



plug & play instruments
oscilloscopes

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Integration with Cleverscope

Cleverscope can be used to calculate the time integral of a waveform, using the Maths Graph.

As an example, a common problem is to estimate the battery life of some equipment that does not draw continuous power. Below is the time graph of a transmitting device that activates twice per second. An 0.86 ohm resistor made a handy current probe.

The current is thus $I = V_i/0.86$. We can estimate the power when using a supply voltage of V_s as $P = VI = V_s V_i/0.86$.

The total energy will be
 $E = \int P dt = \int V_s V_i/0.86 dt$.

In many situations filtering is also useful – here our measurement is polluted with some switch mode power supply noise. To eliminate this, we used a 1KHz Bessel filter (linear phase) to reduce the noise.

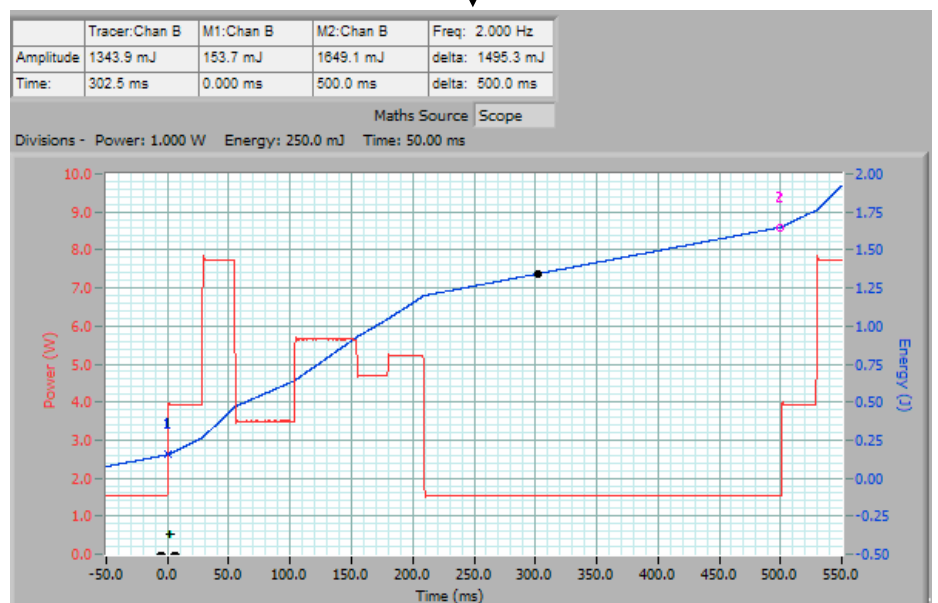
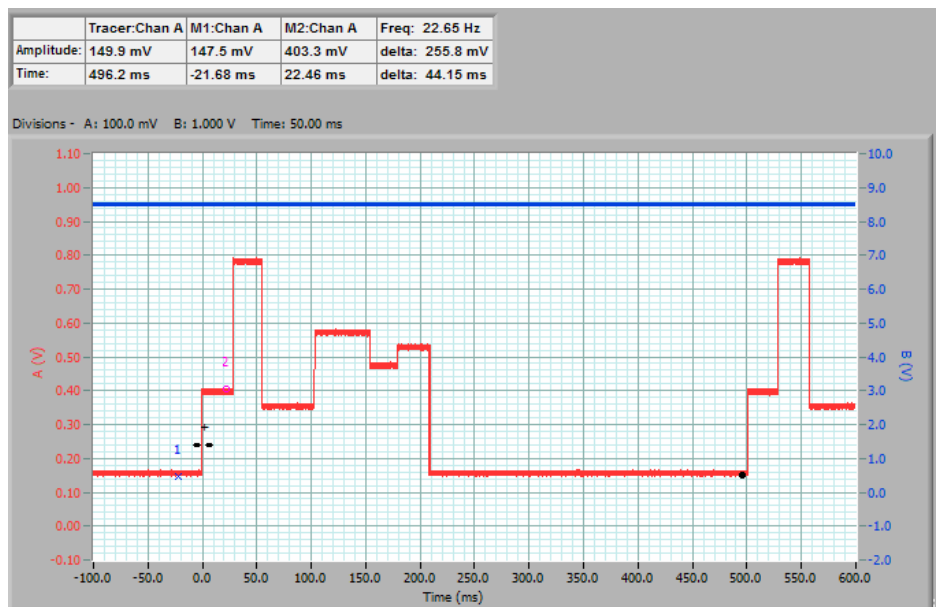
The first graph show the input signals (A is V_i , and B is V_s) – note the noise.

