Basic Electrical Measurements

Matthew Spencer
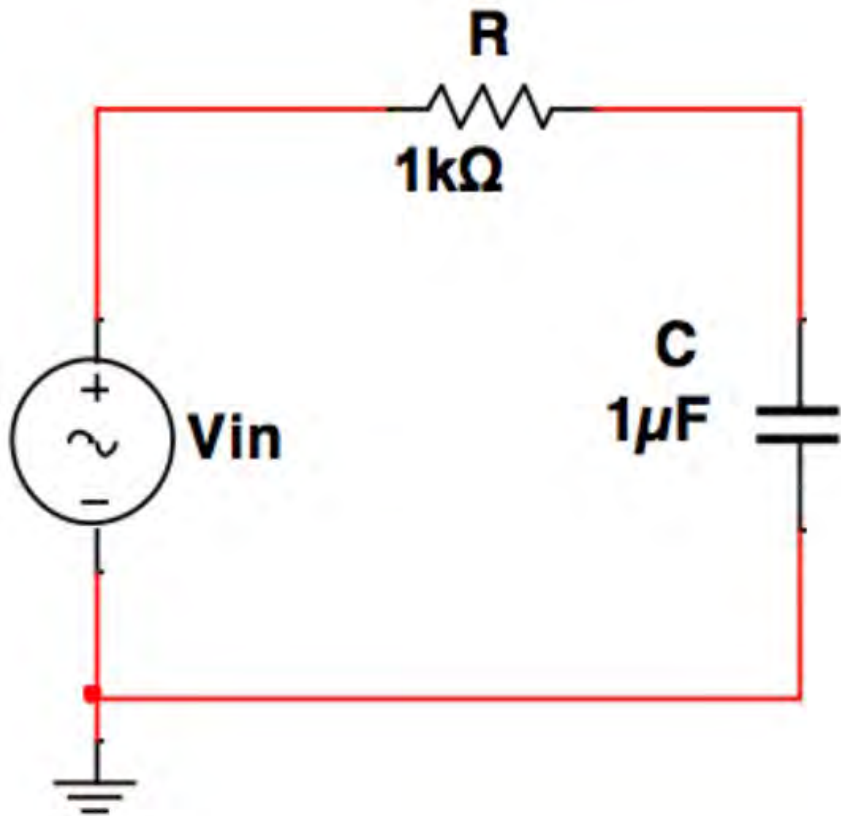
E80 Lecture 4

2016-01-27

Many thanks to Prof. Lee for her excellent work on the lecture figures
