0	1	1
8	1	1	1	0	1
9	1	1	1	1	0
10	0	1	1	1	0
11	0	0	1	1	0
12	0	0	0	1	1
13	1	0	0	0	0
14	0	1	0	0	0
15	0	0	1	0	1
16	1	0	0	1	1

- Thus the sequences repeat constantly with a period corresponding to 16 clock states.
- Length of sequence = $2^4 = 16$
- Now the pseudorandom random sequence pattern is C=1010111100010011

NOTE:KEEP ALL SWITCH ES IN OFF POSITION

PROCEDURE:

1.Make connection as shown in figure.Connect the power supply cables with proper polarity to linkB kit.While connecting this,ensure that the ppower supply is OFF.

2. Keep PRBS switch as shown in Figure to generate PRBS signal..

3. Keep switch SW8 towards TX position.

4. Keep switch SW9 towards TX1 position.

5.Keep the switch SW10 at fiber optic receiver output to TTL position.

6. Select PRBS generator clock at 32KHz by keeping jumper JP4 at 32K position
7. Keep jumper JP5 towards +5v position.
8. Keep Jumper JP6 shorted.
9. Keep Jumper JP8 towards pulse position.
10. Switch on the Power supply.
11. Connect the post DATAOUT PRBS generator to the IN post of Digital buffer and also to the DATA IN post of Bit error rate event counter.
12. Connect the OUT post Digital buffer TX IN post transmitter.
13. Slightly unscrew the cap of LEDSFH756v (660nm).Do not remove the cap from the connector. Once the cap is loosened, insert the one meter fiber into the cap. Now tighten the cap by screwing it back.
14. Slightly unscrew the gap of RX1 photo transistor with TTL logic output SFH551v.Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber into the cap. Now tighten the cap by screwing it back.
15. Connected digital signal TTL OUT to post IN of noise source.
16. Connect post OUT of noise source to post RXDATAIN of bit error rate event counter.
17. Connect post CLKOUT of PRBS generator to post CLKIN of bit error rate event counter.
18. Press switch SW11 to start counter.
19. Vary POT P3 for noise level to observe the effect of noise level on the error count.
20. Observe the error count in received signal in time 10 seconds as shown in figure.

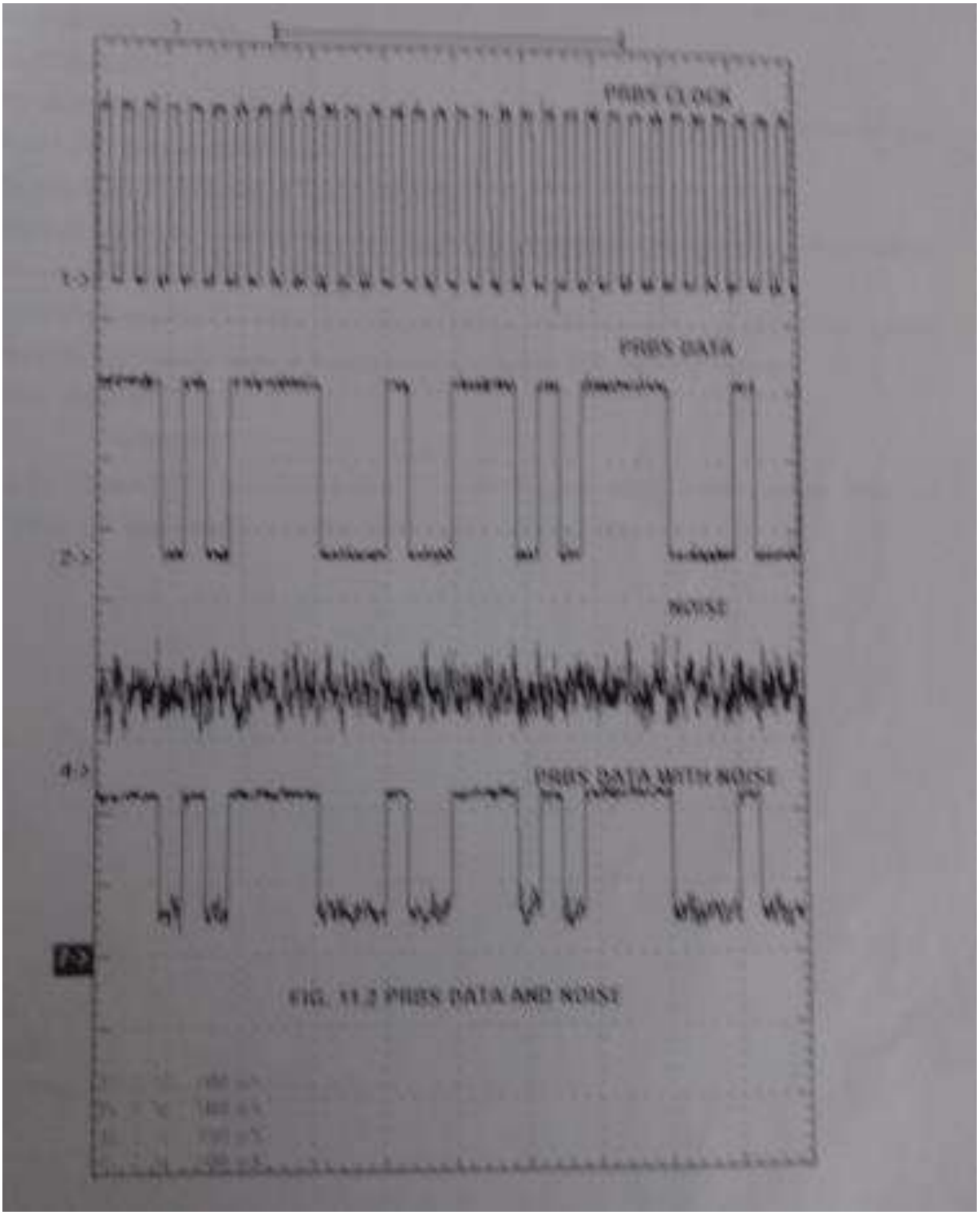


FIG. 11.2 PRBS DATA AND NOISE

BER MEASUREMENT

As per the definition the BER is a ratio of Errored bits (Eb) to the total bits transmitted (Tb) in a period of time t seconds.

ie

$$BER = \frac{E_b}{T_b}$$

For example in this experiment if PRBS data is transmitted at 32K bits per second (jumper selection

at 32KHz) for a period of 10 seconds.so total bits transmitted in 10 seconds(Tb) =320Kbits.

The TTL OUT data and data with noise is fed to BER counter which compares the the two data inputs at each clock input.
The counter displays the Error count(Eb) on LED in 10 bit binary form.(eg.0000001010) which has to be converted in decimal form. (it becomes 10) so the BER ratio then becomes

$$BER = \frac{10}{320\ x10E^{3}}$$

= 0.00003125

ie.the channel bit error ratio is $3.1x10E^{-5(3/100000)}$ or in other words we can say that out of 100000 bits transmitted through the channel gives 3 bits in error.

RESULT

Thus the bit error rate was measured using digital link .

EXP. NO: 5

DATE:

WIRELESS CHANNEL SIMULATION INCLUDING FADING AND DOPPLER EFFECTS

AIM:

To simulate and verify output in wireless Channel including Doppler and fading effects.

APPARATUS REQUIRED:

Personal Computer

MATLAB Software

THEORY:

Rayleigh and Rician fading channels are useful models of real-world phenomena in wireless communication. These phenomena include multipath scattering effects, time dispersion, and Doppler shifts that arise from relative motion between the transmitter and receiver.

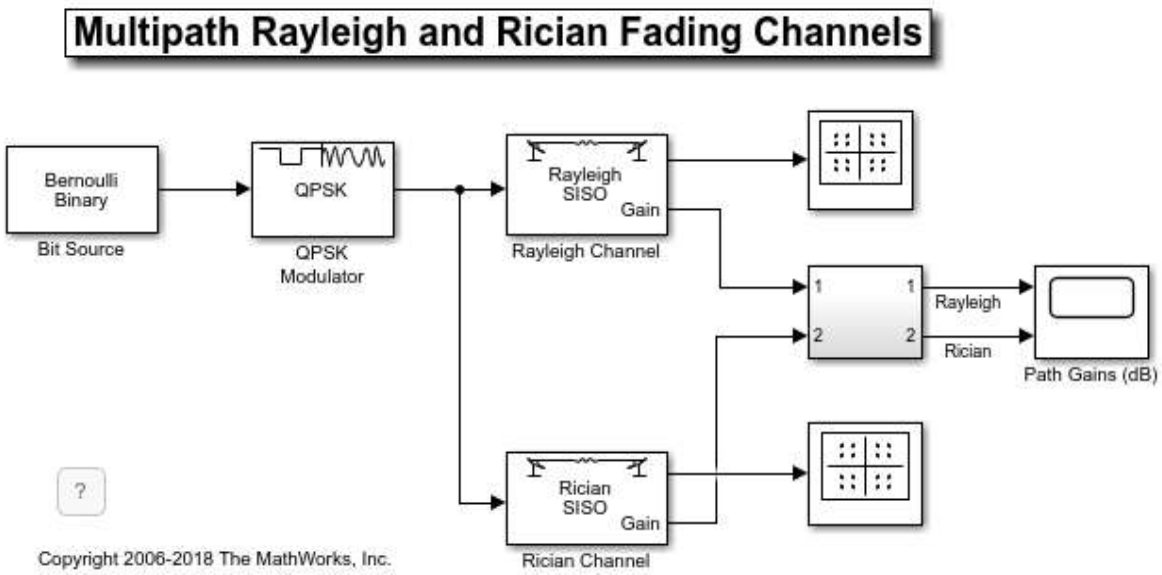
STEPS INVOLVED:

Processing a signal using a fading channel involves the following steps:

1. Create a channel System object™ that describes the channel that you want to use. A channel object is a type of MATLAB variable that contains information about the channel, such as the maximum Doppler shift.
2. Adjust properties of the System object, if necessary, to tailor it to your needs. For example, you can change the path delays or average path gains.
3. Apply the channel System object to your signal using the step method, which generates random discrete path gains and filters the input signal.
4. The characteristics of a channel can be shown with the built-in visualization support of the System object.

Model and Parameters

```
modelname     = 'commmultipathfading';
rayleighBlock = [modelname '/Rayleigh Channel'];
ricianBlock   = [modelname '/Rician Channel'];
rayleighCD    = [modelname '/Rayleigh Constellation Diagram'];
pathGainBlock = [modelname '/Path Gains (dB)'];
open_system(modelname);
```



bitRate % Transmission rate (b/s)
bitsPerFrame % Number of bits per frame
bitRate = 10000000

bitsPerFrame = 2000

delayVector % Discrete path delays (s)
gainVector % Average path gains (dB)
delayVector =

  1.0e-06 *

       0   0.2000   0.4000   0.8000

gainVector = 0   -3   -6   -9

maxDopplerShift % Maximum Doppler shift of diffuse components (Hz)
maxDopplerShift = 200

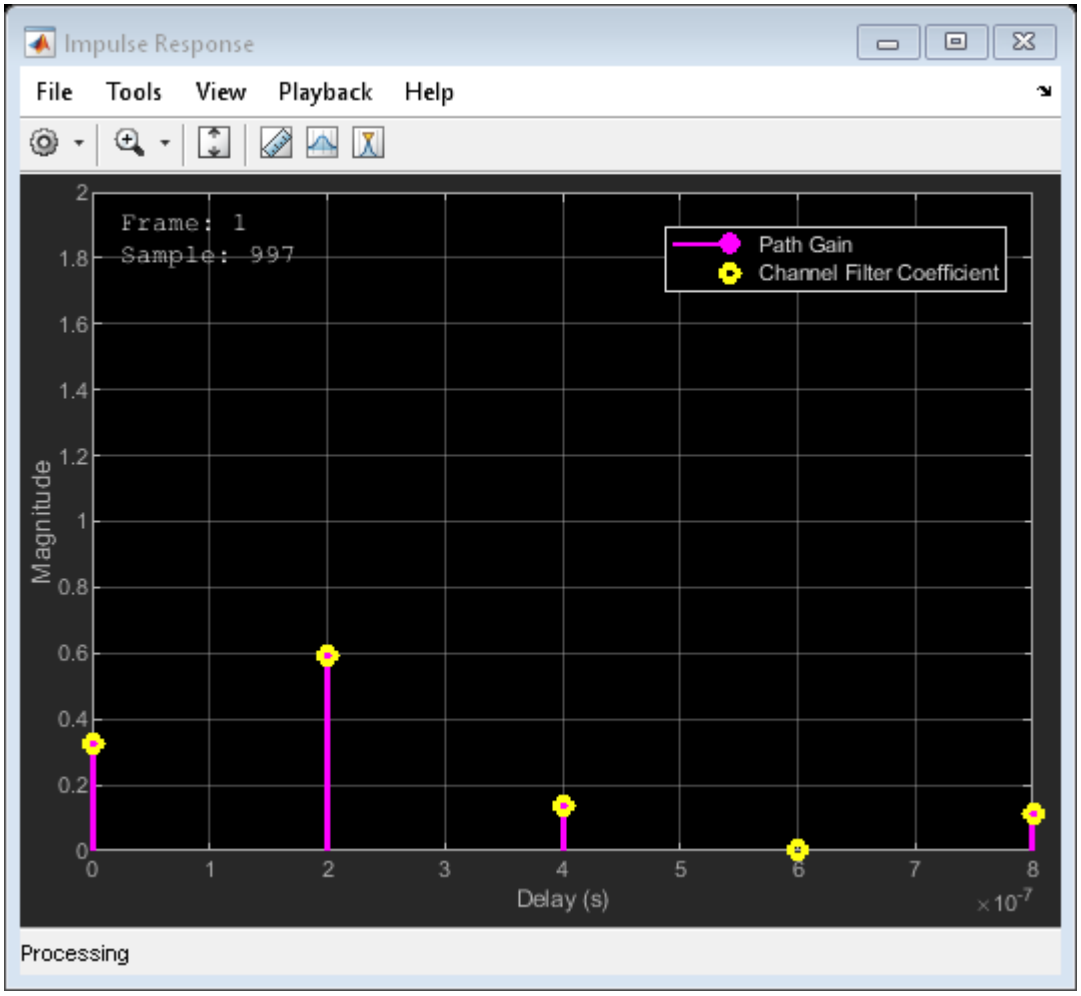
LOSDopplerShift % Doppler shift of line-of-sight component (Hz)
KFactor % Ratio of specular power to diffuse power (linear)
LOSDopplerShift = 100

