Audio Levels and Linux

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Audio Levels and Linux

- What are audio levels?
- Uses of level metering
- Techniques for measuring audio levels
- Software Metering
- Metering on Linux
- PostQC

Audio Levels

- Sound pressure level is measured in decibels
- It is a logarithmic relation between two measures of power
- Not so practical since in audio we generally measure voltage or pressure

$$L_1 = 10 log_{10} \frac{W_1}{W_2}$$

Audio Levels

- Power is related to voltage and pressure by squares
- The formula for decibels can be expressed for voltage or pressure like this:

$$L_p = 10log_{10}\frac{p_1^2}{p_2^2}$$
$$= 20log_{10}\frac{p_1}{p_2}$$

Audio Levels- digital samples

- For single signed integer samples, their individual decibel value (in dB_{FS}) can be calculated as:

$$L_{FS} = 20\frac{ln \mid A_i \mid}{ln10} - 20\frac{lnA_{max}}{ln10}$$

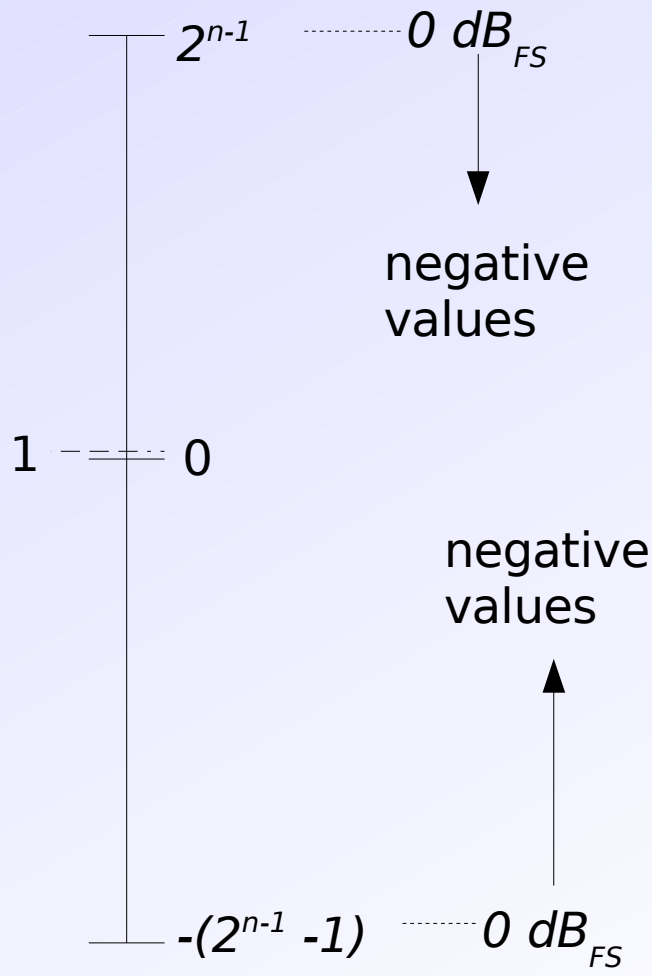
$$= 20\frac{ln(\mid A_i \mid / A_{max})}{ln10} \quad \mid A_i \mid > 0$$

$$= -\infty \quad A_i = 0$$

$A_{max} = 2^{n-1}$

Audio Levels-digital samples

- A_{max} is the maximum amplitude that can be represented in the digital system.
- In dB_{FS} scales, the maximum amplitude takes a value of 0, and all values are negative numbers below it.



Audio Levels- digital samples

- For signed float samples (normalized to 1), their individual decibel value (in dB_{FS}) can be calculated as:

$$L_{FS} = 20\frac{ln(\mid A_f \mid)}{ln10} \quad \mid A_f \mid > 0$$
$$= -\infty \quad A_f = 0$$

Root Mean Square

- A way of calculating “energy” for an oscillating signal is calculating its RMS, since individual samples don't reflect this.
- RMS is defined as:

$$f_{rms} = \sqrt{\frac{1}{T_2 - T_1} \int_{T_1}^{T_2} [f(t)]^2 \, dt}$$

Root Mean Square

- For discrete signals (like digital audio), RMS can be calculated as:

$$x_{rms} = \sqrt{\frac{1}{N}\sum_{k=1}^{n} x_k^2}$$

Loudness

- There is a fundamental difference between perceived loudness and nominal audio levels due to the imperfections of the auditory system.
- This has several causes:
  - Loudness is a function of frequency and this function in turn depends on pressure levels (Described in the well known Equal Loudness contours)
  - Short sounds are perceived softer than longer sounds particularly below 100 ms.

