A Study of Different Oscillators: Electronically Tunable Sinusoidal Oscillator Circuit

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Abstract: **A signal generating circuit is one of the most important building blocks in analog, digital and mixed-signal designs. Oscillators play a critical role in communication systems, providing periodic signals required for timing in digital circuits and frequency translation in radio frequency (RF) circuits. If the output signal varies sinusoidally ,the circuit is referred as sinusoidal oscillator.If the output varies quickly to one voltage level and later drops quickly to another voltage level,the circuit is referred to as square wave oscillator. The oscillator works on the principle of the oscillation and it is a mechanical or electronic device. The periodic variation between the two things is based on the changes in the energy. The oscillations are used in the watches, radios, metal detectors and in many other devices use the oscillators. oscillators are an important class of every electronic circuits and are used in almost every electronic systems.for example,oscillators are employed to produce sinusoidal signals that are used as carrier in radio and television broadcasts.oscillators are also used to produce the square wave used as clock in computers and other synchronous digital systems. This paper presents the design of Hartley and Colpitts oscillator. The Hartley oscillator is an electronic oscillator. The frequency of this oscillation is determined by the tuned circuit. The tuned circuit consists of the capacitor and inductor, hence it is an LC oscillator. The Colpitts Oscillator was by American engineering by Edwin H. Colpitts in the year of 1918. This oscillator is a combination of both inductors and capacitor.**

Keywords: **oscillator, Hartley, Colpitts, capacitor, inductor, feedback**

I. INTRODUCTION

An oscillator is an electronic circuit which uses positive feedback and generates the output which oscillates with constant frequency and amplitude. It converts DC power (from the supply) to a periodic signal. The oscillator converts the direct current from the power supply to an alternating current and they are used in many of the electronic devices. The signals used in the oscillators are a sine wave and the square wave.

Voltage controlled oscillators can be categorized by method of oscillation into resonator-based oscillators and waveform-based oscillators. Resonator based oscillators are categorized into LC and Crystal oscillator. And waveform based oscillator divided into Relaxation and Ring oscillator. Each type has different ways of doing frequency tuning such as current steering for ring oscillator and variable capacitor for LC oscillators. Ring and LC oscillators are good choice for different application. Relaxation and crystal oscillator are not a good choice due to huge phase noise and impractical to design., respectively.

1.1. Tuned circuit oscillator

The oscillators which uses the elements L and C to produce oscillations are called LC oscillator or tuned oscillators.The circuit using elements L and C is called tank circuit or oscillatory circuit.,which is an important part of LC oscillators.This circuit is also referred as resonating circuit or tuned circuit.These oscillators are used for high frequency range from 200KHz to few GHz.

Hartley oscillator

A LC oscillator which uses two inductors and one capacitor in its tank circuit is called hartley oscillator.Two inductors L_1 and L_2 are connected in series across a capacitor C to complete the tank circuit

The density of power radiated from the sun at the outer atmosphere is 1.373 kW/m . Final incident sun light on the earth surface has the peak density of 1 kW/m2 at noon in the tropics. Solar cell can convert the energy of sunlight directly in to electricity.[1] A simplified equivalent circuit of a solar cell consists of a current source in parallel with a.

The resistors R_1,R_2 and R_E provides necessary bias to the circuit.The capacitors C_{C1} and C_{C2} are coupling capacitors.The feedback network consists of tank circuit made up of two inductors L_1,L_2 and one capacitor C.

