IQRA NATIONAL UNIVERSITY

Power Electronics

Final Assignment Spring 2020

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Question-1

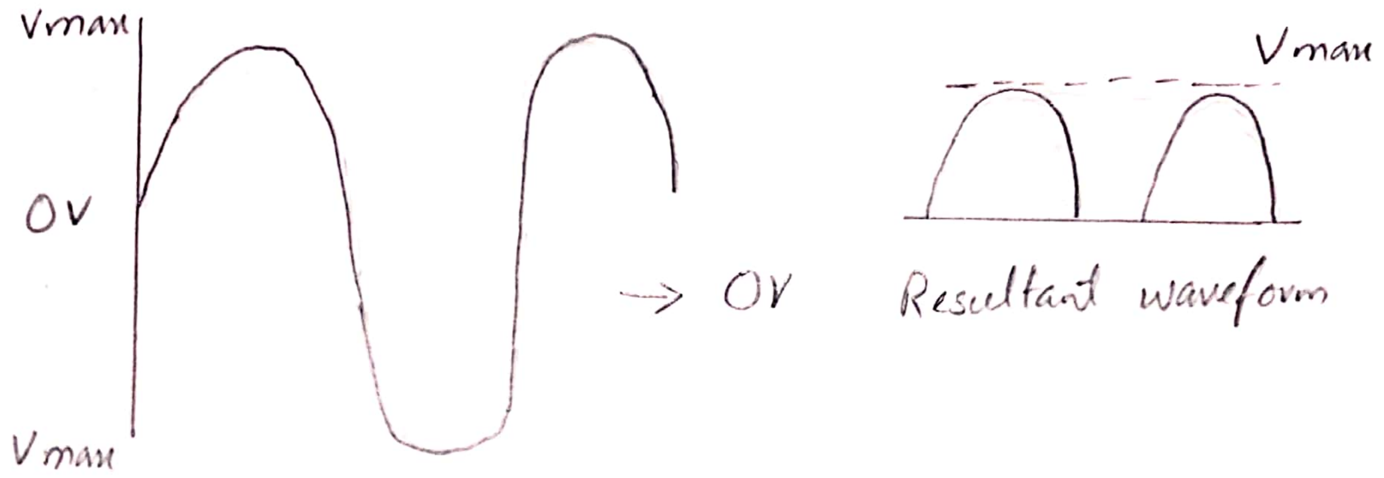
⇒ Difference between single phase half wave and full wave bridge rectifire:

⇒ Half wave rectifier which convert only one half of the AC cycle into pulsating DC. while full wave rectifier is an electronic circuit which convert entire cycle AC into pulsating DC.

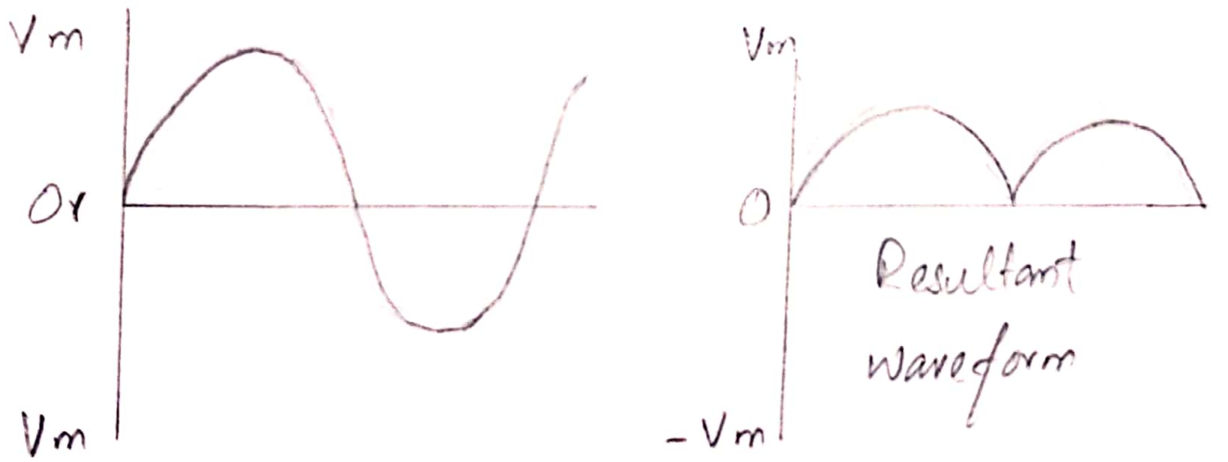
⇒ Half wave utilize only half of AC cycle for the convertion while full have utilize full wave of AC cycle.

