

BMH-1

Binaural Head Microphone
User Guide



audiofrog 

Audiofrog BHM-1 Binaural Head Microphone

Thanks for purchasing your new BHM-1. We hope it will provide years of fun and reliable service. Your BHM-1 has been designed to make it easy to capture the sound of spaces in recordings to be played back over headphones. To ensure the best performance, use over the ear headphones or high quality in-ear monitors for playback.

For playback over loudspeakers, we suggest equalizing the recording for a diffuse field rather than free field. Please see “Equalization for playback over loudspeakers” in the Appendix for appropriate equalization settings for use in your DAW (digital audio workstation) or in an equalizer included in your playback system if you wish to play back the recording over loudspeakers. Playback over loudspeakers will provide some sense of the recording space, but the best performance can be had using headphones.

Your BHM-1 has been designed for use with three different types of audio gear. First, your BHM-1 can be connected to the inputs of professional audio interfaces or recording equipment that provides 48-volt phantom power using the XLR outputs in the base of the head. Your BHM-1 can also be connected to the inputs of a video camera or a consumer grade soundcard with a stereo microphone input that provides a bias voltage of 2-9 VDC. For this connection, you may need to use a Y adapter. Finally, your BHM-1 includes a pair of mic preamps powered by an on-board 9V battery for use with any stereo audio input found in most consumer audio products. Details and diagrams of each of these connections are provided later in this user guide.

Your BHM-1 includes a 1/4-20 threaded insert in the base for mounting the head microphone on a camera tripod, a gimbal or a microphone stand. A 1/4” to 5/8” adapter is included.

Caution:

Your BHM-1 is made of PLA plastic and UV resin. Please do not expose the BHM-1 to temperatures above 110° F (43°C) for long periods because the plastic will soften at high temperatures.

For storage of your BHM-1, please remove the 9V battery (if installed) to prevent corrosion of the terminals. The 9V battery is only required when using the stereo line output of the BHM-1.

Maximum SPL input for your BHM-1 is 110dB. Recording sounds louder than 110dB will result in distortion.

The microphones are mounted in the ears. Microphones are delicate objects. Please do not push on the microphones. Do not poke the microphones with any object.

Do not expose the head, the base or the microphones to harsh cleaners or liquids. Do not submerge the head in water. Do not use compressed air to clean the inside of the ears or the microphones. Do not blow into the ears or the microphones.

Never plug a pair of headphones into the stereo output of your BHM-1. Headphones require more current than the preamp is designed to provide. The preamp is designed for equipment with an input impedance of or higher than 1kΩ.

If you suspect a problem with your BHM-1, please contact us through the contact form at www.audiofrog.com, or email us at customerservice@audiofrog.com.

Your BHM-1 is warranted against manufacturing defects for a period of one year from the date of purchase. Please retain your purchase receipt for submission with any warranty claim.

What can I do with a binaural microphone?

Anytime you want to capture the spatial qualities of a sound event, a binaural head microphone makes it easy. Some examples:

1. Capture the spatial qualities of an audio system set up in a room or a car so a listener can experience those qualities over headphones in a remote location or at a different time. This can be very useful for presenting the benefits of audio equipment or advanced system optimization using a previously optimized system as an example.
2. Capture a soundscape to serve as a sonic environment when making industrial, training or informative videos.
3. Capture the sound of ambient noise so that equalization can be designed into an audio system to mask the effects of such noise.
4. Capture the sound of environmental noise for analysis.
5. Add realism to a recording of any live event—birthday parties, hikes, school plays or concerts. Your imagination is the limit.
6. Make field recordings of natural events or the sounds of animals.
7. Learn about the effects of Head Related Transfer Function (HRTF) and sound localization.

Making binaural recordings with the BHM-1

A binaural head microphone makes it easy to capture the spatial aspects of sound in different environments and to experience those spatial aspects when listening to playback over a good pair of headphones. Compared to other means such as: a) binaural rendering of standard stereo recordings, b) synthesizing of a space using a recording made with an ambisonics microphone and a digital audio workstation plug-in or some other computer program, a direct binaural recording made with a head mic is faster and easier and doesn't include a steep learning curve. You just place the mic, record the event and play it back.

How does the head mic capture all of the spatial qualities?

We hear spaces because sounds that arrive at our ears from sources placed at various distances and angles in 360-degree space arrive at our ears at different times and at different levels. In addition, the shape of our head and torso and the shapes of our ears changes the frequency response of the sound when it arrives from different angles of azimuth and elevation. Making a recording using a microphone shaped like a head with microphones in its ears captures all of those differences automatically.

The frequency response changes that are the result of different orientations in elevation and azimuth are commonly referred to as Head Related Transfer Function, or HRTF. We have documented the HRTF of the BHM-1 at 15° increments in both azimuth and elevation and those measurements are included in the appendix of this manual. The measurements have been saved as simple .txt files and can be easily imported into many measurement and analysis programs. The complete set of measurements is available for download on the BHM-1 section of www.audiofrog.com.

When we listen to a binaural recording (made with a head microphone) through headphones, the timing of the arrival of sounds and their frequency responses recorded by the head microphone--the head microphone's HRTF-- replaces the HRTF of our own head. The result is an astonishingly believable recreation of the recording space.

Making the recording is simple. Attach the BHM-1 to a tripod or a microphone stand and place the stand so the head is in the same place and in the same orientation as a listener's head would be if the listener was

present. Plug the BHM-1 into your chosen audio interface. Press record in your recording program or app and record the event. Once you have made the saved the recording, you may want to import it into a digital audio workstation to adjust levels, clip out silence at the beginning or the end of the track or edit or remix the track in some other way.

Some notes:

- 1.** The BHM-1 does not include an on-board high pass filter. Low frequency sounds that exist in the recording space will be captured and their level can be deceptively high. You may want to enable a filter in your app or digital audio workstation before recording or you may want to attenuate these low frequency sounds in a post process.
- 2.** The maximum input sound pressure level for your BHM-1 is 110dB. Sounds louder than 110dB may cause the microphone to clip and cause distortion in your recording. 110db should be sufficiently high for most applications, but potentially not high enough for capturing the sound of industrial processes or other events (rocket launches, airplane takeoff, etc.).
- 3.** The BHM-1 will capture both elevation and azimuth, so be sure to place the BHM-1 at the same height as an imaginary listener's head and point the BHM-1 in the same direction.
- 4.** The recording made with the BHM-1 will likely be suitable for immediate playback over headphones. If you wish to listen to the recording over loudspeakers, you'll need to apply some equalization to convert the response to a response suitable for a diffuse field (a room with speakers in it). See the appendix for the details of such a filter. You'll need to apply that filter in your recording app (if possible), or in a digital audio workstation or in an equalizer included in your playback system.
- 5.** The microphones in the BHM-1's ears are high quality omnidirectional electret capsules. They have a frequency response of 20Hz – 20kHz. This is the limit of human hearing. When setting the parameters of the recording in your recording app or your digital audio workstation, a sample rate of 44.1k or 48k is sufficient to capture all the sound humans can hear. If you will be recording quiet sounds or if you will be post processing your recording or mixing it with other audio tracks, you may find a bit rate of 24 or 32 bps to be better than 16 bps.

Specifications:

Microphone Element Type: Electret

Microphone Element Pattern: Omnidirectional

Microphone Element Sensitivity: -42 +/-3dB

Microphone Element Frequency Response: 20Hz – 20kHz, +2 to -2dB

Bias Voltage for Separate 3.5mm Outputs: 2V-9VDC

Maximum Output Voltage for 3.5mm Stereo Output: 2V

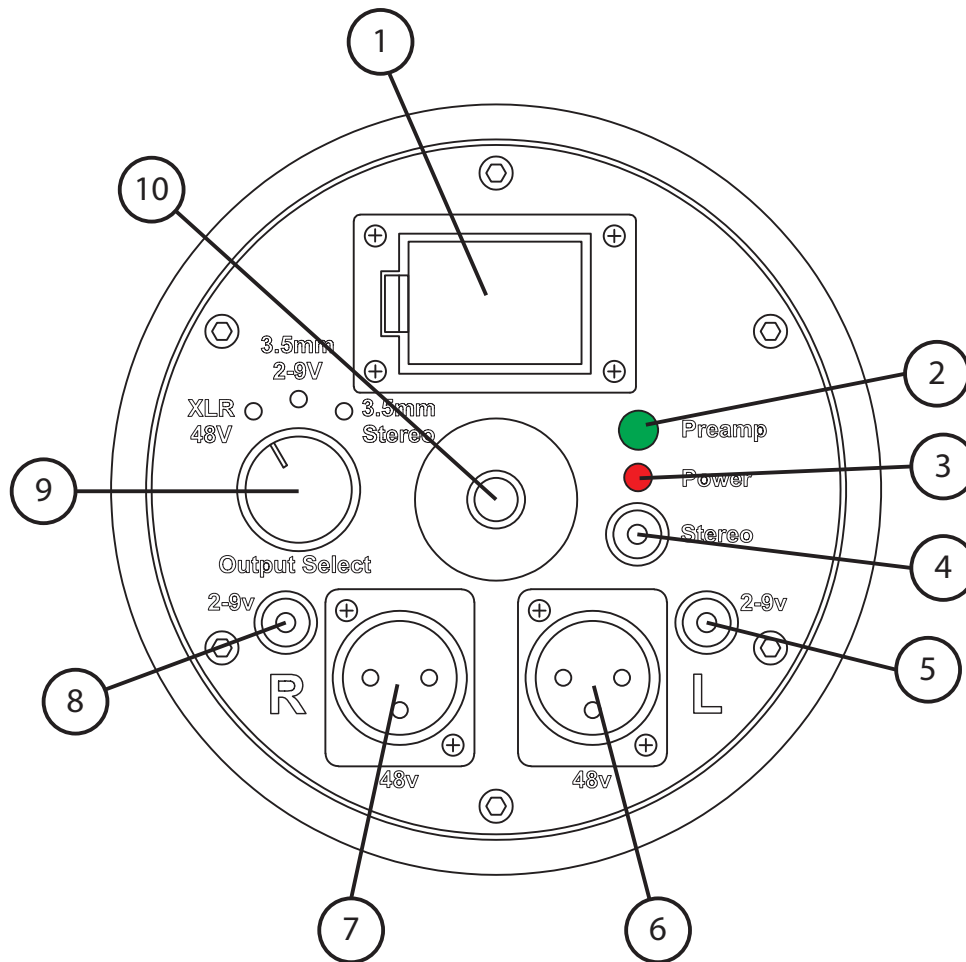
Battery for Stereo Preamp Output: 9V

Expected Battery Life: 100 Hours

Phantom Power: 48V

Mic Stand Adapter: 1/4" 20 thread, 5/8" to 1/4" adapter included

Connections:



1. 9V Battery Compartment: 9 V battery is only necessary if you intend to use the 3.5 mm stereo line output (4). Press to release the clip and slide the battery drawer away from the base to install the battery.

2. Stereo Preamp On/Off Switch: Turns the preamp for the 3.5 mm line output on and off.

3. Stereo Preamp Power Indicator LED: Glows red to indicate the preamp is on.

4. 3.5 mm Stereo Line Output TRS Jack: Provides line level (1 V) stereo output for connection to consumer grade audio gear. Do NOT connect headphones to this jack. 9 V battery must be installed and the preamp must be switched on to use this output.

5. 3.5 mm Left Output TRS Jack: Left microphone output for use with cameras or consumer grade stereo soundcards that provide the required 2-9 VDC bias voltage.

6. Left XLR Output Jack: Left microphone output for use with professional audio interfaces or recorders that provide 48 V phantom power. You must engage the 48 V phantom power in the interface to use this output.

7. Right XLR Output Jack: Right microphone output for use with professional audio interfaces or recorders that provide 48 V phantom power. You must engage the 48 V phantom power in the interface to use this output.

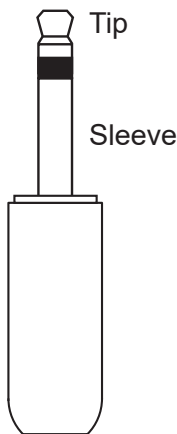
8. 3.5mm Right Output TRS Jack: Right microphone output for use with cameras or consumer grade stereo soundcards that provide the required 2-9 VDC bias voltage.

