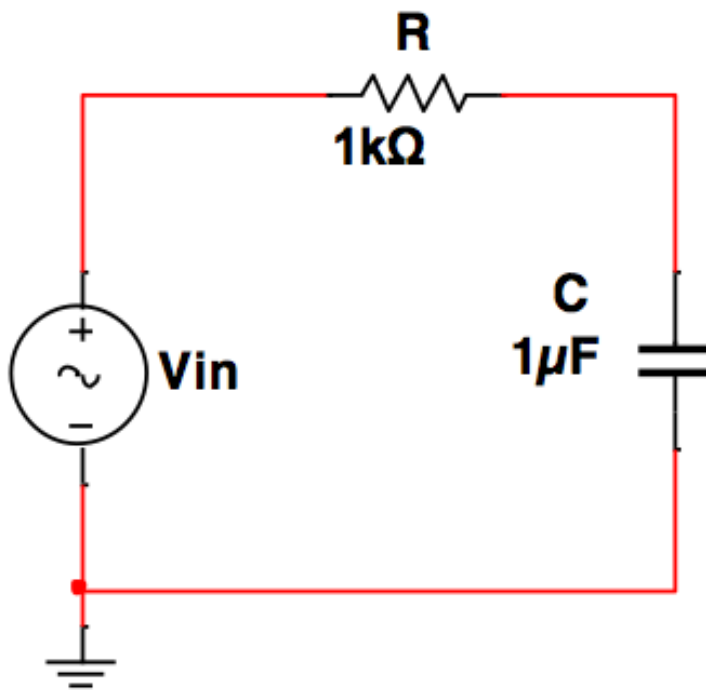


E80 Spring 2015

# Basic Electrical Measurements

**Prof. Angie Lee**

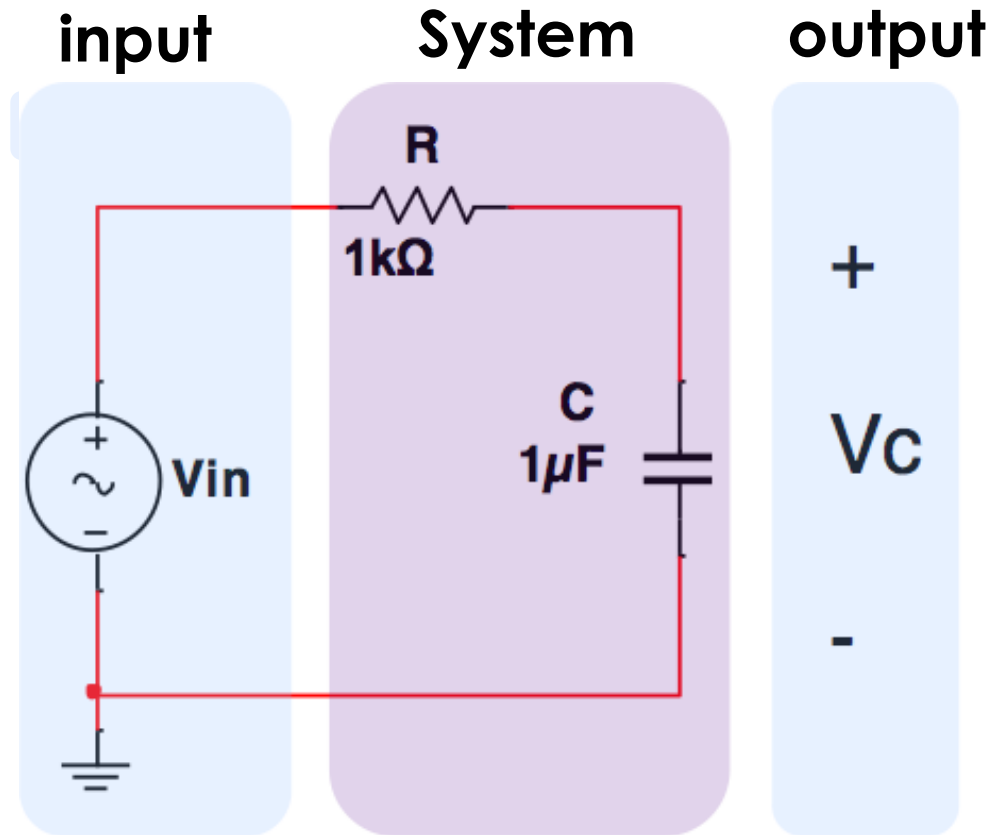
# Example: first order system RC circuit



+  
V<sub>c</sub>  
-

- How to present measurement results?
- What instruments to use?
- How to set up test?
- Any limits?

