Department of Electrical Engineering
Assignment
Date: 27/06/2020

Course Details

Course Title:	Power Electronics	**Module:**	
Instructor:	SIR SHAYAN TARIQ	**Total Marks:**	50

Student Details

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Note: Plagiarism of more than 20% will result in negative marking.
Similar answers of students will result in cancellation of the answer for all parties.

Q1.	Rectifiers are common circuits used in most electronic devices. There are multiple types of rectifiers used now a days. Explain in detail what are the similarities and differences between: 1. 1 – φ Uncontrolled Half Wave Rectifier and Full Wave Bridge Rectifier 2. 1 – φ Uncontrolled Rectifier and Controlled Rectifiers (Bridge Rectifier).	CLO 2 Marks 10
Q2.	A AC voltage of Vm = (Last 2 digits of ID) V has to be delivered to a Resistive DC load of R = (First 2 digits of ID) ohms. The load and source are connected through 2 types of 1 – φ Uncontrolled rectifiers (Half Wave and Full Wave Bridge) and data is collected. Find the following for both rectifiers: 1. Vdc 2. Idc 3. Vrms 4. Irms 5. Which rectifier do you think is better and why.	CLO 2 Marks 10
Q3.	The Buck chopper is a type of DC-DC converter. Explain in detail the principals and working of Buck converter when the switch is open and closed. The buck converter is connected to a DC source voltage of Vin = 50V. The duty cycle is D = (Last 2 digits of ID) %, load of R = (First 2 digits of ID) ohms and switching frequency of 20kHz. What will be the 1. Vout 2. Iout 3. Iin 4. Inductor (L)	CLO 3 Marks 10

0Q4	The Boost chopper is a type of DC-DC converter. Explain in detail the principals and working of Boost converter when the switch is open and closed. The boost converter is connected to a DC source voltage of Vin = 50V. The duty cycle is D = (Last 2 digits of ID) %, load of R = (First 2 digits of ID) ohms and switching frequency of 20kHz. What will be the 1. Vout 2. Iout 3. Iin 4. Inductor (L)	CLO 3 Marks 10
Q5	The Buck-Boost chopper is a type of DC-DC converter. Explain in detail the principals and working of Buck converter when the switch is open and closed. The Buck-Boost converter is connected to a DC source voltage of Vin = 50V. The Output voltage Vout = (Last 2 digits of ID) %, load of R = (First 2 digits of ID) ohms and switching frequency of 20kHz. What will be the 1. Duty Cycle (D) 2. Iout 3. Vin 4. Inductor (L)	CLO 3 Marks 10

Q#1

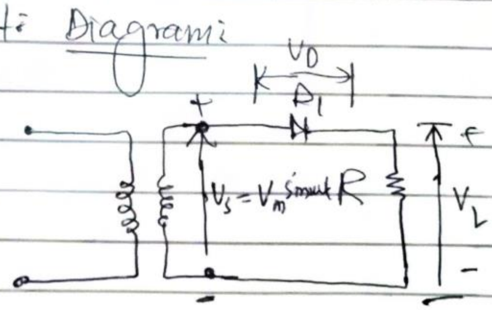
Rectifier:

It is the electronic device which is used to Convert AC in to DC is Called Rectifier.

1) 1-Q Uncontrolled Half Wave Rectifier:

A rectifier is a Circuit that Convert an ac Signal in to unidirectional Signal Diodes are used Commonly in rectifiers. A Single Phase half wave rectifier is the Simplest type is not normally used in industrial applications. However It is useful in under-standing the principle of rectifier operation.

