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Light intensity measurement using Phototransistor as a sensor

Group No. 22

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Abstract

The major goal of the system is to correctly monitor and show the ambient light intensity in real-time. Phototransistors are employed as light sensors because of their light sensitivity, making them ideal for such applications. The output interface is a 16x2 LCD display that provides a user-friendly way to view the measured light intensity.The phototransistor is connected to an analog input pin of a microcontroller which serves as the main processing unit, in the hardware arrangement. Using analog-to-digital conversion techniques, the microcontroller processes the analog voltage output from the phototransistor and converts it to a matching digital value. Based on a predetermined calibration curve or calculation, this digital number is then utilized to calculate the light intensity.The advantages of this project are simple design,compact size,low maintenance cost.

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Chapter 1

Introduction

There are numerous applications available for measuring and maintaining adequate light levels, such as laboratories, hospitals, educational institutions, and so on. Enough light levels in the premises are required to provide a healthier and safer atmosphere. Without being distracted by weather conditions, the light intensity must be suitable for some of the most critical areas and light intensity. To ensure road safety, traffic lights must be plainly visible to all road users.Pollution of lenses or reflectors, aging of the light source, or individual LED failure are all possible causes.To measure this light intensity a small components like phototransistor can be used.

Phototransistors are electro-optical transducers that convert incident light to electric current and are used in applications such as position/presence sensing, light intensity measurement, and high-speed optical pulse detection.

A phototransistor's base is controlled by the external light that shines through its transparent container, hence it only has two external pins. A compact surface mount phototransistor type light sensor with a resistor would most likely be used in an actual device. When exposed to light, a phototransistor is a form of bipolar junction transistor (BJT) that acts as a switch. A standard BJT's base terminal is replaced with light-sensitive material, causing electrons to hop from p-type silicon to n-type silicon, allowing electrons to flow from the emitter to the collector. Phototransistors resemble typical LEDs in appearance and can have similar spectrum ranges and sensitivities to photodiodes. They are often utilized in light-activated sensor applications and can be used to measure light intensity.[**r1**].

Chapter 2

Working and Design of Circuit

2.1 Components

1. **Breadboard**

   A rectangular board with numerous tiny holes in it is called breadboard.Temporary circuits are constructed on a breadboard.

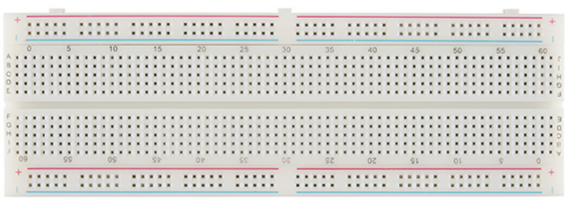

Figure 2.1: figure of Breadboard.

2. **photo transistor**

   A photo transistor is an electronic switching and current amplification component which depends on presents of sunlight to operate.Reverse current that is proportional to the brightness flows when light falls the junction. Photo transistor are used to detect light pulses and convert them into digital electrical signal.

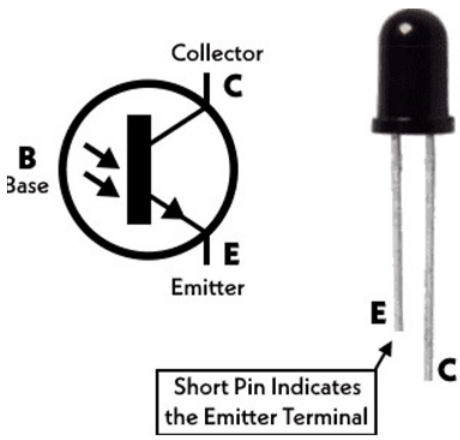

Figure 2.2: figure of photo transistor

3. **22 pf ceramic capacitor**

   Ceramic capacitors are mainly used High stability performances are the key uses for ceramic capacitors.Use this capacitor for circuit timing, power decoupling, and smooth power.Here we used 2 ceramic capacitor.

Figure 2.3: figure of Ceramic capacitor

4. **crystal oscillator**

   A particular kind of resonator is used to produce an oscillating signal at a frequency of 8 million hertz, called a 8 MHz crystal. The crystal's signal can be utilized as a reliable clock signal for digital circuits or to keep track of the passing of time. Crystal oscillators are used in electronic devices, such as computers, cell phones, and radios.

