MUTLI-BAND CONTROL OVER DISTORTION BASED EFFECTS

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ABSTRACT

The following final review details the basic components, implementation and evaluation of a multi-band distortion unit called the FocusAmp. Designed to give an end user a large amount of flexibility, the FocusAmp allows users to choose where crossover points between frequency bands are, what type of distortion is used and how much in each band is applied. The unit is controlled via a text based graphical interface and has been implemented within the Matlab architecture.

1. PROBLEM DESCRIPTION

Mixing music is a long and challenging process that requires deep analysis of every instrument and how it will combine with others to form the full song. Each individual instruments' tone can be seen as the building blocks for the foundation of a mix - if the elements sound bad, the mix will likely crumble. Many audio engineers face the problem of recorded sounds not providing what they need - for that the FocusAmp is the solution. Allowing an engineer to add just the right amount of distortion at particular frequencies is a widely sought after tool that engineers will keep reaching back to as they craft their mixes.

The alternative of course, is to add the distortion first and then use an equaliser or multi-band compression to tame the unwanted frequency content. This however, complicates the process, as engineers will find themselves "chasing their tails" fixing the problems that distorting the full band signal has created.

2. SPECIFICATION

This unit is designed as a multi-band distortion unit that offers multiple adjustable parameters, which allows a user to shape a guitar or bass tone with as little effort as possible. The unit takes a guitar or bass input, splits it into four distinct signals and then applies distortion to each of them. Next, the wet signals are summed back together and then are mixed with an original clean signal at a ratio that is set by the user. Finally, the output signal is normalised for playback. Figure 1 shows the signal flow of the unit.

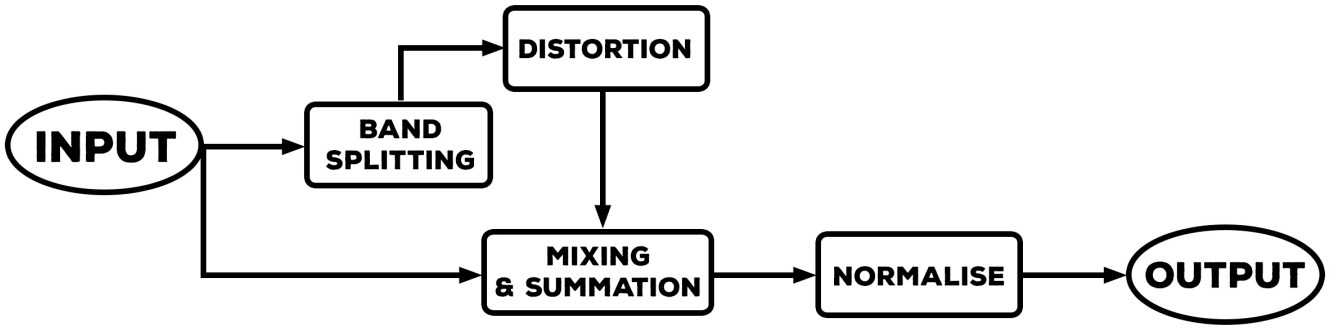


Figure 1 - *Signal flow of FocusAmp*

The FocusAmp provides an end user with numerous switchable parameters, allowing for great depth of control of the unit. The crossover points of each of the frequency bands are controlled by three presets, the unit has a default setting which works well for most applications. In addition to this, "Bass" and "Guitar"

mode can be selected, both of which have crossover points tuned to the typical frequency content of the respective instruments. Further, two types of distortion are available to choose from. The “Overdrive” setting employs a ‘Soft-clipping’ style of distortion, which emulates a warmer sounding distortion such as a Tube Screamer, whereas the “Distortion” setting employs a ‘Hard Clipping’ style, creating a higher gain sound. Figure 2 demonstrates the difference between hard and soft clipping.

