Power System Analysis
Prof. Debapriya Das
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 32
Load Flow Studies (Contd.)

Next are from equation 36 right. So, equation 36 it was P ki that was Pik and this is your P ki right.

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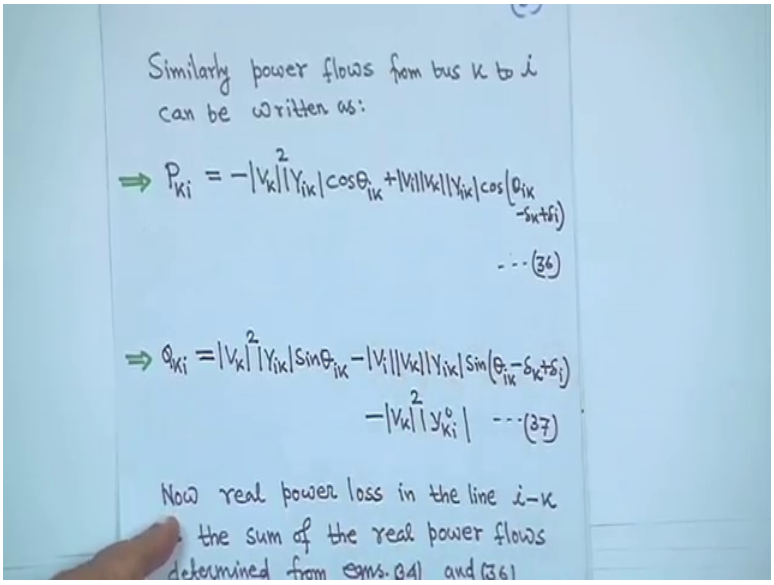

So, this is the expression for this thing is. So, here also find out P21 also right like k is equal to 2 i is equal to 1 in this expression in substitute.

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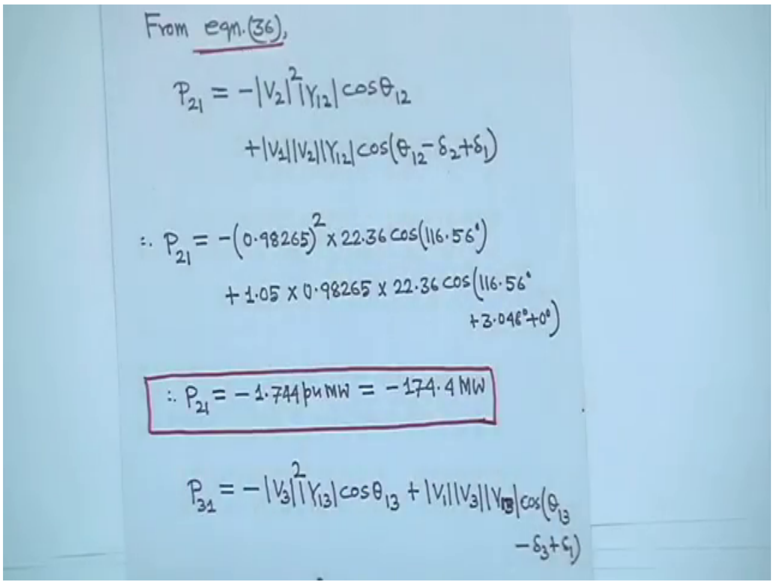

If you do so, that will be the expression for P 21 that is equation 36 right.

So that means, are all the parameters you put it here, put it here then you will get P 21 is equal to your minus 1.744 per unit megawatt minus 174.45 megawatt right.

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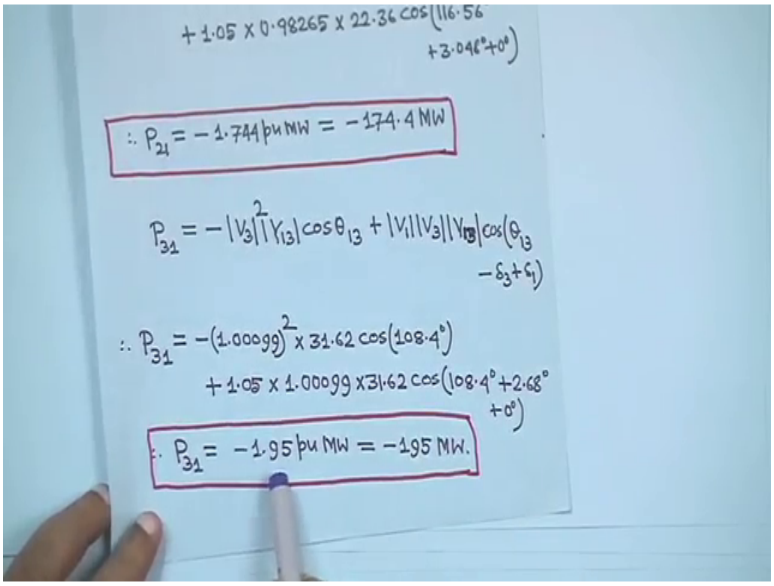

if you see P 12 it P 12 here 181.89 megawatt right and that mean

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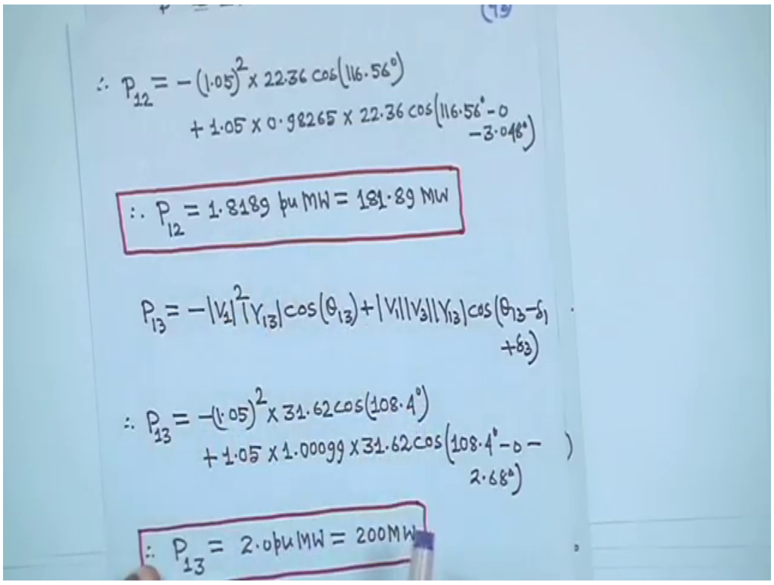

It is positive means power is flowing 1 to2 right and here at the P 21 it is minus 174.4 megawatt, then the power actually flowing from why your what to you call one to two, but is P 21 is showing minus right that mean P 2 in one this one, this one is your P 1 to this one is 1 8, this is one is 181.89, it indicate difference indicate that resistive lose in the in the line right that we will see after this.

So, similarly this is P 21 similarly P 31 using the same equation 36 right k is equal to 3 i is equal to 1. If you put it put all the parameters, P 31 will also become minus 1.95 per unit megawatt that is minus 195 megawatt right.

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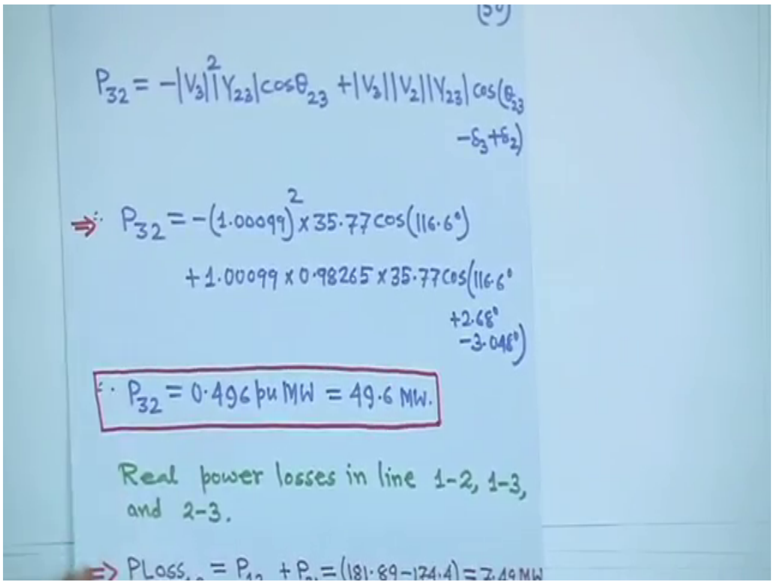

So; that means, power is the power the actual duration of the power flowing is one to 3 because it is minus sign is coming right.

So, next is your P 32 same way you can compute, write this is same equation you can use and put your k 3 i k is equal to 3 i is equal to 2 expand these and you are what you call put this, and there you put all the values you will get P 32 is equal to 49.6 megawatt these all this results are after second iteration only right.

