4.8-1

Tune to 1500 kHz -

Radio has 455 kHz IF

Where else can you hear 1500 kHz?

Answer: $\boxed{590 \text{ kHz.}}$

Why? It is an "Image".

For 1500, the L.O. is at 1500 + 455 = 1955 kHz

For 590, the L.O. is at 590 + 455 = 1045 kHz

but 1045 + 455 = 1500

So you can also hear that.

4.8-2 Want to receive 1-30 MHz

IF = 8 MHz

Set local oscillator to input + 8 MHz → L.O. $\boxed{9-38 \text{ MHz}}$

Tune to 10 MHz, it also receives another frequency. What is it?

For 10 MHz, the L.O. is at 10+8 = 18 MHz

The image is at 18 + 8 = $\boxed{26 \text{ MHz}}$ image

It doesn't make sense to set the L.O. below the input, because ----

1 MHz − 8 MHz = −7 MHz? (1+7=8)

8 MHz − 8 MHz = 0 ?

4-8-2

We want to receive 1–30 MHz
The IF is 8 MHZ

What is the range of the local oscillator frequency?

Tune to 10 mHz –
it receives another frequency (poorly).
what is it?

It doesn't make sense to put the local oscillator below the input. why?

4.4-1 In QAM — with frequency error ΔW and phase error δ

show that ;

instead of $m_1(t)$ you get ;

$$m_1(t)\cos[(\Delta w)t+\delta] - m_2(t)\sin[(\Delta w)t+\delta]$$

instead of $m_2(t)$ you ~~got~~

$$m_2(t)\sin[(\Delta w)t+\delta] + m_2(t)\cos[(\Delta w)t+\delta]$$

For $m_1(t)$, we transmit $m_1(t)\cos(w_c t) + m_2\sin(w_c t)$

To demodulate, multiply by $\cos(w_c t)$

but really use $\cos[(w_c+\Delta W)t+\delta]$

or $2\cos[\quad]$

$$X_1(t) = [m_1(t)\cos(w_c t) + m_2(t)\sin(w_c t)][2\cos((w_c+\Delta w)t+\delta)]$$

$$= 2[m_1(t)\cos(w_c t)\cos((w_c+\Delta w)t+\delta)$$ $w_c t + (\Delta w)t + \delta$

$$+ m_2(t)\sin(w_c t)\cos((w_c+\Delta w)t+\delta)]$$

by -- $\cos(x)\cos(y) = \frac{1}{2}[\cos(x-y)+\cos(x+y)]$, $\sin(x)\cos(y) = \frac{1}{2}[\sin(x-y)+\sin(x+y)]$

$$X_1(t) = 2\Big[m_1(t)\left(\tfrac{1}{2}\right)[\cos(w_c t - w_c t - (\Delta w)t - \delta) + \cos(w_c t + w_c t + (\Delta w)t + \delta)]$$

$$+ m_2(t)\left(\tfrac{1}{2}\right)[\sin(w_c t - w_c t - (\Delta w)t - \delta) + \sin(w_c t + w_c t + (\Delta w)t + \delta)]\Big]$$

$$= m_1(t)\Big[\underbrace{\cos(-(\Delta w)t-\delta)}_{\text{baseband}} + \underbrace{\cos(2w_c t + (\Delta w)t + \delta)}_{\text{2nd harmonic}}\Big]$$

$$+ m_2(t)\Big[\underbrace{\sin(-(\Delta w)t-\delta)}_{\text{baseband}} + \underbrace{\sin(2w_c t + (\Delta w)t + \delta)}_{\text{2nd harmonic}}\Big]$$

Filter out the 2nd harmonic

$$X_1(t) = m_1(t)\cos(-(\Delta w)t-\delta) + m_2(t)\sin(-(\Delta w)t-\delta)$$

$$= m_1(t)\cos((\Delta w)t+\delta) - m_2(t)\sin((\Delta w)t+\delta)$$ ← matches

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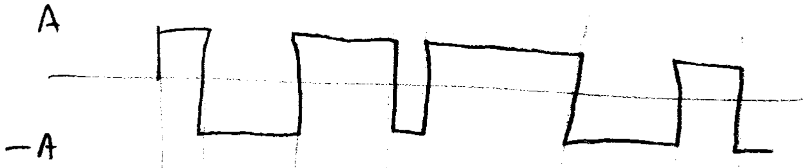
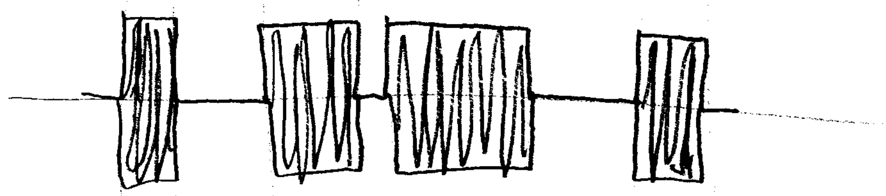
Math is similar for $m_2(t)$

4.3-7 Analyze efficiency in AM for binary signal, $\mu = 1$

Binary signal:



Sketch the AM signal:



For amplitude A: $P_c = \frac{A^2}{2}$ = ← carrier power.

Power in sidebands:

$$\overline{m^2(t)} = A^2$$ (square wave)

(not $\frac{A^2}{2}$ as in sine wave)

↑ mean square value

$$P_s = \frac{1}{2}\overline{m^2(t)} = \boxed{\frac{A^2}{2}}$$ ← sideband power

$$\eta = \frac{P_s}{P_c + P_s} = \frac{\frac{A^2}{2}}{\frac{A^2}{2} + \frac{A^2}{2}} = .5$$