Aim ↬ To design and test the performance of the Hartely & Colpitts Oscillator.

Equipment Required ↬

Bipolar Junction Transistors, resistors, capacitors, inductors, power supply, DSO, breadboard, and connecting wires.

Theory ↬

An oscillator is a circuit that generates periodic waveforms, typically sinusoidal, without the need for an input signal. The Hartley and Colpitts oscillators are two popular types of LC oscillators, both employing inductors (L) and capacitors (C) to determine the frequency of oscillation. The main difference between them lies in the arrangement of the inductors and capacitors within the feedback network, which influences the design and operation of the oscillators. Oscillators like Hartley and Colpitts are commonly used in radio frequency (RF) applications, signal generation, and other communication systems due to their ability to generate stable high-frequency signals.

In a Hartley oscillator, the tank circuit consists of a single capacitor in parallel with two inductors, or a tapped inductor. The frequency of oscillation depends on the values of these inductors and the capacitor, and it is given by the equation:

$$f = \frac{1}{2\pi\sqrt{L_{eq}C}}$$

where L_{eq} is the equivalent inductance of the inductors in the tank circuit, and C is the capacitance. The equivalent inductance for the Hartley oscillator is the sum of the two inductors or the inductance of the tapped inductor. The transistor amplifies the signal, and part of the amplified output is fed back into the input through the inductor tap, providing the necessary feedback to sustain oscillation.

In the Colpitts oscillator, the tank circuit consists of a single inductor in parallel with 2 capacitors. The frequency of oscillation for this circuit is also determined by the values of the inductors and capacitors, and it can be expressed as:

$$f = \frac{1}{2\pi\sqrt{LC_{eq}}}$$

where L is the inductance, and C_{eq} is the equivalent capacitance, which is the series combination of the two capacitors. The Colpitts oscillator provides feedback through the capacitive divider formed by the two capacitors in the tank circuit. The feedback signal is fed back to the base of the transistor, maintaining continuous oscillation.

In both circuits, the transistor serves as an amplifier that compensates for energy losses in the tank circuit, ensuring that the oscillations do not decay over time. For sustained oscillation, the Barkhausen criterion must be met, which states that the total phase shift around the loop must be 360 degrees (or 0 degrees) and the loop gain must be equal to or greater than one.

During the experiment, a power supply is connected to the circuit, and the transistor amplifies the small feedback signal from the tank circuit. The oscillation frequency is controlled by adjusting the inductors or capacitors in the tank circuit, allowing for fine-tuning of the output signal. The Hartley oscillator tends to be more flexible in adjusting the frequency range since it uses tapped inductors, while the Colpitts oscillator is known for its stability due to the use of capacitive feedback.

The expected result of both oscillators is a stable sinusoidal waveform at the calculated frequency. By varying the inductance or capacitance, the oscillation frequency can be adjusted, making these circuits versatile for generating high-frequency signals. These oscillators efficiently generate consistent waveforms and are used in various communication systems and signal-generation devices.

