**Lecture – 33**
Load flow of radial distribution networks (Contd.)

So, next you see that electrical equivalent say of branch 3, each and everything you try to understand this is applicable for lateral branches I have taken applicable main period or lateral branches does not matter exploration will remain same. Now if you consider electrical equivalent of branch 3; that means, sending end node is 3 receiving end node is 4. So, this is 3, this is 4, current flowing through this branch is your I 3, right.

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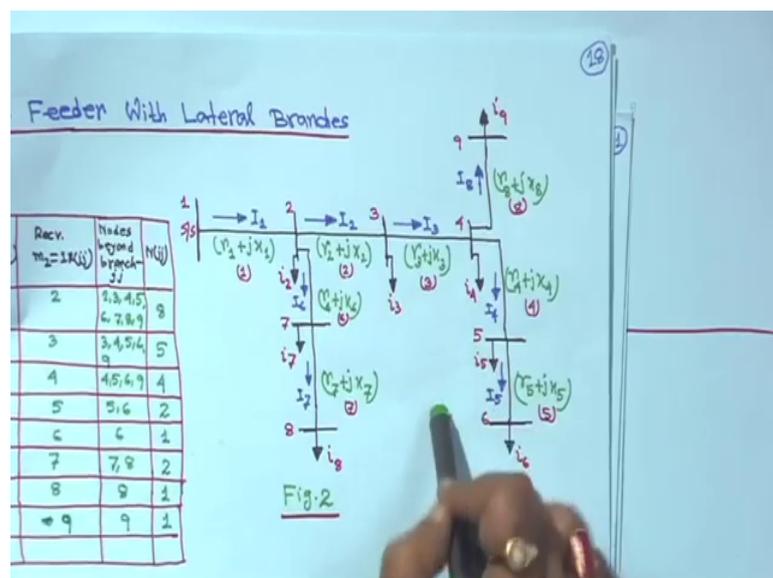
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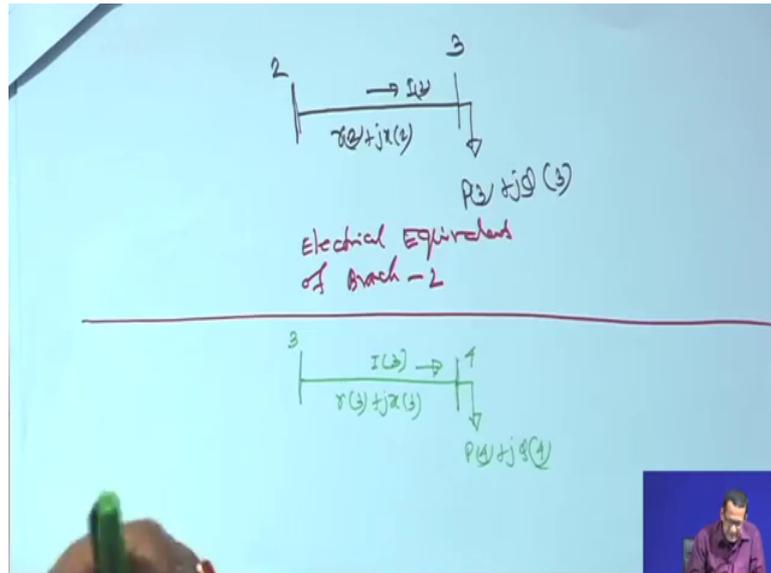
because it is electrical equivalent and total load is receiving end node is your 4. So, total load feeding through this node P4 plus jQ4; that means, if you consider this thing then what is P4 this is the receiving end node what is P4 and Q 4 the total node fed to this node will be P4 will be PL 4 because whenever I am saying I4 means PL 4 plus jQ loads are there. Earlier we have explained also taking main feeder, but here because of the space problem I have not shown, but understandable.

So, P4 will be PL 4 plus PL 5 plus PL 6 plus PL 9 and plus loss of the branch 4 real power loss then real power loss of branch 5 and real power loss of branch 8. Similarly, your reactive load fed through this node that is your Q4 will be QL 4 QL 5 plus QL 6 plus QL 9 plus reactive loss of branch power loss of branch 4 branch 5 and branch 8 that is the total load fed through node 4.

