In this lesson you will move from the level of novice to the more sophisticated. AC Resistor Circuits is a review of series, parallel and series-parallel circuits.

Ohm's and Kirchhoff's Laws are still valid in the calculations for AC Resistor Circuits. The difference is the method of working with the AC voltages.

The use of Eff., RMS, Peak (p) and peak-to-peak (PP), as taught in previous lessons, will be used to calculate voltage, current, and resistance.

In previous conferences concerning resistors, you learned the resistor color code, how to determine total resistance, and how resistors function in DC circuits. Resistors are also used in AC circuits. During this lesson you will learn how resistors operate in AC circuits. You will also learn how to measure voltages in AC resistor circuits. After voltage measurements are thoroughly understood, troubleshooting AC resistor circuits will be presented.

Resistors as a general rule are not affected by a change in frequency. When capacitors and inductors are studied it will be shown that they are frequency sensitive, that is, they change value when frequency changes.

Phase relationships between current and voltage determine whether or not the component is affected by changes in frequency. As long as current and voltages are in phase the component is said to be or have the effect of resistance.

In FIGURE 3, it may be shown that current and voltage are in phase and how this is represented pictorially with sine waves and vectors.

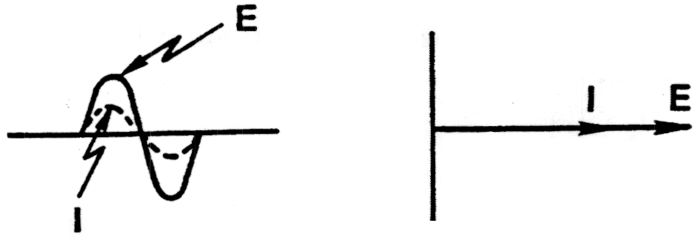

FIGURE 3

From the previous discussion and FIGURE 3, the following conclusions may be drawn;

1. In purely resistive circuits the current and voltage are in phase.

2. Changes in frequency do not affect resistance.

3. Changes in frequency do not affect voltage drops.

In previous lessons we have studied and noted the relationships of DC voltages. Now we must take note of the effect of DC and AC voltages in the same circuit, as shown in FIGURE 4.

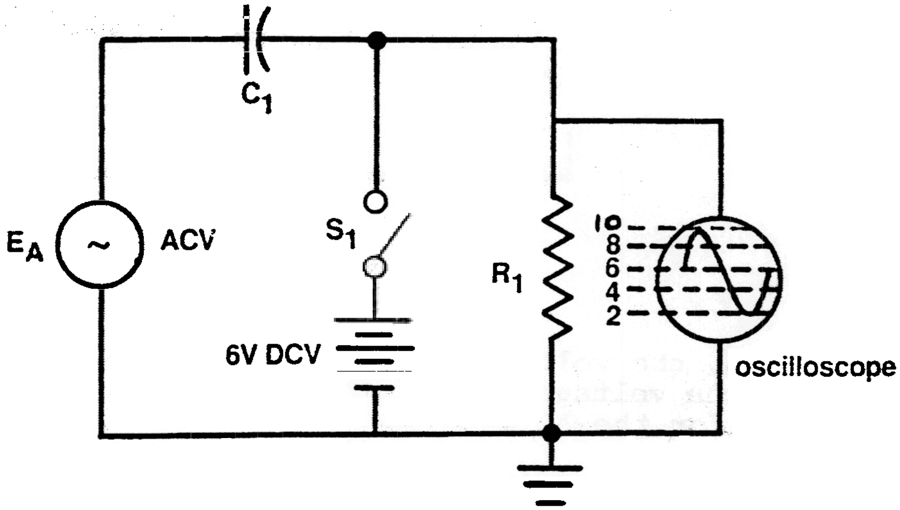

FIGURE 4

In FIGURE 4, we have what is commonly called a coupling circuit consisting of a source, C_1 and R_1. The function of this circuit will be studied in detail in a later lesson. The student must know at this time that the capacitor C_1 blocks DC but allows AC to be seen on the oscilloscope.

The capacitor C_1 prevents the 6VDC from the battery from damaging the signal generator.

Normally electronic circuits will have both DC and AC operating in them. DC supplies the power to amplify the AC.

The purpose of FIGURE 4, is to demonstrate what would be seen on the oscilloscope. With only AC applied, S_1 open, the sine wave (AC) would be at zero reference.

