Aim ↬ To design a Darlington Emitter follower and study its gain.

Equipment Required ↬

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

Theory ↬

A Darlington Emitter Follower comprises of two Bipolar Junction Transistors (BJTs) connected in a way that results in high input impedance and low output impedance. This configuration is commonly used for applications involving signal buffering and impedance matching. The Darlington pair behaves like a single transistor with an overall current gain that is the product of the current gains of the two transistors, significantly boosting the current amplification compared to a single transistor emitter follower.

In this configuration, the input signal is fed into the base of the first transistor. This first transistor amplifies the input current, which is then used to drive the second transistor. The result is a much higher overall current gain, making the Darlington Emitter Follower suitable for situations where substantial current gain is required. Despite this high current gain, the voltage gain of the circuit remains close to unity, meaning that the output voltage closely follows the input voltage, with only a slight reduction due to the voltage drop across the base-emitter junctions of the two transistors.

The high input impedance in the circuit is attributed to the first transistor, while the low output impedance is due to the emitter of the second transistor. This combination makes the Darlington pair highly effective for driving low-impedance loads without introducing significant signal distortion. The voltage gain A_v of the Darlington Emitter Follower can be approximated as:

$$A_V \approx \frac{R_L}{R_L + r_e}$$

where R_L is the load resistance, and r_e is the small-signal emitter resistance of the second transistor. Since r_e is typically very small, the voltage gain is usually very close to 1.

The Darlington Emitter Follower is characterized by its extremely high current gain, which can be several thousand times greater than that of a single transistor, and its low output impedance, making it an ideal choice for driving low-impedance loads while maintaining signal fidelity. This ensures minimal signal loss and distortion, allowing the circuit to be an effective buffer in many applications.

