Scoping out palm-sized USB oscilloscopes

By Jack Ganssle
Embedded Systems Programming

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Have scope will travel. Jack evaluates three cool "microscopes"—USB oscilloscopes that fit in the palm of your hand or next to your pocket protector.

Traditional oscilloscope vendors have greatly shrunk the size of their offerings. Some of Tektronix's products take up a third less space than their predecessors. Yet when saddled with a display and a sea of controls there are limits to how small—and inexpensive—these units can ever be. But for developers and students looking for smaller and cheaper instruments, a number of palm-sized units are available. These instruments substitute a USB connection and the PC's screen for the CRT, and some offer astonishing performance. All are brilliantly designed and utterly cool.

I decided to evaluate these USB "microscopes" to see the units compare with traditional bench scopes. I looked at offerings from Parallax, Saelig/USB Instruments, Picotech, and Bitscope. These are all digital storage oscilloscopes (DSO) and offer more features than traditional analog models. I'll review the Bitscope next month as it's a cross-dressing scope/logic analyzer combo.

The users' manuals (some printed, some only on disk) and

PRODUCT NEWS

I-Logix unveils Statemate 4.1 for auto, aerospace modeling
I-Logix has released a new version of its Statemate 4.1 unified modeling language suite with additional workflow capabilities that allow teams of developers in applications such as automotive and aerospace to coordinate system specification.

Bridging device connects PCIe-based host processors to ASI fabrics
Kestrel, the latest member of StarGen's AXSys switching and software product family, is a PCI Express (PCIe) to Advanced Switching Interconnect (ASI) bridge designed to connect PCIe-based host processors to ASI fabrics.

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DATELINE: EUROPE

Imagination creates graphics support system
Imagination Technologies has set up the 'PowerVR Insider' development programme to promote and endorse excellence at all levels of the mobile graphics ecosystem from silicon providers to games developers.

ARM buys development tool specialist Keil
ARM has bought a supplier of software development tools for

help files were uniformly awful. Though none of the units was hard to use, the documentation served as an effective barrier to understanding.

Only Parallax's unit came with any sort of probes because a decent probe can easily run $100. Plenty of vendors do sell less expensive probes, but buy warily, as a poor choice can distort signals and may be shoddily constructed.

None of these scopes offer the same input ranges as your desktop Agilent or Tektronix. Feed more than a few tens of volts into the inputs and the smoke detectors will smother your yell of rage. But with a x10 probe that's still enough range to work with most circuits found in embedded systems.

These DSOs can apply a Fast Fourier Transform to the signals to rotate amplitude data to the frequency domain, creating a useful spectrum-analyzer mode.

All but one will save captured data to disk. My bench scope is nearly always connected to the PC for the very same reason, which makes me scratch my head and wonder if it's not possible to use a virtual instrument all of the time. More thoughts on that next month.

Parallax USB oscilloscope

For $149 you can't expect much. At least that's what I thought till the Parallax (www.parallax.com) unit arrived, professionally packaged in a blister pack as part of an "Understanding Signals" kit. The iPod-sized scope alone is $129.

Figure 1: From left to right: The Stingray, Picoscope 3206, Parallax USB scope

The unit, shown on the right in Figure 1, isn't designed to meet the need of the serious developer, but it packs an awful lot of punch for the price. Two channels plus an external TTL trigger, 1 million samples per second when using a single channel, half that when both are on. It has a 200-KHz bandwidth with 8 bits of vertical resolution and a +/- 20V input range.

All the other units I'll review have standard BNC input connectors. The Parallax scope, though, uses 0.157-inch cylindrical connectors and comes with crude probes. Eighteen inches of non-coaxial cable terminates in standard clip leads. But perhaps this is a reasonable tradeoff given the unit's 200-KHz bandwidth.

The USB host (PC) provides power to the scope. Don't try to run the device from an unpowered hub.

Installation was trivial, taking under a minute. There's no uninstall, which is sort of a nuisance when evaluating many different devices.

