Integrated Circuits, MOSFETs, OP-Amps and their Applications
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Lecture – 22
Applications of Operational Amplifier: Integrator

Welcome back. In this particular module, we will see how the integrator can be designed using an operational amplifier. So, when you talk about integrated, it performs the function of integration it performs the function of integration that is why the starting of the opamp, I told you the operational amplifier can be used to solve the mathematical functions right mathematical functions. So, let us see how you can design a opamp to work it as an integrator.

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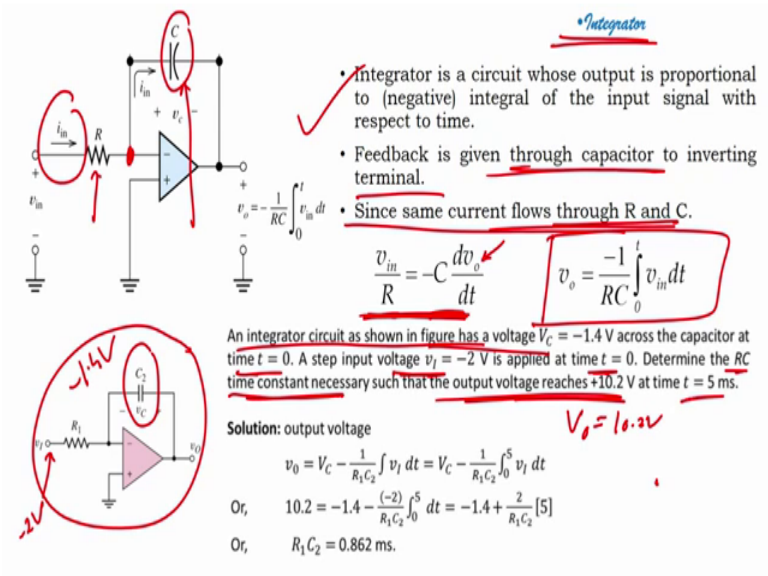

So, if you come to the screen what do you see is integrator is a circuit whose output is proportional to the negative integral of the input signal with respect to time right. So, here what we have done we have a resistor as an input, but in the feedback we have used a capacitor, we have used a capacitor. And if I solve it, if I solve it, what will I have, I will have v o would be minus 1 by R C 0 to t v in dt, v o would be minus 1 by R C 0 to t v in d t. It will integrate the input signal v in all right. So, once again if I see the definition of an integrator, if I see the definition of an integrator, it is a circuit whose output is proportional, this output voltage is proportional to the input, the integral to the negative integral negative integral of the input signal with respect to time. Feedback is given through capacitor to the inverting terminal, feedback is given through the capacitor to the inverting terminal right.

Now, since the same current flows through R and C right, you see here current i 1 flows through R it goes through i 1 goes through C right same current i in flow through R and C since same current flows to R and C, we have here, if I want to measure here right what will be here it will be v in by R equals to i in. You know want to want to measure here then what will I have I will have minus C into d v o by dt correct minus C into d v o by dt or v o equals to if I want to find v o from this equation, this is very simple mathematics that we can use we have to integrate minus 1 by R C into v in dt 0 to t correct. From this equation, if I want to measure, if I want to find the value of v o or we if I want to derive the equation of v o, then what I can do I can have the integration of minus 1 by R C right into 0 to t v in dt right.

Now, I know that ok, this is the formula for the integrator, this is the formula for the integrator. Let us solve a problem for the indicator all right. So, if you are given this circuit and indicator as shown in figure has V c equals to minus 1.4 volts, this V c equals to minus 1.4 volts across capacitor at time t equals to 0. A step voltage v in here minus 2 volts is applied all right. At time t equals to 0 again, determine the R C time constant, R C time constant necessary such that output voltage reaches, so v o equals to 10.2 volts at time t equals to 5 milliseconds right this is what we had to find. What we had to find we had to find the R C time constant, we have to find the R C time constant.

So, if I want to find the R C time constant, first I know that my formula for integrator is v o equals to V c right here. If I just want to find the formula for this one output voltage output voltage would be nothing but v o equals to V c minus 1 by R 1 C 2 integrated by v 1 dt correct. So, if I substitute the value, so what is value from 0 t equals to 0 to t equals to 5 millisecond. So, here I can reduce 0 to 5, 0 to 5 v 1 dt.

