1/(a) For full bridge $\Delta V = \frac{I}{2FC}$

Assuming: Instantaneous charging of the capacitor*
No voltage drop over the diodes. 2

* ie. $\frac{1}{2}$ cycle discharge (alt. answer)

$\Delta V = 0{\cdot}05 . \sqrt{2} . 230$

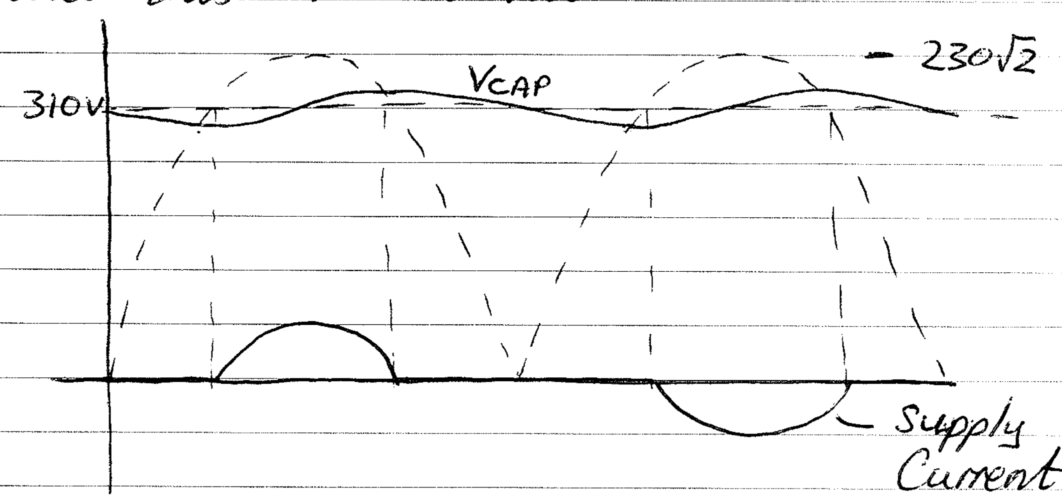
$C = \frac{10}{0{\cdot}05 . \sqrt{2} . 230 . 100} = 6{\cdot}1\,mF$ 4

C discharged. $I = C\frac{dV}{dt}$, max $\frac{dV}{dt}$ at $\hat{V}\sin\theta$

$\hat{I} = C\omega\hat{V} = 6{\cdot}1m . 2\pi . 50 . \sqrt{2} . 230$

$= 628\,A$. 2

In reality the line inductance will greatly reduce this extreme value.

(b) 

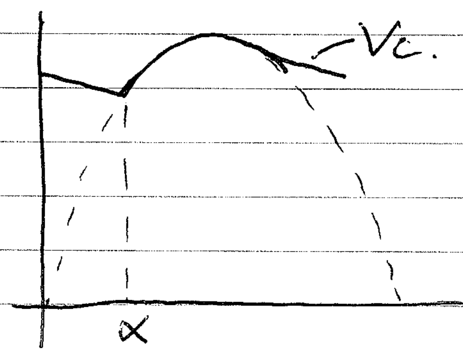
4

1 (b) cont. Peak magnitude from sketch

$$\text{at } I = \frac{\sqrt{2}.230 - 310}{0.5\Omega} = 30A$$ 3

Assuming the capacitor voltage is half charged at π of the sinewave (or 310V is nearly constant). 1

Close the switch (between charges say).



