

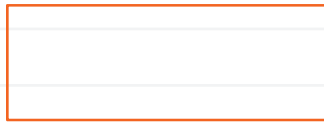
## Impedance

With complex representations for voltage and current, we can introduce the concept of **impedance**. Impedance  $Z$  is the complex ratio of voltage to current in a circuit element.

The real part is called the resistance and the imaginary part the **reactance**:

As with complex voltage and current, we can represent the impedance as a phasor.

We can use the impedance to define the **generalized Ohm's law**:



for each circuit element.

## Impedances of circuit elements

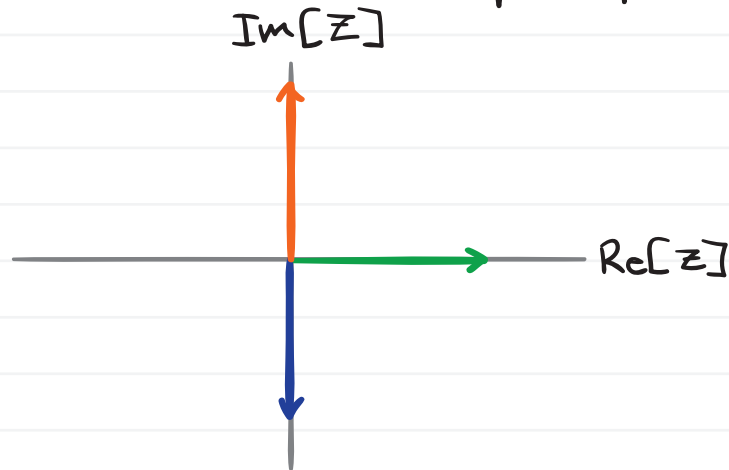
The impedances of the three most common circuit elements are listed below in complex forms. ( $\omega \equiv$  angular frequency)

Resistor:

Capacitor:

Inductor:

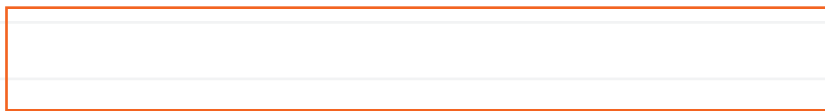
Here is an illustration in the complex plane.



## Combining impedances

As with resistors, impedances may be combined to find an effective impedance. We often want to know the effective impedance of a circuit or portion thereof.

Series impedances can be combined in the following manner:



Parallel impedances can be combined in the following manner:

