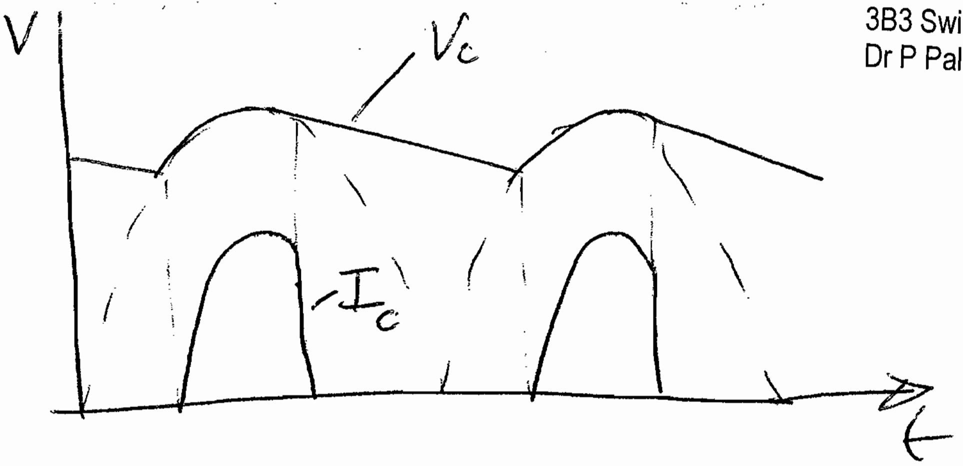
1/ a)



$$I_c = C\frac{dV_c}{dt}$$

The inverter would be switching at a much higher frequency than 50Hz. The power drawn is smooth, neglecting high freq. ripple so the current must be smooth.

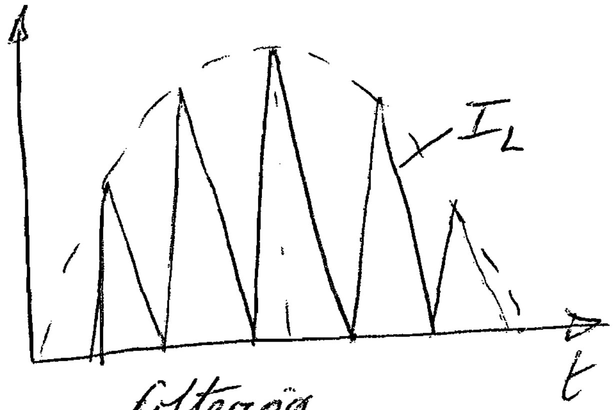
$$\Delta V = \frac{I}{2fC} \quad \therefore \quad C = \frac{I}{2f\Delta V}$$

250 W at $230\sqrt{2} - 5\%$ volts.

$$I = \frac{250}{230\sqrt{2} \times 0.95} =$$

$$C = \frac{\frac{250}{230\sqrt{2}\times 0.95}}{2\times 50 \times 230\sqrt{2} \times 0.10} = 0.25\,\mathrm{mF}$$

1(b)



The ~~fundamental~~ filtering of the triangular wave ~~becomes~~ gives a 50 Hz rectified wave.

Triangles of current.
For unity power factor, the peaks of the triangles should approximately match the voltage waveform sinewave.

∴ make $|V_{supply}|$ the reference for $\hat{I}_L$

250W upf. $\Rightarrow \hat{I} = \sqrt{2} \cdot \frac{0.25k}{230} = 1.54A$

Databook - rectified component at 100Hz.

$$\frac{4}{3\pi} \times 1.54 = 0.654 A.$$

10% ripple at 400V ⇒ 20V peak ripple

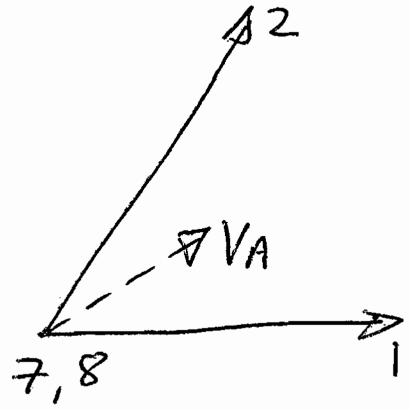
Assume high frequency components and the inverter current ripple can be ignored. ($1/\omega C$ impedance).

$$20 = I \cdot 1/\omega C = 0.654 \cdot \frac{1}{2\pi . 100 \times C} \Rightarrow C = 0.052mF$$

2/(a) dc link voltage, output current, switching frequency, losses. (any 3)

(b)

State	V_a	V_b	V_c
1	1	0	0
2	1	1	0
3	0	1	0
4	0	1	1
5	0	0	1
6	1	0	1
7	1	1	1
8	0	0	0



V_A is made up of 1, 2, 7, 8 and as the time spent in each is adjusted V_A can move.

