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Half Band filter:- (HBF)

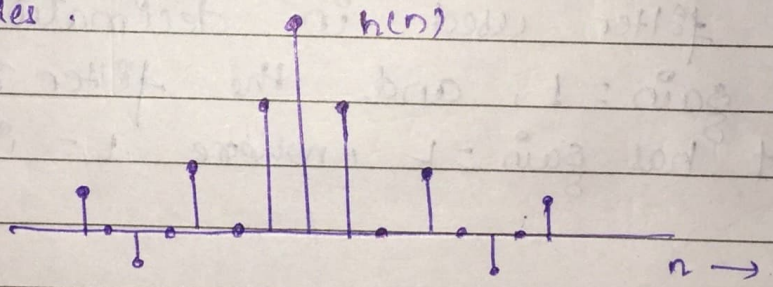
These are lowpass FIR filters with cutoff frequency of one-quarter of sampling frequency f_s.

Some properties of HBF are:-

1. Even symmetry in time domain
2. Passband & stopband bandwidths are equal, making these filters useful for decimation-by-2 and interpolation-by-2.
3. Half of the coefficients in time domain impulse response are zero.

$$h(2n) = \begin{cases} C, & n = 0 \\ 0, & n \neq 0 \end{cases}$$

Except for 0th sample, even samples of h(n) is zero on both sides.



To reduce the computation complexity in convolution, we use half-band filter in place of convolution to make calculation more effecient.

We perform following steps to achieve computational effeciency :-

1. Remove first and last $\left(\frac{L_h - 1}{2}\right)$ samples and calculate only for middle L_x samples.
2. Since, h[n] has zero values at every odd positions, we can ignore this computation.
3. Since h[n] is symmetry about middle position, we can use only half of the values to save computation.

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4. We can ignore computing values which are to be removed while downsampling.

We can compute similarly for the interpolation part.

Half Band filters are a special case of M-band filters; which is given by,

$$h[Mn] = \begin{cases} c, & n=0 \\ 0, & n\neq 0 \end{cases}$$

where $c = 1/2$ for Half Band filters.

$c = 1/M$ for M-Band filters.

The filter used in decimation part has a gain = 1, and the filter in interpolation part has gain = L, where L = interpolation factor.