Example: Bode Plots

- Evaluate stereo system response

○ CD player→ amplifier→ speakers
  - CD player: \( G_{CD}(s) = \frac{V\text{CD}(s)}{CD(s)} \)
  - amp: \( G_{\text{amp}}(s) = \frac{V_{\text{out}}(s)}{V_{\text{in}}(s)} \)
  - Speakers: \( G_{\text{speaker}}(s) = \frac{P_{\text{acoustic}}(s)}{V_{\text{speaker}}(s)} \)

○ System transfer function:
  \[
  G(s) = \frac{P_{\text{acoustic}}(s)}{CD(s)} = G_{CD}(s)G_{\text{amp}}(s)G_{\text{speaker}}(s)
  \]
System frequency response: \( s = j\omega \)

\[
G(j\omega) = G_{CD}(j\omega)G_{\text{amp}}(j\omega)G_{\text{speaker}}(j\omega)
\]

\[
= |G_{CD}(j\omega)| e^{j\arg [G_{CD}(j\omega)]} |G_{\text{amp}}(j\omega)| e^{j\arg [G_{\text{amp}}(j\omega)]} |G_{\text{speaker}}(j\omega)| e^{j\arg [G_{\text{speaker}}(j\omega)]}
\]

System gain and phase:

\[
G(j\omega) = |G(j\omega)| e^{j\arg [G(j\omega)]}
\]

\[
|G(j\omega)| = |G_{CD}(j\omega)| |G_{\text{amp}}(j\omega)| |G_{\text{speaker}}(j\omega)|
\]

\[
\arg [G(j\omega)] = \arg [G_{CD}(j\omega)] + \arg [G_{\text{amp}}(j\omega)] + \arg [G_{\text{speaker}}(j\omega)]
\]

System \( M_{dB} \) sum of components:

\[
M_{dB} = 20 \log_{10} |G(j\omega)|
\]

\[
= 20 \log_{10} |G_{CD}(j\omega)| + 20 \log_{10} |G_{\text{amp}}(j\omega)| + 20 \log_{10} |G_{\text{speaker}}(j\omega)|
\]

\[
M_{dB} = M_{dB}(\omega) = M_{dB}^{CD}(\omega) + M_{dB}^{\text{amp}}(\omega) + M_{dB}^{\text{speaker}}(\omega)
\]

System phase \( \phi \) sum of components:

\[
\phi = \arg [G(j\omega)]
\]

\[
= \arg [G_{CD}(j\omega)] + \arg [G_{\text{amp}}(j\omega)] + \arg [G_{\text{speaker}}(j\omega)]
\]

\[
\phi = \phi(\omega) = \phi_{CD}(\omega) + \phi_{\text{amp}}(\omega) + \phi_{\text{speaker}}(\omega)
\]
• Stereo system response
  o magnitude
  \[ M_{dB} = M_{CD}^{dB}(\omega) + M_{amp}^{dB}(\omega) + M_{speaker}^{dB}(\omega) \]
  o phase
  \[ \phi = \phi_{CD}(\omega) + \phi_{amp}(\omega) + \phi_{speaker}(\omega) \]
AMPLIFIER SECTION

Power Output: 33 watts per channel, min. RMS, at 8 ohms, both channels driven, from 40Hz to 20kHz, with no more than 0.3% THD.

Total Harmonic Distortion: 0.1% at 25W
IM Distortion: 0.1% at 1 watt output
Damping Factor: 35 at 8 ohms
Frequency Response: 20 – 30,000 Hz ±1dB
RIAA Deviation: 20 – 20,000 Hz ±0.8dB

Sensitivity and Impedance:
- Phono: 2.5mV/50 kohms
- CD: 150mV/50kohms
- Tape Play: 150mV/50 kohms
- Tape Rec: 150mV/3.5 kohms (phono)

Phono Overload: 120mV RMS at 1kHz, 0.3% THD

Signal-to-Noise Ratio:
- Phono: 85dB (at 10mV input, A weighted)
- Tape: 76dB (A weighted)
- 80dB (IHF A-202)

Tone Controls:
- Bass: ±10dB at 100Hz
- Treble: ±10dB at 10kHz

Loudness (-30dB):
+7dB at 70Hz, +5dB at 10kHz

TUNER SECTION

FM:
Tuning Range: 87.5 – 108.0MHz (100kHz steps)
Usable Sensitivity:
- Mono: 12.4dBf, 2.3µV
- Stereo: 19.2dBf, 5.0µV

50dB Quieting Sensitivity:
- Mono: 18.2dBf, 4.5µV
- Stereo: 38.2dBf, 45µV

Capture Ratio: 1.5dB
Image Rejection Ratio: 40dB
IF Rejection Ratio: 90dB

Signal-to-Noise Ratio:
- Mono: 70dB
- Stereo: 65dB

Alternate Channel
Attenuation: 55dB
AM Suppression Ratio: 50dB

Harmonic Distortion:
- Mono: 0.15%
- Stereo: 0.3%

Frequency Response: 30 – 15,000Hz ±1.5dB
Stereo Separation: 40dB at 1kHz
30dB at 100 – 10,000Hz

Muting Level: 17.2dBf, 4.0µV
Stereo Threshold: 17.2dBf, 4.0µV

AM:
Tuning Range: 520 – 1710kHz (10kHz steps)
Usable Sensitivity: 30µV
Image Rejection Ratio: 40dB
IF Rejection Ratio: 30dB
Signal-to-Noise Ratio: 40dB
Harmonic Distortion: 0.8%

GENERAL
Power Supply: AC120V, 60Hz
Dimensions (W x H x D): 435 x 97 x 317 mm
17-1/8"x3-15/16"x12-1/2"
Weight: 5.7 kg., 12.6 lbs.

