Audio Measurements using JAAA

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2nd Linux Audio Developers Conference
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What is it ?

FFT based spectrum analysis

Measuring noise
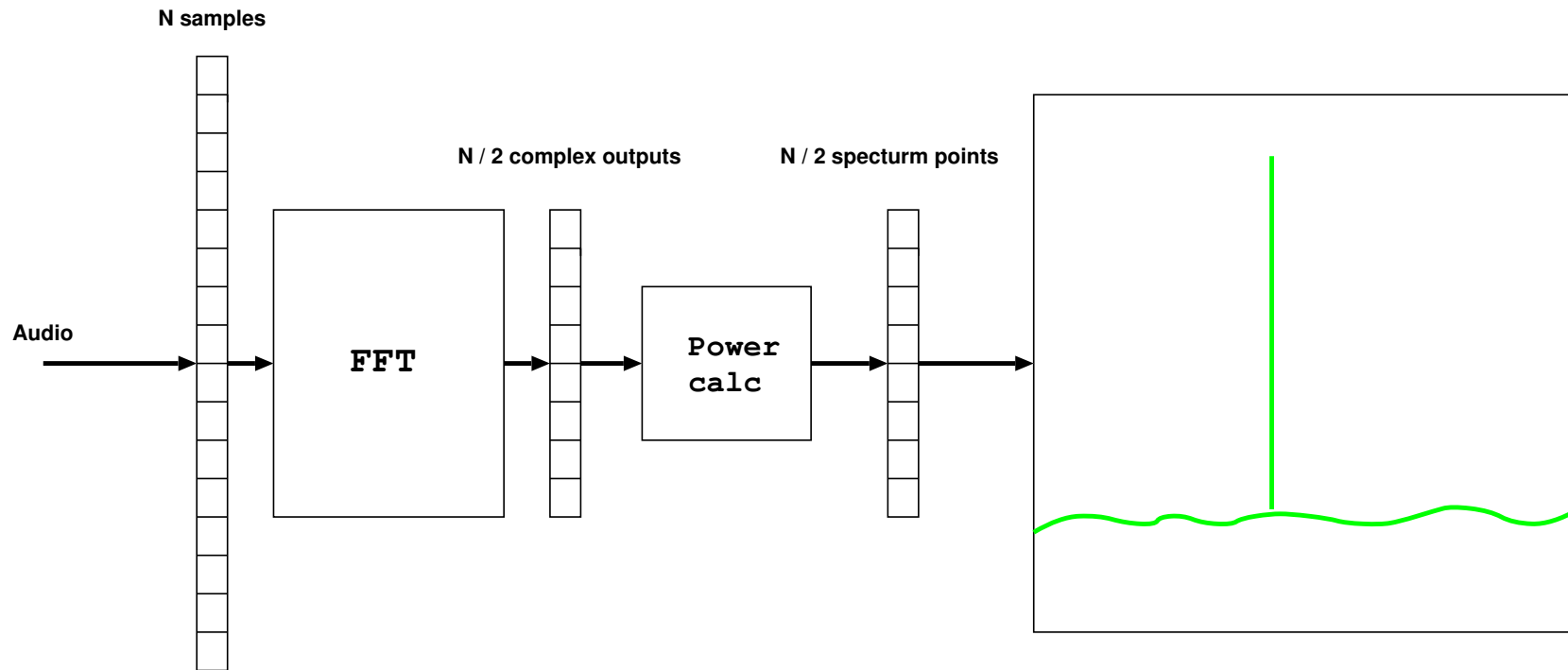
Internals

Demo

Things to do

Questions ?

- A signal generator and spectrum analyser.

- Checking performance of audio HW en SW.

- JAAA is a technical, not a musical tool.

