ES 50 Vocab Cast of Characters: the important players in this lab

1 Resistor color code:

Resistors are some of the most commonly used components, and we will use them in almost every circuit we make. Resistors come in a variety of resistances but tend to be very physically small. Because of their small size, resistors have their resistance values labeled in the form of an easily readable color band code. In this code, resistors are each printed with four color bands. Digits of the resistance value are represented as follows:

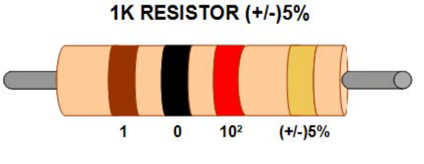
A good way to help remember this is that the middle 6 colors are the 6 commonly cited colors of the color spectrum: ROYGBV.

In addition to the resistance value, resistors also report their tolerances:

To illustrate how this works, consider one of the most commonly used resistors, a 1 kΩ resistor:

Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Color	Tolerance
Gold	5%
Silver	10%
None	20%



(Source: http://www.corollarytheorems.com/Design/ed images/rez g 1.png)

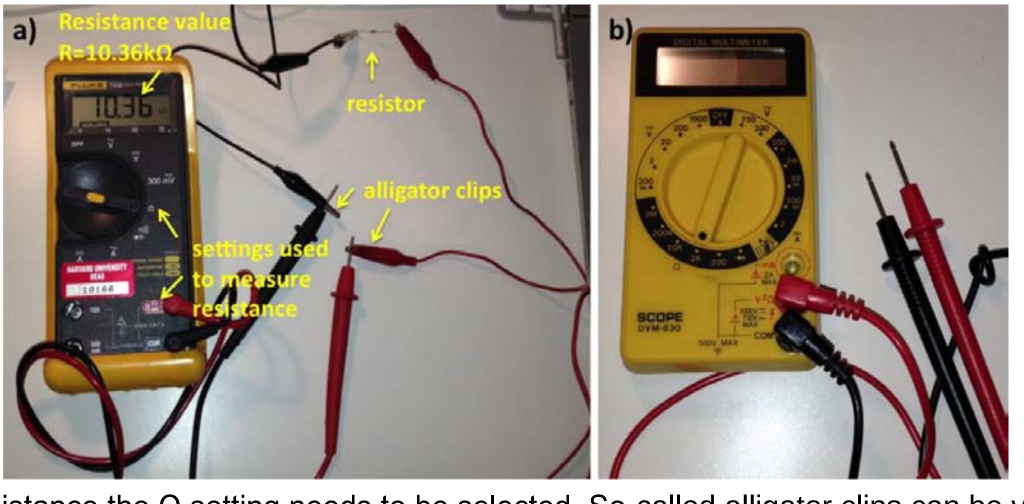
The first color band represents the tens digit, the second color band represents the units digit, and third and final color band represents the exponent of ten used as a multiplier. Finally, the metallic colored band represents the tolerance. In this example, the brown band represents a 1 in the tens place, the black band represents a 0 in the units place, and the red band represents a multiplier of 10^2. This gives a resistance value of:

$$(1 \times 10 + 0 \times 1) \times 10^2\,\Omega = 1000\Omega = 1\ \mathrm{k}\Omega.$$

Finally, the gold band indicates a tolerance of 5%, meaning the actual resistance may be as low as 1000 Ω × 0.95=950 Ω or as high as 1000 Ω × 1.05=1050 Ω.

Another way to figure out the value of the resistances is to measure it using digital multimeters (DMMs). The DMM is one of the most important instruments in the EE laboratory, and it is one of the simplest to understand and to operate. On your bench you have two DMMs: one fancy, bench top instrument, and the other one a portable, handheld instrument (typically they are yellow not sure why...). DMMs can measure voltages (V setting), currents (A), and resistances (Ω). Note that appropriate settings need to be chosen when measuring AC or DC voltages or currents. The figure below indicates how you can measure resistance using the hand-held DMMs that live in the ES 50 lab.

