Power System Engineering
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Lecture - 30
Load flow of radial distribution networks (Contd.)

So, I hope you are understanding all these, right? Things are simple, but just try to understand, not here, your, what you call, not much mathematics is there, but before that you, but you have to understand all these things.

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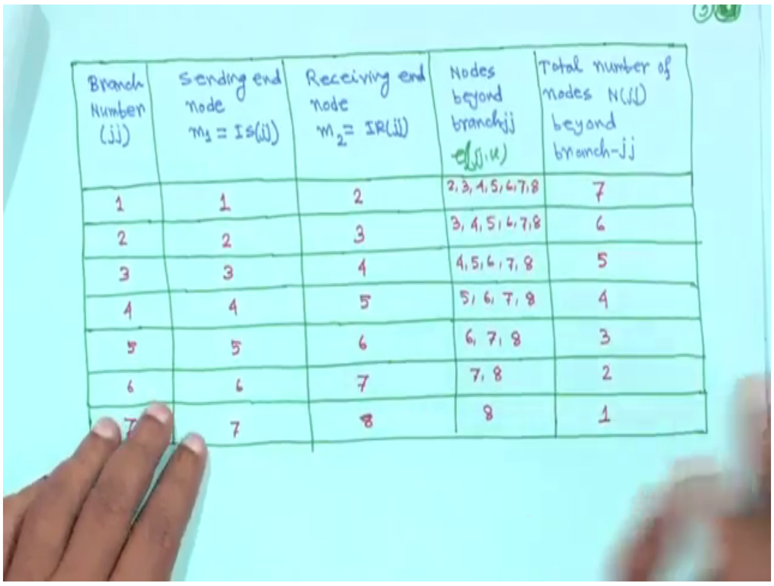

Branch Number (jj)	Sending end node $m_1 = IS(jj)$	Receiving end node $m_2 = IR(jj)$	Nodes beyond branch jj $e(jj,i)$	Total number of nodes N(jj) beyond branch-jj
1	1	2	2, 3, 4, 5, 6, 7, 8	7
2	2	3	3, 4, 5, 6, 7, 8	6
3	3	4	4, 5, 6, 7, 8	5
4	4	5	5, 6, 7, 8	4
5	5	6	6, 7, 8	3
6	6	7	7, 8	2
7	7	8	8	1

So similarly, similarly when branch number say, when branch number jj is equal to 3 right. So, what will happen here? Already for jj is equal to 1and 2, I have told you. So, I think you have understood now. One more, so once more I will tell you, when jj is equal to 3, you have to read all this data, you have to read all this data right. So, when jj is equal to 3 branch number, your m 1 will be is equal to IS jj, there will be IS 3 will be is equal to 3, that is sending inside apart branch 3, and m 2 is equal to IR jj, so m 2 will be equal to IR 3 is equal to your 4.

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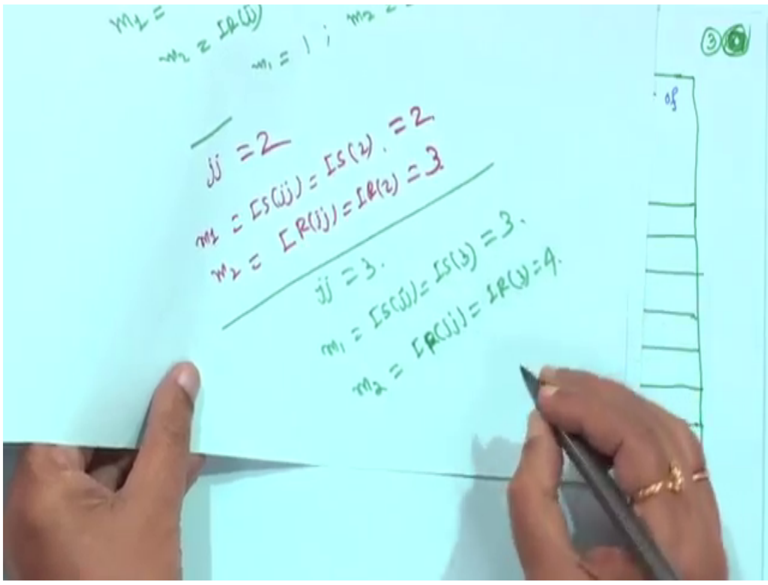

So that means, when jj, when jj is equal to 3, that is branch number 3, m 1 will be is equal to IS jj, is equal to IS 3, that jj is equal to 3, that is equal to 3. So this is 3, and m 2 that is a receiving end node, that is your IS sorry, IR jj, is equal to IR 3 and that is equal to 4. So, receiving end node will be 4.