  - Linear frequency scales
  - Designed for accurate measurements
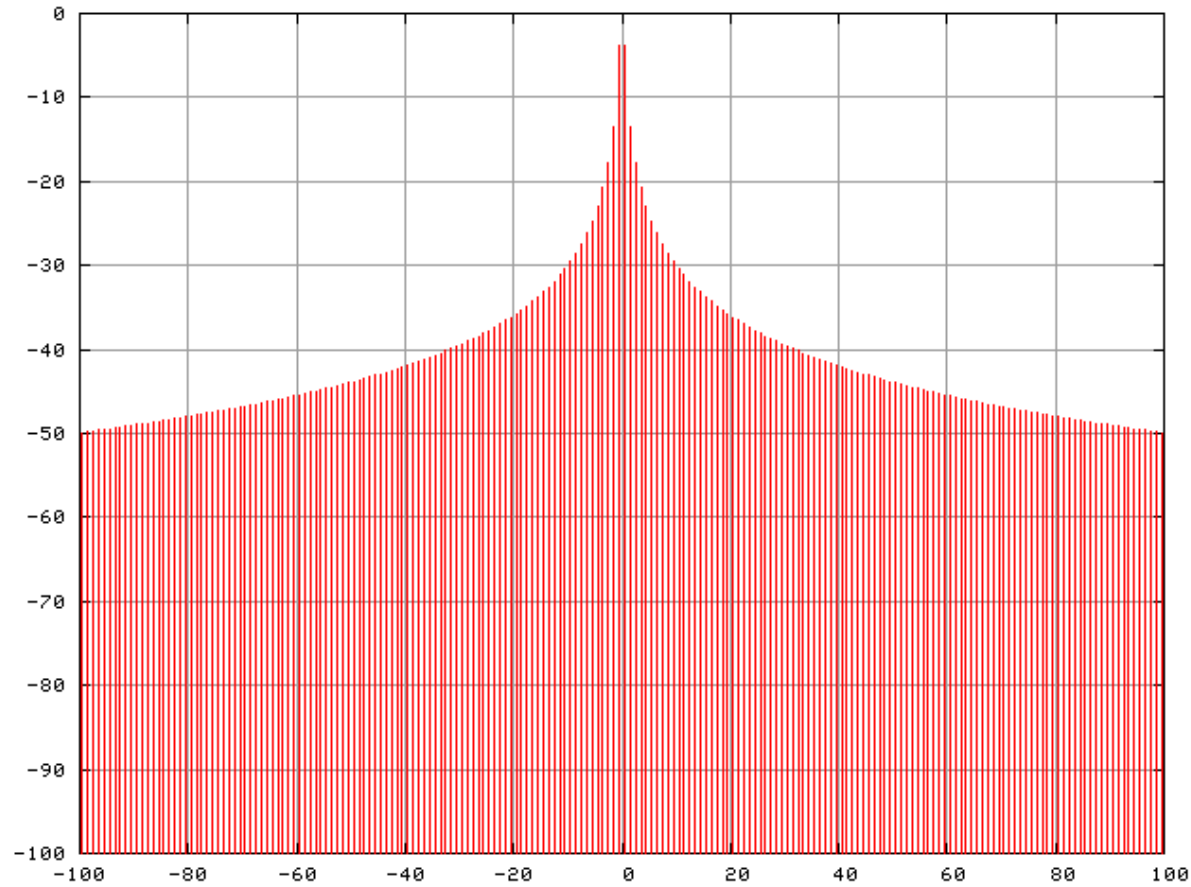 - Requires some technical knowledge

- FT : Fourier Transform. Transforms function of time $f(t)$ (a signal) into a function of frequency $F(\omega)$ (a spectrum).

  - Operates on continuous (not sampled) functions.
  - Can be reversed : no information is lost in the transform.

- DFT : Discrete Fourier Transform. Same as FT, but operating on discrete (sampled) signals,and producing a discrete (sampled) spectrum.

- FFT : Fast Fourier Transform. Optimized version of the DFT.

- FFTW3 : A very nice open source FFT library, used in many Linux applications.

- An N-point FFT replaces $N/2$ bandpass filters.

- Frequency step $\Delta_F = F_{samp}/N$.

- F_{samp} = 44.1 kHz, 1024 point FFT $\rightarrow$ filters at 0, 43, 86, 129 . . . 22007 Hz.

Could it be so simple ? . . .

