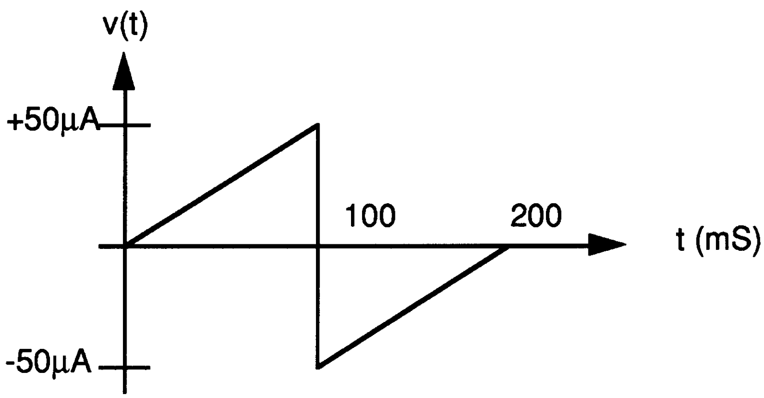
EEAP 244

HW #3 Representing functions mathematically as combinations of other functions

The task was to mathematically represent the following function in a form that you could take the Laplace transform of the function using the tables of known functional transforms and the properties of the Laplace transform.



The slope of the ramp is 50µA/100milliseconds or 500 µA/second. There are at least two ways to write the function.

1. $v(t) = 500tu(t) - 100u(t-0.1) - 500tu(t-.2) + 100u(t-.2)$ µA

2. $v(t) = 500tu(t) - 100u(t-0.1) - 500(t-.2)u(t-.2)$ µA

All times are in seconds.

INS TCP/IP PrintServer 20

Print engine name:	PrintServer 20
Print engine version:	17
Printer firmware version:	32
Server Adobe PostScript version:	48.3
Server software version:	V2.0
Server network node:	crawford
Server name:	crawford
Server job number:	86
Client software version:	WRL-1.0
Client network node:	util
Client name:	flm
Client job name:	hw_4.ps.735168806
Submitted at:	Sun Apr 18 17:51:02 19939 19933X
Printed at:	Sun Apr 18 17:51:03 1993

flm@util
hw_4.ps.735168806

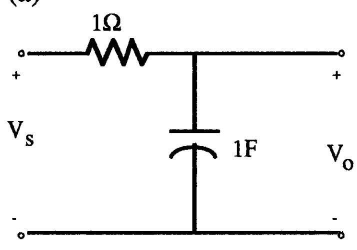
digital

EEAP 244

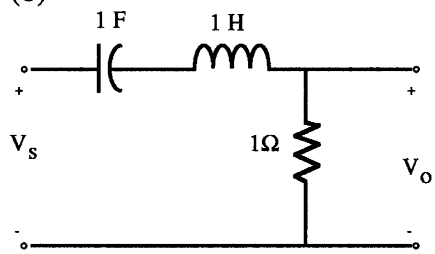
HW #4 Poles&zeros, circuits, differential equations and Bode diagrams

We have seen that there is a clear-cut relationship between
circuits(KVL,KCL)→Diff.Eqns→s-plane→freq. response→impulse response
Consider the following circuits:

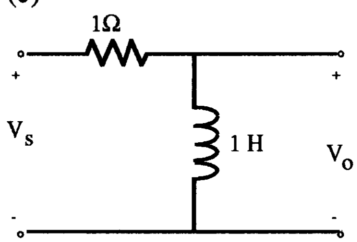
(a)



(b)



(c)