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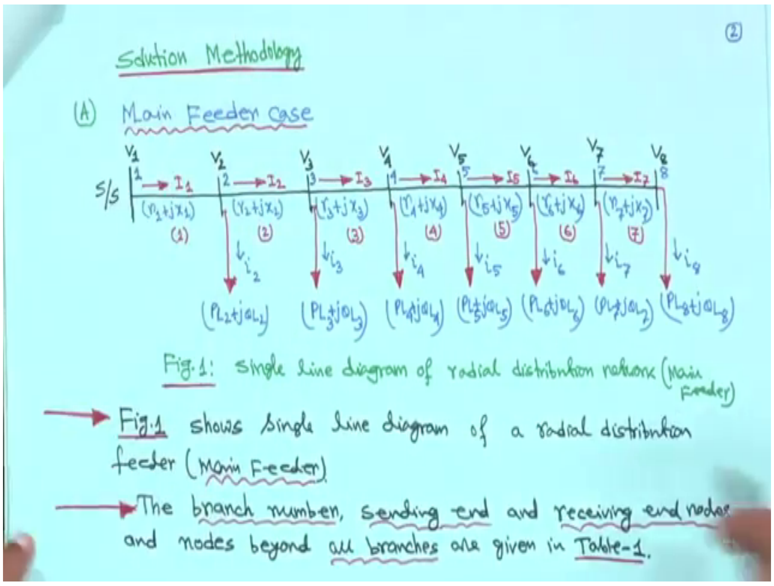

And beyond branch 3, how many nodes are there. So, this is beyond, this is branch 3. So how many nodes are there? If you look, 1, just count, 1, 2, 3, 4, 5. So, here it is 5 total nodes. And how many, what the nodes number? 4, 5, 6, 7, 8. So, node numbers are 4, 5, 6, 7, 8. This is a main feeder simple case, while you take radial branches, things will be different. At that time you will see, how simple it is. Similarly for branch 4, it is branch 4 is 4 to 5, right, branch 4 it is this one, right. So, sending end is branch 4, is your sending end node is 4 receiving end node 5, so 4, 5. And total number of nodes beyond this branch is, node numbers are 5, 6, 7, 8. So 5, beyond this branch it is 5, 6, 7, 8, right, and total nodes are 4.

Similarly for branch 5, branch 6, branch 7 right. Branch 5, for branch 5 this is sending end node, and this is receiving end node, for branch 6 this will be sending end node, this will be receiving end node, for branch 7 this will be sending end node, this will be receiving node right. So, this way you first complete this table branch number, sending end node is jj, we are writing m 1 is equal to IS jj, but you have to read jj, IS jj, then IR jj, nodes beyond branch jj, this one also.

And total number of nodes in jj, beyond branch jj, all these things, first you have to make the table right. This data, this data you have to, your, what you call, you have to, I mean marked your number than network and all the branch number, sending end, receiving end, everything, and accordingly you have to prepare the table, right. This data you have to feed it to the computer, you have to create all these things, but the procedure right. It is not Newton Raphson or Gauss seidel right. So, first you have to make this, data preparation is simple.

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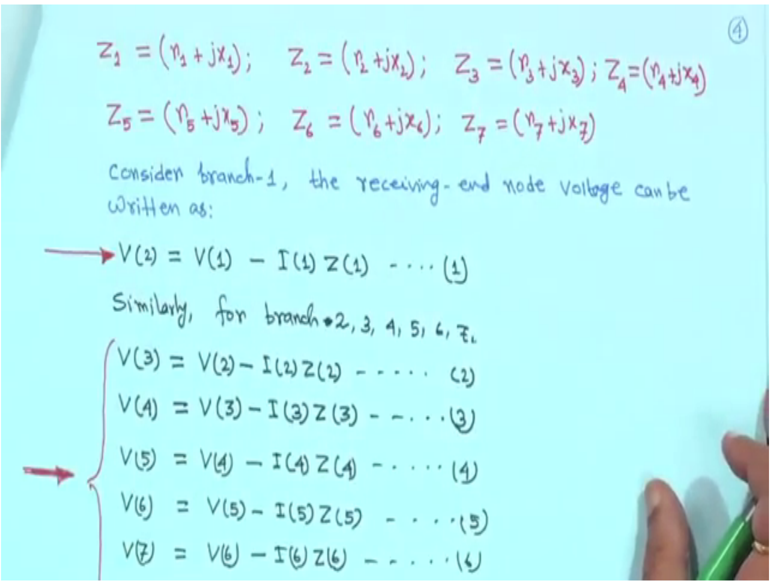

Next is, your impedance of the branch, these are all given a branch 1, branch 2 r 1 plus jx 1, r 2 plus jx 2, and so on, these are given. So, this is actually impedance, we are putting Z 1 is equal to r 1 plus jx 1, Z 2 r 2 plus jx 2 and so on.

There are 7 branches, because there are 8 nodes so 7 branches. Z 7 is r 7 plus jx 7 right. Now if you consider branch 1, the receiving end node voltage can be written as, consider this branch 1, similarly branch 1, if you look at the table branch 1, sending end node receiving end node right, but from the diagram it is sending end node is branch 2, 1 right, V 2 will be, V 2 will be V 1 minus I 1 into Z 1, because Z 1 is equal to r 1 plus the x 1. So, V 2 will be V 1, I told you V 2 and your suffix 2 and bracket V 2 all are same, Z everything is same. Here I am writing for easy writing, that is why Z 1, Z 2 this way writing, but everything remains same right, all I told you Z 1 actually same thing.

