# Noise Reduction with Variable Filter Bands

## Overview

The variable band noise reduction component is a multiband noise-gate which supports a variable number of filter bands. The algorithm splits the audio band into sub-bands. Each sub-band is then subjected to a noise-gate algorithm with variable attenuation and threshold, and with automatic noise-floor tracking. The range over which the bands are spread can be set by the GUI controls, as can the amount of attenuation, and the threshold, which sets the point at which the differentiation is made between 'signal' and 'noise'. The noise reduction is targeted for speech applications operating at sample rates between4kHz and 8kHz. The GUI can be accessed by double-clicking the representation of the block once placed within a process flow within the GDE. The control panel is shown in Figure 1.

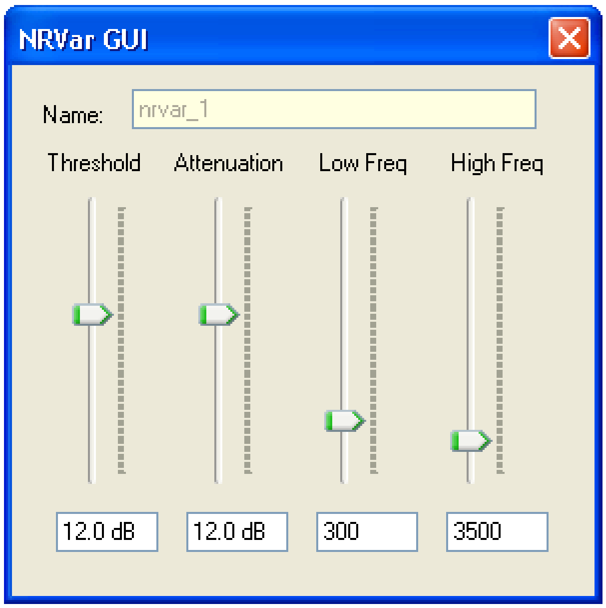


**Figure 1: Noise Reduction Control Panel**

## Algorithm

The algorithm is comprised of the following sequence of processing:

1. The input audio is split into frequency bands
2. Each audio band is 'gated' so that only signal that is a certain threshold above the estimated noise floor is passed
3. The bands are summed to form the output

