What is “Dynamic Range”

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Dynamic Range

• Is it a perceptual thing? What kind of experience do listeners have:
  – Does that mean over the short term?
  – Does that mean from Loudest to Quietest?

• Is it an analytic thing?
  – Does it mean peak signal to lowest level
  – Peak to noise floor
  – RMS to noise floor
  – But what about peak/RMS ratio?
Now, that’s a really really really good question
There are some standards:

• I’m not going there.

• They are standards that are analytic measurements.

• They are what they are.
A Simple way to define it:

- Ratio (usually expressed as dB)
- Flat Noise Floor
- Peak level (same at all frequencies)
Otherwise it hasn’t been defined very well.

• Some issues that might be involved
  – Is it loudness (i.e. perception)
    • Does that vary in the short term? Does that matter?
    • Does it vary in the long term? Does that matter?
    • Is it the Loudest to Softest part of the recording
      – But what about room noise, then?
    • Is it the distribution of loudnesses?
Who remembers what Loudness is?
• Loudness is sensation level

• Energy measurements are analytic levels
Loudness and Intensity

• Loudness is not SPL

• SPL is not loudness

• Don’t forget that.
Some analytic possibilities:

• It’s RMS level vs. noise floor

• It’s Peak Level vs. noise floor

• It’s bit depth
  – Room noise?
A Simple way to define it:

- Peak level (same at all frequencies)
- Ratio (usually expressed as dB)
- Flat Noise Floor
- Room Tone?
What peak?

• Highest level at some given frequency?
• Maximum RMS with white/pink noise?

• Peak level is frequency dependent in some systems.
  – Including some systems fed by PCM data, in fact.
A Simple way to define it:

- Peak level (same at all frequencies)
- Ratio (usually expressed as dB)
- Flat Noise Floor
- Room Tone

Well???
Some Good News

• PCM and most (but not all) low-level electronics have a pretty flat noise floor and peak level.

• Amplifiers, speakers, vinyl, tape, FM, AM, well, not so much.
  – But that’s bad news. Sorry.
Analytic Measurements

• They are very useful in some cases.
  – They help determine noise floor
  – They help determine overload issues

• **They are essential to understanding your overall gain structure.**

• So, when you are setting up a system, pay attention.
About “Dynamic Range” in amplifiers, etc?

• That is an analytic measurement, expressed in dB:
  – Maximum output is measured or calculated
  – Noise floor (perhaps in the presence of signal for digital equipment, to avoid zero-stuffing) is measured
  – The ratio is expressed in dB, providing us with a dynamic range measure.
The dynamic range of a listening room:

- Consider a reasonably quiet listening room, with the usual stereo equipment:
  - Low level (dB C) circa 40dB C
  - Low level (dB A) circa 20dB A
  - Peak level from a stereo 105dB C
  - Dynamic range is then 65dB – Doesn’t seem like much, does it?
    - But wait, why the difference in C vs. A weight?

- True, but useless
  - You need to consider the frequency shape of the noise floor here.
    - And it wouldn’t hurt to consider the spectrum of the signal you’re listening too, either.
Noise Spectrum

• Even in the absence of peak level that changes with frequency, we need to look at the noise floor:
  – This affects PCM with a flat noise floor and peak level when the signal goes through any other equipment.
  – So, maybe a meaningful measurement would be “dynamic range as a function of frequency”
    • But there must still be assumptions made, except when you’re working on your gain structure.
Analytic measures

• Essential for setting up systems, gain structure, etc.
• Not very revealing for the average listening room
• Vary across frequency
  – Nobody measures that
  – Nobody provides that in their specs!
What’s more useful (perhaps)?

• Perceptual systems.
  – Short-term variations in loudness do seem to correlate to “dynamic” signals
  – Long-term variations in loudness seem to give people a sense of dynamic range

• So, are “dynamics” short term or long term?
YES!
What do we measure Dynamic Range in units of, then?

• Well, that’s a good question, presently one will see dB everywhere.
  – Sones or Phons would make sense for the perceptual issues. (remember, loudness is a perceptual quantity, not an analytic quantity)
  – How would we compare this to dB?
    • You can’t.
    • Really.
    • Different problem, different units.
    • Don’t do that, PLEASE?
Perception???

- Measuring loudness is possible, at least for instantaneous loudness.
  - I’ve talked about that already. Probably shouldn’t go into that again. (Loudness tutorial, Apr 2006)
  - What, then, is the “loud” part, and what is the “quiet” part?
    - Do we look at the max and minimum over the entire system, or track, or signal, or music?
    - Do we, rather, look at local variations in loudness?
Well, guess what?

• Some people do one, some the other
  – People can’t even agree on the long-term “loudness” of something (in a perceptual sense)
    • Some regard peak as the “loudness” for a track
    • Some seem to take some sort of average.
    • These can disagree by 10dB in equivalent gain change or more

• Dynamics is even worse
  – Some people want deep, dark quiet
  – Some people are more happy with a “comfort noise” background.
So, what now?

• There is a lot of room for meaningful experimentation
  – Yes, there is BS1770/BS1771.
    • It works great for stuff that’s already been radio processed.
    • Be careful beyond that.

• That still doesn’t cover “dynamic range”
• Ditto what a “dynamic” musical clip is
Some examples of measured loudness

- This is not a perfect measure, there’s no such thing
- It doesn’t consider absolute threshold
- It does not have proper time domain response for high frequencies.
- You can have the script any time you want
- You can improve it if you want
- It still works reasonably well
What’s in the Plots?

• The top plot:
  – Horizontal axis is loudness, in arbitrary units
  – Vertical axis is normalized probability of that loudness

• The bottom plot
  – Horizontal axis is time, without plotting silent blocks
  – Vertical axis is loudness, same arbitrary units
Ragtime Piano
A natural recording in a small space, no processing for good or bad.
Bird on a Wire

An acclaimed, older pop recording.
Songs from the Woods

A newer rock/pop recording, mostly vocal.
Sk8rboi

More recent pop recording.
Strawbs – Part of the Union

Older British Rock recording.
Over the hills (and far away)

Classic 1970’s Rock
Green Day

Modern Rock
Some “Modern Classical” examples

**No Reverb**

**Reverb**
Effects of Normalization
Moderate Squishing
Toothpasting
And made L O U D