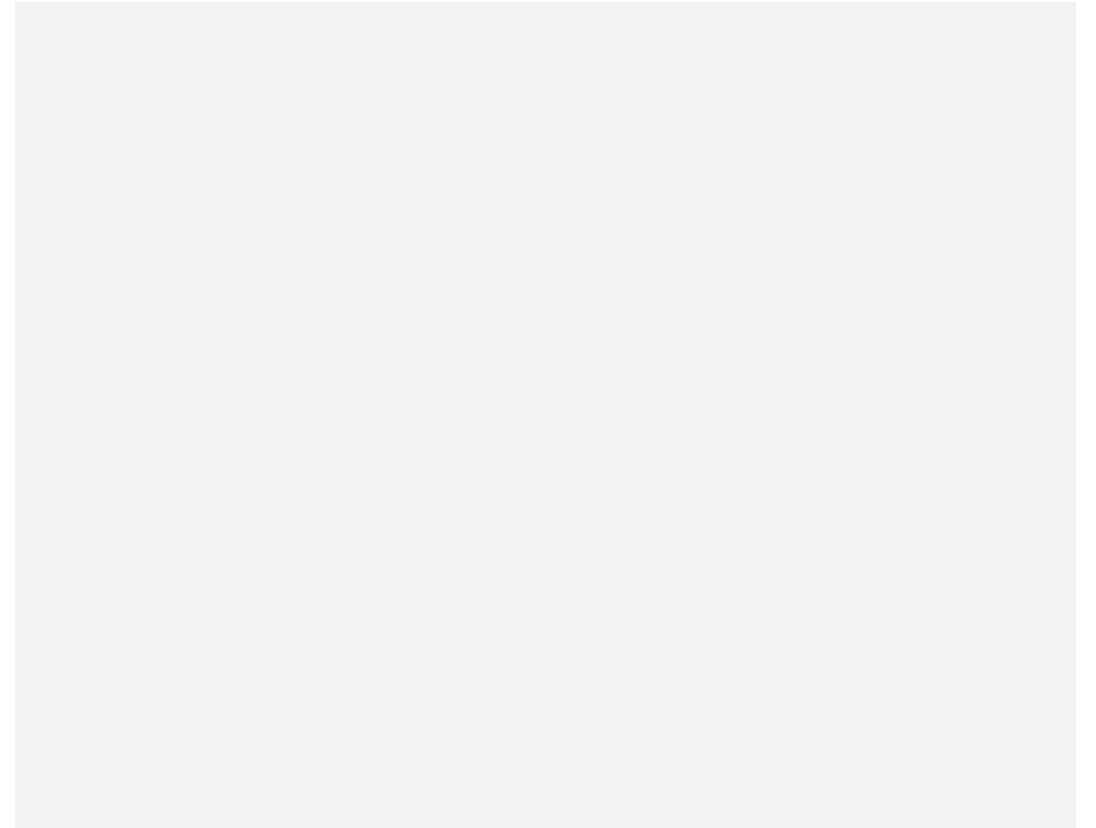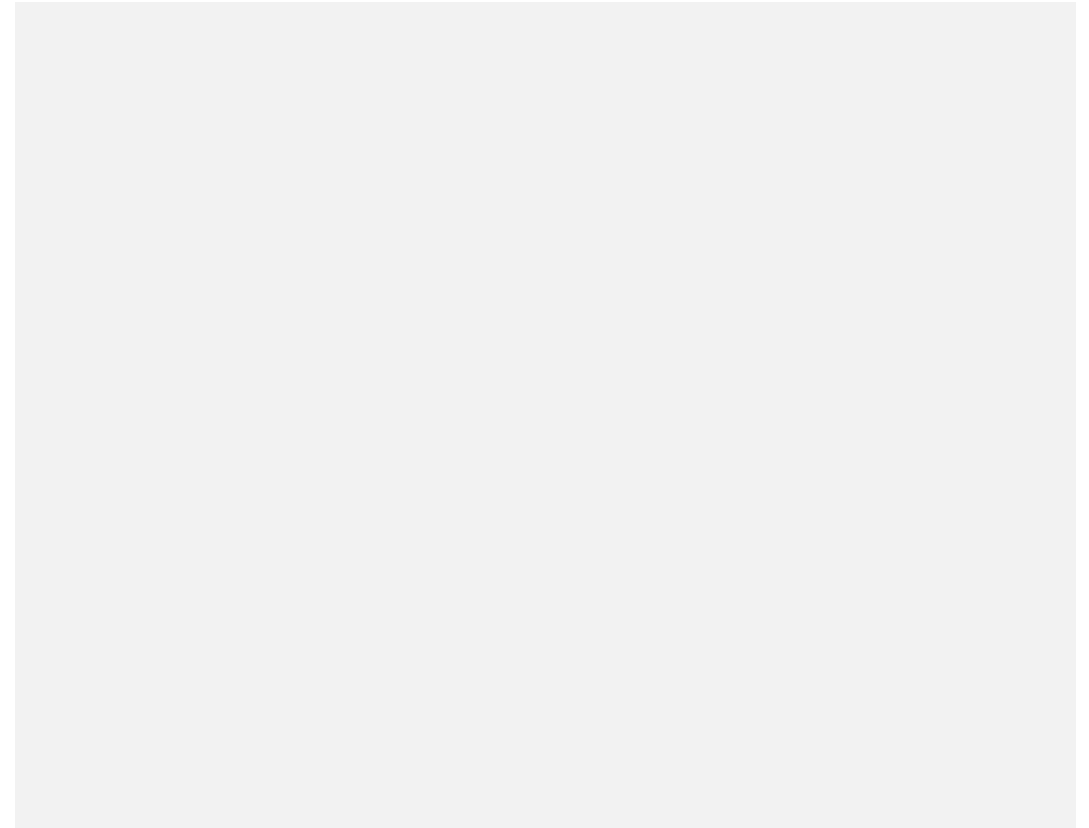# When to Use an Oscilloscope vs a DMM

Liz Makley

Agenda

- What is a DMM?
- What is an oscilloscope?
- Similarities
- Differences
- Application examples

What is a DMM?

- DMM = Digital Multimeter
- Unit for multiple different measurement functions
- Most common are DC voltage, DC current and resistance
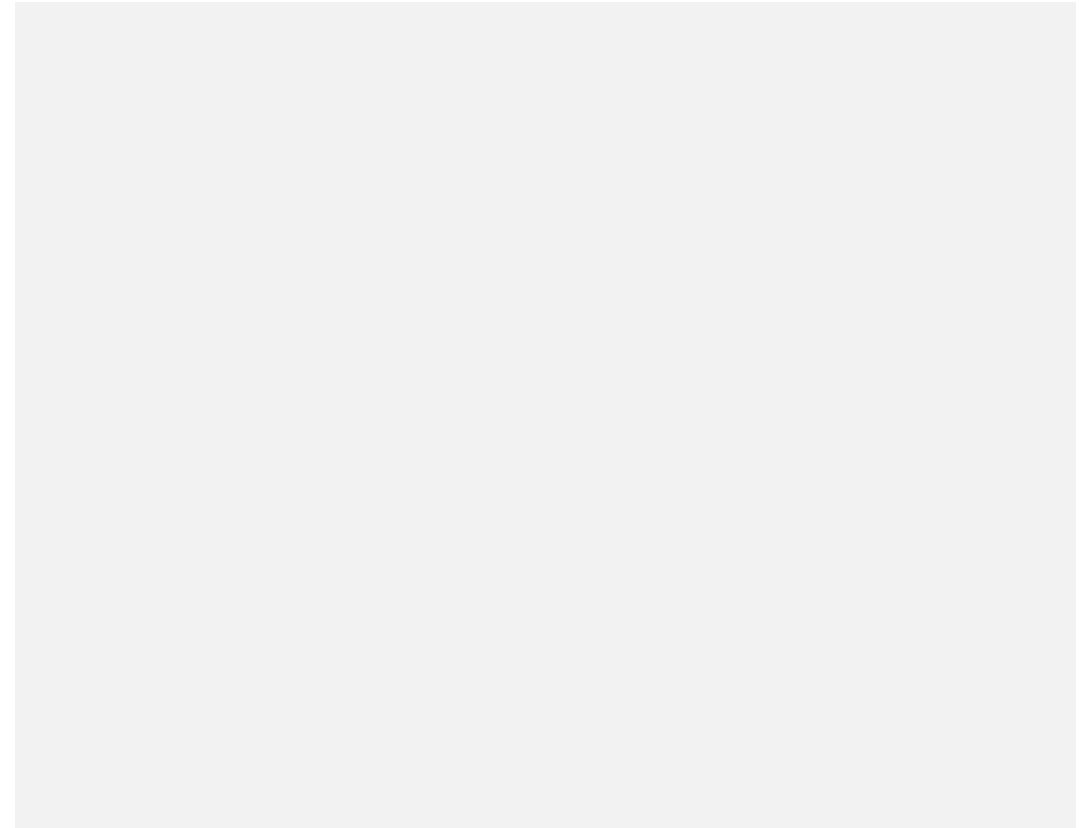- Measurement only!