N samples

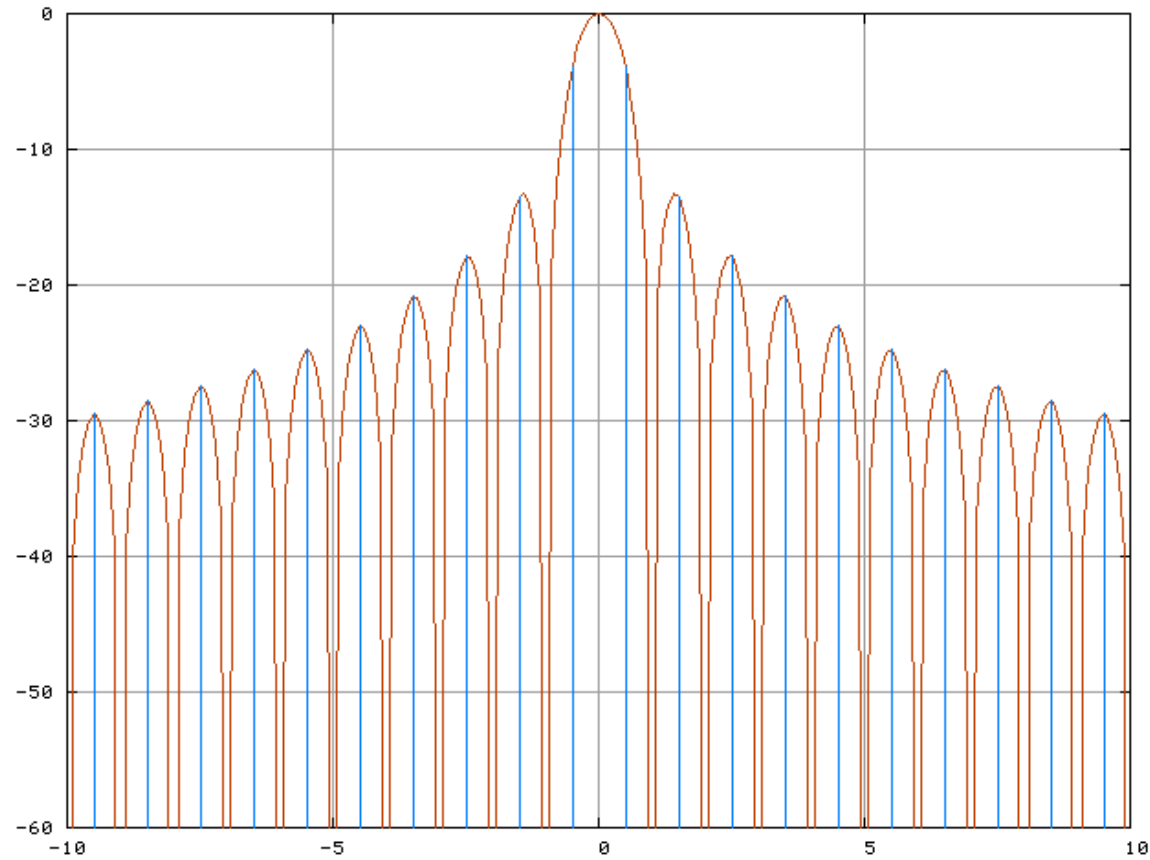**N / 2 complex outputs**

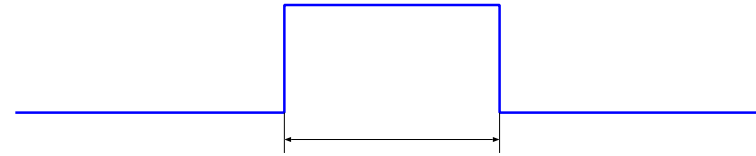**N / 2 specturm points**
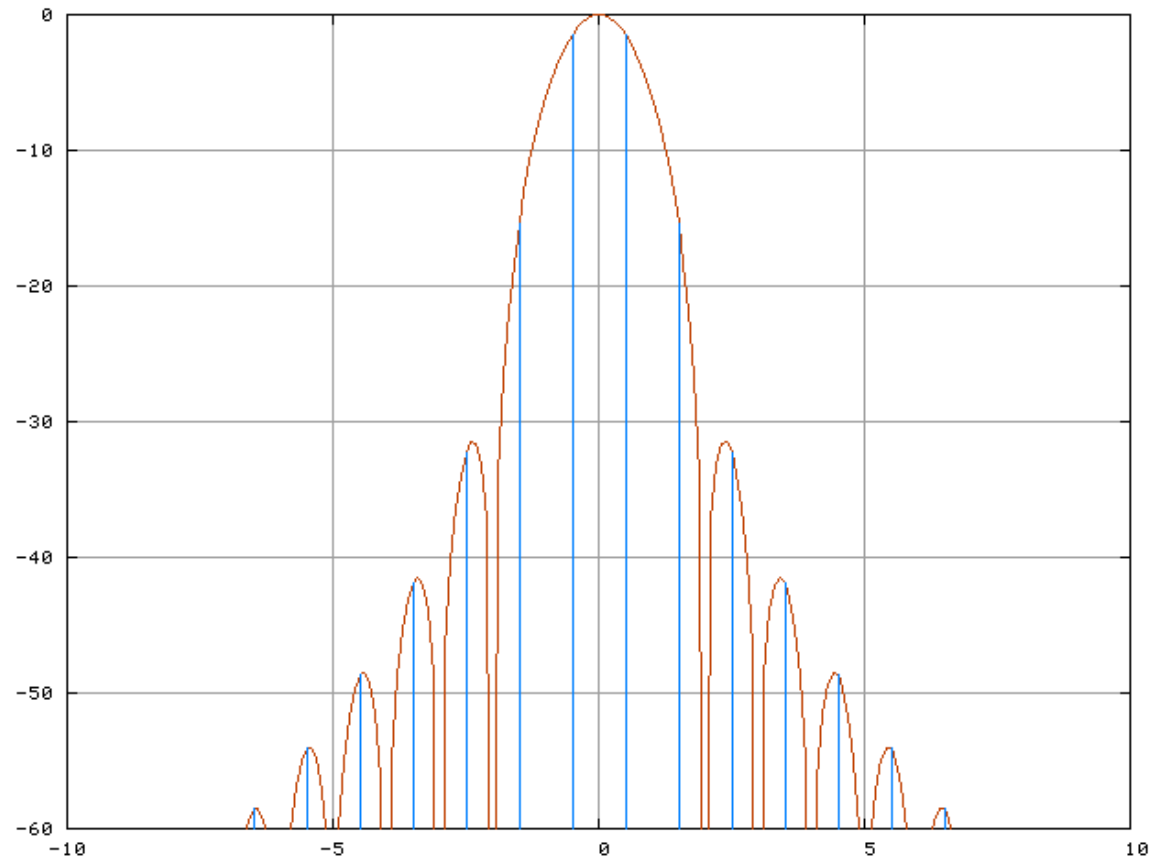
Audio

