Capacitors

OBJECTIVES

- Discuss the construction of a Capacitor
- Describe the way Capacitors react differently in AC and DC circuits
- Define the calculations for connecting Capacitors in Series and Parallel

INTRODUCTION

Capacitors are used for two purposes by an installer; for the Capacitors ability to store energy and the Capacitors ability to filter AC signals. As an introduction to Capacitors neither of these abilities will be discussed in detail in this lesson, but will be covered in later lessons. In this lesson, Capacitors are used for their "ability to oppose a change in Voltage." This property is call CAPACITANCE.

Capacitors

Capacitors are electronic components that have the ability to store voltage. They are similar to a battery in that energy is stored, but the battery and the capacitor are quite different in all other respects. Unlike the battery, a capacitor stores energy that is quickly dissipated (released) and can not sustain long durations of consumption. Capacitors are designed to be used in conjunction with a primary power supply and not as a power supply themselves. In other words, capacitors are used as a helper for the power supply (battery, alternator).

Capacitors and power sources make a good combination because of the capacitor's ability to discharge energy much faster than a battery. While the battery can store a great deal of energy that can be used to operate electrical equipment for long periods of time, it is relatively slow to provide current when required. You may have experienced this first hand in your vehicle. If you have ever seen an audio system that causes the headlights to blink when playing at loud volumes you are witnessing the battery's inability to react quickly enough to sudden demands for power.

A capacitor is used to ensure that voltage levels stay constant and do not fluctuate. As soon as the capacitor detects a drop in voltage it releases its energy into the circuit.

How Do They Work?

Like most electronic components, capacitors react differently to both AC (Alternating Current) and DC (Direct Current).

Capacitors and DC

When a capacitor is introduced to a DC circuit it will charge to the voltage level of the power supply to which it is connected. For example, if installed into an automotive circuit, the capacitor would charge to 12.6 Volts. If the voltage falls below 12.6 V the capacitor releases its stored energy back into the circuit. This action stabilizes the overall voltage of the circuit.

This is accomplished by storing energy between two (2) conductive plates (+ and - plates). The two plates are separated by a Dielectric Material (an insulator). The dielectric allows current to flow and charge the capacitor until the circuit's voltage is matched and then the dielectric blocks further current flow.

This concept is illustrated in Figure 1. Note the two (2) conductive metal plates and the dielectric insulator between the two plates. One plate becomes the positive terminal of the capacitor and the other the negative.

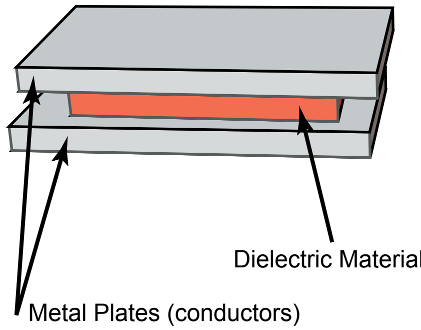


Figure 1

Capacitors typically take the form of a round cylinder. The conductive plates and dielectric insulator are wrapped around each other to form a cylinder. Note in Figure 2 the typical construction for a capacitor.

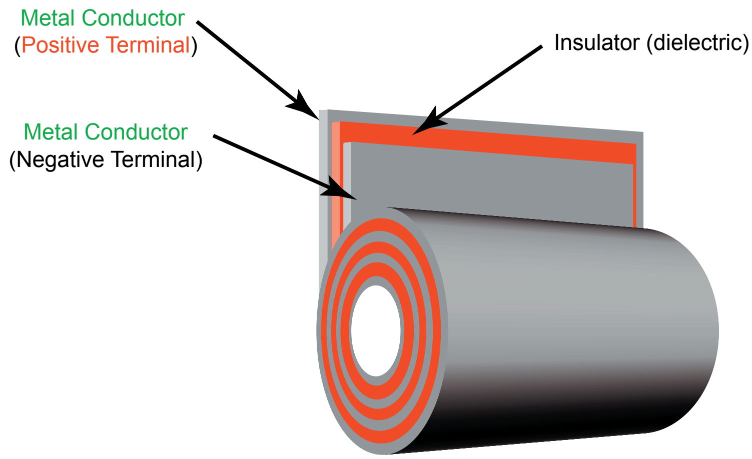


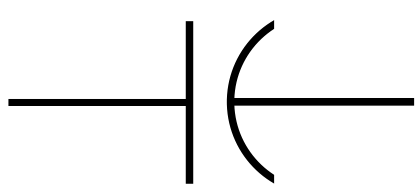
Figure 2

Capacitors and AC

The principles under which the capacitor works remain the same. However, the capacitor reacts differently to AC (Alternating Current) than it does to DC signals. While DC signals build up a charge inside the capacitor, AC signals do not.

