University of Waterloo
Department of Electrical and Computer Engineering
Monday, Feb. 12, 2001
4:30pm to 6:00pm

E&CE-318 Midterm Examination

Instructor: Sherman Shen

Time allowed: 1.5 hours.
NO AIDS ALLOWED (Some mathematical formulas are given on page 3).
Attempt all the questions. **JUSTIFY ALL YOUR ANSWERS.**

The marking scheme is shown in the left margin and [70] constitutes full marks.

---

[20] 1. For the sinusoidally modulated DSB-LC waveform shown in Fig. 1:

[3] (a) Find the modulation index.

[3] (b) Find the modulation efficiency.

[5] (c) Write an expression for the waveform in the form of $A(1 + m\cos\omega_m t)\cos\omega_c t$.

[7] (d) Sketch a line spectrum of the waveform.

[2] (e) Show that the sum of the two sideband lines in part (d), divided by the carrier line, yields the modulation index.

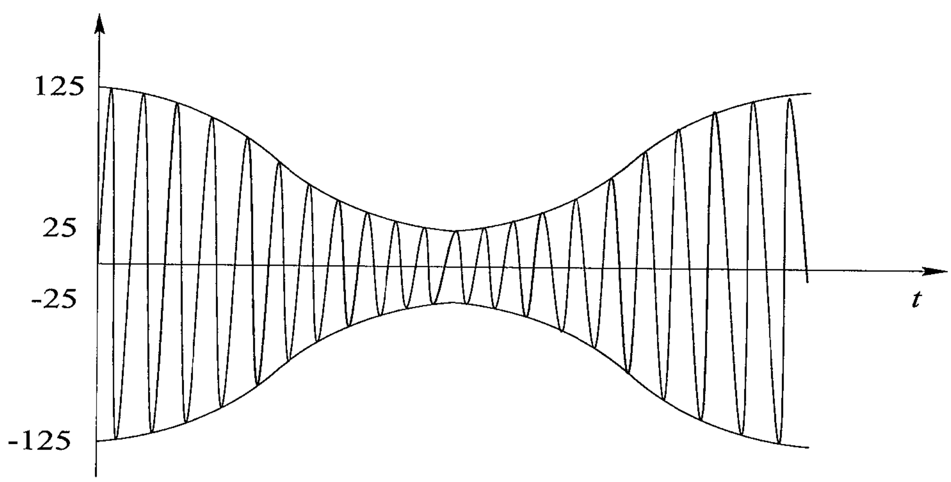

Figure 1:

[20] 2. Figure 2 shows the block diagram of a DSB-SC modulator. The nonlinear devices have the identical input-output relation described by

$$y(t) = ax(t) + bx^2(t)$$

where $x(t)$ and $y(t)$ are the input and output respectively of the nonlinear devices, a and b are non-zero constants.

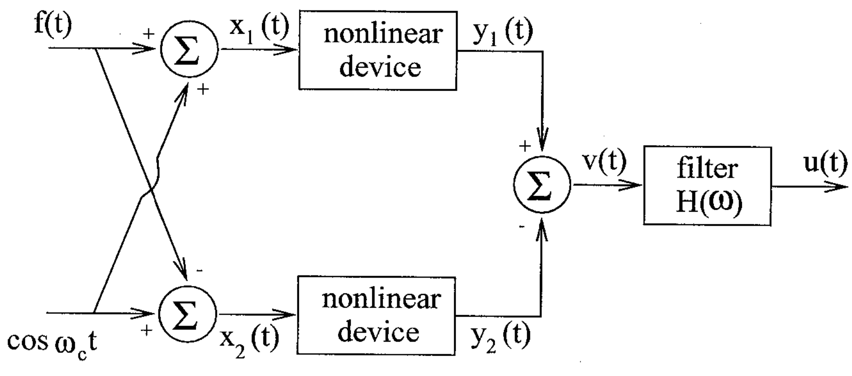

Figure 2:

[12] (a) Given the message signal $f(t)$ and its Fourier transform $F(\omega)$, determine the signal $v(t)$ and its Fourier transform $V(\omega)$.

[6] (b) Specify the transfer function $H(\omega)$ of the filter.

[2] (c) Determine the output signal $u(t)$.

[10] 3. An upper-sideband SSB signal can be generated using the phase shift method, where the input signal is the message f(t).

[5] (a) Draw a block diagram of the modulator and write the expression for the output signal.

[5] (b) If the input to the modulator is $\hat{f}(t)$ instead of $f(t)$, what will be the output? Is the output still an SSB signal with bandwidth equal to that of $f(t)$?

[20] 4. In amplitude modulation as a compromise between bandwidth efficiency and hardware cost, we can transmit one sideband plus a vestige of the other unwanted sideband, resulting in VSB modulation. Figure 3 shows a simplified diagram of VSB modulator.

[6] (a) Represent the spectral density $\Phi(\omega)$ at the modulator output in terms of $H(\omega)$ and the spectral density $F(\omega)$ of $f(t)$.

[10] (b) Draw a block diagram for coherent VSB demodulator and derive the spectral density of the demodulator output.

(c) How should the filter $H(\omega)$ in Figure 3 be designed such that there is no distortion in recovering $f(t)$ at the demodulator?

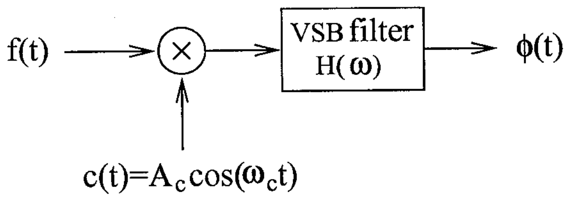

Figure 3:

Trigonometric functions:

$$\sin\alpha\sin\beta = -\frac{1}{2}[\cos(\alpha+\beta) - \cos(\alpha-\beta)]$$
$$\cos\alpha\cos\beta = \frac{1}{2}[\cos(\alpha+\beta) + \cos(\alpha-\beta)]$$
$$\sin\alpha\cos\beta = \frac{1}{2}[\sin(\alpha+\beta) + \sin(\alpha-\beta)]$$

Fourier transform pairs:

time domain	frequency domain
$\delta(t)$	1
1	$2\pi\delta(\omega)$
$\cos(\omega_c t)$	$\pi[\delta(\omega-\omega_c)+\delta(\omega+\omega_c)]$
$\sin(\omega_c t)$	$-j\pi[\delta(\omega-\omega_c)-\delta(\omega+\omega_c)]$
$f(t-t_0)$	$\exp(-j\omega t_0)F(\omega)$
$\exp(j\omega_c t)f(t)$	$F(\omega-\omega_c)$
$f_1(t) * f_2(t)$	$F_1(\omega)F_2(\omega)$
$f_1(t)f_2(t)$	$[F_1(\omega) * F_2(\omega)]/2\pi$