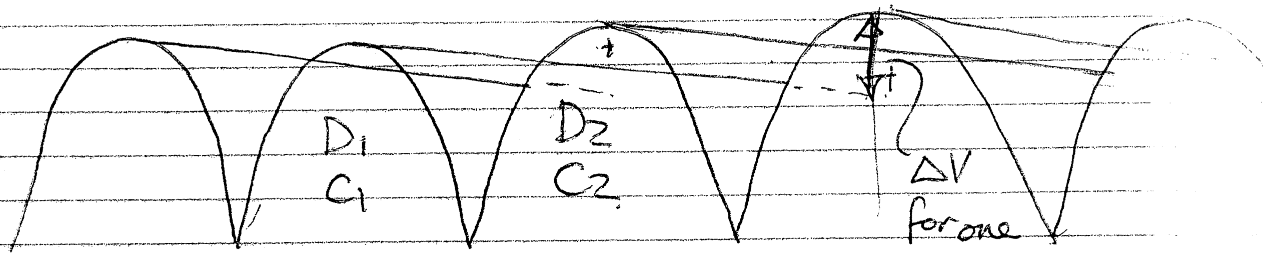
1 a) Charging. $D_1\ C_1$

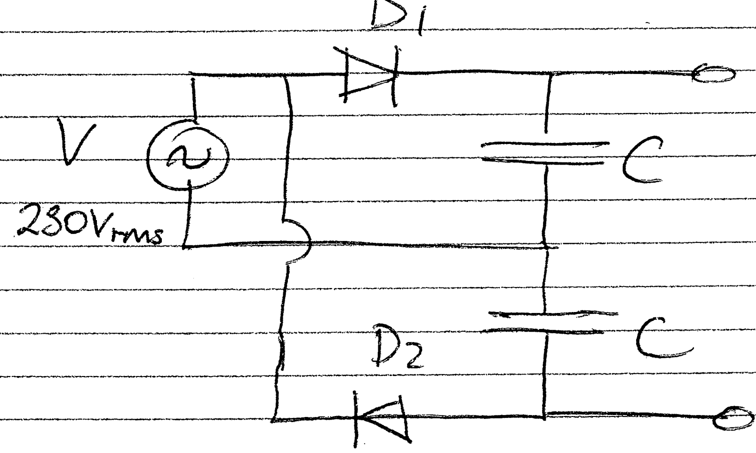


$I = C\dfrac{dV}{dt}$ $\quad \Delta V = \dfrac{I}{fC}$ for l half

Symmetrical but displaced.

In one ½ cycle' total drops $2 \times \dfrac{\Delta V}{2} = \Delta V$

So $\Delta V = \dfrac{I}{fC}$ is the ripple.

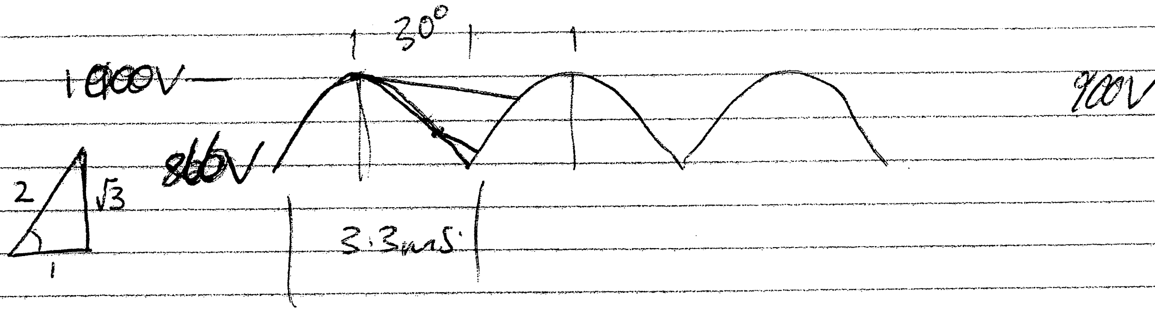


Values. $\dfrac{650 \times 0{\cdot}05 \times 50}{6} = \dfrac{1}{C}$ $\quad C = 3{\cdot}7\,mF$

1b/

3 phase 1400A ⇒ 2000A at low freq.

