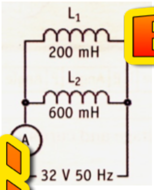
AC Equation Sheet

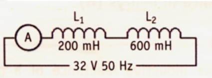
ELI the ICEman



$$X_L = 2\pi f L \text{ in ohms}$$

$I = \frac{V}{X_L}$ $V = IX_L$ $X_L = \frac{V}{I}$ **Ohm's law**

$I_T = I_1 = I_2 = I_3$ etc
$V_T = V_1 + V_2 + V_3$ etc **Series circuits**
$X_L = X_1 + X_2 + X_3$ etc



$I_T = I_1 + I_2 + I_3$ etc
$V_T = V_1 = V_2 = V_3$ etc **Parallel circuits**
$\frac{1}{X_{LT}} = \frac{1}{X_{L1}} + \frac{1}{X_{L2}} + \frac{1}{X_{L3}}$ etc

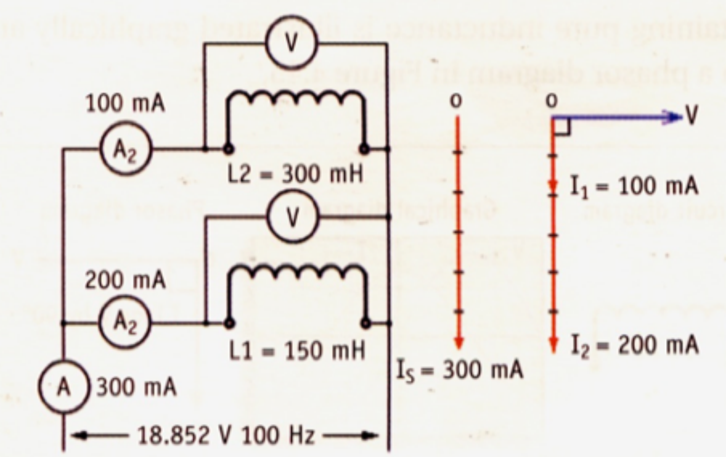
$P = VI$ $P = \frac{V^2}{X_L}$ $P = I^2X_L$ etc **Power**

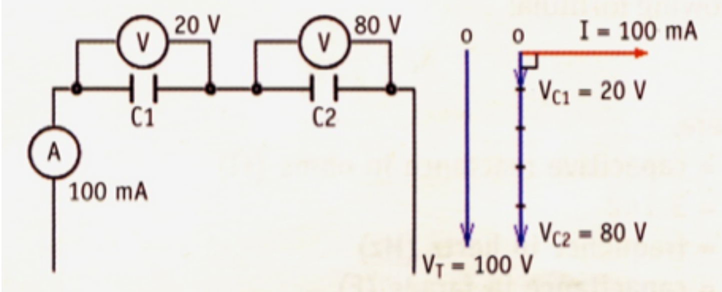
$$X_C = \frac{1}{2\pi f C}$$

$X_C = \frac{V}{I}$ $I = \frac{V}{X_C}$ $V = IX_C$ **Ohm's law**

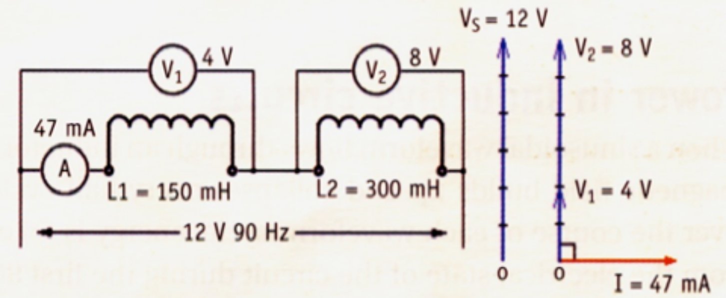
$X_{C_{Total}} = X_{C1} + X_{C2} + X_{C3}$ etc **Series**

