

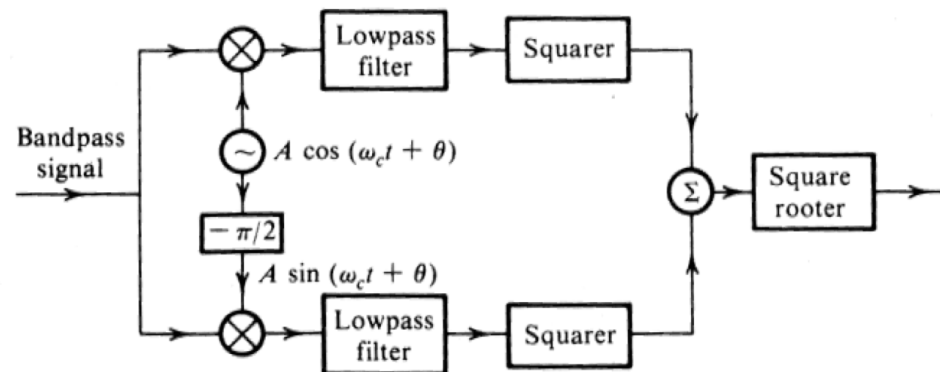
Twelve voice signals, each band-limited to 3 kHz, are frequency-multiplexed using 1 kHz guard bands between channels and between the main carrier and the first channel. The modulation of the main carrier is AM. Calculate the bandwidth of the composite channel if the subcarrier modulation is (a) DSB, (b) LSSB.

The signal $x(t) = \cos(2000\pi t)$ is used to modulate a 5 kHz carrier. Sketch the time waveforms and line spectra if the modulation used is (a) DSB, (b) AM with $\mu = 0.5$, (c) USSB, (d) LSSB.

Show that the system below acts as an envelope detector for a bandpass signal. Verify that the system can indeed demodulate an AM wave. (Hint: Consider a general bandpass signal

$$x_c(t) \cos(\omega_c t) + x_s(t) \sin(\omega_c t).$$

Show that the output is the envelope $\sqrt{x_c^2(t) + x_s^2(t)}$. Assume a narrowband signal.)



Show that a squaring circuit followed by a lowpass filter followed by a square rooter acts as an envelope detector for an AM wave. Show that if a DSB signal $x(t)\cos(\omega_c t)$ is demodulated by this scheme the output will be $|x(t)|$.

Twenty-five radio stations are broadcasting in the band between 3 MHz and 3.5 MHz. You wish to modify an AM broadcast receiver to receive the broadcasts. Each audio signal has a maximum frequency . Describe in detail the changes you would have to make to the standard broadcast superheterodyne receiver in order to receive the broadcast.

A superheterodyne receiver is tuned to a station at 20 MHz. The local oscillator frequency is 80 MHz and the IF is 100 MHz. (a) What is the image frequency? (b) If the LO has appreciable second-harmonic content, what two additional frequencies are received? (c) If the RF amplifier contains a single-tuned parallel resonant circuit with $Q = 50$ tuned to 20 MHz, what will be the image attenuation in dB?

A receiver is tuned to receive a 7.225 MHz LSSB signal. The LSSB signal is modulated by an audio signal that has a 3 kHz bandwidth. Assume that the receiver uses a superheterodyne circuit with an SSB IF filter. The IF filter is centered on 3.395 MHz. The LO frequency is on the high side of the input LSSB signal. (a) Draw a block diagram of the single-conversion superheterodyne receiver, indicating frequencies present and typical spectra of the signals at various points within the receiver. (b) Determine the required RF and IF filter specifications, assuming that the image frequency is to be attenuated by 40 dB.

Five messages with bandwidths 1 kHz, 1 kHz, 2 kHz, 4 kHz and 4 kHz respectively are to be time-division multiplexed. You have a 4 input multiplexer with a maximum sampling rate of 8 kHz and an 8 kHz clock. Design a system, in block diagram form, that will multiplex these signals plus an 8 kHz marker.

In an FDM communication system, the transmitted baseband signal is $x(t) = m_1(t)\cos(\omega_1 t) + m_2(t)\cos(\omega_2 t)$. The system under study has a second-order nonlinearity between transmitter input and receiver output.

Thus, the received baseband signal can be expressed as

$y(t) = a_1 x(t) + a_2 x^2(t)$. Assuming that the two message signals $m_1(t)$ and $m_2(t)$ have spectra $M_1(f) = M_2(f) = \Pi(f/W)$ sketch the spectrum of $y(t)$. Discuss the difficulties encountered in demodulating the received baseband signal. In many FDM systems the subcarrier frequencies ω_1 and ω_2 are harmonically related. Describe any additional problems this presents.

A superheterodyne receiver is designed to cover the RF frequency range of 45 to 860 MHz, with channel spacings of 8 MHz and an IF of 40 MHz.

Assume high-side injection. (a) If the receiver down-converts the RF signals to an IF of 40 MHz, calculate the range of frequencies for the LO. (b) Calculate the range of image frequencies. (Note that the band of image frequencies and the signal band overlap. This is undesirable. So we up-convert to a higher IF of 1.2 GHz.) (c) Calculate the new range of frequencies for the LO. (d) Determine the range of image frequencies.

You have a crystal-controlled 100 kHz oscillator and as many divide-by- n counters ($n \leq 10$), voltage-controlled oscillators, phase detectors and highpass filters as needed. Design a frequency synthesizer that will generate a 343 kHz signal.

An analog multiplier, a lowpass filter with transfer function $H(s) = \frac{0.1s + 100}{s}$ an amplifier with gain $K_a = 10$ and a VCO with $K_v = 2$ MHz/volt are used to make a phase-locked loop. Using the linearized model of a phase-locked loop find the closed-loop system poles. Is this phase-locked loop stable?

A stable phase-locked loop is locked. The input signal's phase suddenly jumps up by a small amount. Describe the sequence of events in the system that makes it settle to a new locked state with the new input signal phase.

A stable phase-locked loop is locked. The input signal's frequency suddenly drops by a small amount. Describe the sequence of events in the system that makes it settle to a new locked state with the new input signal frequency.

A stable phase locked-loop is operating in a locked condition and the output of the lowpass filter is a small positive voltage. The amplitude of the input signal suddenly doubles. The phase-locked loop is momentarily perturbed but soon quickly settles into a new locked state. What happens to the phase relationship between the input signal and the VCO output signal and what happens to the lowpass filter output signal?