Electrical Machines - I
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Lecture - 30
Two Winding Transformer Connected as Auto Transformer

Welcome to 30th lecture. And we are still in Auto Transformers. We have compared an auto transformer with two winding transformer, then I solved some numerical problems in last class that auto transformer, several voltage levels also you can get and you can find out the currents in various parts of the auto transformer that I did.

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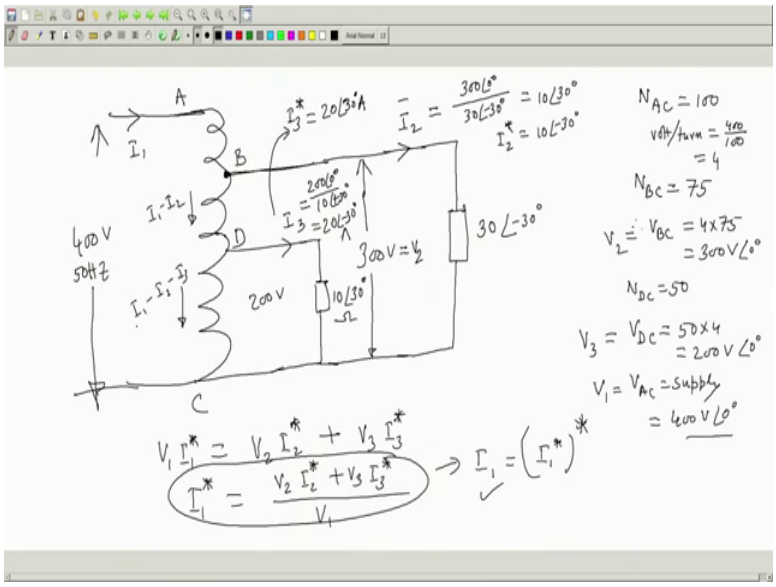

Today, first I will tell you that a two winding transformer I am having two winding transformer.

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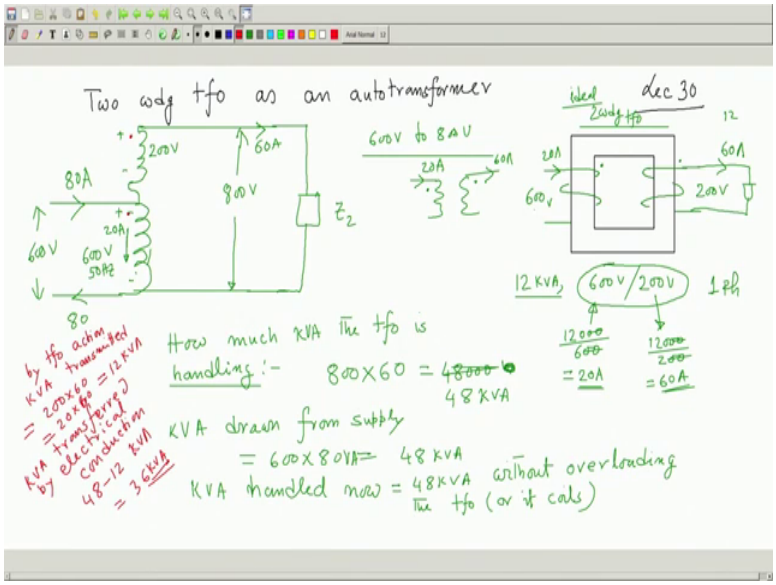

In short form w d g I am writing, two winding transformer as an auto transformer. Remember any transformer a two winding transformer, it is like this. And I was drawing the primary winding this way, they are separate coils, is it not, this is the thing. And we know from this windings sense, these are the polarity. And suppose for easy calculation, I will assume that this transformer is rating of the transformer, voltage rating of the transformer is say 600 volt stroke, 200 volt suppose. And KVA is say 12 KVA, suppose this is a single phase two winding transformer, understood, this is the thing.

What I told you the moment this data is with you, you should immediately calculate what is the rated current of this side which will be 12000 divided by 600, is it not, that is 20 ampere. And this side low voltage side, the current will be more. How much?

Student: (Refer Time: 03:37).

Ah.

Student: (Refer Time: 03:38).

That is I calculate it, you must be, 200, this two go and this is 60 ampere, is it not. This I should be ready the moment KVA ratings and voltage ratings are known and it is a two winding transformer ok.

Now, after having this suppose somebody comes and this is what does this mean, if you apply 600 volt, you will get here 200 volt roughly. Now, somebody comes and tell that ok, what has happened in the lab 600 supply is available voltage, but you have a peculiar load which requires 800 volt, load requirement is 800 volt, in the lab 600 volt supply is there which can be of course, transformed to 200 volt to supply 200 volt load. But suppose I say that no, it has so happened that you require 800 volt, is it possible to use this two winding transformer whose input voltage will be 600 volt, but output voltage will be 200 volt?