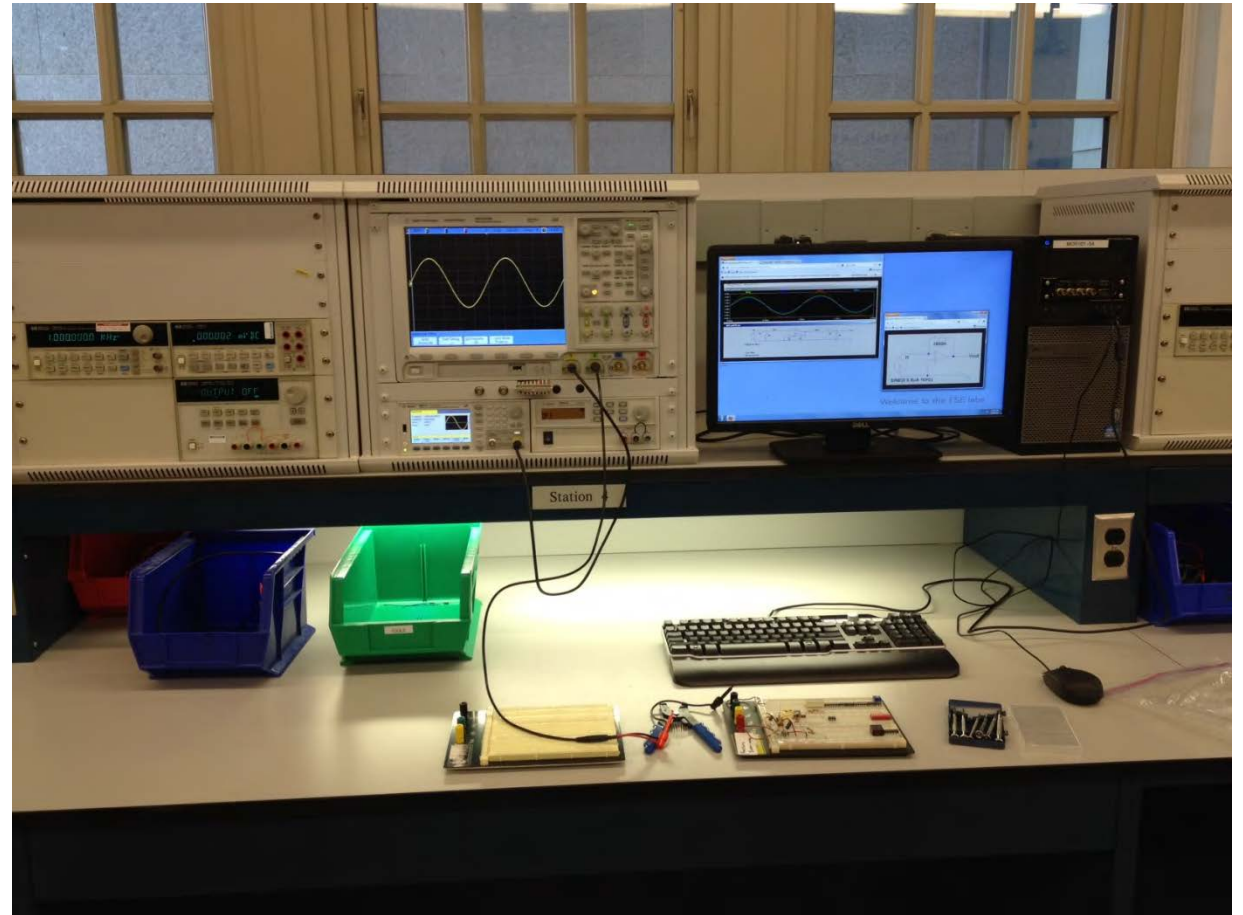
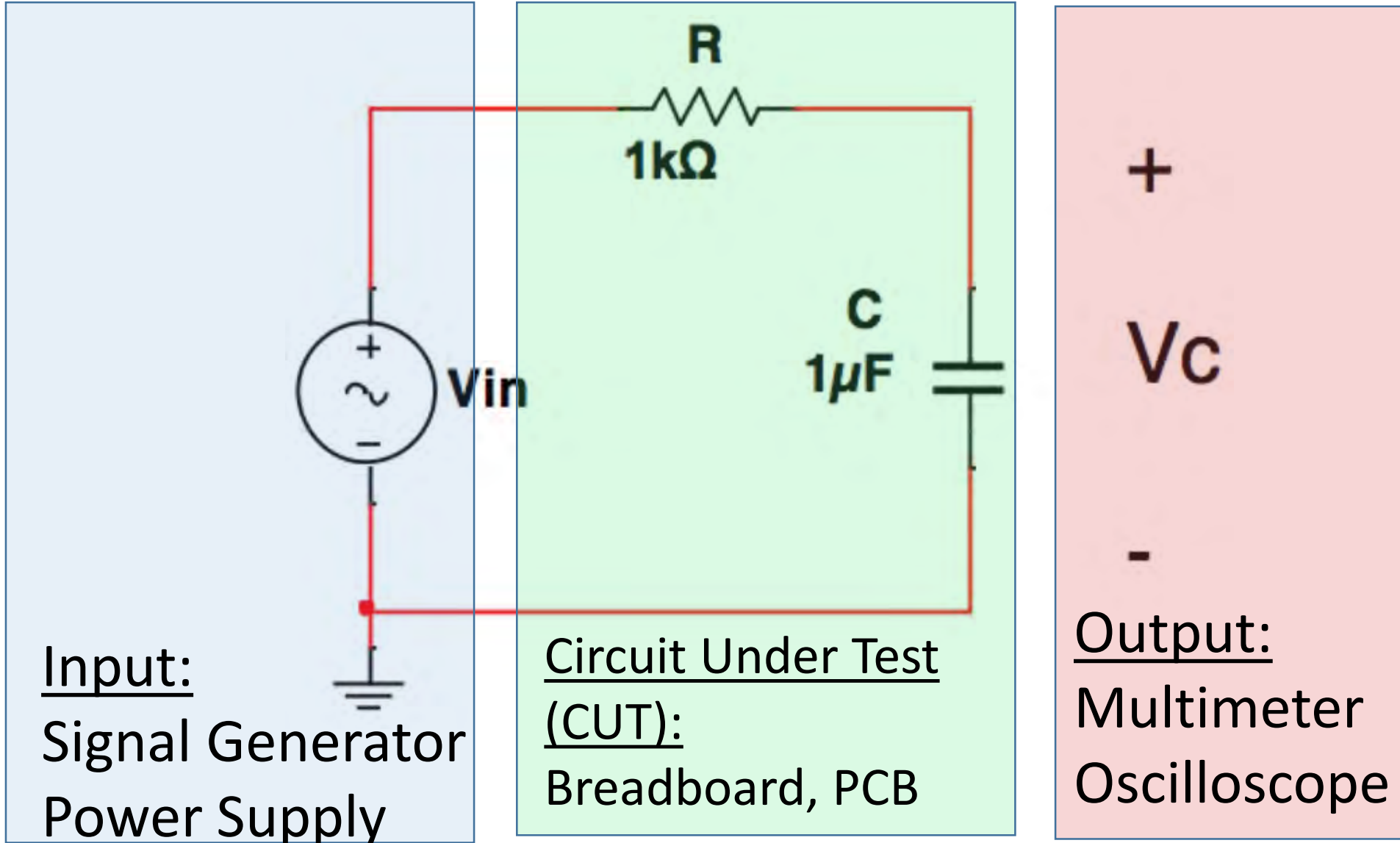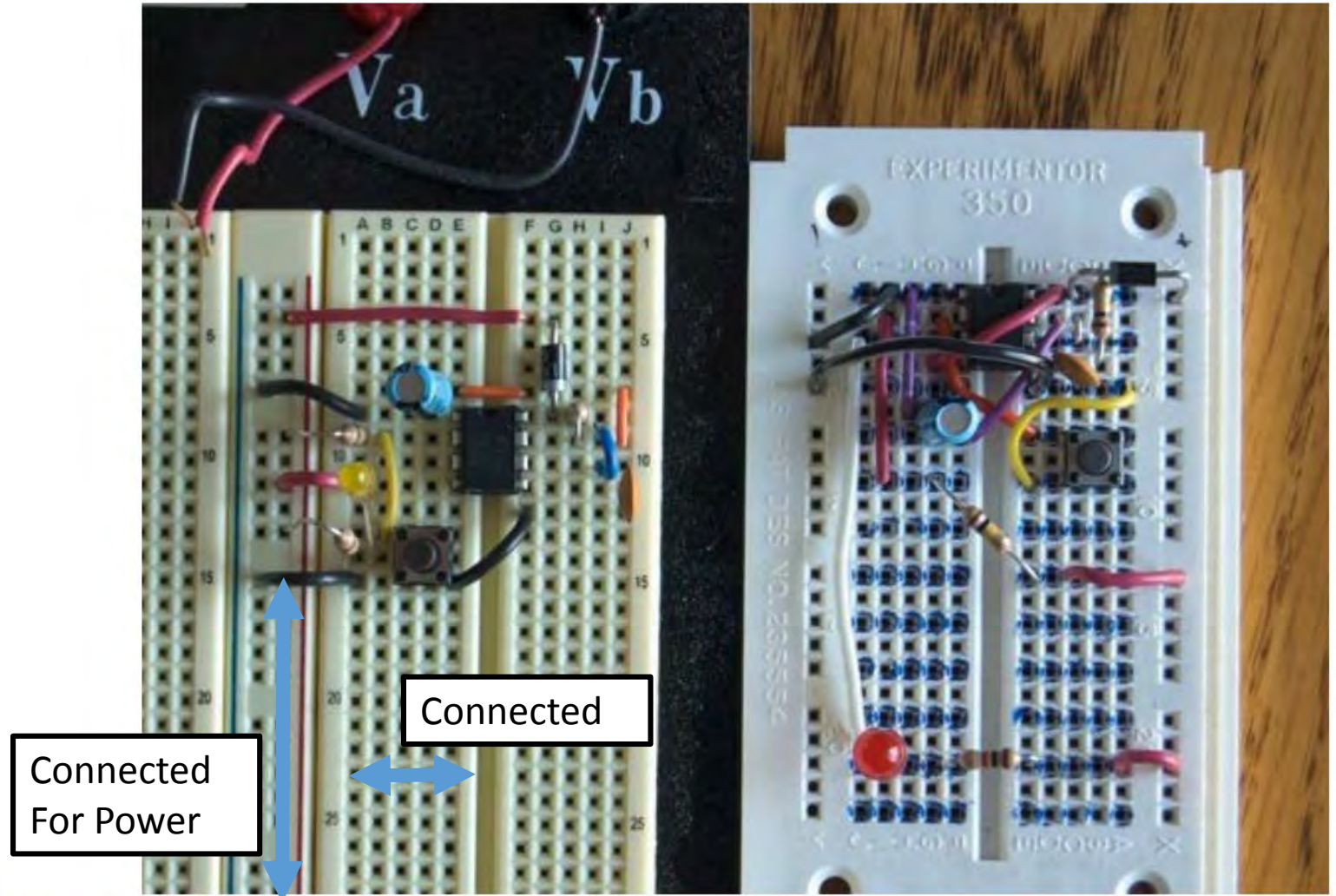# Why are We Talking?

