BLOsc

Description:

Band Limited Oscillator based on Peter Pabon's algorithm. Amplitude normalization function and variable envOddRatio are my own ideas.

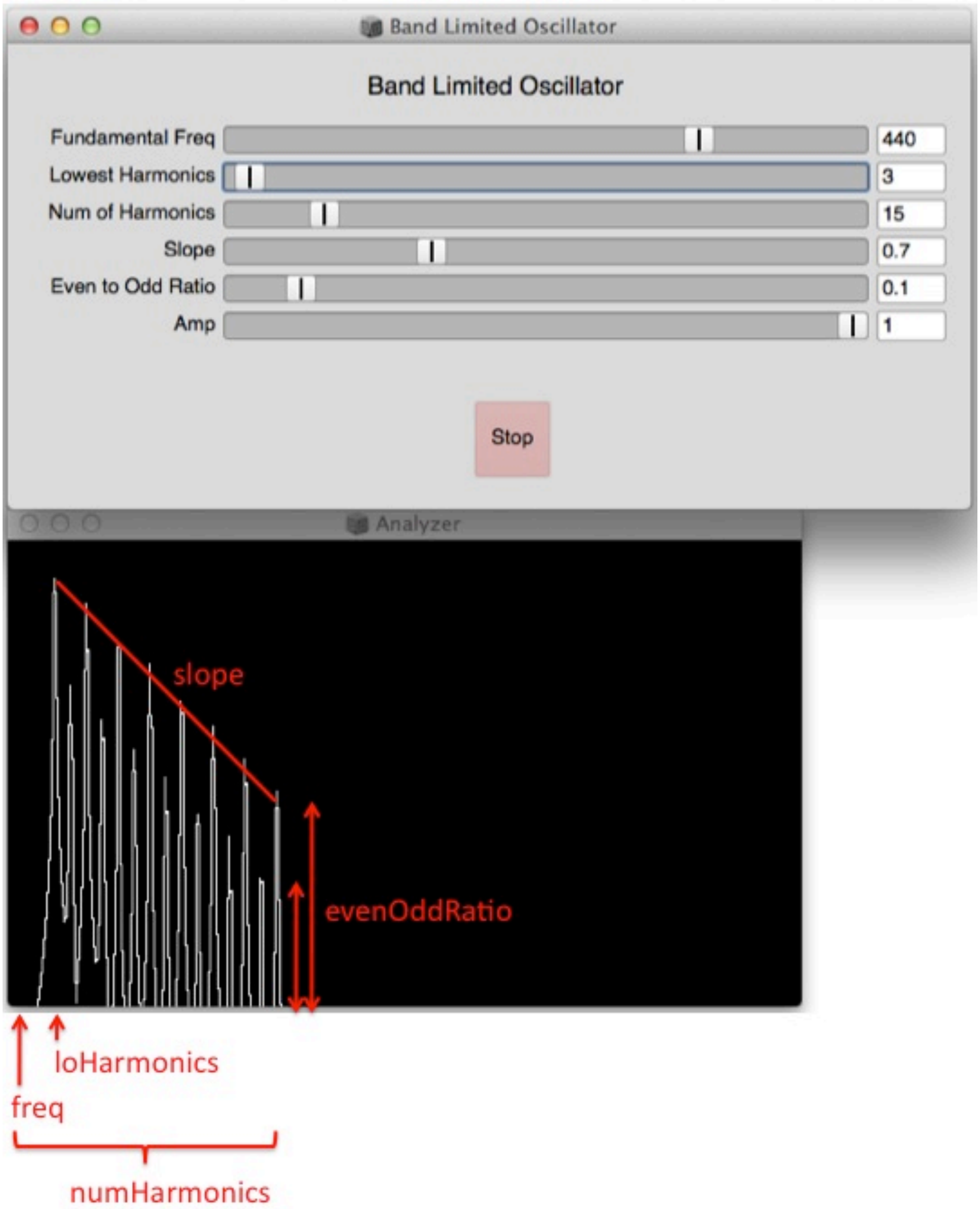
Class Methods:

ar, kr (freq: 440, loHarmonics: 1, numHarmonics: 15, slope: 1, evenOddRatio: 1, mul: 1, add: 0)

Arguments:

freq	Fundamental frequency in Hertz.
loHarmonics	The lowest harmonic index.
numHarmonics	The total number of harmonics.
slope	The slope of spectrum. Should be > 0. <1: The lower the harmonics, the higher the amplitude. =1: Flat spectrum. >1: The higher the harmonics, the higher the amplitude.
evenOddRatio	The amplitude ratio of even number harmonics to odd number harmonics. Should fall between 0 and 1. The lower the value, the more square-wave like sound comes out.
mul	Output will be multiplied by this value.
add	Output will be added to this value.

freq, slope, and evenOddRatio can be modulated with either audio rate or control rate.


Band Limited Oscillator
Band Limited Oscillator
Fundamental Freq
440
Lowest Harmonics
3
Num of Harmonics
15
Slope
0.7
Even to Odd Ratio
0.1
Amp
1
Stop
Analyzer
slope
evenOddRatio
loHarmonics
freq
numHarmonics

The theory behind this Band Limited Oscillator is beyond the scope of this assignment and not explained here. However, the formula to calculate the output values is briefly described because it is essential part to understand the code. Detailed theory of this algorithm will be discussed in my thesis next year.

The following symbol is used for the subsequent expressions.

φ = instantaneous phase
Sl = slope (argument)
Lo = the lowest harmonic index (argument)
Hi = the highest harmonic index
Loe = the lowest even harmonic index
Hie = the highest even harmonic index
Ef = evenOddFactor = 1 – evenOddRatio (argument)

The total number of harmonics is provided as an argument (*numHarmonics*) instead of the highest harmonic index. The highest harmonic index is calculated with the following expression.

$Hi = Lo + numHarmonics - 1$

The calculations of the lowest even harmonic index and the highest even harmonic index are as follows.

If Lo is even, $Loe = Lo$. If Lo is odd, $Loe = Lo + 1$.
If Hi is even, $Hie = Hi$. If Hi is odd, $Hie = Hi - 1$.

The output values of the signal can be obtained as complex numbers with the following expression.

The output value as a complex number =

$$\frac{\left\{Sl^{Lo}\cdot \cos(Lo\cdot \varphi) - Sl^{Hi+1}\cdot \cos\left[(Hi+1)\varphi\right]\right\} + i\left\{Sl^{Lo}\cdot \sin(Lo\cdot \varphi) - Sl^{Hi+1}\cdot \sin\left[(Hi+1)\varphi\right]\right\}}{\left[1 - Sl\cdot \cos\varphi\right] + i\left[-Sl\cdot \sin\varphi\right]} -$$

$$\frac{Ef\cdot \left\{Sl^{Loe}\cdot \cos(Loe\cdot \varphi) - Sl^{Hie+2}\cdot \cos\left[(Hie+2)\varphi\right]\right\} + Ef * i\left\{Sl^{Loe}\cdot \sin(Loe\cdot \varphi) - Sl^{Hie+2}\cdot \sin\left[(Hie+2)\varphi\right]\right\}}{\left[1 - Sl^2\cos(2\varphi)\right] + i\left[-Sl^2\sin(2\varphi)\right]}$$

Here, symbols a to h are used to represent the following values.

$$a = Sl^{Lo} \cdot \cos(Lo \cdot \varphi) - Sl^{Hi+1} \cdot \cos\left[(Hi+1)\varphi\right]$$

$$b = Sl^{Lo} \cdot \sin(Lo \cdot \varphi) - Sl^{Hi+1} \cdot \sin\left[(Hi+1)\varphi\right]$$

$$c = 1 - Sl \cdot \cos\varphi$$

$$d = -Sl \cdot \sin\varphi$$

$$e = Ef \cdot \left\{ Sl^{Loe} \cdot \cos(Loe \cdot \varphi) - Sl^{Hie+2} \cdot \cos\left[(Hie+2)\varphi\right] \right\}$$

$$f = Ef * i\left\{ Sl^{Loe} \cdot \sin(Loe \cdot \varphi) - Sl^{Hi+2} \cdot \sin\left[(Hie+2)\varphi\right] \right\}$$

$$g = 1 - Sl^2 \cos(2\varphi)$$

$$h = -Sl^2 \sin(2\varphi)$$

The output value as a real number is obtained with the following expression.

$$\textit{The output value as a real number} = \left(\left[\frac{bc - ad}{c^2 + d^2} \right] - \left[\frac{fg - eh}{g^2 + h^2} \right] \right)$$

Now, I would like to add the amplitude normalization unit to this expression. In general, ampFactor is derived from the following calculation.

$$AmpFactor = \frac{Sl^{Lo} - Sl^{Hi+1}}{1 - Sl} - \frac{Ef\left(Sl^{Loe} - Sl^{Hie+2}\right)}{1 - Sl^2}$$

However, there is a problem when $Sl = 1$ because it makes denominators of the above calculation to be 0. Thus, I used the following alternative calculation with a specific condition.

$$AmpFactor = numHarmonics - Ef \cdot numEvenHarmonics$$

$$numEvenHarmonics\text{(the total number of even harmonics)} = \frac{Hie - Loe}{2} + 1$$

Now, the output value of the amplitude-normalized signal (as a real number) is calculated with the following expression.

$$z = \left(\left[\frac{bc - ad}{c^2 + d^2} \right] - \left[\frac{fg - eh}{g^2 + h^2} \right] \right) \cdot \frac{1}{ampFactor}$$