CS1031 - Lab 4
Analogue Modulations

February 28, 2017

1 Analogue Modulations

In telecommunications, modulation is the process of changing the properties of a high frequency wave, the *carrier* wave, based on some message signal. This is done for various reasons, such as to perform frequency division multiplexing (FDM) or to transmit a radio signal over the air in a more suitable frequency.

Analogue modulation is a group of modulation schemes where the modulating signal represents the information in a continuous form, as opposed to a digital one. Analogue modulation can be classified into three categories: amplitude modulation (AM), frequency modulation (FM) and phase modulation (PM). These refer to the properties of the carrier being changed: its amplitude, frequency or phase.

In this laboratory you will learn about analogue modulations using MATLAB. To do this you will modulate a tone using amplitude modulation and then a piece of music using amplitude and frequency modulation.

2 Exercise 1: Amplitude and frequency modulation in MATLAB

In this exercise you will modulate a tone using first AM and then FM with a carrier frequency of 30 kHz. The aim of this exercise is:

1. Plot the frequency spectrum of the given unmodulated signal ('exercise1_piece.wav').
   Hints:
   Open the file with the samples of the signal 'exercise1_piece.wav' using the command **audio read**, as illustrated below.
   Here *sampling* is the frequency the signal was sampled and *signal* will be the actual samples obtained from the file.

```
[signal, sampling]=audioread('exercise1_piece.wav');
```

You will need to perform the FFT as in previous exercises and produce a plot similar to the one in fig. 1:

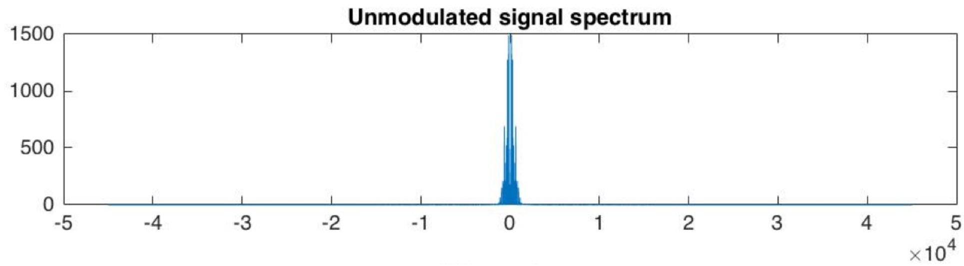


Figure 1: Frequency spectrum of baseband signal

2. Plot the frequency spectrum (doing the fft()) of the AM modulated signal.
   Hints:
   Carry out the modulation using matlab functions ammod()

```
amplitude_modulated_signal=ammod(signal, carrier_frequency,
sampling_rate);
```

You will need to perform the FFT and produce a plot similar to the one in fig. 2:

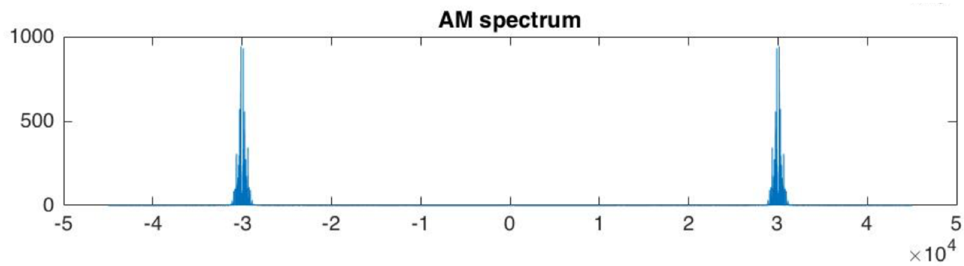


Figure 2: Frequency spectrum of amplitude modulated signal

3. Plot the frequency spectrum (doing the fft()) of the FM modulated signal.
   Hints:
   Carry out the modulation using matlab functions fmmod()

```
frequency_modulated_signal=fmmod(signal, carrier_frequency,
sampling_rate, frequency_deviation);
```

use the value $frequency\_deviation = 10000$.

You will need to perform the FFT and produce a plot similar to the one in fig. 3:

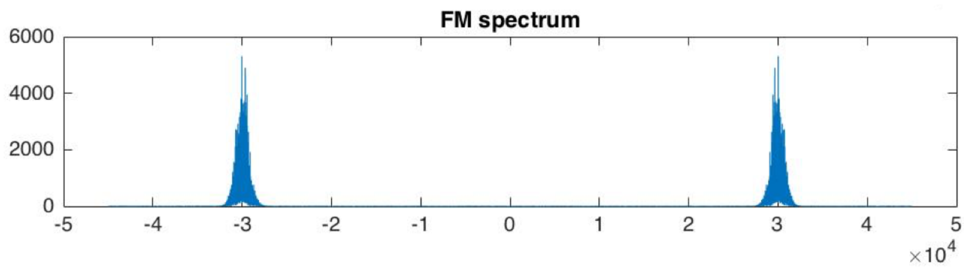


Figure 3: Frequency spectrum of frequency modulated signal

3 Exercise 2: Transmitting a modulated signal with noise

In this exercise, you will compare the resilience to noise of amplitude modulation and frequency modulation. To do this you will modulate a piece of music at 30 kHz, add some noise to it, demodulate it and hear the resulting signal.

