cleverscope

plug & play instruments
oscilloscopes

MANUAL

Oscilloscope

Model CS328

Application CS300 Features

- Separate, freely moveable and resizable windows to display the signal, a zoomed signal view, and the frequency spectrum of the signal, and control panel.
- The zoomed signal view optionally tracks the signal view cursor.
- Spectrum analysis with a variety of conditioning windows and display in log or linear format.
- Each signal window includes a time/amplitude tracer, and two markers for comparison purposes. Colours are user definable.
- Signal averaging (exponential, block and peak hold) and low pass filtering.
- Signal measurement, including Peak to Peak, RMS, DC, pulse width, period and frequency.
- Copy and Paste graphic or data to other applications.
- Save and Open from disk.
- User defined units, signal names and scaling (offset and gain).
- Text annotation of each graph.
- Web server for remote viewing of LAN connected unit.

www.cleverscope.com

Table of Contents

Document Control

Document Version	Date	Cleverscope Version	Description of Changes	Author
1.0	27/8/04	V 2.2	First Draft	ATG
1.1	7 /9/04	V3.1	Small additions	BES
1.2	11/3/05	V3.2	Removed registration description	BES
2.1	12/08/05	V3.418	Basic reformat Add Sig Gen & Digital Inputs Add Maths Equation Builder Update all pictures	IJH

Overview

The **Cleverscope CS328** is a USB connected PC based mixed signal oscilloscope, spectrum analyser, and signal generator which brings benefits to the user that are unavailable from traditional stand-alone oscilloscopes. This innovative approach delivers an unbeatable combination of affordability, ease of use and documentation of test results with the simple "Copy" and "Paste" facility. Graphs and data can be copied and pasted to other applications, saved or loaded from disk, and printed.

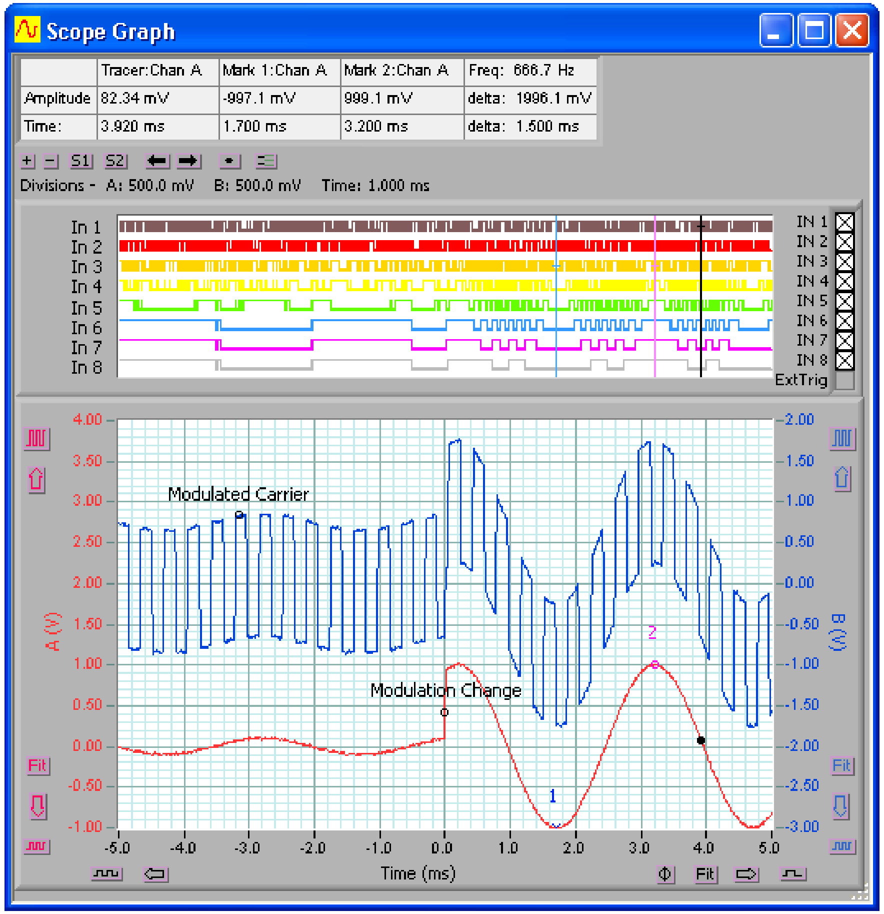
Cleverscope hardware resources include:

- Two 10 bit analog channels sampling simultaneously at 100 MSa/s. AC or DC coupled.
- Scaling and offsetting to view 50mV full scale offset to any value between –8 and +8 V.
  - Gain automatically set from 20mV full scale to 800V full scale by choosing graph view and probe switch setting.
  - Offset automatically set from 0 to ±4 or 40V in 10/100 mV increments by choosing graph view. As an example 20 mV signals may be viewed superimposed on a 3V DC level.
- Analog triggering of the waveform in view with a resolution of 1% of the display height. The analog trigger may optionally be conditioned with a low pass, high pass or noise filter.
- One external trigger, threshold adjustable from 0 to ±20V in 40 mV increments.
- Eight digital inputs sampling at 100 MSa/s, threshold adjustable from 0 to 8 V in 10 mV increments.
- A hardware trigger system based on a rising or falling edge on any input signal, optionally qualified by a user determined digital input combination and a minimum or maximum trigger duration.
- A rear panel I/O connector with a 100 Mbit/s bi-directional LVDS/RS422 link, and three RS422 outputs defaulting to sampling started, trigger received and sampling stopped.
- Each channel (two analog, trigger and 8 digital) includes 4M samples of storage, providing up to 40 ms of simultaneous storage for all channels, with 10 ns resolution.
  - The sample storage may be allocated as between 2 to 1000 frames varying in size from 2M to 4000 samples. These may be used as a history store for reviewing previously captured signals, or to capture up to 1000 trigger events with a minimal 2 μs inter-frame delay, while maintaining time relative to the first trigger for all succeeding frames.
- 25 MHz 5th order Anti-alias filter for improved Spectrum Analysis performance.
- Triggered LED and Power LED on the front panel.
- Input power range from 6 ~ 12V, 5W provided by a universal mains adaptor.
- Low jitter (1 ps rms) sampling clock for 70 dB spurious free dynamic range.
- Self calibration to ensure DC performance specifications is met.
- An optional plug-in signal generator, 0-10MHz, sine, square or triangle.
- Enclosure size: 153 x 195 x 35 mm.

Cleverscope software resources include:

- Separate, freely moveable and resizable windows to display the signal, a zoomed signal view, and the frequency spectrum of the signal, and control panel.
  - The zoomed signal view optionally tracks the signal view cursor.
- Spectrum analysis with a variety of conditioning windows and display in log or linear format.
- Each signal window includes a time/amplitude tracer, and two markers for comparison purposes. Colours are user definable.
- Signal averaging (exponential, block and peak hold) and low pass filtering.
- Full mathematical functions including + - / * sqrt integral differential and filtering.
- Signal measurement, including Peak to Peak, RMS, DC, pulse width, period and frequency.
- Copy and Paste graphic or data to other applications.
- Save and Open from disk.
- User defined units, signal names and scaling (offset and gain).
- Text annotation of each graph.
- Web server for remote viewing of LAN connected unit.

An example of a typical mixed signal window is shown below:



5 Minute Walkthrough

This 5 minute walkthrough is in two parts:

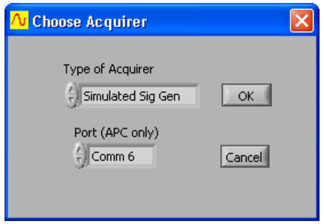
- The first familiarizes you with the software application using a built-in signal generator.
- The second part uses the Cleverscope Acquisition Unit to acquire a signal and compensate your oscilloscope probes.

Once you have familiarized yourself with the software, you can switch to using the Cleverscope Acquisition Unit, and compensate your probes, and get on looking at real world signals.

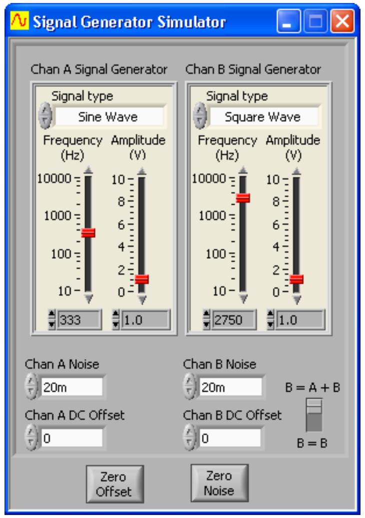
Cleverscope Application Walkthrough

Setup the Signal Generator

Go to the **Cleverscope Control Panel** window.



1. On the **Settings** menu, click **Choose Acquirer**.
2. In the **Type of Acquire** box, click **Simulated Sig Gen**.
3. Click **OK**.
4. On the **View** menu, click **Display Sig Gen Simulator**.



The **Signal Generator Simulator** window controls Cleverscope's internal signal generator. This provides built-in software generated signals for both the A and B channels that can be used to demonstrate the capabilities of the Cleverscope application software without requiring a Cleverscope hardware unit.

In the **Signal Type** box, select **Sine Wave**, **Triangle Wave**, **Square Wave** or **Sawtooth Wave**.

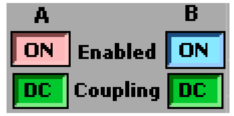
To alter the **Frequency** and **Amplitude**, drag the red sliders.

You can also add background noise and a DC offset to the generated signals to make them more closely approximate real-world signals.

Selecting **B = A + B** causes the sum of the channel A and B signals to be directed to channel B for display.

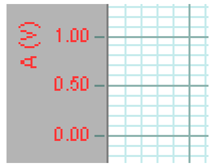
Acquire a Signal for Display

Go to the **Cleverscope Control Panel** window.



1. Enable both channel A and B by clicking on the enable buttons so that they both display ON.
2. In the **TRIGGER** area, use the **Source** box to click **Chan A** as the trigger source.
3. On the special cursor toolbar ( ), click on the rising edge trigger cursor button ( ).

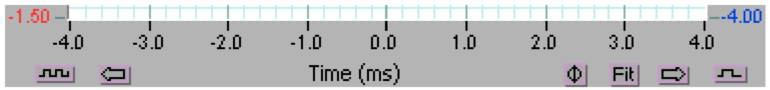
Select the **Scope Graph** by either clicking on it or selecting it from the **Window** menu.



1. Use the up ( ) and down ( ) vertical display buttons and the vertical expand ( ) and contract ( ) buttons for channel A to select 0.50 volts per major horizontal gridline and to ensure that the horizontal gridlines for 1.00 V and 0.00 V are clearly in view within the **Scope Graph** window.
2. Position and click the trigger cursor so that trigger amplitude is between 0.5 and 1.0 V and time is around 2 ms.

Go to the **Cleverscope Control Panel** window.

1. In the **AQUIRE** area, click the Single button to acquire a single frame of signal data. The **Scope Graph** will then display the acquired signal.
2. The auto-fit buttons (Fit and Fit) for channel A and B can be used to bring the signal traces into view. Cleverscope will apply the optimum vertical scaling and positioning for signal data.
3. For the vertical scale, the positioning and scaling of the signal trace with respect to time can be altered using the horizontal display buttons.



Note The trigger point is always positioned at time zero on the horizontal axis.

The Tracer and Markers

Having captured and displayed a signal, the signal data can now be analysed in a number of different ways.

Go to the **Cleverscope Control Panel** window.

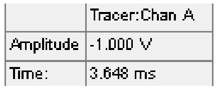
1. In the **DISPLAY** area, click the tracer button (), so that Channel A is selected.

2. Click the **Pan** special cursor ().

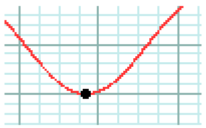
Select the **Scope Graph** window.

1. Move the **Pan** cursor over the scope display.

   Note When you move the **Pan** cursor a little black dot (called the tracer) moves along the channel A. The position of the tracer with respect to level and time is displayed in the **Information** area at the top of the **Scope Graph**.

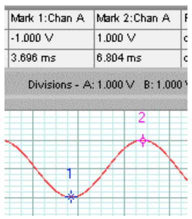


2. Double-click with the tracer position at the bottom of the signal trough.

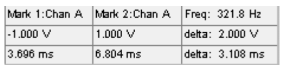


3. Double-click with the tracer positioned at the top of the signal crest.

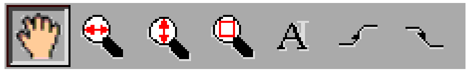
   You will have created two markers, **1** and **2**. The position of these markers with respect to level and time is displayed in the **Information** area at the top of the **Scope Graph**. Up to two markers can be positioned and they will always maintain their horizontal positions on the signal trace.



   Also displayed in the **Information** area is Cleverscope's best calculation, (assuming a repetitive waveform), of the frequency of the signal data of the selected channel, and the level and time differences (**delta:**) between marker **1** and marker **2**.

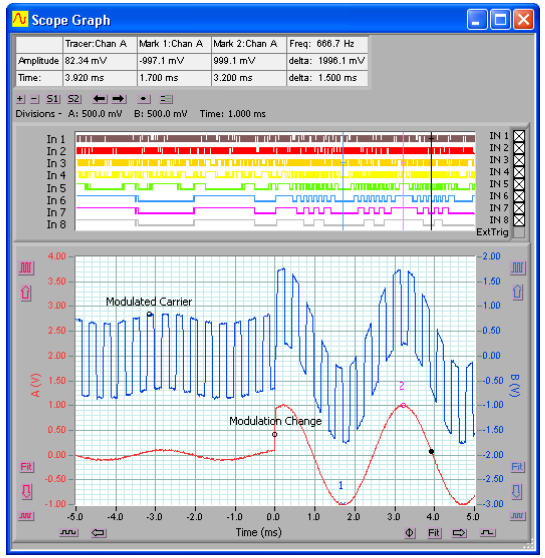


In addition to the **Trigger** () and **Pan** cursor () (for grabbing and moving a graph display) other special cursors include **Horizontal Zoom**, **Vertical Zoom**, **Area Zoom** and an **Annotation** cursor for annotating graphs.



Digital Inputs

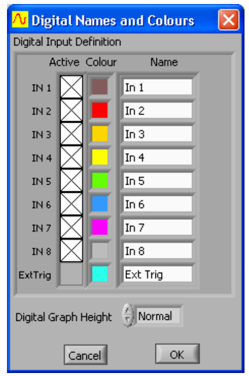
There are **8 digital inputs** available. In this section, the signals will be provided by the built-in signal generator.



Go to the **Cleverscope Control Panel** window.

1. If the **Digital Graph** on the **Scope Graph** window is not already shown, then on the **View** menu, click **Display Digital Graph**.

2. To control the names and colours of the **Digital Graph**, on the **Settings** menu, click **Digital Names and Colours**.



3. To change which digital signals are displayed, click the **Active** check boxes.

4. To change the colour of the digital signals, click the **Colour** boxes and select a colour.

5. To change the name of the digital signals, click and type in the **Name** fields.

6. To change the height of the **Digital Graph**, in the **Digital Graph Height** box, select either **Normal** or **Large**.

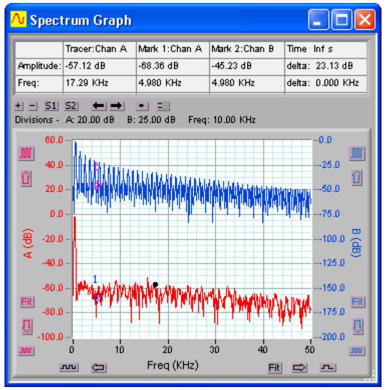
7. Click **OK**.

