Electrical Engineering - Optional For IAS (UPSC)

Power Electronics & Electric Drives - 2015-2021

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UPSC – ELECTRICAL Engineering optional – 2015 Questions

1. A single-phase full converter is connected to RLE load. The source voltage is 230 V, 50 Hz. The average load current of 10 A is constant over the working range. For $R = 0.4\ \Omega$ and $L = 2$ mH, compute: **[20M]**

(a) firing angle delay for $E = 120$ V and input power factor.

(b) firing angle delay for $E = -120$ V and input power factor.

2. A single-phase full converter is supplied from 230 V, 50 Hz source as shown in Figure. The load consists of $R = 10\ \Omega$ and a large inductance so as to render the load current constant. For firing delay angle of 30°, determine: **[20M]**

(a) average output voltage

(b) average output current

(c) average and rms values of thyristor current.

(d) input power factor.

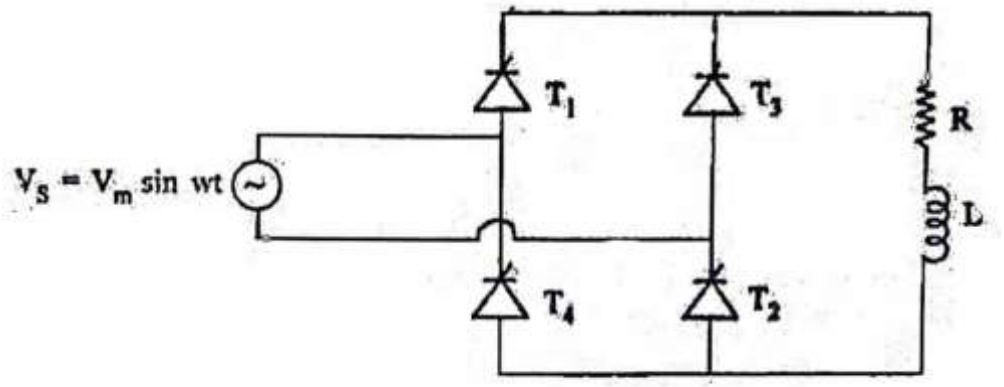
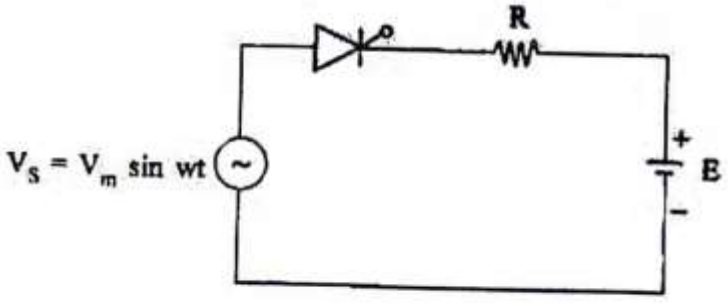


Figure.

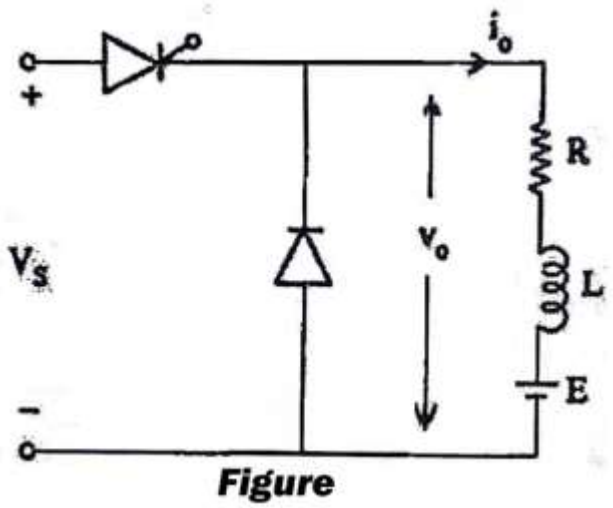
3. A battery is charged through a resistor R as shown in Fig. For an ac source voltage of $230\ V, 50$ Hz find the value of average charging current for $R = 8\ \Omega$ and $E = 150$ V. **[10M]**



