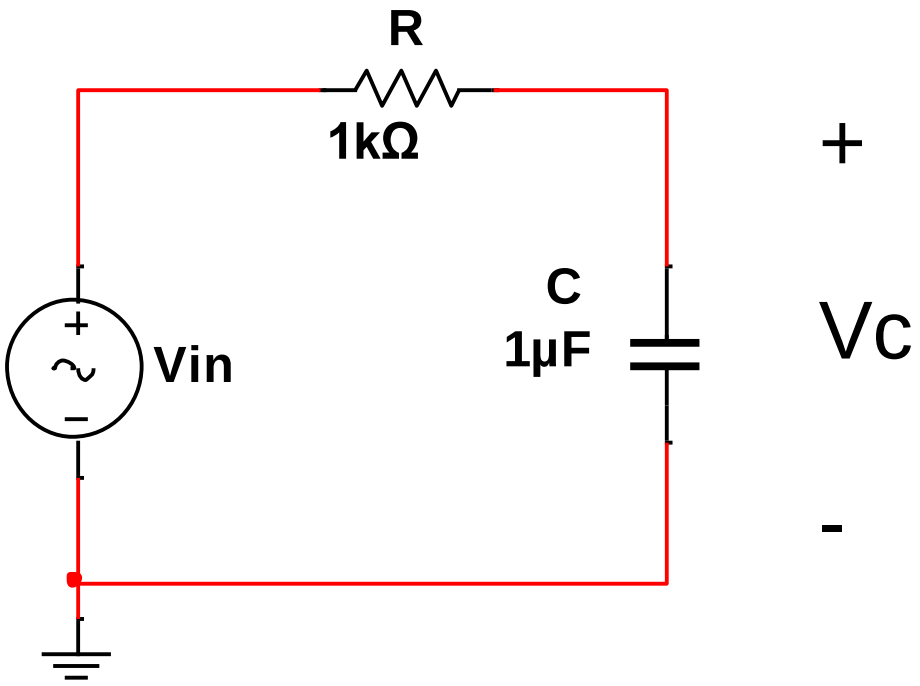
E80 Spring 2014

-Basic Electrical Measurements

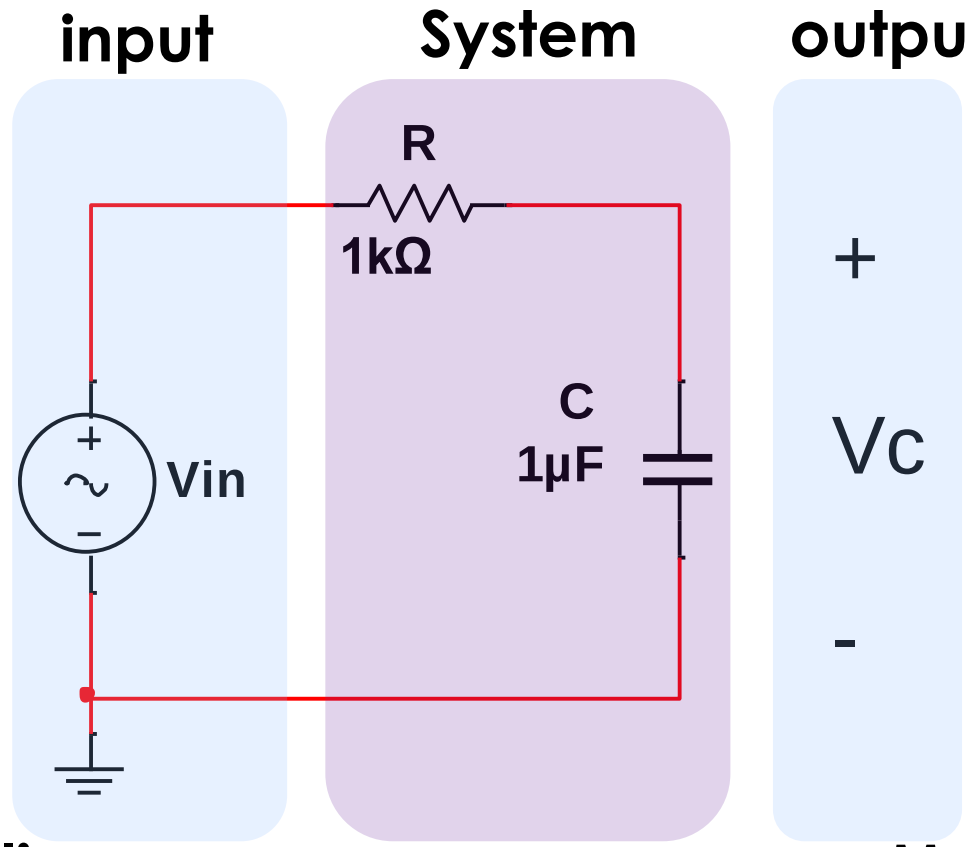
-Intro to OpAmp Characteristics

Example: first order system RC circuit



- How to present measurement results? (E59)
- What instruments to use?
- How to set up test?
- Any limit?

