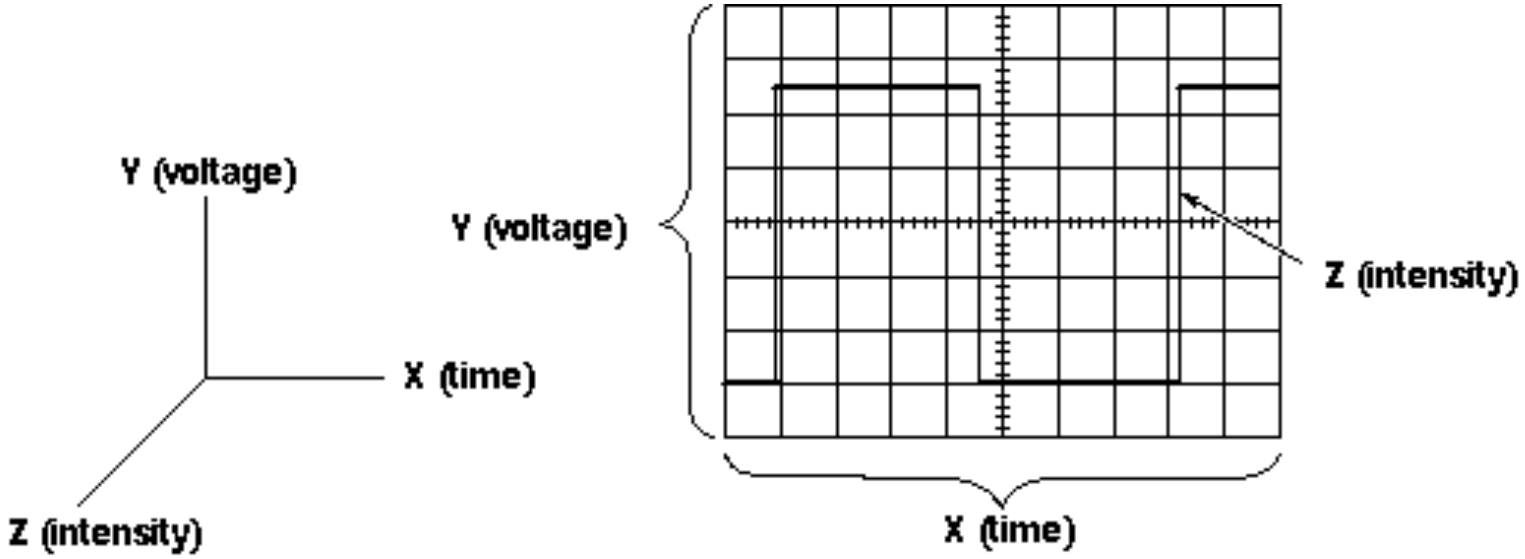
Digital Storage Oscilloscope
4190.309
2008 Fall Semester

Naehyuck Chang
Dept. of EECS/CSE
Seoul National University
naehyuck@snu.ac.kr

Seoul National University

Introduction

- A graph-displaying device of electrical signal
  - X axis: Time
  - Y axis: Voltage
  - Z axis: Intensity or brightness