GIVEN: Schematics

DESIRE: Experiments

http://positron.hep.upenn.edu/wja/p364/2012/detkin_lab_bench_2012.jpg

The Three Parts of a Schematic

R

1kΩ

Vin

C

1μF

+

Vc

-

Input:

Signal Generator
Power Supply

**Circuit Under Test
(CUT):**
Breadboard, PCB

Output:
Multimeter
Oscilloscope

A Circuit Under Test

Stuff to notice:

- Breadboard Routing

- Layout Sins

- Parasitic Elements

- Color Coding

Connected

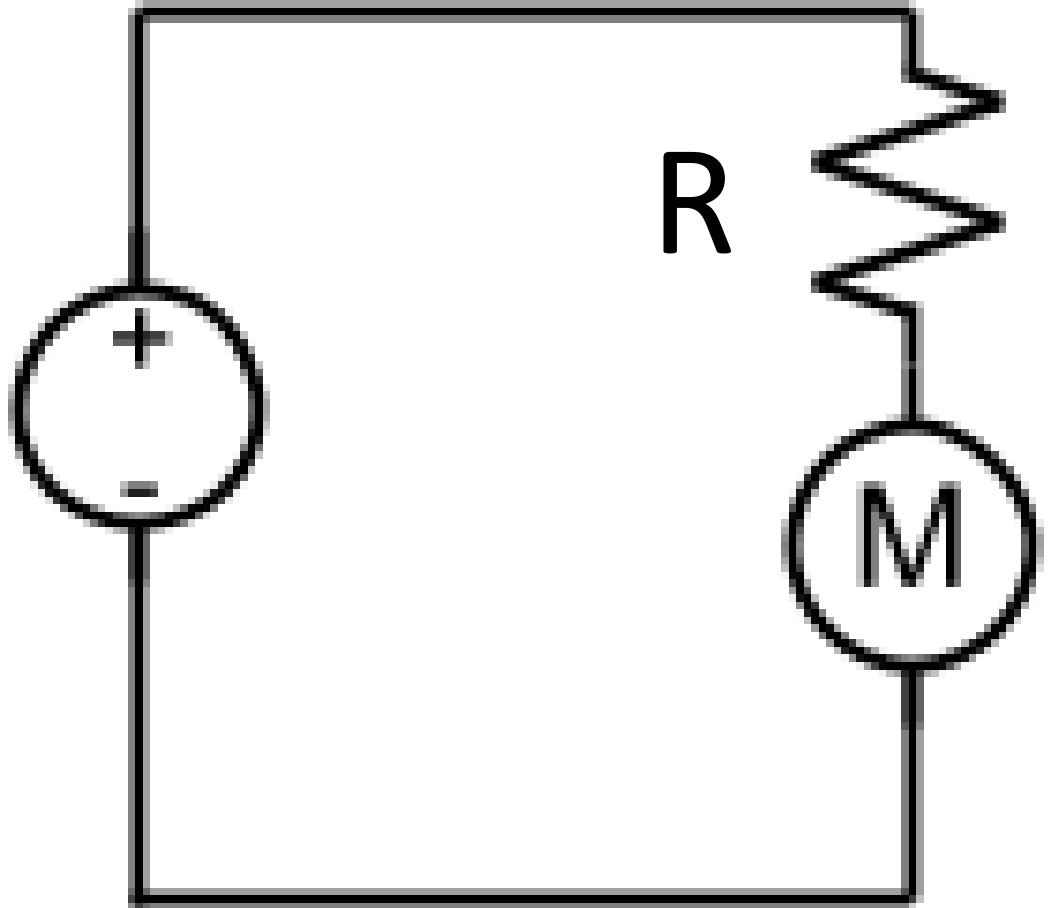Connected For Power

Multimeter

Don't forget this

Two Tricky Things

- What the heck does AC RMS Mean?
  - To the board!
  - It is one number that describes the amplitude of a sine wave*
  - Specifically, it is the DC voltage which dissipates the same power in a resistor as a sine wave of amplitude $V_{ZeroPeak}$
  - $V_{RMS} = V_{ZeroPeak}/\sqrt{2}$ in a sinusoidal wave

