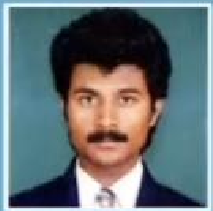

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DIGITAL COMMUNICATION

- Prof. N. B. Kanirkar

- SSB Generation & Reception

SSB Generation

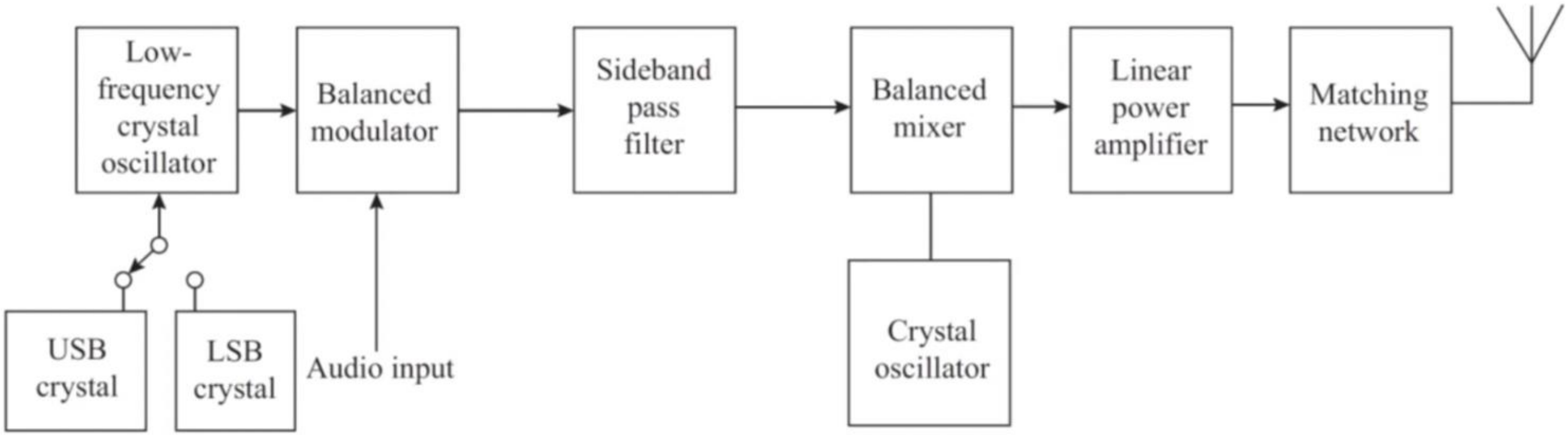
Balanced Modulator–Filter Method

Early SSB transmitters used balanced modulator circuits to generate DSBSC signals followed by sideband filters to remove the unwanted sidebands. Such a transmitter is illustrated in Fig. Initial modulation takes place in the balanced modulator at a low frequency (such as 100 kHz) because of the difficulty of making adequate filters at higher frequencies. The filter is a band-pass filter with a sharp cutoff at each side of the band-pass to obtain satisfactory adjacent sideband rejection. In this case, a single-sideband filter is used, and the carrier oscillator crystal is switched to place the desired sideband in the filter window. Alternatively, two sideband filters (one for each sideband) could be used with a fixed carrier frequency.

The filtered signal is up-converted in a mixer (the second balanced modulator) to the final transmitter frequency and then amplified before being coupled to the antenna. Linear power amplifiers are used to avoid distorting the sideband signal, which might result in regeneration of the second sideband or distortion of the modulated information signal.

