

# Intermediate Oscilloscope Use and Understanding

Feb-2022



# Agenda

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1. Sampling/quantization
2. Basic and advanced triggering
3. Probing Technique
4. Bandwidth and Sample Rates

# Real world weirdness

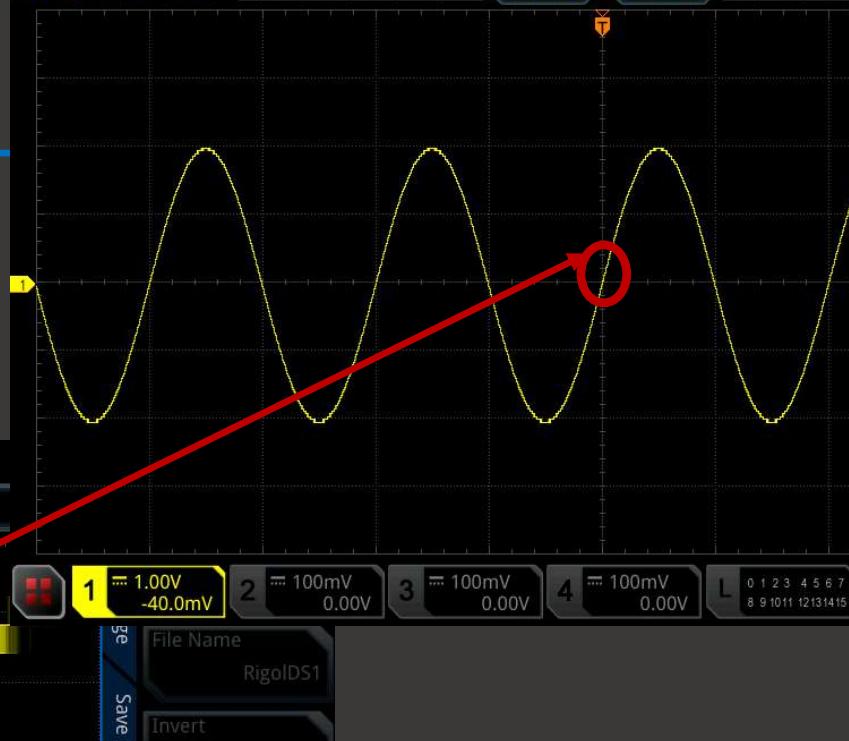
MSO5074 Fri February 04 15:29:01 2022

RIGOL STOP H 10.0us 4GSa/s 20Mpts Measure STOP/RUN D 0.00s



MSO5074 Fri February 04 15:27:10 2022

RIGOL TD H 500us 4GSa/s 20Mpts Measure STOP/RUN D 0.00s

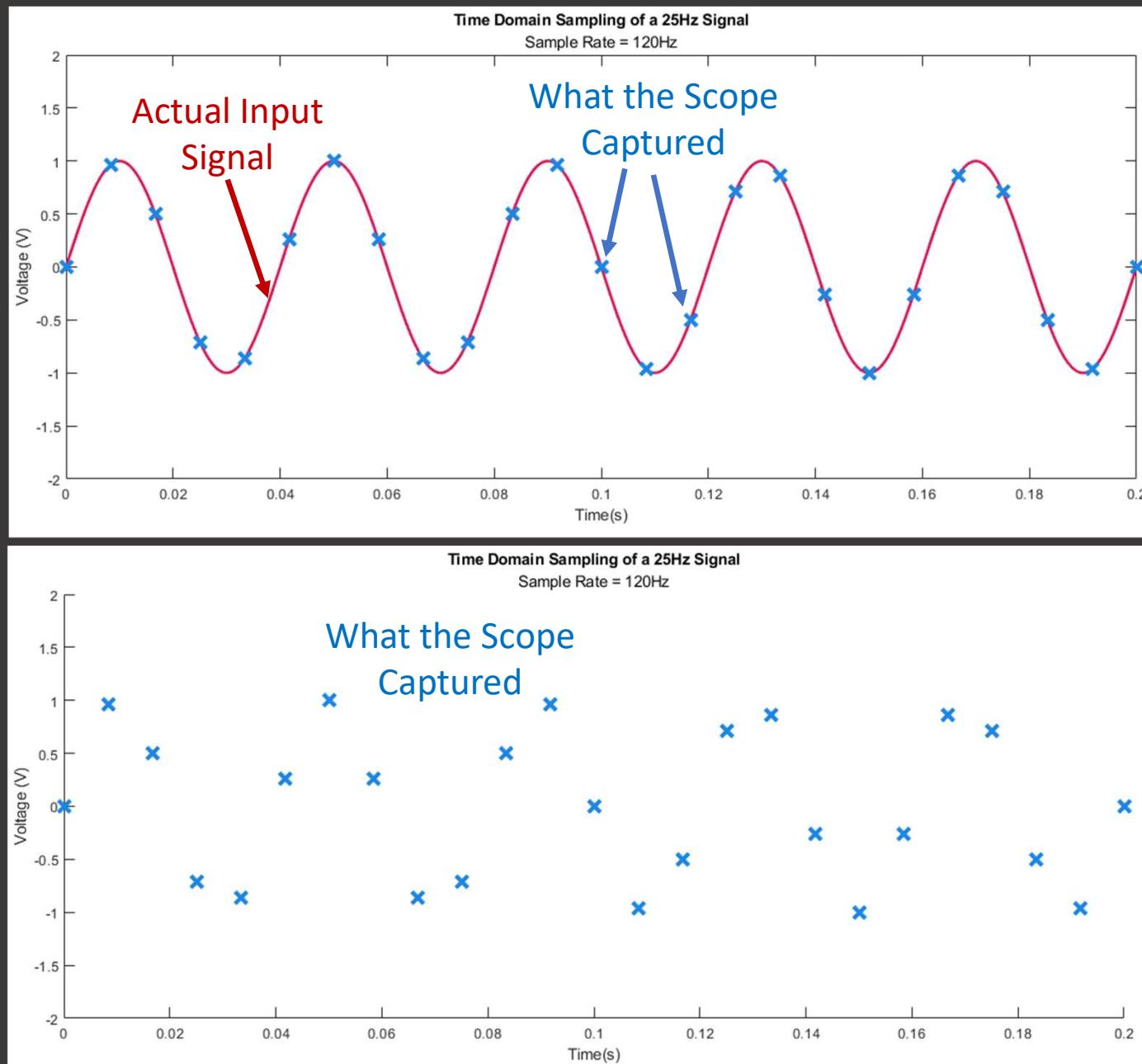


MSO5074 Fri February 04 15:29:27 2022

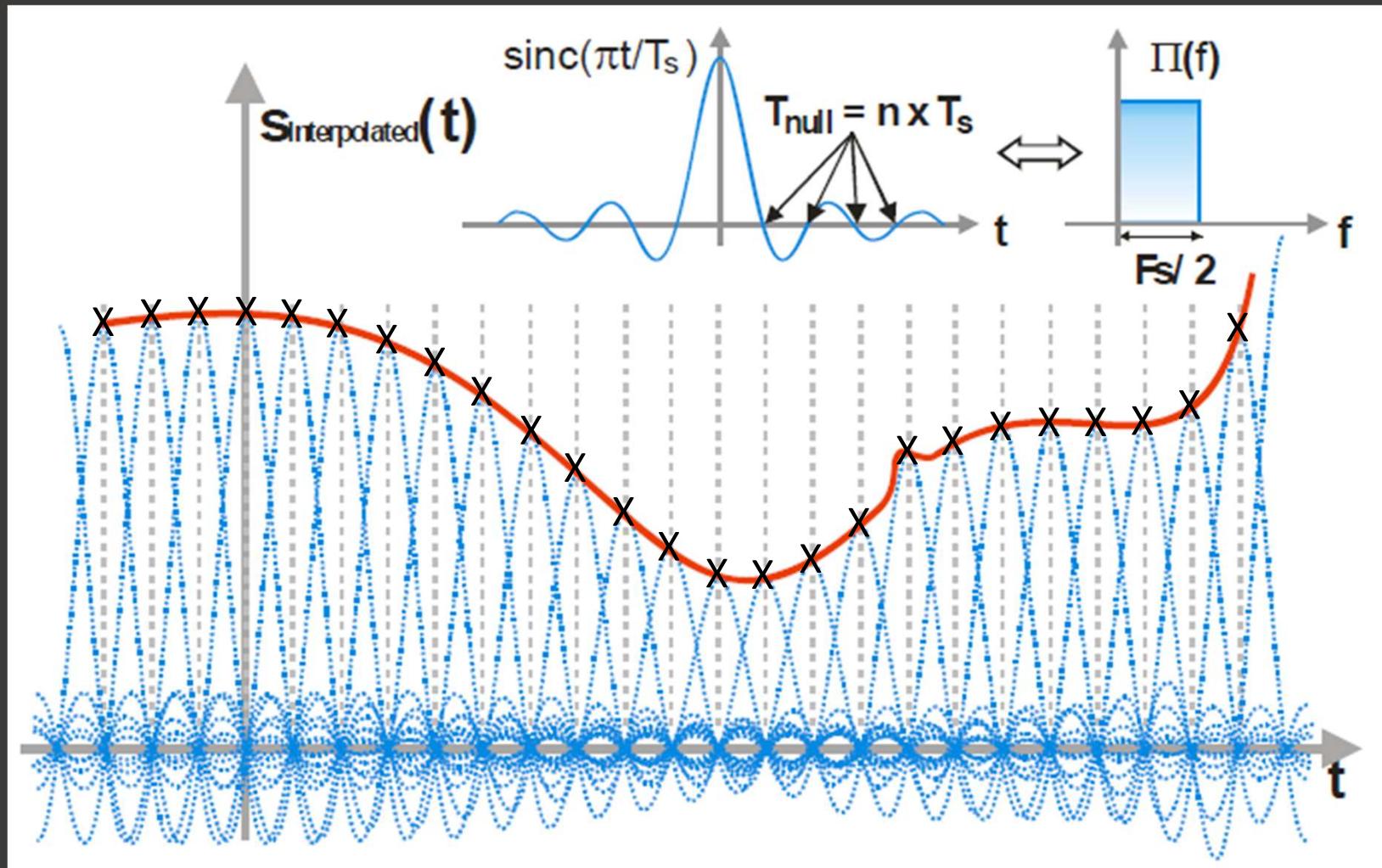
RIGOL STOP H 500ns 4GSa/s 20Mpts Measure STOP/RUN D 820ns