$900\mu F \times 6 \times 3 = 16.2\ mF$



$I = C\frac{dV}{dt}$ $\quad dV = \frac{2000 \times 3.3m}{16.2\ mF} = 407.$

$\frac{dV}{dt} = \frac{2000}{16.2m} = 123\ V/mS.$ 2

$v = V \sin 2\pi f t = 1000 \sin 2\pi.50t.$

$\frac{dV}{dt} = 1000.100\pi \cos 100\pi t. = -123,000.$

$\cos\theta = \frac{123}{100\pi} = 0.39.$

$\theta = 67, 113 \Rightarrow 920V.$ 2

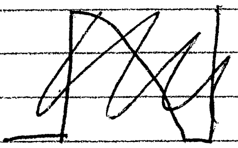
$\frac{7^{\circ}}{30} \times \frac{3.33m}{2}$

$\frac{dV}{dt} = \frac{2000}{16.2m} \times \frac{7}{30} \times \frac{3.33m}{2} = 48\ V$ 2

$920 - 48 = 872\ V.$

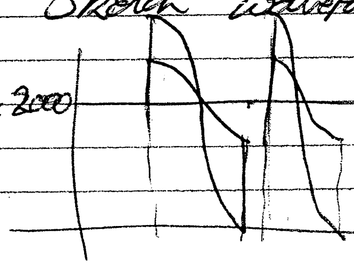
Estimate conduction angle $\approx 60° - 113°$

ie. ≈7° missing. 2

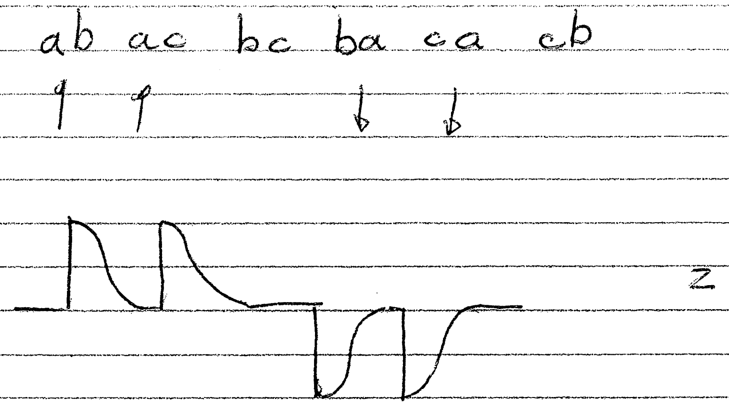


Sketch waveform.

$2000A + C\frac{dV}{dt}$



nice



Detailed Calculations are needed as the ripple is small, but so is that of unsmoothed three-phase (rectified).

3(a) ~~Easily~~ (Capable of 160A, & 10kHz) easy to drive and can be used in a rect 3ϕ dc system

1/ Fast switching

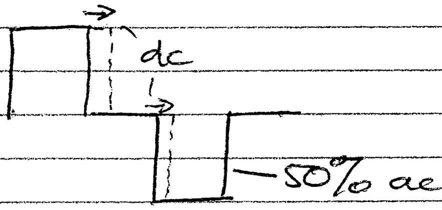
2/ Diode recovery (check)

3/ Switching losses. 5

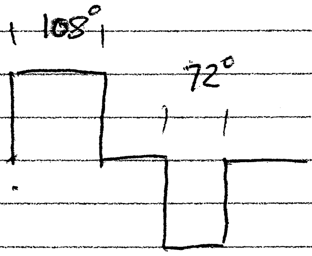
00 01 11 10 1

Equal periods of 01 & 10 give AC.

