

# All Things Digital

Amateur Radio for the 21<sup>st</sup> Century

016

Robert C. Mazur, VA3ROM

E: [va3rom@gmail.com](mailto:va3rom@gmail.com)

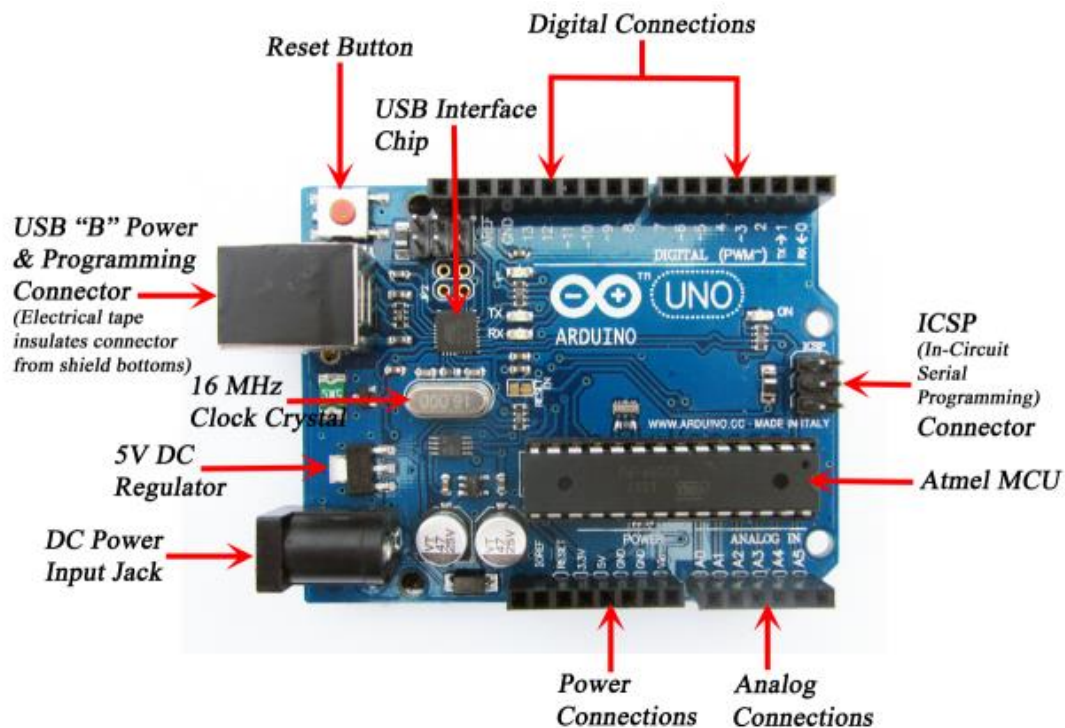
W: [www.va3rom.com](http://www.va3rom.com)



*Article first published in the Nov-Dec 2014 issue of The Canadian Amateur*

## THE ARDUINO UNO MCU: PART UNO

*Note: You may want to read my previous TCA microcontroller (MCU) articles: Nov-Dec 2012 PICAXE and Jan-Feb 2013 BASIC Stamp. MCUs are designed to interface with other devices through sensors to monitor things and through actuators to control things.*



