Electrical Machines - I
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Lecture - 36
Varians Connection 3 Phase Transformer – II

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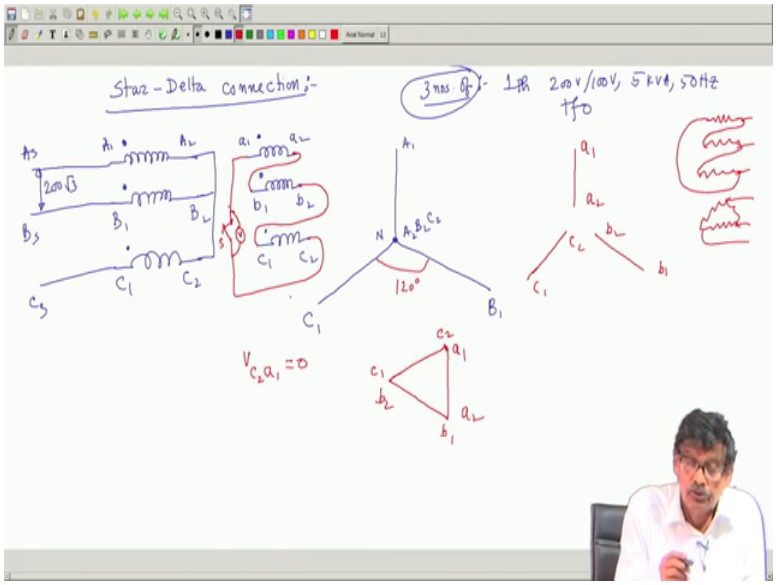

Welcome to lecture number 36 and we have been discussing about the 3 Phase Transformer Connections. Recall that last time, I was discussing about star delta connection. And referred to this diagram, where the primaries are connected in star SV side applied voltage is 200 root 3, then I told you when this 3 coils no connections with this red markings have been made. Then these phasors will maintain their 120 degree phase difference, but they will be in isolated conditions they are separate.

But the moment you connect it in this way suppose, somebody says delta connections means series and closed finally, then he joins a 2 b 1 b 2 c 1 c 2 and before connecting C 2 with A 1 suppose, I have connected a shorting switch which is opened initially. And I would like to know; what is the voltage between these two points? Because the why have connected a shorting switch with the understanding there will be induced voltage here induced voltage there induced voltage there and I am going to short these 3 voltage sources connected in series will not there be any circulating current things like that perhaps prompted me to connect a switch preventive measure. Let me try to understand,

what is the voltage existing there? Because mind you this is the source of EMFS, each one of them has become small a 1 a 2 b 1 b 2 c 1 c 2, because of what because they are primaries have been energized with some voltages.

So, anyway there was a shorting switch; switch was open I want to examine; what is the voltage between these two? How to do this a 1 a 2 these things are there. So, based on this connection I a 1 a 2 I bring it parallel a 2 is connected with b 1. So, position maintained b 2 b 1 parallel here, but b 1 is connected to a 2 plus it here and then b 2 with c 1 plus it here.

Then you see c 2 and a 1 will coincide although I have not connected c 2 a 1 here. It simply tells you that there is no voltage existing there, not that I have forced it to be at the same potential yet, but what will be the voltmeter reading with this open voltmeter reading will be 0. Then I asked myself each one of them is a source of EMF, they are 120 degree apart the resultant voltage existing between a 1 and c 2 that has become 0. Therefore, no EMF exists between these two points therefore, you can close it does not matter.

So, each coil will have induced voltage the circuit is closed now and you get a successful delta connection. And there will be no circulating current here mind you, there cannot be then what I told where from to take the output that I will discuss now.

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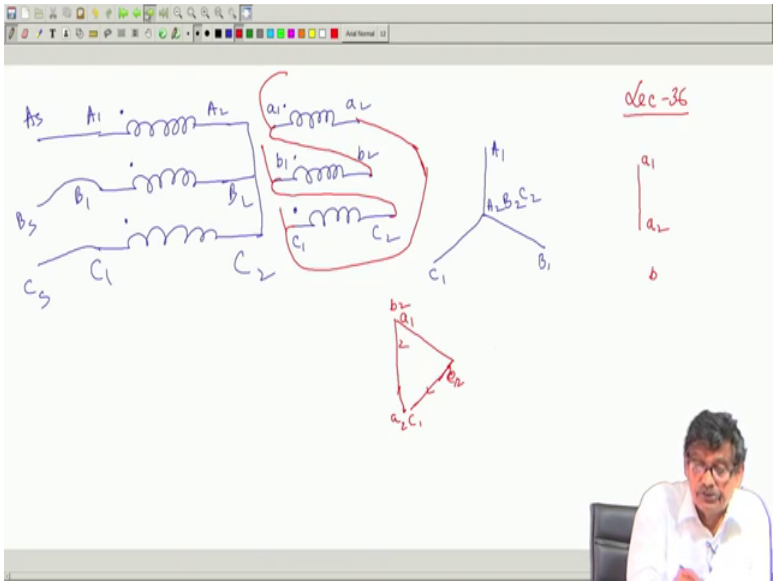

