CENG2030
FUNDAMENTALS OF EMBEDDED SYSTEM DESIGN

LECTURE 3: INSTRUMENTATION AND MEASUREMENT

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COMMON LAB INSTRUMENTS

- Instruments commonly used in electronic/maker laboratory:
  - Multimeter
  - Signal Generator
  - Oscilloscope
  - Breadboard
  - 3D Printer

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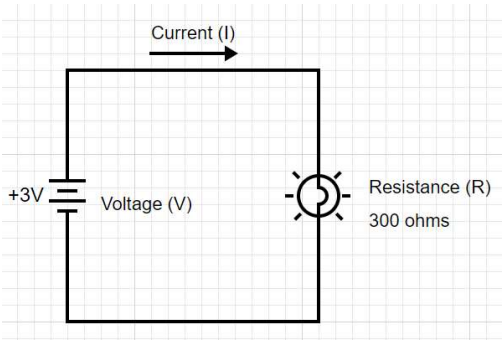
BASIC ELECTRONIC CIRCUIT

- Suppose we have a simple circuit
- How can we measure some basic parameters of the circuit?
- Such as:
  - Voltage (V) in Volt (V)
  - Current (I) in Ampere (A)
  - Resistance (R) in Ohm (Ω)



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MULTIMETER

- Multimeter is an all-in-one devices that can measure various electrical parameters:
  - Current
  - Voltage
  - Resistance
  - Capacitance
  - Frequency
  - Short circuit alarm
  - AC & DC, etc.

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MULTIMETER

- There are two types of multimeter
  - Analog multimeter

  - Digital multimeter

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USE OF MULTIMETER

- Basic steps (or common mistakes) in using multimeter
  1. Connect the measuring probes into the right places
  2. Check if there is any amplification on the measuring probes
  3. Select the correct function for the desired measurement
  4. Place the probes on the correct places on the circuit

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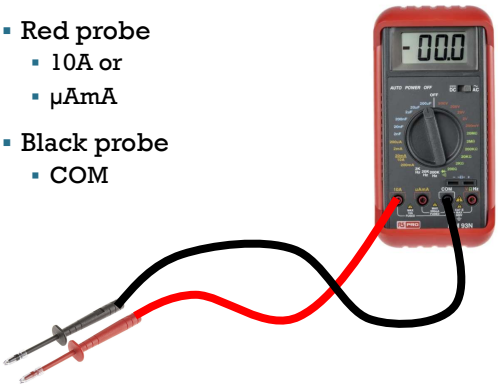
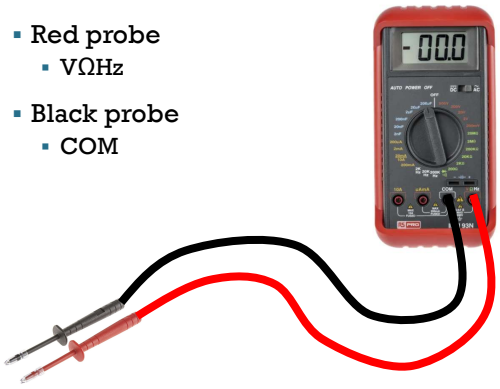
CONNECT THE PROBES

- Current measurements
- Red probe
  - 10A or
  - μAmA
- Black probe
  - COM



- Other measurements
- Red probe
  - VΩHz
- Black probe
  - COM



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CHECK AMPLIFICATION

- Check the probes, especially for oscilloscope
- Is there any amplification switch?
  - X1
  - X10
- If so, you have to take it into account for your measurement

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SELECT FUNCTION

- Select the correct measurement option
- In this example, we have:
  - OFF
  - Voltage (V)
  - Resistance (Ω)
  - Diode/Short Circuit
  - Frequency (Hz)
  - Current (μA, mA, A)
  - Capacitance (nF, μF)

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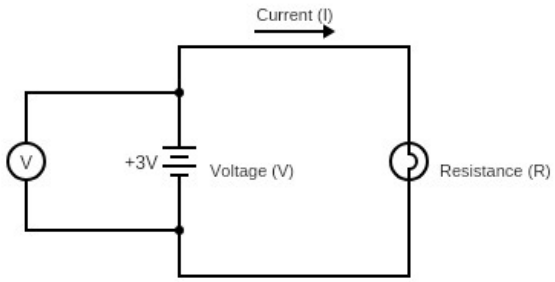
VOLTAGE MEASUREMENT