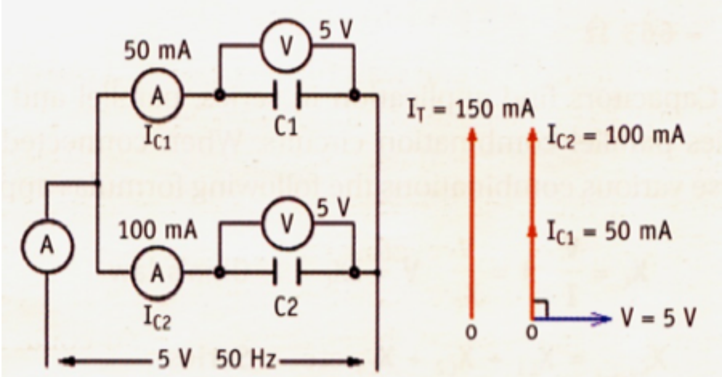
$\frac{1}{X_{CT}} = \frac{1}{X_{C1}} + \frac{1}{X_{C2}} + \frac{1}{X_{C3}}$ etc **Parallel**





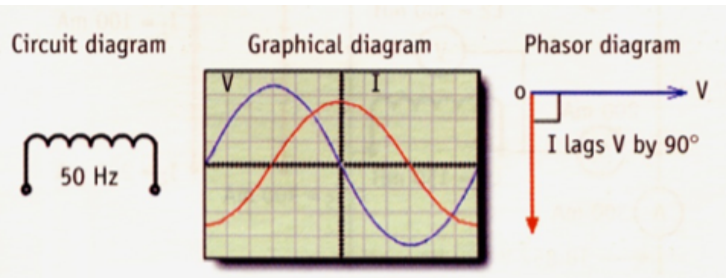
Current is the reference phasor in series… Voltage is the reference phasor in parallel.

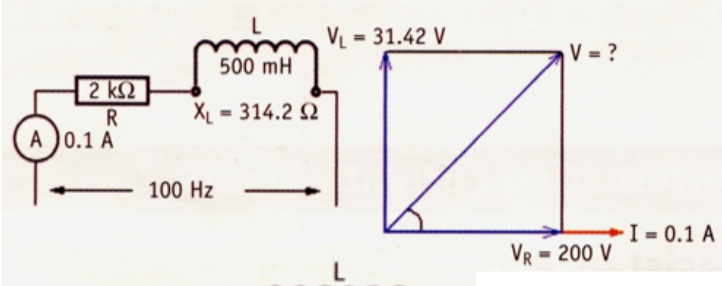




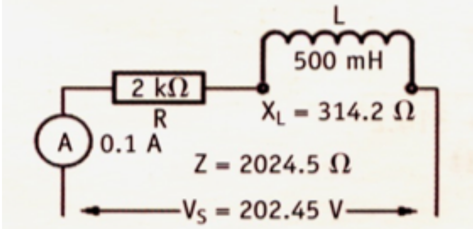
Neglecting any Mutual Inductance between the two coils!!!

$$V_R = IR \quad V_L = IX_L \quad V = \sqrt{V_R^2 + V_L^2}$$





$$Z = \sqrt{R^2 + X_L^2} \text{ in ohms}$$



AC Equation Sheet

ELI the ICEman

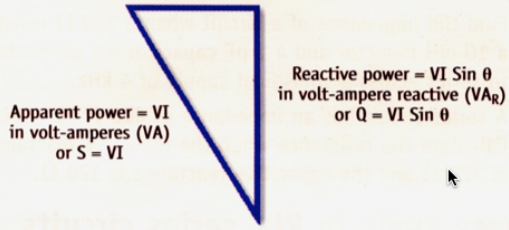
$$\text{Power factor (pf)} = \frac{\text{True power}}{\text{Apparent power}} = \cos\theta$$

