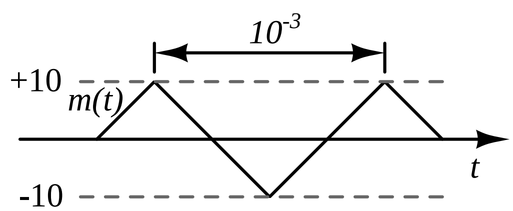
Homework 2

Communication Systems I (EE 341), Autumn 2021

1) The following problems from the book "Communication Systems" by S. Haykin and M. Moher, 5th edition, Chapter 3: 3.5, 3.8, 3.11, 3.17, 3.20, 3.21 and 3.24 on pp. 97-100.
2) Consider the message signal $m(t) = 20cos(2\pi t)$ volts that modulates the carrier wave $c(t) = 50cos(100\pi t)$ volts. Find the power developed across a load of 100Ω due to this AM wave.
3) Sketch the AM signal $[A + m(t)]\cos(2\pi f_c t)$ for the periodic triangle signal $m(t)$ (shown below) of period 10^{-3} and peak-to-peak value of 20 corresponding to the modulation index $\mu = 0.5$.



4) The input to an envelope detector of a tone modulated signal is given as $s(t) = A_c[1 + \mu m(t)]cos(2\pi f_c t)$. Find the maximum value of time constant RC of the detector that can always follow the message envelope.
5) Let $s_{USB}(t)$ denote the SSB wave obtained by transmitting only the upper sideband, and $s^h_{USB}(t)$ its Hilbert transform. Show that:

$$m\left(t\right) = \frac{2}{A_c}[s_{USB}\left(t\right)\cos\left(2\pi f_c t\right)\ +\ s^h_{USB}(t)\sin\left(2\pi f_c t\right)]$$

and

$$m_h(t) = \frac{2}{A_c}[s^h_{USB}\left(t\right)\cos\left(2\pi f_c t\right)\ -\ s_{USB}\left(t\right)\sin\left(2\pi f_c t\right)]$$

where m(t) is the message signal, m_h(t) is its Hilbert transform, f_c the carrier frequency, and A_c is the carrier amplitude.

6) A modulating signal m(t) is given by

$$m(t) = \cos(100\pi t) + 2\cos(300\pi t)$$

a) Sketch the spectrum of m(t).
b) Find and sketch the spectrum of the DSB-SC signal $2m(t)cos(1000\pi t)$.
c) From the spectrum obtained in (b), suppress the LSB spectrum to obtain the USB spectrum.
d) Knowing the USB spectrum in (b), write the expression s$_{USB}$(t) for the USB signal.

7) For the message signal in the previous problem, use the time domain representation of SSB signals to determine the time domain expression $S_{USB}(t)$ for the carrier frequency $f_c = 500Hz$.

8) Consider SSB signals with carrier added to it.
$s_{usb+c}(t) = A_c cos(2\pi f_c t) + [m(t)cos(2\pi f_c t) - m_h(t)sin(2\pi f_c t)]$
where $m(t)$ is the message signal, $m_h(t)$ is its Hilbert transform. Show that $m(t)$ can be recovered from $s_{usb+c}(t)$ by an envelope detector if the carrier amplitude A_c is large enough.

9) Find $v_{lp}(t), v_i(t)$ and $v_q(t)$ when $f_c = 1200$Hz and

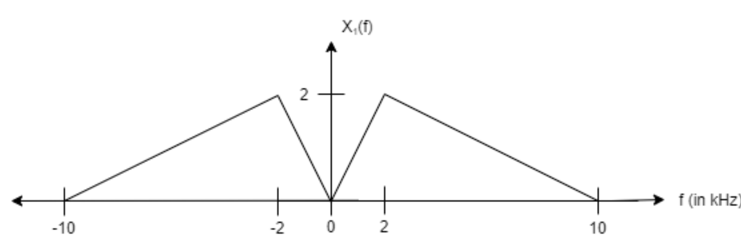
$$v_{bp}(f) = \begin{cases} 1, & 900 \leq |f| \leq 1300 \\ 0, & \text{otherwise} \end{cases}$$

10) Let $v_{bp}(t) = 2z(t)cos[(w_c \pm w_o)t + \alpha]$
Find $v_i(t)$ and $v_q(t)$ to obtain $v_{lp}(t) = 2z(t)e^{j(\pm w_o t + \alpha)}$

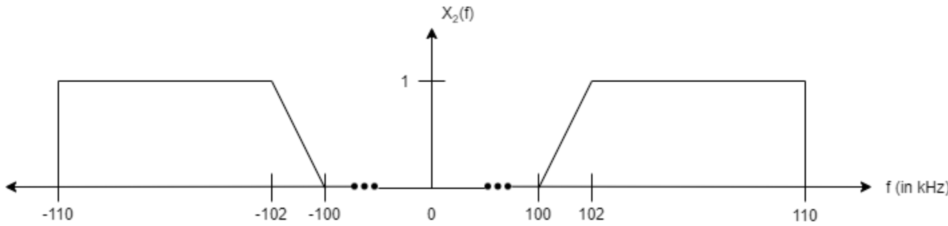
11) Use low-pass time-domain analysis to find and sketch $y_{bp}(t)$ when $x_{bp}(t) = Acos(2\pi f_c t)u(t)$ and $H_{bp}(f) = \frac{1}{1+j\frac{2(f-f_c)}{B}}$, for $f > 0$ which corresponds to the tuned circuit approximation, where $u(t)$ is a step function.

12) For the following spectra shown below determine the pre-envelope spectra

a)



b)



13) Let $g(t) = \frac{1}{1+t^2}$

    Find pre-envelope of $g(t)$ (both frequency and time domain representations).

14) Let $x(t)$ be a sinusoidal pulse given by

$$x(t) = \begin{cases} 2\cos(2\pi 10^6 t) & 0 \le t \le 1\, msec \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

    $x(t)$ is an input to an LTI system with impulse response $h(t) = x(T-t)$, where $T = 1msec$.

    Find $y_{lp}(t)$ and $y(t)$.