CONSTRUCTION AND DATA ACQUISITION OF UV RADIATION METER

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Abstract

The ML8511 UV sensor detects 280 nm – 390 nm light, this wavelength is categorized as part of the UVB-burning rays spectrum and most of the UVA-tanning rays spectrum. The sensor ML8511 has a UV photodiode and internal amplifier which will converts photo current to voltage output depending on the UV light intensity. UV intensity is directly proportional to output voltage so that the program is written according to their relation. The UV intensity in mW/cm^2 is displayed on LCD which is processed by Arduino microcontroller. At the same time, data are sent to the Microsoft (MS) excel spreadsheet via parallex data acquisition (PLX-DAQ) software. Data accompanying with current date and time are uploaded directly from Arduino to MS excel spreadsheet.

Keywords: UV sensor, data acquisition, Excel

Introduction

Ultra violet (UV) index is the one of the important factor for health and environment. Ultraviolet or UV light is filtered to a large degree by the Earth's Ozone layer, a protective layer of gas in the upper atmosphere that absorbs UV radiation. But the ozone layer is not a perfect filter and as a consequence some of the UV makes it through. Too much exposure to UV light can cause serious health problems ranging from burns to skin cancer. Cost effective UV meter can be constructed by using microcontroller and UV sensor. And then, these data are directly transferring to the Microsoft (MS) Excel spreadsheet by using parallax-data acquisition (PLX-DAQ) software.

Background Theory

Ultraviolet (UV) designates a band of the electromagnetic spectrum with wavelength from 10 nm to 400 nm, shorter than that of visible light but longer than X-rays. UV radiation is present in sunlight, and contributes about 10% of the total output of the Sun. It is also produced by electric arcs and specialized lights, such as mercury-vapor lamps, tanning lamps, and black lights. Although long-wavelength ultraviolet is not considered an ionizing radiation because its photons lack the energy to ionize atoms, it can cause chemical reactions and causes many substances to glow or fluoresce. Consequently, the chemical and biological effects of UV are greater than simple heating effects, and many practical applications of UV radiation derive from its interactions with organic molecules.

Sunburn is familiar effects of over-exposure of the skin to UV, along with higher risk of skin cancer. Living things on dry land would be severely damaged by ultraviolet radiation from the Sun if most of it were not filtered out by the Earth's atmosphere. More energetic, shorter-wavelength "extreme" UV below 121 nm ionizes air so strongly that it is absorbed before it reaches the ground. Ultraviolet is also responsible for the formation of bone-strengthening vitamin D in most land vertebrates, including humans (specifically, UVB). The

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UV spectrum thus has effects both beneficial and harmful to human health.

The ultraviolet section of the electromagnetic spectrum extends from 400 nm to 100 nm, just below the X-ray section of the spectrum. It is actually divided into three sections:

UVA – This is the range from 400 nm to 315 nm. The so-called "black lights" that are used for eerie lighting effects fall into this range. UVA is not absorbed by the ozone layer.

UVB – This is the range from 315 nm to 280 nm. The lights used in tanning booths usually are in this range. Most of the Sun's UVB energy is absorbed by the ozone layer but some gets through.

UVC – This is the range from 280 nm to 100 nm. UV light in this range is used in sterilization procedures as its high energy kills bacteria. It is completely absorbed by the ozone layer and upper atmosphere.

Table 1 Electromagnetic spectrum of ultraviolet

Name	Abbreviation	Wavelength (nm)	Photon energy (eV, aJ)
Ultraviolet A	UVA	315−400	3.10−3.94(0.497−0.631)
Ultraviolet B	UVB	280−315	3.94−4.43(0.631−0.710)
Ultraviolet C	UVC	100−280	4.43−12.4(0.710−1.987)
Near ultraviolet	NUV	300−400	3.10−4.13(0.497−0.662)
Middle ultraviolet	MUV	200−300	4.13−6.20(0.662−0.993)
Far ultraviolet	FUV	122−200	6.20−10.16(0.993−1.628)
Hydrogen Lyman-alpha	H Lyman-α	121−122	10.16−10.25(1.628−1.642)
Vacuum ultraviolet	VUV	10−200	6.20−124(0.993−19.867)
Extreme ultraviolet	EUV	10−121	10.25−124(1.642−19.867)

