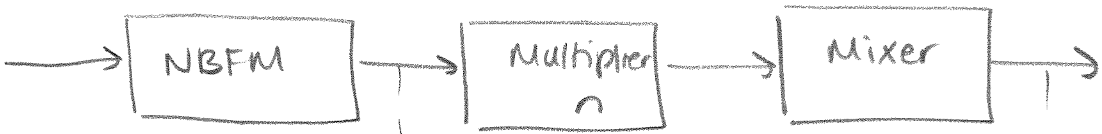
ECE 457

HW #7

Solutions

(1)



$f_{c_1} = 500 \text{kHz}$

$\Delta f_1 = 20 \text{Hz}$

$f_c = 915 \text{MHz}$

$D = 5$

Find n, f_{LO}

$$D = \frac{\Delta f}{W} = \frac{\Delta f}{15 \text{kHz}} \rightarrow \Delta f = 75 \text{kHz}$$ (peak freq. deviation at the output)

$$\Delta f = n \Delta f_1 \Rightarrow 75{,}000 = n(20)$$

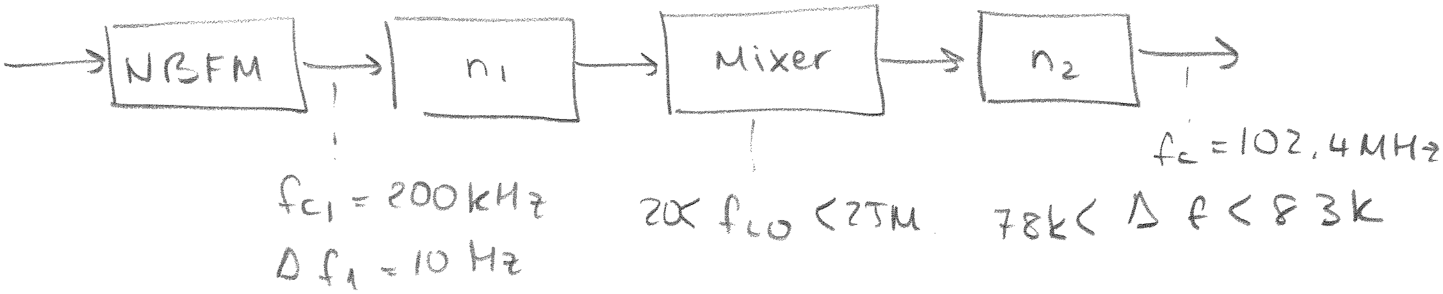
$$\underline{n = 3750}$$

$$f_c = n f_{c_1} \pm f_{LO}$$

$$915 = (3750)(0.5) \pm f_{LO}$$

$$915 = 1875 \pm f_{LO} \Rightarrow \boxed{f_{LO} = 960 \text{MHz}}$$

(2)



You have only frequency doublers

$\Delta f = n_2 n_1 \Delta f_1$ (Mixer does not change the frequency deviation)

$78000 < (n_2 n_1)(10) < 83000$

$7800 < n_1 n_2 < 8300$ $\quad n_1 n_2 \rightarrow$ should be a power of 2.

$2^{13} = 8192$ $\rightarrow$ it's the only one in this range

$\therefore n_1 n_2 = 8192$ //

$f_c = n_2 (n_1 f_{c1} \pm f_{LO})$

$102.4 = (n_1 n_2)\, 0.2 \pm n_2 f_{LO}$

$102.4 = 1638.4 \pm n_2 f_{LO}$ $\Rightarrow n_2 f_{LO} = 1536$

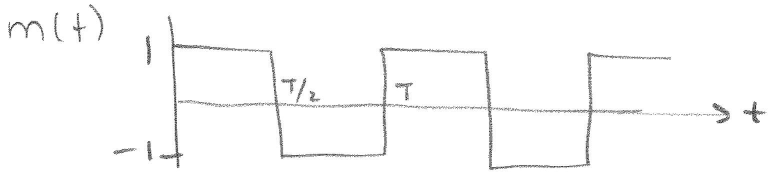
$20 < f_{LO} < 25$ and n_2 should be a power of 2.

