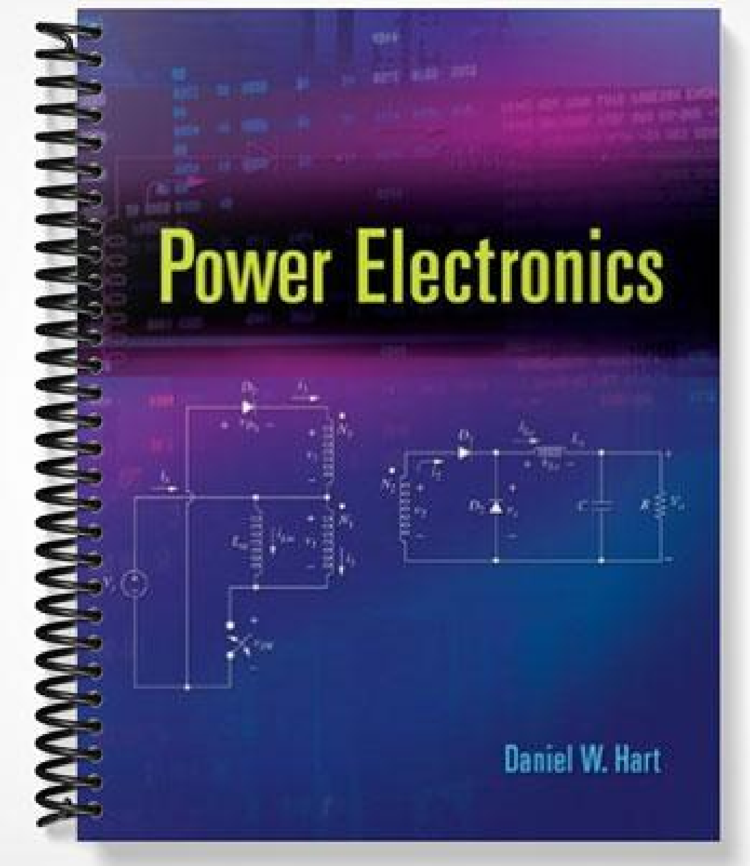
SOLUTIONS MANUAL



CHAPTER 2 SOLUTIONS

2/21/10

2-1) Square waves and triangular waves for voltage and current are two examples.

2-2) a) $p(t) = v(t)i(t) = \dfrac{v^2(t)}{R} = \dfrac{[170\sin(377t)]^2}{10} = 2890\sin^2 377t\ W.$

b) peak power = 2890 W.

c) P = 2890/2 = 1445 W.

2-3)

v(t) = 5sin2πt V.

a) 4sin2πt A.; p(t) = v(t)i(t) = 20 $\sin^2$2πt W.; P = 10 W.

b) 3sin4πt A.; p(t) = 15sin(2πt)sin(4πt) W.; P = 0

2-4) a)

$$p(t) = v(t)i(t) = \begin{cases} 0 & 0 < t < 50\,ms \\ 40 & 50\,ms < t < 70\,ms \\ 0 & 70\,ms < t < 100\,ms \end{cases}$$

b)

$$P = \frac{1}{T}\int_0^T v(t)i(t)\,dt = \frac{1}{100\,ms}\int_{50ms}^{70ms} 40\,dt = 8.0\ W.$$

c)

$$W = \int_0^T p(t)\,dt = \int_{50ms}^{70ms} 40\,dt = 800\ mJ.; \quad or \quad W = PT = (8W)(100\,ms) = 800\ mJ.$$

2-5) a)

$$p(t) = v(t)i(t) = \begin{cases} 70\ W. & 0 < t < 6\,ms \\ -50\ W. & 6\,ms < t < 10\,ms \\ 40\ W. & 10\,ms < t < 14\,ms \\ 0 & 14\,ms < t < 20\,ms \end{cases}$$

b)

$$P = \frac{1}{T}\int_0^T p(t)\,dt = \frac{1}{20\,ms}\left[\int_0^{6ms} 70\,dt + \int_{6ms}^{10ms} (-50)\,dt + \int_{10ms}^{14ms} 40\,dt\right] = 19\ W.$$

c)

$$W=\int_0^T p(t)\,dt=\left[\int_0^{6ms}70\,dt+\int_{6ms}^{10ms}(-50)\,dt+\int_{10ms}^{14ms}40\,dt\right]=0.38\ J.;$$

$$or\quad W=PT=(19)(20\,ms)=380\ mJ.$$

2-6)

$$P=V_{dc}I_{avg}$$

$$a)\quad I_{avg}=2\ A.,\quad P=(12)(2)=24\ W.$$

$$b)\quad I_{avg}=3.1\ A.,\quad P=(12)(3.1)=37.2\ W.$$

2-7)

a)

$$v_R(t)=i(t)R=25\sin 377t\ V.$$

$$p(t)=v(t)i(t)=(25\sin 377t)(1.0\sin 377t)=25\sin^2 377t=12.5(1-\cos 754t)\ W.$$

$$P_R=\frac{1}{T}\int_0^T p(t)\,dt=12.5\ W.$$

b)

$$v_L(t)=L\frac{di(t)}{dt}=10(10)^{-3}(377)(1.0)\cos 377t=3.77\cos 377t\ V.$$

$$p_L(t)=v(t)i(t)=(3.77\cos 377t)(1.0\sin 377t)=\frac{(3.77)(1.0)}{2}\sin 754t=1.89\sin 754t\ W.$$

$$P_L=\frac{1}{T}\int_0^T p(t)\,dt=0$$

c)

$$p(t)=v(t)i(t)=(12)(1.0\sin 377t)=12\sin 377t\ W.$$

$$P_{dc}=\frac{1}{T}\int_0^T p(t)\,dt=0$$

2-8) Resistor:

$$v(t) = i(t)R = 8 + 24\sin 2\pi 60t \ V.$$

$$p(t) = v(t)i(t) = (8 + 24\sin 2\pi 60t)(2 + 6\sin 2\pi 60t)$$

$$= 16 + 96\sin 2\pi 60t + 144\sin^2 2\pi 60t \ W.$$

$$P = \frac{1}{T}\int_0^T p(t)\,dt = \frac{1}{1/60}\left[\int_0^{1/60} 16\,dt + \int_0^{1/60} 96\sin 2\pi 60t\,dt + \int_0^{1/60} 144\sin^2 2\pi 60t\right]$$

$$= 16 + 72 = 88 \ W.$$

Inductor: $P_L = 0.$

dc source: $P_{dc} = I_{avg}V_{dc} = (2)(6) = 12 \ W.$

2-9) a) With the heater on,

$$P = \frac{V_m I_m}{2} = 1500 \ W. \ \rightarrow \ I_m = \frac{(1500)(2)}{120\sqrt{2}} = 12.5\sqrt{2}$$

$$p(t) = V_m I_m \sin^2 \omega t = \left(120\sqrt{2}\right)\left(12.5\sqrt{2}\right)\sin^2 \omega t = 3000\sin^2 \omega t$$

$$\max\left(p(t)\right) = 3000 \ W.$$

b) P = 1500(5/12) = 625 W.

c) W = PT = (625 W)(12 s) = 7500 J. (or 1500(5) = 7500 W.)

2-10)

$$i_L(t) = \frac{1}{L}\int v_L(t)\,dt = \frac{1}{0.1}\int_0^t 90\,d\lambda = 900t \qquad 0 < t < 4\,ms.$$

$$i_L(4\,ms) = (900)(4)(10)^{-3} = 3.6 \ A.$$

a)

$$W = \frac{1}{2}Li^2 = \frac{1}{2}(0.1)(3.6)^2 = 0.648 \ J.$$

b) All stored energy is absorbed by R: $W_R = 0.648$ J.

c)

$$P_R = \frac{W_R}{T} = \frac{0.648}{40\,ms} = 16.2 \ W.$$

$$P_S = P_R = 16.2 \ W.$$

d) No change in power supplied by the source: 16.2 W.