Materials and Method

Arduino microcontroller and Ultraviolet sensor are required to construct the UV meter which displays output voltage of sensor, UV light intensity in mW/cm^2, UV index and UV level in the serial monitor and UV index and UV level on LCD. The ML8511 sensor breakout uses to measure ultraviolet light intensity. The MP8511 UV Sensor outputs an analog signal in relation to the amount of UV light it detects. This can be handy in creating devices that warn the user of sunburn or detect the UV index as it relates to weather conditions. This sensor detects 280 nm - 390 nm light most effectively. This is categorized as part of the UVB (burning rays) spectrum and most of the UVA (tanning rays) spectrum.

ML 8511 UV Sensor

The ML8511 is a UV sensor, which is suitable for acquiring UV intensity indoors or outdoors. The ML8511 is equipped with an internal amplifier, which converts photo-current to voltage depending on the UV intensity. This unique feature offers an easy interface to external circuits such as ADC. In the power down mode, typical stand by current is 0.1 μA, thus enabling a longer battery life.

Its features are-

- Photodiode sensitive to UV-A and UV-B
- Embedded operational amplifier
- Analog voltage output
- Low supply current (300 μA) and low standby current (0.1 μA)
- Small and thin surface mount package

The output voltage is directly proportional to the incident UV intensity. The Figure 2(a) shows the relation of output voltage with respect to UV intensity at wavelength of 365 nm with different temperature. It has straight line characteristics. Within the temperature 75˚C and -25 ˚C, the output voltage is slightly changed. From Figure 2(b), it observes that the relative responsibility of sensor is good enough within the wavelength of 280 nm and 400 nm.

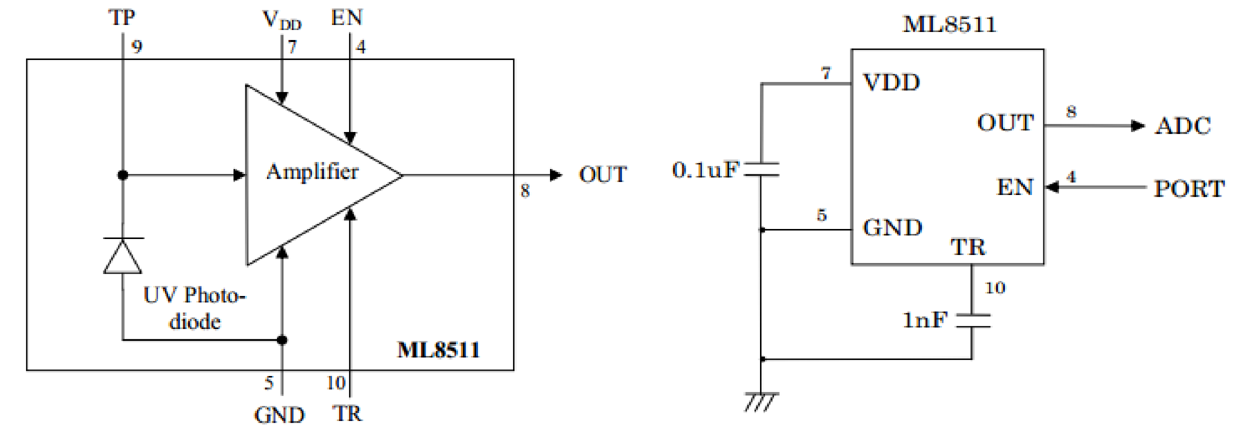
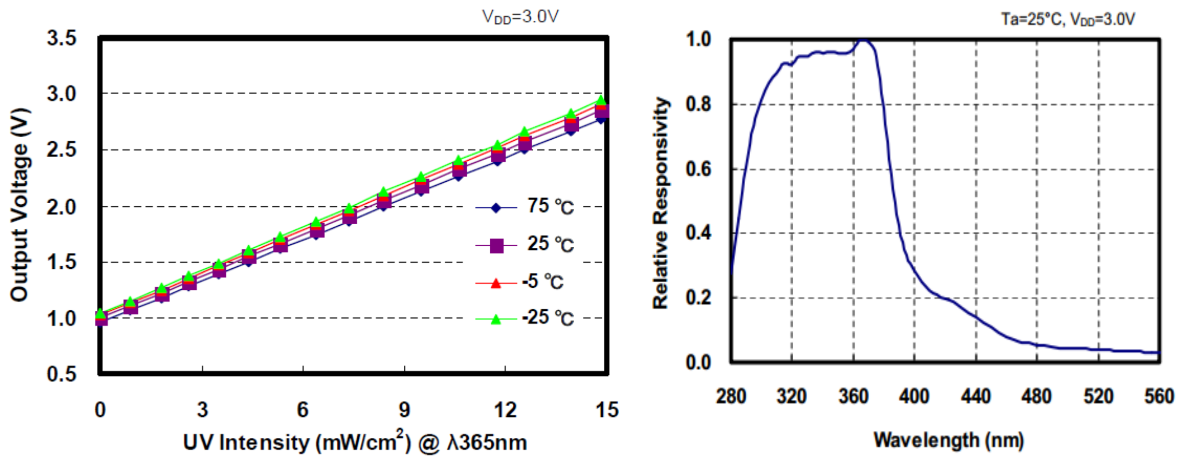


