

# Applications of the Discrete Time Fourier Transform (DTFT) and Filter Design

Adrian Sucahyo Yishar Mendoza Evan Lee William Hurst

## Introduction

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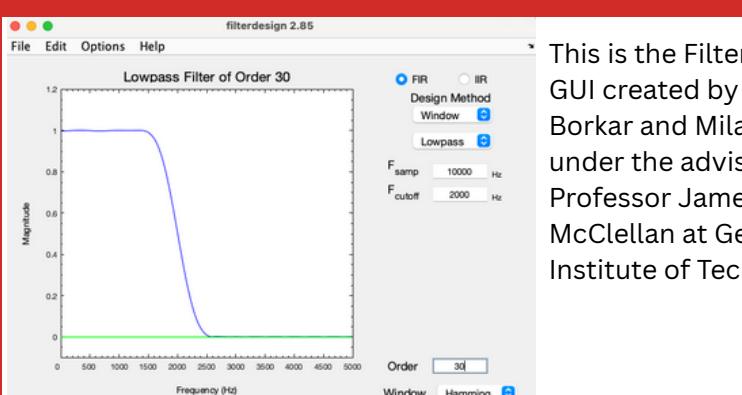
In this presentation, we use the DTFT to design FIR filters through various windowing techniques and examine how these design choices change the resulting time-domain signals. We later apply these same FIR and DTFT concepts to a real-life application: the Dual-Tone Multi-Frequency (DTMF) telephone system.

## Problem Statement

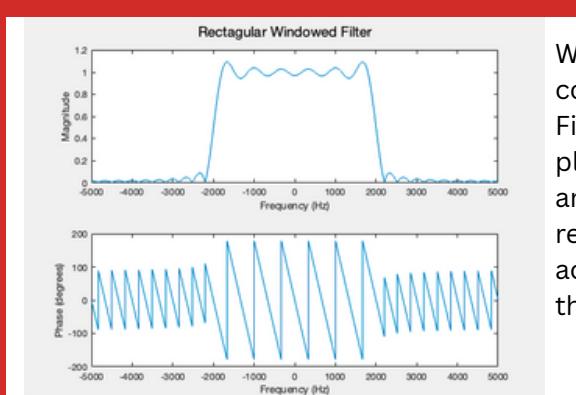
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## Finite Impulse Response (FIR) Filter Design

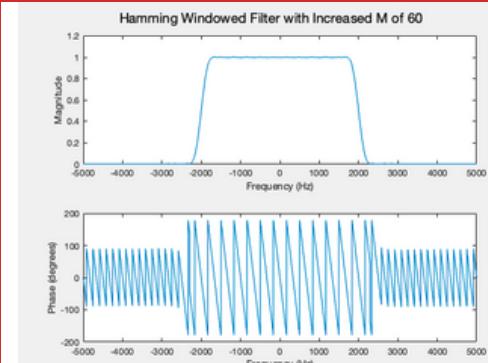
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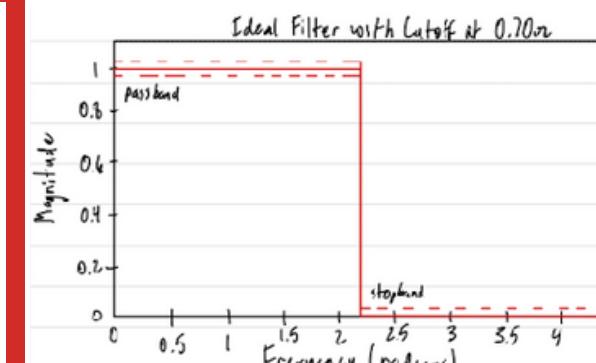
This is the Filter Design GUI created by Miland Borkar and Milan Doshi, under the advisement of Professor James McClellan at Georgia Institute of Technology



We exported the coefficients from the Filter Design GUI and plotted the magnitude and phase with higher resolution to get more accurate readings from the plot.



This is a continuation of the rectangular window plot. It once again uses the exported coefficients, except some of the parameters were changed, such as the order and window type.



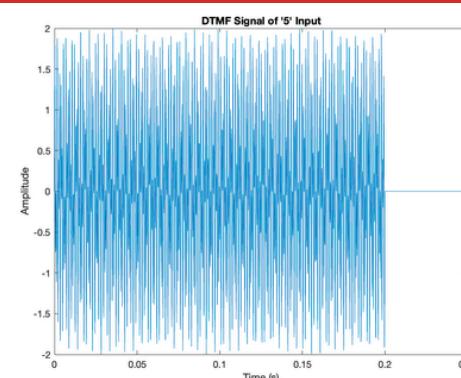
This is a sketched version of an ideal filter with a cutoff frequency at  $0.70\pi$  radians.

## Dual-Tone Multi-Frequency (DTMF) Signaling

Dual-Tone Multi-Frequency (DTMF) is a signalling technique that utilizes two different tones to encode information. One encoding scheme used with DTMF is to use grid aligned characters each represented by a unique combinations of tones. Through synthesis and extraction of these tones, the original characters can be recovered. DTFT is utilized in order to extract these frequency tones.