- Connect the voltmeter in parallel with the circuit element



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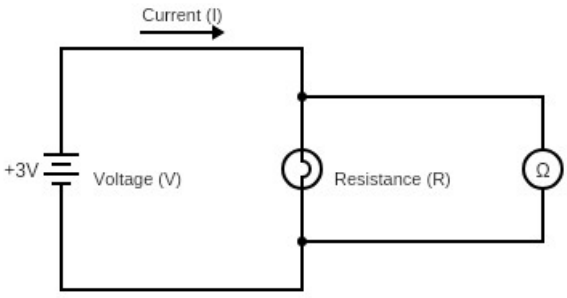
RESISTANCE MEASUREMENT

- Connect the voltmeter in parallel with the resistor



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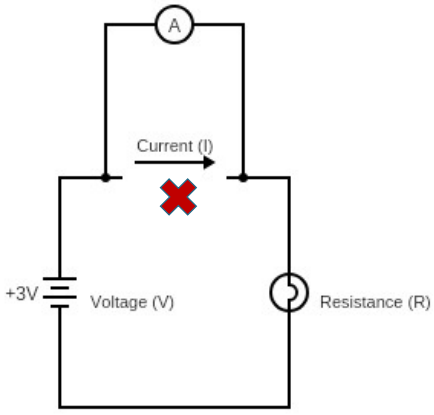
CURRENT MEASUREMENT

- Break the circuit
- Insert the ammeter in the middle
- Therefore, connect the ammeter in series



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CONNECTION CHECKING

- Short circuit alarm
- Normally use for checking whether a connection has been successfully made between to wires
- If the connection is made (i.e. short circuit), there is a beep sound

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SIGNAL GENERATOR

- Generate electric signals for testing purposes

- Parameters
  - Frequency
  - Amplitude

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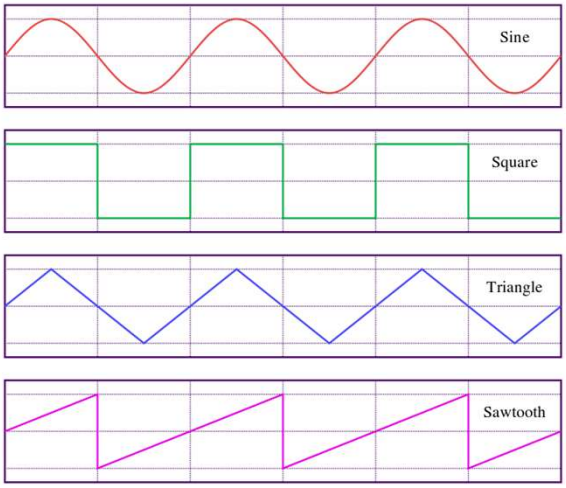
TYPE OF SIGNALS

- Type of signals
  - Sine wave
  - Square wave
  - Triangular wave
  - Sawtooth wave



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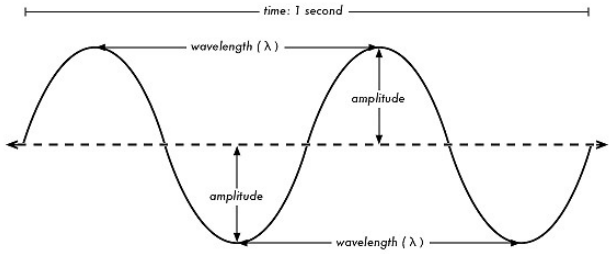
SIGNAL PARAMETERS

- Wavelength (λ)
  - The distance measured from a point on one wave to the equivalent part of the next, for example from the top of one peak to the next
  - Wavelength is measured in meters (m)
- Frequency (*f*)
  - The number of whole waves that pass a fixed point in a period of time
  - Frequency is measured in cycles per second (or Hertz, Hz)
- Amplitude
  - The distance from the center of the wave to the extreme of one of its peaks
  - What is the unit of amplitude?

- In this example, there are 2 complete cycles per second. Therefore, the frequency is 2Hz.



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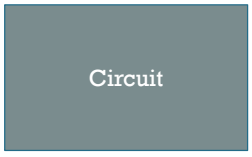
TESTING WITH SIGNALS



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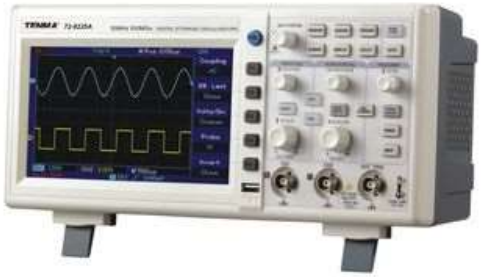
OSCILLOSCOPE

- An Oscilloscope is commonly used to capture, process, display and analyze the waveform and bandwidth of electronic signals.
- The device draws a graph of the instantaneous signal voltage as a function of time.



