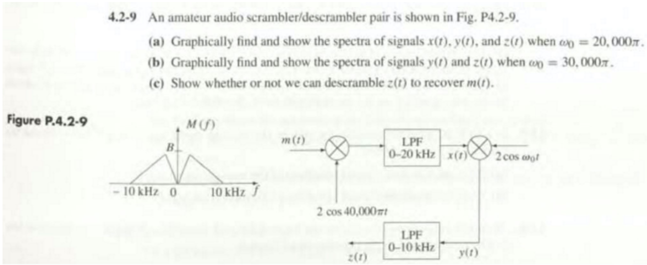
PS3

Sunday, October 3, 2021 3:27 PM



4.2-9 An amateur audio scrambler/descrambler pair is shown in Fig. P4.2-9.

(a) Graphically find and show the spectra of signals $x(t)$, $y(t)$, and $z(t)$ when $\omega_0 = 20,000\pi$.

(b) Graphically find and show the spectra of signals $y(t)$ and $z(t)$ when $\omega_0 = 30,000\pi$.

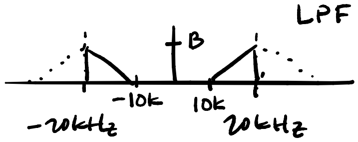
(c) Show whether or not we can descramble $z(t)$ to recover $m(t)$.

Figure P.4.2-9

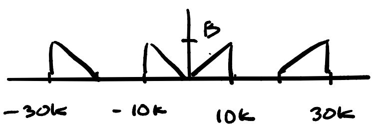
a. $f_0 = 10kHz$

b. $f_0 = 15kHz$

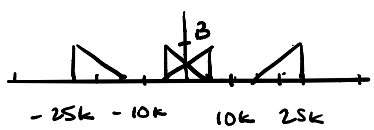
$X(f)$ modulate 20kHz
LPF 0-20k



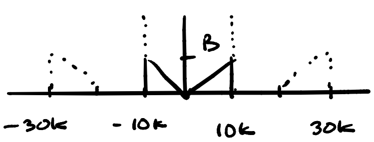
$Y(f)$ modulate 10kHz



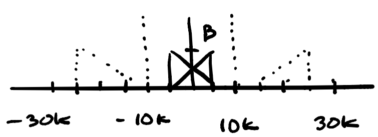
$Y(f)$ mod 15kHz



$Z(f)$ LPF 0-10k



$Z(f)$ LPF 0-10k



2) a. $r_x(t) = 1 + n(t)$

$\phi_x(t) = 3m(t)$

$c_x(t) = (1 + n(t))\cos(3m(t))$

$s_x(t) = (1 + n(t))\sin(3m(t))$

b. $w(t) = n(t)\cos(w_0 t + \pi/4)$
$\quad + m(t)\sin(w_0 t + \pi/4)$

$$= \frac{\sqrt{2}}{2} n(t)(\cos(w_0 t) + \sin(w_0 t)) + \frac{\sqrt{2}}{2} m(t)(\cos(w_0 t) + \sin(w_0 t))$$