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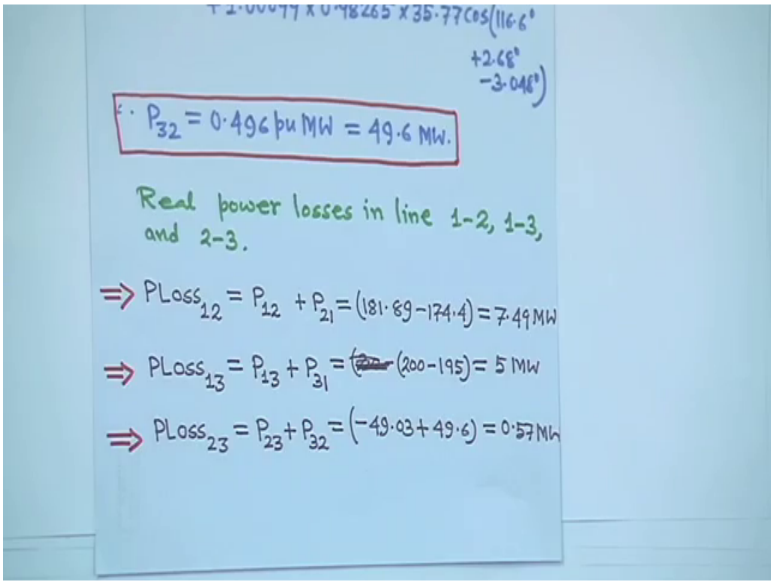

Now real power losses in line 1 2, 1 3, and 2 3; so P Loss 12 actually is equal to the we have showing before know that P your line place P 12 plus P 21 that is 181.89 minus 174.4 that is 7.49 megawatt. Similarly P Loss 13 that is P 13 plus P 31 200 minus 195 that is 5 megawatt and P Loss 23 that is P 23 plus P 32 that is minus 49.03 plus 49.6 is 0.57 megawatt right.

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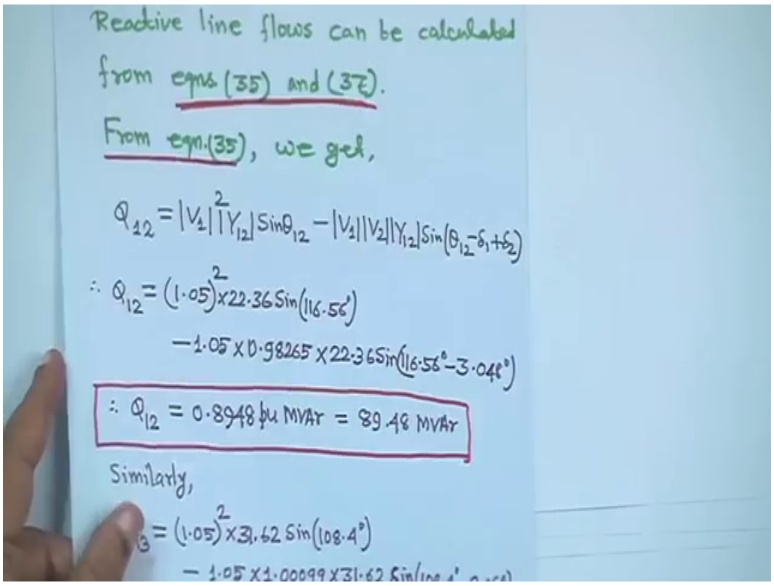

So, these are the result for the loss is after your what you call that second iteration that is a real power loss right. Similarly your reacting line flows we calculated from equation 35 and 37. So, against like your Q your qik expression is given in equation 35 right.

So, there you just put i is equal to 1, k is equal 2 and this expression and put all these parameters you will get Q 12 actually is equal 0.8948 it power unit megawatt, that is multiply your 100, 100 m is the base. So, 89.48 megawatt right similarly Q13 also you compute put all the values.

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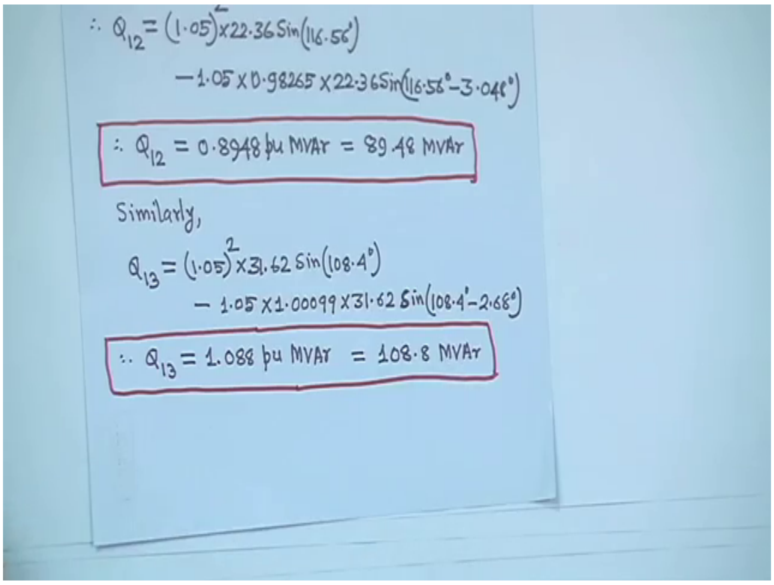

So, Q13 will be become 108.8 megawatt right.

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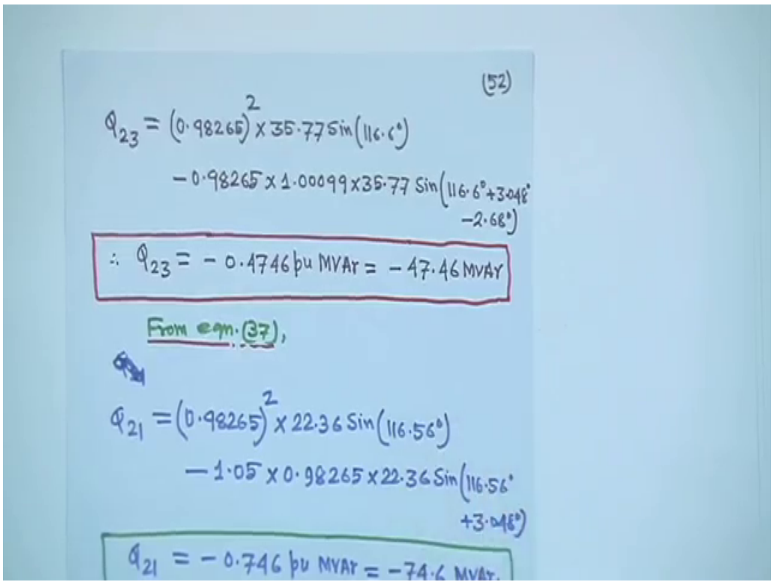

So, similarly Q23 also you compute Q23 also you compute right. So, all these directly I am not writing the formula for Q23 again just you can do it of your own right. So, all all this things are details I have been explained right. So, you can do it. So, Q23 will be become minus 47.46 megawatt right.

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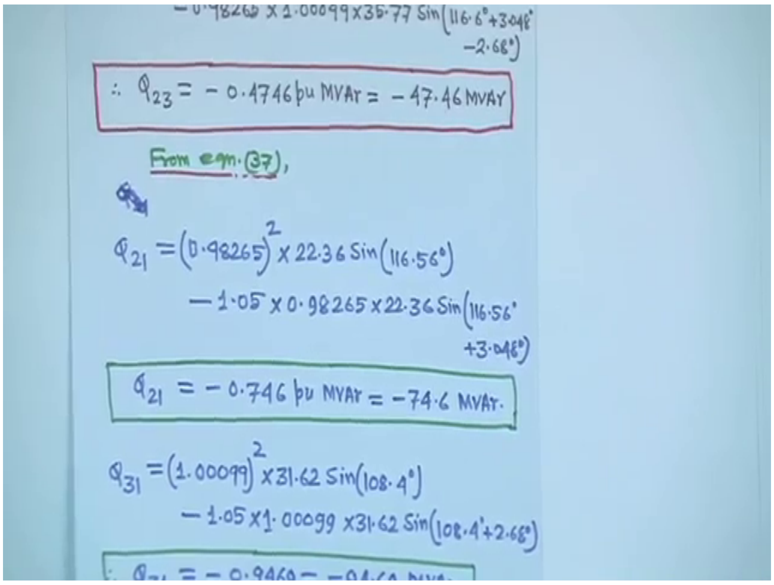

Now similarly from we equation 37 that it that is your that is your Qki.

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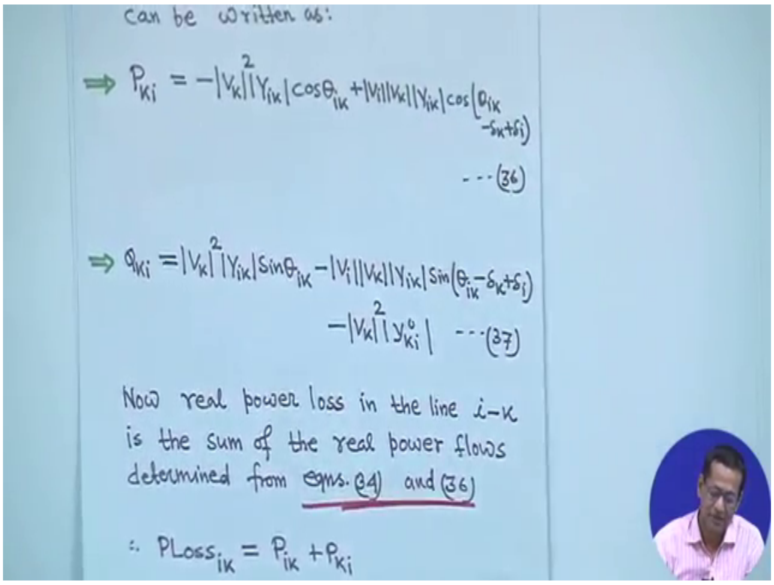

That was your that was Qik and that is Qki this expression is given 37 but note that charging admittance is not considered. So, it will be 0, this term will be 0 right and Qki also for Qik also for Qik also charging admittances 0, but you have not considered that right. So, if you calculate Q21 then it is coming minus 74.6 megawatt using equation 37.