2-11)

a)

$$W = \frac{1}{2}Li^2, \ or \ i = \sqrt{\frac{2W}{L}} = \sqrt{\frac{2(1.2)}{0.010}} = 15.49 \ A.$$

$$i(t) = \frac{1}{L}\int_0^t v(\lambda)\,d\lambda = \frac{1}{0.010}\int_0^t 14\,d\lambda = 1400t \ A.$$

$$15.49 = 1400t_{on}$$

$$t_{on} = 11.1 \ ms$$

b) Energy stored in L must be transferred to the resistor in (20 - 11.1) = 8.9 ms. Allowing five time constants,

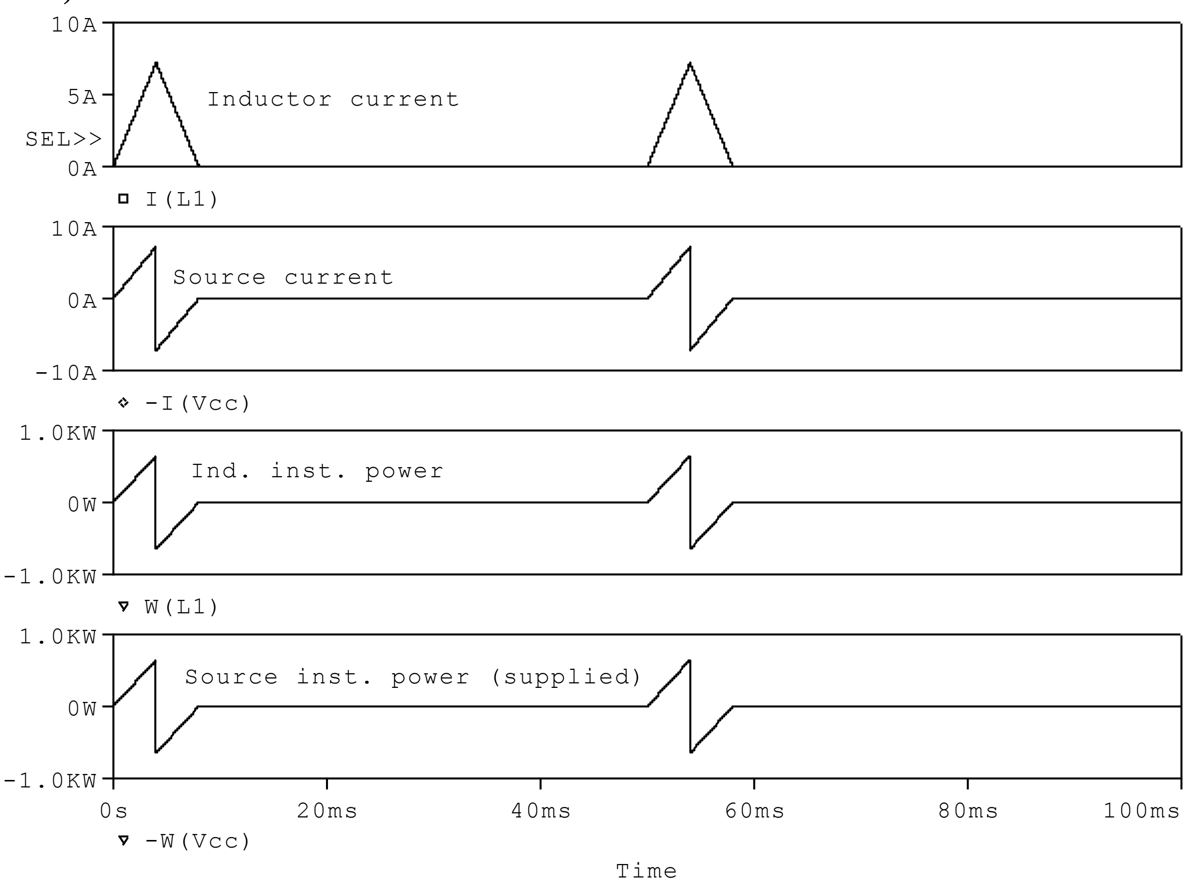
$$\tau \le \frac{L}{R} = \frac{8.9\,ms}{5} = 1.7\,ms.; \qquad R \ge \frac{L}{1.7\,ms} = \frac{10\,mH}{1.7\,ms} = 5.62 \ \Omega$$

2-12)

a) i(t) = 1800t for 0 < t < 4 ms

i(4 ms) = 7.2 A.; W_{Lpeak} = 1.296 J.

b)



2-13)

a) The zener diode breaks down when the transistor turns off to maintain inductor current.

b) Switch closed: 0 < t < 20 ms.

$$v_L = 12\ V. = L\frac{di_L(t)}{dt}$$

$$\frac{di_L}{dt} = \frac{v_L}{L} = \frac{12}{0.075} = 160\ A/s$$

$$at\ t = 20\,ms,\quad i_L = (160)(0.02) = 3.2\ A.$$

Switch open, zener on:

$$v_L = 12 - 20 = -8\ V.$$

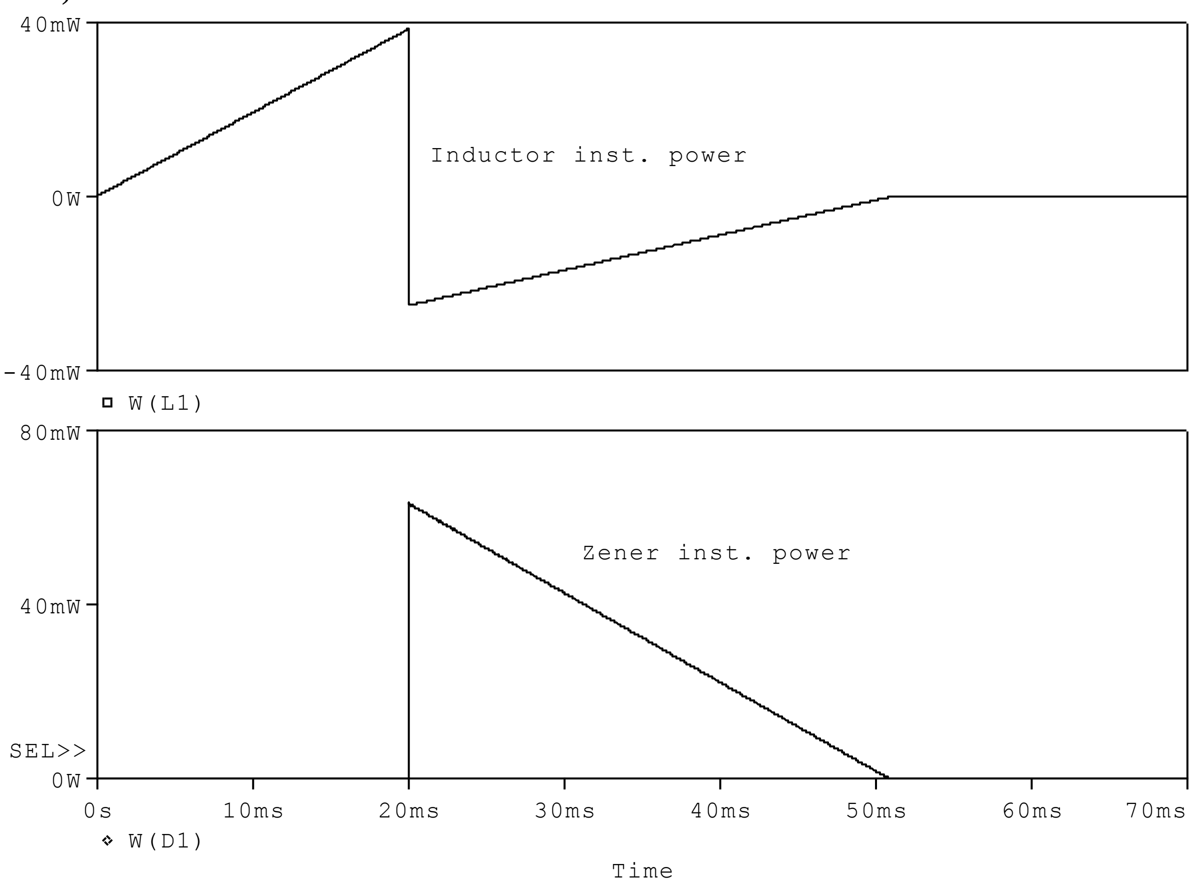
$$\frac{di_L}{dt} = \frac{v_L}{L} = \frac{-8}{0.075} = -106.7\ A/s$$

$$\Delta t\ to\ return\ to\ zero:$$

$$\Delta t = \frac{\Delta i}{-106.7} = \frac{-3.2}{-106.7} = 30\ ms$$

Therefore, inductor current returns to zero at 20 + 30 = 50 ms.
i_L = 0 for 50 ms < t < 70 ms.

c)



d)

$$P_L = 0.$$

$$P_Z = \frac{1}{T}\int_0^T p_Z(t)\,dt = \frac{1}{0.07}\left[\frac{1}{2}(0.03)(64)\right] = 13.73\ W.$$

2-14) a) The zener diode breaks down when the transistor turns off to maintain inductor current.

b) Switch closed: 0 < t < 15 ms.

