NANYANG TECHNOLOGICAL UNIVERSITY
School of Electrical & Electronic Engineering

EE/IM4152 Digital Communications

Tutorial No. 8 (Sem 1, AY2016-2017)

1. In the lecture, we have derived the transfer function of the matched filter as
$$H(f) = P(-f)\,e^{-j2\pi f T_o}$$
where $p(t) \leftrightarrow P(f)$ is a Fourier transform pair and T_o is the pulse duration. Take the inverse Fourier transfer and verify its impulse response to be $h(t) = p(T_o - t)$.

2. It is important to know that the corrector output and the matched filter output are the same **only** at $t = T_o$, where T_o is the pulse duration. Let us ignore the input noise and assume the input signal to be a sine wave as
$$p(t) = \sin 2\pi f_c t, \quad 0 \le t \le T_o$$
where f_c is the carrier frequency. Determine and plot the output of the correlation receiver
$$z_C(t) = \int_0^t p^2(x)\,dx$$
and the output of the matched filter
$$z_M(t) = \int_0^t p(x)\,p(T_o - t + x)\,dx, \quad 0 \le t \le T_o.$$
[Hint: you may ignore the double-frequency terms when computing the integration,]

3. The so-called integrate-and-dump filter is shown in Figure 1. The feedback amplifier is an ideal integrator. The switch s_1 close momentarily and then opens at the instant $t = T_b$, thus dumping all the charge in the capacitor and causing the output to go to zero. The switch s_2 samples the output immediately before the dumping action.
   (a) Determine the output $p_o(t)$ when the rectangular pulse $p(t)$ with amplitude A is applied to the input of the filter.
   (b) Find the noise power σ_n^2 due to additive white Gaussian noise (AWGN) at the output.
   (c) Compute $\rho^2 = p_o^2(T_b)/\sigma_n^2$ for the integrate-and-dump filter and compare it with that of the matched filter [see (12) of your lecture notes].

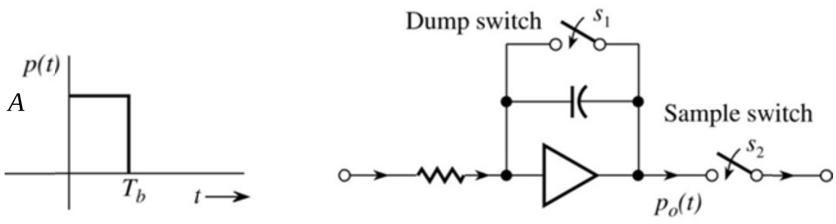

Figure 1

4. Consider the following set of signals
$$s_i(t) = \begin{cases} \sqrt{\dfrac{2E_s}{T}} \cos\left(2\pi f_c t + i\pi/2\right), & 0 \le t \le T \\ 0, & \text{otherwise} \end{cases}$$
where $i = 1, 2, 3, 4$, T is the pulse duration and $f_c T = k$ for some integer k. Choose the basis functions, $\varphi_1(t) = \sqrt{2/T}\cos 2\pi f_c t$ and $\varphi_2(t) = \sqrt{2/T}\sin 2\pi f_c t$, over the same T-second interval and plot the locations of $s_i(t), i = 1, 2, 3, 4$ in the 2-dimensional signal space formed by $\varphi_1(t)$ and $\varphi_2(t)$.