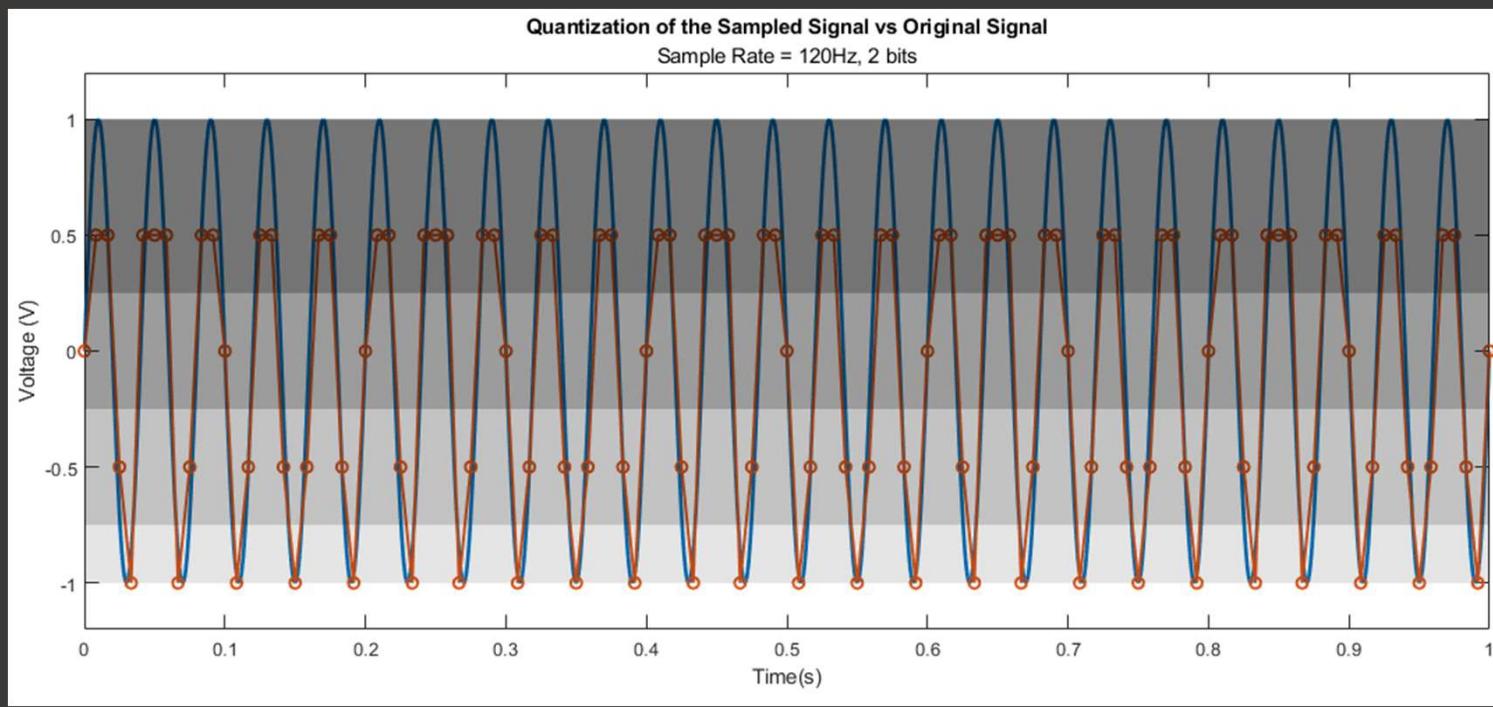
# Sampling – Time and Amplitude Domain



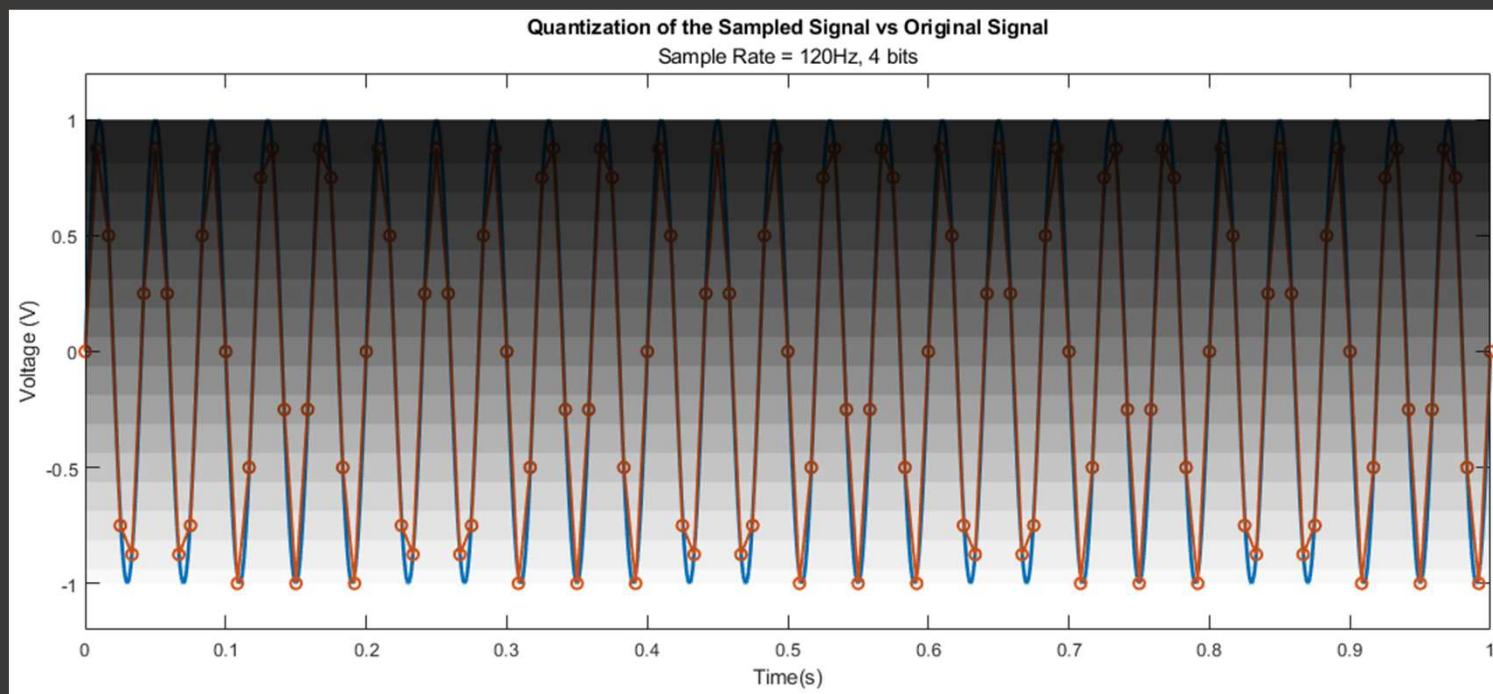
# Interpolation



# Vertical Resolution – Typically 8 bits



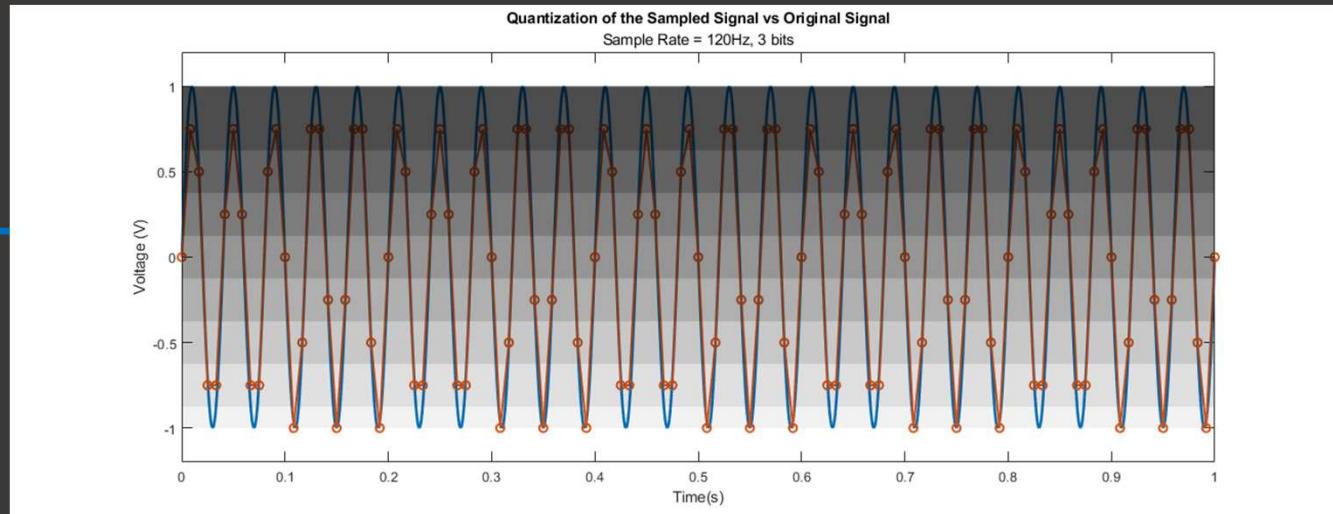
2 bits/  
4 Levels



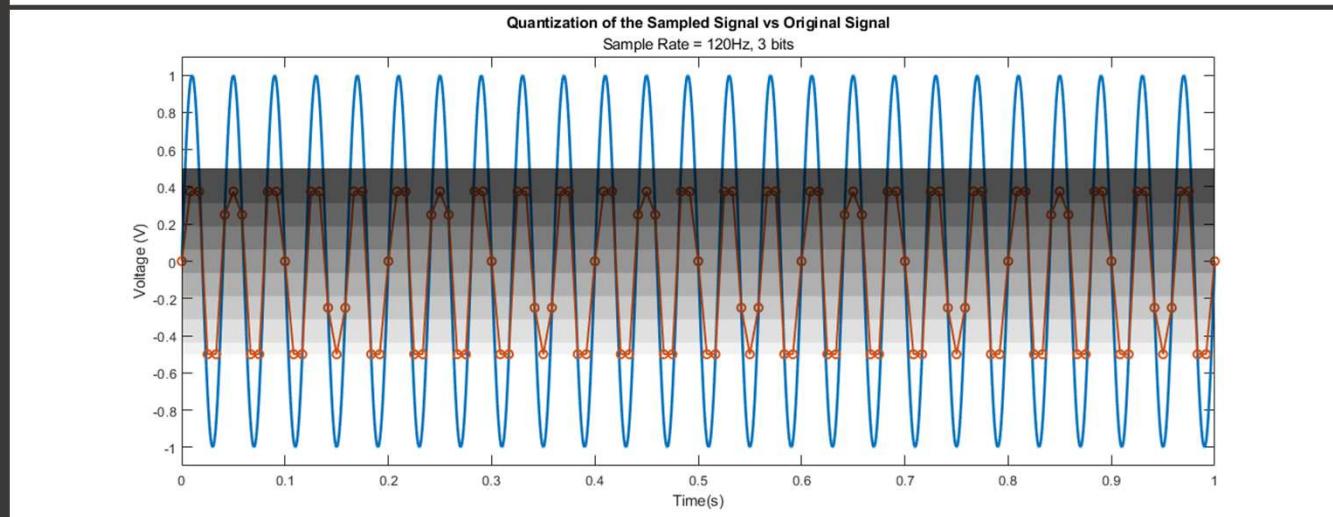
4 bits/  
16 Levels

