Basic Electrical Circuits
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Lecture - 66
Pushing a Voltage Source through a Node

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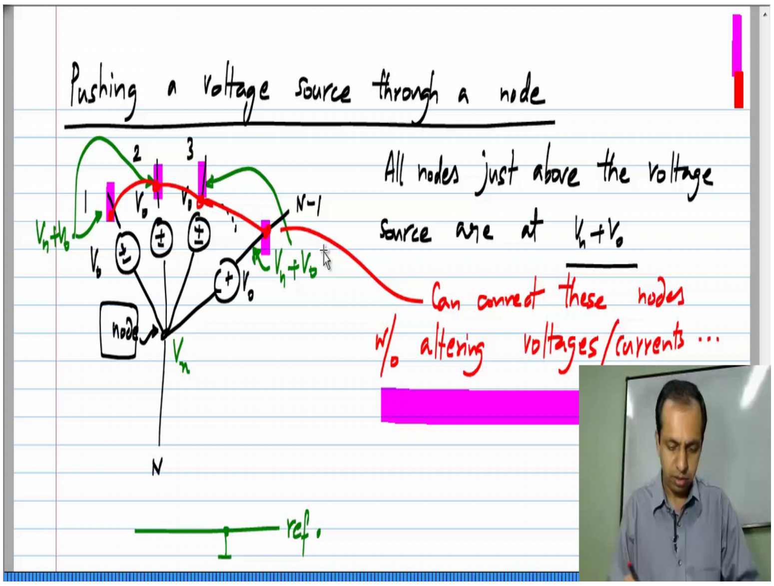

The next theorem I will consider is related to manipulation of circuits which have a voltage source in them in a particular way now the use of this may not be immediately clear, but later sometimes you can easily understand the properties of certain types of circuits using this theorem I will call it pushing a voltage source through a node it will be clear in a movement what I mean by this now consider a node and a number of branches are connected to this node. Let say there are N branches connected to this node and in n minus one of them there are these voltages with the same polarity; that means, that the negative is connected to this node here this is the node of concern there will be other nodes in the circuit, but this is the node we are focusing on and there are the number of voltage sources all of them defined negative towards the node and also all of them have exactly the same voltage V naught.

So, let say this is the case this is some contrived situation which i am using to illustrate the point again we have a node we have n branches connected to the node and in n minus one of them we have identical voltage sources in the same direction and the nth one it can be arbitrary it can be anything now. Let say we have some reference node i will show it like that with respect which we measure all the voltages all the node voltages lets say the voltage at this node is some V n. Now what will be the voltage at this particular node that is between this and the reference again to repeat myself voltage is always measured between two nodes. So, when I say voltage at a particular node it means that the voltage between that node and the reference node.

So, the reference node must be specified before and. So, that this statement is meaningful a statement such as what is the voltage at a node. So, now, the voltage between this node and the reference node is V n, what is the voltage between this node, and the reference node by a simple application of Kirchhoff's voltage law. You see that it is V n plus V naught and then let look at this particular node over here on the first branch. What is that voltage its again V n plus V naught and similarly you see that the voltages at all these points after the voltage source they are exactly the same and equal to V n plus v naught. So, all nodes just above the voltage source are at V n plus v naught so that means, all these nodes are at exactly the same voltage. Now it turns out that if you have different nodes with a same voltage in a circuit you can connect them together with a wire without altering anything else in the circuit.

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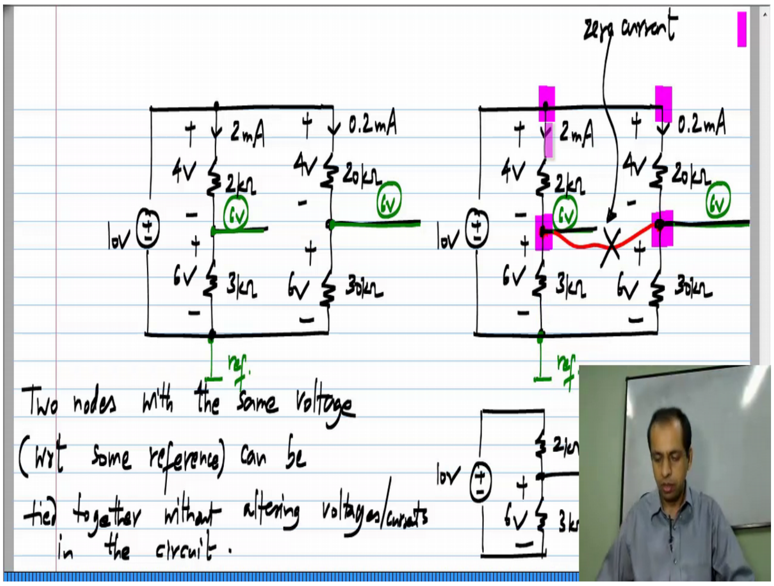

