ECE 4117

Experiment 1

Modeling Equations with TIMS;

Getting Acquainted with PICOSCOPE

The purpose here is to become acquainted with how equations are modeled using the TIMS modules, and to become acquainted with the Picoscope virtual oscilloscope and spectrum analyzer.

Read the “Instructions and Lab Reports” document, and read the material through p. 18 of the Volume A1 manual. As you perform other experiments you may need to go back and reread these again.

Graphs can be copied as graphs using “edit” from the menu, then after opening MS Word, using the MS Word menu save as a JPEG document. In your report these graphs can be adjusted to a reasonable size using the tabs on the sides and top or bottom. You can use other procedures, but this one works well.

For this and all other experiments, leave the black BNC cable connectors that go to the Tektronix oscilloscope on top of the console connected as they are. This oscilloscope is independent of the virtual oscilloscope (“Picoscope”) on the PC.

Squares and products of sinusoids:

This experiment is not in the manual. Hopefully the directions below will be sufficient for you to proceed, but if not, please ask me to clarify.

Some well-known trigonometric formulas of great interest and usefulness in this course are:

$$[A\,\sin(\omega_0 t)]^2 = A^2/2[1 - \cos(2\omega_0 t)] \qquad (1)$$
$$[A\,\cos(\omega_0 t)]^2 = A^2/2\,[1 + \cos(2\omega_0 t)] \qquad (2)$$
$$A\,\sin(\omega_0 t)\,B\,\cos(\omega_0 t = AB/2\,\sin(2\omega_0 t) \qquad (3)$$
$$A\,\cos(\omega_1 t)\,B\,\cos(\omega_2 t) = AB/2\,\{\cos[(\omega_1+\omega_2)t] + \cos[(\omega_1-\omega_2)t]\} \qquad (4)$$

Equations 1 and 2:

Turn all equipment on, and log on to the PC. Since (1) and (2) are essentially the same except for phase, a single experiment will suffice for them. Select either the “sine” or “cos” terminals of the audio oscillator, and connect leads to both the X and Y terminals of the multiplier. Check frequency using the frequency meter, and set at about 1 kHz. The multiplier should have the “dc” switch on, so that if there is a dc voltage you will be able to see it on the scope.

Connect the 1 kHz waveform to CH A1 on the Instrument module, and connect the multiplier output (kXY) to CH B1 (toggles “up” in both cases).

Since the multiplier output is “kXY” (a constant times the product of X and Y) its scale will not generally be as predicted by the equations above.

Open Picoscope. Set sweep to 1 millisecond/division. Set Ch A – Auto – AC - X1 and Ch B – Auto - DC – X1 across the bar for the settings. The “X1” setting in each case gives a scroll bar on the left and a scroll bar on the right of the display. These you will use to shift the waveforms so they don’t overlay. If you don’t use X1 you won’t be able to separate the traces vertically.

Set so that Ch A (blue) is at the bottom and Ch B (red) is above it enough for no overlap. (See example at the end of these instructions.). In using this display sometimes an inadvertent mouse click at the wrong place will create a vertical or horizontal marker bar on the screen, but you can move it off screen with the mouse.

Also on the Tektronix Ch B you should have DC coupling so that you can see the same information there that you see on Picoscope.

Note that the red trace on the graph below has a DC component, as shown by the lower peaks being at 0. This is the "$A^2/2$" part of (1) or (2), by itself. The $A^2/2$ cosine is, of course, the AC part of the red waveform. (Although, as noted, the scale with respect to the B channel depends on the "k" of the XY multiplier, which cannot be adjusted.) Copy and identify with a proper figure caption, as for example in the sample graph below.

Now change Ch B to AC coupling. The voltage swings should now be symmetric above and below the 0 axis. Copy and describe properly, as Fig. 2 of your report..

Click on the yellow icon at upper left of the settings bar; this will give you a display of the frequency spectrum. Set for the 4.8 kHz maximum. With both Ch. A and Ch. B on and with DC coupling for Ch. B, you will see lines at 0, 1 kHz and 2 kHz. Copy and identify as Fig. 3 and give it a caption that tells what it is. Since it won't be clear in a black and white copy, include a statement in your figure caption that the DC and 2 kHz signals belong together (output of multiplier), while the 1 kHz signal is by itself, as the input to both channels of the multiplier. Change Ch. B to AC coupling, and the DC component should disappear while the AC components have the same peak-to-peak values. This will give you Fig. 4, and again give it a proper description in your caption.

Equation 3:

(**AC/DC???**)For verification of Eq. 3 you can leave all scope settings the same. Now we want two inputs to the multiplier, one from "sin" and one from "cos" of the audio oscillator. Ch. 1 of the Tektronix and Ch. A of Picoscope can be either of these, we only want to see the frequency. Ch. 2 / Ch. B will again be the output of the multiplier. Again, get a hard copy in time domain and one in frequency domain; these will be Figs. 5 and 6, respectively.

Example

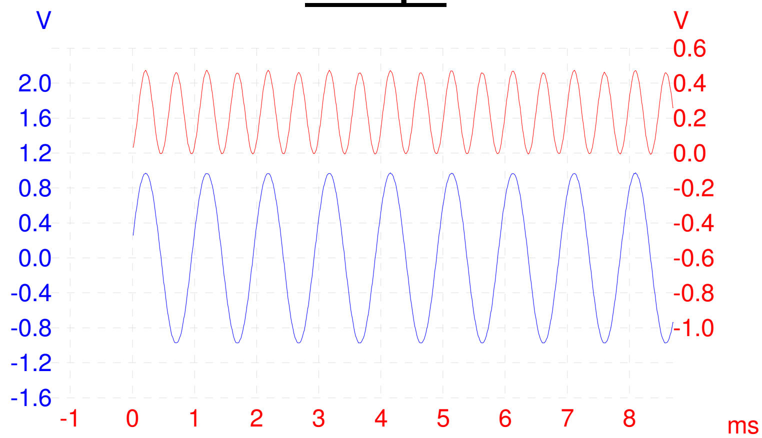

Fig. 1. The upper trace waveform is double the frequency of the lower due to the squaring of the bottom sinusoid. It also has the DC shift predicted by Eqs. 1 or 2 and its amplitude is ½ that of the lower trace..

Certification: I hereby certify that performance of the experiment above and the writing of this report was entirely by me (or by me and my lab partner). I understand that if this certification is false, I am in violation of Academic Honesty rules and may be subject to serious penalty in accordance with those rules.

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