By PETER SMITH

Review: BitScope BS310 mixed-signal oscilloscope

This versatile data acquisition system packs a digital oscilloscope, spectrum analyser, logic analyser, data recorder and waveform generator into one affordable package – and it's Australian-designed and supported!

PC-BASED TEST instruments are nothing new. By using the processing power and graphical interfacing capabilities of the PC, manufacturers have been able to dramatically improve the price/performance ratio of their test equipment.

The advantages of combining test equipment with the power of the PC are not lost on Australian company BitScope Design, who manufacture a small range of mixed-signal oscilloscopes and accessories. BitScope first appeared in 1998, when Australian design engineer Norman Jackson described his "Mixed Signal Capture Engine" in the pages of *Circuit Cellar*. He won first prize in a competition for his efforts.

Subsequently, BitScope went on to offer several designs as do-it-yourself kits. These proved to be very popular but have been recently discontinued, as several through-hole components used in the kits are no longer available. The current models all use surface-mount technology and are therefore sold preassembled and tested.

Despite the shift to preassembled units, the same core principles apply to all BitScope instruments. Their "open design" policy means that all units are supplied with circuit diagrams so that you can see how they work. In addition, detailed architectural information is provided on the BitScope website for those that wish to write their own virtual instrumentation applications.

BS310 captured

We test-drove BitScope's BS310U model. It's housed in a small, extruded aluminium case and features a dual-channel, 100MHz (40MS/s) analog and 8-channel logic data capture engine. Analog and logic data are sampled simultaneously and stored in local 128kS buffers prior to high-speed transfer to the PC via a USB (BS310U model) or Ethernet (BS310N model) connection.

An arbitrary waveform generator (AWG) adds significant versatility to the instrument's capabilities. The AWG can generate single, pulsed or continuous waveforms of up to 128kS at 10MS/s and can operate through BNC channel B. Importantly, it can function concurrently with the capture engine, thus allowing a circuit to be stimulated and its response observed in real time.

Processing and display of raw data from the BS310 is performed by BitScope's "DSO" software running on Windows or Linux. This combines a complete set of virtual instruments under a common user interface: a digital storage oscilloscope, spectrum analyser, logic analyser, data recorder and waveform generator.

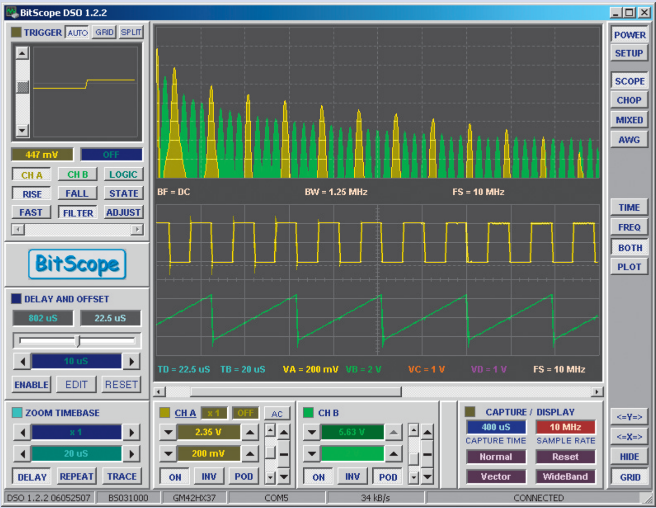


Fig.1: all virtual instruments run in a common graphical interface called "DSO", shown here with the oscilloscope and spectrum analyser enabled. Both analog channels are displayed, with channel B sourced from the pod input. Many parameters are alterable by clicking on left, right, up or down arrows. Some can also be modified by right-clicking on the parameter and choosing from a predefined list that pops up. Others simply allow you to enter a value directly.