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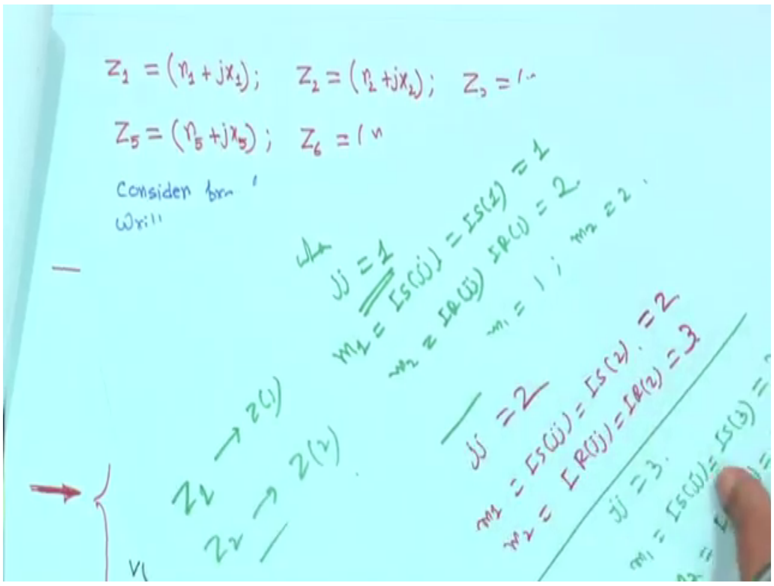

This Z 1 means Z bracket 1, same thing Z 2 means Z bracket 2 same thing right , but this I put it because, coding for the writing and making this slide node. I was thinking from the coding point of view such that, it will be the easy for you to understand right. So, V 2 will be is equal to V 1 minus I 1 Z 1, because this is the current flowing through this branch I 1 so V 2 will be v 1 minus, so V 2 is known now because V 1 is known, V 1 is known and say, later I will see how to compute initial values of I 1, but for the sake of our, your, what you call, understanding, you assume that I 1 is known to you right.

Therefore V 2 is, because z impedance is known for the line right, therefore V 2, V 1 minus I 1 Z 1.

Suppose if I 1 is known, Z 1 is also known, V 1 is a slag by voltage also V 2 is known. Similarly, for branch 2, you can write V 3 is equal to V 2 minus I 2 Z 2. So, here, because V 2 is known here, so v 2 will come here, we assume all I 1, I 2, I 3, I 4, I 5, I 6 all are known, you assume they all are known, how to compute initial values of i, will come later.

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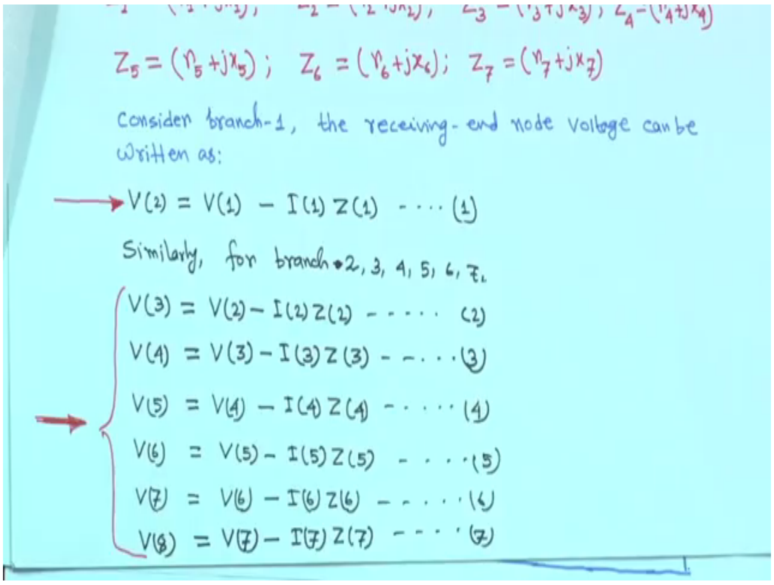

But you assume they are known say, therefore V 3 is equal to V 2 minus I 2 Z 2 right, similarly V 4 will be V 3 minus I 3 Z 3 and so on, because there say, this is, your, what you call, this is a main figure and recursive type of relationship.

Similarly, V 5 is equal to V 4 minus I 4 Z 4, V 6 is equal to V 5 minus I 5 Z 5, all equation numbers have been given, V 7 is equal to V 6 minus I 6 Z 6, and V 8 is equal to V 7 minus I 7 Z 7. Once V 2 is computed, substitute where V 3 is evaluated because these are known, we are assuming these are known right. See I think V 3 is computed, these are known so V 4 will be computed and so on, but before computing this V 1, V 2 is equal to V 1 minus I 1 Z 1, this the initial value of I 1 we have to compute I 1, I 2, I 3, I 4, I 5, I 6, I 7, these initial values we have to compute before we compute this your V 2, V 3, but for your understanding, first I am writing this equation, after that I will show you how to compute this thing.

But in code when you write, these initial values of I 1, I 2 I 3 all I, capital I values you have to compute, before computing this equations right. As you have 7 equation that is why, in general, if last node is 8 it would have been VNV is equal to VNV minus 1, and INV minus 1, then ZNV minus 1 right, but anyway as all nodes are there, we have taken like this. So, this I 1, I 2, I 3 we have to compute right, once this is done I mean these equations are written.

