Power System Analysis
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Lecture - 52
Symmetrical Components (Contd.)

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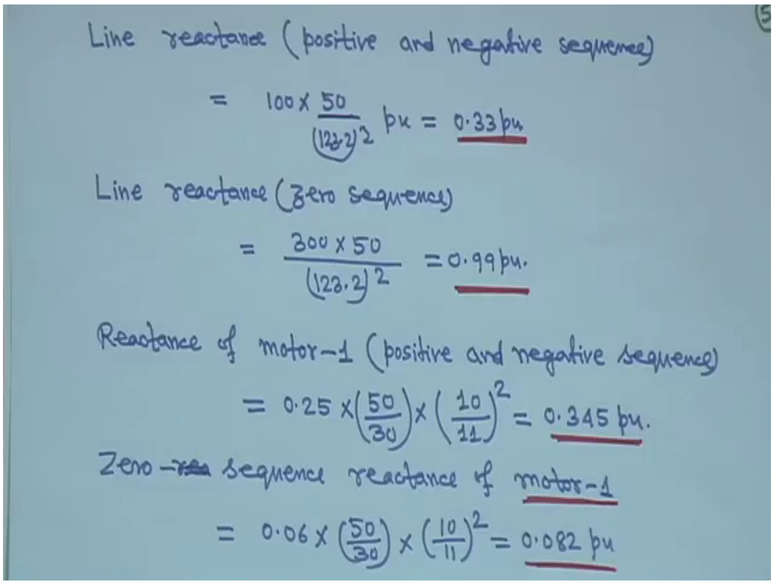

Next that line reactance. Positive and negative we have told for transmission line that positive and negative your sequence reactance will remain same. So, it is 100 ohm line base voltage you have computed one 23.2. So, 100 your in to 50 that is MVA base will remain same throughout right, in to 50 up on 123.2 whole square it is coming 0.33 per unit. Now line reactance your this thing 0 sequence, that was given actually 300 ohm. So, that is that is positive negative that is 100, but 0 sequence it is given 300. So, it is 300 in to 50 up on 123.2 square that is 0.99 per unit right.

So, reactance of motor 1 positive and negative sequence, same way that you just convert the atomic value to it is own base motor base then common base. So, it is point that that is called your new base rather right, 0.25 in to 50 up on 30 in to 10 by 11 whole square. This will become 0.345 per unit. Now 0 sequence reactance of motor 1 that was given 6 percent same way you bring it to your new base. So, 0.06 in to 50 up on 30 because motor rating is 30 MVA and 50 MVA is that common base right. In to 10 by 11 whole square that will become 0.082 per unit this is 0 sequence reactance, next is for motor 2.

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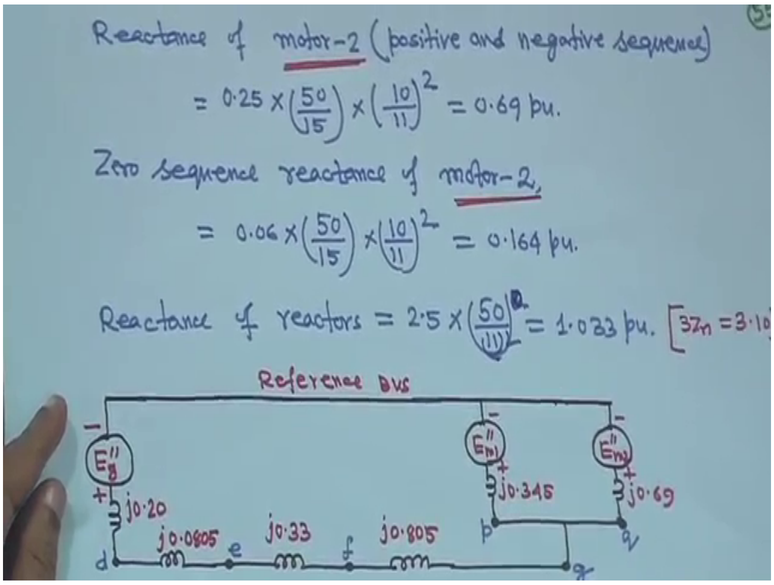

So, these are nothing actually just you have to calculate this parameter correctly right. So, reactance of motor 2 that is positive and negative sequence that is 0.25 it is given 25 percent in to 50 up on 15 because motor 2 rating is 15 MVA in to 10 by 11 square, that is 0.69 per unit. So, 0 sequence reactance of motor 2 that was 6 percent that was given. So, 0.06 in to again 50 up on 15 in to 10 by 11 square, that is actually 0.164 per unit. Now reactance of reactors it is given 2.5 ohm that is 2.5 in to 50 up on 11 your this thing your, it is actually not square it is 50 upon 11 square right. It not it is 50 up on 11 square. So, that is becoming actually your 1.033 per unit, but when you will take this diagram this is when you will draw the 0 sequence diagram this 3 Z n will come.