⇒ Half wave is unidirectional, the conduction is one direction only either convert positive or negative, that why called Half wave rectifier is bidirectional, it convert for positive as well as negative half of the cycle.

⇒ Output waveform of single phase half wave rectifier



And single phase wave bridge rectifier.



⇒ The number of diode in half wave rectifier is 1 while in bridge rectifier is 4.

⇒ Similerities between single phase Half wave & full wave bridge rectifier:

⇒ Peak inverse voltage of single half wave and full wave rectifier are same which is vin & same in both rectifier.

⇒ Both utilize the single phase for the operation.

⇒ Single phase uncontrol and control rectifier difference and similarities:

⇒ Uncontroll they are naturally turn on whenever a positive voltage is applied between its terminal & when they stop by applying it negative voltage.

⇒ while in controll rectifier, the conduction start at any angle in positive half cycle nomally 0 to 180 degree once the conduction turn on & OFF.

Question- 2

Given:- $V_m = 22 V$

$R = 13 \Omega$

Solution:- For half wave.

1 ⇒ V_{dc} :

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

where $V_m = 22 v$ & $\pi = 3.14$

putting these values in eq (1)

$$V_{dc} = \frac{22}{3.14}$$

$$V_{dc} = 7.006$$

For full wave bridg

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

putting values

$$V_{dc} = \frac{2(22)}{3.14}$$

$$V_{dc} = \frac{44}{3.14}$$

$$V_{dc} = 14.012$$

2 ⇒ I_{dc} :

For half wave

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

$$I_{dc} = \frac{22}{(3.14)(13)}$$

$$I_{dc} = \frac{22}{40.82}$$

$$I_{dc} = 0.538 \text{ Amp}$$

for full wave ;

$$I_{dc} = \frac{I_m}{\pi} \rightarrow ②$$

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

$$I_m = \frac{22}{13}$$

$$I_m = 1.69 \text{ A}$$

putting in eq ②

$$I_{dc} = \frac{1.69}{3.14}$$

$$I_{dc} = 0.538 \text{ A}$$

3 ⇒ V_{rms} :

For half wave :

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

$$V_{rms} = \frac{22}{2}$$

$$V_{rms} = 11 \text{ V}$$

For full wave :

$$V_{rms} = \sqrt{2}\, V_s \longrightarrow ③$$

As,

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

$$V_s = \frac{22}{\sqrt{2}}$$

$$V_s = \frac{22}{1.414}$$

$$V_s = 15.5$$

putting values of V_s in eq (3).

$$V_{rms} = (\sqrt{2})(15.5)$$

$$V_{rms} = (1.414)(15.5)$$

$$V_{rms} = 21.917 \text{ V}$$

⇒ 4 ⇒ I_{rms} : For half wave & full wave.

For half wave:

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

putting values ;

$$I_{rms} = \frac{22}{2(13)}$$

$$I_{rms} = \frac{22}{26}$$

$$I_{rms} = 0.846 \text{ Amp}$$

For full wave :

$$I_{rms} = \frac{I_m}{2} \longrightarrow (4)$$

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

$$I_m = \frac{22}{13}$$

$$I_m = 1.69 \text{ A}$$

put value of I_m in eq (4)

$$I_{rms} = \frac{1.69}{2}$$

$$I_{rms} = 0.840$$

5 ⇒ which rectifier do you think is better and why.

⇒ I would like to refer the uncontroll full wave bridge rectifier because the efficiency of the full wave bridge rectifier is better then in half wave rectifier and output frequency also gratter than half wave rectifier.

Question - 3:

Buck Chopper:

⇒ Output voltage is less than input voltage.

⇒ The thyristor in the circuit acts a switch.

⇒ when thyrister is ON. Supply voltage appear across the load.

⇒ when thyrister is OFF, the voltage across the load will be zero.

⇒ practical arrangment includes on inductor L and diode which are used to eliminate current pulsation providing a smoth DC current.

⇒ with S closed, D is off and it remain off and it remain off as long as S in ON.

⇒ The input current build up exponentially and flow through L & Load.

⇒ V_0 equal to V_1

⇒ With S off or open, the current through I decay to zero.

