Communication project: part 2

ECE233 – Fundamentals of Communications

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1 Introduction

This report presents the simulation and analysis of a stereo FM (Frequency Modulation) transmission system using MATLAB. The project includes reading stereo audio signals, generating a baseband composite signal (Xb), applying frequency modulation to produce the transmitted signal (Xc), and demodulating the FM signal to retrieve the original audio. Key features include stereo multiplexing with pilot tone and subcarrier modulation for left/right separation, and frequency modulation using an integrator and phase modulation model. As we implemented the MATLAB program based on figure 1.

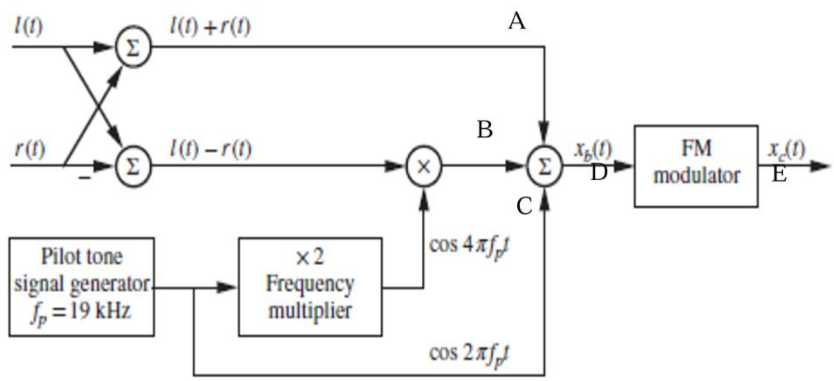

Figure 1: block diagram of an FM Sterio transmitter

2 Audio Signal Preparation

2.1 Audio File Reading

Two audio signals, representing the left and right channels, are read from WAV files using MATLAB's audioread function:

- lt = left channel
- rt = right channel

The signals are truncated to the same length to ensure synchronization.

2.2 Time Vector Calculation

The sampling frequency (fs) is selected as the minimum of the two file sampling rates. A time vector t is created for plotting and further signal processing.

3 Baseband Signal Generation

3.1 Stereo Multiplex Signal (Xb)

The composite baseband signal Xb consists of three components:

- **af (mono signal)**: lt + rt
- **bf2** (stereo difference modulated on 38 kHz): (lt - rt) * cos(4π*fp*t)
- **pilot**: A 19 kHz pilot tone at 10% amplitude

The final baseband signal is:

$$Xb = af + bf2 + pilot$$

This represents the input of the FM modulator.

4 Frequency Modulation

4.1 Integrating the Baseband

To perform FM modulation, the composite signal Xb is integrated:

$$int\_xb = cumsum(xb) * dt$$

Where dt = 1/fs. This integral is used as a phase term in the FM modulation equation.

4.2 Modulated Signal (Xc)

The FM modulated signal is:

$$Xc = Ac * cos(2 * pi * fmc * t + 2 * pi * kf * int\_xb)$$

Where:

- fmc = 99.1 MHz carrier frequency
- kf = 4000 Hz peak frequency deviation
- Ac = 1 (carrier amplitude)

4.3 FM Demodulation

Demodulation is done using MATLAB's fmdemod() function with some edit on the output to make sure that it is actually very close to the input:

$$xcm = -1 * fmdemod(xc, fmc, fs, kf / (2 * pi)) / 10000 - 2.8$$

The signal is scaled and offset to match the amplitude of the original baseband signal.

5 Results and Plots

- **af**: The mono signal (lt + rt)
- **bf2**: Stereo difference modulated with 38 kHz subcarrier
- **pilot**: 19 kHz synchronization tone
- **Xb**: Baseband signal for FM input
- **Xc**: FM modulated signal
- **xcm**: Demodulated output audio signal

The plots verify the presence and structure of the stereo multiplex signal, as well as the accuracy of modulation and demodulation. As shown in figure 2.

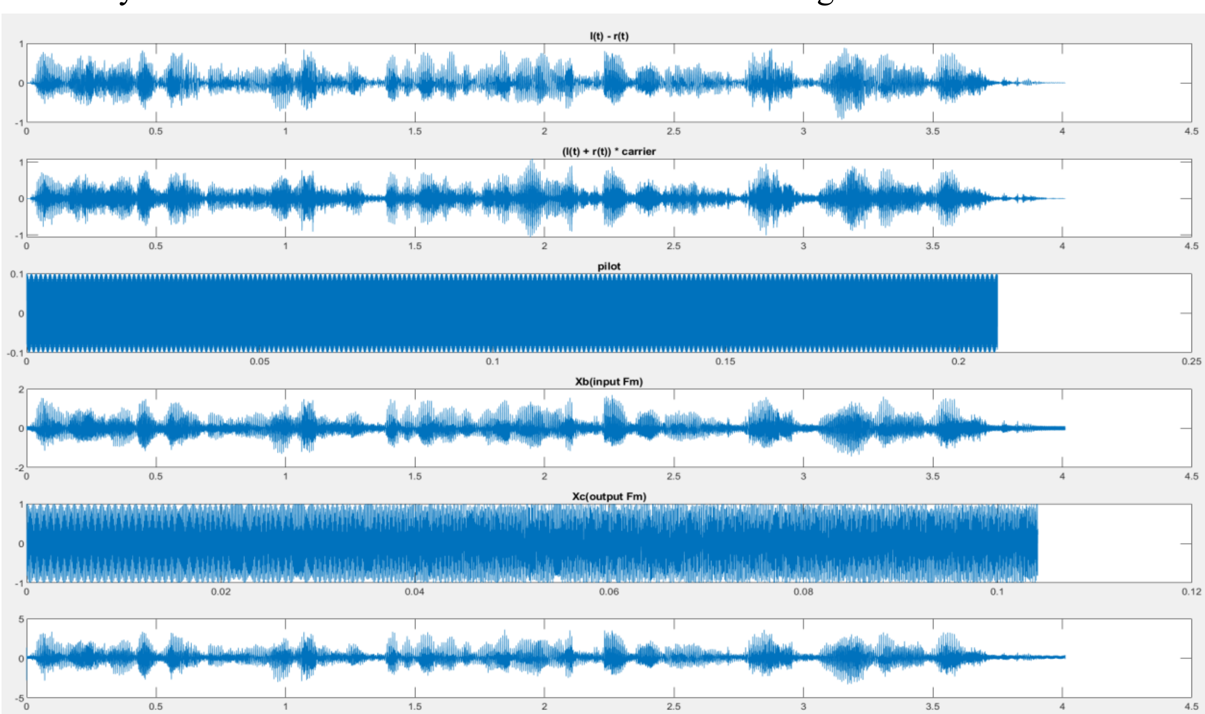

Figure 2: plots of the six graphs

6 File Output

Two WAV files are generated for verification:

- input.wav: The FM baseband input signal (Xb)
- output.wav: The demodulated signal (xcm)

7 Conclusion

This simulation demonstrates a complete stereo FM transmission and reception chain, including audio multiplexing, FM modulation, and demodulation. The composite baseband signal was accurately formed using sum and difference audio channels, a pilot tone, and subcarrier modulation. The FM modulated signal was successfully demodulated using standard MATLAB functions. The system highlights key aspects of FM stereo broadcasting and illustrates the importance of time-domain signal handling, integration for phase modulation, and frequency demodulation.