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Paper - IV, Unit – III, **Oscillators and Multivibrator**

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The Hartley Oscillator

- The Hartley oscillator is similar to the Colpitts except that the feedback circuit consists of two series inductors and a parallel capacitor as shown in Figure 20.
- Instead of using tapped capacitors two inductors L_1 and L_2 are place across a common capacitor C and the centre of the inductors is tapped as shown in figure.
- The tank circuit is made up of L_1, L_2 and C. The frequency of oscillator is determined by the values of L_1, L_2 and C and is given by

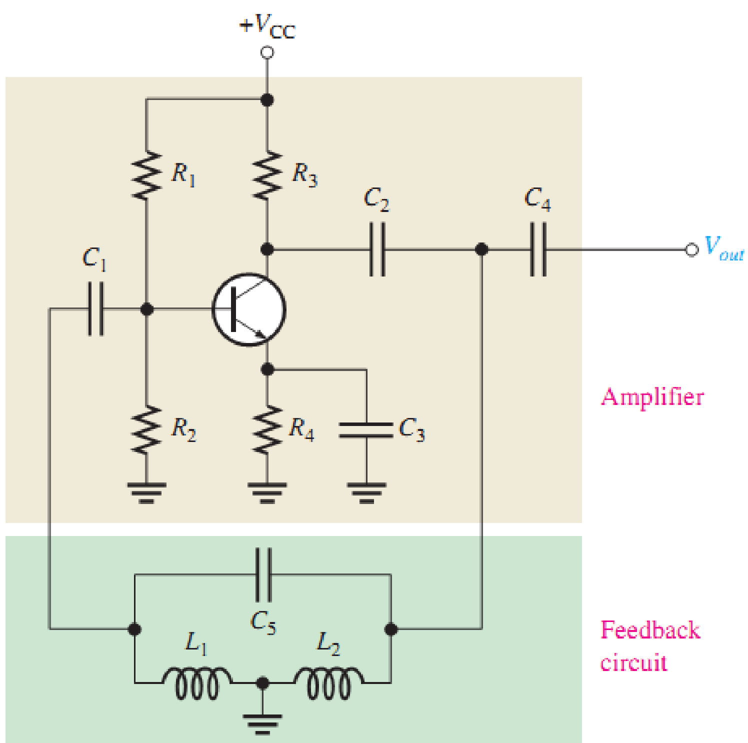

Figure 20 A basic Hartley oscillator.

- In this circuit, the frequency of oscillation for (Q>10) is $f = \frac{1}{2\pi\sqrt{LC_T}}$
- where $L_T = L_1+L_2+2M$, here M = mutual inductance between L_1 and L_2.

  Note that L_1 - L_2 –C is also the feedback network that produces a phase shift of 180^0.

Circuit operation: When the circuit is turned on, the capacitor is charged. When this capacitor is fully charged, it discharge through coils L_1 and L_2 setting up oscillations of frequency determined by above expression. The output voltage of the amplifier appears across L_1 and feedback voltage across L_2. The voltage across L_2 is 180^0 out of phase with the voltage developed across L_1 (V_{out}) as shown in figure. It is easy to see that voltage feedback (i.e. voltage across L_2) to the transistor provides positive feedback. A phase shift of 180^0 is produced by L_1+L_2+2M voltage divider. In this way, feedback is properly phased to produced continues undamped oscillations.

Feedback fraction: In Hartely oscillator, the feeback voltage is across L_2 and output voltage is across L_1.

Since feedback fraction $A_v = \frac{V_f}{V_{out}} = \frac{X_{L_2}}{X_{L_1}} = \frac{L_2}{L_1}$, if the circulating current for the two inductors is the same.

Further, inductive reactance is directly proportional to inductance.

$$A_v = \frac{L_2}{L_1}$$

Loading of the tank circuit has the same effect in the Hartley as in the Colpitts; that is, the Q is decreased and thus f_r decreases.

Advantages of the Hartley oscillator:

- 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.

Disadvantages:

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

Applications: The applications of Hartley oscillator are

- ✓ It is used to produce a sine wave of desired frequency.
- ✓ Mostly used as a local oscillator in radio receivers.
- ✓ It is also used as R.F. Oscillator.

Limitations of LC and RC Oscillators:

The LC and RC oscillators discussed so far have their own limitations. The major problem is such circuits are that their operating frequency does not remain strictly constant. There are two principal reasons for it

(1) As the circuit operators, it will warm up. Consequently, the values of resistor and inductors, which are the frequency determined factors in these circuits, will change with temperature. This causes the change in frequency of the oscillator.

(2) If any component in the feedback network is changed, it will shift the operating frequency of the oscillator.

However in many applications, it is desirable and necessary to maintain the frequency constant with extreme low tolerances. For example, the frequency tolerance for a broadcasting station should not exceed 0.002% of the specified frequency. In fact, the frequency difference between two broadcasting stations is less than 1 %. It is apparent that if we employ LC and RC circuits, a change of temperature may cause the frequencies of adjacent broadcasting to overlap.

In order to maintain constant frequency, *piezoelectric crystals* are used in place of LC or RC circuits. Oscillators of this type are called *crystal oscillators*. The frequency of a crystal oscillator changes by less than 0.1% due to temperature and other change.

Some Important Component of Oscillators and Explanation:

Some essential components are:

(1) **Tank Circuit:** it consist of inductance coil (L) connected in parallel with capacitor (C). the frequency of oscillations in the circuit depends upon the values of inductance of the coil and capacitance of the capacitor.

(2) **Transistor Amplifier:** The transistor amplifier receives d.c. power from the battery and changes it into a.c. power for supplying to the tank circuit. The oscillations occurring in the tank circuit are applied to the input of the transistor amplifier, Because of the amplifying properties of the transistor, we get increased output of these oscillations.

This amplified output of oscillations is due to the d.c. power supplied by the battery. The output of the transistor can be supplied to the tank circuit to meet the losses

(3) **Feedback circuit:** The feedback circuit supplies a part of collector energy to the tank circuit in correct phase to aid the oscillations i.e. if provides positive feedback.

Explanation of Barkhausen Criterion: Barkhausen Criterion is that in order to produce continues undamped oscillations at the output of an amplifier, the positive feedback should be such that $m_v A_v = 1$

Once this condition is set in the positive feedback amplifier, continues undamped oscillations can be obtained at the output immediately after connecting the necessary power supplies.

(i) Mathematical explanation: The voltage gain of a positive feedback amplifier is given by:

$A_{vf} = \frac{A_v}{1-m_v A_v}$ if $m_v A_v = 1$ then $A_{vf} \to \infty$

We know that we cannot achieve infinite gain in an amplifier, it means that a vanishing small input voltage would give rise to finite output voltage even when the input signal is zero. Thus once the circuit receives the input trigger, it would become an oscillator, generating oscillation with no external signal source.