EE3TR4 Lab 2: Amplitude Modulation

Please work individually or in pairs. ***Please note that each group is expected to work independently.*** Please be familiar with the guidelines on academic integrity, summarized on the course outline. The late penalty is 10% per day.

Numerical Experiment: Amplitude modulation and demodulation

The message signal is given by

$m(t) = -2\text{sinc}(t / T_m),$

$\text{sinc}(x) = \sin(\pi x) / (\pi x),$

where T_m = 0.0005 s. The carrier is given by

$c(t) = A_c \cos(2\pi f_c t),$

where A_c = 1 V and f_c = 20 kHz. The AM signal is

$s(t) = A_c[1 + k_a m(t)]\cos(2\pi f_c t).$

1. Plot the message signal in time and frequency domain. As for frequency domain, plot the magnitude spectrum (no need to plot the phase spectrum). Measure the highest frequency component of the message signal (i.e. from the magnitude spectrum) and compare it with analytical calculations.
2. Assume that the % modulation = 50%. Plot the modulated signal in time and frequency domain (for the frequency domain, plot only the magnitude spectrum). The modulated wave passes through an envelope detector and then a DC removal stage, at the receiver. Assume that input time constant $R_s C$ is close to zero and the capacitor follows the input quickly when the diode is forward biased.
   - (i) Let the output time constant $R_L C = 1 / f_c$. Plot the output of the envelope detector and the output of the DC removal. Comment on the ripple.
   - (ii) Let the output time constant $R_L C = 10 T_m$. Plot the output of the envelope detector and the output of the DC removal. Does the signal after the DC removal resemble the message signal? Explain.
   - (iii) Find an optimum value of $R_L C$ by trial and error so that the output of the DC removal stage resembles (as judged by your eye) the message signal. (Note: there is no unique value of $R_L C$ which can be considered as the optimum, but there is a range. Refer to the lecture notes). Plot the output of the envelope detector and the output of the DC removal (and the message signal for comparison).
3. If the % modulation is changed to 200% (and the rest of the parameters are the same as before), plot the modulated signal in time and frequency domain (for the frequency domain, plot only the magnitude spectrum). Assume $R_L C = 0.5(T_m + 1 / f_c)$. Plot the output of the envelope detector and the output of the DC removal (and the message signal for comparison). Can you retrieve the message signal in this case? Provide explanation.

Hints and Suggestions:

1. You can modify the matlab code ‘amp_mod_demod.m’. Change the message signal to sinc in that code. Note that sinc(0) is 1, but matlab may calculate it as sin(pi*0)/(pi*0) which is infinite. So, if you are using a ‘for’ loop to implement sinc, use an if statement, i.e. if t=0, set sinc(0) to 1; otherwise use the definition of sinc. Recent versions of matlab (or probably it is the signal processing toolbox) has a built-in function ‘sinc’. If you have it, you can use it directly without worrying about infinity.
2. The time constant of the output circuit, $R_L C$ is defined in line 107 as RC which you need to change for 2.(i)-(iii).

Lab 2 Report

1. Answer all the questions of (1), (2) and (3). For (1), show your calculations of message bandwidth and compare it with matlab measurement. Attach all the plots and provide explanations.
2. Attach the matlab code.