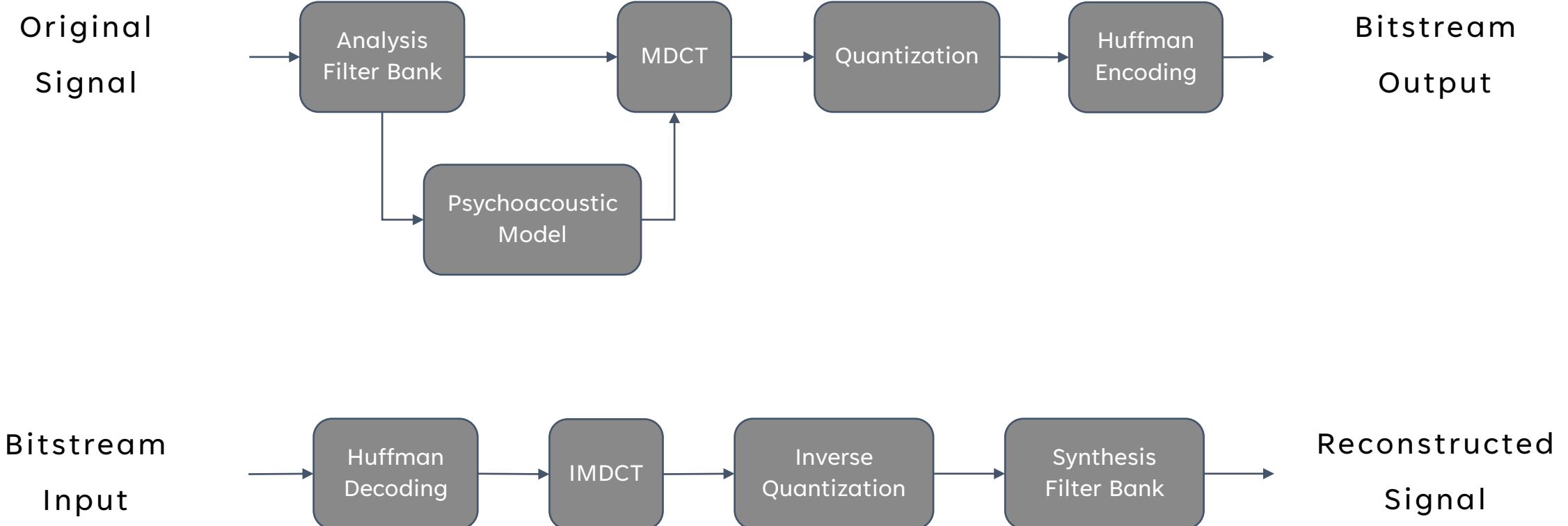


Hybrid Filter Banks and Audio Encoding

Tyler Hattori

ECE 258 Fall 2023

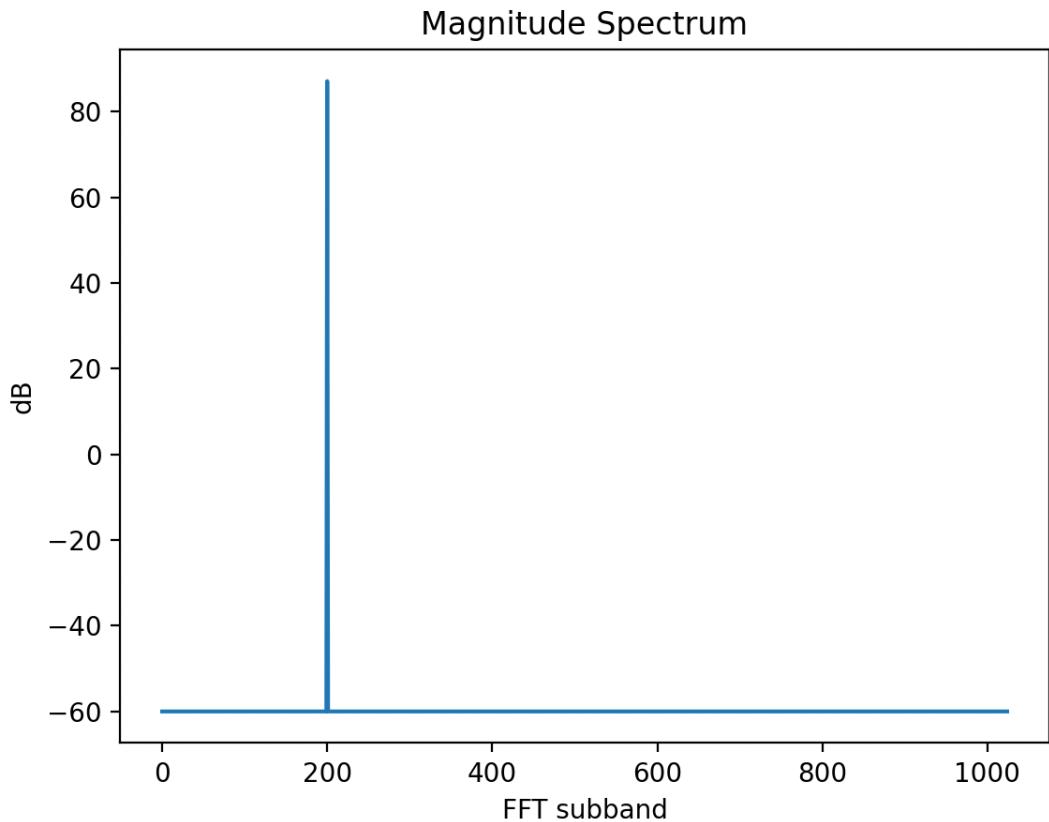
MP3 Audio Encoding and Decoding



The Psychoacoustic Model

Sine Wave Input Example

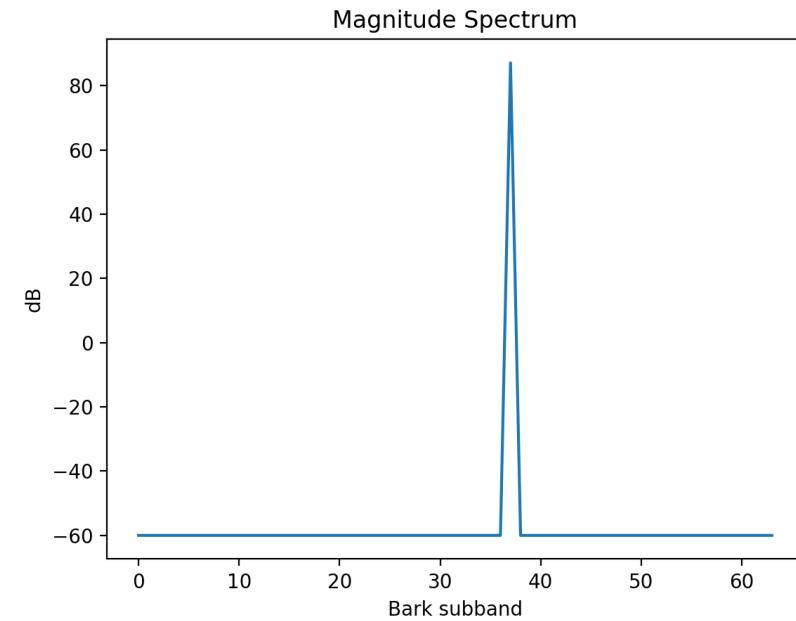
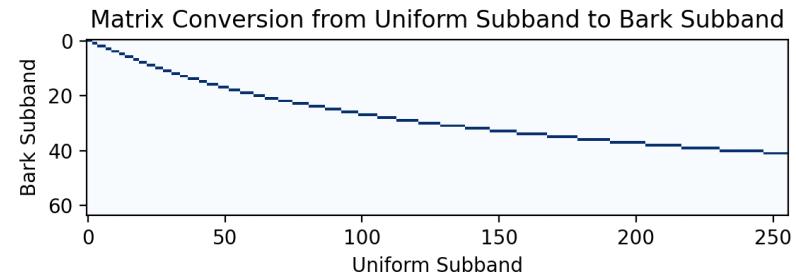
- Take FFT of input
- Convert frequency axis to bark subbands
- Quantize bark coefficients and apply spreading functions
- Consider the natural masking threshold of the human ear
- Determine new masking threshold



The Psychoacoustic Model

Sine Wave Input Example

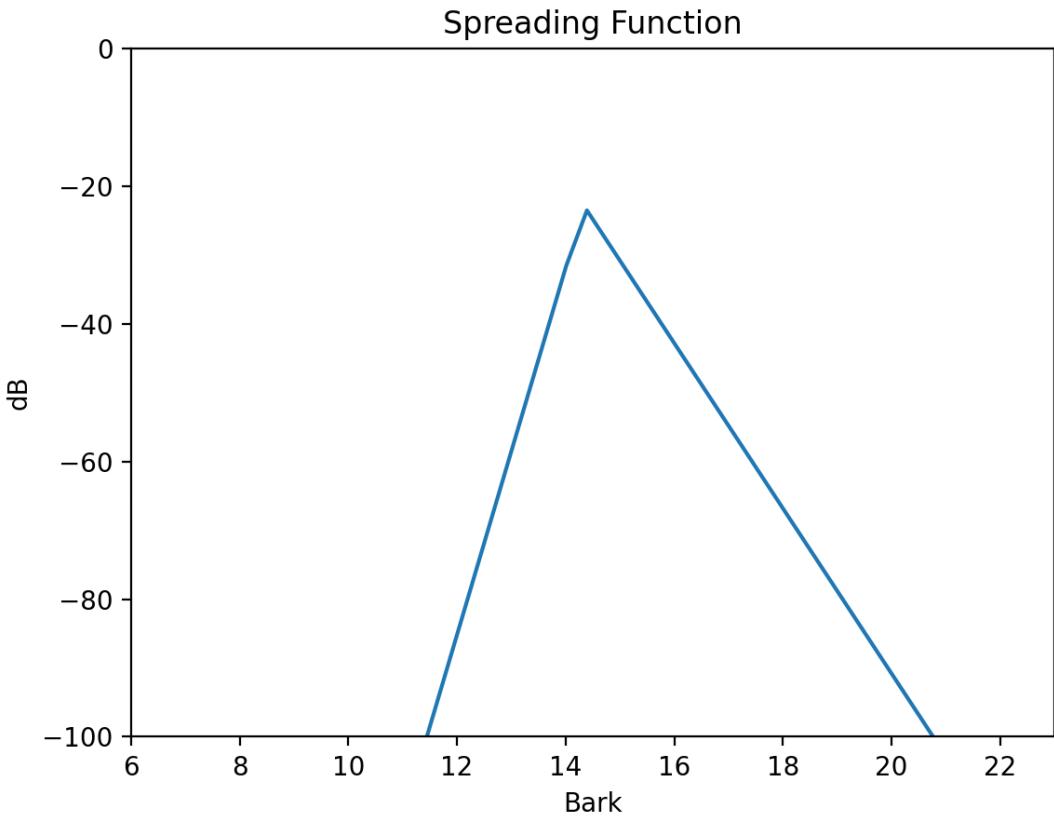
- Take FFT of input
- Convert frequency axis to bark subbands
- Quantize bark coefficients and apply spreading functions
- Consider the natural masking threshold of the human ear
- Determine new masking threshold



The Psychoacoustic Model

Sine Wave Input Example

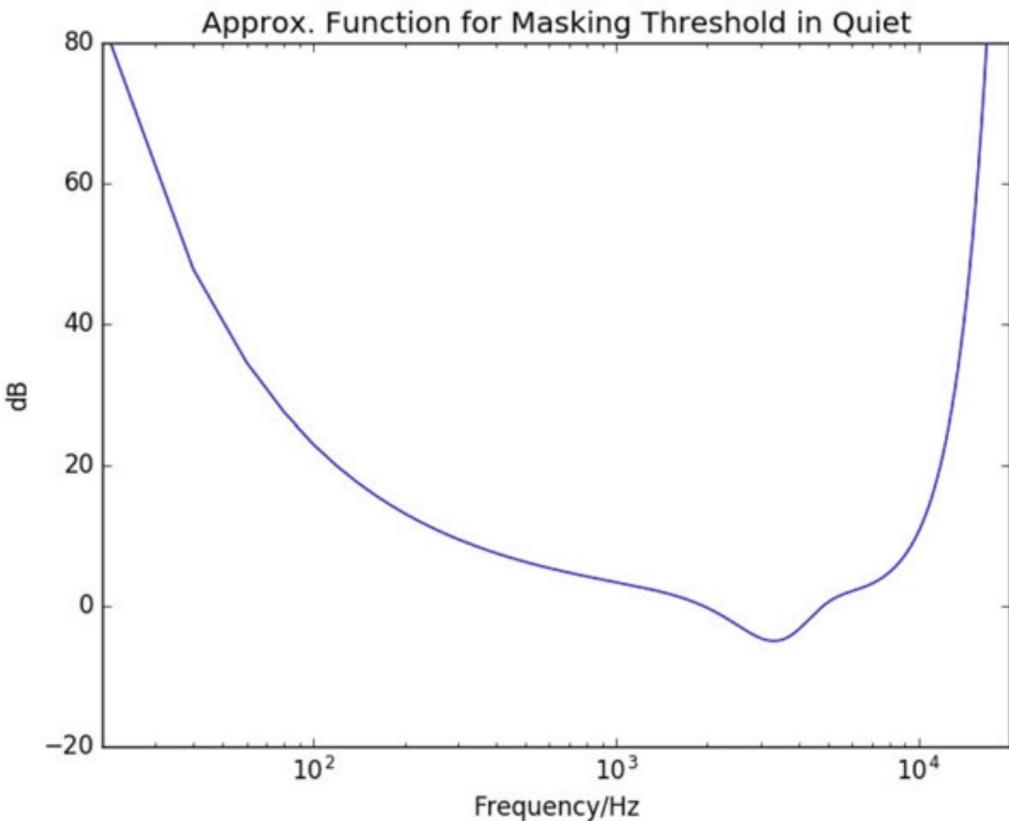
- Take FFT of input
- Convert frequency axis to bark subbands
- Quantize bark coefficients and apply spreading functions
- Consider the natural masking threshold of the human ear
- Determine new masking threshold



The Psychoacoustic Model

Sine Wave Input Example

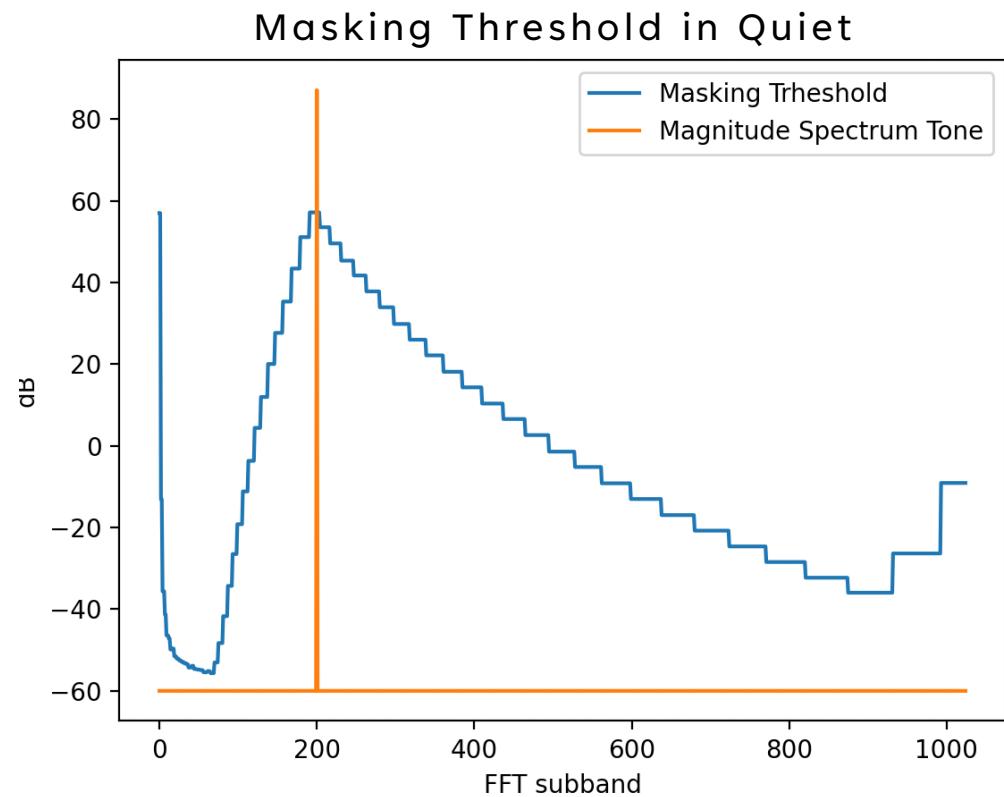
- Take FFT of input
- Convert frequency axis to bark subbands
- Quantize bark coefficients and apply spreading functions
- Consider the natural masking threshold of the human ear
- Determine new masking threshold



The Psychoacoustic Model

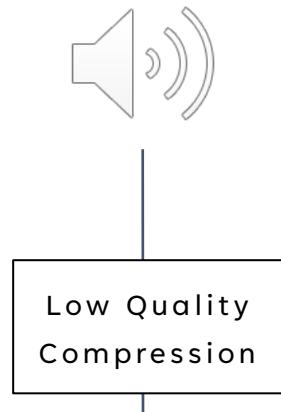
Sine Wave Input Example

- Take FFT of input
- Convert frequency axis to bark subbands
- Quantize bark coefficients and apply spreading functions
- Consider the natural masking threshold of the human ear
- Determine new masking threshold



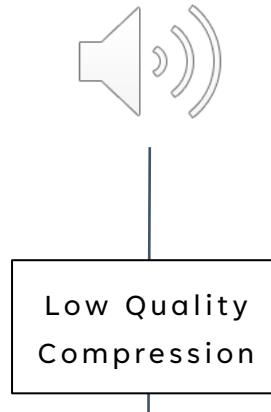
Effects of Quantization Error

Constant Tone



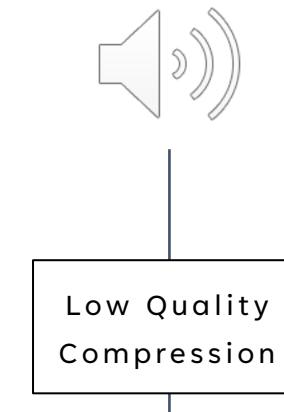
Missing
Harmonics

Castanets



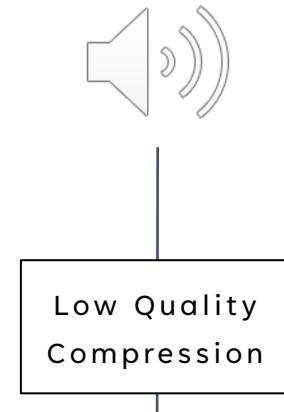
Pre-echo

Male Voice



Reverb and
Pre-echo

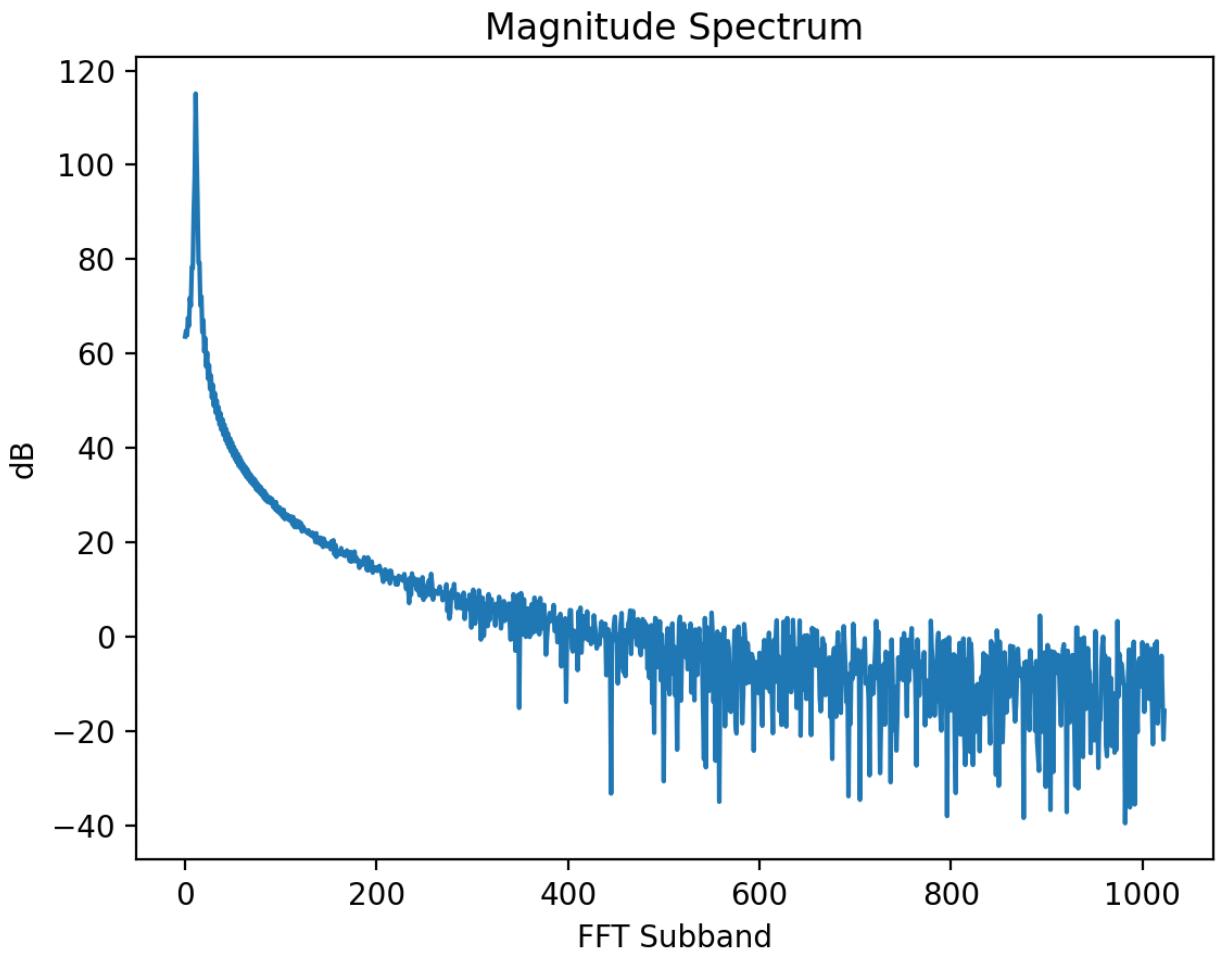
Female Voice



Reverb and
Pre-echo

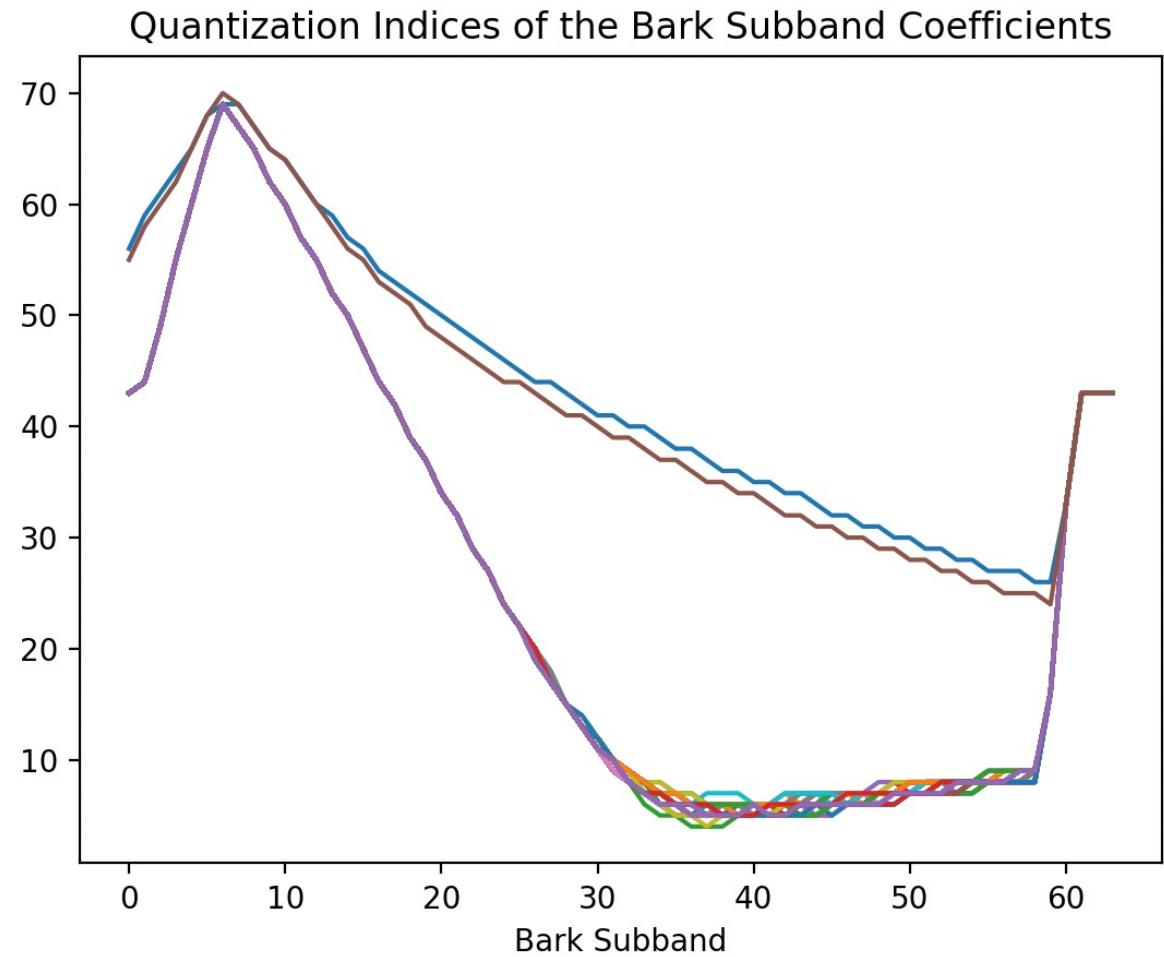
Constant Tone Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- Observe Quantization Error