So, it will become multiply by 3. So, it is 3.10 that will see later. So, all this parameters all this parameters actually are computed.

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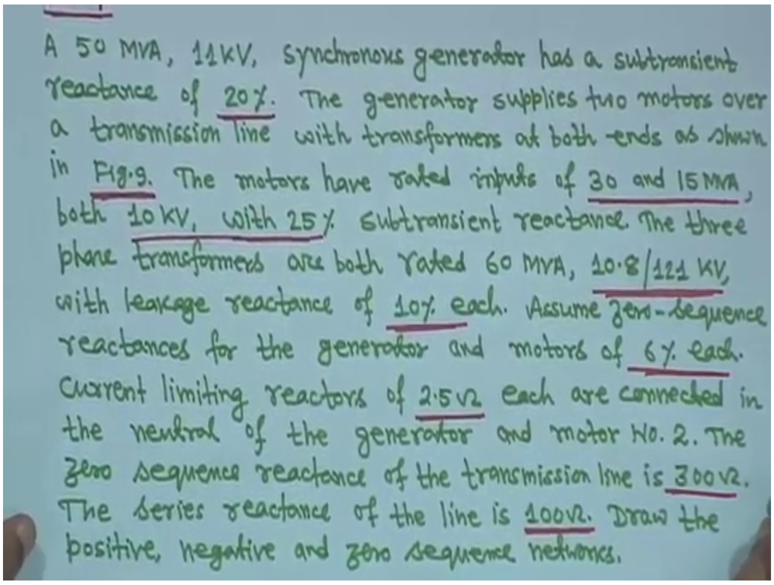

So, this problem when you will read hope it is covering your whole screen right. Just one second I am putting it when you will pause it you can see that whole problem you can note down right.

So, this in this case your just hold on that. So, after making all this phara all this all this your calculations just hold on, here this point I missed it before when I showing the diagram actually this is marked as a g, I have marked it now g. So, the these reference bus you have to take, one reference bus now this is your generator all sub transient parameters are given for generators motors this is your generator. So, this is actually e g double dash this is reference one any one bus one thing we have to taken reference. This is a reference one and this is plus minus and this is j 0.20 for the generator.

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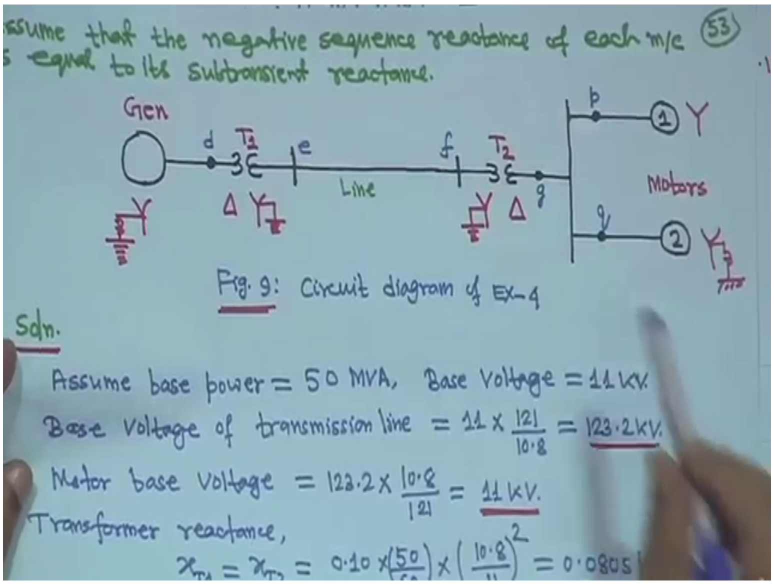

Now this one for this transformer positive sequence only this impedance for transformer. So, j 0.0805 remain same for negative also in this see that, then this j 0.33 that your this that one is coming for your transmission line, this is for transmission line; that means, this is the line next line will come transmission line.

Next this is for transformer 2 then transformer T 2 will come. So, this is your transformer and everywhere I marking d, d to e d to e transformer d to e will not make any mistake then d to e transformer then e to f e to f transmission line. So, this is your what you call this is your j 0.33 then f to g that is your f to g again transformer T 2, same parameter j 0.805 per unit then this these 2 motors are in parallel, because they are connected to the common bus common bus bar this point is p this point is q.

That means this is point this is this is from transformer f to g. So, this is your f then your transformer then g f transformer g point is coming and this 2 transformer in parallel. So, that is why it is p and these 2 are p and q this 2 points p and q. This is your p and this is your q. So, this is your p and this is your q. So, this parameters also computed for the motor this is j 0.345 and this is j 0.69. This is e m 1 dash and this is e m 2 sorry, one m 1 double dash sub transient one this is e m 2 double dash. This is plus minus this is plus minus connected to the reference.

So, this is the positive sequence diagram for the your this whole circuit. This is the positive sequence diagram. Next is negative sequence negative sequence. So, negative sequence there is no source, no voltage source.

