Power System Dynamic, Control and Monitoring

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Lecture - 30
Transient stability (Contd.)

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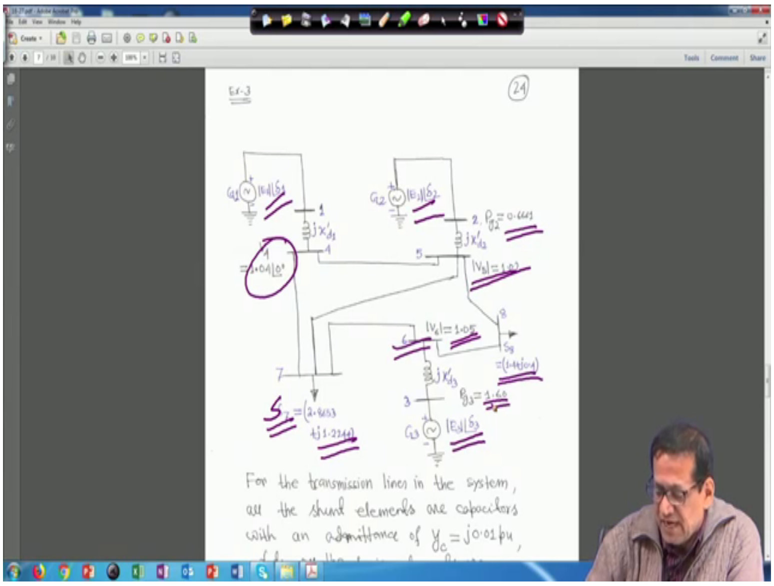

So, we are we are back again this here, I have a your what you call reduce this thing from 200 percent to 100 percent. First I have to explain regarding this diagram because then understanding will be clear right, hope everything will be readable to you. If I enlarge it then it is just crossing that your what you call this monitor and this screen right. So, first that problem, after that I will tell you fault and other thing right; so first is the problem; so here it is actually 3 generators.

Generator 1, generate 2 and generator 3; 3 generators are there right and your that this is bus 1, this is the voltage behind your transient reactance; this way it has (Refer Time: 01:07) xd 1 dash. This is bus 2; it is xd xd 2 dash right and this is your bus 3; a it is xd 3 dash is given right and this is bus 4 bus 5 and bus 6, bus 7, bus 8. This is a big example, but it will not be asked in the exam or assignment you compute so many things. Many data will be provided to you such that you can compute easily right; I mean such that you can do it in the classroom exercise, but this example is taken such that it will your; clear it is it will clear your concept or doubt right and this is one.

So, all these things when this is voltage your this voltage is your E 1 angle delta 1, magnitude I made the E 2 angle delta 2 and this is E 3 angle delta 3 right. This bus is a slag bus right, this bus is a slag bus voltage is 1.04 angle 0. Now this bus; bus 5 is a PV bus right this bus is a PV bus, voltage magnitude with specified right. And this bus 6 also is a PV bus, voltage magnitude is specified. Later I might have mentioned everything right and second thing is bus 7; the load is given in per unit bus 7 load, this is S 7, 2.8653 plus j 1.2244; this load is given P and q. Similarly at bus 8 load is given 1.4 plus j 0.4 this loaded load is given right.

And here P g 2 is 0.006; sorry 0.6661 right per unit and here also P g 3; 1.60 right. So, these are the data given and some and other data are mentioned now right; just hold on. So, this is the problem just hold on let me enlarge it now right.

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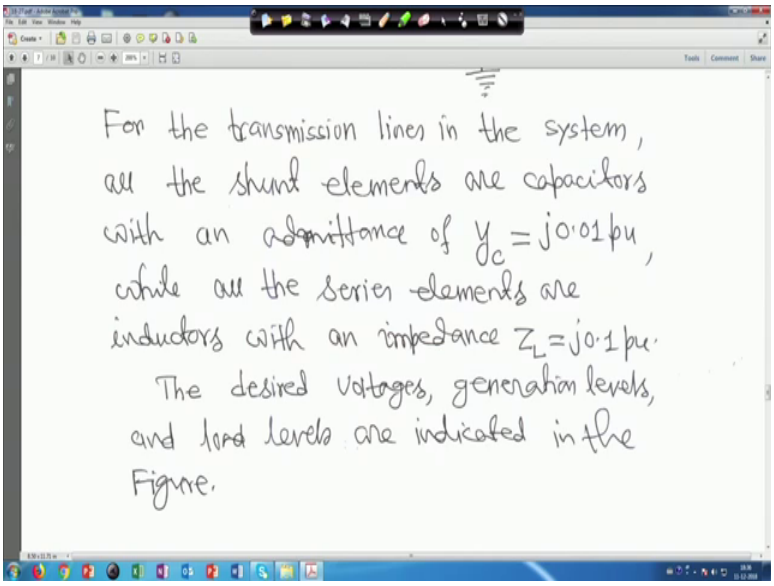

So, this is the diagram I showed you right now it is now the; now, for the transmission line in the system all the shunt element are capacitors with an admittance of yc is equal to j 0.1 per unit right. So, all the shunt element for transmission line it is j 0.1 per unit is given. While all the series elements are inductors with an impedance of Z L is equal to j 0.1 per unit right; this data given. The desired voltages generation levels and the load levels are indicated in the figure; fault I will tell you later right.

So, that figure this figure is more your what you call I told everything right.

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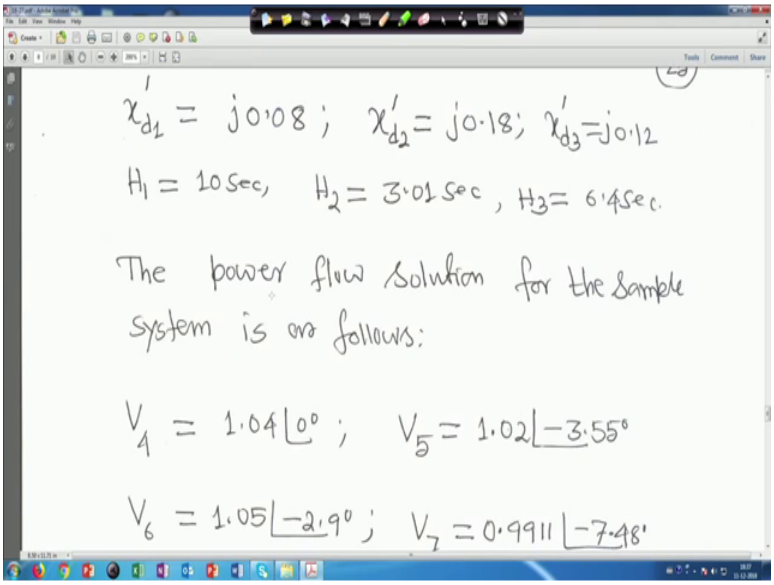

So, now this data are given x d 1 dash is given j 0.08 per unit; everything is in per unit; x 2 dash a x d 2 dash j 0.18 and x d 3 dash j 0.12 right. H 1 that is inertia constant for machine 1; 10 second H 2; 3.01 second and H 3; 6.45 second, the power flow solution also is given right. So, for the assignment or exam purpose we will provide the power flow solution such that otherwise we will not ask you to solve this you need computer right.

So, powerful solution V 4 is given 1.04; 0 angle 0 I told you it is a slag bus; V 5 is 1.02 angle minus 3.55 degree; this is the load flow solution. V 6 is 1.05 angle minus 2.9 degree; V 7 is 0.9911 angle minus 7.48 degree and V 8 is equal to 1.0135 angle minus 7.05 degree; these are the load flow solution.