<u>Problem 1: Which differential equations correspond to the above circuits?</u>

(i) $$\frac{d^2v_o}{dt^2} + \frac{dv_o}{dt} + v_o = \frac{dv_s}{dt}$$

(ii) $$\frac{dv_o}{dt} + v_o = \frac{dv_s}{dt}$$

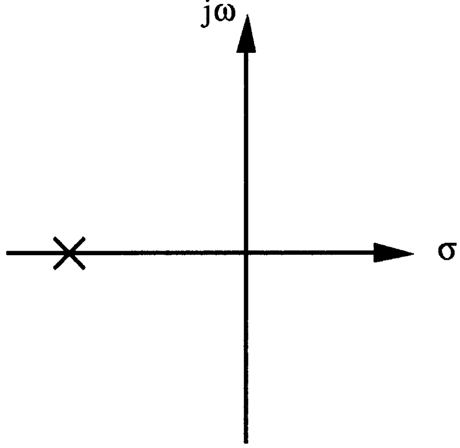
(iii) $$\frac{d^2v_o}{dt^2} + v_o = \frac{dv_s}{dt}$$

(iv) $$\frac{dv_o}{dt} + v_o = v_s$$

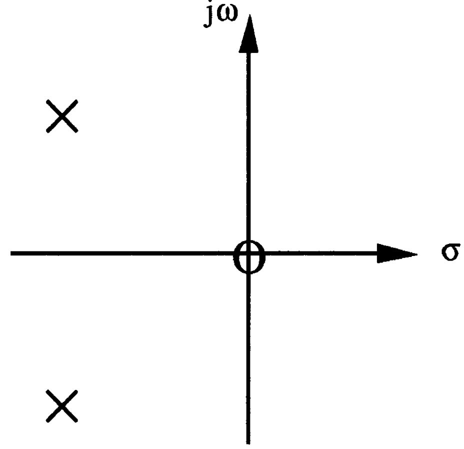
(v) $$\frac{d^2v_o}{dt^2} + \frac{dv_o}{dt} + v_o = \frac{dv_s}{dt} + v_s$$

<u>Problem 2: Which pole-zero diagrams correspond to the transfer functions of the above circuits?</u>

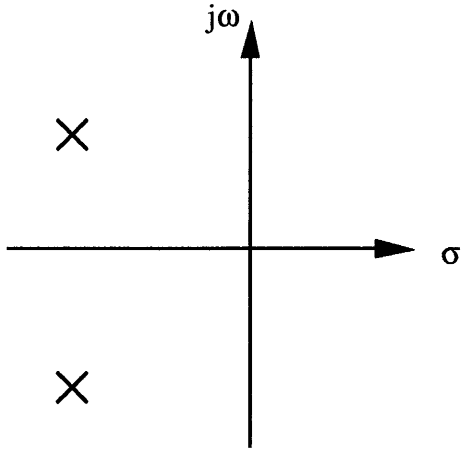
(i)



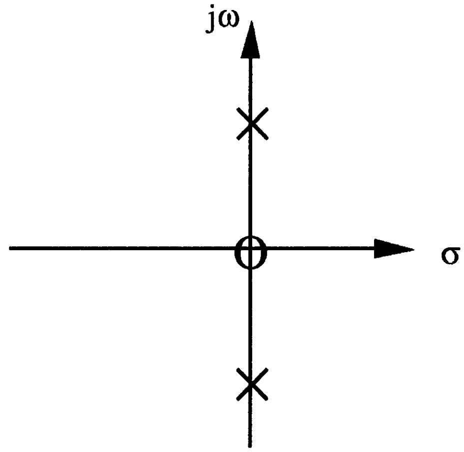
(ii)



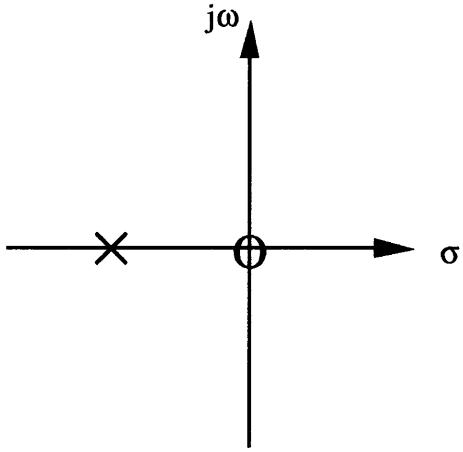
(iii)



(iv)

