Agenda

- Oscilloscope Overview
- How They Work
- Basic Scope Controls
- Common Measurements
- Probes and Accessories

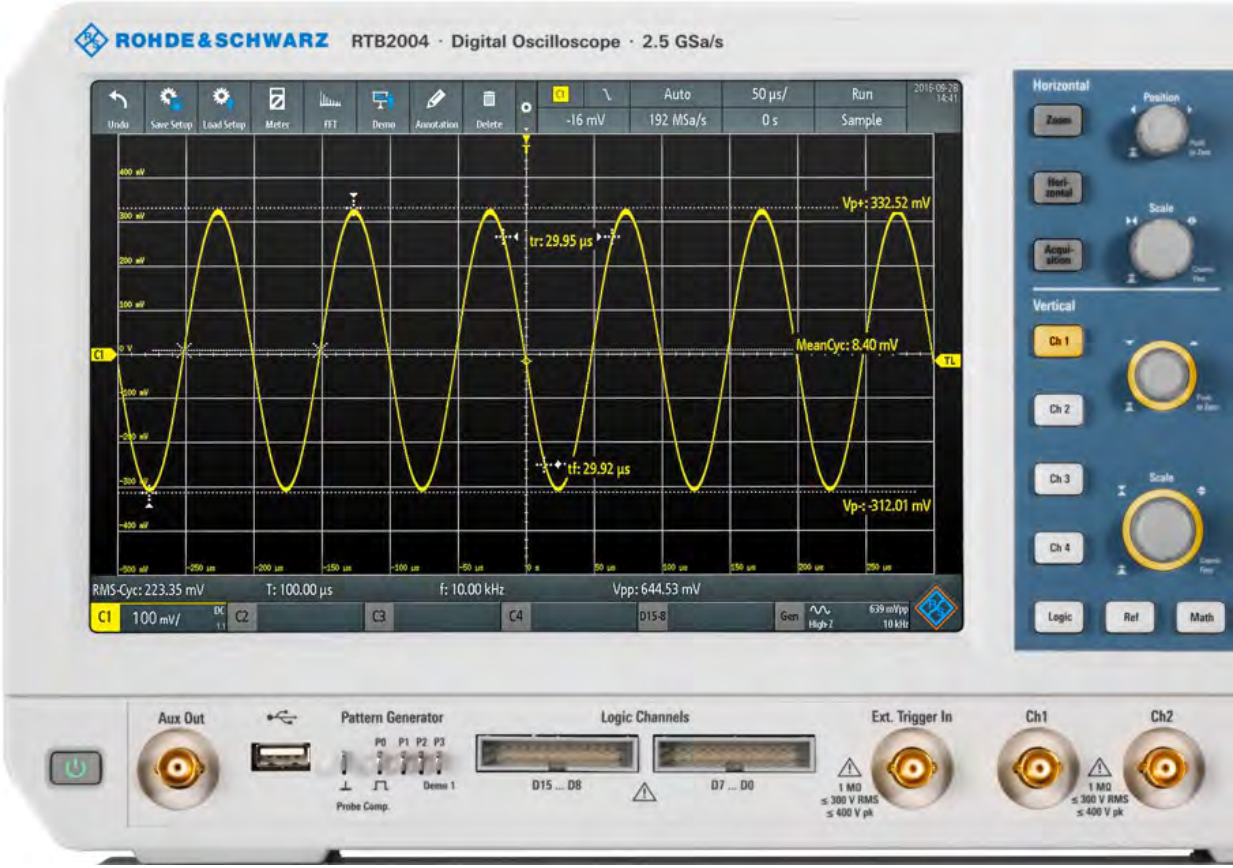
What is an Oscilloscope?

- Oscilloscopes measure Voltage vs. Time
- Used to design, debug, and validate almost all electronics
- Basic operations with many advanced capabilities

Oscilloscope Uses

- Look at supply voltages
- Measure signal timing
- Verify signal integrity
- Debug turn-on

- Visualize the waveforms



Oscilloscope Terms

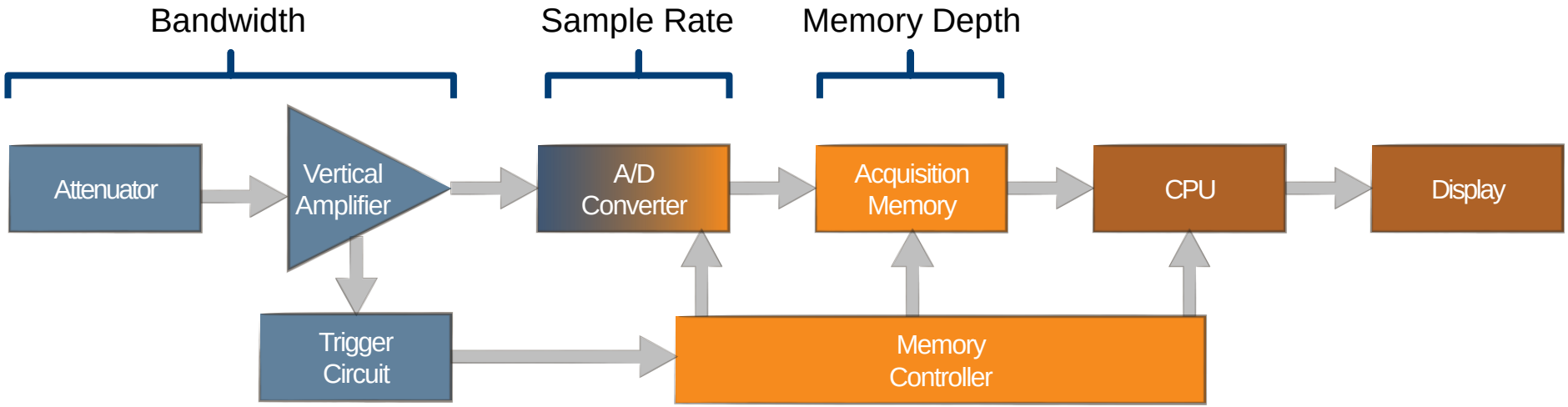
- **Bandwidth**
- **Sample Rate**
- **Analog-to-digital converter (ADC)**
- **Memory Depth**
- Channels

- Waveform Display
- Timebase (Horizontal)
- Vertical (Voltage)
- Trigger
- Measurements
- Single shot