- Why are there so many plug holes?
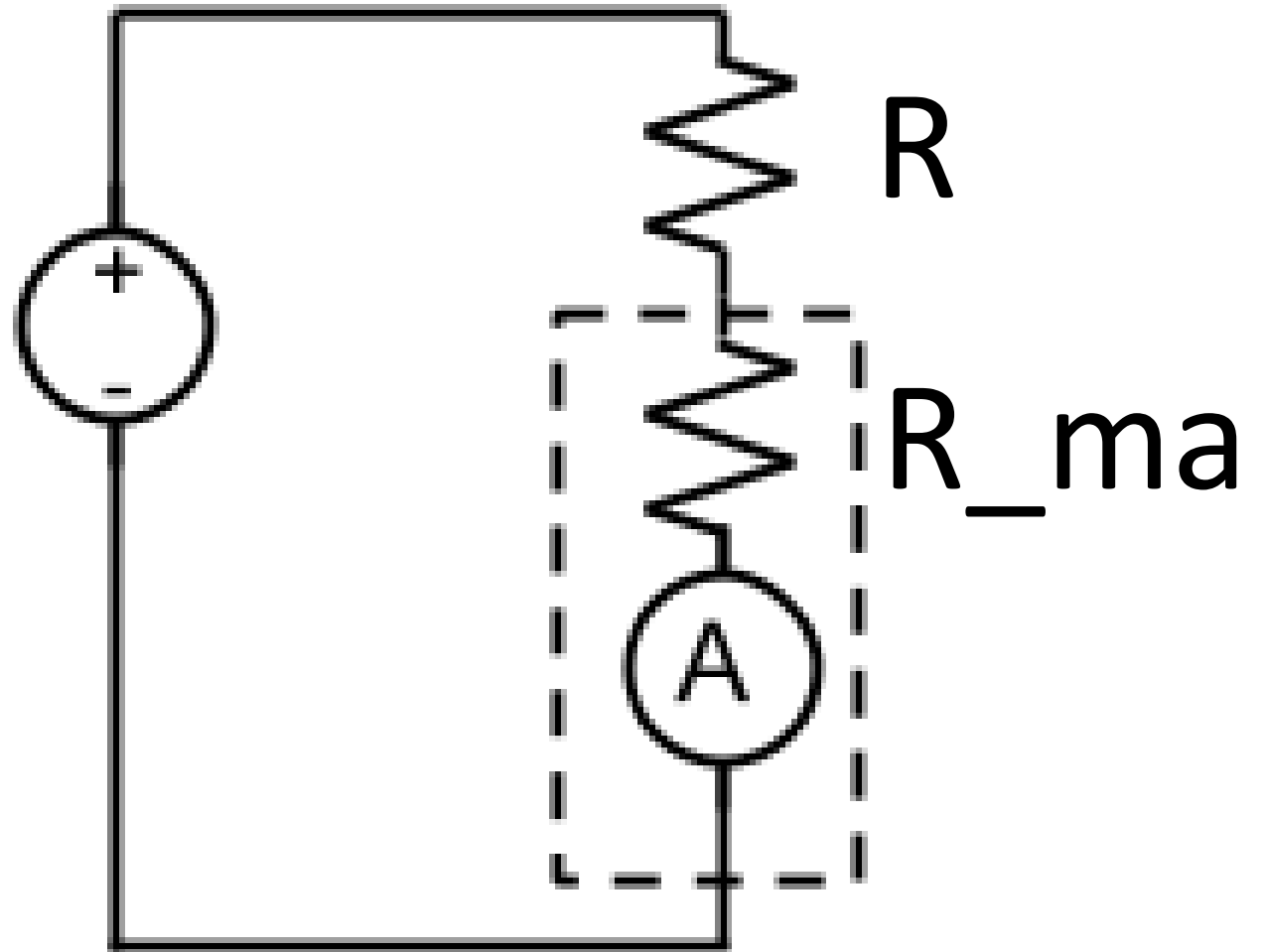 - Next few slides

