Fundamentals of Electrical Engineering
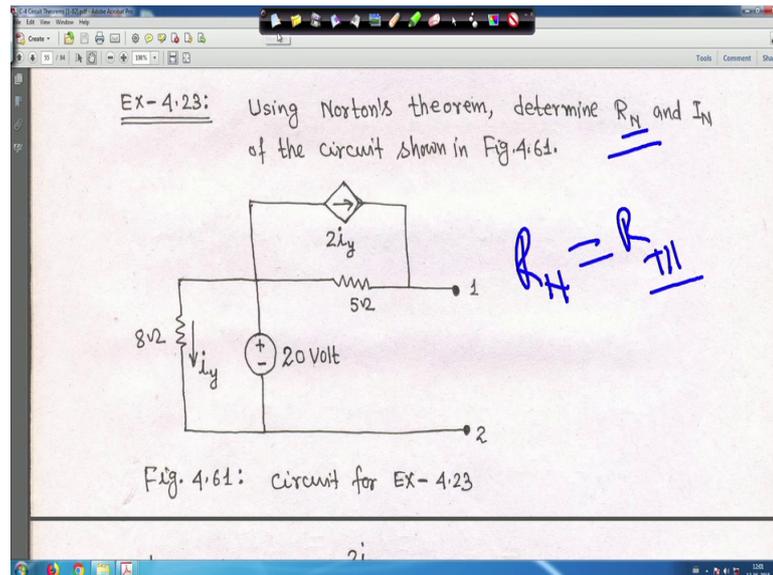**Prof. Debapriya Das**
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Lecture – 24
Circuit Theorems (Contd.)

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So, we will come few you know another example using Norton's theorem, we have to determine that you are R N and I N, actually I we have discussed earlier this R Norton actually it is nothing but your R Thevenin right, so that we have discussed earlier. So, the way we have obtain Thevenin resistance same way Norton so there is no change there.

So, actually we have discussed so many problems right. So, now your what you call that understanding the things will be easier, and I will looking at that you can make out. First thing is that that when will when you have a dependent your sources in the network, you just cannot put them off right, only independent sources can be put it off.
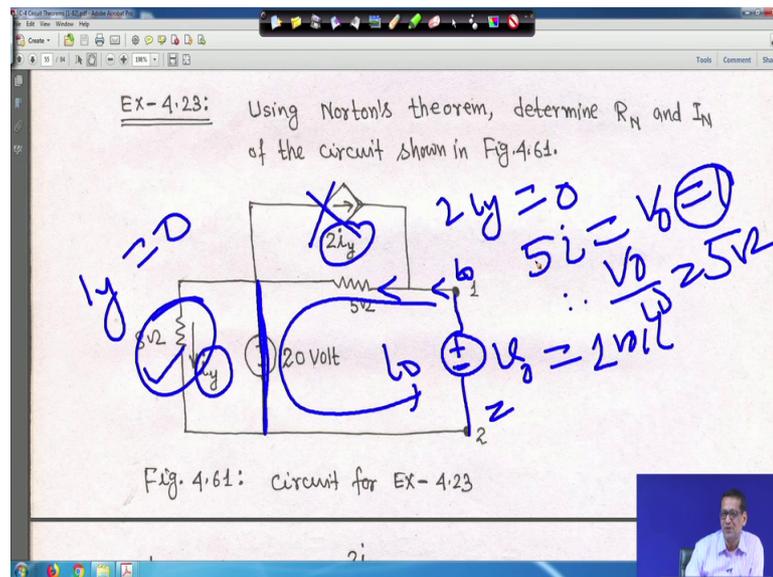
So, if you do so for example, later solutions are there for example, suppose if we want, that we want to find out on this circuit, if you want to find out that your R Norton that is R Thevenin right, so dependent source is there; so we can connect a say a voltage source say this is plus minus right. And you connect a voltage source; say v 0 is equal to 1 volt right. And in that case, what we have to do is, we have to sort this because, dependent sources has to be turned off.

So, if in the case of voltage source, we have to sort it; if you do so, now what will happen now as soon as suppose this current is suppose these current say I 0 this current is I 0 right. Coming from this voltage source, as soon as you short it, so what will happen the current actually will flow through this circuit will flow through this circuit, but there will be nothing here, because it is a short circuit path, so naturally current will not flow through this, that means, your i y will become 0 right. If i y is become 0, then this part it is 2 i y that is also 0, because i y is equal to 0.

So, basically I 0 will be flowing only here, so that means, circuit will be this current I 0 will be like this because this is also then this is also will not be there. And because this path is short and as this path is short so current will take this place. So, there will be no current here i y is equal to 0, because it current generally flows through a flows through the short circuit path. So, there will be nothing here. So, this is also not there. So, i y 0, so this is 0 basically circuit remains only this part.

If that means you are basically 5 i is equal to your V 0 right sorry 5 i is equal to V 0 is equal to 1 right; that means, your V 0 by i 0 is equal to 5 that is 5 ohm right, because V 0 your v anyway V 0 is equal to 1. But if we do not put 1 this we take only V 0 does not matter, because relationship we are getting V 0 is equal to 5 i 0; that means, V 0 by i 0 is equal to 5 let me clear it; that means, rewriting although you put your V 0 is equal to 1 volt does not matter it is 5 ohm.

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So that means, R Norton is same as R Thevenin is equal to your 5 ohm right. So this is your, what you call to get R Norton. So, this as soon as you sort it, there will be no current through this if you put a voltage source, and dependent, independent source you put it turn it off right, so this is your how we get R Norton.

