

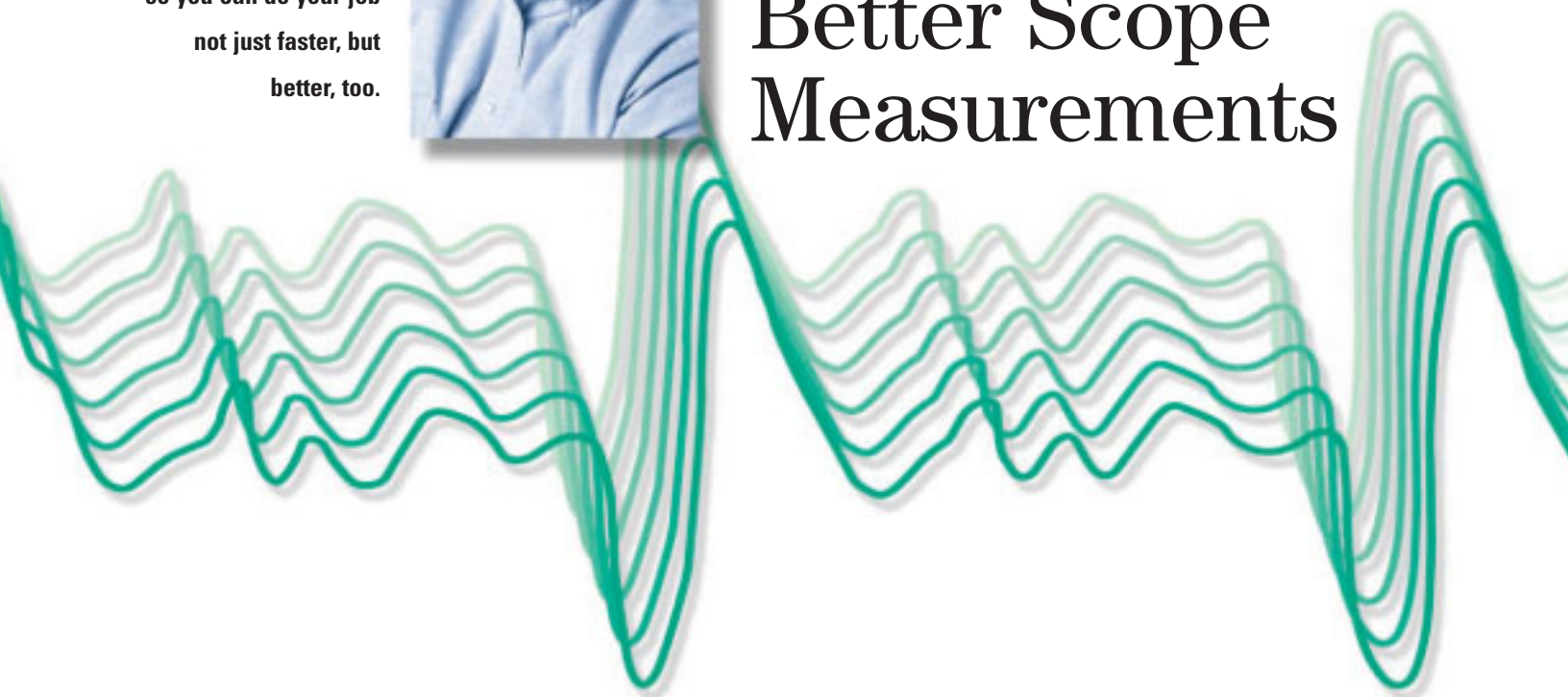
These helpful application tips will assist you in getting the most out of your digitizing scope, so you can do your job not just faster, but better, too.



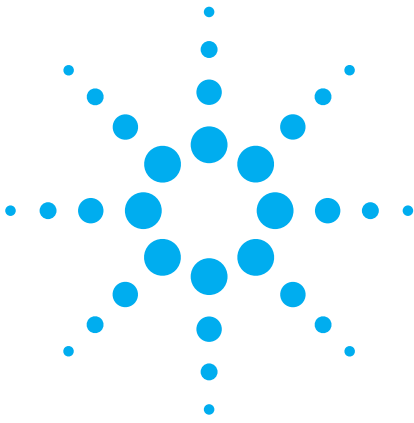
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Hints for making Better Scope Measurements



Agilent Technologies
Innovating the HP Way



Our goal is to make your job less frustrating

Fortunately, the engineers we've talked to haven't been bashful about telling us what they like and don't like about their jobs. You've told us that you have too much to do and not enough time to do it. You've made it clear that your job is becoming more complex — and you don't need your test and measurement equipment to make matters worse.