Similarly, if you come to your if you come to node your branch 4 say these branch if you come if you come to this branch right then is sending end node just see it is 4.
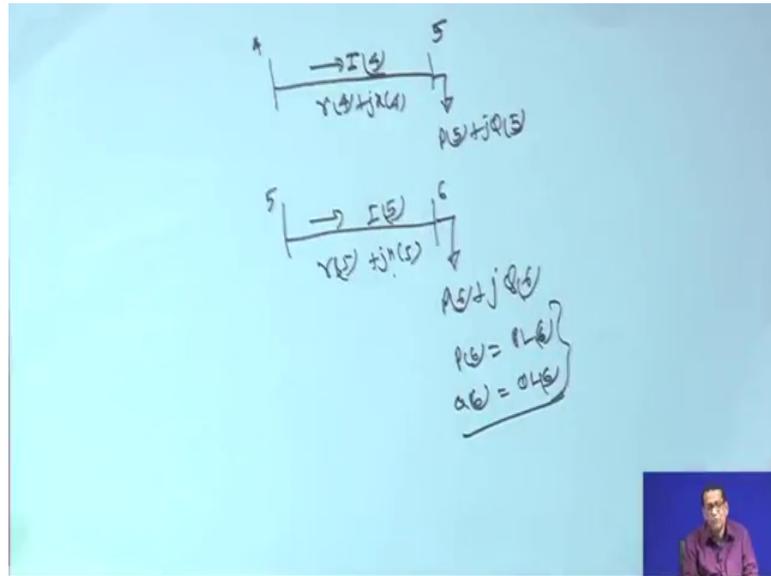
And receiving end node it is 5, this is 4 this is 5 and this is your P5 plus jQ5 there is a total load fed through this and current flowing through this is branch 4 it is I 4 and impedance of this branch is I 4 plus jx 4, this is the electrical equivalent of branch 4 every where I am not writing electrical equivalent, but understandable. So, this is your branch 4 electrical equivalent.

So; that means, what is the total load fed through the node 5 this is actually node 5 what is the total load node 5 is that is P5 will be PL 5 plus PL 6 plus loss of this branch only, because this is that your beyond this branch only this your what you call these 2 nodes are there. So, PL 5 plus PL 6 and loss of branch 5, similarly total load fed through this node will be Q5 will be QL 5 plus QL 6 plus loss of this your what you call branch right?

So, that is that is that is actually you have to find out that what is the total load fed through is done, similarly if you come to this is last one suppose you take this node 5 that is that electrical equivalent of branch 5. So, it is 5 it is 6 total load here fed through this P6 plus jQ6 and current flowing through this is I 5 and impedance of this branch is I 5 plus jx 5, right? So, in this case now this is actually last node beyond this there is no other node or branches.

So, what is the P5 then in this case total load fed sorry it is 5, 6 what is P6 total load fed through these node P6. P6 actually is equal to your PL 6 and Q6 will be just your QL 6 right because this is the last node for example, here load is also there PL 6 plus j QL 6.

So, your pP6 in this case will be PL 6 right or I can put it in bracket here also if you want you can put it in bracket and your Q6 will be is equal to QL 6 a right so; that means, in this case, but no other branches a loss will loss there is no question of adding branch losses. So, any node is coming at the last node total node fed to the node is the load of that node itself. So, that is why for the last node P 6 and jQ 6. So, P 6 is equal to PL 6 Q 6 is equal to QL 6.

Similarly, if you consider the electrical equivalent of branch 8 it is the last node beyond this branch there is no other branch no node, right? So, in that case your P 9 will be PL 9 and Q 9 will be QL 9. Similarly, in this case that branch 7 that 7 and 8 this is the last node. So, in that case P 8 will be PL 8 and your Q 8 will be QL 8 right because there is no other branches so no question of losses this is only for the last node, but all other cases if you take your electrical equivalent of branch 2 to 7 then P 7 will be PL 7 plus PL 8 plus loss of branch 7 they are power loss.