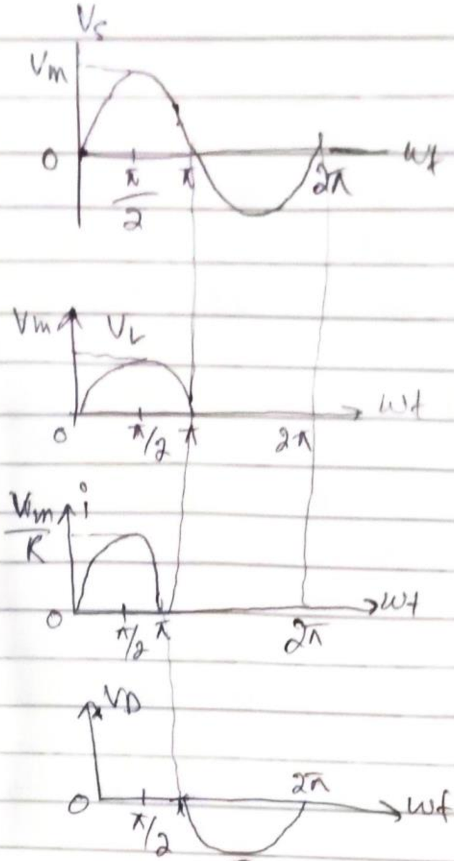
Circuit Diagram:



During positive half cycle. The input voltage, diode D_1 is forward Biase. and Conducts. and Input voltage appear across the load. During negative half Cycle of The input voltage the diode in blocking Condition and output voltage is Zero.

P.T.O

Waveforms:

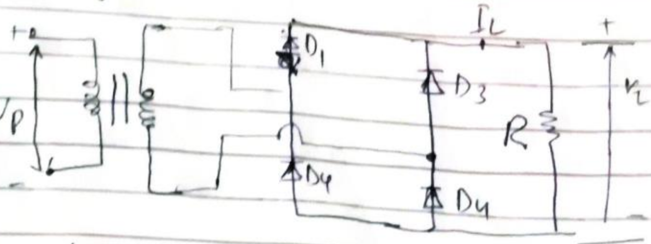


(B)

1-ϕ uncontrolled full wave bridge Rectifier:

We use four diodes in bridge Rectifier Circuit.

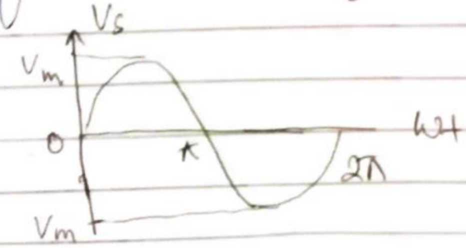
Circuit Diagram:

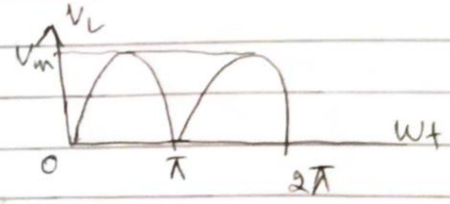


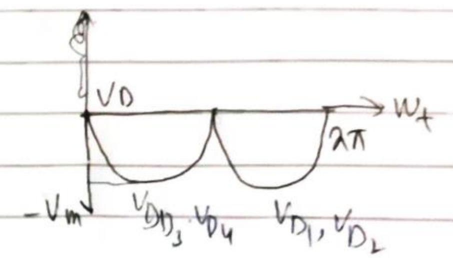
During positive half cycle of the input Voltage the Current flows through the load through diodes D_1 and D_2. During negative cycle Diodes D_3 and D_4 Conducts. The peak

(6) (3) (5)

inverse voltage of a diode is V_m.







<u>Similarities</u> and differences

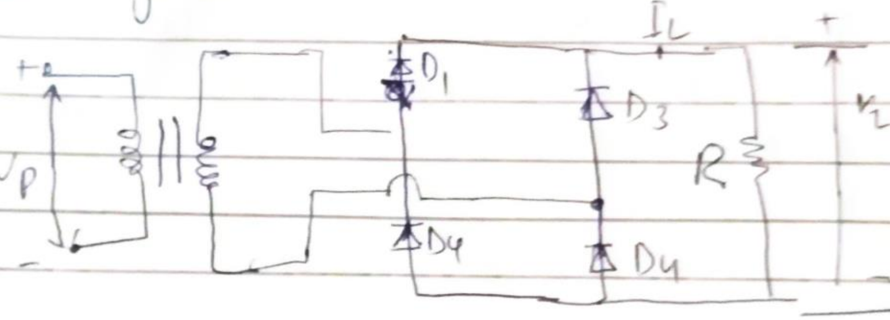
- Both uses diode.
- During positive half cycle both conduct.
- During negative half cycle bridge Rectifier conduct ~~but~~ not conduct the half wave Rectifier.

