Power Electronics

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Lecture - 30

In our last class I discussed the operation of a fly back converter. The fly back converter is nothing but an isolated, a buck - boost converter. The input output relationship is the same as a buck - boost or a chuck converter. In addition, there is a term; the turns ratio - N_2 by N_1. Now, because of this N_2 by N_1 turns ratio, the magnitude of V_0 and V_{DC} can be greatly different. What is the principle of operation? Though there is a transformer, only 1 winding is carrying current at a time. So, close the switch, energy is stored in LM where LM is the magnetizing inductance. Open the switch, stored energy is transferred to to the load.

So remember, though I am using a transformer in fly back, current drawn from the source is the magnetizing current only, because in some other power supplies operation is going to be different. So, that is 1 of the reasons, the fly back converter is very attractive for low power range. Generally, if the power rating is of the order of 200 watts, fly back converter is a very good option.

I told you that invariably, fly back converters are operated in discontinuous mode. In other words, we are resetting the flux completely because operation is always in the first quadrant of BH characteristics. So, if there is a finite current flow in the secondary, in other words, there is some finite flux in the core, so when you close the switch in the next cycle and in case, the value of D has increased; it may so happen that core may get saturated. So, if it get saturated, you may be able to see the smoke coming out from the from the fly back converter or a black bucks. How do you avoid this?

One way is to have an air gap in during the transformer fabrication. So, if I have an air gap, there is going to be a leakage flux. So so when I open the switch, you may be providing a path for the magnetizing energy or magnetizing current. But then there will be a spike due to the the leakage inductance. So, we need to change the power circuit configuration. So, that is why you try to solve 1 problem in order to try to avoid the saturating the saturation of transformer by providing an air gap. The moment I do that it gives another problem, leakage flux.

So, that is why if we try to solve 1 problem, another problem is created. It is almost similar to the law of conservation of energy. Energy can neither be created nor destroyed. It can be transformed. Similarly, sorrows you know, you cannot destroy them nor create them. We can transform them from 1 form to another form. Here also, you had a problem, try to solve 1 problem; it gives rise to another problem.

Coming back to fly back converter, another major advantage of a fly back converter is we can have multiple outputs we can have multiple outputs and 1 point I forgot to tell you in the last class is that close loop operation is a must. Like any boost converter or chuck converter or or a …, close look operation is a must here. Why? Because, I am storing the energy, dumping it to the output. So, accidentally accidentally load gets disconnected. Capacitor voltage goes on building up, may be. So, close loop operation is a must.

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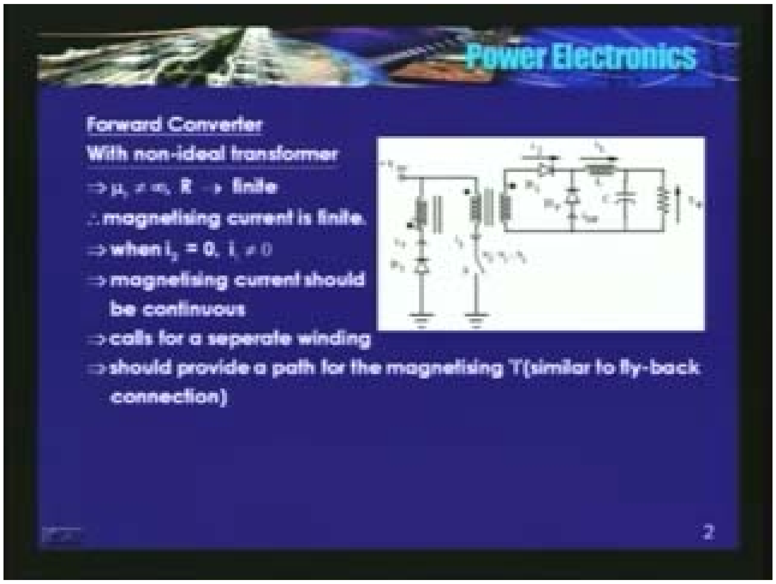

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Forward Converter

With non-ideal transformer

- ⇒ $\mu_r \neq \infty$, $R \rightarrow$ finite
- ∴ magnetising current is finite.
- ⇒ when $i_2 = 0$, $i_1 \neq 0$
- ⇒ magnetising current should be continuous
- ⇒ calls for a seperate winding
- ⇒ should provide a path for the magnetising T(similar to fly-back connection)

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Now, coming back to we also discussed the forward converter which requires a 3 winding transformer. See in this figure, N_1 N_2 N_3, see the dotted terminals here. So, when I close the switch, current enters a dot. So, in the secondary, current can leave the dot. So, current so, i_2 starts flowing when I close the switch. But then that cannot happen in the tertiary winding because of this diode connection.

So, the primary current here is the sum of the the equivalent secondary current plus the magnetizing current. When I open the switch, magnetizing current has to be continuous. In addition, the inductor current should be continuous. So, this current can be made continuous by connecting a freewheeling diode here. So, so inductor current starts flowing through DF when I open the switch. So, the magnetizing current starts flowing through this winding. So, operation of these 2 branches; the primary and the tertiary is same as that of a fly back converter.

Current enters the dot, so direction of flux should be the same. So, here also current enters the dot current enters the dot. So, for a non ideal transformer which is used in a forward converter, we require 3 windings 3 windings. So, this is nothing but an isolated isolated buck because this entire structure, this part is nothing but a buck converter. Forcing function here is is the reflected voltage to the secondary. The primary is being connected to V_{DC}. So, secondary is V_{DC} divided by N_1 multiplied by N_2. So, that is the forcing function and the operation is is similar to a buck converter.

