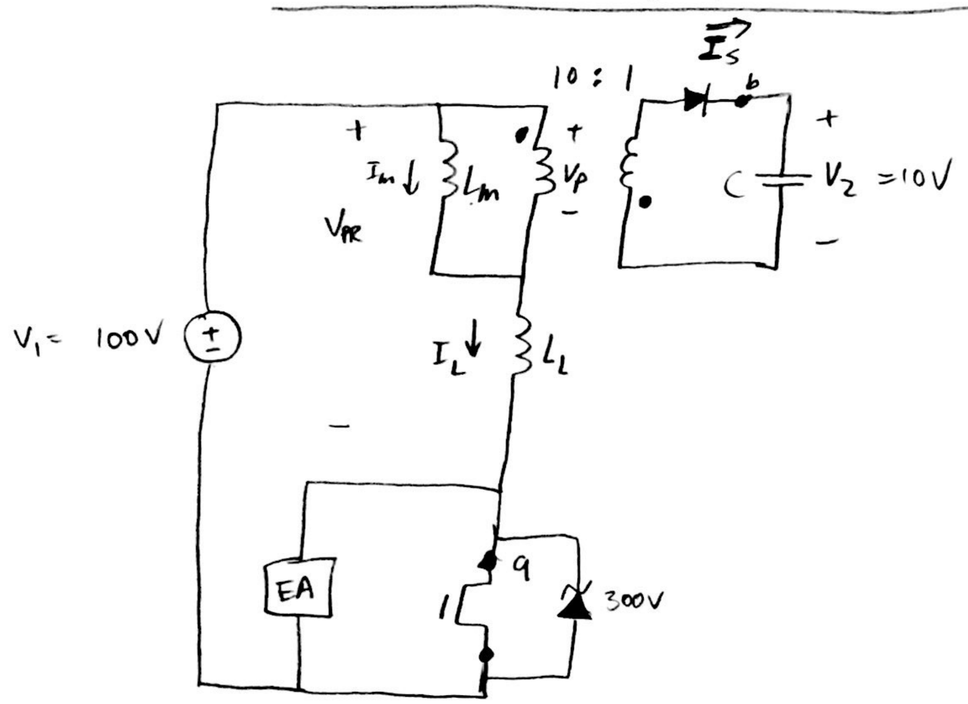
EE 255 HOMEWORK # 5 SOLUTIONS

(1)



(a) 100kHz, $L_m = 100\,\mu H$, $L_L = 5\,\mu H$

Output energy = (10V)(5A)(10μs) = 0.5 mJ/cycle.

The peak current through L_m is $I_{peak} = \frac{V_1}{L_m + L_L} \cdot D_1 T_{cy}$

The energy stored in L_m must equal 0.5mJ every cycle. Thus:

$\frac{1}{2} L_m I_{peak}^2 = 0.5\,mJ$, Thus: $\frac{1}{2} L_m \left(\frac{V_1}{L_m + L_L} \cdot D_1 T_{cy}\right)^2 = 0.5\,mJ$

Substituting L_m, L_L, T_{cy}, and V_1, we solve for $D_1 = 0.332039$

(b) $Loss_{L_L} = \frac{1}{2} L_L I_{peak}^2 = \frac{1}{2} L_L \left(\frac{V_1}{L_m + L_L} D_1 T_{cy}\right)^2 = 25\,\mu J/cycle = Loss_{L_L}$

$$\text{Efficiency} = \frac{\text{output energy/cycle}}{\text{output energy/cycle} + Loss_{L_L}} = \frac{500\,\mu J}{525\,\mu J} = \eta = 95.24\%$$

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(c) we know $I_{peak} = \left(\frac{V_1}{L_m + L_2}\right) \cdot D_1 T_{cy} = 3.16227\,A$

