Ruslan Shakirov, B17-SE-01
B170425

Assignment 6

Task 1

The Task

The task was to implement our own clipping filter.

Implementation

The clipping filter function is simple:

$$clip(x) = \begin{cases} x & \text{if } |x| < \alpha \\ \alpha \cdot sign(x) & \text{else} \end{cases}$$

Implementation is quite straightforward and can be written in one line:

```
y = min(abs(x), a) .* sign(x);
```

It selects the minimal value between absolute source value and α and multiplies it by the source sign. The original signal is shown on Figure 1a and the result with parameter $\alpha = 0.3$ is shown on Figure 1b.

Task 2

The Task

The task was to implement the our own distortion filter.

Implementation

The distortion filter is also very simple:

$$distortion(x) = \alpha \cdot \mathrm{atan}(\beta \cdot x)$$

So the implementation was obvious:

```
y = atan(x * b) * a;
```

We just apply the formula. It makes some kind of "soft clipping". The result with parameters $\alpha = 1$ and $\beta = 20$ is shown on Figure 1c. I did not want to change the amplitude so I left the α at 1.

Task 3

The Task

The task was to observe and compare the effects of the filters in the temporal and spectral domains.

We can see that clean signal has some peaks and silences on the temporal domain - the way the artist plays the guitar. On the spectral domain (Figure 2a) we can see that the guitar produces many frequencies from 1 Hz to about 17 kHz.

The clipped to 0.3 signal looks less dynamic and live. It introduces some noise in the audio and we can notice that amplitude after 17 kHz has increased and now it become more difficult to distinguish that spectral fall (see Figure 2b).

The distorted signal looks and sounds thicker. Due to the high parameter ($\beta = 20$) it becomes much harder to recognize the frequencies of the original audio record (see Figure 2c).

Bonus Task

Non-linearity of clipping function

Let's observe the homogeneity of clipping function:

$$clip(kx) = \begin{cases} x & \text{if } |kx| < \alpha \\ \alpha \cdot sign(kx) & \text{else} \end{cases}$$

In both cases homogeneity breaks as:

1. $|kx| \neq k \cdot |x|$ if $k < 0$.
2. The $sign(x)$ function is not liear itself.

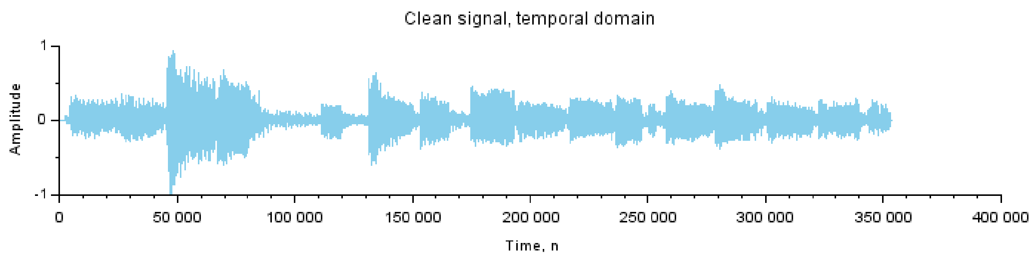
Non-linearity of distortion function

Let's observe the homogeneity of distortion function:

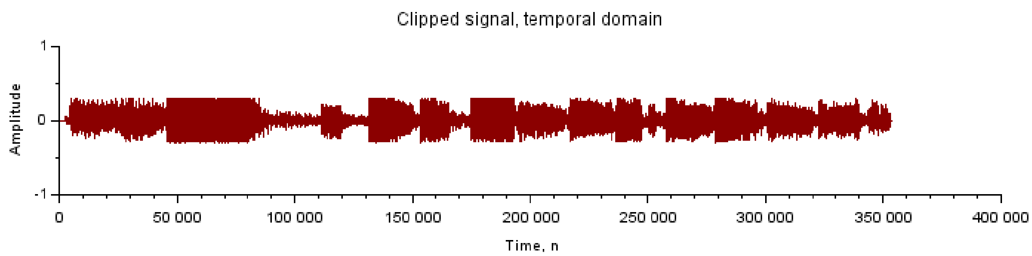
$$dist(kx) = \alpha \cdot \arctan(k\beta x) = \alpha \cdot \arcsin(\frac{k\beta x}{\sqrt{1 + (k\beta x)^2}})$$

$$\alpha \cdot \arcsin(\frac{k\beta x}{\sqrt{1 + (k\beta x)^2}}) \neq k \cdot \alpha \cdot \arcsin(\frac{\beta x}{\sqrt{1 + (\beta x)^2}})$$

