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AMRITA SCHOOL OF ARTIFICIAL INTELLIGENCE

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BONAFIDE CERTIFICATE

This is to certify that the thesis entitled “HARTLEY OSCILLATOR” submitted by group-7, for the award of the Degree of Bachelor of Technology in the “CSE(AI) ” is a bonafide record of the work carried out by group 7 under the guidance and supervision at Amrita School of Artificial Intelligence, Coimbatore.

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DECLARATION

We, hereby declare that this thesis entitled “HARTLEY OSCILLATOR”, is the record of the original work done by us under the guidance of Dr. Ambika PS, Assistant Professor, Centre for Computational Engineering and Networking, Amrita School of Artificial Intelligence, Coimbatore. To the best of our knowledge this work has not formed the basis for the award of any degree/diploma/ associate ship/fellowship/or a similar award to any candidate in any University.

Place: Ettimadai, Coimbatore

Date: 12/07/2023

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AIM:

The aim of this report is to investigate and present the activity of a Hartley oscillator, including its circuit design, theory, implementation, and experimental results

BACKGROUND:

Oscillators

Oscillators are electronic circuits that generate continuous periodic waveforms, such as sine waves, square waves, or triangular waves. These waveforms oscillate between two voltage levels, typically representing high and low states.

The primary function of an oscillator is to provide a stable and reliable source of repetitive signals with a specific frequency. Oscillators find extensive applications in various fields, including communications, signal processing, measurement instruments, and timing devices.

There are several types of oscillators, each with its own circuit configuration and operating principles. Some commonly used types include:

- ### LC Oscillators

LC oscillators are electronic circuits that use inductors (L) and capacitors (C) to generate oscillations at a desired frequency. The LC tank circuit, consisting of the inductor and capacitor, forms the heart of these oscillators. The circuit operates based on the principle of energy exchange between the inductor and capacitor, resulting in continuous oscillations. LC oscillators offer simplicity, low cost, and good frequency stability, making them suitable for various applications such as radio transmitters, local oscillators, and signal generators.

- ### RC Oscillators

RC oscillators are a type of electronic oscillator that employ resistors (R) and capacitors (C) to generate continuous oscillations. These oscillators rely on the charging and discharging of the capacitor through the resistor to create a time-varying voltage waveform. By properly selecting the resistor and capacitor values, the desired oscillation frequency can be achieved. RC oscillators are relatively simple and inexpensive, and they find applications in low-frequency signal generation, timing circuits, and basic waveform generation.

- ### Crystal Oscillators

Crystal oscillators utilize the mechanical resonance of a quartz crystal to generate highly stable and accurate oscillations. The crystal acts as a resonant element, providing a precise frequency reference for the oscillator circuit. Crystal oscillators offer excellent frequency stability, low phase noise, and high reliability, making them indispensable in applications where precise timing is crucial, such as in communication systems, precision instruments, and digital devices.

- Relaxation Oscillators

Relaxation oscillators are a class of electronic oscillators that generate waveforms by periodically charging and discharging a capacitor through a nonlinear device, such as a diode or a transistor. The charging and discharging processes result in a repetitive waveform with a characteristic shape, such as a square wave or a sawtooth wave. Relaxation oscillators are relatively simple and versatile, allowing for easy frequency adjustment. They find applications in various fields, including waveform generation, timing circuits, and voltage-controlled oscillators.

- Voltage-Controlled Oscillators (VCOs)

Voltage-controlled oscillators (VCOs) are electronic oscillators whose output frequency is controlled by an input voltage. By varying the input voltage, the oscillation frequency can be adjusted over a certain range. VCOs are widely used in communication systems, frequency synthesis, phase-locked loops (PLLs), and modulation/demodulation circuits. They offer the advantage of frequency agility and are crucial components in applications requiring frequency tuning, such as wireless communication devices, radar systems, and frequency modulation (FM) radios.

