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

**Lecture - 126**

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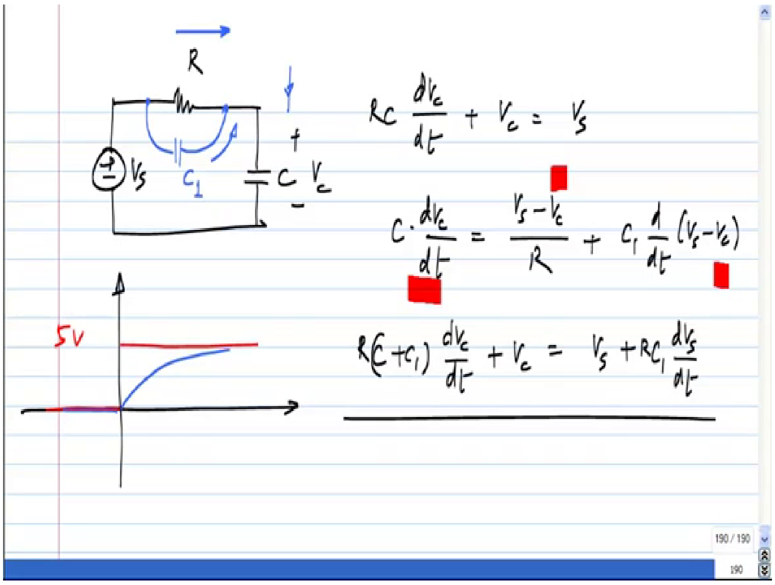


Let us go at to the, this is the differential equation and for a piece vise constant, let say V s. If V s goes from 0 to let say 5 volts, V c will, I assuming it initially 0, it will slowly build up to 5 volts. This is the solution we have already got and how did we say that the step will start from 0, because it was 0 before and then there is no change at t equal to 0, it will remain at 0. The capacitor voltage will remain at 0 and it will start building up. So, now, let me modify this circuit a little.

I have another capacitor. What will be the order of this circuit? Please, again derive the differential equation, we will see this current through R current through C 1, this total equals the current through the capacitor C. The current through the capacitor C, what is that C d v c d t and that equals current through R which is V s minus V c divided by R plus the current through this capacitor C 1, which is C 1. So, if I group the variables to the left hand side and also you put it in the normal form, I will get R C plus C 1.

So, that is take care of this term and that term, plus V c. So, there was that one then equals V s plus R C 1 d v s by d t. But, what is that that you noticed here? What is the order of the differential equation?

Student: 1

1, it is still first order. So, please think about this.

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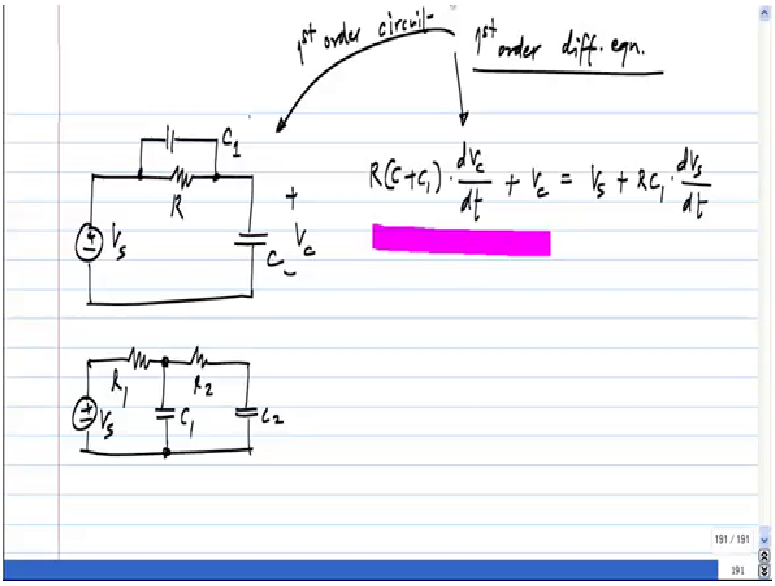


Now, this is the circuit with two capacitors, but when we derived the differential equation we saw that it was of the first order. What was the differential equation in terms of this capacitor voltage V c? R C plus C 1 time derivative of V c plus V s plus R C 1. So, the highest derivative of the variable you see here is 1, so this is a first order differential equation and consequently, this circuit is also a first order circuit. The order of the circuit is nothing but, the order of the differential equation that governs the circuit.