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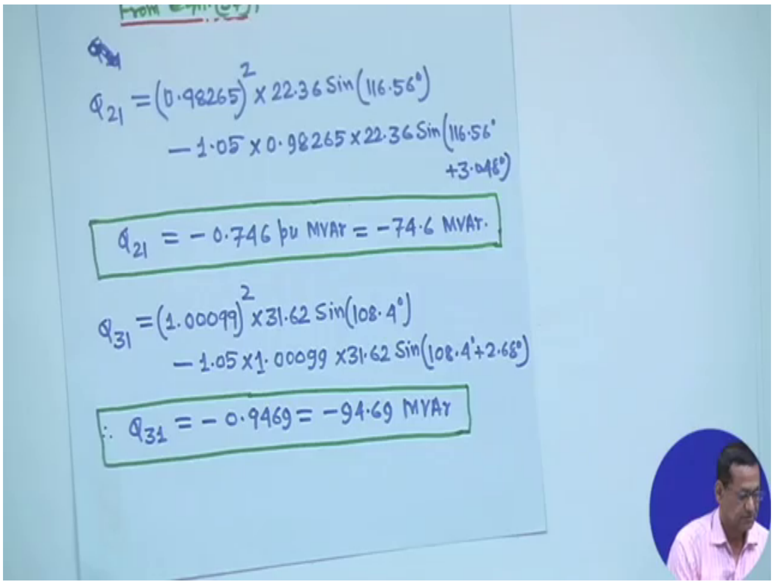

Similarly Q31 you compute often substation there all you will get it is minus 94.69 point six nine megawatt right.

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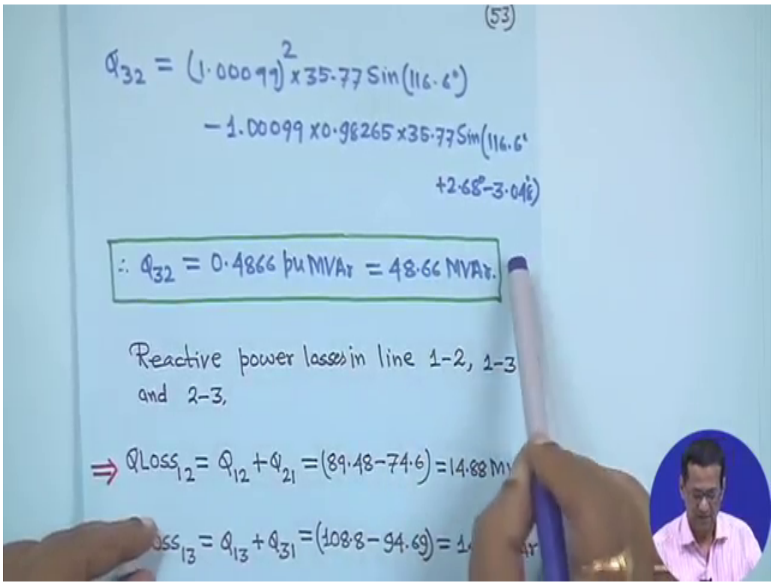

So, then you calculate Q32 that is your Q32 again the same expression put all the values not writing those expression again and again right understandable now right. So, this is coming Q32 is equal to 48.66 megawatt; now reactive power losses in line 1 2, 1 3 and 2 3 same as before, so Q loss 1 2 Q 1 2 plus Q 2 1.

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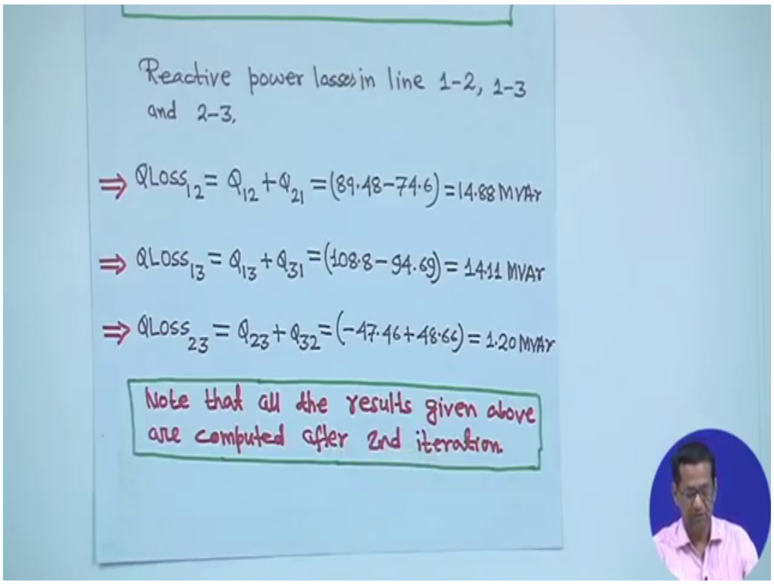

So, you will get 14.88 megawatt. So, Q loss 13 is equal to Q 13 plus Q 31 you will get 14.11 megawatt, and Q loss 23 is equal to Q23 plus Q32 that is coming 1.20 megawatt. Note that all the all the results given above are computed after second iteration only it is not converse result of that convergence you have to make more number of iteration. So, you have to trace the convergence that whatever convergence procedure I have said right next is this example considered for I will all busses are your PQ type busses right.

Now next will take an example that will that I will considered Pv loss also and you can see that have we can accommodate Pv loss in the Gauss-Seidel method. After Gauss-Seidel method we will come to the Newton-Raphson method right and your decouple couple decouple and first decouple right loop loss and then will see that you are for transformer captures in transform representation the pi model, and after that I will tell you that P and pqv your bus accommodation in that loop loss study that how one can do this and what is the your significance of it right.

So, next example is

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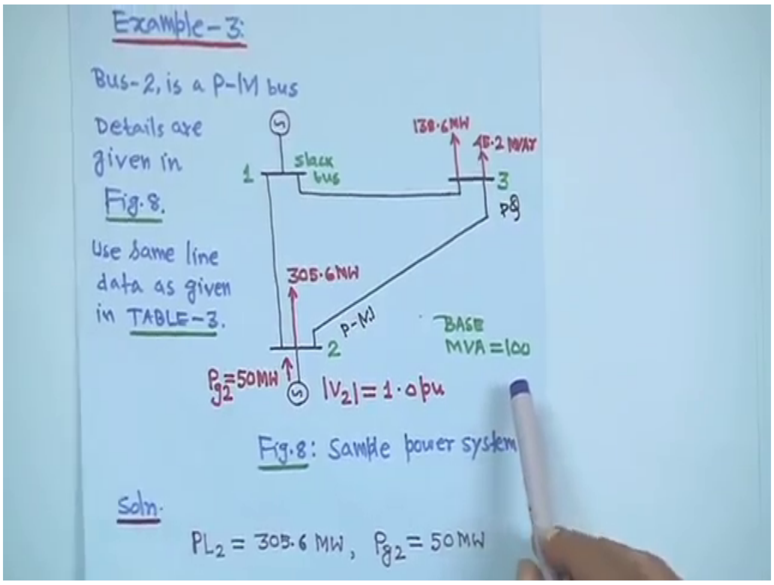

Next example is that your same data we have taken accept one thing, that this is actually in this case this is a slack bus 3 is a PQ bus that same load data as before 138.6 megawatt.

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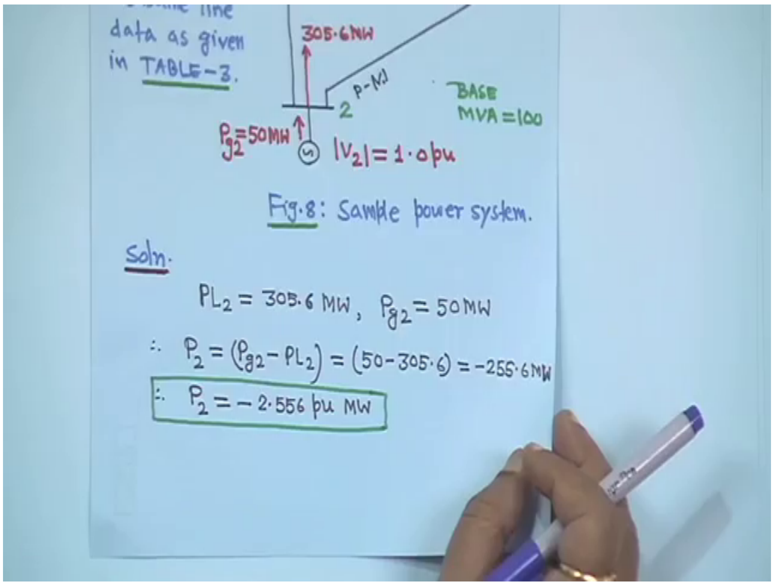

And reactive load is 45.2 megawatt right and this bus is a Pv bus, this bus is a Pv bus. So, here for bus 2 voltage magnitude is specified a Pv bus P has to be specified and voltage magnitude has to be specified. So, voltage magnitude V 2 is equal to 1.0 per unit it is specified. And they load that is 305.6 x megawatt Pg 2 is also 50 megawatt, but you know other thing has been main side right that mean Pv bus means you have to find out that your what you call Q is not given right.

