APOGEE AE-5 / AE-10

DSP Reverse-Engineering Notes & Implementation Instructions

A practical replacement-processing reference based on electrical measurements of original Apogee processing, comparison with a DLC24 factory preset, and the APL-500 service documentation.

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Important: These are reverse-engineered replacement settings. They are not official Apogee factory DSP coefficients, and the original dynamic protection/limiter behaviour has not been fully reconstructed.

Contents

1. Purpose and scope

The Apogee AE-series loudspeakers were designed as processor-dependent systems. The aim of this document is to provide enough information to replace the original Apogee processing with a modern loudspeaker DSP while preserving the intended crossover, response shaping and relative LF/HF behaviour as closely as practical.

The central principle is simple: the electrical transfer function is the target. The exact internal topology of the original processor, or the exact sequence of digital biquads used in a replacement, is secondary as long as the resulting magnitude and phase behaviour is sufficiently close.

Do not treat a list of filters as “the factory preset.” The filter tables in this document are compact measured-fit implementations that reproduce the observed processor transfer functions.

2. Evidence and methodology

The reconstruction is based on four useful classes of evidence:

- Electrical transfer-function measurements of the AE-5 processing.
- Electrical measurements of an Apogee DLC24 loaded with the factory AE-5 preset.
- The Apogee APL-500 service schematic, which documents separate crossover, EQ/notch, limiter/buffer and output circuitry.
- Electrical measurement of an original Apogee P10 LF processor together with a reference trace, allowing the P10 transfer function to be isolated.

The original hardware and the replacement DSP do not have to use the same internal filter topology. In practice, the most reliable approach is to fit conventional minimum-phase DSP filters to the measured processor response, then verify the recreated outputs electrically.

2.1 What the P500/DLC24 comparison established

The DLC24 running its factory AE-5 preset closely tracks the independently measured AE-5 processor transfer functions once overall measurement level is normalized. The measured agreement is approximately:

Channel	Comparison range	Approx. RMS magnitude difference
HF	700 Hz - 20 kHz	~0.38 dB
LF	80 Hz - 1.5 kHz	~0.42 dB

This strongly supports the conclusion that the unusual response shaping is intentional AE-5 processing rather than a fault or anomaly in one particular processor.

3. AE-5 findings

3.1 The processor does much more than crossover

A simple two-way crossover does not reproduce an AE-5. The LF path includes strong low-frequency and midrange contouring before its steep upper roll-off. The HF path contains substantial constant-directivity compensation, rising strongly toward the top octave.

This means a generic setting such as “1.1 kHz LR48 plus HF attenuation” is incomplete. The EQ is part of the loudspeaker alignment.

3.2 Crossover

Channel	Filter	Frequency
LF	Linkwitz-Riley low-pass, 48 dB/oct	~1061 Hz
HF	Linkwitz-Riley high-pass, 48 dB/oct	~1061 Hz

A rounded 1060 Hz value is practical. The processed LF and HF magnitude traces may visually intersect closer to roughly 1.2 kHz because both sides are heavily shaped. That visual intersection should not be used as a substitute for the nominal crossover frequency.

3.3 Polarity and delay

Parameter	LF	HF
DSP polarity	Normal	Normal
DSP delay	0.00 ms	0.00 ms

Some AE-5 cabinets have the HF driver physically wired in reverse polarity. That is a cabinet-level implementation detail. The replacement DSP should not automatically invert HF again, because doing so would undo the intended loudspeaker wiring convention.

No convincing evidence was found for a deliberate LF/HF digital delay offset in the original processing. Start at 0 ms on both paths and treat any later delay as part of acoustic system alignment, not as part of the recreated electrical preset.

4. AE-5 practical DSP reconstruction

The following biquad sets are compact fits to the measured electrical response. They should be treated as implementation parameters, not as literal descriptions of the analogue circuitry inside an original processor.

4.1 LF channel

Stage	Filter type	Frequency	Gain	Q / slope
1	Butterworth HPF, 12 dB/oct	~50 Hz	-	-
2	PEQ	48 Hz	+11.4 dB	Q 1.83
3	Low shelf	247 Hz	+3.4 dB	slope ~2.0
4	PEQ	749 Hz	-8.1 dB	Q 1.02
5	PEQ	2.03 kHz	+8.2 dB	Q 0.78
6	Linkwitz-Riley LPF, 48 dB/oct	1061 Hz	-	-
7	Output gain	-	about -2.5 dB	-

The 2.03 kHz PEQ does not imply meaningful 2 kHz acoustic output from the woofer. It shapes the curvature and phase of the already steep crossover skirt. Individual filters should not be interpreted in isolation.

4.2 HF channel

Stage	Filter type	Frequency	Gain	Q / slope
1	Linkwitz-Riley HPF, 48 dB/oct	1061 Hz	-	-
2	PEQ	~2.38 kHz	-4.1 dB	Q 1.85
3	High shelf	~7.05 kHz	+12.1 dB	slope ~0.14
4	High shelf	~9.48 kHz	+13.0 dB	slope ~1.16
5	Output gain	-	about -13.25 dB	-

The two large shelves reproduce the strong constant-directivity compensation seen in the measured HF transfer function. This is the main reason the HF processing cannot be reduced to a crossover plus one gain trim.