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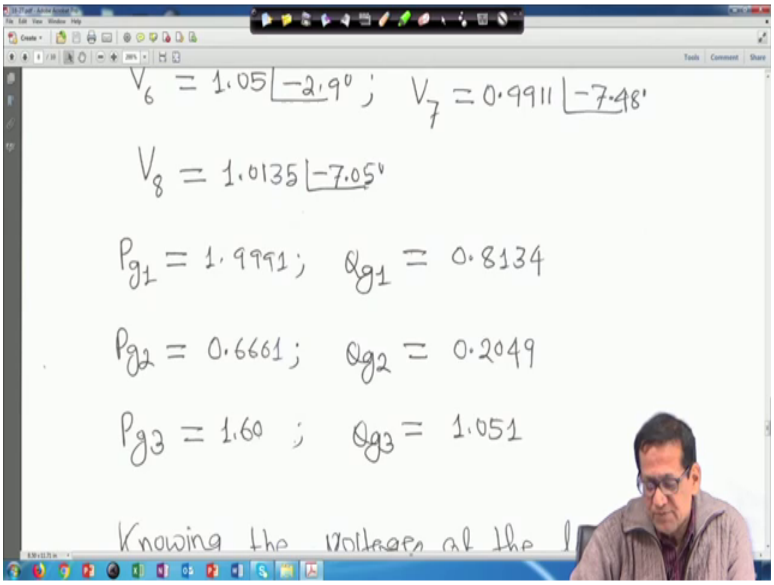

Along with this P g 1 is 1.000 1.9991 per unit Q g 1 is 0.8134 per unit; everything is in per unit. P g 2; 0.6661 per unit; Q g 2, 0.2049 per unit; P g 3 is equal to 1.60 per unit and Q g 3; 1.051 per unit; all these things are given right.

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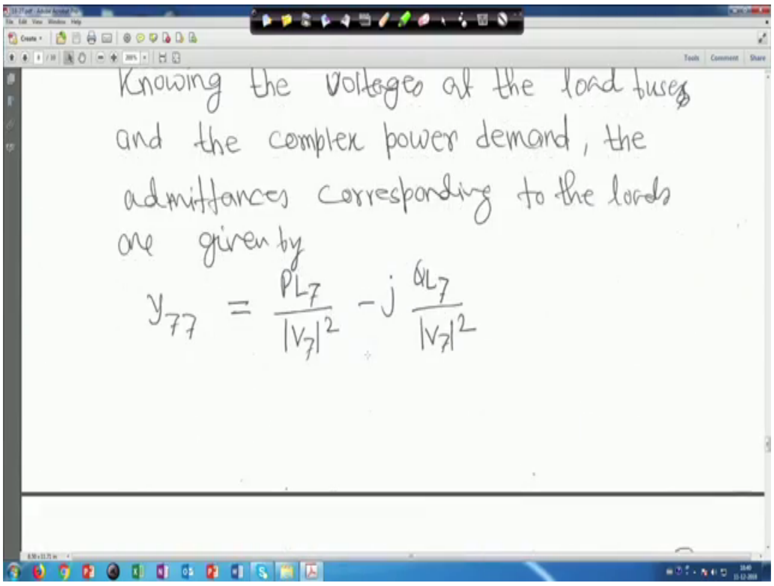

Knowing the voltages at the load buses and the complex power demand the admittances corresponding the loads are given by I mean when you come to this diagram that this for the transmissibility analysis this load are given we have to convert this load in terms of your what you call that admittance right then this will be considered as a slunt element.

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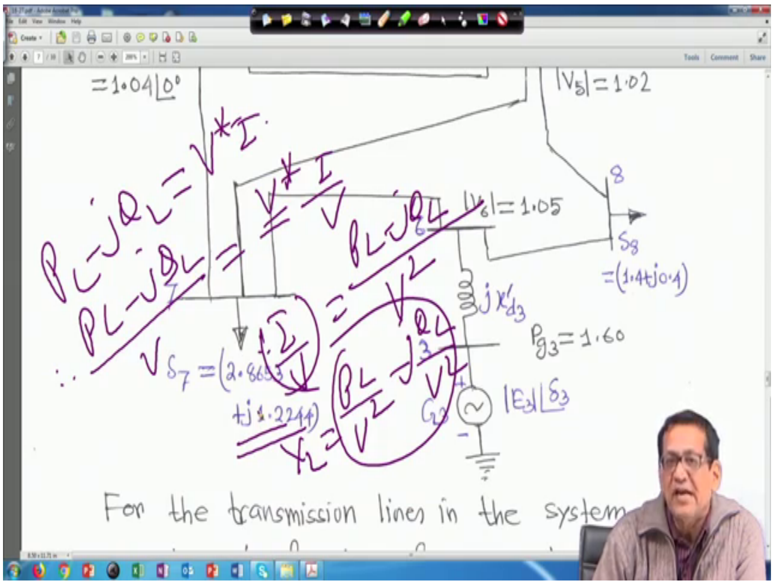

So, in this case generally we know; generally we know that P L minus j Q L. I have we have discussed all this thing before, but I am just telling P in general P L minus j Q L is equal to V conjugate I right this is the thing. Now; that means, P L minus j Q L right divided by; I mean if you divide both side by V; that means, is equal to V conjugate I by V. I am over writing on it right; that means, my I by V; this is my admittance right is equal to P L minus j Q L divided by this V conjugate into V bring this one to this side, this V conjugate and bring to this side.

So, V into V conjugate it will be basically V square; their magnitude right voltage square magnitude. So; that means, this my Y this I by V actually Y that is if it is for a load then Y L; it will be I L is equal to P L by V square Y L is equal to then minus j Q L upon V square. So, this way we have to transform this load into admittance right load admittance.

So, that is why we have that is why we have converted this your Y that bus 7; we will make because we have to convert it to your what you call the admittances. So, we instead of Y 7 we are writing Y 77; P L 7 upon V 7 square because it is bus voltage at this bus 7 right and minus j Q L 7 upon V 7 square just I told you how to make it right.

So, P L and this P L; Q L and V 7 magnitude all are known right and after the load flow studies everything is known.

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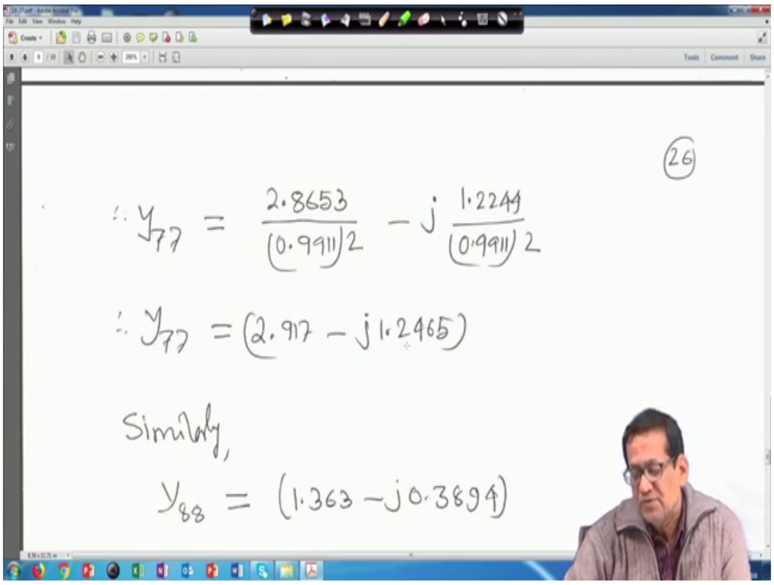

So, if you compute if you compute this right then Y 77 will become that your 2.8653 and V 7 is 0.9911 square; 11 square minus j 1.2244 upon 0.9911 square. So, square this is actually coming your 2.917 minus j 1.2465 per unit right.