KFactor =

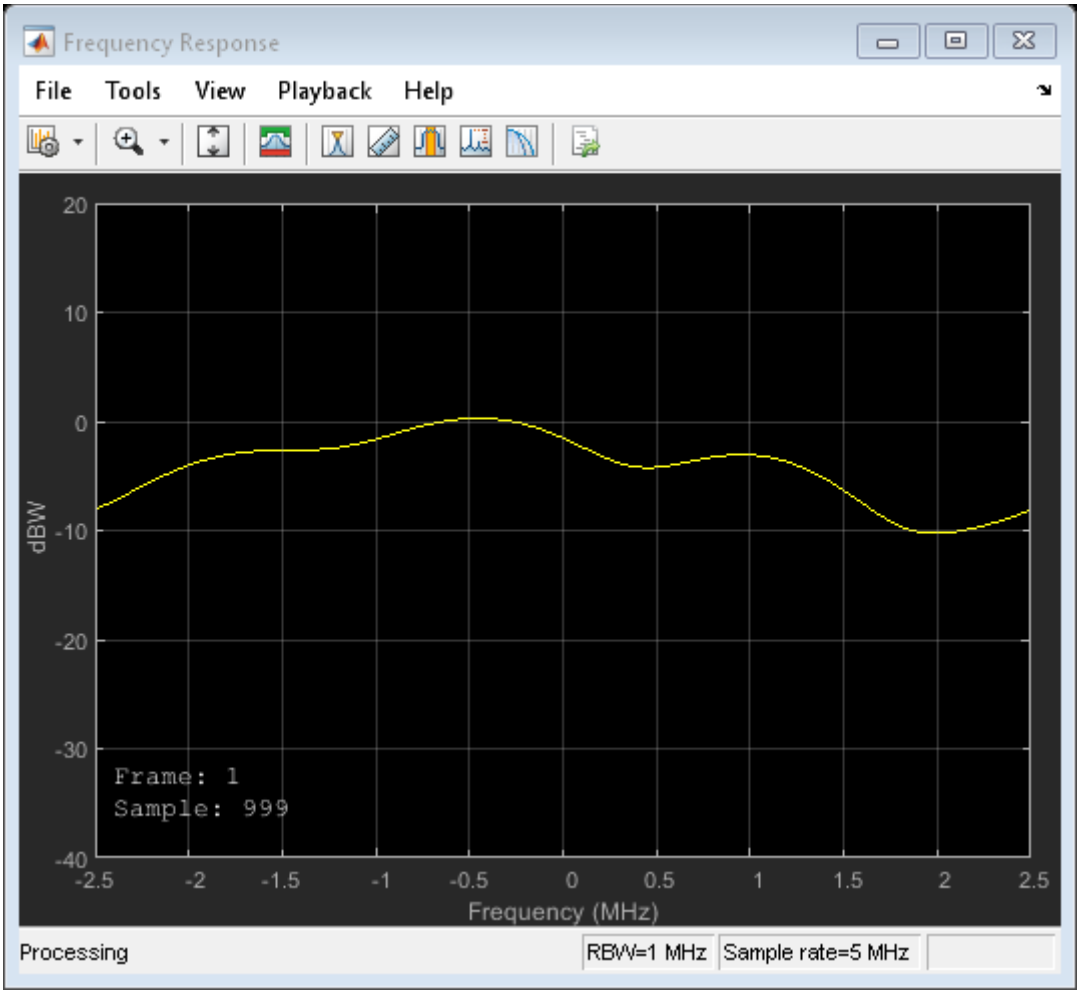
    10

Wideband or Frequency-Selective Fading

```
set_param(rayleighBlock,'Visualization','Impulse response');
set_param(modelname,'SimulationCommand','start');
set_param(modelname,'SimulationCommand','pause');
```

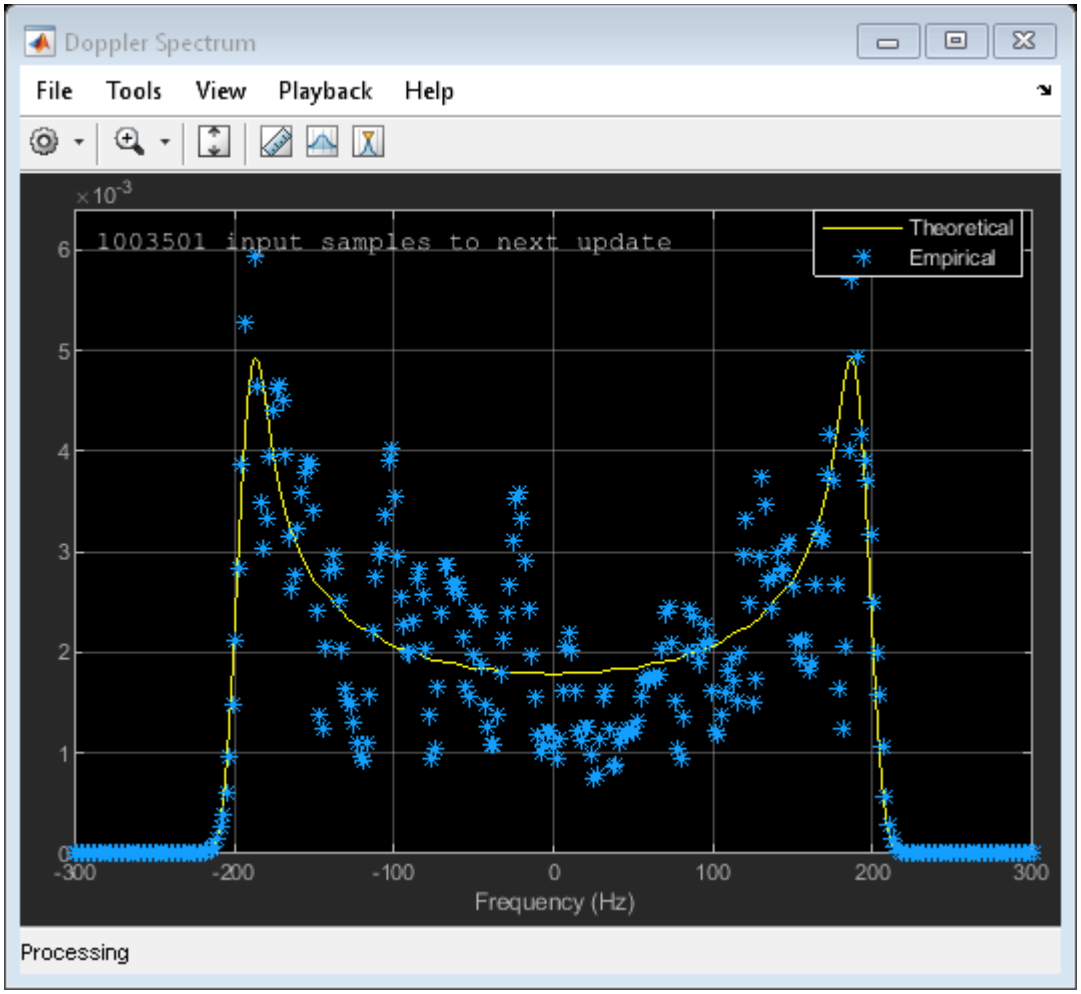



```
set_param(modelname,'SimulationCommand','stop');
set_param(rayleighBlock,'Visualization','Frequency response');
set_param(rayleighBlock,'SamplesToDisplay','50%');
set_param(modelname,'SimulationCommand','start');
set_param(modelname,'SimulationCommand','pause');
```

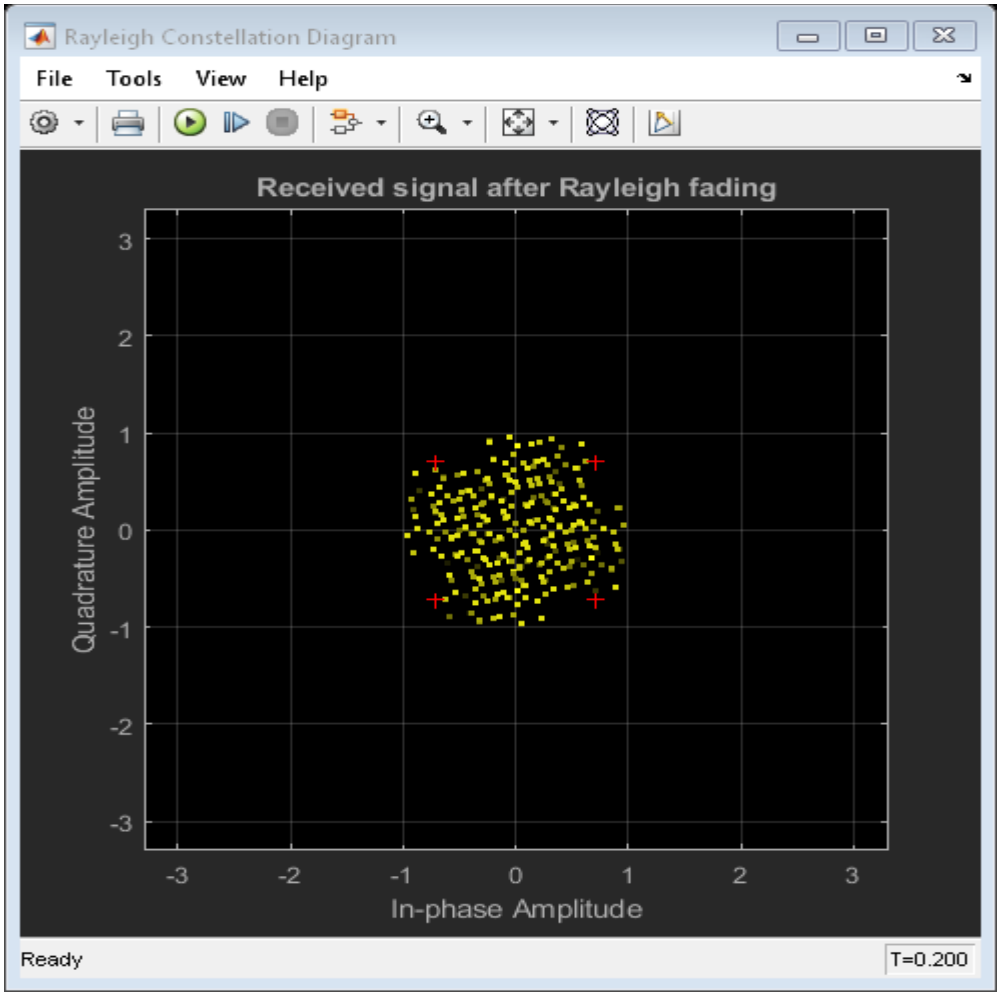


Multipath Fading Channel Simulink

```
set_param(modelname,'SimulationCommand','stop');
set_param(rayleighBlock,'Visualization','Doppler spectrum');
set_param(modelname,'StopTime','3');
set_param(modelname,'SimulationCommand','start');
set_param(modelname,'SimulationCommand','pause');

while get_param(modelname,'SimulationTime') < 2
    set_param(modelname,'SimulationCommand','continue');
    pause(1);
    set_param(modelname,'SimulationCommand','pause');
end
```

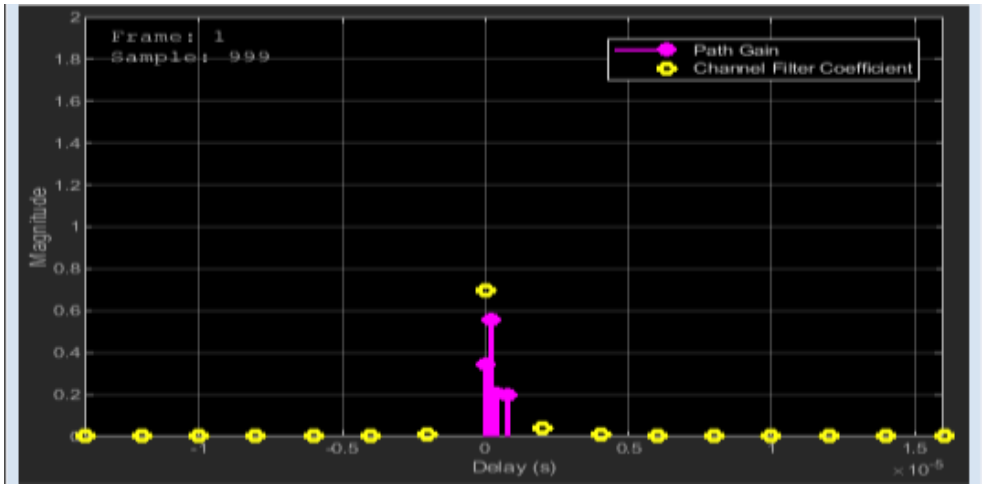


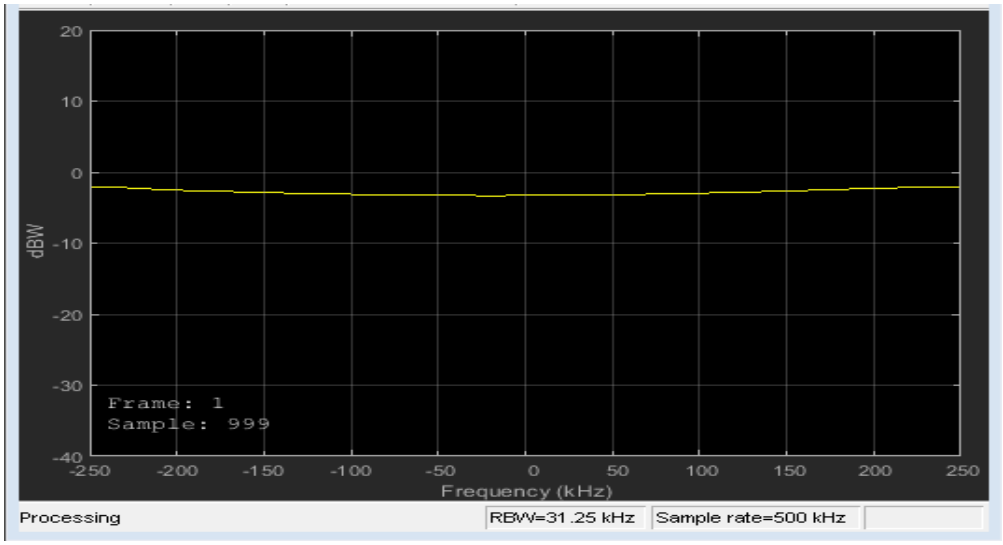

```
set_param(modelname,'SimulationCommand','stop');
maxDopplerShift = 5;
set_param(rayleighBlock,'Visualization','Off');
set_param(rayleighCD,'openScopeAtSimStart','on')
sim(modelname,0.2);
```



