

# Putting the Mac In-touch with the Physical World

## Making a Mac into a Digital Oscilloscope

*This article is directed to the more technically-inclined reader; however, others may be interested to learn something about how a Mac computer can be converted into a sophisticated electronic measuring and analysis instrument.*

**A**n oscilloscope is an instrument enabling the user to observe and/or measure parameters of a rapidly varying voltage. Early uses were for performance analysis or fault finding in electrical and electronic equipment, including radio, television, audio amplifiers and the like, and later for assisting with the development of digital electronic circuitry. At its most basic level, an oscilloscope enables the user to observe the magnitude of an input voltage relative to time. Where the voltage varies cyclically with time, an oscilloscope can show the shape of the variation of one or more cycles – the ‘waveform’ – as a steady display. As a great many physical variables can be converted to a corresponding variable voltage by means of a suitable transducer, e.g. pressure, acceleration (for vibration assessment), displacement, etc, an oscilloscope can fulfill many applications where it is desired to understand how these variables behave in the time domain.

Traditionally, oscilloscopes, like other earlier electronic devices, were analog instruments using vacuum tube (valve) and later transistor circuitry with the display device in the form of a conventional cathode ray tube screen. This led to the instruments being commonly referred to as a ‘CRO’, shorthand for ‘cathode ray oscilloscope’. Quality instruments required difficult-to-achieve stable analog electronic circuitry and attracted a price to match. Digital techniques have circumvented many of the earlier stability and other costly functionality issues for an oscilloscope. They function by rapidly sampling the input voltage signal. As well as dedicated digital instruments, a desk or laptop computer can now double as a quite sophisticated oscilloscope when used in conjunction with a hardware interface and suitable application software.

Digital oscilloscope ‘makeovers’ consisting of a small hardware package and accompanying application software have been available to the enthusiast in the PC world for quite a while, both by mail order and from retail electronics shops. Early last year I went looking for a Macintosh friendly digital oscilloscope package. Here the field was predictably thin, but from an Internet search I discovered a Canadian supplier, Syscomp Electronic Design, offering products suitable for use on a Macintosh platform. After some initial email enquiry, I duly purchased their DSO-101 dual-trace digital storage oscilloscope for US\$186, including p & p (April '09). Figure 1 shows the USB powered hardware device with its two signal (voltage) input ports (standard type BNC connectors) and the CD containing the application software.



Figure 1 DSO-101 hardware and application software

The Syscomp digital oscilloscope software has been written in Linux/Unix code, the same programming language ‘under the hood’ of OSX and was thus, in-principle, Mac compatible. I found out however that I became a Beta tester in respect to the Installation Instructions for implementing the oscilloscope application on a Mac. Over the course of about a week, emails went back and forward between myself and Syscomp in Toronto until the hitches were ironed out and I had it working. During this process, Syscomp were very helpful and supportive and their Macintosh installation instructions for the DSO-101 were subsequently revised to make it easier for later users. Although perhaps a tad annoying that for me it wasn’t an immediate ‘plug and play’ experience, I learnt in the process a few things about Unix code whilst carrying out the installation in the Terminal Mode on my Mac. Once the application is running, the screen display functions like other Mac applications, with clickable controls and pull-down menus.

*(I understand that for Syscomp’s more recent ‘CircuitGear’ product, a disk image (.dmg file) has been created to make the application software a one-button install procedure on a Mac).*

Figure 2 shows the base digital oscilloscope screen with two sine-wave voltages of different frequency – produced from kit built signal generators – on the ‘A’ and ‘B’ channels displayed against time as set by the right-hand Timebase Control. Superimposed in the middle is a simultaneous plot of the two voltages against each other (XY plot). In this case, as the frequency of the channel ‘B’ voltage has been adjusted to three times that of the channel ‘A’ voltage, the XY plot appears as the Lissajous figure familiar to TV viewers as the ABC’s logo.

