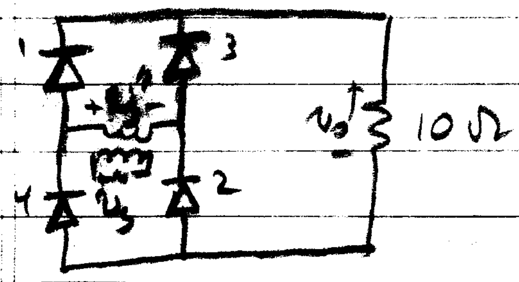
3.7



$v_s'' = V_m'' \sin\omega t$

CALCULATIONS

$V_{o,av} = \frac{2V_m}{\pi} \Rightarrow V_m'' = \frac{\pi}{2} V_{o,av} = \underline{628.32\ V}$

$I_{o,av} = \frac{V_{o,av}}{R} = 40.0\ A$

$V_{o,rms} = V_s'' = \frac{628.32}{\sqrt{2}} = 444.3\ V$

$I_{o,rms} = \frac{V_{o,rms}}{R} = 44.4\ A$

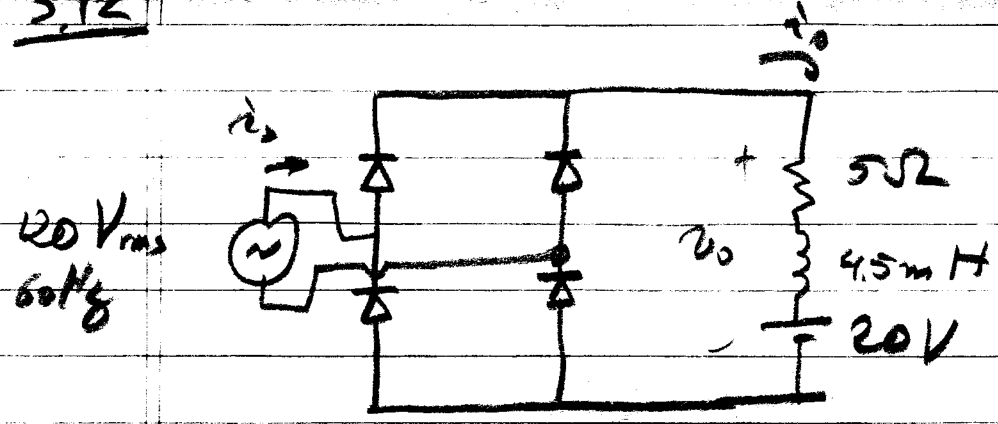
DIODE RATING

$V_{RR} = 628.3\ V$, repetitive reverse peak value
$I_{D,pk} = V_m''/R = 62.8\ A$, peak repetitive current
$I_{D,AV} = I_{o,AV}/2 = 20\ A$, Average current
$I_{D,RMS} = \frac{I_{o,RMS}}{\sqrt{2}} = 31.4\ A$, RMS current

TRANSFORMER

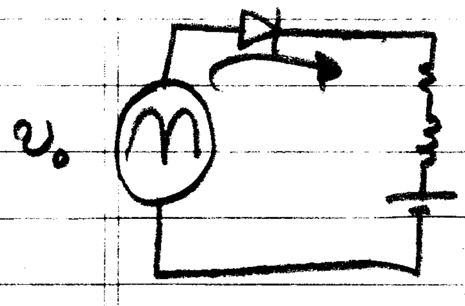
$V_s'' = 444.3\ V$ rms V
$I_s'' = 44.4\ A$ rms I
$VA = V_s'' I_s'' = 19{,}682\ VA$

