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DEEMED TO BE UNIVERSITY UNDER SECTION 3 OF THE UGC ACT, 1956

B. Tech – Computer and Communication Engineering (CCE)

Third Semester

Amrita School of Engineering

Coimbatore Campus (India)

December 2021

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Virtual Radio Broadcasting

Faculty In-charge – Dr S. Kirthiga Mam, Ms R. Karthika Mam and Mr K. Pargunarajan Sir

Abstract

Audio signal processing is a subfield of signal processing that is concerned with the electronic manipulation of audio signals. The project, based on Signal Processing, employs sound as a signal and demonstrates various functionalities that can be performed on it. Further, it simulates complex real-world applications of sound wave/audio by assuming a simpler scenario. These functionalities are made possible with a convenient programming language Python and Spyder Integrated Development Environment (IDE).

A list of channels containing different options available for broadcasting is presented to the user. These options on the list consist of a set of sound processing functionalities. These functionalities include basic operations such as reading, recording, and generating a sound file. Further, sound signals are incorporated in our application-based algorithm to demonstrate a real-world scenario.

The next part of our project consists of an application-based technique in which radio communication and broadcasting are simulated. The following operations have been performed to simulate radio broadcasting:

1. Frequency Modulation and Demodulation
2. Amplitude Modulation
3. Design and Analyse Filters
4. Noise Compression

System Description with Application

The below system depicts the simulation of radio broadcasting using various operations on sound signals.

Process: Modulation technique is used to broadcast the audio signals through radio waves transmission and demodulation technique is used to convert the received signal into nearly audible form.

1. **Modulation** – It is the process of varying one or more properties of a periodic waveform, called the carrier signal, with a separate signal called the modulation signal that typically contains information to be transmitted. This project involves both frequency and amplitude modulation techniques used for radio transmissions and short-range communications respectively.

2. **Demodulation** – It is extracting the original information-bearing signal from a carrier wave. Modulation and demodulation techniques employ phase angle changes to obtain the desired result.

3. **Filters** – They are used to remove some unwanted components or features from a signal. Filtering is a class of signal processing, the defining feature of filters being the complete or partial suppression of some aspect of the signal.

Software Required:

Spyder IDE – Anaconda3 2021.11 (Python 3.10.1 64-bit)

Publisher – Anaconda, Inc.

Library Functions and Packages:

Math	Matplotlib	NumPy
Pydub	Random	SciPy
Sounddevice/Soundfile	Struct	Wave

Methodology

The different steps for our approach are described as follows:

1. **User Input** – The following options are displayed below:
   Option 1 – Music (Reading a sound file).
   Option 2 - News and Politics (Modulation/demodulation techniques).
   Option 3 - Gossip with RJ (Recording a sound file).
   Option 4 - The Kids Arena (Creation of soundtracks).
   Option 5 - Troubleshoot Errors (Filtering & denoising).

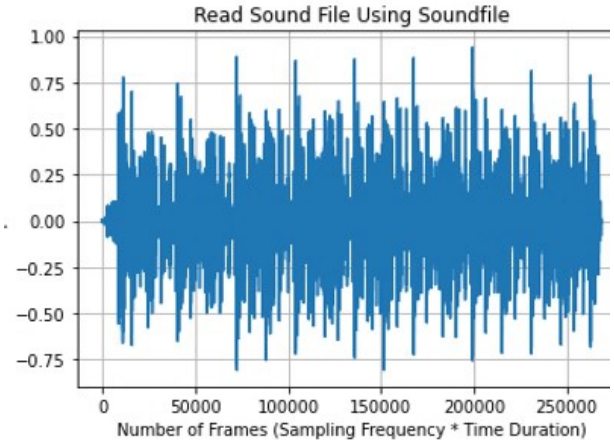
2. **Signal Generation** – It involves reading, generating or recording an audio file containing sound signals. The creation of different soundtracks according to user input is also a part of signal generation.
   - A sound file is read from an external source to either plot its waveform or used for further processing.
   - A sound file is generated with its defined characteristics to denote the start and the end of our project.
   - Recording a sound file is done through an external microphone.

