

# **A New Transducer for Improved Compact Audio System Performance**

Rick Weisman

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# Emerging Audio Trends

- **Compact** speaker systems are becoming more desirable for a less obtrusive appearance and when space is limited.
- **Array** speakers are being introduced into both professional and consumer markets that offer precise pattern control and can create multichannel sound from a single cluster of drivers.
- **Home** audio is moving away from stereo towards multichannel surround that require more speakers, wires and electronics.
- **Automotive** audio systems is also moving towards multichannel surround creating new packaging challenges for automotive interior design.

# Advantages of Compact Full Range Loudspeakers

- **Size/Convenience/Cost:** small full range loudspeakers require much less space so they can be mounted in areas usually thought to be too cramped to fit loudspeakers. A variety of unobtrusive applications become practical. Small speakers are lighter and use less material.
- **Uniform coverage:** small drivers have a more constant beamwidth throughout the frequency range. Large drivers have a very narrow radiation pattern at high frequencies. Constant beamwidth means the loudspeaker can much better reproduce the sound as it was recorded by the microphone.
- **Better in Arrays:** arrays require small transducers able to recreate the full audio spectrum but also able to be packed close together.
- **Array Advantages:** arrays allow a defined coverage based upon either the geometric arrangement of the drivers or upon the signal processing to each driver. Vertical arrays, for example, can produce an ideal cylindrical radiation pattern.

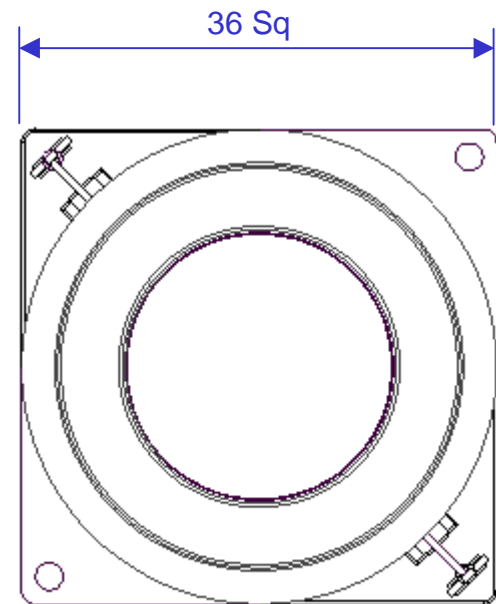
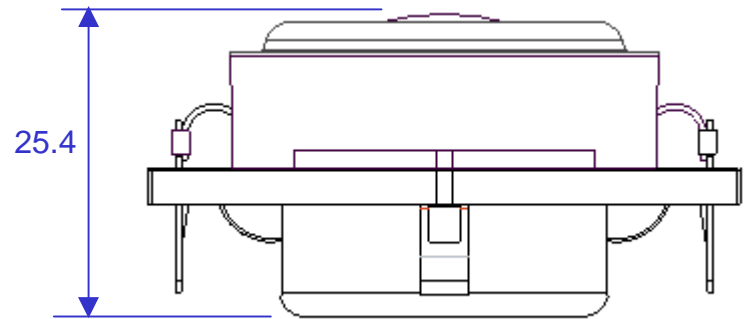
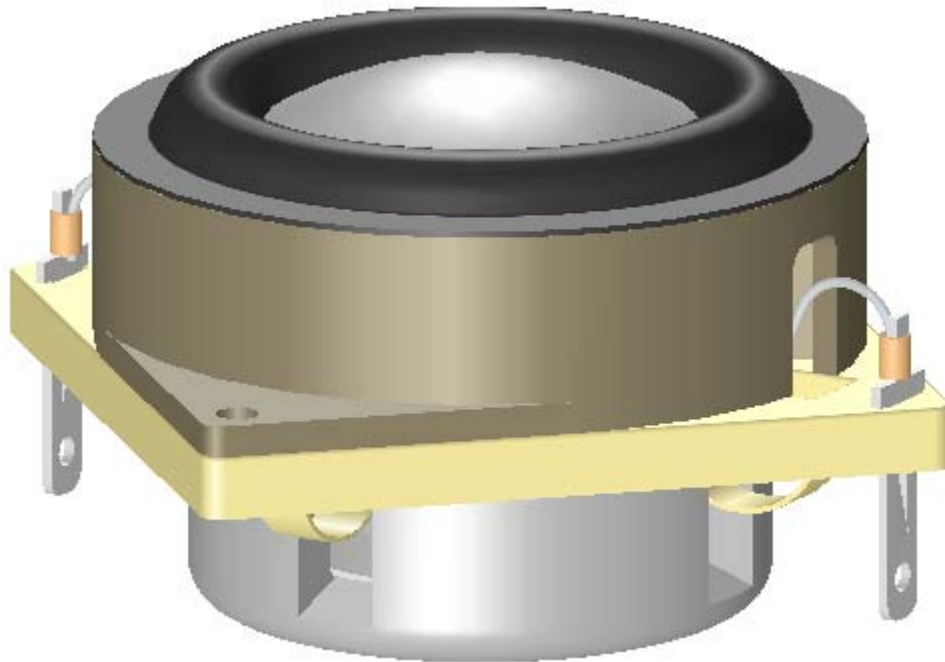
# Challenges to Achieving High Quality Audio in Compact Loudspeakers