Let's Do a Current Measurement

- Put multimeter in series

- Current flows through it

- Multimeter must look like a wire to be non-invasive
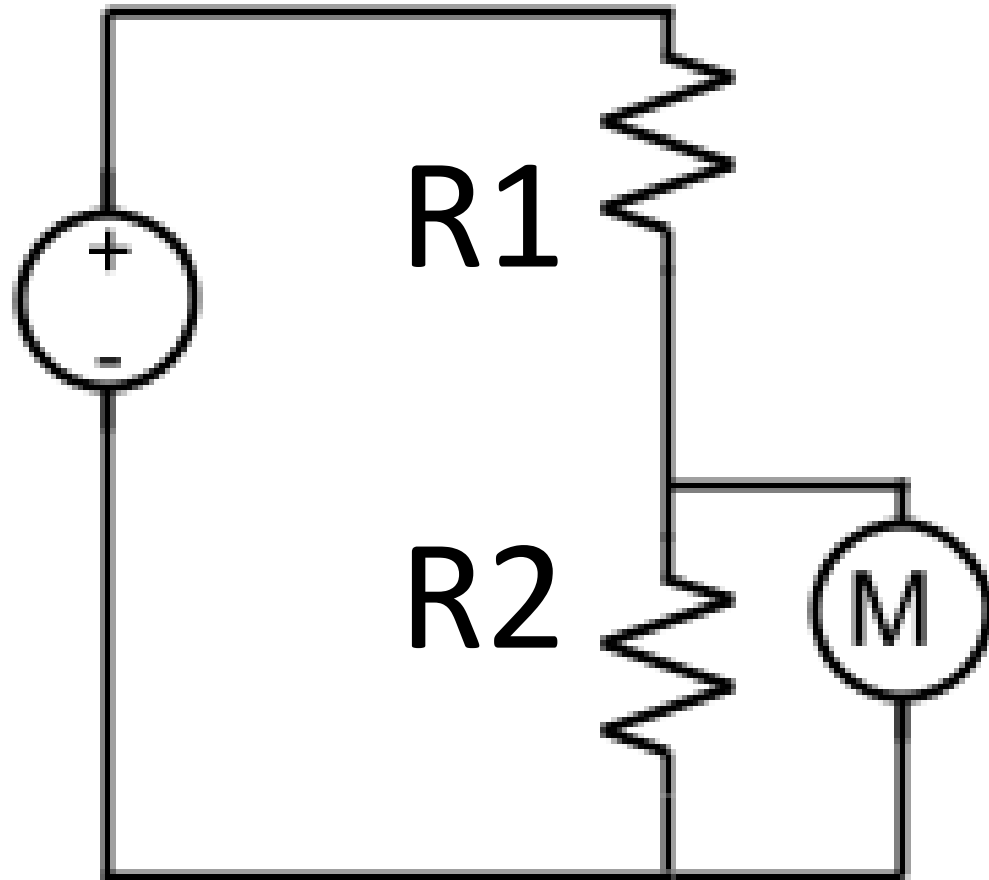
The Multimeter has Impedance

- R_ma is needed to take a measurement.

- Most of the time, this won't matter. It could for small R.
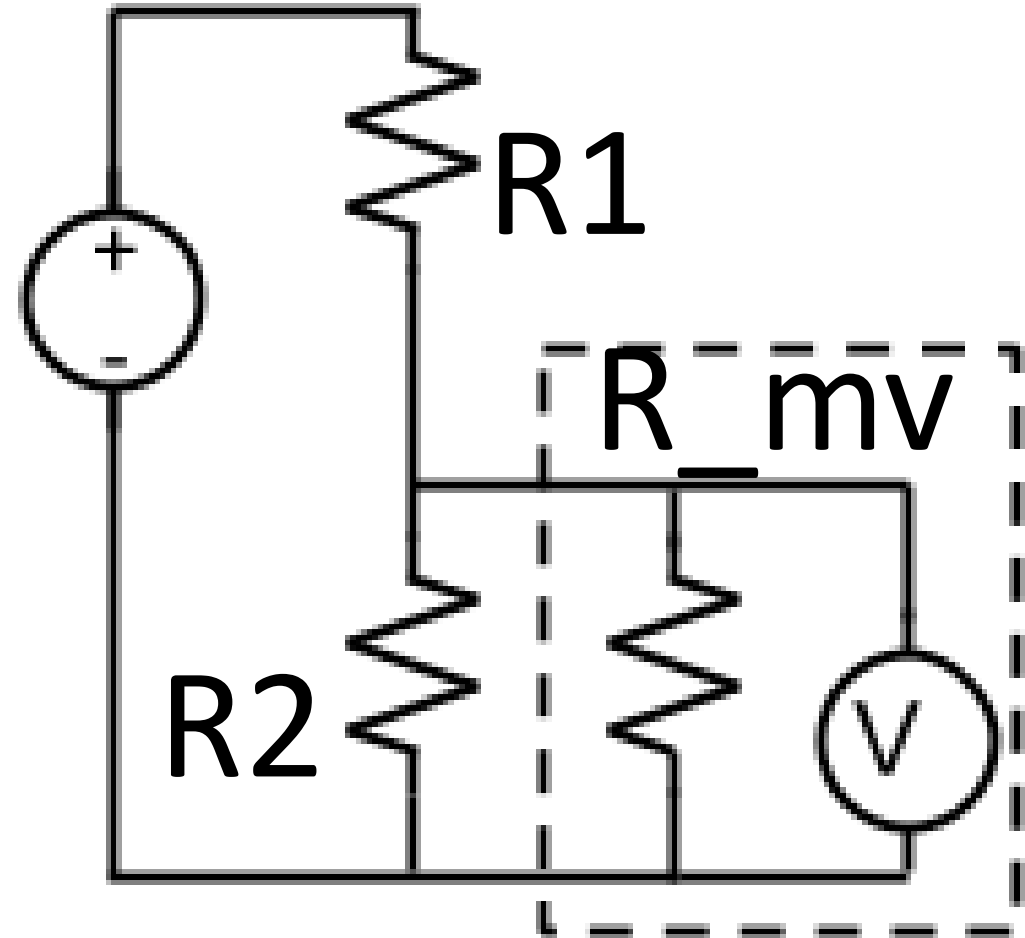
- Do analysis with equivalent circuit model if necessary.
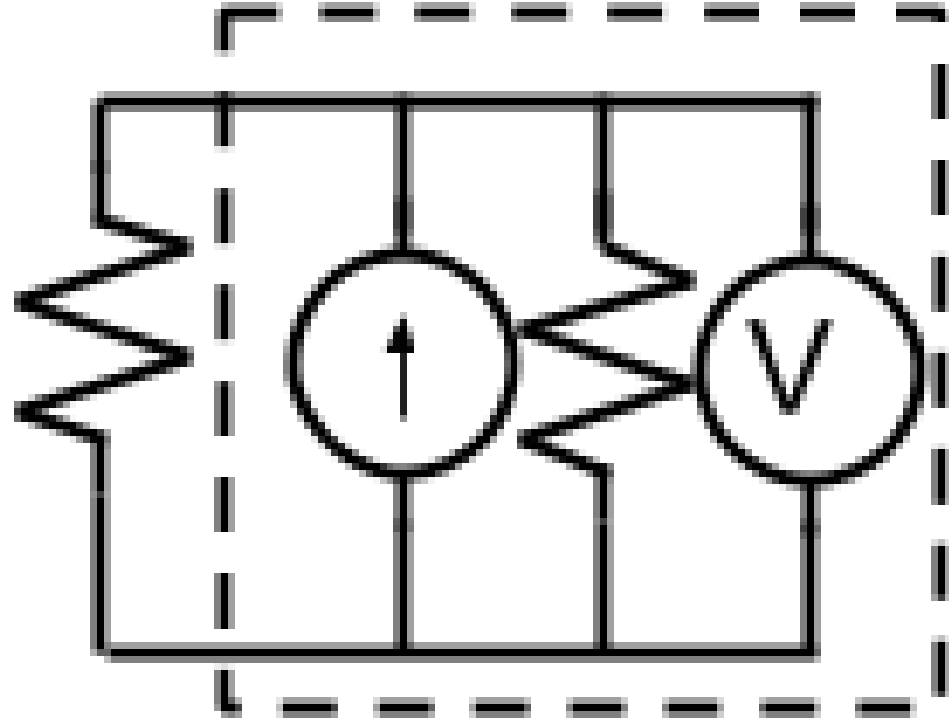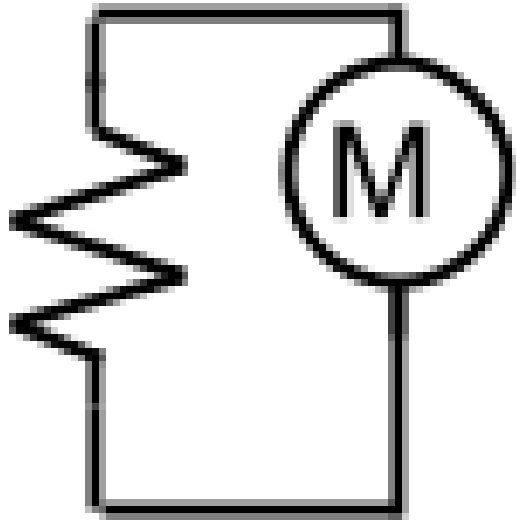
Let's do a Voltage Measurement