(B) (4)

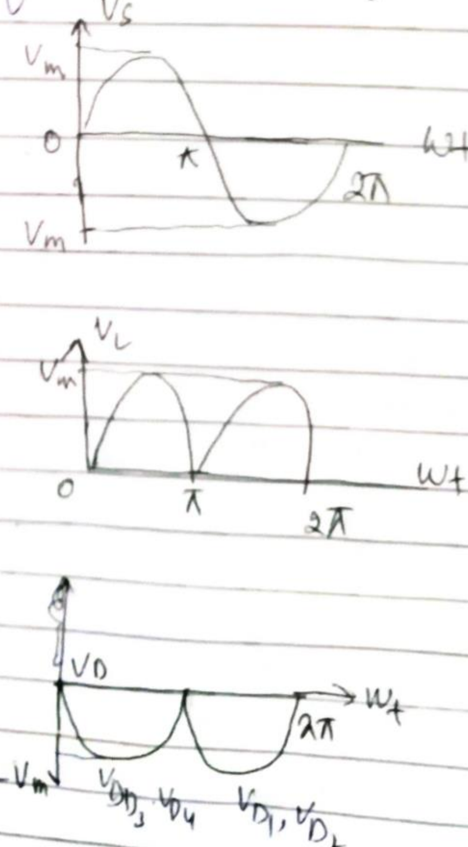
1 - ϕ uncontrolled full wave bridge Rectifier

We use four diodes in bridge Rectifier Circuit.

Circuit Diagram:

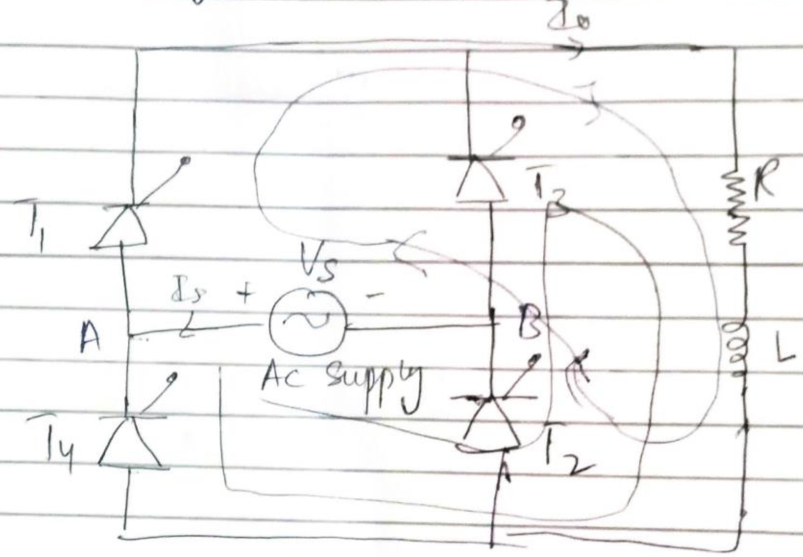


During postive half cycle of the inp Voltage the Current flows through the through diodes D_1 and D_2. During neg cycle Diodes D_3 and D_4 Conducts. The inverse voltage of a diode is V_m.



