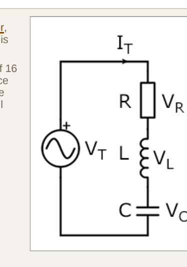
Series RLC Circuit Impedance Calculator



This series RLC circuit impedance calculator determines the impedance and the phase difference angle of a resistor, an inductor and a capacitor connected in series for a given frequency of a sinusoidal signal. The angular frequency is also determined.

Example: Calculate the impedance of a 1 H inductor and a 100 µF capacitor, and a 100 Ω resistor at a frequency of 16 Hz. This example shows the near-resonance impedance of about 100.006 ohms. If you want to check the impedance at almost exact resonance, enter 15.9154 Hz instead of 16 Hz. At this frequency the impedance is slightly capacitive because the phase difference angle φ < 0. If you enter a slightly higher frequency of 15.9155 Hz, the impedance will change to slightly inductive and you will notice that the phase difference angle has become positive.

Input

Resistance, R — ohm (Ω)

Inductance, L — millihenry (mH)

Capacitance, C — microfarad (µF, uF)

Frequency, f — megahertz (MHz)

Calculate | Reset | Share

Output

Angular Frequency	ω=	rad/s
Capacitive reactance	X_C=	Ω
Inductive reactance	X_L=	Ω
Total RLC Impedance	$\|Z_{RLC}\|$=	Ω
Phase difference	φ =	° = rad
Quality factor	Q=	
Resonant frequency	f_0=	Hz ω_0= rad/s

Calculate at the resonant frequency

Click or tap to set the resonant frequency and calculate all output values for it.

Enter the resistance, capacitance, inductance, and frequency values, select the units and click or tap the **Calculate** button. Try to enter zero or infinitely large values to see how this circuit behaves. **Infinite frequency** is not supported. To enter the **Infinity** value, just type inf in the input box.

The following formulas are used for the calculation:

$$\omega = 2\pi f$$

$$Z_{RLC} = Z_R + jX_L + jX_C$$
$$= R + j\omega L + \frac{1}{j\omega C}$$

$$X_L = \omega L = 2\pi f L$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$$|Z_{RLC}| = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$$

$$|Z_{RLC}| = \sqrt{R^2 + (2\pi f L - \frac{1}{2\pi f C})^2}$$

$$\phi = \arctan(\frac{\omega L - \frac{1}{\omega C}}{R})$$
$$= \arctan(\frac{2\pi f L - \frac{1}{2\pi f C}}{R})$$

φ 90° if $1/2\pi fC < 2\pi fL$ and $R = 0$

$\varphi = -90°$ if $1/2\pi fC > 2\pi fL$ and $R = 0$

$\varphi = 0°$ if $1/2\pi fC = 2\pi fL$ and $R = 0$

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

where

Z_{LC} is the LC circuit impedance in ohms (Ω),

$\omega = 2\pi f$ is the angular frequency in rad/s,

f is the frequency in hertz (Hz),

R is the resistance in ohms (Ω),

L is the inductance in henries (H),

C is the capacitance in farads (F),

Q is the quality factor of a series RLC circuit (dimensionless),

ω_0 is the resonant angular frequency in radian per second (rad/s),

f_0 is the resonant frequency in hertz (H),

φ is the phase shift between the total voltage V_T and the total current I_T in degrees (°) and radians, and

j is the imaginary unit.

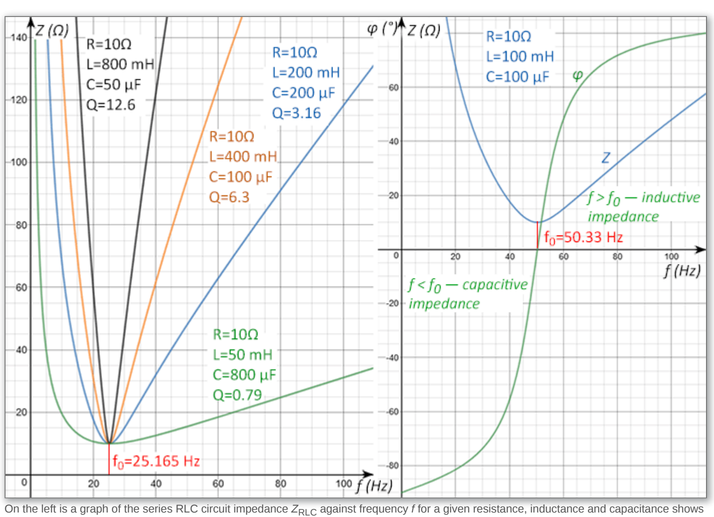
To calculate, enter the resistance, the inductance, the capacitance, and the frequency, select the units of measurements and the result for the RLC impedance will be shown in ohms and for the phase difference in degrees. The Q factor, C and L reactance, and the resonant frequency will also be calculated. Click or tap **Calculate at the resonant frequency** to see what will happen at resonance.

