Critical Considerations for Probing

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driven by technology

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What is Your Probe Selection Process?

The first one you spot in a drawer

Distract a co-worker and take theirs

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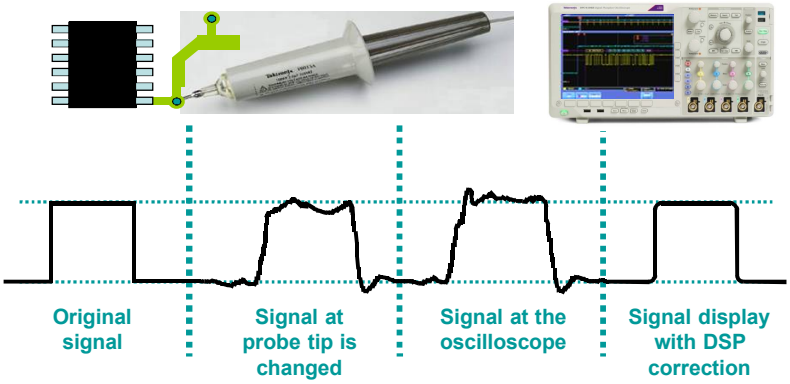
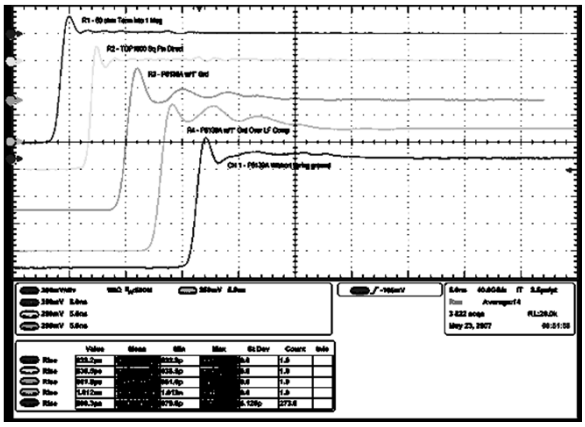
What is Your Probe Selection Process?



Deliver a Signal to the Scope with Good Fidelity

Probe Type and Adapters Do Degrade Your Measurements



Source Through 50 Ohm Terminator + 1 MegOhm CH 1

TDP1000 Square Pin

P6139A w/ 1" Z Lead

P6139A w/ 1" Z Lead (Incorrect LF Comp)

P6139A w/ Short Spring Ground

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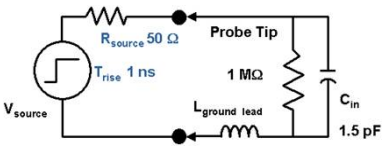
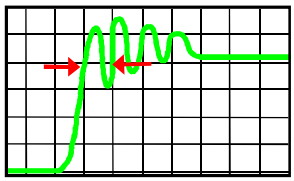
How Does Added Inductance Affect the Measurement?

T_{rise} of 1 ns ~ 350 MHz BW Equivalent



0.05 - 0.1 µH (combined typical)

For a 10X Active Probe with C_{in} = 1.5 pF and a 6"Ground Lead

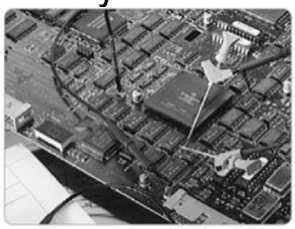


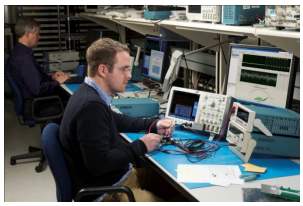
Ring Frequency Using a 1.5 pF Input Capacitance 10X High Z Active Probe and 6" Ground Lead.

$$\text{Ring Frequency} = \frac{1}{2\pi\sqrt{LC}} = \boxed{350\ \text{MHz}}\ \boxed{\text{to}}\ \boxed{500\ \text{MHz}}$$

Probes: Critical Elements of the Measurement System

- The oscilloscope probe makes the physical and electrical connection between the circuit and the oscilloscope.
- The correct probe is critical to measurement quality.
- A poor choice will result in incorrect or misleading measurements.
- There are three defining characteristics for choosing the right probe:
  - Physical attachment (Connectivity)
  - Minimum impact on circuit operation (Signal Loading)
  - Quality signal transmission to the oscilloscope (Measured Response)