. So, so; that means, in PQ bus b and delta are unknown for this bus V3 and delta 3 have to find out and for this busses your Q and delta 2 has to obtained because voltage magnitude specified we all for also specified right. So, in this case we will show only your what you call that couple of iterations right I have to check either are made it 2 iterations or 3 iterations right, but how to make it, but no queue limit nothing will be considered here just to show you that how things can happen right. So, same has V 4 pl t PL 2 is given 305.6 megawatt, Pg 2 is 50 megawatt right your put P 2 is equal to Pg 2 minus PL 2 that minus 255.6 megawatt there put P 2 is equal to minus 2.556 power unit megawatt same as before right and similarly. So, this is again 3 bus problem know.

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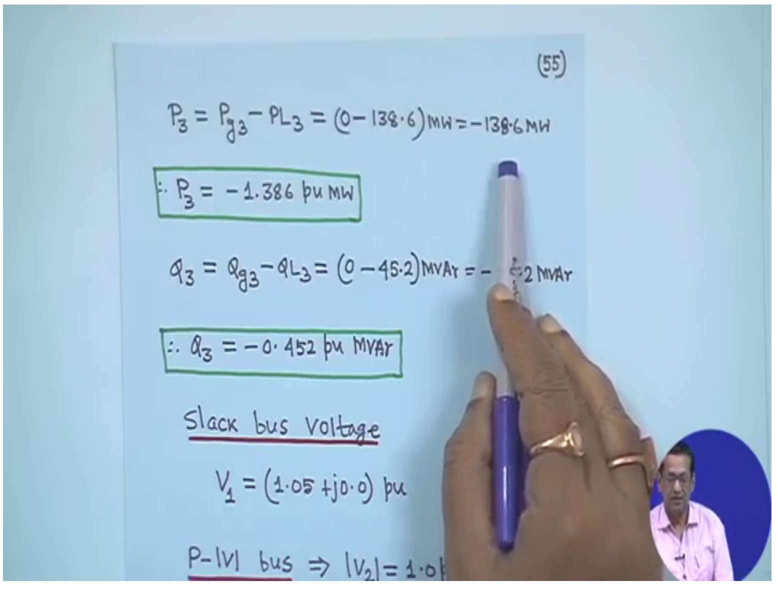

So, similarly P 3 is equal to Pg 3 minus PL 3. So, that is no genert that is no generator at bus 3 sothis 0 minus 138.6 megawatt that minus 138.6 megawatt. So, it is divided by 100, I am not dividing it 100, but if you divided by 100, it is h100 mb is the base so minus 1.386 power unit megawatt right. Similarly per Q 3 is also Qg 3 minus QL 3 is minus 45.2 megawatt so divided by hundred it will be minus 0.452 power unit megawatt. A slack bus voltage is same 1.05 plus j 05 and 0 right.

Now, Pv bus magnitude of voltage magnitude V 2 is equal to one right; that means, V 2 is 0 actually you can take 1 plus j 0, in this case what we will do that the way we solve that your I will follow they its distinc this thing different write the different procedure are this iterative method right.

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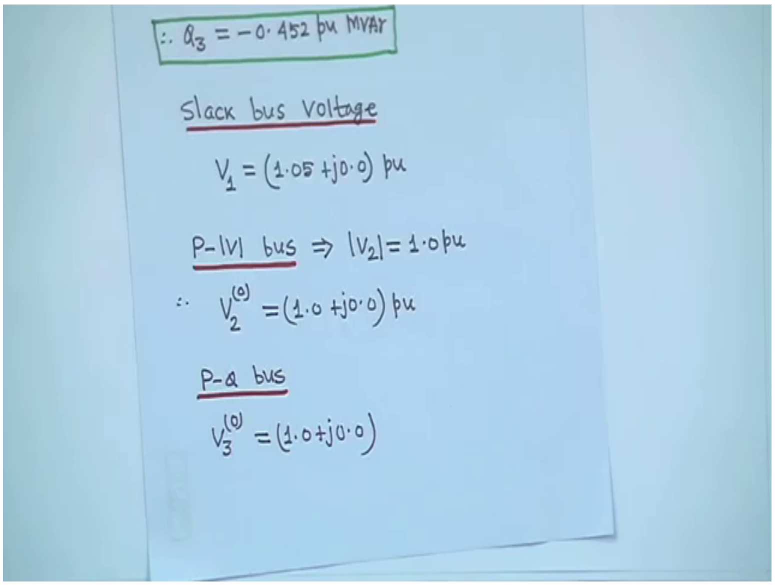

So, what we will do that V 2 is 0 all though this voltage magnitude actually constant right. So, you are soon V 2 0 is equal to1 plus j 0; that means, it magnitude is 1 the initial angel is 0 right. So, this way we assume, but magnitude will always remain constant magnitude will be untouchable right it is given and for PQ bus V 3 0 1 plus j 0 right so, but this PQ bus V 3 both magnitude and angel will vary at here magnitude has to be Q fix right.

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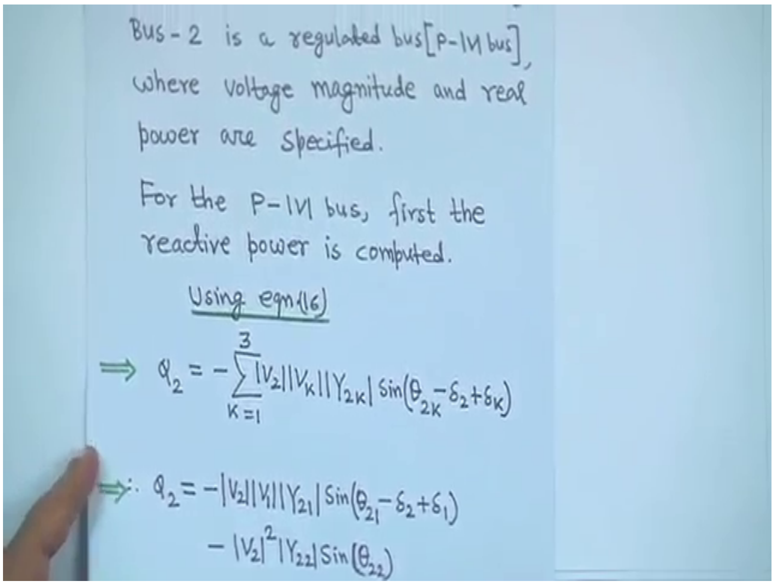

So, this one your bus 2 is a regulated bus that is Pv bus right where voltage magnitude and real power are specified right, and for the Pv bus first the reactive power is computed using equation 16, just let me find out for is equation 16 right I will tell you. So, here it is right.

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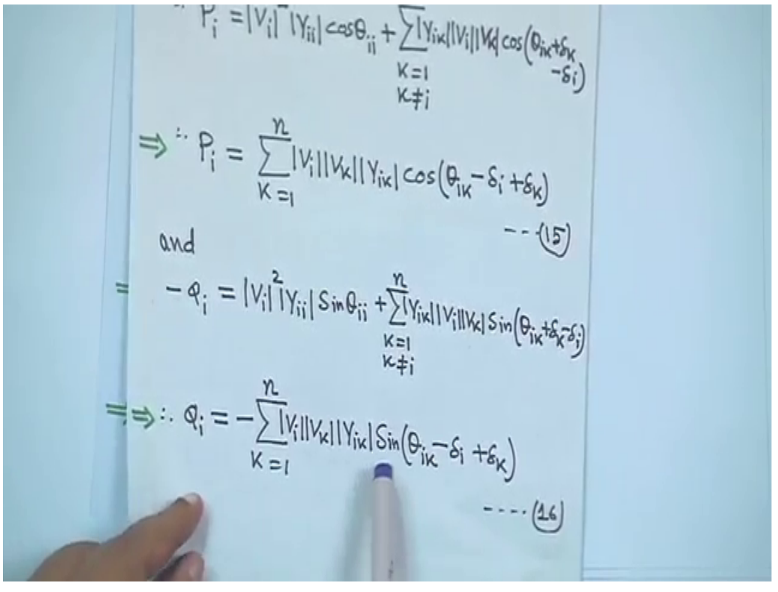

So, this one your equation 16 and n is equal to 3, this is equation 16 then n is equal to 3 because at bus 2 it is your Pv bus. So, in that bus your what you call Q 2 is not known right. So, we have to see that how iteratively you can made it right. So, what you will do it that from this equation n is equal to 3 you expand for i is equal to 2 right because bus 2 actually is it Pv bus right. So, put i is equal to 2 and k is equal to1 2 n, because n is equal to 3 because there are 3 bus problem are solving right therefore, if you put i is equal to 2 n minus it is it is minus sign, minus sign is there right.