Schematic

Schematic w/ Eq. Ckt Model

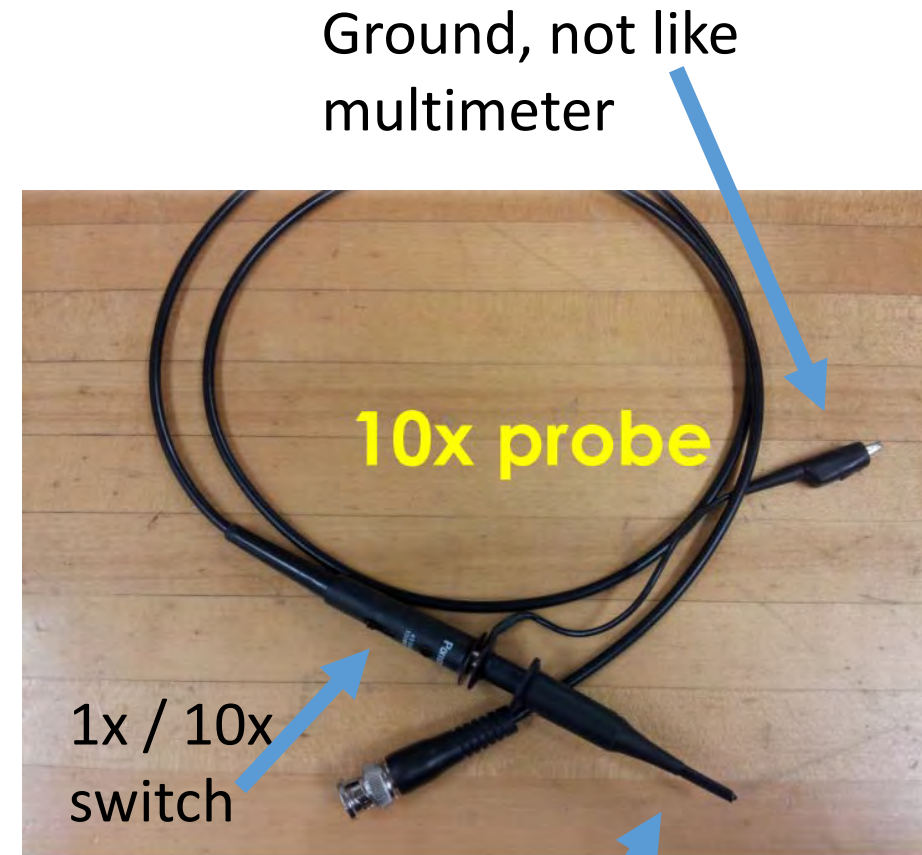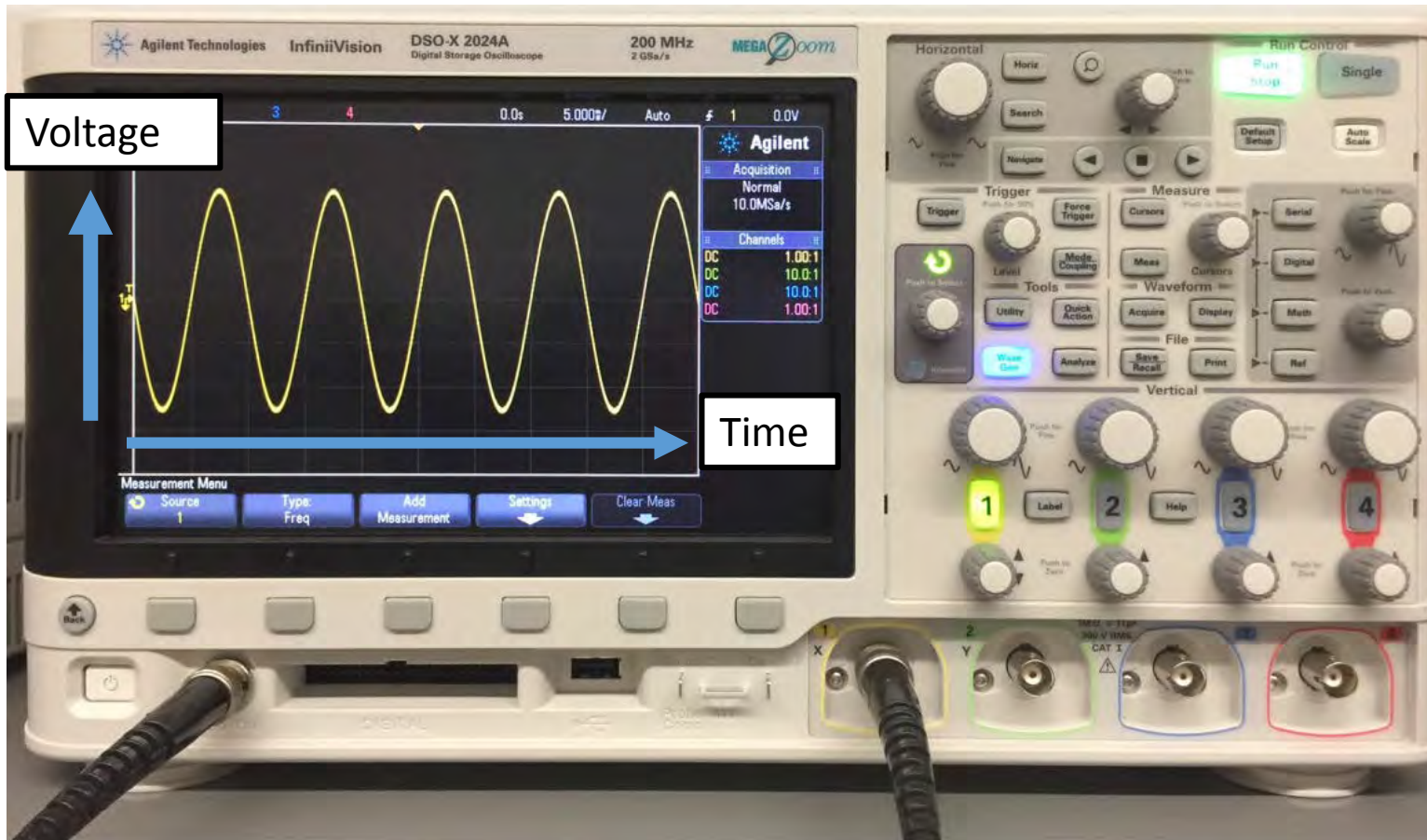# Let's do a Resistance Measurement

- Current source will do weird stuff if it interacts with chips

Oscilloscopes

Voltage

Time

Ground, not like multimeter

