Power System Engineering
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Lecture – 32
Load flow of radial distribution networks (Contd.)

So, please come back to again.

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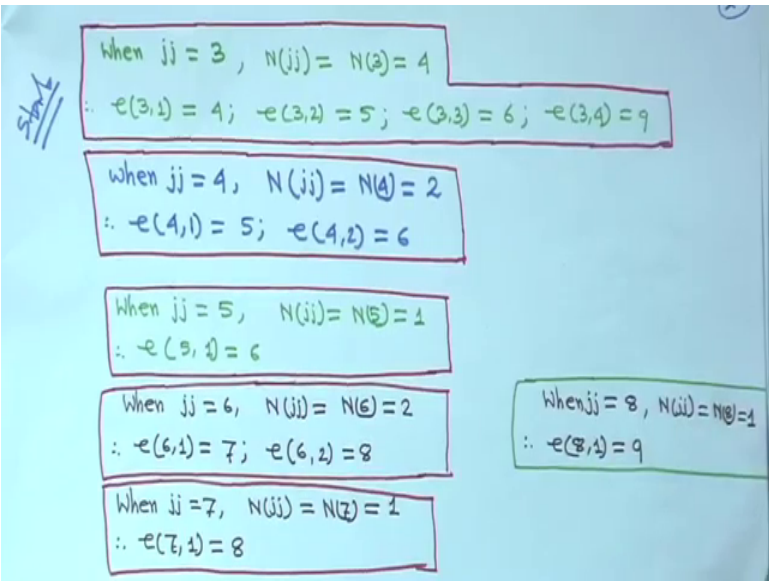

When a branch number j j is equal to 3 right, when a branch number j j is equal to 3.

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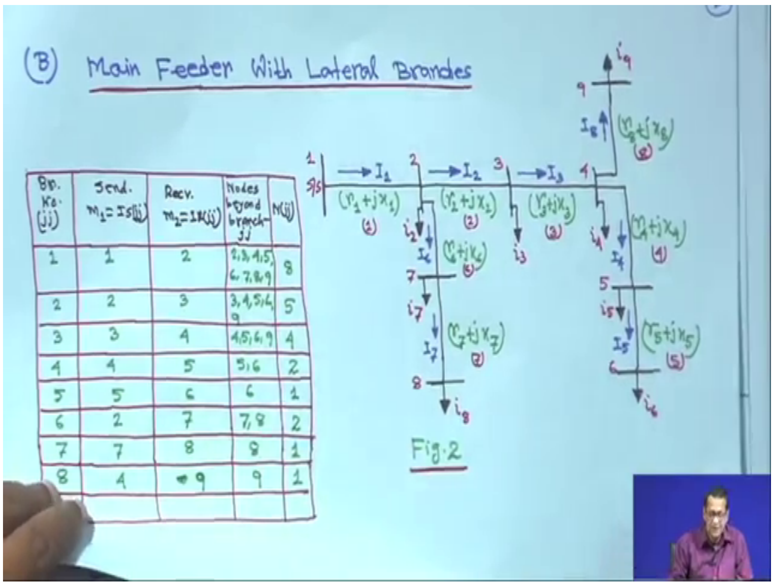

That total look at the diagram the total number of nodes beyond branch 3 is that is 4, then your 5, then 6, and then 9, in the bracket this number actually branches right, and these are the node. So, there are 4,5,6 and 9 there are 4 nodes. So, this is your from the look at the table from the table, and from this band sending end node, for this band sending end node is 3, and receiving end node is 4, and therefore, m 1 is equal to 3, and m 2 to is equal to 4 right, and there are 4 4 nodes 4 p 5, 6, 9 and therefore, Njj the number of node is 4; that means, when jj is equal to 3, then N jj is equal to jj is equal to 3. So, Njj is equal to N 3 is equal to 4.

So, here N 3 is equal to 4, from this table right, and therefore, you jj is equal to 3. So, you form them that your ev matrix. So, ejj k. So, k is varying actually for 1 to 4, here I am not writing understandable. So, it is e 3 1 will be 4; that means, this node it is 4,5,6 and 9. So, e 3 1 will be 4, e 3 2 will be 5, e 3 3 will be 6, and e 3 4 will be 9, here also e 3 1 is equal to 4, e 3 2 5, e 3 3 6 and e 3 4 9.

Now, again when jj is equal to 4, look at the table the branch number is 4 so; that means, this branch in bracket red, red ink the number inside the bracket it is branch number, shows it is sending end node is 4, and receiving end node is 5. So, m 1 is 4, m 2 is 5, and number of nodes beyond these branch is just 5 and 6. So, here is 5 and 6. So, N jj is 2; that means, your N 4 is equal to 2; that means, when jj is equal to 5, N jj is equal to N 5, sorry here when jj is equal to 4 N jj is equal to N 4 is equal to 2; that means, e 4 1 is 5, e 4 2 is equal to 6.