$$v_L = 20\ V. = L\frac{di_L(t)}{dt}$$

$$\frac{di_L}{dt} = \frac{v_L}{L} = \frac{20}{0.050} = 400\ A/s$$

$$at\ t = 15\,ms,\quad i_L = (400)(0.015) = 6.0\ A.$$

Switch open, zener on:

$$v_L = 20 - 30 = -10\ V.$$

$$\frac{di_L}{dt} = \frac{v_L}{L} = \frac{-10}{0.050} = -200\ A/s$$

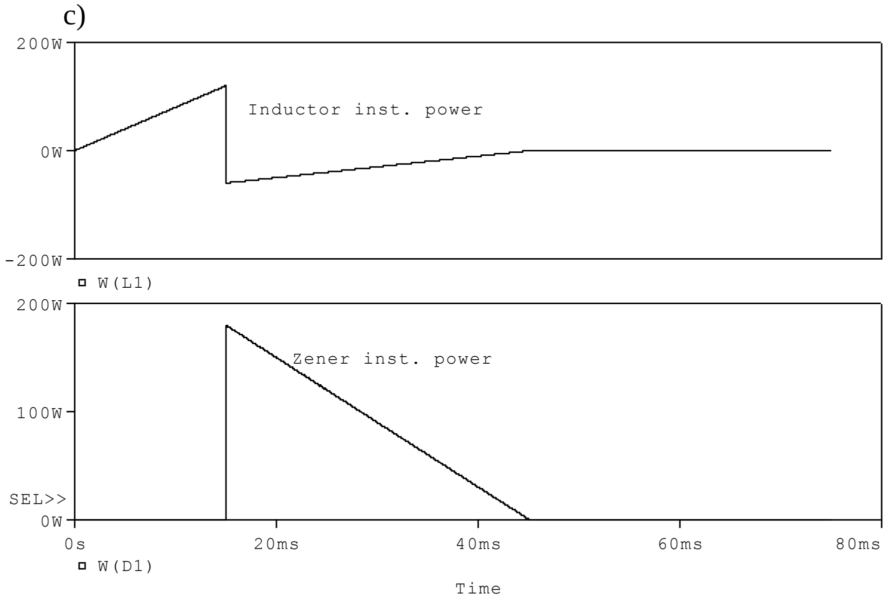
$$\Delta t\ to\ return\ to\ zero:$$

$$\Delta t = \frac{\Delta i}{-200} = \frac{-6.0}{-200} = 30\ ms$$

Therefore, inductor current returns to zero at 15 + 30 = 45 ms.

i_L = 0 for 45 ms < t < 75 ms.

c)



d)

$$P_L = 0.$$

$$P_Z = \frac{1}{T}\int_0^T p_Z(t)\,dt = \frac{1}{0.075}\left[\frac{1}{2}(0.03)(180)\right] = 36\ W.$$

2-15) Examples are square wave (Vrms = Vm) and a triangular wave (Vrms = Vm/√3).

2-16) Phase conductors: $P_\phi = I^2R = 12^2(0.5) = 72\ W.$

Neutral conductor: $P_N = I^2R = \left(12\sqrt{3}\right)^2(0.5) = 216\ W.$

$$P_{total} = 3(72) + 216 = 432\ W.$$

$$R_N = \frac{P_N}{I_N{}^2} = \frac{72}{\left(12\sqrt{3}\right)^2} = 0.167\ \Omega$$

2-17) Re: Prob. 2-4

$$V_{rms} = V_m\sqrt{D} = 10\sqrt{0.7} = 8.37\ V.$$

$$I_{rms} = I_m\sqrt{D} = 4\sqrt{0.5} = 2.83\ A.$$

2-18) Re: Prob. 2-5

$$V_{rms} = V_m\sqrt{D} = 10\sqrt{\left(\frac{14}{20}\right)} = 8.36\ V.$$

$$I_{rms} = \sqrt{\frac{1}{0.02}\int_0^{0.006} 7^2\,dt + \int_{0.006}^{0.01}(-5)^2\,dt + \int_{0.01}^{0.02} 4^2\,dt} = \sqrt{27.7} = 5.26\ A.$$

2-19)

$$V_{rms} = \sqrt{2^2 + \left(\frac{5}{\sqrt{2}}\right)^2 + \left(\frac{3}{\sqrt{2}}\right)^2} = 4.58\ V.$$

$$I_{rms} = \sqrt{1.5^2 + \left(\frac{2}{\sqrt{2}}\right)^2 + \left(\frac{1.1}{\sqrt{2}}\right)^2} = 2.2\ A.$$

$$P = V_0 I_0 + \sum_{n=1}^{\infty} \frac{V_m I_m}{2} \cos(\theta_n - \phi_n)$$

$$= (2.0)(1.5) + \left(\frac{5}{\sqrt{2}}\right)\left(\frac{2}{\sqrt{2}}\right)\cos(-20°) + \left(\frac{3}{\sqrt{2}}\right)\left(\frac{1.1}{\sqrt{2}}\right)\cos(-115°) = 7.0\ W.$$

$$\textit{Note that } -\cos(4\pi 60t + 45°)\ \textit{is}\ \cos(4\pi 60t - 135°)$$

2-20)

$$dc:\ V_0 = 3(100) = 300\ V.$$

$$\omega_1 = 2\pi 60:\ Y_1 = 1/R + j\omega C = 0.01 + j0.0189$$

$$V_1 = \frac{I_1}{Y_1} = \frac{4\angle 0}{(0.01 + j0.0189)} = 187\angle -62.1°$$

$$\omega_2 = 4\pi 60:\ Y_2 = 1/R + j\omega C = 0.01 + j0.0377$$

$$V_2 = \frac{I_2}{Y_2} = \frac{6\angle 0}{(0.01 + j0.0377)} = 153\angle -75.1°$$

$$P = V_0 I_0 + \sum_{n=1}^{\infty} \frac{V_m I_m}{2} \cos(\theta_n - \phi_n)$$

$$= 300(5) + \frac{(187)(4)}{2}\cos(62.1°) + \frac{(153)(6)}{2}\cos(75.1°)$$

$$= 1500 + 175 + 118 = 1793\ W.$$

2-21) dc Source:

$$P_{dc} = V_{dc} I_{avg} = 12\left[\frac{50-12}{4}\right] = 114\ W.$$

Resistor:

$$P = I_{rms}^2 R$$

$$I_{rms} = \sqrt{I_0^2 + I_{1,rms}^2 + I_{2,rms}^2}$$

$$I_0 = 9.5\ A.$$

$$|I_1| = \frac{30}{|4 + j(4\pi 60)(0.01)|} = 3.51\ A.$$

$$|I_2| = \frac{10}{|4 + j(8\pi 60)(0.01)|} = 0.641\ A.$$

$$I_{rms} = \sqrt{9.5^2 + \left(\frac{3.51}{\sqrt{2}}\right)^2 + \left(\frac{0.641}{\sqrt{2}}\right)^2} = 9.83\ A.$$

$$P_R = I_{rms}^2 R = 386\ W.$$

2-22)

$$P = I_{rms}^2 R$$

$$I_0 = \frac{V_0}{R} = \frac{6}{16} = 0.375\ A.$$

$$|I_1| = \frac{5}{|16 + j(2\pi 60)(0.025)|} = 0.269\ A.$$

$$|I_2| = \frac{3}{|16 + j(6\pi 60)(0.025)|} = 0.0923\ A.$$

$$I_{rms} = \sqrt{0.375^2 + \left(\frac{0.269}{\sqrt{2}}\right)^2 + \left(\frac{0.0923}{\sqrt{2}}\right)^2} = 0.426\ A.$$

$$I_{rms} = 0.623\ A.;\quad P = I_{rms}^2 R = (0.426)^2 (16) = 2.9\ W.$$

2-23)

$$P = V_0 I_0 + \sum_{n=1}^{\infty} \frac{V_m I_m}{2} \cos(\theta_n - \phi_n)$$

n	V_n	I_n	P_n	$\sum P_n$
0	20	5	100	100
1	20	5	50	150
2	10	1.25	6.25	156.25
3	6.67	0.556	1.85	158.1
4	5	0.3125	0.781	158.9

Power including terms through n = 4 is 158.9 watts.

2-24)

$$P = V_0 I_0 + \sum_{n=1}^{\infty} \frac{V_m I_m}{2} \cos(\theta_n - \phi_n)$$

n	V_n	I_n	θ_n - ϕ_n°	P_n
0	50.0000	10.0	0	500.0
1	50.0000	10.0	26.6	223.6
2	25.0000	2.5	45.0	22.1
3	16.6667	1.11	56.3	5.1
4	12.5000	0.625	63.4	1.7

Through n = 4, $\sum P_n$ = 753 W.

2-25)

$$P = V_0 I_0 + \sum_{n=1}^{\infty} \frac{V_m I_m}{2} \cos(\theta_n - \phi_n)$$

$$I_0 = \frac{V_0 - V_{dc}}{R} = \frac{50-36}{20} = 0.7\ A$$

$$P_{0,R} = I_0^2 R = (0.7)^2\, 20 = 9.8\ W \quad (dc\ component\ only)$$

$$P_{Vdc} = I_0 V_{dc} = (0.7)(36) = 25.2\ W$$

$$P_L = 0$$

Resistor Average Power

n	V_n	Z_n	I_n	angle	P_n
0	50.00	20.00	0.7	0.00	9.8
1	127.32	25.43	5.01	0.67	250.66
2	63.66	37.24	1.71	1.00	29.22
3	42.44	51.16	0.83	1.17	6.87
4	31.83	65.94	0.48	1.26	2.33
5	25.46	81.05	0.31	1.32	0.99

$P_R = \sum P_n \approx 300$ W.