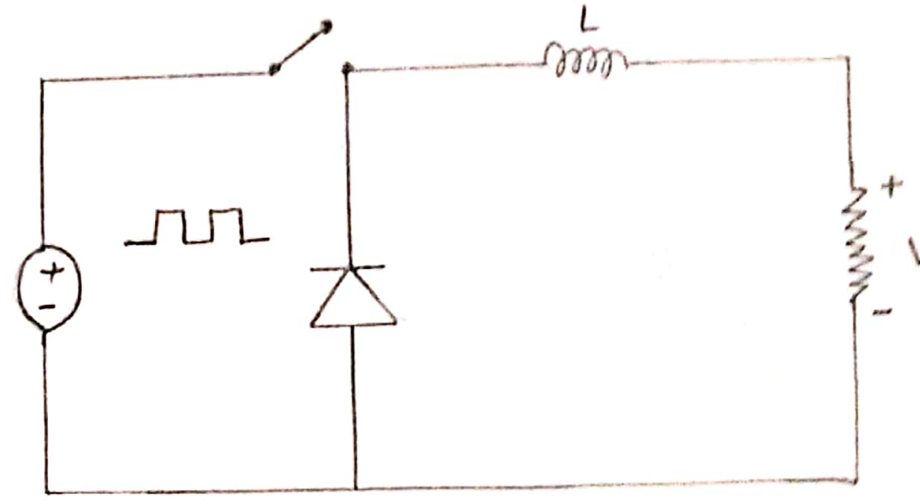
⇒ This cause inductive voltage with opposite polarity across L.

⇒ V_2 forward bias diode D.

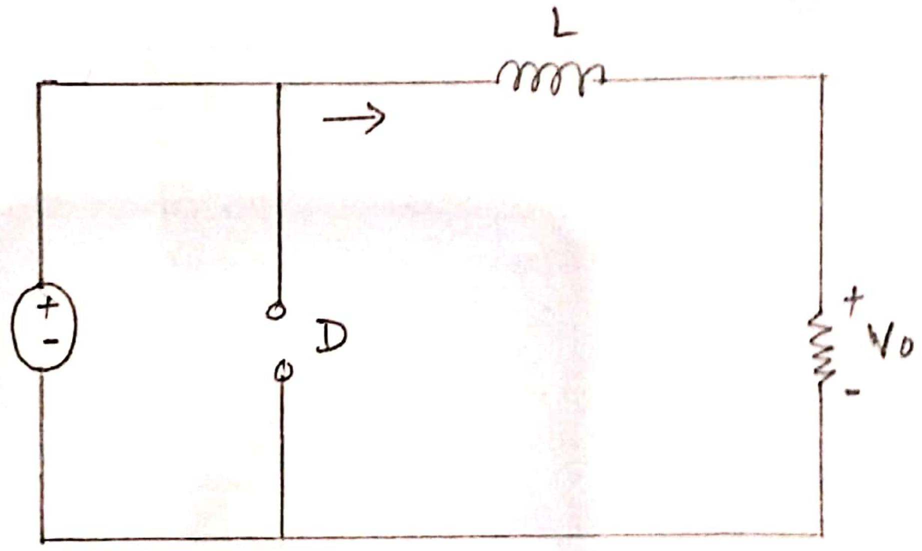
⇒ Current flows through L & Load diode D.

⇒ This arrangment permit the use of simple filtter inductance L to provide a satisfactority smoth DC Load current.

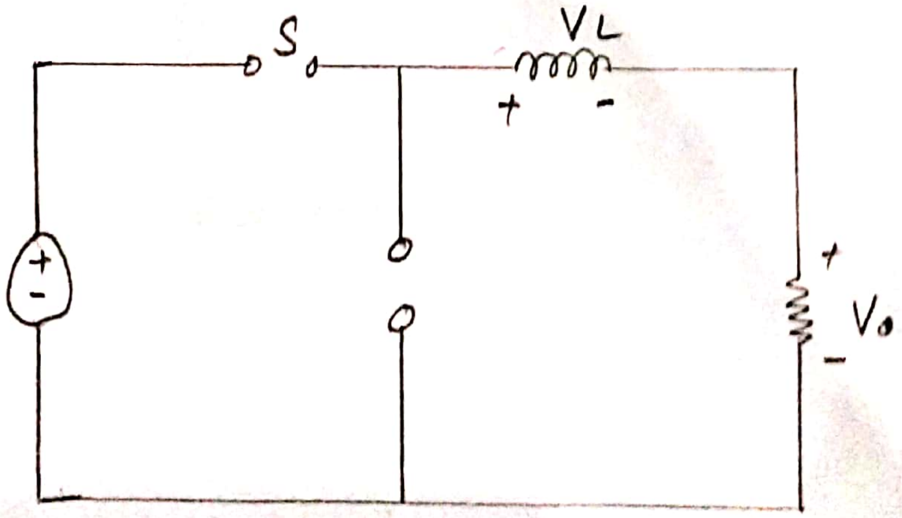
⇒ With high switch frequencey, smaller inductance is sufficient to get desired output.