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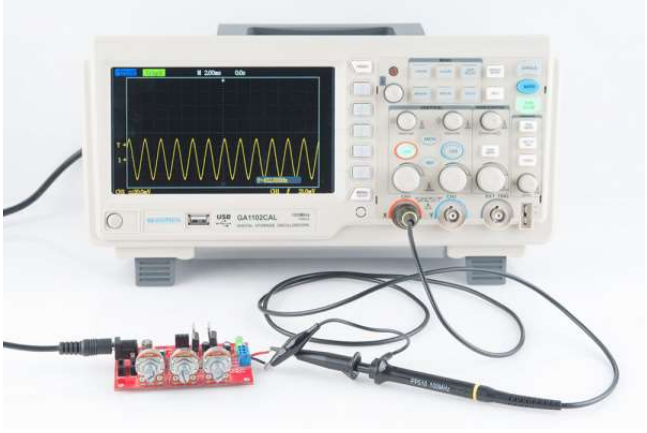
HOW TO USE THE OSCILLOSCOPE?



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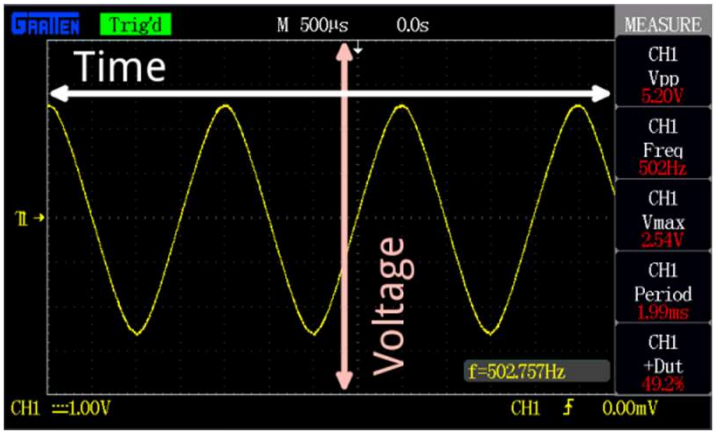
OSCILLOSCOPE

- Two-dimensional graph with time on the x-axis and voltage on the y-axis.



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TIME CHARACTERISTICS

- Frequency and Period
  - Frequency is defined as the number of times a waveform repeats per second
  - Period is the reciprocal of frequency.
  - The maximum frequency a scope can measure varies, but it's often in the 100's of MHz range.
- Duty cycle
  - The duty cycle is a ratio that tells you how long a signal is "ON" versus how long it's "OFF" each period.
- Rise and fall time
  - The duration of a wave going from a low point to a high point is called the rise time, and fall time measures the opposite
  - These characteristics are important when considering how fast a circuit can respond to signals

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VOLTAGE CHARACTERISTICS

- Amplitude
  - Amplitude is a measure of the magnitude of a signal.
  - There are a variety of amplitude measurements including
    - Peak-to-peak amplitude, which measures the absolute difference between a high and low voltage point of a signal
    - Peak amplitude, only measures how high or low a signal is past 0V
- Maximum and minimum voltages
  - The scope can tell you exactly how high and low the voltage of your signal
- Mean and average voltages
  - Oscilloscopes can calculate the average your signal
  - It can also tell you the average of your signal's minimum and maximum voltage

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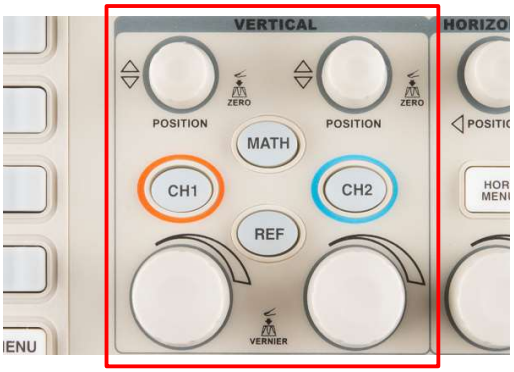
VERTICAL SYSTEM

- The vertical section of the scope controls the voltage scale on the display
- The volts per division (V/div) knob allows you to set the vertical scale on the screen



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HORIZONTAL SYSTEM

- The horizontal section of the scope controls the time scale on the screen
- The seconds per division (s/div) knob rotates to increase or decrease the horizontal scale