With S_1 closed the reference for the sine wave (AC) becomes whatever the DC of the battery is, in this case 6VDC.

Since the Peak to Peak (PP) value of the sine wave (AC) is 8V, or 4V peak (1/2 PP), the positive peak will be the reference 6VDC plus the peak (P) and would be 10V. The negative peak would be 6VDC minus the peak (P) and would be 2V. Thus the sine wave (AC) varies around (above and below) the DC as a reference.

Another example of this type of circuit combination using a voltage divider is shown in FIGURE 5.

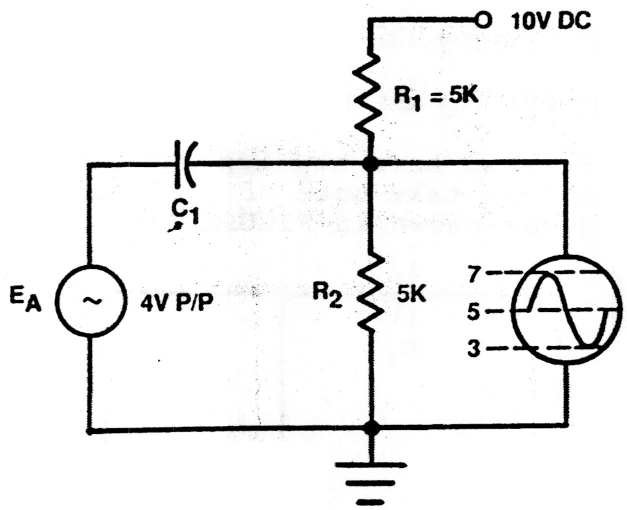

FIGURE 5

In FIGURE 5, the voltage divider consist of R_1 and R_2. Since R_1 and R_2 are equal, the voltage (by ratio) across each resistor will be 5VDC. The reference for the AC is 5VDC.

The AC signal is applied across R_2, thus all of the 4VAC will be shown on the oscilloscope. The AC is 4VPP or 2 VP. Therefore, the positive peak would occur at 5+2 = 7V, and the negative peak will occur at 5-2 = 3V.

To do calculations and make measurements with AC Resistor Circuits you must understand the difference between Peak to Peak (PP), Peak (P) and RMS (Eff.). These relationships will be shown in FIGURE 6.

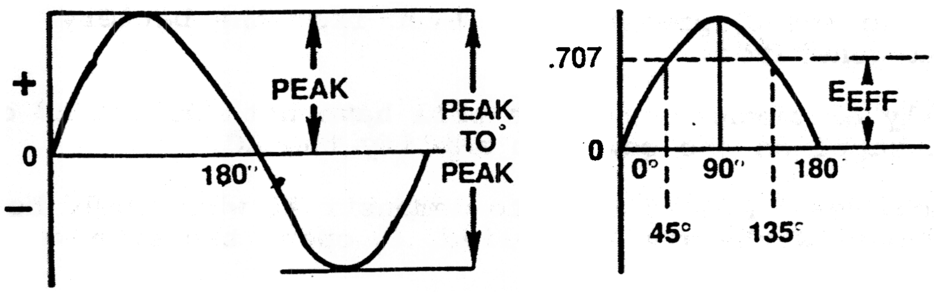

FIGURE 6

The effective value of a sine wave of current is rated in terms of direct current. An alternating current is considered to have an effective value of 1 ampere if, when flowing in a given resistance, it will produce heat at the same rate as 1 ampere of direct current. It has been determined experimentally that 141.4 volts AC (peak) is required to produce the same amount of heat that 100 volts DC produces. Therefore, the following relationships are established:

$$\frac{100 \text{ volts DC}}{141.4 \text{ volts AC}} = 0.707 \quad \text{or}$$

$$\text{volts DC} = 0.707 \times 141.4 \text{ volts AC (pk)}$$

and

$$= 0.707 \times E_{max} \text{ (or } E_{pk}$$

$$= 0.707 \times I_{max} \text{ (or } I_{pk})$$

The effective value is often called the root-mean-square (RMS) value. The term "root-mean-square" is derived from the fact that the square root of the average of the squares of several instantaneous values taken at equal time increments would yield a ratio practically the same as the ratio found experimentally.

