CBCS SCHEME

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15EC73

Seventh Semester B.E. Degree Examination, July/August 2021
Power Electronics

Time: 3 hrs. Max. Marks: 80

Note: ***Answer any FIVE full questions.***

1 a. What is Power Electronics? With the help of block diagram explain it. Explain any four applications of power electronics. **(06 Marks)**

b. With the transient model of MOSFET explain switching its characteristics. **(06 Marks)**

c. Compare between Bipolar Junction Transistor (BJT) and MOSFET. **(04 Marks)**

2 a. What are the peripheral effects of power electronic convertor system? **(04 Marks)**

b. Explain briefly any two types of power electronic convertors. **(04 Marks)**

c. Explain $\frac{di}{df}$ and $\frac{dv}{dt}$ protection for transistor. **(08 Marks)**

3 a. The SCR shown in Fig.Q3(a) has latching current of 40mA and is triggered by the pulse width of 50 μsec. Determine whether the SCR turn ON or not.

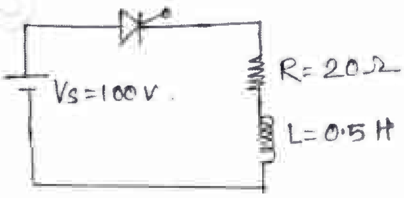

Fig.Q3(a) **(04 Marks)**

b. With the two transistor analogy of thyristor obtain the equation for anode current. **(06 Marks)**

c. Explain the operation of a full wave RC triggering circuit with waveforms. **(06 Marks)**

4 a. Explain class B LC communication with necessary circuit diagram, waveforms and equations. **(08 Marks)**

b. A UJT is used to trigger the thyristor whose minimum gate triggering voltage is 6.2V. The UJT ratings are : $\eta = 0.66$, $I_p = 0.5mA$, $I_v = 3mA$, $R_{B_1} + R_{B_2} = 5k\Omega$, leakage current = 3.2mA, $V_p = 14V$ and $V_V = 1V$. Oscillator frequency is 2KHz and capacitor c = 0.04 μF. Design the complete circuits. **(08 Marks)**

5 a. Explain the working of single phase half wave controlled rectifier connected to resistive load. Derive expression for the average DC output voltage and rms value of output voltage. **(08 Marks)**

b. With the neat circuit diagram and relevant waveforms explain the working of ON-OFF control for single phase AC voltage. Derive expression for rms output voltage. **(08 Marks)**

6 a. Explain the working of single phase dual converter with neat circuit diagram. Draw relevant waveforms. **(08 Marks)**

b. For the single phase bidirectional AC voltage controller, delay angles of thyristors T_1 and T_2 are equal to $\alpha_1 = \alpha_2 = \frac{2\pi}{3}$. The input is $V_s = 120\sqrt{2}\sin 314t$, 50Hz. Calculate :

i) rms output voltage
ii) input power factor
iii) average current through thyristors I_A and
iv) rms current of thyristors. (Fig. Q6(b).

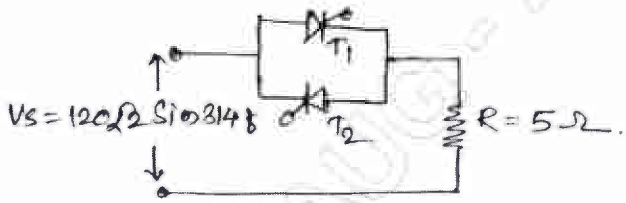

Fig.Q6(b) **(08 Marks)**

7 a. Explain the working of stepdown chopper for resistive load with circuit diagram and waveform. Drive the expressions for average output voltage $V_{0(av)}$, rms output voltage $V_{0(rms)}$ and output power. **(08 Marks)**

b. With the help of circuit diagram and waveforms explain the working of boost regulator. Derive the expression for peak to peak ripple output current and peak to peak ripple output voltage. **(08 Marks)**

8 a. Briefly explain the classification of choppers with circuit diagram, waveforms and quadrant diagram. **(08 Marks)**

b. Input to the step-up chopper is 200V. The output required is 600V. If the conduction time of thyoristor is 200μsec. Compute :

i) Chopping frequency
ii) If pulse width is halved of for constant frequency find the new output voltage. **(08 Marks)**

