

LC Circuits

LC Circuit Fundamentals

An LC circuit consists of an inductor (L) and a capacitor (C) connected together. These circuits form the foundation of resonant systems and are central to understanding how the VIC operates.

Components of an LC Circuit

The Inductor (L)

An inductor stores energy in its magnetic field when current flows through it. Key properties:

- **Inductance (L):** Measured in Henries (H), represents the inductor's ability to store magnetic energy
- **Inductive Reactance:** $X_L = 2\pi fL$ (increases with frequency)
- **Current lags voltage by 90°** in a pure inductor

The Capacitor (C)

A capacitor stores energy in its electric field between two conductive plates. Key properties:

- **Capacitance (C):** Measured in Farads (F), represents the capacitor's ability to store electric charge
- **Capacitive Reactance:** $X_C = 1/(2\pi fC)$ (decreases with frequency)
- **Current leads voltage by 90°** in a pure capacitor

Series LC Circuit

Circuit Configuration: L and C connected in series with the source

Total Impedance:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

At Resonance ($X_L = X_C$):

- $Z = R$ (minimum impedance)
- Current = V/R (maximum current)
- Voltage across L = Voltage across C = $Q \times V_{\text{source}}$

Series LC Behavior

Frequency	Condition	Circuit Behavior
$f < f_0$	$X_C > X_L$	Capacitive (current leads voltage)
$f = f_0$	$X_C = X_L$	Resistive (current in phase with voltage)
$f > f_0$	$X_L > X_C$	Inductive (current lags voltage)

Parallel LC Circuit

Circuit Configuration: L and C connected in parallel

At Resonance:

- Impedance approaches infinity (in ideal case)
- Current from source is minimum
- Large circulating current flows between L and C

Also called: Tank circuit, because it "tanks" or stores energy

Characteristic Impedance ($Z?$)

The characteristic impedance is a fundamental property of any LC circuit:

$$Z = \sqrt{L/C}$$

This value represents:

- The impedance at resonance for a parallel LC circuit
- The ratio of voltage to current in a traveling wave
- A design parameter for matching circuits

Energy Transfer in LC Circuits

In an ideal LC circuit (no resistance), energy oscillates perpetually between the inductor and capacitor:

1. **Capacitor fully charged:** All energy stored in electric field ($E = \frac{1}{2}CV^2$)
2. **Current building:** Energy transferring to inductor
3. **Maximum current:** All energy stored in magnetic field ($E = \frac{1}{2}LI^2$)
4. **Current decreasing:** Energy transferring back to capacitor
5. **Cycle repeats** at the resonant frequency

LC Circuits in the VIC

The VIC uses LC circuits in two critical locations:

Primary Side (L1-C1)

- L1 = Primary choke inductance
- C1 = Tuning capacitor
- Tuned to the driving frequency from the pulse generator
- Develops the initial voltage magnification

Secondary Side (L2-WFC)

- L2 = Secondary choke inductance
- WFC = Water Fuel Cell capacitance
- May be tuned to the same or a harmonic frequency
- Delivers magnified voltage to the water

Design Principle: The relationship between L and C values determines not only the resonant frequency but also the characteristic impedance, which affects how much voltage magnification is achievable.

Practical Considerations

- **Component tolerances:** Real components have tolerances that affect the actual resonant frequency
- **Parasitic elements:** Inductors have parasitic capacitance, capacitors have parasitic inductance
- **Temperature effects:** Component values can drift with temperature
- **Losses:** Real circuits have resistance that dampens oscillations

Next: Quality Factor (Q) Explained →

Revision #1

Created 2026-01-01 20:34:34 UTC by Chris Bake

Updated 2026-01-01 20:35:32 UTC by Chris Bake