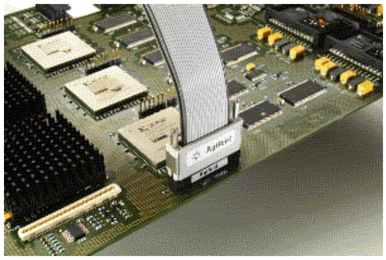
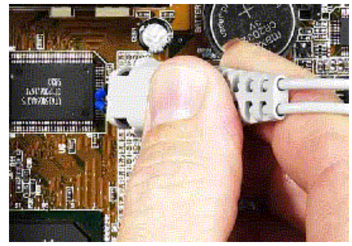
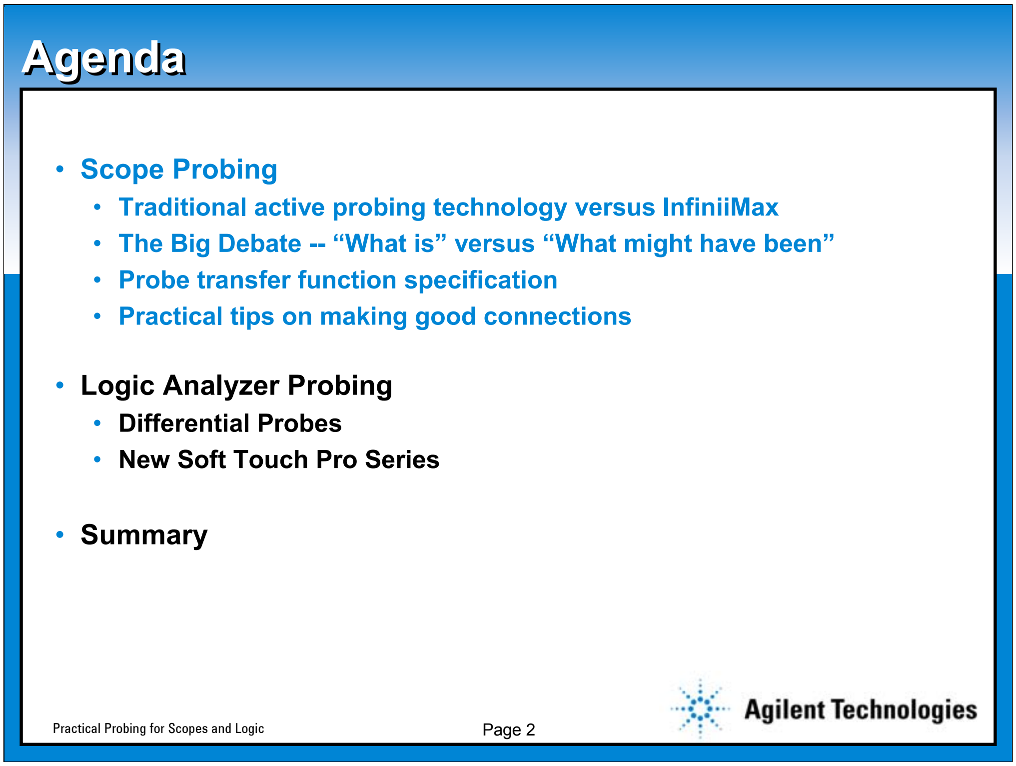




Practical Probing Techniques for Scopes and Logic Analyzers

Agilent Technologies



Agenda

We'll start with theory and then showing measurement results. Next, we get into the architecture/theory of these two types of probes that will explain why we see such a big difference in measurement results between a traditional active probe and Agilent’s InfiniiMax active probe, which uses a innovative design topology that minimizes probe tip connection lengths under various probing use-models.

In the section titled, “The Big Debate”, we will discuss what a probe should show. Should a probe show “what was” or “what might have been” at the test points before the probe is attached, or should a probe show “what is” present at the probe’s tips while the probe is connected with the effects of probe loading? We will then have a short discussion about how probe performance should be characterized and specified. There is currently a controversy in the industry amongst leading oscilloscope vendors about this issue.

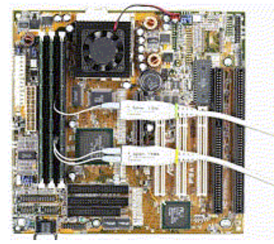
And then we will provide you with some “tips & tricks” on how to best use high bandwidth differential active probes and accessories in order to make the most useable and accurate measurements possible.

Next we will discuss differential probes for logic analysis, first what your options are then some information on the new industry standard Pro Seris Soft Touch probe.

High Bandwidth Probes

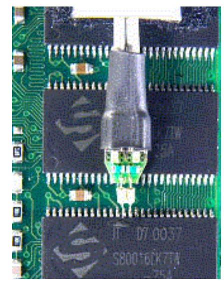
In a Perfect World …

- **Probes don't load your circuit**
- **Probes accurately reproduce signals at the probe tip with high fidelity**



Realities in the Real World …

- **Probes have traditionally been the "weak link" in the measurement chain when making high bandwidth signal integrity measurements**
- **All probes will load the circuit under test to some degree**
- **Probing accessories can degrade performance significantly**

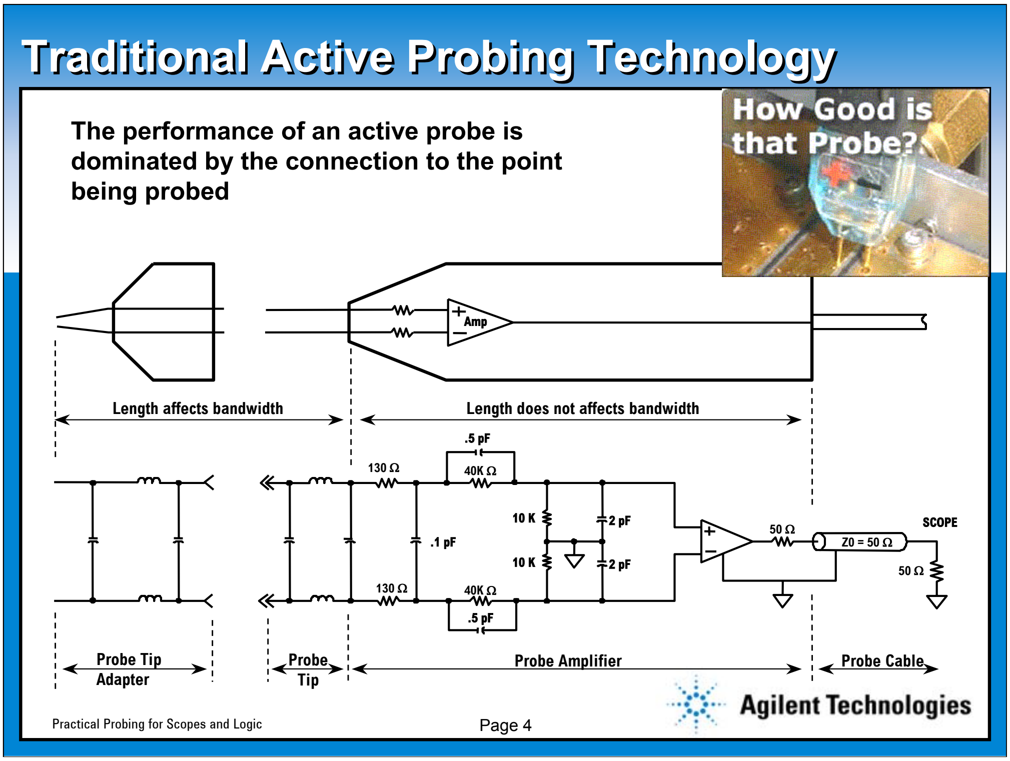


Practical Probing for Scopes and Logic Page 3 Agilent Technologies

High Bandwidth Probes

In a perfect world, probes don't load your circuit, and they accurately reproduce your signals under test. However in the real world, probes have traditionally been the "weak link" in the oscilloscope measurement chain for high-speed applications. All probes will load the circuit under test to some degree. So the goal with high-speed active probing is to minimize circuit loading. In addition, probing accessories are usually the primary culprit in limiting performance of measurements.

Let's now take a look at our agenda today that will address these real world probing issues.

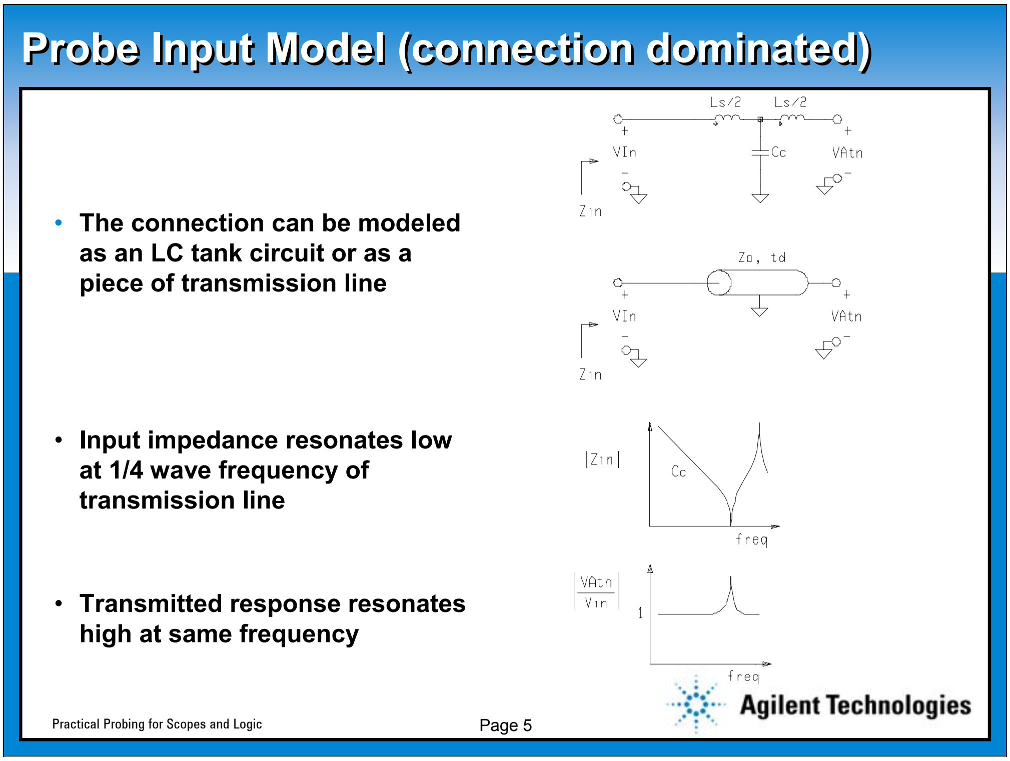


Traditional Active Probing Technology

The primary attribute of a "traditional" active probe concerns the physical placement of the probe's differential amplifier. The amplifier is always positioned as close to the probe tip as possible in order to maintain full-specified bandwidth and signal fidelity. Unfortunately, a short, fixed-tip probing configuration may not always be practical. In a real-world probing situation, which may include using probing accessories to attach probes to your signals, the traditional active probe's performance may be very different (worse!) than the published specified performance.

To put this in perspective, let's take a closer look at a model of a traditional active probe and it's connection. Although we will not get into the details of this model, there is one section of the electrical model that you should focus your attention on. It's the connection! In most cases, the probe connection of a traditional active probe will not only determine the degree of probing loading, but will also determine the measurement bandwidth and signal fidelity of the entire oscilloscope measurement system. The model for a differential probe connection is not just a zero Ohm, zero inductance, and zero capacitance pair of wires. At high frequencies, the probe connection can be modeled as a transmission line, which is a series of parasitic lumped capacitors and inductors.

As you will see during this discussion, the real-world performance of an active probing system is dominated primarily by the connection system. In other words, parasitic components to the left of the body/housing of the probe will be the driving factors in determining the performance of a real-world active probing system in high frequency applications. Let's now take a closer look at the connection model (probe tips + accessories) and characteristics of the probe tips impedance and response as a function of frequency.



