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

Course Details

Course Title: Power Electronics **Module:** 8
Instructor: Sir engr-shahyan 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	CLO 3 Marks 10

	3. Iin 4. Inductor (L)	
Q4	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

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).

Answer:

Classification of Rectifiers based on Control:

- The converter circuit which converts AC to DC is called a Rectifier.
- The rectifier circuit using diodes only is called an Uncontrolled rectifier circuit.
- All rectifiers are broadly categorized into three sections.
- Controlled Rectifier - It has only thyristors. NO diodes
- Half Controlled Rectifier - It has thyristor + diodes
- Uncontrolled Rectifier - Only diodes
- Control here means controlling when to start rectification and when to stop.

Classification of Uncontrolled Rectifiers:

- Single Phase Half Wave Uncontrolled Rectifier (with R load, RL load and RL with FD)

- Single Phase Full Wave Uncontrolled Rectifier.
- Centre Tapped (Mid Point) Rectifier
- Bridge Rectifier
- Three Phase Full Wave Uncontrolled Rectifier.

3 – φ Half Wave Rectifier

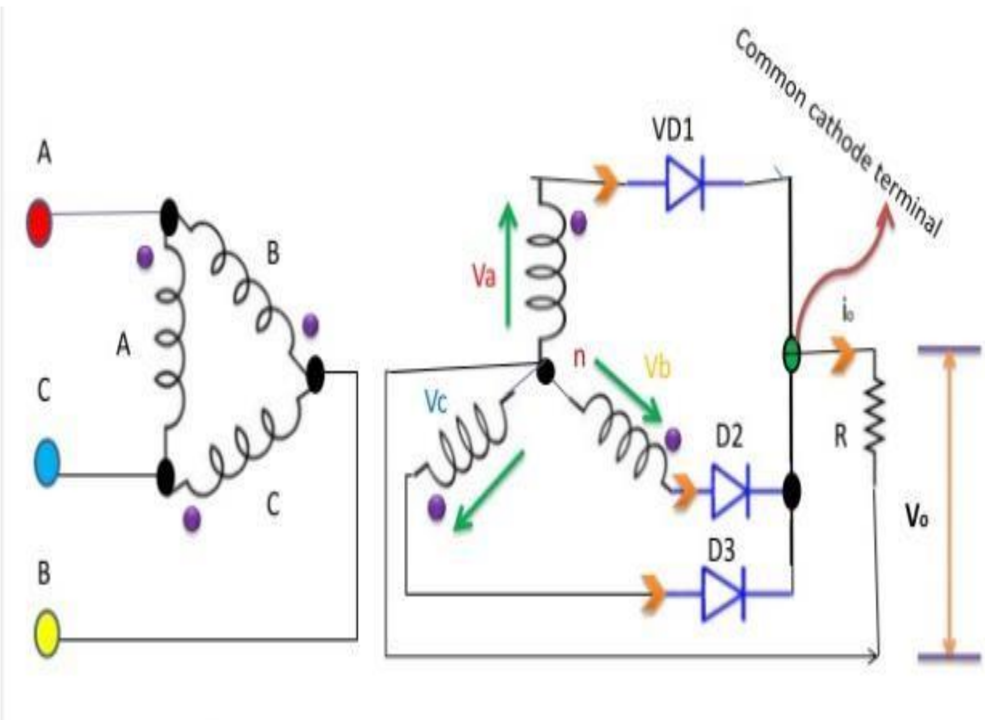
3 – φ Mid Point 6 Pulse Rectifier

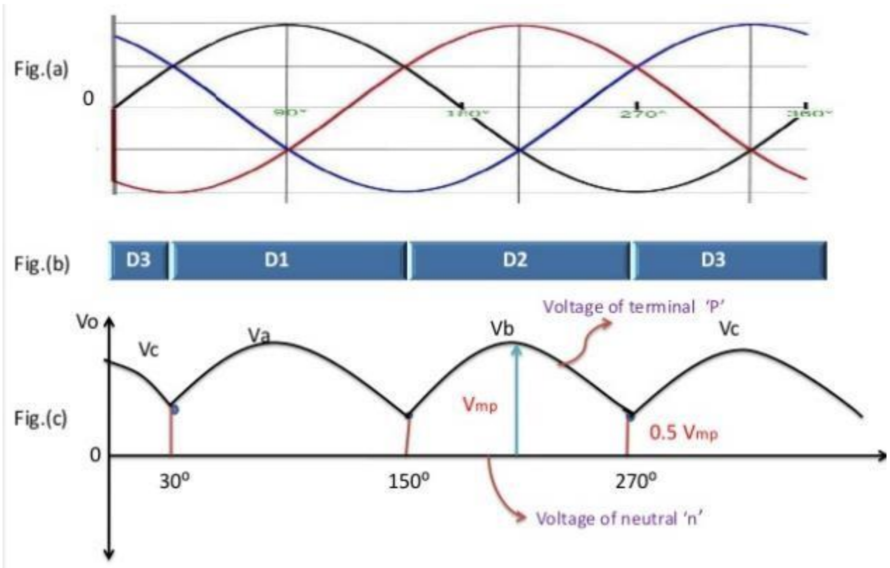
3 – φ Bridge Rectifier

3 – φ 12 Pulse Rectifier

φ Half – Wave Rectifier:

It uses a 3 – φ transformer with primary in delta and secondary in star connection. D1, D2 and D3 have common connected cathode to common load R and all diodes are oriented in different phases and therefore called as Common – Cathode Circuit.





