PH
~~EE~~-211 Electronics lab.

Experiment 6 - Integrator & Differentiator Circuit
Using OP-AMP.

Name - Rohit.R

Roll No - 220121072

$\frac{48}{50}$

Experiment No - 6.

Experiment Name - Integrator & Differentiator Circuits
Using Operational Amplifiers.

Date - 28/06/23

Integrator and Differentiator circuits using op.amp.

A: To study the integrator and differentiator circuits using operational amplifier (IC 741).

Formula Used:

(a) Integrator Circuit

$$A = \frac{V_0}{V_i} = -\frac{R_f}{R}\left[\frac{1}{j2\pi \nu R_f C_f + 1}\right]$$

$$|A| = \frac{R_f/R}{\sqrt{1 + \omega^2 R_f^2 C_f^2}}$$

where

A = voltage gain
V_0 = o/p voltage
V_i = i/p voltage
ω = Angular frequency.

R_f = feedback resistance
R = input resistance in series with r_i
ν = frequency of V_i
C_f = feedback capacitance

(b) Differentiator circuit

$$A = \frac{V_0}{V_i} = -\frac{R_f(j\omega C)}{1 + j\omega CR}$$

$$|A| = \frac{R_f \omega C}{\sqrt{1 + \omega^2 C^2 R^2}}$$

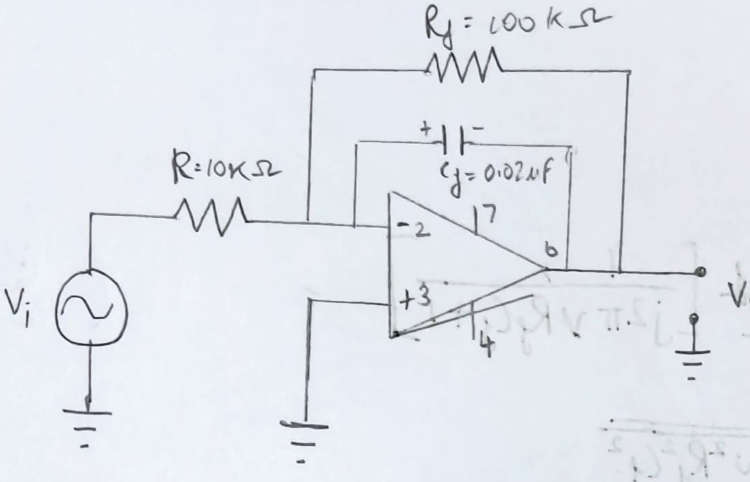
where

A: voltage gain
V_0: o/p voltage
V_i: i/p voltage
ω: angular frequency

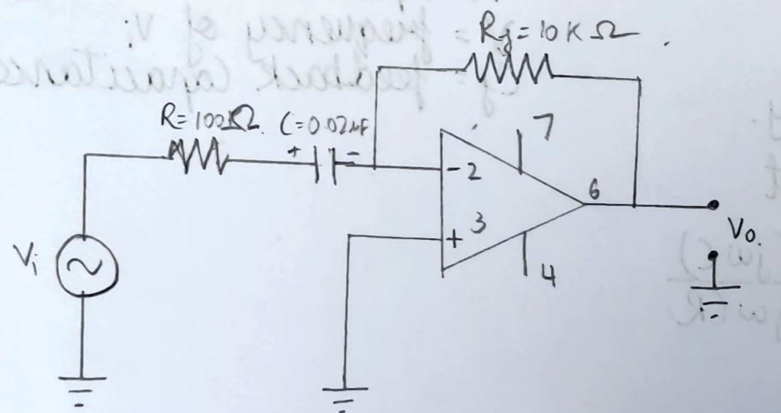
R_f: feedback resistance
R: resistance in series with r_i
C: Capacitor

Circuit Diagram:

1) Integrator Circuit

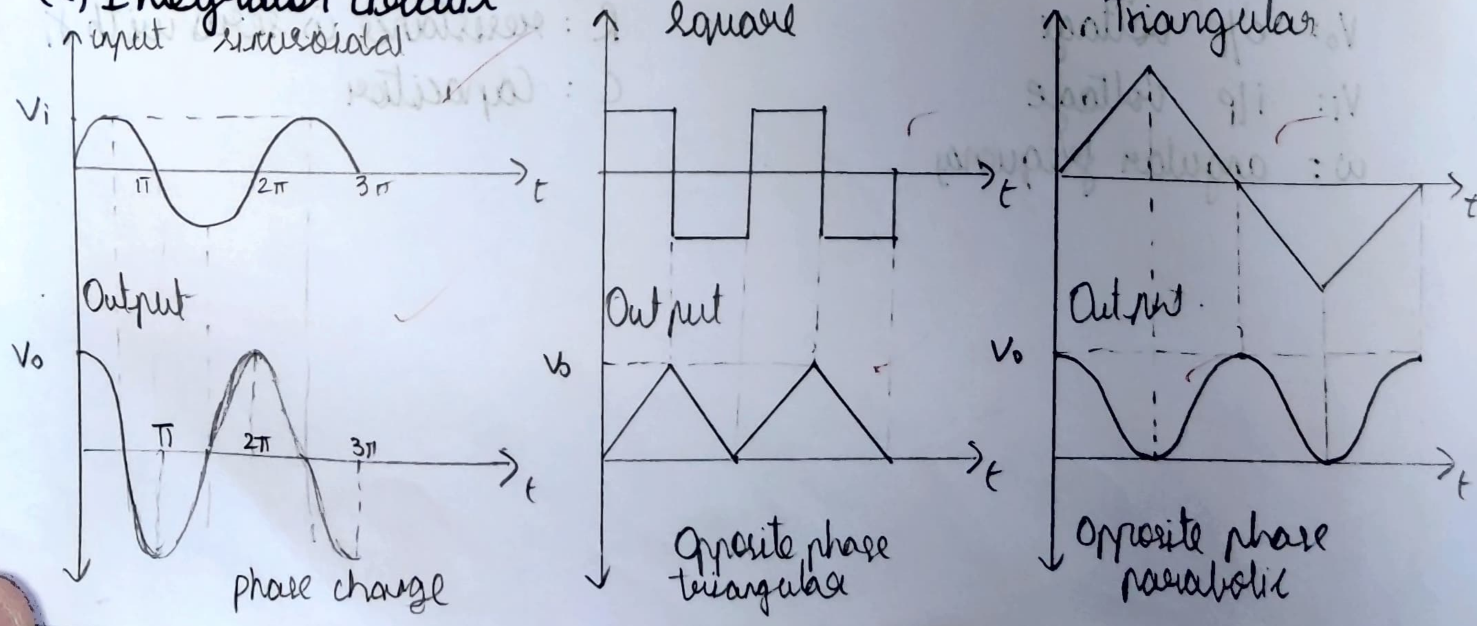


2) Differentiator Circuit

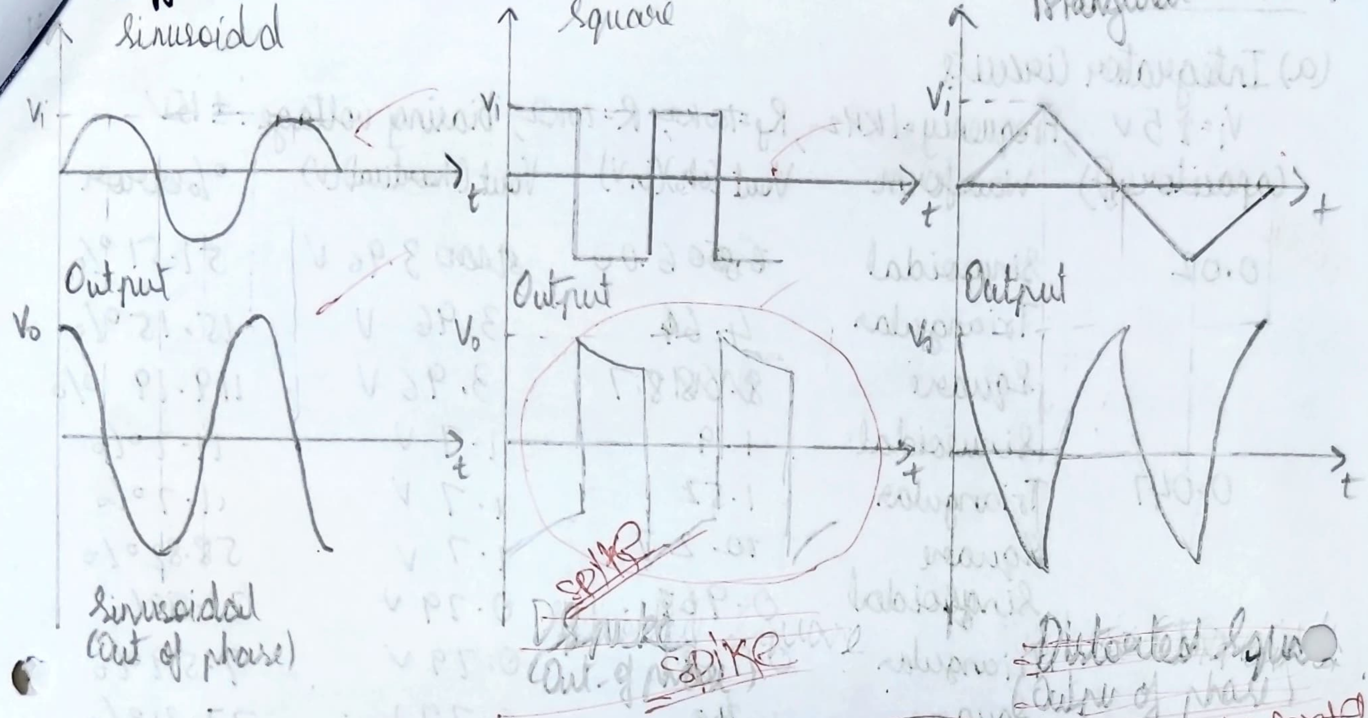


Expected Waveforms

(a) Integrator Circuit

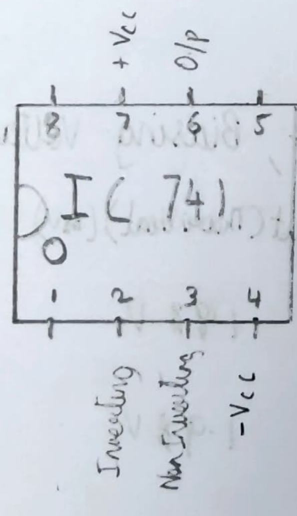


Differentiator Circuits



$Ip = \frac{9}{10}$

Diagram of IC 741



Observations:

(a) Integrator Circuits

$V_i = \pm 5$ V, Frequency = 1 KHz, R_f = 100 kΩ, R = 10 kΩ, biasing voltage: ± 15 V

Capacitor (μF)	Waveform	Vout (obs) (in V)	Vout (Theoretical) (V)	% error
0.02	Sinusoidal	6.00	3.96 V	51.51 %
	Triangular	4.6	3.96 V	15.15 %
	Square	8.7	3.96 V	119.19 %
0.047	Sinusoidal	1.9	1.7 V	11.7 %
	Triangular	1.5	1.7 V	11.7 %