FFT

Power calc
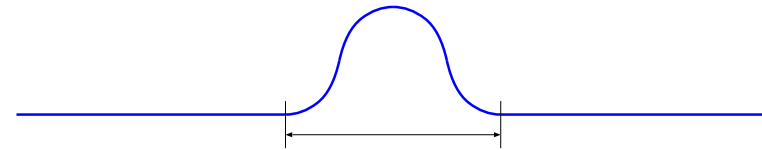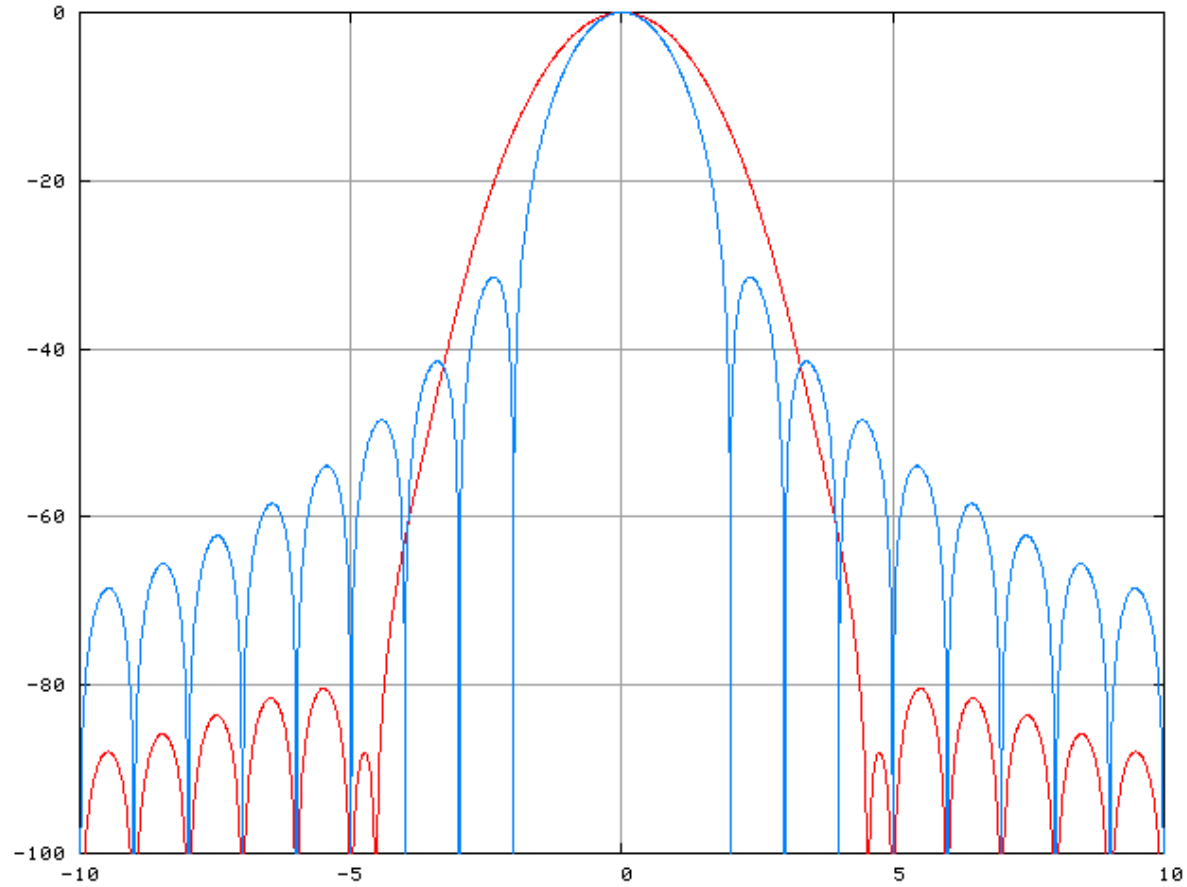
A simple analyser

What's going wrong ?

Filter shape is the FT of the input window.