2-26) a) THD = 5% → I_9 = (0.05)(10) = 0.5 A.
b) THD = 10% → I_9 = (0.10)(10) = 1 A.
c) THD = 20% → I_9 = (0.20)(10) = 2 A.
d) THD = 40% → I_9 = (0.40)(10) = 4 A.

2-27) a)

$$P = \sum P_n = \left(\frac{170}{\sqrt{2}}\right)\left(\frac{10}{\sqrt{2}}\right)\cos(30°) + 0 + 0 = 736\ W.$$

b)

$$I_{rms} = \sqrt{\left(\frac{10}{\sqrt{2}}\right)^2 + \left(\frac{6}{\sqrt{2}}\right)^2 + \left(\frac{3}{\sqrt{2}}\right)^2} = 8.51\ A.$$

$$S = V_{rms} I_{rms} = \left(\frac{170}{\sqrt{2}}\right) 8.51 = 1024\ VA.$$

$$pf = \frac{P}{S} = \frac{736}{1024} = 0.719$$

c)

$$DF = \frac{I_{1,rms}}{I_{rms}} = \frac{10/\sqrt{2}}{8.51} = 0.831$$

d)

$$THD_I = \frac{\sqrt{\left(\frac{6}{\sqrt{2}}\right)^2 + \left(\frac{3}{\sqrt{2}}\right)^2}}{10/\sqrt{2}} = 0.67 = 67\%$$

2-28) a)

$$P = \sum P_n = \left(\frac{170}{\sqrt{2}}\right)\left(\frac{12}{\sqrt{2}}\right)\cos(40°) + 0 + 0 = 781\ W.$$

b)

$$I_{rms} = \sqrt{\left(\frac{12}{\sqrt{2}}\right)^2 + \left(\frac{5}{\sqrt{2}}\right)^2 + \left(\frac{4}{\sqrt{2}}\right)^2} = 9.62\ A.$$

$$S = V_{rms} I_{rms} = \left(\frac{170}{\sqrt{2}}\right) 9.62 = 1156\ VA.$$

$$pf = \frac{P}{S} = \frac{781}{1156} = 0.68$$

c)

$$DF = \frac{I_{1,rms}}{I_{rms}} = \frac{12/\sqrt{2}}{9.62} = 0.88$$

d)

$$THD_I = \frac{\sqrt{\left(\frac{5}{\sqrt{2}}\right)^2 + \left(\frac{4}{\sqrt{2}}\right)^2}}{12/\sqrt{2}} = 0.53 = 53\%$$

2-29)

$$I_{1,rms} = \frac{8}{\sqrt{2}} = 5.66\ A.; \quad I_{2,rms} = \frac{4}{\sqrt{2}} = 2.82\ A.;$$

$$I_{rms} = \sqrt{5.66^2 + 2.82^2} = 6.32\ A.; \quad I_{peak} \approx 10.38\ (graphically)$$

a) $P = V_{1,rms} I_{1,rms} \cos(\theta_1 - \phi_1) = (240)(5.66)\cos(0) = 1358\ W.$

b) $pf = \frac{P}{S} = \frac{P}{V_{rms} I_{rms}} = \frac{1358}{(240)(6.32)} = 0.895 = 89.5\%$

c) $THD_I = \frac{I_{2,rms}}{I_{rms}} = \frac{2.82}{6.32} = 0.446 = 44.6\%$

d) $DF = \frac{I_{1,rms}}{I_{rms}} = \frac{5.66}{6.32} = 89.6\%$

e) $crest\ \ factor = \frac{I_{peak}}{I_{rms}} = \frac{10.38}{6.32} = 1.64$

2-30)

$$I_{1,rms} = \frac{12}{\sqrt{2}} = 8.49\ A.; \quad I_{2,rms} = \frac{9}{\sqrt{2}} = 6.36\ A.;$$

$$I_{rms} = \sqrt{8.49^2 + 6.36^2} = 10.6\ A.; \quad I_{peak} \approx 18.3\ A.\ (graphically)$$

a) $P = V_{1,rms} I_{1,rms} \cos(\theta_1 - \phi_n) = (240)(10.6)\cos(0) = 2036\ W.$

b) $pf = \frac{P}{S} = \frac{P}{V_{rms} I_{rms}} = \frac{2036}{(240)(10.6)} = 0.80 = 80\%$

c) $THD_I = \frac{I_{2,rms}}{I_{rms}} = \frac{6.36}{10.6} = 0.60 = 60\%$

d) $DF = \frac{I_{1,rms}}{I_{rms}} = \frac{8.49}{10.6} = 80\%$

e) $crest\ \ factor = \frac{I_{peak}}{I_{rms}} = \frac{18.3}{10.6} = 1.72$

2-31)

5V: I = 0 (capacitor is an open circuit)

$$25\cos(1000t): Z = \left|R + j\omega L - j\frac{1}{\omega C}\right| = \left|2 + j1000(.001) - j\frac{1}{1000(1000)10^{-6}}\right| = 2 + j0$$

$$I = \frac{25}{2}\cos(1000t) = 12.5\cos(1000t)\ A$$

$$10\cos(2000t):\ Z = 2 + j1.5\Omega$$

$$I_{10} = \frac{10}{2 + j1.5} = 4\angle -37^\circ\ A.$$

$$I_{rms} = \sqrt{\left(\frac{12.5}{\sqrt{2}}\right)^2 + \left(\frac{4}{\sqrt{2}}\right)^2} = 9.28\,A$$

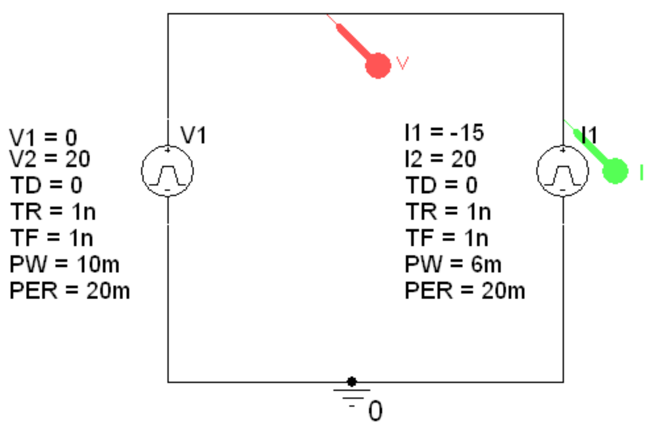
$$P_R = I_{rms}^2 R = 9.28^2(2) = 172.3\,W$$