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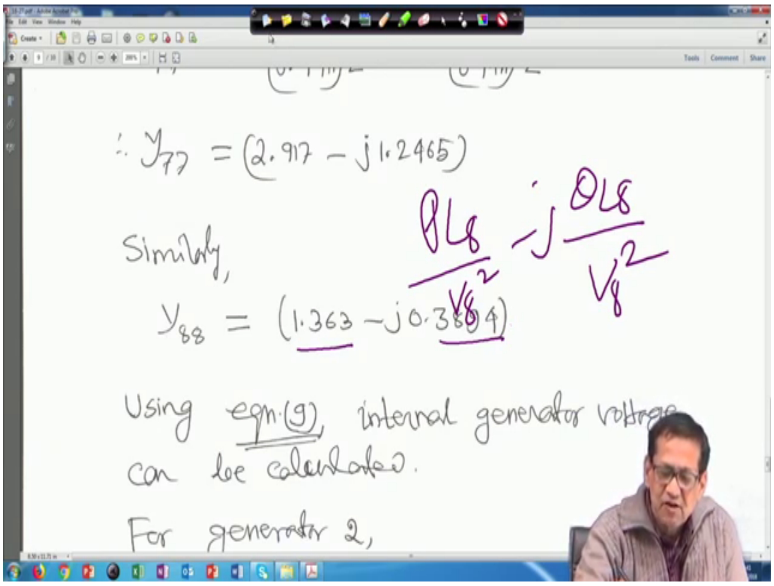

Similarly, you calculate Y 88 right. So, similarly for Y 88 you will calculate that is your; whatever load is there at that bus P L 8 upon V 8 square minus j Q L 8 upon V 8 square right. So, if you compute you will get 1.363 minus j 0.3894 per unit right. I have not written everywhere per unit; but it is understandable. Now, using equation 9 right using equation 9 that internal generator voltage can be calculated as right so; that means, your E 1, E 2 and E 3 we have to compute.

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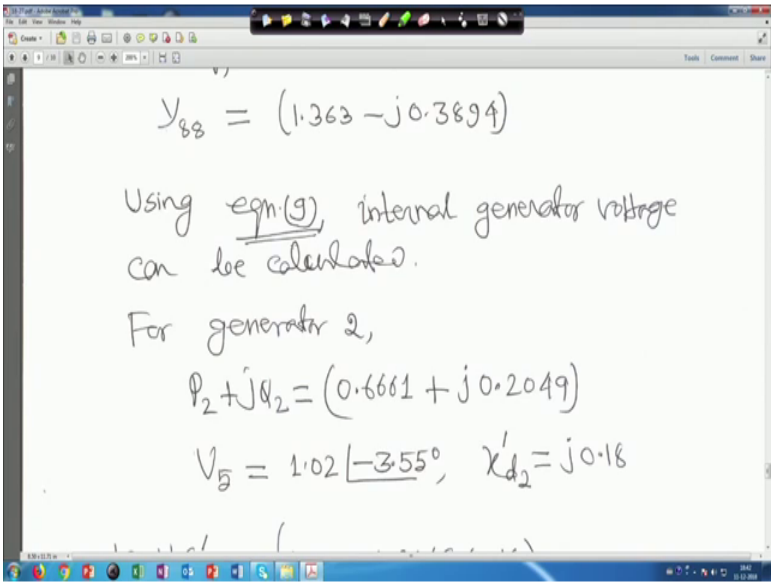

So, equation 9 it is already derived; equation 9 everything is derived that derivation is given.

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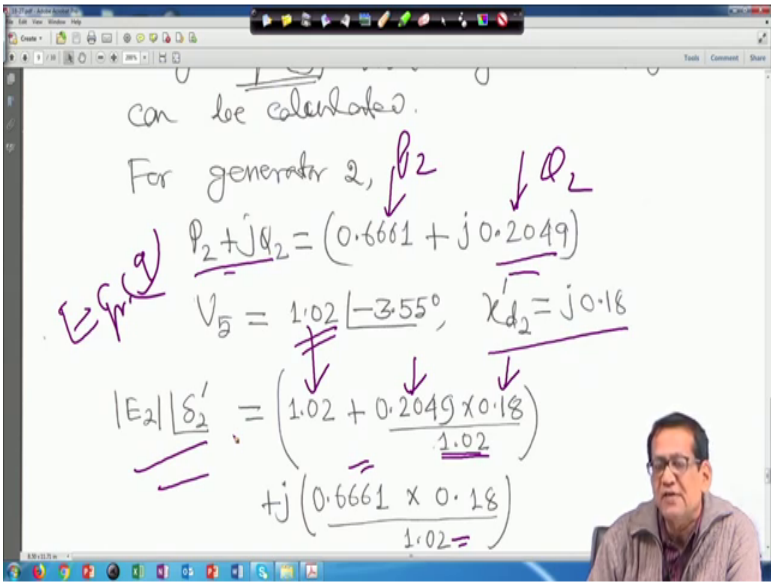

So, for generator 2 that is your for generator 2 that your P 2 plus j Q 2 is equal to this is my P 2 and this is my Q 2 right; 0.6661 plus j 0.2049; it is everything after load flow studies right and V 5 is given 1.02 angle minus 3.55 degree right this is given. So, this is

V 5 and this is my; your delta 5; execute as a xd 2 dash also given j 0.1 and so go back to equation 9; you go back to equation 9 right. So, we can write magnitude of E 2; angle delta 2 dash from equation 9 right is equal to V 5; that means, this voltage magnitude V 5 plus right that Q 2 into x 2 dash.

So, this is Q dash; this is my Q 2 into xd 2 dash. So, this is my x 2 dash divided by your what you call that V 5 that is 1.02 right plus j go to equation 9; it is P 2; 0.6661 into xd 2 dash divided by B 2; that will give you your magnitude angle of the your internal; your generator voltage terminal voltage right.

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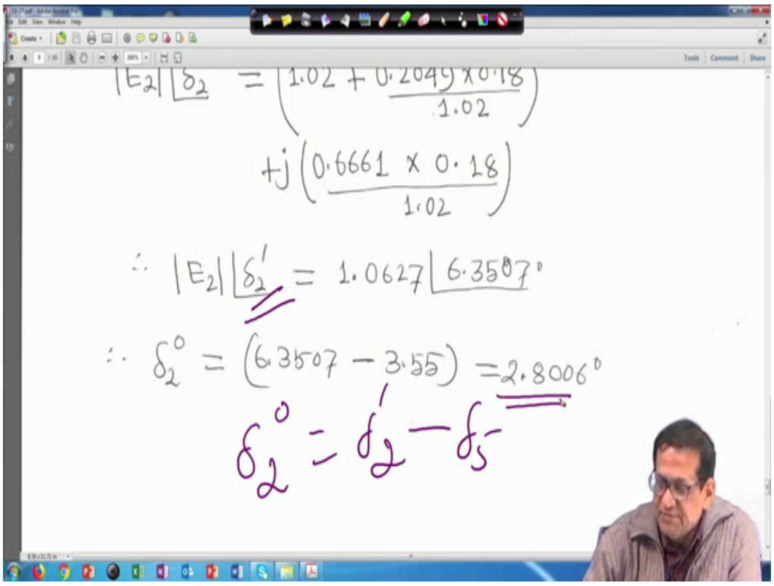

So, if you do; so you will get you will get E 2 angle delta 2 dash is 1.0627 angle 6.3507 degree. Therefore, what will be delta 2 0? It will be 6.3507 minus 3.55 because your this; this voltage, this angle voltage power V 5; it is minus 3.55 degree right. Therefore, this one; this one delta 2 0 will be 6.3507; that means, this degree this one minus that 3.55; it will be 2.8006 degree that is my delta 2 0 right.