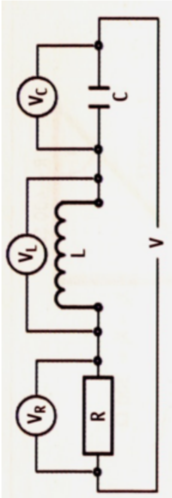
$$P = I^2R = VI\cos\theta$$

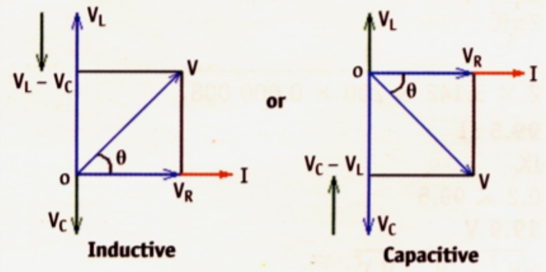
Note: In series circuits, pf may be found using

$$\frac{VR}{V} = \frac{R}{Z} = \cos\theta$$

- **True power** (P) is measured in watts (W) and is dissipated by the resistive component in a series RL circuit. It is equal to the product of the circuit current, the applied voltage and the power factor of the circuit.
- **Apparent power** (S) is measured in volt-amperes (VA) and is the product of circuit current and the applied voltage across the RL circuit.



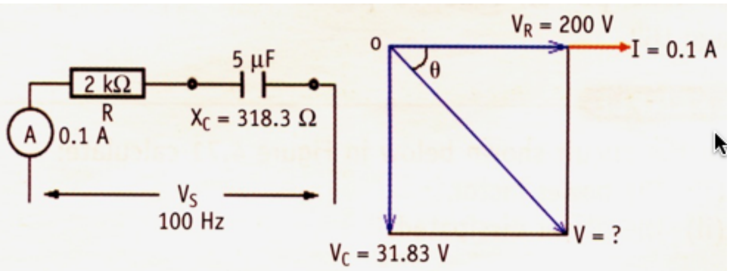




If the capacitive reactance is greater than the inductive reactance then the circuit is capacitive. The voltages in a series RLC circuit are expressed as follows:

$V_R = IR \quad V_L = IX_L \quad V_C = IX_C$

$V = \sqrt{V_R^2 + (V_L - V_C)^2}$ *or* $V = \sqrt{V_R^2 + (V_C - V_L)^2}$



$$V_R = IR \quad V_C = IX_C \quad V = \sqrt{V_R^2 + V_C^2}$$

Phase angle in RC series circuits

$\tan\theta = \frac{X_C}{R}$ in degrees leading

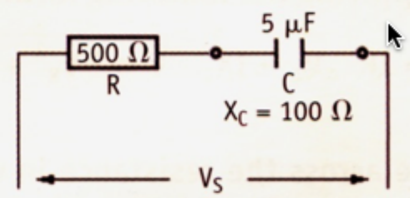
$$Z = \sqrt{R^2 + X_C^2}$$

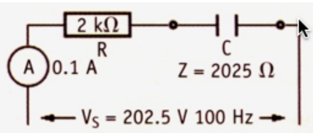
$\tan\theta = \frac{X_C}{R}$

$= \frac{100}{500}$

$= 0.2$

$= 11°$ leading





$\cos\theta = \frac{R}{Z}$

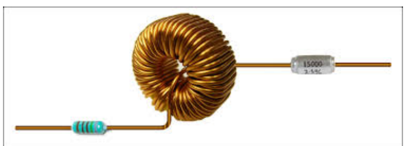
$= \frac{2000}{2025}$

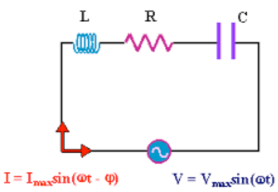
$= 0.9877°$ leading

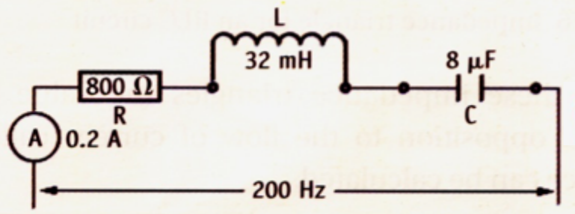
$P = VI\cos\theta$

$= 202.5 \times 0.1 \times 0.9877$

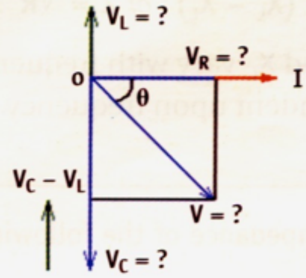
$= 20$ W







$V_R = IR$



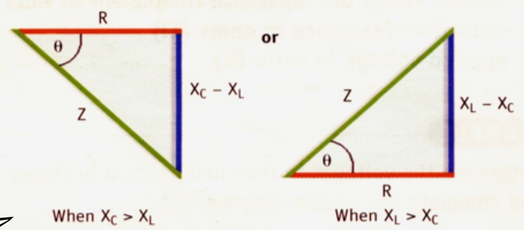
$X_L = 2\pi fL$

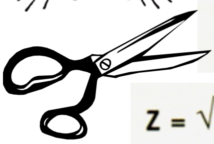
$V_L = IX_L$

$X_C = \frac{1}{2\pi fC}$

$V_C = IX_C$

$$V = \sqrt{V_R^2 + (V_C - V_L)^2}$$



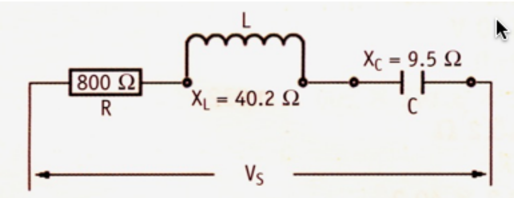


$$Z = \sqrt{R^2 + (X_L - X_C)^2} \text{ or } Z = \sqrt{R^2 + (X_C - X_L)^2}$$

But wait! there's more….

AC Equation Sheet

ELI the ICEman

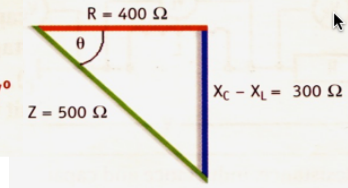


$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$
$$= \sqrt{800^2 + (40.2 - 9.5)^2}$$
$$= 800.58\ \Omega$$

$$\tan\theta = \frac{X_L - X_C}{R} \quad \text{or} \quad \tan\theta = \frac{X_C - X_L}{R}$$

$$\tan\theta = \frac{X_L - X_C}{R} = \frac{300}{400} = 0.75$$

$$\tan^{-1} 0.75 = 37°$$

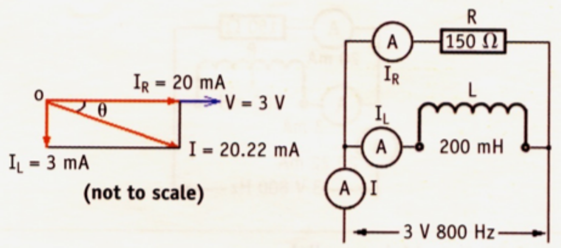


Resistance and inductance in parallel

Currents in RL circuits

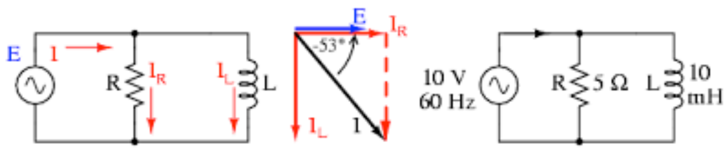
Currents in RL circuits are calculated by applying the following formulas:

$$I_R = \frac{V}{R} \quad I_L = \frac{V}{X_L} \quad I_T = \sqrt{I_R^2 + I_L^2}$$



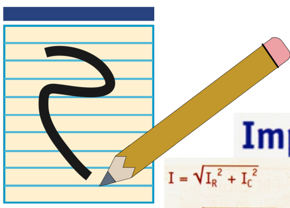
$$I_R = \frac{V}{R} = 20\text{ mA} \qquad X_L = 2\pi fL = 1005.4\ \Omega$$

