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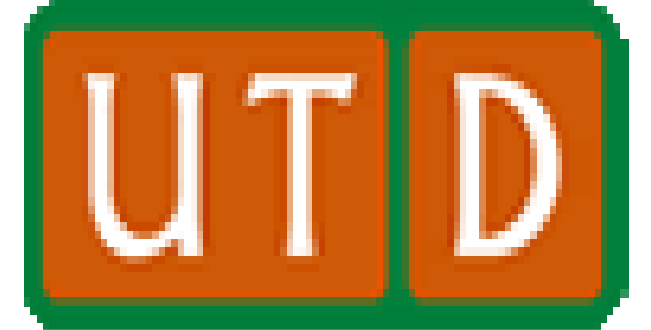
Presents

A Real Time Signal Processing System For Cochlear Implants

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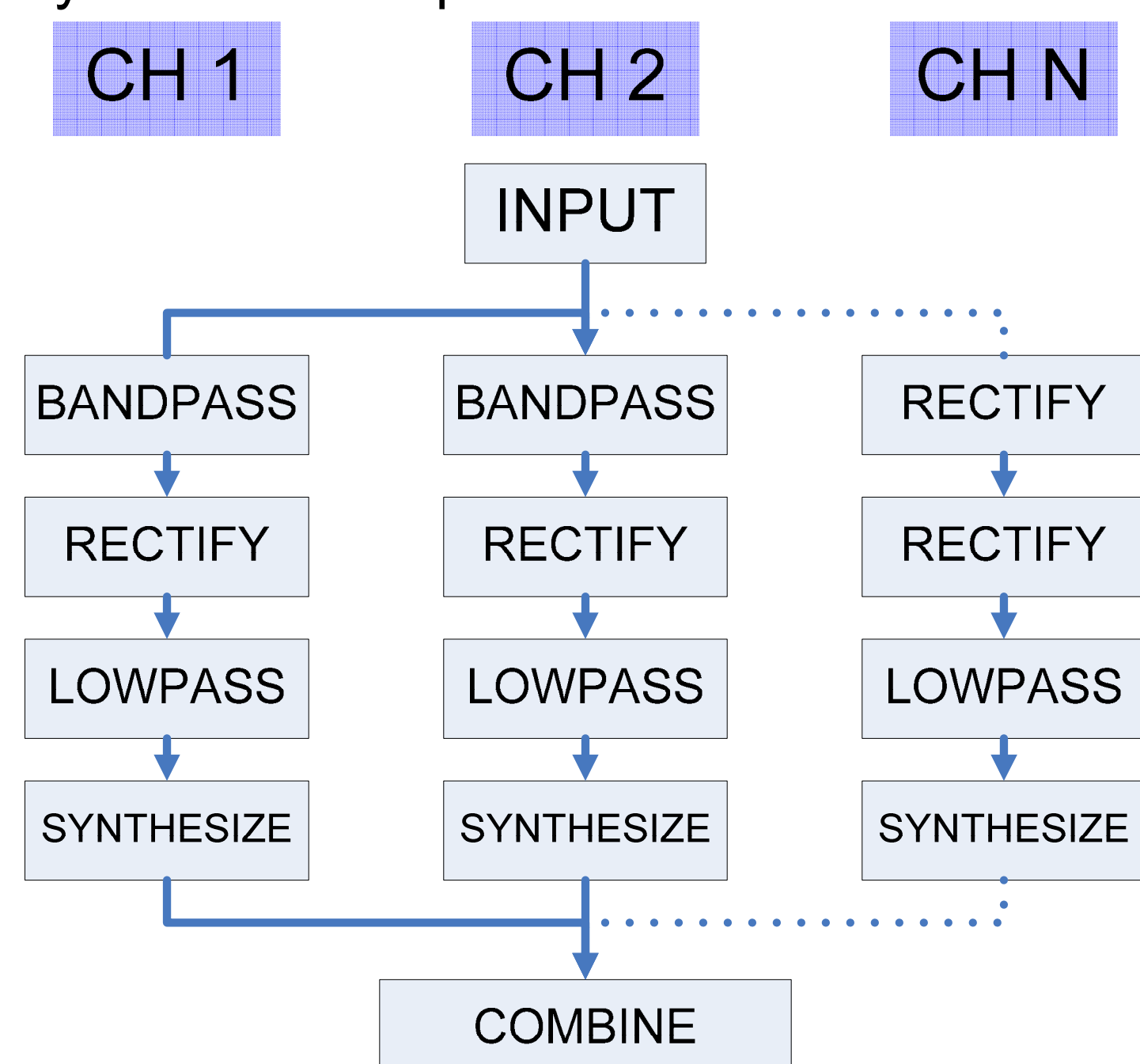


Project Goals:

- ◆ Simulate the output of a multi-channel cochlear implant
- ◆ Recognizable speech in output
- ◆ Real time operation
- ◆ Multiple synthesis options
 - ◆ Noise band excitation
 - ◆ Sinusoidal harmonic mixing
 - ◆ "Fuzzy" tones excitation
- ◆ Channel frequency spacing options