# Example: first order system RC circuit

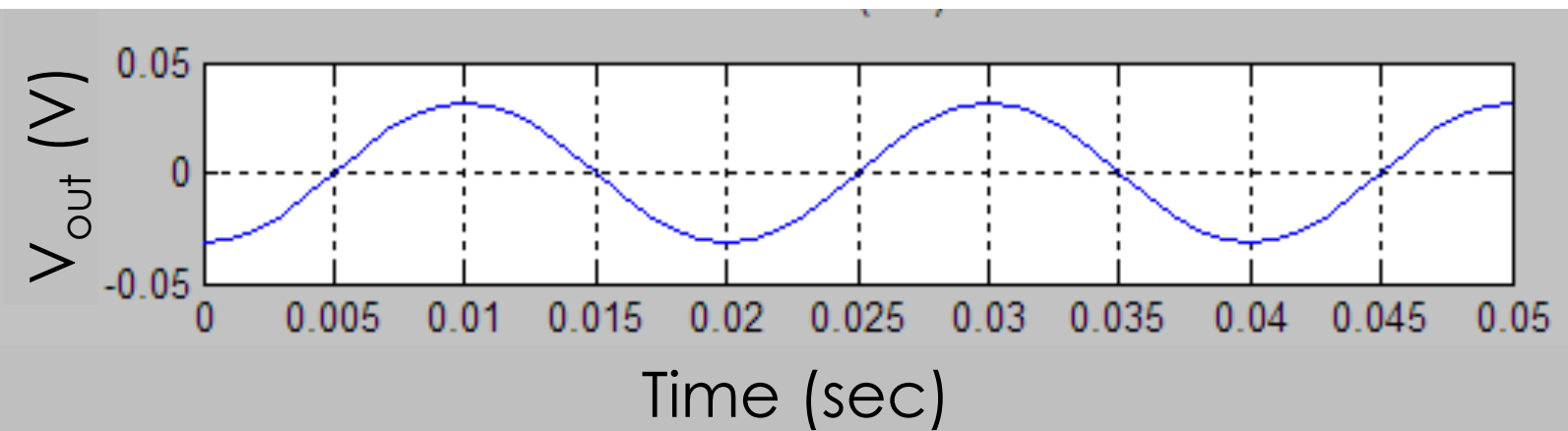
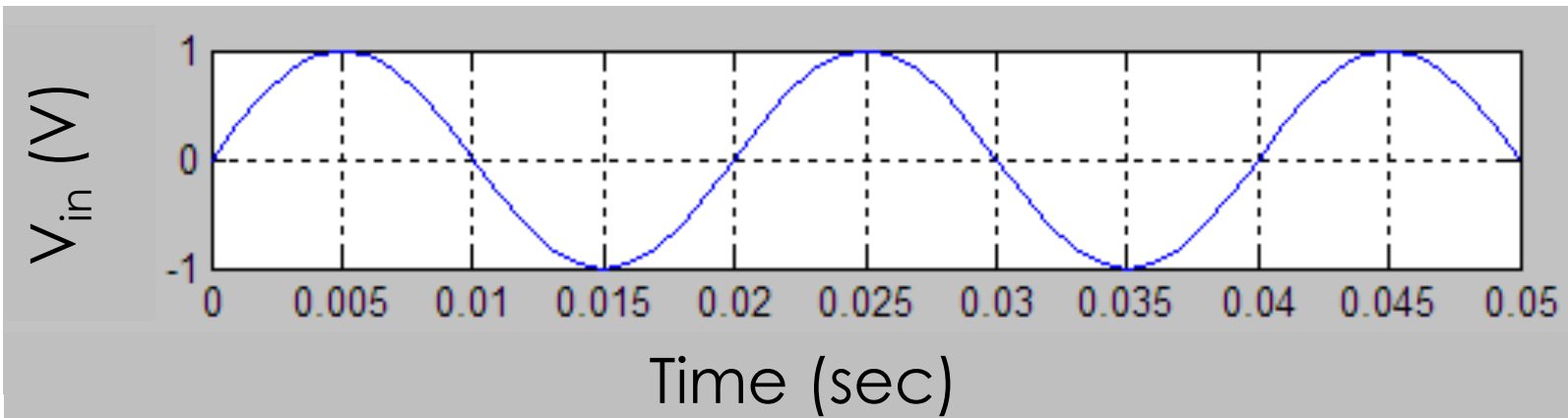


