INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

AV322 – POWER ELECTRONICS

1. A buck boost converter is shown in Fig-1. It is operating at a duty ratio of 0.5 and the switching frequency is 50 KHz. Vs=30V, R=15Ω.
    a. Evaluate 'L' such that the converter operates on the boundary between CCM and DCM.
    b. For this value of 'L' find the value of C such that the ripple in the output voltage is less than 1% of its average value.

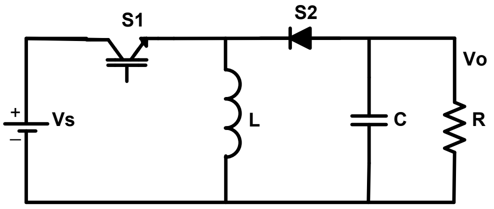

Fig-1.

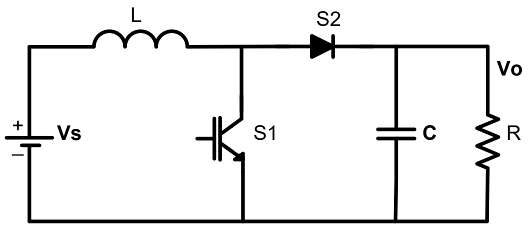

Fig-2.

2. In the boost converter shown in Fig.2, Vs=20V, R=40 Ω, L=50 μH, C= 47 μF, Ts=20 μS, D=0.5
    a. Evaluate the average inductor current and the inductor current ripple.
    b. Indicate if the operation is in CCM or DCM mode.
    c. Evaluate the switching frequency required to reduce the inductor ripple factor to 0.4.

3. The Cuk converter shown in Fig.3 operates in CCM with the following parameters: Switching frequency Fs = 100 KHz, Duty ratio D=0.4, Vs=120V, R=10 Ω, L1=54μH, L2=270μH.
    (a) Sketch the waveforms of currents through the MOSFET and diode and mark all salient points.
    (b) If the diode has a forward voltage drop of 0.8 V and MOSFET has an ON-state voltage drop of 0.9V, evaluate the conduction losses in diode and MOSFET. Ignore the effect of switch non-idealities on output voltage while calculating the losses.

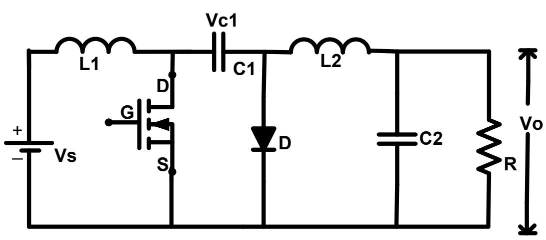

Fig-3

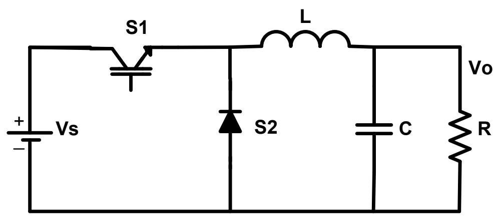

Fig-4

4. A buck converter shown in Fig-4 is operating in DCM and delivering 22.5 W power to the load (R) at 15 V. Vs=24V, Switching frequency is 20 KHz.
    a. Determine the duty ratio (D) of the switch S1, if the diode S2 conducts only for half of the turn off period of the switch S1.
    b. Determine the value of the inductor (L) under this condition.
    c. Sketch the waveform of the inductor current and mark the salient points.

5. In the buck converter shown in Fig.-4, Vs=15V, L=0.16 mH, C=20 μF, R=12 Ω. The internal resistance of the source is 0.01 Ω. The inductor has a parasitic resistance of 0.02 Ω. The ON state voltage drops of the switches S1 and S2 are 0.8V and 0.6V respectively. If the switching frequency is 25KHz and the operating duty ratio is 0.8,
   a. Evaluate (a) Voltage conversion ratio Vo/Vs. (b) Average conduction losses of switches S1 and S2. (c) Efficiency of the converter
   b. Sketch the waveforms of the inductor voltage and the inductor current and mark all salient points.