- **Low efficiency:** varies with the square of the diaphragm area - small diaphragm area means lower efficiency.
- **Poor low frequency output:** LF is related to the volume displaced by the diaphragm - a small loudspeaker must have a very long excursion to make up for its small diaphragm area.
- **Low power handling:** a result of small voice coils and physical constraints to diaphragm motion resulting in limited maximum sound pressure levels.
- **Distortion:** the high excursions required to get LF response usually result in high distortion caused by suspension and magnetic nonlinearities.

# Requirements of an Ideal Compact Full Range Audio Transducers

- **Very compact piston size** ( $< \text{Ø}25$  mm diaphragm) to maintain constant beamwidth throughout its frequency range.
- **Very long linear excursion:**  $X_{\text{max}}$  : diaphragm diameter of  $< 1/20$ . The motor force and the suspension restoring force must be within 10% of linear within the excursion range.
- **High power handling:** allows use of higher power amp to achieve high SPL's.
- **Linear amplitude response** over the entire audio frequency band.
- **Low distortion** and spurious noise

# AX-20 Full Range Transducer

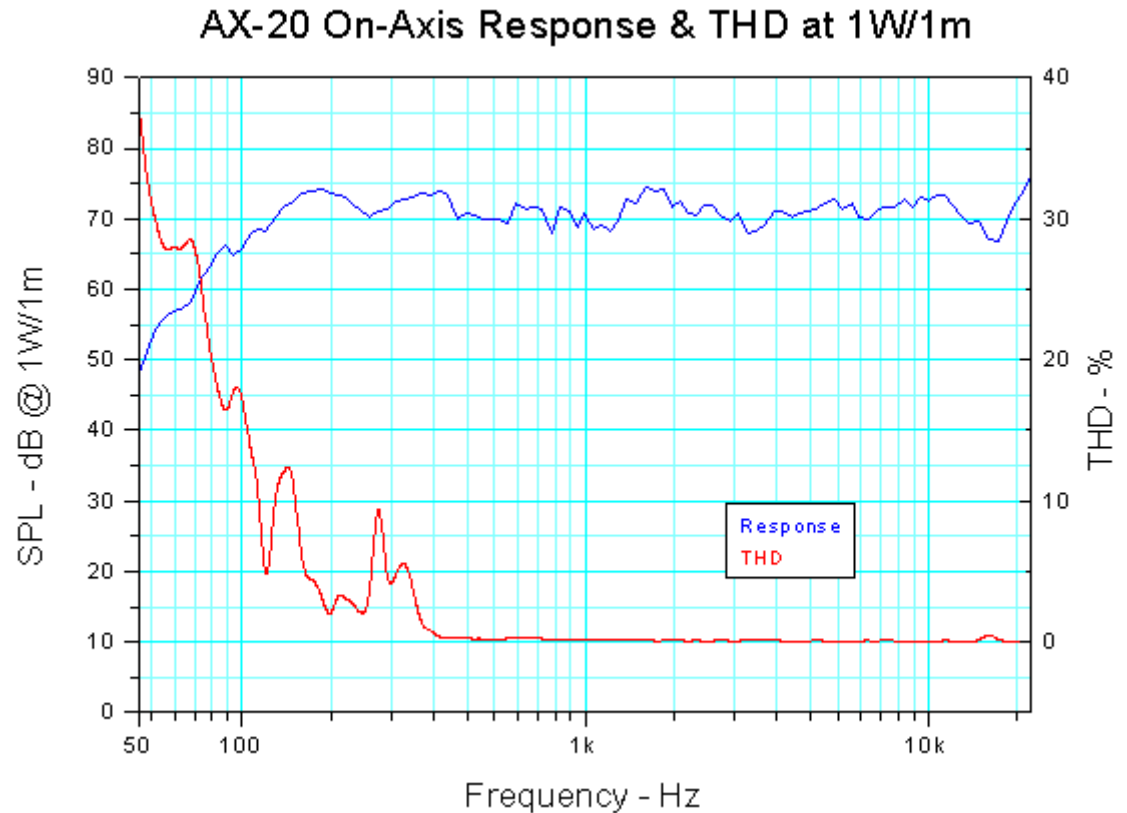


## Preliminary Specifications

Frequency range:	90 - 20 kHz
DCR:	5.5 Ohms
Efficiency:	73 dB@ 1W/1m
Max LF output:	79 dB @ 111 Hz @ 10% THD
Power handling:	12 Watts
Xmax:	2.8 mm