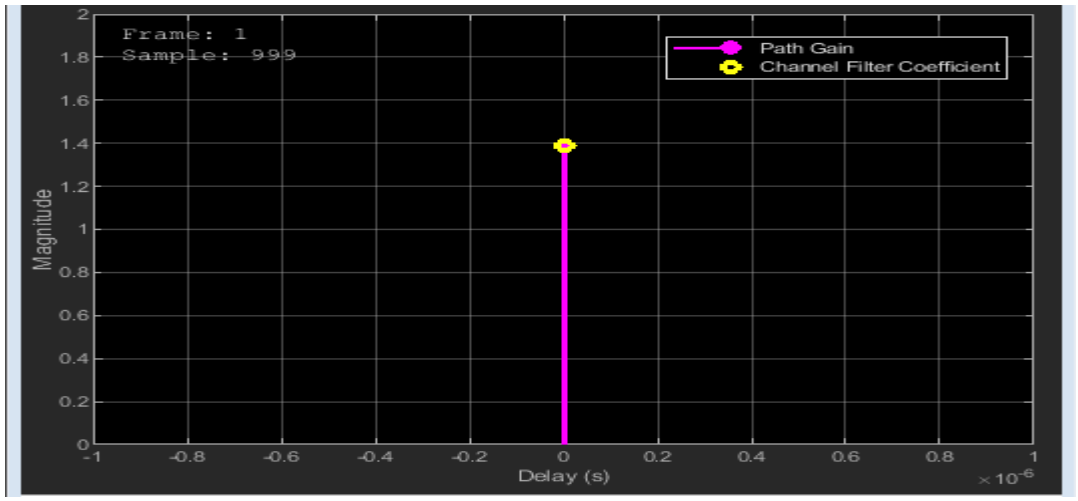
Narrowband or Frequency-Flat Fading

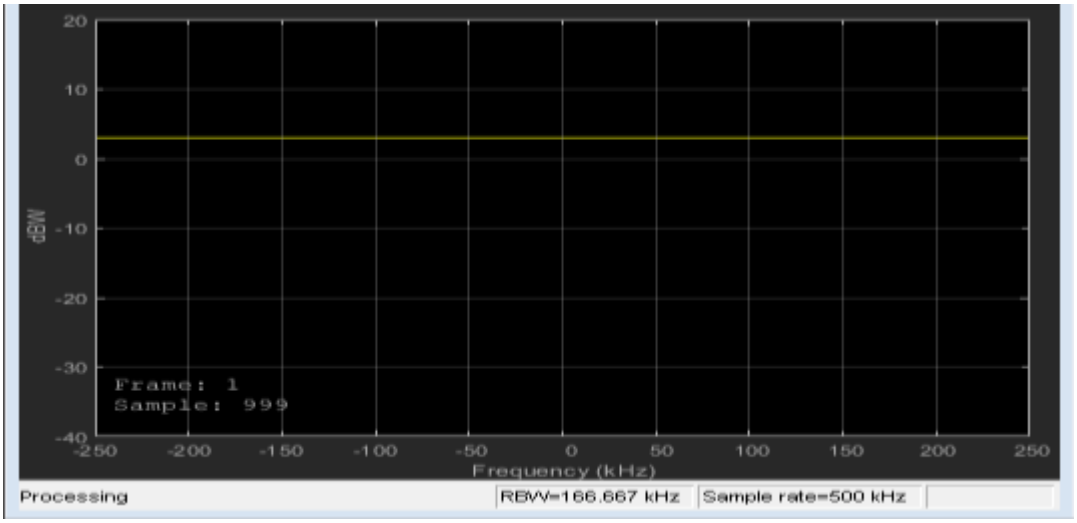
```
bitRate = 1e6  % 50 kb/s transmission
bitRate =

     1000000

close_system(rayleighCD);
set_param(rayleighCD,'openScopeAtSimStart','off')
maxDopplerShift = 200; % Change back to the original value
set_param(rayleighBlock,'Visualization','Impulse and frequency responses');
set_param(modelname,'SimulationCommand','start');
set_param(modelname,'SimulationCommand','pause');
```






```
set_param(modelname,'SimulationCommand','stop');
delayVector = 0;  % Single fading path with zero delay
gainVector = 0;  % Average path gain of 0 dB
set_param(modelname,'SimulationCommand','start');
set_param(modelname,'SimulationCommand','pause');
```

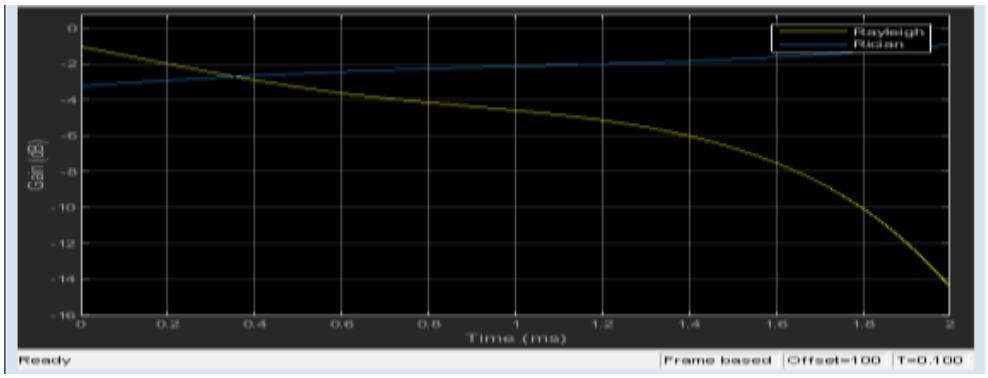





```
set_param(modelname,'SimulationCommand','stop');
delayVector = [0 2 4 8]*1e-7; % Change back to original value
gainVector = (0:-3:-9); % Change back to original value
maxDopplerShift = 5; % Reduce to slow down channel dynamics
set_param(rayleighBlock,'Visualization','Off');
set_param(rayleighCD,'openScopeAtSimStart','on')
sim(modelname,0.15);
```

Rician Fading

```
delayVector = 0;  % Single fading path with zero delay
gainVector = 0;  % Average path gain of 0 dB
maxDopplerShift = 200; % Change back to the original value
close_system(rayleighCD);
set_param(rayleighCD,'openScopeAtSimStart','off')
set_param(pathGainBlock,'OpenAtSimulationStart','on');
sim(modelname,0.1);
```



RESULT:

The simulation of wireless channel using fading effect and Doppler effects were verified.

EXP.NO:6 SIMULATION OF CHANNEL ESTIMATION, SYNCHRONIZATION & EQUALIZATION TECHNIQUES

DATE:

AIM:

To simulate and verify output in -wireless Channel for channel estimation, synchronization and Equalization Techniques.

APPARATUS REQUIRED:

Personal Computer

MATLAB Software

THEORY:

Channel Estimation OFDM communication system consists of channel model through which data symbols are transmitted to the receiver. This channel model produces line of sight communication and also various reflections due to which multipath effect come to picture. To minimize the multipath effect and noise introduced by the channel, we go for channel estimation.

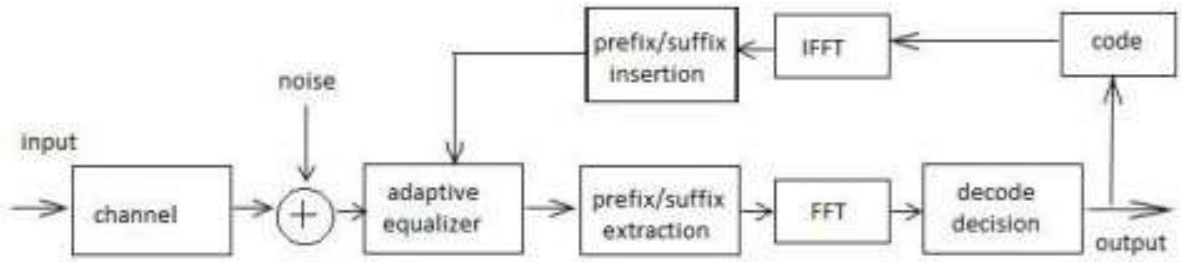


Fig. Channel Equalization

Synchronization and Channel Equalization In OFDM communication systems, at the transmitter digital to analog conversion and at the receiver, analog to digital conversion is carried out. DAC and ADC never have exactly the same sampling period. Due to this, intercarrier interference and the slow shift of the symbol timing point occurs and so orthogonality is lost. This results in need of Synchronization and Channel Equalization.

Cell-Wide Settings

```
enb.NDLRB = 15;                % Number of resource blocks
enb.CellRefP = 1;              % One transmit antenna port
enb.NCellID = 10;              % Cell ID
enb.CyclicPrefix = 'Normal';   % Normal cyclic prefix
enb.DuplexMode = 'FDD';        % FDD
```

SNR Configuration

```
SNRdB = 22;             % Desired SNR in dB
SNR = 10^(SNRdB/20);    % Linear SNR
```

```
rng('default');         % Configure random number generators
```

Channel Model Configuration

```
cfg.Seed = 1;                  % Channel seed
cfg.NRxAnts = 1;               % 1 receive antenna
cfg.DelayProfile = 'EVA';      % EVA delay spread
cfg.DopplerFreq = 120;         % 120Hz Doppler frequency
cfg.MIMOCorrelation = 'Low';   % Low (no) MIMO correlation
cfg.InitTime = 0;              % Initialize at time zero
cfg.NTerms = 16;               % Oscillators used in fading model
cfg.ModelType = 'GMEDS';       % Rayleigh fading model type
cfg.InitPhase = 'Random';      % Random initial phases
cfg.NormalizePathGains = 'On'; % Normalize delay profile power
cfg.NormalizeTxAnts = 'On';    % Normalize for transmit antennas
```

Channel Estimator Configuration

```
cec.PilotAverage = 'UserDefined'; % Pilot averaging method
cec.FreqWindow = 9;               % Frequency averaging window in REs
cec.TimeWindow = 9;               % Time averaging window in REs
cec.InterpType = 'Cubic';         % Cubic interpolation
cec.InterpWinSize = 3;            % Interpolate up to 3 subframes
                                  % simultaneously
cec.InterpWindow = 'Centred';     % Interpolation windowing method
```

Subframe Resource Grid Size

```
gridsize = lteDLResourceGridSize(enb);
K = gridsize(1);    % Number of subcarriers
L = gridsize(2);    % Number of OFDM symbols in one subframe
P = gridsize(3);    % Number of transmit antenna ports
```

Transmit Resource Grid

```
txGrid = [];
```

Payload Data Generation

```
% Number of bits needed is size of resource grid (K*L*P) * number of bits
% per symbol (2 for QPSK)
numberOfBits = K*L*P*2;

% Create random bit stream
inputBits = randi([0 1], numberOfBits, 1);

% Modulate input bits
inputSym = lteSymbolModulate(inputBits,'QPSK');
```

Frame Generation

```
% For all subframes within the frame
for sf = 0:10
```

```
    % Set subframe number
    enb.NSubframe = mod(sf,10);

    % Generate empty subframe
    subframe = lteDLResourceGrid(enb);

    % Map input symbols to grid
    subframe(:) = inputSym;

    % Generate synchronizing signals
    pssSym = ltePSS(enb);
    sssSym = lteSSS(enb);
    pssInd = ltePSSIndices(enb);
    sssInd = lteSSSIndices(enb);

    % Map synchronizing signals to the grid
    subframe(pssInd) = pssSym;
    subframe(sssInd) = sssSym;

    % Generate cell specific reference signal symbols and indices
    cellRsSym = lteCellRS(enb);
    cellRsInd = lteCellRSIndices(enb);

    % Map cell specific reference signal to grid
    subframe(cellRsInd) = cellRsSym;

    % Append subframe to grid to be transmitted
    txGrid = [txGrid subframe]; %#ok

end
```

OFDM Modulation

```
 [txWaveform,info] = lteOFDMModulate(enb,txGrid);
txGrid = txGrid(:,1:140);
```

Fading Channel

```
cfg.SamplingRate = info.SamplingRate;

% Pass data through the fading channel model
rxWaveform = lteFadingChannel(cfg,txWaveform);

% Calculate noise gain
N0 = 1/(sqrt(2.0*enb.CellRefP*double(info.Nfft))*SNR);

% Create additive white Gaussian noise
noise = N0*complex(randn(size(rxWaveform)),randn(size(rxWaveform)));

% Add noise to the received time domain waveform
rxWaveform = rxWaveform + noise;
```

```
offset = lteDLFrameOffset(enb,rxWaveform);
rxWaveform = rxWaveform(1+offset:end,:);
```

OFDM Demodulation

```
rxGrid = lteOFDMDemodulate(enb,rxWaveform);
```

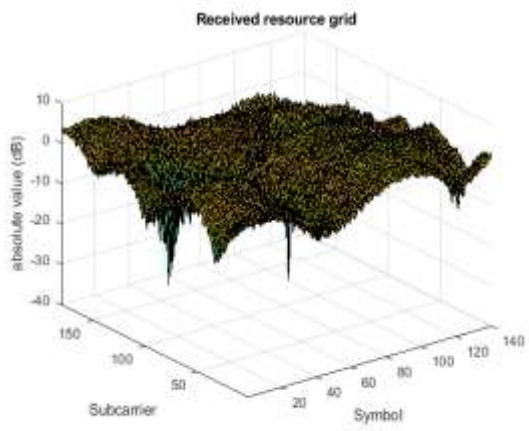
Channel Estimation

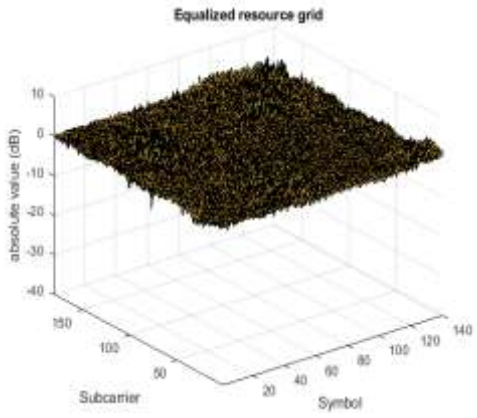
```
enb.NSubframe = 0;
[estChannel, noiseEst] = lteDLChannelEstimate(enb,cec,rxGrid);
```