Figure

[10M]

4. An RLE load is operating in chopper circuit from a 500 V dc source as shown in Figure. For $R = 0, L = 0.064$ and constant E, the duty cycle is 0.2. Find the chopping frequency to limit the amplitude of load current excursion to 10 A. **[10M]**



Figure

5. A separately excited dc motor, operating from a single-phase half controlled bridge (semi-converter) at a speed of 1440 rpm, has an input voltage of 330 sin 314 t and back emf 80V. The SCRs are fired symmetrically at $\alpha = 30°$ in every half cycle and the armature has a resistance of 4 Ω. Calculate the average armature current and the motor torque. **[10M]**

UPSC – ELECTRICAL Engineering optional – 2016 Questions

1. The SCR shown in Fig. 5(c) has a $\frac{di}{dt}$ limit of 10 A/μs. It is to be operated from a 100 V d.c. supply with load resistance $R = 50\Omega$.

(i) What is the minimum value of load inductance L that will protect the SCR?

(ii) If an $R_s C_s$ snubber is connected across the SCR with $R_s = 500\Omega$, what will be the new value of load inductance L to protect the SCR against $\frac{di}{dt}$? **[10M]**

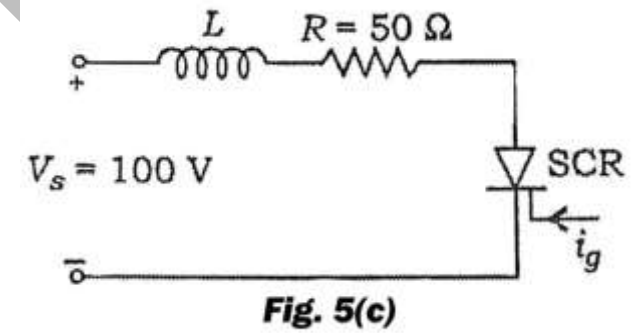


Fig. 5(c)

2. A single-phase full-bridge square-wave inverter is supplying power to a purely resistive load of 20Ω.The d.c. source voltage is 600 V. If the inverter is to operate at 500 Hz with an $\mathrm{r.m.s.}$ load voltage 500 V, find−

(i) average power absorbed by the load;

(ii) average source current (assume no losses in switching);

(iii) average current of each switch.

3. A class-A chopper circuit is supplied from a d.c. source voltage 100 V. The chopper supplies power to a series R-L load with $R = 0.5\Omega$ *and* $\mathrm{L} = 1$ mH. The chopper switch is ON for 1 ms in an overall period of 3 ms. Calculate average load voltage, maximum and minimum value of load current and average load current. Assume continuous current operation of the chopper. **[20M]**

4. A 200 V, 875 $\mathrm{r.p.m.}$, 150 A, separately excited d.c. motor has an armature resistance of 0.06 Ω. The motor armature terminals are fed from a single-phase fully controlled bridge rectifier. The input a.c. supply to bridge rectifier is 240 V, 50 Hz. Assuming continuous and ripple-free armature current, determine the following: **[20M]**

(i) Firing angle of SCRs for rated torque and 750 r.p.m.

(ii) Firing angle for rated torque and -500 $\mathrm{r.p.m.}$

Assume that field winding of the motor is connected to a constant d.c. voltage source.

UPSC – ELECTRICAL Engineering optional – 2017 Questions

1. A three-phase uncontrolled diode rectifier supplies a constant load current of 10 A and its supply voltage is 400 V line to line. Determine the following performance measures:

(i) Average output voltage

(ii) Supply $\mathrm{r.m.s.}$ current

(iii) Supply fundamental $\mathrm{r.m.s.}$ current

(iv) Supply$3\mathrm{rd}, 5\mathrm{th}, 7\mathrm{th}$ and $9\mathrm{th}$ harmonic $\mathrm{r.m.s.}$ current

(v) Supply current displacement factor

(vi) Supply power factor

(vii) AC power (supply power)

(viii) DC power (load power) **[20M]**

2. (i) Explain the operation of Boost converter with voltage and current waveforms across the Boost inductor. Assume continuous conduction.