Choosing a DMM

- Digits/Resolution
- Accuracy
- Function
- Programmability/Usability
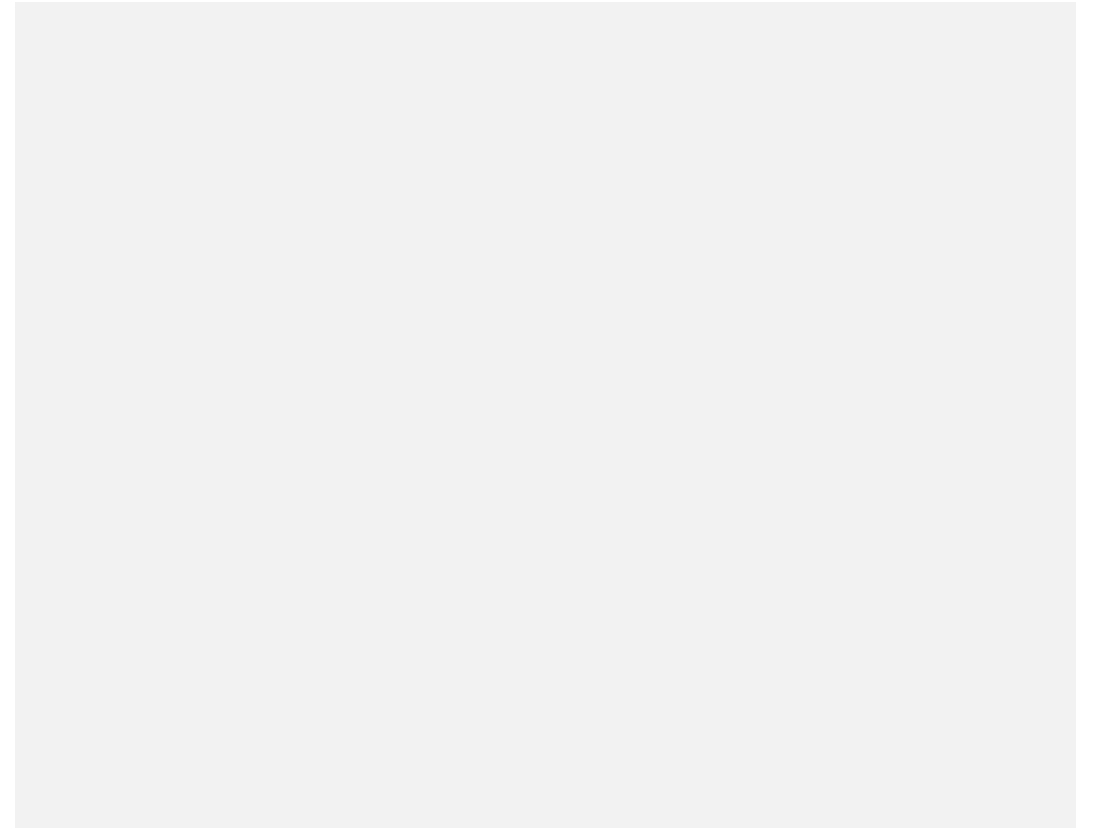
5 ½ Digits

7 ½ Digits

What is an Oscilloscope?

- Also measurement only
- Visual display of signals - time based measurement
- Measures voltage only
  - Different probes can allow us to measure other signals by converting to voltage signals
- Very wide variety of options

Choosing a Scope

- Types of Scopes:
  - Digital Storage (DSO)
  - Digital Phosphor (DPO)
  - Mixed Domain (MDO)
  - Mixed Signal (MSO)
  - Digital Sampling
- Main Features
  - Bandwidth
  - Waveform Capture Rate
  - Sample Rate
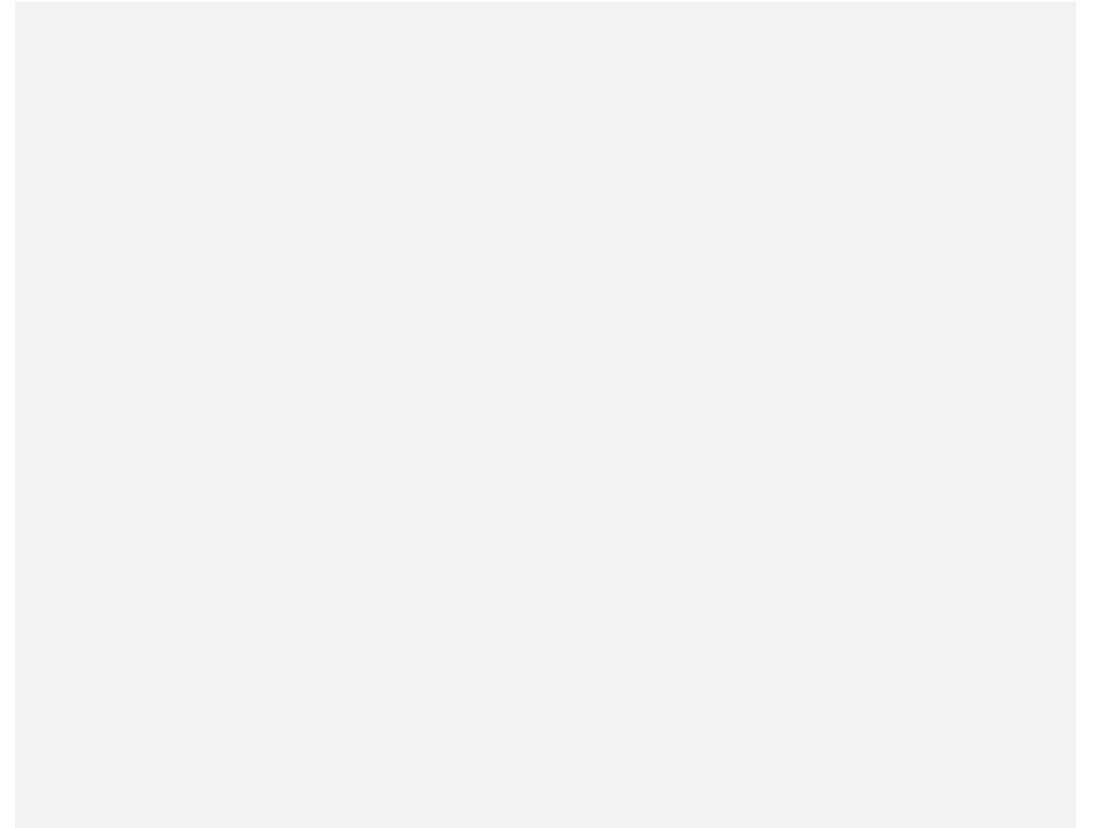 - Rise Time
  - Usability / Connectivity
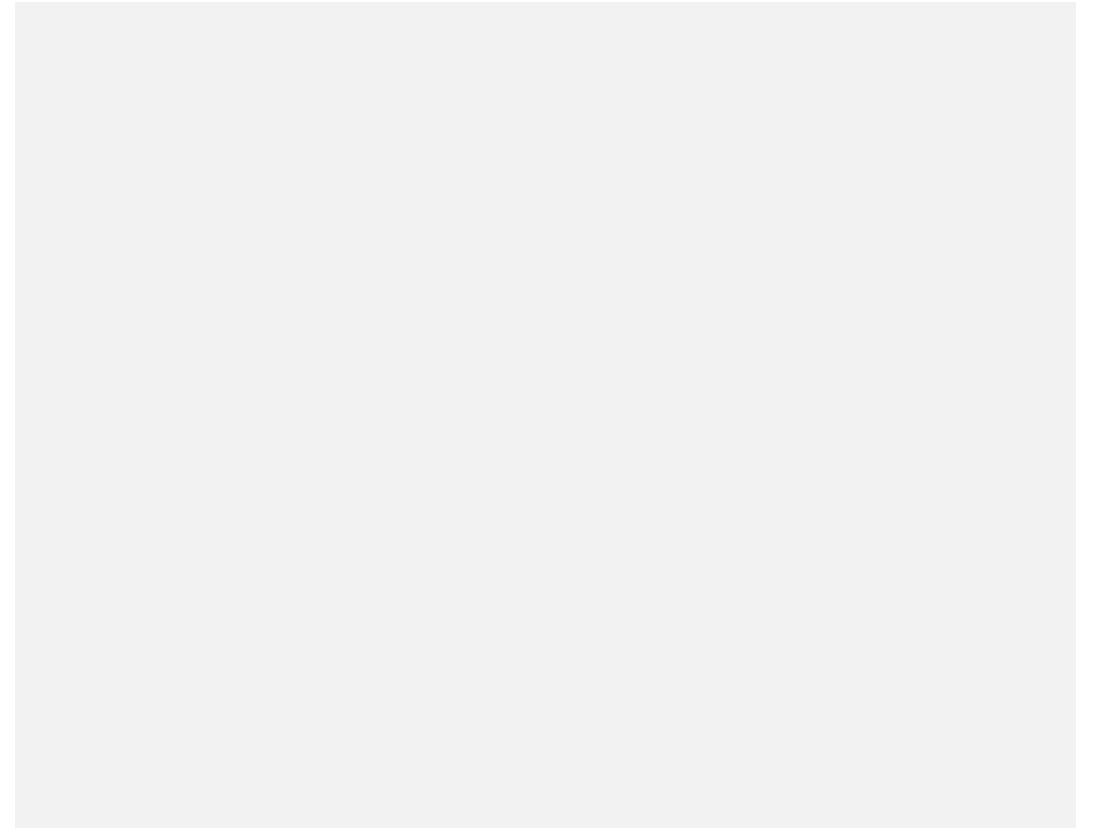
How are DMMs and Scopes Similar?

