Electrical Machines - I
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Lecture - 46
Scott Connection (Contd.)

Welcome to lecture number 46 and we have been discussing Scott connection which is used to transform a 3 phase voltage to a balanced 2 phase voltage.

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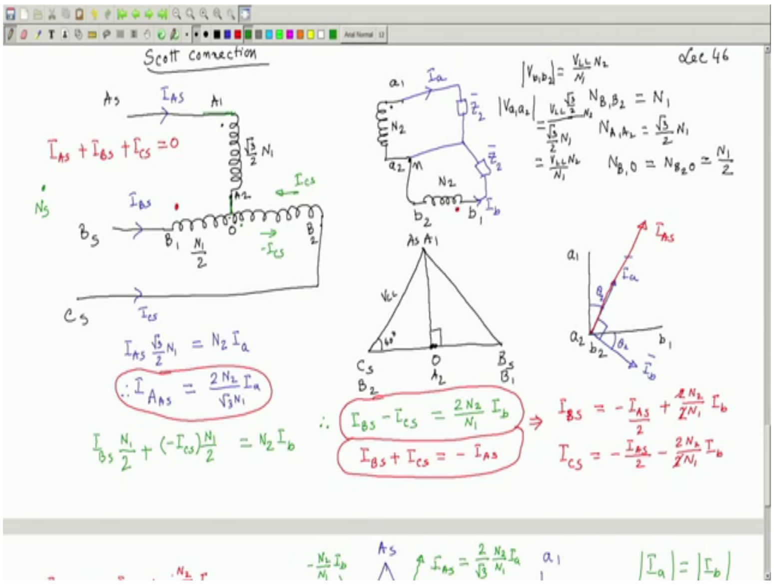

And for this you required 2 transformers ah, one transformer is B 1 B 2 and its corresponding secondary terminals is also b 1 b 2 and an another transformer which is a separate transformer of terminal markings capital A 1 A 2 and small a 1 a 2. What is the thing we discussed that the number of turns of the secondaries are same.

And the primary number of turns of B transformer that is B 1 B 2 turns N B 1 B 2 if it is N 1, then number of turns of A 1 A 2 should be root 3 by 2 into N 1. So, that the voltage per turn in both the transformers become same ok, and we do the phasor diagram it is better we draw that, so that once again and the phasor diagram will be the supply is balanced 3 phase with phase sequence A S, B S, C S.

So, this was my primary voltages A S, B S and C S, A S happens to be also A 1 and B S happens to be B 1 and c S happens to be your B 2. Now, the question is what will be the applied voltage across A 1 A 2, mind you in this transformer B primary has a tapping at 50 percent and that point I called O from this point such that the number of turns this side that is N B 1 O is equal to N B 2 O; these are equal to N 1 by 2, total number of turns is N 1 and the number of turns of this transformer is root 3 by 2 into N 1, and so this is the thing. And now, the question is what is the voltage applied across B 1 B 2, it is B S C S that is this voltage since B 1 B 2 are dot.

So, you will get on the secondary a voltage here which I should call b 1 b 2 that is straighten of straight forward ok. Primary side the question is what is the voltage applied across the primary of transformer a, this point mind you is O; because it is between B S and C S at midpoint, so this will be O.

And this point O happens to be your A 2 O and A 2 are same ; therefore, voltage applied across the primary of transformer A is this one which is at 90 degree to voltage applied to the transformer primary B. Therefore, you will get a voltage here which will be parallel to A 1 A 2 and if you join this a 2 and b 2. Then the phasor diagram tells you that this will be a 1 this will be a 2.

Suppose the line to line voltage applied is V LL therefore, a voltage applied across the primary of B transformer is V LL number of turns is N 1. So, V LL by N 1 into N 2 will give you the voltage here if I write voltage V b 1 b 2 will be V L L by N 1 into N 2 what will be the magnitude of the voltage applied across a 1 a 2 available voltage across a 1 a 2 it will be bolt per turn of this transformer which will be V L L by root 3 by 2 into N 1 is not.