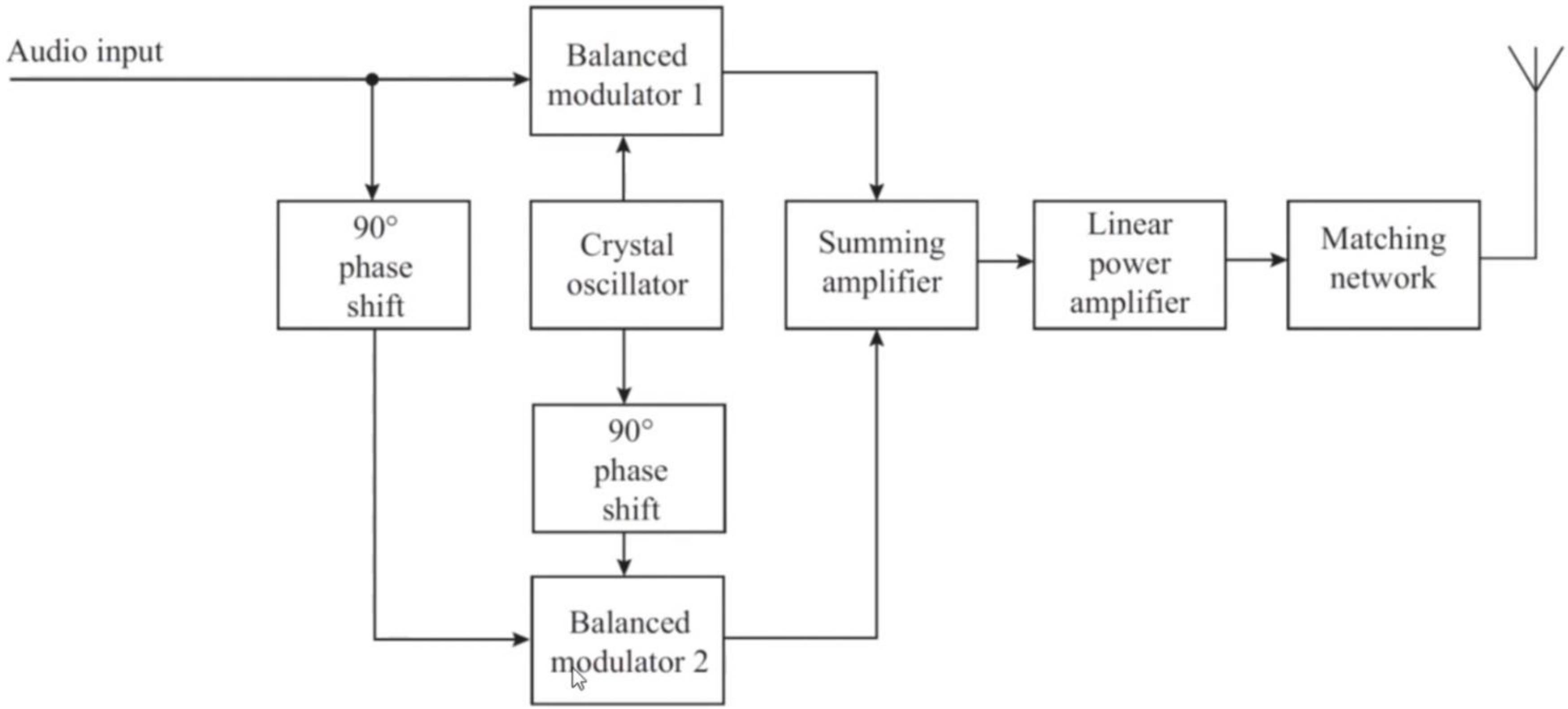
The sideband filters are the critical part of this system. Early sideband filters were expensive and did not have the sharp cutoff characteristic required. The integrated ceramic filters available now offer a very inexpensive and effective solution to this problem.

Filter Method



Single-sideband suppressed carrier transmitter using band-pass filters to eliminate the unwanted sideband.

Phasing Method



SSB suppressed carrier transmitter using phase shift to obtain cancellation of sidebands.

Phasing Method

Figure shows a different means of obtaining an SSBSC signal. This circuit does not have any sideband filters, and the primary modulation can be done at the transmitting frequency. It relies on phase shifting and cancellation to eliminate the carrier and the unwanted sideband.

Assume cosinusoidal signals for both carrier and modulation and that the circuit shown produces the lower side frequency, given by

$$e_{\mathrm{LSF}} = E_{L\,\max} \cos(\omega_c - \omega_m)t$$

The standard trigonometric identity for the difference of two angles gives

$$e_{\mathrm{LSF}} = E_{L\,\max} [\cos \omega_c t \cos \omega_m t + \sin \omega_c t \sin \omega_m t]$$

but

$$\sin \omega_c t = \cos\left(\omega_c t - \frac{\pi}{2}\right)$$

$$\sin \omega_m t = \cos\left(\omega_m t - \frac{\pi}{2}\right)$$

$$e_{\text{LSF}} = E_{L\,\max}\left[\cos\omega_c t \cos\omega_m t + \cos\left(\omega_c t - \frac{\pi}{2}\right)\cos\left(\omega_m t - \frac{\pi}{2}\right)\right]$$

The first term on the right of above Equation is the result of balanced modulator 1, which multiplies the two unshifted signals. The second term is the result of balanced modulator 2, which multiplies the two signals, each shifted by 90. The 90 shift for the carrier is easily accomplished by feeding the signal through a controlled current source (transconductance amplifier) into a capacitor. The phase shifting network for the baseband signal must accurately provide a constant 90 phase shift over a wide frequency range. Such circuits are tricky to build.