Select the **Scope Graph** window.

You can also change which digital signals are displayed by clicking the check boxes to the right of the **Digital Graph**.

Note The tracer and marker cursors have linked vertical cursors in the **Digital Graph**.

Spectrum Graph



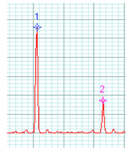
The **Spectrum Graph** displays the Fourier transform of the channel A and channel B signal data.

Go to the **Cleverscope Control Panel** window.

On the **View** menu, click **Display Spectrum Graph**.

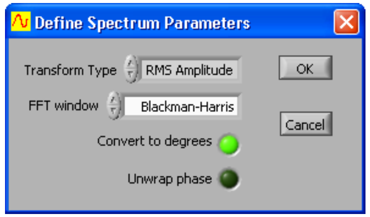
Select the **Spectrum Graph** window.

If necessary use the Fit buttons (, , and) to position the displays. You will now be able to see the spectrum of Channel A and B.



Note The tracer, markers and display controls work as they do in the **Scope Graph**.

Go to the **Cleverscope Control Panel** window.

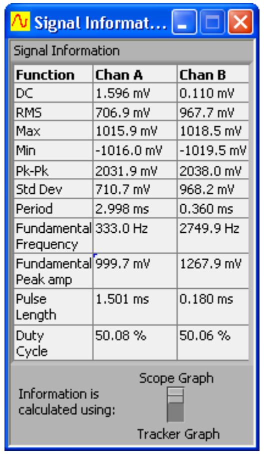


On the **Settings** menu, click **Spectrum** to select the type of Fourier Transform and windowing technique.

Note Gain/Phase plots can be selected as a **Transform Type** to display a plot of gain versus phase for a system under test.

Signal Information

Information about Channel A and B signal data is displayed in the **Signal Information** window.



Function	Chan A	Chan B
DC	1.596 mV	0.110 mV
RMS	706.9 mV	967.7 mV
Max	1015.9 mV	1018.5 mV
Min	-1016.0 mV	-1019.5 mV
Pk-Pk	2031.9 mV	2038.0 mV
Std Dev	710.7 mV	968.2 mV
Period	2.998 ms	0.360 ms
Fundamental Frequency	333.0 Hz	2749.9 Hz
Fundamental Peak amp	999.7 mV	1267.9 mV
Pulse Length	1.501 ms	0.180 ms
Duty Cycle	50.08 %	50.06 %

Go to the **Cleverscope Control Panel** window.

On the **View** menu, click **Display Signal Info**.

Select the **Signal Information** window.

The results of a number of mathematical functions are displayed in a table. Depending on the position of the switch located at the bottom of the dialog box, the functions are either calculated using the **Scope Graph** signal or the **Tracking Graph** signal.

Other Features

A number of other features are available through the **Cleverscope Control Panel** menus.

The **File** menu lets you save signal and graph data, open saved data for display and analysis, print graphs and exit the application.

The **Edit** menu lets you copy an image of the last selected graph or **Information** window to the clip board where it can be pasted into a document.

The **Settings** menu contains all the options and preferences related to the acquiring and the analysis of signal data. The **Settings** menu includes **Analog Names and Units** which allow you to use units other than volts or dBs when displaying signal data.

Averaging can be used with the **Spectrum Graph**, **Scope Graph** or **Tracking Graph**. A number of frames can be arithmetically averaged together to reduce the effect of noise. Equal, exponential and peak averaging can be used to minimize the effects of noise, or to find the average value of a signal in the presence of noise.

You can choose different **Colours** for displaying graphs.

The **View** menu controls which windows are visible.

The **Window** menu lets you select an open window and bring to the front.

Digital triggering can be used in addition to analogue triggering to capture an event associated with a digital pattern.

The Cleverscope acquisition unit is also able to hold a number of sequential frames so that a history of older frames can be recalled.

Keyboard Shortcuts

Movement:

← and → move the cursor left and right
Shift + ← and → move the graph left and right
Ctrl + ← and → change the x-scale up or down

↑ and ↓ move the selected graph up and down
Shift + ↑ and ↓ move the selected graph up and down
Ctrl + ↑ and ↓ change the y-scale up and down

Markers:

1 and **2** set markers one and two
Spacebar sets the next marker

Graph Viewing:

Tab swaps channels
A autoscales the graphs
PageDown zooms in on the tracer
PageUp zooms out on the tracer

Control:

C or **Ctrl** + **C** copies the graph to the clipboard
X or **Ctrl** + **X** clears the graph
P or **Ctrl** + **P** prints the graph
F1 chooses the Pan/Tracer cursor
F2 chooses the Annotation cursor
F3 chooses the Rising Trigger cursor
F4 chooses the Falling Trigger cursor

Sampling:

F7 initiates a single acquisition
F8 initiates automatic acquisition
F9 initiates triggered acquisition

Cleverscope Acquisition Unit Walkthrough

Cleverscope Acquisition Unit

The CS328 or CS320 Cleverscope Acquisition Unit (CAU) is used to acquire signals using the front panel connectors, and transfer the signals (in digital form) to a PC using the USB standard interface connected to the rear panel of the unit.

Figure 1: CAU Front Panel

Inputs are:

Input	Description
CH A	Channel A analog input. Samples at 100 MSa/s 10 bit resolution. BNC standard 1M ohm input.
CH B	Channel B analog input. Samples at 100 MSa/s 10 bit resolution. BNC standard 1M ohm input.
Ext Trig	External trigger input. Set the threshold using the Options/Acquisition Details menu item. BNC standard 1M ohm input.
In 1-4	Digital Inputs 1-4. Sample at 100 MSa/s. Set the threshold using the Options/Acquisition Details menu item.
In 5-8	Digital Inputs 5-8. Sample at 100 MSa/s. Set the threshold using the Options/Acquisition Details menu item.

In addition two indicators and two connectors are provided:

Indicator	Description
Power	Indicates that power is on, and the internal self test has passed.
Trigger	Indicates that a Trigger Event has occurred

Connector	Description
PROBE COMP	Probe compensation output signal (squarewave, 1kHz, 3V pk-pk).
Ground	Signal ground.

Figure 2: CAU Rear Panel

Rear panel connectors are:

Input	Description
USB	Provides the connection to the PC. A standard Type B connector is used.
LINK DIG I/O	Provides a 100 Mbit/s bi-directional LVDS/RS422 link, and three RS422 outputs defaulting to sampling started, trigger received and sampling stopped. Maybe used as a rear input trigger, or as a high speed connection to an extension CS328 used to provide channel expansion.
Sig Gen	Optional. Signal generator output, 0-10MHz, sine, square or triangle.
Power	DC power. Uses a standard 2.5 mm short barrel DC connection. The centre pin is positive. The power supply range is 6-13V DC. Power consumption is 4W (450 mA at 9V).

Connect the Acquirer

1. Connect the DC power cable, and plug the power adaptor into the mains. Observe the green power light.
2. Connect the USB cable to the PC.

   If this is the first time, place the CD in the CD drive, and allow windows to find the drivers. This may take some time. Accept the non-digitally signed driver. When Windows tells you the hardware is installed, you are ready to proceed.

Choose Acquirer

Go to the **Cleverscope Control Panel** window.

1. On the **Settings** menu, click **Choose Acquirer** to use the CAU.
2. In the **Type of Acquirer** box, click **Cleverscope**.

Acquire the Compensation Signal

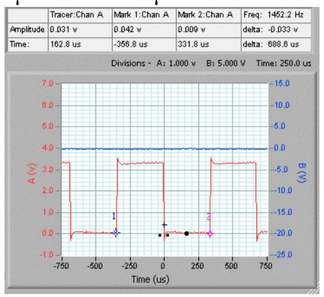
Go to the **Cleverscope Control Panel** window.

1. In the **ACQUIRE** area, set the **Probe** attenuation to **x10**. 

2. In the **TRIGGER** area, set the trigger **Level** to 1V. 

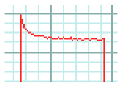
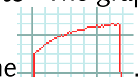
Select the **Scope Graph** window.

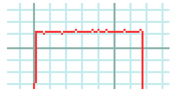
1. Set the A channel graph axis to include the voltage range 0 to 4V.
2. Set the time axis to include the range –750 μs to + 750 μs.
3. Plug the scope probe into the A channel, attach the hook probe tip, and ensure the probe switch is set to x10. Connect the ground crocodile clip to the left hand ground terminal. Connect the probe to the right hand Probe Comp output terminal.



Go to the **Cleverscope Control Panel** window.

1. Click on Trigger, and you should see a graph similar to that shown to the right.

   Note The graph may have either over shoot  or slow rise time .

2. Adjust the small red screw in the body of the probes BNC connector until the graph is flat. This compensates the probe capacitance and ensures flat frequency response. 
3. Repeat with the other oscilloscope probe.

   Note You may like to do this on the B channel, to familiarize yourself with the B channel controls.

Using the Cleverscope Application

Introduction

Cleverscope is an application designed to allow the capture, display, storage and analysis of signals on a Windows compatible PC. Minimum requirements are a Pentium PC with at least 64 MB of memory running Windows XP or Windows 2000. A version that runs under Windows 98 SE, ME and NT4 SP5 is available on request.

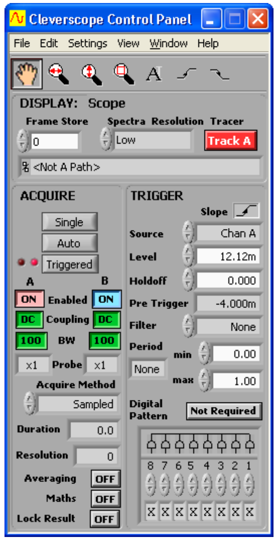
A free evaluation version of the CS300 Cleverscope application may be obtained over the internet by visiting the www.cleverscope.com website. The application includes a software signal generator and PC sound card support. The evaluation version is the same as the full version, although you need the Cleverscope Acquisition Unit (CAU) to fully use its capabilities.

Navigation and Control

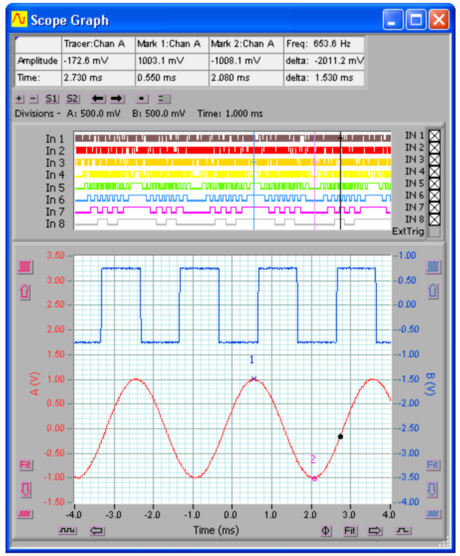
The Cleverscope application uses a **Control Panel** to setup and control signal acquisition. It uses display windows to show alternative but simultaneous views of signal and spectrum data. It also has additional windows that control the way the signal data is process and displayed as well as control of the optional **Signal Generator**.

The windows that can be displayed are:

Cleverscope Control Panel
controls, cursors, pull-down menus

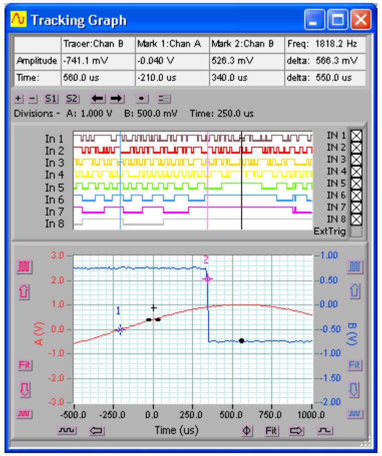


Scope Graph
main signal display window



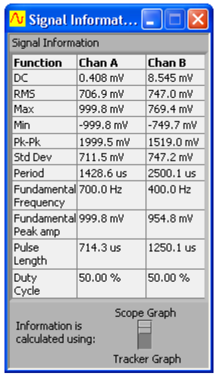
Tracking Graph

used with the Scope Graph for a close-up view



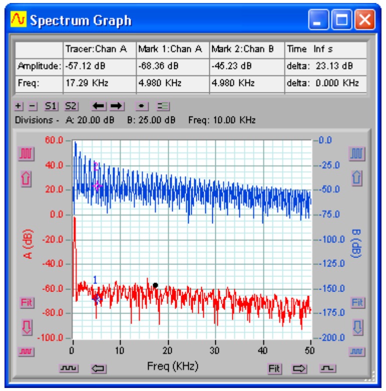
Signal Information Window

displays signal statistics



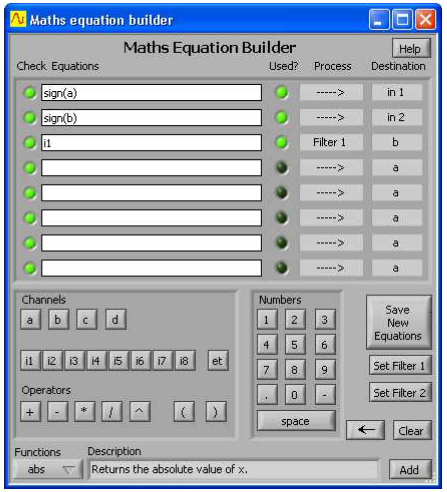
Spectrum Graph

displays the signal spectrum



Maths Equation Builder

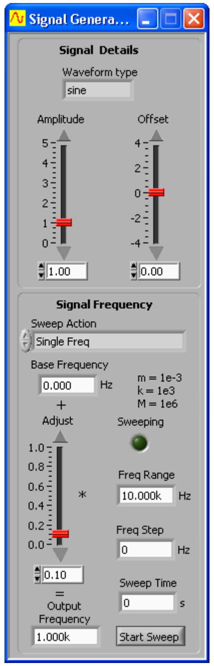
builds equations to process signals



Note You can individually size and position each window to optimize the ease of use and view-ability of signal and spectrum data.