Similarly, total load fed through Q 7 will be your QL 7 plus QL 8 plus reactive loss of branch 7, right? So, this way you have to find out what is the total load fed through each node right? So, I hope this is understand this concept is understandable to you because here concept is more important mathematics is simple, but concept is more important. So now, here if it is electrical.

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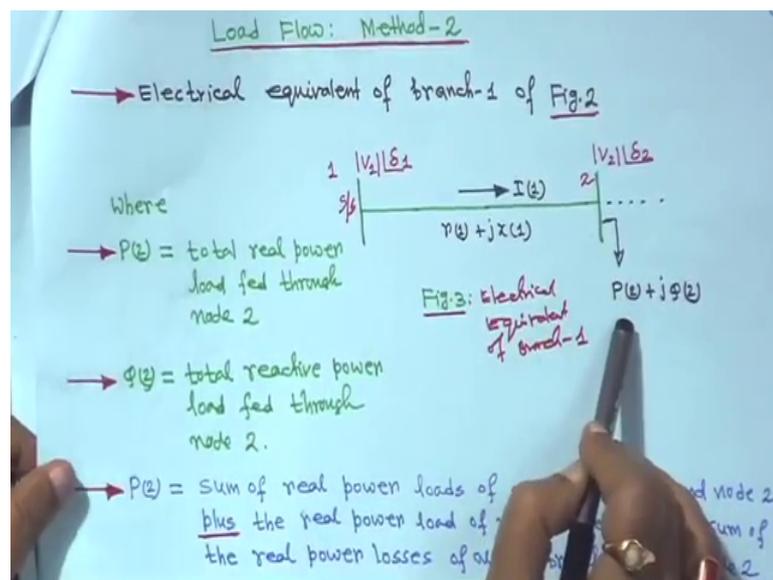
Now, you come to this figure that electrical equivalent of branch 1 because you have to find out some mathematical relationship of V2 voltage V2 and V1 because our objective is to eliminate the angle delta from the mathematical expression. Actually, a similar expression was given I think in the very first your topic that this kind of expression and ask I ask you to derive the expression of the receiving end voltage magnitude, same thing here will make it now for the purpose of this load flow as well as later step I will tell you regarding that voltage stability, right?

So, same thing actually I gave you that rather analyze this thing many of you did it and send it to me through email and I found all of you made it correctly. So, look how I have made it here right? So, this is sending end voltage of course, it is equivalent branch 1, but for generalization will keep V1 delta 1 V1 is the voltage magnitude here. So, again and again magnitude I will not utter and this is V2 angle delta 2 this is the branch current I 1 and this is your impedance r 1 plus jx 1 and this is total load fed through this node 2 when will take the numerical say small numerical at the time whole concept will be very transparent to you.

Now, P 2 is equal to total real power load fed through node 2, right? Similarly, Q 2 is equal to total reactive power load fed through node 2, right? This is Q 2,

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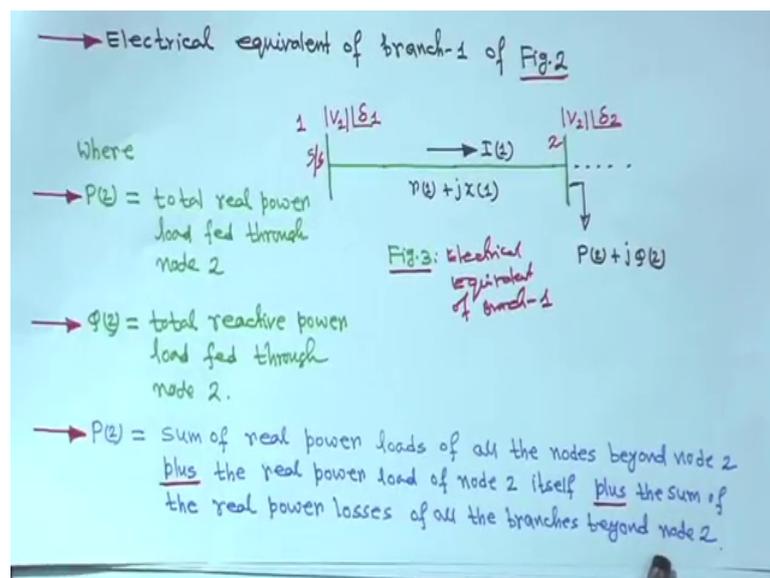
Now what is P 2? Just I told you the P 2 is equal to some of the real power loads of all the nodes beyond node 2 plus the real power load of node 2 itself. I mean I told you