Example: first order system RC circuit

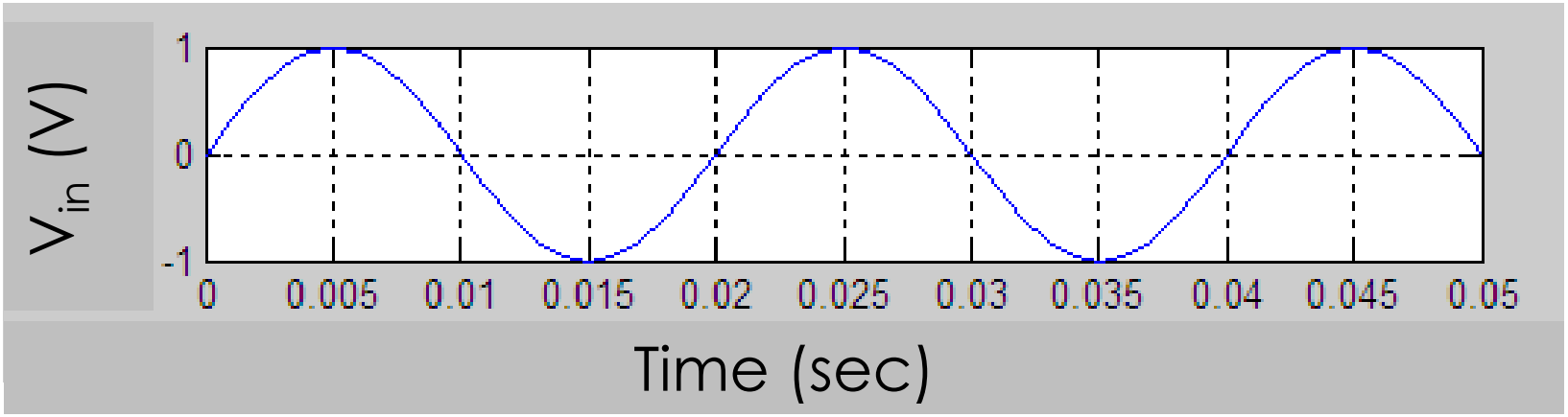


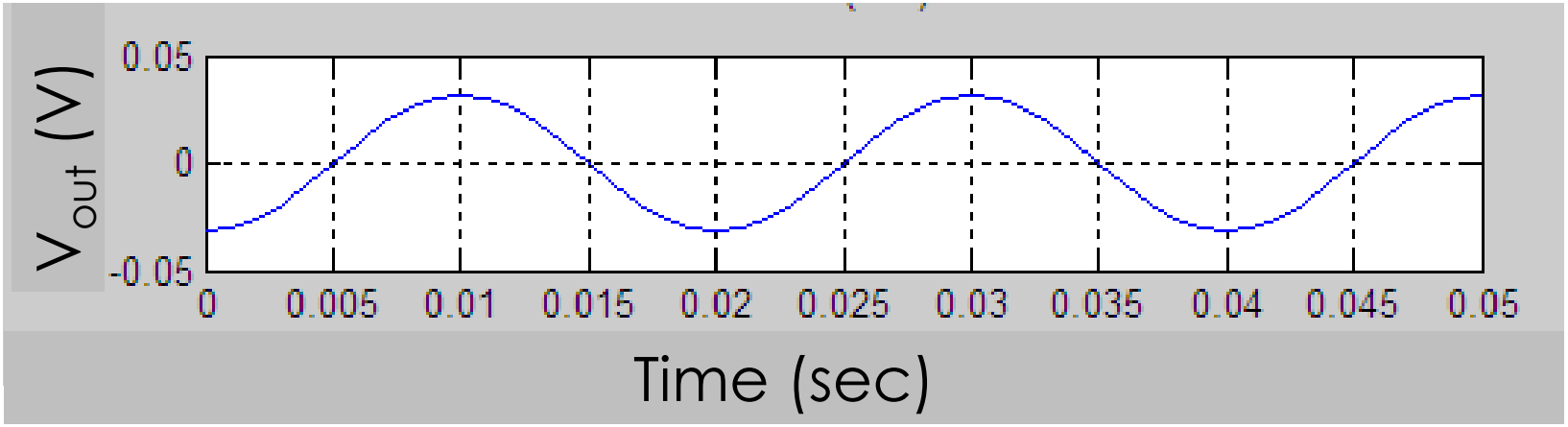
Power supplies
Function generators

Breadboard

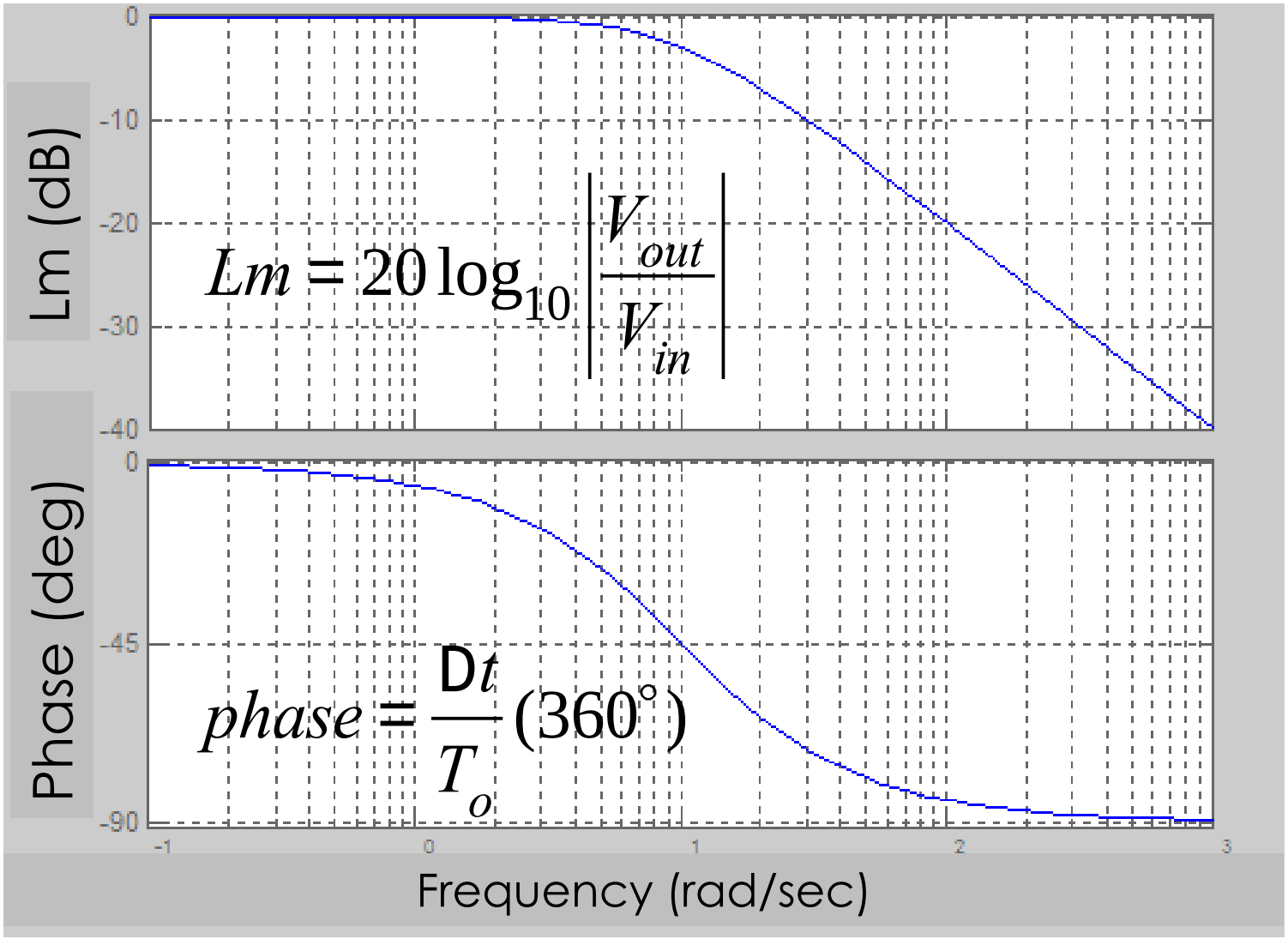
Multimeters
Oscilloscope
DAQ

How to present measurement results? Time-Domain Plots





