Electrical Machines – I
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Lecture – 35
Varians Connections 3 Phase Transformer – I

Welcome to lecture 35 and we have been discussing about 3 Phase Transformers and 3 single phase transformers I have taken earlier, each of rating this much.

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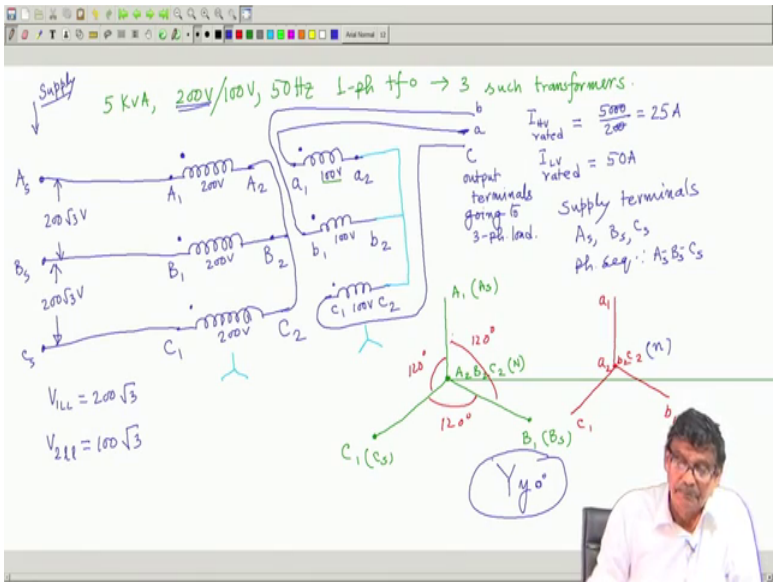

And I showed you a simple star star connection ok. The terminals markings are essential, along with polarity marking. So, I have assumed because three transformers are there, I will name them A transformer B transformer C transformer. Capital A 1, A 2 small a 1, a 2 are the are respectively high voltage and LV side terminals and I have presumed that this 1 1 are the dots for all the phases so that is there, so they here also it was taught anyway.

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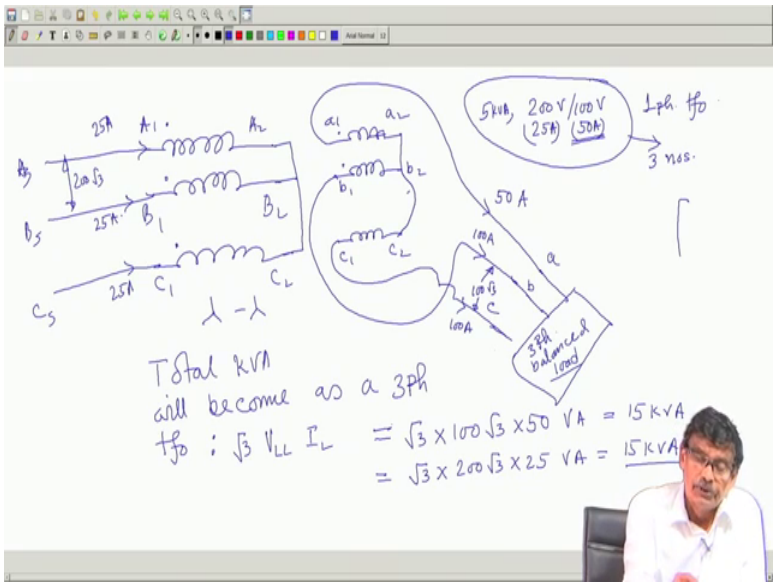

So, and then I told you how to make a successful star connection and the rating of each transformers were 5 k VA and maximum k VA this 3 phase transformer, which has been formed by using three single phase transformer each of rating this will become 15 k VA and it is pretty fine; I mean each one is 5 k VA you can handle 15 k VA that is good. Now today I will go slightly we will try to tell you this one very important thing why polarity is so much important. For example when you take three, because we will start delta connection so, it is better to appreciate this point what do I mean by star connection?