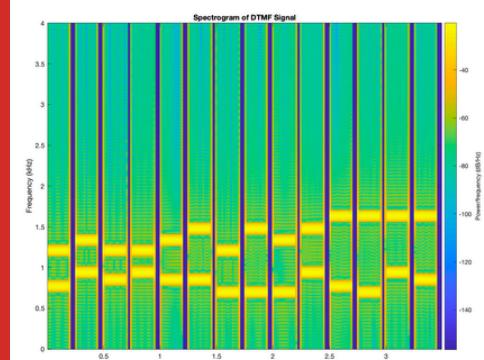
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This is a frequency and symbol table of dual-tones used in a DTFT system used to generate signals.

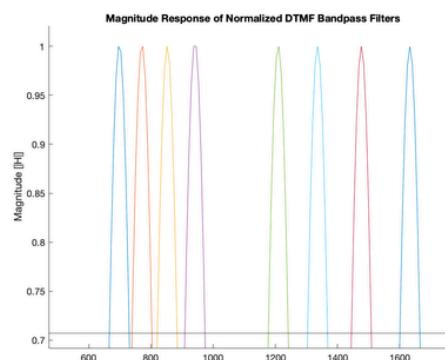


This figure is time plot of a dual-tone signal generated from the number '5'.

Observe that in the time domain, it is almost impossible to confidently discern the frequencies contained within the signal.



The figure on the left shows the spectrogram of a phone number being dialed. The intensity of the plot shows the frequencies that are present in the signal. It is apparent that two different pure tone frequencies are present.



The figure shows the 8 FIR filters used to extract the frequencies present in a given signal.

The FIR filters were designed with a length of 110 taps to be able to distinguish one filter from another.

## Summary

The investigation into the application of DTFT demonstrated the following:

- By varying filter lengths and windowing types, we can see how the frequency response of a signals change in terms of bandwidth and selectivity.
  - Increasing filter order yields better frequency isolation, but also increases computational cost and processing time in large systems
- Frequency-domain analysis and FIR filtering translate into a practical real world communication system.
  - Demonstrated this application through dialing phone numbers using DTMF