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



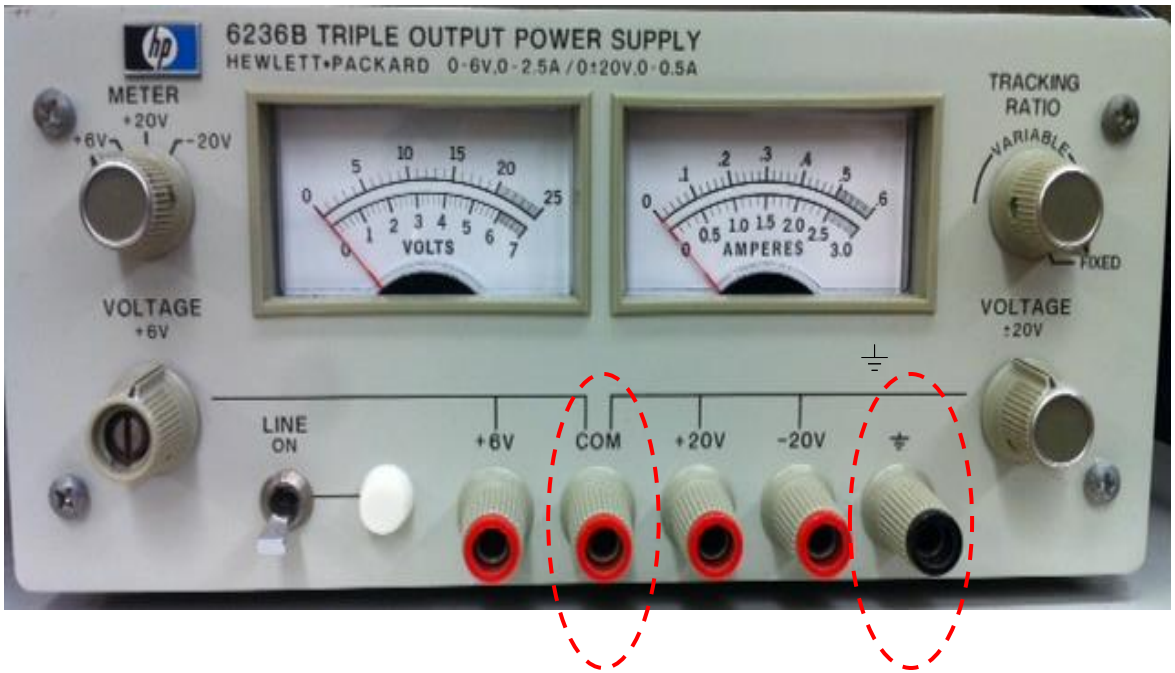
Instrumentation

- 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

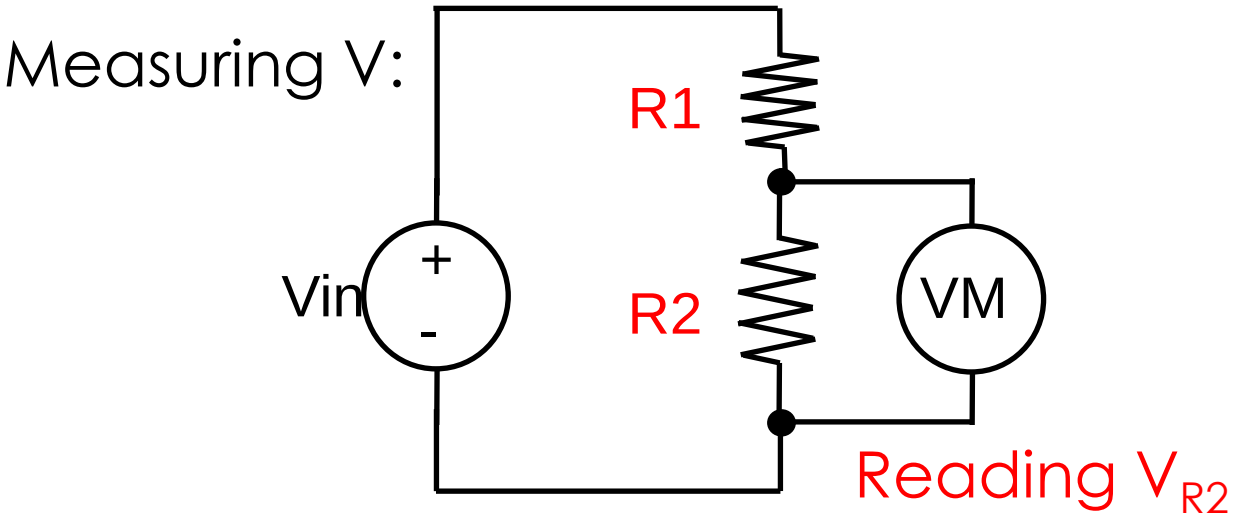
- Waveforms: Sine, square, triangle, sawtooth
- AC signal
- Parameters: Amplitude (Vpp), Frequency (Hz), Out Term (High-Z or 50 Ω)

