Difference Between Resistance and Reactance

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Key Difference - Resistance vs Reactance

Electrical components such as resistors, inductors, and capacitors have some sort of an obstruction for the current passing through them. While resistors react to both direct current and alternating current, inductors and capacitors respond to variations of currents or alternating current only. This obstacle to the current from these components are known as electrical impedance (Z). Impedance is a complex value in mathematical analysis. The real part of this complex number is called resistance (R), and only pure resistors have a resistance. Ideal capacitors and inductors contribute to the imaginary part of the impedance which is known as reactance (X). Thus, the key difference between resistance and reactance is that **resistance is a real part of impedance of a component** whereas **reactance is an imaginary part of impedance of a component.** A combination of these three components in RLC circuits makes impedance on the current path.

What is Resistance?

Resistance is the obstacle the voltage faces in driving a current through a conductor. If a large current is to be driven, the voltage applied to the ends of the conductor should be high. That is, the applied voltage (V) should be proportional to the current (I) that goes through the conductor, as stated by Ohm's law; the constant for this proportionality is the resistance (R) of the conductor.

V = I X R

Conductors have the same resistance irrespective of whether the current is constant or varying. For alternating current, resistance can be calculated using Ohm's Law with instantaneous voltage and current. The resistance measured in Ohms (Ω) depends on the conductor's resistivity (ρ), length (l) and cross-section area (A) where,

$$R = \rho \frac{l}{A}$$

Resistance also depends on the temperature of the conductor since the resistivity changes with the temperature in the following manner. where ρ_0 refers to the resistivity specified at the standard temperature T_0 which is usually the room temperature, and α is the temperature coefficient of resistivity:

$$\rho(T) = \rho_0[1 + \alpha(T - T_0)]$$

For a device with pure resistance, the power consumption is calculated by the product of I^2 x R. Since all those components of the product are real values, the power consumed by the resistance will be a real power. Therefore, the power supplied to an ideal resistance is fully utilized.

What is Reactance?

Reactance is an imaginary term in mathematical context. It has the same notion of resistance in electrical circuits and shares the same unit Ohms (Ω). Reactance occurs only in inductors and capacitors during a change of current. Hence, reactance depends on the frequency of the alternating current through an inductor or capacitor.

In the case of a capacitor, it accumulates charges when a voltage is applied to the two terminals until the capacitor voltage matches the source. If the applied voltage is with an AC source, the accumulated charges are returned to the source at the negative cycle of the voltage. As the frequency goes higher, the lesser the amount of charges kept stored in the capacitor for a short period of time since the charging and discharging time do not change. As a result, the opposition by the capacitor to the current flow in the circuit will be less when the frequency increases. That is, the reactance of the capacitor is inversely proportional to the angular frequency (ω) of the AC. Thus, the capacitive reactance is defined as

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

C is the capacitance of the capacitor and *f* is the frequency in Hertz. However, the impedance of a capacitor is a negative number. Therefore, the impedance of a capacitor is Z = $-i/2\pi fC$. An ideal capacitor is only associated with a reactance.

On the other hand, an inductor opposes a change of current through it by creating a counter electromotive force (emf) across it. This emf is proportional to the frequency of the AC supply and, its opposition, which is the inductive reactance, is proportional to the frequency.

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

Inductive reactance is a positive value. Therefore, the impedance of an ideal inductor will be Z=$i2\pi fL$. Nevertheless, one should always note that all practical circuits consist of resistance as well, and these components are considered in practical circuits as impedances.

As a result of this opposition to the current variation by inductors and capacitors, the voltage change across it will have a different pattern from the variation of current. This means the phase of the AC voltage is different from the phase of the AC current. Due to the inductive reactance, the current change has a lag from the voltage phase, unlike capacitive reactance where the current phase is leading. In ideal components, this lead and lag has a magnitude of 90 degrees.

