Analog and Digital Systems (UEE505)

Lecture # 12
Colpitts & Phase Shift Oscillator

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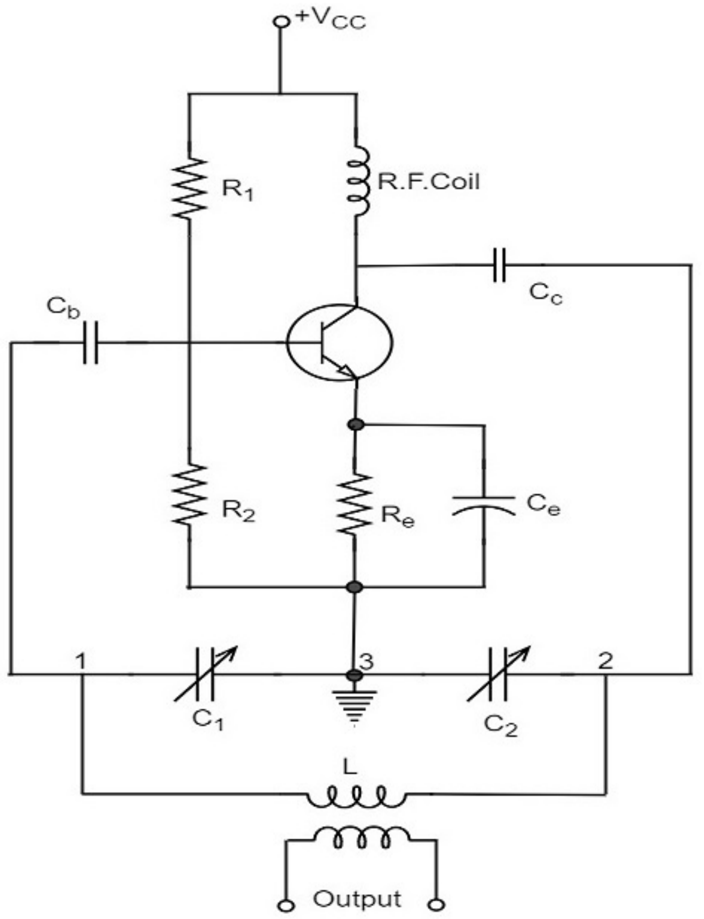
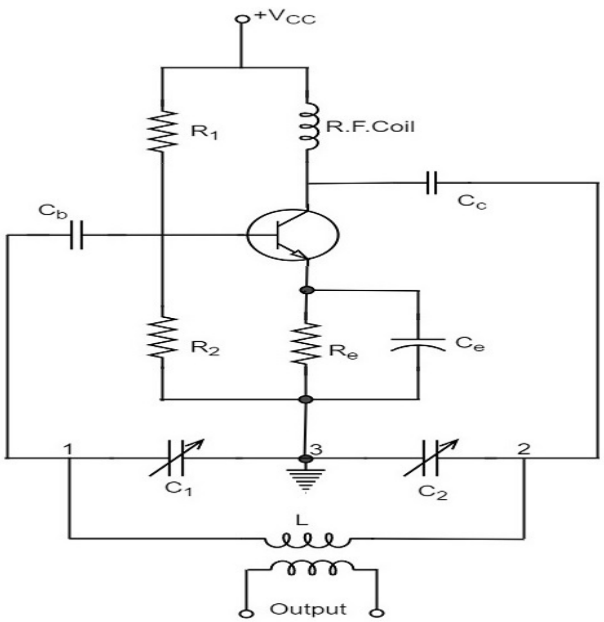
Colpitts Oscillator

- Similar to Hartley oscillator except that the inductors and capacitors are replaced with each other in the tank circuit.
- The frequency determining network consists of variable capacitors C_1 and C_2 along with an inductor L. The junction of C_1 and C_2 are earthed.
- The capacitor C_1 has its one end connected to base via C_b and the other to emitter via C_e.
- The voltage developed across C_1 provides the regenerative(Positive) feedback required for the sustained oscillations.



Colpitts Oscillator Operation



- When the collector supply is given, a transient current is produced in the oscillatory or tank circuit.

- The oscillatory current in the tank circuit produces a.c. voltage across C1 which are applied to the base emitter junction and appear in the amplified form in the collector circuit.
- As the CE configured transistor provides 180° phase shift, another 180° phase shift is provided by the feedback network, which makes 360° phase shift between the input and output voltages.
- This makes the feedback positive which is essential for the condition of oscillations.
- To start up oscillations, loop gain |βA| of the amplifier is greater than one. To sustain the oscillations, loop gain |βA| of the amplifier must be equal to unity.