Power Supply



- DC
- COM = common reference node of circuit
- ⏚ = chassis/earth ground

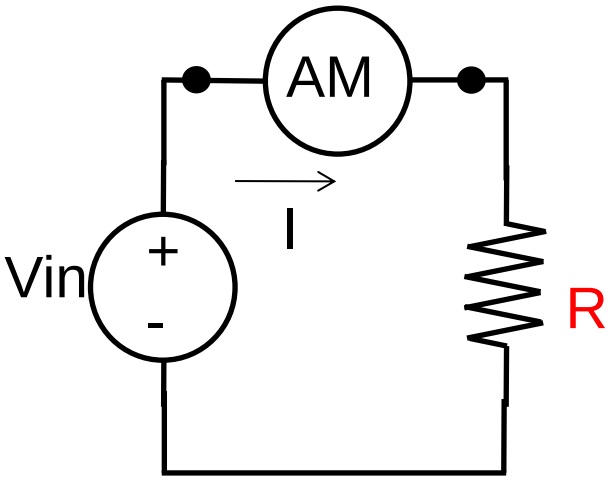
Multimeter- Voltage



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

Multimeter- Current

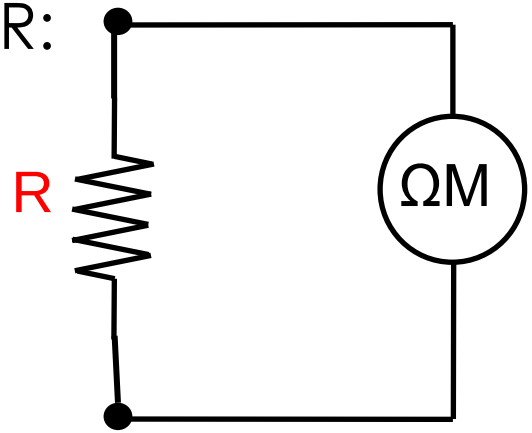
Measuring I:



- 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)
- ΩM has internal battery, so should not connect to active circuits such as power supply

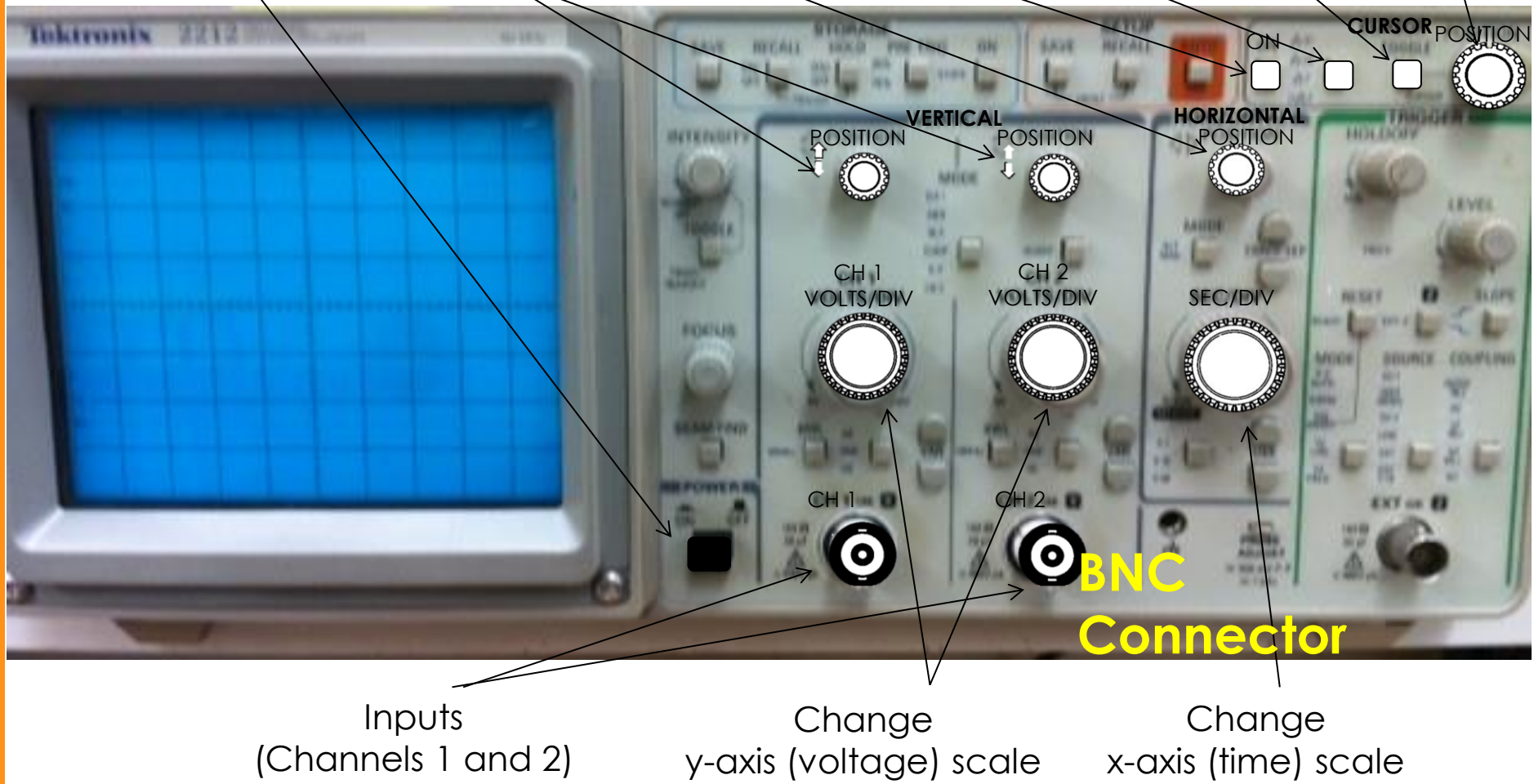
Multimeter –Digital vs. Analog

Simpson 260

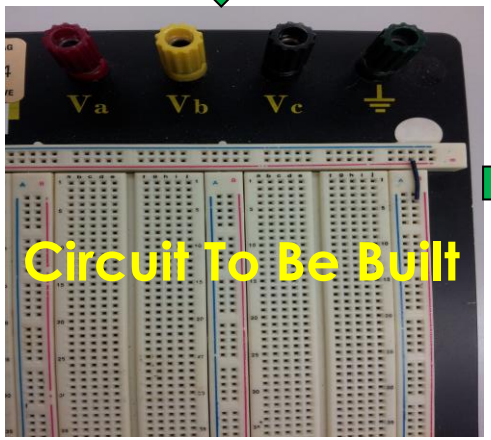
HP34401A
(in E80/VLSI lab)