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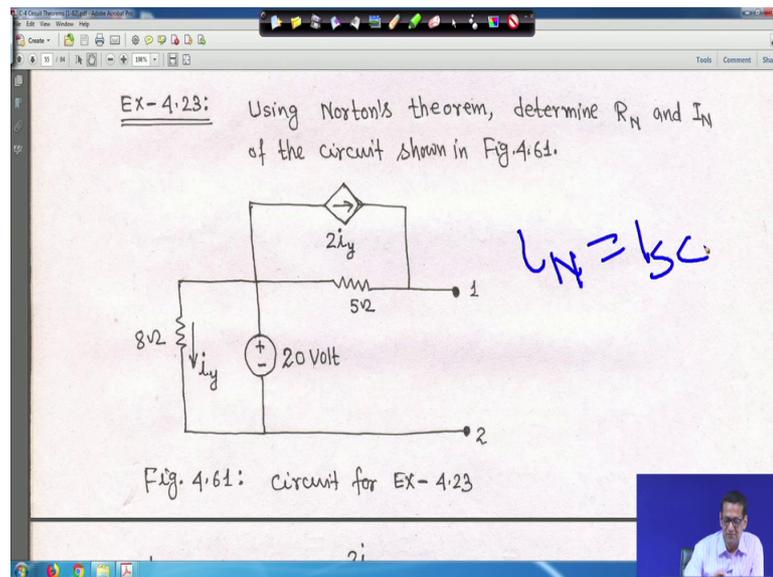
And for getting your, i N that is your Norton current i N is equal to your i SC to get this Norton current, we will draw the circuit later.

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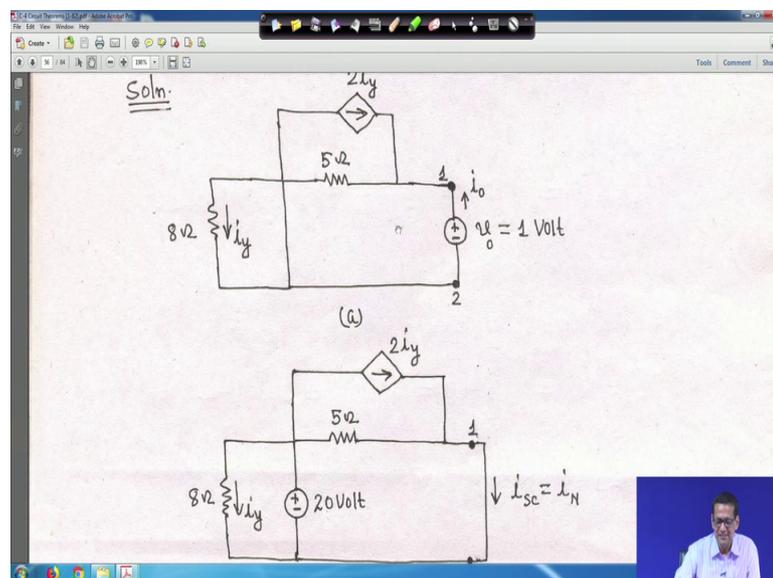
So, in this here we have put v 0 is equal to 1 volt. Actually here v 0 if you do not put 1 volt, does not matter 1 volt, 2 volt, 3 volt it does not matter, basically you have to obtain v 0 by i 0. And this we told you that how we will get your R N is equal to 5 ohm. And now, when it is sorted this you have to find out that your what you call that short circuit

current. So, in this case in this case your what as it is sorted suppose for example, current flowing through this say current flowing through this say it is your i right.
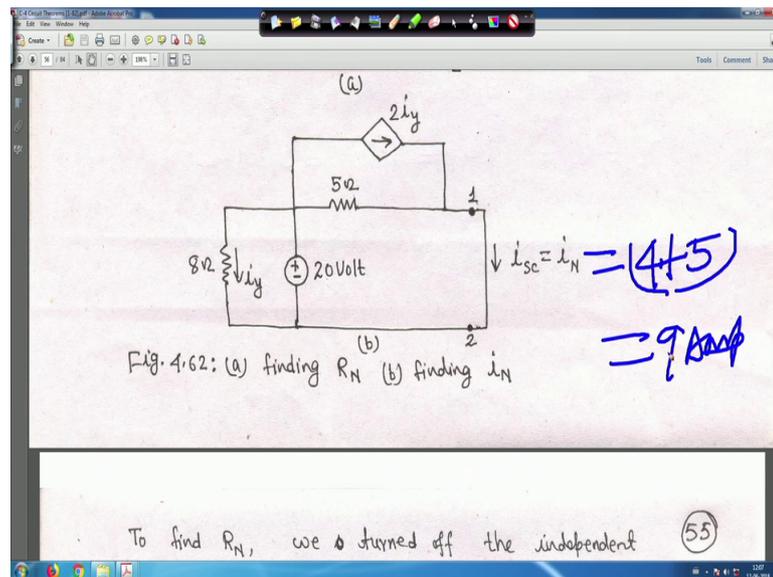
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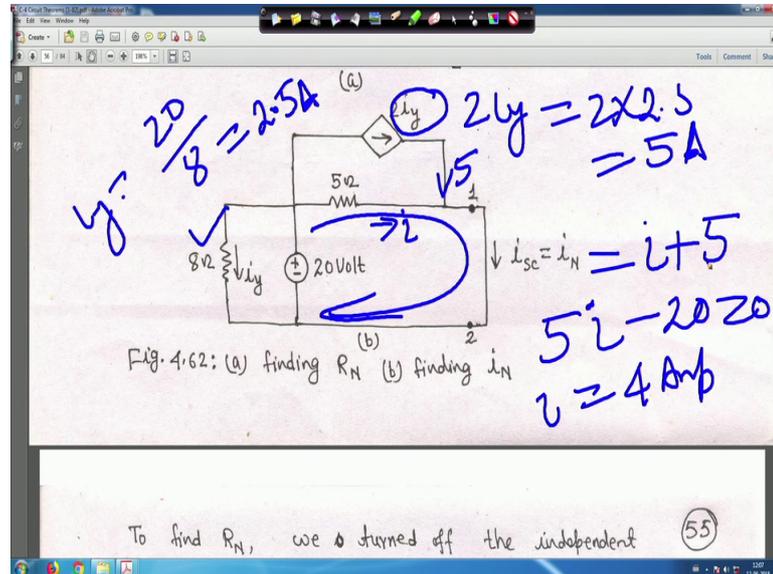
Now, as it is sorted and this 20 volt across this 8 ohm resistance so, in this case what will happen then what will be your i y, your i y is equal to 20 divided by 8 that is equal to your 2.5 ampere right, so 2.5 ampere. So, if i y is equal to 2.5 ampere then this is that dependent current source 2 i y, so it is 2 i y is equal to 2 into 2.5 that is your 5 ampere right that is your 5 ampere. So, question now question is that so here it is your, what you call 5 ampere current is entering right.

