Computer Aided Power System Analysis
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Lecture - 58
Fault Analysis (Cont)

Welcome friends to this lecture on Computer Aided Power System Analysis. We have been looking into the aspect of transformer modeling. In the last lecture we have looked into the case where we have considered an Yg yg 0 transformer and then we have looked into the process of deriving this transformer admittance matrix. Now to continue with this let us today consider another transformer connection.

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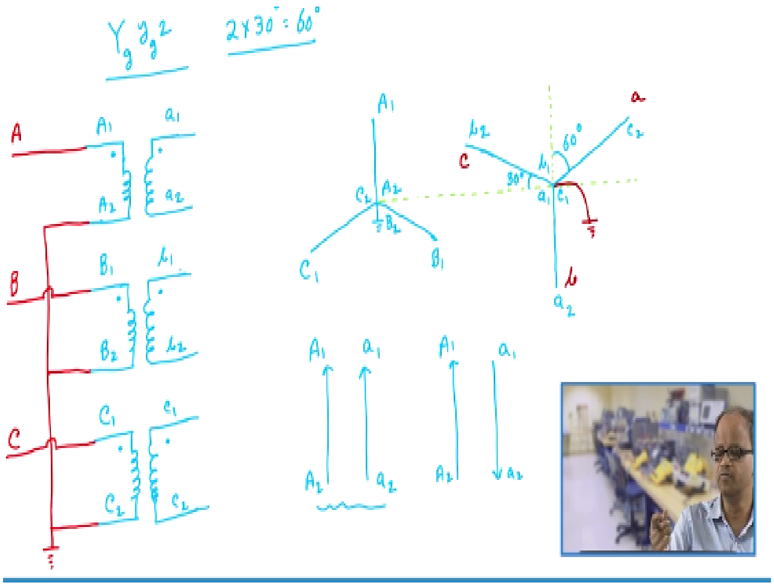

And today we consider transformer connection Yg yg 2. So what does it mean that here in this case also the primary side is connected in star grounded and the secondary side it is connected in star grounded, but now there is a phase difference between the phase A voltage of primary side and the phase A voltage of secondary side which is= 2*30 degree that is=60 degree so that is the case.

So now there is a phase difference. So now as before let us consider that this 3 phase transformer consisting of 3 single phase transformer so then you have got 6 windings and they are connected in this fashion. So we have got 6 windings we are doing exactly the same what we have done in the last lecture. So we are saying this is A1 A2, this is small a1 small a2 these are the terminals. B1 B2 this is small b1 small b2 this is capital C1 capital C2 this is small c1 small c2.

And let us assume that the dots are here and here and we already discussed what is this dot convention means. So this we have got this dot and we have got this dots. So these are the 3 dots. So we have not made any connection we have simply collected these 3 transformers and we have simply collected this 6 windings now we have to make a connection. So for that let us first draw the phasor diagram.

So phasor diagram would be something like this. So first is this and this so this is grounded. So let us say that this is A1 and this is A2 and this is let us say B1 and let us say this is B2 and this is capital C1 this is capital C2. So then what we are saying as before that we are simply connecting A2, B2 and C2 terminals to be there at the primary side and then we are connecting that shorted terminals to ground.

So let us make that connection. So what we are doing is as before here up to this point we are doing as before. So we are simply connecting this 3 terminals together and grounded. And then we say that this is my phase A this is phase B this is my phase C. So then therefore we say that this is my phase A, this is my phase B, this is my phase capital C. So our connection at the primary side is over.

So now at the secondary side now in the secondary side this is also connected it star grounded, but the difference is that now there is a difference of 60 degree phase between phase A voltage of the primary side and the phase A voltage of the secondary side. So that we have to consider so then therefore what we do let us just draw a dotted line and let us draw another dotted line.

So (()) (05:16). So now I mean this is the phase A voltage of the primary side and the secondary side phase A voltage would be 60 degree line behind it. So then secondary side phase A voltage would be simply here something like this and this angle is 60 degree this angle is 60 degree. So this would be the secondary side phase A voltage. Now secondary side phase B voltage would be 120 degree lagging to this.

So then this would be the secondary side phase B voltage so this is secondary side phase A voltage secondary side phase B voltage and secondary side phase C voltage would be 120 degree lagging from this. So then it also would be somewhere like this so it would be something like this. So it would be a secondary side phase C voltage and this angle would be nothing, but= 30 degree right.