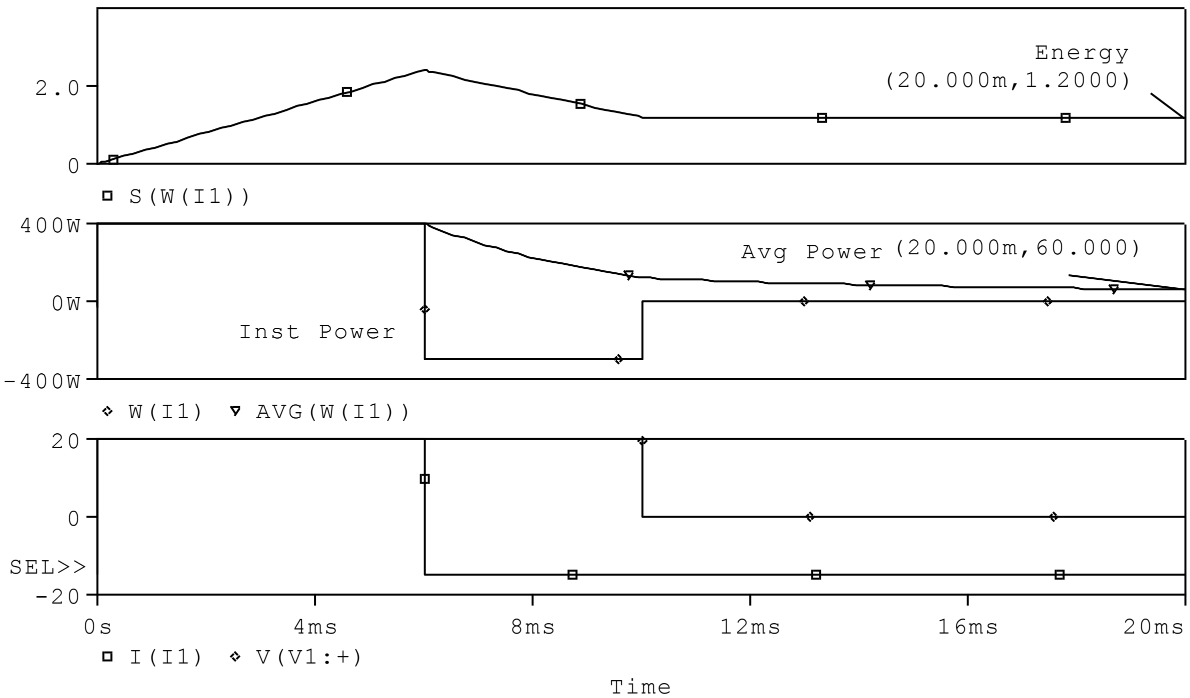
$$P_L = 0$$

$$P_C = 0$$

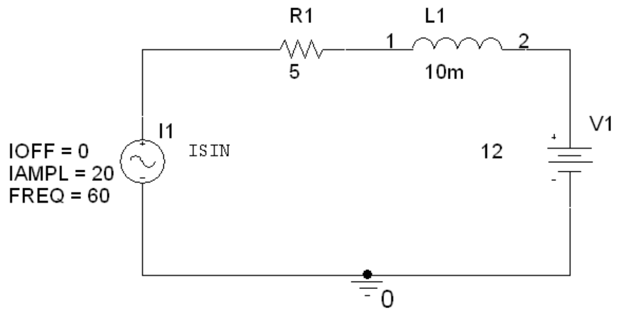
$$P_{source} = -172.3\,W$$

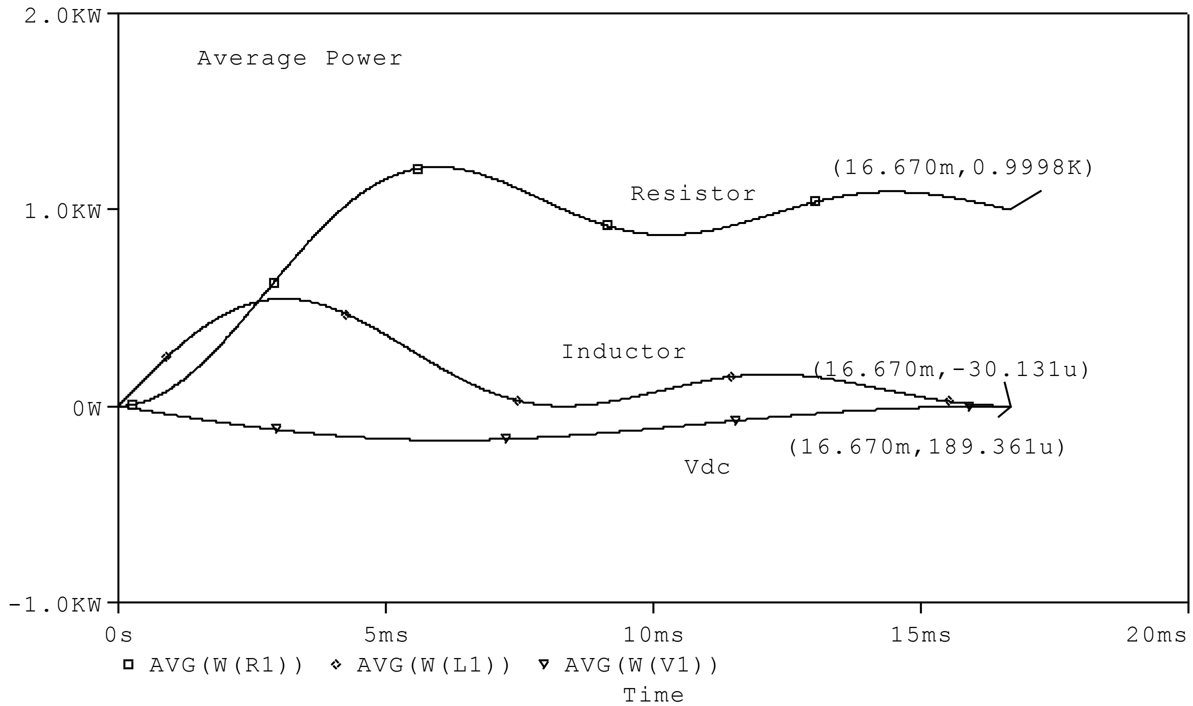
2-32) PSpice shows that average power is 60 W and energy is 1.2 J. Use VPULSE and IPULSE for the sources.

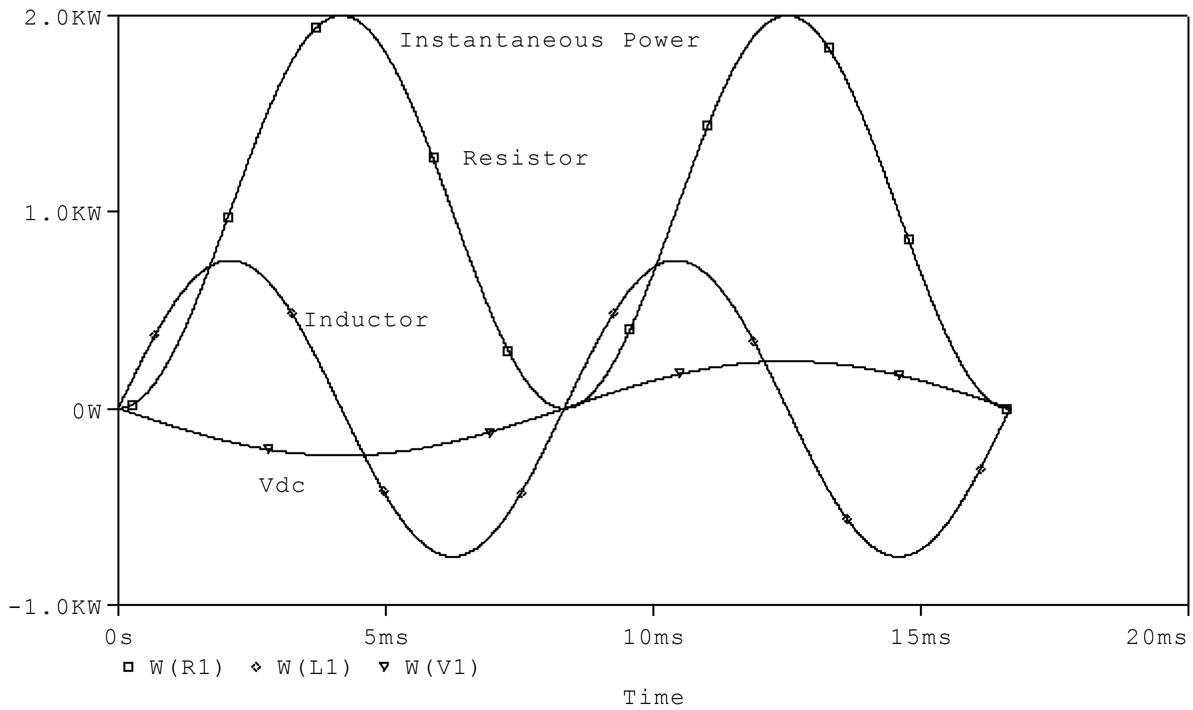



Energy
(20.000m,1.2000)
2.0
0
S(W(I1))
400W
0W
-400W
Avg Power (20.000m,60.000)
Inst Power
W(I1) AVG(W(I1))
20
0
SEL>>
-20
0s
4ms
8ms
12ms
16ms
20ms
I(I1) V(V1:+)
Time

2-33) Average power for the resistor is approximately 1000 W. For the inductor and dc source, the average power is zero (slightly different because of numerical solution).



