Modified

CBCS SCHEME

USN | | | | | | | | | | |

18EE53

Fifth Semester B.E. Degree Examination, Feb./Mar. 2022
Power Electronics

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. With neat circuit diagram, input and output waveform, explain the different types of Power Electronics Converters. **(10 Marks)**

b. With block diagram, explain the peripheral effects of power electronic equipment. **(06 Marks)**

c. Compare the advantages and disadvantages of full wave bridge rectifier and full wave centre tapped transformer rectifier. **(04 Marks)**

OR

2 a. Briefly explain the different types of Power diodes and its applications. **(08 Marks)**

b. List the applications of Power Electronics. **(04 Marks)**

c. With circuit diagram and waveform, explain the working of single phase full wave uncontrolled rectifier with R load. **(08 Marks)**

Module-2

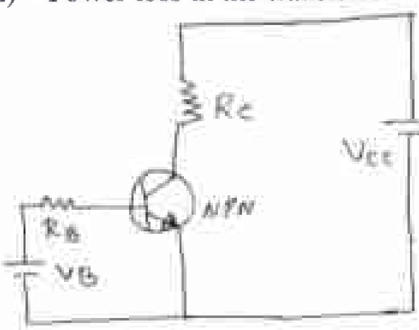
3 a. Explain Switching characteristics of BJT with waveforms. **(08 Marks)**

b. A power BJT is connected as a switch as in figure Q3(b) with the following data. Calculate

i) The value of R_B that will result in saturation with an overdrive factor of 20.

ii) The forced β iii) Power loss in the transistor. **(06 Marks)**

Fig. Q3(b)



V_{CC} = 100V V_B = 8V

$V_{CE\,sat}$ = 2.5 V

$V_{BE\,sat}$ = 1.75V

β of the transistor is varied from 10 to 60.

R_C = 10 Ω

c. Give a comparison between BJT and MOSFET. **(06 Marks)**

OR

4 a. Discuss the need of base drive control in a Power transistor. **(08 Marks)**

b. A simple transistor switch is used to connect a 24V DC supply across a relay coil, which has a DC resistance of 200Ω. An input pulse of 0 to 5V amplitude to applied through a series base resistor R_B at the base so as to turn ON the transistor switch. Sketch the device current waveform with reference to the input pulse. Calculate : i) I_{Csat}.

ii) Value of resistor R_B required to obtain over drive factor of 2.

iii) Total Power dissipation in the transistor that occurs during the saturation state. **(06 Marks)**

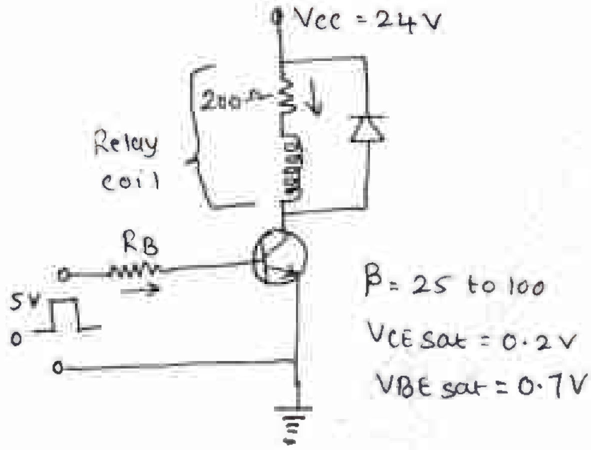


Fig. Q4(b)

c. Explain steady state characteristics of n channel power MOSFET with necessary diagram. **(06 Marks)**

Module-3

5 a. Explain the V.I characteristics of SCR also define :
i) Holding current ii) Latching current. **(12 Marks)**

b. Explain any four method of Turn – ON used for Thyristors. **(04 Marks)**

c. The latching current of an SCR used in a phase controlled circuit. Comprising an inductive load of R = 10Ω and L = 0.1H is 15mA. The input voltage is 325 sin 314t. Obtain the minimum gate pulse width required for reliable triggering of the SCR if gated at $\frac{\pi}{3}$ angle in every positive half cycle. **(04 Marks)**

OR

6 a. Derive an expression for anode current using two transistor model of Thyristor. **(08 Marks)**

b. A UJT is connected across a 220V DC supply. The valley and peak point voltages are 1V and 15V. The period of UJT relaxation oscillator is 20MS. Find the value of charging capacitor, if a charging resistor of 100kΩ is used. **(06 Marks)**

c. Explain Half wave RC firing circuit with necessary diagrams. **(06 Marks)**

Module-4

7 a. With the help of circuit diagram and waveform, explain the working of single phase full wave AC voltage controller with R load. **(10 Marks)**

b. The single phase full wave AC voltage controller operates on a single phase supply voltage of 230V rms at 50Hz. If the triac is triggered at a delay angle of 45° during each half cycle of input supply. i) RMS value of output voltage ii) RMS value of current through heater iii) Average value of triac current iv) RMS value of triac current v) Input power factor. **(10 Marks)**

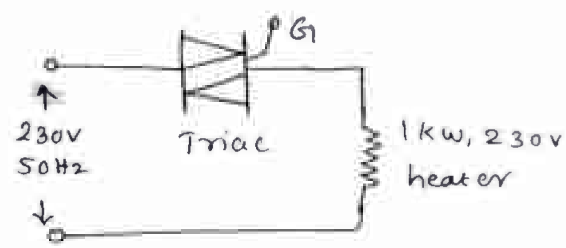


Fig. Q7(b)

OR

8 a. Explain Half wave controlled rectifier with R_L load, without freewheeling diode. Draw necessary diagrams. **(10 Marks)**

b. A single phase half wave converter is operated from a 120V , 50Hz supply and the load resistance R = 10Ω. If the average output voltage is 25% of the maximum possible average output voltage calculate : i) Delay angle α ii) The rms and average output currents iii) The average and rms thyristor currents iv) The input power factor. **(10 Marks)**

Module-5

9 a. A Chopper circuit drives an Inductive load from 200V DC supply. Given the load resistance as 4Ω, the average load current as 30A and operating frequency is 400Hz. Compute the ON period and OFF period of the Chopper. Also determine the duty cycle of the Chopper. **(06 Marks)**

b. With the help of circuit and waveforms, explain the operation of step up Chopper. **(08 Marks)**

c. Explain Performance Parameters of Chopper. **(06 Marks)**

OR

10 a. Explain Single Phase full bridge Inventor operation with R load. Draw necessary diagrams. **(10 Marks)**

b. Draw and explain Single Phase Transistorised Current Source Inverter. **(10 Marks)**

* * * * *

Comments from BOE EEE, to the following Subjects Scheme & Solutions		
Subject Code	Name of Subject	Comments from BOE EEE
18EE53	Power Electronics	Q.No. 3(c) the tabular column should be **MOSFET in the first column** and **BJT in the second column** Q.No. 4 (c) it is not clearly mentioned whether it is for depletion mode or enhancement mode, the given answer is for enhancement mode but we need to consider the depletion mode answer also. (because in the question it is not mentioned whether it is depletion mode or enhancement mode) Give Marks for both mode as per the scheme steps

Hence the may be considered for the further Process.

3|03|2022

BOE Chairman
EEE Composite Board
Dr. H L Suresh

Sir MVIT, Bangalore

" APPROVED "

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Belagavi, Karnataka – 590 018.

Scheme & Solutions

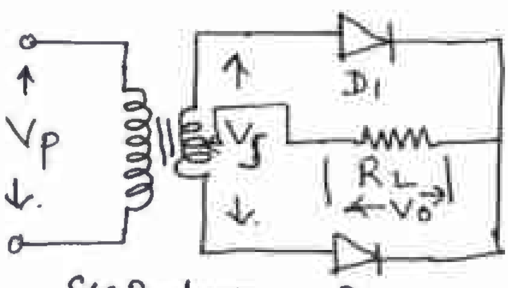
Signature of Scrutinizer

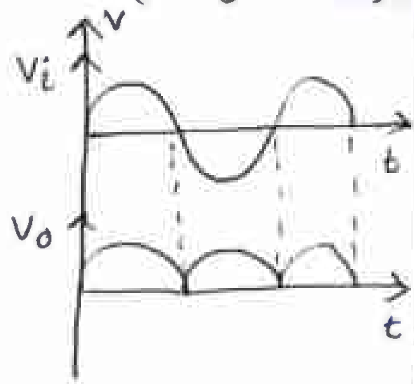
Subject Title: POWER ELECTRONICS **Subject Code:** 18EE53

Question Number	Solution	Marks Allocated
(1) (a)	a) Ac to Dc converter (Rectifier) i) uncontrolled Rectifier. ii) controlled Rectifier. b) Dc to Ac converter (Inverter) c) Dc to Dc converter (chopper) d) Ac to Ac converter (Ac Voltage controller)	

(a) Ac to Dc converter (Rectifier).

i) uncontrolled Rectifier. (using diode)





01m

Step down Tfr

$V_s < V_P$

V_s = secondary Voltage.

