MMI 604 - Audio Signal Processing 3

Project Report

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Date: 9/15/2023

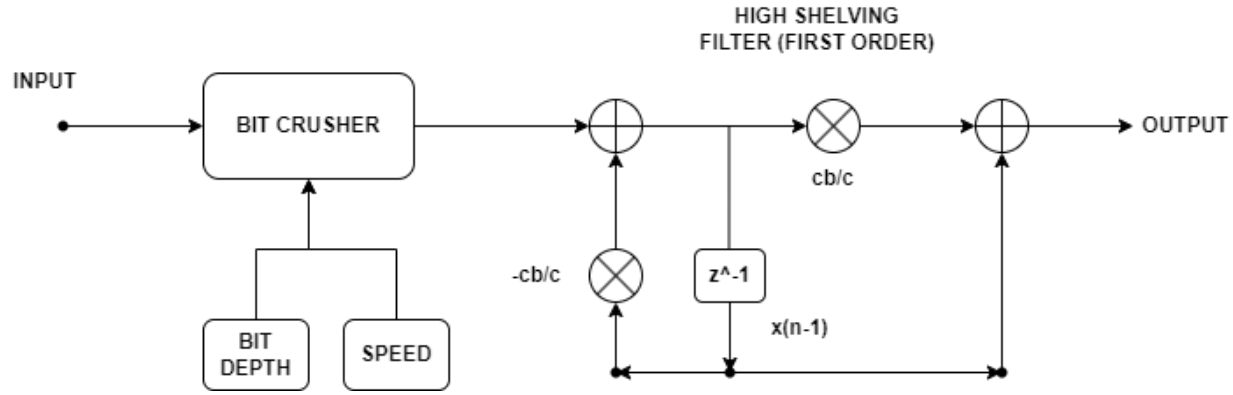
Project Description and Problem Statement: The plugin is a “lo-fi” bitcrusher with a high shelf cutoff and gain control. The motivation behind the plugin comes from a personal preference of the sound of a vintage, noisy or “hissy” low-quality record. Certain genres in music like Lo-Fi hip hop, retro Synthwave, and most recently Mallsoft Vaporwave utilize various techniques of bitcrushing and making low-quality sounding music. Since there is a general abundance of bitcrushers for distortion-specific approaches, this particular project is aimed towards implementing a more “smoothening” bitcrush effect.

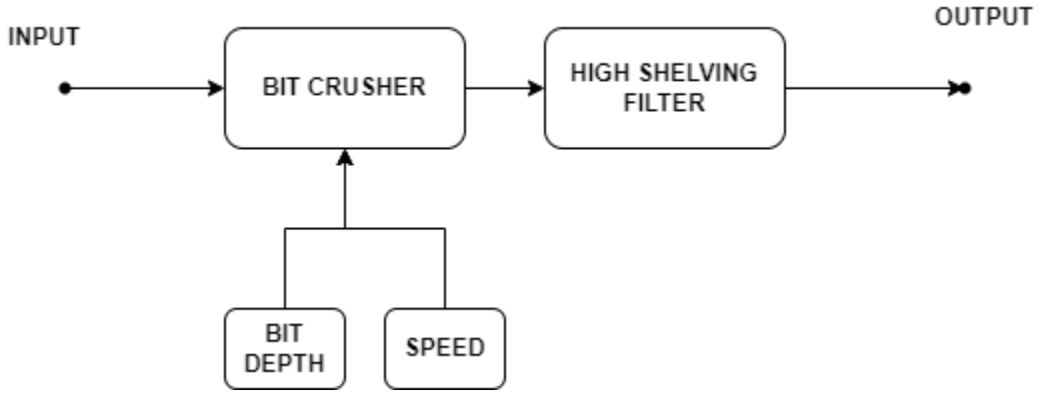
Methodology: Describe the functions you are developing

Bitcrusher function: The function takes in the input, and is basically running it through a quantizer algorithm, reducing the bit depth of the input signal. The desired bit depth is taken from the user, and a step value is calculated for quantization. The higher the bit depth, the finer the quantization and smoother signal. The phasor variable is used to keep track of the current phase position. The phasor is incremented by a normalized frequency or “speed” of the bitcrusher effect. If phasor exceeds or equals 1.0, the phasor is reset back to zero and quantizes the input sample. The quantized value is calculated by rounding the input sample to the nearest multiple of the step size. This rounding operation simulates the bitcrushing effect, reducing the bit depth of the audio signal. The effect simulates a sample and hold behavior commonly found in bitcrusher effects.

High Shelving function: The algorithm for the high shelf function is a first order high shelf filter with one pole and one zero. The filter is designed for either boosting or cutting high frequencies in the input signal. The function takes in the cutoff and gain values, and calculates the coefficients based on these inputs. The sampling rate is also taken into account for the normalized cutoff frequency (2 * pi * input cutoff frequency/sampling rate). Depending on the gain, the coefficient “c” is calculated. The gain is positive for boosting and negative for cutting.

Block Diagram: The flow of this effect is as follows.





MATLAB Test Results: For the plots, the following values were choses, unless mentioned otherwise in the plot:

Bit Depth = 8

Speed (normalized frequency) = 1

High Shelf Cutoff = 15000;

High Shelf Gain = 0;