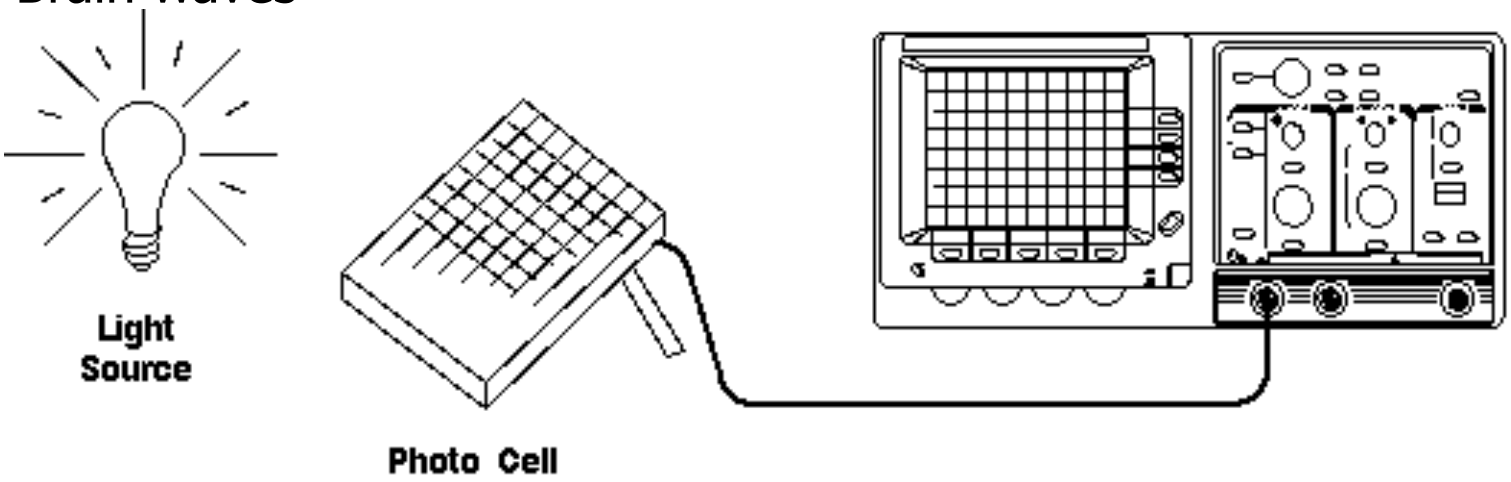


Introduction (contd.)

- Information given by oscilloscopes
  - Time and voltage
  - Frequency and phase
  - DC and AC components
  - Spectral analysis
  - Rise and fall time
  - Mathematical analysis

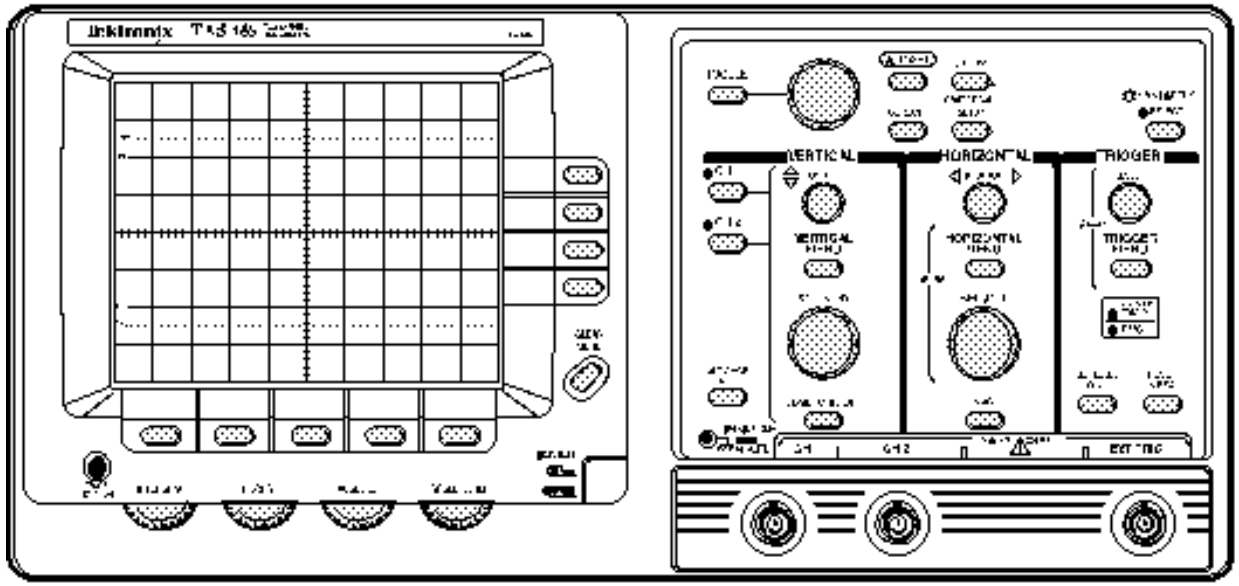
What can you do with oscilloscopes?

