Basic Electrical Circuits
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Lecture - 74
Worked Out Example- Thevinin Theorem

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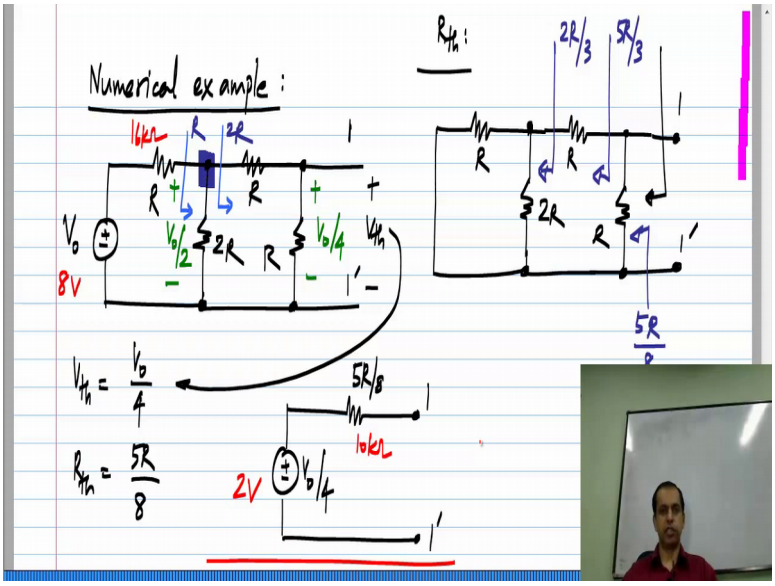

Let me take an example. I will consider a simple circuit, but it can be anything; this is the circuit given to me. So, let say this is V naught, and this is R, 2 R, R and R. And I want to model it that these two terminals. Again I want to emphasize that this equivalence is valid for the voltage and current at these two terminals nothing else. So, it says that if you connect the circuit or it model to any circuit you want then the behavior will be exactly the same at these two terminals and also inside the circuit that you connect with. So, now I have to find the thevinin voltage, and for that all I need to do is do not connect anything between 1 and 1 prime and find the voltage across it.

In this particular case, I chosen the values so that is very easy for me to calculate, because looking here, I have a series combination of R and R which gives me 2 R. So, this is 2 R and looking here I have 2 R parallel to R, so I have R. So, effectively between V naught and this point I have R and R. So, the voltage that appears here will be V naught by 2. And between that point and here again I have R and R, so voltage that appears here will be V naught by 4. So, my thevinin voltage V t h will simply be V naught 4 four. Then I have to calculate R t h for that what I have to do is I have to set this voltage is to 0, so I short circuit it and I have R,

2 R, E and R, again 1 and 1 prime. So, by the way I measured V t h with this polarity, so that is V naught by 4; if I taken the opposite polarity, it could have been minus V naught by 4.

Now have to look back and calculate the resistance, we can apply a test voltage and find the current, but in this case it is a simple combination of resistors. So, it is quite easy to do. What I will do is look here I have 2 R parallel R, which gives me 2 R by 3. And here I have that 2 R by 3 in series with R, which gives me 5 R by 3. And finally, here I have five R by 3 in parallel with R which gives me 5 R by 8, so Thevinin resistance is 5 R by 8. So, the equivalent circuit would simply be V naught by 4 in series with resistance 5 R by eight and this is 1, and this is 1 prime that comes from the polarity with which I measured V t h, so this is 1 that is 1 prime. Now if you are given specific values. So, let say V naught was a 8 volts, and R was a 16 kilo ohms then this would be 2 volts, this five R by 8 would be 10 kilo ohms. And you can do this for any circuit that you want; now if the circuit is more complicated the procedure to find the voltage and the resistance may be little more laborious, but the principle is exactly the same.

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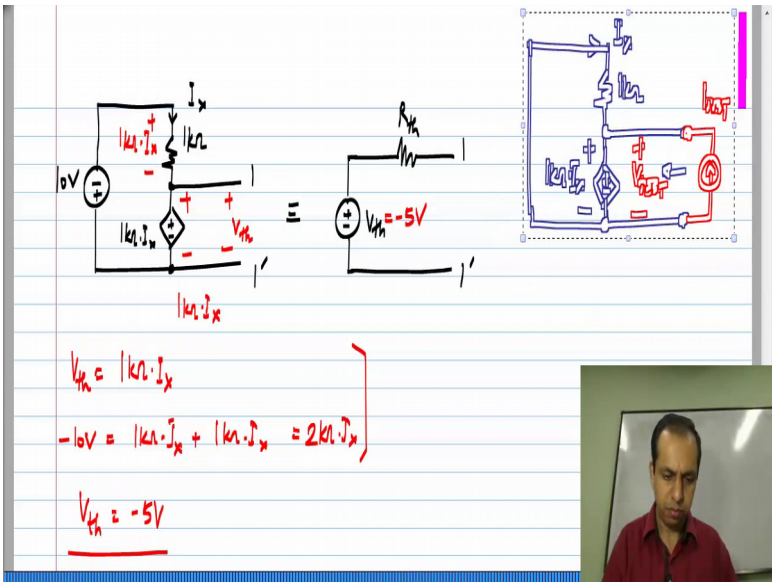