6. In the boost converter shown in Fig.2, Vs=40V, R=20 Ω. The switching frequency is 5 KHz and the duty ratio of the switch S1 is 0.6. The ON-state voltage drops of switches S1 and S2 are 0.8V and 0.6V respectively. The input source has an internal resistance of 0.01 Ω and inductor has a parasitic resistance of 0.05 Ω.
   a. Evaluate the voltage conversion ratio and efficiency of the converter.
   b. Evaluate the conduction loss in switch S1 and diode S2.

7. In the buck-boost converter shown in Fig.1, Vs=50V, L=0.75 mH, R=20 Ω. The switching frequency is 10 KHz and the duty ratio of the switch S1 is 0.6. The ON-state voltage drops of switches S1 and S2 are 0.8V and 0.7V respectively. The inductor has a parasitic resistance of 0.05 Ω. Neglect switching loss.
   a. Evaluate the output voltage Vo.
   b. Evaluate the average power loss in [1] IGBT (S1), [2] Diode (S2).

8. The forward converter shown in Fig.5 is operating at a duty ratio of 0.3. The MOSFET has a voltage drop of 0.9V in the ON state. Diodes while in conduction will have a voltage drop of 0.7V. R= 5 Ω. Vs=30V. Switching frequency is 20 KHz. Turns ratio Np:Nt:Ns=3:3:2. Evaluate (i) Output voltage (ii) Efficiency of the converter ignoring the loss in D3.

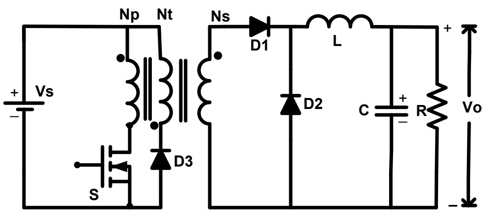

Fig-5.

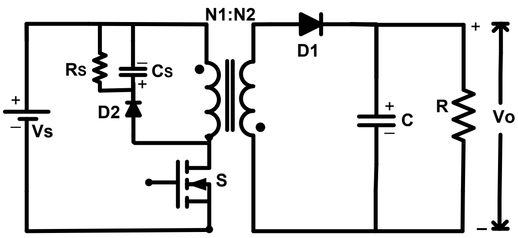

Fig-6.

9. The flyback converter shown in Fig.6 supplies 4 A current at 5V to the load (R). The primary has 45 turns and the secondary has 4 turns. Vs=120 V. The primary inductance is 20 mH. The leakage inductance referred to primary winding is 0.4 mH. Rs=100 Ω. Cs=100 μF . The switching frequency is 50 KHz. Evaluate the following
   a. Duty ratio.
   b. Power dissipated in the snubber resistor (Rs) at steady state.

10. A four quadrant separately excited DC drive shown in Fig-7 is used in an electric vehicle powered from a 120V battery. The field current of the motor is kept constant. The armature resistance of the motor is 0.5 Ω. The vehicle was being driven on a level road at a constant motor speed of 500 RPM while the converter was operating at a duty ratio of 0.85 and armature drawing a current of 50A. The vehicle then moves down a gradient in the same direction but the same speed is maintained by employing regenerative braking. Determine the duty ratio of the converter during regenerative braking if the motor current under this condition is 10 A.

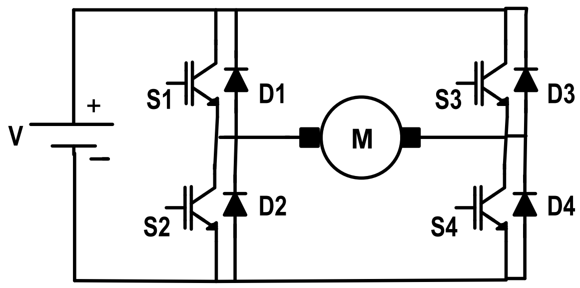

Fig-7.

