53 (IE 602) PWEL

2014

POWER ELECTRONICS

Paper : IE 602

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any 5 (Five)** questions.*

1. *(a)* Derive an expression for the anode current in the two-transistor model of a thyristor. Discuss the turn-on mechanism of the thyristor with the application of gate signal. 7

   (b) A thyristor, having maximum *rms* on-state current of 45*A*, is used in a resistive circuit. Compute its average on-state current rating for half-sine wave for conduction angle of $\pi/3$. 4

(c) Draw a firing circuit for thyristor and mention the equation for gate voltage. 3

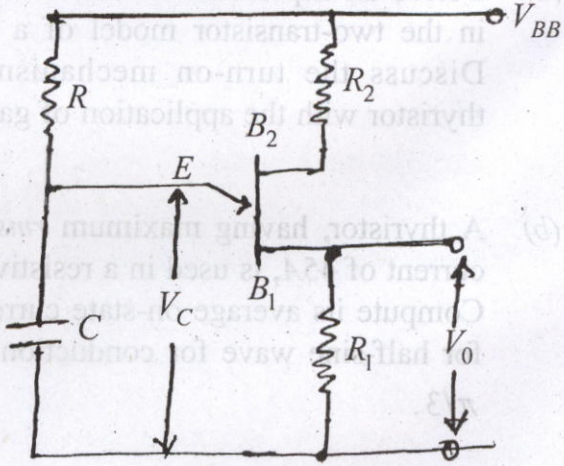
(d) A relaxation oscillator using an UJT as shown in figure below, is to be designed for triggering an SCR. The UJT has the following data :

$\eta = 0 \cdot 72, I_P = 0 \cdot 6mA, V_P = 18 \cdot 0V,$

$V_v = 1 \cdot 0V, I_v = 2 \cdot 5mA, R_{BB} = 5k\Omega,$

Normal leakage current with emitter open $= 4 \cdot 2mA.$ 4

The firing frequency is $2KHz$. For $C = 0 \cdot 04\mu F$, compute the values of R, R_1 and R_2

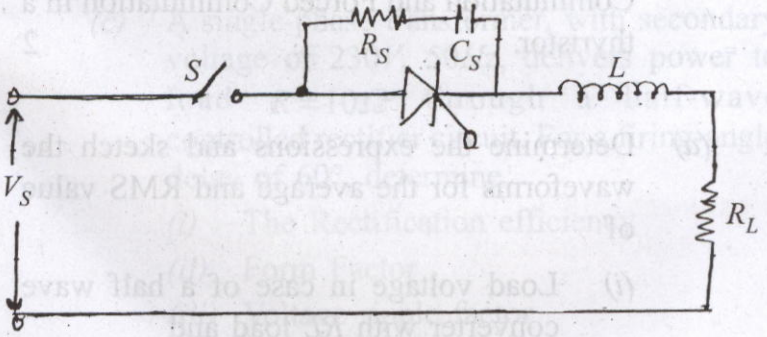


(e) What do you mean by latching current and holding current in a thyristor ? 2

2. (a) What do you mean by Snubber Circuits ? Why they are used ?

In the following figure, a thyristor is used to control power in a load resistance R_L. The supply voltage is $220V\ dc$ and the specified limits for di/dt and dv/dt for the SCR are $40A/\mu sec$ and $300V/\mu sec$ respectively. Determine the values of L, R_S and C_S.

7



(b) A thyristor string is made up of a number of SCRs connected in series and parallel. The string has voltage and current ratings of $11kV$ and $4kA$ respectively. The voltage and current ratings of available SCRs are $1800V$ and $1000A$ respectively. For a string efficiency of 90%, calculate the number of series and parallel connected SCRs.

For these SCRs, maximum off-state blocking current is $12mA$. Determine the value of static equalizing resistance for the string. 5

(c) Explain the different modes of operation of a Triac. 6

(d) Draw the circuit diagram for Load Commutation and Forced Commutation in a thyristor. 2

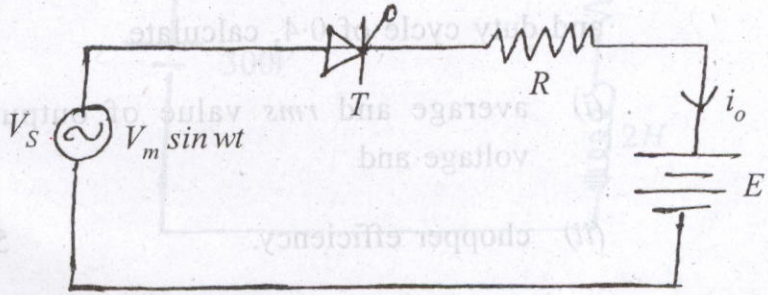
3. (a) Determine the expressions and sketch the waveforms for the average and RMS value of

(i) Load voltage in case of a half wave converter with *RL* load and

(ii) Load voltage in case of a full wave converter with *R* load. 8

(b) A *d.c* battery is charged through a resistor R as shown in the figure below. Derive an expression for the average value of charging current in terms of V_m, E, R, firing angle delay α etc.