(Q) 1-Φ Controlled bridge Rectifier

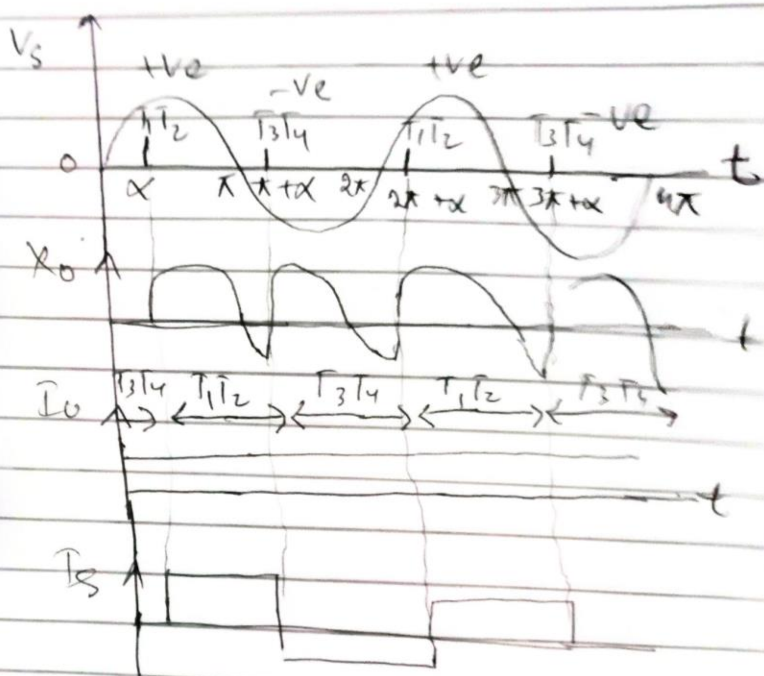
Circuit diagram:



Its function is basically subdivided in to two parts postive half and negative half cycle. During postive half cycle T_1 and T_2 will become forward bias. If we give gate pulse to T_1 and T_2 Current will flow in the loop. During negative half cycle Terminal A is negative with respect to Terminal B, T_3 and T_4 will be in forward bias. If we give gate pulse to T_3 and T_4 Current will flow in another loop.

(7) (8)

Graph:



Similarities and difference-

- Uncontrolled rectifier uses diodes
- Controlled rectifier uses SCR.
- ~~Here~~ In Controlled Rectifier we control the output by using the gate pulse. When we give gate pulse then it trigger otherwise ~~so~~ not.

Q#2

Solution:

$V_m = 23$

$R = 13$

We know that

for half wave

1) Vdc

$\frac{V_m}{\pi} \rightarrow (1)$

$V_m = 23V$

$\pi = 3.14$

put in eq (1)

$\frac{23}{3.14} = 7.32$

For full wave bridge

$\frac{2V_m}{\pi}$

$= \frac{2(23)}{3.14} = 14.6V$

(2) Idc

For half wave

$~~V_{rms}~~ = \frac{V_m}{\pi R}$

$$I_{dc} = \frac{V_m}{\pi R}$$

$$= \frac{23}{(3.14)(13)} = \frac{23}{40.82} = 0.56A$$

For Full wave

$$I_{dc} = \frac{I_m}{\pi}$$ where $I_m = \frac{V_m}{R}$

$$= \frac{23}{13}$$

$$I_m = 1.76A$$

$$I_{dc} = \frac{1.76}{3.14}$$

$$= 0.56A$$

(3) V_{rms}

For half wave

$$V_{rms} = \frac{V_m}{2}$$

$$= \frac{23}{2} = 11.5V$$

For full wave

$$V_{rms} = \sqrt{2}\, V_s$$

$$V_{rms} = (\sqrt{2})(16.3)$$

$$V_{rms} = 23V$$

$$V_s = \frac{V_m}{\sqrt{2}}$$

$$= \frac{23}{\sqrt{2}} = \frac{23}{1.41}$$

$$V_s = 16.3V$$

(4) Irms

4) Irms for half wave and full wave bridge.

Half wave

$$I_{rms} = \frac{V_m}{2R}$$

$$= \frac{23}{2(13)} = 0.88\,A$$

For full wave

$$\frac{I_m}{2} \rightarrow (1)$$

where $I_m = \frac{V_m}{R}$

$= ~~26~~$

$$= \frac{23}{13}$$

$$= 1.76\,A$$

put in (1)

$$= \frac{1.76}{2} = 0.88\,A$$

(5) I would like to refer the uncontrol full wave bridge rectifier because the efficiency of the full wave bridge rectifier

is better than in half wave rectifier and output frequency also greter than half wave rectifier.