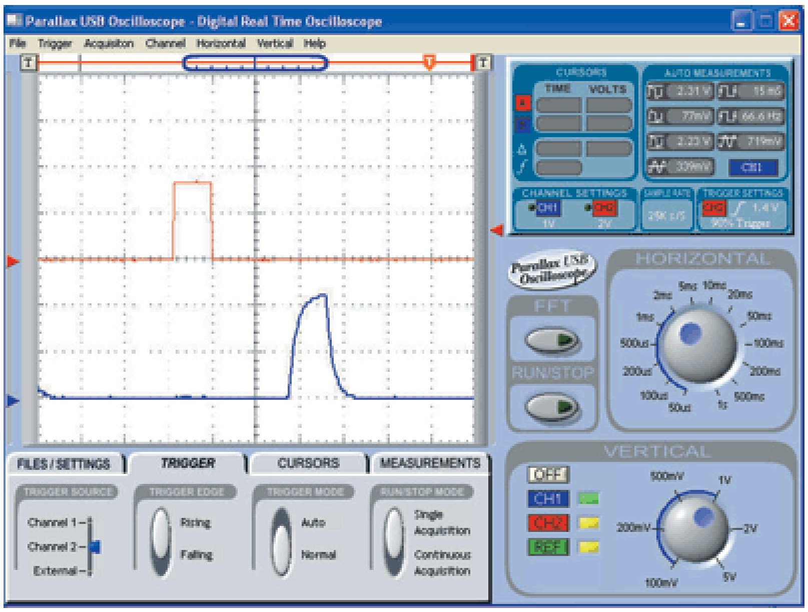

Figure 2: Main screen, Parallax USB oscilloscope

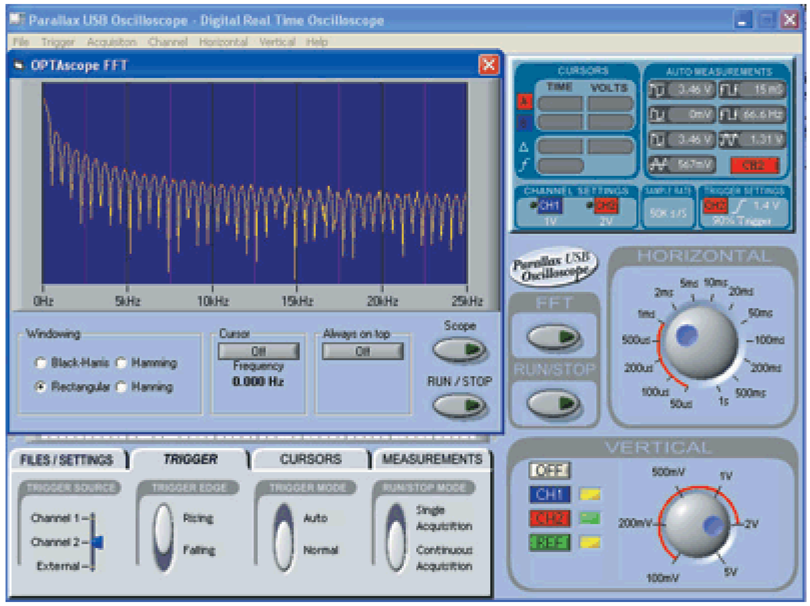

Figure 3: Spectrum analyzer display, Parallax USB oscilloscope

The GUI is simply beautiful and looks a lot like the front panel of an ordinary bench scope. (Figure 2 shows the main screen; see Figure 3 for the spectrum-analyzer display.) Two big knobs control the vertical scale and time base. Drag them with the cursor. The single vertical does double duty for both input channels; I'd prefer two knobs.

Trigger the unit from either channel or the external input (which is a digital signal, not analog). The trigger level is a slider that puzzled me at first requiring my only trip into the help file.

Very easily adjusted horizontal and vertical cursors appear on the screen. Position them with the mouse and the GUI will measure time, voltage, frequency, and deltas.

Though all of the scopes were responsive, this one took my breath away. Updates at reasonable sample rates were instantaneous. One visitor noted that it took forever to update the screen and then realized he was sweeping at 1 sec./div, requiring 30 seconds for a single acquisition.

At $129 this sounds like a toy scope, but the only toy-like features are the 200-KHz bandwidth and simple probes. I'd recommend the Parallax unit for low-speed applications, educational use, and to get your kids interested in electronics. At audio frequencies this is all the scope you'll ever need. The very well-thought out "Understanding Signals" kit for $20 more, plus a BASIC Stamp microcontroller, will teach newbies about scopes and analog and digital circuits. The kit's manual is on-line at www.parallax.com/dl/docs/prod/sic/Signals.pdf.

Stingray

UK-based USB Instruments (www.usb-instruments.com) manufactures the Stingray, which is sold in the USA by Saelig Instruments (www.saelig.com) for $220. For some reason the documentation calls it the "EasyScope II."