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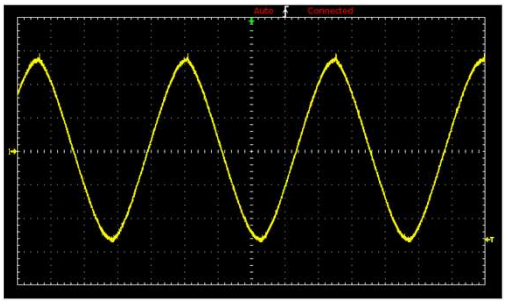
TRIGGERING SYSTEM

- The trigger section is devoted to stabilizing and focusing the oscilloscope



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THE PROBE

- Check the amplification
- Connect both Signal and Ground correctly

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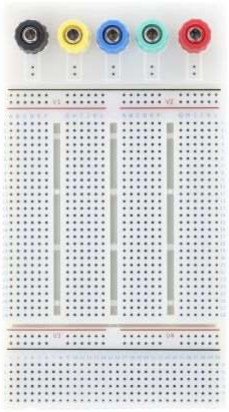
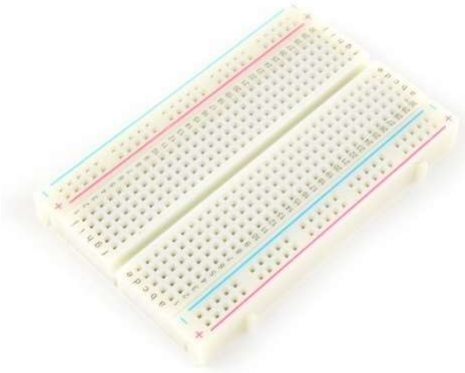
BREADBOARD





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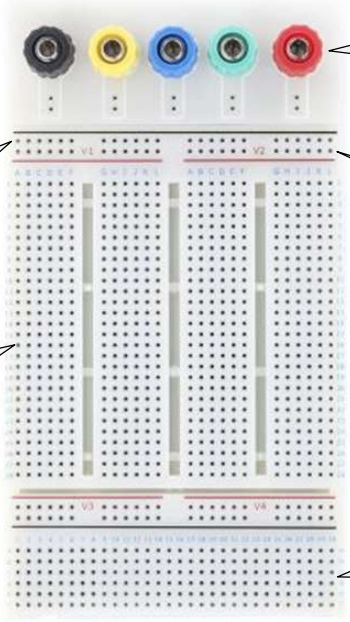
BREADBOARD



These sockets are NOT yet connected to anywhere on board

As indicated by the black line, the first row of holes are all connected together

As indicated by the red lines, the second row of holes are divided and connected as two segments

In this board, 6 holes are grouped and connected together horizontally in this portion

In this board, 6 holes are grouped and connected together vertically in this portion

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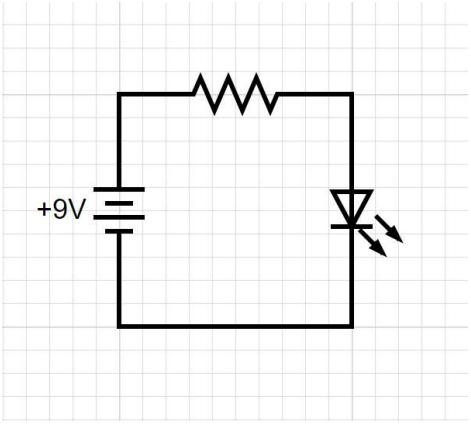
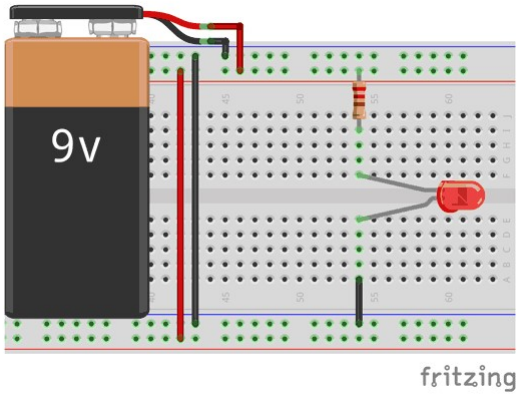
EXAMPLE OF USING BREADBOARD





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3D PRINTER

- Finish your 3D drawing in SolidWorks, and export it to .STL file format
- The 3D object can then be printed by using 3D printer

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ANY QUESTIONS ?

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