As shown in the data sheet, this approach does not require the use of transformers or tuned circuits. The balanced modulator function is achieved with matched transistors in the differential amplifiers, with the modulating signal controlling the emitter current of the "diff-amps." The carrier signal is applied to switch the diff-amps' bases, resulting in a mixing process with the mixing product signals out of phase at the collectors. This is an extremely versatile device since it can be used not only as a balanced modulator but also as an amplitude modulator, synchronous detector, FM detector, or frequency doubler.

## 4-3 SSB Filters

Once the carrier has been eliminated, it is necessary to cancel one of the sidebands without affecting the other one. This requires a sharply defined filter, as Figure 4-3 helps illustrate. Voice transmission requires audio frequencies from about 100 Hz to 3 kHz. Therefore, the upper and lower sidebands generated by the balanced modulator are separated by 200 Hz, as shown in Figure 4-3.

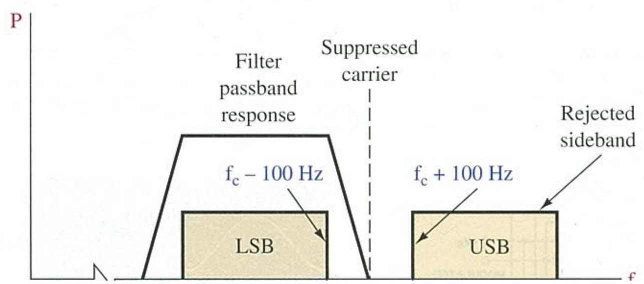
The required $Q$ depends on the center or carrier frequency, $f_c$; the separation between the two sidebands, $\Delta f$; and the desired attenuation level of the unwanted sideband. It can be calculated from

$$Q = \frac{f_c(\log^{-1} \mathrm{dB}/20)^{1/2}}{4\Delta f} \tag{4-1}$$

where dB is the suppression of the unwanted sideband.

**Example 4-1**

*Calculate the required Q for the situation depicted in Figure 4-3 for*
*(a) A 1-MHz carrier and 80-dB sideband suppression.*
*(b) A 100-kHz carrier and 80-dB sideband suppression.*




**Solution**

(a)

$$Q = \frac{f_c(\log^{-1} \mathrm{dB}/20)^{1/2}}{4\Delta f}$$

$$= \frac{1\ \mathrm{MHz}(\log^{-1} 80/20)^{1/2}}{4 \times 200\ \mathrm{Hz}} = \frac{1 \times 10^6(10^4)^{1/2}}{800}$$

$$= \frac{1 \times 10^8}{8 \times 10^2} = 125{,}000$$

(b)

$$Q = \frac{100\ \mathrm{kHz}(\log^{-1} 80/20)^{1/2}}{4 \times 200\ \mathrm{Hz}}$$

$$= \frac{10^7}{8 \times 10^2} = 12{,}500$$

A practical consequence of the preceding example is that the would be generated around the lower 100-kHz carrier in conjunction filter. Then, after removing one sideband, an additional frequency trans ally employed to get the sideband up to the desired frequency range complished with a mixer circuit.

Both SSB transmitters and receivers require selective bandpass region of 100 to 500 kHz. In receivers a high order of adjacent chann required if channels are to be closely spaced to conserve spectrum sp used, therefore, must have very steep skirt characteristics (fast roll- bandpass characteristic to pass all frequencies in the band equally well. quirements are met by crystal filters, ceramic filters, and mechanical f type of high-$Q$ filter of more recent popularity is the **surface acousti filter.** It is often used in TV and radar applications and is treated in C most applicable to higher frequencies than are typically used in SSB

### Crystal Filters

The crystal filter is commonly used in single-sideband systems to at wanted sideband. Because of its very high $Q$, the crystal filter pass rower band of frequencies than the best $LC$ filter. Crystals with a 50,000 are available.

The equivalent circuit of the crystal and crystal holder i Figure 4-4(a). Recall that the basics of crystal operation were introduc The components $L_s$, $C_s$, and $R_s$ represent the series resonant circuit self. $C_p$ represents the parallel capacitance of the crystal holder. T a very low-impedance path to the frequency to which it is reso impedance path to other frequencies. However, the crystal holder shunts the crystal and offers a path to other frequencies. For the cry a bandpass filter, some means must be provided to counteract the s the crystal holder. This is accomplished by placing an external var the circuit [$C_1$ in Figure 4-4(b)].

In Figure 4-4(b), a simple bandpass crystal filter is shown.