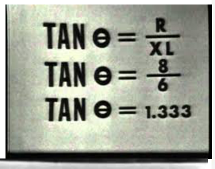
$$I_L = \frac{V}{X_L} = 3\text{ mA} \qquad I_T = \sqrt{I_R^2 + I_L^2} = 20.22\text{ mA}$$

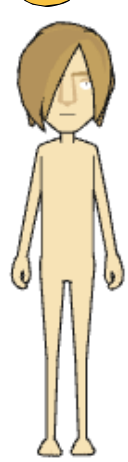


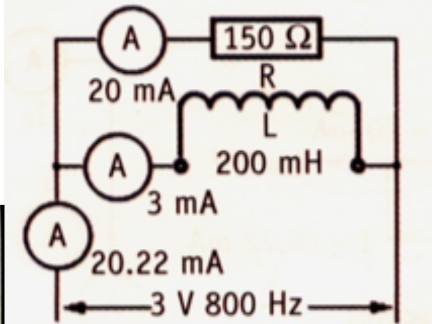
$I = I_R + I_L$

$E = E_R = E_L$









$$I = \sqrt{I_R^2 + I_L^2} = 20.22\text{ mA}$$

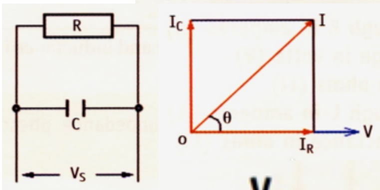
$$Z = \frac{V}{I} = 148.37\ \Omega$$

From Youtube, Airforce Training video. Oldie but a goodie.

Phase angle in parallel RL circuits

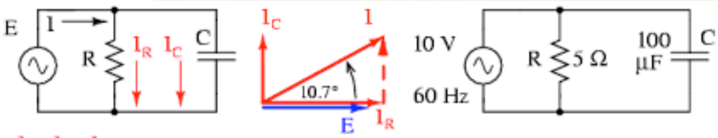
$$\tan\theta = \frac{I_L}{I_R}$$

Resistance and capacitance in parallel



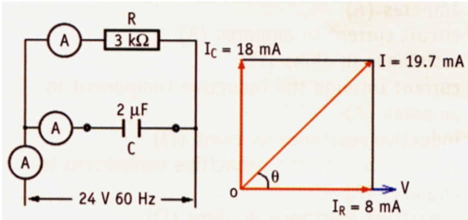
But wait! there's more….

$$I_R = \frac{V}{R} \quad I_C = \frac{V}{X_C} \quad I = \sqrt{I_R^2 + I_C^2}$$



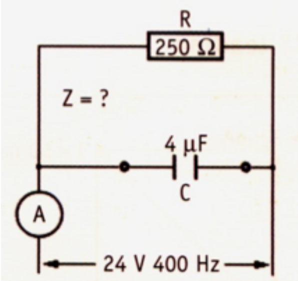
$I = I_R + I_L$

$E = E_R = E_C$



$$I_R = \frac{V}{R} \quad X_C = \frac{1}{2\pi fC} \quad I_C = \frac{V}{X_C}$$

$$I = \sqrt{I_R^2 + I_C^2}$$
$$= \sqrt{8^2 + 18^2}$$
$$= 19.7\text{ mA leading}$$



Impedance in parallel RC circuits

$$I = \sqrt{I_R^2 + I_C^2} = \sqrt{96^2 + 240^2} = 258.5\text{ mA leading}$$

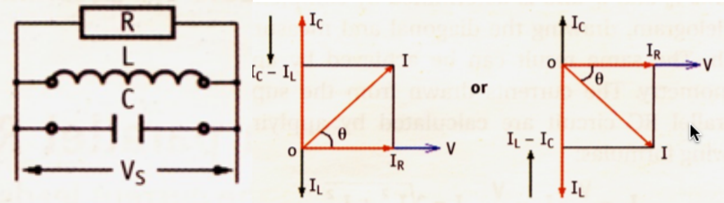
$$Z = \frac{V}{I} = \frac{24}{0.2585} = 92.84\ \Omega$$

$$Z = \frac{V}{I}\ \text{in ohms}$$

ELI the ICEman

AC Equation Sheet

Resistance, inductance and capacitance in parallel



$$I_R = \frac{V}{R} \quad I_L = \frac{V}{X_L} \quad I_C = \frac{V}{X_C}$$

$$I = \sqrt{I_R^2 + (I_L - I_C)^2} \quad or \quad I = \sqrt{I_R^2 + (I_C - I_L)^2}$$