Similarly, when branch number jj is equal to 5. So, m 1 is 5 sending end node is 5, when this is your branch number this is the branch 5. So, sending end node is 5, receiving end node is 6. So, m 1 is 5, and m 2 is 6, and only one node beyond this branch that is node 6, and to Njj is 1, because there only one node; that means, when jj 5 Njj is equal to N 5 is equal to 1; that means, only 1 e element that is e 5 1 is equal to 6.

Now, come to branch 6, that is this is your branch 6 right. So, when jj is equal to 6, your sending end node will be 2, that mean this is for this branch node 2 is the sending end node, and node 7 is the receiving end node. So, m 1 is equal to 2, m 2 is equal to 7, and beyond this branch only 2 nodes are there 7 and 8. So, this is 7 8 only 2 nodes are there hence Njj that is your N 6 is equal to 2; that means, when jj is equal to 6, Njj is equal to

N 6 is equal to 2; that means, from this branch right therefore, e 6 1 will be 7, e 6 2 will be 8; that means, e 6 1 is 7, e 6 2 is 8.

Next you come to branch 7; that means, this branch beyond this is this come look at the table, here beyond this branch only 1 node is there, but it is sending end node is 7 this being node is 8. So, m 1 is 7, m 1 is always sending end node, and m 2 we have taken all is receiving end node, and only 1 node 8. So, Njj 1 that is N 7 is 1 therefore, when jj is equal to 7, Njj is equal to N 7 is equal to 1 therefore, e 7 1 the e element only 1 element that is your 8 right.

Come to the branch 8, I mean this branch this is the branch 8, it is sending end node is 4 receiving end is 9, and beyond this your a branch only 1 node that is these are only receiving end side 9. So, m 1 is 4 sending end node, m 2 is 9 receiving end node for this branch, and only 1 node 9 and N 8 is equal to 1; that means, here I have written here when jj is equal to 8, Njj is equal to N 8 is 1 therefore, e 8 1 is equal to 9, this way your identifying all the nodes beyond each branch, and you have to put it in a your, if you read the I mean you have to a read those data if you write to your what you call computer coding right.

So; that means, how to be identify and nodes beyond all the branches, that you have put into tabular form, but identification algorithm is also there, instead of making the table, just reading sending and receiving end node and branch number it can identify, but for this course I have decided I should keep that rather than I should give you this thing in tabular form, such that it will be easier for you to understand right. So, this is your next is, I mean then you might have understood that all the nodes, beyond each branch how to find out right, next is that you are from equation 27 right.

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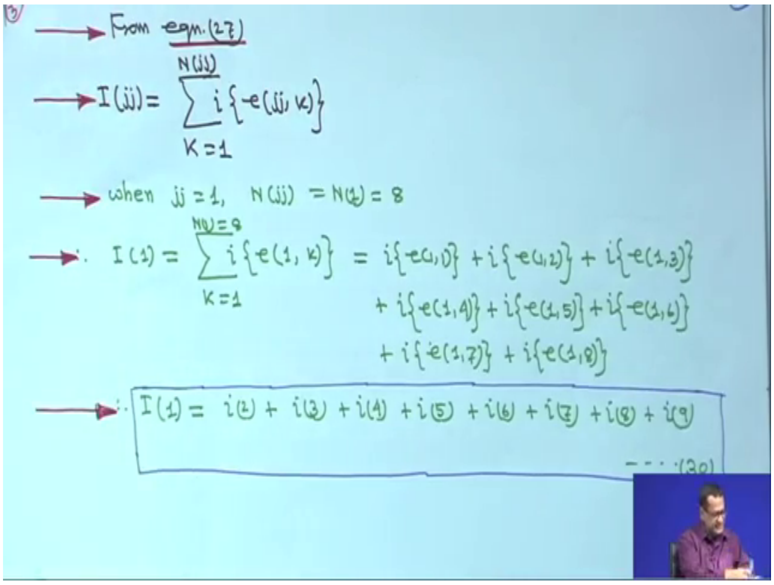

So, this equation actually rewriting if you rewrite the equation that, if ijj that is the branch current right, that is the branch current; that means, capital I; that means, this diagram these are the branch current i 1,i 2,i 3 and so on.

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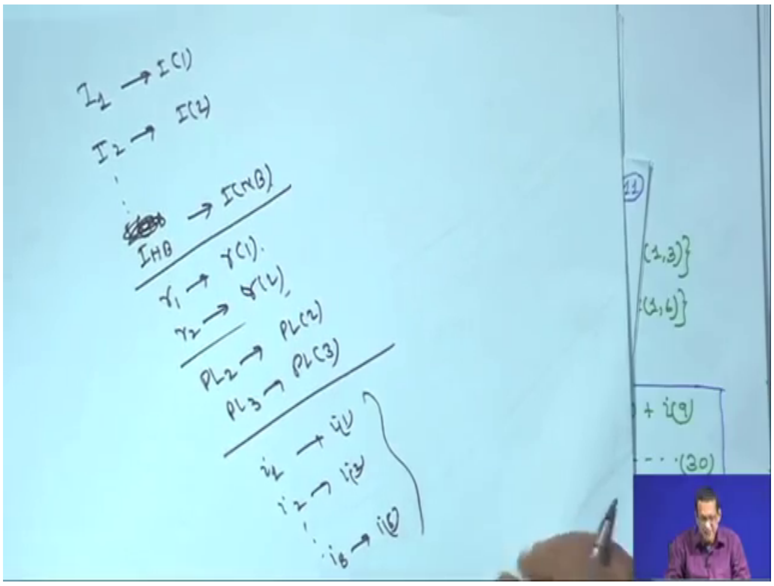

But one thing I will just I am telling again, that when I am writing in mathematics form, I am writing say i suffix say I 1, I 1 actually it is I 1 right when you right I 2 it is actually I 2 right, this way I am writing in mathematics and for coding also this way we should right rather than I 1, I 2 right.