The answer to this question, yes, it can be used provided you suitably connect this to coils. For example, in a simplified diagram, I will draw it like this, instead of drawing this two separate coils, this is the 600 volt side. I will just draw them vertically, so that this I can draw it anywhere I like so long I know these two are these two coils electrically nothing wrong in that. And suppose this two are dots. So, these two coils I have drawn here. This is the high voltage coil and it can be supplied with 600 volt 50 Hertz, I will supply a all are RMS values here 600 volt. But the moment you apply 600 volt, you are sure you are going to get 200 volt here, why that true rule will change, because same flux links.

Therefore, you are having this two voltages with this polarity is also known. If it is plus at any instant, these also plus, this is minus, this is minus. Therefore, it looks like if I connect this two in series, this two points I join, then what will be the voltage available here, 800 volt, why not, you will get 800 volt here. Therefore, this two winding transformer, no doubt, it can be used to change a 600 volt to 200 volt or vice versa. If 200 volt is there, you can get 600 volt connect loads.

But it I now after learning not yet I have connected it with auto transformer, but I am simply telling that if you apply 600 volt 200 volt here this coils only I have drawn in a convenient way, so that I understand it much better. So, if you apply 600 volt here, there must be induced voltage here connect it here. So, you will get 800 volt, this two winding transformer can be also used to change a voltage from 600 volt to 800 volt, why not, provided you connect like this. And the moment you connect like this, you can immediately tell, then it is like an auto transformer, where you are stepping up the voltage, this way you have connected that is the thing I want to tell. It can be connected in this way 800 volt ok.

Now, one interesting thing I must tell you here that rated currents of the windings are known LB side rated current is 60, HB side is 20 ok. Now, the question is how much current I will allow to flow, what sort of impedance should I connect, what will be the rated I mean the maximum current I can draw from this combination, here what should be the current I must allow to flow through the load, this is load, how much? The rated current of 200 volt is 60 ampere.

So, pass 60 ampere, I can pass no problem, these winding. Because the from the dot if 60 ampere comes out I know through the dot here 20 ampere must flow, this I know from my two winding transformer. Whenever in this is dot, this is dot, this fellow carries 60 ampere rated current, this will draw 20 ampere ideal transformer consider first, it will draw 20 ampere. Why it should draw 20 ampere, so that it can balance this mmf, so that the flux is created only by that magnetizing current which is very little, because KVL is to be satisfied here, flux will remain same, no matter what you are connecting across this two terminals that the good old explanation.

Therefore, simply because you have connected in this fashion those rules are still not existing is not correct, it is there. Through the dot if you want to draw some current, through this dot, do not show it here, 20 ampere through this high voltage winding there must be 20 ampere in this direction.

Student: (Refer Time: 10:39).

So, this is 60, this is 20, is it not?

Student: (Refer Time: 10:52).

I will come, just let me see whether any mistake I have done, but let me carry on. So, this is 60, this is 20. Then what is the input current, input current must be 80 ampere. So, 80 ampere goes there, 20 ampere comes, 60 comes here. So, KCL is satisfied here, there and so on, everything is fine ok. And I will say I will be very happy, flux will be at the rated value as in a two winding transformer when it is used, coils are carrying rated currents that is also very good.

But one interesting thing has happened that is if you now look with a an open mind, you will see [FL] this way if you connect, how much KVA the transformer is handling, how

much KVA I write it how much KVA the transformer is handling that is the question? How much KVA it is supplying to the load or how much KVA it is drawing from the source, this is source? How much KVA it is delivering? 800 into 60 and that is 48, 48000. What that is KVA, so 48 kilo volt ampere, 48 KVA. And how much KVA it is drawing from supply, KVA drawn from supply is 600 into 88 that is also this is volt ampere and this is same as 48 KVA ideal, ideal to winding transformer.

As I told you that better start with ideal transformer it things will be closed to this numbers nothing. So, and it is fine, it is delivering 48 kilo Watt as I told you in the previous example, nothing doing it must also absorb 48 KVA from the supply. But here lies the some fallacy is there, when you use these two winding transformer, as a winding transformer that is you will connect load here, this current 60 ampere. And at that time this current HB side current will be 20 ampere. What is the KVA handled? If it is used at the rate winding transformer, 12 KVA and that is what it is rated 2.

