EE3005: Communication Systems

Problem Set 4: Amplitude Modulation

1. Consider a message signal $m(t) = 2\cos\left(2\pi t + \frac{\pi}{4}\right)$.

   (a) Sketch the spectrum $U(f)$ of the DSB-SC signal $u_p(t) = 8m(t)\cos 400\pi t$. What is the power of u?

   (b) Carefully sketch the output of an ideal envelope detector with input u_p. On the same plot, sketch the message signal $m(t)$.

   (c) Let $v_p(t)$ denote the waveform obtained by high-pass filtering the signal $u(t)$ so as to let through only frequencies above 200 Hz. Find $v_c(t)$ and $v_s(t)$ such that we can write

   $$v_p(t) = v_c(t)\cos 400\pi t - v_s(t)\sin 400\pi t$$

   and sketch the envelope of v.

2. A message to be transmitted using AM is given by

   $$m(t) = 3\cos 2\pi t + 4\sin 6\pi t$$

   where **the unit of time is milliseconds**. It is to be sent using a carrier frequency of 600 KHz.

   (a) What is the message bandwidth? Sketch its magnitude spectrum, clearly specifying the units used on the frequency axis.

   (b) Find an expression for the normalized message $m_n(t)$.

   (c) For a modulation index of 50%, write an explicit time domain expression for the AM signal.

   (d) What is the power efficiency of the AM signal?

   (e) Sketch the magnitude spectrum for the AM signal, again clearly specifying the units used on the frequency axis.

   (f) The AM signal is to be detected using an envelope detector (as shown in Figure 4.1), with $R = 50$ ohms. What is a good range of choices for the capacitance C?

3. Consider a message signal $m(t) = \cos(2\pi f_m t + \phi)$, and a corresponding DSB-SC signal $u_p(t) = Am(t)\cos 2\pi f_c t$, where $f_c > f_m$.

   (a) Sketch the spectra of the corresponding LSB and USB signals (if the spectrum is complex- valued, sketch the real and imaginary parts separately).

   (b) Find explicit time domain expressions for the LSB and USB signals.

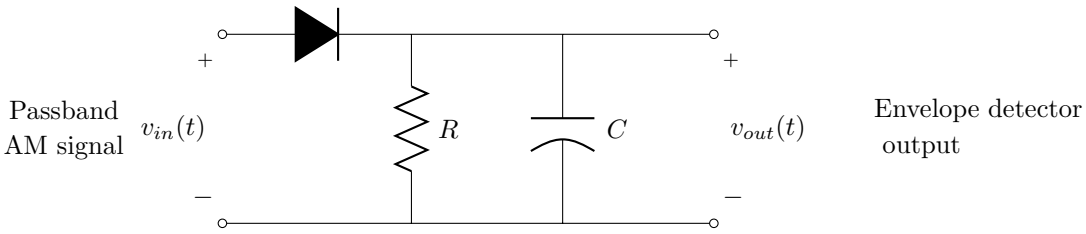

Figure 4.1: Envelope detector demodulation of AM, used in problem 2.