Computer Aided Power System Analysis
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Lecture - 57
Fault Analysis (Contd.)

Hello friends, welcome to this lecture on Computer Aided Power System Analysis. So far we have looked into the process of building up of ybus matrix of with 3-phase unbalanced system including transmission lines as well as the transformers. And after that you have looked into the process of finding out default admittance matrix of different types of faults and then subsequently you have looked into that how to perform the fault analysis in the phase domain.

Now in this; all this analysis we have essentially assumed that this transformer admittance matrix which is nothing but a 6/6 matrix is actually known to us. For example, we said that any transformer, we said that any transformer.

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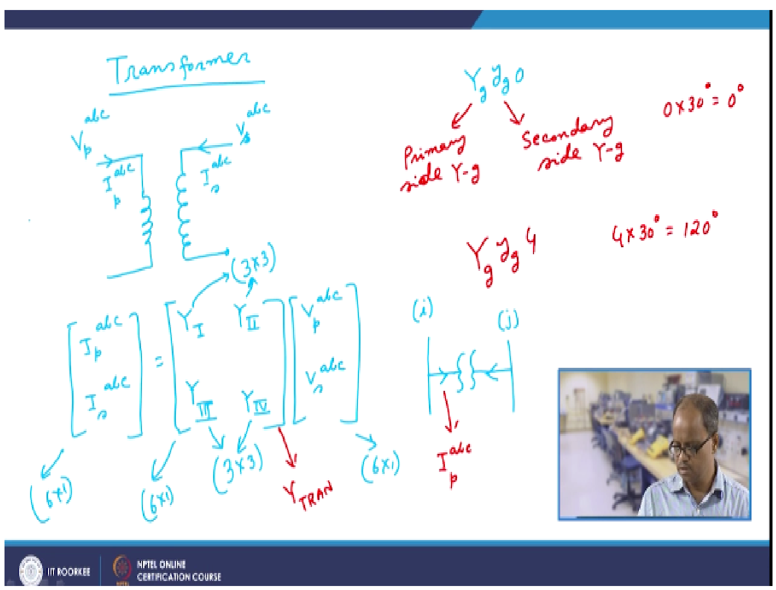

Any transformer can be modeled as; any transformer. For example, if I have an transformer; this is basically 3-phase transformer, so this is basically 3-phase transformer so here we have Vp abc and here Ip abc and here we have let us say Vs abc and we have let us say Is abc. And then we have said that Ip abc Is abc we have said that this can be represented as some 4 metrics that we have said.

We have said that, we assume that with this admittance metrics are known and base on that we have looked into the process of including this transformer admittance matrix into the overall ybus matrix of the entire system. Now we have assumed that this matrix is to be known. Of course this is 6x1 because all of them are 3x3 so this is 6x1 and this is also 6x1.

And individually all these metrics are 3x3 all these metrics are 3x3, all these metrics 3x3 they also 3x3 so that you know. Now today we would be looking into that looking into the process of finding out these four metrics given any transformer connection. For example, suppose we say that we have a transformers connected as Yg yg 0 this means that this primary side, I mean we this is primary side grounded primary side, this is Yg, this is the secondary side yg, secondary side also Yg.

So what we are doing is we are denoting the primary side as the capital I mean we are actually denoting the primary side with a capital letter and we are essentially denoting the secondary side with a small letter, this g, this g transferred that this is connected in stalled grounded fashion and this is also essentially denoting that the secondary side is also connected in stalled grounded fashion. The 0 denotes the phase difference between the corresponding phases of primary and secondary side.

So as we know from our basic analysis of transformer vector group that this 0 means that essentially the phase difference between the primary side and the secondary side between the corresponding phase voltage is 0*30 degree, so that is essentially 0 degree. So then therefore, if I have another connection let us say Yg yg say 4 so therefore, what we will simply know from this connection or rather from this notation is that, here also our primary side is connected in stalled grounded fashion.

Here also our secondary side is connected in stalled grounded fashion but there is a phase difference between the phase A voltage of the primary side and the phase A voltage of the secondary side and this phase difference is 4*30 degree that is equal to 120 degree, right.

