AES 115th Convention
Tutorial Session

All About Equalizers
(for live sound use)

Dennis Bohn   Don Pearson   Bruce Jackson

Rane   *Ultrasound*   *Lake*

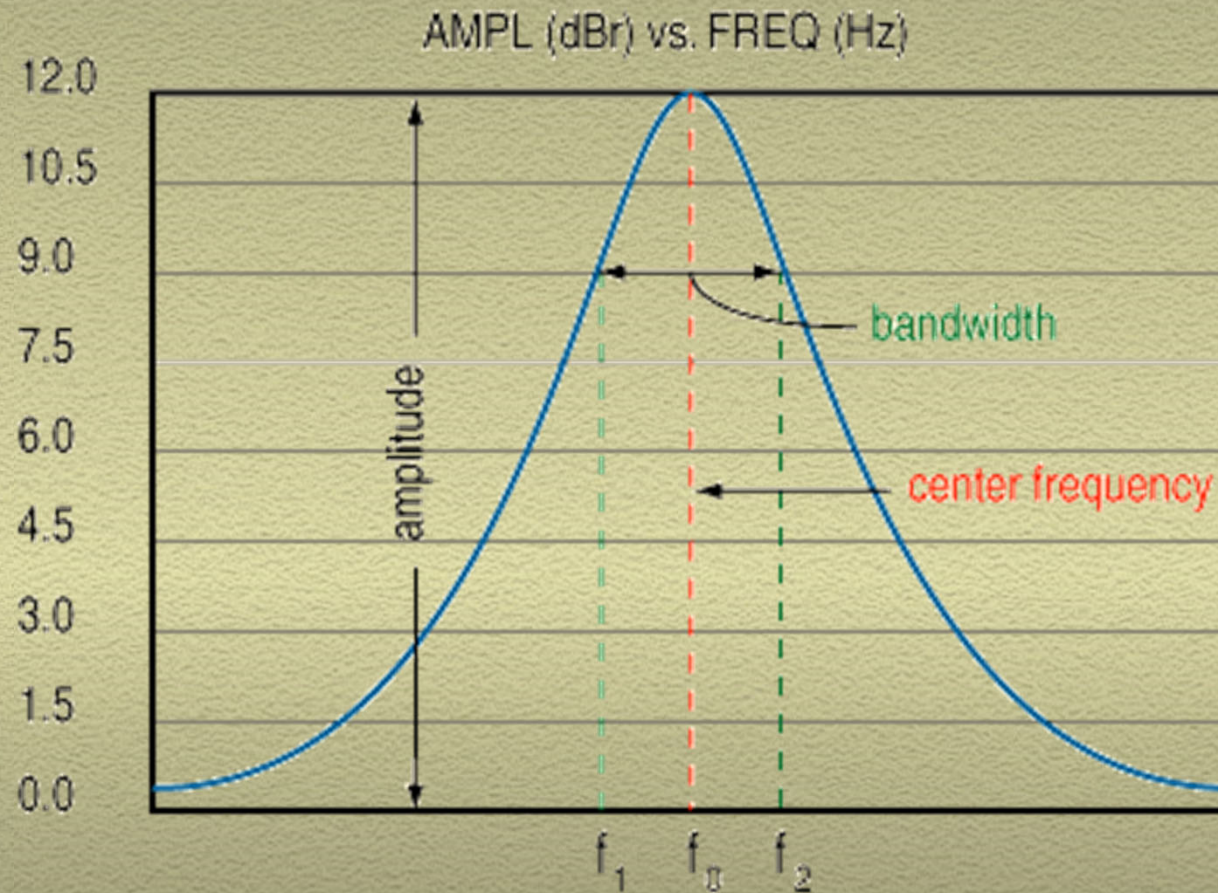# Equalizer Designs & Choices

Dennis Bohn

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Changing Face of EQ Choices

- 1988: 33 EQ Mfgrs

- 2003: 68 EQ Mfgrs (if you count software plug-ins, then 100 mfgrs!)

- Gone are passive, real inductors, cut-only, & slider-operated parametrics.

- New are digital EQs (28 mfgrs vs. 1 in 1988), combo graphic+parametric, & true response graphics.
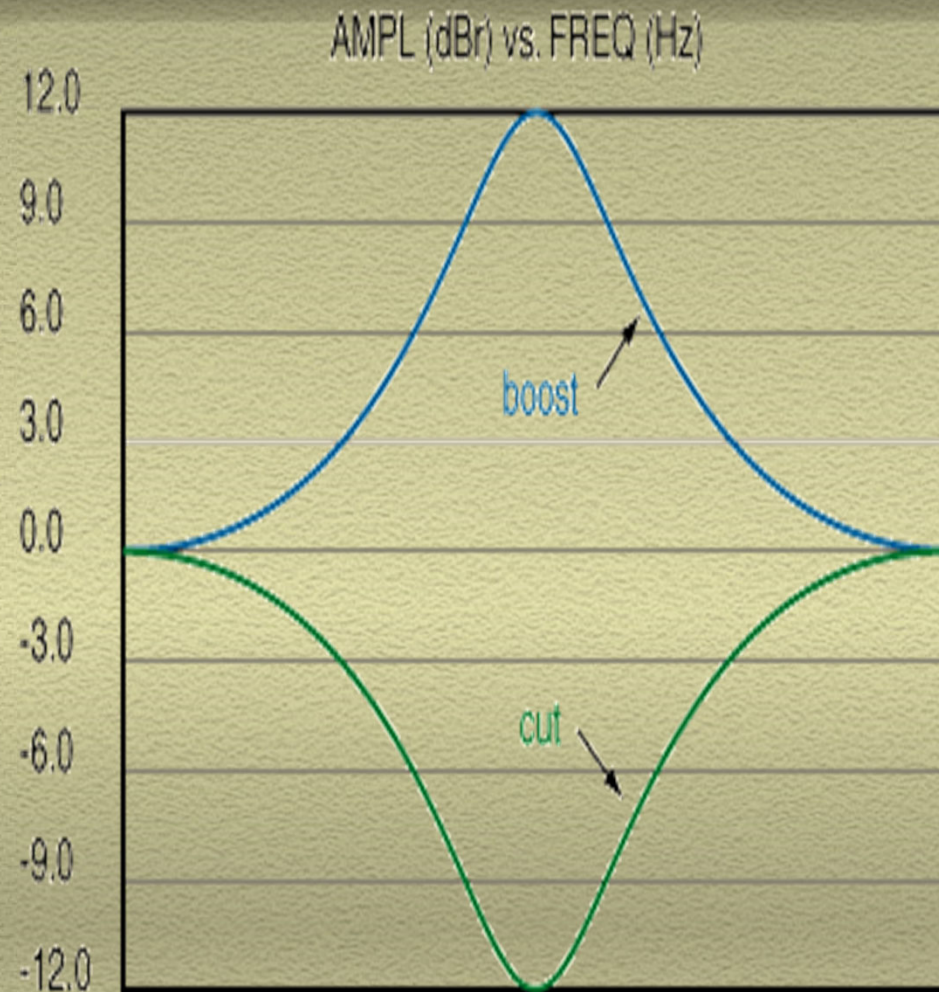
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Bandpass Filter Parameters

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EQ Filter Terminology

AMPL (dBr) vs. FREQ (Hz)

boost

cut

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Equalizer Terminology

- **Bandwidth Frequencies:** −3 dB points = half power points labeled as f_H and f_L

- **Center Frequency:** $f_C = \sqrt{f_H f_L}$ (geometric mean)

- **Bandwidth** = reciprocal of **Q** (Selectivity Factor)

$$Q = \frac{f_C}{f_H - f_L} = \frac{f_C}{BW}$$

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Why 1/3-Octave Centers?

