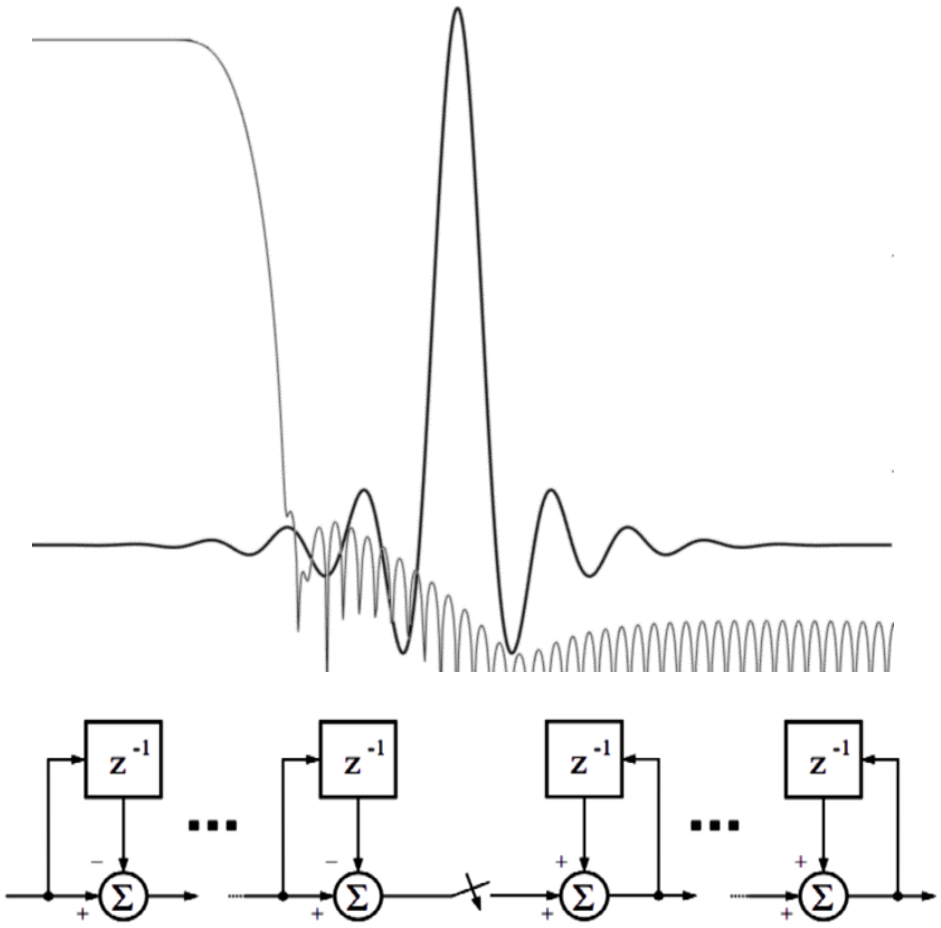
LOW-COMPLEXITY PDM DECIMATOR



Overview

This program implements a **decimation of a Pulse Density bit-stream**. For example, the bit-stream generated by a digital microphone. The typical use-case of this program is to decimate the PDM stream of a microphone to the usual audio sampling-rates. For example 16kHz for the keyword recognizer of Alexa voice services.

A **bit-exact demonstration** files and executable (BATCH_SRC.BAT) is located at :
http://firmware-developments.com/WEB/P6x/PDMDEC/DEMO/

The code is ported and benchmarked for **ARM Cortex-M4 / M7**, and can be executed on any processor using 32-bits arithmetic. The first processing stage is a 4^{th} order CIC decimator with decimation rate of 32 or 64, followed by an half-band decimator and DC-offset canceller using **floating point** arithmetic.

Example with a PDM rate is 2.048MHz with an Over Sampling Ratio (OSR) of 128, the targeted sampling rate is 2.048MHz/128 = 16kHz. The CIC decimator consumes **9.5 cycles/bits** of a Cortex-M7, 39 cycles/samples at OSR=2 for the second decimator, 10 cycles for the DC-offset canceller.

The computation of 16kHz output sample from a 2.048MHz PDM bit-rate takes about **20MHz of CPU load**.

