

Phase Measurement with Picoscope

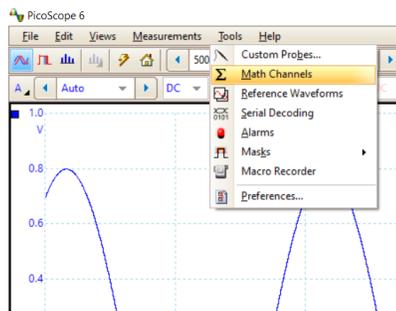
(compiled JE 15 Sep 2020)

This is a quick note with directions of how to add a “Math Channel” to make a phase measurement with Picoscope.

The tech note below is based on this forum post: <https://www.picotech.com/support/topic10569.html>

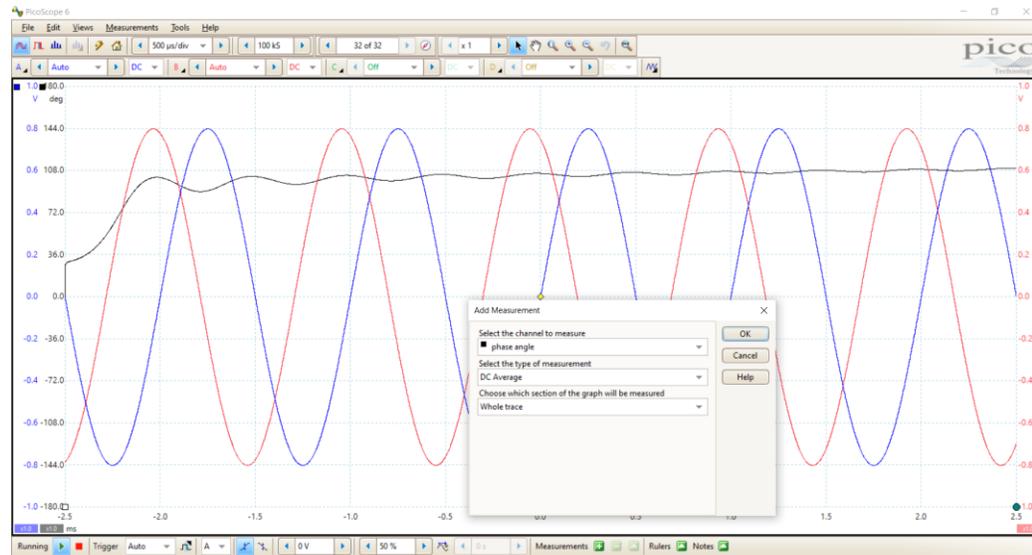
Directions:

1. Add a Math Channel.
 - a. Select “Tools > Math Channels...”



- b. A box will pop up “Create New Math Channel”. Click “Next”
 - c. In the top text box under “Enter the equation for this Math Channel, enter the following:
$$\text{acos}(\text{integral}(A*B) / (\text{sqrt}(\text{integral}(A*A)) * \text{sqrt}(\text{integral}(B*B)))) / \text{Pi} * 180$$

You can read more below how this formula works
 - d. Click Next
 - e. In the “Math Channel Wizard Box” you can name the channel using the eponymous text box “Name”. Type in “Phase angle” or something similar. You can also choose the color that the math channel will display in the oscilloscope. Then click Next.
 - f. For Units: there are two fields. For “Long Name” enter “degrees” and for short name “deg”. For Range: you can optionally click the “Override automatic range selection” box and then enter in the range -180 to 180 deg. Note, if you don’t like degrees, you can modify the formula above to keep everything in radians, then update the Units here accordingly.
 - g. The last box asks you to confirm everything looks right. If so, click Finish.
 - h. Now, in the Tools > Math Channels menu, look under the “Library” section. You should see your newly created “Phase angle” channel. Click the box to the left of it and click OK. A phase vs time plot should now appear! (E.g. see below).



2. **Measuring the phase angle:** Now that the Phase channel is being displayed on the plot, we can make various measurements using that data, just like we can for channels A or B.
 - a. Select Measurements > Add Measurement...
 - b. When the box pops up, select your phase channel. Then select “DC average”. For now, just leave the third box as “Whole trace”. This tells Picoscope to use all data displayed on the plot. The start-up transient that is clearly problematic factors into this calculation for now. If the measurement is bunk, you can go back and select “Between rulers” then drag the little dots at bottom left and right to set the time window in which the phase is computed. A bit more trouble than its worth in my limited experience.
 - c. Look at the bottom, the phase measurement, averaged over the data displayed is now printed before your very eyes. Be VERY careful to note if this is a positive or negative phase angle. If channel A (blue) is V_{in} and channel B (red) is output, in view of the figure below, we can see that blue (input) hits a peak AFTER red (output). In other words, the input LAGS behind the output. This goes in the books as a negative phase angle. Conversely, if the input hits a peak just before the output, that goes in the books as a positive phase angle. *Let your eyes do the looking and your brain do the thinking—don't just write down whatever picoscope prints out.*

3. **How the phase formula works.** This is basically a correlation metric. Note the formula computes 3 integrals. The numerator computes the integral of $A*B$, where A and B are the “math functions” being displayed on the scope. If A and B are the same (perfectly correlated), the integral is maximized—e.g. this just becomes $\cos \omega t * \cos \omega t = \cos^2 \omega t$, which is always positive, hence the integral is maximized. If A and B are 90 degrees shifted, they show no correlation, in which case, the integral of $A*B$ time averages to 0. The denominator basically computes A^2 and B^2 integrals, which normalizes the argument of $\text{acos}()$ to be in the range of -1 to 1.

The integrals part computes as 1 when perfectly correlated (0 deg phase shift); 0 when no correlation (90 deg phase shift); and -1 when anti-correlated (180 phase shift). The `acos(.)` function converts the correlation measure back into radians, and `Pi/180` converts to degrees