- Both measure electrical signals
- They can both measure DC and AC signals (with some limitations)
- Both are great for debugging circuits
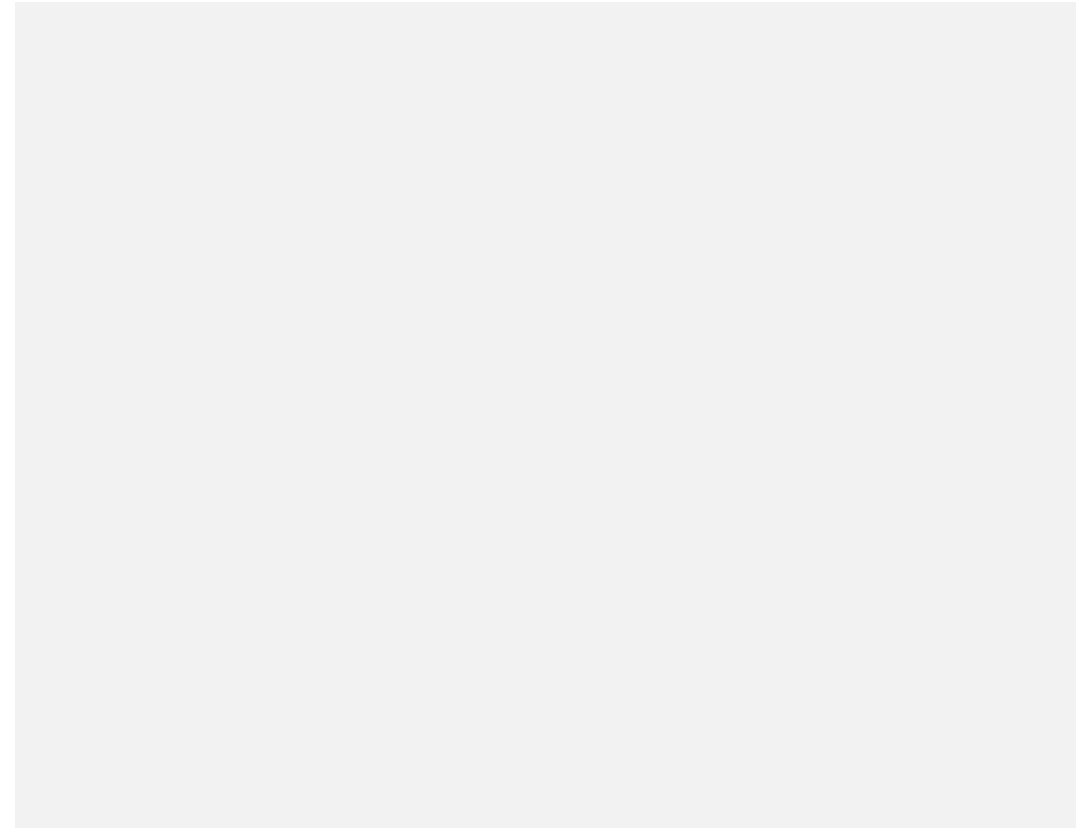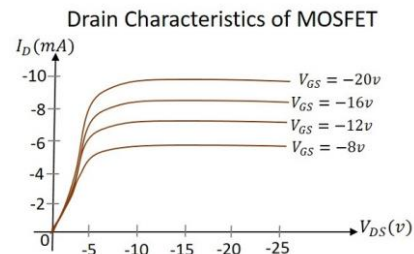- Scopes can have DMM functions, and DMMs can have digitizers
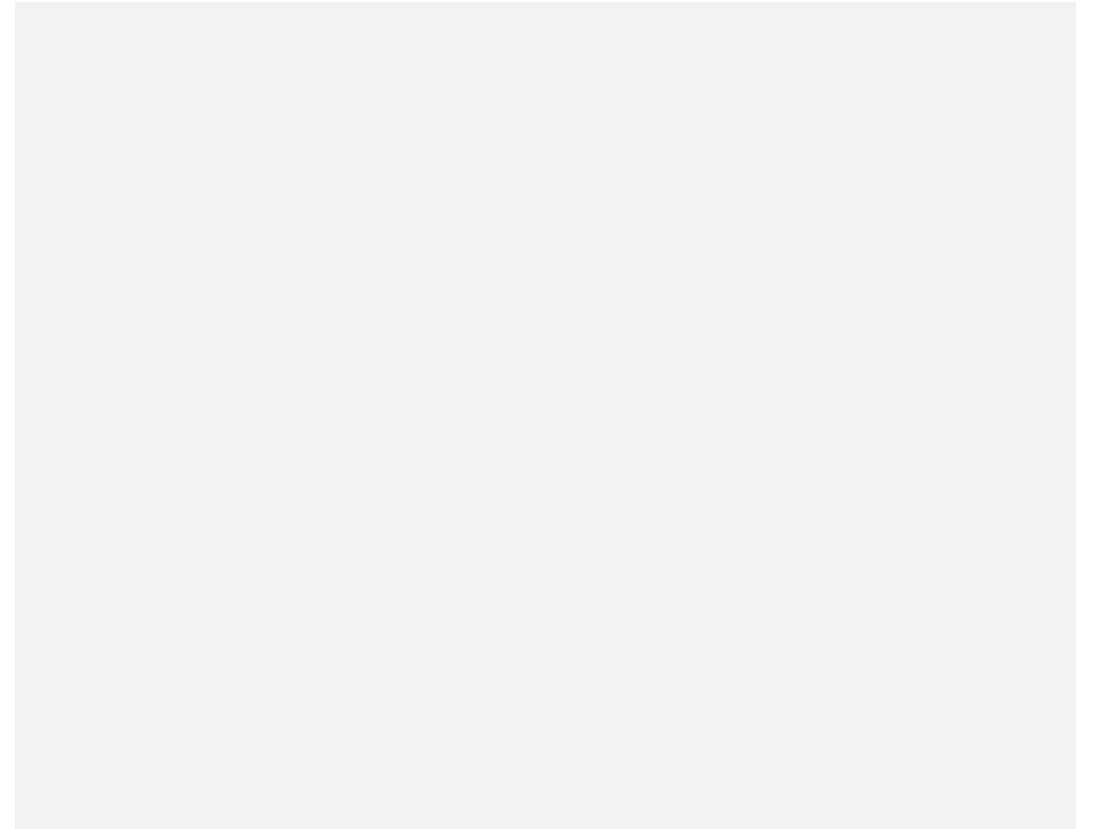
How Do They Differ?