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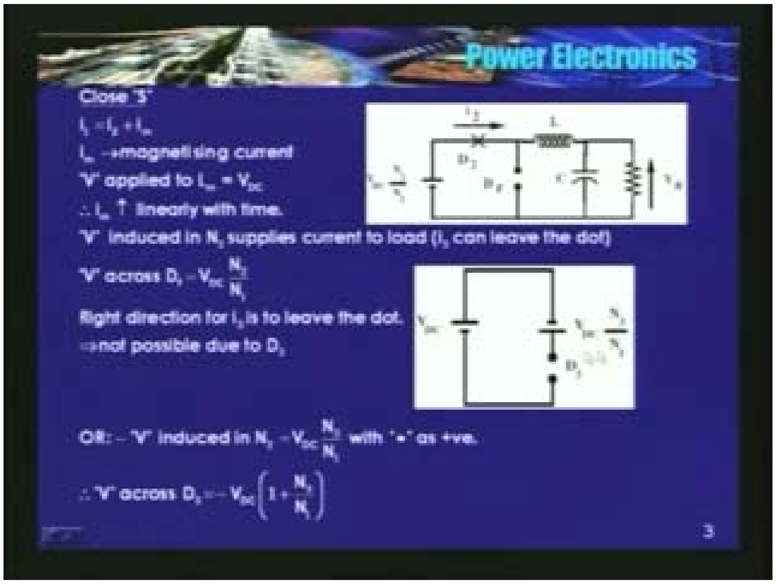

Close 'S'

$I_1 = I_2 + I_m$

$I_m \rightarrow$ magnetising current

'V' applied to $L_m = V_{DC}$

$\therefore I_m \uparrow$ linearly with time.

'V' induced in N_2 supplies current to load (I_2 can leave the dot)

'V' across $D_3 - V_{DC} \frac{N_3}{N_1}$

Right direction for I_3 is to leave the dot.

$\Rightarrow$ not possible due to D_3

OR:- 'V' induced in $N_3 - V_{DC} \frac{N_3}{N_1}$ with '•' as +ve.

$\therefore$ 'V' across $D_3 = -V_{DC}\left(1 + \frac{N_3}{N_1}\right)$

So, transfer function is transfer function is V_{DC} into N_2 by N_1 multiplied by the duty cycle. So, what is the voltage that is appearing across D_3 when when the switch is on? So, in this circuit, voltage applied to the primary is V_{DC} with the dot as positive. So, this is positive. So, this terminal voltage induced in this one is going to be negative and it is magnitude is V_{DC} divided by N_1 into N_3.

So, this is positive, negative and I have a source V_{DC}. So, equalant circuit is something like this; V_{DC} into N_3 by N_1 in series with V_{DC} is a voltage that is appearing across D_3. So, diode should be able to withstand this voltage, V_{DC} plus 1 plus N_3 by N_1.

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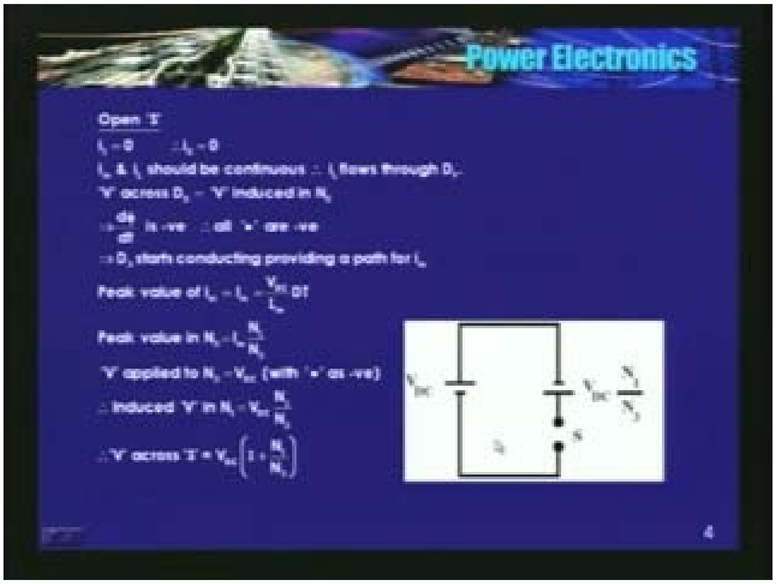

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Open 'S'

$i_1 = 0 \quad \therefore i_2 = 0$

i_m & i_3 should be continuous $\therefore$ i_3 flows through D_3

'V' across D_2 = 'V' induced in N_2

$\Rightarrow \frac{d\phi}{dt}$ is -ve $\therefore$ all '•' are -ve

$\Rightarrow D_3$ starts conducting providing a path for i_m

Peak value of $i_m = I_m = \frac{V_{DC}}{L_m} DT$

Peak value in $N_3 = I_m \frac{N_1}{N_3}$

'V' applied to $N_3 = V_{DC}$ (with '•' as -ve)

$\therefore$ Induced 'V' in $N_1 = V_{DC} \frac{N_1}{N_3}$

$\therefore$ 'V' across 'S' $= V_{DC}\left(1 + \frac{N_1}{N_3}\right)$

So, open S, current starts magnitizing. Current starts flowing through the tertiary winding. Voltage applied to the tertiary winding is V_{DC}. So, what are the voltage that is appearing across the switch and and the diode that is connected in the secondary, the D_2? Same, you need to use transformer principle. If I know the voltage applied to 1 winding, so voltage induced in the secondary is or voltage winding induced in the other winding is it just depends on the turns ratio. But then what is the magnitude of the current that is flowing through the tertiary winding?