4.3 Why the output-gain values are not "sacred"

The LF ~-2.5 dB and HF ~-13.25 dB gains belong to this particular mathematical decomposition. They are not universal Apogee gain constants. Gain can be redistributed between shelves, PEQs and dedicated gain blocks without changing the final transfer function, provided the complete response remains the same and internal clipping is avoided.

This was important in SigmaStudio, where some filter blocks limited the amount of positive gain. Splitting a large boost across multiple filters and compensating later is valid if the combined transfer function remains correct.

Implementation invariant: H_total(f) = H1(f) x H2(f) x ... x Hn(f). The resulting electrical response matters more than the exact distribution of gain between blocks.

4.4 Preferred implementation strategy

Two approaches are valid:

1. Enter the compact filter values above, then verify the electrical outputs against the reference transfer curves.
2. Use the measured transfer functions as the target and fit your own filter set using whatever PEQ/shelf topology your DSP supports.

The second approach is preferred when the DSP has unusual filter definitions, limited shelf slopes, restricted gain range, or different Q conventions.

4.5 Phase matters

Matching magnitude alone is not sufficient through the crossover region. A replacement should also preserve the relative LF/HF phase around roughly 800 Hz to 1.5 kHz. Ordinary minimum-phase IIR PEQ and shelf filters are therefore the safest default. Arbitrary FIR magnitude correction can give a similar-looking amplitude curve while changing phase and acoustic summation.

5. AE-10 / P10 findings and preset

The AE-10/P10 reconstruction is much simpler than the AE-5. Using the P10 LF measurement and its separate reference trace, the isolated P10 transfer function can be reproduced closely with a conventional HPF, one strong PEQ and a low-pass filter.

5.1 Compact P10 recreation

Stage	Setting
Polarity	Normal
Gain	+2.2 dB
High-pass filter	29 Hz Butterworth, 12 dB/oct
PEQ	31.5 Hz, +12.7 dB, Q 0.83
Low-pass filter	120 Hz Butterworth, 24 dB/oct

Signal chain: Input -> 29 Hz BW12 HPF -> 31.5 Hz / +12.7 dB / Q 0.83 PEQ -> 120 Hz BW24 LPF -> +2.2 dB gain -> limiter -> amplifier -> AE-10.

5.2 Fit accuracy

Across approximately 15-300 Hz, the compact model is around 0.85 dB RMS from the measured P10 transfer function. Representative points are shown below.

Frequency	Measured P10 transfer	Compact model
20 Hz	+2.2 dB	+2.2 dB
25 Hz	+8.1 dB	+8.3 dB
30 Hz	+12.1 dB	+12.1 dB
40 Hz	+11.5 dB	+11.6 dB
50 Hz	+9.5 dB	+9.4 dB
80 Hz	+5.9 dB	+5.4 dB
100 Hz	+2.7 dB	+3.5 dB
120 Hz	-0.5 dB	+0.8 dB
150 Hz	-6.7 dB	-5.2 dB
200 Hz	-15.5 dB	-15.0 dB

Do not use the +12.7 dB PEQ without the 29 Hz HPF. The boost and high-pass work together as an alignment network. Omitting the HPF would greatly increase very-low-frequency excursion.

5.3 AE-5/AE-10 system crossover

There are two different crossover problems in a complete system: the internal AE-5 LF/HF crossover at ~1061 Hz, and the external AE-10/AE-5 sub-to-top crossover. The P10 already rolls the subwoofer off around 120 Hz. When building a new controller, verify the actual acoustic overlap rather than blindly stacking an additional generic crossover on top of the reconstructed P10 response.

6. System integration and amplifier gain

A perfect DSP preset can still produce the wrong acoustic result if LF and HF amplifier voltage gains differ. In a bi-amped AE-5, a 3 dB amplifier-gain mismatch is effectively a 3 dB LF/HF level error and changes the crossover summation.

Use amplifiers with matched voltage gain, or measure/calculate amplifier gain and compensate the difference in DSP. Rated wattage is not the same thing as voltage gain.

6.1 Recommended generic DSP architecture

Path	Recommended order
AE-5 LF	Input -> LF alignment/EQ -> 1061 Hz LR48 LPF -> gain correction -> RMS/peak limiter -> LF amplifier
AE-5 HF	Input -> 1061 Hz LR48 HPF -> HF EQ/CD compensation -> gain correction -> RMS/peak limiter -> HF amplifier
AE-10	Input -> 29 Hz BW12 HPF -> 31.5 Hz PEQ -> 120 Hz BW24 LPF -> gain -> limiter -> amplifier

7. Limiting and protection

This is the part of the original Apogee system that has not been completely reverse-engineered. A normal transfer-function sweep reveals crossover, EQ, gain and phase, but not the complete dynamic protection behaviour.

The measurements do not reliably reveal attack time, release time, RMS integration window, peak limiting, thermal models, dynamic EQ, load-dependent behaviour or any protection derived from amplifier sense lines.