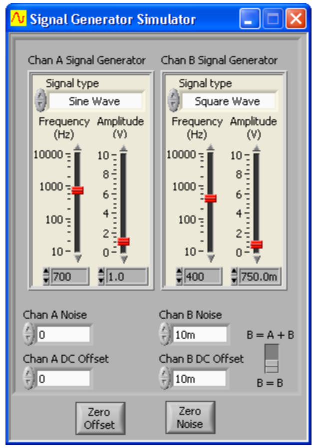
Signal Generator Control

signal generator output controls



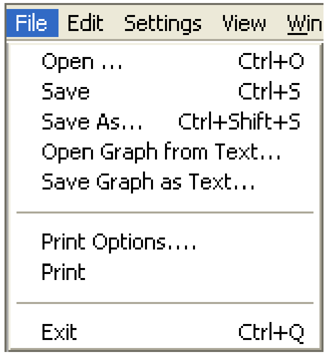
Signal Generator Simulator

virtual built-in signal generator controls

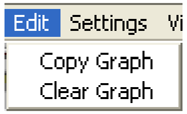


Only the **Cleverscope Control Panel** has pull down menus. These are shown below:

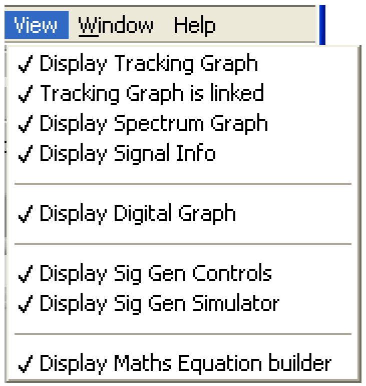
File Menu
open and save signal data, printing



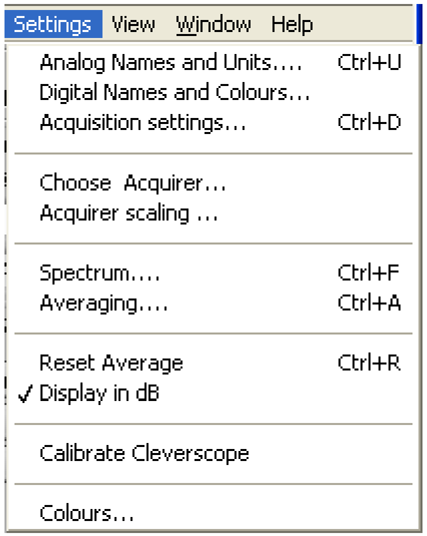
Edit Menu
copying and clearing graphs



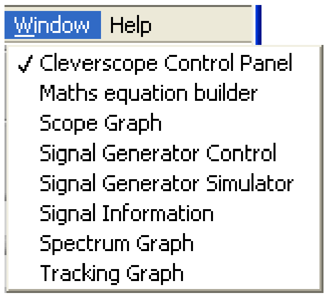
View Menu
selects which windows are displayed



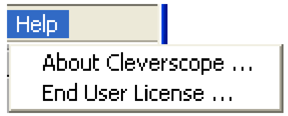
Settings Menu
set-up and options



Window Menu
for selecting the active window



Help Menu
keyboard shortcuts, license and version info



Keyboard Shortcuts

As well as using the mouse to navigate and control Cleverscope there are a number of keyboard shortcuts that can be used to save time and improve ergonomics. These are described below:

Movement:

← and → move the cursor left and right
Shift + ← and → move the graph left and right
Ctrl + ← and → change the x-scale up or down

↑ and ↓ move the selected graph up and down
Shift + ↑ and ↓ move the selected graph up and down
Ctrl + ↑ and ↓ change the y-scale up and down

Markers:

1 and **2** set markers one and two
Spacebar sets the next marker

Graph Viewing:

Tab swaps channels
A autoscales the graphs
PageDown zooms in on the tracer
PageUp zooms out on the tracer
L locks the tracking graph while you move to it

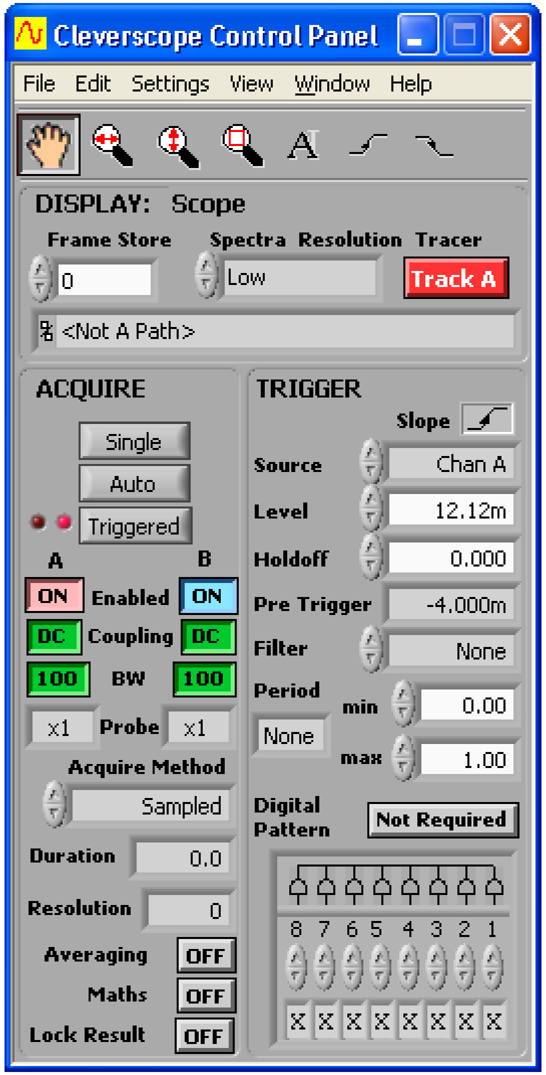
Control:

C or **Ctrl** + **C** copies the graph to the clipboard
X or **Ctrl** + **X** clears the graph
P or **Ctrl** + **P** prints the graph
F1 chooses the Pan/Tracer cursor
F2 chooses the Annotation cursor
F3 chooses the Rising Trigger cursor
F4 chooses the Falling Trigger cursor

Sampling:

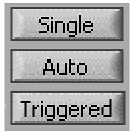
F7 initiates a single acquisition
F8 initiates automatic acquisition
F9 initiates triggered acquisition

Cleverscope Control Panel



The **Cleverscope Control Panel** contains all of the controls and menu items for capturing, and saving signal data.

Signal Acquiring



Use the **AQUIRE** button controls to start and stop signal capture in the following three different modes:

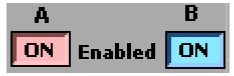
Single is a single shot, based on the trigger condition being met. This is for capturing a single frame positioned around a trigger point.

Auto free-runs (unless there is a trigger), this is for free running un-triggered signal capture.

Triggered is just like single, expect that following a trigger and display, sampling for a trigger is automatically restarted. This is for capturing repetitive waveforms positioned around a

constant trigger point.

Channel Enabling



The channel **Enabled** buttons turns each channel on or off.

AC/DC Coupling

The AC/DC **Coupling** buttons set each channels coupling to either AC or DC coupled.

Anti-aliasing Filter Bandwidth

The **BW** buttons set each channels bandwidth to either 25 MHz or 100 MHz. The **Cleverscope Acquisition Unit** employs 5th order low pass anti-aliasing filters on each channel to prevent high frequency out of band signals from aliasing back into the displayed signal graph. The unit samples simultaneously for both channels at 100 M samples/s and the corner frequency of the anti-aliasing filters can be selected to be either 25 MHz or 100 MHz.

Probe Attenuation

The **Probe** attenuation for each channel can be set to **x1**, **x10** or **x100** to match the attenuation switch settings of the connected probe.

Method for Acquiring Signals

Acquire Method selects the method of acquiring signal data. The choices are **Sampled**, **Peak Captured**, **Filtered** and **Repetitive**.

When **Sampled** is selected, samples are taken at regular intervals from the sample frame. None of the intermediate samples are displayed, which means that some signal information, such as high frequency signals, or pulses will not be seen. The sampling interval depends on the maximum frequency or time resolution required to be displayed and is automatically selected by Cleverscope depending on graph display settings.

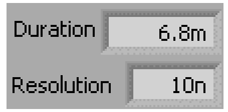
When **Peak Captured** is selected, all samples are processed, with both the minimum and maximum value of the signal being displayed at every pixel point on the screen. Hidden pulses will become visible, and high frequency content will be seen as a solid bar on the screen.

When **Filtered** is selected, a 1st order low pass filter with a corner frequency of 1 MHz is applied to the recorded samples. Filtering may be useful when viewing low frequency (<500 kHz) signals at low levels, as sample noise is significantly reduced.

When **Repetitive** is selected, acquired signals are folded back on themselves (interlaced) at the measured frequency to fill in the gaps in the acquisition. This results in high frequency repetitive waveforms being displayed with more resolution.

Duration and Resolution

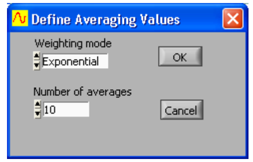
The sampling **Duration** is the length of time for which a continuous sequence of samples is available for display. The time **Resolution** is the minimum time between samples available for display.



Duration and the **Resolution** are updated after an acquisition has been started using the **Single**, **Auto** or **Triggered** buttons. The **Duration** is at least equal to the time width of the **Scope Graph**, but may be longer to make best use of the sample buffer. The **Resolution** is set by the number of samples available in each frame. A total of 4 million samples divided by the number of sample frames are available. Reducing the number of sample frames increases the number of samples available, and so will increase the time resolution. Here the sampling duration is 6.8ms, with a time resolution of 10ns per sample.

Averaging

The **Averaging** button turns averaging on and off. **Averaging** arithmetically averages a number of signal frames together to reduce the effect of noise, or to see the long-term value of a varying signal.



On the **Settings** menu, clicking **Averaging** allows you to select one of three types of averaging: **Linear**, **Exponential** and **Peak**. You can also select the **Number of averages**.

Linear averaging applies equal weighting over a number of signal frames, processing the number of frames chosen in **Number of averages** before presenting the result.

Exponential averaging provides a moving average where a greater weighting is applied to more recently acquired frames than older frames. The averaged frame is displayed after every acquisition. Each new frame is scaled prior to being added to the aggregated past signal. The scaling is determined by the **Number of averages**. A large number results in a small proportion of the new signal contributing to the average.

Peak averaging is used to accumulate maximum frequency points from the spectra of a number of frames and is therefore only applied to data displayed in the spectrum graph. It may be used to generate a frequency response graph (Gain/Phase plot).

Because noise is random, and has an average value of 0, averaging will reduce the effective amplitude of the noise in each time sample. The amount of reduction is dependant on **Number of averages** – making this number larger, will reduce the noise more, but it will take longer to settle the signal being measured.

On the **Settings** menu, click **Reset Average** (or Ctrl + R) to reset the average to 0.

Maths

The **Maths** button turns on and off the maths functions as defined by the **Maths Equation Builder**. See the **Maths Equation Builder** section below for a full description of its function.

Lock Result

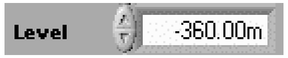
When the **Lock Result** button is turned on, it inhibits updates from the sampler. This is especially useful when **Maths** is turned on and you want to zoom in on the result on the **Tracking Graph** without the **Maths** being re-applied.

Triggering

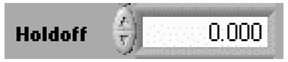
All the triggering controls are grouped in the **TRIGGER** area, apart from the trigger cursors which are with the other cursors at the top of the **Cleverscope Control Panel**.

The **Slope** button is used for selecting whether the voltage level will be increasing or decreasing through the trigger point when triggering occurs. The triggering slope is initially determined by the choice of an upward or downward trigger cursor but it can be changed at any time using the slope button without changing the level of the trigger point.

The trigger **Source** selection box is used to determine the source of triggering which can be channel A, channel B, the external trigger, the digital inputs or the rear input available on the Mini-Din connector at the back of the capture unit.

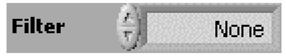


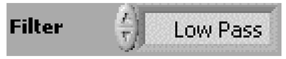
The triggering **Level** is normally set using the trigger cursors in conjunction with the Scope Graph however it may also be set using the triggering level selection box. A triggering level may be either typed into the box or the up and down buttons can be used to raise or lower the triggering level.



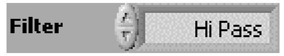
The **Holdoff** time is the time from receiving a trigger to next allowing a trigger to occur again. For example, to see only the first edge in a sequence of edges, while ignoring remaining edges in the sequence, set the hold off time greater than the duration of the sequence.

The **Pre Trigger** time displayed is the time between the first sample in a frame and the trigger point. The trigger point is always set at time zero in the **Scope Graph**. The amount of pre-trigger time is determined by how much pre-trigger time you are requesting to view in the **Scope Graph**. Using the **Scope Graph** left and right horizontal controls (and) therefore directly influences the pre-trigger time.

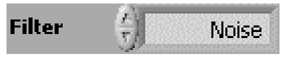




The trigger **Filter** is used to improve trigger capture. The choices available are **Low Pass**, **Hi Pass**, **Noise** or **None** (no filtering).

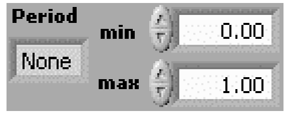


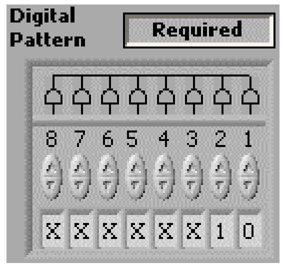
Low Pass filtering is used to capture a low frequency signal in the presence of high frequency noise.



Hi Pass filtering is used to capture high frequency signals (such as edges) in the presence of a low frequency signal; for example triggering on a pulse on a mains frequency waveform.

Noise filtering is used to achieve a more reliable trigger in the presence of large amounts of noise. This is done by increasing the hysteresis band about the trigger point. A wider hysteresis band means that the signal amplitude must be wider than the hysteresis band to ensure reliable triggering. The standard hysteresis band is ½ a vertical division. When noise filtering is enabled it becomes 1 division. Signals must fully transition through the hysteresis band to cause a trigger.



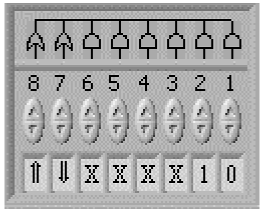


Period provides additional trigger control as follows: **<** allows a trigger if the trigger signal rises and falls in less than the **min** time; **in** allows a trigger if the trigger signal rises and falls after **min** time but before the **max** time has elapsed; **>**

allows a trigger if the trigger signal rises and falls in more than the **max** time;

The **Digital Pattern** is an optional qualifier to the analog trigger. When **Not Required** is selected, analog triggering proceeds as explained above. When **Required** is selected, the analog trigger cannot take place until the digital inputs match the digital pattern chosen. As an example, assuming the **Digital Pattern** is **Required**, an analog trigger will not be recognized until **Digital Inputs 1** and **2** matches **0** and **1** respectively. Inputs labelled **X** are 'don't care'.

Digital Triggering



When **Dig Trig** is selected as the triggering **Source** then Cleverscope will trigger when the digital inputs match the pattern set by the digital input selection box, shown to the right.

There are two groupings of inputs:

OR inputs:
qualified with the symbol above them,

AND inputs:
qualified with the symbol above them.

AND ( ) or OR ( ) can be selected for each digital input by clicking directly on the or symbol.

To achieve a trigger:

1. Any one of the OR conditions must be met
AND
2. All of the AND conditions must be met.

Conditions are:
0 – the digital input must be below the digital threshold.
1 – the digital input must be above the digital threshold
X – the digital input is ignored
⇑ - the digital input transitions from 0→ 1
⇓ - the digital input transitions from 1 → 0

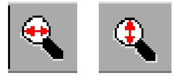
As an example, the pattern shown will cause a trigger if input 1 = 0, input 2 = 1, and either input

7 falls or input 8 rises.

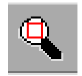
Cursors

When you click on one of the cursor buttons shown, you will be able to zoom a graph, or annotate it, or set a trigger level.

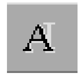
The ‘grabbing hand’ or **Pan** cursor is used to pan the graph by clicking and dragging anywhere inside the graph window to slide the graph into its desired position.



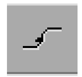
The horizontal zoom cursor is used to horizontally expand the graph in which it is used. The vertical zoom cursor is used to vertically expand the graph in which it is used.

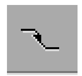


The ‘selected area’ zoom cursor is used to select a rectangle to zoom into by clicking on the top left corner and then dragging, and releasing at the bottom right corner of the rectangle to be zoomed into.



The annotation cursor is used to annotate graphs. Following its selection you can click at a position in a graph where it is desired to locate text. Drag the little open circle to move the annotation. The horizontal position of the text is locked to a position in time corresponding to where the annotation cursor was clicked. The vertical position of the text is locked to a voltage level corresponding to the where the annotation cursor was clicked and for whichever channel (A or B) was selected at the time.





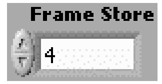
The rising slope trigger cursor is used to set the trigger level for triggering on a rising edge. The channel that is to be the trigger source, and the axis to be used to set the trigger level, are determined by whichever channel (A or B) is selected at the time the trigger cursor is clicked.

The falling slope trigger cursor is used to set the trigger level for triggering on a falling edge.

