3.17 Weaver's SSB modulator is illustrated in Figure P-3.17. By taking the input signal as $m(t) = \cos 2\pi f_m t$ where $f_m < W$, demonstrate that by proper choice of f_1 and f_2, the output is a SSB signal.

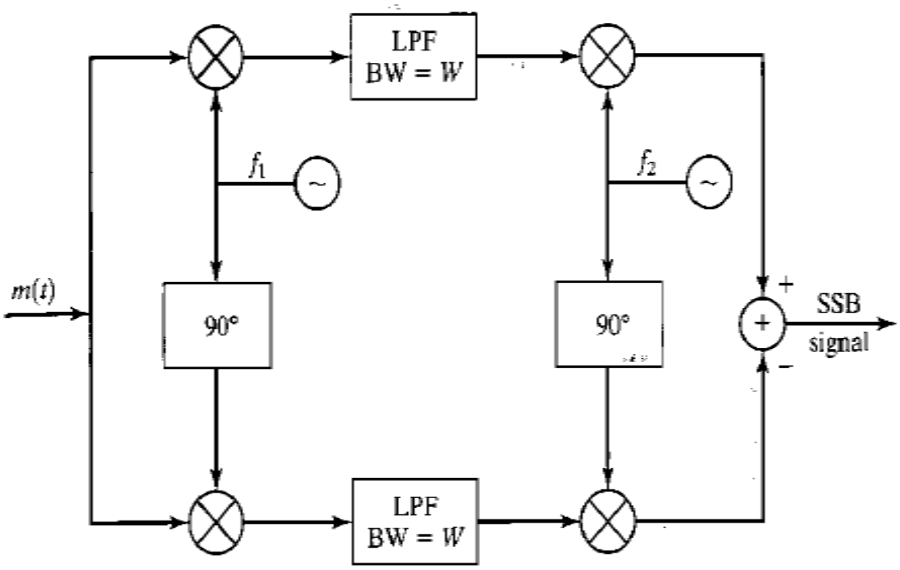

Figure P-3.17

COMPUTER PROBLEMS

3.1 Double-sideband (DSB) AM

The message signal $m(t)$ is given by

$$m(t) = \begin{cases} \text{sinc}\,(100t), & 0 \le t \le t_0 \\ 0, & \text{otherwise} \end{cases},$$

where $t_0 = 0.1$. The message signal modulates the carrier $c(t) = \cos 2\pi f_c t$, where $f_c = 250$ Hz, to produce a DSB-AM signal $u(t)$.

1. By selecting the sampling interval $t_s = 0.0001$, generate samples of $m(t)$ and $u(t)$ for $0 \le t \le t_0$ and plot them.
2. Determine and plot the spectra of $m(t)$ and $u(t)$.
3. Repeat Parts 1 and 2 when $t_0 = 0.4$, and comment on the results between $t_0 = 0.1$ and $t_0 = 0.4$.

3.2 Conventional AM

The message signal $m(t)$, which is given in Problem CP-3.1, modulates the carrier $c(t) = \cos 2\pi f_c t$ using conventional AM. The carrier frequency is $f_c = 250$ Hz and the modulation index is $a = 0.80$.

1. Plot the message signal $m(t)$ and the modulated signal $u(t)$, using a sampling interval $t_s = 0.0001$.
2. Determine and plot the spectra of the message signal $m(t)$ and the modulated signal $u(t)$.
3. Repeat Parts 1 and 2 when $t_0 = 0.4$, and comment on the results between $t_0 = 0.1$ and $t_0 = 0.4$.

3.3 Single-sideband AM

The message signal $m(t)$, which is given in Problem CP-3.1, modulates the carrier $c(t) = \cos 2\pi f_c t$ and produces the lower SSB signal $u(t)$. The carrier frequency is $f_c = 250$ Hz.

1. Plot the message signal $m(t)$, its Hilbert transform $\hat{m}(t)$, and the modulated LSSB signal $u(t)$.
2. Determine and plot the spectra of the message signal $m(t)$ and the modulated LSSB signal $u(t)$.
3. Repeat Parts 1 and 2 when $t_0 = 0.4$, and comment on the results between $t_0 = 0.1$ and $t_0 = 0.4$.

