Experiment 7: INTEGRATOR AND DIFFERENTIATOR USING OP-AMP

Aim/Objective: To design, construct, and analyze the working of:

- An **Integrator** using Op-Amp
- A **Differentiator** using Op-Amp

and to observe the input-output relationships for different waveforms.

Pre-requisite: NI Multisim and MyDAQ

Description:

Integrator:

The integrator circuit produces an output that represents the integral of the input signal, within a specific frequency range determined by the circuit's time constant and the Op-Amp's bandwidth. Since the input is applied to the inverting terminal, the output signal is inverted with respect to the input. In an ideal integrator, the output tends to drift and eventually saturate at the supply voltage limits due to input offset voltage. To maintain a stable DC operating point and prevent this saturation, a resistor Rf is added in parallel with the feedback capacitor C as shown in the figure below.

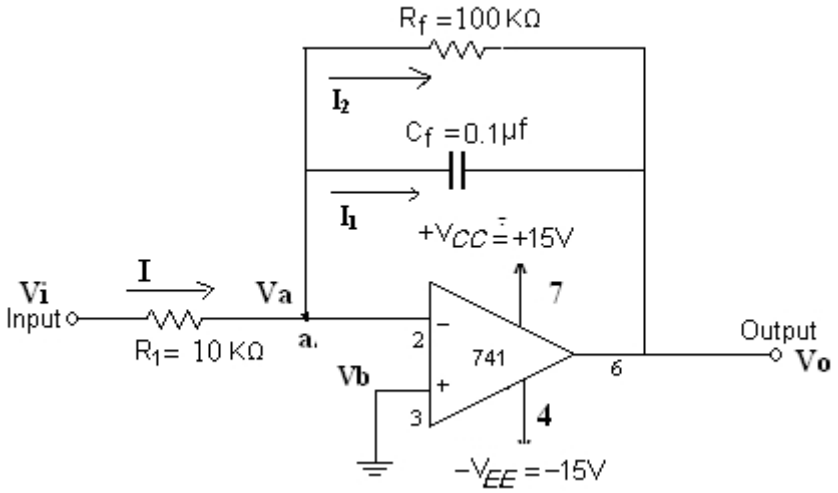


Figure 1: Integrator Circuit

The ideal integrator's input output relationship is given by the below equation (without Rf).

$$V_o(t) = -\frac{1}{R_1 Cf}\int_0^t V_i(t)dt$$

Differentiator:

The differentiator circuit outputs the derivative of the input signal over a frequency range based on the circuit time constant and the bandwidth of the amplifier. The input signal is applied to the inverting input so the output is inverted relative to the polarity of the input signal. The ideal differentiator circuit is fundamentally unstable and requires the addition of an input resistor, a feedback capacitor, or both, to be stable.

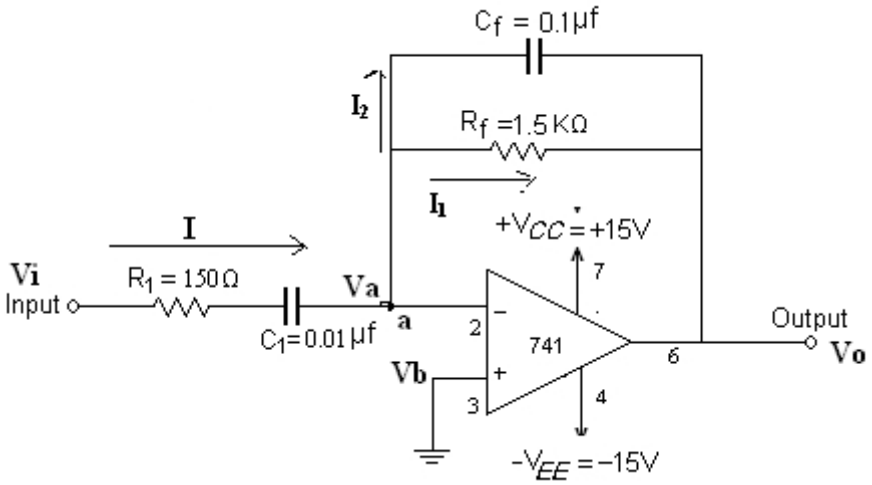


Figure 2: Differentiator Circuit

$$V_o(t) = -R_f C_1 \frac{d}{dt} V_i(t)$$

Pre-lab Session

1) Derive the expression for the output voltage of an ideal integrator circuit using an Op-Amp. Mention the assumptions made.

2) What is the role of the feedback capacitor in an Op-Amp integrator circuit? How does it affect the output signal?

3) Describe the difference in circuit configuration and function between an Op-Amp integrator and differentiator

4) What will be the output waveform of an Op-Amp integrator if the input is a square wave? Explain your reasoning

5) What are the potential limitations or drawbacks of a differentiator circuit at high frequencies? How can they be mitigated?