Hartley Oscillator

The Hartley oscillator is a type of LC oscillator that generates continuous periodic waveforms, typically sine waves, using an inductor (L) and a capacitor (C) in its feedback network. It was invented by Ralph Hartley in 1915 and is widely used in various electronic applications [1].

The key components of a Hartley oscillator include an active device (such as a transistor or an operational amplifier), an inductor (L), and two capacitors (C1 and C2). The oscillator operates based on the principle of positive feedback, where a fraction of the output signal is fed back to the input with the correct phase and amplification.

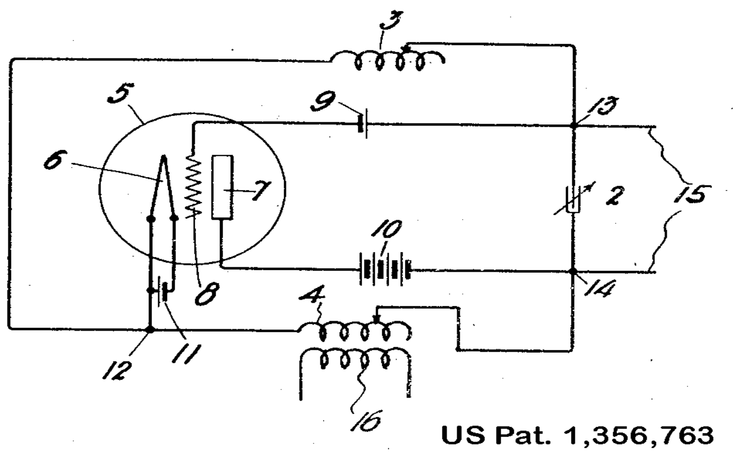

Figure 1:Original Hartley Oscillator patent [1] [2]

MATERIALS REQUIRED:

- 1 - ADALM2000 Active Learning Module
- 1 - 2N3904 NPN transistor
- 1 - 10 uH inductor
- 1 - 100 uH inductor
- 1 - 1 nF capacitor (C1 optional values as listed below)
- 2 - 0.1 uF capacitors (marked 104)
- 1 - 0.01 uF capacitor (marked 103)
- 1 - 1 KΩ resistor

CIRCUIT DIAGRAM:

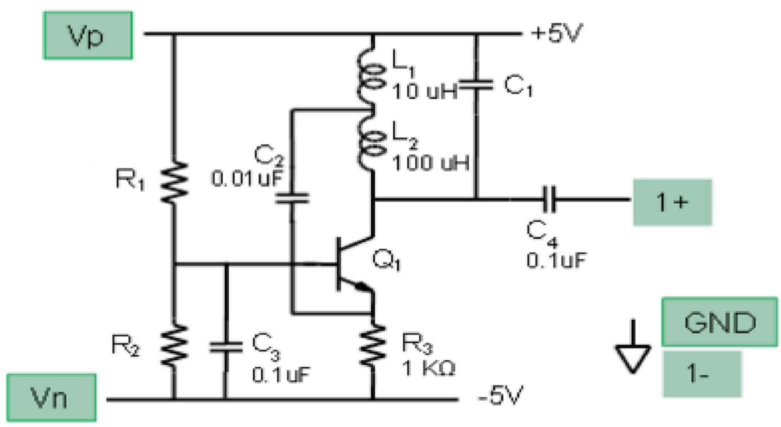

Figure 2: Hartley Oscillator [3]

THEORY:

The Hartley Oscillator is a particularly good circuit for producing fairly low distortion sine wave signals in the RF range, 30kHz to 30MHz. The Hartley configuration can be recognized by its use of a tapped inductor divider (L1 and L2 in figure 2). The frequency of oscillation can be calculated in the same way as any parallel resonant circuit, using:

$$F_{\mathrm{r}} = \frac{1}{2\pi\sqrt{(LC)}}$$

Where $L=L_1+L_2$ [3]