*(In the early days of oscilloscopes Lissajous figures were used to determine the frequency of an unknown signal relative to a known adjustable frequency signal with the multiplication factor indicated by counting the number of nodes on the looping Lissajous figure).*

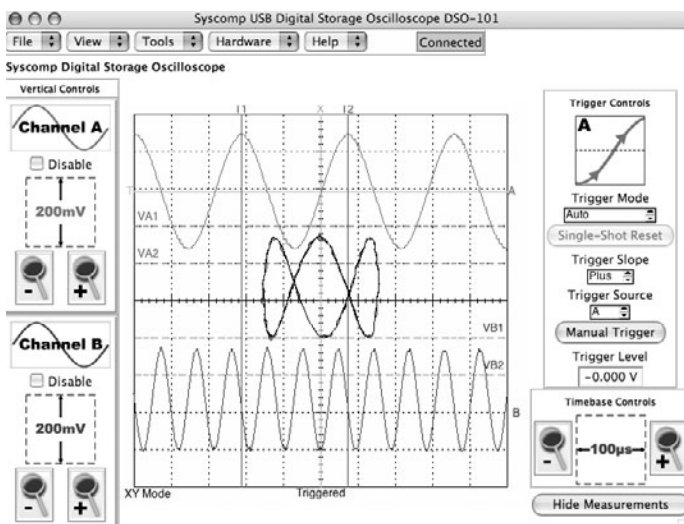


Figure 2 Oscilloscope with two sine wave inputs plus XY plot

Figure 3 shows the digital oscilloscope used to demonstrate amplitude modulation where the amplitude of the higher frequency voltage signal on 'A' channel is being altered or 'modulated' by the lower frequency signal on the 'B' channel. This is the method of transmission for AM radio, where the amplitude of the radio frequency signal or 'carrier' is modulated by the much lower frequency audio signal for purposes of transmission.

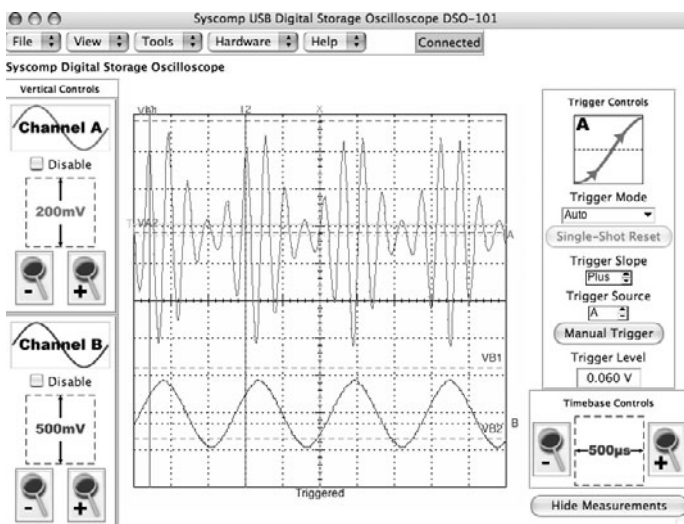


Figure 3 Oscilloscope displaying amplitude modulation

Figure 4 shows the digital oscilloscope being used to observe the AC current waveform of a compact fluorescent lamp. (The current measurement in this case has been represented by the voltage-drop across a small resistance in series with the lamp). It can be clearly seen that the power electronics circuitry in the compact fluorescent lamp results in the AC current waveform being well removed from the sine-wave shape of the supply voltage. By using the Frequency Analysis facility included under the 'Tools' menu, the relative magnitudes of the harmonic current components (integer multiples of the fundamental frequency) can be measured.

*(Harmonic currents from power-electronics devices, including computer power supplies, are feed back into the electricity supply network and can cause overheating or other problems – a form of 'network pollution').*

Importantly for this kind of investigation on a mains operated device, the device – the lamp in this case – MUST be supplied through an isolating transformer.