1. **Direc Delta**

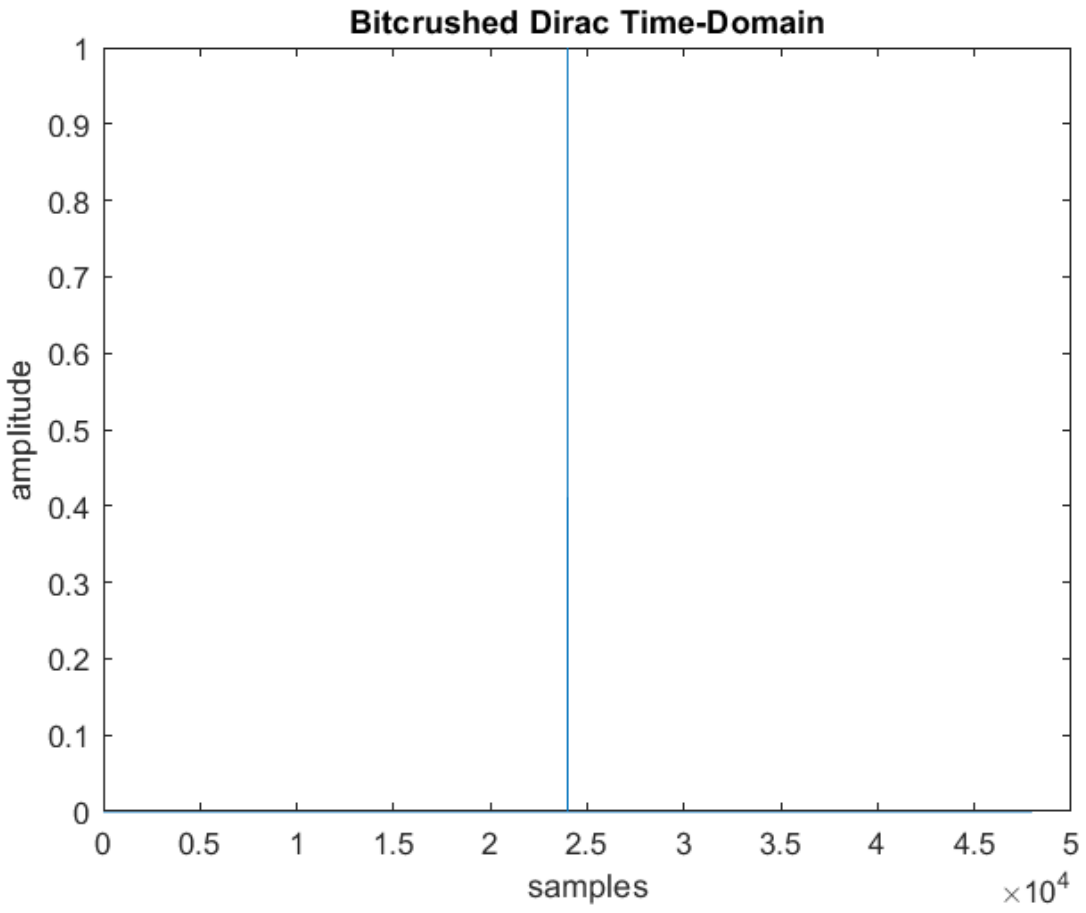


Fig.1(a) Direc Delta Time Domain.