beyond this branch you sum up all the loads beyond node beyond a node 2; that means, this node this node this node this node this node this node and this node plus the node of the node 2 itself that is your PL 2.

So, that is why some of real power loads of all the nodes beyond node 2 plus the real power load of node 2 itself plus you have to go for adding this branch losses these branch these branch these branch this one this one this one this one and this one. So, in general plus the sum of the real power losses of all branches beyond node 2 that mean beyond this node 2 whatever branches are there you have to add their real power losses, right? So, this is actually total load fed through node 2 what is losses how to compute later will come.

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$Q(2) =$ sum of reactive power loads of all the nodes beyond node 2 **plus** the reactive power load of node 2 itself **plus** the sum of the reactive power losses of all the branches beyond node 2.

Table-3

Br. No (ij)	Send. $m_1 = I_S(ij)$	Recv. $m_2 = I_R(ij)$	Nodes beyond branch-ij	$N(ij)$	Branches beyond branch-ij	Total number of branches beyond branch-ij $B(ij)$
1	1	2	2,3,4,5,6,7,8,9	8	2,3,4,5,6,7,8	7
2	2	3	3,4,5,6,9	5	3,4,5,8	4
3	3	4	4,5,6,9	4	4,5,8	3
4	4	5	5,6	2	5	1
5	5	6	6	1	0	0
6	2	7	7,8	2	7	1
7	7	8	8	1	0	0
8	4	9	9	1	0	0

Similarly, Q 2 is equal to sum of reactive meaning is same only instead of real power will replace the real what real by reactive rest is same. So, Q 2 is equal to sum of reactive power loads of all the nodes beyond node 2 plus the reactive power load of node 2 itself plus the sum of the reactive power losses of all branches beyond node 2; that means, they are same as before so this is your total load fed through reactive power load fed through node Q 2 is equal to sum of all the reactive load of all the nodes plus reactive load of the node 2 itself plus all the reactive power losses of this one this one this one this one, I mean beyond this node 2 whatever number of your what you call or beyond this branch

whatever number of your nodes are there you will branches are there just you identify and add their losses with that therefore, that is your Q 2.

Now, here for load flow studies here we have to make little bit of different in this case we have seen that how many nodes are there beyond each branch right? Now we have to find out how many nodes are there branches are there also beyond your each branch then our job will be simple. So, for this for the same diagram right such that your what you call same diagram I have taken such that it will be easy for you to understand.

These are the branch number there are 1 to 8 branch number that we have seen sending end node m 1 is equal to isjj m 2 is equal to IRjj that we have seen 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 6, then 2 to 7 that is your 2 to 7, 7 to 8 and then 4 to 9, 2 to 7, 7 to 8 and 4 to 9. This were make it nodes beyond branch jj all these things have been explain in the previous table and detail explained these are the nodes beyond branch jj.

So, beyond each branch how many are they are here it is their same thing I have copied it here same thing here and number of nodes beyond each branch here also given 8, 5, 4, 2, 1, 2, 1, 1 here also same thing up to this it is same right? After that branches beyond branch jj; that means, beyond this the each branch for example, beyond these branch how many branches are there their numbering and number their total number of branch and their numbering branch number and total number right beyond this branch how many branches are there, because why you do we need the branches because we have to identify the branches beyond each branch because we have to find out the power loss is real and reactive power loss is in each branch that is why it is your what you call you have to know the branches beyond each branch right?