So, this is the thing. So, here are the coils very quickly we you are also now used to it draw it and do not forget to mark the terminals, B 1 B 2 and C 1 C 2 small a 1 a 2 secondary of a, secondary of b and secondary of c. And with the understanding that all one terminals a 1 a 1, these are dots polarity 3 individual transformers and I have shorted this fine and here I have given supply A s, B s and C s.

So, what I am telling the primary EMFs are like this A1 A2 B 1 B 2 and C 1 C 2. A 1 is A s B 1 is B s and C 1 is C s on the secondary side what I am telling you have got these 3 voltages available now, not yet connected I will play with these phasors. So, that it becomes a meaningful delta connection and then b 1 b 2 will be parallel c 1 c 2 will be parallel. Why this will be parallel? Because it is a single phase transformer, it must be parallel to its respective primary voltage and so on. And since the input voltages are 120 degree apart, they will be also 120 degree apart.

Now, what I am telling here is your a 1 a 2; a 1 a 2 ok. And suppose this time, I have joined a 1 with b 2 suppose b 1with c 2. Delta connection I will make they must be in series and these also should be closed, I have not yet closed.

Let us first examine, what is going to happen? Since I have already joined a 1 with b 2; a 1 and b 2 cannot be an isolution they must be at same potential. So, what I will do is, I will move this the a 2 1 a I will what I mean to say this phasor I will now, since b 2 has been connected with a 1 I will move it here b 2 winding and place it here ok. Anyway this I will write b 2 are you getting this b 2 b 1, I will put it like this. Similarly, I have joined b 1with c 2. So, c 1 I will move and c 2 has been connected with b 1, it is move parallel and c 2 will be connected here.

But only thing is there of same length, it is because of my imperfection there in drawing. It will then come here together; are you getting? C 1 and this was a 2 these becomes a anyway you have got the idea.

So, what will be the voltage across a 2 and c 1 0 voltage. Not because I have joined a 2 c 1 these three are sources of EMF voltage is 0 therefore, I will be very confident to short this. So, this is also a successful delta connection and I will take the outputs from here from the junctions, a 1 b 1 c 1 that is the whole idea ok.

Therefore two ways; a successful delta connections will be achieved. I will show you one case, where I make it delta the way suppose I do not care about polarity try to make a delta connection, what will be the consequence that I will show now.

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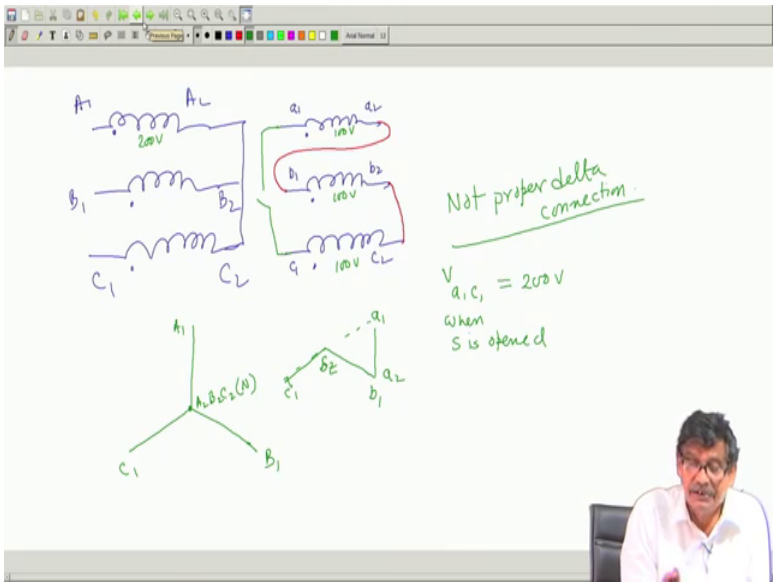

Suppose somebody says that, this is the primaries and these are the secondary's. So, that you can appreciate that the points, here a is A 1 A 2 B 1 B 2 and C 1 C 2. And he makes star connection this way he makes. And mind you dots are known, but he does not care. These are a 1a 2 b 1 b 2 and small c 1 c 2.