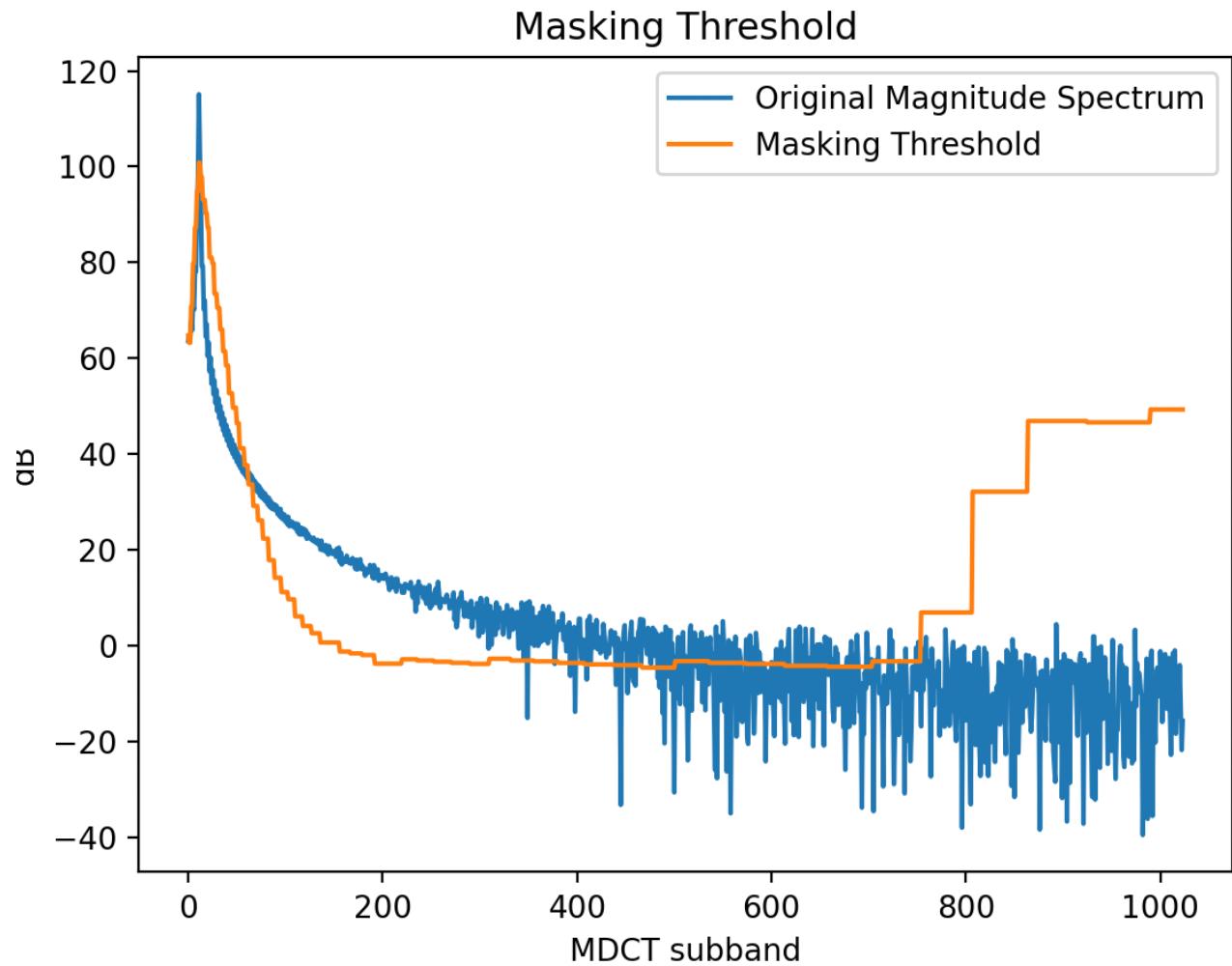
Constant Tone Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- Observe Quantization Error



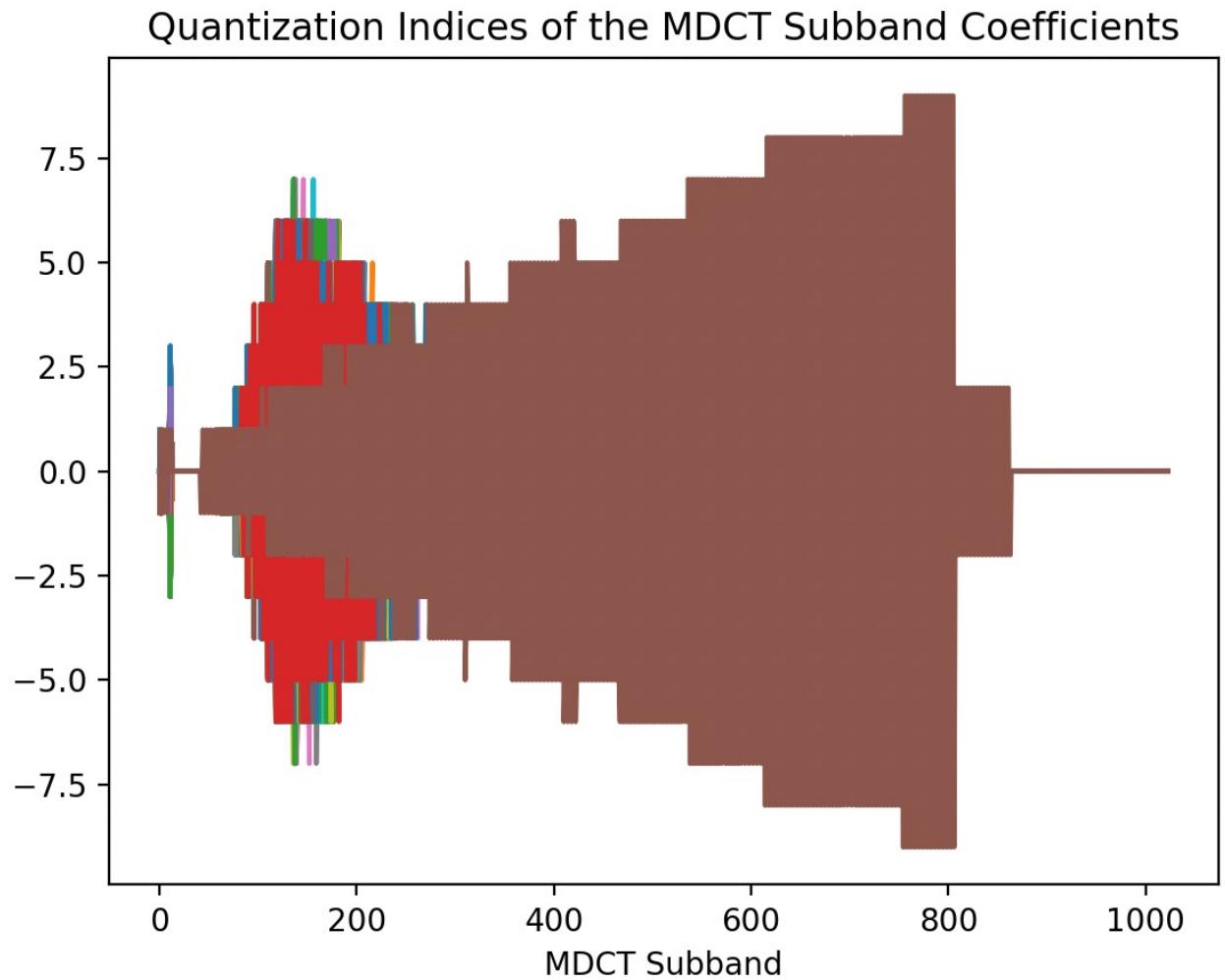
Constant Tone Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- Observe Quantization Error



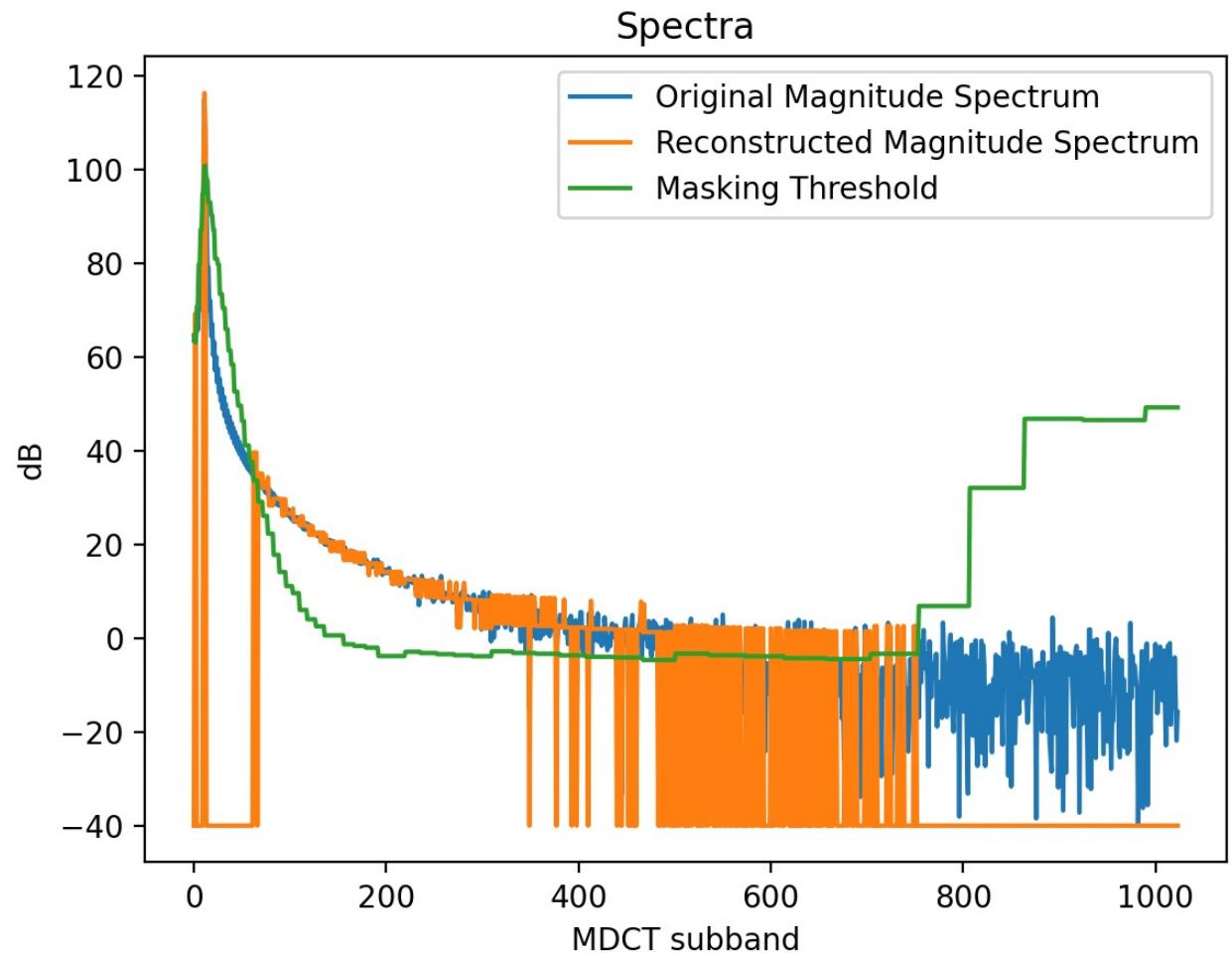
Constant Tone Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- **Allocate Quantization Bits**
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



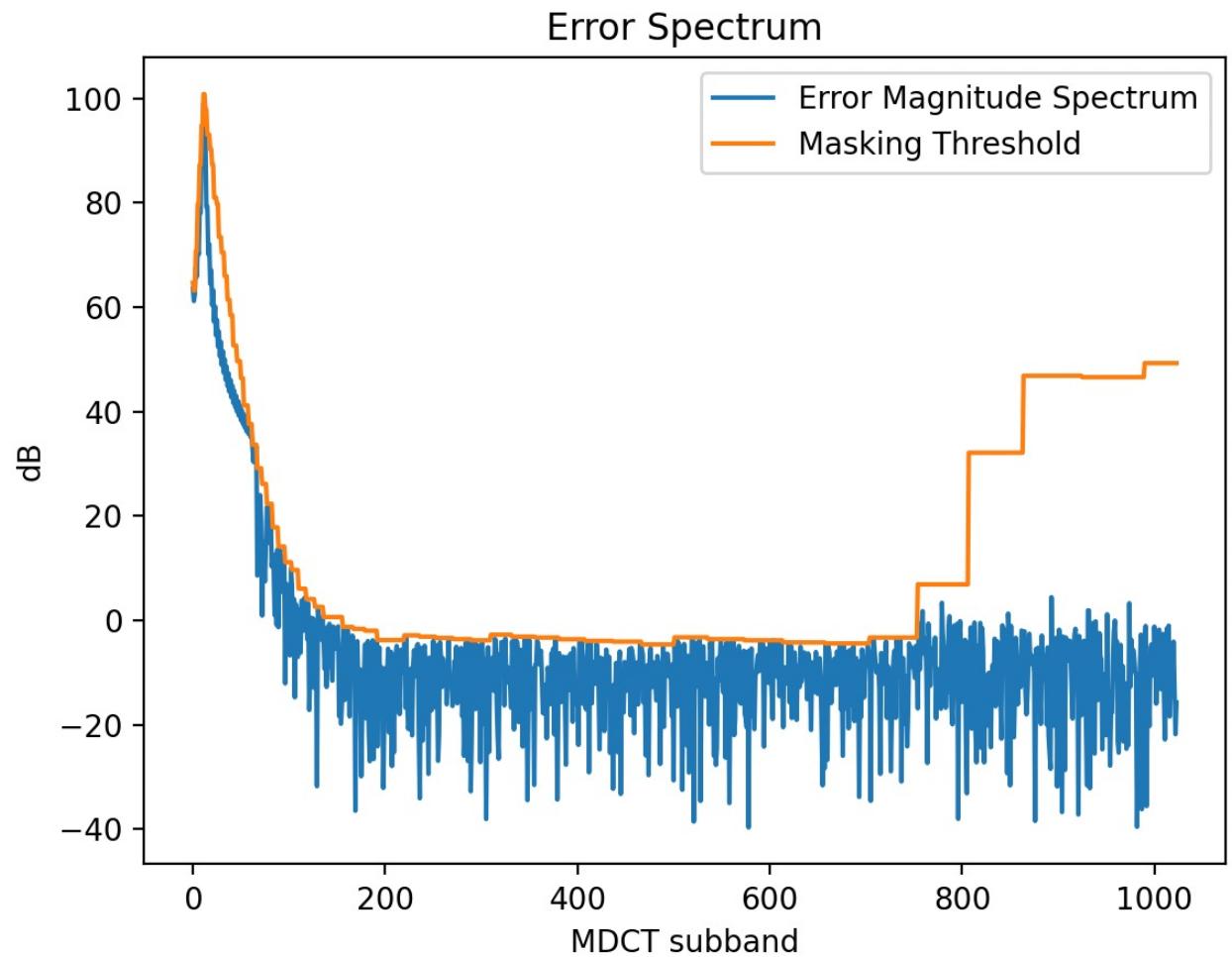
Constant Tone Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



Constant Tone Quantization Error

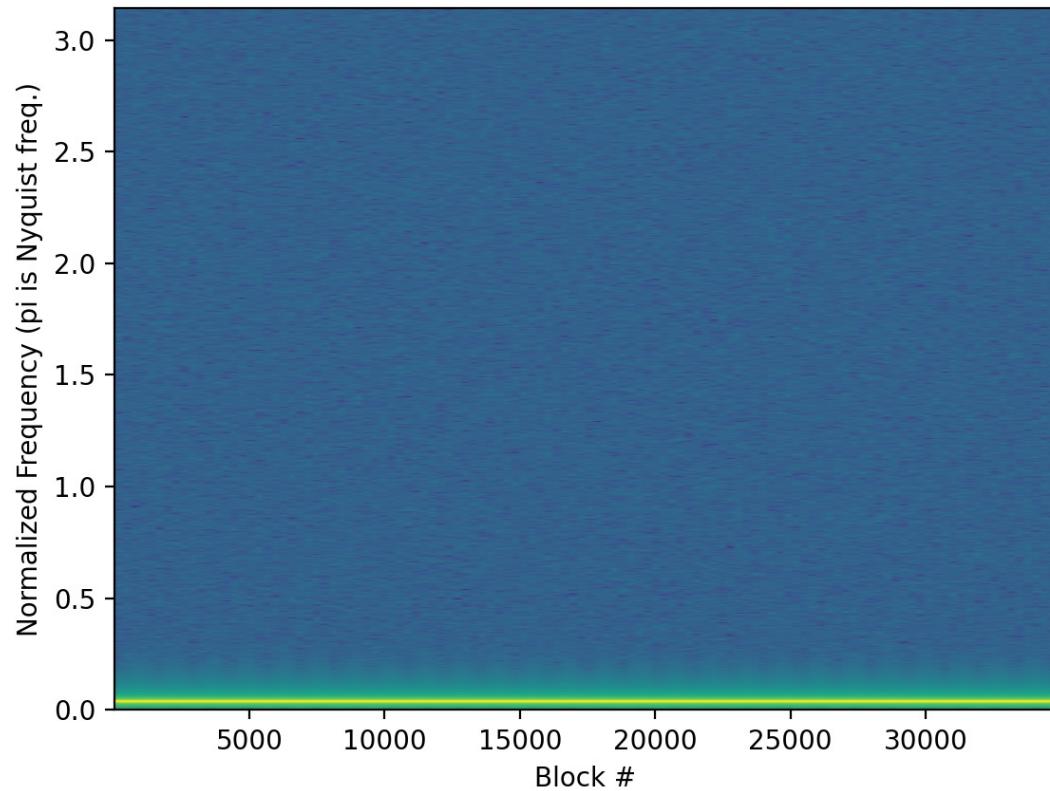
- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