Display Controls

Controls related to signal data storage and display are located in the **DISPLAY** area.

The Cleverscope acquisition unit is able to hold a number of sequential frames so that a history of older frames can be recalled.

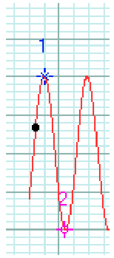


Following an acquisition the **Frame Store** number represents the latest frame acquired. To display an earlier frame, click on the down control, or type a number directly into **Frame Store**. The graphs will update to display the signal in the frame selected. **Frame Store** '1' is always the oldest frame, the higher the number, the more recent the frame. The maximum is set on the **Settings** menu, clicking **Acquisition Details** and setting the **Number of Frames**. The 4 Million samples available in the Cleverscope acquisition unit are divided between the **Number of Frames** allocated.

Spectra Resolution lets you select the spectrum analysis frequency resolution displayed in the **Spectrum Graph**. This is achieved by increasing the number of samples returned from the capture unit to the spectrum analyzer. The choices for **Spectra Resolution** are **Low**, **Medium**, **High**, and **Maximum** corresponding to 512, 1024, 2048 and 8192 frequency bins per graph display.

The **Tracer** buttons lets you select which channel the tracer will apply to. The tracer is a small black circle that can be moved along the A or B channel signal trace by selecting a display graph (Scope, Spectrum or Tracking) and simply moving the mouse left or right.

As the tracer is moved along a signal (or spectrum) its position in both amplitude and time (or frequency) is displayed in the **Information** area at the top of the display graph. The tracer assists the accurate positioning of markers which enable points of interest to be tagged and calculations on selected segments of signal data to be undertaken. See also the section on **Scope Graph** below for a description on the use of the tracer and markers.



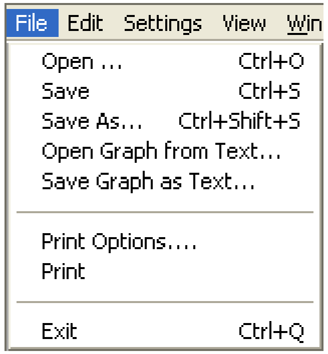
Cleverscope lets you save signal data as either a Cleverscope file or a text file. On the **File** menu, click either **Save As**, **Save Graph as Text** or **Save** to do this. The file path for the last stored file is displayed in the path display box.

Cleverscope Menus

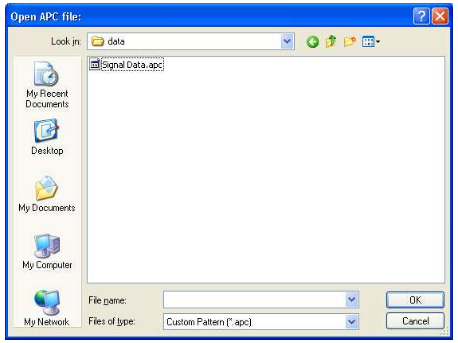
The Cleverscope **File**, **Edit**, **Settings**, **View**, **Window** and **Help** pull down menus are all available from the **Cleverscope Control Panel** window. The graphs do not contain pull down menus.

File Menu

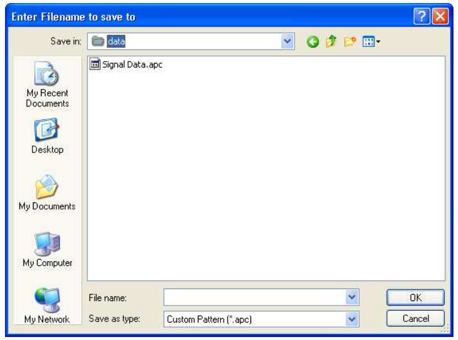
The **File** menu lets you save signal and graph data, open saved data for display and analysis, print graphs and exit the application.



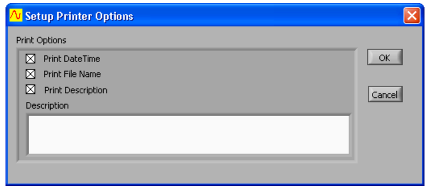
The standard, familiar Windows open and save file dialogs are used to save and open files. **Open** lets you open APC files (*.apc) containing previously saved Cleverscope signal data. It can only be used to open APC files. Text files must be opened using the **Open Graph from Text**.



Save, **Save As** and **Save Graph as Text** let you save signal data as APC or text files. If you save signal data in an APC file then your Cleverscope settings will also be saved along with the signal data. This means that when you reopen an APC file the data will be displayed in the display graphs exactly as it was when you saved it and all the Cleverscope settings as defined through the various menu items in the **File**, **Settings**, and **View** menus will also be reapplied. Text files must be saved using the **Save Graph as Text**. Cleverscope automatically sizes the graphs to fit the restored signal when opening text files.



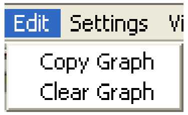
Print Options is used to choose what other information is printed with the graph. You can choose the date, time and a text description to be printed above a graph printout.



Print is used to print the currently selected graph or signal information window.

Exit lets you exit the Cleverscope application.

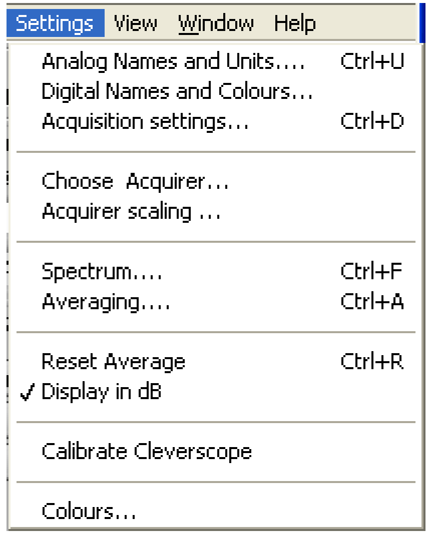
Edit Menu



Copy Graph lets you copy an image of the last selected graph or information window to the clip board. You can then paste the copied item into a document or similar in another application.

Clear Graph lets you clear signal data from the last selected graph.

Settings Menu

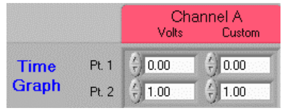


The **Settings** menu contains all the options, preferences, and settings related to the acquiring and analysis of signal data, including calibrating your CAU. In addition, you can choose different names, colours, and units for displaying graphs.

Analog Names and Units

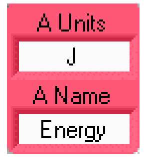
Analog Names and Units lets you use units other than volts or dBs when displaying signal data.

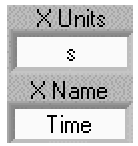
To set up custom units you need to define the relationship between the internal units in volts and the units to be used for displaying signal data.



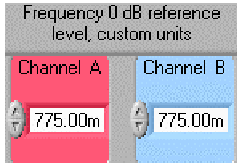
A plot showing the relationship between internal units in Volts and your custom units must be a straight line. Points 1 and 2 fix this straight line, and therefore define the scaling between internal units and your custom units.

As an example, suppose a light energy generating system connected to channel A had a terminal voltage of 0.28V for 3.4 J of output energy, and a terminal voltage of 12.6V for 76 J of output energy.





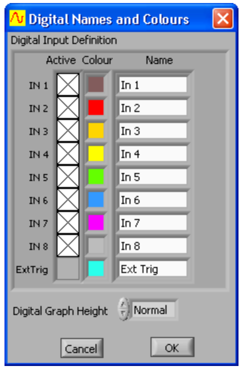
To customize the units for this system you would enter 0.28 for **Pt. 1** under Volts and 3.4 for **Pt. 1** under Custom for Channel A. You would then also enter 12.6 for **Pt. 2** under Volts and 76 for **Pt. 2** under Custom for Channel A. Then type *J* into Time Graph Units A Units and *Energy* into **Time Graph Units** A Name. Channel B can be similarly customized for the **Time Graph**, as can both channel A and B for the Linear, Logarithmic and Gain/Phase Frequency Graphs (spectrum graphs).



Both **Units** and **Name** labelling for the horizontal **X** axis can also be customized whether it be for time, or frequency (for linear, logarithmic or gain/phase graphs).

The zero dB reference point for the logarithmic Frequency (spectrum) graph can also be customized. The default 775 mV corresponds to 0dBm into a 600 ohm load. To display dBV change this value to 1.

Digital Names and Colours

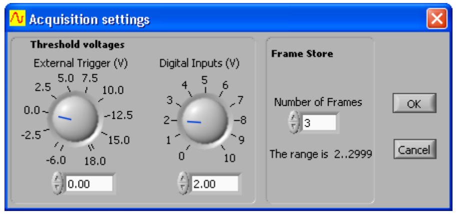


Digital Names and Colours controls what digital inputs are displayed, what colour they are, their name, and how big the digital display area is.

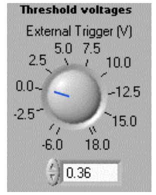
The **Active** check boxes change which digital signals are displayed. The **Colour** boxes select each signals colour. You can change the name of a signal by typing in the **Name** fields.

In the **Digital Graph Height** box, select either **Normal** or **Large** to change the height of the **Digital Graph**, **Large** is twice the size of **Normal**.

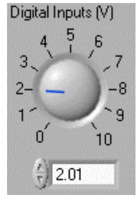
Acquisition settings



Acquisition settings adjusts your Cleverscope Acquisition Unit for external trigger and digital input threshold voltages and the number of frames stored.



The threshold voltage for the external trigger can be set to any level (at increments of 12.5 mV) between –6 and 18 volts by dialling, typing or nudging the voltage up and down.

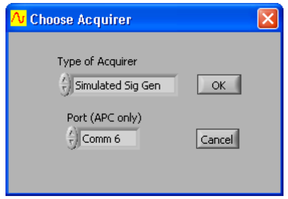


The level determining when a digital input is read to be a ‘1’ as opposed to a ‘0’ (digital input threshold) can be set to be any voltage between 0 and 10 volts in 10mV increments.

The Cleverscope acquisition unit can store up to 4 million samples of signal data per channel. These samples can be allocated to a single frame or can be divided among multiple frames. This is so that a history of previously captured frames can be recalled or so successive trigger events can be captured with a minimal 2μsec inter frame delay.

Sample storage is allocated evenly between the **Number of Frames** defined, which can be up to 2999. If 2999 frames are defined then each will contain 1300 samples.

Choose Acquirer

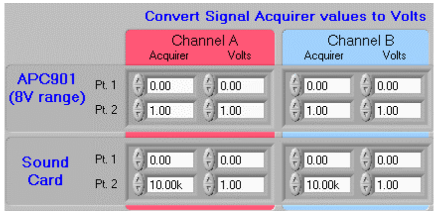


Choose Acquirer lets you select the hardware you wish to use to acquire signal data (or virtual hardware in the case of the internal Simulated Signal Generator). The choices are **Simulated Sig Gen**, **Cleverscope**, **Soundcard**, **APC901**, and **APC901A**.

If you select the **APC901** or **APC901A** then you must also select the serial **Port** that the Strobes APC hardware is connected to.

Acquirer Scaling

Acquirer Scaling lets you define scaling and offset to be applied to measurements made by the Strobes hardware (901 and 901A) and soundcards to compensate for any difference between volts as read by the acquirer and any associated input circuitry and the actual volts at the input.

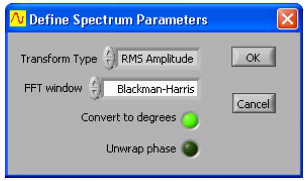


An X/Y plot showing the linear relationship between the actual volts at the input and the measurement in volts as made by the acquirer must be a straight line. **Pt. 1** and **Pt. 2** fix this straight line, and therefore define the scaling and offset to ensure that the volts as read in Cleverscope are the same as the actual volts present at the input.

For example, if by measurement the acquirer reads 10mV for a real 23 mV signal and 1.2 Volts for a real 1.1 Volt signal, then **Pt. 1** and **Pt. 2** should be as shown on the right.

Spectrum

Spectrum lets you select the type of Fourier transform to be applied, the windowing technique to be used, whether phase information is plotted in degrees or radians, and whether Phase should be plotted between -180 and 180 degrees or 0 to 360 degrees.



The Fourier **Transform Type** can be **RMS Amplitude**, **Power**, **Power Density**, or **Gain/Phase**.

The **RMS Amplitude** returns the magnitude of a signal in volts. **RMS amplitude** is the most common type of Fourier transform. The root mean square (RMS) voltage for each frequency bin is displayed. This value is equivalent to a continuous sinusoid at the bin frequency with a RMS amplitude equal to that displayed. The RMS value of a sinusoid is a constant voltage equal to the sum of each squared instantaneous voltage value divided by the time over which the sinusoid is measured.

The **Power** spectrum returns the magnitude of the power content of an equivalent continuous periodic signal at the bin frequency. Assuming a voltage input, **Power** spectrum represents the power dissipated at each frequency bin into a one ohm resistor. The **Power** spectrum can be scaled by setting the 0 dB reference level. For example, let the reference value be 1W dissipated in a 50 ohm load:

From $P= V^2/R$, $V = \sqrt{(PR)} = \sqrt{(1 \times 50)} = 7.07$ V.

Therefore, set the reference level to 7.07 V.

The **Power Density** returns the magnitude of the power spectral density. This is the power content of an equivalent continuous periodic signal at the bin frequency divided by the frequency width of the bin. The reference is used as for **Power** spectrum.

Gain/Phase assumes that Channel A is connected up to the input of a system under test and that Channel B is connected to the output of the system. By performing a Fourier analysis on frames of signal data representing the input and output of a system, gain versus frequency and the phase versus Frequency can be plotted for the system under test.

The gain plot is presented as Channel A and the phase plot replaces Channel B. Gain is plotted in either dBs or in linear units of gain depending on whether you have selected **Display in dBs** or not (also in the **Settings** menu, see below). The phase plot is presented in degrees or radians dependant on **Convert to degrees**.

Phase is plotted between -180 degrees and +180 degrees. To avoid discontinuities at 180 degrees (π radians) phase can be plotted between 0 and 360 degrees if **Unwrap Phase** is selected.

FFT window controls which windowing technique is used. Fourier analysis makes the assumption that the sampled section of a waveform as captured in a frame is repeated infinitely both forward and backward in time. Using the special case of a sine-wave to illustrate the point, a captured sine wave will not necessarily finish in the frame at the same point in its cycle that it started.

Assuming that such a frame is repeated endlessly will therefore add discontinuities where the frames join that are not actually present in the real signal. These discontinuities are called end-point errors and they are common to all Fourier Transform Analysers. Windowing is a mathematical technique used to minimize such end-point errors.

The choices of windowing techniques in Cleverscope are:

- None
- Hanning
- Hamming
- Blackman-Harris
- Exact Blackman

- Blackman
- Flat Top
- 4 Term B-Harris
- 7 Term B-Harris
- Low Sidelobe

These windows have the following characteristics:

Window	-3 dB Main Lobe Width (bins)	-6 dB Main Lobe Width (bins)	Maximum Side Lobe Level (dB)	Side Lobe Roll-Off Rate (dB/decade)
Uniform (None)	0.88	1.21	-13	20
Hanning (Hann)	1.44	2.00	-32	60
Hamming	1.30	1.81	-43	20
Blackman-Harris	1.62	2.27	-71	20
Exact Blackman	1.61	2.25	-67	20
Blackman	1.64	2.30	-58	60
Flat Top	2.94	3.56	-44	20

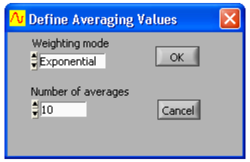
The choice of window to use depends on the type of signal being examined, and the desired trade off between Frequency resolution, spectral leakage and amplitude accuracy.

