International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 03 | March - 2022 ISSN: 2582-3930

The Hartley Oscillator Using BJT

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ABSTRACT

This paper discusses about Hartley oscillator circuit, it's working, advantages and disadvantages, and applications The Hartley Oscillator design uses two inductive coils in series with a parallel capacitor to form its resonance tank circuit producing sinusoidal oscillations.

Keywords—BJT, Oscillator, Circuit

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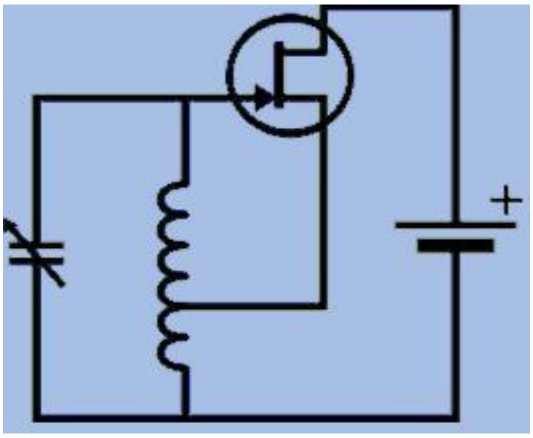
1. Introduction :

The Hartley oscillator is an electronic oscillator circuit in which the oscillation frequency is determined by the tuned circuit consisting of capacitors and inductors, that is, an LC oscillator. The Hartley oscillator was invented by Hartley while he was working in the Research Laboratory of the Western Electric Company. The circuit was invented in 1915 by American engineer Ralph Hartley. The personal feature of the Hartley oscillator is that the tuned circuit consists of a single capacitor in parallel with two inductors are in series or a single tapped inductor, and the feedback signal needed for oscillation is taken from the center connection of the two inductors.

2. What are Hartley Oscillators?

Hartley oscillator is inductively coupled, variable frequency oscillators where the oscillator may be a series or shunt fed.

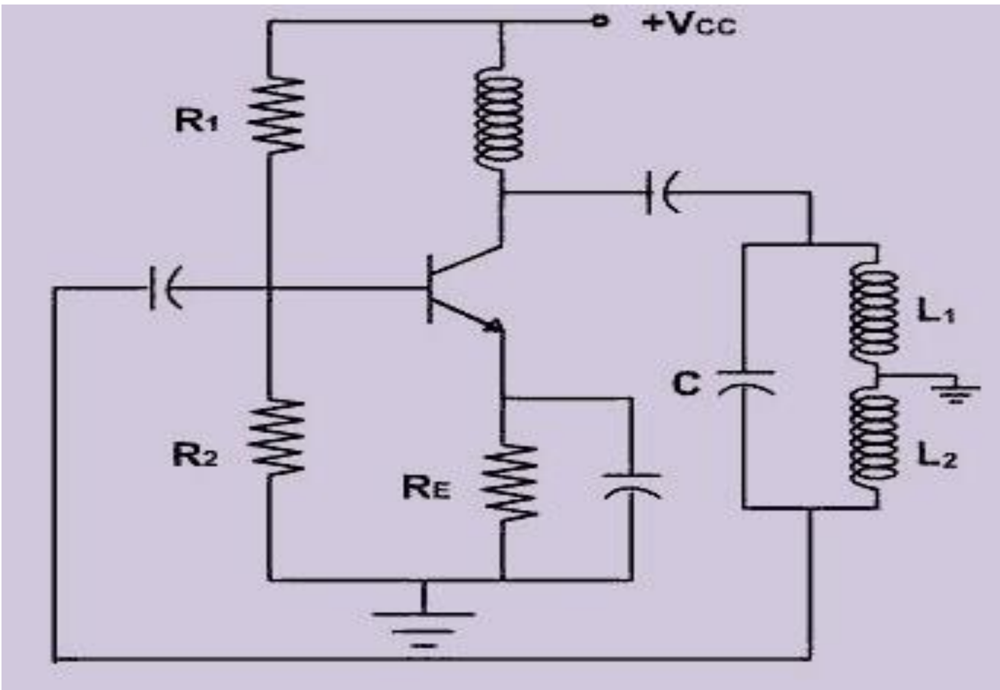


Hartley Oscillator

3. Working of Hartley oscillator :

The circuit diagram of a Hartley oscillator is shown in the below figure. An NPN transistor connected in a common emitter configuration works as the active device in amplifier stage. R1 and R2 are biasing resistors and RFC is the radio frequency choke, which provides the isolation between AC and DC operation.