a) FLUKE (name of the brand) hand-held digital multimeter (DMM). To measure

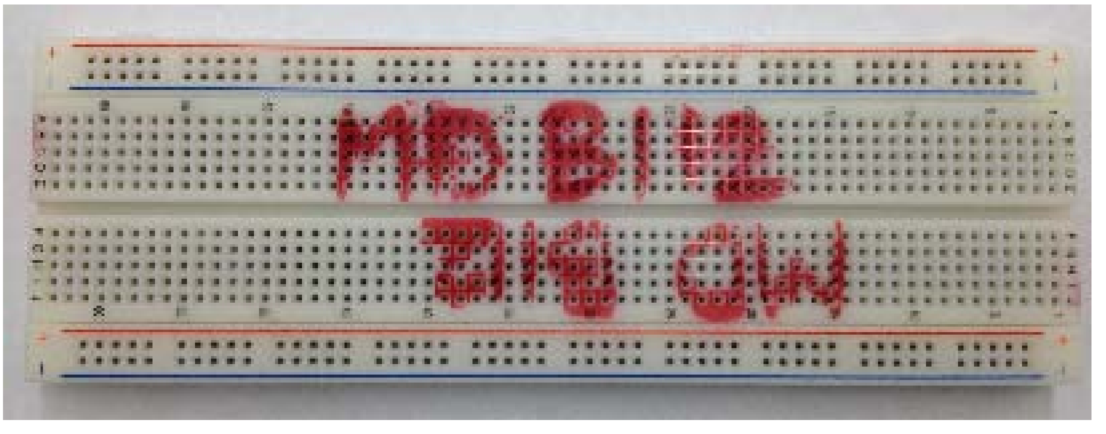


resistance the Ω setting needs to be selected. So-called alligator clips can be very helpful -make sure you have plenty of them at your workbench :)! Btw, it would be totally fine to use your hands instead of alligator clips. The measured resistance is 10.36Ω. Remember, this is an engineering course, and not math, and the exact value of the resistances will often not be so important. Therefore, we will refer to this resistor as ”10kΩ” resistor :). b) Another type of DMMs that you will be using.

2 Breadboards:

'Solderless' breadboards are used to quickly prototype and build electrical circuits without having to solder components on (using flowable metal to fix the components in place). Breadboards are composed of two sections, terminal strips, which are electrically connected vertically in the picture below, and bus strips, which are electrically connected horizontally in the picture below. On this breadboard there are four bus strips that run the entire horizontal length of the board: two in the top section of the breadboard and two in the bottom section of the breadboard, each adjacent to either a red or blue line. This board also has numerous terminal strips that are composed of 5 vertically electrically connected holes, lettered either A through E or F through J. In column 1, for example, 1A through 1E are all electrically connected to each other but not to 1F through 1J.(It's difficult to see the precise placement of the holes in the diagram, but in the lab, play around with the placement of components in the holes and see which holes are electrically connected (or 'shorted) and which ones are not).

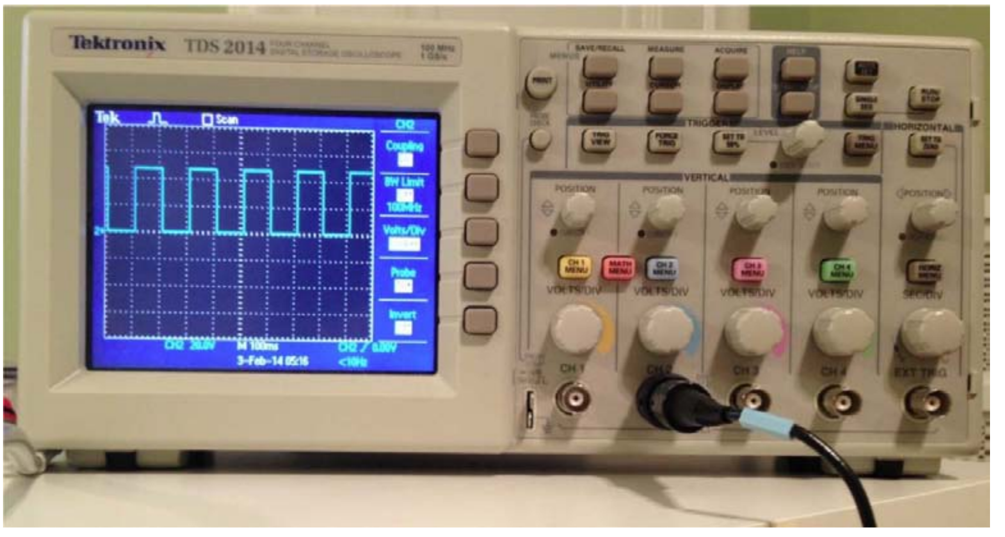
The bus strips are typically used to provide power to circuits. Ground is conventionally connected to one or both of the blue (-) bus strips and the power supply is conventionally connected on one or both of the red (+) bus strips. The terminal strips are used for all of the other electrical points in a circuit.



