

Hartley oscillator

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The **Hartley oscillator** is an electronic oscillator circuit in which the oscillation frequency is determined by a tuned circuit consisting of capacitors and inductors, that is, an LC oscillator. The circuit was invented in 1915 by American engineer Ralph Hartley. The distinguishing feature of the Hartley oscillator is that the tuned circuit consists of a single capacitor in parallel with two inductors in series (or a single tapped inductor), and the feedback signal needed for oscillation is taken from the center connection of the two inductors.

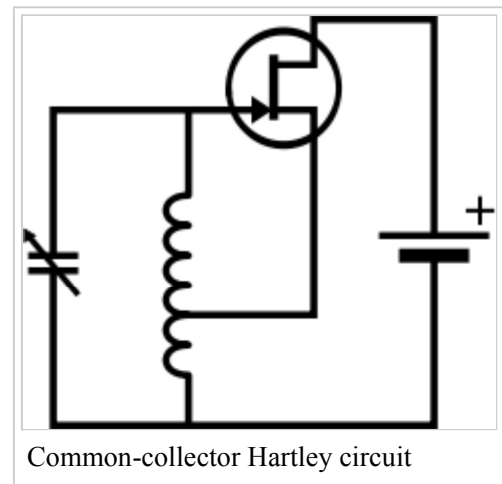
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Operation

The Hartley oscillator is distinguished by a tank circuit consisting of two series-connected coils in parallel with a capacitor, with the feedback signal needed for oscillation taken from the center connection between the coils; the coils act as a voltage divider. The Hartley oscillator is the dual of the Colpitts oscillator which uses a voltage divider made of two capacitors rather than two inductors. Although there is no requirement for there to be mutual coupling between the two coil segments, the circuit is usually implemented using a tapped coil, with the feedback taken from the tap, as shown here. The optimal tapping point (or ratio of coil inductances) depends on the amplifying device used, which may be a bipolar junction transistor, FET, triode, or amplifier of almost any type (non-inverting in this case, although variations of the circuit with an earthed centre-point and feedback from an inverting amplifier or the collector/drain of a transistor are also common), but a Junction FET (shown) or triode is often employed as a good degree of amplitude stability (and thus distortion reduction) can be achieved with a simple grid leak resistor-capacitor combination in series with the gate or grid (see the Scott circuit below) thanks to diode conduction on signal peaks building up enough negative bias to limit amplification.

The frequency of oscillation is approximately the resonant frequency of the tank circuit. If the capacitance of the tank capacitor is C and the total inductance of the tapped coil is L then



$$f = \frac{1}{2\pi\sqrt{LC}}$$

If two *uncoupled* coils of inductance L_1 and L_2 are used then

$$L = L_1 + L_2$$

However if the two coils are magnetically coupled the total inductance will be greater because of mutual inductance k ^[1]

$$L = L_1 + L_2 + k\sqrt{L_1 L_2}$$

The actual oscillation frequency will be slightly lower than given above, because of parasitic capacitance in the coil and loading by the transistor.

Advantages of the Hartley oscillator include:

- The frequency may be adjusted using a single variable capacitor, one side of which can be earthed
- The output amplitude remains constant over the frequency range
- Either a tapped coil or two fixed inductors are needed, and very few other components
- Easy to create an accurate fixed-frequency Crystal oscillator variation by replacing the capacitor with a (parallel-resonant) quartz crystal or replacing the top half of the tank circuit with a crystal and grid-leak resistor (as in the Tri-tet oscillator).

Disadvantages include:

- Harmonic-rich output if taken from the amplifier and not directly from the LC circuit (unless amplitude-stabilisation circuitry is employed).

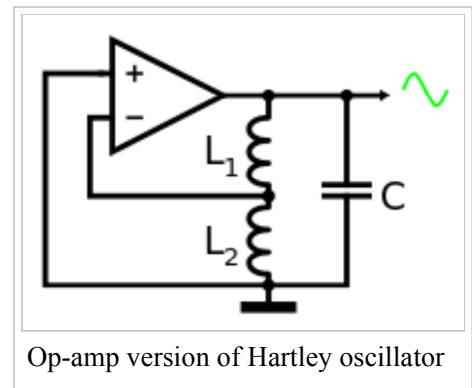
History

The Hartley oscillator was invented by Ralph V.L. Hartley while he was working for the Research Laboratory of the Western Electric Company. Hartley invented and patented the design in 1915 while overseeing Bell System's transatlantic radiotelephone tests; it was awarded patent number 1,356,763 (<http://patimg2.uspto.gov/.piw?Docid=01356763&homeurl=http%3A%2F%2Fpatft.uspto.gov%2Fnetacgi%2Fnph-Parser%3Fsect1%3DPTO1%2526sect2%3DHITOFF%2526d%3DPALL%2526p%3D1%2526u%3D%25252Fnethtml%25252FPTO%25252Fsrchnum.htm%2526r%3D1%2526f%3DG%2526l%3D50%2526s1%3D1,356,763.PN.%2526OS%3DPN%2F1,356,763%2526RS%3DPN%2F1,356,763&PageNum=&Rtype=&SectionNum=&idkey=NONE&Input=View+first+page>) on

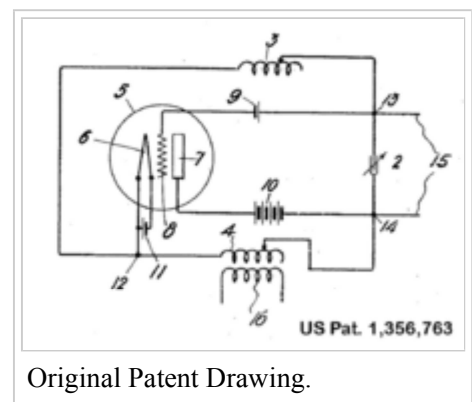
October 26, 1920. Note that the above basic schematic is essentially the same as in the patent

drawing, except that the tube is replaced by a J-FET, and that the battery for a negative grid bias is not needed.

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Op-amp version of Hartley oscillator



Original Patent Drawing.

In 1946 Hartley was awarded the IRE medal of honor "For his early work on oscillating circuits employing triode tubes and likewise for his early recognition and clear exposition of the fundamental relationship between the total amount of information which may be transmitted over a transmission system of limited band-width and the time required."^[2](The second half of the citation refers to Hartley's work in information theory which largely paralleled Harry Nyquist.)

See also

- Opto-electronic oscillator

References

- ↑ Jim McLucas, Hartley oscillator requires no coupled inductors, EDN October 26, 2006 http://www.edn.com/article/CA6343253.html
 - ↑ Ralph V. L. Hartley, Legacies, IEEE History Center, updated January 23, 2003, http://www.ieee.org/organizations/history_center/legacies/hartley.html
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 - Langford-Smith, F. (1952), *Radiotron Designer's Handbook* (4th ed.), Sydney, Australia: Amalgamated Wireless Valve Company Pty., Ltd.
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External links

- Hartley oscillator (http://www.tpub.com/content/neets/14181/css/14181_81.htm), Integrated Publishing

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