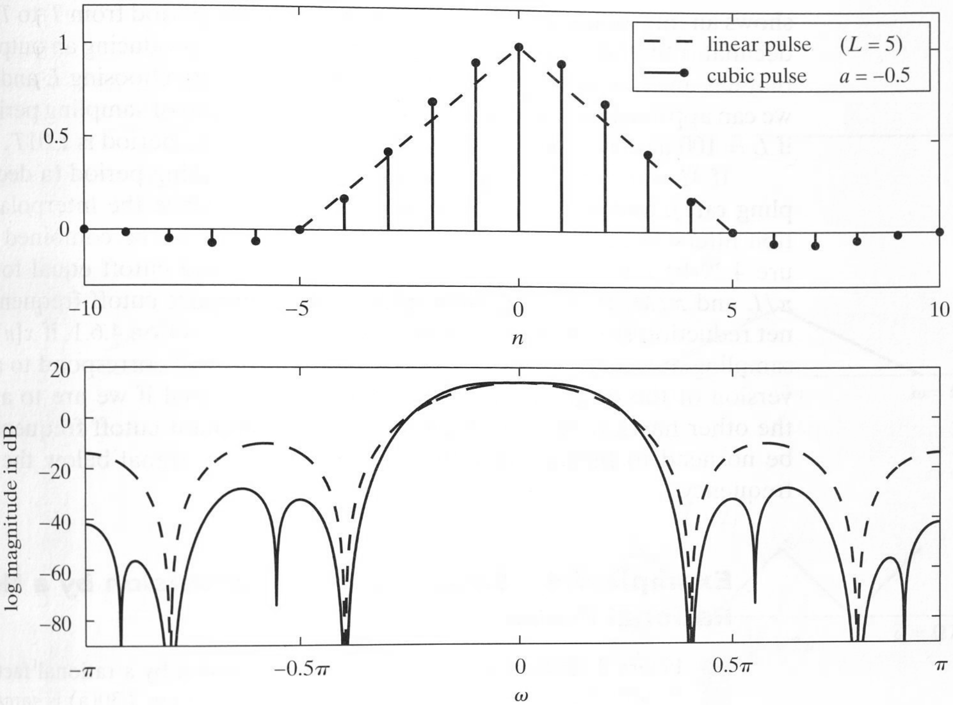

Figure 4.28 Impulse responses and frequency responses for linear and cubic interpolation.

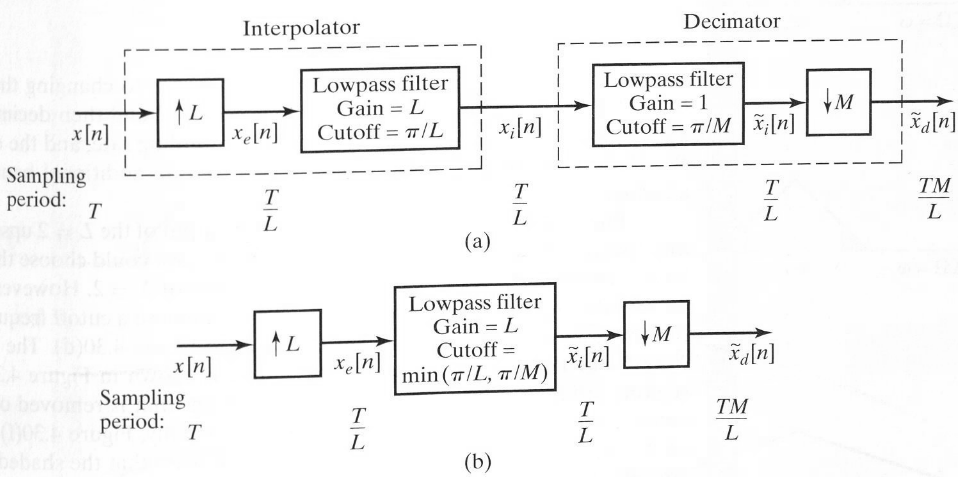

Figure 4.29 (a) System for changing the sampling rate by a noninteger factor. (b) Simplified system in which the decimation and interpolation filters are combined.

SCRETE-TIME PROCESSING OF CONTINUOUS-TIME GNALS

A major application of discrete-time systems is in the processing of continuous-time signals. This is accomplished by a system of the general form depicted in Figure 4.10. The system is a cascade of a C/D converter, followed by a discrete-time system, followed by a D/C converter. Note that the overall system is equivalent to a continuous-time system, since it transforms the continuous-time input signal $x_c(t)$ into the continuous-time output signal $y_r(t)$. The properties of the overall system are dependent on the choice of the discrete-time system and the sampling rate. We assume in Figure 4.10 that the C/D and D/C converters have the same sampling rate. This is not essential, and later sections of this chapter and some of the problems at the end of the chapter consider systems in which the input and output sampling rates are not the same.

The previous sections of the chapter have been devoted to understanding the C/D and D/C conversion operations in Figure 4.10. For convenience, and as a first step in understanding the overall system of Figure 4.10, we summarize the mathematical representations of these operations.

The C/D converter produces a discrete-time signal

$$x[n] = x_c(nT), \tag{4.29}$$

i.e., a sequence of samples of the continuous-time input signal $x_c(t)$. The DTFT of this sequence is related to the continuous-time Fourier transform of the continuous-time input signal by

$$X(e^{j\omega}) = \frac{1}{T}\sum_{k=-\infty}^{\infty} X_c\left[j\left(\frac{\omega}{T} - \frac{2\pi k}{T}\right)\right]. \tag{4.30}$$

The D/C converter creates a continuous-time output signal of the form

$$y_r(t) = \sum_{n=-\infty}^{\infty} y[n]\frac{\sin[\pi(t-nT)/T]}{\pi(t-nT)/T}, \tag{4.31}$$

where the sequence $y[n]$ is the output of the discrete-time system when the input to the system is $x[n]$. From Eq. (4.28), $Y_r(j\Omega)$, the continuous-time Fourier transform of $y_r(t)$, and $Y(e^{j\omega})$, the DTFT of $y[n]$, are related by

$$Y_r(j\Omega) = H_r(j\Omega)Y(e^{j\Omega T}) = \begin{cases} TY(e^{j\Omega T}), & |\Omega| < \pi/T, \\ 0, & \text{otherwise.} \end{cases} \tag{4.32}$$

Next, let us relate the output sequence $y[n]$ to the input sequence $x[n]$, or equivalently, $Y(e^{j\omega})$ to $X(e^{j\omega})$. A simple example is the identity system, i.e., $y[n] = x[n]$. This

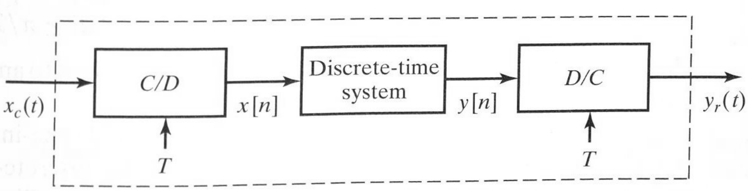

Figure 4.10 Discrete-time processing of continuous-time signals.