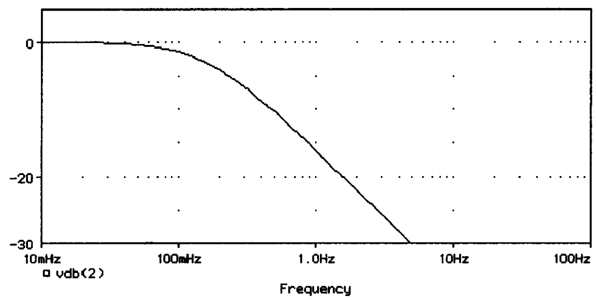


(v)

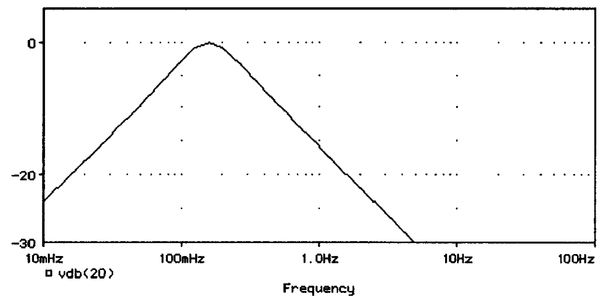


Problem 3: Which Bode plots correspond to the above circuits?

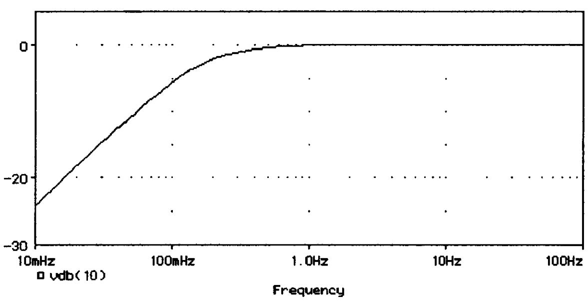
(1)



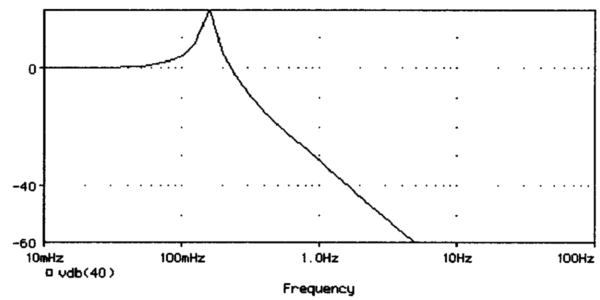
(2)



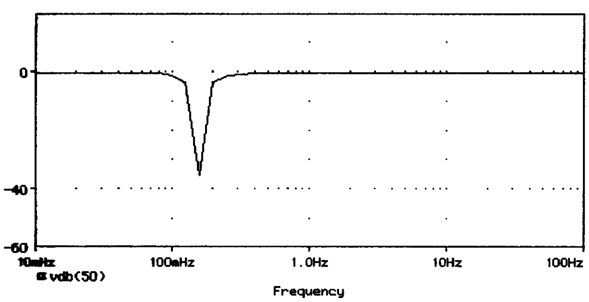
(3)



(4)

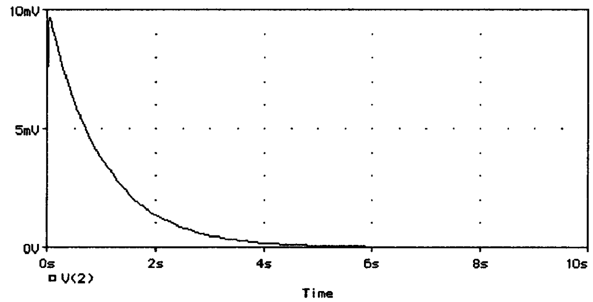


(5)

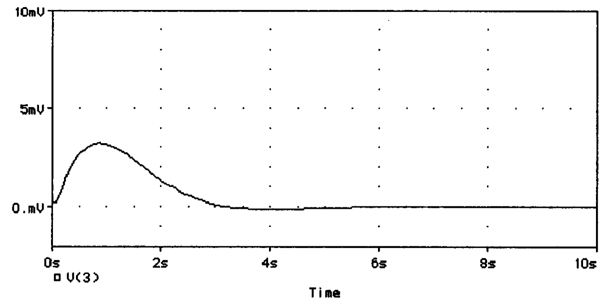


Problem 4: Which impulse responses correspond to the above circuits?