Now to get your this i value right, to get the i value, so this is this is 5 ampere; that means, your i SC is equal to i Norton; if I write from here, it will be basically i plus 5, so we have to obtain i. So, to get this what you do apply here K V L. So, it is simply 5 i it is simply 5 i minus 20 is equal to 0 that means, your i is equal to 4 ampere that means, i SC is equal to i Norton is equal to 4 plus 5; that means, 9 ampere right. So, I am so how things are i think things are understandable to you. So, if we clear it that means, this one actually your 4 and plus 5. So, that is your i Norton that is 9 ampere right.

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Fig. 4.62: (a) finding R_N (b) finding i_N

$\downarrow i_{sc} = i_N = (4+5)$

$= 9 \text{ Amp}$

So, hope these things are understandable to you. So, that is what has been done here.

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So, all this write up is here, you can go through of your own; but i have explained everything right, all this write up is there you can go through. The way I told, same way it is written right. And so i y that your R N is equal to 5 ohm, I told you how to compute. Here I have taken v 0 is equal to 1 volt, no need actually v 0 by 1 0 directly we will get 5 ohm right; 1 volt, 2 volt whatever you take right, it will become 5 ohm.

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And similarly, this one I told you that through 8 ohm resistance 2.5 ampere. And this one also I told you, 4 plus here much detail in written, but they are K C L we applied and showed you how to get it; so this is 9 ampere. So, i Norton is equal to i short circuit current is equal to 9 ampere. So, everything is understandable to you.
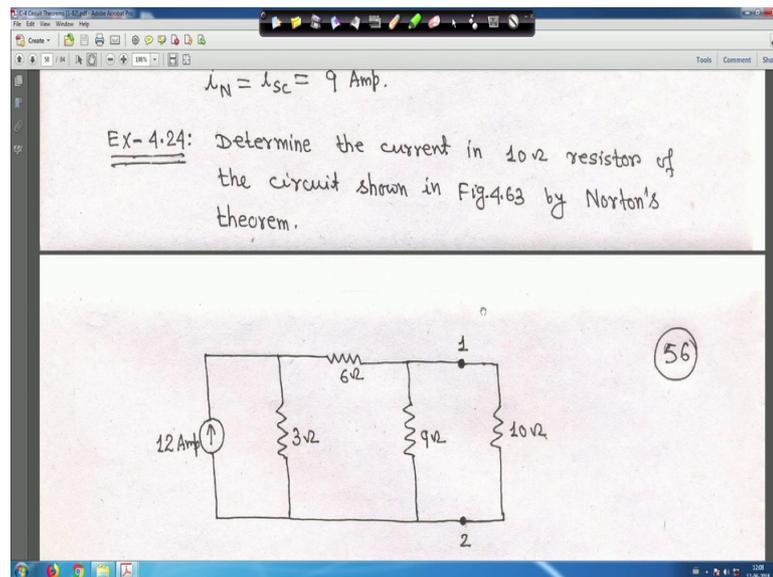
Next one is determine the current, in 10 ohm resistor of the circuit shown in see figure 63 by Norton's theorem. So, you have to find out the current through this your what you call this 10 ohm resistance right using Norton theorem. So, first thing is that you have to what you call, you have to first take the 10 ohm out, then you have to go for your what you call that your finding out your R N and your i SC, i N short circuit current right. So, what you can do is that to find out this short circuit current, this is the circuit you have to find out you have to find out, your short circuit current.
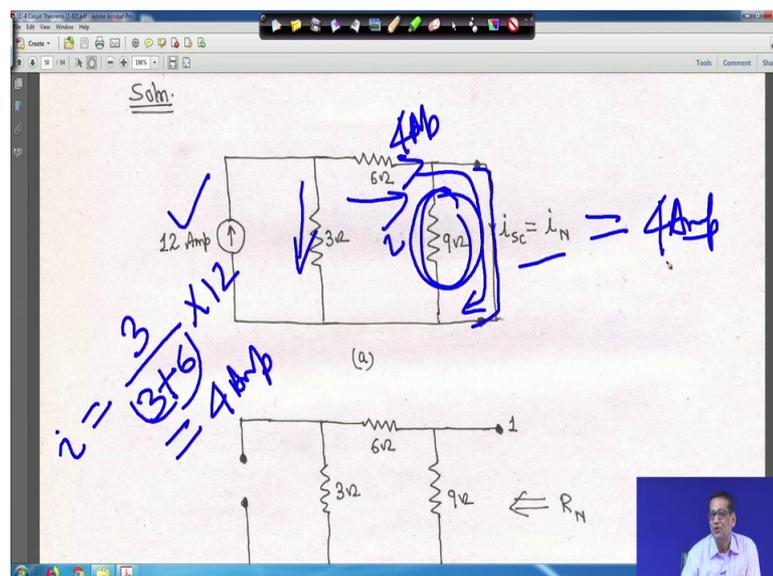
So, this i SC is here right, look how will how we will do it. So, this is short circuit. So, 10 ohm is out now. Now, this is 12 ampere. So, find out the your current through this branch, and current through this branch right. Say for the time being, our interest is current through 6 ohm resistance say your this i. So, using current division method using current division method, your i will be is equal to i will be is equal to this is we want to find out the current through your 6 ohm resistance; that means, 3 divided by 3 plus 6 into this 12 ohm 12 ampere that independent current source is there. So, into 12 ampere right; so it becomes 4 ampere; that means, this i current flowing through this i is 4 ampere right.

Now, this is shorted this path is shorted right, that means this 9 ohm nothing will flow, because this 4 ohm 4 ampere current will take this path will take this path. So, there will be no current in 9 ohm resistance, so current is 0, because this is short circuit right, that means i SC is equal to i N will be is equal to 4 ampere. So, this is this little bit thing we have to understand simple thing, but as it is short circuit. So, there will be no current through 9 ohm resistance all current will go through this short circuit path, that means this 4 ampere current will flow through this short circuit path. So, i SC is equal to i N is equal to 4 ampere. Hope it is understandable to you.