## Credits

FIR Analysis  
 • Evan Lee  
 • William Hurst

DTMF Application  
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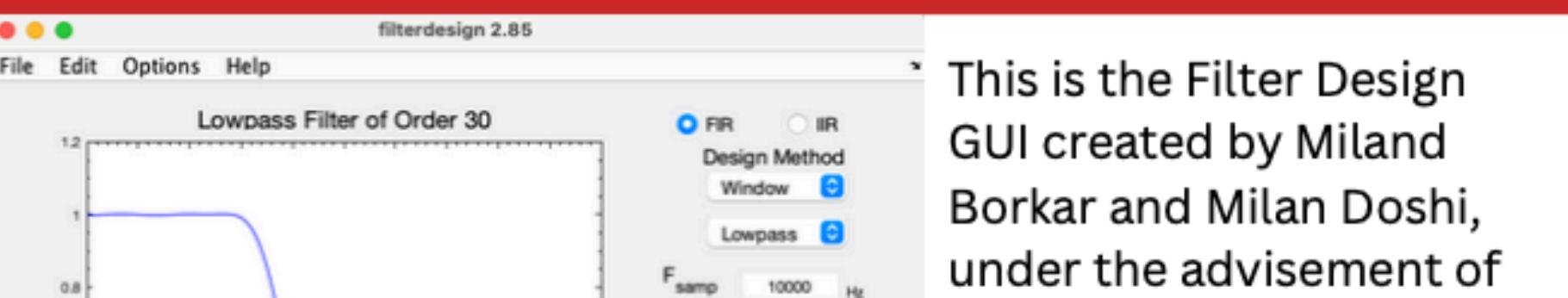
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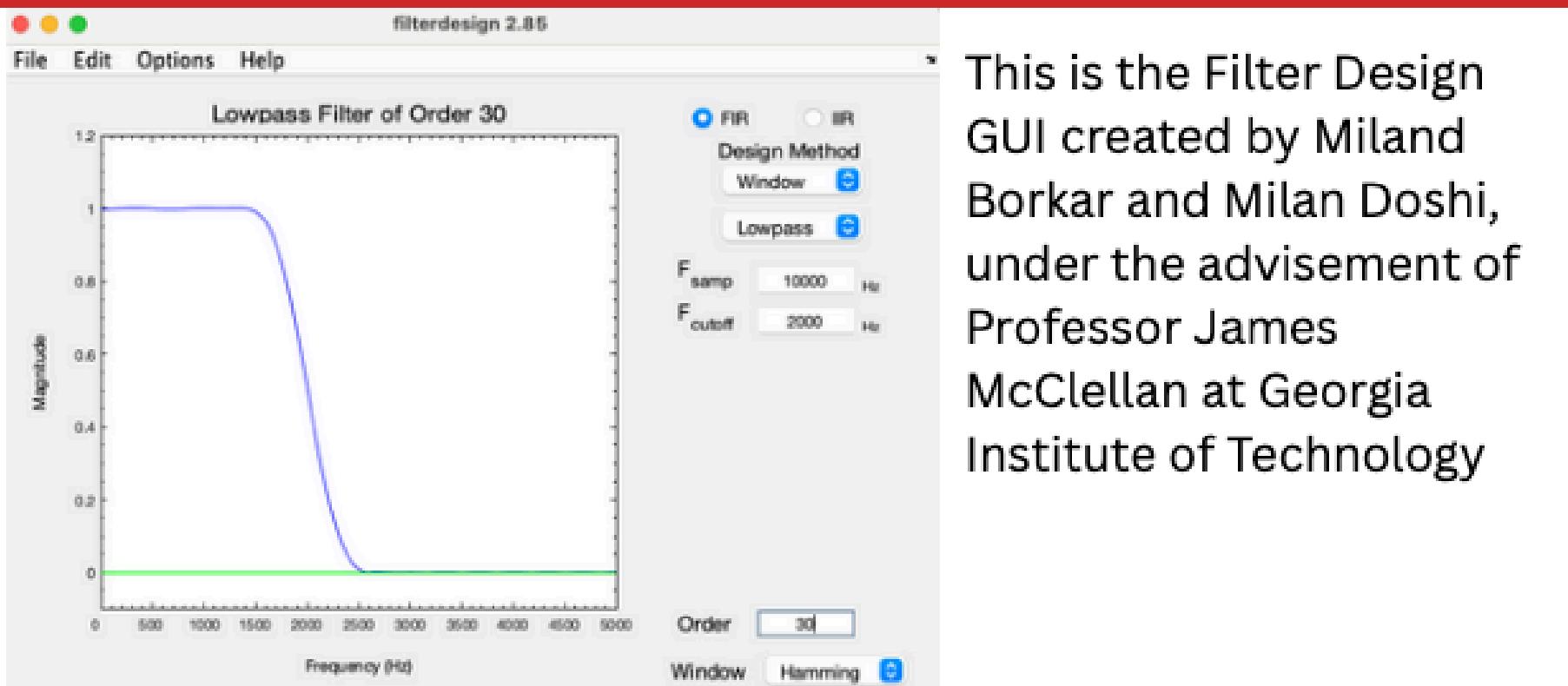
