Course EE4361-001 (Introduction to DSP)

Class Project

1. Stereo Radio Signals:

The signal broadcasted from stereo radio stations can be received and played by both stereo and mono radio receivers. The stereo receivers have two and mono receivers have one speaker. In stereo radio stations usually two microphones are used for speech (or music) recording. The stereo transmitter adds the signals recorded from two microphones together and modulates and sends the result on one particular frequency band that both stereo and mono receivers can demodulate and play it. Also, the recorded signals are subtracted from each other, modulated, and sent on another frequency band that only stereo receivers can demodulate. Stereo receivers then once again add and subtract these two received signals in order to reconstruct the original signals recorded from the microphones. This project is intended to show how this traditional stereo radio concept can be done digitally using digital signal processors and fast A/D:

Two speech signals from two speakers (one male and one female) were recorded with $16\,kHz$ sampling rate. Both signals were band limited by a low pass filter with cut off frequency of $5\,kHz$. As per Figure 1, we name these two signals $x_1(n)$ (male speaker) and $x_2(n)$ (female speaker). The two signals were added together and called $s_1(n)$ and subtracted from each other and called $s_2(n)$. $s_1(n)$ was modulated by a carrier signal with $f_c = 70\,kHz$ and so was $s_2(n)$ by a carrier signal with $f_c + f_\Delta$, where $f_\Delta = 20kHz$. Both modulated signals were added and transmitted as a single signal. The received signal at the receiver is called $RX(t)$. Figure 2 shows the magnitude spectrum $RX(e^{j2\pi fT_s})$. $RX(t)$ is sampled with sampling frequency of $f_S = 400kHz = 1/T_S$ and is called $RX(n) = RX(nT_S)$. $\omega = 2\pi fTs$, Ts is sampling interval.

