Madde and RTSect

...or the magic of sinusoids

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Outline

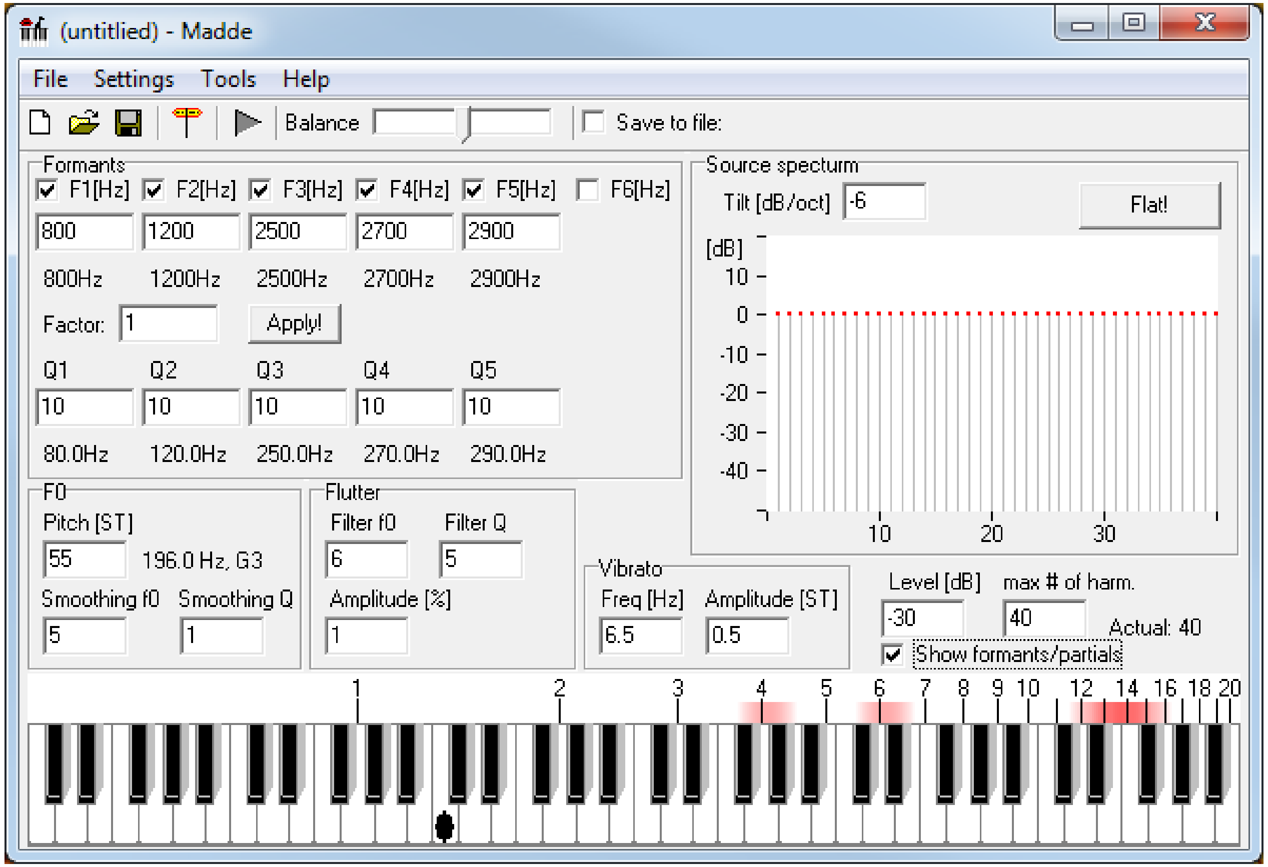
- Madde
- RTSect
- What *is* a partial, really?
  - Sinusoids, spectra, intervals, voice source
- Back to Madde and RTSect, demos and tricks

Madde

- Madde is a singing synthesiser
- Madde is written in honour to Musse, the KTH singing synthesiser from the 1970's
- Musse used an oscillator as the voice source, Madde uses additive synthesis, so that the spectrum of the voice source can be controlled in more detail
- Madde is more of a demonstrator than a research tool