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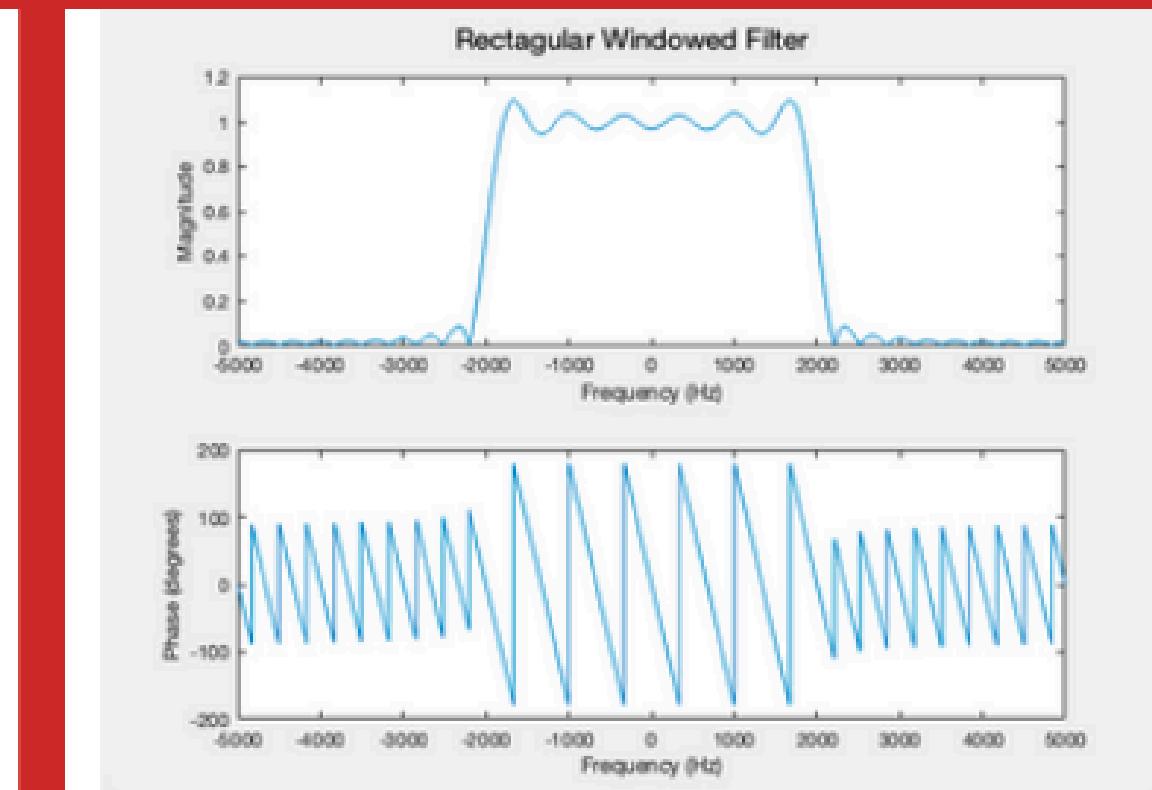
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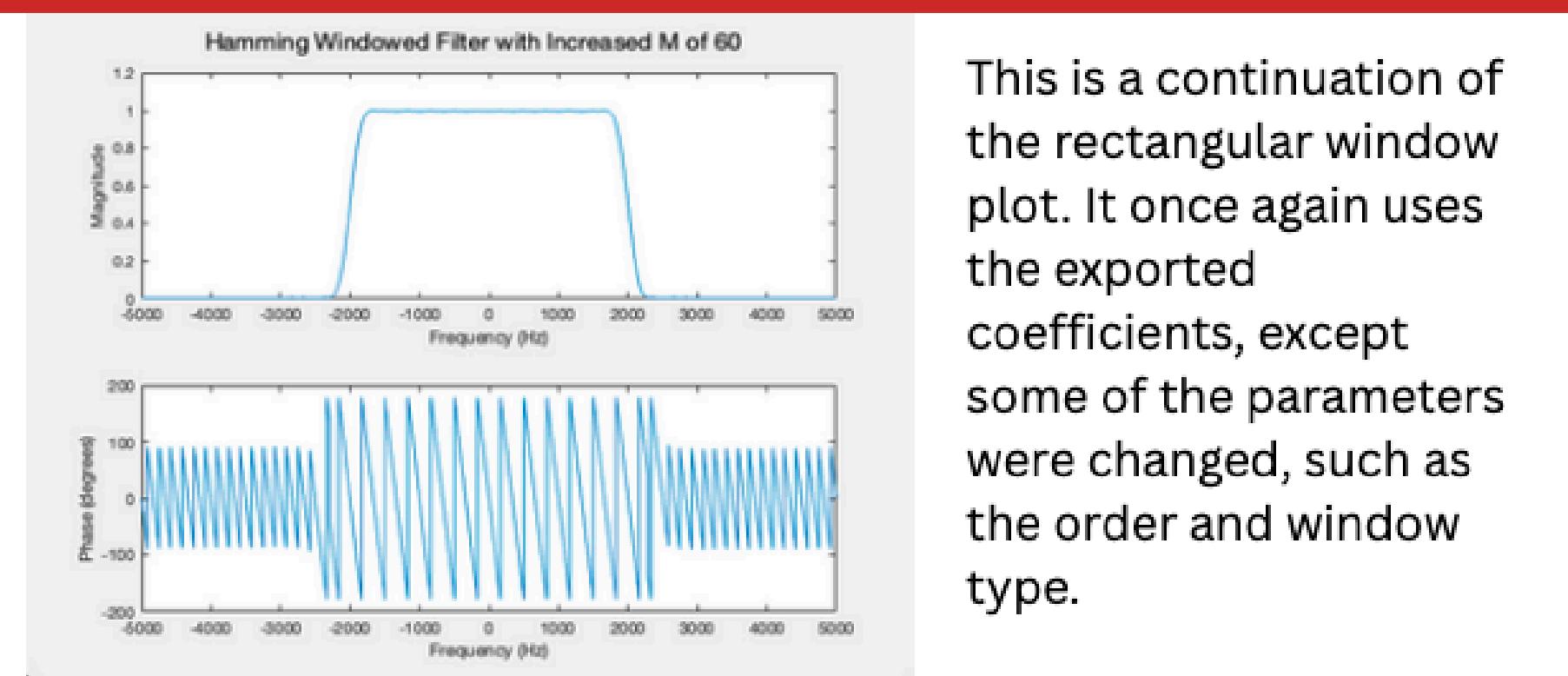
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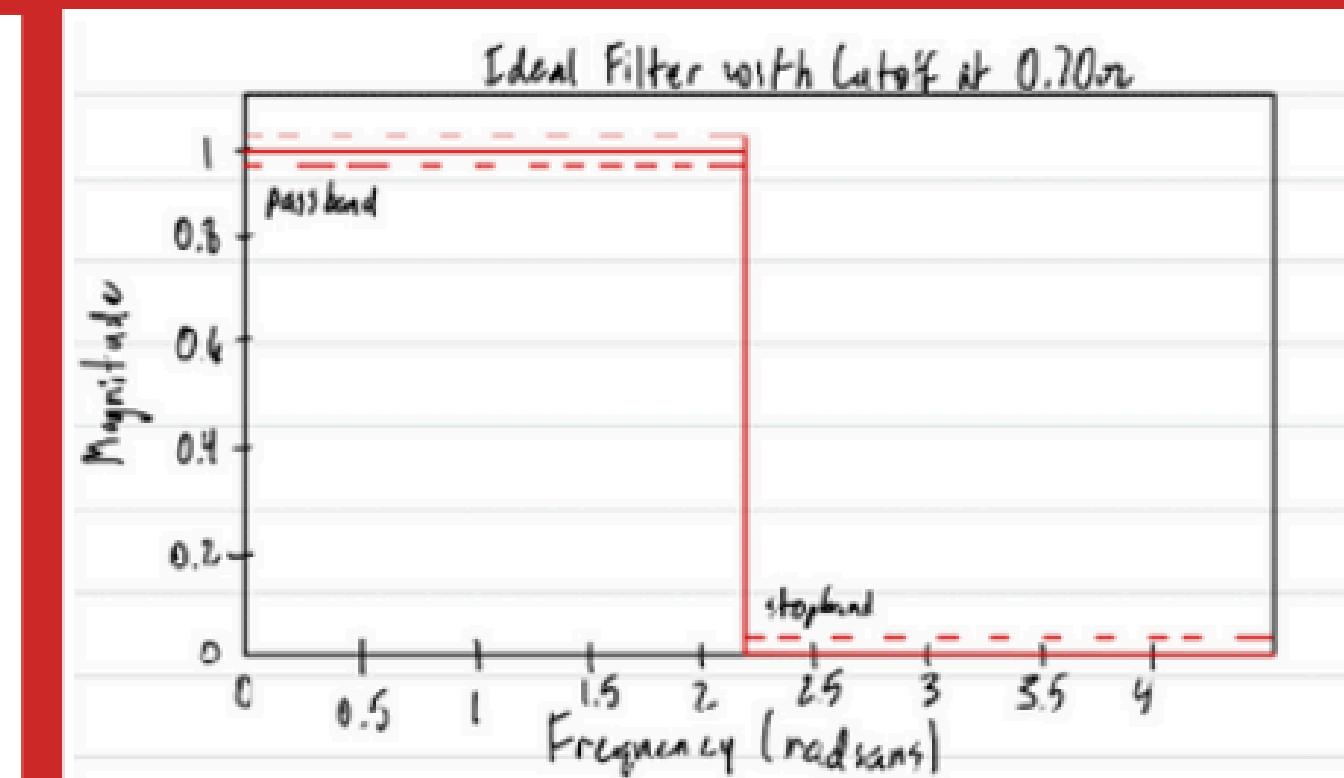