Q#3

Principal and working of buck Converter

The main working principle of buck Converter is that the inductor in the input Circuit resist Sudden variation in the input current. When Switch is ON The inductor stores energy in the form of magnetic energy and discharges it when the Switch is closed. The Capacitor in the output Circuit is assumed large enough that the time Constant of RC Circuit in the output Stage is high. The Large Time Constant Compare to Switching period ensures a Constant output voltage $V_o(t) = V_o$ (Constant).

Data

$V_{in} = 50V$

$D = 23\%$

$R = 13\Omega$

frequency = 20KHz

(1) V_{out}

We know that

$V_{out} = D\alpha V_s$ —(1)

$V_{out} = D \times V_s$

α = Duty cycle.

$23\% = 0.23$

put in eq (1)

$= (0.23)(50) = 11.5V$

(2) I_{out}

$$I_o = \frac{V_o}{R}$$

$$= \frac{11.5}{13} = 0.88A$$

(3) I_{in}

We know that

$$I_o = \frac{I_i}{\alpha \text{ or } D}$$

$$I_i = I_o \times \alpha$$

Where α is duty cycle.

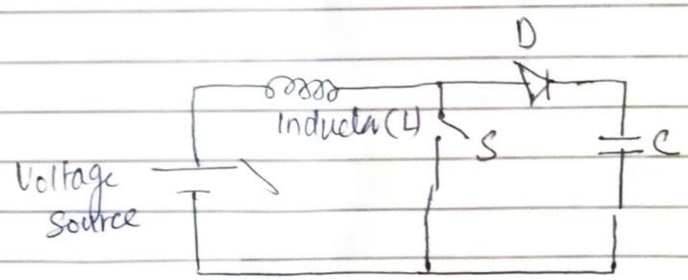
$$I_i = 0.88 \times 0.23$$

$$\boxed{I_i = 0.202A}$$

(4) Inductor

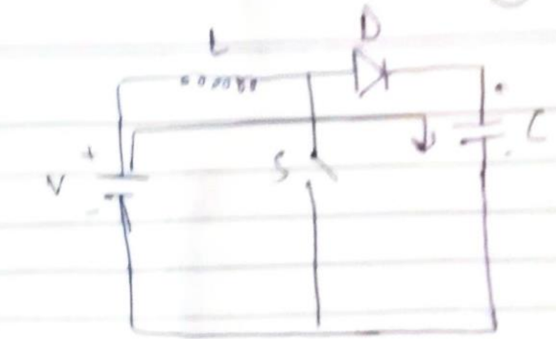
Q#4

Boost choppers:- A boost Converter is one of the Simplest type of Switch mode Converter, It takes an input voltage and boost it. All Consist of is an inductor a Semiconductor Switch a diode and a Capacitor. It is also Called a Step up Converter.

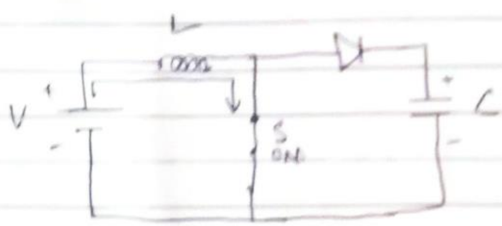


Working principle:

The main working principle of boost Converter is that the inductor in the input Circuit resist Sudden Variation in the input Current. When Switch is OFF the inductor Stores energy in the form of magnetic energy and discharge it When the Switch is Closed. The Capacitor in the output Circuit is assumed Large enough that the Time Constant of RC Circuit in the output Stage is high.



The output Capacitor is charged to the input voltage minus one diode drop.



When the Switch is ON. Our Signal Source goes high turning on the MOSFET. All the current is directed through MOSFET through the inductor. The output Capacitor stays ~~through the inductor~~ charged since it can't discharge through the now back-biased diode.

The Switch is ON and therefore represents short circuit ideally offering zero resistance to the flow of current. Let us say the switch is ON for a time t_{ON} and is OFF for the time t_{OFF}. We define the time period T, as $T = T_{ON} + T_{OFF}$ and the switching frequency

$$f_{Switch} = \frac{1}{T}$$

Now define another term duty cycle.

$$D = \frac{T_{ON}}{T}$$

Boost Converter in Steady State operation for this mode using KVL.