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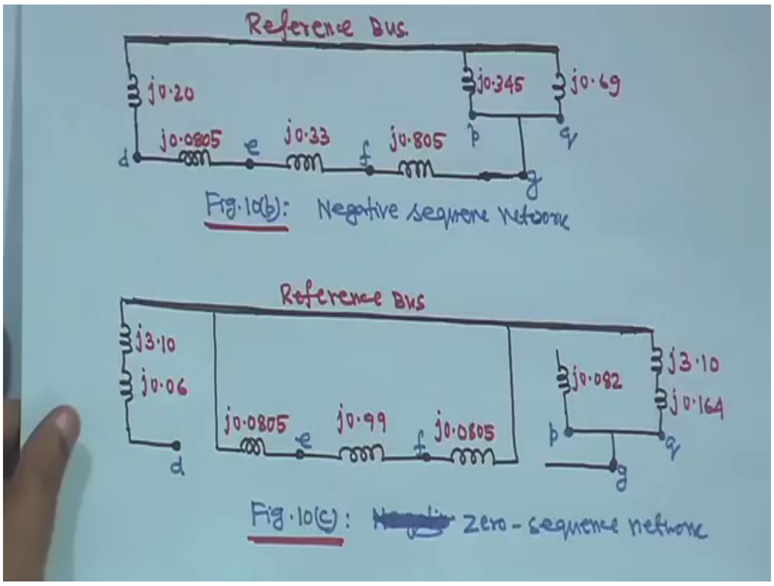

So, in the negative sequence diagram if you see that this one that is your just hold on, this is your this is your negative sequence diagram. So, reference one look positive sequence this voltage sources are not there, but look all other parameters same, because negative sequence parameters same as positive sequence parameter. So, only voltage sources are not there, here it was j 0.20, here also j 0.20. Here it is j 0.0805 here also j 0.8 your 0.805. Here also j 0.33 here also j 0.33. Here also j 0.805 here also j 0.805 here also j 0.345 here also j 0.345, here also j 0.69m here also j 0.69 connected to the reference bus,

So, this is negative sequence. So, no voltage source, but all parameters remain same diagram without any voltage source. And now this is for your what you call this is for your negative sequence. Now we have to come to the 0 sequence. This is your reference bus for 0 sequence diagram right. Now question is come from come from this side to it will move to this side. Now star is grounded and this side is delta. Although star is grounded delta means delta there may be a circulating there will be a circulating current inside delta. And star that is generator star is grounded means that is your what you call that 0 sequence current it will flow it has to be connected to the reference bus.

But question is that delta is isolated it has no neutral circulating current will be inside the delta and, but star is grounded; that means, this is reference bus this is connected your what you call this is your this 3.10 actually that is 3 Z n. I calculate somewhere know here, that is your 3 Z n. Z n we here that is reactance of reactors that is basically Z n. So, this is 3 point 1.033 multiply by 3. So, it is 3.10. So, that is why this is 3.10 and 0 sequence your reactance for the generator it is j 0.06 it is given, but as it is grounded. So, it is connected to the reference bus, but this side is isolated because delta. It is your circulating current cannot leave the terminal. So, it has to be isolated that is isolated no connection right. Hope you have understood this. Next is the next is line side will come this is grounded this is grounded both are grounded. So, there is a path for your 0 sequence current to flow that is why this is connected to reference this is connected to the reference this is also connected to the reference, because both are grounded both are grounded.

That that in between what is happening? This transformer thing is coming j 0.0805 then your 0 the 0 sequence reactance of the line is a it is actually j 0.99 you have computed. And this is j 0.805 and second transformer this one and this is closed because this is grounded this is grounded. So, there is a 0 sequence current will flow to the line right. So, this is your this thing and the transformer. Next is the motor. Motor is one is ungrounded; that means, this will not be connected to the reference bus. So, it is this is motor 1 it is 0 sequence is given that j 0.082 you have computed, but it will not connected to the reference bus, because it is ungrounded. And this is this is this motor is grounded; that means, it will be connected to the reference bus. So, it is connected to the reference bus which 3 Z n j 3.10 and j that motor your what you call 0 sequence reactance everything is given it is j 0.164 this is there. So, this point is p and q, this point is p and q this is f to g f then it is it will be remain isolated; here also it will remain isolated because this side is delta circulating current will be there your circulating 0 sequence current. And this is your star grounded right. So, it is connected to the reference by this side, but there is an isolation. So that means, no 0 sequence current can flow. So, that is why there is an isolation here.

So, this is like this and this is your 0 sequence network. I hope you have understood this. Only 0 sequence is the major issue positive and negative is simple as same as before right. I mean positive sequence. You have a voltage source negative sequence all voltage source should not be there, but parameters of this positive sequence network and secondary I mean line I mean impedances will remain same. But negative sequence only we have to see this grounded or ungrounded star or delta accordingly you have to make it with respect to the reference bus. So, this is 0 sequence diagram, because this is important when you will take that unbalanced fault problem. Next one next one is this one that you have to draw 0 sequence network the power system as shown in figure 11.