3.12



Assume $V_D = 0\,V$

$V_m = \sqrt{2}\,V_s = 169.7\ V$



For continuous conduction v_o is the rectified v_s or

$v_o = V_m |\sin\omega t|$, using the

— part a —

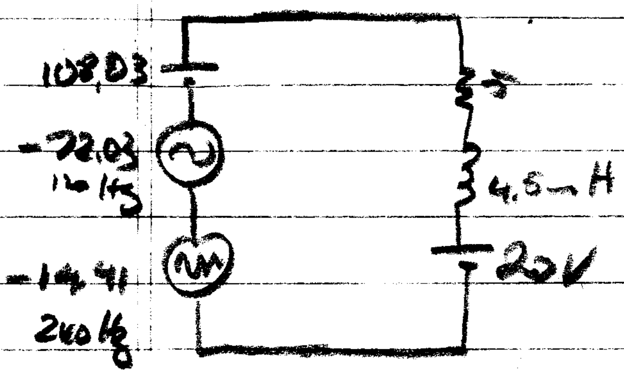
(1) F.S.

$$v_o(t) = \frac{2V_m}{\pi} - \frac{4V_m}{\pi} \sum_{n=2,4,\ldots} \frac{1}{(n-1)(n+1)} \cos n\omega t$$

using the first two terms ($n=2, 4$)

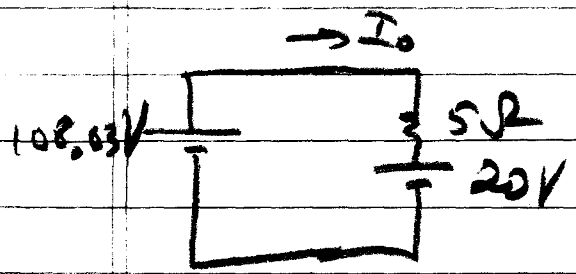
$$v_o(t) = 108.03 - 216.1\left(\frac{1}{3}\cos 2\omega t + \frac{1}{15}\cos 4\omega t\right)$$

$$= 108.03 - 72.03\cos 2\omega t - 14.41\cos 4\omega t$$



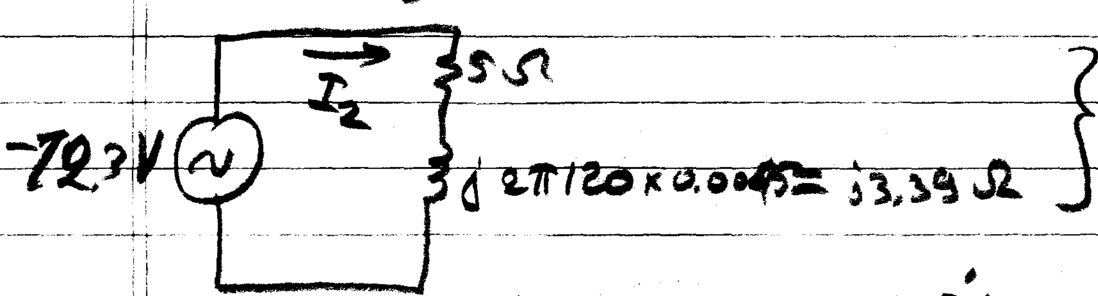
Apply frequency superposition

(a) $f = 0$ Hz



$$I_0 = \frac{108.03 - 20}{5} = 17.6\ A$$

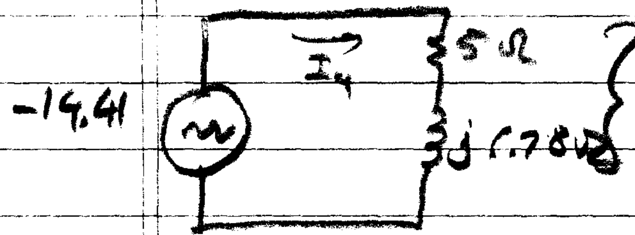
(b) $f = 120$ Hz



$Z = 6.04 \angle 34.1°$

$$\bar{I}_2 = \frac{-72.3\ V}{6.03 \angle 34.1} = 12 \angle 145.9\ A \quad \text{or} = -12 \angle -34.1$$