Now, this voltage applied across the primary is not V L L, but V L L sin 60 degree, so this is into root 3 by 2 that is the primary voltage applied across this one is A 1 O which is V L L sin 60 degree that is V L L into root 3 by 2 and this number of turns.

And so, that the voltage per turns is once again V L L by N 1 and this into N 2. So, magnitude of the secondary voltages will be saying and that is why you require the number of turns of transformer A 2 B 2 to root 3 by 2 into N 1. If you take same N 1 turns voltage per turn will not be same, our goal is to get a balance 2 phase voltage at the secondary points.

So, this is the star point and that is what we did and then we will connect a load here say a balance 2 phase load balance load. Suppose Z bar Z bar and write Z 2 to indicate secondary load, so this is a balance 2 phase load and these are the voltages. Then what I told you this point is crucial that when you connect a balance 2 phase load on the secondary side there will be balance 2 phase current. Let this current be called I a, where this I a will be; depending upon the power factor of the load this I a will be here lagging this voltage by the power factor angle, theta 2 that is the thing.

Similarly in the b phase b 1 b 2 same load I have connected, so this current these are the line currents I b will be also lagging this by same angle, I b phasor and this angle 2 will be theta 2. Obviously, since these 2 phasors are shifted by same angle theta 2 and angle between the voltages where 90 degree, so this angle 2 will be 90 degree. So, a balance 2 phase current will be flowing to the load.

Now, the question is you have been able to transform a balance 3 phase voltage to a balance 2 phase voltage. Now, if I want to examine what will happen to the currents on the 3 phase side, will it also remain balanced or not. The answer we will soon see that it is yes and how it is to be calculated; therefore, I know I a what will be my I A S that I want to find out, what is my I B S and what is my I C S. From where shall I find out secondary currents are known I will calculate reflected currents on this side and if you see that I A S, I B S, I C S are of same magnitude. But one twenty degree apart then I will conclude that the ac side current is also balanced.

Now how do I do that, to do this you have to balance the m m f follow the rules of sort of a ideal transformer like the m m f of the secondary through the dot current is coming out. So, that is N 2 into I 2 this must be equal to through the dot current is drawn in, it must be equal to I A S into it is number of turns root 3 by 2 into N 1.

Therefore, you know I A S will be equal to 2 N 2 sorry 2 N 2 by root 3, and here I made a mistake it is not I 2, but I a small I a into I a by N 1, this is equal to I A S, this is the thing.

So, therefore, I A S how to draw this I a your I A S will be in same phase with I a, because this is only a scaling factor. So, your I A S will be suppose in same phase with this with I A S. See we are using whatever you have learnt from single phase transformers beat the transformer is operating as single phase, 3 phase, 2 phase individually secondary and primary coil the relationships they must be maintained that is there will be reflected current and so on.

So, will be your I A S, so IAS is known. Now, the question is how to calculate I B S and I C S, this part we have to go carefully, so these are the dot terminals. So, through the dot current I b I have shown coming out, therefore, the m m f of the; I will use different colour for these calculations. So, it will be this one N 2 into I b phasors; I b is phasor, I am not drawing bar over this things.

This must be equal to the m m f produced by the primary coil and I should always take currents going into it through the dot the same logic. But here the problem is current in this portion 50 percent turns and in these portions there different, but no problem. So, what I will do for this N 1 by 2 terms that is B 1 O turns it should be I B S into N 1 by 2, I am sorry N 1 by 2. And for this part current flowing in this direction that is I C S or I can say minus I C S is flowing like this from right to left I can say, and this is dot means this is also dot.

So, through the dot what is the current flowing minus I C S into N 1 by 2 N 1 by 2 that is the thing, which means that therefore, we get IBS minus I C S this 2 terms is equal to 2 N 2 by N 1 into I B. So, this is another important equation, because I A S already I know and I have draw it in terms of I a. I want to know in the similar way what will be I B S and I C S in terms of I a or I b whatever it is secondary currents because I a and I b as known this blue coloured phasors from that we are trying to get.

