Assignment

problems: chapter-4 : Amplitude Modulation Reception.

4-1 / 142) Determine the improvement in the noise figure for a receiver with an RF bandwidth equal to 200kHz and an IF bandwidth equal to 10kHz.

Sol:

$$BI = \frac{200\,kHz}{10\,kHz} = 20$$

$$NF_{improvement} = 10 \log BI = 10 \log 20 = 13\,dB$$

4-2 / 147) For an AM commercial broadcast band receiver (535 kHz to 1605 kHz) with an input filter Q-factor of 54, determine the bandwidth at low and high ends of the RF spectrum

Sol:

AM spectrum:

low freq. end

$$B = \frac{540\,kHz}{54} = 10\,kHz$$

high freq. end

$$B = \frac{1600\,kHz}{54}$$

$= 29,630\,Hz$

But this should be less than or equal to 10kHz

$\Rightarrow$ let $Q = 160$

$\Rightarrow B = \frac{1600\,kHz}{160} = 10\,kHz$

$$B = \frac{540\,kHz}{160} = 3375\,Hz$$

4-3/150) For an AM Superheterodyne Receiver that uses high-side injection and has a local oscillator freq. of 1355 KHz, determine IF carrier, upper side & lower freq for an RF wave. [905 KHz (upper), 900 KHz (carrier), 895 KHz (lower)]

Sol: $f_{IO} = 1355 KHz$

for high side rejection

$f_{IO} = f_{RF} + f_{IF}$

~~= 1355 KHz~~

$f_{IF} = f_{IO} - f_{RF}$

f_{RF}: upper 905 KHz — lower 895 KHz

950 KHz

$f_{IF} = 460 KHz$

IF carrier = 1355 KHz − 900 KHz = 455 KHz.

4-5/156) for ~~tracking the curve~~ an AM broadcast band Superheterodyne receiver with IF, RF, local oscillator freq: (455 KHz, 600 KHz & 1055 KHz)

find 1) Image freq

2) IFRR for a preselector of Q of 100.

Sol: $f_{im} = 1055\text{kHz} + 455\text{kHz} = 1510\text{kHz}$.

$$\rho = \frac{1510\text{kHz}}{600\text{kHz}} - \frac{600\text{kHz}}{1510\text{kHz}} = 2.113$$

$$IFRR = \sqrt{1+Q^2\rho^2}$$
$$= \sqrt{1+109^2(2.113)^2}$$
$$= 212.15$$

$\therefore IFRR_{dB} = 10\log(212.15) = 23.23\text{ dB}$.

9-6 / 157) For a citizens band receiver using high side rejection with an RF carrier of 27MHz and IF center freq. of 455kHz. find
a) f_{IO} b) f_{im} (c) IFRR with $Q = 100$ &
d) for RF = 600kHz find Q, to have the same IFRR

Sol: a) $f_{IO} = 27\times10^6 + 455\times10^3 = 27.455\text{ MHz}$.

b) $f_{im} = f_{IO} + f_{IF} = 27.455\text{MHz} + 455\text{kHz}$
$= 27.91\text{MHz}$.

c) $IFRR = \sqrt{1+Q^2\rho^2}$

$$\rho = \frac{f_{im}}{f_{RF}} - \frac{f_{RF}}{f_{im}} = \frac{27.91\text{MHz}}{27\text{MHz}} - \frac{27\text{MHz}}{27.91\text{MHz}}$$
$= 1.033703704 - 0.9673951989$
$= 0.0663$

$$IRRR = \sqrt{1+109 \times 4.39569 \times 10^{3}}$$

$$= \sqrt{44.9569} = 6.7049$$

$$= (20 \log 6.7049)\ dB$$

$$= 8.2639\ dB$$

d) $Q = \frac{\sqrt{(IRRR)^2 - 1}}{\rho}$ if RF = 600 kHz

$f_{lO} = 600\ kHz + 455\ kHz = 1055\ kHz.$

$f_{im} = 1055\ kHz + 455\ kHz = 1510\ kHz.$

$\therefore \rho = \frac{1510\ kHz}{600\ kHz} - \frac{600\ kHz}{1510\ kHz}$

$= 2.51667 - 0.39735$

$= 2.119319$

$$Q = \frac{\sqrt{(6.7049)^2 - 1}}{2.119319} = \frac{\sqrt{43.95568}}{2.119319}$$

$$= \frac{6.6299}{2.119319}$$

$$= 3.128$$

9-7 / 170) Determine the overall bandwidth for

a) 2 Single tuned amp each with BW of 10 kHz.

