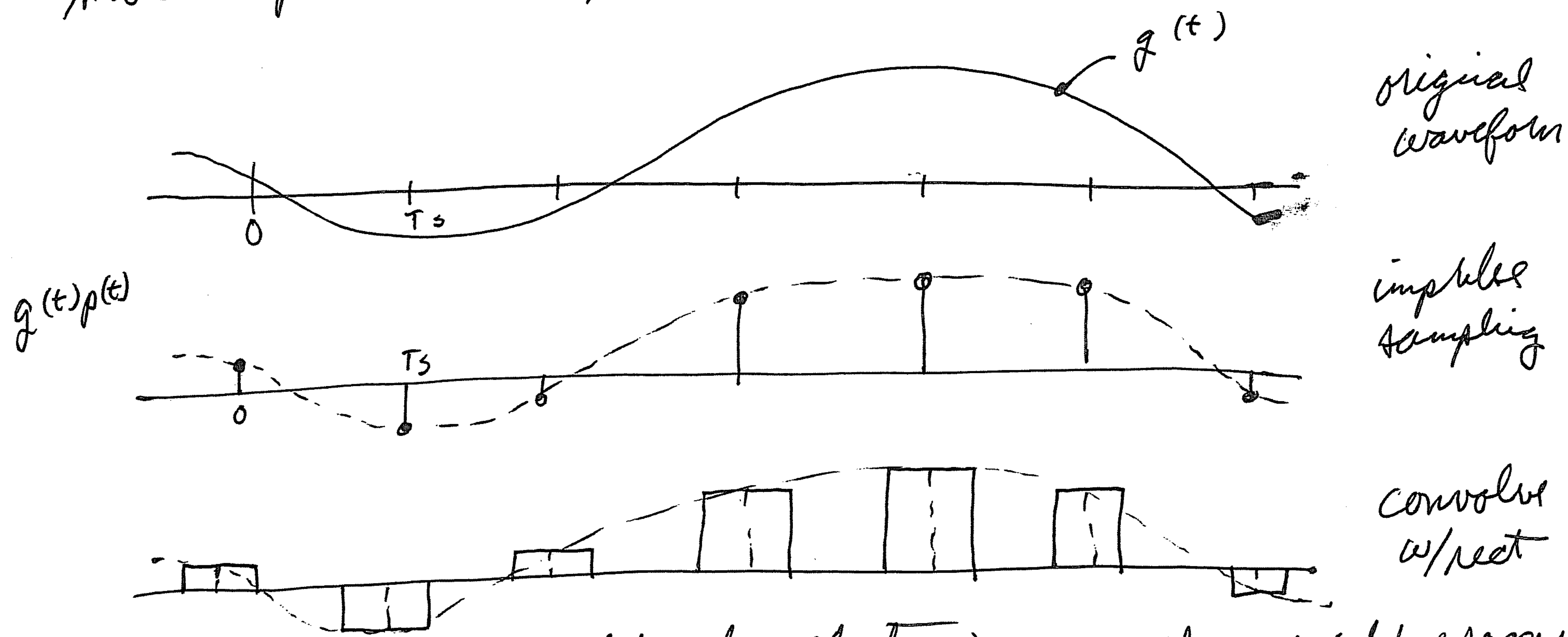
EE630: Lecture 11D

"Flat Top Sampling"

Flat Top sampling is the prefered model for most practical A/D and D/A converters.



The flat top models the electronic sample and hold process.

$$g_F(t) = \left(g(t)\,p(t)\right) * \text{rect}\left(t/\tau\right)$$

$$= \left[g(t) \sum_n \delta(t - nT_s)\right] * \text{rect}\left(t/\tau\right)$$

The spectrum of $g_F(t)$ is

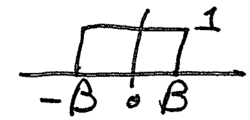
$$G_F(f) = \left[G(f) * \frac{1}{T_S} \sum_k \delta(f - k/T_S) \right] \tau \, Sa(\pi f \tau)$$