Unequal periods give dc, magnitudes set by 00, 10 p

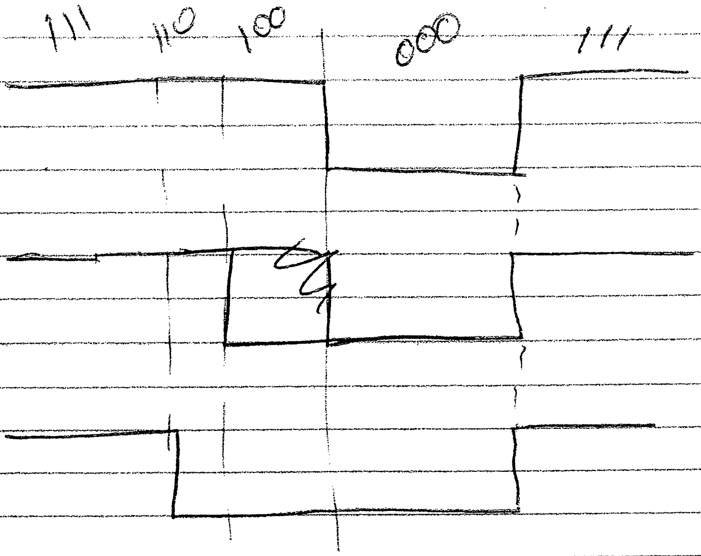


2



4

2b/



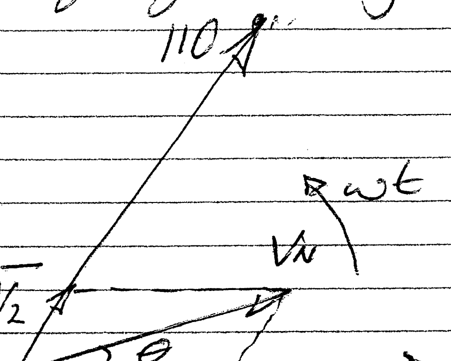
2

But this lacks the effective doubling of the switching frequency.

Also there are wasted switching instants such as 000 to 111 causing more losses. 2

Splitting the 000 & 111 states evenly within the cycle of $\frac{1}{f_s}$ as shown in the Fig 2c reduces the harmonic content of the output by means of symmetry. 1

SVM

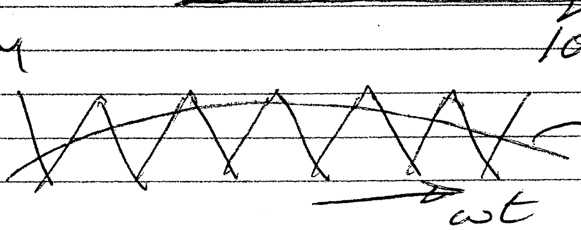


We need a sine function

$P_2 \bar{V_2} = m \sin\alpha$

3

SPWM



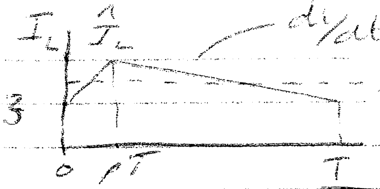
sine reference also needed.

3 a/ Mosfets can be integrated easily by "parallelling" actually making wide devices which can carry large currents. However the need to b n channel and that requires a bootstrap circuit for the upper device. D_3 & D_4 are the freewheel diodes for T_2 & T_1 respectively. T_4 charges the bootstrap for T_1.

T_3 sinks overvoltages at the output.

1 for each sentence.

3b/



— di/dt same
— I_{av} — same
so $\hat{I}_L$ higher ...