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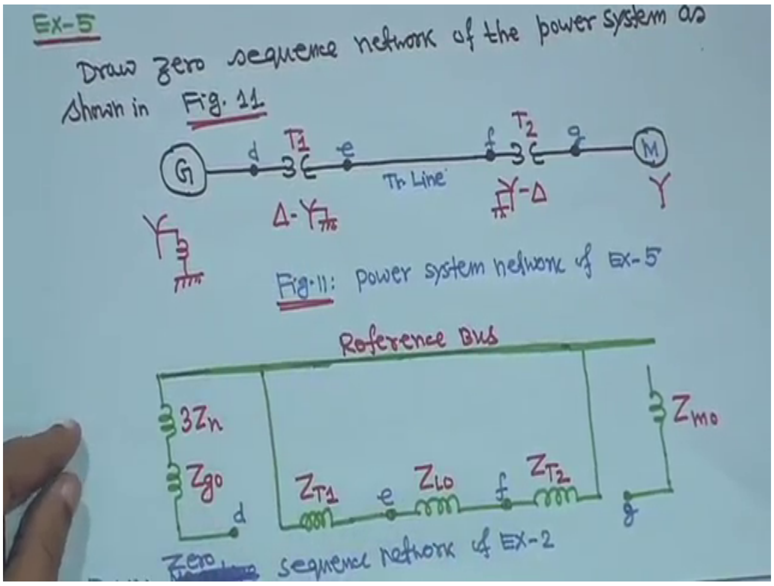

So, a small circuit diagram is given. This is generator is grounded, only positive negative sequence now easy. I am not doing it my objective is to show you that 0 sequence network right. So, this is del this is your delta star correction this thing, and star is grounded this is star delta star is grounded. And this is motor generator is supplying the this thing power to motor and this is your star, but ungrounded, you have to draw the negative sequence diagram parameters are not given, but you have to take something and you have to make it. So, so generator is grounded if Z n is that your grounding reactance this one, then it will be 3 generator it is it is grounded. So, it will be 3 Z n. So, that is why 3 Z n.

And say 0 sequence impedance of the generator is z g 0. So, I made it z g 0, but this sides just now we have seen the previous problem, but this is delta. So, there is an isolation. So, it will remain open it will this is remain open. And this side this star grounded this side also transformer star grounded. So, it will come here come here come here like this.

So, this is Z T 1 transformer 0 sequence your transformer positive negative and 0 sequence reactance same right. And this is for the line 0 sequence reactance z l 0. And this is Z T 2 this is all point you mark d e f g the way have marked it right. And then you connect to the reference and this thing is this side is delta this side is star. So, isolation is there and at is it not grounded. So, it is open it is not cannot be connected to the reference bus and this is Z m 0. So, that is transformer 0 sequence reactance. So, this is the 0 sequence diagram for this power system network. Hope you have this 0 sequence only you try to understand. Positive negative simple.

Next is next is this one, you have to draw the 0 sequence network of the system shown in figure 13. So, this is generator is grounded, this is delta star delta and this is star your grounded. There is no difference except one thing that here previous problem it was ungrounded. Now here we have made this grounded nothing else. So, here z g 0 I made it because your this thing we assume in that this there is no ground impedance here. So, 3 Z n I have not make it assume that there is no Z n is 0.

So, in this case it is z g 0 and this is star grounded, but delta isolation will be there. So, this is actually open, then this side star grounded this side also star grounded. So, this reference bus connect this is your p this is your r this point is r right. This point your what you call. So, this one you can take this is your this point actually should not be r, this is your q r line. So, this is before transformer this point should have been r. And this point this is actually q it cannot be q this point actually q. This is q this is r q r, r transmission line by mistake I have written here. So, this is actually transformer Z T 1, this is Z T 1, then point q will come then transmission line z l 0 then your this is your then after this point r that is your Z T 2 and this star is grounded.

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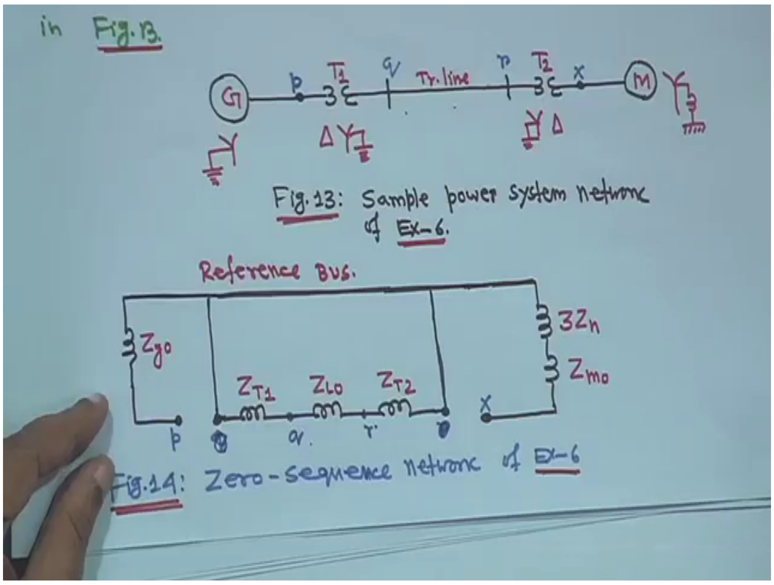

So, connect it and here star is grounded connected, but this is delta this is star isolation is there. So, it cannot be connected. So, this is the 0 sequence network for this kind of for this network. Next one is that figure 15 actually this is a double circuit line look it.