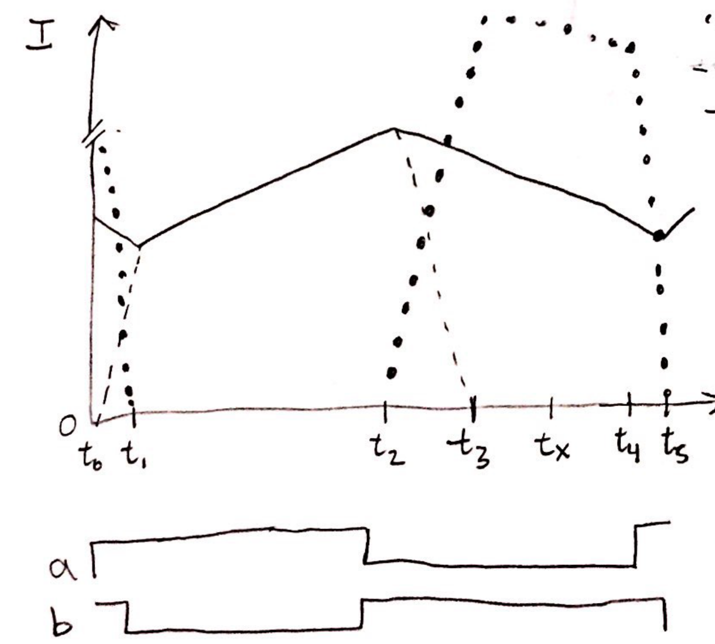
$$\Delta t_{commutation} = \frac{\Delta I}{V_{FET} - V_1 - 10V_2} \cdot L_L = \frac{3.16227A}{100V} \cdot 5\mu H = \boxed{0.158\mu s}$$

The voltage during commutation across L_L is the 300V of the avalange diode less the 100V from the reflected secondary (i.e. $10V_2$), and the 100V suppy (i.e. V_1).

(d) 200 kHz, $L_m = 1mH$, $L_L = 0\,\mu H$, we know by volt second balancing while ignoring L_L that $V_2 = \frac{ND_2}{1-D_2} V_1$, where $V_2 = 10V$, $V_1 = 100V$, $N = \frac{1}{10}$, so D_2, or the duty factor across the magnetizing inductance, **must be 0.5**

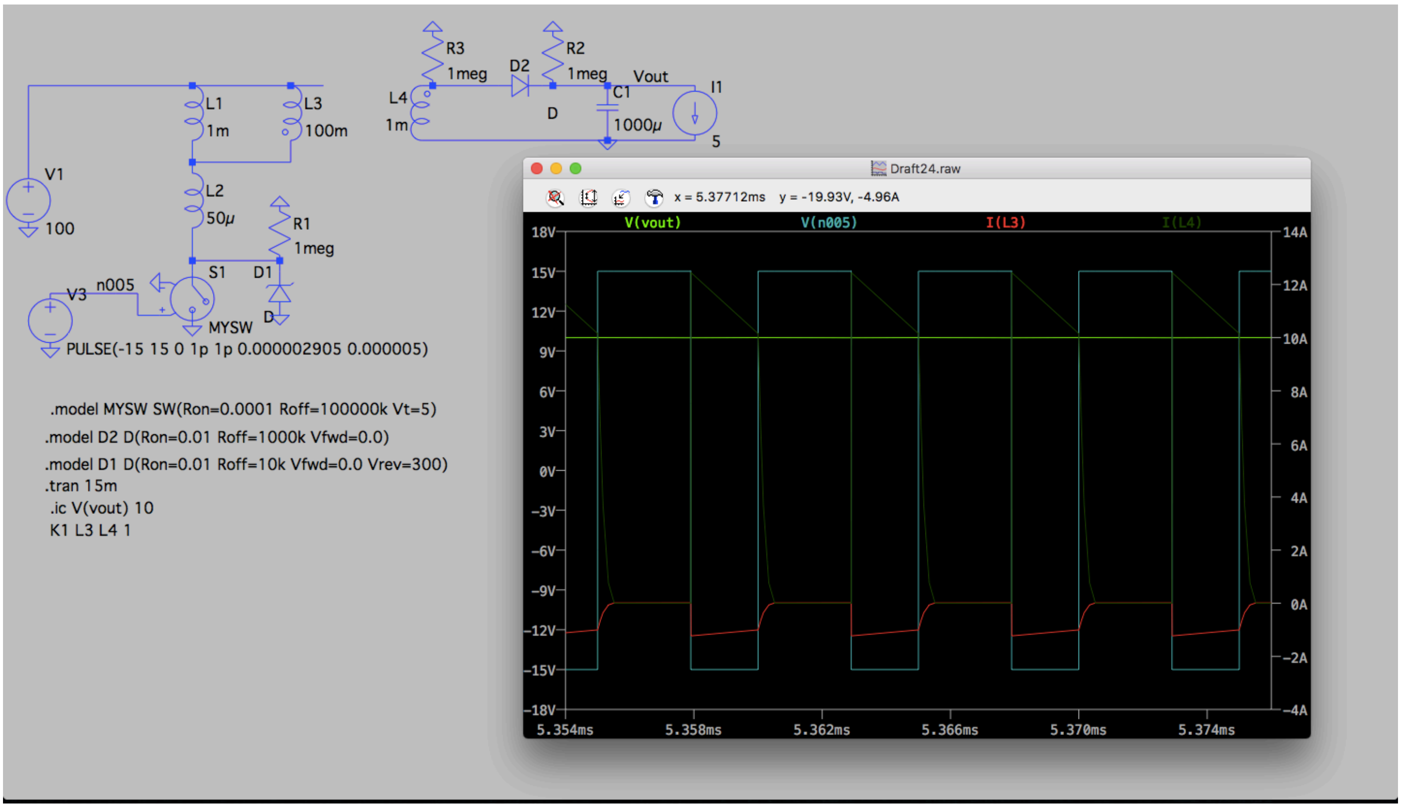
(With $L_L = 50\mu H$)