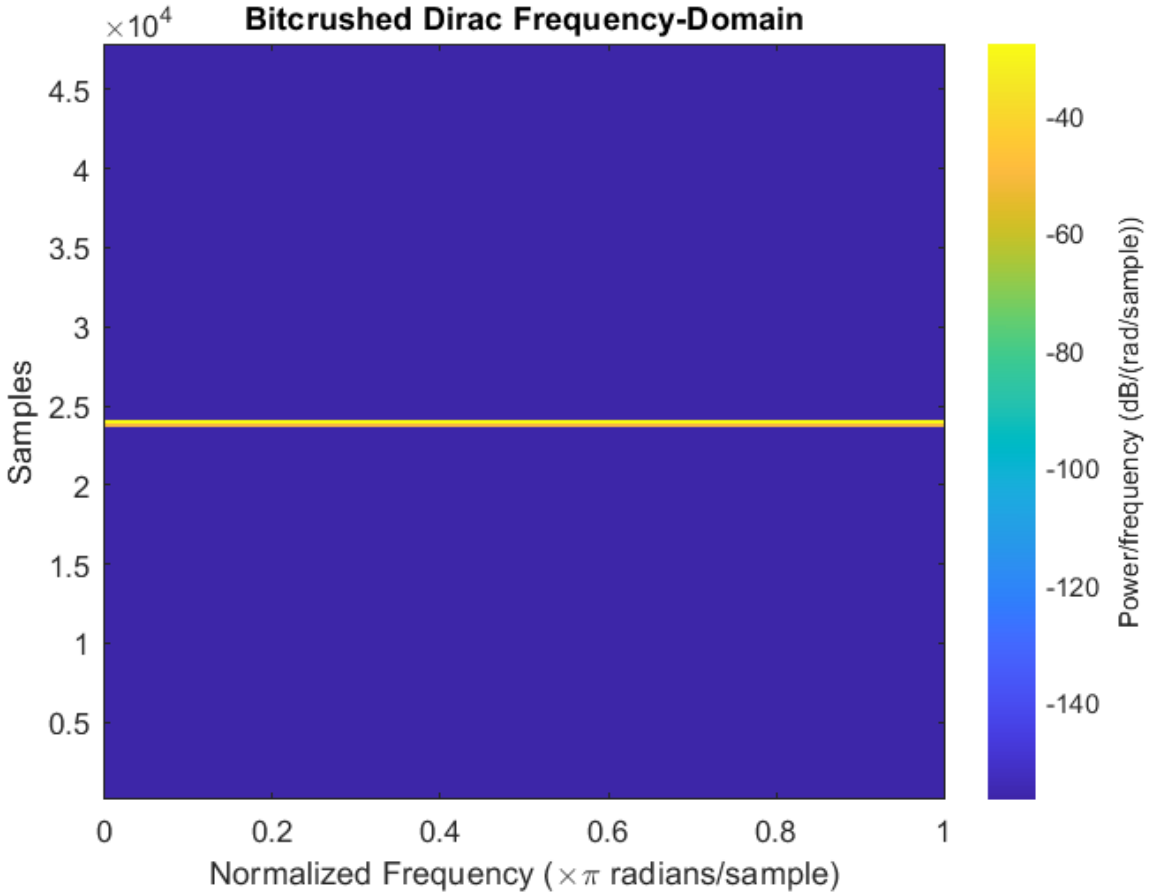


Fig. 1(b) Direc Delta Spectrogram

2. Sine Sweep

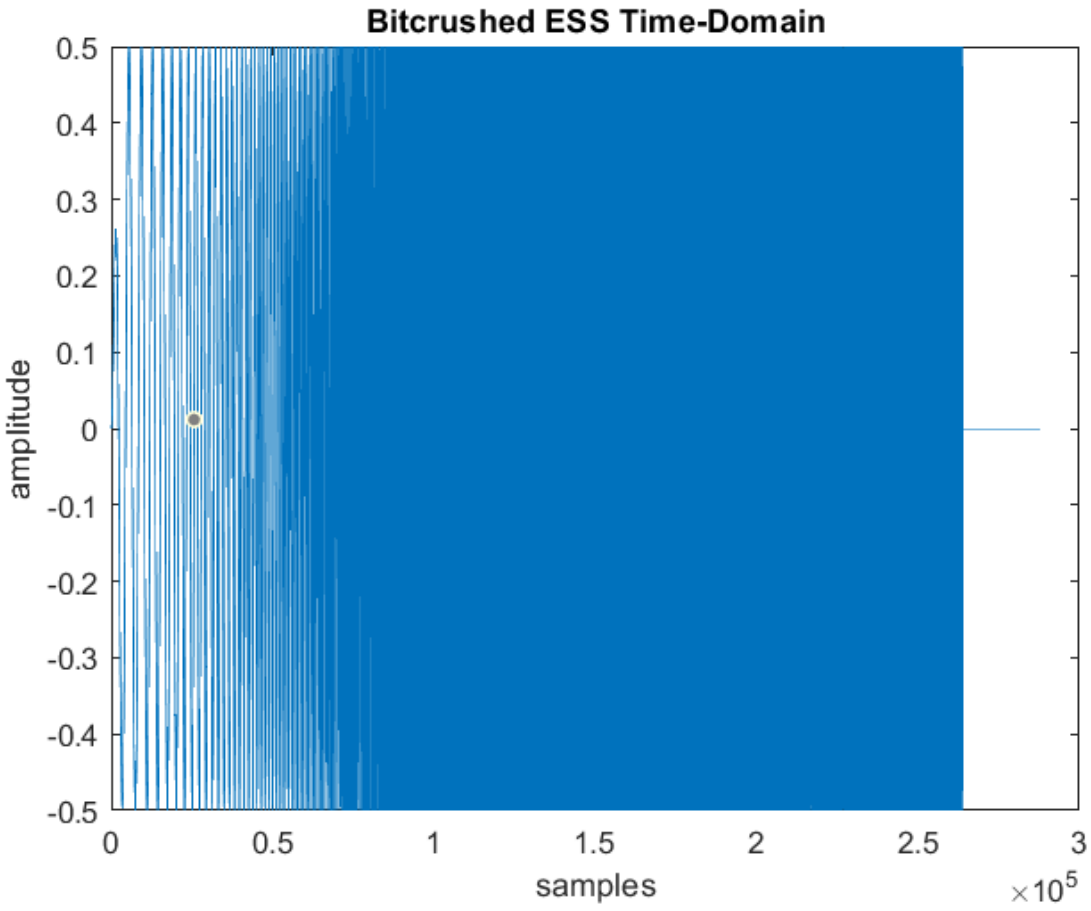


Fig. 2(a)

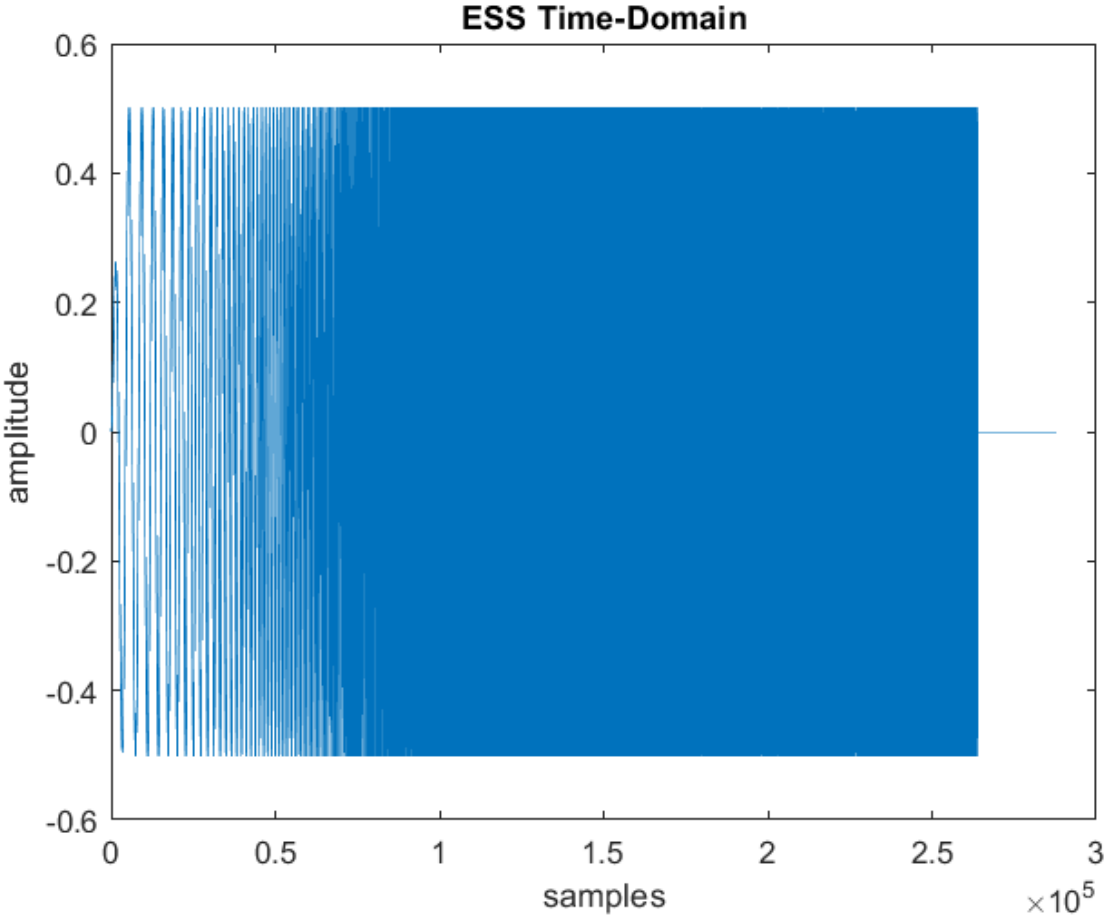

ESS Time-Domain
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
amplitude
0
0.5
1
1.5
2
2.5
3
samples
×10^5

Fig. 2(b)