Interfaces

The program works from a bit-steam of PDM bits packed and addressed on 32bits words boundaries.

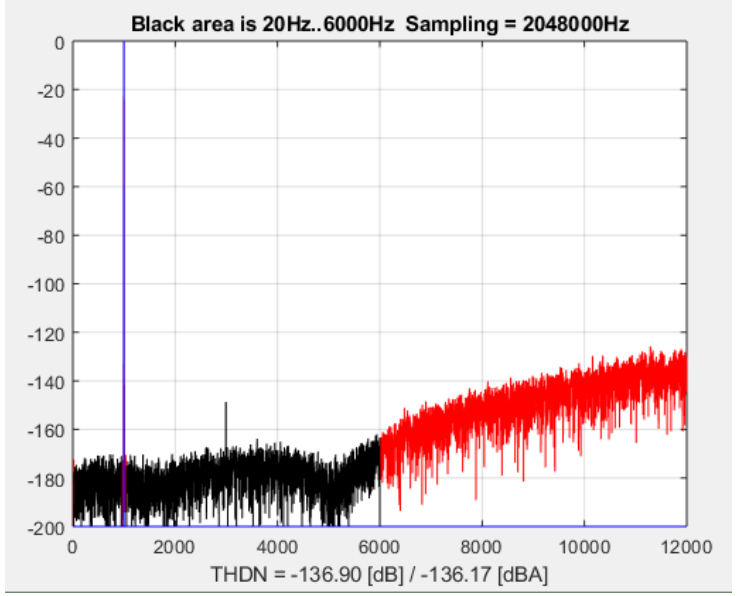
The public APIs of the programs are:

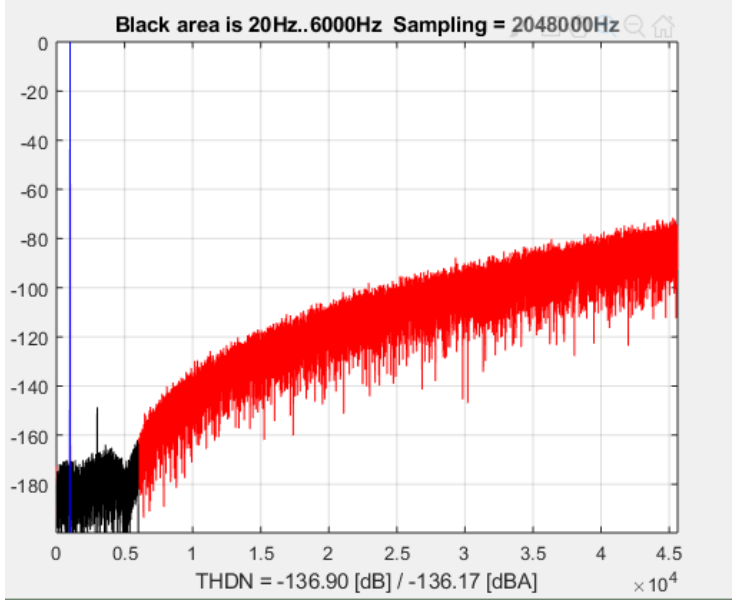
- Settings from several input parameters : output samples format, OSR (over sampling ratio), CIC filter order (3, 4 or 5), gain, optional DC canceller and cut-off frequency.
- Create an instance of the sample-rate converter and initializing it
- Process one instance, taking an input mono audio buffer and returning the new stream of samples