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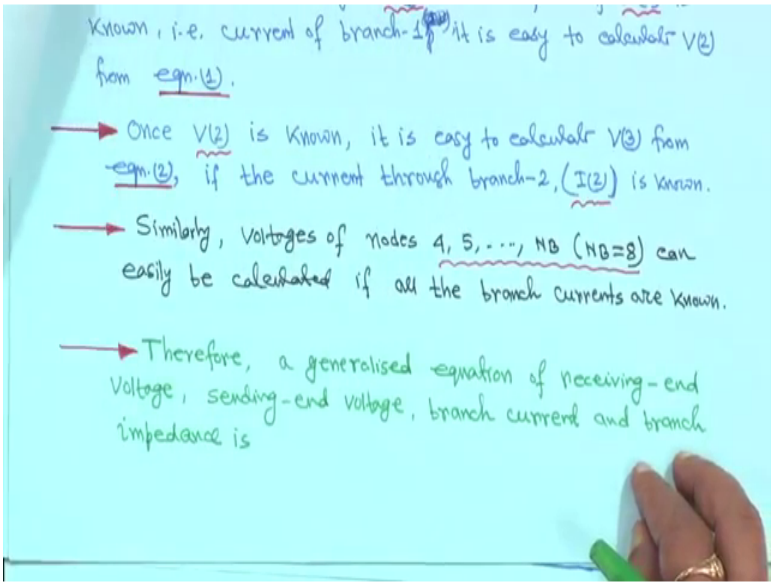

The next one is that, just for you, the other, they will make some matrix form rather than directly, because we have main figure plus main figure with lateral branches, we will come to that, that how to get the solution right, substitution voltage v 1 is known.

So, if I 1 is known; that means, if we know this I 1, I 2 everything, but for the first branch if I 1 is known, say, right. That is current of branch 1, it is easy to compute V 2 from equation 1, V 2 from equation 1, and V 2 can easily computed because if I 1 is known right. Similarly once V 2 is known, it is, V 2 is known, easy to calculate V 3 if I 2 is known because, Z impedances are known for you right.

So, therefore, voltages, similarly voltages are node 4 5 up to node NB, in this case total number of node NB is equal to 8, for this example, I mean the diagram, whatever you have taken we have 8 node. So, NB is equal to 8, can easily be calculated if all the branch currents are known right.

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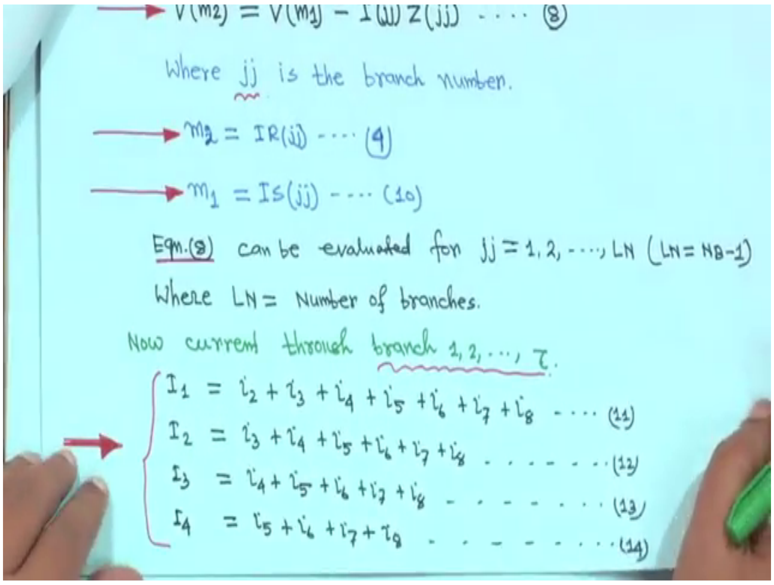

Therefore, a, generalized equation of receiving-end Voltage, sending-end Voltage, branch current and branch impedance is, therefore you have to write a generalized equation. So, generalized equation will be V m 2 is equal to V m 1 minus I jj Z jj right, but I jj is not computed here, you have to do, but how you will do it? When we write the code right, like for j is equal to 1 to LM.

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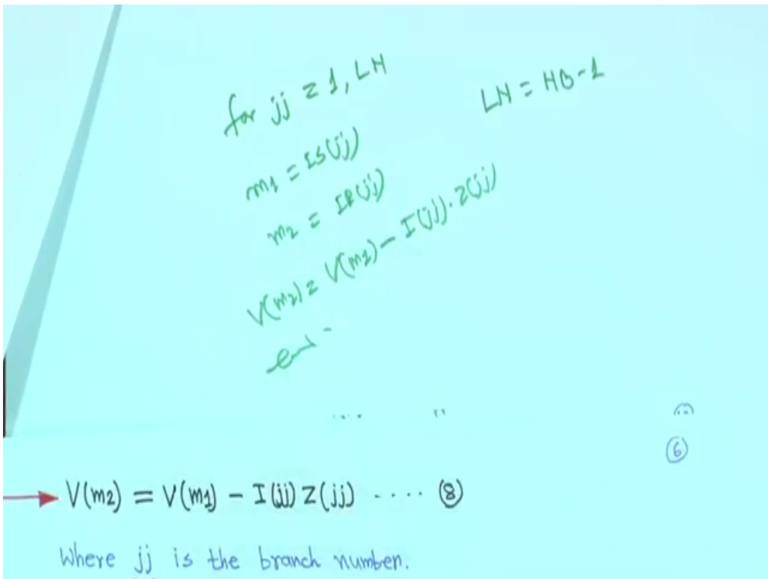

LM is the total number of branches, that is LM actually is equal to NB minus 1 right, NB is the total number of nodes. So, branch number will be one less.