At high frequencies, the reactance value of this choke is very high, hence it can be treated as an open circuit. The reactance is zero for DC condition, hence causes no problem for DC capacitors. The CE is the emitter bypass capacitor and RE is also be a biasing resistor. The CC1 and CC2 are the coupling capacitors.



Hartley Oscillator Circuit

When the DC supply (Vcc) is given to the circuit, the collector current starts raising and begins with the charging of the capacitor C. Once capacitor C is fully charged, it starts discharging through L1 and L2 and again starts charging.This back-and-fourth voltage waveform is a sine wave which is a small and leads with its negative alteration. It will eventually die out unless it is amplified.

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Now the transistor comes into the picture. The sine wave generated by the tank circuit is coupled to the base of the transistor through the capacitor CC1.

Since the transistor is configured as common-emitter, it takes the input from tank circuit and inverts it to a standard sine wave with a leading positive alteration.

Thus the transistor provides amplification along with inversion to amplify and correct the signal generated by the tank circuit. The mutual inductance between L1 and L2 provides the feedback of energy from collector-emitter circuit to the base-emitter circuit.

The frequency of oscillations in this circuit is

$$\mathbf{fo = 1/\ (2\pi \sqrt{\ } (Leq\ C))}$$

Where Leq is the total inductance of coils in the tank circuit is given as

$$\mathbf{Leq = L1 + L2 + 2M}$$

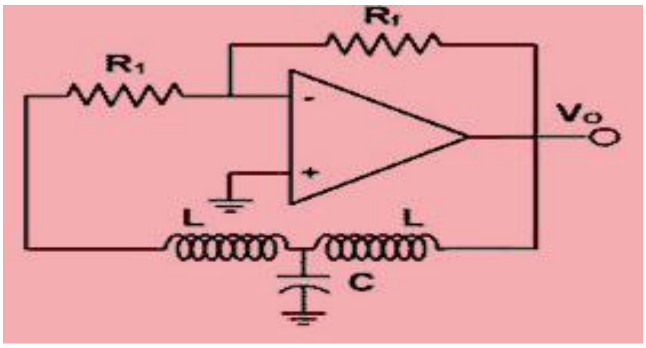
For a practical circuit, if L1 = L2 = L and the mutual inductance are neglected, then the frequency of oscillations can be simplified as

$$\mathbf{fo = 1/\ (2\pi \sqrt{\ } (2\ L\ C))}$$

4. Hartley Oscillator Circuit Using Op-Amp

The Hartley oscillator can be implemented by using an operational amplifier and its typical arrangement is shown in the below figure. This type of circuit facilitates the gain adjustment by using feedback resistance and input resistance.

In transistorized Hartley oscillator, the gain depending up on the tank circuit elements like L1 and L2 whereas in Op-amp oscillator gain is less depends on the tank circuit elements and hence provides greater frequency stability.



Hartley Oscillator using Op-Amp

The operation of this circuit is similar to the transistor version of the Hartley oscillator. The sine wave is generated by the feedback circuit and it’s coupled with the op-amp section. Then this wave is stabilized and inverted by the amplifier.