Figure 2.4: figure of Crystal oscillator

5. **Voltage regulator**

   A linear voltage regulator with three terminals is L7805CV and it has a fixed output voltage.It is positive regulator used in electronic circuits to reduce the voltage from a higher input voltage and provides a regulated output of +5V .

Figure 2.5: figure of Voltage regulator

Table 2.1: Pin no, Pin name and description of Voltage regulator

Pin no	Pin name	Description
1	Input(V+)	Unregulated input Voltage
2	Ground(Gnd)	Connected to Ground
3	Output(vo)	Outputs regulated +5

6. **B10k Potentiometer**

   B10k Potentiometer is a three-terminal devices with a rotating knob. It is a one type of variable resistor that is used to adjust the resistance between 0 to 10k ohms by simply rotating the knob in an electrical circuit. It is also called as a rotary potentiometer.

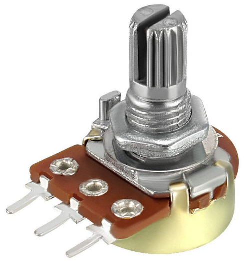

Figure 2.6: figure of B10k Potentiometer

7. **PIC16F73 Micro-controller**

One of the main advantages of the PIC16F73 Micro-controller is the use of FLASH memory technology, which permits several write-erase operations. It features two 8-bit timers and one 16-bit timer, making a total of 28 pins available for input and output.

Figure 2.7: figure of PIC 16F73 Micro-controller

It can run at up to 20MHz of frequency.The range of the operating voltage is 4.2 to 5.5 volts.If we give it a voltage more than 5.5 volts, it could sustain long-term damage.Numerous industrial instruments, home automation systems, security and safety apparatus, and remote sensors all make use of it.

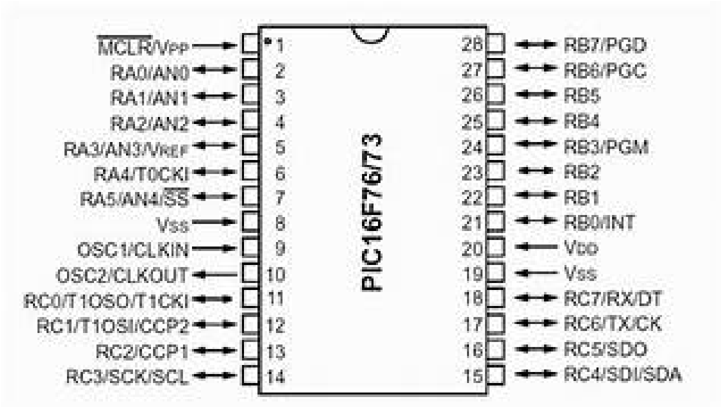

Figure 2.8: figure of pin configaration of PIC 16F73 Micro-controller

8. **Resistor**

A resistor is an electrical component which limits or restricts the flow of electricity that are passing across a circuit in an electronic device. A certain level of voltage can be supplied via resistors to an active component.Here, we used 2K ohm and 10K ohm resistor.

Figure 2.9: figure of Resistor

9. **LCD**

LCD means Liquid Crystal Display .In this case, we used a 16×2 character LCD module.It can display two lines of 16 characters. An 8 Bit mode 16×2 LCD can be interfaced with micro-controller. Data lines D0 to D7 are used to transmit LCD commands in 8 Bit mode character data. Data strobe is provided through E of the LCD and 8 bit data is sent at a time.

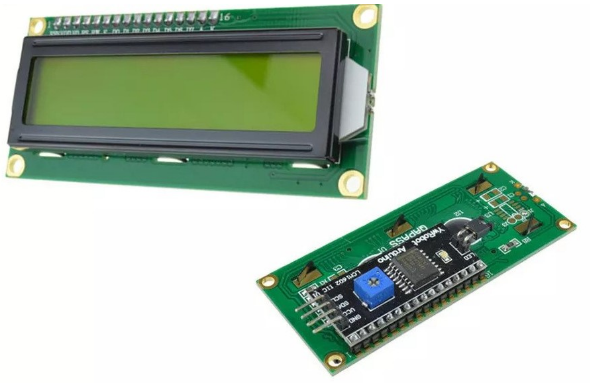

Figure 2.10: figure of 16×2 character LCD module

Table 2.2: Pin no, Pin name and description of LCD .

