ECE 642 - Midterm Spring 2016

Please justify all your responses (responses without justifications will not be considered). Please label your axes and plot with care.

1. (3 points) Consider the baseband signals

$$\begin{aligned} x_I(t) &= -u(t) + 2u(t-1) \\ x_Q(t) &= u(t) - 2u(t-2) \end{aligned}$$

for $0 \leq t \leq 3$. Note that these signals may represent the encoding of two digital information messages.

a. Plot $x_I(t)$ and $x_Q(t)$ (by hand).

b. Calculate and plot the corresponding signals $x_A(t)$ and $x_P(t)$.

c. Plot the passband signal $x_c(t)$ whose complex baseband equivalent is $x_z(t) = jx_Q(t)$, where $x_Q(t)$ is given as above for $f_c = 1$ Hz.

2. (5 points) We are given the baseband equivalent filter

$$H_z(f) = \begin{cases} jf & \text{for } -2 \leq f \leq 2 \\ 0 & \text{otherwise} \end{cases}$$

a. Plot absolute value and phase of $H_z(f)$, and of the corresponding passband filter $H_c(f)$ for carrier frequency $f_c = 20$ Hz.

b. Assume that the input to the filter is the signal $x_c(t) = \sqrt{2}(\cos(2\pi t))\cos(40\pi t)$. Calculate the output passband signal $y_c(t)$ (Hint: You can directly calculate the equivalent baseband signal $y_z(t)$ and then upconvert).

c. Choose a suitable sampling frequency for the output signal $y_c(t)$.

3. (2 points) A message

$$m(t) = \begin{cases} 1 - |t| & \text{for } -1 \leq t \leq 1 \\ 0 & \text{otherwise} \end{cases}$$

is given.

a. Find a reasonable value W to approximate the bandwidth of $m(t)$. Explain your reasoning in detail (Hint: What is the auto-correlation function of a rectangular waveform?).

b. Assuming FM, find an approximate value for the bandwidth B_T of the modulated signal with $k_f = 1$ and $f_c = 100$ MHz.