University of Illinois at Urbana-Champaign
Department of Electrical and Computer Engineering

ECE 359: Communications I

Fall 2000

Problem Set 4

Amplitude Modulation Schemes

Issued: Thursday, September 21st. **Due:** Never.

Reading from Lathi: Chapter 4, Sections 4.1–4.6.

Reading from Haykin: Chapter 3, Sections 3.1–3.9.

Announcement: The first Mid-Semester Exam will be held on Thursday, September 28th, from 1:30pm to 2:50pm in 161 Everitt. The exam will cover all material from the beginning of the term *up to and including* the lecture on Thursday, September 21st. The corresponding material includes Problem Sets 1 through 4 and:
(i) **Lathi**: Chapters 1, 2, 3, and 4 (excluding sections 4.7–4.9), OR
(ii) **Haykin**: Chapters 1, 2 and 3 (excluding Sections 3.10–3.14).
During the exam, you can bring an 8.5 × 11-inch double-sided sheet of *handwritten* notes. Calculators are allowed but will not be necessary.
A copy of an old exam can be downloaded from `http://www.ece.uiuc.edu/ece359` . This exam does not necessarily resemble this year's exam (also notice that the material covered in this old exam is slightly different from the material covered in this year's exam).

Problem 4.1

(a) Problem 4.2-4 from Lathi, p. 202.

(b) Problem 4.3-2 from Lathi, p. 204.

(c) Problem 4.3-4 from Lathi, pp. 204–205.

Problem 4.2

Recall that the complex envelop $\widetilde{x}(t)$ of a real signal $x(t)$ is generally complex and can be written in the form

$$\widetilde{x}(t) = x_I(t) + jx_Q(t) ,$$

where $x_I(t)$ and $x_Q(t)$ are the in-phase and quadrature components of $x(t)$.

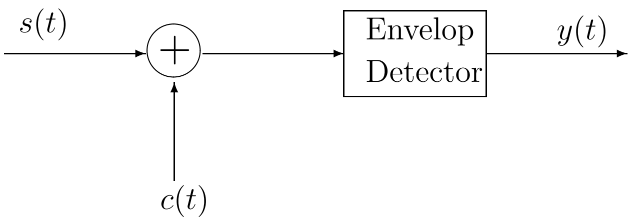
Find the expressions for the in-phase and quadrature components of the following signals:

(a) DSB-SC signal $x(t) = m(t)\cos(\omega_c t + \theta)$.

(b) DSB-TC signal $x(t) = [A + m(t)]\cos(\omega_c t + \theta)$.

Problem 4.3

A DSB-SC signal can be demodulated by an envelop detector if a sufficient amount of carrier is reinserted at the receiver as shown below.



In particular, show that if the carrier $c(t) = A\cos[(\omega_c + \Delta\omega)t + \delta]$ is reinserted in the received DSB-SC signal $s(t) = m(t)\cos\omega_c t$ and the resulting signal is envelop-detected, then the output (after DC blocking) is given by $y(t) = m(t)\cos(\Delta\omega\, t + \delta)$.

Problem 4.4

(a) Problem 4.5-1 from Lathi, pp. 205–206.

(b) Consider the SSB modulated waveform

$$s(t) = m(t)\cos\omega_c t - \hat{m}(t)\sin\omega_c t\ ,$$

where $m(t)$ is the message signal and $\hat{m}(t)$ is its Hilbert transform. Suppose that $s(t)$ is the input to a square-law device whose output $y(t)$ is then given by

$$y(t) = s^2(t)\ .$$

Show that $y(t)$ contains a frequency component at twice the frequency. Do you think it would be practical to try and recover the message signal $m(t)$ from this component?

Problem 4.5

A VSB-SC signal $s(t) = m(t)\cos\omega_c t - m'(t)\sin\omega_c t$ is coherently demodulated by a locally generated carrier $A\cos[(\omega_c + \Delta\omega)t + \delta]$ as shown below. Find the output signal $y(t)$.