So, that is why this another 2 columns have been made. So, for example, branches beyond branch jj right, when branch jj is equal to 1 branch jj is equal to these are the branches beyond in the bracket that is in red color 2 3 4 5 6 7 and 8 right these are the branches. So, 2 3 4 5 6 7 and 8. Then beyond branch 2 what are the branches branch 3 4 5 and 8. So, beyond this branch 2 these are the branches beyond branch 3 4 5 and 8 similarly beyond branch 3; that means, you are this branch beyond your branch 3 here it is how many branches are there 4 branch 5 and branch 8.

So, beyond branch 3 it is 4 5 and 8 total branch it is 3 previously it was 4 and first one it was 7, right? Similarly, beyond the next is beyond branch 4. So, this is your branch 4

beyond branch 4 how many branches are there only 1 branch is there. So, this is branch 4. So, come to that only one branch is there is number is branch 5 this is branch 5, right? And only 1. So, it is one here your what you call here it was given njj that is the number of nodes beyond branch jj here space was not there I did not write, but Njj is explained before same thing right same thing and this is total number of branches beyond branch that is bjj we are making it right?

Similarly, if you come to your branch 5, then it is 5 to 6 then what is beyond this branch there is no branch actually 0; that means, if you come to branch 5 there is no branch. So, it is 0. So, number of branch is also 0 similarly if you come to branch 6, 2 to 7 that is your 2 to 7 there this is the branch beyond this branch only one branch is there. So, 2 to your what you call 2 to 7 that is branch 6 7 8 there are 2 nodes 7 and 8 2 nodes and only 1 branch that is your branch 7. So, bjj is 1, right?

Similarly, if you consider branch 7 that with these branch beyond this branch there is no branch; that means, 0 branch; that means, bjj will be 0. So, if you look at branch 7 it is 7 to 8 up to this is known all this up to this was they are previously, but as beyond this branch there is no branch it is 0 therefore, bjj will be 0 similarly if you come to last one the branch 8; that means, this one beyond this branch there is no branch right that mean bjj here also will be 0 and number of branches also 0.

So, therefore, it is if you come branch 8 the branches beyond this branch 8 it is 0 therefore, bjj is 0; that means, this 2 additional table you have to make it for the second method of the load flow this one will remain as it is, but these 2 additional data you have to feed to the computer, but this branches identification node identi of all algorithms are available, but I thought rather than that one this will be very easy for you to understand right?

So, if you want how to identify you can think and you can make the algorithm, but here I am not trying it right there are couple of algorithms are there that how to identify the nodes and or the way you want, but here these are the data I mean for this load flow second method all the data you need to feed into the computer right? So, this is your total load fed through any node concept right therefore, for this case ejjk that is matrix will remain same this ejjk matrix.
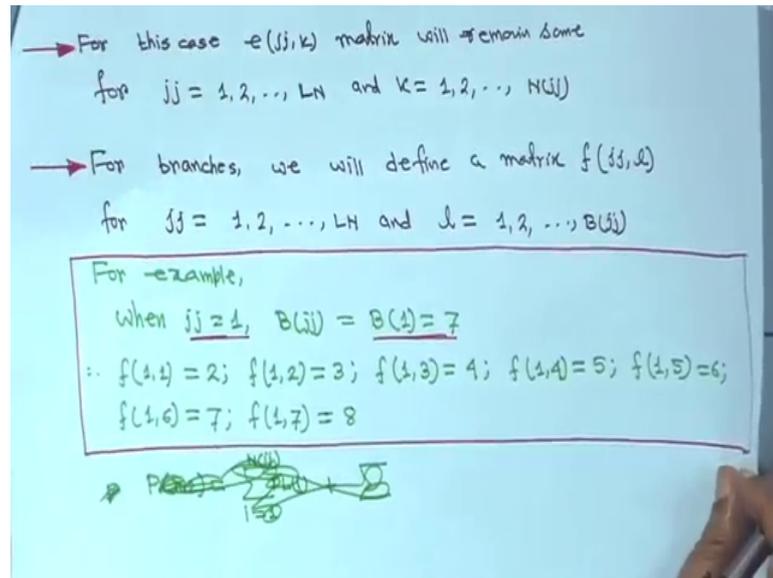
We have previously defined for jj is equal to 1 to up to ln the total number of your branch number and for k is equal to 1 to njj this ejj matrix we will remain same and we have seen how to make it right?