The frequency of an oscillator is varied by using a variable capacitor in the tank circuit, keeping the feedback ratio and the amplitude of the output is constant for over a frequency range. The frequency of oscillations for this type of oscillator is the same as the above-discussed oscillator and is given as

$$\mathbf{fo = 1/\ (2\pi \sqrt{\ } (Leq\ C))}$$

Where: Leq = L1 + L2 + 2M

Or

Leq = L1 + L2

To generate the oscillation from this circuit, the amplifier gain must and should be selected greater than or at least equal to the ratio of two inductances.

$$Av = L1 / L2$$

If the mutual inductance exists between L1 and L2 because the common core of these two coils, then the gain becomes

$$Av = (L1 + M) / (L2 + M)$$

5. Advantages

Instead of two separate coils L1 and L2, a single coil of bare wire can be used and the coil grounded at any desired point along with it.

By using a variable capacitor or by making core movable (varying the inductance), the frequency of oscillations can be varied.

Very few components are needed, including either two fixed inductors or a tapped coil.

The amplitude of the output remains constant over the working frequency range.

6. Disadvantages

It cannot be used as a low-frequency oscillator since the value of inductors becomes large and the size of the inductors becomes large.

The harmonic content in the output of this oscillator is very high and hence it is not suitable for the applications which require a pure sine wave.

7. Applications

The Hartley oscillator is to produce a sine wave with the desired frequency

Hartley oscillators are mainly used as radio receivers. Also note that due to its wide range of frequencies, it is the most popular oscillator

The Hartley oscillator is Suitable for oscillations in RF (Radio-Frequency) range, up to 30MHZ

8. History and Present Development

Hartley Oscillator Circuit is mainly used to generate sine wave in various devices like Radio transmitter and receivers. The first radio transmitters, used during the initial three decades of radio from 1887 to 1917, a period called the spark era, were spark gap transmitters which generated radio waves by discharging a capacitance through an electric spark. Each spark produced a transient pulse of radio waves which decreased rapidly to zero. These damped waves could not be modulated to carry sound, as in modern AM and FM transmission. So spark transmitters could not transmit sound, and instead transmitted information by radiotelegraphy. The transmitter was switched on and off rapidly by the operator using a telegraph key, creating different length pulses of damped radio waves ("dots" and "dashes") to spell out text messages in Morse code. FM is commonly used at VHF radio frequencies for high fidelity broadcasts of music and speech. It is also used at intermediate frequencies by all analog VCR systems, including VHS, to record both the luminance and the chrominance portions of the video signal. It can also be used at audio frequencies to synthesize sound. The Hartley oscillator was extensively used on all broadcast bands including the FM 88-108MHz band. In retrospect, Armstrong started a revolution in oscillator technology that quickly made spark transmitters obsolete, thus leading to the development of high-performance radio receivers. From the time of Armstrong's discoveries in the 1910s to the modern era, VCO technology has progressed from vacuum tube oscillators to transistor oscillators, to oscillator module solutions, and finally to today's RFIC-based oscillators. The face of VCO technology is again rapidly changing, and soon in many systems will only resemble early oscillators in basic topology and/or mathematically.

Armstrong's discovery was soon improved upon by Ralph V. L. Hartley with his invention of oscillator circuit topology. Hartley used improvements in vacuum-tube technology and devised an oscillator circuit in which the vacuum tube acted as an amplifying device with inductive feedback applied to create a regenerative oscillation. The frequency of oscillation was established by the coil inductance and the circuit capacitance. This circuit was a breakthrough in the generation of a sinusoidal signal; it provided a much greater range of possible frequencies simply by varying the value of the coil or capacitor. The Hartley oscillator circuit was popular in transmitters and was quickly adapted for use in World War I. Both transmitters and receivers used the new tube-based oscillator circuit. Oscillator circuit innovations proliferated, and led to the predominant circuit topologies still used today, such as Hartley, Colpitts, Clapp, Armstrong, Pierce, and other topologies.

