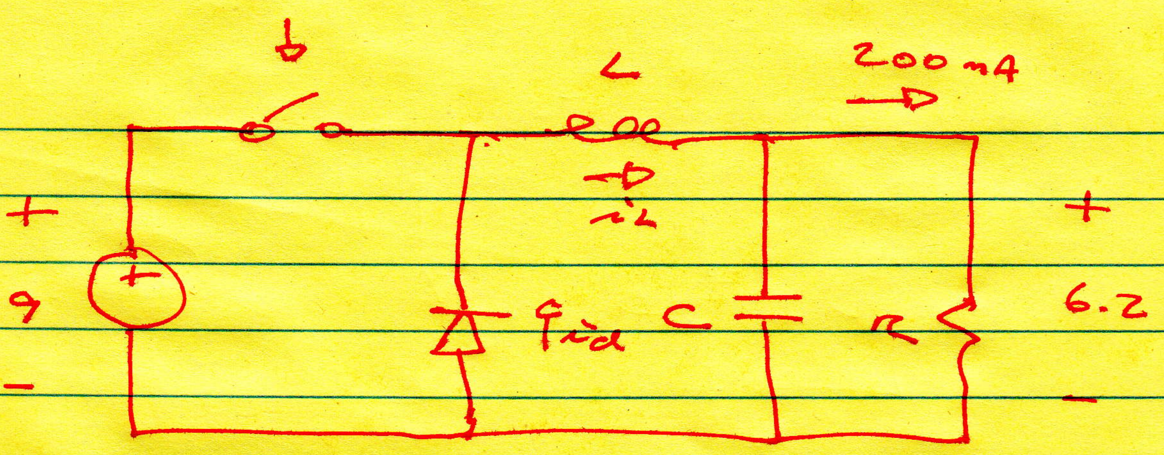
4.16

$f = 180\ \text{kHz}$



$v_{ripple} < 0.2\ V$

$R = \dfrac{6.2}{0.2} = 31\,\Omega$

$D = \dfrac{6.2}{9} = 0.69$

$L > \dfrac{v_b(1-D)DT}{2 \times \text{dc load current}}$

$= \dfrac{9(0.31)(0.69)}{0.4 \times 180 \times 10^3} = 26.7\ \mu H$

$\longrightarrow$ choose 33 μH

$RC \sim 10T \longrightarrow C = \dfrac{10}{31 \times 180 \times 10^3}$

$= 1.79\ \mu F$

$\longrightarrow$ choose 2.2 μF

$i_{L,p\text{-}p} = \dfrac{v_b(1-D)DT}{L} = 0.32\ A$

$\longrightarrow ESR < \dfrac{0.2}{0.32} = 0.63\,\Omega$

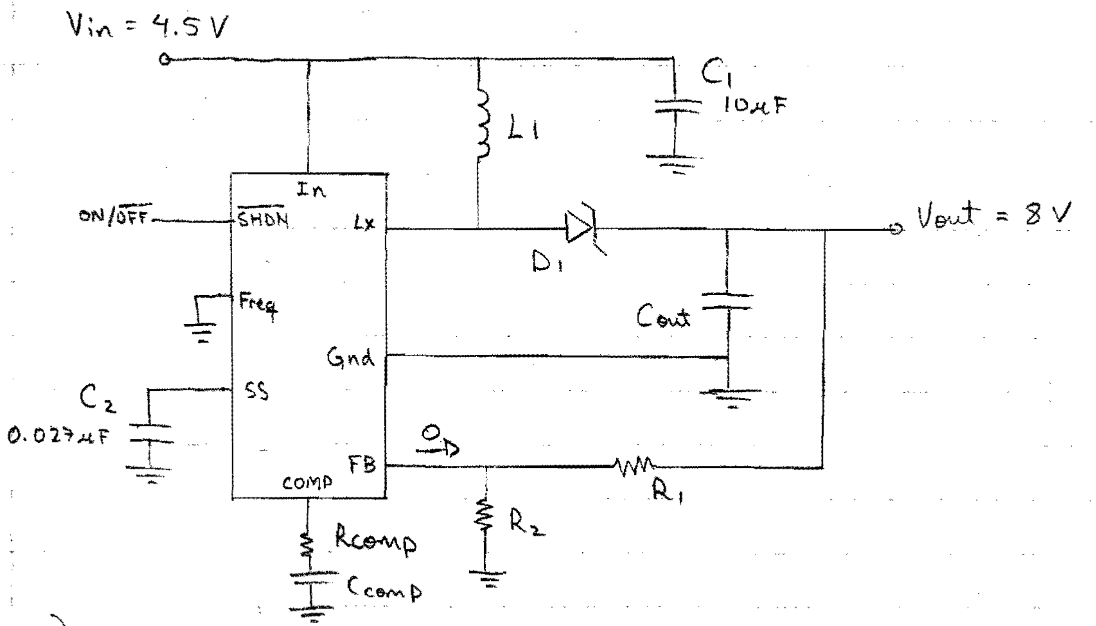
$i_d(\max) = i_L(\max) = 200\ mA + 320\ mA$