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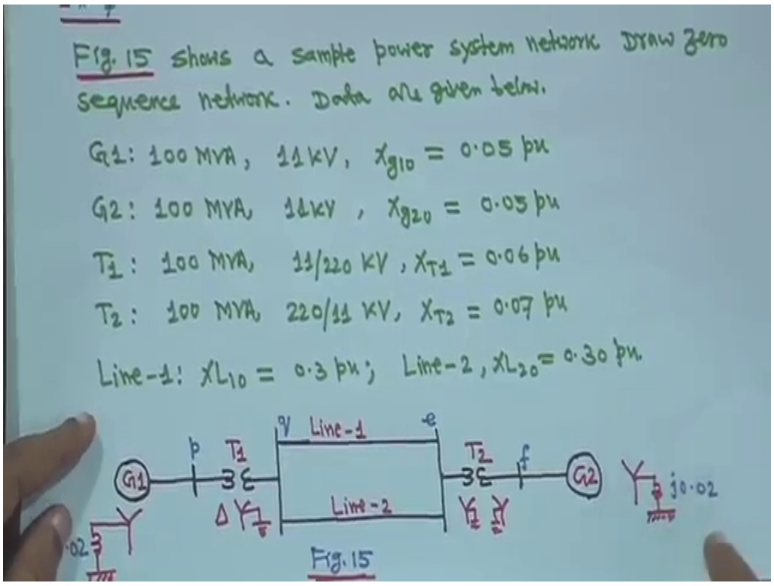

So, far you have taken a single circuit problem. Now if it is a parallel circuit double circuit line. So, figure 15 this is your figure 15 is shows a sample power system network you have to draw 0 sequence network data are given below. Actually G 1, generator 1 this is generator 1 right. 100 MVA 11 k v x G 1 0 is given 0.05.

Now, G 2 actually given 100 MVA 11 k v x G 2 0 is equal to 0.05. And T 1 transformer one; that means, this one is 100 MVA 11 by 220 k v and given x T 1 is given 0.06 per unit and. T 2 100 MVA again this is step down 220 by 11 k v x T 2 is 0.07 per unit. Line 1 x l 1 0 is 0.3 p u this is the line 1 right. Double circuit and your this is line 2 x l 2 is a 0.3 0 per unit. And this is the diagram you have to draw the your 0 sequence network. So, this generator is grounded again delta star we have taken here right. And this is double circuit line parallel line and this is star both are grounded. And this is also generator star grounded; here this Z n is given actually j 0.02. So, this one is given. So, this we have to multiply by 3, because it will become 3 Z n. So, it will become j 0.06 and here also j 0.02 is given we will draw the your 0 sequence diagram it has to be multiplied by 3, it will be then 0.06.

Now, question is that, I mean if mark all the point like there is a p before transformer after this q this is e this is f. This way first you mark and then move step by step. Then you will find things are very easy. So, 0 sequence diagram how things will be then that first thing is, first thing is that this is you this is you draw the reference line and this is star grounded, but this is delta. So, there will be an isolation. And before showing this diagram I will give an exercise to you, instead of delta star you take star transformer, but star grounded both this side primary side, you take star and star grounded and please draw the 0 sequence network of your own. But from this problem and these are all star grounded these are all star grounded this is also star grounded.

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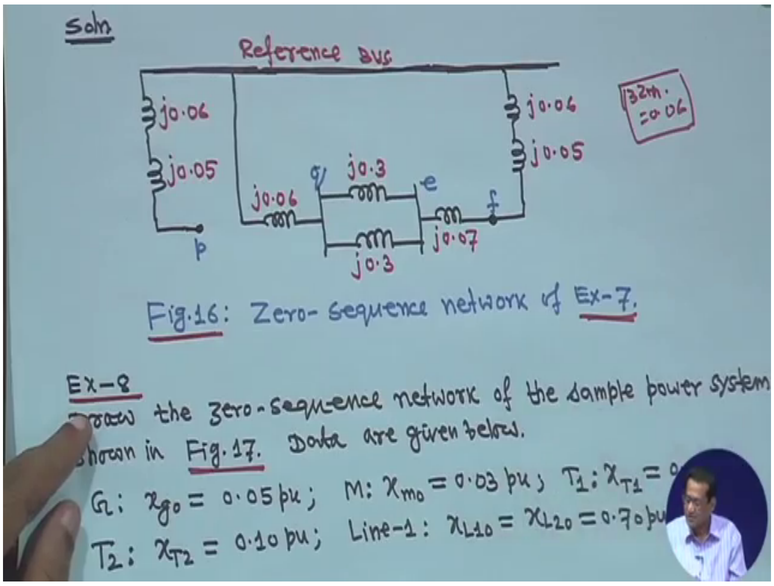