Just prior to opening the switch, the magnitude of the magnitizing current the magnitude of magnitizing current is V_{DC} divided by LM into D into T. V_{DC} by LM is a slope of the the rate of rise of magnitizing current, DT is the duration for which the switch is on. So, the peak value is V_{DC} divided by LM into D into T. So, when I open the switch, the current gets transferred to the tertiary having N_3 number of turns. So, peak value of the current that is flowing in N_3 is I_m into N_1 divided by N_3 because I_m is the peak current that was flowing in N_1 turns. Now, the current gets transferred to N_3 coil or the coil which is having N_3 number of turns. So, this is the peak value of current that is flowing through the diode and the tertiary winding.

Now, voltage applied to the tertiary winding is V_{DC}. So, voltage induced in the primary is V_{DC} multiplied by N_1 into N_3. Remember, when when N_3 is carrying current, d phi by dt is negative d phi by dt is negative, flux is decaying now. So, this is the equivalent circuit. So, voltage across the switch is the sum of these 2 sum of these 2, V_{DC} plus V_{DC} into N_1 plus N_3 is the voltage across the switch.

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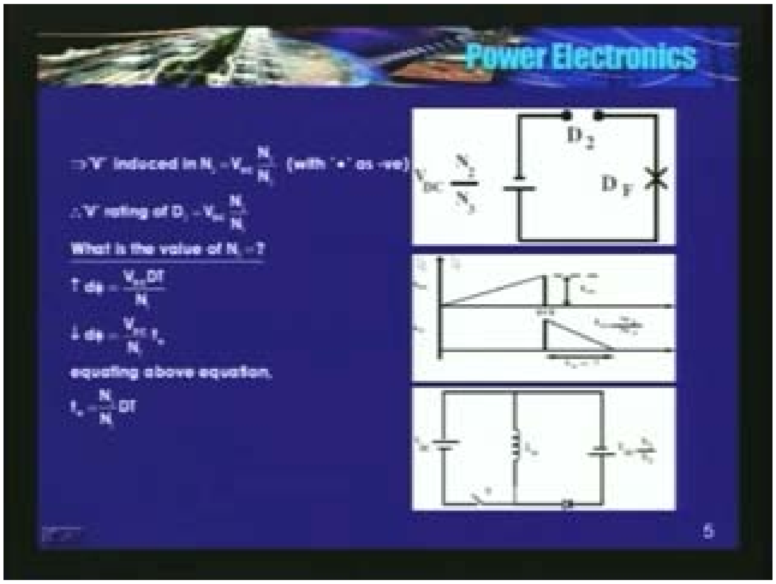

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⇒ 'V' induced in $N_2 = V_{DC}\frac{N_2}{N_3}$ (with '•' as -ve)

∴ 'V' rating of $D_2 = V_{DC}\frac{N_2}{N_3}$

What is the value of N_3 = ?

$\uparrow d\phi = \frac{V_{DC}DT}{N_1}$

$\downarrow d\phi = \frac{V_{DC}}{N_3}t_x$

equating above equation,

$t_x = \frac{N_3}{N_1}DT$

What is the voltage that is appearing across diode D_2? Voltage is same principle, voltage applied to the tertiary winding is V_{DC}. So, voltage induced in the secondary is V_{DC} divided by N_3 multiplied by N_2. Again, d phi by dt is negative. So, this is the equivalent circuit, the voltage induced in the secondary. DF is conducting. When I open the switch, because of LF, DF is conducting. Freewheeling diode is conducting. Voltage across the D, voltage across the D_2 is is only V_{DC} into N_2 by N_3.

So, the transfer function between the input voltage and the output, it depends on N_2 and N_1. Now, how many … number of turns should be there in the tertiary winding? How do I choose the number of turns in the tertiary winding? By the way, what is the purpose of providing a tertiary winding? It is for the continuity of flux. What is the condition? Flux in the core should become 0 just prior to closing the switch, again in the next cycle. Invariably, even in forward converter, we need to operate in discontinuous mode of operation discontinuous mode of operation. Again, same concept as that of the fly back converter. Discontinuous current in the sense, flux in the core is 0 or in other words, we are completely resetting the flux in the core.

Now, let us see what should be the number of turns that are required in N_3? So, peak value of current, magnetizing current I_m that is flowing in N_1 turns is V_{DC} divided by LM into D into T. That is the peak value of current that is flowing. Now, when I open S, that current gets transferred to the tertiary. So, this value of current is I_m into N_1 divided by N_3. So, here is the equivalent circuit. See, even I close the switch, LM starts flowing. When I open the switch, it starts flowing through diode D_3 and this is the voltage.

Now, V_{DC} into N_1 and N_3, this is the voltage referred to the primary. So, when I close S, d phi by dt is positive or flux increases. So, it is given by V_{DC} divided by N_1 into d into t, volts second per turn volts second per turn. Now, what is decrease in flux or d phi? It is V_{DC} divided by N_3

and T_a is the time for which D_3 conducts or this is the time T_a because for continuity of flux or continuity of flux is being provided by tertiary winding.

So, at steady state, increase in flux should be equal to decrease in flux or if it starts from 0, it should reach 0 at the at at T_a. So, I will equate it, I will find that T_a is equal to N_3 divided by N_1 into D into T and for discontinuous conduction; T_a should be less than 1 minus D. I will repeat, for discontinuous conduction, T_a should be less than 1 minus D because DT is the time for which the switch S is conducting. The remaining time, 1 minus D into T is for which if the current is continuous, D_3 will conduct. For discontinuous conduction, so T_a should be less than or equal to equal to 1 minus D into T.

