Aim ↪ To design a single-stage RC Coupled Amplifier and study its gain & bandwidth by plotting frequency response.

Equipment Required ↪

Bipolar Junction Transistors, resistors, capacitors, power supply, multimeter, waveform generator, breadboard, and connecting wires.

Theory ↪

A single-stage RC coupled amplifier consists of a Bipolar Junction Transistor (BJT) connected with resistors and capacitors to provide amplification of low-frequency signals. The amplifier's input signal is coupled to the base of the transistor via a coupling capacitor, which blocks any DC component and allows only the AC signal to pass through. The transistor amplifies the signal, and the amplified signal is then coupled to the output through another capacitor.

In an RC coupled amplifier, the operating point is set by the resistor network (biasing), and the capacitors ensure that only the AC signal is amplified. The amplification is controlled by the transistor, and the gain depends on the collector resistor and the characteristics of the transistor. The frequency response of the amplifier depends on the RC components, particularly the cutoff frequencies determined by the coupling capacitors and the load resistance.

The gain of an amplifier is a measure of how much the input signal is amplified, and it varies with frequency. At low frequencies, the gain is reduced due to the capacitive reactance of the coupling capacitors. At high frequencies, parasitic capacitances in the transistor and the wiring limit the gain. The bandwidth of the amplifier is the range of frequencies over which the amplifier maintains a reasonably constant gain. By plotting the frequency response, the gain and bandwidth of the amplifier can be studied.

In a single-stage RC coupled amplifier, the voltage gain A_V can be expressed as the ratio of the output voltage to the input voltage. The gain primarily depends on the transistor's current gain β, and the resistors used in the circuit, particularly the collector resistor R_C and the load resistance R_L. The voltage gain is given by the formula:

$$A_V = -\beta \times \frac{R_C \parallel R_L}{r_e}$$

where r_e is the small-signal emitter resistance, and $R_C \parallel R_L$ represents the parallel combination of the collector and load resistances. The negative sign indicates a phase shift of 180 degrees between the input and output signals.

The amplifier's bandwidth is determined by the coupling capacitors and the resistances in the circuit. The lower cutoff frequency f_L is influenced by the coupling capacitors and can be estimated using the formula:

$$f_L = \frac{1}{2\pi R_{in} C_{in}}$$

where R_{in} is the input resistance and C_{in} is the input coupling capacitor. At the high-frequency end, the bandwidth is limited by the parasitic capacitances of the transistor and the circuit layout.
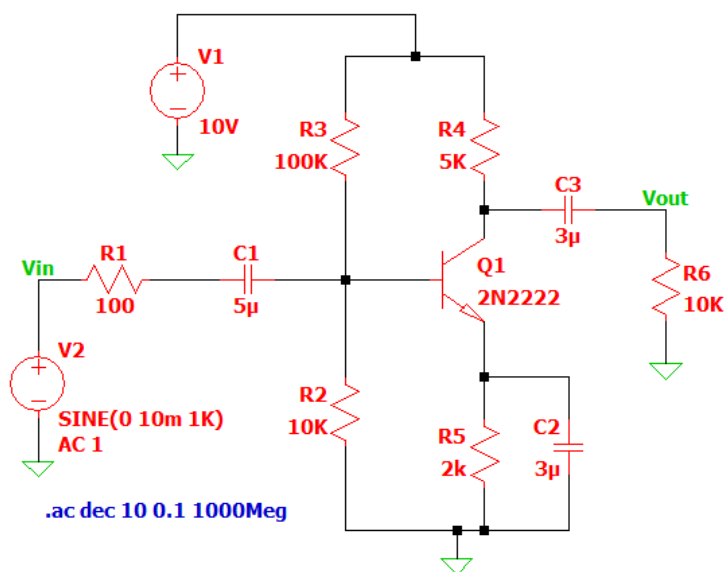
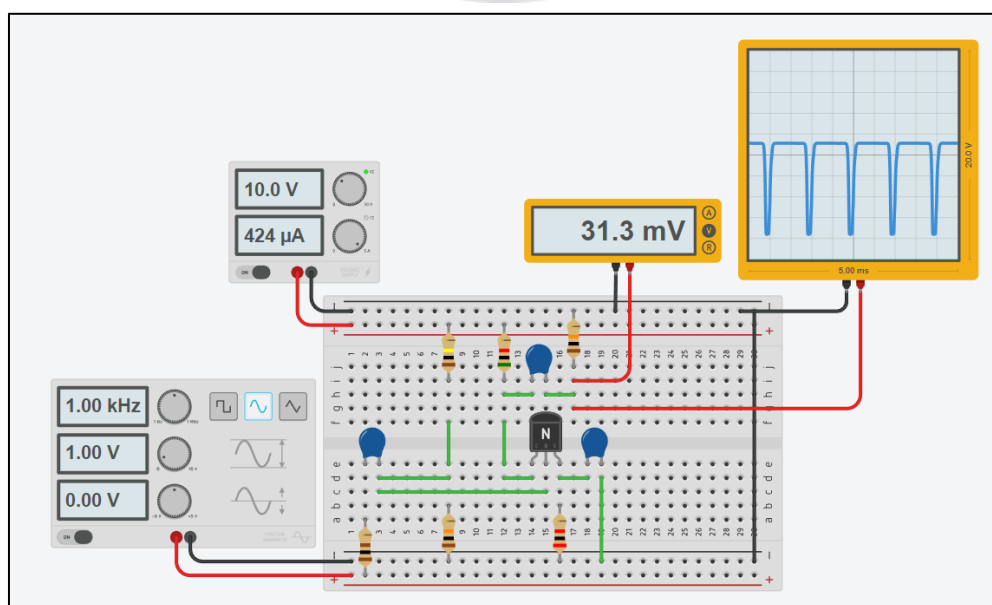## Circuit Diagram ↪

