Basic Electrical Circuits

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Lecture - 78

Earlier in the course we have looked at modeling and simplified representations of complicated circuits. The earliest example was if you have a network of resistors, then if you have given two terminals, across those two terminals you can represent the entire complicated circuit by a single resistor. The idea is that, if you put this complicated circuit in a box and then, bring out only these two terminals it is indistinguishable, you cannot figure out the difference between this box and another box, which contains only a single resistor of the equivalent value and whose two terminals are brought out.

So, that is what it meant by this resistor is equivalent to that complicated circuit at those two terminals. So, by studying the electrical behavior at those two terminals you cannot distinguish between the two. Then, later on we saw examples and this business of equivalent resistance holds for any linear circuit, not just a network of resistors, but also a network of resistors and the linear control sources.

Later we also saw Thevenin and Norton's equivalents, which are equivalents of a circuit containing independent sources and linear components. The entire circuit; however, complicated it is, can be modeled at those two terminals using a single voltage source and a single resistance and series or a single current source and a single resistance in parallel. Now, in this unit we will discuss two port parameters, which is the way of extending this abstract representation of equivalent resistance to more than one pair of terminals.

So, before we go into that I will discuss some extreme cases and show you why many representations are necessary. We have different sets of parameters and describing the same two port, why all of them are necessary I will describe, because in turns out that in some extreme cases some circuits can be represented only by one and not by others. Now, there are many circuits which can be represented equally well by all of them, I will show you with examples that in some cases some of the parameters will be undefined.

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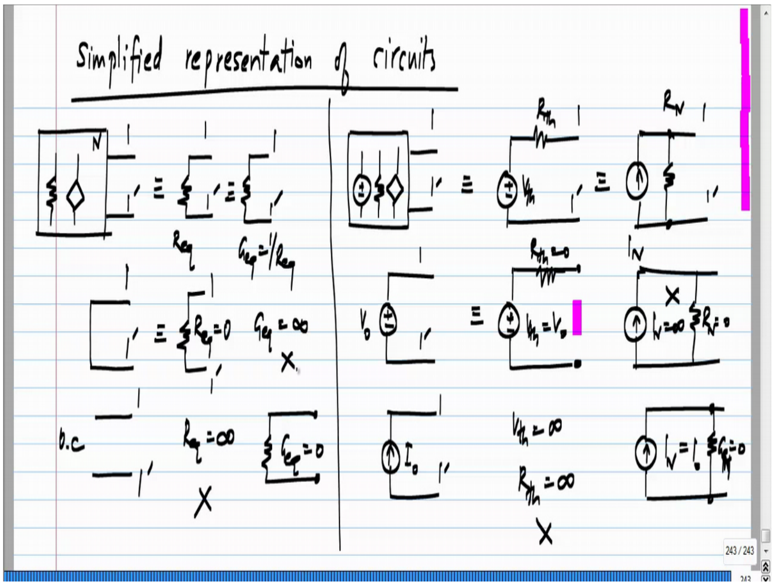

If you have a network containing resistors and linear controlled sources and pair of terminals brought out, then at these pair of terminals it is equivalent to a single resistance. The resistance could be positive or negative, if this network consists only of physical resistors, then this resistance will also be positive; otherwise, if it also contains control sources it could be negative. And similarly, if we have independent sources, resistors and controlled sources, it is equivalent to having a voltage source and series with the resistance, which is also equivalent to a current source in parallel with a resistance.

By the way instead of specifying the equivalent resistance in this particular case, I could also specify the equivalent conductance. Now, we may be wondering, why so many alternatives are necessary. I will show you very simple examples, where some of them are legitimately defined and the others are not. For instance, let say that between 1 and 1 prime there is a short circuit, inside the circuit; somehow it could be a derived short circuit or it could be emulated using control sources, whatever it is.

Then, this can be legitimately represented by an equivalent resistance, which is 0; on other hand if you calculate the equivalent conductance it will be infinity. Now, infinity is not a useful quantity in the sense that, you cannot make usual calculations that you do with finite numbers when you have infinities, 0 is okay but infinity is not fine. When you have to manipulate infinities sometimes, what you have to do is to assume that the quantity is finite and then, take the limit as it goes to infinity.

So, when you have a short circuit saying that resistance is 0 is legitimate representation, you can use this in calculations. This is correct to say that the conductance is infinity, but you cannot use this number in any useful calculation. So, this is the very simple example of why specifying resistance or conductance can be useful and also you can see why in this particular case only one of them has a finite value. Similarly, when you have an open circuit between 1 and 1 prime, it is an open circuit the resistance is infinity.

So, it is not useful to specify this way, but you can specify as a conductance whose value is 0, so it means the same thing. Similarly, coming back to these equivalent circuits Thevenin and Norton's, let us take a simple case, where between these two we have the voltage source. So, the entire circuits consists of voltage source, again it could be a single voltage source or it could be the equivalent effect of a complicated circuit. Now, clearly this can be represented with V t h, if this is V naught V t h will be V naught and R t h will be 0.

I should write try to find the Norton's equivalent, if you have just a voltage source and it you try to find the short circuit current you will find that the short circuit current is the infinity that is, because you cannot short circuit voltage source and you will also find that the Norton resistance which is the same as a resistance is 0. And in this case this representation is useless, because we need finite values, so only this representations is legitimate.

Clearly you would have guess that if you had only a current source, then you cannot represented as a voltage source in series with the resistance, because the open circuit voltage of a current source is infinite, so this V t h will be infinite and this R t h will also be infinite. So, this not useful instead you have to represented as a Norton current source whose value equals the value of the current source i naught and Norton resistance, which is infinite or a conductance which is 0 Norton conductance, which is 0.

So, you can from this see that you will have to define parameters in different ways, so that you can describe all circuits with finite valued parameters. So, there was the just preliminaries, now I will going to two port parameters, which are basically way of describing circuits, where two pairs of terminals are exposed to you and you can describe the electrical behavior to those two pairs of terminals with an equivalent circuit as usual the internal circuit can be very complicated, but as long as you are given access to only those pairs of terminals with their use the full complicated circuit or the equivalent circuit they will be no difference.