MMSE Equalization

```
eqGrid = lteEqualizeMMSE(rxGrid, estChannel, noiseEst);
```

```
% Calculate error between transmitted and equalized grid
eqError = txGrid - eqGrid;
rxError = txGrid - rxGrid;

% Compute EVM across all input values
% EVM of pre-equalized receive signal
EVM = comm.EVM;
EVM.AveragingDimensions = [1 2];
preEqualisedEVM = EVM(txGrid,rxGrid);
fprintf('Percentage RMS EVM of Pre-Equalized signal: %0.3f%%\n', ...
        preEqualisedEVM);
Percentage RMS EVM of Pre-Equalized signal: 124.133%
% EVM of post-equalized receive signal
postEqualisedEVM = EVM(txGrid,eqGrid);
fprintf('Percentage RMS EVM of Post-Equalized signal: %0.3f%%\n', ...
        postEqualisedEVM);
Percentage RMS EVM of Post-Equalized signal: 15.598%
% Plot the received and equalized resource grids
hDownlinkEstimationEqualizationResults(rxGrid, eqGrid);
```



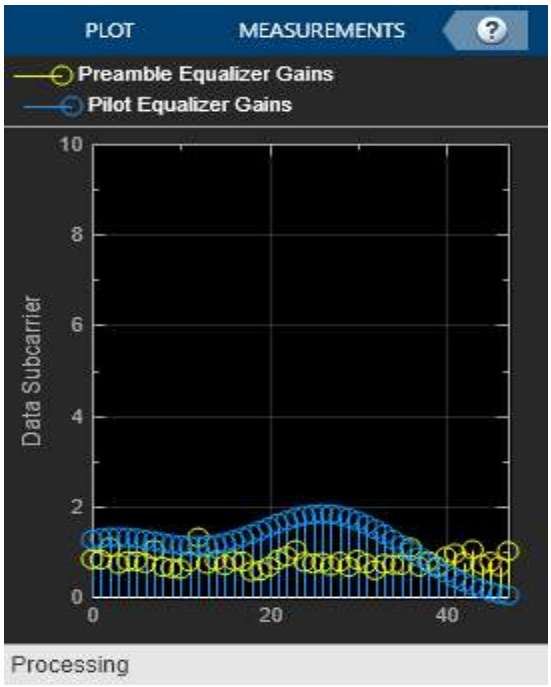


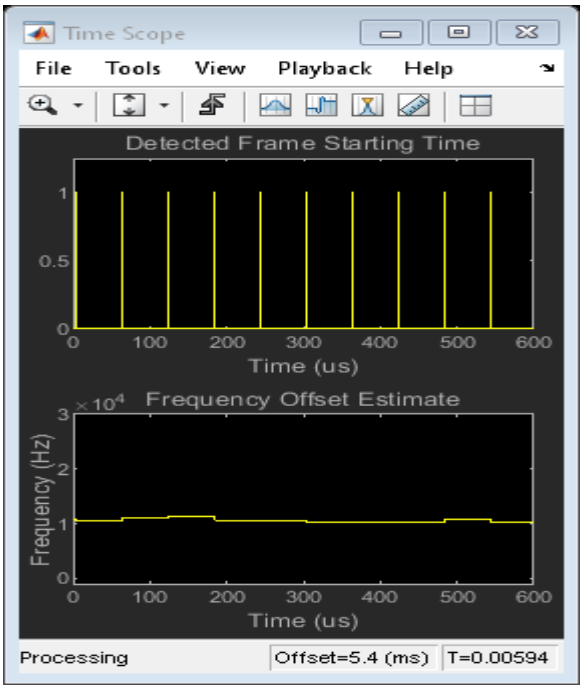
SYNCHRONIZATION

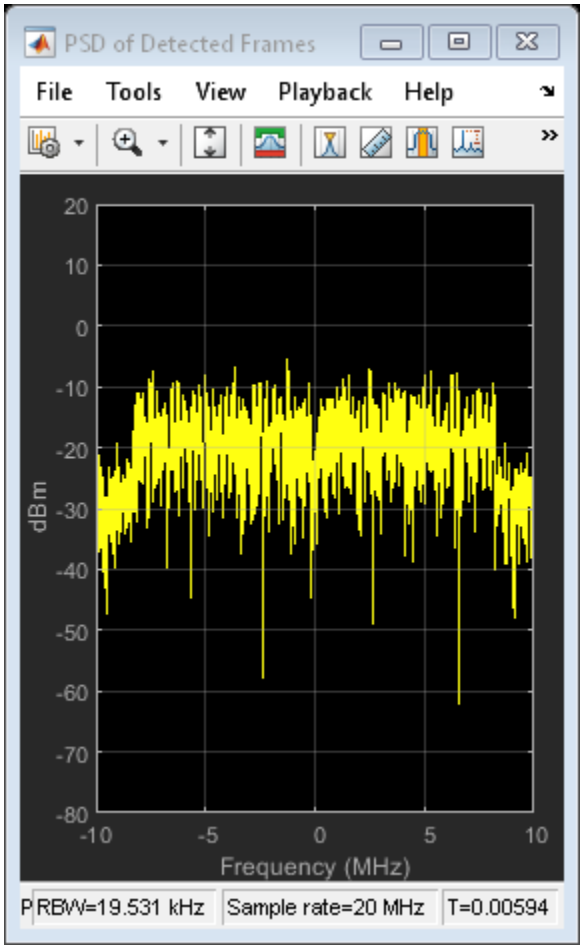
```
message = 'Live long and prosper, from the Communications Toolbox Team at MathWorks!';
numFrames = 1e2;

% Adjustable channel parameters
EbN0dB = 12; % Channel noise level (dB)
frequencyOffset = 1e4; % Frequency offset (Hz)
phaseOffset = 15; % Phase offset (Degrees)
delay = 80; % Initial sample offset for entire data stream (samples)

% Display recovered messages
displayRecoveredMsg = false;

% Enable scope visualizations
useScopes = true;

% Check for MATLAB Coder license
useCodegen = checkCodegenLicense;
if useCodegen
  fprintf(['--MATLAB Coder license found. ',...
    'Transmitter and receiver functions will be compiled for ',...
    'additional simulation acceleration.--\n']);
end

% By default the transmitter and receiver functions will be recompiled
% between every run, which is not always necessary. To disable receiver
% compilation, change "compileIt" to false.
compileIt = useCodegen;


% Compile transmitter with MATLAB Coder
if compileIt
    codegen generateOFDMSignal -args {coder.Constant(message),
coder.Constant(numFrames)}
end

% Generate transmission signal
if useCodegen
    [txSig, frameLen] = generateOFDMSignal_mex(message, numFrames);
else
    [txSig, frameLen] = generateOFDMSignal(message, numFrames);
end

% Pass signal through channel
rxSig = applyOFDMChannel(txSig, EbN0dB, delay, frequencyOffset, phaseOffset);

% Compile receiver with MATLAB Coder
```

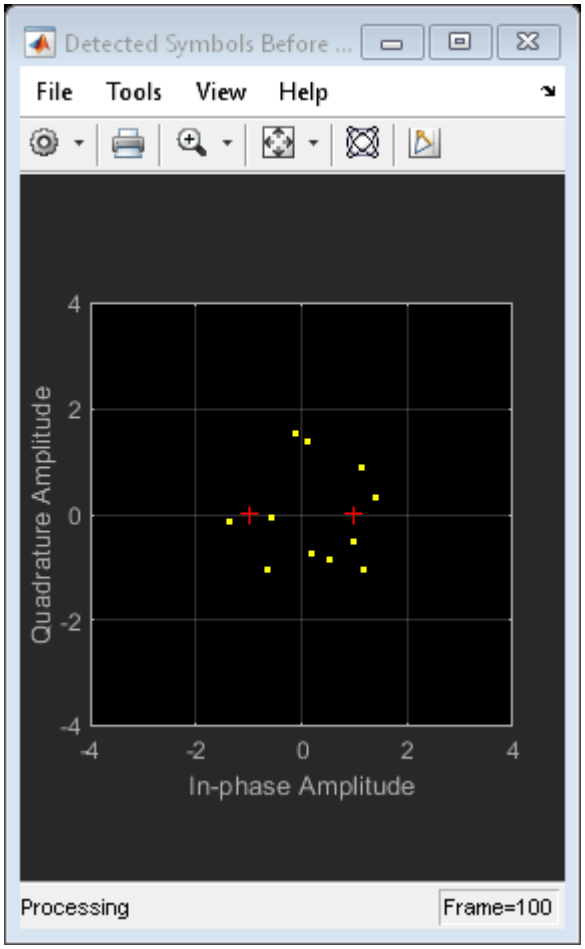
```
if compileIt
   codegen  receiveOFDMSignal -args {rxSig, coder.Constant(frameLen),
coder.Constant(displayRecoveredMsg), coder.Constant(useScopes)}
end

% Recover signal
if useCodegen
    [decMsgInBits, numFramesDetected] = receiveOFDMSignal_mex(rxSig, frameLen,
displayRecoveredMsg, useScopes);
else
    [decMsgInBits, numFramesDetected] = receiveOFDMSignal(rxSig, frameLen,
displayRecoveredMsg, useScopes);
end

% Calculate average BER
[FER, BER] = calculateOFDMBER(message, decMsgInBits, numFramesDetected);
fprintf('\nAt EbNo = %5.2fdB, %d frames detected among the %d transmitted frames with
FER = %f and BER = %f\n', ...
    EbN0dB, numFramesDetected, numFrames, FER, BER);
```

```
At EbNo = 12.00dB, 100 frames detected among the 100 transmitted frames with FER = 0.010000 and
BER = 0.000098
```









RESULT:

Thus the Wireless Channel Simulation of channel estimation, synchronization and Equalization Techniques were implemented by using MATLAB.

EXP. NO: 7 ANALYSIS THE IMPACT OF PULSE SHAPING AND MATCHED FILTERING

DATE:

AIM:

To analyze the impact of pulse shaping and matched filter using MatLab.

TOOLS REQURIED:

- PC
- MATLAB

THEORY

At the transmitter, we focus on pulse shaping; while at the receiver, we focus on matched filtering. Pulse shaping is the process of shaping pulses to be transmitted based on the symbols generated via modulation. The goal is to make the signal suitable to be transmitted through the communication channel mainly by limiting its effective bandwidth

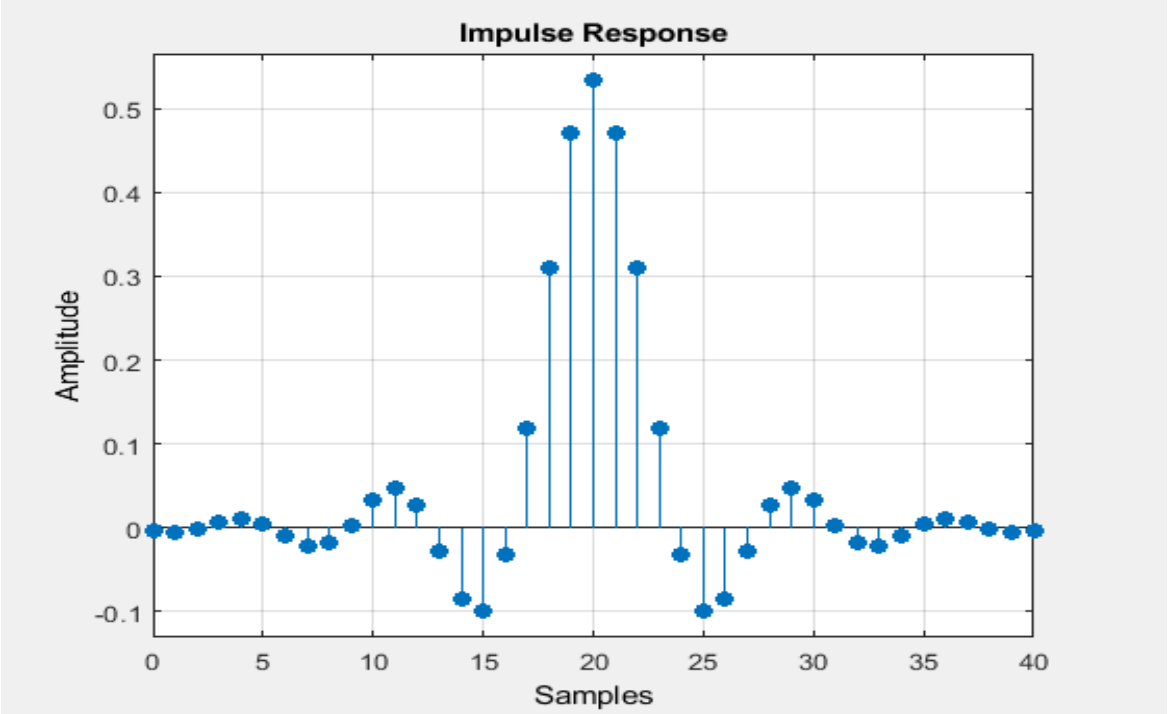
PROGRAM

Establish Simulation Framework

```
M = 16; % Modulation order
k = log2(M); % Number of bits per symbol
numBits = 3e5; % Number of bits to process
sps = 4; % Number of samples per symbol (oversampling factor)

filtlen = 10; % Filter length in symbols
rolloff = 0.25; % Filter rolloff factor
```

Use the `rcosdesign` function to create an RRC filter.

```
rrcFilter = rcosdesign(rolloff,filtlen,sps);

fvtool(rrcFilter,'Analysis','Impulse')
```