10x probe

1x / 10x switch

Signal

- Leave wires in your board, don't wrap around probes
- Don't lose probe hats!

Power Supplies Make DC Voltage

Use this to make negative V
Sets $\quad -1 * V_{-20}/V_{+20}$
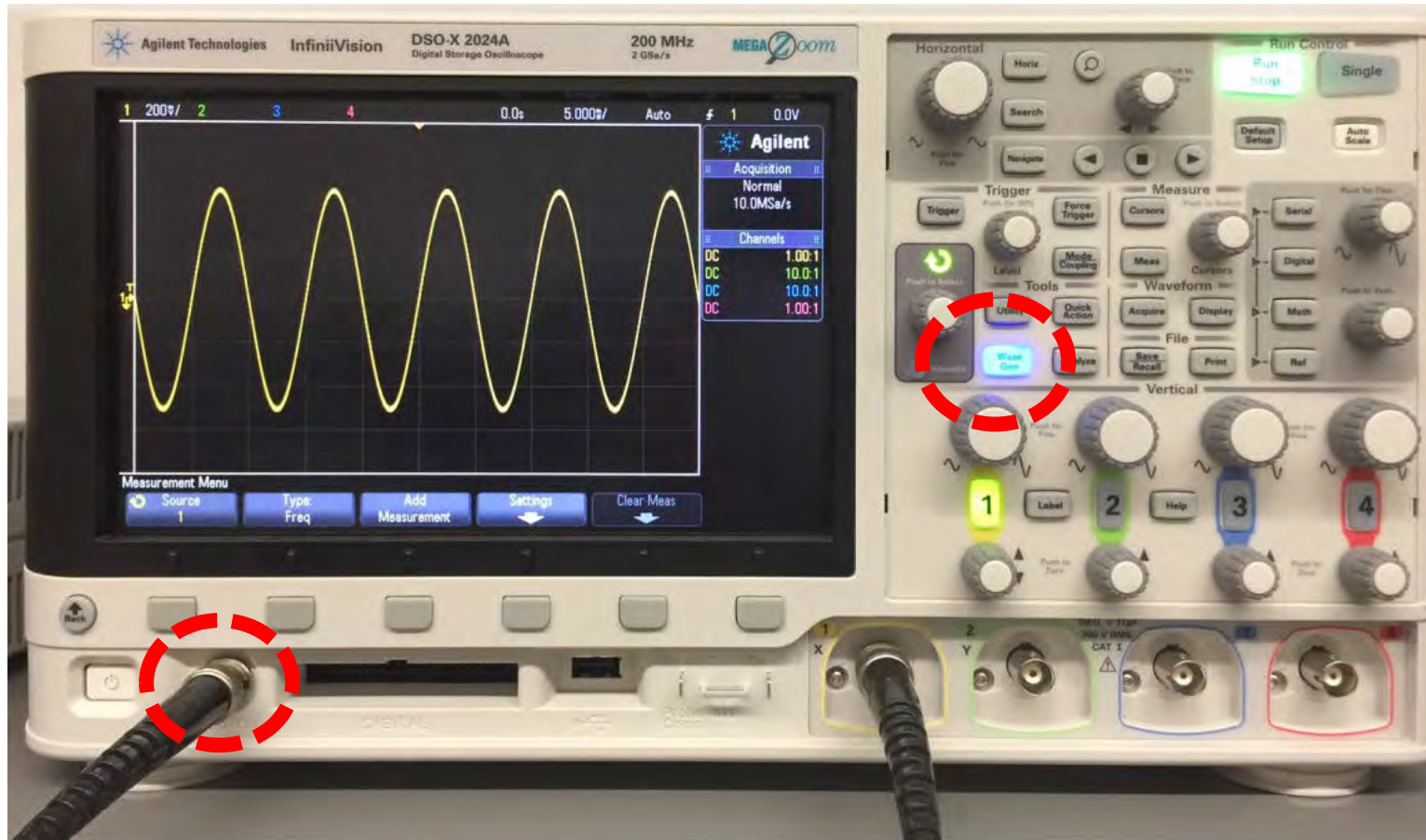
Circuit Ground
"Common" Node

