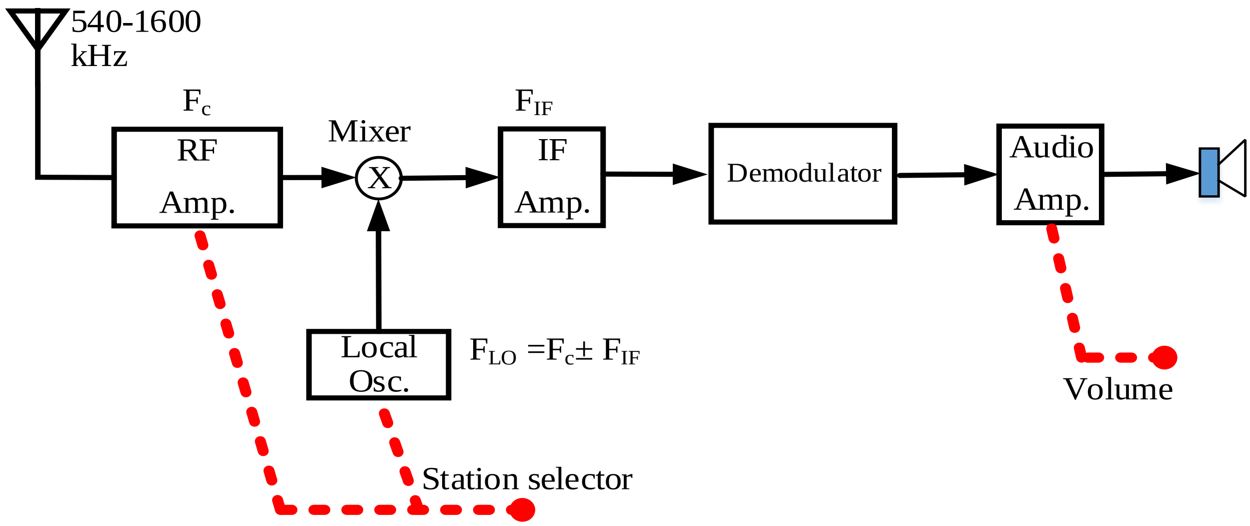
3- Superhytrodyne receiver:



The incoming modulated signal (with carrier frequency f_c) is translated to a new center frequency called Intermediate Frequency F_{IF} (for Am:455 kHz,(MW) for FM:10.7 MHz, for TV: 44 MHz.) by multiplying the incoming modulated signal by variable local carrier $F_{LO} = F_C \pm F_{IF}$. For example if AM station at 600 kHz is designed and if the local oscillator operates above the incoming frequency, the local frequency would be $600 + 455 = 1055\ kHz$. Mixing $1055\ kHz$ with $600\ kHz$ produces two frequencies $1655\ kHz$ and $455\ kHz$, the IF amplifier would pass the frequency $455\ kHz$ and thus the incoming frequency is translated to intermediate frequency.

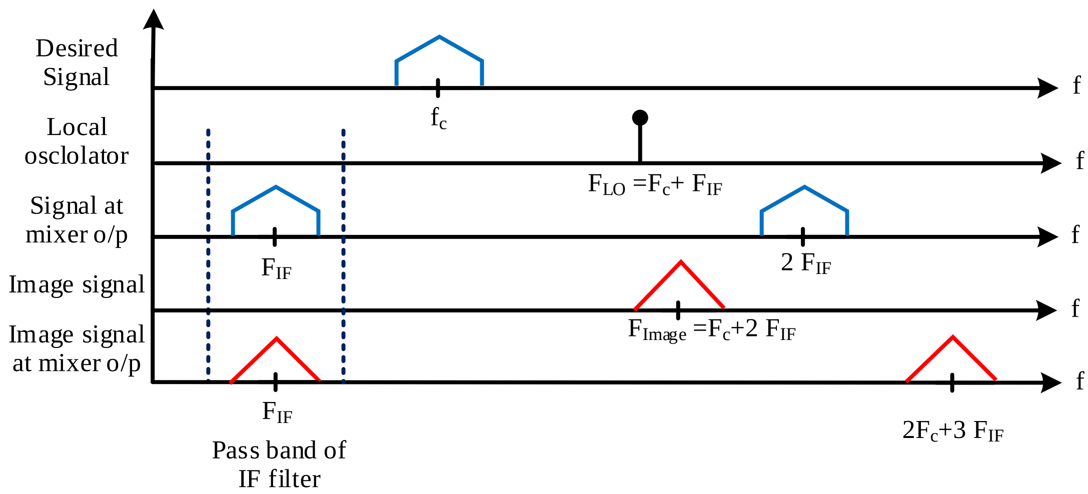
Advantages:

- The amplification and filtering is performed at a fixed frequency regardless of station selection.

