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[ STUDENT > # Attempt to verify conclusion for light-bulb test of
[ phase rotation using superposition
[ STUDENT > # see
[ http://www.eng-tips.com/viewthread.cfm?qid=240139&page=1
[ STUDENT > restart;
[ STUDENT > # ===SYMBOLS =====
[ STUDENT > # Va, Vb, Vc are voltages referenced to the POWER SUPPLY
[ neutral (assumed balanced)
[ STUDENT > # Vn is the "FLOATING neutral" created at the wye point of
[ the 2 R's and C(different than power supply neutral)
[ STUDENT > # (power supply neutral and this floating neutral are two
[ different things)
[ STUDENT > # Phasors are assumed rotating CCW in the complex plane
[ STUDENT > # a terminal which leads another terminal has a more
[ positive phase angle
[ STUDENT > # a terminal which lags another terminal has a more
[ negative phase angle
[ STUDENT > # A:=exp(I*2*Pi/3) is the 120 deg phase shift between
[ original vectors Va,Vb, Vc
[ STUDENT > # All voltage magnitudes Va Vb Vc assumed to have
[ magnitude 1
[ STUDENT > # Arbitrarily start with phase B as our 0 phase angle
[ STUDENT > # As we go from A to B to C we are going in the lagging
[ direction -> divide by A
[ STUDENT > # Solve Vn by superposition
[ STUDENT > # Vn = floating neutral voltage (different than power
[ supply neutral)
[ STUDENT > # Vna = contribution to Vn from Va with other two sources
[ shorted
[ STUDENT > # Vnb = contribution to Vn from Vb with other two sources
[ shorted
[ STUDENT > # Vnc = contribution to Vn from Vc with other two sources
[ shorted
[ STUDENT > # Zc = impedance of C
[ STUDENT > # Zp = impedance of Zc in parallel with R
[ STUDENT >
[ STUDENT >
[ STUDENT > # Find Vna by simple voltage divider
[ STUDENT > Vna:=Va*Zp/(R+Zp);

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$$V_{na} := - \frac{I V_a R}{w C \left( -\frac{I}{w C} + R \right) \left( R - \frac{I R}{w C \left( -\frac{I}{w C} + R \right)} \right)}$$

[ STUDENT > # Find Vnc by simple voltage divider

[ STUDENT > Vnc:=Vc\*Zp/(R+Zp);

$$V_{nc} := - \frac{I V_c R}{w C \left( -\frac{I}{w C} + R \right) \left( R - \frac{I R}{w C \left( -\frac{I}{w C} + R \right)} \right)}$$

[ STUDENT > # Find Vnb by simple voltage divider

[ STUDENT > Vnb:=Vb\*(R/2)/(R/2 + Zc);

$$V_{nb} := \frac{1}{2} \frac{V_b R}{\frac{1}{2} R - \frac{I}{w C}}$$

[ STUDENT > # Vn is sum of Vna, Vnb, Vnc:

[ STUDENT > Vn:=Vna+Vnb+Vnc;

$$V_n := \frac{V_a Z_p}{R + Z_p} + \frac{1}{2} \frac{V_b R}{\frac{1}{2} R + Z_c} + \frac{V_c Z_p}{R + Z_p}$$

[ STUDENT > # Compute values of Zc and Zp which will be used in Vn

[ STUDENT > Zc:=1/(I\*w\*C);

$$Z_c := - \frac{I}{w C}$$

[ STUDENT > Zp:=Zc\*R/(Zc+R);

$$Z_p := - \frac{I R}{w C \left( -\frac{I}{w C} + R \right)}$$

[ STUDENT > # Display Vn with new values Zc and Zp substituted

[ STUDENT > Vn;

$$\begin{aligned} & - \frac{I V_a R}{w C \left( -\frac{I}{w C} + R \right) \left( R - \frac{I R}{w C \left( -\frac{I}{w C} + R \right)} \right)} + \frac{1}{2} \frac{V_b R}{\frac{1}{2} R - \frac{I}{w C}} \\ & - \frac{I V_c R}{w C \left( -\frac{I}{w C} + R \right) \left( R - \frac{I R}{w C \left( -\frac{I}{w C} + R \right)} \right)} \end{aligned}$$

[ STUDENT > # Simplify

[ STUDENT > Vn:=simplify(Vn);

$$V_n := \frac{-I V_a + V_b R w C - I V_c}{-2 I + R w C}$$

[ STUDENT > # THE ABOVE EXPRESSION IS ENOUGH TO ANSWER THE QUESTION

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[ STUDENT > # ASSUME R*w*C <<1. => Denominator ~ -2 *I
[ STUDENT > # Numerator is -I*(Va + Vc) + Vb * R * w * C
[ STUDENT > # When we divide numerator by -2*I we get
[ STUDENT > # Vn ~ 0.5*[(Va + Vc) + I*Vb * R * w * C]
[ STUDENT > # Now we will simply assume Vb = 1 ANGLE 0
[ STUDENT > # This covers both scenarios
[ STUDENT > #   ABC rotation: {Vb=1,Vc=1/A,Va=1/A^2};
[ STUDENT > #   ACB rotation: {Vb=1,Va=1/A,Vc=1/A^2};
[ STUDENT >
[ STUDENT > # Since Va and Vc appear symmetrically, we will get the
[           # same solution Vn
[ STUDENT > # regardless of which orientation one we choose
[ STUDENT >
[ STUDENT > # To find out whether Vn is closer to Va or Vc we need
[           # only look at the imaginary part
[ STUDENT > # We see imaginary part is I*Vb * R * w * C
[ STUDENT > # The imaginary part of Vn is postive
[ STUDENT > # If we choose ABC rotation, Vn is closer to Va and light
[           # attached to A will be dimmer
[ STUDENT > # If we choose ACB rotation, Vn is closer to Vc and light
[           # attached to A will be dimmer

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