$$= \frac{\sqrt{2}(n(t)+m(t))}{2}(\cos(w_0 t) + \sin(w_0 t))$$

$$c_x(t) = s_x(t) = \frac{\sqrt{2}(n(t)+m(t))}{2}$$

$$\phi_x(t) = \tan^{-1}(1) = \pi/4$$

$$e_x(t) = |n(t)+m(t)|$$

$$c_x(t) = \cos(\phi_x(t))e_x(t) = \frac{\sqrt{2}}{2}|n(t)+m(t)|$$

$$s_x(t) = \frac{\sqrt{2}}{2}|n(t)+m(t)|$$

c. $x(t) = v(t-\tau) = (1+n(t-\tau))\cos(w_0(t-\tau) + 3m(t-\tau))$

$$= (1+n(t-\tau))\cos(w_0 t - w_0\tau + 3m(t-\tau))$$

$$e_x(t) = 1 + n(t-\tau)$$

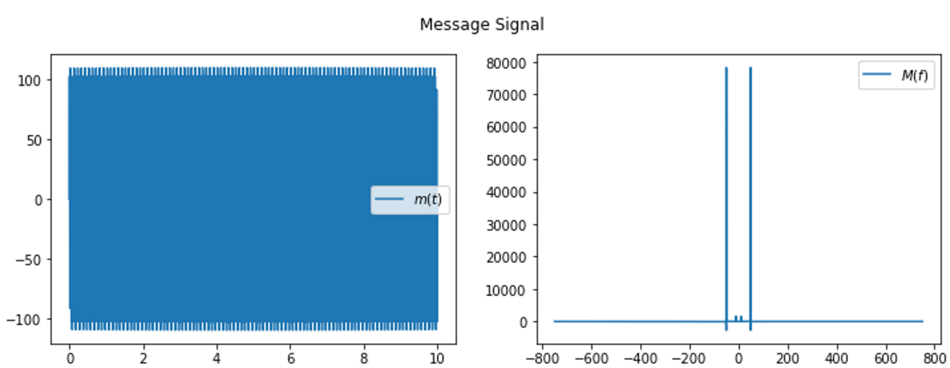
$$\phi_x(t) = w_0\tau + 3m(t-\tau)$$

$$c_x(t) = (1+n(t-\tau))\cos(w_0\tau + 3m(t-\tau))$$

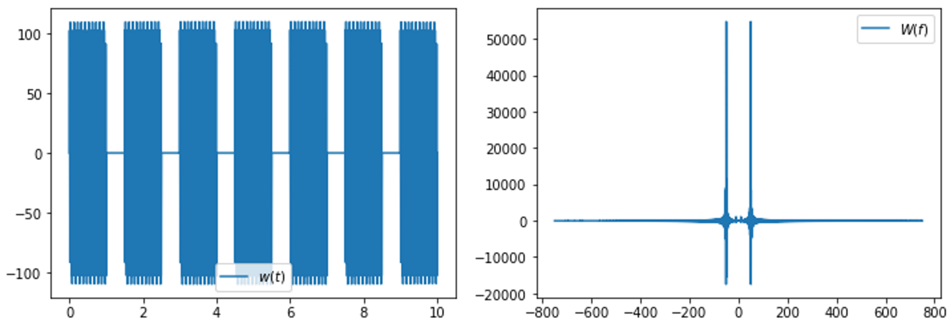
$$s_x(t) = (1+n(t-\tau))\sin(w_0\tau + 3m(t-\tau))$$

3) $m(t) = 10\sin(2\pi \cdot 10t) + 100(2\pi \cdot 50t)$

- used pulse train with $T = 0.75\text{s}$
  $\tau = 0.5$
- 15000 samples from 0 - 10s

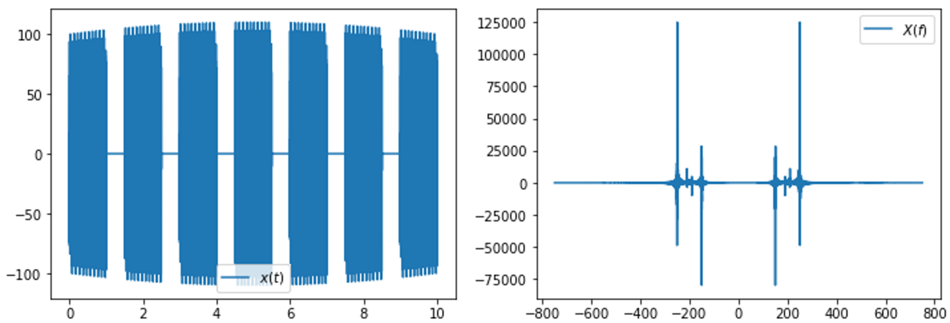


Message Signal filtered through Pulse Train



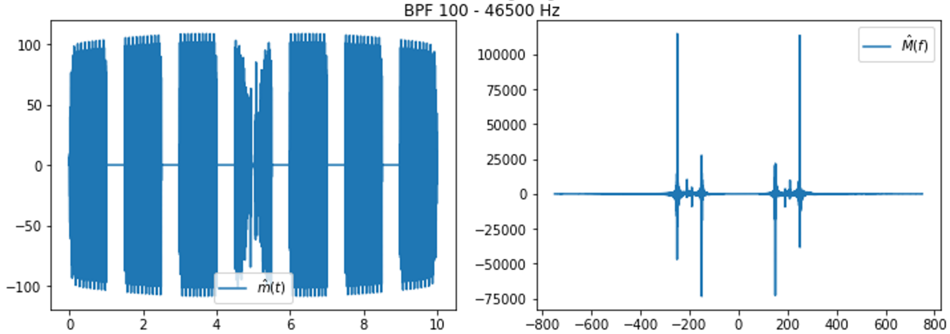
- modulated to f_0 = 200 Hz

Modulated Message Signal

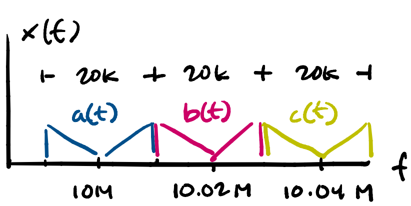


- used a Buttersworth filter ($n = 4$)
  - BPF from 100 – 46500 Hz
    (If I make this range smaller, $\hat{m}(t)$ looks almost unrecognizable)

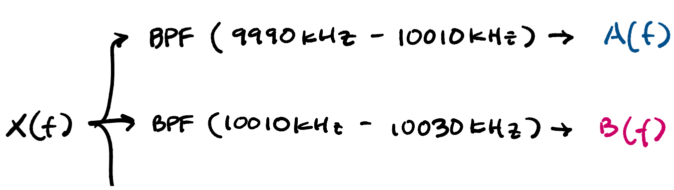
Reciever Message Signal
BPF 100 - 46500 Hz



4) a.



b.



$$
\begin{tikzcd}
X(f) \arrow[r] \arrow[dr] & \text{BPF (10010 kHz - 10030 kHz)} \arrow[r] & B(f) \\
& \text{BPF (10030 kHz - 10050 kHz)} \arrow[r] & C(f)
\end{tikzcd}
$$