- The rectifier element connected to the line at the highest +ve instantaneous voltage can only conduct and pulsates between V max and 0.5 V max.
- It is called 3 – φ 3 pulse rectifier as the o/p is repeated thrice in every cycle of V s.
- The ripple frequency (f r) of the o/p voltage is

$fr \quad = nfs;\ n = no.\ of\ diodes,\ fs = AC\ supply\ freq.$

- The ON diode connects its most +ve source terminal to the other two diode cathodes

keeping the other diodes OFF.

- The sudden switchover from one diode to another is called "commutation".
- Each diode conducts for 120 º intervals.
- Delta connection provides path for triplen (odd multiples of the 3rd harmonic) harmonic

currents stabilizing the voltage on star secondary.

Full wave uncontrolled Rectifier:

On the positive half cycle of transformer secondary supply voltage, diodes D1 and D2 conduct, supplying this voltage to the load.

On the negative half cycle of supply voltage, diodes D3 and D4 conduct supplying this voltage to the load.

It can be seen from the waveforms that the peak inverse voltage of the diodes is only V m

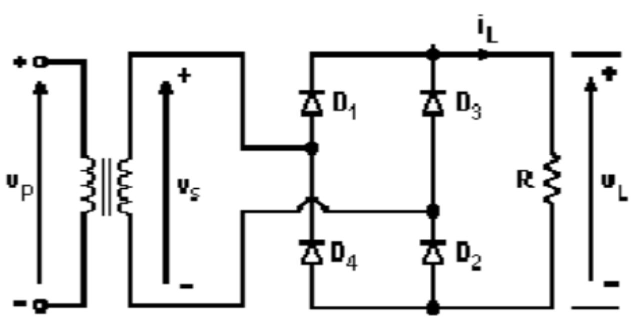
The average output voltage is the same as that for the centre - tapped transformer full- wave rectifier.

$Peak\ Repetitive\ Diode\ Current\ I =$ / R

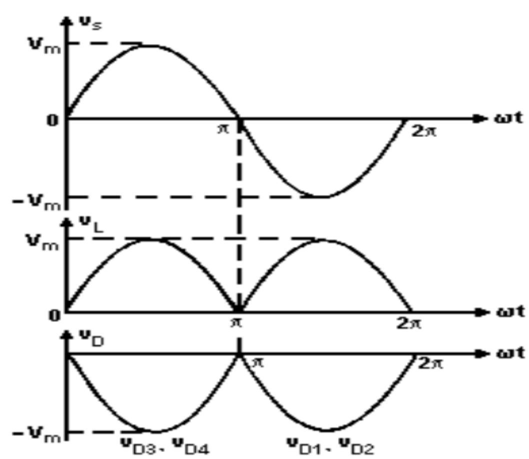
$Av.\ Output\ Voltage\ V = 2Vm/\pi$

$RMS\ Output\ Voltage =$ 2Vs

$Av.\ Diode\ Current\ I = 1/\pi\ \ 2\sin\omega t\ d\ (\omega t) = \ Im/\pi$



(a) Circuit diagram



(b) Waveforms

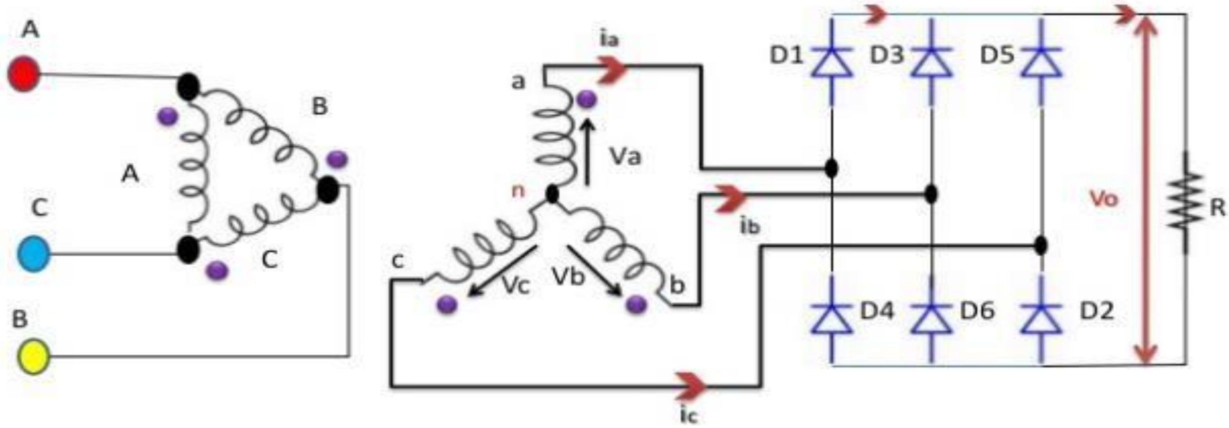
(2)