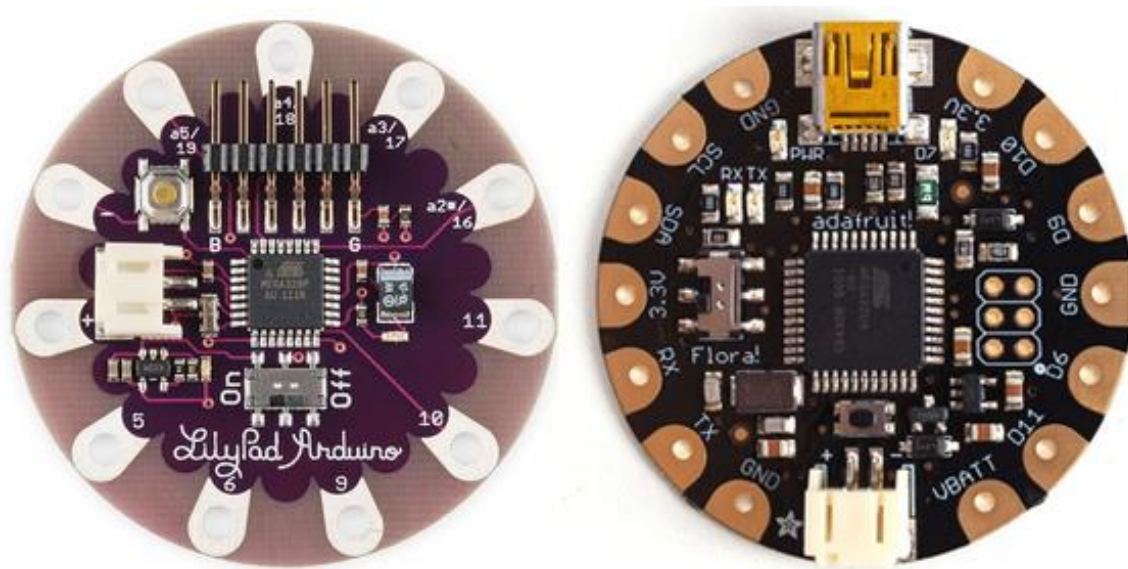
**FIGURE 1: THE ARUDINO UNO MCU**

The Arduino Uno (see Figure 1), it's "offspring" and various clones have become ubiquitous in the 2010's because of their availability, versatility, ease of use and low cost. The concept of a simple and inexpensive MCU platform created for non-technical people was developed by artist/designer Hernando Barragon in his master's thesis (2004). The next year, a development team was created in Italy (Barragon, Massimo Banzi, David Cuartielles, et al) to design and manufacture the hardware built around an Atmel microcontroller with a software integrated development environment (IDE) based on the Processing computer programming language (a C/C++ variant) which itself was created for artists/designers and why all Arduino programs are called "sketches". There's some confusion about what the name means, but the Latin phrase "est ardui no uno" meaning "it [this] is not difficult for [any] one" is my best guess.

The Arduino is based on the open source hardware/software concept whereby anyone can freely contribute to and/or use the software resources, but more importantly, anyone can develop/sell their own "duino" hardware variants without paying royalties because only the name "Arduino" and its logo are registered trademarks. And while it may be getting "ancient" as far as MCUs go, the Uno is still the most popular/cloned MCU and compatible with the older plug-in daughter boards or "shields" (Arduino term).

### **DR. L AND LADYADA**

Two extraordinary people have blazed trails for others to follow in a very male orientated and dominated industry. Massachusetts Institute of Technology (MIT) Media Lab, High-Low Technology research group director Dr. Leah Buechley created the "LilyPad" concept in her PhD dissertation (2005) whereby MCU-based components are sewn into clothing and/or other accessories (electronic textiles or e-textiles) and two years later the LilyPad Arduino (see Figure 2) entered the market.