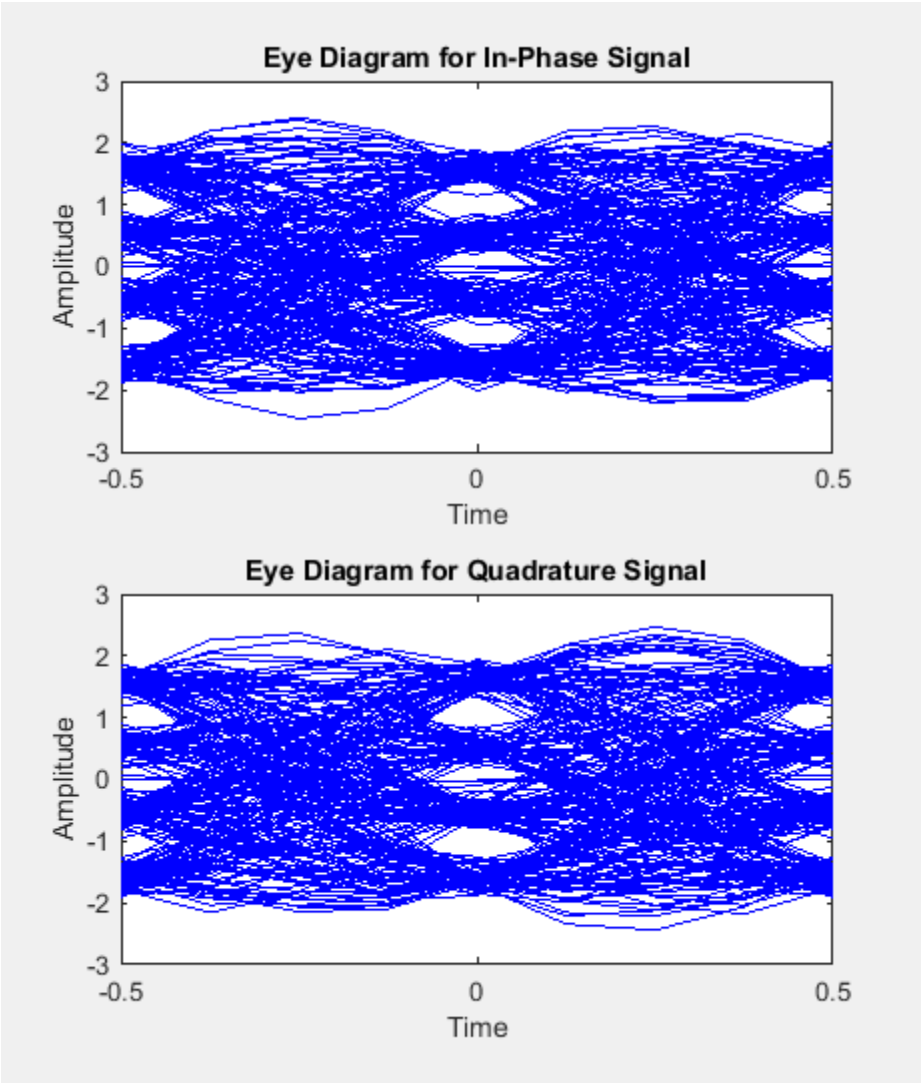


Compute System BER

```
rng default; % Use default random number generator
dataIn = randi([0 1],numBits,1); % Generate vector of binary data
dataInMatrix = reshape(dataIn,length(dataIn)/k,k); % Reshape data into binary 4-tuples
dataSymbolsIn = bi2de(dataInMatrix); % Convert to integers
dataMod = qammod(dataSymbolsIn,M);
txFiltSignal = upfirdn(dataMod,rrcFilter,sps,1);
EbNo = 10;
snr = EbNo + 10*log10(k) - 10*log10(sps);
rxSignal = awgn(txFiltSignal,snr,'measured');
rxFiltSignal = upfirdn(rxSignal,rrcFilter,1,sps); % Downsample and filter
rxFiltSignal = rxFiltSignal(filtlen + 1:end - filtlen); % Account for delay
dataSymbolsOut = qamdemod(rxFiltSignal,M);
dataOutMatrix = de2bi(dataSymbolsOut,k);
dataOut = dataOutMatrix(:); % Return data in column vector
 [numErrors,ber] = biterr(dataIn,dataOut);
fprintf('\nFor an EbNo setting of %3.1f dB, the bit error rate is %5.2e, based on %d errors.\n',
...
    EbNo,ber,numErrors)
```

Visualize Filter Effects

```
EbNo = 20;
snr = EbNo + 10*log10(k) - 10*log10(sps);
rxSignal = awgn(txFiltSignal,snr,'measured');
rxFiltSignal = upfirdn(rxSignal,rrcFilter,1,sps); % Downsample and filter
rxFiltSignal = rxFiltSignal(filtlen + 1:end - filtlen); % Account for delay
eyediagram(txFiltSignal(1:2000),sps*2);
```

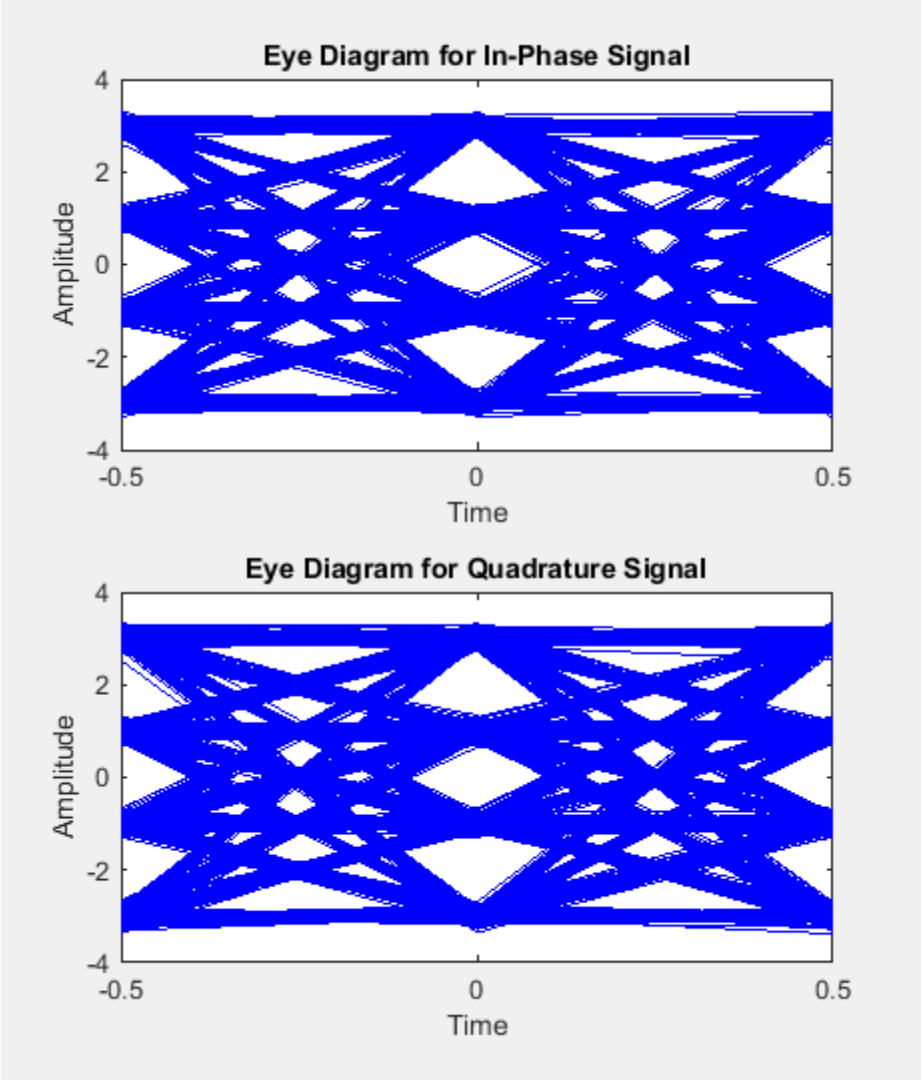


Displaying the eye diagram of the signal after the channel noise shows the signal with RRC filtering and noise. The noise level causes further narrowing of the eye diagram eye-opening.

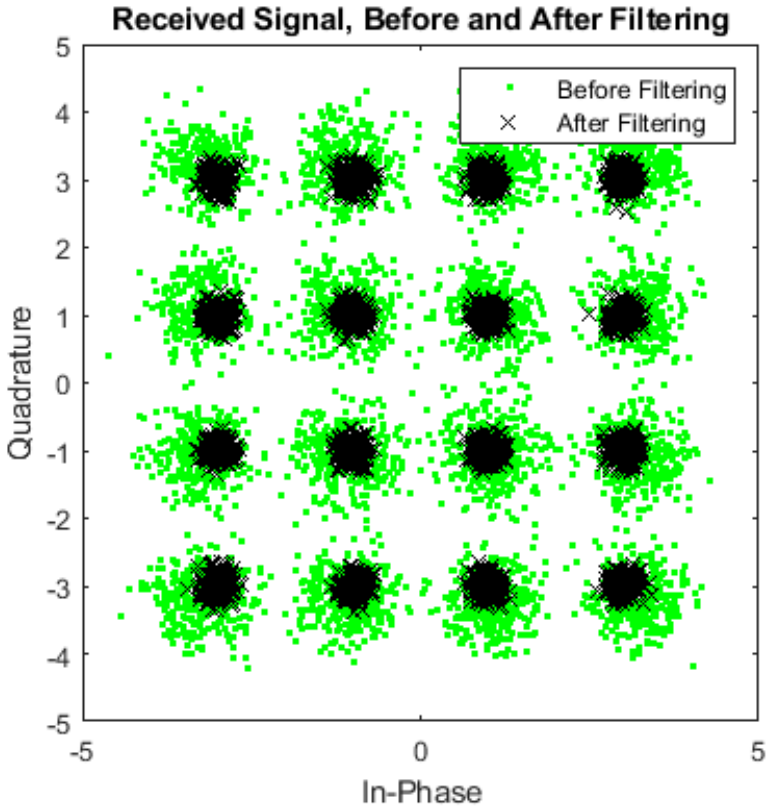
```
eyediagram(rxSignal(1:2000),sps*2);
```

Displaying the eye diagram of the signal after the matched receive filtering is applied shows the signal with raised cosine filtering. The wider eye diagram eye-openings, the signal has less ISI with raised cosine filtering as compared to the signal with RRC filtering.

```
eyediagram(rxFiltSignal(1:2000),2);
```




```
scatplot = scatterplot(sqrt(sps)*...
    rxSignal(1:sps*5e3),...
    sps,0,'g.');
hold on;
scatterplot(rxFiltSignal(1:5e3),1,0,'kx',scatplot);
title('Received Signal, Before and After Filtering');
legend('Before Filtering','After Filtering');
axis([-5 5 -5 5]); % Set axis ranges
hold off;
```



Matched Filtering of Linear FM Waveform

```
waveform = phased.LinearFMWaveform('PulseWidth',1e-4,'PRF',5e3,...
    'SampleRate',1e6,'OutputFormat','Pulses','NumPulses',1,...
    'SweepBandwidth',1e5);
wav = getMatchedFilter(waveform);
```

Create a matched filter with no spectrum weighting, and a matched filter that uses a Taylor window for spectrum weighting.

```
filter = phased.MatchedFilter('Coefficients',wav);
taylorfilter = phased.MatchedFilter('Coefficients',wav,...
    'SpectrumWindow','Taylor');
```

Create the signal and add noise.

```
sig = waveform();
rng(17)
x = sig + 0.5*(randn(length(sig),1) + 1j*randn(length(sig),1));
```

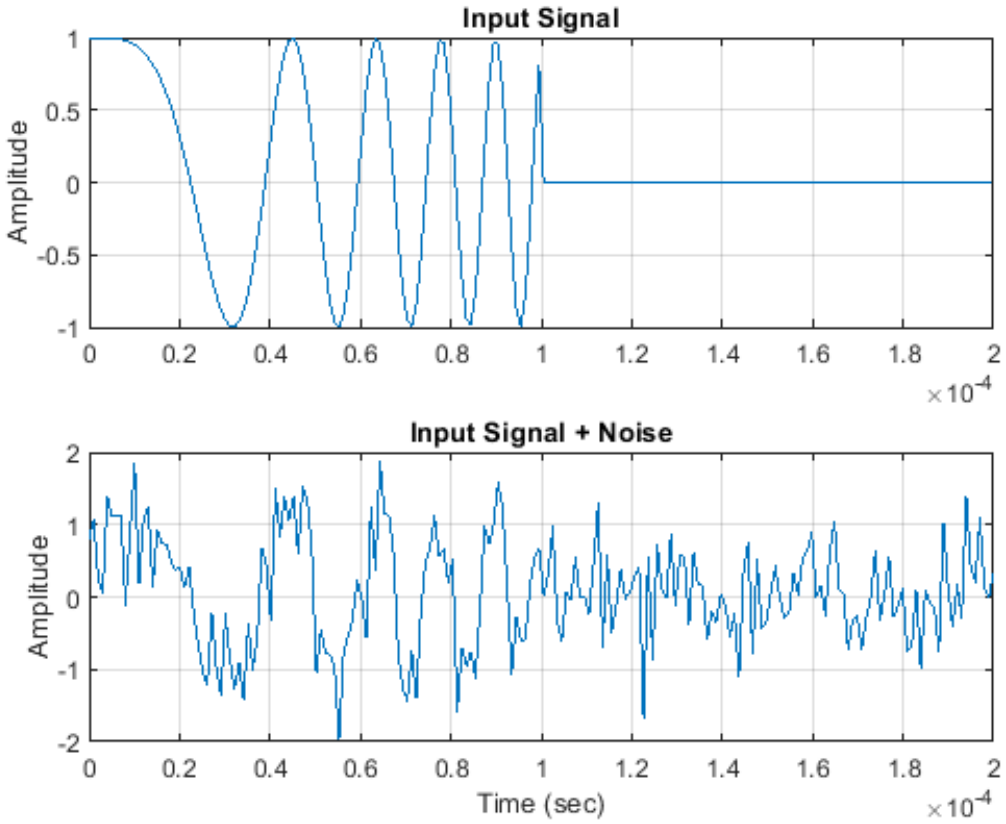
Filter the noisy signal separately with each of the filters.

```
y = filter(x);
y_taylor = taylorfilter(x);
```

Plot the real parts of the waveform and noisy signal.