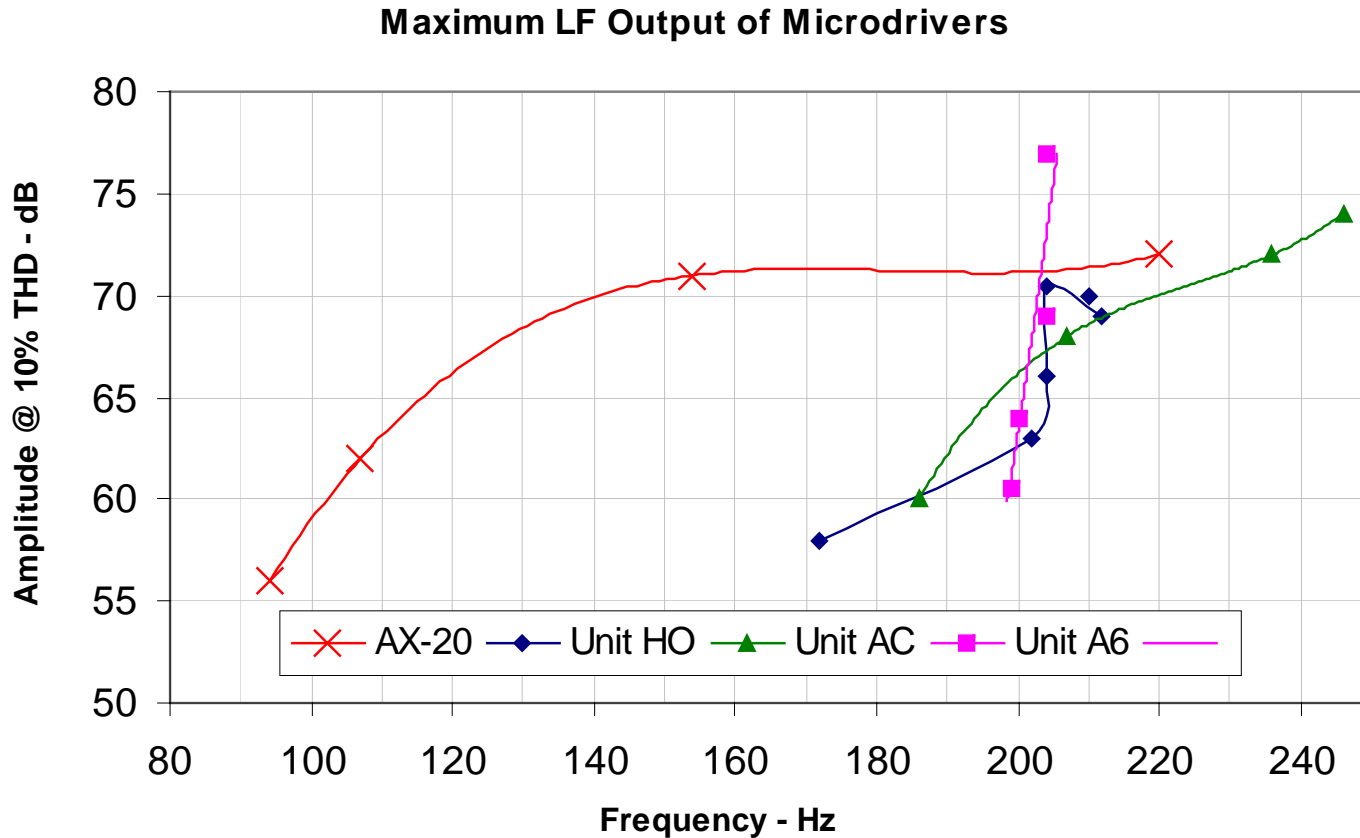
# AX-20 Parameters & Response

<b>F<sub>s</sub></b>	150 Hz
<b>V<sub>as</sub></b>	.06 liters (60 cc)
<b>Q<sub>ts</sub></b>	1.06
<b>Q<sub>es</sub></b>	1.6
<b>Q<sub>ms</sub></b>	3.14
<b>R<sub>e</sub></b>	6 Ohms
<b>S<sub>d</sub></b>	5.56 cm <sup>2</sup>
<b>C<sub>ms</sub></b>	1.02 mm/N
<b>M<sub>ms</sub></b>	.65 grams
<b>R<sub>ms</sub></b>	0.328 kg/s
<b>L<sub>e</sub></b>	0.234 mH
<b>R<sub>es</sub></b>	20.27 Ohms
<b>X<sub>max</sub></b>	2.8 mm
<b>BL</b>	2.68 N/A
<b>SPL</b>	73 dB 1W @ 1m