Now, this one you have to see proper branches we will define a matrix a fjjl right, will define a previous 1 was your ejjk and this one is the matrix fjjl, for jj is equal to 1 to up to branch number ln and l is equal to 1 to up to your bjj; that means, this one; that means, your this one this data you have to feed to the computer; that means, this one that this one this bjj right this one you have to you have to make it in the tabular form right therefore,. So, for the other matrix fjjl therefore, jj is equal to 1 to ln right and l is equal to 1 to up to bjj.

So, for example, when jj equal to 1 suppose in branch number jj is equal to 1 bjj is equal to b 1 is equal to 7 therefore, bjj is equal to b 1 is equal to 7; that means, for jj is equal to 1 it will be f 1 l right and l will vary from 1 to your 7. So, you can make it that f1 1 is equal to 2 here it is given f1 is 2, f1 2 3, f1 3 4, f1 4 5, f1 5 6, f1 6 7 and f1 8 is equal to a f1 7 is equal to 8, right?

So, this matrix 1 2 3 4 all you have to read it that a matrix this data you have to create and you just put it in computer this data you have to make it. Similarly, when jj is equal to 2 right? So, m1 this thing your total number of beyond branches beyond branch 2 it is basically 3 4 5 8 and bjj that is b 2 is equal to 4 right; that means, you are ah just hold on

this one after I think this one I have explained later here I have made it, I have explained it later before that what I have done it, you that your that total load fed through this know your what you call fed through this node Pm 2 this expression.

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I first I have shown this one so f 2 to I will come your f 2 l matrix I will come later. So, this a Pm 2 that is the total load fed through receiving end node. So, m 2 is equal to IRjj these you write k is equal to 1 to njj. PL ejj k matrix earlier we are writing I/ ejjk that therefore, first method in this case PL ejjk plus l is equal to 1 to bjj the number of branch P loss f jjl this is equation 38. This equation will be slightly changed first you understand then this equation will be slightly different right?

Similarly, total reactive power load fed through the receiving end it is generalized equation Qm 2, m 2 is equal to if it is IRjj is equal to jj 1 then m 2 will be 2, right? So, in general Q m 2 is equal to IRjj is equal to k is equal to 1 to njj QL in bracket you put ejjk this matrix your element will remain same as before. So, no or not explaining this one right plus l 1, l is equal to 1 to bjj Q loss fjjl this is equation 39 for example, this this this element we have taken f1 1 f1 2 and so on.

So, when jj for jj is equal to 1 branch ,1 m 2 is equal to IRjj is equal to IR 1 is equal to 2 this is the receiving end node this is the this is the receiving end node m 2 it is equal to 2 therefore, you are what you call an njj n 1 is equal to 8 from this table we have seen that

n your njj is equal to 8 this is for your n 1 is equal to 8 in this case right and similarly your for jj is equal to 1 b 1 is equal to 7 bjj is equal to b 1 is equal to 7.

Therefore, bjj is equal to b 1 is equal to 7 therefore, this expression when m 2 is equal to 2, P2 is equal to k is equal to 1 to n 1 because jj is equal to 1 n 1 is equal to PL e 1 k this will be similar to your previous load flow method only instead of I it is PL right, plus your l is equal to 1 to b 1, b 1 is equal to 7 P loss f1 l, now you expand this you expand this right? If you expand this what will happen? This one same as before it will come 2 3 4 like this.

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So, directly I am writing PL 2 plus PL 3 plus PL 4 plus PL 5 plus PL 6 plus PL 7 plus PL 8 plus PL 9 this is I am writing directly plus this your this f matrix when we expand this it will be f1 1, f1 2, f1 3 and so on. So, here all these elements I have to given you f1 1 2, f1 2 3 and so on. So, if you expand and substitute all these it will become P loss 2 plus P loss 3 plus P loss 4 plus P loss 5 plus P loss 6 plus P loss 7 plus P loss 8 1 step I have just not written because earlier this way I have explained for I; that means, in this case for example, in this case your if we expand this if first term will be P loss in bracket f1 1, but you are f1 1 2 it will be P loss 2 second term will be your P loss f1 2. So, f1 2 is 3. So, it will be P loss 3 and so on, right? That is why it is P loss 3 and so on this is equation 40.

