Basic Electrical Circuits
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Lecture – 76

Now, I will illustrate the couple of examples of finding the Norton's equivalent of a circuit.

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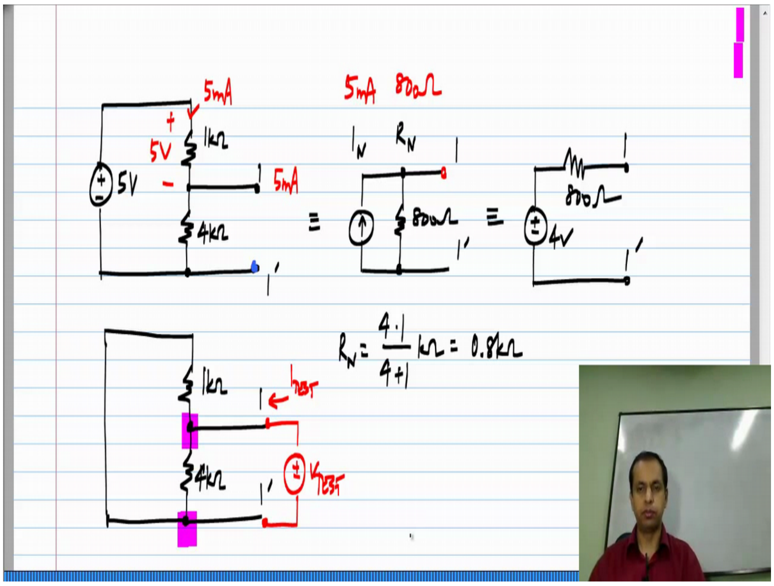

Let us take a very simple circuit and we want to find the equivalent model in this form with a Norton current source and a Norton resistance in parallel. To find the Norton current source, we have to short circuit these two terminals and find the current going through the short circuit. So, I will short circuit this, then you clearly see that this 5 volt appears entirely across this 1 kilo ohm. So, here we have 5 volts and 5 volts across 1 kilo ohms result in a current of 5 milliamps and that goes through the short circuit.

Remember, this 4 kilo ohm is across the short circuit, so all of the current will go into the short circuit, not the 4 kilo ohm resistor, so it will be 5 milliamp in that direction. So, I N which is the current going from 1 to 1 prime; obviously, if you short circuited this, you would have all of I N going from 1 to 1 prime. So, I N in this case is simply 5 milli amperes and to find R N, we have to deactivate this voltage source and find the resistance looking back between 1 and 1 prime.

I short circuit the 5 volt source by nulling it and I have these two resistors, 1 kilo ohm and 4 kilo ohm and if I apply thrust voltage, I can find the current, take the ratio to find the resistance. This case is very easy, you see that there is 1 kilo ohm and 4 kilo ohm are in parallel. It is drawn in a convoluted way, but both the 1 kilo ohm resistor and the 4 kilo ohm resistor are connected between these two terminals.

So, the equivalent resistance R N is simply the parallel combination, which is 4 times 1 by 4 plus 1 kilo ohm, which gives you 0.8 kilo ohms or 800 ohms. The Norton equivalent this circuit consists of a 5 milliamp current source in parallel with an 800 ohm resistor. Now, just for completeness if we evaluate the Thevenin equivalent, the Thevenin resistance will be the same as this, it will be 800 ohms and the Thevenin voltage will be I N times R N as we evaluated earlier.

You can also reduce that by computing the open circuit voltage between 1 and 1 prime. So, using the voltage divider expression, the voltage between these two is 4 kilo ohm divided by the total resistance 5 kilo ohms times 5 volts, so that is 4 volts. So, that also confirms the formula that we derived earlier. So, this will be a 4 volt source in series with 800 ohms, so very simple example.

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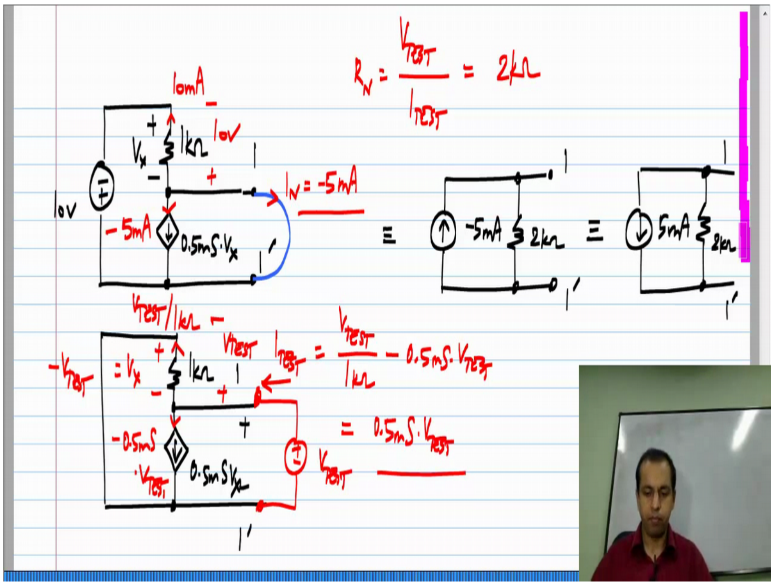

Now, let us consider another case, this has a 1 kilo ohm resistor, I will define V x like this and this voltage control current source happens to be 0.5 Millisiemens times V x has 1 and 1 prime. So, first I have to find the short circuit current, so I form a short circuit between these two, so then we can clearly see that this 10 volt source appears directly across this 1 kilo ohm resistor and the polarity is like that; that is 10 volts, so this V x is minus 10 volts.

So, first of all this 10 volt across the resistor causes a current of 10 milliamp in that direction and this V x is minus 10 volts. So, we have minus 0.5 Millisiemens times 10 volts; that is, minus 5 milliamp in that direction or 5 milliamp flowing upwards. The current I N here is the negative sum of 10 milliamps and minus 5 milliamps, so it is equal to minus 5 milli amperes, the short circuit current I N is minus 5 milli amperes in this case.

Now, to find the Norton resistance we have to short circuit the voltage source, we have to null it; which means, it is a short circuit and we have to find the resistance between 1 and 1 prime, as usual we apply a test voltage and find the current flowing that way. So, now, this is V x and V x simply equals minus V test. We also observed that, this V test appears directly across this 1 kilo ohm resistor with this polarity; that is V test.

So, first of all here we have a current V test divided by 1 kilo ohm and in this direction, we have a current minus 0.5 Millisiemens times V test. So, the total current I test flowing that way is the sum of this and that one, which is V test by 1 kilo ohm minus 0.5 Millisiemens times V test, which is equal to 0.5 Millisiemens times V test. So, the ratio R N which is the ratio V test by I test equals 2 kilo ohms.

So, this entire circuit is equivalent to a minus 5 milliamp source in this direction and a 2 kilo ohm resistance in parallel, so that is the equivalent source and considering the direction of the current, you could also write it as a 5 milliamp current source pointing downwards and 2 kilo ohms with 1 and 1 prime. Again, what I want to emphasis here is that the method of finding the equivalent is always the same, you form a circuit between the terminals 1 and 1 prime, find the short circuit current in the right direction and then, you deactivate all the independent sources in the circuit. The dependent sources remain what they are with their controlling quantities also as they should be and you find the resistance looking back into the two terminals, that gives you the Norton resistance.