# Vertical Scale Impact

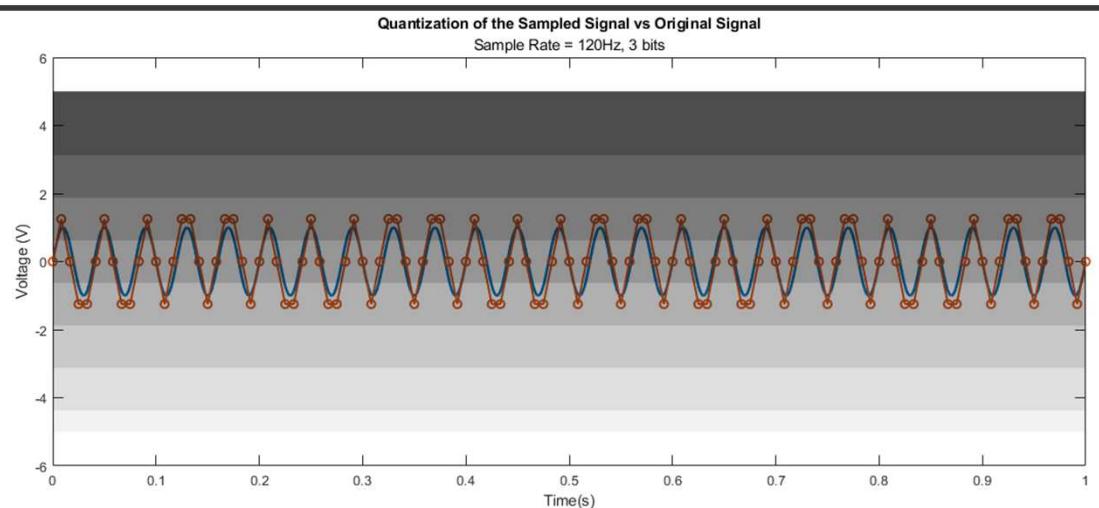
8 levels,  
perfect  
range



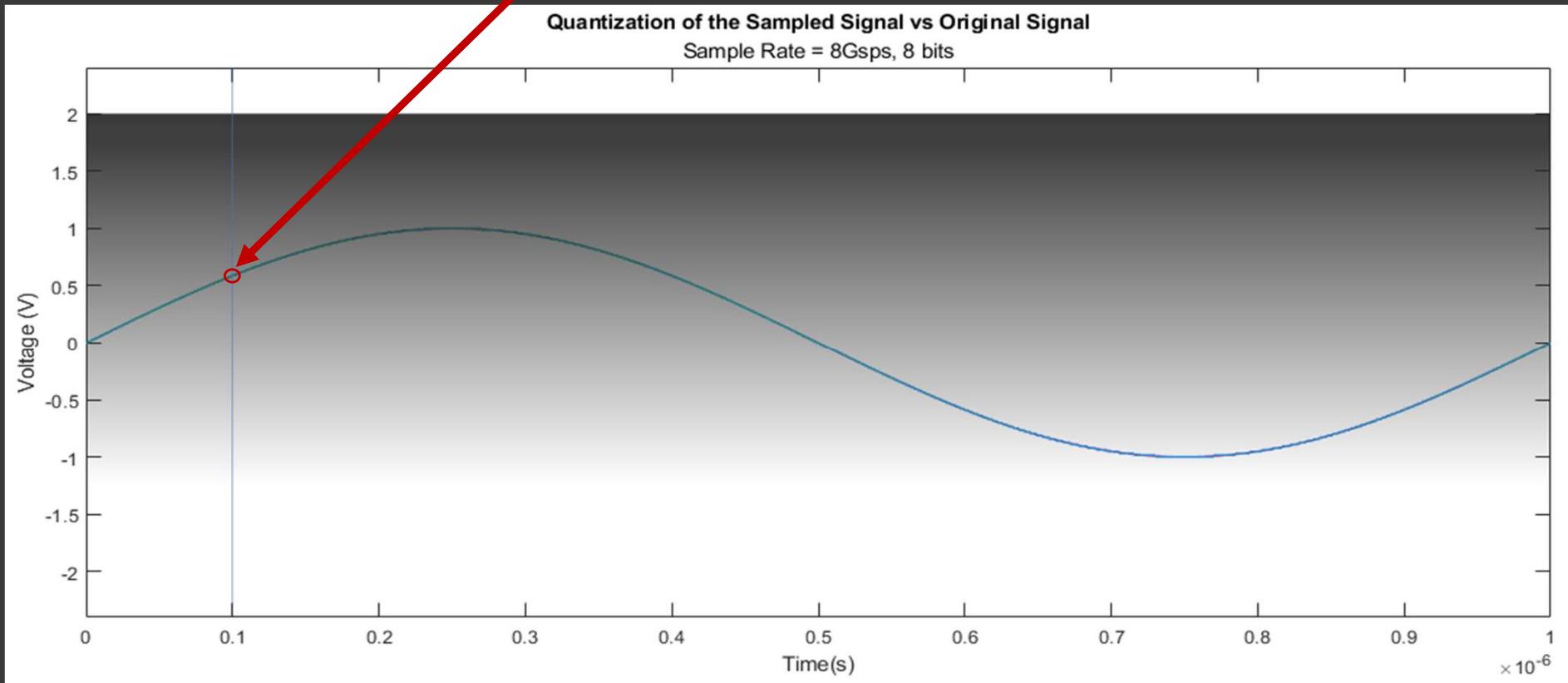
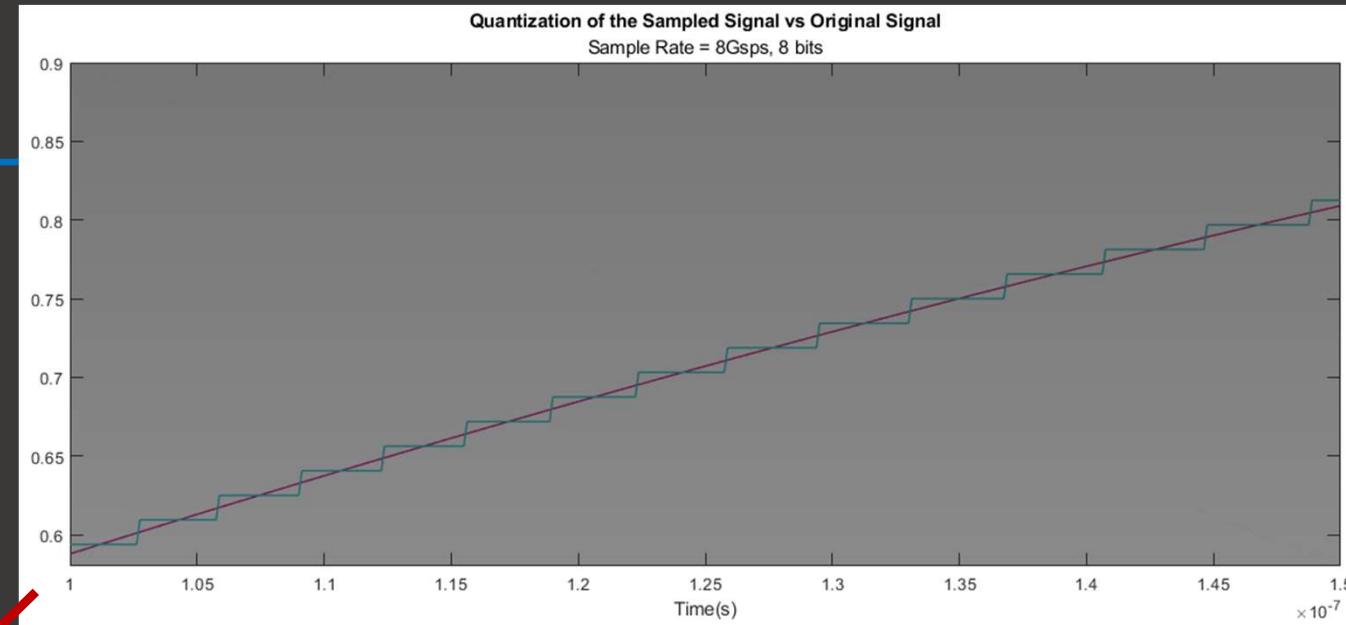
8 levels, but  
missing part  
of waveform



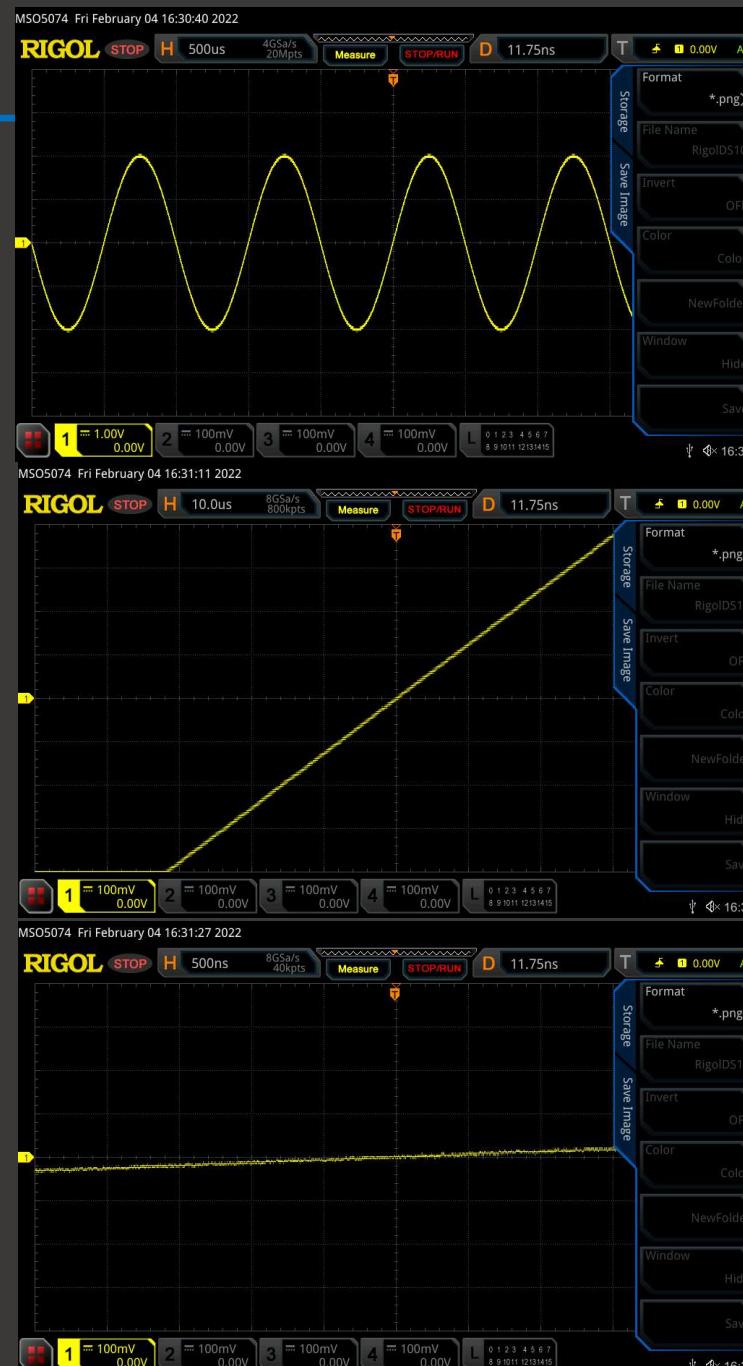
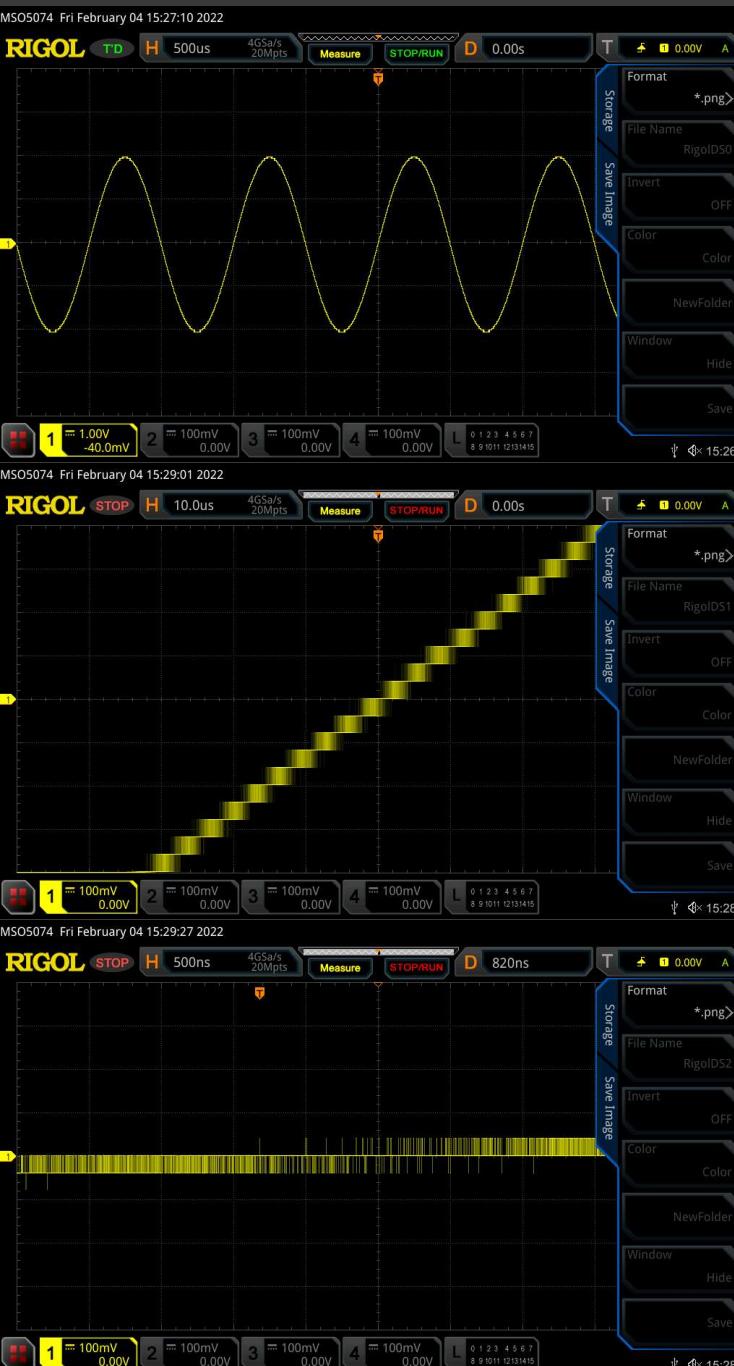
3 effective  
levels



