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

Lecture - 115

As of now spent a lot of time discussing circuit analysis, but there are something missing in those circuits, some important elements like capacitors and inductors. So, everything we did so far was analysis of memory less circuits, meaning you do not have either capacitors or inductors. You do not have that, if you have only resistors and linear controlled sources and so on, any branch quantity at any instance in a circuit depends only on the inputs at that instant. The history is not required; it is required only for capacitors and inductors, because the capacitor voltage is the integral of current up to that time.

So, what happens to current, previously affects the voltage at this time. Similarly, the inductor current is dependent on inductor voltage across history up to that instance. So, those are circuits with memory and to analyze that, we have to go through solving differential equations. So, for everything we did was algebraic equations and sometime they look complicated, but they were in terms of matrices and after all, it is still algebraic equations.

So, what we will do for the next few classes is to discuss the circuits with capacitors or inductors. Now, we will not deal with differential equations in the same general way that if you take a mathematics course in differential equations that will be in a different manner. There the focus will beyond solving like many different types of differential equations, for us the very simplest type of differential equations will do.

We only be looking at first and second order and from there, you can kind of generalize to higher order. But, we are look at those things in quit a lot of detail, because we want to get some insights into the behavior of circuits.

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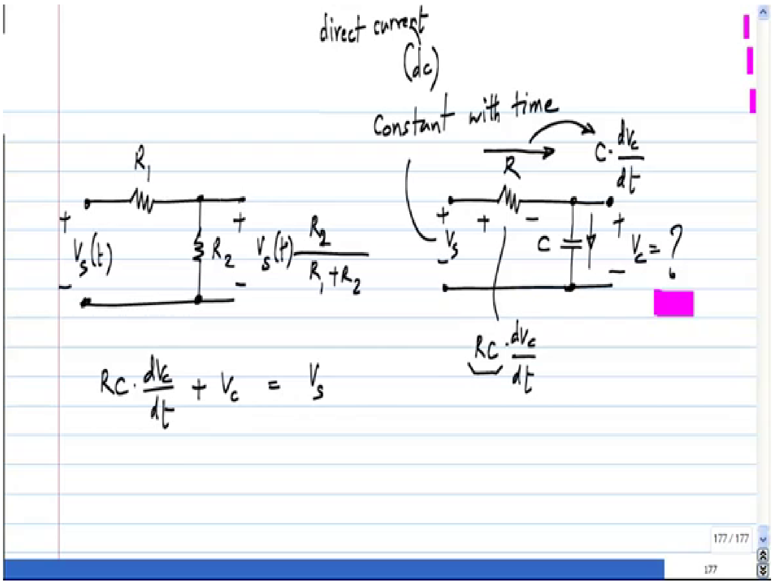

What is the voltage here? V s R 2 by R 1 plus R 2 and this V s could have any arbitrary shape with respect to time and that will simply become that V s of t times the same ratio. What is it in this case? How would you tell? First of all, if I have this arbitrary V s of t it becomes quite difficult. So, first we will start with constant V s constant with time, which is also referred to as dc. I think you are familiar with this term, it stands for direct current actually, but it is quite common to say dc voltage or dc current although it is redundant.

So, what it means is, that the quantity is constant with time and the control part is alternating current, which varies with time in some specific way, so in general the input can vary in many anyway, any possible way. So, let me remove this R 1 since there is only one resistor in the circuit, I will call this R. So, how would we go about solving for this? What do we do first to solve for any, it is only one answer, K C L and K V L. So, this V s equals the sum of the voltage across the resistor and the voltage across the capacitor and let say, it is the voltage across the capacitor that I am interested in. So, I will write everything in terms of that variable dc.

So, in that case what is the current? What is the current through the capacitor? C times the time derivative of V c and exactly the same current flows there as well. So, the voltage drop across the resistor is R c. What are the dimensions of R time C?

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Time, it has to be right, because you have time here, so that has canceled with that to give you a voltage. So, this has some dimensions of some time and actually, it is a significant quantity as we will see soon. So, what is K V L say now? As usual I will put the variables from the left side and the input which is the constant on the right side. So, this is what we have and V c itself is time dependent, all the V s is a constant. I am sure you have solved equations to this step. What is the solution to an equation of this type? So, we will look at in some detail.

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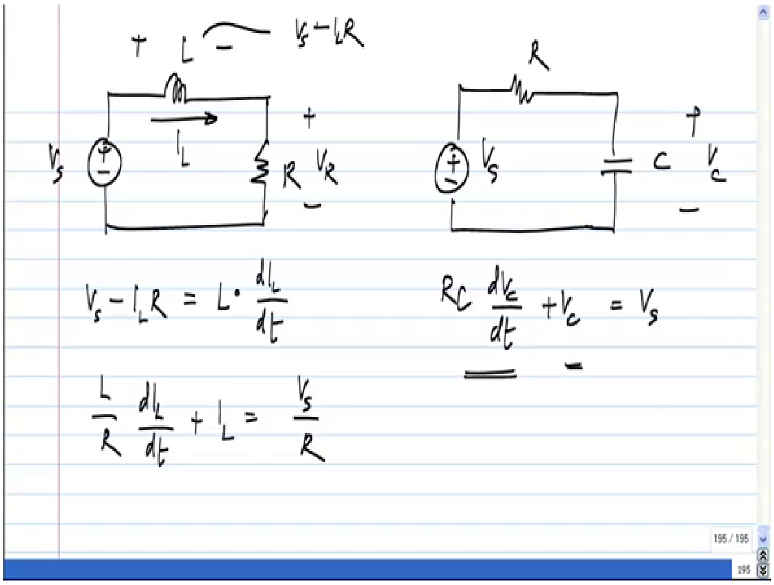

Inductors they work in exactly the same way, as I will not spend lot of time of this and let me take the familiar one also. We know the differential equation for this V c here and here I will write it for I L. So, this one we know I am going to write it right away, this is the voltage across the capacitor, this is the voltage across the resistor and the total equals V s. Now, in this case what do we have? V s minus I L R, which is the voltage across the inductor is L times d l by d t.