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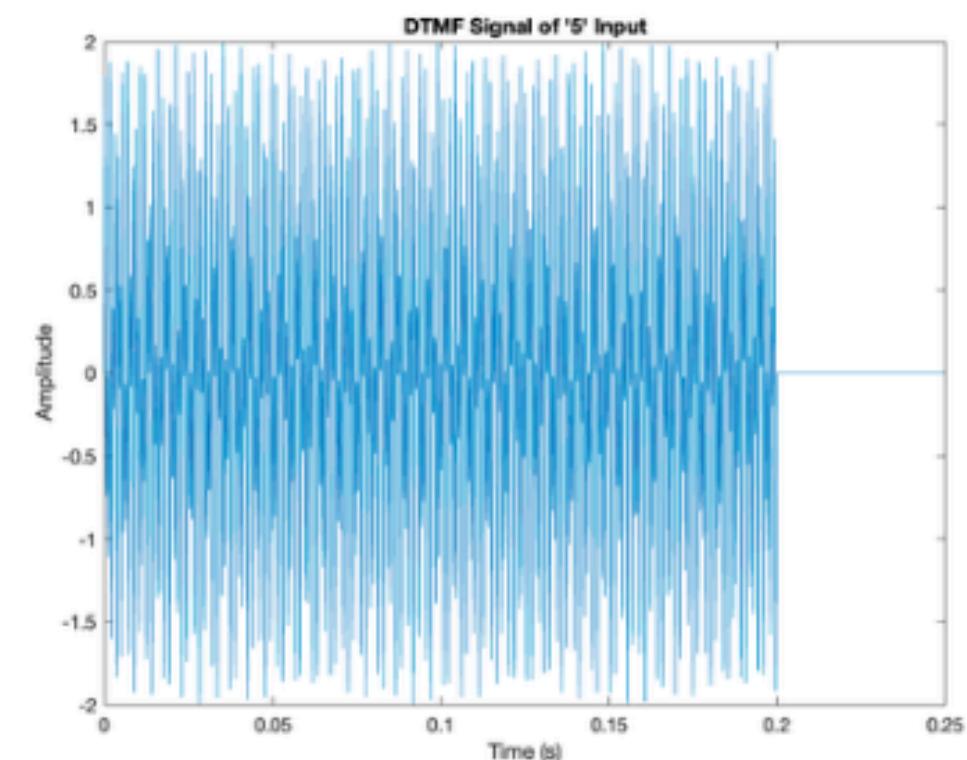
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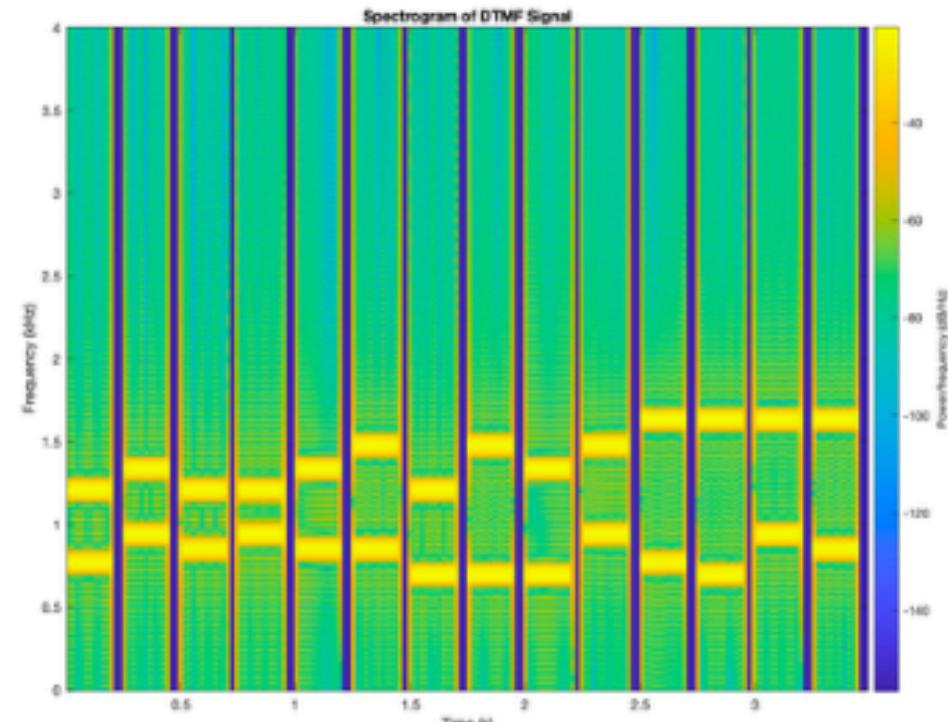
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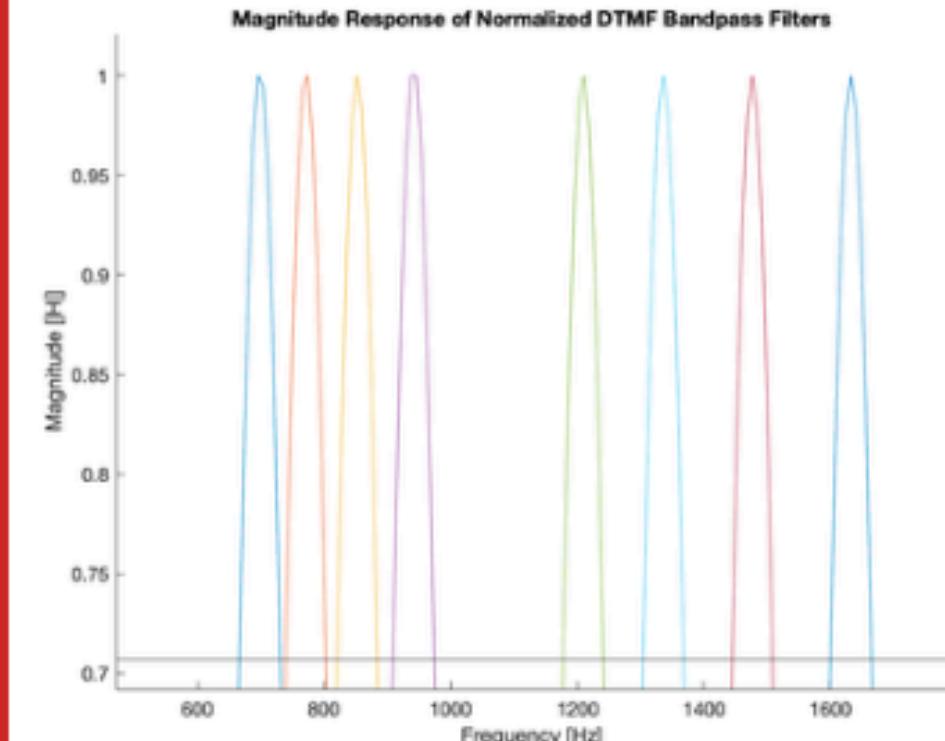