**Power supplies**  
**Function generators**

**Breadboard**

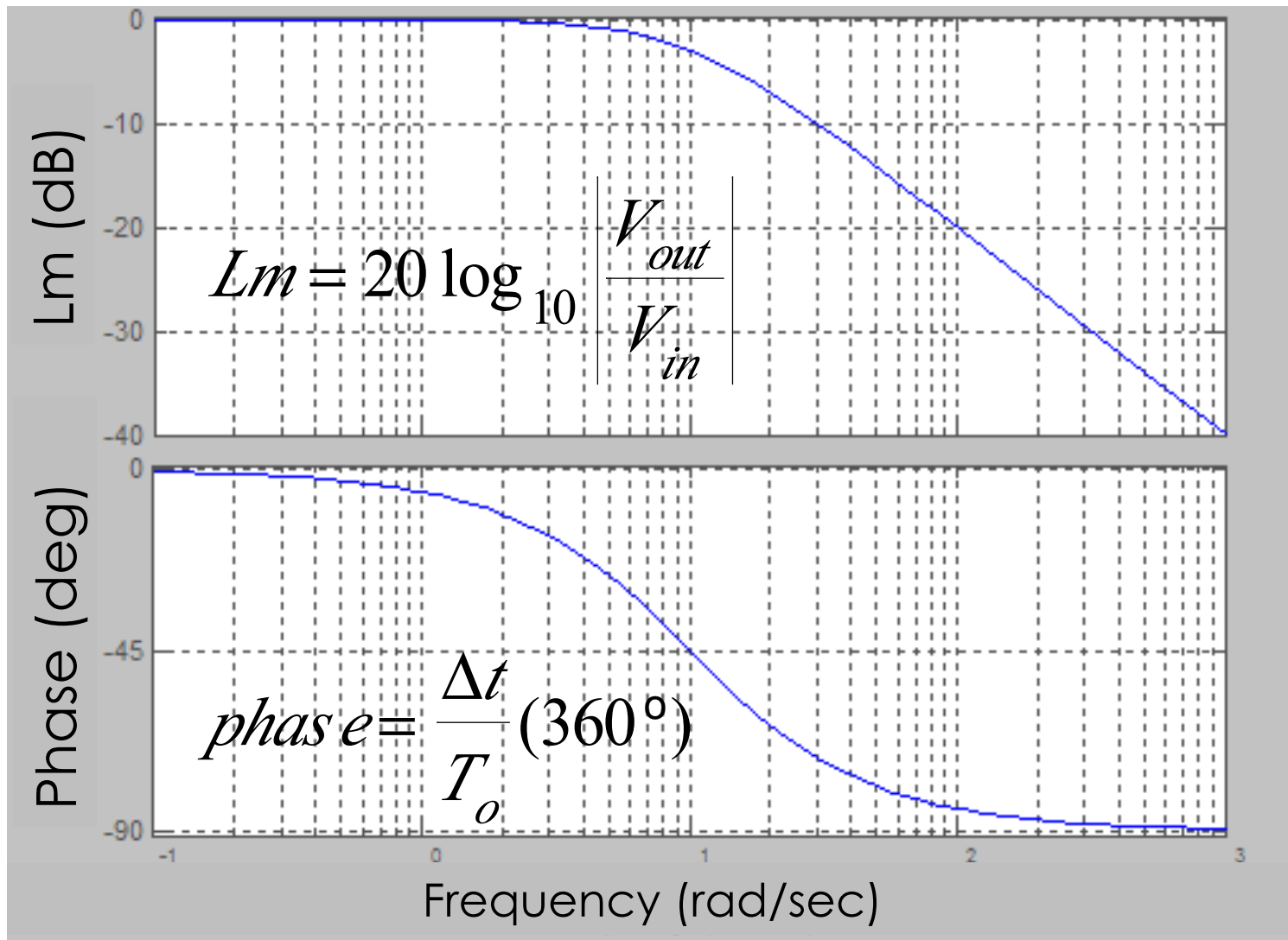
**Multimeters**  
**Oscilloscope**  
**DAQ**