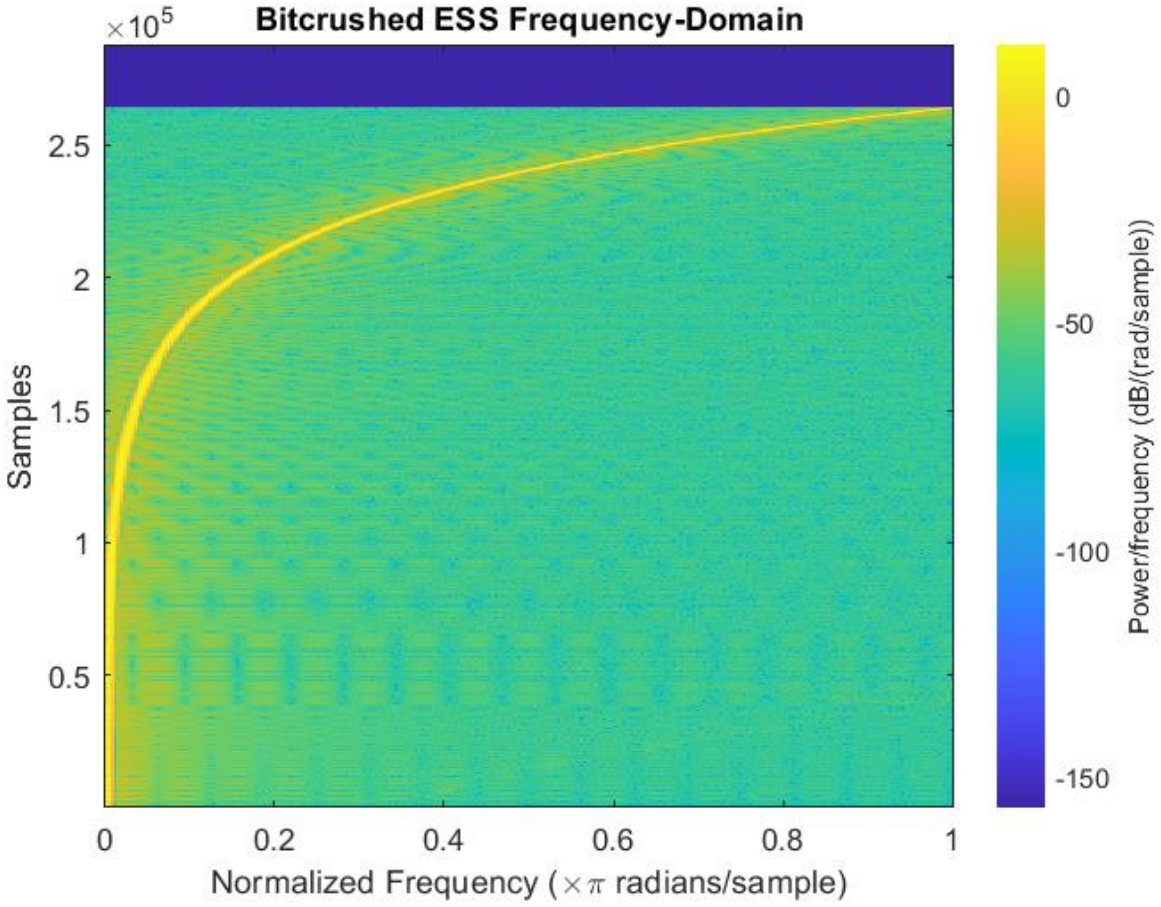

Bitcrushed ESS Frequency-Domain
×10^5
Samples
2.5
2
1.5
1
0.5
0
0.2
0.4
0.6
0.8
1
Normalized Frequency (×π radians/sample)
0
-50
-100
-150
Power/frequency (dB/(rad/sample))

Fig. 2(c)

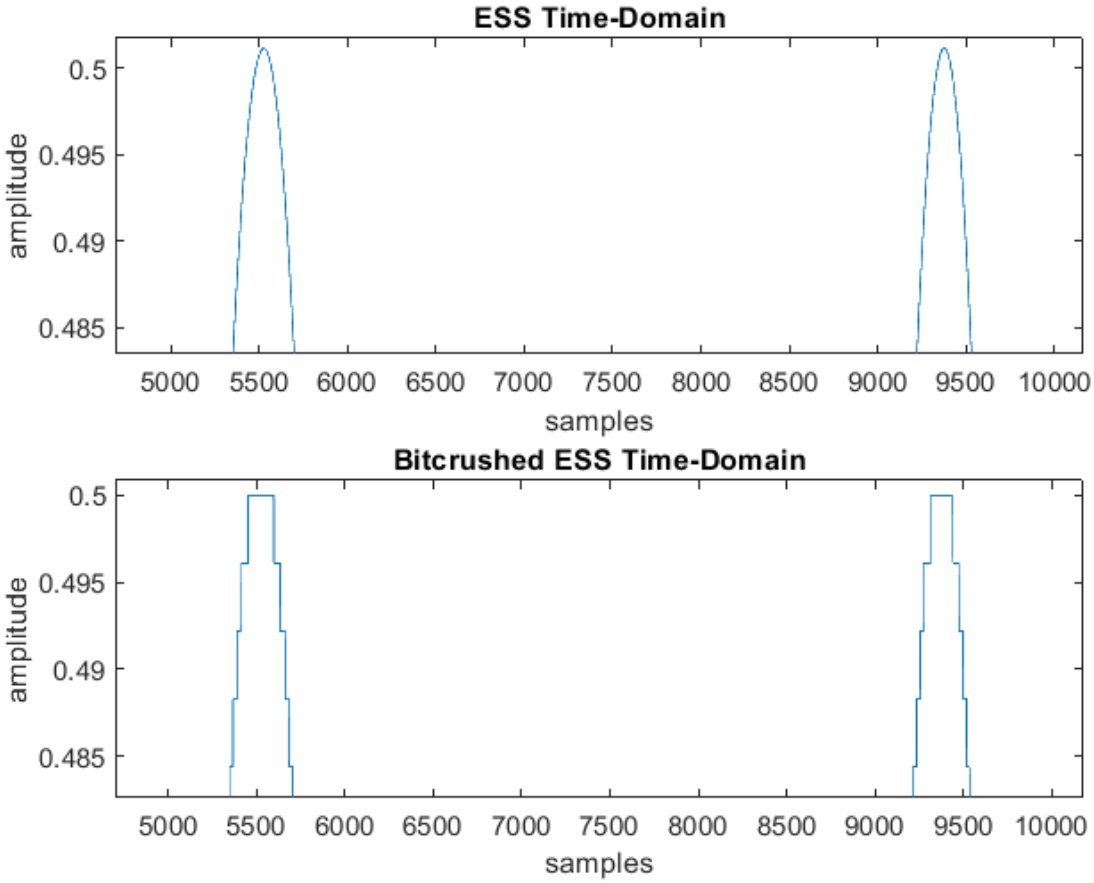

ESS Time-Domain
amplitude
0.5
0.495
0.49
0.485
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
samples
Bitcrushed ESS Time-Domain
amplitude
0.5
0.495
0.49
0.485
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
samples

Fig. 2(d)