The carrier signal is canceled out in this circuit by both of the balanced modulators, and the unwanted sidebands cancel at the output of the summing amplifier. It is left as an exercise for the student to expand the outputs of the two balanced modulators into sideband form and show that the cancellation does occur on summing. The two outputs are summed to produce the lower sideband signal.

Examination of the trigonometric identity shows that if the two outputs are subtracted instead of added the upper sideband will result, since

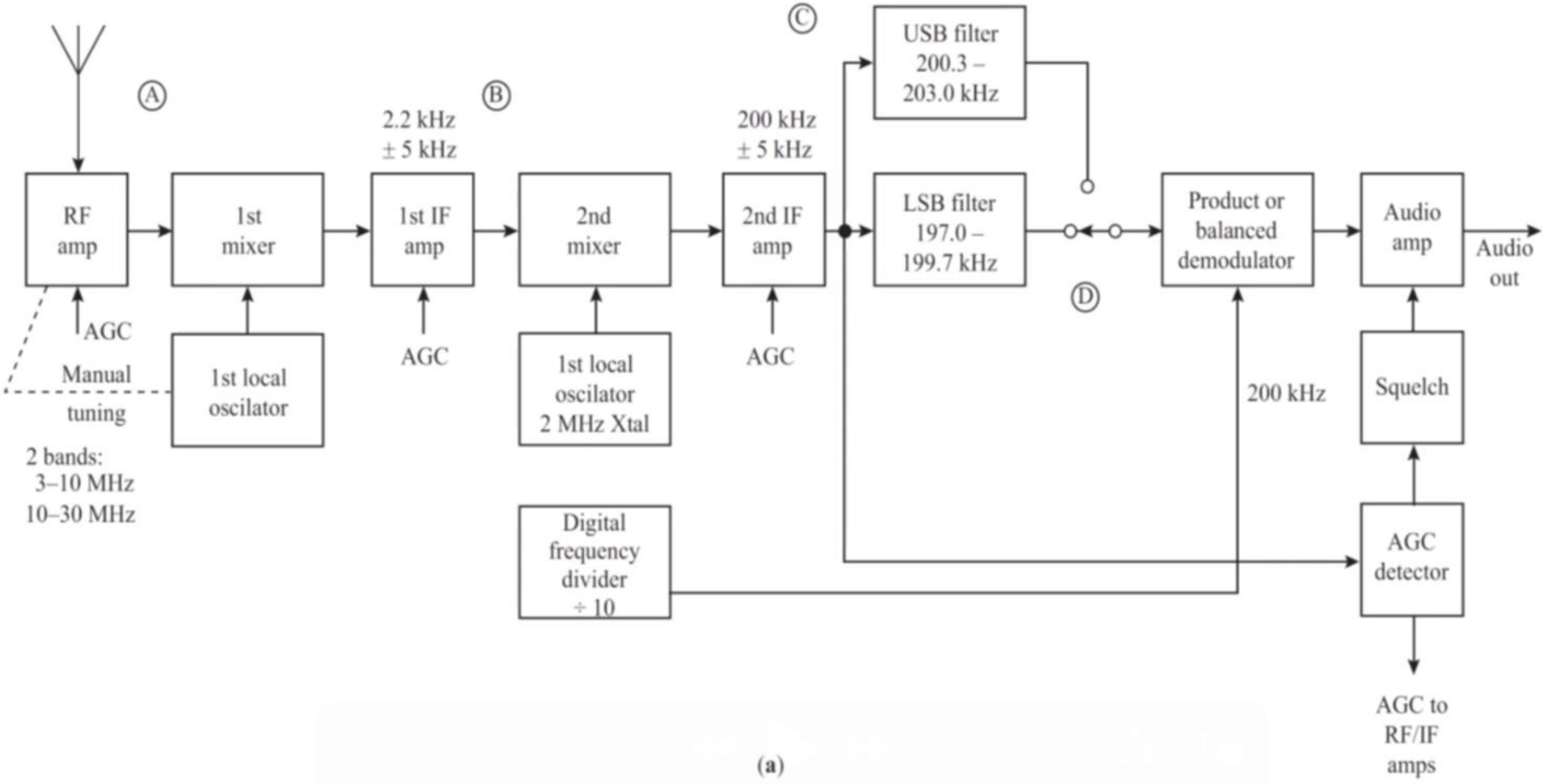
$$
\begin{aligned}
e_{\mathrm{USF}} &= E_{U\,\max} \cos(\omega_c + \omega_m)t \\
&= E_{U\,\max} \left[\cos \omega_c t \cos \omega_m t - \sin \omega_c t \sin \omega_m t\right]
\end{aligned}
$$