Uses of level metering

- To keep levels within equipment limits
- To assist subjective judgement of levels
- To comply with program delivery or industry standards

Techniques for measuring audio

- VU (Voltage Units)
  - Developed in 1939
  - Power measurements with time averaging
  - 0 VU = 1000 Hz tone @ +4 dB_U (4 dB above 0.775 Volts(RMS))
  - 300 ms to reach 99% of the target value (Rise time)
  - Slow, doesn't show short transients
  - OK for approximation of speech loudness and avoiding distortion on consoles with little headroom.

Techniques

- PPM (Peak programme meter)
  - Designed to address short comings of VU's.
  - Faster response, similar to an ear's response to transients and distorsion.
  - Different standards
    - Nordic: Attack time 5 ms for 77.77% target level, Decay time 1.5 seconds for 20dB. Scale from -36 to 9.
    - BBC/EBU: Attack time 10±2 ms for 77.77% target level, Decay time 2.8±0.3 seconds in fast mode, 3.8±0.5 seconds in slow mode for 24 dB. BBC scale from 1 to 7 (4 = 0 dB). EBU scale from -12 to 12
    - DIN defines another type of fast PPM metering

Techniques for measuring audio

- Sample peak meter
  - Shows the maximum sample value
  - Implements some “fall off” mechanism to improve readability. Usually the last peak is multiplied by a factor, and compared to the new sample. The greatest of the two is the current peak value
  - Can miss intersample peaks that may appear on the DAC. (corrected with interpolated upsampling)

Techniques for measuring audio

- Equivalent continuous sound Level
  - Identified by some studies as an accurate measure of perceived loudness.
  - Implemented mostly on sound pressure level meters, not recording equipment
  - Adopted by Dolby on their flagship LM-100 level meter.
  - Basically an A-weighted RMS measurement.

Equivalent Continuous Sound Level

- Equivalent continuous sound level is defined as:

$$L_{A_{eq}T} = 20log_{10}\left[\frac{\sqrt{(1/T)\int_{t-T}^{t} p_A^2(\xi)d\xi}}{p_0}\right]$$

- Expressed for discrete systems as:

$$L_{A_{eq}T} = 20log_{10}\left[\frac{\sqrt{(1/N)\sum_{k=1}^{n} x_k^2}}{p_0}\right]$$

Other loudness calculation techniques

- Zwicker Loudness model
- LARM and HEIMDAL algorithms from TCElectronics
- Claim to be better models, but neither is broadly accepted or implemented.

Weighting

- An important part of loudness measurement involves simulating the ear's relation between frequency and loudness.
- Weighing networks are used (basically filter network frequency response specifications)

Weighting

- A,B and C weighting
  - For low, medium and high pressure levels respectively
  - Low pass and high pass filters with a flat middle range
- M weighting
  - “Movie” weighting used to measure film trailer loudness

Weighting

- RLB and RL2B
  - Revised low frequency B-weighings
  - Some studies suggest this weighing as the most accurate for perceived loudness measurements
  - Standardized by ITU for an Leq(RLB) measurement.
- Still no concensus on the best weighting. Several contradictory results.

Software Metering

- Spectrafoo
- Signal Tools
- Pinguin Audio Meter Pro
- Many others....

