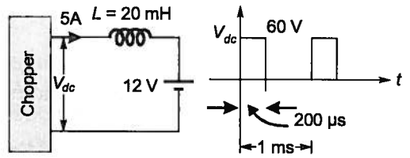
4 Choppers

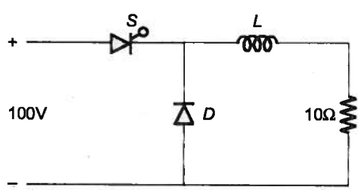
Multiple Choice Questions

Q.1 A chopper is employed to charge a battery as shown in figure. The charging current is 5 A. The duty ratio is 0.2. The chopper output voltage is also shown in figure. The peak to peak ripple current in the charging current is



(a) 0.48 A (b) 1.2 A
(c) 2.4 A (d) 1 A **[GATE-2003]**

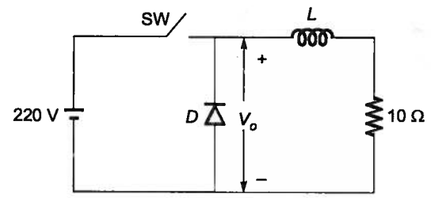
Q.2 Figure shows a chopper operating from a 100 V dc input. The duty ratio of the main switch S is 0.8. The load is sufficiently inductive so that the load current is ripple free. The average current through the diode *D* under steady state is



(a) 1.6 A (b) 6.4 A
(c) 8.0 A (d) 10.0 A

[GATE-2004]

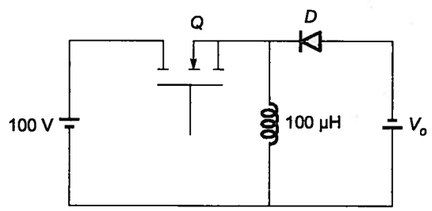
Q.3 The following chopper circuit is operating at a switching frequency of 1 kHz with a duty cycle ratio of 50%. Assume a voltage drop of 2 V across the switch when it is ON. Find the converter circuit efficiency.



(a) 95% (b) 98%
(c) 100% (d) 99%

Q.4 In the above question, the minimum average output voltage of the chopper will be
(a) 70 V (b) 47.5 V
(c) 35 V (d) 0 V **[GATE-2006]**

Q.5 In the following circuit, MOSFET Q is switched at 100 kHz with a duty ratio of 0.5. MOSFET is having an ON state resistance of 1 Ω when it is ON. Find average conduction losses in MOSFET



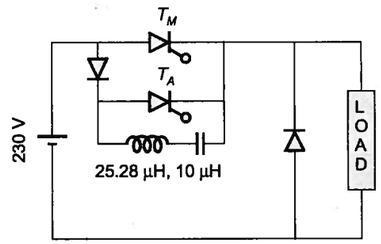
(a) 20.41 W (b) 41.67 W
(c) 12.5 W (d) 4.1667 W

Q.6 The average load current of a D.C. chopper feeding a pure resistive load is I amps. If a variable inductance connected in the load circuit is progressively increased from zero value, keeping the duty ratio unchanged, then the average load current will
(a) increase starting from I
(b) decrease with a starting value of I
(c) remain the same at I
(d) increase to some highest value of current and then decrease again to I

[IAS-1998]

Q.7 In a step down chopper, for eliminating 5th harmonic from the output voltage wave, the ripple factor sould be
(a) 1 (b) 2
(c) 3 (d) 4

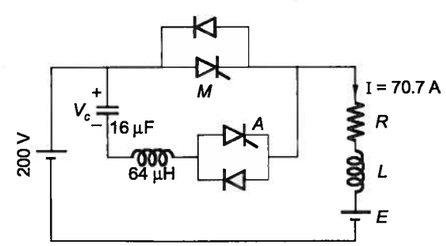
Q.8 The circuit in the figure is a current commutated dc - dc chopper where T_M is the main SCR and T_A is the auxiliary SCR. The load current is constant at 10 A. T_M is ON. T_A is triggered at $t = 0$. T_M is turned off between