Pin no	Pin name	Description
1	Vss	Ground
2	Vdd	+ve supply
3	Vee	Constrast
4	RS	Register Select
5	R/W	Read/Write
6	E	Enable
7	D0	Data bit 0
8	D1	Data bit 1
9	D2	Data bit 2
10	D3	Data bit 3
11	D4	Data bit 4
12	D5	Data bit 5
13	D6	Data bit 6
14	D7	Data bit 7

2.2 Mamthematical Formula

Inline equation : $f(x) = a * x^b + c$

Coefficients

a=3.838e-10(-3.612e-10,1.129-09)

b=18.65(17.4,19.91)

c=32.72(16.89,48.54)

Table 2.3: Data table of Luxmeter

Reference	Experimental	Error(Percent)
64	63.04	1.5
66	64.58	2.15
73	71.05	2.67
76	78.42	3.18
78	81.25	4.2
101	102.17	1.16
110	112.24	2.04
127	122.5	3.15
149	144.01	3.34
158	153.6	2.78
183	178.4	2.5
236	227.9	3.4
261	255.8	2
328	333.7	1.78
385	380.9	1.17
427	418.07	2.09

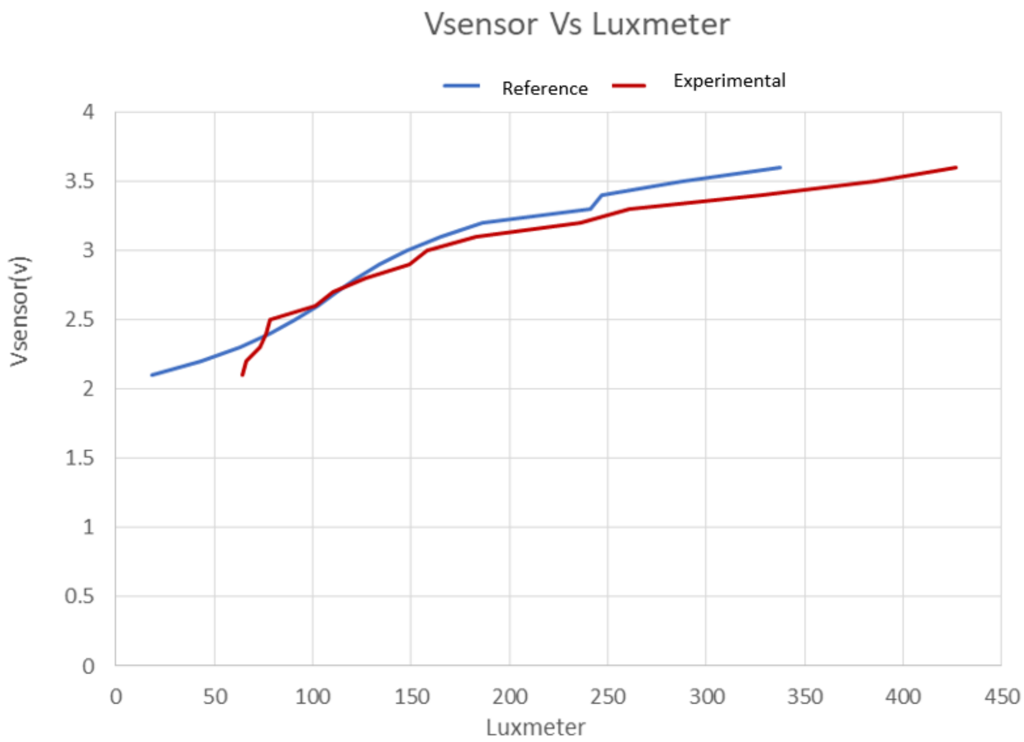

Figure 2.11: Graph of Luxmeter vs Vsensor

Accuracy=97.56 Percent

2.2.1 Program code

Listing 2.1: Code label

```
// LCD module connections
sbit LCD_RS at RB7_bit;
sbit LCD_EN at RB6_bit;
sbit LCD_D4 at RB4_bit;
sbit LCD_D5 at RB3_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D7 at RB1_bit;
sbit LCD_RS_Direction at TRISB7_bit;
sbit LCD_EN_Direction at TRISB6_bit;
sbit LCD_D4_Direction at TRISB4_bit;
sbit LCD_D5_Direction at TRISB3_bit;
sbit LCD_D6_Direction at TRISB2_bit;
sbit LCD_D7_Direction at TRISB1_bit;
// End LCD module connections
float v,va,vd;
char txt[15];
void Display()
 {
                 Lcd_init();
                 Lcd_Cmd(_LCD_CLEAR);
                 Lcd_cmd(_LCD_CURSOR_OFF);
                        if(vd!=0)
                            {
                               Lcd_out(1,1,"Intesity in lux");
                               Lcd_out(2,12,"Lux");
                               floattostr(vd,txt);
                               Lcd_out(2,1,txt);
                           }