if $n_2 = 64$, $f_{LO} = 24$ (this is the only n_2, that'll give f_{LO} in this range)

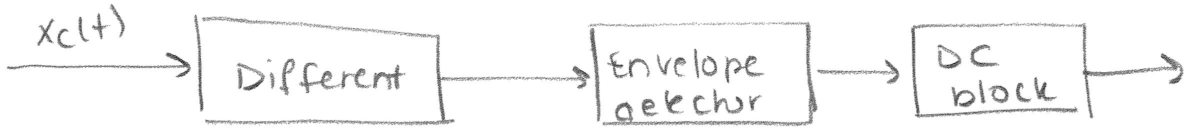
$\Rightarrow n_2 = 64$, $f_{LO} = 24\,MHz$, $n_1 = 128$.

$\Delta f = (8192)(10) = 81.92\,kHz$ (it's the range given).

(3)



Assume T is the period of square wave.



$x_c(t) = A\cos(2\pi f_c t + 2\pi f_d \int m(\tau)\,d\tau)$

↳ instantaneous freq. $f_i(t) = f_c + f_d m(t)$

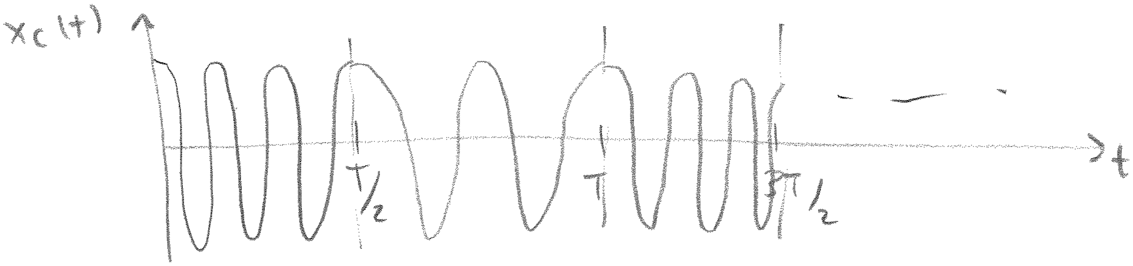
$$f_i(t) = \begin{cases} 10\text{kHz} + f_d & 0 < t < T/2 \\ 10\text{kHz} - f_d & \frac{T}{2} < t < T \\ 10\text{kHz} + f_d & T < t < \frac{3T}{2} \\ \vdots & \text{so on.} \end{cases}$$

$\Delta f = 1\text{kHz}$ ↗ peak freq. deviation

$\Delta f = f_d \underbrace{\max|m(t)|}$

$\boxed{f_d = 1\text{kHz}/V}$

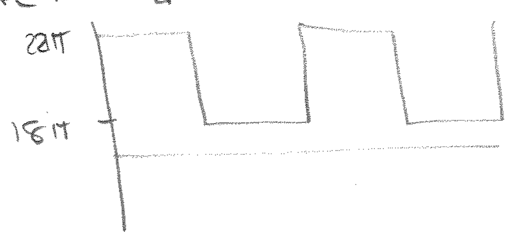
∴ $f_i(t)$ changes between 11kHz & 9kHz

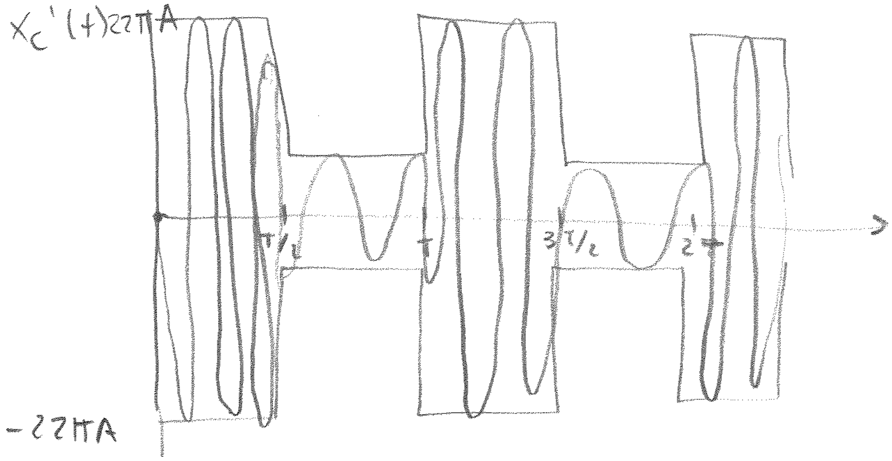


Output of differentiator:

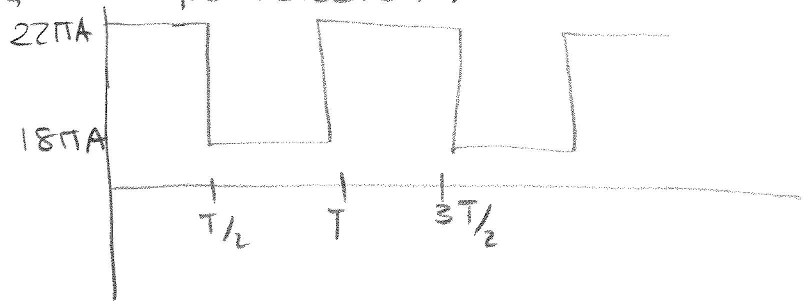
$x_c'(t) = -A.\,(2\pi f_c + 2\pi f_d m(t))\sin(2\pi f_c t + 2\pi f_d \int m(\tau)\,d\tau)$

$2\pi f_c + 2\pi f_d m(t) = 20\pi + 2\pi m(t)$

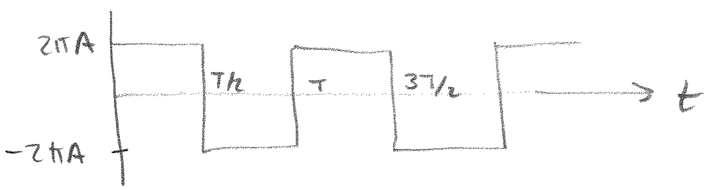




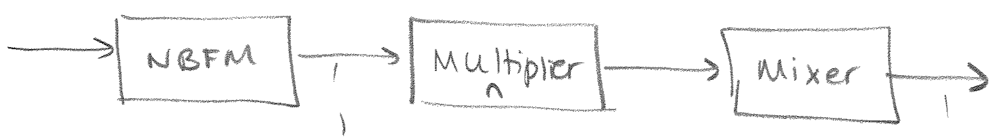
Output of envelope detector:



Output of DC Block



(4)



$W = 10\text{KHz}$

$f_{c1} = 110\text{KHz}$

$D_1 = 0.05$

$D = 20$

$f_c = 100\text{MHz}$

$$D = nD_1 \Rightarrow 20 = n(0.05)$$

$$\boxed{n = 400}$$

$$f_c = nf_{c1} \pm f_{LO}$$

$$100 = (400)(0.11) \pm f_{LO}$$

$$100 = 44 \pm f_{LO}$$

$$f_{LO} = 56\text{MHz} \quad \text{or} \quad f_{LO} = 144\text{MHz}$$

BPF is centered at 100MHz, with $BW = 2(D+1)W$
$= 2(21)(10k) = 420\text{KHz}$ //

(5) 3.21

$f_{IF} = 2500kHz$

input carrier at 1120kHz

(1) $f_{LO} = f_c + f_{IF} = 3620kHz$

$f_{im} = f_c + 2f_{IF} = 6120\ kHz$.

(2) $f_{LO} = |f_c - f_{IF}| = 1380kHz$.

$f_{im} = |f_c - 2f_{IF}| = 3880kHz$.

(6) $f_c = 1500kHz$

$f_{IF} = 455kHz$

$f_{im} = f_c + 2f_{IF} = 2410kHz$

The station transmitting at 2410kHz will also be heard

$f_{LO} = f_c + f_{IF} = 1955kHz$.

If a station transmitting at 2410kHz goes through the initial RF filter, at the output of local oscillator it will have two frequency components, one at 455kHz, the other at 4365kHz.

The component at 455kHz will pass through the IF filter and be heard.