(a) $0\ \mu s < t < 25\ \mu s$ (b) $25\ \mu s < t < 50\ \mu s$
(c) $50\ \mu s < t \leq 75\ \mu s$ (d) $75\ \mu s < t < 100\ \mu s$

[GATE-2007]

Q.9 The capacitor is charged with 200 V before the main thyristor is ON. The maximum current in the main SCR can be



(a) 200 A (b) 170.7 A
(c) 141.14 A (d) 70.7 A

Q.10 The stepdown chopper operates from a D.C. voltage source V_s and feeds a D.C. motor with a back emf E_b. From oscilloscope traces it is found that the current increases for time t_r, falls to zero over time t_f and remains zero for time t_0, in every chopping cycle. Then the average D.C. voltage across the free-wheeling diode is

(a) $\frac{V_s t_r}{t_r + t_f + t_0}$ (b) $\frac{V_s t_r + E_b t_f}{t_r + t_f + t_0}$

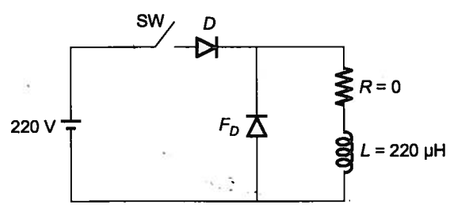
(c) $\frac{V_s t_r + E_b t_0}{t_r + t_f + t_0}$ (d) $\frac{V_s t_r + E_b (t_f + t_0)}{t_r + t_f + t_0}$

[GATE-2000]

Q.11 A D.C. to D.C. transistor chopper supplied from a fixed voltage D.C. source feeds a fixed RL load with freewheeling diode. The chopper operates at 1 kHz and 50% duty cycle. Without changing the value of the average D.C. current through the load, if it is desired to reduce the ripple content of the load current, the control action needed will be to
(a) increase the chopper frequency keeping its duty cycle constant.
(b) increase the chopper frequency and duty cycle in equal ratio.
(c) decrease only the chopper frequency.
(d) decrease only the duty cycle.

[ESE-2010]

Q.12 An RL load is connected to DC voltage source of 220 V through a diode as shown below. A free wheeling diode is connected across the load to recover the trapped energy. Assume that switch is closed for 100 ms and then opened. Find the final energy stored in the inductor by assuming negligible load resistance.



(a) 1 J (b) 0.5 J
(c) 1.5 J (d) 1.1 J

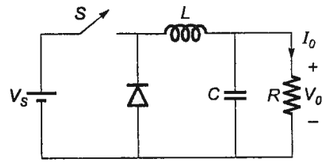
Q.13 In the above question, the PEAK-TO-PEAK source current ripple in Amps is

(a) 0.96 (b) 0.144

(c) 0.192 (d) 0.288

[GATE-2013]

Q.14 In a buck converter, as shown in the figure:



The ripple in the output voltage depends on

(a) C, α (b) C, α, f

(c) L, C, α, f (d) L, α, f

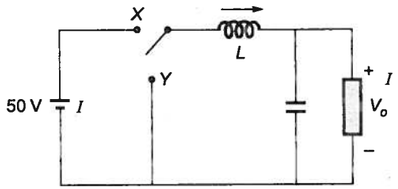
Q.15 What is the waveform of the current flowing through the diode in a buck-boost converter?

(a) square wave (b) triangular wave

(c) trapezoidal wave (d) sinusoidal wave

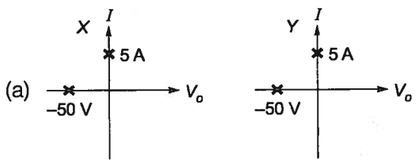
[ESE-2011]

Q.16 A Power converter is shown in the figure has two power switching devices namely *X* and *Y*. The source voltage is 50 V. The inductor current is steady 5 A without any ripple.

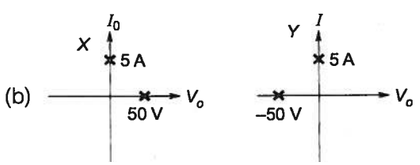


On the V-I plane, identify the correct operating points of switches from the given options.