Madde

- Demo



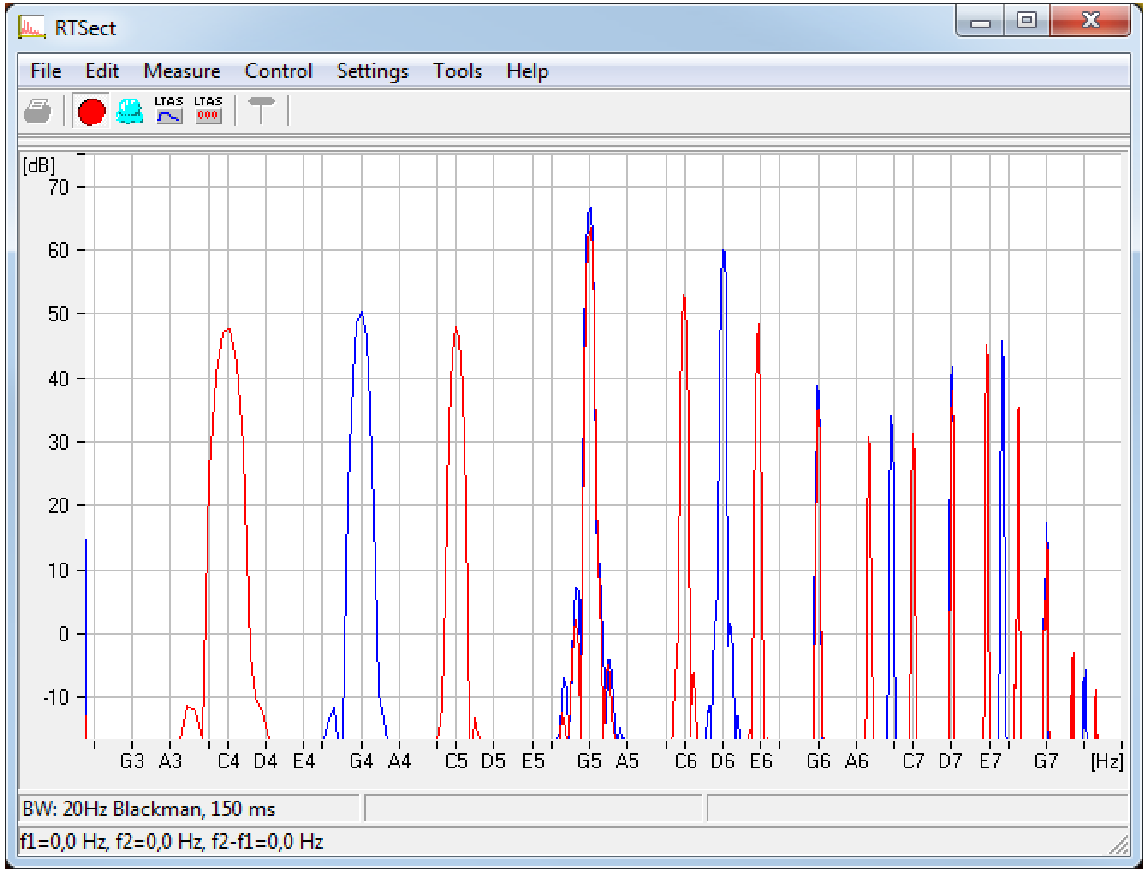
(untitlied) - Madde
File Settings Tools Help
Balance
Save to file:
Formants
F1[Hz] F2[Hz] F3[Hz] F4[Hz] F5[Hz] F6[Hz]
800 1200 2500 2700 2900
800Hz 1200Hz 2500Hz 2700Hz 2900Hz
Factor: 1
Apply!
Q1 Q2 Q3 Q4 Q5
10 10 10 10 10
80.0Hz 120.0Hz 250.0Hz 270.0Hz 290.0Hz
F0
Pitch [ST]
55
196.0 Hz, G3
Smoothing f0 Smoothing Q
5 1
Flutter
Filter f0 Filter Q
6 5
Amplitude [%]
1
Vibrato
Freq [Hz] Amplitude [ST]
6.5 0.5
Source spectrum
Tilt [dB/oct] -6
Flat!
[dB]
10
0
-10
-20
-30
-40
10 20 30
Level [dB] max # of harm.
-30 40
Actual: 40
Show formants/partials
1 2 3 4 5 6 7 8 9 10 12 14 16 18 20

RTSect

- RTSect shows the spectrum in real time
- It can show two spectra simultaneuosly
- The frequency axis can be marked with tones (A4, E2 etc) instead of Hz
- Good for showing intervals, formants etc