- Designing and repairing electronic equipment
- With the proper transducer (Ex: microphone)
  - Electrical signal in response to physical stimuli, such as sound, mechanical stress, light, or heat.
  - Engine vibrations
  - Brain waves



Control panel of an oscilloscope

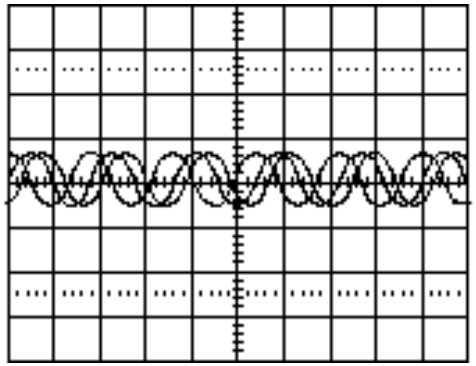
- Vertical Section
- Horizontal Section
- Trigger Section



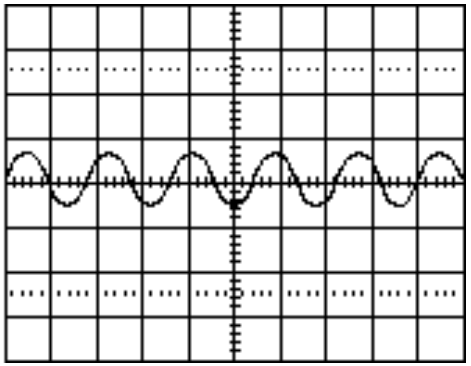
Basic setting

- Vertical system
  - attenuation or amplification of signal (volts/div)
- Horizontal system
  - The Time base (sec/div)
- Trigger system
  - To stabilize a repeating signal and to trigger on a single event

Untriggered Display



Triggered Display



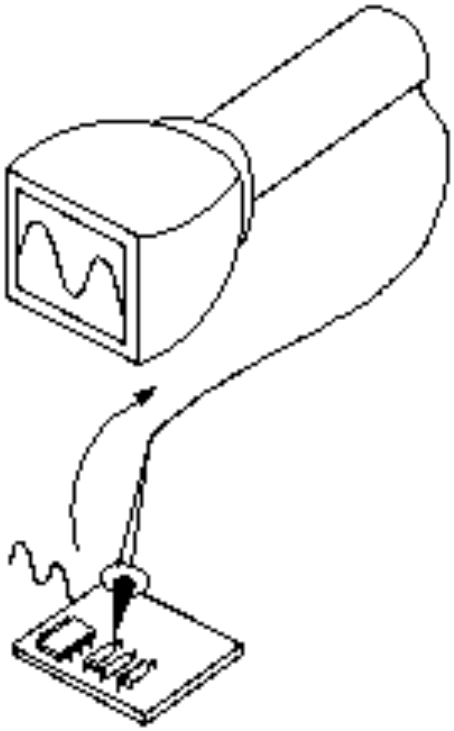
In digital circuits

- Measuring
  - Logic level
  - Timing
  - Logic strength
  - Rise and fall time
  - Frequency
  - Signal integrity
    - Waveform distortion
    - Noise level

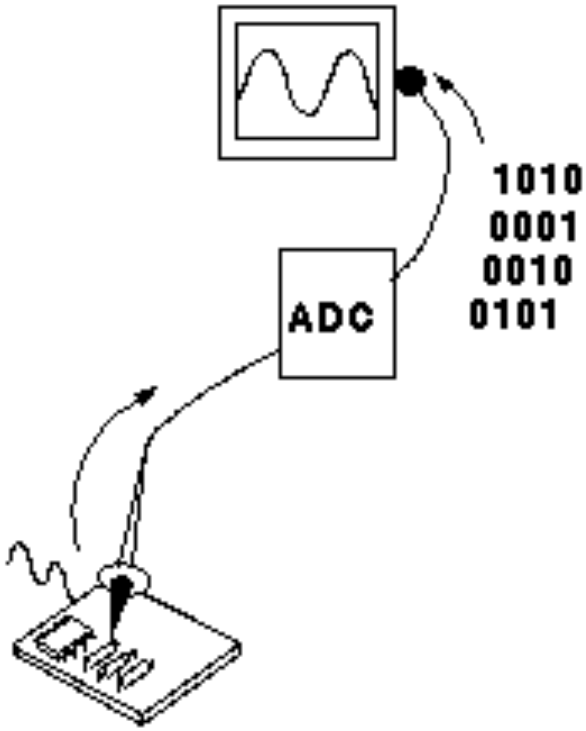
In digital circuits (contd.)