Frequency of Oscillation

- The equation for **frequency of Colpitts oscillator** is given as:

$$f = 1/2\pi\sqrt{LC_T}$$

where C_T is the total capacitance of C_1 and C_2 connected in series.

$$C_T = C1 + C2$$

$$Or \quad C_T = C1 \times C2 / (C1 + C2)$$

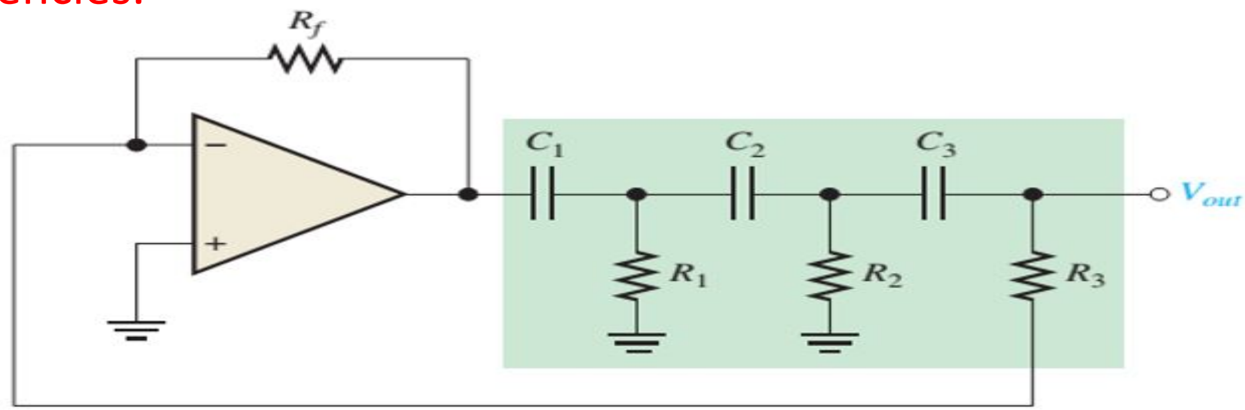
Colpitts Oscillator

Applications :

- Colpitts oscillator can be used as High frequency sine wave generator.
- This can be used as a temperature sensor with some associated circuitry.
- Mostly used as a local oscillator in radio receivers.
- It is also used as R.F. Oscillator.
- It is also used in Mobile applications.

Phase Shift Oscillator

In LC Oscillators, Inductors are bulky and expensive. These LC oscillator cannot be used for low frequencies.



- The phase-shift oscillator uses three RC circuits in the feedback path that have a total phase shift of 180° at one frequency. Oscillation occurs at the frequency where the total phase shift through the three RC circuits is 180°.
- The inverting configuration of the op-amp provides the additional 180° and thus phase shift around the feedback loop would be 360° (or 0°) which is one of the requirement for sustained oscillations.
- The gain(in terms of voltage) of the three-section RC feedback circuit is 1/29
- Therefore to meet the unity loop gain requirement, the closed-loop voltage gain of the inverting op-amp must be 29.

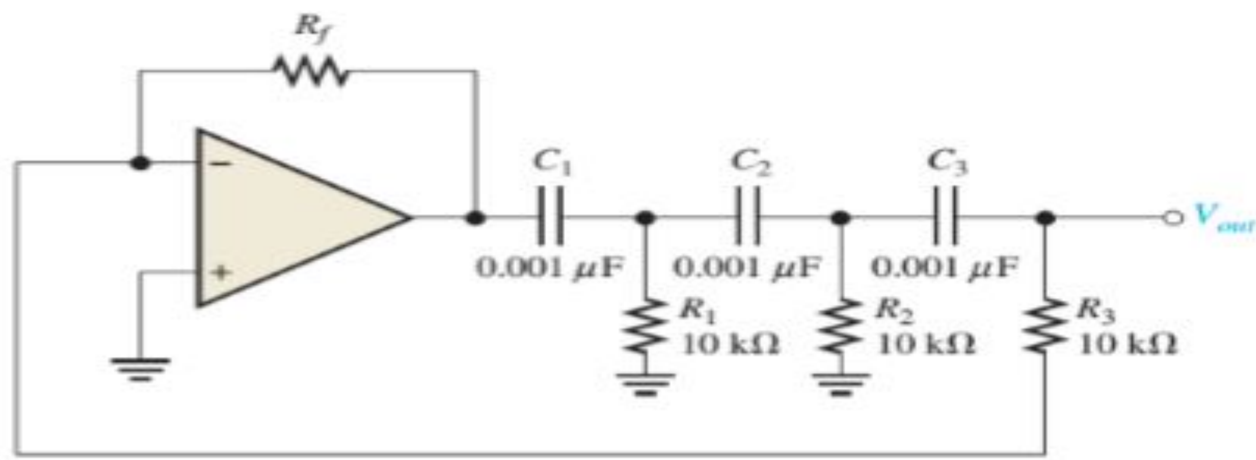
Frequency of Oscillation

- Consider the conditions for oscillation in the phase-shift oscillator is that if all R ’s and C ’s are equal, the amplifier must have a gain of at least 29 to make up for the gain of the feedback circuit. This means that $R_f / R_3 \geq 29$
- Then the frequency of oscillation is given by:

$$f_r = \frac{1}{2\pi\sqrt{6}RC}$$

Example

Determine the frequency of oscillation in the given figure.



Solution:

$$f_r = \frac{1}{2\pi\sqrt{6}RC}$$

$$= \frac{1}{2\pi\sqrt{6}(10\,\text{k}\Omega)(0.001\,\mu\text{F})} \cong \mathbf{6.5\,kHz}$$

References

- For more details, refer to:
  - *Boylestad R. L., Electronic Devices and Circuit Theory, Pearson Education*
  - *Neamen, Donald A., Electronic Circuit Analysis and Design, McGraw Hill*
  - Thomas L. Floyd, Electronic Devices, *Pearson Education*