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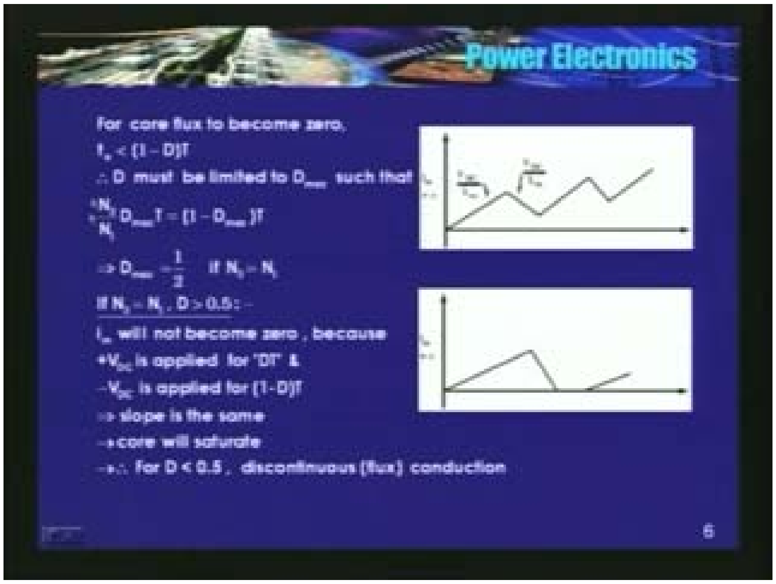

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For core flux to become zero,

$t_a < (1-D)T$

∴ D must be limited to D_{max} such that

$\frac{N_3}{N_1} D_{max} T = (1 - D_{max})T$

⇒ $D_{max} = \frac{1}{2}$ if $N_3 = N_1$

If $N_3 = N_1$, D > 0.5: -

i_m will not become zero, because

+V_{DC} is applied for "DT" &

−V_{DC} is applied for (1-D)T

⇒ slope is the same

→ core will saturate

→∴ For D < 0.5, discontinuous (flux) conduction

So, if D is equal to D_{max}, this is the relationship. I will choose N_1 is equal to N_3 number of turns in both the windings is the same. So, I will find that maximum value of D is 0.5 maximum value of D is 0.5. In a forward converter, if the number of turns in the tertiary and the primary is the same, the maximum value you can go is 0.5. Can you go or is it possible to go above 0.5 or what happens if I increase D above 0.5?

See, this is the situation; when I close S, rate of rise of current is determined by LM. Voltage applied is V_{DC}. So, slope of this line is V_{DC} divided by LM. I will open the switch. See here, current starts flowing in in in tertiary winding. Number of turns is the same is the same. Voltage applied is also the same. So, this voltage increases the flux, this voltage because this voltage, flux decreases and magnitude of both the voltage, this is the same.

So, if this switch is on for a time which is greater than the time for which diode is on, I will repeat; if the switch is on for a time which is greater than the time for which is diode is on, flux will not become 0 when I close the switch for the second time. Because, rate of rise is the same, rate of fall the slope is also the same but then on time is higher than the off time. So, there is going to be some residual flux. See here, if if the flux is being completely reset, we have something this sort of a situation. Flux becomes 0, it starts from there.

So, when I close the switch for the second time and assume that same value of D has been maintained, now magnitude of flux that is flowing in the core is higher than or this value is higher than this because D has been not changed, D has been kept same. So, when I open the switch for the second time, again this point is higher than this and if you continue, it may so happen that core may is get saturated or core will get saturated because you will have a some sort of a build up process of the flux because time for which in this circuit just see, time for which S is on is higher than the time for which the diode is on.

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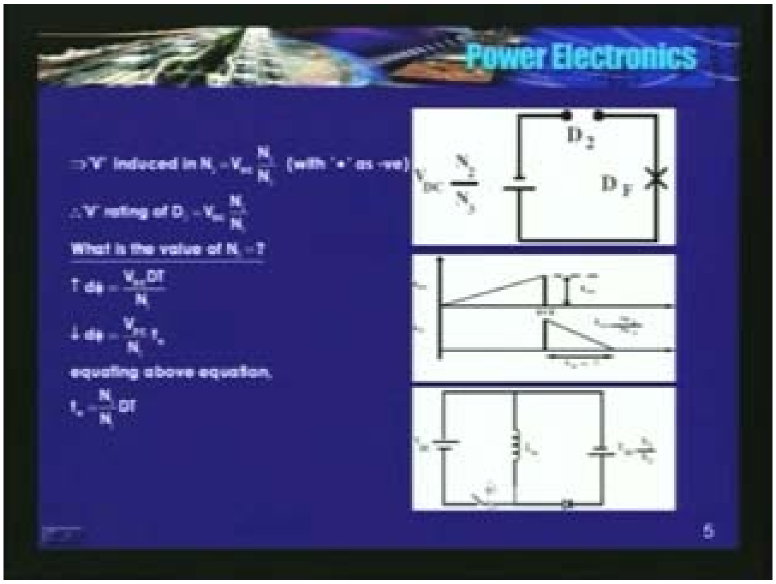

⇒ 'V' induced in N = V N/N (with '•' as -ve)

∴ 'V' rating of D = V N/N

What is the value of N ?

↑ dφ = $\frac{V_{DC} DT}{N}$

↓ dφ = $\frac{V_{DC}}{N} t$

equating above equation,

t = $\frac{N}{N}$ DT

So, this is positive D phi and this is negative D phi. Flux increases, flux decreases flux decreases. Now, voltage applied is also same, number of turns in both the windings is also same. So, I can have a just continuous conduction with D is equal to 0.5. So, for D is equal to less than 0.5, you will have a discontinuous conduction and if you go D is equal to and if you go D above 0.5, you may end up with saturation.

Now, let us draw the waveforms for a forward convertor. Now, let me tell you 1 thing, I think I have not drawn the waveforms for a fly back convertor. But then I have drawn all the waveforms when I was discussing the recovery of trap energy. So, both are the same. So, I will expect you to go back and draw the various waveforms for fly back convertor. Principle of operation is the same.

