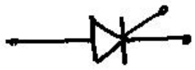
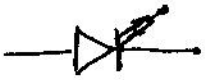
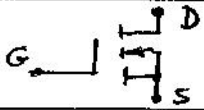
Jordan University | **Power Electronics (903461)** | **Date: 22.3.2010**
Dept. of Elect. Engg | **First Examination** | **Time: 1 Hour**

Name(in Arabic)

Student No. **Section**

Programmable calculators are not allowed.
Derive any formula you use.

1. Answer the following by marking √ for correct answer and **X** for wrong answer **3marks (each question 0.5 mark)**

	Full Name	Symbol
SCR	Silicon Controlled Rectifier	
GTO	Gate turn off thyristor	
MOSFET	Metal Oxide Semiconductor field effect transistor	

2. Fig 1 shows the diode recovery characteristics of certain diode. **1mark**

Softness factor = $\frac{t_b}{t_a} = \frac{1.5}{0.5} = 3$

3. Fig 2 shows the characteristics of two diodes connected in series with a total reverse voltage of 5kV. **2marks**

Find the values of the equalizing resistances needed to get equal voltage drop across the two diodes and to have a total reverse current of 10mA.

R_1 = [833] kΩ
R_2 = [385] kΩ

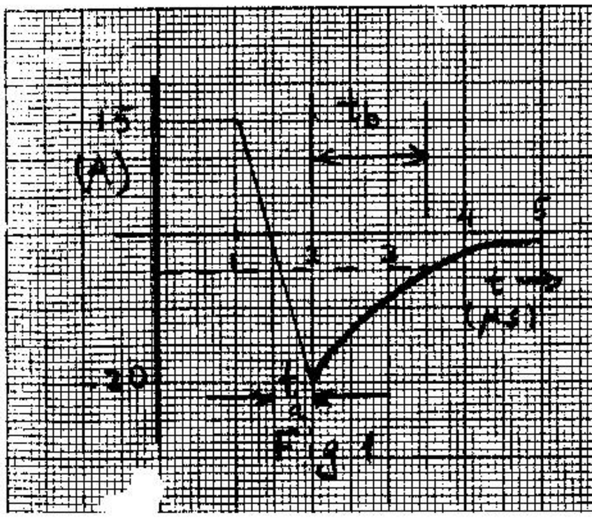
$V_{D1} = V_{D2} = \frac{5000}{2} = 2500\,V$

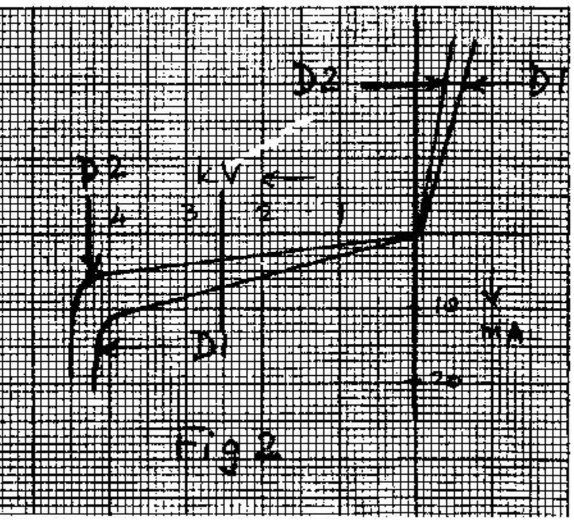
At 2500 $I_{D1} = 7$ mA

$I_{D2} = 3.5$ mA

$\therefore I_{R1} = 10 - 7 = 3$ mA $\therefore R_1 = \frac{2500}{3 \times 10^{-3}} = 833$ kΩ

$I_{R2} = 10 - 3.5 = 6.5$ mA $R_2 = \frac{2500}{6.5 \times 10^{-3}} = 385$ kΩ





4. A voltage source v(t) = 300 sin (2π x 50 t + π/6) is applied to a non linear load drawing a current of i(t) =
   20 sin (2π x 50 t) + 8 sin (2π x 100 t) + 6 cos (2π x 100 t) A