So, there is absolutely there is no problem for this drawing this 0 sequence network. So, what you will do this is your reference bus, this is your reference bus. So, generator actually this is j 0.02. So, 3 Z n; that means, j 0.06 and isolation is there, because star grounded, but this is delta. So, you know connectivity will be there, and this is this is given j 0.05 is given and this is 3 Z n that is 0.02 is given multiply by 3, but there is an isolation.

But as star is grounded for the generator. So, you have to connect it to the reference bus. Now next is that transformer that p point right. This is p is open after that that transformer this side you have to consider. So, delta star. So, T 1 x T 1 is given. So, this is j 0.06 that is given for transformer one point 0.06 it is given. But as is both are your grounded both are grounded. So, 0 sequence current will flow. So, that is why it is connected here. Now after this double circuit line in there. So, 2 parallel circuit you draw. So, line 1 it is q this is q and e, in between this thing 2 parallel line. So, this is j 0.03 j 0.03 both are equal both that is also given.

This is 0.3, 0.3 both the lines it is given. Next is that your transformer T 2 this is star this thing. So, it is your j 0.07 and as this side is star generator 2 also this side is star grounded this is also star grounded; that means, that this is 3 Z n, j 0.06. So, this is this has to be connected to the reference bus, and this one your this transformer this your this generator 2 it is given x G 2 0.05 that 0 sequence reactance is given. So, that is why after that it is j 0.05 and this point will be f and this is star grounded this is also star. So, 0 sequence current will flow. So, connectivity will be there star grounded star grounded here also star connectivity will be there. So, then you connect this transformer j 0.07 this is the second transformer j 0.07. So, j 0.07 connected to the line this connected to the line. So, this is the 0 sequence diagram for the your what you call for this for this kind of problem. Say positive negative I am not drawing because it is easy, but 0 sequence one is important. So, I hope you have understood this kind of problem right. So, so this is this another example of this kind of thing. So, you draw 0 sequence network of the sample power system shown in figure 17, I will show you, data are given below x g 0 is given. Your motor also is there x m 0 is given. Transformer T 1 also given.

X T 2 is given. Line 1 that is equal to both 2 lines are line 1 actually it is not line 1 line 1 is equal to actually it is line 1 line 2 is there both are there actually. So, line 1 is equal to this one. So, I can say line 1 line 1 is x l 1 0 that is x l 2 0 2 lines are there. Both are actually equal your, what you call, equal reactance.

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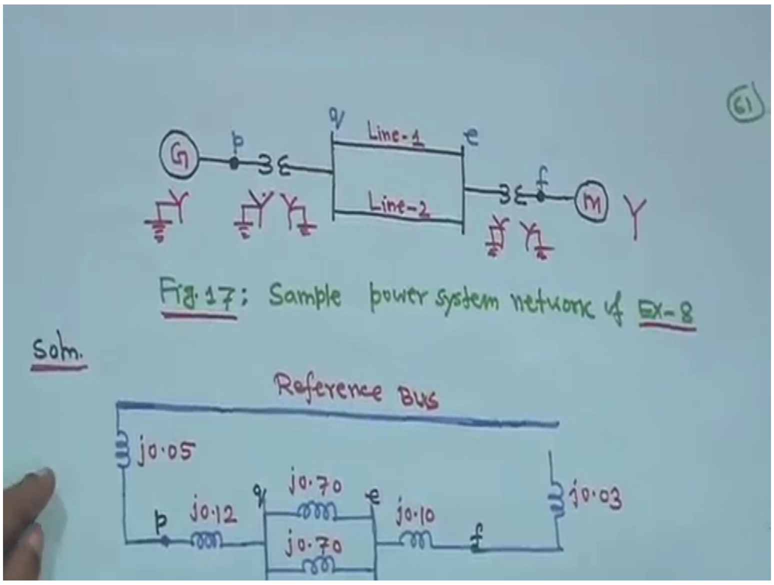

So, this is all parameters are given you have to draw the 0 sequence diagram. In this case in this case same thing, but no delta or star delta transformer. So, it is star grounded star grounded star grounded all star grounded, but this is ungrounded that motor. So, reference bus you will take.