So, I required then another equation what is the another equation; another equation is in this side if you look at it we know I A S plus I B S plus I C S these are all phasors sum is equal to 0 that is the third equation. Therefore, I get that I B S plus I C S is equal to minus of I A S is not that is what I get. So, this is the third equation, these two equation is to be solved to get I B S and I C S.

So, add them and divide by 2 you will get I B S supply current on the 3 phase side in the B phase I B S will be equal to adding these two that is minus I A student: and minus I A S and plus of 2 N 2 by N 1 I b by 2, 2 I B S you will get if you add them and similarly, if you subtract this and this you will get I C S; 2 I C S is equal to minus I A S by 2, this minus this minus 2 N 2 by N 1 into I B by 2, so these 2 goes. So, finally, what I get; I get I, I will repeat that all the 3 currents; what is this colour.

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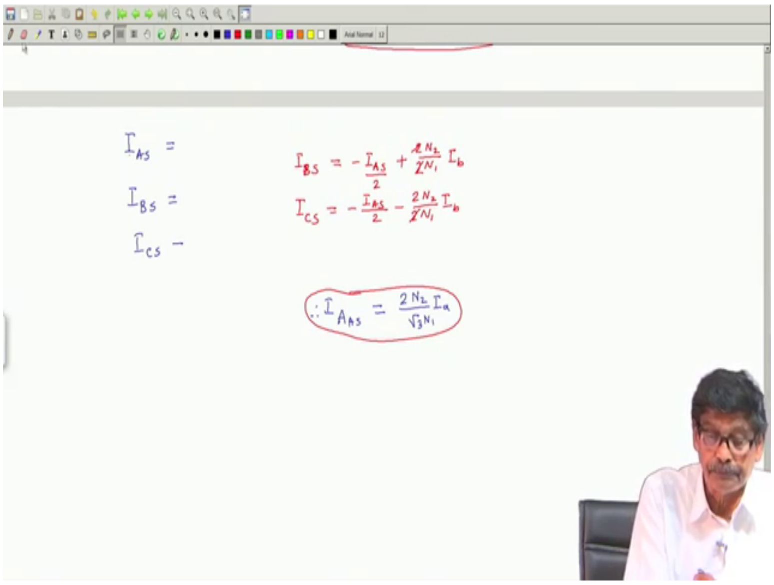

We got I A S, I B S and I C S as I A S is 2 N 2 by root 3 N 1 that is this one why not I am copying and putting it. So, I will get I A S here ok and so this is the I A S and what is I B S we have got I am just I will take straight away from this; it is let me write I B S is equal minus I A S by 2 and this one.

So, I take this copy it and paste it that is all. So, this is the thing I have got I will put it in the corner, so that you can do something. So, this is the thing I A S, I B S, and I C S, and let me draw the phasor diagram of the secondary side voltage and primary. So, that phasor diagram is also needed to indicate that.

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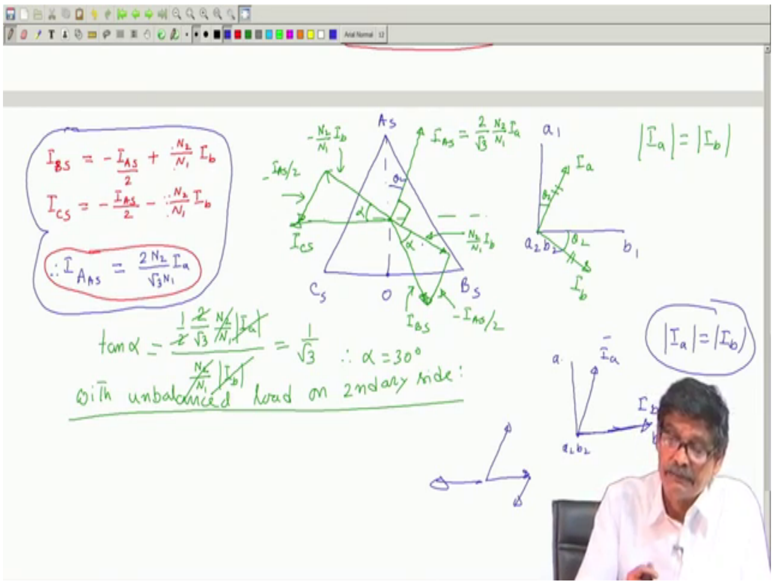

So, it was like this, a 1 b 1 and this is a 2 b 2 and primary phasor diagram was like that A S, B S and C S and this was the point O it was like this. Now, these currents where you recall I a and this current was I b their lengths are same, because balance load I have assumed and this is the power factor angle theta 2.

