BITS PILANI K. K. BIRLA GOA CAMPUS
SEMESTER-II, 2022-2023
POWER ELECTRONICS (COMPREHENSIVE) EEE_INSTR F342 (Part-A)

Date-06/05/2023 Total Marks: 10×3M=30 Duration: 40 min

[Take necessary assumptions with proper justifications whenever required]

[Write your answers up to four decimal places]

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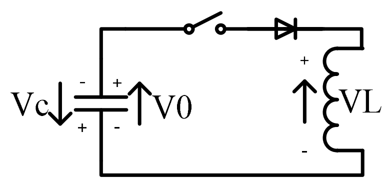
1. Consider an isolated buck converter which is excited by 50 V dc source. If the turns ratio $N_p: N_s: N_t = 20: 80: 20$, determine the maximum possible load current (IL_max, in A) if the converter delivers power to a purely resistive load of $R = 10\ \Omega$. **[3]**
2. Consider a buck-boost converter that operates at the boundary condition between CCM and DCM mode with a critical load resistance value of 2.5 Ohm at 30 % of duty ratio. Determine the switching frequency (fs, in kHz) of the converter if the inductor value is $10\ \mu H$. **[3]**
3. Consider a 50 Hz single phase full bridge inverter for which the width of the output voltage pulse is 140 degree for every half cycle. If the inverter is excited with a dc voltage of 215 V dc, determine the rms value (V_rms, in V) of the output voltage waveform. **[3]**
4. Consider the diagram given below where the values of $L = 5\ \mu H$ and $C = 20\ \mu F$. The capacitor is initially charged to V0=200 V. The current flowing through the inductor is zero before the switch was closed. At t=0, when the switch is closed, determine the magnitude of maximum value of the current (|I_max|, in A). **[3]**



5. Determine the time (t_max, in μ-Sec) at which the current reaches the maximum value as obtained in Problem No-4. **[3]**
6. Consider a forward converter where the tertiary winding is added as the core resetting circuit. The converter is excited with 50 V dc supply and the tertiary to secondary turns ratio is $N_t: N_s = 5: 15$. If the inductor used in low pass filter has the value of $10\ mH$, determine the inductor current ripple (I_ripp, in A) present while the converter is working at 20 % of duty cycle with switching frequency of 30 kHz. **[3]**
7. Consider a three-phase voltage source inverter which is working at 120 degree mode. The inverter is excited by 120 V dc voltage supply. Determine, the rms value of the phase voltage (Vrms_phase, in V). **[3]**
8. A single-phase full wave bridge rectifier is connected to RLE load with $R = 0.4\ \Omega$, $L = 2\ mH$ and $E = 120\ V$. The average load current of 10 A is continuous over the working range of the rectifier. If the source voltage is 230 V at the frequency of 60 Hz, determine the input power factor (pf lag). **[3]**
9. A single source two capacitors integrated half bridge inverter delivers power to a purely resistive lamp load of $R = 50\ \Omega$. The source is a dc voltage of 230 V. Determine the magnitude of the peak inverse voltage (V_PIV, in V) across any switch. The capacitors used are identical and have very high value of capacitance. **[3]**
10. Consider a single-phase bridge inverter which is excited from 230 V dc source. This bridge inverter delivers power to a series RLC load with $R = 1\ \Omega$, $X_L = 6\ \Omega$, and $X_c = 8\ \Omega$. Determine the RMS value of the fundamental component of load current (I_fund_rms, in A). X_L, X_C values are given at fundamental frequency. **[3]**

END of Part-A**********************************

BITS PILANI K. K. BIRLA GOA CAMPUS
SEMESTER-II, 2022-2023
POWER ELECTRONICS (COMPREHENSIVE) EEE_INSTR F342 (Part-B)

Date-06/05/2023 Total Marks: 60 Duration: 140 min

[Take necessary assumptions with proper justifications whenever required]

[Write your answers up to four decimal places; Diagrams should be properly labelled for full credit; Prepare an index at the first page; Answers should be according to the order of the questions]

Q1. A single-phase full bridge inverter delivers power to a series RLC load connected at the AC side (50 Hz). The input side DC voltage of the inverter is 220 V dc. For the series RLC load, the values of R is 5 Ω, L is 0.3 H and C is 50 μF. The output voltage across the load is represented in Fourier series as

$$v(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos n\omega t + \sum_{n=1}^{\infty} b_n \sin n\omega t$$

a) Determine the coefficients a_n, b_n in the Fourier series as the function of n, where n is the order of the harmonics. **[3]**