9. Output Selector Switch: Use this switch to select between the three output types: XLR 48V, 3.5mm 2-9V, or Stereo.

10. 1/4-20 Tripod/Mic Stand Mounting Attachment: Attach a mic stand, tripod or gimbal here. A 1/4" to 5/8" adapter is included with your BHM-1.

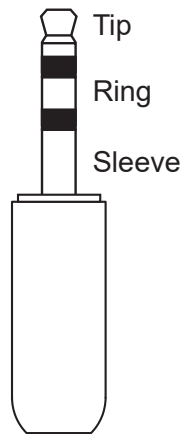
Connection pin out diagrams:

3.5mm (2-9V)



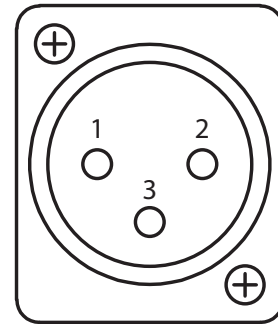
Tip: Signal +
Sleeve: Signal - (ground)

3.5mm (Stereo)



Tip: Left Signal +
Ring: Right Signal +
Sleeve: Signal - (ground)

XLR (48V)



1: Ground (Shield)
2: Positive (Hot)
3: Negative (Cold)

Refer to the drawings above when considering how you will connect your BHM-1 to other equipment. We have made every effort to use standard connections and configurations, but there are many possibilities.

For connections to cameras and video cameras that provide a bias voltage for the microphones, you **MUST** use the separate 3.5 mm jack on your BHM-1 and not the stereo output. Consult the owner's manual for your camera to confirm the connection type. You will probably need a 3.5 mm stereo to dual 3.5 mm mono adapter.

The 3.5 mm Stereo connector provides a standard analog audio output and is suitable for connection to the input of any consumer grade stereo recording device. The microphone input to most phones is a mono input. Stereo recording with your phone will require a USB interface device with a stereo input. These are available in configurations that provide a bias voltage for a stereo microphone. Use these devices with the 3.5 mm (2-9 V) jack. They are also available in configurations that will accept a standard stereo input. Use these devices with the 3.5 mm Stereo output included in your BHM-1. Shop carefully! We recommend the Rode AI Micro for use with phones. It's also compatible with any PC or Mac with a USB connection.

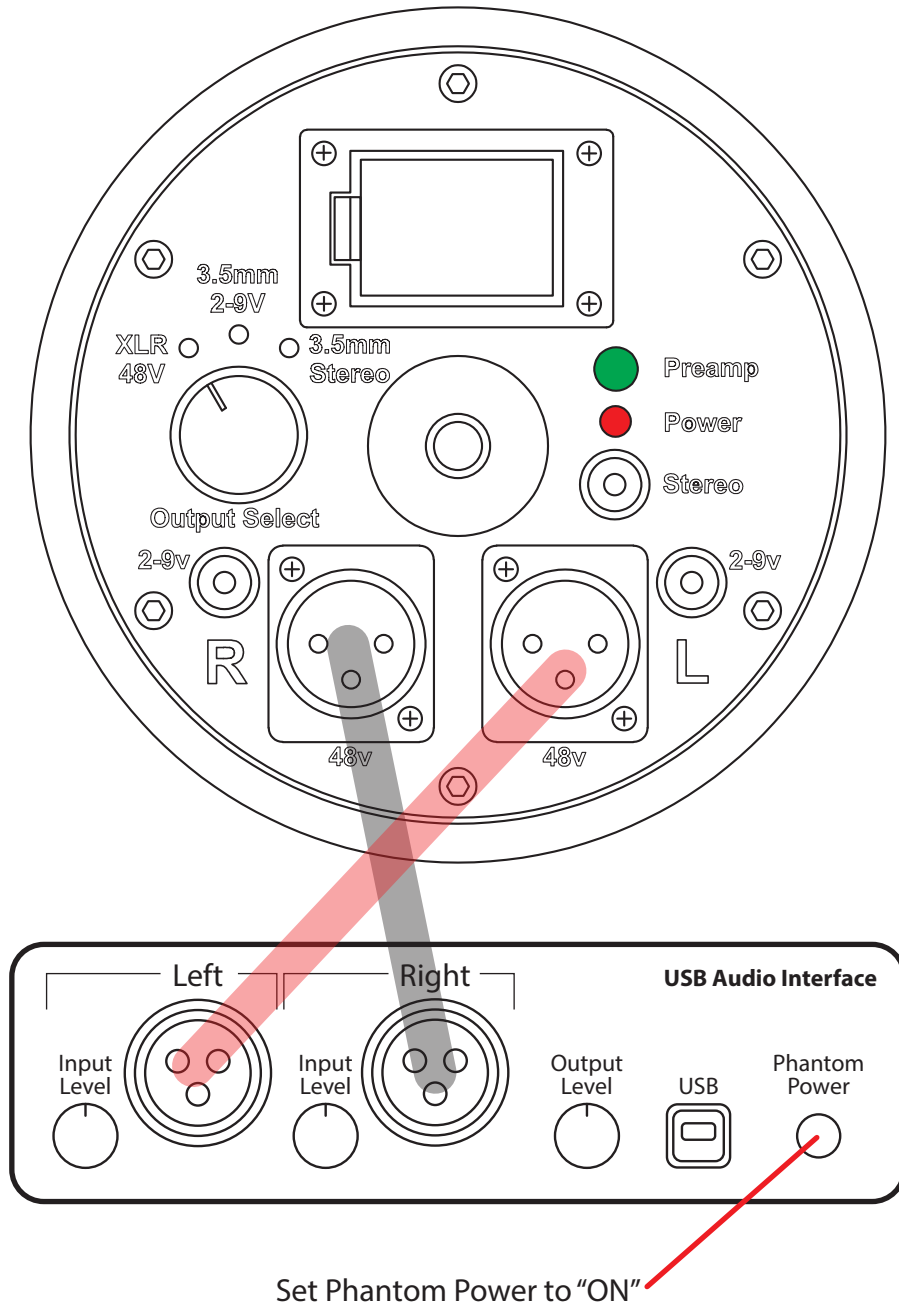
Never plug a pair of headphones or non-amplified speakers of any kind into the 3.5mm (Stereo) output of the BHM-1. This will damage the preamp.

When using the XLR outputs to connect to the BHM-1 to a professional USB audio interface, you must turn on the interface's 48 V phantom power to provide the bias voltage to the BHM-1's microphones. The XLR pin out is a standard configuration.

Connecting the BHM-1 to Recording Equipment:

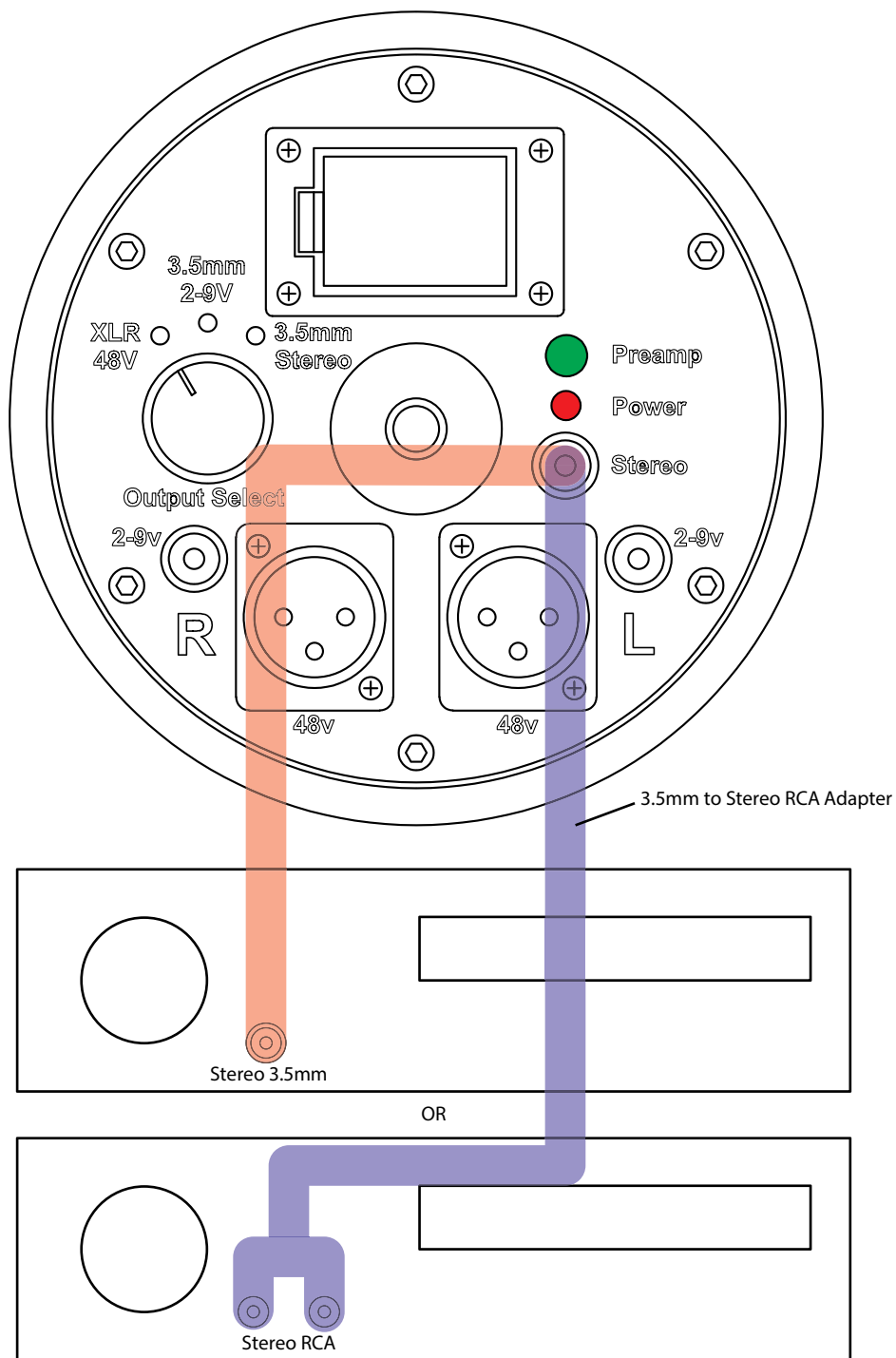
In order to capture the space in which the recorded event happens, it is imperative that a stereo recording is made. Be sure that the soundcard or the audio interface to which you attach the BHM-1 provides a stereo input. Many consumer grade soundcards that include a microphone input and a headphone output provide only a single input channel for the microphone. Using this with the stereo output of the BHM-1 will make a mono recording since the single input channel will add the left and right outputs of the BHM-1 together.