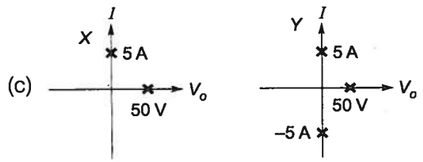
(a)



(b)

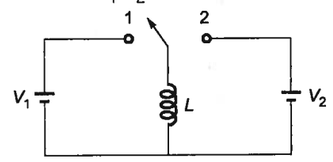


(c)



(d) None

Q.17 In the following DC-DC converter circuit the switch is operating at frequency 10 kHz. When the switch is at position 1, the inductor stores energy for a period of 50 μs and release energy is 20 μs when the switch is moved to position 2. Find ratio of V_1/V_2.

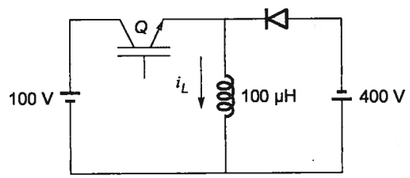


(a) $\frac{2}{5}$ (b) $\frac{5}{2}$

(c) $\frac{7}{2}$ (d) $\frac{2}{7}$

Numerical Data Type Questions

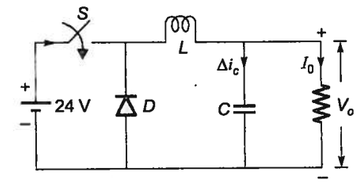
Q.18 In the following chopper circuit, The IGBT Q is switched at 10 kHz. The circuit is operated in steady state at the boundary of continuous and discontinuous inductor current. If IGBT has a constant voltage drop of 0.5 V when it is ON, Find the conduction loss in IGBT.



(a) 853 W (b) 16 W

(c) 32 W (d) None

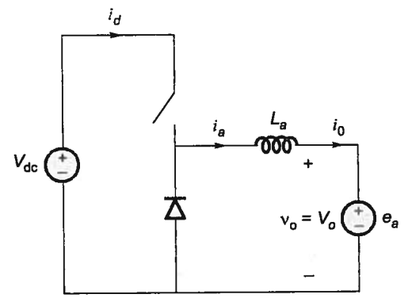
Q.19 In the circuit shown below, an ideal switch *S* is operated at 100 Hz with a duty ratio of 50%. Given that ΔI_C = 1.6 A peak to peak and I_0 is 5 A D.C., the peak current in *S* is _____ A.



[GATE-2012]

Statement for Linked Answer Questions (20 and 21):

The chopper below controls a dc machine with an armature inductance L_a = 0.2 mH. The armature resistance can be neglected. The armature current is 5 A. f_s = 30 kHz and D = 0.8.



Q.20 The average output voltage V_0, equals to 200 V. Calculate the ripple in armature current.

(a) 8.332 A (b) 2.5 A

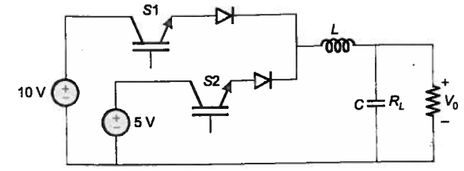
(c) 6.667 A (d) 1.6675 A

Q.21 The load on the dc machine is now reduced and $I_{a,max}$ = 2 A. The current is now discontinuous. What is the back emf voltage E_a?

(a) 250 V (b) 200 V

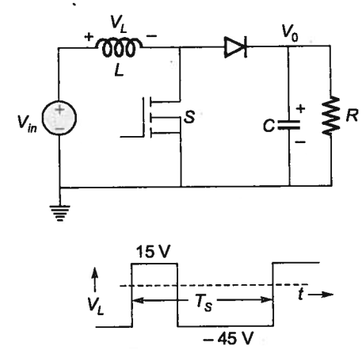
(c) 175 V (d) 235 V

Q.22 The circuit shown is meant to supply a resistive load R_L from two separate DC voltage sources. The switches *S*1 and *S*2 are controlled so that only one of them is ON at any instant. *S*1 is turned on for 0.2 ms and *S*2 is turned on for 0.3 ms in a 0.5 ms switching cycle time period. Assuming continues conduction of the inductor current and negligible ripple on the capacitor voltage, the output voltage V_0 (in Volt) across R_L is _____.