The first Hextant bounded by 1,2.

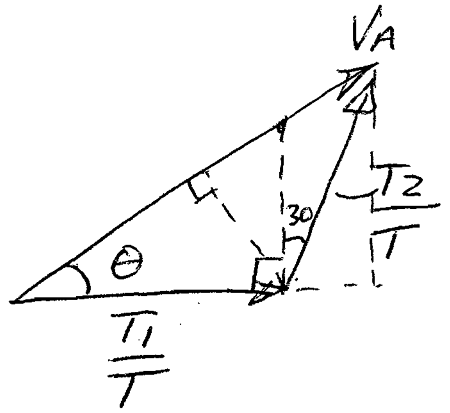
The states are changed for each segment.

The switching can be reduced compard to pwm eg. 12721812 7. . . .

2/(b) cont.

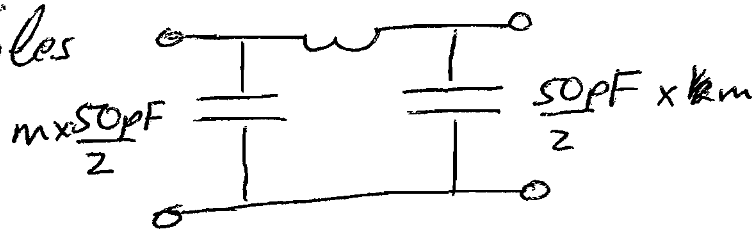
Time spent in state 1 is T_1

" " " " 2 is T_2.



$$V_A^2 = V^2\left[\left(\frac{T_1}{T} + \frac{T_2}{T}\sin 30\right)^2 + \left(\frac{T_2}{T}\cos 30\right)^2\right]$$

(c) Cables



The inverter waveform implicitly has steep edges. The line is capacitive, so the current $I = C\frac{dV}{dt}$ could be massive and blow up the inverter. Use inductors on the output (expensive) or control the dV/dt (losses).

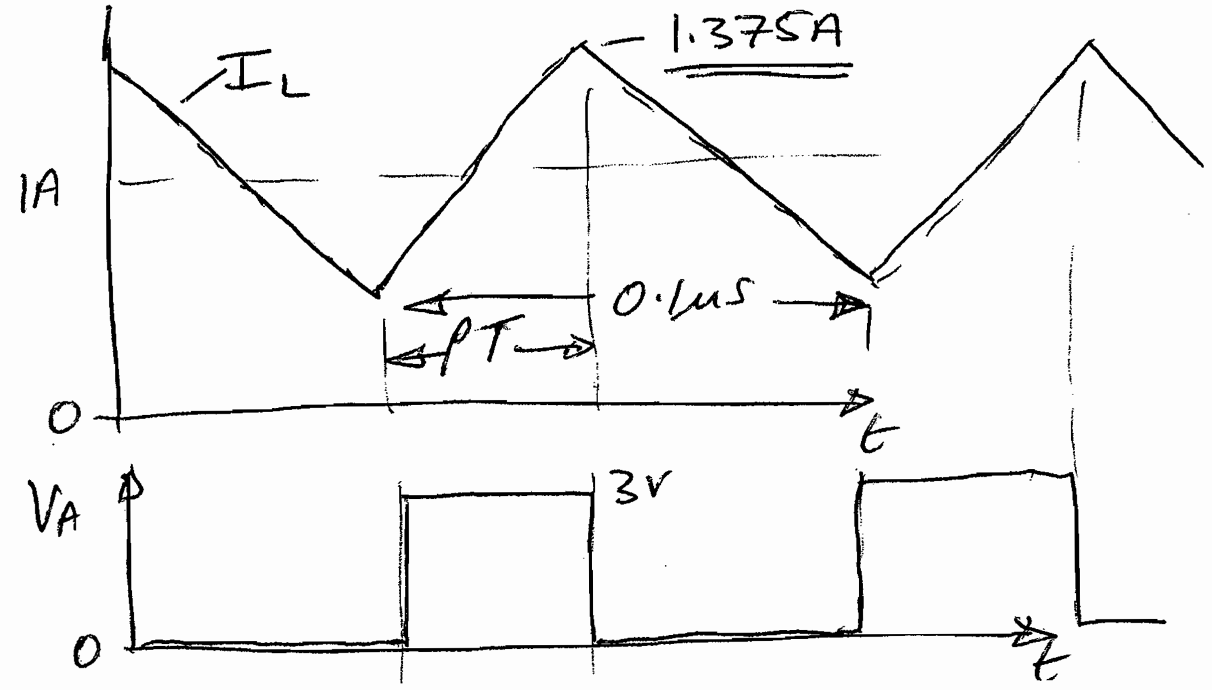
3/ Discontinuous mode occurs when the current in L built up when the Mosfet is on is extinguished when the mosfet is off. The advantage is the inductor can be smaller, with the drawback that there will be more losses in the Mosfet (I^2R_{ch} for a low voltage mosfet)

