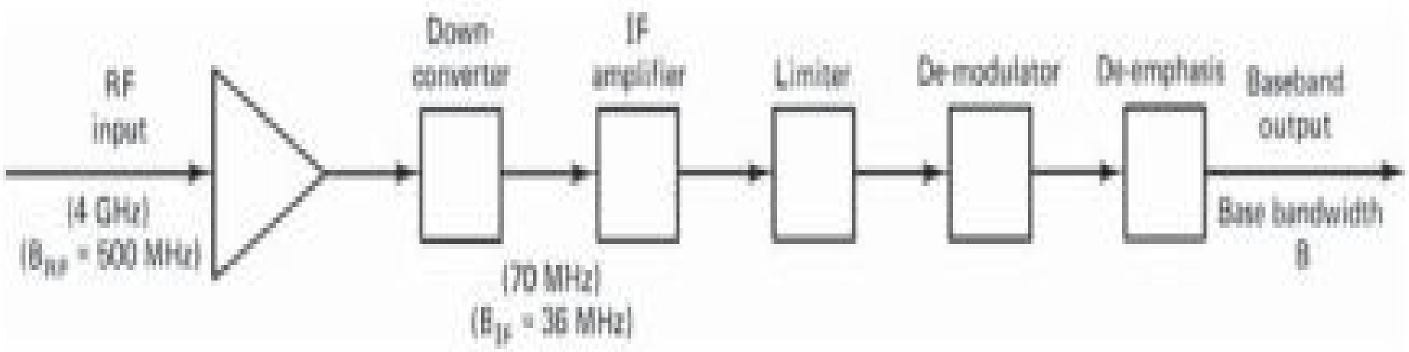
Frequency Modulation

- transferred to the microwave carrier by means of FM. Instead of being done in one step, this modulation usually takes place at an intermediate frequency. signal is then frequency multiplied up to the required uplink microwave frequency. In the receive branch of the incoming (downlink) FM microwave signal is downconverted to an intermediate frequency, and the baseband signal is recovered from the intermediate frequency (IF) carrier in the demodulator. The actual baseband video signal is now available directly via a low-pass filter, but the audio channels must each undergo an additional step of FM demodulation to recover the baseband audio signals. A major advantage associated with FM is the improvement in the postdetection signal-to-noise ratio at the receiver output compared with other analog modulation methods. This improvement can be attributed to three factors:

- Amplitude limiting
- A property of FM which allows an exchange between signal-to-noise ratio and bandwidth
- A noise reduction inherent in the way noise phase modulates a carrier These factors are discussed in more detail in the following sections.

the basic circuit blocks of an FM receiver. The receiver noise, including that from the antenna, can be lumped into one equivalent noise source at the receiver input, as described. It is emphasized at this point that thermal-like noise only is being considered, the main characteristic of which is that the spectral density of the noise power is constant. This is referred to as a flat spectrum. (This type of noise is also referred to as white noise in analogy to white light, which contains a uniform spectrum of colors.) Both the signal spectrum and the noise spectrum are converted to the



RF
input
(4 GHz)
(B_{RF} = 500 MHz)
Down-
converter
IF
amplifier
Limiter
De-modulator
De-emphasis
Baseband
output
Base bandwidth
B
(70 MHz)
(B_{IF} = 36 MHz)