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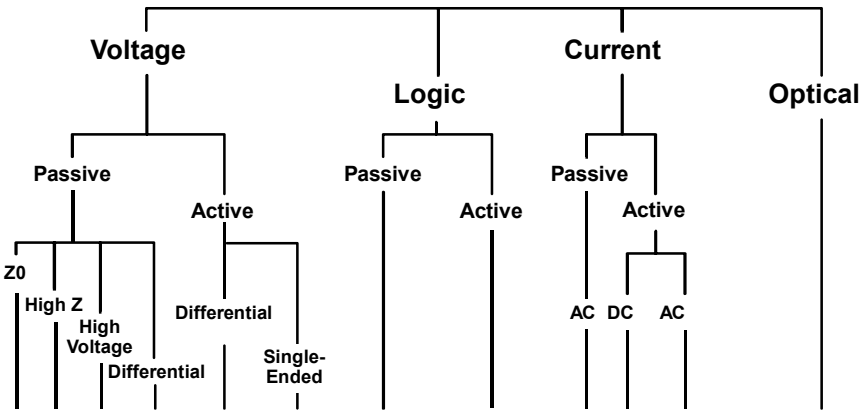
Basic Probe Types



Passive Voltage Probes

Most basic probe with no active components

Available in 1X, 2X, 10X, 100X and switchable

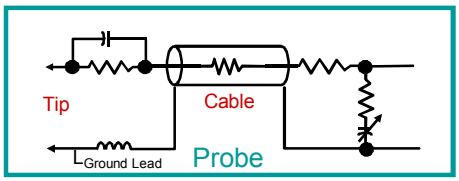
Advantages

- Inexpensive
- Mechanically Rugged
- Wide Dynamic Range
- High Input R

Disadvantages

- High Input C

Tektronix P2220 Probe
1/10X, 200 MHz



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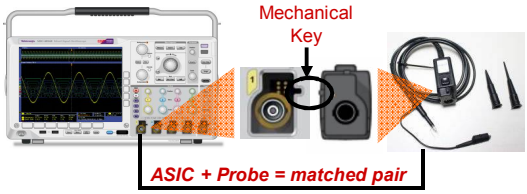
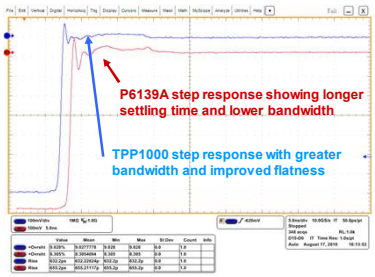
Breakthrough in Passive Probing



- Custom ASIC inside the oscilloscope is matched to the probes
- Probe notifies oscilloscope what type of probe it is (via TekVPI)
  - Sets input in oscilloscope to special path (not 1MΩ or 50 Ω)
- Scope can optimize signal input path to remove differences in hardware
  - AC compensation across frequency band
- Mechanical keying so TPP0500 and TPP1000 cannot be plugged into an oscilloscope without the matched ASIC

Low Capacitance Passive Voltage Probing

- Industry leading 3.9pF capacitive loading
- TPP0500: 500 MHz passive voltage probe
  - Standard with 350 MHz and 500 MHz models
- TPP1000: 1 GHz passive voltage probe
  - Standard with 1 GHz and 2 GHz models
- Multiple ground connections included
  - Six inch ground lead
  - Short spring clip ground leads
- AC calibration routine optimizes frequency response
- Application usage
  - Digital system debug



Half the loading with twice the bandwidth

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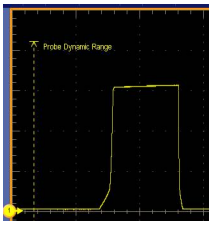
Active Voltage Probe

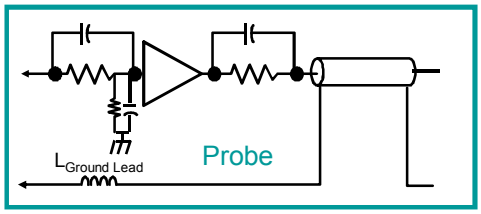
Uses active components

Advantages
- Low Input C
- Wide Bandwidth
- High Input R
- Better Signal Fidelity

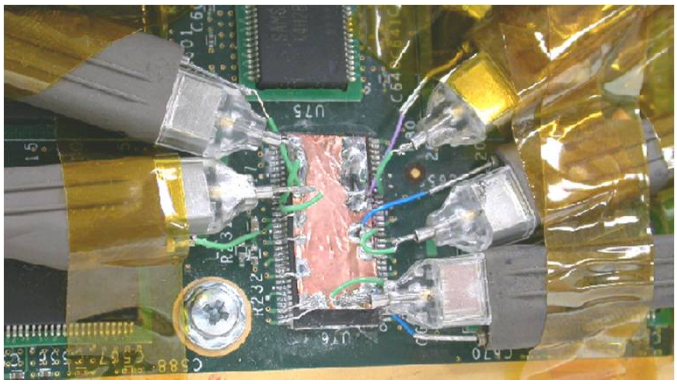
Disadvantages
- Higher Cost
- Limited Dynamic Range
- Mechanically Less Rugged



Tektronix TAP1500
Active Voltage Probe
10X, 1.5 GHz



Active Voltage Probe



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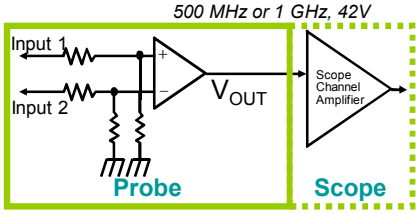
Differential Voltage Active Probes

Differential Probes measure signals that are referenced to each other instead of earth ground.