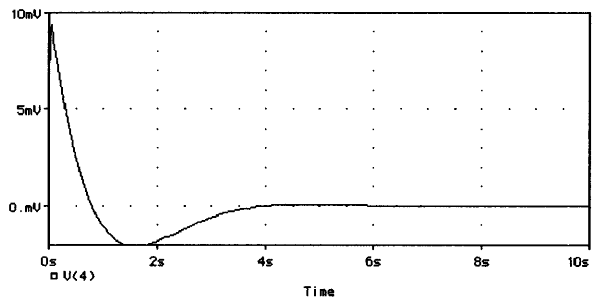
(i)



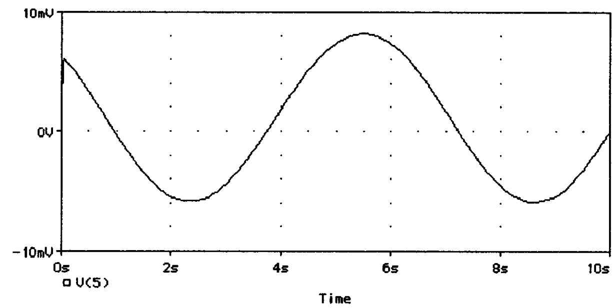
(ii)



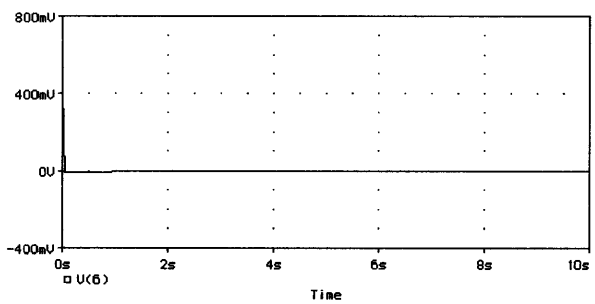
(iii)



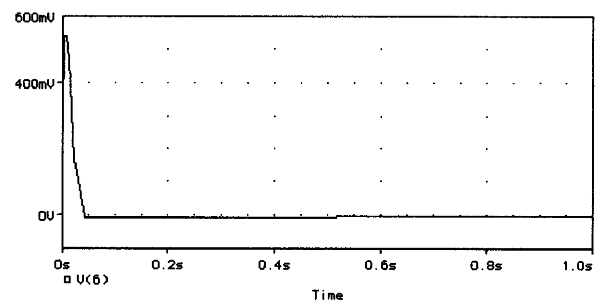
(iv)



(v)



(v) Expanded scale.



3/9.

EEAP 244

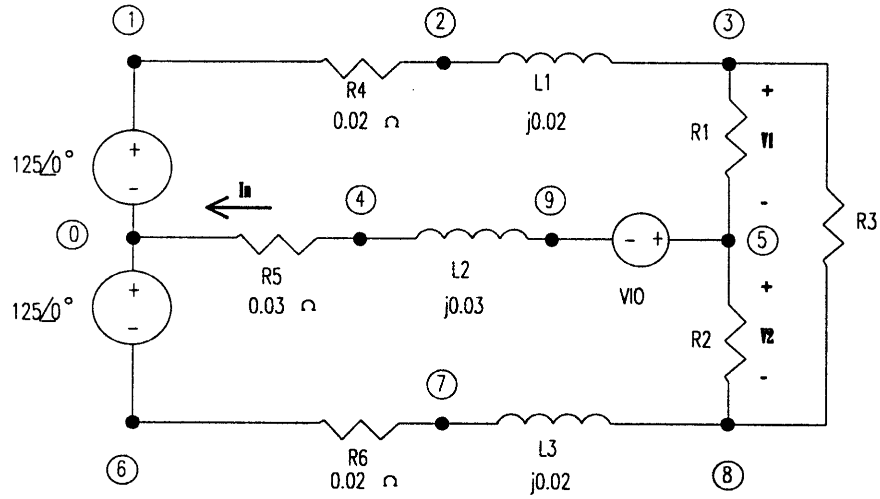
Extra Credit #1

Problem 10-45

David Sarafian
3-8-93

A (well-deserved)