The following table gives a first approximation to the best type of window to use:

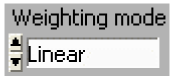
Signal Content	Window for best frequency resolution	Window for best spectral leakage	Window for best amplitude accuracy
Sine wave or combination of sine waves	Hanning	Exact Blackman	Flat Top
Narrowband random signal (vibration data)	Hanning	Blackman Harris	Blackman Harris
Broadband random (white noise)	Uniform (None)	Blackman	Uniform
Closely spaced sine waves	Uniform, Hamming	Hamming	Blackman
Excitation signals (Hammer blow)	Uniform (None)		
Unknown content	Hanning		

Averaging

Averaging can be used with either the **Spectrum Graph** or the **Scope Graph/Tracking Graph**. A number of frames can be arithmetically averaged together to reduce the effect of noise.



Averaging is usually used to minimize the effects of noise and to find the average value of a signal in the presence of noise.



Weighting mode provides three types of averaging; **Linear**, **Exponential**, and **Peak**. **Peak** averaging can only be applied to the **Spectrum Graph**.

Linear does averaging with equal weighting. It sums a number of captured frames and then calculates a new frame which is the average of them all. The number of frames being averaged may be set in **Number of averages**.

If 16 frames are being averaged then a new frame is displayed only after 16 frames have been captured, transferred and averaged. Triggering can be used to ensure that all of the averaged frames are aligned with respect to the cycle of the captured signal.

With **Exponential** averaging the PC calculates the average for a new frame every time a frame is captured and transferred from the acquisition hardware. Automatic frame capture, triggering and frame transfer will continue to work as it does without averaging. As for **Linear** averaging, triggering can be used to ensure that all of the averaged frames are aligned with respect to the cycle of the captured signal.

Older frames contribute less than more recent frames to each calculated average. The contribution of a frame to each new calculated average diminishes exponentially with time as new frames are transferred and new averages calculated. The contribution of older frames to the most recently calculated average is never lost however (unless averaging is turned off or reset).

Let N represent the **Number of averages** when exponential averaging is selected. The value of a sample in a newly averaged frame is calculated as follows:

The value of a sample in a new frame is added to N-1 multiplied by the value of the equivalent sample in the last 'averaged' frame and the total is divided N.

$$V_{newcalc} = (V_{new} + (N\text{-}1)V_{previouscalc})/N$$

Where $V_{newcalc}$, V_{new}, $V_{previouscalc}$, all represent samples which are in equivalent positions in a frame with respect to time and:

$V_{newcalc}$ is the newly calculated average for a sample.

V_{new} is the most recently measured and transferred value for the equivalent sample.

$V_{previouscalc}$ is the previously calculated average for the equivalent sample.

This form of averaging is called exponential averaging because the weighting given to each frame of samples, as you go back in time, represents an exponentially decaying curve. If N is 4 the weighting given to the samples in each frame going from the most recent frame backwards is represented by the following series:

$V_1 1/4,\ V_2\ 3/16,\ V_3 9/64,\ V_4 27/256,\ V_5 81/1024\ \ldots$

Where V_1 is the amplitude of a sample in the most recent frame and V_5 is the amplitude of the equivalent sample in the 5^{th} most recent frame.

Peak averaging can be used in a situation where you want to accumulate in one spectrum the maximum frequency points from the spectra of a number of frames. **Peak** averaging can only be used to accumulate the peak frequency levels from consecutive spectra and is not relevant for use in the time domain.

When **Peak** averaging is used the spectrum of a frame of signal data is calculated and the frequency points are saved in an averaging array. When the frequency points of a newly captured frame are loaded into the averaging array only those points whose levels are both greater than their counterparts in the current array are actually loaded. In this way all the frequency points in the peak averaging array represent the greatest levels so far recorded at those points.

Peak averaging is very useful if you are doing **Gain/Phase** plots. Instead of using a white noise generator to produce an input signal that contains all the frequency points of interest in one frame, a sweep frequency signal generator can be used to build up the gain and phase response of the system over a number of frames.

Note The choice of **Number of averages** is not relevant for **Peak** averaging.

Averaging in the Scope Graph

If you wish to do time averaging, you must have a periodic waveform whose phase variation is relatively stable so you achieve a stable trigger. If your acquisition hardware provides a choice of sample rate use a relatively high rate to also maximize triggering stability.

Use equal averaging when all frames are equally important (a periodic waveform with noise, for example). Use exponential averaging when you wish to get the best estimate of the current value of a varying signal (for example a pulse train with jitter).

Averaging in the Spectrum Graph

If you wish to do frequency domain averaging then you should be aware of the difference that Triggered and Auto frame capture has on averaging. If Triggered has been selected, Cleverscope assumes you have a periodic waveform and a good trigger, and averaging will be performed in the time domain, before transforming the resulting average to the frequency domain. If Auto is selected, the signal data is transformed and the averaging is performed in the frequency domain.

Use Triggered when you have a stable periodic signal with impressed random noise. Use Auto when the signal is not periodic and a stable trigger is not available. When Auto is used (and averaging is done in the frequency domain) endpoint errors will be smoothed as they will have different frequency content from frame to frame. End-point errors are discussed under 'Windowing' above.

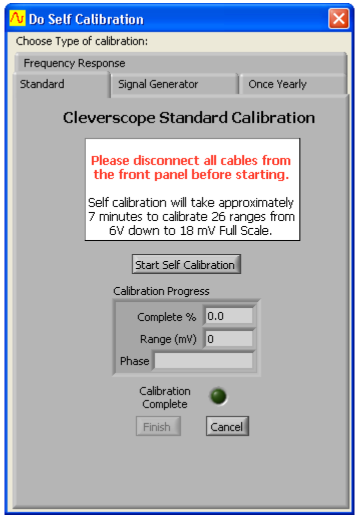
Reset Average

Reset Average restarts any averaging process that may be underway. The averaging process that is currently selected will start again when the next frame is captured.

Display in dB

When **Display in dB** is selected then the vertical axis the **Spectrum Graph** will be displayed logarithmically in dB as opposed to a linear amplitude scale. The exception to this is the Phase plot when **Gain/Phase** is selected for the **Spectrum Graph** because phase is always graphed in degrees or radians.

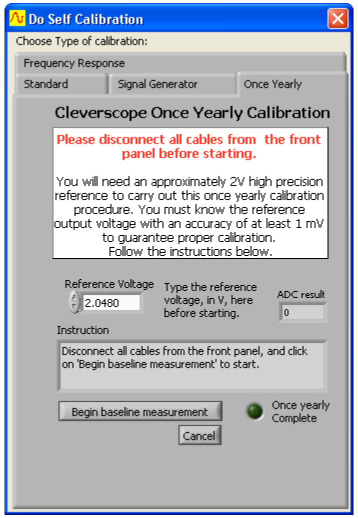
Calibrate Cleverscope



Standard self calibration should be executed if the temperature changes by more than 10°C. Cleverscope includes an internal reference which is used to self calibrate all the analog circuitry within the **Cleverscope Acquisition Unit**. Before initiating a **Standard** self calibration, disconnect all probes from the front of the **Cleverscope Acquisition Unit** and ensure that it has been powered up for more than 5 minutes, then click **Start Self Calibration**. The self calibration process takes about 7 minutes.

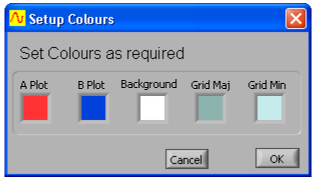
The **Signal Generator** calibration only needs to be done once after you install the optional **Signal Generator Unit** yourself. If your **Cleverscope Acquisition Unit** came with a **Signal Generator Unit** installed then this calibration will have been completed at the factory. Before initiating a **Signal Generator** calibration, connect a lead from the **Signal Generator** output to the **Chan A** input, and then click **Start Sig Gen Calibration**.

The **Frequency Response** calibration is completed at the factory. If you think there is a problem with the frequency response of your **Cleverscope Acquisition Unit**, contact Cleverscope support before carrying out a **Frequency Response** calibration.



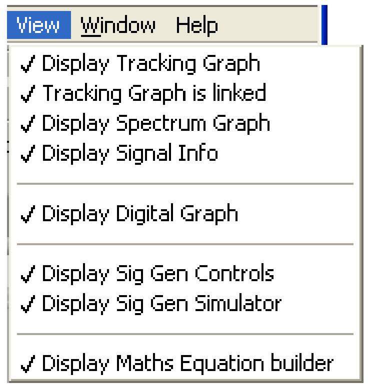
The **Once Yearly** calibration requires a high precision reference of around 2 V. You must know the reference output voltage with an accuracy of at least 1 mV to guarantee proper calibration. Before initiating a **Once Yearly** calibration, disconnect all probes from the front of the **Cleverscope Acquisition Unit** and ensure that it has been powered up for more than 5 minutes, then click **Begin baseline measurement** and follow the instructions. A **Once Yearly** calibration should always be followed by a **Standard** self calibration.

Colours



Colours lets you select different colours for graph plotting. You can select colours for channel A plotting, channel B plotting, graph backgrounds, and major and minor grid lines.

View Menu

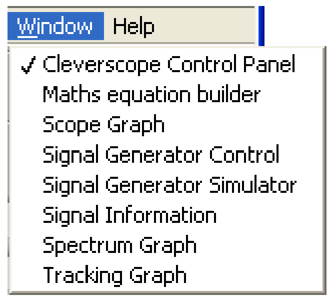


Various windows can be selected for display under the **View** menu. The operation of each of these windows is discussed in the following section.

Note The **Digital Graph** is not a window in its own right, but is built into the **Scope Graph**. It can be de-selected to save screen space.

When **Tracking Graph is Linked** is selected the tracer in the **Scope Graph** will mimic the tracer in the **Tracking Graph**, and vice versa. The **Tracking Graph** time axis will change to keep the tracer in the centre of the graph. If the **Tracking Graph** is not linked, the two graphs can be manipulated independently of each other.

Window Menu



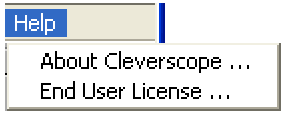
The **Window** menu is used to select which of the displayed Cleverscope windows you wish to be currently active. A window can also be made active by simply clicking inside it, but this presumes that it is visible, or in front on the desktop.

Note A window will only appear in the **Window** menu if it is currently selected to be displayed in the **View** menu.

Help Menu

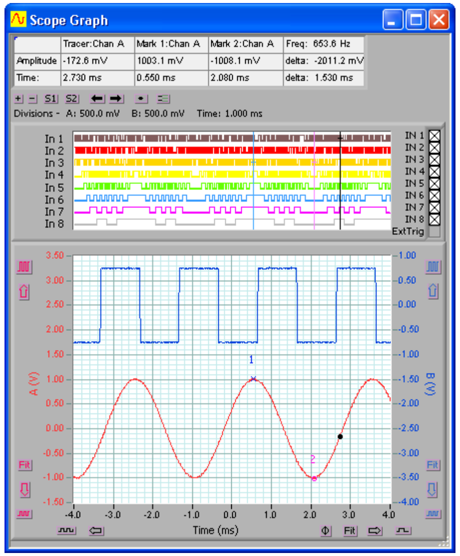
About Cleverscope shows the various

keyboard shortcuts and the current version number of the Cleverscope Application software. **End User License** shows your license agreement.

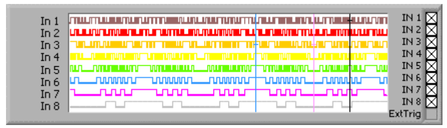


Scope Graph

The **Scope Graph** is used to view captured signals in the time domain, and to determine the boundaries of the signal to be captured in both amplitude and time. It is divided into three areas; the **Information** area at the top, the digital graph in the middle and the analogue scope at the bottom.



Viewing the signal on the **Scope Graph** is like viewing a signal on a normal oscilloscope. The channel A and B signal traces are laid over each other and visible in the same window as they are in an oscilloscope. As with an oscilloscope both channels A and B are referenced to the same horizontal time axis but each has their own vertical or voltage axis. As with an oscilloscope triggering can be used to ensure that repetitive waveforms remain stationary on the Scope Graph as frames are acquired and displayed on a continuous basis.

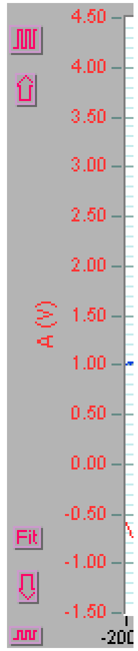


The **Digital Graph** for displaying the pulse trains present on each of the 8 digital inputs is located above the main **Scope Graph**. Its horizontal (time) axis is locked into the horizontal axes for the **Scope Graph** below it and so the horizontal display controls for the **Scope Graph** also apply to the

Digital Graph.

Note To conserve display space the **Digital Graph** can be turned off in the **View** menu.

Vertical Axis



To the left of the A channel vertical axis are a number of buttons for controlling the vertical positioning and scaling of the A channel signal data. The same buttons for the B channel are positioned to the right of the vertical B channel axis.

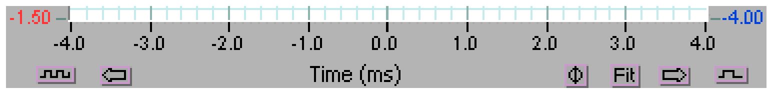
Use the up arrow button ( ) to move a channels signal trace up. Similarly, use the down arrow button ( ) to move a channels signal trace down.

Use the auto-fit button (Fit) to let Cleverscope decide and apply the optimum vertical scaling and positioning for a channels signal data.

Use the vertical expand ( ) and contract ( ) buttons to vertically expand or contract a channels signal data.

The **Scope Graph** setup also determines how a signal will be captured. The vertical axis setup determines the internal scaling and offset. Cleverscope's full 10 bit analogue resolution maps onto the chosen minimum and maximum amplitude axis values. The values for Channels A and B are independent of each other.

Horizontal Axis



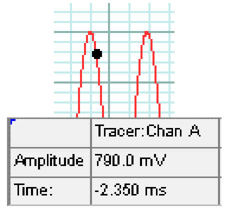
Below the horizontal time axis are the buttons for controlling the positioning and scaling with respect to time of both A and B channel signal traces.

The left and right arrows (and) move the signal left or right in time. The horizontal contract ( ) and expand ( ) buttons horizontally expand or contract the signal with respect to time.

The Fit (Fit) button will let Cleverscope decide and apply the optimum position and scaling with respect to time for the Scope Graph. The zero button (Φ) repositions the graph so that zero time is in the centre.

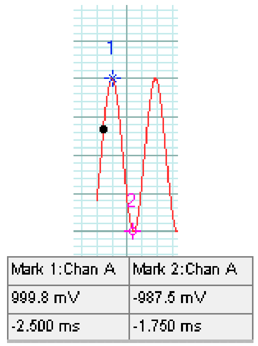
The time axis determines the start and stop time of the signal captured relative to the trigger. The trigger position is always time 0. Positioning the time axis so that the left hand side of the axis is negative means that you will see signal before the trigger occurred. Similarly, positioning the left hand side of the time axis to be positive means that there will be a delay following the trigger before signals are acquired and displayed.

The Tracer



The tracer is a small black circle that can be moved along a signal trace using the mouse. The voltage level and position in time is displayed in the **Information** area. By moving the tracer to a point of interest on the signal trace or spectrum you can read the voltage level and time at that point.

Placing Markers

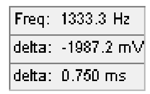


Markers are used to measure the time and amplitude of a time plot – or the frequency and amplitude for a spectrum plot. You place markers like this:

1. Move the tracer to the location of interest.
2. Place a marker by either:
    - double clicking
    - pressing the space bar
    - pressing the 1 or 2 keys

Up to 2 markers can be positioned in this way. The markers will always maintain their horizontal positions on the signal trace. Their positions are displayed in the **Information** area.