$$\alpha = \sin^{-1}\frac{310}{325} = 72.5°.$$

$$I = C\frac{dV}{dt} = 6.1m.\ 325.\ 2\pi.50 \cos 72.5°.$$

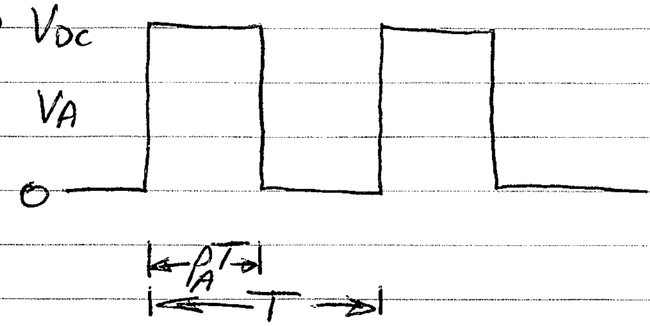
$$= 187A$$ 2

Still pretty horrible ⇒

Use a MOSFET as a controlled resistor

or add small inductor 2

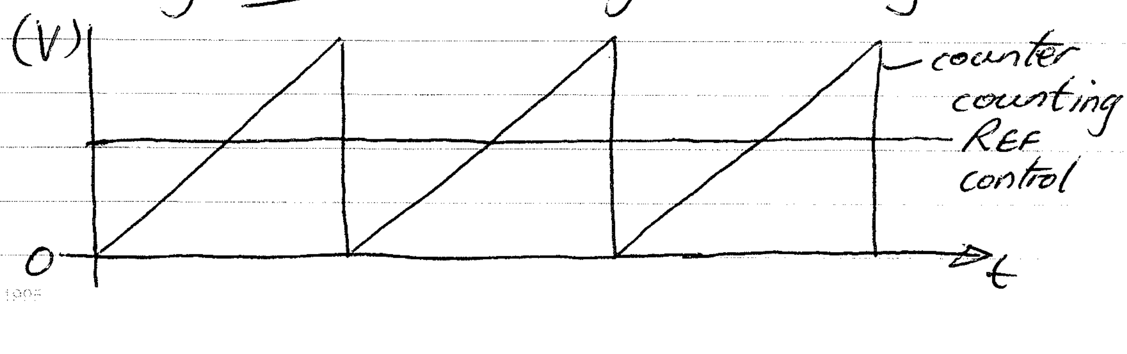
2 (a)



The <u>average</u> value of V_A is $\rho_A V_{DC}$.
If the load is inductive the high frequency components are filtered out and only the dc component comes through. This may vary, however, as long as its not too fast, for the filter effect may cut it down. 3

Only the M_1 switching matters as $M_4 = \overline{M_1}$ to avoid the voltage depending on the current sense. 1

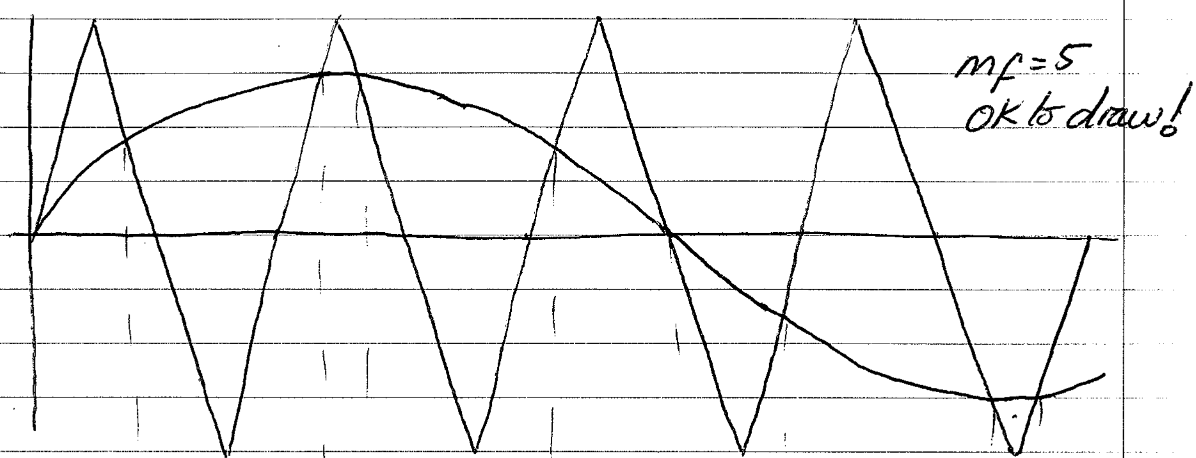
Bipolar mode $M_2 = M_1$, $M_3 = M_4 = \overline{M_1} = \overline{M_2}$
so only <u>one</u> control signal necesary.