# Realistic Example w/o interpolation 8Gsps, 8bits



# Trigger then zoom vs zoom then trigger



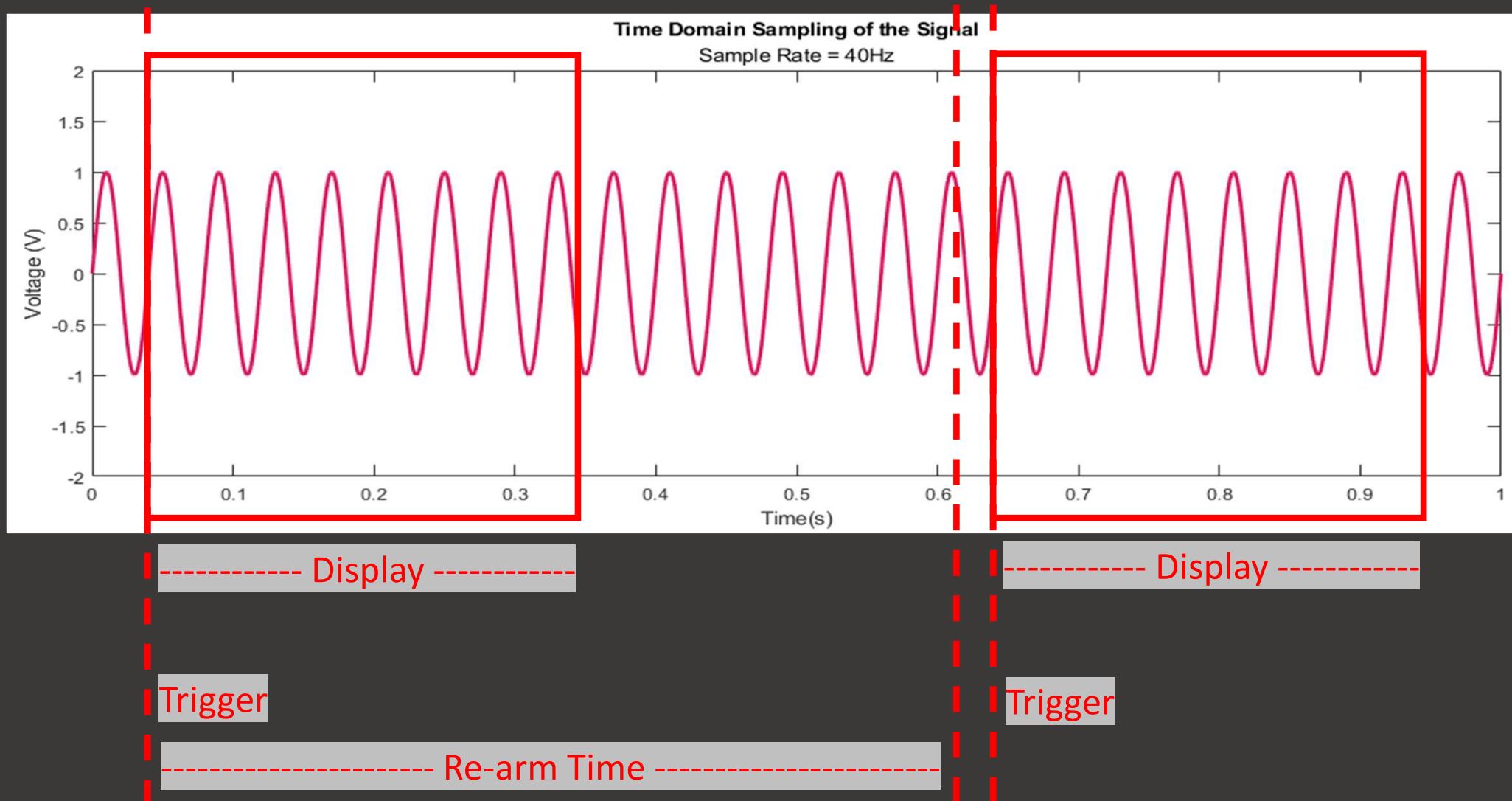
8 bit (256 level)  
resolution range  
is reset each  
time we change  
vertical scale

# Triggering

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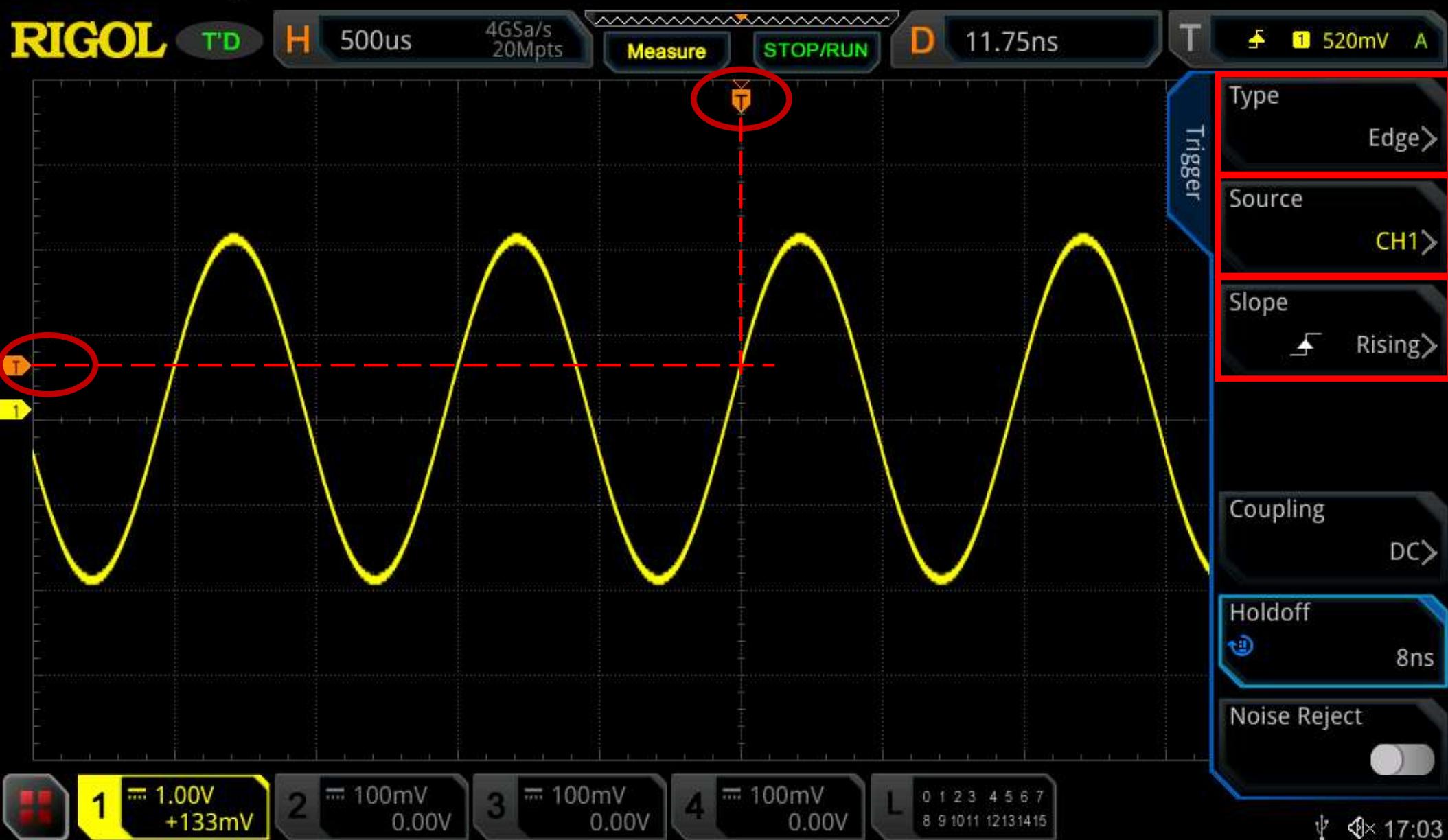
- Overview
- Edge
  - Rising
  - Falling
- Rarm/Hold-off
- Single Shot
- Other

# Rising Edge Trigger/Re-Arm System



# Trigger Setup

MSO5074 Fri February 04 17:03:47 2022



# Edge Rising/Falling/Both

MSO5074 Fri February 04 15:35:02 2022



MSO5074 Fri February 04 15:35:42 2022

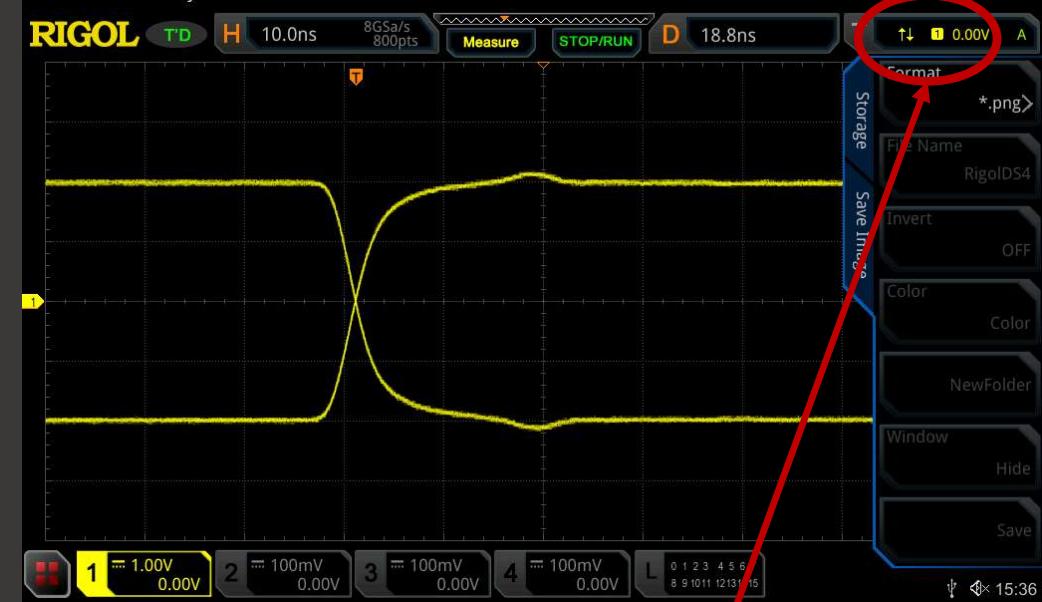


1 1.00V 0.00V 2 100mV 0.00V 3 100mV 0.00V 4 100mV 0.00V L 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

MSO5074 Fri February 04 15:36:18 2022



MSO5074 Fri February 04 15:37:14 2022



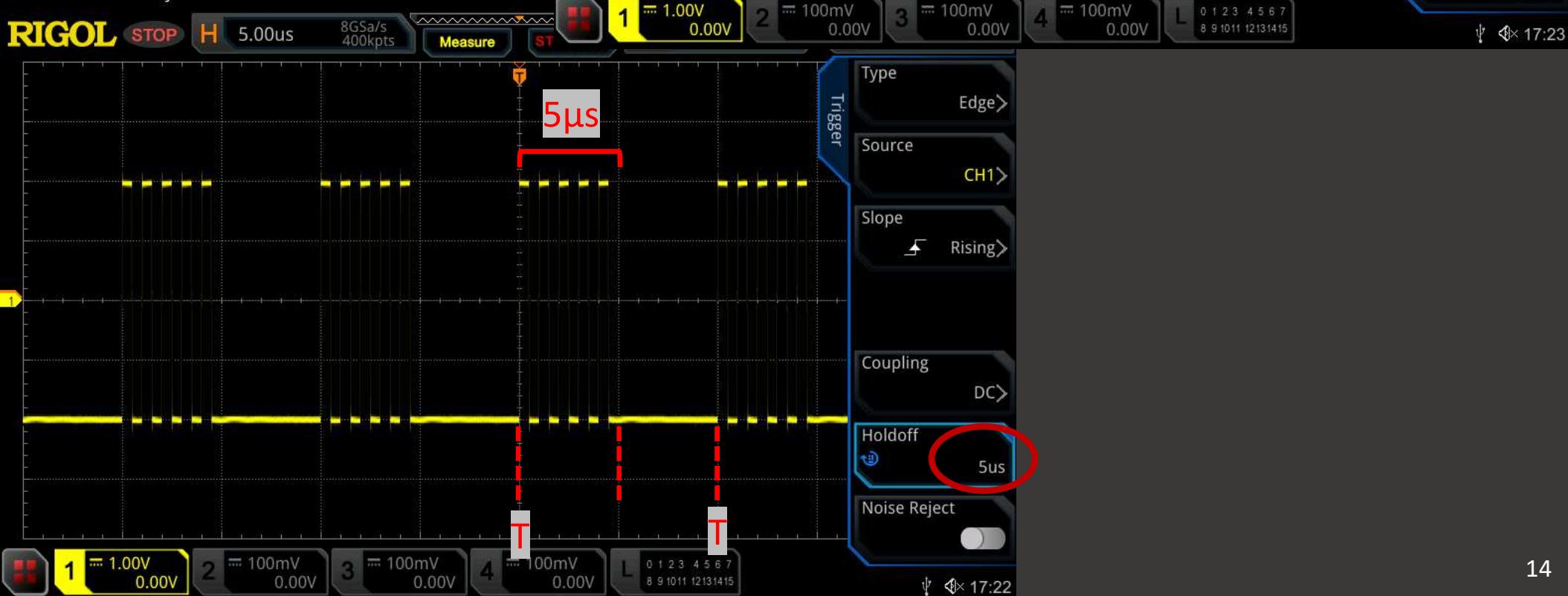
1 1.00V 0.00V 2 100mV 0.00V 3 100mV 0.00V 4 100mV 0.00V L 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