 }
void main()
         {
          ADCON1=0b00000000; // configure --------------------000
          trisa=0b11111111; // All pins of port A are declared as i/p
          Lcd_init();
          Lcd_Cmd(_LCD_CLEAR);
          Lcd_cmd(_LCD_CURSOR_OFF);
          Lcd_out(1,1," LUX METER ");
          while(1)
                {v = ADC_Read(0); //Digital level count, read from RA0
                    va=(v*4.9)/255; //analog voltage read, multiplying digital
   level with resolution, Vref=4.9V
                             if(va>2)
                               { vd=3.838e-10(-3.612e-10,1.129-09)x
   ^18.65(17.4,19.91+18.65(17.4,19.91);
 //Fitted curve, vd is lux
                                }
                               else
                               vd=0;
                            Display(); //Display Function call and return
   values
                            Delay_ms(200);
                                }
            }
end
```

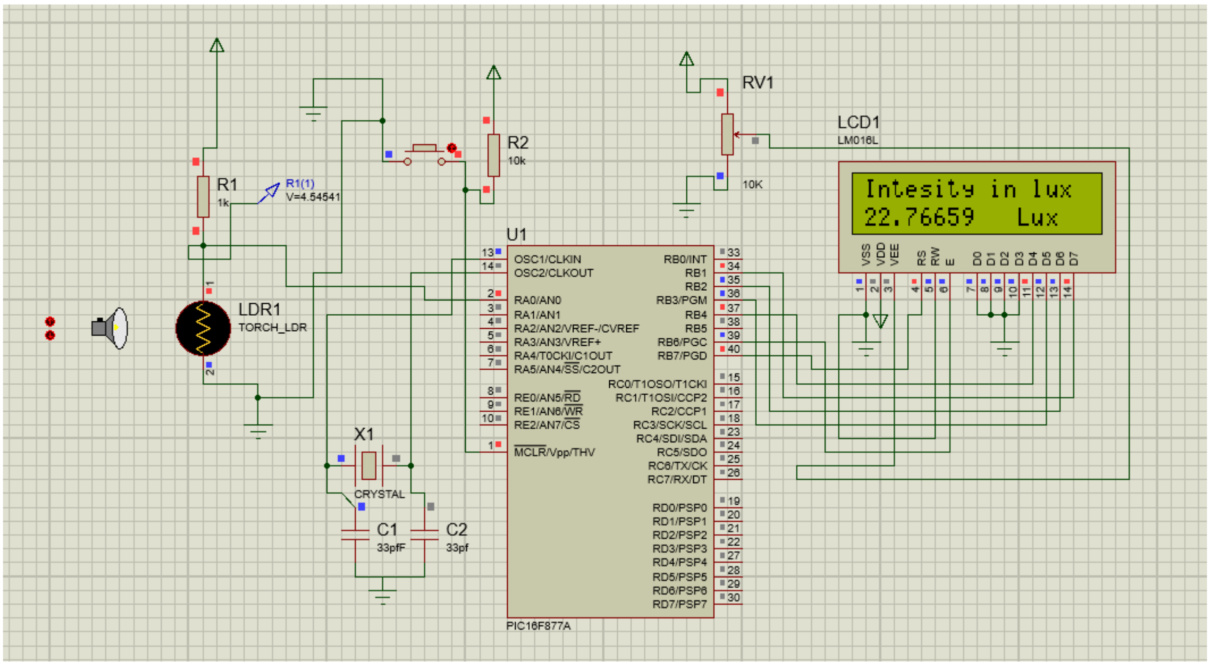

Figure 2.12: proteus simulation

Due to missing of phototransistor in proteus 8.0 we have used LDR in the proteus simulation and have found our output using our code and hex file

Chapter 3

PCB layout

Most contemporary electronic gadgets are built from the ground up using printed circuit boards (PCB). PCB stands for printed circuit board. It is an insulation sheet, such as one made of fibreglass,containing a printed or etched metallic circuit or track relates to electrical conductivity. For the PCB design, we have used Proteus to draw the connection diagram .Here we have connected the components in a method that the design must be easy to analysis and the proper distribution of component throughout the board. **Circuit simulation diagram**

