Calculating Area In X-Y Displays

Waveform Math Finds Area Enclosed By X-Y Display

Many applications involving cyclic phenomena result in the need to determine the area enclosed by an X-Y plot. A typical example is the power loss per cycle in a magnetic core which is proportional to the area enclosed by a plot of magnetic field intensity against flux density. This area can be readily measured using waveform math available in LeCroy oscilloscopes.

The area enclosed in an X-Y plot can be calculated as :

$$\text{Area} = \int y(x)\,dx = \int x(y)\,dy$$

The oscilloscope has the data for both traces as a function of time, t. The variables can be changed in the integral to calculate the area based on the acquired traces:

$$\text{Area} = \int y(t)\,\frac{dx(t)}{dt}\,dt$$

$$= \int x(t)\,\frac{dy(t)}{dt}\,dt$$

To implement this on a scope we have to differentiate one of the traces then multiply it by the other trace and integrate the result. The integral, evaluated over 1 cycle of the periodic waveform, equals the area contained within the X-Y plot.

Figure 1 shows an X-Y plot enclosing a circular area. Based on the geometry of the display

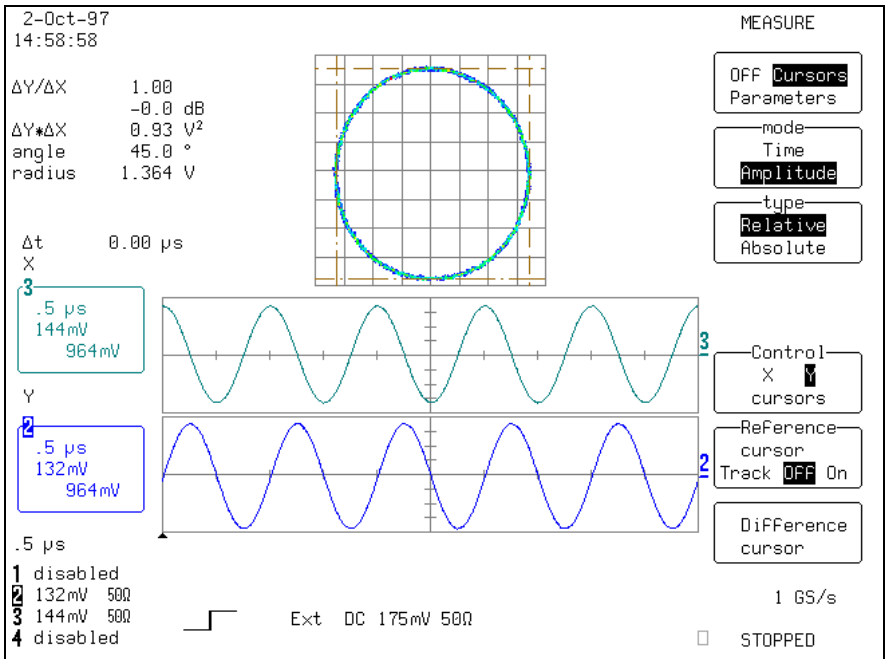

Figure 1 Area of circle = p(.964/2)^2 = 0.730 V^2

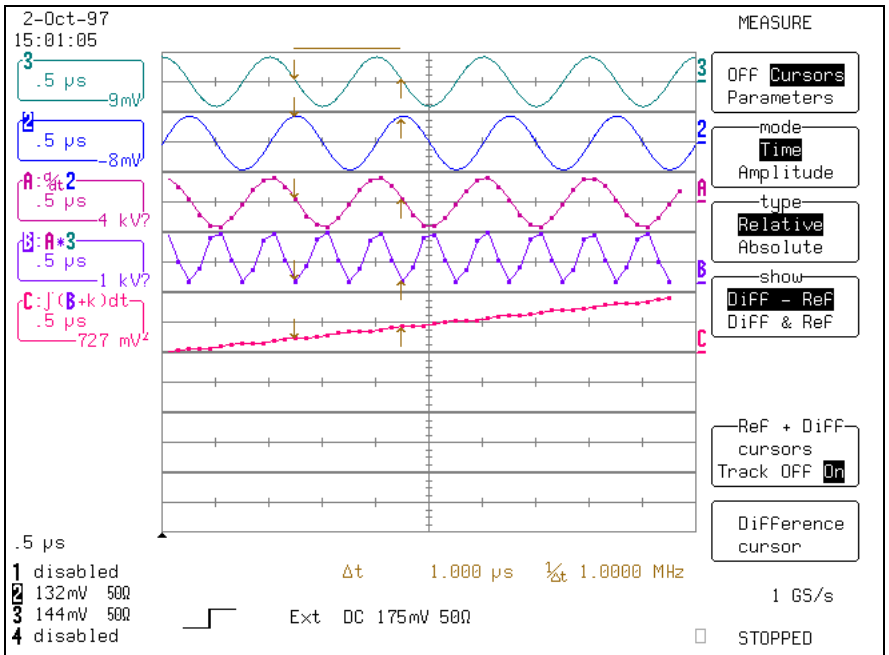

Figure 2 - Calculated area = 0.727 V^2

measured using the X-Y cursors we can determine the enclosed area as a test of the process outlined above. The relative amplitude cursors measure the diameter of the circle as 964 mV. In

figure 2 the actual calculation is performed with closely matching results.