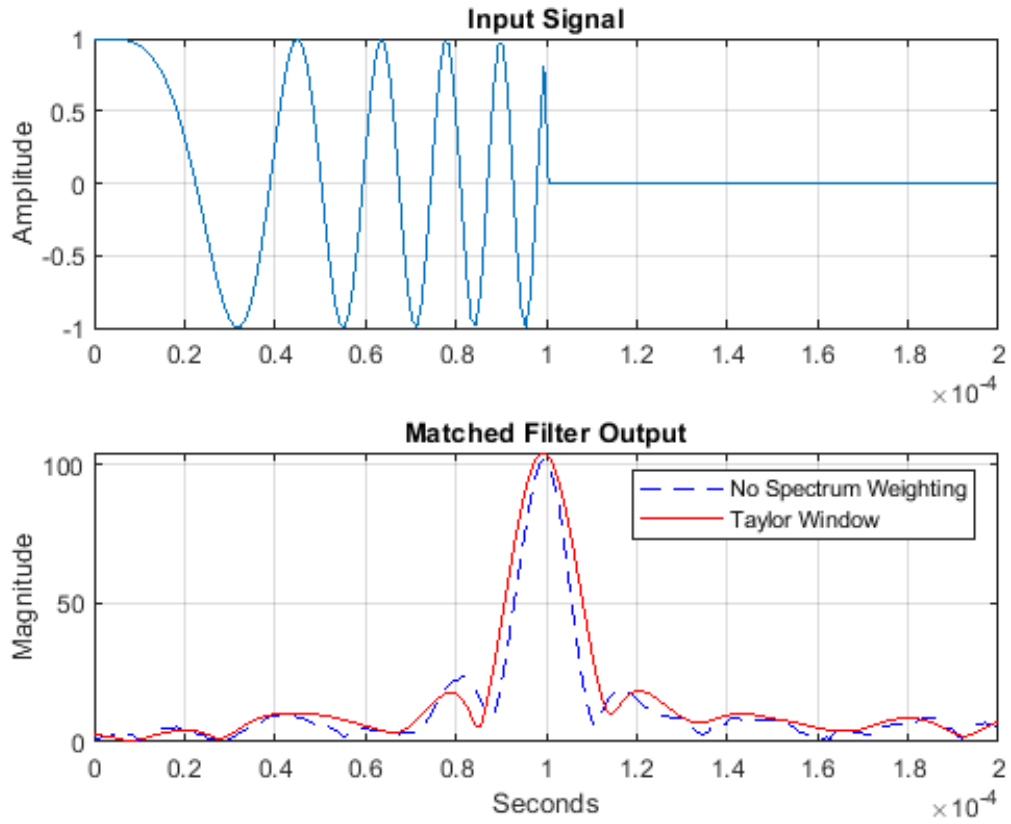
```
t = linspace(0,numel(sig)/waveform.SampleRate,...
    waveform.SampleRate/waveform.PRF);
subplot(2,1,1)
plot(t,real(sig))
```

```
title('Input Signal')
xlim([0 max(t)])
grid on
ylabel('Amplitude')
subplot(2,1,2)
plot(t,real(x))
title('Input Signal + Noise')
xlim([0 max(t)])
grid on
xlabel('Time (sec)')
ylabel('Amplitude')
```



Plot the magnitudes of the two matched filter outputs.

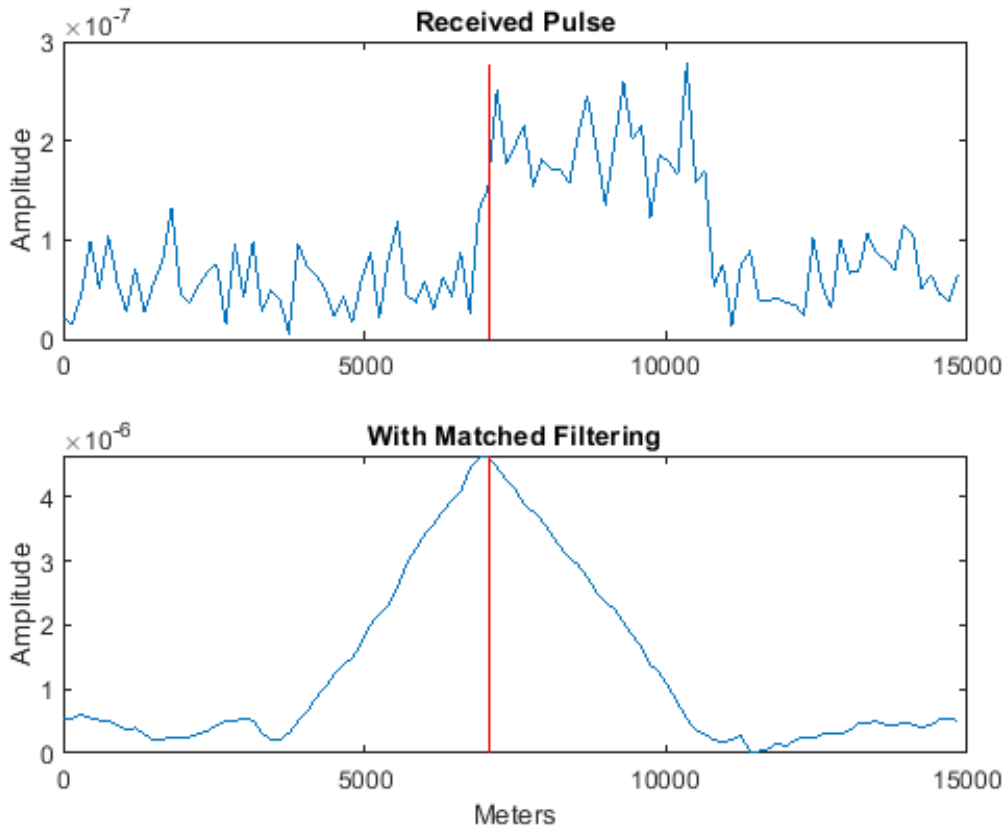
```
plot(t,abs(y),'b--')
title('Matched Filter Output')
xlim([0 max(t)])
grid on
hold on
plot(t,abs(y_taylor),'r-')
ylabel('Magnitude')
xlabel('Seconds')
legend('No Spectrum Weighting','Taylor Window')
hold off
```



Matched Filtering to Improve SNR for Target Detection

```
antenna = phased.IsotropicAntennaElement('FrequencyRange',[5e9 15e9]);
transmitter = phased.Transmitter('Gain',20,'InUseOutputPort',true);
fc = 10e9;
target = phased.RadarTarget('Model','Nonfluctuating',...
   'MeanRCS',1,'OperatingFrequency',fc);
txloc = [0;0;0];
tgtloc = [5000;5000;10];
transmitterplatform = phased.Platform('InitialPosition',txloc);
targetplatform = phased.Platform('InitialPosition',tgtloc);
[tgtrng,tgtang] = rangeangle(targetplatform.InitialPosition,...
   transmitterplatform.InitialPosition);
waveform = phased.RectangularWaveform('PulseWidth',25e-6,...
   'OutputFormat','Pulses','PRF',10e3,'NumPulses',1);
c = physconst('LightSpeed');
maxrange = c/(2*waveform.PRF);
SNR = npwgnthresh(1e-6,1,'noncoherent');
Pt = radareqpow(c/fc,maxrange,SNR,...
   waveform.PulseWidth,'RCS',target.MeanRCS,'Gain',transmitter.Gain);
transmitter.PeakPower = Pt;
radiator = phased.Radiator('PropagationSpeed',c,...
   'OperatingFrequency',fc,'Sensor',antenna);
channel = phased.FreeSpace('PropagationSpeed',c,...
   'OperatingFrequency',fc,'TwoWayPropagation',false);
collector = phased.Collector('PropagationSpeed',c,...
   'OperatingFrequency',fc,'Sensor',antenna);
```

```
receiver = phased.ReceiverPreamp('NoiseFigure',0,...
   'EnableInputPort',true,'SeedSource','Property','Seed',2e3);
filter = phased.MatchedFilter(...
   'Coefficients',getMatchedFilter(waveform),...
   'GainOutputPort',true);
wf = waveform();
 [wf,txstatus] = transmitter(wf);
wf = radiator(wf,tgtang);
wf = channel(wf,txloc,tgtloc,[0;0;0],[0;0;0]);
wf = target(wf);
wf = channel(wf,tgtloc,txloc,[0;0;0],[0;0;0]);
wf = collector(wf,tgtang);Receive target echo.
rx_puls = receiver(wf,~txstatus);
[mf_puls,mfgain] = filter(rx_puls);
Gd = length(filter.Coefficients)-1;
mf_puls=[mf_puls(Gd+1:end); mf_puls(1:Gd)];
subplot(2,1,1)
t = unigrid(0,1e-6,1e-4,'[)');
rangegates = c.*t;
rangegates = rangegates/2;
plot(rangegates,abs(rx_puls))
title('Received Pulse')
ylabel('Amplitude')
hold on
plot([tgtrng, tgtrng], [0 max(abs(rx_puls))],'r')
subplot(2,1,2)
plot(rangegates,abs(mf_puls))
title('With Matched Filtering')
xlabel('Meters')
ylabel('Amplitude')
hold on
plot([tgtrng, tgtrng], [0 max(abs(mf_puls))],'r')
hold off
```



RESULT

The Pulse shaping and Matched filtering are analyzed using MATLAB.

EXP. NO: 8 SIMULATION OF OFDM SIGNAL TRANSMISSION AND RECEPTION

DATE:

AIM:

To simulate the OFDM signal transmission and reception.

TOOLS REQURIED:

- PC
- MATLAB

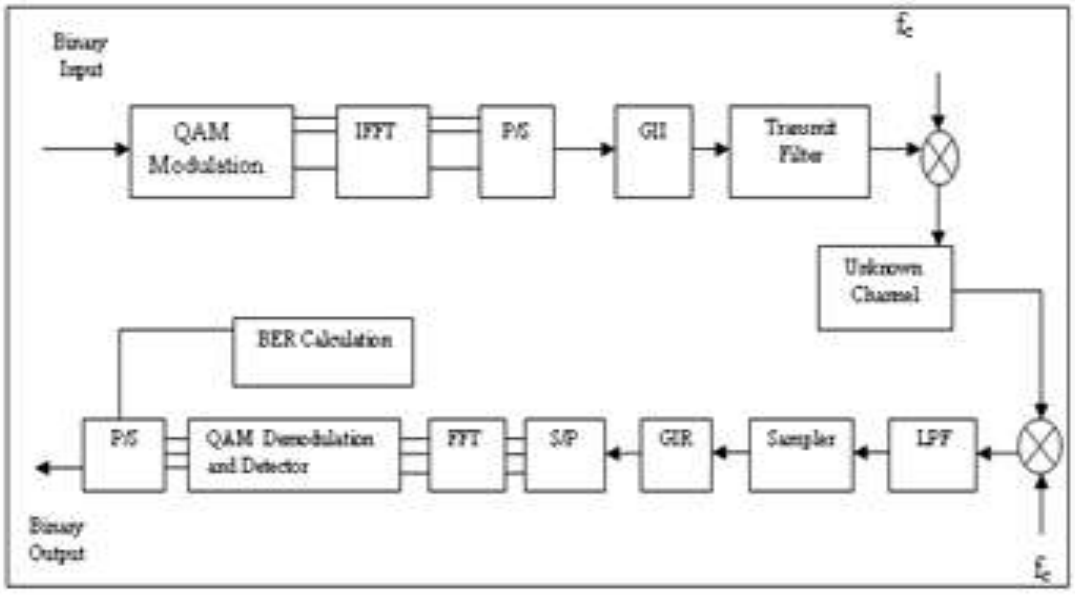
THEORY

OFDM is a form of multicarrier modulation. An OFDM signal consists of a number of closely spaced modulated carriers. When modulation of any form - voice, data, etc. is applied to a carrier, then sidebands spread out either side. It is necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data. As a result when signals are transmitted close to one another they must be spaced so that the receiver can separate them using a filter and there must be a guard band between them. This is not the case with OFDM. Although the sidebands from each carrier overlap, they can still be received without the interference that might be expected because they are orthogonal to each another. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period.

The OFDM scheme differs from traditional FDM in the following interrelated ways:

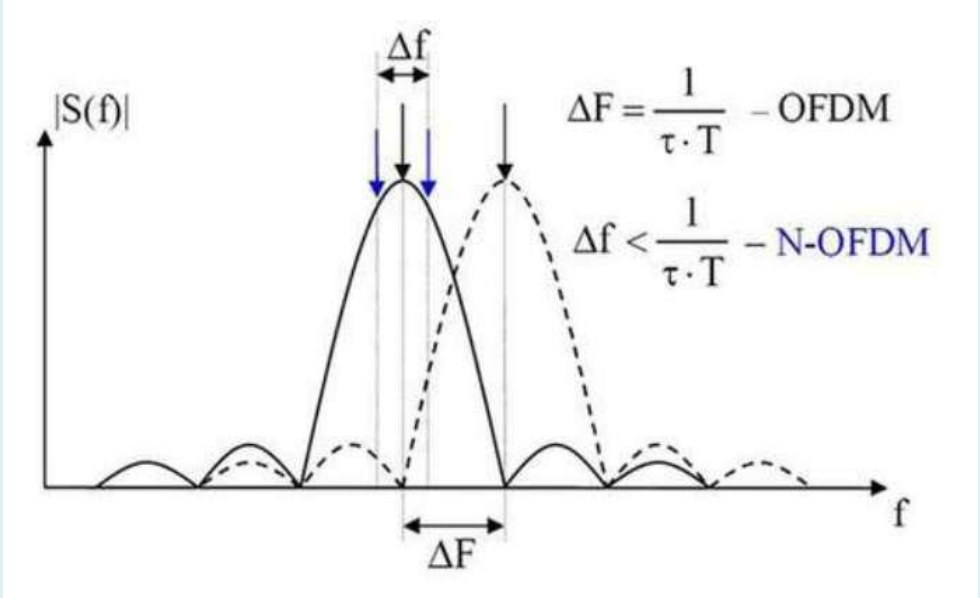
- Multiple carriers (called subcarriers) carry the information stream
- The subcarriers are orthogonal to each other.
- A guard interval is added to each symbol to minimize the channel delay spread and intersymbol interference.