PROBLEM 10-45



Circuit For Problem 10-45

This circuit is to be analyzed under several conditions, one of which is when the 'neutral' or branch connecting nodes 0 and 5 is open. It was determined that the analysis would be best handled by P-SPICE. The assumption was made that the applied frequency is 60 Hz, so the impedance values of L1-L3 were converted to their inductance values by dividing by 120π (L1, L3 = 53.1uH, L2=79.6uH). These values were then used in the P-SPICE simulation.

A). Show that I_n=0 if R1=R2.

The code and results for this analysis appear below:

```
******* 03/08/93 ******* Evaluation PSpice (July 1989) ******* 17:24:03 *******
Problem 10-45. Residential wiring example (CLOSED neutral, R1=R2)

****    CIRCUIT DESCRIPTION
******************************************************************************
V1    1   0   AC   125   0
V2    0   6   AC   125   0
VIO   5   9   DC   0
R1    3   5   10
R2    5   8   10
R3    3   8   15
R4    1   2   0.02
R5    0   4   0.03
R6    6   7   0.02
L1    2   3   53.052E-6
L2    4   9   79.577E-6
L3    7   8   53.052E-6
.AC   LIN   1   60   60
.PRINT  AC   Im(VIO) Ip(VIO) Vm(3,5) Vm(5,8)
.END
```

```
****    AC ANALYSIS                 TEMPERATURE =  27.000 DEG C
******************************************************************************
 FREQ       IM(VIO)     IP(VIO)      VM(3,5)     VP(3,5)      VM(5,8)     VP(5,8)
6.000E+01  6.897E-18  -9.034E+01  1.244E+02  -2.661E-01  1.244E+02  -2.661E-01
JOB CONCLUDED
```

Resistors R1 and R2 were arbitrarily chosen to be equal. R3 was also given an arbitrary value. A voltage source of magnitude zero was included to measure the neutral current. The DC portion of the analysis was not included, as all values were zero. The AC analysis shows that for all intents an purposes the neutral current is zero when R1=R2.

B). Show that V1=V2 if R1=R2.

The same analysis just performed also measured the voltages V1 and V2. The analysis shows that these voltages are also equal in magnitude and phase.

C). Open the neutral, and calculate V1 and V2 with R1=40Ω, R2=400Ω and R3=8Ω

The circuit was re-arranged slightly and the analysis re-run. The results are shown below:

```
******* 03/08/93 ******* Evaluation PSpice (July 1989) ******* 19:55:56 *******
Problem 10-45.  Residential wiring example (open neutral)

****    CIRCUIT DESCRIPTION
******************************************************************************
V1    1    0    AC    125   0
V2    0    7    AC    125   0
R1    3    4    40
R2    4    5    400
R3    3    5    8
R4    1    2    0.02
R5    6    7    0.02
L1    2    3    53.052E-6
L2    5    6    53.052E-6
.AC   LIN   1    60    60
.PRINT  AC    Vm(3,4) Vp(3,4) Vm(4,5) Vp(4,5)
.END

****    AC ANALYSIS                 TEMPERATURE =  27.000 DEG C
******************************************************************************
 FREQ       VM(3,4)     VP(3,4)      VM(4,5)     VP(4,5)
6.000E+01  2.261E+01  -2.902E-01  2.261E+02  -2.902E-01

      JOB CONCLUDED
```

The analysis shows that the voltage across the 40Ω resistor is about 1/5 of it's normal value (23V) of 125V while the voltage across the 400Ω resistor is almost double what it should be (226V).