Similarly, if you have in total number of sorry total number of nodes INB. So, we should the said inb right similarly I told you I think in the previous lecture, similarly if r 1 it is there it is actually r 1, same thing if it is r 2 and r 2 it is same thing right. So, there should not be any confusion similarly for x and similarly for load PL and QL for example, if load is PL 2 then this PL 2 their same thing, if it is PL 3 then it is PL 3 their same thing, similarly for Q right.

So, such that there should any, any there should not be any confusion. So, this branch current from equation actually equation 27 where re writing, capital I jj k is equal to 1 to N jj then i small i in bracket e jjk, there is because you have to identify all the nodes beyond is branch, look how will you do this.

When jj is equal to 1, we have seen N jj is equal to N 1 is equal to 8, we have seen when jj is 1 N jj there are 8 nodes, and N, N Njj is equal to N 1 is equal to 8 therefore, jj is equal to 1 and N 1 is equal to 8, there for i 1 that is branch current to branch 1, k is equal to 1 to N 1 that is k is equal to actually 1 to 8, then i in bracket e 1 k. So, k will vary from 1 to 8 right, details I have made it such that you will assess that it will be easy for you to understand, now we expand this a your k is equal to 1 10, then it will be i then e 1 1, plus i e 1 2 small i of course, plus i then e 1 3, plus ie 1 4, plus i e 1 5, plus i e 1 6, plus i e 1 7, plus i e 1 8, but e 1 1 already this has been explained to you, that e 1 1, e 1 2, e 1 3, all these elements you I have been explained right.

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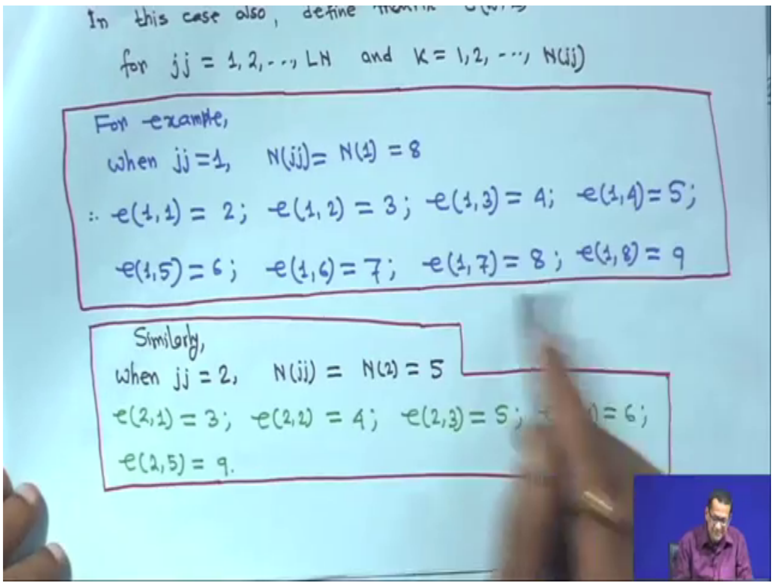

So, what you do the e 1 1 2, e 1 2 is equal to 3, all you substitute here, if you substitute here like, all the from the table also e 1 1 is equal to 2, e 1 2 3. E 1 is equal to 4. E 1 4 is equal to 5. And so, on right if you put it. Then it will be capital I 1 that is the current through your branch 1 is equal to i 2 plus, i 3 plus, i 4 plus, i 5 plus, i 6 plus, i 7 plus, i 8 plus, i 9 this is equation 30; that means, if you look at the branch and again there should not be any conclusion, that i in x diagram, I am writing i 1 that is actually i 1 that is the load current, i 2 that is actually i 2 same thing.

Similarly, your i 8 actually it is i 8 same thing right. So, meaning is same, but when I am writing in mathematics thing I have taken suffix, but when I am trying to explain in that computer, how to make computer coding or according to that, I am writing like this has that it will easy for you to understand the things right therefore, if you that is that the beyond this branch, I mean branch, that i 1 current find out how many the including this your this receiving end node of this branch, that i 2, i 3, i 4, i 5, i 6, then i 7, i 8 and i 9, this is the if you add all this load current this is actually your branch current, where basically if you want to make it that you will write that, i 1 is equal to if we apply Kirchhoff's first law here, the do not write like this your objective is to sum up all the load current that will branch current, if you apply Kirchhoff's first law at N node 2, then your i 1 let me use the another color that your i 1 is equal to this is i 2, this is i 2 plus, this current going through this branch also plus i 6, plus this load current also, going through this i 2 right.