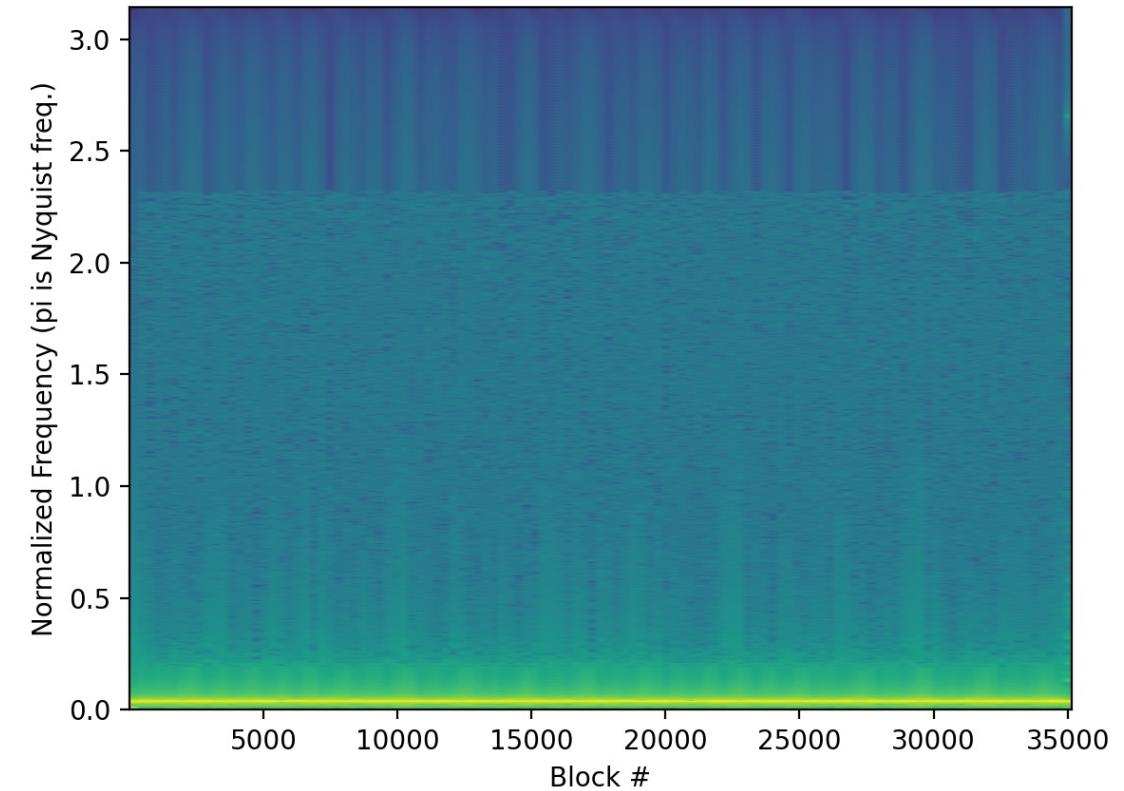
Constant Tone Quantization Error

60 Quality, 1024 MDCT Subbands

Original



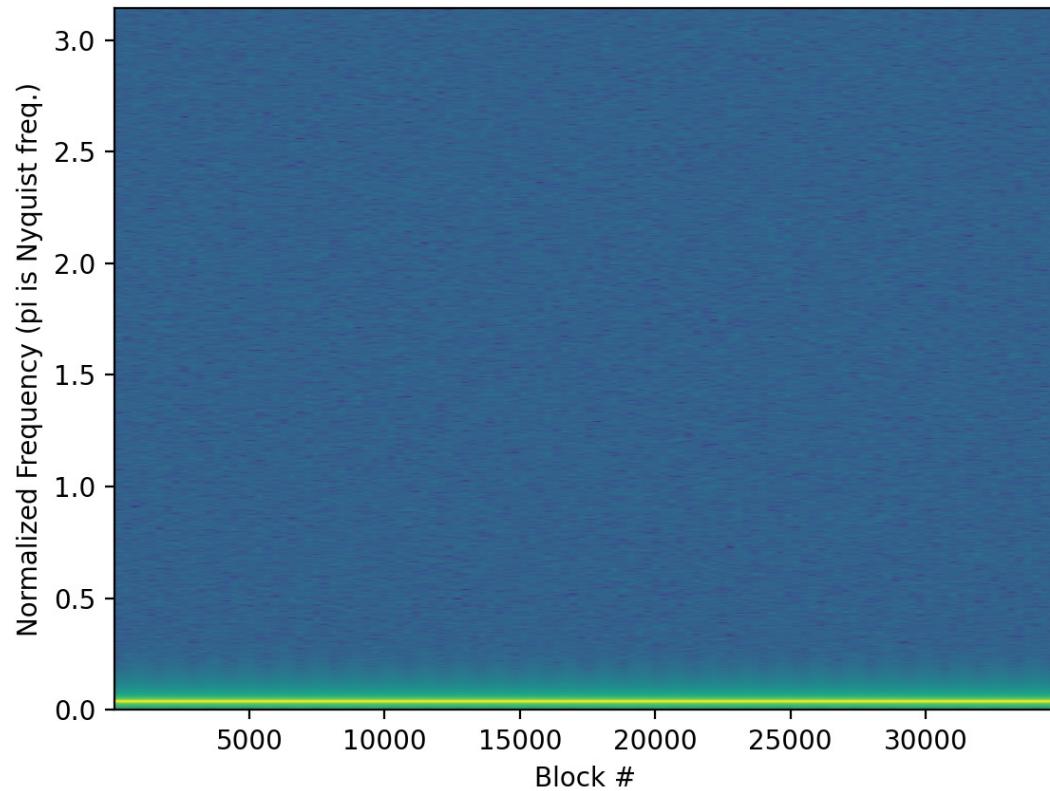
Reconstructed



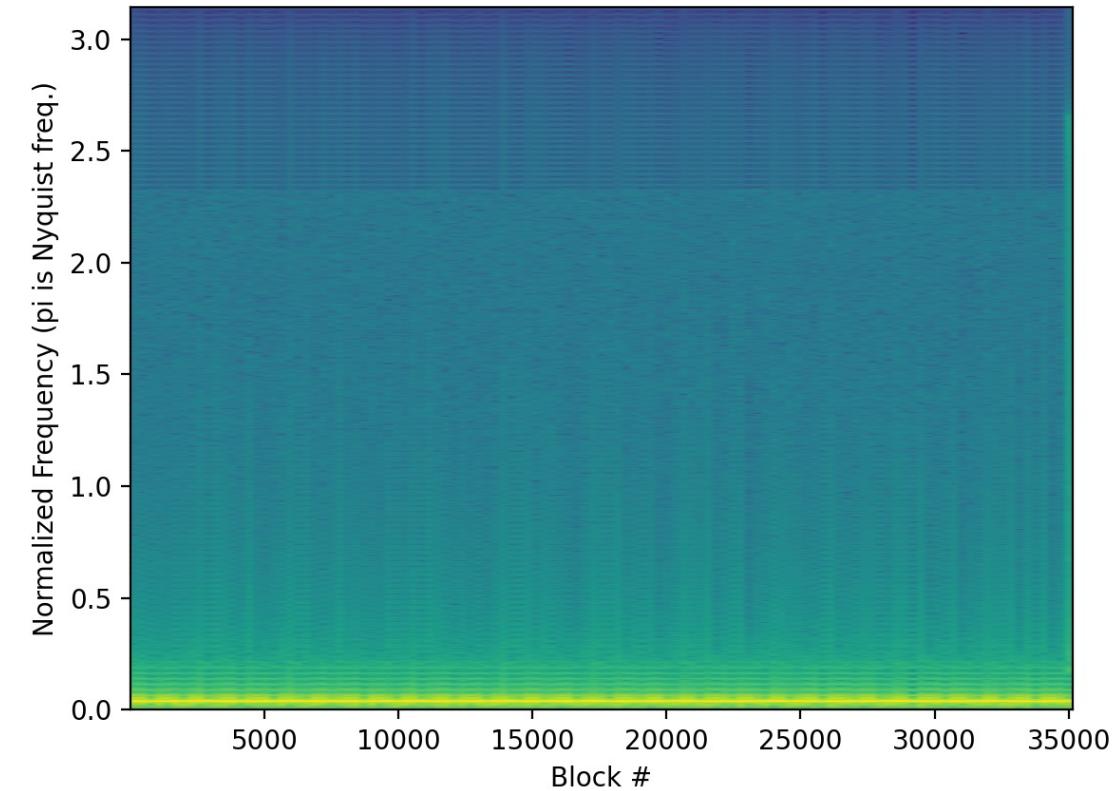
Constant Tone Quantization Error

60 Quality, 256 MDCT Subbands

Original



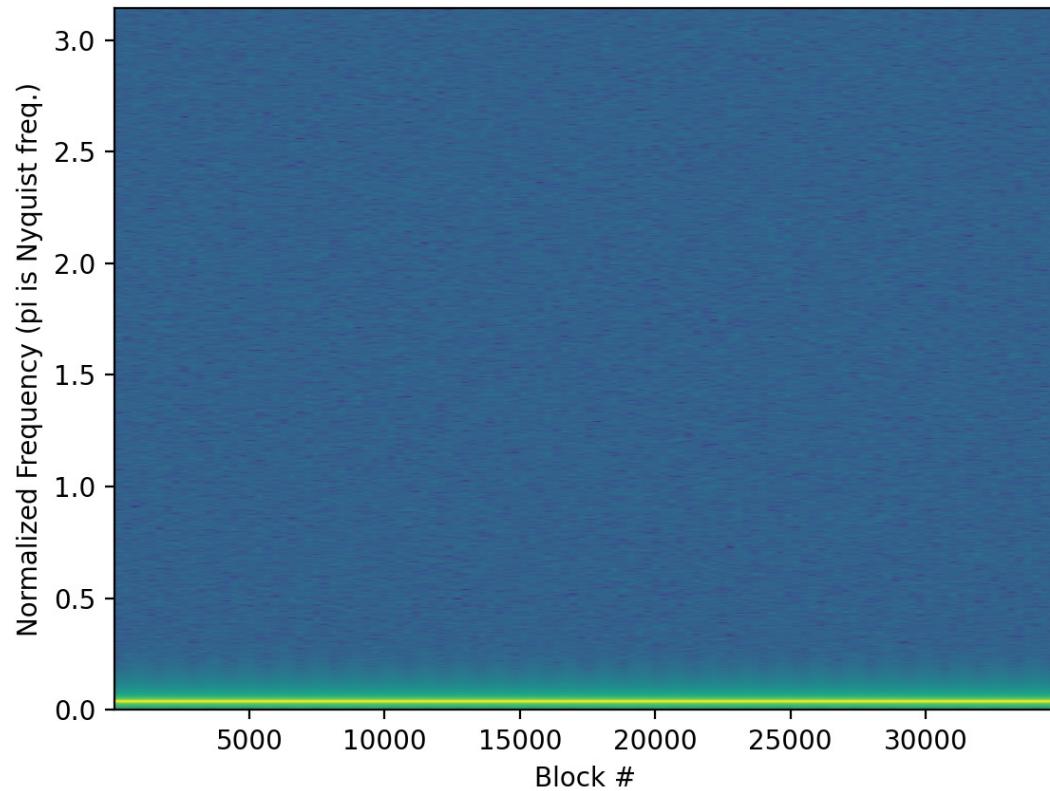
Reconstructed



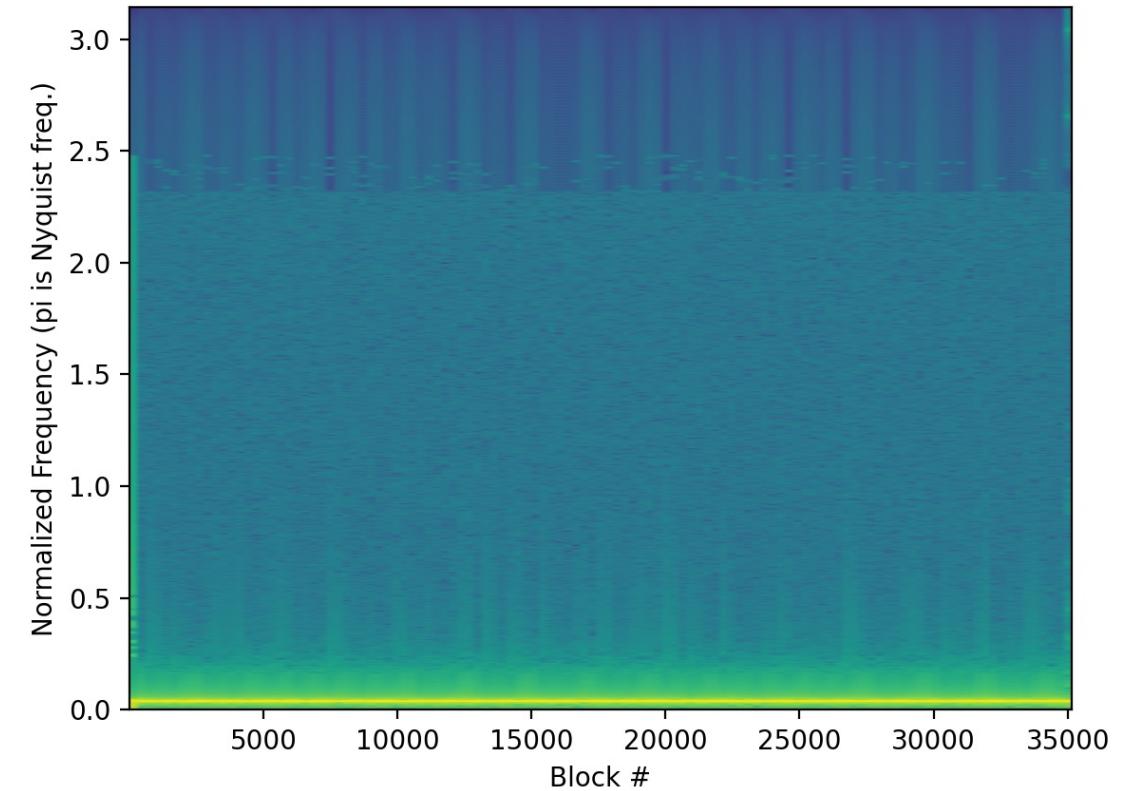
Constant Tone Quantization Error

100 Quality, 1024 MDCT Subbands

Original



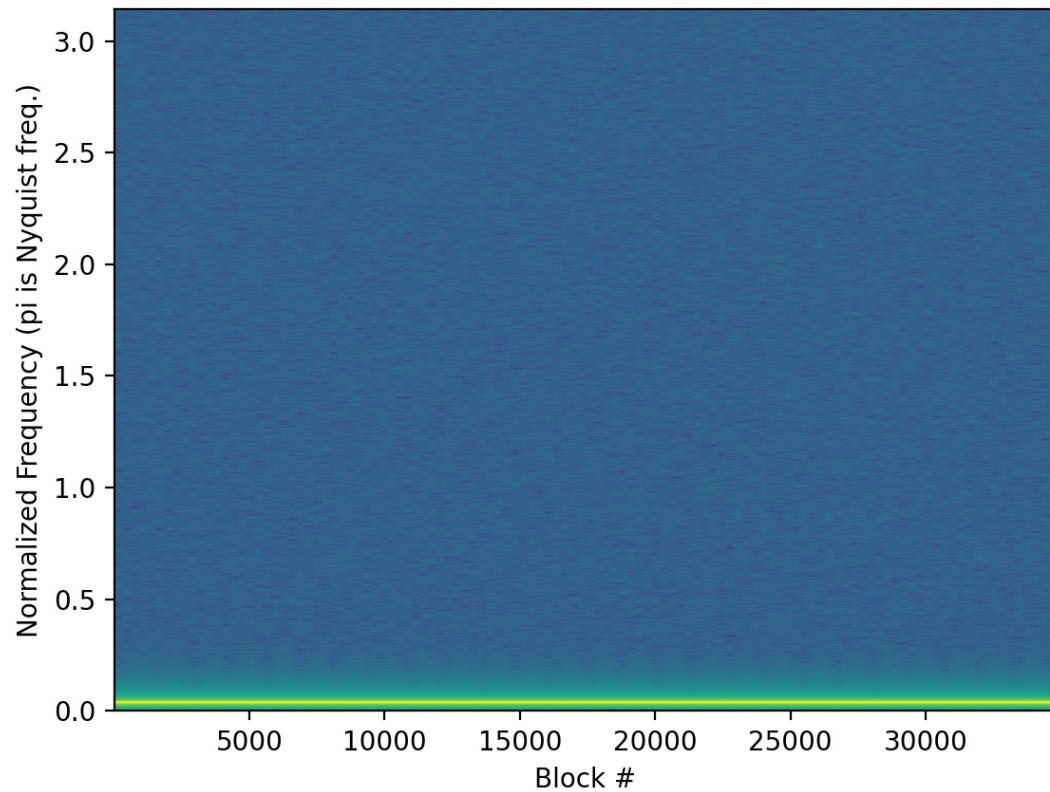
Reconstructed



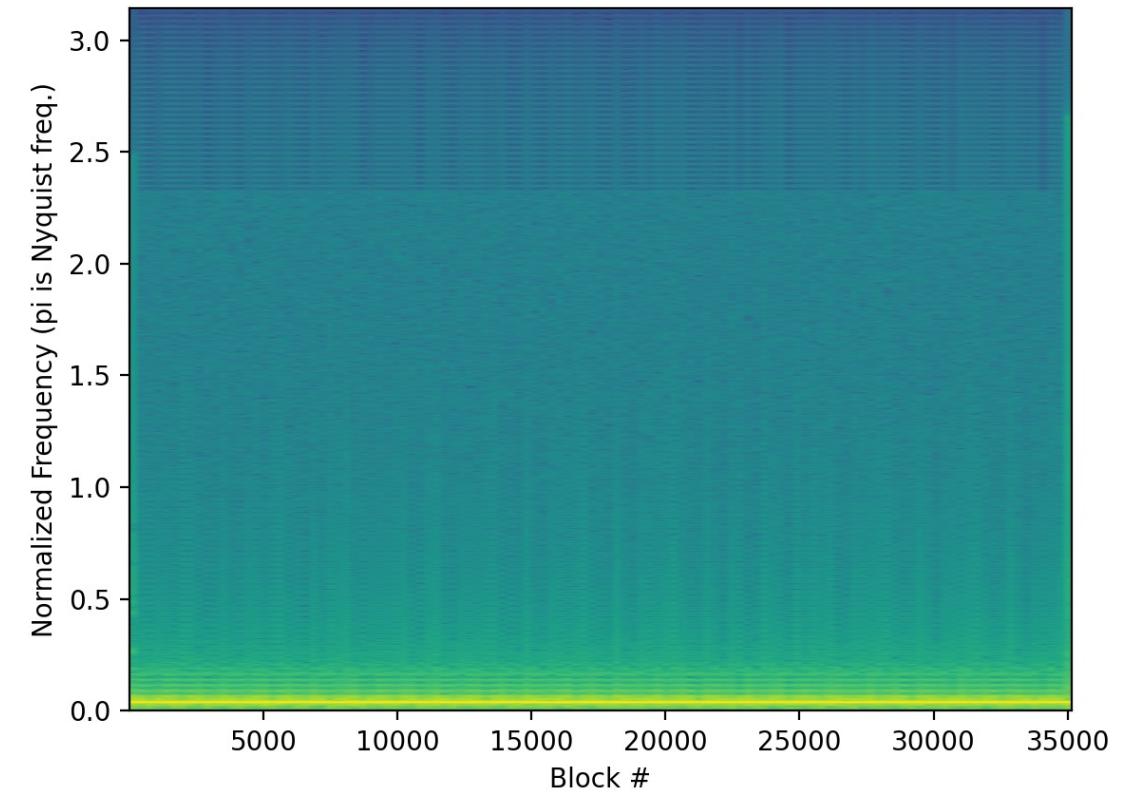
Constant Tone Quantization Error

100 Quality, 256 MDCT Subbands

Original

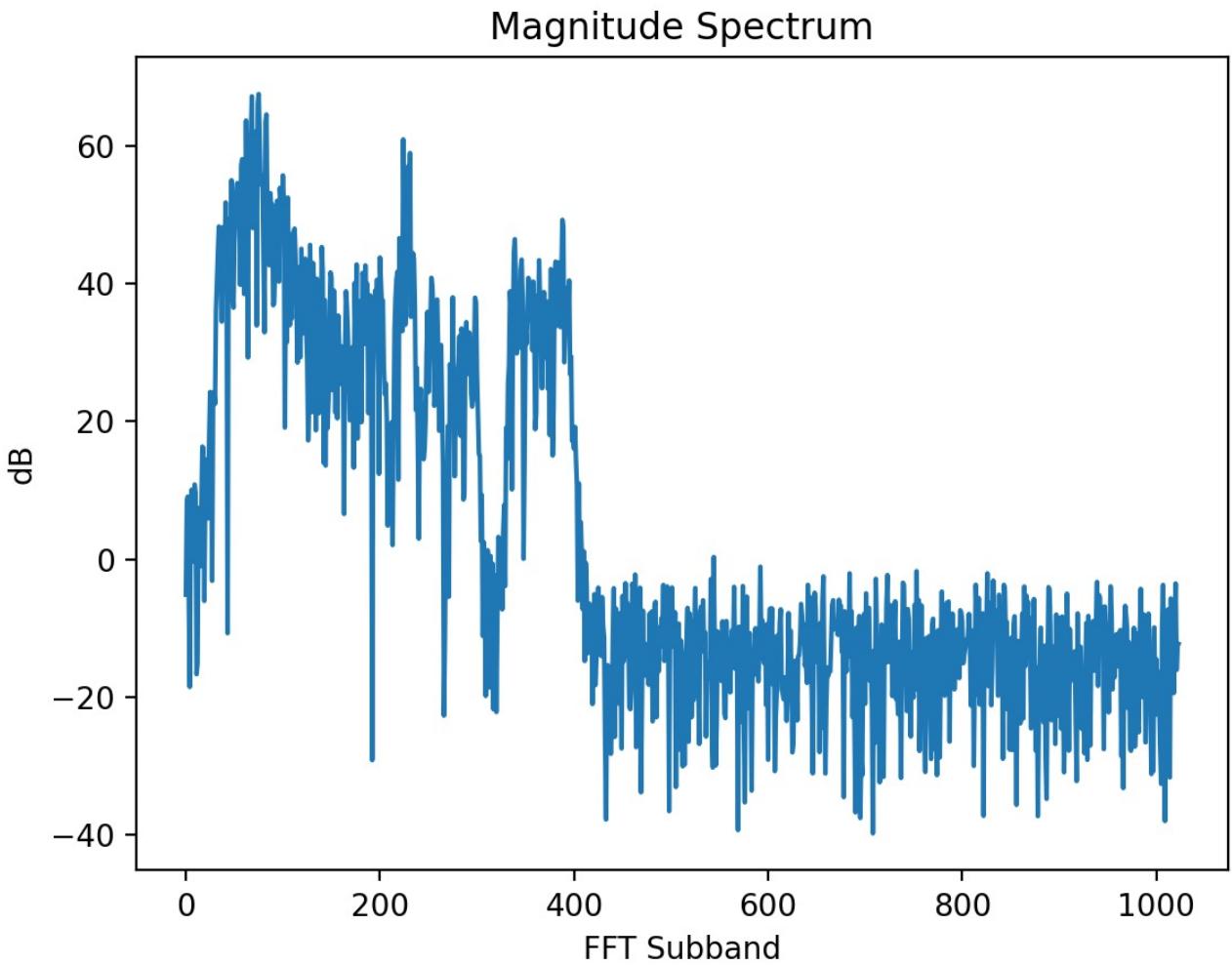


Reconstructed



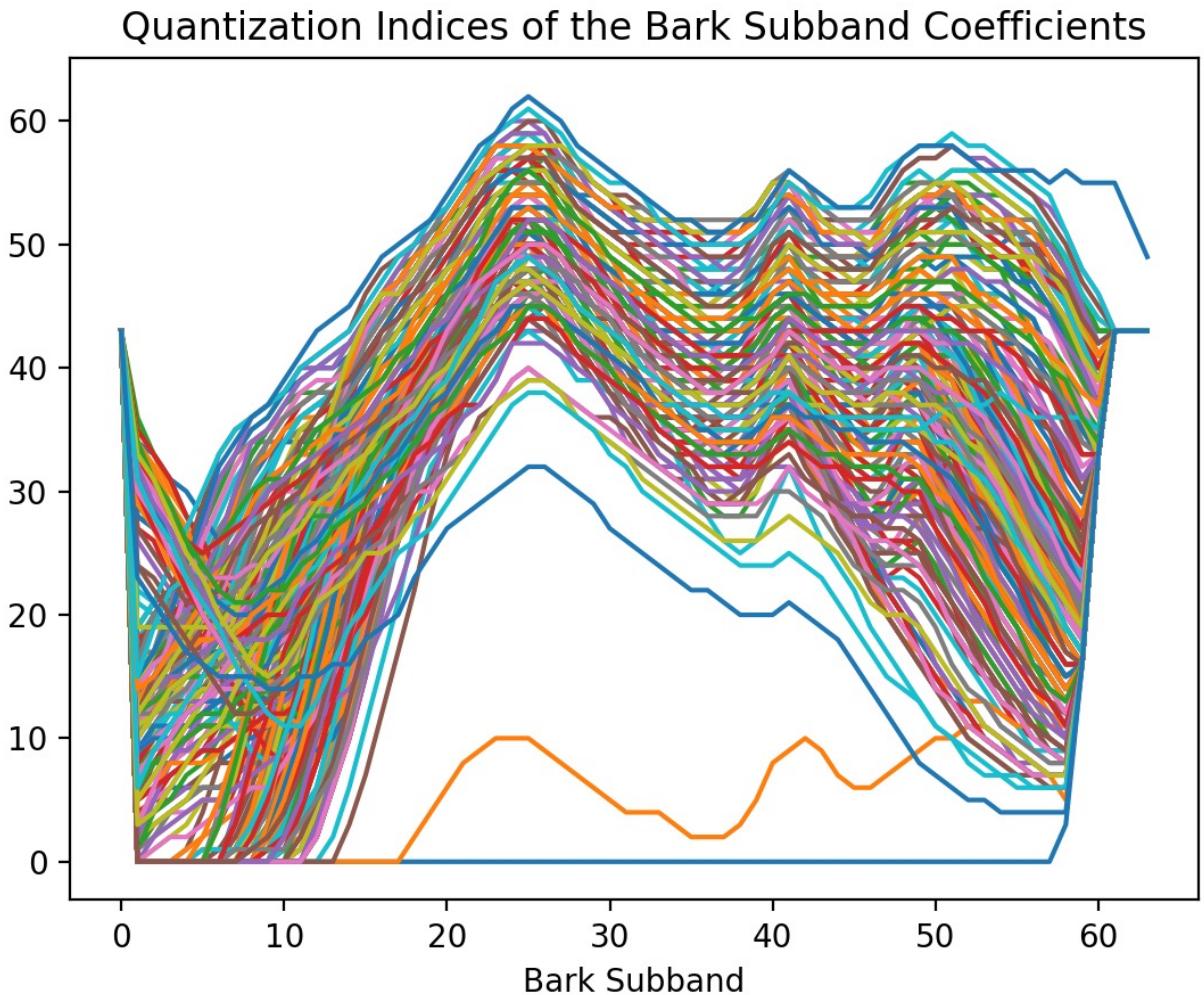
Castanets Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



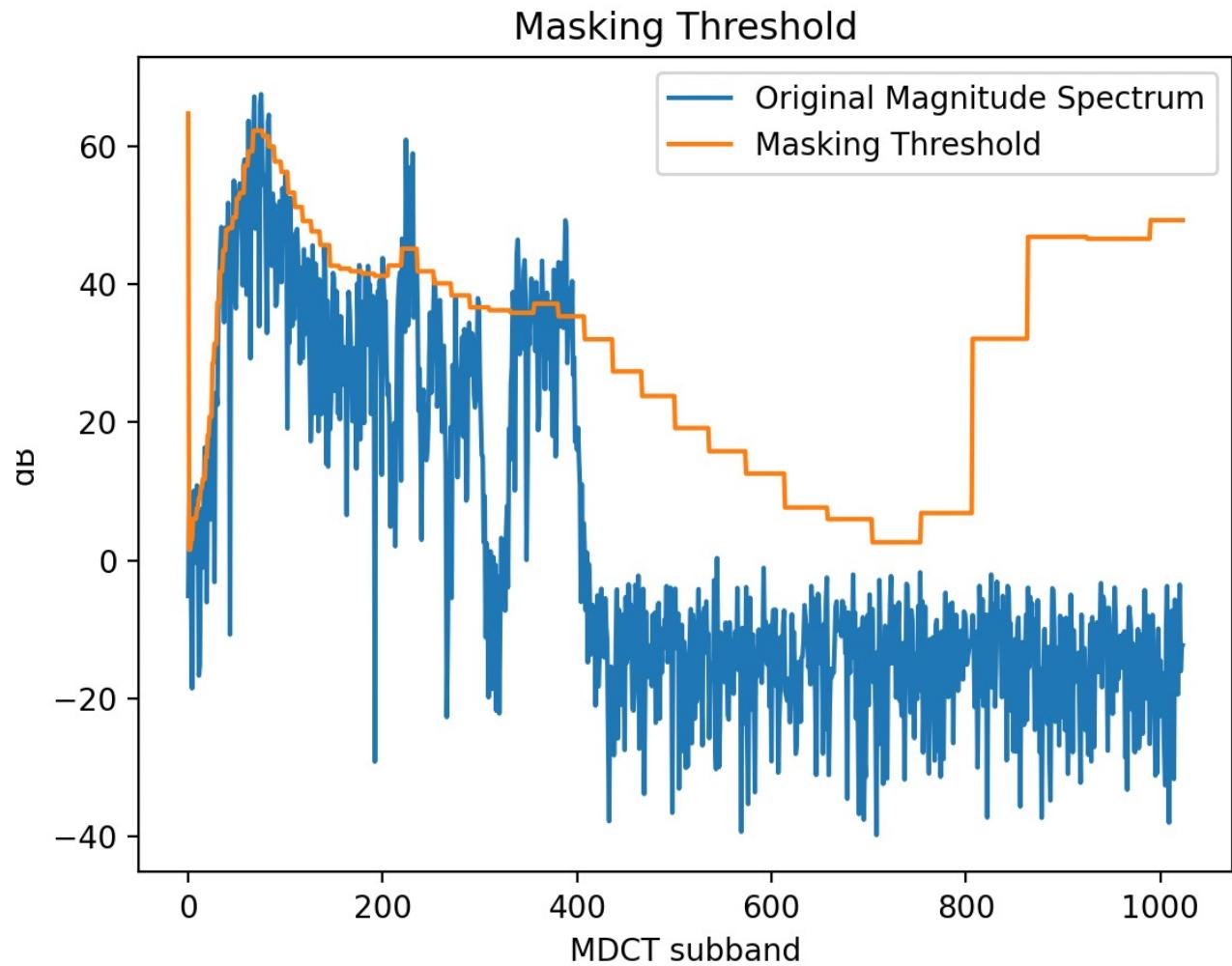
Castanets Quantization Error

- FFT
- **Quantize Bark Coefficients**
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