So, why do that come on to the first order? Should I expect the first order relationship here or, okay let me take some other circuit which you can try out writing the differential equation for. And let say, it is also driven by V s, you can pick any variable and you can try this out later, but you will find that the equation that you get in this will be second order, because of the presence of two capacitors. So, what is it that, that makes this first order?

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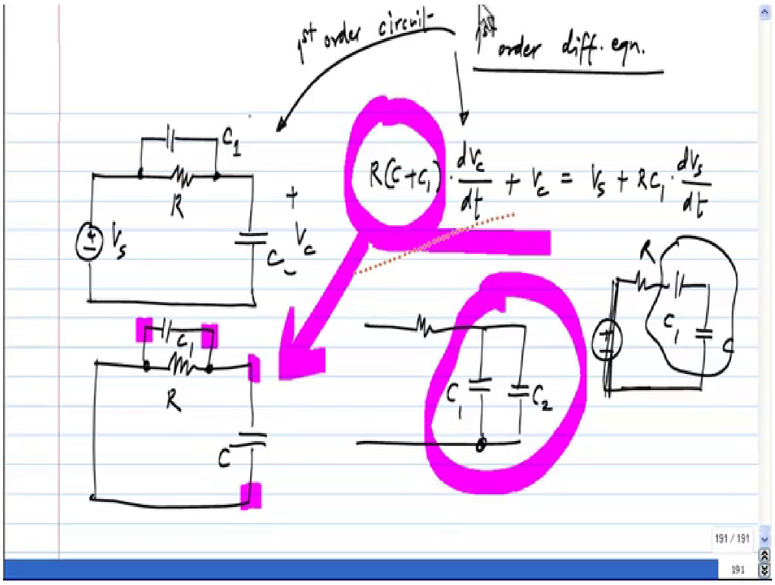


Now, what I have highlighted here is the left hand side, which is the homogeneous part if I reduce the right side to 0. Now, what condition does the homogeneous differential equation correspond to for the circuit? The homogeneous differential equation also describe the circuit, but under what condition.

Student: ((Refer Time: 04:53))

V s equals to 0, so the source free circuit when you set the source to 0, the differential equation that governs to circuit is the homogeneous equation. So, that is why the right hand side is 0, the input is 0. So, what is it mean and in that condition, what happens to the circuit, when V s is 0? So, when V s equals 0, I have R C 1 and C. So, how many capacitors do we have? 2, like in the previous circuit also just because I draw C 1 and C 2 that does not mean there are really two capacitors, it is just here. The two can be observed into one.

Similarly, here these two capacitors are in parallel, is not it in the source free condition. So, that is what makes it a first order circuit and in fact, you can determine the time constant from this, is not it. What is the total capacitance you have?

Student: ((Refer Time: 05:56))

What is the resistance across it?

Student: R.

R, so that is exactly what you see here. Of course, this is the time constant only if the coefficient here is 1, but I have normalized it like that. So, the point is, not how many capacitors I draw in this circuit. So, first you set all the sources to 0 and then you merge all of the possible parallel combinations into a single capacitor. For instance, in this case you know very clearly that this is a first order circuit with an effective capacitance of C 1 plus c 2.

So, the same thing happens here also, it slightly more complicated, because with V s present it is not obvious that they are in parallel, but if V s set to 0, it is very clear that they are in parallel. So, it is very much of first order circuit. You have a different circuit, where R C 1 and C R in series. So, that is not the case here, in fact those two are in series, series connection means that KCL forces the current through them together same, so they are in series.

So, now, it turns out that the series case is slightly more complicated, there are some certainties involved, but for the purpose of this course, let say you want to find the order of the system you set the sources to 0, then you merge all of the possible series and parallel combinations into single capacitors. Then, look at how many capacitors are remaining, that is the order of the circuit and of course, in this case we will be dealing only with the first order system and you also find the time constants in the same way.

So, you reduce the entire thing into first order network, that is you do all the, see merging of parallel and series capacitors. You will get a single capacitor, then you find what resistance appears across the capacitor, that effective capacitance times the effective resistance is the time constant. So, I mean if you have C 1 and C 2 in series, you take it as a single capacitor of value C 1 C 2 divided by C 1 plus C 2. So, this is also a first order circuit, so that is how you determine the order of a circuit by counting the number of effective capacitors as long as the order is 1, the methods we describe in these lessons will apply.