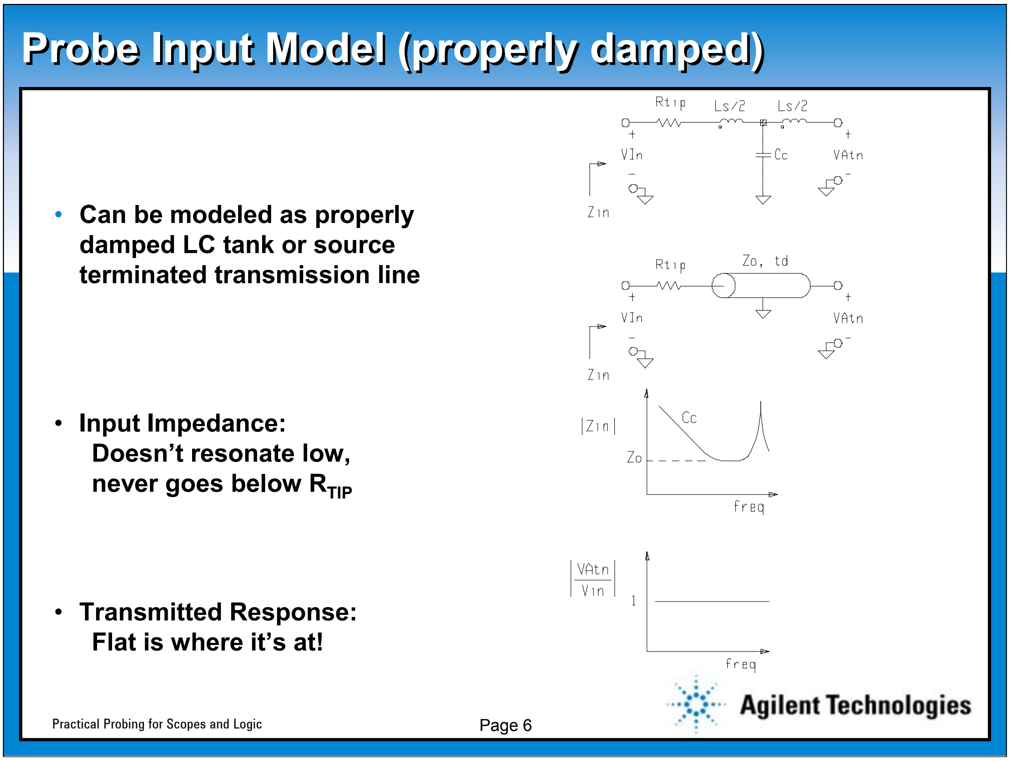
Probe Input Model (connection dominated)

The model of our input connection begins to look like a transmission line at high frequencies. And unfortunately, it is an uncontrolled transmission line, as opposed to a very well controlled 50Ω transmission line such as that employed in higher frequency RF designs. This model of the probe connection usually dominates the performance of the oscilloscope system. In many cases, you can assume that the model for the probe amplifier and oscilloscope is perfect with an infinitely flat response and infinite input impedance.

For simplicity, the input probe connection can be modeled as a simple L-C-L circuit. Or for engineers that are comfortable with the RF/frequency domain, we can model it as a simple transmission line. Unfortunately though, it is a relatively “uncontrolled” transmission line as previously mentioned.

Question: So what happens to an L-C tank circuit, or a transmission line at a particular frequency?
Answer: For the L-C tank model, the input impedance will resonate low at it’s resonant frequency. Or if you consider the transmission line model, the input impedance will resonate low at the quarter wave frequency of the transmission line. And the transmitted response will be peaked at this same frequency. As you will see in a few minutes from measured characterizations that we will show, this is NOT good. This resonant frequency probably will occur within the –3dB bandwidth of your measurement system for high-frequency applications using a high bandwidth active probe. We call this “in-band resonance”. So, watch out for this phenomena!

In addition to the in-band resonance problem caused by the connection, the bandwidth of the connection has a inverse relationship to the length of the connection. The longer the connection, the lower the bandwidth. Unfortunately, with traditional active probe technology, the only way to minimize bandwidth loss is to minimize the connection length. But there is a relatively easy technique to solve the in-band resonance problem (low impedance & peaking/ringing). Let’s now see how we solve the in-band resonance problem.



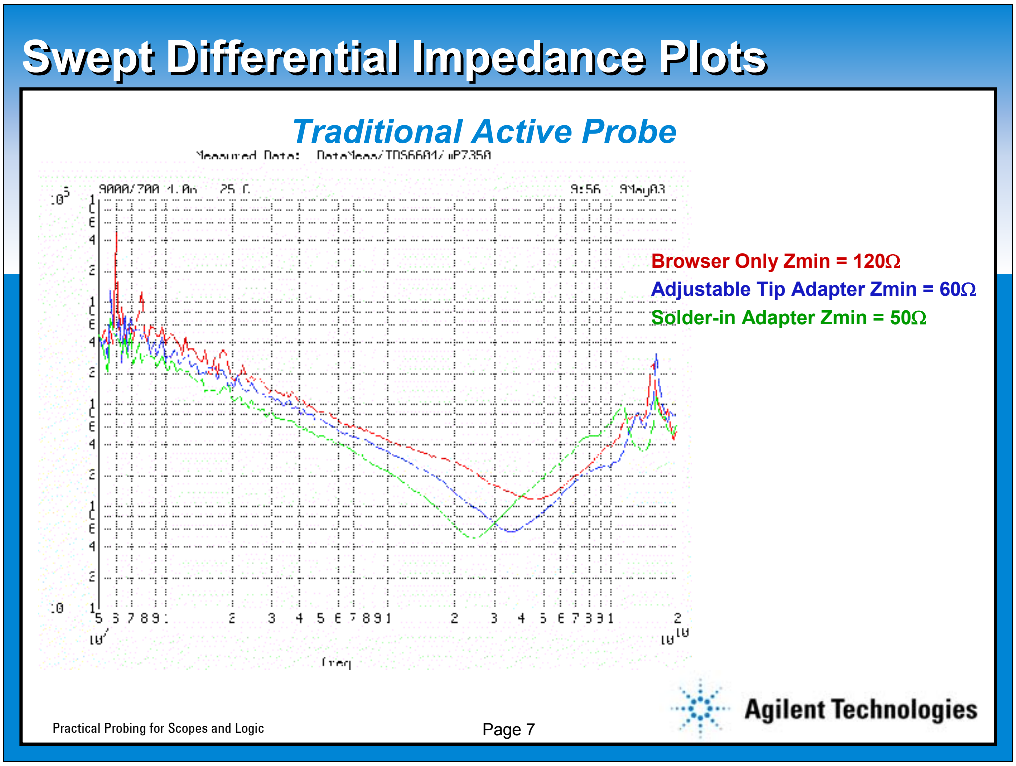
Probe Input Model (properly damped)

In the past the only way to keep the frequency of resonance above the bandwidth of the probe was to use an ultra-short, stubby point at the input of the probe. Although this produces good high frequency fidelity, it is often difficult to connect such a short blunt point to your circuit.

A different method of limiting the loading effect of an L-C tank circuit is to simply properly damp the L-C tank with a small resister on the front-end of the probing system. Or in transmission line terminology, source-terminate the transmission line. This allows for a longer, easier-to-use connection to be used at the input of a probe.

With a properly damped probe input, the loading/input impedance will never drop below the value of the damping resistor, which will be in the range of 80 to 250Ω. (The actual value depends upon the actual probing connection.) In addition, the transmitted response will no longer be peaked up, but will remain flat (ideally). But the damping resistors MUST be positioned as close as possible to the connection point to be effective.

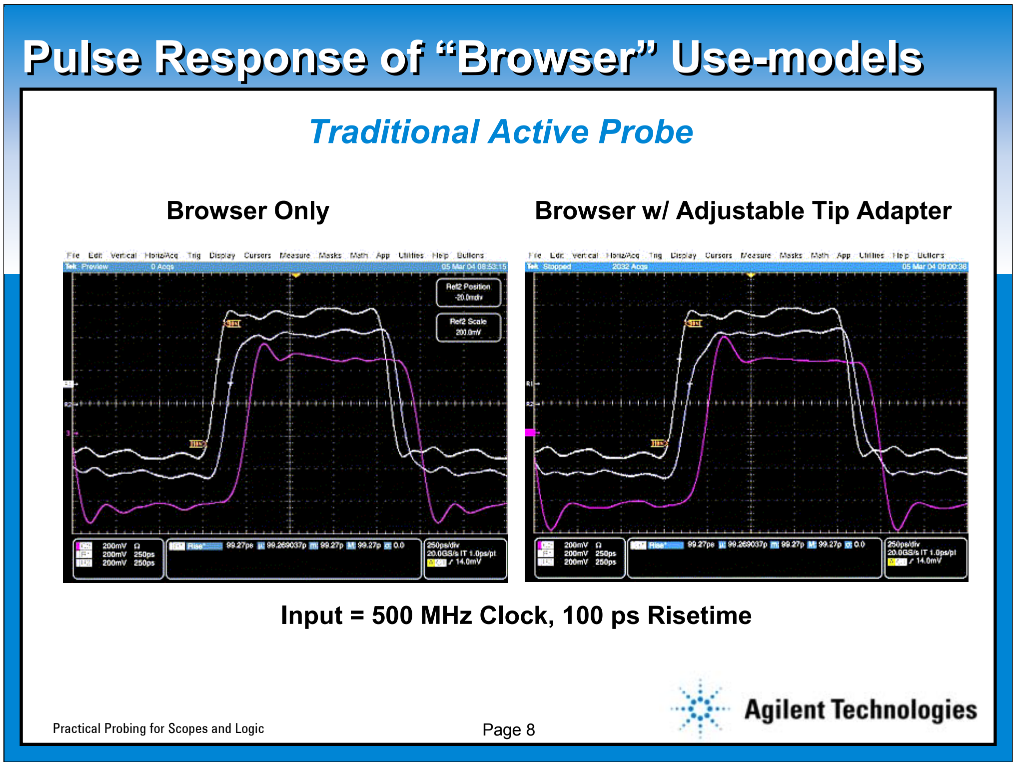
So practically speaking, how does Agilent properly damp the input connection? With Agilent Technologies newest active probes, the user is provided with a variety of probe tip connection accessories with damping resistors physically positioned very close to the connection point. One of the accessories is an insertable browsing tip. This browsing tip basically consists of a resistor embedded within the body of the tip. For the solder-in probe head, the differential connection devices are actually small 8-mil diameter resistors mounted at the end of the passive probe head. Let's now look at swept impedance measurements of a traditional active probe using various probe tip accessories, and then we will look at some pulse response measurements.



Swept Differential Impedance Plots

This slides shows the measured impedance of a traditional active probe. As you can see at higher frequencies, the probe's load impedance can become very low as a function of the connection length. With a solder-in adapter, the input impedance goes as low as 50-Ohms. Impedance would drop even lower if we used an undamped wire accessory (not shown).

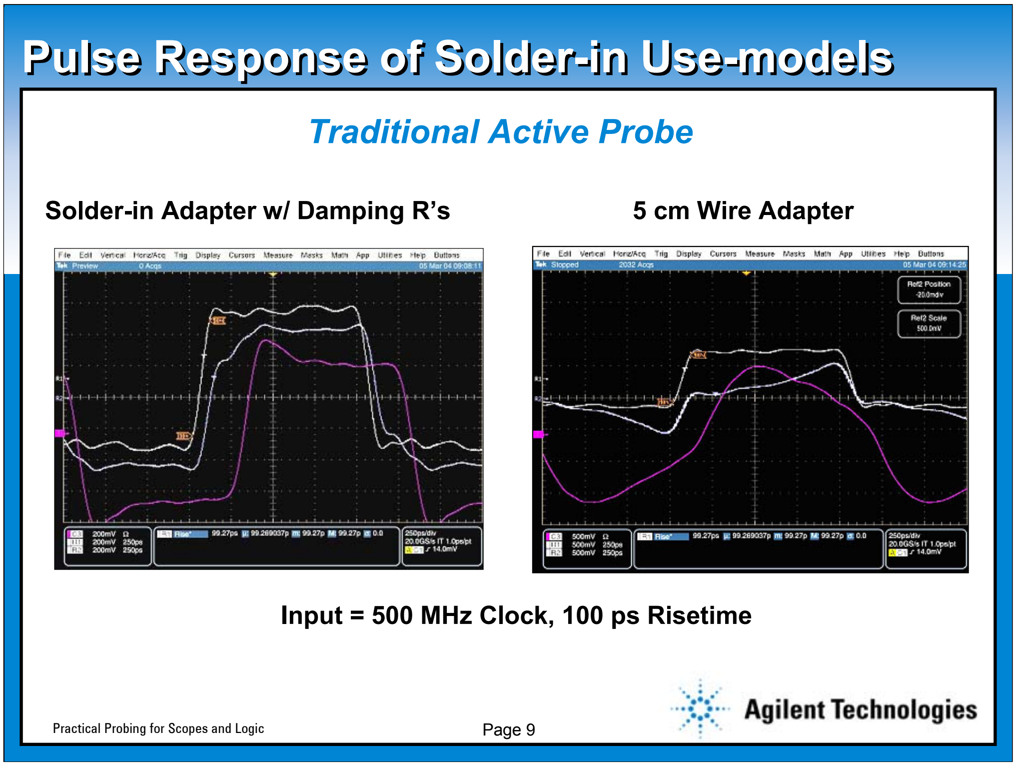
Even though this particular probe does employ the use of damping resistors, the positioning of the damping resistors has not been optimized in either the browser probe or accessories. This probe includes small damping resistors embedded in the body of the probe. The ideal position is "at" the connection point, NOT in the body of the probe.



