Learnabout Electronics - AC Theory

Formula Finder

Facts & Formulae for AC Theory

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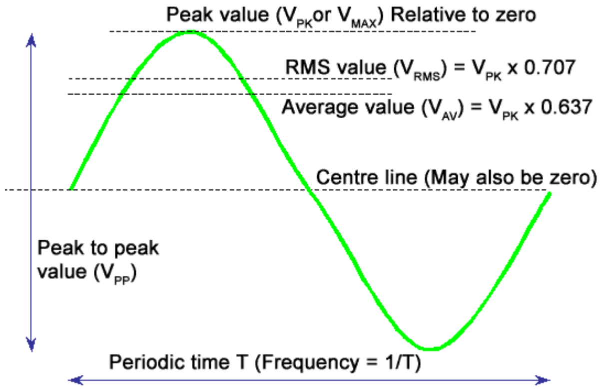
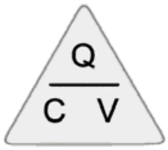
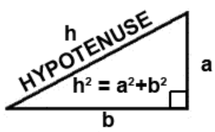
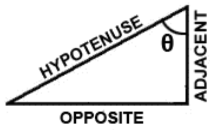
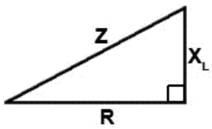
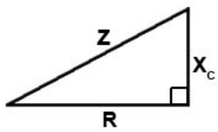
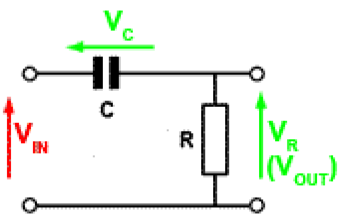
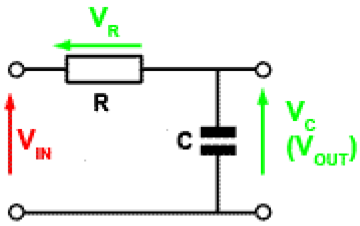
AC Wave Values	
Capacitance	**Sub unit** / **Abbreviation** / **Standard notation** micro Farads / µF / x 10^{-6} nano Farads / nF / x 10^{-9} pico Farads / pF / x 10^{-12}
	Capacitance depends on four things; 1.The area of the plates 2.The distance between the plates 3.The type of dielectric material 4.Temperature
	Capacitance (C) is **DIRECTLY PROPORTIONAL TO THE AREA OF THE TWO PLATES** Capacitance (C) **is INVERSELY PROPORTIONAL TO THE DISTANCE BETWEEN THE PLATES.**
Charge on a Capacitor	 Q = CV or C = Q/V or V = Q/C Where V is the voltage applied, in Volts. C is the capacitance in Farads. Q is the quantity of charge in Coulombs.
Total Capacitance	$\frac{C_1 \times C_2}{C_1 + C_2}$ Series Network C1 + C2 + C3 + ...etc. Parallel network
Inductance	1 Henry is the amount of inductance needed to induce an EMF of 1 volt when the current in a conductor changes at the rate of 1 Ampere per second. The Henry is a rather large unit to be useful in electronics and the milli-Henry (mH) and micro Henry (mH) are more common.
Ohms Law	Voltage across a resistor $V_R = I \times R$