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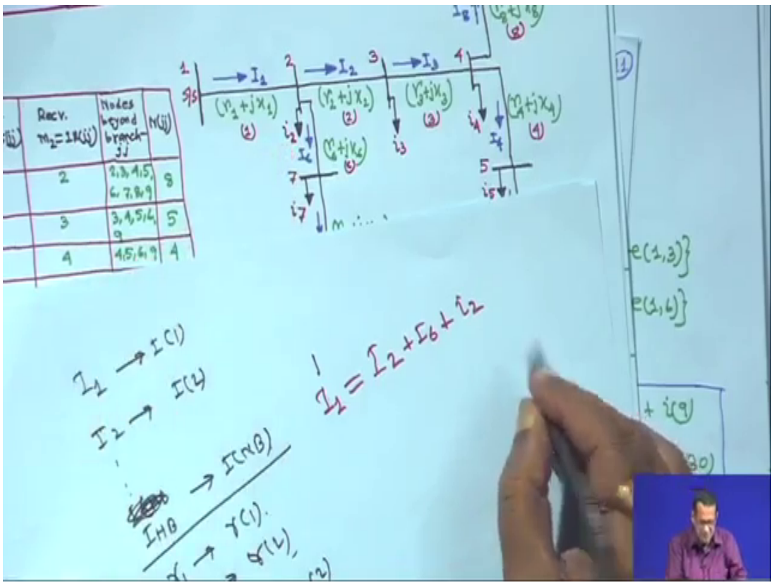

But if you substitute i 2 also then capitalize 6 capitalize is equal to what capitalized 6, what ultimately, i 1 is equal to you will get all the all the load current i 2 plus, i 3 plus, i 4 plus, i 6 I mean whatever is coming beyond each branch. So, in this case also that you are capital I 1 the branch current of your this thing current of branch 1 that is i 2 plus, i 3 plus, i 4 plus, i 5 plus, i 6 plus, i 7 plus, i 8 plus, i 9, I think this is easy for you to understand, the way we are trying to make it I think it will be very easy for you right.

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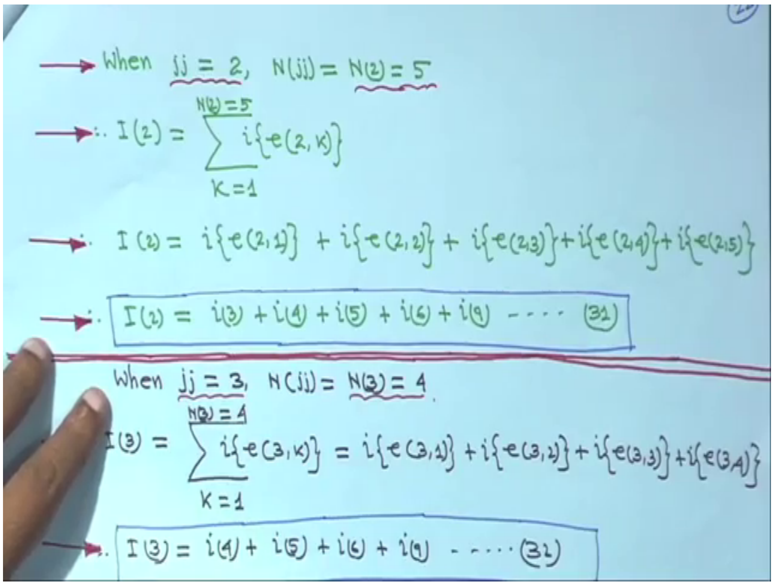

Similarly, when for just such I mean you such that you can understand each and every state that is why everything is written for this explanation right. When jj is equal to 2 that mean look at that right branch jj is equal to 2 your total number of node, beyond this branch actually 1,2 your 3,4,5, total number of branches 5 a mark and there are 3, 4, 5, 6 and 9 right.

So, when jj is equal to 2, I capital I to the current of branch 2 that is k is equal to 1, 2, N2 is equal to 5, that is k is equal to 1 to 5, ie in bracket it will be e 2 k because it is your from equation 27, just now just now there is some same equation, from this equation all you substitute jj is equal to 2, and k is equal to 1,2, N2 is equal to 5, this is a i mean the same question from equation 27 only write, all these equations will be written from this equation only 27.

Here I have not a written an equation number so; that means, that means k is equal to 1 to 5 it is small i, then bracket you put e 2 k, now k you vary 1 to 5 therefore, capital I 2 is equal to I in bracket e 2 1 plus, i e 2 2 plus, i e 2 3 plus, i e 2 4 plus, i e 2 5 right, now we have seen this e 2 1 all these things yeah we are already we have explained e 2 1 is equal to 3, e 2 2 is equal to 4, e 2 3 is equal to 5, e 2 4 is equal to 6, and e 2 5 is equal to 9, this all these things just we have explained.

