EE 340: Communications Laboratory
Autumn 2021

Lab 3: FM Pre-emphasis & De-emphasis

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

- Upsample the File Music.wav which is sampled at 32 Khz to 44.1 Khz. Pre-emphasise with same filter as in Part1-A Frequency Modulate it with a carrier of 200 Khz sampled at 3.528 MHz and save the complex modulated signal in a file Task1.dat

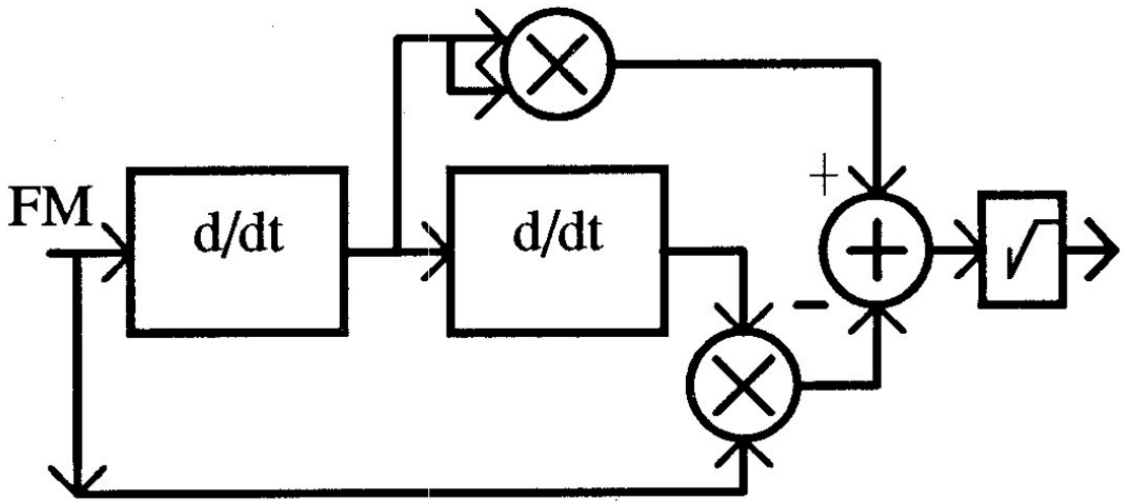
- 1- Demodulate Task1.dat

- 2- Get real part of modulated signal Task1.dat using Complex to real Block. Perform demodulation using real part.(Hint use Frequency discrimnator)

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

Part 2 FM Demodulation Continued

Doraemon has a gadget which he calls Magic_demod



Magic_demod

Part 2 FM Demodulation Continued

1- Derive the output equation of Magic_demod for frequency modulated signal as input to it.

2- Explain under what condition Magic_demod can be used to demodulate FM

3- Get the real Part of Task1.dat and use Magic_demod to demodulate it. Use Transcdental block for square rooting. If you are observing negative spike before square rooting try Using abs block as temporary workaround.

4-Ziyan and Shizuka (Future wife of Nobita) appear on Nobisuki FM station. Nobita uses Magic_demod to listen their program. Whose Program will be recieved clearer.

Part 2 FM Demodulation Continued

(Optional)

5- Using Taylor expansion it can be shown that instantaneouus demodulation error is given by-

$$e(t) = \frac{f^{'}(t)\sin\left[2\left\{\omega_c t + k_f \int_0^t f(\tau)d\tau\right\}\right]}{4\left\{\omega_c + k_f f(t)\right\}\left|f(t)\right|_{\max}}$$

Where f(t) is message signal.

Observe the above equation and Comment If the choices of fc, kf you made at modulator end is suitable for magic_demod to work well.