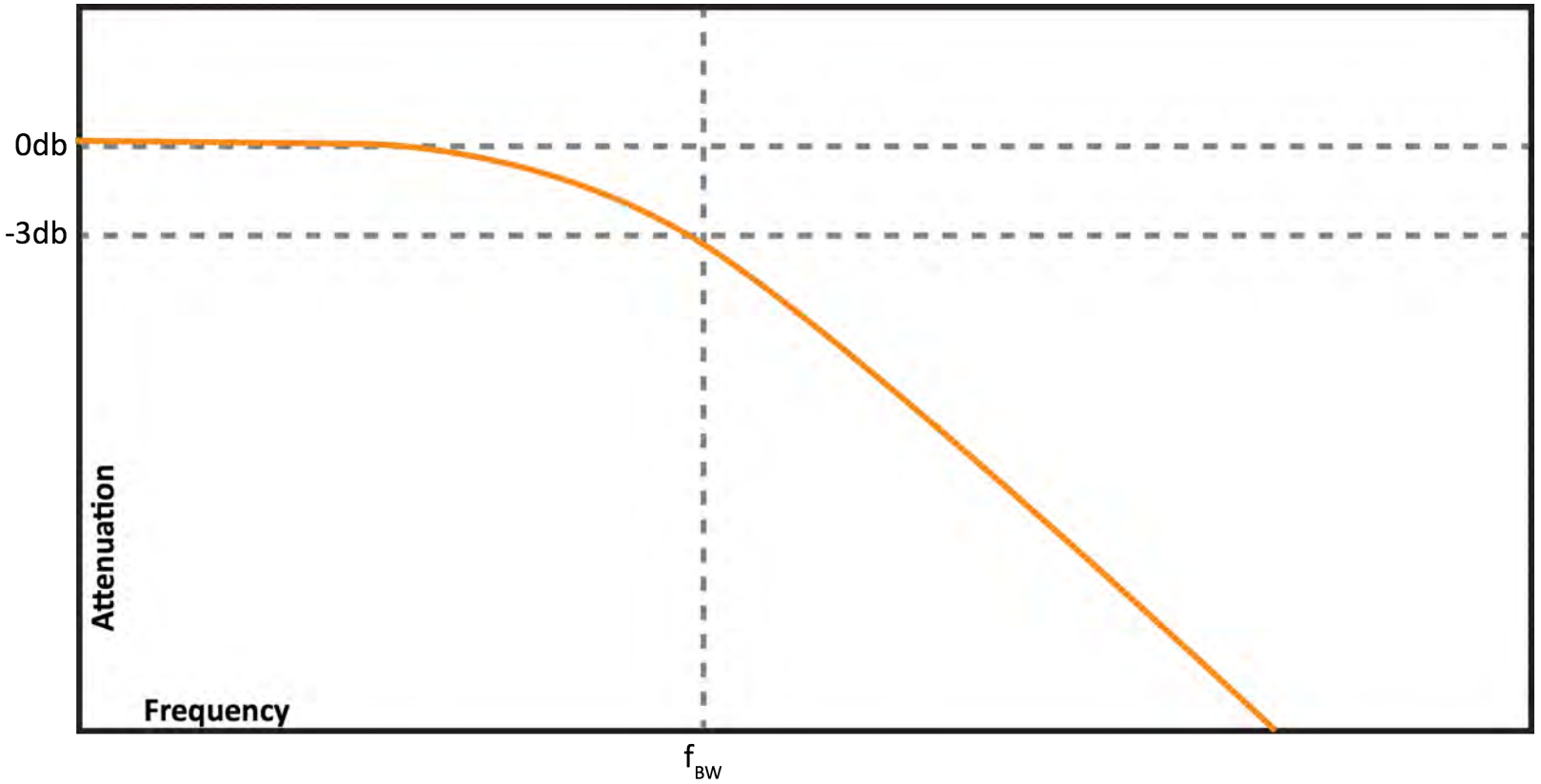
Instrument Fundamentals: Oscilloscopes

Functional Overview

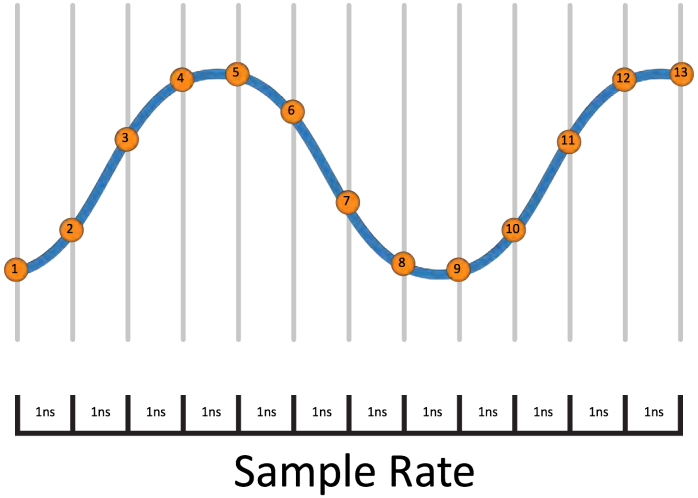
Oscilloscope Block diagram

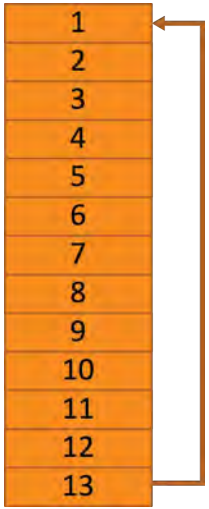


Analog Bandwidth



Digital Sample Rate

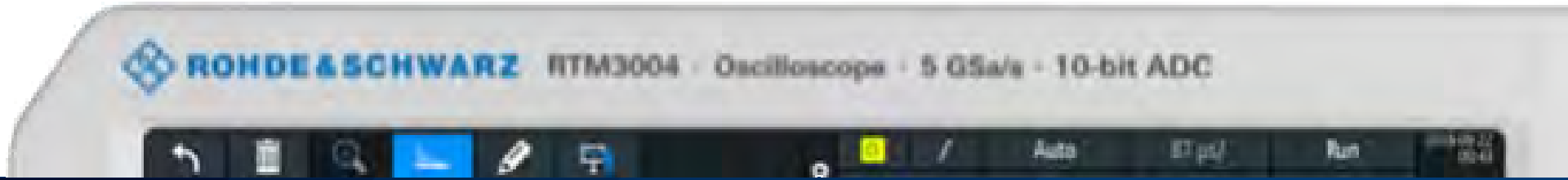




$$\text{Digital Resolution} = \frac{1}{\text{Sample Rate}}$$

$$= \frac{1}{1\text{Ga/s}}$$

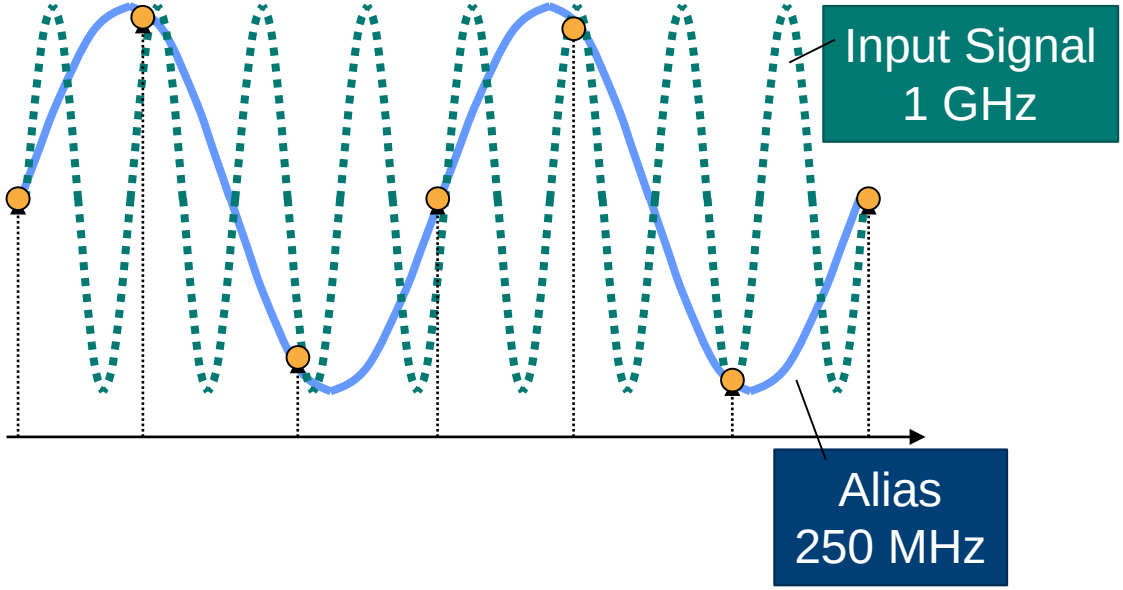
$$= 1\text{ns}$$



How much sample rate do you need?

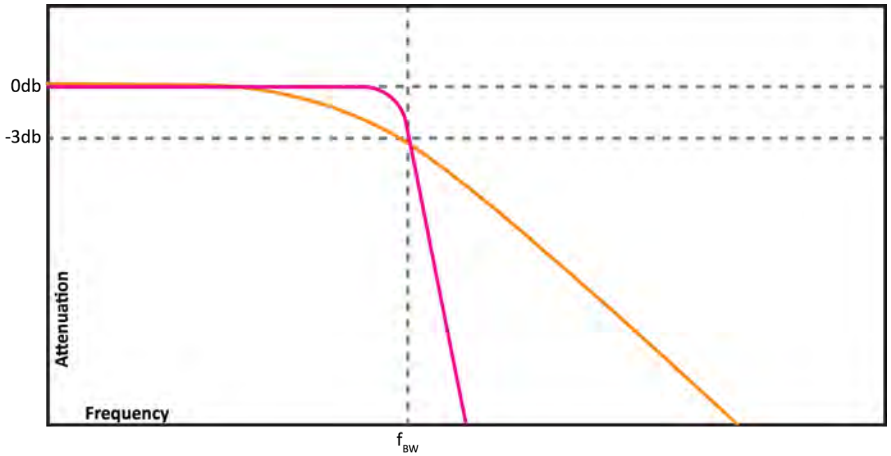