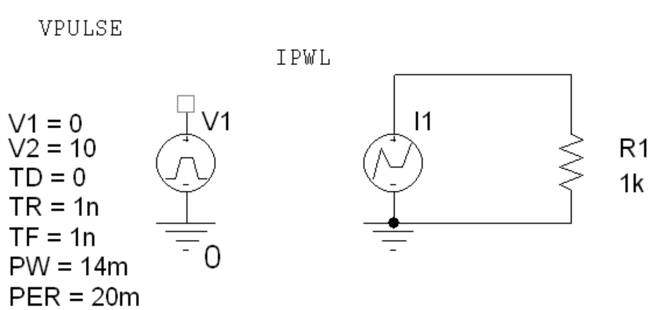




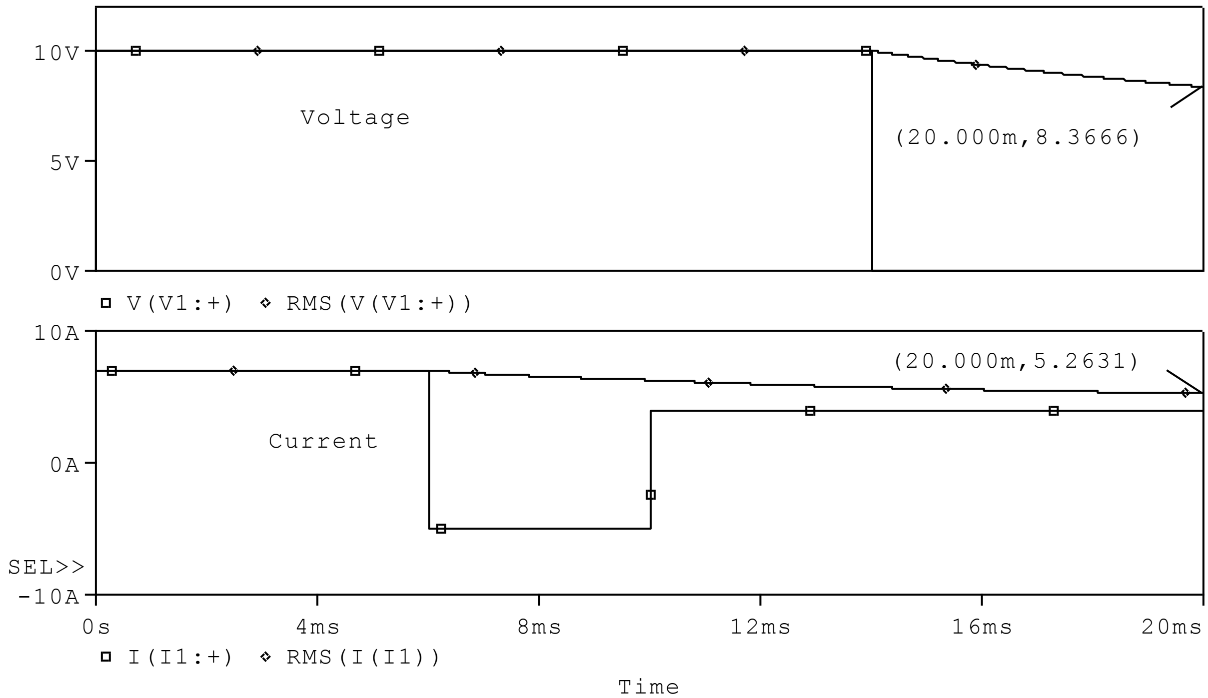
2.0KW
1.0KW
0W
-1.0KW
Instantaneous Power
Resistor
Inductor
Vdc
0s
5ms
10ms
15ms
20ms
W(R1) W(L1) W(V1)
Time

2-34)

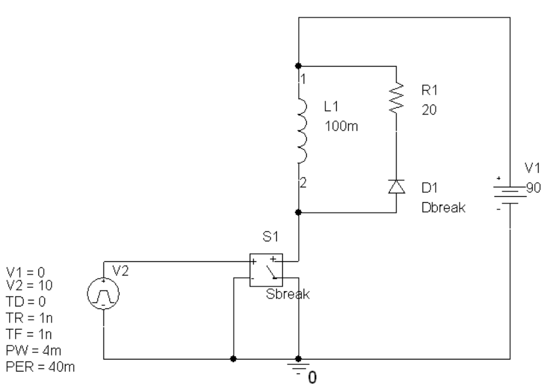
Graphic	IPWL.Normal
I1	7
I2	7
I3	-5
I4	-5
I5	4
I6	4
I7	
I8	
ID	
Implementation	
nplementation Path	
nplementation Type	PSpice Model
ocation X-Coordinate	400
ocation Y-Coordinate	190
Name	INS138
Part Reference	I1
PCB Footprint	
Power Pins Visible	
Primitive	DEFAULT
PSpiceOnly	TRUE
PSpiceTemplate	I^@REFDES %+ %- ?DC|DC
Reference	I1
Source Library	C:\ORCAD\ORCAD_16.
Source Package	IPWL
Source Part	IPWL.Normal
T1	0
T2	6m
T3	6.00001m
T4	10m
T5	10.0001m
T6	20m

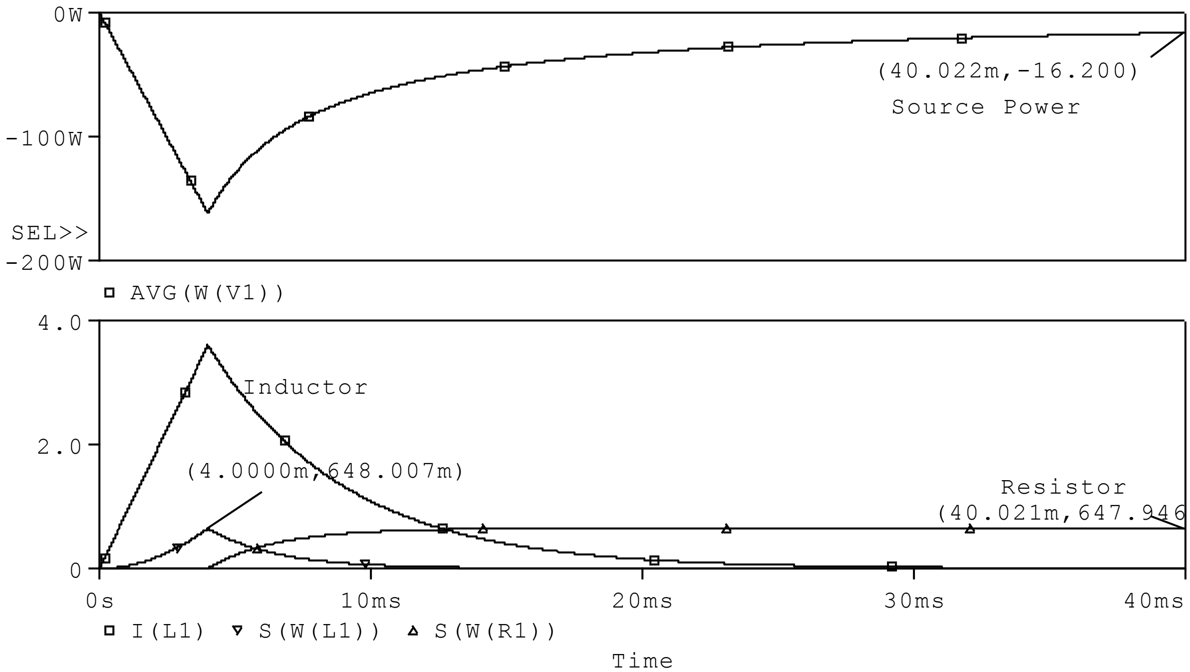


Rms voltage is 8.3666 V. Rms current is 5.2631 A.



2-35) See Problem 2-10.

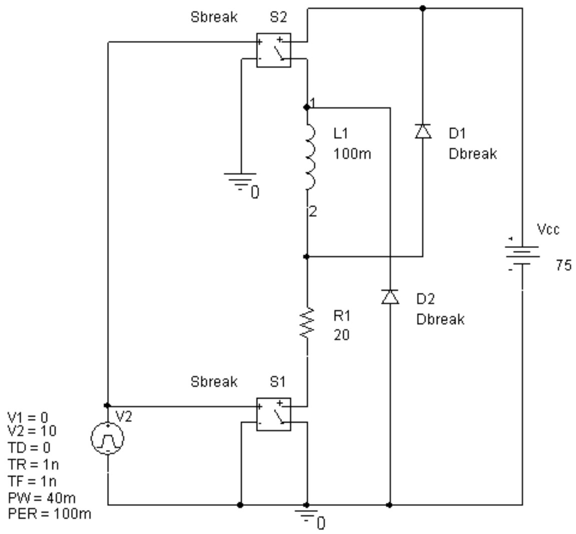




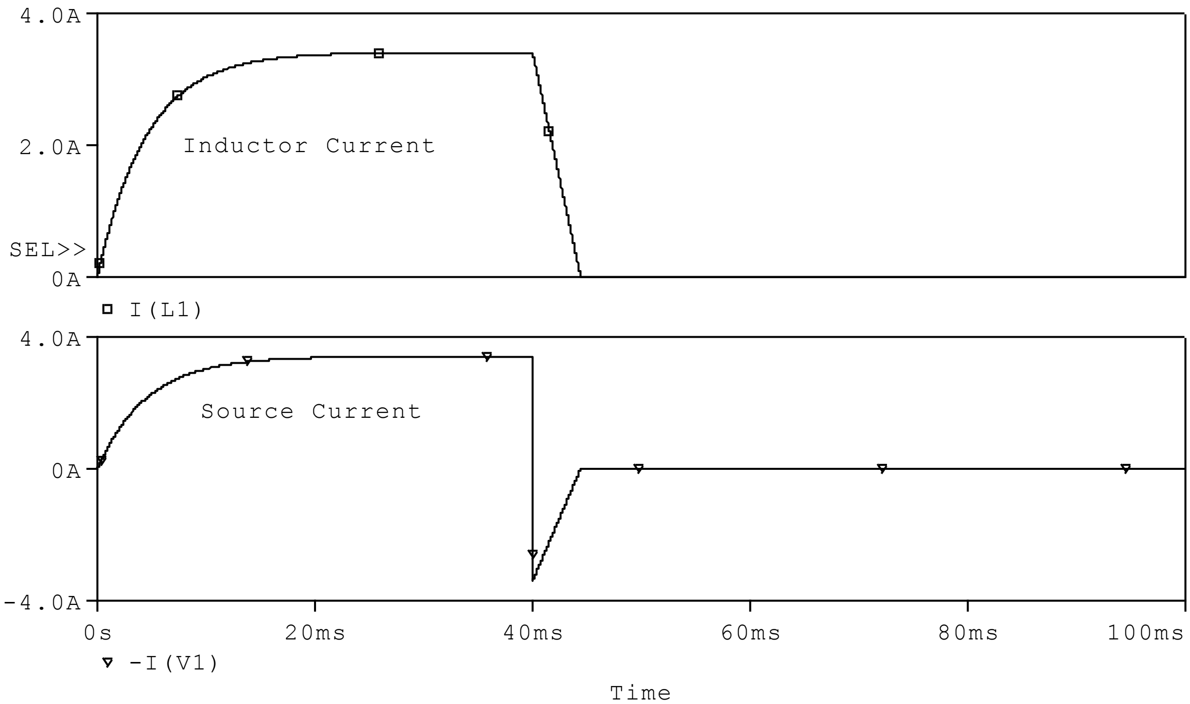
The inductor peak energy is 649 mJ, matching the resistor absorbed energy. The source power is -16.2 W absorbed, meaning 16.2 W supplied.

b) If the diode and switch parameters are changed, the inductor peak energy is 635 mJ, and the resistor absorbed energy is 620 mJ. The difference is absorbed by the switch and diode.