A series RLC circuit consists of a resistor R, an inductor L, and a capacitor C connected in series. The sequence of letters in the circuit name can be different: RLC, RCL, LCR, etc. Like a pure series LC circuit, the RLC circuit can resonate at a resonant frequency and the resistor increases the decay of the oscillations at this frequency.

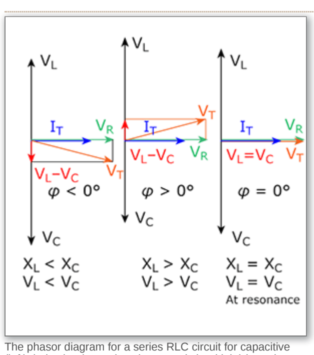
The resonance occurs at the frequency at which the impedance of the circuit is at its minimum, that is if there is no reactance in the circuit. In other words, if the impedance is purely resistive (or real). This phenomenon occurs when the reactances of the inductor and the capacitor are equal and because of their opposite signs, they cancel each other (the canceling can be observed on the right phasor diagram below).

The calculator defines the resonant frequency of the RLC circuit and you can enter this frequency or the value slightly above or below it to view what will happen with other calculated values at resonance.

The calculator can also define the **Q factor** of the series RLC circuit — a parameter, which is used to characterize resonance circuits and not only electrical but mechanical resonators as well. Damped and lossy RLC circuits with high resistance have a low Q factor and are wide-band, while circuits with low resistance have a high Q factor. For a series RLC circuit, the Q factor can be calculated using the formula above.



On the left is a graph of the series RLC circuit impedance Z_{RLC} against frequency f for a given resistance, inductance and capacitance shows only resistive impedance at resonant frequencies. When the frequency increases, the inductor's reactance is increasing and the capacitor's reactance is decreasing. If, however, the frequency approaches zero (or DC), the inductor's reactance is decreasing to zero and the capacitor's reactance is increasing to infinity. At zero frequency the series RLC circuit acts as an open circuit. The right graph shows the impedance and the phase angle of a series RLC circuit against frequency. To the right of the resonant frequency, the impedance is inductive and to the left of the resonant frequency, the impedance is capacitive.



The phasor diagram for a series RLC circuit for capacitive (left), inductive (center) and pure resistive (right) impedance. The voltage vectors on the diagram produce a rectangular voltage triangle with a hypotenuse V_T, vertical leg V_L–V_C and horizontal leg V_R.

In the series circuit, the same current flows through the resistor, the inductor, and the capacitor, but the individual voltages across the components are different. The phasor diagram shows the V_T voltage of the ideal sine voltage source. The voltage drop on the resistor V_T is shown on the horizontal axis in phase with the current that flows through the circuit. The inductance voltage vector V_L lags the current in the inductance vector by 90°, therefore it is drawn at +90°. The capacitance voltage vector V_C leads the current in the capacitor vector by 90° and it is drawn at –90°. The vector sum of the two opposing vectors can be pointed downwards or upwards depending on the voltage drop across the inductor and the capacitor. The total voltage vector V_T is obtained using Pythagoras' theorem.

At the resonant frequency the capacitive and inductive reactances are equal and if we look at the equation for |Z| above, we will see that the effective impedance is equal to resistance R because the two opposing voltages simply cancel each other. The current flowing through the inductor and capacitor is the same and the voltages across them are equal and opposing. So, at the resonant frequency, the current drawn from the source is limited only by the resistance because the ideal series LC circuit at the resonant frequency acts as a short circuit.