As AC voltage is ever changing from positive (+) to negative (-) the capacitor can not develop a charge. However, as the frequency of AC decreases (lower frequencies) the capacitor starts to actually block AC voltage from passing through the capacitor.

Have you ever noticed that on a 2-way or 3-way speaker there is a little capacitor mounted behind the tweeter? If not, check it out the next time you see one of these speakers. The capacitor is there not to store energy but to block low frequency AC signals coming from the amplifier. Low frequency AC signals (bass for example) can actually damage tweeters. The capacitor is there to block this low frequency energy from hurting the tweeter (you just learned something about passive crossovers).



Electrical Symbol for a Capacitor

Unit of Measure

Capacitors are measured in Farads, Microfarads, and Picofarads. A Farad of capacitance is a very large value and typically capacitors are built in millionths or trillionths of a farad. A millionth of a farad being, 1μF, read as 1 Microfarad, and a trillionth of a Farad being, 1pF, read as 1 Picofarad.

$$\text{F}, \mu\text{F}, \text{pF}$$

Capacitor Types

As with resistors, capacitors come in two (2) primary types. Both FIXED and VARIABLE capacitors are used throughout the electronics industry. However, fixed capacitors are by far the most common for mobile electronics installation projects. Variable capacitors are primarily used for radio signal management and do not apply to the installers daily routine.

Fixed Capacitors

By far the most common to installer use, these capacitors (Caps) are used in several applications. The most common fixed capacitors are, NON- POLAR or NON-POLARIZED capacitors. This term simply means that of the two (2) terminals on the capacitor it doesn't matter which you use for positive (+) or negative (-). In other words they don't have a positive or negative and can be installed either way into a circuit. Of these capacitors the following types are most common:

1) Polypropylene
2) Mylar
3) Electrolytic

These capacitor types are usually named for the material from which the dielectric is constructed. In all cases the conductors are made of some form of metal (usually aluminium).

Fixed Capacitor Value Calculation

Similar to that of high wattage resistors, most capacitors are simply labeled for their value.

There are two (2) capacitor specifications that are important to consider. They are as follows:

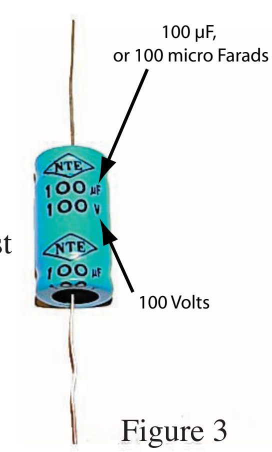


Figure 3

a) Capacitance - measured in Farads (F), Microfarads (μF), or Picofarads (pF). Most of the capacitors you will be using are either in the μF or F range of capacitance.

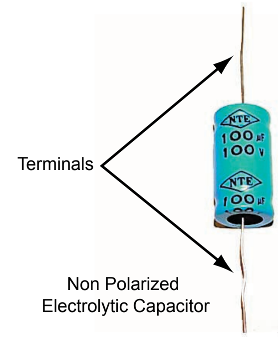
Note that in Figure 3, the capacitor has a value of 100 μF or 100 micro Farads.

b) Voltage - measured in Volts, this rating indicates how much working voltage the capacitor can handle. Note that if the voltage is exceeded, a risk of damage to the capacitor exists. In fact, if exceeded to a large degree the capacitor may actually explode.

Note that in Figure 3, the capacitor voltage rating is that of 100 Volts. Depending on the application, this value is an important consideration. This is especially true when installing capacitors in series for crossover use.

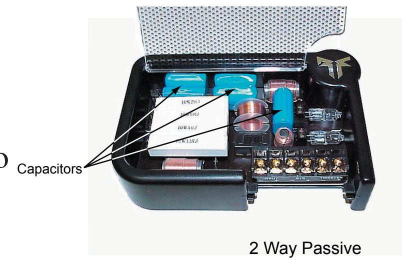
Fixed Capacitor Applications

Non Polarized Electrolytic Capacitors



These capacitors are typically used in charging system noise control. As discussed earlier, capacitors have the ability to block certain AC (Alternating current) signals. This ability is used to filter out unwanted noise generated by the vehicles alternator. A mathematical equation is used to calculate the exact capacitor value in order to block a specific frequency range. The capacitor is connected to the head unit power wire.