D.) Re-connect the neutral and repeat part C.

The P-SPICE code for this part is the same as in part A, except for the values of R1-R3. Shown below is the AC analysis from running the simulation:

```
****    AC ANALYSIS              TEMPERATURE =  27.000 DEG C
*******************************************************************************

 FREQ       IM(VIO)     IP(VIO)      VM(3,5)     VM(5,8)
6.000E+01  2.795E+00  -3.636E-01  1.242E+02  1.245E+02

        JOB CONCLUDED
```

This analysis shows that the voltages across R1 and R2 are back to their expected values of about 125V, now that the neutral is re-connected.

E.) Why shouldn't the neutral be fused so that it could open while a "hot" is energized?

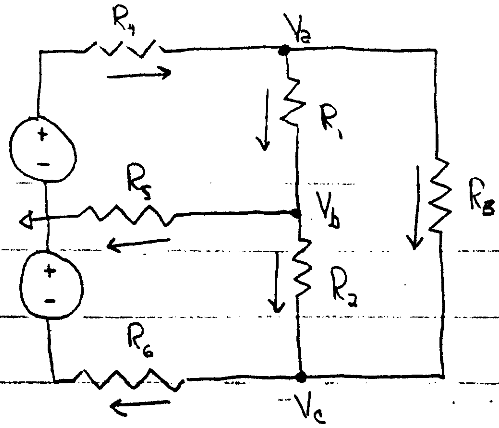
The previous analysis showed that if the neutral becomes open while the "hot" branches are still energized, the voltages across elements which depended on the neutral for a return current path could become abnormally high or low. This could result in excessive (or deficient) currents flowing in other circuit elements. Throughout the analysis, R3 is unaffected due to the fact that it is normally across the two "hot" branches and does not use the neutral for a current path. It would seem reasonable that the neutral should be fused for a higher capacity than either of the branch circuits.

Jackson Harvey
EEAP 244
Extra Credit Homework

10.45) a)

A

10.45 A
10.67 A



$$\frac{V_s - V_a}{R_4} - \frac{V_a - V_c}{R_3} - \frac{V_a - V_b}{R_1} = 0 = \frac{V_s}{R_4} - \frac{V_a}{R_4} - \frac{V_a}{R_3} + \frac{V_c}{R_3} - \frac{V_a}{R_1} + \frac{V_b}{R_1}$$

$$\frac{V_a - V_b}{R_1} - \frac{V_b}{R_5} - \frac{V_b - V_c}{R_2} = 0 = \frac{V_a}{R_1} - \frac{V_b}{R_1} - \frac{V_b}{R_5} - \frac{V_b}{R_2} + \frac{V_c}{R_2}$$

$$\frac{V_a - V_c}{R_3} + \frac{V_b - V_c}{R_2} - \frac{V_c + V_s}{R_6} = 0 = \frac{V_a}{R_3} - \frac{V_c}{R_3} + \frac{V_b}{R_2} - \frac{V_c}{R_2} - \frac{V_c}{R_6} + \frac{V_s}{R_6}$$

$R_1 = R_2 = R \qquad R_4 = R_6 = R_w$

$$\frac{V_s}{R_w} - \frac{V_a}{R_w} - \frac{V_a}{R_3} + \frac{V_c}{R_3} - \frac{V_a}{R} + \frac{V_b}{R} = 0$$

$$\frac{V_a}{R} - \frac{V_b}{R} - \frac{V_b}{R_5} - \frac{V_b}{R} + \frac{V_c}{R} = 0 = \frac{V_a}{R} - \frac{2V_b}{R} - \frac{V_b}{R_5} + \frac{V_c}{R}$$

$$\frac{V_a}{R_3} - \frac{V_c}{R_3} + \frac{V_b}{R} - \frac{V_c}{R} - \frac{V_c}{R_w} - \frac{V_s}{R_w} = 0$$

$$V_a\left(-\frac{1}{R_w} - \frac{1}{R_3} - \frac{1}{R}\right) + V_b\left(\frac{1}{R}\right) + V_c\left(\frac{1}{R_3}\right) = -V_s\left(\frac{1}{R_w}\right)$$

$$V_a\left(\frac{1}{R}\right) + V_b\left(-\frac{2}{R} - \frac{1}{R_5}\right) + V_c\left(\frac{1}{R}\right) = 0$$

$$V_a\left(\frac{1}{R_3}\right) + V_b\left(\frac{1}{R}\right) + V_c\left(-\frac{1}{R_3} - \frac{1}{R} - \frac{1}{R_w}\right) = V_s\left(\frac{1}{R_w}\right)$$