Therefore, all this number or that e 2 1, e 2 2 you put it here, then it is it will be i 2 is equal to i 3 plus, i 4 plus, i 5 plus, i 6 plus, i 9 right, this is equation this as the current flowing through branch your 2, now if we look at the branch 2 beyond branch 2 this current is there i 3 then, i 4 then, i 5 then i 6, and then i 9. So, here also we are getting the same thing i 3, i 4, i 5, i 6, i 9, that is why give this in tabular form such that it will be easy for you to understand.

Similarly, when jj is equal to 3. So, came from equation 27 only, that Njj is equal to N 3 is equal to 4 right; that means, here when jj is equal to 3 right. So, Njj is equal to 4, that is N 3 is equal to 4, and there are 4 nodes 4,5,6,9; that means, your i that is k is equal to 1,2, N3 that is equal to 4, i bracket e 3 k, now we expand this it is i 3 1 plus, i 3 2 plus, i 3 3 plus, i 3 4 right i 3 4.

So; that means, i 3 1 is your here it is their i 3 1 is 4, i 3 2 5, i 3 3 6 and i 3 3 9. So, it will be i 3 is equal to i 4, plus i 5, plus i 6, plus i 9, that is the current through branch 3, then this is your branch 3, beyond this these are all load current know i 4, i 5, i 6 and i 9 right. So, i 4, i 3 will be is equal to i I 4 plus, i 5 plus, i 6 plus, i 9. So, here also i 4 plus, i 5 plus, i 6 plus this is equation 32 right.

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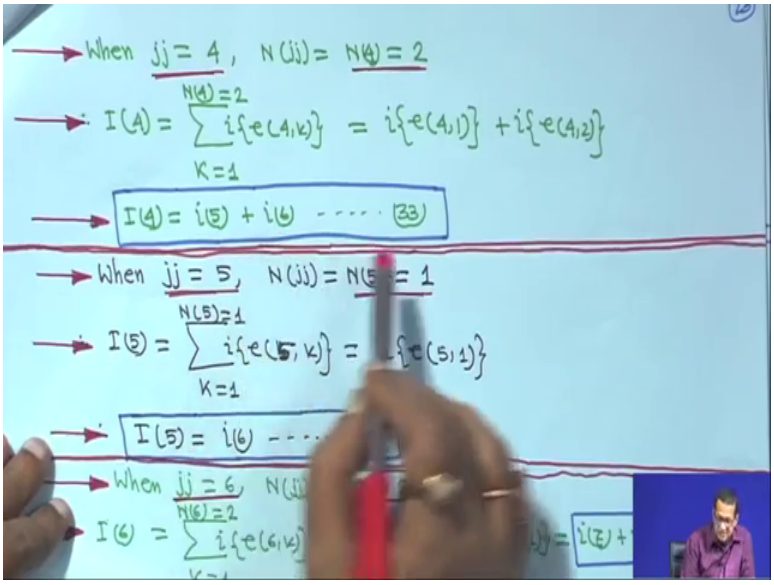

Next is when jj is equal to 4, branch jj is equal to 4, there are 2 nodes 5 and 6, and Njj that is N, N 4 is equal to 2. So, this is your branch 4. So, this is branch 4 beyond this node 2 nodes are there 5 and 6. So, 5 and 6 and N 4 is equal to 2 there for when jj is equal to 4, then N jj is equal to N 4 is equal to 2, there for capital I 4 k is equal to 1,2, N4 that is equal to 2 i e 4 k, because jj is equal to 4. So, it is i 4 1 plus i e 4 2. So, substitute value of e 4 1 and e 4 2 these are all integer values. So, i 4 is equal to i 5 plus, i 6 this is i have made equation 33.

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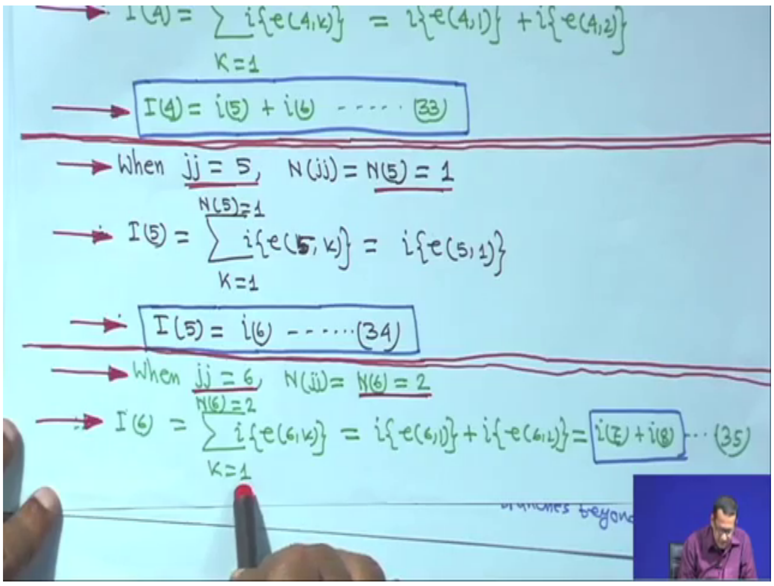

Similarly, when jj is equal to 5 right, when jj is equal to 5 branch 5, that is jj is equal to 5 means, beyond this branch only 1 node, that is your i this this branch receiving end node 1 itself, load current that is i 6, there is no other branch beyond this. So, only this node current is there; that means, actually i 5 is equal to capital i 5 is equal to small i 6. So, it is your only 1 node and N 5 is equal to 1 right, N 5 is equal to 1 therefore, k is equal to 1 N 5 is equal to 1 e 5 k. So, i e 5 1. So, you have actually it is i 5 is equal to i 6.

