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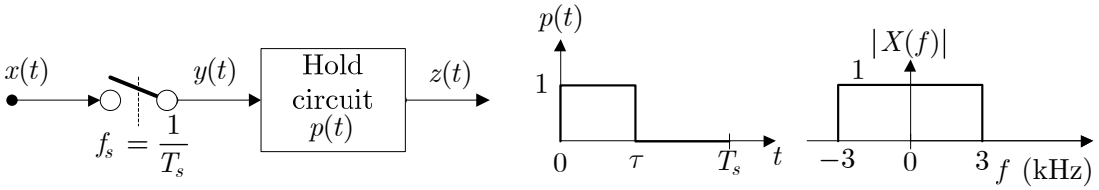
Sistemas de Processamento Digital de Sinais

Problem: Sampling and numerical representation

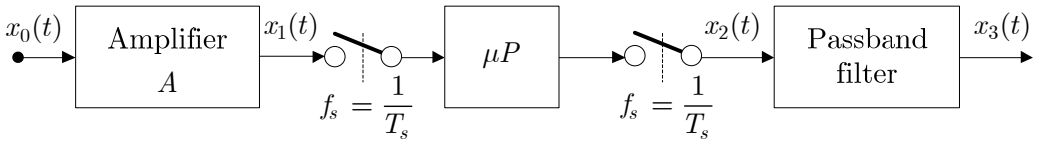
I – Consider the sampling system depicted in the figure which uses an ideal impulse sampler followed by an hold circuit which retains the sample during a time equal to the sampling period, $\tau = T_s$. The analog signal spectrum is represented in the figure. The sampling frequency is $f_s = 10$ kHz.



a) State the advantages and inconvenients of sample holding relative to ideal sampling.

b) Determine the frequency response $P(f)$ of the hold circuit and sketch its modulo $|P(f)|$ for $|f| \leq 2f_s$. Sketch also the spectrum of the signals $y(t)$ and $z(t)$ for $|f| \leq 2f_s$.

II — Consider the signal processing system represented in the figure which uses ideal impulse sampling. The (non-ideal) amplifier A has the transfer characteristic $x_1 = x_0 + \alpha \cdot x_0^2$ and the passband filter is ideal with cutoff frequencies $6.5f_0$ and $7.5f_0$.



a) Consider a sinusoidal input signal, $x_0(t) = A_0 \cos(2\pi f_0 t)$. Determine the minimum sampling frequency $f_{s_{\min}}$ so that *aliasing* does not occur. **Note:** $\cos^2 x = \frac{1 + \cos(2x)}{2}$.

b) For the same input signal and for $f_s = 2f_{s_{\min}}$ sketch the modulo of the spectrum of $x_2(t)$ and $x_3(t)$, admitting that the signal processor only copies the input sample to the output.

c) **III** — Consider the real numbers $x = 17.35$ and $y = 0.15$ and its processing using fixed point arithmetic.

a) Determine the arithmetic formats which allow the most accurate representation of x and y with 16 bit and $z = x \cdot y$ with 32 bit.

b) Determine the values of x and y in these formats and the resulting value of z, z_{real}. Compute the relative absolute error of z, $\varepsilon_{\text{rel}}(z) = \left| \frac{z_{ideal} - z_{real}}{z_{ideal}} \right|$. How could this error be made smaller?