- Scopes show pictures, DMMs show numbers
- Scopes are optimized for AC behavior, DMMs are optimized for DC
- Scopes take time-based measurements, DMMs take measurements in instances of time
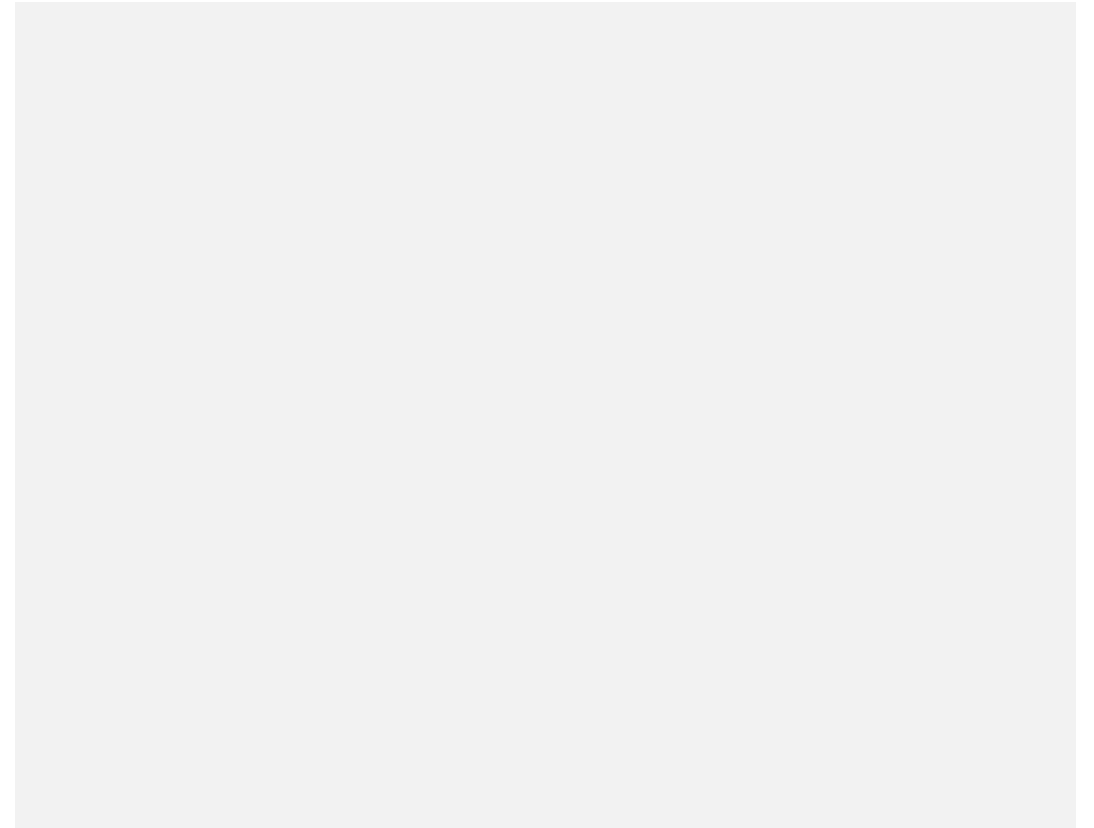
I Want to Measure Component Behavior

- Tool to use: DMM
- Measuring behavior with respect to other circuit parameters not time
- More accurate for DC point measurements
- Exceptions
  - Your component involves high frequency signals
  - You're looking for transient behavior (like MOSFET turn on/off characteristics)

Drain Characteristics of MOSFET

$I_D (mA)$

-10
-8
-6
-4
-2
0

$V_{GS} = -20v$
$V_{GS} = -16v$
$V_{GS} = -12v$
$V_{GS} = -8v$
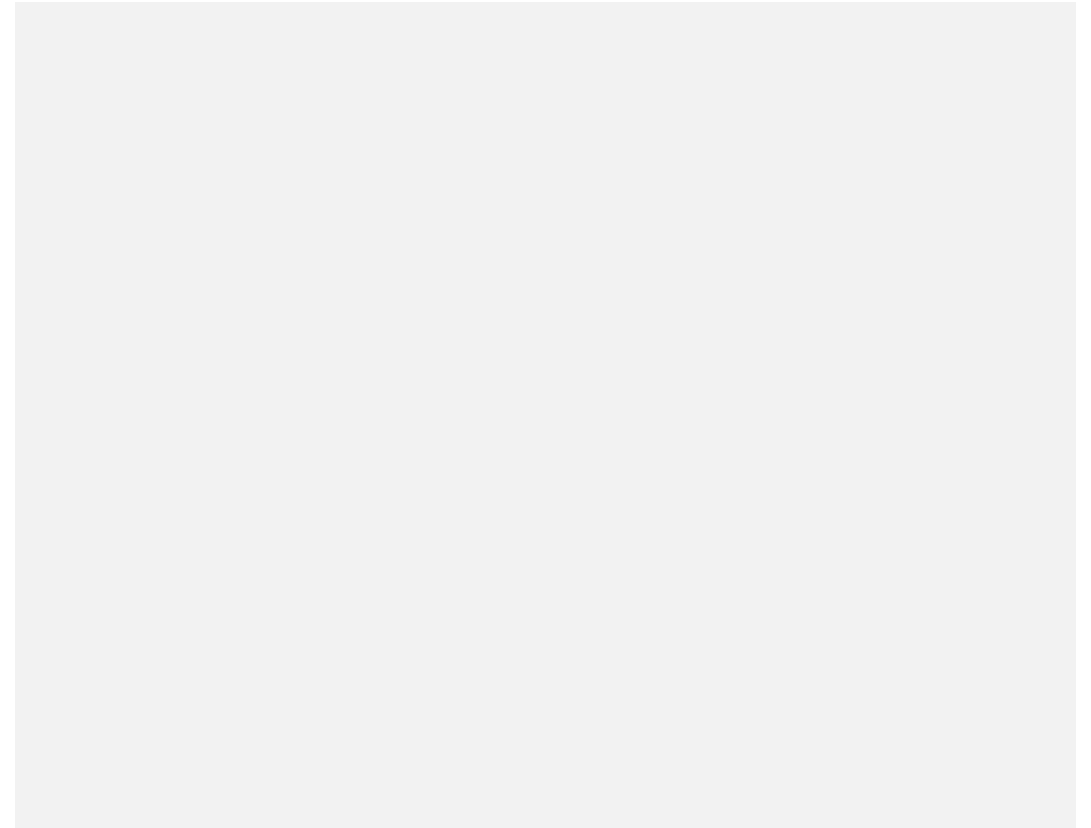
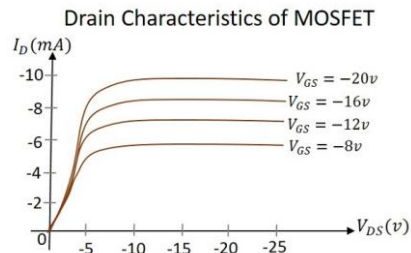-5   -10   -15   -20   -25 $V_{DS}(v)$

Why is a DMM More Accurate Than a Scope for Single Measurements?