RTSect

- Demo



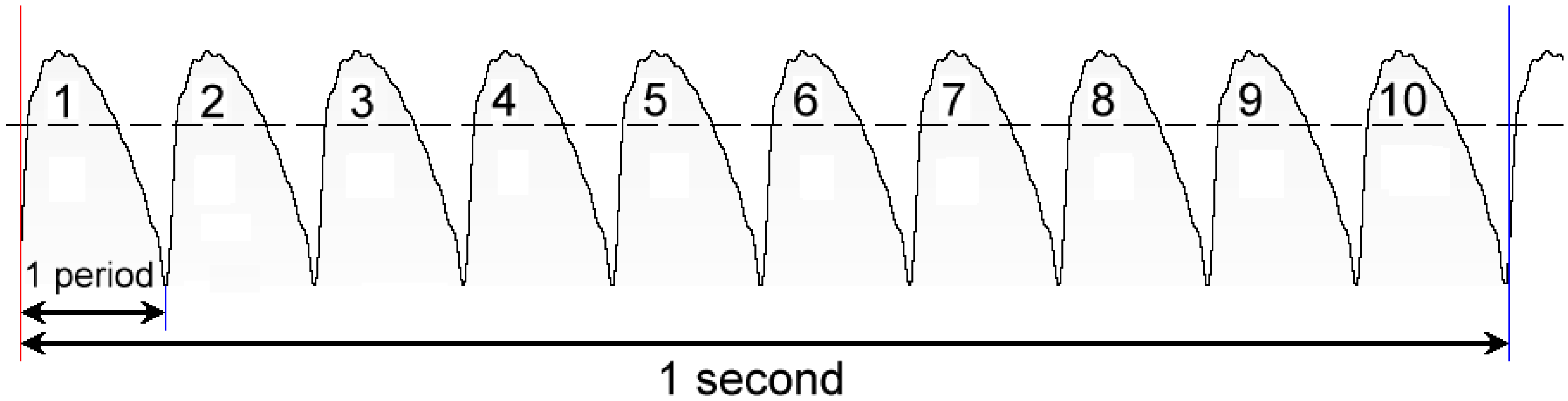
RTSect
File Edit Measure Control Settings Tools Help
[dB]
70
60
50
40
30
20
10
0
-10
G3 A3 C4 D4 E4 G4 A4 C5 D5 E5 G5 A5 C6 D6 E6 G6 A6 C7 D7 E7 G7 [Hz]
BW: 20Hz Blackman, 150 ms
f1=0,0 Hz, f2=0,0 Hz, f2-f1=0,0 Hz

Spectrum?

- So, what *is* a spectrum, really?
- And what are partials?
- Exactly what do we mean when we say that a signal contains both low and high frequencies?
- And what *is* a frequency?

Frequency?

- Frequency means ”often-ness”, ie how often something happens
- So, for example this waveform repeats itself 10 times per second, so it has a frequency of 10 hertz (Hz)