Next that R N or R that R Norton is equal to your R Thevenin same thing. Next this current source, it is independent current source; so, turned it off, but means it will be open circuit right. And you have to find out R N in between your 1 and 2. So, so this 6 and 3 right, so if you look into that this is open. So, 6 and 3 they are in your series. So, 9 and 9 they are in parallel.
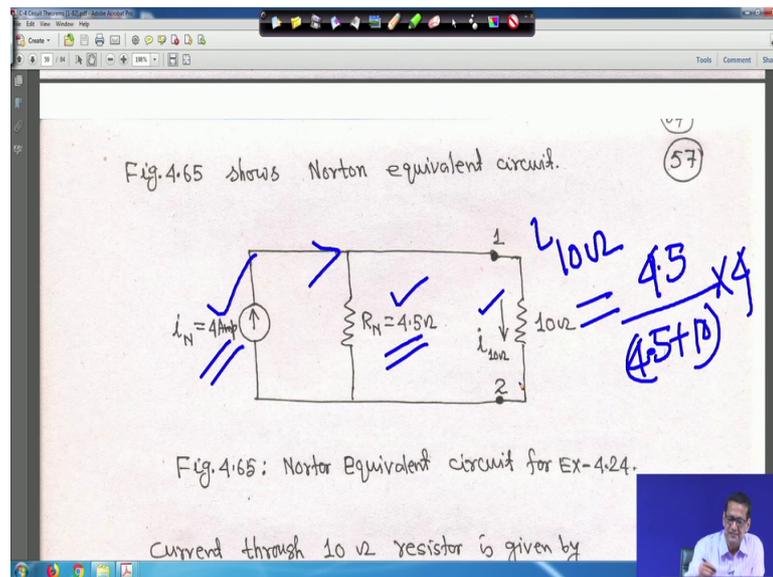
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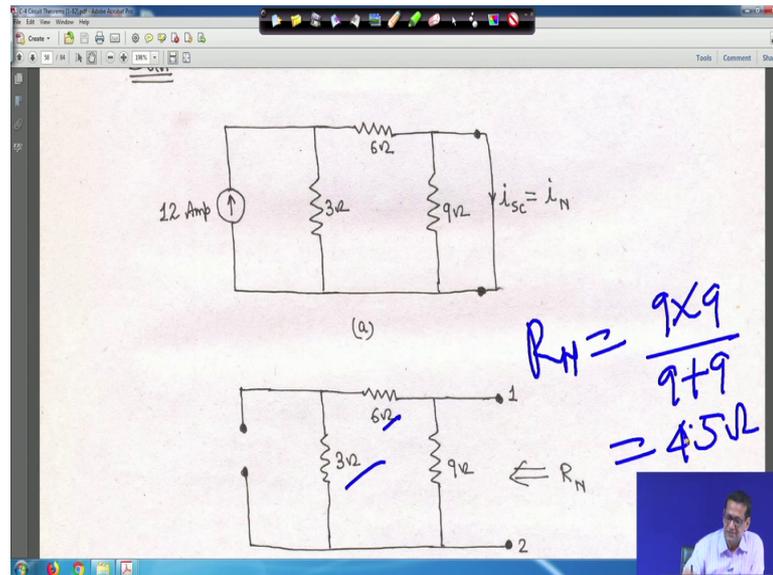
So, basically your R N will be is equal to your 9 into 9 by 9 plus 9 that is your it will become 4.5 ohm 4 4.5 ohm right, so that is your R N. So, basically 9 by 2 so, that means R N we got, so 4.5 ohm.

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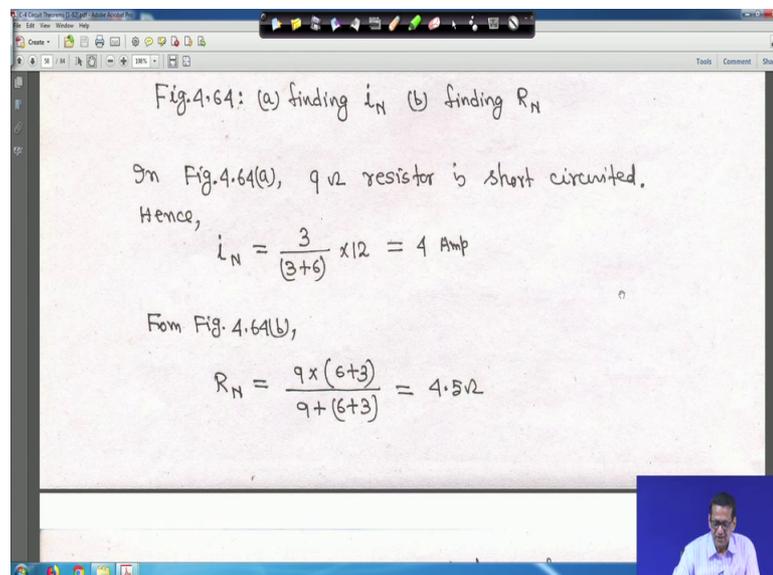
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Now, look at the equivalent circuit. Thevenin's theorem we have seen that V Thevenin and R Thevenin are in series; here we here your i N we have got 4 ampere, and R N we have got. And now this now 10 ohm is connected across your this R Norton right. So, in that case, you can easily find out that what is your now i 10 through current division, it is written i 10 ohm, that means current through 10 ohm resistance. So, i 10 ohm i 10 ohm is equal to that is your this is your 4 ampere current right, this is the current source, this 4 ampere.