So, it will be NB minus 1, for jj is equal to 1, LM, then what you define? You define m 1 is equal to sending end node IS jj.

And you define, m 2 is equal to IR jj right, after that you write, V m 2 is equal to V m 1 minus your I jj into Z jj and LM right. Because this table you are reading, this table, whatever we have made this table, all branch number, sending end node, receiving end node, beyond branch jj and total number of nodes, all you are reading as data, this also will be required later, but m 1 is IS jj into all these things are reading. So, when you write code or something you write for j is equal to 1 to LM, then put m 1 is equal to sending end node IS jj, and automatically after reading this, it will take, those were writing code you know, it will take. And m 2 is equal to IR jj, then you write V m 2 is equal to V m 1 minus I jj into Z jj this is end.

So this is automatically, all the, your, receiving end voltages for each branch we will be computed. It is always 1, 2, 3, 4 lines only, 5 lines, if you write the code. And your, what you call, you read those data so; that means, here, here in that, here I have not written there here right. So, here I am writing only V m 2 is equal to V m 1 minus I jj, I told you that how to write the coding part, right.

Where m 2 is equal to IR jj, m 1 is equal to IS jj therefore, equation 8 can be evaluated for jj is equal to 1 to LN, I just told you for jj is equal to 1 to LN, this thing only, this thing only right, where LN is equal to number of branches, that is LN is equal to here I have written that is NB minus 1. Now you have to, you have to compute the, now, current through branch 1 to 7.

Because you have this diagram, this diagram you have 7 branches 1, 2, 3, 4, 5, 6, 7. Now what is I 1? You apply Kirchhoff's first, I 1 is equal to this i 2, what about the current going to the load? i 2 plus i 3 plus i 4 plus i 5 plus i 6 plus i 7 plus i 8, this is, you just apply Kirchhoff's first law. So, our I 1 is equal to the current branch 1, 2, up to 7, 7 branches are there.

So, I 1 is equal to, whenever writing here, I am putting suffix, I am not putting in bracket, but when I will see the mathematics I will put them in brackets, but they are same, there should not be any sort of confusion right. So, I 1 is equal to i 2 plus i 3 plus i 4 plus i 5 plus i 6 plus i 7 plus i 8; that means, this i 2, i 3, i 4 all you have to compute, will come in the next step right, we will come later.

So, this is the equation 11, similarly that branch current I 2, this is your I 2, I 2 is equal to actually i 3 plus i 4 plus i 5 plus i 6 plus i 7 plus i 8.

Because, this is the current I 2 entering into this, entering here. So, this current, will go, basically it is going here only, this current right. So, Kirchhoff's first law again. So, I 2 will be i 3 plus i 4 plus i 5 plus i 6 plus i 7 plus i 8, this is equation 12. Everything I have made it here, such that you should understand this, right. Then I 3, this is the branch current, I 3 is equal to i 4 plus i 5 plus i 6 plus i 7 plus i 8 again Kirchhoff's first law. So, it is i 4 plus i 5 plus i 6 plus i 7 this is equation 13 say.

Similarly, branch 4 current, it will be i 5 plus i 6 plus i 7 plus i 8, it is I 4 is equal to i 5 plus i 6 plus i 7 plus i 8, this is equation 14 right. Similarly current through branch 5, I mean current through branch 5, I 5, this one, it will be i 6, i 7 plus i 8.

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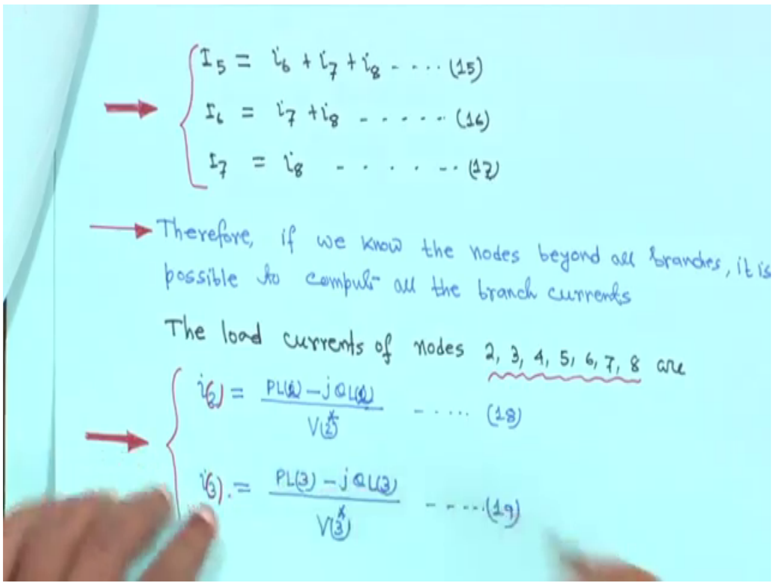

So, I 5 is equal to, your, it is i 6 plus i 7 plus i 8, this is a question 15. Similarly I 6 is equal to the current through branch, so it will be i 7 plus i 8 Kirchhoff's first law only right, but I am not writing I 6 is equal to i 7 plus your, what you call, your I, your this small I is I 6 also is equal to the small i 7 plus capital I 7, here also I 1 is equal to capital I 2 plus small i 2.