So, I will show you an example. Let say I have a ten volt source over here; I have a two kilo ohm and three kilo ohm and you easily see that the voltage across this is six volts and the voltage across that is four volts and the current here is two milli ampere. Let me take another set of resistors connected to the same voltage source may be this is twenty kilo ohm and this is thirty kilo ohm. Again you see that across the lower resistor we have

6 volts and across the upper resistor we have 4 volts and the current here is 0.2 milli ampere. Now let say we take this as the reference node we see that this node voltage here is six volts and this node voltage here is also six volts.

Now, what am I saying what I am saying is that these two nodes can be connected together because there both are six volts without altering anything else in the circuit this is a simple circuit and what else is there if you look at the currents through these resistors with and without this connection. Let me show a copy of this and remove the connection over there. Without this connection, you see that there is two milliamps flowing through that point two milliamps flowing there and these are at six volts. And if I make this connection forget the fact that I derived this circuit from that circuit, if you had this circuit given to you and you are asked to analyze, this you would easily see that this point is at six volts and the current through this is two milliamp the current through that is 0.2 milliamp, because after all if you look at this circuit these two kilo ohm and twenty kilo ohm are in parallel this three kilo ohms and thirty kilo ohms are in parallel.

So, we will have two kilo ohm parallel twenty kilo ohm which is equal to ninety by thirty three kilo ohms and if you calculate this voltage here it will come out to be exactly six volts. So, this voltage still be at six volts and these currents now if you look at this resistor for instance we have four volts across the resistor and two milliamps through that and point milliamps through the twenty kilo ohm register and so on. So, the voltages and the currents in the circuits do not change, if you take two points which are at the same voltage with respect to the reference node and connect them together.

Now, later will see that there is some exception to this, but for now we can consider this to be true. So, I will just say that two nodes with the same voltage regardless to say it is it is with respect to some reference; obviously, both voltages with respect to the same reference can be tied together that is you can take a wire and short these two nodes without altering voltages and currents in the circuits I have illustrated this with an example and. In fact, if you have a circuit likes this and you have this wire over here this wire will carrying zero current. The red wire it carry zero current.

So, if you break it nothing happens the current will still be zero and there will be no change so that there can consider as a another result, if you have a wire which is carrying zero currents you can cut it off without altering the voltages and currents in the circuit because if you imagine Kirchhoff's current law equations that either node they will be exactly the same if you cut this wire of or not because if you have these wire only zero current was flowing through it. So, the current through these two kilo ohms of resistors equals that through the three kilo ohm of the register if you open this wire then clearly these two currents have to be equal to each other. So, it does not make any difference at all now lets you get back to what I was saying over here because these voltages are all equal to each other what I am saying now is that we can connect all of those nodes together. These nodes can all be connected together we can connect these nodes without altering voltages or currents in the rest of the circuit.

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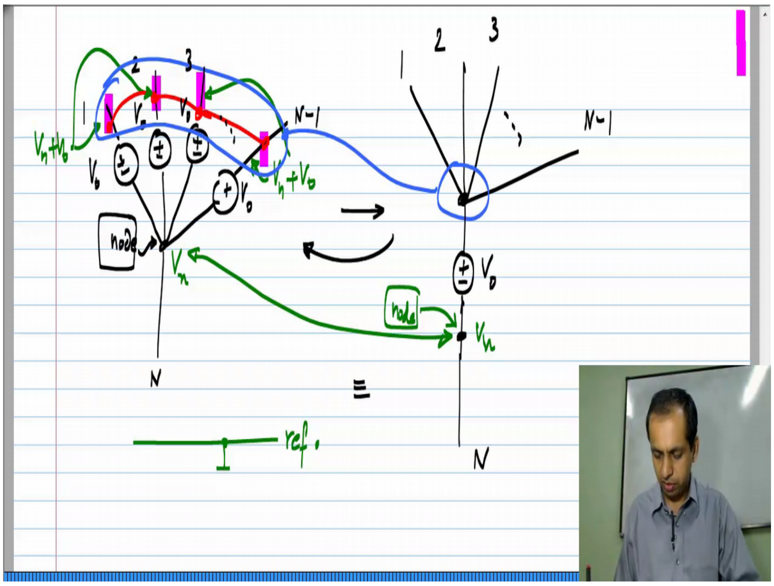