But the moment you connect it in this fashion, we find that this way of connecting the transformer can handle 48 KVA without overloading the transformer that is the most important part. It is now handling 48 KVA. So, KVA handled now is 48 KVA and I must write along with it without overloading the transformer, overloading, without overloading the windings or transformer, without overloading the transformer or its winding, its coils, it is not overloaded rated current of this 60 amperes fine, rated current of this 20 ampere it is fine, rated voltage of this winding 600 volt, rated voltage of this winding is 200 volt.

So, everything is in rated condition so far as windings or coils are concerned. And still it is handling as it winding transformer it could handle only 12 KVA, but to much of surprise it looks like 4 times more it is handling, is not what is the thing which makes it to deliver 48 KVA. The answer to this is that in an auto transformer, power is delivered from the primary to the secondary side is by two means.

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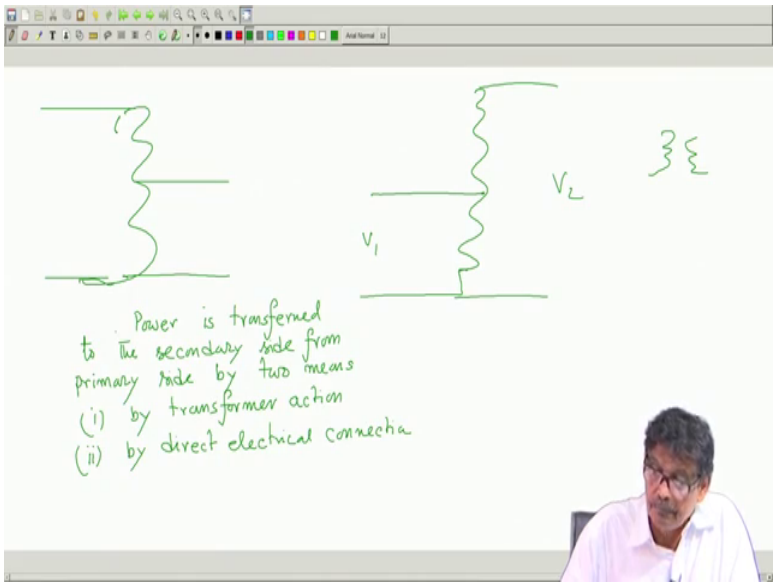

Why, for example, in an auto transformer which is stepped down we have considered I have not told anything about that till now this an auto transformer. Give some input power get some output power that is fine. And in this case, it is (Refer Time: 17:26) up, and I told you nothing is sacred about V 1, V 2 that is fine in whichever way you go.

So, this input power is transmitted to this secondary by two mains; one is power is transferred to the secondary side. Both first step down and step up case, it does not matter here as you can see power is transferred to this secondary side by two mains to the secondary side from primary side, from primary side by two means. What are the two means? One by transformer action and two by direct electrical connections that is how we explain this by direct electrical connection, connection.

What is this direct electrical connection? In this case through this, whether there was some induced voltage or not still power would have delivered here also there is a direct connection. But as it winding transformer that is that electrical conduction transfer from primary to secondary is not there, because there is no connection between these two, but here this is how this thing.

Now, the question is how much, therefore, it looks like out of this 48 KVA, a portion is transferred by because of magnetic induction by transformer action. And the remaining portion then must have been delivered because of direct conduction of power from

primary to secondary side. Now, the question is how to calculate the power delivered by transformer action?

Listen here, come here in this slide. This two windings this two are separate windings this fellow is carrying 60 and then this fellow is drawing 20 from the dot in the winding. Therefore, by these two coils can be treated as isolated coil and the volt ampere handled by this because of transformer action, I write by different color that is by transformer action KVA transmitted should be equal to 200 into 60 or that is same as 20 into 600, either way because this equal to 12 KVA.

In fact, by transformer action, it cannot do anything better 12 KVA only and then I will say 48 KVA is total transferred. So, I will say KVA transferred by electrical conduction must be 48 minus 12, so much KVA that is equal to 636 KVA. So, this is quite interesting to note, that is a two winding transformer will carry rated currents will have rated voltage across it and still it can transfer a much more KVA provided you connect it in this fashion ok. And this is always done like this. For example, I will just the same problem I will do, so that you understand where we are going.