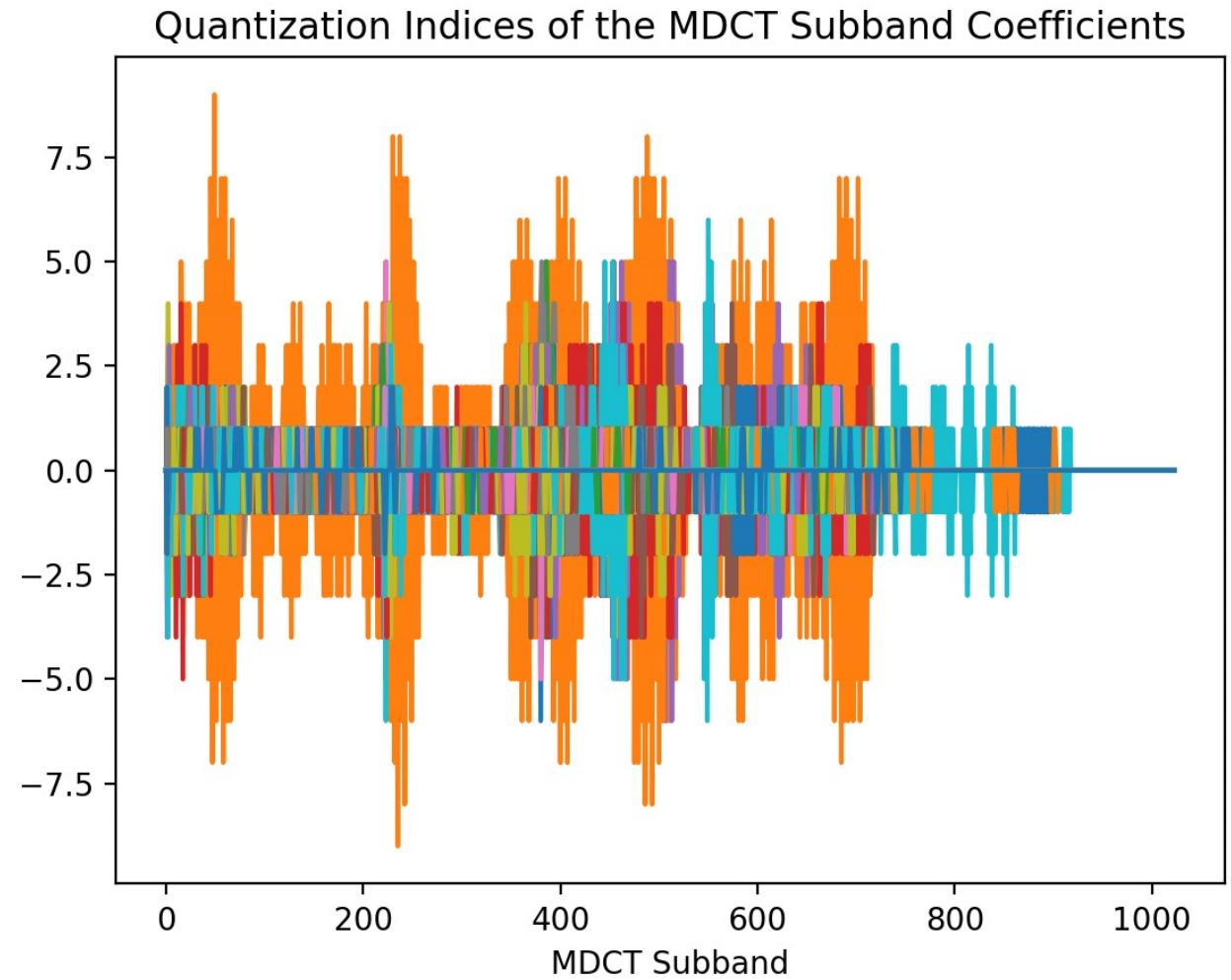
Castanets Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- Observe Quantization Error



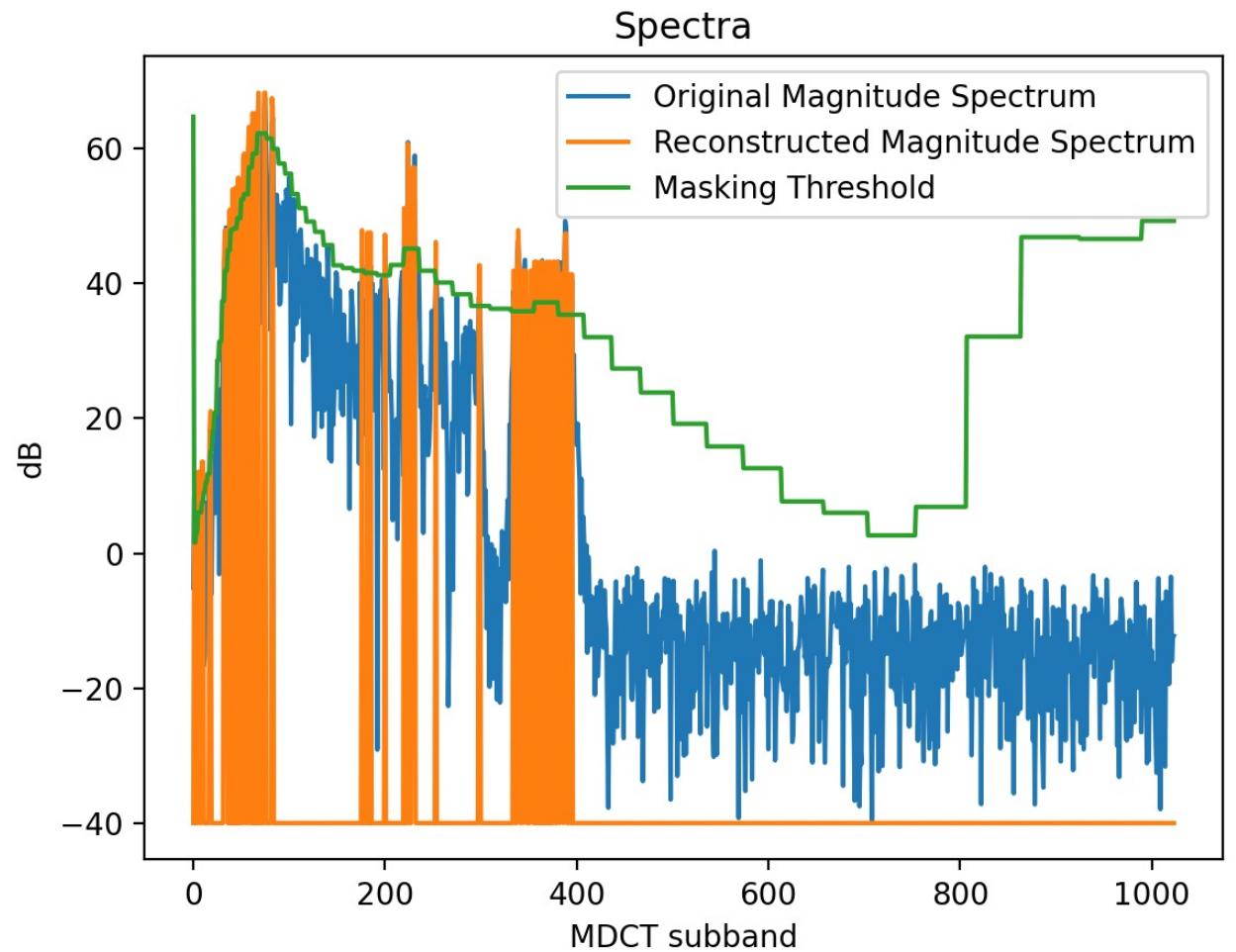
Castanets Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- **Allocate Quantization Bits**
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



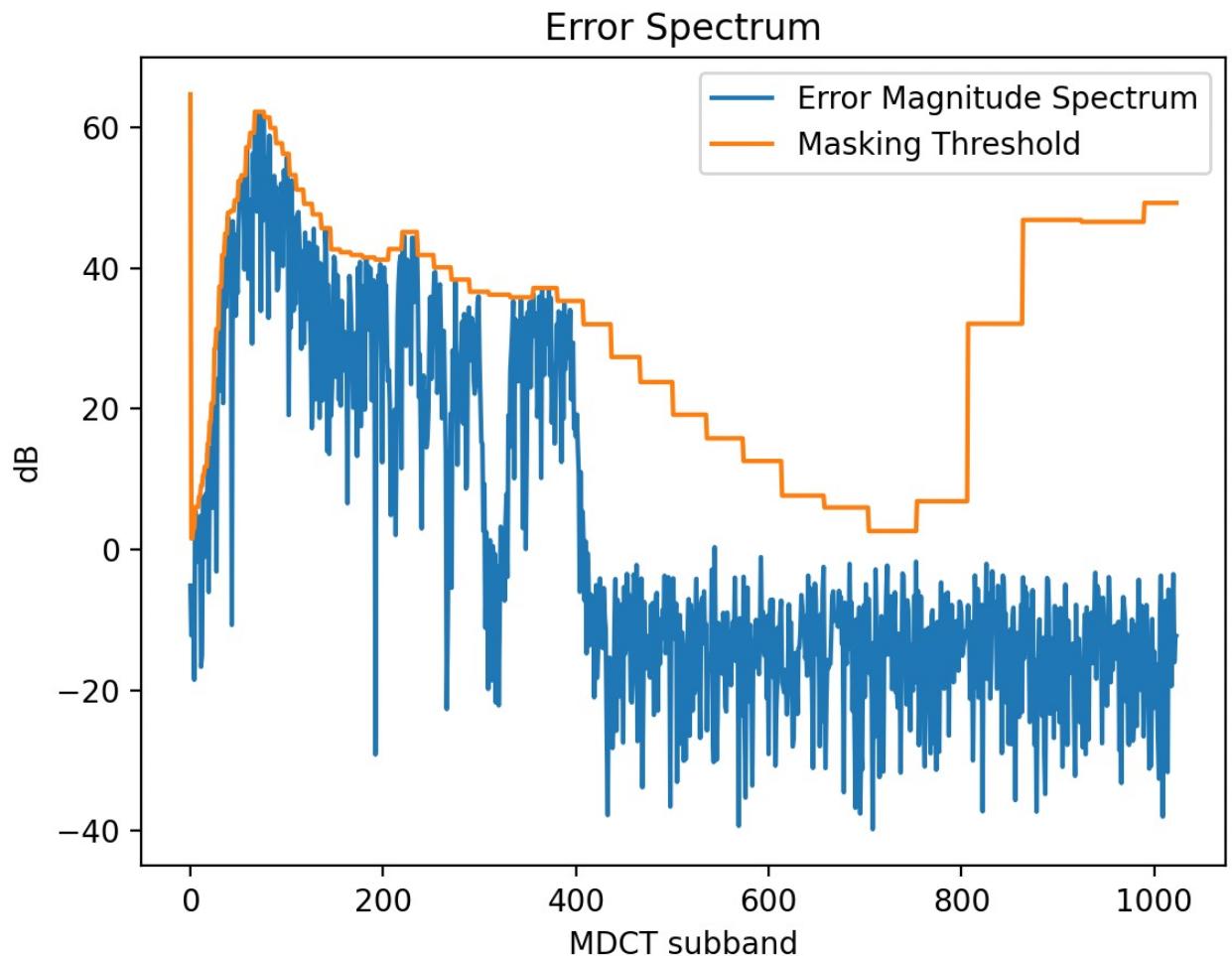
Castanets Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



Castanets Quantization Error

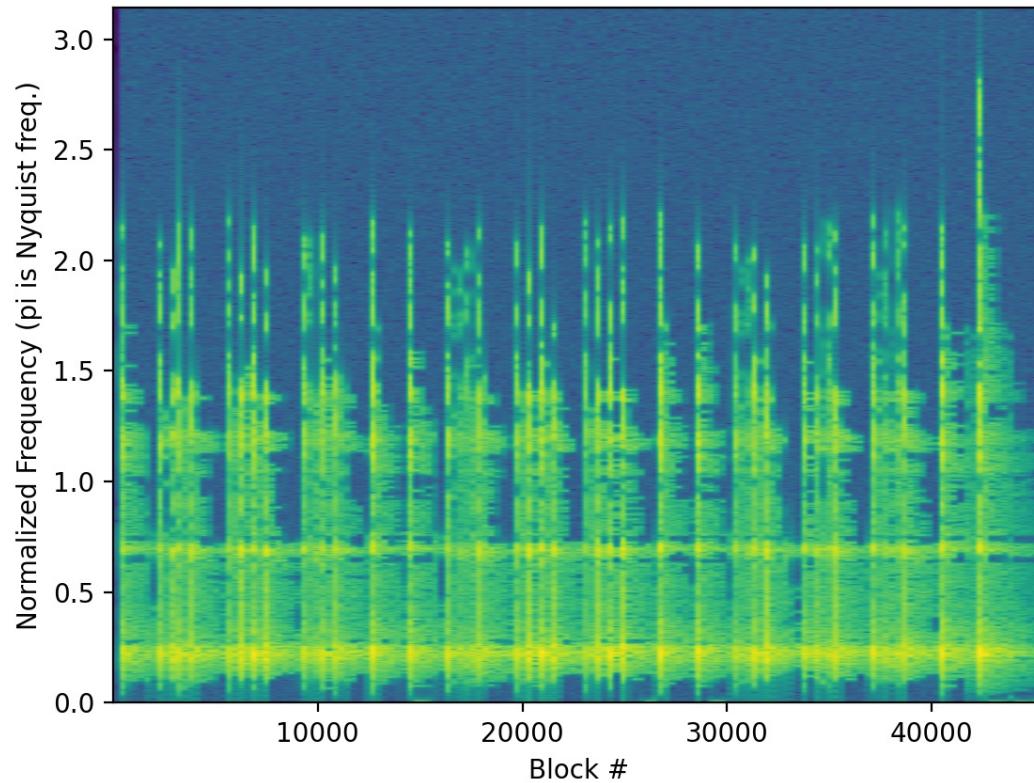
- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