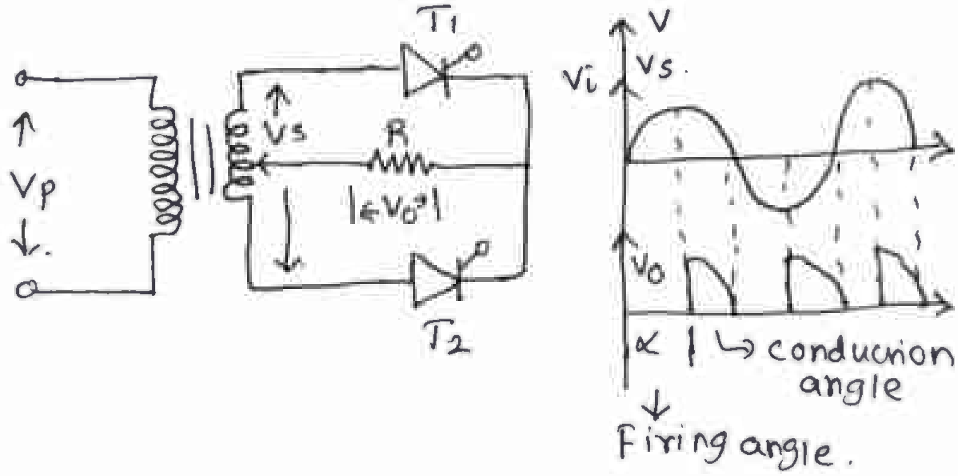
V_P = Primary Voltage

V_i = Input Voltage

V_o = output Voltage

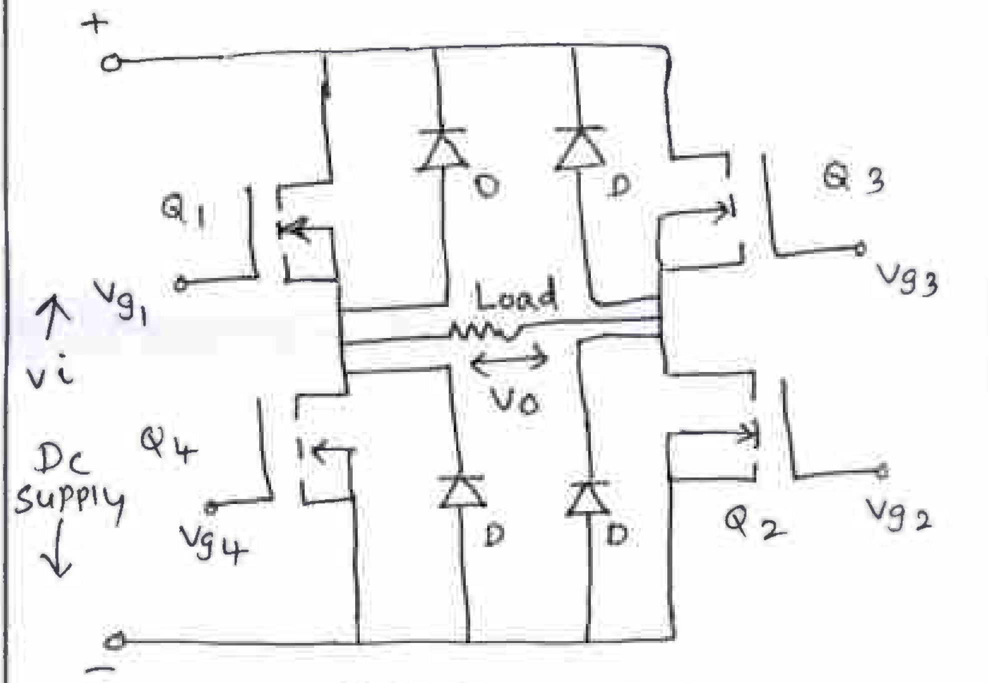
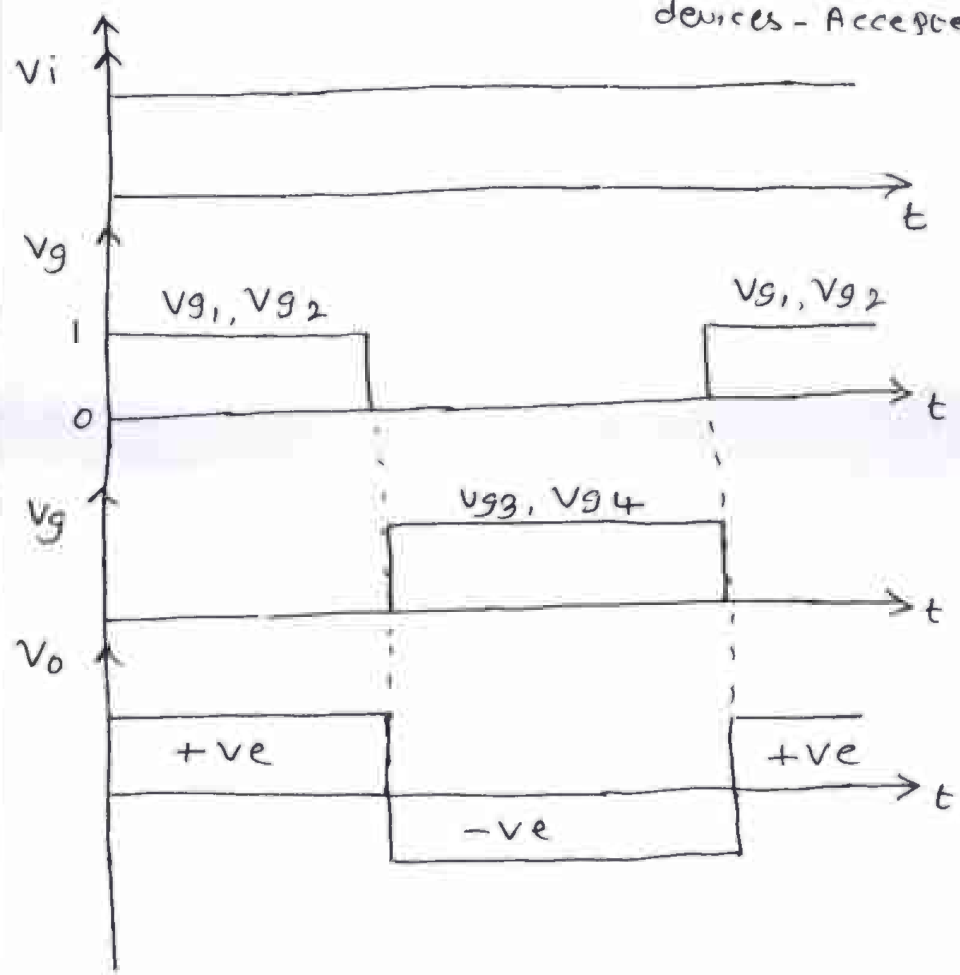
P.T.O.

Subject Title : POWER ELECTRONICS   Subject Code : 18EE53

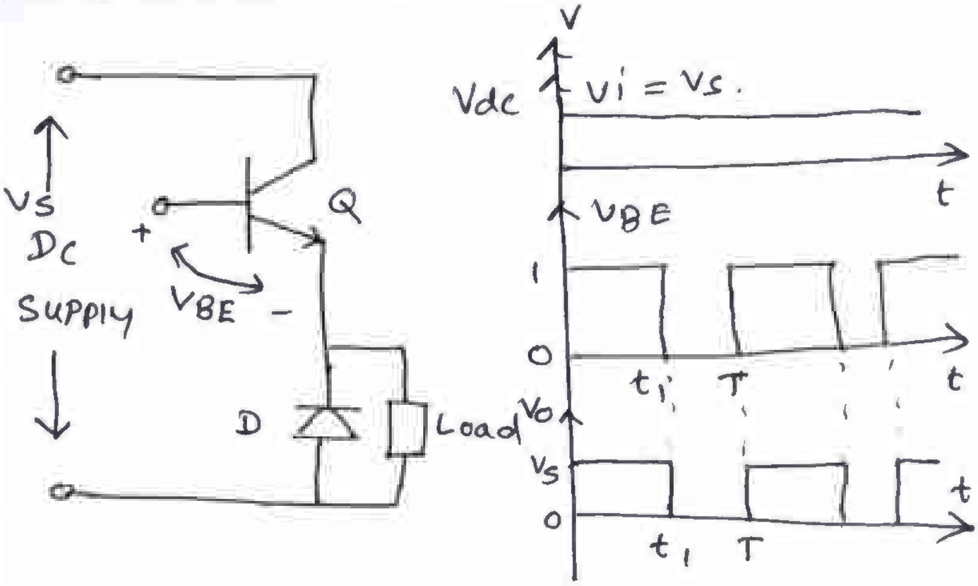
Question Number	Solution	Marks Allocated
	The converter circuit which converts AC to DC is called a Rectifier. The Rectifier circuit using diode only are called uncontrolled Rectifier circuit.	01m
	ii) Controlled Rectifier (using SCR's) 	01m
	The Rectifier circuit using SCRs are called controlled Rectifier circuit. Output Phase angle will be controlled by SCR's.	
	(b) DC to AC converter (Inverter) A DC to AC converter is also known as an Inverter. The Input to the Inverter is fixed DC Voltage usually obtained from battery. The output of the Inverter is the fixed or variable frequency AC Voltage.	01m

