$$P(s) \approx \left(1 + a_1 s\right)\left(1 + \frac{a_2}{a_1} s\right) \cdots \left(1 + \frac{a_k}{a_{k-1}} s + \frac{a_{k+1}}{a_{k-1}} s^2\right) \cdots \left(1 + \frac{a_n}{a_{n-1}} s\right) \tag{8.91}$$

The conditions for accuracy of this approximation are

$$\left|a_1\right| \gg \left|\frac{a_2}{a_1}\right| \gg \cdots \gg \left|\frac{a_k}{a_{k-1}}\right| \gg \left|\frac{a_{k-2}\,a_{k+1}}{a_{k-1}^2}\right| \gg \left|\frac{a_{k+2}}{a_{k+1}}\right| \gg \cdots \gg \left|\frac{a_n}{a_{n-1}}\right| \tag{8.92}$$

Complex conjugate roots can be approximated in this manner.

When the first inequality of Eq. (8.88) is violated, that is,

$$\left|a_1\right| \not\gg \left|\frac{a_2}{a_1}\right| \gg \left|\frac{a_3}{a_2}\right| \gg \cdots \gg \left|\frac{a_n}{a_{n-1}}\right| \tag{8.93}$$

then the first two roots should be left in quadratic form:

$$P(s) \approx \left(1 + a_1 s + a_2 s^2\right)\left(1 + \frac{a_3}{a_2} s\right) \cdots \left(1 + \frac{a_n}{a_{n-1}} s\right) \tag{8.94}$$

This approximation is justified provided that

$$\left|\frac{a_2^2}{a_3}\right| \gg \left|a_1\right| \gg \left|\frac{a_3}{a_2}\right| \gg \left|\frac{a_4}{a_3}\right| \gg \cdots \gg \left|\frac{a_n}{a_{n-1}}\right| \tag{8.95}$$

If none of the above approximations is justified, then there are three or more roots that are close in magnitude. One must then resort to cubic or higher-order forms.

As an example, consider the damped EMI filter illustrated in Fig. 8.28. Filters such as this are typically placed at the power input of a converter, to attenuate the switching harmonics present in the converter input current. By circuit analysis, on can show that this filter exhibits the following transfer function:

$$G(s) = \frac{i_g(s)}{i_c(s)} = \frac{1 + s\,\dfrac{L_1 + L_2}{R}}{1 + s\,\dfrac{L_1 + L_2}{R} + s^2 L_1 C + s^3\,\dfrac{L_1 L_2 C}{R}} \tag{8.96}$$

This transfer function contains a third-order denominator, with the following coefficients:

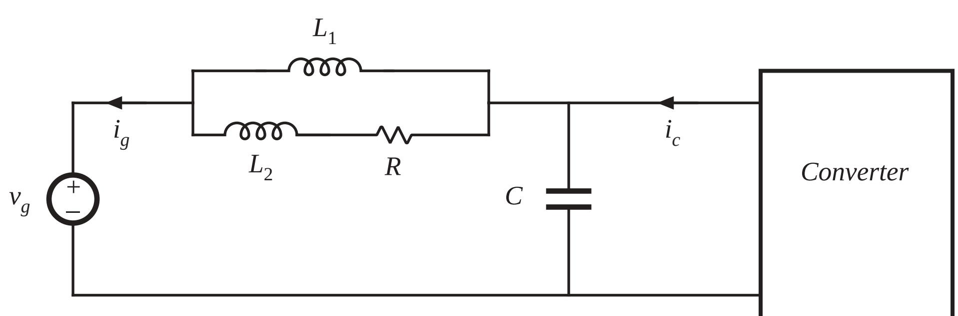

Fig. 8.28 Input EMI filter example.