The frequency determining parallel resonant tuned circuit is formed by L1, L2 and C1 and is used as the collector load impedance of the common base amplifier Q1. This gives the amplifier a high gain only at the resonant frequency. This configuration of the Hartley oscillator uses a common base amplifier, the base of Q1 is biased to an appropriate DC level by resistor divider R1 and R2 but is connected directly to an AC ground by C3. In the common base mode the output voltage waveform at the collector, and the input signal at the emitter are in phase. This ensures that the fraction of the output signal from the node between L1 and L2, fed back from the tuned collector load to the emitter via the coupling capacitor C2 provides the required positive feedback [3]

C2 also forms a low frequency time constant with the emitter resistor R3 to provide an average DC voltage level proportional to the amplitude of the feedback signal at the emitter of Q1. This provides automatic control of the gain of the amplifier to give the closed loop gain of 1 required by the oscillator. The emitter resistor R3 is not decoupled because the emitter node is used as the common base amplifier input. The base is connected to AC ground by C3, which will provide a very low reactance at the oscillator frequency [3]

PROCEDURE:

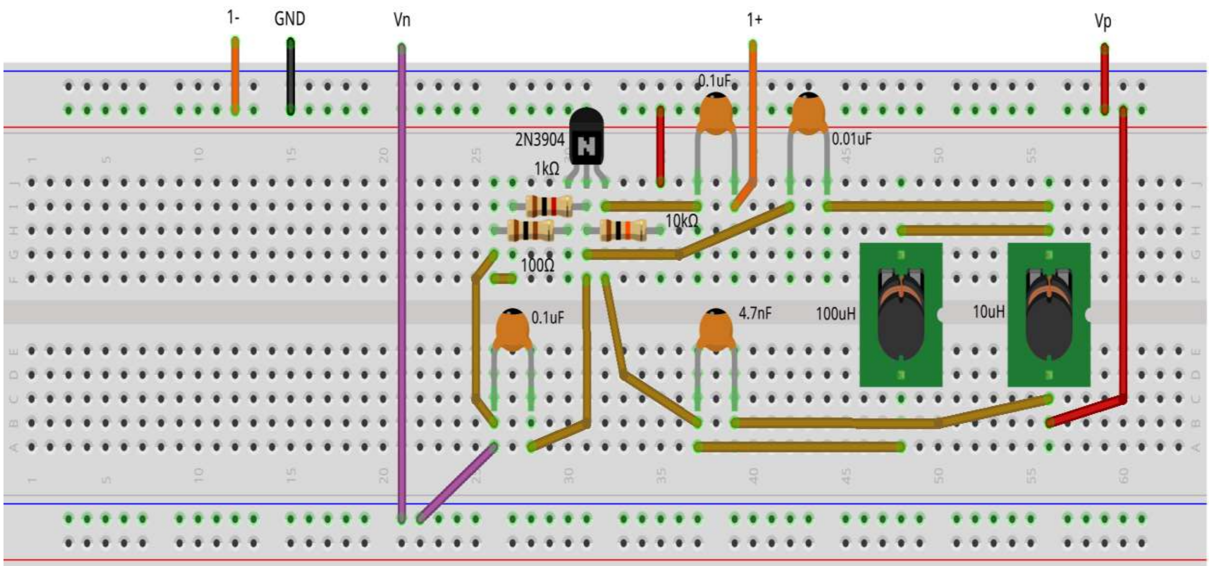

Figure 3:Hartley Oscillator Breadboard diagram

We need to do all connections on a circuit board and solder those connections properly. By soldering we are making sure connections don't come lose but we also have a loss in terms of electrical conductivity and heat dissipation.

Then the following must be done in Scopy:

- Enable Power supply and set positive to +5V and negative to -5V
- Then in Oscilloscope, we can set channel one time base and Volts to suitable values

RESULT

Figure 4:Output Diagram

In the results of our Hartley oscillator project, we observed the generation of a sine wave at a time interval of 500 nanoseconds, which corresponds to an approximate frequency of 2 megahertz. This indicates that the oscillator circuit is producing oscillations within the expected frequency range. However, it is important to address the relatively low gain that was observed during the analysis.

