Basic Electronics Part 29
by
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Now let's return to the series circuit that contains a resistor, R, a capacitor, C, and an alternating current, Fig 1.

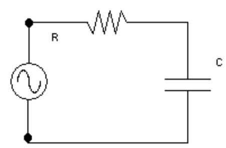

Fig. 1

The total opposition to current in a circuit is called the impedance. Impedance is denoted by Z. The relationship connecting the impedance to the current and the total voltage is

$$V_T = I\,Z\,.$$

Here the current is in amperes and the impedance is in ohms.

Referring back to Basic Electronics, Part 28, we measured the current in the circuit at 100 mA, the resistance was 500 ohms, and the capacitive reactance was 75 ohms. We calculated the total voltage as $V_T = 50.6$ volts. This means that

$$50.6 = (100 \times 10^{-3})\,(Z)\,.$$

Solving for Z we get

$$Z = \frac{50.6}{100 \times 10^{-3}}$$

or

$$Z = 506\,\Omega\,.$$

Notice that this is NOT the sum of the resistance and the capacitive reactance.

To understand why this is the case we must return to the vector diagrams of Part 28. Recall that the voltage across the resistor is in phase with the current through the resistor; however, the voltage across the capacitor lags the current through the capacitor by 90 degrees. We represent the current and voltage with a vector diagram (Fig. 2).

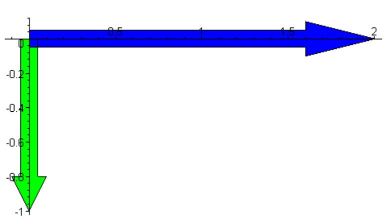

Fig. 2

Here the blue vector represents the voltage across the resistor and the green vector represents the voltage across the capacitor. If we alter the plot so we have a right triangle to allow us to use the Pythagorean relationship again, we have Fig. 3.

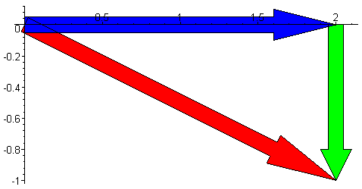

Fig. 3

Here the blue vector is still the voltage across the resistor, 50 volts, and the green vector is the voltage across the capacitor, 7.5 volts. The red vector is the resultant vector and it represents the sum of the two voltages using the phase difference. Since the voltage across the resistor is $I\ R$ and the voltage across the capacitor is $I\ X_C$ then the total voltage is

$$V_T = \sqrt{(I\ R)^2 + (I\ X_C)^2}$$

But $V_T = I\,Z$, therefore,

$$I\,Z = \sqrt{(I\ R)^2 + (I\ X_C)^2}$$
$$= I\sqrt{R^2 + X_C{}^2}\ .$$

Dividing out the common current, I, we get

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

Since $R = 500\,\Omega$ and $X_C = 75\,\Omega$, then

$$Z = \sqrt{500^2 + 75^2}$$
$$= \sqrt{255625}$$
$$= 506\,\Omega\,.$$

This is a result that is similar to the result we obtained in Part 27 when we were dealing with a series circuit involving an inductor.

In the next part we will consider what happens when we have a series circuit involving a resistor, a capacitor, and an inductor.