# Hold Off

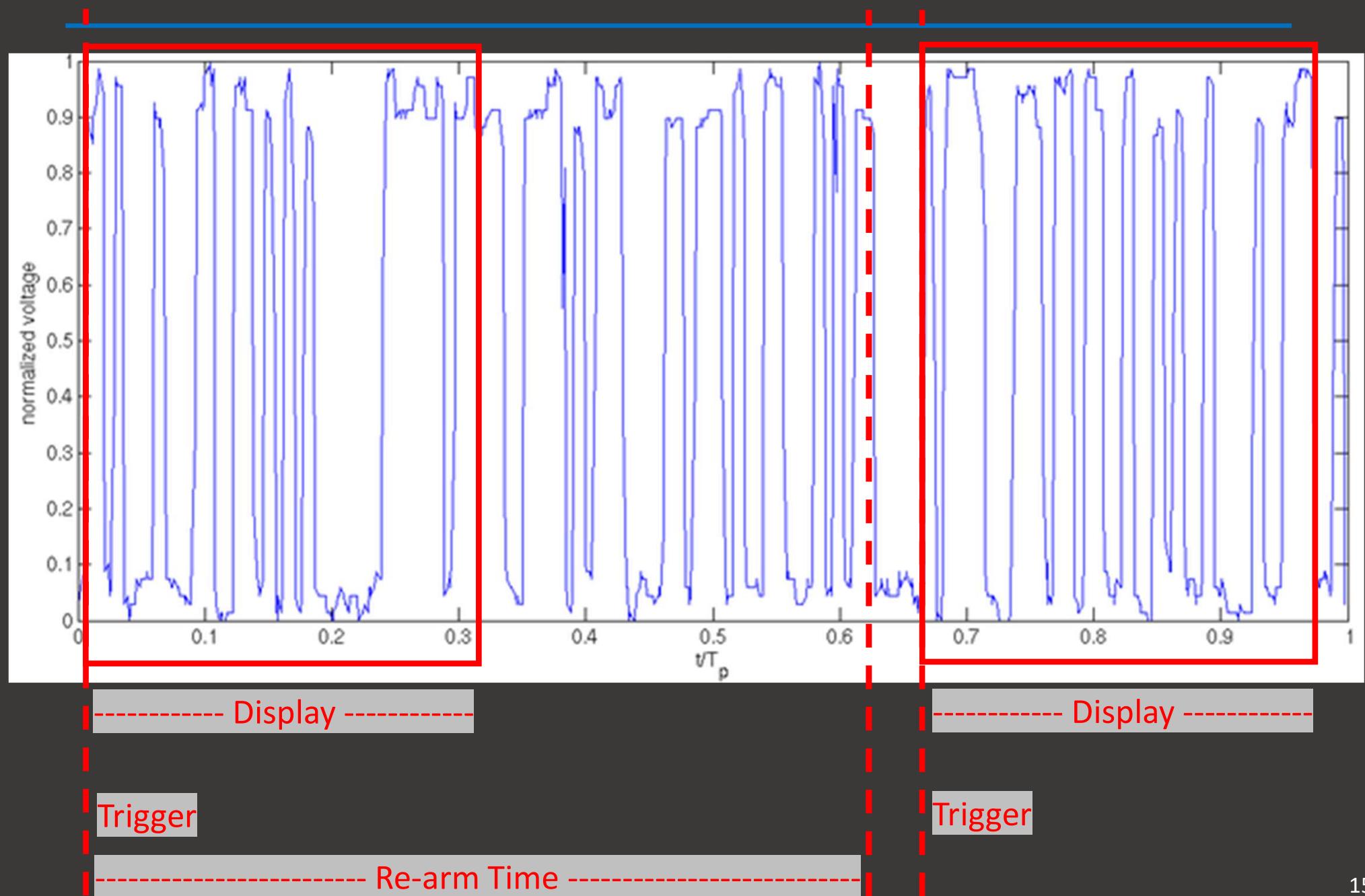
MSO5074 Fri February 04 17:23:45 2022

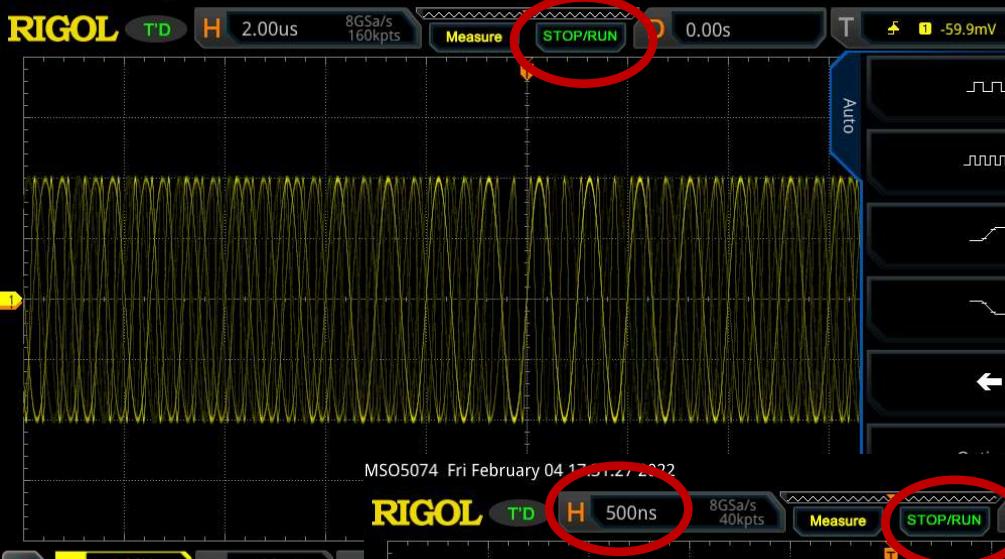


MSO5074 Fri February 04 17:23:12 2022

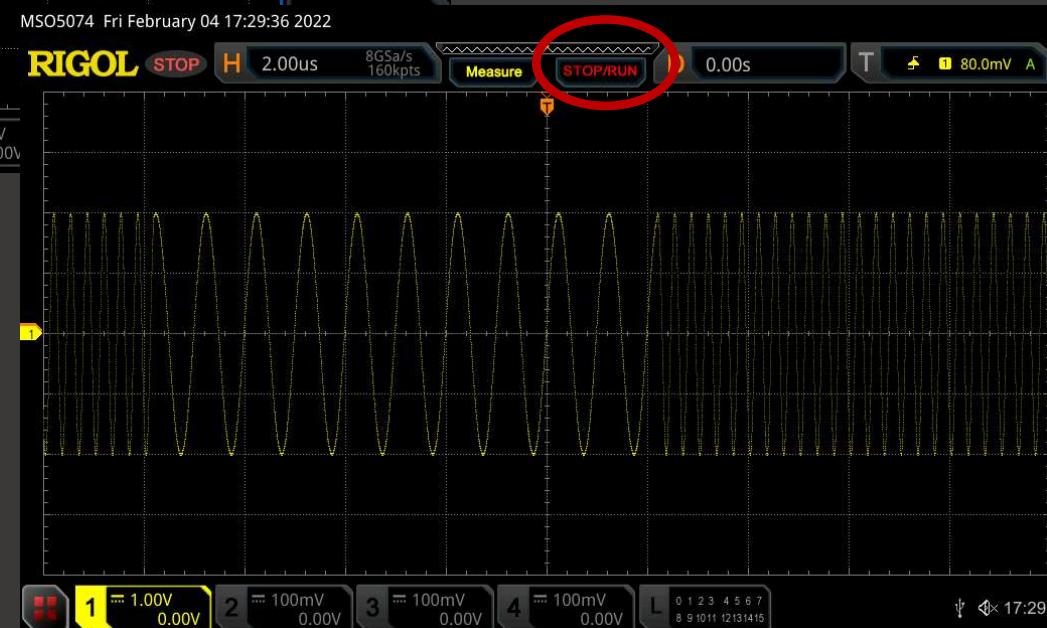
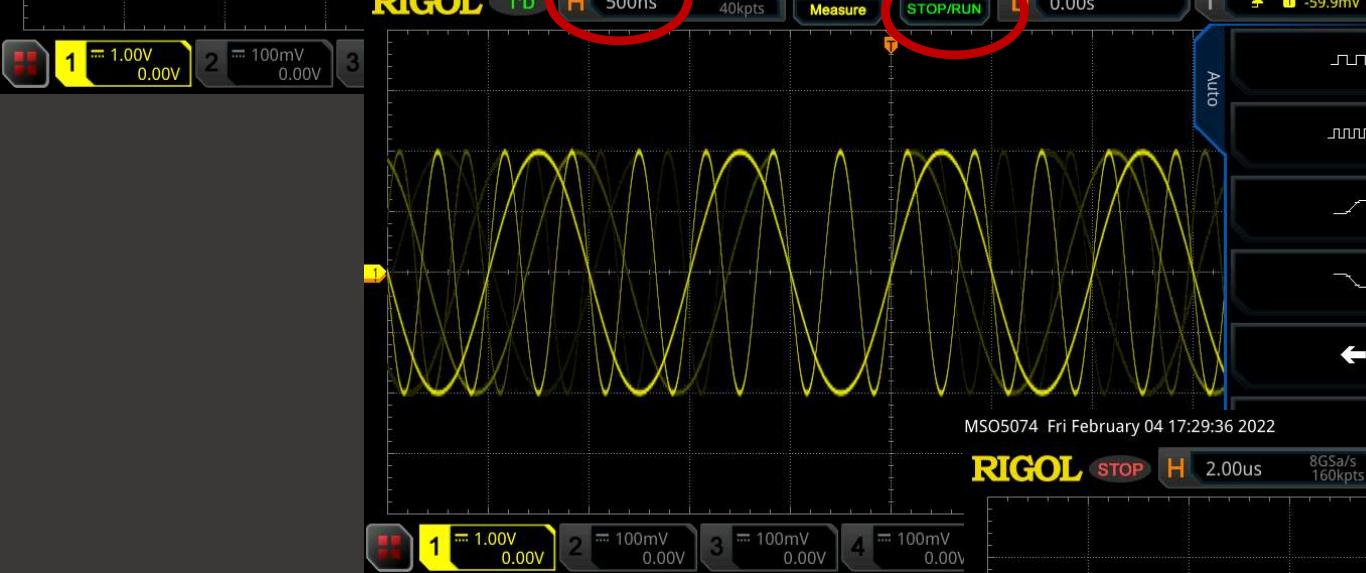


# Triggering on Non-Repetitive Signals





“Single/One-Shot”  
is your friend

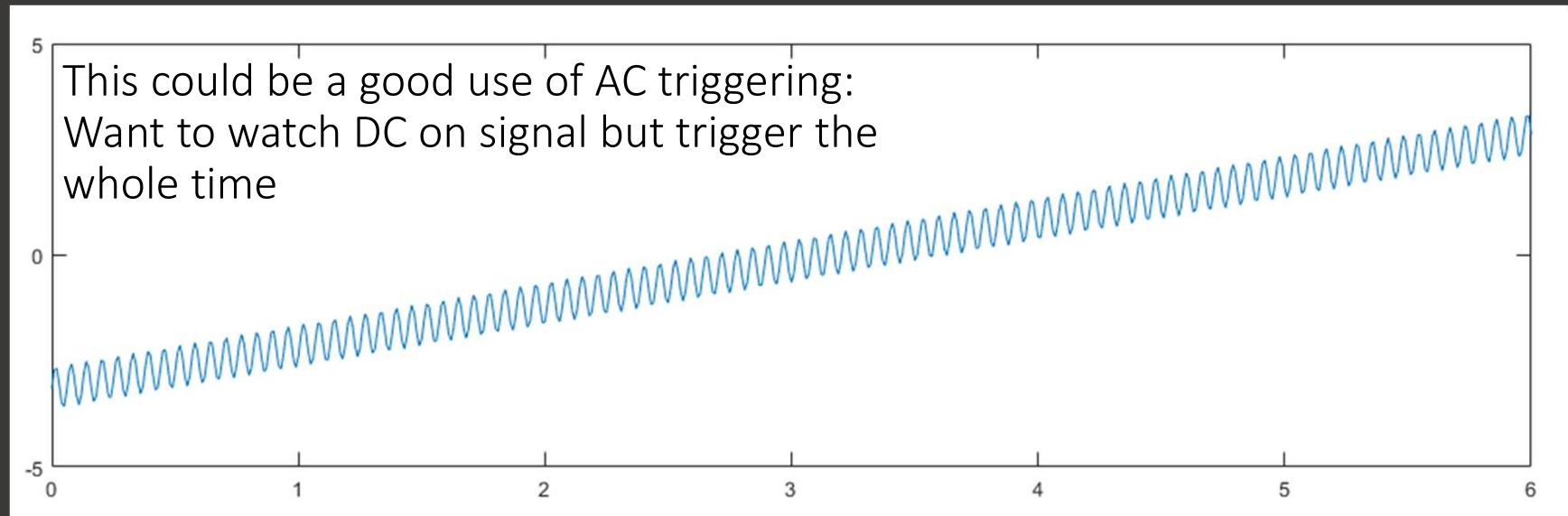


# Trigger AC/DC/Bandwidth

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TL;DR

- Use DC coupling – 99% of the time it's fine
- If it doesn't trigger, try AC, LFC (low freq cutoff), HFC (high freq cutoff)
- AC was more useful in older scopes due to architecture differences



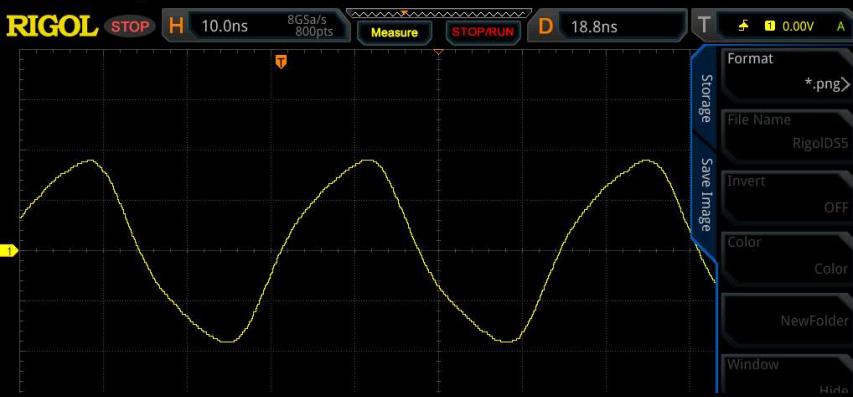
# Probing Technique

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- Overview
- Edge
  - Rising
  - Falling
- Rearm/Hold-off
- Single Shot
- Other