- Nyquist - Shannon
  - Sampling rate >2x highest signal frequency

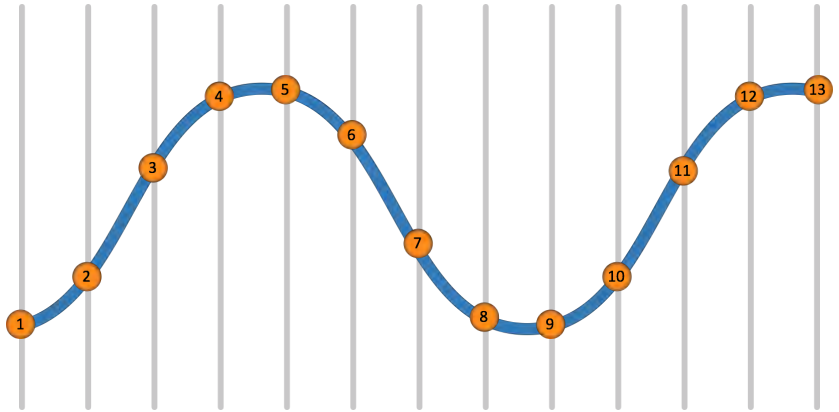
>2x



Sample Rate: 750 Megasamples/sec

Bandwidth vs. Sample Rate





Bandwidth
Determines Analog Signal Content
e.g. 1 GHz

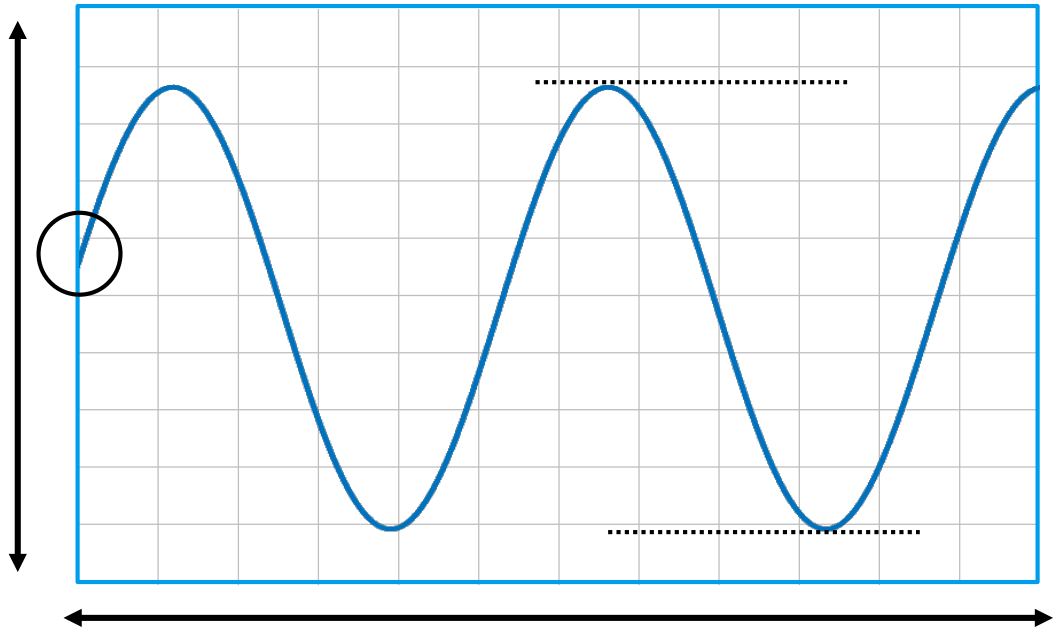
At least 3X the measured signal

Sample Rate
Ability to reconstruct the waveform
e.g. 2.5 GSa/s

> 2.5x the analog bandwidth

Basic Oscilloscope “Systems”

- Four primary “systems”:
  - Vertical system
  - Horizontal system
  - Trigger system
  - Display system

