Example 6.17 Using frequency sampling method, design a bandpass filter with the following specifications.

$$\text{sampling frequency F} = 8000\text{Hz}$$
$$\text{cut off frequencies } f_{c1} = 1000\text{Hz}$$
$$f_{c2} = 3000\text{Hz}$$

Determine the filter coefficients for $N = 7$.

Solution

$$\omega_{c_1} = 2\pi f_{c_1} T = \frac{2\pi f_{c_1}}{F} = \frac{2\pi(1000)}{8000}$$
$$= \frac{\pi}{4}$$

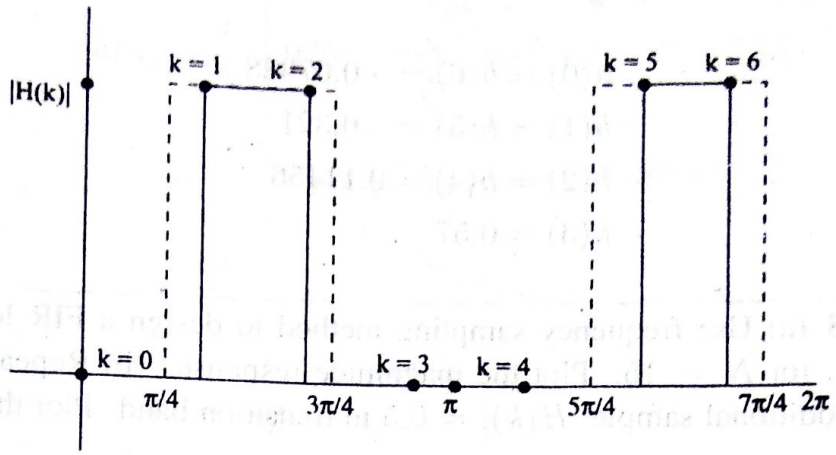

Fig. 6.61 Ideal magnitude response with samples for example 6.17

$$\omega_{c_2} = 2\pi f_{c_2} T = \frac{2\pi f_{c_2}}{F} = \frac{2\pi(3000)}{8000}$$
$$= \frac{3\pi}{4}$$

$$H(k) = H_d(e^{j\omega})\Big|_{\omega=\frac{2\pi}{7}k} \quad k = 0, 1, \ldots, 6$$

$$|H(k)| = 0 \qquad \text{for } k = 0, 3$$
$$= 1 \qquad \text{for } k = 1, 2$$
$$\theta(k) = -\left(\frac{N-1}{N}\right)\pi \qquad \text{for } 0 \le k \le \frac{N-1}{2}$$
$$= -\frac{6}{7}\pi k \qquad \text{for } 0 \le k \le 3$$
$$H(k) = 0 \qquad \text{for } k = 0, 3$$
$$= e^{-j6\pi k/7} \qquad \text{for } k = 1, 2$$

The filter coefficients are given by

$$h(n) = \frac{1}{N}\left[H(0) + 2\sum_{k=1}^{\frac{N-1}{2}} \text{Re}(H(k)e^{j2\pi kn/N})\right]$$
$$= \frac{1}{7}\left[2\sum_{k=1}^{3} \text{Re}(e^{-j6\pi k/7}e^{j2\pi kn/7})\right]$$
$$= \frac{1}{7}\left[2\sum_{k=1}^{2} \cos\frac{2\pi k}{7}(3-n)\right]$$
$$= \frac{2}{7}\left[\cos\frac{2\pi}{7}(3-n) + \cos\frac{4\pi}{7}(3-n)\right]$$

$$h(0) = h(6) = -0.07928$$
$$h(1) = h(5) = -0.321$$
$$h(2) = h(4) = 0.11456$$
$$h(3) = 0.57$$