(e) in part (e), we have commutation time where both the FET and diode are conducting. Let's draw our expected current curves. As you can see this is quite complicated.



First of all, we know over one cycle the integral of our output current, I_s, is $(5A)(5\mu s) = 25\mu C$. We can break down the I_s curve into three components: from $(t_2 - t_3)$, from $(t_3 - t_4)$, and from $(t_4 - t_5)$. We need to solve for these three times and currents after figuring out our new initial duty factor without commutation time, which can be done with a volt second balance given L_m and L_s create a voltage divider of $\left(\frac{1000}{1050}\right) \cdot 100V = 95.2V$, when "a" is closed. Once we know this, we find the times and currents, by using $\frac{\Delta i}{\Delta t} = \frac{V}{L}$ for the leakage inductance and knowing the area is $25\mu C$. This then sets the magnetizing current. From inspection, we can see that we have to redo all our calculations to converge to our final answer. We thus use LTSpice to avoid excessive hand calculations. We find that a **DF of [redacted]** (due to commutation time loss) we meet our specs.

0.581



R3
1meg
D2
R2
1meg
Vout
L4
1m
C1
1000μ
D
I1
5
L1
1m
L3
100m
V1
100
L2
50μ
R1
1meg
S1
D1
V3
n005
MYSW
D
PULSE(-15 15 0 1p 1p 0.000002905 0.000005)
.model MYSW SW(Ron=0.0001 Roff=100000k Vt=5)
.model D2 D(Ron=0.01 Roff=1000k Vfwd=0.0)
.model D1 D(Ron=0.01 Roff=10k Vfwd=0.0 Vrev=300)
.tran 15m
.ic V(vout) 10
K1 L3 L4 1
Draft24.raw
x = 5.37712ms y = -19.93V, -4.96A
V(vout)
V(n005)
I(L3)
I(L4)
18V
15V
12V
9V
6V
3V
0V
-3V
-6V
-9V
-12V
-15V
-18V
14A
12A
10A
8A
6A
4A
2A
0A
-2A
-4A
5.354ms
5.358ms
5.362ms
5.366ms
5.370ms
5.374ms