We use the Maths Equation Builder (View/Maths Equation Builder) to build two equations. You can either just type them in, or use the builder functions at the bottom of the window.

Equation	Process	Destination
$(a/0.86)*b$	Filter 1	a
a	Integral	b

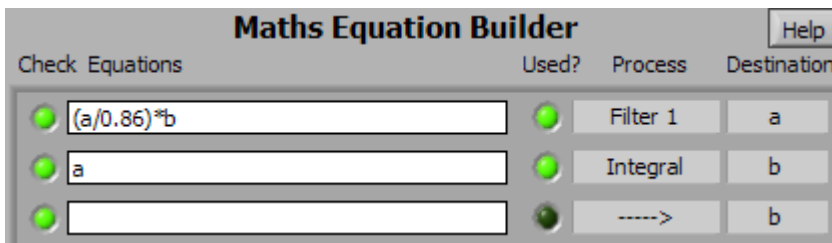
In the first equation we calculate power, and filter the signal, and send it to the A channel. In the second equation we take the integral of the power, and send it to the B channel.

Note that the Maths graph has reduced noise, because of the filter, and it is also using custom units – displaying values in power and energy. Markers were used to measure the energy difference between two points. The total energy used for a 500msec period was 1.495 Joule (or Ws) - the difference between Markers 1 and 2.



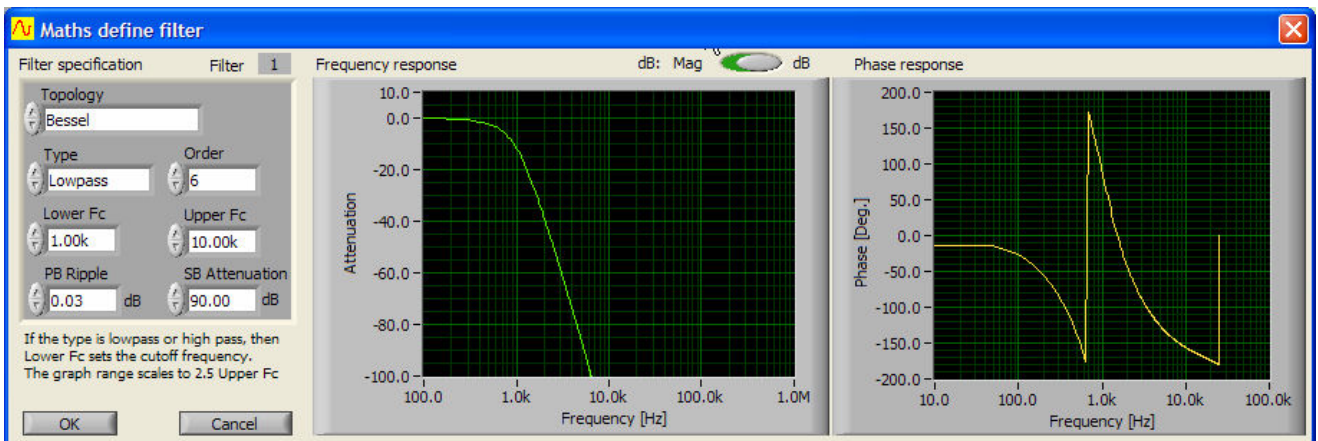
Say we have a 6Ah 9V battery, this has a capacity of about $6 \times 9 \times 3600 = 194.4 \text{ kJ}$. Thus this battery could run the device for $194.4 \text{ kJ} / 1.495 = 130,033 \text{ cycles}$, or $65,016 \text{ seconds}$ – about 18 hours.

Here are the applicable equations:

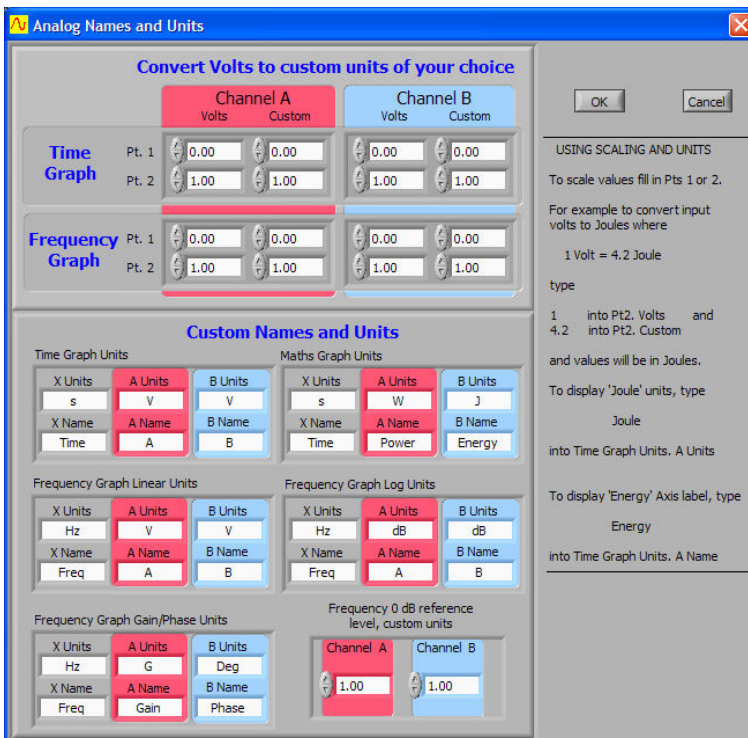


Note that you need to set up the Filter by clicking on Set Filter 1, and once everything has been set up click on Apply Equations.

For this example we used a 1 kHz low pass Bessel (linear phase) filter:



To display the graph in the correct units, we used the Settings/Display Analog Names and Units, and set the Maths Graph units:



Integrating over small time differences

The integral is over time. This means that if dT (the underlying sample interval) becomes small, then so will the integral. It is useful in these circumstances to pre-multiply the value to be integrated with a constant to compensate for the time units used.

As an example we integrate a triangle wave with a time base of 5ms/div, and send the result to Channel B:

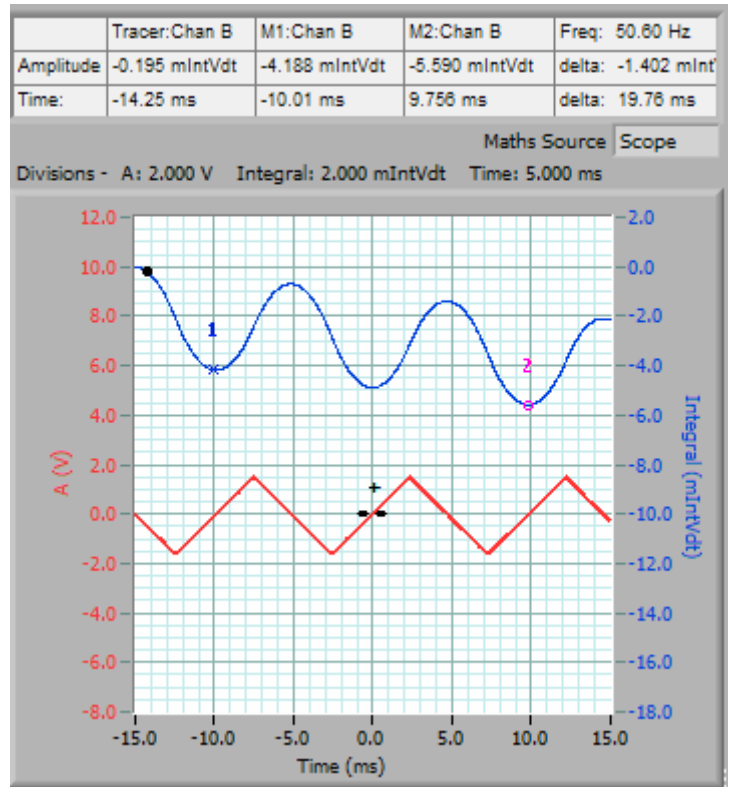
Because we are integrating in the ms time scale, we pre-multiply the signal by 1000, and set the units to mIntVdt (to indicate what we are doing).

The signal has a slight DC offset, which we can see in the Integral's slight downward trend.

The difference between the two markers shows the integral of this DC offset (-1.402 mIntVdt).

If we did not pre-multiply, then the displayed numbers would all be of the order 0.001.

Channel A shows the original signal.



We used a Maths Equation Builder setup of:

Maths Equation Builder

Check Equations	Used?	Process	Destination
<input checked="" type="checkbox"/> a*1000	<input checked="" type="checkbox"/>	Integral	b
<input checked="" type="checkbox"/> a	<input checked="" type="checkbox"/>	---->	a
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	---->	b
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	---->	a
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	---->	a
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	---->	a
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	---->	a
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	---->	a