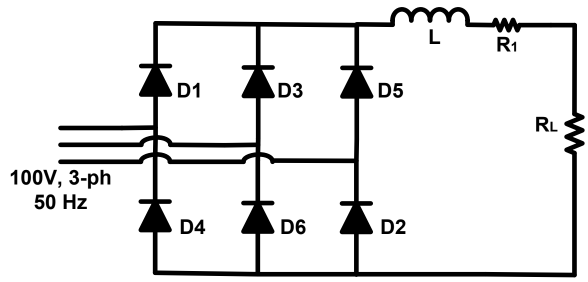

Fig-8

11. A three-phase diode bridge rectifier is shown in Fig-8. It is supplied from a 100 V (line to line), 3-phase, 50Hz source. A large inductor is connected at the output of the rectifier such that the DC current ripple is negligible. This inductor has a parasitic resistance of 1 Ω. The load resistance at the DC side is 10 Ω. The forward voltage drop of the diode during conduction is 0.8V. Evaluate the following.
    a. Power delivered to the load (R_L).
    b. RMS value of the diode current.
    c. Power factor of the converter.
    d. Total conduction loss in the converter in watts.

12. The buck converter shown in Fig.-9, is operating in DCM mode with the following parameters. Vs=30V, L=0.30 mH, Duty ratio D=0.5, R=50 Ω. The switching frequency is 20KHz. All components are ideal.
    (a) Evaluate the conduction time of the diode (S2).
    (b) Sketch the waveform of the voltage across the switch (S1) and mark all salient points.
    (c) Evaluate the RMS value of the current flowing through the diode.

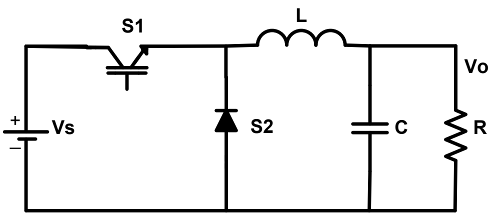

Fig.-9

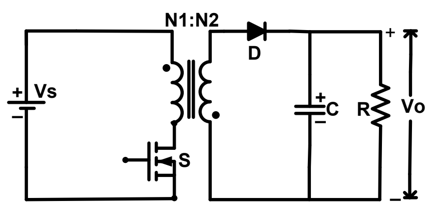

Fig.-10

13. The flyback converter shown in Fig.10 is delivering a power of 25W to a load of resistance R=1 Ω . The turns ratio N1:N2 is 1 : 0.125. Vs=20 V. The secondary inductance is 25 µH. The

capacitance C= 100 μF. The switching frequency is 20 KHz. All components are considered to be ideal.

(a) Determine the mode of operation of the converter (DCM or CCM).

(b) Sketch the waveform of the primary and secondary current and mark all salient points.

(c) Evaluate the ratio of the energy stored in the converter to the energy delivered to the load in a switching period.

14. A pulse width modulated H-bridge inverter is shown in Fig.-11. Vs=100V. The inverter output voltage is a quasi-square wave with quarter wave symmetry. Frequency of the fundamental component of output voltage is 50Hz. R-L load of R=10 Ω, L=30 mH is connected across the terminals A-B.

    (a) Evaluate the pulse width required for realizing a fundamental output voltage of 70 V (RMS value).

    (b) Determine the Total Harmonic Distortion (THD) of the load current considering only the first two dominant current harmonics, for the condition specified in 5(a).

    (c) Determine the duration of conduction of the diode D1 in a switching cycle considering only the fundamental components of load voltage and current.

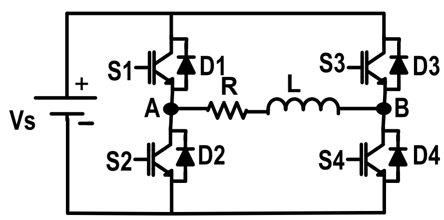

Fig.-11

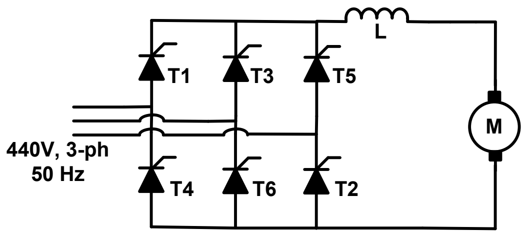

Fig.-12

15. A three-phase, phase-controlled SCR bridge rectifier feeding a separately excited DC motor, rated 50HP, 500 V, 1200 RPM is shown in Fig-12. The motor runs at 1200 RPM drawing a current of 10A at no- load when 500V is applied across the armature terminals. The controlled rectifier is supplied from a 440 V (line to line), 3-phase, 50Hz source. A large inductor is connected at the output of the rectifier such that the DC current ripple is negligible. The efficiency of the motor is 90% and its armature resistance is 0.5 Ω. The forward voltage drop of the SCR during conduction is 0.8V.