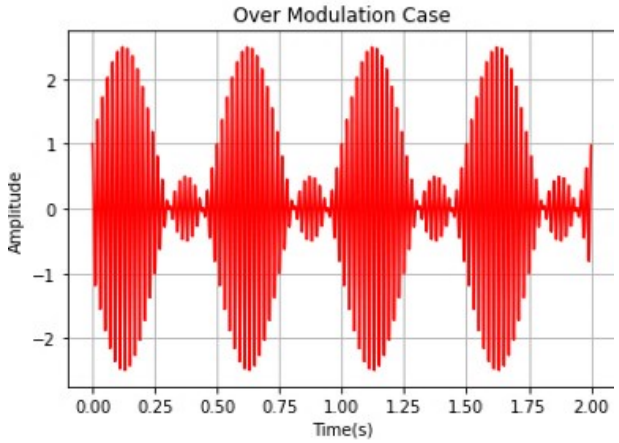
3. **Signal Processing** – In this step, sound files are made ready for broadcasting. The sound signal is modulated with a carrier wave for transmission. After this, the modulated sound signals are transmitted and received at the other end. This received signal is demodulated to extract the sound signal. This sound signal must be filtered to restore its original form. In our project, removing noise and filtering sound signals are part of the troubleshooting and diagnosing process.

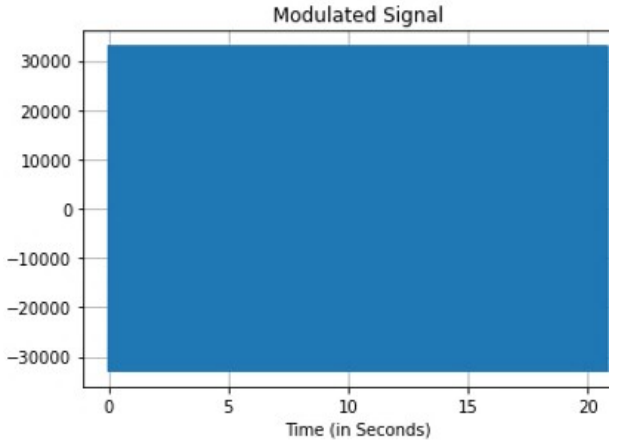
4. **Results** – The corresponding sound file for the entered option from the menu is played. It is also plotted as a waveform.

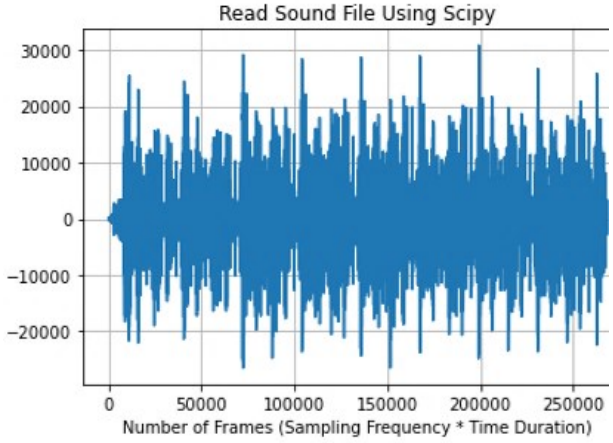
Simulation Results

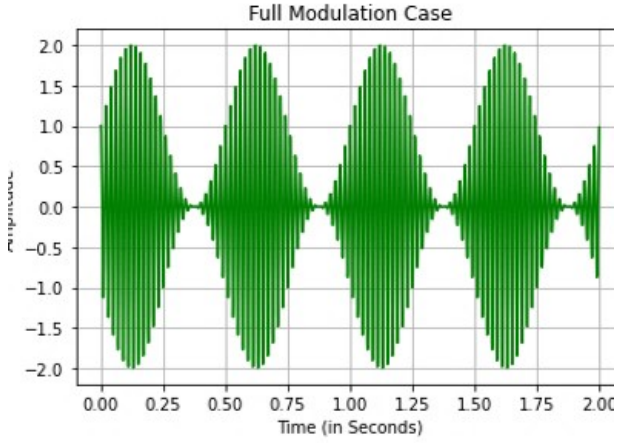
(PTO)

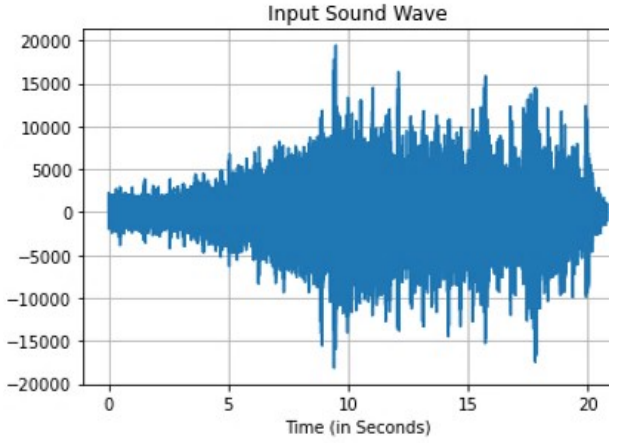

Read Sound File Using Soundfile
Number of Frames (Sampling Frequency * Time Duration)