Figure 1 ML8511UV sensor and circuit connection



(a) (b)

Figure 2(a) Characteristics of ML8511UV sensor **(b)** Spectral responsibility characteristics

Parallax Data Acquisition (PLX-DAQ)

Parallax Data Acquisition tool (PLX-DAQ) software add-in for Microsoft Excel acquires up to 26 channels of data from any Parallax microcontrollers and drops the numbers into columns as they arrive. PLX-DAQ provides easy spreadsheet analysis of data collected in the field, laboratory analysis of sensors and real-time equipment monitoring.

PLX-DAQ is a Parallax microcontroller data acquisition add-on tool for Microsoft Excel. Any of microcontrollers connected to any sensor and the serial port of a PC can now send data directly into Excel. PLX-DAQ has the following features:

- Plot or graph data as it arrives in real-time using Microsoft Excel
- Record up to 26 columns of data
- Mark data with real-time (hh: mm: ss) or seconds since reset
- Read/Write any cell on a worksheet
- Read/Set any of 4 checkboxes on control the interface
- Baud rates up to 128 K

Experimental Setup

Arduino microcontroller, ML8511 UV sensor, LCD are used in construction of UV meter. For data acquisition, parallax data acquisition (PLX-DAQ) software is used. Figure 3 shows the block diagram of the construction of UV meter and data acquisition. Table 2 shows the circuit connections of Arduino with LCD and Figure 4 shows the connection between Arduino and ML8511 UV sensor. The schematic circuit diagram drawn by Proteus software is shown in Figure 5.

