Electrical Machines - I
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Lecture - 06
Rating of Single Phase Transformer: Rated Current & Rated Voltage with Example

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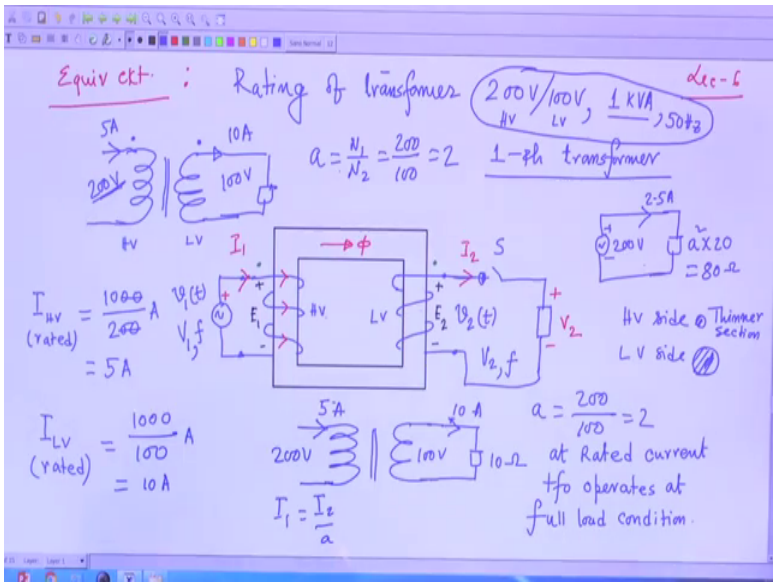

Welcome to 6th lecture. And we were discussing about the Equivalent Circuit of Transformers, Equivalent Circuit. And equivalent circuit can be drawn equivalent circuit is a simple model of this whole complicated things you live in one side and get the results, ok. We discussed with that.

In the last class I told you that product of voltage and current on the primary and the secondary side they remain constant, ok. Let us suppose say that, now I will tell you that it is because of this fact that volt ampere product remain same. Suppose, the rating of a transformer let me tell you rather in this way rating, how rating should be specified, rating of transformer. If you look at the rating of a transformer see, what will be the ratings of the transformer? The voltage rating of the two sides must be specified how much voltage should you apply, how much voltage should you apply to the secondary side and so on. And also, what is the current carrying capacity of these coils on both the sides

So, you can specify the voltage rating of the primary side and current, voltage rating of the secondary side and the current. For example, somebody says that a transformer, he writes it like this the voltage ratings are 200 volts to 100 volt. Instead of telling that primary side is 200 volt, secondary side is 100 volt which you we will also use this terminology no doubt, but more scientific way of telling that this is the voltage rating this coil I will call HV coils suppose this is HV.

And this is called low voltage coil, whichever side has got low voltage we can also identify the coils like that because you must be now feeling that no point either of them can be used as primary.

But, only thing when LV is used as primary you should apply 100 volt and then you will get 200 volt there and vice versa. Therefore, it is a sometimes a more scientific to tell in terms of HV LV to describe a transformer rather than primary secondary. User will decide which one will become your primary, which one will become your secondary. Suppose, 100 volt is available you have this transformer you required 200 volt, then there is no other way how it energize the LV side with 100 volt get 200 volt to supply your load or vice versa [FL]. So, these are called the voltage rating.

Then I told you the current ratings of the coils should also be specified. Instead of that because we know the volt ampere product remain same what is specified current ratings are specified indirectly. What is specified is a KVA rating, suppose the KVA rating is 1 KVA and also frequency will be specified 50 Hertz. And also, it will be told about what kind of transformer, it is single phase transformer, got the point. So, a transformer is specified in this way.

From these numerical values, what we conclude. I will now draw it instead of drawing this elaborate diagram, I will simply draw two coils like this and core material may be shown by this vertical line a simplified way of telling all this things, instead of drawing this core along with coils I will draw it like this two are dots that is important I will specify, and this is suppose HV winding and this is LV winding. Now, from this I can calculate what is the rated current of the HV side, I HV rated it will be this KVA 1000 volt ampere divided by 200 so much ampere, it will become 5 ampere. Similarly, I will calculate I LV rated as KVA remain same, so 1000 divided by 100 ampere which is equal to 10 ampere.