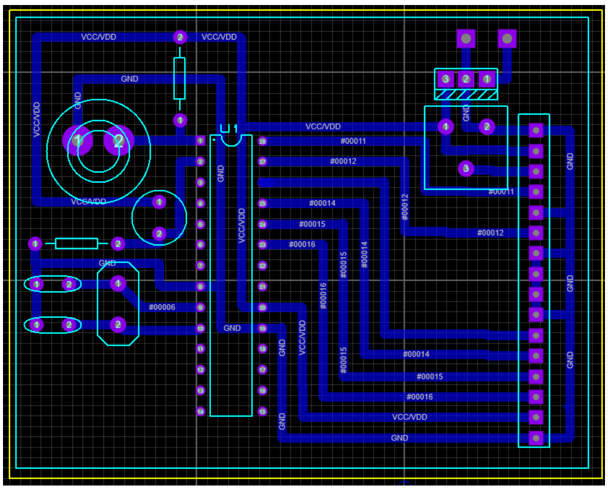

Figure 3.1: PCB layout

Chapter 4

Breadboard Implementation

graphicx In this project,for breadboard implementation Follow these instructions to measure light intensity with a photo transistor, show the findings on a 16x2 LCD, and interface with a PIC16F73 microcontroller:

Components required:

1.Photo transistor (component that responds to light)

2.PIC16F73 microcontroller (or any other PIC microcontroller comparable)

3.LCD module with 16x2 resolution and an HD44780 controller

4.Jumper wires with a breadboard

5.Optional resistors (for voltage divider circuit)

6.10k potentiometer.

7.voltage converter.

Here's a quick rundown of the connections:

Connect the power supply as follows:

1.Connect the PIC16F73's VCC(20 number pin) and GND(19 number pin) to the breadboard's power rails.

2.Connect the 16x2 LCD module's VCC(A pin and vdd pin) and GND(1 number pin,Rw pin,D0-D3 pin and K pin) to the breadboard's power rails.

3.connect the potentiometers left side pin to Vcc and right pin to the ground.

4.connect the voltage converters middile pin to GND and left pin to the breadboard's power rails and right pin to the 9V battery supply.

Connect the LCD to the PIC16F877A as follows:

1.Connect the LCD's RS(RB7/PGD pin), and EN(PGC pin) pins to two different digital pins on the PIC16F73.

2.Connect the LCD's D4-D7 pins(RB4,RB3,RB2,RB1 pin) to four distinct digital pins on the PIC16F877A.

3.Connect the VSS and VDD pins of the LCD to ground and VCC, respectively.

4.To change the contrast (brightness) of the LCD, connect its VEE pin to a variable resistor (potentiometer) or a fixed resistor divider circuit.

5.Connect the A and K pins of the LCD to VCC and GND, respectively.

Connect the photo transistor as follows:

1.Connect the photo transistor's collector to the breadboard's VCC (5V).

2.Connect the photo transistor's emitter to the PIC16F73 's RA0 pin and current-limiting resistor (2k ohm) and then to the breadboard's ground (GND).

Write the following code for the PIC16F73:

1.Set up the required digital pins as inputs and outputs.

2.Configure the ADC (Analog-to-Digital Converter) module to read the photo transistor's analog input.

3.Convert the ADC data to the corresponding levels of light intensity.

4.Using the proper LCD commands, display the light intensity on the LCD.

Please keep in mind that the particular pin connections and code may differ depending on the photo transistor model, LCD module, and desired method of obtaining the analog value. It need to make changes to the connections and code. Consider including adequate delays in the code to allow for correct readings and LCD display.