- Diagnosing
  - Timing fault
  - Proper fan-in and fan-out
  - Proper pull-up and/or termination
  - Collision
  - Signal integrity
    - Reflection
    - Noise, crosstalk and ground bounce
  - Open, short or stuck at 0 or 1

Analog and digital oscilloscope



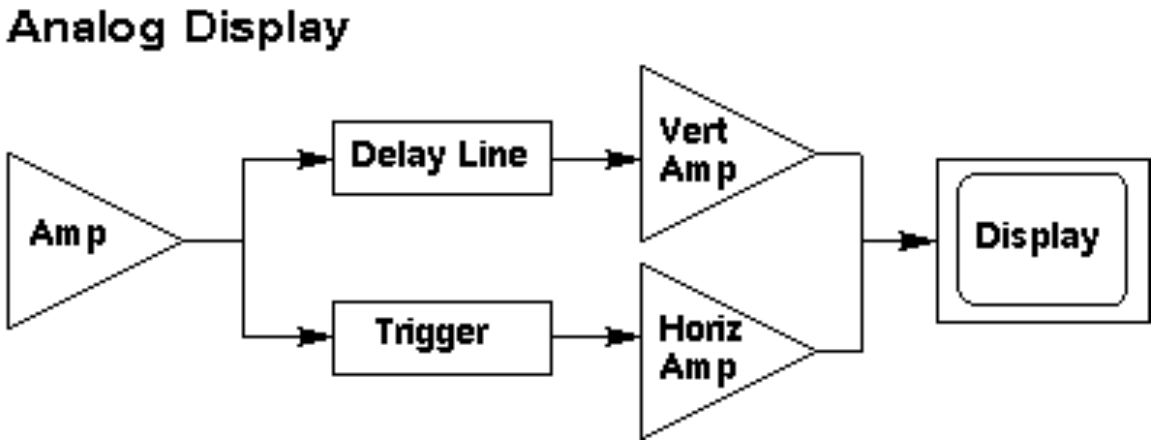
Analog Oscilloscopes
Trace Signals



Digital Oscilloscopes Sample Signals
and Construct Displays