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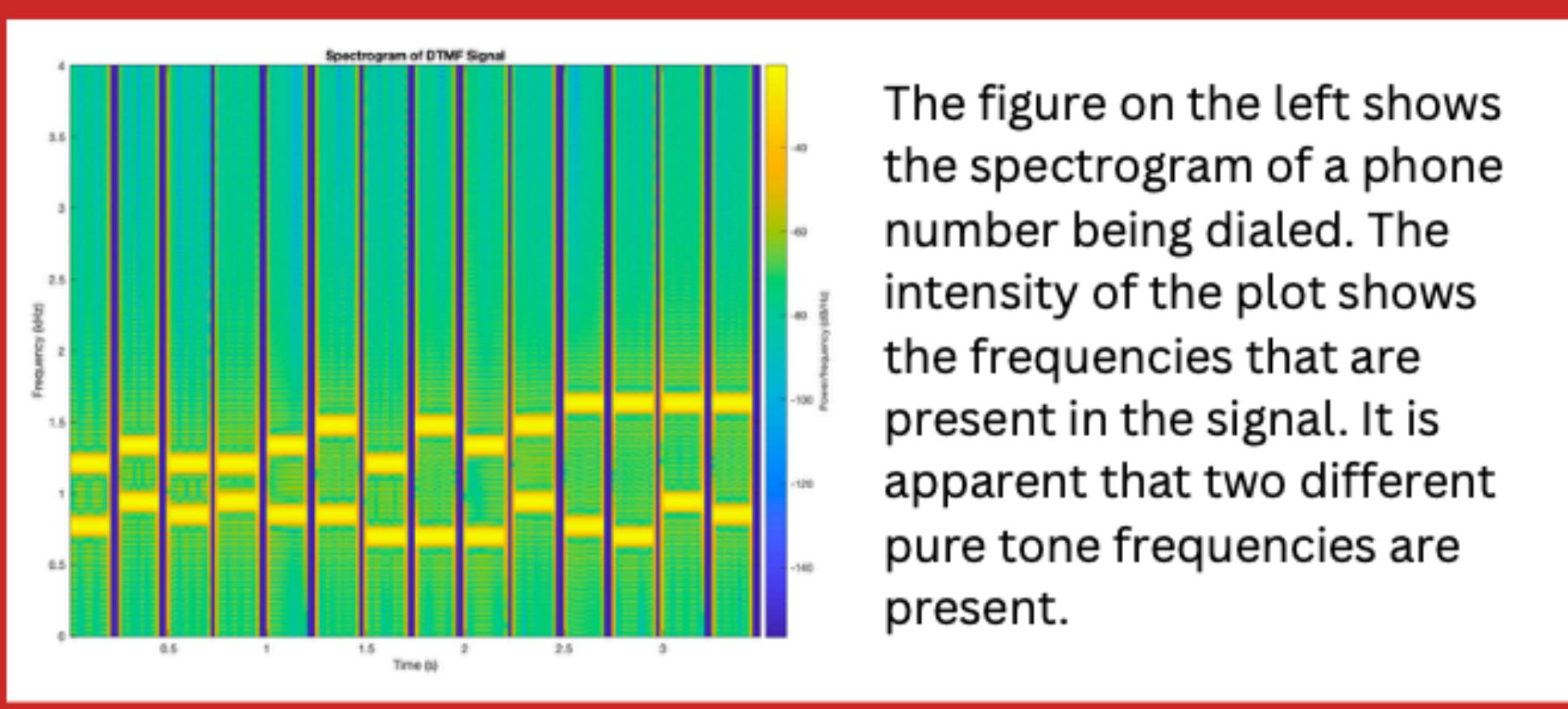


