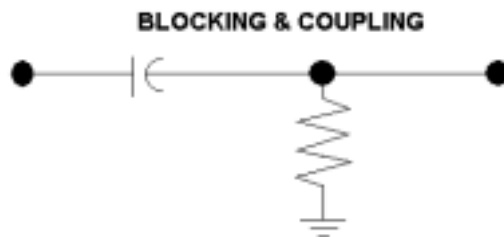


APPLICATIONS

BLOCKING: A capacitor is used to block or prevent DC voltages from circuit elements. To block the DC voltage, the capacitor is placed in series with the circuit element.

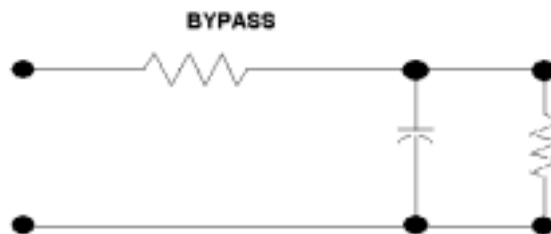
The major characteristics for the capacitor are insulation resistance, ESR, and voltage rating.



BYPASS (DECOUPLING): A bypass capacitor is used to keep the AC portion of an input signal from reaching a circuit element. The capacitor is placed in parallel with the circuit element to produce a low impedance path around the circuit element.

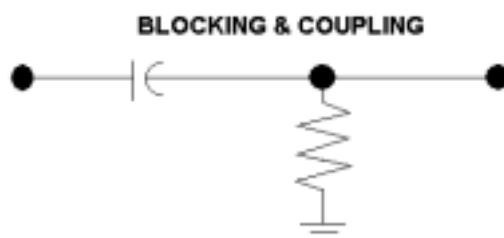
The impedance of the capacitor should be 10% of the input impedance of the circuit element.

The main characteristics for the capacitor are insulation resistance and ESR.



COUPLING: A coupling capacitor is used to couple or link together only the AC signal from one circuit element to another. The capacitor is connected in series between the circuit elements just like in a capacitor's blocking application.

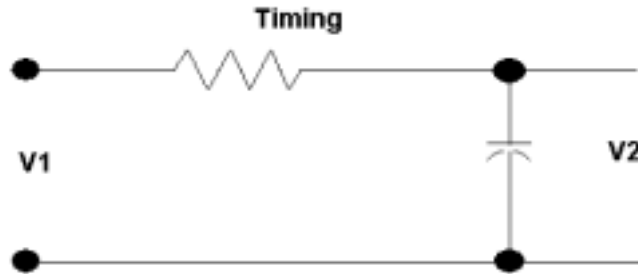
The major characteristics are insulation resistance, ESR, and voltage rating.



TIMING: A capacitor is used to store a charge until a specific amount of time has elapsed.

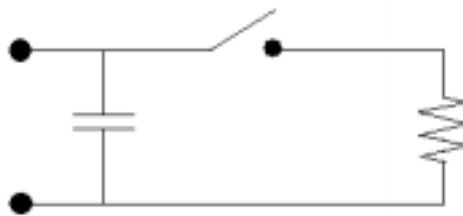
The capacitor is connected from bus to ground.

The major capacitor characteristics are insulation resistance/leakage current, capacitance stability, ESR and dielectric absorption.



SAMPLE AND HOLD: The capacitor is used to store a charge until a sample is taken. Its operation is similar to a timing application.

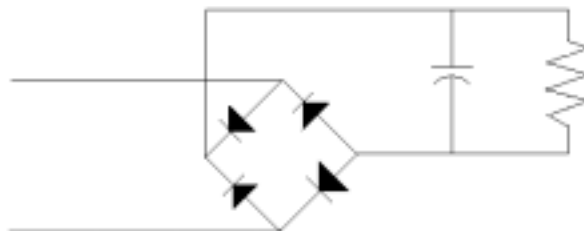
Sample and Hold



FILTERING: A filter capacitor is used to smooth the DC pulses after rectification. The capacitors store charge and deliver it to the load when the rectified or pulsating DC voltage decreases below the peak of the DC voltage signal.

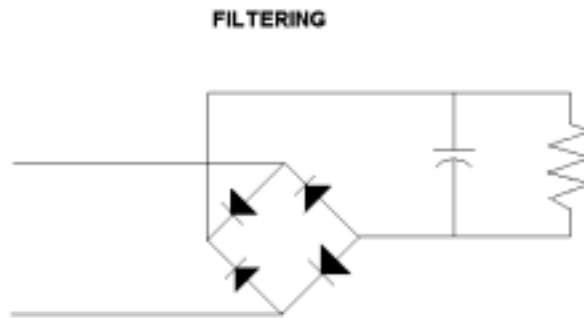
The major capacitor characteristics are capacitance, ESR, and ripple current rating.

