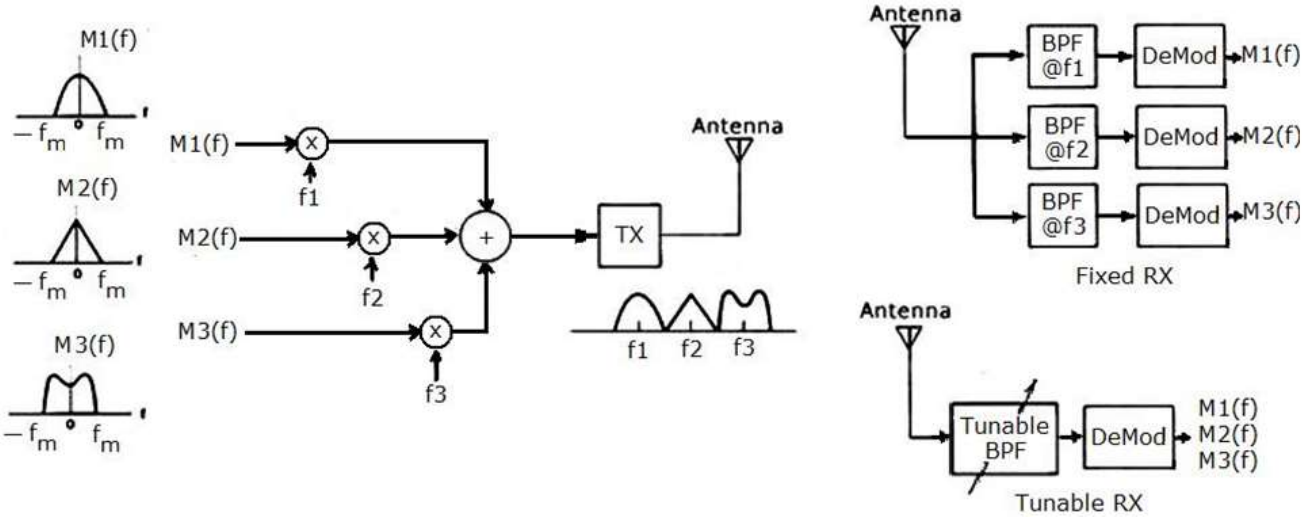
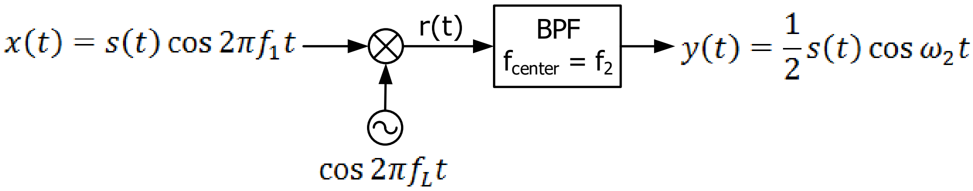
3.3 FREQUENCY DIVISION MULTIPLEXING (FDM)

It is possible to send several signals simultaneously by choosing different carrier frequency for each signal. These carriers must be chosen so that the signals spectra do not overlapping. This technique is used basically in the commercial radio and TV stations. In practical AM radio broad-casting stations, they are allocated 10kHz per station i.e. 5kHz per sideband. *Is it sufficient?*



3.4 CARRIER FREQUENCY CONVERSION

Which sometimes referred to as frequency translating, changing, mixing, or heterodyning. Suppose that we have a modulated wave $s(t)$ whose spectrum is centered on a carrier frequency f_1 and the requirement is to translate it upward/downward in frequency such that its carrier frequency is changed from f_1 to a new value f_2. This requirement may be accomplished using the mixer shown in Figure below.



Where the local oscillator frequency $f_L = f_1 \pm f_2$

If $x(t) = s(t)\cos(\omega_1 t)$ then

$r(t) = x(t)\cos(\omega_L t)$

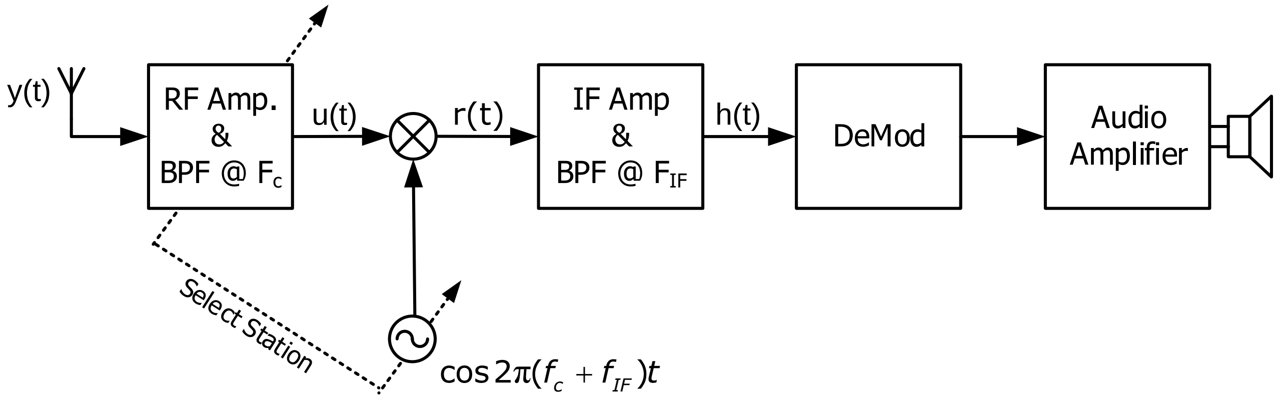
$= s(t) \times \cos(\omega_1 t) \times \cos[(\omega_1 + \omega_2)t]$

$= \frac{1}{2}s(t)\cos(\omega_2 t) + \frac{1}{2}s(t)\cos[(2\omega_1 + \omega_2)t]$, the last term removed by the BPF Amplifier.

$\therefore y(t) = \frac{1}{2} s(t) \cos(\omega_2 t)$

3.5 Super-Heterodyne Receiver

For commercial radio receivers, it is difficult to design a good demodulator for wide range of frequencies. In this type, the carrier of the incoming signal is translated to a fixed frequency value (called intermediate frequency $f_{IF} = 455\text{kHz}$), and finally demodulated by well designed system.



If $y(t) = m(t) \cos \omega_c t$ then for the moment, let $u(t) = y(t)$, the frequency convertor results:

$h(t) = \frac{1}{2} m(t) \cos(\omega_{IF} t)$

Which represent the main message signal $m(t)$ re-modulated by new carrier of the value f_{IF} .

Image Station Problem

Now, suppose there is another station with a carrier $f_C + 2f_{IF}$ is available at the receiving input, so:

$$u(t) = y_1(t) + y_2(t)$$
$$= m_1(t) \cos(\omega_c t) + m_2(t) \cos[(\omega_c + 2\omega_{IF})t]$$
$$r(t) = \frac{1}{2} m_1(t)\{\cos(\omega_{IF} t) + \cos[(2\omega_c + \omega_{IF})t]\} + \frac{1}{2} m_2(t)\{\cos(\omega_{IF} t) + \cos[(2\omega_c + 3\omega_{IF})t]\}$$
$$\therefore h(t) = \frac{1}{2} [m_1(t) + m_2(t)] \cos(\omega_{IF} t)$$

Which means both *m1* and *m2* will pass to the demodulator (overlapping). So, in the super-heterodyne receivers, for each desired station frequency f_c there is an *image station* at frequency $= f_C + 2f_{IF}$ which called the *image frequency*. The RF-Amplifier stage of the super-heterodyne receiver prevents an image station from passing.