Pulse response of "browser" use-models

This slides shows the pulse response of a traditional active probe with a 500MHz clock input with edge speeds of approximately 100ps (10% to 90%). The image on the left shows the best-case response of a "browser" connection without any accessories attached to the tips. The top waveform represents the input signal (source) before the probe is attached to the test points (unloaded). The middle waveform represents the actual loaded input signal at the probe tips while the probe is attached the test points. As you can see, the signal has change minimally. And the bottom waveform represents the measured response of the traditional active probe and real-time oscilloscope. Even though this differential active probe has very short tip lengths, the inductance of the probe's tips has induced a small amount of peaking relative to the input signal at the tips. At this point, it appears that the embedded damping resistors in the body of the probe are doing their job to minimize loading and resonant peaking since the actual probe tips are very short.

Unfortunately, this particular probe is very difficult to use because of the shortness of the tips and its fixed spacing, making it sometimes impossible to probe test points with a different spacing. To enhance usability, we have connected a small adapter to the end of the probe that will allow us to manually adjust the probe tip span. As you can see in the image on the right, this small adapter which adds length (~5 mm) to the connection, induces additional loading on the input signal and also induces additional peaking. Some of the effects of this loading and peaking could have been minimized if the damping resistors were more correctly positioned nearer to the connection point, rather than embedded in the probe's body.



Pulse response of solder-in use-models

We will now show the effects of probe loading and peaking when larger adapters/accessories are used to solder the probe onto the device-under-test. This may be necessary in order access hard-to-reach test points, such as probing between tightly spaces DIM cards, or to provide for a hands-free probing solution.

As you see in the image on the left, the small solder-in adapter that includes small damping resistors soldered onto the test board has induced even more loading and additional peaking. Unfortunately, the small damping resistors at the connection point only have a value of 10Ω, since they are in series with the embedded 130Ω damping resistors in the probe's body.

And in the image on the right, we have used a 5 cm undamped wire adapter attached to the end of the probe. Unfortunately, using this seemingly short 5 cm adapter has made this probe configuration totally useless for high-speed applications. Note that if you were using this accessory to probe a "live" signal, you probably would have caused the system to crash due to excessive loading on the input signal. And the measured response has no similarity to either the unloaded or loaded input signal.

Characteristics of Traditional Active Probes

The Facts:

- **Probe connection lengths dominate probe system performance.**
- **Long connections reduce bandwidth and induce in-band resonance (loading and peaking).**
- **“Long” is a relative term, and can actually be very “short” in high-bandwidth applications.**
- **Damping resistor technology eliminates in-band resonance.**
- **Damping resistors MUST be positioned nearest the connection point to be effective.**
- **Damping resistors do NOT help the bandwidth loss problem when using probe tip extension adapters.**

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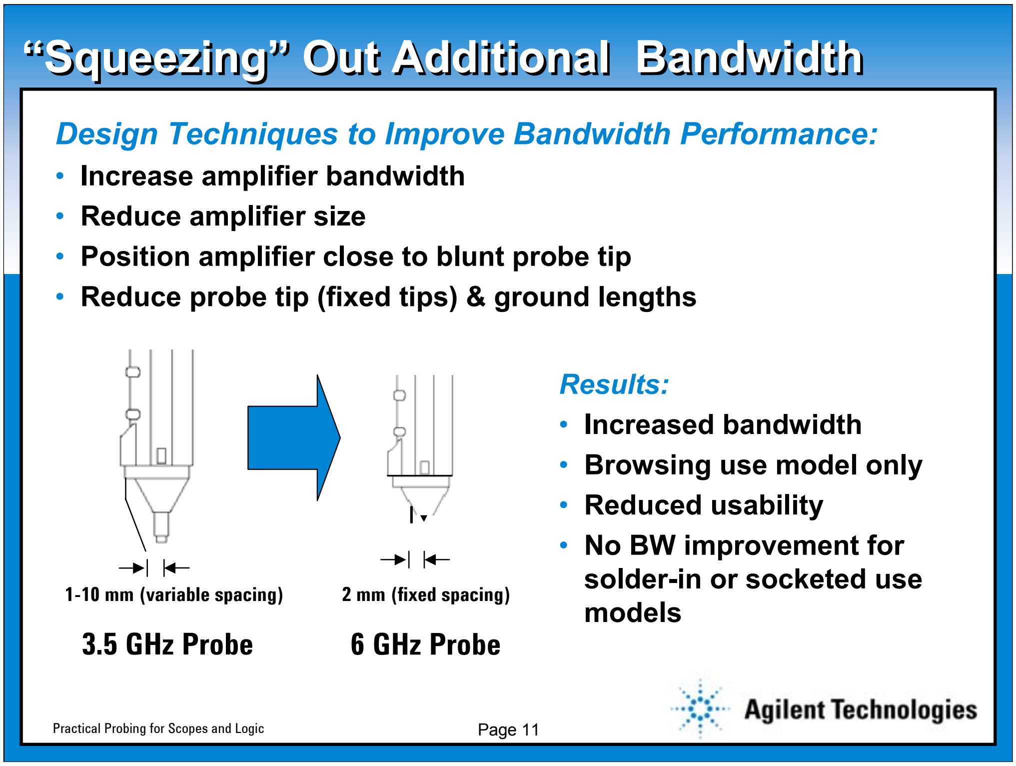
Agilent Technologies

Characteristics of Traditional Active Probes

To summarize what we have just seen in actual measurements using a traditional active probe, the length of the connection dominates probe system performance. The longer the connection length in front of the body of the probe, the more induced loading and resonant peaking will occur. And “long” is a relative term. For high-speed probing application, just a few millimeters of probe tip connection length can make a big difference.

Also, the use of damping resistors can help reduce the effects of resonance, but to be most effective, the damping resistors must be positioned as close to the connection point as possible. Even though damping resistor technology can significantly improve signal fidelity and probe loading, they do NOT help the bandwidth loss bandwidth when extending the probe connection point beyond the standard probe tips.



"Squeezing" out Additional Bandwidth

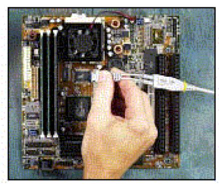
Increasing the bandwidth performance of a traditional active probe is primarily a mechanical challenge that involves physics. The traditional approach includes increasing the probe amplifier bandwidth, reducing the amplifier's physical size, positioning the amplifier closer to the probe tip, reducing the probe tip connection lengths, and also implementing probe tips with fixed-tip spacing. This is the approach that all oscilloscope probe vendors have been taking for years to increase active probe bandwidth.

But this design approach has several tradeoffs. First of all, the reduction in size and with fixed and closely spaced connection leads, usability will be reduced significantly. In addition, this approach only increases the bandwidth for the "browsing" use model. The moment you add any accessories such as solder-in wire connections, you lose bandwidth. For example, if you attach a 5 cm wire connection accessory to the end of a traditional active probe, you will have just reduced the bandwidth of the probe system to approximately 1.5GHz. Remember, with the traditional active probe technology, the probe connection length determines the performance of the probe.

So as you can see, the traditional active probe technology is up against a physical performance "barrier".

The Ideal High Bandwidth Active Probe

- **Probe bandwidth ≥ oscilloscope's bandwidth**
- **Optimized for all probe use models**
  - ✓ **Browsing by hand**
  - ✓ **Browser in probe stand**
  - ✓ **Socketed connections**
  - ✓ **Solder-in connections**
- **Allows flexible connection options *without a performance trade-off***
- **Can make high bandwidth single-ended or differential measurements**



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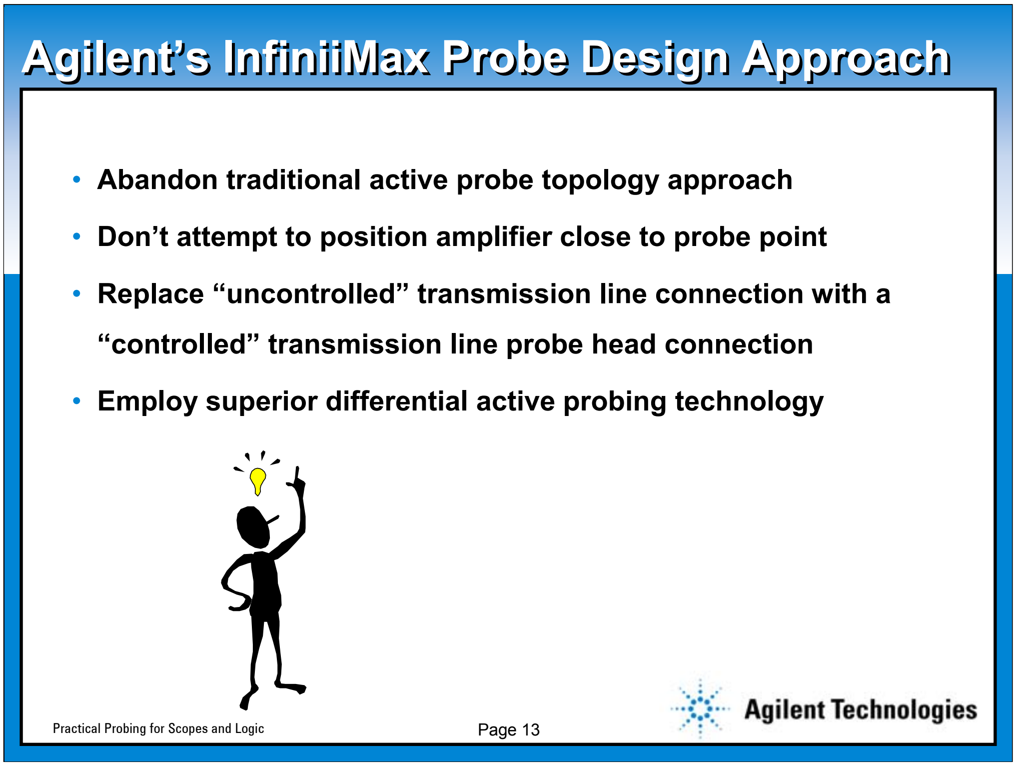
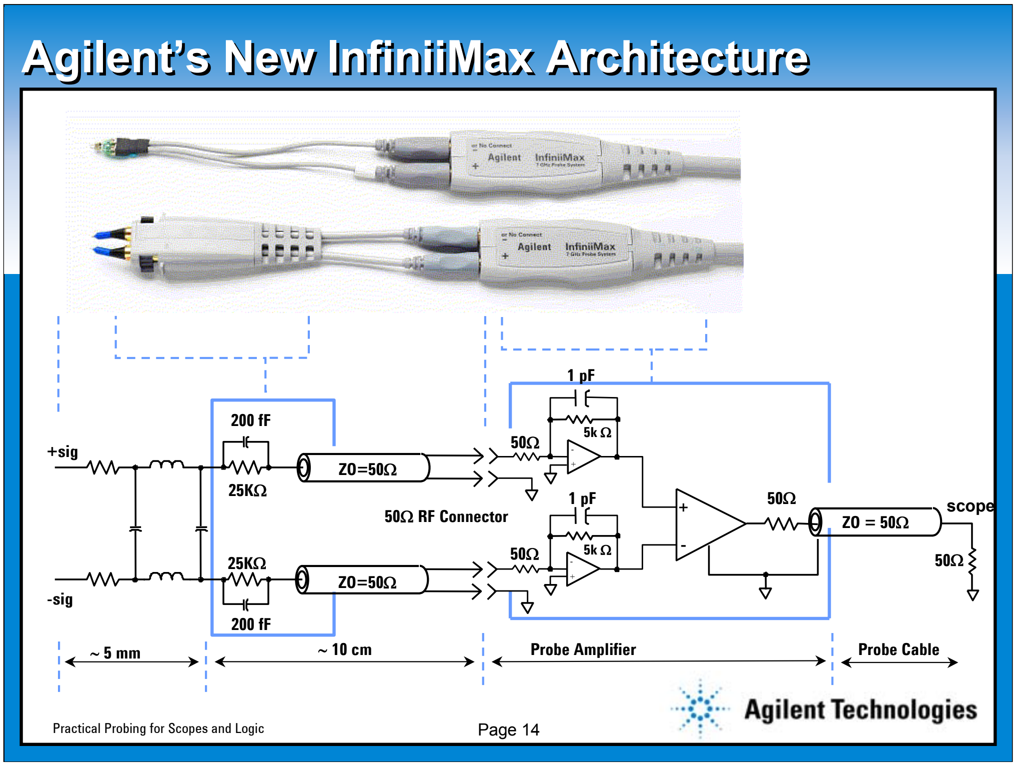
The Ideal High Bandwidth Active Probe

Let's now transition out of the real-world and back into a "perfect" world. In a perfect world, the active probe's bandwidth would always be at least equal to or greater than the oscilloscope's bandwidth. In addition, the ideal active probe would be optimized for all use models, and without any tradeoff in bandwidth due to connection lengths. And lastly, the ideal active probe would be able to make both single-ended and differential measurements. Is all of this possible?