P.T.O

Subject Title : POWER ELECTRONICS Subject Code : 18EE53

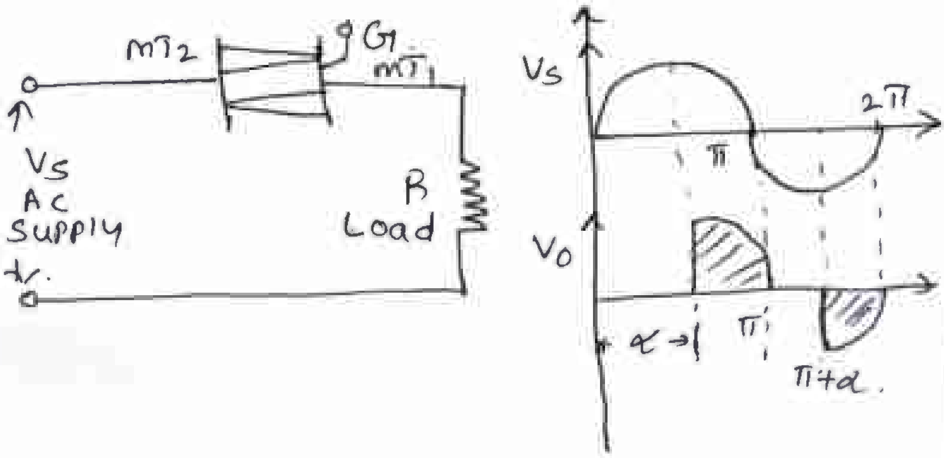
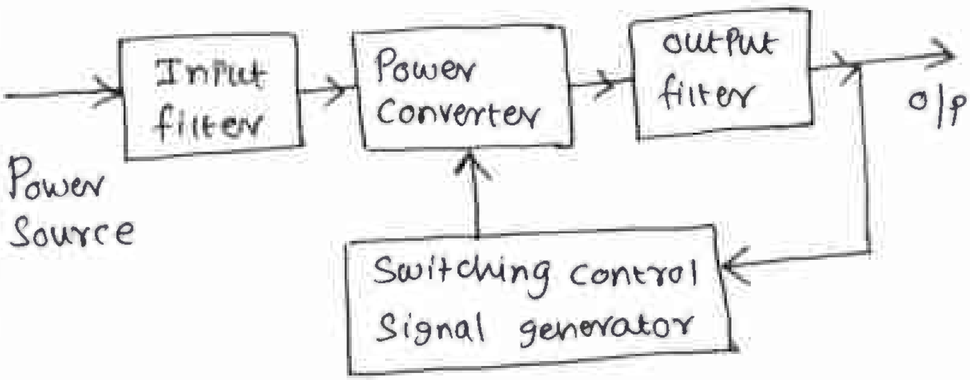
Question Number	Solution	Marks Allocated
		01m
	Q_1 Q_2 Q_3 Q_4 → Any switching devices - Accepted	
		01m

Subject Title : POWER ELECTRONICS | Subject Code : 18EE53

Question Number	Solution	Marks Allocated
	(c) DC to DC Converter (Chopper)	
	A chopper is a static device that converts fixed DC input voltage to a variable DC output voltage. It is basically a high speed on/off semiconductor switch.	01m
		01m
	when switch is ON $V_o = V_s$	
	when switch is OFF $V_o = 0$.	
	(d) AC to AC converter (Voltage controller)	
	A single phase AC voltage controller is a device which converts fixed single phase alternating voltage directly to a variable alternating voltage without a change in frequency.	01m

P.T.O

Subject Title : POWER ELECTRONICS **Subject Code :**

Question Number	Solution	Marks Allocated
	 	01m 10m
1 (b)	Peripheral effects:-  Explanation about each --- block	02m 04m 06m
1 (c)	Centre tapped transformer:- 1. center tapped rectifier as the name Suggest is requires a center tapped transformer. 2. The Peak Inverse Voltage (PIV) of diode in center tapped full wave rectifier is twise the transformer Secondary terminal Voltage.	

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Question Number	Solution	Marks Allocated
	3. center tapped Rectifier uses only two diodes in its circuit.	
	4. The transformer utilization factor (TUF) is equal to 0.672.	
	Bridge Rectifier	
	1. No center tapped transformer required in bridge Rectifier.	
	2. Peak inverse voltage PIV of diode is equal to the transformer secondary voltage. Thus this type of rectifier can be used for high voltage applications.	
	3. Bridge Rectifier uses four diodes in ~~the~~ its circuit. This result to increment in the circuit complexity in case of the bridge Rectifier.	
	4. The transformer utilization factor (TUF) is equal to 0.810 for bridge Rectifier.	
	(or)	
	Any four Points for each Rectifier 1 x 4	4 m
		04 m

P.T.O.

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Question Number	Solution	Marks Allocated

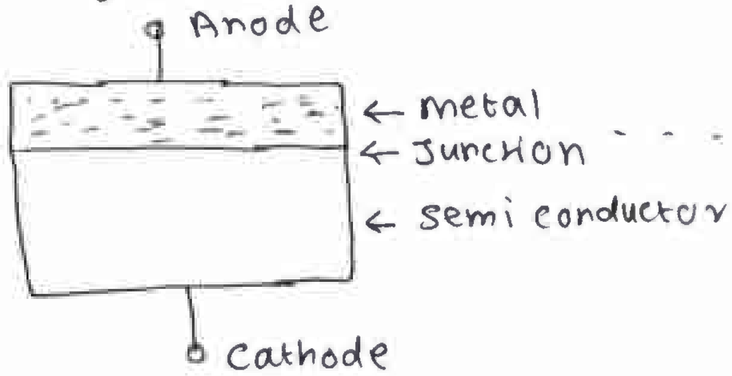
2 (a)

Types of diodes:

1. General Purpose diodes
   Explanation ---- 1m

2. Fast recovery diodes
   Explanation ---- 1m

3. Schottky diodes



---- 1m

Explanation ------ 1m

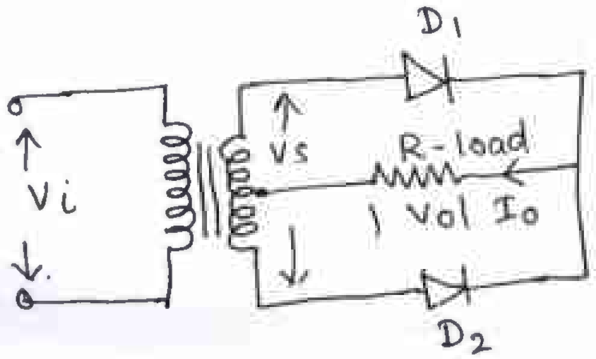
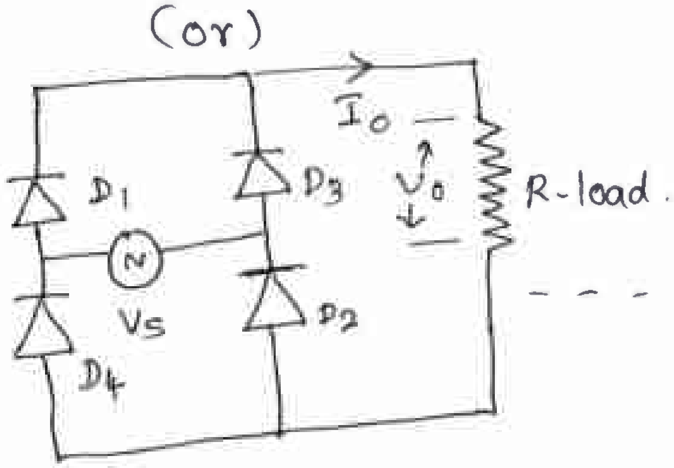
Applications:

1. Power diodes are used in uncontrolled Rectifier.
2. Feedback and freewheeling operations in choppers, Inverters and controlled converters use Power diodes.
3. Almost all the Commutating circuits for SCR's use Power diodes.
4. Half controlled converters and half bridge Inverters use Power diodes. 1x4 4m