Advantages

- Wide bandwidth
- Large Common Mode Rejection Ratio (CMRR)
- Minimal skew between inputs
- Small input capacitance

Tektronix TDP0500 and TDP1000 Differential Probe
500 MHz or 1 GHz, 42V



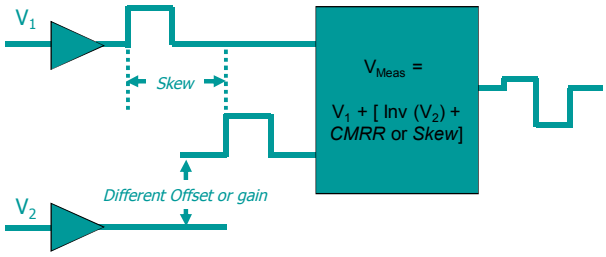
Differential Measurements with Single Ended Probes

Poor CMRR

- Inaccurate measurement (combination of offset and gain)
- Noisier measurement

Skew

- Amplitude and timing errors



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Differential Measurements with Single Ended Probes

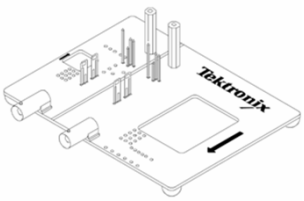
Deskew is a source for error

Deskew is important when measuring:

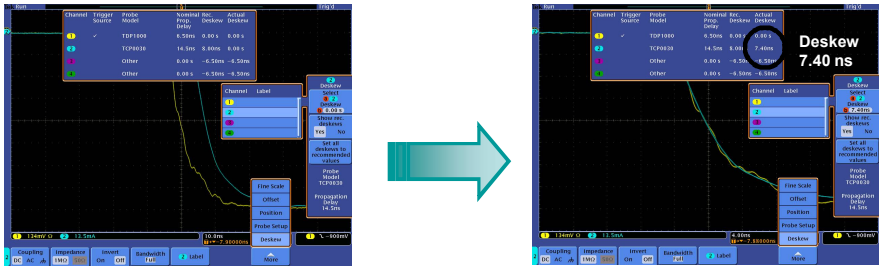
- Pseudo-differential (CH1 + (Inv (CH2))
- Timing/Propagation Delay

Include Probe adapters in deskew adjustment

If possible, use the same probe family



Deskew Fixture



Result of "Floating" Measurement with Ground Connection

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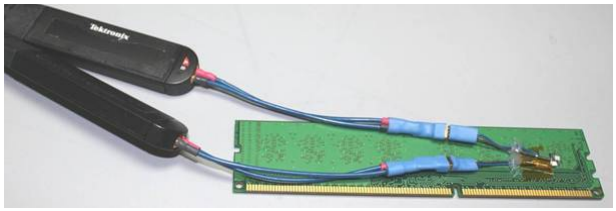
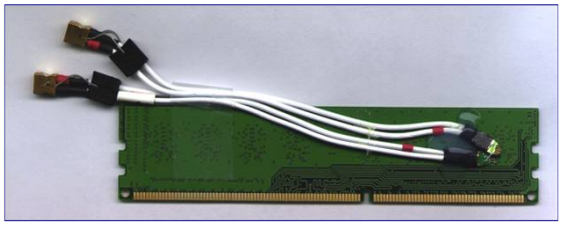
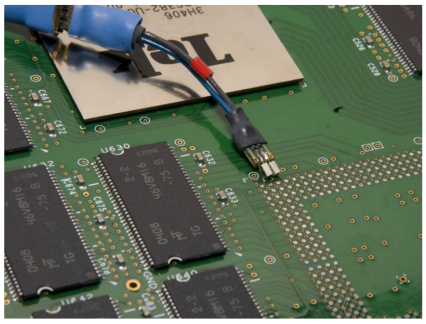
High-Bandwidth Solder-In Probe Solutions

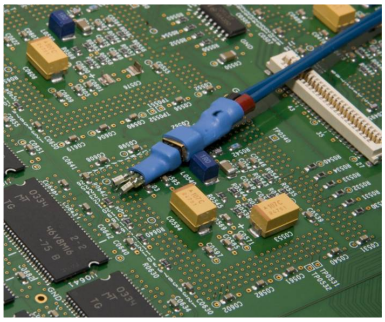


P7500 Series
Tri-Mode Probes



High-Bandwidth Solder-In Probe Solutions





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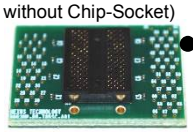
BGA Chip Interposer Probe Solutions