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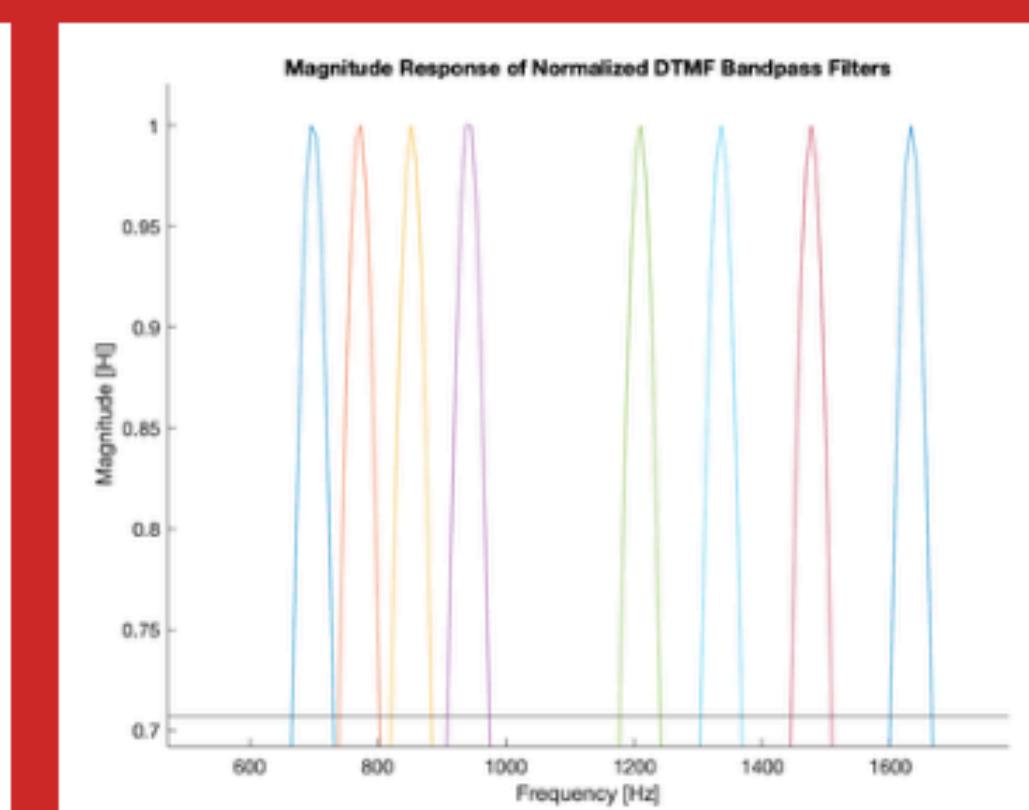