So, if I rearrange this I get L by R time derivative of I L plus I L equals V s by R. Now, you can see that the differential equations are exactly the same in the R L circuit and the R C circuit. The co coefficients are of course, different; they are dependent on the specific components, but the equations themselves are the same; which means, that the solutions will be also the same.

So, what I will do is, discuss the R C circuit in great detail and the solutions for the R L circuit can be obtained by comparing the terms to that of the R C circuit.

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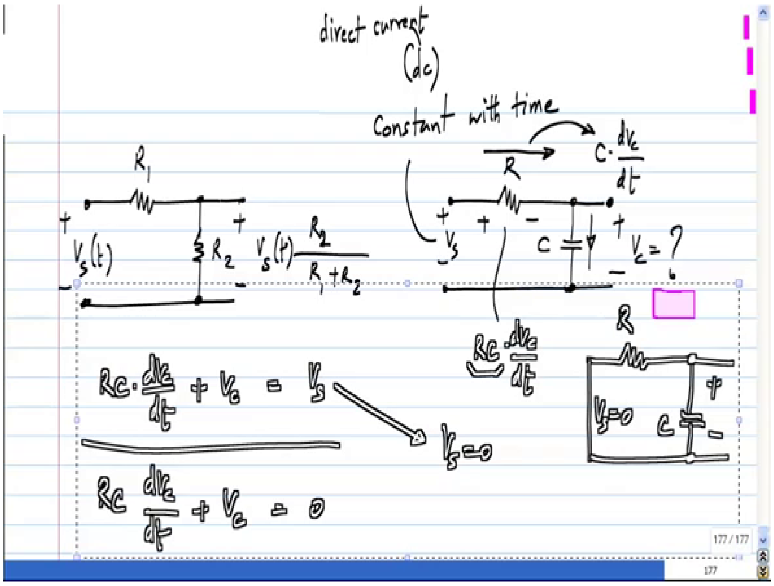

So, first we will try to do it with, I mean even easier case with V s is equal to 0. So, essentially we will try to solve for the circuit, this is I will set V s to 0 and I have R and C, so what happens to this voltage that is the question. Now of course, if that voltage were initially 0 then clearly nothing will happen, because there is 0 current through the resistor and 0 current through the capacitor no change at all. So, if I have... So, V c being 0 forever is a possible solution.

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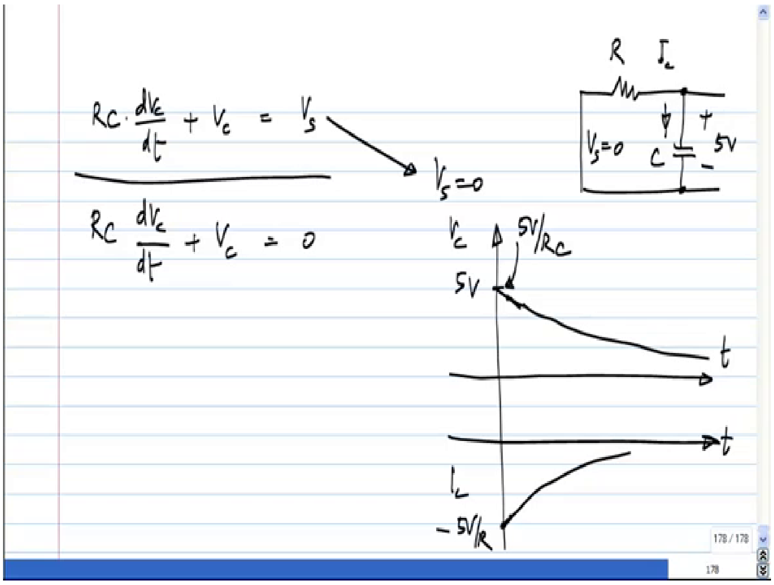

But, let say V c initially was some other value. If V c what to some other value then what happens there are many way we can think about this, first let say this was some 5 volts so something and I will define I will like this I c also verses time. What is the initial value of I c? It has the satisfied K V L what is it.

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Minus 5 volts by r, so it will start from some negative value, so; that means, that what happens to V c initially it has to fall, because I c the way I have return it is negative. So, current is flowing to upward through the capacitor so; that means, that the capacitor voltage will have to fall, what is the rate are change capacitor voltage it is I c by c. So, it will start falling I will show content of segment just show that what will be the slope there, initially it will be 5 volts by R C.

But of course, it want go in a straight line like that, because as soon as a drop what happens to a current, the current itself is related to the voltage, but as this voltage drops as this voltage falls the magnitude of the current decreases. So, it is still negative current, but of a smaller magnitude, so what happens to the slope here, slope will decrease. So, it will start becoming shallower and shallower.

So, you can expect that it will do something and that is all, as the voltage across the capacitor decreases the current through it also decreases, so the rate of change of voltage goes on decreasing, so that is what gives you curve of this type. So, graphically you could even without having herd of derivatives or differential equations, you could have got this curve and then if you workout for I c it will also do something other sort. So, the important thing we can take from here is that the initial of voltage of course, 5 volts and the initials slope is 5 voltages by R C for this circuit.