- Tradeoff: Speed for Noise/Accuracy
- Oscilloscopes are optimized for speed
- DMMs are optimized for noise/accuracy
  - Additional features like NPLC and filtering to further boost the accuracy
- Your scope isn't inaccurate! On a 1 V measurement
 - Scope might vary by 10 mV
  - DMM might vary by 10 uV

I Want to Measure Component Behavior

- Tool to use: DMM
- Measuring behavior with respect to other circuit parameters not time
- More accurate for DC point measurements
- Exceptions
  - Your component involves high frequency signals
 - You're looking for transient behavior (like MOSFET turn on/off characteristics)

Drain Characteristics of MOSFET

$I_D\,(mA)$

-10 — $V_{GS} = -20v$

-8 — $V_{GS} = -16v$

$V_{GS} = -12v$

-6 — $V_{GS} = -8v$

-4

-2

0   -5   -10 -15 -20 -25 $V_{DS}(v)$

I Want to Debug a Signal/Waveform/Circuit

- This can include
  - Noise
  - Jitter
  - Runt Pulses
  - Transients
  - Design Flaws
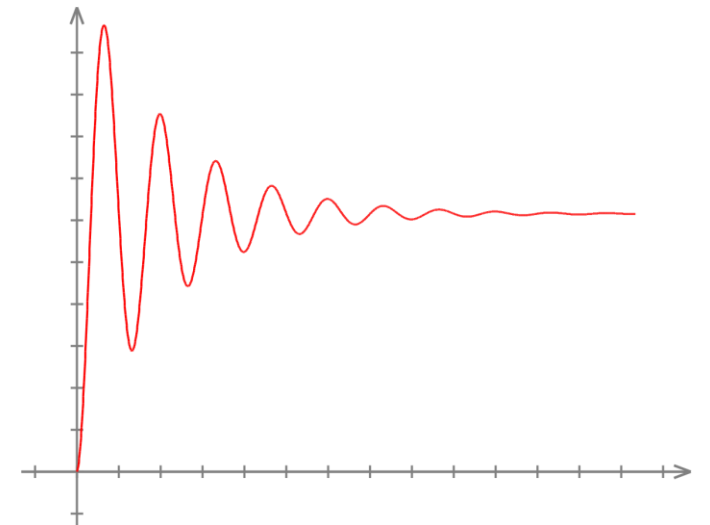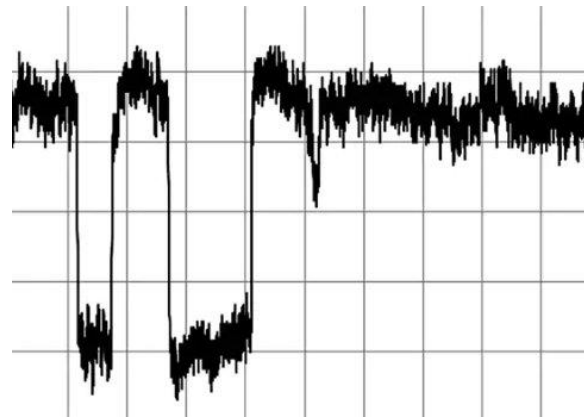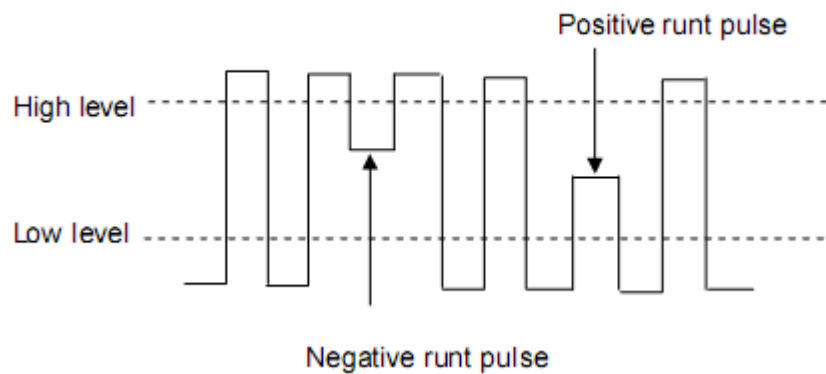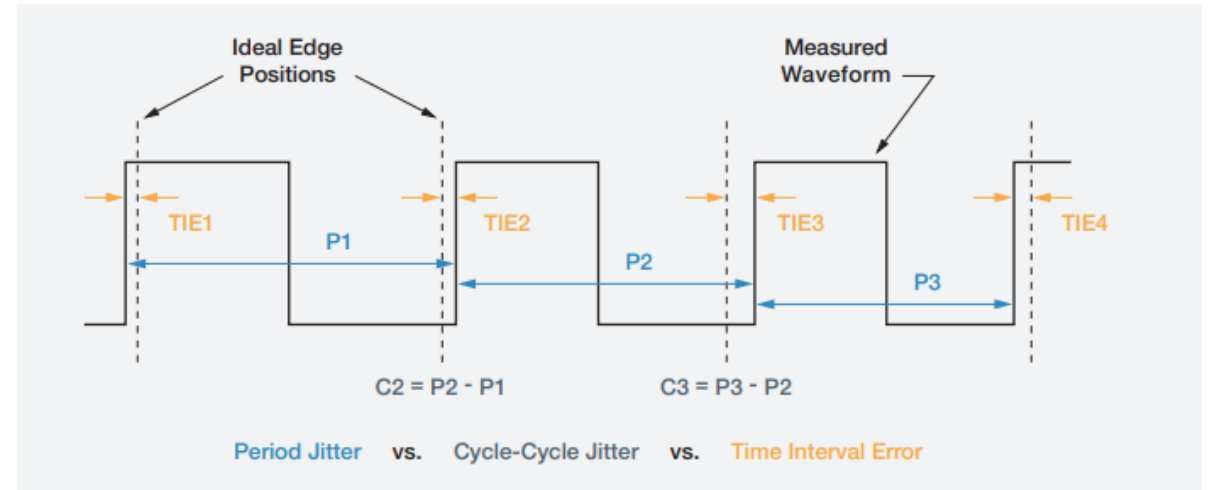
I Want to Debug a Signal/Waveform/Circuit

- Tool to use: SCOPE
- Scopes are optimized for speed and waveform visualization – you can SEE what's wrong with your signal
- High end scopes can even have packages to decode common data formats
- Exception: the behavior is lower frequency and you have a DMM with a digitizer
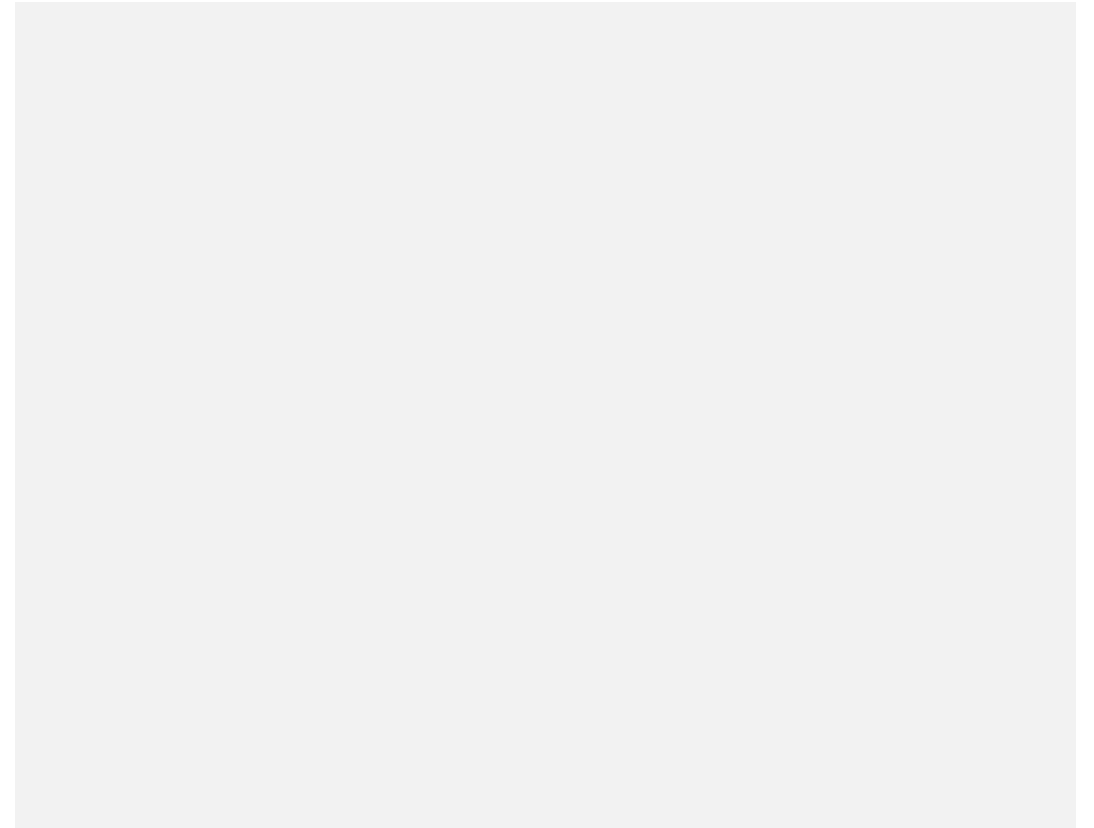
What's the Digitizer in my DMM?