But again I 2 is equal to, if you write i 3 plus capital I 3, ultimately it will be sum of all these, all these currents right. So, what we our objective is, the branch current can be represented by the load current , but I am not writing I 1 is equal to I 2 plus, a capital I 2 plus small i 2, do not do that, then you have to write many more equations. So, only this load current right, because this current will be all these things.

So, but if you again put I 2 is equal to I 3 plus i 3, ultimately we will find I 1 is equal to your, i 2 plus i 3 plus i 5 are to summation of I 8 right. So, do not do that. So, similarly I 6 is equal to your, i 7 plus i 8 this load current.

Ultimately this current is, this current, you can say i 7 plus capital I 7 , but capital I 7 will be small i 8, ultimately i 7 plus i 8, same is applicable here. So, do not consider this, I 1 means all this current, Kirchhoff's law, I 1 is equal to capital I 1 is equal to capital I 2 plus small i 2. Again you will try to put this way, but directly you can put this, ultimately it will be same right, that is why all these things are made. So, similarly capital I 7 that is the last one is equal to small i, because this is the current actually going to the load because no other branches beyond that right. So, it is i 8. So, and in terms of power, it is given PL 2 plus because this data will be known right.

So, these are all branch current mathematics, I mean simple thing, very simple thing. This last one is equation 17, now therefore, if we move the nodes beyond all branches, it is possible to compute all the branch current; that means, this table, if you know all these nodes beyond all branches, then article, if branch 1 current can be computed; that means, if branch 1, beyond branch 1, these are the node 2, 3, 4, 5, 6, 7, 8.

Therefore, capital I 1 is equal to, it is small i 2 plus i 3 plus i 4 plus i 5 plus i 6 plus i 7 plus i 8, if you know beyond branch 2, all these your nodes, then it will be capital I 2, the current, will be small i 3 plus small i 4 plus small i 5 plus small i 6 plus small i 7 plus small i 8, whatever we have just seen. Similarly all this thing, capital I 7 will be is equal to actually your small i 8 right, sending end, receiving end this way you have moved right.

That is why we have written, capital I 7 is equal to small i 8; that means, that is why this is necessary, that nodes beyond branches, this is necessary. You have to make this table, you have to read this data and similarly, but no variable is given, why not given I will come later, how we have given this right. And similarly, total number of nodes this one you have to make it right. So, question is that, this, here I have kept blank, when I will explain at that time, I put something here, at that time, things will be understandable, right. So now, the load current of node, load currents of your node 2, so look, this is, this is the node had voltage V 2, this is the V 2, and this is the load connected PL 2 plus jQL 2, I 2 is the current going to the load.

So, you know no, from load flow studies, in general p minus j 2 is equal to V conjugate i, we have studied in our power system analysis load flow studies therefore, you can write PL 2, when you put in mathematics PL 2 minus jQL 2 is equal to V 2 conjugate into i 2, that is why we were writing, here I am not putting in this thing, what you call, this one I am putting in bracket, but this one here, I have not put it in bracket, but later I have made it right, later, later, I have made it.

So, what we have done is, later I will give you, this generalized thing is given i 2 is equal to this one PL 2 and your QL 2, that suffix 2 and bracket 2, all are same, but here I did not put in bracket, later I have generalized, at the time I put them in bracket. So, i 2 is equal to PL 2 minus jQL 2 upon V 2 conjugate, voltage also and putting them in bracket right. If you want, you can make it in bracket no problem, but I have not done it. So, i 3 is equal to PL 3 minus j QL3, V 3 conjugate ; that means, here your, your this, this load is connected to that node 3, V 3 is the voltage and i 3 is the current therefore, i 3 is equal to PL 3 minus jQL 3 upon V 3 conjugate, this is equation 19.

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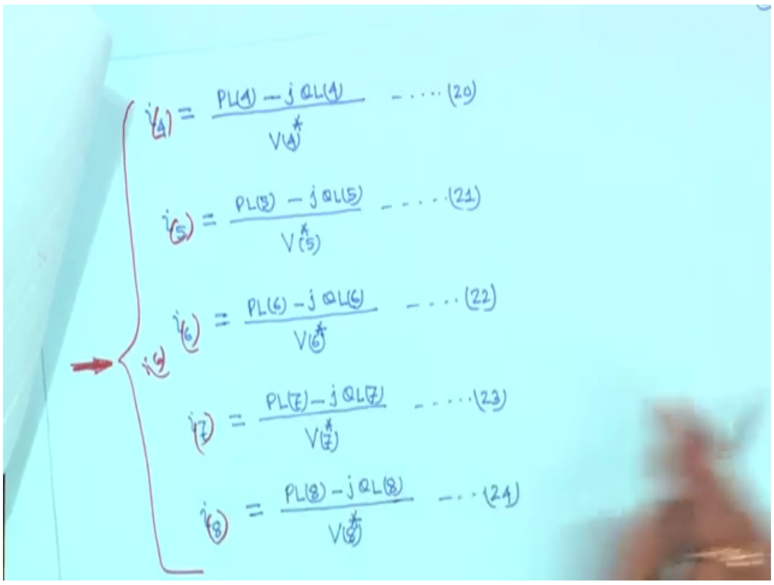

Similarly your, all i 4, i 5, i 6, i 7, i 8 all you can compute; that means, that means, i 4 is equal to PL 4 minus jQL 4 upon V 4 conjugate, i 5 is equal to PL 5 minus jQL 5 upon V 5 conjugate, i 6 is equal to PL 6 minus jQL 6 upon V 6 conjugate.