In continuous mode $V_0 = \rho V_{IN}$

$\rho = 0.5$

$V = L\frac{di}{dt}$ $\therefore$ $1.5 = 0.2\mu \times \frac{\Delta i}{0.05\mu}$

$\therefore$ $\Delta i = 0.375A$



3/ cont. 1.2V out, $\bar{I}_o = 0.25$

Power out = 1.2×0.25 = Power in = $3 \times \frac{\hat{I}}{2}\rho$

asumming no losses.

$$\frac{\hat{I}}{2}\rho = 0.1 \quad — ①$$

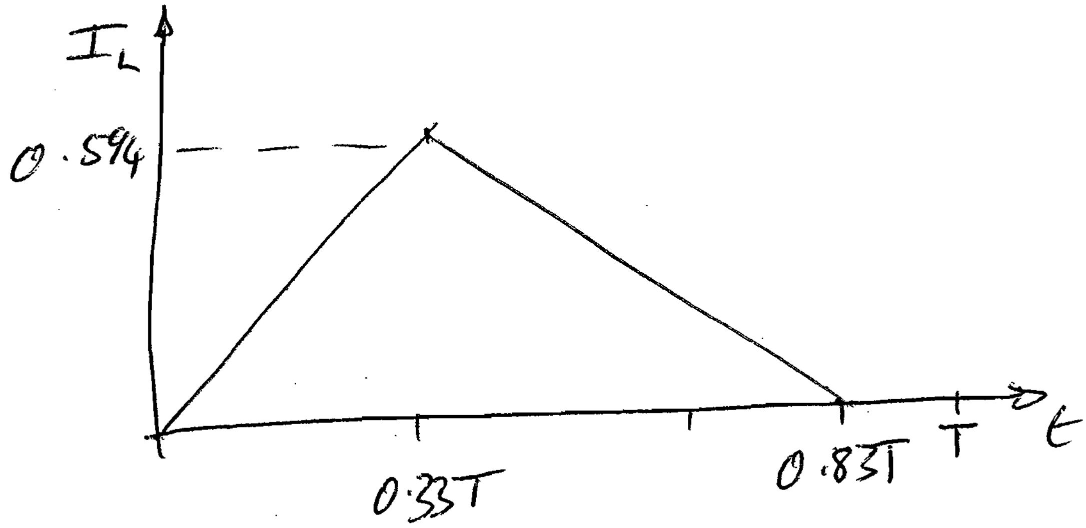
$$\hat{I} = \frac{1}{L}\int_0^{\rho T} V - V_o \, dt = \frac{V_a - V_o}{L}\rho T = \frac{1.8 \times \rho \times 0.1\mu}{0.1\mu}$$