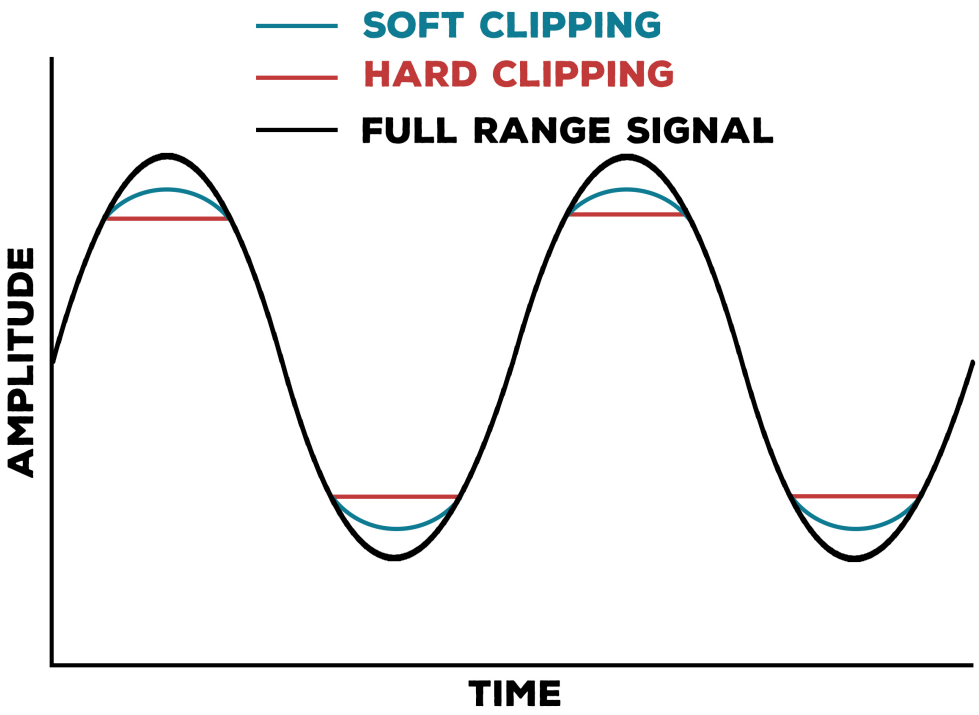


Figure 2 - *Illustration of Distortion Parameters*

Next, the user selects the amount of distortion to be applied to each band. Note, if the value of a particular band is set to zero, the unit will see this as a bypass, and pass the signal through to the summing section unaffected. Finally, the user is able to control the ratio between the processed signal, and the original, unaffected input. Figure 3 shows a potential GUI for the control of these parameters.

Figure 3 - *Potential GUI for the FocusAmp*

3. MATLAB IMPLIMENTATION

3.1 Frequency Splitting

The FocusAmp splits the audio into 4 distinct frequency bands through the use of Butterworth filters, which have the advantage of no pass-band ripple, however, do roll off slower than other filter designs. This is permissible within this application as the crossover points are set to specific frequencies based on the input of the system, meaning that the number of poles and zeroes of the filter can be optimised for each setting.

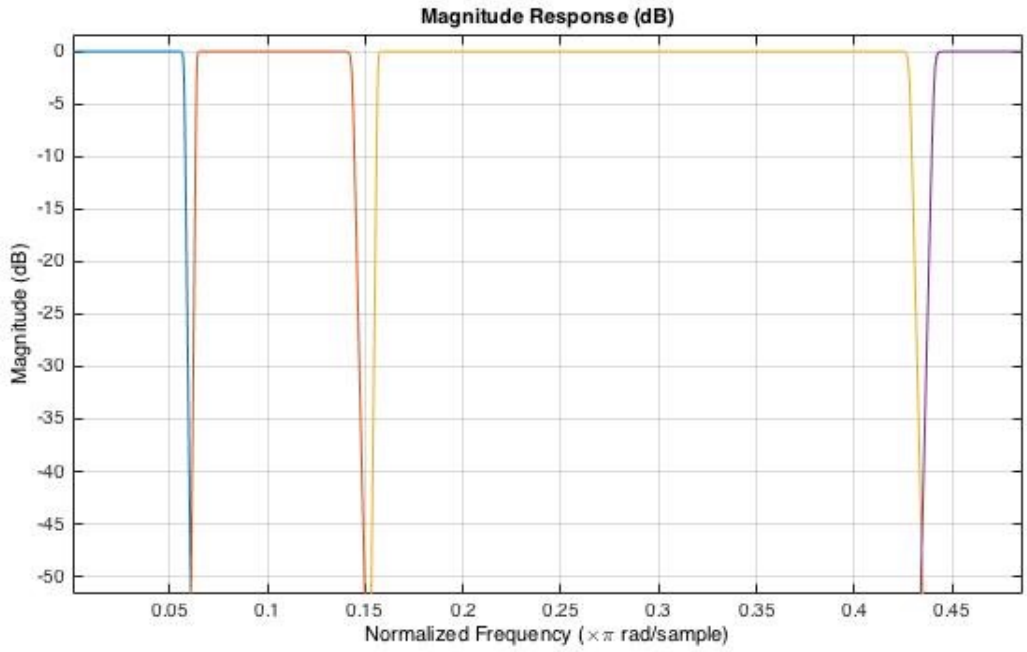


Figure 4 - *Plot of frequency over magnitude for bass guitar preset*

3.2 Distortion

The FocusAmp enables users to switch between two distinct distortion functions, both of which have distinct sonic characteristics. Overdrive mode is produced by a symmetrical soft clipping function called "symclip" This function provides the warm overdrive characteristic similar to a tube screamer. Figures 4 and 5 show how higher input levels correspond to higher distortion values.

