Flat Top sampling

The analog Signal (continuous - time signal) is multiplied with a periodic impulse train, referred to as **Sampling Function**. A sampled signal is then obtained as shown in figure below.

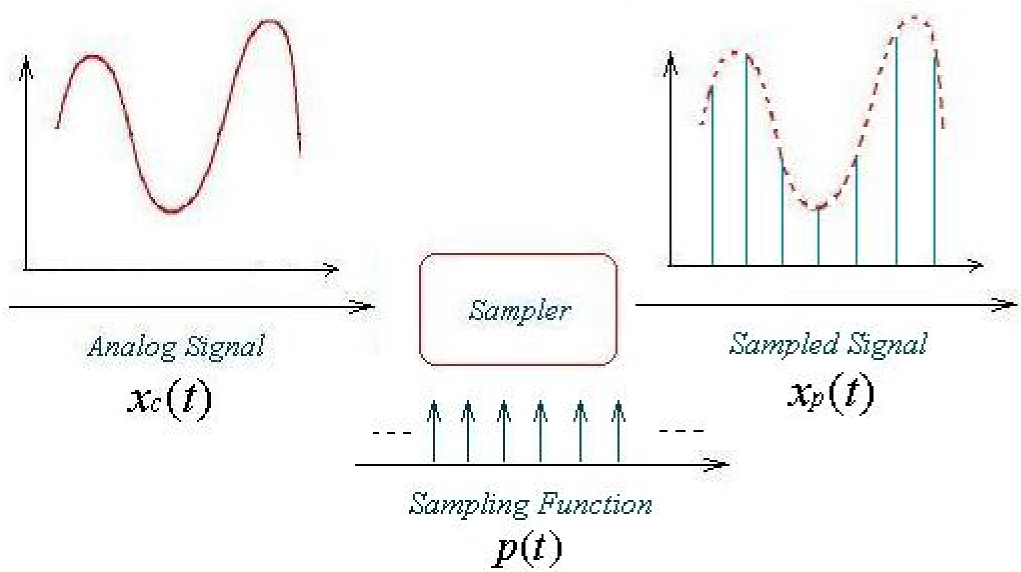

Figure 5.7

The ideally sampled signal $\mathbf{x_p(t)}$ is the product of the impulse train $\mathbf{p(t)}$ and the analog signal $\mathbf{x_c(t)}$ and is written as $x_p(t) = x_c(t)p(t)$

$$p(t) = \sum_{-\infty}^{\infty} \delta(t - nt_s)$$

$$x_p(t) = \sum_{-\infty}^{\infty} x(nt_s)\delta(t - nt_s) = \sum_{n=-\infty}^{\infty} x[n]\delta(t - nt_s)$$

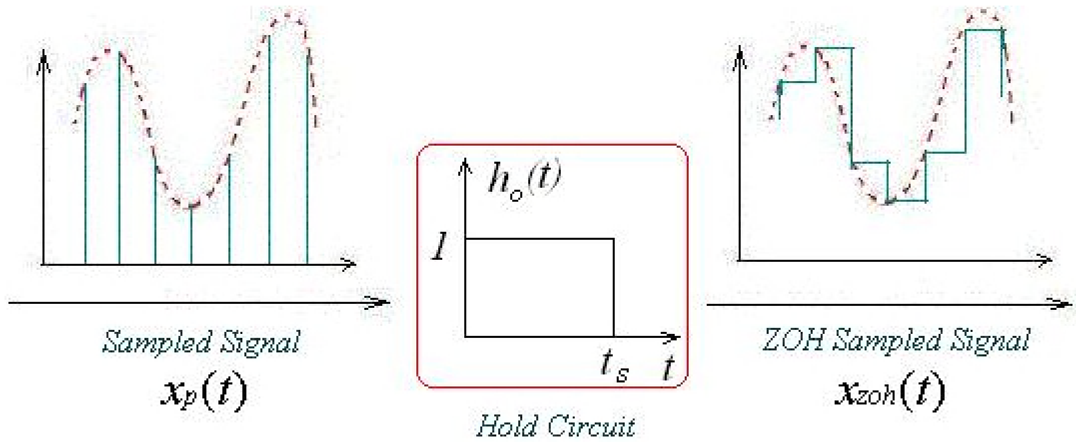

Figure 5.8

The **ZOH Sampled Signal $x_{ZOH}(t)$** can be regarded as the convolution of **$h_o(t)$** and a sampled signal **$x_p(t)$**

$$\begin{aligned} x_{ZOH}(t) &= h_o(t) * x_p(t) \\ &= h_o(t) * \left[\sum_{n=-\infty}^{\infty} x(nt_s)\delta(t - nt_s) \right] \\ &= \sum_{n=-\infty}^{\infty} x(nt_s)\, h_o(t - nt_s) \end{aligned}$$

There are two types of distortion :-

a) Aliased Component Distortion : Aliased Component distortion can be corrected, if required by cascading another better lowpass filter.

b) Baseband Spectrum Distortion (Sinc Distortion) : Baseband Spectrum Distortion is corrected by an **Equalizer**. An Equalizer is an LSI system with Fourier Transformable impulse response which acts like an inverse **1 / H (f)** to another LSI system, at least in a certain range of frequencies. Equalizer is also used to correct channel imperfections in a communication system.

The higher the sampling rate f_s, the less is the distortion in the spectral image X(f) centered at origin.

An ideal lowpass filter with unity gain over **$-0.5\ f_s \leq\ f \leq 0.5\ f_s$** recovers the distorted signal.

$$\tilde{X}(f) = X(f)\mathrm{Sinc}(\frac{f}{f_s})e^{-j\pi f/f_s} \quad -0.5 f_s \leq f \leq 0.5 f_s$$

To recover X(f) with no amplitude distortion, we must use a compensating filter that negates the effects of the Sinc distortion by profiling a concave shaped magnitude spectrum corresponding to the reciprocal of the Sinc function over the principal period **$|\ f\ | \leq 0.5\ f_s$**

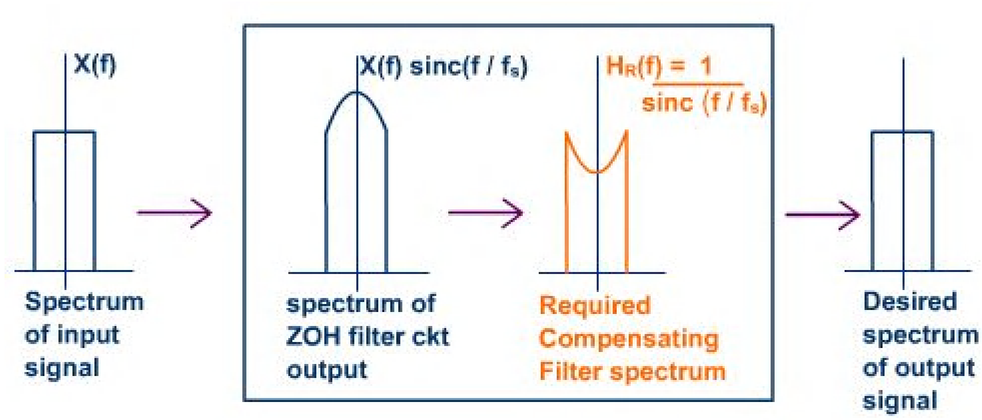

Figure 5.9

Figure : Spectrum of a filter that compensates for Sinc distortion

The magnitude spectrum of the compensating filter is given by

$$|H_r(f)| = \frac{1}{\mathrm{Sinc}(\frac{f}{f_s})} \quad |f| \leq 0.5 f_s$$