9 a. Explain the operation of single phase full bridge invertors supplying resistive load. Derive an expression for output RMS voltage. **(08 Marks)**

b. Explain voltage control in inverter by single pulse width modulation and sinusoidal pulse width modulation. **(08 Marks)**

OR

10 a. With neat circuit diagram and waveforms explain transistorized current source inverter. **(08 Marks)**

b. Write short note on solid state relays, and microelectronic relays. **(08 Marks)**

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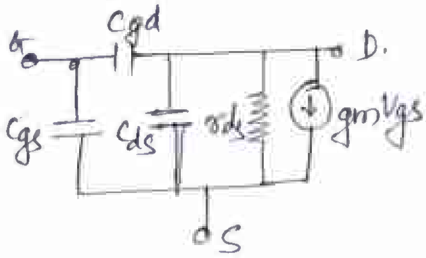
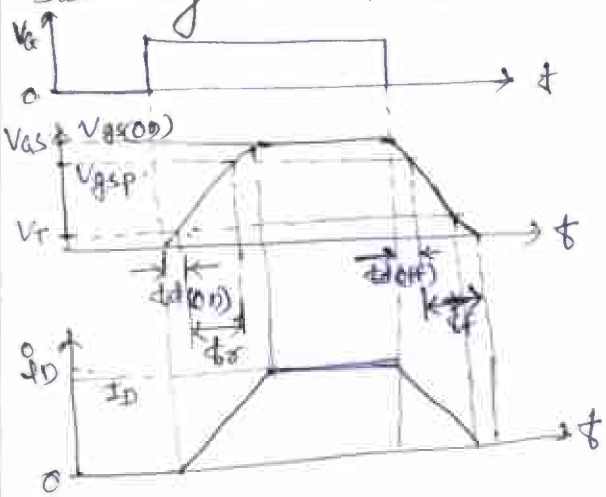
Scheme & Solution

Signature of Scrutinizer

Subject Title: Power Electronics. **Subject Code:** 15EC73.

Question Number	Solution	Marks Allocated
Q. 1 a.	Definition of power electronics.	1
	Block diagram of power electronics and explanation	3
	Four applications of power electronics	2
b.	Transient or switching model & explanation.  	2.
	switching characteristics  Explanation of - $t_{d(on)}$, t_r, $t_{d(off)}$ & t_f. $t_{(on)} = t_{d(on)} + t_r$ $t_{(off)} = t_{d\,off} + t_f$.	4
c.	Compair BJT & MOSFET - (At least 6 different points.)	4
Q. 2. a	Peripheral effects - Explanation should contain - Because of high switching - votage & current pulses, spikes produced, harmonics induced in power supply, RFI & EMI. induced.	2
	Block Dia with with I/p & O/p filter to reduce the above effect.	2.

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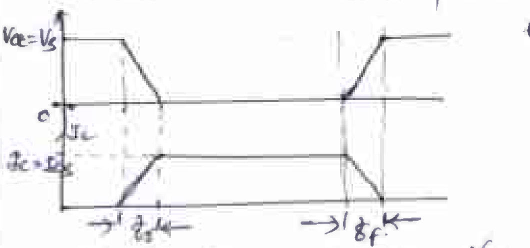
Question Number	Solution	Marks Allocated

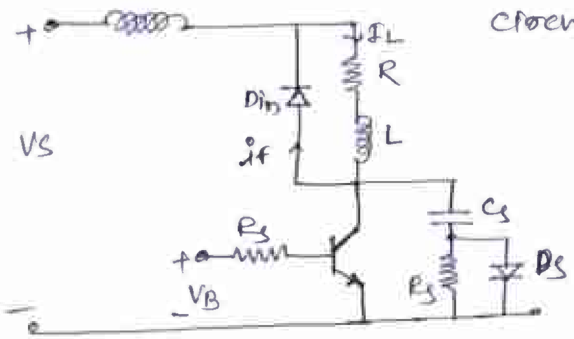
Q.2.b. Explanation of any two types of power converter with relevant circuit diagram and waveform. (2 marks for one converter type) — **4**