BLOCK DIAGRAM



%code for OFDM signal transmission and reception in AWGN channel

```
n = 256; % Number of bits to process
x = randint(n,1); % Random binary data stream
M = 16; % Size of signal constellation
k = log2(M); % Number of bits per symbol
xsym = bi2de(reshape(x,k,length(x)/k).',’left-msb’);
% Convert the bits in x into k-bit symbols.
y = modulate(modem.qammod(M),xsym); % Modulate using QAM
tu=3.2e-6;%useful symbol period
tg=0.8e-6;%guard interval length
ts=tu+tg;%total symbol duration
nmin=0;
nmax=64;%total number of subcarriers
scb=312.5e3;%sub carrier spacing
fc=3.6e9;%carrier frequency
Rs=fc;
tt=0: 6.2500e-008:ts-6.2500e-008;
c=ifft(y,nmax);%IFFT
s=real(c’.*(exp(1j*2*pi*fc*tt)));%bandpass modulation
figure;
plot(real(s),’b’);
title(‘OFDM signal transmitted’);figure;
plot(10*log10(abs(fft(s,nmax))));title(‘OFDM spectrum’);
xlabel(‘frequency’)
ylabel(‘power spectral density’)
title(‘Transmit spectrum OFDM’);
snr=10;%signal to noise ratio
ynoisy = awgn(s,snr,’measured’);%awgn channel figure;
plot(real(ynoisy),’b’);title(‘received OFDM signal with noise’);
z=ynoisy.*exp(j*2*pi*fc*tt);%Bandpass demodulation
z=fft(z,nmax);%FFT
zsym=demodulate(modem.qamdemod(M),z);%demodulation of bandpass data.
z = de2bi(zsym,’left-msb’); %Convert integers to bits.
z = reshape(z.’,prod(size(z)),1);%matrix to vector conversion
[noe,ber] = biterr(x,z) ;%BER calculation figure;
subplot(211);stem(x(1:256));
title(‘Original Message’);
subplot(212);stem(z(1:256));
title(‘recovered Message’);
```



RESULT:

The simulation of OFDM Signal was verified.

EXP. NO: 9A VSWR MEASUREMENT
DATE:

AIM:

To determine the standing-wave ratio and reflection coefficient.

EQUIPMENTS REQUIRED:

1. Klystron tube (2k25)
2. Klystron power supply (skps - 610)
3. VSWR meter (SW 115)
4. Klystron mount (XM – 251)
5. Isolator (XF 621)
6. Frequency meter (XF 710)
7. Variable attenuator (XA – 520)
8. Slotted line (X 565)
9. Wave guide stand (XU 535)
10. Movable short/termination XL 400
11. BNC CableS-S Tuner (XT – 441)

THEORY:

Any mismatched load leads to reflected waves resulting in standing waves along the length of the line. The ratio of maximum to minimum voltage gives the VSWR. Hence minimum value of S is unity. If S<10 then VSWR is called low VSWR. If S>10 then VSWR is called high VSWR. The VSWR values more than 10 are very easily measured with this setup. It can be read off directly on the VSWR meter calibrated. The measurement involves simply adjusting the attenuator to give an adequate reading on the meter which is a D.C. mill volt meter. The probe on the slotted wave guide is moved t get maximum reading on the meter. The attenuation is now adjusted to get full scale reading. Next the probe on the slotted line is adjusted to get minimum, reading on the meter. The ratio of first reading to the second gives the VSWR. The meter itself can be calibrated in terms of VSWR. Double minimum method is used to measure VSWR greater than 10. In this method, the probe is inserted to a depth where the minimum can be read without difficulty. The probe is then moved to a point where the power is twice the minimum.

BLOCK DIAGRAM

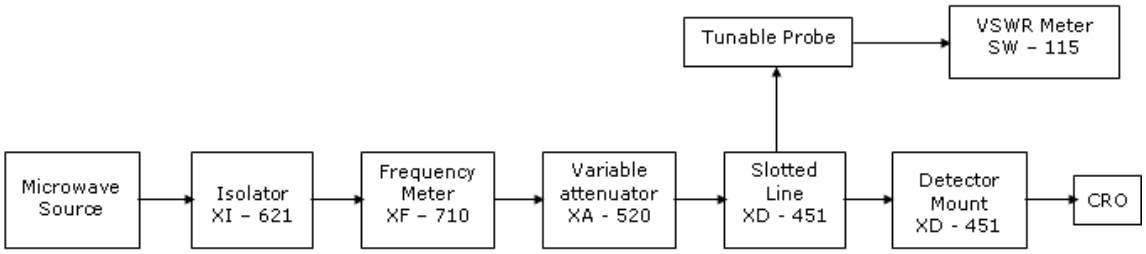


FIG: SET UP FOR LOW VSWR MEASUREMENT

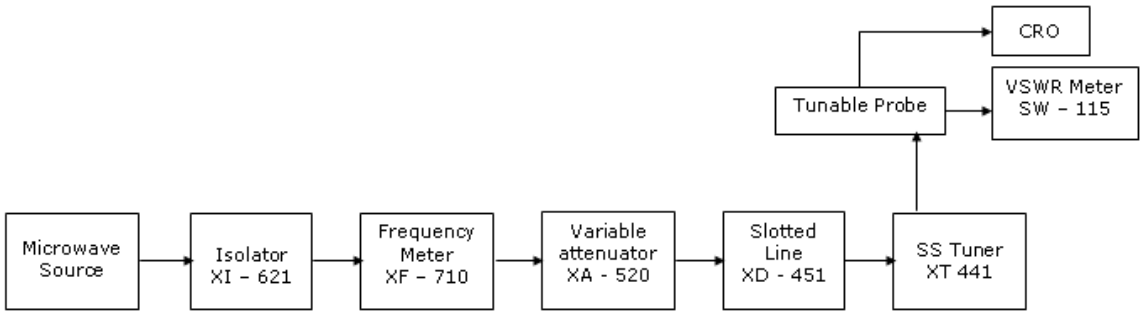


FIG: SET UP FOR HIGH VSWR MEASUREMENT

PROCEDURE:

1. Set up equipment as shown in figure.
2. Keep variable attenuator in minimum attenuation position.
3. Keep control knobs of VSWR meter as below

   Range dB = 40db / 50db Input
   switch = low impedance Meter
   switch = Normal
   Gain (coarse fine) = Mid position approximately

4. Keep control knobs of klystron power supply as below. Beam
   Voltage = OFF
   Mod-Switch = AM

   Beam Voltage Knob = fully anti clock wise Reflection
   voltage knob = fully clock wise
   AM-Amplitude knob = around fully clock wise AM
   frequency and amplitude knob = mid position
5. Switch 'ON' the klystron power supply, VSWR meter and cooling fan.
6. Switch 'ON" the beam voltage switch position and set (down) beam voltage at 300V.
7. Rotate the reflector voltage knob to get deflection in VSWR meter.
8. Tune the O/P by turning the reflector voltage, amplitude and frequency of AM modulation.
9. Tune plunges of klystron mount and probe for maximum deflection in VSWR meter.
10. If required, change the range db-switch variable attenuator position and (given) gain control knob to

get deflection in the scale of VSWR meter.

11. As your move probe along the slotted line, the deflection will change.

A. Measurement of low and medium VSWR:

1. Move the probe along the slotted line to get maximum deflection in VSWR meter.
2. Adjust the VSWR meter gain control knob or variable attenuator until the meter indicates 1.0 on normal VSWR scale.
3. Keep all the control knob as it is move the probe to next minimum position. Read the VSWR on scale.
4. Repeat the above step for change of S-S tuner probe depth and record the corresponding SWR.
5. If the VSWR is between 3.2 and 10, change the range 0dB switch to next higher position and read the VSWR on second VSWR scale of 3 to 10.

B. Measurement of High VSWR: (double minimum method)

1. Set the depth of S-S tuner slightly more for maximum VSWR.
2. Move the probe along with slotted line until a minimum is indicated.
3. Adjust the VSWR meter gain control knob and variable attenuator to obtain n a reading of 3db in the normal dB scale (0 to 10db) of VSWR meter.
4. Move the probe to the left on slotted line until full scale deflection is obtained on 0-10 db scale. Note and record the probe position on slotted line. Let it be d1.
5. Repeat the step 3 and then move the probe right along the slotted line until full scale deflection is obtained on 0-10db normal db scale. Let it be d2.
6. Replace S-S tuner and termination by movable short.
7. Measure distance between 2 successive minima positions of probe. Twice this distance is guide wave length λg.
8. Compute SWR from following equation

$$SWR = \frac{\lambda g}{\pi (d1 - d2)}$$

OBSERVATION TABLE:

LOW VSWR

VSWR = _____

HIGH VSWR

Beam Voltage (v)	x_1 (cm)	x_2 (cm)	x_1 (cm)	x_2 (cm)	Avg (x_1-x_2) = x (cm)	$\lambda g=2x$ (cm)

$\lambda g = 6cm$

d1 (cm)	d2 (cm)	d1-d2 (cm)	VSWR = $\lambda g / \pi(d1-d2)$

RESULT: .

Thus the VSWR meter has been used to measure standing wave ratio.

EXP. NO: 9B IMPEDANCE MEASUREMENT
DATE:

AIM

To measure an unknown impedance using the Reflex klystron.

EQUIPMENT REQUIRED:

1. Klystron tube 2k25
2. Klystron power supply Skps-610
3. Klystron mount XM-251
4. Isolator XF 62
5. Frequency meter XF 710
6. Variable attenuator XA – 520
7. Slotted line XS 565
8. Tunable probe XP 655
9. VSWR meter
10. Wave guide stand SU 535
11. S-S tuner (XT 441)
12. Movable short/termination

THEORY

The impedance at any point on a transmission line can be written in the form R+jx. For comparison SWR can be calculated as

$$S = \frac{1 + |R|}{1 - |R|}$$ where reflection coefficient 'R

Given as

$$R = \frac{Z - Z_0}{Z + Z_0}$$

Z_o = characteristics impedance of wave guide at operating frequency. Z is the load impedance

The measurement is performed in the following way.

The unknown device is connected to the slotted line and the position of one minima is determined. The unknown device is replaced by movable short to the slotted line. Two successive minima portions are noted. The twice of the difference between minima position will be guide wave length. One of the minima is used as reference for impedance measurement. Find the difference of reference minima and minima position obtained from unknown load. Let it be 'd'. Take a smith chart, taking '1' as centre, draw a circle of radius equal to S. Mark a point on circumference of smith chart towards load side at a distance equal to d/λg.

Join the center with this point. Find the point where it cut the drawn circle. The co- ordinates of this point will show the normalized impedance of load.

PROCEDURE:

1. Calculate a set of Vmin values for short or movable short as load.
2. Calculate a set of Vmin values for S-S Tuner + Matched termination as a load.

Note: Move more steps on S-S Tuner

3. From the above 2 steps calculate $d = d_1 \sim d_2$
4. With the same setup as in step 2 but with few numbers of turns (2 or 3). Calculate low VSWR.

Note: High VSWR can also be calculated but it results in a complex procedure.

5. Draw a VSWR circle on a smith chart.
6. Draw a line from center of circle to impedance value (d/λg) from which calculate admittance and Reactance ($Z = R \pm jx$)

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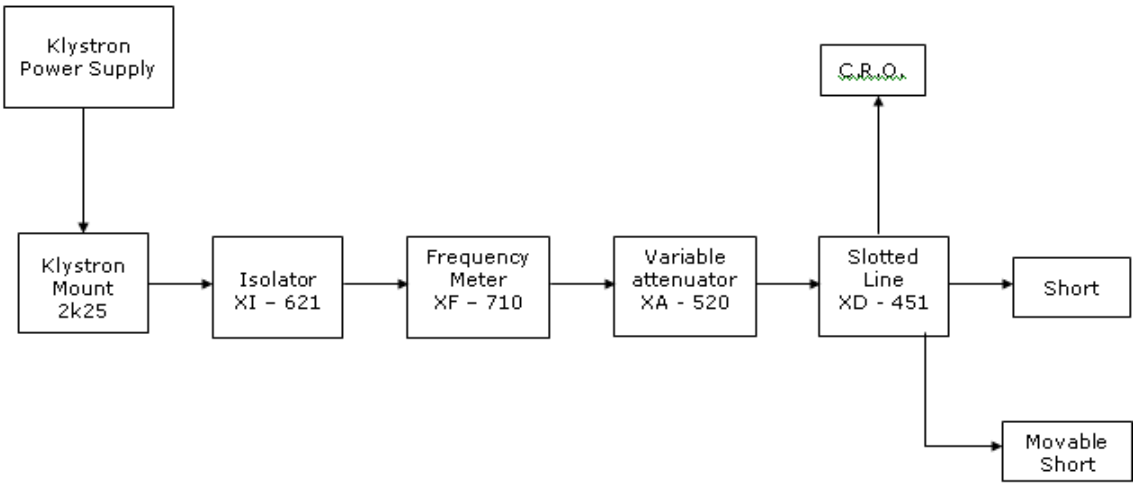

FIG: SET UP FOR IMPEDANCE MEASUREMENT

OBSERVATION TABLE:

Load (short or movable short)					
x_1 (cm)	x_2 (cm)	x_1 (cm)	x_2 (cm)	x_1 (cm)	x_2 (cm)

x = _____ λg =

_____

Load (S.S. Tuner + Matched Termination)

S.S Tuner + Matched Termination	Short or Movable Short

d1= , d2 =

d = d1 ~ d2 = Z =

d/λg =

RESULT

Thus the unknown impedance has been measured by using Reflex klystron.

EXP.NO:10A DIRECTIONAL COUPLER CHARACTERISTICS
DATE:

AIM:

To study the function of multi-hole directional coupler by measuring the following parameters.

1. The Coupling factor, Insertion Loss and Directivity of the Directional coupler

EQUIPMENT REQUIRED:

1. Microwave Source (Klystron or Gunn-Diode)
2. Isolator, Frequency Meter
3. Variable Attenuator
4. Slotted Line
5. Tunable Probe
6. Detector Mount Matched Termination
7. MHD Coupler
8. Waveguide Stand
9. Cables and Accessories
10. CRO.