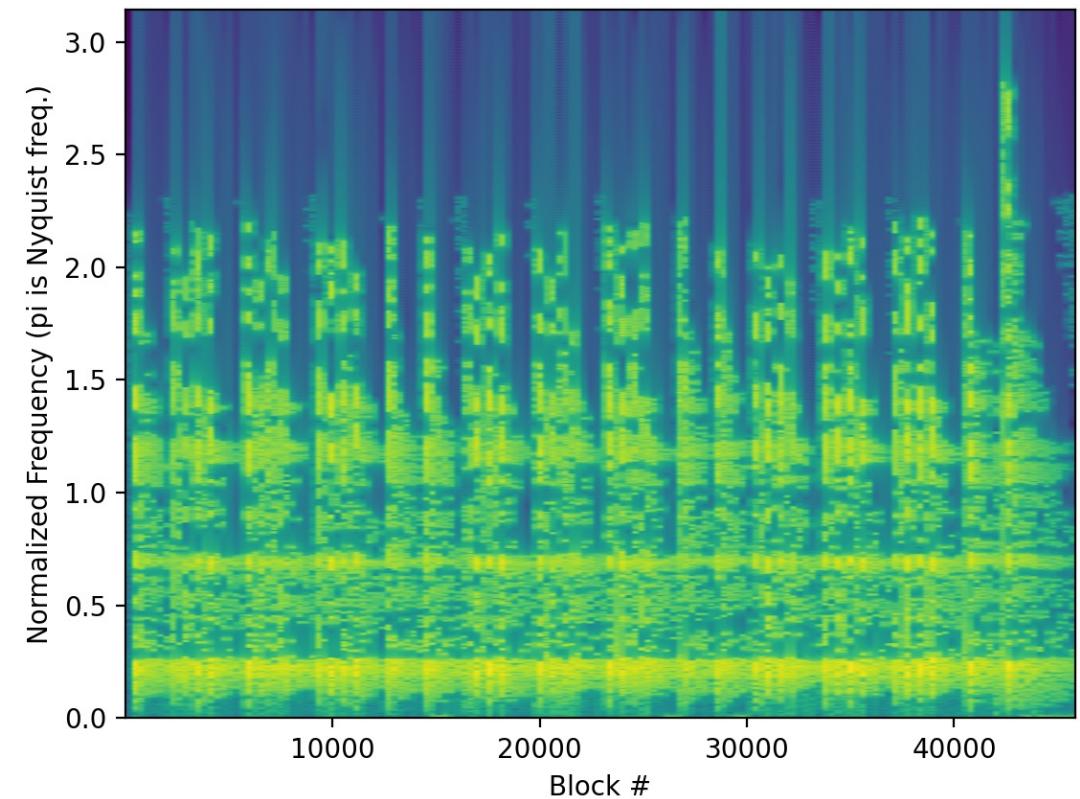
Castanets Quantization Error

60 Quality, 1024 MDCT Subbands

Original



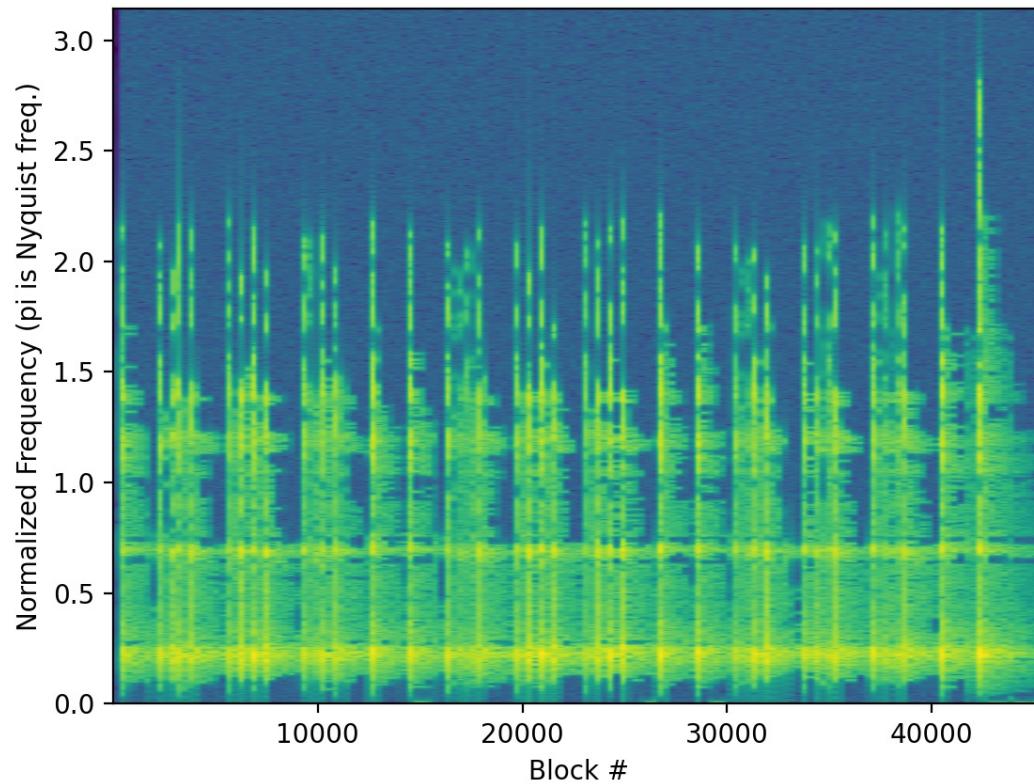
Reconstructed



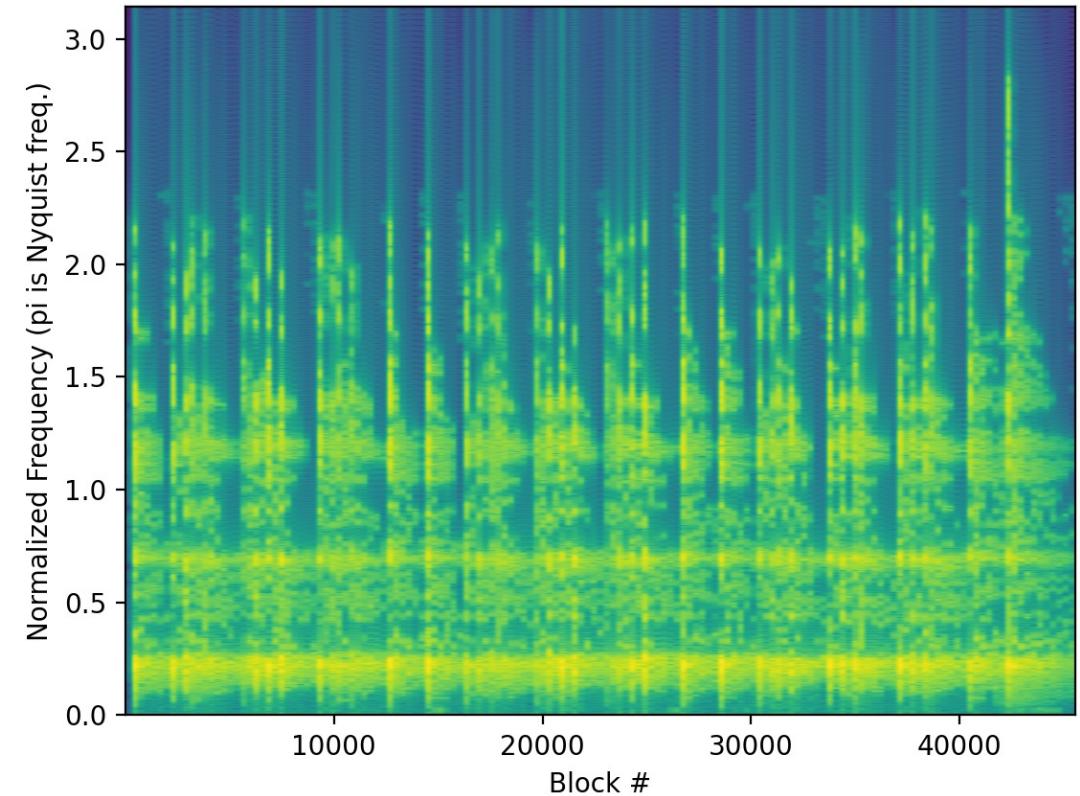
Castanets Quantization Error

60 Quality, 256 MDCT Subbands

Original



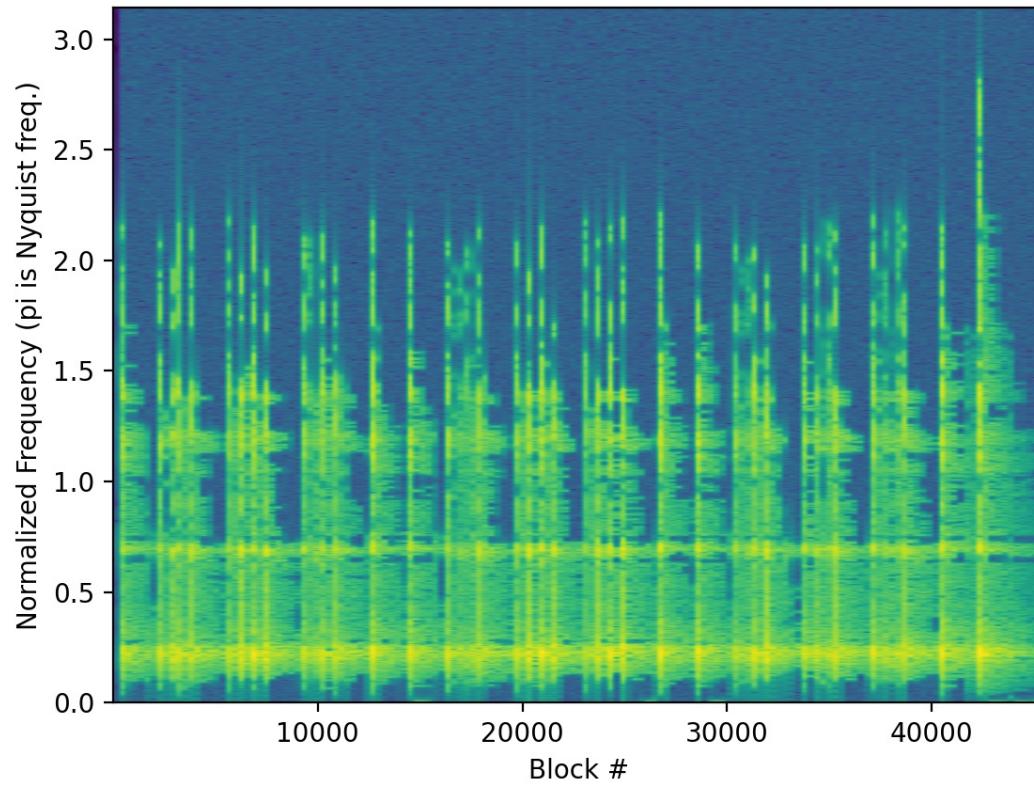
Reconstructed



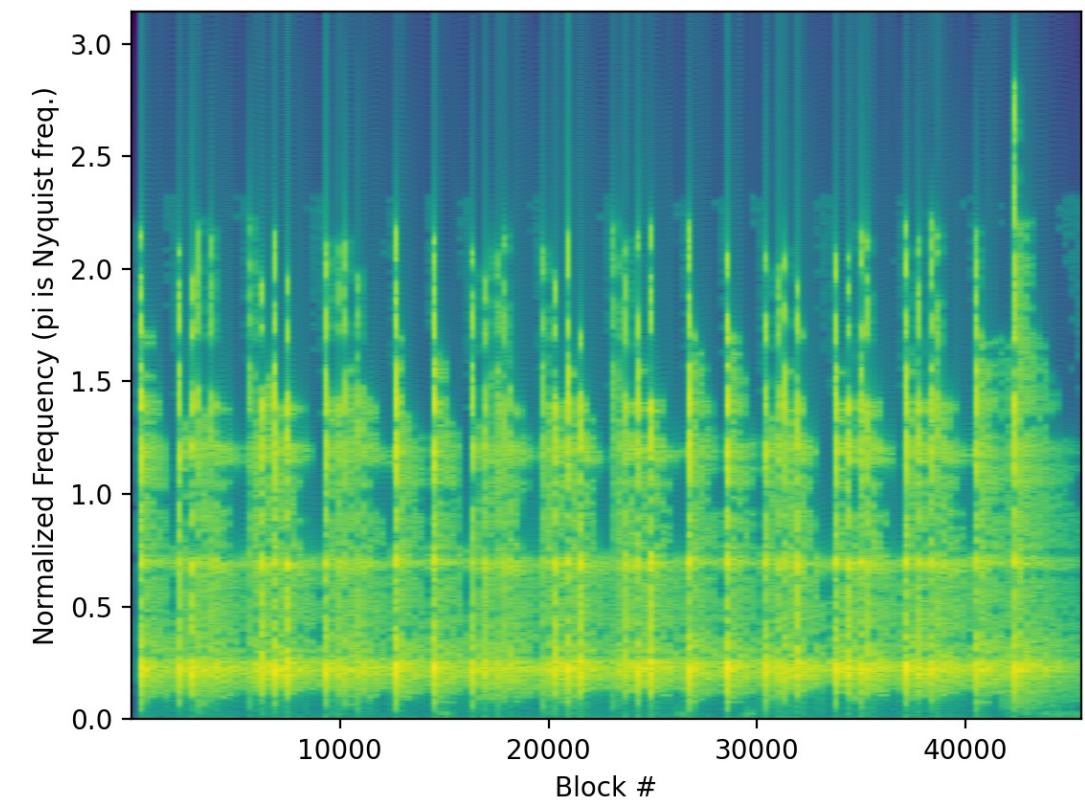
Castanets Quantization Error

100 Quality, 1024 MDCT Subbands

Original



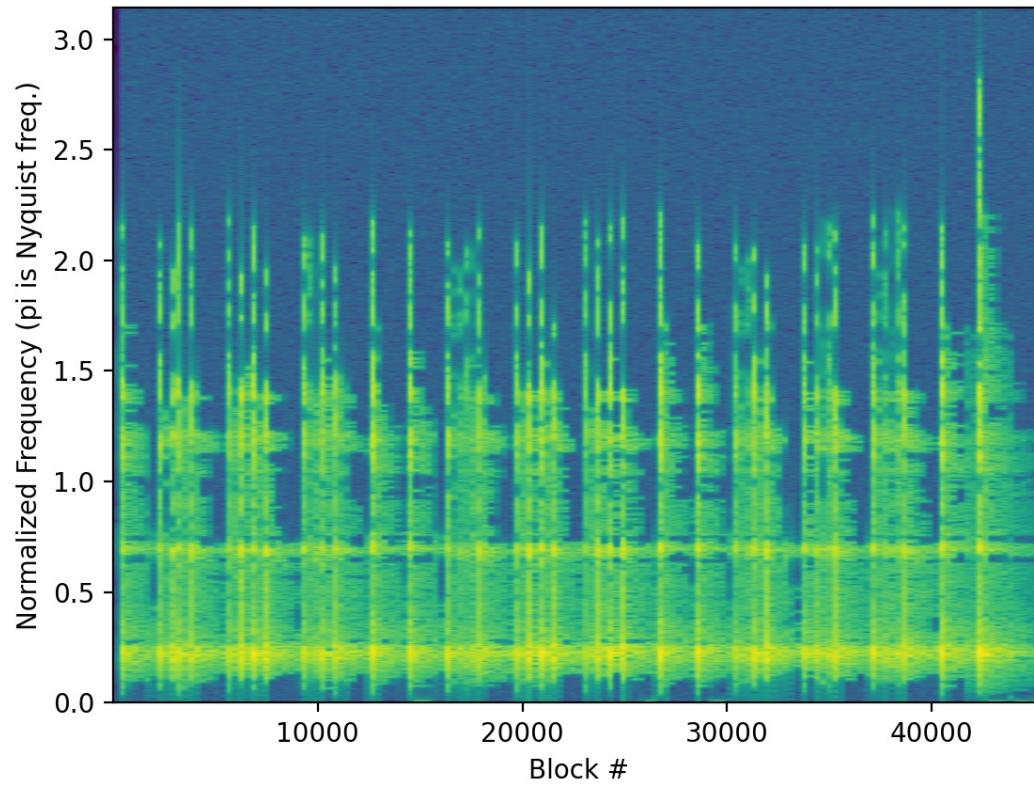
Reconstructed



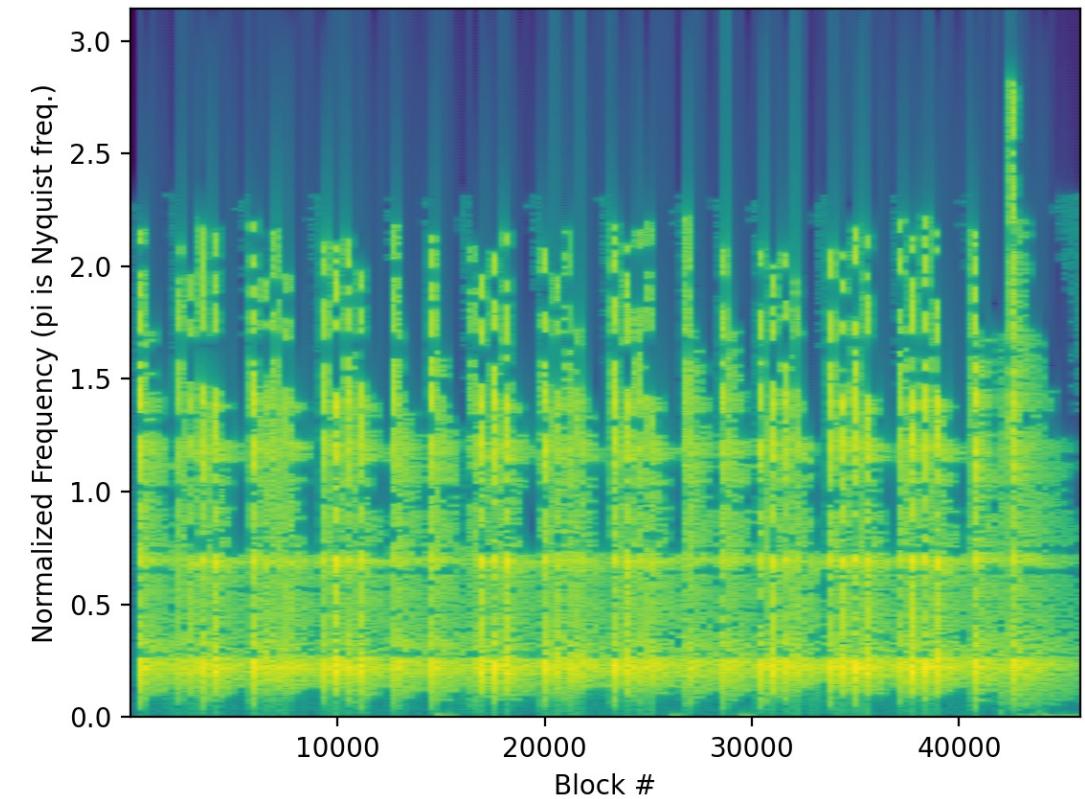
Castanets Quantization Error

100 Quality, 256 MDCT Subbands

Original

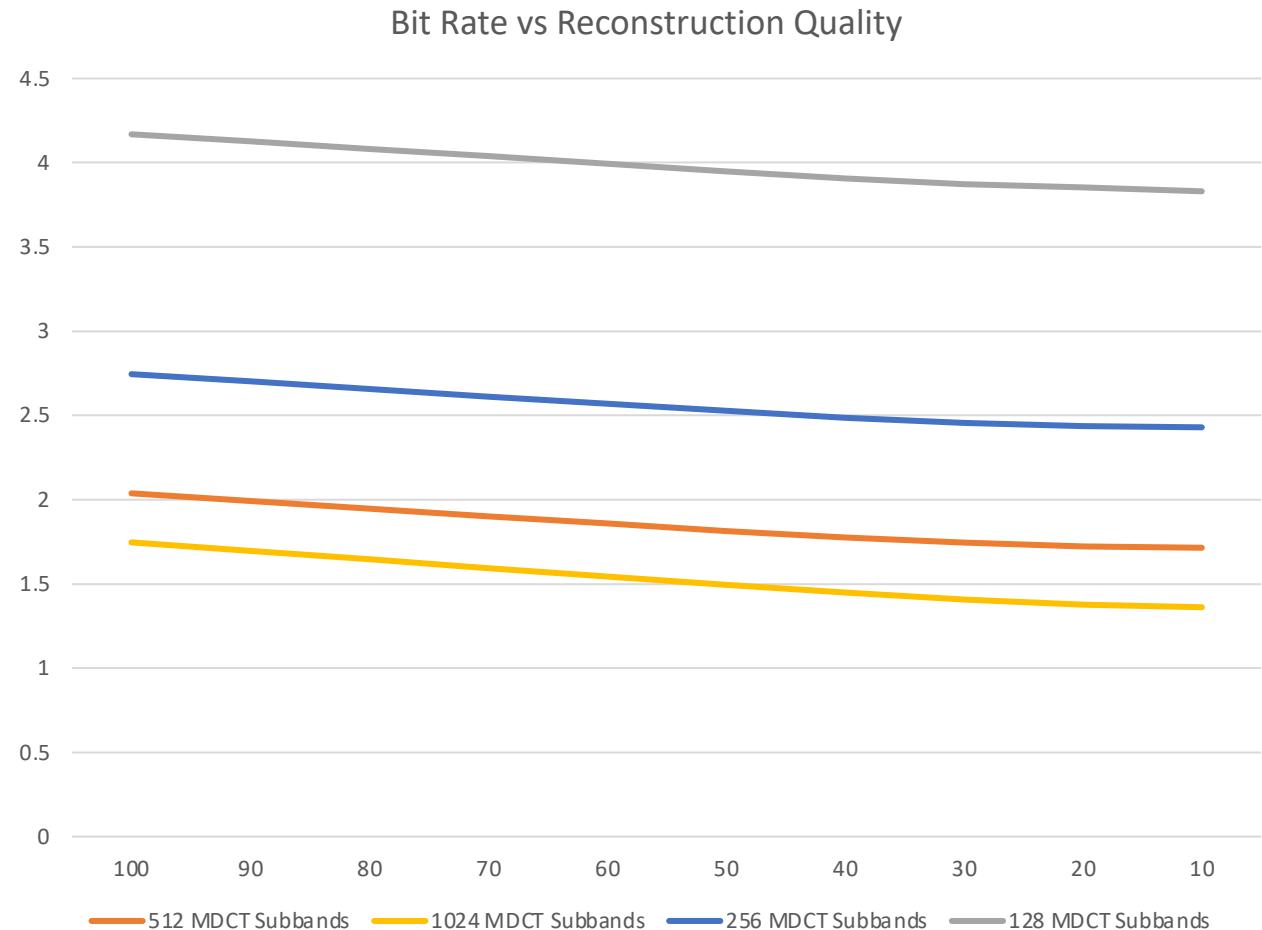


Reconstructed



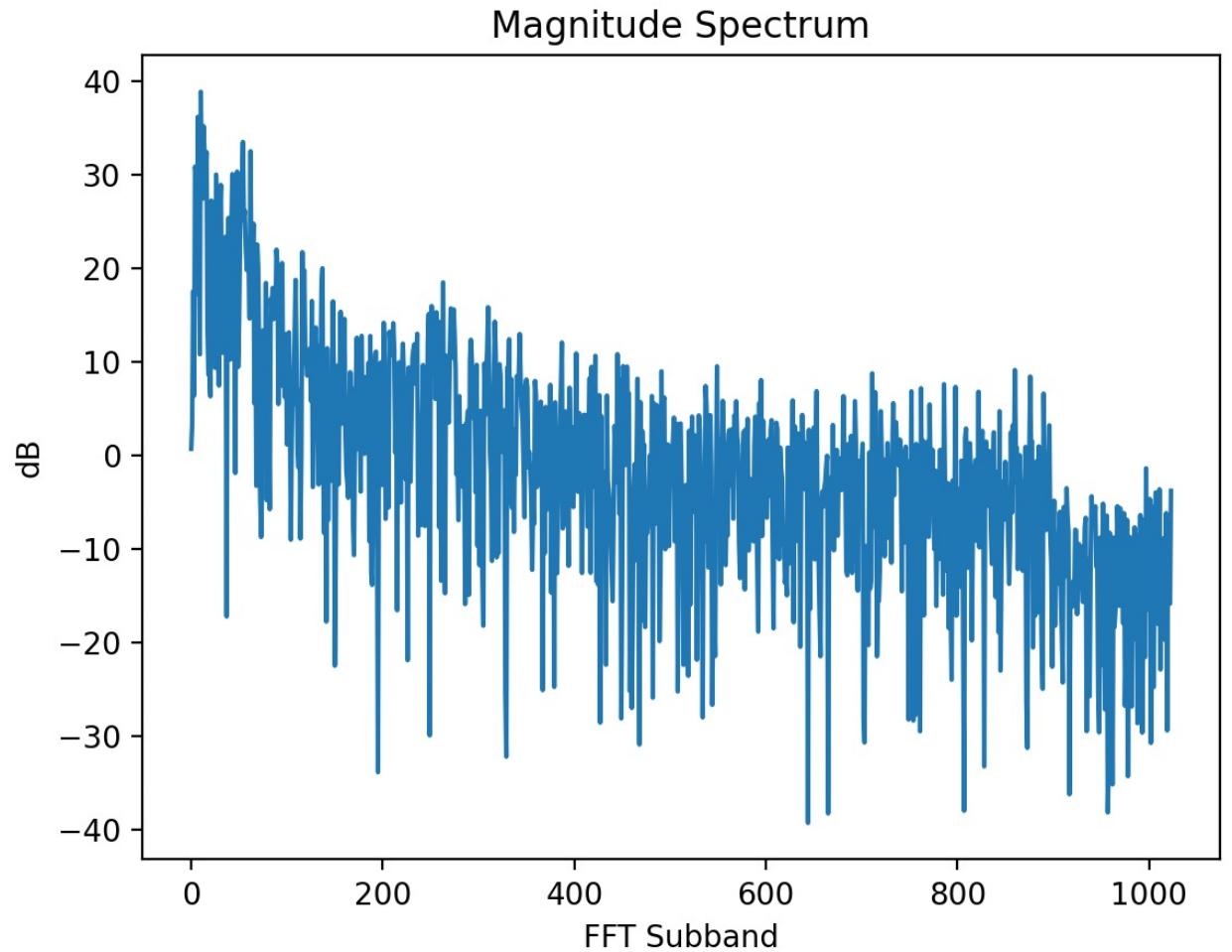
Castanets

- Decreasing MDCT Subbands removes pre-echo but increases bit rate
- Decreasing reconstruction quality (increasing the masking threshold) decreases bit rate but increases pre-echo



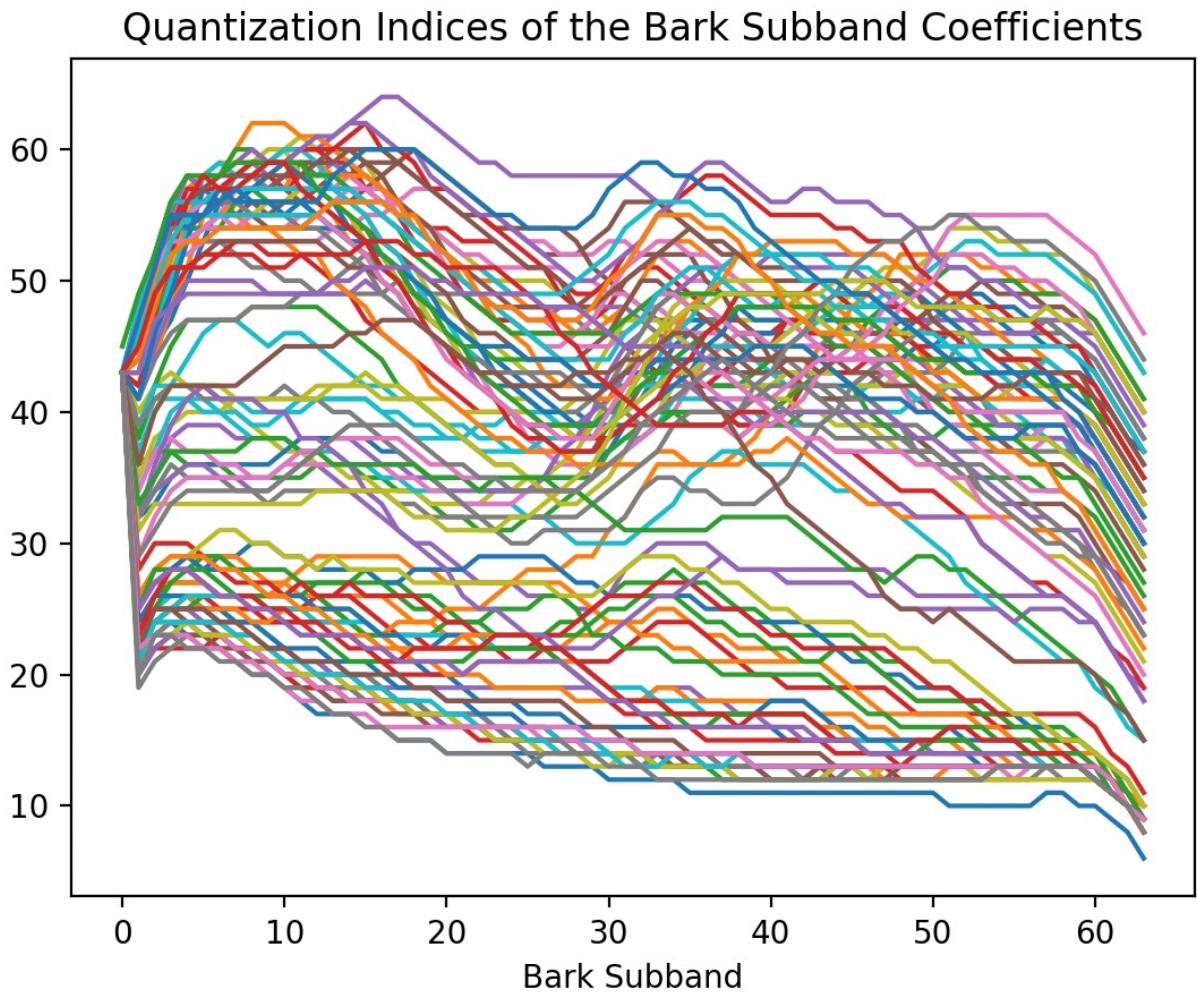
Male Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



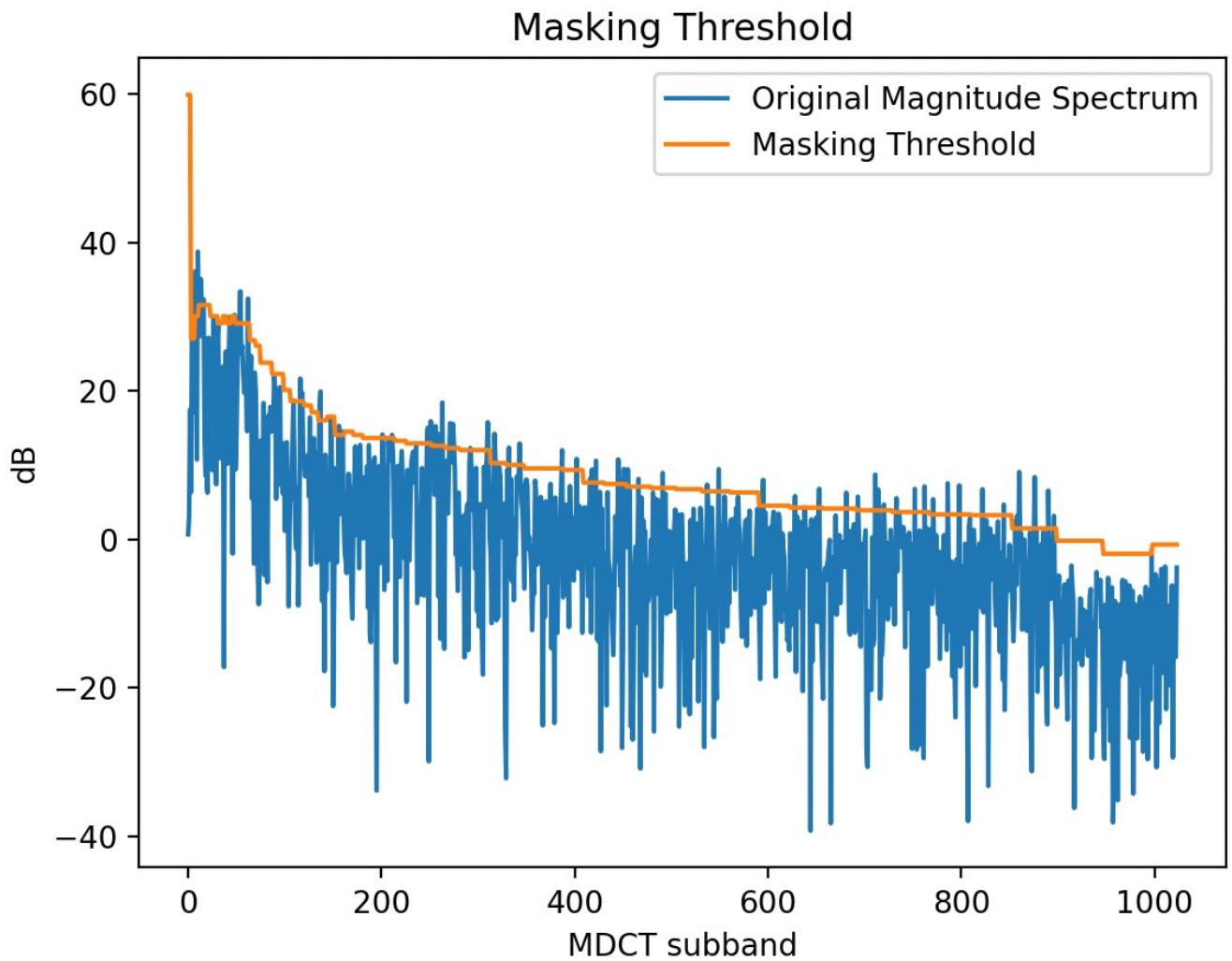
Male Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- Observe Quantization Error