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

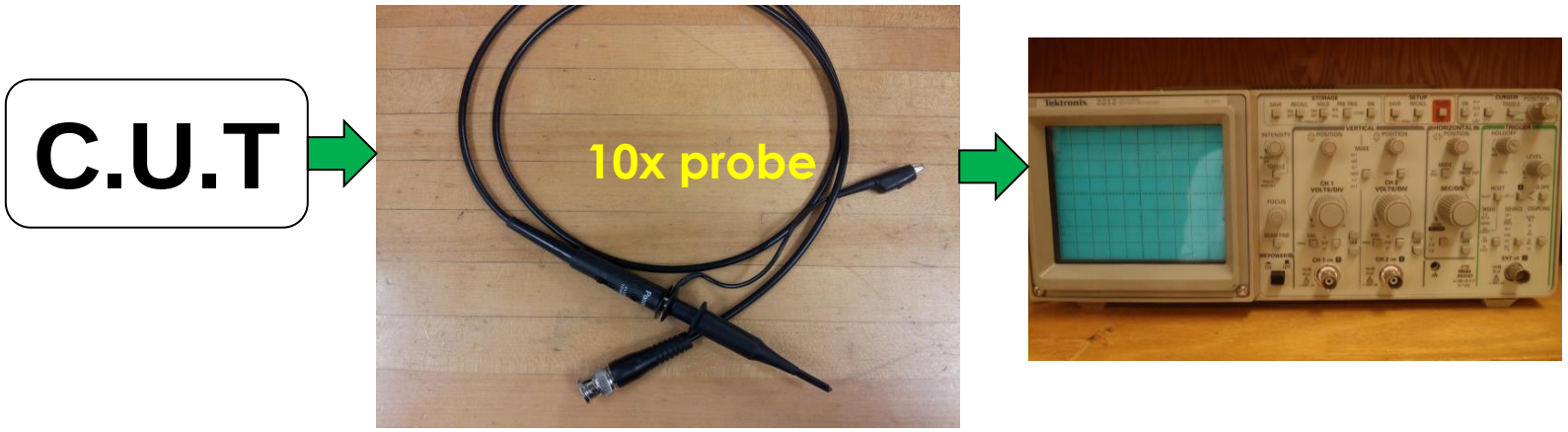
Oscilloscope:
Voltage Measurement (Time domain)



Oscilloscope Probe

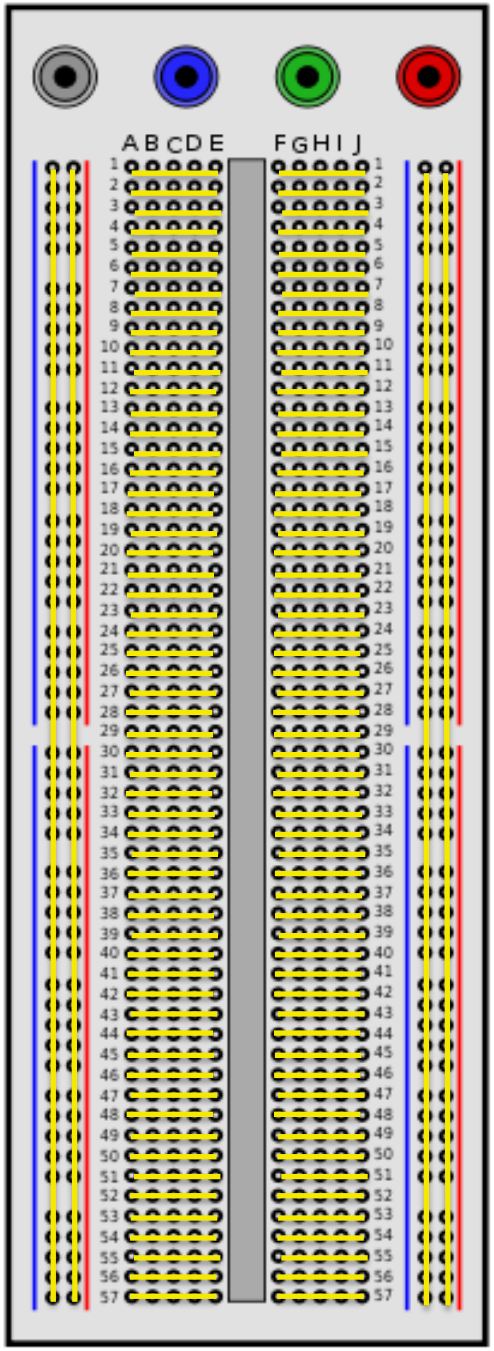


Oscilloscope Probe



- Oscilloscope: 1MΩ input resistance, 20pF capacitance
- Coax cable capacitance typically ~ 100pF
- 10x probe: 9MΩ, 1/9*(120pF). **Improved input impedance by a factor of 10 not only for low frequency but also for high frequency**
- Oscilloscope bandwidth 60MHz
- Tuning of 10x probe (instruction see BEM guide)

Breadboard (Protoboard)