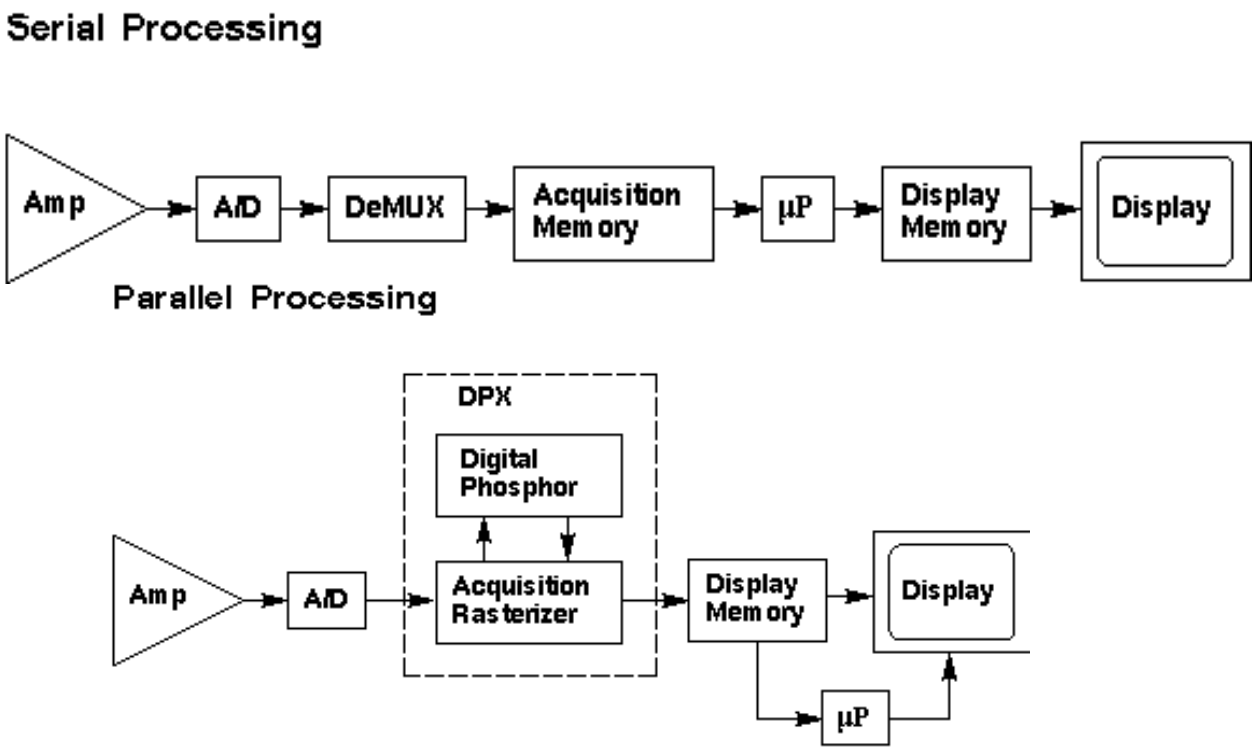
Analog oscilloscope

- Real-time display of signals
- Block diagram
  - Sweep generator and vertical amplifier
  - Earthquake recorder



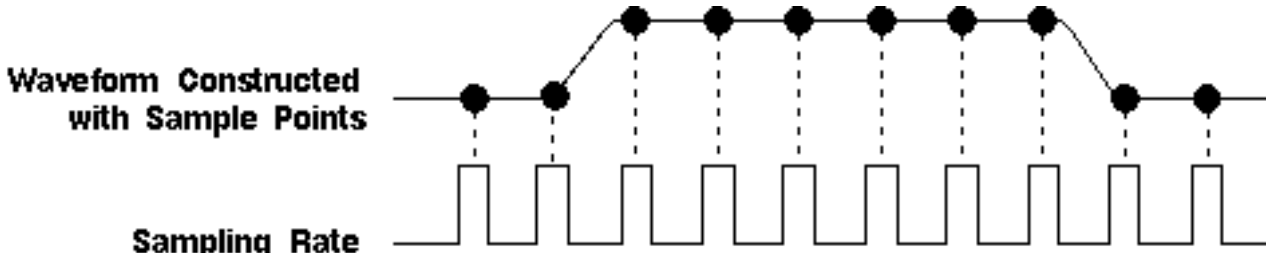
Digital oscilloscope

- Capture and view events
  - Digital storage oscilloscope (DSO)

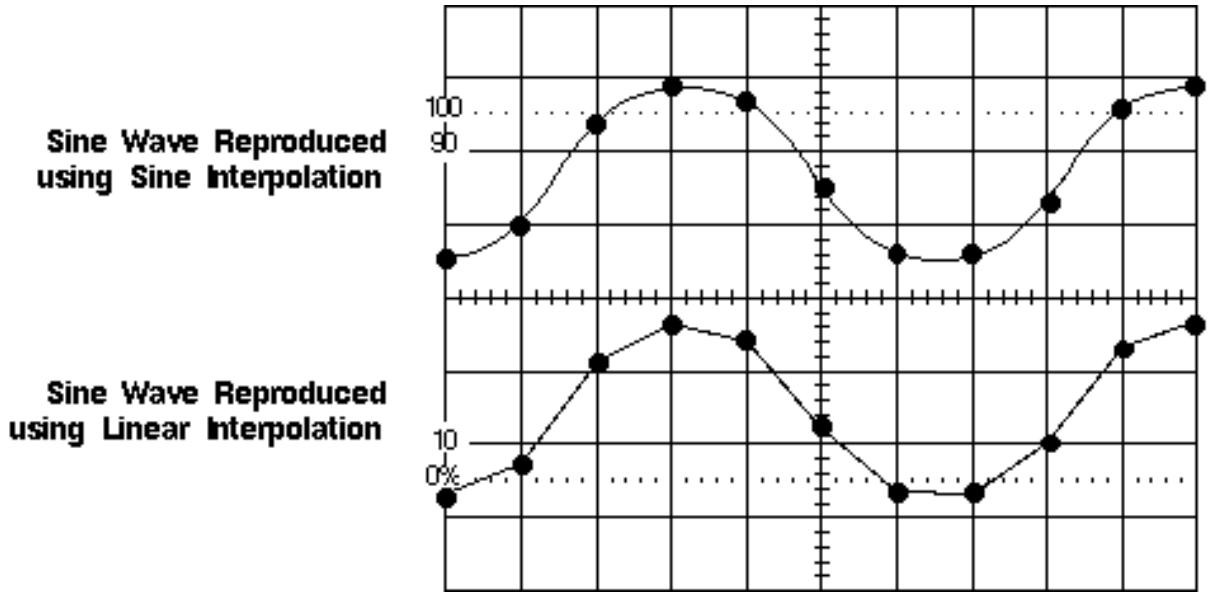


Digital oscilloscope (contd.)