While the system is more complex than one using filters, the individual circuits are quite straightforward, and by using integrated-circuit balanced modulators, very little adjustment is required. Only a simple band-pass filter to remove any harmonics is required in the output before application to the final transmitter amplifier.

It should be noted that the modulation signal is usually a broad band of frequencies of varying amplitudes, which the modulator system must not distort. If the capacitor–transconductance amplifier combination causes such distortion, complete cancellation of the unwanted sideband will not occur, and the wanted sideband will have distortions introduced into it.

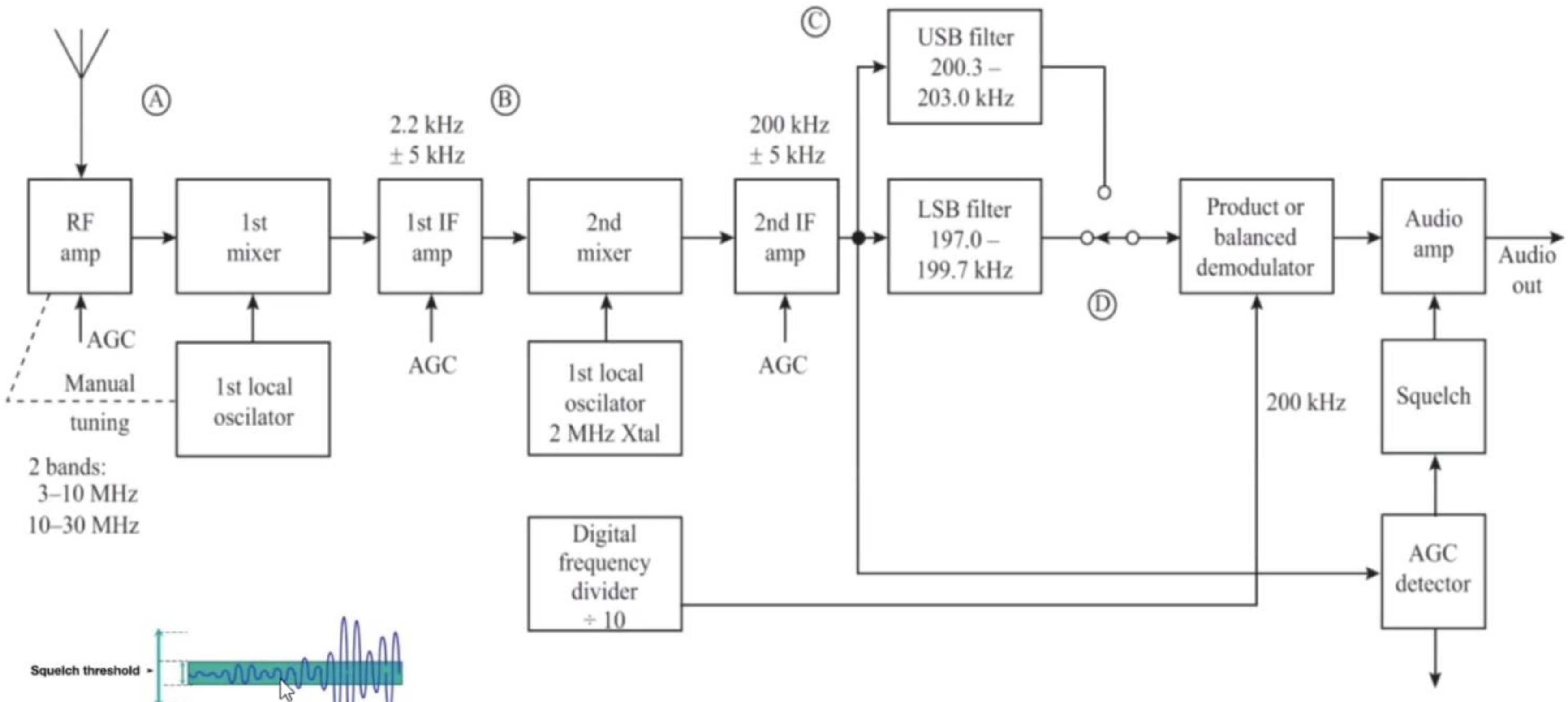
The third method described next eliminates this problem.