Q.2.c. di/dt and dv/dt protection.



waveforms — **2**

$$\frac{di}{dt}=\frac{I_L}{t_r}=\frac{I_{cs}}{t_r}, \quad \frac{dv}{dt}=\frac{V_s}{t_f}=\frac{V_{cs}}{t_f}.$$



Circuit Diagram — **2**

Explanation with equations for. — **4.**

$$L_s=\frac{V_s t_r}{I_L}$$

$$C_s=\frac{I_L t_f}{V_s}$$

$$R_s=2\sqrt{L_s/C_s} \quad \& \quad R_s=\frac{1}{3 f_s C_s}$$

Q.3.a.

$$i(t)=\frac{V_s}{R}\left(1-e^{-tR/L}\right)$$ — **1**

For pulse width 50μs $i(t) = 10$ mA — **2**

SCR current is less than latching current & hence SCR will not triggered. — **1.**

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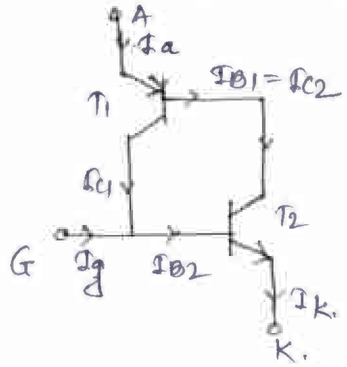
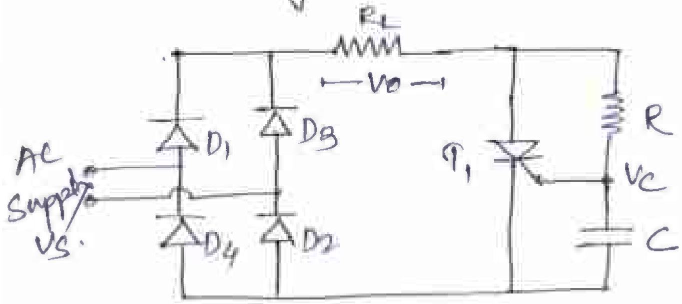
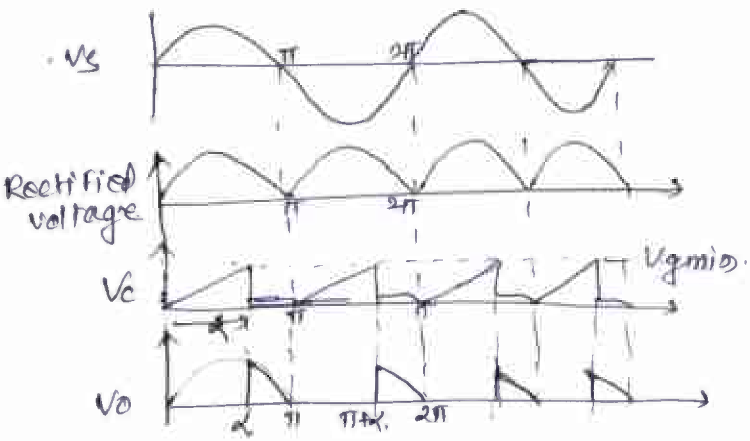
Question Number	Solution	Marks Allocated
Q.3.b.	Two transistor model.	
		
	$I_K = I_a + I_g$. $I_{B1} = I_{C2}$ & $I_{C1} = I_{B2}$	2.
	Proof for. $I_a = \frac{I_g + I_{CO1} + I_{CO2}}{1-(\alpha_1+\alpha_2)} \simeq \frac{I_g}{1-(\alpha_1+\alpha_2)}$	4.
c.	Full wave RC- firing circuit Circuit Diagram.	
		2
		2
	Explanation with eqn $RC \geq \frac{0.157}{2\pi f}$	4