Now, from this you can see that I A S will be in phase with I a and if I just want to sketch here taking some arbitrary point it need not be neutral I just superimposing this current. Then I a should be like this with vertical theta 2 it will be I A S in phase with I a and here I draw that, this is the thing. Then if you see I B S it is equal to I b is like this, so N 2 by N 1 into I b. So, this part suppose I B S I am plotting it is this term, so erase these two;it is not there now.

So, N 2 by N 1 into I b, I b is here multiplied by N 2 by N 1. So, it will be here this is equal to this part N 2 by N 1 into I b, to this I have to add minus I A S by 2 this is I A S. So, to this you add minus I A S by 2 and then you will get I B S. Similarly, I C S is N 2 by N 1 into I b negative of that, so N 2 by N 1 into I b has already been drawn. So, negative of that this length is minus N 2 by N 1 into I b and to this I have to add minus I A S by 2.

So, I A S minus I A S by 2; this is minus I A S by 2 and then this current will be your I C S is that clear. So, the reflected current and mind you what is I A student:; I A S is 2 by root 3, 2 by root 3 into N 2 by N 1, N 1 into I a and mind you magnitude of small i a and magnitude of small i b they are same is not, so this is the thing and; obviously, this angle is 90 degrees is there.

Because I have shifted I A S by theta 2 same angle; similarly, I b is shifted by theta 2, so this angle is 90 degree. Therefore, I must show if I can show that this angle is 30 degree then I will conclude that it will be a balanced 3 phase currents that is the thing. That is very easy to prove you calculate tan alpha from this right angle triangle tan alpha is equal to length of this, what is the length of this; I A S by 2.

So, it will be 2 by root 3 into N 2 by N 1 into I a by 2 up this length I have no negative sign just from the right angle triangles this divided by this one and that is equal to N 2 by N 1 into I b, the magnitudes I b I b magnitudes are same. So, the this will cancel out, and this cancels out, this cancels out and you are left with 1 by root 3 which indicates that alpha equal to 30 degree.

Similarly from this triangle this is also alpha same ratios. Therefore, we conclude that when the secondary current is balanced 2 phase current like this when Z 2 are same both in magnitude and power factor angle then secondary current will be balanced. But it will also ensure that the current drawn from the 3 phase side will be also balanced.

So, it is a very nice connection you require 2 single phase transformers whose which are not identical in the sense that number of turns are different. Primary side must have a total number of turns N 1 and with a 50 percent tapping otherwise you cannot implement that. The second transformer primary must have it is number of turns same as this transformer, but with root 3 by 2 into N 1 turns secondary turns are same.

So, what actually people do is this they say take 2 identical transformer having same turns this is also N 1, this is also N 1. This fellow primary one primary should have a centre tap another primary should have a taping at root 3 by 2 person that is a 87 percent or, so. You understand that; any way this is I do not want to complicate the figure by drawing that because this is the thing and you get balanced 2 phase system [FL].

If I say that it is just a question if you have understood it correctly, suppose you have a supply neutral also available ns and I ask you can this NS be connected to somewhere in this circuit. See star connecteds load supplied from a 3 phase 4 wire system neutrally straight away connected to the star point; is not and abc are in the other 3. Now, I am asking you it is not a star connection although looks like star this is one (Refer Time: 28:31) this is one this is O. Suppose I ask you where this N S can be connected to not at 2 you should not connect N S here, where it should be at the centroid of the supply triangle and it will come over here and that I can calculate how much it will be; centroid it is.

Therefore, at this point which will be here and I can specify at what tappings we have to take to connect that; is not. So, so this is how a scott connection will be here only one last point is this that this diagram I have drawn for balance load but these equations are true for balanced and unbalanced load as well, what I mean by saying that with unbalanced load what happens we unbalanced load connected load on secondary side no problem.