3. Pink Noise

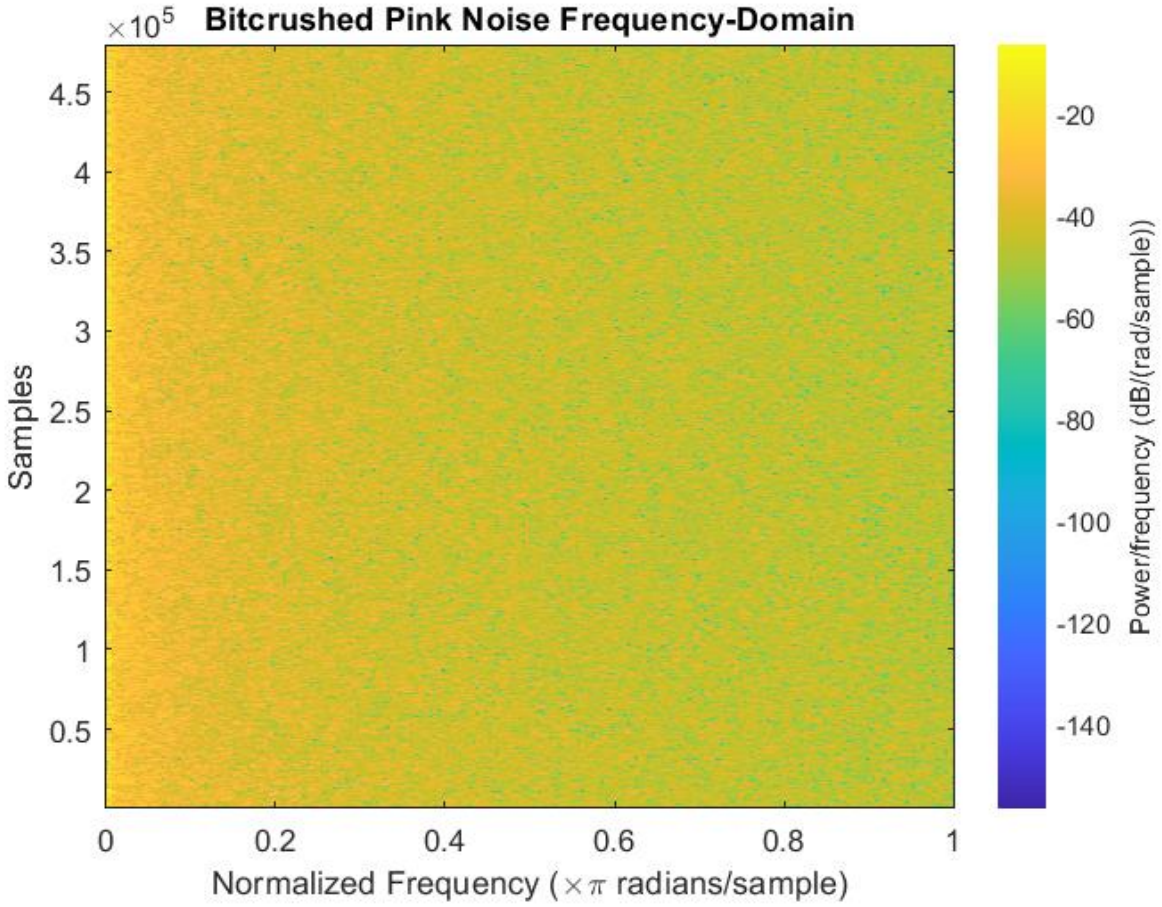


Fig. 3 (a)

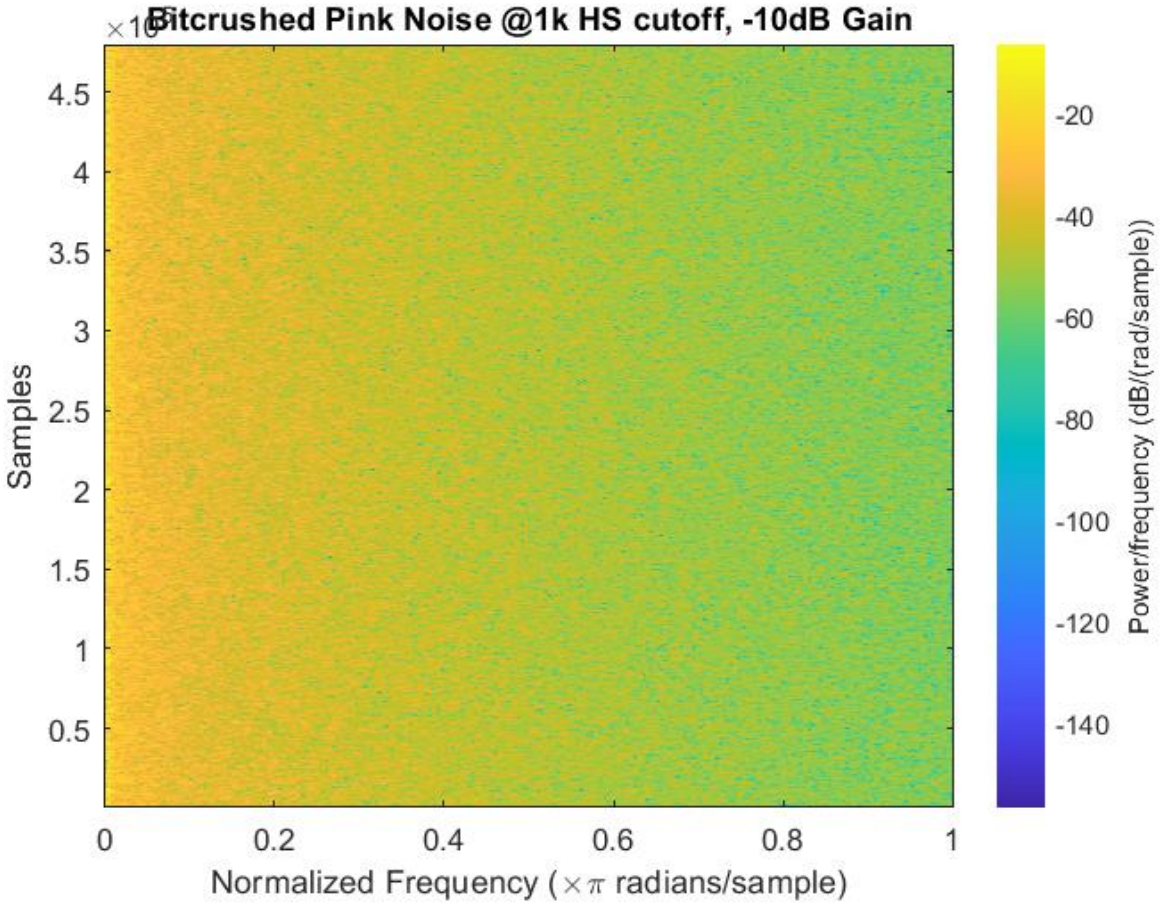

Bitcrushed Pink Noise @1k HS cutoff, -10dB Gain
×10^5
Samples
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.2
0.4
0.6
0.8
1
Normalized Frequency (×π radians/sample)
-20
-40
-60
-80
-100
-120
-140
Power/frequency (dB/(rad/sample))

Fig. 3 (b)