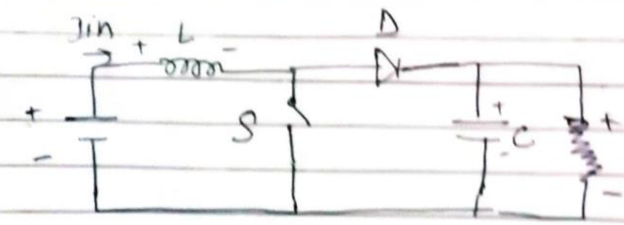
$$V_{in} = V_L$$

$$V_L = L\frac{di}{dt} = V_{in}$$

$$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{DT} = \frac{V_{in}}{L}$$

Since the switch is closed for a time $T_{ON} = DT$ we can say that $\Delta t = DT$

$$(\Delta i_L)_{closed} = \left(\frac{V_{in}}{L}\right) DT$$



In this mode the polarity of the inductor is reversed. The ~~polarity~~ energy stored in the inductor is released and is ultimately dissapated in the load resistance and this helps to maintain the flow of current in the same direction through the load and also step up the voltage as the inductor is now also acting as a source in Conjunction with the input Source.

Analyze The Circuit using KVL

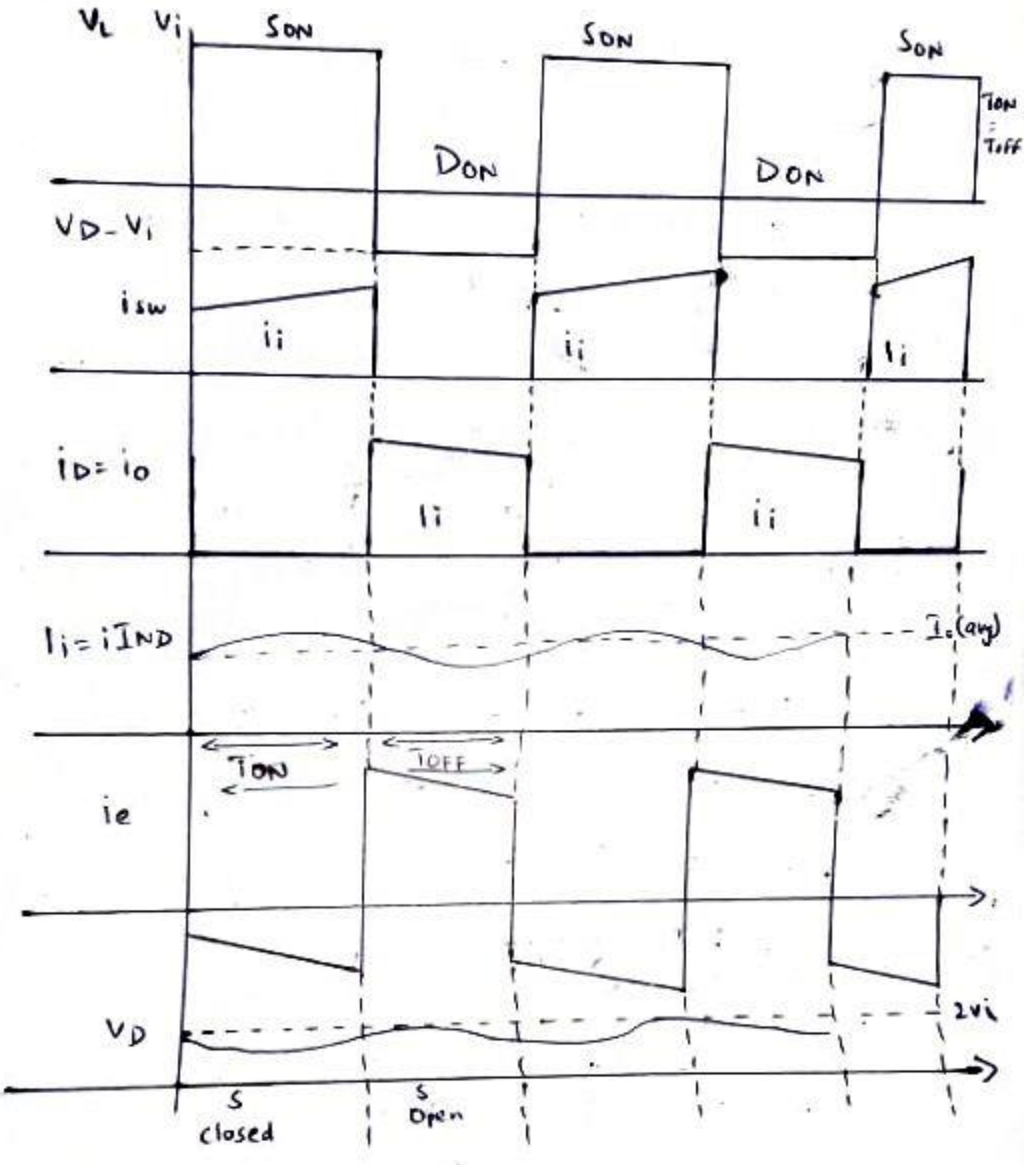
Boost Converter in Steady State operation for mode 2 using KVL.