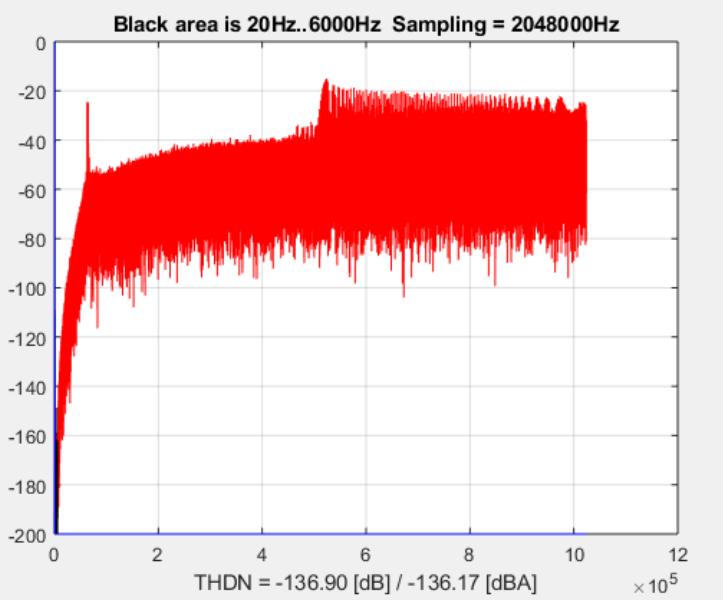
Performances

The estimation of the distortion introduced by the decimation is made from a PDM stream computed from a CRFB modulator of 4th order. The plots represent the same spectrum of the PDM stream at different zoom level.

With this modulation test pattern, the maximum achievable THD+N is 136dB.







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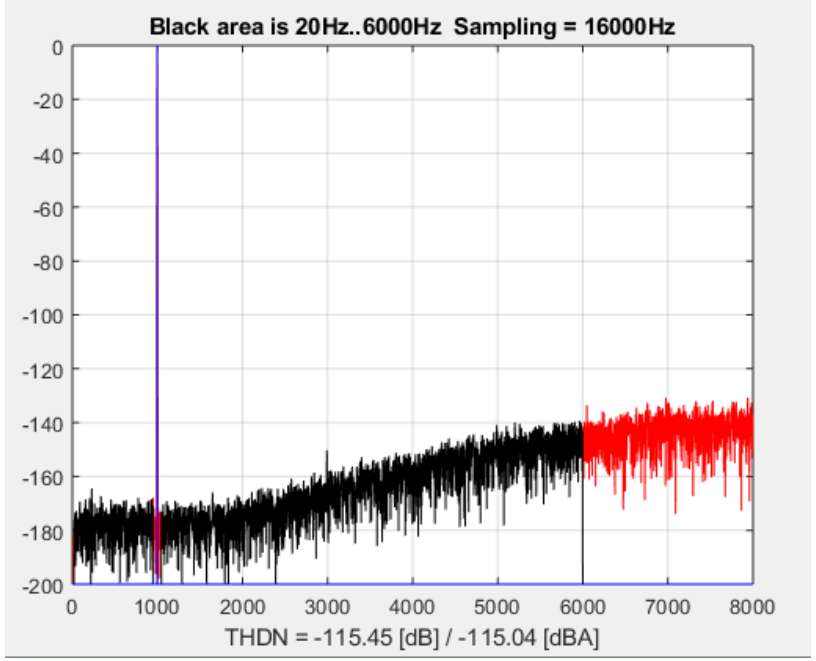
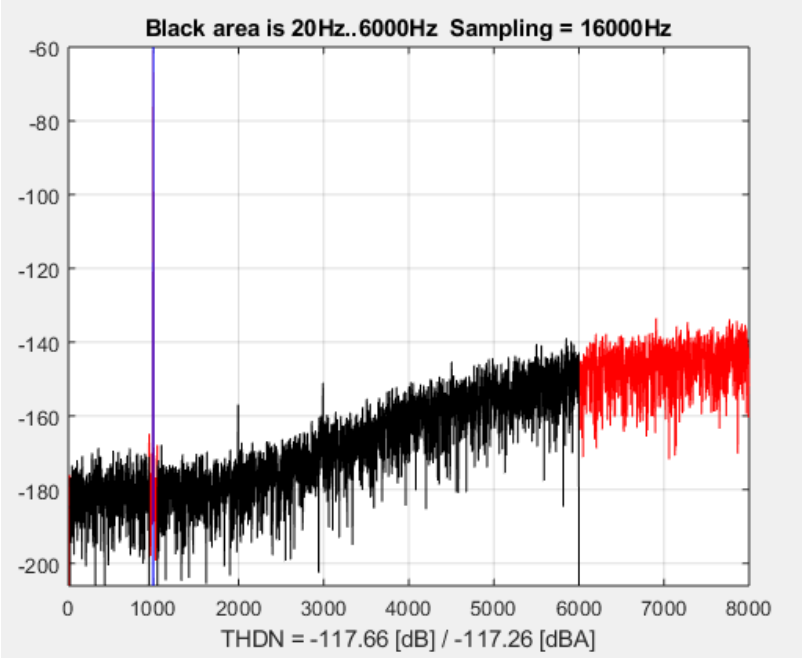
Performances CIC 4th order