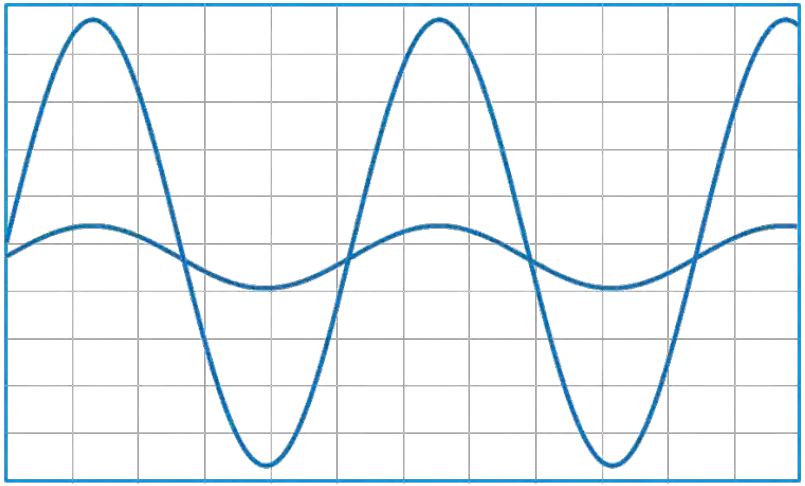


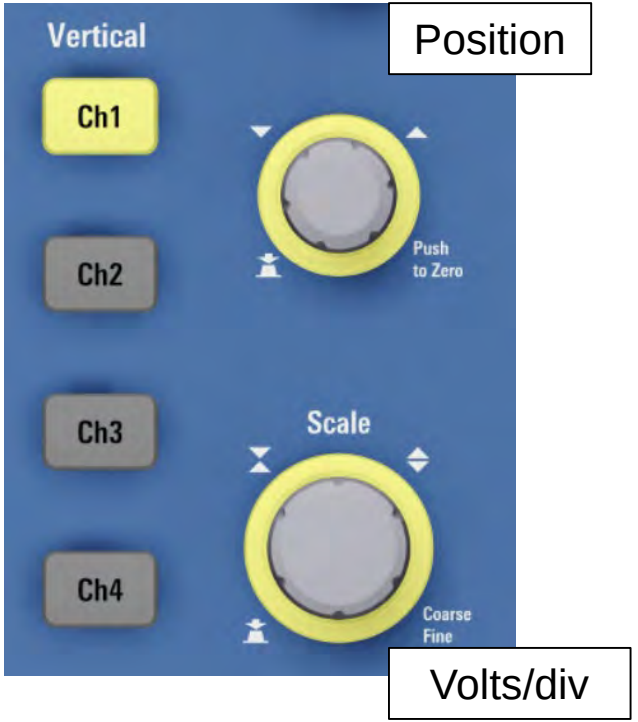
Instrument Fundamentals: Oscilloscopes

Basic Controls

Vertical (Voltage) System

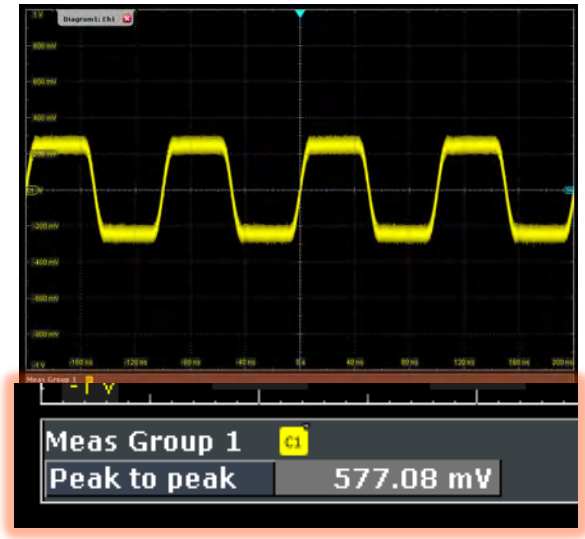
- Use **volts/div** control to maximize the waveform on the screen
  - Uses all the bits of the ADC
  - Easier to see details



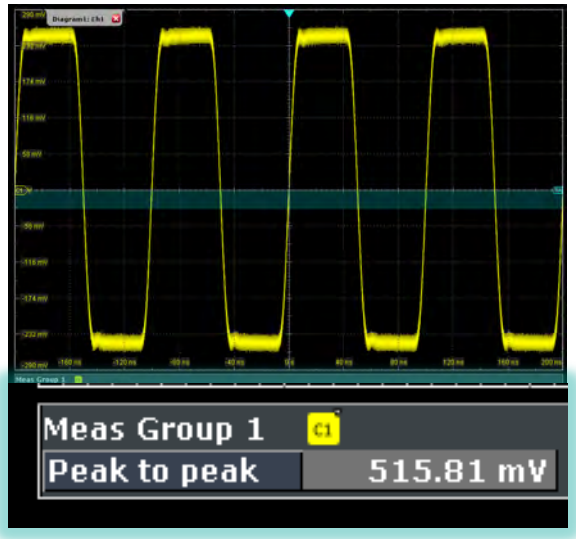


Fill the screen without clipping

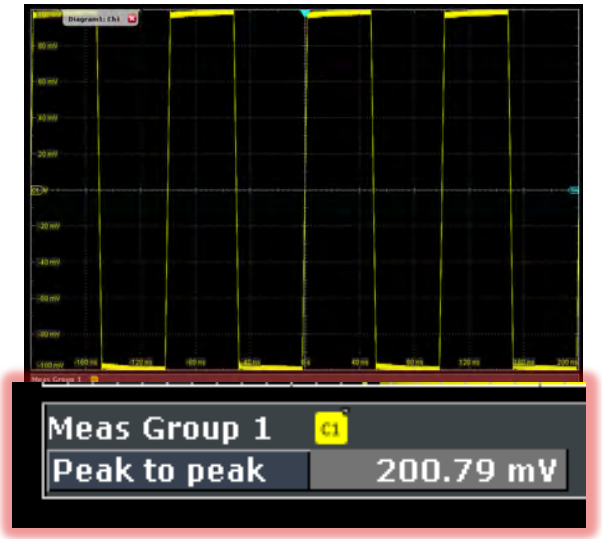
2 Divisions



Full Scale

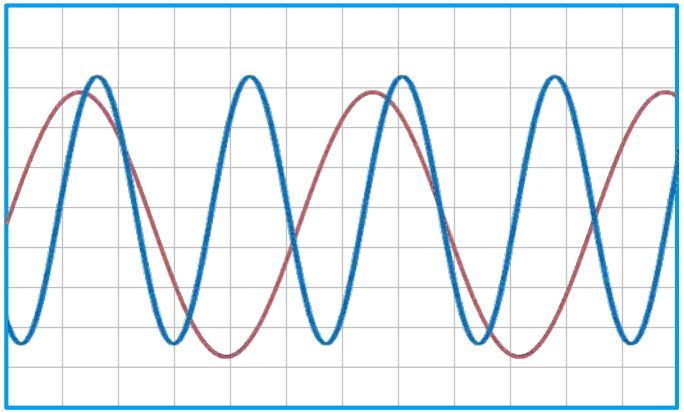


Clipping



Horizontal (Timebase) System

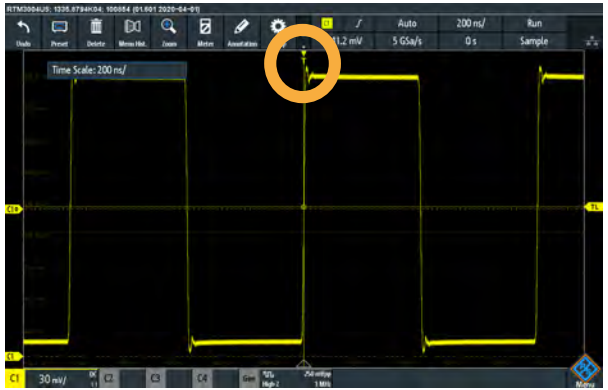
- Use **time/div** control to control how much time is captured
  - Long time to see slow events
  - "Zoom in" for higher sample rate