- Much faster sampling rates – usually up to MHz range
- There is a tradeoff on accuracy and precision
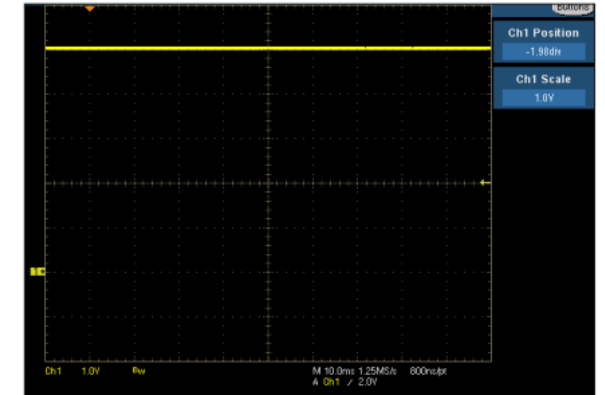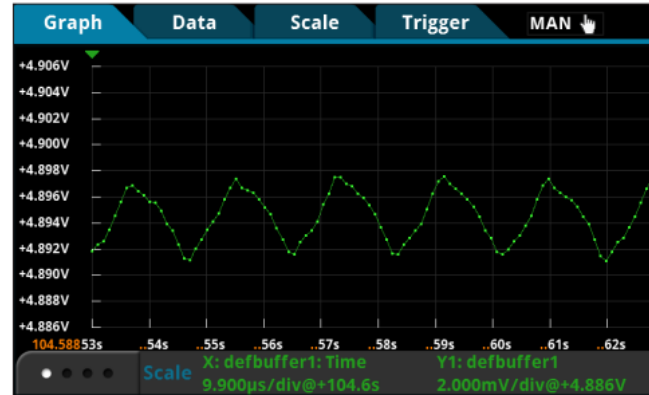- Good for low current/voltage measurements over a scope

Figure 3a. DC-coupled ripple voltage from the Model DMM7510 (left) and from a typical mid-range oscilloscope (right).

Figure 3b. AC-coupled ripple voltage from the Model DMM7510 (left) and from a typical mid-range oscilloscope (right).
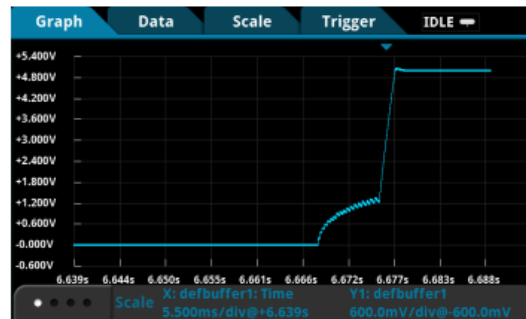

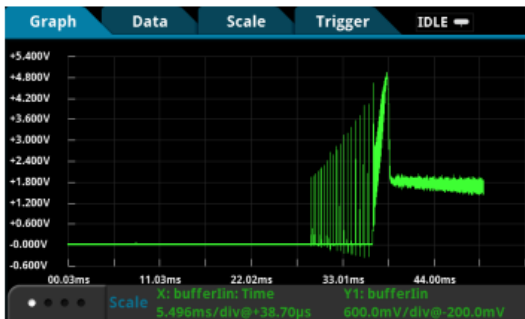Figure 6a. Individual waveform display of simultaneous input current and output voltage measurement.
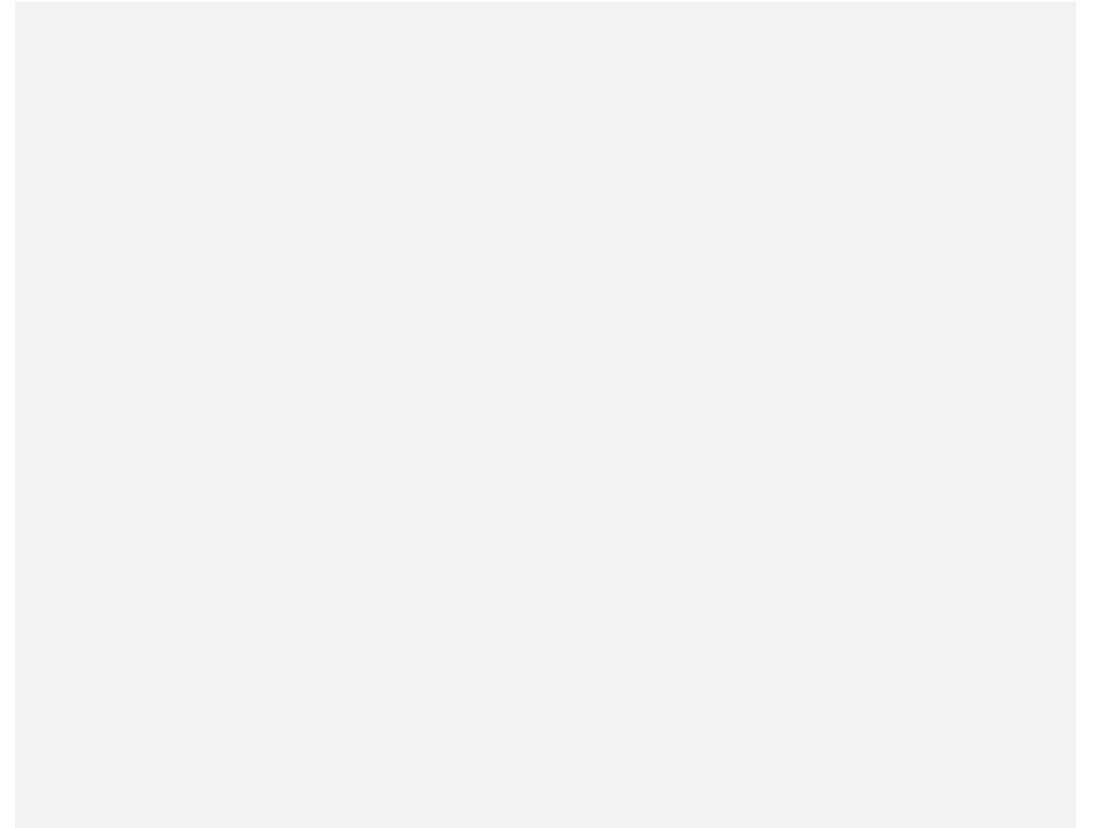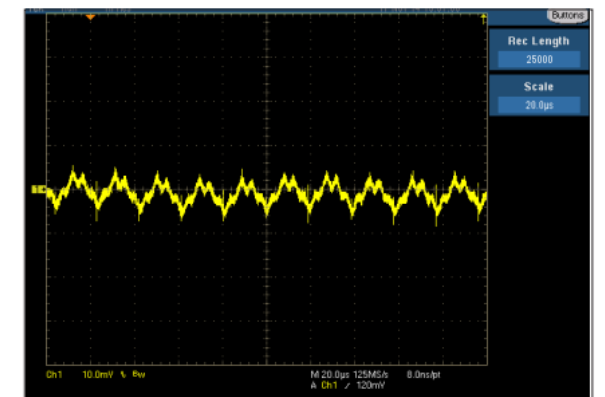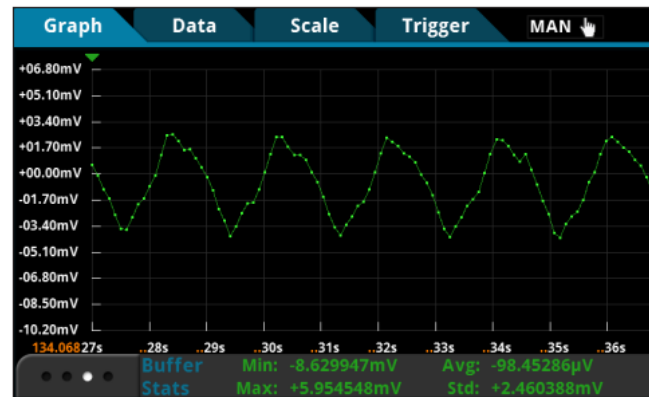
I Want to Diagnose Weird DMM Measurements

- Tool to Use: SCOPE

- Scopes are good for measuring and visualizing noise

- Scopes have spectrum analysis tools as well, so you can see what frequencies are present