As a manufacturer of test and measurement equipment like oscilloscopes, we can do a lot to reduce the complexity and frustration you face every day. Of course we can't control how much work your boss gives you. But we can help you reduce the time you spend researching how to make a particular measurement, so you have more time for troubleshooting.

How do we accomplish this? By creating high-performance instruments that simplify your life — scopes that make it easier to accomplish simple tasks (like adjusting voltage ranges or the timebase, for example) and give you easy access to advanced functionality. Instruments designed to be usable. And we'll add value by helping you build the measurement expertise you need to do your job.

One of the ways we can help you gain insight and expertise is by gathering and providing hints on making better measurements. The oscilloscope tips and tricks in this booklet range from simple reminders to more complex and application-specific suggestions.

These hints were submitted to us by hard-working engineers who face the same issues you do. Some of the engineers use scopes made by other manufacturers. That didn't matter to us. What mattered is that these engineers had found ways to make better measurements with their scopes, and they were willing to share their shortcuts and tricks. We feel confident that you'll find valuable information here that will help you increase your effectiveness in using scopes to make critical measurements.

Because we'd like to continue to supply you with helpful information and equipment, we'd appreciate it if you'd let us know what else we can do to ease the frustration in your job. Email your comments to meas_hints@col.agilent.com.

We're listening. And we're here to help.

meas_hints@col.agilent.com

Don't forget to check that probe

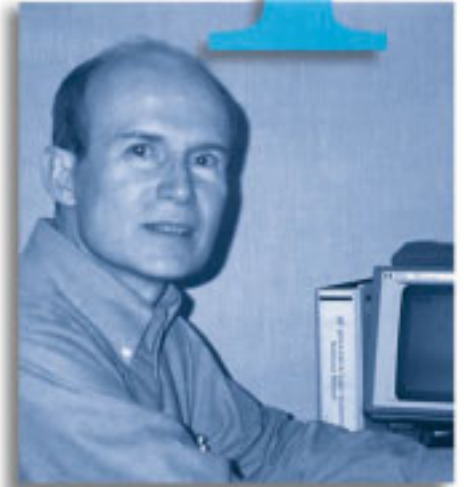
Submitted by Dave Howard

It's easy to forget to check probe compensation before making amplitude measurements on sinewaves. Generally the excuse is, "Oh, I'm not working with a fast risetime, so I don't have to worry." What that ignores is that risetimes within the scope's measurement system also have an impact, and that hidden effect can cause errors even when measuring signals with frequencies of several hundred kHz. It's good practice to check probe compensation before any important or critical amplitude measurement.

As an Engineer/Scientist for Tracor Inc., Dave spends his time doing electronic design on projects for a variety of government agencies.

His biggest on-the-job frustration is trying to keep up with rapid changes in technology. "The technology is moving so fast and people are becoming so specialized that you don't have to work very long in one area before you're behind in others. When I was in school, an engineering professor once told us that we should expect to relearn much of our curriculum every five years. It seemed like an exaggeration at the time, but in many senses he was correct. There's always a new challenge."

Dave's preference in test and measurement equipment: "small instruments that are really capable."



Dave Howard

A quick, easy way to troubleshoot mixed hardware/software prototypes

Submitted by Steve Hendrix

The process of designing and troubleshooting hardware driven with software often involves looking at lengthy and complex bit streams. It's often quite an effort to trigger the scope at the exact place in the bit stream you need to look at. An easy way around this is simply to find an unused I/O pin on the prototype as a trigger point, and insert code into the software to toggle that pin at the appropriate time. You can even use this capability to look at other signals occurring before the event of note. Sure, digitizing scopes often have fairly advanced triggering capabilities, and many can be set up to capture complex events like this. However, if the engineer can easily program a sync pin, you're saved the trouble of learning more complex scope features, and you're in complete

control via SW of where the trigger will occur. Steve notes that such a sync capability can even be left intact in production code IF it is well documented; that can make field service and diagnostic work much easier, too.

Steve is an independent consultant offering hardware and software design and other electrical engineering services. His clients are primarily small high-tech companies that are pushing the edge of new technologies. He enjoys the variety afforded by working for different companies and the learning opportunities that come his way as a result.

Steve is frustrated by companies that sell "vaporware", and he hates wasting his valuable time playing telephone tag to get crucial product information. "With time-to-market pressures, the price and delivery lead times are every bit as important as voltage or current specs," he says.



