MULTISIM DEMO 8.3: POWER FACTOR IN MULTISIM

Is there a way to plot power factor in Multisim? It may not seem readily apparent, but there is in fact a way. It is rather complicated and involves some pretty long equations. But the end result is a very useful graph which can teach us a lot about a circuit.

Construct the simple circuit shown in Fig. 8.3.1 below. Our goal is to find the power factor and the angle ϕ_z of the RL load component in the circuit at 50 Hz, and if necessary add a compensating capacitor in parallel to get the power factor up to at least 0.95.

The source component is the AC_POWER source, not AC_VOLTAGE as we've used in previous Demos. It can be accessed under:

Group: Sources Family: POWER_SOURCES Component: AC_POWER



Just as a refresher, let's first do an AC Analysis where we plot the complex power of the load from 0.1 Hz to 1 kHz. Using the variables in Fig. 8.3.1, the equation for the complex power of the load should be: 0.5*(real(-I(v1)),-imag(-I(v1)))*V(1). Simulate to get the plot shown in Fig. 8.3.2 on the next page. From that figure, we can see that the **S** of the load at 50 Hz is about 819.7919 angle(32.12°) VA

So now how do we plot the power factor?

Power factor *pf* is equal to P_{av}/S . In Multisim this corresponds to: real(0.5*(real(-I(v1)),-imag(-I(v1)))*V(1))/(0.5*(real(-I(v1)),-imag(-I(v1)))*V(1)))

By default Multisim will plot (when in AC Analysis), the magnitude and the phase of whatever variables it is analyzing. In this case, the magnitude would correspond to the power factor pf, and the phase would correspond to $-\phi_z$. This is because P_{av} is entirely real, and $\phi_z = \phi_s$. Since we are dividing a real number by S, then the end product will be some constant at an angle of $-\phi_s$ which corresponds to $-\phi_z$.



Plotting $-\phi_z$ is ok, but it would be more useful if we could plot $+\phi_z$. This can be accomplished by slightly adjusting the equation so that we plot P_{av}/S^* . This will result in a value with a magnitude of *pf* and a phase of $+\phi_z$. When plotted, then this will give us the *pf* and ϕ_z .

For the circuit we are analyzing, P_{av}/S^* is written as the following:

$$\label{eq:real} \begin{split} real(0.5*(real(-I(v1)),-imag(-I(v1)))*V(1))/(real(0.5*(real(-I(v1)),-imag(-I(v1)))*V(1)),-imag(0.5*(real(-I(v1)),-imag(-I(v1)))*V(1))) \end{split}$$

You should hopefully never have to enter a more involved equation than the one shown above. If you do, I pity you.

Enter the behemoth of an equation in the selected variables for analysis field in the AC Analysis window. Set the AC Analysis to sweep from 0.1 Hz to 50 Hz with a resolution of 50 points per decade. Run the simulation. The plot which appears shows the power factor on top and the ϕ_z below. Let's use the cursors to find what the power factor is at 50 Hz. Click on the \mathbb{M} button to bring up the cursors.

Are you surprised? Is your vision obstructed by an extremely large window similar to that shown in Fig. 8.3.3 on the next page? By default Multisim names traces whatever variable or equation (however long it may be) they are describing. Since we inserted a really long equation, we get a really long title. In the cursor window, scroll all the way to the right to see the values. Move the cursor. You MAY encounter a bug where the numbers do not refresh properly as you move the cursor and instead just sort of pile on top of one another obstructing anything readable. This happens when there are really long titles for some reason. We need to remedy this situation.

AC Analysis						
	real(0.5*(real(-I(v1)),-imag(-I(v1)))*V(1))/(real(0.5*(real(-I(v1)),-imag(-I(v1)))*V(1)),-imag(0.5*(
x1						
y1						
x2						
¥2						
dx						
dy	-					
1/dx						
1/dy						
min x						
max x						
min y						
max y						
offset x						
offset y	-					
•						
Figure 8.3.3 Obnoxiously large heading on the cursor screen.						

Can we right click on the trace and rename it? Yes and no. If you go and do that and rename the trace "pf" the size of the cursor window will not change. Once you have opened the cursor window for a given simulation the size of the column is fixed and we can't shrink it. This is another bug.

To fix this problem, exit the Grapher window completely, and re-run the simulation. BEFORE you click on the cursors button, right click on the top plot and bring up the Properties window. Click on the Traces tab and change the Label to "pf", as shown in Fig. 8.3.4 below. Do this also for the bottom plot but name it "phi z" or "pf angle" or something similar.

Now it is safe to bring up the cursors. The cursor windows should be sized to a much more manageable width, as shown in Fig. 8.3.5 on the next page.

Graph Properties General Traces Left Axis Bit	ottom Axis Right Axis	Top Axis		
Trace 1 Label pf	Show Trace	Sample		
Color Red	•			
Bottom Axis	Vertical Axis [●] Left Axis [●] Right Axis	Offsets X Offset 0 Y Offset 0 Auto-Separate		
Restore	OK Cancel	Apply	lp	
Figure 8.3.4 Gett	ing rid of the re	eally large headings.		



So we can see that at about 50 Hz, the power factor is 0.846 and ϕ_z is +32.1579° which makes sense since the load is inductive. The power factor is less than 0.95 so we have to add a compensating capacitor in order to get it up to that value of 0.95. The textbook discusses in Chapter 8's Example 8-6 how to mathematically arrive at a value for a compensating capacitor. Since the goal of this tutorial is more to understand the workings of Multisim than to grind through the math of figuring out the capacitor value, we'll just jump to the solution. Based on theory, a capacitor of 13.65 µF will give us a power factor of 0.95.

It might be good practice for an exam to make sure you can show why 13.65 pF will improve the power factor to 0.95.

Incorporate this capacitor into the original circuit as shown in Fig. 8.3.6 on the next page. Now let's re-run the AC Analysis. When you do this you should get a plot similar to that in Fig. 8.3.7.

AGAIN, remember to rename your two traces before you open up the cursors window to avoid being broadsided with a huge heading.

Using the cursors we see that the power factor at 50.032 Hz is now 0.9498 and ϕ_z is +18.2288°, both of which are much nicer than what we had earlier. The compensating capacitor worked as expected!