What he does, he knows delta connection means connect 3 coils in series and close this. And suppose he says, he connects it in this way are you getting? He joins this points. So, these two are in series, then he makes this series connection by joining these two. And he is planning to join this two points also, now to make a delta he tells that three elements must be connected in series and from the junction, so, you take the output. If he does like that what is going to happen? Let us see. So, primary is this primary voltages are A 1 B 1 and C 1, this point is A 2 B 2 C 2 this is neutral fine.

On the secondary site earlier, when no connection was made these 3 voltages was available to me; one was a 1 a 2 another was b 1 b 2. It is conditioned by the primary voltages, this is c 1 c 2 and they were in isolation, but the moment you have joined a to b 1 a 2 with b 1 this phasor cannot remain in isolation, because a 2 has been connected to b

1. So, this thing that is I will move it such that it remains parallel to b 1 b 2, but a 2 get connected with b 1. So, move it, it will be like this is not that will be the thing.

Then what he has done b 2 he has joined with c 2 is not; that means, he has moved this phasor and b 2 with c 2 he has joined. So, he will connect it like this, is not? And he is planning to short a 1 c 1, now there will be a problem because what is the voltage across a 1 and c 1. It is not 0 now it is this length this sorry this point if it is correctly done with 60 degree 120 degree it would have been this length. A 1 and c 1 a large voltage will exist, source voltage will exist secondary after all is becoming a source of the voltage. And if you are planning to short these two points, you are virtually short circuiting it. Large current will flow transformer may be damaged and so on.

Therefore in star connection you may make mistake, but in delta connection something terrible is going to happen, you cannot be whimsical just telling that delta connection means all series and close it know this you should not do. It in fact, if it is 200 volt, this is 100 volt between these two points this length will be 200 volt a 1 c 2 voltage a 1 c 1, when S is opened is equal to a 1 c 1 this voltage is about 200 volt it will be. This is 100 this is 100volt. Therefore, proper delta connection is either this way or the other way. So, this is not the proper delta not proper delta connection, never do it not proper delta connection.

So, you should be extremely careful. And you will be always be correct provided we have followed this rule. First find out the dot, put the dots, mark the terminals accordingly do it everything will be fine, that is why so many words I have spent. So, that you understand the importance of dot conventions particularly in 3 phase transformer, at least making the connection itself demands that you understand what is what. So, far as polarity of the induced voltages are concerned. Now, after telling all these things, let us now so, this is some star delta connections we are discussing.

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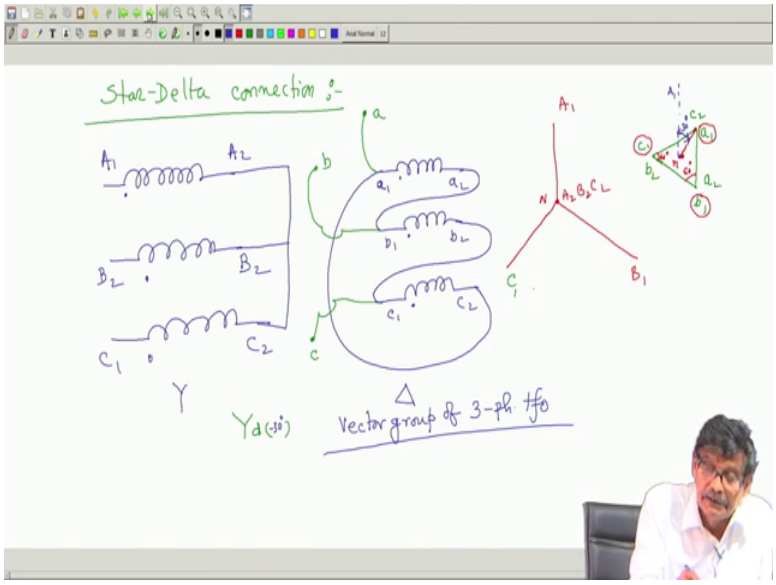

And now star delta connection I will do star delta connection and see what are the variety is possible star delta connection. So, you take this thing primaries and these are A 1 A 2 maybe you will be feeling slightly bored, because same thing I am doing, but you practice it so, that it will give you confidence. And these are dots, but bear with me. And suppose I have connected correct star connection here and this side is delta corresponding secondary's c 1 as now a 1 a 1 small a 1 a 2, small b 1 b 2 and small c 1 c 2 and these are also dots ok. And delta connections only two ways it can be done correctly. So, I choose one and this way I will connect correct delta, easy to remember either this way or other way. So, this is delta and this side is star ok.