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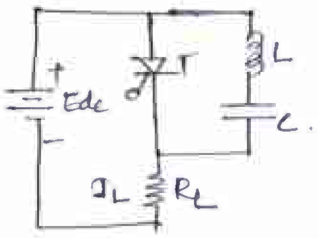
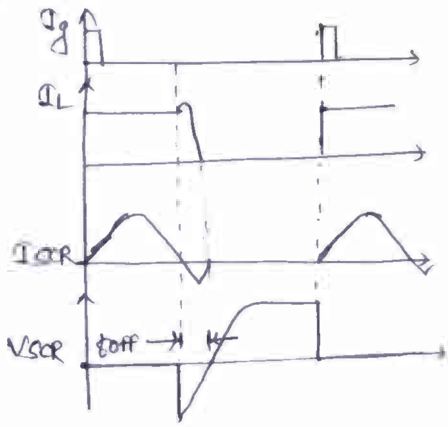
Question Number	Solution	Marks Allocated
Q.4.a.	Class B LC commutation.	
	Circuit Diagram & Waveforms.	4.





Explanation with equations for. — 4.

$$i(t) = E_{dc}\sqrt{C/L}\,\sin\omega_0 t.$$

$$\omega_0 = 1/\sqrt{LC}$$

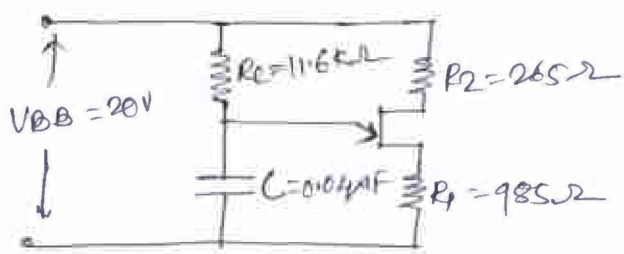
$$i_{c\,peak} = E_{dc}\sqrt{C/L} = 2I_L$$

$$t_{off} = \frac{\pi}{2}\sqrt{LC}$$

Q.4.b.

		Marks
$R_C = 11.6\ K\Omega$.	$(T = R_C C \ln(\frac{1}{1-\eta}))$	1
$V_{BB} = 20V$	$(V_P = \eta V_{BB} + V_D)$	1
$R_2 = 265\Omega$	$(R_2 = \frac{0.7(R_{B2}+R_{B1})}{\eta V_{BB}})$	1
$R_1 = 985\Omega$	$(V_{BB} = I_{leakage}(R_1+R_2+R_{B1}+R_{B2}))$	1
$R_C\,max = 12\,K\Omega$	$(R_{C\,max} = \frac{V_{BB}-V_P}{I_P})$	1
$R_C\,min = 6.33\,K\Omega$	$(R_{C\,min} = \frac{V_{BB}-V_V}{I_V})$	1

Circuit Dia — 2.