Measuring Differences and Frequency



You measure differences by placing two markers, and then reading the differences in the right most **Information** box. Here the time difference is 0.75 ms. You can measure differences between plots by placing the first marker, and then pressing the **Tab** key to move from one plot to the next, and placing the second marker.

Also displayed in the **Information** area is Cleverscope's best calculation (assuming a repetitive waveform) of the selected channel's frequency. The frequency is calculated by completing a Fourier transform to estimate each frequency component of the signal. The highest amplitude frequency component is chosen, and its frequency is displayed.

Volts/Division and Secs/Division are

displayed above the top left hand side of the graph.

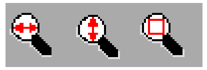
Graph Settings

There are a series of buttons between the graph and the information area that control graph settings.

The **Zoom In** () and **Zoom Out** () buttons zoom in and out on both channels at the same time. The **Setup 1** () and **Setup 2** () buttons restore graph setup 1 and 2. **Shift** + **Setup 1** () and **Setup 2** () save graph setup 1 and 2. **Previous Graph Setting** () button goes back to the previous graph setting and the **Next Graph Setting** () button goes forward to the next graph setting. The settings buffer can hold up to 50 previous settings. The **Tracer Cursor Style** () button toggles between a dot and a line cursor. The **Normalize Grid** () button normalizes the scales of the grid.

Zooming the Graph

You zoom the graph in these ways:

1. Use the graph enlarge/reduce tools to enlarge or reduce the graph. For the time axis, the contract button () zooms out on the signal and expand () buttons zooms in on the signal. For the amplitude axis, the expand button () zooms in, and the contract button () zooms out.
2. Use the Control Panel Tools  to zoom on time, amplitude or both.
3. Use the key commands to zoom on the marker:

   ← and → move the cursor left and right
   Shift + ← and → move the graph left and right
   Ctrl + ← and → change the x-scale up or down

   ↑ and ↓ move the selected graph up and down
   Shift + ↑ and ↓ move the selected graph up and down
   Ctrl + ↑ and ↓ change the y-scale up and down

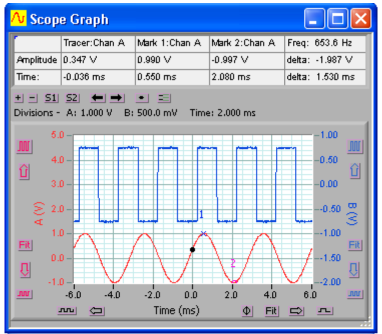
How Zooming Works

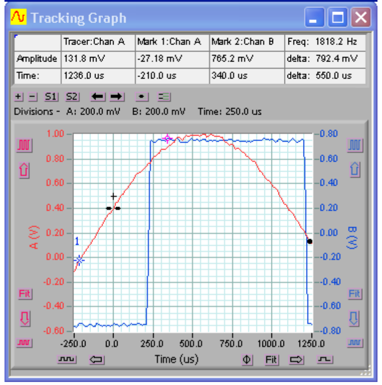
Cleverscope keeps all the samples in the acquisition unit. When you zoom the graph, the Cleverscope application requests a new graph view from the acquisition unit. The acquisition unit finds the samples, and returns them, via the USB. The acquisition unit can keep up to 2 M samples in any one display buffer.

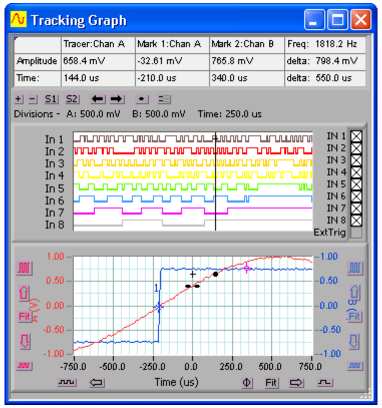
Digital Tracers and Markers

Notice that as you move the tracer, the black tracer line on the digital display follows the analog tracer. Similarly the markers are mirrored to the **Digital Graph**, which is synchronized with the analog graph. If you want to pay particular attention to a digital input, drag the threshold marker to the input of interest.

Tracking Graph







Use the **Tracking Graph** together with the **Scope Graph** to have both an overview of the entire frame of signal data and a close-up view of a portion of the signal trace that interests you.

First ensure that you have turned on the **Tracking Graph** display and that the **Tracking Graph is Linked** using the **View** menu. As you move your mouse along the signal trace in the **Scope Graph**, the **Tracking Graph** window will also move giving a close-up view of the signal centred on the position of the tracer in the **Scope Graph**. The tracer positions in both graphs will refer to the same point.

The **Tracking Graph** works in an identical fashion to the **Scope Graph**. Zoom, pan and annotate in exactly the same way. The **Tracking Graph** has its own markers and annotations.

As you move the mouse/tracer outside the current window view in the **Scope Graph**, the tracking window will move to accommodate the new tracer position. This ensures that the tracer is always in view.

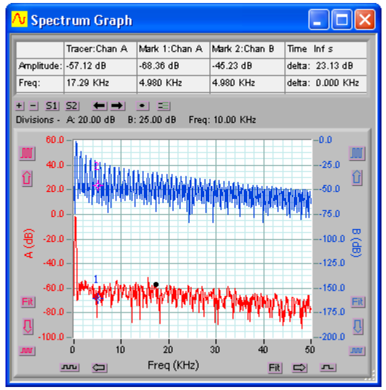
As with the **Scope Graph**, when **Display Digital Graph** is selected on the **View** menu, the **Tracking Graph** also displays the **Digital Graph**.

There are many occasions where you find a feature of interest in the **Scope**

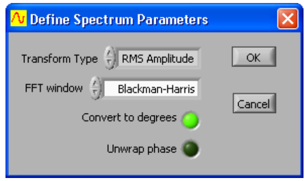
Graph, and wish to examine it more closely. To do this, position the tracer on the feature in the **Scope Graph**, type 'L' to temporarily lock the **Tracking Graph** position. You can now manipulate the **Tracking Graph** view. Clicking on the **Tracking Graph** will clear the lock.

As with the **Scope Graph**, the **Tracking Graph** also has an **Information** area displaying information about the position of the **Tracking Graph** tracer, markers, marker differences and signal frequency.

Spectrum Graph



The **Spectrum Graph** displays the Fourier transform of the channel A and channel B signal data.



There are four choices of Fourier transform. On the **Settings** menu, click **Spectrum**. The Fourier **Transform Type** can be:

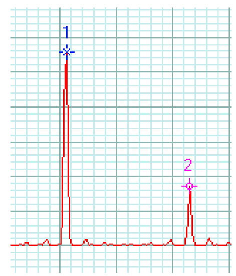
- RMS Amplitude
- Power
- Power Density
- Gain/Phase

The windowing technique can also be selected as follows:

- None
- Hanning
- Hamming
- Blackman-Harris
- Exact Blackman
- Blackman
- Flat Top
- 4 Term B-Harris
- 7 Term B-Harris
- Low Sidelobe

Fourier transforms and windowing techniques are discussed in detail in the **Spectrum** section of the **Settings** menu description above.

As with the **Scope Graph** and **Tracking Graph**, the display controls for the **Spectrum Graph** work the same way, except that the horizontal axis represents frequency instead of time.



A tracer may be moved along the spectrum trace in the same way as the **Scope Graph**. Markers may be placed on the spectrum trace at points of interest by double clicking at the desired tracer position.

	Tracer:Chan A	Mark 1:Chan A	Mark 2:Chan A	Time 0.000 s
Amplitude:	7.384 mV	2790.7 mV	863.2 mV	delta: -1927.5 mV
Freq:	0.000 KHz	1.107 KHz	3.288 KHz	delta: 2.181 KHz

The **Information** area displays information about the position of the tracer, the markers, the amplitude and frequency differences between the markers and the inverse frequency difference between markers, labelled as time.

Signal Information

Information about Channel A and B signal data is displayed in the Signal Information window.

Signal Informat...

Signal Information

Function	Chan A	Chan B
DC	0.408 mV	8.545 mV
RMS	706.9 mV	747.0 mV
Max	999.8 mV	769.4 mV
Min	-999.8 mV	-749.7 mV
Pk-Pk	1999.5 mV	1519.0 mV
Std Dev	711.5 mV	747.2 mV
Period	1428.6 us	2500.1 us
Fundamental Frequency	700.0 Hz	400.0 Hz
Fundamental Peak amp	999.8 mV	954.8 mV
Pulse Length	714.3 us	1250.1 us
Duty Cycle	50.00 %	50.00 %

Information is calculated using: Scope Graph / Tracker Graph

The results of a number of mathematical functions are displayed in a table. Depending on the position of the switch located at the bottom of the dialog box the functions are either calculated using the entire frame of signal data (Scope Graph) or calculated using the signal data located between the markers as positioned in the Tracking Graph.

DC is calculated by taking the mean amplitude value of the signal data (either full frame or between tracking markers). It represents the DC offset of the signal data for which it was calculated.

RMS (root mean square) is calculated by squaring the value of each sample, taking the mean value of these squares; and then taking the square root of this mean value. As for all functions the calculation is either done for the entire frame or between the tracker markers.

Max (maximum) is simply the maximum value of all the samples within the range specified.

Min (minimum) is the minimum value of all the samples within the range specified.

Pk-Pk (peak to peak) is calculated by taking the difference between the minimum value and the maximum value within the sample range specified.

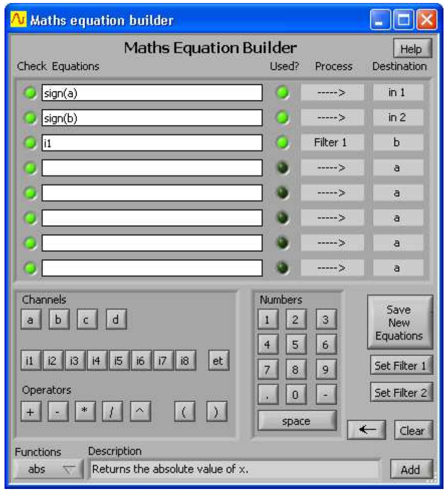
The **Period** is calculated by finding the mid level crossings, and estimating the time between crossings. A hysteresis approach is taken to finding the mid level crossing point to avoid the effects of overshoot and ringing.

The **Frequency** for the highest amplitude component chosen is displayed from a Fourier transform of the signal.

To calculate **Pulse Length** Cleverscope assumes that the signal is repetitive. The pulse length is calculated by finding the mid level crossings and calculating the time difference between the positive going crossing and the next negative going crossing.

To calculate **Duty Cycle** Cleverscope assumes that the signal is repetitive. The duty cycle is calculated by taking the time at which three consecutive mid level crossings occur. The duty cycle is percentage ratio of the time from the first rising mid level crossing to the next falling mid level crossing divided by the time from the first rising mid level crossing to the next rising mid level crossing.

Maths Equation Builder Walkthrough

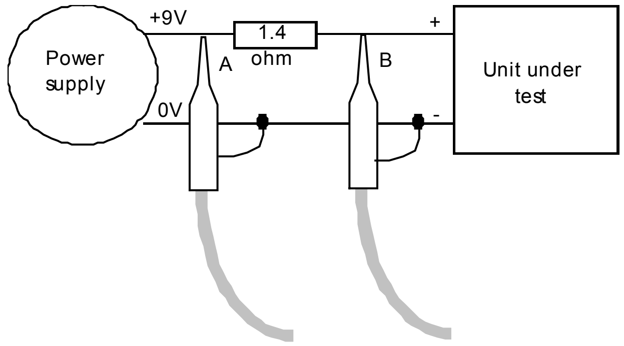


The mathematical functions are very useful for visualising information that can be derived from the measured signals. This section describes deriving first the differential voltage across a resistor, followed by conversion of that value to a current, then using a multiply to derive power, and finally by integrating the power to measure energy.

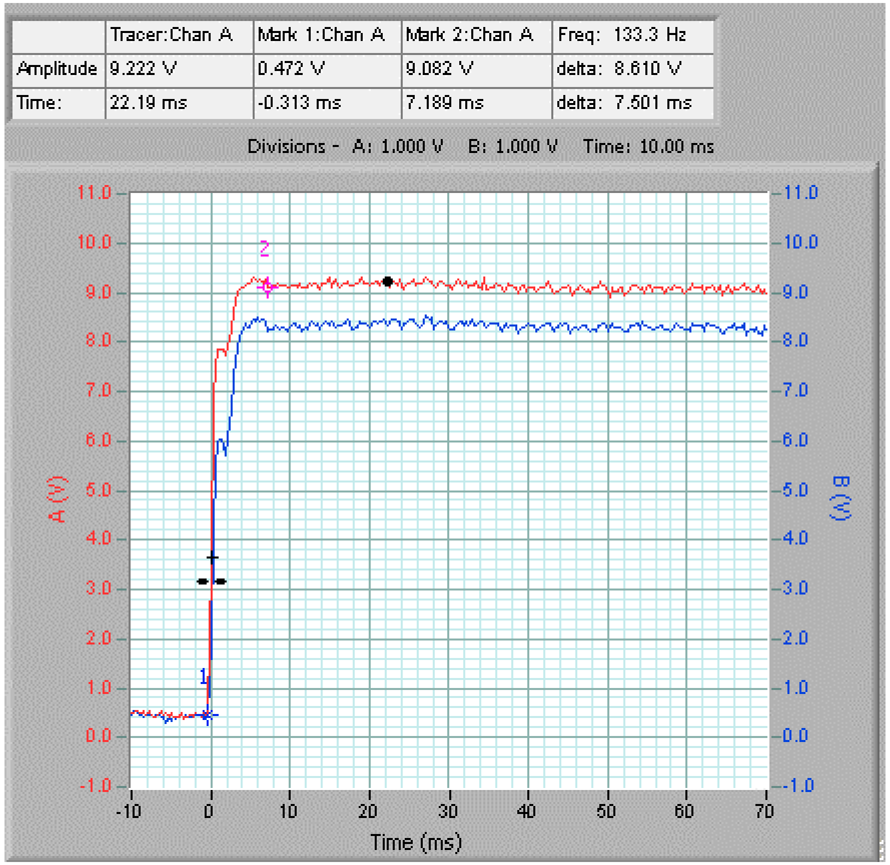
Derivation is very useful in a number of other areas – for example using I and Q signals to demodulate base band signals, using 4 quadrant multiplication to simulate modulation and investigate the resulting signal bandwidth, using filters to estimate what the real world measurement of a conditioned sensor might be.

The Example

As an example consider power consumption measurement. Here is a typical example – a power supply delivers 9V to a battery powered Unit Under Test (UUT). Our goal is to measure current, and power consumption, and arrive at the total energy needs of the UUT. To do this we use a series resistor (it could be a DC capable current clamp) to measure the current. Because the resistor is in the positive line we need to do differential measurements to see the current.



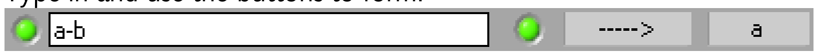
Here is a graph captured from a typical UUT starting up, configured as in the diagram:



Deriving Differential Voltage

Go to the **Cleverscope Control Panel** window.

1. On the **View** menu, click **Display Maths Equation Builder** to show the equation builder.
2. Type in and use the buttons to form:



This equation subtracts each sample value in channel B at a particular time, from the sample value in channel A at the same time. Next it transfers it into channel A.