- 1/3-octave approximately represents the smallest region humans reliably detect change. (Note: $2^{1/3\ oct}$ = x 1.26)

- Relates to *Critical Bands*: a range of frequencies where interaction occurs; an *auditory filter.*

- About 1/3-octave wide above 500Hz (latest info says more like ~1/6-oct); 100 Hz below 500 Hz

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Types of Equalizers

Graphic

- Fixed Center Frequency
- Fixed Bandwidth
    - $\frac{1}{3}$-Octave
    - $\frac{2}{3}$-Octave
- Adjustable Boost/Cut
- Many Bands (27-31)

Parametric

- Adjustable Frequency
- Adjustable Bandwidth
- Adjustable Boost/Cut
- Analog: Few Bands (3-6)
- Digital: Many Bands (10-20, or infinite if arbitrary magnitude design)
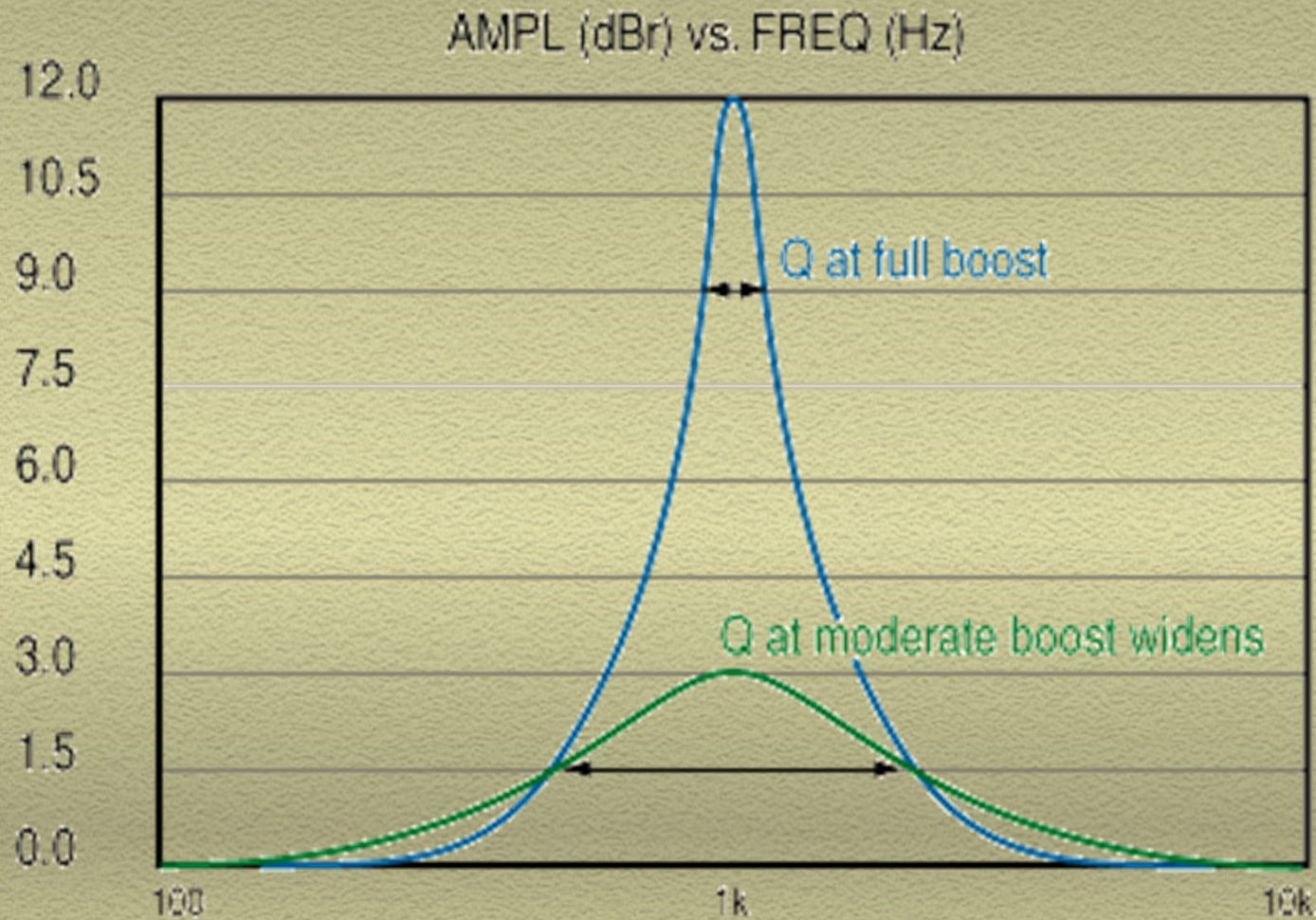
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Graphic EQ Technologies