Agilent's InfiniiMax Probe Design Approach

Electrical and mechanical design engineers at Agilent Technologies realized that the traditional active probe technology was "hitting" a physical performance barrier. Producing higher probe system bandwidth without reducing usability would require a new approach. This meant abandoning the traditional active probe topology where the probe amplifier is positioned as close to the probe point as possible. However, once we made the decision to move the amplifier further away from the probe point, we then had to replace the "uncontrolled" transmission line connection with a "controlled" transmission line probe-head technology. In addition, in order to make both differential and single-end measurements with the same probe, Agilent Technologies employed a superior differential active probe technology. Let's take a closer look at the electrical and physical model of Agilent's new InfiniiMax probe topology.

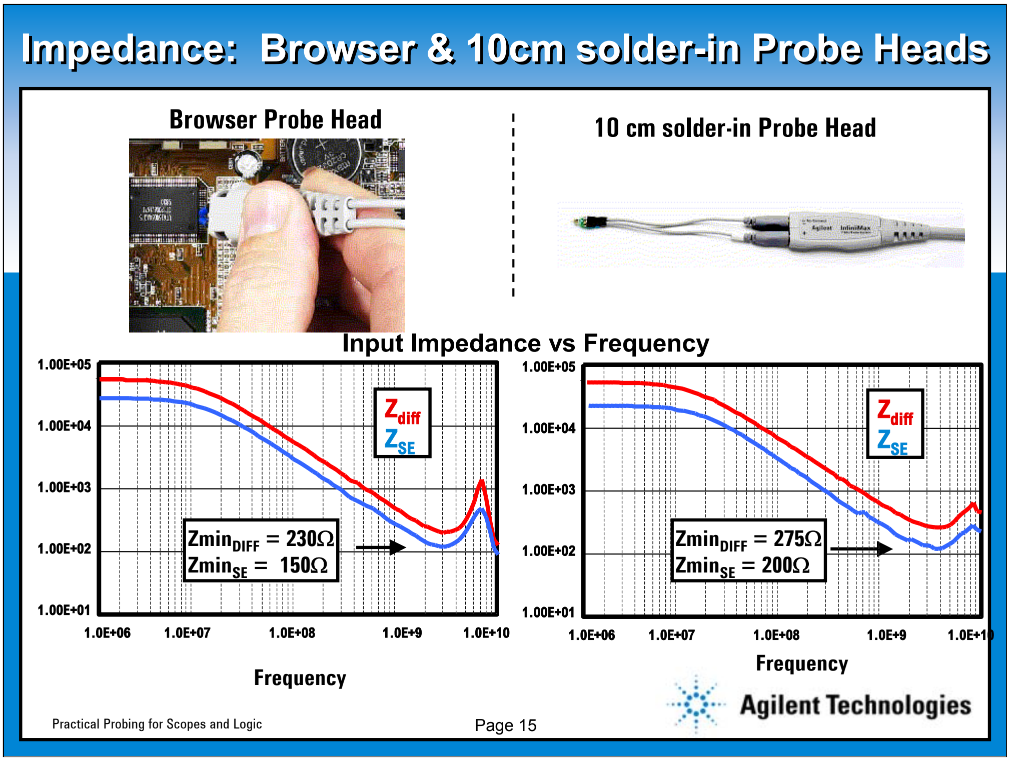


Agilent's New InfiniiMax Architecture

In this slide we show the physical and electrical model of Agilent's new InfiniiMax active probing system. The electrical model of the amplifier and cabling section (sections on the right) are essentially the same as the traditional active probe. With the InfiniiMax probing system, the amplifier is always a differential amplifier, for either differential or single-ended connections. The big change in this topology is in the connection end. With the traditional approach, everything to the left of the amplifier section is the primary determinant of the system bandwidth depending upon the connection length. However in the InfiniiMax probe system model, the 10 cm probe head connection is now essentially a "controlled" transmission line using Agilent RF technology, as opposed to the "uncontrolled" transmission line connection of the traditional approach. The "controlled" transmission line probe heads utilize a 50Ω coaxial transmission line cable that is terminated at the source end with a high impedance termination (25kΩ), and then terminated at the amplifier end into 50Ω. The characteristic of this "controlled" transmission line probe head includes an in-band "zero" in the frequency domain. Within the probe amplifier is a matching "pole" which results in a very flat system response. This pole-zero matching scheme in the frequency domain was patented by Hewlett-Packard/Agilent Technologies many years ago.

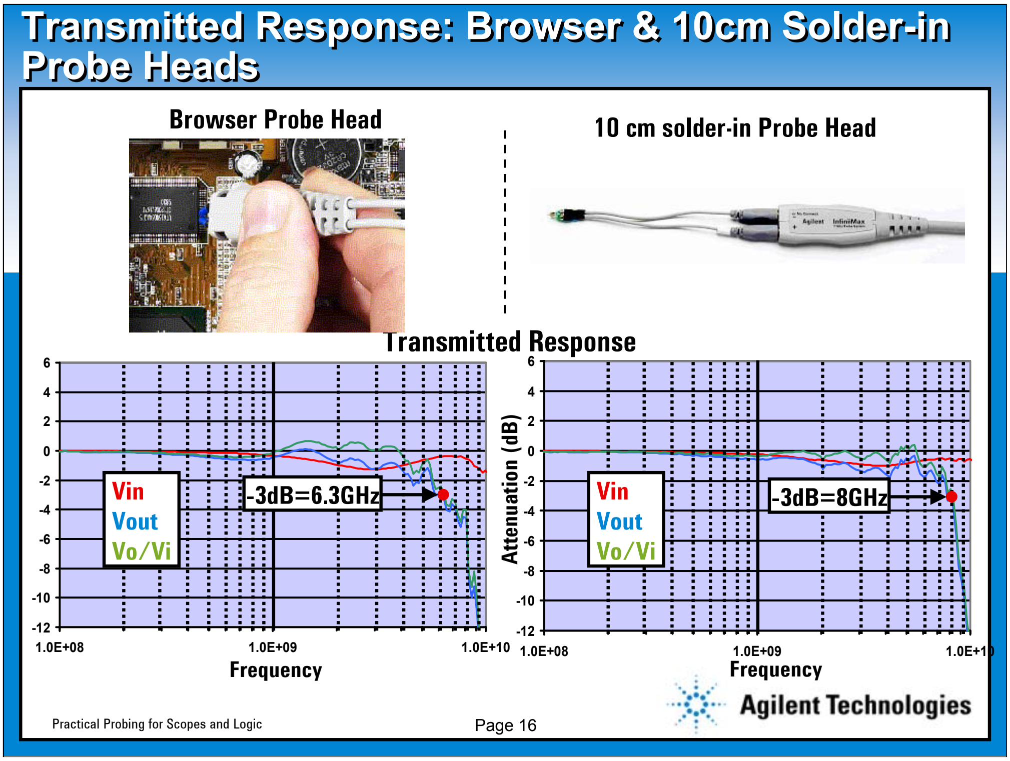
With this new active probe topology, the 10 cm "controlled" transmission line probe head does NOT degrade probe system bandwidth. You can now get the probe head into very tight spacing without bandwidth loss. The section to the far left is the actual connection with damping resistors positioned as close to the connection point as possible. This section of the model can affect the probe system's bandwidth depending upon the length of the connection. But with the very small 10 cm probe head connection, the actual connection length can usually be minimized such that it doesn't affect the probe system bandwidth.

The single-ended model looks very similar. But instead of two 50Ω coaxial "controlled" transmission lines in the 10 cm section, there is only one 50Ω coaxial "controlled" transmission line section.



Impedance for "browser" and 10cm solder-in probe heads

In these impedance graphs we are comparing the probe system input impedance of a "browser" connection with a 10 cm solder-in probe head connection. In addition, we are showing the input impedance for both single-ended and differential measurements, using a differential probe. For both of these connection options, the low frequency input impedance is 50kΩ for differential measurements and 25kΩ for single-ended measurements. As expected, the impedance drops as frequency increases, but never resonates too low due to damping resistor technology. For either the "browser" or "solder-in" probe head, the differential input impedance never drops below 230Ω. This is because Agilent has positioned the damping resistors very close to the connection point for both of these use-models.

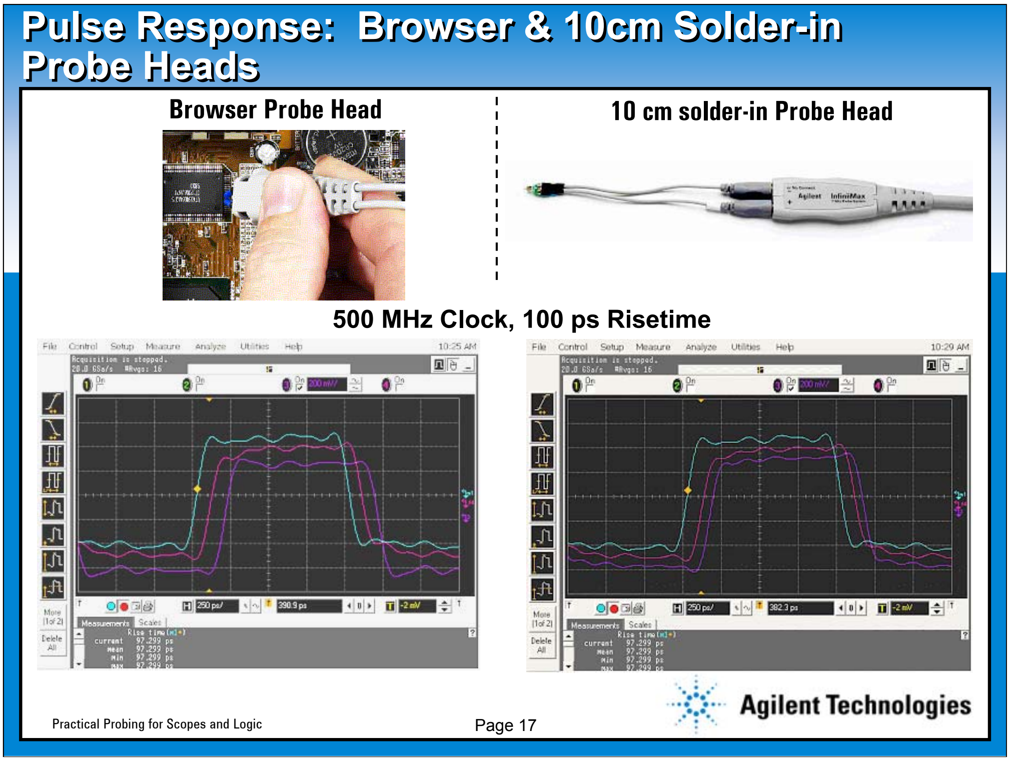


Transmitted Response for "browser" and 10cm solder-in probe heads

The red trace in each of these graphs represents V_{in}, which is NOT the same as V_{source}. As expected, V_{in} takes a slight dip due to some loading as shown in the previous impedance plots. This amount of loading cannot be avoided. But V_{in} does not take a "dive", which would be the case if damping resistor technology was not present.

Both V_{out} (blue) and V_{out}/V_{in} (green) are fairly flat until they naturally roll-off at higher frequencies. The "browser" connection exhibits a typcial –3dB bandwidth at 6.3GHz, and the 10 cm solder-in probe head connection exhibits a typical –3dB bandwidth at approximately 8GHz. Note that this is the opposite that you would expect from the traditional probe technology. The 10cm solder-in probe head actually gives us higher bandwidth performance than the "browser" connection. This is because the actual connection length in the solder-in probe head is shorter than the "browser" connection.