So, the moment of these ratings is known I can draw this diagram and say that, HV side maximum voltage you can apply 200 volt 50 Hertz, and you will get 100 volt 50 Hertz here. And you will you are going to connect some load, but do not connect any load you connect such a load such that the current while it will deliver to the load does not exceed these 10 ampere, it should not exceed. Your load current must be less than equal to 10 ampere.

So, any impedance you do not connect. And when it will deliver this rated current I LV rated, let us assure you do not have to do anything your primary at that time will carry 5 ampere that is what we have learned. If 10 ampere goes, what is the value of a? a is N 1 by N 2 which is equal to V 1 by V 2 is equal to 2 is not that is all therefore, the ratings current ratings of the HV and LV windings are indirectly given in terms of KVA and voltages. You have to do a little bit of calculations here to know exactly what is the rated current [FL].

Let me do something more with this. Suppose, this is the transformer I have applied here 200 volt and I have connected an impedance here we will get 100 volt immediately if you apply 200 volt 100 volt. Suppose, you have somebody connects an impedance of 5 ohm, what is going to happen? 200 volt 100 volt 100 by 5, 2 ampere, 20 ampere you are trying to draw and you will say oh rated current is 10 ampere. No, this is not allowed. So, do not connect 5 ohm then. Are you getting? You must understand this.

Therefore, connect what is the minimum impedance you can connect? 100 by 10, that is 10 ohm. Do not connect impedance. If you connect 10 ohm fine, 10 ampere here, if it is 10 ampere you be rest assured it has it will be automatically 5 ampere, ok. If you are these things I will do quickly, so that things go to your mind

Suppose somebody connects 20 ohm here impedance then this current will be 5 ampere and it is well within the red below the rated current it is allowed, but if it is 5 ampere this current will become 2.5 ampere because it will be always half. So, several simple, but important things; this should be in your mind always playing, ok. You have connected 20 ohm, this current is 5 ampere, HV side current is always I 1 is equal to I 2 by a. And here what is a? a is 200 by 100 is equal to 2. So, current will be reduced by factor of 2.5 and so on.

With respect to suppose, so I have used HV as my source side, source I have connected to HV. I could also connect source to the LV side and you can do that you try that. So, henceforth I will draw this circuit instead of drawing all the time this and getting the results. So, this will be the thing. Another interesting thing comes out that this ratio of current whatever impedance you have connected, only you have to see that secondary impedance you have connected does not make the current in the LV side greater than the rated current that is only should be your concept.

But, the moment this current is known this current is fixed. What will be the equivalent circuit of the transformer? It will be a source 200 volt very quickly I will do, and across it you have connected an impedance for this if you have connected 20 ohm I will say you have connected an impedance of a square into 20 that is equal to 80 ohm, a is 2, 80 ohm And 200 by 80, so this current is 2.5. So, I will draw the equivalent circuit oh impedance has.

So, sometimes it transfer of impedance people say transformer means it changes the value of the impedance source you are physically connecting an impedance of 20 ohm, but to the source it appears to be 80 ohm. You can manipulate the impedance, ok. So, this is the thing. Then after calculating this I will say I will come back here and say, this current will be then 2.5 into 2 is equal to 5 ampere.

Now, after going through this, corresponding to this rated current here I am under utilizing the transformer, the impedance have it can carry deliver a current of 10 ampere, but I have connected 20 this I can always do. Under full load condition rated condition I should connect an impedance which is equal to 10. 10.

At rated condition if you want to apply I will connect here 10 ohm and then this current will be 10 ampere rated current, and this current will be 5 ampere and I will say the transformer is operating at full load condition when the currents are rated. So, at rated condition at rated currents sorry, at rated currents transformer operates at full load condition. We will discuss much more with the loading etcetera full, we have not at full load condition, got the point.

And another thing we immediately come to the conclusion that on the high voltage side voltage is high current will be less compared to the LV side, where voltage is less current is high because the product is to remain same. So, if voltage has reduced current must

increase by the same proportion that is why KVA remain same volt ampere. Kilo volt ampere is a very practical unit. But what I want to say if you want to see after all while making this coil you have to use piece of wire [FL], wind it like this. The cross section of this wire gage of the wire is decided by the magnitude of the current. Therefore, on HV side thicker conductor will be used, HV side conductor cross section will be thicker I am just drawing symbolically. LV side conductor cross section will be less, LV side it will be high correct sorry because LV side conductor (Refer Time: 16:05) be one, ok.