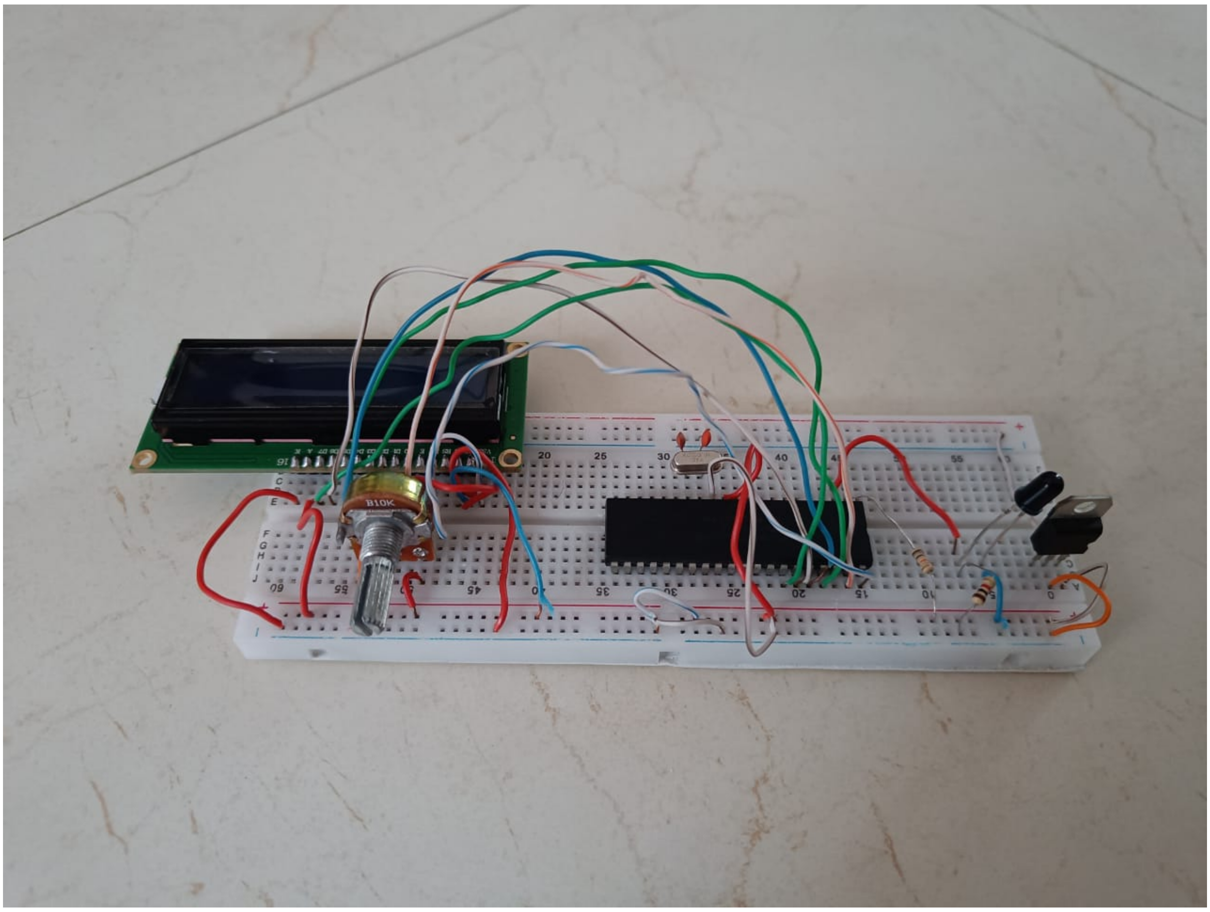

Figure 4.1: breadboard implementation

Chapter 5

PCB Implementation

There are many steps for implement the circuit design in the PCB board.They are given below-

- Schematic Design:

  Create a schematic diagram of your circuit using electronic design automation (EDA) software like Eagle, KiCad, Altium Designer, or others. Add components, connect them using nets, and define their properties.

- Component Selection:

  Choose appropriate components based on their specifications, availability, and compatibility with your design requirements. PCB Footprint Design:

- Create or select PCB footprints for each component. Footprints define the physical layout of the component's pins and pads on the PCB.

- Placement: Arrange components on the PCB layout, considering factors like signal integrity, thermal management, and ease of manufacturing. Group components based on their functionalities and connectivity.

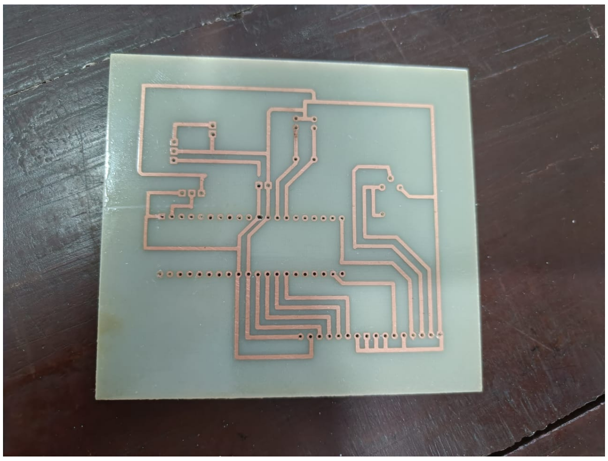

Figure 5.1: PCB board after implementation of the print

For placing the footprint in the board we have to do some steps and we need some components .like-