**FIGURE 2: LILYPAD & FLORA WEARABLE E-TEXTILE MCUS**

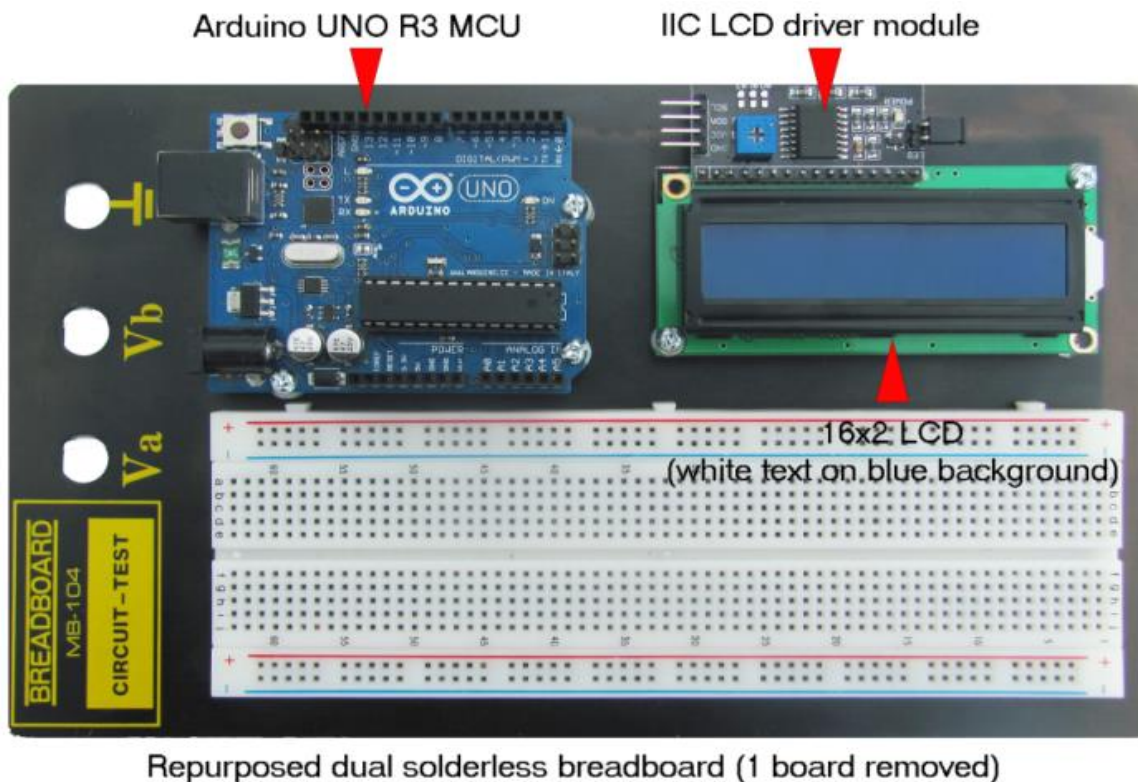
Fellow MIT graduate Limor “Ladyada” Fried started Adafruit in her dorm room (2005) and the company designs, manufacture/sells various MCU products/kits, and created its own line of e-textiles products (see Figure 2) called “FLORA” and “GEMMA” (2012). Limor is a driving force in the open source hardware community and was the first *female* engineer to be featured on the cover of *Wired* magazine (2011). “If there's one thing I'd like to see from this, it would be for some kids to say to themselves ‘I could do that’ and start the journey to becoming an engineer and entrepreneur.”

### **GETTING STARTED**

1. Highly recommended reading is *Getting Started with Arduino*.
2. Visit the Arduino website and download the free IDE (Windows, Linux or Apple) and have a look at the help topics and sketch language references.
3. If you have a good selection of electronic parts (resistors, capacitors, pushbuttons, wires, etc.) you only need the Uno board (or clone), a 16x2 liquid crystal display (LCD) with inter-integrated circuit (IIC, I<sup>2</sup>C or I2C) display driver, a solderless breadboard and assorted #22 jumper wires or DuPont connectors; a mounting plate is optional (see Figure 3).

4. Otherwise, purchase an Arduino starter kit which includes all the basic parts and tutorials/instructions to begin experimenting with MCUs.