The Stingray's case, shown on the left in Figure 1, is as sexy as its name, a streamlined wedge smaller than a CD. It comes in a faux-leather pouch that can hold a couple of probes as well as the instrument. Saelig must have hired a marketing person from Apple.

The unit has two channels that accept +/- 50V signals, and an external trigger input that takes an input in the +/- 3.5V range. The analog bandwidth is 250KHz with one million samples per second in single-shot mode, or 20 million for repetitive signals. Inputs are sampled with 12-bit resolution into a 32KB buffer, which works out to 8K samples per channel. A nice feature lets you reduce the buffer depth to 1K for faster updates at slow sweep rates.

The difference between 8- and 12-bit resolution is palpable. Ramps look significantly smoother. For high-precision analog work I'd go with the 12 bits.

Installation was easy but a little odd; it seems to install twice, once per channel. Thankfully an uninstall is included. Help is adequate—barely—and very concise.

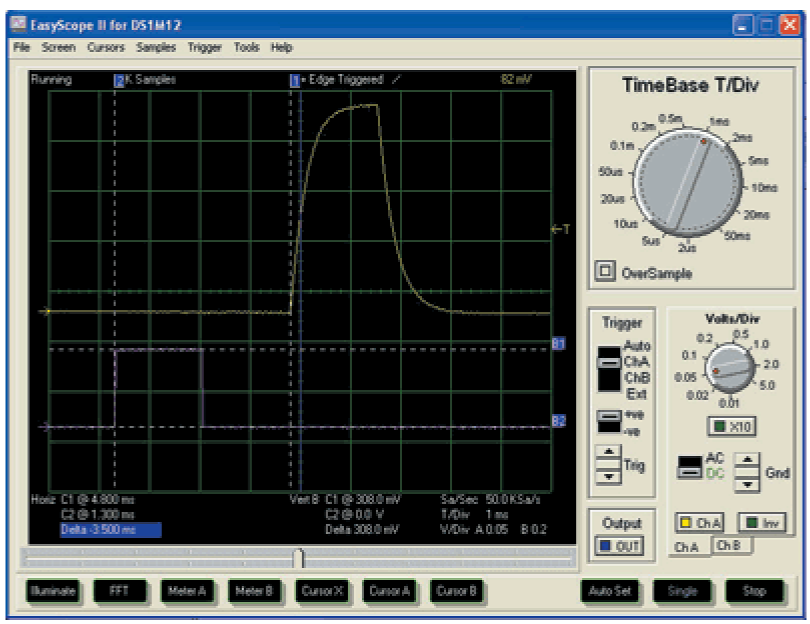

Figure 4: Main screen, Stingray

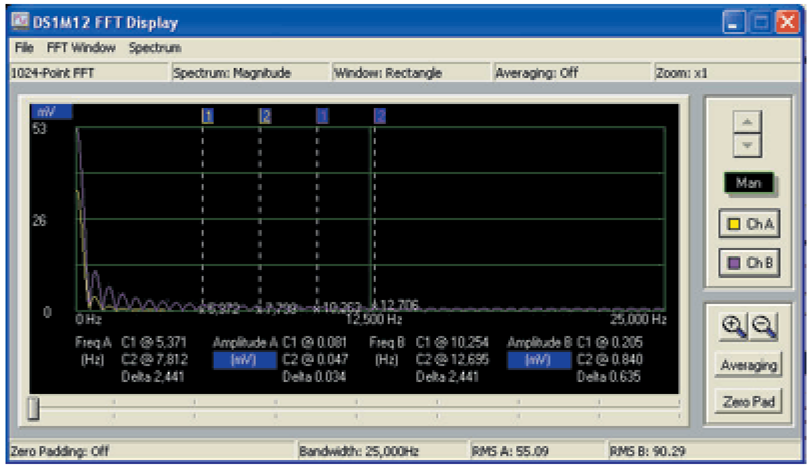

Figure 5: Spectrum-analyzer display, Stingray

The GUI, shown in Figure 4, is even prettier than Parallax's, though the cursor, FFT (see Figure 5), and meter buttons across the bottom are a bit clunky-looking. Again, two big knobs set vertical and horizontal ranges. And again, I'd sure prefer separate knobs for the two vertical channels. The cursors are particularly simple to use.

But the trigger adjustment is cumbersome. Though it looks like a slider, one must click repeatedly on up/down buttons to adjust the level. A knob or real slider would be a big improvement.