So, i 5 actually same this is the branch current same current is going to the load, because this is the last branch of this rather, your this i this branch is the last branch of this lateral branches, right that is why i 5 is equal to i 6. So, when jj is equal to 6, then means this side this is your branch number 6, but there are 2 nodes 7 and 8. So, 7 and 8. So, N 6 is equal to 2. So, when jj is equal to 6 Njj is equal to N 6 is equal to 2; that means, capital I 6 k is equal to 1, to i your N 6 is equal to 2 i e 6 k that is ie 6 1 plus, i e 6 2 that is i basically it is i 7 plus i 2, because these are the elements it is 6,1, 6,2, all are explained previously and from the table also 6,1, is 7, and 6,2, is equal to 8 right so, this is equation 35.

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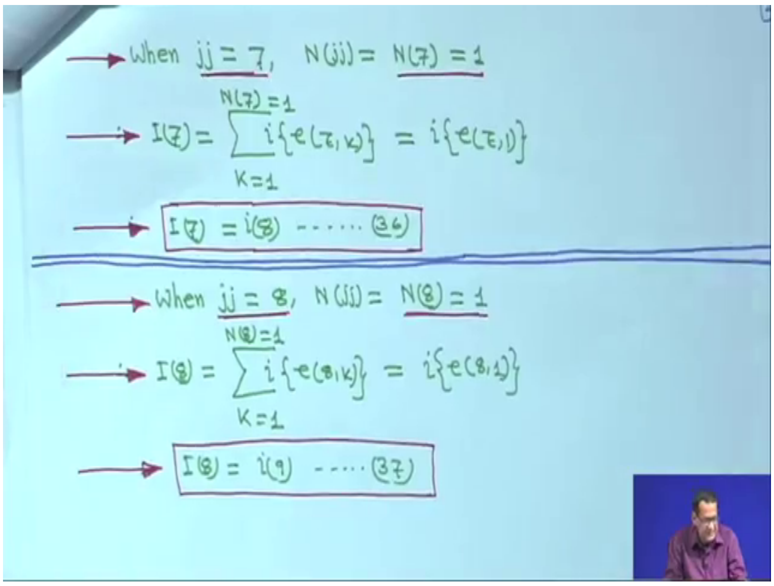

Now similarly when jj is equal to 7, This is the jj is equal to 7 last branch, beyond this branch, I mean there is no other branch in any way. So, this is the receiving node. So, that is a capitalize 7 is equal to small i 8, from that your from this circuit you can easily make out right. So, therefore, jj is equal to 7, Njj is equal to N 7 equal to 1 therefore, I capitalized 7, that is sigma k is equal to 1 to N 7 equal to 1, ie 7 k, that is ie 7 1 because only k is equal to 1 to 1 1 element. So, capitalize 7 is equal to i 8. So, from this figure also you can make out capitalized 7 is equal to i 8 right.

When jj is equal to 8, that is that this branch jj is equal to 8, that is this branch 4 to 9 only this node is there 9, and basically capital i 8 it is equal to small i 9, right because this is also the or beyond this branch there is no other branch and this is the only node here. So, i 8 is equal to i 9. So, here also Njj is equal to N 8 is equal to 1 therefore, I 8 capital I 8 that is current through branch 8 k is equal to 1 to N 8 is equal to 1 ie 8 k, that is i e bracket e 8 1 that is i 8 is equal to capital I it is will i 9 this is equation 37; that means, all these e matrix that how I ask you to put in even the diagram is very large, this matrix you can make it easily, and this you can feed it to the computer to read this data, then no identification algorithm will require automatically it will read it, and it will try to find out the branch current right it of course, the load currents are known i 1, i 2, i 3, i 4, all are known, but how to compute will come right.

So, this is that all this branch current evaluation how to do it I have shown you.