Steve Hendrix



Using Scopes to Measure Noisy Signals

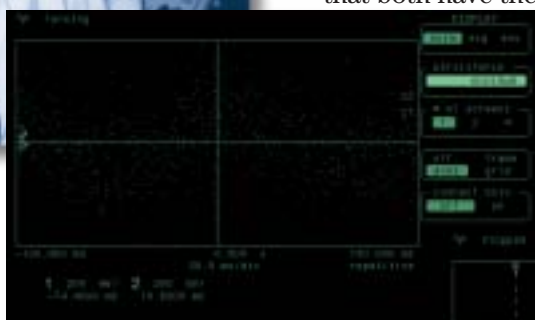
Here are several quick ways to resolve noise problems.

Measuring very low frequency signals

Submitted by Peter Higgins



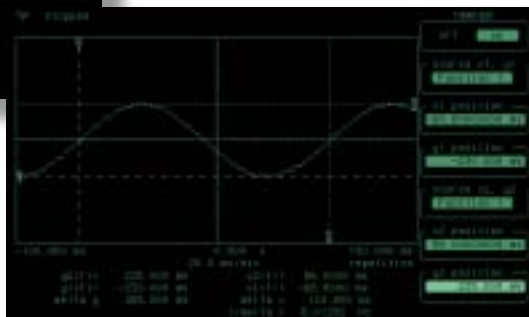
Peter Higgins



It's difficult to see the underlying waveform here...

There are times when you're looking for dc or very low frequency signals in the presence of noise or other ac components. One good example is low frequency wander. A quick way to eliminate most of your noise uses two scope channels. Set one input to dc coupling and one to ac coupling, and make sure that both have the same amplitude range. Now set your scope to display CH1 - CH2

(or invert one



...Peter's hint makes the waveform pop out!

channel and add them), and apply both probes to your test point. Since the ac component at the test point is common to both scope inputs, it will be subtracted out, leaving only the dc component and any ac component that is below the scope's ac coupling frequency.

It's no wonder that Peter's biggest frustration is having too much to do. He has two jobs: he's a senior field applications engineer for a manufacturer of semiconductor test equipment AND he's an independent consultant for other high-tech companies. As busy as he is, having fast, easy access to his scope's advanced capabilities is important to Peter.

"Squeezing out the last picosecond of resolution or the last nanovolt of performance is in some ways not as important as being able to get to the measurement you want in ten seconds, rather than five minutes, after having to pull out the manual and make a few bad attempts."



Getting intimate with your noise

Submitted by Ron Thomas



Ron Thomas

When you're chasing down an unknown intermittent noise source, it's to your benefit to get to know as much as you can about it. One simple, often useful, characteristic to find is the direction of the initial noise transition. If that transition is negative, it's likely that a voltage drop caused the change, and you might want to look for loads turning on elsewhere in the system. If the first transition is positive-going, it could be some type of inductive surge such as that caused by a solenoid turning off. Other helpful clues might be found in the position of a spike within a periodic waveform, any detectable period in the noise signal itself, or even the shape of

the spike and its decay. If you're in the "spike detector" business, maintaining a log of known and suspected noise contributors and signals can help speed your task and help those working with you.

A systems engineer for GM, Ron oversees the development of rotational position sensors for car engines. Fortunately, he likes technical challenges. "You get into a situation where a device is not operating in an expected manner and nobody can figure out why. The analytical challenge involved in trying to figure out different variables is entertaining."

His frustration with scopes: "I want as much functionality as monetarily possible, but typically when you get to a great depth of functionality, there are so many functions that they are hard to find."



Looking for EMI and EMC noise sources with your scope probe

Submitted by Christopher Reggiardo and Michael Covington

You can create a “bargain basement” magnetic probe by simply connecting your scope probe’s ground lead to the probe tip. Set your scope channel to it’s maximum sensitivity, and you can then sniff out oscillations and other sources of noise on your DUT without needing to touch it. You can check cabinets for EMC leaks, determine optimal cable routing, and more with this approach. Remember that magnetic signals are strongest when the loop is at 90 degrees to the signal when you do your snooping.

Christopher Reggiardo:

Getting a clean signal without EMI is important to Christopher, an engineer for Ventritek, who designs circuitry that connects directly to a patient’s heart. He wants everyone to know that he didn’t invent this hint. “I don’t mind sharing it,” he says, “because it’s something I’ve found useful more than once. But I’m not taking credit for creating it.”