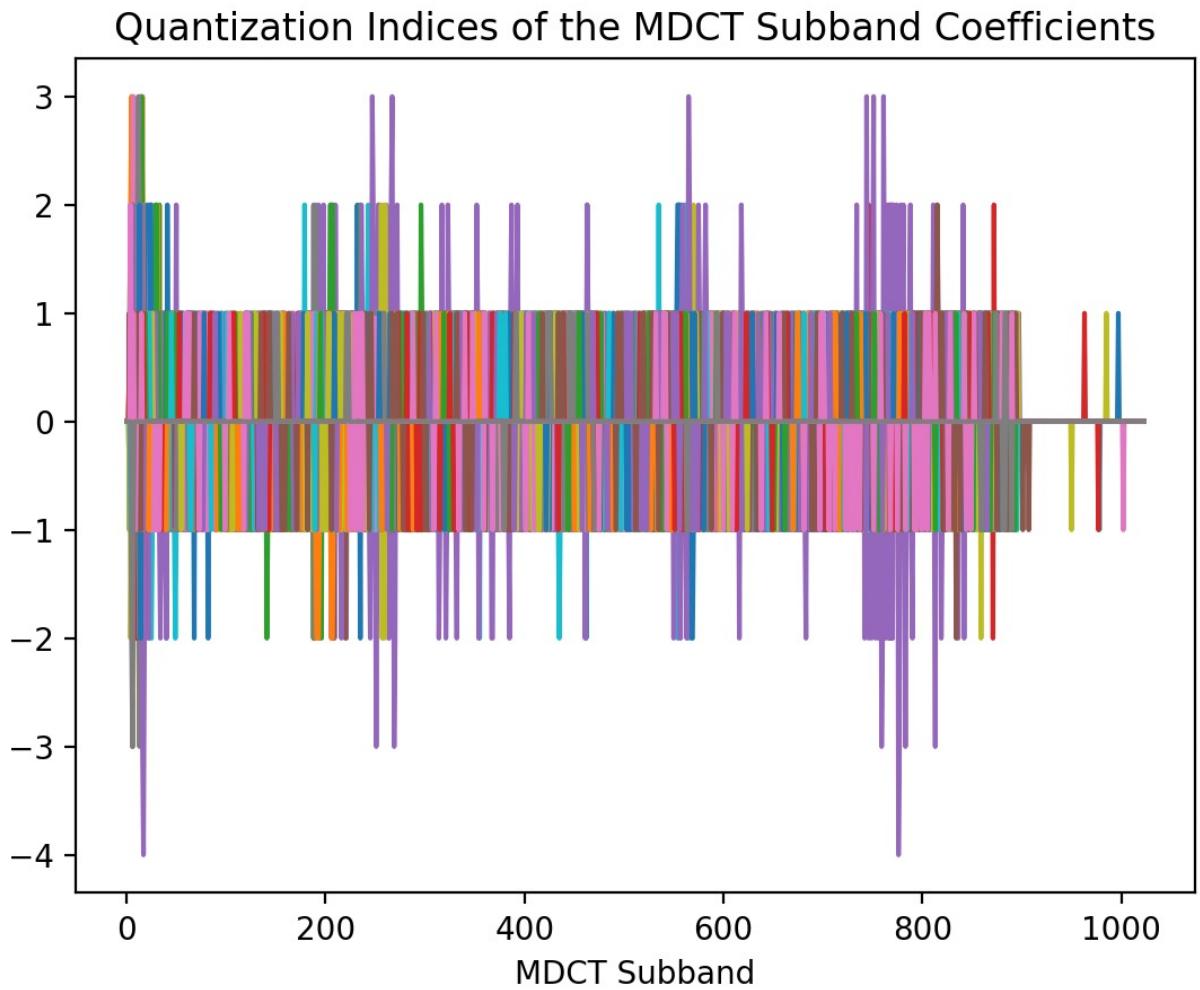
Male Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- Observe Quantization Error



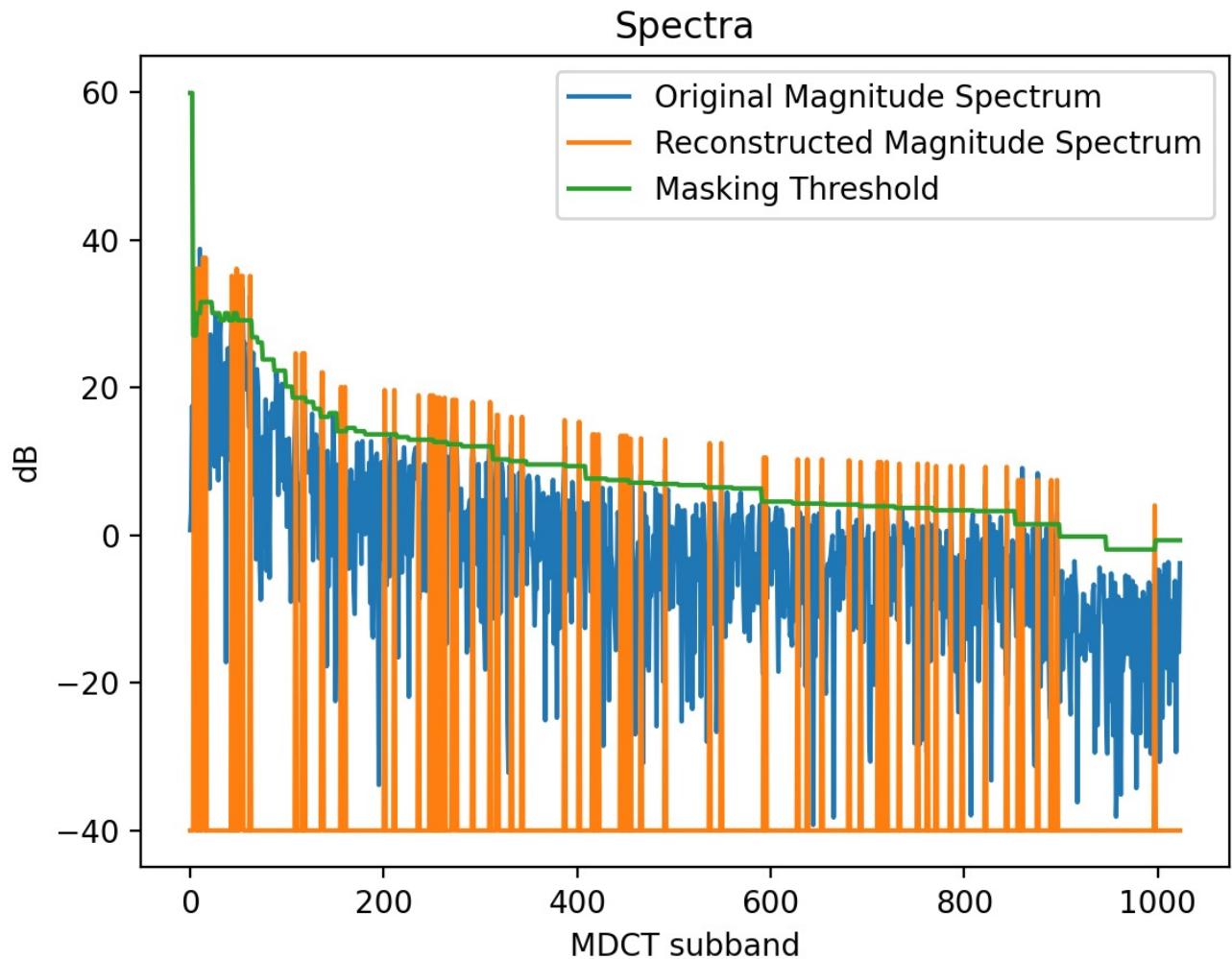
Male Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- **Allocate Quantization Bits**
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



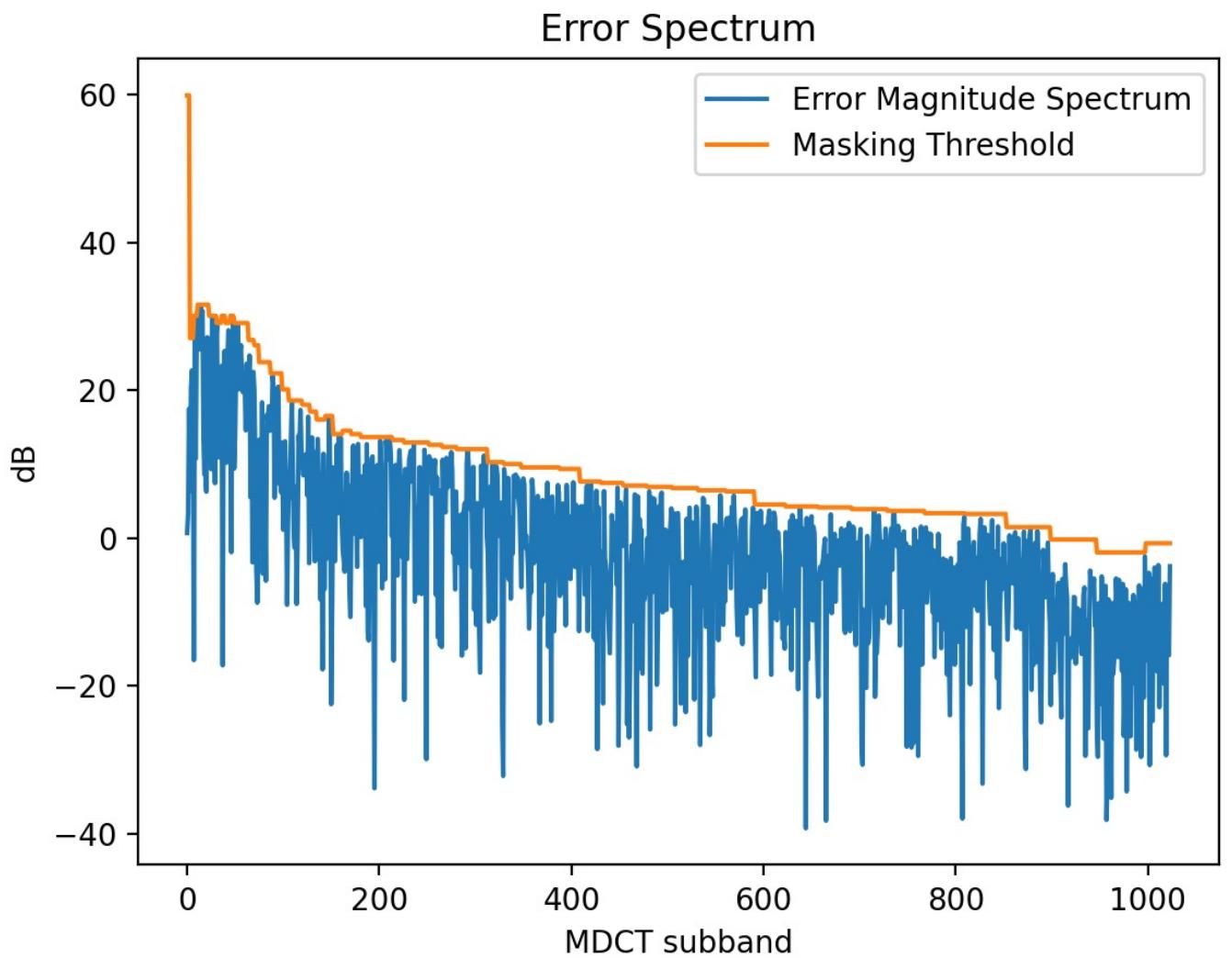
Male Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



Male Voice Quantization Error

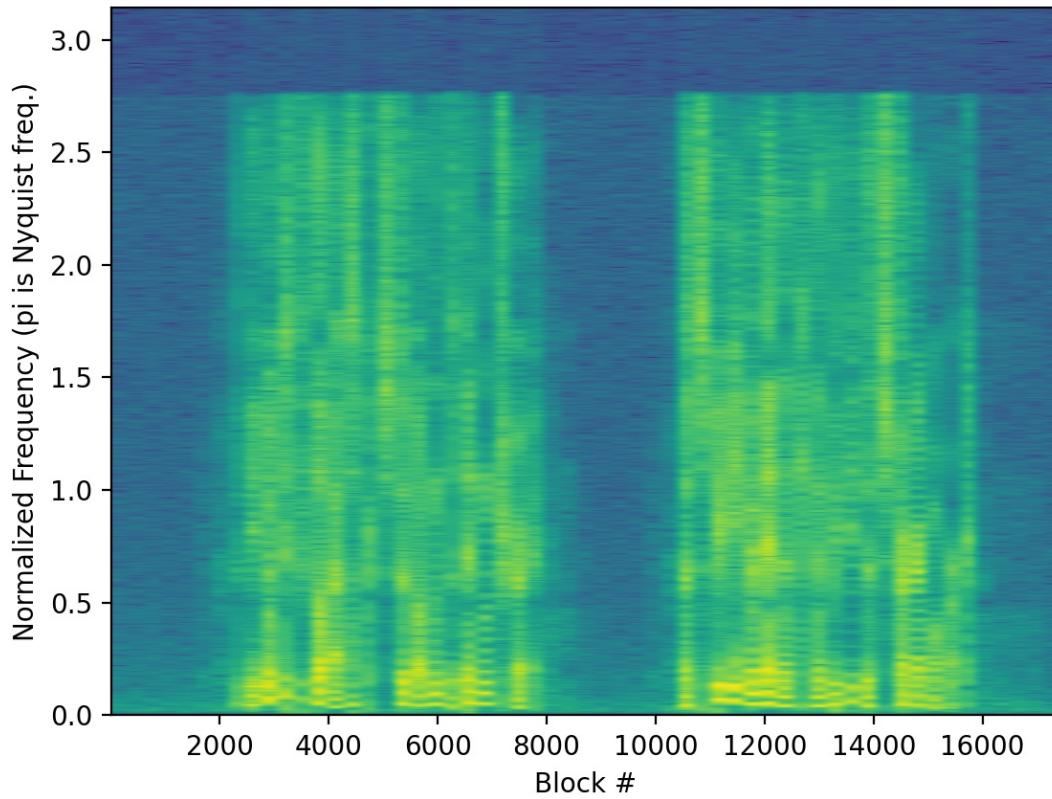
- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- Observe Quantization Error