(ii)Derive its output voltage equation in terms of duty cycle and input voltage. **[10M]**

3. Find the value of r. m. s. current drawn from the source. **[10M]**

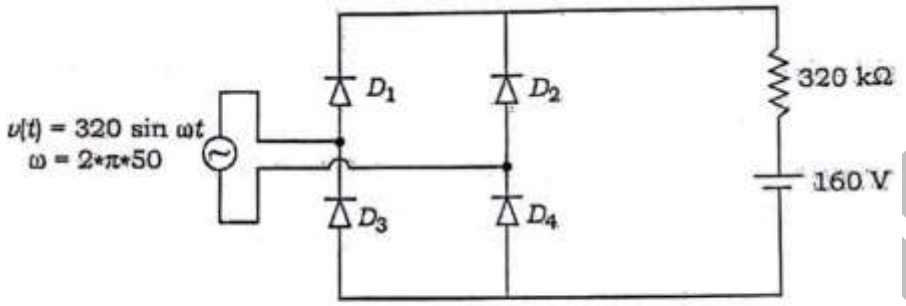


Fig. 6(a)

UPSC – ELECTRICAL Engineering optional – 2018 Questions

1. (i) Draw thyristor gate characteristics and state its application in design of gate drive circuit.

(ii) A thyristor has a maximum average gate power dissipation limit of 0.4 watts. It is triggered with pulsed gate current of frequency 20 kHz at a duty ratio of 0.5.If the gate cathode voltage drop is 1 volt, find permissible peak gate current magnitude. **[10M]**

2. A full bridge or H-bridge inverter has a switching sequence which results in a square wave output voltage. Let the switching frequency be 50 Hz and inverter is supplying a RL load having R = 10Ω and L = 30 mH. Determine: **[20M]**

(i) An expression for load current.

(ii) The power absorbed by load.

(iii) The average current in the D.C. source.

(iv) The area in output voltage waveform where antiparallel diodes across switches conduct. (Assume Input D.C. voltage = 100 V)

3. A buck converter (D.C.-D.C. converter) has LC filter in the output to reduce ripple in output voltage. For continuous conduction mode, draw the waveforms of output voltage, inductor current and capacitor current. If the converter is switched at frequency 'f', prove that minimum values of 'L' and 'C' for ΔI_L ripple in inductor current and ΔV_0 ripple in output voltages are given by

$$C = \frac{(1-D)}{8L(\Delta V_0/V_0)f^2} \text{ and } L = \frac{V_0(1-D)}{(\Delta I_L)f}$$

Assume any data missing. D is duty cycle of switch and V_0 is the average output voltage. **[20M]**

4. Draw output voltage and current waveforms and determine r.m.s output voltage of a three-phase half-wave rectifier supplied by three-phase balanced a.c. supply. Also determine the form factor. If the supply voltage of the above converter is 220 V(r.m.s) at 50 Hz and the load is of 1 kW at 200 V, purely resistive, determine power consumed by the load with given supply voltage. **[10M]**

5. A 220 volts, 1500 r.p.m., 50 A separately excited D.C. motor is fed from a three-phase fully controlled rectifier. The rectifier is supplied with a balanced three-phase source with phase voltage of 230 volts (r.m.s.) at 50 Hz. Motor is holding an overhauling load at 1200 r.p.m. at full load torque. Determine the firing angle of converter if armature resistance is assumed to be 0.2 Ω. **[20M]**

UPSC – ELECTRICAL Engineering optional – 2019 Questions

1. A Type-A chopper circuit shown in Figure 1 below supplies a motor load from a DC source. Determine the value of maximum average current of the switch SW for constant load current operation of motor. **[10M]**