So, it is k is equal to 12 3, then it will magnitude V 2 Vk magnitude Y 2 k sin theta 2 k minus delta 2 plus delta k. For k is equal to 1 2 3 you expand this equation right. If you expand this equation right then you will get this Q 2 is equal to this 1 that minus magnitude V 2 magnitude V 1 magnitude Y 2 1 sin theta 2 1 minus delta 2 plus delta 1 then minus magnitude V 2 square magnitude Y 2 2 sin theta 2 2 right minus magnitude V 2 magnitude V 3 magnitude Y 2 3 right sin theta 2 3 minus delta 2 plus delta 3

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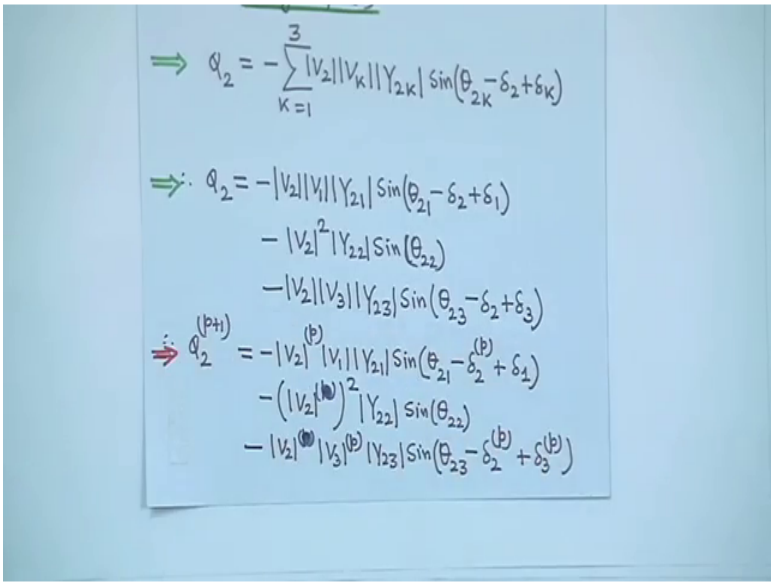

Now, if we want for iterative procedure right then Q 2 P plus 1 right then V 2 P right V 1 is a slack bus. So, no question of put in this one Y 2 1 in a constant sin theta 2 1 minus delta 2 P because bus 2 is a PQ bus delta 2 will also vary that is why it is P plus delta one is the slack bus angel otherwise it is a 0 actually right then minus V 2 P whole square right because it is V 2 square right and when this one this magnitude one these V 2 P square magnitude one actually no need to put P, because this is actually bus 2 is a Pv bus this voltage magnitude will remain constant. So, minus V 2 square rather right no P then magnitude Y 2 2 sin theta 2 2 minus again here also magnitude of V 2 will remain constant no need to put P right.

So, magnitude V 2 because Vp your bus 2 is a Pv bus. So, V 2 is fixed magnitude V 2 is constant. So, no need to put P right then into V 3 P capital Y 2 3 sin theta 2 3 minus delta 2 P plus delta 3 p, but bus 2 that delta 2 P you have to put it here and here because it all it is a Pv bus. So, delta is varying, but magnitude V 2 always constant. So, no need to put P right. So, this is your Q 2 P plus; now Y matrix is a same as example one same Y matrix right; so no change.

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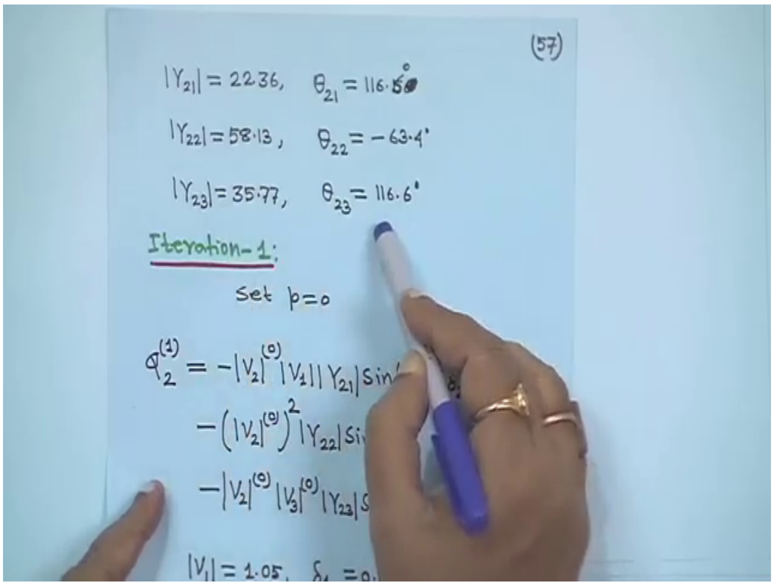

So, in that case; so these are the Y matrix these magnitude an angel magnitude an angel magnitude an angel all Y 2 1, Y 2 2, Y 2 3. So, now iteration set P is equal to 0 look we are not computing at present any voltage anything only we are computing king power injection at bus 2 right.

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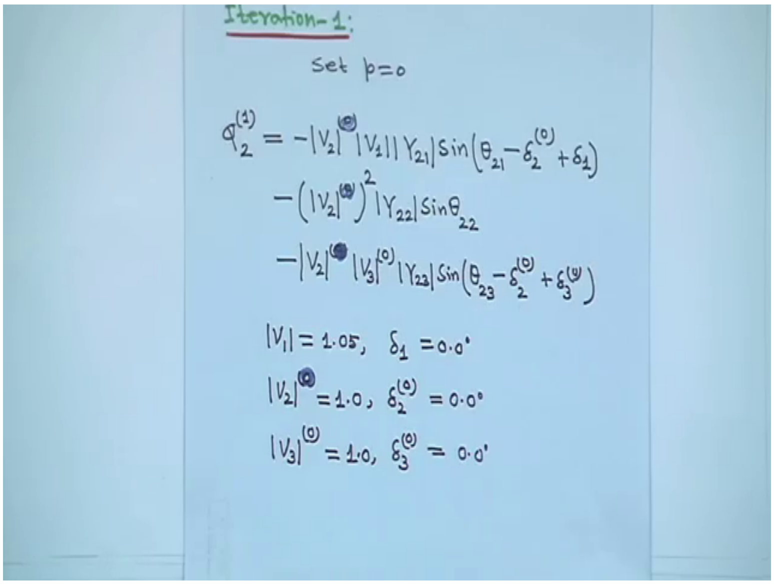

Therefore because after that we will see how will go for iterative process right. So, in this case that Q 2 1 you when P is equal to 0, when P is equal to 0 here you write Q 2 1. So, this is be this Q 2 0 this equation will be right that your magnitude your this one what you call here also magnitude V 2 P this P also should not be there because magnitude voltage is this thing is your magnitude is constant.

So, here also this is not require, here also this is not require, here also this is not require actually right this is not require. So, and rest you are the way the they are your given delta 2 0, delta 2 0, delta 3 0 all are there. Delta 1 anyway it is 0 angel right because it is slack bus and slack bus voltage also low question of iteration because it is fixed right. So, we with that you put Q 2 1. So, V 1 is 1.05 angel delta 10.0 magnitude V 2 0 actually it cannot be 0, because it will magnitude will all are remain constant right and delta 2 0 is equal to 0.0 degree and V 3 0 is equal to 1.0 and delta 3 0.0. All these in substitute here you substitute here you substitute here right.

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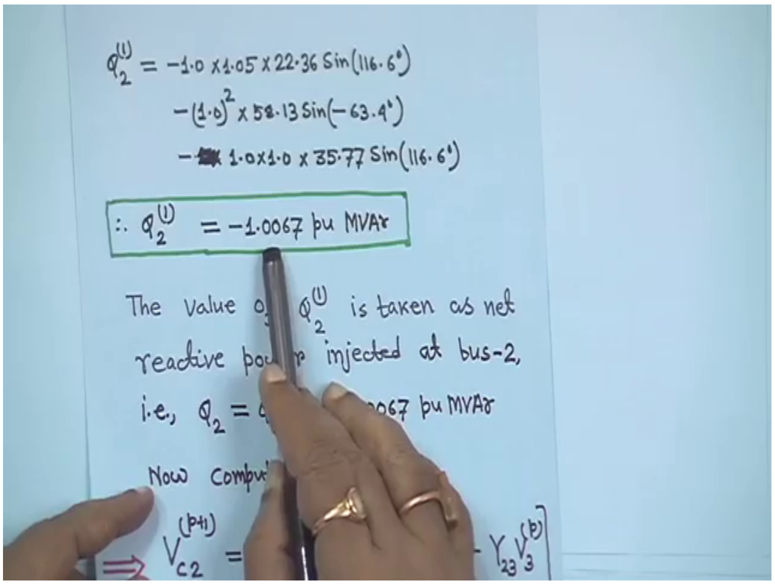

If you do so, then what you will get? You will get Q 2 1 values put and simplified right you get compute Q 2 1 is minus 1.0067 power unit megawatt this is the value of Q 2 1 right. Now the value of Q 2 1 is taken as net reactive power injected at bus 2 right that is Q 2 is equal to Q 2 1 is equal to minus 1.0067 will take right. So, first of your doing for Pv bus your trying first after your trying to compute that are Pv bus the reactive power injection right. So, that that for we will take that Q 2 is equal to this much as reactive power injection at bus 2, iteratively you have to obtained iteratively right.

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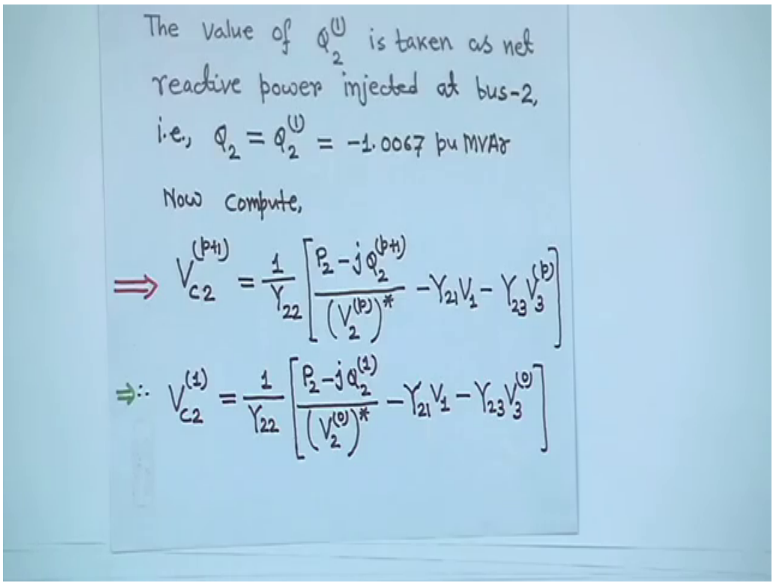

So, Q 2 is equal to Q 2 1 that is a Q 2 value in the very fast iteration right I hope you are understanding this right, once it is done then instead of writing equation V 2I will writing V c 2 P plus 1, because this is not the correct value of the your what you call bus 2 because bus 2 is a Pv bus and is voltage values is one, but using this equation it will never be magnitude will never be one right.