Connecting to a pro-audio USB interface for use with PC or MAC based digital audio workstations or recording apps:



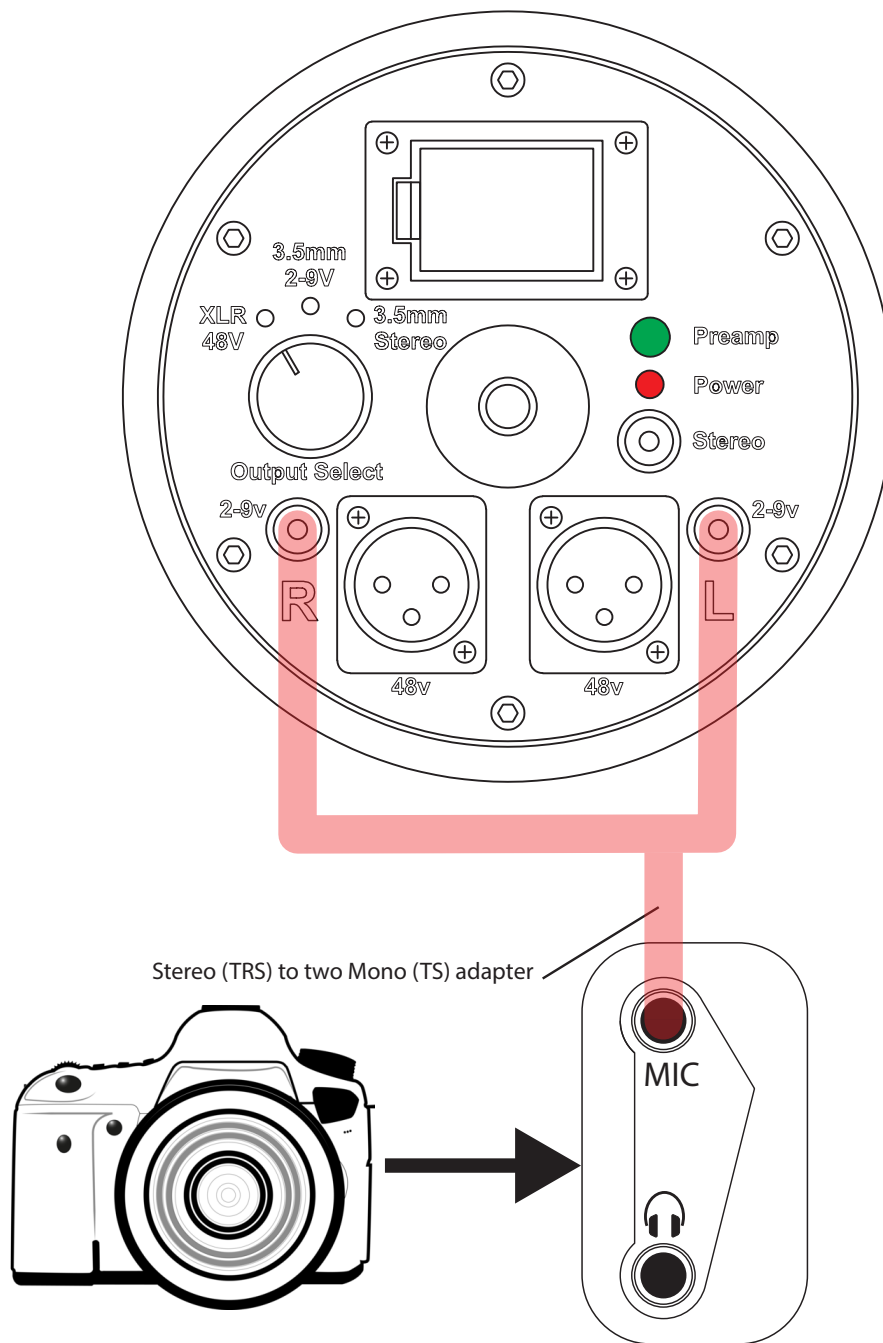
1. Connect R and L XLR outputs to R and L XLR inputs of the interface.
2. Set BMH-1's output switch to "XLR 48V".
3. The interface phantom power will power the microphones, so there is no need to turn on the pre-amp.
4. Make sure the USB interface Phantom Power is turned on.
5. Connect USB connector on interface to PC (or MAC) USB.
6. Use left and right input gain controls if necessary to increase or decrease level. Be sure the adjustment controls are set equally.

Connecting to a consumer audio device's line level input:



1. Connect the Stereo output to the stereo line level input of the consumer device. A “Y” adapter or a 3.5 mm to stereo RCA adapter may be required.
2. Set BHM-1’s output switch to “3.5mm Stereo”.
3. Be sure a 9 V battery is installed in the battery compartment.
4. Turn on the preamp by pressing the “Power” button.

Connecting the BHM-1 to a camera or a video camera:



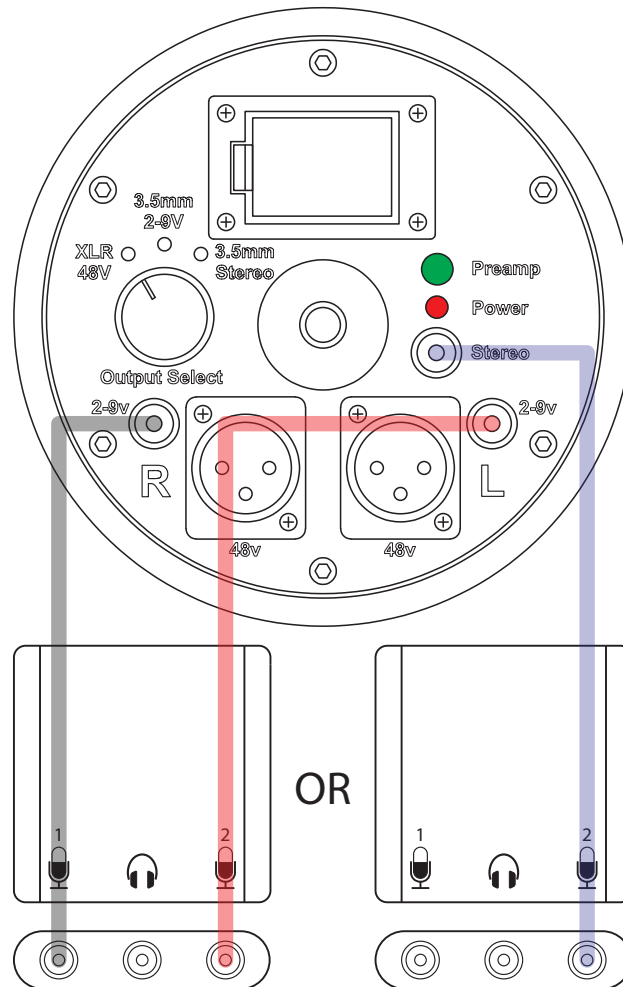
1. Consult your camera's owner's manual to confirm that the microphone input is a stereo input. If your camera has an input labeled "mic" it probably includes bias voltage sufficient for the BHM-1 Left and Right 3.5 mm Outputs. You can confirm this indirectly by checking to see if a stereo electret microphone is available as an accessory for your camera from the camera's manufacturer (Canon DM-E1 microphone for Canon EOS D6, for example).

2. Once you have confirmed the microphone input is stereo, connect the BHM-1 using a 3.5 mm Stereo (TRS) to dual 3.5 mm Mono (TS) adapter as shown below.

3. Set BHM-1's output switch to 3.5mm (2-9V).

Connecting to a phone using a Rode AI Micro (available from Rode Microphones at www.Rode.com)

Rode Microphones makes a handy solution that will connect your BHM-1 to a phone using a USB connection. It will work with PCs and Macs, too. It comes with a convenient phone app to make recording and saving files on your phone easy. Those files can be transferred to a PC or MAC based digital audio workstation for editing or there are some basic editing tools included in the app. See <https://rode.com/en-us/interfaces-and-mixers/ai-series/ai-micro> for details.



1. Connect the 3.5 mm Stereo output to either of the AI Micro's 3.5 mm inputs.
2. Turn on your BHM-1's preamp to provide the bias voltage for the microphones.
3. Connect your phone or PC to the AI Micro using one of the USB cables provided with the AI Micro.
4. Set BHM-1's Output switch to 3.5mm Stereo.

Or

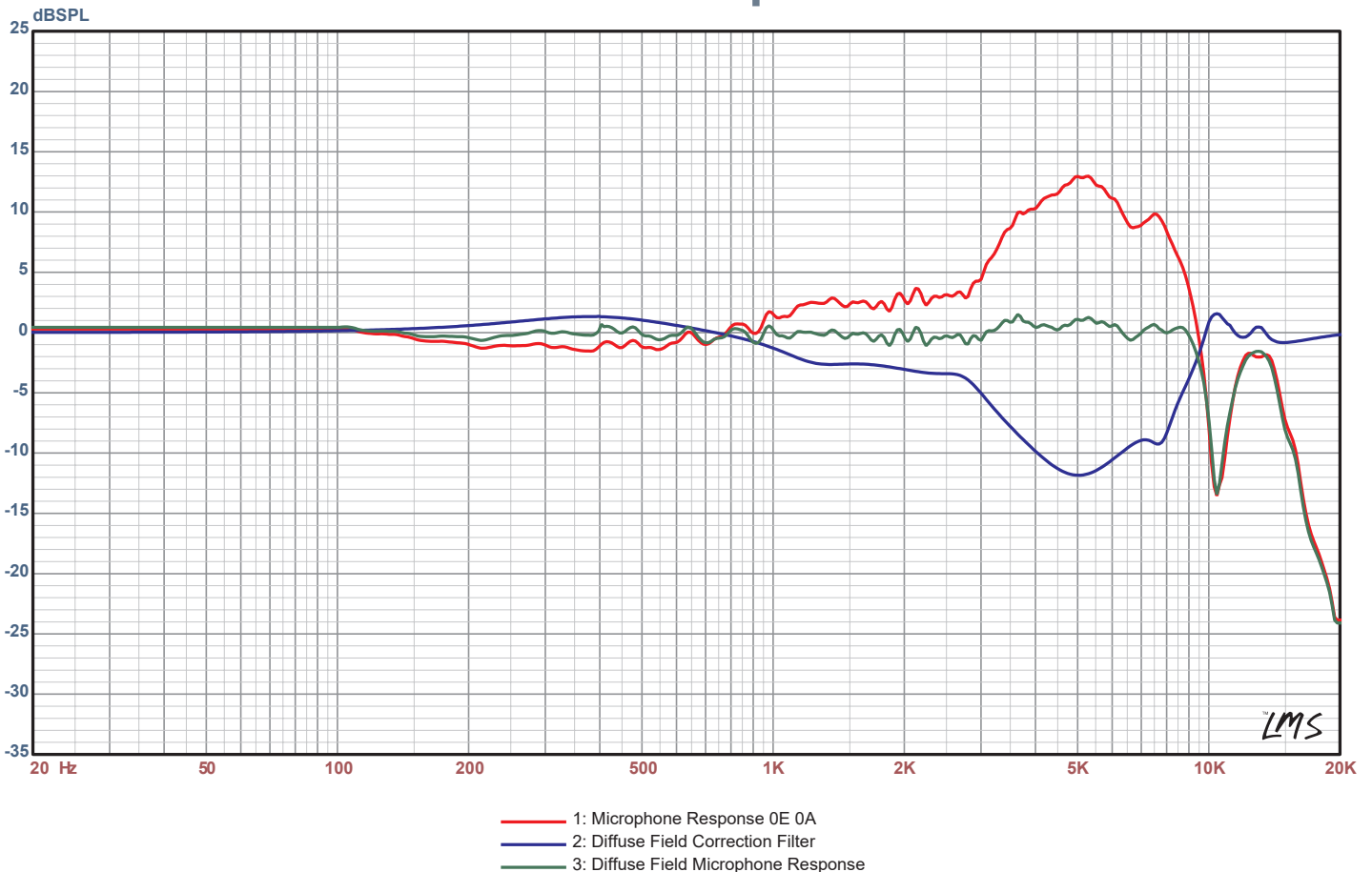
1. Connect the two 3.5 mm (2-9V) outputs of your BHM-1 to each of the two 3.5 mm inputs of the Rode Micro using two TS or TRS cables.
2. Connect your phone or PC to the AI Micro using one of the USB cables provide with the AI Micro.
3. Set BHM-1's Output switch to 3.5mm 2-9V.

Appendix:

Equalization for playback over speakers:

Recordings made with a binaural head work when we listen to them over headphones, because the headphones play sound directly into our ears without the influence of our own HRTF. The head microphone's HRTF is substituted for our own. If you want to listen to the binaural recordings you make with the BHM-1 over loudspeakers in a room, there will still be some, however greatly reduced, spatial effect. In addition, the dramatic high frequency boost caused by the shape of our ears and the changes in midrange response should be removed from the recording. This will improve the tonal aspects of the playback. Equalization settings to be used in an equalizer included in the playback system or to be used in post processing your recording in your digital audio workstation are included as correction filter settings, below.