Thinner wire, thinner, thinner wire means section, thinner section. And the section of the LV side because it has to carry rated current. When LV side carries rated current HV side has to carry rated current therefore, if a transformer is given if you look if the windings are available to you, you can see you can always immediately see the section of this wire this wire will be LV side will be much higher than the HV side. So, what we have learned till now? We are still considering mind you ideal transformer it does not matter. This is what happens and based on that I told you about the ratings of the transformer importance of KVA rating and voltage ratings.

On the HV side of course, if you apply instead of 200 volt if you apply 100 volt what is going to happen? On this side you will be getting 50 volt that you are allowed to do because you should not exceed the rated voltage of the winding. So, you should not apply on the HV side here a voltage greater than 200 volt, less than 200 volt you can apply no problem. And then current ratings I know.

If I ask you this question that, this is the actual rating of the transformer suppose on the HV side I have applied 100 volt, how much current you will allow to flow? What will be the KVA rating then? Current you can go up to rated values, no problem. So, transformer will then be de rated, that is there. We will see several problems, we will solve. So, this is the thing. [FL]

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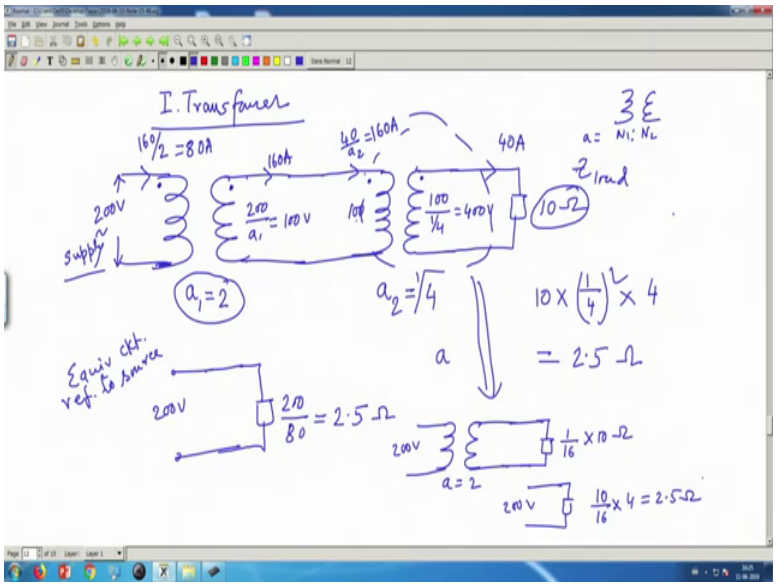

Next thing in this lecture, so that it creates interest in you, I now say that we are continuing with ideal transformer, mind you, ideal transformer. Suppose, somebody has connected a transformer here, and the trans ratio of this transformer is suppose 2 and yes connected another transformer here. And, it is trans ratio is suppose half suppose somebody has connected like this, and understood. Suppose, and he has connected an impedance here on this side 10 ohm, and suppose you have connected a 200 volt 50 hertz source here, 200 volt AC rms. Tell me what is the voltage here? I i want to find out the currents.

So, if you have applied 200 volt, if the ratio is this what will be this voltage? 100 volt because V 1 by a 1 will come here; so, this will be 200 by a 1 is equal to 100 volt. So, this 100 volt is applied to this transformer. And you have suppose let us consider this to be 1 by 4 trans ratio, I will this transformer is having a trans ratio of 4, 1 by 4. What will be the voltage here? It will be 100 by a 2, 1 by 4, it will become 400 volt. If I make any mistake you please point me out through your mails or whatever it is.

But what I am trying to tell that you can see the nicety of analyzing of circuits involving transformer, it is so easy I mean in the first place actual transformer there will be equivalent circuit which will be slightly complicated things like that. But if you even if you assume that to be ideal you will be getting results very close to the correct values

that is why this exercise, and also it tells you how the ratio of the current, voltages these are decided.