And all the equation numbers are given, i 7 is equal to PL 7 minus jQL 7 upon V 7 conjugate, and i 8 is equal to PL 8 minus jQL 8, V 8 conjugate.

Now if you want, if you want, here also, this one also you can put in bracket right. If I want to say, this is, this is my i 2, this is my i 3 in brackets say, all are in bracket say, this is i 4, this is i 5, this is i 6, instead of suffix, I am putting in bracket, actually it is say, i 6 right, this is your i 7, this is your i 8 right. You can put it like this; that means, in general, in general; that means, i 2, i 3, i 4, i 5, i 6, i 7, i 8 all can be computed.

How it will be computed? Because you have to know, because, PL QL known, but V 2, V 3 all are not known. So, load flow studies you know that your flat voltage start. So, for V 2, V 3 whatever is the slack bus voltage, for all these initial values of V 2, V 3, V 4, all these voltages will be your consider as the slack bus voltage, initial one, such that initial values of i 2, i 3 all can be computed, we will come to that right.

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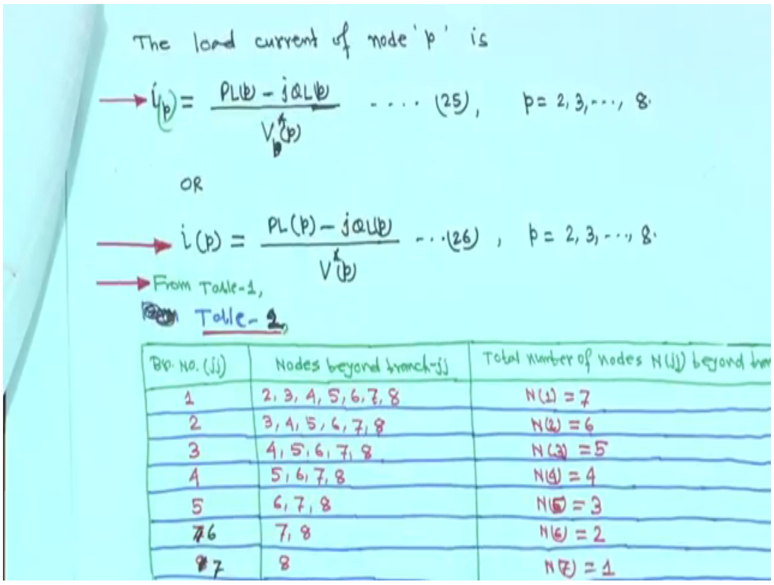

Therefore, the load current of say, node p, it can be written as i p, again I have writing, PL p minus jQL p upon your V conjugate p in bracket. So, this one also, if you want you can put it in bracket, no problem right here, but anyway for general thing, it is p is equal to 2, 3, 8 because it is a currents are at 2, 3, 4.

So, here I am writing, i p is equal to PL p minus jQL p upon V conjugate p, where p is equal to 2, 3, 8. If you put p is equal to 2, you will get i 2 value, if you get p is equal to 3, but initial values are known right now, question is that again I have made this table, you have just understand, very easy actually, very easy right. Now branch number jj 1, 2, 3, 4, 5, 6, 7 right.

There are 7 branches, and nodes beyond branches, all these things where given in the table right, or in this table it is given, all these things are given, all these things are given. So, just rewriting, on the, this sending end, receiving end, not putting in the table 2 right. Only these nodes I am putting, these notes I am putting.

So, these are the nodes are given, and total number of nodes here given, total number of nodes N jj beyond branch jj, it is given 7, 6, 5, 4, 3, 2, 1 in this case; that means, when jj is equal to 1, N 1 is equal to 7, when jj is equal to 2, N 2 is equal to 6, when jj is equal to 3, N 3 is 5 and so on. That is why here, I am writing N 1 is equal to 7, N 2 is equal to 6, and N 3 is equal to 5, N 4 is equal to 4, N 5 is equal to 3, N 6 is equal to 2, and N 7 is equal to 1; that means, this thing we are putting again in better form that this one only, this one and this one same, this one and this one they are same right, and this is the branch number and this is the branch number right. So, this way we were putting, then this is my N 1, N 2, N 3. I hope this is understandable right.

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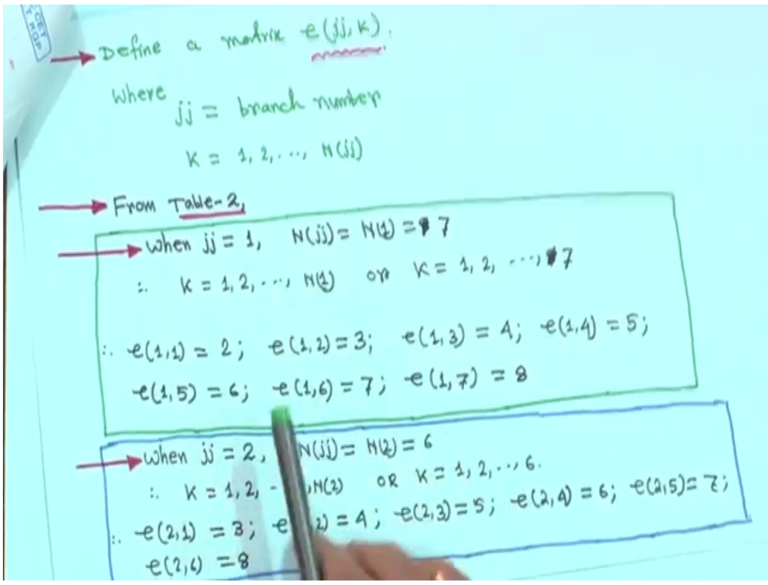

Next one is, now we have to define a matrix e jj k; that means, they are that nodes beyond branch jj, you have to store this in a matrix, in a matrix right. So, here nodes beyond branch jj is given, but this whole matrix you have to store in a matrix form because, you have to read the data in the computer. So, what you have to do is, Newton Raphson's so many things we have seen in algorithm right.