Fig. i) Circuit in LTSpice

Fig. ii) Circuit in TinkerCad

Observation Table ↬

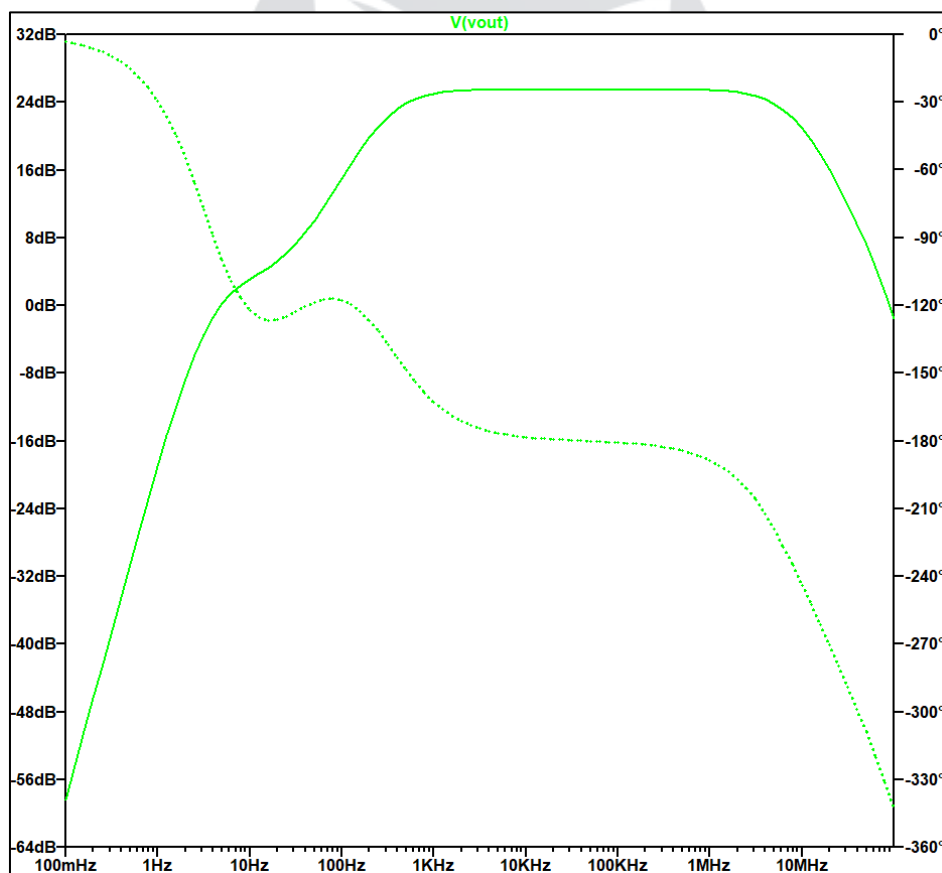| S.No.	Freq[Hz]	Vout	Gain	Gain[dB]
1	0.1	0	0	-58.36
2	1	0.1	0.1	-19.02
3	10	1.43	1.43	3.11
4	100	5.61	5.61	14.98
5	1k	17.84	17.84	25.03
6	10k	18.77	18.77	25.47
7	100k	18.79	18.79	25.48
8	1M	18.62	18.62	25.40
9	10M	11.14	11.14	20.94
10	100M	0.84	0.84	-1.56
11	1G	0.04	0.04	-28.48

