**EXPERIMENT- 9**

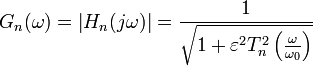
**AIM:** To design the low pass filter using Chebyshev type-1 approximation.

**THEORY:**

**Chebyshev filters** are analog or digital filters having a steeper roll-off and more pass band ripple (type I) or stop band ripple (type II) than Butterworth filters. Chebyshev filters have the property that they minimize the error between the idealized and the actual filter characteristic over the range of the filter, but with ripples in the passband. This type of filter is named in honor of Pafnuty Chebyshev because its mathematical characteristics are derived from Chebyshev polynomials.

**TYPE 1 Chebyshev filter**

These are the most common Chebyshev filters. The gain (or amplitude) response as a function of angular frequency \omega of the *n*th-order low-pass filter is



where \varepsilon is the ripple factor, \omega_0 is the cutoff frequency and T_n() is a Chebyshev polynomial of the nth order.

The passband exhibits equiripple behavior, with the ripple determined by the ripple factor \varepsilon. In the passband, the Chebyshev polynomial alternates between 0 and 1 so the filter gain will alternate between maxima at *G* = 1 and minima at G=1/\sqrt{1+\varepsilon^2}. At the cutoff frequency \omega_0 the gain again has the value 1/\sqrt{1+\varepsilon^2} but continues to drop into the stop band as the frequency increases. This behavior is shown in the diagram on the right. The common practice of defining the cutoff frequency at −3 [dB](http://en.wikipedia.org/wiki/Decibel) is usually not applied to Chebyshev filters; instead the cutoff is taken as the point at which the gain falls to the value of the ripple for the final time.

The order of a Chebyshev filter is equal to the number of reactive components (for example, inductors) needed to realize the filter using analog electronics.

The ripple is often given in [dB](http://en.wikipedia.org/wiki/Decibel):

Ripple in dB = 20 \log_{10}\sqrt{1+\varepsilon^2}

so that a ripple amplitude of 3 dB results from \varepsilon = 1.

An even steeper [roll-off](http://en.wikipedia.org/wiki/Roll-off) can be obtained if we allow for ripple in the stop band, by allowing zeroes on the j\omega-axis in the complex plane. This will however result in less suppression in the stop band. The result is called an elliptic filter, also known as Cauer filter.

**MATLAB CODE:**

rp=input('Enter the passband attenuation');

rs=input('Enter the stopband attenuation');

wp=input('Enter the passband frequency');

ws=input('Enter the stopband frequency');

fs=input('Entering sampling frequency');

w1=2\*wp/fs;

w2=2\*ws/fs;

[n,wn]=cheb1ord(w1,w2,rp,rs,'s');

[b,a]=cheby1(n,rp,wn,'s');

w=0:0.01:pi

h=freqs(b,a,w);

mag=abs(h);

mag1=20\*log10(mag);

phase=angle(h);

subplot(2,1,1)

plot(mag1);

title('Magnitude response');

subplot(2,1,2);

plot(phase);

title('Phase response');

Output:

Enter the passband attenuation0.23

Enter the stopband attenuation47

Enter the passband frequency1300

Enter the stopband frequency1550

Entering sampling frequency7800

**OUTPUT:**