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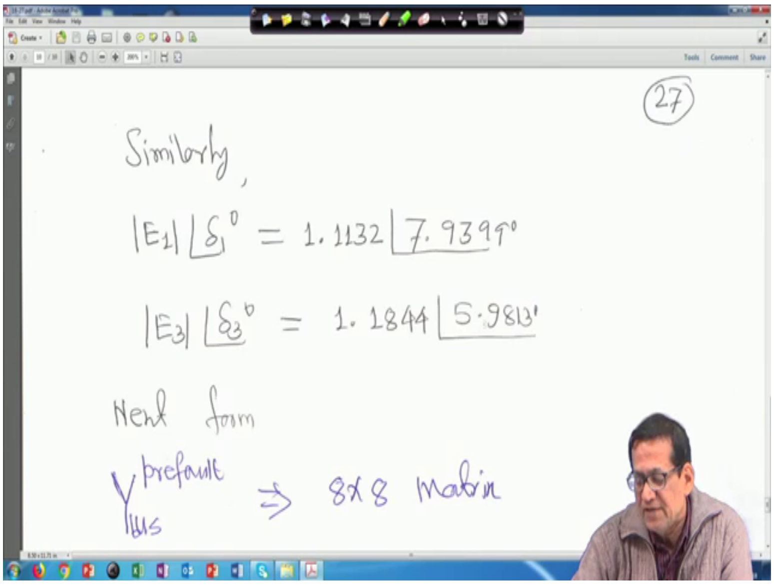

Similarly; similarly you please calculate your E 3 angle; your E 1 and your E 3 right. Similarly we have computed that E 1 angle delta 1 0 will be 1.1132, angle 7.9399 degree and E 3 angle delta 3 will be 1.1844; angle 5.9813 degree; note that this is delta 2 dash right, this is delta 2 dash right. So, basically delta 2 0 is equal to delta 2 dash minus your delta 5; that is your bus voltage angle delta 5. So; that means, here it is 2.8005 degree.

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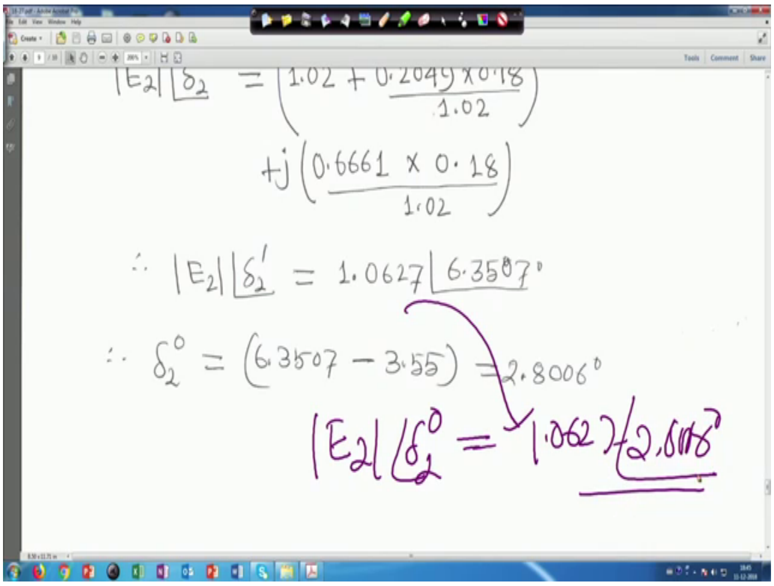

That means; that means, my magnitude of E 2 angle delta 2 0 is equal to your 1.0627 and these voltage 1.0627 and angle 2.8006 degree right. So, that is why for 1 and 3 we are instead of writing delta 1 dash, delta 2 dash right we are writing E 1 angle delta 1 0; E 3 angle. If you please compute these two; to save the time direct answer is given right.

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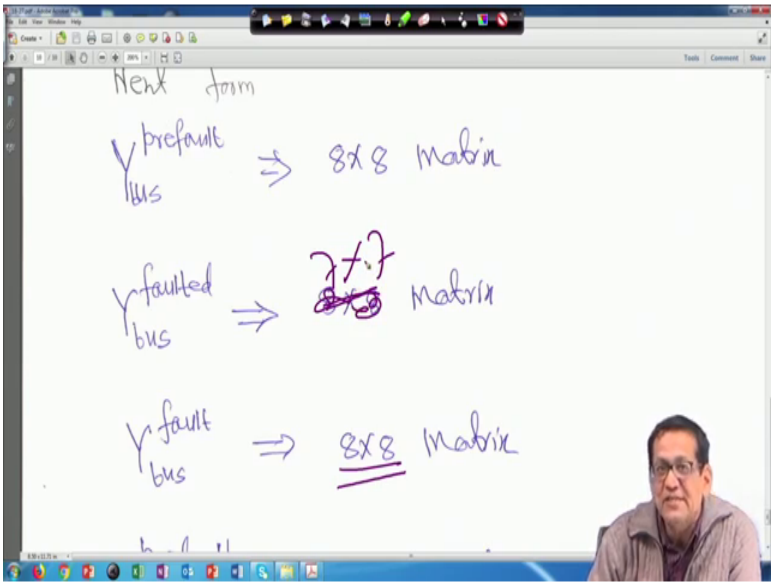

Next is your Y bus prefault Y bus prefault is 8 into 8 matrix and Y was faulted actually it is 7 into 7 matrix right; that we will see later. And Y bus fault again will be 8 into 8 matrix because one row and column will be eliminated; so, it will be your 7 into 7 right.

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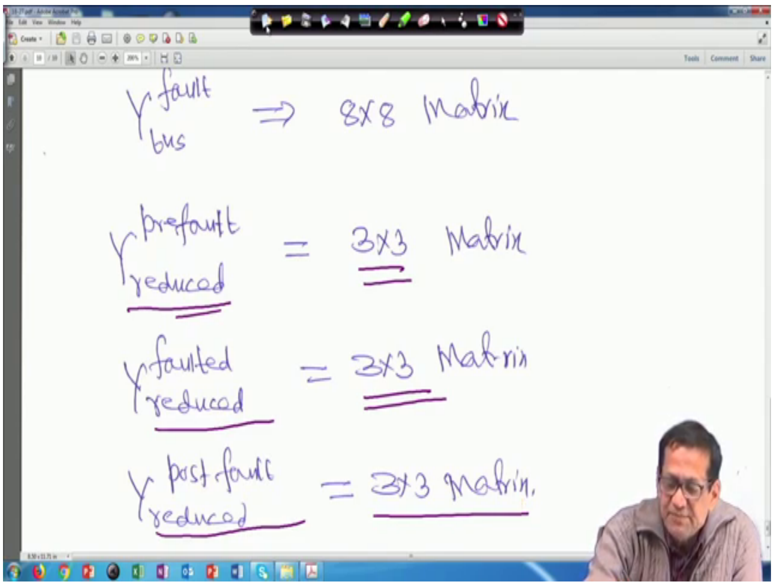

So, and when you reduce it that it is there are 3 machines; there are 3 machines. So, pre fault matrix will be 3 into 3 matrix, Y was faulted also will be 3 into 3 matrix and Y bus reduced that post part also will be 3 into 3 matrix right because 3 machines are there.