- PCB board
- Fecl3 (Ferric chloride)
- Heating Item
- Drill bit and drill machine
- soldering machine

STEPS OF IMPLEMENTATION OF PCB FOOTPRINT IN THE BOARD

1.Firstly we have to implement our PCB layout design in a laser glossy paper by using a laser printer

2.we have to attach the design in to the PCB board by masking tape and provide heat and pressure to transfer the design in the board . After doing this

3.After perfectly transferring the design in the board,we have to check weather the design has placed perfectly ,if any line is blurry we have used permanent maker.

4.After this we have to transfer the board in Fecl3 liquid so that other part of the board neutralized the copper without the lines

5. Now we have to do drill to place the components in board and finally by doing soldering we finally placed the components in the board

6. Finally we connected all components on the board and connecting the battery we fulfilled our desire project.

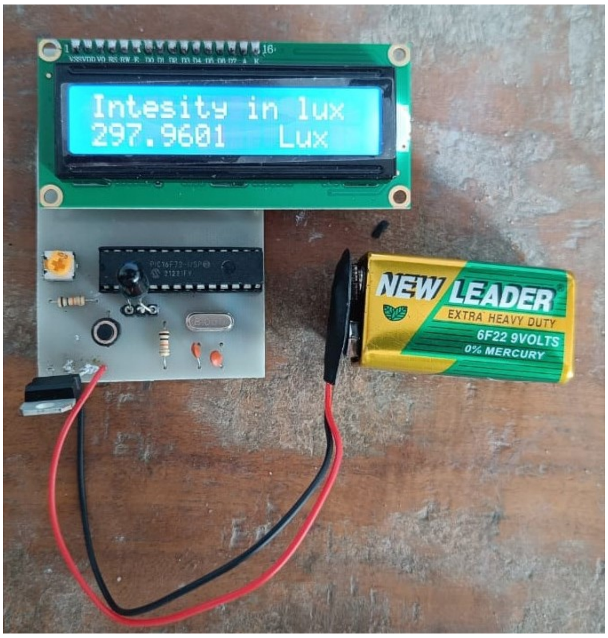

Figure 5.2: Final PCB board Implementation

Chapter 6

Price Table

Table 6.1: Price list of Components

Serial no.	Components name	Price
01	BreadBoard	150
02	PIC16F73	180
03	Phototransistor	10
04	Voltage Regulator	15
05	10k and 2k resistor	20
06	22pf Crystal Capaitor	20
07	Crystal OscillatOr	10
08	16*2 LCD display	250
09	10k PotentiOmeter	18
10	9V battery	110
11	PCB board	80
12	Connecting wire	20
13	Female port	20
	Total Price	903

Chapter 7

Future Improvement

Recent research interest in organic field-effect transistor (FET) memory has switched to photoprogramming capabilities due to its potential applications in multibit data store and light-assisted encryption, as well as its low energy consumption and broad response to many optical bands. Phototransistor memory may be modified by electrical stress as well as light illumination, allowing it to operate as an orthogonal operating technique without mutual interference.

The following sections introduce the fundamental design concepts, requirements, and architectures of phototransistor memory. Channel-only, channel-with-photogate, photochromatic channel devices and floating gate, photoactive polymer, and organic molecule-based electrets are all classified systematically. The operating mechanism and impact of effective channel and electret combinations are explored in order to provide a fundamental understanding of photoprogramming and its prospective future development applications as nonvolatile memory. Recent breakthroughs in phototransistors and their numerous applications, such as nonvolatile memory, artificial synapses, and photodetectors, are also summarized. Finally, the future development of phototransistors is reviewed briefly. A complete overview of current advances in phototransistors is offered.

Here some potential future improvements for projects involving the measurement of light intensity using phototransistors. Here are some possible areas of improvement:

Higher Sensitivity Phototransistors: Research and development might lead to the creation of phototransistors with even higher sensitivity to light. This would allow for more accurate and precise measurements of light intensity, especially in low-light conditions.

Wider Spectral Range: Phototransistors are often designed to be sensitive to a specific range of wavelengths. Future improvements could involve expanding this spectral range to cover a broader portion of the electromagnetic spectrum, enabling the measurement of light in different ranges, including ultraviolet or infrared.