So, current division method, so i 10 is equal to your 4.5 divided by your, because these are this in parallel. So, 4.5 plus 10 right into this 4 ampere, whatever it comes that will be your i 10; this numerical value is given below right, that is your current through this 10 ohm resistance. So, let me clear it. So, this is your, it is it comes actually 1.241 ampere right.
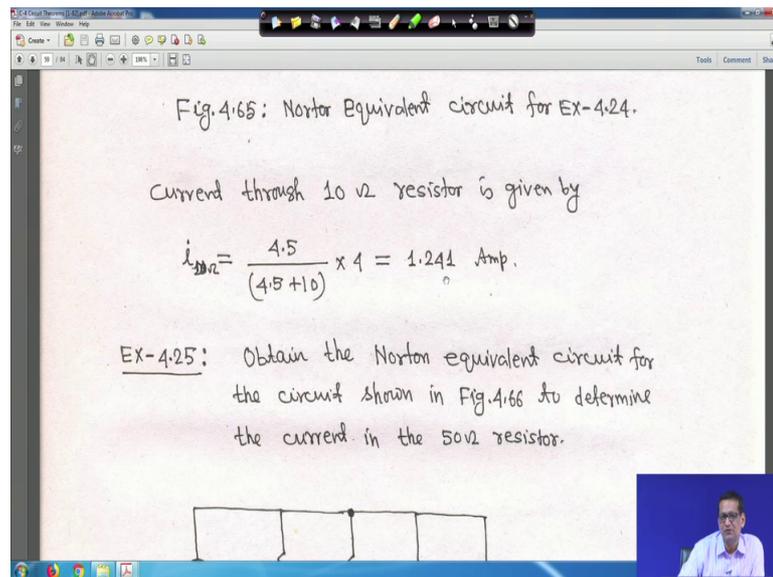
Another one is next one, you take hope things are understandable to you right.
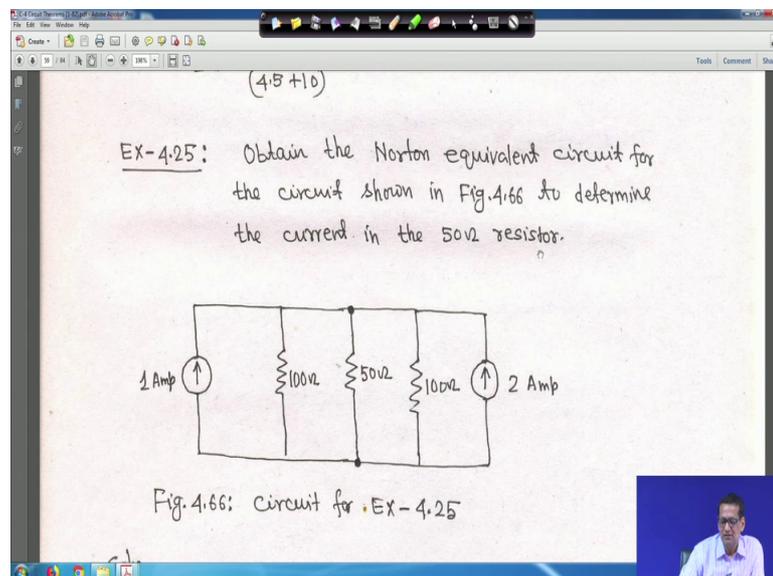
So, obtain the Norton equivalent circuit of the circuit shown in figure your 66 right, we have to find out to determine the current in the 50 ohm resistance right. So, we have to current find out the current through this 50 ohm resistance. So, we have to find out your what you call that your short circuit current, you have to find out R N and i N; i N is equal to i SC the short circuit current right. So, first you have to find out the R N and your what you call that your i SC or i N. After that with that R N all your i SC that

current source then R N, and then this 50 ohm all will be in parallel basically right. So, let me clear it.

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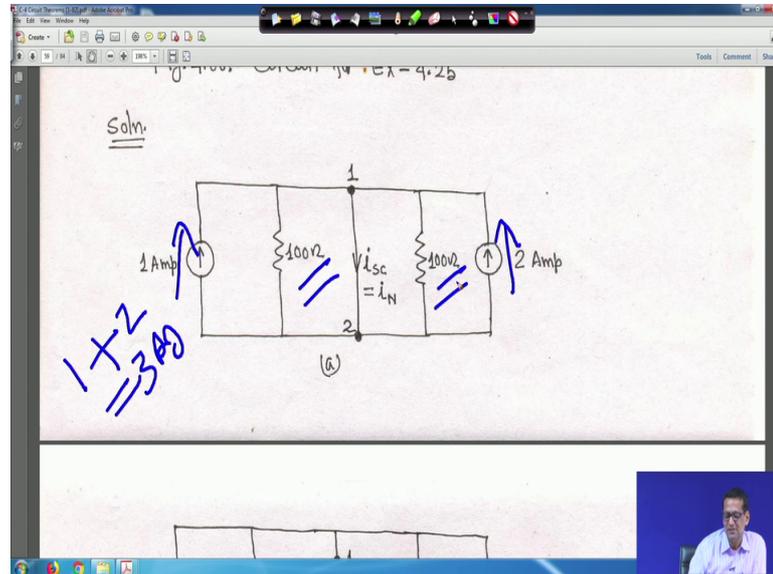
So, let us move to this now. To get this your short circuit current, this is shorted this is shorted right. So, question is that that what then how they another thing is to get the your R N this two current source turned off, and this is open right. So, here if you look into that, that your i SC is your shorted. And at the same time this 2 ampere just look into this; this 2 ampere, it is upward right; and this 1 ampere, it is also upward.

So, their resultant is 1 plus say 2 is equal to 3 ampere, and it is showing the direction is given this way upward right. And this is sorted, this is sorted and this 3 ampere is there that to so basically if you look into this circuit, so basically it what will happen at these two things are sorted. So, this 100 ohm and 100 ohm actually they are in parallel right. So, in that case that what will be your this thing whatever I mean whatever what will be your short circuit current right. So, that is i SC.

Now, now let us go to here right. So, both 100 ohm resistors are short circuited and i SC is equal to i N 1 plus 2 3 ampere right. And for as soon as it is open it is in parallel, so what is happening here that your this one as this path is sorted. So, this 1 ampere current will be flowing like this. So, because it will this current will not flow through this 1 ampere sorry through this 100 ohm resistance, because it is sorted and similarly this 2 ampere current also will flow through this, because these two are ineffective, because it is sorted.

That means my I SC is equal to your I SC is equal to 1 plus 2 that is 3 ampere, what was I telling that 2 plus 1 initially 3 both in upward. And finally, this 1 ampere current here is flowing and 2 ampere current is flowing here. So, and this, this, this is shorted, and this is shorted.

