

Aim ➡ To design and verify the integrator circuit using an Operational Amplifier.

Equipment Required ➡

Resistors, Capacitor, IC 741 OP-AMP, Function Generator, DSO, Breadboard & Wires.

Theory ➡

An **integrator circuit** is an analog circuit that performs mathematical integration, generating an output voltage proportional to the time integral of the input voltage. It is widely used in signal processing, waveform generation, and control systems. The circuit consists of a resistor R connected to the input and a capacitor C in the feedback loop.

When an input voltage is applied, the resistor allows current to flow to the capacitor, which stores charge over time. The voltage across the capacitor, which determines the output, changes proportionally to the integral of the input signal. Mathematically, the output voltage is expressed as:

$$V_{out} = -\frac{1}{RC} \int V_{in} dt$$

The resistor-capacitor combination ensures the integration operation, while the negative sign indicates a phase inversion. The circuit is effective for low-frequency signals, integrating accurately without distortion. However, high-frequency noise or DC offsets can cause output drift, mitigated by practical design adjustments.

The integrator circuit primarily converts a square wave input into a triangular wave, demonstrating its ability to process and reshape signals. The slope of the output waveform depends on the amplitude of the input signal and the values of R and C, highlighting its role in waveform generation applications. It is also used in analog computers, filters, and control systems to perform operations like smoothing signals or solving differential equations. The circuit's accuracy depends on the components' quality and the power supply's stability.

In practical applications, the circuit is sensitive to input noise and offsets, which can lead to output drift over time. To overcome this, a high-value resistor is often parallel to the capacitor, creating a path for DC feedback and stabilizing the output. Additionally, proper selection of R and C ensures that the circuit operates effectively within the desired frequency range, with the critical frequency $f_c = \frac{1}{2\pi RC}$ marking the transition between integration and attenuation behavior. These design considerations make the integrator versatile and robust for real-world applications.

