EE 115 Lab 1

1) (50 points) In this task, we will examine the average power of a random signal that has its minimum value larger than or equal to -1, and also examine its impact on the power efficiency of the conventional amplitude modulation (AM) signals.

   a) Use the Gaussian-random-number generator to generate a random sequence

   $$m[1], m[2], \cdots, m[N]$$

   where N could be 200 or some other large integer.

   b) Determine the minimum value of the sequence and denote it by $-M_0$.

   c) Compute the normalized sequence $m_n[k] = \frac{1}{M_0} m[k]$ whose minimum value should be now -1.

   d) Compute the average power of $m_n[k]$ by $P_m = \frac{1}{N} \sum_{k=1}^{N} m_n^2[k]$.

   e) If we apply the conventional AM to $m_n(t) = m_n[k] rect(\frac{t-k}{T})$ where $rect(\frac{t}{T})$ is a rectangular pulse of width equal to T, the resulting AM signal is

   $$u_{AM}(t) = A_c(a_{mod} m_n(t) + 1) \cos(2\pi f_c t) \tag{1}$$

   and then its power efficiency is

   $$\eta_{AM} = \frac{a_{mod} P_m}{1 + a_{mod} P_m}. \tag{2}$$

   Plot η_{AM} versus P_m subject to $0 < P_m < 1$ for each of $a_{mod} = 1, 0.75, 0.5$.

   f) What is the value of η_{AM} for each of $a_{mod} = 1, 0.75, 0.5$ when P_m equals to that from d)? What is your thought on the power efficiency of the conventional AM?

2) (50 points) In this task, we will examine the quality of a simple DC blocker which consists of a capacitor C and a resistor R (in serial connection). We know that the frequency response $H(f)$ of the DC blocker is

   $$H(f) = \frac{R}{R + \frac{1}{j2\pi C}} = \frac{j2\pi f}{j2\pi f + \frac{1}{RC}}. \tag{3}$$

   a) Plot $|H(f)|$ versus f for $|f| < B$ for each of $RC = 0.01, 0.1, 1, 10$. Hint: for each value of RC, choose B such that $2\pi BRC = 10$. Why is this a good choice of B?

   b) Repeat the above but plot $20 \log_{10} |H(f)|$ (which is in dB) versus f. Here, to avoid the negative infinity at $f = 0$, you can set the vertical range to be from -60dB to 0dB.

c) If we want to use the above RC circuit as DC blocker to remove the DC component in $a_{mod}m_n(t) + 1$ where the spectrum of (real-valued) $m_n(t)$ occupies the band from 20Hz to 5KHz and also from -5KHz to -20Hz, what should be an acceptable range of the RC values? Hint: What should be the minimum value of RC such that $0.95 \leq |H(f)| \leq 1$ for $|f| \geq 20$Hz? Namely, what should be the minimum value of RC such that $|H(f)|$ only introduces tolerable distortions to $m_n(t)$?