$$= \tau/T_S \sum_k Sa(\pi \tau f) \, G(f - k/T_S)$$

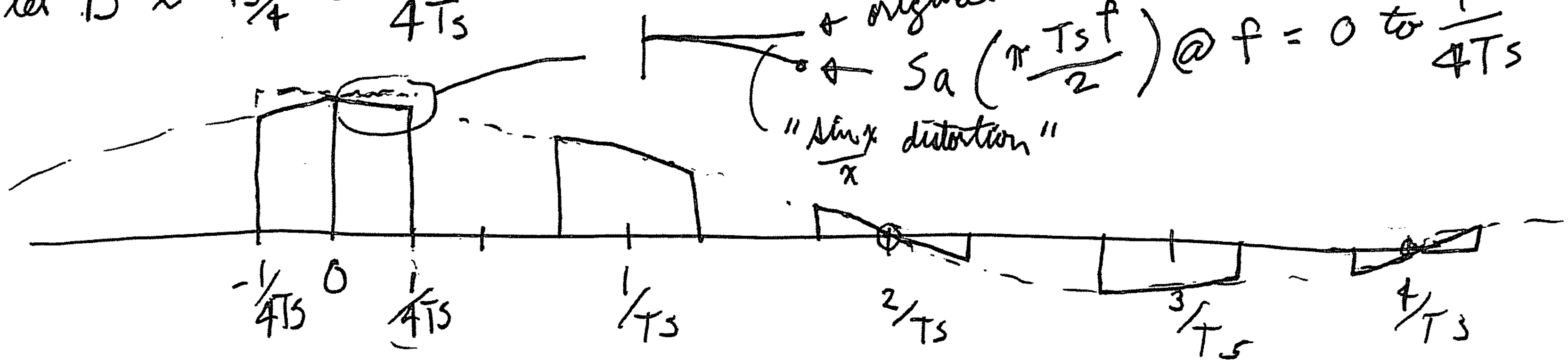
Ex: Let $\tau = T_S/2$ or 50% duty $\tau/T_S = 0.5$

$$Sa\left(\pi \frac{T_S}{2} f\right) = 0 \text{ for } \pi \frac{T_S f}{2} = m\pi \text{ for } m = \pm 1, \pm 2, \pm 3 \ldots$$

$$f = \frac{2m}{T_S} = \text{nulls @ even harmonics}$$

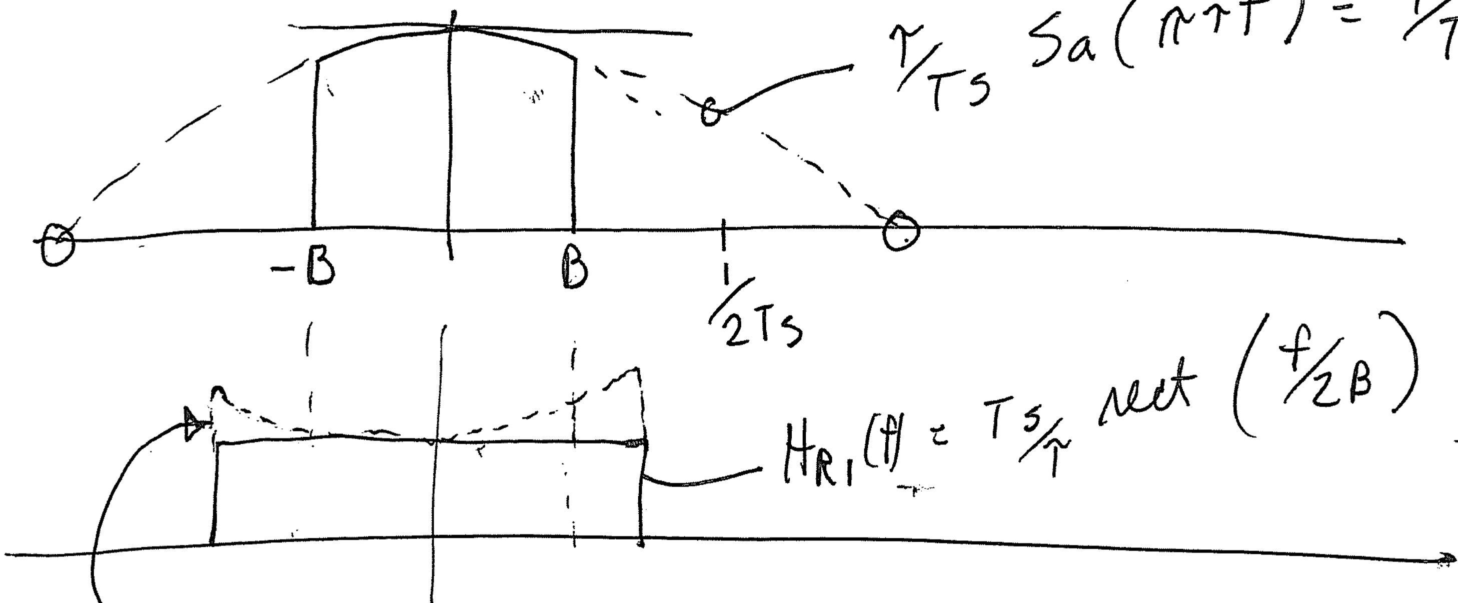
let the input spectra be $G(f) = \text{rect}\left(\frac{f}{2B}\right) =$ 