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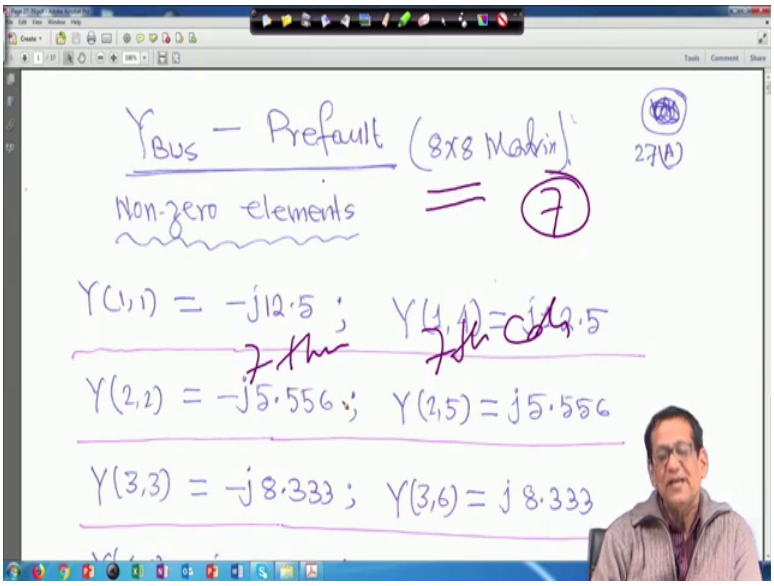

For that example; Y bus prefault is 8 into 8 matrix right; whatever data were given all these things were computed. I am writing capital Y 11 is equal you will get to I; I suggest these are all the non-zero element, other elements are 0 right only non-zero elements I am writing. So, Y 11 is minus j 12.5, Y 1, 4 you will get j j 12.5.

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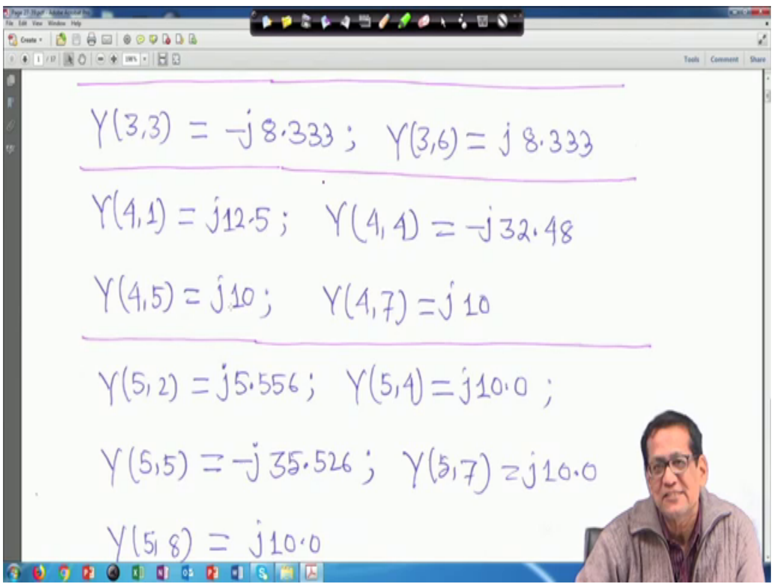

Similarly, Y 22 we will get minus j 5.556 and Y 2, 5 we will get j 5.556. Similarly Y 33 we will get minus j 8.333 and Y 3 6; you will get j 8.333. Just you can compute yourself, but for exam purpose or these parameters will be provided right; otherwise because otherwise it is a time consuming process.

Y 4 1 will be j 12.5 and Y 44; you will get minus j 32.48; only I will request when we will compute it please see that all calculations are correct or not right. If you find any computation error you just put it that put that question in the forum right; we will we will rectify that Y power 5 will be j 10 and Y 4 7 will be also j 10 right. So, and Y 5 2 will be j 5.556; Y 5 4 will be j 10, Y 5 5 will be minus j 35.526; Y 5, 7 you will get j 10 and Y 5 8 also j 10.

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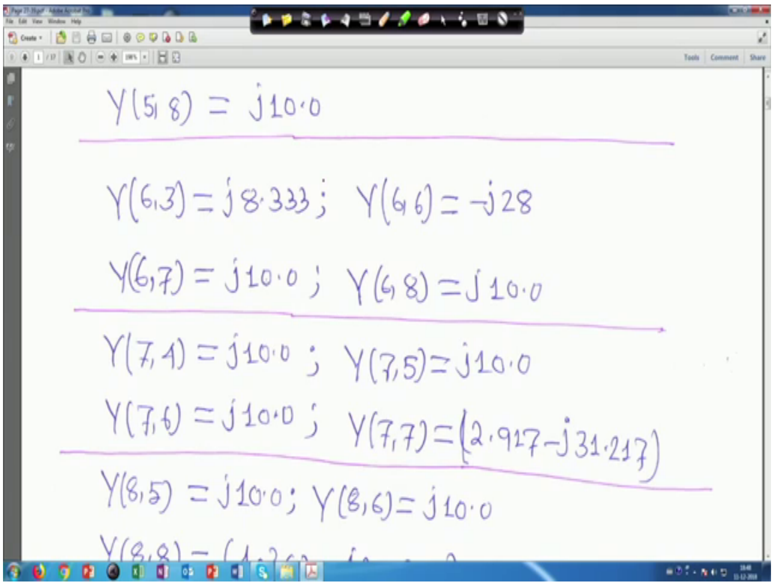

Now, Y 6 3 you will get your j 8.333; Y 6 6 minus j 28; Y 6 7 j 10; Y 6 8 actually you will get j 10.

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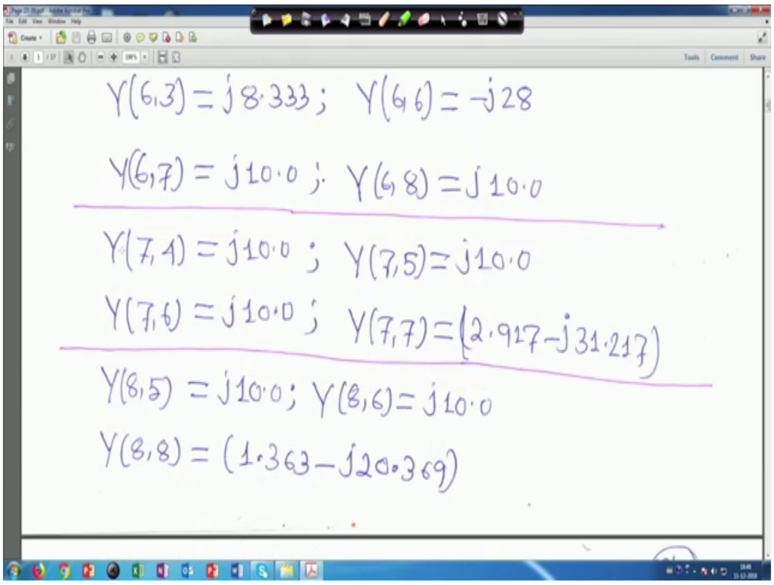

Say next Y 7 4; you will get j 10, Y 7 5 we will get j 10, Y 7 6 j 10 and Y 77 you will get 2.917 minus j 31.217 because here that your at bus 7 that load admittance is there that you have that real an imagination in a both parts are there. For the load admittance that will be that will be considered as shunt admittance and that is why it is a complex; it is a what you call is real an imaginary part both are there right in Y 7 7.

Similarly, for Y 8; Y Y at Y 8 5 j 10; Y 8 6 j 10 and Y 88 you will get 1.363 minus j 20.369 because at bus 8; also you will find the load is there right and Y bus faulted matrix right.