So then therefore, now so then therefore, we need to look that what would be the transformer admittance matrix that this metrics if we denote let us say this is the; if you denote that this is Y Tran, so then we need to find out that would be this transformer admittance matrix that is why Y Tran matrix for this connection or let us say this connection or for let us say for any other connection. So that is objective of this lecture as well as the next couple of lectures.

So let us stalled with the simplest possible connection that is Yg yg 0 and then we will try to see for other types of connections if our time permits. So what we are now doing is that we are now trying to consider that how to develop the transformer admittance matrix for a given transformer connection.

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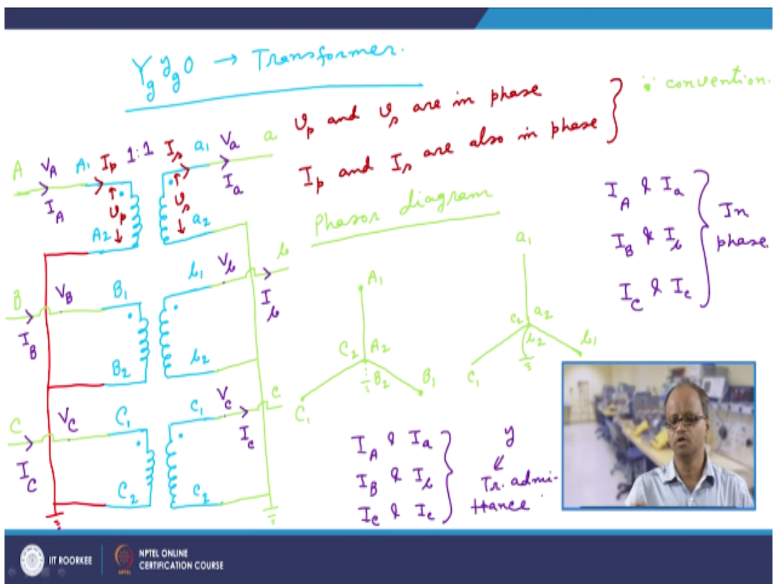

So to stalled with we are taking that Yg small yg 0, so this is the transformer. So now because this is the 3-phase transformer we assume that any 3-phase transformer is actually consisting of 3-single phase transformer, so then therefore we have three set of primary winding and three set of secondary winding. Let us say we do have a three set of primary winding as; so these are the; so these are the, right.

So let us say we do denote these terminals as A1, A2 this terminal denoted as capital B1, capital B2 and this terminal is denoted as C1, C2. And similarly, these terminals are denoted as small a1, small a2 and this terminal denote b1, small b2, this is denoted at small c1, small c2. Now we know that for any transformer to be represented correctly we also need to put a dot on the windings of the transformer, so then let us put that dots at this point and at this point dot at this point and dot at this point and dot at this point dot at this point.

So what is the significance of this dot convection? Significance of this dot convention is if we do recollect so let us say this voltage Vp, Vp here, so this voltage Vp and if this voltage is Vs, Vs and Vp, Vp and Vs so then this Vp and Vs are in phase. So when I say that this voltage Vp, Vp means potential of this point as compare to this point; as well as potential of this point as compare to this point these are in phase, so therefore this voltage in this reduction and this voltage in this reduction they are in phase.

Similarly, if the current here entering is let us say Ip and if the current going out of this is Is, so then this Ip and Is are also in phase. So this is the convention of the, so this is the dot convention. So we say, that this is nothing but the, this is the dot, this is the dot convention. So this was the dot convection, right. Now, one thing we again have to recollect, if I say that this voltage and this voltage they are in phase so then therefore when we would be drawing the phased diagram of this voltage and this voltage, they should be drawn as parallel lines to each other.

So similarly, this voltage and this voltage because these are in phase that is basically this voltage with respect to this point and this voltage is respect to this point because they are in phase so therefore, these two voltages also should be drawn in parallel to each other. Similarly, these two voltages also should be drawn in parallel to each other because they are in phase.

Now our connection is Yg, yg 0. So then therefore, it first make the connection at the secondary; at the primary side. So we make the connection in the primary side as, so make the connection in the primary side, so what we do is that we simply join these and make it to ground. So what we are doing? So now what I have? Now, so after I join this, after that we draw the phase diagram, after that we draw the phased diagram. So now let us say that phased diagram.