Demo

- Record voice

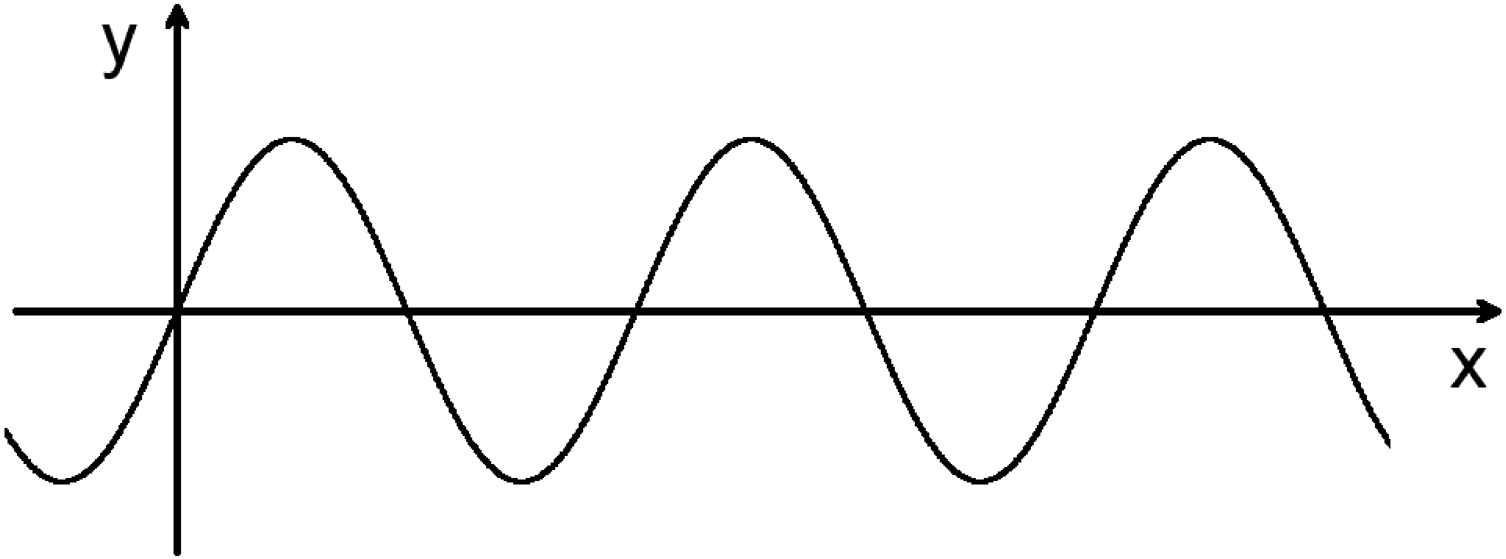
Spectrum = Fourier analys

- Fourier said:
  - Give me any periodic waveform and I can describe it as a sum of sinusoids.

Jean Baptiste Joseph Fourier, 1768-1830, a french scientist

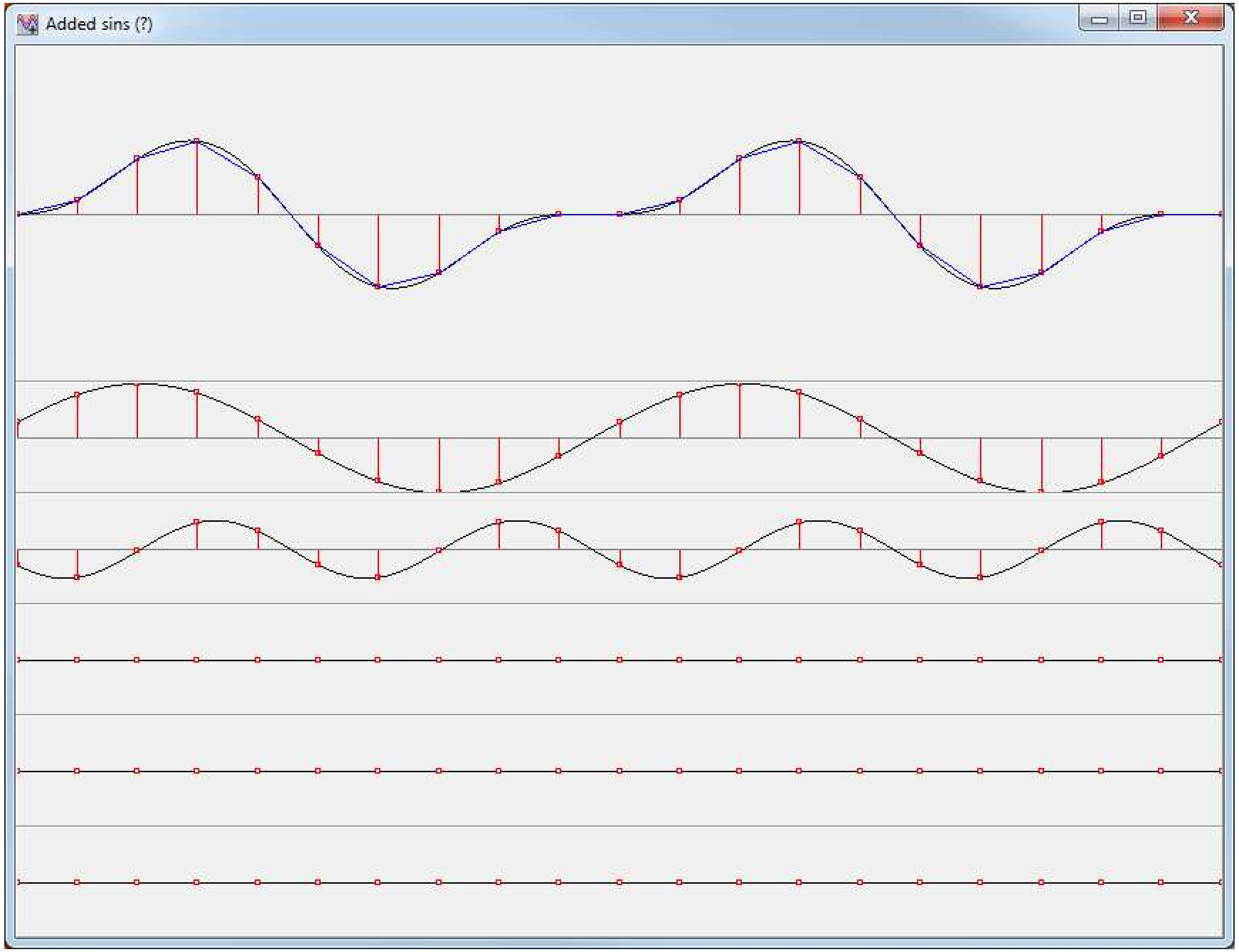
Sinusoid?