Now, now tell me this is a 2 is equal to 1 by 4. So, it supplied voltage 100, 100 by a 2 400 volt. If you know this is 400 volt this is 10. So, this current will be 40 ampere. If this is 40 ampere this and mind you I should have shown you the dots, ok. If this is 40 ampere this current will be I 2 by a each secondary current is 40. So, this current will be 40 by a 2, 40 by a 2 means 160, it will be 160 ampere. If it is 160 ampere this secondary what will be this current? It will be 160 by a 1, 160 by a 1 that is 2 is equal to 80 ampere, got the point.

Now, what I am telling is the equivalent circuit of this whole system with respect to this is the only source supply. So, this is 200 volt equivalent circuit referred to source will be, if you have solved these I am telling you this impedance will be simply this voltage by this current 200 by 80. How much it is?

Student: (Refer Time: 23:55).

2.5 ohm, 2.5 ohm, it is coming 2.5 ohm. You see I will now do what, this 10 ohm to this source I will I will try to get back this same result This is the original z z load, discrete value, z load is this. So, to this here, this impedance will appear to be 10 into a square that is 1 by 4 square, this impedance. This impedance is connected across these and this into 4 a 1 square and you see it is 2.5 ohm. Therefore, this is the thing therefore, this is the equivalent circuit referred to this source.

Similarly, you can say the equivalent circuit referred to the load is nothing but this 10 ohm supplied from a 400 volt source. So, this simple calculation will make you understand better what is happening. If you know this current you should be able to calculate this current. See whether I will just give you a tips. See, a I have defined for a transformer, I have defined a to be N 1 is to N 2, a is this it may be greater than or less than 1, depending upon whether stepping up stepping down voltage etcetera.

Therefore if you, current should be divided by a, voltage should be multiplied by a, students get sometimes confused while solve solving numerical problems. But what I am telling you calculate this a trans ratio, you should always remember current on the LV side will be higher voltage on the LV side will be lower.

For example, take this transformer trans ratio is 2, 200 volt LV side voltage will be lower and a is greater than 1. So, you have to divide it by 2. And if you know this current this side current this side current which is LV side, I know which one is LV, which one is LV, HV and I am telling you LV side current is always higher therefore, this current 80 ampere should be multiplied by 2 then, to get a 160 or if you know 160, it should be divided by this a to get 80. So, I have a lot of practice, so that you can transfer the impedance.

See, these one just to conclude this I am telling you it this whole system can be drawn like this also. First transformer I will keep, if I go step by step this is the transformer, first transformer. I am drawing this whole circuit here this is 200 volt fine. And here was a transformer. Treat once transformer at a time, eliminate this transformer first. Then I will say across this transformer and impedance is connected whose value is a square into 10, here this transformer this transformer I will replace. So, this impedance will appear to be a square into 10 a is one-fourth. So, it will be 1 by 16 into 10, so much ohm if any mistake point out. So, I can do it like that also.

And then this 10 by 116 and this transformer trans ratio is 2. So, it will be 4 by 16. So, then the next step is sub supply and this is 200 volt, and this was 10 by 16 and then once again into 4 and equal to 2 point and there are several ways you find out your own convenient way of interpreting the results this time.

Therefore, I so far what I have done is this one that a rating of a transformer this is very important, KVA remain same on both primary and secondary. And then LV side current will be very large therefore, cross sectional area of the wire with which you make this LV winding will be larger compared to the cross sectional area of the wire of the HV side.

Of course, the voltage ratings I have just taken, so that calculations become easier, 200 volt stroke, 100 volt, but in practice voltage ratings could be one side of kilo volts another side may be 220 volt or 440 volt, ok. So, current ratings decides the cross sectional area of the wires and voltage ratings is going to decide the insulation level.

You must have seen transformer from where terminals are coming out with sort of insulations, bushings, they call it. You have seen distribution transformer on the road side, 3-phase transformer. So, these are bushings through which, so this is the these are insulation, ok. So, insulation level will be decided by the voltage rating of the

transformer and cross sectional area of the copper wire with which you make the coils they will be decided by the rated currents of the transformer. So, have a thorough knowledge about the topics which I have discussed here which will make our live much simpler in future. We will continue next class.

Thank you.