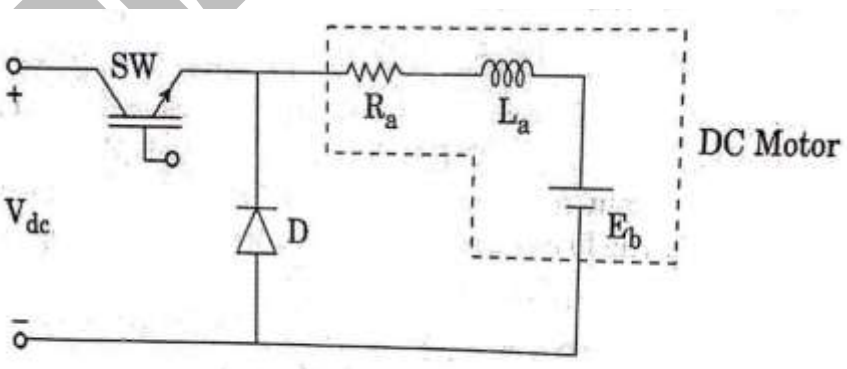


Figure 1

2. For a series inverter shown below, the time interval between the instant ThyristorT_1 is turned OFF and the instant Thyristor T_2 is turned ON is T_{off} seconds; where $T_{off} > t_{q-min}$ (minimum turn-off time of Thyristor T_1). Draw steady state waveforms of i_{g_1}, i_{g_2} (gate currents of Thyristor T_1 and T_2 respectively), capacitor voltage V_C, inductor voltage V_L, load current i_{Load} and supply current i_S. Analyse and identify in waveform drawn, different modes of circuit operations; namely Mode-1, Mode-2 and Mode-3. Analysis may be accompanied by relevant equations and their derivation. **[20M]**

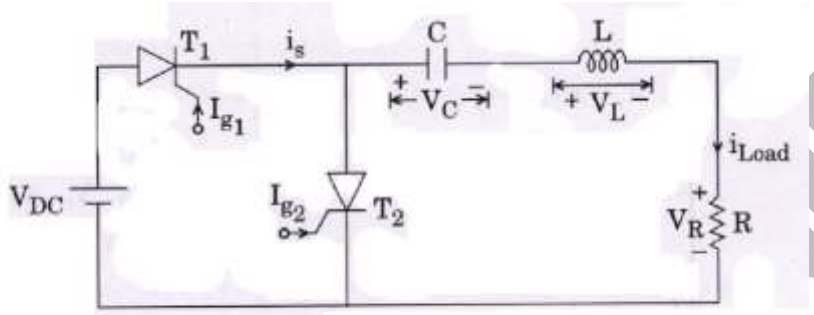


Figure 2.

3. Determine ripple factor of output voltage (V_0), rectifier efficiency (η)and transformer utilization factor (TUF) for a single-phase half-wave controlled rectifier circuit fed from a source $V_S = 220 \sin 314\, t$ to a load $R = 10\ \Omega$. Assume firing angle $\alpha = \pi/4$ and transformer to be lossless. **[10M]**

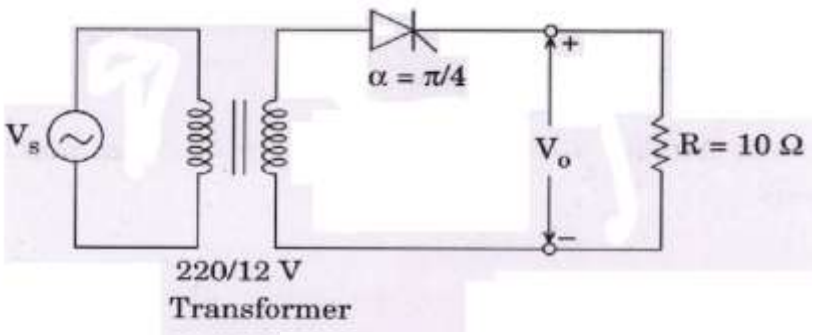


Figure 3.