The Stingray's external trigger is apparently a TTL input. The GUI lets you trigger on a rising or falling edge of this signal.

Like the Parallax unit, the Stingray is very responsive. Change a setting and the screen updates with new data immediately.

Though the datasheet suggests the unit has a delayed timebase function, I couldn't find any reference to this in the documentation and couldn't find on-screen controls to use such a function.

Easy-to-use horizontal and vertical cursors measure amplitude and time, though not frequency. You can enable up to six digital meters that display frequency and instantaneous, peak, or root mean square (RMS) voltage. That might be useful in a production environment where the technician must make routine measurements.

Interestingly, the external trigger input can also function as an output for a signal generator. The unit will generate sine, square, triangle, ramp, and even custom waveforms you design yourself. It's limited to audio frequencies only, and the waveforms are more than a little rounded, so don't toss your bench signal generator. But for those on a tight budget with limited needs this is a handy feature.

PC-hosted instruments can have features limited only by the imagination and software. In this case an "EasyLogger" feature captures data and displays it like a strip chart recorder (remember those?) and to a file.

The bottom line: the 250KHz bandwidth is too narrow for most of us working on the digital end of an embedded system. But if your processor is slow (and a lot are) or you need a handy scope for routine analog work, this device will suit most users fine. Slip it into your pocket for travel and have fun convincing the TSA folks that the device isn't a threat to national security.

Picoscope 3206

Picotech (www.picotech.com) has a broad line of PC-hosted DSOs, ranging in price from a $132 (at current exchange rates) one-channel 20-KHz model to the $1,535 top of the line 3206 that I tested. Other 3000-series units have similar features at lower bandwidths and buffer sizes, priced at $766 and up. The Picoscope moniker is unfortunate as this unit offers mega performance.

The 3206 is somewhat larger than the others I looked at, but at 5 x 7 x 1.5 inches it could still fit comfortably in a purse. It requires an external wall transformer and doesn't have a power switch.

The software comes with an uninstall, a welcome addition since it took a couple of tries to get the software to recognize the DSO. But once running it performed flawlessly.

Picotech is UK-based, which perhaps explains why I wrestled so hard with the 82-page PDF manual. As Churchill noted, we're two peoples divided by a common language, which in this case means Norteamericanos will glean little of use from the documentation. Since "tips" don't appear when mousing over menus I spent a lot of time in the not terribly helpful help file.

The input range is +/- 20 volts for both channels and the external trigger input.

A 200-MHz analog bandwidth and 100 million samples/second data collection (200 million when using only one channel) makes the 3206 quite the speed demon. On repetitive signals it'll suck in an effective 10 billion samples/sec. In all modes it has 8 bits of vertical resolution, and a 1MB data buffer. The trigger can be positioned at any point in the buffer, a very important feature needed to capture pre- and post-trigger events.