Circuit Diagram ↬

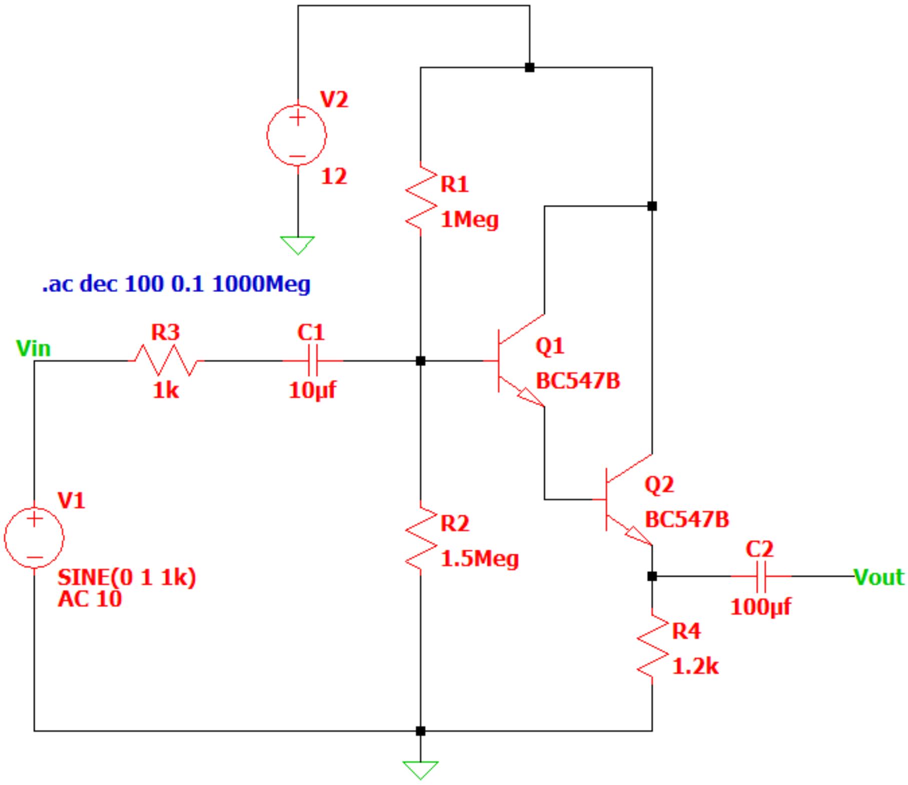

Fig. i) Circuit in LTSpice

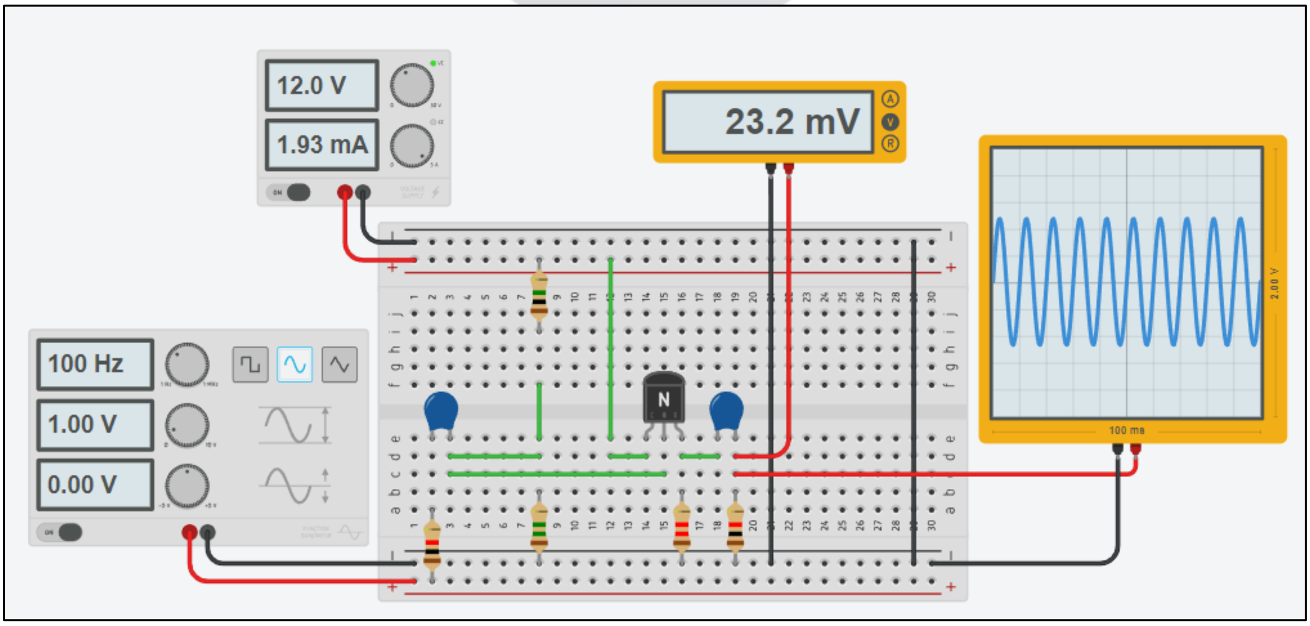

Fig. ii) Circuit in TinkerCad

Observation Table ↬

S.No.	Freq[Hz]	Vout	Gain	Gain[dB]
1	0.1	0.95	0.95	-0.41
2	1	0.987	0.987	-0.11
3	10	0.988	0.988	-0.11
4	100	0.988	0.988	-0.11
5	1k	0.988	0.988	-0.11
6	10k	0.988	0.988	-0.11
7	100k	0.988	0.988	-0.11
8	1M	0.986	0.986	-0.13
9	10M	0.927	0.927	-0.65
10	100M	0.346	0.346	-9.22
11	1G	0.044	0.044	-27.12