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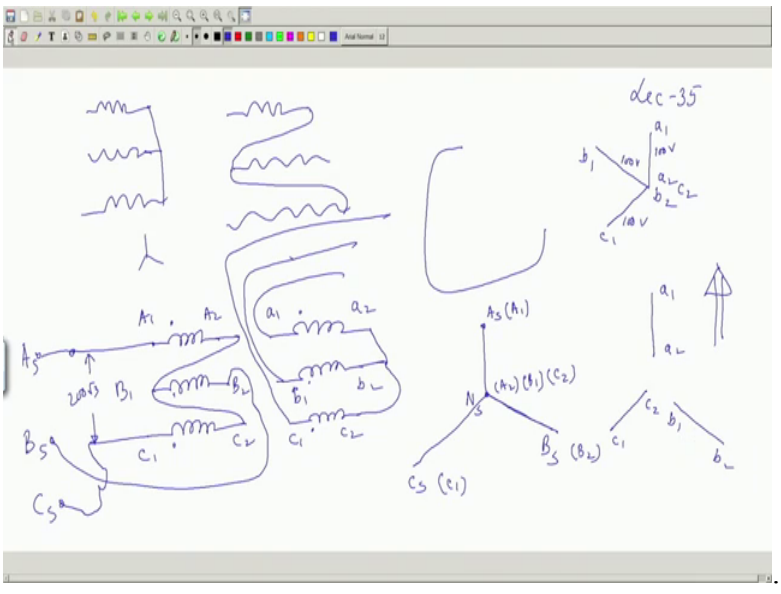

If suppose three resistances are there, three resistances are there I ask you to connect them in star means any one terminals from each of these elements you short them. Either you short it is a star connection or you could short it like this also, this and this will be also star connection no difference.

So, star connection means two terminal devices three are there. So, one from each you just short them without asking any polarity or descent that is what I am telling similarly what is delta connection? So, this is also star this is also star suppose their resistance or inductance or capacitance any way you connect it is fine. Now suppose I ask you to connect this thing in delta three resistances, what is this connection, connection this connection in language we tell it that connect them in series first, series this series this series and close this path it becomes delta connection.

And from the junctions you take the output. Although, we draw it like this that is fine here also we are doing this second resistance third resistance, you connect and from the junctions you take the output and it gets delta connected is this different from this? No. So, this is the way we will be drawing delta connected here coils will be in series and closed and from the junctions you take the outputs that is it.

[FL] If that be the case then suppose I say that, somebody a has a three single phase transformers like this A 1, A 2; B 1, B 2 sorry A 1, A 2 its secondary small a 1, a 2. And then and then later three are there, so B 1, B 2 small b 1, b 2 and this is small c 1 c 2 identical transformer C 1 C 2.

Suppose he does not care a careless person for example, he argues that star connections, I know one from each I will short and other three p terminals will become the terminals of this star connected devices. So, he does like this. For example, he does not care about polarity, he tells that this is also my star connection why not? And he tells that you connect this although I know for discussion purposes, but I know that capital A 1 small a 1 are dots capital B 1 small b 1 dot, capital C 1 small c 1 are dot.

This is the actual thing which is prevailing, but he does not care what he does he tells that, this is the thing connect this star in the primary going by this general definition of star; and decides that he will give supply to supply he has got three terminals A S B S C S of S sequence ABC. He gives supply to here A, then this B supply terminal what he does he gives it to here are you getting me? B and C supply he gives it to there. And he

tells that I have connected the primary in star and I have energized secondary he has not done anything.

Now, in this case if you look carefully the supply is balanced 3 phase ok, supply is a balanced 3 phase system and you have connected like this. So, supply A 1 A 1 is connected to A S and B S B 2 terminal has B connect connected to B S. So, with respect to neutral it will be just not correct in terms of phase sequence; because what we know that A S B S C S is a balanced 3 phase system for example, A S this is this is suppose supply neutral this is your B S, this is C S C S.

Now, you have energized the primary of this coil with a voltage this voltage and this A Sis A 1 is not? And your this N S is equivalent to your A 2, 1 by root 3 times. B S I have connected to B 2 is not I have connected to B 2 therefore, this B S terminal is B 2 and B 1 is connected here. So, B S is B 2, I have connected. And here is your B 1, similarly C S I have connected to C 1 and this is C 2 that is fine. This is what I have done.