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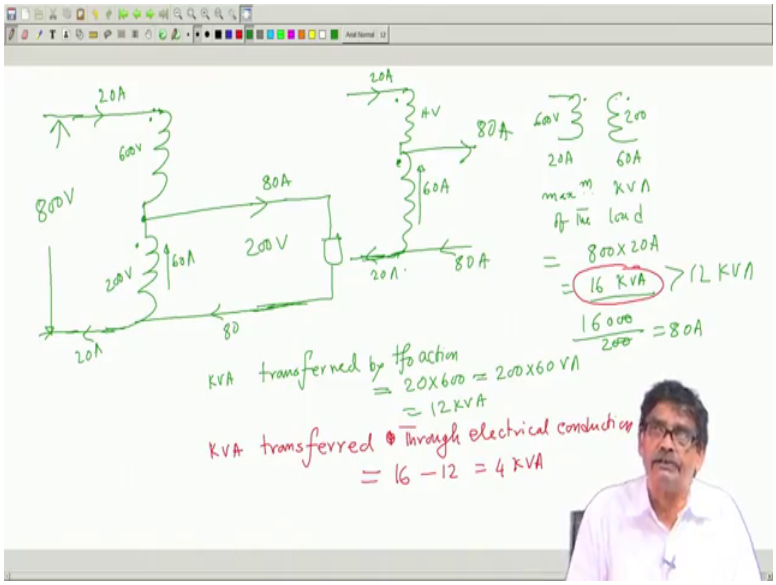

Suppose, this two coils the same transformer can be connected in different ways, suppose what was the rating, one was 600 volt, another is 200 volt ok. So, suppose I say that this is the 600 volt, this is the 200 volt, this two windings have connected in series. I can say that this can be also used. And suppose your supply voltage is 800 volt that I can apply,

because it is then the voltage will be divided induced voltage in this ratio N 1 by N 2, whatever it is a 800 volt. And I can take tapping here and supply a 200 volt to the load is that clear? So, the same 200 two winding transformer this is 600 volt, this is 200 volt, this two are dots. I have connected them in series with regard to dot polarities and supplied it with 800 volt.

So, if it is 800 volt, then there the voltage will be 600 volt, even when load has not been connected, because voltage for turn remains same and 200 volt here. And I can supply a 200 volt here. Now, here once again I pose the same problem it is a step down connection. So, the question is how much current should I now allow to I mean what should be my load impedance, so that the transformer winding currents will be rated. Are you getting? You cannot just connect any impedance. So, without satisfying yourself that ok, if I connect these value of impedance then winding currents will be rated.

It is true when the HB side will carry rated current, you do not have to worry LB side will automatically carry rated current, so that the mmf will be balanced. Now, the big question is how to handle this situation this I will handle in this way now. What is the rated current of the HB side, it was?

Student: 20.

20 ampere this side rated current is?

Student: 60.

60 ampere low voltage side higher current, high voltage side low current. Therefore, I can say that look here under no circumstances, the maximum possible load maximum current you should draw here that will yield 60 ampere here, because that is the rated current that is the rated current of this winding, I am so sorry, this is 20 ampere, is not it? I should not allow a current, so maximum KVA and KVA here KVA there. So, maximum KVA of the load should be 800 into 20 ampere, 800 into 20 ampere that is 16 KVA and this 16 KVA will come here I know the voltage. So, 16000 divided by 200 80 ampere.

So, I will allow I will draw 80 ampere, I am because this is not the winding current. And you see yourself this is 20 ampere, this is 80 ampere apply KCL here, is it not? What will be this current 60 ampere? Then only this will be 20, 60, 80. Here also 80, 60 goes up 20

comes here. So, once again it is KVA handled by the transformer this time is not 48 KVA, 16 KVA which is greater than 12 KVA. How much KVA is conducted by conduction? KVA conducted by magnetically or by transformer action will be 12 KVA, whatever is the 600 into 20.

So, KVA transferred by transformer action will be equal to either 20 into 600 or 200 into 16, whichever way you want to tell that is 12 KVA. These are volt ampere 12 KVA. And I know what is the maximum KVA it can handle that KVA is 16 KVA, this number. So, where from this extra KVA is coming, I will conclude that KVA transferred by through electrical conduction is this 16 KVA, 16 has been the total minus 12 that is 4 KVA.

Therefore, I will request you, you try several combinations of connecting this two coils in series, apply voltage, stepping up, stepping out down, it may be it may so happen that you your dot is here, this dot is there. So, I leave it that has an exercise and find it out. Except one thing I will tell, this could be this numbers I calculated like this, also it could be done like this very quickly I will tell this is the thing. Here was the load.

Now, first thing I told you that this two are dots given is it not? And I told you that this is the HV side, HV this is the HV side. And I will not allow this 20 ampere first I decide 20 ampere. But then I will argue if this is 20 ampere instead of calculating in input KVA, I could also say like this. If this is 20 ampere coming in through the dot of this transformer at that 20 ampere must 60 ampere flow, then only this two mmfs will be balanced and then I could arrive at this 60, 20, 80 alternatively also in this way. So, get used to it please 20 ampere, very simple calculation otherwise.

Thank you, we will continue with this.