So, here this data you have to store in a computer. So, you have to put this in a, in an array, in a matrix form that will be better.

So, you, what we define? We define a matrix say e is equal to, sorry matrix e jj, k right, your, this is the matrix say jj k, where jj is the branch number and k will vary from 1, 2, 1, 2 up to N jj right; that means, this thing, these whole thing actually the matrix, it is in the form, these whole thing is a matrix, the here also, here also, these whole thing you put in a matrix right.

Here if we write that thing, that will be actually e bracket jj, k right, this is the whole thing we are putting in a matrix. So, here also it whole thing actually jj k, this whole thing we will put in a matrix, it will be e jj k. Here I am not writing, but here it is actually e jj k, this way you to make, but how to take it, how to take it, how to put it in an array right.

What we will do is this all, this total number is given nodes beyond branch jj is given right, but let me tell you identification of nodes beyond all branches, algorithm is there, and we know, the, and the identification of branches beyond branch jj, identification algorithm is there right, but I am not here, I, we do not want to make that your, identification algorithm, just if you have the single line diagram will not work, you can prepare the data, and you can easily get the solution by reading this data.

But this node also can be identified by identification algorithm, but that algorithm I thought in the classroom purpose, better not to discuss. So, this thing I have made it of my own, that how to give the data such that your things will easier right. So, identification algorithm is there.

But question is that, we are not showing it here, just we will see that, put this data in an array and see that how things are, things can be computed. So, for example, this matrix; that means, whole data we are keeping in a matrix e jj k. So, this is actually given jj is branch number and k equal to 1, 2, N jj for example, when jj is equal to 1, N jj is equal to N 1, is equal to 7, because this is the total nodes, the N jj is the total node beyond branch jj. So, you have for j is equal to, jj is equal to 1, N 1 is 7 because here you have 7 nodes, you mark those 7 nodes right therefore, why I have taken this e jj k matrix, e jj k matrix because, if you, in that case if lateral branches will be there.

So, same matrix e jj k will be used and automatically it will, automatically data, data will be read right. So, for example, when jj is equal to 1 then N jj is equal to N 1 is equal to 7. And therefore, k is equal to 1 to N jj; that means, k is equal to 1, 2 up to N 1 or k is equal to 1, 2 up to 7 right; that means, that when jj is equal to 1, it is e 1, 1, e 1, 2, e 1 3, e 1, 5, e 1, 6, e 1, 7 ; that means, your e 1, 1 read this data, you have to read it, e 1,1 is equal to 2.

So, when jj is equal to 1, e 1,1 which 2 ,then e 1, 2 is equal to 3, e 1, 2 is equal to 3, that e 1, 3 is equal to 4, then e 1, 3 is equal to 4, then e 1, 4 is equal to 5, this is the fourth element, e 1, 4 is equal to 5, is the fifth element, e 1, 5 which equal to 6 this is given, then this is, if this is that you sixth element, e 1, 6 is equal to 7, e 1, 6 is equal to 7, this seventh element, e 1, 7 is equal to 8. So, this is that your e 1, 1, e 1, 2, up to e 1, 7 because k is varying from 1 to up to N jj and, j you are changing right, j you are changing and; that means this, for jj is equal to 1, these are the element, these are the data you have to read in the computer rather than identification algorithm you will find these things quite easier, quite easier right.

When jj is equal to 2, that is N jj is equal to N 2 is 6 ; that means, here if there are 6 numbers, so n 2 is equal to 6 right. Therefore, even jj is equal to 2 means, it will be e 2, 1 because jj is equal to 2, your matrix is your e jj k. So, when jj is equal to 2 into 6 right, because N jj is equal to N 2 is 6 right, and k is varying 1, 2 up to N 2, or N 2 is equal to 6 1, 2 up to 6, and jj is equal to 2 because your matrix is jj k right. So, you can write e 2, 1 is equal to 3. So, e 2 1 is equal to 3 the second row here.

Then e 2, 2 is equal to 4, e 2, 2 is equal to 4, then your e 2, 3, e 2, 3 is equal to 5. Therefore, e 2, 3 is equal to 5, then your e 2, your, what you call e 2, 4 is equal to 6, e 2, 4 this is a fourth element 6, then e 2, 5 is 7, e 2, 5 it is, it is your, what you call, it is 7, e 2, 5 is equal to 7, and then your e 2, 6 is equal to 8, e 2, 6 is equal to 8, this element first you identify, and put this, read this in the computer, all this data e 1, 1 e e or e e matrix we have to read this data in the computer; so, similarly e 2, 5 7, e 2, 6 8.

Thank you very much, we will be back.