let $B \approx f_S/4 = \frac{1}{4T_S}$



Compensation of "$\frac{\sin x}{x}$" distortion

$$\tau/T_S \; Sa(\pi\tau f) = \tau/T_S \frac{\sin \pi\tau f}{\pi\tau f}$$



$$H_{R1}(f) = T_S/\tau \; \text{rect}\left(f/2B\right)$$ } conventional reconstruction

$$H_R(f) = H_{R1}(f)\,\frac{\pi\tau f}{\sin \pi\tau f}$$

then $G_S(f)\,H_R(f) = G_S(f)\,H_{R1}(f)\,\frac{\pi\tau f}{\sin \pi\tau f}$

Ex: Given an audio signal

$$G(f) = A\,\mathrm{rect}\left(f/2B\right)$$

where $B = 15$ Khz

Assume we have ideal filter and need only 0 to 3Khz of $G(f)$.

Design a flat top sampling system with minimum sampling rate and no $\frac{\sin x}{x}$ distortion

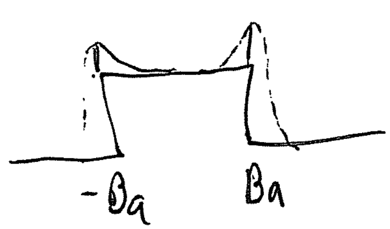
Also assume $\tau = T_s$

1. Use an anti-aliasing filter $H_a(f) = \mathrm{rect}\left(\frac{f}{2B_a}\right)$ where $B_a = 3$ Khz
2. Sampling rate is $\frac{1}{T_s} = 2B_a = 6$ KHz
3. $\tau = T_s = \frac{1}{6000}$ sec.

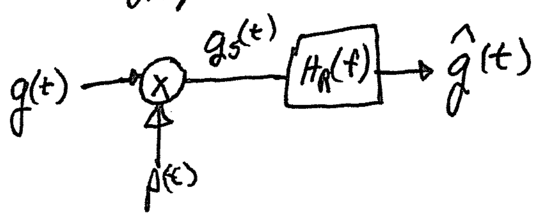
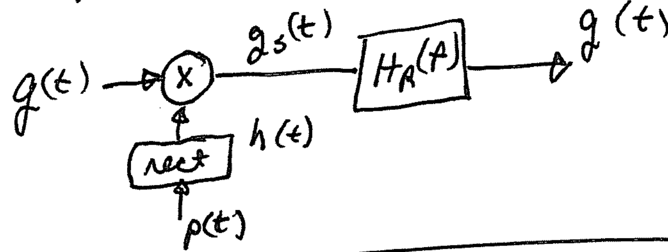
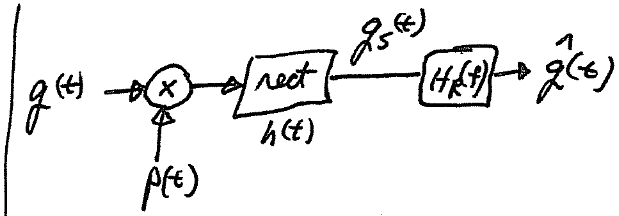
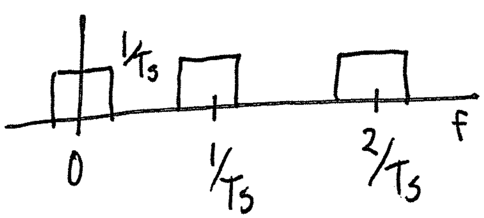
4. Reconstruction filter is $H_R(f) = \frac{T_s}{\tau} \frac{\text{rect}\left(\frac{f}{2B_a}\right)}{Sa(\pi \tau f)}$

$$H_R(f) = \frac{\text{rect}\left(\frac{f}{2B_a}\right)}{Sa\left(\pi f / 2B_a\right)}$$

Calculate $Sa\left(\frac{\pi f}{2B_a}\right)$ @ $f = B_a$ to get the amount of attenuation



Comparison of Impulse, Natural and Flat Top

	Impulse	Natural	Flat Top
			
Sampling	$g_s(t) = g(t)\,p(t)$	$g_s(t) = g(t)\,h(t)$ $= g(t)\,(\mathrm{rect}(t/\tau) * p(t))$	$g_s(t) = (g(t)\,p(t)) * \mathrm{rect}(t/\tau)$
DT	$g[n] = g_s(nT)$	no analogy	$g[n] = g_s(nT)$ sample hold
Spectrum	$G_s(f) = G(f) * P(f)$	$G_s(f) = G(f) * (\tau\, Sa(\pi\tau f)\, P(f))$	$G_s(f) = (G(f) * P(f))\,\tau\, Sa(\pi\tau f)$
		Let $G(f) = \mathrm{rect}(f/2B)$ 50% duty