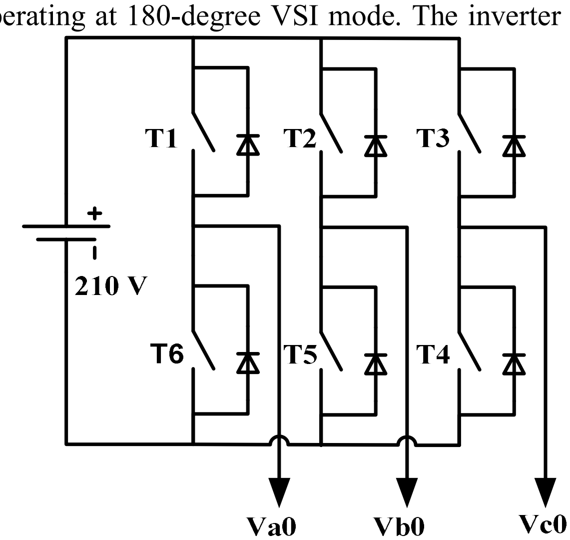
b) Determine the load current expression up to the 6th order harmonics. **[6]**

c) Determine the total active power absorbed by the load while the load current is expressed up to 6th order harmonics. **[2]**

d) Determine the RMS value of thyristor current. **[2]**

e) If only the fundamental component of the current is considered, then determine the conduction time of each thyristor and the diode. **[4]**

Now consider a three-phase full bridge inverter (50 Hz) that delivers a purely balanced star connected resistive load and excited by 210 V dc. The inverter is operating at 180-degree VSI mode. The inverter is given below



f) Draw the labelled sequence diagram of all 6 switches for two complete cycles mentioning the six steps in the diagram. **[3]**

g) Draw the labelled output three phase voltage (V_{a0}, V_{bo}, V_{co}) waveforms for two complete cycles after finding out all the phase voltages for first three steps. **[6]**

h) Draw the labelled three output line voltage (V_{ab}, V_{bc}, V_{ca}) waveforms for two complete cycles. **[4]**

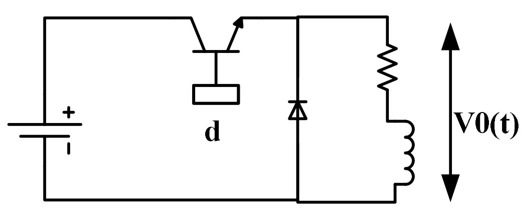
[No credit will be given for Part-(g) and (h) if the sequence diagram in Part-(f) is incorrect. To get the full credit, label all the waveforms properly. Where derivations are asked in this problem (Q1), simply writing the final expressions or values will not be given any credit.]

Q2. Consider an isolated Buck converter with tertiary winding core resetting circuit. The converter is excited by a 64 V dc voltage. The transformer winding turns ratio is $N_P: N_T: N_S = 10: 10: 5$ and the magnetizing reactance of the transformer is 200 μH. The LC filter used in the converter has inductance of 40 μH and capacitance of 450 μF. The converter delivers power to purely resistive load of $R = 1\ \Omega$. The converter operates at 50 kHz with 25% of the duty cycle.

a) Determine the minimum and maximum values of the LC filter inductor current and draw the inductor current waveform with proper labelling. **[3]**
b) Determine the maximum magnetizing current and draw the magnetizing current waveform with proper labelling. **[3]**
c) Draw the waveforms of the currents flowing through the blocking diode and the freewheeling diode with proper labelling. **[2]**
d) Draw the active switch current waveform mentioning all the values with proper labelling. **[4]**
e) Draw the primary winding current and source current waveforms mentioning all the values with proper labelling. **[6]**
f) Draw voltage waveform across the active switch of the converter with proper labelling. **[2]**

[To get the full credit, label all the waveforms properly in this question and draw all the waveforms for two complete cycles.]

Q3. Consider an actual switch which is a combination of active switch (transistor) and a passive switch (diode) which is shown below.



The active switch is operating at 40 % of duty ratio with switching frequency of 250 Hz. The exciting dc voltage is 60 V dc. If the voltage across the diode is represented in Fourier series as below

$$v_0(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos n\omega t + \sum_{n=1}^{\infty} b_n \sin n\omega t = \sum_{n=1}^{\infty} C_n \sin(n\omega t + \phi_n)$$

a) Determine the RMS and the Average value of the voltage across the passive switch. **[2]**
b) Derive the values of a_n, b_n and C_n as the function of n where n is the order of harmonics. **[4]**
c) Determine the maximum possible 5th harmonics voltage magnitude present in diode voltage waveform. **[2]**
d) Determine the maximum possible duty ratio for the maximum 5th harmonics voltage obtained in part-(c) Q3. **[2]**

**********************************BEST OF LUCK********************************