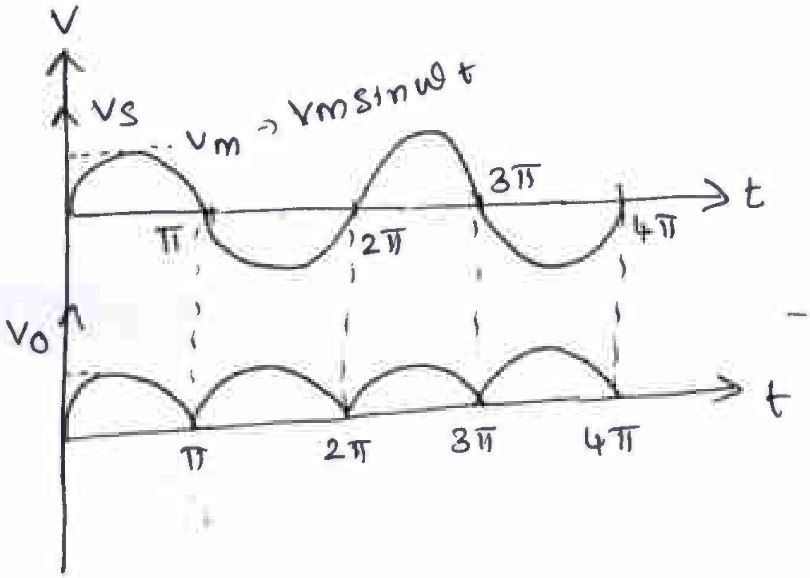
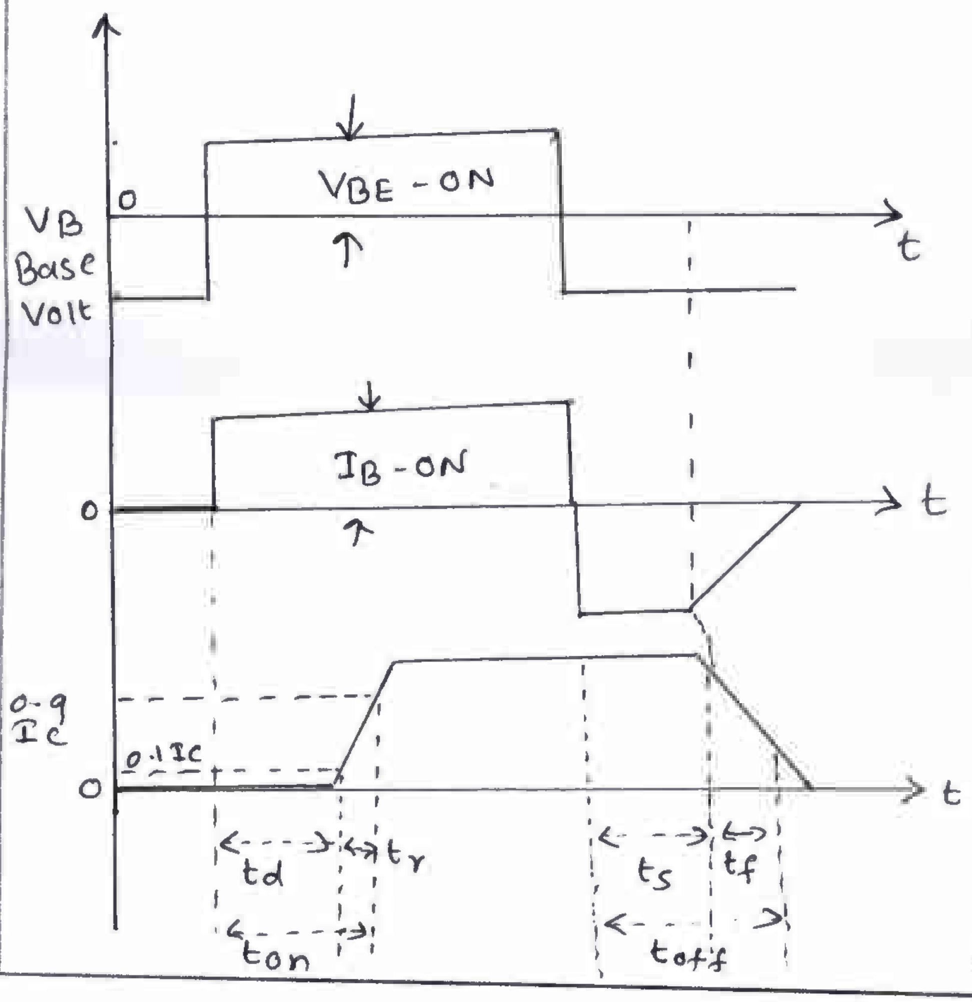
08m

P.T.O

Subject Title : **Subject Code :**

Question Number	Solution	Marks Allocated
2 b	1. UPS and Stand by Power supplies for critical loads such as computers, medical equipments etc. 2. Power control in resistence welding, induction heating, elecrolysis Process etc. 3. Power conversion for HVDC and HVAC transmission system. 4. Speed control of motors which are used in traction drives, textile mills, rolling mills, cranes, lifts, compressor, pumps etc. (or) Any four Points 1×4	4 m 4 m
2 c	 (or) 	02 m

Subject Title : POWER ELECTRONICS Subject Code : 18EE53

Question Number	Solution	Marks Allocated
		02 m
	Explanation	04 m
		08 m
3) a)		03 m

P.T.O

Subject Title : POWER ELECTRONICS   Subject Code : 18EE53

Question Number	Solution	Marks Allocated
	Explanation - - - - -	03m
	$t_{on} = t_d + t_r$ - - - - - $t_{off} = t_s + t_f$ - - - - -	02m
		08m
3 (b)	Solution	
	i) To obtain value of R_B	
	From collector emitter loop	
	$I_{c\,sat} = \frac{V_{cc} - V_{ce\,sat}}{R_c} = \frac{100 - 2.5}{10}$ - - - -	01m
	$I_{c\,sat} = 9.75\,A$	
	$I_{B\,sat} = \frac{I_{c\,sat}}{\beta_{min}} = \frac{9.75}{10} = 0.975\,A$ - - - -	01m
	$ODF = \frac{I_B}{I_{B\,sat}} \Rightarrow 20 = \frac{I_B}{0.975}$ $I_B = 19.5A$ ..	01m
	From base emitter loop	
	$V_B = I_B R_B + V_{BE}$	
	$8 = 19.5 \times R_B + 1.75 \Rightarrow R_B = 0.32\,\Omega$ ..	01m

P.T.O

Subject Title : Subject Code :

Question Number	Solution	Marks Allocated
	ii) To obtain forced β_f	
	$\beta_{forced} = \frac{I_{c\,sat}}{I_B} = \frac{9.75}{19.5} = 0.5$ - - - -	01m
	iii) To obtain Power loss in transistor	
	$P_T = V_{BE} I_B + V_{CE} I_C$	
	$= 1.75 \times 19.5 + 2.5 \times 9.75 = 58.5W$	
	$P_T = 58.5$ watts - - - - - - -	01m 06m
3) c)	Compare BJT and MOSFET	

~~BJT~~ MOSFET	~~MOSFET~~ BJT
1. N channel and P channel	1. NPN and PNP
2. output current is Controlled by input gate voltage.	2. output current is Controlled by input base current
3. more expensive	3. less expensive
4. very high current gain	4. Lower current gain
5. High input resistance 10^7 ohms.	5. very low.
6. Input current Pico amps	6. micro amps or milli amps

Any six points. 6x1 — 06m

06m

P.T.O

Subject Title : POWER ELECTRONICS Subject Code : 18EE53

Question Number	Solution	Marks Allocated
(4) (a)	**Requirement of base drive:-**	
	1. A fast rising (< 1μs) current to turn on the device.	1
	2. A hard drive of adequate magnitude (IB) to reduce Turn on loss.	
	3. A steady base current of adequate (IB) to keep the device in saturation during the on period of the switch.	1
	4. A fast falling (<1μs) current of adequate magnitude (IB-) during the storage time (typically 5 to 10μs) of the turn ON period of the switch.	
	5. A base voltage of adequate negative magnitude typically 5V during the OFF period of the device.	1
	6. The drive circuit must be such that the switching performance is insensitive	
	7. Electrical isolation between the control input and the switch may be desired. This will be necessary very often when the system has several switches located at different electrical potentials.	1
	8. The drive circuit must have overriding protection to switch of the device under fault. 1X 8	8 m
		8 m.

P.T.O

Subject Title : Subject Code :

Question Number	Solution	Marks Allocated
4 (b)	Solution:	
	i) To obtain I_{Csat}	
	From collector emitter loop	
	$I_{Csat} = \frac{V_{CC} - V_{CE\,sat}}{R_C}$	01M
	$= \frac{24 - 0.2}{200} = 0.12A$	
	$I_{Csat} = 0.12A$	01M
	ii) To obtain R_B for ODF = 2	
	$I_{B\,sat} = \frac{I_{C\,sat}}{\beta_{min}} = \frac{0.12}{25}$	
	$I_{Bsat} = 4.8\,mA$	01M
	$ODF = \frac{I_B}{I_{Bsat}}$	
	$2 = \frac{I_B}{4.8 \times 10^{-3}}$	
	$I_B = 9.6\,mA$	01M
	From emitter base loop we get	
	$V_B = I_B R_B + V_{BE}$	
	$R_B = \frac{V_B - V_{BE}}{I_B} = \frac{5 - 0.7}{9.6 \times 10^{-3}}$	
	$R_B = 448\,\Omega$	01M

