

# Common Mode Filter Design Guide

## Introduction

The selection of component values for common mode filters need not be a difficult and confusing process. The use of standard filter alignments can be utilized to achieve a relatively simple and straightforward design process, though such alignments may readily be modified to utilize pre-defined component values.

## General

Line filters prevent excessive noise from being conducted between electronic equipment and the AC line; generally, the emphasis is on protecting the AC line. Figure 1 shows the use of a common mode filter between the AC line (via impedance matching circuitry) and a (noisy) power converter. The direction of common mode noise (noise on both lines occurring simultaneously referred to earth ground) is from the load and into the filter, where the noise common to both lines becomes sufficiently attenuated. The resulting common mode output of the filter onto the AC line (via impedance matching circuitry) is then negligible.

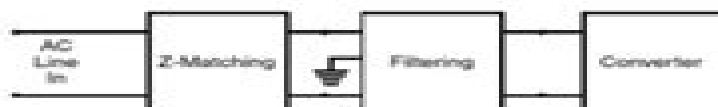


Figure 1. Generalized line filtering

The design of a common mode filter is essentially the design of two identical differential filters, one for each of the two polarity lines with the inductors of each side coupled by a single core:



Figure 2. The common mode inductor

For a differential input current ( (A) to (B) through L1 and (B) to (A) through L2), the net magnetic flux which is coupled between the two inductors is zero.

Any inductance encountered by the differential signal is then the result of imperfect coupling of the two chokes; they perform as independent components with their leakage inductances responding to the differential signal; the leakage inductances attenuate the differential signal.

When the inductors, L1 and L2, encounter an identical signal of the same polarity referred to ground (common mode signal), they each contribute a net, non-zero flux in the shared core; the inductors thus perform as independent components with their mutual inductance responding to the common signal; the mutual inductance then attenuates this common signal.

## The First Order Filter

The simplest and least expensive filter to design is a first order filter; this type of filter uses a single reactive component to store certain bands of a spectral energy without passing this energy to the load. In the case of a low pass common mode filter, a common mode choke is the reactive element employed.

The value of inductance required of the choke is simply the load in Ohms divided by the radian frequency at and above which the signal is to be attenuated. For example, attenuation at and above 4000 Hz into a 50Ω load would require a 1.99 mH ( $50/(2\pi \times 4000)$ ) inductor. The resulting common mode filter configuration would be as follows:

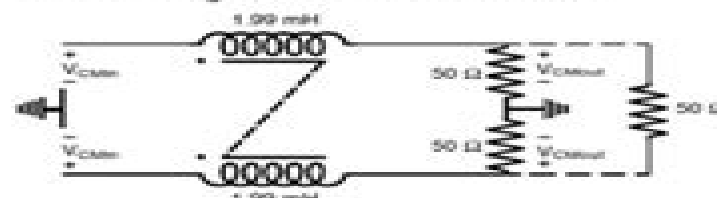


Figure 3. A first order (single pole) common mode filter

The attenuation at 4000 Hz would be 3 dB, increasing at 6 dB per octave. Because of the predominant inductor dependence of a first order filter, the variations of actual choke inductance must be considered. For example, a  $\pm 20\%$  variation of rated inductance means that the nominal 3 dB frequency of 4000 Hz could actually be anywhere in the range from 3332 Hz to 4999 Hz. It is typical for the inductance value of a common mode choke

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**Yi-Tong Ma**

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