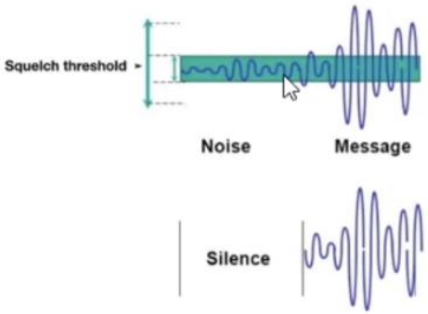
SSB HF Receiver



(a) Single-sideband HF receiver

SSB HF Receiver





(a) Single-sideband HF receiver

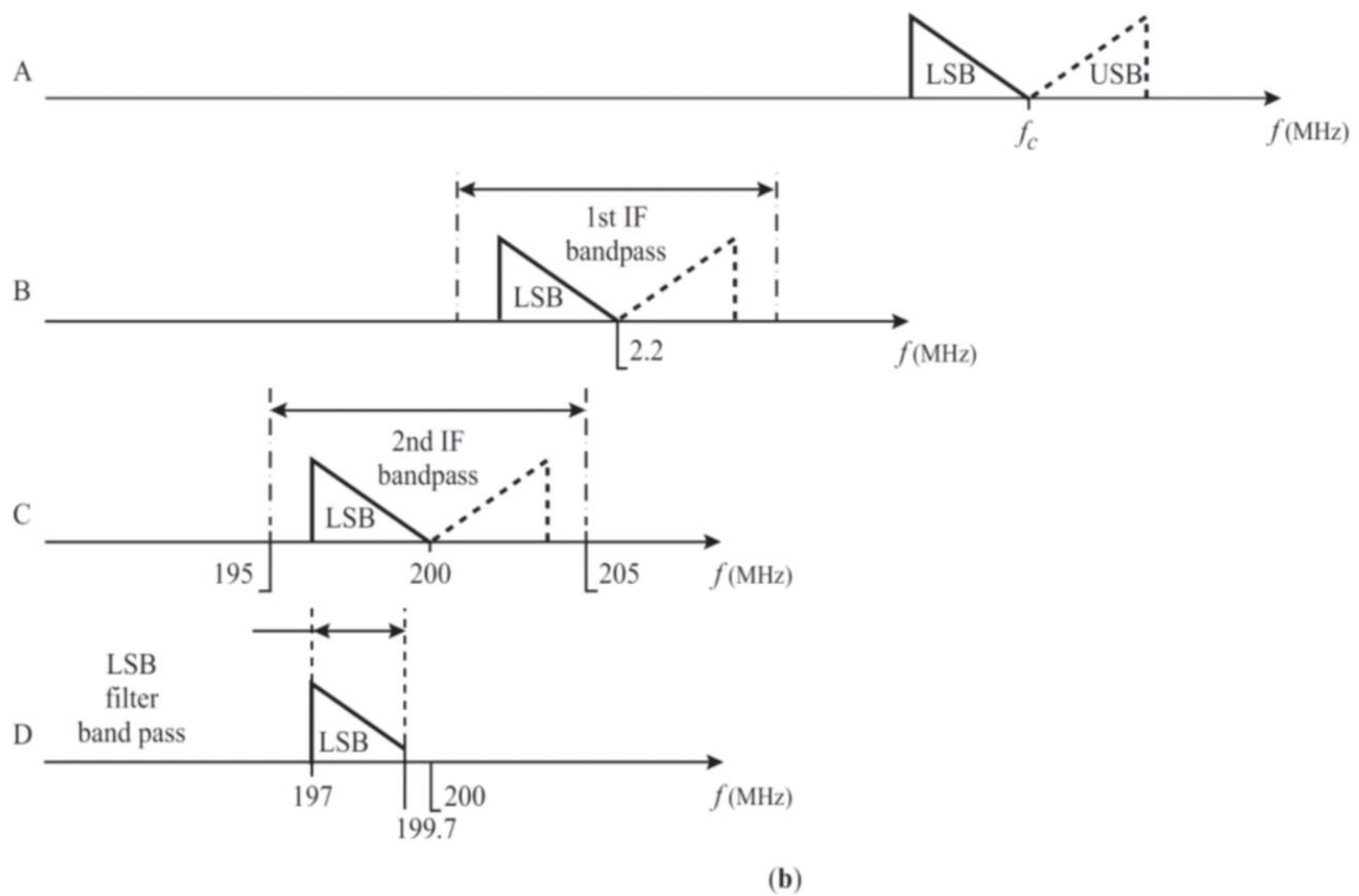
In telecommunications, squelch is a circuit function that acts to suppress the audio output of a receiver in the absence of a strong input signal. Essentially, squelch is a specialized type of noise gate designed to suppress weak signals

