EE340 – Communications Laboratory (IIT Bombay)

Mid-Sem Exam Batch A: Wednesday, Sept. 2, 2015; 14:00 – 16:00 hrs Max. Marks: 20

Roll No.: _____ TA/RA Name(s): _____

IMPORTANT INSTRUCTIONS: Save all the snapshots and GNU-Radio files you've made in a folder (named as your roll number). You have to provide this folder to your TA at the end of the session and attach the question paper to the answer scripts you are submitting. Also, don't forget to get signatures of your TA at the front page bottom right corner of your answer book when you submit your folder and the answer script. If some simulation parameters are not provided, choose them yourself appropriately so that your simulation results are not affected by them significantly. Also make sure that your axes in the plots are marked properly.

1. Generate random noise using the 'Noise Source' block in GNU-Radio as a complex signal. Use the low pass filter block to filter out spectral components outside -20 kHz to +20 kHz frequency range. Treat the output of the low pass filter as your complex baseband 'message signal' $x(t)$. *[2+2+4]*

   (a) Show the spectrum of the signal $x(t)$.

   (b) You have to transmit this signal using passband IQ modulation at 100 kHz RF frequency. Generate the desired RF signal $s_{RF}(t)$ (which can be directly fed to the antenna). Show the spectrum of $s_{RF}(t)$.

   (c) Make a flow graph to generate the SSB modulated RF signal for transmitting the lower sideband of the real part (i.e. in-phase component) of $x(t)$, with 100 kHz carrier frequency. You have to use the Hilbert Transform block here. Show the spectrum of this RF signal. Can you suppress the upper sideband perfectly (give reason)?

2. Consider the single-balanced mixer circuit shown below in Fig. 1. We wish to use it for DSB-FC modulation of a 10 kHz sinewave over a carrier of frequency $f_c = 100\,kHz$. Assume that the transistors Q1 and Q2 act like perfect switches, i.e. when the base voltage of Q1 is higher than that of Q2, Q1 is ON and Q2 is OFF, and when base voltage of Q1 is lower than that of Q2, the states of the switches gets reversed.

   Also, assume that Q3 acts like an ideal BJT, with $I_E \approx I_C$, $I_B \approx 0$ and voltage at node A (V_A) is always 0.7 V lower than the voltage at the base of Q3.

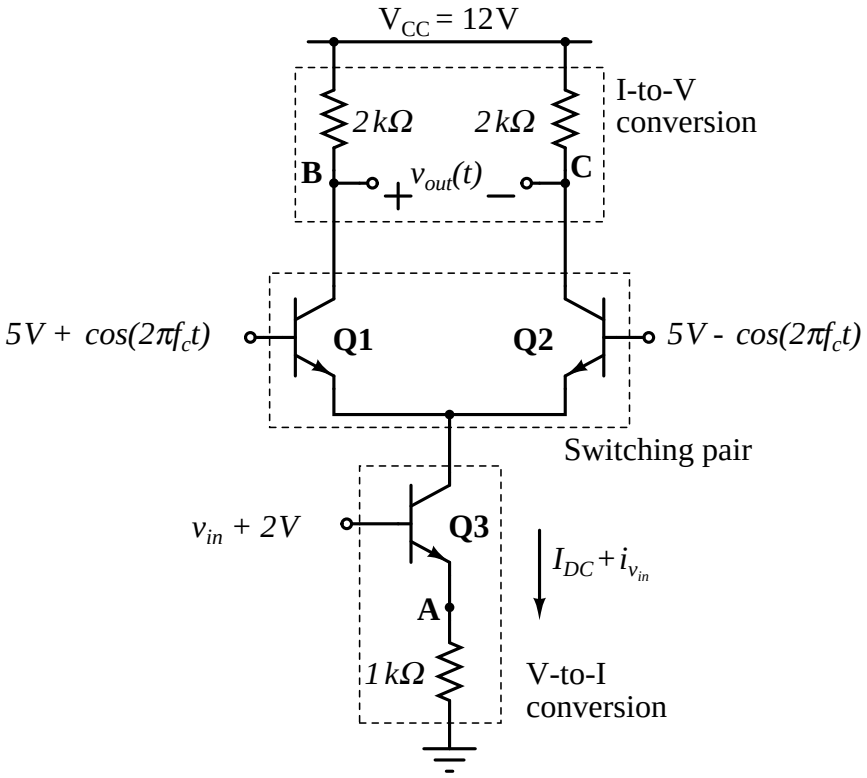

Figure 1: Single-balanced mixer for DSB-FC modulation.

Using ideal multipliers, adders, subtractors etc. in GNU-Radio, make a flow graph to emulate the circuit. For switching, you can use multiplication by square waves (in 'Signal Source' block) instead of sinusoids. Also, you should initially use the signal (v_{in}) amplitude of 0.4 V and add 0.01 V random noise to it. *[4+1+2+1+2+2]*

(a) Show the time domain voltages at nodes A, B, and C. In particular, plot voltages at nodes B and C in a common Scope Sink window (by selecting 2 as the number of inputs to the block).

(b) Show the differential output voltage in time domain.

(c) Show the single ended voltages (at nodes B and C) and the differential output voltage in frequency domain for frequency at least up to 1 MHz frequency.

(d) Why do the signals at nodes B and C individually have a frequency component at 10 kHz, while the differential output signal does not have it?

(e) Verify that the relative amplitudes of the frequency components at LO harmonic frequencies in the observed spectrum is as expected theoretically by deriving the relative amplitudes analytically.

(f) What should be the amplitude of the input sinusoid to achieve the modulation index of 0.5.