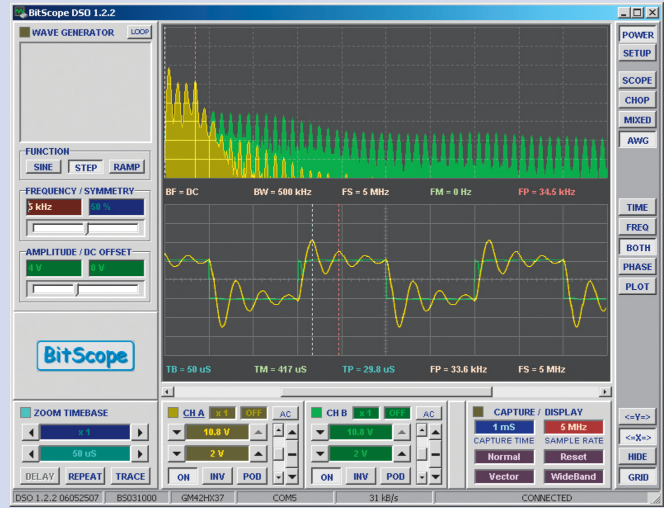


Fig.2: here we've running three instruments simultaneously – the waveform generator, oscilloscope and spectrum analyser. Channel B shows the generator's output, which is a 5kHz, 4V square wave. Channel A is measuring an LC tank circuit stimulated with the square wave. Using the cursors, we can see that the tank circuit oscillates at about 33.6kHz. Check out the BitScope website for a similar, more detailed example in the AWG section of the Online User Guide.

DSO's virtual instruments enjoy the benefits of the host's processing power and data storage. Additionally, the software automatically adjusts to accommodate the large, widescreen displays now common on many PCs. Simply put, you get to see a lot more of the signal at a time than would ever have been possible with a standalone instrument!

More on the box

Most of this review focuses on the software side of the package but before we get into that, let's look briefly at the front panel connectors and switches, the logic pods and some of the more notable hardware features not yet mentioned.

The two front-panel BNC inputs can be terminated with 1MΩ or 50Ω, selectable via miniature toggle switches. Signal coupling may be AC or DC and is software selectable. When needed, input sensitivity can be increased 10 or 50-fold by enabling an analog input multiplier, again under software control.

Also of note is the programmable triggering logic for both the analog and digital channels. Moreover, a cross-triggering function allows the digital trigger to operate from the analog (A/D converter) output, making this instrument extremely useful for mixed-signal work – a normal requirement in today's electronics.

A 25-pin "D" connector on the front panel gives access to all eight of the digital logic inputs and provides two alternate analog inputs as well. For low-speed work, this connector can be wired directly to the logic circuits under test. However, in most cases, one of BitScope's optional logic pods is required to interface the test signals to the BS310's inputs.

The basic pod consists of a small circuit board that carries a HCMOS buffer chip and a few passive components and is +5V and +3.3V TTL/CMOS logic compatible. 26-way header plugs mount on opposite edges of the board. One plug connects to the front-panel "D" connector via a short length of ribbon cable, while individual "E-Z hook" style leads are pushed onto the desired signal input and ground pins on the other plug for connection to the circuits under test.

Power supply and serial I/O lines are provided on the "D" connector for those wanting to design a custom "smart" pod for specialised applications. In fact, BitScope offer the "ProtoBoard" for just such a purpose. This board plugs directly into the "D" connector and offers a convenient, low-cost platform for 18-pin PIC development.

DSO software

As mentioned, all of the DSO's virtual instruments run under one common user interface. Individual instruments are enabled via a row of selection buttons on the right side of the DSO window.

In some cases, more than one instrument can be active at a time. For example, either the spectrum analyser or logic analyser can operate concurrently with the oscilloscope. In these cases, the waveform display area is automatically divided in half to accommodate both instruments.

Once the desired settings have been made, most of the controls can be hidden to maximise the waveform display area, if desired.

OK, lets' look briefly at each of the major components of the software, starting with the oscilloscope.

Digital storage oscilloscope

The oscilloscope display is laid out on an 8x10 grid. The horizontal and vertical scales are not displayed against the X and Y-axes but instead are determined from a list of "information variables" that appear immediately below the graticule.

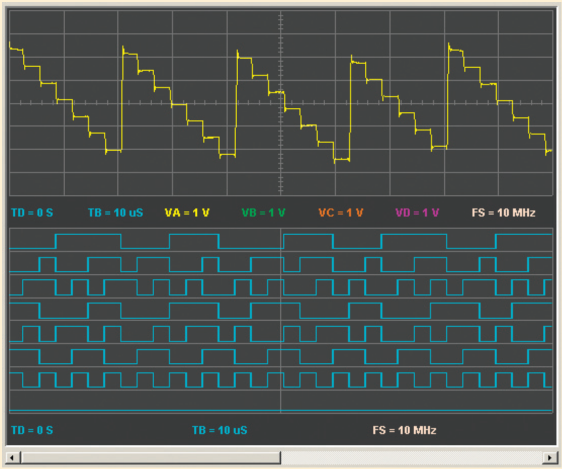


Fig.3: in mixed signal mode, one analog channel and all eight digital channels are displayed in a time-aligned fashion. With the aid of the cursors, it's easy to relate events between the domains.