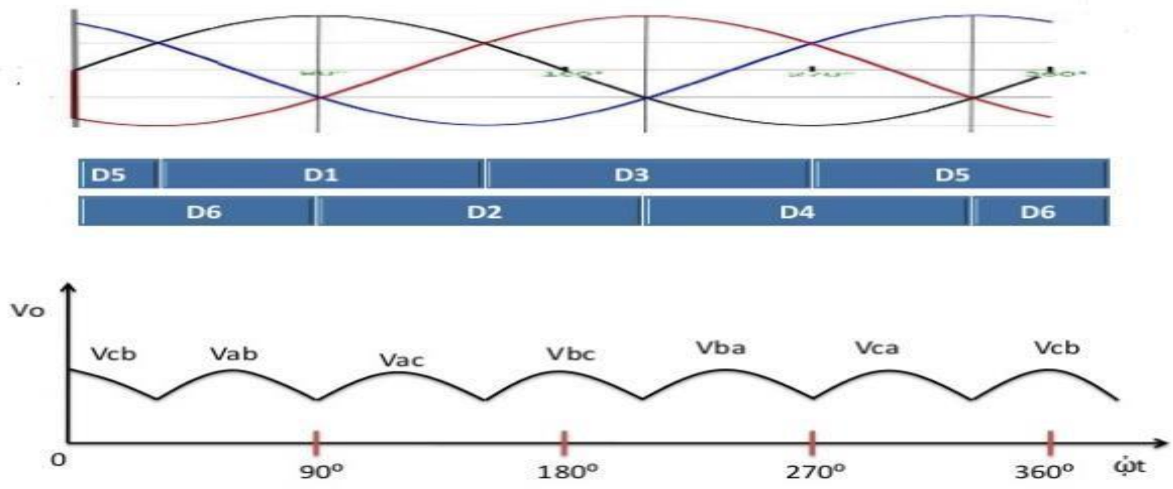
Uncontrolled bridge rectifiers:

- Two series diodes are always conducting while four diodes are blocking.
- One of the conducting diodes is odd numbered while the other is even numbered.
- Each diode conducts for 120 º.
- Current flows out from the most +ve source terminal through an odd numbered diode through the load followed by the even numbered diode and then back to the most –ve source terminal.
- Output has less ripples and the diodes are numbered in accordance to their conductance.
- The bridge uses both the +ve and –ve halves of the i/p voltage.
- Ripple frequency is 6*f.
- Upper set of diodes constitutes the +ve group while the lower set constitutes the –ve.
- Transformer Primary – Secondary is in Delta – Star configuration.
- The diode with the most +ve voltage will be conducting.
- B is chosen as reference.
- During 0º - 30º, the voltage at C is highest (arbitrarily). Hence D5 is conducting as it is the most +ve.
- Between 30º and 150º, A becomes the most +ve and hence conducting.
- During 150º - 270º, B being most +ve conducts.
- The cycle repeats itself.

o Each diode conducts for 120º.

Output Voltage V= 1/ π3 2π/3 sin ωtd (ωt) 3Vm/ π = 0.955





Controlled Rectifiers:

The converter circuit which converts AC to DC is called a Rectifier.

The rectifier circuit using diodes only is called an Uncontrolled rectifier circuit. All rectifiers are broadly categorized into three sections.

1. Controlled Rectifier - It has only thyristors. NO diodes
2. Half Controlled Rectifier - It has thyristor + diodes
3. Uncontrolled Rectifier - Only diodes

Control here means controlling when to start rectification and when to stop.

Unlike diode, an SCR does not become conducting immediately after its voltage has become positive.

It requires triggering by means of pulse at the gate.

So it is possible to make the thyristor conduct at any point on the half wave which applies positive voltage to its anode.

Thus the output voltage is controlled.

Steel rolling mills, paper mills, textile mills where controlling of DC motor speed is necessary.

- Electric traction.
- High voltage DC transmissions.
- Electromagnet power supplies.

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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.

Answer:

Given data:

Vm=73

R=68ohm

Solution:

Q2

$V_m = 71$

$R = 13$

Find V_{DC}, I_{DC}, V_{rms}, I_{rms}

(i) $V_{DC} = ?$

$V_{DC} = \frac{V}{\pi}$

$V_{rms} = \frac{V_m}{2} = 4.5V$

$I_{rms} = \frac{V_m}{2R} = \frac{71}{2(13)} = \frac{71}{26}$

$= 2.73A$

$I_{dc} = \frac{V_m}{\pi R} = \frac{71}{(3.14)(13)} = \frac{71}{40.82}$

$I_{dc} = 1.73$

1-Q Full bridge rectifier

$V_s = V_o = V_{dc} = \frac{2V_m}{\pi} = \frac{2(71)}{3.14}$

$= \frac{142}{3.14}$

$V_{dc} = 45.22V$

$I_{dc} = \frac{V_m}{R} = \frac{71}{13} = 5.46A$

$I_{dc} = 5.46A$

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

$= \sqrt{2}(45.22V)$

$= 63.76$

4.Irms=Im/2=5.46/2=8.73

5. Where as in center tapped rectifierthe invers voltage coming across each diode double the maximum voltage across the half the secondary windings the transformer utilization factor also more is bridge rectifier as compared to the center tapped full wave rectifier within make it more advantage.

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)

Answer:

Step Down (Buck) Chopper:

Output Voltage is less than input voltage.

The thyristor in the circuit acts as a switch.

When thyristor is ON, supply voltage appears across the load

When thyristor is OFF, the voltage across the load will be zero.

Practical arrangement includes an inductor (L) and a diode which are used to eliminate current pulsations providing a smooth DC current.

With S closed, D is Off and it remains Off as long as S in On.

The i/p current builds up exponentially and flows through L and load.

V O equals V I.

With S OFF or open, the current through L decays to zero.