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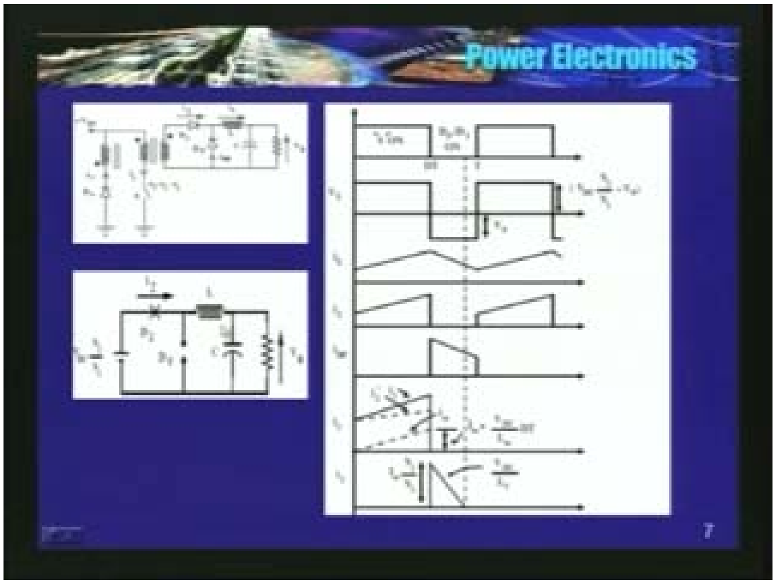

Now, forward convertor we will draw. S is on and in this period DF, the freewheeling diode and D_3 are on. They may be on if the flux becomes 0. So, D_3 is on till here and I told you that this part can be approximated to a current source and expect that i_L to be continuous i_L to be continuous. So, so in the entire this period or from DT to T, D_3 is assumed to be on. See, i_L increases when I close the switch because voltage that is induced here is V_{DC} divided by N_1 into N_2. See here, diode D_2 is on, nothing but a buck convertor nothing but a buck convertor. Current increases when I open S. So, load current starts flowing through DF and it is assumed to be continuous.

So, DF is on for the entire off period of the switch S. But then D_3 conducts only for a finite duration. So, voltage applied to the inductor when the switch is on is V_{DC} into N_2 divided by N_1 minus V_0 is a voltage applied to the inductor LF and when the switch is open, since DF is conducting, voltage applied to LF or this inductor is minus V_0 minus V_0. So, by equating you get the transfer function. When I close S, inductor current is same as i_2. i_L is same as i_2. We said that i_2 is increasing, so this is the waveform for i_2.Why it starts from a finite value?

It is because just prior to closing the switch in the next cycle, current through DF was finite. So, this is the current that was flowing through the diode DF, just prior to closing the switch S. So, this current starts flowing through D_2. Open the switch, D_2 becomes 0 and this current jump to or starts flowing to through DF. So, this is the current waveform. Mutually this magnitude should be equal to this magnitude.

How does i_1 look like? i_1 has 2 components, i_1 has 2 components; 1 is the reflected secondary current and the magnetizing current. We are assuming that I_m has become 0. In the sense, we have completely resented the flux. So, I_m starts from 0. But then, i_2 prime is non 0. It is finite because we have we have connected an inductor in the in the load circuit. In other words, load can be represented by current source and I told that current increases and decreases and it is off and just prior to closing the switch S, current that is flowing through DF is finite so that current starts flowing through i_2. So, i_2 dash is a finite quantity.

So, so the primary current, see, I_m starts from 0 this is and varies linearly and this dotted line is i_2 prime i_2 prime. The sum of these 2 is the primary current. See, because i_2 i_2 is finite, i_2 prime is again is finite. So, this is i_2 prime, I_m and this is i_1 and this peak value of I_m is V_{DC} divided by LM into D into T. So, when I open S, this current or flux has to be continuous. Continuity of flux is being provided by the tertiary winding. It gets transferred here. So, I_m into N_1 divided by N_3 is the peak current that is flowing through the tertiary winding. Voltage applied is V_{DC} and L_3 is an inductance of the coil N_3 having N_3 number of turns. I am I have taken here some arbitrary number of turn N_3. I have not assumed N_1 is equal to N_3, I have not assumed N_1 is equal to N_3. So, slope here is L_3 because it is flowing through a coil having N_3 number of turns.

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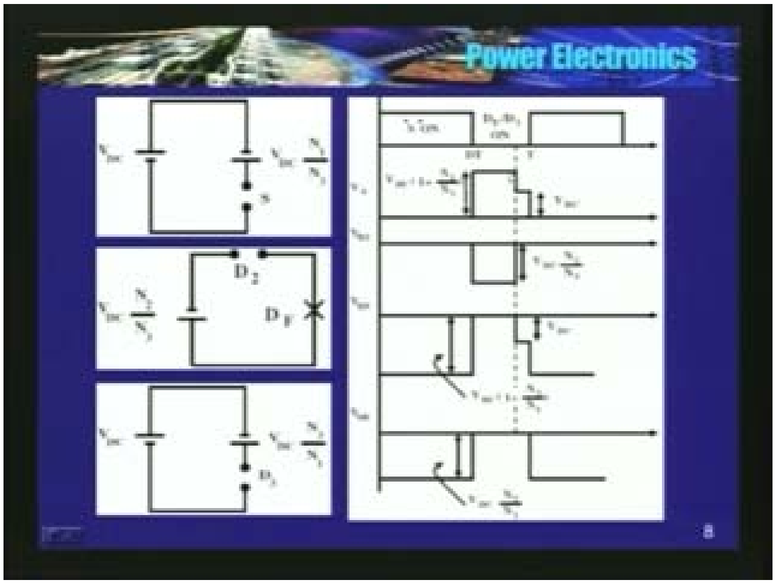

Now, see the various voltage waveforms. S is on S is on, so voltage across the switch is V_{DC} plus this quantity when diode D_3 is conducting. What happens when D_3 stops conducting? What is the voltage that was coming across various devices? Flux is 0, no current is flowing in any of these windings – primary, secondary, tertiary. So, you cannot use the transformer action principle. So, entire V_{DC} is blocked by D_3 diode here because no current that is no current is flowing in this coil.