Circuit Diagram ↬

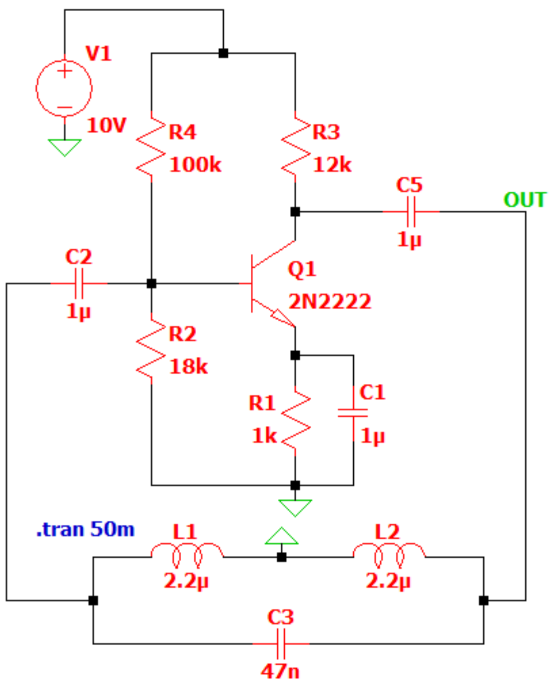

Fig. i) Hartley Oscillator

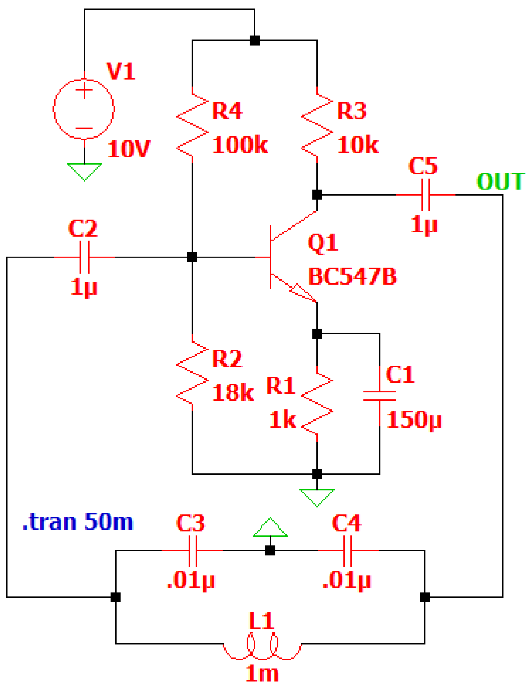

Fig. ii) Colpitts Oscillator

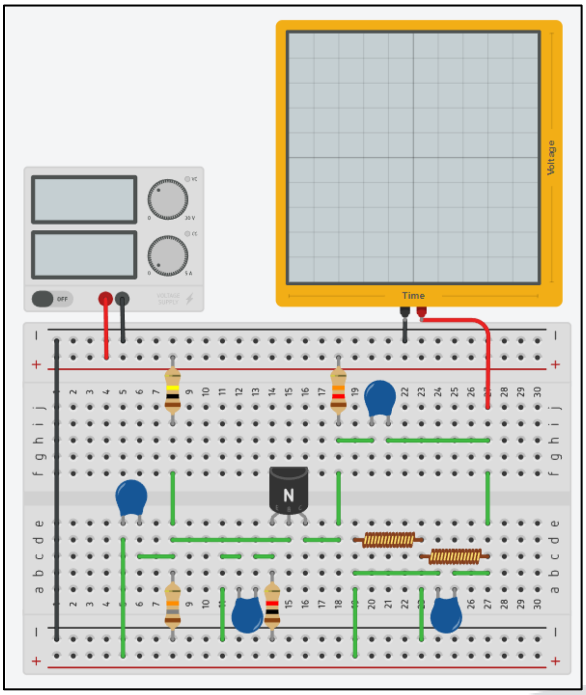

Fig. iii) Hartley Oscillator

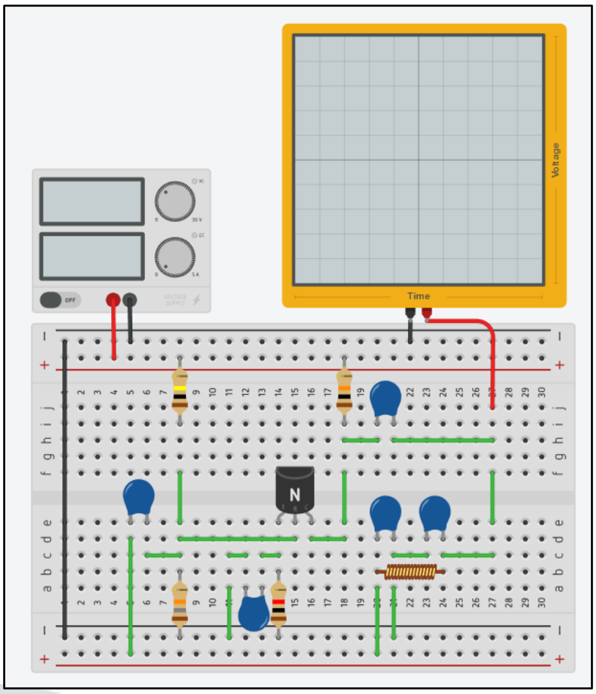

Fig. iv) Colpitts Oscillator

Graphs ↬

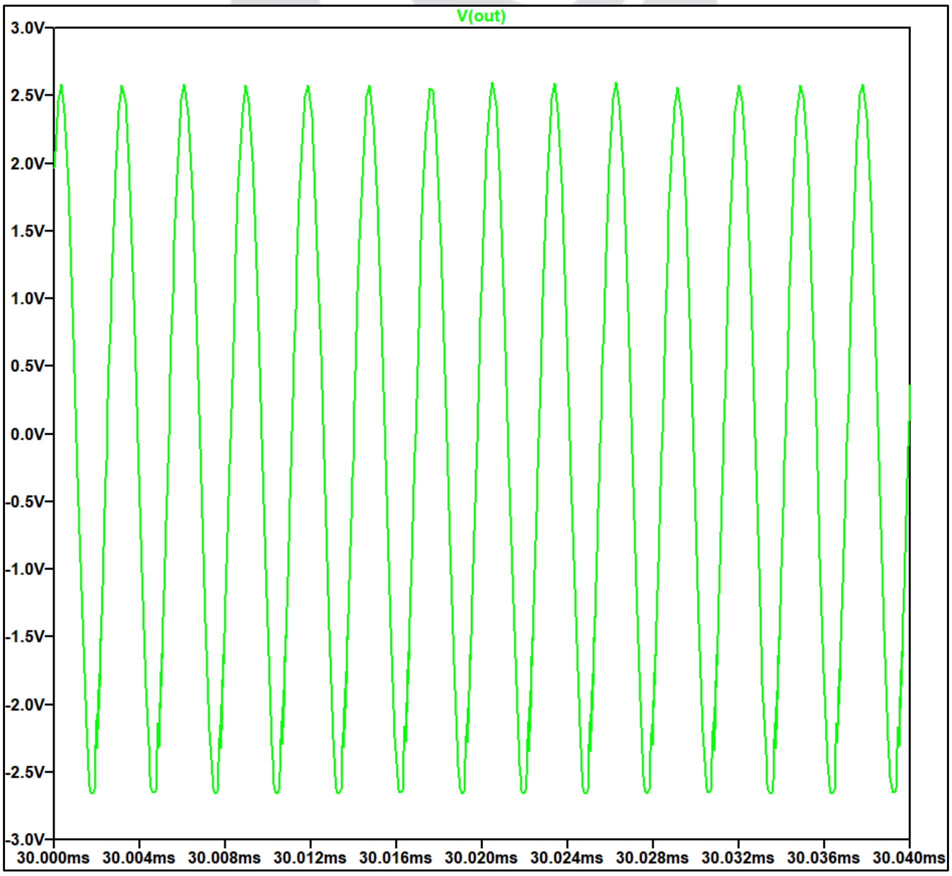

Fig. v) Output – Hartley Oscillator

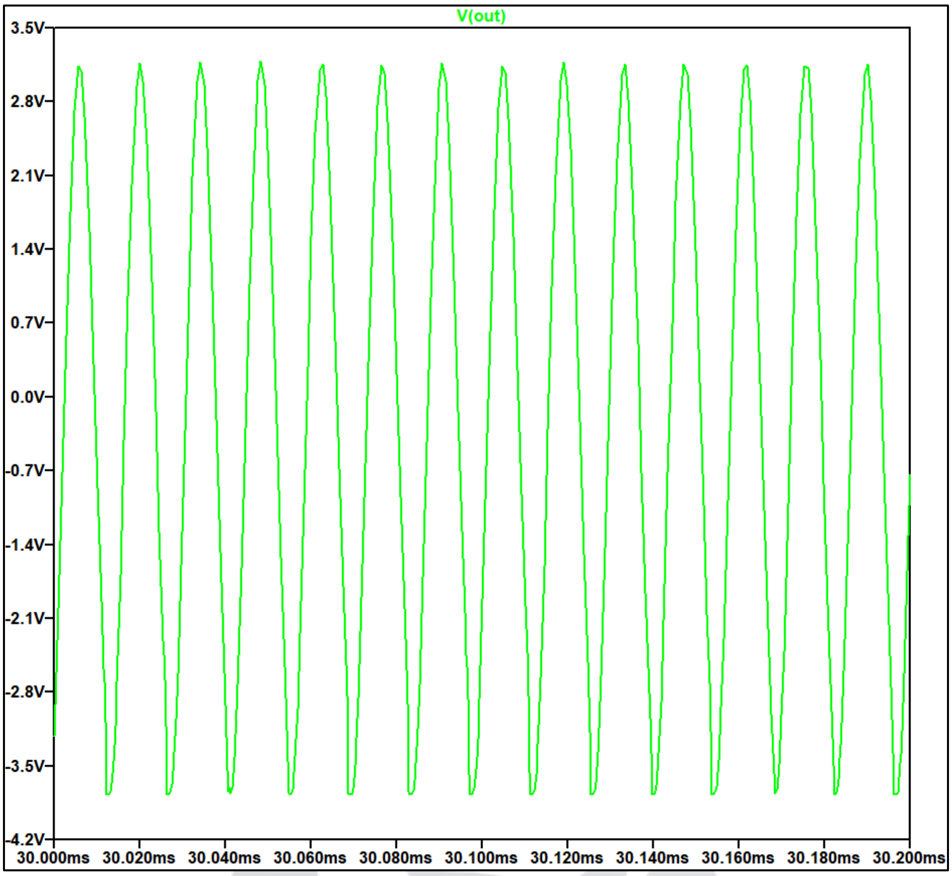

Fig. vi) Output – Colpitts Oscillator

Calculation ↬

- ### Hartley Oscillator ↪

$$f = \frac{1}{2\pi\sqrt{L_{eq}C}}$$

$$L_{eq} = 2.2\mu H + 2.2\mu H = 4.4\mu H \qquad \& \qquad C = 47nF$$

$$f = \frac{1}{2 \times 3.14 \times \sqrt{4.4 \times 10^{-6} \times 47 \times 10^{-9}}}$$