Rectangular window

Raised cosine window

FFT based spectrum analysis

Raised cosine — JAAA window

FFT based spectrum analysis
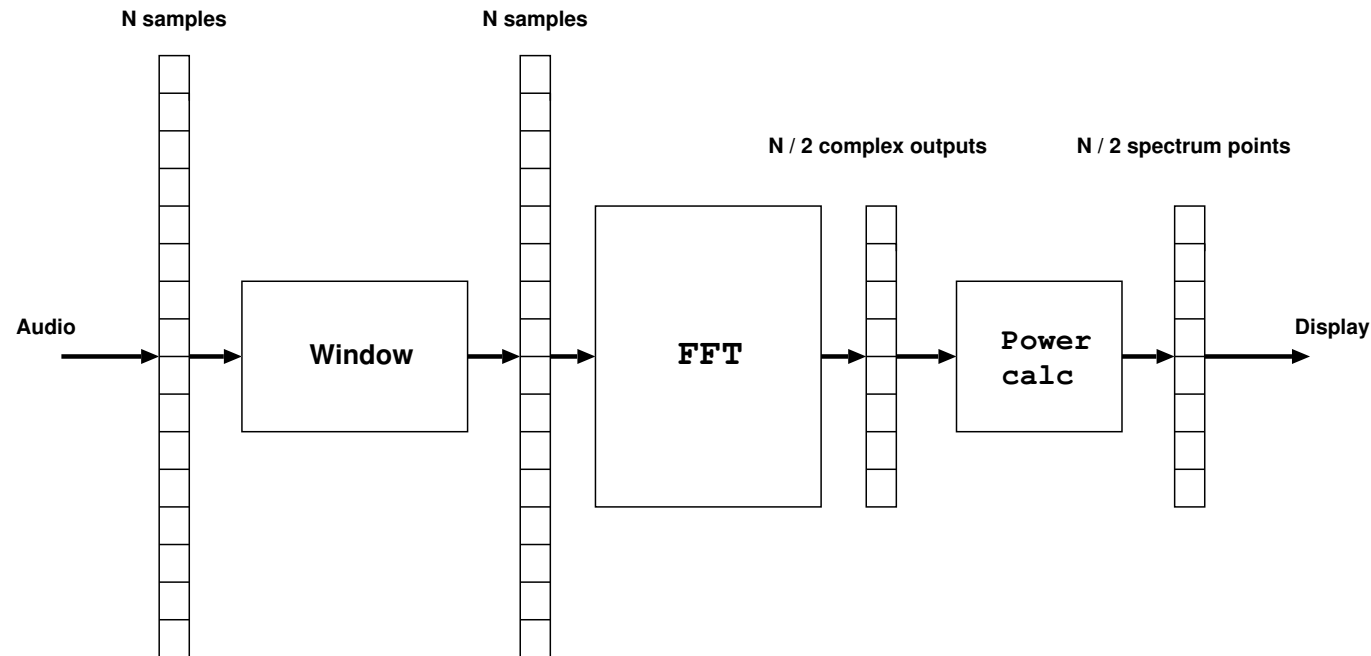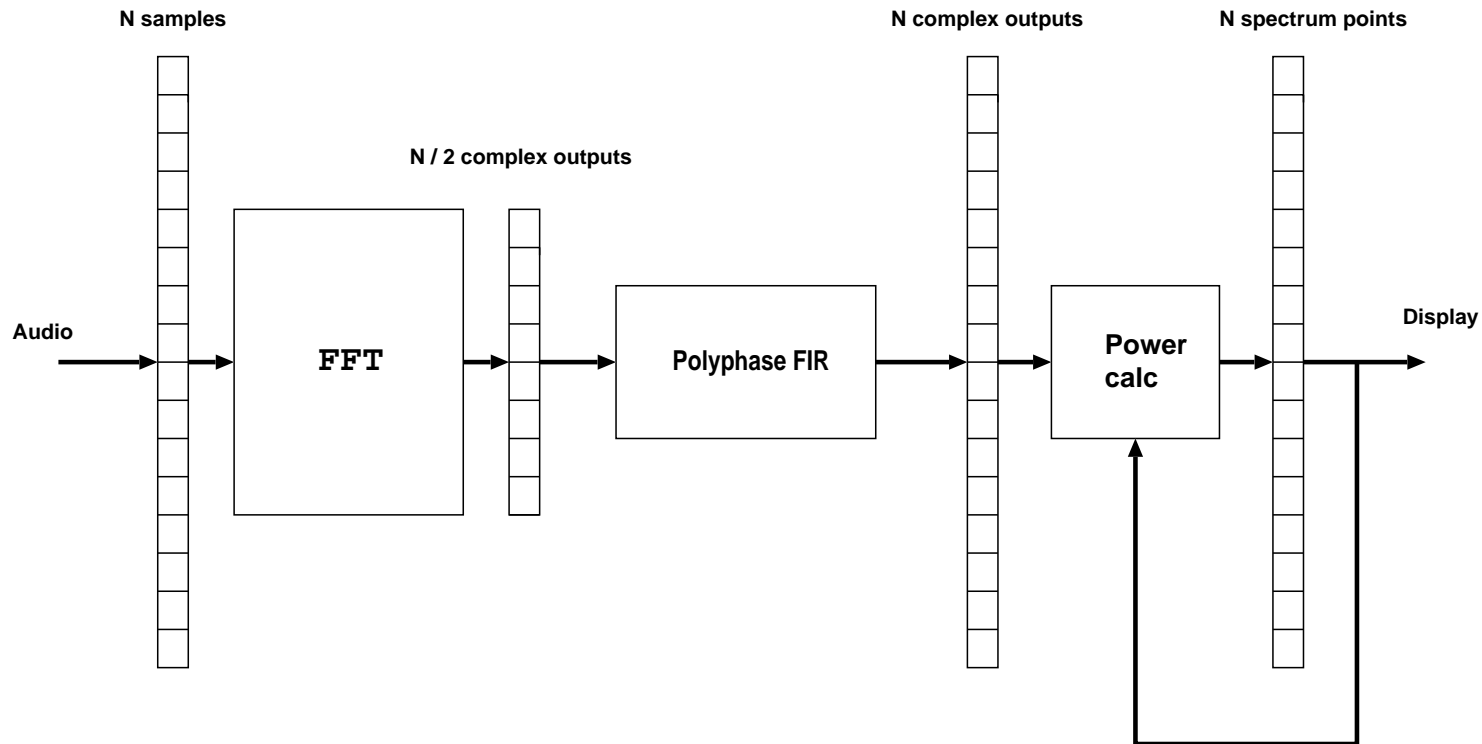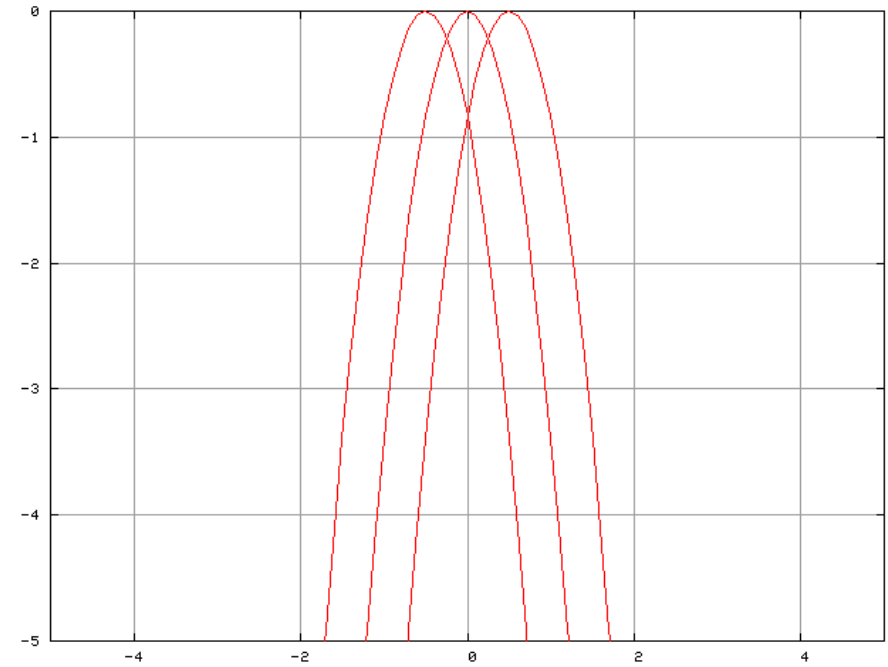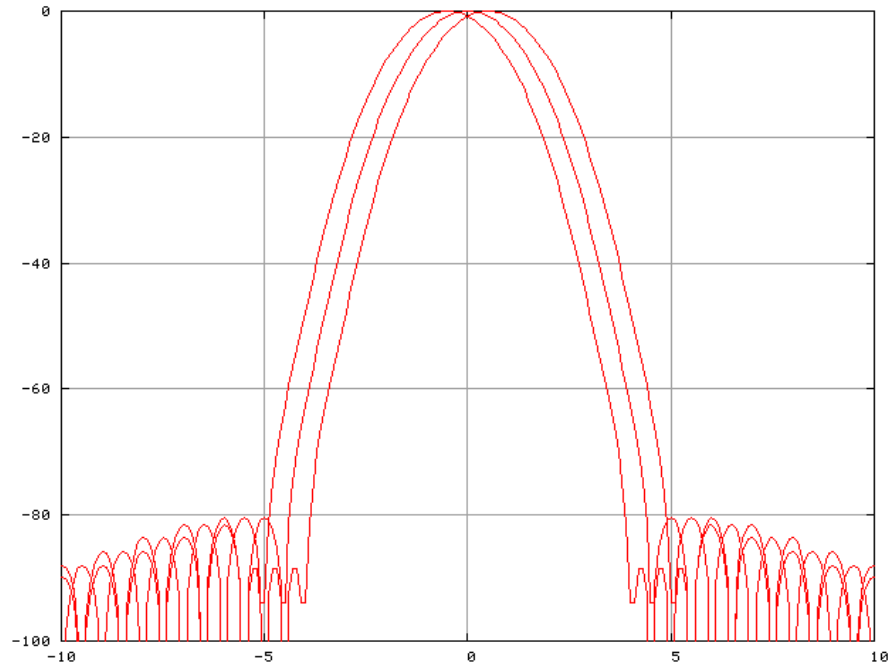