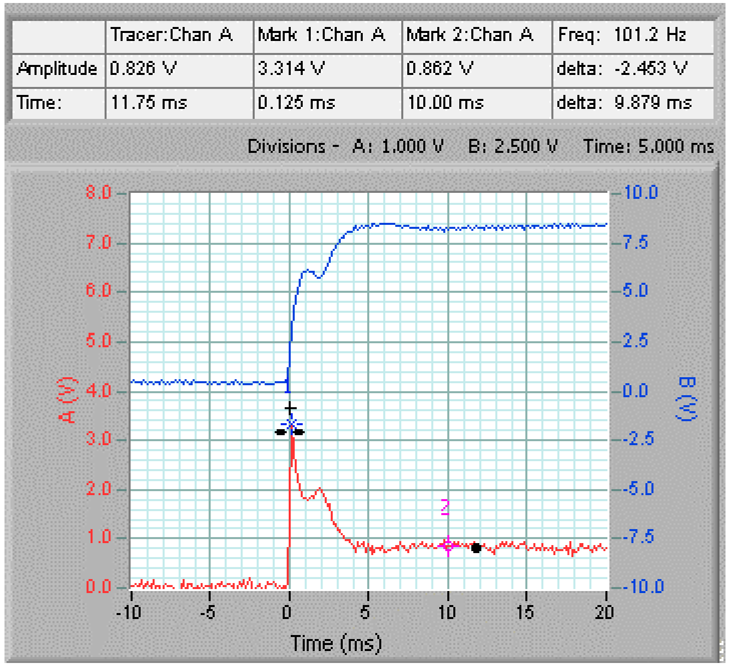
Channel B displays the actual voltage going into the UUT.

3. Click on **Save New Formulas** to save the formula.

Go to the **Cleverscope Control Panel** window.

- In the **ACQUIRE** area, click **Maths** to update the displays to show whatever formula you have entered.

By using **Maths**, with A-B → A, we arrive at the following graph:



Deriving Current

We can see the current demand was initially high, and then fell back following startup. However it would be useful to have this in mA.

From V = IR, and using a 1.4 ohm resistor, we can see that

I = V/R

= V x 1000 x 1/1.4   mA

= 714 V mA

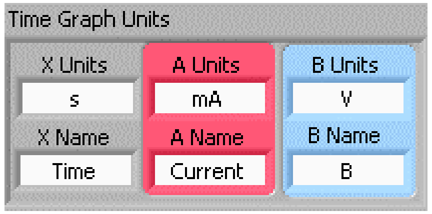
Go to the **Maths Equation Builder** window.

1. Enter equation as:

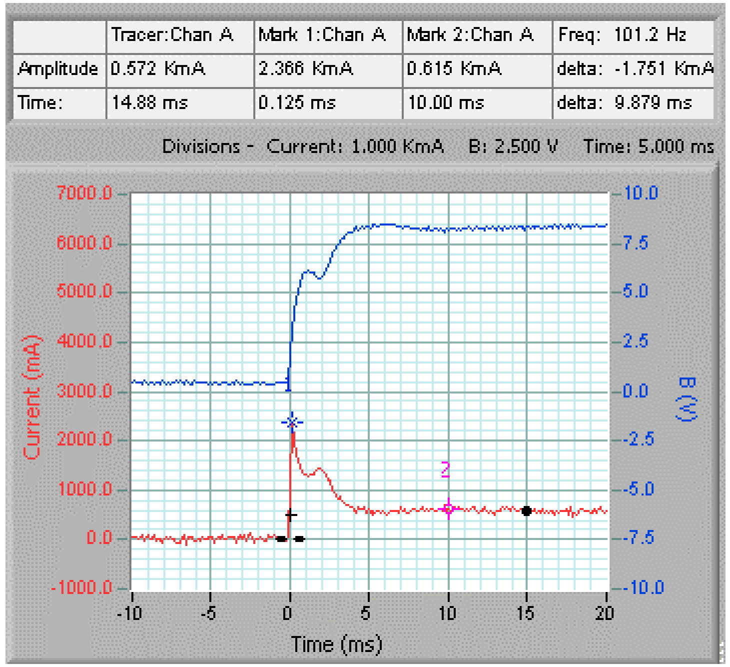
2. Click **Save New Formulas**.

Go to the **Cleverscope Control Panel** window.

1. On the **Settings** menu, click **Analog Names and Units**.
2. Change **A Units** to *mA* and **A Name** to *Current*.
3. Click **OK**.



Note The units and names change immediately on the graphs and information areas:



The graph is much more useful now – we can read the current off directly. We see the following:

1. The peak current demand is 2366 mA.
2. The stabilized current demand is 615 mA.
3. The increased current demand lasts for about 5 ms.

Deriving Power

The B channel shows the actual voltage going into the UUT. Many battery modules are rated in AHr which is the design continuous current consumption available for one hour of use. As an example a 9.6 V (8 cell) NiCad battery pack might be rated at 700 mAHr meaning that after one hour of constant current drain of 700 mA, the battery terminal voltage will have fallen to 80% of the full charge terminal voltage, and the battery will be nearly empty. When using a switch mode power supply, we are more interested in the power consumption, because the current will vary with terminal voltage. Assuming a straight line reduction in battery terminal voltage (i.e. an average of 90% of the fully charged terminal voltage), we can estimate the energy content of the battery in Watt Hr (or Joules, with constant conversion), and use this to calculate actual battery life.

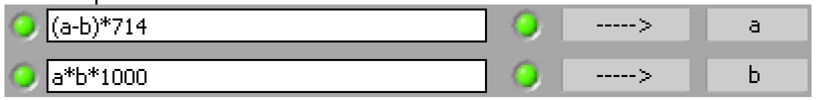
For the battery above, the capacity is:

0.9 x 9.6 x 0.7 = 6 Watt Hour, or

0.9 x 9.6 x 0.7 x 3600 = 21.7 kJoule.

Go to the **Maths Equation Builder** window.

1. Enter equations as:

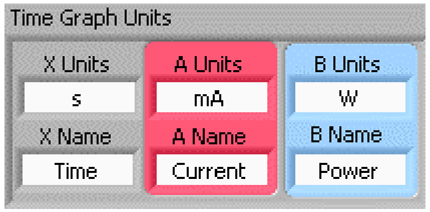


We include the *1000 because the current is in mA, and we want it in A to get W.

Note There are now two equations. The first puts the current into channel A. The second equation runs after the first, and uses the new current values in A to calculate the power.

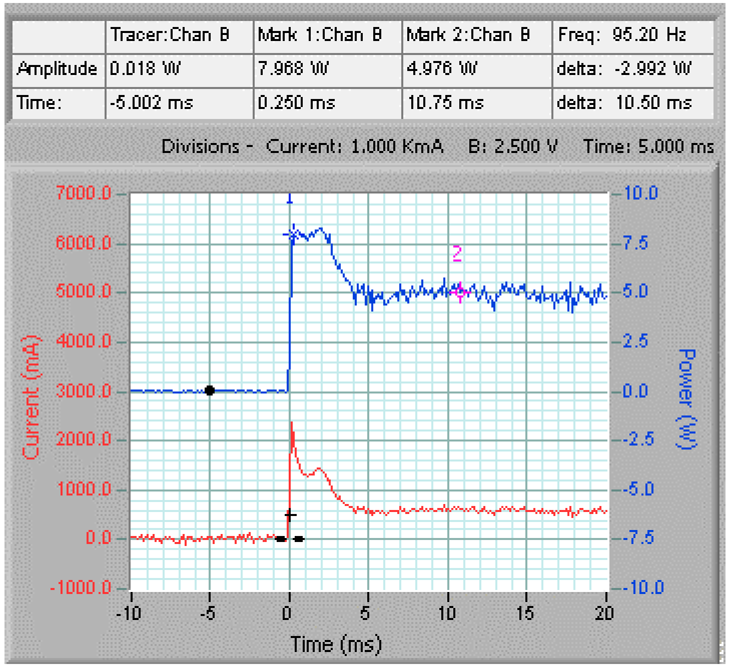
2. Click **Save New Formulas.**

Go to the **Cleverscope Control Panel** window.



1. On the **Settings** menu, click **Analog Names and Units.**
2. Change **B Units** to *W* and **B Name** to *Power.*
3. Click **OK.**

Again we have used the **Maths**, first multiply B x A → B to get Watts in the B channel, and re-label the axis for power:



The peak power usage is 8W, while the normal power usage is 5W. If we ignore the initial power pulse, we could estimate the battery life at 6/5 = 1.2 Hours.

Deriving Energy

If the power consumption is varying markedly, we could measure the actual energy consumption, by integrating the power used over an appropriate period. This can be done with the integrating process applied in the Maths equation.

Go to the **Maths Equation Builder** window.

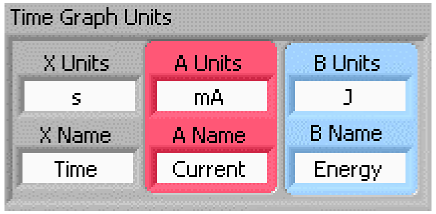
1. Enter equations as:

Note The Integral Process is now turned on.

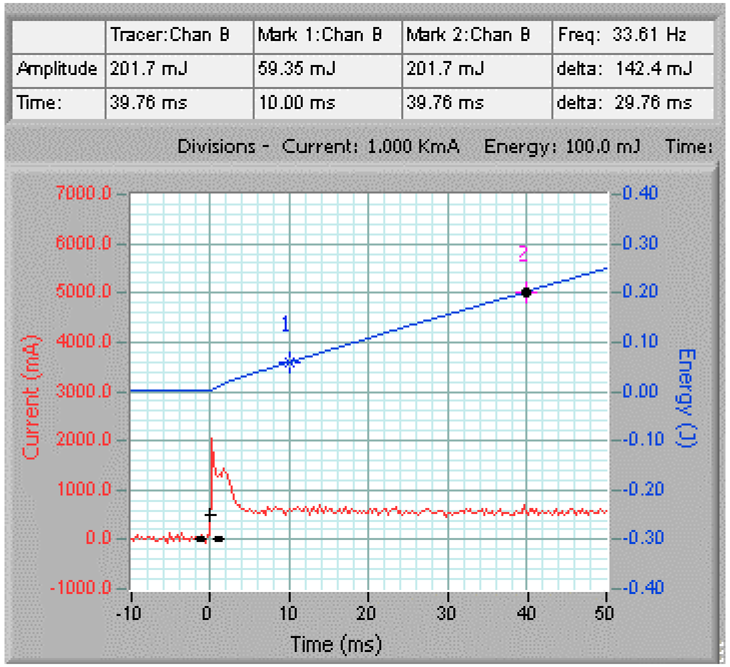
2. Click **Save New Formulas**.

Go to the **Cleverscope Control Panel** window.

1. On the **Settings** menu, click **Analog Names and Units**.
2. Change **B Units** to *J* and **B Name** to *Energy*.
3. Click **OK**.



Just to get a flavour, here is the graph above with an integral applied:



The axis has been relabelled to Energy (J), and shows energy consumed since the start. We see the energy use between Markers 1 and 2 as 142.4 mJ, over 29.76 ms, or 0.02976/0.1424 s/J. As a very rough estimate,

battery life will be:

Life = 21700 (j) x (0.02976 /0.1424) (s/j) = 4,528 secs, or 1.26 hours.

You can see here the great flexibility and reduction in error that can be achieved by using the mathematical equations, and custom units, to make the graphs far more meaningful than the raw measured voltages.

Signal Generator Control

Cleverscope includes an optional direct digitally synthesised signal generator, CS300. The signal generator synthesises sine, square and triangle waves, at a frequency between 0.2 Hz and 10 MHz. You can vary the amplitude over the range 0 → 5V p-p and the offset over the range –4→ + 4V.

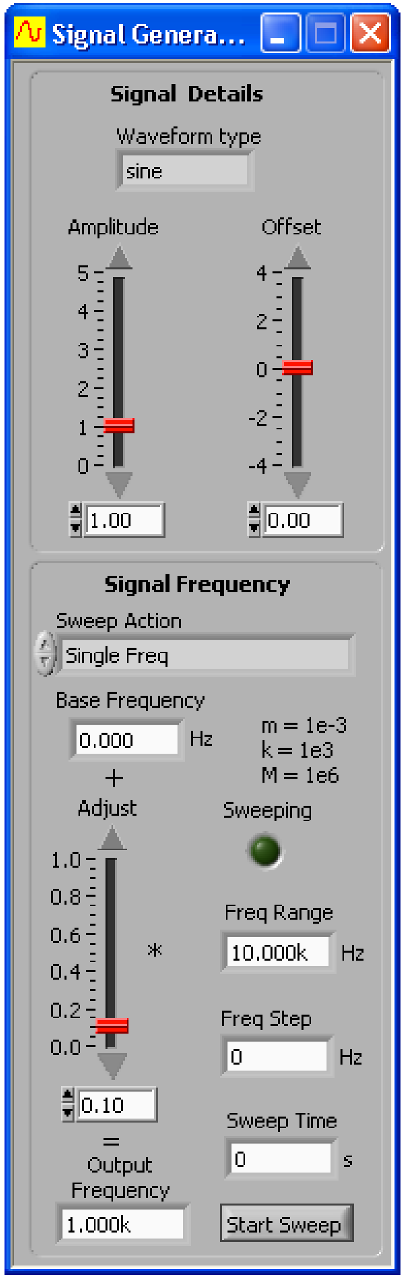
The signal generator outputs samples at a 50 MHz rate and uses a 5th order modified Chebychev reconstruction filter.

The **Waveform Type** can be **sine**, **triangle**, or **square**. **Amplitude** and **Offset** are adjusted using the red sliders or by typing a value in directly.

Base Frequency sets the minimum frequency. **Freq Range** sets the range over which the **Adjust** slider operates. **Output Frequency** displays the actual frequency that is output, i.e. **Output Frequency** = **Base Frequency** + **Freq Range** x **Adjust**.

The **Sweep Action** can be **Single Freq**, **Sweep asynchronous**, **Sweep synchronous**, or **Sweep synchronous autostep**.

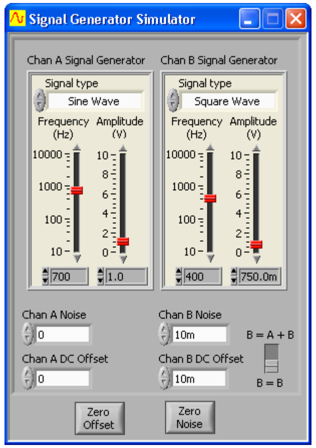
When **Single Freq** is selected, no sweeping occurs. When **Sweep asynchronous** is selected, frequency steps occur at strict fixed time intervals and are therefore asynchronous with



and are therefore asynchronous with
the sampling system. When **Sweep synchronous** is selected, frequency is only adjusted between sample frames. Since this is synchronous with the sampling system no smearing of the spectra will occur. **Sweep synchronous autostep** is the same as **Sweep synchronous** only the **Freq Step** is determined by Cleverscope to achieve the highest resolution for a Bode plot.

Freq Step controls the size of each step during a sweep. **Sweep Time** sets the total time of the sweep. **Start Sweep** starts and stops the sweep. The **Sweeping** LED indicates when a sweep is in progress.

Signal Generator Simulator



The Cleverscope signal generator provides built-in software generated signals for both the A and B channels that can be used to demonstrate the capabilities of the Cleverscope application software without requiring a Cleverscope hardware unit.

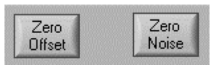
The Cleverscope Signal Generator control window enables you to alter the frequency, amplitude and wave-shape for both channel A and channel B of the internally generated signals.

The choices for wave-shape are sine, triangle, square and sawtooth. These choices can be selected independently for channel A and channel B using the signal type selection boxes at the top of the signal generator setup dialog box.