So what would be the phased diagram in the primary side this is a; this and this so this is grounded. So let us say this terminal, so let us say that this point is A1, this point is A2, this point is B1, this point is B2, this point is capital C1, this point is C2. So then from this diagram what we can see that essentially.

So now what we have done is that as if put these three winding in the appropriate fashion and what we are doing that we are simply connecting this terminals A2, B2 and C1 together and then simply sorting this connection to ground and that is what exactly we have done, we have simply sorted A2, B2 and C2 together and then short connection we have connecting to ground. So then therefore, and this is my phase A.

So essentially this is my phase A, this my phase B so this is my phase C, so we can see that this is my phase A and this is my phase B at the primary side and this is my phase C. So then therefore, at the primary side A1 terminal denotes phase A, B1 terminal denotes phase B, C1 terminal denote phase C. Now the point is how do I make the connection at this side. So for that what we have to do that we have to now draw the vector diagram at the secondary side.

Now we are saying that this side is also are stalled grounded and the phase difference between the phase A voltage of the primary side and phase A voltage at the secondary side is 0, so then therefore, the phased diagram at the secondary also would be exactly similar to this. So this is basically phase A voltage, if this is the phase A voltage so therefore this voltage should be in parallel with this voltage, similarly this voltage should be in parallel with this voltage and this voltage should be in parallel this voltage and that is what precisely we have done.

Now because these two are parallel in nature, so then therefore; and we have also said that from this dot convention when terminal A1 is positive with respect to terminal A2 at that instance terminal small a1 will also has to be positive with respect to terminal small a2, right. So then therefore, if this is capital A1, capital A2 and because these two are in parallel so therefore this also should be a1 a2 so this terminal should be 1A2.

Similarly, of this is B1, B2 I mean this point is B1 and this point is B2 and because this two and this two would be parallel so then therefore their orientation of this winding and this winding also would be in parallel so then therefore this is B1 so this terminal is b1 and this terminal is b2 and similarly this would be small c1 and this would be small c2 and because it is grounded so we make them grounded. Correct.

So then what we are doing, so from this vector diagram what we are doing is that essentially we are connecting A2, B2 and C2 together so we are connecting A2 B2 and C2 together and sorting that connected terminals to ground. And if this is phase A, so then therefore this is also phase A so then therefore at the secondary side also this is phase A. And if this is phase B at the primary side so then therefore this is also phase B so then therefore, from B1 we also take phase B and from C1 similarly we take phase C, correct.

So this is the vector diagram and this is the corresponding connection, right. Now, if I say that this voltage is Va and this point is grounded, now let us see what happens. Now from this particular circuit diagram what I can see. If I say, that this voltage is VA, if I say that this voltage is VA so then therefore, this point could be VA because point is already grounded. Similarly, this point voltage would be VB, similarly this point would be VC, similarly this point voltage would be Va, this point voltage would be Vb and this point voltage would be Vc, right.

And now let us denote that this is IA that it is the current which is entering the phase A voltage at the primary side to this current is IA. Similarly, this current we denote as IB so that is the B phase current at primary side. Similarly, we denote the current I capital C. And in the same tokens same wind the current which is going away or rather which is going towards the A phase terminal in this away from the winding we will say that is Ia because as we have said we denote the secondary side with small letter and we denote the primary side with capital letter, so this current is Ia, this current is let us say Ib and this current is Ic.

So then therefore, from this arrangement and this phased diagram and this circuit we can easily say that Ia and and Ia they are in phase. Similarly, Ib and Ib they are in phase and I capital C and I capital; small c are also aim phase, right. Now, here this transformer ratio let us say nominal ratio is 1:1. Please understand that, because we are doing everything in per unit so then therefore nominal ratio n per unit 1:1. In any case, we are also taking it at 1:1.

So in per unit it is 1:1 that means basically if I give here a per unit voltage 1, per unit I would also get 1 per unit voltage here, right. So in per unit this is 1:1 of course in actual value this could be vastly different for example, I mean for example this can be let us say a 400kv and let us say this can be let us say a 33kv, right. So in actually value this to winding voltage rating could be vastly different but in per unit they would be 1:1.