Similarly here, the entire supply voltage is blocked by the switch S which appears across S. So, it is very simple here. Tertiary and primary voltage, these are V_{DC}. What happens in the secondary?

Diode is conducting. So, DF is conducting. So, voltage appearing across N_2 turns is the voltage is the voltage across the diode D_2. But then there is no current flowing in these 2 windings. There is no voltage here there is no voltage here. If one of the way to carry your current, that would have been a reflected voltage or induced voltage. Now, no current is flowing, so no relationship at all. So, there is no voltage induced in this coil, no current in this as well as this.

So, in practical, it is a 0 voltage that is appearing here, 0 voltages because this is this point. So, see the waveforms here; V_{DC} that is voltage across the switch, similarly D_2. When the diode DF is conducting, it is V_{DC} divided by N_3 into N_2 and it is 0 and similarly, voltage across the switch or voltage across D_3 is this waveform and it is 0 when it is conducting and when current has become 0, voltage across jumps to V_{DC}.

So, if the current is just continuous or if the flux is just continuous in the core, so you will not have this jump. That is only the difference; you will not have this jump. If the flux is just continuous, you will not have this jump at all and this is the voltage appearing across the freewheeling diode, DF. So, when it is conducting, voltage across it is 0 and when it is off, voltage across it is voltage induced in the secondary winding itself. See here, D_2 is conducting. So, voltage induced in N_2 is a voltage appearing across the diode DF. So, there is a short here. Voltage across N_2 induced in N_2 is a voltage across DF. This is nothing but V_{DC} divided by N_1 into N_2.

So, these are the various waveforms of for a forward convertor using 3 winding transformer. Now, let us discuss some special cases in forward convertor. So far we discussed a forward conductor wherein the tertiary winding is connected to the supply voltage V_{DC}. Same voltage that is being applied to to the primary or the coil having N_1 number of turns and I told you that N_1 and N_3, they form a fly back connection.

You do not have to connect the third coil to the same supply voltage. The purpose of the third coil is to just to provide the flux continuity, nothing else. So, instead of feeding the energy stored in the magnetizing branch to the source, you can transfer it to a capacitor and a load, nothing but a fly back convertor.

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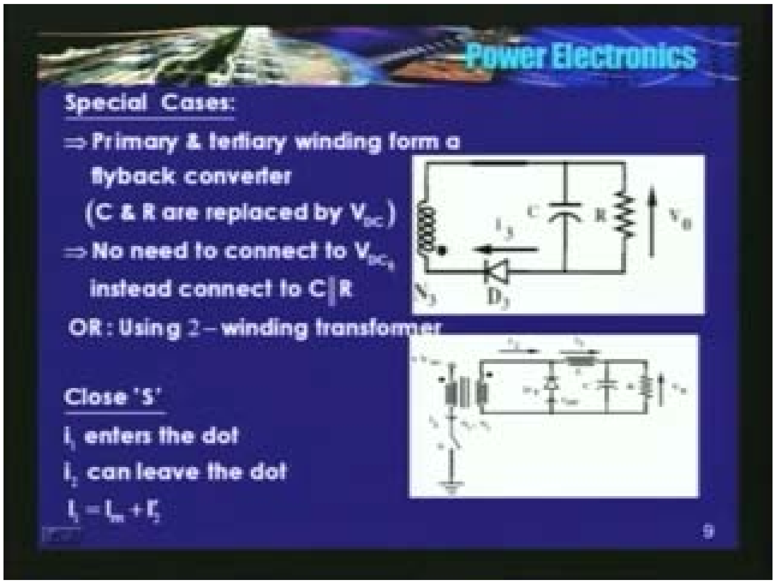

Special Cases:

⇒ Primary & tertiary winding form a flyback converter

(C & R are replaced by V_{DC})

⇒ No need to connect to V_{DC_1} instead connect to C‖R

OR: Using 2 – winding transformer

Close 'S'

i_1 enters the dot

i_2 can leave the dot

$i_1 = i_m + i'_2$

See something like this; N_3 coil, diode D_3 and C and R. This is nothing but a fly back convertor. I have not shown the primary here, primary does exist primary does exist because see here, in the previous see, this current is entering the dot here, current is entering the dot in the primary. So, for a flux continuity, the tertiary current also should enter the dot current also should enter the dot.

So, see here current is also entering the dot. So, I connected D_3 where this so capacitor voltage polarity is this, this is positive, this is negative. So, I can have 1 forward and 1 fly back convertor. So here, the V_0 is again, you can use the transfer function that we derived for fly back convertor please, the principle is the same. Again, you need to find out when the flux become 0? If it is just continuous, you use the same transfer function that we derived for the fly back convertor. So, you do not have to connect the tertiary winding to the same source. You can have a fly back supply convertors in a forward convertor itself.

By the way, why we using the third winding? What if I do not use a third winding using a non ideal transformer? In an ideal transformer, I told you that you do not require the third winding because reluctance is 0, mu R is infinity, so ampere turns required to establish the flux in the core is 0. So, there is no magnetizing current. So, you do not require a tertiary winding. Now, I will use a non ideal transformer wherein there is a finite magnetizing current. But I will not use the third winding and I will do some modification. Let us see what happens what happens?

See here, this is what I have done. Let us see what happens, whether it will work or if it works what is going to happen? I have not connected or I have not used D_2 here. There is no D_2. So, when I close S close S, what happens? Current is entering the dot. Current can leave the dot in the secondary.