- Proportional- or Variable-Q
  - Bandwidth varies as a function of boost/cut
- Constant-Q
  - Bandwidth varies much less than above
- True Response
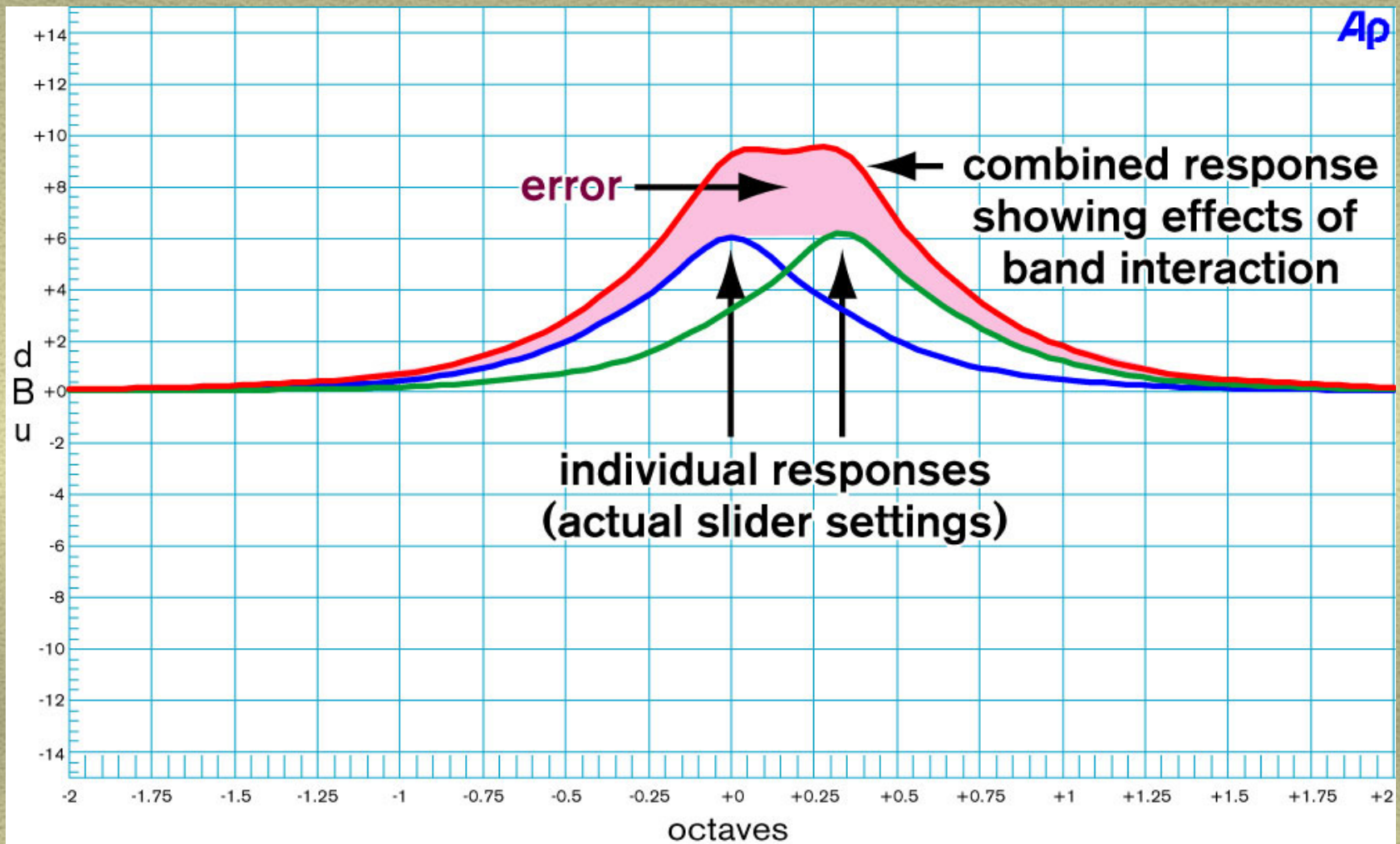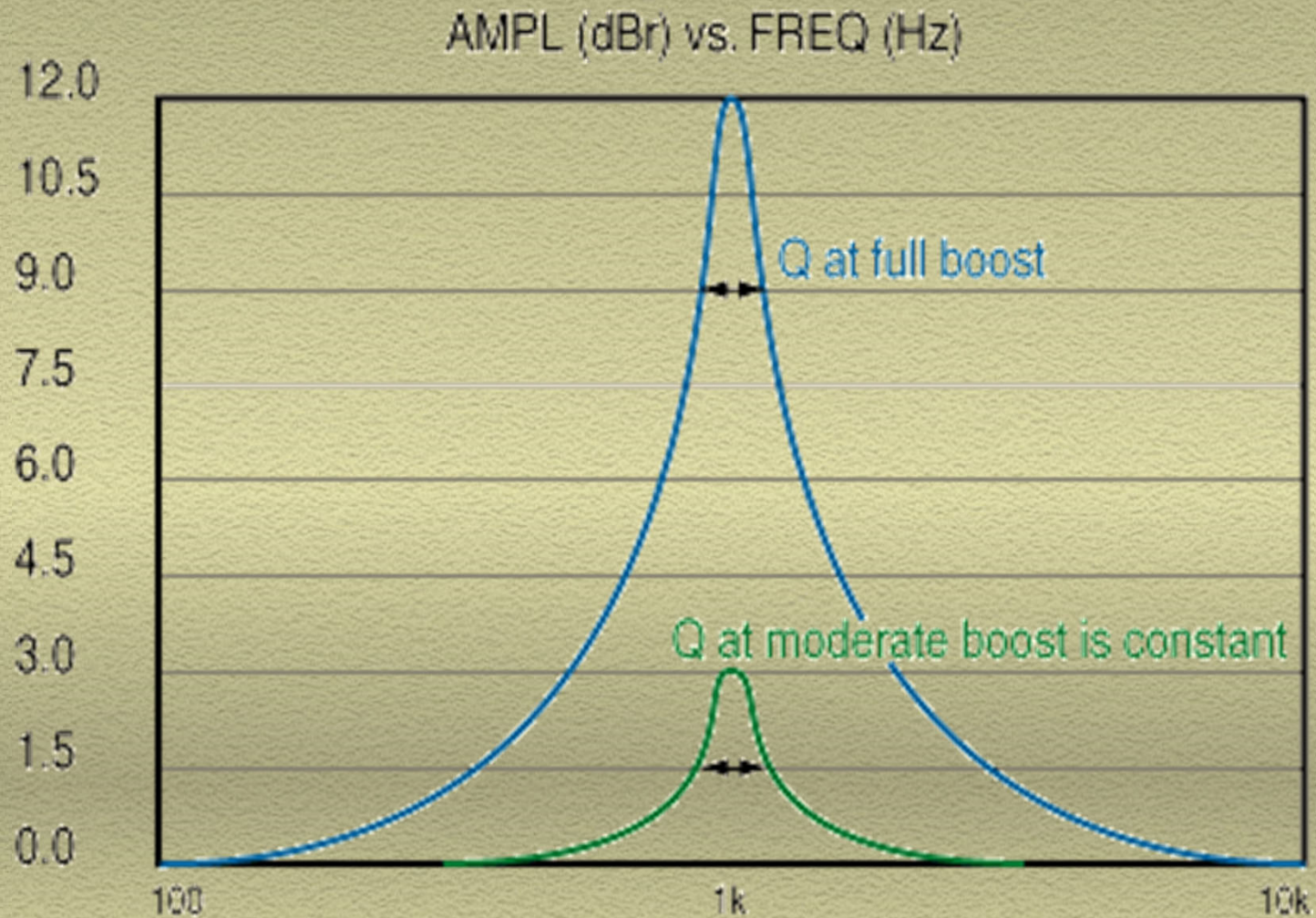 - Bandwidth does not vary with boost/cut, i.e., true WYSIWYG
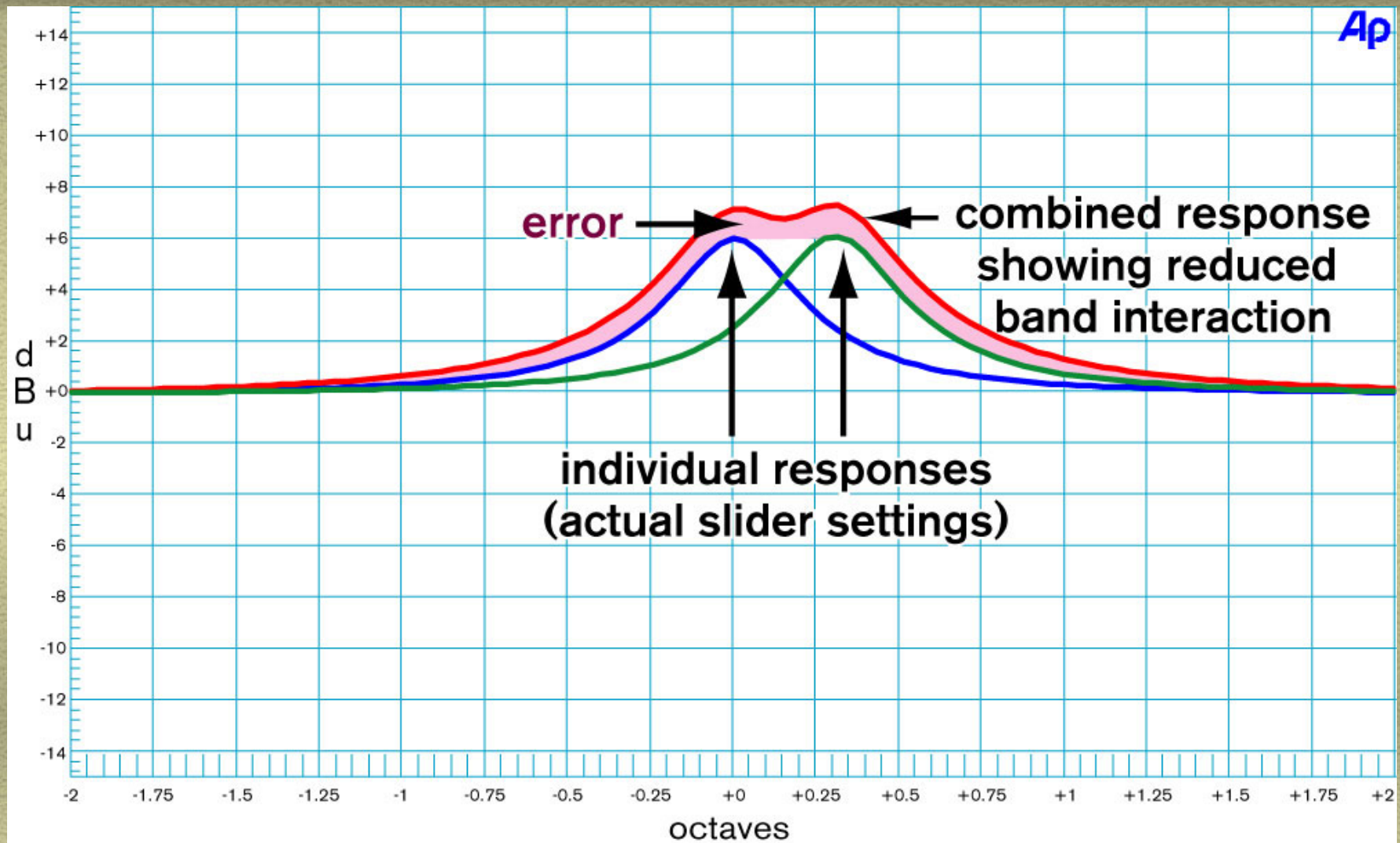
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Proportional- or Variable-Q