For an *ac* source voltage of $230V$, $50Hz$, find the value of average charging current for $R = 10\Omega$, $E = 110V$ and for firing angle delay $\alpha = 30°$. 6



(c) A single-phase transformer, with secondary voltage of $230V$, $50Hz$, delivers power to load $R = 10\Omega$ through a half-wave controlled rectifier circuit. For a firing-angle delay of 60°, determine

(i) The Rectification efficiency

(ii) Form Factor

(iii) Voltage ripple factor

(iv) Transformer utilization factor and

(v) P/V of thyristor. 6

4. *(a)* For a three phase half-wave converter, derive an expression for the average value of output voltage for firing angle α when

(i) α is less than 30° and

(ii) α is greater than 30°. 6

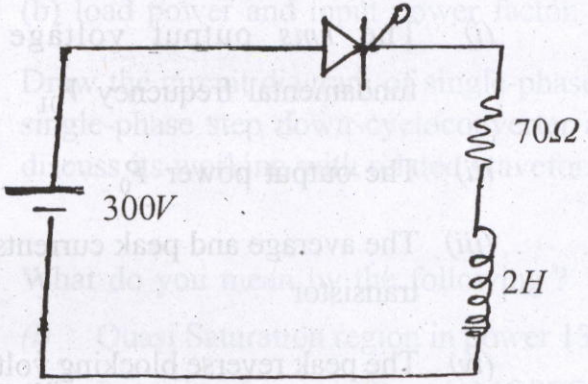
(b) For a type-A chopper with *dc* source voltage $= 230V$, load resistance $= 10\Omega$ and duty cycle of 0·4, calculate

(i) average and *rms* value of output voltage and

(ii) chopper efficiency. 5

(c) Explain the operation of type D chopper with relevant waveforms. 5

(d) In the circuit below, the thyristor is gated with a pulse width of 40 *microsec*. The latching current of thyristor is $36mA$. For a load of 70Ω and $2H$, will the thyristor get turned on ? 2



(e) For a thyristor, maximum junction temperature is $125°C$. The thermal resistances for the thyristor-sink combination are $\theta_{jc} = 0 \cdot 16$ and $\theta_{cs} = 0 \cdot 08°C/W$. For a heat-sink temperature of $70°C$, compute the total average power loss in the thyristor-sink combination. 2

5. *(a)* Draw the circuit diagram of single phase inverter and explain its operation. 4

(b) The single-phase full-bridge inverter has a resistive load of $R = 2 \cdot 4\Omega$ and the *dc* input voltage is $V_S = 48V$. Determine

(i) The *rms* output voltage at the fundamental frequency V_{01}

(ii) The output power P_0

(iii) The average and peak currents of each transistor

(iv) The peak reverse blocking voltage V_{BR} of each transistor

(v) The THD. 6

(c) Discuss the principle of working of a three-phase bridge inverter with an appropriate circuit diagram. Draw phase and line voltage waveforms on the assumption that each thyristor conducts for 180° and the resistive load is star-connected. 10

6. *(a)* A single phase full wave *ac* voltage controller feeds a load of $R = 20\Omega$ with an input voltage of $230V, 50Hz$.

Firing angle for both the thyristors is 45°. Calculate (a) *rms* value of output voltage (b) load power and input power factor. 5

(b) Draw the circuit diagram of single-phase to single-phase step down cycloconverter and discuss its working with related waveforms. 6

(c) What do you mean by the following ? 3

(i) Quasi Saturation region in power 13JT.

(ii) Inversion Layer in Power MOSFET.

(iii) Drift region in power devices.

(d) Draw the gate drive circuit for Power BJT and Power MOSFET. Discuss how these circuits work. 6

7. *(a)* Write short notes on ***any two :*** 5×2=10

(i) Current Inverter

(ii) UPS

(iii) Microprocessor/Microcontroller control of power devices.

(b) Draw the block diagram of buck converter. Deduce the relations for ΔI and ΔV in a buck converter. 6

(c) Draw the circuit diagram for bidirectional and resonant power supplies. 4