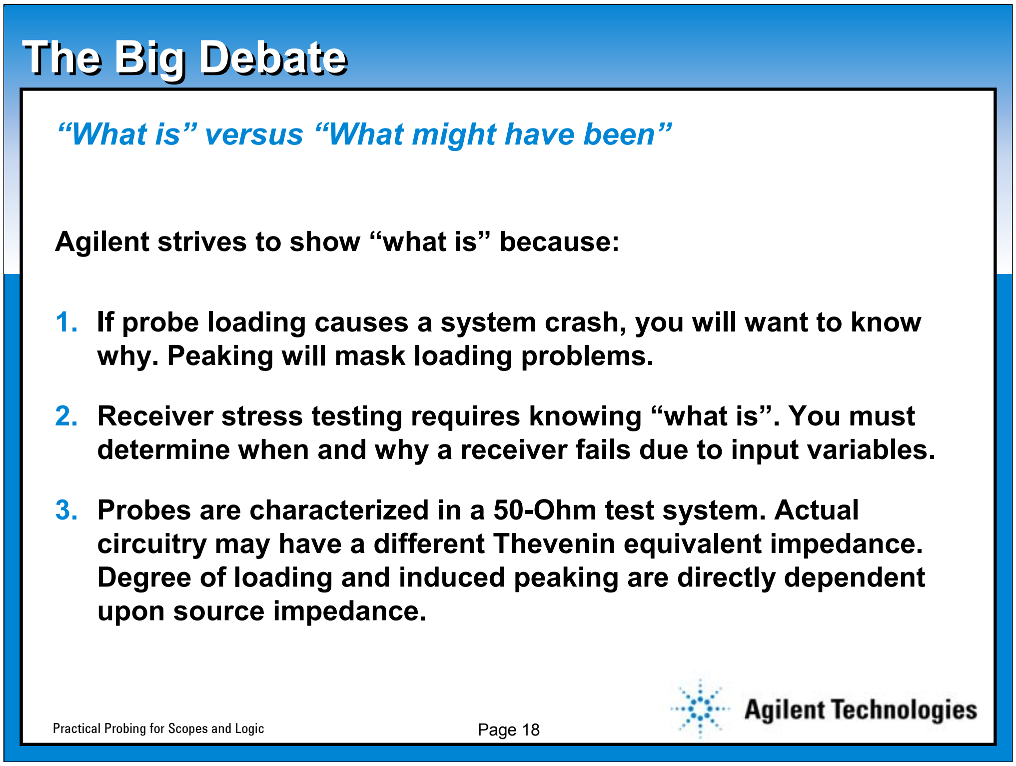
Let's now look at some time domain pulse response waveforms using the InfiniiMax probing system.



Pulse Response for Browser & 10cm solder-in probe heads – 500MHz Clock, 100ps Risetime

The image on the left shows the response of Agilent’s browser probe head. The results are very similar to what we observed with the traditional active probe. There is a small degree of loading and a small amount of peaking. This is unavoidable due to the length of this probe head’s tips, which includes replaceable tips with embedded damping resistors. The big advantage of this probe is that it is very useable with adjustable tip spans.

The image on the right shows the response using Agilent’s solder-in probe head. This solution provides the highest fidelity, highest bandwidth, and lowest loading characteristics. This is just the opposite of what you would expect from a traditional active probe where wire accessories of minimal length reduce bandwidth and signal fidelity.



The Big Debate

There is some debate in the oscilloscope industry concerning what a probe should show. Some claim that a probe should show “what was” at the test points before the probe loaded the signal. Actually, this should be more correctly stated as “what might have been”. Others claim, including Agilent, that a probe should attempt to accurately show “what is” at the probes tips while probing. And remember, due to probe loading at high frequencies “what is” will always be different than “what was”.

There are three primary reasons why Agilent believes that it is more important to show “what is” as opposed to “what might have been”.

1. If you are testing active signals in a live system, if probe loading causes your system to crash, then seeing “what is” might give you a clue as to why the system crashed.
2. If you are performing stress testing at the input of a receiver, you may intentionally vary input amplitudes or inject jitter in order to test when a receiver fails. Knowing actual input conditions (what is) that may cause a failure condition is what must be measured.
3. Some vendors will claim that the probe can be designed with intentional hardware induced peaking in order to restore a signal due to loading effects. Unfortunately the amount of loading is a variable that is dependent upon the source impedance of the device-under-test. However, induced peaking is a constant. This is why we prefer to say “what might have been” as opposed to “what was”. We really have no way of knowing “what was” at the test points without knowing something about the circuit under test.

How Should Probes Be Specified?

Historical Method of Characterization

Transfer function = V_{out}/V_{source} (in a controlled 50-Ω test system)

Assumption: $V_{source} = V_{in}$ (true at lower frequencies)

Agilent's Improved Method of Characterization:

Transfer function = V_{out}/V_{in} (independent of impedance)

Assumption: V_{in} must be accurately measured

Note: Since effects of loading must be taken into account for today's higher frequency active probes, Agilent provides impedance plots and accurate SPICE models.

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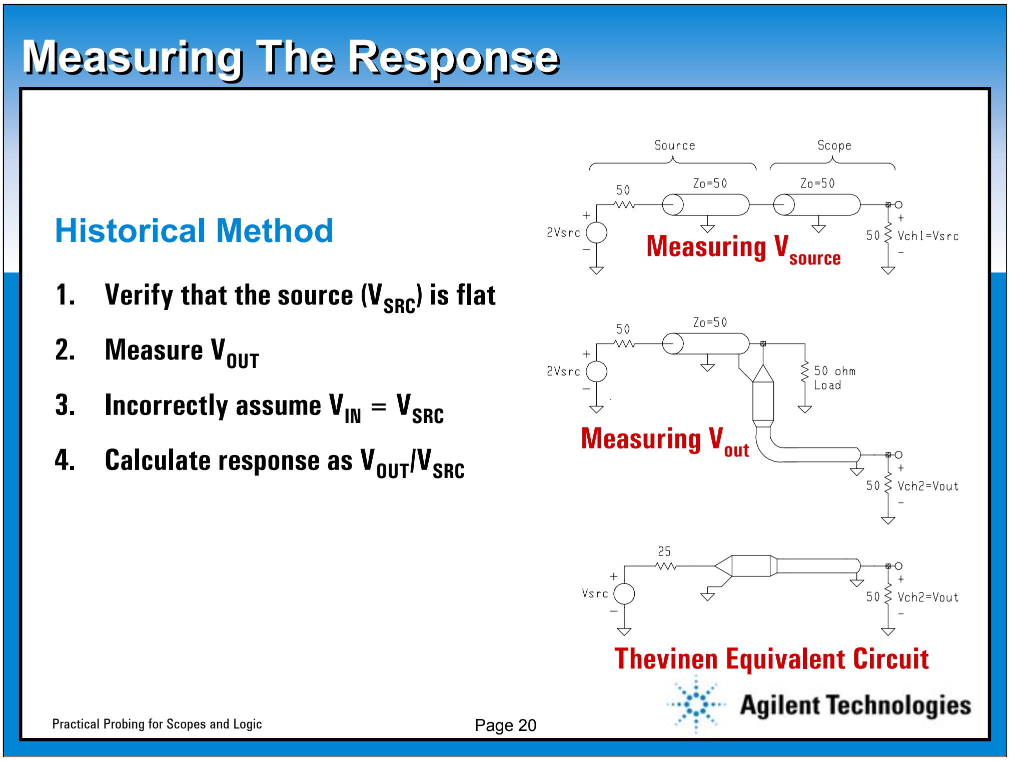
How should probes be specified?

There is also a bit of controversy in the oscilloscope industry concerning how probes should be specified. The historical (or is it hysterical?) method of characterizing probes has been to measure the response of a probe in a controlled 50Ω test environment in both the frequency domain or time domain. In the past, the transfer function was then computed as V_{out}/V_{source}, with an assumption that V_{in}, which is the actual input signal at the probes tips, is the same as V_{source}. This assumption has been valid in the past when characterizing lower bandwidth probes. However, as you have seen during this seminar, V_{in} and V_{source} can be very different in high-speed applications. Unfortunately, some of our competitors still use the old/historical characterization model.

Today, Agilent accurately measures both V_{out} and V_{in} so that a more accurate and industry accepted computation of the probe's transfer function can be computed as $V_{out}/_{Vin}$.

Unfortunately, the transfer function of either $V_{out}/_{Vin}$ or V_{out}/V_{source} will tell you nothing about the degree of loading. This must be taken into account as a separate characteristic. For this reason, Agilent provides frequency-dependent impedance plots, as well as SPICE models of our probes with various probe heads so that you accurately model you circuit's behavior with and without probe loading.

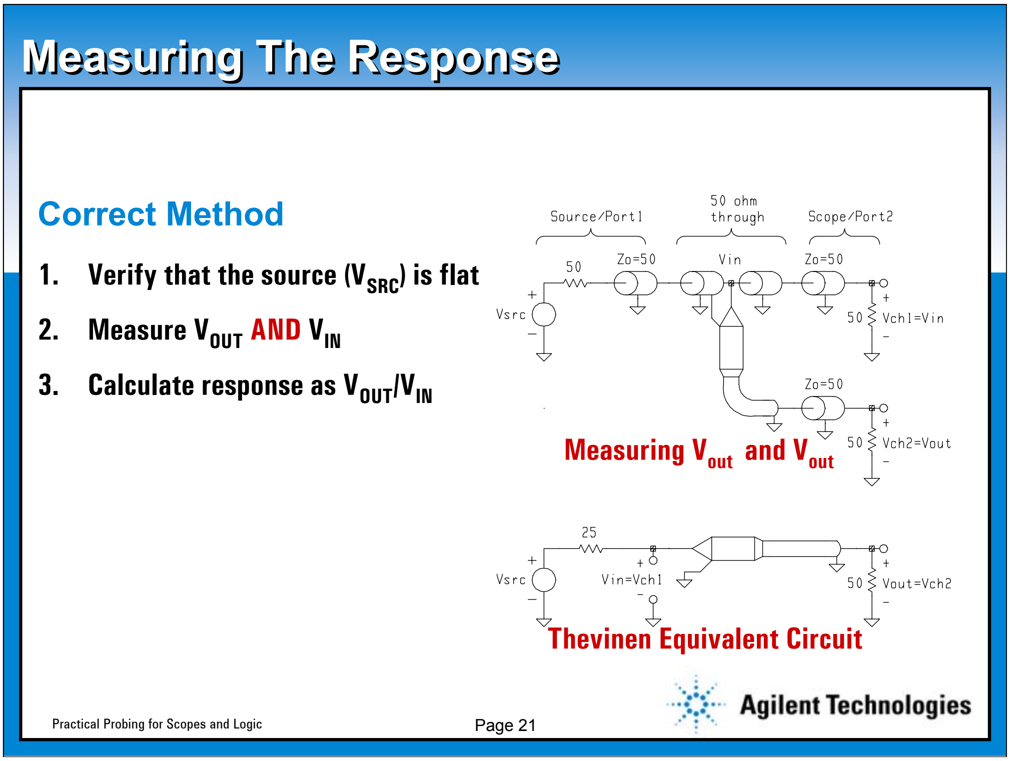


Measuring the Response (Historical Method)

The historical method (or perhaps it should be called the "hysterical" method!) of measuring a transmitted response (V_{out}/V_{in}) is to assume that V_{in} is the same as V_{source}. This method was fine for lower frequency applications when the resonant frequencies caused by the parasitics of the probing connection were beyond the frequency band of the probe. Unfortunately, this is no longer the case for high frequency probes of today. This was the method that Agilent used on some of our previously introduced probes. And it is still the method used today by some of our competitors.

With the historical method, the first step was to initially terminate the signal source into 50Ω and verify that the signal source demonstrates a flat response over a broad frequency range, without the probe attached. Then using a precision 50Ω "through" test fixture, you can then probe near the termination point and measure the response over a broad frequency range. With the incorrect assumption that V_{in} equals V_{source}, you can then easily calculate the transmitted response as Response = V_{out}/V_{in}. Unfortunately, V_{in} will NOT equal V_{source} for higher frequency components of the swept input signal.