2-36)



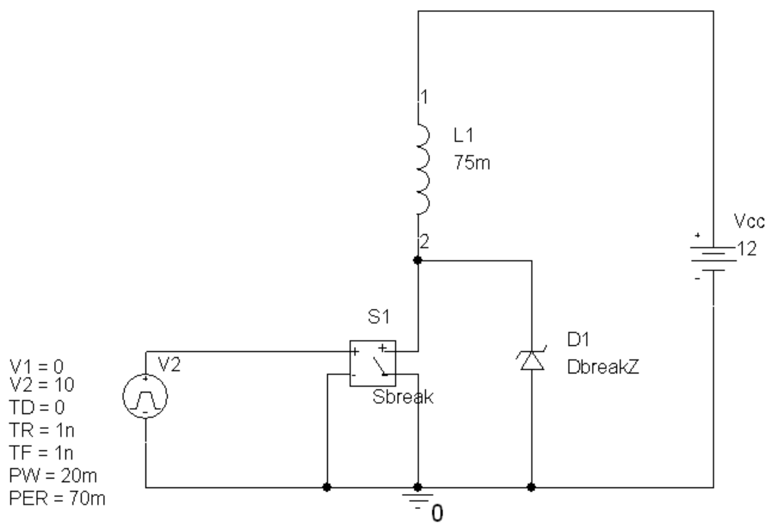
The inductor current reaches a maximum value of 3.4 A with the resistances in the circuit: I = 75/(20+1+1) = 3.4 A.

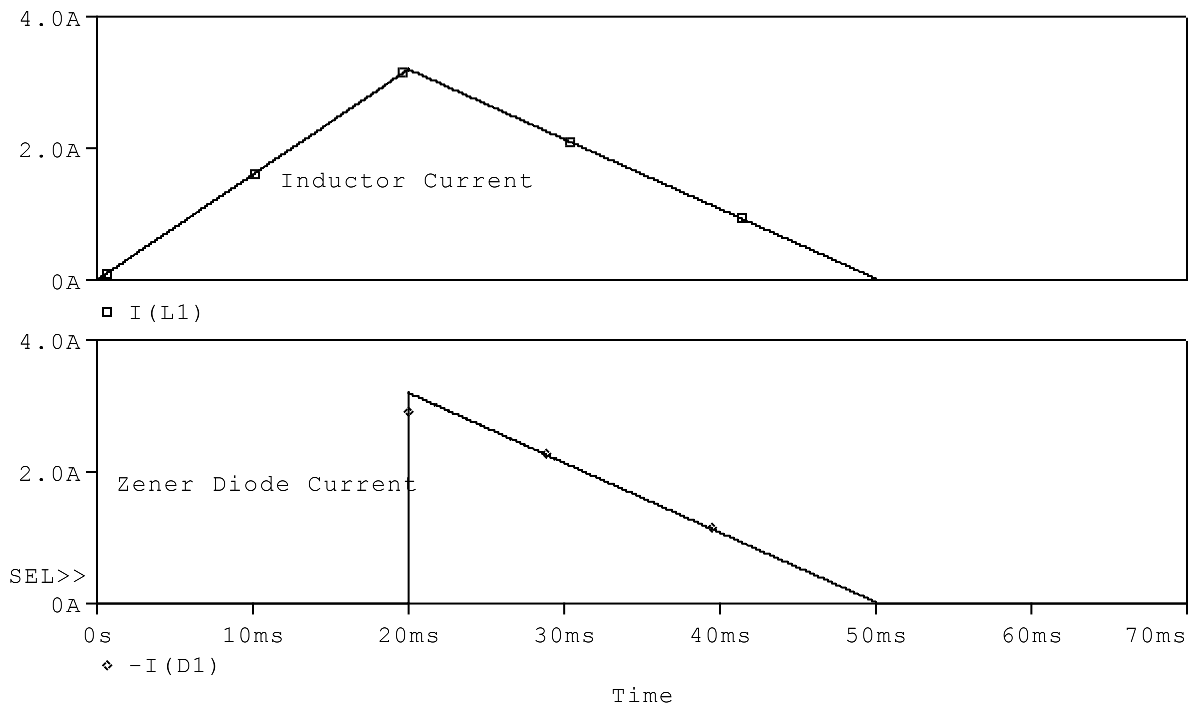


Quantity	Probe Expression	Result
Inductor resistor average power	AVG(W(R1))	77.1 W
Switch average power	AVG(W(S1))	3.86 W each
Diode average power	AVG(W(D1))	81 mW each
Source average power	AVG(W(Vcc))	-85.0 W

2-37)

a) Power absorbed by the inductor is zero. Power absorbed by the Zener diode is 13.8 W.



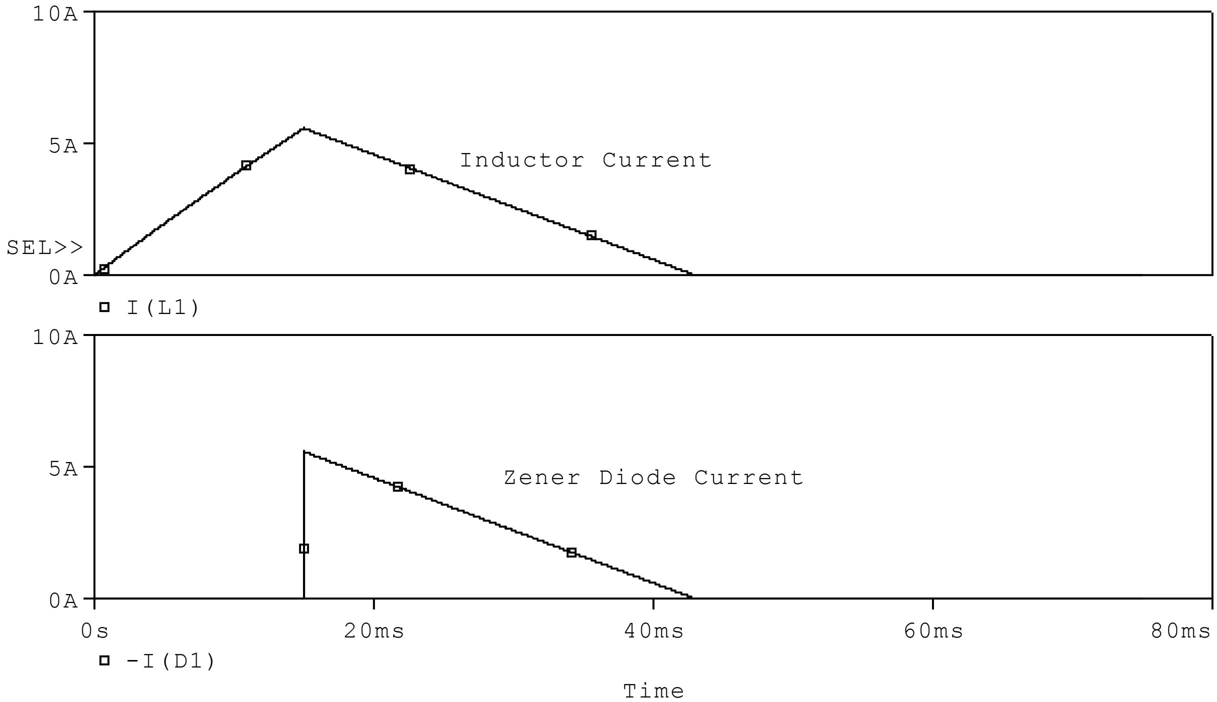


b) Power in the inductor is zero, but power in the 1.5Ω resistor is 1.76 W. Power absorbed by the Zener diode is 6.35 W. Power absorbed by the switch is 333 mW.