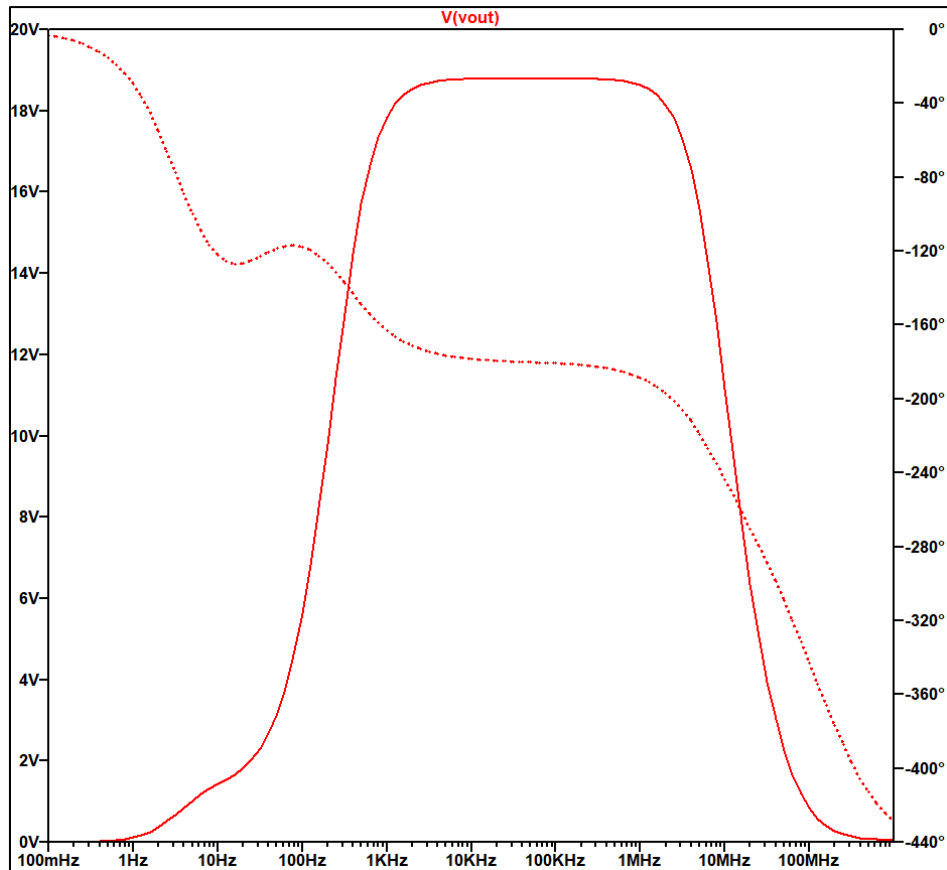**Graphs ↬**

Fig. iii) Frequency Response [Decibel]

Fig. iv) Frequency Response [Linear]

Result ↝

The single-stage RC coupled amplifier showed significant voltage gain in the mid-frequency range, with reduced gain at low and high frequencies due to capacitor and transistor limitations. The frequency response confirmed the expected bandwidth and amplifier behavior.

Conclusion ↝

The RC-coupled amplifier was designed and tested successfully. Its frequency response and bandwidth were consistent with theoretical predictions, showing stable mid-frequency gain and reduced gain at extremes.

Precautions ↝

- Ensure that the transistor operates within its specified ratings to avoid damage.
- Check all connections thoroughly before powering the circuit to prevent short circuits or incorrect configurations.
- Handle capacitors carefully, as improper polarity in electrolytic capacitors may cause failure.