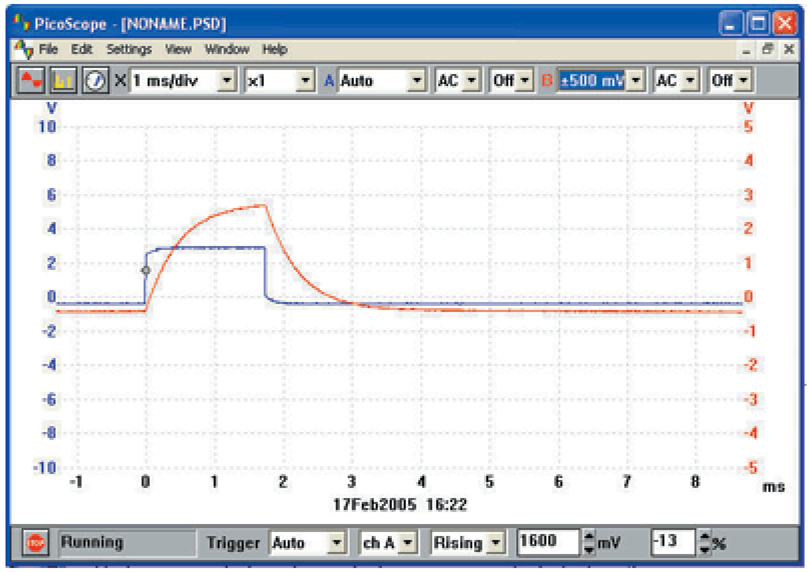

Figure 6: Main screen, Picoscope 3206

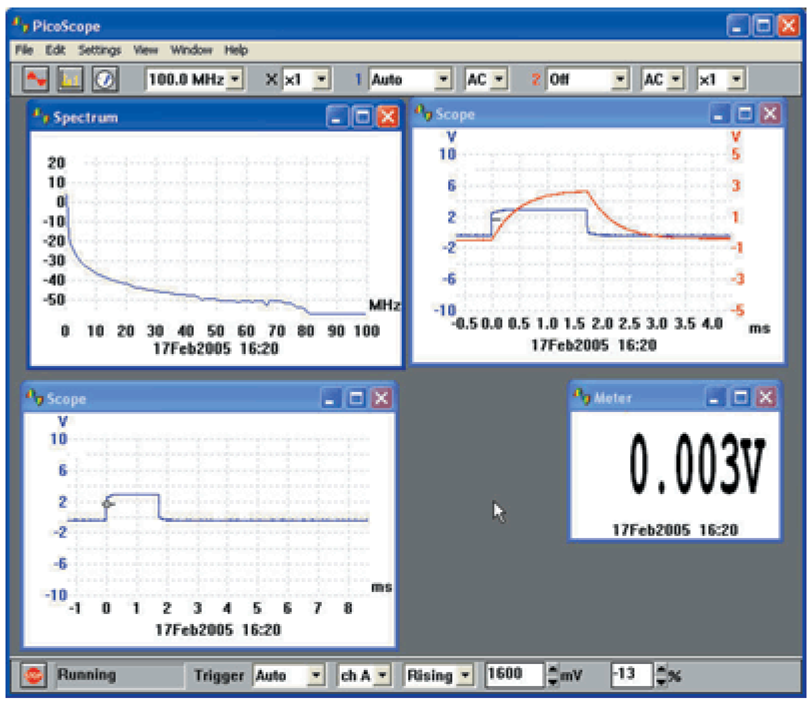

Figure 7: Picoscope 3206 “composite” window, in this case showing a spectrum-analyzer display, two scope windows, and one voltmeter

The GUI, shown in Figure 6, makes no attempt to imitate the knobs on a traditional scope. It's somewhat clumsier than the other user interfaces, though the signals are displayed with a hard-to-describe but breathtaking clarity. This interface is all about the displayed data, not the controls.

Much more versatile than the others I've described, the 3206's GUI supports multiple displays. Maybe you'd like to view channel A with one time scale and B with another—with just a couple of clicks two scope windows appear. Add the spectrum analyzer in a third, and a voltmeter in a fourth. The unit is very responsive and has fast screen updates except when a spectrum-analyzer window and one or more scope views are open at the same time, as shown in Figure 7. Then things get sluggish. Close a window and the speed issues disappear.

A zoom feature that expands and pans through the deep 1MB buffer works well and is very fast. Suppose you capture a signal with the time base set to 50 msec/division and need to look at an edge in more detail. Just zoom . . . and zoom ... and zoom, up to 1,000x, without recapturing.

A single mouse click selects the two horizontal and vertical cursors (confusingly called "rulers" in the help file), which enable the usual spectrum of measurements. But Picotech adds much more—you can display averages and even standard deviations of the data and can select which parts of the signal contribute to the calculations. Displaying a color burst or swept waveform? Measurements on most scopes are meaningless since the frequency varies across the screen. On the 3206 just pop up a dialog to select where to take data.

Variable persistence lets signals stay on-screen forever or fade from view after a specified time. In digital color mode areas of the trace that repeat frequently are red; those that don't head toward the blue. It's easy to spot infrequent events like a glitch.

The 3206's internal signal generator creates sine, square and triangle waves at speeds to 1MHz. Under 500KHz their frequency stability was 1% or better; above 500KHz stability degenerated.

This is a fast scope with a deep buffer that's useful for real work on real embedded systems. It's a reasonable substitute for some bench instruments and is great for travel.

Till next month

Space limitations prevent reviewing Bitscope's product here, so that will have to wait till next month. But their product is really a mixed-signal scope, so it forms a perfect segue into discussing a number of USB logic analyzers.

Till then, check out www.pc-oscilloscopes.com/oscilloscope_selection_guide.htm and http://cpliterature.product.agilent.com/litweb/pdf/5989-0552EN.pdf for vendor-biased but useful information about selecting a DSO.