# How to present measurement results? Time-Domain Plots

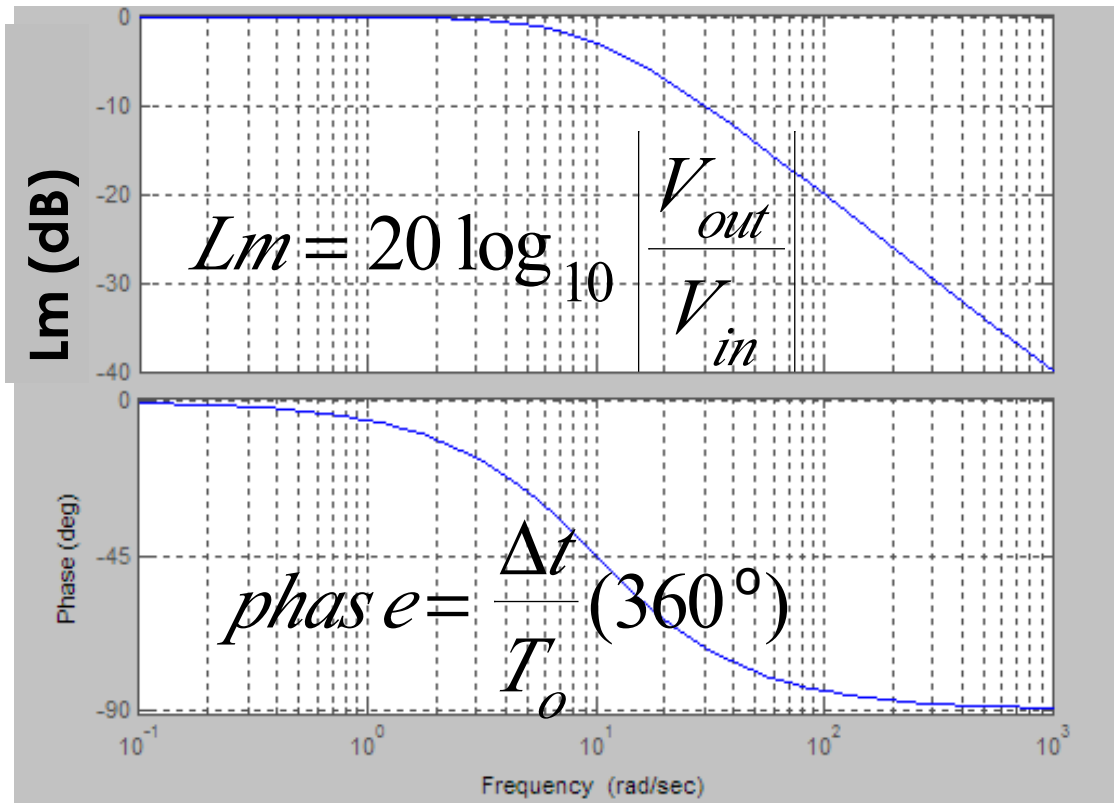
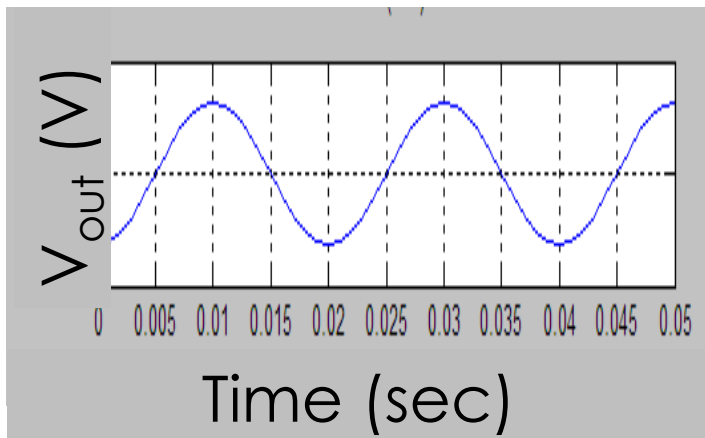
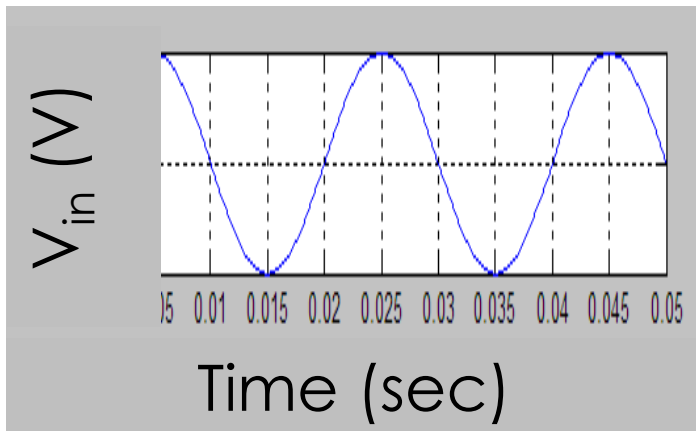




# How to present measurement results? Frequency-Domain (Bode) Plots



# Data Organization

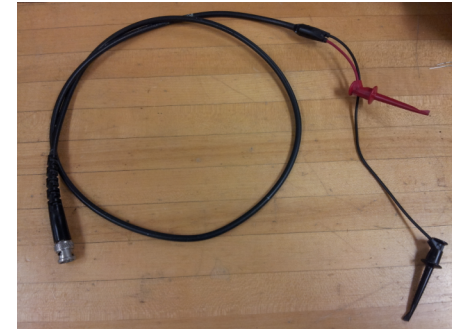


How many data points to take?  
Useful data analysis tool?  
DAQ and LabVIEW (automation)?