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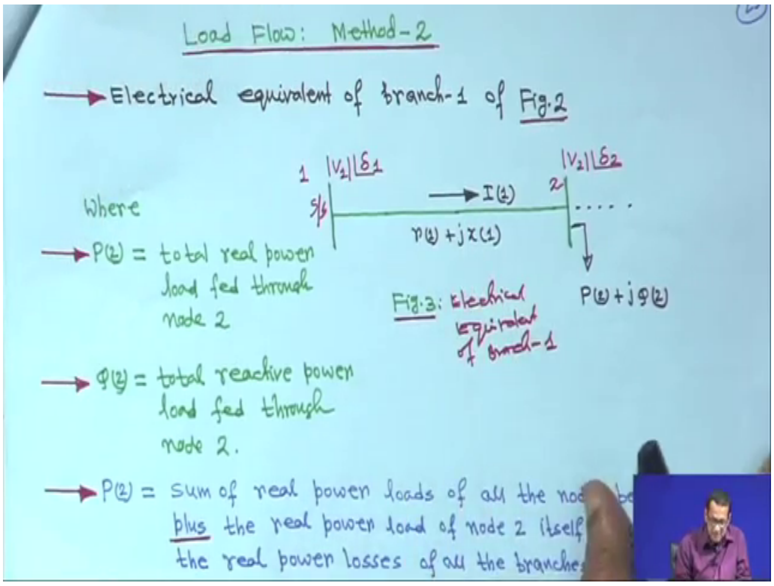

Now load flow method, now we have to come that how will solve the load flow, now what will us right. So, in this case your branch current evaluation.

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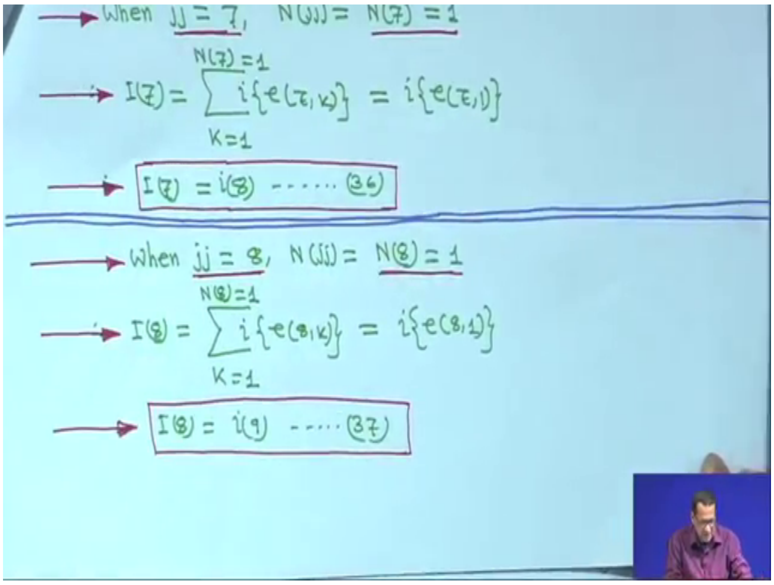

And this one just hold on, and this one that all i 9 will when will take the example, algorithm is given even the lateral branches are there, those algorithms are valid for all the things right, whether it is a main feeder case, or in the lateral branches that your what you call this this method this lateral branches or main figure, what your load flow algorithm has been explained, that is actually valid for both.

So, that is why the e matrix is defined right, such that whether it is a main feeder or lateral case, you can easily understand this right. So, next we will come to the or load flow method 2, will take the same diagram, but we will go for another technique these 2 techniques only we will learn right. So, first you have to here previous case we have seen the complex numbers are involved, let me trigonometric transfer coming right, but in this case second method we will try to eliminate the trigonometric functions in the load flow studies as opposed to the standard load flow case right.

We will try to solve the voltage magnitude only, because in distribution system, that variation of voltage angle starting from the substation to the tail end of the feeder, the variation of the voltage angle is very, very small therefore, we will find out some methodology, where it will solve voltage magnitude, and here I mean when we will go for doing all mathematics, things are not difficult one, but just you see how things are, but those previously whatever e matrix we have made it, that e matrix is required in addition to that, we will make another matrix called f matrix right, these 2 are required, but directly we will get all the voltage magnitude.

Now, first you have to understand that electrical equivalent of branch 1 of figure 2 what does it mean, this is actually suppose this is the figure it is a radial network right, and electrical equivalent of branch 1, I mean what is the electrical equivalent of branch 1. So, if you look into that suppose this is this is actually branch 1 in this case. So, this is actually substation in this case, this is substation here also it is substation right, this is that branch current i 1 is flowing. So, I put it in bracket here right so, but same thing right suffix or i in bracket 1 same thing.

So, this voltage say this is substation this is your slag bas for distributional load flow later will see, this mod v 1 is voltage magnitude again and again, I will not utter mod v 1 mod v 2 and so on, I will simply make v 1 angle delta 1, but understandable that this is magnitude. So, v 1 delta 1, delta 1 is the angle of the your slag bus, but for our study will assume delta 1 is 0, but that is not the case will take delta 1 say, and similarly this node 2 this is the voltage magnitude v 2 and angle delta 2, this is node 1 net node 2, current flowing to this branch 1 actually this is your branch 1, this 1 and 2 is electrically equivalent, what is electrical equivalent right this is i 1 and impedance of this branch is r 1 plus jx 1, right this say you have taken instead of r suffix 1 x suffix 1 i put it in bracket.

now here you have to see the what is the total load fed through node 2; that means, here this is branch 1, but look this when your what you call, when this current is living to this branch 1 to 2 N power some power been flowing through this line, and some is going to this load, and some is also going through this branch 6, some power i mean some power is going to branch 2, some power is going to branch 6 and summer sum is to the load.