AMPL (dBr) vs. FREQ (Hz)

Q at full boost

Q at moderate boost widens

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Proportional-Q Response

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Constant-Q

AMPL (dBr) vs. FREQ (Hz)

Q at full boost

Q at moderate boost is constant

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Constant-Q Response

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True Response

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Graphic EQ Choices

Graphics

Analog **Digital**

Constant-Q (24) **Constant-Q (4)**

Variable-Q (2) **True-Response (4)**

Digitally-Controlled (1) **Analog-Controlled (5)**

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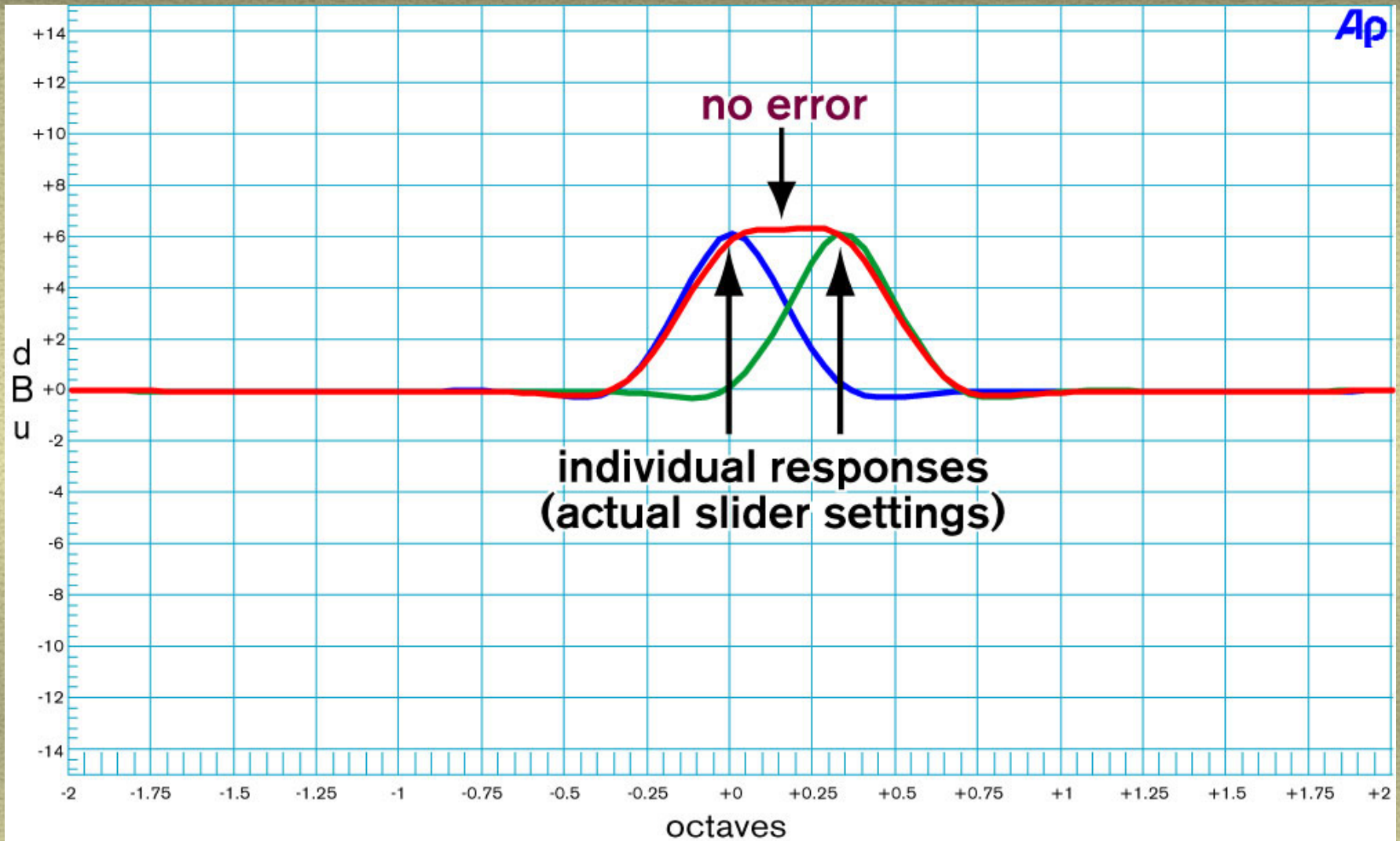
Parametric EQ Choices