# Instrumentation

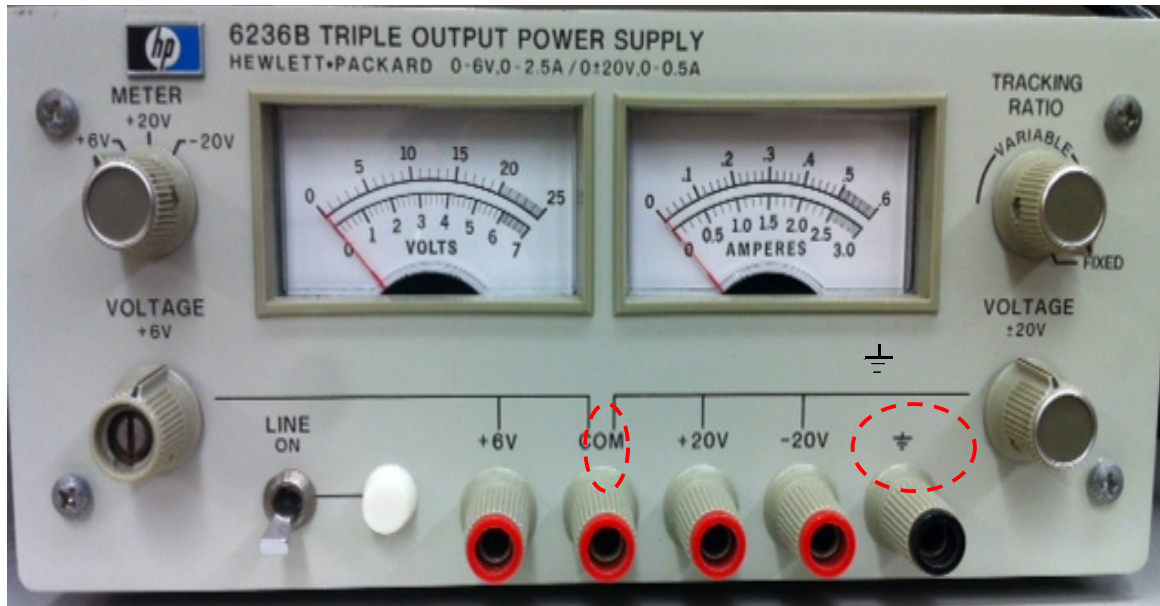
- Instruments that **GENERATE** signals
  - Signal generator (AC or DC)
  - Power supply (DC)
- Instruments that **MEASURE** signals
  - Multimeter (AC/DC voltage/current, resistance)
  - Oscilloscope (AC)
  - DAQ
- Wires and cables that **CONNECT** the instruments
- **BREADBOARD**

# Function Generator



- Waveforms: Sine, square, triangle, sawtooth
- AC signal
- Parameters: Amplitude (Vpp), Frequency (Hz), Out Term (High-Z or 50  $\Omega$ )

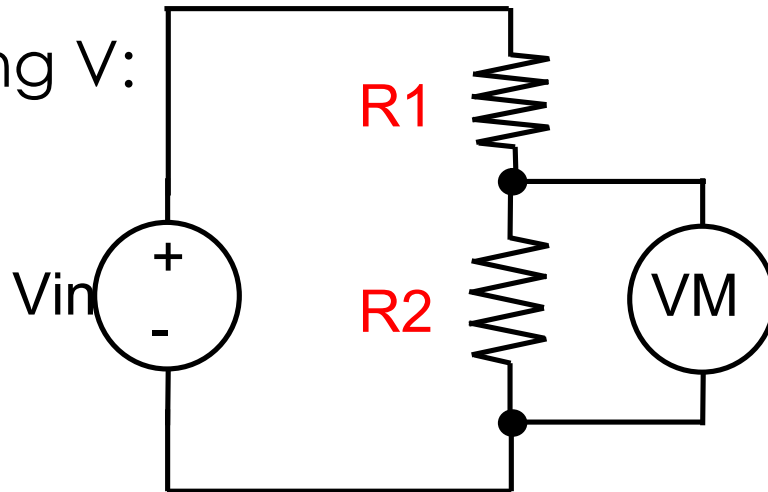
# Power Supply



- DC
- COM = common reference node of circuit
- $\perp$  = earth ground

# Multimeter- Voltage

Measuring V:



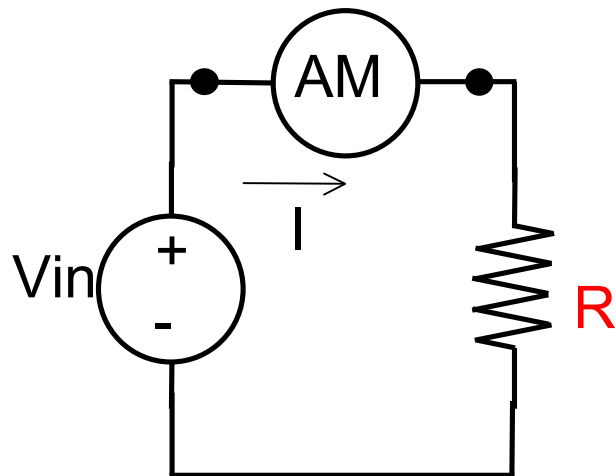
- Connect in parallel with C.U.T
- Internal resistance of VM should be large,  $10M\Omega$  for Elenco
- DC vs. AC (RMS for sinusoid)
- Range





# Multimeter- Current

Measuring I:

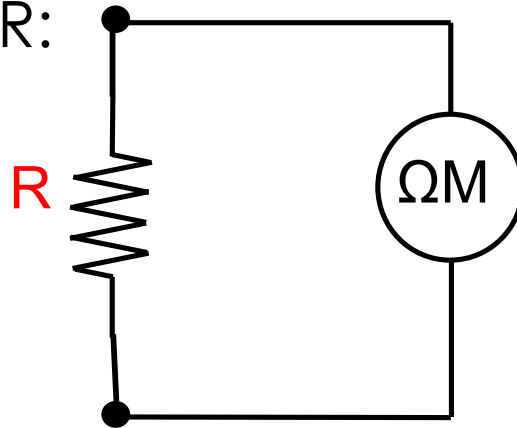


- Connect in series with the C.U.T.
- Internal resistance of AM must be very small, can be ignored.
- DC vs. AC (RMS for sinusoid)
- Range



# Multimeter -Resistance

Measuring R:



- Connect across R (isolated from other circuits)
- $\Omega M$  has internal battery, so should not connect to active circuits such as power supply