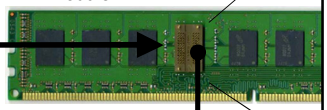
BGA Chip Interposer Probe Solutions

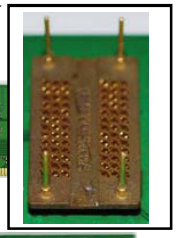
BGA Chip Interposer

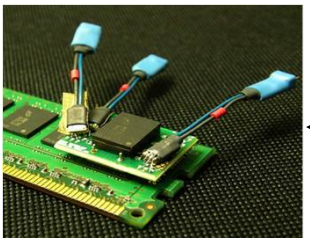
(with and without Chip-Socket)

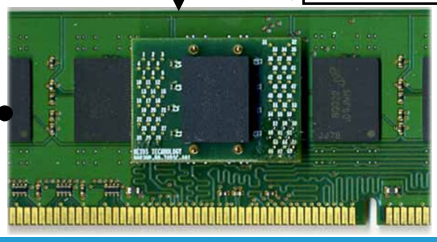


Component Interposer on DDR-Module









Interposer with Probe Tip for DQ, DQS and CLK

Component Interposer with Chip Interposer on DDR-Module

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Current Probes

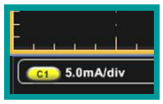
Measures the electromagnetic flux field around a conductor to determine the current flow

Two Major Types:

- AC current probes (passive)
- AD/DC current probes (active)

Features to Consider:

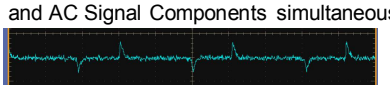
- Automatic scaling and units
- Split-core vs. fixed-core connection to the device



Tektronix TCP0150
AC/DC Current Probe
150 A, DC to 20 MHz

Current Probe Degauss

- Removes residual magnetic flux from probe's magnetic components
- High impact of measurement result (blue current waveform before and after degaussing)
- Capability of measuring DC (Hall-Element) and AC Signal Components simultaneously



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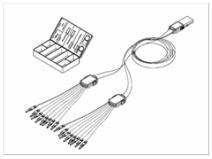
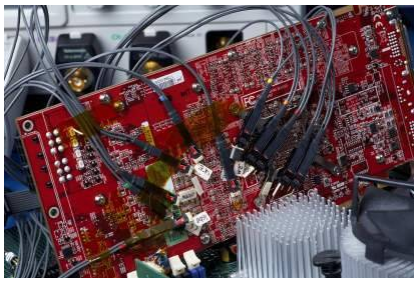
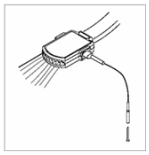
Logic Probes

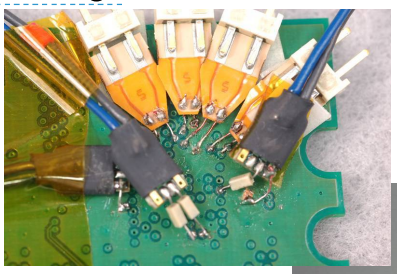


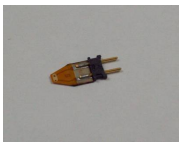


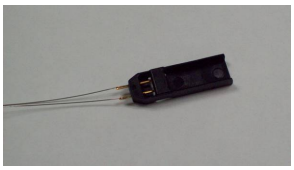
Tektronix P6616

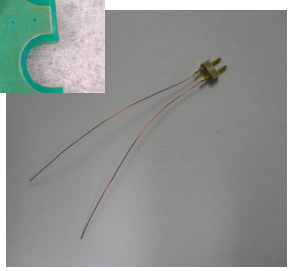


Logic Probes









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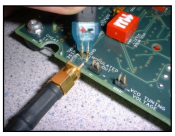
Device Under Test Recommendations

- Keep the device under test in its original configuration, if at all possible.
- If a special test extension fixture is needed, beware of the errors that can be caused.
- One inch of extra socket lead length can increase the circuit signal return inductance by up to 30 nH. If the load capacitance is 10 pF, a ring of abut 290 MHz can occur. This is because a 1 nsec risetime has plenty of energy to “ring the bell” of this series resonant circuit.
- Rule of Thumb: If a test extension fixture is truly needed, make sure that the ring frequency caused by adding L and/or C is at least three times the signal bandwidth of 0.35/risetime.



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Thank You!

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Recommended reading:
ABC of Probes
XYZ of Oscilloscope
(www.tek.com or mail me)