# 30MHz Signal Probing

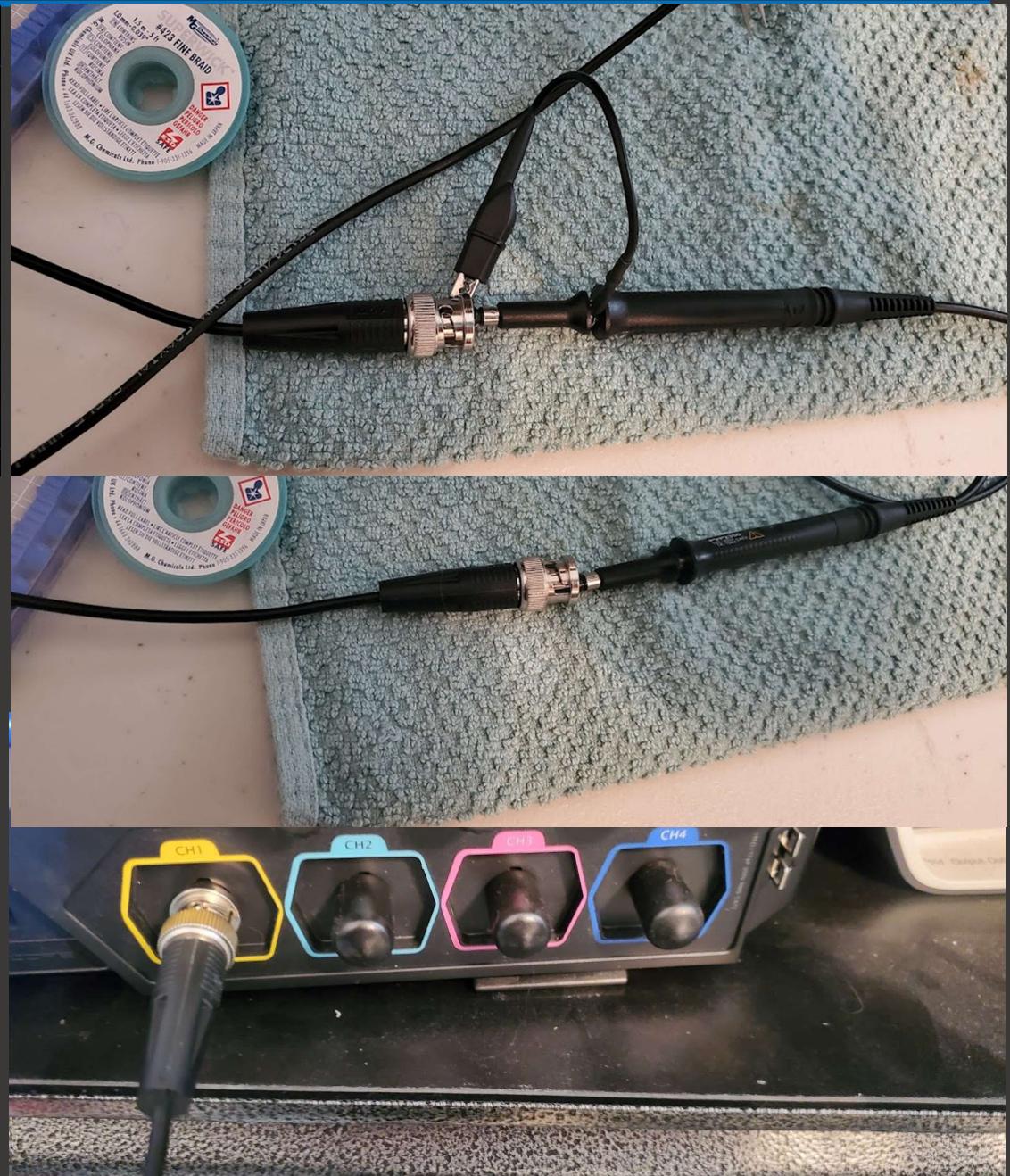
MSO5074 Fri February 04 15:48:52 2022



MSO5074 Fri February 04 15:49:06 2022



MSO5074 Fri February 04 15:49:41 2022



# 1MHz Signal Probing

MSO5074 Fri February 04 16:14:37 2022



MSO5074 Fri February 04 16:14:53 2022

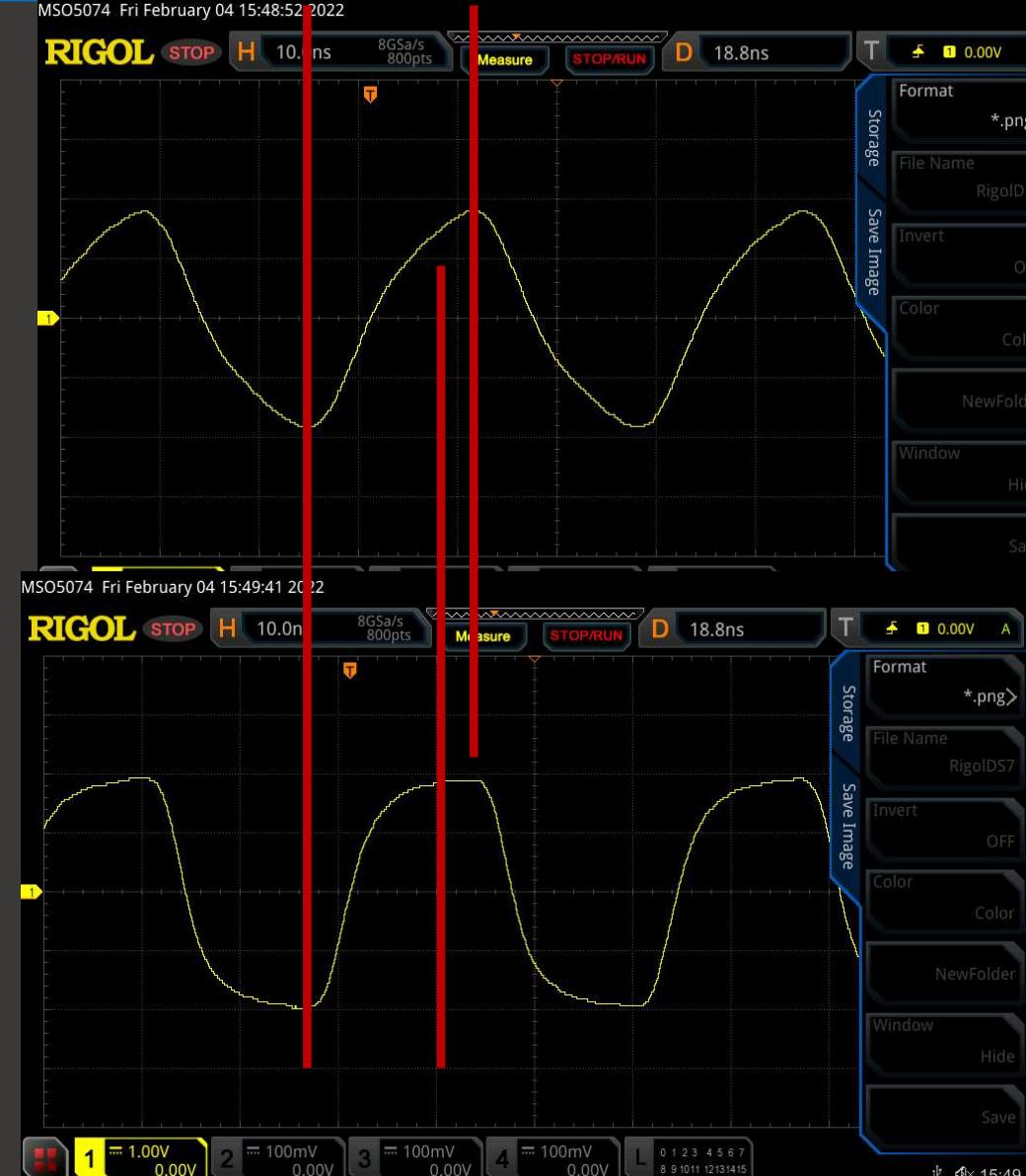


# 1MHz vs 30MHz Comparison

## Rising edge error worse at 1MHz!

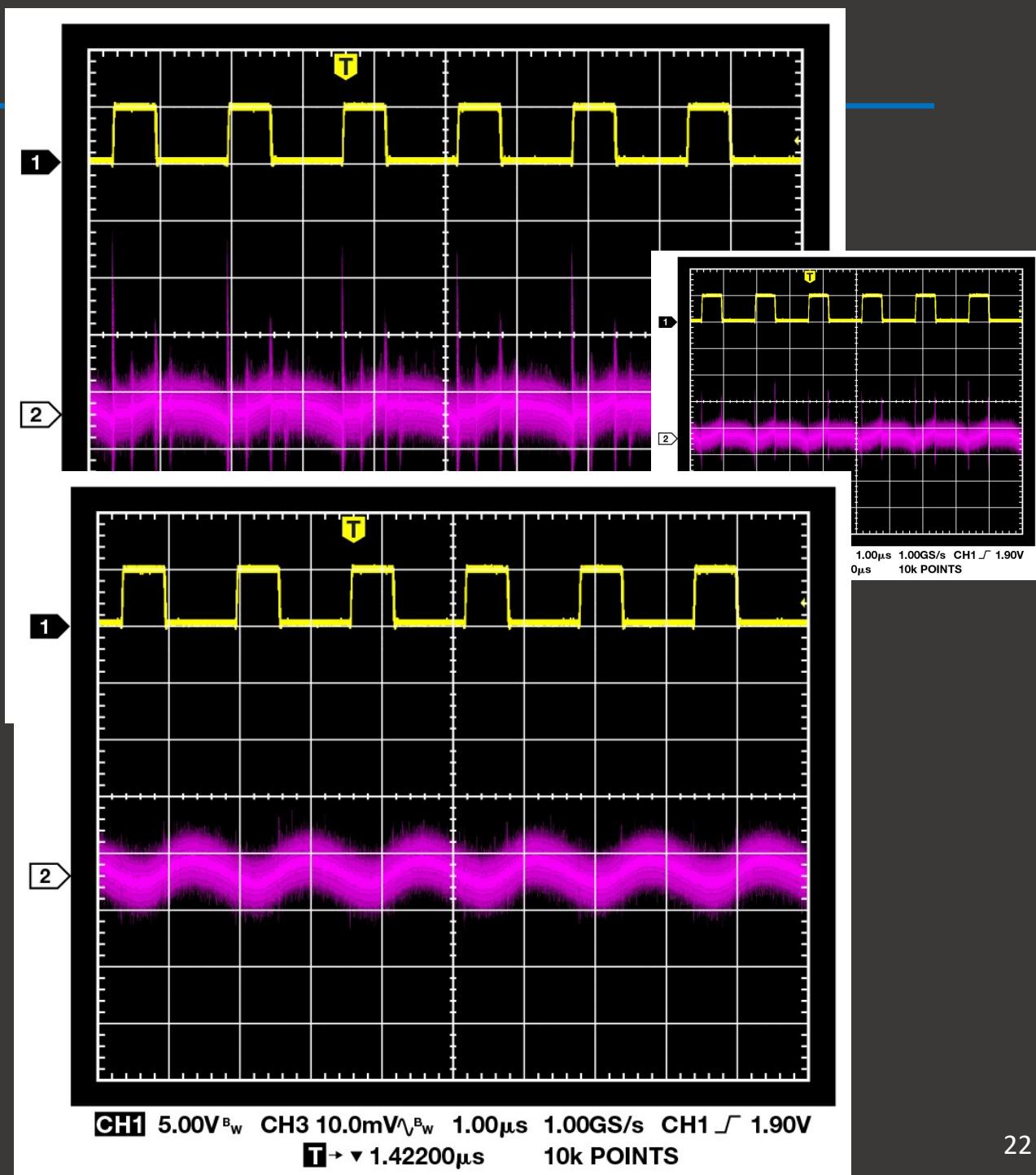
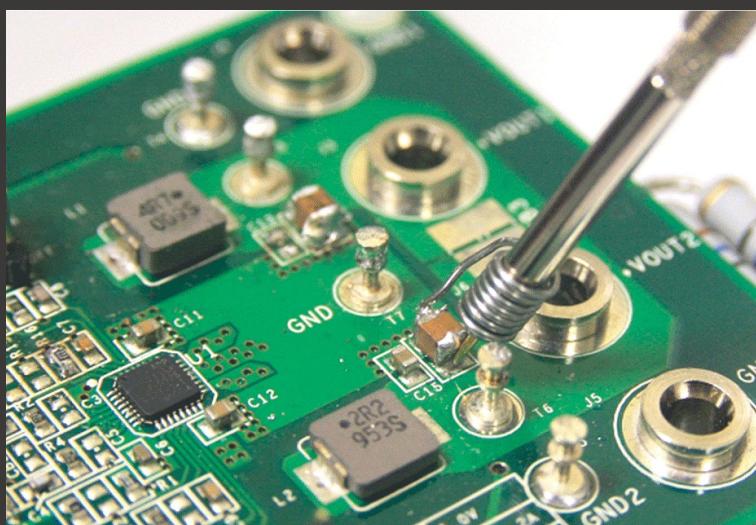
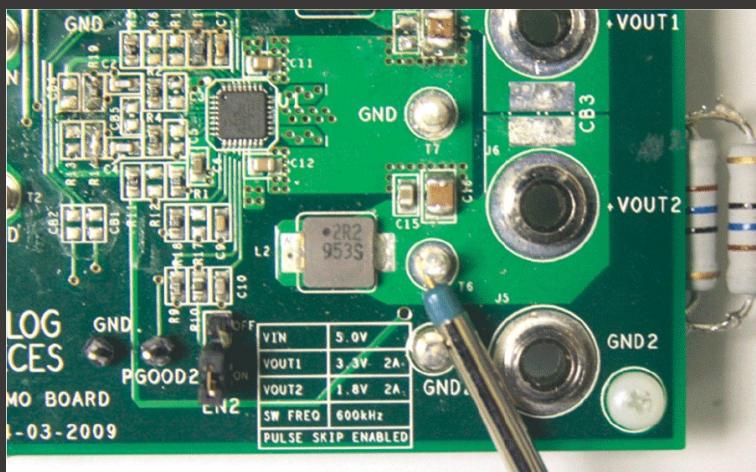
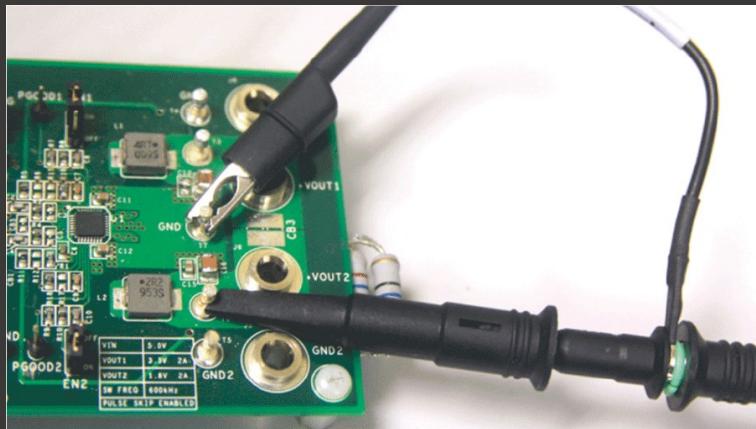