So, sorry this 1 2 is shorted, so there will be no current to 100 ohm, and no current through this 100 ohm resistance. So, all the current these 2 ampere take the short circuit path, so it will be 3 ampere that means my I SC is equal to I Norton is equal to your 3 ampere right. And, and when it will be in parallel that, when we will try to find out in between one and two are Norton, because at that time this is open, this is also open and this is also we have to find out between 1 and 2. So, at that time 100 and 100 ohm are in parallel right, when it is open. So, 100 so R N is equal to 50 ohm.

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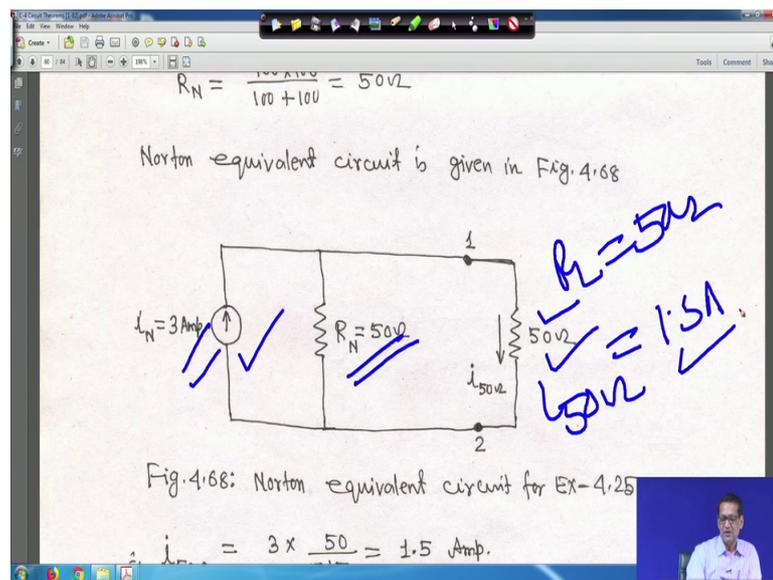
So, finally, if you draw this circuit, so i N is equal to 3 ampere, R N is equal to 50 ohm, and this and you want to ah, we want to find out the current also through that 50 ohm resistance. So, it is 50-50 and this is 3 ampere. So, basically it is i 50 ohm equal current division, it will be 1.5 ampere right, 1.5 ampere. So, this is how actually we find out that means, in Norton that all the things are in parallel; this resistance 50 ohm and this is equivalent Norton, and this is what you call that Norton your current in the case of Thevenin, V Thevenin R, Thevenin R L all are in series. In the case of Norton, i N, R N, and this is basically R L say. If we say it is R L is equal to 50 ohm say all are in parallel,

and it is 50-50, so current will be half-half, so that means, through this 50 ohm resistance, it will be 1.5 ampere right.

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So, next one is so obtain the Norton equivalent circuit of the circuit shown in figure 69.

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So, we have here we have to obtain the Norton equivalent circuit. So, this is your a 30 volt source is there independent source, 110 ampere your current source is there. So, once you have to find out short circuit current, another is you have to find out the your in 1 and 2 Norton equivalent circuit right. So, sorry Norton equivalent resistance so, in the

case of your R N is equal to R Thevenin. So, in that case to get this your here you have to find out R N right; in that case this source should be turned off short circuit. And this current source should be open; it should not be there. So, in that case what will happen that means, this that means, this 1 ohm and 5 ohm, it will be in series right. So, it will be your 6 ohm and this will be 3 ohm. So, 6 ohm and 3 ohm are in parallel right. So, let me clear it.

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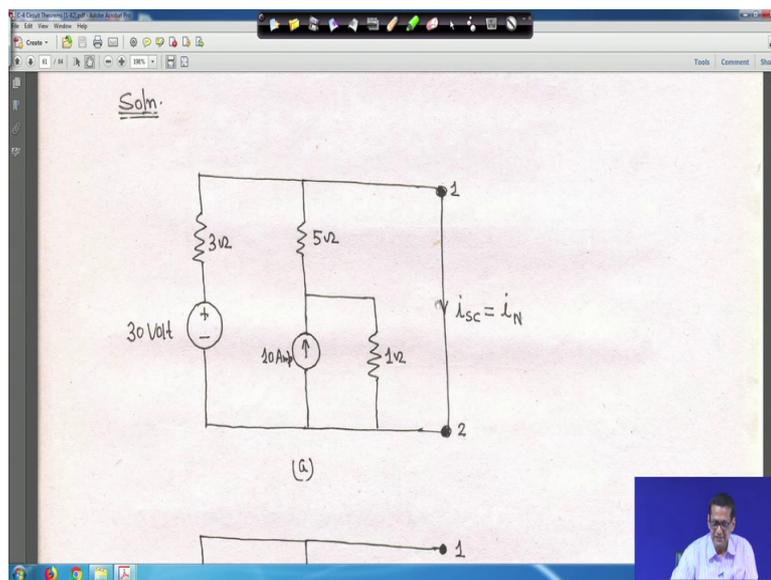
So, you will get this what you call this is short circuit current.

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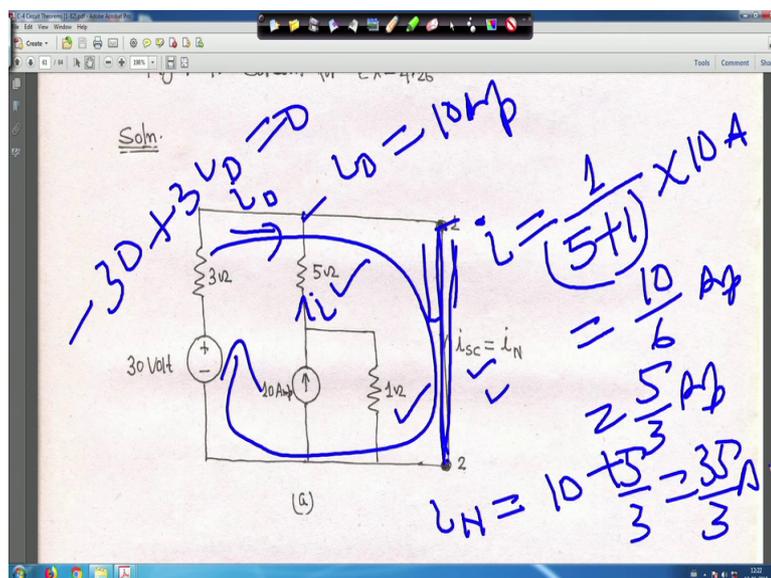
For R N, you will get your 2 ohm, R N will become your.