	Square	2.7	1.7 V	58.82 %
0.1	Sinusoidal	0.96	0.79 V	21.51 %
	Triangular	0.73	0.79 V	7.59 %
	Square	1.4	0.79 V	77.21 %

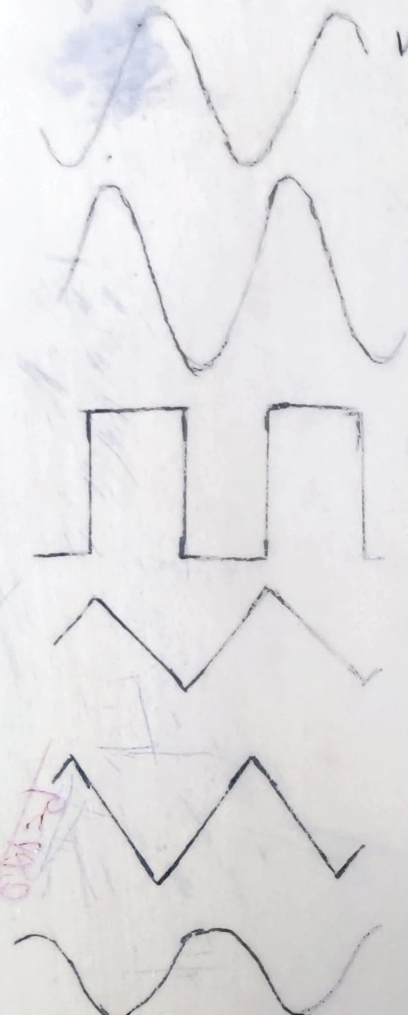
(b) Differentiator Circuits

V_i = 1.5 V, C_f = 0.02 μF, Frequency = 1 KHz, Biasing Voltage = ± 15 V

Waveform	Vout (obs) (in mV)	Vout (Theoritical) (mV)	% error
Sinusoidal	2.0 V	1.9 V	10.5 %
Triangular	2.0 V	1.9 V	10.5 %
Square	27.6 V	1.9 V	1352.6 %

→ Apparatus:
Digital storage Oscilloscope, function generator, Multilink Power supply, bread board, connecting wires, capacitors (0.02 μF, 0.047 μF, 0.1 μF) resistors (100 Ω, 10 kΩ, 100 kΩ), opamp (IC 741) and Multimeter.