$= 520\ mA$

$\longrightarrow$ 1-A diode good

4.24) Design boost converter that delivers 60 mA at 8V from a 4.5-V dc source. Use the MAX 1790 controller at 640kHz. Specify pin connections.

easy filtering
Faster loop performance



a)

$$L = \left(\frac{V_{in}}{V_{main}}\right)^2 \left(\frac{V_{main} - V_{in}}{I_{main(max)} \cdot f_{osc}}\right)\left(\frac{\eta_{typ}}{LIR}\right)$$

$$= \left(\frac{4.5}{8}\right)^2 \left(\frac{8-4.5}{(0.06)(640000)}\right)\left(\frac{0.87}{0.5}\right)$$

$$= 50.180054\ \mu H \approx 51\ \mu H$$

$$I_{in(DC,Max)} = \frac{I_{main(max)} \cdot V_{main}}{V_{in(min)} \cdot \eta_{min}} = \frac{0.06 \cdot 8}{4.5 \cdot 0.87} = 0.122605\ A$$

$$I_{ripple} = \frac{V_{in(min)} \cdot (V_{main} - V_{in(min)})}{L \cdot V_{main} \cdot f_{osc}} = \frac{4.5(8-4.5)}{(51\times10^{-6})\,8(640\times10^3)} = 0.06032\ A$$

$$I_{peak} = I_{in(DC,max)} + \frac{I_{ripple}}{2} = 0.1528\ A$$

$V_{ripple} = I_{ripple} \cdot 0.1\Omega$

ESR

series resistance of inductor $\rightarrow$ $0.1\ \Omega$

$$\therefore\ C \geq \frac{0.5 \cdot L \cdot (I_{peak})^2}{V_{ripple} \cdot V_{out}} = \frac{(0.5)(51\times10^{-6})(0.1528^2)}{(0.006032)\cdot(8)} = 12.09\ \mu F \rightarrow 15\mu F$$

standard value

$$R_1 = R_2\left(\frac{V_{out}}{V_{FB}} - 1\right)$$

$V_{FB} = 1.24V$

So can choose $R_1 = 110\ k\Omega$

$R_2 = 20\ k\Omega$

$$R_{comp} = \left(200\,\frac{\Omega}{A^2}\right)\left(V_{out}\right)^2\left(\frac{C_{out}}{L}\right)$$

$$= 200\,(8)^2\left(\frac{15}{51}\right) = 3.765\ \text{k}\Omega \rightarrow 3.6\ \text{k}\Omega$$

$$C_{comp} = \left(0.4\times10^{-3}\,\frac{A}{\Omega}\right)\left(\frac{L}{V_{in}}\right)$$

$$= \left(0.4\times10^{-3}\right)\left(\frac{51\times10^{-6}}{4.5}\right) = 4.53\times10^{-9} \rightarrow 470\ \text{pF}$$

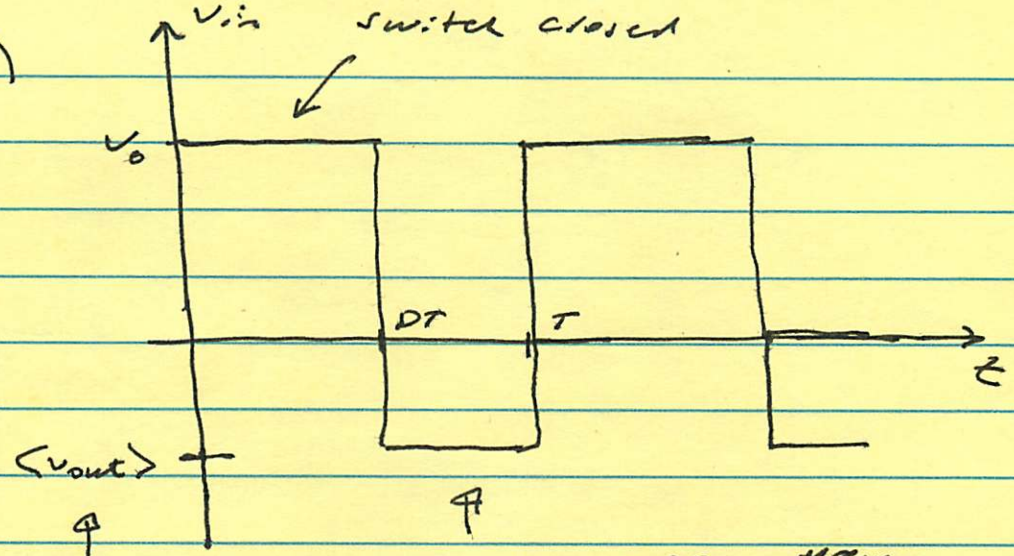
b) Based on the graphs for the typical operating characteristics of the MAX 1790 (page 5 of datasheet), the efficiency is approximately 87 %.