Find **4marks**

(i) The power factor [0.7745]

$$V_{rms} = \frac{300}{\sqrt{2}} = 212.16\,V$$

$$I_{rms} = \sqrt{\left(\frac{20}{\sqrt{2}}\right)^2 + \left(\frac{8}{\sqrt{2}}\right)^2 + \left(\frac{6}{\sqrt{2}}\right)^2} = 15.81\,A$$

$$P.F = \frac{P}{VI} = \frac{212.16 \times \frac{20}{\sqrt{2}} \times \cos\frac{\pi}{6}}{212.16 \times 15.81} = 0.7745$$

(ii) The displacement factor [0.866]

$$\cos\phi_1 = \cos 30^\circ = 0.866$$

(iii) The distortion VA [1500] VAD

$$P = \frac{20}{\sqrt{2}} \times \frac{300}{\sqrt{2}} \times \frac{\sqrt{3}}{2} = 2600\,W$$

$$Q = \frac{20}{\sqrt{3}} \times \frac{300}{\sqrt{2}} \times \frac{1}{2} = 1500\,W$$

$$D = \sqrt{\left(\frac{8}{\sqrt{2}}\right)^2 + \left(\frac{6}{\sqrt{2}}\right)^2} \times \frac{300}{\sqrt{2}} = 1500\,VAD$$

(iv) The total harmonic distortion [0.5]

$$THD = \sqrt{\frac{\left(\frac{10}{\sqrt{2}}\right)^2}{\left(\frac{20}{\sqrt{2}}\right)^2}} = \frac{1}{2}$$

5. A single phase half wave rectifier with an RL load and a freewheeling diode. $V_m = 200V$. $R = 10\ \Omega$, $L = 0.05H$, $f = 50Hz$.

Find **5marks**

(i) The dc output current [6.366] A

$$I_{dc} = \frac{1}{\pi R}\int_0^{\pi} V_m \sin\omega t\, d\omega t = \frac{V_m}{\pi R} = \frac{200}{10\pi} = 6.366\ A$$

$$f(t) = \frac{V_m}{\pi R} + \frac{V_m}{2R}\sin\omega t - \frac{2V_m}{R\pi}\sum_{n=1}^{\infty}\frac{\cos 2n\omega t}{4n^2-1}$$

(ii) The rms output current [7.468] A

(iii) The output power [557.7] W

(iv) The supply power factor [0.528] lagging

n	V_n	Z_n	$I_{n\,max}$	$I_{n\,rms}$
0	63.66	10	6.366	6.366
1	$\frac{200}{2} = 100$	$\sqrt{10^2 + (2\pi \times 50 \times 0.05)^2} = 18.62$	5.37	3.797
2	$\frac{2 \times 200}{3\pi}$	$\sqrt{10^2 + (2\pi \times 100 \times 0.05)^2} = 32.97$	1.287	0.91
4	$\frac{2 \times 200}{15\pi}$	$\sqrt{10^2 + (2\pi \times 200 \times 0.05)^2} = 63.62$	0.133	0.094

$$I_{rms} = \sqrt{6.366^2 + 3.797^2 + 0.91^2 + 0.094^2} = 7.468\ A$$

$$P = 7.468^2 \times 10 = 557.7\ W$$

$$PF = \frac{557.7}{\frac{200}{\sqrt{2}} \times 7.468} = 0.528 \text{ lagging}$$

6. A single phase half wave rectifier with a resistive load and a smoothing capacitor. $V_m = 200V$, $R = 1\ k\Omega$. The output voltage, the capacitor current and the diode current are shown below. **6marks**

Find the following

(i) Value of the angle θ in degrees [99°]

(ii) Value of the angle α in degrees [27°]

(iii) The value of the capacitor needed to achieve these waveforms [20.1] μf

(iv) The maximum and minimum values of the capacitor currents

I_{cmax} = [1.125] A

I_{cmin} = [−0.198] A

(v) The maximum value of the diode current [1.216] A

(vi) The output voltage ripple. [109.2] V

$$\theta = \frac{5.5\times10^{-3}}{20\times10^{-3}} \times 360 = 99^\circ = 99\times\frac{2\pi}{360} = 1.728 \text{ rad}$$