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I want to sleep, one last...

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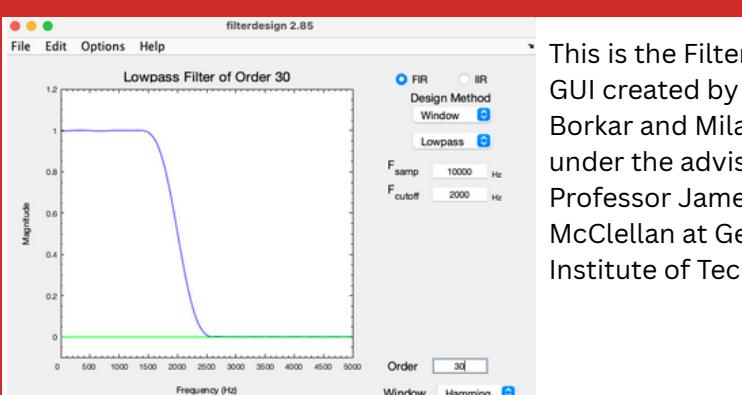
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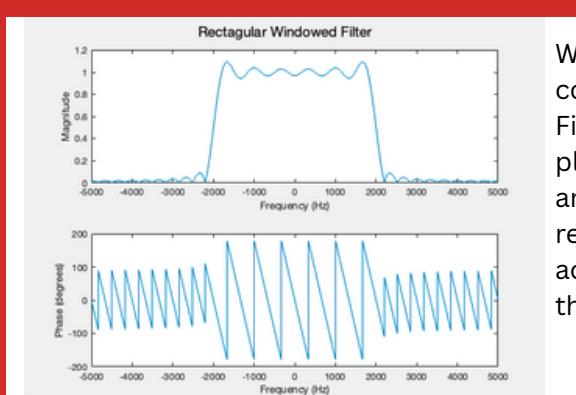
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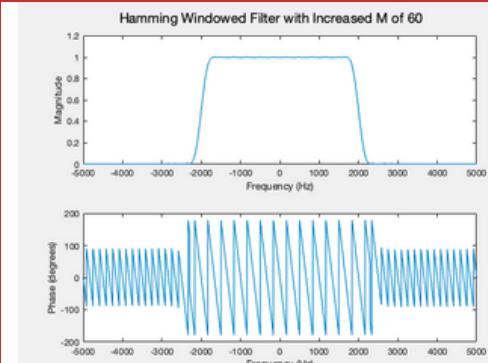
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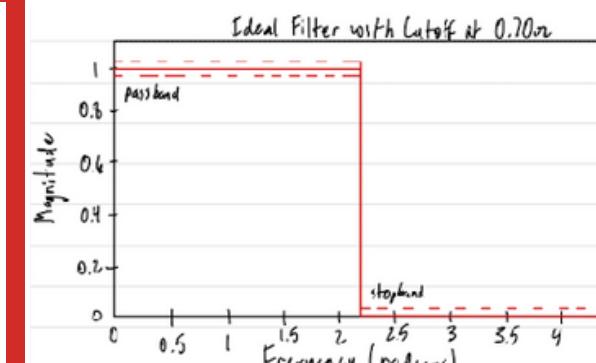
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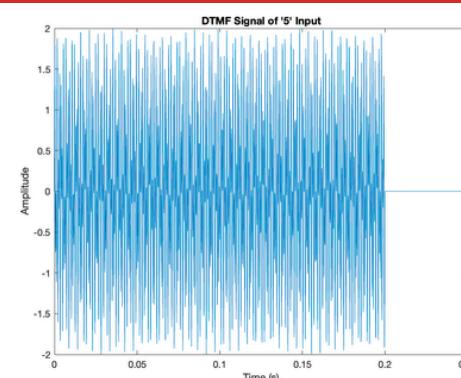
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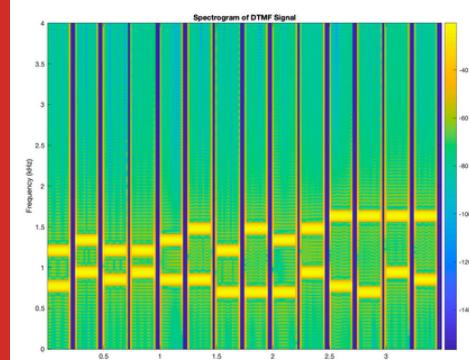
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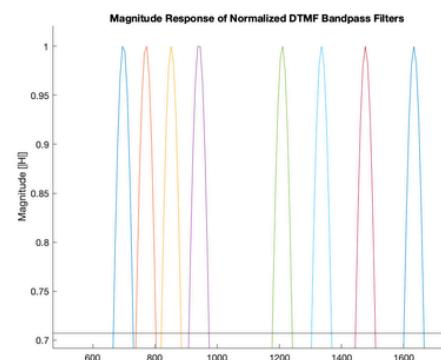


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