# Multimeter – Digital vs. Analog



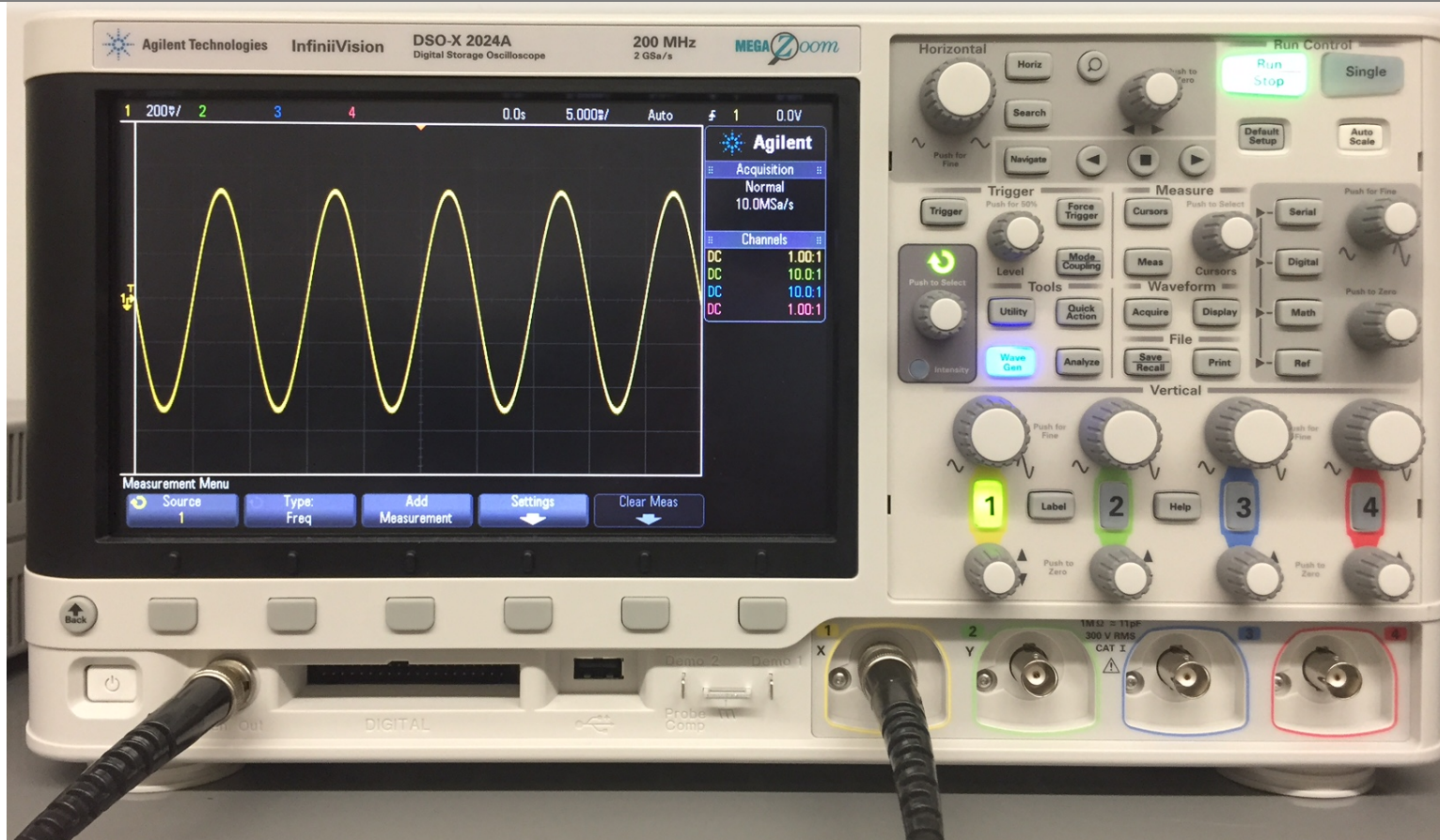
Simpson 260



HP34401A  
(in E80/VLSI lab)

- Analog meter (less precision in VM due to lower input resistance)
- Digits vs. needle position
- Higher performance: precision, true RMS reading

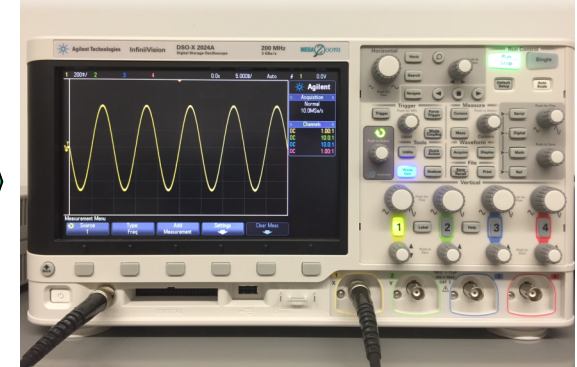
# Oscilloscope: Voltage Measurement (Time domain)



- Graphical display of electrical signal: y-axis represents voltage, x-axis represents time
- New oscilloscopes have a built-in signal generator!

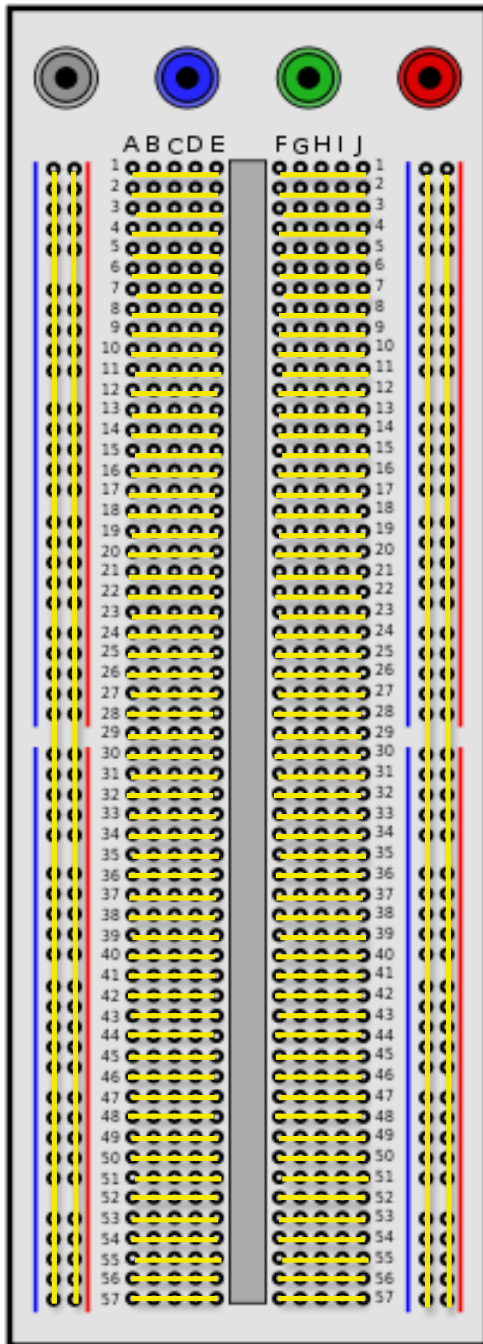
# Oscilloscope Probe

C.U.T



- Oscilloscope:  $1\text{M}\Omega$  input resistance
- 10x probe: **Improved input impedance by a factor of 10 not only for low frequency but also for high frequency**
- Signal reading on 10x probe is 1/10 of the signal at probe tip
- Oscilloscope bandwidth 60MHz
- Tuning of 10x probe (for instructions, see BEM guide)