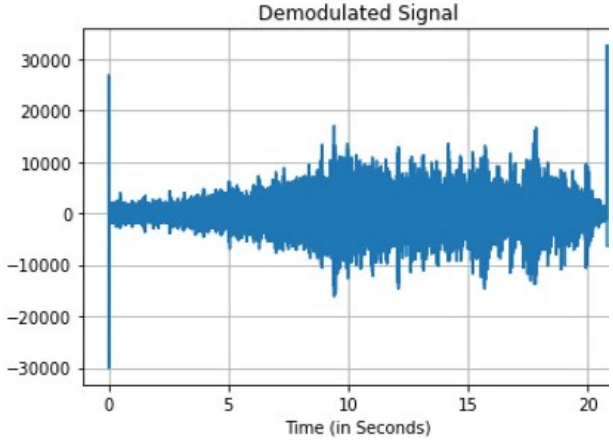

Over Modulation Case
Amplitude
Time(s)

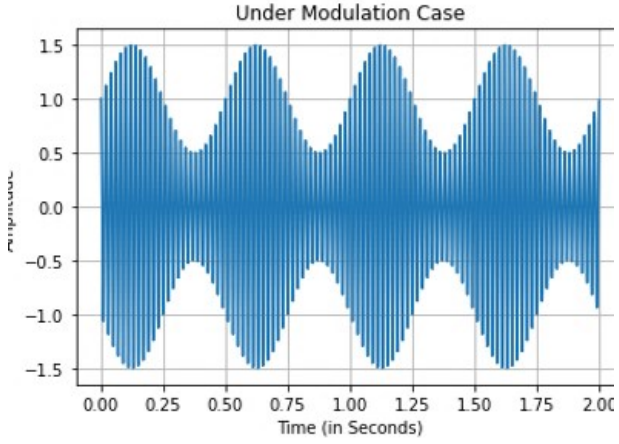

Modulated Signal
Time (in Seconds)

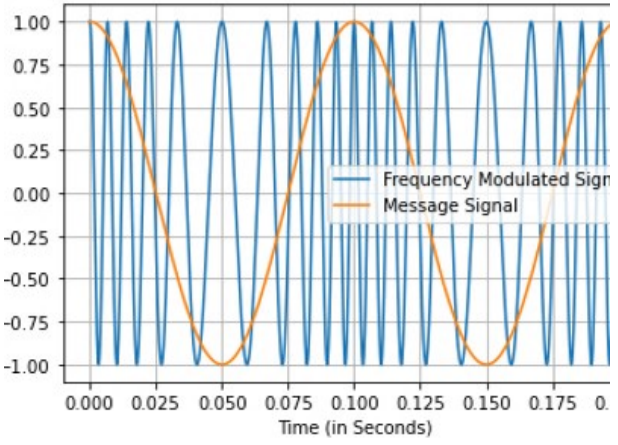

Read Sound File Using Scipy
Number of Frames (Sampling Frequency * Time Duration)

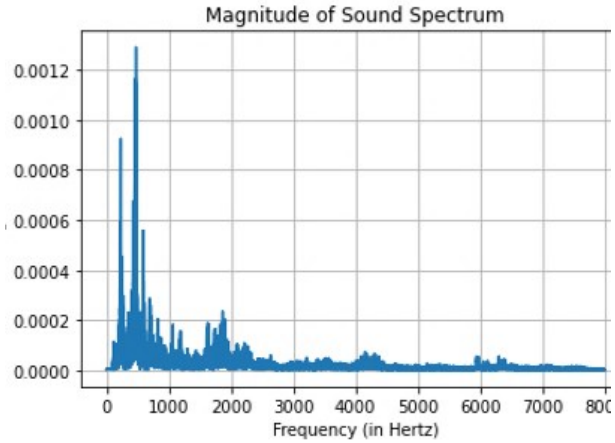

Full Modulation Case
Time (in Seconds)