**FIGURE 3: MY ARDUINO PROTOTYPING PLATFORM**

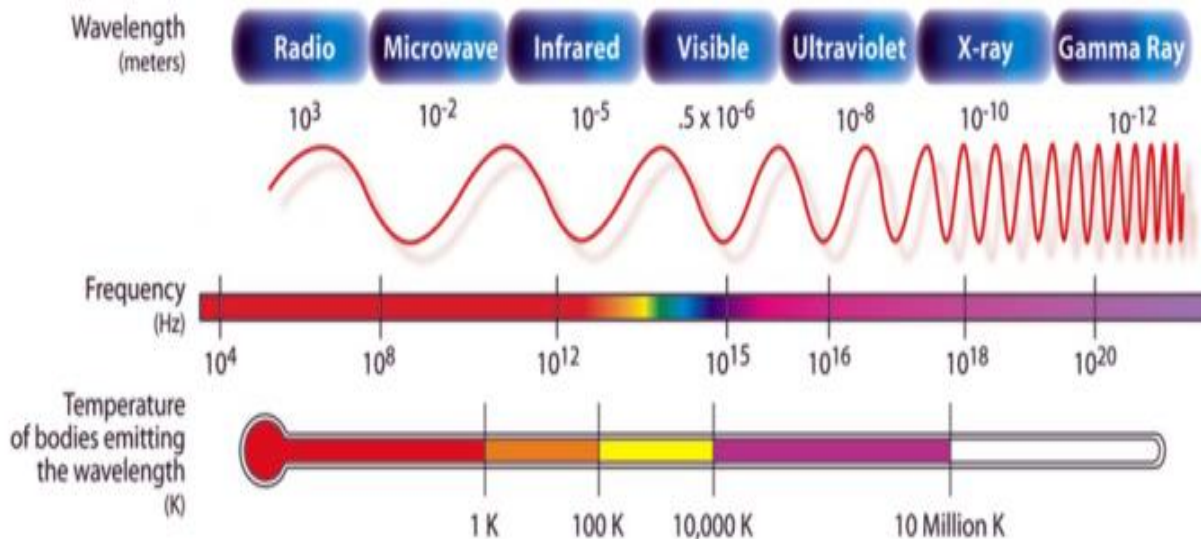


When you get an idea for a project (called a “gadget”), sketch (draw) it on paper and write a concise one-line objective sentence describing what the gadget does or is. Many “new” Arduino sketches are just modified versions of existing ones with the most commonly used/popular collected into libraries you can “include” in your own sketches, and most of the time you build gadgets using off-the-shelf components. This is a plug ‘n play rapid prototyping system designed to be very “Lego-like”—if you can think it, you can build it!

## THE LED “MIMS EFFECT”

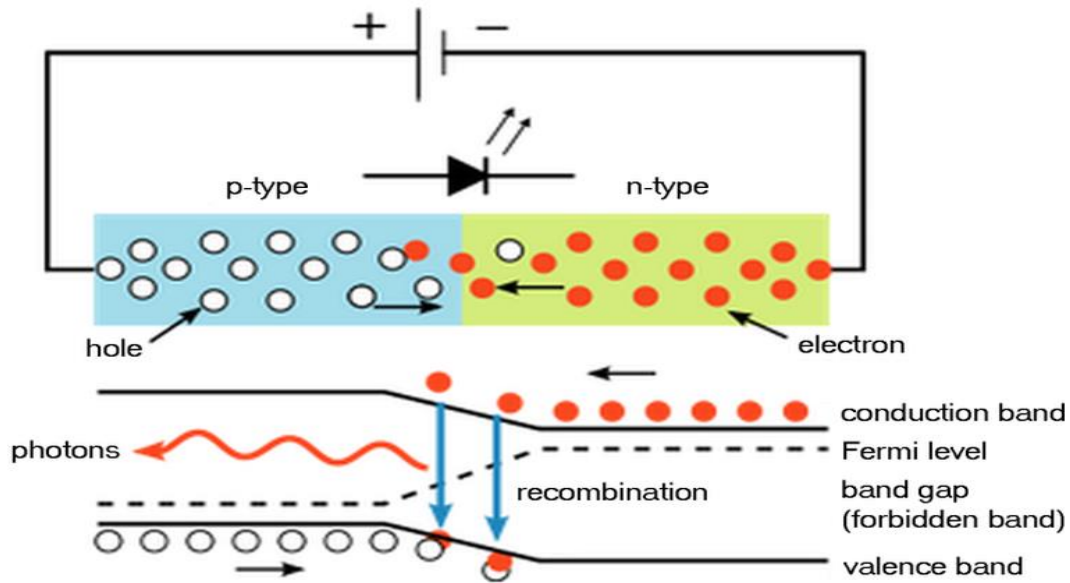
*Note: We have to sidetrack a bit to setup this MCU sketch and gadget.*

Radio waves, the invisible/visible light spectrum and various types of “radiation” are composed solely of light-speed discrete bundles (packets) of wave-particle energy called photons (Greek: phos [light]) that radiate alternating magnetic and electric fields throughout the electromagnetic (EM) spectrum (see Figure 4a). At the low-end, photons behave more wave-like and exposure is relatively safe (non-ionizing radiation) but when “juiced up” to the extreme ultraviolet (UV) and beyond, they act particle-like blasting electrons from atoms/molecules, and prolonged exposure is deadly (ionizing radiation).