Now what do we have, let me copy this over; now we have taken a wire, and shorted all of these thing. So, this whole thing now these entire thing is a single node because you taken a wire and shorted all of that stuff. So, if I rewrite this, I will get all these branches here one two three n minus one where ever they are they are going to something I am not sure on what they have because that is not of concern and this node here this is the same as that node which is formed by merging. All these nodes because I shorted all of those nodes together and what do I have I have basically equal voltage sources in parallel. Now we earlier said that you cannot have voltage sources in parallel unless there of equal value here from that beginning we have defined all these voltages to be of exactly the same value. So, these voltages are we associates cannot be connected together and parallel and there will be equivalent to a single voltage source of value v naught.

So, if you have multiple voltage sources which are equal in value you connect them in parallel the result is equivalent to a single voltage source of that value. So, this is what we have and then this point is what I originally said had a voltage of V n this is the node of concern and it goes to some branch the nth one over there. So, what we finally, have if we have node with n branches and let say N minus 1 of them have this voltage in the same direction and of equal magnitude then it is the same as having that voltage in the single branch the nth branch in this point. So, these two are exactly the same as each other now a most interesting thing is to go backwards which is to say that.

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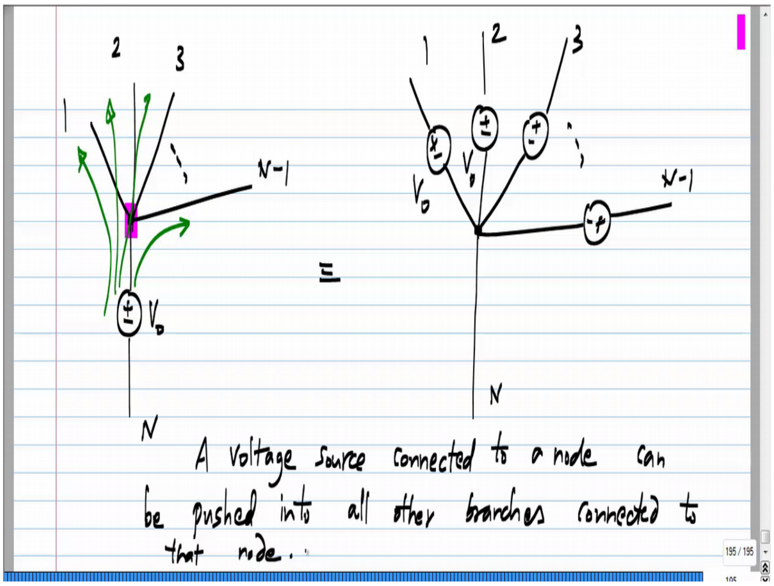

Let say you have a node with N branches, I label them 1, 2, 3, N minus 1, N and one of them has a voltage source v naught in this direction. Now this can go to anything, it does not matter what is direct to be a voltage source current source any component you want similarly these branches can also have any components these are just wires going to some place, but you have a node where N wires are connected together. Now going backwards from how I reasoned out earlier I will say that this is exactly equivalent to having a voltage source v naught in every one of these branches other than this one we started from this and proved that it is the same as this. And the more interesting thing is to go from here to there, you can see that in this case this voltage source has been pushed into this branch that branch that branch in that branch to get this.

So, we take this voltage source push it there, push it into that one, push it into that one and push it into that one. We get this particular picture and that is why this theorem I originally titled it pushing a voltage source to a node and that is exactly what we are doing if you have node with a number of branches connected to it and one of the branches has a voltage source that voltage source can be pushed through the node into all the other branches. A voltage source connected to a node can be pushed into all other branches connected to that node so that is the result and this result is sometimes useful for quick and easy understanding of a certain type of circuits and it is also useful for certain types of circuit analysis and proving other circuit properties and so on.