Some hints to maximize accuracy:

1. The derivative should be calculated with the minimum number of points to minimize noise. In the following examples the math operations were performed using 50 points.
1. Maximize the input signals in the dynamic range by using the variable attenuator.

Figures 3 and 4 contain another example using an easily verified figure, a square. The geometric area is determined using the X-Y cursor readouts as 0.46 V^2. Calculation of the area yields an result of 0.461 V^2 as read from the cursor readout field for trace C

LeCroy oscilloscopes offer a high level of functional integration which is evident in this application. X-Y displays include both Cartesian and polar coordinate cursors making reference measurements easy. Math functions can be chained permitting up to 4 simultaneous math operations at one time yielding an answer on a single screen display..

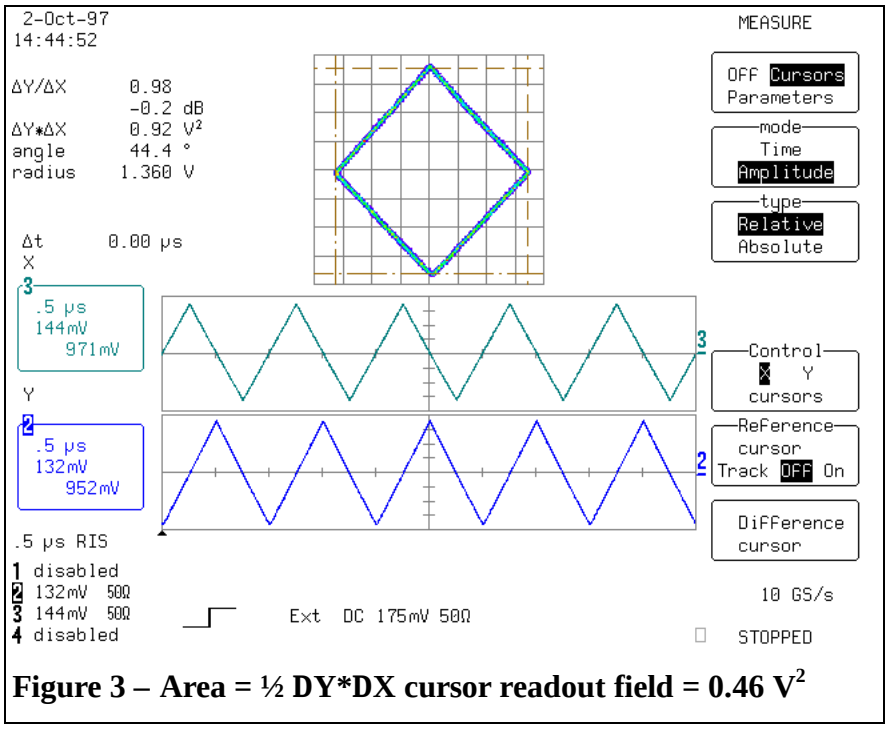

Figure 3 – Area = ½ DY*DX cursor readout field = 0.46 V^2

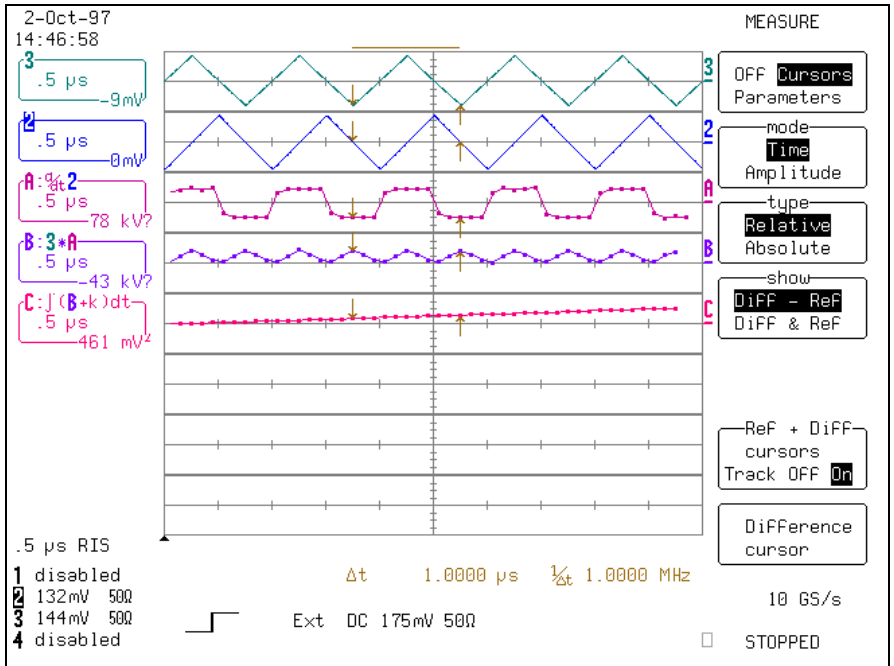

Figure 4 - Calculated area = 0.461 V^2