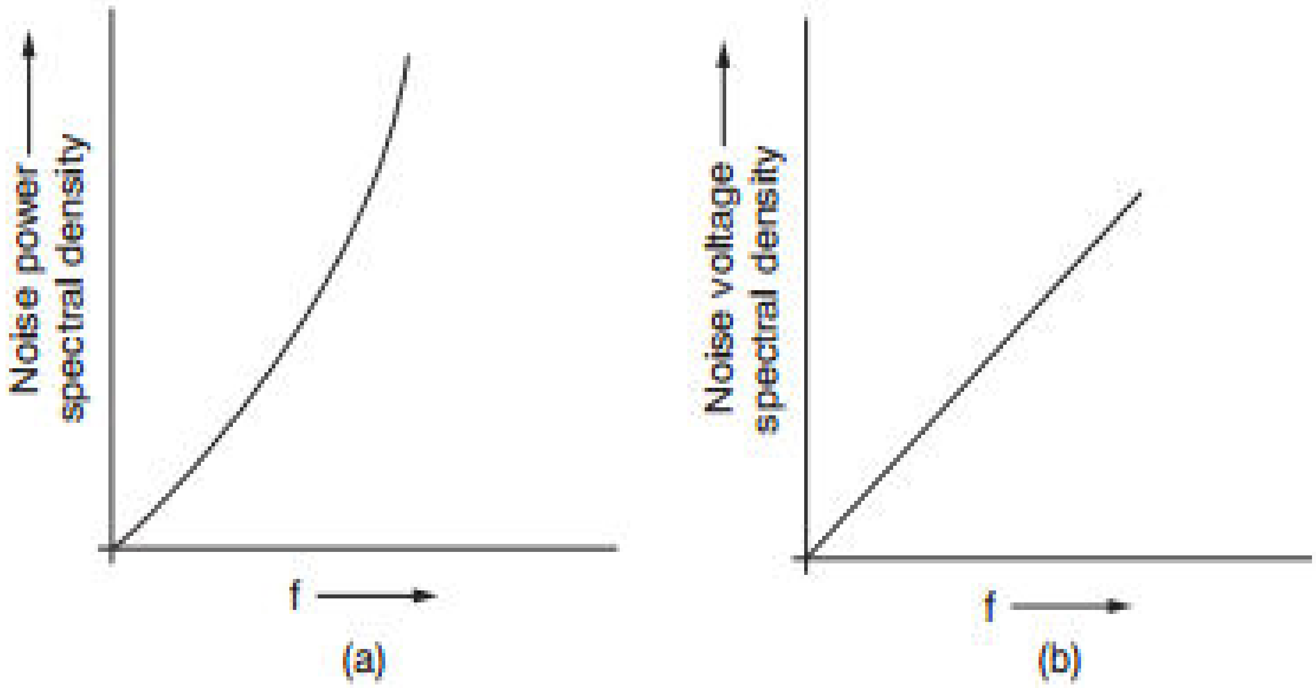
- a telephony channel is typically 3.1 kHz. In theory, the spectrum of a frequency-modulated carrier extends to infinity. In a practical satellite system, the bandwidth of the transmitted FM signal is limited by the intermediate-frequency amplifiers. The IF bandwidth, denoted by BIF, must be wide enough to pass all the significant components in the FM signal spectrum that is generated. The required bandwidth is usually estimated by Carson's rule as