Diffuse Field Equalization



Correction Filter Settings:

1. Fc: 1,250 Hz	Gain: -1.5 dB	Q: 2.0
2. Fc: 400 Hz	Gain: 1.5 dB	Q: 0.8
3. Fc: 5,000 Hz	Gain: -12 dB	Q: 0.8
4. Fc: 2,750 Hz	Gain: 2 dB	Q: 3
5. Fc: 7,800 Hz	Gain: -3 dB	Q: 6
6. Fc: 10,400 Hz	Gain: 4 dB	Q: 4
7. Fc: 13,000 Hz	Gain: 2 dB	Q: 6

HRTF measurements:

The measurements depicted in the graphs that follow were made in an anechoic chamber at the Western Electro-Acoustic Laboratory in Santa Clarita, CA. The BHM-1 Microphone was placed on a stand and the stand was placed on a turntable. A reference speaker was mounted one meter away on a semicircular jig. The frequency response of the test speaker was measured with a reference microphone (ACO Pacific) using REW and that response was saved and implemented as a microphone calibration file. The resulting measurements were normalized and propagation delay was removed.

For each adjustment of elevation in 15 degree increments between -75° and 90° , the BHM-1 was rotated through 345° with the turntable in 15° increments for each measurement. No measurements were made at -90° of elevation. A picture of the setup is included below.



In the graphs that follow, the response of the right ear microphone was measured.

0 degrees of azimuth (0A) represents the head facing the speaker. Then, the head was rotated in 15° increments toward the right ear. 90° of azimuth (90A) shows the response when the right ear is pointed at the speaker. 180° of azimuth (180A) shows the measurements when the head is facing away from the speaker. 270° of azimuth (270A) shows the response of the right ear microphone when the left ear is facing the speaker.

Similarly, the same 24 measurements of azimuth were made with the speaker oriented at higher and lower elevations, also in 15° increments. 0° of elevation (0E) represents the speaker mounted at ear level. 15° of elevation (15E) shows the response when the speaker is elevated by 15° from 0° . -15° of elevation (-15E) or (N15E) shows the measurement with the speaker mounted 15° below 0° .

Each of the graphs here are made on a single angle of elevation (in the first group) or a single angle of azimuth (in the second group). Magnitude response plots and polar plots are included. Polar plots depicting frequency response over elevation are limited to the forward angles. See the next page for a complete map of the measurement locations.

You can download the normalized data as text files in the BHM-1 section at www.audiofrog.com.

Measurement positions

0° Elevation



● 90° Elevation, 0° Azimuth

0° Azimuth

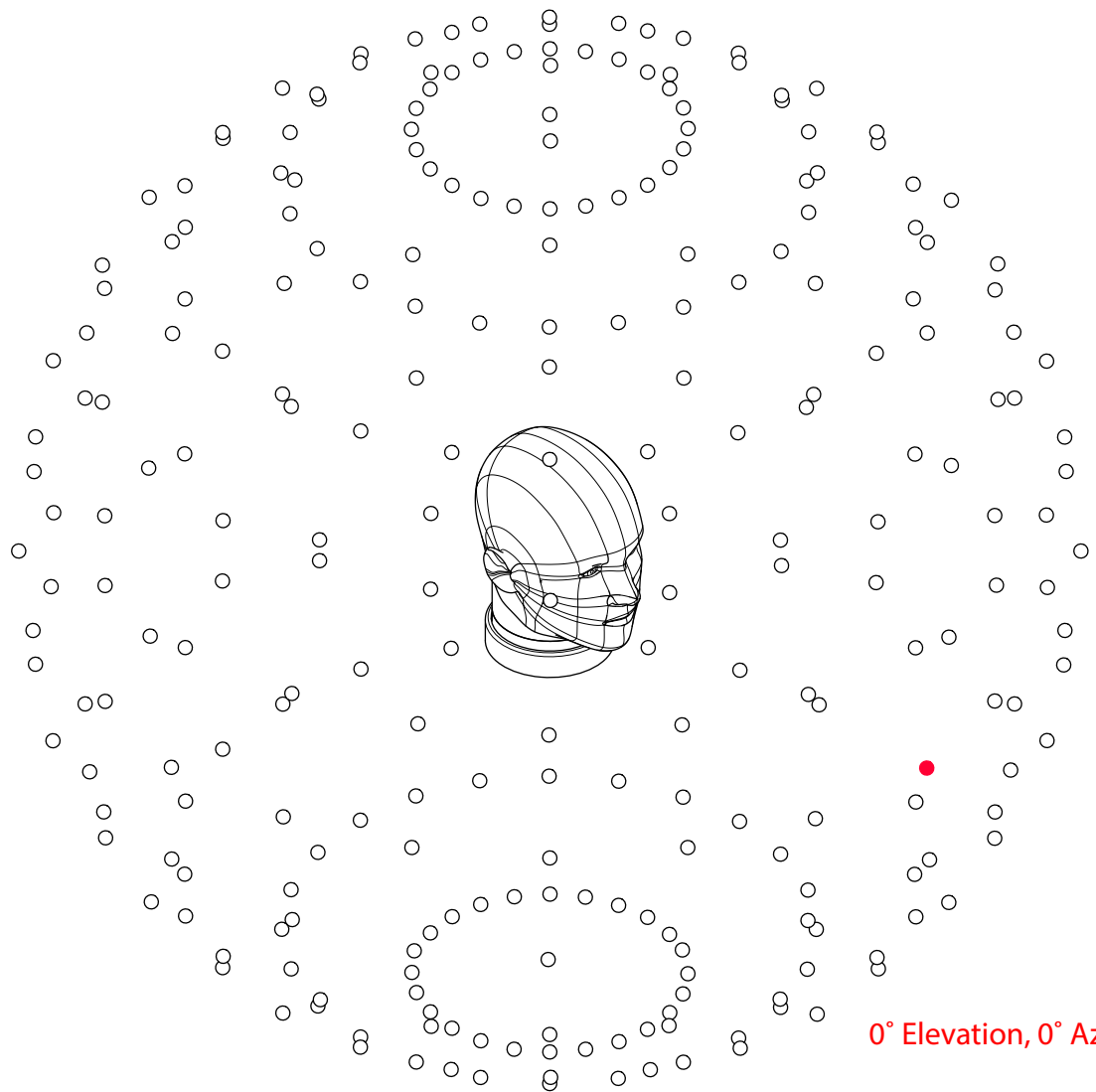
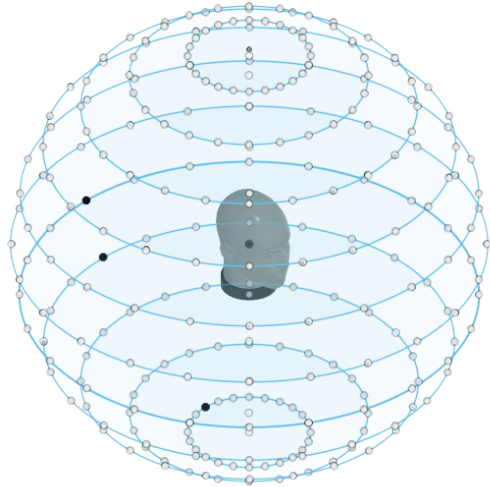


In the graphs on the following pages each of the curves depicted in the frequency response plots will be named according to the convention described in the graphics on this page:

0° Elevation, 0° Azimuth is directly in front of the head. 0° Elevation, 90° Azimuth is to the right of the head. 0° Elevation, 180° Azimuth is directly behind the head. 0° Elevation, 270° Azimuth is to the left of the head. 90° Elevation is directly above the head.

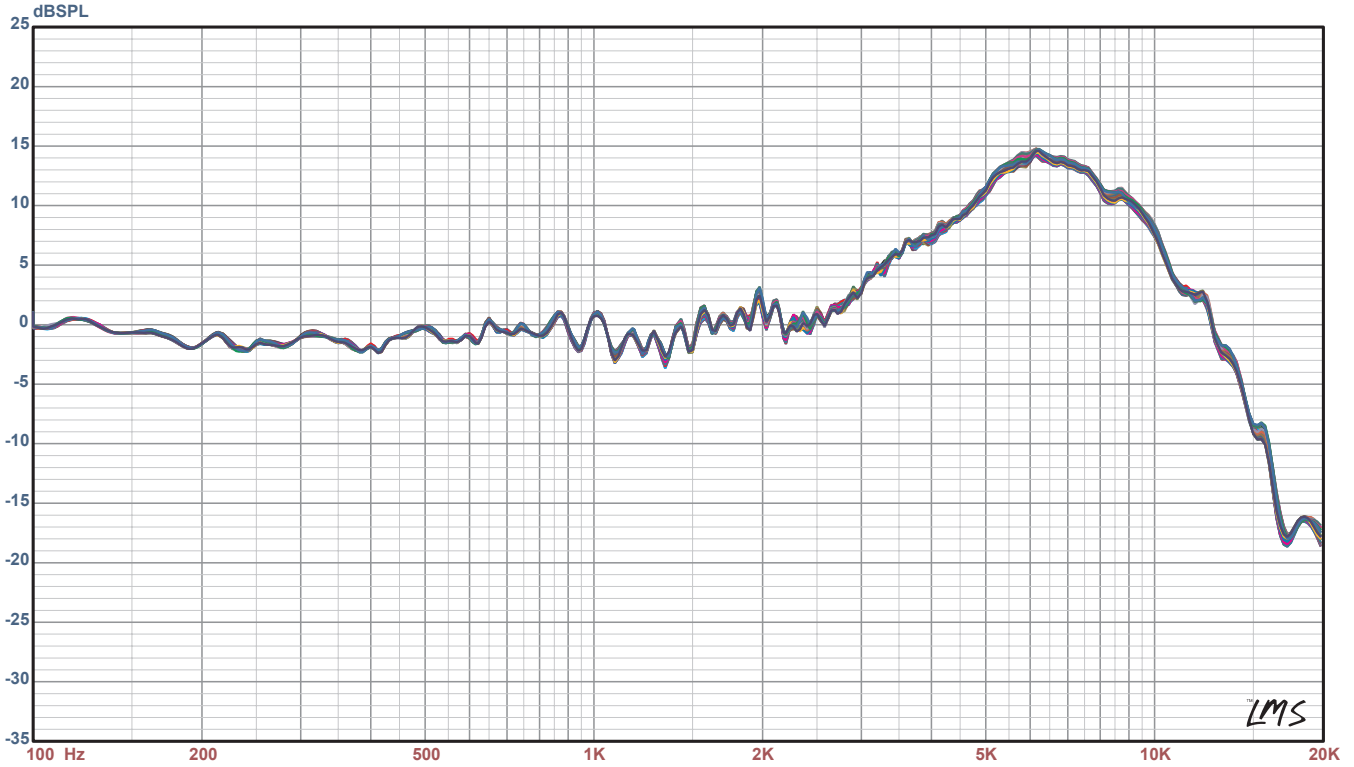
If you choose to download all of these measurements as text files to use in your own analysis, you'll find a similar naming convention for those. No special characters can be used in file names, so "0E 0A.txt" will be the file for 0° Elevation, 0° Azimuth.

Graphics on this page depict all of the measurement positions represented in the graphs on the following pages and in the text files available for download. The baseline position, 0° Elevation, 0° Azimuth is highlighted in red below.