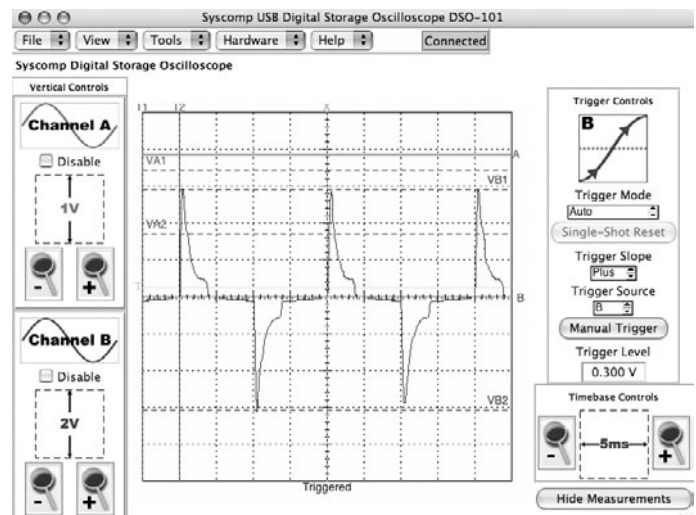


Figure 4 Oscilloscope displaying compact fluorescent lamp current waveform

A 'Measurements' sub-window is also available which tabulates, frequency and voltage values for the A and B input signals, and for the computed and displayed 'Math' tool function ( $A + B$ ;  $A - B$  or  $A \times B$ ). Figure 5 shows the oscilloscope displaying two 5 kHz AC voltage signals 'A' and 'B' and between them, the derived  $A \times B$  periodic function which varies at twice the individual input signal frequency. The 'Measurements' window has been called up and overlays the right-hand side of the oscilloscope window. Amongst other information this shows the frequency of the two input signals (5kHz) and the double frequency (10kHz) of the product.

*If one channel represented the voltage across a circuit element and the other channel represented the current flowing through it, then the  $A \times B$  function depicts the instantaneous power. (The elliptical XY Lissajous figure also displayed on the screen, confirms that the two input voltage signals are of the same frequency).*

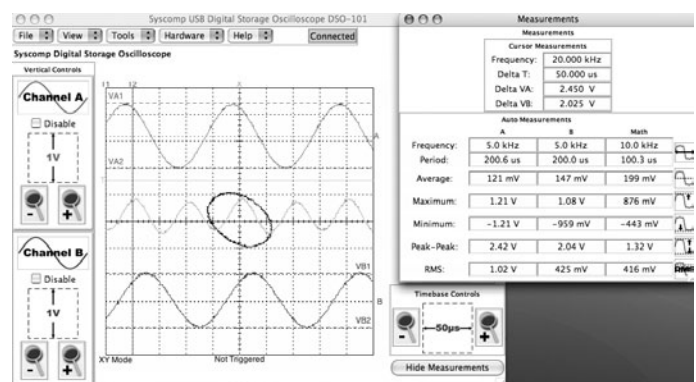


Figure 5 Oscilloscope window and "Measurements" sub-window

The DSO-101 package that I purchased last year was an alternative to Syscomp's somewhat dearer 'CircuitGear' model which as well as being a dual channel digital oscilloscope, it incorporates a controllable waveform generator. It is now their flagship oscilloscope product. The application software is nominated as being suitable for Mac OS X 10.4 or higher, PowerPC or x86. (I have been running the DSO-101 on an iBook G4 with OS 10.4.11).

The performance specifications for the Syscomp digital oscilloscopes are impressive with a peak sampling rate of 20M samples/sec and a bandwidth of 2MHz; an accurate adjustable time-base and input scaling facilities; an ability to store sampled data and later export it for separate processing, and a range of ancillary 'Tools' functions. Not that many years ago, this kind of instrument in its less capable analog guise would have been in the \$1000+ price range.

Whilst the above examples are included to give some indication of practical use of the digital oscilloscope, the applications are many and varied and can include such areas as mechanical vibration analysis (using an accelerometer to produce a voltage analog); checking sound amplifier performance (e.g. distortion measurement, etc.); testing of power electronics devices and as an education or instruction aid.

This article has been written without any affiliation with or remuneration from Syscomp Electronic Design and is intended simply to illustrate another way in which a Macintosh can be configured to provide a useful, albeit technically oriented, tool. For those readers wanting to delve further, the Syscomp Electronic Design web site URL is: <http://www.syscompdesign.com/>

*(Other suppliers may now be able to offer similar priced Mac friendly digital oscilloscope packages, however this author has no knowledge or experience of them or their products).*

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