(c) $f = 240$ Hz



$Z = 8.42 \angle 53.6°\ \Omega$

$$\bar{I}_4 = \frac{-14.41}{8.42 \angle 53.6} = 1.71 \angle 126.4\ A \quad \text{or} = -1.71 \angle -53.6$$

and

$$i_0 \simeq 17.6\,A - 12\cos(2\omega t - 34.1°) - 1.71\cos(4\omega t - 53.6$$

at $\omega t = 0$, $i_0 = 17.6 - 12\cos(-34.1) - 1.71\cos(-53.6)$
$= 6.65\ A$

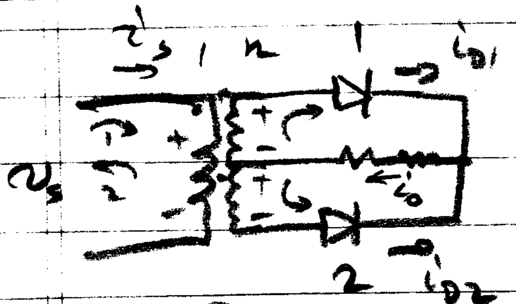
(2) Average diode current
$I_{D,av} = \frac{I_{0,AV}}{2} = 8.8\,A$

(3) RMS diode current $I_{D,RMS} = \frac{I_{0,RMS}}{\sqrt{2}}$, but $I_{0,RMS} \simeq \sqrt{17.6^2 + 12^2 ...}$

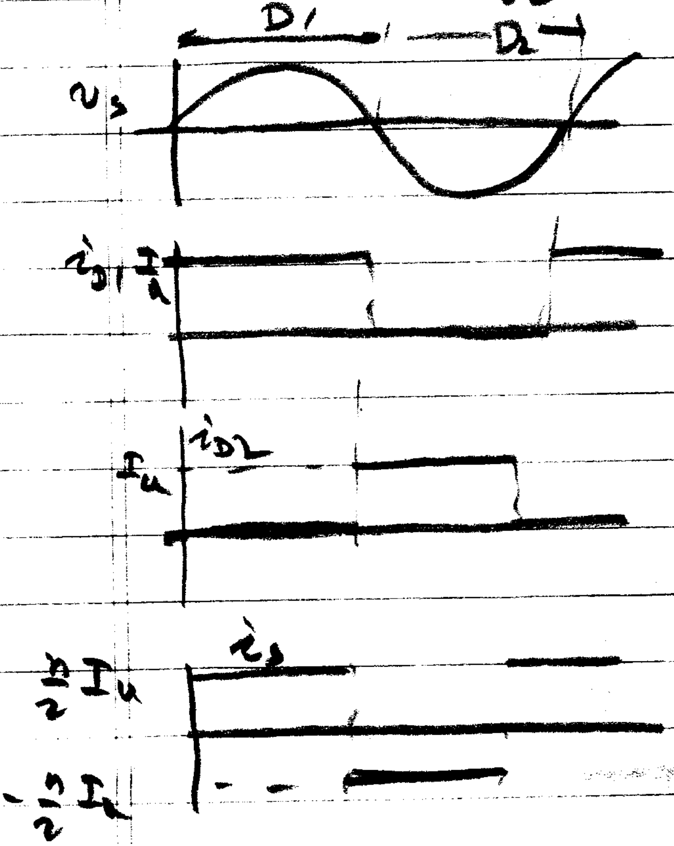
$= (\ldots)\,A$ and $I \ldots = 12.86\ldots$

3.21

(a)



$i_o = I_a$



square pulse

(b)

$$i_s = \sum_{n=1,3,\dots} b_n \sin n\omega t$$

only odd harmonics are sin because of odd symm.