c) Cost Analysis

Component Type	Digi-Key part number	Manufacturer part number	Description	Manufacturer	Price (1000 components)
Capacitor Cout	399 3298 2 ND	C1210C156K8PACTU	CAP ceramic 15µF 10V X5R 1210	Kemet	$ 221
Resistor R1	218794953ND	218794953	RES 110K OHM 1/5 W 5% 0603	TE connectivity	$ 2.9
Resistor R2	18794955ND	1879495-5	RES 20.0K OHM 1/5 W 5% 0603	TE connectivity	$ 2.9
Capacitor C1	1812YC106JAT2A ND	1812YC106JAT2A	CAP CER 10µF 16V 5% X7R 1812	AVX corporation	$ 490
Capacitor C2	478 1168 1 ND	06035A270JAT2A	CAP CERM 27PF 5% 50V NPO 0603	AVX corporation	$ 61
Diode D1	FLZ8V2BTR ND	FLZ8V2B	Diode Zener 8.2V 500 MW SOD-80	Fairchild Semiconductor	$49
Inductor L1	ASPI6045S510MTND	ASPI6045S510MT	Inductor Power 51µH SMD	Abracon Corporation	$ 225
Resistor Rcomp	818794946ND	818794946	Res 3.60K OHM 1/5 W 5% 0603	TE connectivity	$ 2.9
Capacitor Ccomp	478 6201 1 ND	06033A471JAT2A	CAP CER 470PF 25V NPO 0603	AVX corporation	$ 77
					$ 1131.70

Add Max1790 component

4.29 a)



negative

Prove shortly

switch open, zero diode voltage if $i_L > 0$

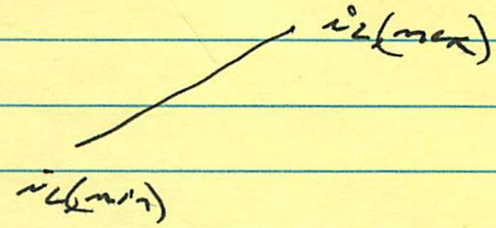
b) $\langle v_L \rangle = \langle v_{in} \rangle = 0$

$$0 = \frac{1}{T}\left[v_0 DT + \langle v_{out} \rangle (1-D)T \right]$$

$$\hookrightarrow \quad v_{out} = \frac{-Dv_0}{1-D}$$

c) switch closed

$$L\frac{di_L}{dt} = v_0$$



$$i_L(max) - i_L(min) = \frac{v_0 DT}{2}$$

4.29 (cont.)

Inductor energy gained $= \frac{1}{2} L i_{L(max)}^2 - \frac{1}{2} L i_{L(min)}^2$

$$= \underbrace{\frac{1}{R}\left[\frac{-DV_0}{1-D}\right]^2}_{\text{Load Power}} DT$$

DT ← switch closure time

$$\left(\tfrac{1}{2}L\right)\underbrace{\left(i_{L(max)} - i_{L(min)}\right)}_{\frac{V_0 DT}{2}}\left(i_{L(max)} + i_{L(min)}\right)$$

$$= \frac{DT}{R}\,\frac{D^2 V_0^2}{(1-D)^2}$$

$$i_{L(max)} + i_{L(min)} = \frac{2V_0 D^2}{R(1-D)^2}$$

$$i_{L(max)} - i_{L(min)} = \frac{V_0 DT}{2}$$

$$i_L\binom{max}{min} = \frac{V_0 D^2}{R(1-D)^2} \pm \frac{V_0 DT}{2L}$$

d) $i_{L(min)} > 0$

$$\hookrightarrow \quad L > \frac{RT(1-D)^2}{2D} = \frac{R}{2} DT \left(\frac{V_0}{V_{out}}\right)^2$$

e) $RC \gg T$