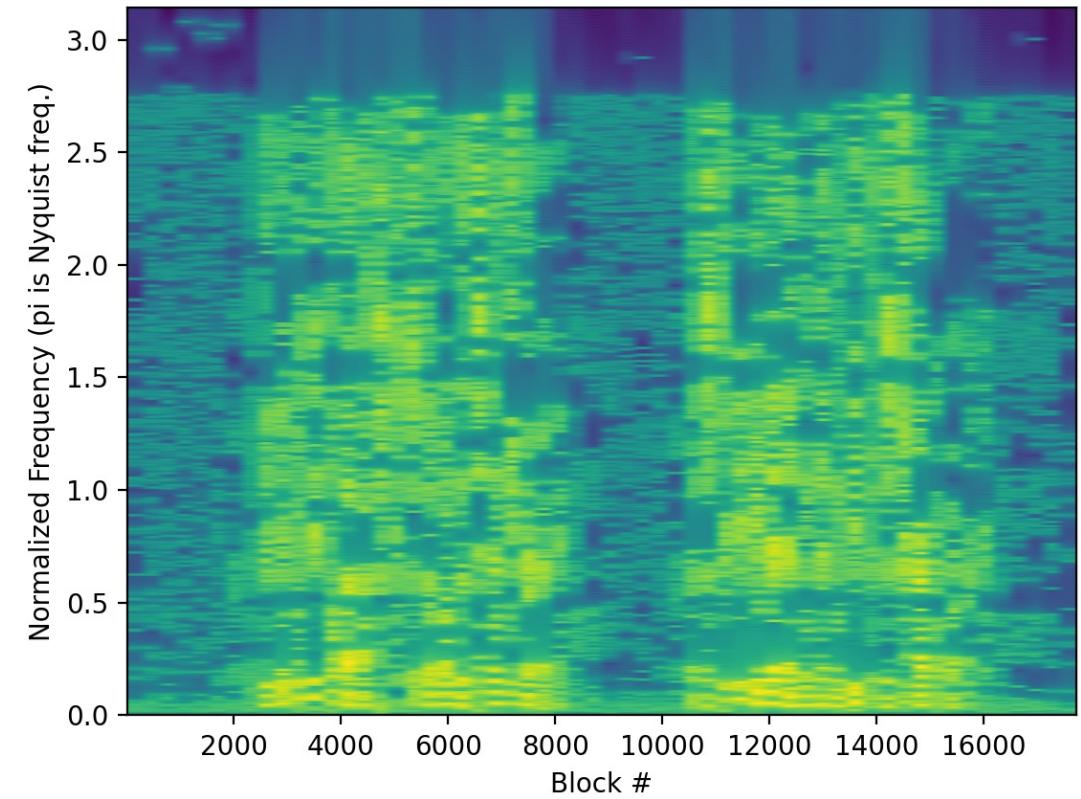
Male Voice Quantization Error

60 Quality, 1024 MDCT Subbands

Original



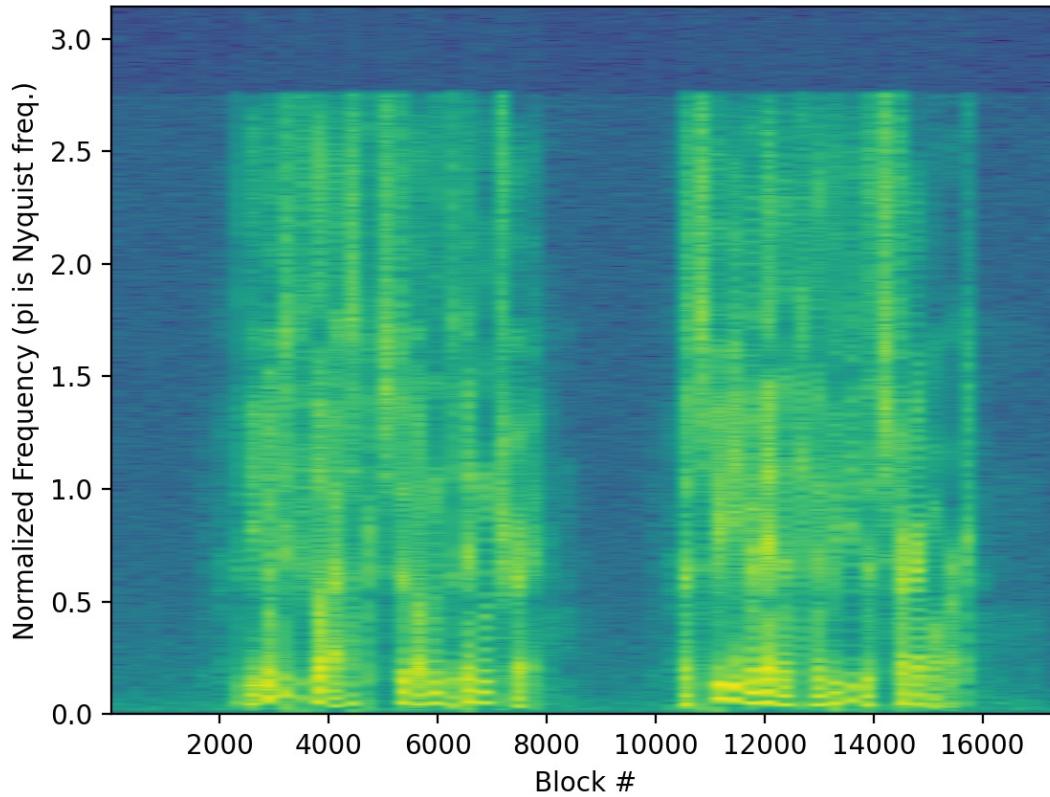
Reconstructed



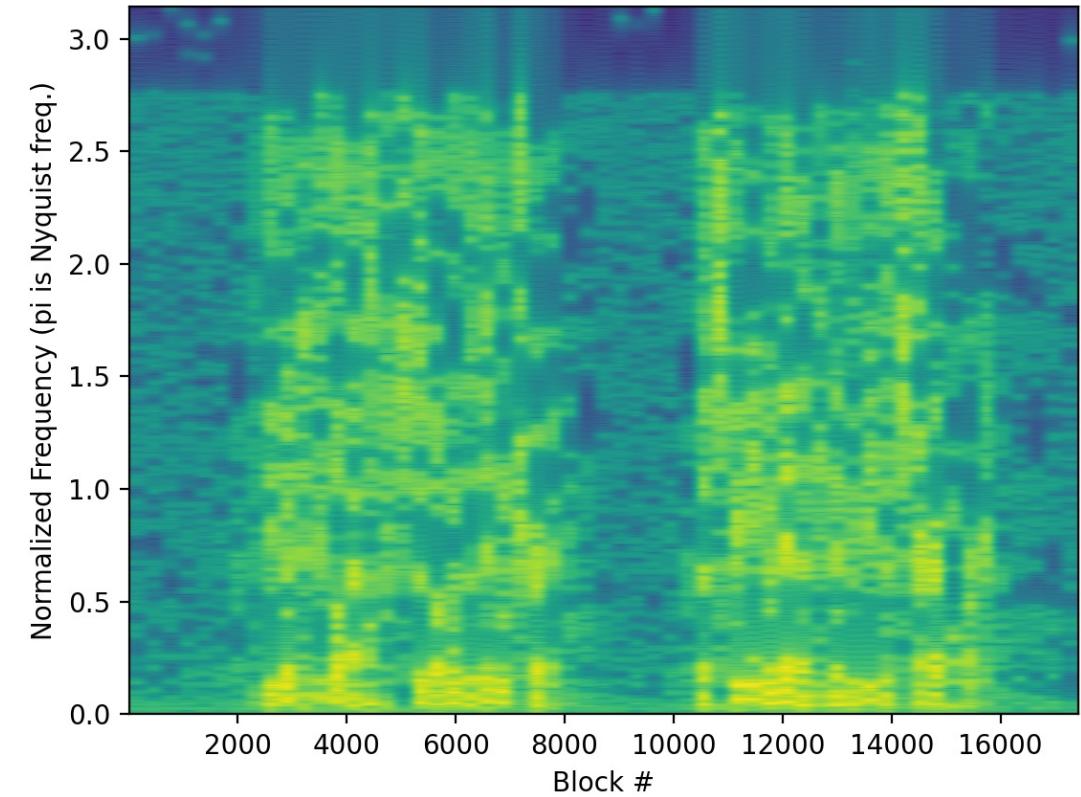
Male Voice Quantization Error

60 Quality, 256 MDCT Subbands

Original



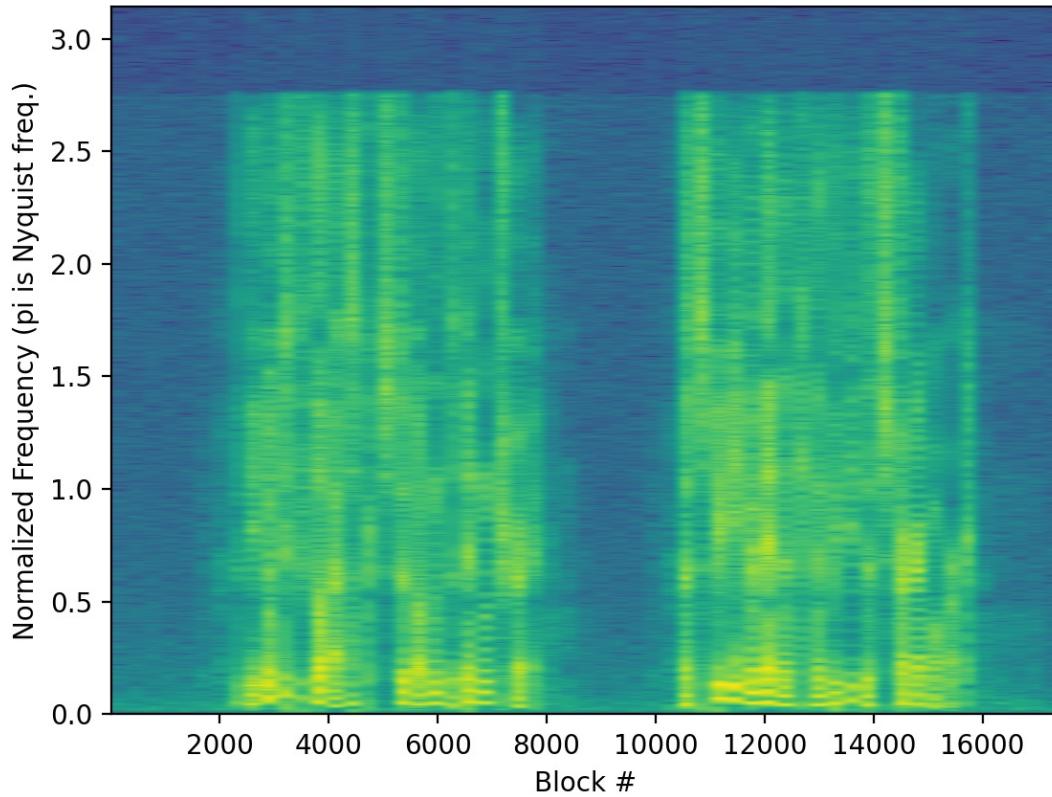
Reconstructed



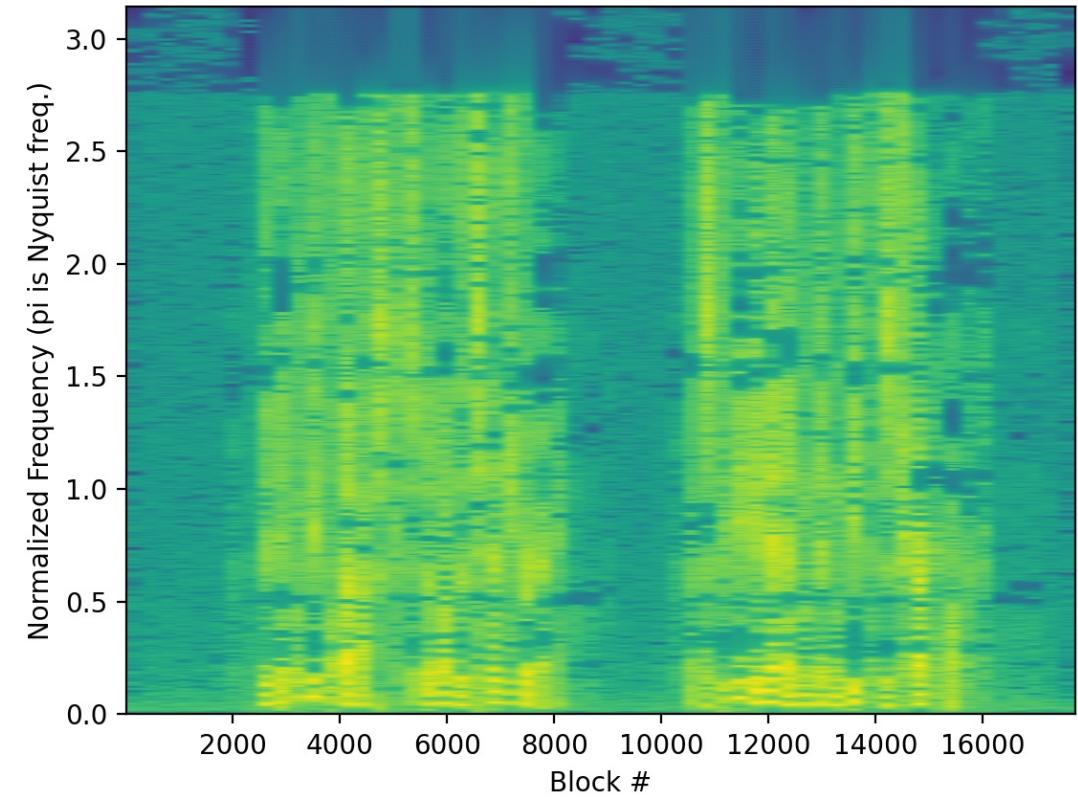
Male Voice Quantization Error

100 Quality, 1024 MDCT Subbands

Original



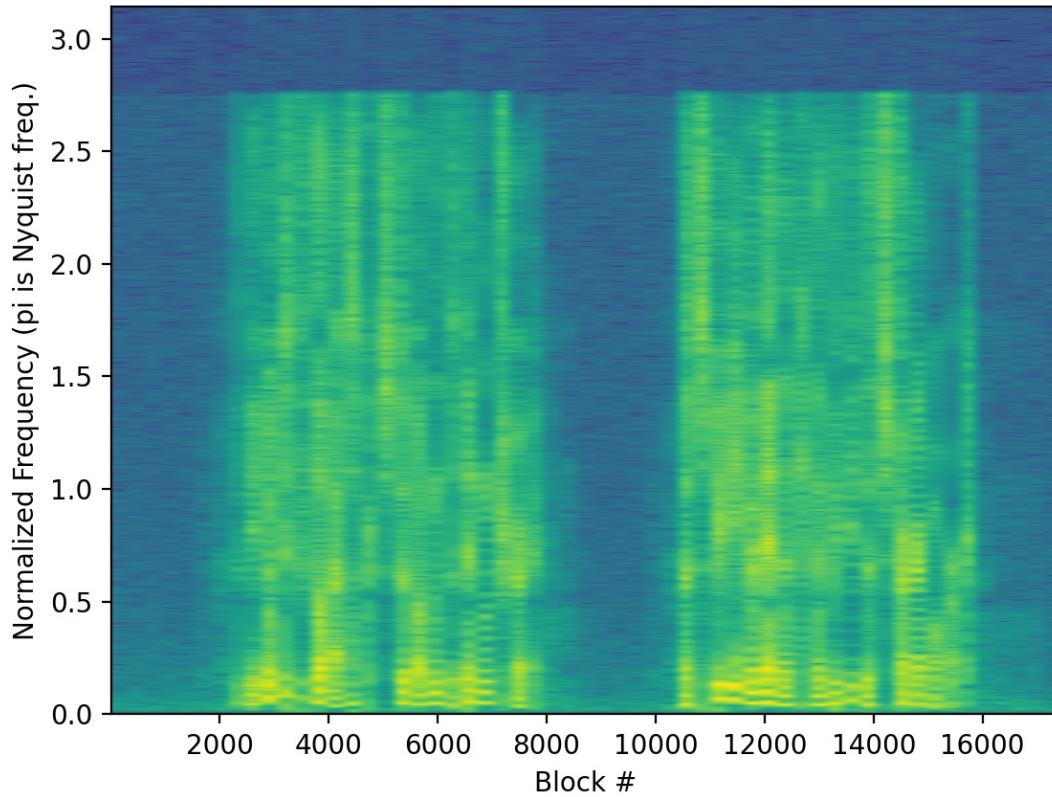
Reconstructed



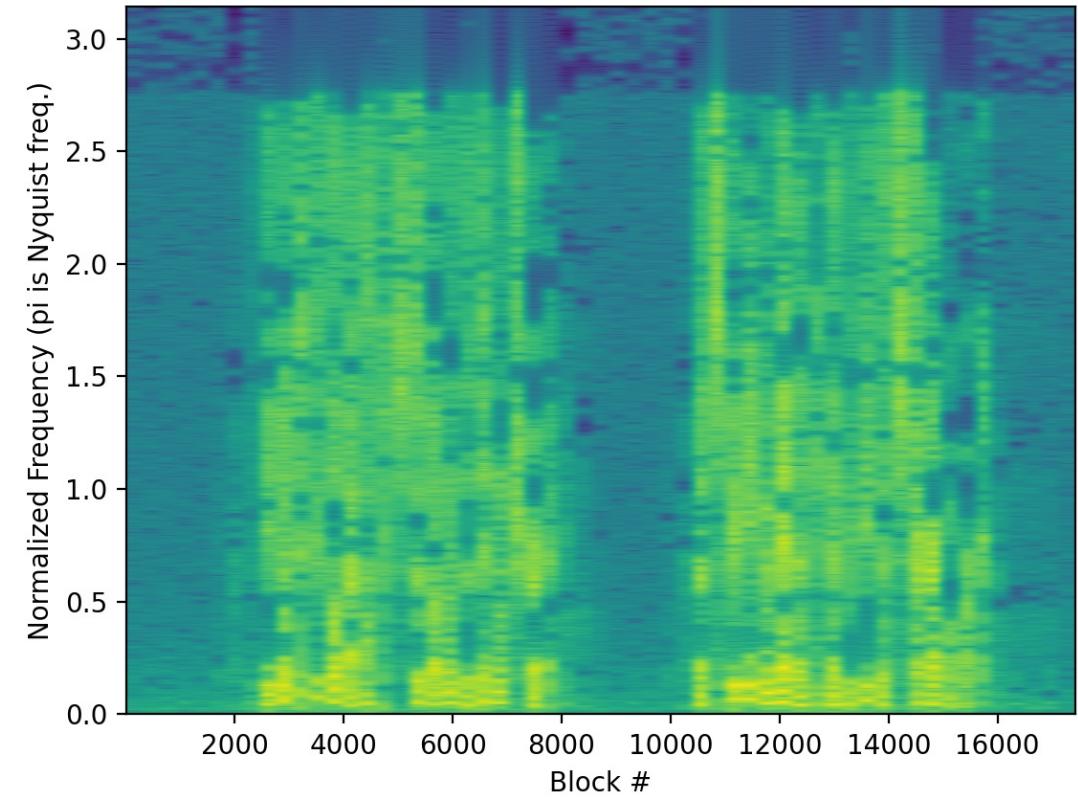
Male Voice Quantization Error

100 Quality, 256 MDCT Subbands

Original

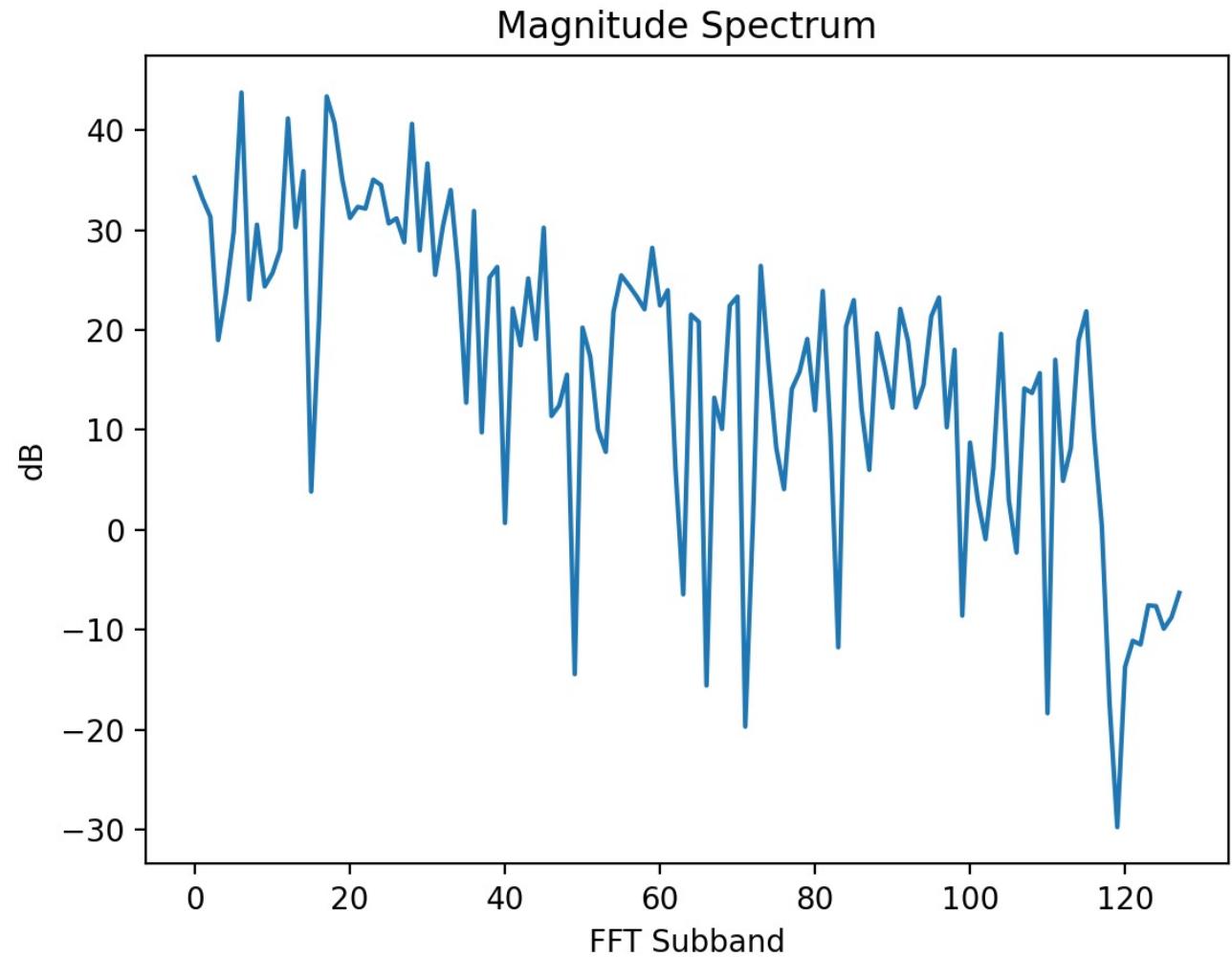


Reconstructed



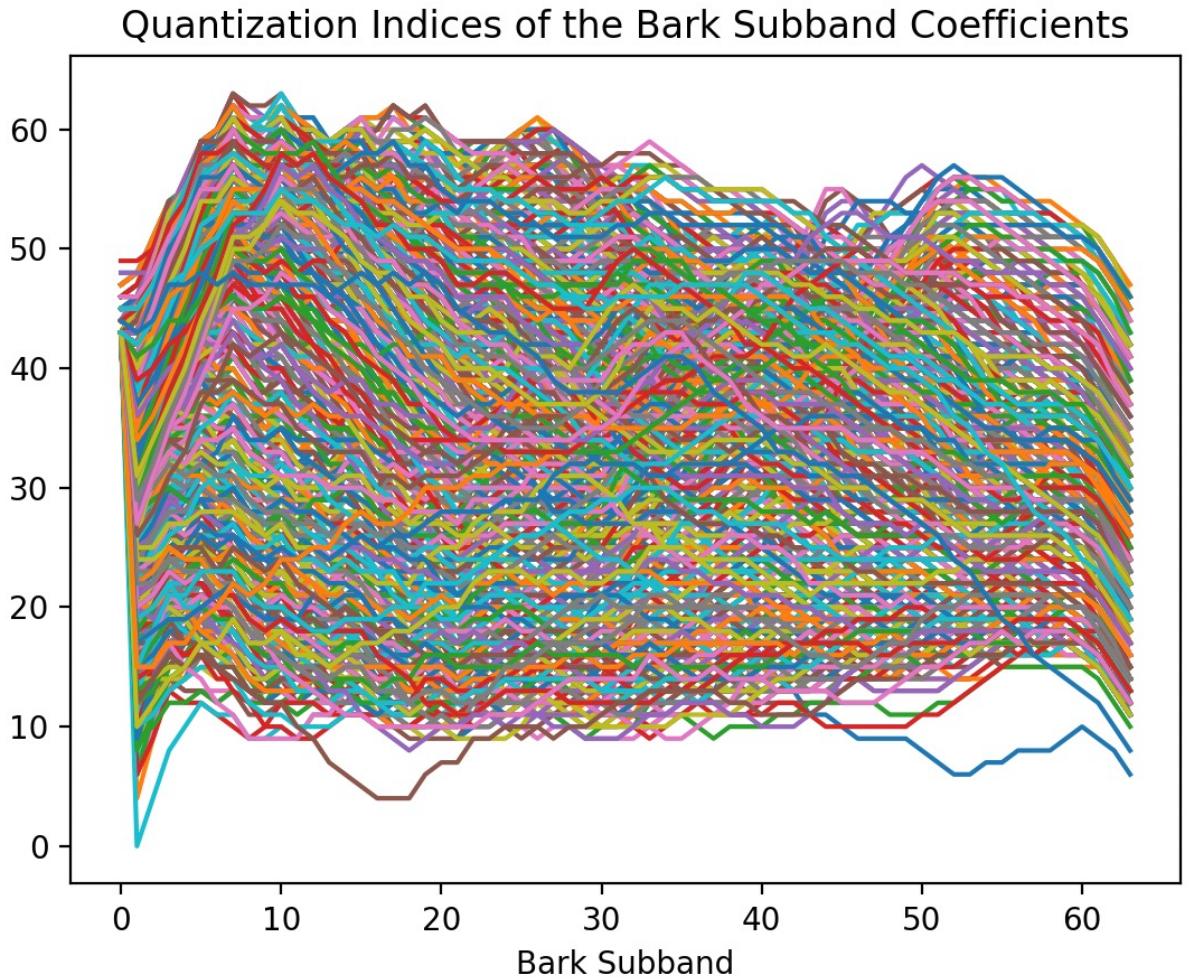
Female Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- Observe Quantization Error



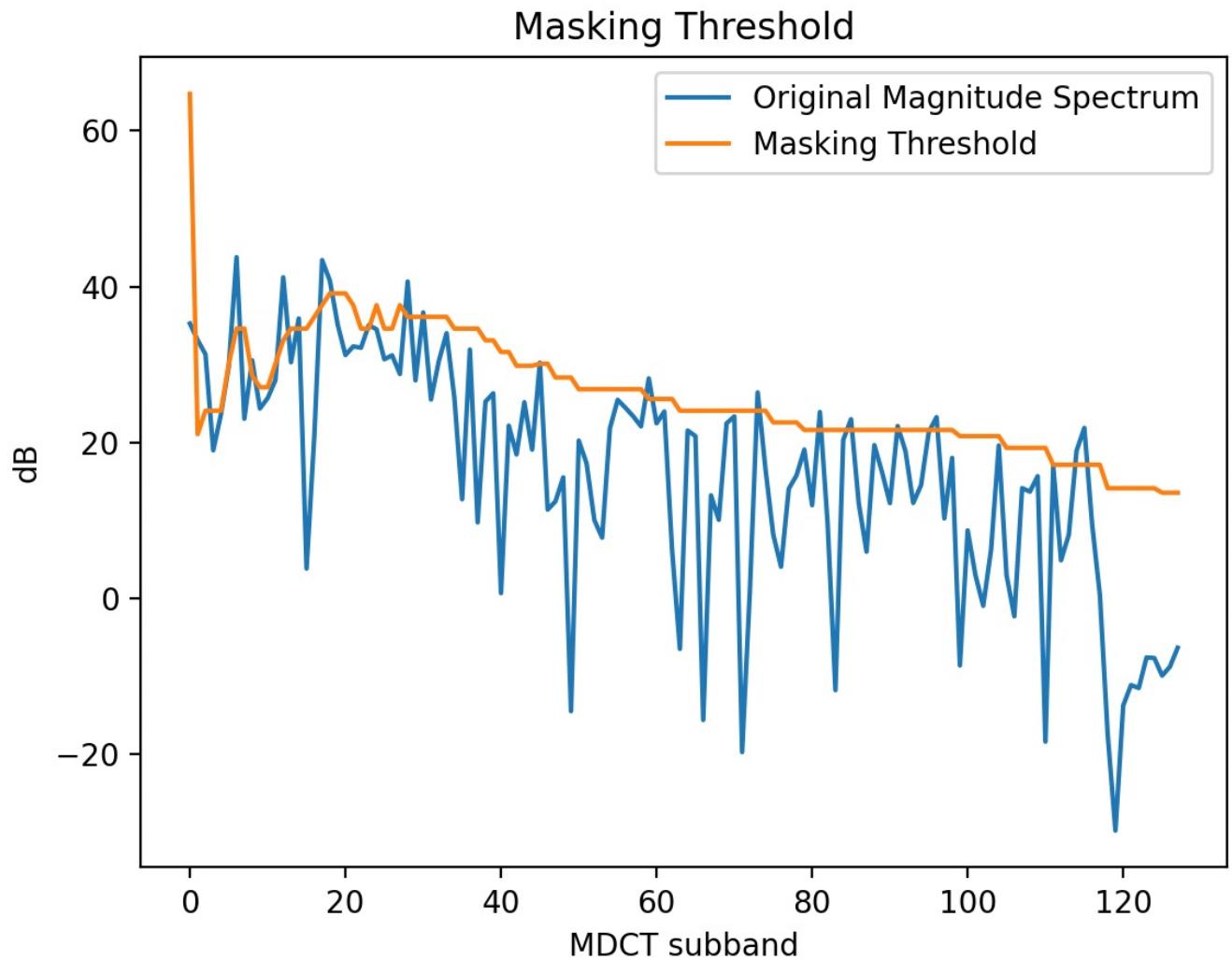
Female Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



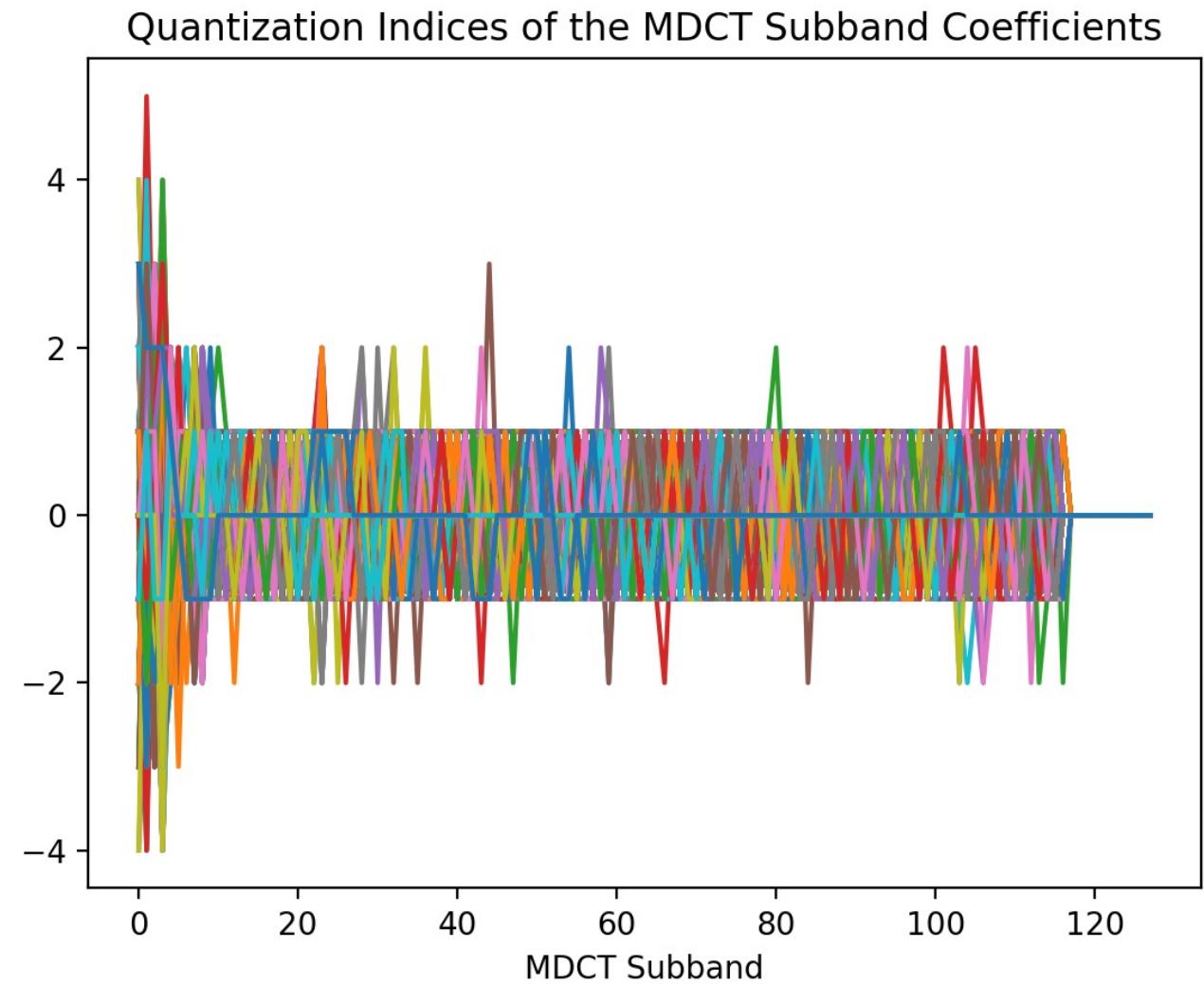
Female Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
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- Observe Quantization Error



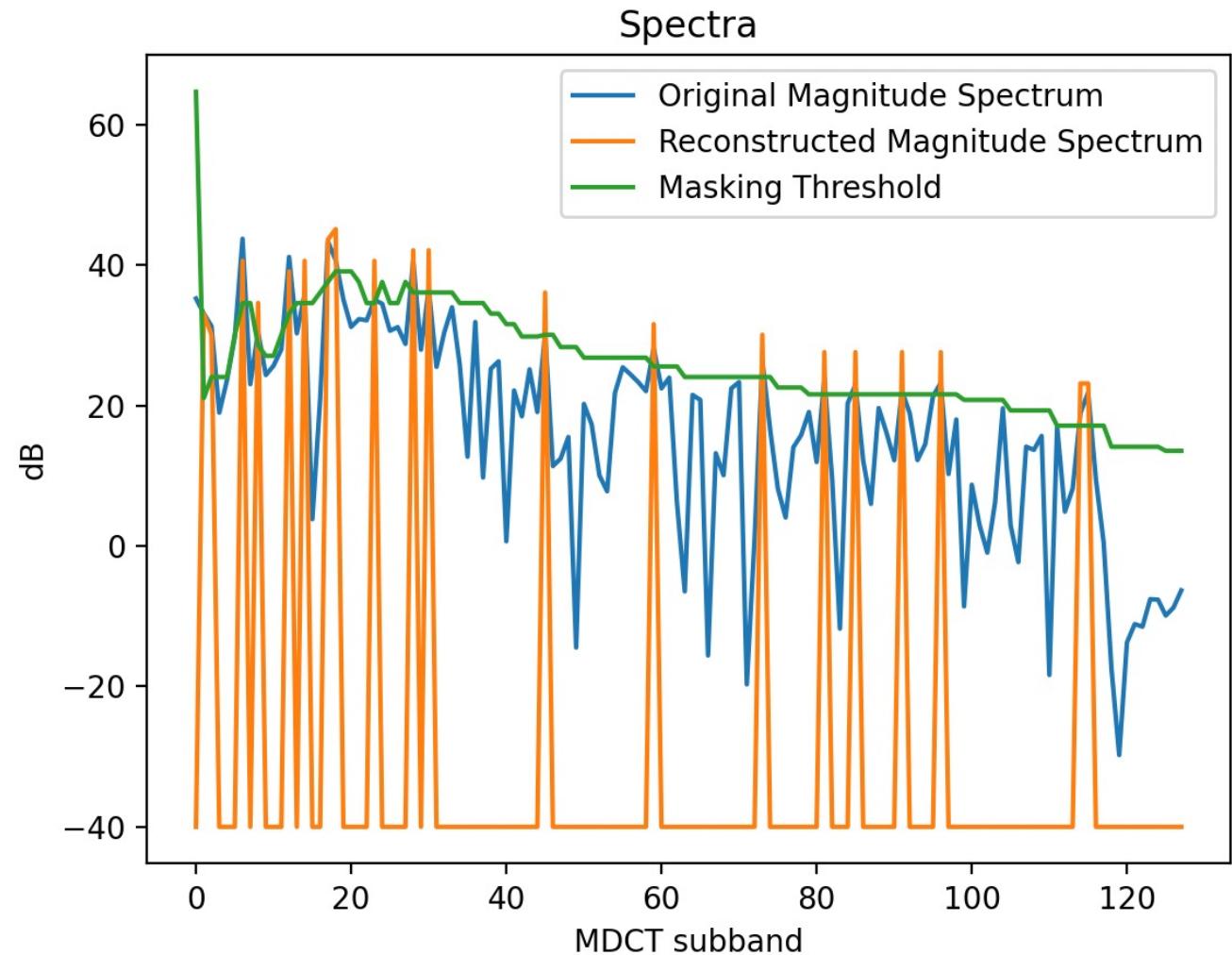
Female Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- **Allocate Quantization Bits**
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