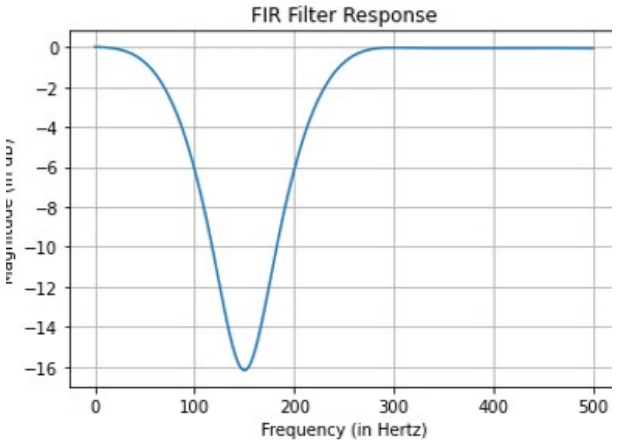

Input Sound Wave
Time (in Seconds)

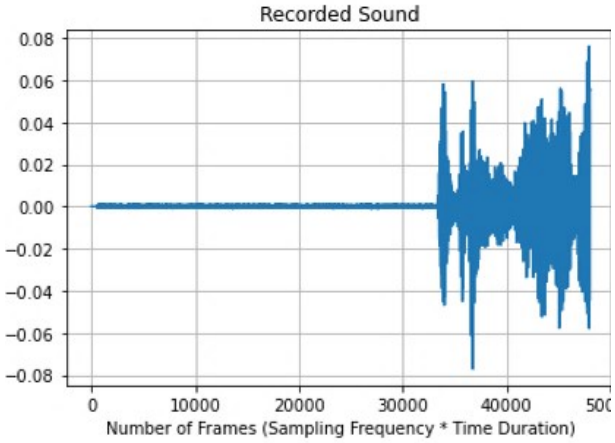

Demodulated Signal
Time (in Seconds)

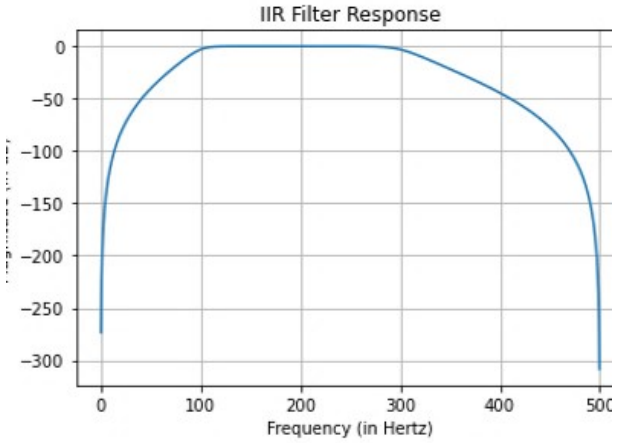

Under Modulation Case
Time (in Seconds)

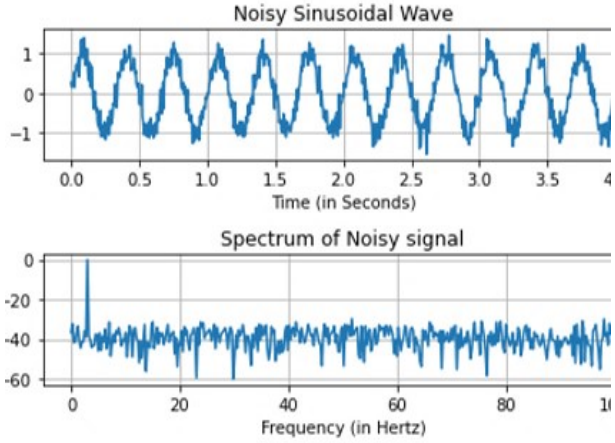

Frequency Modulated Sign
Message Signal
Time (in Seconds)

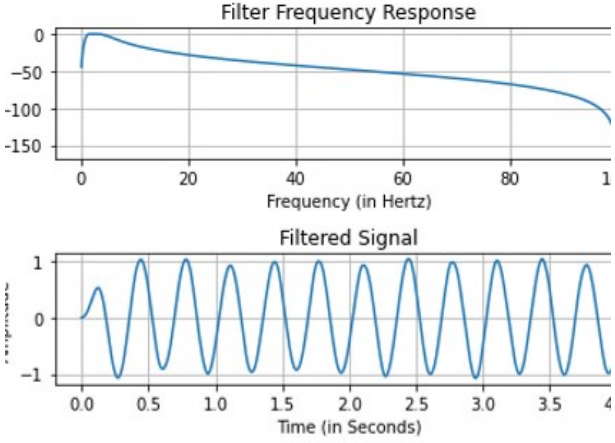

Magnitude of Sound Spectrum
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
0
1000
2000
3000
4000
5000
6000
7000
Frequency (in Hertz)