$$y = \sin(x)$$



AddSin

- Demo



Adding sinusoids

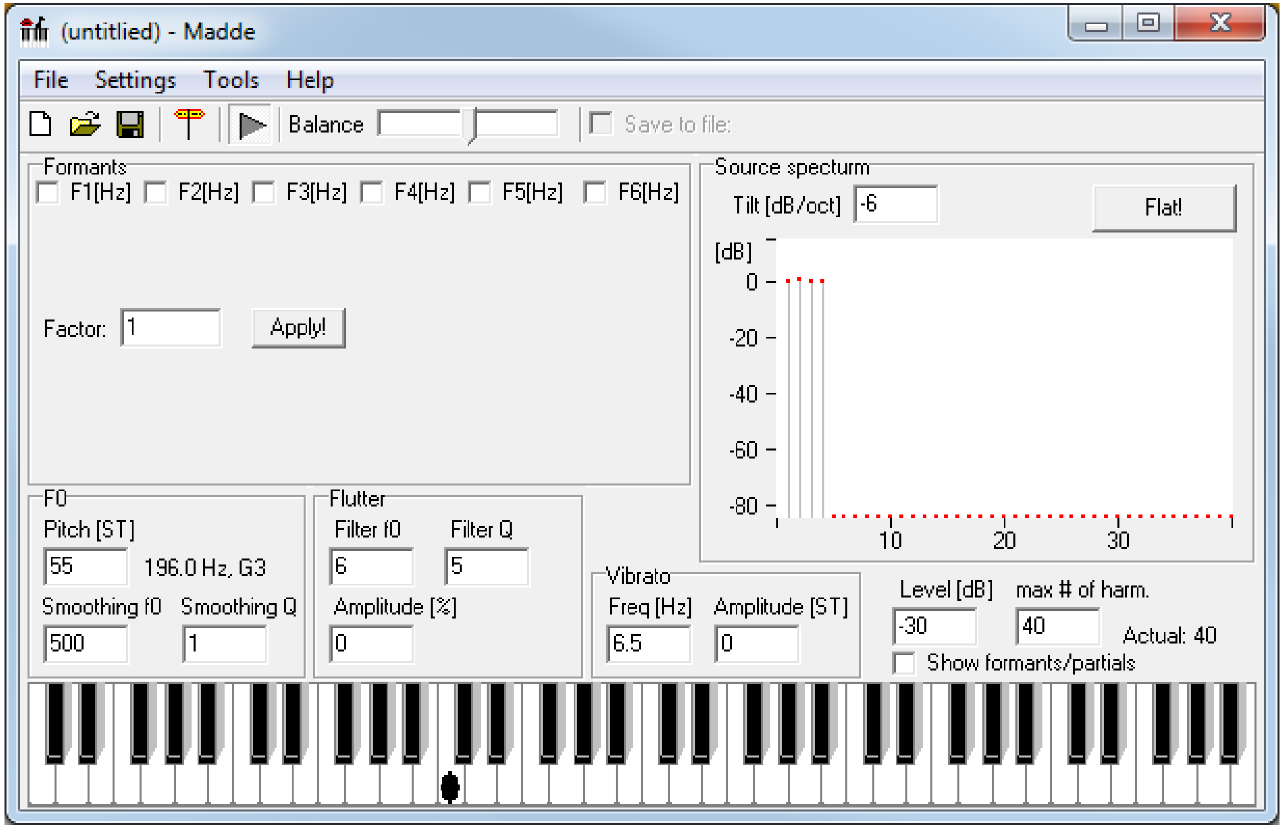
- So, by adding sinusoids we can get any waveform = any sound
- As Fourier said:
  - Give me any periodic waveform and I can describe it as a sum of sinusoids.