So we have located the phase A voltage phase B voltage phase C voltage of the secondary side. Now we have to mark the terminals. Now for marking the terminal we need to understand one thing we actually need to recollect one thing that when we say that 2 voltage is our in phase that means they are not only in parallel, but their orientation is also parallel. So then therefore if I say that this voltage is VA1 A2 is in phase of VA1 (()) (07:09).

So then therefore if I draw this 2 parallel lines so it will denote A1 and this denote A1 so then therefore if this denotes A1 and this denotes A2 and because these 2 are in phase so then therefore this also should denote a1 and this also should denote a2. So it means that they are parallel and in phase. On the other hand, for example if we say that these 2 are in anti-parallel. So then in that case what would have been the case.

In that case the case would have been this and this so then it would have been. So this is A1 A2 and anti parallel is something like a1 a2. So then therefore when 2 phases are so when 2 voltage vectors are in parallel so then therefore or rather when 2 voltages are in phase. So then therefore those phases would be not only in parallel, but their orientation would also be the same.

So then therefore so now let us see. So let us look at that what are the 2 parallel vectors. Now if I look at this vector and this vector obviously this vector is parallel to this vector right and this vector is parallel to this vector. Now if this vector is parallel to this vector and this has to be in phase so then therefore if this is capital C1 C2 so then therefore this also should be small c1 and c2.

Because this voltage and this voltage they are in parallel so then therefore if this voltage is C1 C2 so then therefore this voltage this voltage should also be small c1 and c2 because these 2 are parallel in and in phase because we have put this dot line. Similarly, this and this would be in parallel and their orientation also should be the same. So then therefore this would be small a1 and this would be small a2 right because their orientation would also be the same.

So then therefore this top point is A1 here also this top point is small a1 and similarly a2 and this vector is parallel to this vector and because these 2 have this dot here like this so then therefore this would be small b1 and this would be small b2 right. So these are the marking of the different terminals. And so then therefore we say that this is actually our phase a and we say that this is phase a, this is my phase b and this is my phase c.

And of course because this is grounded so then therefore this terminal also should be grounded. So then from this phasor diagram what we are seeing. This phasor diagram tells me that if we wish to realize a transformer of this type of vector connection here we should connect A1, B1, C1 together and ground that particular shorter terminal and we should denote terminal C2 as phase A and we should denote terminal A2 as phase B.

And we should denote terminal B2 as phase C correct. So if we do so now here if we do so it would be little more complicated so then to actually realize it I mean let us again redraw this diagram.

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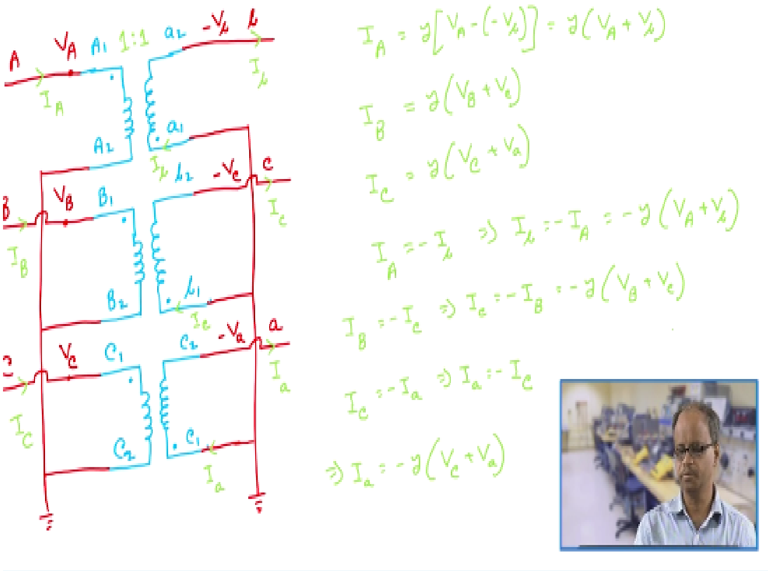

So what we have got is A1, A1 so we have got A1 A2, B1 B2, C1 C2 and we have dot here and what we have here is we now say a2 a1. So this dot would be now we are just simply putting this winding in a reverse manner. Similarly, we say that this is b2 and this b1 so then this dot would be here and this dot is here. Please note that these dots are still at capital B1 and small b1 terminal as here.

