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Communication
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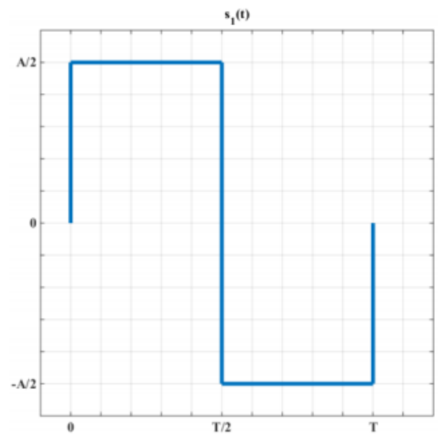
Sheet 1
Matched Filters

Problem 1

Consider the signal $s_1(t)$ as shown in Fig

1) Determine the impulse response of the matched filter (write an expression)
2) Draw the matched filter as function of time
3) Plot the matched filter output as function of time
4) Determine the peak value of the output



Problem 2

Consider the signals $s(t)$ defined as

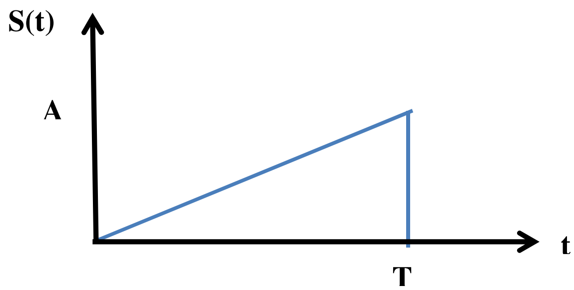
$$s(t) = \frac{A}{T}\cos(2\pi f_0 t)\,, \qquad 0 \le t \le T$$

1) Determine the impulse response of the Matched Filter for this signal.
2) Draw the Matched Filter as function of time.
3) Determine the output of the Matched Filter at $t = T$.
4) Suppose the signal $s(t)$ passes through a correlator that correlates $s(t)$ with $s(t)$. Determine the correlator's output at t=T, and compare it with the result of part (3).

Problem 3

Consider the signal $s(t)$

1) Determine the impulse response of the matched filter (write an expression)
2) Draw the matched filter as function of time
3) Determine the time at which the output of the matched filter is maximized
4) Determine the peak value of the matched filter's output.



Problem 4

Consider the signals $s(t)$ defined as

$$s(t) = A, \qquad 0 \leq t \leq T$$

It is required to approximate the Matched Filter of $s(t)$ by an ideal Low Pass Filter of bandwidth B, such that the peak pulse SNR is maximized.

1) Determine the optimum value of B such that the LPF provides the best approximation to the Matched Filter.
2) Describe the relative performance of the LPF compared to the Matched Filter.

Hint: You may use the approximation $sinc(x) \approx \cos\left(\frac{\pi}{2}x\right)$.

Problem 5

In this problem we explore another method for the approximate realization of a matched filter, this time using the simple resistance-capacitance (RC) low-pass filter shown in Figure P4.4. The frequency resonse of this filter is

$$H(f) = \frac{1}{1 + jf/f_0}$$

where $f_0 = 1/2\pi RC$. The input signal $g(t)$ is a rectangular pulse of amplitude A and duration T. The requirement is to optimize the selection of the 3-dB cutoff frequency f_0 of the filter so that the peak pulse signal-to-noise ratio at the filter output is maximized. With this objective in mind, show that the optimum value of f_0 is $0.2/T$, for which the loss in signal-to-noise ratio compared to the matched filter is about 1 dB.

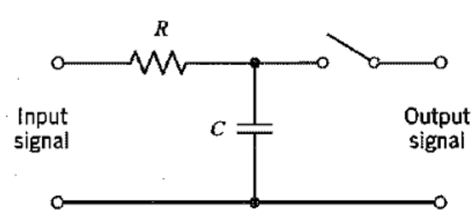


FIGURE P4.4