The signal is a full-scale sine-wave at 997Hz.
The **THD+N is 117dB in the voice band** used for speech recognition in far-field conditions (-60dBFS)





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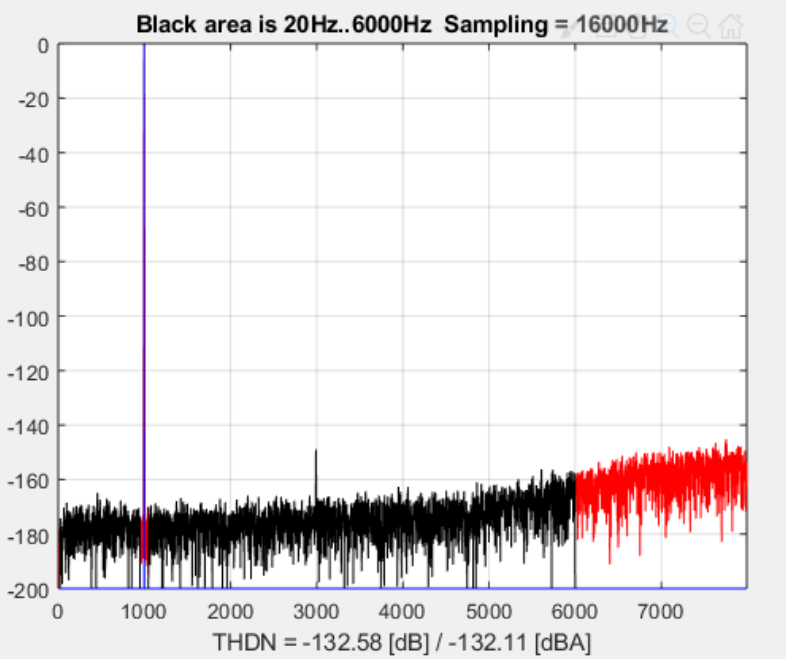
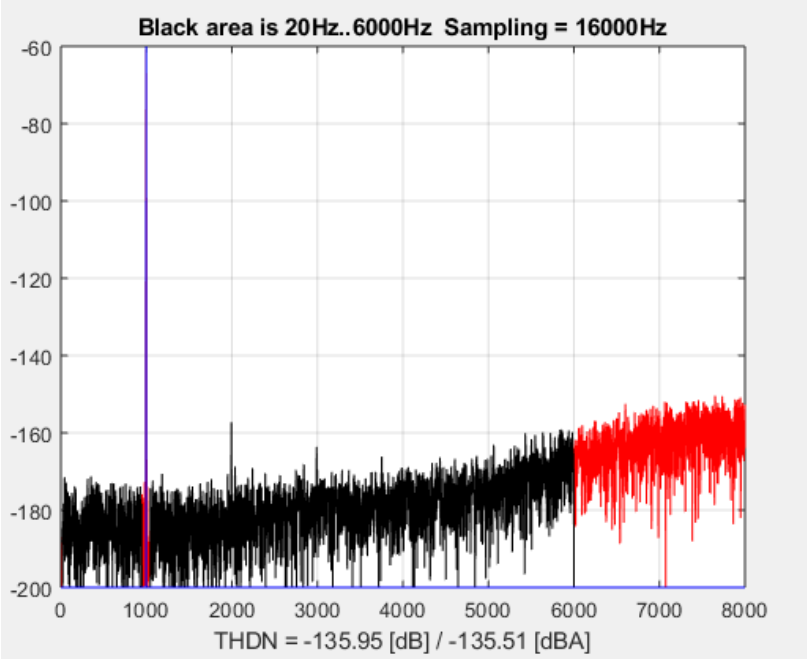
Performances CIC 5th order

The signal is a full-scale sine-wave at 997Hz.
The **THD+N is 136dB in the voice band** used for speech recognition in far-field conditions (-60dBFS).
This THD+N is the maximum achievable performance possible with this PDM test pattern.





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