So we have not changed this dot point. What we have done we have simply putting this winding in a reverse fashion nothing else. So let simply putting this winding in a reverse fashion. So you have got C2 C1 this dot is here and this dot is here. So we again make this connection so in the primary side what we have. We simply make this connections together so this is our connections together.

And this we say at phase A this is phase B this is phase C. Now at the secondary side this phasor diagram tells me that A1, B2, C1 should be connected together and again shorted to ground. So what we are doing A1, B1 and C1 we are connecting together and making it to ground then what we are saying that a2 should be denoted as phase b. So it is actually phase b then b2 should be denoted as phase c so b2 should be denoted as phase c and c2 should be denoted as phase a right.

So then from this vector diagram we have got this connection so this connection is made. So then therefore now this point potential would be because this would be V capital A right this should be V capital B this should be V capital C. And what would be this voltage? This voltage would be actually 0- this because now essentially what will happen because there are dots together so when this is positive this is positive.

So then therefore this is actually negative so then we can say that this is actually –Vb we can say that this is actually –Vc and this is –Va because this is grounded. So then therefore at every time this should be positive to this. So then therefore if this VC is positive to corresponding to this grounded so then therefore which is 0. So then therefore if this is 0 so then therefore this should be negative because this point should be positive to with respect to this.

So then therefore these are denoted so this voltages will be –Vb –Vc- Va and now we denote this currents as IA, IB, IC right. This currents are IA, IB and IC right this currents are IA, IB and IC. And here this current would be I small b current should be I small c I small a as usual transformer is 1:1. So then therefore so with this all this notation and this connection and we have denoted all this voltages and currents.

So then therefore now we are ready to write down the equations so then what would be the equation. Equation would be IA*y y is again this transformer leakage admittance would be VA- of this voltage – of Vb. So that means it would be y*VA+ Vb. Similarly, what would be

IB. IB is y*VB+ V small c. VB+ small c I capital C is y* VC+ small Va right. Now what happens to this current?

Now if we recall the dot convention of any transformer if we recall the dot convention of it of any transformer what this dot convention says. For example, here if I say that this current is Ip and if I say that this current is Is we say that Ip and Is they are in phase. What does it mean that the current entering the dotted terminal dot terminal at the primary side would be in phase with the current leaving the dot terminal at the secondary side.

I repeat this dot convention says that this current entering the dot terminal at the primary side would be in phase with the current leaving the dot terminal at the secondary side. Now here what happens here what happens here this current is IA is entering the dot terminal, but the current is IB is actually entering this dot terminals. Please note that if this current is IB here so then this current should be IB here.

Similarly, this current is also entering this dot terminal here and similarly this current is also entering the dot terminal here. So then therefore this current and this current they would be out of phase each other. So then therefore I can write that I capital A=-Ib. I capital A= -Ib or I can say that Ib=- IA and IA means – of y*VA+ Vb right. Similarly, I can write down that I capital B= -I small c and this –I small c.

So therefore IC= -IB and –IB=-y*VB+ Vc and capital C= -Ia or in other words Ia= -of capital IC or in other words I small a==of y*Vc+ Va right. So then therefore these are the 6 equations we have got now. So now with this 6 equations now we are ready to find out the Y bus matrix. We are ready to find out the Y bus matrix. Now again as usual our I primary now if I say.

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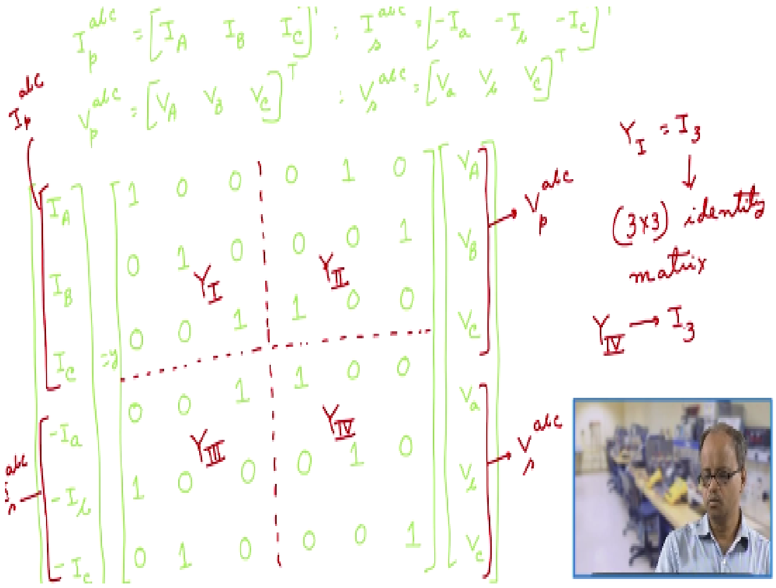