Graphs ↬

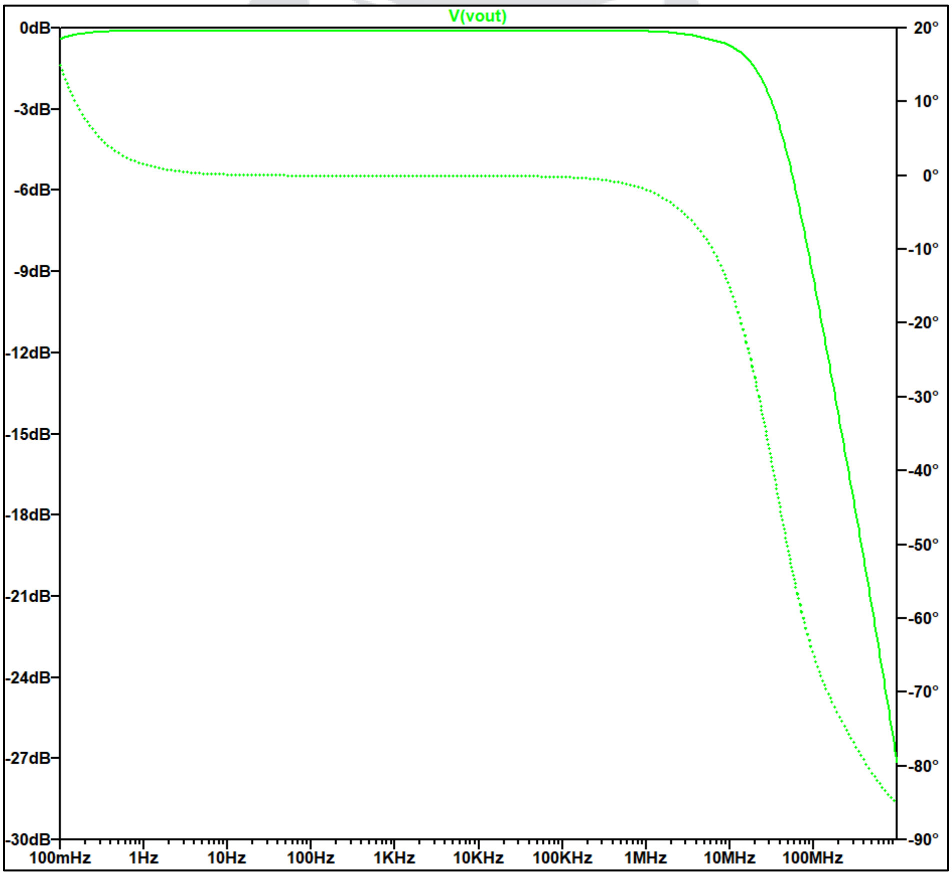

Fig. iii) Frequency Response [Decibel]

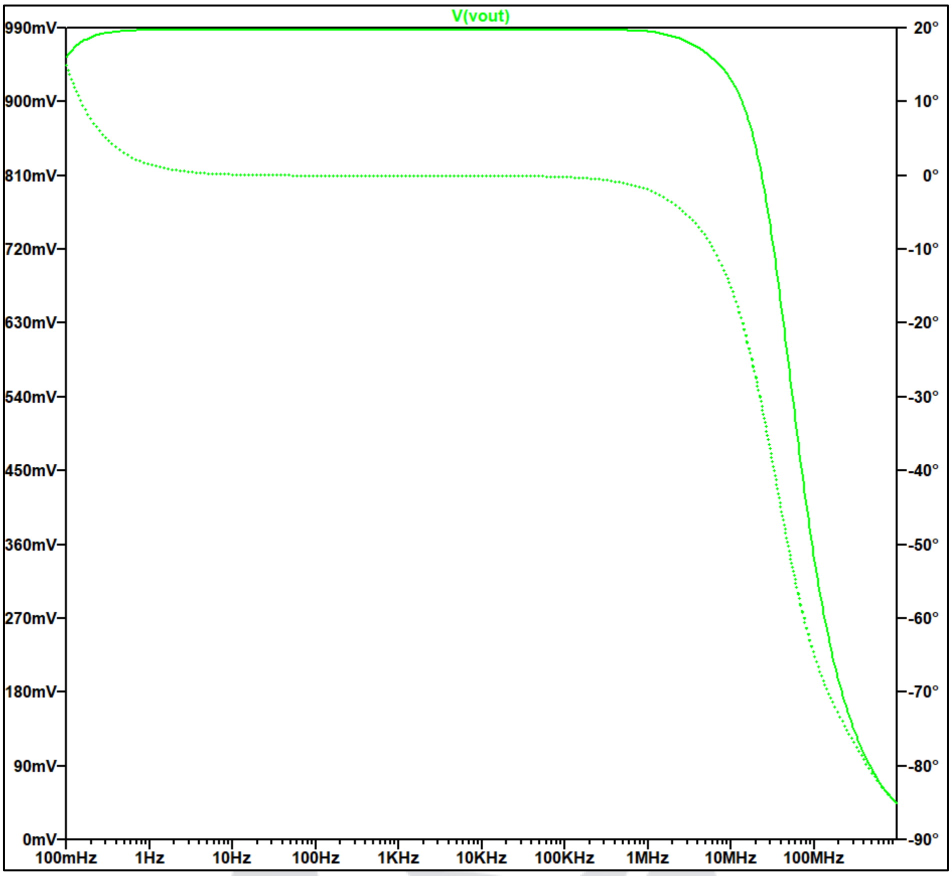

Fig. iv) Frequency Response [Linear]

Result ↬

The Darlington Emitter Follower showed near-unity voltage gain with significantly higher current gain compared to a single transistor. High input impedance and low output impedance were observed, confirming its effectiveness as a buffer.

Conclusion ↬

The circuit was successfully tested, demonstrating high current gain and effective impedance matching, with results in line with theoretical predictions.

Precautions ↬

- Ensure that the transistors used are within their operating limits to avoid thermal damage.
- Check the circuit connections carefully before powering the system to prevent component failure.
- Ensure proper biasing of the transistors for stable operation and to avoid saturation or cutoff conditions.