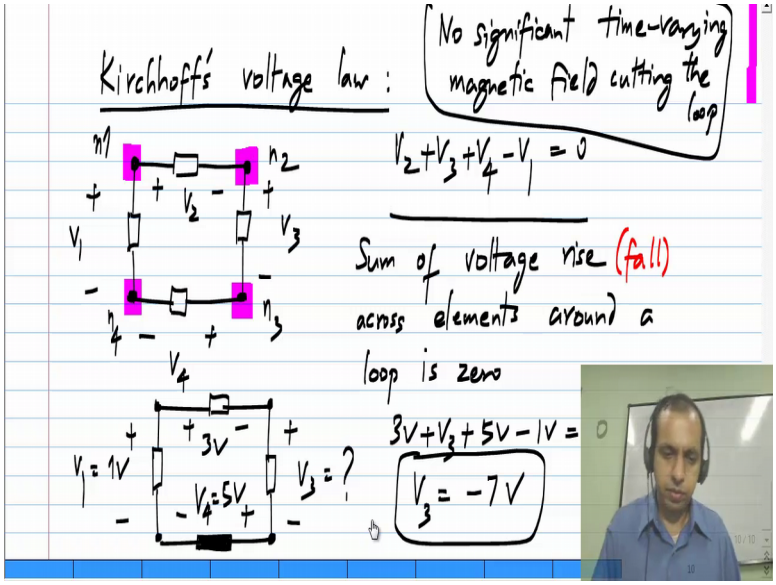
Basic Electrical Circuits
Dr Nagendra Krishnapura
Department of Electrical Engineering
Indian Institute of Technology Madras

Lecture – 06

(Refer Slide Time: 00:13)



Now just like this Kirchhoff's current law which is the general properties of currents, we have general properties of voltages around a loop and that is given by Kirchhoff's voltage law. And what it tells is that let say we take a loop of elements and each element has a certain voltage across it, and let me call this V 1, V 2, V 3 and V 4. So you start from particular node and trace your way around the loop and you look at the total voltage rise or voltage fall. You look at any one of them this is analogous to either looking at currents entering the node or currents leaving the node.

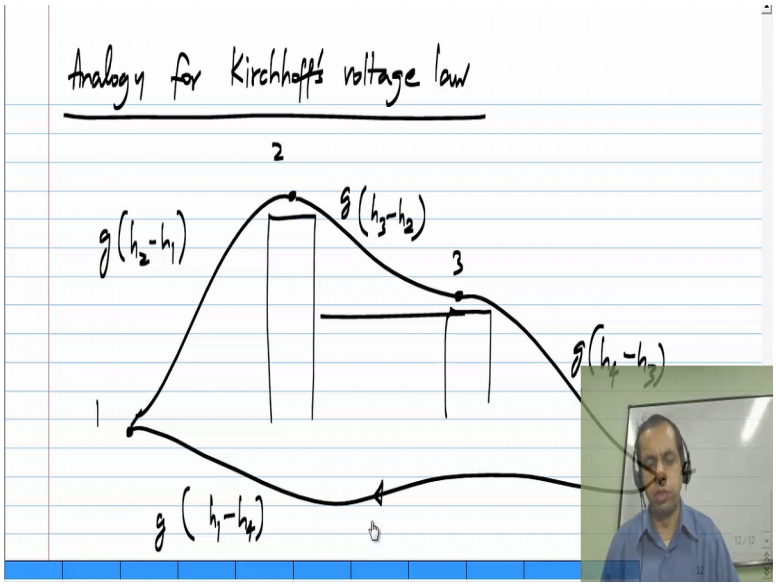
So let us say you look at the voltage fall as you go down this path, so when you go from let me call this node n 1 to node n 2 the voltage falls by V 2, because n 1 is higher than n 2 by V 2 so that means, that when you go from n 1 to n 2 the voltage falls by V 2. Similarly when you go from n 2 to n 3 voltage falls by another V 3 and when you go from n 3 to n 4 voltage falls by another V 4. And finally, when you go from n 4 to n 1 the voltage fall by minus V 1; you can see than n 1 is above n 4 so when you go from n 4 to n 1 the voltage rises by V 1 which is the same as saying the voltage fall by minus V 1 this is the reason I emphasized earlier that you can think of n 1 as being above n 4 by V 1 or below n 4 by minus V 1, so you

will need to be comfortable with these conventions in order to apply the rules correctly. So what Kirchhoff's voltage law says is that this is equal to 0 that is you go around the loop and sum all the voltages in a consistent direction you take either rise or fall the sum will be equal to 0.

Of course, you start from a node and come back to the same node that is when you would have trace the loop once and just like you can take the rise you can also equally will take fall, but whichever you take you just do it consistently so that your calculations are correct. This is Kirchhoff's voltage law, what does this mean why this is useful. So let say you know that let me take the same circuit again there is V 1 is 1 volt, V 2 is 3 volts V 3 is unknown and V 4 is 4 volts. What does it mean this is equal to 0 so that means, that 3 volts plus V 3 plus 5 volts which is V 4 minus 1 volt which is V 1 equal to 0, and this tells you that V 3 is minus 7 volts. So you can calculate unknown voltage.

Now what are the conditions under which the Kirchhoff's voltage law is true. This assumes that there is no significant time varying magnetic field cutting the loop. You know that if a time varying magnetic fields cuts the loop, it induces a voltage in the loop. In that case, the sum of voltages as you go around the loop is not necessarily zero. Now we exclude such cases, again if our circuits are very small compared to some dimensions, which early one specified for now, this is true. And this is actually useful things, which is true for a large number of circuits, it is not that this is applicable only in some narrow useless context, it is actually applicable in a lot of useful context as well so that is why we use that.

(Refer Slide Time: 06:03)



We can also make an analogy for Kirchhoff's voltage law based on everyday experience that is let say you start from a certain point and you go up on top of building, you gain a certain height h 2 minus h 1 may be you will come down to a shorter building and you will gain a height of h 3 minus h 2; h 3 minus h 2 is actually a negative. And then maybe you will walk down to some underground place, so you will have h 4 minus h 3, and finally, you come back to where you started off with you will gain a height of h 1 minus h 4. So obviously, if you sum these gain in heights which are basically stands in for gain in potentials if I multiply this by g, I will have potential gain from 1 to 2, 2 to 3, 3 to 4, and 4 to 1. If you sum up all of these things; obviously, you will end up with zero. And Kirchhoff's voltage law is directly analogous to this, and the actual potential arise in any part could be either positive or negative from 1 to 2, it is a one sign; from 2 to 3, it is a opposite sign and so on, but the sum of all of those things taken in a consistent way is 0. Here I have taken the height that is gained so that means that this is positive and that is negative, but you could also take it with opposite polarity and you will end up with exactly the same result.