Parametric Equalizers

Analog (15) **Digital (3)** **Analog-Controlled Digital (2)**

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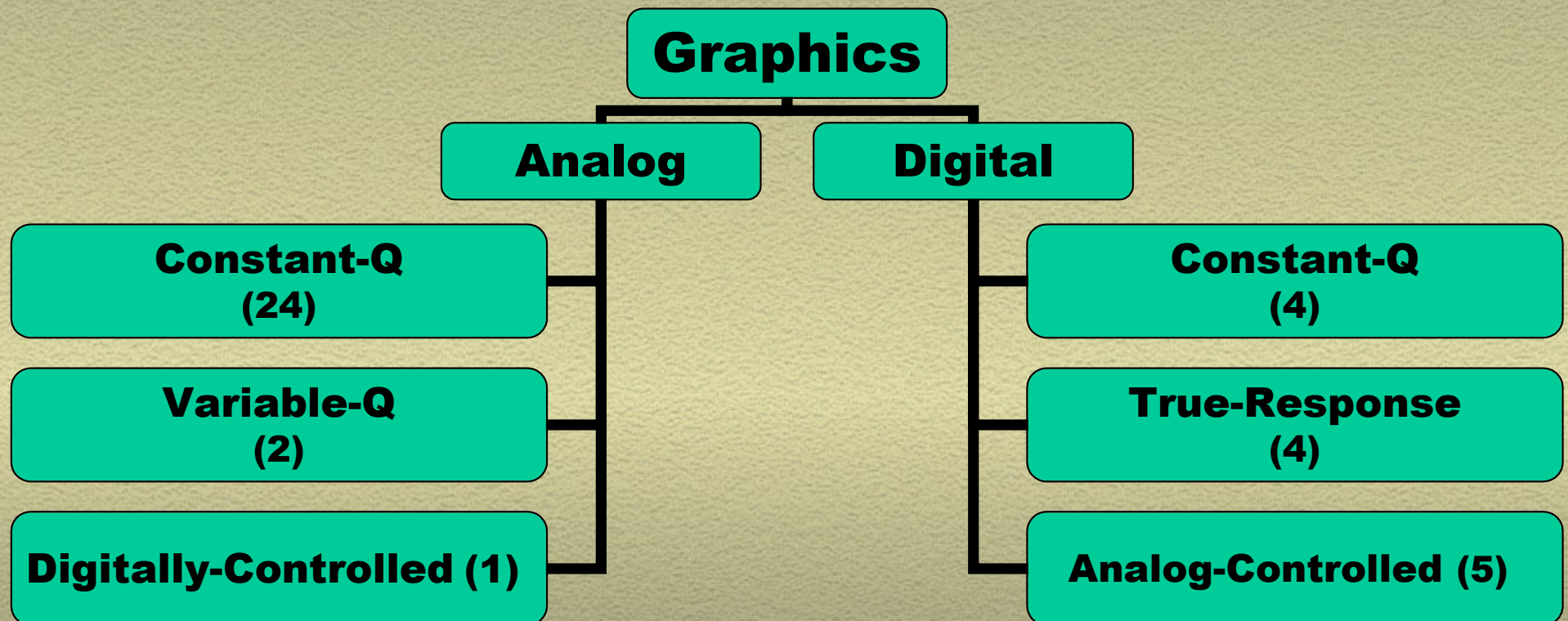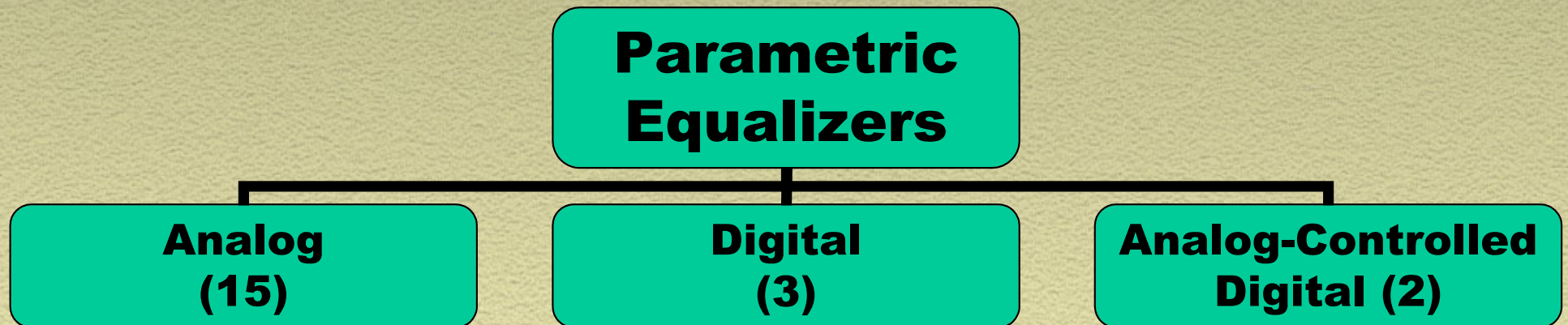
Graphic + Parametric Choices

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┌─────────────────────────────┐
│    Graphic + Parametric     │
└─────────────────────────────┘
         ┌───────┴───────┐
┌────────────┐   ┌────────────┐
│   Analog   │   │  Digital   │
│    (2)     │   │    (2)     │
└────────────┘   └────────────┘
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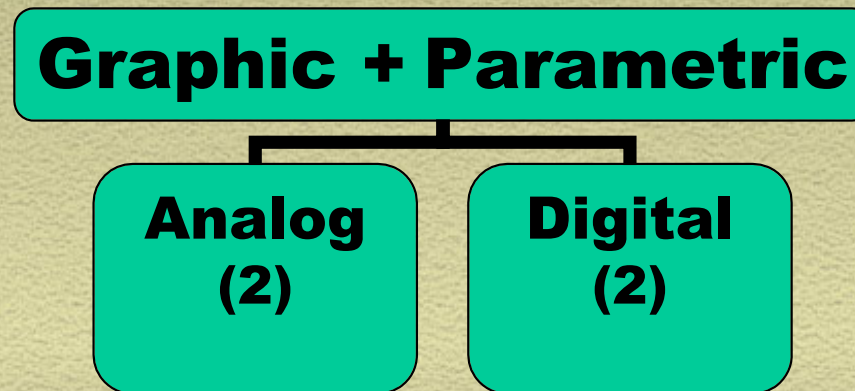
Digital EQ Multiprocessors

Digital EQ
Multiprocessors
(22)

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Digital EQ Multiprocessors

- Combine Digital Graphics & Parametrics
- Notch Filters
- High- & Low-Cut Adj. Filters
- Real Time Analyzers & Signal Sources
- Room Correction Algorithms
- Compressors & Limiters
- Noise Gates
- Crossovers, Delay, etc.

