Dolby

AGC Tuning and Verification

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2022

Adaptive Gain Control

- Existing feature in PC baseline for SBA
  - Protects against out-of-range going into the core codec.
- Currently disabled by default, pending further tuning and testing.
- Here we present tuning and testing results.

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Testing

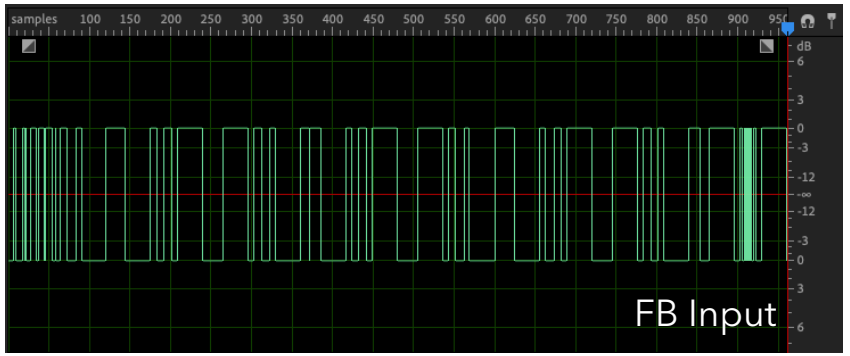
Out of range signals in SBA encoder

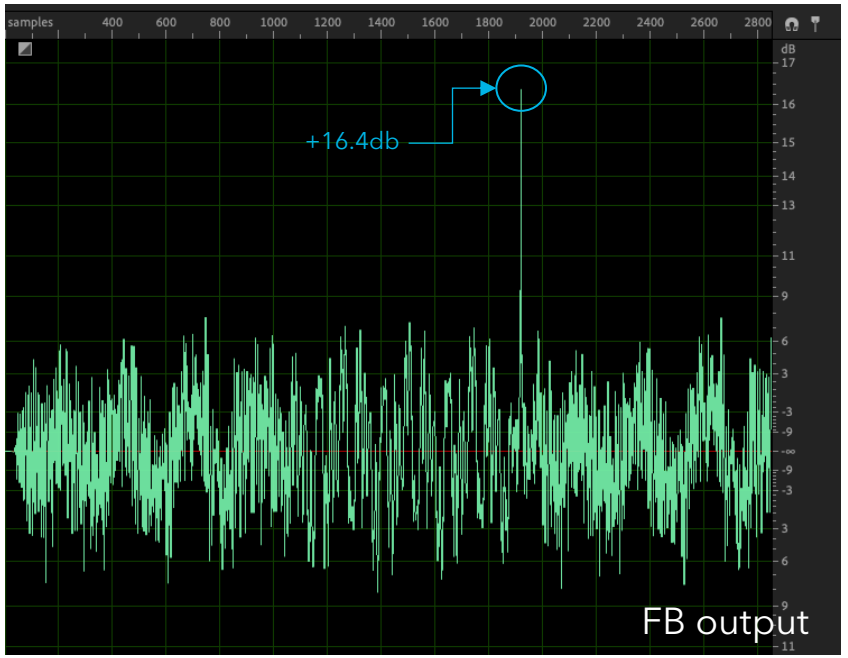
- 3 ways in which signals can go out of range (> 0dBFS) before entering the core coder
  - **Encoder filter bank gain**
  - **SPAR downmix**
  - **HPF gain + DC bias**

Out of range signals in SBA encoder

Encoder filter bank gain

- Encoder filter bank can have out-of-range output given single in-range input and band gains in the range -1 to 1.
- Worst case was found to be **+16.4dB**
  - Gain vector: g = [1, -1, -1, 1, -1, 1, -1, -1, 1, -1, 1, -1]
  - Worst-case signal: sign($h_g(-t)$)
- The gain vector exposes constructive interference that can occurs due to overlapping band responses.





Out of range signals in SBA encoder

SPAR downmix

- Downmixing 4 channels to 1 transport channel can cause up to 6dB of gain.