- Scopes can also show if your signal is changing in ways you aren't expecting
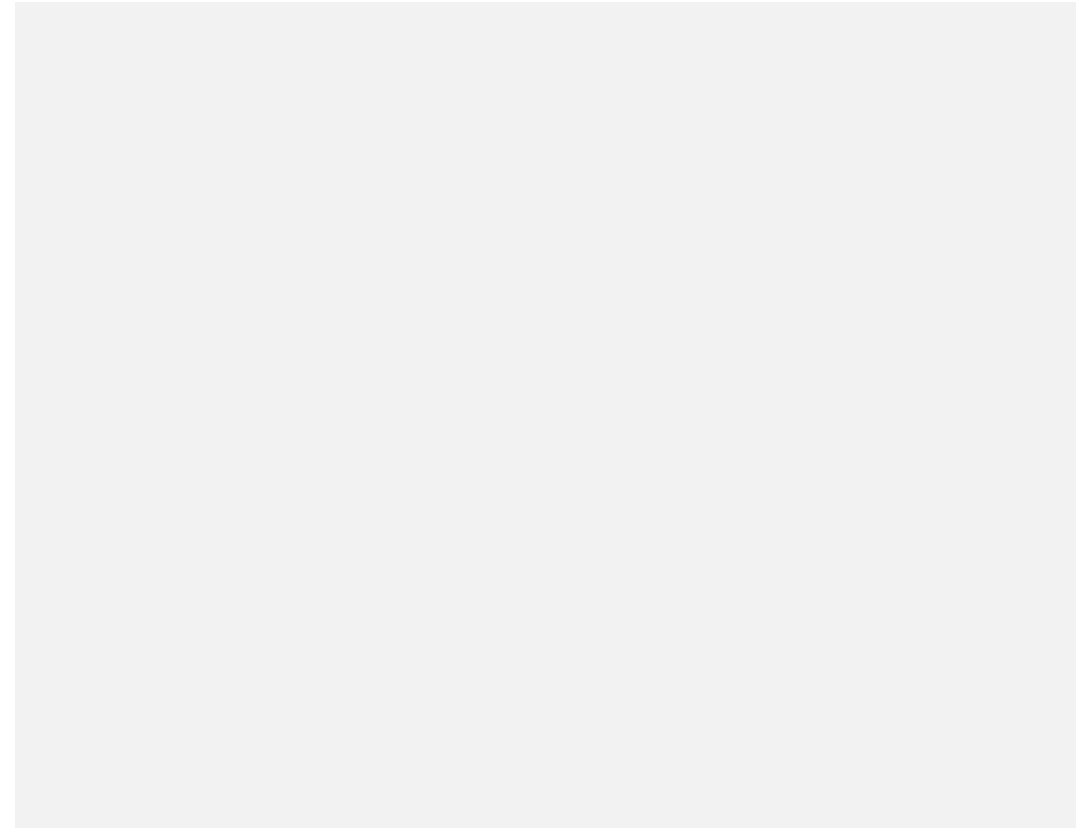
I Want to Measure AC Voltage

- Tool to use: DMM or SCOPE
- Use a DMM if…
  - Your signal is approximately a sine wave or within the crest factor spec
  - The signal is lower frequency (< 100s of kHz)
  - You're looking to measure frequency or RMS voltage/current
- Use a Scope if…
  - The signal isn't approximately a sine wave
  - The signal is higher frequency
 - You want to make measurements other than RMS or frequency

I Want to Measure More Than One Signal

- Tool to Use: DMM or Scope
- Scopes often have multiple analog channels
- Typical DMMs are only 1 channel
- But DMMs that have switching capabilities can measure more than 1 signal without rewiring – still a sequential measurement
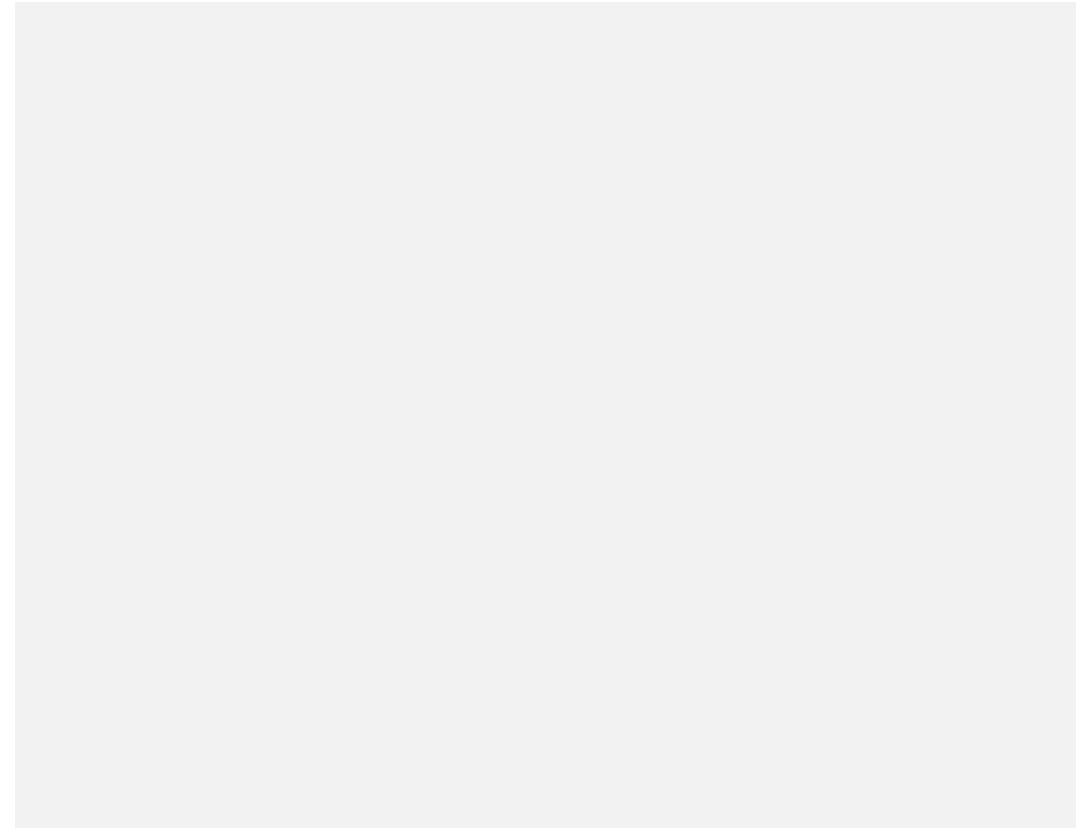
Product Highlight: DMM6500

- 6.5 Digit Resolution
- 1 MSa/s Digitizer
- 0.0025% 1 Year DCV Accuracy
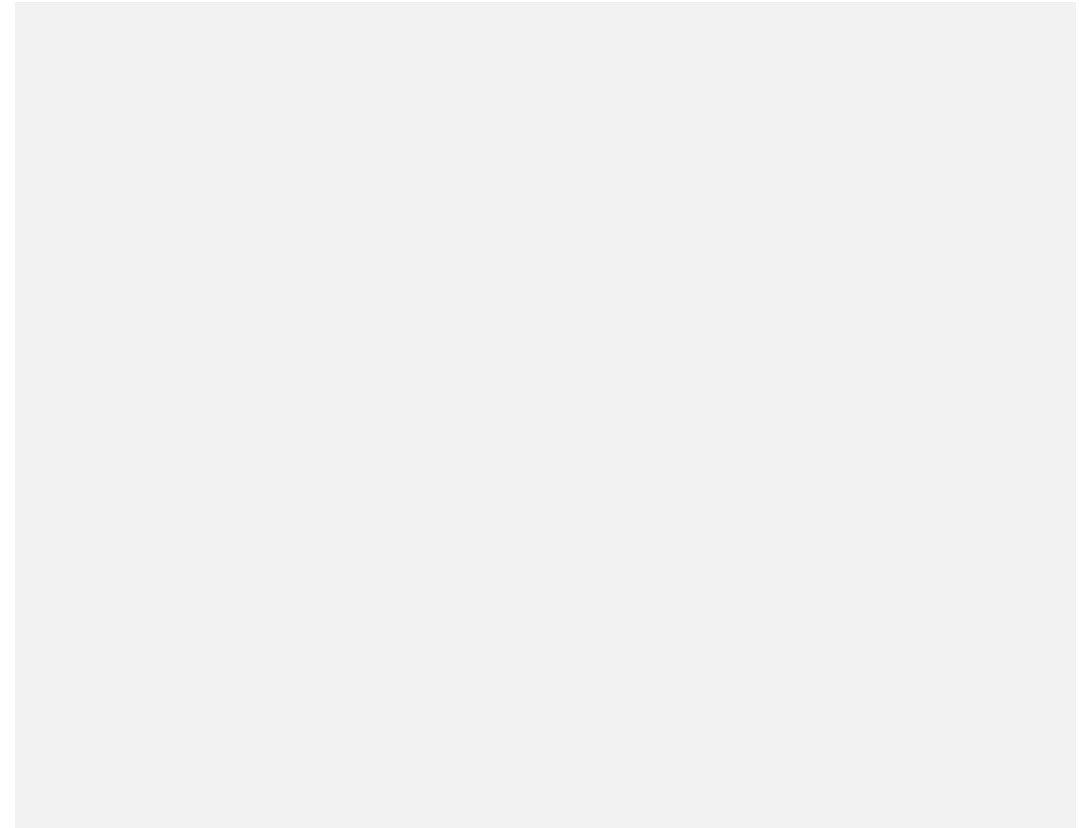
Product Highlight: 2 Series MSO