Jack G. Ganssle is a lecturer and consultant on embedded development issues. He conducts seminars on embedded systems and helps companies with their embedded challenges. Contact him at jack@ganssle.com or visit his Web site at www.ganssle.com.

Reader Response

As the new Technical Support Manager at Saelig Co., I read your recent review on palm-sized USB oscilloscopes with great interest.

I did want to point out a few minor items about Stingray.

The trigger level controls (up & down arrows) work better by simply holding either button down, and watching the trigger level arrow move accordingly. This is preferable to clicking repeatedly. Clicking on the button between the arrows brings the trigger level arrow back to the center of the vertical axis.

The Delayed Timebase function is found under the “Trigger’ pull-down menu in V 1.2.0, which is the version we have available presently. I’m not sure that the Stingray you evaluated had this revision number. At any rate, the feature consists of a horizontal sliding scale that allows delay to be added in micro- or milliseconds, depending on the setting of the main timebase. It works as expected and the delays seem to correspond with the digital values shown in the feature. I realize that there isn’t a ‘soft knob’ for this feature, but one can open the window and slide it off to the border of the display where it’s ready to use if needed.

- Al MacRobbie

I work on the Stingray oscilloscope designed by USB-Instruments and just thought I should add a few comments to Jack's article.

The driver is indeed loaded twice during installation as the Stingray uses a dual USB interface IC (FT2232C). One USB channel is used to configure a FPGA and the other is used to communicate with the oscilloscope.

The external trigger is level sensitive rather than edge sensitive.

The cursor can measure both time and frequency. Clicking on the blue box surrounding the measurement value toggles between an interval and a frequency measurement.

- Kevan Johnston

As a software guy who has to rely on the hardware guys to hook up the oscilloscope or logic analyzer in the lab, I found this fascinating. This puts scopes into the realm of inexpensive cool toys to putter with at home. Now I can learn it on my own. After visiting the Parallax website, I ordered several sets from their Stamps In Class line. My 14-year-old son has been asking me to teach him programming, so this is an excellent way to introduce him to embedded systems. We now have a complete development and lab environment at home, along with enough sensors, emitters, servos, etc. to do real hands-on learning. Of course, my son wants to know when he can build a game system from scratch and write games for it. I haven't yet introduced him to the concept of man-year (or man-decade)! For me, this is a way to expand my competency on the hardware side.

- Steve Branam

I found the article on palm-sizd scopes helpful but would like to point out that it was George Bernard Shaw, not Winston Churchill, who said "England and America are two countries separated by a common language."

- Jim Grady

I just read your "microscope" evaluation and see that you fell for the same error that I did when I bought a dozen of them for our college labs. The vertical voltage is NOT plus/minus 20 volts. Instead, it is really plus/minus 10 volts (they say 20 volts peak-to-peak). Yes, this actually means that with their supplied probes they are worthless for seeing any signals above +10 volts. We expected to use them for viewing +12 to +15 volt analog signals and they just won't do it. I confirmed this with Parallax. The only way to use them above the +10 volt limit is to supply your own voltage divider probe. Unfortunately then all the measurement readings will be incorrect (unless you can remember to multiply them). This is not something that most student seem to remember. However, for the price they still are a great value. Hopefully, someday Parallax will modify their software to allow for higher readings (and supply the divider probes). The best part of then is that they are very intuitive to operate and most students can use them almost immediately with little training. . . . Thanks for the article. I wished that you had included the DSO 2102S by Link Instruments. It is much more difficult and less intuitive to use, but has the great high-performance features of a bench scope. We successfully use them for there the Parallax Optascope won't get the job done.

- Ron Hunt

These small scopes are pretty cool for the price. it makes me wonder why Tek, Lecroy and Agilent make us a 30000 dollar scope with a PC built in? Why don't they offer pod scopes like this with USB connections. After all what we are buying from them is the analog front end and they can design them better than anyone. The PC is generic, I guess these small companies dont have to worry about hurting an existing business for 30000 dollar scopes. We have bought several of these soft scopes which do allow use at higher voltages check it out:

http://www.softdsp.com/product/sds200a_01.htm

- Kevin Parmenter

Another good informing article by Jack. I didnt realize their were some many budget scopes out there now a days. When my high dollar Tektronix was starting to fail on me earlier this year I bought the 310U by Bitscope. Let me tell you I could never been happier with this product. Is it a Tektronix? No. But for the price I dont mind. For everyones info I bought mine from http://www.pc-oscilloscopes.com Very good product.

Paul Doserier

- Paul Doserier

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