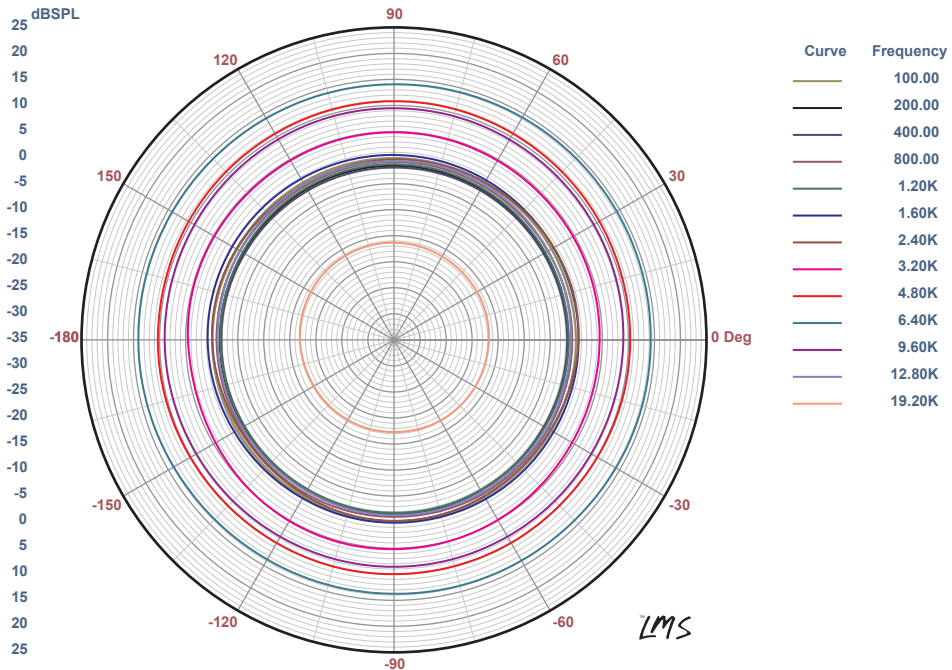
0° Elevation, 0° Azimuth

90° Elevation

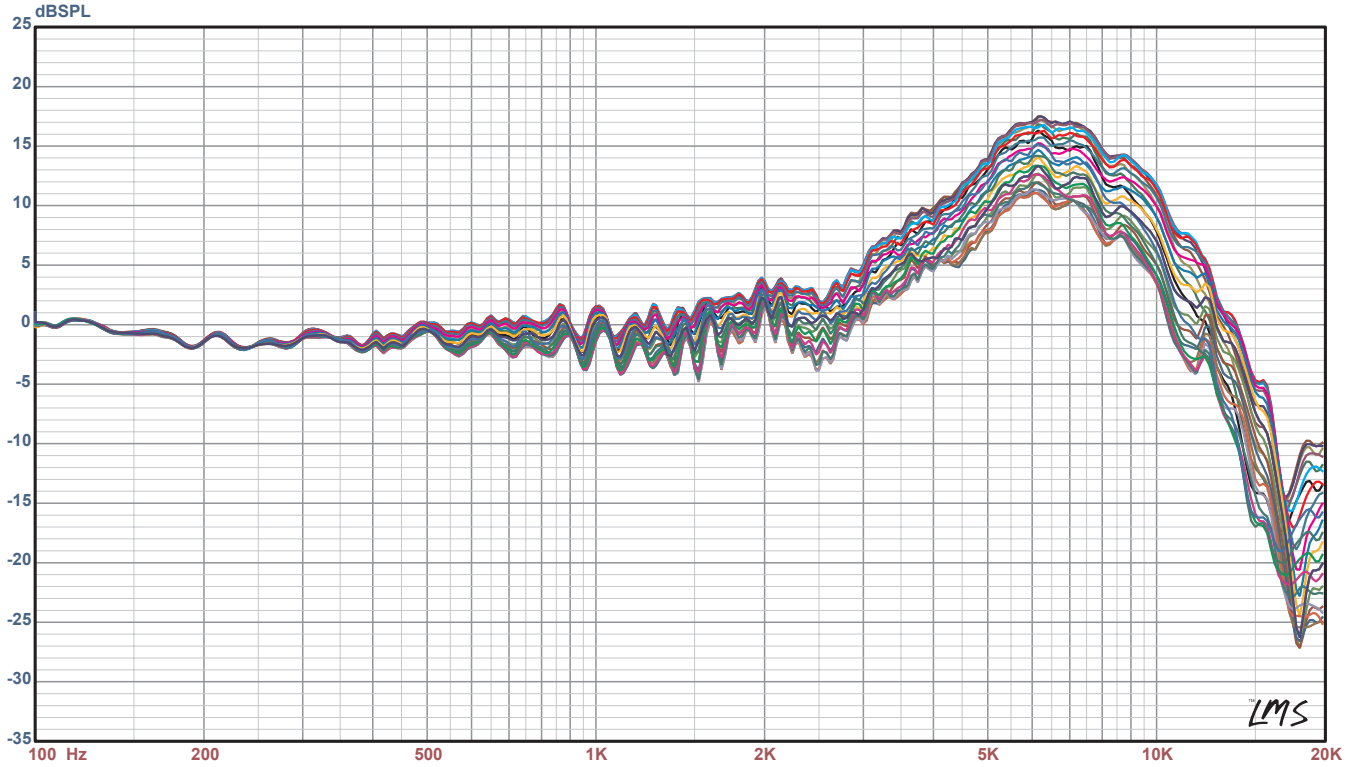


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|------------------|------------------|------------------|------------------|
| 1: 90E 0A.txt | 4: 90E 45A.txt | 7: 90E 90A.txt | 10: 90E 135A.txt |
| 2: 90E 15A.txt | 5: 90E 60A.txt | 8: 90E 105A.txt | 11: 90E 150A.txt |
| 3: 90E 30A.txt | 6: 90E 75A.txt | 9: 90E 120A.txt | 12: 90E 165A.txt |
| 13: 90E 180A.txt | 16: 90E 225A.txt | 19: 90E 270A.txt | 22: 90E 315A.txt |
| 14: 90E 195A.txt | 17: 90E 240A.txt | 20: 90E 285A.txt | 23: 90E 330A.txt |
| 15: 90E 210A.txt | 18: 90E 255A.txt | 21: 90E 300A.txt | 24: 90E 345A.txt |

90° Elevation

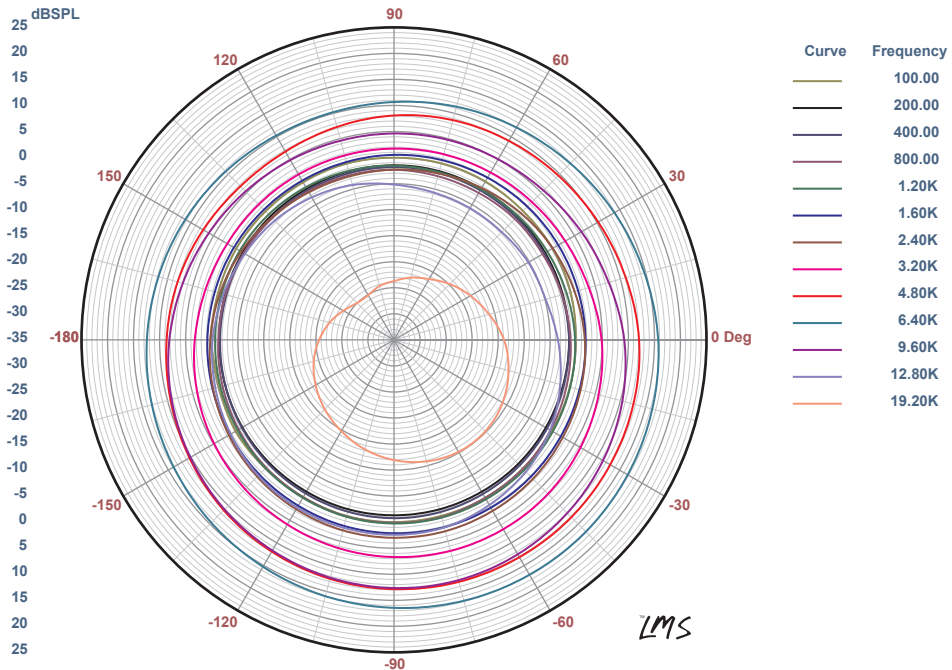


75° Elevation

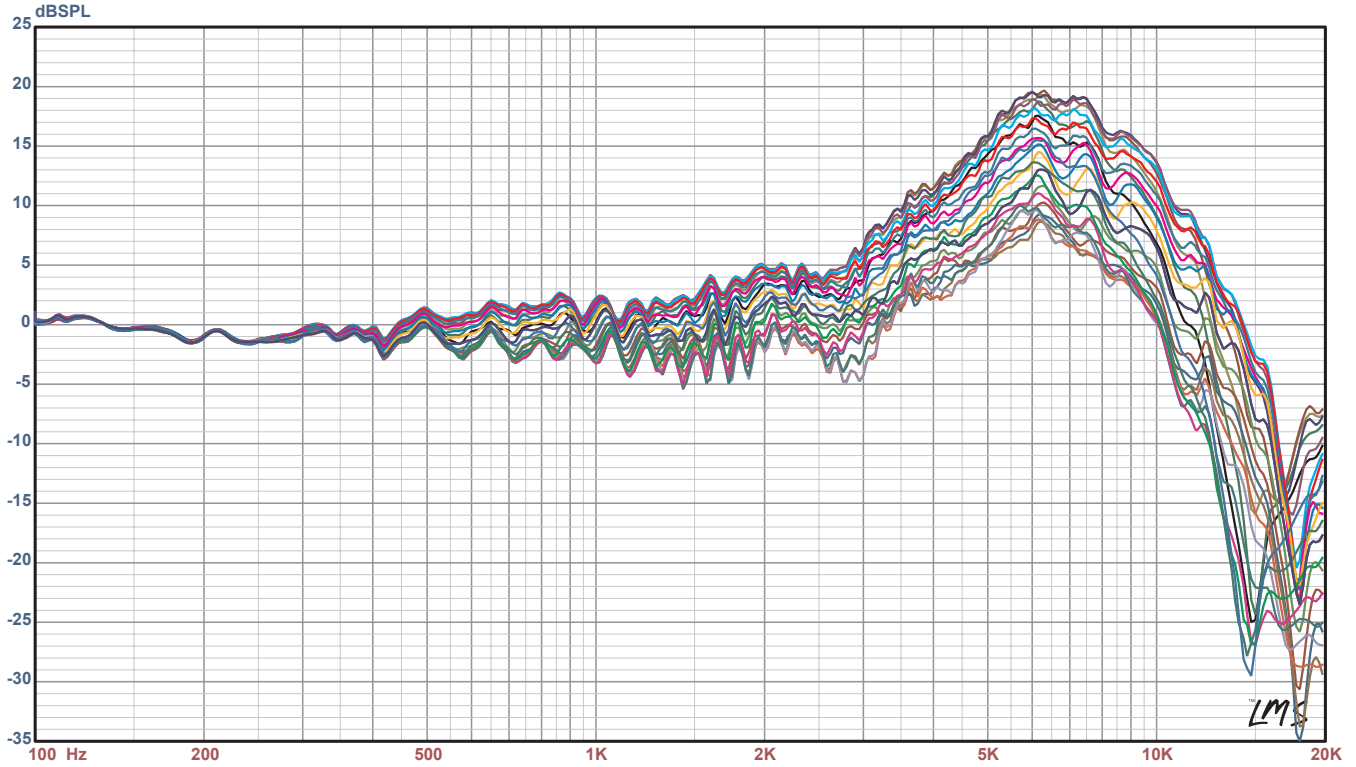


- | | | | |
|------------------|------------------|------------------|------------------|
| 1: 75E 0A.txt | 4: 75E 45A.txt | 7: 75E 90A.txt | 10: 75E 135A.txt |
| 2: 75E 15A.txt | 5: 75E 60A.txt | 8: 75E 105A.txt | 11: 75E 150A.txt |
| 3: 75E 30A.txt | 6: 75E 75A.txt | 9: 75E 120A.txt | 12: 75E 165A.txt |
| 13: 75E 180A.txt | 16: 75E 225A.txt | 19: 75E 270A.txt | 22: 75E 315A.txt |
| 14: 75E 195A.txt | 17: 75E 240A.txt | 20: 75E 285A.txt | 23: 75E 330A.txt |
| 15: 75E 210A.txt | 18: 75E 255A.txt | 21: 75E 300A.txt | 24: 75E 345A.txt |