So, but same equation variety 1upon Y 2 2 P 2 minus j, instead of Q 2 I writing Q 2 P plus 1 because that Q 2 P plus 1 that equation your what you to call that this you have opted iteratively. So, this Q 2 P plus 1, this is Q 2 P plus 1 right. So, you have put in minus jq 2 P plus 1 upon V 2 P conjugate minus same as before Y 2 and V 1 minus Y 2 3 V 3 P right that mean this is Vc 2 not just making Vc 2. So, in P is equal to 0 and P is equal to 0 that Vc 2 1, is equal to 1 upon Y 22 P 2 minus j Q 2 1, Q 2 1 is already computed here Q 2 1 is already computed here right here it is, here it is and P 2 already earlier your made it generate injected power at bus 2 those that are known right minus Y 2 1 V 1 minus Y 2 3 V 3 0 this is the thing.

Now, same as before you compute P 2 minus jQ 2 1 multiply this whole thing by 1upon Y 2 2; so you have to compute P 2 minus jQ 2 1 upon Y 2 2 minus Y 2 1 upon Y 22 minus Y 2 3 upon Y 22 right. So, if you do so, then P 2 minus P 2 are minus 2.556 and Q 2 are just Q 2 1 was just minus 1.0067 here computed. So, substitute all divided by Y 2 2 you will get 0.04725 angle 221.9 degree.

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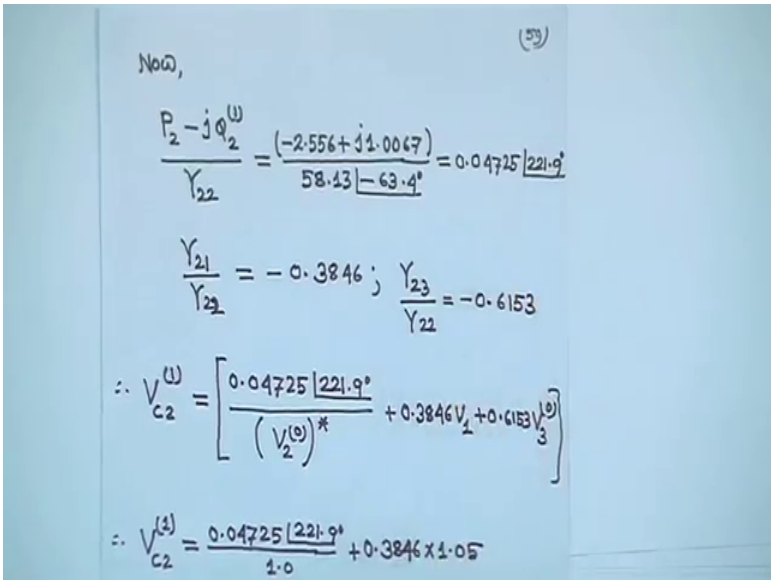

And next capital Y 2 1 upon capital Y 2 2 earlier we have got it that is minus 0.3846 similarly capital Y 2 3 upon capital Y 2 2 earlier we have got it minus 0.6159 with these this equation Vc 2 1 that mean this equation that is this equation this equation will become your 0.047 2.04725 angle 221.9 degree divided by V 2 0 conjugate plus 0.3846 V 1 plus 0.6153 V 3 0 right.

So, with this all V 2 0 known v one known V 3 0 known everything is known then you substitute all and then it then you simplify you can compute. It is coming Vc 2 1 0.98396 minus j 0.03155 if you take its magnitude it is never one right, but you have to make it one.

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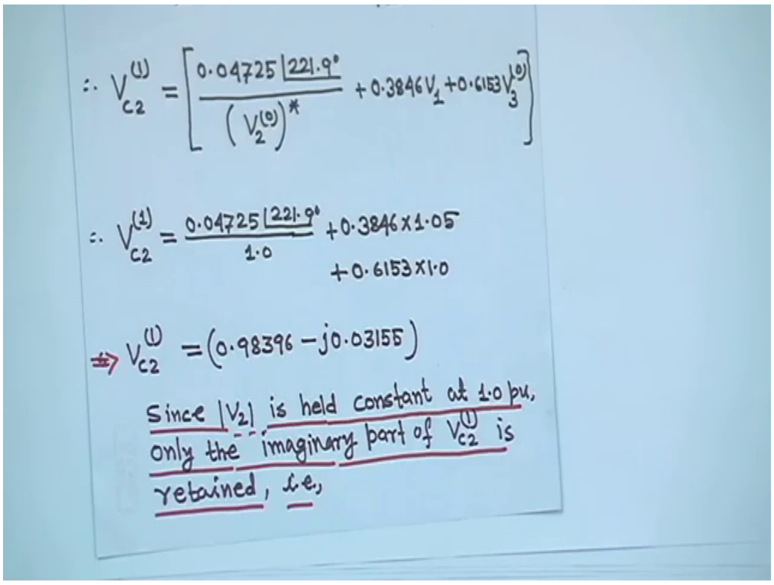

So, what we will do Pv bus consideration in Gauss-Seidel method. What you will do since V 2 is held constant at 1.0 per unit right only the imaginary part of Vc 2 1 is retained; that means, what we will do.

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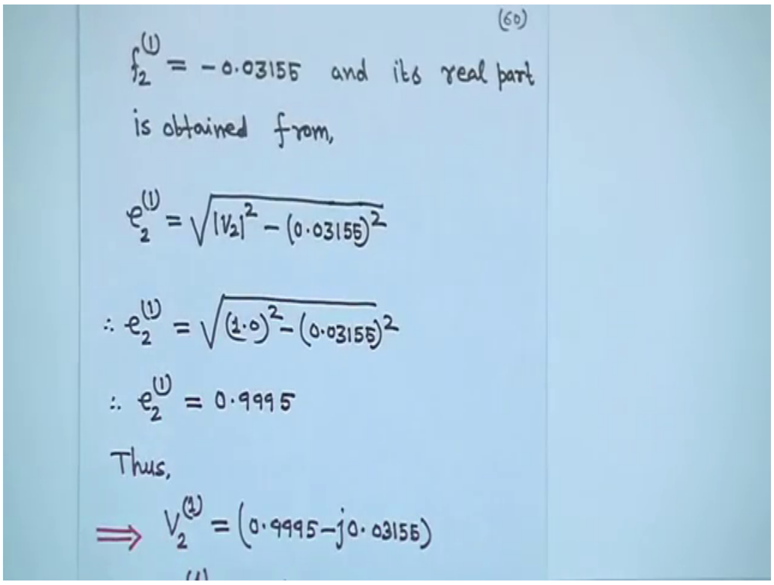

That imaginary part whatever you have got it using that Q 2 V your considering that Q 2 injection that imaginary part will retained, but this one will compute this one will find out how will do this.

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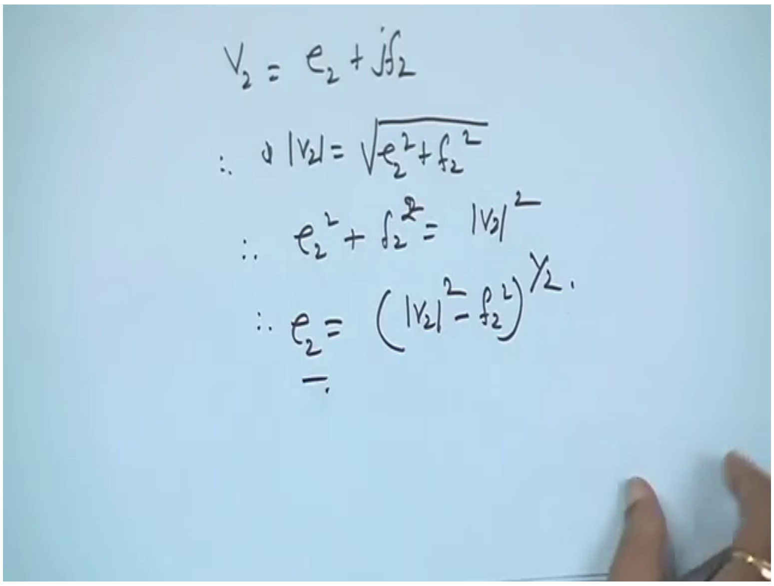

Now; that means, imaginary part we will take f 2 1 is equal to because your V 2 actually V 2 is equal to your say e 2 plus jf 2 right this your taking. That means, your magnitude of V 2 is equal to root over e 2 square plus f 2 square; that means, other way you can write e 2 square plus f 2 square is equal to magnitude of V 2 square right; that means, e 2 is equal to your magnitude V 2 square minus your f 2 square to the power half right whatever value comes.