FILTERING

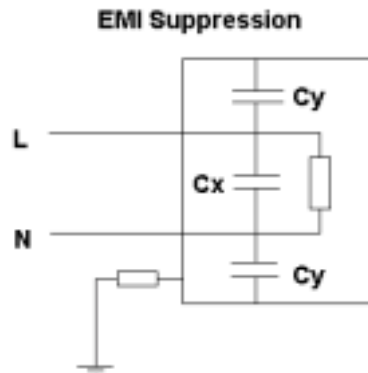


ENERGY STORAGE: Capacitors in energy storage applications are used to deliver a high energy, short duration pulse of energy.

Major capacitor characteristics: ESR, pulse rating and voltage rating.

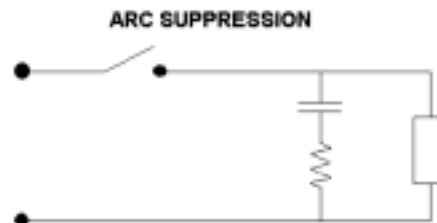
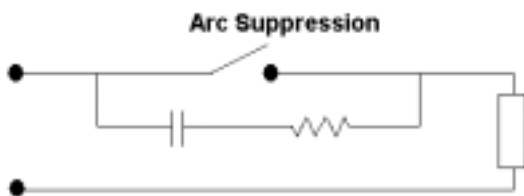


EMI SUPPRESSION: Capacitors in EMI Suppression are used to suppress noise pulses that could damage the circuit elements. EMI filters are commonly capacitors or capacitor resistor networks mounted across the input of a device. Depending on how they are mounted and the voltage rating, the capacitors can be classified as X1, X2, Y1, and Y2.



ARC SUPPRESSION (SNUBBER): A capacitor resistor network is used to suppress arcs across relays or switches which will eventually damage the relays or switches contacts.

The values of the capacitor and resistor can be approximated using the following formulas:



$$C = \frac{I^2}{10} \quad R = \frac{V}{10(1+\frac{50}{V})}$$

I = Load current at contact open
V = Source voltage

Peak current of snubber:

$$I_{pk} = \frac{V_o}{R_s} \text{ or } \frac{dv}{dt} = \frac{V_o}{R_s C}$$

$$C = \frac{1}{V^2 F_s} \text{ and } R_s = \sqrt{dL/C}$$

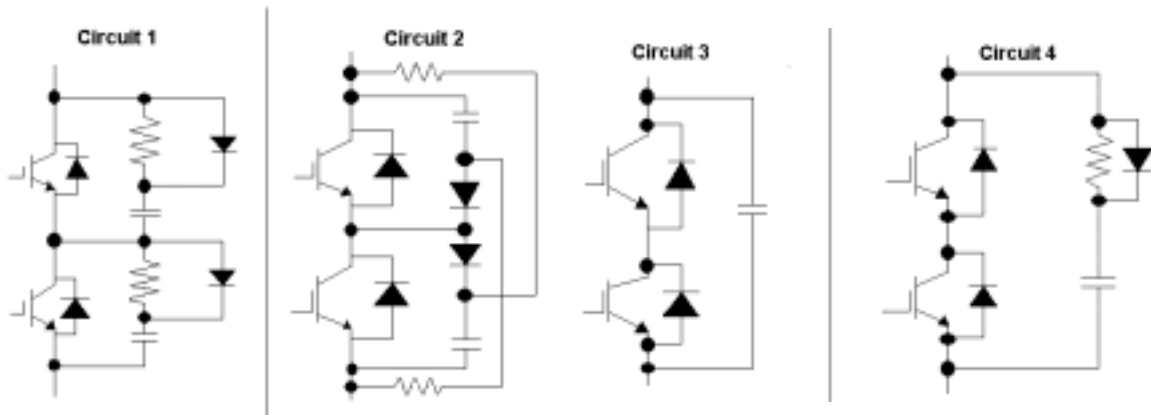
V_o = Open circuit voltage
R_s = Snubber circuit resistance
C = Snubber circuit capacitance
F_s = Switching frequency
L = Circuit inductance

IGBT SNUBBERS: Capacitors are used to reduce the turn-off surge voltage. These snubbers consequently add to the system power loss and circuit inductance. Capacitors used in IGBT snubbers should have as low self inductance as possible and heavy lead to be able to conduct the large currents associated with the IGBT circuits.

Turn off surge voltages are determined by: $V_{sm} = L di/dt$

Below are the four basic snubber circuits.

- Circuit 1 is for inverters with a carrier frequency between 1 and 2 kHz.
Power = $1/2C (V_{sm} + V_{cc})^2$
- Circuit 2 is for high frequency switching and reduces the losses in the circuit.
Power = $1/2C (V_{sm})^2$
- Circuit 3 is used in low power inverters and in high power applications when used in conjunction with snubber Circuits 1 or 2.
- Circuit 4 is used as an alternative circuit. Its advantage is used to prevent resonance that can occur when using Circuit 3.