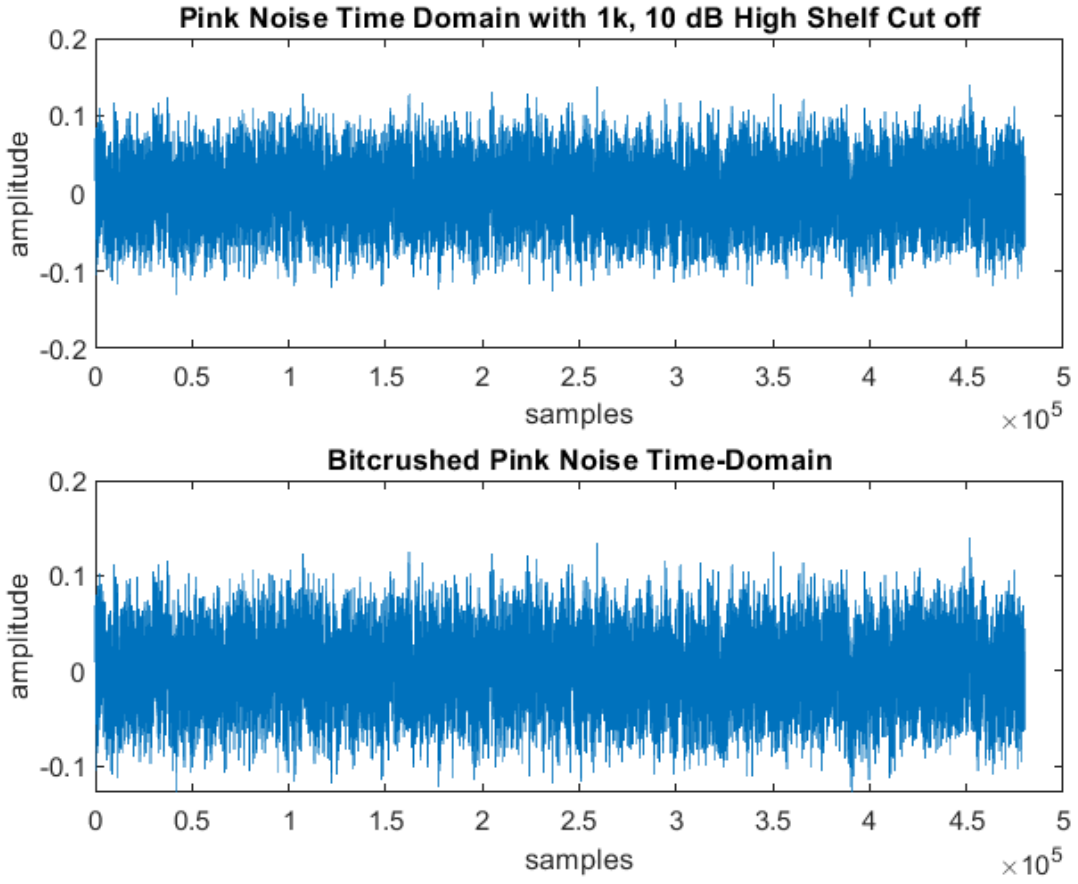
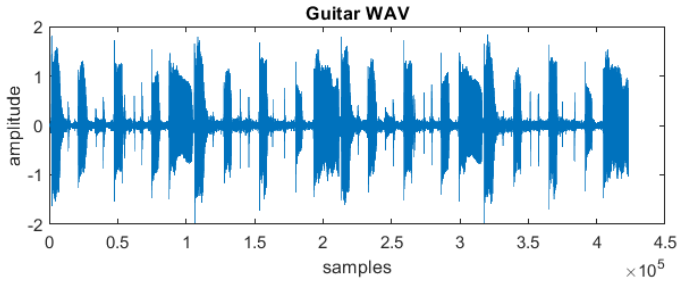
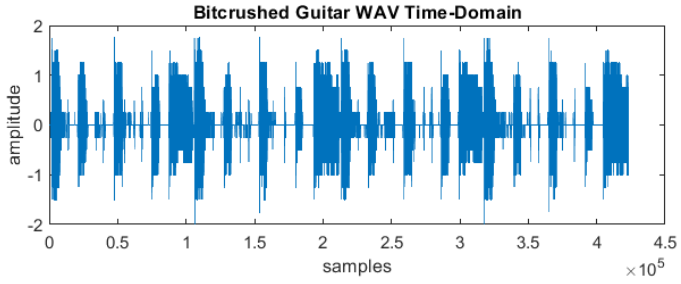
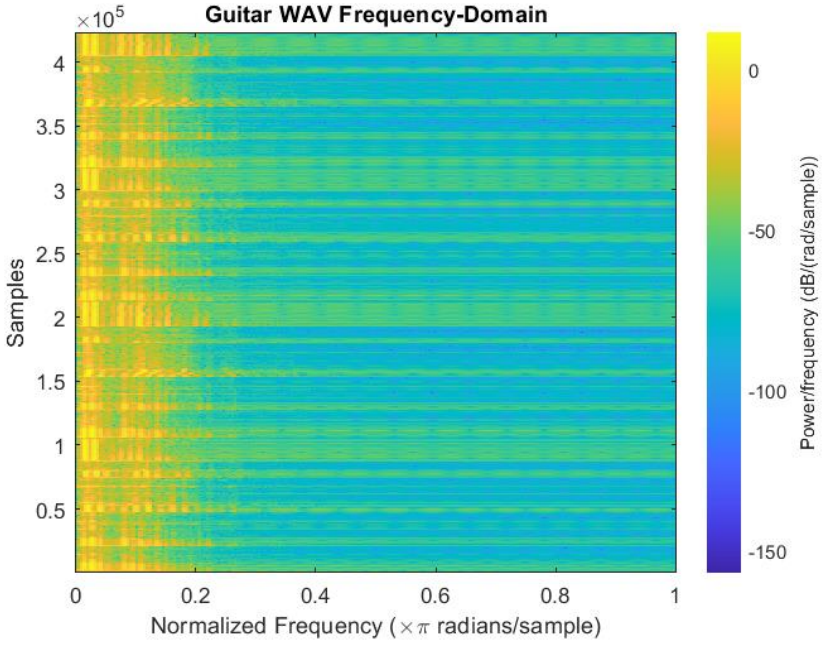

Pink Noise Time Domain with 1k, 10 dB High Shelf Cut off
amplitude
0.2
0.1
0
-0.1
-0.2
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
samples
×10^5
Bitcrushed Pink Noise Time-Domain
amplitude
0.2
0.1
0
-0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
samples
×10^5