.So, what same thing where doing it here that your f 2 is here we got minus 0.03155. So, this is my f 2 right this is my f 2. So, and its real part is obtain from these equation e 2 1 just now I wrote now V 2 square minus f 2 square to the power half, same thing that your V 2 square root over V 2 square minus f 2 square here actually in bracket one it although it will be positive one minus sign is there before here it is minus because here it is minus. So, 1 minus is there right.

So that means, your this one, but V 2 will be here constant at one. So, this one we have kept fix right minus your here also minus is missed. So, this is also your minus right.

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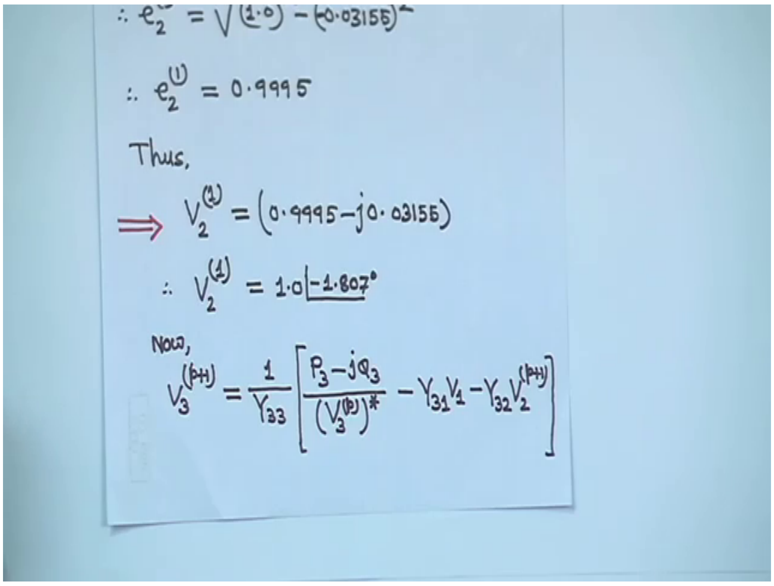

So; that means, it will become e 2 1 that is 0.9995, then you will take V 2 1 actually 0.9 triple 95 minus j this 1, this will give you magnitude one because based on that only got this e right and it a angle is be minus 1.807 degree that mean this one this one using Q 2 injection that is we got 0.98396 and minus j 0 0.0315, but corrected value we corrected right.

By considering this approach considering this approach such that be your this one magnitude if you take it will become one now an angle will be minus 1.807 degree, that mean this V 2 in first iteration magnitude is fixed because Pv bus, but angle you have got it right. So, similarly your, but the bus 3 is your PQ bus, bus 3 is a PQ bus. So, in that case this same equation same way you can write this equation V 3 P plus 1 upon Y 1 upon Y 33 capital Y 3 3, P 3 minus jQ 3 upon V 3 P conjugate minus capital Y 3 1, V 1 minus capital Y 3 2 V 2 P plus 1 because V 2 already computed; so I writing V 2 P plus 1 not V 2 P right.

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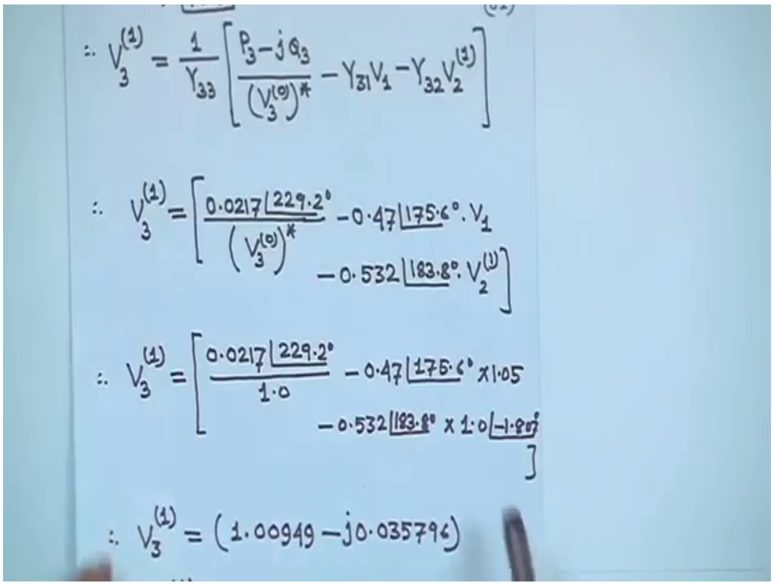

So, if these with these with P is equal to 0 the first iteration V 3 1, all these thing are there this is the equation right. So, P there minus jQ 3 upon V 3 0 already you have computed before it is same here right and this one also same this one also same right. So, if that put all these values all these value for being the equation of V 3 all these values . So, you will get V 3 1 is equal to 1.0101 angle minus 2.03 degree V 3 is a PQ bus. So, no question of this thing directly or getting.

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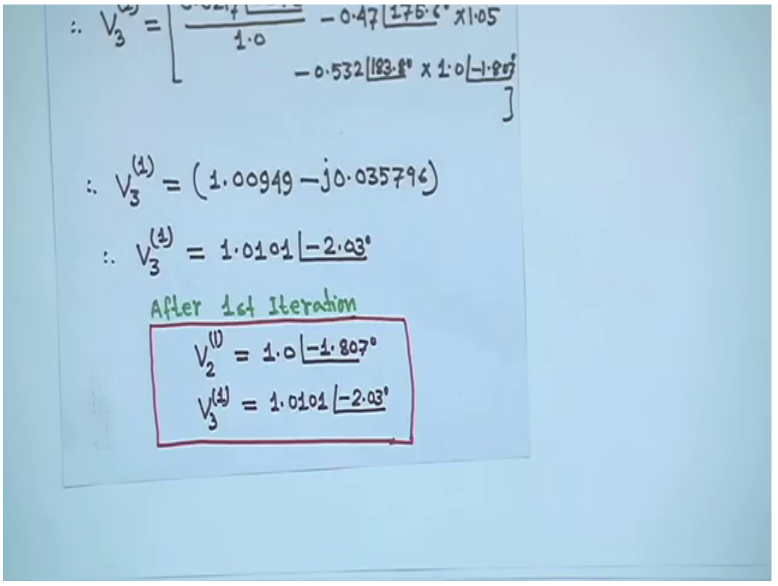

So, after first iteration you got V 2 1 is equal to magnitude remain constant because Pv bus right angle minus 1.807 degree and V 3 1 is 1.0101 angle minus 2.03 degree right.

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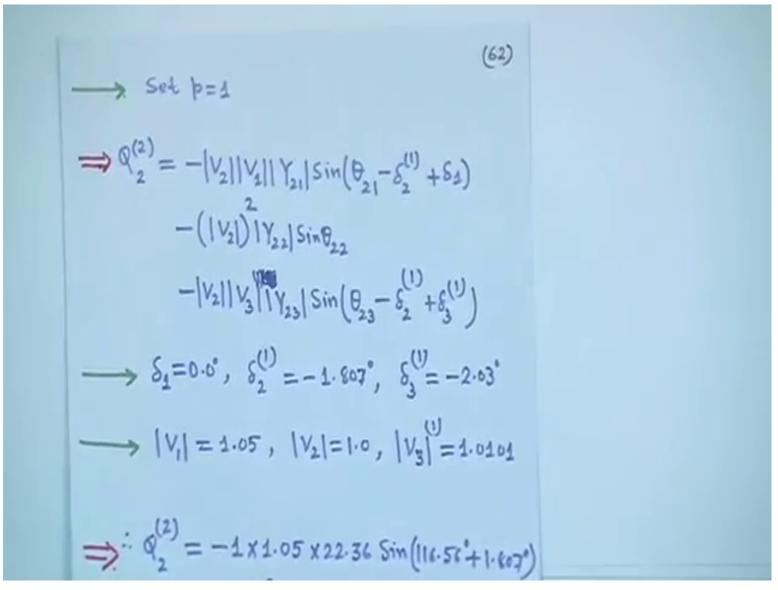

This is after first iteration, now at list what you have to do is now again you have to compute Q 2 for the second iteration you have to find out again and you have to go for the correction to the real part of that Pv bus voltage magnitude right real part of the Pv bus voltage. So, if similarly set P is equal to 1 then this Q 2 2 will be the same equation will come right.

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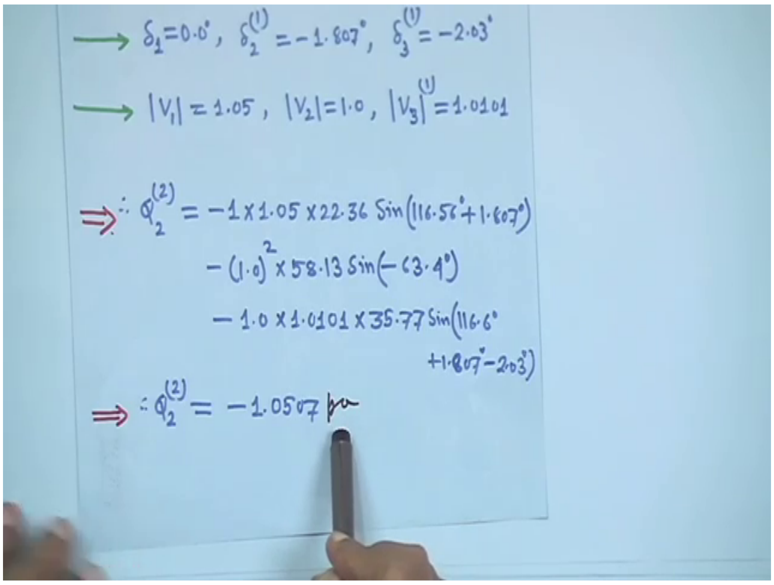

And all the units all the values are delta 1 is 0, delta 2 1 is computed this much minus 1.807 degree delta 3 1minus 2.03 degree magnitude V 1 is 1.05, magnitude V 2 all is constant 1 and magnitude V 3 in first iteration 1.0101 per unit right.