Now because these are in per unit, so then therefore, I can say that this current IA and Ia would be same, similarly current IB and Ib would be same, similarly current IC and Ic would be same because they are in per unit, this is same in per unit they would be same. In per unit they would be same, so that means if I given an 1 per unit current here I will also get 1 per unit current here. Now suppose the transformer leakage impendence is y.

This is the transformer impedance, transformer admittance. This is the transformer admittance. It is basically transformer leakage admittance. So what is that? So essentially what we are doing, we know that for a transformer there is essentially series branch and also there is a basically Magnetizing Shunt branch, right. But here in this analysis we are simply neglecting the Magnetizing Shunt branch so then therefore, what you are getting.

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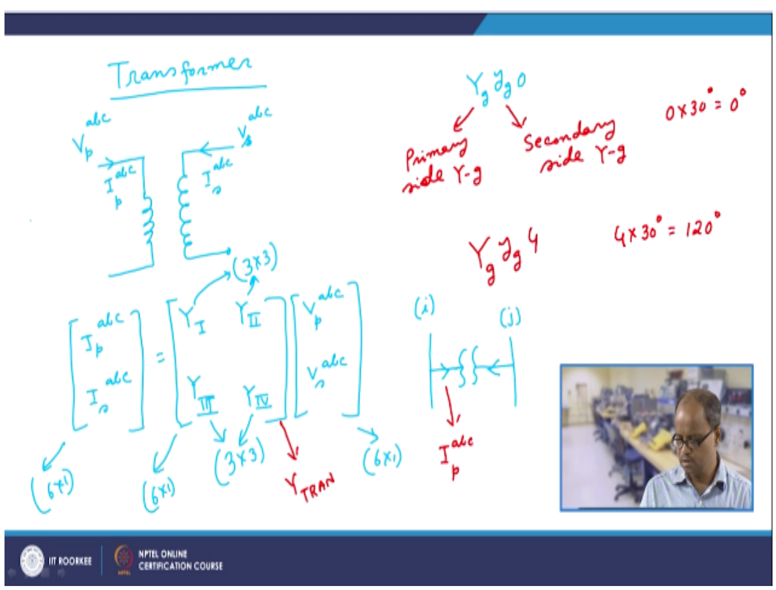

So from .A, so this is .A and so this is .a so then you would be getting some impedance z and y is nothing but y 1/z. Here; essentially Magnetizing Shunt branches are neglected. So here transformer, so we should write that transformer magnetizing shunt branch is neglected. So now what we have done that in this particular diagram we have essentially represented in this particular diagram, I mean this particular transformer by its equivalent circuit like this and like this.

So this point is VA, this point is Va and this and between A and a there is a transformer leakage at middle that is y. So then therefore, if I have a current Ia here, right so then I can have IA=y* this voltage difference, y*A-Va. Similarly, IB also would be y* here, so now what happens? So now the current IB which would be entering there would be nothing but this voltage – this voltage * this transformer shunt admittance so it would be y*VB, V capital B – Vb then IC would be equal to y*Vc, capital C please note, Vc, we should write it as capital C.

Unfortunately for capital C and small c it is not much of a difference in a shape, there is only difference in size so therefore it should be little more careful. So IA=y*VA-Va, and IB=y*VB-Vb the capital B, so this is the primary side, this is the secondary side we are calculate everything in per unit.

So then what would be IA? IA would be nothing but = I capital A because this is 1:1 transformer, we have already argued because this 1:1 transformer so therefore, IA = capital A and they also would be in phase to each other so therefore Ia = capital A and so then therefore, it is y*VA-V0a; Ib=I capital B=y*VB-Vb and Ic this is small c =I capital C that would be y*V capital C-V small c.

So what we have, that we have got; so now we have represented all the 6 currents I capital primary current and secondary current in terms of this primary side voltage and secondary side voltage. So then here in this case my I primary abc would be nothing but IA IB, IC transpose and Is abc is Ia, Ib, Ic transpose. Similarly, the primary abc is VA, VB, VC transpose Vs secondary is Va small b, small c transpose.