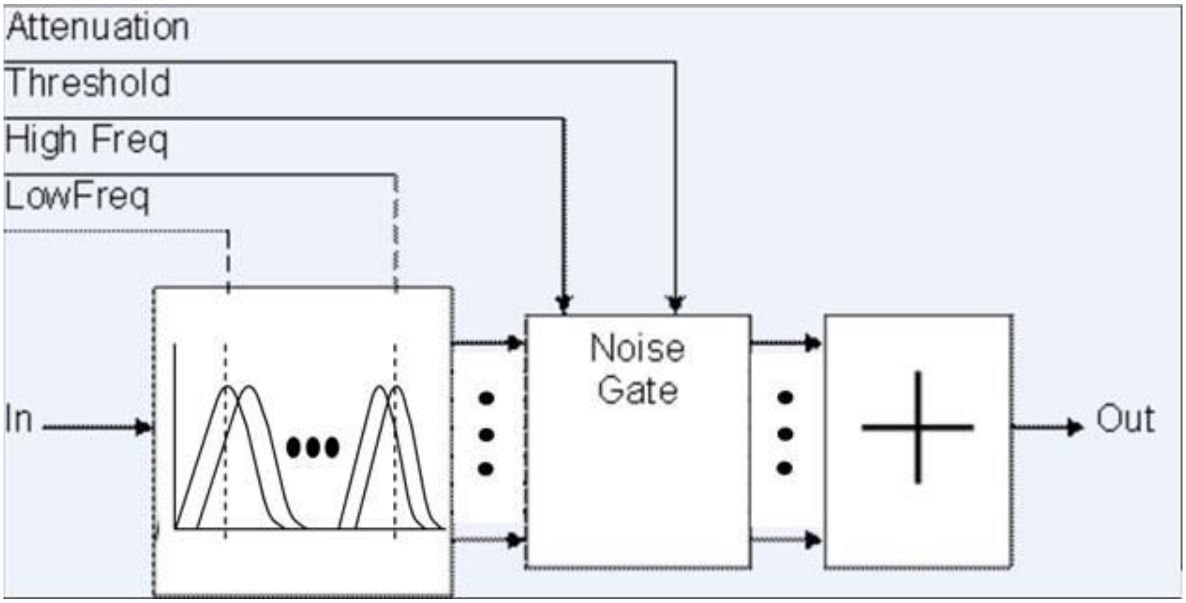


**Figure 2: Algorithm Overview**

## Filter Adjustment

The filter bank is built from 4th order band pass filters. Each 4th order band pass filter is made from a cascade of a pair of second order band pass filters. The configurable properties **`HighFreq`** and **`LowFreq`**set the center frequencies of the lowest and highest bandpass filters as shown in Figure 3.

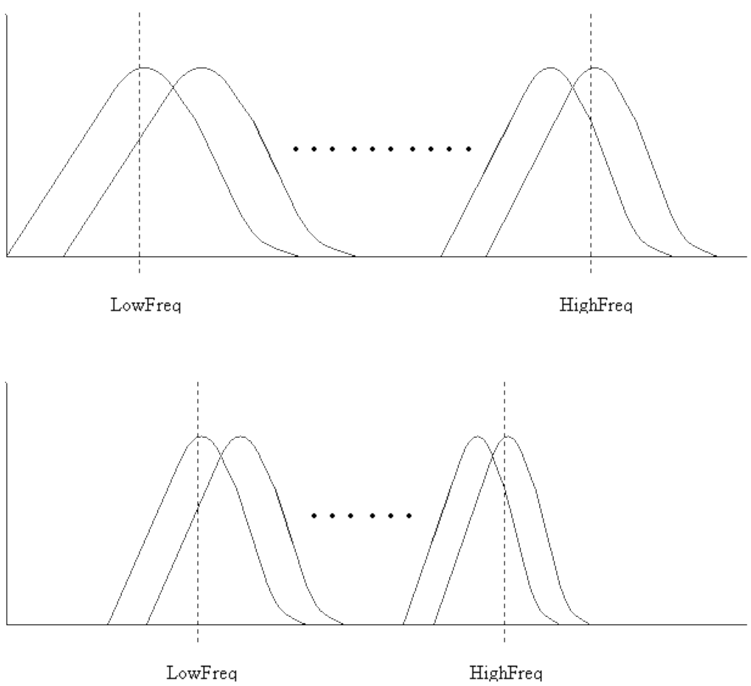


**Figure 3: High Freq and Low Freq settings**

The coefficients for all the filters are calculated by the GUI and returned to the GDE. The 'Q' factor for each filter is managed automatically to obtain good frequency response flatness when the outputs from all filters are summed.

Typical frequency response error after summation is <0.5dB. An example is shown in Figure 3.