Now, on the secondary coils there will be induced voltages, following the rules of single phase transformer capital A 1, A 2, you will get a voltage here because these polarities are correct polarities are like this. So, you will have a voltage here a 1, a 2. For the second transformer, you will have B S is connected to B 2, you will have a voltage phasor parallel to this; b 2 b 1 that is what you will get.

And here C S is c 1, c 2 you will get ok. Now the point I want to make it without doing polarity test, you should never try to connect the 3 phase transformer. Either in star or delta and the difficulty what will come that I am telling. I am telling somebody connects like this although the polarities actual polarities are like this, but he does not care star connection ok, I connect supply then what I am telling. Look at the individual applied voltage across the primaries.

For the A transformer it is A 1, A 2. For the B transformer it is B 2 B 1, B 2 is connected to B S which is 120 degree apart. Because, your supply is balanced 3 phase supply with phase sequence A S B S C S; for C 1 of course, C S is connected to C 1. Therefore, induced voltage in the secondary's of each of the coils, will be parallel to the primary voltages, which for a phase A 1, A 1; A 2, A 2 parallel to this, for C phase C 1 C 2; C 1, C 2; for B phase B 2 B 1.

So, it must be this way getting the point. Now suppose he says that secondary I have to connect in parallel, he has quite arbitrarily connecting the things. For example, let us assume he is a crazy man he is telling that star connection, he decides that he will connect like this. Secondary these voltages are available in this way. And he tells that I will connect the secondary also in star in this way.

If he does, then these phasors are no longer staying in isolation some of the conditions you have put. What is this condition? A 2, b 2, c 2 you have forced them to be at same potential. Therefore, this three phasors I will write here sorry this is not necessary. Now where is the (Refer Time: 13:01) one ok, so this is the thing.

So, here from this I now say that ok, this is how you have connected then these three phasors will have their existence like that you cannot do anything. This is the this follows from single phase transformer fundamentals. But what we have done is, you have made a 2, b 2, c 2 to be at forced them to be at same potential; so a 1, a 2 and this b 2 is there, but b 1, b 2 will be parallel to this fellow that will not you cannot do anything.

So, move it parallel bring it here, here is the most important point b 2, b 1. c 1, c 2; c 2 has been joined with a 2, b 2. Therefore, it will be like this c 1, c 2 that is what you will get. Length of each of them will be 100 volt provided you have applied here 200 root 3. Length of this at 200, so 100 volt; 100 volt; 100 volt and then he tells that from this you take the output 3 phase output. Is he going to get a balanced 3 phase voltage? And that is, no.

You get some three terminals, the voltage of each phase looks like same, but they are not 120 degree apart. So, a balanced 3 phase voltage you will not you are not getting. Therefore, a just from the definition of star connections of passive elements one should not proceed. In a 3 phase transformer connection, this must be connected of course, just to point it out. If he would have connected in the same way here while connecting I think you are getting my point. So, I will draw it here, what I am telling they the secondary I am telling.

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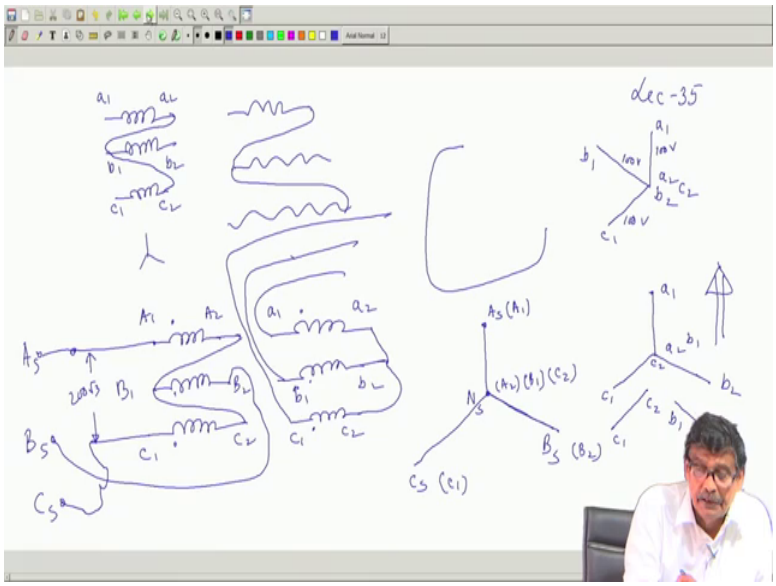