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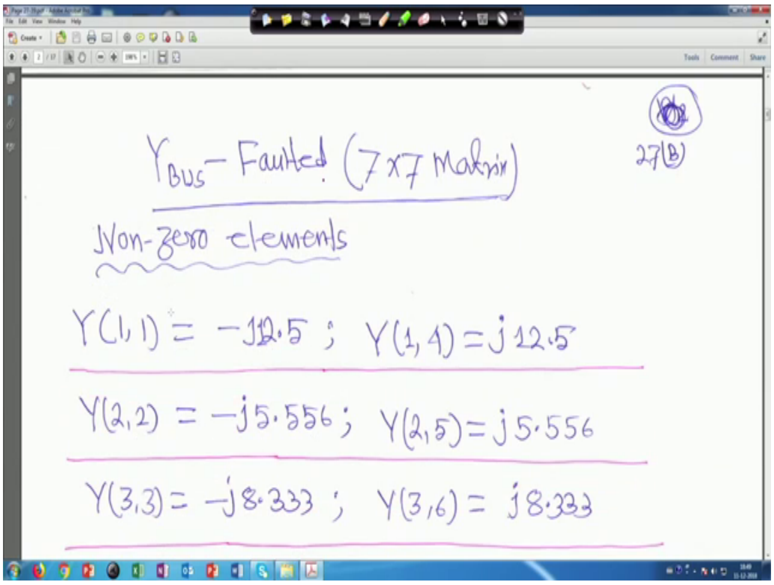

So, nonzero element; so in this case it will be 7 into 7 matrix. So, non-zero element will be all Y 1, 1 will be minus j 12.5; Y 1, 4 will be j 12.5 and Y 2, 2 will be minus j 5.556 right and Y 2, 5 is j 5.556. Now Y 3, 3 will be minus j 8.333 and Y 3, 6 is j 8.333 and Y 4, 1 is j 12.544 will be minus j 32.48 and Y 4, 5 we will get j 10.

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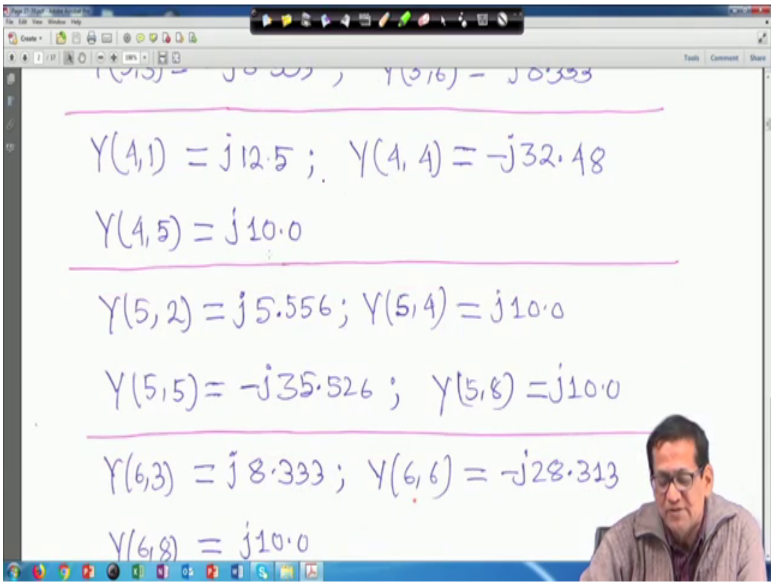

So, Y 5, 2 is equal to j 5.556; Y 5, 4 you will get j 10; Y 5, 5; we will get minus j 35.526 and one for Y 5, 8 will get j 10. Similarly Y 6, 3 you will get j 8.333; Y 6, 6 you will get minus j 28.313 and Y 6, 8; you will get j 10 right.

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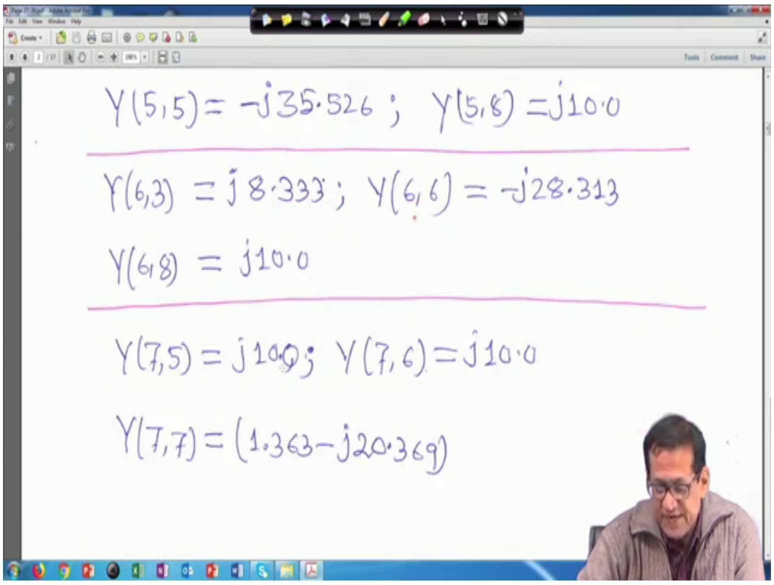

And Y 7 5 you will get j 10; Y 7, 6 you will get j 10; Y 7, 7 will get 1.363 minus j 10.369; actually that fault has occurred at bus 7 at 3 phase fault has occurred at bus 7. So, from this Y matrix when you write right that that for this is your full matrix; in this matrix that is that is your 8 into 8 matrix and this fault has occurred a 3 phase fault has occurred at bus 7 right. So, what we will do that from this 8 into 8 matrix that seventh row and seventh column right seventh column you completely eliminate right seventh row and seventh column you eliminate.

So, faulted matrix will be 7 into 7 right. So, fault has occurred at, but 7 a 3 phase fault has occurred at bus 7. So, this will be your what you call that your 7 into 7 matrix for bus faulted bus right; it is bus fault has at bus 7.

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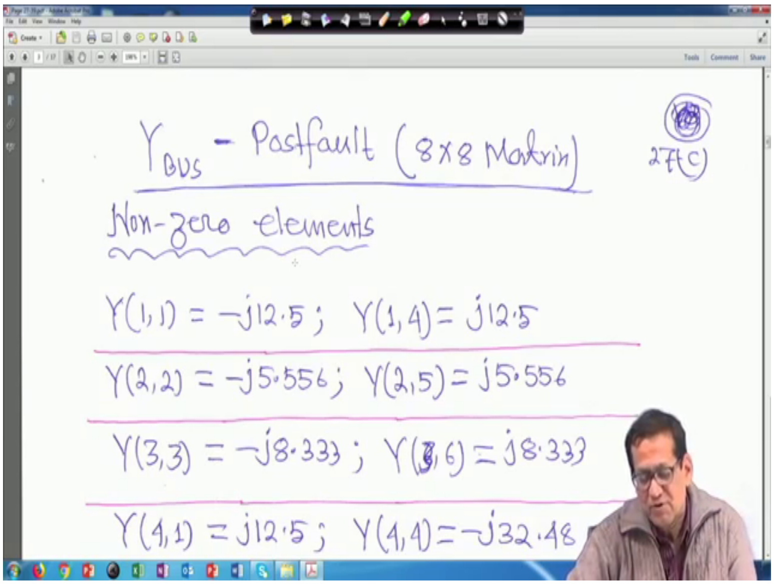

And for your post fault case the nonzero element; then again you will go back to 8 into 8, but in that case that your fault a your what you call that line was removed right. So, in that case if you your just hold on just let me; let me go back to that diagram again right that just hold on let me go back to that diagram again; just hold on yeah right. So, when for in this fault has occurred actually at this thing, but 3 phase fault at bus 7 such a voltage a bus 7 will be 0.

So, that line was completely your what you call that sorry that you are that seventh row and seventh column was eliminated right. So, that is why matrix will become 7 into 7, but 3 lines are there; so just hold on right. So, this is your post 4 matrix if you come to that.