7.1 Conventional RMS voltage limiting

A conventional starting point can be derived from driver power and nominal impedance:

V_RMS = sqrt(P x R)

For example, 300 W into 8 ohms corresponds to approximately 49 V RMS at the loudspeaker terminals. The corresponding DSP limiter threshold depends on amplifier voltage gain.

V_DSP = V_speaker / G_v   and   dBu = 20 log10(V / 0.775)

This is why a limiter threshold quoted only in dBu is not portable between systems unless amplifier gain and DSP output calibration are also specified.

7.2 Sense lines

Some original Apogee processing used loudspeaker/amplifier sense connections. A generic modern DSP without amplifier feedback cannot reproduce that behaviour literally. The static crossover, EQ, phase and gain can still be recreated accurately, but dynamic protection should be regarded as a separate engineering task.

8. Electrical verification procedure

Before connecting an AE-5 compression driver, verify the new DSP electronically at low level.

3. Feed a measurement reference signal into the DSP.
4. Route each DSP output through an appropriate pad or measurement interface input.
5. Measure LF and HF independently as transfer functions.
6. Confirm the LF output contains the expected low-frequency response and steeply rejects HF.
7. Confirm the HF output strongly rejects low frequencies before connecting the compression driver.
8. Overlay the measured replacement curves with the original reference curves.
9. Check magnitude and relative phase through the ~800 Hz - 1.5 kHz crossover region.
10. Only after routing, crossover and level have been confirmed should the loudspeaker be connected.

8.1 Practical acceptance targets

RMS magnitude error over the useful band	Assessment
< 0.5 dB	Excellent
< 1.0 dB	Very good
< 1.5 dB	Generally very usable

Chasing the last 0.1 dB is usually not useful because component tolerances, amplifier gain tolerances, driver production variation and measurement uncertainty are already present. The genuine DLC24-to-processor comparison itself is around 0.4 dB RMS.

9. Accuracy, confidence and known uncertainties

Finding	Confidence
AE-5 requires substantial dedicated processing	Very high
AE-5 crossover is approximately 1060/1061 Hz	High
Very steep LF/HF crossover	High
Large HF constant-directivity compensation	Very high
No additional DSP delay required as a starting point	Moderate to high
DSP HF polarity should remain normal	High
AE-5 biquads in this document reproduce the measured curve	High as a measured-fit approximation
These biquads are the literal original Apogee coefficients	No - do not claim this
DLC24 represents essentially the same AE-5 voicing	Very high
P10 29 Hz / 31.5 Hz PEQ / 120 Hz reconstruction	Very high
Original dynamic limiter/protection behaviour	Not sufficiently characterized

9.1 Central conclusion

The strongest result is not that a hidden “factory EQ menu” has been discovered. It is that measured electrical target transfer functions for the AE-5 and AE-10 processing can be reproduced closely with ordinary modern DSP, making the original Apogee processors unnecessary for crossover/EQ duties. Protection/limiting remains the principal area that still deserves dedicated work.

10. Source material and measurement files

This document was assembled from the following project material:

- AE5 HF and LF traces.rtf / AE5 HF and LF traces(1).rtf - measured AE-5 processor transfer data.
- DLC24-HF1.csv and DLC24-LF1.csv (including repeated measurement files) - factory AE-5 preset measurements from an Apogee DLC24.
- P10-LF.csv - measured output of an original Apogee P10 LF processor.
- REF-P10LF.csv - reference trace recorded for the P10 measurement.
- apogee_sound_international_apl-500_loudspeaker_sch.pdf - APL-500 service schematic used to understand the original processing topology.
- AE-5 phase/group-delay and impulse measurement plots generated during the reconstruction work.

For publication, it is recommended that the raw transfer-function files be shared alongside this document where possible. That allows other owners to validate alternative DSP implementations instead of relying only on a single set of fitted biquads.

Quick-reference settings

AE-5 LF

Function	Setting
HPF	~50 Hz BW12
PEQ	48 Hz, +11.4 dB, Q 1.83
Low shelf	247 Hz, +3.4 dB, slope ~2.0
PEQ	749 Hz, -8.1 dB, Q 1.02
PEQ	2.03 kHz, +8.2 dB, Q 0.78
LPF	1061 Hz LR48
DSP polarity / delay	Normal / 0 ms
Gain in this decomposition	~ -2.5 dB

AE-5 HF

Function	Setting
HPF	1061 Hz LR48
PEQ	~2.38 kHz, -4.1 dB, Q 1.85
High shelf	~7.05 kHz, +12.1 dB, slope ~0.14
High shelf	~9.48 kHz, +13.0 dB, slope ~1.16
DSP polarity / delay	Normal / 0 ms
Gain in this decomposition	~ -13.25 dB

AE-10 / P10

Function	Setting
HPF	29 Hz BW12
PEQ	31.5 Hz, +12.7 dB, Q 0.83
LPF	120 Hz BW24
Gain	+2.2 dB
Polarity	Normal

Verify electrically before connecting the AE-5 HF driver. A routing or crossover mistake can damage a compression driver very quickly.