Circuit Diagram ⇄

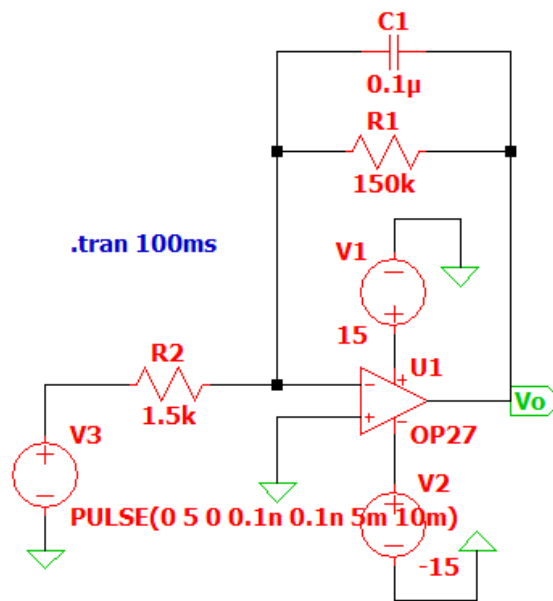


Fig. i) Integrator Circuit using OpAmp

Graphs ⇄

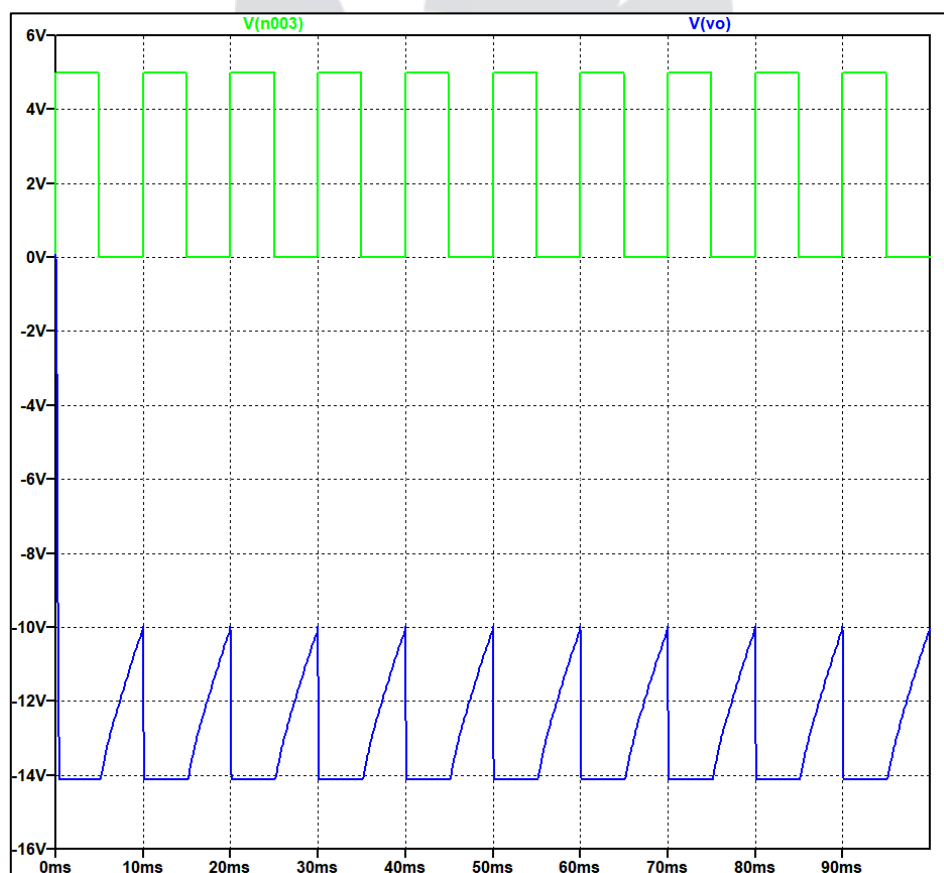


Fig. ii) Integrating Pulse Wave into Triangular Wave

Output ⇌



Fig. iii) Input Square wave

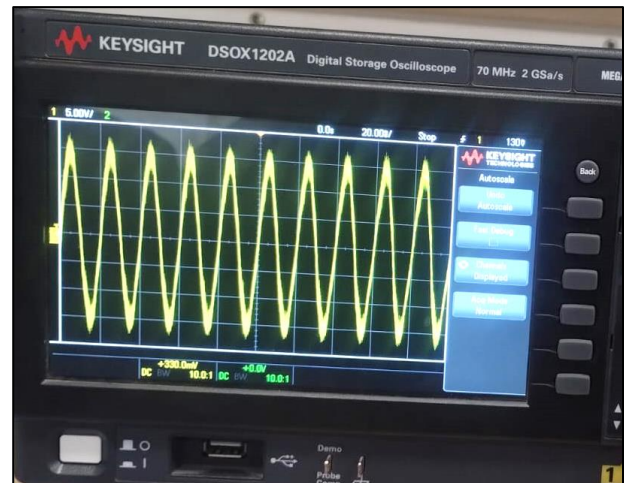


Fig. iv) Output Triangular wave

Result ⇌

The integrator circuit was successfully designed and tested, producing an output waveform proportional to the time integral of the input signal, as expected.

Conclusion ⇌

The circuit operated as predicted, demonstrating the functionality of the integrator and validating the theoretical calculations for signal integration.

Precautions ⇌

- Ensure proper placement of the resistor and capacitor and correct wiring of the circuit components on the breadboard.
- Verify the power supply connections to the OpAmp to prevent damage.
- Make sure input voltage levels are within the allowable range for the IC 741 OpAmp to avoid distortion or malfunction.
- Double-check the values of the resistor and capacitor to ensure accurate integration and proper circuit operation.
- Avoid high-frequency noise at the input, as it can affect the output waveform accuracy.