Vertical settings range from 500µV to 5V in familiar 1-2-5 steps. This is separate from the analog input range, which can be set to 513mV, 2.35V, 4.7V or 10.8V with the multiplier off. With the multiplier set to x50, the selections shrink to 10.3mV, 47mV, 94.1mV or 216mV.

Naturally, the idea is to set the input range to maximise resolution, taking into account the amplitude of the input signal. The latest version of DSO does this automatically, although the settings can still be altered independently if desired.

The vertical settings also cater for probe type (x1, x10, x100 of x1000), input signal multiplier (OFF, x10 or x50) and coupling (AC or DC). The signal can be sourced from the pod rather than the BNC input by clicking on the "POD" button and can be inverted by clicking on "INV".

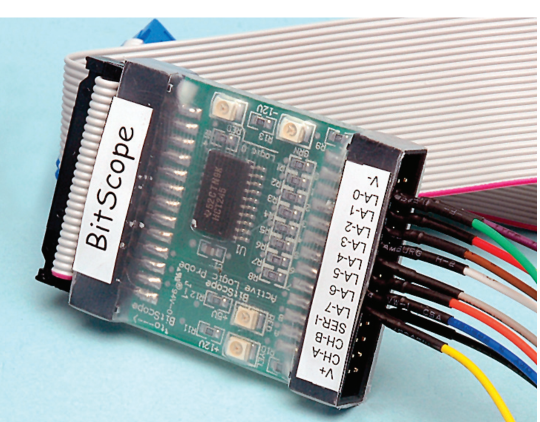
Dragging a slider or clicking on "up" and "down" arrows alters trace position. The BitScope engineers have obviously put some thought into these controls, because despite their small size they're quite easy to use.

The horizontal timebase is straightforward, with settings ranging from 10ns to 500ms, again in 1-2-5 format. DSO automatically dials in the appropriate sample rate each time the timebase is altered.

A "zoom" setting directly above the main timebase slider allows horizontal zooming of up to 50 times. Panning through the display buffer to find the section of interest can then be achieved by dragging the waveform offset slider just below the graticule.

DSO includes a second, delayed (or "zoom") timebase that is indispensable when you want to examine a small section of a repetitive waveform in detail. A shuttle control eliminates the need to fiddle with manual parameters when trying to find the segment of interest, which is highlighted in the main timebase display by a grey band. Once the area of interest is identified, a click on the "ENABLE" button brings the segment into full view. Slick indeed!

Analog triggering is fully featured and can be set to rising or falling edge. It can also be filtered and can have a hold-off period programmable from 3µs to 150µs. In addition, a pre-trigger feature allows the position of the trigger in the captured data to be selected from 0%, 25%, 50%, 75% and 100% of the buffer.



BitScope's basic logic pod consists of a small circuit board that carries a HCMOS buffer chip and a few passive components and is +5V and +3.3V TTL/CMOS logic compatible.

Spectrum analyser

In keeping with the ease-of-use mantra, DSO features a fully automatic spectrum analyser (FFT). For the mathematically clued, it utilises a variable size windowed DFT processing engine suitable for both one-shot and periodic waveforms and is capable of displaying spectra from DC to over 100MHz.

The time and frequency displays share the same data source and therefore the same timebase and trigger. This means that the spectrum analyser instrument can operate simultaneously with the oscilloscope, if desired. Clicking the "BOTH" selection button splits the display in half, with the top half showing the spectra and the bottom half the oscilloscope.

Measurements within the time and frequency domains can be made with the aid of "X" and "Y" cursor pairs, which are simply enabled with a mouse click and then dragged to the desired points of interest on the waveform. Values such as period, pulse width, slew rate, frequency and bandwidth are all readily determined.

Logic analyser

The logic analyser operates in what is known as "mixed" mode. The top half of the waveform display area shows oscilloscope inputs A or B (only one analog channel can be used in this mode) and the bottom half the eight analyser traces. However, it's also possible to enable only the logic analyser (or oscilloscope) portion of the display for easier interpretation.

This instrument operates synchronously with the oscilloscope and so shares the same timebase settings. Triggering can be on any logic state, with each bit definable as high, low or "don't care". Crucially, the trigger can also come from one of the analog channels, providing the cross-triggering function we mentioned earlier.

The BitScope literature makes a big deal out of the product's mixed analog and digital logic display and cross-triggering capabilities – and with good reason! Just about all electronics these days incorporates both domains, so the ability to see them working together is indispensable.

Waveform generator

This instrument operates much like a conventional signal generator, supporting sine, step and ramp functions. Frequency, symmetry, amplitude (up to 10V) and offset are all fully programmable.