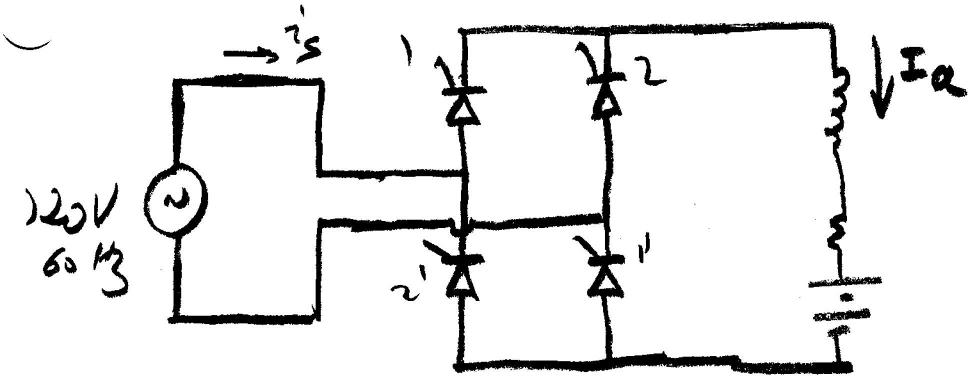
$$b_n = \frac{1}{\pi}\int_0^{2\pi} i_s \sin n\omega t \, d\omega t = \frac{2}{\pi}\int_0^{\pi} I_a \sin n\omega t \, d\omega t =$$

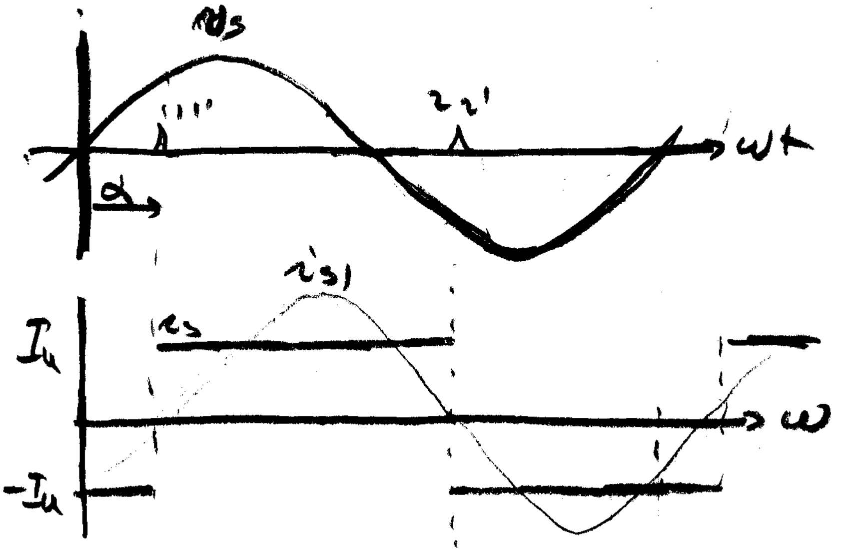
$$= \frac{2I_a}{n\pi}\left(-\cos n\omega t\right)\Big|_0^{\pi} = \frac{2I_a}{n\pi}\left(1-\cos n\pi\right) \quad n=1,3,5$$

$\cos n\pi = -1 \Rightarrow b_n = \frac{4I_a}{n\pi}$ and

$$i_s = \frac{4I_a}{\pi}\cos\omega t + \frac{4I_a}{\pi}\sum \frac{1}{n}\cos n\omega t$$

Prob 10.7





$$i_s = \frac{4I_a}{\pi}\sin(\omega t-\alpha) + \frac{4I_a}{\pi}\sum_{n=3,5}^{\infty}\frac{1}{n}\sin(n\omega t - n\alpha)$$

