

Classical approximating functions are widely used in specifying the performance requirements of a filter. The most common classical approximating functions are the Butterworth, the Chebyshev, the Elliptic, and the Thompson/Bessel functions. This experiment will focus on the classical approximating functions.

### Part 1

- Give the 6<sup>th</sup>-order Butterworth and Chebyshev approximations for a unity gain lowpass function with a 3dB band edge of 1 rad/sec in rational fraction form.
- Plot the magnitude and phase responses of these two approximations and compare their performance.
- Give the 6<sup>th</sup>-order Butterworth and Chebyshev approximations with the same specifications as in part a) but with a 3dB band edge of 5KHz

### Part 2

The Chebyshev approximation is based upon the Chebyshev polynomials with a magnitude squared approximation of

$$H_{CC}(\omega, n, \varepsilon) = \frac{1}{1 + \varepsilon^2 C_n^2(\omega)}$$

where  $C_n(\omega)$  is the n-th order Chebyshev polynomial. Though  $C_n(\omega)$  is an odd function for n odd, by squaring this function, an even function in  $\omega$  is obtained for  $H_{CC}(\omega, n, \varepsilon)$ .

But  $C_n(\omega)$  is even for n even. Consider the following magnitude-squared approximating function

$$\hat{H}_{CC}(\omega, n, \varepsilon) = \frac{1}{1 + \varepsilon^2 C_{2n}^2(\omega)}$$

Is  $\hat{H}_{CC}(\omega, n, \varepsilon)$  a useful magnitude-squared approximating function and, if so, compare the performance of  $\hat{H}_{CC}(\omega, 3, 1)$  and  $H_{CC}(\omega, 3, 1)$ .

### Part 3

Obtain the minimum order Butterworth approximation that meets the performance requirements shown. Plot the magnitude response to show that it meets the specified performance requirements.