$V_b = 0$

$V_a = -V_c$ (by inspection (hypothesis is supported by equations))

$I_n = V_b - 0/R_5 = 0/R_5 = 0$

b) $V_1 = V_a - V_b$

$V_2 = V_b - V_c$

$V_a = -V_c$

$V_b = 0$

$V_1 = V_a = -V_c = V_2$

c) $$Z_{Tot} = 2(0.02 + 0.02j) + \frac{(R_1 + R_2)R_3}{R_1 + R_2 + R_3} = 0.04 + 0.04j + \frac{3520}{448} =$$
$$7.897 + 0.04j = 7.897\angle .29°$$

$$I_1 = \frac{V_{TOT}}{Z_{TOT}} = \frac{250\angle 0^\circ}{7.897\angle .29^\circ} = 31.66\angle -0.29^\circ$$

$$V_1 + V_2 = 250\angle 0^\circ - I_1(.02 + .02j) - I_2(.02 + .02j) =$$

$$250\angle 0^\circ - 31.66\angle -0.29^\circ(.056\angle 45^\circ) =$$

$$250\angle 0^\circ - 1.77\angle 44.71^\circ =$$

$$250 - 1.26 - 1.245j = 248.74 - 1.245j = 248.74\angle -.29^\circ$$

$$V_1 = \frac{R_1}{R_1 + R_2}(V_1 + V_2) = 22.61\angle -.29^\circ$$

$$V_2 = 226.13\angle -.29^\circ$$

d) $$\frac{V_s}{R_w} - \frac{V_a}{R_w} - \frac{V_a}{R_3} + \frac{V_c}{R_3} - \frac{V_a}{R_1} + \frac{V_b}{R_1} = 0 = \frac{125\angle 0^\circ}{.03\angle 45^\circ} - \frac{V_a}{.02 + .02j} - \frac{V_a}{8} + \frac{V_c}{8} - \frac{V_a}{40} + \frac{V_b}{40}$$

$$\frac{V_a}{R_1} - \frac{V_b}{R_1} - \frac{V_b}{R_5} - \frac{V_b}{R_2} + \frac{V_c}{R_2} = 0 = \frac{V_a}{40} - \frac{V_b}{40} - \frac{V_b}{.03 + .03j} - \frac{V_b}{400} + \frac{V_c}{400}$$

$$\frac{V_a}{R_3} - \frac{V_c}{R_3} + \frac{V_b}{R_2} - \frac{V_c}{R_2} - \frac{V_c}{R_w} - \frac{V_s}{R_w} = 0 = \frac{V_a}{8} - \frac{V_c}{8} + \frac{V_b}{400} - \frac{V_c}{400} - \frac{V_c}{.02 + .02j} - \frac{125\angle 0^\circ}{.03\angle 45^\circ}$$

$$4166.67\angle -45^\circ - V_a\left(\frac{.02 - .02j}{.0008}\right) - .125V_a + .125V_c - .025V_a + .025V_b = 0$$

$$.025V_a - .025V_b - V_b\left(\frac{.03 - .03j}{.0018}\right) - .0025V_b + .0025V_c = 0$$

$$.125V_a - .125V_c + .0025V_b - .0025V_c - V_c\left(\frac{.02 - .02j}{.0004}\right) - 4166.67\angle -45^\circ = 0$$

$$4166.67\angle -45^\circ - 25V_a + 25jV_a - .125V_a + .125V_c - .025V_a + .025V_b = 0$$