Integrator circuit



Sinusoidal
$\nu = 1000 Hz$
$V_i = 5 V_{p-p}$

V_i

V_o

Square wave
$\nu = 1000 Hz$
$V_i = 5 V_{p-p}$

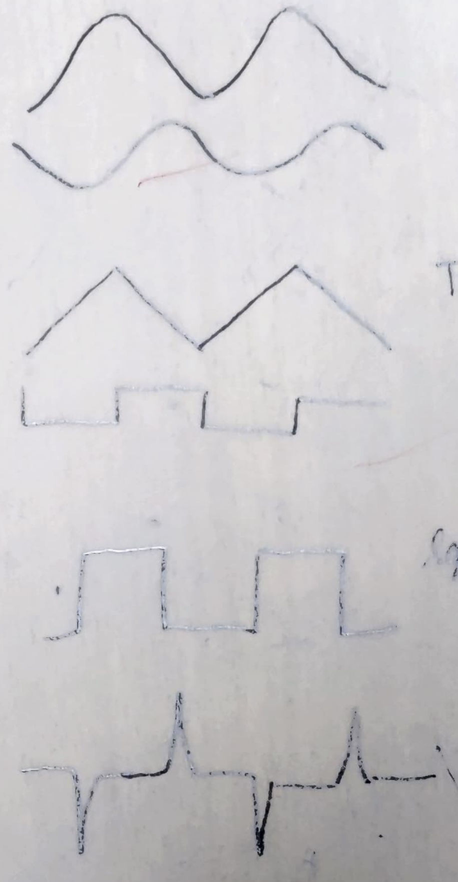
V_i

V_o

Triangular
$\nu = 1000 Hz$
$V_i = 5 V_{p-p}$

$C_F = 0.02 \mu F$
$R_f = 100 k\Omega$
$R = 10 k\Omega$

Differentiator



Sinusoidal

Triangular

Square

$V_i = 1.5 V_{pp}$
$R_f = 10 k\Omega$
$R = 100 \Omega$
$C_F = 0.02 \mu F$
$F = $ [illegible] Hz

ulation:

(a) Integrator Circuits

$$A = \frac{R_f/R}{\sqrt{1+\omega^2 R_f^2 C_f^2}}$$

$R_f = 100\,k\Omega$, $R = 10\,k\Omega$

$\omega = 2\pi \times 10^3$

$V_i = 5\,V$

① $C_f = 0.02\,\mu F$

$$A = \frac{10}{\sqrt{1+(2\pi)^2\times(10^5)^2(10^{-6})\times(0.02)^2\times(10^3)^2}} = 0.79$$

$\therefore V_o = V_i \times A = \cancel{0.79\,V}\ 3.96\,V$

② $C_f = 0.047\,\mu F$

$A = \frac{10}{\sqrt{1+872}} = 0.34$ $\therefore V_o = 1.70$

③ $C_f = 0.01\,\mu F$

$A = \frac{10}{\sqrt{1+3947}} = 0.1597$ $\therefore V_o = 0.79\,V$

④ $C_f =$

$A =$ $\therefore V_o$

(b) Differentiator Circuits. $V_i = 1.5V$

$$|A| = \frac{R_f \omega C}{\sqrt{1+\omega^2 C_f^2 R^2}}$$

$R_f = 10\,k\Omega$, $C = 0.02\,\mu F$

$R = 100\,k\Omega$, $f = 1000\,Hz$

$\therefore A =$ 1.25V

$V_o = V_i \times A = 1.88\,V$

ecl=10

Result:

1. In the integrator circuit, as the value of the capacitor increases the output voltage decreases
2. The output of the square waveform shows maximum error
3. Integrator circuit

Input	Output
Sinusoidal	Sinusoidal
Triangular	Parabolic
Square	Triangular

Differentiator:

Input	Output
Sinusoidal	Sinusoidal
Triangular	Distorted square
square	Spikes (Dirac-delta)

Precautions and Discussion

1. Make sure that all connections are tight
2. Apply biasing voltage between 12-15 V
3. Keep Vin ≤ 2V during differentiator circuit.
4. Ensure that the polarity of capacitor is carefully checked and the circuit made keeping its polarity in mind
5. In the integrator circuits triangular waveform generally has the least ammount of error while the square waveform has the most error
6. There is generally a larger error in this experiment due to resistance in the operational amplifier along with variance in the resistance of resistor & capacitance of capacitor
7. The voltage that is given at the input should be reduced untill there is no clipping observed in the output
8. The most amount of error is seen on the spots where there is distortion in the input voltage due to noise.
Due to this in the differentiator circuit we get a waveform of instead of which results in a higher than average error.
The same is observed in Integrator circuit where square waves have much higher % error due to Noise.
9. In the integrator circuit the Vout decreases as the capacitance increases