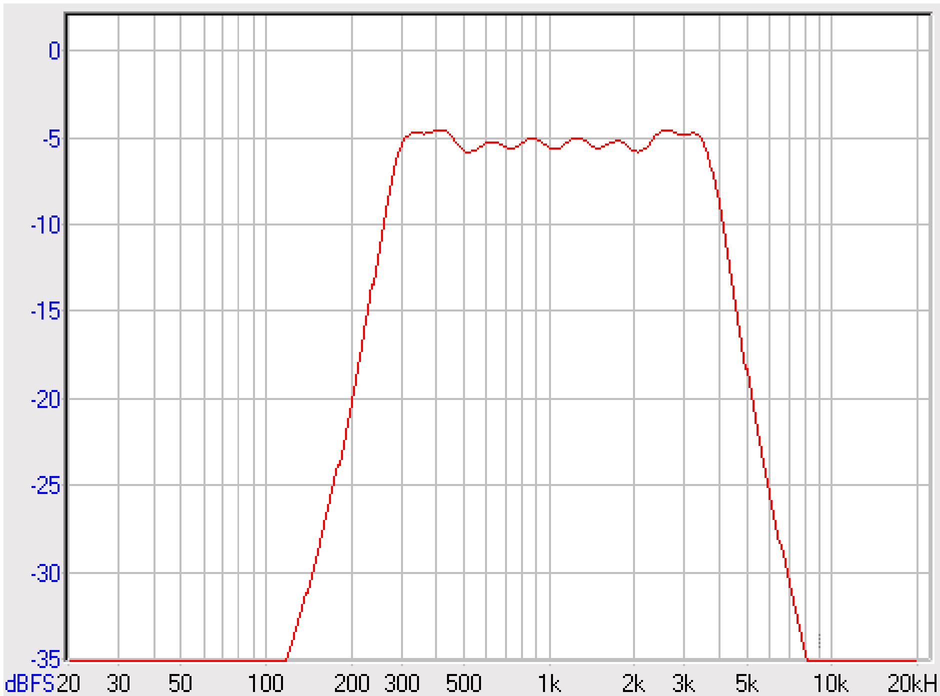


**Figure 3: Typical frequency response after summation**

## User Controls

It is required that the user control the Noise Reduction algorithm using only the GUI which calculate all the coefficients. These coefficients are updated to run-time properties The GUI screen is shown above in Figure 1.

## Run-time Configurable Properties (Use GUI to change the values)

| Property | Description |
|---|---|
| `Threshold` | Defines the level below which the signal is classified as noise and attenuation is applied. Range 0 to 20 dB. Set in GUI. |
| `Attenuation` | Amount of attenuation applied to the signal that is below the `Threshold` level. Set in the GUI, the value can range from 0dB (no attenuation) to 20dB (maximum attenuation). |
| `LowFreq` | Represents the center frequency of the lowest filter within the filter bank. Changing this value in the GUI causes all filter coefficients to be updated. |
| `HighFreq` | Represents the center frequency of the highest filter within the filter bank. Changing this value in the GUI causes all filter coefficients to be updated. |

## Design-time Configurable Properties

| Property | Description |
|---|---|
| **NumBanks** | The number of filter banks used can be set here. Note that selecting more banks uses more CPU resources. If your design doesn't fit, try reducing the number of banks. Range 4 to 16 filter banks. |
| **Enable_Noise_Readout** | If set 'TRUE', makes available the noise floor estimates in each bank for readout but has the penalty of using up to 81 additional instructions. |

## I2C Interface

The I2C interface to NRVAR is as follows:

| I2C Address | DSP Memory Address | Size | Description |
|---|---|---|---|
| I2CAddress1 | DspCoefBlockStart1 | 8 bytes | Threshold and Attenuation coefficients. |
| I2CAddress2 | DspCoefBlockStart2 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section (lowest frequency) |
| I2CAddress3 | DspCoefBlockStart3 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress4 | DspCoefBlockStart4 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress5 | DspCoefBlockStart5 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress6 | DspCoefBlockStart6 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress7 | DspCoefBlockStart7 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress8 | DspCoefBlockStart8 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress9 | DspCoefBlockStart9 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress10 | DspCoefBlockStart10 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress11 | DspCoefBlockStart11 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress12 | DspCoefBlockStart12 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress13 | DspCoefBlockStart13 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress14 | DspCoefBlockStart14 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress15 | DspCoefBlockStart15 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |
| I2CAddress16 | DspCoefBlockStart16 | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section |

| | | | |
|---|---|---|---|
| `I2CAddress17` | `DspCoefBlockStart17` | 16 bytes | Coefficients B0, B2, A1, A2 for Filter Bank biquad section (highest frequency) |
| `I2CAddress18` | `DspCoefBlockStart18` | Up to 68 bytes | Noise floor estimates for each filter band |

## Usage

The Noise Reduction component can be used to improve signal-to-noise ratio, particularly of speech, in the presence of ambient noise.