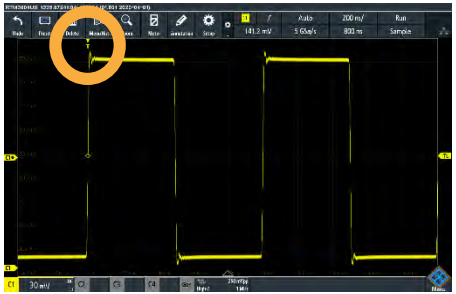
Horizontal (Timebase System)

Time Scale: 100 µs/

Time Scale: 200 ns/



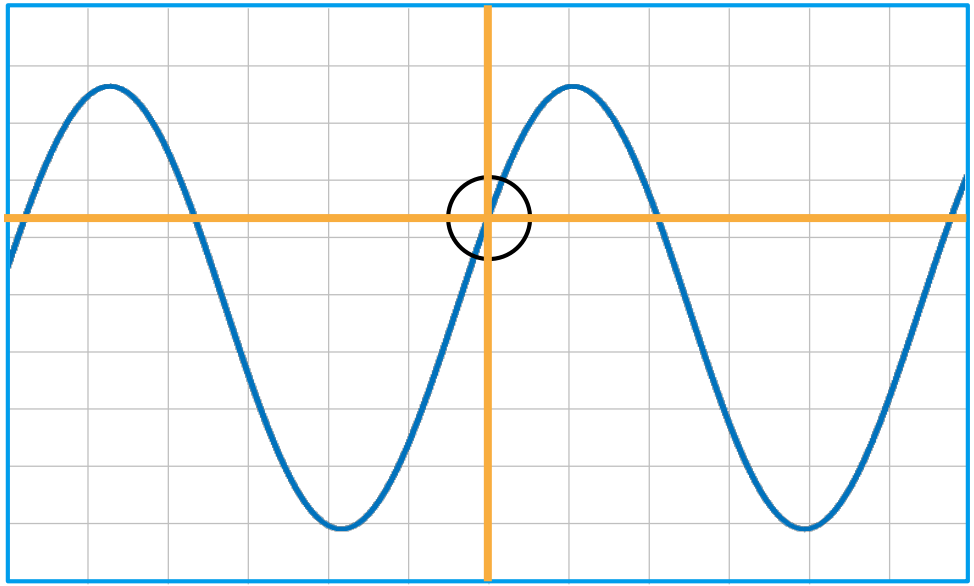
Time Scale: 10 ns/



Trigger System

- Identifies a signal event in voltage
- Can stabilize the screen
- Useful for Single-shot or rare events
- (Position Knob moves Trigger point)

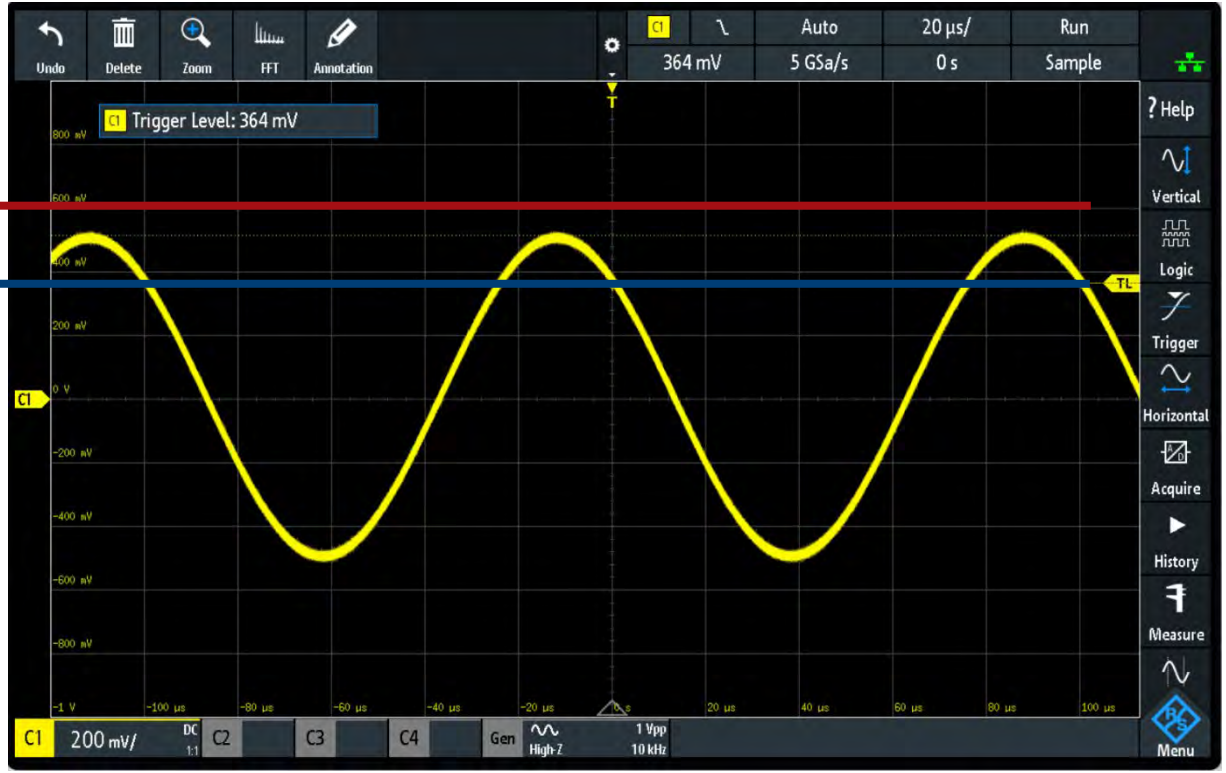
- Many trigger types:
  - Edge
  - Pulse Width
  - Window
  - Runt
  - Serial Pattern
  - Etc.