As radio technologies advanced, sustained innovation occurred in the implementation of oscillator circuits. Engineers devised countless types of coils, variable capacitors, feedback techniques, and vacuum tubes to implement oscillator and frequency-conversion circuits. Many elaborate and elegant schemes were devised to provide precise, high-quality tuning of the oscillator frequency through a mechanical dial on the front of the radio. Figure 1 is a picture of a recreated vintage 1929 Hartley-style transmitter (as recreated by Ham radio enthusiast W9QZ). Like many early electronic implementations, the circuit was bulky and expensive, and required high supply voltages.

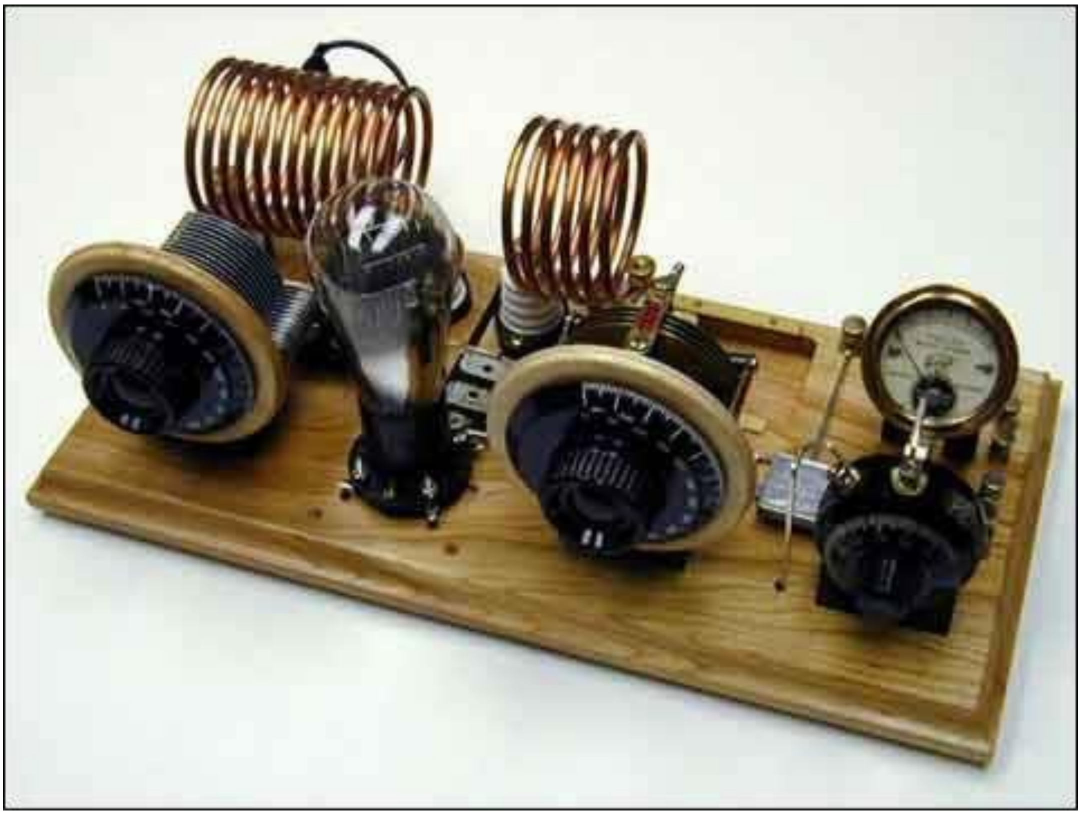


Figure 1. Vintage 1929 Hartley-style transmitter.

9. Conclusion

Hartley Oscillator consists of a parallel LC resonator tank circuit whose feedback is achieved by way of an inductive divider. Like most oscillator circuits, the Hartley oscillator exists in several forms, with the most common form being the transistor circuit above.

This Hartley Oscillator configuration has a tuned tank circuit with its resonant coil tapped to feed a fraction of the output signal back to the emitter of the transistor. Since the output of the transistors emitter is always "in-phase" with the output at the collector, this feedback signal is positive. The oscillating frequency which is a sine-wave voltage is determined by the resonance frequency of the tank circuit.

10. References

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