Disadvantages:

- High gain IF stages are tuned outside the assigned frequency band.
- Image frequency problem:

If the desired station at $F_C = 600\,kHz$, the local carrier would be $F_{LO} = F_C + F_{IF} = 1055\,kHz$, if there is another station at $F_{image} = 1510 = (F_C + 2F_{IF})$ it would be also received (since $1510 - 1055 = 455\,kHz$).



Notes:

- $F_{Image} = F_C + 2F_{IF}$ when $F_{LO} = F_C + F_{IF}$ …(4-29)
- $F_{Image} = F_C - 2F_{IF}$ when $F_{LO} = F_C - F_{IF}$ …(4-30)
- To avoid image frequency problems, we choose F_{IF} such that:

  $2\,F_{IF} \geq F_{max} - F_{min}$ …(4-31)

Where F_{max} & F_{min} are the maximum and minimum allowed operating frequencies of the receiver.

Ex 4.11:

A given radar receiver operating at a frequency of 2.8 GHz and using a superhytrodyne principle has local oscillator frequency of 2.86 GHz. A second radar receiver operate at the image frequency of the first and interference results.

a) Determine the intermediate frequency of the first radar receiver.

b) What is the carrier frequency of the second receiver?

c) If you were to design a radar receiver, what is the minimum intermediate frequency you would choose to prevent image frequency problems in the range 2.8- 3 GHz radar band?

Solution:

a) $F_{IF} = F_{LO} - F_C = 2.86GHz - 2.8GHz = 60\ MHz$

b) $F_{Image} = F_C + 2\ F_{IF} = 2.80GHz + 0.12GHz = 2.92\ GHz$

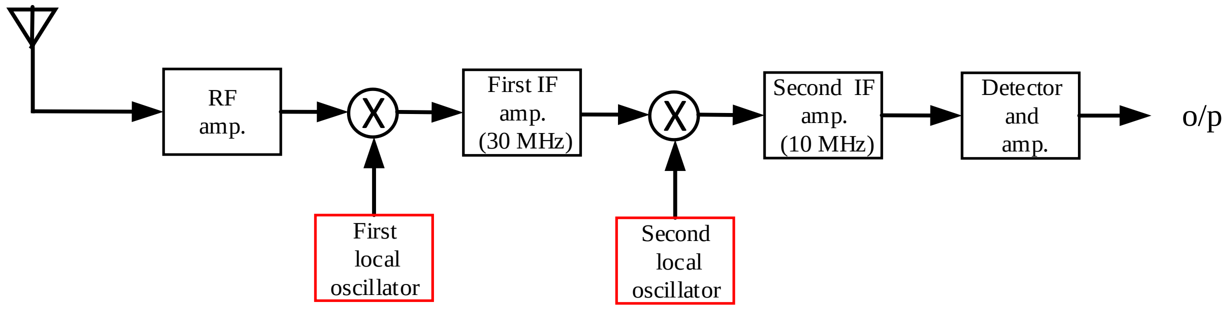
c) $2\ F_{IF} \geq F_{max} - F_{min} = 3.0\ GHz - 2.8\ GHz$

$$= 0.2\ GHz$$

$$\therefore\ F_{IF} \geq 100\ MHz$$

H.W:

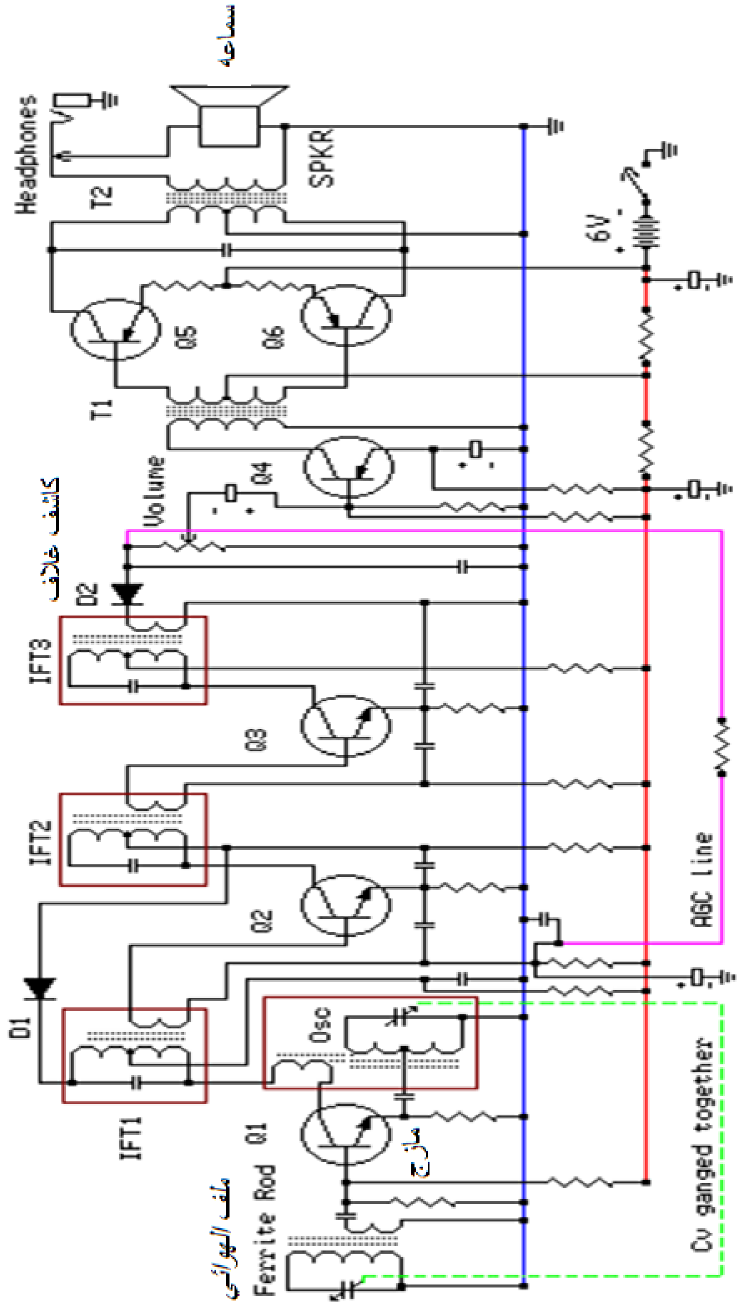
The figure below shows a satellite receiver uses two hytrodyne operations. It is used to receive transmissions at 136 MHz. the first local oscillator operates below the incoming carrier frequency, while the second operates above the first IF frequency. Find all possible image frequencies.



Ans: 76 MHz

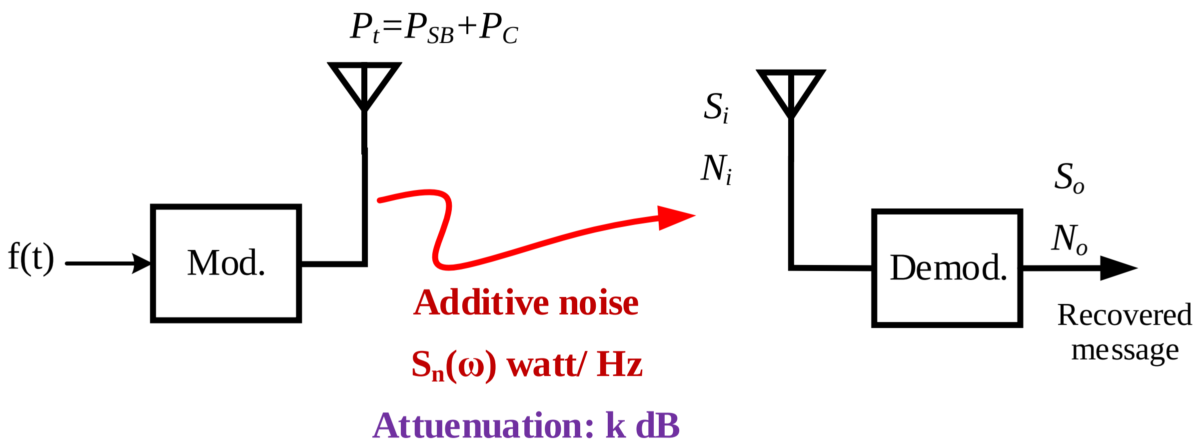
156 MHz

56 MHz



AM syperhytrodyne reciever دائرة لجهاز الاستلام نوع

Noise in AM Systems:



Above diagram shows a simplified model of AM system with noisy channel. The modulator produces a total power of P_t watt. Due to the path losses (attenuation) usually measured in dB. The received signal power S_i would be:

$$S_i\Big|_{dB} = P_t\Big|_{dB} - k\Big|_{dB} \qquad \ldots(4\text{-}30)$$

The received noise power could be computed if the noise power spectral density and transmission BW are known using:

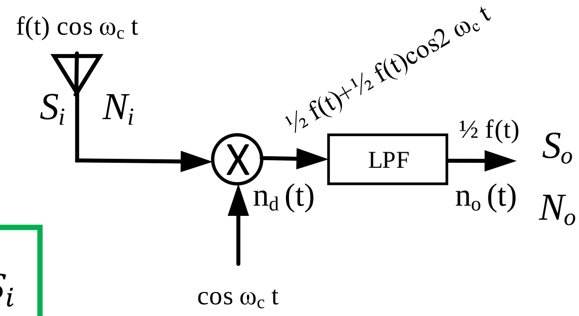
$$N_i = \frac{1}{2\pi}\int_{Bw_{tr}} S_n(\omega)d\omega \quad watt \qquad \ldots(4\text{-}31)$$

The output signal to noise ratio $\frac{S_o}{N_o}$ depend on the structure of the demodulator and the modulation type used.

1- DSB-SC

- Synchronous detector:

$$S_i = \overline{[f(t)cos\omega_c t]^2} = \frac{1}{2}\overline{f(t)^2}$$



$$S_o = \overline{\left[\frac{1}{2}f(t)\right]^2} = \frac{1}{4}\overline{f^2(t)} \quad \boxed{= \frac{1}{2}S_i}$$

$$n_d(t) = \frac{1}{2}n_c(t) + n_c(t)cos2\omega_c t - \frac{1}{2}n_s(t)sin2\omega_c t$$

$$n_o(t) = \frac{1}{2}n_c(t)$$

Defining $\overline{n_i^2(t)} = N_i$

We have $N_o = \overline{n_o^2(t)} = \frac{1}{4}\overline{n_c^2(t)} = \frac{1}{4}\overline{n_i^2(t)} = \boxed{\frac{1}{4}N_i}$

$$\therefore \quad \boxed{\frac{S_o}{N_o} = 2\frac{S_i}{N_i}} \qquad \ldots(4\text{-}32)$$

∴ In DSB-SC system, the detector improves the signal to noise ratio by factor of two.

2- SSB-SC

$$\emptyset_{SSB_\pm} = f(t)cos\omega_c t \mp f\widehat{(t)}sin\omega_c t$$

$$S_i = \overline{\emptyset^2(t)} = \frac{1}{2}\overline{f^2(t)} + \frac{1}{2}\overline{f^2\widehat{(t)}}$$

Since $\overline{f^2(t)} = \overline{f^2\widehat{(t)}}$

$$\therefore \ S_i = \overline{f^2(t)}$$

The output signal is $\frac{1}{2}f(t)$

$$S_o = \overline{\left[\frac{1}{2}f(t)\right]^2} = \frac{1}{4}\overline{f^2(t)} = \boxed{\frac{1}{4}S_i}$$

$$\therefore \quad \boxed{\frac{S_o}{N_o} = \frac{S_i}{N_i}} \qquad \ldots(4\text{-}33)$$

3- <u>SSB-LC</u>

- Envelope detector

$$\emptyset(t) = [f(t) + A_c]cos\omega_c t$$

$$S_i = \overline{[[f(t) + A_c]cos\omega_c t]^2} = \frac{1}{2}A_c^2 + \frac{1}{2}\overline{f^2(t)}$$

$$S_i(t) + n_i(t) = [f(t) + A_c]cos\omega_c t + n_c(t)cos\omega_c t - n_s(t)sin\omega_c t$$

The envelope of the signal is

$$r(t) = \sqrt{\{[f(t) + A_c] + n_c(t)\}^2 + \{n_s(t)\}^2}$$

$$\cong A_c + \underline{f(t)} + n_c(t) \quad \text{for High SNR}$$

$$\therefore \quad \boxed{\frac{S_o}{N_o} = \frac{2\overline{f^2(t)}}{A_c^2 + \overline{f^2(t)}} \cdot \frac{S_i}{N_i}} \qquad \ldots(4\text{-}34)$$

For single tone $f(t) = mA_c cos\omega_m t,$ $\qquad \overline{f^2(t)} = \frac{m^2A_c^2}{2}$

$$\therefore \quad \boxed{\frac{S_o}{N_o} = \frac{2m^2}{2 + m^2} \cdot \frac{S_i}{N_i}} \qquad \ldots(4\text{-}34)$$

<u>H.W</u>

Derive the relation between output signal to noise ratio and input signal to noise ratio for SSB-LC system, what would be the relation for S.T case?