$$= 1.8\rho \quad — ②$$

$$\frac{1.8}{2}\rho^2 = 0.1 \qquad \rho = 0.33$$

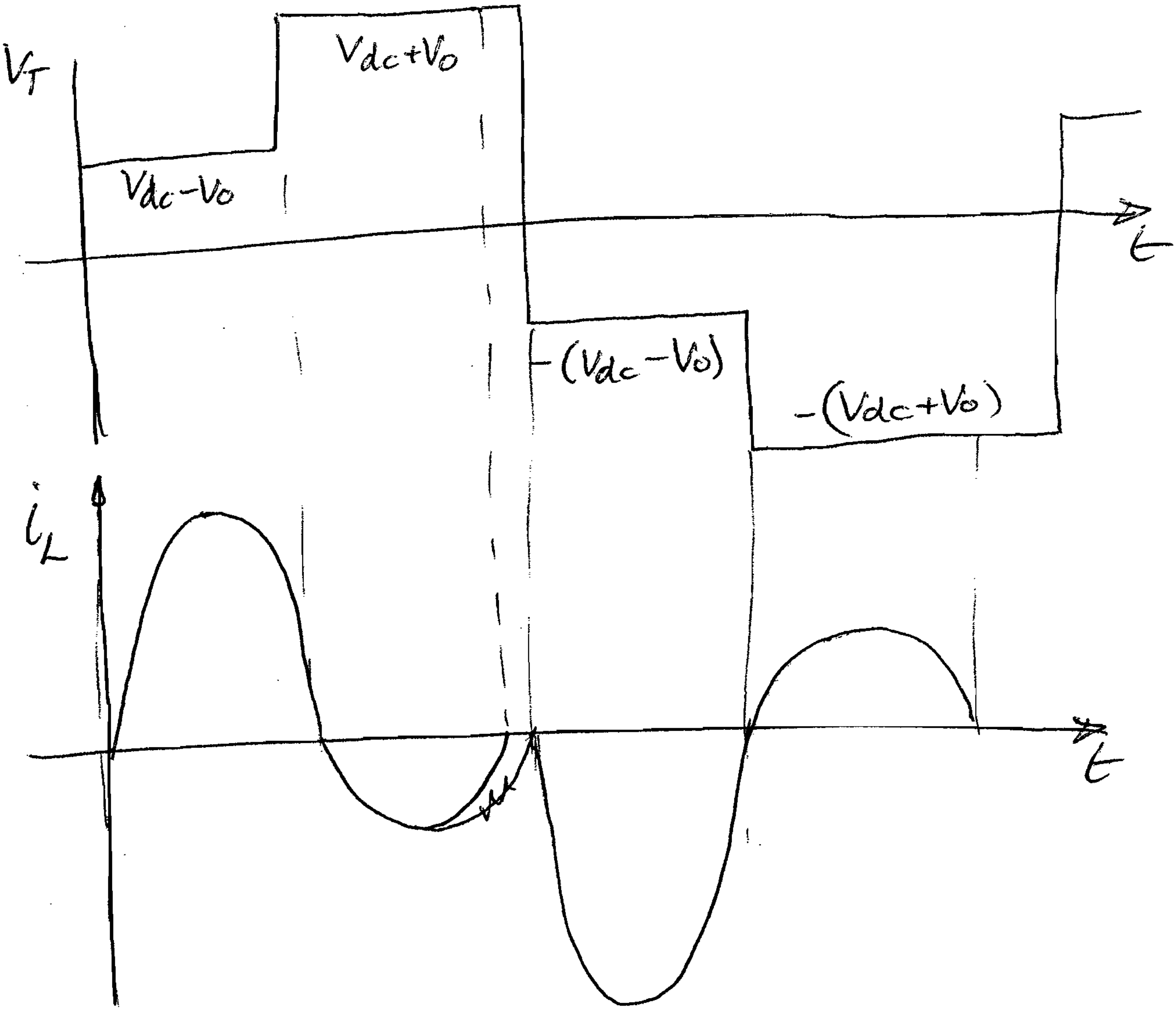
$$\hat{I} = 0.594A$$

Current fall time $0.33T \times \frac{1.8}{1.2} = 0.495$



4/. With discontinuous conduction, the current is in single complete cycles so the switching is zero current at all times. The output voltage is easily adjusted by means of the deadtime.

The voltage at the rectifier always opposes the current.



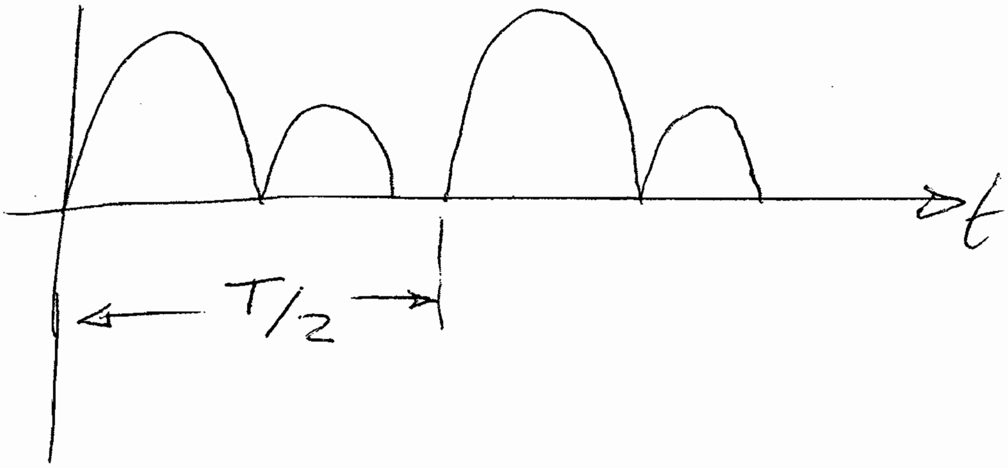
The initial condition gives the larger first half cycle.

4/ (cont) $V_{dc} - V_o - (-2V_o) = V_{dc} + V_o$ on an uncharged L-C.

So V_c resonates to $2(V_{dc}+V_o) - 2V_o = 2V_{dc}$.

This gives an energy on C of $\frac{1}{2}CV^2 = \frac{1}{2}C4V_{dc}^2$

Current charging C_o:



The charge on C at its peak V is CV

$$q = C2V_{dc}$$

By definition all of that charge is delivered to the output in a half cycle. $I_o = \frac{2q}{T}$

$$\therefore I_o = 4\frac{CV_{dc}}{T}$$

So T must be adjusted ∝ to I_o. (NB. ω_o is fixed!)

Mosfets, diodes, inductor - losses dominate