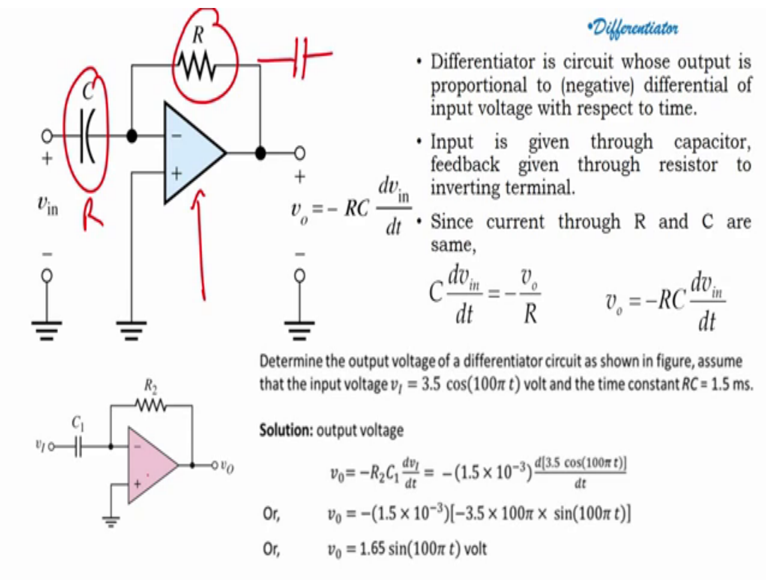
Integrated Circuits, MOSFETs, OP-Amps and their Applications

Prof. Hardik J Pandya
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture – 23
Applications of Operational Amplifier: Differentiator

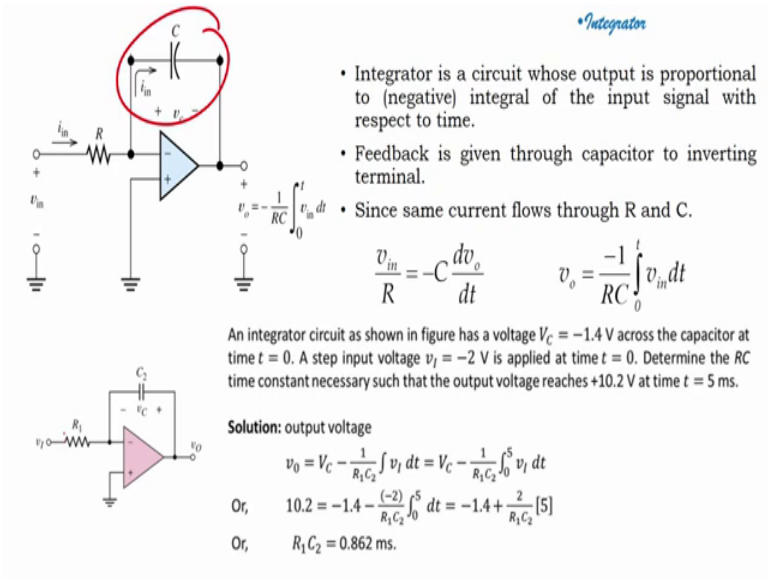
Welcome back. So, this is the last module for this particular lecture, where we were looking at the opamp and using the opamp as several circuits. What we have used, we have used opamp a as a inverting amplifier, we have used opamp as a non inverting amplifier, we have used opamp as an a summing amplifier, we have used opamp as an integrator. Now, we will see how the opamp can be used as a differentiator of course, we have also used opamp as a unity gain amplifier right unity gain amplifier. And we have tried to solve several problems and we found the solution how can you solve the problem. And most the things that I am teaching you in the theory class, I will also show you as a part of the experiment classes as a part of the experiment class.

(Refer Slide Time: 01:07)



So, now if you can come back on the on the slide, what you see is a differentiator what do you see is it is a differentiator. So, if you have seen the last module, if you have seen the last module, what was that the capacitor the integrator was a circuit where your this R was having capacitor and this capacitor was having a register right.