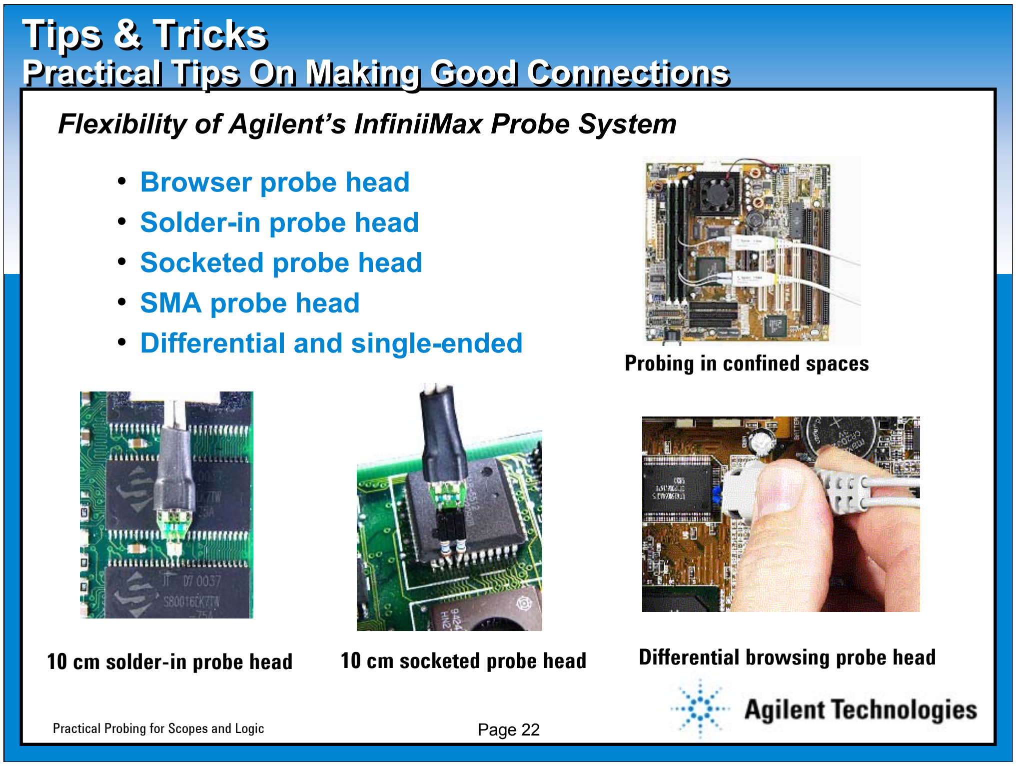
The simplified schematic at the bottom of this slide shows the Thevinen-equivalent circuit of our controlled probe-characterization test setup. As you can see, if the input impedance is not infinite at all frequencies of the input, then V_{in} at the probe's tips will NOT be equal to V_{source}. As this circuit shows, we have voltage-divider network. At lower frequencies, V_{in} will essentially be the same as V_{source} for a high-impedance active probe. But at higher frequencies, the input impedance of the probe can drop significantly, meaning that V_{in} will NOT be the same as V_{source}.



Measuring the Response (Correct Method)

A more accurate method of characterizing a probe's transmitted response is to not only measure V_{out} and V_{source}, but also measure V_{in}. With the active probe connected to the precision 50Ω "through" test fixture, you can connect the output of the 50Ω "through" to the input of your measurement system (microwave sampling scope, power meter, or vector network analyzer). The probe's output should then be connected to another input of your measurement system. This way, you can measure both V_{in} and V_{out} at the same time. Even though $V_{in\text{-}measured}$ may NOT exhibit a flat response (like V_{source}), you can still make an accurate calculation of the transmitted response of the probe simply by calculating $V_{out\text{-}measured}/V_{in\text{-}measured}$, which is the industry-standard formula for computing the transmitted response of a voltage transfer device, such as a probe.

Again, the bottom schematic in this slide shows the Thevinen-equivalent circuit of our test characterization setup. As you can see, V_{source} only equals V_{in} for lower frequency input signals when the input impedance of the probe is high.



Tips & Tricks – Practical tips on making good connections

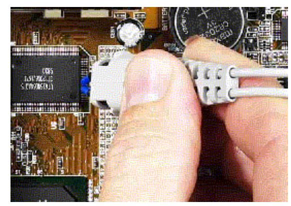
Agilent's InfiniiMax probing system has a variety of probe heads optimized specifically for different probing use-models, including browsing, solder-in, socketed, and SMA connections. In addition, Agilent provides both differential and single-ended probe heads. However, it should be pointed out that differential probe heads can be used for both differential and single-ended measurements, and provide for a higher performance measurement including higher common-mode rejection and higher bandwidth.

Instructions to presenter: After showing this slide, if you are running short on time to complete this seminar, you can skip the next five slides and now show the video titled, "Flexibility of Agilent's InfiniiMax Active Probe System". Otherwise, quickly run through the next five slides and then show the video.

Browser Probe Head

Characteristics:

- **6 GHz BW**
- **Most Versatile**
- **Least Accurate**
- **Least reliable connection**
- **Z-Axis compression enhances connection**
- **Adjustable tip spans**
- **90 degree probing angle recommended**
- **Ergonomic sleeve enhances usability**
- **Replaceable damping resistor tips**
- **Can be used with probe stand holder**



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Browser Probe Head

The most common use-model for an oscilloscope probe is hand-held "browsing". The term "browsing" simply means easily moving from one test point to the next. Although browsing may be the most common probing use-model, it is also the least accurate and provides for the least reliable connection. In order to make the "browser" probe head as useable as possible, there are a few performance tradeoffs. The connection length of this probe is the longest when compared to either the solder-in or socketed probe head. This means that you will probably observe some effects of probe loading and a small level of peaking in the probe's response when observing fast edge signals. This characteristic of the probe head was NOT intentionally designed-in, but was an unavoidable tradeoff in order to make this probe useable.

In order to provide a reliable/non-intermittent connection, the differential tips of this probe head have spring compression. When connecting to your device-under-test at a near 90-degree angle, both probe tips will compress, which is an indication that you have a reliable connection. In addition, you can easily adjust the probe tip span using the levers on the sides of the probe head to fit your test points, rather than fitting your test points to your fixed-tip probe, as our competitors offer. This probe head also has replaceable probe tips with embedded damping resistors to maximize signal fidelity. If a probe tip happens to break or is lost, it can be easily replaced. Probe's with fixed-tips are expensive to repair.

To enhance usability, the browser probe head also comes with an ergonomic sleeve that joins the probe head and amplifier together, providing the user with a single unit to easily hold onto.

And finally, the browser probe head can be used in conjunction with a probe stand holder for hands-free probing applications. Agilent recommends the Agilent EZ Probe Positioner for these applications.

Solder-in Probe Head

Characteristics:

- **7 GHz BW**
- **Most accurate**
- **Least versatile**
- **Most reliable connection**
- **Least space requirement**
- **Replaceable damping resistors (8 mil)**

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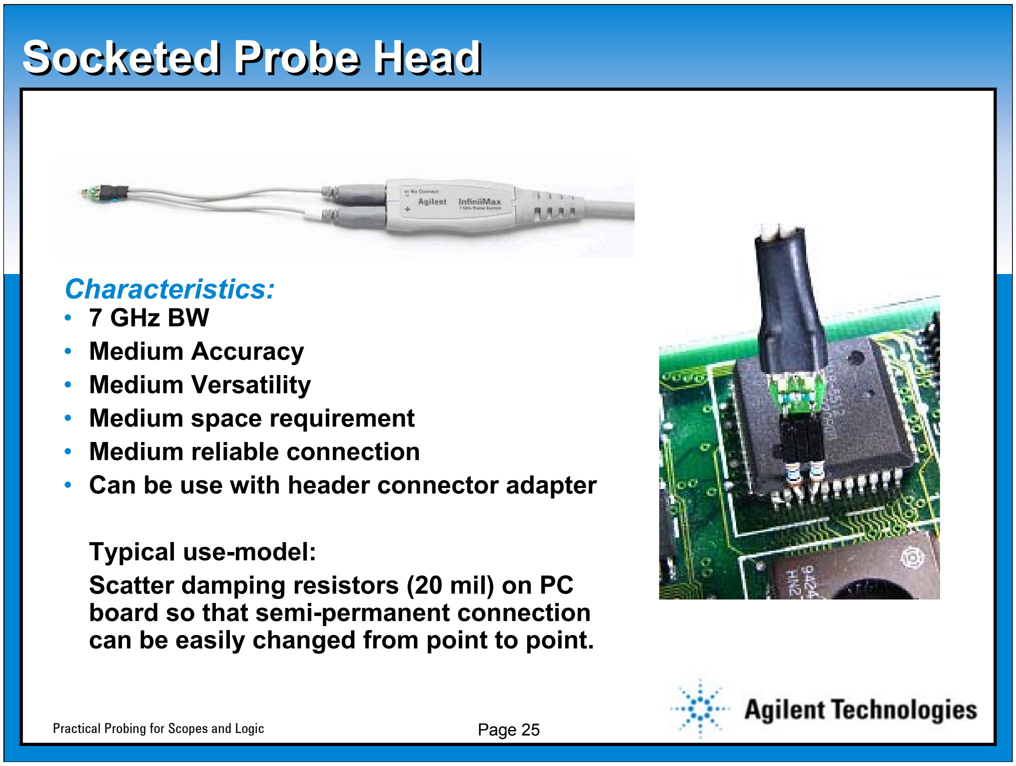
Solder-in Probe Head

Use of a “solder-in” probe head is often necessary to access hard-to-reach test points, such as probing between tightly spaced DIM cards as shown here. In addition to being the highest fidelity and least “probe-loading” solution, the solder-in probe head connection also provides for an inexpensive hands-free, but semi-permanent probing connection.

Although this probe head comes with pre-installed 8-mil diameter damping resistors, they will eventually break after multiple usage. But they can be easily replaced with the damping resistor replacement kit, which ships with this probe head.



Socketed Probe Head

For a semi-permanent connection, the socketed probe head provides lots of versatility, although the actual performance is slightly less than the solder-in probe head, but better than the browser probe head. With pairs of 20-mil diameter damping resistors pre-soldered onto your circuit board, you can easily move this probe head from test point to test point. In addition, you can connect this probe to a pre-installed header connector on your circuit using a small header connector adapter that includes embedded damping resistors. However, you should carefully account for the added capacitive and inductive parasitics associated with the addition of the test header connector to your design.

Differential SMA Probe Head

Characteristics:

- **50-Ohm Input Impedance**
- **7 GHz BW**
- **Span-adjustable semi-rigid coax**
- **High common-mode rejection**
- **Cable loss compensation**
- **Cost effective (compared to dedicated SMA probe)**
- **Can apply DC offset bias**

Differential SMA Probe Head

For applications where you have a test board with differential SMA connectors that are designed to be terminated into 50Ω, you can use the differential SMA probe head. This solution provides for higher common mode rejection and also compensates for cable loss, as opposed to using two standard SMA cables terminated into two channels of the oscilloscope. In addition, this method saves a channel of the oscilloscope for other important measurements, and eliminates the need to de-skew between channels.

The biggest advantage of Agilent's SMA probe head connection over our competitor's solution is that this is a relatively inexpensive and flexible solution. There is no need to purchase an expensive and dedicated SMA probe for differential 50Ω terminated applications. The amplifier used with this probe head can also be used with other probe heads provided by Agilent.

Scope Probe Summary

- **Traditional active probing topology has restrictive use limitations, and is near the end of its performance range.**
- **InfiniiMax probe head technology allows probing in tight spaces without performance degradation through the use of a variety of probe heads designed and optimized for specific use-models.**
- **A differential active probe should show as accurately as possible "what is" at the tips of the probe and should be specified as such.**
- **Although "Signal fidelity begins at the probe tip", it shouldn't end there. Don't let your probe be the "weakest leak"!**

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Summary

As we have learned today, traditional active probing topology is hitting a performance wall and has lots of usability limitations. If you add any accessories to this type of active probe, performance will degrade significantly.

Agilent's InfiniiMax probe-head technology solves many of the problems associated with traditional active probe technologies. You can now get your probe into very tight spaces without a loss of bandwidth.

As pointed out in this seminar, a probe should as accurately as possible show the signal that is present at the probe tip (what is), as opposed to attempting to show "what might have been" at the test points prior to connecting the probe. In addition, high bandwidth active probes should be characterized and specified based on the industry accepted standard of Vout/Vin for the transfer function of a voltage transfer device (such as a probe).