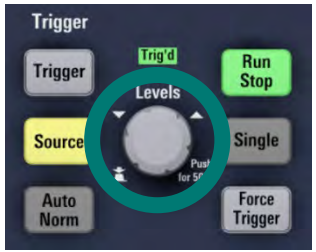


Setting a trigger level

TL = +616 mv

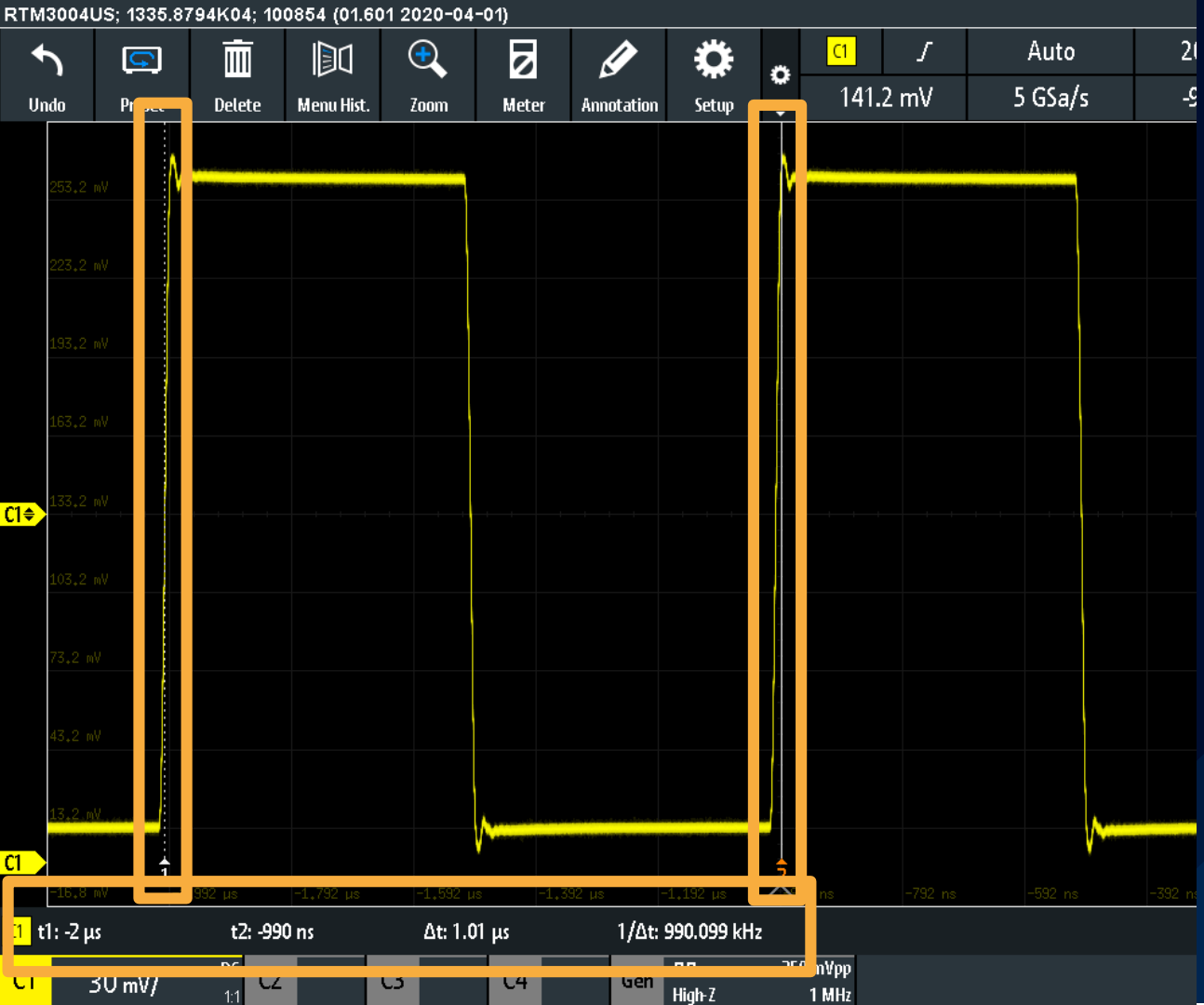
TL = +360 mv





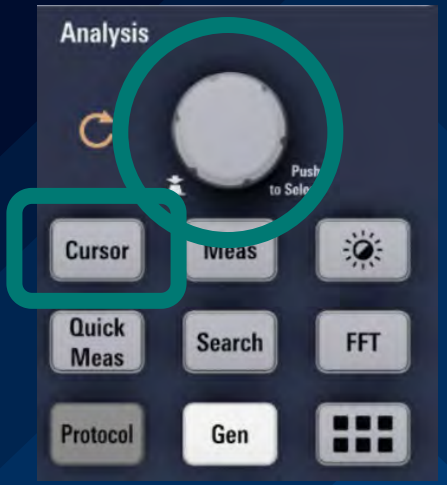
Instrument Fundamentals: Oscilloscopes

Common Measurements



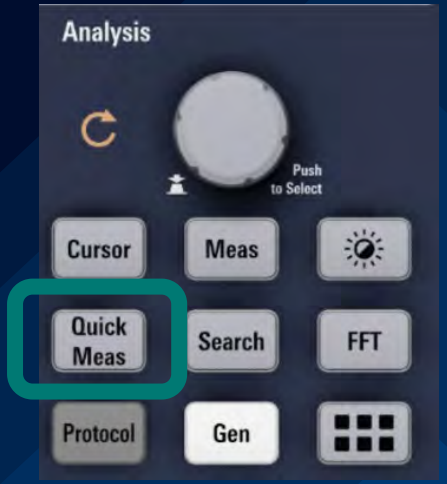
Cursors

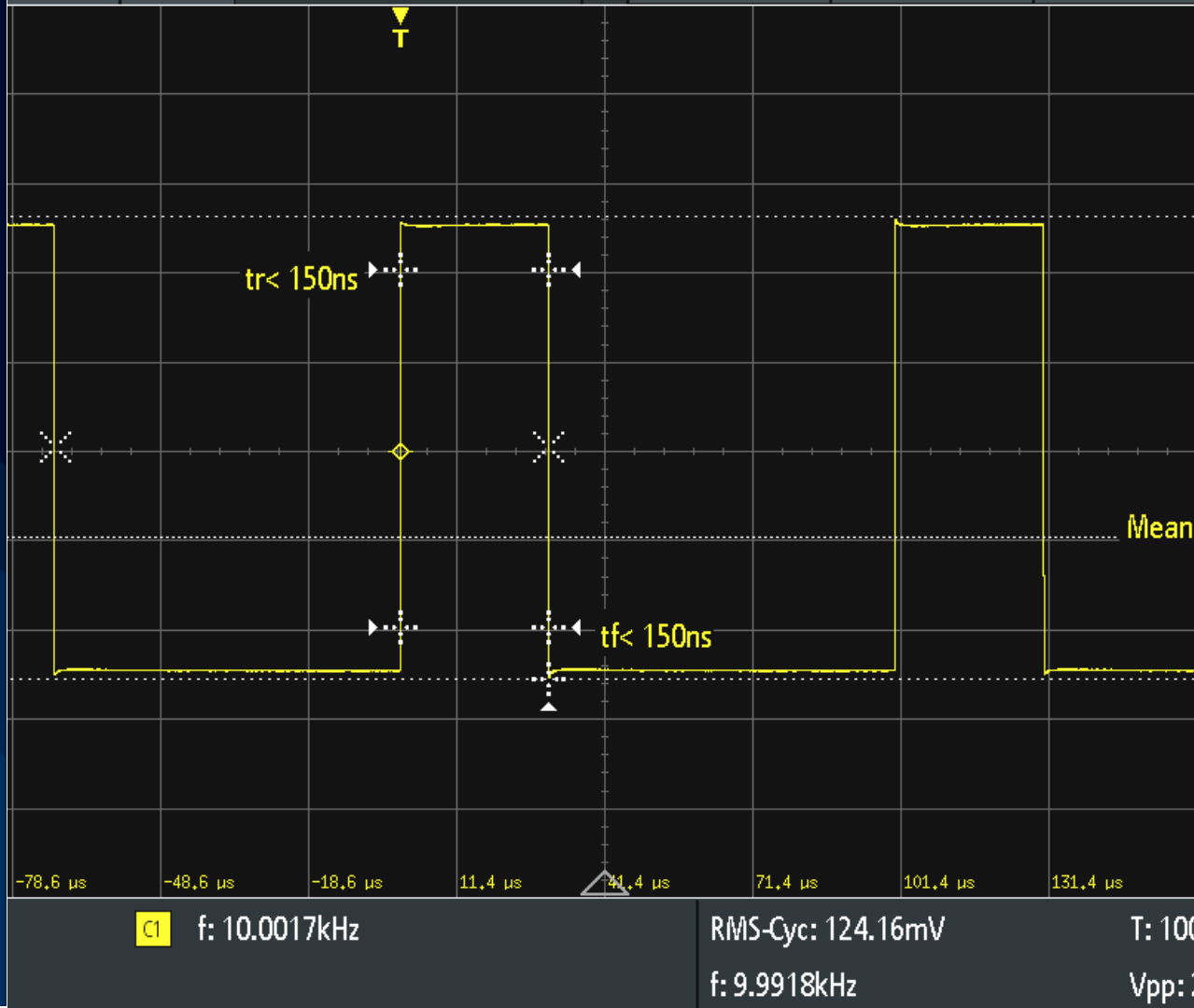
- Manual way to measure a waveform
- Faster than counting divisions
- Good for documentation



Waveform Measurements

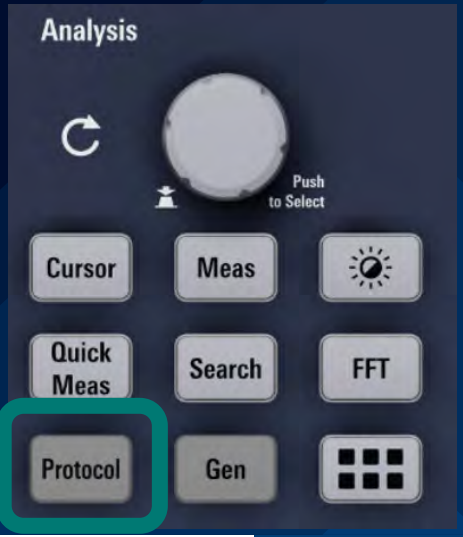
- Peak(-to-peak) voltage
- Frequency
- Rise/fall times
- Slew rate
- Statistical measurements