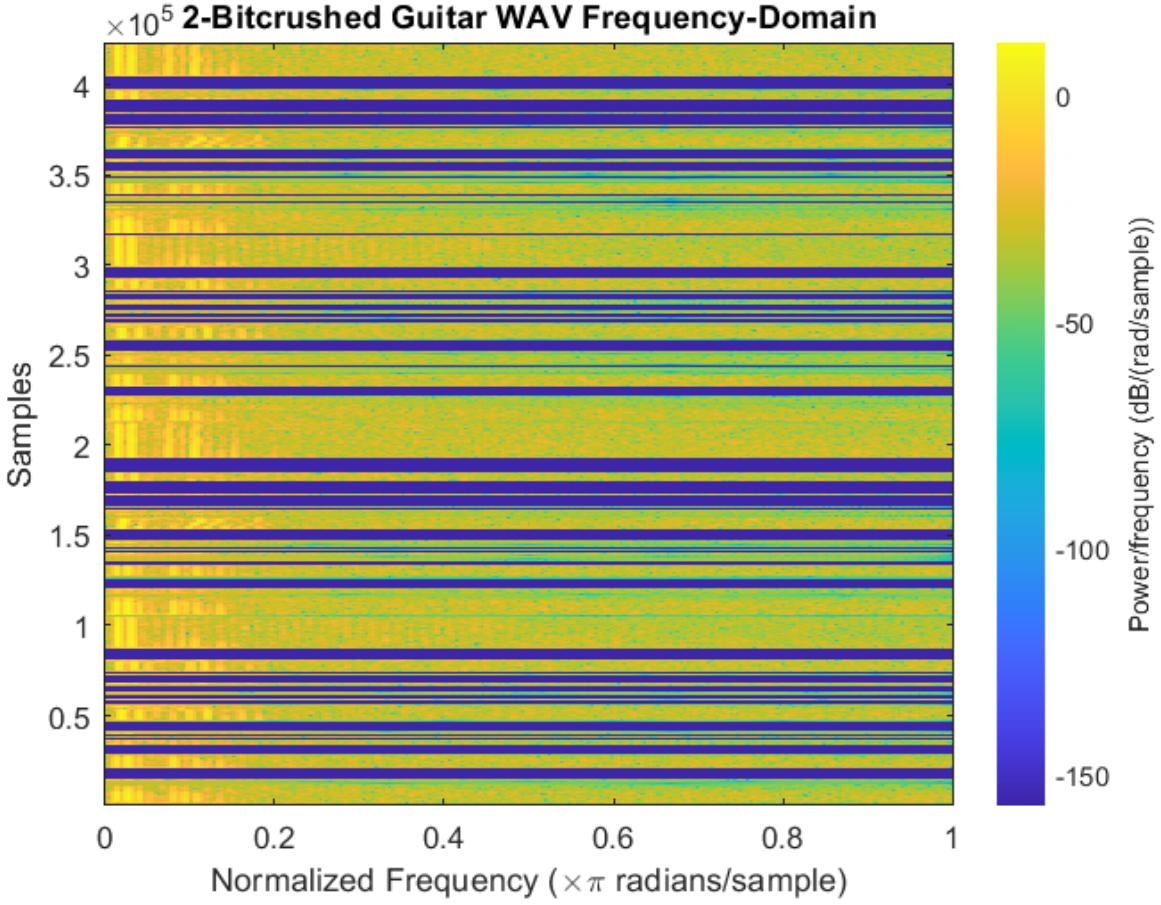
Fig. 3(c)

4. Guitar Track

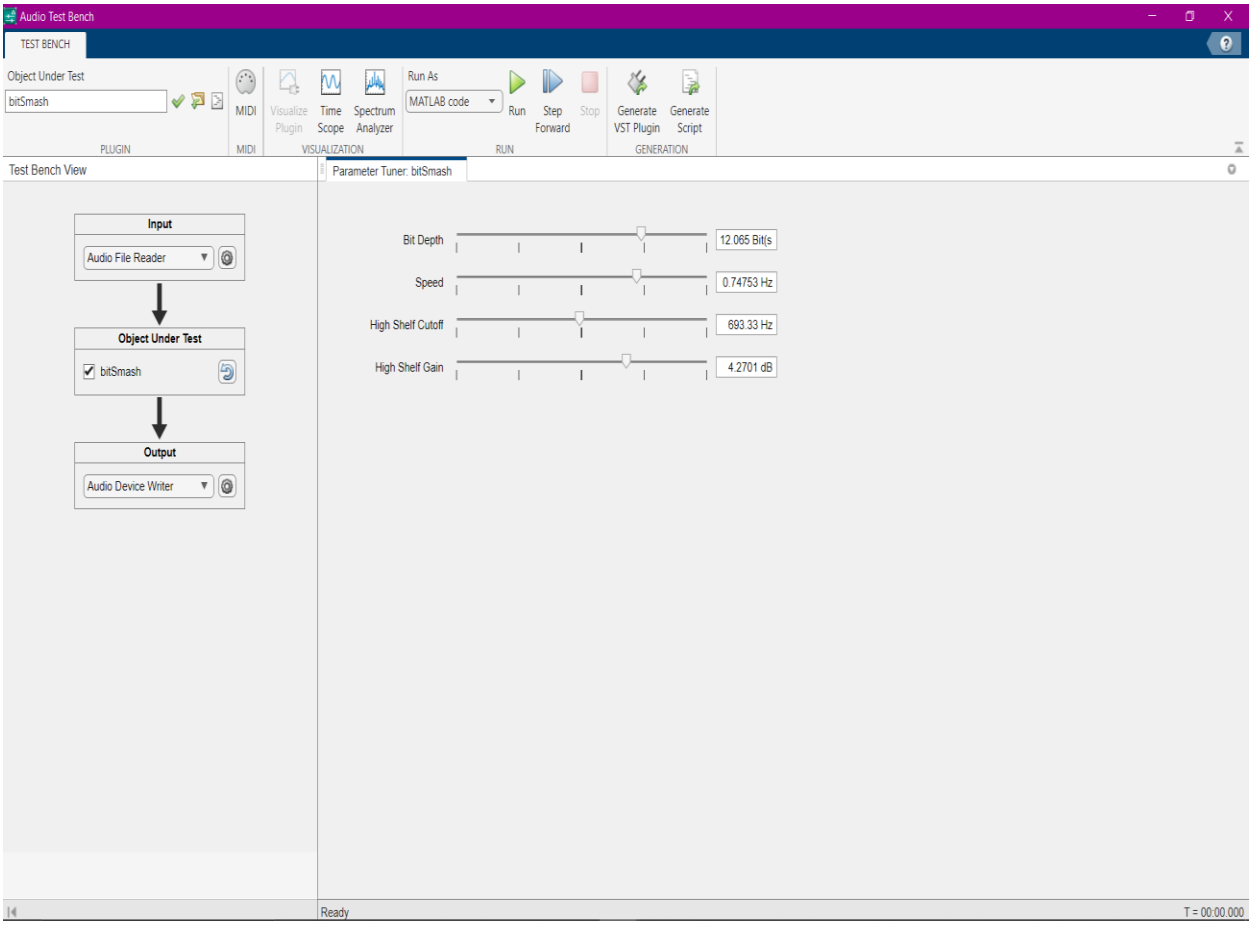






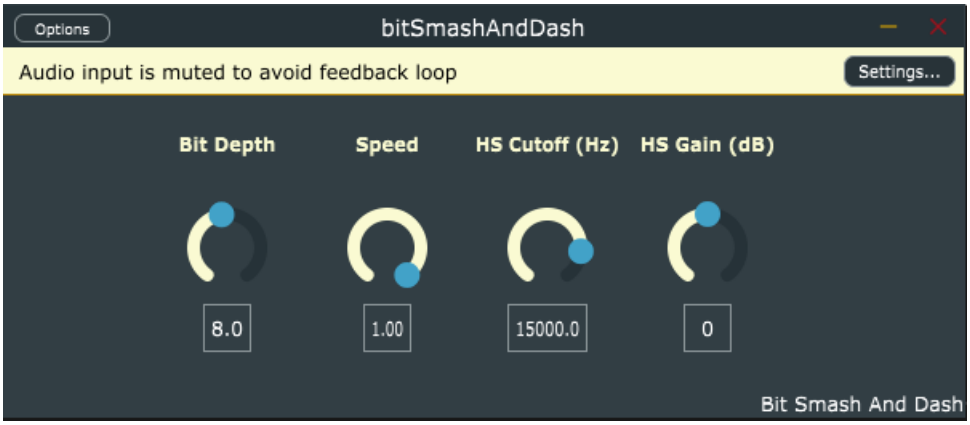

2-Bitcrushed Guitar WAV Frequency-Domain
×10^5
Samples
4
3.5
3
2.5
2
1.5
1
0.5
0
0.2
0.4
0.6
0.8
1
Normalized Frequency (×π radians/sample)
0
-50
-100
-150
Power/frequency (dB/(rad/sample))

5. Audio Test Bench



The plugin worked as intended in the MATLAB Audio Test Bench.