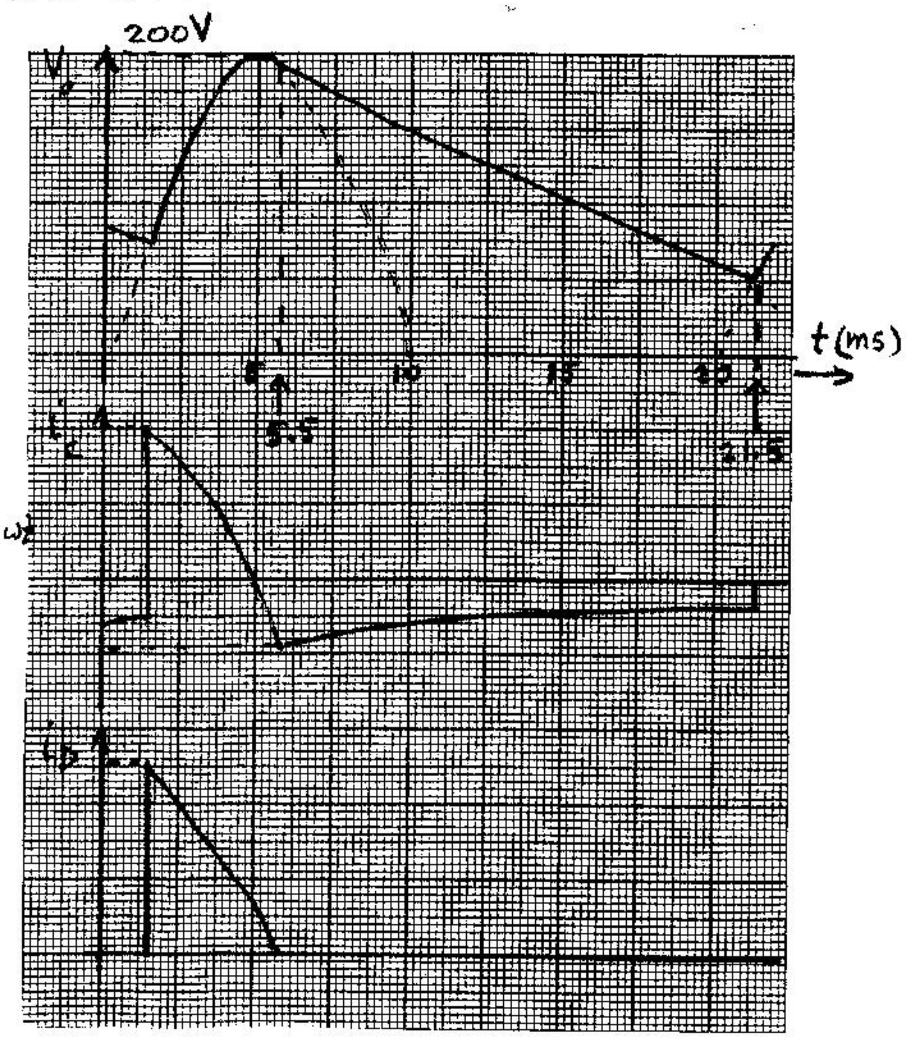
$f = 50Hz$

$$\alpha = \frac{1.5\times10^{-3}}{20\times10^{-3}} \times 360 = 27^\circ = 27\times\frac{2\pi}{360} = 0.471 \text{ rad}$$

$$\theta = \pi - \tan^{-1}(\omega RC) = 99^\circ \qquad 81 = \tan^{-1}\omega RC$$

~~tan θ~~ $\omega RC = 6.31375$

$$C = \frac{6.31375}{2\pi\times50} = \underline{20.1\ \mu f}$$



$$i_c = C\frac{dv}{dt} = C\frac{d}{dt}(V_m \sin\omega t)$$
$$= CV_m\,\omega\cos\omega t$$
$$= 20.1\times10^{-6}\times200\times2\pi\times50\cos\omega t$$
$$= ~~1.125~~\ 1.293\cos\omega t$$

$$I_{cmax} = 1.293\cos27^\circ = \underline{1.125}$$

$$I_{cmin} = 1.293\cos99^\circ = \underline{-0.198}$$

$$i_D = i_c + i_R$$
$$= 1.293\cos\omega t + \frac{200\sin\omega t}{1000}$$
$$I_{Dmax} = 1.293\cos\alpha + 0.2\sin\alpha = \underline{1.216\ A}$$

$$\Delta V = 200 - 200\sin27 = \underline{109.2}V$$