$$V_{in} = V_L + V_0$$

$$V_L = \frac{L\,di_L}{dt} = V_{in} - V_0$$

$$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{(1-d)T} = \frac{V_{in} - V_0}{L}$$

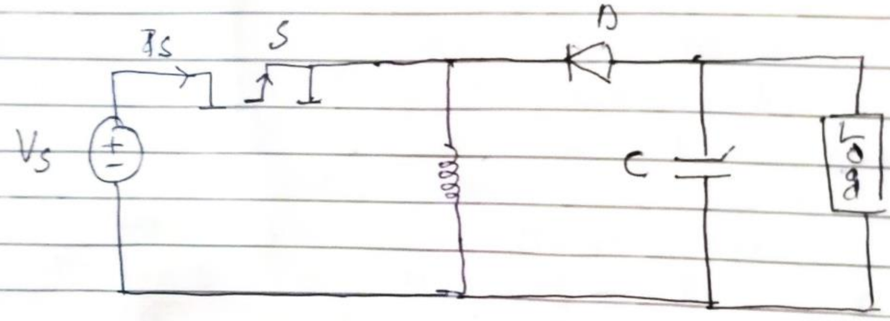
Since the Switch is open for a Time $T_{OFF} = T - T_{ON} = T - DT = (1-D)T$ we Can Say that $\Delta t = (1-D)T$.


VL
Vi
SON
DON
SON
DON
SON
TON = TOFF
VD-Vi
isw
ii
iD= io
ii
Ii= iIND
Io(avg)
TON
TOFF
ie
VD
2vi
S closed
S Open

Q#5

Buck - Boost Chopper:- A buck boost ~~Chopper~~ Converter which can operate as an Dc - Dc Step down Converter OR Dc - Dc Step up Converter depending upon the duty cycle D.

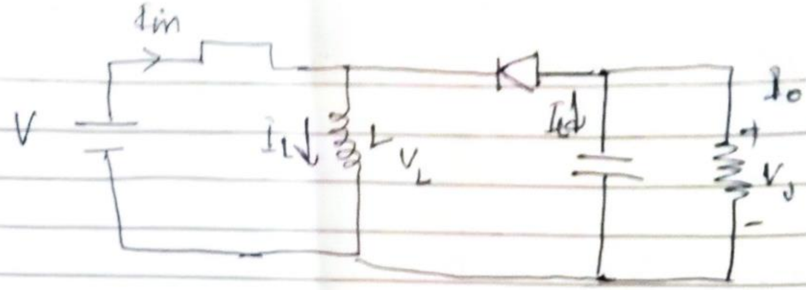
Buck Boost Converter is Shown



The input voltage Source is Connected to a Solid State device. The Second Switch is used is a diode. The diode is Connect in reverse to the direction of power flow from Source. To the Capacitor and the load and Two are Connected as shown in fig.