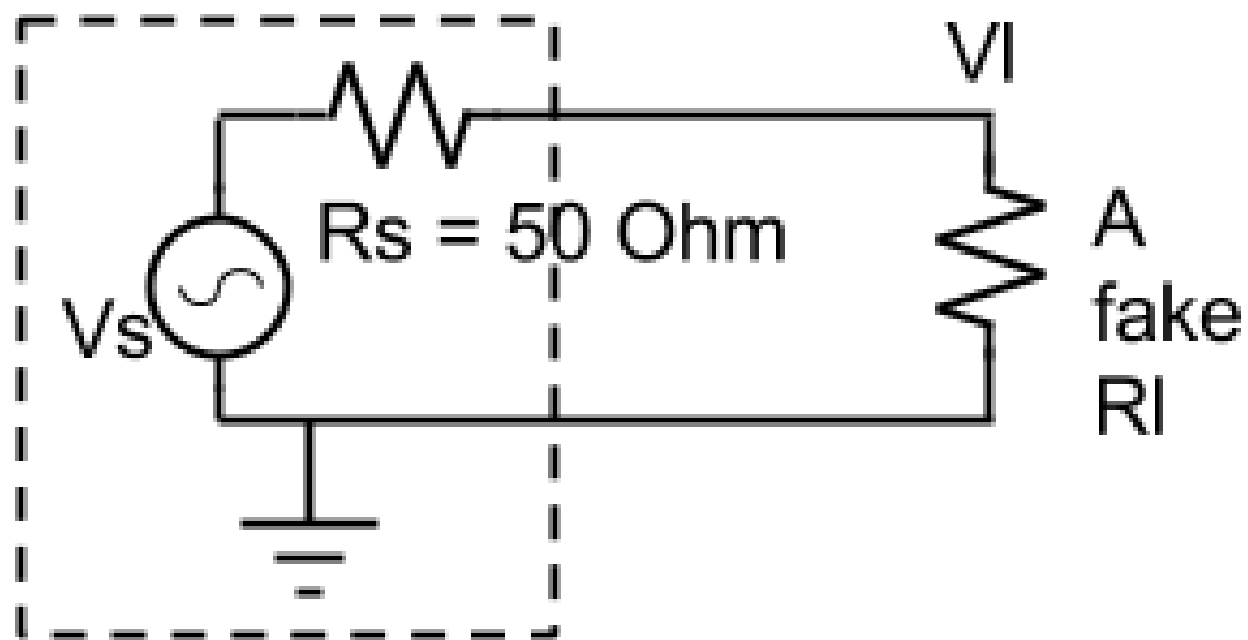Earth Ground
Connects to wire in wall

Old Signal Generators

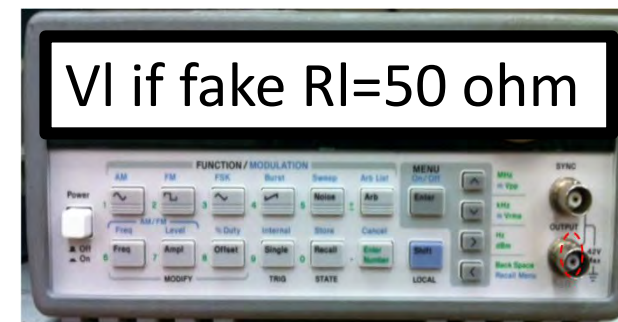

Bad Habit to use these for oscilloscopes

New Signal Generators

Model of Signal Generators and 50 Ohm/Hi Z

Rs = 50 Ohm

Vs

VI

A
fake
RI

Output term set to 50 Ohm

VI if fake RI=50 ohm

Output term set to Hi Z

VI if fake RI=infinity

- Output term has NO PHYSICAL EFFECT

- This confuses _lots_ of people. Use Hi-Z.

- I hate the 50 Ohm setting, but it has some historical significance related to high speed measurements.