He also connects the only the secondary's I am drawing, I a 1, a 2, b 1, b 2 and c 1, c 2; c 1, c 2. Now in the same way star connection he does in the same way like this as he has done in the primary. Suppose he has drawn in the same way, in that case of course, this secondary voltage is will be balanced 3 phase voltages why? Because, if you connect like that what we have done a 2, b 1 and c 2 you have shorted. So, a 2 and b 1 you have shorted. So, bring this phasor here, a 2 b 1 and c 2 bring c 2 there, parallel to this you will get a balanced 3 phase supply that is there. But it is left two chances (Refer Time: 16:57) if you do you do not know.

And not only that, the terminals are marked as that is why terminal markings are very essential and we would also like to say that supply you are giving to a 1, b 1, c 1, take the supply output from a 1, b 1 c 1. Here although you will get balanced 3 phase supply if he connects like that, but there is a mix up see this is a 1, that is b 2 this is c 1.

So, to avoid all confusions, we must adhere to the terminal markings. And this terminal markings business becomes much more crucial if it is delta connections ok. Star connection its somebody connects just like that without we with any due regard to the polarity, then this kind of situations may happen you may not get to balanced 3 phase output voltage of although you have connected a balanced 3 phase voltage there.

And if you see and you can argue I have connected the primary in star, secondary in star, still I am not getting balanced 3 phase voltage. It is simply because; you have not

followed the proper dot polarity anyway. So, we have discussed about star star connection, connect star star connection here. Now this star star connection, as you can see which I have done here in the first slide is called, star star Y. Generally, this is how it is written Y y star star small y for the low voltage side, capital Y for the high voltage side.

And then, there is a number written 0 degree besides it Y y 0. It means that, the primary and secondary as star connected and phase displacement of the a phase voltage, with respect to neutral of the secondary side. And a phase voltage with respect to neutral of the primary side they are same, no phase displacement vertical b 1 b 2 this is the secondary neutral n.

So, with respect to neutral B phase voltage is in phase with B phase voltage of the primary side B 1 with respect to neutral. So, sometimes it is called Y y 0 [FL]. In this connection, I will use better a new page. So, better do not do star connection not like that ok, this is it is not at all suggested to do like that. You always carry out the connections as per.

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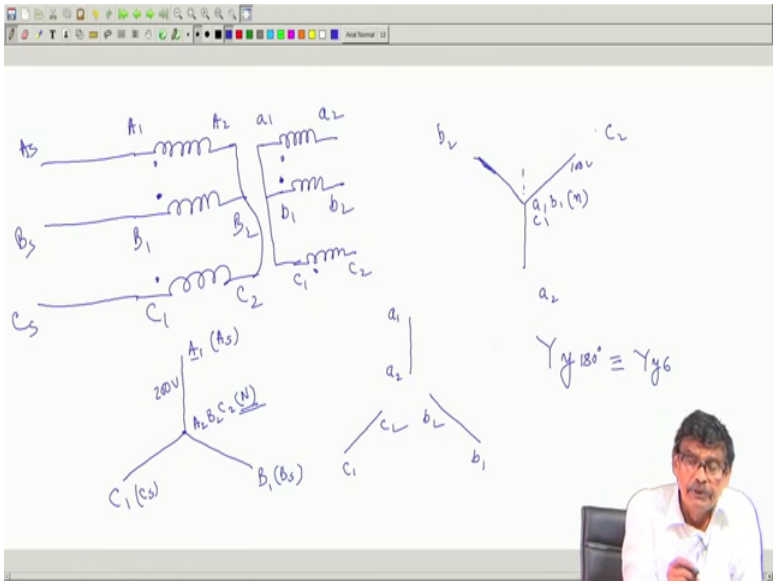

So, let me come back to this one, A 1, A 2 and I will be henceforth drawing very quickly and you have understood me hopefully what I mean this these are very important. B 1, B 2 primary, its secondary b 1 small b 2 these are dots. And this is the third transformer I have named it C transformer, that is why its terminals are like this ok. This is the proper

polarity connection. Now and suppose let me go like this, I have joined A 2, B 2, C 2, I have connected supply A S to A; B S, supply B S and supply C S, I have connected like that phase sequence is A B C.