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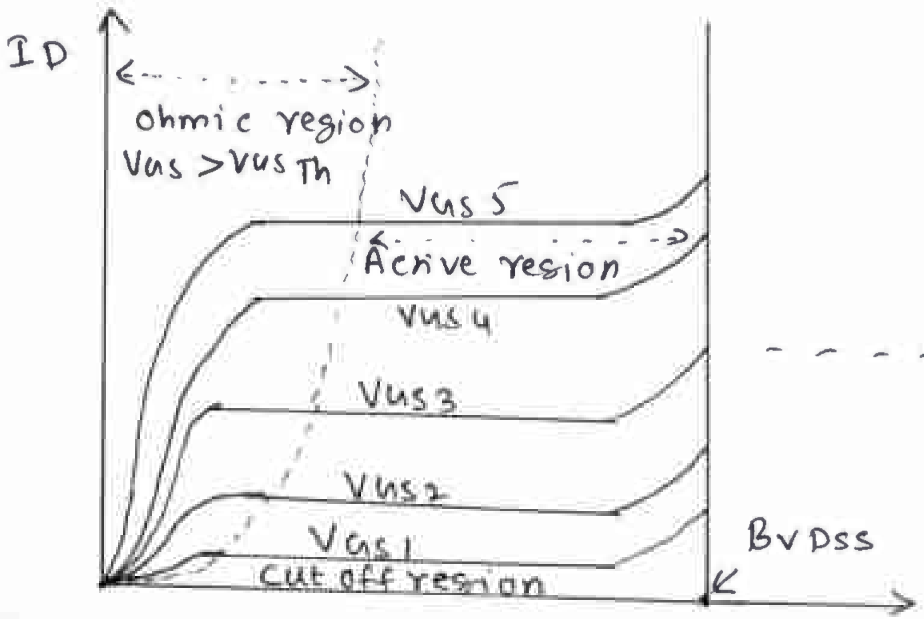
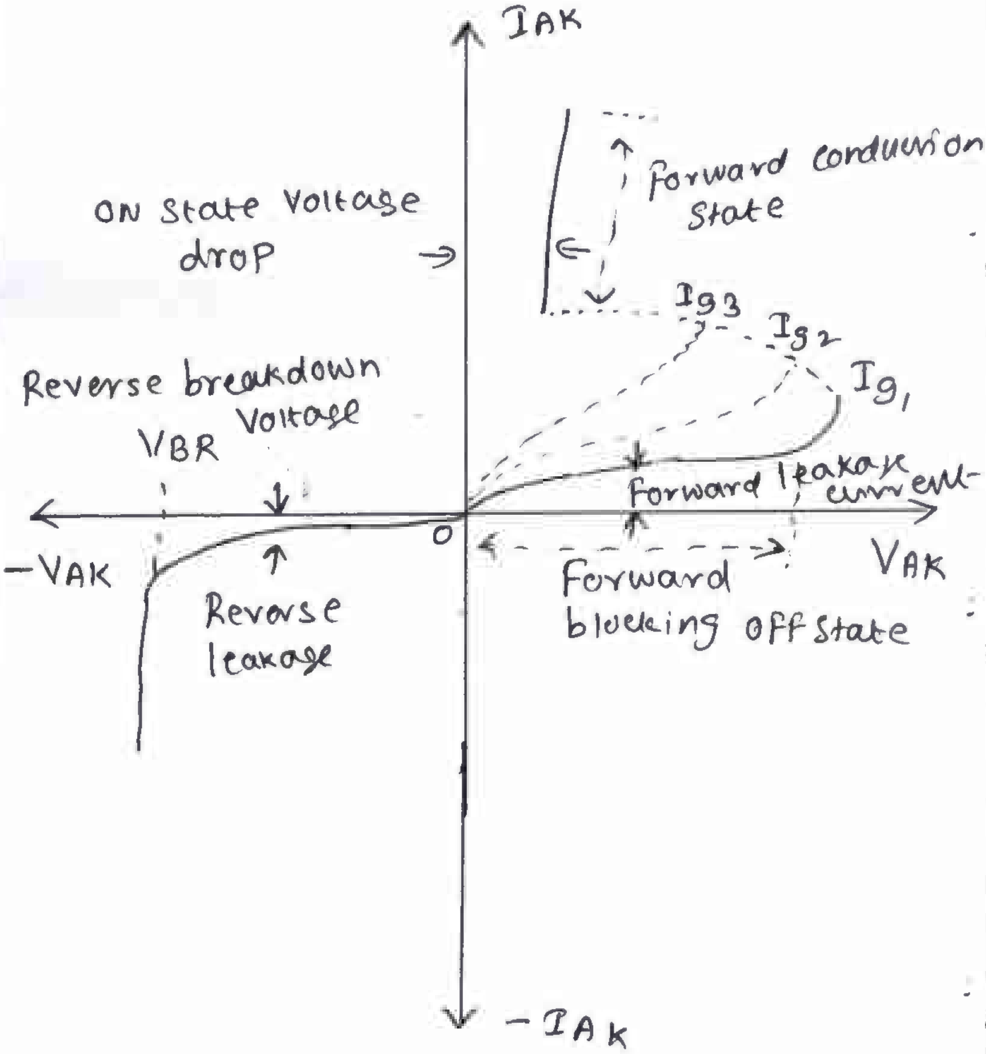
Subject Title : POWER ELECTRONICS Subject Code : 18EE53

Question Number	Solution	Marks Allocated
	iii) To obtain Power dissipation	
	$P_T = V_{BE} I_B + V_{ce} I_c$	
	$= 0.7 \times 9.6 \times 10^{-3} + 0.2 \times 0.12$	
	$P_T = 0.0307$ watts - - - - - - -	01m
		06m
4 c	 - - - -	02m
	Vgs 5 > Vgs 4 > Vgs 3 > Vgs 3 > Vgs 2 > Vgs 1	
	Explanation - - - -	04m
		06m

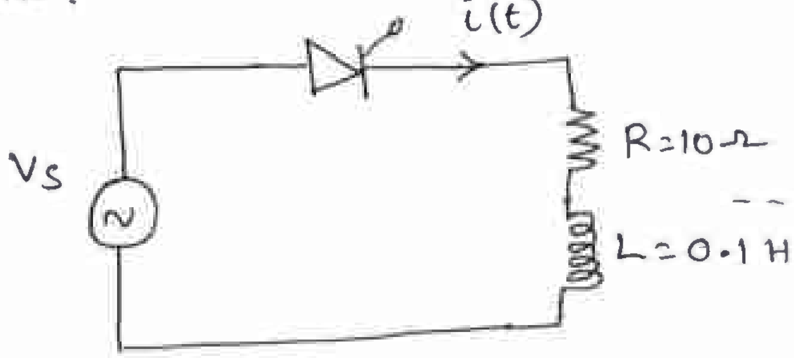
Subject Title : POWER ELECTRONICS Subject Code : 18EE53

Question Number	Solution	Marks Allocated
5 (a)		2m
	1. Reverse blocking mode Explanation - - - - - - - -	2m
	2. Forward blocking mode Explanation - - - - - - -	2m
	3. Forward conduction mode Explanation - - - - - - -	2m
	4. Latching current Explanation - - - - - - -	2m
	5. Holding current Explanation - - - - - -	2m
		12m

P.T.O

Subject Title : POWER ELECTRONICS Subject Code : 18EE53

Question Number	Solution	Marks Allocated
5 b)	1. Gate drive – Explanation 2. High Forward Voltage – Explanation 3. $\frac{dv}{dt}$ – Explanation 4. Light – Explanation 5. High temparature – Explanation. Any four methods. 4 x 1	4 m
		4 m
5 c)	Solution:	



01 m

$V_s = 325 \sin 314t$

The SCR is triggered at $\frac{\pi}{3}$. Hence applied voltage at this angle will be

$V_s = 325 \sin \frac{\pi}{3}$

$= 281.458$ Volts .... 01 m

The current through load is

$$i(t) = \frac{V_s}{R}\left(1 - e^{-t\frac{R}{L}}\right)$$ ---- 01 m

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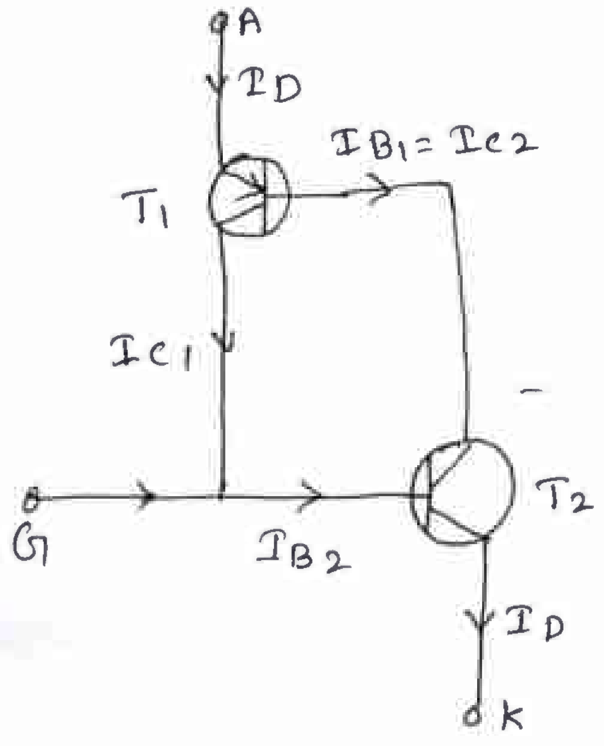
Subject Title : POWER ELECTRONICS Subject Code : 18EE53