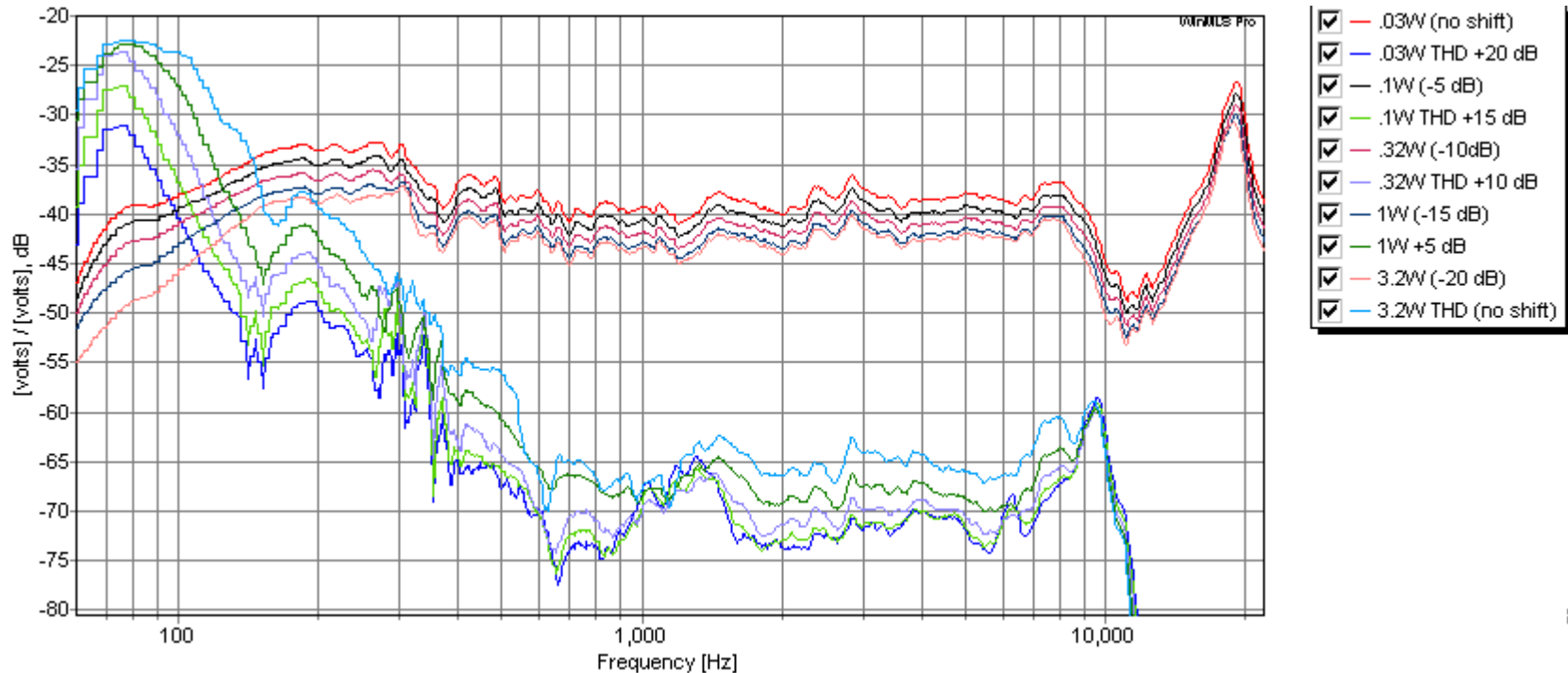
Response measured w/ drivers mounted in 1.0 liter box w/ gated MLS signal. Parameters are preliminary based upon prototypes measured with the Klippel analyzer.

# Maximum Low Frequency Output vs. Competitive Product



This plot shows the point at which each tested driver reaches 10% total harmonic distortion at increasing input power levels. Input power was the same for all drivers with drive voltage adjusted for DC impedance.

