Exams

Final Exam in 2014 - 6

6. (10%) Suppose $x(t)$ is a continuous-time signal, $p(t)$ is a narrow pulse with duration $\tau < T$, and $y(t)$ is a pulse train modulated by the samples of $x(t)$,

$$y(t) = \sum_{n=-\infty}^{\infty} x(nT)p(t-nT).$$

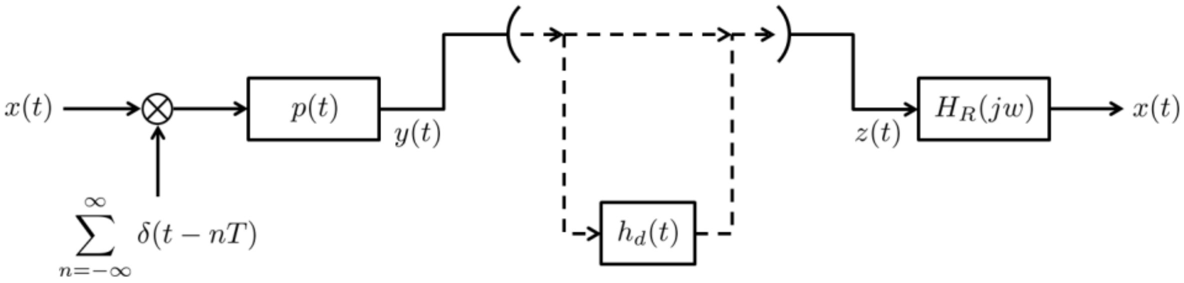
$y(t)$ is transmitted through some channel and received at the receiver as $z(t)$. The transmission through the channel can be modeled as a convolution by some distortion filter $h_d(t)$,

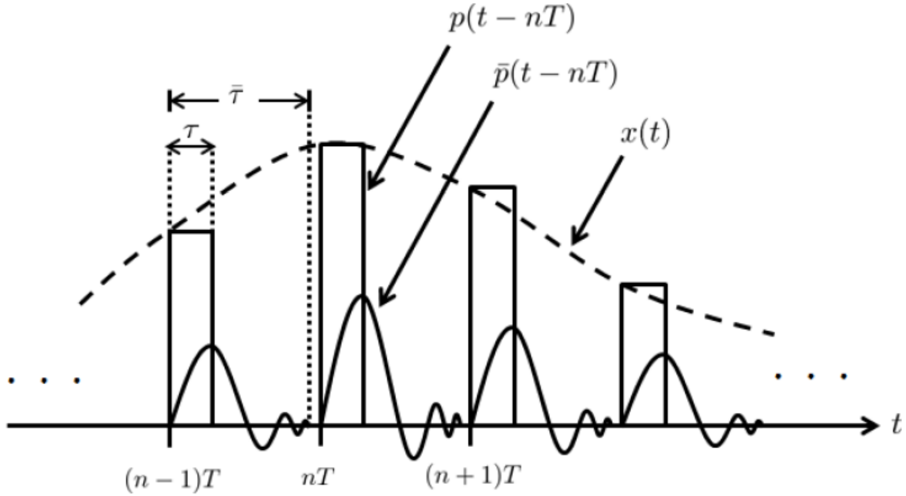
$$z(t) = y(t) * h_d(t) = \sum_{n=-\infty}^{\infty} x(nT)\bar{p}(t-nT),$$

where

$$\bar{p}(t) = p(t) * h_d(t).$$

The duration of $\bar{p}(t)$ is $\bar{\tau}$, it is possible that $\bar{\tau} < T$ or $\bar{\tau} > T$.





An engineer thinks he can apply a filter $H_R(jw)$ at the receiver end, and reconstruct the original signal $x(t)$ by passing $z(t)$ through $H_R(jw)$.

Do you think he is correct or not? If yes, is there any condition for it? Write it down and verify your answer. What this $H_R(jw)$ should be? If not, explain why not and verify it.

Final Exam in 2014 - 7

7. (4%)

(a) (2%) Explain why phase modulation with a signal $x(t)$ corresponds to frequency modulation with a signal $\frac{d}{dt}x(t)$.

(b) (2%) A signal $x(t) = au(t)$ is frequency modulated where a is a constant and $u(t)$ is a unit step function, and the output signal is $y(t)$. Plot the general shape of $y(t)$.

Final Exam in 2014 - 8

8. (2%) An information-bearing signal $x(t)$ is amplitude modulated,

$$y(t) = x(t)\cos(w_c t + \theta_c).$$

and $y(t)$ is synchronously demodulated with a local carrier with a phase ϕ_c, i.e.,

$$w(t) = y(t)\cos(w_c t + \phi_c),$$

and $w(t)$ is lowpass filtered as in the synchronous demodulation. Explain what happens when (i) $\phi_c = \theta_c$ and (ii) $\phi_c \neq \theta_c$ in both time and frequency domains.

Final Exam in 2013 - 5

5. (5%) Intersymbol interference can be avoided in a pulse-amplitude modulation system by constraining the pulse shape to have zero-crossings at integer multiples of the symbol spacing T_1. Consider the pulse $p_1(t)$ that is real and even and has a Fourier transform $P_1(j\omega)$ with odd symmetry around π/T_1 so that

$$P_1(-j\omega + j\frac{\pi}{T_1}) = -P_1(j\omega + j\frac{\pi}{T_1}), \quad 0 \le \omega \le \frac{\pi}{T_1}.$$

Given that $p_1(kT_1)=0$, $k=\pm1, \pm2, \pm3, \ldots$, show that a pulse $p(t)$ with Fourier transform

$$P(j\omega) = \begin{cases} 1 + P_1(j\omega), & |\omega| \le \frac{\pi}{T_1} \\ P_1(j\omega), & \frac{\pi}{T_1}|\omega| \le \frac{2\pi}{T_1}. \\ 0, & \text{otherwise} \end{cases}$$

also has the property that $p(kT_1)=0$, $k=\pm1, \pm2, \pm3, \ldots$.