The lower-than-expected gain in the oscillator's output can be attributed to several factors. One possible reason could be a mismatch or improper selection of the circuit's components, such as the inductor (L) and capacitors (C). The values of these components play a critical role in determining the resonant frequency and overall performance of the oscillator. If the chosen values are not well-matched or are not within the desired range, it can lead to a suboptimal gain.

Another factor that can affect the gain is the biasing conditions of the active components in the circuit, such as transistors or operational amplifiers. Improper biasing can result in a reduced amplification or distortion in the output waveform, impacting the overall gain of the oscillator.

Furthermore, the presence of parasitic elements, such as stray capacitance or inductance, can also contribute to the observed low gain. These parasitic elements can affect the resonance characteristics of the oscillator, resulting in a deviation from the expected gain.

Additionally, the layout and physical construction of the circuit can introduce unintended coupling or interference, leading to reduced gain. Improper grounding techniques, inadequate shielding, or poor isolation between components can all contribute to the observed output behavior.

To address the low gain and optimize the oscillator's performance, further adjustments and tuning are required. This can involve iteratively modifying the component values, improving the biasing conditions, minimizing parasitic elements, and optimizing the circuit layout. By carefully analyzing the circuit's characteristics and considering these factors, we can work towards achieving a higher gain and improving the overall performance of the Hartley oscillator.

Overall, understanding the reasons behind the observed low gain is crucial in troubleshooting and improving the oscillator circuit. Through further analysis, experimentation, and modifications, it is possible to fine-tune the circuit parameters to achieve the desired gain and enhance the overall performance of the Hartley oscillator.

CONCLUSION

In conclusion, the Hartley oscillator project provided a hands-on opportunity to construct and analyze a practical Hartley circuit. By utilizing the ADALM2000 and Scopy software, we were able to gain valuable insights into the oscillator's behavior and performance. The generated sine wave, albeit at a frequency close to 2 megahertz, highlighted the functionality of the oscillator. However, the observed low gain during the analysis indicated a deviation from the expected resonant frequency, suggesting the need for further adjustments and tuning.

Expanding upon this conclusion, it is essential to emphasize the significance of the project in enhancing our understanding of oscillator circuits and their practical implementation. Constructing the Hartley oscillator circuit allowed us to gain hands-on experience in assembling electronic components, soldering, and circuit layout. Additionally, utilizing advanced tools like the ADALM2000 and Scopy software enabled us to accurately measure and analyze the oscillator's performance, providing valuable data for further evaluation.

Furthermore, the project presented several learning opportunities and challenges. The analysis process using Scopy allowed us to observe the waveform characteristics, measure key parameters such as amplitude, frequency, and distortion, and gain insights into the oscillator's stability and reliability. It is worth noting that the low gain we observed indicated the need for fine-tuning and adjustments in the circuit's component values or biasing conditions to achieve optimal performance. This aspect of the project highlighted the importance of iterative testing, troubleshooting, and optimization in electronic circuit design.

Moreover, the utilization of the ADALM2000 and Scopy showcased the benefits of modern measurement and analysis tools in the field of electrical engineering. These tools not only provided accurate and reliable measurements but also facilitated the visualization and interpretation of the obtained data, enabling us to make informed decisions regarding circuit modifications and improvements.

In summary, the Hartley oscillator project offered a comprehensive exploration of oscillator circuits, from circuit construction to analysis using the ADALM2000 and Scopy software. While the generated sine wave confirmed the basic functionality of the oscillator, the observed low gain indicated the need for further refinement. This project provided valuable insights into practical circuit implementation, measurement techniques, and the iterative design process. By applying the knowledge gained from this project, future endeavors in oscillator design and other electronic circuits will benefit from a more informed and skilled approach.

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