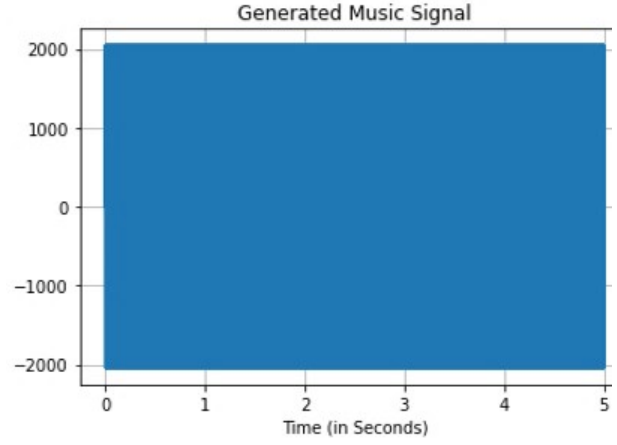

FIR Filter Response
0
−2
−4
−6
−8
−10
−12
−14
−16
0
100
200
300
400
500
Frequency (in Hertz)

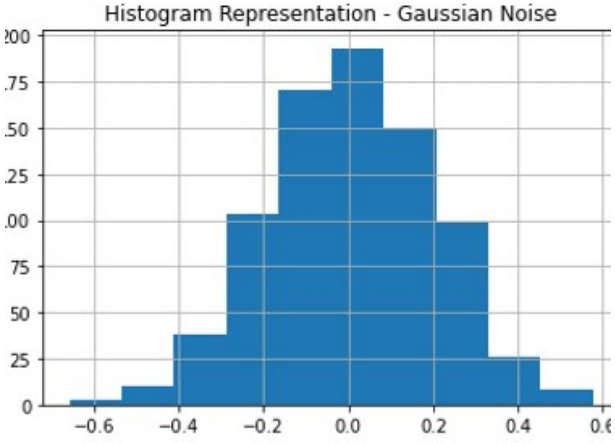

Recorded Sound
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.08
0
10000
20000
30000
40000
Number of Frames (Sampling Frequency * Time Duration)


IIR Filter Response
0
−50
−100
−150
−200
−250
−300
0
100
200
300
400
Frequency (in Hertz)


Noisy Sinusoidal Wave
1
0
−1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Time (in Seconds)
Spectrum of Noisy signal
0
-20
-40
-60
0
20
40
60
80
Frequency (in Hertz)


Filter Frequency Response
0
−50
-100
-150
0
20
40
60
80
Frequency (in Hertz)
Filtered Signal
1
0
−1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Time (in Seconds)


Generated Music Signal
2000
1000
0
−1000
−2000
0
1
2
3
4
5
Time (in Seconds)


Histogram Representation - Gaussian Noise
.75
.50
.25
.00
75
50
25
0
−0.6
−0.4
−0.2
0.0
0.2
0.4

Conclusion

Audio/sound processing is a special case of signal processing, which is applied to process and analyse speech signals. Some of the typical applications of speech processing are speech recognition, speech coding, speaker authentication, speech enhancement, detection and removal of noise, speech synthesis, text to speech conversion, etc.

Here, the simulation of broadcasting which involves modulation/demodulation, filtering, is done using programmed sound operations.

Future Prospects

Although the advantages of digital signal processing technology are obvious, its shortcomings such as sound quality and signal transmission rate cannot be neglected. Therefore, it is necessary to continue research on digital signal processing technology, for convenient and reliable communication.

References

1. Think DSP: Digital Signal Processing in Python, Allen B. Downey, O'Reilly Media, 2016 (ISBN: 9781491938515)
2. Digital Audio Signal Processing, Udo Zölzer, Wiley, 2008 (ISBN: 9780470680025)
3. Real-time FM Radio for Teaching DSP and Communication Systems: https://ieeexplore.ieee.org/abstract/document/6684995
4. Signal Processing in Musical Terms and Music Theory Visualization: https://towardsdatascience.com/music-in-python-2f054deb41f4
5. How to Perform Frequency Modulation with a Digitized Audio Signal: https://www.allaboutcircuits.com/technical-articles/how-to-perform-frequency-modulation-with-a-digitized-audio-signal/
6. Virtual Labs: Amrita Laboratories Universsalizing Education (https://vlab.amrita.edu/) and Jagadish Chandra Bose Research Organisation (https://www.jcbrolabs.org/)
7. Other Community Sources: Python Documentations, Stack Overflow, GeeksForGeeks, YouTube