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First I am coming to that R R N is equal to 2 ohm right. This is R N.

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Now, next that, because from this equivalent circuit you can easily get it right. That is, is this is open this 30 volt source is shorted. So, 1 plus 5 – 6, and 6 and 3 are parallel, so 6 into 3 upon 6 plus 3, so 18 by 9, so 2 ohm right. And when it is now when it is sorted, we have to find out that your what you call that what is the short circuit current that we have to find it out. Now, question is that as soon as it is as soon as it is sorted, if you look into

the circuit, if you look into the circuit as this path is as this path is sorted as this path is sorted, this is sorted right.

So, in that case, what will happen you will see that 5 ohm and 1 ohm actually are in parallel. If you bring this terminal somewhere here I mean if you read on bring it here, then because this is this is this is all are common. So, it will find 5 ohm and 1 ohm are in your what you call in parallel that means, what is the current flowing through this 5 ohm resistance right. So, if suppose these current suppose if it is i, then this is the 10 ampere current source, I want to divide this current in 1 ohm and 5 ohm then what is the current through the 5 ohm resistance. So, in that case through the current division because 5 and 1 are in parallel, so current division method your i should be is equal to this is 1 divided by 5 plus 1 right into this 10 ampere right into 10 ampere.

So, basically it will be 10 by 6 ampere that is 5 by 3 ampere that is the current flowing through this right and. Another thing is another thing is that that your we have to find out the short circuit current because this is the short circuit current is equal to Norton current right. So, as soon as this is shorted that as soon as this terminal is shorted right then what is the then what is this current. Suppose, this current is i 0 this current is i 0 right. So, then we have to find out i 0 then I SC will be basically i 0 plus i. So, in this case, what will happen that to get this your i 0 current then simplest way what you can do is this is although this is a 0 potential, but what your you know for easy calculation say we can make it KVL like this.

So, in that case it will become 3 i 0 is equal to 30 because if you move like this it is minus 30 plus 3 i 0 is equal to 0 right that means, my i 0 is equal to say 10 ampere right. So, i 0 is equal to 10 ampere and here we got i is equal to 5 by 3 ampere. So, therefore, i Norton that is equal to I SC this current is equal to your 10 plus 5 by 3 that is 35 by 3 ampere right, so that is my short circuit current or i N. So, let me clear it. So, if it is so, so look at this 35 by 3 that is your ampere. So, short circuit current we got 35 by 3 ampere right. And your R N also Norton we have got 2 ohm.
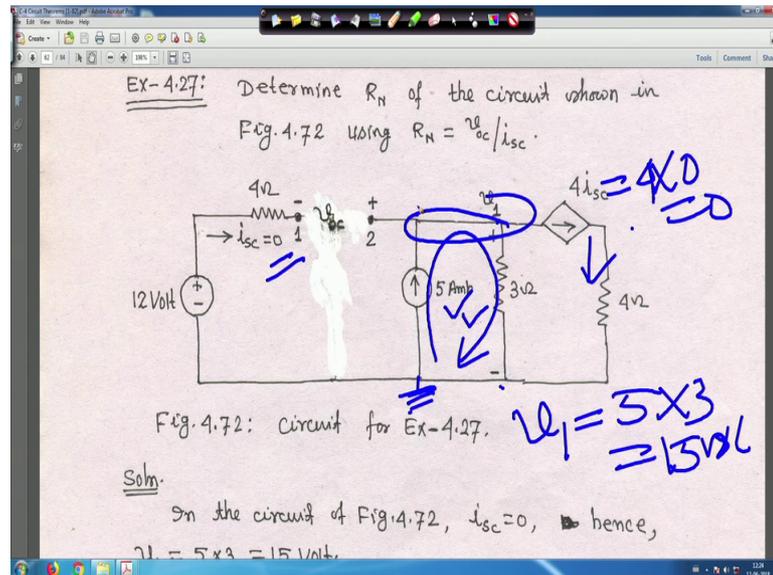
So, that means, this is that Norton equivalent circuit right. So, determine now this is another example. Determine R N of the circuit shown in figure 72 using R N is equal to v open circuit divided by short circuit. So, in this case, this is your V o c; this is open this is v o c terminal is 1 2, so that means, short circuit current it is 0 here it because that is open. So, no current is flowing through this. And one dependent source is also there, one dependent source is there.

Look just before going to that solution, so this is we have to find out Voc. But as it is open, so this I SC is equal to 0; if i SC is equal to 0 that means, this term also 4 into 0 is equal to 0 right that means this part is if it is 0 then your this circuit there is no current 4 into I SC this current source. So, no current is here also here also it is going 0 current because i SC here it is 0 it is dependent source here it is 0. So, then what is happening this 5 ampere independent current source this current actually you will circulate like this right. So, this is my your what you call 5 ampere current.

This is this 5 ampere will circulate like this. So, this is actually from nodal analysis this is grounded right if it is so that means, my v 1, v 1 means with respect to the your reference point. So, this is my reference point. So, my v 1 will become 5 into 3 that is your 15 volt right. So, v 1 will be 15 volt. And as this is actually common terminal so right. If here it is 15 then here also it is 15 right. So, next will go to that so, this is first you obtain that v 1 right when it is open circuit.