3.4 Demodulation of the DSB-AM Signal

The message signal $m(t)$, which is given in Problem CP-3.1, modulates the carrier $c(t) = \cos 2\pi f_c t$ and results in the DSB-AM signal $u(t) = m(t)c(t)$. The carrier frequency $f_c = 250$ Hz and $t_0 = 0.1$.

1. By selecting the sampling interval $t_s = 0.0001$, generate 1000 samples of the message signal $m(t)$ and the modulated signal $u(t)$, and plot both signals.
2. Demodulate the sampled DSB-AM signal $u(t)$ generated in Part 1 by using the demodulator shown in Figure CP-3.4. Perform the demodulation for $\phi = 0, \pi/8, \pi/4$, and $\pi/2$, and plot the received message signal $m_r(t)$. The lowpass filter is a linear-phase-FIR filter having 31 taps, a cutoff frequency (-3 dB) of 100 Hz, and a stopband attenuation of at least 30 dB.
3. Comment on the results obtained in Part 2.
4. Instead of using a time-domain-lowpass filter to reject the frequency components centered at $2f_c$, compute the discrete-Fourier transform (DFT) of 1000 samples of the mixer output, set to zero those frequency components centered at $2f_c$ and compute the inverse DFT to obtain the time-domain signal. Compare the results of this frequency-domain filtering with the time-domain filtering in Part 2.

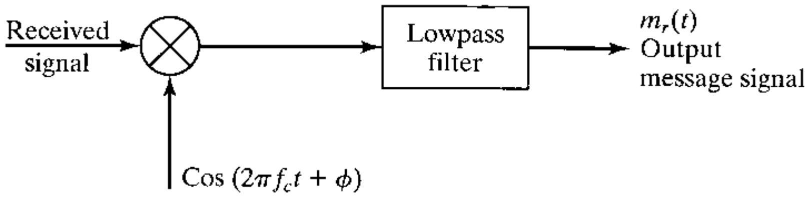

Figure CP-3.4 Demodulation for DSB-SC AM signal.

3.5 Demodulation of the SSB-AM signal

The message signal $m(t)$, which is given in Problem CP-3.1, modulates the carrier $c(t) = \cos 2\pi f_c t$ and produces the lower SSB signal $u(t)$. The carrier frequency is $f_c = 250$ Hz.

1. By selecting the sampling interval $t_s = 0.0001$, generate 1000 samples of the message signal $m(t)$, its Hilbert transform $\hat{m}(t)$, and the modulated LSSB signal $u(t)$. Plot these three signals.
2. Demodulate the sampled LSSB signal $u(t)$ generated in Part 1 by using the demodulator shown in Figure CP-3.4. Perform the demodulation for $\phi = 0,\ \pi/8,\ \pi/4$, and $\pi/2$, and plot the demodulated received message signal $m_r(t)$. The characteristics of the lowpass filter to be designed are given in Part 2 of Problem CP-3.4.
3. Comment on the results obtained in Part 2.
4. Instead of using the time-domain filter in Part 2, suppose the filtering of the frequency components centered at $2f_c$ is performed in the frequency domain by using the DFT as described in Part 4 of Problem CP-3.4. Perform the filtering in the frequency domain and compare the demodulated signal with that obtained by time-domain filtering.

3.6 Demodulation of Conventional AM

The message signal $m(t)$, which is given in Problem CP-3.1, modulates the carrier $c(t) = \cos 2\pi f_c t$ to produce a conventional-AM signal. The carrier frequency is $f_c = 250$ Hz and the modulation index is $a = 0.80$.

1. By selecting the sampling interval $t_s = 0.0001$, generate 1000 samples of the message signal $m(t)$ and the modulated conventional AM signal $u(t)$. Plot these two signals.
2. Demodulate the sampled conventional-AM signal $u(t)$ generated in Part 1 by computing the envelope of $u(t)$, i.e., by computing

   $$e(t) = \sqrt{[1 + am(t)]^2} = |1 + am(t)|$$

   and subtracting the DC value term to obtain the demodulated signal $m_r(t)$. Plot the demodulated received-message signal $m_r(t)$.
3. Comment on the results obtained in Part 2.