(a) RMS value of i_s, $I_s = I_a$

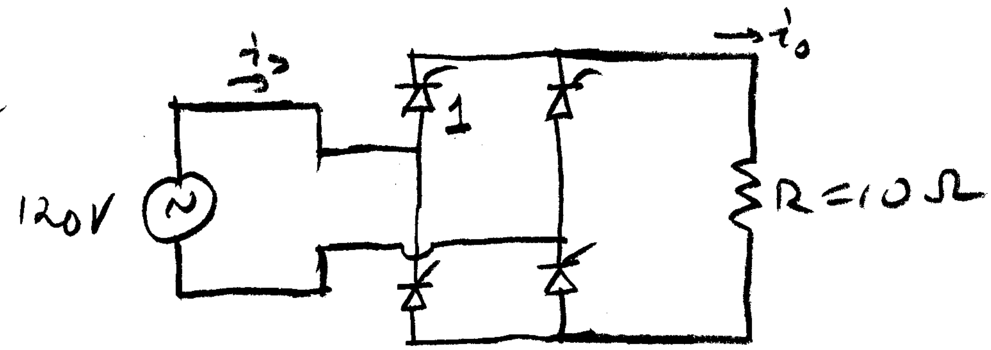
fund. $i_{s1} = \frac{4I_a}{\pi}\sin(\omega t-\alpha)$, fund. rms, $I_{s1} = \frac{2\sqrt{2}}{\pi}I_a = 0.9\,I_a$

$$HF = \frac{\sqrt{I_a^2 - .9^2 I_a^2}}{0.9\,I_a} = 0.48 \ (48\%)$$

(b) $DF = \cos\alpha = \cos\frac{\pi}{3} = 0.5$

(c) $$pf = \frac{V_s I_{s1}\cos\alpha}{V_s I_s} = \frac{I_{s1}}{I_s}\cos\alpha = \frac{0.9\,I_a}{I_a}\cos\alpha = 0.9\cos\alpha = 0.45 \text{ lag}$$

Prob 10.8



$V_m = \sqrt{2}\,120 = 169.7\ V$

(a) $V_{o,av,mx} = \frac{2V_m}{\pi} = 108.03 \Rightarrow$

$V_{o,av} = 25\%\ 108.03 = 27\ V$. but $V_{o,av} = \frac{2V_m}{\pi}\cos\alpha$ for a resistive load w/ large inductance.

Thus $\cos\alpha = \frac{\pi \times 27}{2V_m} = 0.25 \Rightarrow \underline{\alpha = 75.5°}$.

(b) $i_o = \frac{V_{o,av}}{10} = 2.7\ A$ const. (no ripple)

$i_s = 2.7 \cdot sqw(\omega t) = \frac{4 \times 2.7}{\pi} \sum_{n=1,3,\ldots} \frac{\sin(n\omega t - n\alpha)}{n}$

$I_s = 2.7\ A$ (rms)

$I_{s1} = \frac{2\sqrt{2}}{\pi} \times 2.7 = 2.43\ A$ (fund. rms)

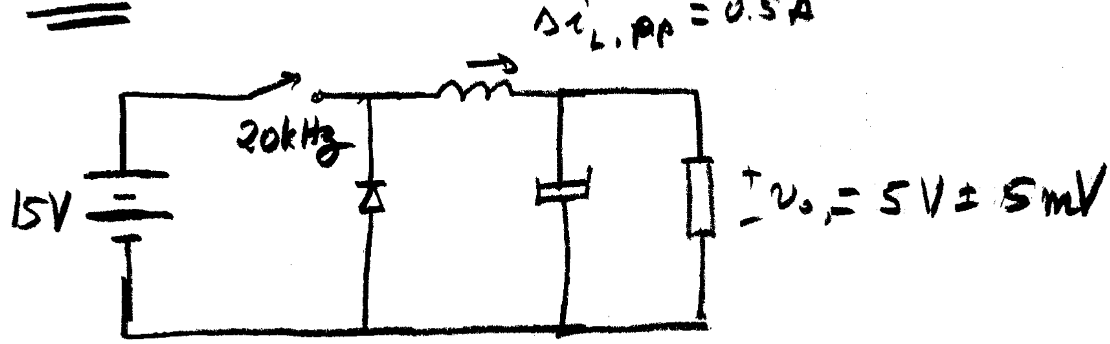
(c) Thyristor current:

$I_{T1,av} = \frac{2.7}{2} = 1.35\ A$ (conducts ½ periods)

$I_{T1,rms} = \frac{2.7}{\sqrt{2}} = 2.036\ A$

(d) $pf = \frac{V_s I_{s1} \cos\alpha}{V_s I_s} = \frac{I_{s1}}{I_s}\cos\alpha = 0.9\cos\alpha = \underline{0.225\ \text{lag}}$

5.9

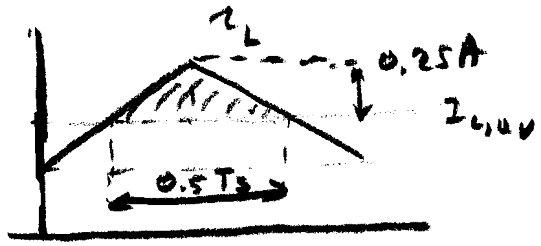


Assume $V_{sw} = V_F = 0$ (since not given)

(a) $k = \dfrac{V_{o,av}}{V_s} = \dfrac{5}{15} = \underline{0.33}$

(b) $\Delta I_L = \dfrac{V_s - V_{o,av}}{L} kT_s \Rightarrow L = \dfrac{V_s - V_{o,av}}{\Delta I_L f_s} k = \dfrac{10 \cdot k}{0.5 \cdot 20k} = \underline{\underline{333\ \mu H}}$

(c)



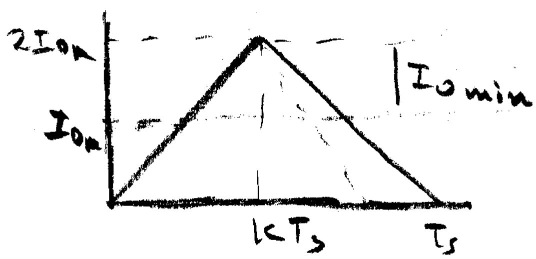
Capacitor charge variation

$\Delta Q = \frac{1}{2}\left(\frac{\Delta I_L}{2}\right) 0.5 T_s = 3.125\ \mu C$

Therefor $C = \Delta Q / \Delta V_o = 3.125\ \mu c / 10\ mV = \underline{\underline{312.5\ \mu F}}$

(d) The critical value of ΔI_L for cont. cond. is

$\Delta I_L = 2 I_{o\,min}$, $\underline{I_{o\,min} \text{ is the minimum expected load current}}$

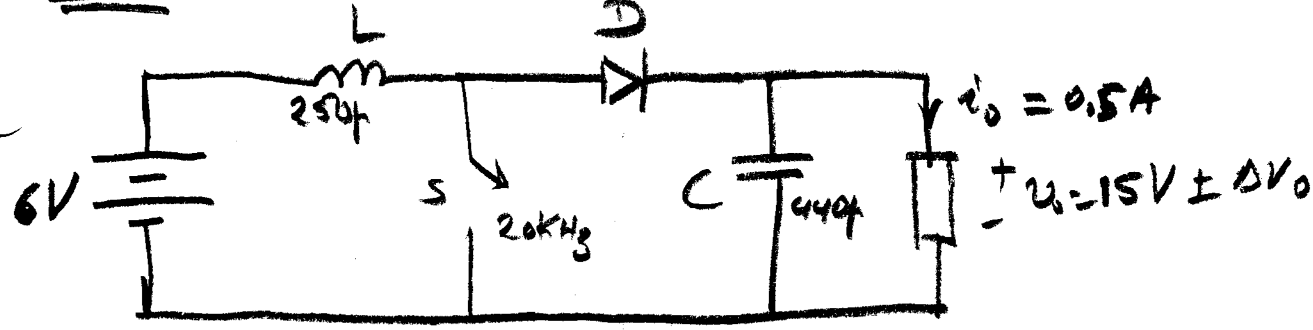


Thus $L_{cr} = \dfrac{V_s - V_{o,av}}{2 I_{o\,min} f_s} k$

Also $\Delta Q_{cr} = \frac{1}{2} I_{o\,min} \frac{kT_s}{2} = \frac{1}{4} \frac{k I_{o\,min}}{f_s}$ and