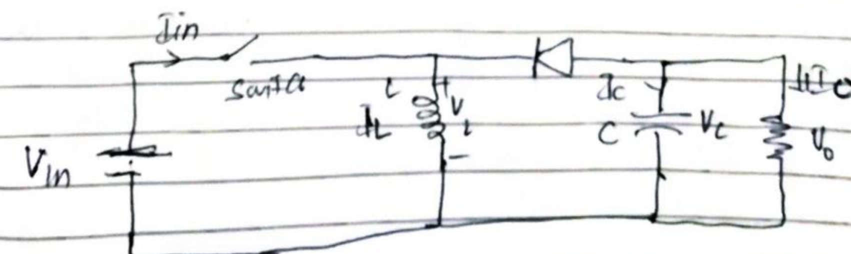
The Controlled Switch is turned ON. & OFF by using pulse width modulation. PWM Can be time based or frequency based. The Time based is mostly used for Dc - Dc Converter it is Simple to Construct and use. Frequency remain Constant in this type of PWM modulation

Mode 1: Switch IS ON, Diode OFF.



The Switch is ON and therefore represent a Short Circuit a ideally offering zero resistance to the flow of Current. So when The Switch is ON all the Current will flow through the Switch and the inductor and Back to the Dc input Source. The inductor Stores Charge during The Time when The Switch is ON and when the Solid State Switch is OFF The polarity of the inductor reverses So that the Current flows through the load and through the diode and back to the inductor. So The direction of the Current remain Same.

Mode II Switch is OFF, Diode is ON



In this mode the polarity of the inductor is reversed and energy stored in the inductor is released. So the current through the inductor can't abruptly change the diode must carry the current so it commutates and begin conducting. Energy is transferred from the inductor to the capacitor resulting in a decreasing inductor current and a voltage across the resistor with the opposite polarity compared to Vin.

(1) In discontinous conduction mode. If the inductor current reaches zero.

(2) In continuous conduction mode if the inductor current never reaches zero.

Data:

Vin = 50V

Vout = 23%

Resister = 13 Ω

frequency = 20KHZ

(1) Duty cycle (D)

$$\frac{V_o}{V_I} = \frac{-D}{1-D}$$

$V_o = +V_i\, d$

$= (1-d)$

$0.23 = +50 \frac{d}{1-d}$

$(0.23)(1-d) = 50d$

$0.23 - 0.23d = 50d$

$0.23 = 50d + 0.23d$

$0.23 = 50.23d$

$= \frac{0.23}{50.23} = 0.0045$

(2) Iout =

$$I_{max} + I_{min} = \frac{2dV}{R(1-d)^2}$$

$$I_{max} + I_{min} = \frac{2(0.0045)(50)}{13(1-0.0045)^2}$$

$$= \frac{0.45}{13(0.9955)^2} = \frac{0.45}{13} = 0.0346 \text{ — (1)}$$

$$I_{out} = \frac{I_{max} + I_{min}}{2}$$

$$\frac{0.0346}{2} = 0.0173A$$

(3) $I_i = ?$

$$I_i = I_L d$$

$$= 0.0173 \times 0.0045$$

$$= 0.00007785A$$

Q#4 (numarical part)

(1) Vout

We know

$$V_o = V_i \left(\frac{1}{1-d}\right)$$

$$V_o = 50\left(\frac{1}{1-0.23}\right)$$

$$V_o = 50\left(\frac{1}{0.77}\right)$$

$$V_o = 64.93V$$

Iout

$$I_o = I_1(1-d) \rightarrow (1)$$

First we have find Iin

$$= \frac{50}{10.01} = 5A$$

$I_o = I_i (1-d)$

$I_o = 5(1-0.23)$

$I_o = 5(0.77)$

$I_o = 3.85$

(4) Inductor

$$L = \frac{R T_{ON}}{2}(1-d)^2 \quad (1)$$

$$d = \frac{T_{ON}}{T} \qquad T = \frac{1}{20 \times 1000}$$

$T = 20000$

$T_{ON} = 0.23 \times 0.00005$

$T_{ON} = 0.000013$

$$L = \frac{R T_{ON}}{2}(1-d)^2$$

$L = 13(0.000013)(1-0.23)^2$