- 2 or 4 Channel Options
- 70 MHz – 500 MHz Bandwidth
- Up to 2.5 GSa/s sample rate

Summary

- Use DMMs for
  - DC Measurements
  - Lower frequency AC Measurements
  - Device Characterization
  - General purpose
- Use Scopes for
  - High frequency signals
  - Measurements on complex signals
  - Time or frequency based measurements
  - Debugging/Troubleshooting
- Both tools have a place on your bench!
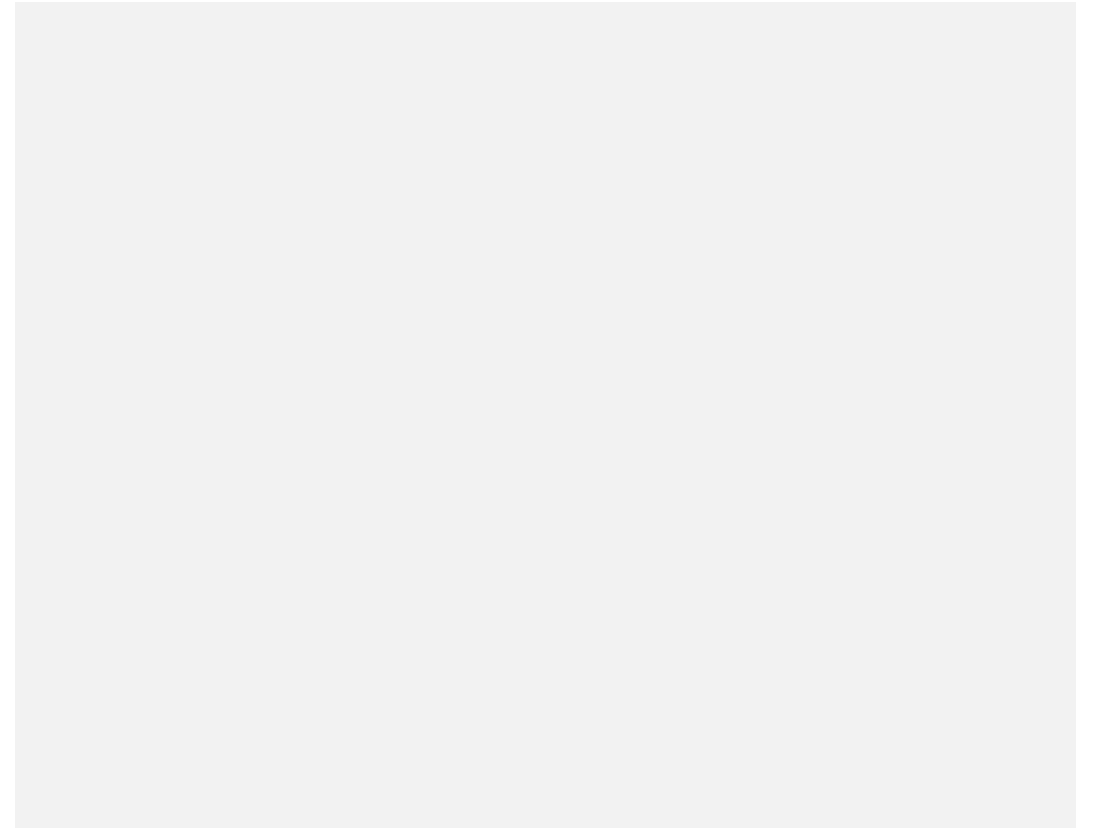
More Information and Resources

- 2 Series MSO Datasheet
- DMM6500 Digital Multimeter Datasheet
- XYZ's of Oscilloscopes Primer
- Digital Multimeter Selector Guide
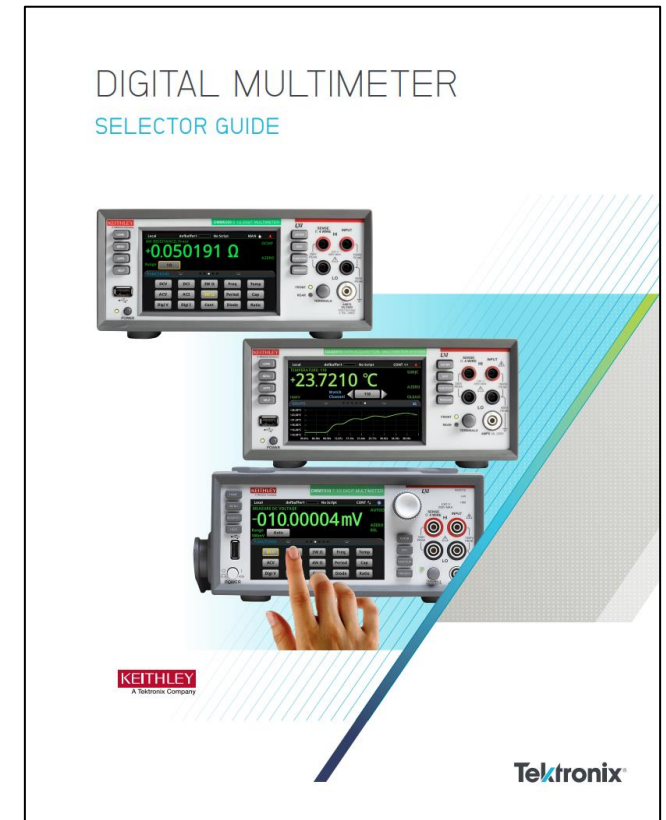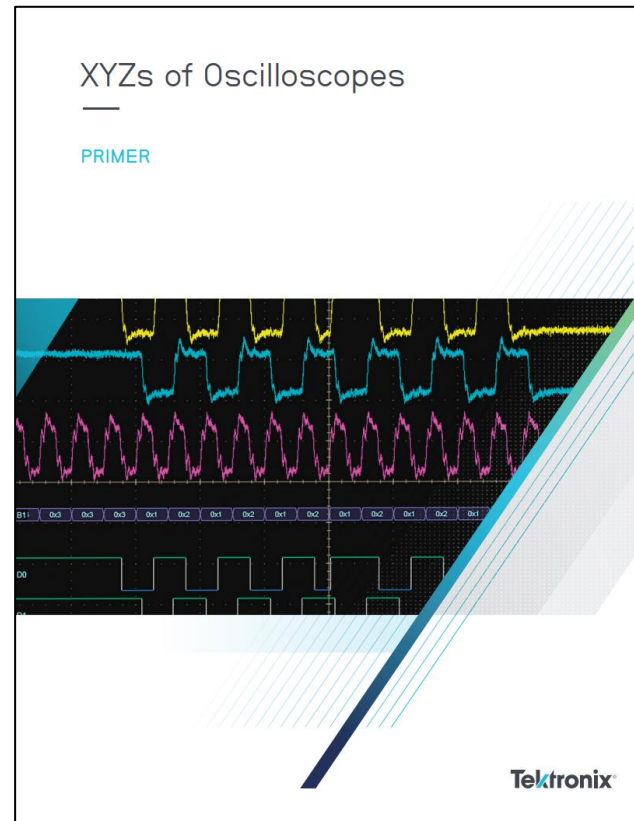
Thank you for attending!
Questions?