Stepdown.

$$\Delta I = \frac{V_o}{L}\left(1-\frac{12}{32}\right)T \qquad \bar{I} = 5A$$

$$\Delta I = 1.5A$$

$$L = \frac{12\left(1-\frac{12}{32}\right)}{1.5 \times 400kHz} = \frac{12 \times 5/8}{3/2 \times 400k} = \frac{5}{0.4} = 12.5\mu$$

$$\hat{I} = 5 + \frac{1.5}{2} = 5.75$$

Step up.

$$\Delta I = \frac{1}{L} V_{DC}\, \rho T = \frac{V_o(1-\rho)\rho T}{L} \quad — (2)$$

try $V_{DC} = 8 \quad V_o = 12 \quad \frac{8}{(1-\rho)} = 12 \Rightarrow \rho = \frac{1}{3}$

$V_{DC} = 10 \quad V_o = 12 \quad \frac{10}{(1-\rho)} = 12 \Rightarrow \rho = \frac{1}{6}$

put into (2) $\quad \frac{2}{9} > \frac{5}{36} \quad$ 8 is lowest V_{DC} goes

$$\Delta I = \frac{12 \;\; 2/3 \times 1/3 \;\; T}{12.5\mu} = \frac{12}{12.5} \times \frac{2}{9} \times \frac{1}{0.4}$$

$$= 0.533$$

ΔI is smaller (here than for step down)

$$\hat{I} = \bar{I} + \frac{\Delta I}{2}$$

$$(1-\rho)\bar{I} \times V_o = P \qquad \bar{I} = \frac{60}{12 \times 2/3} = 7.5A$$

$$\hat{I} = 7.5 + \frac{0.533}{2} = \underline{\underline{7.75\,A}} \quad 3$$

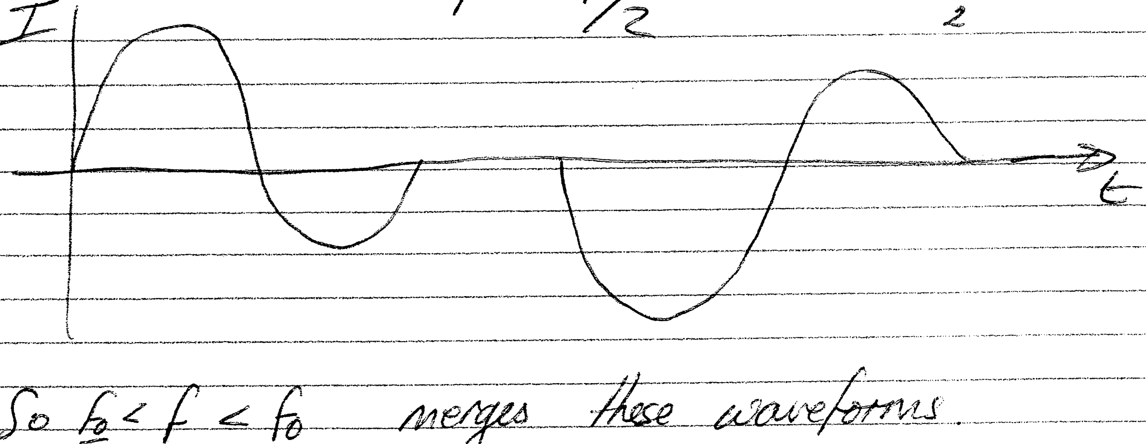
~~Efficiency of step up is much worse than that of step down.~~ Inductor design should be optimised for efficiency.

4 a) Triac control of the basic oven means trying to phase control a transformer with a big magnetising inductance, so the control is burst mode only — cycles on & cycles off. It lacks precision, as one finds heating some things in a microwave!

The 50 Hz transformer is large with fairly large losses making the oven inefficient

At half resonant frequency the inverter completes a full cycle of current then stops and waits.