**FIGURE 4A: ELECTROMAGNETIC [PHOTONIC] SPECTRUM**

In a light emitting diode (LED), energized electrons (produced by electric current) “fall” across a semi-conductor gap and recombine with electron deficient atoms called “holes” which causes them to release their kinetic energy as photon particles (electroluminescence). See Figure 4b. For the Trekkies, electrons create photonic copies or “holographic images” of themselves that carry away (or radiate) the same alternating magnetic/electric fields (data) while the electronic “originals” remain behind.

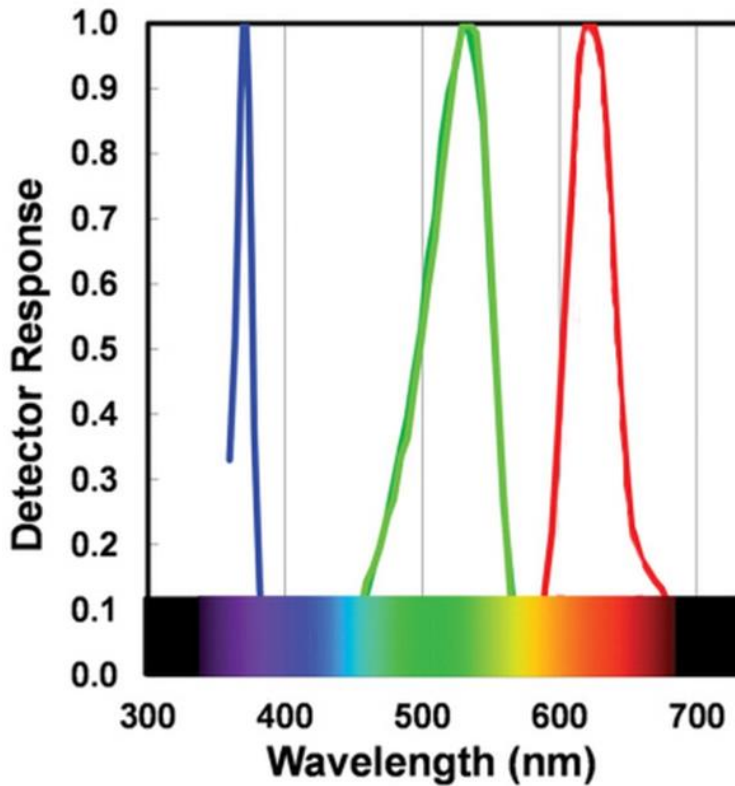


**FIGURE 4B: HOW THE LED WORKS**

When photons hit our retinas, they are absorbed by atoms transferring energy (and data) back which energizes electrons producing an electric current in the optic nerve (photoelectric effect). In 1972, Forrest Mims III (*Mims Engineer's Mini-Notebooks*) discovered that ordinary LEDs detected photons at specific frequencies/wavelengths (colours/temperatures) via the photoelectric effect and could be used to send and receive data! *Note: Colour "temperature" means the temperature (in kelvin) something would have to be heated to for it to radiate a specific colour/hue.*

A simple reciprocal relationship exists between wavelength and temperature as exists between wavelength and frequency ( $\lambda = c / f$  and  $f = c / \lambda$ ).

$$\lambda = 2.9 \times 10^6 / K \text{ and } K = 2.9 \times 10^6 / \lambda$$



**FIGURE 4C: LED SPECTRUM CURVES**

Where “ $\lambda$ ” (lamda) is wavelength in nanometres (nm), “K” is temperature in kelvin (0K = -273.15 °C or absolute zero) and “ $2.9 \times 10^6$ ” (rounded) is “Wien's displacement constant” adjusted for nanometres per kelvin (nm/K). A typical red LED emits/detects photons and peaks around 635nm (4567K) or  $474 \times 10^{12}$  Hz = 474 Terahertz (THz), green 540nm (5370K) or 568THz and blue 465nm (6237K) or 642THz (see Figure 4c) but this can vary

(+/- 20nm) or more. Photographers prefer using colour temperature while scientists prefer frequency or wavelength.

