EMI/RFI FILTERS

GENERAL DESCRIPTION

EMI/RFI low pass filters are used in computers, data terminals, test equipment and process controllers to suppress high frequency noise coming into or exiting electronic equipment.

LOW-PASS FILTER NETWORKS FOR EMI/RFI SUPPRESSION

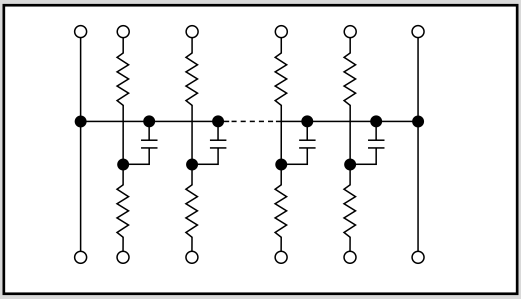

FIGURE 1. RC filter network

BI Technologies supplies a variety of customized RC networks in through hole DIP, SIP and surface mount packages. Included in this section is a discussion of filter theory and FCC regulations.

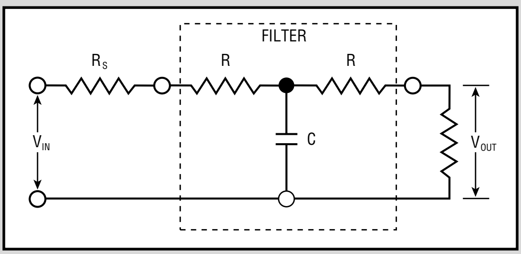

FIGURE 2. Filter configuration

Under steady state conditions, capacitor C blocks the DC component of the input waveform. The DC component of the signal voltage is passed to the load reduced in value by the voltage drop across the two series resistors, R.

Noise is attenuated by a voltage divider consisting of the first resistor R and C. Ideally, for high frequencies, little or no noise reaches the load. Input noise, therefore, will minimally affect the desired signal voltages at the load.

Symmetrical filter design means operation is the same for waveforms traveling in the opposite direction. Such a symmetrical design is useful for filtering signals on a bidirectional bus.

FILTER DESIGN CONSIDERATIONS

R_S = Source Resistance
R_L = Load Resistance
R = Resistance of filter
C = Capacitance of filter

The filter cutoff frequency, f_C, is defined as the frequency where the filter passes one-half the power it receives at its input terminal. Typical frequencies range from a few megahertz up to about 100MHz. The cutoff frequency is determined by the R and C values chosen. Custom resistor and capacitor values are available to optimize system performance.

The specification of R and C values depends upon noise frequencies, system performance requirements and driver loading. The following is suggested as a starting point for approximate values of R and C. Exact values are usually determined by breadboarding.

First choose the desired cutoff frequency, f_C, of the filter. f_C should be selected to pass the signal frequency and reject the dominant frequencies of the EMI/RFI noise.

The transfer function for the filter shown in figure 2 is given in equation 1.

$$\frac{V_{OUT}}{V_{IN}} = \frac{R_L}{j\omega C(R + R_S)(R + R_L) + (R_S + R_L + 2R)}$$

EQUATION 1.

The pole of the filter is determined by setting the denominator of the transfer function equal to zero. The cutoff frequency is given in equation 2.

$$f_c = \frac{R_S + R_L + 2R}{2\pi C(R + R_S)(R + R_L)}$$

EQUATION 2.

Ensure that the additional RC time constant will not cause the signal to violate any input restrictions of the receiving IC.
The rise time from 10% to 90% amplitude can be calculated with equations 3 and 4.

$$t_{10-90} = 2.2\ R_{th}C$$

$$t_{10-90} = 2.2\ \frac{(R + R_S)(R + R_L)}{R_S + R_L + 2R}\ C$$

EQUATIONS 3 AND 4

Where R_{th} is the Thevenin equivalent resistance seen by the capacitor.
Minimize the insertion loss by choosing small R values relative to the load impedance. Typical values for R range from 10 to 50 ohms.

EMI/RFI LIMITS

The maximum radiation of electromagnetic interference and radio frequency interference (EMI/RFI) to the environment is limited by regulations in most developed countries. According to FCC regulations (Parts 15 and 18), emissions must not exceed certain maximum levels. The levels depend on whether the equipment is for industrial use or for residential use. A graphical representation of these limits is shown in Figure 3.

Similar restrictions apply to equipment sold in Europe (VDE 0871, a German standard), Japan (VCCI) and to the military (MIL-STD-461/462).

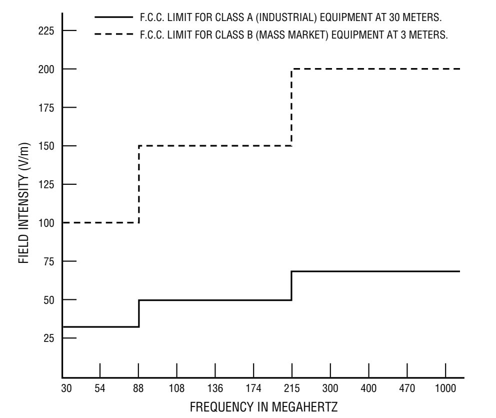

FIGURE 3. FCC radiation limits for class A and class B computing devices

EMI/RFI control methods include grounded metal enclosures, shielded cables, component placement, interconnect designs, power-supply decoupling and low-pass filtering of signal and power lines.

Low-pass filtering can be effective for EMI/RFI filtering when the noise components to be rejected occur at frequencies higher than the signal frequency.

A typical application would be to filter signal lines between RS-232 drivers and their corresponding connectors. In such low to medium frequency applications, these networks represent a more useful (and economical) solution than inductive type filters such as ferrite beads. In fact, ferrite beads become mostly ineffective below 10MHz.

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