Analyser with windowing

Multiplication before FFT is equivalent to convolution after FFT.
A short convolution can be done by an FIR fiter, so...

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FFT based spectrum analysis

JAAA analyser

Polyphase FIR replaces windowing, and interpolates the spectrum.
Feedback path added for averaging power over time.

Filter responses spaced $\Delta/2 \rightarrow$ maximum error = 0.25 dB.
More accurate measurements are possible by interpolation.

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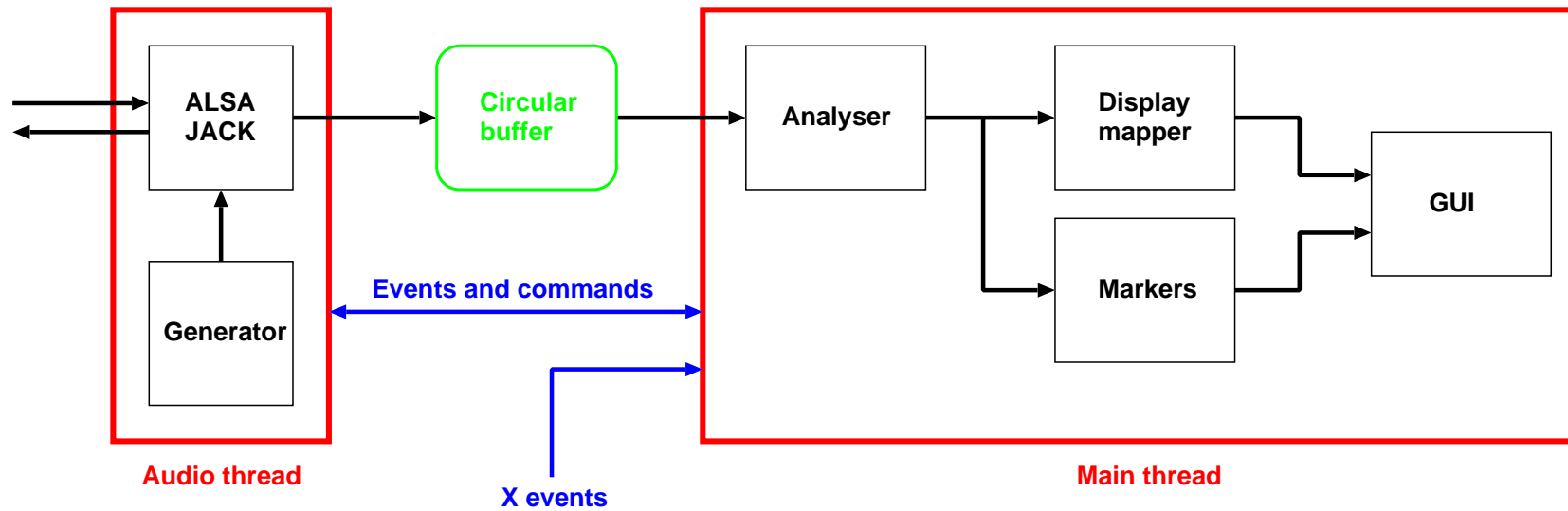A spectrum analyser can be used to measure noise density, N_0.

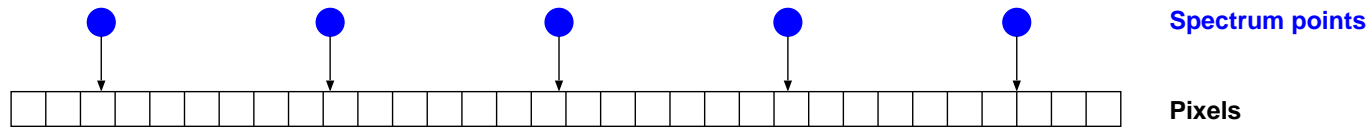N_0 is noise power per 1 Hz of bandwidth.

Total noise power = $N_0 \times B$.

The unit of N_0 is 1 / Hz, or dB / Hz.

Noise level = -10 dB, F_{sample} = 44.1 kHz $\rightarrow$ B = 22.05 kHz = 43.43 dBHz $\rightarrow$ N_0 = -53.43 dB/Hz

Noise level = -10 dB, F_{sample} = 48.0 kHz $\rightarrow$ B = 24.00 kHz = 43.80 dBHz $\rightarrow$ N_0 = -53.80 dB/Hz