1MHz



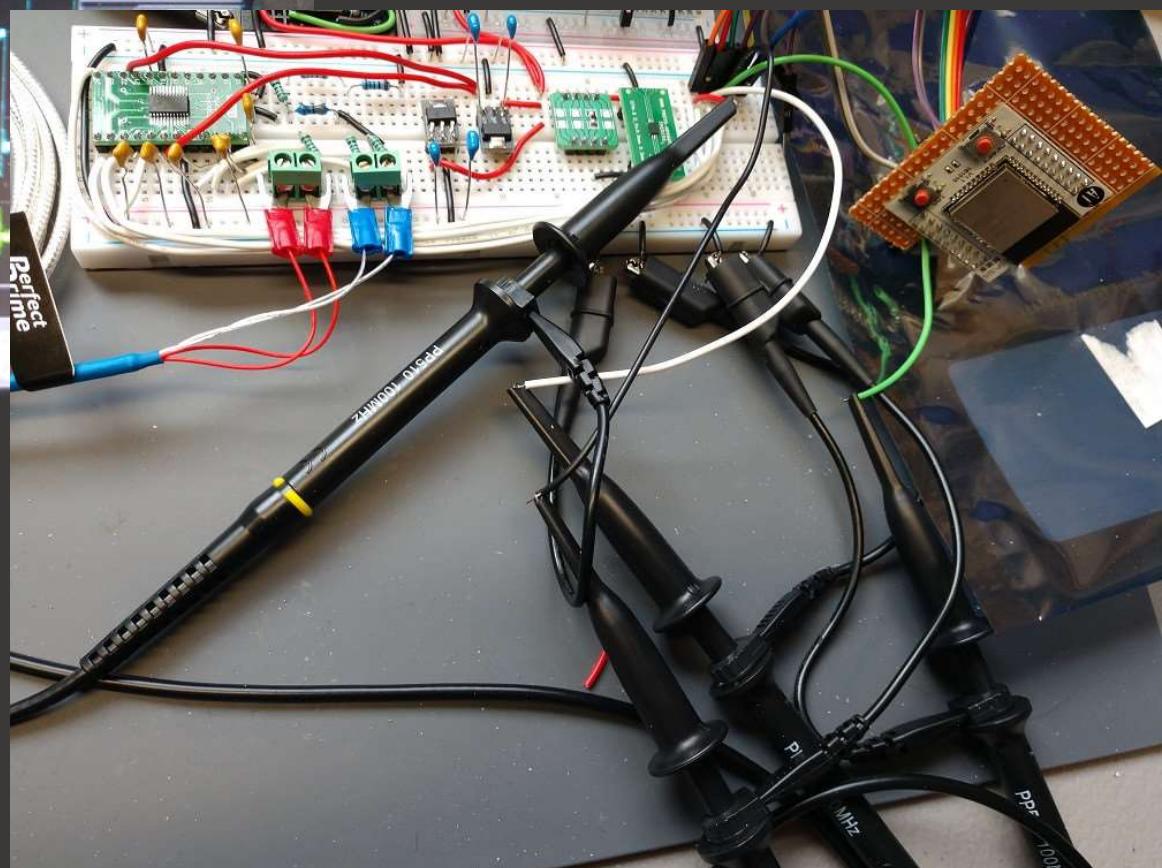
30MHz

# Probing Techniques



# Stack Exchange Question

Is the overshoot real?



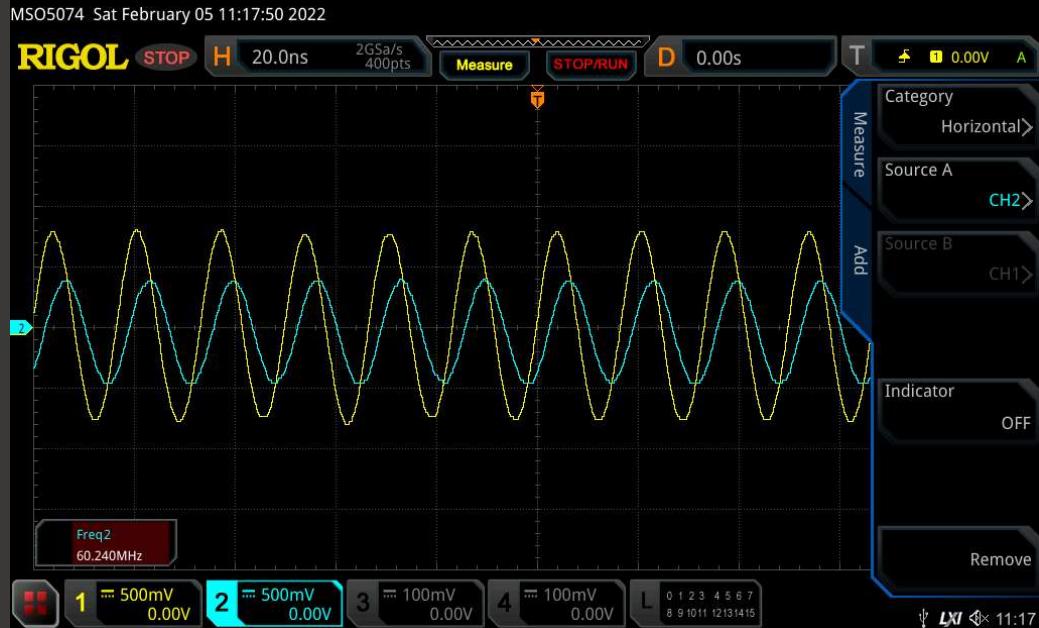
# 1x vs 10x vs 50Ω Probes

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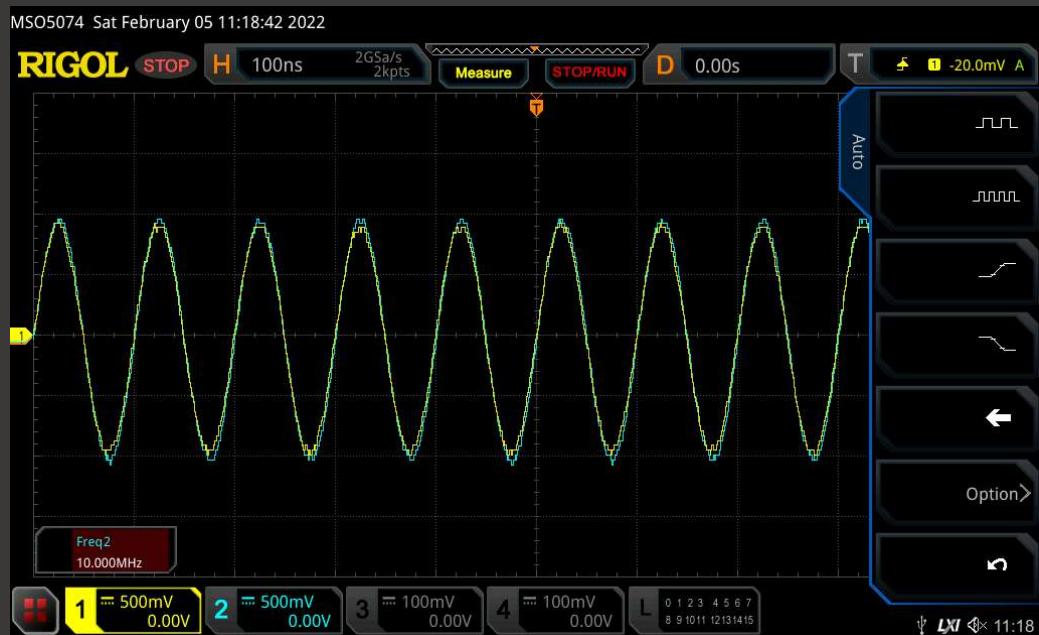
TL;DR

- Use 10x probe
- If measuring very low-voltage signals which are getting buried in noise – use 1x probe
- If measuring something that expects a  $50\ \Omega$  load – use  $50\Omega$ 
  - Function generator
  - RF test equipment
  - RF amplifiers
  - Not all scopes have a  $50\Omega$  option
- If measuring very low-voltage signals which are getting buried in noise – use 1x probe
- 10x probe setting typically has much better bandwidth

# 1x vs 10x Probe Bandwidth



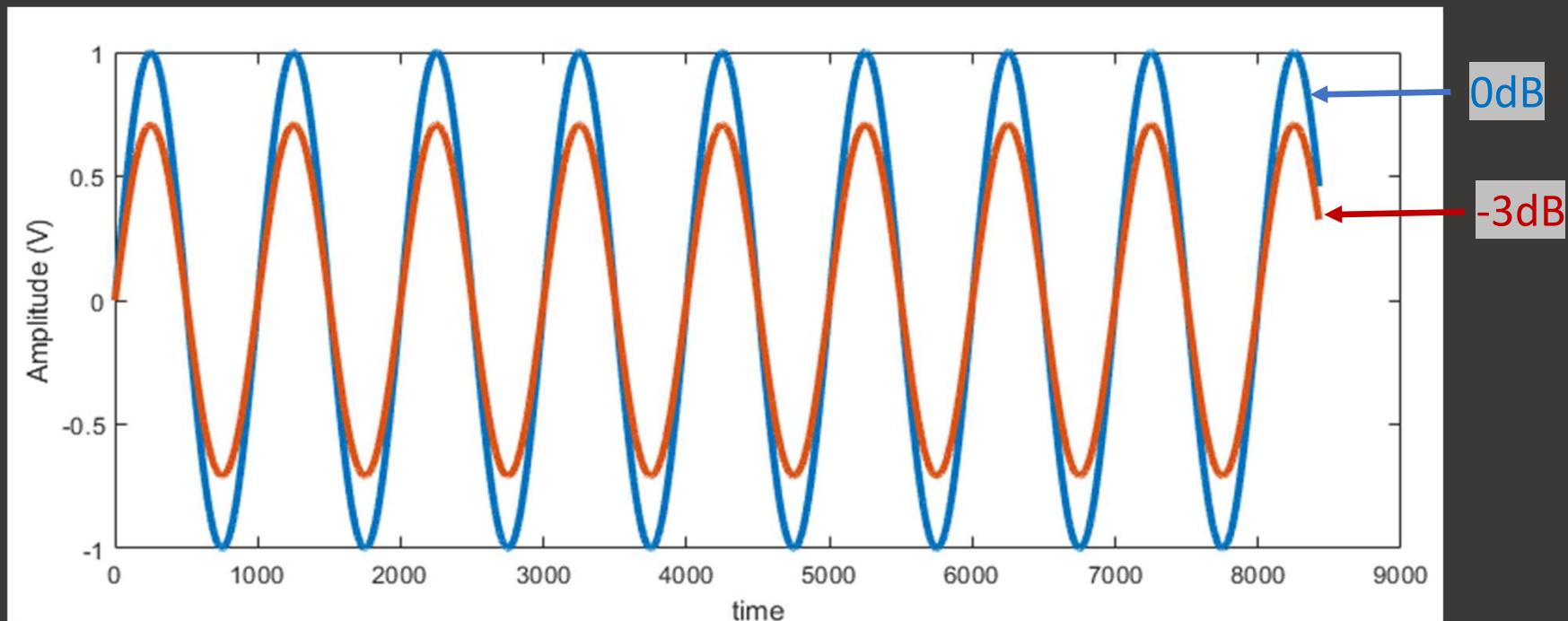
60MHz



10MHz

# Scope Bandwidth

- IEEE 1057: Scope bandwidth is where a sine wave is displayed 3dB below its actual amplitude value
  - A 1V sine wave would display as 0.707V
- This may not actually be true for a given scope
- What's enough bandwidth?
  - Audio: 50kHz
  - General purpose analog/digital – 1MHz-50MHz?



# Sample Rate

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- Sample rate - # of samples per second
- Often divided by number of active channels
- What's good enough?
  - At least 4x the data rate of digital signals
  - I2C: 1Msps
  - 1MHz SPI: 4Msps
  - 10MHz bus with clock:  $9 \times 40\text{Msps} = 360\text{Msps}$