So, generator star is grounded. So, it is actually for the generator no Z n is given. So, you just j 0.05 here it is data are given data are given so, j 0.05 right. And your transformer that just, let me see whether this Z n is given or not, no it is not given. And for transformer one it is 0.12 per unit. So, that is why 0.12 per unit and it is all this diagram that all are stars star connection right. All are star, star, star grounded except this motor. So, start from the reference bus this is transformer T 1, it is given. Then this double circuit line both are given j 0.7, 0.70 given then your this is also star right. So, that is also given for this transformer it is 0.10 given star. So, this is the point your this is the point f after that this is under grounded. So, there is this is motor is j 0.03 this is ungrounded. So, there should not be any connection there will be an isolation.

So, but do not make the mistake, suppose you will come up to this after that you will make connection like this and this is ungrounded you will make isolation it is not like that, this side is star, star. So, you make it this is grounded, but this is ungrounded. So, take j 0.03 then you make this portion is open because this is ungrounded. So, this is your what you call the 0 sequence diagram, so all the version right. I have I have shown you then this is the last one, looks like this is the last one, the another version that you draw that 0 sequence network of the sample power system. And shown in figure 19, this is your figure19.

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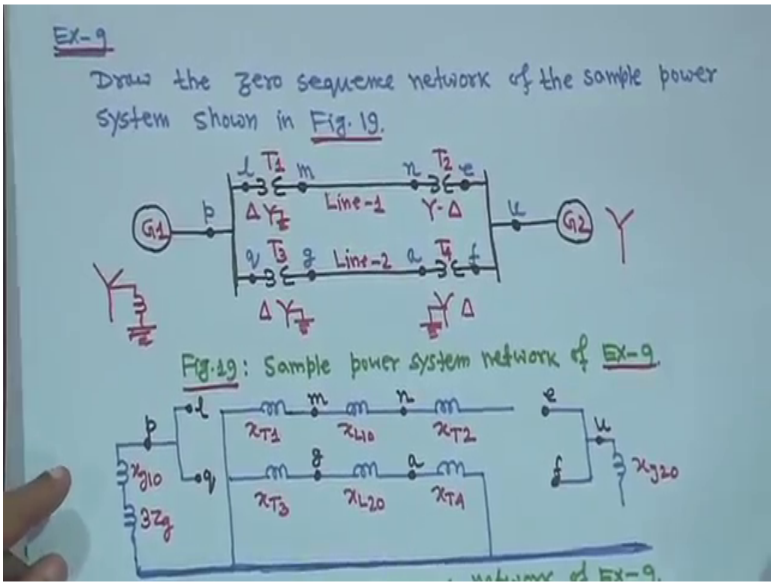

So, you have a generator star grounded you have a point mark here p l m n e q g a f u all I have marked you mark of your own. This is delta star transformer star is grounded. This is star delta it is ungrounded delta star transformer star is grounded, but this here star is grounded delta transformer, but here star is not grounded and here it is star.

So, in this case you have to draw the 0 sequence network look. So, what you will do you take this reference bus I have taken here at the bottom now, such that it will be easier for me to draw is a bottom now then it is it is z g suppose it is given. So, it will be 3 z g for the generator and generator 1 x G 1 0 will be there. So, it is it will because it is grounded. So, it has to be connect to a reference bus, then your this side is delta for line 1 it is delta and for line 2 also it is delta star delta star both are grounded, but as it is delta. So, there will be isolation. So, make this one and then your l m I have showed as if it is not it is isolation. There is no connection here. Then this star this star here grounded star here grounded.

So, consider line 1 star one grounded. So, it is connected here to the reference one right. Then x T 1 you take consider this x T 1 then consider line 1 x l 1 0 then transformer x 2 you take x T 2 you take x T 2 you take, but here star is not grounded star is not grounded; that means, it is isolation, there will be it is open because it is star is not grounded it will open. And if you come to this side this generator that this generator sorry, this generator this star connected ungrounded. So, it should not be connected to the reference bus it is x G 2 0 right. And this is your e and f point e and f point, but this is delta this is delta. So, complete isolation. So, that is why this is totally open, this is totally open. And because delta I told you that circulating, even if circulating I mean even if circulating current you will be there, but that cannot leave the your what you call that delta terminal so it will be isolate isolation. And for the line 2 when you will come this is also grounded line to this is also line to x T 3.

Then this line is actually x l 2 0 right. And this transformer is x T 4 x T 4 that transformer, but this is actually grounded star is grounded. So, it is grounded. So, this way this is that your what you call the 0 sequence network of this your this example. So, this way you should you should little bit practice then things will be easier for you. So, with this with this we have completed that your symmetrical components. So, one symmetrical component is and all sort of positive negative, positive sequence and negative sequence and 0 sequence all sort of, all sort of things I have showed you, but positive sequence when you are drawing the positive sequence it is same as is the way you draw the circuit diagram with voltage sources.

So, that is very simple and for negative sequence actually almost say it is same all the positive negative sequence impedance as for all the components more or less same it is same. So, only voltage sources should not be there. So, 2 very easy positive and negative and 0 sequence component that you have to consider, but because 0 sequence actually you have to draw it correctly. And if when you will see the fault studies then you will and when you will try to solve it using positive negative and 0 sequence components, at that time will see it is your what you call usefulness. So, symmetrical component is more or less completed. And another thing I told you regarding that your a matrix inverse. So, very easy to remember that a inverse is equal to one third, a conjugate transpose. So, you know a matrix. So, you can easily make it a inverse.