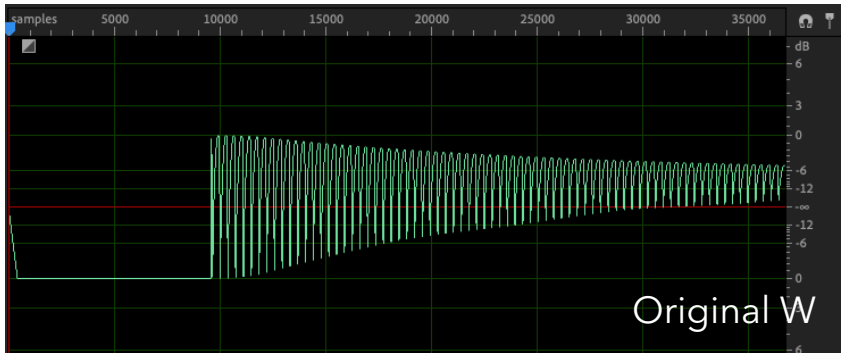
  (taking into account SN3D normalization)

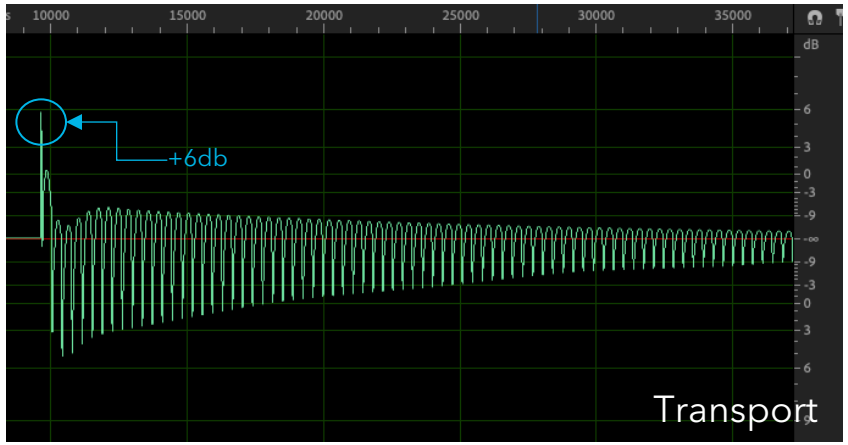
- Active W mode can increase this to 9db of gain.

Out of range signal in SBA encoder

HPF gain + DC bias

- When a large DC bias passes through the HPF at the front of the encoder, a large ~6dB peak can be observed.