Because what I will do is this; the secondary voltages are balanced a 1 a 2, b 1 and this is a 2 b 2 neutral and suppose the load you have connected such that it is I a and in the other phase you have connected a load I b whose magnitudes may be different and these two angles is not 90 degree. So, it is a (Refer Time: 30:35) power factor load, primary power factor, but what I am telling is this equation remains intact; m m f balance equation will not change. Only thingI will not I will be (Refer Time: 30:49) of this simplification that is magnitude of I a is equal to magnitude of I b we crossed out separate thing know.

So, it should be then I a it is reflected current will be I A S is this I a you have to take in phase with this I will just indicate it. Similarly, N 2 by N 1 into I b this time it will be like this getting me and minus I A S by 2 if you join I will just indicate; it is your duty to study that. So, it can be done unbalanced load and you will see that primary side current is also not unbalanced and also note that the primary current will be balanced and what will be the power factor of that balanced current drawn from the supply same as theta 2; why?

Because this is the phase voltage of the primary side and I A S lags it by an angle of theta 2. If secondary current is unbalanced primary current is unbalanced, but what I am trying to tell these equations I A S, I B S. and I C S these equations are true no matter whether balanced load you have connected or unbalanced but if it is unbalanced load I will not be able to use this information, and that is why this angle alpha etcetera will be different and not it will not come, so nice as 1 by root 3; why it should; got the point?

So, scott connection is a very nice connection and another thing I will ask you to explore is that this connection that is this is this side connected, this is this side connected. Suppose I plan to apply a 2 phase voltage to this side shall I get a balance 3 phase output voltage on this side this you please explore got the point, that is what I am telling is a is in the reverse way it will work.

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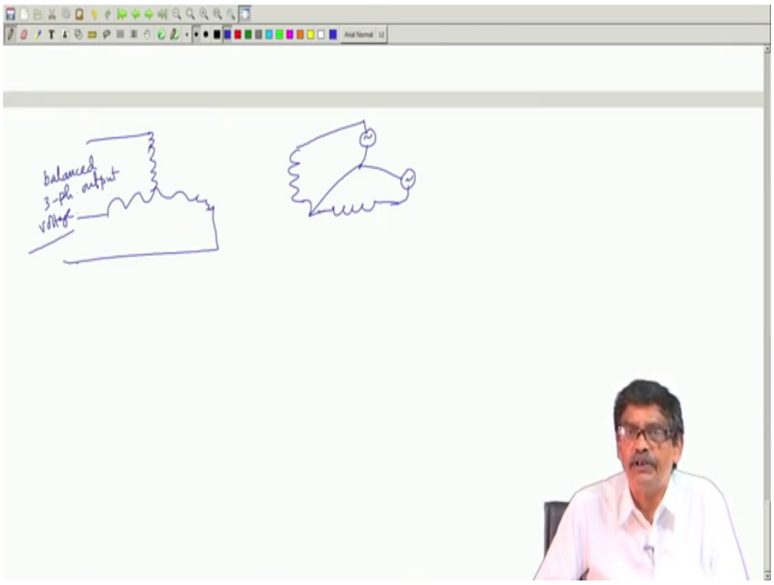

That is this is the secondary 2 coils and primary connection is like this I will just indicate it. I have planned 3 phase to phase vectors 3 phase supply give here balanced 2 phase you get, but suppose I supplied this with a balanced 2 phase voltage this side. Should I get a balance 3 phase output voltage here, draw phasor diagram and you will get the answer. Reverse way suppose secondary side because in any transformer after all whether you can energize primary secondary side you get something. Secondary side you energize you will get something in the primary.

Any way scott connection is popular because of the fact that 2 phase supply is not readably available what is available is, 3 phase supply, single phase supply these things are available in your lab or whatever it is and if you have a 2 phase load for example, a 2 phase induction motor or things like that or a 2 phase furnace. Then scot connection you have to use and of course, balanced loads are preferred ok.

So, thank you for this lecture we will see what we can teach in the next lecture