And lastly, not only should signal fidelity begin at the probe tip, but it shouldn't end there. If the probe connection limits the performance of the oscilloscope measurement system, then the bandwidth and sample rate of the oscilloscope that the probe is connected to may not matter. The "weakest leak" in the measurement system chain usually determines the overall performance of the entire measurement system. Don't let your probe be the weakest link!

Agenda

- **Scope Probing**
  - **Traditional active probing technology versus InfiniiMax**
  - **The Big Debate -- “What is” versus “What might have been”**
  - **Probe transfer function specification**
  - **Practical tips on making good connections**
- **Logic Analyzer Probing**
  - **Differential Probes**
  - **New Soft Touch Pro Series**
- **Summary**

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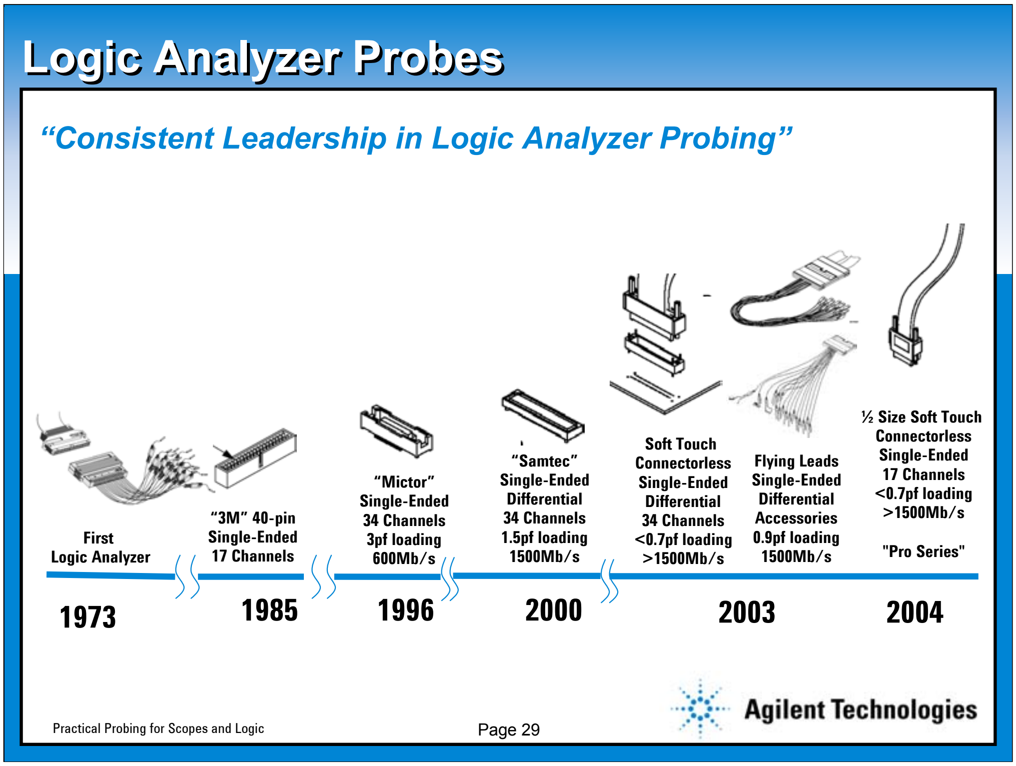
Agenda



Agilent has a long history of providing the next generation in logic analysis probes from the first logic analyzer to the latest industry standard, the Soft Touch Pro series.

Differential Logic Analyzer Probing

Three form factors are available for differential probing:

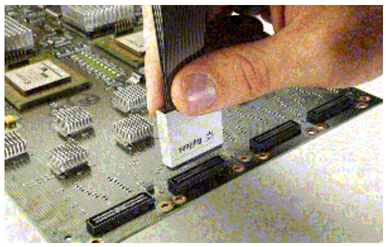
A) Connector Probes	(designed-in)
B) Connector-Less Probes	(designed-in)
C) Flying Lead Probes	(after-thought)

Agilent is here to proved a number of probing solutions for differential measurement capability.

May want to digress into a discussion about “designed-in” and “after-thought”. This is to emphasize that even if you forgot a signal, Agilent has a solution. Oh, and by the way, EVERYONE forgets a signal.

Differential Connector Probe (Samtec)

A connector-based probe requires the user to design-in a connector and route traces to/through the connector. The connector used is a 100-pin Samtec.



Max Data Rate	= 1.5 Gb/s
Analog Bandwidth	= 2.3 GHz
Loading	= 1.5 pF
# of Channels	= 17

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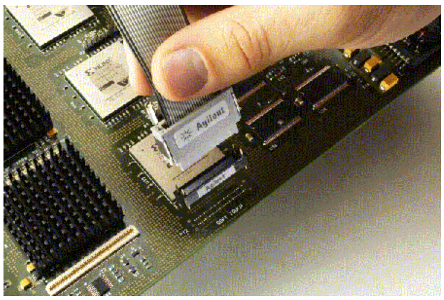
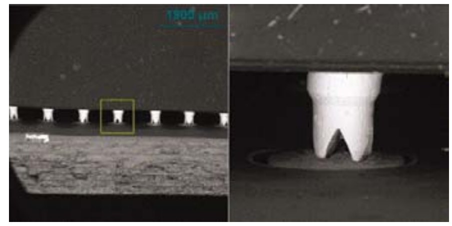
Samtec

It's important to route through the connector. The LA is not a termination and thus should be in the middle of the route, near the receiver. There should be no, or very small, stubs.

Differential Connector-less Probe (Soft Touch)

A connector-less probe requires only landing pads on the target in addition to small alignment holes. Spring-Pins serve as the compression interconnect.





Max Data Rate	= 1.5 Gb/s 2.5 Gb/s "Pro"
Analog Bandwidth	= 2.3 GHz
Loading	= 0.7 pF
# of Channels	= 17

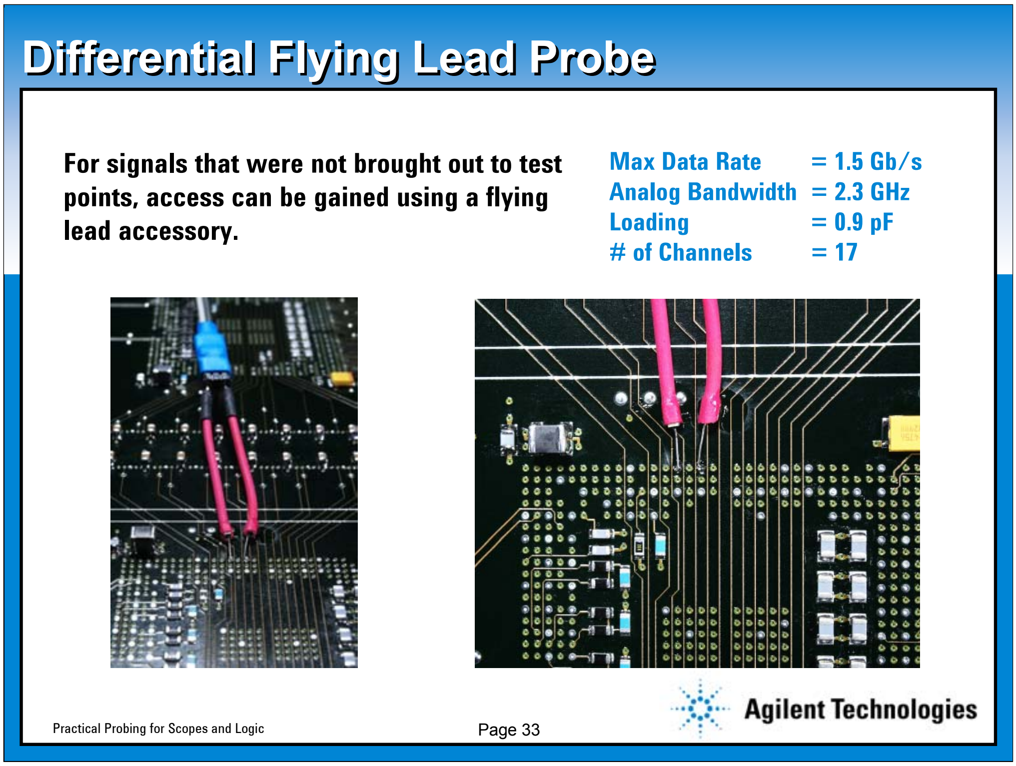
SoftTouch, this is the latest and greatest technology. Does not require a connector on the board. It can pierce contamination (schmutz) and withstand non-planar PCBs.

-Has at least 0.025″ compliance

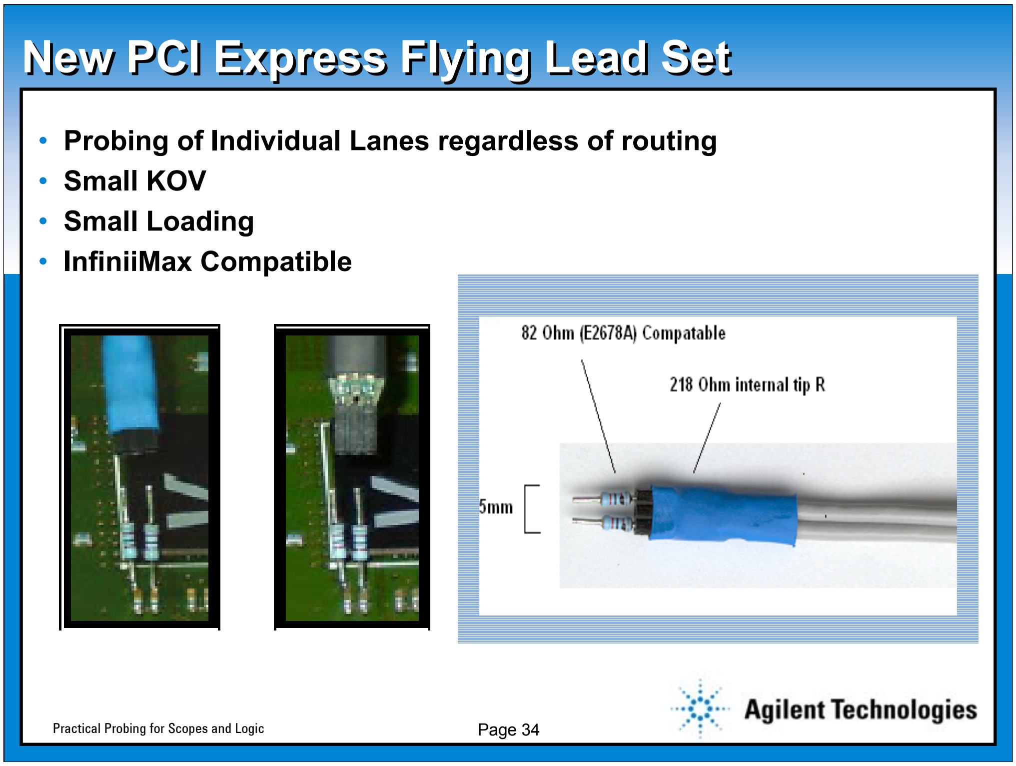
-Doesn’t require cleaning

-Eats through contamination (works with HASL and Organic Coat)

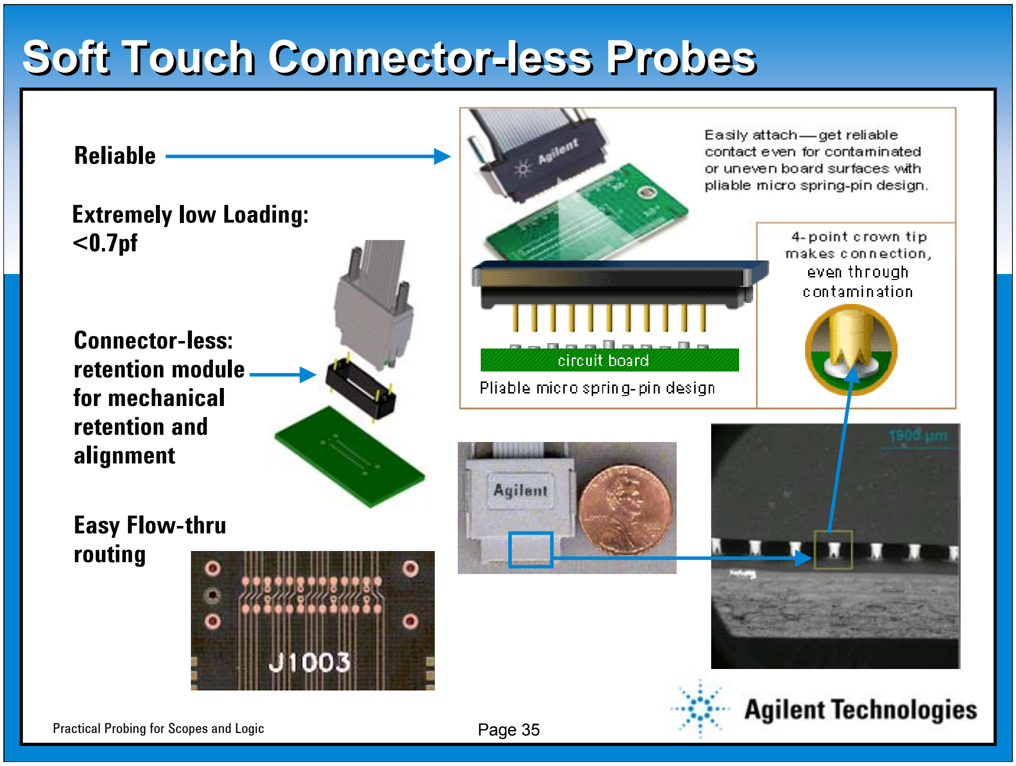
-Low loading



If you forget to put down testability, Agilent still has you covered. The flying leads can easily probe 1mm pitch BGA's and still provide full bandwidth measurements. The wires used to make this connection are custom with resistors embedded in the tips for damping.



