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Resonant Circuits

Simple explanation without complex mathematics

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A very important element of any radio communications equipment is the LC circuit. L is the inductance measured in Henries (H) and named after Joseph Henry (1797–1878**).** The symbol L for inductance was chosen to honour Heinrich Lenz (1804-1865) who pioneered work in electromagnetic induction. The C is capacitance measured in Farads (F) and named after the English physicist Michael Faraday (1791-1867).

As the name implies, the components in the circuit are an inductor and a capacitor. Depending on how the components are connected dictates how the circuit will operate.

Quick rehash: A capacitor is a component with two plates separated by a dielectric. The capacitor will block DC and can store energy. The governing factors for capacitance are the size of the plates, type of dielectric, and the distance between the plates.

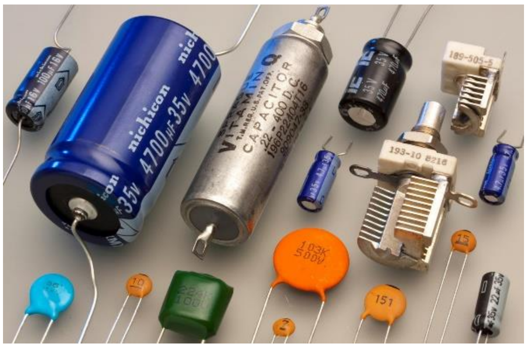


Figure 1: Capacitors.

An inductor, sometimes called a choke, is a designed coil of wire either in open air or with a rod of material in the centre. An inductor can also store energy and will block AC signals. Inductance is determined by the shape of the coil and the interaction of the generated magnetic field.

Figure 2: Inductors.

Every electrical and electronic component has a direct current resistance value measured in Ohms. The opposition to alternating current by inductors or capacitors is called reactance. The reactance, also measured in Ohms, is dependent on the types and makeup of the components used.

Reactance is designated with the letter X, so capacitive reactance is X_C and is measured in positive numbers and inductive reactance is X_L and is measured in negative numbers.

The components for the LC circuit can be connected in series or in parallel. An easy way to identify if the components are in series or parallel, is to look at the current path. If the current in the circuit splits and goes through the inductor and capacitor separately, this is a parallel circuit as in Figure 3. If all the current goes through one component, then the other component, the circuit is in series as in Figure 4.

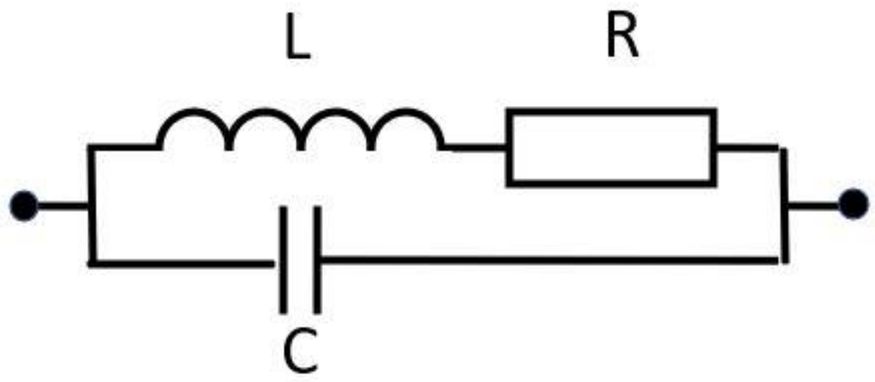


Figure 3: Parallel LC Circuit. Often referred to as a tank circuit or tuned circuit.

Figure 4: Series LC Circuit ~

The useful thing about LC circuits is that with any combination of the C value and the L value, they will have a resonant frequency. At this resonant frequency, the circuits act differently than the components individually. The formula for these values is available on the internet.

A parallel LC circuit, Figure 3, will block any signal that is operating on the resonant frequency. In a parallel LC circuit at resonance, the time taken for the capacitor to charge and discharge, is the same time taken for the inductor to charge and discharge. The energy in the circuit will charge the capacitor and, as the capacitor discharges, the energy will charge the inductor. As the inductor discharges, the energy recharges the capacitor. So, at the resonant frequency, the LC circuit will oscillate. A signal at any other frequency will pass through the parallel LC circuit.

At resonance, the parallel tuned circuit has a high reactance to the alternating signal.