3-38)

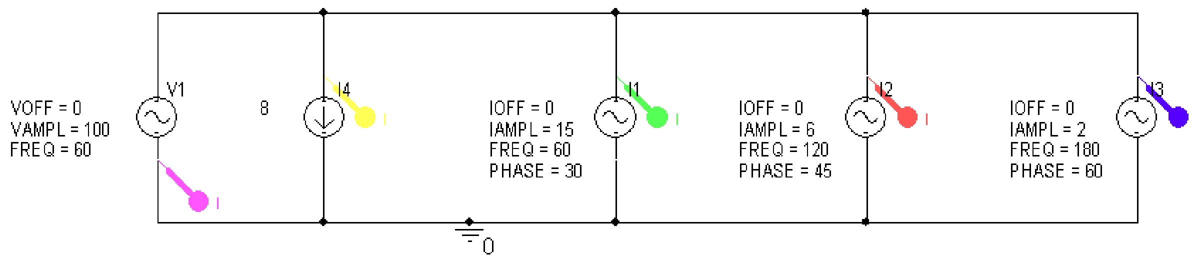
See Problem 3-37 for the circuit diagram.

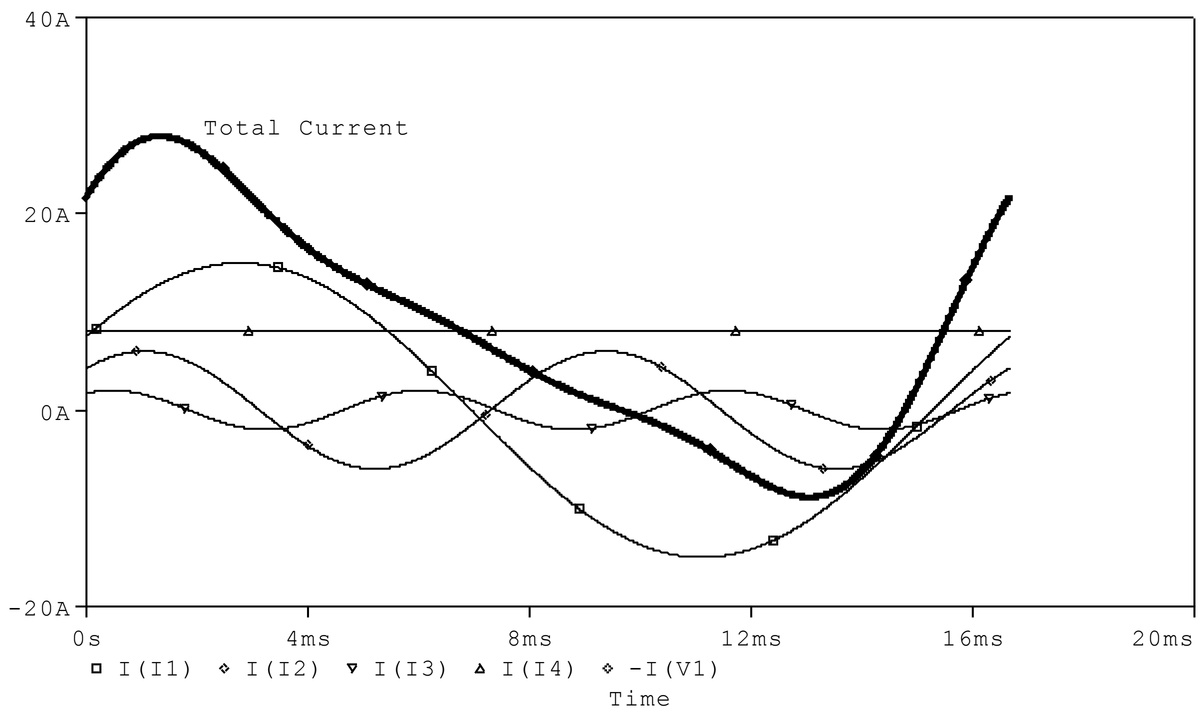
a) Power absorbed by the Zener diode is 36.1 W. Power absorbed by the inductor is zero.



b) Power in the inductor is zero, but power in the 1.5Ω resistor is 4.4 W. Power absorbed by the Zener diode is 14.2 W. Power absorbed by the switch is 784 mW.

2-39)



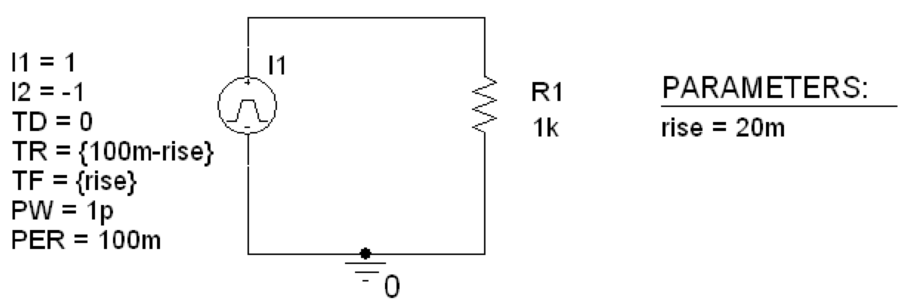


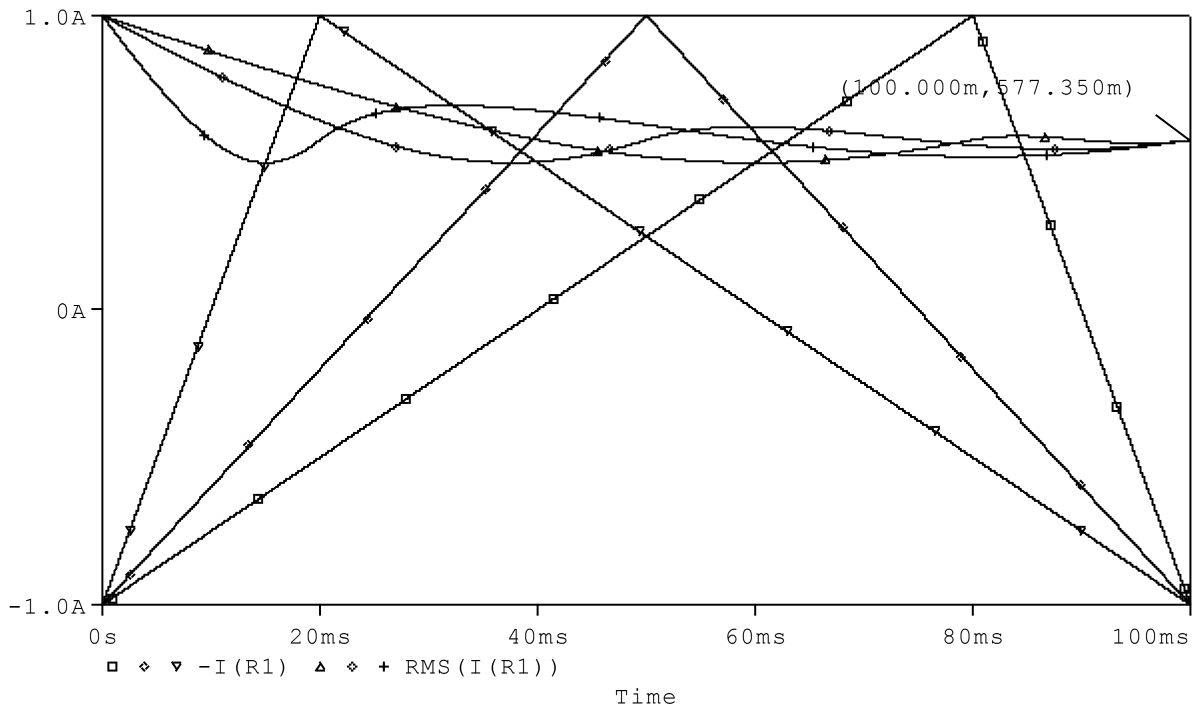
Quantity	Probe Expression	Result
Power	AVG(W(V1))	650 W
rms current	RMS(I(V1))	14 A
Apparent power S	RMS(V(I1:+))* RMS(I(V1))	990 VA
Power factor	AVG(W(V1)) / (RMS(V(I1:+))* RMS(I(V1)))	0.66

2-40)

DESIRED QUANTITY	ORIGINAL RESULT	NEW VALUES
Inductor Current	max = 4.5 A.	4.39 A
Energy Stored in Inductor	max = 2.025 J	1.93 L
Average Switch Power	0.010 W.	0.66 W
Average Source Power (absorbed)	-20.3 W.	-19.9 W
Average Diode Power	0.464 W.	.449 W
Average Inductor Power	. 0	0
Average Inductor Voltage	. 0	0
Average Resistor Power	19.9 W.	18.8 W
Energy Absorbed by Resistor	1.99 J.	1.88 J
Energy Absorbed by Diode	.046 J.	.045 J
Energy Absorbed by Inductor	. 0	0
rms Resistor Current	0.998 A.	0.970 A

2-41) Use the part VPULSE or IPULSE (shown). Here, the period is 100 ms, and the rise times chosen are 20 ms, 50 ms, and 80 ms. The fall times are the period minus the rise times. Each rms value is 0.57735, which is identical to $1/\sqrt{3}$.




1.0A
0A
-1.0A
(100.000m,577.350m)
0s
20ms
40ms
60ms
80ms
100ms
-I(R1)
RMS(I(R1))
Time