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Digital Filters and DSP

Allow circuit designers to do new things. We can go back and solve old problems …
like the truth-in-slider-position bugaboo of graphic equalizers:

- Proportional-Q is good
- Constant-Q is better
- True Response is best

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True Response Equalizers

- True WYSIWYG Response – What You See Is (Really) What You Get
- Output exactly matches front panel or GUI settings
- Eliminates Band Interaction & Overload
- Independent Band Adjustment
- Constant Bandwidth For All Slider Settings
- Minimum-Phase Response

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True Response EQ History

- Digitally-Controlled Analog:
  - 1987 ART IEQ *Smartcurve*™ (U.S. Patent 4,939,782)
  - 1987 TC Electronic TC 1128 (*still available*)
- Analog:
  - 1988 TDM Designs 30GE-1 (*newly reissued as TDM Audio products*)
- DSP Solutions
  - 1988 Motorola DSP Graphic (U.S. Patent 5,687,104)
- Today Affordable DSP Solutions Exist From Behringer, Lake and Rane.
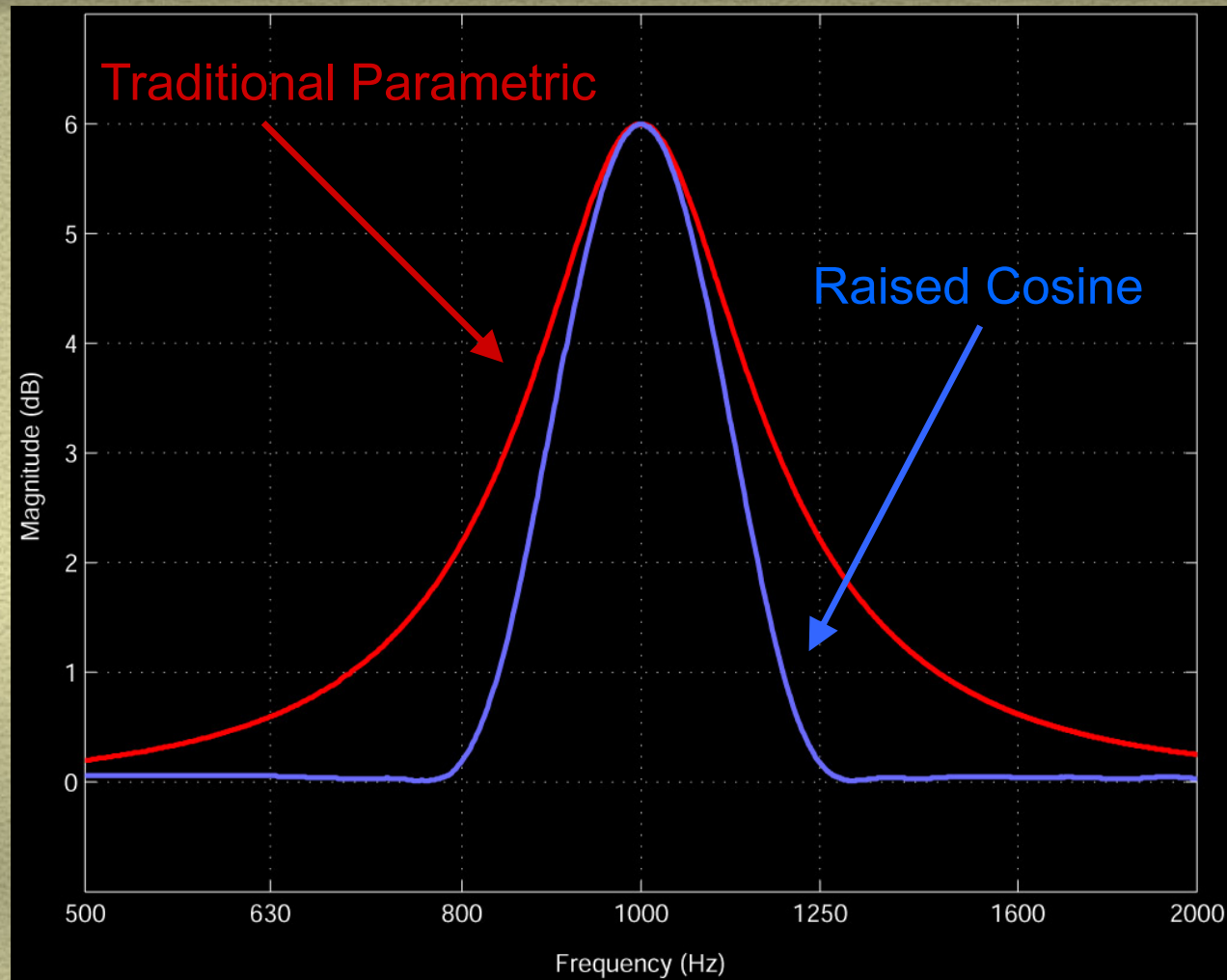
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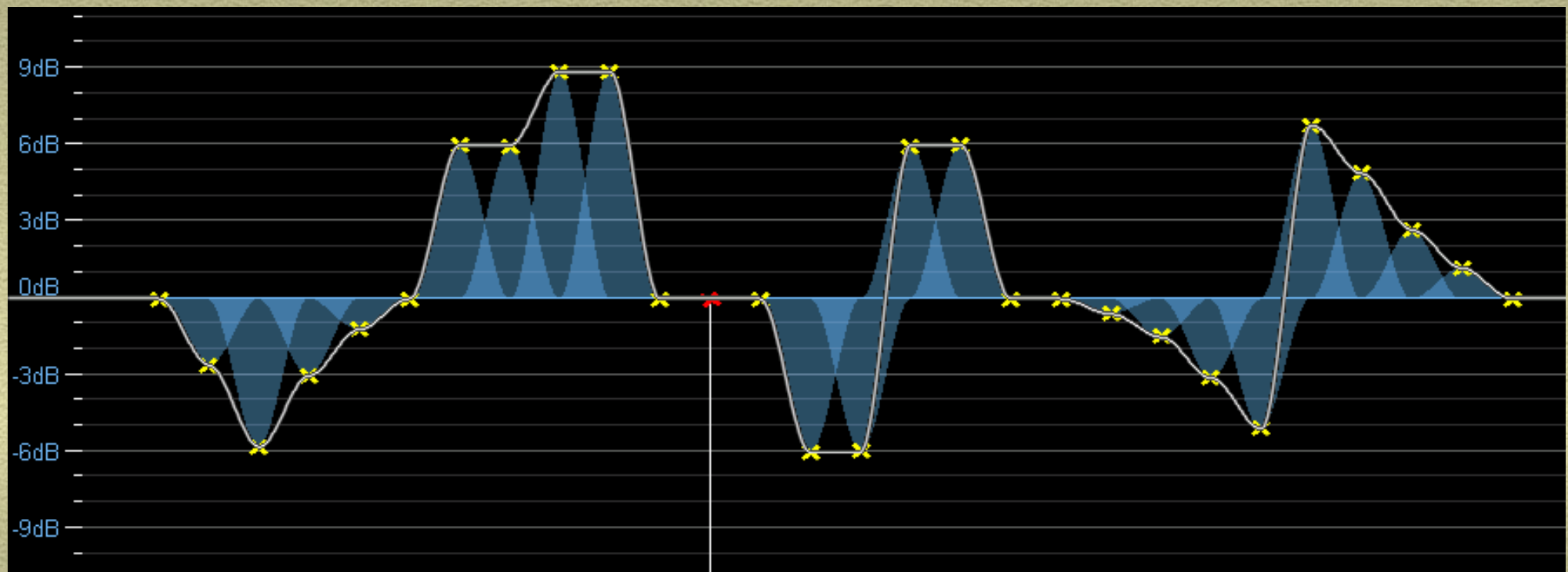# Behringer Ultra-Curve™