UPSC – ELECTRICAL Engineering optional – 2020 Questions

1. In Figure 2(a)(ii)(A), the ideal switch S is switched on and off with a switching frequency $f = 10$ kHz. The circuit is operated in steady state at the boundary of continuous and discontinuous conduction, so that the inductor current i is shown in the Figure 2 (a)(ii)(B). Find the values of on-time T_{on} of the switch and peak current of inductor I_p. **[10M]**

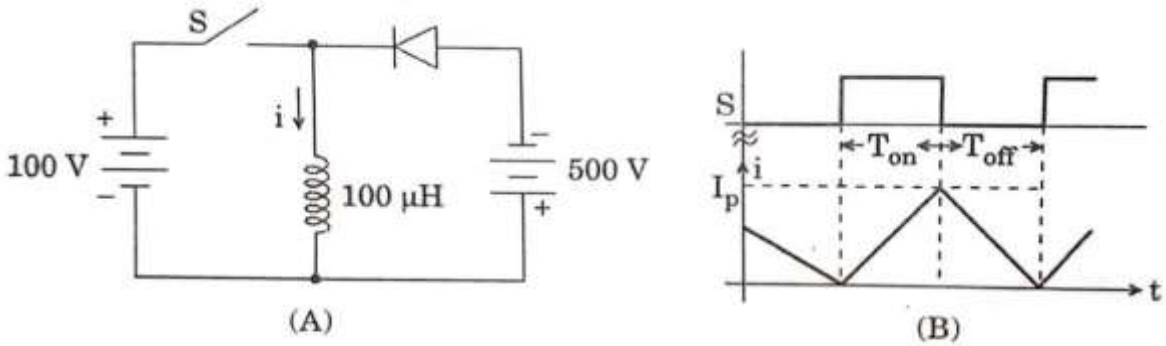


Figure 2(a)(ii)

2. **(i)** Figure 6(b) shows a step-up dc-dc converter with ideal devices and elements. In its steady-state analysis the output filter capacitor is assumed to be very large to ensure a constant output voltage $v_0(t) \cong V_0$. The switch is turned on and off periodically with a frequency of f_s and duty ratio of D. With the help of neat waveforms, find the expressions for peak-to-peak current ripple of inductor (I_L, peak) and output voltage ripple (ΔV_0) at steady-state in terms of circuit parameters and variables. **[20M]**

(ii) In a step-up dc-dc convertor shown in Figure 6(b), $V_d = 12$ V, $V_0 = 24$ V, $I_0 = 0.5$ A, $L = 150$ μH, $C = 470$ μF, and $f_s = 20\ kHz$. Calculate peak-to-peak output voltage ripple (ΔV_0) and the rms value of the ripple in diode current (which also flows through the capacitor).

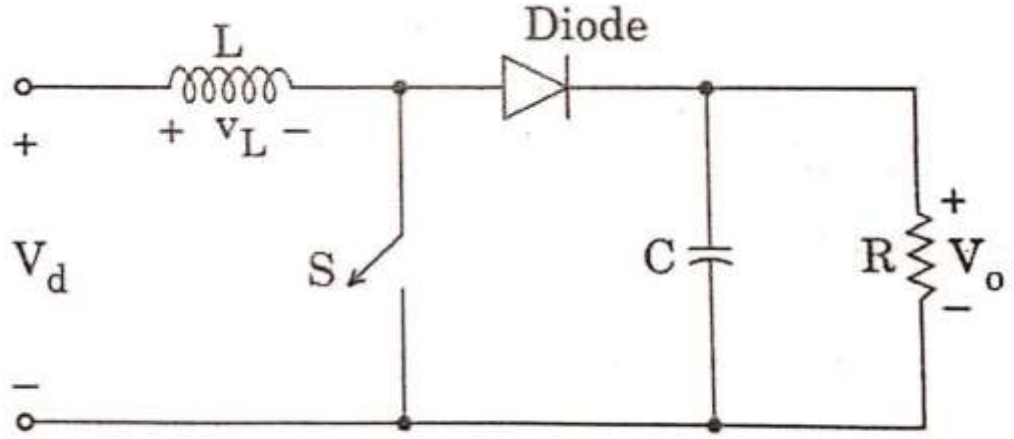


Figure 6(b)