Reduced Noise and Interference: Advancements in materials and manufacturing techniques might lead to phototransistors with reduced noise levels and improved immunity to external interference. This would enhance the signal-to-noise ratio and result in more accurate measurements.

Miniaturization: Continued miniaturization of electronics could lead to even smaller phototransistors, allowing for integration into smaller and more compact devices while maintaining their functionality.

Power Efficiency: Future improvements could focus on designing phototransistors that consume less power while still providing accurate measurements. This would be beneficial for applications where power conservation is crucial.

Integration with IoT and Wireless Technologies: Phototransistor-based light intensity measurements could be integrated with Internet of Things (IoT) devices and wireless communication technologies. This would enable remote monitoring and control of light levels in various applications.

Advanced Calibration and Compensation Techniques: Developing better calibration and compensation techniques could enhance the accuracy of measurements. This could involve software algorithms that correct for variations in phototransistor performance due to temperature changes or other environmental factors.

Enhanced Data Processing and Analysis: As computing power increases, future projects could involve more sophisticated data processing and analysis techniques. This could lead to real-time adjustments based on the measured light intensity, enabling more responsive systems.

Multifunctional Devices: Phototransistors could be integrated into multifunctional sensor devices that measure not only light intensity but also other environmental parameters such as temperature, humidity, and gas levels. This integration would provide a more comprehensive picture of the surroundings.

Application-Specific Designs: Phototransistors could be optimized for specific applications, such as medical devices, agriculture, automotive systems, or industrial automation. Tailoring the design to the requirements of each application could lead to more efficient and accurate measurements.

Remember that these potential improvements are speculative and based on trends in technology development. To get the most up-to-date information, I recommend checking recent research articles, industry publications, and technology news sources

Chapter 8

Conclusion

With the help of an PIC16F73 microcontroller, this project proposes and discusses an effective light meter implementation. The features of this microcontroller allow for the interfacing and implementation of this digital luxmeter design. The suggested system employs an ADC module to digitally transform analog phototransistor sensor signals. Last but not least, LCD displays the numerical values when there are sunlight falling on the phototransistor sensor.

Chapter 9

Plagiarism Declaration

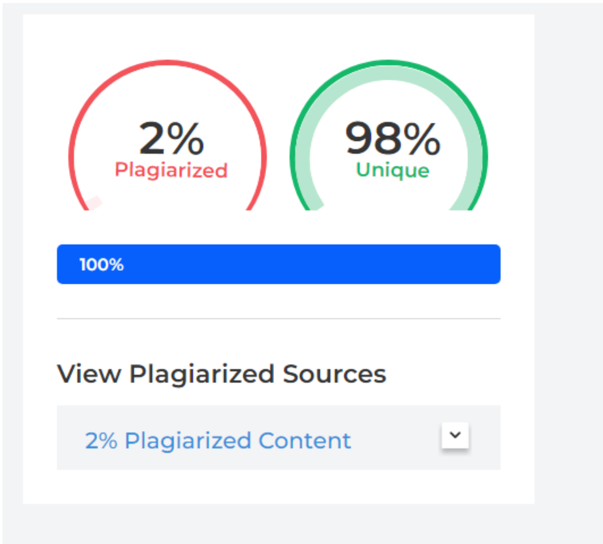

Figure 9.1: Plagiarism Detection

With the exception of any statement to the contrary, all the material presented in this report is the result of my our efforts. In addition, we also take help of the different paper which we mention in reference.We have checked our content plagiarism by using 'Plagiarism detector' website and found that there is almost 2 percent plagiarism.

References

[1] murtylight,LIGHT INTENSITY MONITORING SYSTEM USING RASBERRY PI,MURTY, YALLA RAMANA and PRASANTH, KAMIDI and PEETHALA, SWAPNA KUMARI and PALLAVI, GUDDATI

[2] Recent advances in organic phototransistors: nonvolatile memory, artificial synapses, and photodetectors, Lin, Yan-Cheng and Yang, Wei-Chen and Chiang, Yun-Chi and Chen, Wen-Chang, Small Science[journal], 2[volume], 4[no], 2100109[page], 2022[year], Wiley Online Library[publisher]

[3] Efficient LuxMeter Design Using TM4C123 Microcontroller with Motion Detection Application — IEEE Conference Publication — IEEE Xplore