It may also be noted as shown in FIGURE 6, that the RMS (Eff.) value of a sine wave (AC) is the same as and coincides with the instantaneous value of the voltage at 45° and 135°, or that the sine of 45° is .707.

When a value of current or voltage is used in AC circuitry, it is assumed that it is the RMS or effective value unless otherwise indicated. Therefore:

$$I_{eff} = I_{rms} = I \quad \text{or}$$

$$E = 0.707 \times E_{max} \quad \text{and}$$

$$I = 0.707 \times I_{max}$$

It must be noted here that the Digital Multimeter will always measure the RMS (Eff.) value of a sine wave (AC). The oscilloscope will only measure Peak (P) or peak to peak (PP).

Ohm's Law for AC resistor circuits can be demonstrated in the series resistor circuit shown in FIGURE 7.

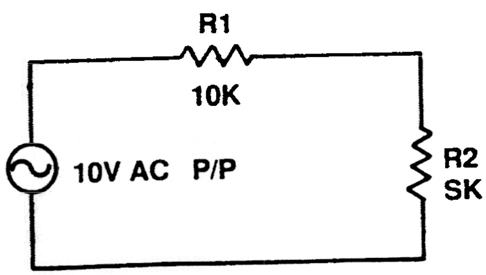

FIGURE 7

Using effective values.

$E_{eff} = 5 \times .707 = 3.5$ volts effective

Calculate total resistance.

R_T = 10K + 5K

15K Ω

Calculate effective current.

$I_{eff} = \frac{3.5}{15K}$

.233mA

Voltage across resistors.

.233mA x 10K

2.3 volts

= .233mA x 5K

= 1.11 volts

Peak-to-peak voltage across resistors.

$= \frac{E_{P/P}}{R_T} = \frac{10}{15K} = .67mA$

.67mA x 10K

6.7 volts

E_{R2} = .67mA x 5K

= 3.35 volts

FIGURE 8, shows a series parallel circuit. This circuit will be used as an example to demonstrate some typical malfunction that could occur. The simple way to troubleshoot this circuit is to determine the values of Req., R_T, I_T, E_{Req}, I_2, I_3, and I_4.

Some observations may be shown for FIGURE 8 as follows:

1. R_1 open - E_{R1} increases to approximately E_A, E_{R2}, E_{R3}, decreases to 0V. R_T increases to infinity (∞).

2. R_2 open - E_{R2} increases to approximately 3.2V. E_{R3}, E_{R4}, increases to 3.2V. E_{R1} decreases 1.8V. R_T increases to 13.9K. E_{R1} equals 1.8V. E_{R2} and E_{R3} each equal 3.2V.

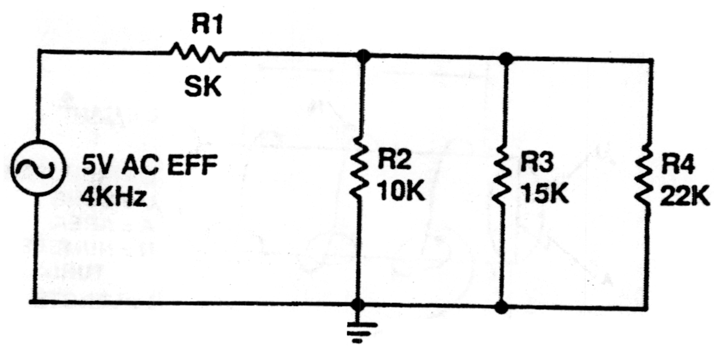

FIGURE 8

3. R3 open - Similar voltage indication as R2 open. R_T increases to 12K. R1 = 2V. R2 and R4 = 3V.

4. R4 open - Similar voltage indication as R2 or R3 open. R_T increases to 11K. R1 = 2.3V. R2 and R3 = 2.7V.

5. R1 shorted - E_{R1} decreases to 0V. E_{R2}, E_{R3}, E_{R4} increase to R_T decreases to 4.7K.

6. Parallel short - E_{R1} increases to E_A. E_{R2}, E_{R3}, E_{R4} decrease to 0V. R_T decreases to 5K.

SUMMARY:

At this time you have completed the theory of AC resistor circuits. You have practiced calculating voltage drops, both effective, peak and peak-to-peak. Now you will study AC circuits using the Electronic Training Unit, make voltage measurements, and locate malfunctions.