Of course, DF is reverse biased, current starts flowing here, i_L starts increasing, i_L therefore, i_2 starts increasing. i_1 does have a component of magnetizing current. Magnetizing current is still there. It is a non ideal transformer, i_2 plus i_2 prime plus I_m. So, this is the primary current.

Opening the switch after DT, what will happen? Flux must be continuous and second is the inductor current i_L should be continuous.

Now, for the continuity of flux, the correct direction for the current in the secondary is to enter the dot. See, I will repeat; when I close the switch, i_1 enters the dot. The correct direction in the secondary is to leave the dot. It is possible because there is no D_2. I will open the switch after DT. i_2 becomes 0. But then magnetizing current has to be continuous. Now, that can be made continuous by suitable current that is in the secondary. What is the correct direction for the current that is flowing in the for in the secondary. If current is entering the dot in the primary, when I open the switch, current must enter the dot in the secondary.

I will repeat; see here, current starts entering the dot and current is leaving. This is perfectly a transformer action now. I will open the switch; magnetizing current has to be continuous. So, it is entering the dot. Now, current starts entering or current should enter this terminal.

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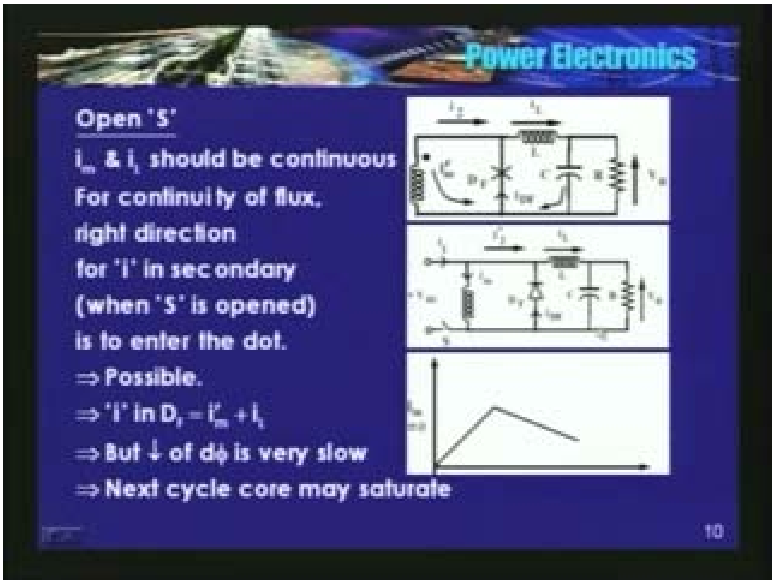

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Open 'S'

i_m & i_L should be continuous

For continuity of flux, right direction for 'i' in secondary (when 'S' is opened) is to enter the dot.

⇒ Possible.

⇒ 'i' in D_F = $i'_m + i_L$

⇒ But ↓ of $d\phi$ is very slow

⇒ Next cycle core may saturate

So, the equivalent circuit is here. So, this is the path this is the path and this current also should be continuous. So, DF carries the magnetizing current as well as as well as the inductor current i_L. Of course, it is a reflected magnetizing current. See, this is the equivalent circuit; close S, I_m starts flowing, i_2 prime also starts flowing because there is nothing here. Open S, I_m starts flowing through this branch, i_L also starts flowing through this branch.

So, in a 3 winding case, since I used D_2 in the secondary, it cannot happen there because reverse flow of current is not possible in a diode. So, I have not used D_2. Now, i_2 or the equivalent magnetizing component of current can flow in the secondary. It should enter the dot and it tries to enter the dot and it flows. But then what happens to the rate of decay of flux?

See the equivalent circuit here; I am connecting a diode across an inductor. If the resistance is 0, what will happen to I_m? Ideal diode is also ideal, this coil is also ideal, no R, I_m will remain constant. Whatever that was there, that was flowing through the primary winding, it get transferred and the magnitude will remain constant. In the sense, it will not decay it will not decay.

Now, if there is a finite resistance, it starts decaying slowly decaying slowly because whatever the stored energy is dissipated as heat in the winding resistance and may be internal resistance of diode DF. So, very slow decay. So, when I close the switch for the second time, may be, after some time, there was finite flux. On rate of decay, flux is very slow. It may so happen that core will saturate, core will saturate.

So, when I use a 3 winding transformer, I am using a negative voltage across LM. See here, see in the previous, see here, a negative voltage is applied across LM. So, decay is faster decay is faster.

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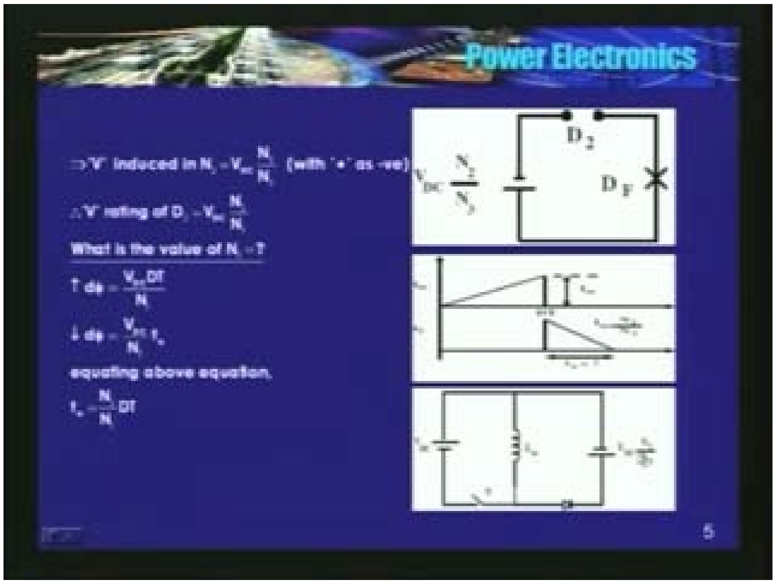

Power Electronics

⇒ 'V' induced in $N_2 = V_{DC} \frac{N_2}{N_1}$ (with '•' as -ve)

∴ 'V' rating of $D_2 = V_{DC} \frac{N_2}{N_1}$

What is the value of N_3 = ?