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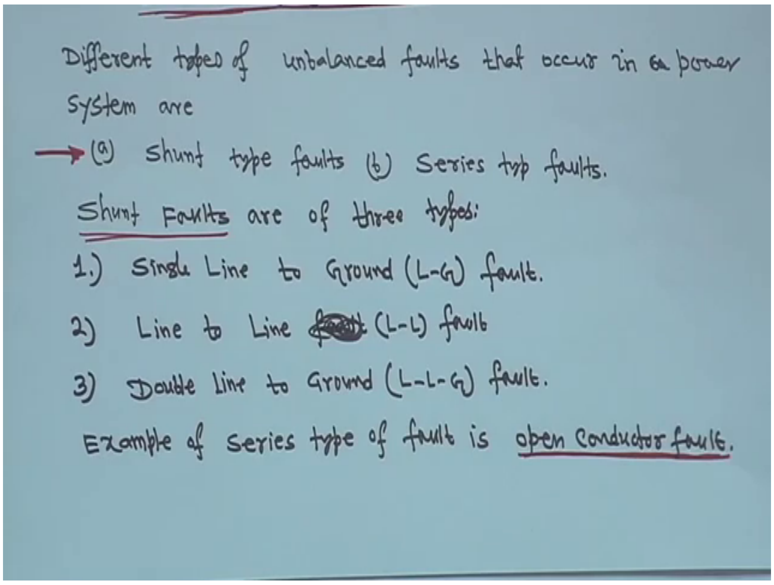

So, next we will begin that your unbalanced unsymmetrical unbalance or unsymmetrical faults. So, unbalanced or unsymmetrical faults actually occur in a power system. Actually these are the faults very common, because in the previous we have seen 3 phase fault that probability of occurrence of that fault is very rare. But this kind of fault is very common. So, one thing is that shunt type fault another is series type of faults. But shunt type of faults actually single line to ground fault that is one thing is very common. But another thing is that line to line fault that is also common. Sometimes double line to ground fault. So, this 3 faults are very common and as you know that that generally that for 3 phase short circuit or 3 phase fault the fault current is very high, but sometimes that single line to ground fault also that current is as severe as your 3 phase fault for a particular thing that if the fault occurs near the generator terminal. It is the single line to ground fault if happens near the generator terminal then that severity will be almost like your 3 phase fault current right.

So, but simultaneous occurrence of 2 fault for example, say phase a to ground fault and phase c to ground fault. This probability of simultaneous occurrence of such fault is very rare. Or line to ground fault one another phase suppose, phase a line to ground fault and phase b and c line to line fault this occurrence are very rare, will not study those things. So, that probability is almost you know negligible, so anyway. So, shunt faults basically single line to ground fault will study, line to line fault will study and double line to ground fault. And example of series type of fault is open conductor fault suppose suddenly conductor has opened right. So, this is very rare, but one conductor open or 2 conductor open fault will see and we will try to analyze it using symmetrical component, unbalanced. So, unbalanced fault analysis actually very important this is more this because occurrence of this fault are very you know very often.

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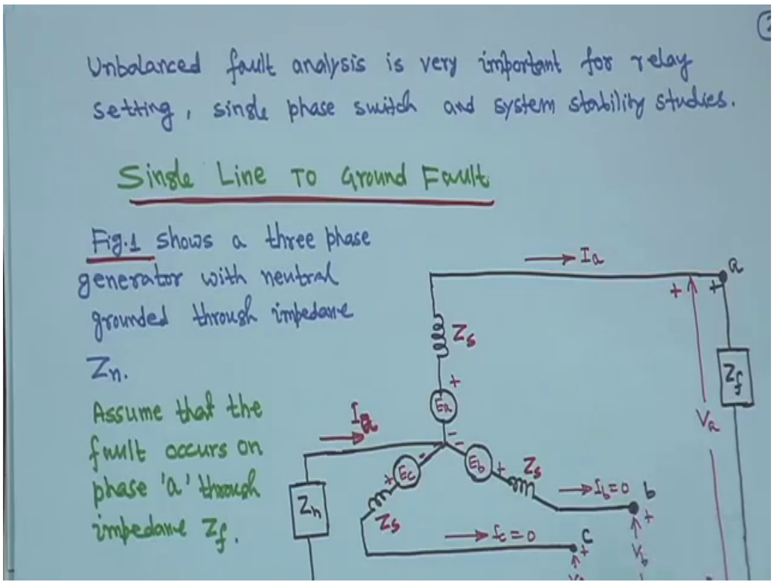

So, in that case that unbalanced fault analysis actually basically important for relay setting single phase switching and system stability studies. So, we are so because these are the fault very common. So, next we will see single line to ground fault.

Thank you, I will come again.