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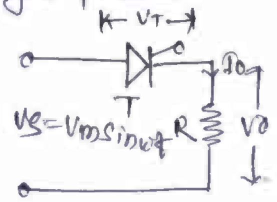
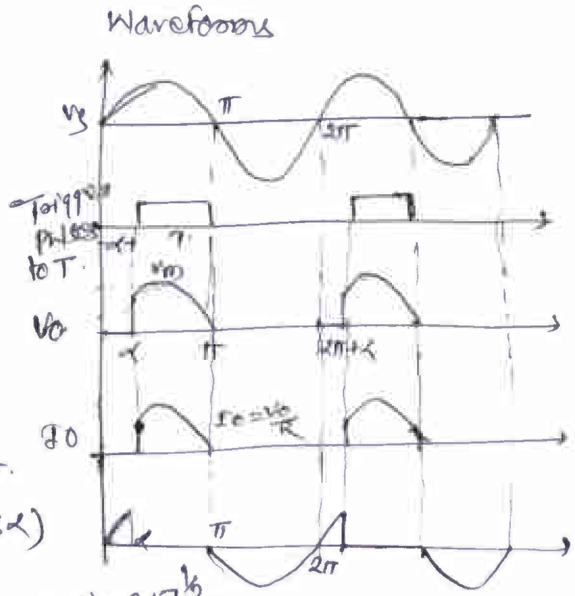
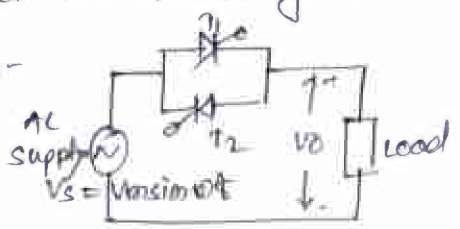
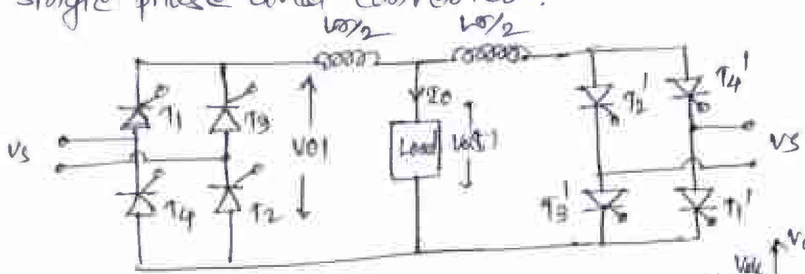
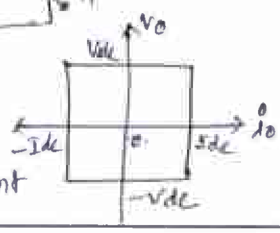
Question Number	Solution	Marks Allocated
Q.5 a.	Single phase half wave controlled rectifier.  Circuit Diagram. 	3
	Expression proof for. $V_{o(av)} = \frac{V_m}{2\pi}(1+\cos\alpha)$ $V_{o rms} = \frac{V_m}{2}\left[\frac{\pi-\alpha+\frac{\sin 2\alpha}{2}}{\pi}\right]^{1/2}$	5.
b.	Single phase ON-OFF AC voltage controller. Circuit Dia.- 	1
	Waveforms for AC i/p, trigger pulses, output voltage & output current for n cycles ON & m cycles off	2.
	Proof for $V_{o(rms)} = \frac{V_m}{\sqrt{2}}\sqrt{K}$. $K = \frac{n}{n+m}$ $V_{o(rms)} = V_{s(rms)}\sqrt{K}$	5.
Q.6. a.	Single phase dual converter.  Circuit Diagram.	2 1
	 4 Quadrant	

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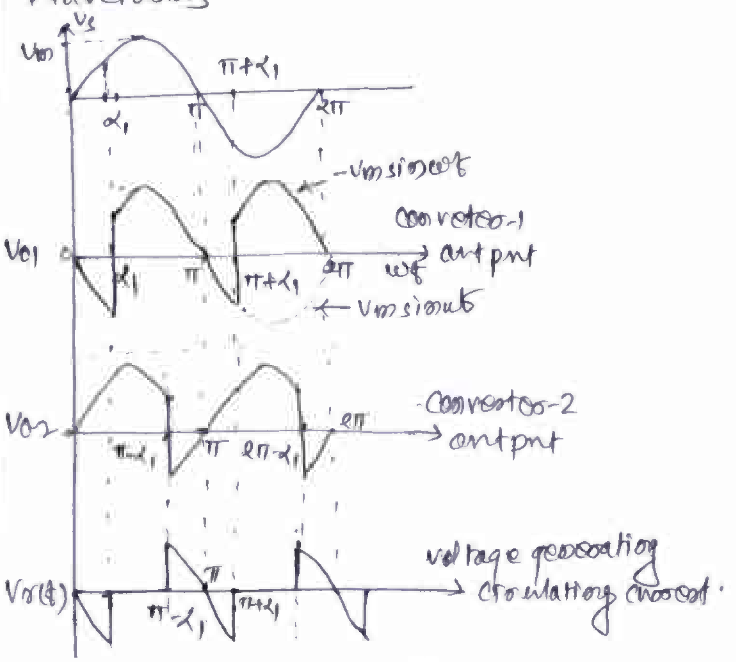
Question Number	Solution	Marks Allocated
Q.6 a.	Waveforms: 	2
	Explanation with equations $V_{o1} = \frac{2V_m}{\pi}\cos\alpha_1$, $V_{o2} = \frac{2V_m}{\pi}\cos\alpha_2$ $\alpha_2 = \pi - \alpha_1$ $i_r = \frac{2V_m}{\omega L_r}(\cos\alpha_1 - \cos\omega t)$	3
Q.6. b.	$V_{orms} = V_m\sqrt{\frac{\pi-\alpha+\frac{\sin 2\alpha}{2}}{2\pi}} = 53V$	1
	$I_{orms} = \frac{V_{orms}}{R} = 10.6\ A$	1
	Active power $= I_{o}^{rms}R = 561.8\ W.$	1
	Total rms input power $= V_{rms} \cdot I_{rms} = 1272\ VA.$	1
	Power factor $= \frac{\text{Active power}}{\text{Total rms I/p power}} = 0.4416$ OR $= 44.16\%$ lagging	1
	$I_{T(av)} = \frac{V_m}{2\pi R}(1+\cos\alpha) = 2.7\ A$	2.
	$I_{T\,rms} = \frac{I_{orms}}{\sqrt{2}} = 7.49\ A.$	1