Project Overview:

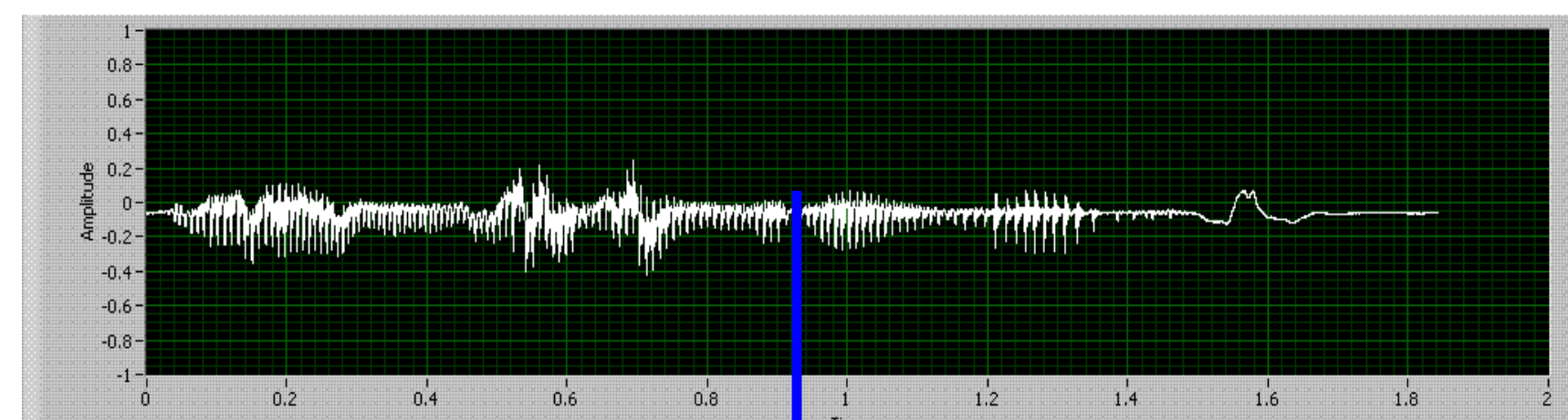
- ◆ Design
 - ◆ We chose to design a channel vocoder, which operates in four basic steps for every channel of input.



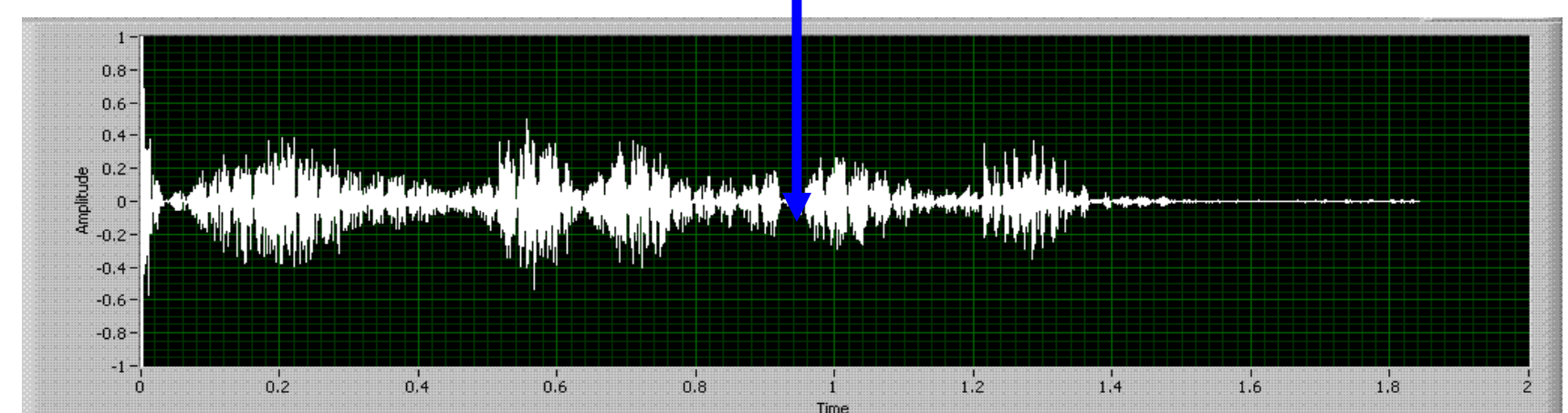
- ◆ Vocoder Steps
 - ◆ Input – Record fixed frame of sound from microphone input
 - ◆ Bandpass Filtering – separate input into frequency bands
 - ◆ Full Wave Rectification – Determine jagged envelop of the signal
 - ◆ Lowpass Filter – Smooth envelope of the signal
 - ◆ Synthesize – Mix corresponding carrier signal with envelope
 - ◆ Combine – Add synthesized channels for output
- ◆ Implementing Recognizable Speech involves four key requirements
 - ◆ Real time processing
 - ◆ Hybrid programming
 - ◆ Efficient programming techniques
 - ◆ Used frame size of 63 milliseconds
 - ◆ Logarithmic frequency spacing
 - ◆ Used MATLAB to compute frequency spacing
 - ◆ High number of channels
 - ◆ Used sixteen channels in design
 - ◆ Flexible design to allow any number of channels
 - ◆ Complex synthesis techniques
 - ◆ Operation allows one of three synthesis methods to be selected