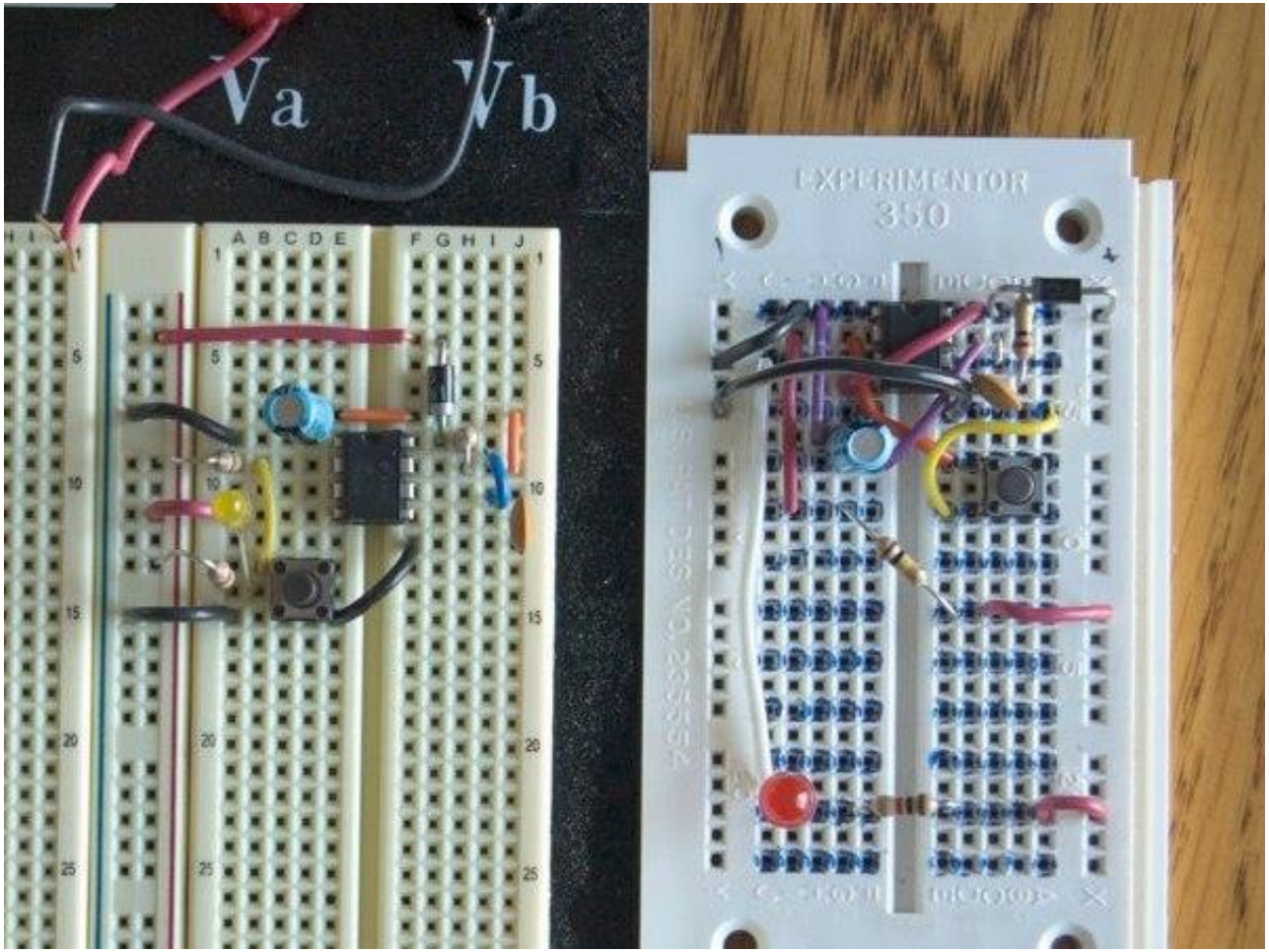
Use long busses for power and ground:
Don't use them for signals

Color-code wires:
Red = V+ power
Black = V– power
Green = ground
White or Blue = signal

Keep components close to the board:
Trim resistors, capacitors, wires

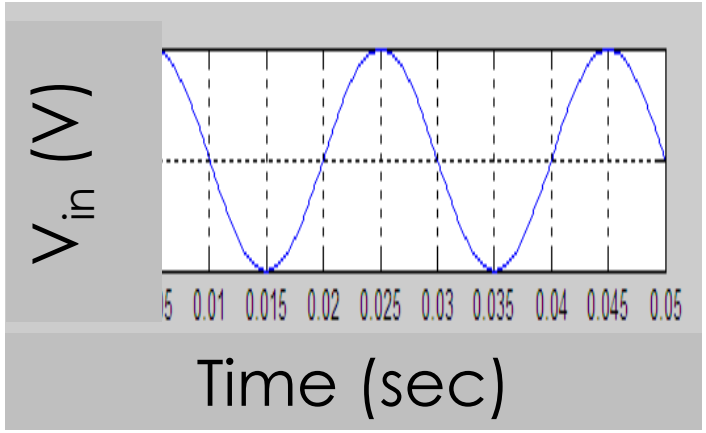
Check individual component before constructing the whole circuit