3. An SCR having a turn ON time of 5 μ sec, latching current of 50 mA and holding current of 40 mA is triggered by a short duration pulse and is used in the circuit shown in Figure 8(a)(i). Find the minimum pulse width required to turn the SCR ON. **[10M]**

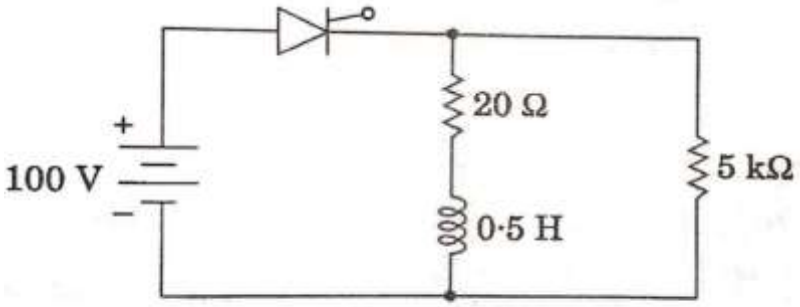


Figure 8(a)(i)

UPSC – ELECTRICAL Engineering optional – 2021 Questions

1. A step down dc chopper is feeding a load of R = 10 Ω and L = 20 mH. The dc supply voltage is 100 V. The chopper is switching at a frequency of 2 kHz with a duty cycle of 50%. Determine the load current and the peak-peak ripple current as an absolute value and as percentage of dc. **[10M]**

2. A three-phase bridge inverter shown in Figure 6(b) is used to feed a Y-connected resistive load with R = 10 Ω per phase. The dc input to the inverter V_S = 400 V and the output frequency is 50 Hz. If the inverter is operating with 180° conduction mode, **[20M]**

(i) compute the rms value of the load current,

(ii) compute the rms value of the current in each switching device,

(iii) calculate the output power, and

(iv) draw the waveforms of phase and line voltages.

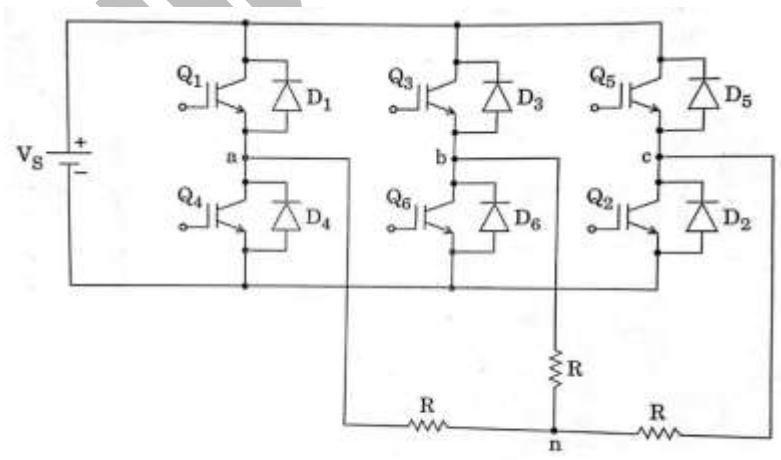


Figure 6(b)

3. A three-phase, full-wave thyristor bridge converter is operated from a three-phase, Y-connected $220\ V,\ 50\ Hz$ supply and the load resistance is $20\ \Omega$.

   It is required to obtain an average output voltage of 50% of the maximum possible output voltage. Determine the following: **[20M]**

   (i) The delay angle α
   (ii) The rms and average output currents
   (iii) The rms and average thyristor currents
   (iv) The rectification efficiency
   (v) The input PF

4. A $220\ V,\ 1500\ rpm, 10\ A$ separately excited dc motor has an armature resistance of 1 ohm. It is fed from a single phase fully-controlled bridge rectifier with an ac source voltage of $230\ V,\ 50\ Hz$. Assuming continuous load current, determine the following: **[10M]**

(i) Motor speed at the firing angle of $30°$ and torque of 5 Nm

(ii) Developed torque at the firing angle of $45°$ and speed of 1000 rpm.