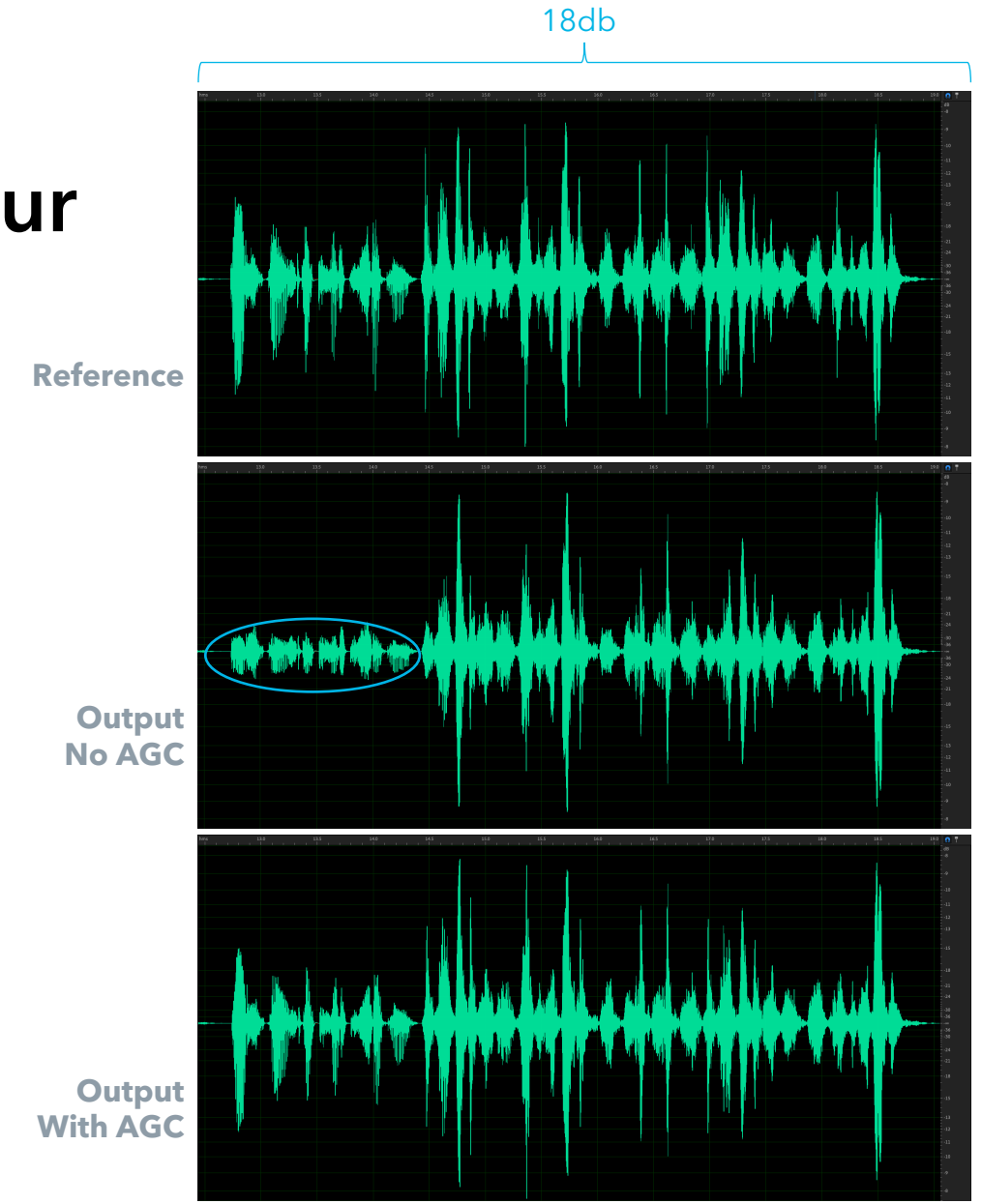


SCE behaviour on OOR signals

- Out of range (OOR) signals cause undesired behaviour in SCE at <= 32kbps.
- Experiment:
  - A voice + bird chirping FOA signal was constructed, scaled and repeated such that the peak amplitude would be 8dB, 12dB, 18dB and 24dB
  - The code was modified to allow the signal to be injected just before the AGC component in the encoder and dumped just after the AGC component in the decoder.
    - In this way, the effect of AGC and core coder components alone can be examined.
  - The codec was run in SBA mode, 32kbps.

Out of range signal SCE behaviour

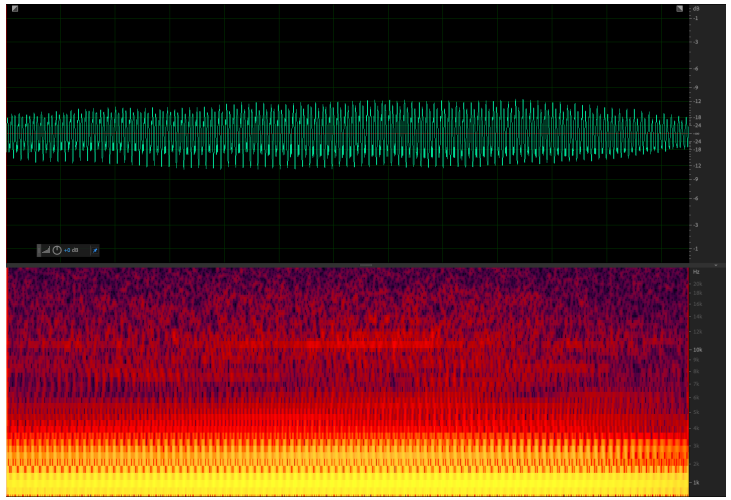
- We see signal loss and artifacts due to signal going out of range
  - Reference: signal before core coder
  - Output No AGC: signal after core coder in the case where AGC is disabled
  - Output AGC: signal after both core coder and AGC, where AGC was enabled
- The signal sounds very compressed and distorted