Time Constants	Time constant of a CR circuit **T = CR seconds** Voltage after 1 Time constant = 63.2% of Maximum voltage (supply voltage) Fully charged after 5 time constants. Discharges to 36.8% of maximum voltage after 1 time constant.
	Time constant of a LR circuit **T = L / R seconds.** Current after 1 Time constant = 63.2% of Maximum Current Max Current reached after 5 time constants
Phase	 In a pure inductor, voltage (V_L) leads current (I_S) by 90° In a pure capacitor, voltage (V_C) lags current (I_S) by 90°
Angular Velocity	In calculations involving rotation, it is common to use the angular unit RADIAN (rad.) where 360° = 2π rads. A phasor can therefore be said to rotate through $2\pi f$ radians per second. This is called the ANGULAR VELOCITY of the phasor, and is commonly represented by $2\pi f$ or alternatively by the symbol ω (omega).
Phasor Diagrams.	**Rule 1.** The length of the phasor is directly proportional to the amplitude of the wave depicted. **Rule 2.** In L, C & R in SERIES circuits, the phasor representing CURRENT is horizontal, and called this the REFERENCE phasor. This is because the current in a series circuit is common to all the components. **Rule 3.** In PARALLEL circuits the SUPPLY VOLTAGE phasor is always drawn in the reference direction (horizontally) because in a parallel circuit the supply voltage is common to all components. **Rule 4.** The direction of rotation of all phasors is considered to be ANTI-CLOCKWISE. **Rule 5.** In any one diagram, the same type of value (RMS, peak etc.) is used for all phasors, not a mixture of values.
Pythagoras' Theorem	The square of the hypotenuse of a right angle triangle is equal to the sum of the squares of the two adjacent sides 

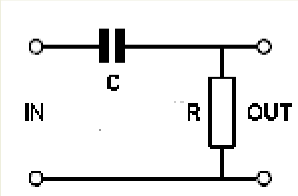
Trigonometry	The formula for finding an angle depends on which sides of the triangle have a known value. The choice for finding the unknown angle **θ** (in degrees) is between	$\theta° = \sin^{-1}$ (Opposite / Hypotenuse) $\theta° = \cos^{-1}$ (Adjacent / Hypotenuse) $\theta° = \tan^{-1}$ (Opposite / Adjacent) 
Reactance	INDUCTIVE REACTANCE (X_L) $2\pi f L$ or ωL	CAPACITIVE REACTANCE (X_C). $\frac{1}{2\pi f C}$ or $\frac{1}{\omega C}$
Impedance	$Z = \sqrt{(R^2 + X_L^2)}$ 	$Z = \sqrt{(R^2 + X_C^2)}$ 
	IMPEDANCE TRIANGLE When using this formula on a calculator it is important to remember to use the brackets, or alternatively, to find the sum of $R^2 + X_L^2$ before using the square root key.	
CR Filter Circuits	High Pass Filter	Low Pass Filter
Corner (Cut off) Frequency	Corner Frequency (CR High/Low pass filter)	$f_C = \frac{1}{2\pi CR}$
	Corner Frequency (LR High/Low pass filter)	$f_C = \frac{1}{2\pi LR}$
LCR Series Circuits	**6 Things you need to know about LCR Series Circuits.** 1. **AT RESONANCE (f_r)** V_C is equal to, but in anti-phase to V_L 2.; **AT RESONANCE (f_r)** Impedance (Z) is at minimum and equal to RESISTANCE(R) 3. **AT RESONANCE (f_r)** Circuit current (I_S) is at a maximum. 4. **AT RESONANCE (f_r)** The circuit is entirely resistive. 5. **BELOW RESONANCE (f_r)** The circuit is capacitive. 6. **ABOVE RESONANCE (f_r)** The circuit is inductive.	

