EE 340: Communications Laboratory
Autumn 2018

Lab 5: FM Pre-emphasis & De-emphasis, Single sideband modulation

Part 0: Generation of FM signals

- Generate an FM signal with two sinusoidal tones of frequencies 1.1 kHz and 11 kHz, and each having an amplitude 0.5 (so that the peak amplitude of the two sinusoids added together is 1).
- Use the method provided in prelab document.
  - To implement an integrator, use the IIR filter with FF coefficient: [b_0]; FB coefficient:[1,1]; Old Style of Taps: “True”;
    Show that this is an integrator (using the assumption given in pre-lab material)
  - You can use the Phase Modulator block for FM generation

    What should be the value of phase modulator sensitivity(k_f) so that maximum frequency deviation is 75 kHz for the signal above.
    Phase Modulator output should have the higher sampling rate. Therefore, you may need to use a Rational Resampler for upsampling before PM.

- Observe the modulated spectrum.

Part 0: Demodulation of FM signals

- Before demodulation, add random noise to the FM signal to emulate the noise added by the wireless channel.
  - Use ‘Noise Source’; Noise Type: Gaussian; Amplitude: 0.2
- Implement the FM Demodulator.
  - You can use ‘Complex to Arg’ block to get the phase of a complex signal
- Observe the demodulated spectrum. Is the noise floor higher at higher frequencies? Why?

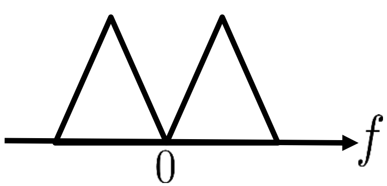
Part 1: Adding pre-emphasis/ de-emphasis

- Implement pre-emphasis and de-emphasis:
  - Use IIR Filter block to implement ($1-0.95z^{-1}$) transfer function for pre-emphasis of the message signal at Audio Rate (before Phase Modulation).
  - Use IIR Filter block to implement $1/(1-0.95z^{-1})$ transfer function for de-emphasis of the message signal at Audio Rate (after demodulation and down sampling).

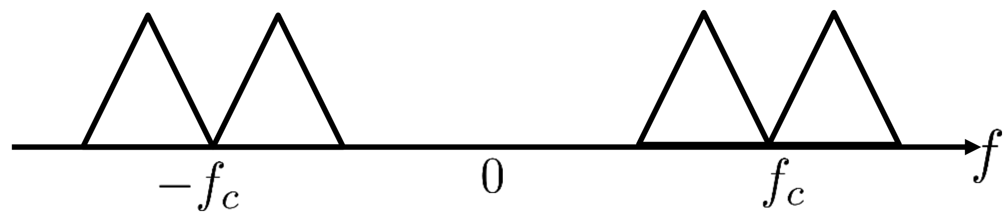
- Now observe the demodulated signal spectrum. Has pre-emphasis/de-emphasis reduced high-frequency noise in the demodulated signal?

Part 2: Single sideband modulation

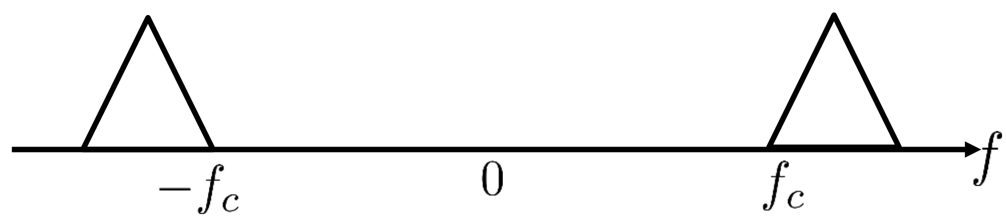
You have already implemented DSB-SC modulation. Our goal today is to implement single sideband modulation – here, only one sideband of the message is transmitted. For real messages, note that this is sufficient. This requires only half the bandwidth of DSB transmission!



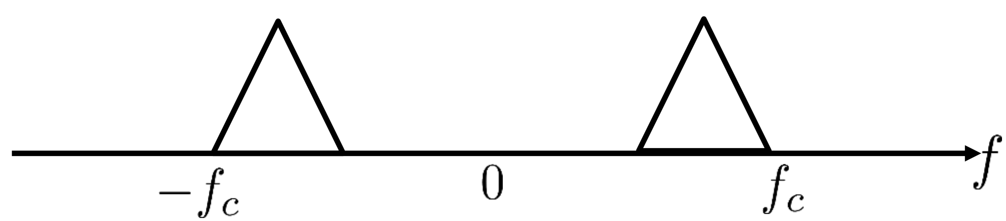
Message signal



DSB-SC transmitted signal



SSB-SC (upper sideband) transmitted signal



SSB-SC (lower sideband) transmitted signal

Part 2: Single sideband modulation

- Implement the modulation flowgraph for SSB-SC (upper sideband) transmission. Use a single tone at 10kHz as the message, and 500 KHz as the carrier frequency.

  Hint: Think of the transmitted (passband) signal as

$$\begin{aligned} s_p(t) &= \mathrm{Re}\left([s_I(t) + j s_Q(t)] e^{j2\pi f_c t} \right) \\ &= s_I(t)\cos(2\pi f_c t) - s_Q(t)\sin(2\pi f_c t) \end{aligned}$$

  What should s_I and s_Q be for SSB transmission? Use Hilbert Txform

- Observe the spectrum of the modulated signal.

- Implement the demodulation flowgraph.

- Observe the spectrum of the demodulated message signal.

- Replace the tone message signal with an audio message. Can you recover the message post-demodulation?

- Repeat the above to achieve lower sideband transmission.

Part 3 (Optional, for your mid-sem prep)

Complete Problems 1 & 2 of the mid-sem exam from last year.
The question paper is posted on moodle.
The data files you need are here:

https://www.ee.iitb.ac.in/~jayakrishnan.nair/ee340/