(Refer Slide Time: 01:34)

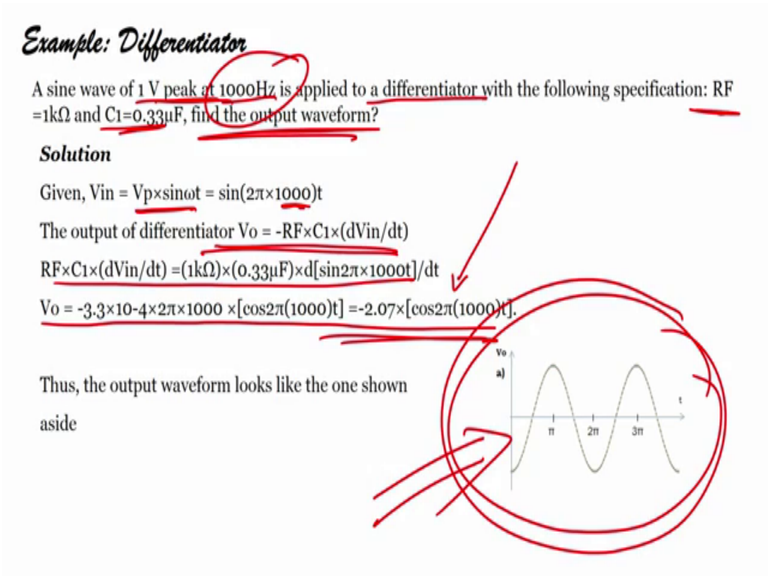


Remember, you do not remember? See integrator, integrator right, capacitor is here, differentiator, integrator, differentiator. See, so just by changing the position of R and C, I can form a integrator and differentiator circuit all right. So, differentiator what is differentiator? Differentiator is a circuit whose output is proportional whose output is proportional to the negative differential of the input voltage right. The differentiator is a circuit whose output is proportional to negative differential input voltage with respect to time. So, if I want to write the equation for v o output voltage will be nothing but minus R C into d v in by dt.

Now, since the current through R and C are same, again the same thing right. My current through here, and that current through here would be same right. I can write down this current equation for this particular, this for this one and V in c into dv in by dt equals to for here what is written minus v o by R. So, from here I can find the value of v o, v o will be R, the equation of v o, v o will be minus R C the v in by dt very easy extremely easy right extremely easy.

Now, for a given circuit, for this circuit, determine the output voltage of differentiator circuit as shown in figure. Assume that the input voltage is 3.5 volts and time constant is 1.5 milliseconds all right. For a given value of input voltage and given value of time constant, if what I had to find, I had to find the output voltage. So, it is very easy because I know the formula. I know that v o equals to minus R C dv in by d t. I already know that v o is nothing but minus R C into dv in by dt. So, if I substitute the value of v o, substitute the value of R, substitute value of C right, and I already know what is v one right then I can easily find then I can easily find my output voltage v o. And when you solve it, so you will get the value of v o equals to 1.65 sin 100 pi t volts right.

(Refer Slide Time: 04:07)



So, if you are given an example of a differentiator, if you given an example of a differentiator such that a sin wave 1 volt peak to peak at 1000 hertz is applied to a differentiator with the following specification, RF is given, C 1 is given, find the output waveform, find the output waveform. So, what is given that if I apply a sin wave 1 volt peak to peak at 1000 hertz right to a differentiator right, and I know what is value of RF, I know what is the value of C 1, find the output waveform.

So, this value is given, V in equals to sin wave right, sin wave 1 volt. So, V p into sin omega t equals to sin into 2 pi into 1000 right into t. So, output of voltage differentiator is given by this value. When I substitute the value, I will find that v o is nothing but minus 2.07 into cos 2 pi 1000 t. Thus the output waveforms looks like one shown here right. So, if you have this formula for output voltage, your output waveform would be this. So, we will see again by applying different voltages by applying different wave forms at the input of the differentiator, we will see how we can get the different waveforms at the output of the differentiator all right.

So, what we have seen, we have seen the opamp as a differentiator, and then we have seen the example of operational amplifier as a differentiator all right. So, in the next lecture, we will concentrate on using opamp as a filter alright the opamp as a filter circuit So, now, the opamp can be used for several applications and one of its application is filter. So, we will see how we can design filters. And similar kind of filter circuits and similar kind of this amplifier circuits, whether it is a inverting, non-inverting indicator, differentiator, summer right, unity gain amplifier, we will see the examples how we can implement those circuits on the breadboard. Or we will also see software called simulink and we will see how we can do how we can perform the simulation right, so that will give a little bit more understanding on how the circuit can be implemented what kind of equipment you can use and how you can design a particular circuit using operation amplifier all right.

So, till then you understand what exactly differentiator. You once again see how we can solve the problem for a differentiator. And then in the next class, in the next lecture, we will see how the opamp can be used as a filter, whether it is a passive filter, it is a active filter and there are several type of filter that we will be discussing in the next lecture. So, till then you just look at the whole lecture, where you have understood how the opamp can be used as an amplifiers all right.

So, till then you take care, and I will see you in the next lecture, bye.