Metering on Linux

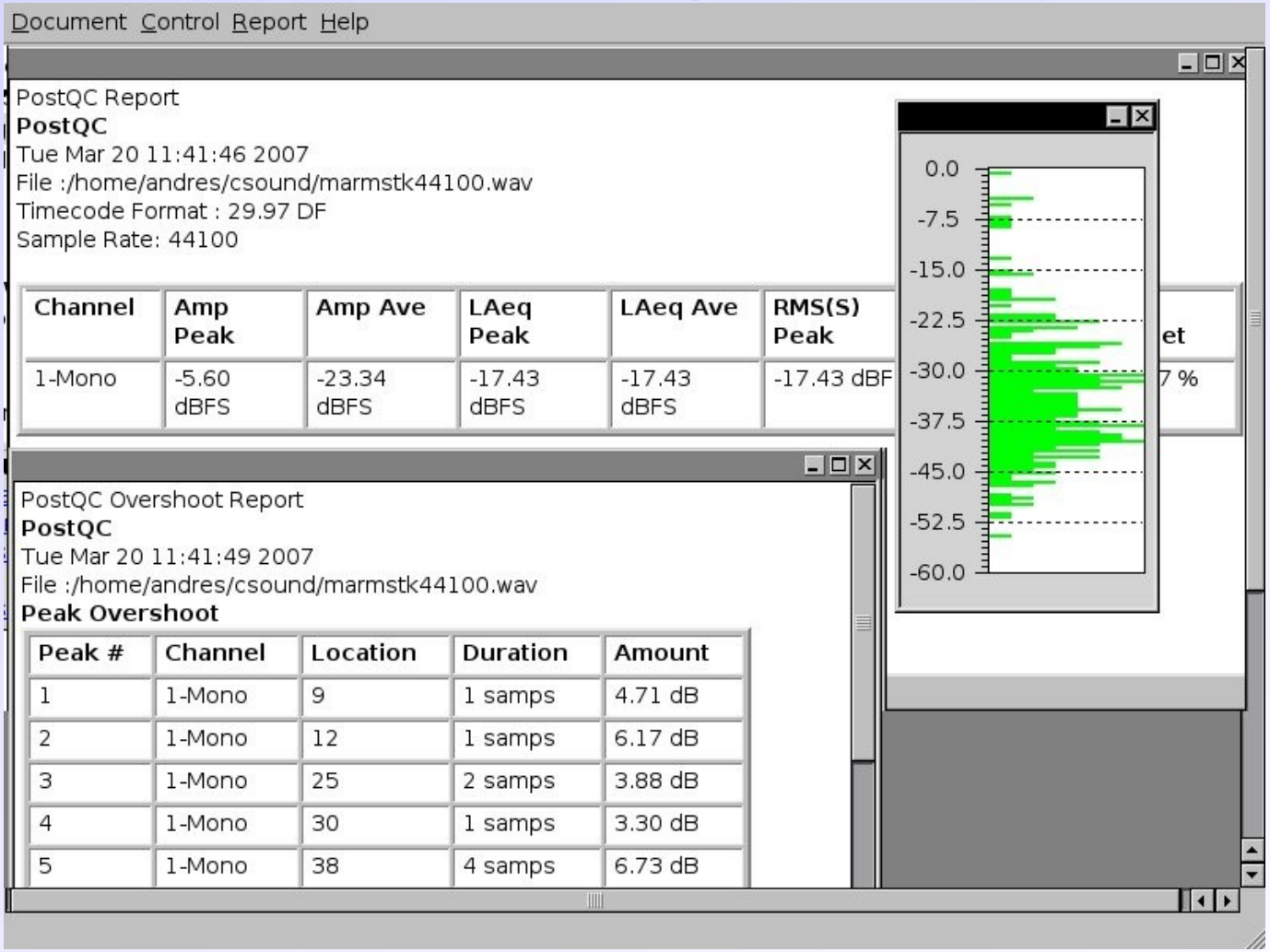
- Audio recording and editing software usually implement Sample Peak Meters, which are easy and efficient to implement
  - Sometimes as graphics (Ardour, Rosegarden, etc.)
  - Sometimes as text (Csound, PD, etc.)
- Meterbridge by Steve Harris
  - VU, Peak and PPM meters
  - Visually appealing

What's missing

- Modern standard compliant Loudness metering (LAeqT, Leq(RLB), etc.) especially for Digital TV post production.
- Meter logging
  - Text log
  - Timeline
  - Histogram
- Accurate perceived loudness measurements for use in automatic loudness matching.

PostQC

- In early alpha stage (horrible code and design...)
- Some features already working, though



PostQC Goals

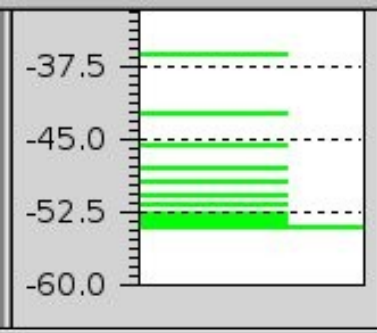
- Realtime and offline analysis
- Many types of standard metering
- Real-time graphical meters
- Upsampled peak metering
- Written report of results
- Lashified
- Emulation of LM100 dialog detection
- Overshoot report
- Histograms
- Careful adherence to standards

PostQC

Document Control Report Help

PostQC
Tue Mar 20 11:50:21 2007
File :/home/andres/tonostereo.flac
Timecode Format : 29.97 DF
Sample Rate: 48000

Channel	Amp Peak	Amp Ave	LAeq Peak	LAeq Ave	RMS(S) Peak	RMS(S) Ave	DC Offset
1-Left Front	-6.00 dBFS	-15.96 dBFS	-8.90 dBFS	-9.06 dBFS	-8.90 dBFS	-9.06 dBFS	0.00 %
2-Right Front	-6.00 dBFS	-15.96 dBFS	-8.90 dBFS	-9.06 dBFS	-8.90 dBFS	-9.06 dBFS	0.00 %
3-Left Surround	-6.00 dBFS	-15.96 dBFS	-8.90 dBFS	-9.06 dBFS	-8.90 dBFS	-9.06 dBFS	0.00 %
4-Right Surround	-6.00 dBFS	-15.96	-8.90	-9.06	-8.90 dBFS	-9.06 dBFS	0.00 %



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File :/home/andres/tonostereo.flac
Peak Overshoot

Peak #	Channel	Location	Duration	Amount
1	1-Left Front	2	20 samps	14.00 dB
2	1-Left Front	26	20 samps	14.00 dB
3	1-Left Front	50	20 samps	14.00 dB
4	1-Left Front	74	20 samps	14.00 dB

PostQC

- http://sourceforge.net/projects/postqc
- GPL
- All and any help most welcome!

Questions...