Understanding the Behavior of Complex Impedances

Understanding the Behavior of Complex Impedances at very low frequency (i.e., $f \approx 0$) and at very high frequency (i.e., $f >> 0$ or $f \approx \infty$).

For Inductive Reactance, $X_L = \omega L$
If $\omega = 0$, then $X_L = \omega L = 0$
If $\omega >> 0$, then $X_L = \omega L >> 0 \approx \infty$

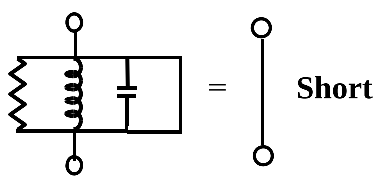
For Capacitive Reactance, $X_C = 1 / \omega C$
If $\omega = 0$, then $X_C = 1 / \omega C >> 0 \approx \infty$
If $\omega >> 0$, then $X_C = 1 / \omega C \approx 0$

R = R regardless of ω.

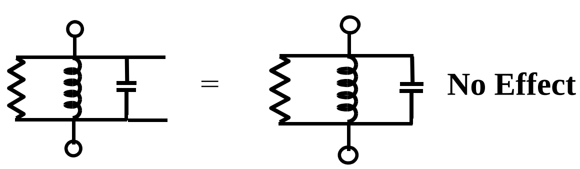
From Ohm's Law for Alternating Current, Impedance $Z = v(t) / i(t)$
$Z = R + j(X)$ where X is the reactant component due to circuit capacitors and inductors at a given frequency.

IF $Z = 0$, then **Short**, i.e., like a wire conductor, very high current ($I = V/Z$).
If $Z >> 0$ ($Z \approx \infty$), then **Open**, i.e., like a open switch, no current.

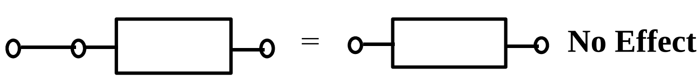
A **Short** in parallel with any other number of elements appears as a Short overall; i.e., just a wire conductor.



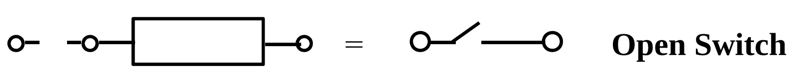
An **Open** in parallel with another element can be considered to be no existent, i.e., no effect.



A **Short** in series with another element can be considered to be just a wire conductor.



An **Open** in series with another number of elements appears as an Open Switch.

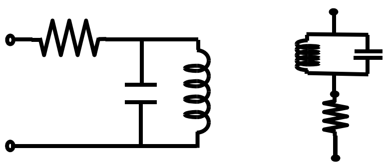


If $\omega = 0$, then $X_L = \omega L = 0$ and $X_C = 1 / \omega C \gg 0$.
If $\omega \gg 0$, then $X_L = \omega L \gg 0$ and $X_C = 1/ \omega C = 0$.
R = R regardless of ω.
IF Z = 0, then Short, i.e., like a wire conductor, very high current (I = V/R).
If $Z \gg 0$ ($Z \approx \infty$), then Open, i.e., like a open switch, no current.

For series: $Z + 0 = Z$ and $Z + \infty = \infty$ (Open)
For parallel, $Z \,\|\, 0 = \dfrac{Z(0)}{Z+0} = 0$ (Short) and $Z \,\|\, \infty = \dfrac{Z(\infty)}{Z+\infty} = \dfrac{Z(\infty)}{\infty} = Z$

From Complex Impedance Quiz & BME/ISE 3511Fall 2015 Test Four

A.

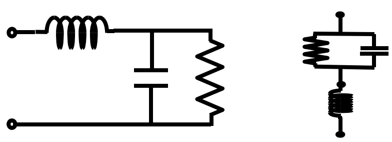


$$R + \frac{X_C X_L}{X_C + X_L}$$

if $\boldsymbol{\omega = 0}$, then $R + \dfrac{X_C X_L}{X_C + X_L} \approx R + 0 = R$ (Note: $X_L = 0$) **Overall Effect = Resistive**

if $\boldsymbol{\omega \gg 0}$, then $R + \dfrac{X_C X_L}{X_C + X_L} \approx R + 0 = R$ (Note: $X_C = 0$) **Overall Effect = Resistive**

B.

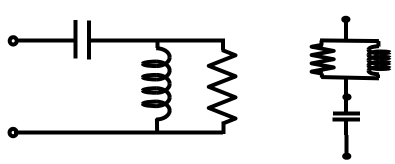


$$X_L + \frac{R X_C}{R + X_C}$$

if $\boldsymbol{\omega = 0}$, then $X_L + \dfrac{R X_C}{R + X_C} \approx 0 + \dfrac{R X_C}{R + X_C} \approx 0 + \dfrac{R X_C}{X_C} = 0 + R = R$ (Note: $X_L = 0$ and $X_C \gg 0$)
Overall Effect = Resistive

if $\omega \gg \mathbf{0}$, then $X_L + \dfrac{R X_C}{R + X_C} = \infty + 0 = \infty$ Open (Note: $X_L = \infty$ and $X_C = 0$)
Overall Effect = Open

C.



$$X_C + \frac{R X_L}{R + X_L}$$

if $\boldsymbol{\omega = 0}$, then $X_C + \dfrac{R X_L}{R + X_L} \approx \infty + \dfrac{R(0)}{R+0} \approx \infty + 0 = \infty$ Open (Note: $X_C \gg 0$ and $X_L = 0$)
Overall Effect = Open

if $\boldsymbol{\omega \gg 0}$, then $X_C + \dfrac{R X_L}{R + X_L} \approx 0 + \dfrac{R X_L}{R + X_L} \approx 0 + \dfrac{R X_L}{X_L} = 0 + R = R$ (Note: $X_C = 0$ and $X_L \gg 0$)
Overall Effect = Resistive