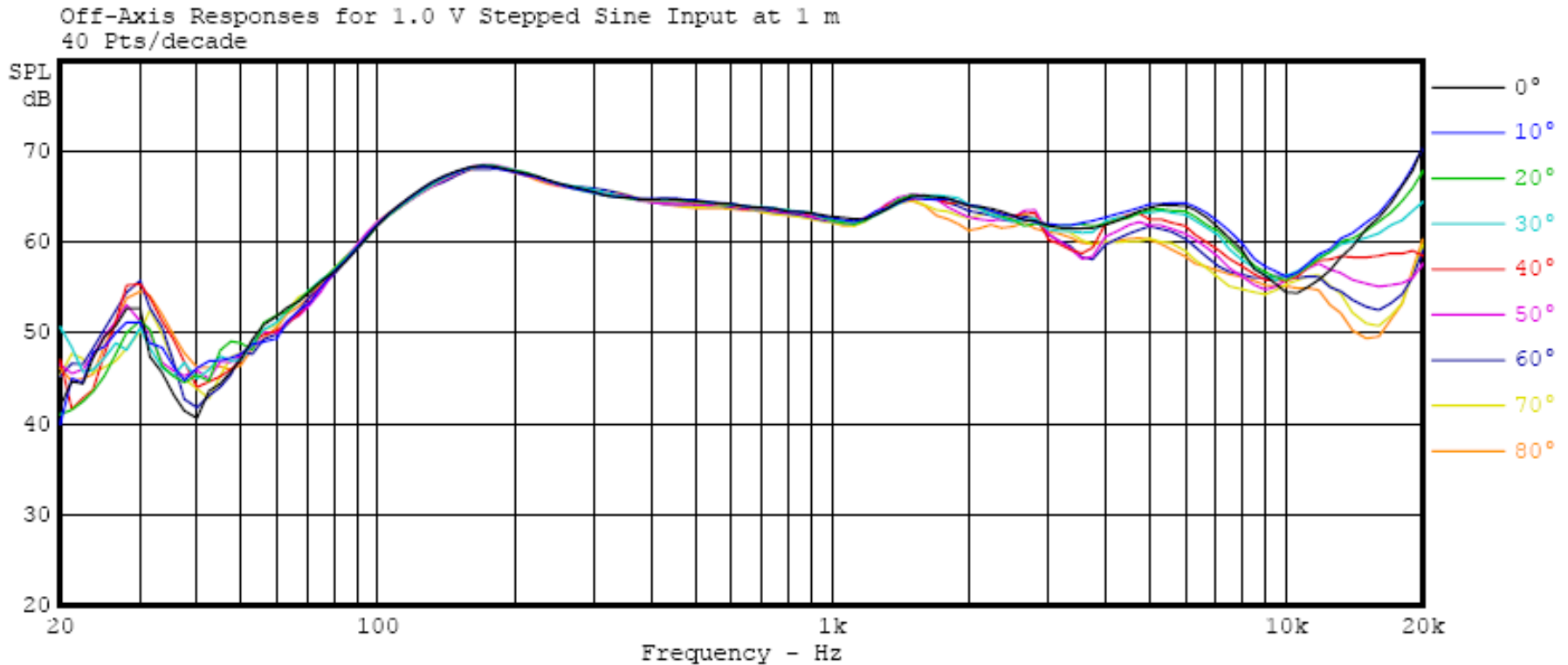
# Maximum Low Frequency Output of AX-20



The curves show the nonlinear behavior of an early AX-20 prototype as input power is increased. The top curves are the frequency response to a log swept sine wave where the input power is increased by 5 dB for each measurement. The curve is then shifted down by 5 dB for each measurement such that all the curves would be superimposed as one thick line if the driver had no large signal nonlinearities.