Table 2 The circuit connections of Arduino with LCD

Arduino	LCD
D7	RS
D6	E
D5	DB4
D4	DB5
D3	DB6
D2	DB7

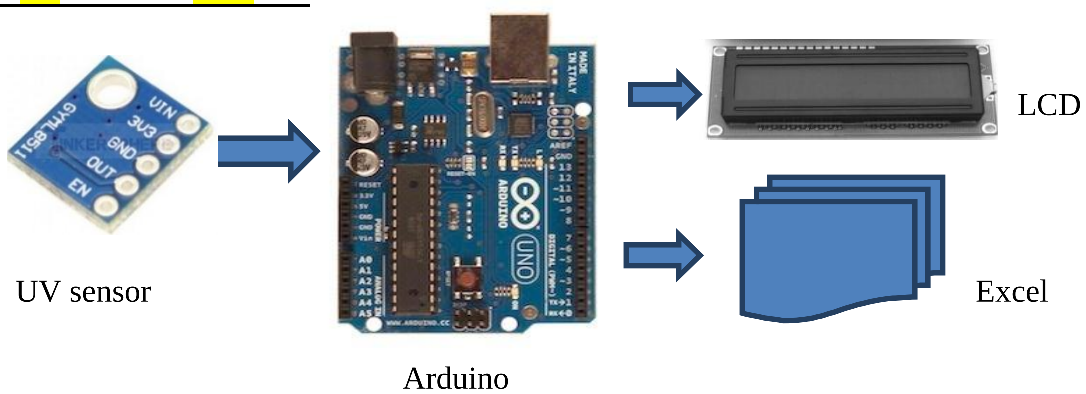


Figure 3 Block diagram of UV meter

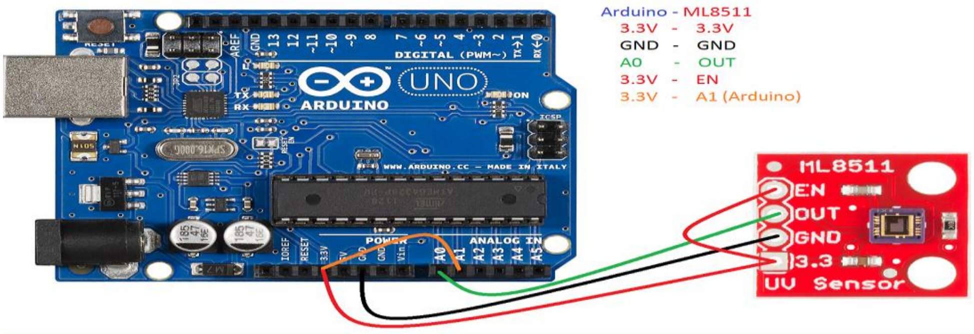


Figure 4 Circuit connections between Arduino and ML8511 UV sensor

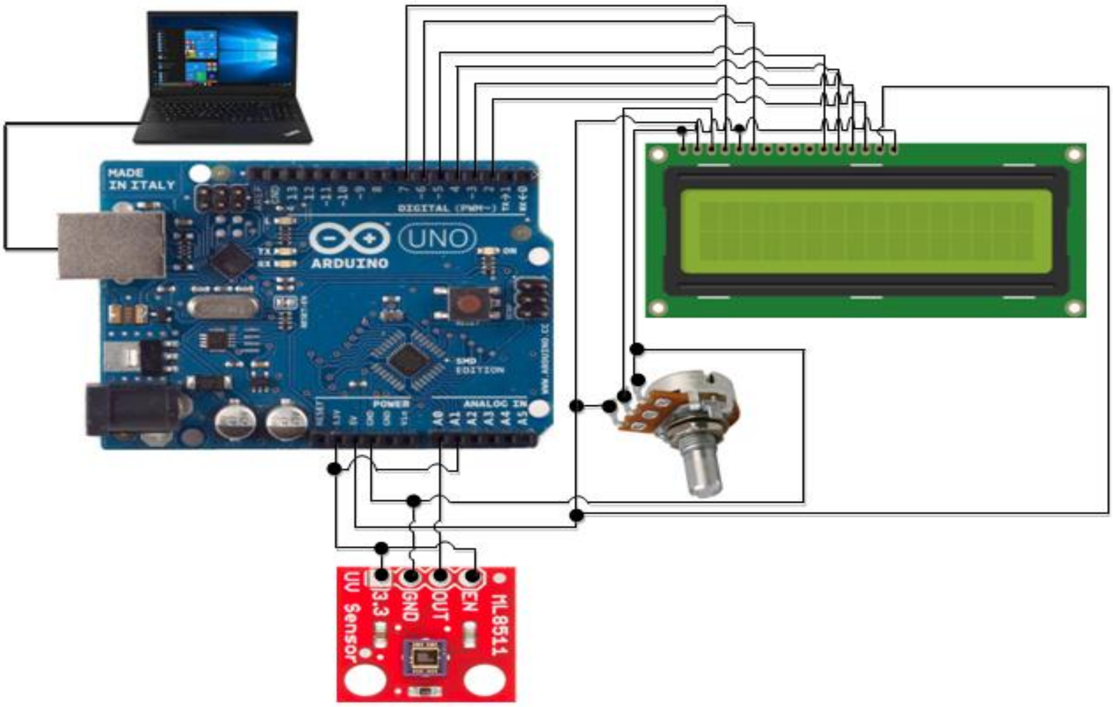


Figure 5 Schematic circuit diagram of UV meter

Operation

In the Setup routine the serial monitor is initialized at 9600 bauds. Make sure that the serial monitor on Arduino IDE is also set to the same speed, if not then change either the code or the serial monitor speed setting to make them match. The reference voltage level is selected as;

unsigned int UVOUT = A0; //Output from the sensor

intREF_3V3 = A1; //A1 is connected to 3.3V on-board power supply

The output voltage is determined as;

Unsigned int uvLevel = average Analog Read (UVOUT);

unsigned int refLevel = average Analog Read (REF_3V3);

float uvIntensity = mapfloat (output Voltage, 0.99, 2.9, 0.0, 15.0);

Dependency of UV intensity on output voltage is linearity. In the UV region voltage is varied between 0.99 V and 2.9 V. Using the map instruction, the UV intensity can be determined.

The data are processed to display on LCD as follows. The UV intensity is measured in mW/cm^2. UV level is also displayed on LCD.