We can consider another example, this time including controlled sources. I have a voltage source here and I have this 1 kilo ohm resistor, the current through 1 kilo ohm resistor I x. And this current controlled voltage source is 1 kilo ohm times I x, procedure is exactly the same as before. What I want to find of course is the equivalent of this between the terminals 1 and 1 prime with the voltage source value V th, and the resistance value R th. Now to find the voltage V th, all I have to do is you do not connect anything to one and one prime and find the voltage between these, so that is I have to find the voltage over there, and that I know that the drop here is 1 kilo ohm times I x and in the drop here is also 1 kilo ohm times I x because

I x is flowing through the 1 kilo ohm resistor. So, V th will be 1 kilo ohm times I x, because this drop is exactly the same as that. And applying KVL around this loop, we have minus 10 volts equals 1 kilo ohm times I x, which is the drop across the resistor plus 1 kilo ohm times I x which is the drop across the current controlled voltage source. This is equal to 2 kilo ohm times I x.

Solving these two we easily see that V t h is minus 5 volts. Deliberately I 2 the case where V th comes out negative; the polarity is quite important. We are measuring the voltage between one and one prime with one being positive and it comes out negative. So, in this particular case, V th will be minus five volts. And to calculate R th, I have to take this circuit disable the independent sources but retain the dependent sources exactly as they are. So, I short the 10 volt independent source, and I have 1 kilo ohm here; I x is defined exactly the same way as before and this voltage is 1 kilo ohm times I x. And I want to find the impedance looking in that way, now because I have a current controlled voltage source over here. So, let me apply a test current I test, and see what voltage is developed across this.

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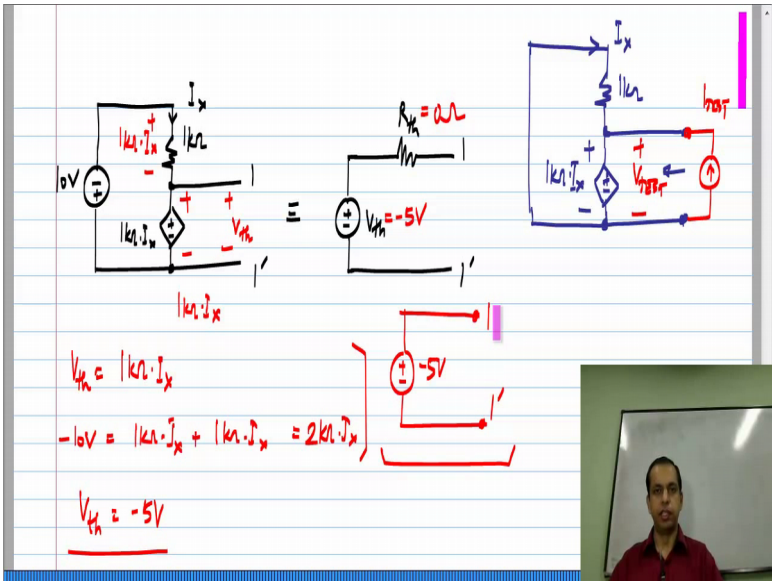

Now I know that this V test equals 1 kilo ohm times I x; I do not yet know what I x is, now I also know that this V test is also the voltage between these two points and that voltage drop considering the direction of I x is minus I x times 1 kilo ohm. So, V test is also equal to minus 1 kilo ohm times I x. So, by adding these two, V test will come out to be zero independently of I test so that means that the thevinin resistance which is V test divided by I test will be equal to 0 ohm. So, again, this is a little weird case, but because the output is across the current controlled voltage source, you expect that you see a zero ohm resistance, so we have

R th to be 0 ohms, so this is 0 ohm. And the circuit, in fact, acts like an ideal minus 5 volts voltage source between 1 and 1 prime. So, if this for a resistor, you would have got some resistance in series with it, but this is a current controlled voltage source. So, the resistance looking back this way happens to be zero, but again what I want to highlight here is that the procedure is very systematic, you open circuit the output, find the open circuit voltage and you null all the independent sources in the circuit, and determine the Thevinin resistance R th.