Digital Audio Workshop 2.0

IEEE UCF Skills Series

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About Me

1. 3rd year Electrical Engineering Major, Signals & Communications Track
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4. Undergraduate Research in UCF ECE's NWSL, & CFRSL
5. Free Time: Church, Reading, Music Production, Tennis/Pickleball/Basketball, Spicy Food

Overview

Audio Fundamentals

Longitudinal sound waves are a form of energy transfer through a medium, usually the air. However, in this workshop, we will focus on *transverse* waves, which we are used to seeing in our classes. Audio is a mathematical phenomenon, and by extension, an electrical one as well.

Signal Characterization

Analog - in a finite range of amplitude, has an infinite possibility of numerical values

Digital - in a finite range of amplitude, has a finite possibility of numerical values

Continuous - in a finite duration of time, has an infinite possibility of numerical values

Discrete - in a finite duration of time, has a finite possibility of numerical values

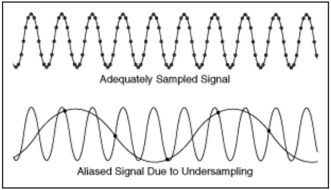
ADC, DAC

Analog-to-Digital Conversion (ADC) changes a continuous analog signal into a discrete digital. This method is called *sampling*.

Digital-to-Analog Conversion (DAC) is the reverse process. This method is *sample-and-hold*.

A Rule to Follow in DSP

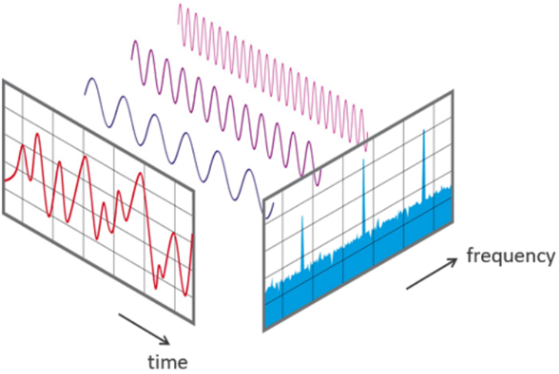
To prevent aliasing, a periodic signal should be sampled at greater than 2x the frequency of its highest component.



Theorem (Nyquist Sampling Theory)

$f_s \geq 2 * f_0$

The Frequency Domain



Question: Is there such a thing as negative frequency?

Fourier Analysis

1878: Joseph Fourier publishes "The Analytical Theory of Heat." This is adapted to the discipline of electrical signals and called the *Fourier Series*.

Further adaptations:
FT/FFT, DFT/DTFT

SECTION II.

FIRST EXAMPLE OF THE USE OF TRIGONOMETRIC SERIES IN THE THEORY OF HEAT.

ART. PAGE

171—178. Investigation of the coefficients in the equation

$$1 = a\cos x + b\cos 3x + c\cos 5x + d\cos 7x + \text{etc.}$$

From which we conclude

$$a_i = \frac{1}{2i-1}\frac{4}{\pi}(-1)^{i+1},$$

or $$\frac{\pi}{4} = \cos x - \frac{1}{3}\cos 3x + \frac{1}{5}\cos 5x - \frac{1}{7}\cos 7x + \text{etc.}$$ 137

Tools

yt-dlp is an open-source program that allows for quick extraction of audio from YouTube videos. Download here: GitHub (requires ffmpeg and Python 3.8 or later)

ffmpeg is "fast forward moving picture experts group." It is used by yt-dlp to extract and process audio. Download here: GitHub

Installation Tutorial: YouTube

Dependencies: MediaFire

yt-dlp command

```
yt-dlp --ignore-errors --format bestaudio
--extract-audio --audio-format mp3 --audio-quality 160k
--output "%(title)s.%(ext)s" "INSERT-URL-HERE"
```

For a playlist, insert - -yes-playlist before the URL. ffmpeg files must be in the PWD or added to your PATH.

MATLAB functions

1. audioread() - why are there 2 columns of data?
2. audiowrite()
3. sound()
4. fft()
5. fftshift()
6. abs()

The units for the audioread() data are normalized. We aren't given the specific energy of the wave, only the relative amplitude. Really this tells us the pressure readings from whatever transducer recorded the signal.

MATLAB scripts

generator.m produces a sum-of-sines with a uniformly distributed noise layer and outputs to playback so we can listen.

denoise.m is where we design a filter to recover a portion of the signal. While some noise is removed, we do not perform noise cancellation.

Low Frequency Oscillator (LFO)

Using the digital audio workstation LMMS (Linux Multi-Media Studio), we can simulate a digitally controlled, multi-input, single output system. In this demo, the dynamic system is a lowpass filter and the controller is an LFO. The inputs are the control signals and the output is the synthesized sound.

Is this a linear time-invariant system? ▸ Article

Relevant Coursework

- EEL3123C Linear Circuits II
- EEL3552C Signal Analysis & Analog Communication
- EEL4750 DSP Fundamentals
- EEL4515C Digital Communications
- EEL4140C Analog Filter Design
- EEL5513 DSP Applications
- EEE5555 Surface Acoustic Waves
- EEL5630 Digital Control Systems