Circuit of Buck Converter



Circuit when closed



Circuit when switch is open

Given Data:

$V_{in} = 50V$

$D = 0.22\ \%$

$R = 13\ \Omega$

Frequency $(f) = 20\ KHz$

1) ⇒ V_{out}

we know that

$V_{out} = \alpha \times V_s$ OR $D \times V_s \longrightarrow ①$

Here α = Duty cycle.

which $22\ \% = 0.22$

putting all value in eq ①

$V_{out} = (0.22)(50)$

$V_{out} = 11\ V$

2 ⇒ I_{out} :

$$I_{out} = V_o / R$$

$$= \frac{11}{13}$$

$$I_{out} = 0.846 \text{ A}$$

3 ⇒ I_{in} :

we know that

$$I_o = \frac{I_i}{\alpha \cdot RD}$$

$$I_i = I_o \times D$$

$$I_i = 0.846 \times 0.22$$

$$I_i = 0.186$$

4 ⇒ Inductor :

we know that

$$L = \frac{T \cdot OFF}{2} \times R$$

Let Suppose T.OFF = 0.009

$$L = \frac{0.006}{2} \times 13$$

$$L = 0.039 \text{ H}$$

Question - 4

Boost Chopper:

⇒ The output voltage is more that the input voltage by saveral time.

⇒ L is used to provide smooth input current.

⇒ The SCR (S) acts as the switch which work in PWM mode.

⇒ With S ON, the L is connected to the supply.

⇒ Load voltage V_L jumps instantaneously to V_1 but current through L increase linearly & stored energy.

⇒ When S is open, the current collapses and energy stored in L is transfered to C through D.

⇒ The induced voltage across the inductor reverse and adds to source voltage, increasing output voltage.

⇒ The current that was flowing through S now flow through L, D & C to load.

⇒ Energy stored in inductor is released to load.

⇒ When S closed again, D becomes reverse baise, the capacitor energy supplied the load voltage and cycle again

$$V_o = V_i + V_L$$

⇒ V_o is always higher than V_1 as polarity of inductor voltage V_L is same as V_1.

⇒ If inductor L is very Large, source current I_1 is ripple free & considered constant $W_{ON} = V_1 T_i T_{ON}$

⇒ Assuming C to be large enough to neglect the voltage ripple, V_0 is considered constant.

$$W_{OFF} = (V_0 - V_i) * I_i * T_{OFF}$$

⇒ Since Losses are neglect, the energy stored transfered during T_{OFF} by L min be equal to energy gained during T_{ON}

$$W_{ON} = W_{OFF} = V_i I_i T_{ON}$$

$$= (V_0 - V_i) * I_i * T_{OFF}$$

$$V_0 = V_1 \left(1 + \frac{T_{ON}}{T_{OFF}}\right) = V_1 \left(\frac{T}{T - ON}\right)$$

$$V_i \left(\frac{1}{1 - \frac{T_{ON}}{T}}\right) = V_i \left(\frac{1}{1-d}\right)$$

Thus V_0 is always greater than V_1

$\Rightarrow P_1 = P_0 \rightarrow V_1 I_1 = \frac{V_0^2}{R} \Rightarrow I_1 = \frac{V_0^2}{V_L} * \frac{1}{R}$

$\Rightarrow I_0 = I_1 \times \frac{T_{OFF}}{T} \Rightarrow I_0 = I_1 (1-d)$

$\Rightarrow P_0 = P_1 \Rightarrow V_1 I_1 \Rightarrow \frac{V_0^2}{R} = \frac{V_i^2}{(1-d)^2} * \frac{1}{R}$

$$\Rightarrow I_1 = \frac{V_1}{(1-d)^2} * \frac{1}{R}$$

$$\Rightarrow I_L = \frac{V_1}{(1-d)^2} * \frac{1}{R}$$

$$\Rightarrow I_L = \frac{I_{max} + I_{min}}{2} = I_1$$

$$\Rightarrow I_{max} + I_{min} = 2 * I_1$$

$\Rightarrow$ voltage across L is;