75° Elevation

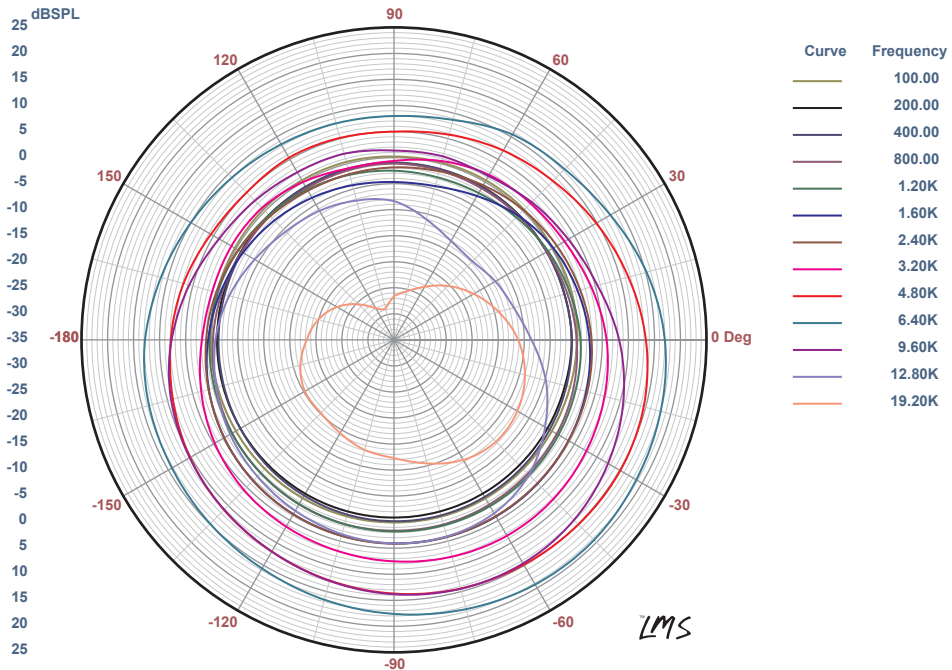


60° Elevation

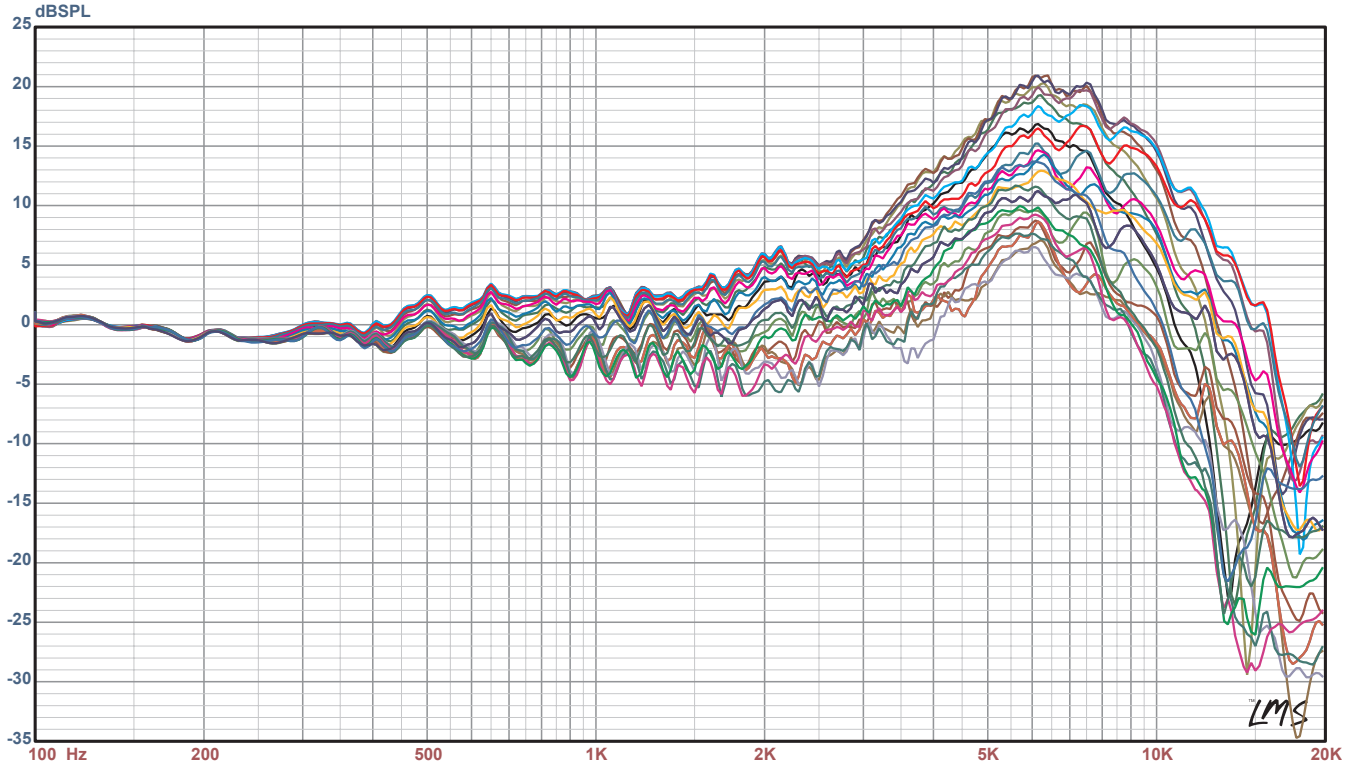


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| 2: 60E 15A.txt | 5: 60E 60A.txt | 8: 60E 105A.txt | 11: 60E 150A.txt |
| 3: 60E 30A.txt | 6: 60E 75A.txt | 9: 60E 120A.txt | 12: 60E 165A.txt |
| 13: 60E 180A.txt | 16: 60E 225A.txt | 19: 60E 270A.txt | 22: 60E 315A.txt |
| 14: 60E 195A.txt | 17: 60E 240A.txt | 20: 60E 285A.txt | 23: 60E 330A.txt |
| 15: 60E 210A.txt | 18: 60E 255A.txt | 21: 60E 300A.txt | 24: 60E 345A.txt |

60° Elevation

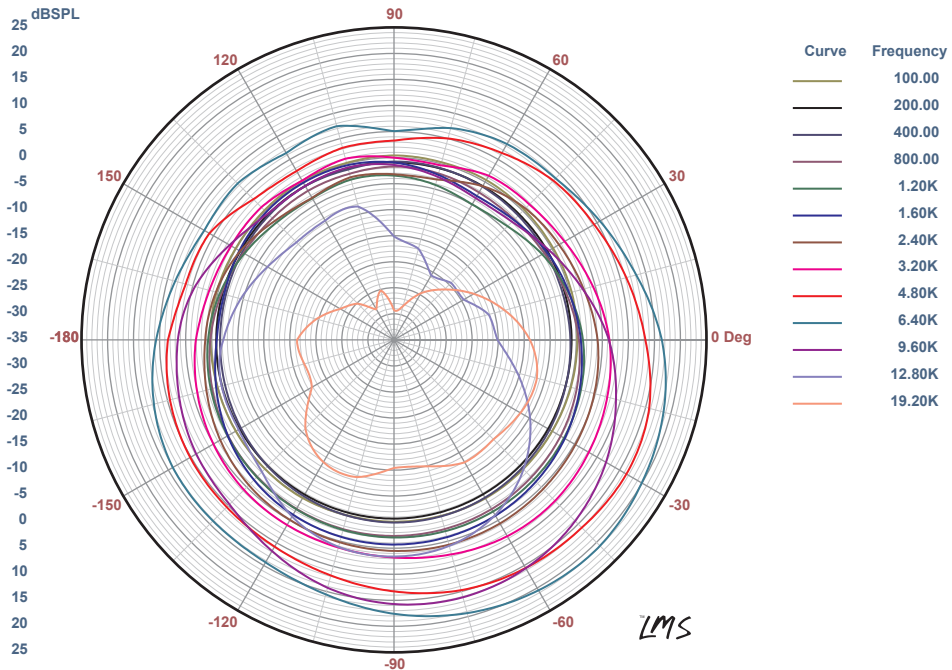


45° Elevation

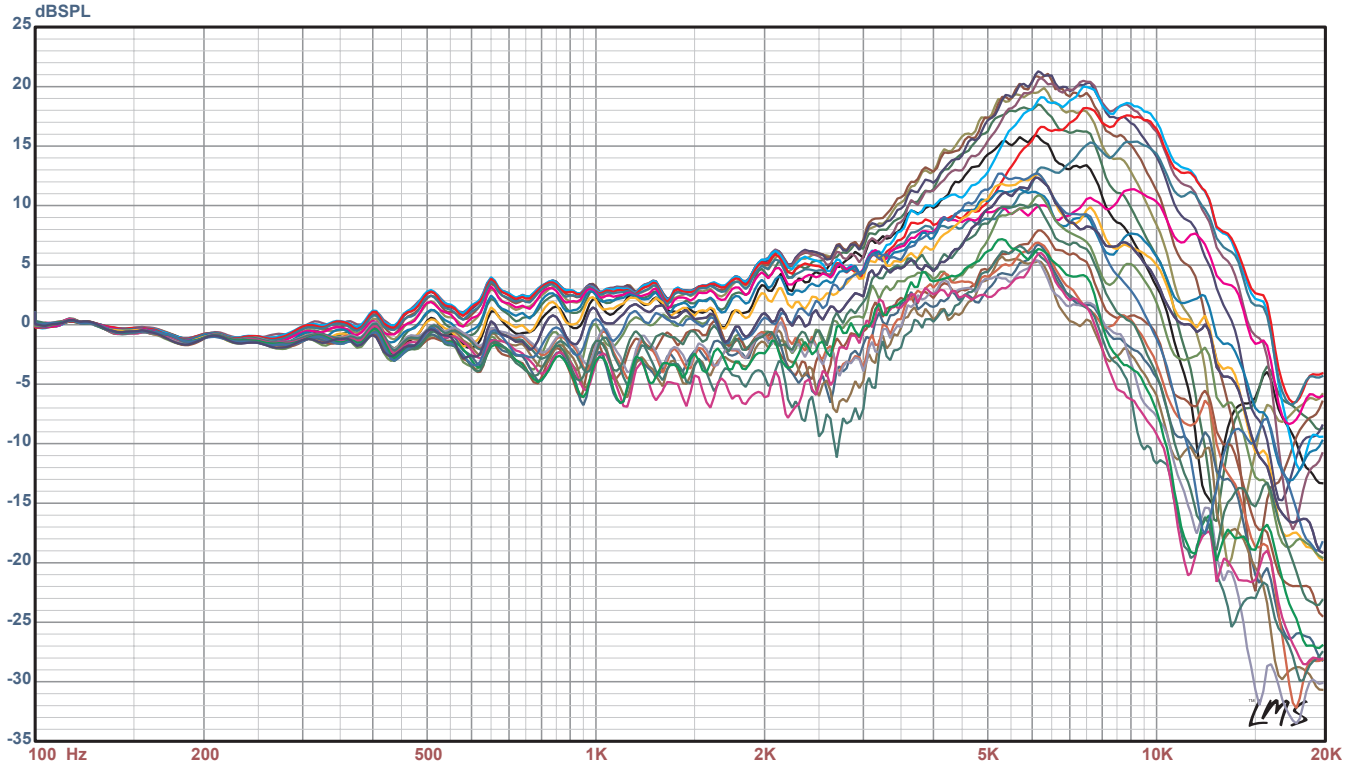


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| 2: 45E 15A.txt | 5: 45E 60A.txt | 8: 45E 105A.txt | 11: 45E 150A.txt |
| 3: 45E 30A.txt | 6: 45E 75A.txt | 9: 45E 120A.txt | 12: 45E 165A.txt |
| 13: 45E 180A.txt | 16: 45E 225A.txt | 19: 45E 270A.txt | 22: 45E 315A.txt |
| 14: 45E 195A.txt | 17: 45E 240A.txt | 20: 45E 285A.txt | 23: 45E 330A.txt |
| 15: 45E 210A.txt | 18: 45E 255A.txt | 21: 45E 300A.txt | 24: 45E 345A.txt |