$C_{cr} = \dfrac{\Delta Q_{cr}}{\Delta V_o} = \dfrac{1}{4} \dfrac{k I_{o\,min}}{f_s \Delta V_o}$

5.10



Assume $V_{sat} = V_F = 0$

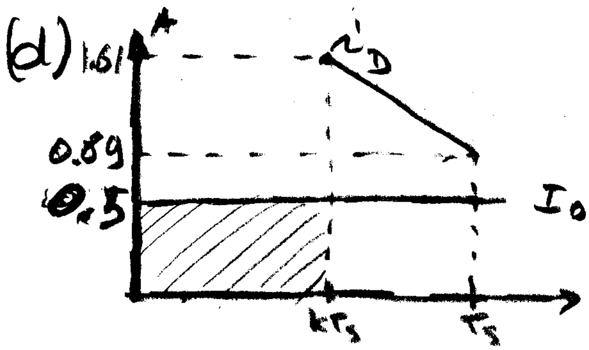
(a) For cont. cond. $V_o = \dfrac{V_s}{1-k} \Rightarrow 1-k = \dfrac{V_s}{V_o} = 0.4$ and $\underline{\underline{k = 0.6}}$

(b) $\Delta I_L = \dfrac{V_s k T_s}{L} = \dfrac{V_s k}{L f_s} = \underline{\underline{0.72\ A}}$

(c) $I_{Lpk} = I_{Lav} + \dfrac{\Delta I_L}{2}$, but in cont. cond $I_{Lav} = \dfrac{I_o}{1-k} = \dfrac{0.5A}{.4} = 1.25$

Thus, $I_{Lpk} = 1.25 + \dfrac{.72}{2} = \underline{\underline{1.61\ A}}$ (Also, $I_{Lmin} = 0.89\ A$)

(d)



Capacitor charge

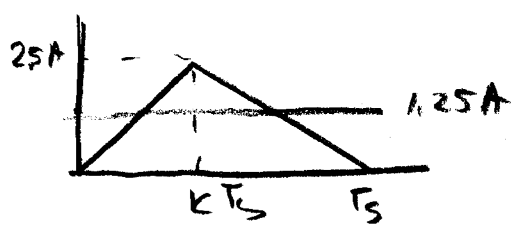
$\Delta Q = I_o \cdot kT_s = 15\ \mu C$

Therefore, $\Delta V_o = \dfrac{\Delta Q}{C} = \underline{\underline{34.1 mV}}$

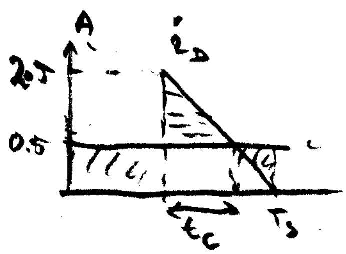
(e) The critical L is found by letting $I_{Lmin} = 0$ or

