

Basic Electronics Part 28
by
Thomas Atchison W5TV

Now let's consider what happens in a series circuit that contains a resistor, R, a capacitor, C, and an alternating current, Fig 1.

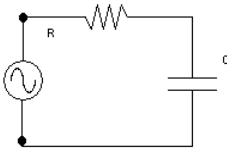


Fig. 1

Suppose we measure the current through this series circuit to be 100-mA. This current flows through each part of the circuit. If the resistance R is 500 ohms and the capacitor C has a capacitive reactance of 75 ohms, then we can calculate the voltage across each component using Ohm's law.

For the resistor we have $E_R = I R$ where $I = 100 \text{ mA} = 100 \times 10^{-3} \text{ amp}$ and $R = 500 \text{ ohms}$. So

$$\begin{aligned} E_R &= 100 \times 10^{-3} \times 500 \\ &= 50 \text{ volts.} \end{aligned}$$

For the capacitor we have $E_C = I X_C$ where $I = 100 \times 10^{-3} \text{ amp}$ and $X_C = 75 \text{ ohms}$. So

$$\begin{aligned} E_C &= 100 \times 10^{-3} \times 75 \\ &= 7.5 \text{ volts.} \end{aligned}$$

We cannot just add these voltages to get the total applied voltage because the voltages are not in phase. In this case we realize 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 as we did in Part 26, (see Fig. 2).

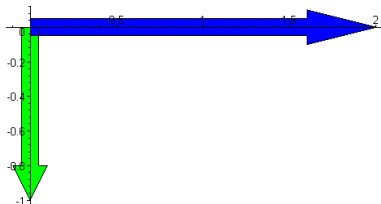


Fig. 2

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.

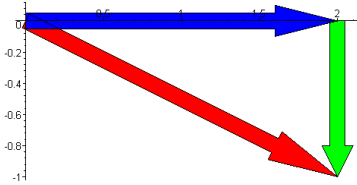


Fig. 3

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. In this case we have

$$\begin{aligned} \text{Total Voltage} &= \sqrt{(50)^2 + (7.5)^2} \\ &= \sqrt{2556.25} \\ &= 50.6 \text{ volts} . \end{aligned}$$

The angle between the blue vector and the red vector is called the phase angle between the circuit current and the total voltage. If we designate this angle as A , then we can use the tangent function from trigonometry to calculate this phase angle. Therefore,

$$\tan(A) = \frac{\text{length of opposite side}}{\text{length of adjacent side}}$$

In this diagram, the length of the opposite side is 7.5 and the length of the adjacent side is 50. This means we have

$$\tan(A) = \frac{7.5}{50} = 0.15$$

Using the inverse tangent function on a calculator we find that $A = 8.5 \text{ degrees}$. We say that the current leads the voltage by 8.5 degrees or that the voltage lags the current by 8.5 degrees.

We usually call angles positive if they are measured counter-clockwise from 0 degrees. We usually call angles negative if they are measured clockwise from 0 degrees. Since the angle A is measured clock-wise from the blue vector to the red vector, we designate the phase angle as -8.5 degrees .

In this case we would specify the total voltage as 50.6 volts at -8.5 degrees .