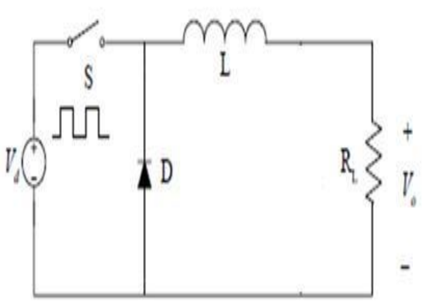
This causes an inductive voltage with opposite polarity across L.

V L forward biases diode D.

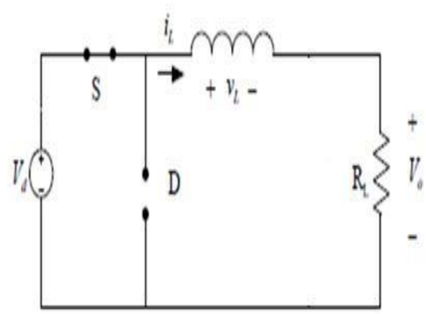
Current flows through L, Load and D.

This arrangement permits the use of simple filter inductance L to provide a satisfactorily smooth DC load current.

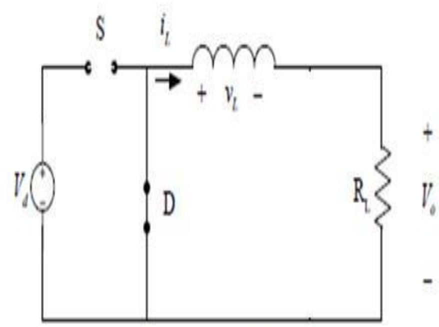
With higher switching frequency, smaller inductance is sufficient to get desired O/P.



CIRCUIT OF BUCK CONVERTER



CIRCUIT WHEN SWITCH IS CLOSED



CIRCUIT WHEN SWITCH IS OPENED

The o/p voltage is equal to the i/p voltage when the switch is ON and D is reverse biased.

Diode current is same as the load current during T OFF.

During T ON, I O is same as I I.

Step Down (Buck) Chopper – Continuous Current:

As elements are ideal, DC power drawn from source must equal the DC power absorbed by load.

Step Down (Buck) Chopper – Continuous current:-

⇒ The average value of Inductor current is:

$$I_L = \frac{I_{max} + I_{min}}{2} = I_0 = V_0/R$$

= Again $V_L = V_0 = L\frac{d_0}{dt} \to \frac{d}{t} = \frac{V_0}{L} \to \Delta_0 = \frac{V_0}{L}\Delta$

⇒ with switch open.

$$P\text{-}P = \Delta_0 = I_{max} - I_{min} = \frac{V_0}{L}T_{OFF}$$

= Hence

$$I_{max} = \frac{V_0}{R} + \frac{V_0}{2}T_{OFF} \quad I_{min} = \frac{V_0}{R} - \frac{V_0}{2L}T_{OFF}$$

$I_D = \frac{I T_{OFF}}{T}$; $I_0 = \frac{I}{d}$; d = du.

$PO = Pi \rightarrow VoIo = Vi\,Ii$

Step Down (Buck) Chopper – Discontinuous Current:

For low value of “d” with low L, I L decreases and may fall to zero during T OFF.

It again builds up with T ON, and hence it is called discontinuous current

This mode is undesirable and is avoided by proper selection of chopping frequency and L.

The minimum value of L for continuous current mode is ensured by setting I min = 0.

Imin=0=Vo/R-Vo/RToff

Vo/R=ToFF=VO/2L

2L=TOFFR

L=Tooff/2R

A Buck converter is a switch mode DC to DC electronic converter in which the output voltage will be transformed to level less than the input voltage. It is also called as step down converter. The name step down converter comes from the fact that analogous to step down transformer the input voltage is stepped down to a level less than the input voltage. By law of conservation of energy the input power has to be equal to output power (assuming no losses in the circuit).

Input power (Pin) = output power (Pout)

Since Vin > Vout in a buck converter, it follows then that the output current will be greater than the input current. Therefore in buck converter

$$Vin > Vout \text{ and } Iin < Iout$$

Principle of operation of Buck converter:

The main working principle of buck converter is that the inductor in the input circuit resists sudden variations in input current. When switch is ON the inductor stores energy in the form of magnetic energy and discharges it when 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 compared to switching period ensures a constant output voltage Vo(t) = Vo(constant)

Modes of operation of Buck converter

The buck converter can be operated in two modes

a) Continuous conduction mode in which the current through inductor never goes to zero i.e. inductor partially discharges before the start of the switching cycle.

b) Discontinuous conduction mode in which the current through inductor goes to zero i.e. inductor is completely discharged at the end of switching cycle.

Circuit analysis of Buck converter:

Assume in the entire analysis that the current swing (maximum to minimum value) through inductor and voltage swing through capacitor is very less so that they vary in a linear fashion. This is to ease the analysis and the results we will get through this analysis are quite accurate compared to real values.

Continuous conduction mode

case-1: When switch S is ON

When switch in ON for a time ton, the diode will be open circuited since it is in reverse biased condition(the n side of diode is at higher voltage(Vin) compared to p side which is shorted to ground through the switch). Hence the buck converter can be redrawn as follows

During this state the inductor charges and the inductor current increases. The current through the inductor is given as

$$I_L = (1/L) * \int V * dt$$

Assume that prior to the opening of switch the inductor current is I'L, off. Since the input voltage is constant

$$I_{L,on} = (1/L) * \int (V_{in} - V_{out}) * dt + I'_{L,on}$$

Assume the switch is open for ton seconds which is given by D*Ts where D is duty cycle and Ts is switching time period. The current through the inductor at the end of switch on state is given as

IL, on = (1/L) *(Vin-Vout)*D*Ts + I'L, on (equation 1)

Hence ΔIL,on = (1/L)*(Vin-Vout)*D*Ts.

case 2: When switch is off

When switch in OFF the diode will be forward biased (short circuited to ground) and the buck converter circuit can be redrawn as follows

The inductor now discharges through the diode and RC combination. Assume that prior to the closing of switch the inductor current is I''L, off. The current through the inductor is given as

$$I'''_{L,off} = -(1/L) * \int V_{out} * dt + I''_{L,off}$$

Note the negative sign at the front end of equation signifies that the inductor is discharging. Assume the switch is open for toff seconds which is given by (1-D)*Ts where D is duty cycle and Ts is switching time period. The current through the inductor at the end of switch off state is given as

I'''L, off = -(1/L) *Vout*(1-D)*Ts + I''L, off (equation 2)

In steady state condition as the current through the inductor does not change abruptly, the current at the end of switch on state and the current at the end of switch off state should be equal. Also the currents at the start of switch off state should be equal to current at the end of switch on state. Hence

$$I'''_{L,off} = I_{L,on} \quad \text{also} \quad I'_{L,off} = I''_{L,off}$$

Using the equations 1 and 2 we get

(1/L) *(Vin-Vout)*D*Ts = (1/L) *Vout*(1-D)*Ts

(Vin-Vout)*D =Vout*(1-D)

Vin* D= Vout*(1-D+D)

Vout/Vin = D(duty cycle)

Since D < 1, Vout < Vin. Assuming no losses in the circuit and applying the law of conservation of energy

$$Vout*Iout = Vin*Iin$$

This implies Iout/Iin = 1/D, Thus Iout > Iin. As the duty cycle increases the output voltage increases and output current decreases.

Discontinuous conduction mode

As mentioned before the converter when operated in discontinuous mode the inductor drains its stored energy completely before completion of switching cycle. The current and voltage wave forms of buck converter in discontinuous mode is shown in the figure below

The inductor in discontinuous mode drains all the current which it piled up in charging interval of same switching cycle. The current through the inductor is given as

= (1/L)*area under the curve of voltage v/s time. Hence from the wave forms shown in the figure

$$Vout*\delta*Ts = (Vin-Vo)*D*Ts$$

$$Vout/Vin = D/(D+\delta)$$

and the ratio of output to input current from law of conservation of energy is Iout/Iin =(D+ δ)/D.

<u>Applications of Boost converter:</u>

Buck converters are used in self-regulating power supplies.

They are used as low-loss current sources to drive LED arrays(solid state lighting applications).

Used as interface between battery and components in Notebooks.

Buck converters are used as Point-of-load (POL) converters in servers

Buck converters are used in advanced telecom and datacom systems

Part(B).

Data:

$V_{in} = 50V$

duty Cycle = $d = 71\% = 0.71$

↳ last digits of ID (13171)

$R = 13\,\Omega$

↳ First digits of ID (13171)

$f = 20khz = 20000\,Hz$

(i)

$V_{out} = ?$

$V_o = d(V_i)$

$= (0.71)(50)$

$V_o = 35.5\,V$

(ii)

$I_{out} = ?$

$I_{out} = \frac{V_o}{R}$

$I_o = \frac{35.5V}{13}$

$I_o = 2.73\,A$

(iii) $I_{in} = ?$

$I_{in} = \frac{V_i}{R}$

$I_{in} = \frac{50}{13}$

$I_{in} = 3.84\,A$

~~(iv)~~ Inductor. (L)

(iv) Inductor (L) = ?.

$$L = \frac{T_{OFF}}{2} * R \quad \text{—(1)}$$

As we know that

$V_o = d V_i$

$$d = V_o / V_i = \frac{35.5}{50} = 0.71$$

(*) $\frac{T_{ON}}{T} = 0.71$ $\qquad \therefore d = \frac{T_{ON}}{T}$

$T_{ON} = 0.71 * T$ $\qquad \therefore T = \frac{1}{f}$

$$T_{ON} = \frac{0.71}{f}$$

$$T_{ON} = \frac{0.71}{20(10^3)\,Hz} = 35.5\,\mu s$$

Also from equation (*) we have.

$$\frac{T_{ON}}{T} = 0.71$$

$$\frac{T_{ON}}{0.71} = T \Rightarrow \frac{35.5\,\mu s}{0.71} = 50\,\mu s$$

Now

(**) $T = T_{ON} + T_{OFF}$

$T_{OFF} = T - T_{ON}$

$T_{OFF} = 50\,\mu s - 35.5\,\mu s = 15\,\mu s$

$T_{OFF} = 15\,\mu s$

Now put this value in eqn (1) we get $L = \frac{15\,\mu s}{2} \times 13$ $= 97.5\,\mu H$

Q4

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)

Answer:

What is a Boost Converter:

A boost converter is one of the simplest types of switch mode converter. As the name suggests, it takes an input voltage and boosts or increases it. All it consists of is an inductor, a semiconductor switch (these days it's a MOSFET, since you can get really nice ones these days), a diode and a capacitor. Also needed is a source of a periodic square wave. This can be something as simple as a 555 timer or even a dedicated SMPS IC like the famous MC34063A IC.

As you can see, there are only a few parts required to make a boost converter. It is less cumbersome than an AC transformer or inductor.

They're so simple because they were originally developed in the 1960s to power the electronics systems on aircraft. It was a requirement that these converters be as compact and as efficient as possible.

The biggest advantage boost converters offer is their high efficiency – some of them can even go up to 99%! In other words, 99% of the input energy is converted to useful output energy, only 1% is wasted.

How Does a Boost Converter Work:

It's time to take a really deep breath, we're about to plunge into the depths of power electronics. I'll say at the outset that it is a very rewarding field.

To understand the working of a boost converter, it is mandatory that you know how inductors, MOSFETs, diodes and capacitors work.

With that knowledge, we can go through the working of the boost converter step by step.

STEP – 1

Here, nothing happens. The output capacitor is charged to the input voltage minus one diode drop.

STEP – 2

Now, it's time to turn the switch on. Our signal source goes high, turning on the MOSFET. All the current is diverted through to the MOSFET through the inductor. Note that the output capacitor stays charged since it can't discharge through the now back-biased diode.

The power source isn't immediately short circuited, of course, since the inductor makes the current ramp up relatively slowly. Also, a magnetic field builds up around the inductor. Note the polarity of the voltage applied across the inductor.

STEP – 3

The MOSFET is turned off and the current to the inductor is stopped abruptly.

The very nature of an inductor is to maintain smooth current flow; it doesn't like sudden changes in current. So it does not like the sudden turning off of the current. It responds to this by generating a large voltage with the opposite polarity of the voltage originally supplied to it using the energy stored in the magnetic field to maintain that current flow.

If we forget the rest of the circuit elements and notice only the polarity symbols, we notice that the inductor now acts like a voltage source in series with the supply voltage. This means that the anode of the diode is now at a higher voltage than the cathode (remember, the cap was already charged to supply voltage in the beginning) and is forward biased.

The output capacitor is now charged to a higher voltage than before, which means that we have successfully stepped up a low DC voltage to a higher one!

I recommend that you go through the steps once again very slowly and understand them intuitively.

These steps happen many thousands of times (depending on the frequency of the oscillator) to maintain the output voltage under load.

The basic principle of a Boost converter consists of 2 distinct states

in the On-state, the switch S is closed, resulting in an increase in the inductor current;

in the Off-state, the switch is open and the only path offered to inductor current is through the flyback diode D, the capacitor C and the load R. This results in transferring the energy accumulated during the On-state into the capacitor.

The input current is the same as the inductor current as can be seen in figure 2. So it is not discontinuous as in the buck converter and the requirements on the input filter are relaxed compared to a buck converter.

Step Up (Boost) Chopper:

The output voltage is more than the input voltage by several times.

L is used to provide a smooth i/p current.

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

With S On, the L is connected to the supply.

Load voltage V L jumps instantaneously to V I, but current through L increases linearly & stores energy.

When S is Open, the current collapses and energy stored in L is transferred to C through D.

The induced voltage across the inductor reverses and adds to the source voltage increasing the O/P voltage.

The current that was flowing through S now flows through L, D and C to the load.

Energy stored in the inductor is released to the load.

⇒ Step up (Boost) Chopper:-

= with S closed again D becomes reverse based the capacitor energy supplies the load voltage and the cycle repeats.

$$V_O = V_i + V_L$$

⇒ V_O is always higher than V_I as polarity of inductor voltage V_L is same as V_I.

⇒ $W_{ON} = V_I T_{ON}$

⇒ $W_{OFF} = (V_O - V_i) * I * T_{OFF}$.

⇒ $W_{ON} = W_{OFF} = V_I T_{ON} = (V_O - V_I) * I * T_{OFF}$

$$V_O = V_I \left(1 + \frac{T_{ON}}{T_{OFF}}\right) = V_I \left(\frac{T}{T - T_{ON}}\right) = V_I \left(\frac{1}{1 - \frac{T_{ON}}{T}}\right) = V_I \left(\frac{1}{1-d}\right)$$

⇒ Thus V_O is always greater than V_I.

= $P_I = P_O \rightarrow V_I F = O \rightarrow I = O V^2 * R \quad \frac{V^2}{V_I} \frac{1}{R}$.

= $b = \bar{I} * \frac{T_{OFF}}{T} \Rightarrow b = I 1 - d ( )$

= $P_O - P_I \Rightarrow V_I = O = \frac{V^2}{R} \frac{V^2_I}{(1-d)^2} * \frac{1}{R}$

= $I_I = \frac{V_I}{(1-d)^2} * \frac{1}{R}$

= $I_L = \frac{I_{max} + I_{min}}{2} = I_I \Rightarrow \therefore I_{max} + I_{min} = 2 \times I$

⇒ Voltage arcoss L is

⇒ $V_L = V_i = L * \frac{di}{dt}$ o $d = \frac{V_I}{tL}$

= $V_I = \frac{V_I}{L} T_{ON}$ o $I_{max} - I_{min} = \frac{V_I}{L} T_{ON}$ $I_{max} + I_{min} = 2 \times I\ I$

Solving:-

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

= $I_{p\text{-}p} = I_{max} - I_{min} = \frac{V_I T_{ON}}{L}$

⇒ For continous current mode $I_{min} = 0 = V$

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

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

Part (B)

Given data:

Vin=50v

D=71

R=13ohm

f=20hz

to find.

1. Vout
2. Iout
3. Iin
4. Inductor (L)

Solution:

We kown that.

1.Vout=vo=d(vi)=(0.71)(50)=35.5v

2.Iout=vo/R=35.5/13=2.73A

3.Iin=vi/R=50/13=3.84A

4. L=Toff/2*R

Vo=Dvi=D=Vo/vi=35.5/50=0.71

Q(5).
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)

Answer:

Buck – Boost Chopper:

It combines the concept of both the step – up and step – down choppers.