Spectrum

- Those sinusoids are actually the ”partials” or ”harmonics” that can be seen in a spectrum
- The spectrum is the signal *seen as* a sum of sinusoids

Madde

- Demo of the sound from added sinusoids



How to find the sinusoids

- That was building a waveform from sinusoids
- Can we go the other way, ie find what sinusoids that are needed to build the signal?
- Yes, RTSect does that (by Fourier analysis)

For a given waveform, how do we find the partials?

- How to find ω_p in f(x):

$$\int_0^T f(x)\cdot\sin(\omega_p\cdot t)dt = \int_0^T A\sin(\omega_1\cdot t)\cdot\sin(\omega_p\cdot t)dt = \frac{A}{2}\int_0^T(\cos((\omega_1+\omega_p)\cdot t)+\cos((\omega_1-\omega_p)\cdot t))dt$$

$$\int_0^T\cos((\omega_1+\omega_p)\cdot t)dt = 0$$

$$\int_0^T\cos((\omega_1-\omega_p)\cdot t)dt = 0 \quad \text{if} \quad \omega_1\neq\omega_p$$

$$\int_0^T\cos((\omega_1-\omega_p)\cdot t)dt = \int_0^T 1dt = T \quad \text{if} \quad \omega_1=\omega_p$$

$$\int_0^T f(x)\cdot\cos(\omega_p\cdot t)dt = \int_0^T A\cos(\omega_1\cdot t)\cdot\cos(\omega_p\cdot t)dt = \frac{A}{2}\int_0^T(-\cos((\omega_1+\omega_p)\cdot t)+\cos((\omega_1-\omega_p)\cdot t))dt$$

$$\int_0^T\cos((\omega_1+\omega_p)\cdot t)dt = 0$$

$$\int_0^T\cos((\omega_1-\omega_p)\cdot t)dt = 0 \quad \text{if} \quad \omega_1\neq\omega_p$$

$$\int_0^T\cos((\omega_1-\omega_p)\cdot t)dt = \int_0^T 1dt = T \quad \text{if} \quad \omega_1=\omega_p$$

$$\int_0^T f(x)\cdot\sin(\omega_p\cdot t)dt \quad \text{and} \quad \int_0^T f(x)\cdot\cos(\omega_p\cdot t)dt$$

Use complex numbers and calculate the cosine integral in the real part and the sine integral in the imaginary part

$$\int_0^T f(x)\cdot(\cos(\omega_p\cdot t)+j\sin(\omega_p\cdot t))dt = \int_0^T f(x)\cdot e^{j\omega_p\cdot t}dt$$