## PROJECT UNO

**Objective:** Study the LED “Mims Effect” using the Arduino Uno.

### Required:

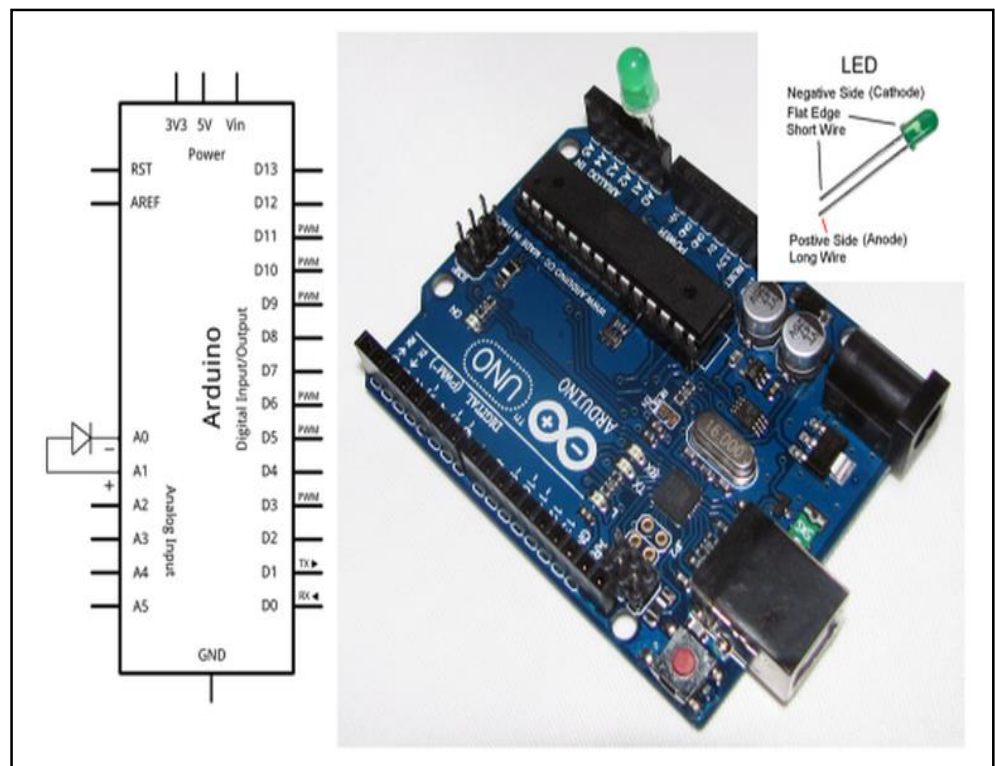
1. Installed/working copy of Arduino IDE.
2. Arduino Uno (or clone) and USB power/programming cable.
3. Green LED (3 or 5 mm diameter). Green is in the middle of the visible light spectrum and our eyes evolved to see this colour best.
4. Project sketch, logging spreadsheet and other resource material (download from my website).

### Build and Use:

1. Insert LED's negative cathode (shorter lead on "flat" side) into Uno analog input "A0" and insert positive anode (longer lead) into analog input "A1" (see Figure 5a). You've just built a simple, uncalibrated "radiometer" gadget which can measure (meter) the light spectrum (radiation) at various wavelengths depending on the LED used!
2. Connect the programming/power USB cable, run the Arduino IDE, load sketch and open Serial Monitor window (see Figure 5b).
3. Put the Uno board/computer in room or outside with indirect/diffuse sunlight during daylight hours and record data with spreadsheet (see Figure 5c). If used outside, the LED needs to "see" the overhead sky but should be shaded from direct sunlight in the shadow of your house or other structure. *Note: For outdoors use, slip a 25mm length of black heat shrink tubing (collimator) over the LED's housing to better cohere incoming photons and block any side or reflected light.*