THEORY:

A directional coupler is a device with which it is possible to measure the incident and reflected wave separately. It consist of two transmission lines the main arm and auxiliary arm, electromagnetically coupled to each other Refer to the Fig.1. The power entering, in the main- arm gets divided between port 2 and 3, and almost no power comes out in port (4) Power entering at port 2 is divided between port 1 and 4.

The coupling factor is defined as

Coupling (db) = 10 $\log_{10}$ [P1/P3] where port 2 is terminated, Isolation (dB) = 10 $\log_{10}$ [P2/P3] where P1 is matched.

With built-in termination and power entering at Port 1, the directivity of the coupler is a measure of separation between incident wave and the reflected wave. Directivity is measured indirectly as follows:

Hence Directivity D (db) = I-C = 10 $\log_{10}$ [P2/P1]

Main line VSWR is SWR measured, looking into the main-line input terminal when the matched loads are placed at all other ports.

Auxiliary live VSWR is SWR measured in the auxiliary line looking into the output terminal when the matched loads are placed on other terminals.

Main line insertion loss is the attenuation introduced in the transmission line by insertion of coupler, it is defined as:

Insertion Loss (dB) = $10 \log_{10} [P1/P2]$

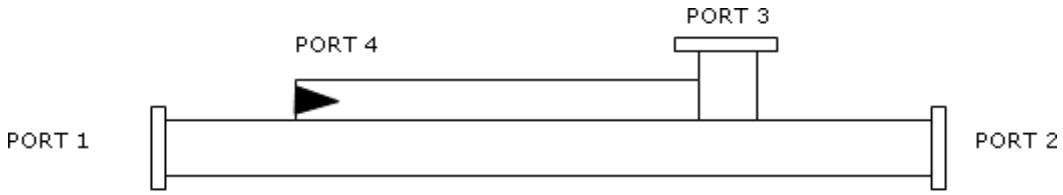

FIG. DIRECTIONAL COUPLER

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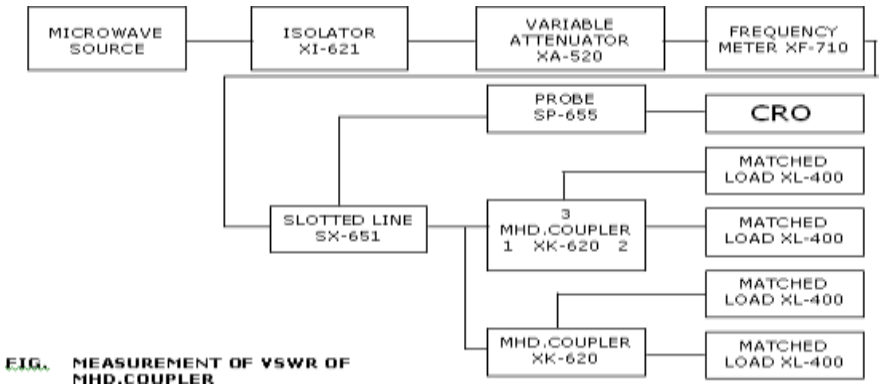


FIG. MEASUREMENT OF VSWR OF MHD.COUPLER

EXPERIMENTAL PROCEDURE:

1. Set up the equipments as shown in the Figure.
2. Energize the microwave source for particular operation of frequency .
3. Remove the multi hole directional coupler and connect the detector mount to the slotted section.
4. Set maximum amplitude in CRO with the help of variable attenuator, Let it be X.
5. Insert the directional coupler between the slotted line and detector mount. Keeping port 1 to slotted line, detector mount to the auxiliary port 3 and matched termination to port 2 without changing the position of variable attenuator.
6. Note down the amplitude using CRO, Let it be Y.
7. Calculate the Coupling factor X-Y in dB.
8. Now carefully disconnect the detector mount from the auxiliary port 3 and matched termination from port 2 , without disturbing the setup.
9. Connect the matched termination to the auxiliary port 3 and detector mount to port 2 and measure

the amplitude on CRO, Let it be Z.

10. Compute Insertion Loss= X – Z in dB.
11. Repeat the steps from 1 to 4.
12. Connect the directional coupler in the reverse direction i.e., port 2 to slotted section, matched termination to port 1 and detector mount to port 3, without disturbing the position of the variable attenuator.
13. Measure and note down the amplitude using CRO, Let it be Y_0.

Compute the Directivity as $Y-Y_0$ in dB.

RESULT:

Thus the Characteristics of Directional coupler were measured.

EXP.NO:10B SCATTERING PARAMETERS OF CIRCULATOR
DATE:

AIM:

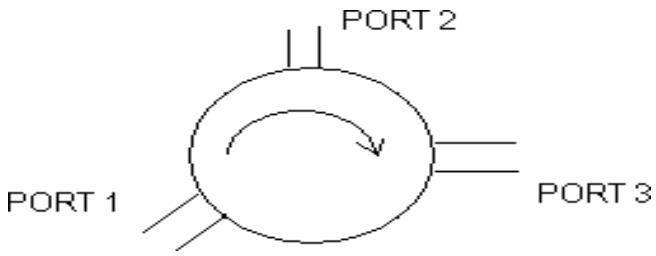
To study the Isolator and circulators and measure the Insertion Loss and Isolation of Circulator.

EQUIPMENT REQUIRED:

1. Microwave Source (Klystron or Gunn-Diode)
2. Isolator, Frequency Meter
3. Variable Attenuator
4. Slotted Line
5. Tunable Probe
6. Detector Mount Matched Termination
7. Circulator
8. Waveguide Stand
9. Cables and Accessories
10. VSWR Meter.

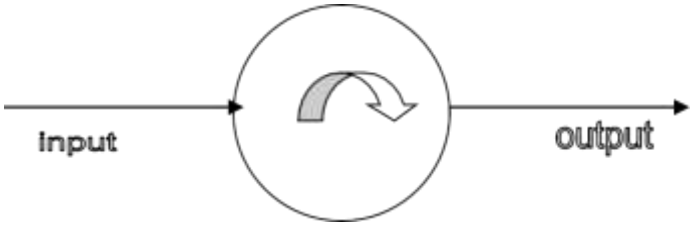
CIRCULATOR:

Circulator is defined as device with ports arranged such that energy entering a port is coupled to an adjacent port but not coupled to the other ports. This is depicted in figure circulator can have any number of ports.



ISOLATOR:

An Isolator is a two-port device that transfers energy from input to output with little attenuation and from output to input with very high attenuation.



The isolator, shown in Fig. can be derived from a three-port circulator by simply placing a matched load (reflection less termination) on one port.
The important circulator and isolator parameters are:

A. Insertion Loss

Insertion Loss is the ratio of power detected at the output port to the power supplied by source to the input port, measured with other orts terminated in the matched Load. It is expressed in dB.

B. Isolation

Isolation is the ratio of power applied to the output to that measured at the input. This ratio is expressed in db. The isolation of a circulator is measured with the third port terminated in a matched load.

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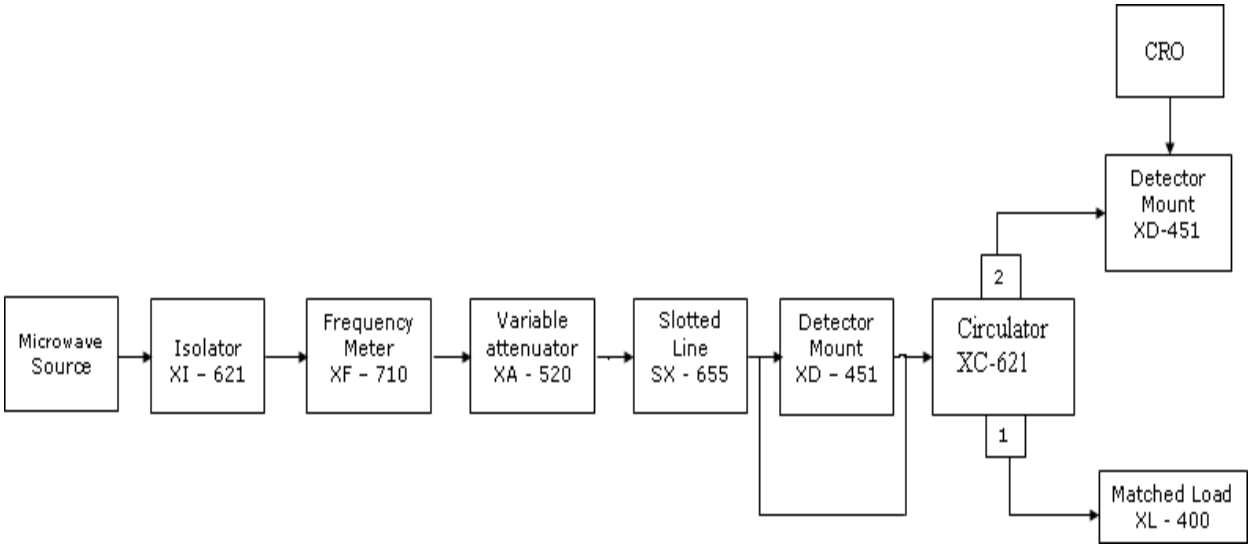

EXPERIMENTAL PROCEDURE:

Measurement of insertion

1. Remove the isolator or circulator from slotted line and connect the detector mount to the slotted section. The output of the detector mount should be connected with CRO.
2. Energize the microwave source for maximum output for a particular frequency of operation. Tune the detector mount for maximum output in the CRO.
3. Set any reference level of output in CRO with the help of variable attenuator, Let it be V_1.
4. Carefully remove the detector mount from slotted line without disturbing the position of the set up. Insert the isolator/circulator between slotted line and detector mount. Keep input port to slotted line and detector its output port. A matched termination should be placed at third port in case of Circulator.
5. Record the output in CRO, Let it be V_2.
6. Compute Insertion loss given as V_1-V_2 in db.

Measurement of Isolation:

7. For measurement of isolation, the isolator or circulator has to be connected in reverse i.e. output port to slotted line and detector to input port with other port terminated by matched termination (for circulator).
8. Record the output of CRO and let it be V_3.
9. Compute Isolation as V_1-V_3 in db.
10. The same experiment can be done for other ports of circulator.
11. Repeat the above experiment for other frequency if needed.

RESULT:

Thus the Characteristics of Circulator and Isolator were measured.

EXP.NO:11 GUNN DIODE CHARACTERISTICS
DATE:

AIM:

To measure the V-I characteristics of Gunn diode.

EQUIPMENT REQUIRED:

1. Gunn power supply
2. Gunn oscillator
3. PIN Modulator
4. Isolator
5. Frequency Meter
6. Variable attenuator
7. Slotted line
8. Detector mount and CRO.

THEORY:

Gunn diode oscillator normally consist of a resonant cavity, an arrangement for coupling diode to the cavity a circuit for biasing the diode and a mechanism to couple the RF power from cavity to external circuit load. A co-axial cavity or a rectangular wave guide cavity is commonly used.

The circuit using co-axial cavity has the Gunn diode at one end at one end of cavity along with the central conductor of the co-axial line. The O/P is taken using a inductively or capacitive coupled probe. The length of the cavity determines the frequency of oscillation. The location of the coupling loop or probe within the resonator determines the load impedance presented to the Gunn diode. Heat sink conducts away the heat due to power dissipation of the device.

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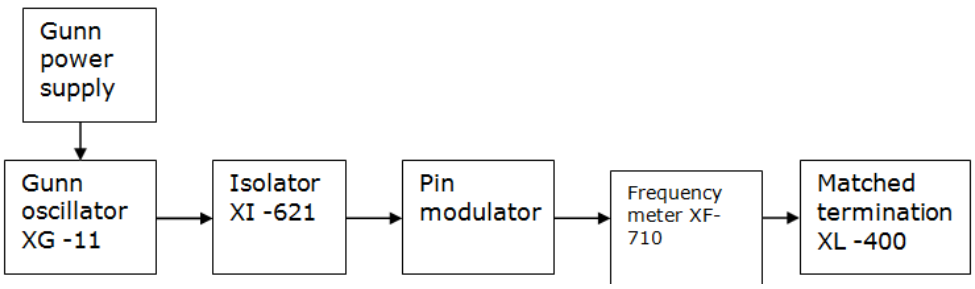
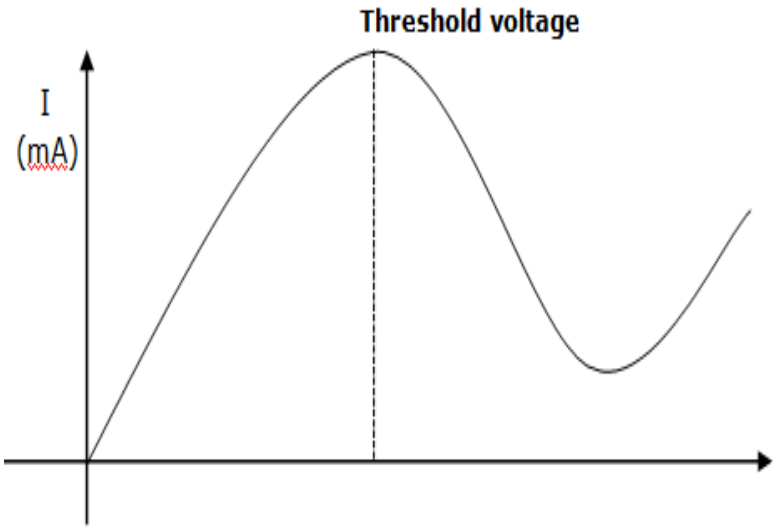


EXPERIMENTAL PROCEDURE:

Voltage-Current Characteristics:

1. Set the components and equipments as shown in Figure.
2. Initially set the variable attenuator for minimum attenuation.
3. Keep the control knobs of Gunn power supply as below Meter
   switch – "OFF"
   Gunn bias knob – Fully anti clock wise PIN
   bias knob – Fully anti clock wise PIN mode
   frequency – any position
4. Set the micrometer of Gunn oscillator for required frequency of operation.
5. Switch "ON" the Gunn power supply.
6. Measure the Gunn diode current to corresponding to the various Gunn bias voltage through the digital panel meter and meter switch. Do not exceed the bias voltage above 10 volts.
7. Plot the voltage and current readings on the graph.
8. Measure the threshold voltage which corresponding to max current.

MODEL GRAPH



OBSERVATION TABLE

Gunn bias voltage (v)	Gunn diode current (mA)

RESULT

Thus the V-I Characteristics of Gunn diode has been measured.