Now our I primary abc is nothing but I capital A I capital B, I capital CT and our I small abc would be. Please note now here at this terminals this currents are outgoing, but I again repeat we again have to recollect that what we have done is what our convention is that if I have a transformer between 2 buses if I have a transformer between 2 buses then our convention is that these 2 current will be always entering the transformer from both the sides.

So then therefore Is abc would be=-Ia, -Ic and =Ib, -Ia, -Ib and –Ic. So then therefore Is abc would be –Ia, -Ib –Ic transpose and so then therefore (()) (21:38) Vp abc is VA, VB, VC please note that this is capital and Vs abc, V small a V small b, V small c. So now if I now write down the IA, IB, I capital C-Ia –Ib -Ic so that is= VA, VB, V capital C Va, Vb, V small c. Now what is IA IA is again y*VA+ Vb.

So there should be one y and VA+ Vb so this is 1 and 0 then 0 VA+ Vb so then 0 and 1 and 0. IB is y*VB+ Vc. So this is 0 VB so 1,0, 0, 0, 1. So these are all 1. What is IC I capital C y*VC+ small a so it is 0, 0, 1 VC+ small a so this and this so then this is 1,0, 0. And now what is –IA sorry. Now what is –Ia. Now if Ia= -y*VC+ Va . So then y* VC+ so -Ia=0, 0, 1, 1, 0, 0 –IB what is-IB –IB=y*Va+ VB then 0. And –Ic is y*VB+ Vc so 0, 1 (()) (25:11) so this is the matrix.

So again here we again denote that this is Ipabc so this is Ipabc. This is Isabc this is Vpabc and this is Vsabc. So now we make the partition we now make the partition. So this is the partition. So then obviously a y so this 3 cross 3 matrix should be Y I this 3 cross 3 matrix should be Y II this 3 cross 3 matrix should be Y III and this 3 cross 3 matrix should be Y IV.

So then Y I is nothing but I3.

We can see that it is an identity matrix of 3 cross 3 and what is I3 I repeat that it is a 3 cross 3 identity matrix. Similarly, Y IV is also here I3 cross 3 identity matrix. YII is 0, 1, 0, 0, 0, 1, 1, 0, 0.

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$$Y_{II} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}; \quad Y_{III} = \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

$$Y_{II} = Y_{III}^{T}$$

So YII is 0, 1, 0, 0, 0, 1 and 1, 0, 0. So this is YIII 0, 0, 1 then 1, 0, 0 and 0, 1, 0. So these are the 4 matrices and one very important observation is that YII is transpose. So these 2 matrices are actually transpose of each other. So this is a cross check for a correct transformer modeling right. So this particular 3 cross 3 matrix and this particular 3 cross 3 matrix should be always transpose of each other especially if there is no phase shifting tap so then this 3 cross 3 matrix and this 3 cross 3 matrix should be transpose of each other.

So then therefore so this is how the transformer modeling is to be done. Again here as we can see that we have really not taken any kind of assumption. We have started with this transformer connection from this we have reduced that this is what is the phase difference between the phase A voltage of primary side and secondary side and from that we have first taken all this particular terminals together without making any connection.

Then we have first drawn the phasor diagram of the primary side indicated the terminals and from this terminals indication we have done this connection then we have drawn the phasor diagram of the secondary side and then also indicated the transformer taking into account the basic operation of any transformer as well as the basic concept of the parallel phasor representation from there we have made the connection.

And once we have made the connections then we have noted down all this voltages and current and these voltage and currents sign of this voltage and current. So we have made according to the standard dot convention. So once we have made all this voltages and currents or rather once we have essentially denoted all this voltages and currents properly taking into account this standard dot convention after that we have simply written down the equation and then from there we have found out the transformer (()) (30:56).

So then therefore we can find out that to model a transformer actually nothing is to remember. It can be done in a very easy step-by-step manner. So we stop today in the next lecture we will again try to see some other example if possible. Thank you.