JUCE UI Mapping Diagram: Insert a screenshot of your JUCE plugin and show how the controls map to the algorithms.



The Bit Depth parameter is mapped to the “step” equation.

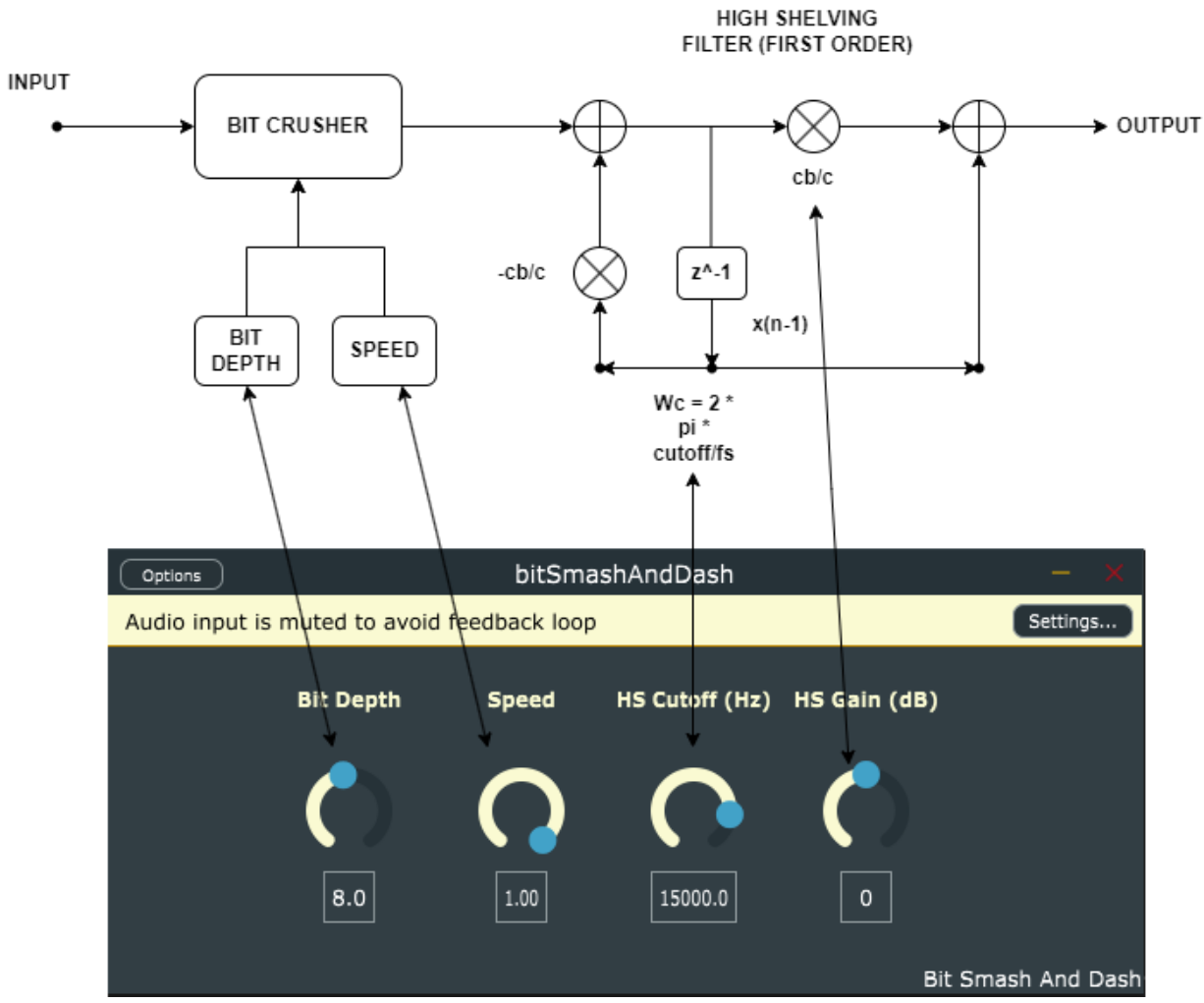
Step = ½^(bitDepth).

The speed parameter is mapped to the phasor math: phasor += speed (normalized frequency).

The phasor is updated every sample, it determines the speed of quantization.

The high shelf cutoff and gain is mapped to the co-efficients Wc and V0 respectively.

Wc is the normalized cutoff frequency (2 * pi * cutoff/sampling rate), and V0 is calculated as follows: V0 = 10^(Gain/20).


HIGH SHELVING
FILTER (FIRST ORDER)
INPUT
BIT CRUSHER
OUTPUT
cb/c
-cb/c
z^-1
x(n-1)
BIT
DEPTH
SPEED
Wc = 2 *
pi *
cutoff/fs
Options
bitSmashAndDash
Audio input is muted to avoid feedback loop
Settings...
Bit Depth
Speed
HS Cutoff (Hz)
HS Gain (dB)
8.0
1.00
15000.0
0
Bit Smash And Dash

Discussion: A bitcrusher is useful in a lot more creative sense of way. By taking away bits, there is noise induced into the signal. This kind of effect has a warm, fuzzy sound to it and is used in a lot of creative ways in music and visual media. To sometimes replicate an old sounding vinyl record or the hiss from 80's recording cassettes, a bitcrusher is a good option. Apart from downgrading the "qualtiy" of audio, bitcrushers are also used as distortion. Since the noise floor increases with decrease in bit depth, there is also a gain introduced in the signal. This gives way to a separate use case for bitcrushers as distortion plugins.

The high shelf filter is used to quell the excess high frequencies during bit crushing. The filter can provide that "warm" sounding low pass effect by not exactly being a hard low pass filter.

This plugin can be tweaked in multiple ways to provide a "lo-fi" sounding effect, or maybe perhaps a distorted and unorthodox clipping sound effect. By providing control on the high shelf filter (cutoff and gain), the user has more creative ways to utilize the plugin as the bitcrushing effect is induced.