Project Results:

- ◆ Input sound is recreated accurately with the following settings:
 - ◆ Fuzzy tones synthesis
 - ◆ 300 Hz low frequency cutoff
 - ◆ 5500 Hz high frequency cutoff
 - ◆ Logarithmic frequency spacing
 - ◆ 63 ms frame size
 - ◆ Fixed point filter coefficients
- ◆ Input "Mary had a little lamb"

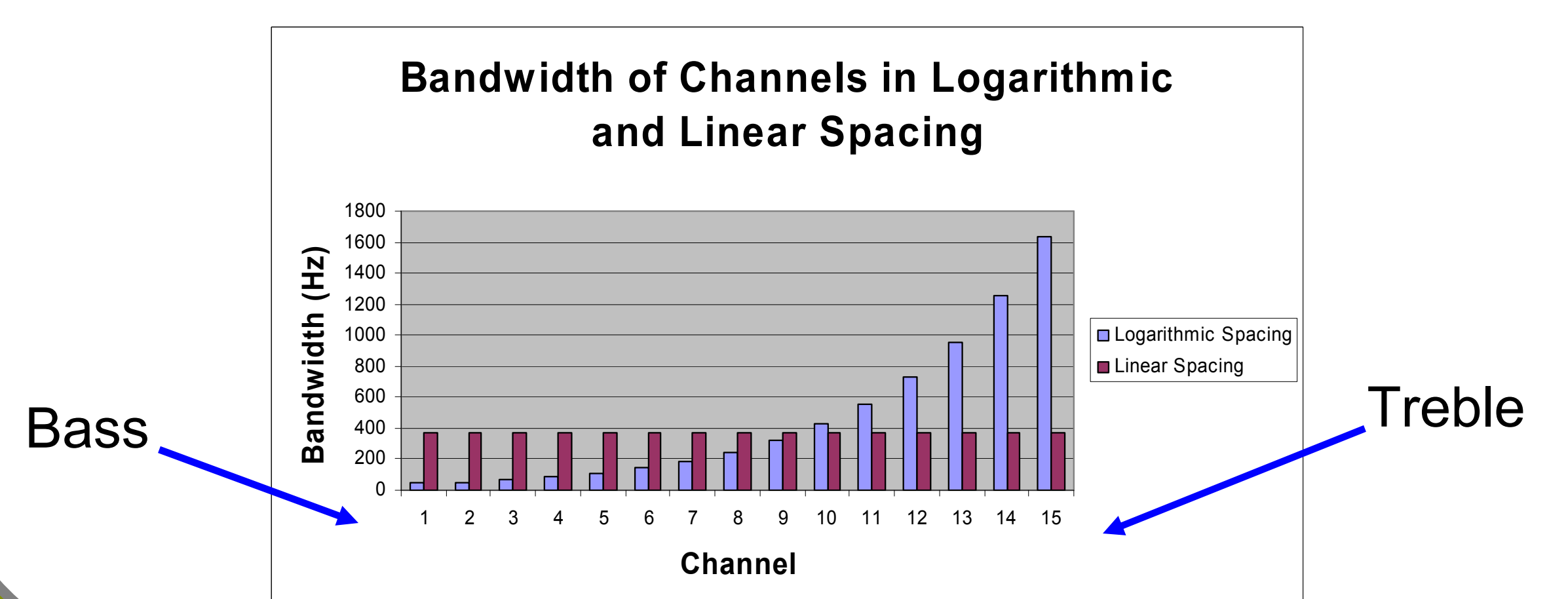


- ◆ Output Waveform



The figure above shows the almost unnoticeable delay between input and output. The envelope of the output also matches the input.

- ◆ Logarithmic spacing vs. linear spacing



Project Conclusions & Outcomes:

- ◆ **Adding channels increases sound quality drastically.** Although studies have shown that speech can be intelligible with four channels, sixteen channels creates a good balance between speed of processing and quality of sound.
- ◆ **Synthesis using fuzzy tones creates the most intelligible speech.** Sinusoidal harmonics tend to create a very robotic sound, while noise band creates a too much static.
- ◆ **A frame length of 100 milliseconds or less is required** for natural, real-time speech processing. Beyond this, the voice appears unnatural and the lips are jagged and confusing.
- ◆ **Logarithmic frequency spacing creates a better sound quality** than linear frequency spacing. Linear spacing does not provide the natural balance of bass and treble the human voice contains.