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

The output voltage polarity can also be reversed.

The switch is either an SCR or GTO or IGBT.

When S in ON, D is reverse biased & I D is zero.

The voltage across L is equal to the i/p voltage.

The capacitor supplies energy to the output load

The current through the inductor increases linearly with time.

With S OFF, the source is disconnected.

The current through inductor does not change instantaneously and it forward biases the diode, providing a path for the load current.

O/P voltage becomes equal to the inductor voltage.

The buck boost converter is a DC to DC converter. The output voltage of the DC to DC converter is less than or greater than the input voltage. The output voltage of the magnitude depends on the duty cycle. These converters are also known as the step up and step down transformers and these names are coming from the analogous step up and step down transformer. The input voltages are step-up/down to some level of more than or less than the input voltage. By using the low conversion energy, the input power is equal to the output power. The following expression shows the low of a conversion.

Input power (Pin) = Output power (Pout)

For the step up mode, the input voltage is less than the output voltage (Vin < Vout). It shows that the output current is less than the input current. Hence the buck booster is a step up mode.

Vin < Vout and Iin > Iout

In the step down mode the input voltage is greater than the output voltage (Vin > Vout). It follows that the output current is greater the input current. Hence the buck boost converter is a step down mode.

Vin > Vout and Iin < Iout

What is a Buck Boost Converter

It is a type of DC to DC converter and it has a magnitude of output voltage. It may be more or less than equal to the input voltage magnitude. The buck boost converter is equal to the fly back circuit and single inductor is used in the place of the transformer. There are two types of converters in the buck boost converter that are buck converter and the other one is boost converter. These converters can produce the range of output voltage than the input voltage. The following diagram shows the basic buck boost converter.

Buck Boost Converter

Working principle of Buck-Boost Converter:

The working operation of the DC to DC converter is the inductor in the input resistance has the unexpected variation in the input current. If the switch is ON then the inductor feed the energy from the input and it stores the energy of magnetic energy. If the switch is closed it discharges the energy. The output circuit of the capacitor is assumed as high sufficient than the time constant of an RC circuit is high on the output stage. The huge time constant is compared with the switching period and make sure that the steady state is a constant output voltage $Vo(t) = Vo(constant)$ and present at the load terminal.

There are two different types of working principles in the buck boost converter.

Buck converter.

Boost converter.

Buck Converter Working:

The following diagram shows the working operation of the buck converter. In the buck converter first transistor is turned ON and second transistor is switched OFF due to high square wave frequency. If the gate terminal of the first transistor is more than the current pass through the magnetic field, charging C, and it supplies the load. The D1 is the Schottky diode and it is turned OFF due to the positive voltage to the cathode.

Buck Converter Working:

The inductor L is the initial source of current. If the first transistor is OFF by using the control unit then the current flow in the buck operation. The magnetic field of the inductor is collapsed and the back e.m.f is generated collapsing field turn around the polarity of the voltage across the inductor. The current flows in the diode D2, the load and the D1 diode will be turned ON.

The discharge of the inductor L decreases with the help of the current. During the first transistor is in one state the charge of the accumulator in the capacitor. The current flows through the load and during the off period keeping Vout reasonably. Hence it keeps the minimum ripple amplitude and Vout closes to the value of Vs

Boost Converter Working:

In this converter the first transistor is switched ON continually and for the second transistor the square wave of high frequency is applied to the gate terminal. The second transistor is in conducting when the on state and the input current flow from the inductor L through the second transistor. The negative terminal charging up the magnetic field around the inductor. The D2 diode cannot conduct because the anode is on the potential ground by highly conducting the second transistor.

Boost Converter Working:

By charging the capacitor C the load is applied to the entire circuit in the ON State and it can construct earlier oscillator cycles. During the ON period the capacitor C can discharge regularly and the amount of high ripple frequency on the output voltage. The approximate potential difference is given by the equation below.

$$VS + VL$$

During the OFF period of second transistor the inductor L is charged and the capacitor C is discharged. The inductor L can produce the back e.m.f and the values are depending up on the rate of change of current of the second transistor switch. The amount of inductance the coil can occupy. Hence the back e.m.f can produce any different voltage through a wide range and determined by the design of the circuit. Hence the polarity of voltage across the inductor L has reversed now.

The input voltage gives the output voltage and atleast equal to or higher than the input voltage. The diode D2 is in forward biased and the current applied to the load current and it recharges the capacitors to VS + VL and it is ready for the second transistor.

Modes Of Buck Boost Converters

There are two different types of modes in the buck boost converter. The following are the two different types of buck boost converters.

Continuous conduction mode.