In-Lab Session

Procedure:

INTEGRATOR:

1. Connect the circuit as shown in fig 1.
2. Apply a symmetrical square wave of 2Vp-p amplitude and 1 KHz frequency.
3. Connect the input and output of the circuit to channel 0 and channel 1 of the MyDAQ respectively and observe the waveforms.
4. Draw the waveforms along with the levels on a graph.
5. Compare the practical values with theoretical values.
6. Repeat the same for sine-wave.

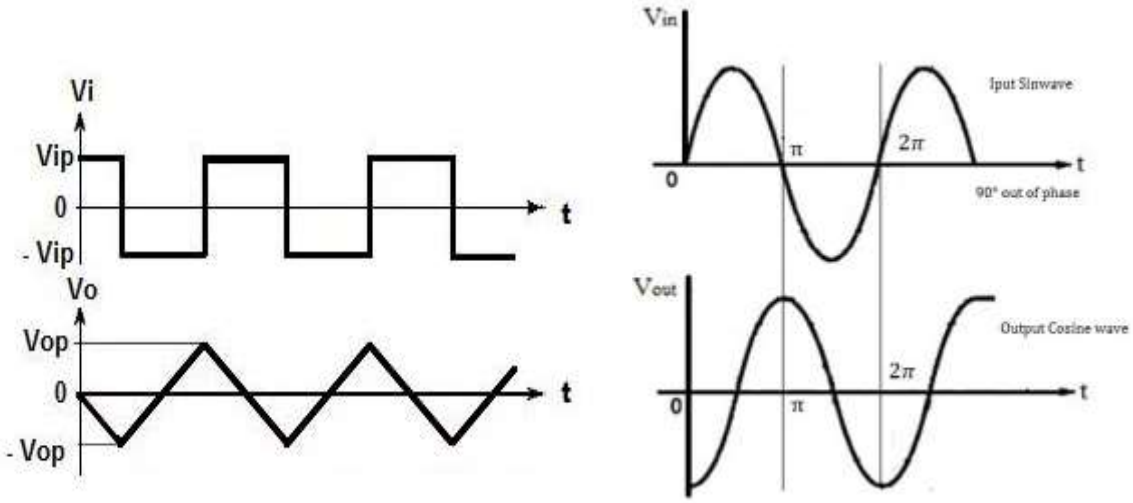
DIFFERENTIATOR:

1. Connect the circuit as shown in fig 2.
2. Apply a symmetrical triangular wave of 2Vp-p amplitude and 1KHz frequency.
3. Connect the input and output of the circuit to channel 0 and channel 1 of the MyDAQ respectively and observe the waveforms.
4. Draw the waveforms along with the levels on a graph.
5. Compare the practical values with theoretical values.
6. Repeat the same for the sine-wave.

INTEGRATOR:DIFFERENTIATOR:

S.no	Input Waveform	Time period	Amplitude	Output	amplitude	Time period
1	Square wave (1KHz)					
2	Sine wave (1KHz)					

Output Waveform of Integrator



Analysis and Inference:

When a sinusoid of lower frequency (10Hz) is applied to the integrator, how is the output behaving? Is the integration being observed?

When a sinusoid of higher frequency is applied (10KHz) is applied to the differentiator, how is the output behaving? Is differentiation being observed?

VIVA-VOCE Questions (In-Lab):

1) **In an ideal integrator circuit, the output is:**
   A. Directly proportional to the input
   B. A delayed version of the input
   C. The time integral of the input
   D. The time derivative of the input

2) **A capacitor in the feedback path of an Op-Amp typically indicates:**
   A. Comparator operation
   B. Amplifier operation
   C. Integrator operation
   D. Buffer operation

3) **If a sine waveform is applied to an ideal differentiator, the output will be:**
   A. A square waveform
   B. A cosine waveform
   C. Another sine waveform
   D. A delayed triangle waveform

4) **A practical differentiator includes a resistor in the feedback path mainly to:**
   A. Increase gain
   B. Limit low-frequency response
   C. Reduce loading effect
   D. Prevent high-frequency instability

5) **Which component determines how quickly the output of an integrator changes in response to the input?**
   A. The power supply
   B. The feedback capacitor
   C. The input connector
   D. The output terminal

Post-Lab Session

Observe how changing the resistor or capacitor value affects the output waveform of an integrator or differentiator circuit.

Choose the differentiator circuit and change resistor and capacitor values one at a time and apply the input. Observe how the output waveform is changing.

Result:

Studied the integrator and differentiator using Opamp

Evaluator Remark (if Any):	**Marks Secured: _____out of 50**
	Signature of the Evaluator with Date