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Op-Amp applications

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1 About LM358 ic

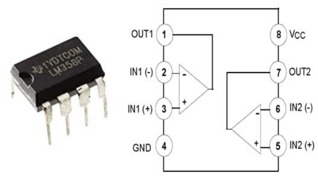
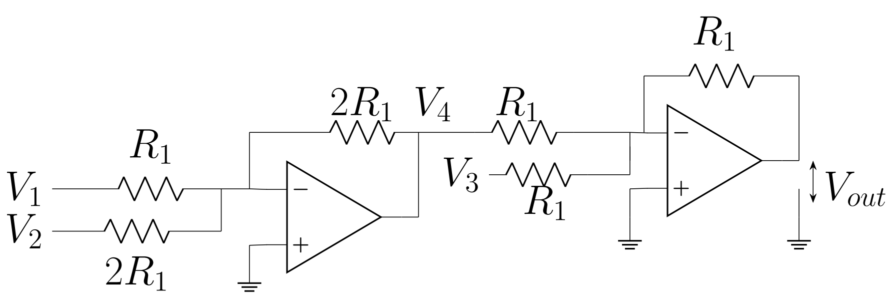


Figure 1: Schematic Diagram

The LM358 is a dual operational amplifier (op-amp) IC widely used in various analog electronic applications. It contains two independent, high-gain, internally compensated op-amps, which can be used for a wide range of tasks, such as signal amplification, filtering, and feedback control. The LM358 operates with a single supply voltage, typically ranging from 3V to 32V, making it suitable for low-voltage circuits. Due to its low power consumption and versatile application in both inverting and non-inverting configurations, the LM358 is a popular choice for many analog signal processing tasks.

2 Custom Weighted Summing Amplifier



Theory

- A **summing amplifier** is an op-amp circuit that combines multiple input signals into a single output signal. The output is a weighted sum of the input signals.
- The **inverting summing amplifier** uses an op-amp with multiple input resistors and a feedback

resistor. The output voltage is given by:

$$V_{\text{out}} = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$$

where R_f is the feedback resistor, and R_1, R_2, R_3 are the input resistors.

- By carefully selecting the resistor values, you can achieve specific weighting coefficients for the inputs. For example, to implement $V_{\text{out}} = 2V_1 + V_2 - V_3$, you would choose resistor values such that:

$$\frac{R_f}{R_1} = 2, \quad \frac{R_f}{R_2} = 1, \quad \frac{R_f}{R_3} = 1$$

- If a **non-inverting input** is required, you can combine inverting and non-inverting amplifiers.

How to Perform the Experiment

- **Components Required**:
  - Op-amp (e.g., LM358, TL081)
  - Resistors (carefully selected for weighting)
  - DC power supply
  - Function generator (for input signals)
  - Oscilloscope
- **Steps**:
  - Design the circuit using an inverting summing amplifier configuration.
  - Choose resistor values R_1, R_2, R_3, and R_f to achieve the desired weighting coefficients.
  - Connect the input signals V_1, V_2, and V_3 to the input resistors.
  - Connect the feedback resistor R_f between the output and the inverting input of the op-amp.
  - Power the op-amp using the DC power supply.
  - Use the oscilloscope to measure the output voltage V_{out} and verify that it matches the expected weighted sum of the inputs.

By the following the above steps , we get the output response.

1. $V_{out} = 2V_1 + V_2 - V_3$,
   Values taken are,$V_1 = 3, V_2 = 4, V_3 = 7,$
   Then $V_{out} = 3$

2. $V_{out} = 2V_1 - V_3$(By keeping $V_2 = 0$)
   Now, for the values, $V_1 = 2, V_3 = 3$,
   $V_{out} \quad is \quad 1V$

For Case-I:

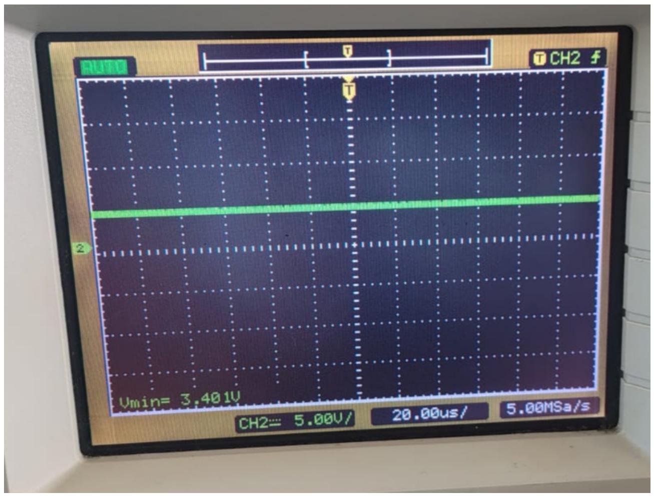


Figure 2: output

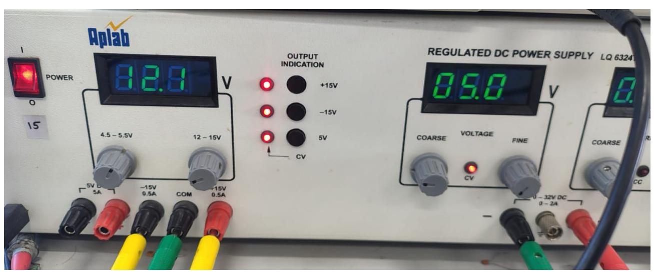


Figure 3: DC power supply

Figure 4: Function Generator

Case-II:

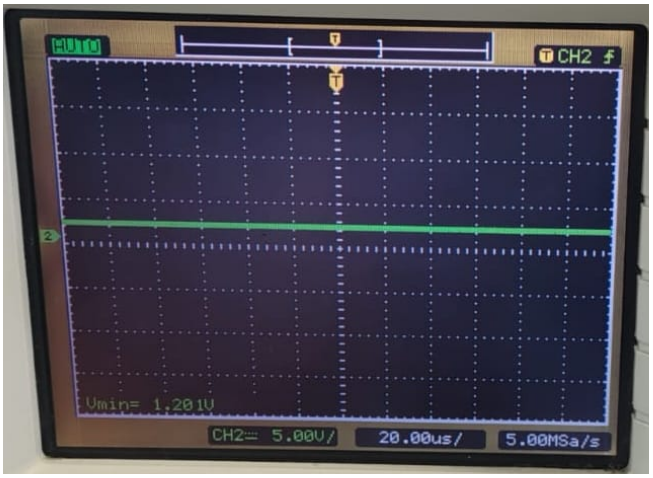


Figure 5: Output

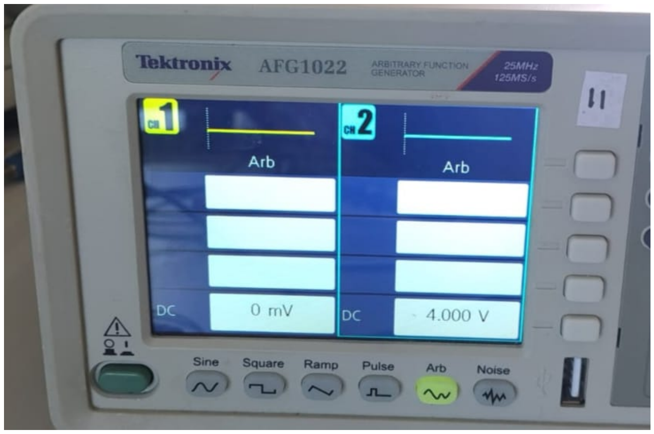


Figure 6: Function generator

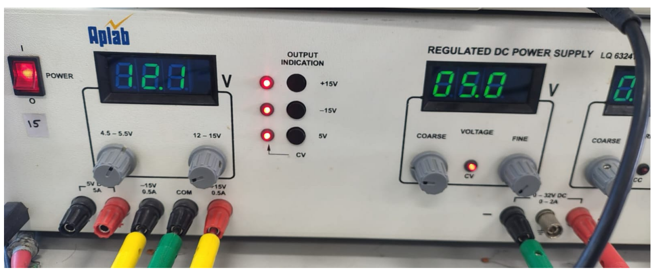
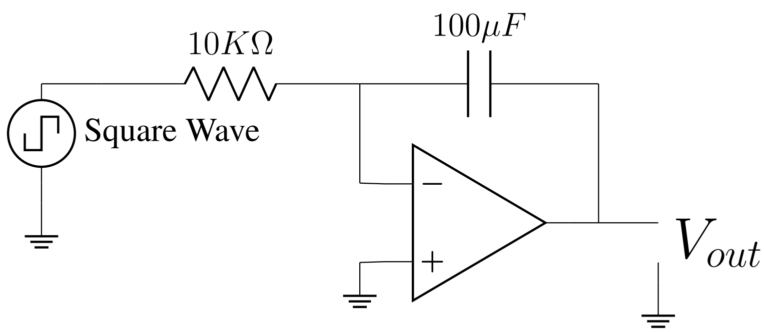


Figure 7: DC supply

3 Op-Amp Integrator



Theory

- An **op-amp integrator** performs mathematical integration of the input signal. The output voltage is proportional to the integral of the input voltage:

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

  where R is the input resistor, and C is the feedback capacitor.

- The integrator converts a **square wave input** into a **triangular wave output** because integration of a constant (square wave) results in a linear ramp (triangular wave).

- This circuit is widely used in signal processing, waveform generation, and control systems.

How to Perform the Experiment

- **Components Required**:
  - Op-amp (e.g., LM741, TL081)
  - Resistor (R)
  - Capacitor (C)
  - DC power supply
  - Function generator
  - Oscilloscope
- **Steps**:

- Design the integrator circuit by connecting the input resistor R to the inverting input of the op-amp and the feedback capacitor C between the output and the inverting input.
- Connect the non-inverting input of the op-amp to ground.
- Power the op-amp using the DC power supply.
- Apply a square wave input signal using the function generator.
- Use the oscilloscope to observe the output waveform. The output should be a triangular wave, confirming that the circuit is performing integration.