$\uparrow d\phi = \frac{V_{DC} DT}{N_1}$

$\downarrow d\phi = \frac{V_{DC}}{N_3} t_x$

equating above equation,

$t_x = \frac{N_3}{N_1} DT$

Now here, decay is very slow, very slow may be, some time just the opposite that we what we did in AC to DC conversion. In my very first lecture in AC to DC when I introduced the concept of freewheeling, I said that we have to maintain some current in the load. If there is no freewheeling diode, voltage that is appearing across the load becomes negative beyond pi. I will repeat; because beyond pi the input voltage becomes negative. So, if I apply negative voltage to a load which is RL, rate of decay is going to be faster. So, I want to reduce the rate of decay, so I said I will apply 0 voltage. In other words, I will connect a freewheeling diode. I have told this in the very first lecture of AC to DC conversion. So, if you apply negative voltage, decay process is going to be faster. If I apply 0 voltage, decay is very slow. May be, just the opposite that is required here, I want to reset the flux in the core because again unidirectional, excitation.

Operation is always in the first quadrant. So rate rate of decay is very slow and it may so happen that in the second cycle the core will saturate.

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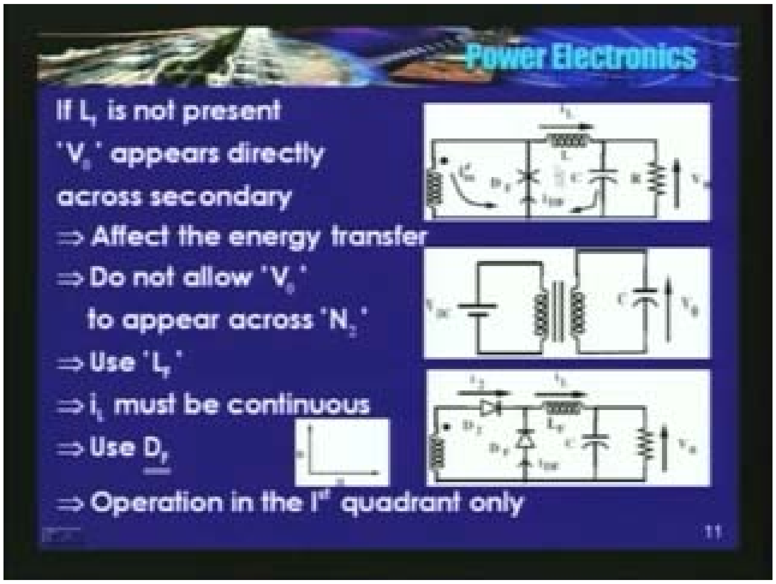

Power Electronics

If L_f is not present

'V_0' appears directly

across secondary

⇒ Affect the energy transfer

⇒ Do not allow 'V_0'

to appear across 'N_2'

⇒ Use 'L_f'

⇒ i_L must be continuous

⇒ Use $\underline{D_f}$

⇒ Operation in the I^{st} quadrant only

What is what is the third case? What is the third case? The third interested case is there is no LF at all. Do not use LF, do not use LF, do not use LF. Just because we had used LF, we wanted we connected a DF here because when I open the switch, this current has to be continuous. So, it will start flowing through DF. So, if there is no LF, you may not even require this DF. But then what will happen?

See in this circuit, there is no LF, there is no DF. Close the switch in the primary, current enters the dot, current leaves the dot. So, this capacitor gets connected across the secondary because this is not there, even L this is also not also there. So, when diode is on, so this gets connected to the secondary. So, we have a case something like this; primary, a voltage source of V_{DC}, secondary, I have another voltage source of some other magnitude V_0 V_0 and wave forms of V_{DC} may not be the same the waveform of V_0.

So, I have a case wherein the transformer, both sides of a transformer, I have connected 2 voltage sources. I do not think you can have this sort of a situation, wherever, even in AC supply I connect a source to the one of the winding, second winding is connected to the load. We do not connect 2 voltage sources of 2 different waveforms to the power transformer.

So, if I do that, it may affect the power transfer or energy transfer. So, I should not allow the capacitor voltage to appear directly across the secondary turns when the switch is on. So, I use an inductor. So, since I am using an inductor now, current has to be continuous. So, I use a freewheeling diode. So, that is how we have reached to this stage. We should not allow the capacitor voltage directly to appear across the secondary when primary is carrying current. So, you connect an inductor here. If you connect an inductor, this current has to be continuous. So, use a diode, DF here.

So, that is it about the forward converter. Generally, it is used for voltage above 200 watts, from 200 to approximately 5 to 600 watts. This could be more also, could be more also. But then as the power rating increases, the trend is to go towards a forward converter. Now, you may be able to reason it. What could be the reason? What could be the reason? What happened in fly back when I close the switch and what happens in a forward converter when I close the switch?

In a fly back converter, we are storing the energy in the magnetizing inductance, transferring it to the load. Source current is only the magnetizing current. What happens now in a forward converter? Source current is the sum of magnetizing as well as the equivalent load current equivalent load current. So, may be every obvious, there are only magnetizing energy, store it and dump it. Here, source supplies equivalent current or source supplies power directly to to the load here.

So, when I close the switch, there is an equivalent current in the primary. So, as the power rating increases, so the size of the transformer that is required in a fly back is going to be high, it increases. So, that is one of the reasons to go towards the forward converter for high power range. More about it, we will see later in the next class.

Thank you.