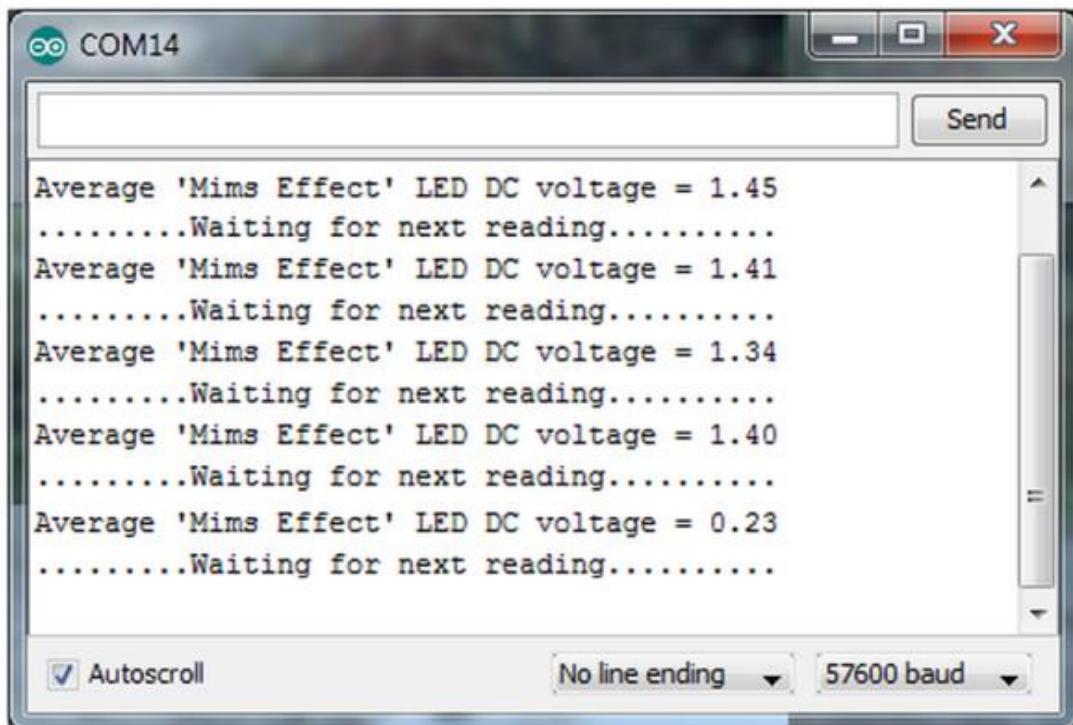
**FIGURE 5A: GADGET CONSTRUCTION**

If you have various types and colours of LEDs try each in sequence. Swap one out for another, press the Uno board reset button, record the reading then repeat the process with another LED.





