

Reflectivity Measurement of Materials

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ABSTRACT

Reflectance of the surface of a material is its effectiveness in reflecting radiant energy. It is the fraction of incident electromagnetic power that is reflected at an interface. Reflectivity is an optical property of material, which describes how much light is reflected from the material in relation to an amount of light incident on the material. The reflection occurs always on the surface of the material, for the translucent materials also in the volume of the material. Reflectivity is a natural phenomenon which can be exploited in several ways to benefit mankind. In such potential applications, the measurement of intensity of electromagnetic radiation reflected by any given surface is of considerable importance to many branches of engineering. We use a source and a sensor here to measure reflectivity of different materials by bouncing the light off the material which is being tested.

Keywords: Reflection measurement, reflectivity, optical property, light shelf, materials reflection, coating, light source, BH1750FVI.

1. INTRODUCTION

The main aim of this project is to measure the reflectivity of any given material. For measuring incident intensity of light, we use a reference material, a mirror of 92% reflectivity. We assume that value to be a constant and compare with the values of light reflected from the material to get relative reflectivity of the material being tested.

2. BASIC MODEL OF THE SYSTEM

➤ Materials Used:-

1. Light source
2. BH1750 light sensor
3. Arduino uno
4. Wooden box (20* 20* 20cm)

5. Reference mirror (10*10cm)
6. Material to be tested (10*10cm)
7. Motor to rotate source

2.1 Light Source

Here we use a torch of 5cm diameter to act as a source. The torch emits white light as it has an LED inside. LEDs have a lifespan of up to 60,000 hours compared to 1,500 hours for incandescent bulbs. LED lights generate virtually no heat therefore they are cool to the touch.

2.2 BH 1750 sensor

BH1750FVI Is a Digital Light sensor, which is a digital Ambient Light Sensor IC for I2C bus interface. It is the most suitable to obtain the ambient light data for adjusting LCD and Keypad backlight power of Mobile phone. It is possible to detect wide range at High resolution.

2.3 Arduino uno

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

2.4 Wooden box

It is of 20*20*20 cm dimensions, made of 12mm plywood. It contains a holder to place the mirror or material. The entire box is blackened on the inside so no light enters from outside. The box is closed on all sides. It can be opened on the top, to replace the reference mirror with surface to be tested into the holder and then closed.

2.5 Reference mirror

A mirror with 92% reflectivity is chosen as the mirror loses 4% of its intensity on entering the mirror, and another 4%, on exiting the mirror. It is used to measure incident intensity.

2.6 Material to be tested

We can use any reflective material as the surface to be tested. It has to be 10*10 cm dimension.

2.7 Motor

A DC motor is used to control the rotation of the source. It moves in clockwise and in anticlockwise direction. It is interfaced with the Arduino board and a relay module to control its movement with the help of codes in Arduino.

3. IMPLEMENTATION

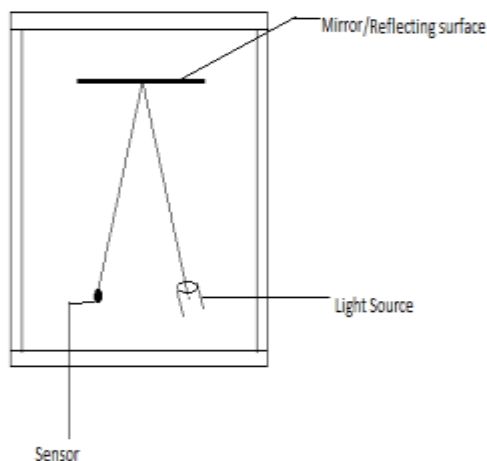


Fig 1: Basic setup

The source is mounted on the shaft of the motor and rotates on the vertical axis. The distance between the mirror and source is kept at least 6 cm to get good values of readings. The source and sensor are kept 4 cm apart from the centre, so that the light from source does not fall directly on the sensor.

The motor is rotated from the starting point to a degree of 40° and the readings are observed in the laptop when the Arduino is connected. Now the box

is opened and the reference mirror is replaced with the material whose reflectivity is unknown. Now repeat the experiment after closing the box. It should be observed that, when source is turned off, and box closed, the reading shown by the sensor must be 0 lux. (SI unit of luminance).