- Sampling



- Interpolation



Why DSO?

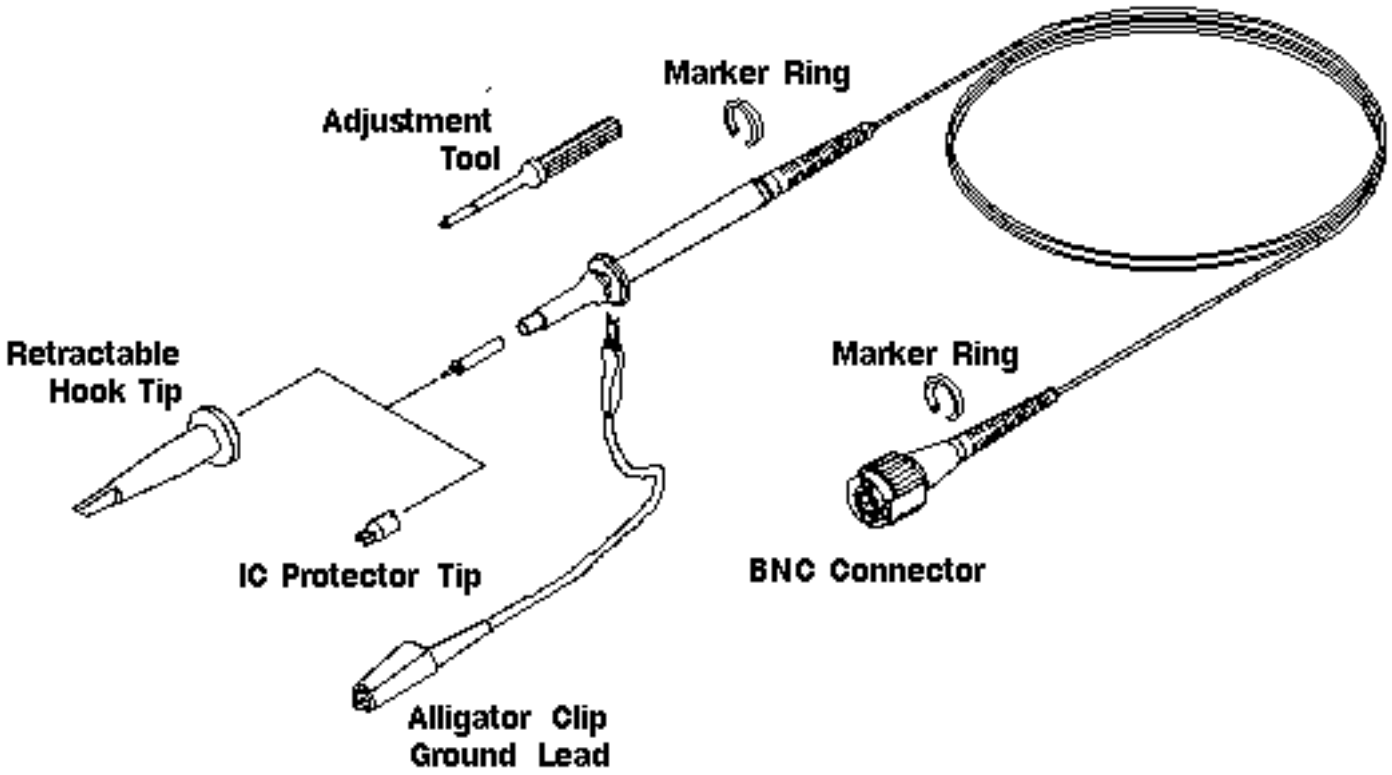
- Trend
- Easy of use
- One-shot measurement
  - Non-periodic waveform
- Recoding
  - Lengthy waveform analysis
- Triggering
  - Complex trigger condition
- Data reuse
- Connectivity

Probes

- High quality connector
  - No discontinuity
- High impedance (10MΩ)
  - Invisible observer (no circuit loading)
- 50Ω for high frequency measurement
- Passive probe and active probe

Probe (contd.)