So, that the primary applied voltage I will connect, it will be a 1 which happens to be AS supply. This three points I have joined, they would must be at the same potential and that is the neutral. And then supply B S I have connected to B 1 only. So, this is capital B 1, which happens to be same as supply B S. And then your and these are 120 degree apart; C 1 and this is also C S generally, A S, B S, C S we may avoid. And in the secondary as I told you I have got suppose I have not connected anything, but these things are available these voltages, a 1, a 2 parallel to this a 1, a 2; b 1, b 2 parallel to b 1, b 2. In this case and this c 1, c 2 parallel to this c 1, c 2 these are available.

Now, suppose somebody says I will connect the secondary coils in star, but this time I will join it like this. I will short a 1, b 1, c 1 ok, I will short it. If you do this and I will take output from a 2, b 2, c 2, then what he is essentially doing, the moment you connect this phasors are not in isolation, a 1, b 1, c 1 are at same potential. So, what you do is this you have to now move this phasors in such a way that a 1, b 1, c 1 are at the same potentials.

But nonetheless a 1 it will be parallel to capital A 1, A 2 that is the boundary condition. Because, single phase transformer each one of them is. Therefore, they must satisfy the principle of transformer. So, the way if you connect these this is suppose a 1, a 2 now I have joined b 1 with a 1 therefore, what I will do is this I will move this phasor parallel and put it here b 1, b 2 getting the point. Similarly c 1, c 2 I will put on a parallel and put it here c 2, c 1.

Then you know it is also a correct balance 3 phase output voltage you will get across a 2 b 2 c 2. But this time this is the neutral this is the secondary neutral a 2, b 2, c 2, is the primary neutral, then I will say and also see the supply phase sequence is ABC everything is fine. And there is no mix up of this terminals if it is a 2 a 2, b 2, c 2. Earlier case there was a mix up although balanced 3 phase you will be getting here, but it is a 1 it is b 2, c 1. Technically correct I mean it will work, but the point is I should be very systematic in doing that, so that things are standardized there are.

So, this is the thing here is also no mix up a 2, b 2, c 2 balanced 3 phase sequence is ABC like that. And if you apply here each one of them 200 volt this length the each one of them is 100 volt of course, scale I am not properly drawn and these are much less. Here I think you got the idea just to explain that I am do here.

So, anyway these are 120 degree. So, balanced 3 phase voltage will be available. Now this connection diagram, how do I specify? Earlier one was Y y 0 and this one I must then say it is Y y star connections secondary, star primary and perhaps I will write 180 degree. Because, a phase voltage with respect to neutral of the secondary side is 180 degree a phase voltage of the primary is this these are parallel know. So, a phase voltage a 1 with respect to the primary neutral and a phase voltage of the secondary with respect to neutral of the secondary side, they are one eighty degree apart the that is why it is called Y y 180 degree ok.

And sometimes we will soon tell you that this is also people say it is Y y 6 why this 6? I will come slightly later, but I hope you have understood the importance of dot connections, you cannot just have a general way of connecting star. Three resistance do not bother connect, in anyways star star delta delta, but in case of transformer connection you should be extremely careful. So, I will now discuss one delta connection let us see.

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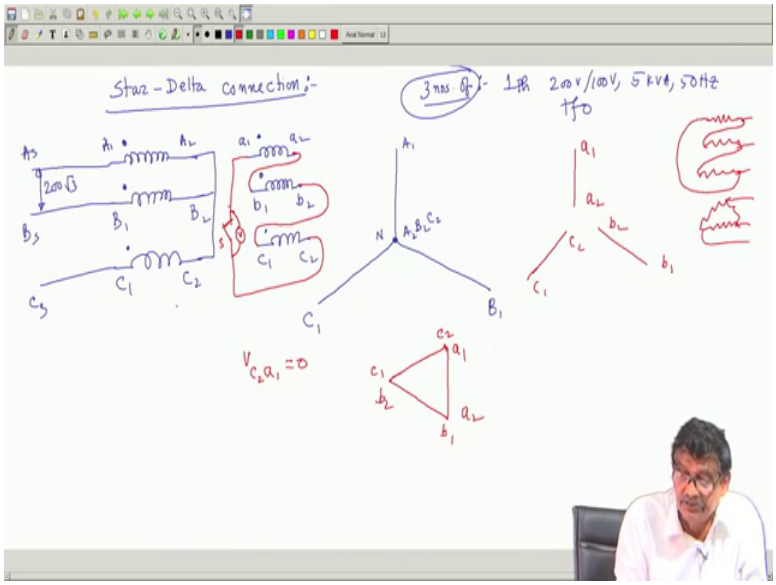