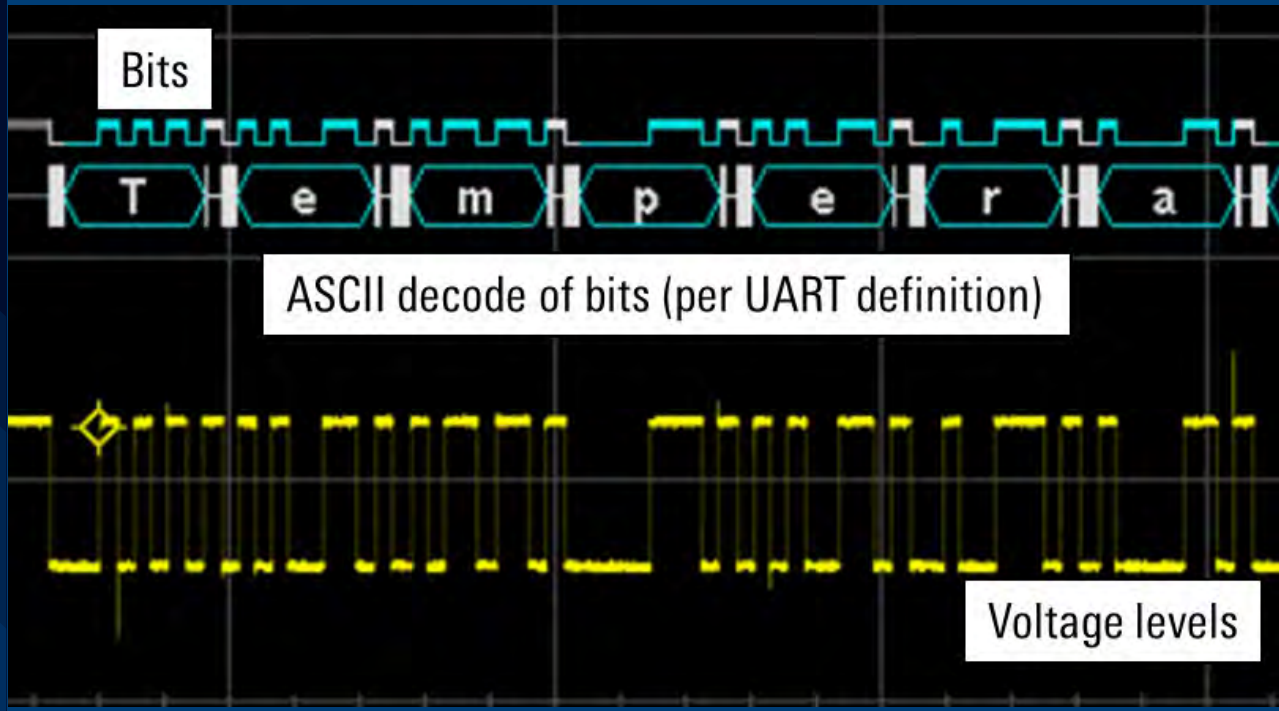




Protocol Decode

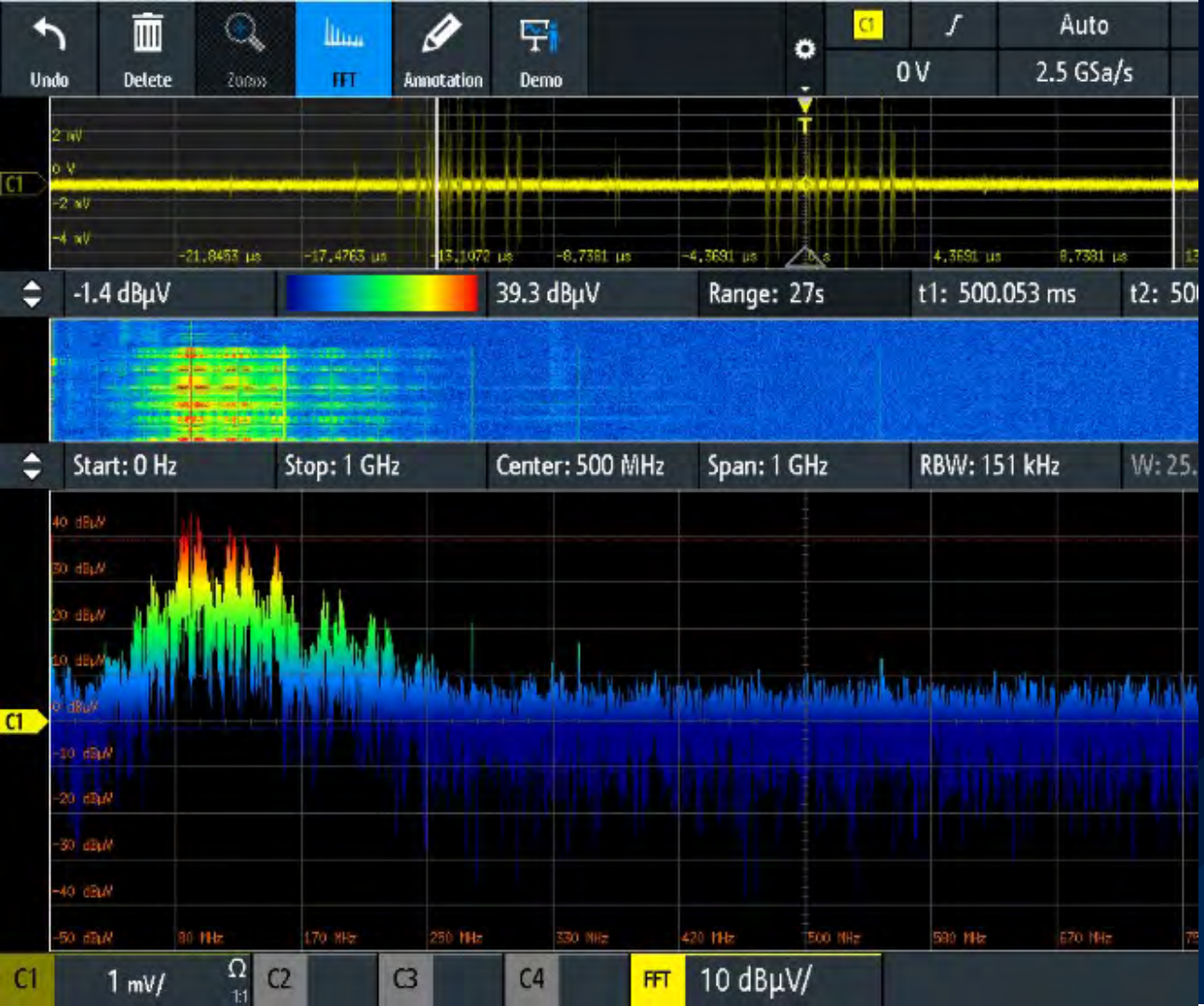
- UART Example
- I²C, SPI, USB, CAN, etc
- PCI-Express, MIPI, DDR

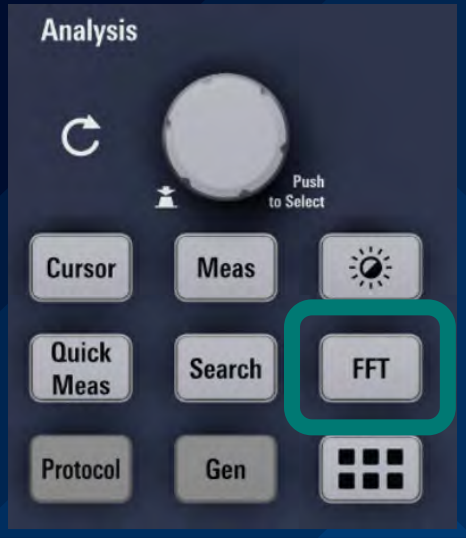




FFT

- Frequency Analysis
- Great for EMI Debug
- Analyze noise in a system

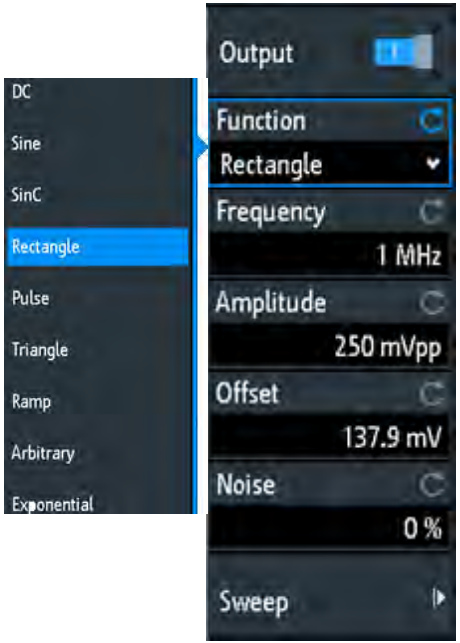




Oscilloscopes are more than scopes

Frequency Counter

Volt Meter

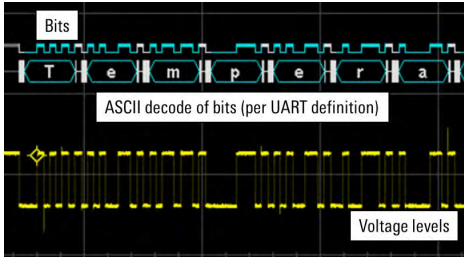


Function Generator

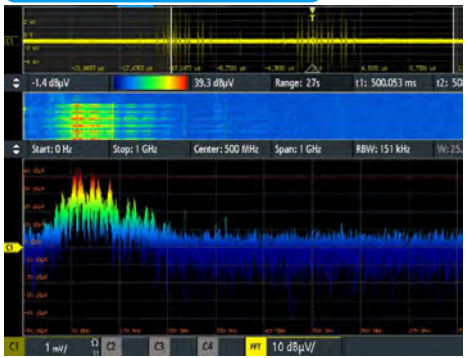
Pattern Generator

Logic Analyzer

Protocol Analyzer



Spectrum Analysis



Instrument Fundamentals: Oscilloscopes

Probes and Accessories

Oscilloscope probes types

Passive

Single Ended

Differential

Power Rail

Current

A probe for every application

Standard | Broadband

Single-ended | Differential | Modular

PASSIVE

ACTIVE

EMC near field

Fixtures

Logic

High voltage | Current

Power Rail

Multi-channel V/I

SPECIALIZED

Instrument Fundamentals: Oscilloscopes

Conclusion

Summary

- Key Specifications
- Bandwidth & Sample Rate
- Key Systems
- Vertical (Voltage), Horizontal (Time), and Trigger
- Measurements
- Parameters, Serial Decode, Frequency
- Accessories
- Many probe options