The UV Index scale was developed by Canadian scientists in 1992, then adopted and standardized by the WHO in 1994. According to WHO standard, four UV levels are classified as the following program.

```
lcd.setCursor(1, 1);
lcd.print(uvIntensity);
lcd.setCursor(7, 1);
lcd.print("mW/cm^2");
lcd.setCursor(0,0);
if (uvIntensity< 3.0)
{
lcd.print("Low UV Level");
}
else if (uvIntensity>= 3 &&uvIntensity< 6)
{
lcd.print("Medium UV Level");
}
else if (uvIntensity>= 6 &&uvIntensity< 8)
{
lcd.print("High UV Level");
}
else
{
lcd.print("Extreme UV Level");
}
Serial.println();
```

Results and Discussion

In the cloudy day, the UV intensity and UV level are displayed on LCD as shown in Figure 7. This shows UV level is low. The data measured are directly transferred to excel spreadsheet and can be logged in hard drive of PC. The graph can be drawn by excel format as shown in Figure 8 and Figure 9. As the output voltage of UV sensor is directly proportional to the UV intensity the curve of output voltage and UV intensity are same but different values. It is observed clearly in the Figure 10.

Using UV touch light and sunlight, the test measurement of UV meter is observed. The data are expressed in Figure 11 (a) and Figure 11 (b). These data show that the UV meter (Figure11 (a) and Figure 11 (b)) constructed properly works.

The Figure 11 (b) shows that there are high levels of sunlight in the winter and in the summer when there are UV rays in the sun.