$$f(x) = \begin{cases} 2x & \text{for} \quad 0 \leq x \leq 1/3 \\ \frac{3-(2-3x)^2}{3} & \text{for} \quad 1/3 \leq x \leq 2/3 \\ 1 & \text{for} \quad 2/3 \leq x \leq 1. \end{cases}$$

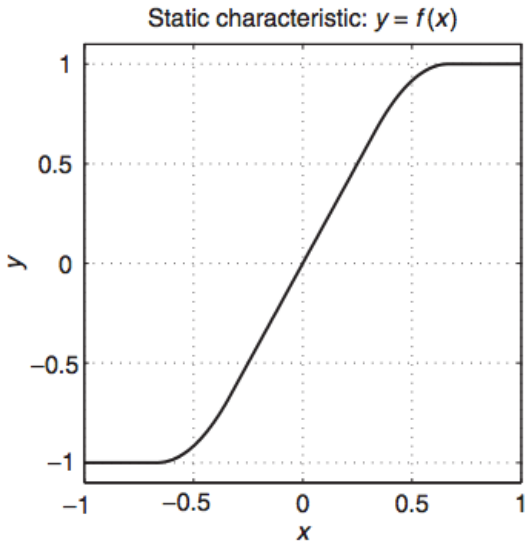


Figure 5 - Left: *Input values and their corresponding outputs for "symclip"* (Zölzer, 2011, p.125)
Right: *Static input to output relation* (Zölzer, 2011, p.125)

In Distortion mode the system implements the “tanh” function, which “returns the hyperbolic tangent of an element in an array” ("Hyperbolic tangent - MATLAB", 2016)

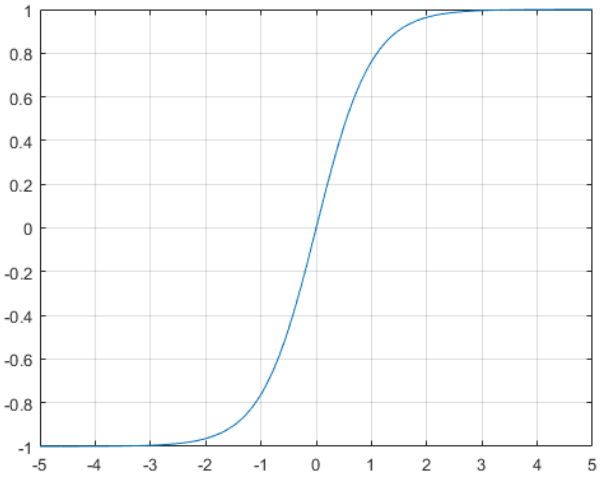


Figure 6 - *Static input to output relation of the tanh function* ("Hyperbolic tangent - MATLAB", 2016)

4. USER INTERFACE

Currently the FocusAmp is running within the Matlab architecture and thus an advanced GUI is not practical, however for testing purposes a simple text based GUI has been constructed to allow users to operate the program without the need to edit the syntax. Following the prompt for the input file the user is shown a dialogue box (Figure 7) to select the input parameters.

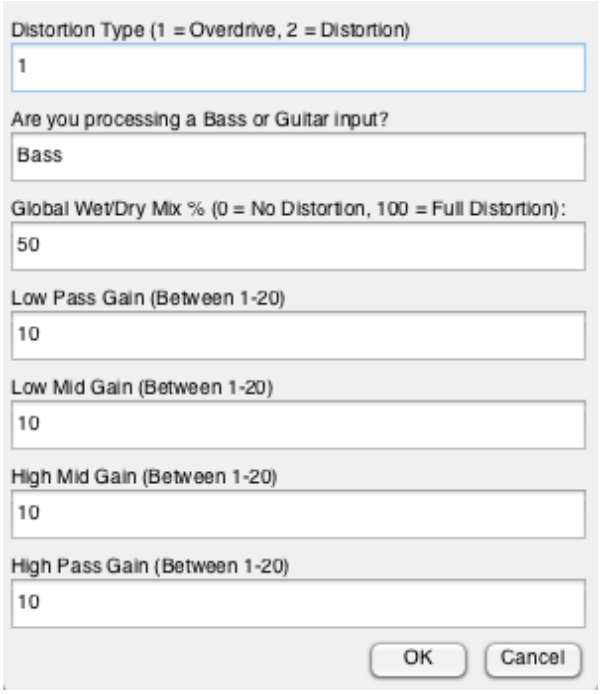


Figure 7 - *Text based GUI with default settings*

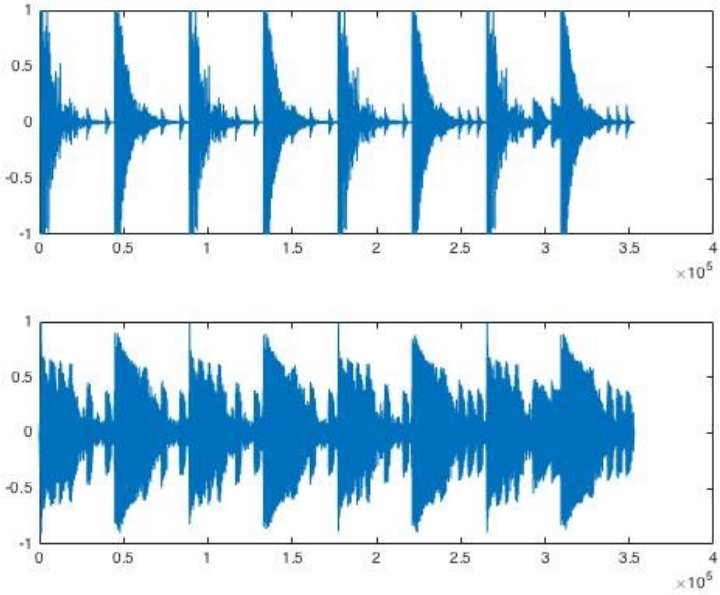
It should be noted that users can move outside of the recommended ranges of distortion, but these will produce more sonically “experimental” sounds.

5. PRODUCT EVALUATION

The FocusAmp has been tested with a wide variety of input parameters and signals, and has found to be very stable across the board. There are a number of redundancy measures to prevent user error from returning undesirable results, as well as error checks to ensure the program is running as intended. When used within the recommended gain values, the unit consistently produces sonically pleasing results. Further, when pushed outside these values, the unit still performs well. Results can vary however, so experimentation between different values is key. Finally, the unit has been further streamlined from previous builds, and runs far more efficiently.

An evaluation of the digital output in addition to an aural assessment has been completed to substantiate these claims. Files have been included within the FocusAmp package showing the inputs pre and post distortion, and examples have been provided to give a graphical representation of the systems effects.

Example 1 - Drum Loop

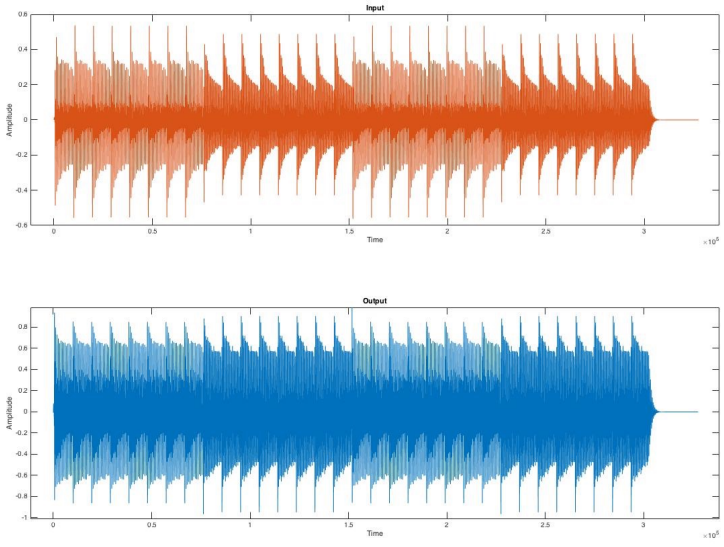


Input: Drum_Loop.wav
Output: Drum_Loop_OD.wav

Input Parameters
Distortion Type: Overdrive
Crossover Preset: Default
Global Wet/Dry mix: 100%
Low Pass Gain: 15
Low Mid Gain: 2
High Mid Gain: 2
High Pass Gain: 2

The goal of this example was to significantly distort the kick drum whilst leaving the cymbals relatively undistorted. This showed that while the overdrive can prove mellow and warm distortion, when pushed into the upper reaches of the recommended gain range the unit can produce quite harsh distortion.

Example 2 - Bass Run

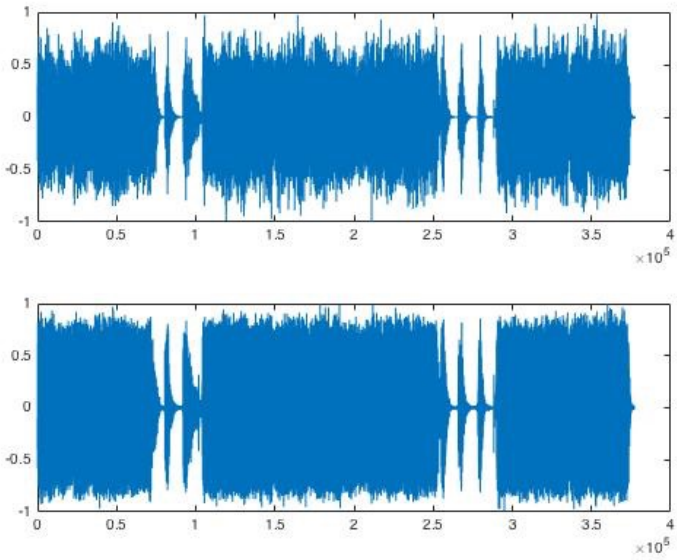


Input: Bass.wav
Output: Bass_OD1.wav

Input Parameters
Distortion Type: Overdrive
Crossover Preset: Bass
Global Wet/Dry mix: 80%
Low Pass Gain: 4
Low Mid Gain: 12
High Mid Gain: 2
High Pass Gain: 0

This example shows a nice amount of distortion being added into the low-mid frequencies of the input, whilst leaving the higher frequencies untouched. This has taken a somewhat bland bass track and added in just the right amount of crunch and warmth.

Example 3 - Distorted Guitar

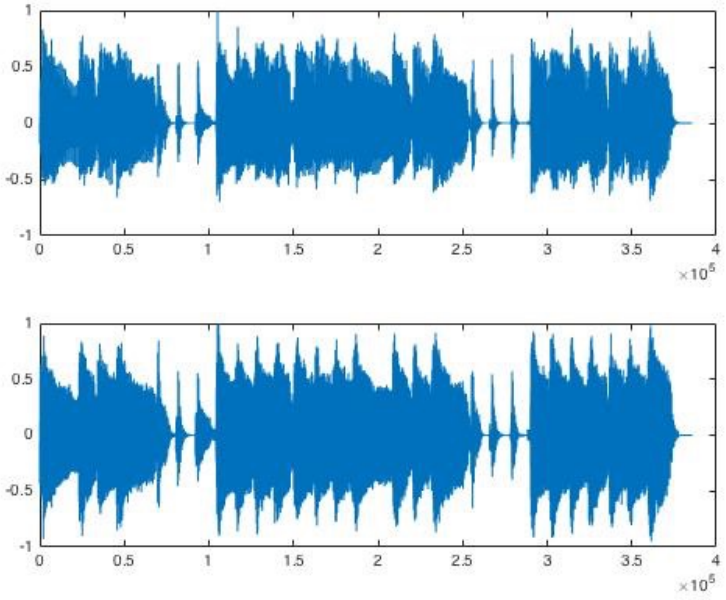


Input: Guitar_Dist.wav
Output:Guitar_Dist_OD1.wav

Input Parameters
Distortion Type: Overdrive
Crossover Preset: Guitar
Global Wet/Dry mix: 100%
Low Pass Gain: 4
Low Mid Gain: 10
High Mid Gain: 15
High Pass Gain: 5

This example aimed to add high frequency “fizz” to the guitar tone. This is likely the easiest application for the unit to handle, as a large amount of distortion is already present within the input signal, and as a result, the unit is performing more of a tone shaping role, rather than a boosting/ distorting a clean signal.

Example 4 - Clean Guitar



Input: Guitar_Clean.wav
Output:Guitar_Clean_OD1.wav

Input Parameters
Distortion Type: Distortion
Crossover Preset: Guitar
Global Wet/Dry mix: 100%
Low Pass Gain: 10
Low Mid Gain: 15
High Mid Gain: 8
High Pass Gain: 1

Finally, this example aimed to take an essentially clean guitar and provide the user with a useable distorted signal on the output. This application is the hardest for the FocusAmp to perform, as it is required to provide all of the signature distortion characteristics of the output signal. However, the unit still performs well and the output signal would be appropriate for some situations.

6. BIBLIOGRAPHY

Hyperbolic tangent - MATLAB. (2016). Mathworks. Retrieved 4 June 2016, from http://au.mathworks.com/help/matlab/ref/tanh.html

Zölzer, U. (2011). DAFX: Digital Audio Effects (2nd ed.). Chichester: John Wiley & Sons Ltd.