3 Oscilloscope:

An oscilloscope is a tremendously useful instrument that allows us to view how an electrical signal changes over time, plotted and displayed on the screen of the oscilloscope. Some scopes are fast enough that they can see changes in signals that our eyes or ears cannot detect.

ES 50 Oscilloscope. Channel 2 is connected and displays pulse sequence with



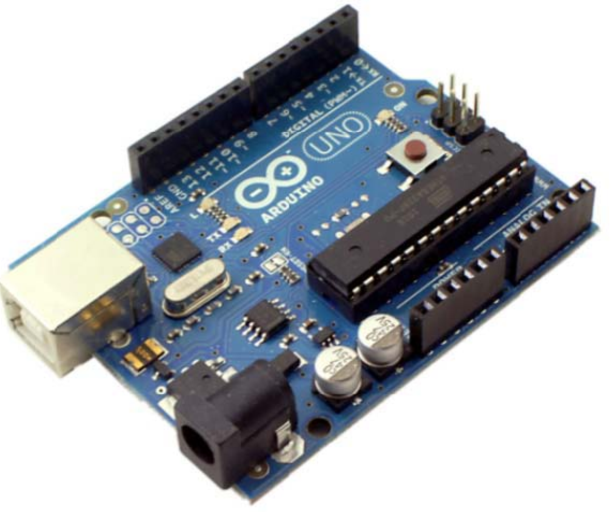
amplitude A=5V and periodicity T=200ms, corresponding to frequency of f=5Hz. The duty cycle (DC) of this sequence, that is the ratio between the duration of ”high” signal and the period is DC = 50%

The figure shows that the oscilloscope we use in our lab (a Tetronix TDS 2014 ’Digital’ Oscilloscope) can take in 4 inputs through 4 channels. We can also see that the screen displays a time-varying ’waveform’: the horizontal axis is ’time’, and we can control the scale by changing a ’SEC/DIV’ knob, that you will find when you actually play with the scope. Our scope is rated at ’100 MHz’, which means that is can ’faithfully’ respond to and record an input signal whose frequency is less than or equal to 100 MHz or 10^8 cycles per second (!), probably a lot faster than we will need for ES 50, but it’s nice to know that we have that capability. In general, this oscilloscope has tremendous capabilities that we may only begin to use. If we take in several time-varying signal at once, we can use a single ’trigger’ for all signals so we have a record of the ’slow’ and ’fast’ signals (with respect to the trigger) -in this way, we can get a visual representation of a difference in phase. We can also compare the amplitudes and frequencies of different signals.

4 The Master Controller: ARDUINO

The ARDUINO UNO is like the brain stem of your electronic system. Arduino is set up to (1) take in different signals (audio, light, temperature indicators), (2) modulate, combine, shape those signals and (3) send an output signal to turn on/off and control outputs like lights, Light Emitting Diodes (LEDs), lasers, motors, audio speakers.

Arduino Uno



The UNO is the simplest, starter brain:the ARDUINO family includes a variety of different 'board s', including 'ARD UINO LILYPADS' with a format compatible with 'wearable electronics', incorporating electronics with textiles. 'ARDUNIO SHIELDS' allow you to connect your system to the Internet, go wireless. We can program Arduino to perform simple tasks, using software with a simple set of instructions. In the beginning, we will start using pre-set programs and circuits, but you can rapidly build your own circuit ideas using the ARDUINO platform. There are tons of online information about ARDUINOs. For instance, check out: http://arduino.cc/. There are also resources on our course iSites:
http://isites.harvard.edu/fs/docs/icb.topic1386863.files/Lab%201/Make_Arduino_Bots_and_Gadgets_Ch1_and_2.pdf.

5 Device Components:

The following list includes some of the important device components we will be working with in the first lab:

a) Light Emitting Diode, LED: a device that gives off light when current is passd through it. The diodepart of LED means that the device turns on and gives off light only if the current passes through the device in one direction. LEDs come in various distinct colors.

Light Emitting Diode

b) Photoresistor, ’photocell’: is a light-controlled resistor, where the resistance decreases as the incident light on the cell is increased.

Photoresistor

c) Potentiometer: this is a variable resistor, a way of continuously changing the resistance in a circuit without taking out and putting in various discrete resistors of different values.

Potentiometer