Final Exam in 2013 - 6

6. (6%) Consider a modulating signal $x(t)$ with highest frequency ω_M. We want to design an AM communication system to transmit the signal $x(t)$ by using the carrier signal $c(t)$ with carrier frequency ω_c.

(a) (2%) Suppose the modulating signal $x(t)$ is a wideband signal such that $\omega_M \geq \omega_c$. Design a *modulator* and a *demodulator* for this AM system, assumed that the phases of the modulating carrier and demodulating carrier are both zero.

(b) (2%) Now, suppose the modulating signal $x(t)$ is a narrow band signal such that $\omega_M < \omega_c$. Since we know that the single-sideband modulation (SSB) can save the bandwidth for transmission, describe two approaches at the transmitter to generate the SSB modulated signal from the original double-sideband modulation (DSB) modulated signal.

(c) (2%) We know that, in practice, the phases of the modulating carrier and demodulating carrier may not be zero, and hence, there are commonly two methods: *synchronous demodulation* and *asynchronous demodulation* for demodulation. Describe the pros and cons of the two methods.

10. (10%) Let a communication system use a modulation technique to transmit a message signal $x(t)$.

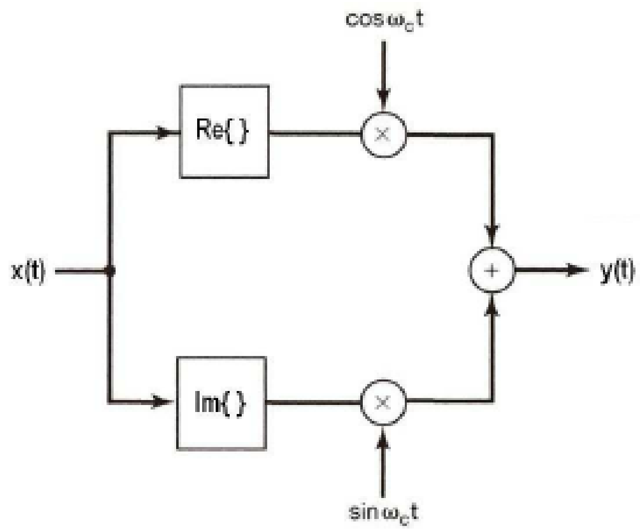
(a) (3%) Assume that $x(t) = \sin(1000\pi t)/\pi t$ and the modulated signal $y(t) = (x(t) + A)\text{con}(10000\pi t)$. Find the largest permissible value of the modulation index m that would allow envelope detector to be used to recover $x(t)$ from $y(t)$. You must justify your answer.

(b) (3%) Assume that the transmitter creates a modulated signal $y(t) = \cos\left(\omega_c t + m\int_{-\infty}^{t} x(\alpha)d\alpha\right)$. Find the modulated signal $y(t)$ when $m << \pi/2$. You must justify your answer.

(c) (4%) Find the relationship between the bandwidth of $y(t)$, the bandwidth of $x(t)$ and the ω_c in Part (b). You must justify your answer.

Final Exam in 2012 - 7

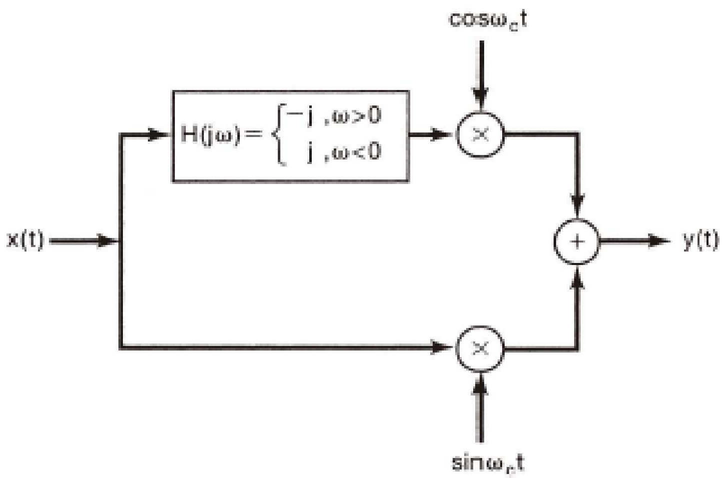
7. (15%) Consider the following modulator, where the input signal $x(t) = A\text{sinc}(\frac{t}{T}) + jA\text{sinc}(\frac{t}{T})$, $T = 10^{-5}$ seconds, $\omega_c = 10^6 \pi$ rad/sec, and Re{} and Im{} denote the operations generating the



real part and imaginary part of the input, respectively. Find an expression for the Fourier transform $Y(j\omega)$ of the output signal $y(t)$. Plot the real and imaginary parts of $Y(j\omega)$.

Final Exam in 2011 - 9

9. [8] Consider a system for generating a modulated signal $y(t)$ from the message signal $x(t)$ as follows:



Assume that the message signal $x(t)$ has its spectrum $X(j\omega) = 0$ for $|\omega| > \omega_M$ and $\omega_c > \omega_M$.

(a) Is $y(t)$ a real modulated signal if $x(t)$ is real? Justify your answer. [4]

(b) How do you recover the message signal $x(t)$ from the modulated signal $y(t)$? Justify your answer. [4]