So, I take suppose I want to do star delta connection of the same 3 phase transformer. So, once again follow me follow these steps, draw the coils A 1, A 2. Each secondary small a

1, a 2 second transformer B coil; B 1 b 2 second transformer b coil b 1, b 2 and third transformer C 1, C 2 and its c 1, c 2. Number of turns of each of these secondaries are same, each of the primaries are same ok.

That is understood because the ratings of each of the single phase transformer, I have taken three numbers of this transformer what is that? 200 volt, stroke 100 volt, 5 k VA 50 Hertz, single phase transformers. Three numbers I have taken each one of them is this. [FL] Now what I say then I will I have as I have told you I will always maintain these dots I have marked with one and other things left of this so, this is the dot convention [FL].

Now, suppose I connect them in star proper star A 2, B 2, C 2. And here is my supply terminals A S, B S, C S phase sequence is, A B C. Therefore, the primary voltages I can immediately draw, is not? That is this one is A 1, A 2. And A 1 is A S that I am not writing. Similarly here it is B 1, B 2, A 2, B 2, C 2, I shorted; C 1, C 2 this whole thing is the primary neutral. And the length of each one is 200 volt because I let us presume that I have applied 200 root 3 here.

Now, on the secondary as I told you next step is they first keep them in isolation and you have this three phasors available with you, whose length is half of this length. And each one of them is parallel to their respective primary voltages. So, b 1, b 2 parallel to this line and this line and this line 120 degree apart, so angle between them is also 120 degree.

Similarly, here parallel to c 1, c 2 length of each one of them are same this slightly has become more. So, this is the thing I hope you have understood, so this is how it is there. Now what is delta connection? Delta connection means you have to connect for three rheostat I was telling now, let me repeat this is. This way always think now you are now much more matured, connect them in series closed this series and from the junctions take the output, it has become a delta connection like this like this [FL].

Now, here you see that suppose I connect without much discussion suppose somebody knows this and he connects it like this he joins these two points. He joins these two points and he is planning to join these two points. And suppose he has connected a switch there to complete the delta suppose. Now, this three phasors are in isolation the moment you make a connection like this, they are no longer in isolation.

So, now you position these phasors, based on these connections. For example; for example, here was a 1, a 2, I draw that once again a 1, a 2, but I have connected a 2 with b 1. So, what I will do, I will ship this phasor here, keeping it parallel to this and put this b 1 b 2 here are you getting me? Because, I have connected so a 2 and b 1 must be at same potential.

Earlier I was joining a 2, b 2, c 2 or a 1, b 1, c1, but I have joined only this a 2 and b 1 and certain they are at same potential. So, move this phasor here, then you have to connect a what you have done what connection you have made b 2 with c 1. So, move this phasor here, such that c 1 is connected here c 1 is put there. And c 2 is here is not, this is how it will be connected got the point?

Now, suppose I take a voltmeter and connect across this switch, I measure the voltage across a 1, a 2 this all will be 100 volts. Here, voltage across this coil voltage across this coil 100 volts; what will be the voltmeter reading across this coil? That is V; c 2, a 1 here is a switch which is kept open, I have connected them in series, but somehow I have I am telling you I have not closed it yet. Tell me what is the voltmeter reading what will be the voltmeter reading?

If you can tell me, you are half way through yes, voltmeter reading is V; c 2, a 1 is not a 1 and c 2 these two points. And what is the voltage between c 2 and a 1 it is 0, it is equal to 0. Therefore, even if it is closed c 2 will whether it is closed or not, c 2 and a 1 there is no potential difference, so you can close this no problem, no circulating current. Although, each one of the coil has become a seat of emf they are connected in series.

And you are closing those, but these are 120 20 degree apart balanced 3 phase voltages. So, resultant will be 0, no circulating current nothing. So, this is a successful delta connection. We will continue with this in the next class.

Thank you.