

Lab 1

EE115, Introduction to Communication Systems, Fall 2025

Problem 1: Examining a random signal and AM power efficiency

In this problem, 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 conventional amplitude modulation (AM) signals.

- a) We begin by using the Gaussian-random-number generator to generate a random sequence

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

where we will set N as 200 [a large integer]. We can do so in MATLAB by employing the `randn` function.

- b) We can then use the `min` function in order to determine the minimum value of our sequence, which we can denote by $-M_0$. Verbatim, `m_nk = 1/M_0 * m_k; min(m_nk);`.
- c) We can then compute the normalized sequence

$$m_n[k] = \frac{1}{M_0} m[k], \quad (1)$$

where its minimum value is found to be

$$m_n[k] = -1.$$

- d) We can then compute the average power with

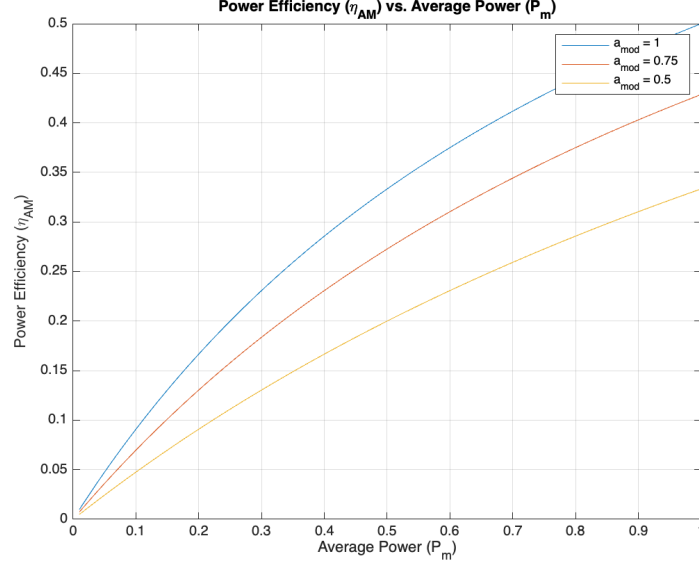
$$P_m = \frac{1}{M} \sum_{k=1}^N m_n^2[k]. \quad (2)$$

In MATLAB, this is achieved with `P_m = (1/N) * sum(m_nk.^2)`.

- e) Considering the power efficiency of the AM signal, we can determine its power efficiency through

$$\eta_{AM} = \frac{a_{mod} P_m}{1 + a_{mod} P_m}. \quad (3)$$

We can plot η_{AM} versus P_m subject to $0 < P_m < 1$ for each of $a_{mod} = 1, 0.75, 0.5$ in MATLAB, where we observe the following plot:



- f) Selecting some values of a random run of the MATLAB program thus far, we observe η_{AM} for each of $a_{mod} = 1, 0.75, 0.5$ using the same P_m as before. An example run allows us to obtain the values

$$\eta_{AM} = 0.1682 : a_{mod} = 1$$

$$\eta_{AM} = 0.1317 : a_{mod} = 0.75$$

$$\eta_{AM} = 0.0918 : a_{mod} = 0.5$$

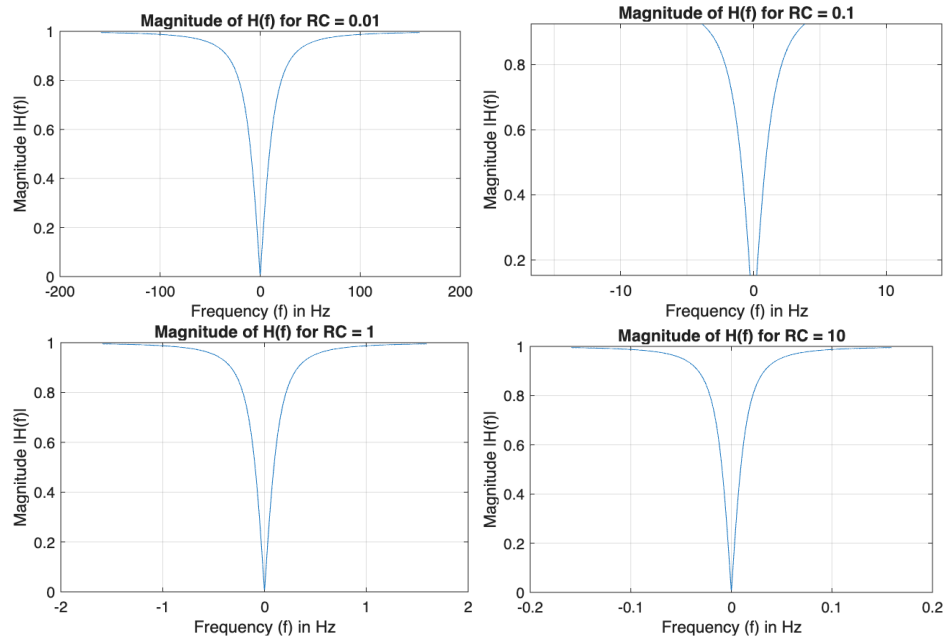
where it becomes evident, once interpreting the respective η_{AM} values as percentages, that conventional amplitude modulation is a very power-inefficient method of transmission.

Problem 2: Examining the quality of a simple DC blocker

In this problem, we will examine the quality of a simple DC blocker which consists of a capacitor C and a resistor R in series. We are given the frequency response of the DC blocker,

$$H(f) = \frac{R}{R + \frac{1}{j2\pi C}} = \frac{j2\pi f}{j2\pi f + \frac{1}{RC}}. \quad (4)$$

- a) Plotting $|H(f)|$ versus f for $|f| < B$ for each of $RC = 0.01, 0.1, 1, 10$, we observe the following plots:



Here, we chose B such that $B = \frac{10}{2\pi RC}$ for each of the respective RC values. This is an appropriate choice, as it allows us to observe the behavior of $|H(f)|$ as it approaches its asymptotic value of 1. We are also able to observe the stopband behavior of the DC blocker as f approaches 0, and everything in between.

b)