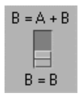
You can also add background noise and a DC offset to the generated signals to make them more closely approximate real-world signals that might be captured using a hardware unit.

The amplitude of background noise can be adjusted using the Chan A or B noise selection boxes.

The level of DC offset can also be adjusted using the Chan A DC offset or Chan B Noise offset selection.



The offset and noise levels can be zeroed using the buttons provided at the bottom of the signal generator setup dialog box.



Selecting B = A + B using the switch provided at the bottom right of the signal generator setup dialogue box will cause the sum of the channel A and B internally generated signals to be directed to channel B for display.

Cleverscope Support

The Cleverscope software has been developed by Cleverscope Ltd. as a tool for displaying and manipulating captured analog electrical signals on a PC.

It can be set to work with a variety of other signal acquirers including the Strobes 901/901A Acquisition Units or an internal soundcard.

If you are having problems, please contact us at:

Email support@cleverscope.com

Phone +64 9 524 7456

Mail Cleverscope Ltd.
P. O. Box 26-527
Epsom
Auckland
New Zealand

Minimum PC Requirements

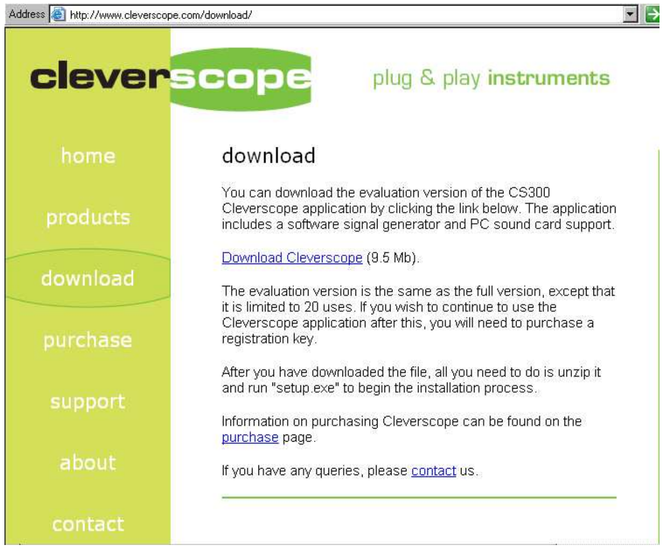
The minimum PC requirements to use the Cleverscope CS328 are a Pentium class computer with at least 64 Mbyte of memory.

Full performance is assured with a Pentium III+ computer running at 500 MHz or more and with 64 Mbyte of memory or more.

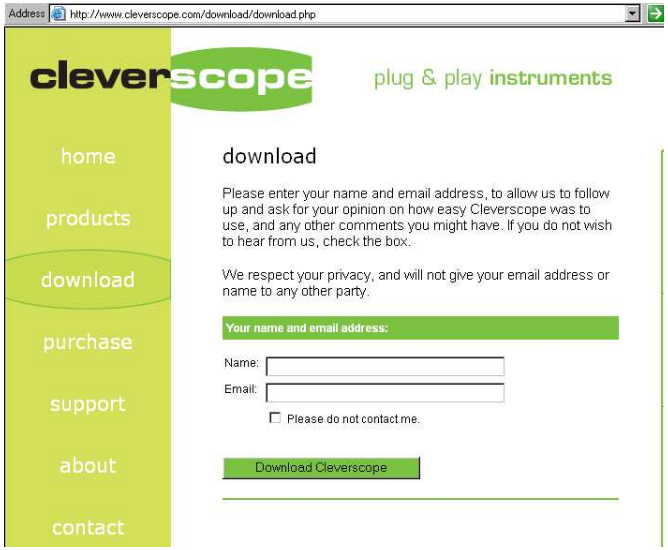
Download and installation of software

You may download a copy of the latest Cleverscope application software from the Cleverscope website at www.cleverscope.com. The following explanation is for Windows XP and the process will vary slightly for other operating systems.

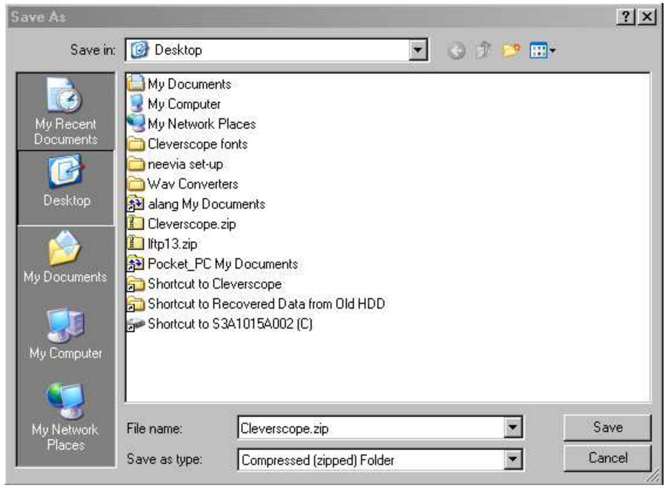
Visit the www.cleverscope site, and then go to the download page shown below.



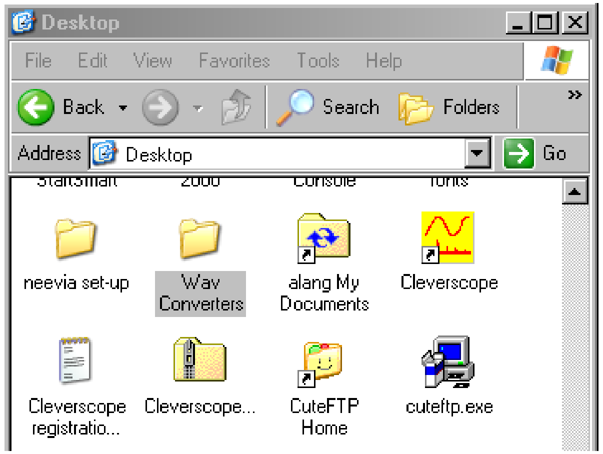
Next you click on download Cleverscope.



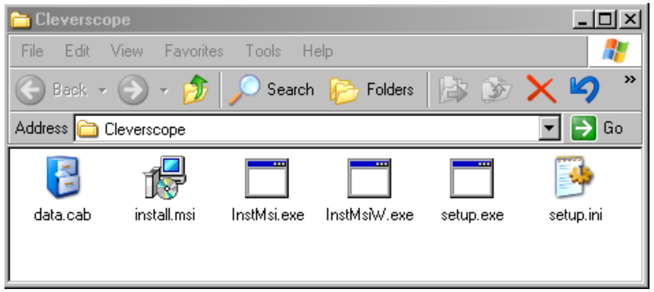
You will then be downloaded a zipped file which must be saved.



Choose the option of saving the zip file rather than opening it. In this example it has been saved on the desktop.

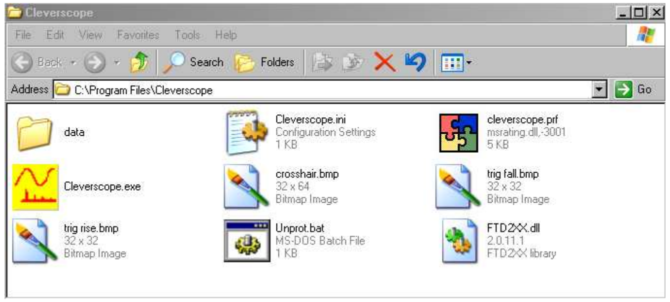


You then unzip the file and you will be presented with a Cleverscope folder containing a number of files. Double click on setup.exe to run the Cleverscope installer



The installer will create a Cleverscope folder in your program files folder and save a number of files into it. It will also create a desktop icon and an entry in the programs menu under the windows 

button.



You are then able to run a demonstration version of Cleverscope.

Specification

Acquisition

Acquisition Modes	Sample, Peak Detect, Filtered, Average, Spectrum
Acquisition Modes	Single Shot, Triggered, Automatic, Multiple Frame
Acquisition Rate to PC, via USB	10 Frames per second
Acquisition Rate, multiple frame	Continuous capture until buffer is full (4000 frames of 1024 samples)

Analog Inputs

Number	2
Input Coupling	DC, AC, GND
Input Impedance, DC coupled, all channels	1 MΩ ±2% in parallel with 20 pF ±3 pF
Probe Attenuation	1X, 10X
Maximum Voltage between Signal and Common at input BNC	300 Vrms (420V peak, duty cycle <50%, pulse width <100 ms) For steady state sinusoidal waveforms, de-rate at 20 dB/decade above 100 kHz to 10 Vpk at 3MHz and above.
Time delay between channels, typical	200 ps
Channel to Channel Crosstalk, typical	-70 dB at 20 MHz, signal at 0.5 Full Scale.

Vertical

Digitizers	10 bit resolution
Full Scale Volts Range	100 mV to 20V, 1X probe
Resolution	0.1 mV, 100 mV Full Scale.
Position Range	Full Scale Range as above moved anywhere in the range ±12.5V with 10mV resolution.
Analog Bandwidth	120 MHz, -3dB
Instantaneous Capture Bandwidth	25 MHz, with sin(x)/x interpolation
Repetitive Sampling Bandwidth	100 MHz, -3 dB
Analog Bandwidth in Peak Detect Mode	50 MHz
Analog Bandwidth with Anti-Aliasing filter on	25 MHz 5^{th} Order 0.5 dB passband ripple, 50 dB down at 100MHz.
Analog Bandwidth with Moving average filter on	2 MHz
Lower Frequency limit, AC coupled	10 Hz, 1x probe, 1Hz, 10x probe
Rise time at the BNC, typical	<3 ns
Peak detect response	Captures all pulses >10 ns in duration.
DC Gain accuracy	±3% for Sample or Averaged acquisition mode
DC Measurement accuracy	±3% for Sample or Averaged acquisition mode +0.1 divisions.
Delta Volts measurement	Volts between any two points, ±3% for Sample or Averaged acquisition mode +0.02 divisions.

Horizontal

Sample Rate Range	100 MSa/s to 1500 samples/s
Waveform interpolation	Sin(x)/x
Record Length	1024 – 4,000,000 samples for each channel
Sec/Div Range	10 ns/div to 5 s/div in 1,2,5 sequence

Sample Rate and Delay time Accuracy	+/50 ppm over any >1 ms interval
Sample Clock jitter, typical	1 ps rms
Delta Time Measurement Accuracy	(±1 sample interval + 50 ppm +0.4 ns).
Position Range	+/- 21.47 secs of the trigger point, with 10 ns resolution.
Captured Sample window duration	1 µs – 40 ms with 10ns resolution 40 ms – 42.9 secs with 10 ns - 10 µs resolution. (Lower sample rates are available for smaller capture buffer sizes)

Trigger

Trigger Sensitivity, Edge Triggered	Analog Channels – 0.02 Div from DC to 50 MHz Analog Hardware Trigger – 0.5 div from DC to 100 MHz External Trigger – 50 mV from DC to 100 MHz Digital Inputs – 100 mV from DC to 100 MHz Rear Input – 2.5V fixed
Trigger Modes	Edge, Window, Pattern, Pulse Duration
Trigger Filtering	Noise reject, HF reject, LF reject
Trigger Level Range	Internal: ±10 divisions from centre of screen External: ±12.5V in 12 mV increments Digital: 0 – 10V in 10 mV steps
Trigger Level Accuracy	Internal: ±3% External: ±3% + 50 mV Digital: ±3% + 100 mV
Holdoff Range	0 – 42.9 secs with 10ns resolution
Trigger Delay Range	0 – 21.47 secs with 10ns resolution.

Digital Inputs

Number	8
Input impedance	100kΩ ±2% in parallel with 10 pF ±2 pF
Input voltage range	-16 to + 20V
Threshold range	0 – 10V in 10 mV steps
Threshold sensitivity	100 mV
Sample Rate	100 MSa/s

Calibration

Calibration method	Automatic self calibration
Calibration Voltage Source	Range +/-2.5V Resolution 1 mV Drift 11 ppm/°C Accuracy ±1%
Calibrated Temperature Range	0-40 °C in 1 °C steps
Temperature Compensation	Via Internal temperature sensor, ±1.5°C accuracy

Displays

Windows	Simultaneous Capture, Tracking, Spectrum, Information and Control windows
Capture window functions	Defines capture specification for signal acquisition unit, defining amount of time before trigger, amount of time after the trigger, lower amplitude limit, upper amplitude limit. Defines Tracking graph time position, when tracking graph is linked. Defines trigger level and direction Full zoom and Pan in both axis. Annotations. Custom colours
Tracking window functions	Displays zoomed section of captured signal. Resolution from 10ns to 5s/div. Full zoom and Pan in both axis. Annotations. Custom colours
Spectrum window functions	Display spectrum of signal captured in capture window. User definable bandwidth User definable resolution Full zoom and Pan in both axis.

	Annotations. Custom colours
Information window functions	Displays automated measurements (see below) User chooses which measurements to show.
Control window functions	Provides graphical control horizontal and vertical settings. Provides Sample control – single, triggered or automatic. Provides access to tools – Pan, Zoom, Annotate, and Trigger setting. Provides Autoscale control.

Measurements

Cursors	Voltage Difference between cursors Time difference between cursors Reciprocal of ΔT in Hertz ($1/\Delta T$).
Automated measurements	DC component RMS value Maximum voltage Minimum Voltage Peak-Peak Period Frequency Pulse width Duty Cycle RT60
Custom units	6 characters
Custom signal names	20 characters
Custom scaling	Scale + offset by defining two (Vin, Vout) points
User definable colours	Signals, Background, Major Grid, Minor Grid

Mathematical Functions

Functions on one signal	Inversion, Differentiation, Integration
Functions between two signals	Addition, subtraction, multiplication, division, squaring, square root, (inverse) sine, cosine, tangent,
Maximum number of mathematical operations	5

Spectrum Analysis

Frequency Range	User definable, Range = 0- $F_{sample}/2$
Analysis Output	RMS Amplitude, Power, Power Density, Gain/Phase
Output type	Volts, Power, Gain/Phase in linear, dB, degree or radian values. Custom units can be applied.
Window types	None, Hanning, Hamming, Blackman-Harris, Flat top, Low Sidelobe
Averaging	Moving average, block average, peak hold.
Averaging method	Vector averaging in time domain if triggered. RMS averaging in frequency domain if not triggered.

Windows facilities

Standard Functions	Copy and Paste Save and Open native format (saves full setup) Save and Open (*.csv) text file Print with Date/Time, File Name and Description. Print Setup
Windows	Dynamically resized Can be placed anywhere on desktop

	Can be made to stay in front
User settable units	6 characters
User settable signal names	20 characters
User settable scaling	Scale + offset by defining two (Vin, Vout) points
User definable colours	Signals, Background, Major Grid, Minor Grid

Probe Compensator Output

Output Voltage, typical	3V into >100kΩ load
Output Frequency	1 kHz

Power Source

Source voltage into unit	6-14V DC
Power Consumption	5W
Standard power adaptor voltage range	100 – 240VAC 50-60 Hz

Environmental

Temperature	Operating: 0°C to +50°C Storage: -20°C to +60°C
Cooling Method	Convection
Humidity	0°C to +40°C <90% relative humidity >40°C <60% relative humidity
Altitude	Operating 3,000 m Non-operating 15,000m

Mechanical

Size	Height 35 mm Width 153 mm Depth 195 mm (including BNC)
Weight (approx)	Standard packaging: 2 kg

Expansion Capability

Increase in sampling channels	Stack two units on top of each other. Delivers 4 analog, and 16 digital channels. A link cable CS310 is required.
Signal Generator Output	Plug in DDS based 0-10 MHz signal generator, CS300.