    (a) Regenerative braking is employed by reversing the armature terminals and operating the converter in inversion mode to bring down the speed of the motor from 1200 RPM to 800 RPM at full load. If the regenerative braking is done at constant load current (full load current) and constant flux, determine the range of firing angle variation during braking.

    (b) Evaluate the total average conduction loss in six SCRs when the motor runs at full load and 1200 RPM.

    (c) Evaluate the input power factor of the converter when the motor runs at full load and 1200 RPM.

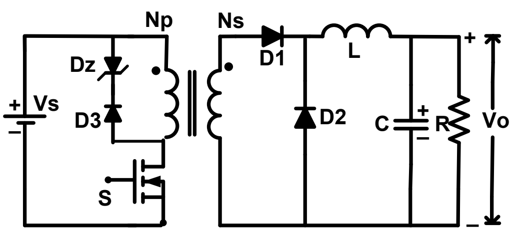

Fig.-13

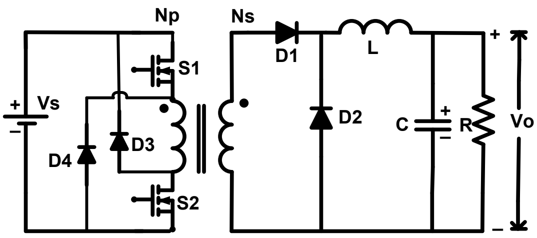

Fig.-14.

16. A forward converter with a flux resetting circuit consisting of diode (D3) and Zener diode (Dz) is shown in Fig.13. The zener diode has adequate power dissipation capability. Turns ratio Np:Ns is 1 : (2/3). Vs=24 V. Duty ratio of the active switch (S) is 0.4. The magnetising inductance referred to primary is 500 µH. The ON-state voltage drop of MOSFET (S) is 0.4 V. The diodes have a voltage drop of 0.8V during conduction. Resistances of the primary and secondary windings are 30 m Ω and 60 m Ω respectively. The inductor (L) has a parasitic resistance of 15m Ω . The load resistance R=1 Ω. Switching frequency is 50 KHz.
    (a) Determine the output voltage of the converter.
    (b) Evaluate the inductor (L) such that the peak to peak ripple in the inductor current is 10% of the average inductor current.
    (c) Evaluate the efficiency of the converter.

17. The two switch forward converter shown in Fig.14 is operating with the following parameters: Input voltage (Vs)=100V, Load resistance R=2 Ω, L=24 µH. Duty ratio D=0.4. Switching frequency is 50KHz. Primary magnetizing inductance is 4mH. The switches S1, S2, D1 and D2 have a voltage drop of 1V in the ON-state. The diodes D3 and D4 may be considered ideal. Turns-ratio Np:Ns= 1 : 0.25. Evaluate the output voltage and efficiency of power conversion.

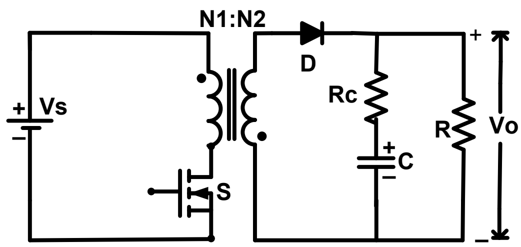

Fig.15

18. A flyback converter operating in DCM is shown in Fig.15. It delivers a voltage of 15V to the load of R=10 Ω Vs=48V. The secondary winding conducts for one half of the OFF time of the active switch (S). The switching frequency is 20KHz. Turns ratio N1:N2= 1:0.5.
    (a) Evaluate primary inductance and secondary inductance.
    (b) Sketch the waveforms of primary current and secondary current and mark all salient points.