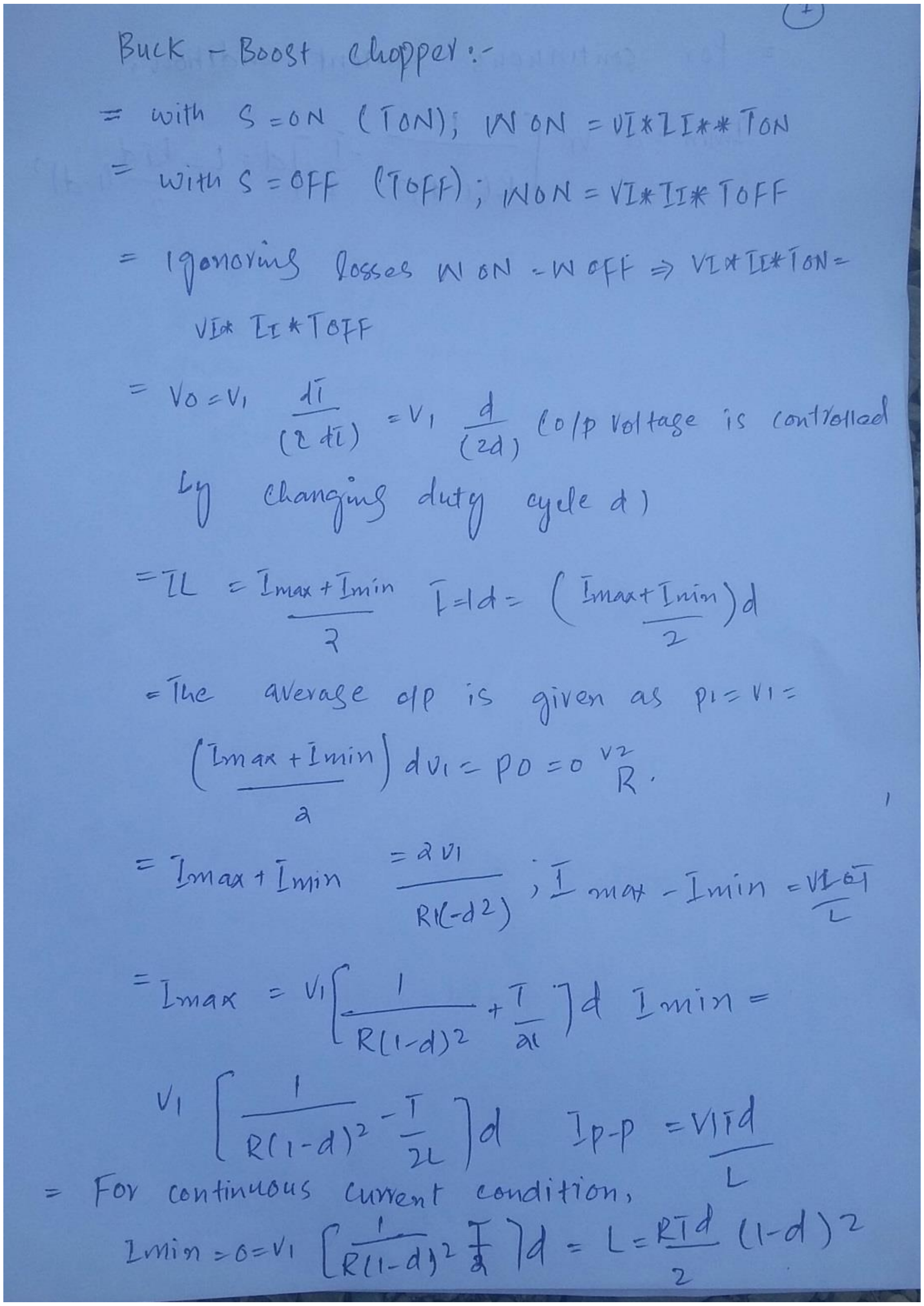
Discontinuous conduction mode.

Continuous Conduction Mode:

In the continuous conduction mode the current from end to end of inductor never goes to zero. Hence the inductor partially discharges earlier than the switching cycle.

Discontinuous Conduction Mode

In this mode the current through the inductor goes to zero. Hence the inductor will totally discharge at the end of switching cycles.



Buck - Boost chopper:-

= with S = ON (TON); W ON = VI*II** TON

= with S = OFF (TOFF); W ON = VI*II* TOFF

= Ignoring losses W ON = W OFF ⇒ VI*II*TON = VI* II*TOFF

= $V_0 = V_1 \frac{dT}{(2 dT)} = V_1 \frac{d}{(2d)}$ (o/p voltage is controlled by changing duty cycle d)

= $IL = \frac{I_{max} + I_{min}}{2}$ $I = Id = \left(\frac{I_{max} + I_{min}}{2}\right)d$

= The average o/p is given as $p_1 = V_1 = \left(\frac{I_{max} + I_{min}}{2}\right) d V_1 = p_0 = 0 \frac{V_2}{R}$.

= $I_{max} + I_{min} = \frac{2 V_1}{R(1-d^2)}$; $I_{max} - I_{min} = \frac{V_1 dT}{L}$

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

= For continuous current condition,

$I_{min} = 0 = V_1 \left[\frac{1}{R(1-d)^2} \frac{T}{2}\right] d = L = \frac{RTd}{2}(1-d)^2$

Applications of Buck boost converter:

It is used in the self regulating power supplies.

It has consumer electronics.

It is used in the Battery power systems.

Adaptive control applications.

Power amplifier applications.

Advantages of Buck Boost Converter

It gives higher output voltage.

Low operating duct cycle.

Low voltage on MOSFETs

Par(B).

Given data:

Vin=50v

Vout=73%

R=68ohm

f=20hz

Solution:

Find duty cycle,

1. I-D=-vin/vo-vin
   -D=-vin-1/vo-vin
   D=vin+1/vo+vin
   D=50v+1/0.73+50
   =1.0053
2. Iout=vo/0.73/68=0.01073A
3. Iin=IoD/I-D=2.03525A
4. L=Vin*D/f*delta I=50*1.0053/20hz*10^3*(Iout-In)=50-285/9.574=5.252