b) 3

c) 4

d) A double tuned amplifier with optimum coupling, a critical coupling of 0.02, Resonant freq. of 1 MHz.

e) Repeat a, b, c for part d.

Sol) Single tu

$B_n = BW (2^{1/n} - 1)^{1/2}$

a) $B_2 = 10\,kHz \sqrt{2^{1/2} - 1} = 10^4 \sqrt{1.414 - 1} = 10^4 \sqrt{0.414} = 6434.28$ Hz

b) $B_3 = 10\,kHz \sqrt{2^{1/3} - 1} = 10^4 \sqrt{1.2599 - 1} = 10^4 \sqrt{0.2599} = 5098.03$ Hz

c) $B_4 = 10\,kHz \sqrt{2^{1/4} - 1} = 10^4 \sqrt{1.1892 - 1} = 10^4 \sqrt{0.1892} = 4349.71$ Hz

d) $B_{nd} = B_{opt} (2^{1/n} - 1)^{1/4}$

$= 1.5 (0.02) \times 10^6 (2^{1/n} - 1)^{1/4}$

$= 0.03 \times 10^6 (2^{1/n} - 1)^{1/4}$

n = 2 → $0.03 \times 10^6 \sqrt[4]{2^{1/2} - 1} = 0.03 (0.414)^{1/4} \times 10^6 = 24064.1$ Hz

3 → $0.03 \times 10^6 \sqrt[4]{2^{1/3} - 1} = 0.03 (0.2599)^{1/4} \times 10^6 = 21420.1$ Hz

4 → $0.03 \times 10^6 \sqrt[4]{2^{1/3} - 1} = 0.03 (0.1892)^{1/4} \times 10^6 = 19785.70$ Hz

4-8 / 183) For an AM receiver with a −80dBm RF input signal level and

Gains: RF amp = 33 dB, IF amp = 47 dB, audio amp = 25 dB

Losses: preselector loss = 3 dB
mixer loss = 6 dB
detector loss = 8 dB

determine net receiver gain & the audio signal level.

Sol: Sum of gains = 33 + 47 + 25 = 105 dB
Sum of losses = 3 + 6 + 8 = 17 dB

∴ Net gain = 105 − 17 = 88 dB
audio signal level = −80 dBm + 88 dB
= 8 dBm.

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* $V_{am}(t) = E_c \sin(2\pi f_c t) + (m E_c \sin(2\pi f_m t)) \sin(2\pi f_c t)$

$\Rightarrow m E_c \sin(2\pi f_c t) \sin(2\pi f_m t)$

$\rightarrow \frac{m E_c}{2} \, 2 \sin(2\pi f_c t) \sin(2\pi f_m t)$

$\rightarrow \frac{m E_c}{2} \left[\cos(2\pi f_c t - 2\pi f_m t) - \cos(2\pi f_c t + 2\pi f_m t) \right]$

$$\rightarrow \frac{mE_c}{2}\left(\cos 2\pi(f_c - f_m)t - \cos 2\pi(f_c + f_m)t\right).$$

$$\therefore V_{am}(t) = E_c \sin(2\pi f_c t) - \frac{mE_c}{2}\cos 2\pi(f_c + f_m)t + \frac{mE_c}{2}\cos 2\pi(f_c - f_m)t.$$

formula used here is

$$\cos(A+B) - \cos(A-B) = -2\sin A \sin B.$$