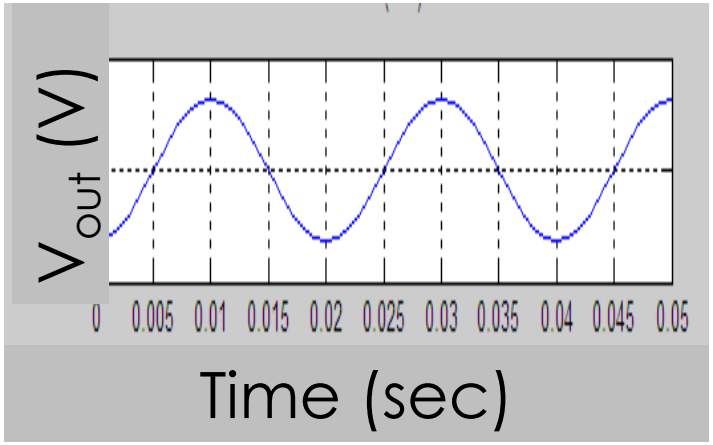
Pay Attention to Details and Practice

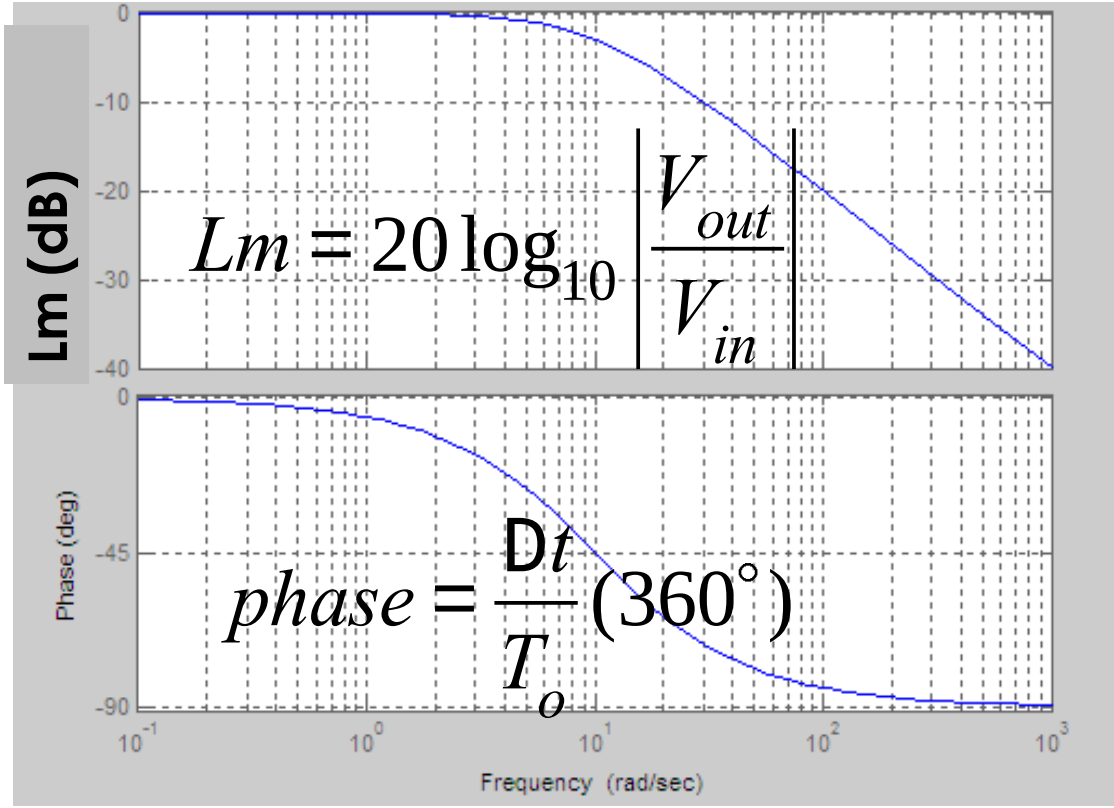


http://makezine.com/2010/03/22/improving-breadboard-layout-through/

Data Organization



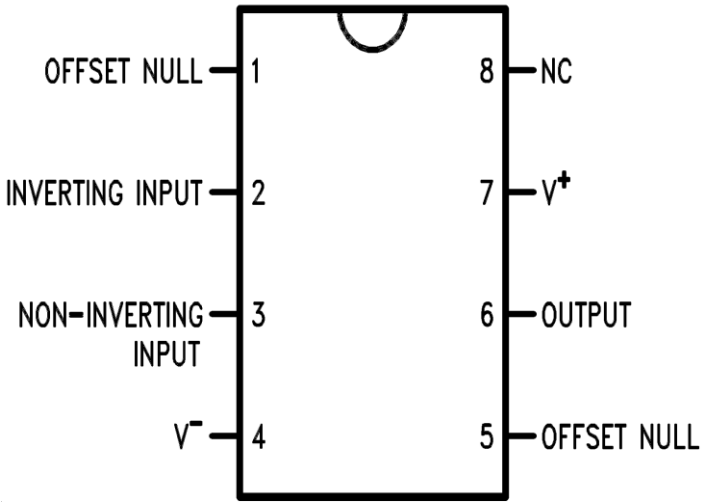




How many data points to take?
Useful data analysis tool?
DAQ and LabVIEW (automation)?

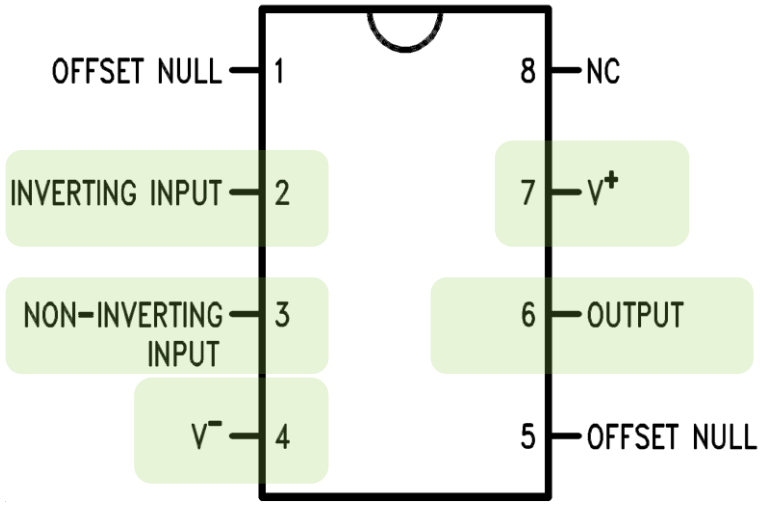
Introduction to Opamp

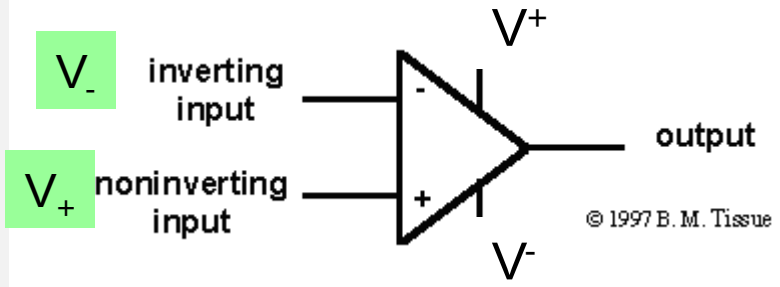
- Characteristics
- Simple analysis procedure
- Construct unity-gain amplifier or buffer



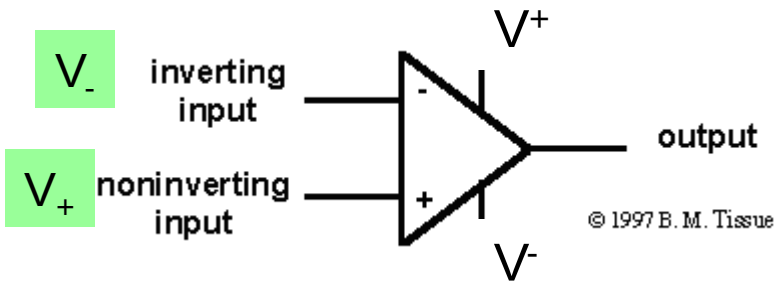
Introduction to Opamp

- Active components→ provide power gain, requires power supply V^+ and V^-
- Dual polarity vs. single polarity power supply
- $V_{out}=A(V_+-V_-)$