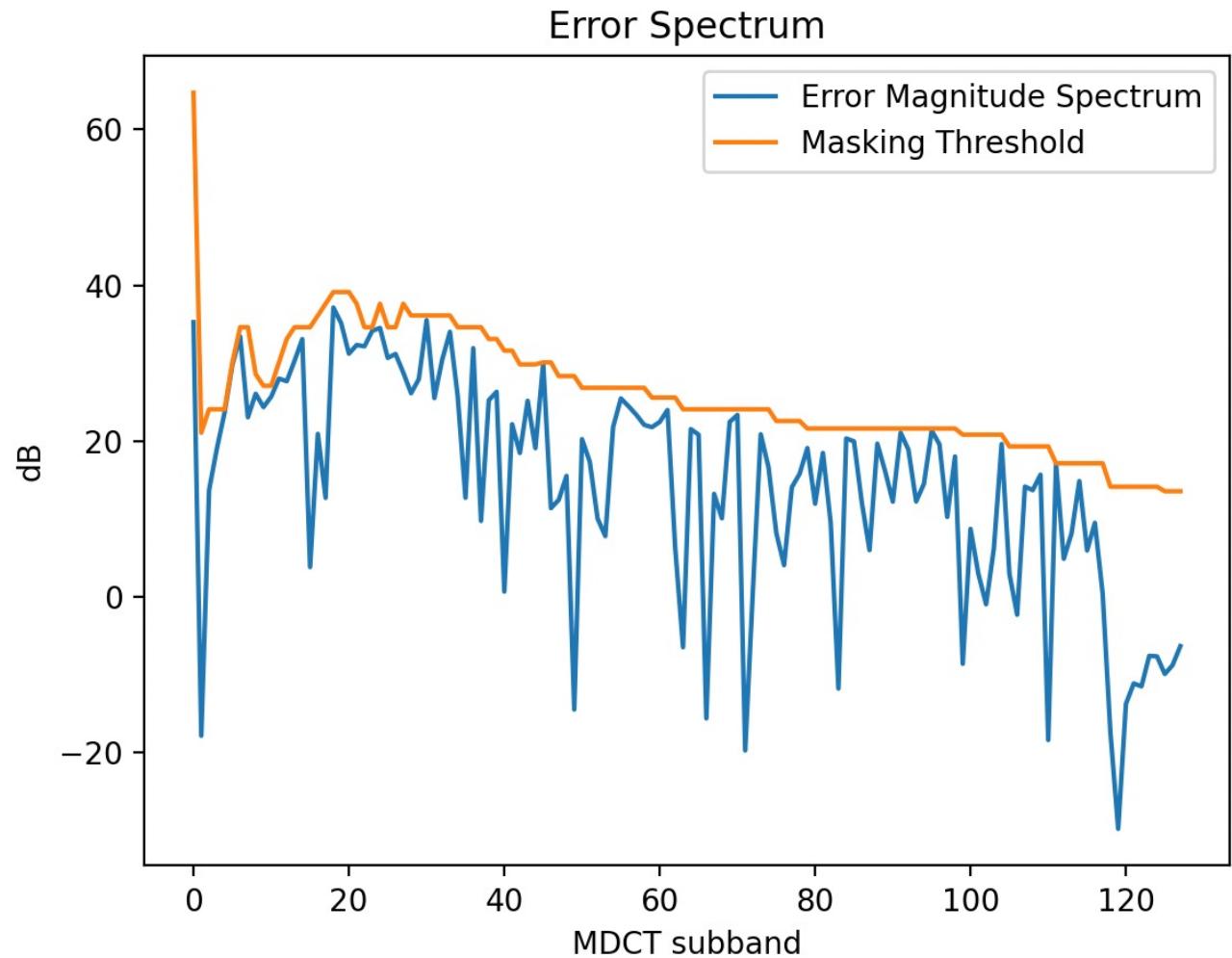
Female Voice Quantization Error

- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and
Observe Reconstruction
- Observe Quantization Error



Female Voice Quantization Error

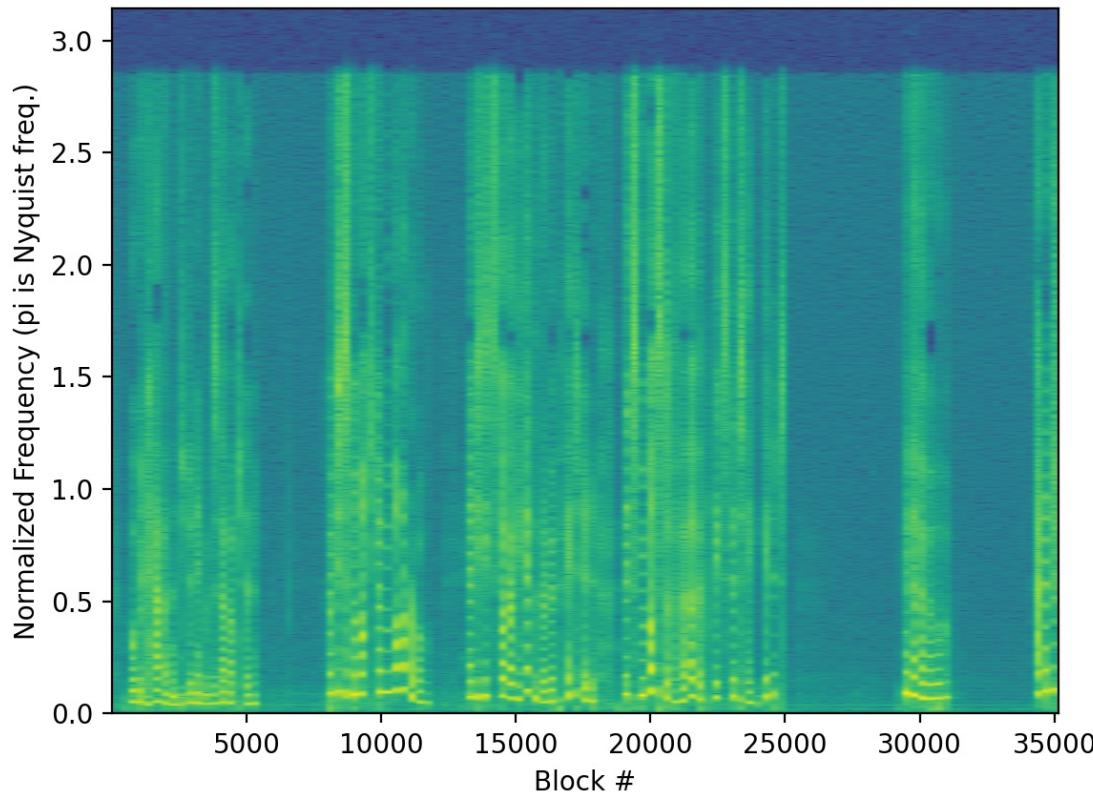
- FFT
- Quantize Bark Coefficients
- Calculate Masking Threshold
- Allocate Quantization Bits
- Apply Huffman Coding and Observe Reconstruction
- **Observe Quantization Error**



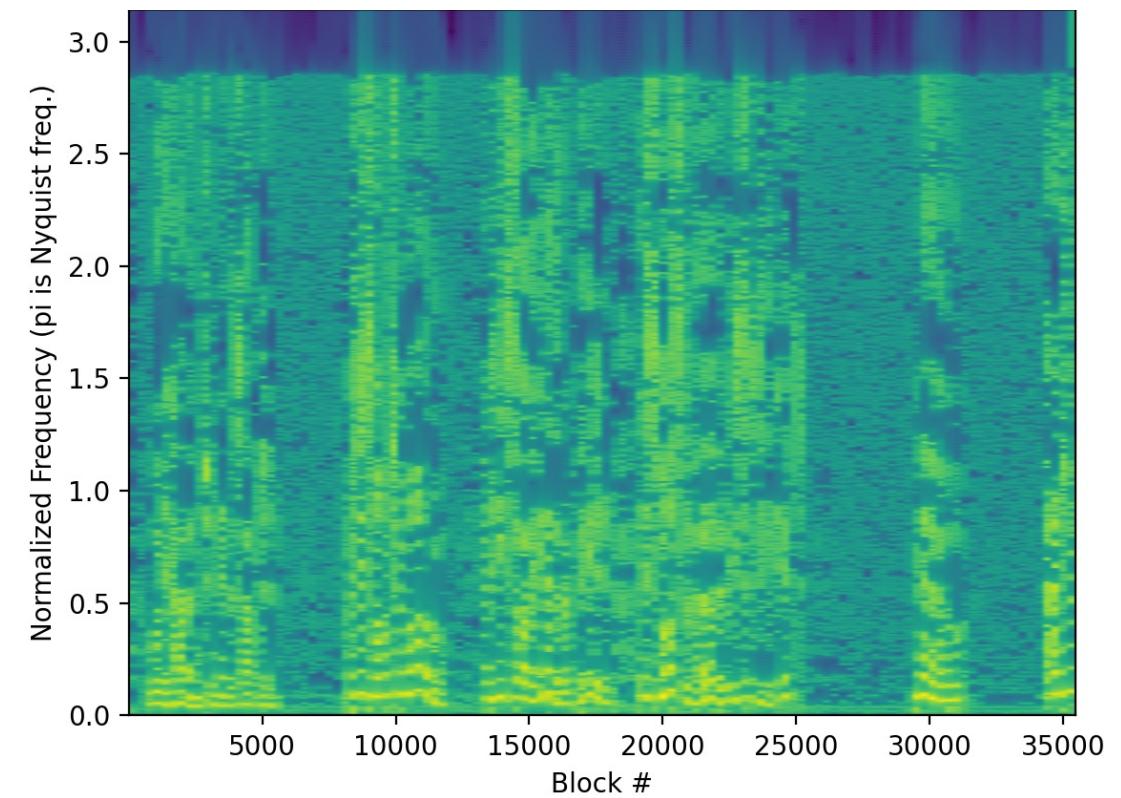
Female Voice Quantization Error

60 Quality, 1024 MDCT Subbands

Original



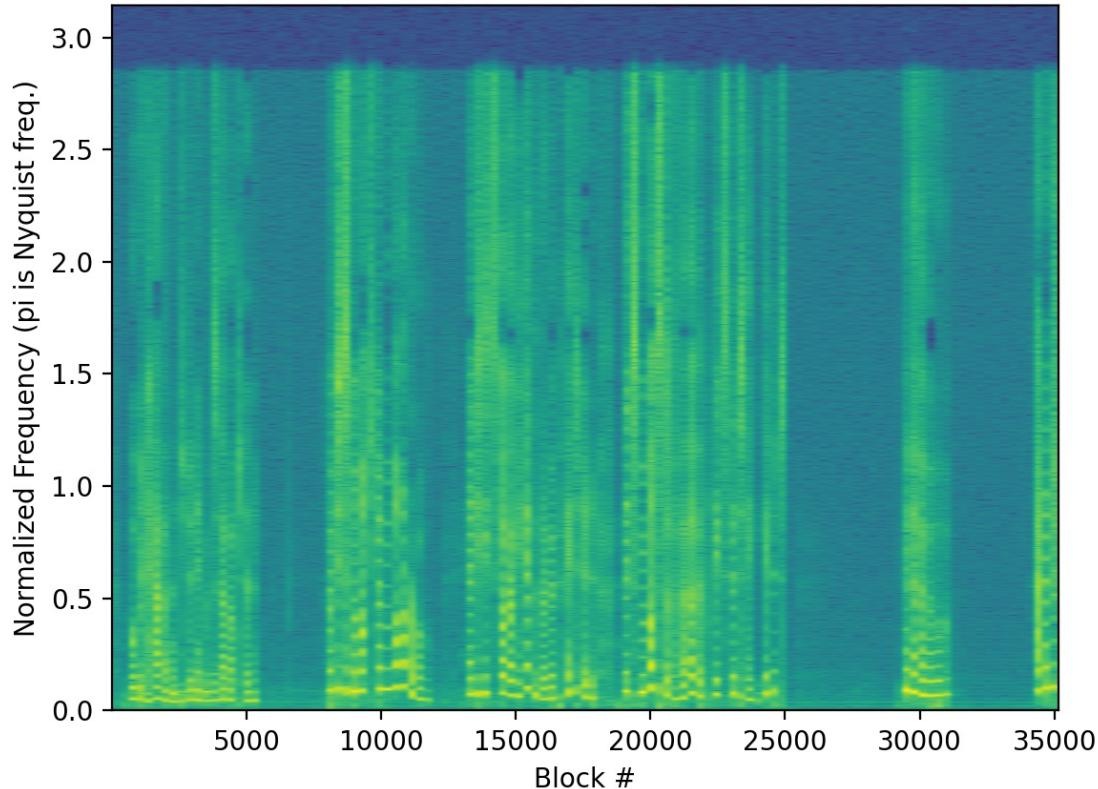
Reconstructed



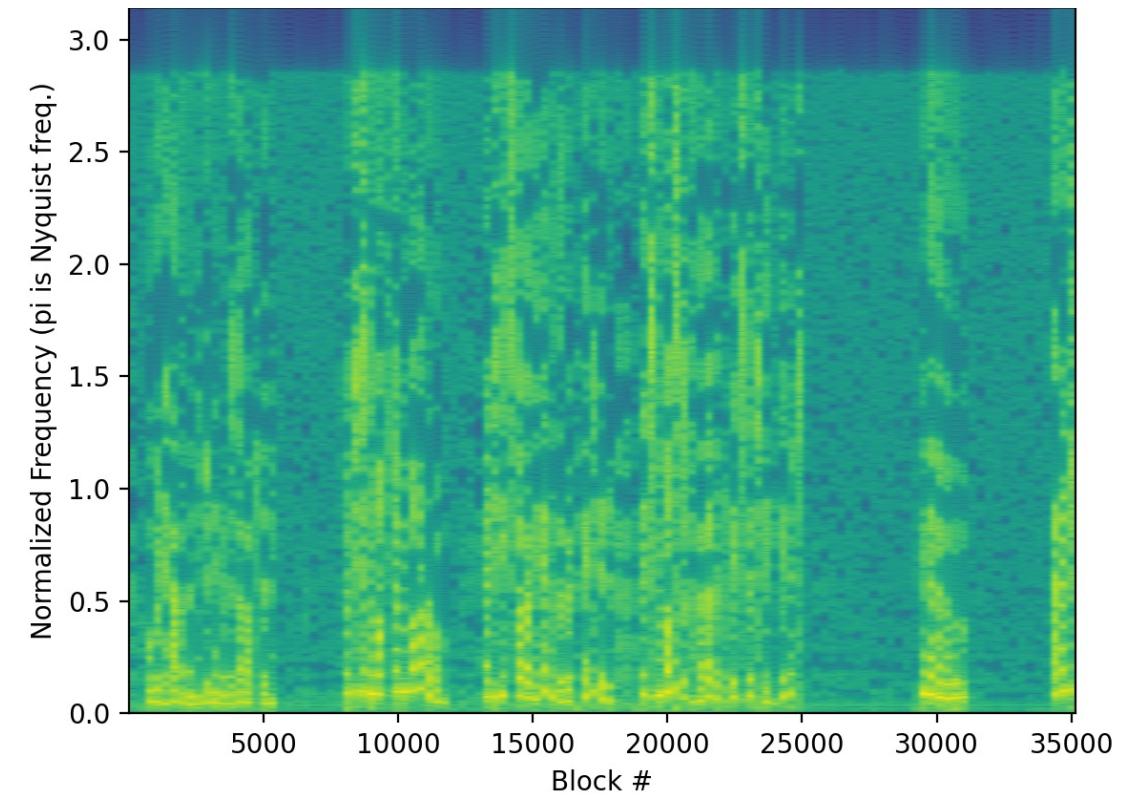
Female Voice Quantization Error

60 Quality, 256 MDCT Subbands

Original



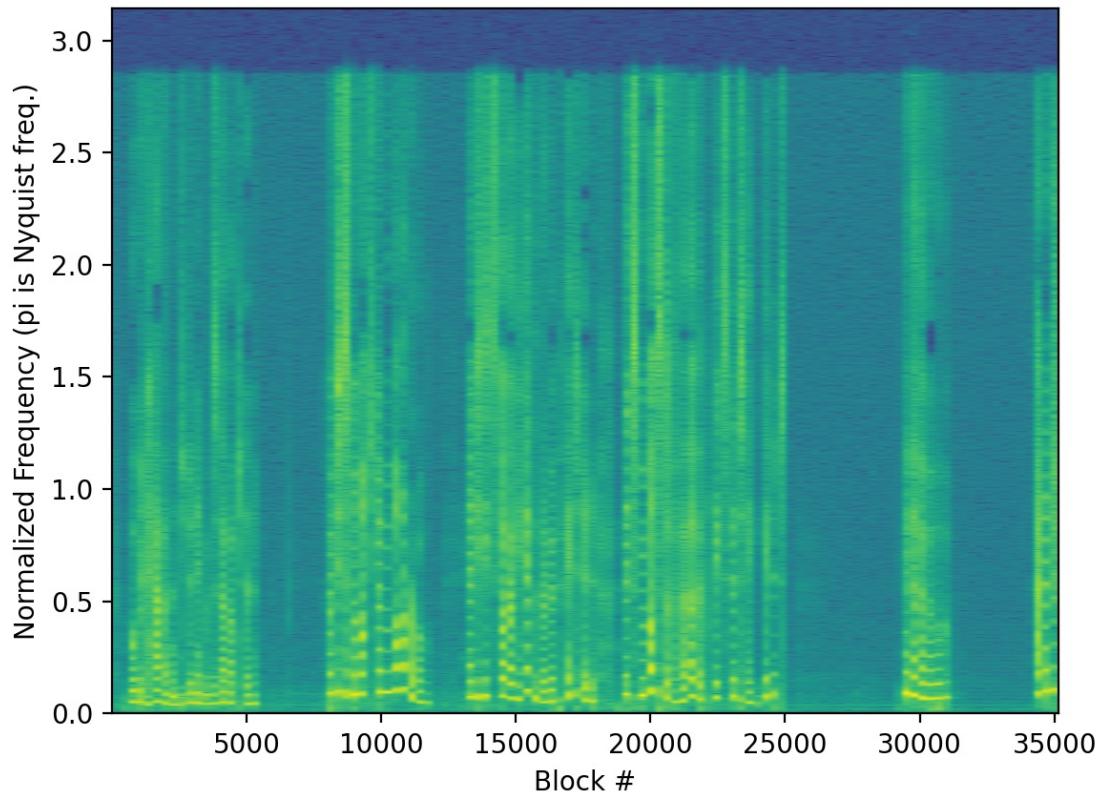
Reconstructed



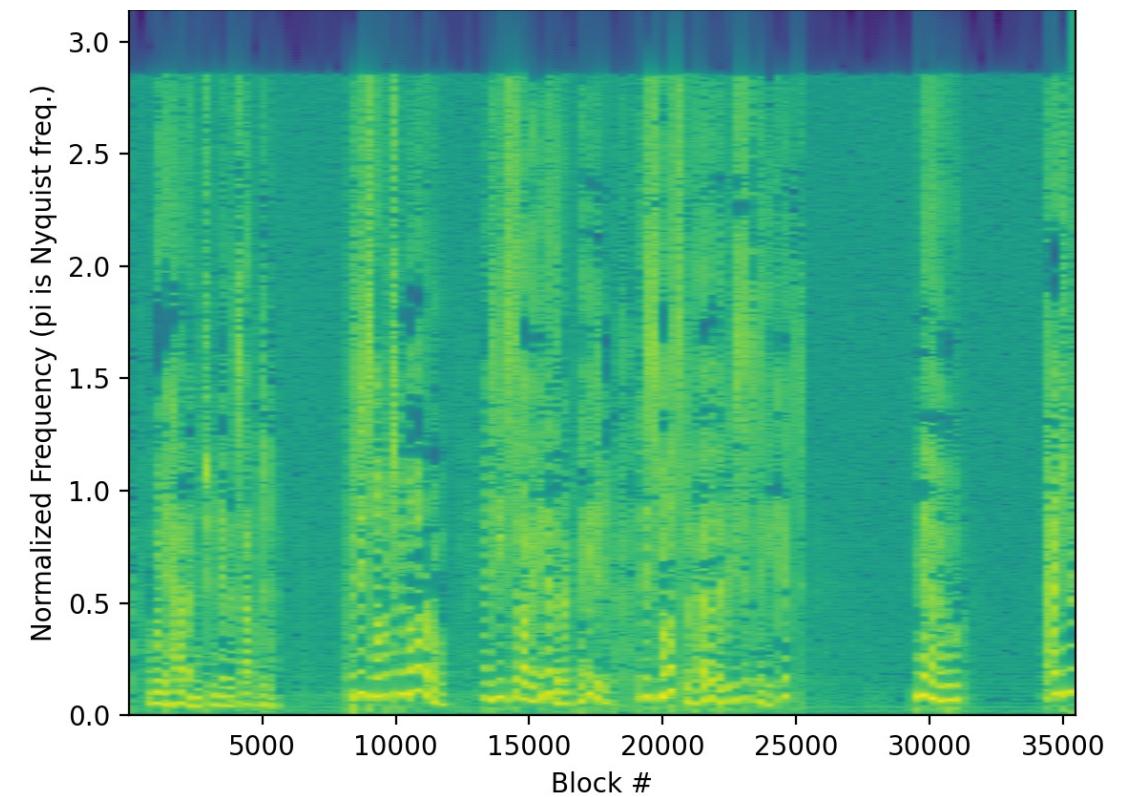
Female Voice Quantization Error

100 Quality, 1024 MDCT Subbands

Original



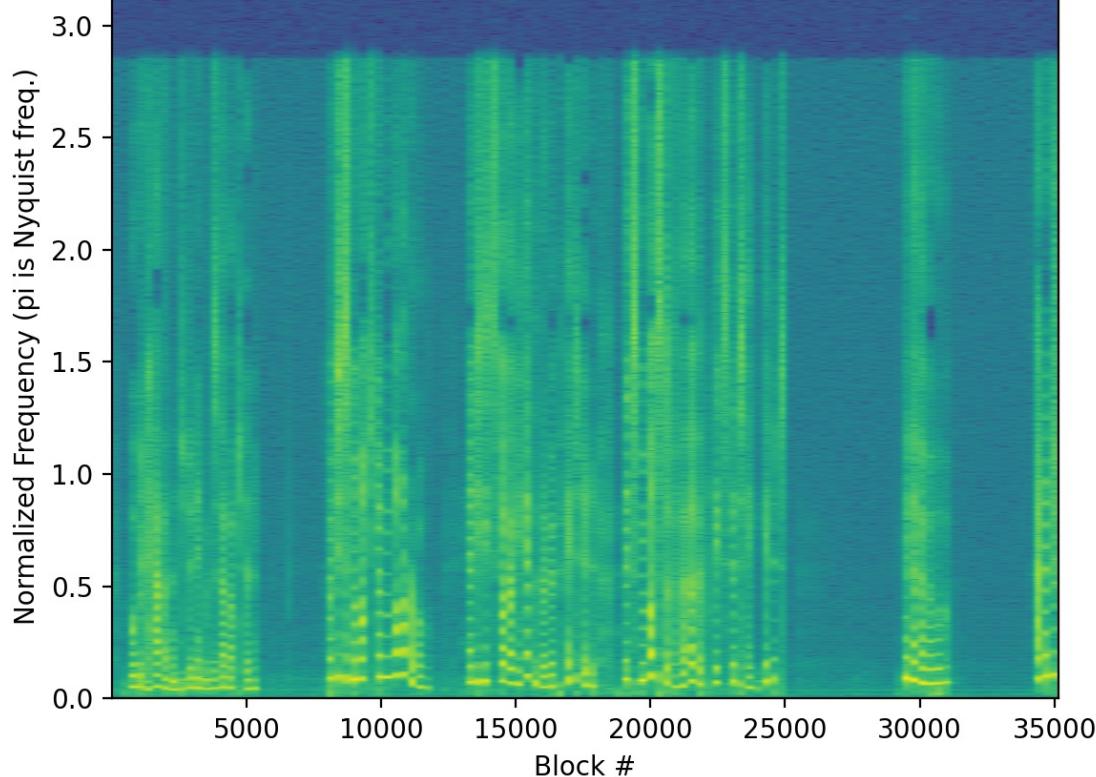
Reconstructed



Female Voice Quantization Error

100 Quality, 256 MDCT Subbands

Original



Reconstructed

