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[ STUDENT > # Attempt to verify conclusion for light-bulb test of
[ phase rotation
[ 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 > # Equation1 - expresses KVL at the floating neutral
[ STUDENT > # VnSolution is the solution for Vn based on KVL
[ 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 > # Assume an ABC rotation, Va leads Vb, Vb leads Vc, Vc
[ leads Va etc
[ 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 > # ABCsubs = substitution of values for voltage vectors Va,
[ Vb, Vc
[ STUDENT >
[ STUDENT > ABCsubs:={Vb=1,Vc=1/A,Va=1/A^2};
[
[ 
$$ABCsubs := \{ Vb = 1, Va = \frac{1}{A^2}, Vc = \frac{1}{A} \}$$

[ STUDENT > # Kirchoff's Current Law for current entering the floating
[ neutral
[ STUDENT > Equation1:=(Va-Vn)/R + (Vc-Vn)/R + (Vb-Vn)*2*Pi*f*C*I=0;
[
[ 
$$Equation1 := \frac{Va - Vn}{R} + \frac{Vc - Vn}{R} + 2 I (Vb - Vn) \pi f C = 0$$

[ STUDENT > # Substitute in our values for Va, Vb, Vc:
[ STUDENT > Equation1ABC:=subs(ABCsubs,Equation1);

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$$\text{Equation1ABC} := \frac{\frac{1}{A^2} - V_n}{R} + \frac{\frac{1}{A} - V_n}{R} + 2 I (1 - V_n) \pi f C = 0$$

STUDENT > # Solve the above equation for Vn

STUDENT > VnSolutionABC:=solve(Equation1ABC,Vn);

$$\text{VnSolutionABC} := \frac{1}{2} \frac{1 + A + 2 I \pi f C A^2 R}{A^2 (1 + I \pi f C R)}$$

STUDENT > # Substitute in the definition of A:

STUDENT > VnSolutionABC:=subs(A=exp(I\*2\*Pi/3),VnSolutionABC);

$$\text{VnSolutionABC} := \frac{\frac{1}{2} + \frac{1}{2} I \sqrt{3} + 2 I \pi f C \left( -\frac{1}{2} + \frac{1}{2} I \sqrt{3} \right)^2 R}{2 \left( -\frac{1}{2} + \frac{1}{2} I \sqrt{3} \right)^2 (1 + I \pi f C R)}$$

STUDENT > # Simplify:

STUDENT > VnSolutionABC:=simplify(VnSolutionABC);

$$\text{VnSolutionABC} := - \frac{-1 - I \sqrt{3} + 2 I \pi f C R - 2 \pi f C R \sqrt{3}}{(-1 + I \sqrt{3})^2 (1 + I \pi f C R)}$$

STUDENT > # Substitute in values for R, C, f:

STUDENT > Rvalue:=220^2/50:

STUDENT > Cvalue:=3E-6:

STUDENT > fvalue:=50:

STUDENT > values:={R=Rvalue,C=Cvalue,f=fvalue};

$$\text{values} := \{ R = 968, C = .3 \cdot 10^{-5}, f = 50 \}$$

STUDENT > VnSolutionABC:=subs(values,VnSolutionABC);

$$\text{VnSolutionABC} := - \frac{-1 - I \sqrt{3} + .290400 I \pi - .290400 \pi \sqrt{3}}{(-1 + I \sqrt{3})^2 (1 + .145200 I \pi)}$$

STUDENT > # Expand VnSolutionABC to polar form:

STUDENT > evalc(VnSolutionABC);

$$\frac{-\frac{1}{8} - .03630000000 \pi \sqrt{3} - \frac{1}{8} (\sqrt{3} - .290400 \pi) \sqrt{3}}{1 + .02108304000 \pi^2} + .145200 \frac{\left( -\frac{1}{8} \sqrt{3} + .03630000000 \pi + \frac{1}{8} (1 + .290400 \pi \sqrt{3}) \sqrt{3} \right) \pi}{1 + .02108304000 \pi^2} + I \left( \frac{-\frac{1}{8} \sqrt{3} + .03630000000 \pi + \frac{1}{8} (1 + .290400 \pi \sqrt{3}) \sqrt{3}}{1 + .02108304000 \pi^2} \right)$$

$$- .145200 \frac{\left( -\frac{1}{8} - .036300000000 \pi \sqrt{3} - \frac{1}{8} (\sqrt{3} - .290400 \pi) \sqrt{3} \right) \pi}{1 + .02108304000 \pi^2}$$

[ STUDENT >

[ STUDENT > # Look at the IMAGINARY part of VnSolution:

[ STUDENT > VnSolutionABC\_Imaginary:=evalc(Im(VnSolutionABC));

$$VnSolutionABC\_Imaginary := - \frac{\frac{1}{8} \sqrt{3} - .036300000000 \pi + \frac{1}{8} (-1 - .290400 \pi \sqrt{3}) \sqrt{3}}{1 + .02108304000 \pi^2} \\ + .145200 \frac{\left( \frac{1}{8} + .036300000000 \pi \sqrt{3} - \frac{1}{8} (-\sqrt{3} + .290400 \pi) \sqrt{3} \right) \pi}{1 + .02108304000 \pi^2}$$

[ STUDENT > # evaluate the above expression to give the magnitude of the imaginary portion of Vn

[ STUDENT > evalf(VnSolutionABC\_Imaginary);

.5663848127

[ STUDENT > # Imaginary part of Vn is positive, i.e. Vn lies in upper half of complex plane

[ STUDENT > # so it is closer to Va, so light attached to Va will be dimmer

[ STUDENT >

[ STUDENT > # WHAT ABOUT THE ACB SYSTEM:

[ STUDENT > # Solving the ACB system can be accomplished simply by swapping the roles of Vc and Va. The calculated value of Vn would be the same (positive imaginary part). It would now (ACB rotation) be closer to Vc, so the light attached to Vc will be dimmer

[ STUDENT >