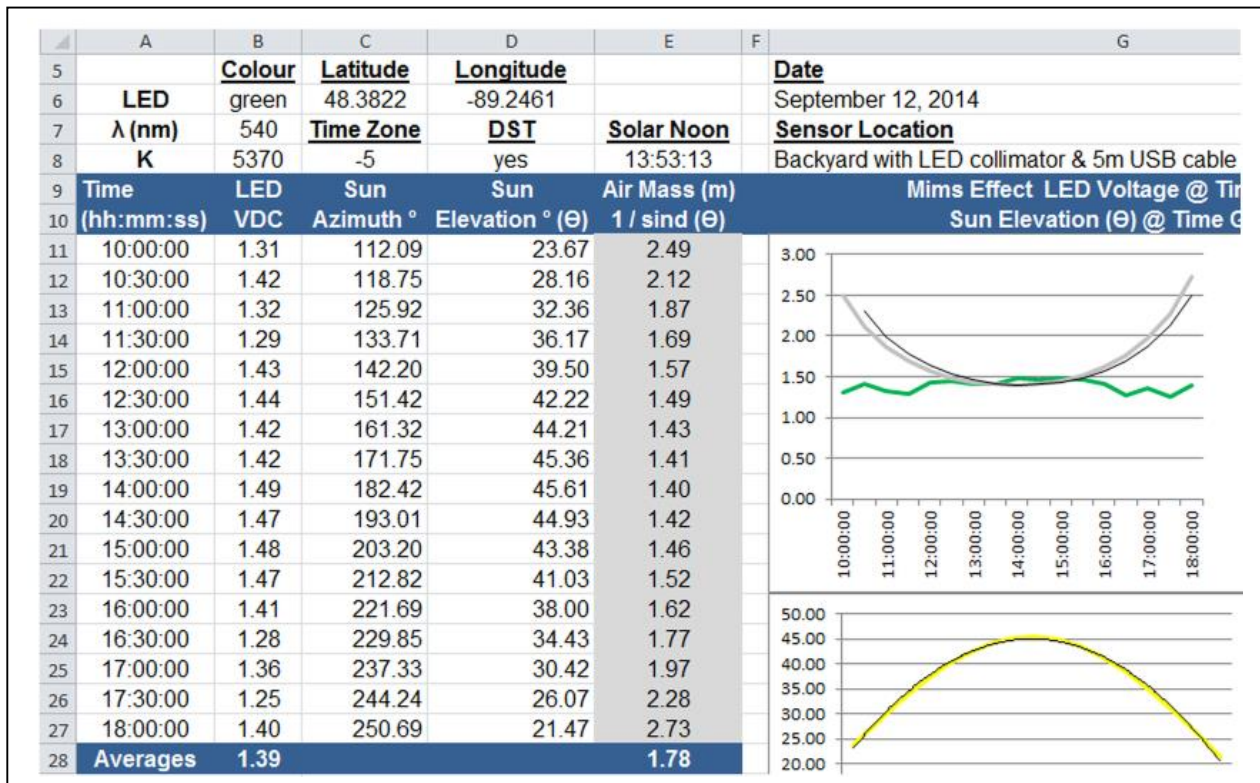
You will soon notice some very interesting things if used outside. On overcast days, the longer red light waves easily penetrate cloud cover and a red LED generates a higher Mims Effect voltage while the shorter blue/UV light waves are mostly blocked and a blue LED generates a lower voltage; when the sky is less cloudy the blue light voltage increases while the green LED voltages remain fairly constant, regardless.



**FIGURE 5B: SERIAL MONITOR OUTPUT**

The greenish-yellow light spectrum is where we see best because our ancestor's eyes evolved from exposure to our primarily greenish-yellow sunlight, and we hide in caves from predators at night so our night vision is very poor in comparison. But our eyes are very photosensitive to the deeper blue light spectrum (near-UV or around 440nm) and seriously affected by photo-oxidation and it's what darkens my Transitions eyeglasses (the "blue-light" syndrome) which occurs well before our skin reacts from sunburn.

In winter, ground snow reflects the full [white] light spectrum at all angles, nearly doubling the effect of UV which can cause “snow blindness” or photokeratitis to unprotected eyes. So you can get a sunburn (or “snowburn”) in the winter just as easily in the summer! Interestingly, snowflakes are made up of clear ice crystals and they have no colour but appear white because of this [diffuse] light reflection.



**FIGURE 5C: GREEN LED RECORDED RESULTS**

The Sun’s sky arc (at 15 degrees/hour) is a 2<sup>nd</sup> degree polynomial (quadratic equation) but the LED’s voltage output is relatively flat across the spectrum which shows the average lighting conditions versus time. See if this is the same for other colours/types of LEDs.

### MY FINAL

In part Duo, we’ll enhance the sketch and gadget to build a multichannel photometer with added components and disconnect the computer.—73

## REFERENCES AND RESOURCES

### **Adafruit FLORA Arduino**

<http://tinyurl.com/nvdkv9r>

### **Arduino (IDE & Information)**

<http://arduino.cc>

### **Dr. L & Ladyada**

<http://tinyurl.com/ppghld5>

<http://tinyurl.com/kqy22mh>

### **Forrest Mims III**

<http://tinyurl.com/3woj7t4>

<http://tinyurl.com/nvulko5>

### ***Introduction to Arduino (PDF)***

<http://www.introtoarduino.com>

### **Light Colour, Frequency and Wavelength**

<http://tinyurl.com/p7nhwku>

### **LilyPad Arduino**

<http://lilypadarduino.org>

### **My NASA Data**

<http://tinyurl.com/mxfhjpp>

### **Sample Uno Starter Kits**

<http://tinyurl.com/4xbnb7v>

<http://tinyurl.com/ogv8vby>

**VA3ROM: All Things Digital**

<http://tinyurl.com/og2acxq>