Balanced modulator circuits or product demodulator circuits are used for demodulation. The carrier signal for the demodulator must be locally generated if the signals are true SSB signals with the carrier completely suppressed. This requires extreme stability for the local oscillator signals used for demodulating and for the superheterodyne converters in the receiver front end. Crystal-controlled oscillators are universally used, often in conjunction with frequency synthesizer circuits.

Very good adjacent channel selectivity must be provided since SSB signals are usually packed closely together in the frequency spectrum. Double conversion is often used in SSB receivers. The second mixer oscillator is crystal controlled and may also provide a primary frequency reference for the demodulator oscillator and the first converter oscillator.

Several variations on SSB are used in communications. First, either the upper or lower sideband may be used for a particular channel. In some cases, as for stereo or for telephone multiplexing, the two sidebands of a carrier may be independently modulated with different signals. Next, a reference or *pilot* carrier signal may be transmitted (not necessarily at the same frequency as the actual suppressed SSB carrier). In another method a partial synchronous carrier may be transmitted with the SSB signal (that is, a normal carrier signal, but at much lower amplitude).

SSB HF Receiver Spectra



(b) Spectra in the HF receiver for an LSB signal: Ⓐ, received RF signal: Ⓑ, output of first IF amp; Ⓒ, output of second IF amp; Ⓓ, output of LSB filter.

Figure shows the block diagram of a scanning communications receiver designed for SSB reception in the HF range (3 to 30 MHz). The circuitry is that of a standard double-conversion AM receiver down to the output of the second IF amplifier, except for the local oscillators. The first IF has a bandwidth of 10 kHz centered at 2.2 MHz. The second IF also has a bandwidth of 10 kHz, but centered at 200 kHz, down to the SSB filter inputs. This band-pass is wide enough to pass a normal AM signal (or two adjacent SSB signals), and an envelope detector could be added at this point to allow for AM reception as well as SSB.

The first local oscillator and RF amplifier are manually tuned in two switched bands. The second local oscillator is crystal controlled at 2 MHz. Its output is divided by 10 in a digital counter to provide the 200 kHz carrier signal for the demodulator.

Two SSB filters follow the second IF amplifier. The USB filter passes the IF upper sideband of 200.3 to 203 kHz and rejects the lower sideband. The LSB filter passes the 197- to 199.7-kHz IF lower sideband. The appropriate sideband is selected by a switch that connects the output of the desired filter to the product detector. The RF oscillator must be adjusted to position the incoming SSB IF signal in the IF band-pass so that it exactly falls in the selected SSB filter window and matches the 200-kHz demodulator oscillator to allow distortionless reception.

The output from the detector is passed through a gated audio amplifier that turns off the output to keep the noise down when the signal level drops below a preset threshold. This is called *squelch.* The amplified IF signal (before the detector) is rectified to provide the AGC voltage for the RF and IF amplifiers and for the squelch circuit.


Bye


Thank you