$f < f_0/2$ 2

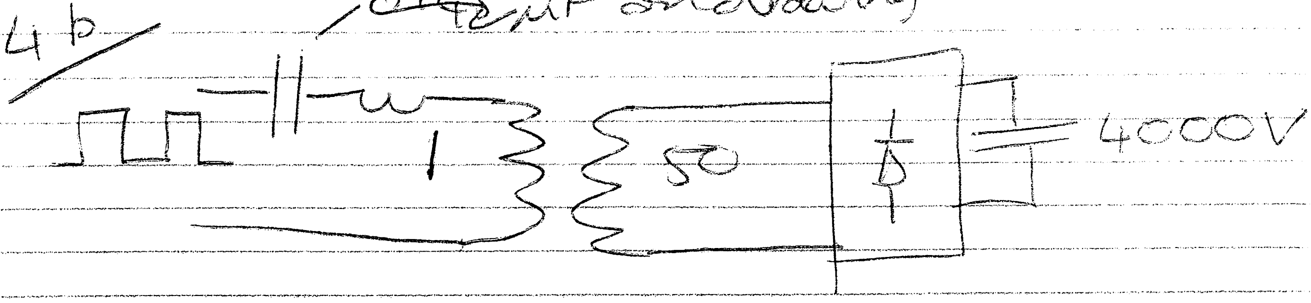


So $\frac{f_0}{2} < f < f_0$ merges these waveforms.

$f > f_0$ simple "resonant" but really acts like a filter. 2

	$f < f_0/2$	$f_0/2 < f < f_0$	$f > f_0$
IGBT	(ZCS)	stress at turn-on	stress at turn-off
DIODE	(ZCS)	stress at recovery	—
	no stress!		

4b



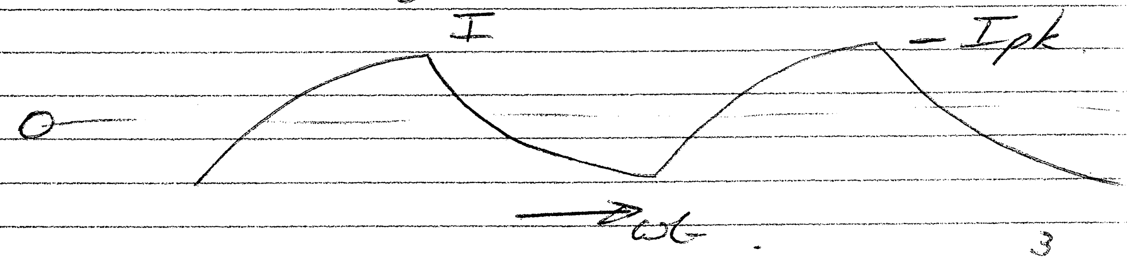
10 kHz $\quad 2\pi f = \frac{1}{\sqrt{LC}} \quad L = \frac{1}{C \cdot 4\pi^2 f^2}$

$= \frac{1}{0.45 \times 4 \times \pi^2 \times 10^8}$

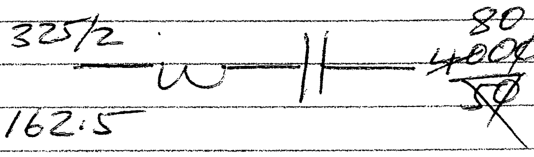
$= \frac{1}{1.8 \times 1000}$

$= 5.63 \times 10^{-4}$

20kHz its very inductive ~ like a filter



Ipk =



$\frac{4}{\pi} \times 82.5V^2$ over $j\omega L + \frac{1}{j\omega C} = j\frac{1 \times 2\pi 20k}{1.8k} + \frac{1}{j2\pi 20k \ldots}$

$= 70.75 - 17.69$

$= 53j\Omega$

$I = \frac{4}{\pi} \times 82.5/53 = 1.56A \times \frac{4}{\pi} = 1.98A$

Rectified through the bridge $\frac{2\sqrt{2}}{\pi} \times 1.98 = 1.78A$

Through the transformer: $1.78 \times \frac{3000}{50} = \underline{107}$ W