45° Elevation

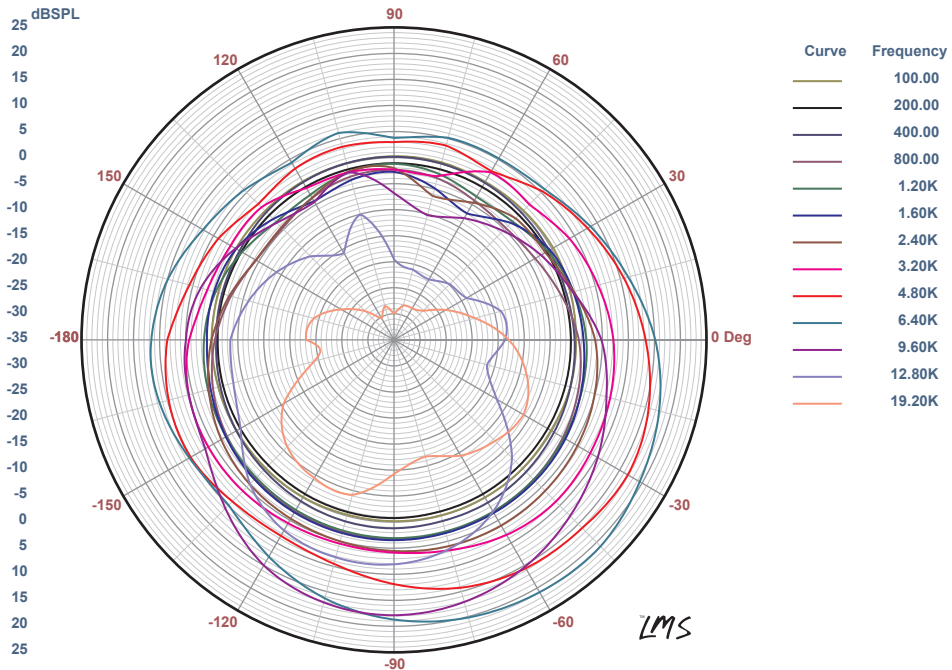


30° Elevation

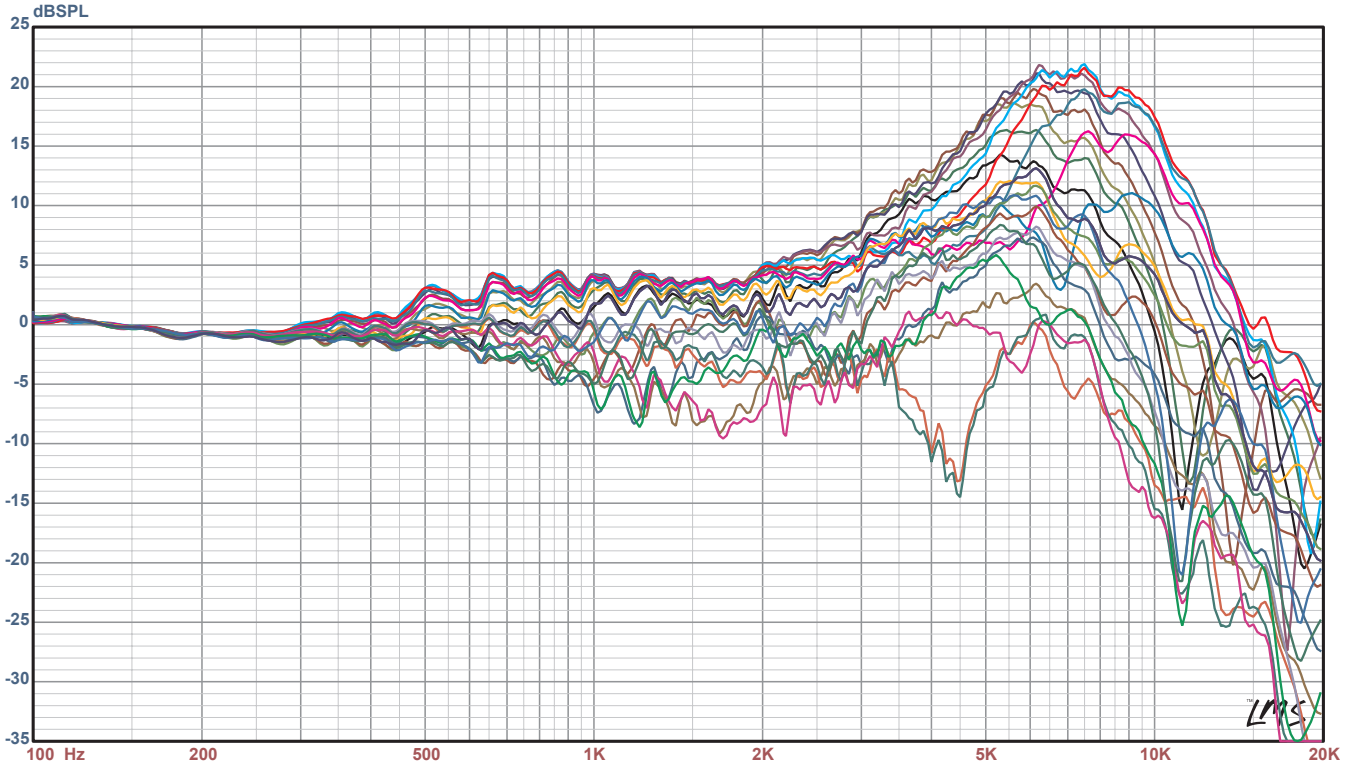


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|------------------|------------------|------------------|------------------|
| 1: 30E 0A.txt | 4: 30E 45A.txt | 7: 30E 90A.txt | 10: 30E 135A.txt |
| 2: 30E 15A.txt | 5: 30E 60A.txt | 8: 30E 105A.txt | 11: 30E 150A.txt |
| 3: 30E 30A.txt | 6: 30E 75A.txt | 9: 30E 120A.txt | 12: 30E 165A.txt |
| 13: 30E 180A.txt | 16: 30E 225A.txt | 19: 30E 270A.txt | 22: 30E 315A.txt |
| 14: 30E 195A.txt | 17: 30E 240A.txt | 20: 30E 285A.txt | 23: 30E 330A.txt |
| 15: 30E 210A.txt | 18: 30E 255A.txt | 21: 30E 300A.txt | 24: 30E 345A.txt |

30° Elevation

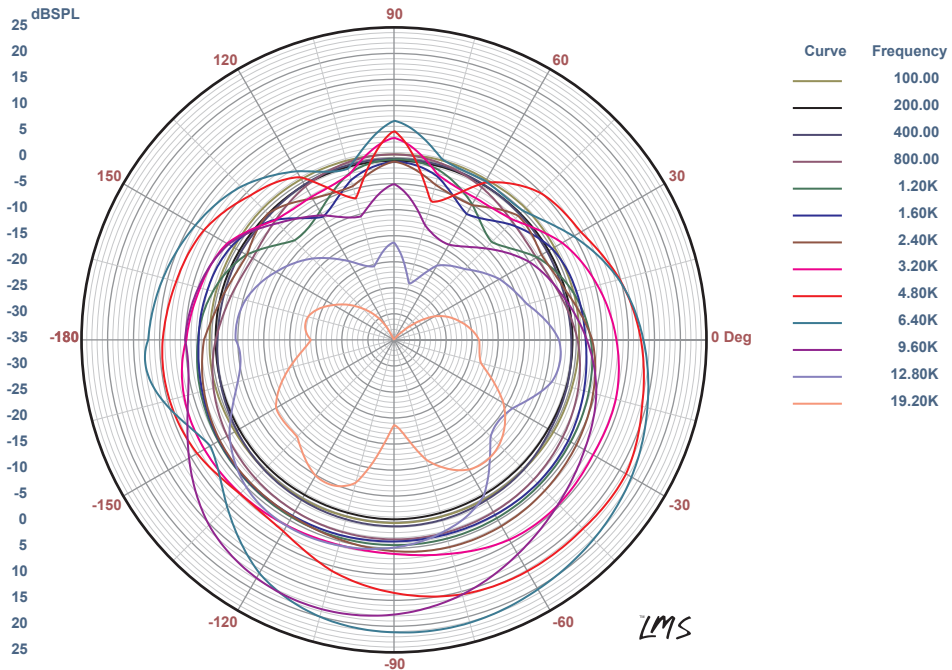


15° Elevation

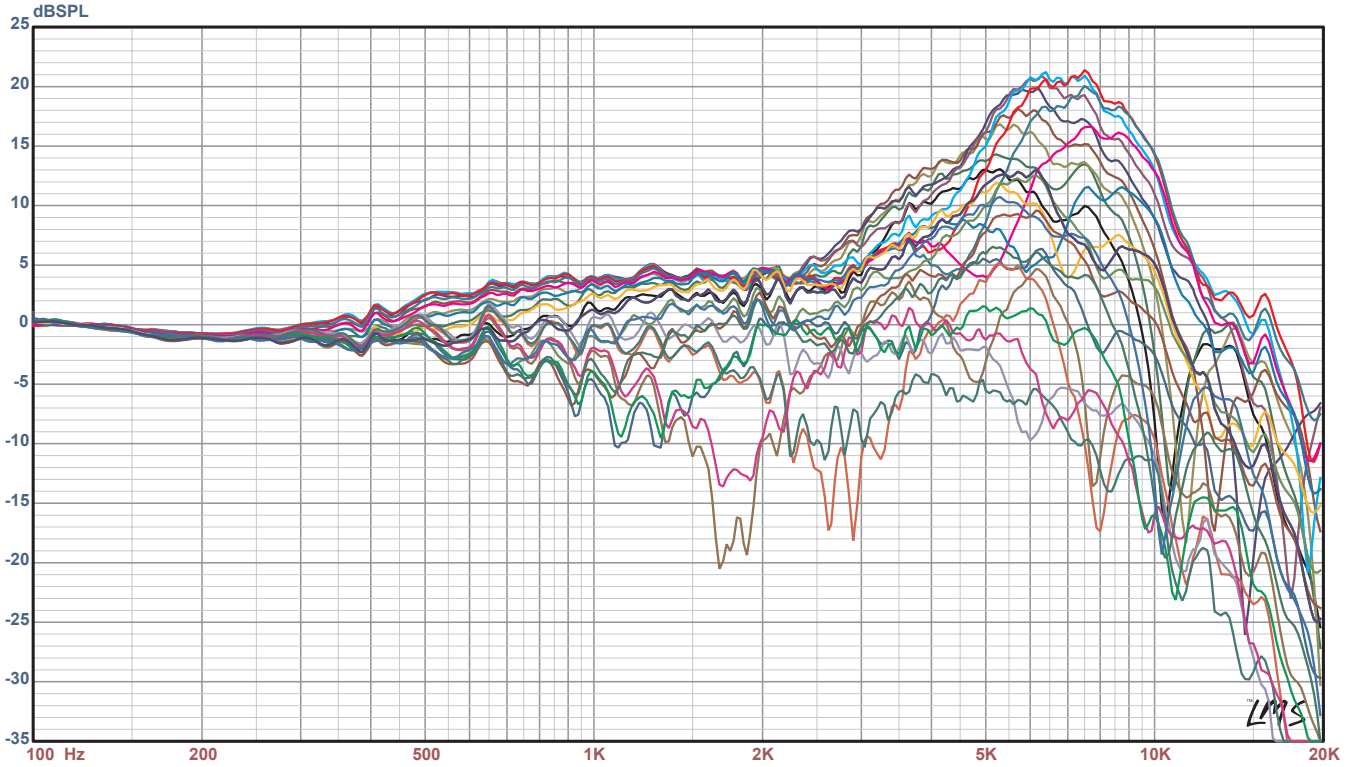


- | | | | |
|------------------|------------------|------------------|------------------|
| 1: 15E 0A.txt | 4: 15E 45A.txt | 7: 15E 90A.txt | 10: 15E 135A.txt |
| 2: 15E 15A.txt | 5: 15E 60A.txt | 8: 15E 105A.txt | 11: 15E 150A.txt |
| 3: 15E 30A.txt | 6: 15E 75A.txt | 9: 15E 120A.txt | 12: 15E 165A.txt |
| 13: 15E 180A.txt | 16: 15E 225A.txt | 19: 15E 270A.txt | 22: 15E 315A.txt |
| 14: 15E 195A.txt | 17: 15E 240A.txt | 20: 15E 285A.txt | 23: 15E 330A.txt |
| 15: 15E 210A.txt | 18: 15E 255A.txt | 21: 15E 300A.txt | 24: 15E 345A.txt |