1. Load the signal ('exercise2_piece.wav') using he **audioread** function like above.

2. Play the signal ('exercise2_piece.wav') using the function [sound(music,fsampling)], where music is the array of points making up the music piece and fsampling the sampling rate.

3. Analyse how noise affects amplitude modulation:

   (a) Modulate the signal with AM at 30KHz.

   (b) Add gaussian noise to the modulated signal with the **randn** function to create a vector and multiply it by 0.01. **Make sure the size of the vector matches the size of your signal.**

   (c) Demodulate the signal [amdemod(signal,carrier_frequency, sampling_rate)],

(d) Play the new demodulated signal to assess how was it affected by noise.

4. Analyse how noise affects frequency modulation:

   (a) Modulate the signal with FM at 30KHz with a freq_dev value of 20KHz

   (b) Add gaussian noise, as above.

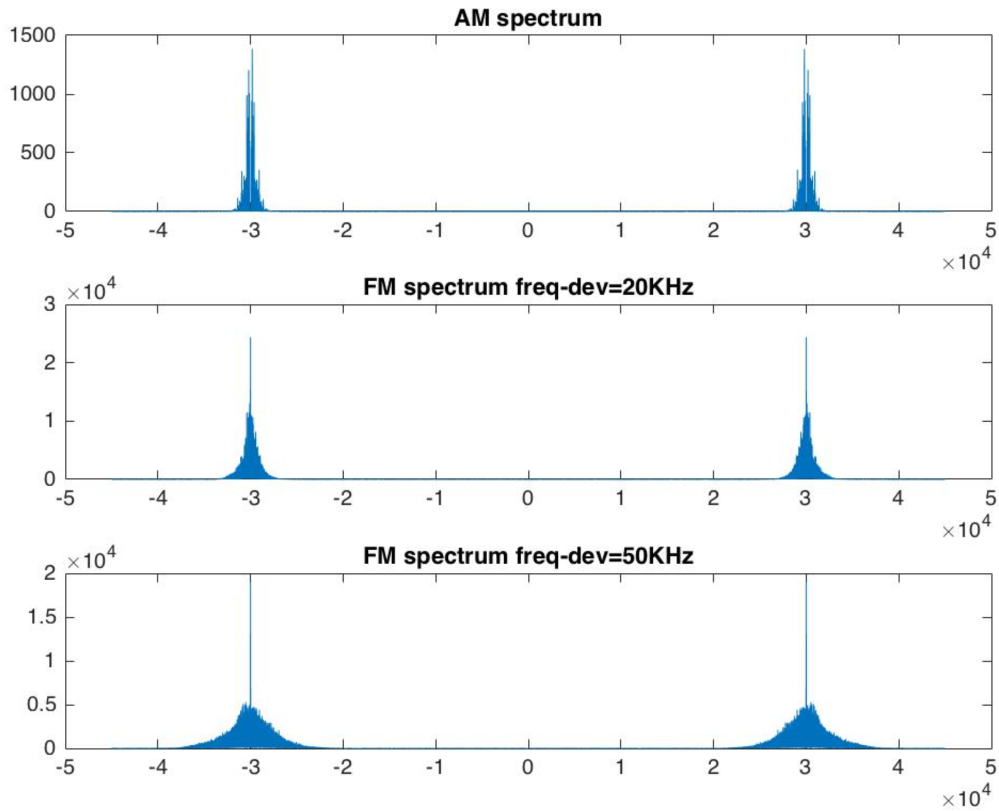
   (c) Demodulate the signal [fmdemod(signal,carrier_frequency, sampling_rate,frequency_deviation)].

   (d) Play the new demodulated signal to assess how was it affected by noise.

5. Repeat point 3, chaining the freq_dev value of the FM signal to 50KHz.

6. Determine, by playing the signal with the **sound** function, which of the three modulations is affected most and which is affected least by the noise.

7. Plot the spectrum of the AM modulated signal and the FM modulated with frequency deviation of 20KHz and 50 KHz: the frequency spectrum should look like those below.


AM spectrum
FM spectrum freq-dev=20KHz
FM spectrum freq-dev=50KHz
×10^4