Using a front-panel toggle switch,

the AWG output can be directed to the channel B input, so there's no need to probe the circuit to see the waveform. The second analog channel is free to measure circuit response.

The above holds true when the AWG is set to produce repeating one-shot waveforms. However, when set to produce continuous waveforms like a dedicated AWG, no other virtual instrument can be used at the same time.

Data recorder

Analog and logic waveforms can be recorded to disk using the DSO Data Recorder (DDR) instrument. Data is saved in "CSV" file format, so is compatible with all popular analysis tools such as MatLab and Excel.

This handy feature allows records to be instantly replayed for comparison with newly captured data. A brand new function in DSO even allows the waveform data to be loaded when no BitScope hardware is connected. So yes, you can now take your work home with you!

Look & feel

Virtual instrument designers must be tempted to pack in every conceivable feature to make their products more appealing. After all, one of the big advantages of a software-based interface must be that it doesn't cost near as much to add a function as it would in a hardware-dominated product.

But would such a feature-laden beast really be usable? Probably not! And this is what we liked most about this system. Everything that you want is right there in front of you – there's no need to go fishing through the menus (or God forbid, the manuals) to get the job done.

Waveforms can be displayed in "raw", "wideband" or "enhanced" formats and can even be given phosphor-like qualities of persistence for viewing eye patterns, spectral plots and the like. In fact, DSO's waveform rendering and signal processing produces an image on screen that's not unlike a conventional analog scope and must be one of the best we've seen.

Check it out

As with any test system of this nature, it's difficult to get a feel for the product unless you actually have it in your hands. BitScope have tried to make evaluation easier by connecting a BitScope to the Internet, where anyone can get access to it.

To get connected, first download and install the latest version of DSO from **www.bitscope.com**. Next, launch the software and click on the "SETUP" button. On the "Setup" tab, select a connection type of "ETHERNET" and an IP address of "SYDNEY".

It's then just a matter of hitting the "POWER" button to make the connection to the BS300N model at BitScope's Sydney office. Watch out though – someone else might be fiddling with the controls, too!

Note: your firewall rules must allow UDP connections on port 16,385 ($4001) for BitScope communication over the Internet.

BitScope BS310 Specifications Summary

Analog Inputs	2 x BNC or 2 x POD
Analog Bandwidth	100MHz (see product specifications for details)
Input Impedance	1MΩ‖20pF (BNC), 100kΩ‖5pF (POD)
Input Voltage Range	±513mV to ±10.8V & ±5.13V to ±108V (x10 probe)
Input Multiplier Gain	x10 and x50 (user selectable)
Analog Sensitivity	2mV - 40mV (x1)
Maximum Sensitivity	300µV (time), 70µV (frequency) & 10µV (mean)
Fast Sample Rates	4, 5, 10, 13.5, 20, 25, 33 & 40MS/s
Slow Sample Rates	4kHz – 1MHz (slow) and < 1Hz (burst)
Channel Buffer Depth	128kS (analog) + 128kS (logic)
Glitch Capture	25ns
BitScope Digital Trigger	8-bit combinatorial on logic or A/D output
High Speed Analog Trigger	Yes
Waveform Generator	10MS/s (switchable through BNC channel B)
Data upload speed	1.2Mb/s (max)
PC Host Interface	USB 2.0 (also USB 1.1 compatible) or 10BaseT Ethernet
Size	150 x 55 x 100mm (W x H x D)

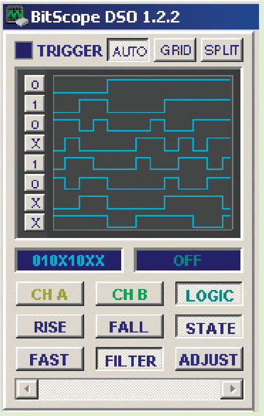


Fig.4: triggering in mixed signal mode can original from an analog channel or the logic channels. For logic triggering, the state of each bit determines the trigger – in this case, 010X10XX (X= don't care if high or low).

Final thoughts

Unfortunately, we can't hope to cover every feature of DSO or indeed the BS310U in this short review. Although it's already a mature product, BitScope continue to develop their DSO software, as can be seen with the addition of their "Waveform Intuitive Display Engine" (WIDE) in the latest release. We'll leave it up to you to discover exactly what WIDE can do!

At time of publication, the BS310U was priced at $650.12 plus GST and delivery. Scope probes and logic pods are not included in the price but can be ordered separately. Other models, including a larger quad-channel version, are also available.

Check out **www.bitscope.com** for all the details or phone (02) 9436 2955. If you live in Sydney, you can drop into their office at G03/28 Chandos St, St. Leonards. **SC**