Now, let us come to be phasor diagram of this whole thing. Primary phasor diagram, if you see it is like this A 1 and this is A 2 B 2 C 2 I am not writing A s Bs C s it is understood and this is B 1and this is B 2 this will be the thing. Now, the secondary voltages, I will now draw straightaway like this. Small a 1 a 2 cannot, but be here parallel to this it will be there. B 1 b 2 parallel to this and I have joined a 2 with b 1. So, this line I will bring it here b 1 with b 2 and finally, I am sorry this is c 1 it is correct it. So, c 1 c 2 and c 1 is connected with b 2. So, you place this phasor here, c 1 and c 2 and a secondary is delta primary star ok.

Now, listen to me carefully, this connection then I should write it like this. Y delta generally Y d you can write. D stands for delta Y for star. Now in relation with this phase angle, how to specify in the case of star I told you it is either YY 0 or YY 180 degree.

Only these two things are possible here, what is the thing possible? And how to specify the phase angle business here, what should I write? That is the thing.

Now, what I told you that to find out the phase angle, where from I am going to take output. See it is A 1 B 1 C 1. So, I will take output from a 1 the that is this will be my 1 output I will call it a b 1 from the junctions. So, this will be another output secondary output b and c 1 is another junction, which is the output a b c is the output which will go to the load. Therefore, I circle them these are my although c 2 is present, but it is a 1 is there it is b 1 is there it is c 1 is there that way I will say the output terminals are abc.

One may say why not you are telling a 2 b 2 c 2, it could be also circle and told this is a voltage b phase this is c phase no I will not do that. This was a 1 I will stick to small a 1, that is why it will make you much more discipline. Not that a 2 b 2 c 2 that way if you mark things will not work it will work, but be consistent that is what the idea is, so, a 1 b 1 c 1 a 1 a 1.

Now, why this a 1 is stated? See on the secondary side I have no neutral available star connection natural neutral is available. What I told you? To find out the phase difference of the input side and the output side voltage, it is better you consider the a phase voltage with respect to the primary neutral that is this one. This is the A phase voltage. Go to secondary side, where is your a phase this one and what is this voltage with respect to its neutral, but there is no neutral available.

So, what you do? You go to the artificial neutral, in delta where is the neutral? You can always see here is the at the centroid the neutral is there. Are you getting? Or across abc you connect three reactors in stars that point becomes neutral with respect to that this voltage; got the point I hope. So, this neutral is not there in the windings, but artificial the centroid of the triangle you go. Then you say with respect to the secondary neutral, the a phase voltage will be this one. Do not forget that the these angles are 60 degree because of this 120 degree business, this angle has become 60 degree.

So, these angles has become 30 degree, this at this and this I call small n. So, I have got a phase voltage with respect to neutral of the primary side that is a 1 n. I have got the a phase voltage of the secondary side with respect to each neutral, which is just not available you have to artificially create it or whatever it is, but it centroid it will become with respect to that this is the a phase voltage. Is there a phase displacement between

them? Yes, if you draw the this primary voltage a phase only stick to 1 phase other phase it will be automatically satisfied because, each one of them is 120 degree apart.

So, what you do you draw a line here, parallel to this A 1 n suppose, this phasor this phasor you shift it here A 1 and n. And it is these angle, then because this is vertical with vertical how much angle this is making will tell you the respective phase relationship of the secondary a phase voltage with respect to its neutral.

What is this angle is? 30. So, I will be rather telling that this is Y d and secondary voltage is, lagging the primary voltage by 30 degree is not? Y d minus 30 I could right. Got the point? Therefore, the this is called the vector group of transformer connection; vector group of 3 phase transformers is this Y d minus 30 degree.