Michael Covington:

Michael is one of the most knowledgeable amateur scope users we’ve encountered. He’s been dabbling in electronics since he was 9 years old. He’s a regular contributor to Electronics Now magazine, which recently printed an article he wrote about fixing up old scopes — his hobby. His day job? Associate director of the artificial intelligence lab at the University of Georgia.



Christopher Reggiardo

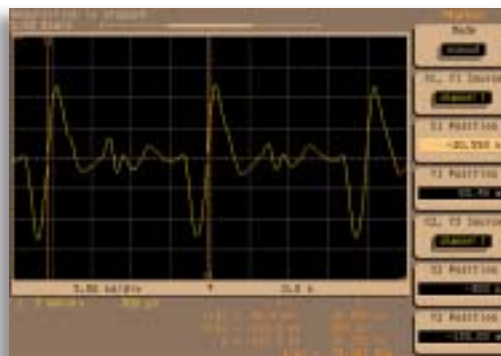


John Tulloch’s probe

Probing for high frequency noise

Submitted by John Tulloch

We found a refinement to this idea with in Agilent’s scope development labs. John Tulloch, a sales support engineer, created a probe from a length of semi-rigid coax by bending the coax into a small loop, stripping away a small portion of the shielding, and then soldering the tip of the exposed center conductor back to the shield. The outer conductor shields the electric field so that only magnetic fields are picked up by the loop. This technique provides higher frequency

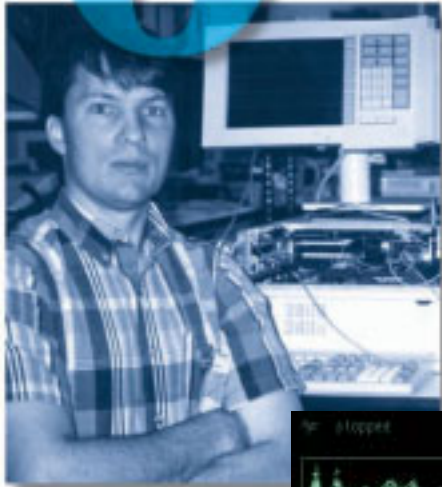


John’s probe showing noise from a 50 MHz clock on a digital board.

response, and since the probe only “sees” the magnetic component of an EMI signal, the user has a much better idea of the direction and therefore source of spurious signals. If sensitivity is critical, removing the shield around the entire loop increases sensitivity at the expense of directional accuracy. Remember, the size of the loop will affect the optimum detection frequency; pull out your electromagnetic theory books if you need more information.



Michael Covington



Jeff Summers

Taking a look at eye patterns

Submitted by Jeff Summers

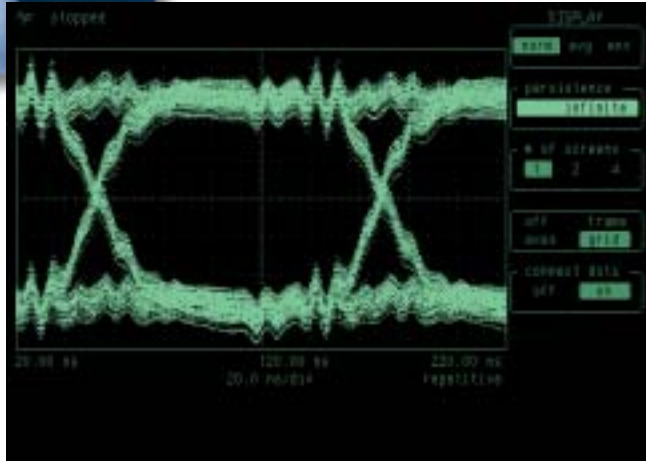
Jeff used an Agilent digitizing scope to measure the eye pattern of an Ethernet driver. The IEEE standard gives a jitter specification for Ethernet in the form of a template inside which all transitions must fall. In order to measure this, Jeff put the scope in infinite persistence mode and then ran several hundred transactions between the UUT and a host. First, he set the scope to display two bits worth of data on screen (20 ns/div for the 10 Mbit Ethernet card Jeff was designing). Then Jeff set the scope to trigger on a rising edge at his signal's zero crossing, set the

timebase delay to the recommended time from the trigger (for Ethernet, the jitter is measured 8 bit times away from the trigger point), and captured several hundred waveforms on screen. What he ends up with is a nice eye pattern, and it's pretty easy to use measurement cursors to determine if the waveform falls within the required template.