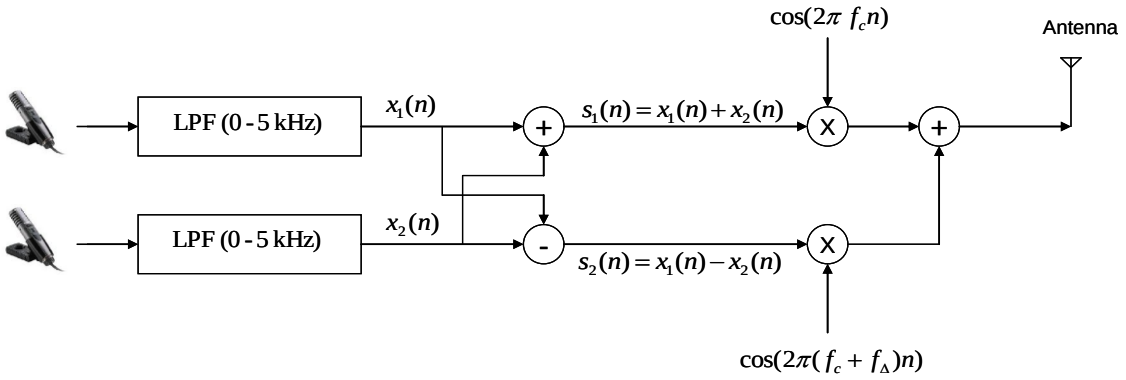

Figure 1. Stereo transmitter

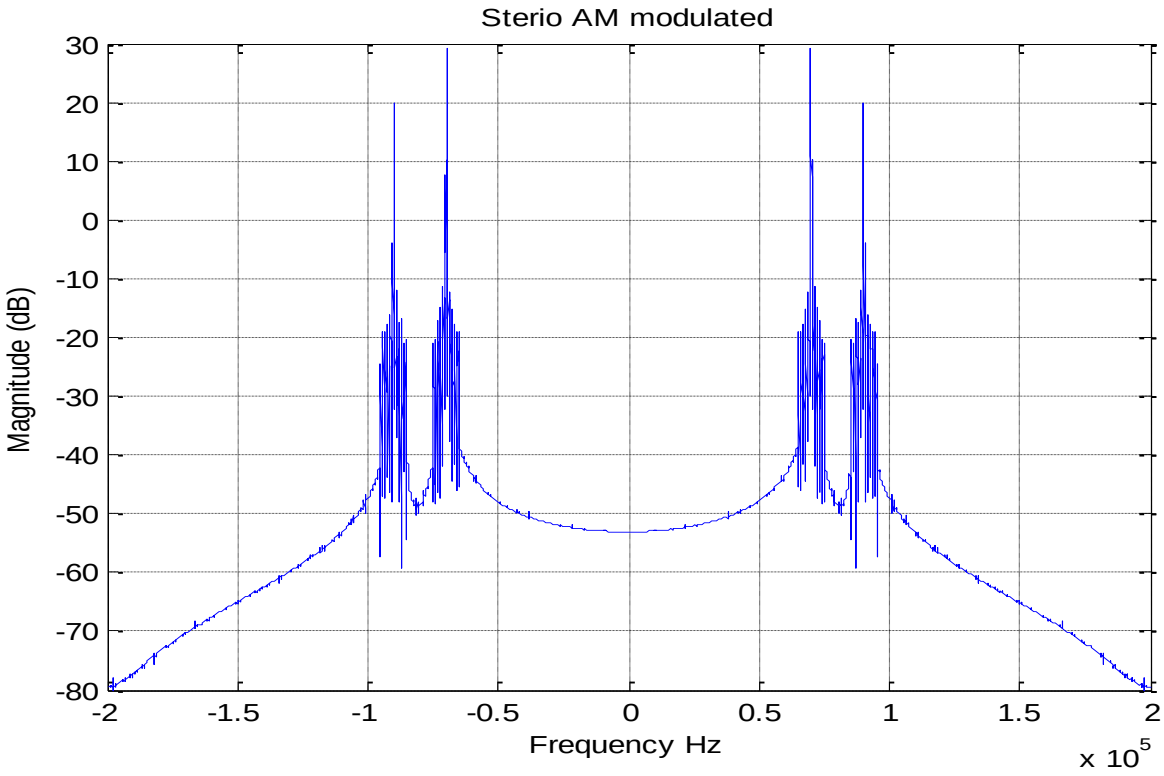

Figure 2. The spectrum of $20\log(\left|RX(e^{j2\pi fT_s})\right|)$

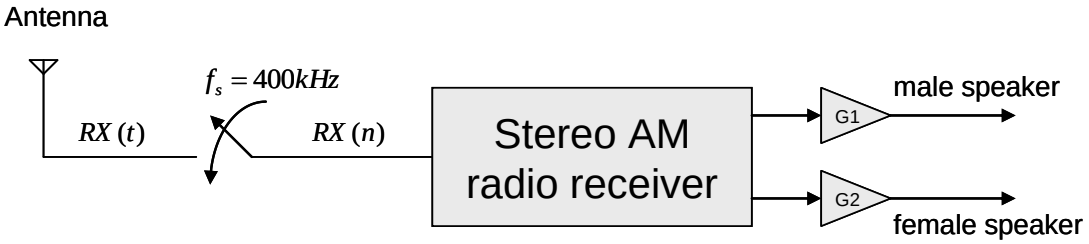

Figure 3. Stereo radio receiver

2. ASSIGNMENT:

1) Develop and write down the complete analytical formulation of the problem, at the transmitter and at the receiver and, how and why $x_1(n)$ and $x_2(n)$ and the gains are obtained in your report.

2) See, analyze, and use the given data file for $RX(n)$. Then design a radio receiver (Figure 3) to demodulate and extract $s_1(n)$ and $s_2(n)$. Then using these two signals, reconstruct the recorded $x_1(n)$ and $x_2(n)$. Signals $x_1(n)$ and $x_2(n)$ should have the sampling rate of $16kHz$. Also compute and find the total energy of each signal.

3) Plot time domain and spectrum of the recovered signals $x_1(n)$ and $x_2(n)$. Label the figures and plots very well.

NOTE: You should be able to play and hear $x_1(n)$ ***and*** $x_2(n)$ ***played on your computer!***

Some useful MATLAB functions: (*audioread), (audiowrite), (sound['audiofilename.wav', sampling rate]), (fir1,filter), (fft, fftshift), (freqz).*

3. COMPLETION DATE AND PROJECT REPORT DELIVERY:

- This assignment must be completed by you individually, and the professionally written project report must be submitted individually **by December 2, 2021, in the classroom**.
- The project report must be written, cleanly, clearly, and readable. Figures must be clear, labeled well, and readable too.
- Negative points will be given to the project and report if any requirement mentioned in this project is not fully met.
- **No late delivery!** No report will be accepted after Dec. 2, 2021.

4. REPORT STRUCTURE:

- Your report **must** be prepared/typed using MS-Word, Equations, or MS-Power point. **A soft copy of your work/report *may be* requested.**
- Your report **must** have your complete full name, your UTD email, course name and number - **all printed in upper case letters and numbers on the first page.**
- Your report **must** include this entire write-up as its first pages.
- Pages of your report **must** be stapled together. Every page **must** be numbered.
- The same notations, variable names used in this write-up **must** be used throughout your report.
- You **must** use upper case bold letters for the matrices, and lowercase bold letters for vectors. Functions and variables **must** be in *Italic* format (see notations used in your textbook).
- Organize and write your report well. **BE BRIEF.** Write down and explain only **your own work, equations, answers, and results** clearly and efficiently. Avoid redundancy and writing unnecessary or irrelevant materials.
- Figures and plots, if any, **must** be numbered and labeled very well.
- **Negative credit** will be given if any of the report's requirements is not fully met.

The End.