So, all these values all these values you substitute here you substitute here right. If you do so, then you will get after calculation Q 2 2 will be minus 1.0507 per unit right

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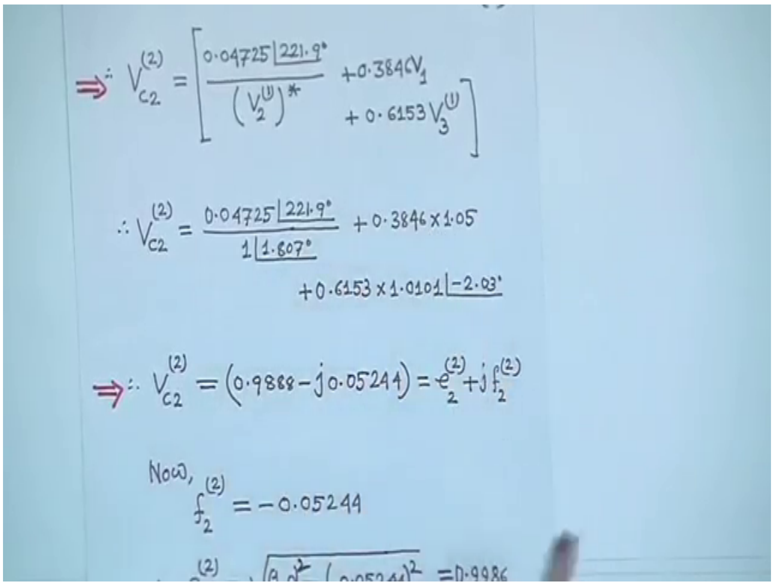

This Q 2 will get and the once you get these in same way you calculate your that your what you call that Vc took a Vc 2 computation right . So, you will you will get that Vc 2 in the second iteration will be in this form same thing, again you make it this is constant this is constant and you will find with that values of Q this is more or less same right this 0.04725 all most same right.

So, when you all the initial value all the values are known to you. So, you substitute all the values right.

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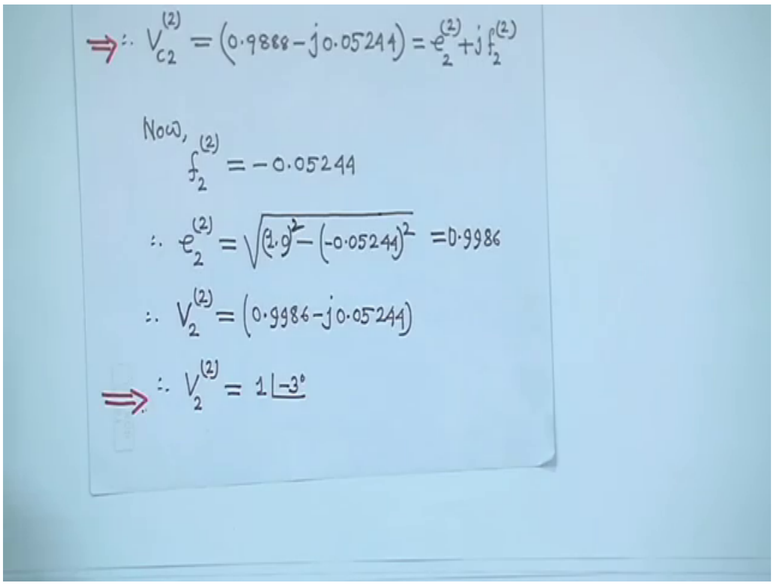

So, in that case what will get Vc 2 2 in the second iteration, 0.9 triple 8 minus j 0.05244 this one we can write e 2 2 in the second iteration real part plus j in an real part f 2 2 in the second iteration. Now f 2 2 here written in this is your taking minus 0.05244, but e 2 2 because voltage magnitude and bus 2 has to be will constant. So, it is one. So, e 22 is root over 1.0 square minus this minus 0.05244 whole square that is coming 0.9986 right; that means, V 2 2 actually 0.9986 minus this one. All though all though with are key reactive power injection it was coming like this, but it is corrected right and now it is not 0.9986 and minus j 0.05244.

So, V 2 2 actually one angle minus 3 degree magnitude is fixed again, but all the angle is baring right.

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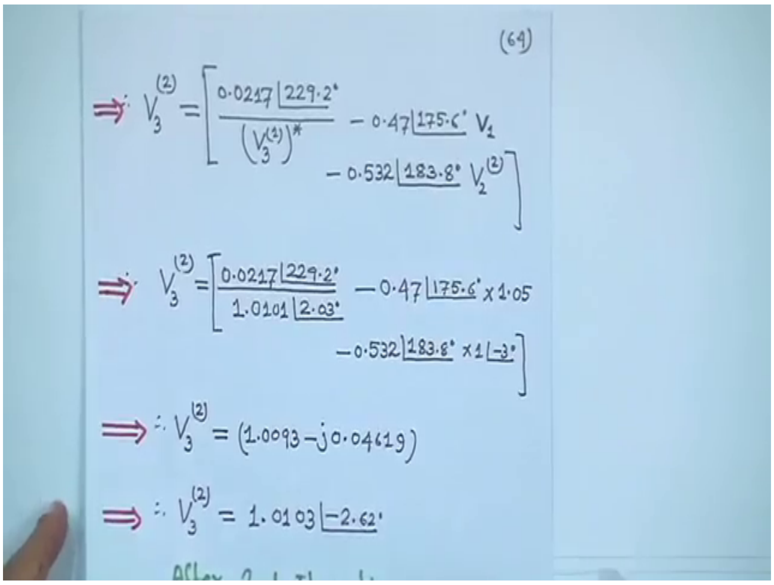

Similar way right similar way that V 3 2 you can compute again you compute all these values this will remain constant, this are also constant we already computed only this values we have to substitute right therefore, V 3 2 you will get in a V 2 3 is second iteration right you put it you will get it is 1.0093 minus j 0.04619.

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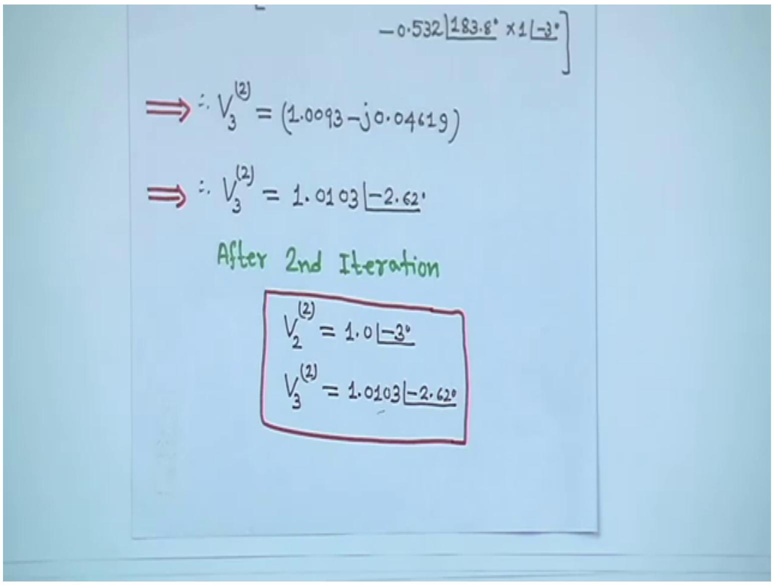

So, V 3 2 is 1.0103 angle minus 2.6 degree. So, after second iteration that V 2 and V 3 in the second iteration its 1 V 2 magnitude fixed one angle 0 minus 3 degree and this one

1.0103 angle minus 2.6 this is the result after second iteration actually I have done it up to second iteration right.

So, this is your what you call that Gauss-Seidel method that have one can use Gauss-Seidel method a solving load flow studies right. So, only thing is that in Gauss-Seidel method that number it takes more number of iteration because convergence characteristic actually is a linear right. If time permits at the end if time permits then I can show you the proof that convergence characteristic of Gauss-Seidel linear and Newton-Raphson its a quadratic if time permits there not at the end of this topic, but at the end right if I find one hour extra time there I can show you the proof right.

So, question is that in whatever to examples we have seen it is a 3 bus problem only right and with that also you have seen the huge computations are required right. |I am giving you lecture. So, making all these things, but a when you will calculate it, it will take more time right. So, this is one thing and you have took make all the calculations correctly and all these angles 175, 175 183 or 229 all these angles when you are making it be is check carefully which coordinative are. Accordingly you take the angles sometime calculator you will take something calculator making different angle may be this way.

So, you have to see that which coordinate this thing are an accordingly you take the take the angle the accordingly I have taken right otherwise you make otherwise there is a possibility of you know mistake right. So, be careful about that and all the calculations Y matrix other thing and charging admittance are not considered right, but your what you call this, but you have got they your what you call got some ideas, that how to solve load flows using in Gauss-Seidel method for considering you have in bar a buses are PQ bus or buses and bus another thing is the Pv bus right.

So, but a these are the thing, but different buses are consideration of Pv buses are there in the literature for Gauss-Seidel method, but I have given you this bus an because I found this bus an is quite is easier right with next we will take Newton-Raphson method little break.

Thank you.