$$B_{\mathrm{IF}} = 2(\Delta F + F_M)$$

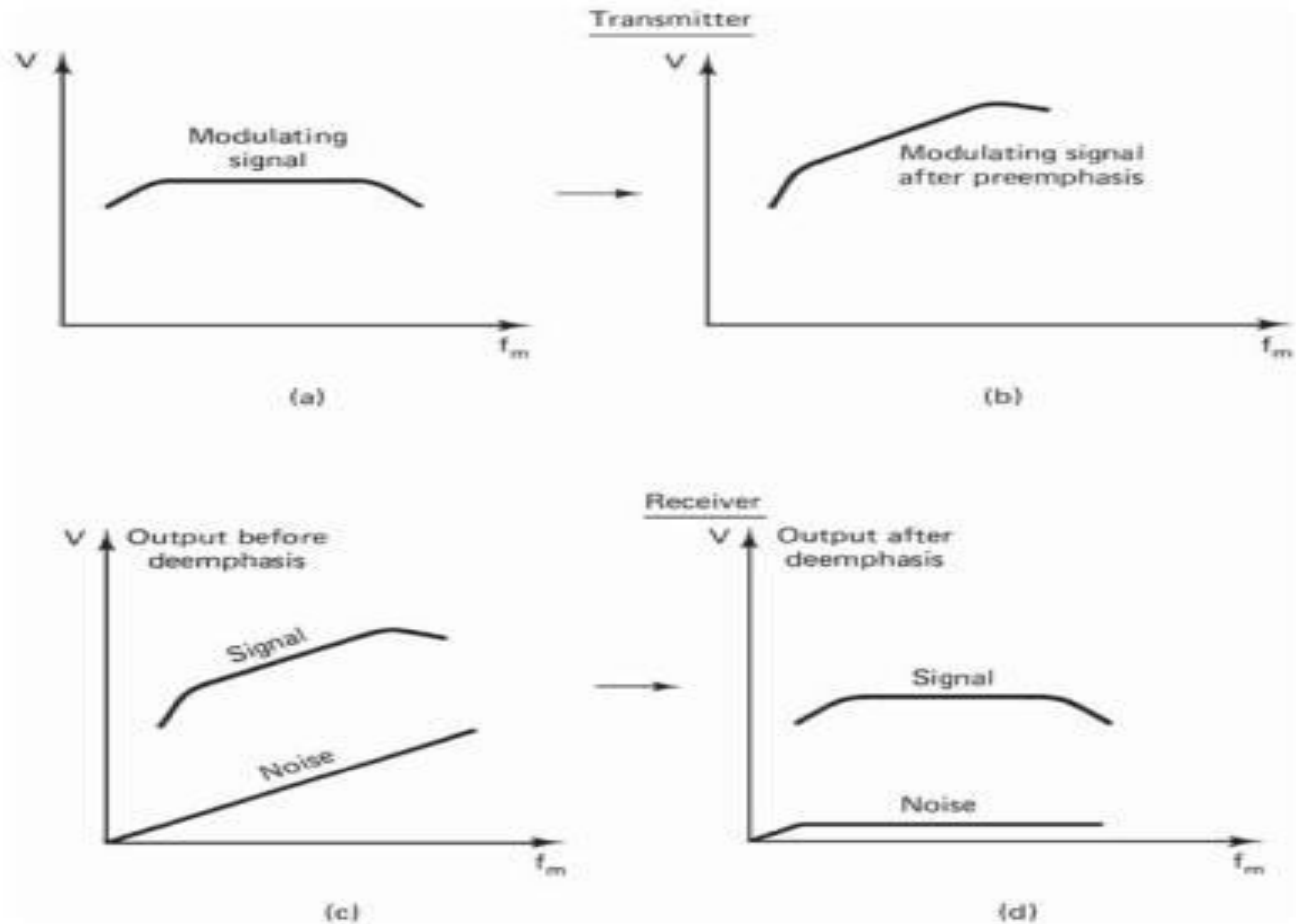
Preemphasis and deemphasis

- the noise voltage spectral density increases in direct proportion to the demodulated noise frequency. As a result, the signal-to-noise ratio is worse at the high-frequency end of the basebanda fact which is not apparent from the equation for signal-to-noise ratio, which uses average values of signal and noise power. For example, if a test tone is used to measure the signal-to-noise ratio in a TV baseband channel, the result will depend on the position of the test tone within the baseband, a better result being obtained at lower test tone frequencies.
- For FDM/FM telephony, the telephone channels at the low end of the FDM baseband would have better signal-to-noise ratios than those at the high end

- To equalize the performance over the baseband, a deemphasis network is introduced after the demodulator to attenuate the high-frequency components of noise. Over most of the baseband, the attenuation-frequency curve of the deemphasis network is the inverse of the rising noisefrequency characteristic shown in Fig. after deemphasis, the noise-frequency characteristic is flat, as shown in Fig. 9.13d. Of course, the deemphasis network also will attenuate the signal, and to correct for this, a complementary preemphasis characteristic is introduced prior to the modulator at the transmitter. The overall effect is to leave the postdetection signal levels unchanged while the high-frequency noise is attenuated.



(a) Output noise power spectral density for FM. (b) The corresponding noise voltage spectral density.



(a and b) Effect of preemphasis on the modulating signal frequency response at the transmitter. (c and d) Effect of deemphasis on the modulating signal and noise at the receiver output. The deemphasis cancels out the preemphasis for the signal while attenuating the noise at the receiver

- The resulting improvement in the signal-to-noise ratio is referred to variously as preemphasis improvement, deemphasis improvement, or simply as emphasis improvement. It is usually denoted by P, or [P] decibels, and gives the reduction in the total post detection noise power. Preemphasis curves for FDM/FM telephony are given in CCIR Recommendation) and for TV/FM in CCIR Recommendation 405-1. CCIR values for [P] are 4 dB for the top channel in multichannel telephony, 13.1 dB for 525-line TV, and 13.0 dB for 625-line TV. Taking into account the emphasis improvement, as per given equation.

$$\left[\frac{S}{N}\right] = \left[\frac{C}{N}\right] + [G_p] + [P]$$

Signal-to-noise ratio

- The term signal-to-noise ratio introduced and is used to refer to the ratio of signal power to noise power at the receiver output. This ratio is sometimes referred to as the postdetector or destination signalto-noise ratio. In general, it differs from the carrier-to-noise ratio at the detector input (the words detector and demodulator may be used interchangeably), the two ratios being related through the receiver processing gain in decibel form as

$$10\log_{10}\frac{S}{N} = 10\log_{10}\frac{C}{N} + 10\log_{10}G_P$$

- As indicated in App. G, it is useful to use brackets to denote decibel quantities where these occur frequently

$$\left[\frac{S}{N}\right] = \left[\frac{C}{N}\right] + [G_P]$$

This shows that the signal-to-noise in decibels is proportional to the carrier-to-noise in decibels. However, these equations were developed for the condition that the noise voltage should be much less than the carrier voltage. At low carrier-to-noise ratios this assumption no longer holds, and the detector exhibits a threshold effect. This is a threshold level in the carrier-to-noise ratio below which the signal-to-noise ratio degrades very rapidly.

Signal-to-noise ratio for TV/FM

- Television performance is measured in terms of the postdetector video signal-to-noise ratio, defined as

(S/N)v="peak-to-peak video voltage"/rms noise voltage

Because peak-to-peak video voltage is used, 2ΔF replaces ΔF in Eq.

. Also, sinc $\left(\frac{S}{N}\right)_v^2 = 1.5\frac{C}{N}\frac{B_N(2\Delta F)^2}{W^3}$ onal to voltage squared,

where W is the highest video frequency. With the deviation ratio D = ΔF/W, and the processing gain for TV denoted as G_{PV},

$$
\begin{aligned}
G_{PV} &= \frac{(S/N)_V^2}{C/N} \\
&= 12D^2(D+1)
\end{aligned}
$$

digital modulation and demodulation,