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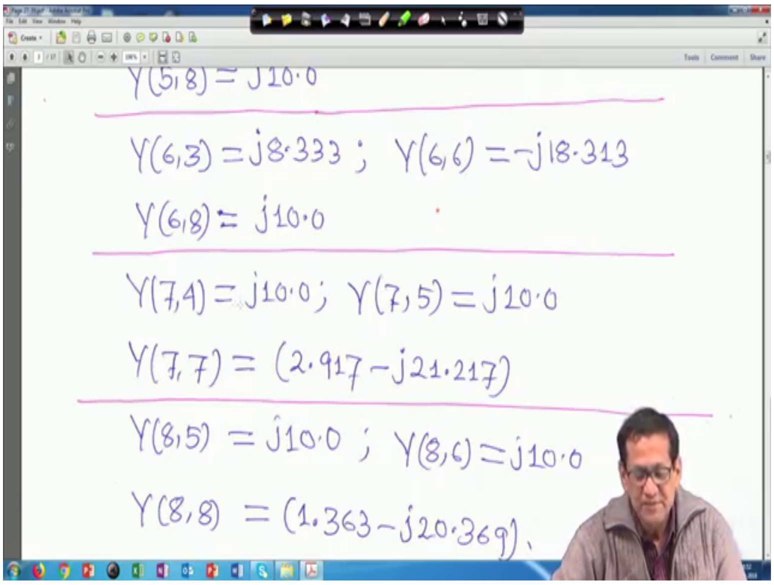

So, it will be 7 4; your 7 4; 7 5 and 7 7 are there right and here it is 8 5 8 6 and 8 8 is there. If you go back 7 4; 7 5 right and 7 7; so let me go back to that diagram 7 4 and 7 5 right; let me go back to that diagram. So, because it is just we are putting it away right just hold on. So, this your 7 4; 7 5 is there and I think line 7 and 6 where after they fault was cleared that line 7 6 is out right; line 7 and 6 is out. So, if 7 and 6 is out; so 7 4, 7 5 is there; so 7 6 Y 7 6 will not be there.

So, that is why when fault is clear line 7 6 were out right. So, in this case your for your post fault case; if you look into that Y 7 4, 7 5, 7 7 is there Y 7 6 is not there. But when your P fault case; if you look into that just hold on 7 6 was there. So, up when fault was clear that line 7 to 6; I removed right it is open. So, that is why your faulted matrix 7 4; 7 5 and 7 7 is there and Y 8 5, 8 6, 8 8 is there right. So, this is your; what you call that your post fault matrix.

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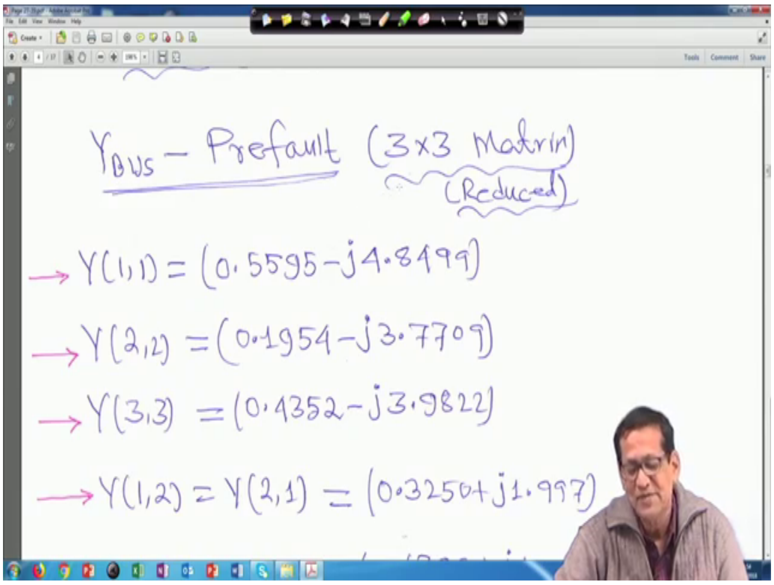

Now, if you if you just go for matrix reduction that reduce Y bus matrix; it will be coming like this. Just it is given that your you because it is a; it is a 8 into 8 matrix or 7 into 7 matrix.

So, inverse and other thing is impossible in the classroom you need help of computer, but final if you do; so this data will be provided for your easy calculation. So, when you reduce to prefault one that Y 1 1 is this much is given Y 2 2 is given, Y 3 3 is given and this is a symmetric matrix.

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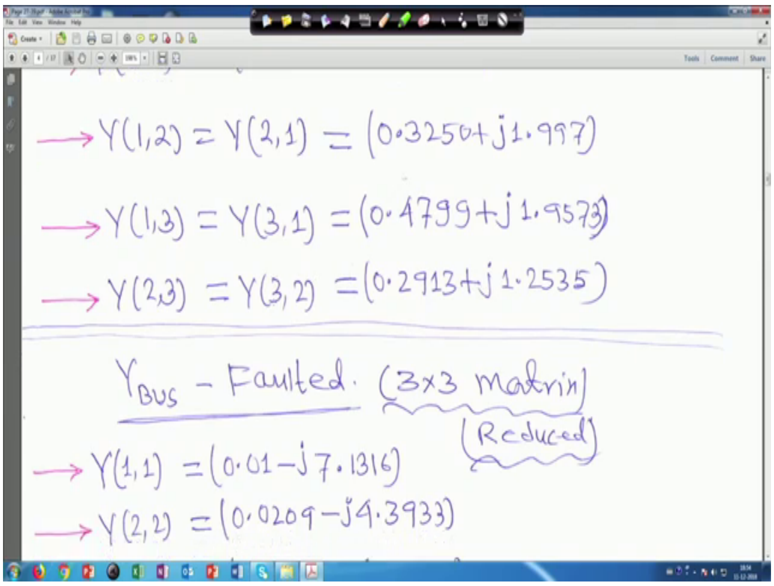

So, Y 1 2 will be Y 2 1 is this much; Y 1 3 is equal to Y 3 1 will be this much and Y 2 3 is equal to Y 3 2 will be this much right and Y bus faulted.

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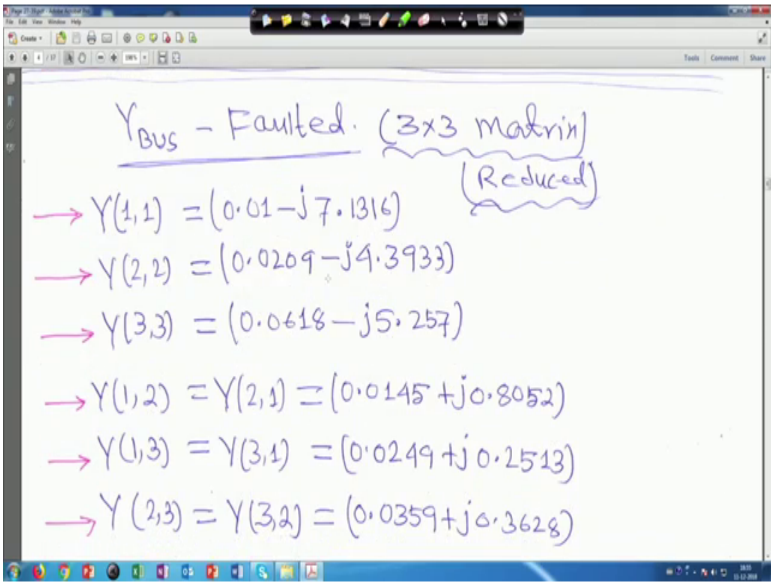

So, 3 into 3 matrix the reduced or reduced one; it will be 7 into 7 matrix after the reduced right 3 into 3. Y 1 1 is given this much, Y 2 2 is given this much and Y 3 3 is given this much right and Y 1 2 is equal to Y 2 1 is this much Y 1 3 is equal to Y 3 1 is this much and Y 2 3 is equal to Y 3 2; 2 3 is equal to 3 2 is equal to this much right and this is your during fault right.

So, this is 3 into with the matrix the matrix reduction.