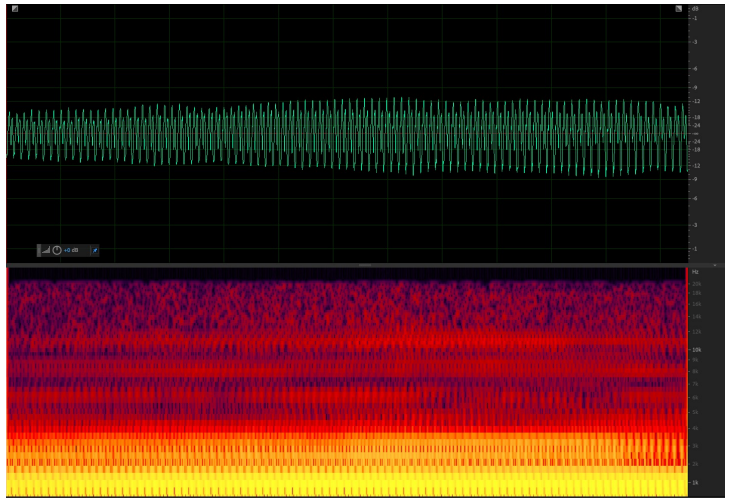
Clicks found with AGC on

- A dynamically compressed signal, typically found with music content, was passed through the codec in both AGC on and AGC off case.

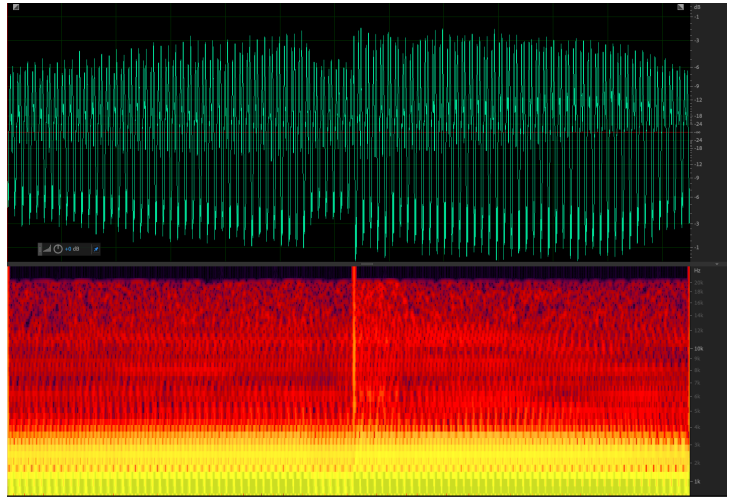
- We can see that a ‘click’ artifact is introduced when AGC is on for bitrates <= 32kbps