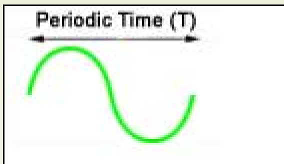
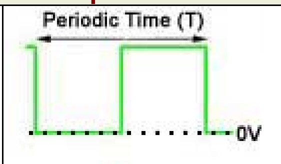
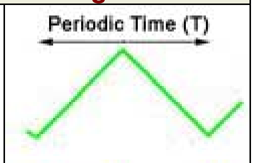
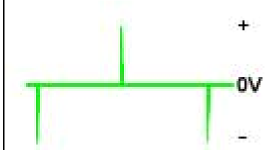
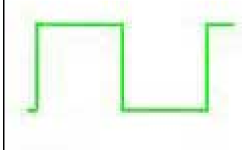
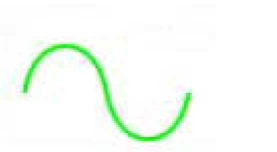
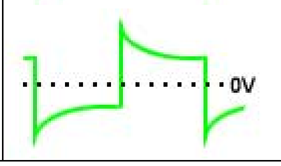
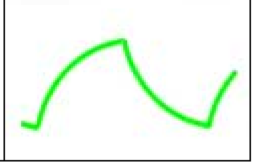
Resonant Frequency	Resonant frequency of Series or Parallel LCR Circuit	$f_r = \frac{1}{(2\pi\sqrt{LC})}$
	Resonant frequency - Low frequency version where L contains an appreciable amount of internal resistance.	$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$
Q factor	(Series or Parallel Circuit)	$Q = \frac{X_L}{R}$ or $\frac{2\pi f_r L}{R}$
Dynamic Resistance	Dynamic Resistance (R_D) Parallel Circuit	$R_D = \frac{L}{CR}$
Bandwidth	Bandwidth (B) as a function of frequency (f_r) and Q factor (Q)	$Q = \frac{f_r}{B}$ or $B = \frac{f_r}{Q}$
LCR Parallel Circuits	6 Things you need to know about LCR parallel Circuits (and that are different to the Series Circuit.) 1. **AT RESONANCE (f_r)** V_C is not necessarily exactly equal to V_L but **V_S and I_S are IN PHASE** 2. **AT RESONANCE (f_r)** Impedance (Z) is at maximum and is called the DYNAMIC RESISTANCE (R_D) 3. **AT RESONANCE (f_r)** Circuit current (I_S) is at minimum. 4. **AT RESONANCE (f_r)** The circuit is entirely resistive. 5. **BELOW RESONANCE (f_r)** The circuit is inductive. 6. **ABOVE RESONANCE (f_r)** The circuit is capacitive.	

Differentiation

Table 8.4.1 Differentiation.

When a high pass filter is used with a sine wave input, the output is also a sine wave. The output will be reduced in amplitude and phase shifted when the frequency is low, but it is still a sine wave. This is not the case for square or triangular wave inputs. For non-sinusoidal inputs the circuit is called a differentiator.

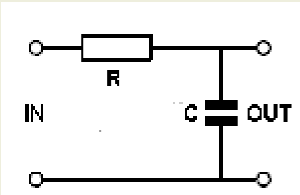


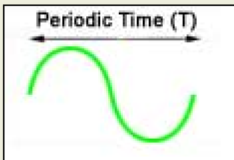
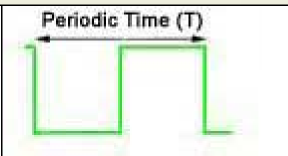
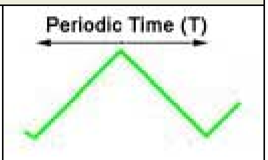
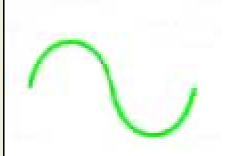
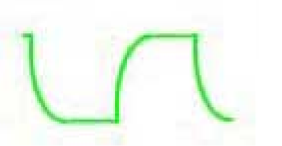
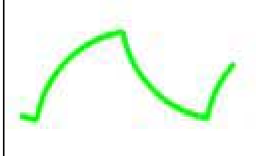
	Sine Wave	Square Wave	Triangular Wave
Input Wave			
Output at low frequency. (Periodic time T is much longer than time constant CR.)			
Output at high frequency. (Periodic time T is similar to or shorter than time constant CR).			

Integration

Table 8.5.1 Integration.

When a low pass filter is used with a sine wave input, the output is also a sine wave. The output will be reduced in amplitude and phase shifted when the frequency is high, but it is still a sine wave. This is not the case for square or triangular wave inputs. For non-sinusoidal inputs the circuit is called an integrator and its actions are in some (but not all) ways, opposite to that of a differentiator.



	Sine Wave	Square Wave	Triangular Wave
Input Wave			
Output at low frequency. (Periodic time T is much longer than time constant CR.)			
Output at high frequency. (Periodic time T is similar to or shorter than time constant CR).