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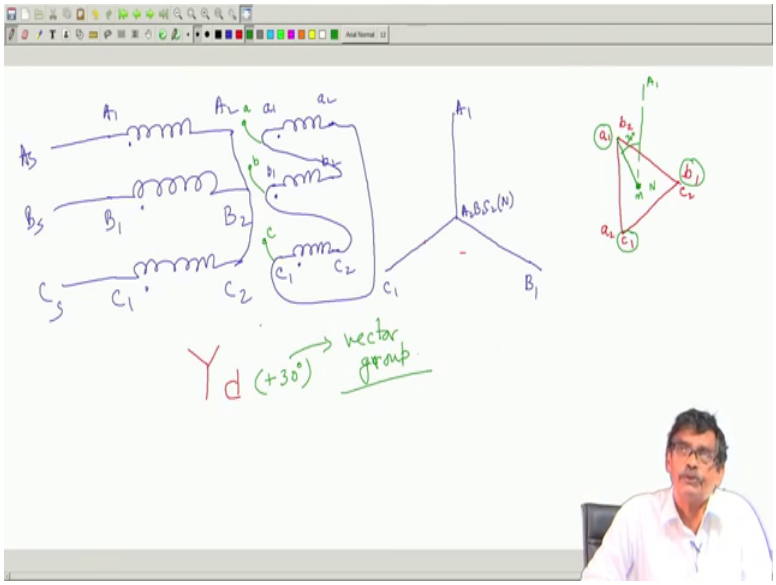

And let us see another connection for example, star delta I will make, but delta this time I will go other way around for example, this is A 1 A 2 this is B 1 B 2 and this is C 1 C2 these are dots not these and these dot we are talking about each secondary dot that is each secondary these are three separate transformers no question of mutual drop. So, this is dot b 1 b 2 and this is c 1 c 2 this is also dot.

Now, in previous case I told you there are two valid delta connection, these way I have connected no not this way ; this way I have connected a 2 with b 1 b 2 with c 1 c 2 with a 1. I will now go other way round a 1 b 2 like that. So, here that is other way means, I will

now connect it in this way. That is also valid delta and these three you join and do not worry the potential difference a to c 1, even if you do not connect will be 0 that is why you are allowed to short it that is what I want to tell. Where from and of course, this side is I have connected a valid star and here is your supply with phase sequence A s B s and C s got the point.

Where from should I take. So, what will be the phasor diagram first? Phasor diagram will be A 1 B 1 C 1 these are 120 degree apart, this is A 2 B 2 C 2 and that is the neutral of this side.

On the secondary side, once again I will draw separately first the voltage. I not drawn separately, I can now draw straight away. Because, this is the thing we got it will be like this. So, first I will I am slightly drawing higher this is half of this length this is a 1 a 2; b 1 b 2 is available parallel to this capital B 1 B 2, move it parallel and put such that b 2 gets connected with a 1; that is it will come here b 2 b 1.

Then what I have done b 1 with c 2. So, bring this c phasor c 1 c 2 phasor such that, it gets connected to c 1 c 2 c 2 with b 1 is not? And your connection is complete. So, I will write it here star and secondary side is delta d now I have to examine what will be this phase angle. So, what is the next step next step is this is your a phase b phase c phase.

I am going to take the outputs from this a 1 b 1 and c 1 from the junctions and I will say this is my a phase this is my b phase this is my c phase. The reason I told you because capital A 1 small a 1 like that and this is also abc phase sequence. So, this terminal I will mark it as small a small b and small c. This is the neutral of primary this is the a phase voltage here a 1 n where is the a phase here where is the neutral centroid.

Therefore, your a phase voltage with respect to the secondary artificial neutral is this length and where is your primary voltage; primary voltage with respect to primary a one and n it is here is your a 1 and n that voltage this you bring it. So, this angle is 30 degree. So, secondary voltage is leading or lagging, the primary voltage, neutral voltage.

Student: Leading.

Leading. So, I will write here plus 30 degree. Got the point? Although, I have not told you anything about when to use star; star connection, when to use star delta connection,

when to use delta star connection no nothing like that we are getting used to how to connect the transformers correctly polarity marketing are so, important. And what is vector group? This vector group is also specified in terms of some clock minute hand and hour hand, that also I will discuss next class.

But I hope you are understanding, the idea given a 3 single phase transformers without doing polarity test. Do not go to connect the 3 phase connections, either star; star delta star it is the it will be then left to chances. Particularly with delta connections you may face disasters condition short circuiting the supply. So, the point is these dots must be ascertained separately, terminals are marked be systematic and then connect correct star and correct delta. 2 correct star connections are possible either short A 1 B 1 and C 1 or short A 2 B 2 C 2.

Similarly, two correct delta connections are possible, either go this way after we have mark the polarities or you go this way. I hope you are not only understanding, but you are taking interest that is much more important. Please go through this notes and discuss with your friends, you will like it I hope.

Thank you.