AV332: Digital Communication Lab

Lab 2
SSB and AM using Emona DateX Kit — Date: 18th and 22nd August 2016

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1 Single side band modulation and demodulation (SSB)

1.1 Task 1 (Compulsory)

Prelab assignment (5 marks)

1. Draw a block diagram representation of the phase discrimination method of SSB generation. Think about how you will use the components in your Emona kit to implement the phase discrimination method if the modulating signal is a sinusoid of frequency 2 kHz. Draw a block diagram representation of SSB demodulation.

2. Write down the power spectrum of the: (a) modulated signal at the channel input and (b) the signal after downconversion (multiplication in the demodulator) if the modulating signal is $m(t) = 2sin(2\pi 2000t)$ for both upper SSB and lower SSB.

In lab tasks (5 marks)

1. Using what you have done in the first prelab assignment implement a SSB modulator and demodulator first for upper SSB and then for lower SSB. For each case the modulating signal $m(t) = 2sin(2\pi 2000t)$ and the carrier has a frequency of 100 kHz.

2. For upper SSB and lower SSB compare the power spectrum that you have obtained from the DSA with what you had done in the second task in the prelab assignment. Report on how the time domain SSB signal looks like. Is it possible to express the SSB signal as a signal obtained from a hybrid AM-FM method?

1.2 Task 2 (Optional)

Prelab assignment

1. In the phase discrimination method of SSB generation we need a phase-shifter. Write down the frequency response of an ideal phase shifter to be used for SSB.

2. Suppose the modulating signal used in the phase discrimination method is a single tone; $m(t) = 2sin(2\pi f_m t)$. Analyze what would be the SSB modulator's output if we use a non-ideal phase shifter, which produces a phase shift of θ with unit gain at frequency f_m, in the phase discrimination method.

In lab tasks

1. Explore the phase and magnitude response of the tunable phase shifter (in the low frequency mode). Report on the response on any two frequencies within the passband of the phase shifter. (Hint: the idea is to see whether the tunable phase shifter produces the same shift for different frequencies.)

2. Simulate the effect of a non-ideal phase shifter as considered in the second task of the prelab assignment using the tunable phase shifter. Suppose this non-ideal phase shifter is used in the SSB generation method, then does what you observe in the DSA correspond to what is predicted by theory in the second prelab task? Report on the observed SSB spectrum and its comparison to that predicted by the theory.

1.3 Task 3 (Optional)

Prelab assignment

1. Draw the block diagram for the frequency discrimination method of SSB modulation.

2. Write down the power spectrum for a periodic triangular wave with period T_p, zero dc offset, and peak to peak voltage of 2V. Write down the power spectrum of the modulated signal if this periodic triangular wave is used as the modulating signal for upper SSB at a carrier frequency of f_c.

3. Think about how you will "demonstrate" SSB modulation using frequency discrimination using components of the Emona kit (and maybe an external function generator). To demonstrate SSB modulation you can choose T_p and f_c as you wish. Draw a block diagram of the system you can use to demonstrate SSB.

In lab tasks

1. Implement what you have thought about in the third prelab task. Report on the constraints that you faced while implementing this and their relationship with T_p and f_c.

2 Amplitude modulation

2.1 Task 1 (Compulsory)

Prelab assignment (5 marks)

1. Draw the block diagram representation of a plain AM modulator and envelope detector demodulator. Suppose the modulating signal is $m(t) = 2sin(2\pi 2000t)$, then write down the power spectrum of the modulated signal.

2. Find out what is meant by modulation index for plain AM modulation. Derive a relationship between the modulation index and the maximum and minimum values of the positive envelope of the modulated signal for the modulating signal $m(t)$ above. What is the relationship between modulation index and overmodulation distortion.

In lab tasks (5 marks)

1. Using the Emona kit implement the plain AM modulator and envelope detector demodulator that you have studied in the first prelab task. Make sure the modulation index for your implementation is a parameter that can be tuned. The modulating signal $m(t) = 2sin(2\pi 2000t)$ and the carrier is at a frequency of 100 kHz. Write down the observed power spectrum at a modulation index of 50% and compare with what is predicted by theory.

2. For a modulation index of 50%, 90%, and 110% observe and report on the envelope of the modulated signal. Report the corresponding values of k_a (the sensitivity). Also report the envelope detector output.

3. For the above modulation indices, check if the relationship that you have obtained in the second prelab task above is correct or not. Tabulate the values obtained.

2.2 Task 2 (Optional)

Prelab assignment

1. Think about whether the condition $k_a m(t) < 1$ is necessary or sufficient for preventing overmodulation distortion. Is the condition $k_a m(t) > -1$ necessary or sufficient?

2. Write down the conditions that R and C in the envelope detector has to satisfy for proper envelope detection.

In lab

1. Use the plain AM modulator and demodulator setup that you have made in Task 1 to prove your claims in the first prelab task. Report on what your claim is, and then how the experiment with the plain AM modulator setup allowed you to prove your claim.

2. Explore what happens to the detected envelope when the conditions that you have written down in the second prelab task are violated. Since R and C are fixed in the kit the conditions are to be violated by changing the modulating signal. Report on the time domain waveforms.