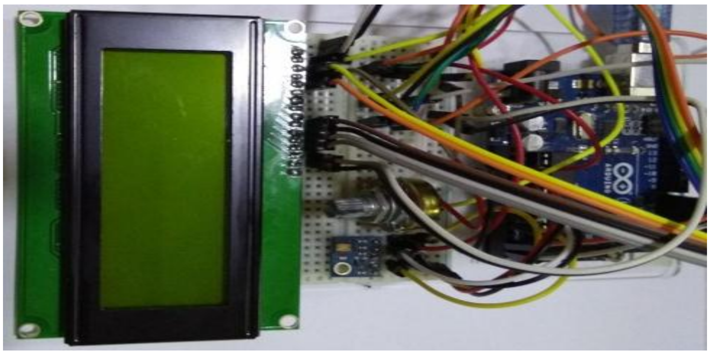


Figure 6 Experimental setup

Figure 7 UV intensity and UV level on LCD

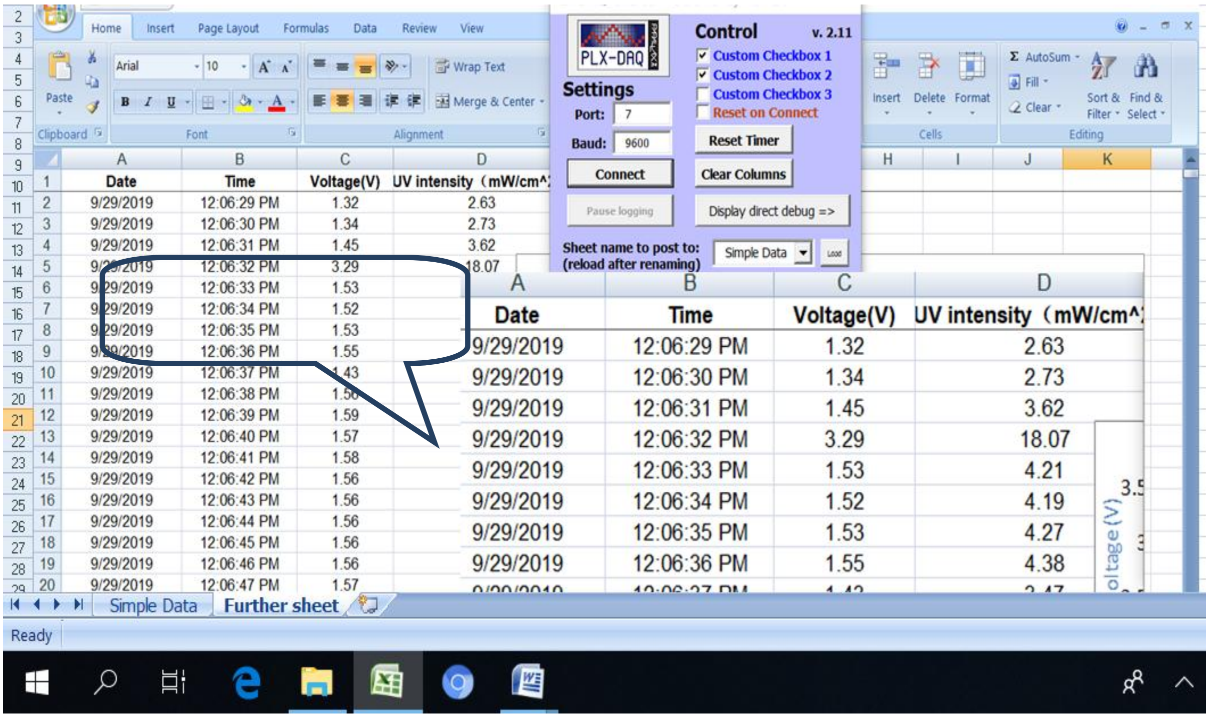


Figure 8 Data logging in excel directly

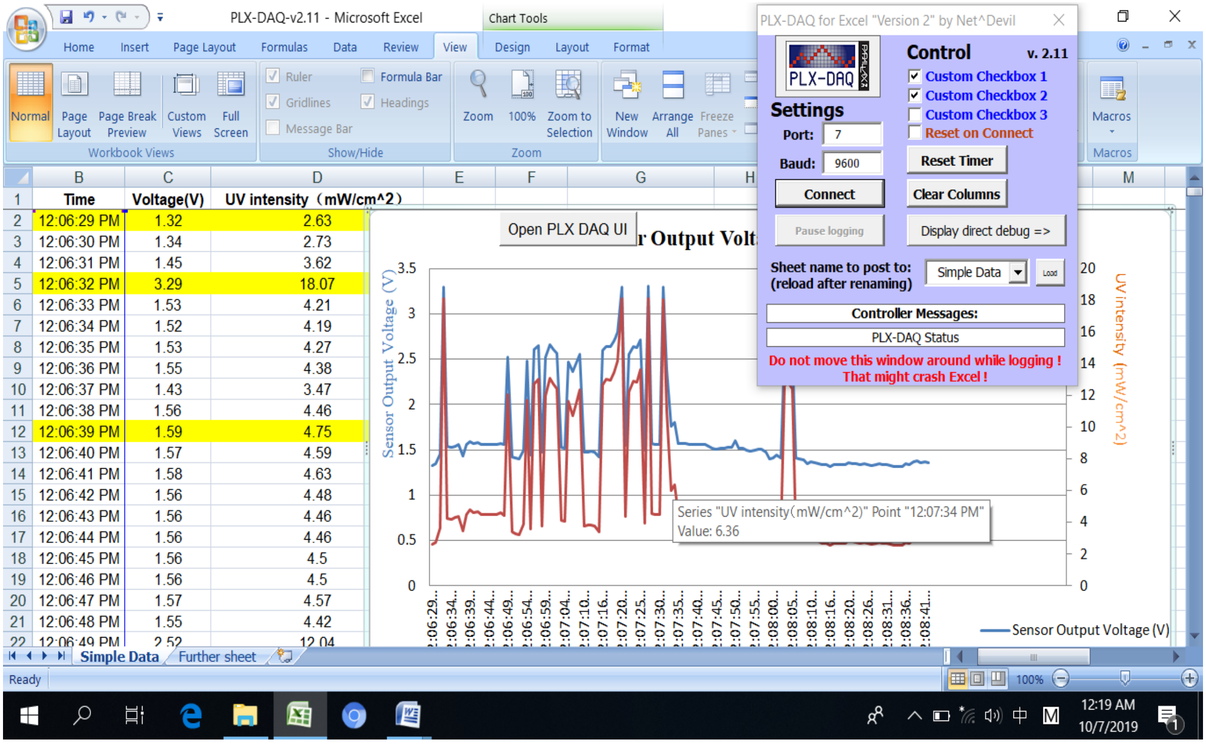


Figure 9 Graph drawn in excel

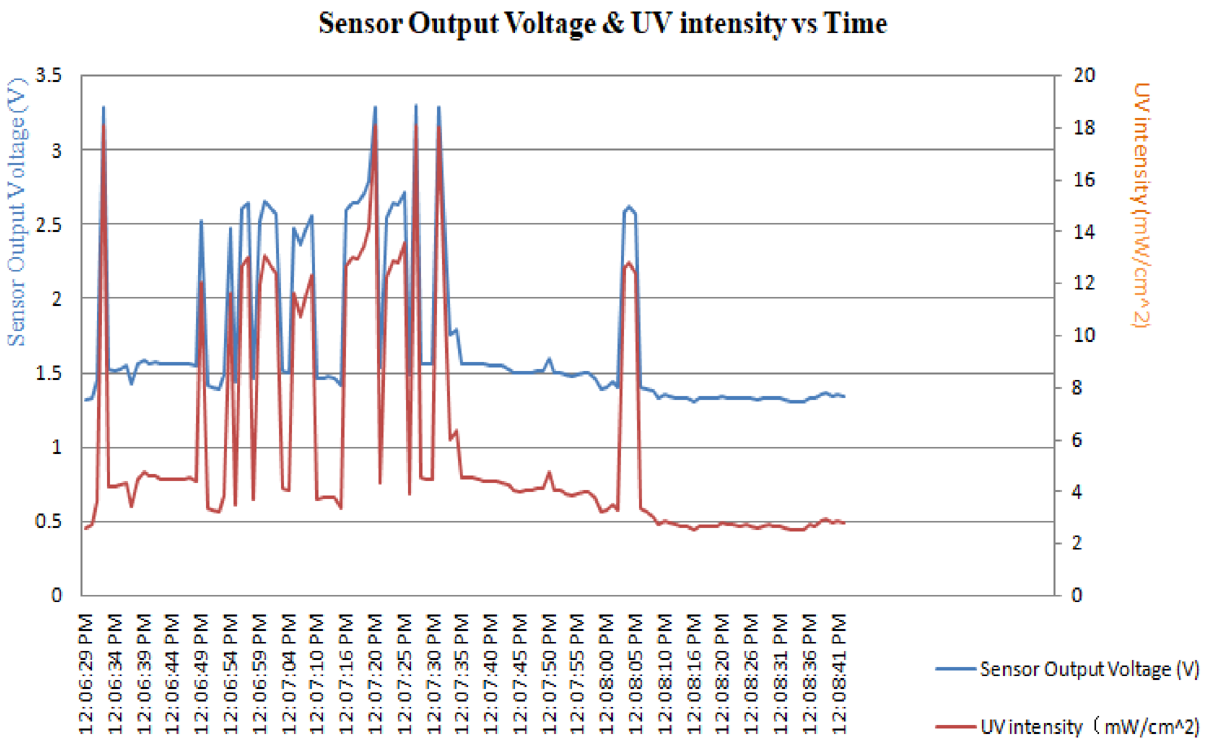
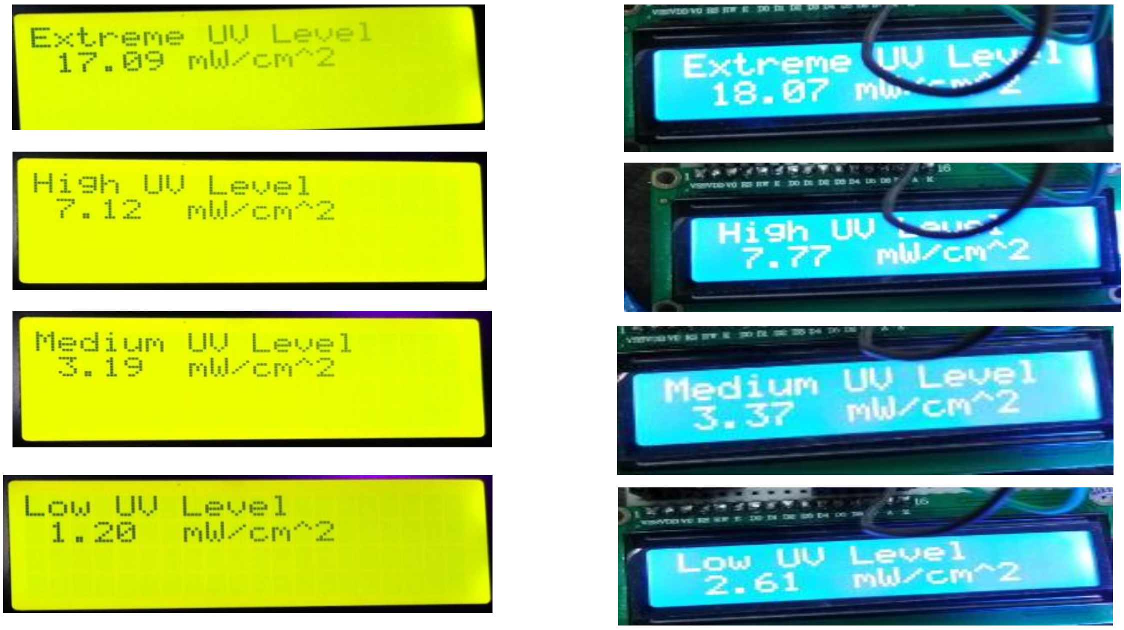


Figure 10 Graph of sensor output voltage and UV intensity



(a) (b)

Figure 11(a) UV level testing with touch light **(b)** UV level testing from sunlight

Conclusion

UV sensor which is the surface mount type package is very susceptible to heat in reflow mounting and humidity absorbed in storage. Do not press or rub the surface of the resin covering the top of the package where, which is on the UV-ray is light received. In addition, do not apply pressure at high temperature. This UV Index meter can be a valuable tool in protecting from the harmful effects of the Sun's rays.

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References

Banzi M, (2009) *Getting Started with Arduino*. U.S.A.

Boxall J, (2013) *Arduino Workshop*. San Francisco, No Starch Press.

Haigh, Joanna D, (2007) *The Sun and the Earth's Climate: Absorption of solar spectral radiation by the atmosphere*. U.S.A.

NASA Science, (2009) *Reference Solar Spectral Irradiance: Air Mass*. U.S.A.

Purdun J, (2012) *Beginning C for Arduino Apress*. New York.

Wackern M, Holick M F (2013) *Sunlight and Vitamin D*. U.S.A.