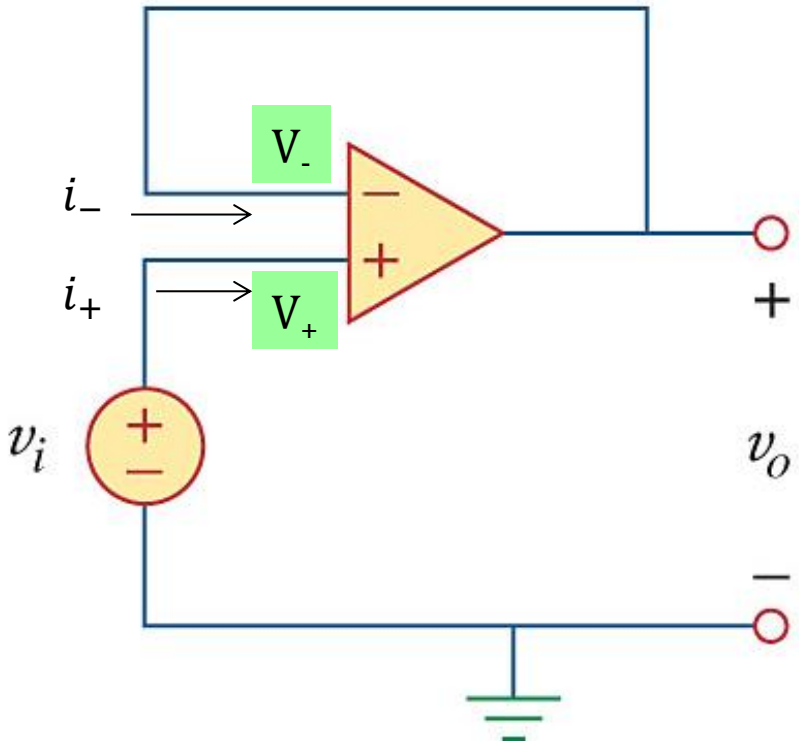
Characteristics of Opamp



System response: $V_{out}=A(V_+-V_-)$

- Typical $A=10^5 \rightarrow$ $V_+ \cong V_-$ (since V_{out} is some finite value <power supply)
- Typical Rin=few MΩ → current into opamp = $i_- = i_+ \cong 0$

Unity Gain Amplifier



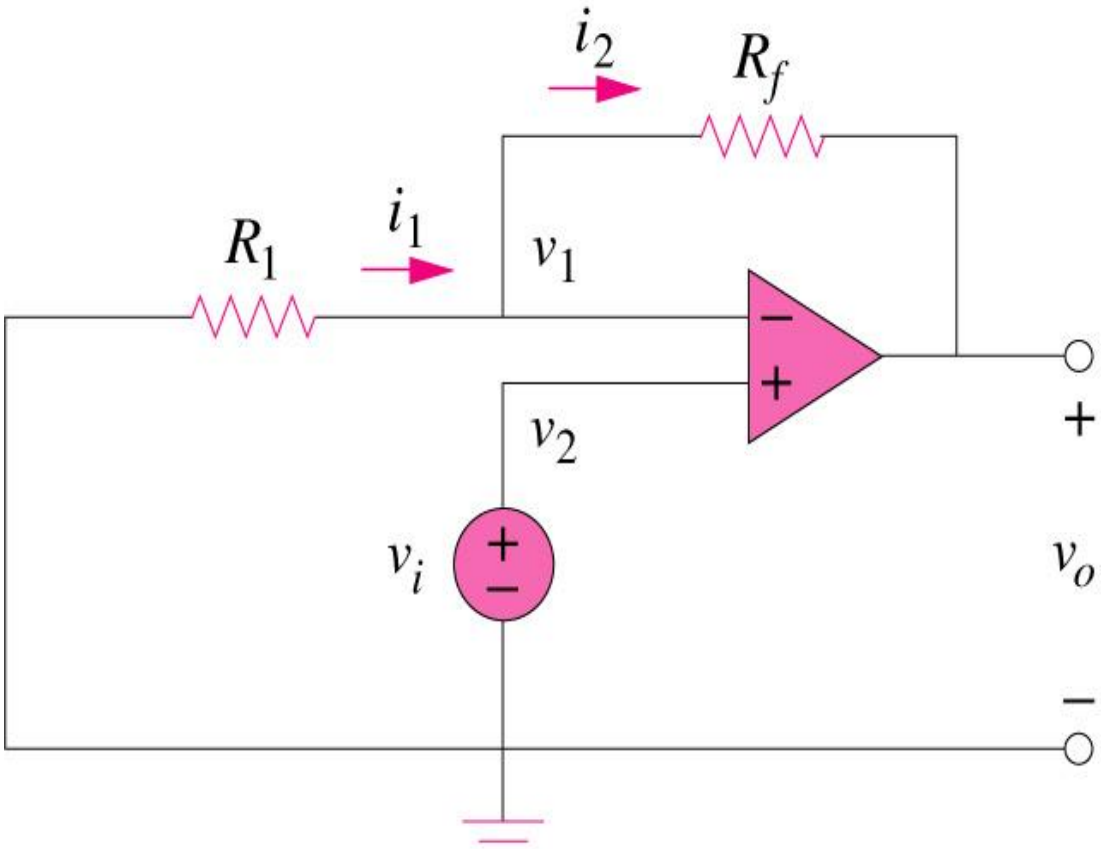
$V_+ \cong V_-$

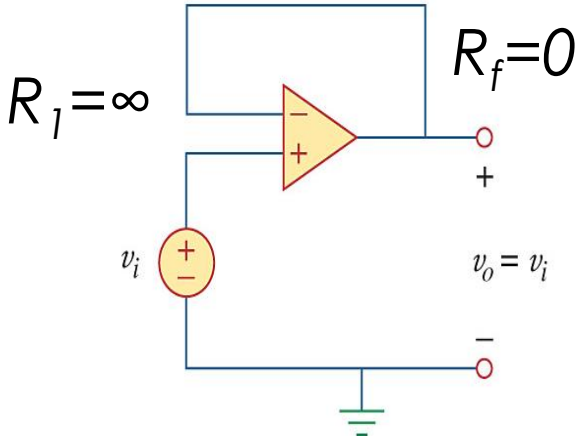
$i_- = i_+ \cong 0$

$v_0 = ?$

What is the purpose of this buffer?

Non-inverting amplifier





$$\frac{v_0}{v_i} = 1 + \frac{R_f}{R_1}$$