$$.025V_a - .025V_b - 16.67V_b + 16.67jV_b - .0025V_b + .0025V_c = 0$$

$$.125V_a - .125V_c + .0025V_b - .0025V_c - 25V_c + 25jV_c - 4166.67\angle -45^\circ = 0$$

$$V_a(25.1275 - 25j) - .025V_b - .125V_c = 4166.67\angle -45^\circ =$$

$$.025V_a - (16.694 - 16.67j)V_b + .0025V_c = 0$$

$$.125V_a + .0025V_b - (25.1275 - 25j)V_c = 4166.67\angle -45^\circ.$$

MATLAB™ claims

$$V_a = 165.83 - .83i = 165.8\angle -.28^\circ$$

$$V_b = .11 + .11i = .156\angle 45^\circ$$

$$V_c = -165.83 + .83i = 165.8\angle -.28$$

$$\therefore V_1 = 165.72\angle -.33$$

$$V_2 = 165.9\angle -.25$$

↳ Math error somewhere. [illegible]

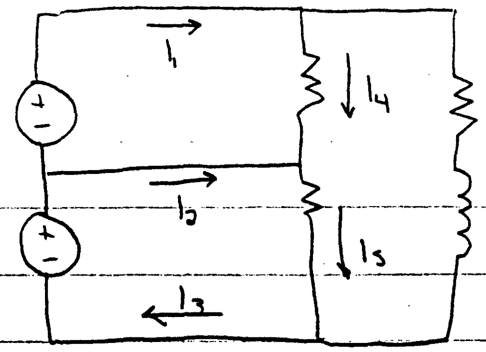
Jackson Harvey

10.45) e) If the neutral conductor is opened when the 125V loads have greatly different impedances, the voltages will be greatly different. The appliances (loads) would then be subjected to voltages for which they are not built. With the neutral conductor in place this situation does not occur.

Jackson Harvey
EEAP 244

10.67) a)

A



$I_4 = \frac{V_S}{R_4} = \frac{120\angle 0}{24} = 5\angle 0°$

$I_5 = \frac{V_S}{R_5} = \frac{120\angle 0}{12} = 10\angle 0°$

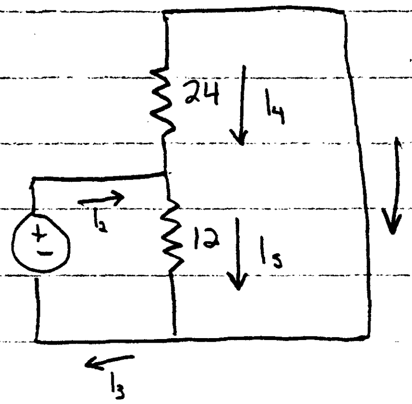
$I_6 = \frac{2V_S}{R_6} = \frac{240\angle 0}{8.4+6.3j} = \frac{240\angle 0}{10.5\angle 36.87} = 22.86\angle -36.87°$

$I_2 = I_5 - I_4 = 5\angle 0°$

$I_1 = I_4 + I_6 = 5\angle 0° + 22.86\angle -36.87° = 23.29 - 13.71j = 27.03\angle -30.48$

$I_3 = I_5 + I_6 = 10\angle 0° + 22.86\angle -36.87° = 28.29 - 13.71j = 31.44\angle -25.86$

b)



$I_5 = \frac{120\angle 0}{12} = 10\angle 0°$

$I_1 = 0$

$I_4 = \frac{-120\angle 0}{24} = -5\angle 0°$

$I_2 = I_5 - I_4 = 15\angle 0°$

$I_6 = -I_4 = 5\angle 0°$

$I_3 = I_5 + I_6 = 15\angle 0°$

c) The voltage differences were maintained that were present before the fuse was interrupted.

d) It would not operate because, as the circuit is set up, the short circuit through the fan motor caused Fuse A to blow, and the current through the fan motor decreases.

e) The current through the fuse drops as soon as Fuse A is blown. *Okay, but explain more thoroughly next time.*