



Implementing Headroom Adaptive Gain Curve in an ICC v4 AToB0 Look-Up Table

Luke Wallis - ICC Experts Day - 21st September 2026 - Gjøvik, Norway

The problem

- The installed base of ICC CMMs predates HDR entirely
 - No concept of headroom, tone mapping, or dynamic metadata
- Handed an HDR profile as-is, a legacy renderer either:
 - fails to produce anything meaningful, or
 - misreads PQ/HLG as an SDR transfer function — bad or corrupted image

The idea

- Bake the Headroom Adaptive Gain Curve, evaluated at target headroom = 1.0 (SDR), into a static lutAToBType ATOb0 tag
- The result is indistinguishable from any other ATOb0:
 - A-curves → CLUT → matrix
- Following the standard ICC v4 ATOb0-to-PCS path produces a perceptually reasonable SDR rendering
- No knowledge of HDR, PQ/HLG, or HAGC required on the consuming side

Purely additive

- The live HAGC tag stays in the profile, untouched
 - An HDR-aware CMM keeps evaluating it dynamically, for the *actual* target headroom
- The static A2B0 is strictly a fallback path for renderers that can't do anything else

Background: lutAToBType structure

Stage	Channels	Role
A-curves	3 × 1-D	Linearize the encoded HDR signal
CLUT	3-D	Apply the HAGC tone-map for target headroom = 1.0 (SDR)
Matrix	3 × 4	Convert linear RGB to PCSXYZ via the source profile's primaries

The CLUT statically approximates the HAGC tone-mapping step for target headroom = 1.0 (SDR)

The conceptual pipeline

1. Decode — apply the EOTF (PQ or HLG), normalized so reference white = 1.0
2. Apply the HAGC at target headroom = 1.0, in the normalized linear domain
3. Convert to PCSXYZ using the matrix derived from the source profile's primaries

The encoding problem

- Two issues with encoding the EOTF directly as a 16-bit A-curve:
 - HDR linear values exceed 1.0
 - 16-bit fixed point doesn't have enough resolution to follow the steepness of EOTF
- PQ, peak white at 10,000 cd/m², reference white 203 cd/m² → normalized value ≈ 49.26
- HLG, peak white at 1000 cd/m² → normalized value ≈ 4.93
- curveType's unsigned 16-bit encoding cannot represent anything outside [0, 1]

The fifth-root trick

- $A(u) = L(u)^{1/5}$
- $L(u)$ is the linearization function (PQ EOTF, HLG EOTF)
- The fifth power maps the HDR working range comfortably into $[0, 1]$
- It also concentrates resolution in the dark portion of the curve — where banding is most visible

Building the CLUT

For each grid coordinate:

1. Raise each coordinate to the fifth power — undo the A-curve compression
2. Evaluate the HAGC tone-map on (R, G, B) at target headroom = 1.0
3. Clamp each output channel to [0, 1]
4. Quantize to 16-bit unsigned

The matrix stage

- Computed from the cicpTag's ColourPrimaries — the same primaries-to-matrix calculation ICC.1 already uses to derive redMatrixColumnTag/greenMatrixColumnTag/blueMatrixColumnTag in a TRC/Matrix profile
- Converts linear RGB to PCSXYZ
- Note: this is the same matrix the source profile uses in the HDR pipeline

Assembly and profile patching

1. Serialize as mAB (lutAToBType)
 2. Insert to the profile under signature A2B0
- No profile header version change is required by this construction
 - The original HAGC tag is left intact in the patched profile

Parameter choices

Parameter	Recommendation
A-curve table size	1024 entries — reasonable compromise between profile size and reconstruction error
CLUT grid size	17 (viable min), 33 (de facto default), 45 (better accuracy for steep gains, ~2.5× more storage)

Result

- A standards-conformant profile any ICC v4 CMM can read
- Closely approximates the SDR rendering of an HAGC-aware renderer at target headroom = 1.0
- No SMPTE ST 2094-50 implementation required on the consuming side

Sample Images (1 of 5)



Headroom Adaptive Gain Curve

A2B0 based on Headroom Adaptive
Gain Curve

Sample Images (2 of 5)



Headroom Adaptive Gain Curve



A2B0 based on Headroom Adaptive
Gain Curve

Sample Images (3 of 5)



Headroom Adaptive Gain Curve

A2B0 based on Headroom Adaptive
Gain Curve

Sample Images (4 of 5)



Headroom Adaptive Gain Curve

A2B0 based on Headroom Adaptive
Gain Curve

Sample Images (5 of 5)



Headroom Adaptive Gain Curve



A2B0 based on Headroom Adaptive
Gain Curve

Note

A companion white paper on this subject was submitted along with the HDR profile proposal.

Questions?