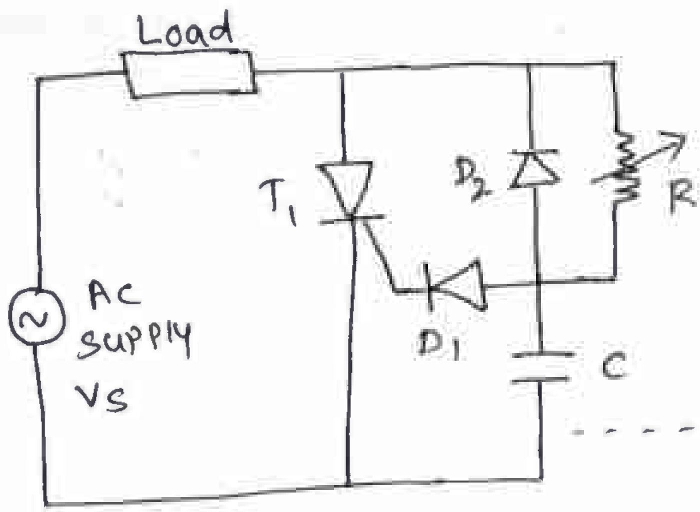
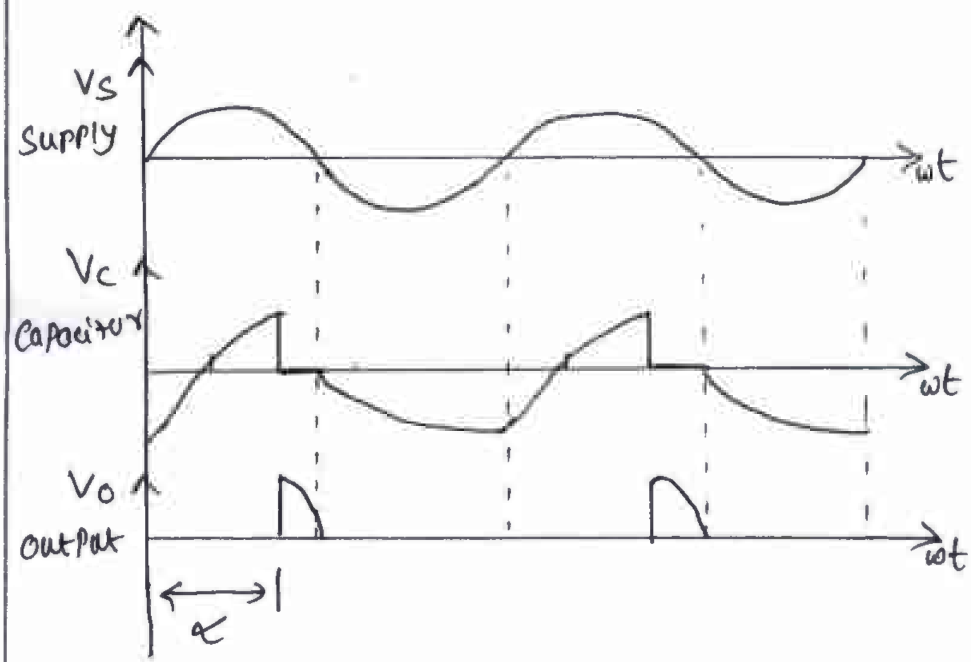
Question Number	Solution	Marks Allocated
	when $i(t) = I_L = 15mA$	
	$15\times10^{-3} = \frac{281.458}{10}\left(1-e^{-t\frac{10}{0.1}}\right)$	
	by above eauarion	
	$t = 5.33\ \mu$ seconds	01m
		04m
6 (a)		02m
	$I_{C1} = \alpha_1 I_{E1} + I_{CO1}$	01m
	$I_{E1} = I_D$ and I_{CO1} is leakage currert of T_1 Similarly for T_2	
	$I_{C2} = \alpha_2 I_{E2} + I_{CO2}$	01m

Subject Title : POWER ELECTRONICS   Subject Code : 18EE53

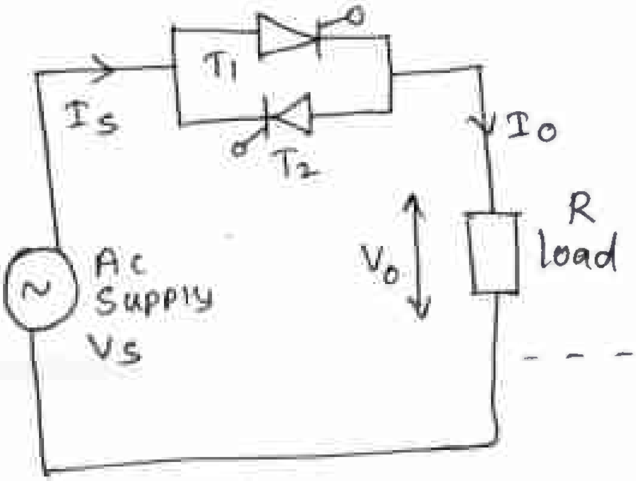
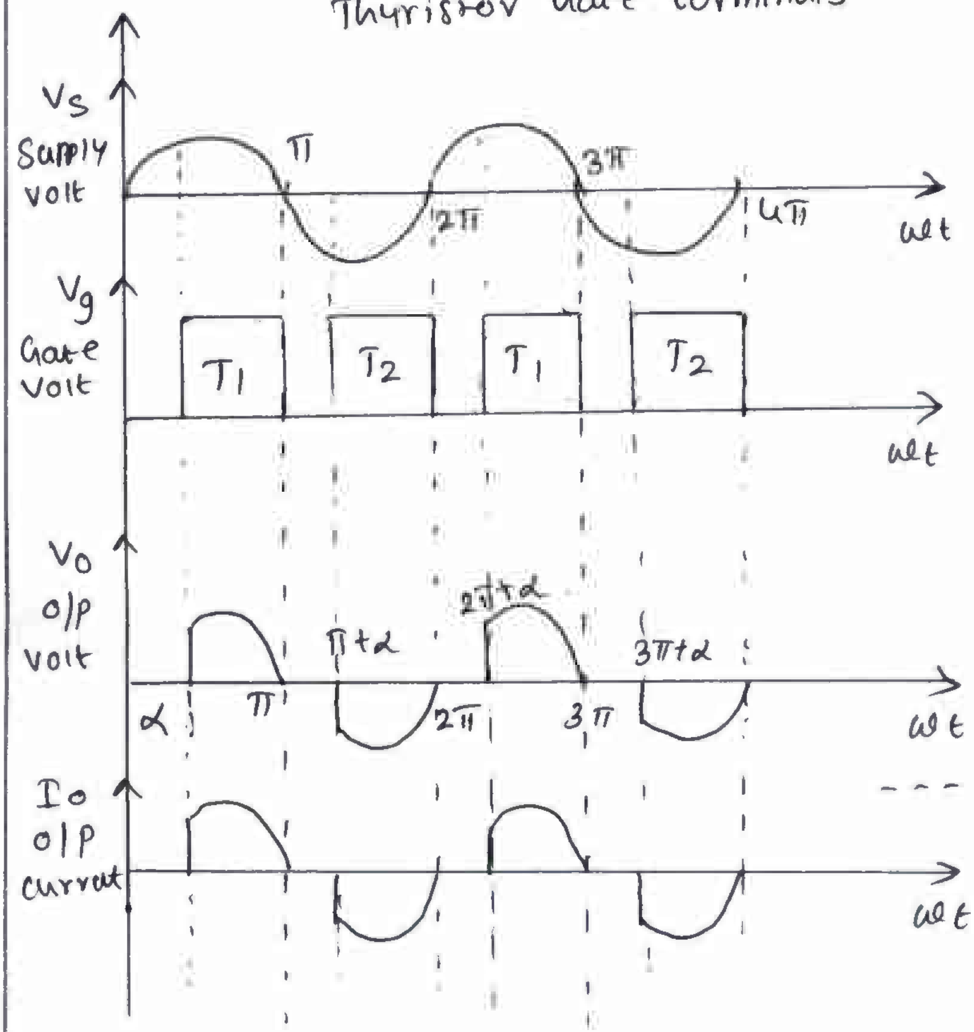
Question Number	Solution	Marks Allocated
	$I_{E2} = I_D$ and I_{CO2} is leakage current of T_2	
	$I_{C1} = \alpha_1 I_D + I_{CO1}$	
	$I_{C2} = \alpha_2 I_D + I_{CO2}$ - - - - - -	01m
	$I_D = \dfrac{I_{CO1} + I_{CO2}}{1-(\alpha_1+\alpha_2)}$ - - - - - -	02m
	$I_D = \dfrac{I_{CO}}{1-(\alpha_1+\alpha_2)}$ - - - - - -	01m
		08m
6 b	Solution:	
	$V_{BB} = 220V$ $V_v = 1$ $V_p = 15V$ $T = 20\times10^{-3}s$	
	$R_C = 100\,k\Omega$	
	The peak voltage of the UJT is given as	
	$V_p = \eta V_{BB} + V_D$	
	$V_D = 0.8$	
	$15 = \eta \times 20 + 0.8$	
	$\eta = 0.71$	
	$T = R_C C \ln\left(\dfrac{1}{1-\eta}\right)$ - - - - - -	03m

P.T.O

Subject Title : POWER ELECTRONICS   Subject Code : 18EE53

Question Number	Solution	Marks Allocated
	$20\times10^{-3} = 10\times10^{3}\times C \ln\left(\frac{1}{1-0.71}\right)$	
	$C = 0.162\,\mu F$ - - - - - -	03m
		06m
6 c)	 - - - - - -	01m
		02m
	Explanation - - -	03m
		06m

Subject Title : POWER ELECTRONICS **Subject Code :** 18EE53

Question Number	Solution	Marks Allocated
7 (a)		02m
	Vg → Gate Voltage applied to Thyristor Gate terminals	
		03m
	Explanation	05m
		10m

P.T.O

Subject Title : POWER ELECTRONICS Subject Code : 18EE53

Question Number	Solution	Marks Allocated
7 (b)	Solution:	
	i) To obtain $V_{o\,rms}$.	
	$V_{o\,rms} = V_m \sqrt{\dfrac{\pi - \alpha + \frac{\sin 2\alpha}{2}}{2\pi}}$	
	$V_{o\,rms} = 230 \times \sqrt{2} \sqrt{\dfrac{\pi - \frac{\pi}{4} + \frac{\sin\left(2 \cdot \frac{\pi}{4}\right)}{2}}{2\pi}}$	
	$V_{o\,rms} = 219.3\,V$ - - - - - - -	01m
	ii) To obtain Rms value of output current.	
	The resistance of the heater will be	
	$R_L = \dfrac{(230)^2}{1000} = 53\,\Omega$ - - - - - -	01m
	Rms current through the heater	
	$I_{o\,rms} = \dfrac{V_{o\,rms}}{R_L} = \dfrac{219.3}{53}$	
	$I_{o\,rms} = 4.137A$ - - - - - -	01m

