QMFDesign

This program designs a prototype filter for use in a Quadrature Mirror Filter filterbank. This two-channel filterbank has four filters, each based on a lowpass prototype $H(z)$. The analysis filters are $H_L(z)$ and $H_H(z)$ and the synthesis filters are $G_L(z)$ and G_H(z),

$$H_L(z) = H(z); \quad H_H(z) = H(-z);$$
$$G_L(z) = G_L(z); \quad G_H(z) = -2H(-z).$$

This filter bank has an alias cancelling property, but does introduce a ripple into the end-to-end frequency response. The design procedure minimizes a weighted combination of the ripple energy and the stopband energy of the lowpass prototype filter. The design procedure is motivated by a paper by Jain and Crochiere.

> V. K. Jain and R. E. Crochiere, "Quadrature Mirror Filter Design in the Time Domain", *IEEE Trans. Acoustics, Speech, Signal Processing*, vol. 32, no. 2, pp. 253–361, April 1984.

This routine returns the coefficients of the N-coefficient symmetric prototype filter $H(z)$. The coefficients are normalized to have energy 1/2. When the analysis and synthesis filters are configured as shown above, the overall system has an impulse response with a unity coefficient at a delay of $N - 1$ samples.

The procedure described in the paper above was modified to employ a cautious update during the iteration process – without this modification, the procedure did not converge.

Example

A sample use of `QMFDesign` is shown below.

```
N = 32;
h0 = QMFDesign(N, 0.3, 1);  % H(z)
h1 = (-1).^(0:N-1)' .* h0;  % H(-z)
h00 = conv (h0, 2*h0);
h11 = conv (h1, -2*h1);

[f, Hp] = PlotFilter (h00, 'linear-radian');
close;
PlotFilter (h11, 'linear-radian');
hold on;
plot(f, Hp);
hold off;

xlabel ('Frequency');
ylabel ('Amplitude')

text (0.1, 1.84, '|{\itH}_0(\omega)|^2');
text (0.8, 1.84, '|{\itH}_1(\omega)|^2');
```

This procedure uses `PlotFilter` (available as a separate package) to plot the frequency responses. The result is shown below.