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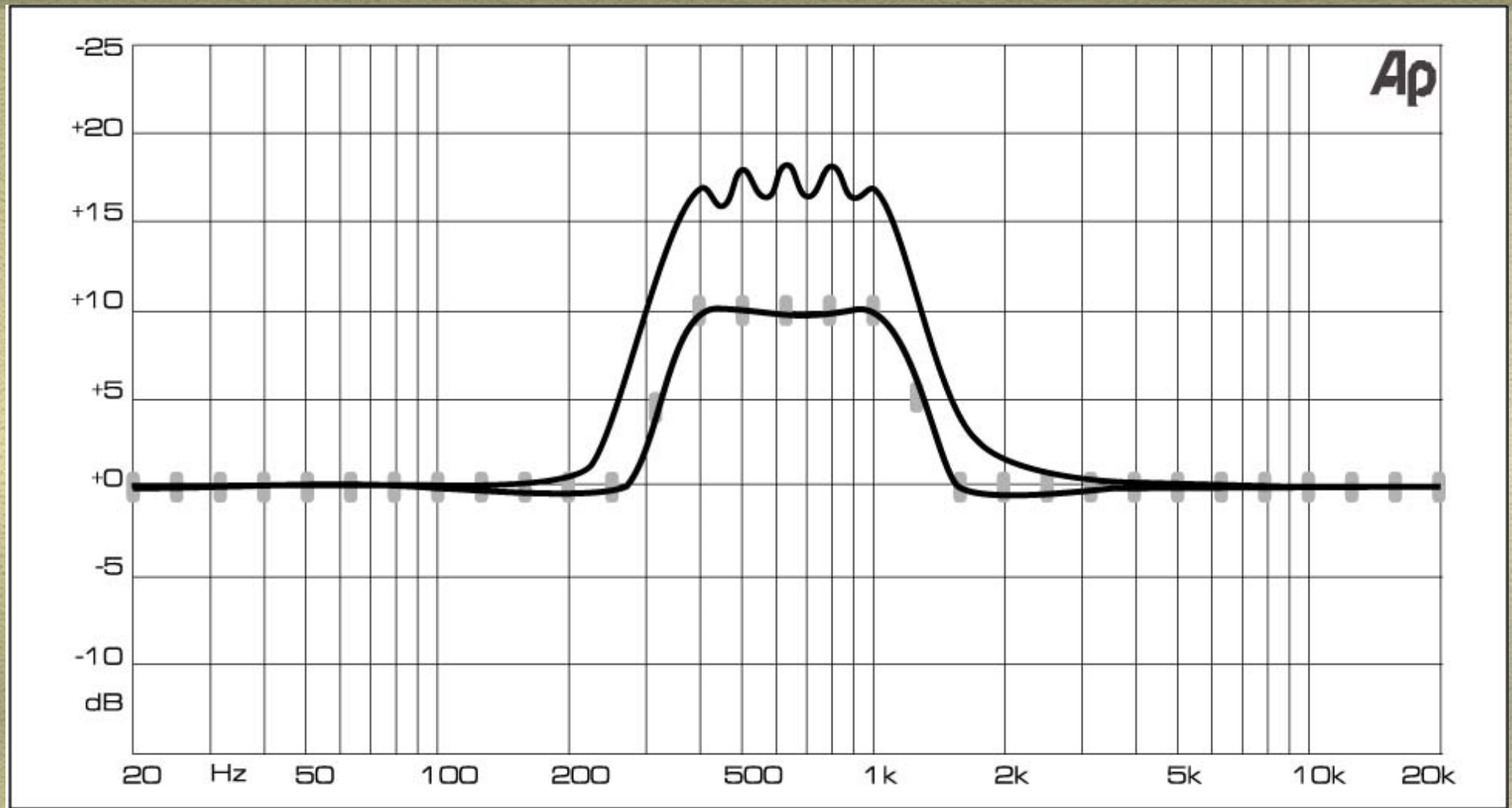
Lake's Raised Cosine Response