The resonant frequency of a series RLC circuit is determined considering that

$$X_L = X_C$$

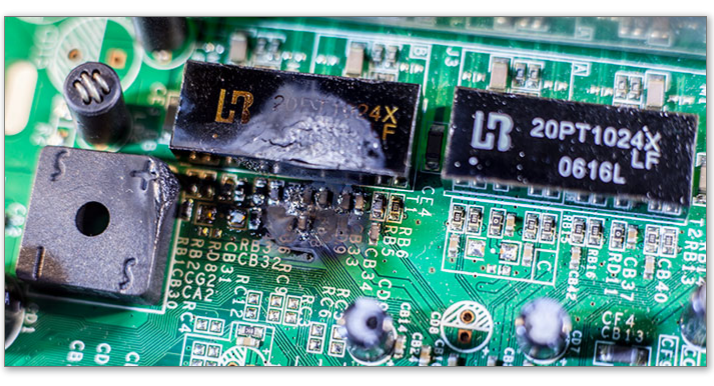
$$2\pi f L = \frac{1}{2\pi f C}$$

Multiplying both sides of the equation by the frequency f, we will get

$$2\pi f^2 L = \frac{1}{2\pi C}$$

Dividing both sides by $2\pi L$, taking the square root of both sides of the equation and simplifying, we will get

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$



Failure Modes

What if something goes wrong in this circuit? Click or tap a corresponding link to view the calculator in various failure modes:

Failed Component	Failure Mode	
Resistor	Short	Open
Capacitor	Short	Open
Inductor	Short	Open

Special Modes

Click or tap a corresponding link to view the calculator in various special modes:

Various direct current modes

Short circuit

Open circuit

Purely capacitive circuit

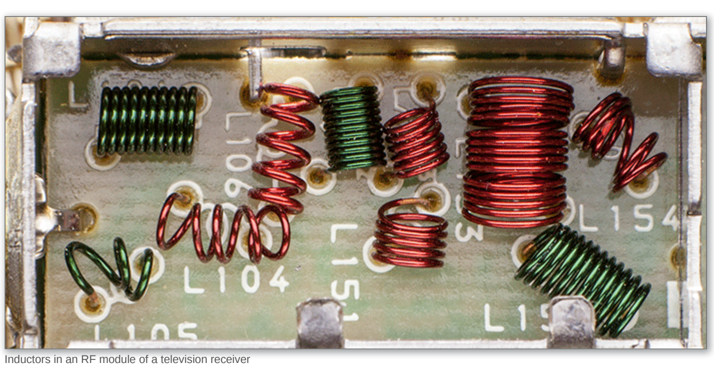
Circuit at resonance

Purely inductive circuit

Inductive circuit

Notes

- In our explanations of the behavior of this circuit, zero frequency means direct current. If f = 0, we assume that the circuit is connected to an ideal DC voltage source.
- At zero frequency, we consider the capacitor reactance to be zero if its capacitance is infinitely large. If the capacitor has a finite capacity, its reactance at zero frequency is infinitely large and for a DC voltage source, it represents an open circuit or, in other words, a removed capacitor.
- At zero frequency, we consider the reactance of an ideal inductor to be infinitely large if its inductance is infinitely large. If the inductor has a finite inductance, its reactance at zero frequency is zero and for a DC voltage source, it represents a short circuit.



Inductors in an RF module of a television receiver

This article was written by Anatoly Zolotkov

Random converter

Electrical, RF and Electronics Calculators

Electronics is a branch of physics, electrical engineering, and technology concerned with the design and use of electrical circuits containing active electrical components (diodes, transistors, and integrated circuits) and passive electrical components (resistors, inductors, and capacitors) and connections between them.
Radio-frequency engineering (RF engineering) is a field of engineering that deals with devices that transmit or receive radio waves in the radio frequency spectrum (3 kHz to 300 GHz). Examples of such devices are mobile phones, routers, computers, two-way radios, credit cards, satellite receivers, televisions, and other equipment that transmits and receive radio waves.
In this part of the TranslatorsCafe.com Unit Converter, we present a group of calculators related to various aspects of electrical engineering, electronics, and RF engineering.

This online unit converter allows quick and accurate conversion between many units of measure, from one system to another. The Unit Conversion page provides a solution for engineers, translators, and for anyone whose activities require working with quantities measured in different units.

Learn Technical English with Our Videos!

We work hard to ensure that the results presented by TranslatorsCafe.com converters and calculators are correct. However, we do not guarantee that our converters and calculators are free of errors. All of the content is provided "as is", without warranty of any kind. Terms and Conditions.

If you have noticed an error in the text or calculations, or you need another converter, which you did not find here, please let us know!

TranslatorsCafe.com Unit Converter YouTube channel