$$V_L = V_1 = L * \frac{di}{dt}$$

$$\Delta I_1 = \frac{V_1}{L} * T_{ON}$$

Given Data :-

$V_{in} = 50V$

duty cycle $D = 0.22\%$

Resistor $R = 13\Omega$

frequency $F = 20\ kHz$

1 => V_{out}

As we know

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

$$V_o = 50 \left(\frac{1}{1-0.22} \right)$$

$$V_o = 50 \left(\frac{1}{0.78} \right)$$

$$V_o = 64.10$$

2 => I_{out}

$$I_o = I_1 (1-d) \longrightarrow ①$$

First finding I_{in}

$\Rightarrow$ I in

$$I_{in} = \frac{V_i}{(1-d)^2} * \frac{1}{R}$$

$$I_{in} = \frac{50}{(1-0.22)^2} \times \frac{1}{13}$$

$$I_{in} = \frac{50}{(0.78)^2} \times \frac{1}{13}$$

$$I_{in} = \frac{50}{0.6084} \times \frac{1}{13}$$

$$I_{in} = 148.63 \times \frac{1}{13}$$

$$I_{in} = 6.32 \text{ A}$$

Putting this values in eq ①.

$$I_{out} = I_1 (1-d)$$

$$I_{out} = 6.32 (1-0.22)$$

$$I_{out} = 4.9296 \text{ A}.$$

Question - 5

⇒ Buck - Boost chopper:

⇒ It combines the concept of both step-up & step-down chopper.

⇒ The output voltage is either higher or lower than input voltage.

⇒ The output voltage polarity also be reserved.

⇒ The switch is either an SCR or GTO or IGBT.

⇒ when S in ON, D is reverse biase and I_D is zero.

⇒ While S is OFF, the source is disconnected

⇒ The current through inductor does not change instantanously and it forward biase the diode, providing path for the load.

⇒ With S = ON (T_{ON}) ; $W_{ON} = V_1 * I_1 * T_{ON}$

⇒ with $S = OFF (T_{OFF})$;

$$W_{OFF} = V_1 * I_1 \times T_{OFF}$$

⇒ Ignoring losses;

$$W_{ON} = W_{OFF} = V_1 * I_1 * T_{ON}$$

$$\Rightarrow V_1 * I_1 * T_{OFF}$$

$$\Rightarrow V_0 = V_1 \frac{dt}{(1-d)T} = V_1 \frac{d}{(1-d)}$$

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

$$I_1 = I_L d = \frac{(I_{max} + I_{min})}{2} \times d$$

The average and put $P_1 = V_1 I_1$

$$= \left(\frac{I_{max} + I_{min}}{2}\right)$$

$\times dv \Rightarrow P_0 = \frac{V_0^2}{R}$

$$I_{max} - I_{min} \Rightarrow \frac{V_i}{L} T_{ON}$$

Again $I_{max} + I_{min} = 2 * I_1$

Now,

$$I_{max} = V_1 \left[\frac{1}{R(1-d)^2} + \frac{T_{ON}}{2L} \right]$$

$$I_{min} = V_1 \left[\frac{1}{R(1-d)^2} - \frac{T_{ON}}{2L} \right]$$

$$I_{P-P} = I_{max} - I_{min} = \frac{V_1 T_{ON}}{L}$$

For continous current mode.

$$I_{min} = V_1 \left[\frac{1}{R(1-d)^2} - \frac{T_{ON}}{2L} \right]$$

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

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

Given Data :-

$V_{in} = 50V$

$V_{out} = 22\% = 0.22$

Resistor (R) = 13Ω

Frequency $f = 20 kHz$

1 ⇒ Duty cycle (D)

we know that

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

$$V_o = \frac{V_i d}{1-d}$$

$$\Rightarrow 0.22 = 50 \frac{d}{1-d}$$

$$\Rightarrow 0.22(1-d) = d50$$

$$\Rightarrow 0.22 - 0.22d = d50$$

$$\Rightarrow 0.22 = d50 + 0.22$$

$0.22 = 50.22 d$

$\Rightarrow d = 0.0022$

2 $\Rightarrow$ I_{out}

we know that

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

$$= \frac{2(0.0022) 50}{13(1-0.0022)^2}$$

$$= \frac{0.22}{12.94}$$

$I_{max} + I_{min} = 0.0017 \rightarrow (1)$

we know that

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

putting eq (1) in place of $I_{max} + I_{min}$

$I_{out} = \frac{0.0017}{2} \Rightarrow 0.00085A$

3 ⇒ $I_i = ?$

$$I_i = I_L d$$

$$I_i = 0.00085 \times 0.0022$$

$$I_i = 000.0000016 \text{ A}$$

4 ⇒ Inductor:

$$L = \frac{RTd}{2} (1-d)^2$$

putting value where $T = 1/F$

$$L = \frac{13(5 \times 10^{-5}) \times 0.0022}{2} (1 - 0.0022)^2$$

$$L = \frac{0.0000014}{2} (0.99)$$

$$\Rightarrow L = 6.93 \times 10^{-7} \text{ H}$$