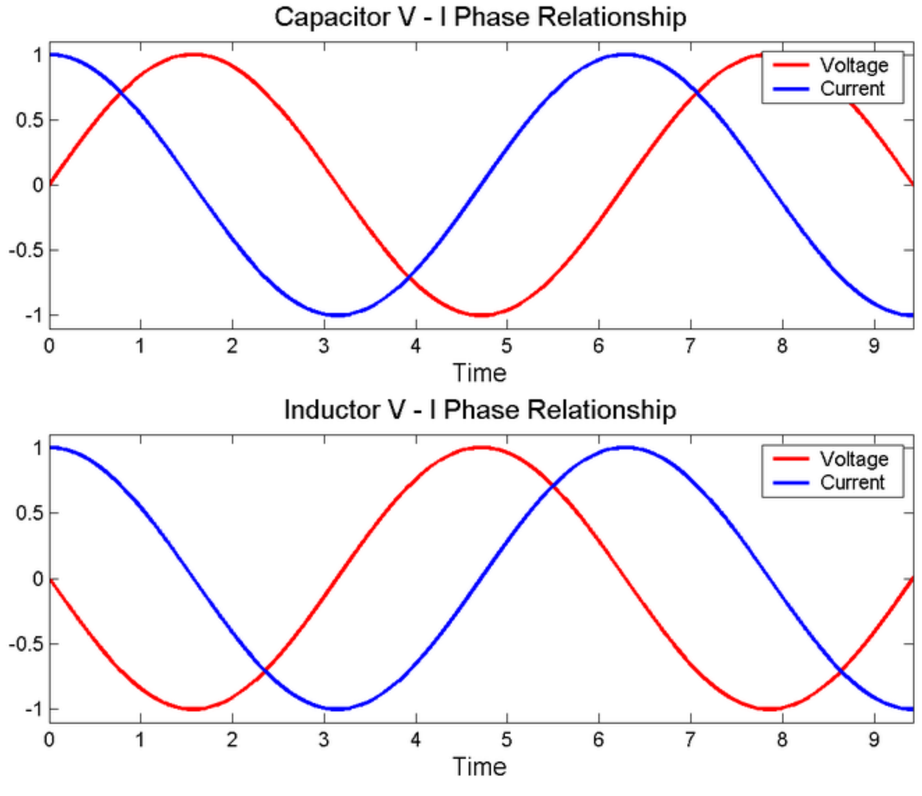

Figure 01: Voltage-current phase relationships for a capacitor and an inductor.

This variation of the current and voltage in AC circuits are analyzed using phasor diagrams. Because of the difference of the phases of current and voltage, the power delivered to a reactive circuit is not fully consumed by the circuit. Some of the power delivered will be returned to the source when the voltage is positive, and the current is negative (such as where the time=0 in above diagram). In electrical systems, for a difference of Θ degrees between the voltage and current phases, cos(Θ) is called the power factor of the system. This power factor is a critical property to control in electrical systems since it makes the system run efficiently. For the maximum power to be utilized by the system, the power factor should be maintained by making ϴ = 0 or nearly zero. Since most of the loads in electrical systems are usually inductive loads (like motors), capacitor banks are used for the power factor correction.

What is the difference between Resistance and Reactance?

Resistance vs Reactance	
Resistance is the opposition to a constant or varying current in a conductor. It is the real part of impedance of a component.	Reactance is the opposition to a variable current in an inductor or a capacitor. Reactance is the imaginary part of the impedance.
Dependency	
Resistance depends on the conductor's dimensions, resistivity, and temperature. It does not change due to the frequency of AC voltage.	Reactance depends on the frequency of the alternating current. For inductors, it is proportional, and for capacitors, it is inversely proportional to the frequency.
Phase	
The phase of the voltage and current through a resistor is the same; that is, the phase difference is zero.	Due to the inductive reactance, the current change has a lag from the voltage phase. In capacitive reactance, current is leading. In an ideal situation, the phase difference is 90 degrees.
Power	
Power consumption due to resistance is real power and it is the product of voltage and current.	Power supplied to a reactive device is not fully consumed by the device due to lagging or leading current.

Summary - Resistance vs Reactance

Electrical components such as resistors, capacitors, and inductors make an obstacle know as impedance for the current to flow through them, which is a complex value. Pure resisters have a real-valued impedance known as resistance, while ideal inductors and ideal capacitors having an imaginary-valued impedance called reactance. Resistance occurs on both direct current and alternating currents, but reactance occurs only on variable currents, thus making an opposition to change the current in the component. While the resistance is independent of the frequency of AC, reactance changes with the frequency of AC. Reactance also makes a phase difference between the current phase and voltage phase. This is the difference between resistance and reactance.

Reference:

1. "Single: Capacitor, Resistor or Inductor Circuits." Department of Chemical Engineering and Biotechnology. University of Cambridge, 16 Dec. 2013. Web. Available here. 06 June 2017.
2. "Electrical reactance." Wikipedia. Wikimedia Foundation, 28 May 2017. Web. Available here. 06 June 2017.

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How to Cite this Article?

APA: Difference Between Resistance and Reactance. (2017, June 05). Retrieved (date), from http://www.differencebetween.com/difference-between-resistance-and-vs-reactance/

MLA: "Difference Between Resistance and Reactance." *Difference Between.Com*. 05 July 2017. Web.

Chicago: "Difference Between Resistance and Reactance." *Difference Between.Com*. http://www.differencebetween.com/difference-between-resistance-and-vs-reactance/ (accessed [date]).