In a series LC circuit, Figure 4, the energy goes through one component then the next. Any signal below the resonant frequency will be predominantly blocked by the capacitor. Signals above the resonant frequency will be predominantly blocked by the inductor. Signals at the resonant frequency are not blocked by the capacitor or the inductor.

At resonance, the series tuned circuit has a low reactance to the alternating signal.

The ratio of the reactance to the resistance, in an operational circuit, is called the Q (Quality Factor) of the circuit. If the current in the circuit is plotted against frequency, either side of the resonant frequency, the result will be a Q plot resembling a bell curve. The base of the bell and the height of the bell indicate the bandwidth of the circuit.

A sample Q plot of a series tuned circuit is shown in Figure 5. As the frequency drops, the capacitive reactance X_C is predominant while the inductive reactance X_L is predominant in the higher frequencies.

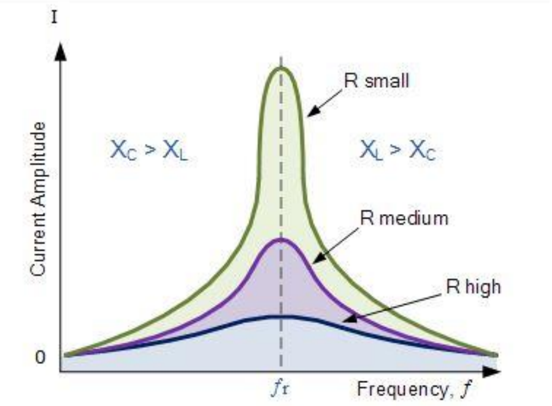


Figure 5: Q plot; frequency against current for a series tuned circuit.

These LC circuits are an essential building block in communications equipment. They can act as filters, tuning circuit for a radio, or the basis of an oscillator.

Figure 6 shows a parallel tuned circuit used as the frequency source for an oscillator. The tickler coil, L1, provides regenerative feedback to the oscillator to maintain the tuned circuit oscillations.

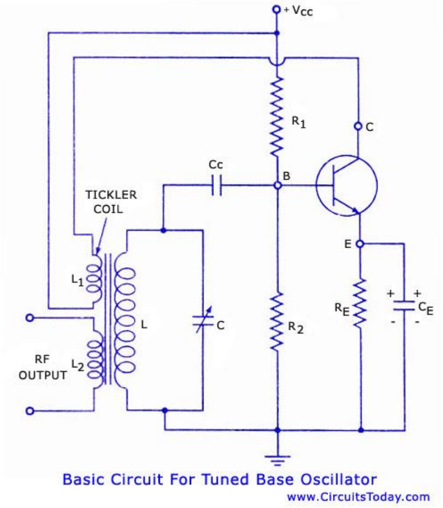
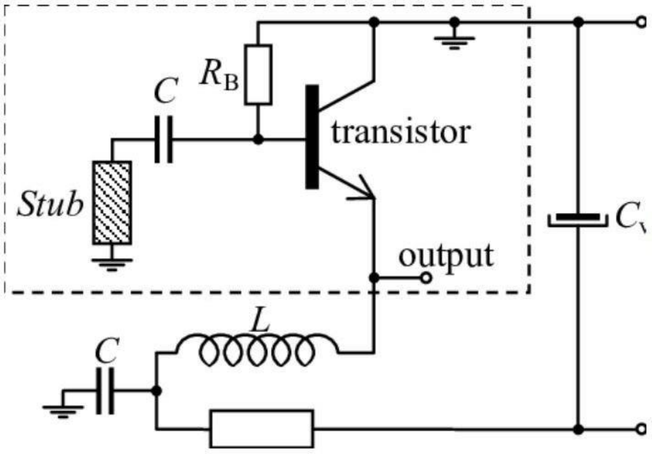


Figure 6: Parallel tuned circuit oscillator application.

Figure 7[i] shows a series tuned circuit in an oscillator circuit. A stub or resonant stub is a length of transmission line or waveguide connected at one end only. The free end of the stub is either left open-circuit or short-circuit and the stub length would determine the oscillator frequency. Any frequency, not at the LC circuit's resonant frequency, would be shunted to earth through the series LC circuit.



Transistor oscillator circuit.

Figure 7: Parallel tuned circuit oscillator application.

Have fun and stay safe.

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