EE 340: Communications Laboratory
Autumn 2021

Lab 3: 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 should use ‘Complex to Arg’ block to get phase after differentiating phase of the complex modulated signal, as in discrete-time implementation in GNU radio, the phase value obtained using the ’Complex to Arg’ block has an ambiguity of $2n\pi$, where n is an integer (mentioned in the prelab).

- Observe the demodulated spectrum. Is the noise floor higher at higher frequencies? Why?

Part 1A: 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 which is 44.1K (after demodulation and down sampling).

  Set Old style of taps False

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

Part 1B FM Demodulation Continued

- An audio signal sampled at 44.1 KHz is frequency modulated with a carrier at 200 Khz. Pre emphasis is done with the same filter used in Part 1A.
- The transmitted complex signal has sample rate 3.528 MHz and is stored in file Task_1B.dat

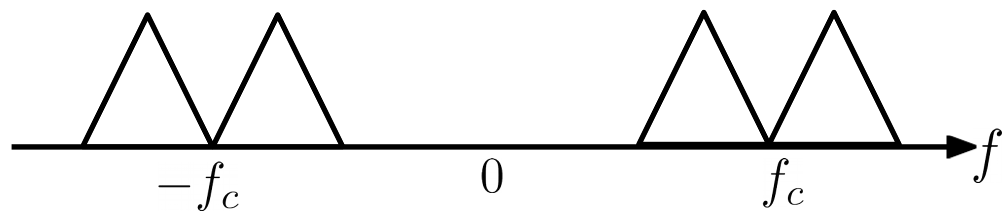
- 1 Demodulate the given complex modulated signal

- 2 Get real part of modulated signal using Complex to real Block. Perform demodulation using real part.

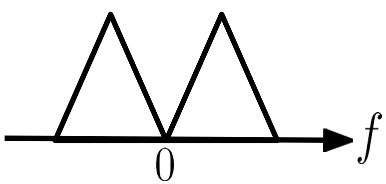
- 3 Will it matter if you used Complex to imaginary Block instead of real in Part2? Why?

Part 2: Single sideband modulation

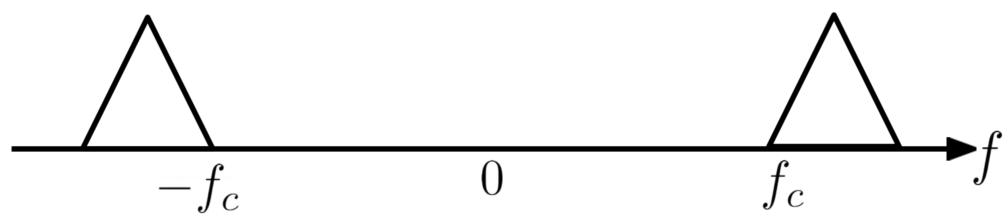
You have already implemented DSB-SC modulation. Our goal today is to implement single sideband modulation – here, only one sideband of the message is transmitted. For real messages, note that this is sufficient. This requires only half the bandwidth of DSB transmission!



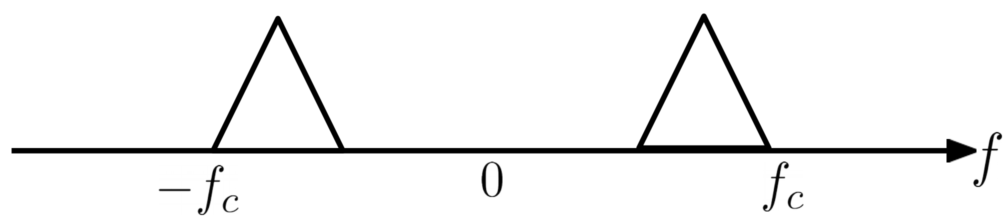
DSB-SC transmitted signal



Message 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

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

  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.