So, ultimately whatever comes here at the receiving end, that is actually equivalent load, that whole thing that is why dividing p 2 plus jQ 2, that that is total load fed through this node; that means, this is your this is your node 2; that means, this total load fed through this node 2 means load at this point what a power right at this point at the just out outside of this node 2 at this point exist of the node 2, then this branch then this branch 6 and whatever power is going to the load right, that is actually total load fed through this node 2, that is why this is the total load fed through node 2 p 2 across jQ 2.

Before coming to this explanation, I will come what does it mean p 2 and your Q 2 right, if you see this is this is branch this is branch 1 then, what will be p 2? P 2 will be total load real power load fed through this node 2; that means, p 2 will be actually load up this branch here, I am saying i 2 current, but abrial load is there PL 2 plus jQ l 2, then p l 3 plus jQ l 3 I have shown earlier in this diagram main peter case.

But here a space is a problem that is why it will become clumsy, I have just written i, but it is your load PL 3, QL 3, PL 4, QL 4. So, whatever loads are there beyond this branch 1, that is your p l 2 plus, PL 3 plus 4, whatever it is you sum it up right, plus the loss also you have to account. So, whatever beyond this branch whatever branches are there this branch, that what will be the loss, that will local load fed to the load means, the load of the node to itself that is load of the receiving in node itself right, plus all the loads beyond this branch; that means, all the loads beyond this branch plus, all the power losses in all the branch beyond this branch right, beyond this branch all the power losses, that is actually total load fed through your real power load fed through node 2.

Similarly, when you consider the reactive power load, that is total reactive power load fed through load 2; that means, that is Q 2 whatever it will be that is all if that load of the your node 2 Q reactive load of the node 2 itself plus, all the reactive load of all the nodes beyond this branch right, plus all the reactive power losses of all the branch beyond this branch, that is beyond branch 1, this is actually branch 1 right, here just I marked figure 3, but this is electrical equivalent of branch 1 right, if you want you can write, this one actually electrical equivalent right of branch 1 right.

So; that means, if you know p 2 and Q 2 because the laws are not known PL 2, QL 2, PL 3 loads are known, but laws are not known. So, we have to go some iterative method later will see right. So, that is actually electrical equivalent of branch 2 right, similarly sorry branch 1, similarly if you think the electrical equivalent of branch 2, because further explanation all this explanation first you see how things are suppose if I want electrical equivalent of branch 2; that means, my sending end node each will node 2.

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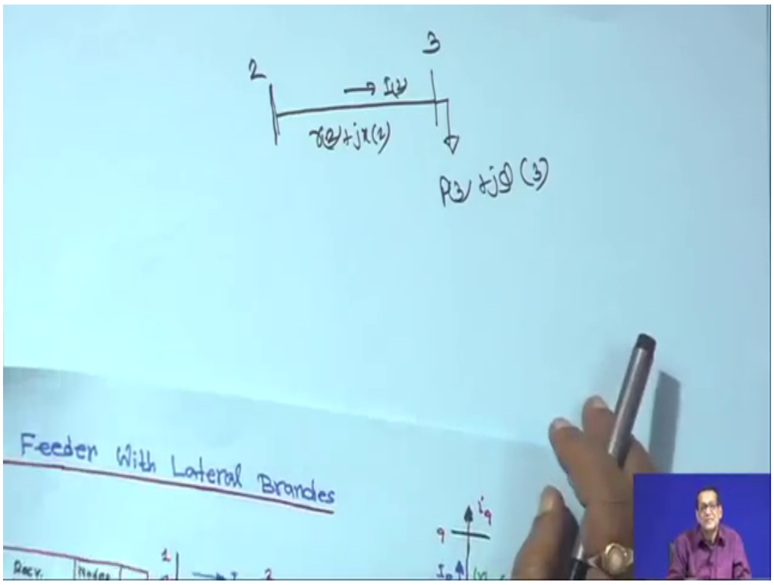

And receiving end node is node 3, and total load fed to this node is p 3 plus a jQ 3 current flowing through this branch is i 2, and impedances is of this branch i 2 plus j x 2 right.

So, this is this is the way the I way I showed for branch 1, this is electrical equivalent of branch 2, now if you think this is the electrical equivalent of branch 2. So, this branch you have this is you forget branch value forget, this is we are taking then what is the total load fed to this node 2, look as soon as your coming to branch 2, we are leaving this is your behind we will see only in only beyond this that is in pond right.

So, whatever p 3 and Q 3 will be that is P 3 should be load of this node say PL 3 plus, PL 4, PL 5, PL 6 plus, PL 9 plus, the loss of this branch 3, branch 4, branch 5, and branch 8, similarly for your reactive load total load fed through this; that means, Q 3 node 3, it will be Q 3 should be load of this node itself QL 3 plus, Q l 4, QL 5, and QL 6 plus, QL 9 plus, loss of this branch, reactive loss of this branch that will reactive loss of the branch 3, branch 4, branch 5, and branch 8, that is that total your p 3 and Q 3 and that is that you are what you calling a meaning of electrical equivalent.

Thank you we will be back.