Specifications and features are subject to change without notice.
S.E.A. STEREO GRAPHIC EQUALIZER
SEA-22/SEA-22B

The SEA-22 and SEA-22B have the same performance but are different colors: the SEA-22 is silver and the SEA-22B is black.

Die Modelle SEA-22 und SEA-22B besitzen die gleichen Leistungspartner, unterscheiden sich jedoch in der Farbgebung: Modell SEA-22 ist silberfarben, Modell SEA-22B schwarz.

Les SEA-22 et SEA-22B ont les mêmes caractéristiques mais sont de couleur différente. Le SEA-22 est couleur argent et le SEA-22B, noir.

De SEA-22 en SEA-22B hebben dezelfde kenmerken maar verschillen van kleur; de SEA-22 is zilver, de SEA-22B is zwart.

Los modelos SEA-22 y SEA-22B son de igual rendimiento pero tienen colores diferentes; el SEA-22 es plateado y el SEA-22B en negro.

For Customer Use:

Enter below the Model No. and Serial No. which is located on the rear of the cabinet. Retain this information for future reference.

Model No. ____________________________
Serial No. ____________________________
Loudness control and noise filter capability

The response of the SEA-22/SEA-22B ensures the most suitable loudness control and noise filter capabilities.

Producing various sounds

In the process of studio recording or tape editing, music unique to a certain orchestra is enhanced by performing technical operations for acoustic response compensation or sound effect.

The SEA-22/SEA-22B system has made it possible to produce new and varied sound; with this SEA system, for example, even inexpensive stereo equipment reproduces music as if it is from a high-class stereo.

Control method without waste

Bass or treble controls in normal amplifier sometimes emphasize unnecessarily low and high sounds exceeding the audible frequency band; this tends to increase motor rumble interference in the low range and noise in the high sound range. The SEA-22/SEA-22B, however, adjusts only those necessary frequency bands for sound reproduction within the audible frequency range. It can therefore be called a control method without waste.
S.E.A. controls
The SEA-22/SEA-22B Graphic Equalizer divides the audio spectrum from 63 Hz to 16 kHz into 7 frequency bands having their center frequencies at intervals of 4/3 octave starting from 1 kHz in both directions.
When the knob is set to ‘0’ (center position), frequency response is flat. The response can be varied by ±12 dB by raising or lowering the knob.

63 Hz: Raise to emphasize the very low bass response of organs, drums, and contrabass. It produces stable and solid sound by raising the knob and eliminates the unclear sound response of low frequencies by lowering the knob.

160 Hz: Raise the knob to obtain a more expanded low sound. Lower the knob to eliminate unclear sound caused by large spaces in listening rooms.

400 Hz: This frequency range is the base on which music is constructed. Raise this knob to really put a punch in your music.

1 kHz: Most effective in emphasizing or de-emphasizing the human voice. Raise the knob to cause the vocalist to be brought to the foreground, or lower for causing it to recede into the background.

2.5 kHz: This frequency stimulates the human ear. If the music sounds hard or metallic, lower the knob.

6.3 kHz: Boost to add clarity to winds and strings. Moving this control varies the tonal expression, influencing the subtleties of the music.

16 kHz: Boosting this frequency range properly adds to the delicacy of highs, with cymbals and triangles resounding in a more ear-pleasing manner, and provides a feeling of extension.
Compensation for room acoustics

The frequency response of a listening room varies depending on the mode of the room or on the position of the listener in the room. Sound response inherent to the listening position is therefore produced by a different degree of reverberation, reflection, echo and absorption in each room.

The SEA system can function to make the sound response of a room flat by emphasizing those frequencies having a high degree of absorption and de-emphasizing those frequencies having a high degree of reflection.

The frequency ranges affected by 'absorption' and 'reflection' are narrow, therefore it is necessary only to compensate the corresponding frequency band.

Since conventional tone control systems simply adjust the highs and lows centered around the 1 kHz frequency, they influence other frequencies.

The SEA-22/SEA-22B system has 7 separate audible frequency bands and functions to compensate only the necessary frequency range, so as to compensate for the acoustic response of each listening position and room.
Example of transmission response in a hall
Übertragungs-Charakteristika in einer Halle
Exemple de réponse de transmission dans un hall
Voorbeeld van een overdrachtskarakteristiek in een zaal.
Ejemplo de respuesta de transmisión en una sala

Example of transmission response in a room with little echo
Übertragungs-Charakteristika in einem Raum mit geringem Echo
Exemple de réponse de transmission dans une salle ayant un peu d'écho
Voorbeeld van een overdrachtskarakteristiek in een kamer met weinig echo.
Ejemplo de respuesta de transmisión en una pieza con un poco de eco
Compensation for reproduction responses of cartridges and speakers
Almost all moving-magnet cartridges have response curve peaks between 10 kHz and 20 kHz. The SEA graphic equalizer, with which minute adjustments at each frequency band is possible, has enabled the flat reproduction of their responses compensated over the entire frequency range.
The SEA graphic equalizer can compensate for attenuated response below 100 Hz, peculiar to airtight speaker enclosures, by adjusting the 63 Hz control. It can also compensate for an obscure vocal by lowering the 6.3 kHz control and raising the 400 Hz and 1 kHz controls. Also for mid- and high-range horn type speakers, the SEA system can eliminate harsh, grating sounds by lowering the 6.3 kHz control.
Fine compensation
The SEA graphic equalizer having response curves to be adjusted by ±12 dB can compensate for relatively great variations in response, such as those in listening rooms and speaker systems.
Example of speaker reproduction response (The dotted line (....) indicates the frequencies after compensation.)