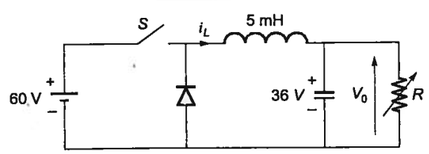
[2015 : 2 Marks, Set-1]

Q.23 For the switching converter shown in the following figure, assume steady-state operation. Also assume that the components are ideal, the inductor current is always positive and continuous and switching period is T_s. If the voltage V_L is as shown, the duty cycle of the switch *S* is _____.



[2015 : 2 Marks, Set-2]

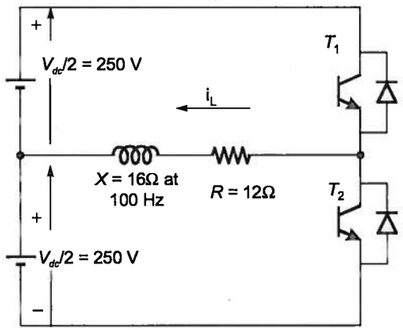
Q.24 A buck converter feeding a variable resistive load is shown in the figure. The switching frequency of the switch *S* is 100 kHz and the duty ratio is 0.6. The output voltage V_0 is 36 V. Assume that all the components are ideal, and that the output voltage is ripple-free. The value of *R* (in Ohm) that will make the inductor current (i_L) just continuous is _____.



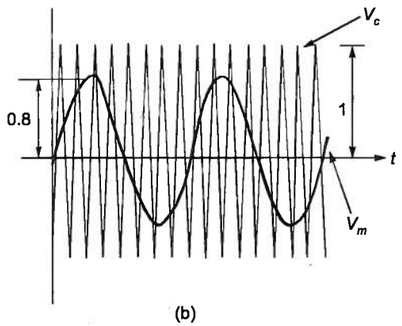
[2015 : 2 Marks, Set-2]

Q.25 The switches T1 and T2 in Figure (a) are switched in a complementary fashion with sinusoidal pulse width modulation technique.

The modulating voltage $v_m(t) = 0.8 \sin(200\pi t)$ V and the triangular carrier voltage (v_c) are as shown in Figure (b). The carrier frequency is 5 kHz. The peak value of the 100 Hz component of the load current (i_L), in ampere is _____.



(a)



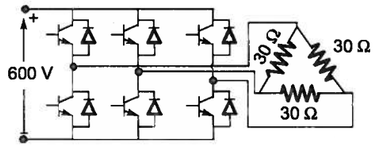
(b)

[GATE-2016]

Q.26 A single-phase full-bridge voltage source inverter (VSI) is fed from a 300 V battery. A pulse of 120° duration is used to trigger the appropriate devices in each half-cycle. The rms value of the fundamental component of the output voltage, in volts, is

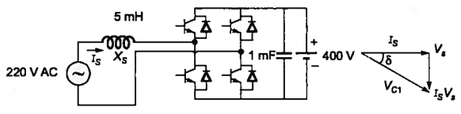
(a) 234 (b) 245
(c) 300 (d) 331 **[GATE-2016]**

Q.27 A three-phase Voltage Source Inverter (VSI) as shown in the figure is feeding a delta connected resistive load of 30 Ω/phase. If it is fed from a 600 V battery, with 180° conduction of solid-state devices, the power consumed by the load, in kW, is_____.



[GATE-2016]

Q.28 A single-phase bi-directional voltage source converter (VSC) is shown in the figure below. All devices are ideal. It is used to charge a battery at 400 V with power of 5 kW from a source V_s = 220 V (rms), 50 Hz sinusoidal AC mains at unity p.f. If its AC side interfacing inductor is 5 mH and the switches are operated at 20 kHz, then the phase shift (δ) between AC mains voltage (V_s) and fundamental AC rms VSC voltage (VC1), in degree, is _____.