JAAA program architecture

Spectrum points

Pixels

More pixels than spectrum points, the easy case.
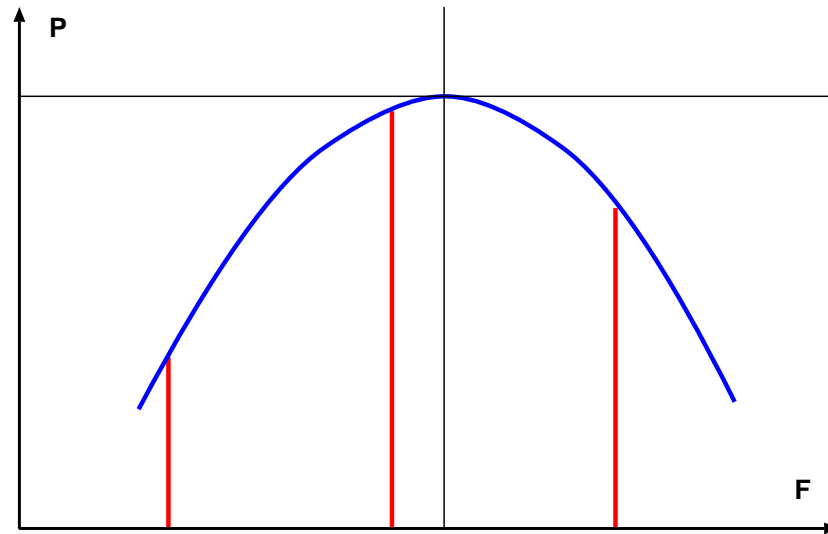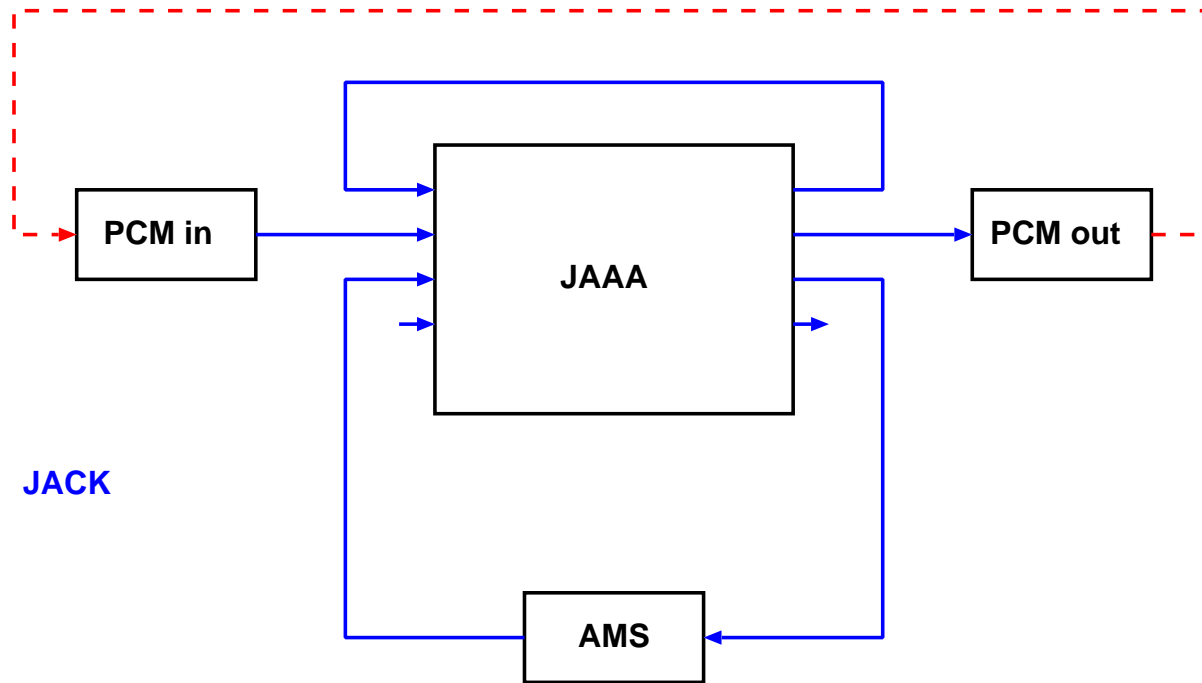
Spectrum points
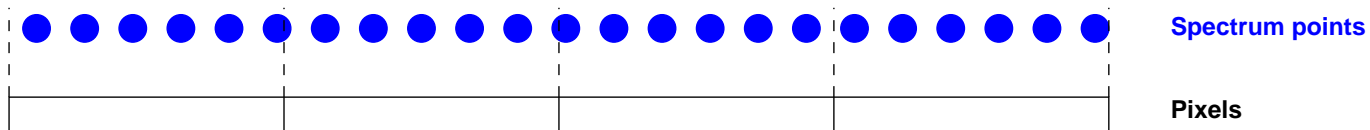
Pixels

More spectrum points than pixels.

Correct signal level display requires peak value
Correct noise level display requires average value

JAAA displays two traces in this case.

Peak markers are calculated using 2nd order interpolation.

Demo signal routing.

- Clean up the code

- Documentation

- More signal generators

- Integrated noise calculation

- Trace memories

- JACK transport

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Question time !

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