$$f = 349.981\ kHz$$

- ### Colpitts Oscillator ↪

$$f = \frac{1}{2\pi\sqrt{LC_{eq}}}$$

$$C_{eq} = \frac{0.01\times10^{-6}\times0.01\times10^{-6}}{0.01\times10^{-6}+0.01\times10^{-6}} = 5nF \qquad \& \qquad L = 1mH$$

$$f = \frac{1}{2 \times 3.14 \times \sqrt{1 \times 10^{-3} \times 5 \times 10^{-9}}}$$

$$f = 71.176\ kHz$$

Result ↬

Both the Hartley and Colpitts oscillators produced stable sinusoidal waveforms at their respective calculated frequencies. The measured oscillation frequencies were close to the theoretical values, confirming the accuracy of the design. Frequency stability was observed in both oscillators, with minimal variation during adjustments.

Conclusion ↬

The Hartley and Colpitts oscillators were successfully designed and tested. Both circuits exhibited reliable sinusoidal oscillation at the expected frequencies. The Hartley oscillator allowed more flexibility in frequency tuning, while the Colpitts oscillator provided stable operation, matching theoretical expectations.

Precautions ↬

- Ensure proper polarity when connecting electrolytic capacitors to avoid component damage.
- Handle inductors carefully to prevent altering their inductance values through mechanical stress.
- Verify all connections to avoid short circuits or open circuits that may disrupt the oscillation.
- Monitor the transistor's temperature to ensure it operates within its specified limits, preventing thermal failure.