Some newer scopes offer features specific to the telecom and datacom industries, providing automatic mask measurements or specialized triggering functions. For example, the 83480A digital communications analyzer provides a full range of automated statistical measurements (jitter, eye width, extinction ratio, and more) and industry-standard tests for high-speed digital communications.

As a senior design engineer for NCR Corp., Jeff is currently the project lead engineer on a 686-based Point of Sale (POS) retail terminal. His day-to-day activities have included everything from board design and debug for peripheral boards to ASIC design and development.

Jeff enjoys the wide variety of day-to-day technical issues he faces. "They range from the mundane, like verifying compatible voltage levels and signal integrity issues, to the exotic, like determining that a circuit failure is due to bacteria growing underneath a component."



Eye diagram similar to Jeff's.



John Rupkalvis

Custom graticules work for any scope

Submitted by John Rupkalvis

While today's scopes can often make specialized measurements on complex waveforms like eye diagrams, it's sometimes quicker and simpler to work with equipment on hand. John Rupkalvis sent in his suggestion to consider using cheap and easily available materials like Chartpak tape and transparency material to create templates that can be taped to the scope screen. You can work from templates contained in specification documents, or even create templates from "golden waveforms" captured on screen. John often works with a variety of tape and color copying methods to create custom graticules which he uses for reviewing video signals and other waveforms with his scope.

John says, "Many people use scopes for very esoteric purposes." We believe him. John is a stereoscopic imaging consultant, or a specialist in 3-D imaging. John works with many clients in the entertainment industry — but he also serves companies in other fields, including manufacturing, medicine, and education.

These custom templates have helped John to improve his test and measurement efficiency and he highly recommends them for others working with special applications.



How much of the time is my signal on?

Independently submitted by Kadett Yuen and Allen Montijo

One advantage digitizing scopes have over analog scopes is trace persistence. Infrequent waveform features are easily seen when using infinite persistence mode. However, the relative frequency of a signal's occurrence on a digitizing scope can sometimes be less obvious than when looking at the trace intensity of an analog scope. These two hints provide some quick ways to determine how often specific waveforms occur.

It's often useful to know the relative distribution of pulse widths in a digital signal with two primary pulse widths. Turn on averaging in your scope and trigger on any pulse's rising edge. You will see an intermediate step in the displayed falling edge. If that step is at the 50% point, the relative distribution between the two pulses is 1:1. If the step is at the 90% point, then the wider pulse occurs 90% of the time (and the narrower pulse occurs 10% of the time!). It's a simple formula; if we assume pulses with width t_1 and t_2 where $t_1 > t_2$, then:



This waveform had a ratio of two narrow pulses for each wider pulse. The step is $\frac{1}{3}$ the amplitude of the total—as predicted!



Kadett Yuen



Allen Montijo

$$\% \text{ of Time Pulse of Width } t_1 \text{ Occurs} = \frac{\text{Intermediate Step Level}}{(\text{High Level} - \text{Low Level})} \times 100$$

You can use a similar method to find how much of the time a digital signal is high or low. Here's an easy way to do that with a digital scope. First, use a standard non-averaging mode to find the voltage of the high and low states. Now turn averaging on with a large number of averages. After the trace settles, measure the average level. The time your signal is high can be found with this equation:

$$\frac{(\text{Average Level} - \text{Low level})}{(\text{High Level} - \text{Low Level})} \times 100 = \% \text{ of Time Signal is High}$$

Kadett Yuen:

Kadett is a principal engineer in ASM Assembly Automation, Ltd., a firm that produces semiconductor assembly and packaging equipment in Hong Kong. "My work involves the development of controller and power system in our machines," says Kadett. "I'm interested in board-level analog and digital circuit design, simulation, prototyping, and troubleshooting."

Kadett describes his hint as a casual discovery he made while measuring jitter in a phase detector.

Allen Montijo:

The results of Allen Montijo's work may be sitting on your bench. Allen works in an R&D lab designing mid-range to high-end oscilloscopes for Agilent's Electronics Measurements Division — the folks who bring you Agilent Basic Instruments as well as high-performance scopes. Fortunately for all of us, Allen's biggest joy is solving problems. His biggest frustration is the same as everyone else's: too much to do and not enough time.

Share your scope tips and tricks

To submit a hint, please send email to meas_hints@col.agilent.com. Please write "Scope Hints" on the subject line and attach any screen captures or graphic files in TIFF, GIFF, PICT or BMP format. Please also include your phone number and a note giving us permission to edit and publish your hint.

Thank you to all the engineers who contributed to this booklet!

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