- Components

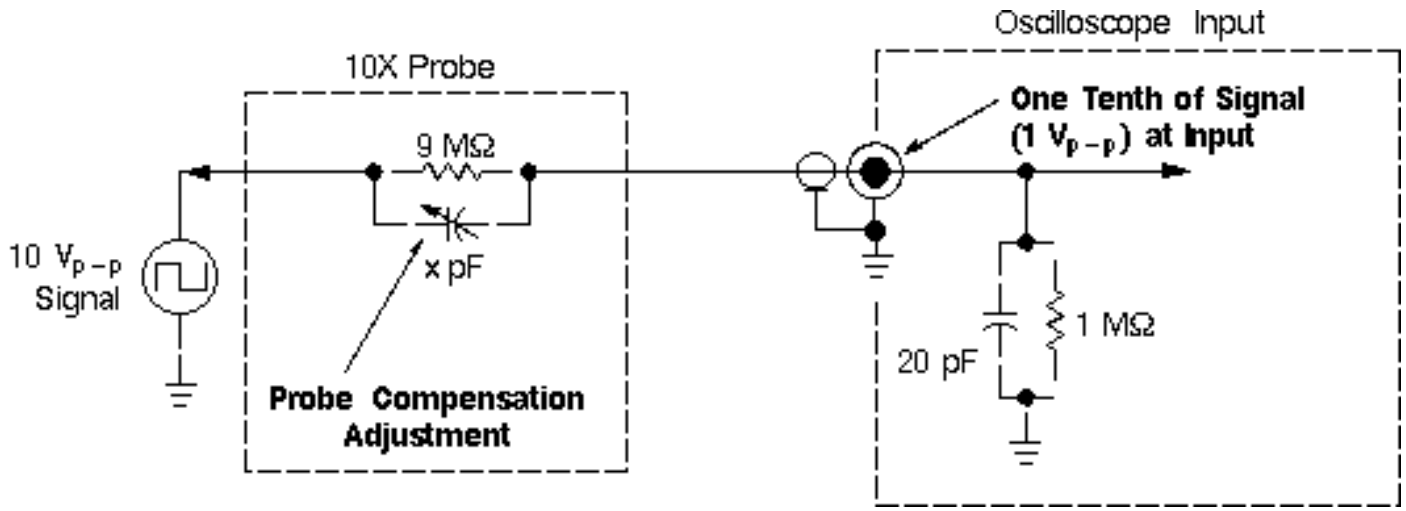


Passive probe

- 10× attenuation
  - Good for low circuit loading
  - Suitable to high frequency signal
  - Difficult to measure less than 10mV signals
- 1× attenuation
  - Good for small signals
  - Introducing more interference
- 20x attenuation
  - Newly announced
  - Low-capacitance passive probe
  - Tektronix P6158, 3GHz 20x

Passive probe (contd.)

- Bandwidth and capacitance
  - 10MHz (100pF) and 500MHz (10pF)
  - < 20K Won and < 500K Won
  - 20:1 high-speed passive probe



Active probe

- Signal conditioning⟹oscilloscope
- 1GHz (1.5pF) <5M Won
- Require power source
- Good for high speed digital signals over 100MHz clock frequency (up to 500ps fall time)

Point to remember in probes

- Probe characteristics are described assuming that there is **zero length of ground lead loop**.
- More expensive, high performance (mostly low capacitance) probe is more severely affected by the ground lead loop.
- Don't even think about ground lead extension!
  Do not waste money.
- No ground lead…Can you imagine?

High-performance DSO

- Why high speed?
  - High-fidelity measurement of digital signals
- Who degrade the fidelity of measurement?
  - Probe
  - Font-end analog amplifier
  - Sampling and interpolation
- How fast DSO do we need?
  - Bandwidth of the digital signals
    - Clock frequency, rise time and fall time

DSO performance measure

- Bandwidth (3dB or RMS)
  - Measurable frequency range
- Sampling rate
- Rise time
  - Adding rise time to the original signal
- Vertical sensitivity
  - Measurable weak signal (mV/div)
- Gain accuracy

DSO performance metrics

- Time base or horizontal accuracy
- Other metrics
  - ADC resolution (vertical resolution)
  - Record length