Similarly, for equation 39 Q 2 will be QL 2 plus QL 3 plus QL 4 plus QL 5 plus QL 6 plus QL 7 plus QL 8 plus QL 9 plus all the branch accordingly will come QL loss 2 plus

Q loss 3 plus Q loss 4 plus Q loss 5 plus Q loss 6 plus Q loss 7 this is equation 41. Now for jj is equal to 2 now we will come to that for jj is equal to 2; that means, this branch right for jj is equal to 2 right your m 2 is equal to 3 receiving end node that is for jj is equal to 2 m 2 is equal to 3 because it is m 2 is equal to IR 2 is equal to 3. So, m 2 is equal to 3 and njj is equal to n 2 is equal to 5 this is already there this we have done same as before, but for the branches it will be branches beyond there are 4 branches 3, 4, 5, 8 and Bjj is equal to b 2 is equal to 4. So, Bjj is equal to b 2 is equal to 4.

Now, fjj matrix l means f 2 l and your l bearing for l is equal to 1 2 to b 2 that is 1, 2, 3, 4 there are 4 elements. So, f2 1 is 3, f2 1 3, f2 to 4, f2 3 5 and f 2 4 8, right? So, these are all 4 elements.

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So, that means from equation 38; that means, this equation directly you use this value that this equation right, after this we have given or the generalized equation for this one this your this equation these equation 38 this equation 38 right equation 38 similar this equation 39.

So, equation 39 you put those things you will get P3 is equal to PL 3 plus PL 4 plus PL 5 plus PL 6 plus PL 9 at the same time you look at your what you call and the diagram figure that whatever from figure you have taken and you verify plus P loss 3 plus P loss 4 plus P loss 5 plus P loss 8 this is equation 42. Similarly from equation 39 Q 3 is equal to QL 3 plus QL 4 plus QL 5 plus QL 6 plus QL 9 plus Q loss 3 plus Q loss 4 plus Q loss 5

plus Q loss 8 this is equation 43, this is for branch your what you call branch 2 and for jj is equal to 3 branch 3, m 2 is equal to IRj is equal to IR 3 is equal to 4; that means, for branch 3 you are receiving end node is 4 these are same here you have 3 nodes beyond branch 3 and total branch is 3. So, b bjj b 3 is equal to 3, right?

So, in this case also m 2 is equal to 4 n 3 is equal to sorry m 2 is equal to 4 n 3 is equal to 4 and your bjj is equal to your b 3 is equal to 3. So, fjjl so, jj is equal to 3 f 3 l matrix for l is equal to 1 2 b 3 that is just 3 elements 1, 2 and 3. So, no need to put comma here it is 3 elements only. So, no need to put it dot, dot, dot. So, 1, 2, 3, 3 elements are there right therefore, P4 will be using the same again from equation 38 this P4 equation 38 Q for equation form equation 39.

So, P4 is equal to PL 4 plus PL 5 plus PL 6 plus PL 9 and plus P loss 4 plus P loss 5 plus P loss 8 right and these elements are given here f31 is 4, f3 2 5, f3 3 8, it is given here this is 4 5 8 this 3 events are here right. Similarly, Q 4 QL 4 plus QL 5 plus QL 6 plus QL 9 and this 1 plus QL loss 4 plus 3 bunches are there 4 5 and 8. So, Q loss 4 plus Q loss 5 plus Q loss this is equation 45 and this one equation 44, right?

So, from this I mean, I hope this thing is very easy for you to understand, right. similarly, when jj is equal to when jj is equal to 4 not go into the diagram again and again because this is understandable.