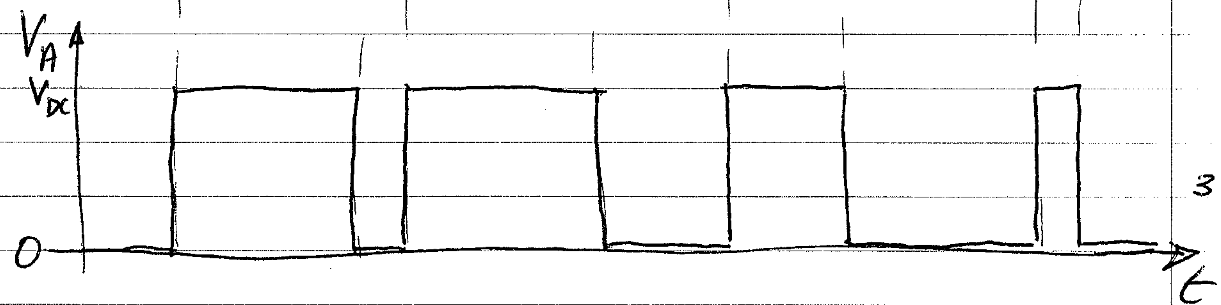
If count > REF M_1 ON ; $V_A = V_{DC}$

If count < REF M_1 OFF ; $V_A = 0$ 4

(b) To avoid subharmonics use integer m_f.
(Odd integer x 3 is best!)



$m_f = 5$; (9 is hard to draw!)



3

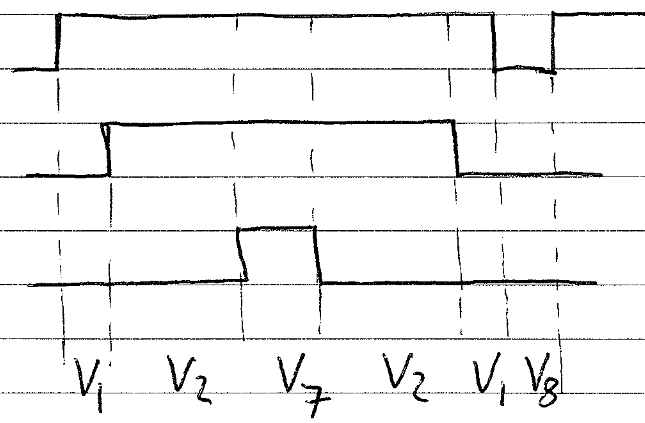
3 SVM sequences:

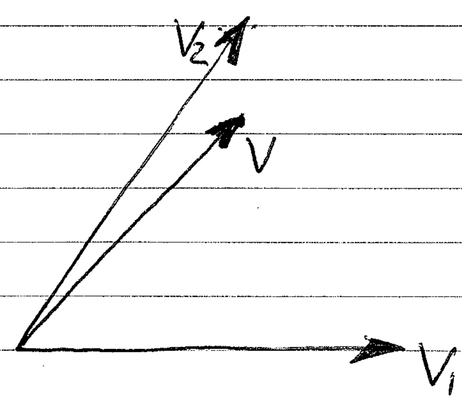
eg. $V_1 V_2 V_7 V_1 V_2 V_7$ . . . . .
$V_1 V_2 V_8 V_1 V_2 V_8$ . . . . .
$V_1 V_2 V_7 V_2 V_1 V_8 V_1$ . . . . . ⇐ minimal switching.

V_1	1^*	0	0
V_2	1	1^*	0
V_7	1	1	1^*
V_2	1	1	0^*
V_1	1	0^*	0
V_8	0^*	0	0

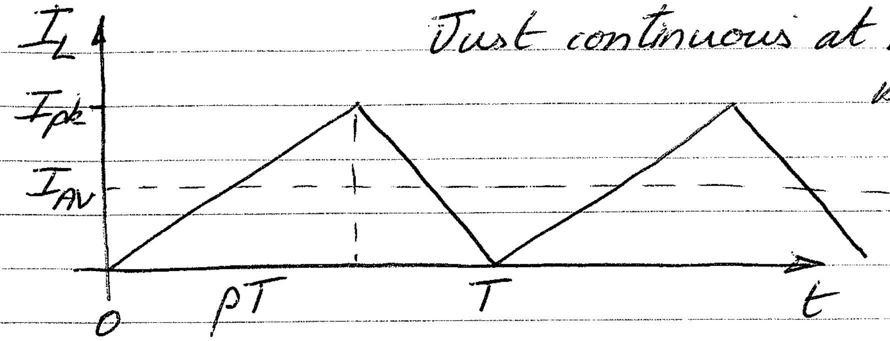
*Only 1 commutation * per change of state.*

eg.





3/



Just continuous at max load. is best.

Current drawn from 12V all the time.

$\Rightarrow$ $500W = 12 \times I_{AV}$ $\quad I_{pk} = 2 I_{AV}$.

$\therefore I_{pk} = 83.3A \quad I_{AV} = 41.6A$.

So MOSFET withstands 42V, 83.3A. MOSFETS below 60V are very good and 83.3A is quite possible, maybe with two in parallel.