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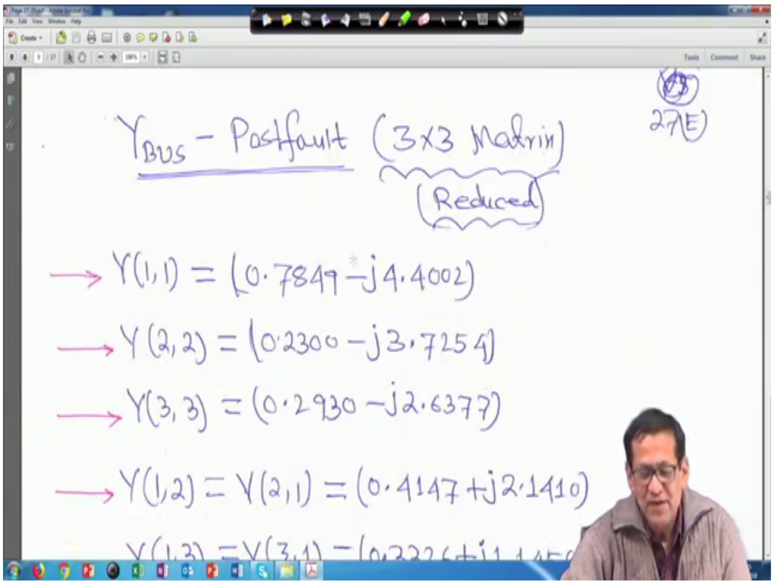

And then Y bus post fault 3 into 3 matrix again. So, all Y 1 1, Y 2 2, Y 3 3 are given all off diagonal elements are also given; it is symmetrical, symmetric matrix right.

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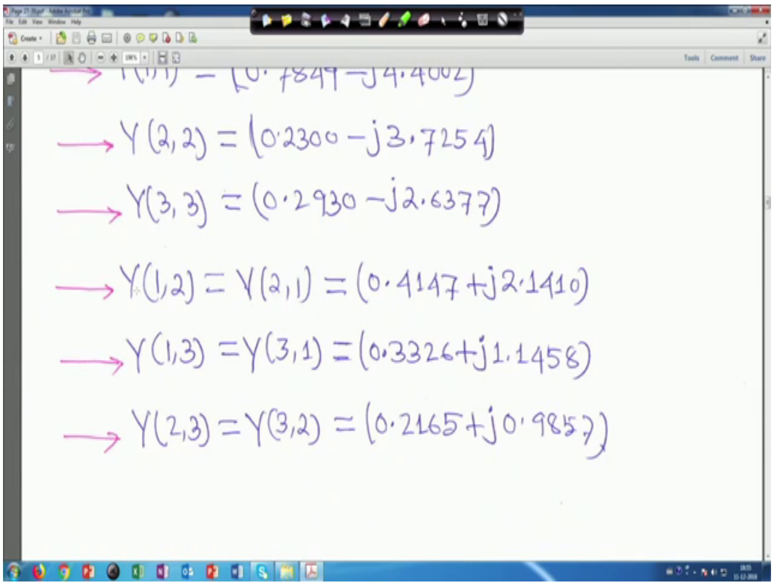

So, it is Y 1 2 is equal to Y 2 1, Y 1 3 is equal to Y 3 1 and Y 2 3 is equal to I 3 Y 3 2 right these are given. So, this is actually power transfer is not shown here just reduced matrix and how things are that. In the problem actually here that fault has occurred at bus 7 and after when fault was cleared; line 7 6 was removed right. And you have to consider that represent that loads in terms of admittance and you have to incorporate that thing in that Y matrix right.

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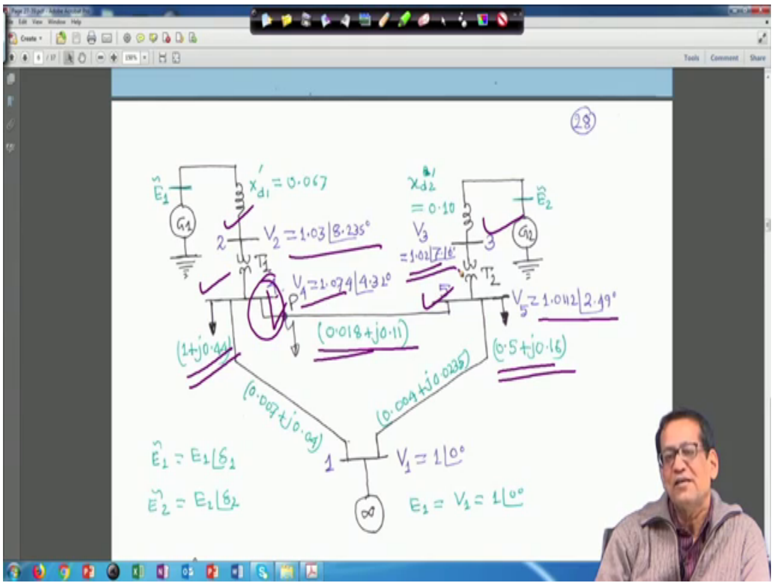

And this is another example just hold on; I will reduce this thing little bit alright. So, this is another example we have taken; so in this case that your before going to that fault and other thing; first we have to see that there are 3; 3 basically 3 generators well this is E 1 generator 1; this is generator 2 and this is your another one that is infinite bus right that infinite generator we have made it like this and this voltage this is a slag bus 1 angle 0.

So, in this case we are taking E 1 is equal to V 1 is equal to 1 angle 0 right. Now the loads are given and this is actually; in this case this one and this one not considered as a bus number; I think it is not required. Because this previous example there was no transformers, but here that transient reactance are there xd 1 dash and here also xd 2 dash; these 2 are there, but here we have your what you call put one transformer and transformer reactances will be there right. That means, whatever transformer reactance will be there with that you have to add these 2 reactances and then you find out the admittances.

So, that will be your Y 2 2; so you need not consider this one again and this one as another bus. So, things will be what you call it will be your copy no need no need right no need. So, that that is one thing, but previous example there was no transformer; there was no transformer right.

Now, another thing is that these bus your load flow result everything is given and here at bus 4 that load is given. We have to convert this load in terms of your admittance same as before; bus 5 also this load is given, we have to convert it in terms of admittance right. And other things are that all the load flow solutions are given in this right; V 3 is equal to 1.02 angle 7.16 degree; this is load flow solution. V 5 is 1.0112 angle 2.49 degree and V 4 is given 1.074 angle 4.32 degree and V 2 is 1.03 angle 8.235 degree; all these things are given.

Next is the line parameters are given; this is your r and x values that 0.018 plus j 0.11; this is all in per unit. This is also 0.007 plus j 0.04 per unit and this is also 0.004 plus j 0.023 5 per unit; these parameters are given. A fault has occurred near bus 4 right; a 3 phase fault has occured right. So, first thing is this is bus 1, bus 2, bus 2, bus 3, bus 4 this is bus 4 and this is bus 5. First you have to make that 5 into 5 matrix; Y matrix right and when fault has occurred that bus 4 right; that means, that voltage at bus 4; during fault will be 0 then will fourth row and fourth column of the Y matrix will be eliminated right.

So, as usual prefault also will make your whatever number of machines are there; accordingly we will reduce right. Similarly for your what you call that your during fault condition and during post fault condition and after that we will slide down that power equation; how to write, then we will write swing equation during fault and post fault condition.

So, this example is taken or these all the result whatever you see; all the result whatever is given for voltages and other thing and your; what you call that these are all load flow data detail load flow data. Other thing we will also show everything and for the exam purpose also all these things will be provided to you because it is impossible to compute in the class right. All these things will be provided to you; your objective is to compute other things very correctly right.

So thank you very much; we will be back again.