$\Delta I_{Lcr} = 2 I_{L,av} = 2 \times 1.25A = 2.5A$

and $L_{cr} = \dfrac{V_s k T_s}{\Delta I_{Lcr}} = 72\ \mu H$



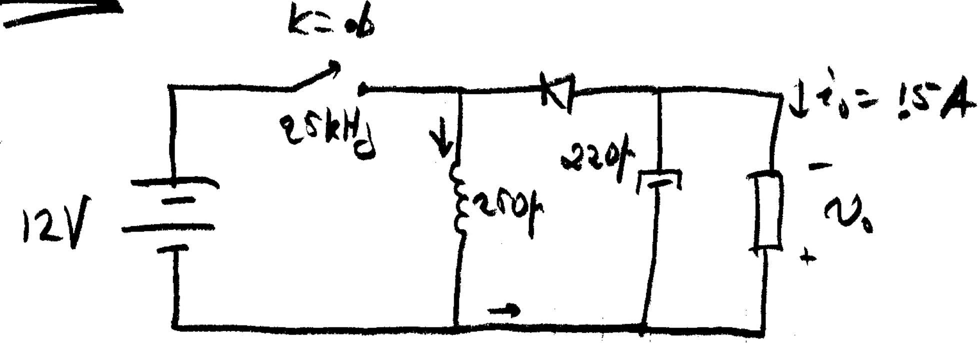
ΔQ_{cr}



$\dfrac{t_c}{2.5-.5} = \dfrac{(1-k)T_s}{2.5} \Rightarrow t_c = 16\ \mu s$ and $\Delta Q_{cr} = 16\ \mu C$

$C_{cr} = \Delta Q_{cr} / \Delta V_o = 469\ \mu F$ ($\Delta V_o = 34.1$ mV)

5.11

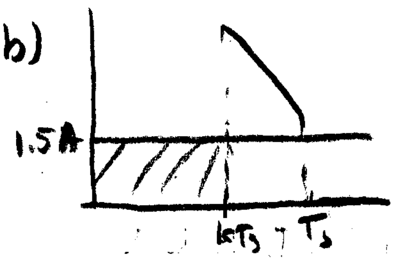


$V_{sw} = V_F = 0$

(a) Assume cont. cond.

$V_{o,av} = \frac{k}{1-k} V_s = \underline{\underline{18\ V}}$

(b)



$\Delta Q = I_o k T_s = \frac{I_o k}{f_s} = \frac{0.6 \times 1.5}{25k} = 36\ \mu C$

$\Delta V_o = \frac{\Delta Q}{C} = \underline{\underline{163\ mV}}$

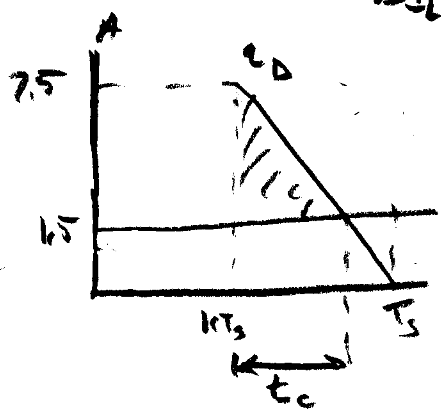
(c) $\Delta I_L = \frac{V_s k T_s}{L} = \frac{V_s k}{L f_s} = \underline{\underline{1.152\ A}}$

(d) $I_{LAV} = \frac{I_o}{1-k} = 3.75\ A$, $I_{LMN} = 3.75 - \frac{1.152}{2} = 3.174\ A$

$I_{LMX} = 3.75 + \frac{1.152}{2} = \underline{4.326\ A}$

(e) $\Delta I_{Lcr} = 2 I_{LAV} = 7.5\ A$

and $L_{cr} = \frac{V_s k T_s}{\Delta I_{Lcr}} = \underline{\underline{38.4\ \mu H}}$



$\frac{t_c}{7.5-1.5} = \frac{(1-k)T_s}{7.5} \Rightarrow t_c = \frac{6}{7.5}\frac{(1-k)}{f_s} = 12.8\ \mu s$

$\Delta Q_{cr} = \frac{1}{2}(7.5-1.5)\, t_c = 38.4\ \mu C$

assume $\Delta V_o = 163\ mV \Rightarrow C_{cr} = \frac{\Delta Q_{cr}}{\Delta V_o} = \underline{\underline{236\ \mu F}}$