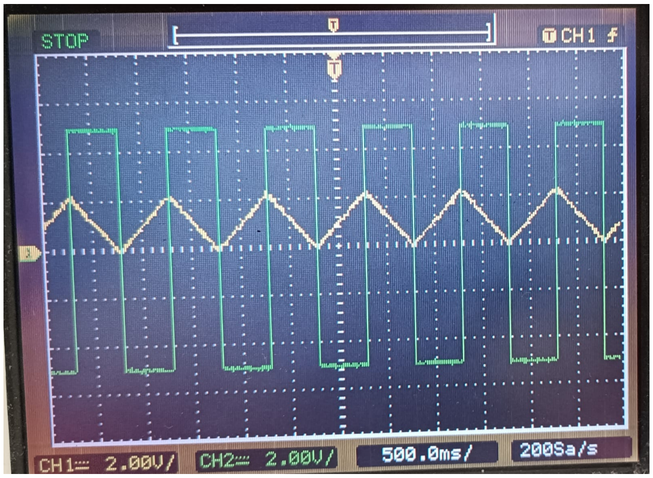
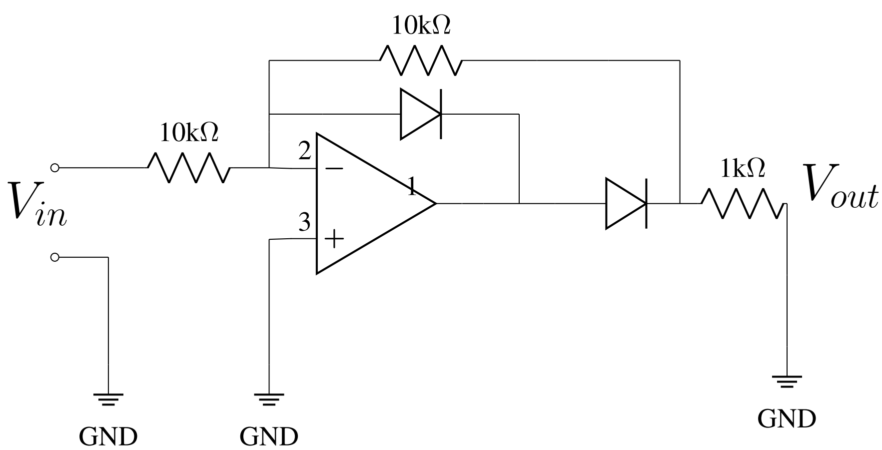


Figure 8: Op-Amp integrator when square input is given.

4 Precision Rectifier (Super Diode)



Theory

- A **precision rectifier** uses an op-amp to eliminate the voltage drop (typically 0.7V) associated with a standard diode. This allows rectification of small AC signals with high accuracy.
- There are two types of precision rectifiers:
  - **Half-wave rectifier**: Passes only the positive half of the input signal.
  - **Full-wave rectifier**: Combines the positive half of the input signal with the inverted negative half, resulting in a fully rectified output.
- The op-amp ensures that the output follows the input without the diode's threshold voltage drop.

How to Perform the Experiment

- **Components Required**:
  - Op-amp (e.g., LM358, TL081)
  - Diode (e.g., 1N4148)
  - Resistors
  - AC signal generator
  - Oscilloscope
- **Steps**:
- **Full-wave rectifier**:
  - Add an additional summing stage to combine the positive and inverted negative portions of the input signal.
  - Apply an AC input signal and observe the fully rectified output on the oscilloscope.

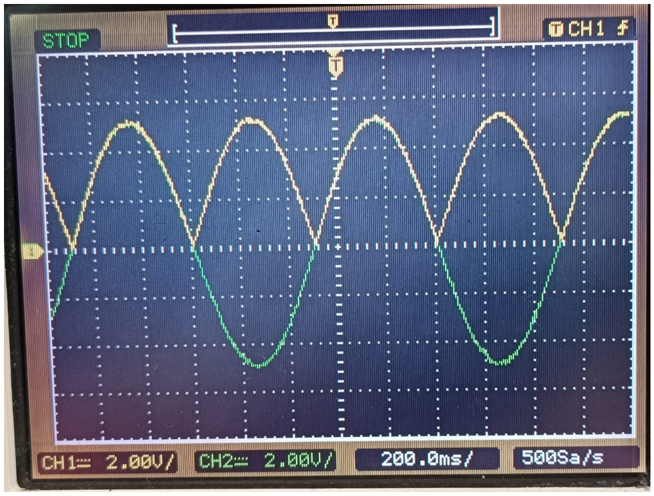


Figure 9: Full Wave rectifier.

Summary of Steps for All Three Parts

- **Custom Weighted Summing & Difference Amplifier**:
  - Design the circuit with appropriate resistor values.
  - Apply input signals and measure the output to verify the weighted sum.
- **Op-Amp Integrator**:
  - Build the integrator circuit with a resistor and capacitor.
  - Apply a square wave input and observe the triangular wave output.
- **Precision Rectifier**:
  - Construct the half-wave or full-wave rectifier circuit.
  - Apply an AC input and observe the rectified output on the oscilloscope.