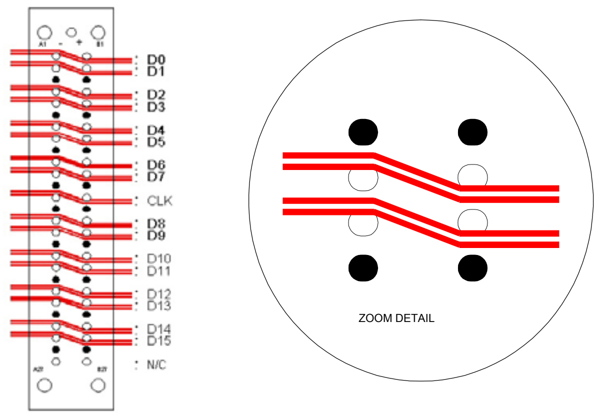
The flying leadset is ideal for customers who may have no board space for a midbus footprint, or who’s midbus footprint may have accidentally disappeared between board revs. It provides full speed access to the 2.5 Gb/s, and is small enough to probe in extremely tight spaces. It provides support for up to x16 PCI-E, and has the added benefit of being compatible with the Infiniimax scope probes as well (they both use the same 82-ohm resistors).



Here's an overview of the key features and benefits of the Soft Touch connector-less probes.

Soft Touch Footprint

The small footprint allows outer layer traces to be routed *through* the pattern, thus allowing in-system measurements with minimal disturbance to routing channels.



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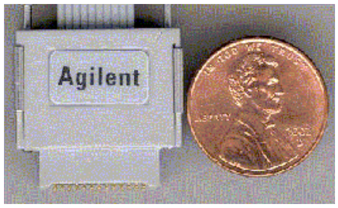
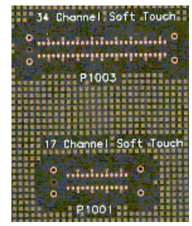
With Soft Touch, since only the pads are present, you can route "through" the pattern. This is big because you can probe signals in their native environment. You can also leave testability in the final design because the only thing on the board are the pads (80fF) and don't affect operation at all.

Half Size Soft Touch Probe



Soft Touch Connector-less Probes Deliver:

- **World's smallest footprint (7mm x 22mm)**
- **Probing at higher speeds (>2.5 Gb/s)**
- **Single-ended signal support**
- **Reliable connections**
- **Easy signal routing & attachment**
- **High density, low loading (<0.7 pF)**
- **No electrical connectors – mechanical only**



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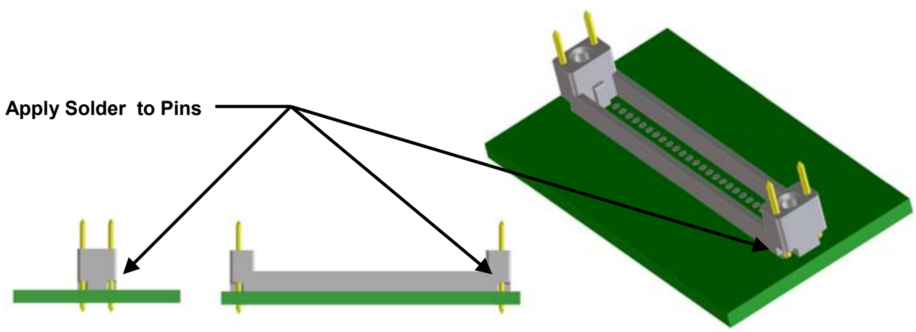
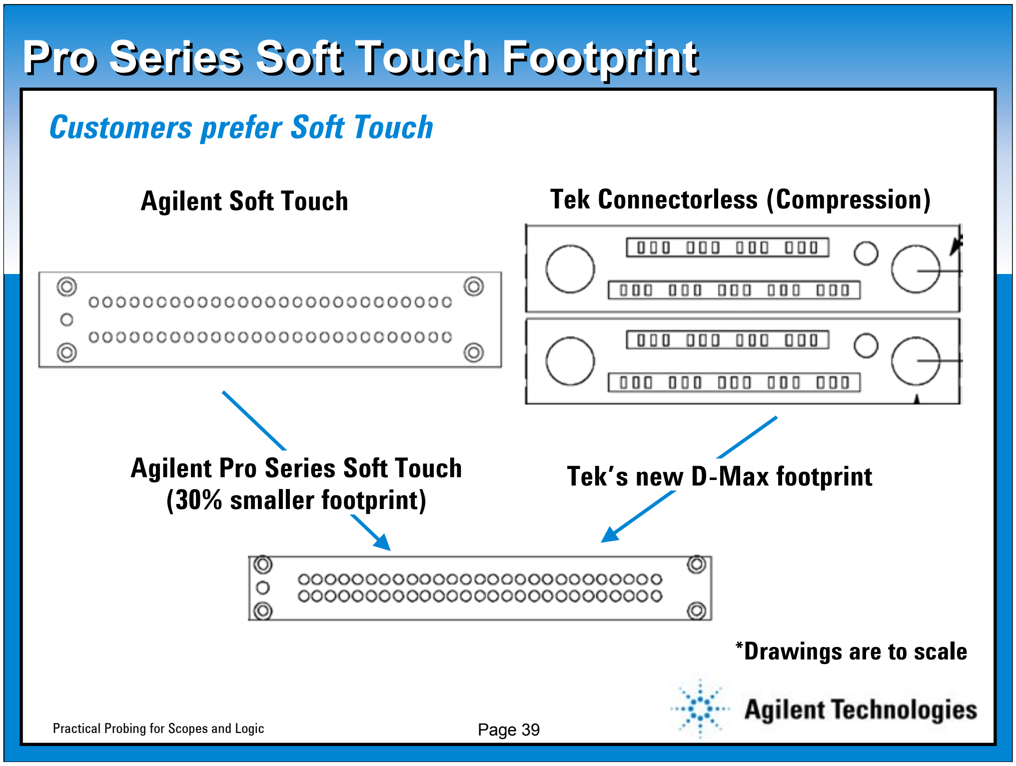
A new half-size Soft Touch connector was introduced. It allows for a smaller footprint and greater data rates.

New Pro Series Soft Touch Probes

- 30% Smaller Footprint
- New “Top-side” Mount Retention Module
- Easier to use — no need to access the bottom of the board
- Can tolerate thick boards — don’t need a portion of the pin available to solder on the bottom of the board





Several of the worlds largest logic analyzer customers approach Agilent and tell us: "We love connectorless probing, we love soft touch and we prefer the soft touch footprint. We would love it if you and your competitors could use the same footprint"

Working directly with one of these customers Agilent and Tek converge on the soft touch pro footprint which is very similar to the original soft touch footprint.

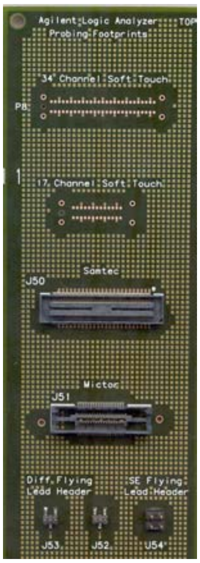
Tek needed a whole new probe (shape, size, format, interconnect) to be competitive—and it looks a lot like soft touch

Agilent just modified our soft touch probe for the new soft touch pro standard.

Q. Why didn't Agilent use this footprint in the first place?

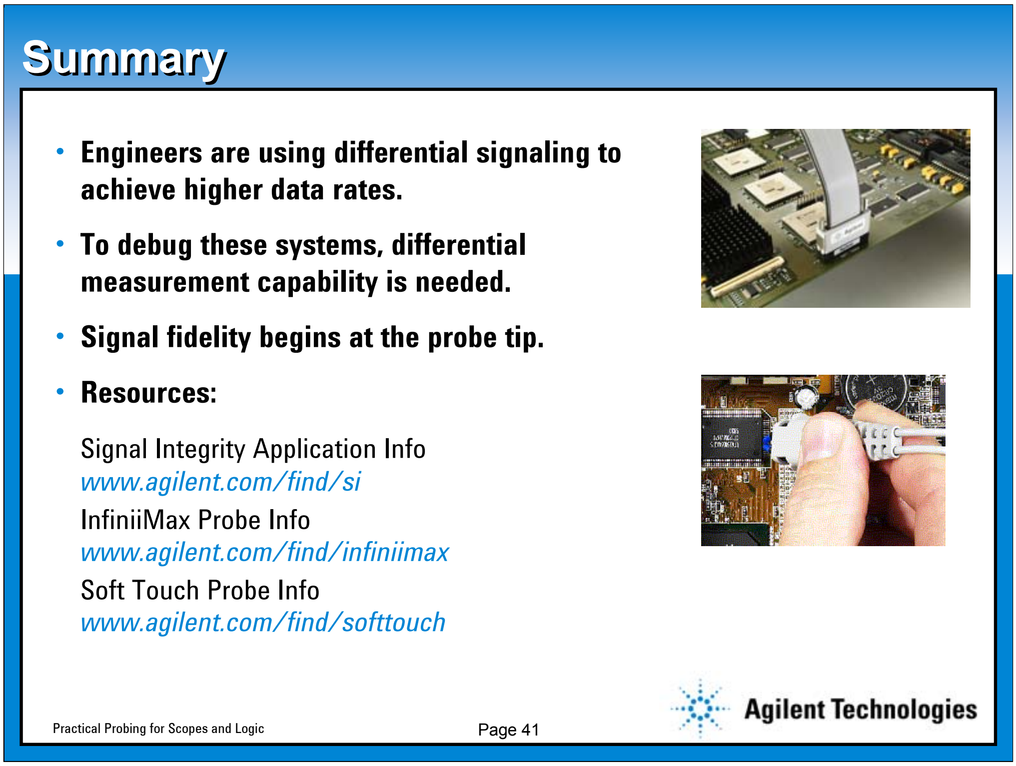
A. The original soft touch footprint was designed to accommodate vias, grounds and provide the best signal routing for PCI-Express.

Agilent Logic Analyzer Probe Summary



Select	If You Want
Soft Touch Connector-less Probe	• Extremely Low Loading—<0.7pf • Ability to Capture Very Fast Signals—2500 Mb/s • Easy Flow Thru Routing • Differential Signaling • The Joy of no connector on the board
Samtec Connector Probe	• Very Low Loading—1.5pf • Ability to Capture Very Fast Signals—1500 Mb/s • Flow Thru Routing • Differential Signaling • High performance probe at a low price
Mictor Connector Probe	• Low Loading—3.0pf • Ability to capture Fast Signals—600 Mb/s • Common Probing
Flying Lead Probe	• Extremely Low Loading—As low As 0.9pf • Ability to Capture Very Fast Signals—Up to 1500Mb/s • Differential Signaling • The Ultimate in probing Flexibility

Here's a quick review of the logic analyzer probe choices for Agilent logic analyzers.



-Everyone wants to go faster, so they are going to differential

-Everyone needs to test their systems, so everyone needs differential measurement capability

-When using diff signaling, you need to make consideration about the probe (just like designing your system).

-No matter what you do, connector, connector-less, or forget, Agilent has a probe that will help you debug your system