Now, here one thing we need to remind ourselves, one thing we need to remind ourselves. We have done a mistake. Here we have actually done a mistake. What is said, we said actually this current reduction is not in this reduction, this current reduction is not in this reduction, this current reduction is actually in this reduction, in this reduction because if we do remember what is said that I do have an bus i and j and we do have a transformer right.

And we said that this current is Iabc and this current is Is so therefore, at both the sides current is entering into the transformer, so for this transformer modular both the sides current was entering into the transformer so then therefore this is Ip abc and this was Is abc so both these sides current is entering into the transformer.

So then here to note this Is abc would be current entering in the transformer so it would be –Ia –Ib and –Ic because here in this diagram Ia Ib Ic are going out but for this transformer module it should be go into the transformer so then therefore, Is abc would be –Ia, Ib and Ic transformer, right. So now with this notation if you now write-down this equations in a matrix form what do we get?

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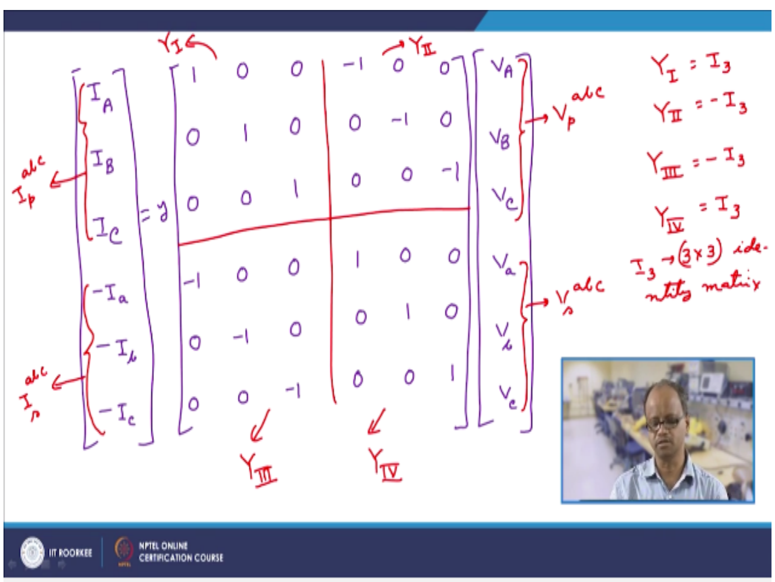

We get IA, IB, IC then –Ia, -Ib, -Ic and then something we will write what is that something, so this is VA, this is VB, this is VC this is Va, this is Vc, this is small c. Now IA=1 and so that should be now everything is actually multiplied into 1 by y so that we can take this y as a common, so it take y as a common, so it take y as a common, y as a common; so 1 then 0 0 and then it would be -1 0 0; for IB 0 1 0 0 -1 0; for IC 0 0 1 0 0 -1.

What is –IA? –IA is nothing but –IA+A so this is nothing but -1 0 0 then 1 0 0 similarly it would be 0 -1 0 then 0 1 0 and it would be 0 0 -1 right, so it is 0 0 -1 and then 0 0 1. So this is the admittance matrix. So this is the representation. So here we have to look at everything. So then therefore this is nothing but Ip abc and this is nothing but Is abc. This is nothing but Vp abc. This is nothing but Vs abc.

So then therefore, if I do partition it, if I do partition it so then therefore, this is so this portion is y1, so this is y1, so if I do partition so then this is Y1 matrix; this 3x3 matrix is Y2; this 3x3 matrix is Y3 and this 3x3 matrix is Y4. So then therefore, what we can see that Y1 = actually I3; Y2 is actually –I3; Y3 is also –I3 and Y4 is actually I3. Now that is actually I3, I3 is the 3x3 identity matrix, right.

So then therefore, for an Yg yg 0 transformer just from the very basic principle of transformer modeling and the phased diagram and the very basic operational principle of the transformer, right we can directly derive all these four submatrices, right. So it is; so here actually we really do not have to remember anything, just following the basic principles of this transformer operation we can simply derive these transformer matrices. So we stop here today and in the lecture we will be also looking at some other example of transformer modeling. Thank you.