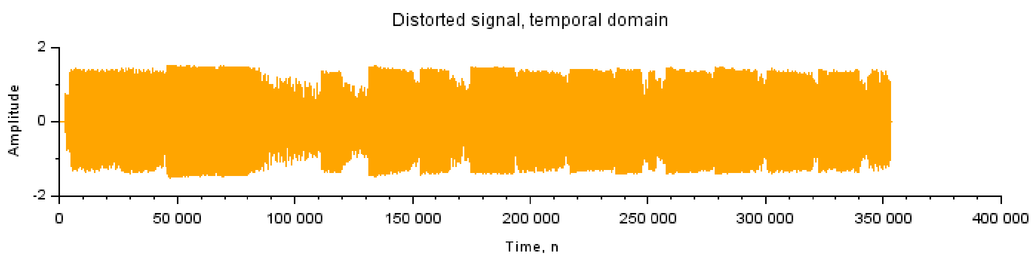
The homogeneity breaks, thus distortion is not linear.



(a) Clean

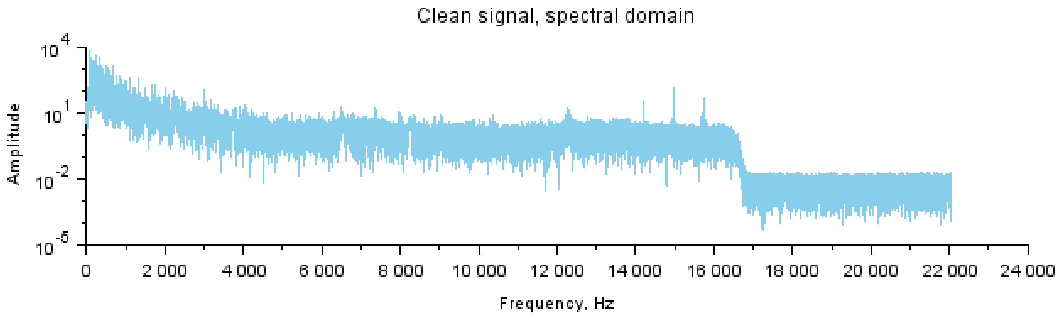


(b) Clipped

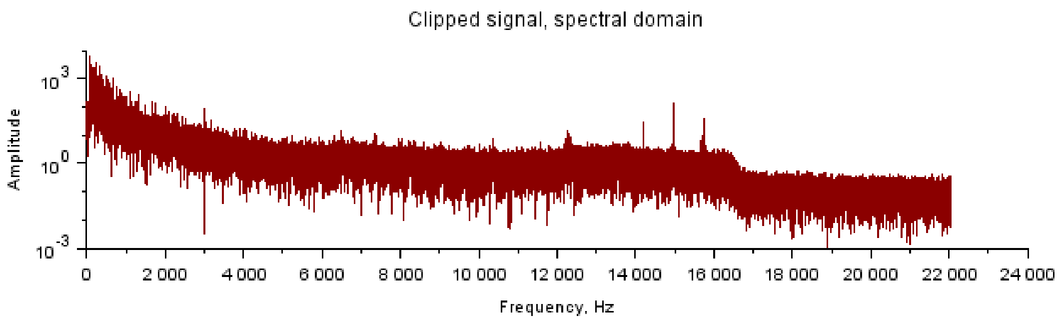


(c) Distorted

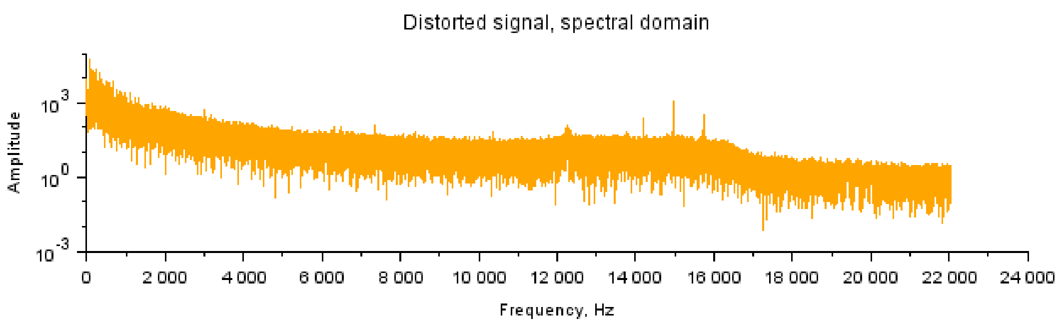
Figure 1: The signal in temporal domain



(a) Clean



(b) Clipped



(c) Distorted

Figure 2: The signal in spectral domain