So, output voltage v o is what output voltage v o is 10.2, 10.2 equals to minus 1.4 which is my V c and then I substitute this value from 0 to 5 dt. Then what will I have when I substitute the value, I can find my value of R 1 C 2 to be 0.862 millisecond, 0.862 millisecond is my R C time constant alright is my R C time constant when I am given a integrator when I am given a integrator circuit to work on.

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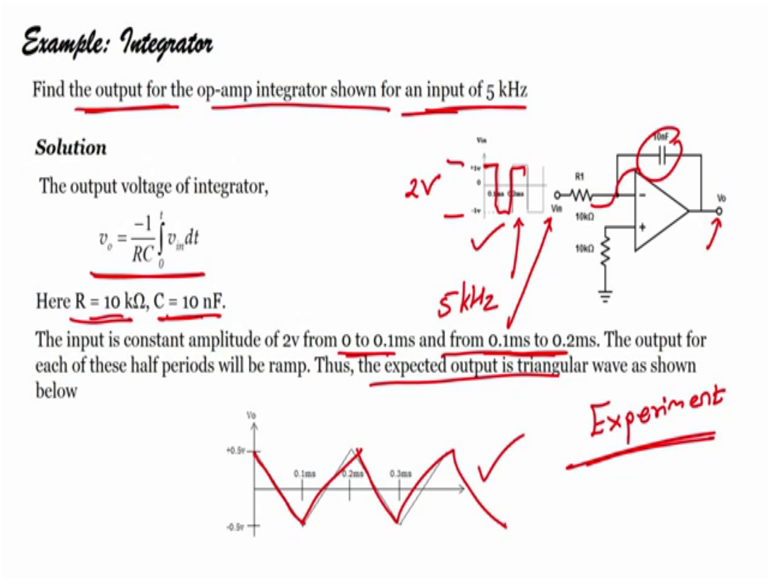

Let us take another example; let us take another example. So, again integrator is also used to change the signal all right or change the shape of the signal. So, it is a safe generator also, because if I apply a square wave I can obtain a triangle wave, I can obtain a triangle wave. And this we will see in the experimental section all right. I will show you how the integrator can be worked we can design integrator in the experimental section, when we perform the experiments. When we perform the experiments, I will show you how you are applying the input voltage in which particular signal is applied and what is the signal at the output voltage whether the shape is change or not.

So, here for this particular problem, what we are asked to find, we are asked to find the output for the opamp integrator shown in figure for an input of 5 kilohertz. So, it is saying that if I apply the input of 5 kilohertz, I had to find the output voltage. So, we know this value right, we know this equation. Now, R equals to 10 kilo ohm is given; C equals to 10 nanofarad again given. The input is constant. So, what is this here voltage, voltage is peak to peak voltage is 2 volts right. So, it is 2 volts. And it is constant from 0 to 0.1 milliseconds, and from 0.1 milliseconds to 0.2 milliseconds that is what the output of each of these half periods will be ramped. So, if I apply this input if they apply this input my output will be for each of these half period would be ramped and thus the expected output would be triangular wave.

So, if I apply this one right, if I apply the signal, I had to see how my capacitor will charge how my capacitor will charge and now charging and discharging of the capacitor I will form the I will get the wave at the output. I will get the triangular wave at the output. So, this is how the integrator would work.

Now, in the next module, what I want to show you is what is the differentiator, what is the differentiator. Now, integrator what we have seen if I take an example of the inverting amplifier and if I take an example of the integrator the thing that is different or non-inverting amplifier the main thing in integrator was that now the feedback is given through the capacitor, so that becomes our integrator. Our input resistance R, feedback capacitor C integrator, but if I change the capacitor from its point its feedback to the input, and I have feedback resistor then my circuit will become a differentiator.

We will see the differentiator in the next module, till then you just quickly see the integrator. Try to implement the circuit on the breadboard. It is very easy. You have to use function generator, you have to apply a dc power supply because you are using opamp. If it is a 741 opamp, you have to apply plus minus 15 volts; you know apply plus minus 2 volts peak to peak with a frequency of 5 kilohertz, this is a square wave. And when you when you see the output at the integrator what you will be able to see is that you can see this output with the help of oscilloscope it can be CRO it can be DSO. And you will be able to see that on applying the square wave the output will be triangular wave; that means, this integrator can also be used as a waveform generator, it can also be used as a waveform generator.

Differentiator and integrator both the circuits are also used as a filters, and also used as a filters, which will be our next lecture. So, I will see you in the next module, and we will see quickly very short module which will show the opamp as a differentiator.

Till then you take care, I will see you in the next module, bye.