P.T.O

Subject Title : POWER ELECTRONICS Subject Code : 18EE53

Question Number	Solution	Marks Allocated
	iii) Average value of triac current	
	The average value of triac current = 0	
	= zero ----	01m
	iv) Rms value of triac current	
	The triac current is same as O/P current	
	$I_T rms = I_{orms} = 4.137A$ - - - - -	01m
	v) To obtain input Power factor	
	Active load Power $= I_o^2 rms \times R_L$	
	$= (4.137)^2 \times 53$	
	= 907 watts - - - - -	01m
	Total Rms input Power $= V_{orms} \times I_{srms}$	
	$= 230 \times 4.137$	
	= 951.5 VA - - - - -	01m
	Then input Power factor will be	
	$PF = \frac{O/P\ Power}{I/P\ Power} = \frac{907}{951.5}$ - - - - -	01m
	Power factor = 0.953 - - -	02m
		10m

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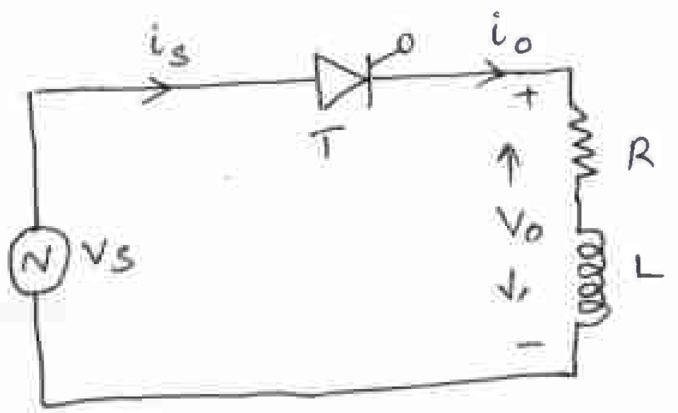
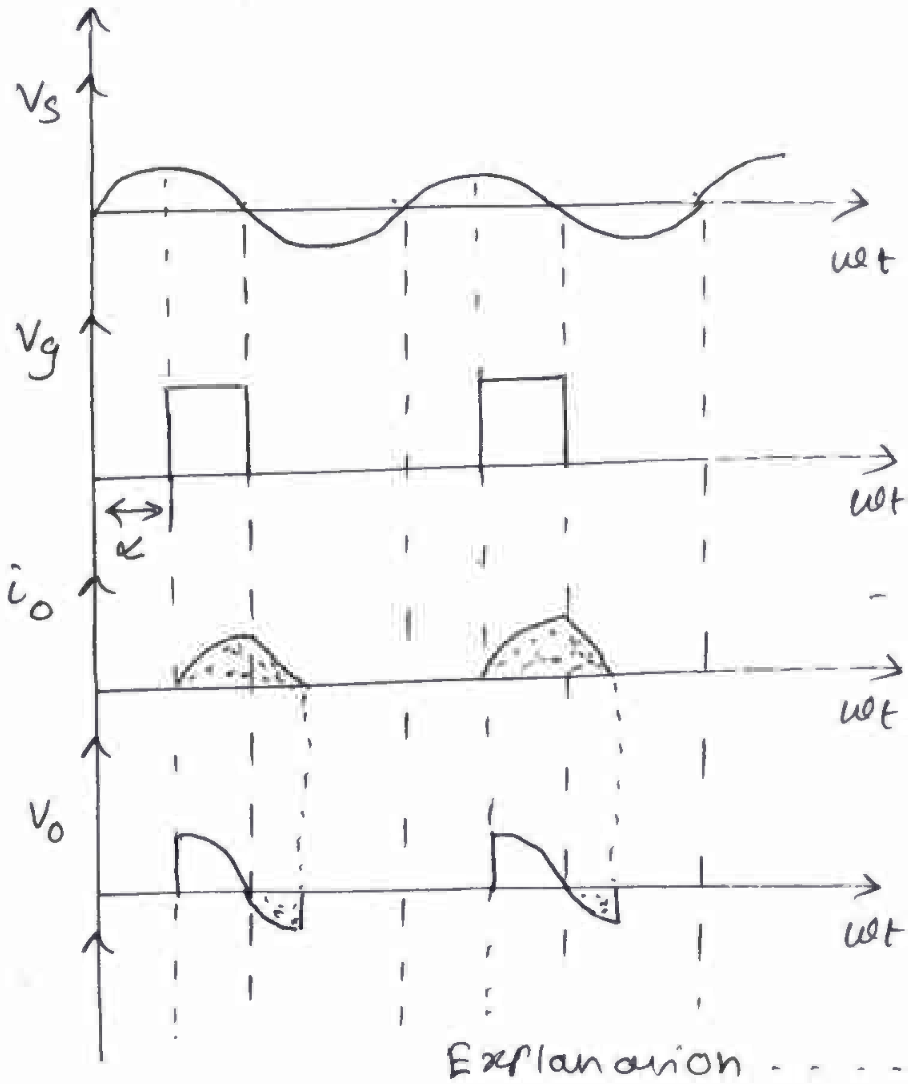
Question Number	Solution	Marks Allocated
8 (a)		02m
		03m
	Explanation	05m
		10m

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Question Number	Solution	Marks Allocated
8 b)	**Solution:**	
	i) To obtain delay angle α	
	The average output voltage of half wave converter is given	
	$V_{o\,av} = \frac{V_m}{2\pi}(1+\cos\alpha)$ $\therefore V_m = V_s\sqrt{2}$, $V_m = 120\times\sqrt{2}$, $V_m = 169.7V$	01M
	$V_{o\,av}$ is maximum at $\alpha = 0$	
	$V_{o\,av\,max} = \frac{V_m}{2\pi}(1+\cos\alpha)$	01M
	$= \frac{V_m}{2\pi}(1+\cos 0)$	
	$= \frac{V_m}{\pi} = \frac{169.7}{\pi}$	01M
	$V_{o\,av\,max} = 54V$	01M
	Average output voltage is 25% of its maximum value.	
	$V_{oav} = 25\%$ of $V_{oav\,max}$	
	$= 0.25\times 54 = 13.5V$	01M
	$V_{oav} = \frac{V_m}{2\pi}(1+\cos\alpha)$	
	$13.5 = \frac{169.7}{2\pi}(1+\cos\alpha)$ $\alpha = 2.09$ radian, $\alpha = 120^\circ$	01M

P.T.O

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Question Number	Solution	Marks Allocated
	ii) To obtain rms and average output currents.	
	$I_{oav} = \frac{V_{oav}}{R}$	
	$= \frac{13.5}{10} = 1.35A$ - - - - -	01m
	$I_{oav} = 1.35A$	
	The rms output voltage	
	$V_{orms} = \frac{V_m}{2}\left[1 - \frac{\alpha}{\pi} + \frac{\sin 2\alpha}{2\pi}\right]^{1/2}$	
	$= \frac{169.7}{2}\left[1 - \frac{2.09}{\pi} + \frac{\sin(2\times 2.09)}{2\pi}\right]^{1/2}$	
	$V_{orms} = 37.718V$ - - - - -	01m
	Hence rms current will be	
	$I_{orms} = \frac{V_{orms}}{R} = \frac{37.718}{10}$	
	$I_{orms} = 3.77A$ - - - - -	01m
	iii) Rms and average thyristor currents	
	$I_{Tav} = I_{oav} = 1.35A$	
	$I_{Trms} = I_{orms} = 3.77A$	
	iv) Input power factor = 0.04 lagging ..	01m
		10m

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Question Number	Solution	Marks Allocated
9 (a)	i) To obtain V_{oav}	
	$V_{oav} = R \times I_{oav}$	
	$= 4 \times 30$	
	$V_{oav} = 120V$	2m
	ii) To obtain δ	
	$V_{oav} = \delta V_s$	
	$\delta = \frac{V_{oav}}{V_s} = \frac{120}{200} = 0.6$	2m
	iii) To obtain T_{ON} and T_{OFF}	
	$\delta = \frac{T_{ON}}{T} = T_{ON} \times f$	
	$T_{ON} = \frac{\delta}{f} = \frac{0.6}{400} = 1.5$ msec.	
	$T = T_{ON} + T_{OFF}$	
	$T_{off} = T - T_{ON} = \frac{1}{f} - T_{ON}$	
	$T_{off} = \frac{1}{400} - 1.5 \times 10^{-3}$	
	$T_{off} = 1$ msec.	2m
		06m

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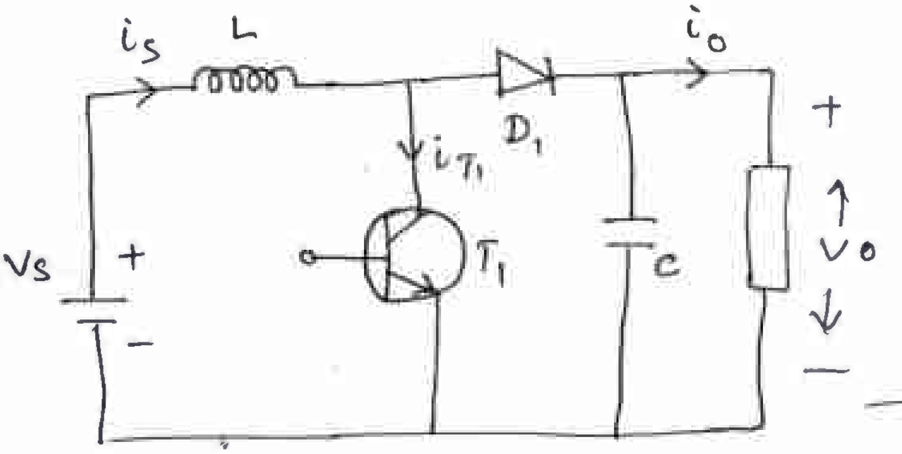
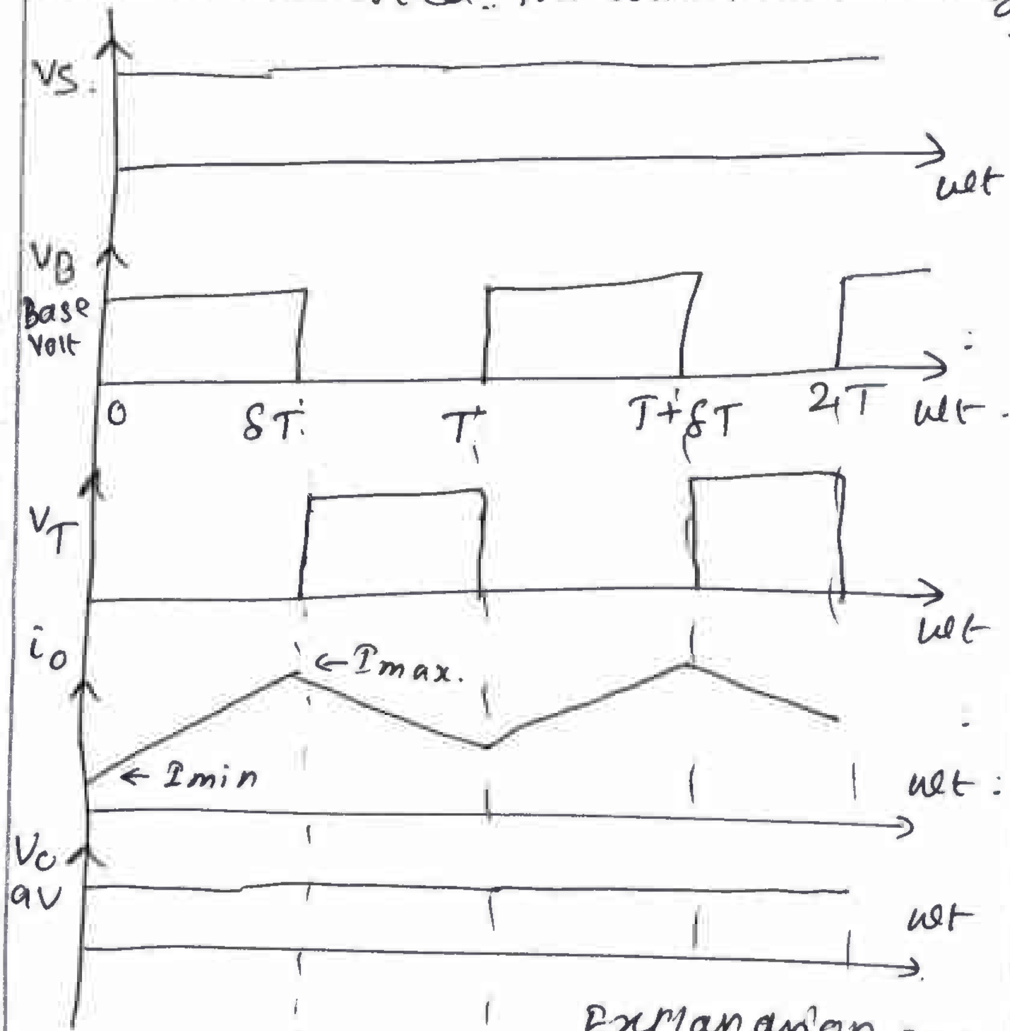
Question Number	Solution	Marks Allocated
9 b		



02 m

With capacitor or without capacitor both are accepted. The waveform will change.



03 m

Explanation --- 03 m

08 m

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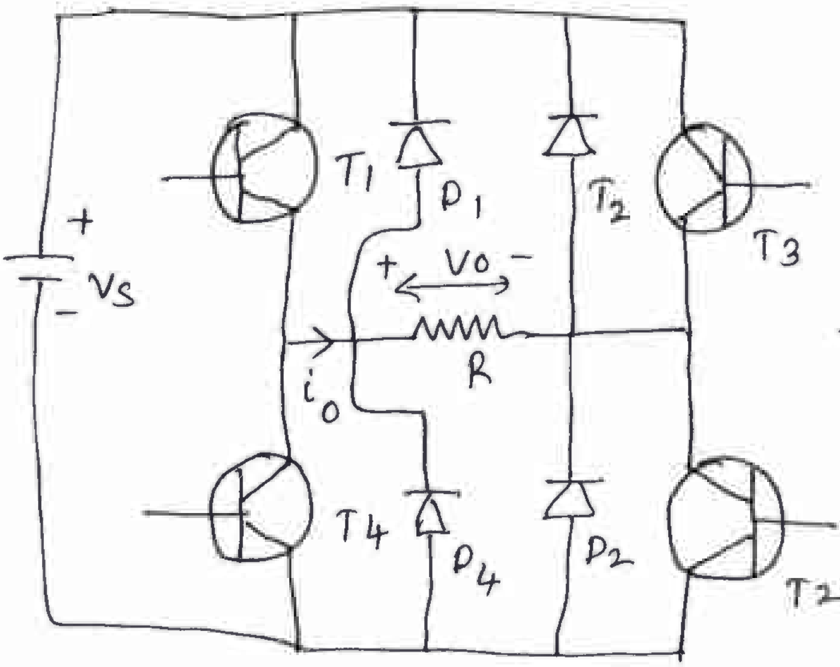
Question Number	Solution	Marks Allocated
9 (c)	**Performance Parameters:-**	
	1. Duty cycle - δ with explanation - - - - - - -	02m
	2. operating speed of switch (devices) with explanation - - - - - - -	02m
	3. Frequency of the chopper (f). with explanation - - - - - - -	02m
		06m
10 (a)		03m

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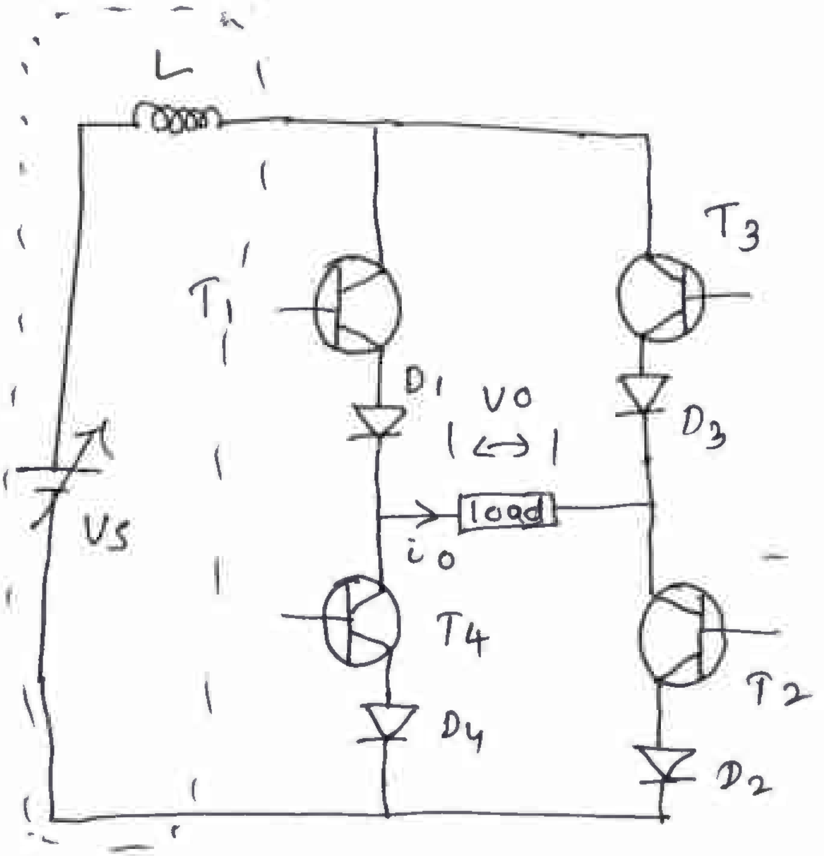
Question Number	Solution	Marks Allocated
	Waveforms ----	03m
	Explanation ----	04m
		10m
(10) (b)	 ----	03m
	Constant curral source	
	waveform ----	03m
	$i_{on} = \sum_{n=1,3,5}^{\infty} \frac{4I}{n\pi} \sin\frac{n\delta}{2} \sin n\omega t$ ---	01m
	Explanation	03m
		10m

— End —