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Now m 2 receiving end node is 5 and njj n 4 is 2 same as before and in that case Bjj b 4 is 1 that is only 1 element right. Therefore, fjjl f 4 l. So, l is equal to just 1 2 b 4. So, it is only 1 element else is equal to 1 therefore, f 4 1 is equal to 5 therefore, from equation 38 P 5 is equal to PL 5 plus PL 6 plus P loss 5 this is equation 46 and from equation 39 Q 5 is equal to QL 5 plus Q loss 6 plus Q loss 5 this is so from this f matrix branch you can see that how important it is and how it is easy it is to find out all the load fed through the node receiving end node of each branch right?

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Similarly, when jj is equal to 5 m 2 is equal to IRjj IR 5 is equal to 6. So, njj is equal to n 5 is equal to 1 so bjj is equal to b 5 is equal to 0 that is no branches beyond this so; that means, P 6 I just showed you before also I explained you that P 6 will be PL 6 Q 6 will be QL 6 this equation 48 this is equation 49 because there are no branches beyond branch 5. So, it will be like this so in this case b 5 is 0 means that second term of equation 30 it and 39 will not exist then only single term I come to that later.

When jj is equal to 6 m 2 is equal to your IRjj IR 6 is 7 and njj is equal to n 6 is equal to 2 this is same as before and Bjj is equal to b 6 is equal to 1 from the table only you can check right? So, fjjl is equal to f 6 l that is l is equal to 1 so only 1 element f 6 1 is equal to 7 therefore, P 7 is equal to PL 7 plus PL 8 plus this P loss 7 because this element is 7 branch this is f 6 1 is 7 branch 7. So, and Q 7 is equal to your QL 7 plus QL 8 plus Q loss

7. So, this is equation 51 these 2 equations are same this is for P and this is for q, but addition everything even same right same term.

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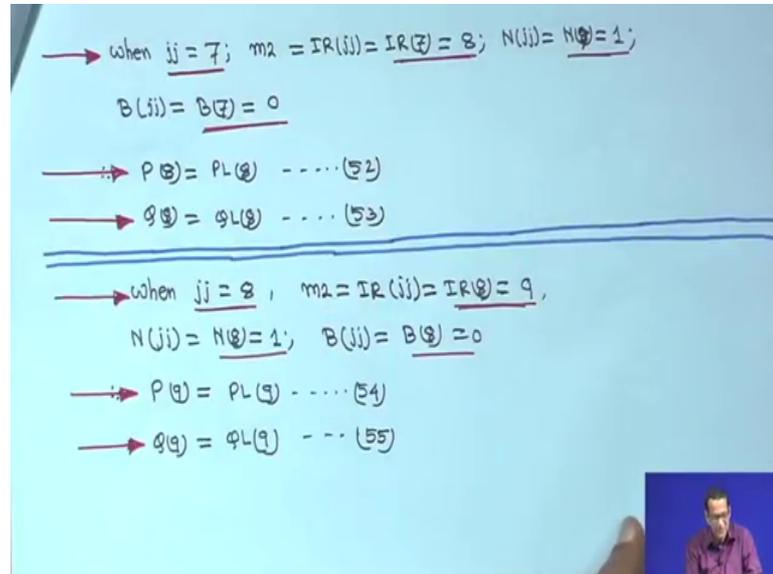
When jj is equal to 7 so m 2 is equal to IRj IR 7 is equal to 8 these are this is that your last bunch of lateral branches njj is equal to your n 7 is equal to 1 right and your Bjj is equal to b 7 0 because beyond this branch there is no other branch. So, P 8 will be is equal to PL 8 and Q 8 will be QL 8. So, second term of equation 38 and 39 will not be there because there is no other branch beyond this right? And when jj is equal to 8 the last branch m 2 is equal to IRjj is equal to IR 8 is equal to 9 right then will this one show you once again this branch these branch and in that case also n 8 it is 1 njj is equal to n 8 Bjj b 8 0 because beyond this branch also there is no branch right therefore, P 9 I told you P 9 total load fed through PL 9 and Q 9 will be QL 9. So, Q 9 will be QL 9 this is equation 54 and this is equation 55.

So, thank you we welcome.