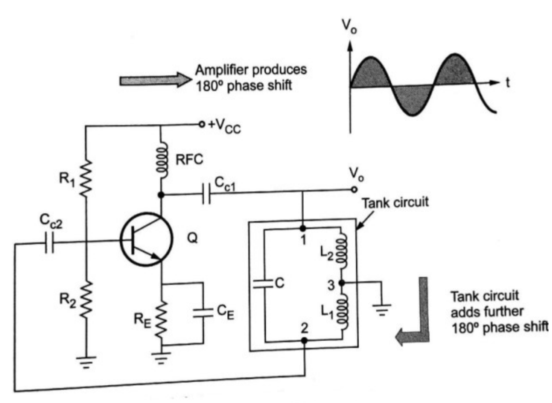

Figure 1. Hartley oscillator

RFC is the radio frequency choke,is a large inductor. It acts as a d.c short to the power supply V_{CC} i.e it allows dc current to easily pass through.It acts as a open circuit for a.c.Hence due to RFC ,the isolation between a.c and d.c operation is achieved.The CE amplifier provides a phase shift of 180◦.When circuit is switched ON,capacitor C gets charged and tank circuit provides 180◦ phase shift.When feedback is adjusted such that |Aβ|=1,the circuit works as an oscillator.
The frequency of oscillation is given by

$$f = \frac{1}{2\pi\sqrt{L_{eq} C}}$$

here are 2 inductors hence equivqlent inductance of the tank circuit is $L_{eq}= L_1+ L_2$. If mutual inductance M is considered while dtermining the equivalent inductance L_{eq},then

$$L_{eq}= L_1+ L_2+2M.$$

The condition for sustained oscillation is

$$h_{fe} \geq \frac{L_1+M}{L_2+M}$$

Neglecting the mutual inductance,the condition for sustained oscillation is given by

$$h_{fe} \geq \frac{L_1}{L_2}$$

Colpitts oscillator

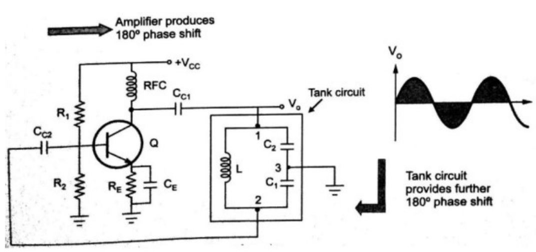

Figure 2. crystal oscillator

An LC oscillator which uses two capacitive reactances and one inductive reactance in the feedback network i.e. tank circuit is called colpitts oscillator. The tank circuit of colpitts oscillator uses 2 capacitors and one inductor.The two capacitors C_1,C_2 are connected in series across inductor L.The resistors R_1,R_2 and R_E provides necessary bias to the circuit.The capacitors C_{C1} and C_{C2} are coupling capacitors.The capacitance divider C_1,C_2 in a tank circuit provides necessary feedback for oscillation.The RFC(radio frequency choke) is used to schieve isolation between a.c and d.c conditions.The amplifier stage stage uses an active device as transistor in common emitter configuration,which introduces a phase shift of 180◦. When the supply is switched ON,the oscillatory current is set up in the tank circuit.it provides a.c voltage across C_1 & C_2.Tank circuit provides 180◦ phase shift.When feedback is adjusted such that |Aβ|=1,the circuit works as an oscillator.

The frequency of oscillation is given by

$$f = \frac{1}{2\pi\sqrt{L C_{eq}}}$$

$$\text{where,} \quad C_{eq} = \frac{C_1 C_2}{C_1+C_2}$$

The condition for sustained oscillation is

$$h_{fe} \geq \frac{C_2}{C_1}$$

1.2. Tables

Table 1a. values usied in the design of Hartley oscillator

Values	Hartley oscillator
R1	47KΩ
R2	8.2KΩ
Rc	1.8KΩ
R_E	470Ω
L1	100μH
L2	100 μH
C	2.5nF
$C_{C1}= C_{C2}$	0.1μF
f	225KHz (designed) 220KHz(practical)

Table 1b. values usied in the design of Colpitts oscillator

Values	Colpitts oscillator
R1	47KΩ
R2	8.2KΩ
Rc	1.8KΩ
R_E	470Ω
C1	220pF
C2	220pF
L	100 μH
$C_{C1}= C_{C2}$	0.1μF
f	1.5MHz(designed) 1.2MHz(practical)

II. CONCLUSION

A Hartley Oscillator circuit having two individual inductors of 100μH each, are designed to resonate in parallel with a capacitor 2.5nF and 500pF produces a frequency of 220KHz.A colpitts oscillator having two individual capacitors of 0.1μF are designed to resonate in parallel with a inductor of 100μH produces a frequency of 1.2 MHz.

REFERENCES

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