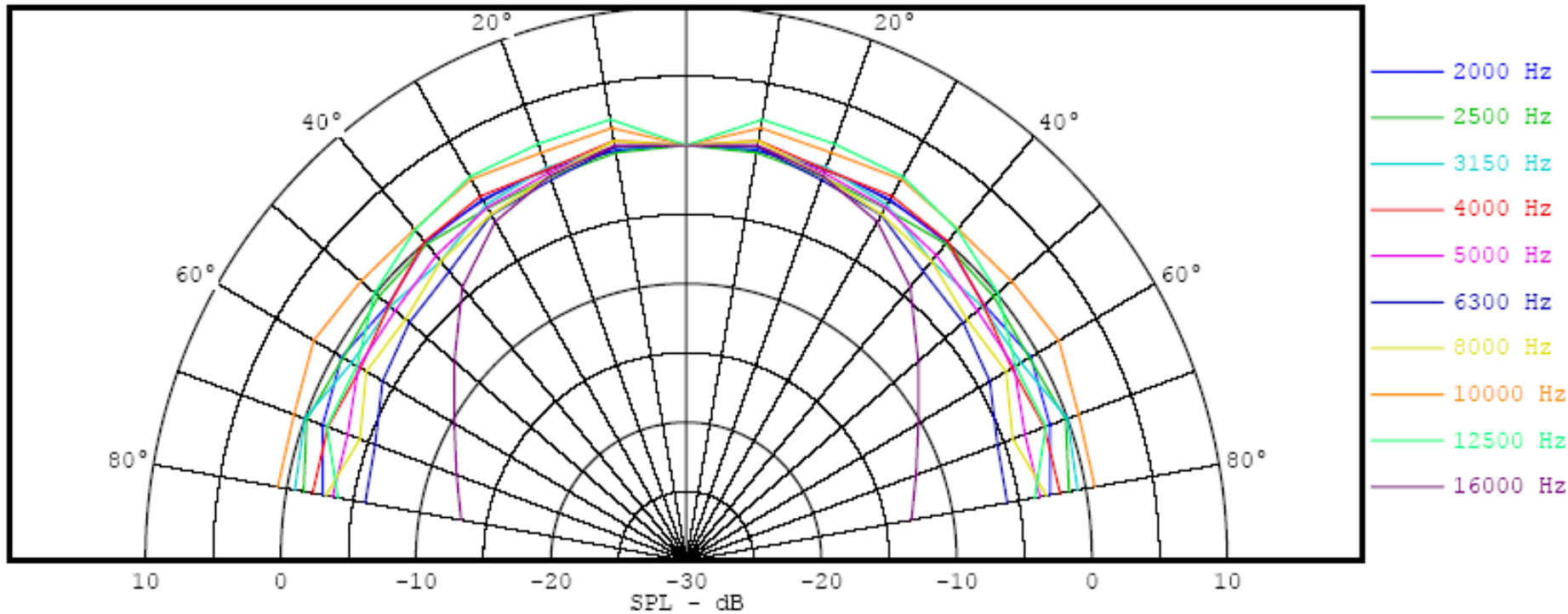
As with the frequency response curves, the THD curves are shifted lower by 5 dB each time the power is raised by 5 dB so that they should be superimposed for a perfect driver. The THD curves are raised by 20 dB so that when each THD curve intersects with its corresponding frequency response curve, we know that is where the distortion is 20 dB down from the fundamental corresponding to a THD of 10%.

# Off Axis Response (1 V)



# Polar Response

Normalized Polar Response Characteristics for 1.0 V Stepped Sine Input at 1 m



# Applications

## Home Audio

- Vertical line arrays for ideal cylindrical radiation at all frequencies.
- TV & Flat panel display audio
- Architectural audio: in-wall, light fixtures
- Acoustic phased arrays for steering multichannel beams from a single panel or for directivity control

## Portable Audio

- Very compact USB portable stereo for use w/ projectors
- Compact high quality portable boom box

## Automotive Audio

Unusually good low frequency output & small size allows for unusual placement such as:

- Headliners
- Instrument panel
- A, B & C pillars
- Headrests & Seatbacks

## Pro Audio

- Lightweight steerable arrays to replace compression drivers & horns
- Compact stage monitors
- Public address & sound reinforcement

# Compact Flat Panel Premium Sound

## Benefits

- Fits within narrow vertical & horizontal bezels
- Center channel provided by horizontal shaded array
- Excellent low frequency response (Sd ~ 8" woofer)
- Surround either by discreet or virtual



# Array Speaker Examples



## Pioneer Surround DSP Array

Produces 5 channel surround from a single panel by using phased array technology to steer surround channels that are bounced off the walls.