[GATE-2016]

Conventional Questions

Q.29 A voltage commutated chopper has the following parameters:

V_s = 220 V, Load circuit parameters, R = 0.5 Ω, L = 2 mH, E = 40 V

Commutation circuit parameters

L = 20 μH, C = 50 μH

T_{ON} = 800 μs, T = 2000 μs

For a constant load current of 80 A, compute the following:

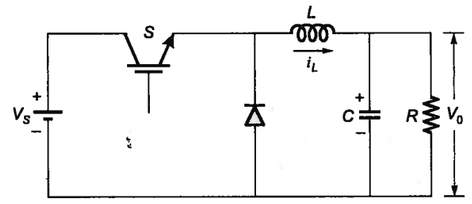
(a) effective on period
(b) peak currents through main thyristor 'T_m' and auxiliary thyristor T_A
(c) turnoff times of T_m and T_A
(d) total commutation interval
(e) capacitor voltage 150 μs after T_A is triggered

Q.30 A step down D.C. chopper has load resistance of 20 Ω. Chopper input voltage is 200 V (D.C). The chopper switch has the voltage drop of 1.5 V when conducting. If the chopper frequency is 2 kHz. Find the input and output power of the chopper at the duty cycle of 0.5. Also find chopper efficiency.

[ESE-2009]

Try Yourself

T1. In the chopper circuit shown in figure, the input dc voltage has a constant value V_s. The output voltage V_0 is assumed ripple free. The switch S is operated with a switching time period T and a duty ratio D. What is the value of critical inductance (L_C) at the boundary of continuous and discontinuous conduction of the inductor current i_L?



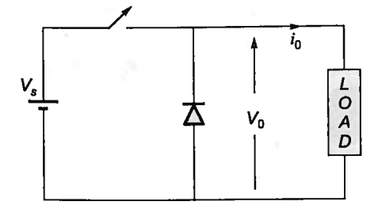
(a) $L_C = \dfrac{\alpha V_s(1-\alpha)}{2I_0 f}$ (b) $L_C = \dfrac{V_0(2f\,I_0)}{(1-\alpha)I_0^2}$

(c) $L_C = \dfrac{V_0(1-f)}{2\alpha I_0}$ (d) $L_C = \dfrac{V_s(1-\alpha^2)}{2I_0 f}$

[Ans: (a)]

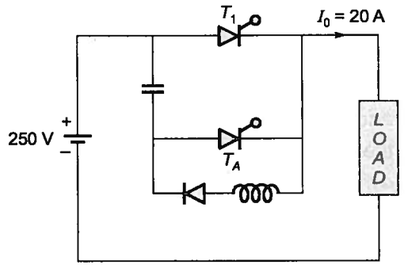
T2. A chopper circuit shown below has input DC voltage of 200 V and a load of R = 10 Ω. In series with L = 80 mH. If load current varies linearly between 12 A and 16 A, then time ratio

$\dfrac{T_{ON}}{T_{OFF}}$ for this chopper is _____.



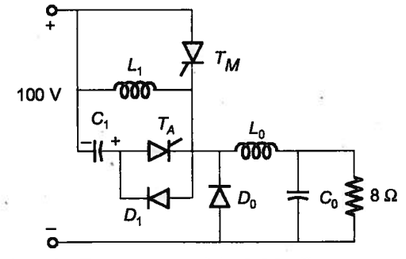
[Ans: (2.33)]

T3. In a voltage commutated chopper DC voltage input V = 250 V, constant load current I_0 = 20 A, chopper frequency = 250 Hz, commutating components L = 1.25 mH and C = 8 μF.
The maximum load or output voltage is ____ V.



[Ans: (250)]

T4. In the chopper circuit shown, the main thyristor (T_M) is operated at a duty ratio of 0.8 which is much larger the commutation interval. If the maximum allowable reapplied $dv/d\,t$ on T_M is 50 V/μs, what should be the theoretical minimum value of C_1? Assume current ripple through L_0 to be negligible.



(a) 0.2 μF (b) 0.02 μF
(c) 2 μF (d) 20 μF

[Ans: (a)]