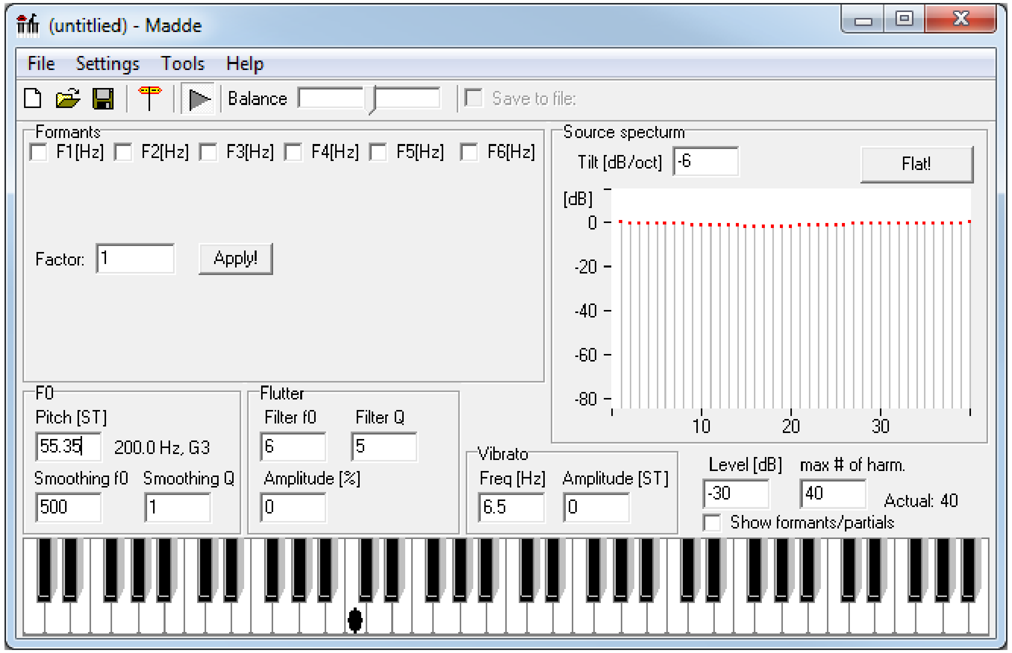
+ add some constants

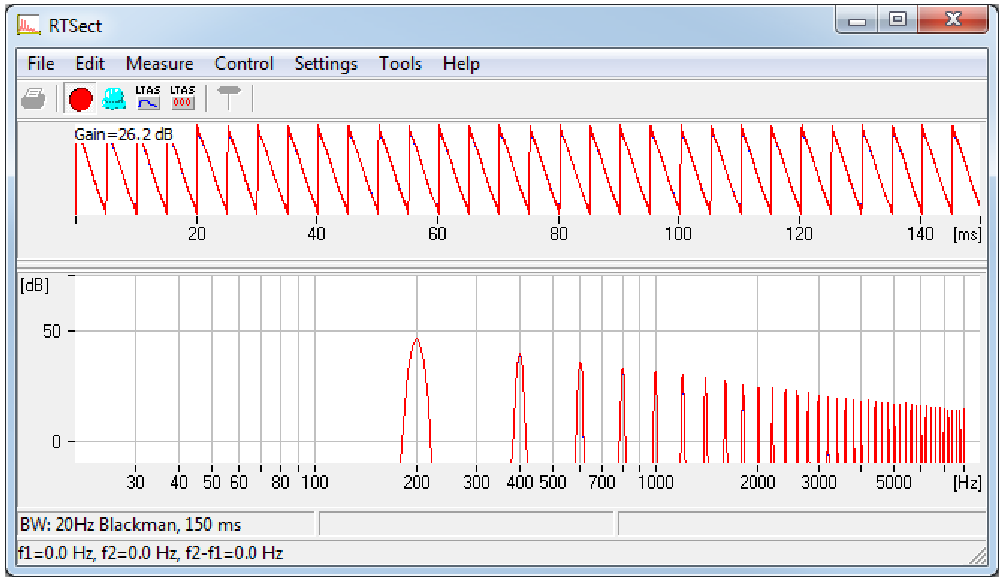
RTSect

- RTSect does the Fourier analysis
  - It shows the partials of a sound

RTSect

- Demo of partials



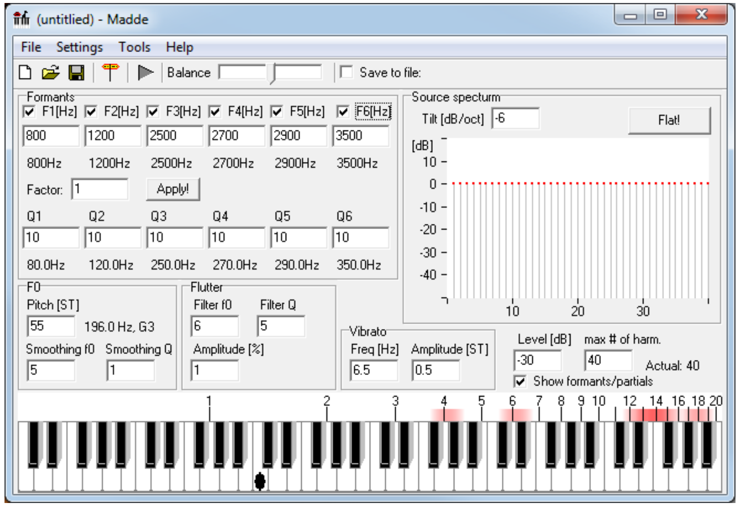


Madde + RTSect

- Partials
- Formants
- 2x Madde – intervals

Madde

- Demo of
  - Formants
  - Throat lengthening
  - Vibrato
  - Flutter
  - Partial/formant matching



RTSect

- Demo of
  - Single/dual channels
  - Frequency axes
  - Bandwidth