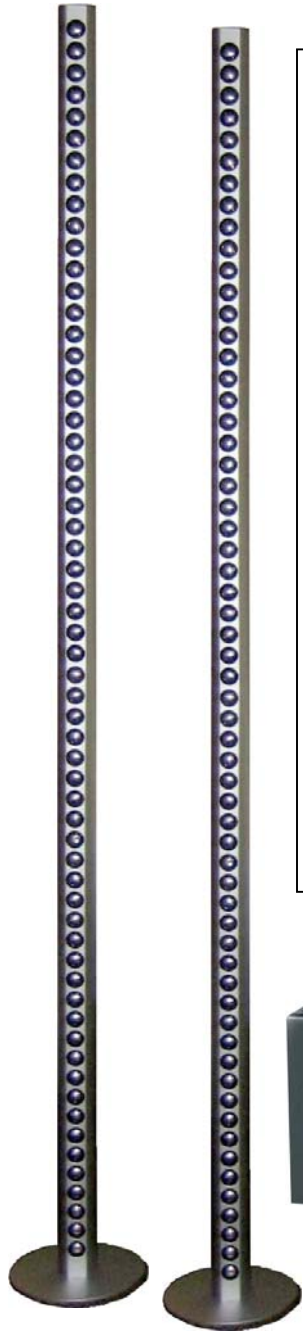
## Yamaha Adaptive Array Speakers

# Wave9 Vertical Line Arrays

## VLA-1 2.1

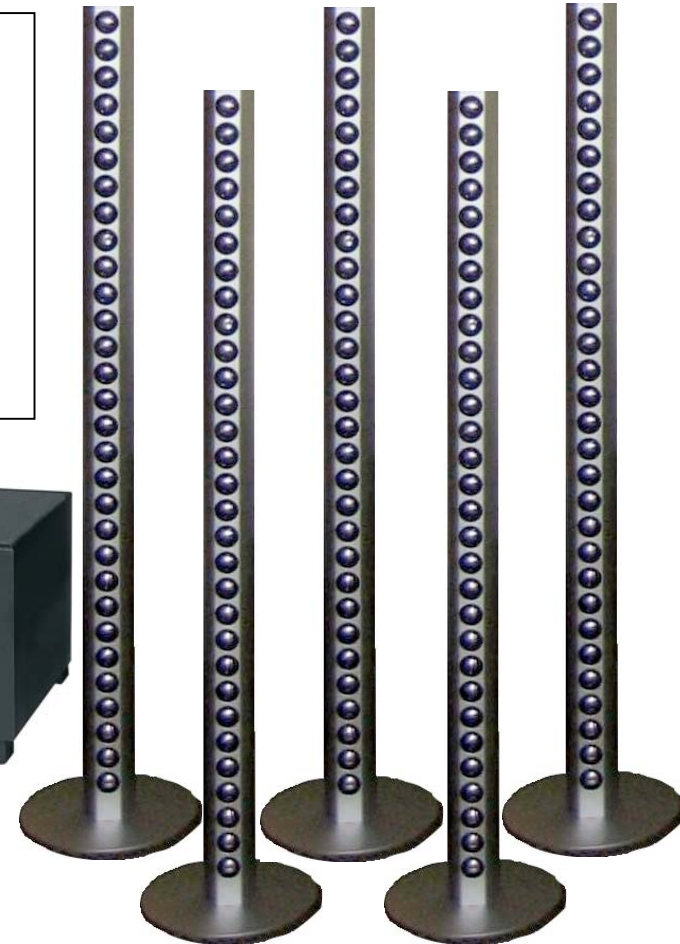
Full range floor to ceiling vertical line array.

- Near field sound in all the room
- Ideal cylindrical horizontal sound radiation
- No crossovers
- Very small foot print and space



## VLA-2 5.1

Compact High performance room friendly theater sound



# Inquiries:

Rick Weisman

(626) 395-9713

(626) 744-1886 fax

(626) 533-1956 cell

[rweisman@ieee.org](mailto:rweisman@ieee.org)

[rw@wave9systems.com](mailto:rw@wave9systems.com)

In Hong Kong

(852) 2484 5616

(852) 6335 2873 cell