If the load is disconnected the voltage would be uncontrolled and too high if there is no feedback controller, (and the load will vary here)

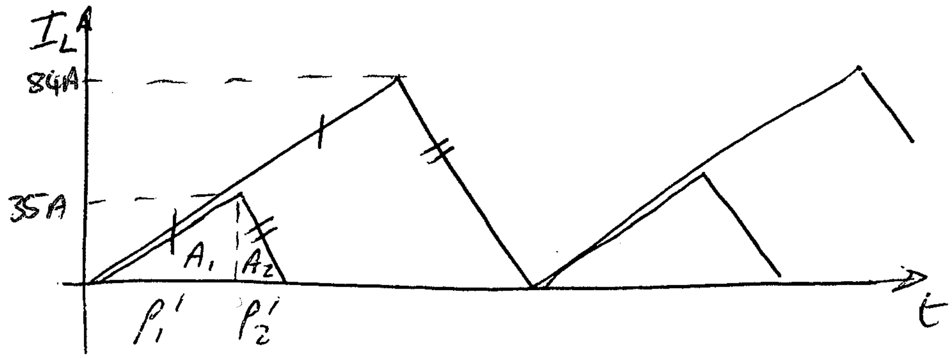
Discontinuous gives zero turn-on loss and smaller value of L (no saturation danger either).

$$|L\Delta i| = |12\rho T| = |(42-12)(1-\rho)T|$$

$$\Rightarrow \quad 12\rho = (42-12)(1-\rho) = 42 - 12 - 42\rho + 12\rho$$

$$\rho = \frac{42-12}{42} = \underline{\underline{0.714}} \qquad V = L\frac{\Delta i}{\Delta t}$$

$$L = 12.\rho T / 83.3 \qquad \underline{\underline{L = 4.11\,\mu H}}$$



$$I_{max} = \frac{12}{L} \cdot \rho_1 T \quad \left(\frac{V_{in}}{L} \rho_1 T\right)$$

Similarly $$\rho_2 T = \frac{I_{max} L}{(V_o - V_{in})}$$

Substituting $$\rho_2 T = \frac{V_{in} \rho_1 T}{L} \cdot \frac{L}{V_o - V_{in}}$$

Energy taken from supply per cycle $= A_1 + A_2$

$$A_1 + A_2 = \frac{1}{2}(\rho_1 + \rho_2) T \times I_{max}$$

$$= \frac{1}{2}\left(\rho_1 + \rho_1 \frac{V_{in}}{V_o - V_{in}}\right) T \cdot \frac{V_{in} \rho_1 T}{L}$$

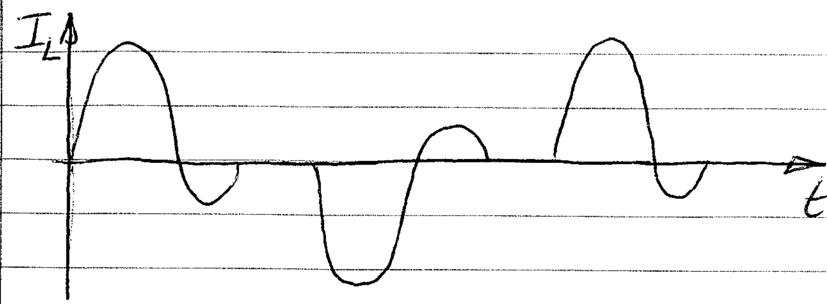
$$= \frac{1}{2L} \rho_1^2 T^2 \frac{V_o V_{in}}{V_o - V_{in}}$$

Everything is constant except ρ_1 so scale the power (energy per cycle × f) by ρ_1^2

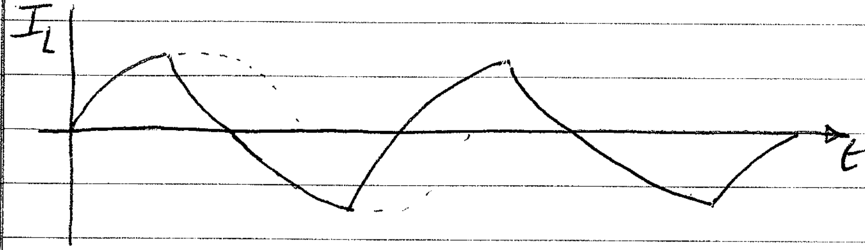
$$\frac{500}{0.71^2} \times 0.3^2 = \underline{\underline{89\,W}}$$