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Lake Contour™

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Rane Perfect-Q™
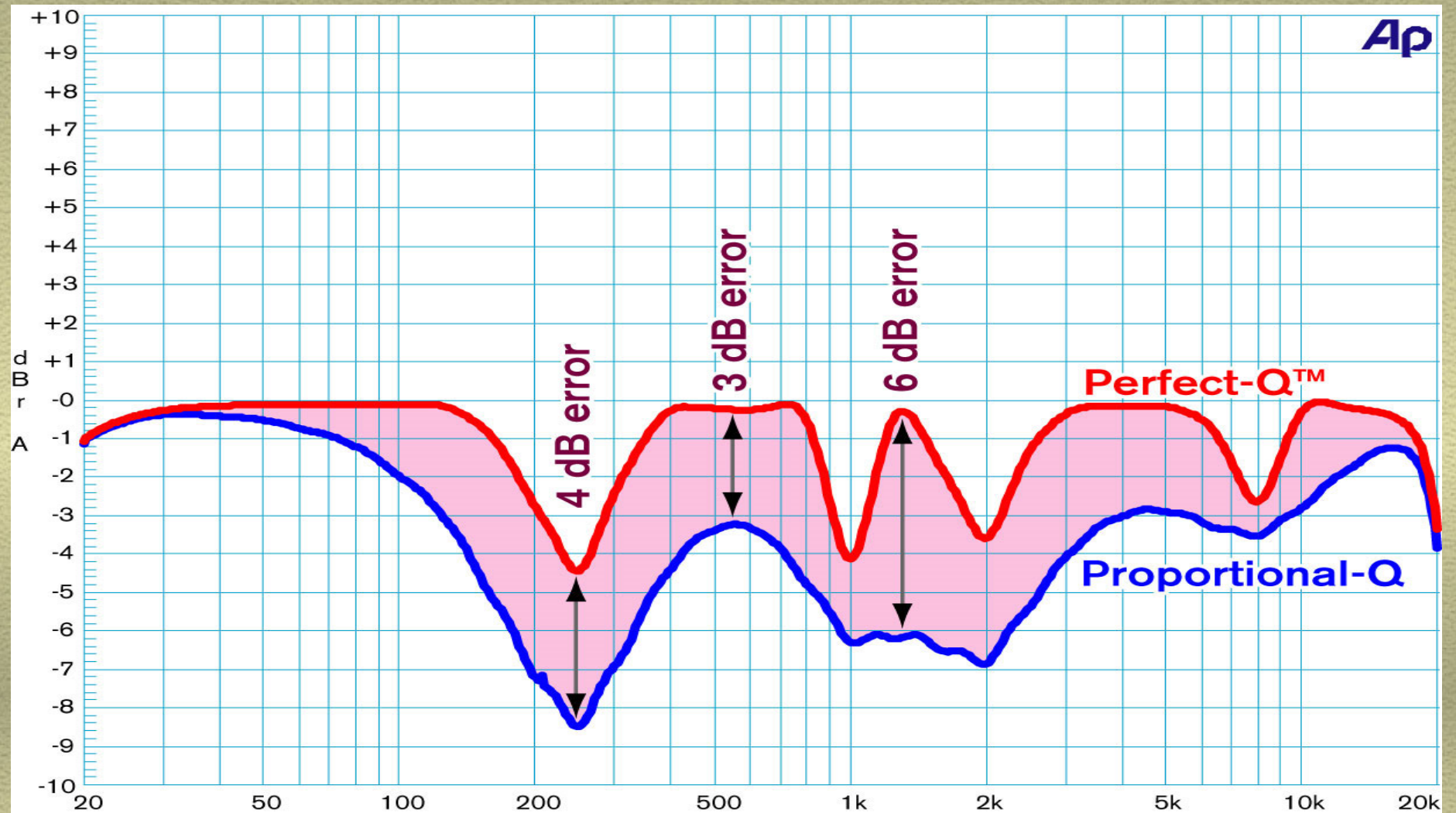
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Importance of True Response

- Advantages yield more than an accurate picture
- Provide a degree of adjustment never before possible.
- Crucial subtle refinements of frequency response are possible
- Allows an unequaled ease of operation and clarity of sound reproduction.
- Changing a 1/3-octave setting changes **only** that setting.
- Finally true 1/3-octave graphic equalizers exist.

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Lake Mesa Filter

- New technology based on arbitrary magnitude response – acts like infinite filters
- Capable of creating any magnitude response to about $^1/_{12}$-octave resolution
- Allows asymmetric adjustment of parametric filters, i.e., adjust each side separately, change center frequencies and adjust slopes independently
- Possible to match asymmetric loudspeaker responses

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Lake Mesa Filter

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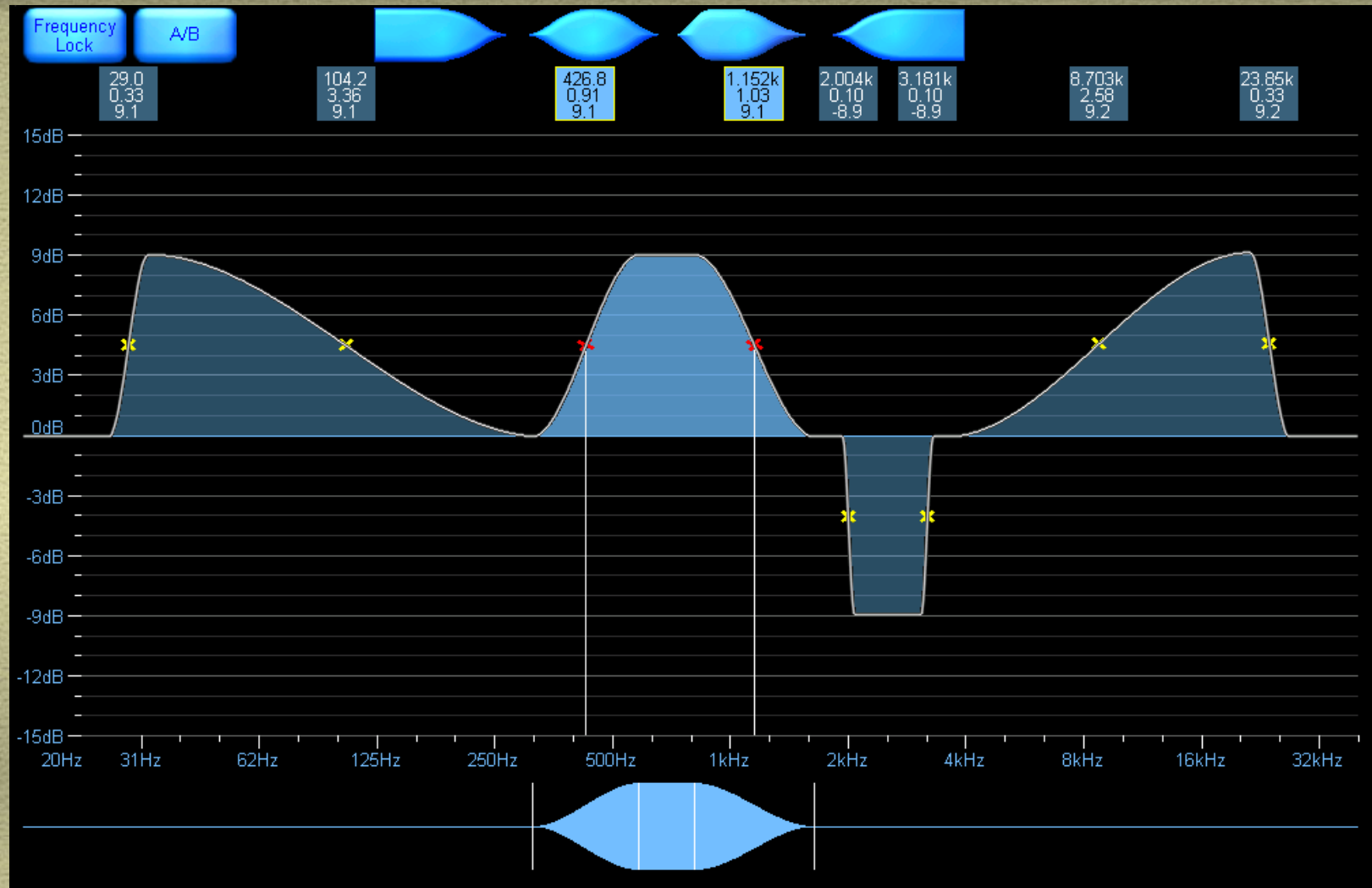
Next Up:

EQ Applications with

Don Pearson
Ultrasound/Pro Media
and
Bruce Jackson
Lake Technology