A parallel RLC circuit with an applied voltage of 16 V 50 Hz has an inductive reactance of 1600 Ω and a capacitance of 10 μF. If the current through the resistor is 80 mA, calculate the currents drawn by the circuit and complete the phasor diagram (Figure 4.91).

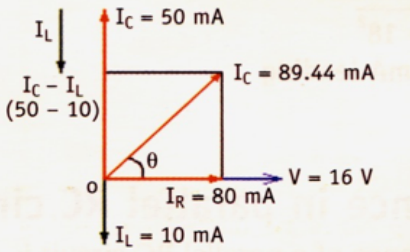
$I_R = 80$ mA

$$I_L = \frac{V}{X_L} = \frac{16}{1600} = 10 \text{ mA}$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2 \times 3.142 \times 50 \times 0.000\,01} = 318.3\ \Omega$$

$$I_C = \frac{V}{X_C} = \frac{16}{318.3} = 50 \text{ mA}$$

$$I = \sqrt{I_R^2 + (I_C - I_L)^2} = \sqrt{80^2 + (50 - 10)^2} = 89.44 \text{ mA}$$



Impedance—parallel circuits

The impedance triangle that was used to evaluate impedance in a series circuit cannot be used with a parallel circuit because the phasors that represent current are inversely proportional to resistance, reactance and impedance.

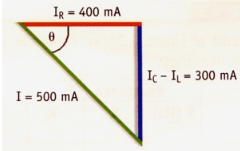
****See my notes and powerpoint about Susceptance, Admittance and Conduductance

$$|Y| = \sqrt{G^2 + B^2} \qquad Y \equiv \frac{1}{Z}$$

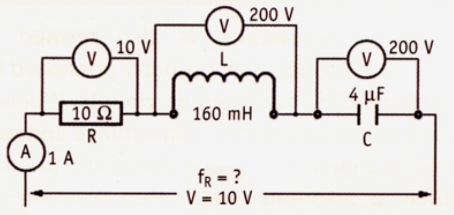
Phase angle in a parallel RLC circuit

$$\text{Tan } \theta = \frac{I_L - I_C}{I_R} \quad or \quad \text{Tan } \theta = \frac{I_C - I_L}{I_R} \quad or \quad \text{Cos } \theta = \frac{I_R}{I_T}$$

$$\text{Tan } \theta = \frac{I_C - I_L}{I_R} = \frac{300}{400} = 0.75 = 37°$$



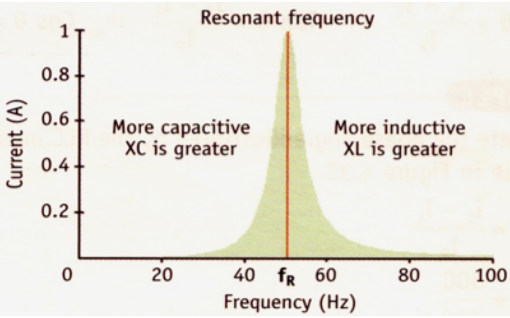
Resonance in series circuits



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

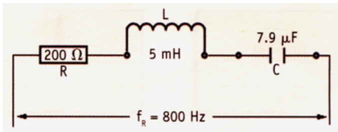
$$X_L = X_C$$

$$f_R = \frac{1}{2 \times 3.142 \times 0.0008} = 200 \text{ Hz approx}$$



Series Resonant circuit graph

$$Q = \frac{V_L}{V} \quad or \quad \frac{V_C}{V} \quad and \quad Q = \frac{X_L}{R}$$



$$X_L = 2\pi fL = 2 \times 3.142 \times 800 \times 0.005 = 25\ \Omega$$

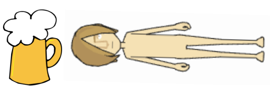
$$Q = \frac{X_L}{R} = \frac{25}{200} = 0.125$$

