Experiment No: 5

INTEGRATOR AND DIFFERENTIATOR USING OP-AMP

AIM

To design and set up an integrator and differentiator circuit using op-amp.

APPARATUS REQUIRED

Power supply, CRO, function generator, bread board, op-amp, capacitor and resistors.

THEORY

INTEGRATOR

Refer to the figure 1. This circuit performs the integration of the input waveform. The output voltage V_o can be expressed as $V_o = -\frac{1}{RC}\int V_i dt + k$ where k is the constant of integration which depends upon the value of V_o at $t = 0$. The peak of the output waveform V_T is given by the expression $V_T = \frac{VT}{4RC}$, where T is the time period of the input square wave. Integrators are commonly used in analog computers and wave shaping networks.

DIFFERENTIATOR

If the input resistor of the inverting amplifier is replaced by a capacitor, it forms an inverting differentiator. The output of the circuit is the derivative of the input. Gain of the differentiator increases with increase in frequency, which makes the circuit unstable. This is a drawback of the circuit. The output voltage V_o can be expressed as $V_o = -R_F C_i \frac{dV_i}{dt}$. Differentiator functions as high pass filter. At high frequency it becomes unstable and breaks into oscillations. Input impedance decreases with increase in frequency which makes the circuit very susceptible to high frequency noise. Both stability and high frequency noise problems can be reduced significantly by additional circuit elements.

DESIGN AND CIRCUIT DIAGRAMS

DESIGN OF INTEGRATOR

Let the input frequency be 1 kHz. The frequency at which the integrator gives unity gain output is given by, $f = \frac{1}{2\pi R_1 C}$

Let $C = 0.01\mu F$. then $R_1 = 15.9\ k\Omega$. Use 15 kΩ std.

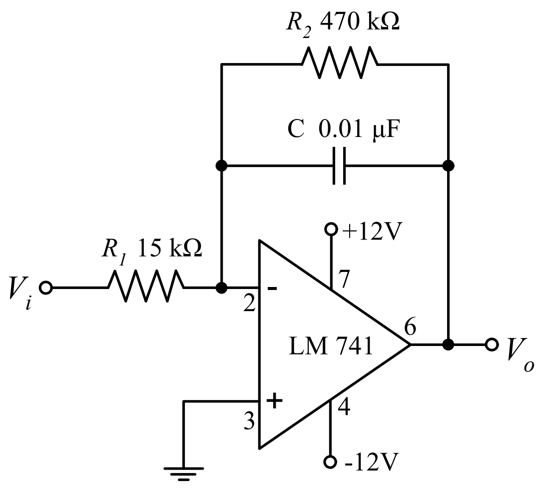

Fig. 1. Circuit diagram of Integrator

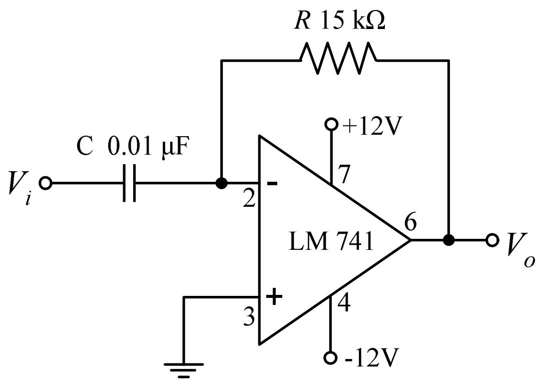

Fig. 2. Circuit diagram of Differentiator

The resistor R_2 in the integrator is provided to attenuate low frequency signals, particularly input dc offset voltage that may be present. Typically, the value of R_2 is selected as 10 times R_1 or more. Select the value of R_2 as 470 k.

DESIGN OF DIFFERENTIATOR

We have, $f = \frac{1}{2\pi RC}$

Let $C = 0.01\mu F$. then $R = 15.9\ k\Omega$. Use 15 kΩ std.

PROCEDURE

INTEGRATOR

1. Set up the integrator circuit as shown in figure. Give a rectangular wave of ±5V (10V pp) and 1 kHz frequency at the input and observe the input and output simultaneously on CRO.
2. Vary the dc offset of the square wave input and observe the difference in the output waveform.
3. Repeat the experiment by feeding triangular wave and sine wave at the input and observe the output.

DIFFERENTIATOR

1. Set up the differentiator circuit as shown in figure. Give a rectangular wave of ±5V (10V pp) and 1 kHz frequency at the input and observe the input and output

simultaneously on CRO.

2. Repeat the experiment by feeding triangular wave and sine wave at the input and observe the output.

WAVEFORMS

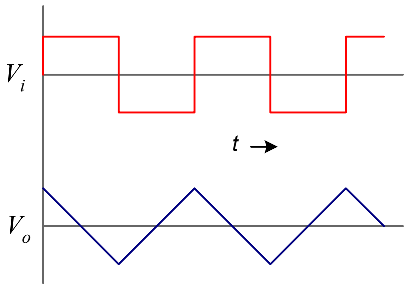

Fig 3. Integrator output

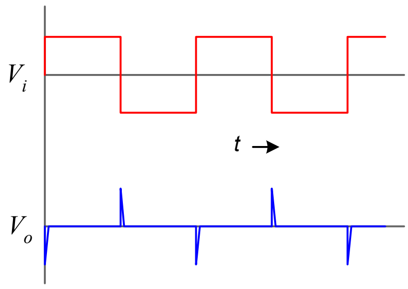

Fig 4. Differentiator output