Obvious from the sketch above!
($\hat{I}^2$ ratio)

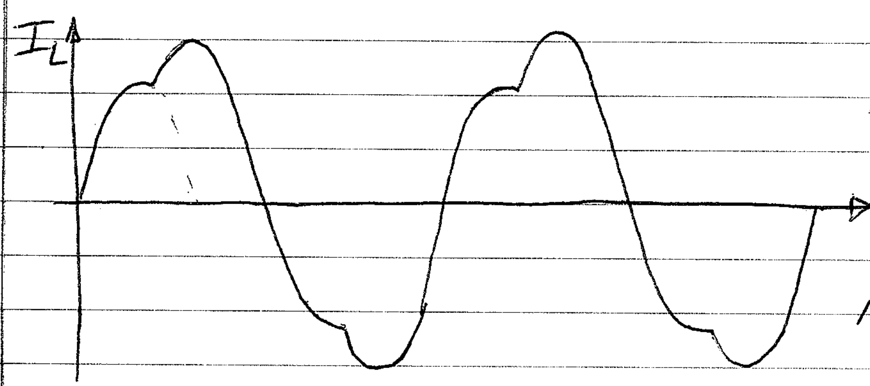
4



$f < \frac{f_o}{2}$



$f > f_o$



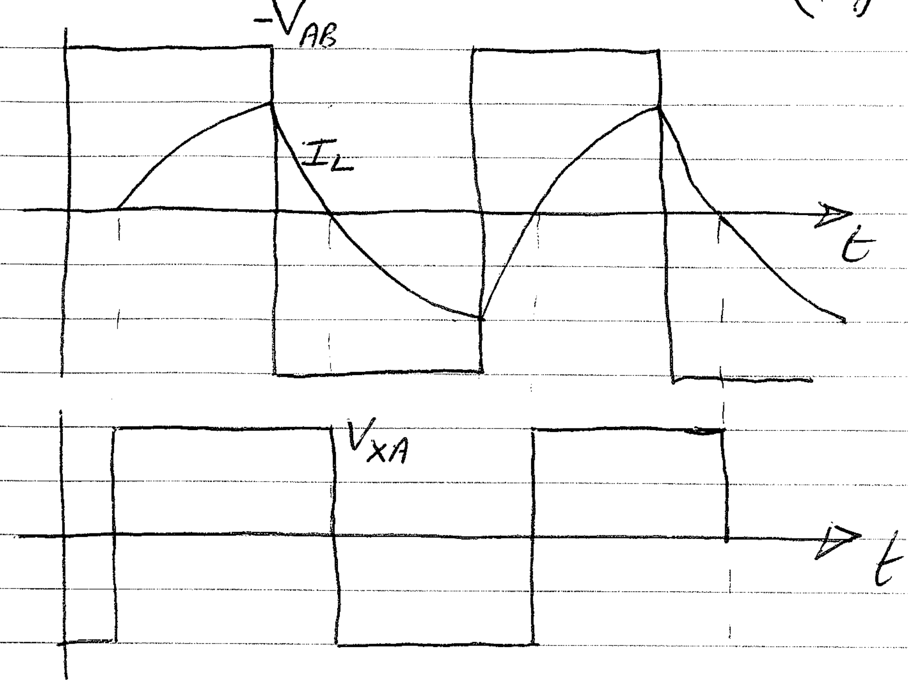
$\frac{f_o}{2} < f < f_o$

f_o ~ natural resonance

$f > f_o$ means hardswitched turn-off and soft switched turn-on, so no diode recovery problem and no turn-on losses. Both are important at high frequencies (high di/dt and losses $\propto f$)

cont/ Waveforms:

(eg. $f \approx 2f_0$)



Rectifier, Co and R look like a resistor Req as the current I_L is in phase with the voltage V_{XA}.

So its a simple circuit:

$$\left|\frac{V_{XA}}{-V_{AB}}\right| = \left|\frac{R_{eq}}{R_{eq} + sL + 1/sC}\right| = \left|\frac{R_{eq}\, sC}{1 + s^2LC + sR_{eq}C}\right|$$

$$= \frac{1}{\sqrt{1 + \frac{(1-\omega^2LC)^2}{\omega^2 R_{eq}^2 C^2}}}$$

Note: $\frac{4}{\pi}$ cancels

To reduce the turn-off losses add a small capacitor to each leg output A-zero B-zero to act as a snubber

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