Input



Baseline with AGC disabled



Baseline with AGC enabled

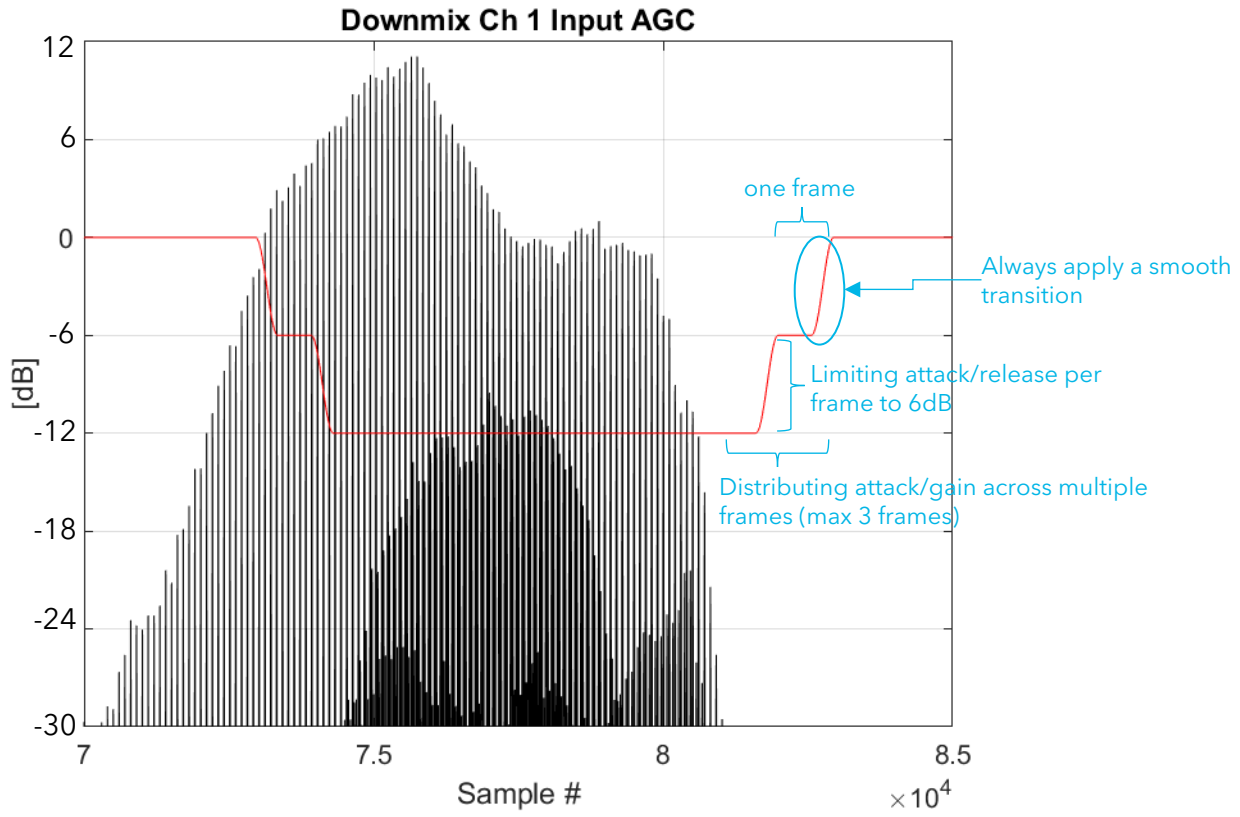
Tuning

Source of the ‘click’ artifact

- AGC currently changes the level instantaneously when a large gain attenuation is required.
- Core coder poorly handles such abrupt changes in the signal, occasionally producing click artifacts when AGC undoes the attenuation.

Solution to ‘click’ artifact problem

- Limiting the attack/release done per frame to 6dB
- Always distributing the total amount of attack/release to be done across a maximum of 3 frames
- Removing hard transition cases and instead always doing a smooth transition
- Tuning is BE for signals that do not become OOR within the encoder
- For OOR signals, it is of-course non-BE after tuning changes.



Complexity (WMOPS)

Scenario	24.4kbps AGC on before tuning update	24.4kbps AGC on after tuning update	32kbps AGC on before tuning update	32kpbs AGC on after tuning update
Encoder – FOA – OOR*	134.014 (2.633)	133.358 (2.637)	143.264 (2.633)	143.327 (2.637)
Decoder – FOA – OOR*	141.905 (0.701)	141.925 (0.701)	144.350 (0.701)	144.370 (0.701)

Scenario	24.4kbps AGC off	24.4kbps AGC on	32kbps AGC off	32kpbs AGC on
Encoder – FOA – No OOR	131.253	133.336	141.526	143.609
Decoder – FOA – No OOR	142.005	142.005	144.466	144.466
Encoder – FOA – OOR	131.054	133.358	140.736	143.327
Decoder – FOA – OOR	141.925	141.925	144.370	144.370

- Input was an FOA signal and the decoder was configured to produce FOA output.
- Tuning change doesn't have a significant changes to the WMOPS (below 1.0 WMOP)
- AGC feature in general has an average WMOPs increase of ~2.5WMOPs in the encoder when turned on. No change in decoder.
- * The numbers shows whole encoder max cummlative WMOPs and in brackets the number shows the max cummlative WMOPs of just agc_enc/dec_process