POWER FACTOR: It is the ratio of the active power to the apparent power. Capacitors are used to bring the phase angle of the circuit back to unity. Failure to do so will result in the power companies charging a penalty.

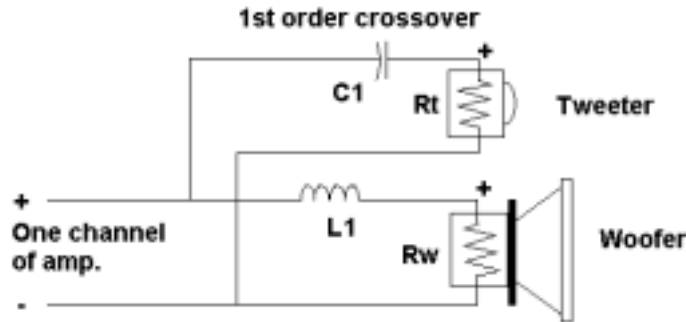
$$\text{P.F.} = \frac{\text{Active Power}}{\text{Apparent Power}} = \frac{W}{VA}$$

SPEAKER CROSSOVER: Separates input signal to direct signals to the appropriate speaker.

1st Order Crossover – 2-Way Speakers

$$C = \frac{1}{6.28318 F_c R_t} = \frac{.1599155}{F_c R_t}$$

F_c = Crossover Frequency (Hz)
 R_t = Tweeter rated impedance (Ω)



2nd Order Crossover – 2-Way Speakers

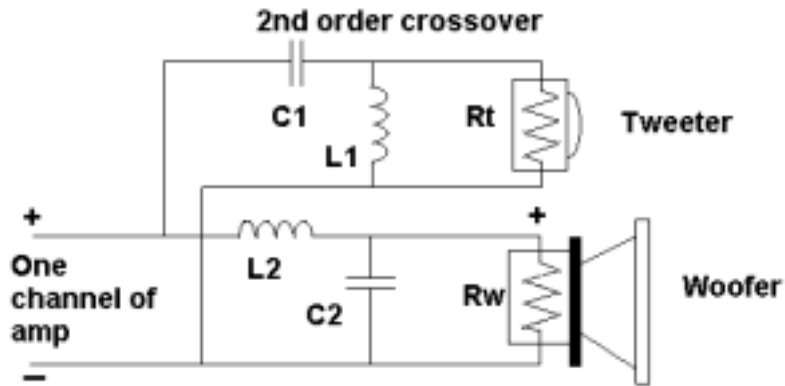
Tweeter Section

$$C_1 = \frac{1}{4 \cdot F_c R_t}$$

Woofer Section

$$C_2 = \frac{1}{4 \cdot F_c R_w}$$

C_1, C_2 = Tweeter Section
 = Capacitance (\bullet F)
 C_3 = Woofer Section
 = Capacitance (\bullet F)



3rd Order Crossover

Tweeter Section

$$C_1 = \frac{106,103}{F_c R_t}$$

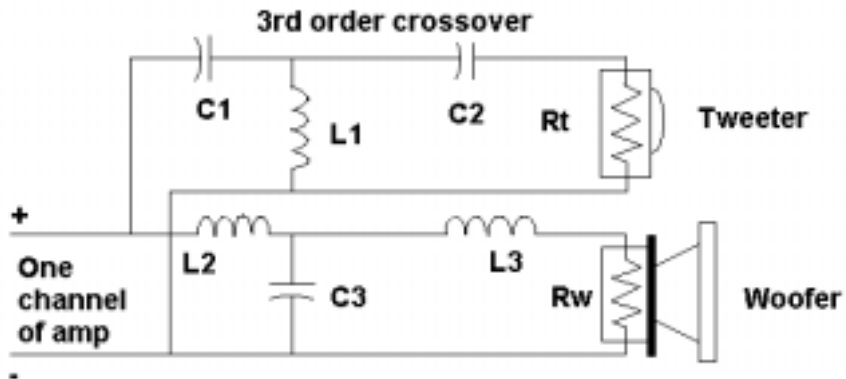
$$C_2 = \frac{318,391}{F_c R_t}$$

Woofer Section

$$C_3 = \frac{272,207}{F_c R_w}$$

$C_1, C_2 =$ Tweeter Section
= Capacitance (\bullet F)

$C_3 =$ Woofer Section
= Capacitance (\bullet F)



1st Order Crossover – 3-Way

Tweeter Section
(High Pass)

$$C_1 = \frac{159,155}{F_{HC} R_t}$$

Mid-range
(Band Pass)

$$C_2 = \frac{159,155}{F_{LC} R_m}$$

C_1 = Tweeter Section Capacitance (μF)
 C_2 = Mid-range Section Capacitance (μF)
 F_{HC} = High Frequency Crossover
 F_{LC} = Low Frequency Crossover

1st order 3 way speaker crossover