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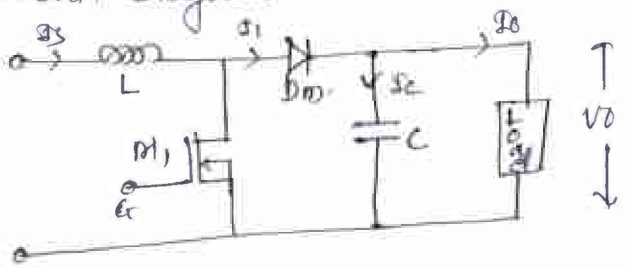
Question Number	Solution	Marks Allocated
Q.7. a.	Step down chopper for resistive load. Circuit Diagram and waveforms. $V_{o(av)} = K \cdot V_s$ K = duty cycle RMS output voltage $V_{o(rms)} = \sqrt{K}\, V_s$ Output power $P_o = \frac{K V_s^2}{R}$	2 2 2 2
b.	Boost Regulator Circuit Diagram 	2
	Waveforms	2
	Explanation with expressions. $V_{o(av)} = \frac{V_s}{1-K}$ $I_{o(ripple)} = \frac{V_s K}{f L}$ $V_{o(ripple)} = \frac{I_{o(av)} K}{f C}$	4
Q.8. a.	Chopper classification. First quadrant, second quadrant, first and second quadrant, Third and fourth quadrant, & four quadrant converters. explanation with quadrant diagram waveforms & circuit explanation. 1st, 2nd quadrant	2
	— " — 1st & 2nd quadrant	2
	— " — 3rd & 4th quadrant	2
	— " — four quadrant	2

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Subject Title: **Subject Code:**

Question Number	Solution	Marks Allocated
Q.8. b.	$V_{o(av)} = \frac{V_s}{1-K}$	
	$K = 0.6667$	2
	$f = \frac{K}{T_{on}} = 3.3\ KHz$	2
	$K = \frac{T_{on}}{T} = 0.333$	2
	$V_{o(av)} = 300V$	2
Q.9. a.	Single phase full bridge inverter	
	Circuit Diagram.	2
	Waveforms.	2
	Explanation	2
	Expression for $V_{orms} = V_s$	2.
b.	Voltage control in inverter.	
	i) single pulse width modulation.	
	Waveforms & explanation	2.
	Expression for $V_{orms} = V_s \sqrt{\frac{P}{\pi}}$	2.
	ii) Sinusoidal pulse width modulation.	
	Waveforms & ~~explanation~~	2
	Explanation with ~~wavef~~ equations -	
	$m_f = \frac{V_r}{V_c}$, Number of pulses $= \frac{m_f}{2}$, $V_{orms} = V_s \sqrt{\sum_{m=1}^{2p} \frac{P_m}{\pi}}$	2.
Q.10. a.	Transistorized current source inverter.	
	Circuit Diagram	2
	Waveforms.	3
	Explanation.	3.
b.	Brief explanation & circuit dia. of solid state relays	4.
	Brief explanation with circuit diagram of microelectronic relays.	4.