Non Polarized Mylar and Polypropylene Capacitors



2 Way Passive Crossover

Know for their high level of sound quality, these capacitors are ideal for crossover applications. They are used to filter low frequency AC signals from both tweeters and midrange speakers. Again, a mathematical equation is used to determine the exact value of capacitor to do the job.

Polarized Electrolytic Capacitors

As discussed earlier, one of the main application for capacitors in an electronic circuit is that of stabilizing voltage. The most common use for this capacitor application for installers is that of voltage stabilization to power amplifiers.

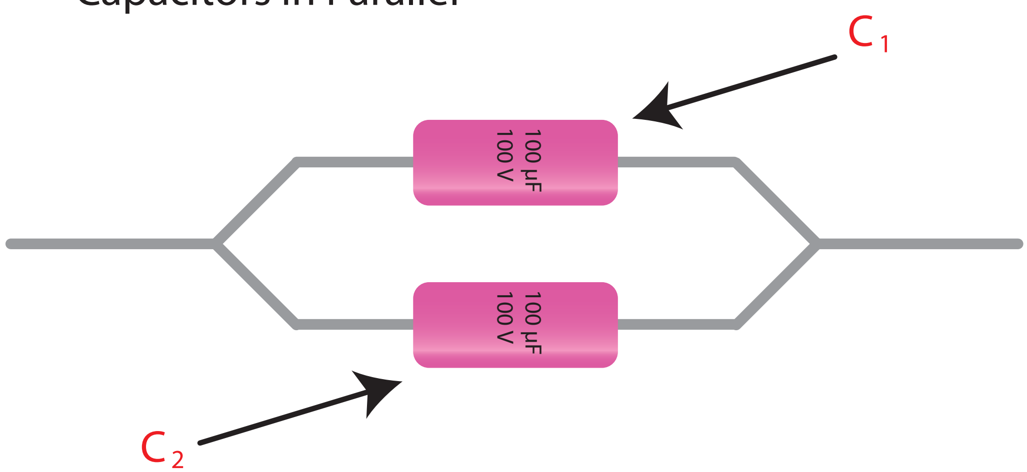
These capacitors are typically much larger than those used for crossovers or noise suppression. Often these capacitors are rated one Farad or more of capacitance. A relatively huge amount of capacitance when compared to other caps used in our industry. These capacitors are connected in parallel with the amplifier's power supply and ensure ample energy for the large transient demands of high powered systems.

Series and Parallel Capacitor Connection

When capacitors are connected to a circuit in series or parallel, the capacitance of the circuit reacts differently. This fact is useful when trying to attain a certain amount of capacitance. It is possible to combine capacitor values to derive the desired amount of capacitance.

Note in the illustrations below how the same two (2) caps react differently when connected in parallel and in series. Following each illustration note the formula used to determine total capacitance (C_t).

Capacitors in Parallel



Total Capacitance (C_t) = 200 µF

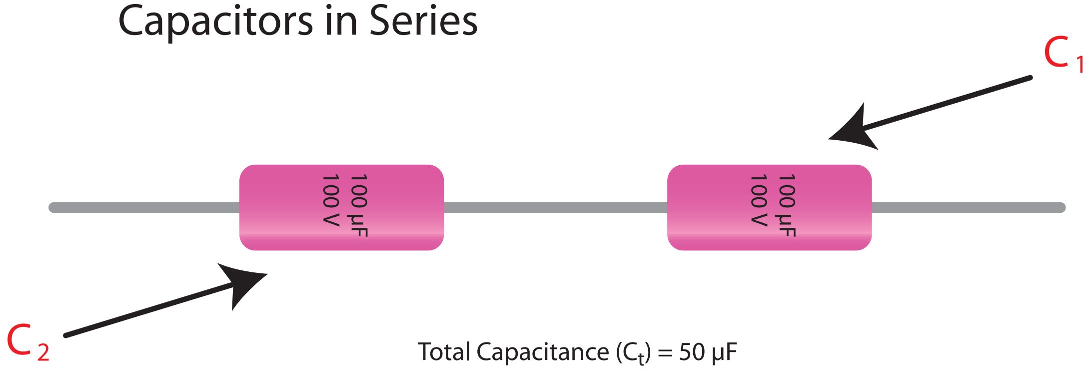
Calculation

$$C_t = C_1 + C_2$$

Or

$$C_t = 100 + 100$$

Capacitors in Series



Total Capacitance (C_t) = 50 µF

Calculation

$$C_t = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$$

Or

$$C_t = \frac{1}{.01 + .01}$$