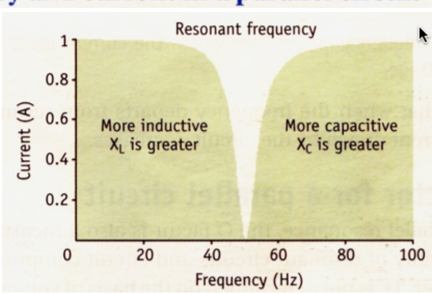
OMG!

$$I_L = I_C$$

Frequency and current in a parallel circuit

Parallel Resonant circuit graph

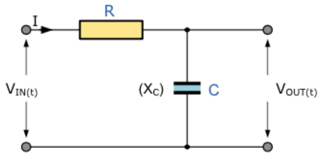


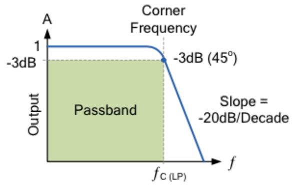


AC Equation Sheet

ELI the ICEman

Low Pass RC Filter





$$A = \frac{V_{OUT}}{V_{IN}} = \frac{X_C}{Z} = \frac{X_C}{\sqrt{R^2 + X_C^2}}$$

$$A = \frac{1}{\sqrt{1 + (\omega RC)^2}}$$

$$f_C = \frac{1}{2\pi RC} \quad \text{or} \quad \omega_C = \frac{1}{RC}$$

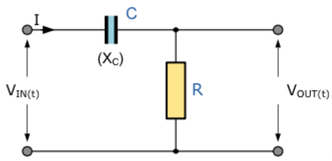
$$A_f = -3\text{dB} = \frac{1}{\sqrt{2}} = 0.7071 V_{IN}$$

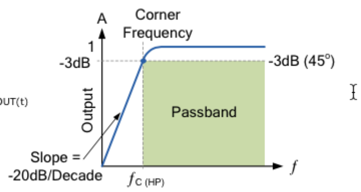
Roll-off = -20dB/Decade
or -6dB/Octave

Prototype equation sheet made with Swift Publisher on a Mac.
Version 1.01

TAFE NSW Western Sydney Institute
Mount Druitt College

High Pass RC Filter





$$A = \frac{V_{OUT}}{V_{IN}} = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + X_C^2}}$$

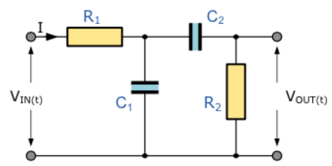
$$A = \frac{R}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$$

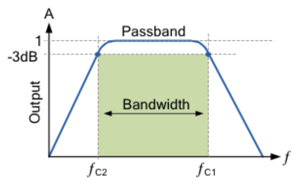
$$f_C = \frac{1}{2\pi RC} \quad \text{or} \quad \omega_C = \frac{1}{RC}$$

$$A_f = -3\text{dB} = \frac{1}{\sqrt{2}} = 0.7071 V_{IN}$$

Roll-off = -20dB/Decade
or -6dB/Octave

Band Pass RC Filter





R_1C_1 = Low Pass
R_2C_2 = High Pass

$$f_{C1} = \frac{1}{2\pi R_1 C_1}$$

$$f_{C2} = \frac{1}{2\pi R_2 C_2}$$

if $R_1 = R_2$ and $C_1 = C_2$

$$f_C = \frac{1}{2\pi RC} \quad \text{or} \quad \omega_C = \frac{1}{RC}$$

$$f_{PASSBAND} = \sqrt{f_{C1} - f_{C2}} = \text{Bandwidth}$$

$$f_{CENTER} = \sqrt{f_{C1} \times f_{C2}}$$

$$Q = \frac{f_{CENTER}}{f_{C1} - f_{C2}}$$