4. PROCEDURE

Place the reference mirror (blue mirror) on the holder and trigger all external circuits. The maximum magnitude obtained from the light sensor corresponds to the reflected intensity of light from the reference material. The reference mirror is removed from the setup and the material with unknown reflectivity is placed inside the system. Using the same procedure (as stated above), the reflected intensity of the unknown material is measured

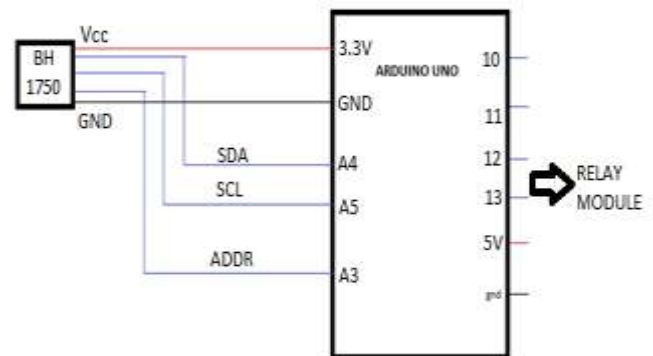


Fig 2: Connections

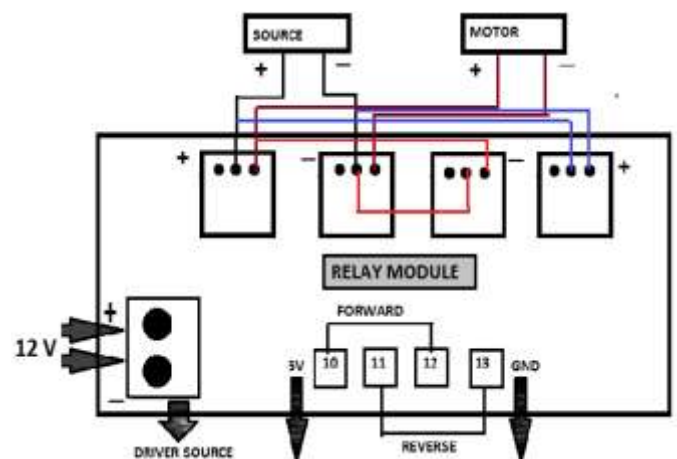


Fig 3: Relay module

Table 1. Reflected intensity from reference mirror

☺	
☺	
Light: 3581 lx	Light: 2915 lx
Light: 3581 lx	Light: 1735 lx
Light: 3581 lx	Light: 1735 lx
Light: 3581 lx	Light: 1735 lx
Light: 3581 lx	Light: 1735 lx
Light: 3581 lx	Light: 1735 lx
Light: 3581 lx	Light: 1735 lx
Light: 3579 lx	Light: 1735 lx
Light: 3579 lx	Light: 1754 lx
Light: 3579 lx	—
Light: 3579 lx	—
Light: 3579 lx	—
Light: 3579 lx	—
Light: 3579 lx	—
Light: 3579 lx	—
Light: 3575 lx	—
Light: 3575 lx	—
Light: 3575 lx	—
Light: 3575 lx	—
Light: 3575 lx	—
Light: 3575 lx	—
Light: 3575 lx	—
Light: 3575 lx	—
Light: 2915 lx	—
Light: 2915 lx	—
Light: 2915 lx	—
Light: 2915 lx	—
Light: 2915 lx	—
Light: 2915 lx	—
Light: 2915 lx	—

Table 2. Reflected intensity from blue mirror

☺	
☺	
Light: 1058 lx	Light: 1870 lx
Light: 1058 lx	Light: 1876 lx
Light: 1055 lx	Light: 1876 lx
Light: 1055 lx	Light: 1876 lx
Light: 1055 lx	Light: 1876 lx
Light: 1055 lx	Light: 1876 lx
Light: 1055 lx	Light: 1876 lx
Light: 1055 lx	Light: 1876 lx
Light: 1055 lx	Light: 1876 lx
Light: 1055 lx	Light: 1876 lx
Light: 1054 lx	—
Light: 1054 lx	—
Light: 1054 lx	—
Light: 1054 lx	—
Light: 1054 lx	—
Light: 1054 lx	—
Light: 1054 lx	—
Light: 1286 lx	—
Light: 1286 lx	—
Light: 1286 lx	—
Light: 1286 lx	—
Light: 1286 lx	—
Light: 1286 lx	—
Light: 1286 lx	—
Light: 1870 lx	—
Light: 1870 lx	—
Light: 1870 lx	—
Light: 1870 lx	—
Light: 1870 lx	—
Light: 1870 lx	—
Light: 1870 lx	—