Memory usage

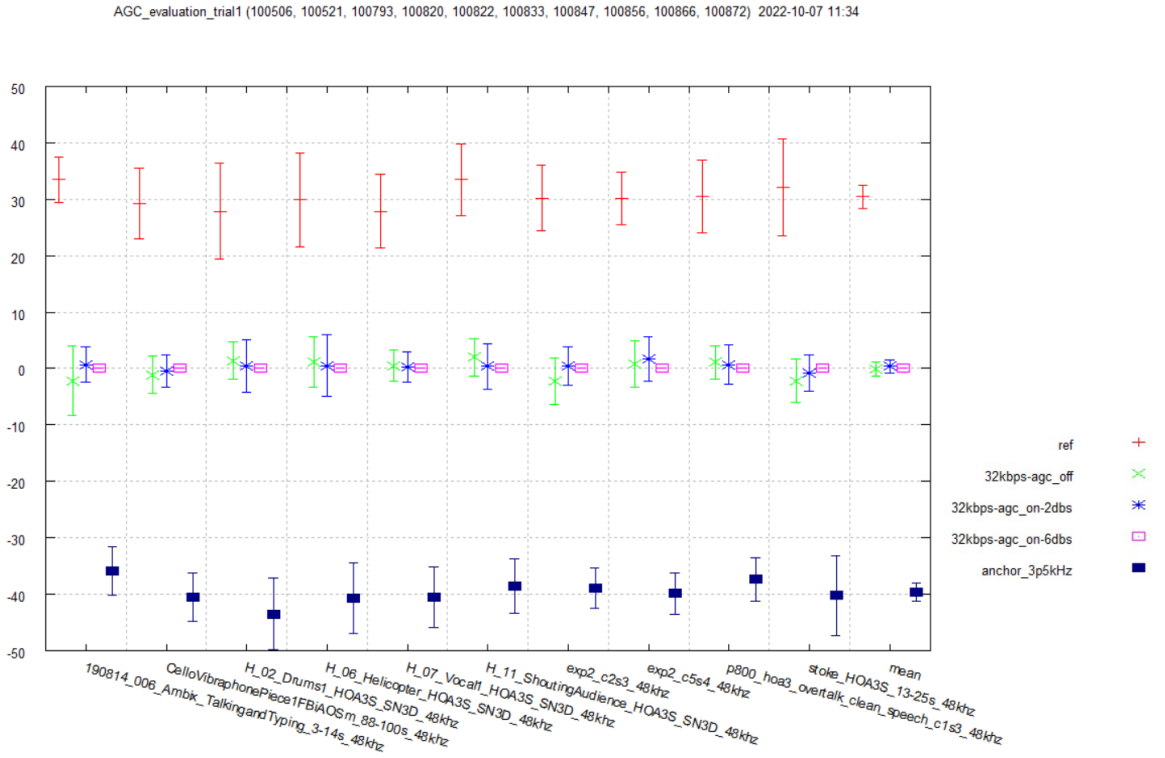
- Less than 12 words increase in memory usage before and after tuning update
- No difference in memory usage between agc on vs off

Metadata

- No change in the amount of metadata with tuning change
- 1 signaling bit is used to signal whether AGC is on or off
- For in-range frames, no extra metadata is used
- For OOR frames, bits used is 1 + N + M*3, where
  - N = Number of transport channels
  - M = number of transport channels which have OOR samples
- Worse case MD rate for 1 transport channel is 4 bits as no channel signaling bit is required.

Subjective listening test results

- Test material included a mix of voice vectors and general audio vectors.
- These vectors were dynamically compressed to ensure AGC is triggered many times throughout the vector.
- Such dynamic compression is not uncommon for some types of audio content such as mastered music.
- All test conditions were using 32kbps bitrate, 48kHz audio, FOA input, FOA output, binauralised using the python renderer. The conditions were:
  - Reference (no codec)
  - No AGC case
  - AGC with 2dB attack/release per frame
  - AGC with 6dB attack/release per frame
  - 3.5kHz anchor
- No statistically significant degradation in quality for signals when AGC is turned on. These signals did not trigger the SCE behaviour described in the previous slides, which is why no improvement is seen



Proposed changes

- Add tuning change for click artifact
  - Enclosed within the `AGC_TUNING_IMPROVEMENT` switch
- Enable AGC by default for 24.4kbps and 32kbps bitrates
  - AGC command line switch will remain to allow the AGC to enabled or disabled for any bitrate.
  - Enclosed within the `AGC_ENABLE_FOR_LBR` switch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