**Use long busses for power and ground:**

Don't use them for signals

**Color-code wires:**

Red = V+ power

Black = V- or ground

White or Blue = signal

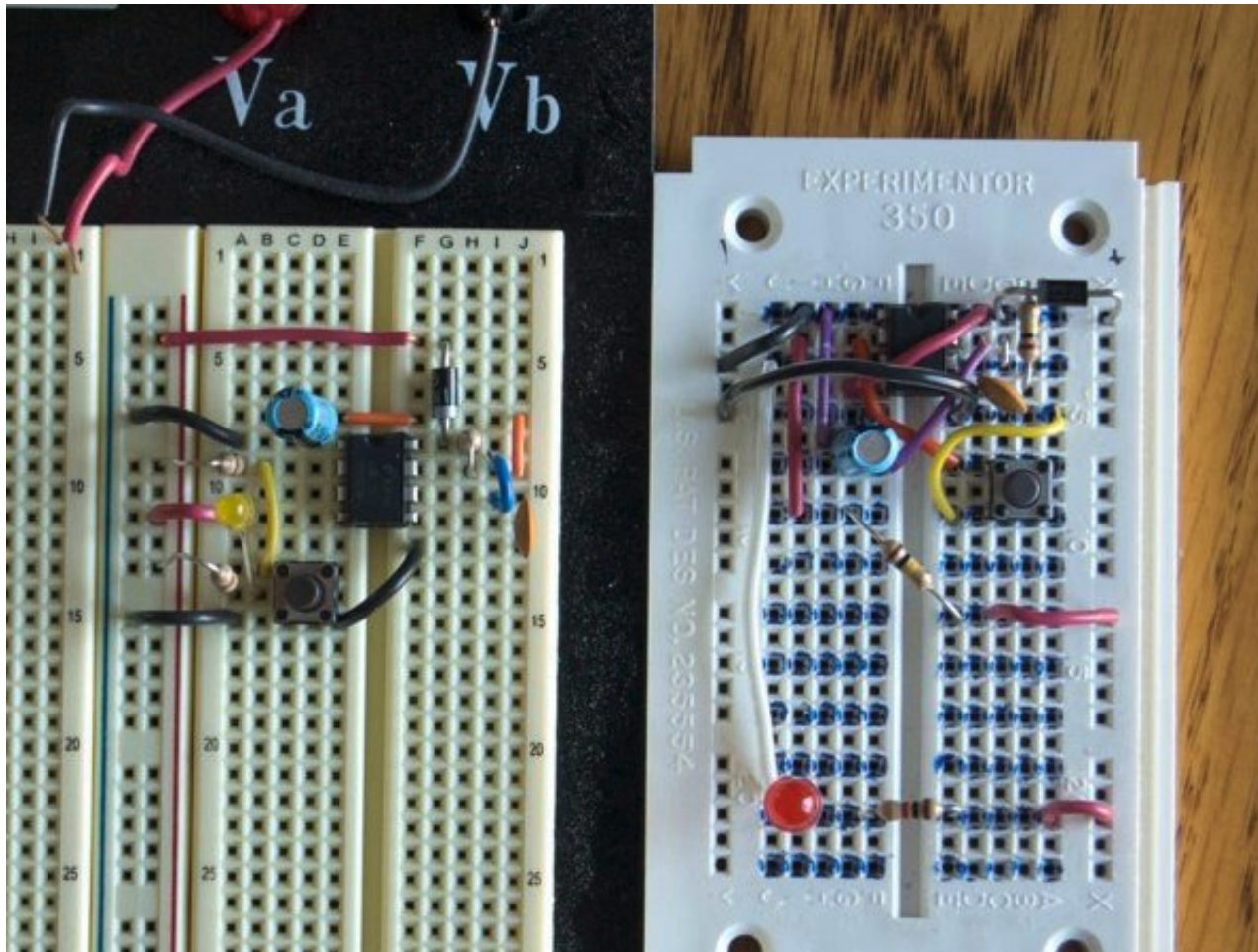


**Keep components close to the board:**

Trim resistors, capacitors, wires

**Check individual components before constructing the circuit**

# Pay Attention to Details and Practice



<http://makezine.com/2010/03/22/improving-breadboard-layout-through/>