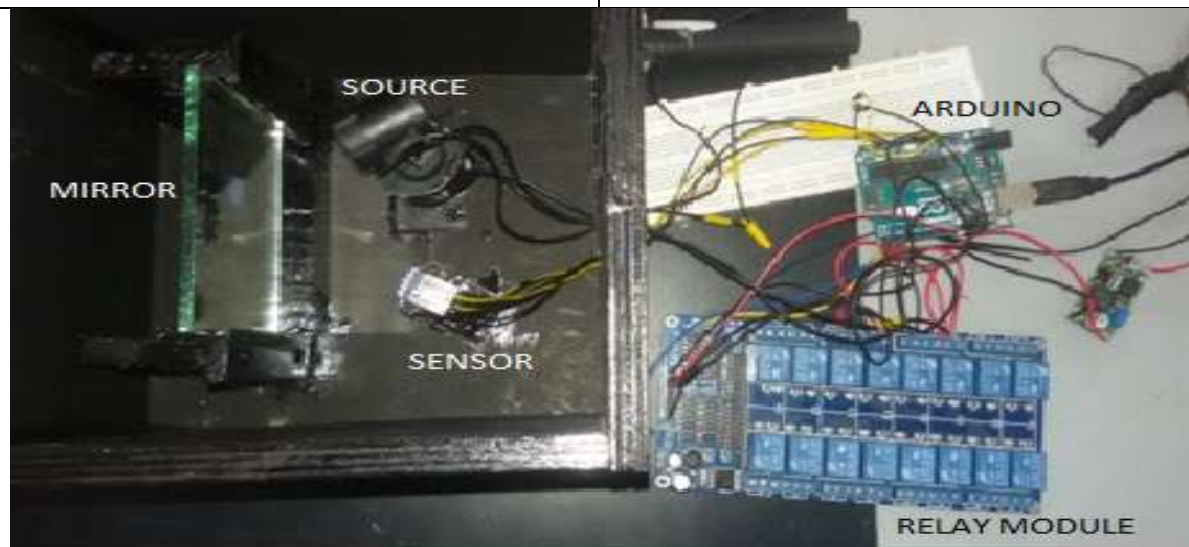


Fig 4: Experimental setup

5. CODING

```

#include <Wire.h>
#include <BH1750FVI.h>
BH1750FVI lightMeter;
int led=13;
int led2=12;
int led3=11;
int led4=10;
void setup()
{
  Serial.begin(9600);
  lightMeter.begin();
  lightMeter.SetAddress(Device_Address_L);

  lightMeter.SetMode(Continuous_H_resolution_Mode
);
  Serial.println("Light sensed...");

  pinMode(led,OUTPUT);
  pinMode(led2,OUTPUT);
  pinMode(led3,OUTPUT);
  pinMode(led4,OUTPUT);
}

void stepone()
{
  digitalWrite(led,HIGH);
  digitalWrite(led2,LOW);
  digitalWrite(led3,HIGH);
  digitalWrite(led4,LOW);
  delay(20);
  for (int k=0;k<4;k++){
    uint16_tlux= lightMeter.GetLightIntensity();
    Serial.print("Light: ");
    Serial.print(lux); Serial.println(" lx");
    delay(10);
  }
  digitalWrite(led,LOW);
  digitalWrite(led2,LOW);
  digitalWrite(led3,LOW);
  digitalWrite(led4,LOW);
  for (int n=0;n<4;n++){
    uint16_tlux= lightMeter.GetLightIntensity();
    Serial.print("Light: ");
    Serial.print(lux);
    delay(10);
  }
}

void loop() {
  for (int i=0;i<150;i++)
  stepone();
  for(int j=0;j<150;j++)
  steptwo();
}

for (int l=0;l<4;l++){
  uint16_tlux= lightMeter.GetLightIntensity();
  Serial.print("Light: ");
  Serial.print(lux);
  delay(10);
}}

void steptwo(){
  digitalWrite(led,LOW);
  digitalWrite(led2,HIGH);
  digitalWrite(led3,LOW);
  digitalWrite(led4,HIGH);
  delay(20);
  for (int m=0;m<4;m++){
    uint16_tlux= lightMeter.GetLightIntensity();
    Serial.print("Light: ");
    Serial.print(lux); Serial.println(" lx");
    delay(10);
  }
  digitalWrite(led,LOW);
  digitalWrite(led2,LOW);
  digitalWrite(led3,LOW);
  digitalWrite(led4,LOW);
  for (int n=0;n<4;n++){
    uint16_tlux= lightMeter.GetLightIntensity();
    Serial.print("Light: ");
    Serial.print(lux);
    delay(10);
  }
}

```

6. INFERENCE

As seen from the readings ,the plain mirror of 92% reflectivity has higher value of lux, because it reflects light much more than the blue mirror, which is the material being tested here, which reflects light less than the plain mirror. We can assume the lux value of the plain mirror to be a constant and compare the reflective values of other materials with it. The lux value keeps changing as the source is continuously rotating on the motor.

7. APPLICATION

This method can also be used for calculating reflectivity of a surface with a Infra-Red radiation source and an IR sensor in order to measure the reflectivity of IR of any given reflecting / partially reflecting surfaces. By measuring the reflectivity of materials, we can use these for other experiments like light shelf etc. Light shelf is a project where an aluminum sheet is placed outside the window of a building. As the sun's rays hit the sheet, it illuminates the room inside as the sheet is tilted at an angle.

8. ACKNOWLEDGEMENT

This was done as an IIT Madras Winter project under Prof. Benny Raphael of the Civil Department.

9. REFERENCES

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