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So, if v 1 is 15, then that means, this voltage this voltage actually v 1 right. And v 1 is equal to 15 volt right. And this is plus; this is minus. Now, if you want to find out what is V o c, then arrow means plus and it is not no arrow means if I just keep it as it is it is minus and I told you again and again. Now, here you apply your what you call that your K V L. So, i SC is equal to 0, so it will be 4 it is open circuit right. So, no need to write 4 into 0, because this is open circuit. So, if we move like this, so it will be minus 12 is coming first, then your minus V o c here it is plus your v 1 plus v 1 is equal to 0 right.
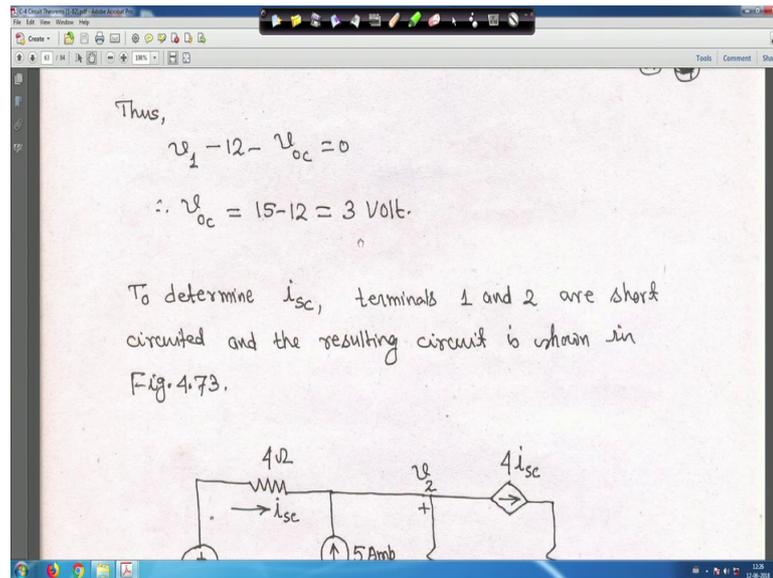
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And V 1 is equal to 15 volt that means if you put v 1 is equal to 15 here, so V o c will be 15 minus 12 that is your 3 volt right that means, open circuit V o c voltage you got 3 volt. So, let me clear it. That means, my V o c is equal to 3 volt. So, we have got V o c we have to obtain now i SC right. So, in this case if you got i SC, then we have to go to this circuit.

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So, V o c we got 3 volt; I explained everything. Now, to get I o c this is sorted right I mean this, this 1 and 2 is sorted now because we have to get I o c.

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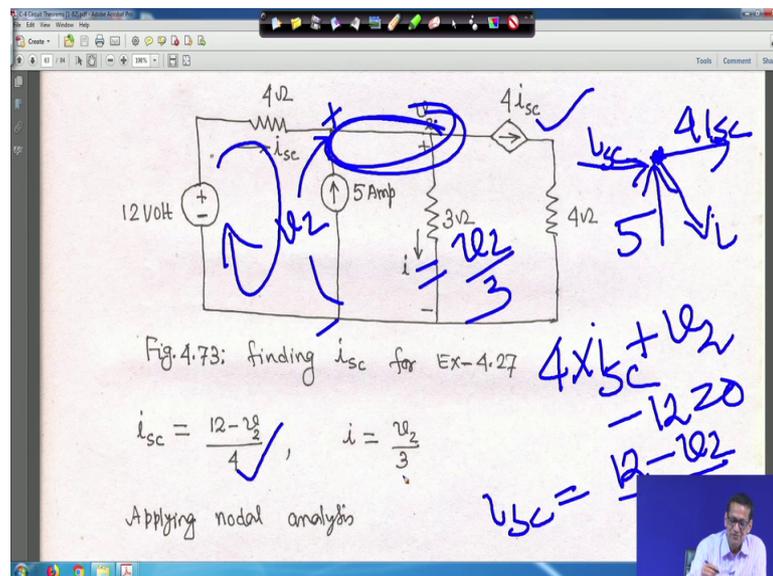
So, this is your what you call it is sorted and 1 voltage source is there 12 volt, 5 ampere. And as it is sorted now things are changed. So, this voltage is now say v 2 right. Now, question is that this voltage is v 2 with respect to the reference with respect to the reference right. So, just hold on with respect to the reference. Now, question is that your first you have to find out what is i SC that this is a common terminal, this is a common terminal. So, this voltage, this voltage is v 2; and this is your minus right.

So, same as before several times we have done it. So, apply K V L in this mesh. So, you will get 4 into 4 into I sc right then plus this v 2 plus v 2 minus 12 is equal to 0 right; that means, I sc is equal to your 12 minus v 2 divided by 4 that is here it is written right. And another thing is this i is equal to this i is equal to writing here itself, because voltage here is v 2. So, moving downwards, so it is v 2 by 3 right now with this you apply your K C L at the because this is a common node you apply K C L here. If you apply K C L here, so what will happen for your understanding suppose this is my this node right this current is coming. So, we have taken i SC in this direction. So, current is entering here this is i SC; 5 ampere is also entering here, this is 5 right and next 4 i SC leaving this terminal.

So, 4 leaving this node 4 i SC and this I also leaving i is equal to v 3; this is i; that means, i SC plus 5 the incoming current is equal to your 4 i SC 4 i SC plus this your what you call this i right this i means this v 2 by 3 right. So, and 4 i SC means expression of i SC we have got it here, here you have to substitute; that means, it will be 4 into 12 minus v 2 upon 4 effectively, it will become 12 minus v 2 and this i should be is equal to v 2 by 3. So, everything equation you will get in terms of v 2 such that you will easily get what is the value of v 2, then only we will compute i SC. So, let me clear it.

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So, hope these things are understandable to you. Now, apply nodal analysis I told you that it will be now 12 minus v 2 plus 5 is equal to v 2 by 3 that is your i plus 4 into your I SC. So, i SC is equal to 12 minus v 2 by 4. So, 12 minus v 2 by 4, 4 4 will be cancel you solve for v 2, v 2 will be 9.6 volt right. Therefore, your therefore, your i SC this expression we have seen 12 minus v 2 by 4. So, it is 0.6 ampere. And therefore, Norton resistance R N is equal to V o c by i SC V o c we got 3 volt and this is i SC; and this is your 5 ohm right. So, we got and this is actually is equal to i Norton right i SC is equal to i Norton, so that is your this thing.

So, thank you very much. We will be back again.