15° Elevation

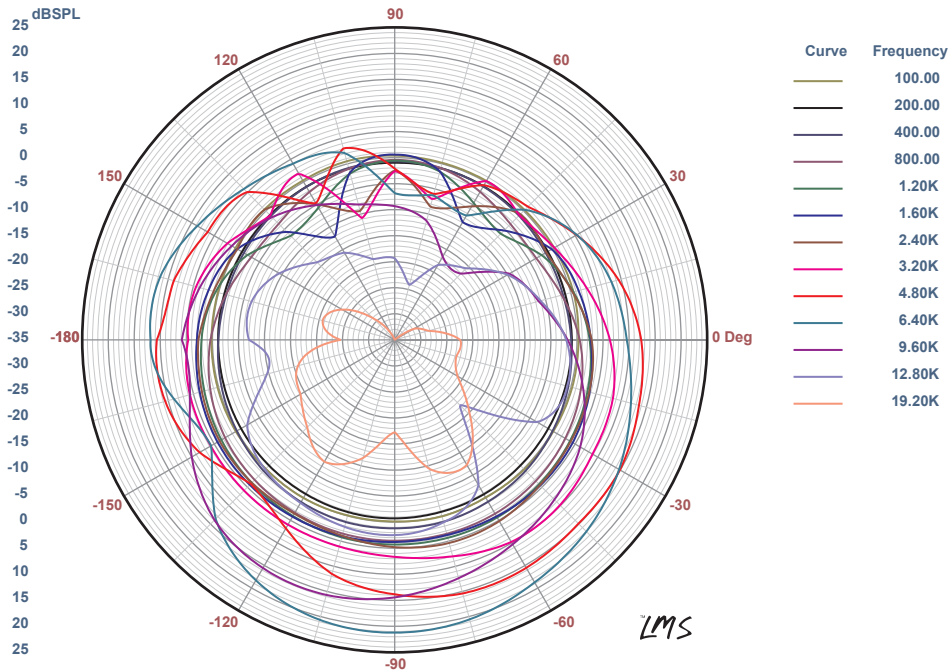


0° Elevation

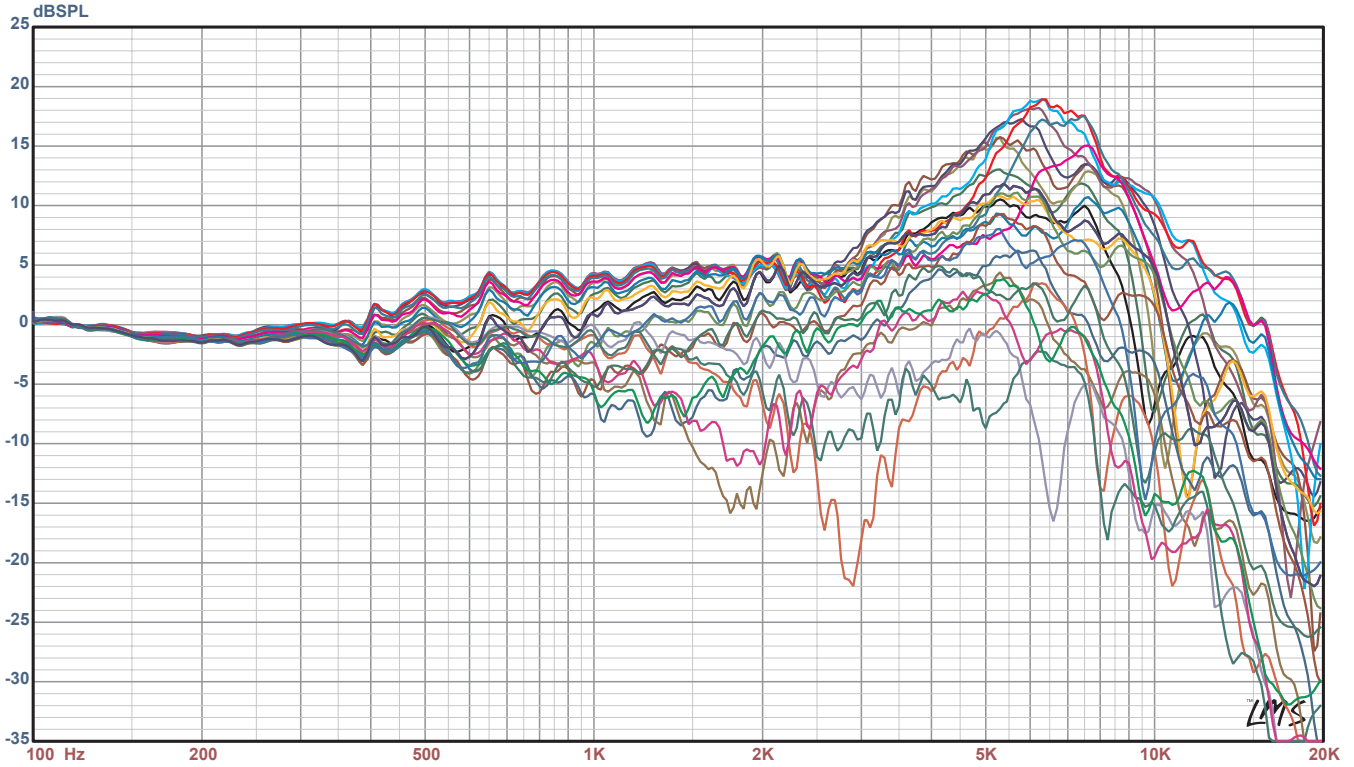


- | | | | |
|-----------------|-----------------|-----------------|-----------------|
| 1: 0E 0A.txt | 4: 0E 45A.txt | 7: 0E 90A.txt | 10: 0E 135A.txt |
| 2: 0E 15A.txt | 5: 0E 60A.txt | 8: 0E 105A.txt | 11: 0E 150A.txt |
| 3: 0E 30A.txt | 6: 0E 75A.txt | 9: 0E 120A.txt | 12: 0E 165A.txt |
| 13: 0E 180A.txt | 16: 0E 225A.txt | 19: 0E 270A.txt | 22: 0E 315A.txt |
| 14: 0E 195A.txt | 17: 0E 240A.txt | 20: 0E 285A.txt | 23: 0E 330A.txt |
| 15: 0E 210A.txt | 18: 0E 255A.txt | 21: 0E 300A.txt | 24: 0E 345A.txt |

0° Elevation

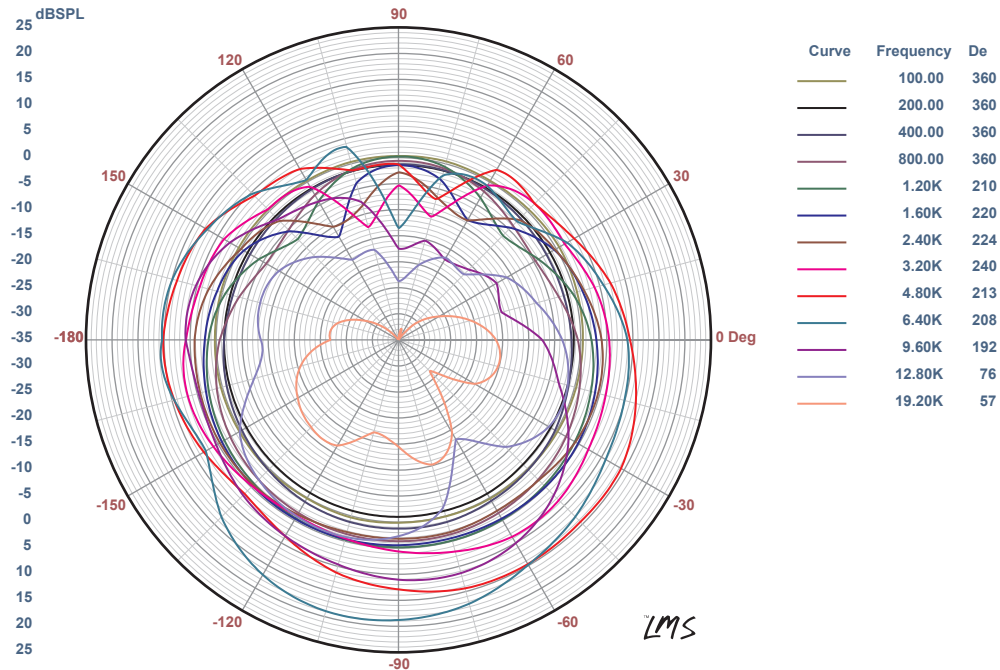


-15° Elevation

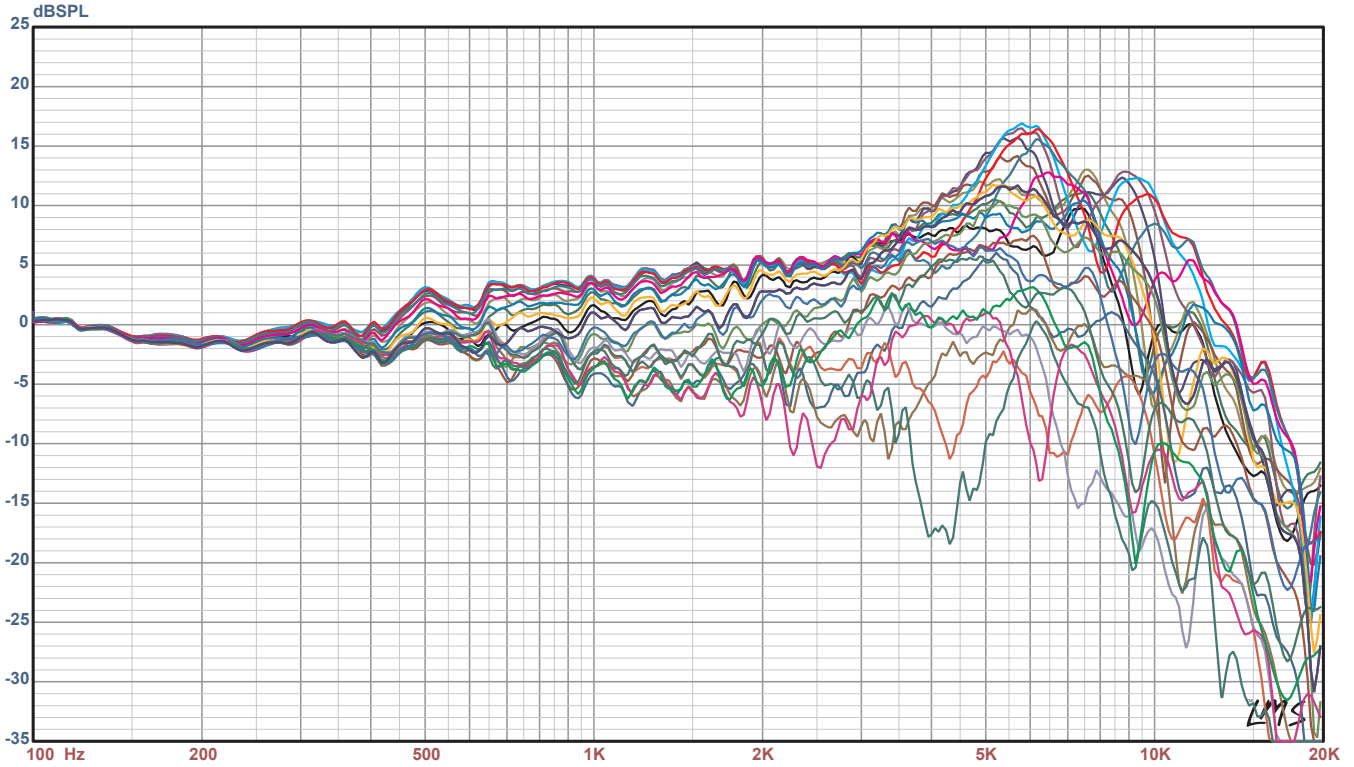


- | | | | |
|-------------------|-------------------|-------------------|-------------------|
| 1: -15E 0A.txt | 4: -15E 45A.txt | 7: -15E 90A.txt | 10: -15E 135A.txt |
| 2: -15E 15A.txt | 5: -15E 60A.txt | 8: -15E 105A.txt | 11: -15E 150A.txt |
| 3: -15E 30A.txt | 6: -15E 75A.txt | 9: -15E 120A.txt | 12: -15E 165A.txt |
| 13: -15E 180A.txt | 16: -15E 225A.txt | 19: -15E 270A.txt | 22: -15E 315A.txt |
| 14: -15E 195A.txt | 17: -15E 240A.txt | 20: -15E 285A.txt | 23: -15E 330A.txt |
| 15: -15E 210A.txt | 18: -15E 255A.txt | 21: -15E 300A.txt | 24: -15E 345A.txt |

-15° Elevation

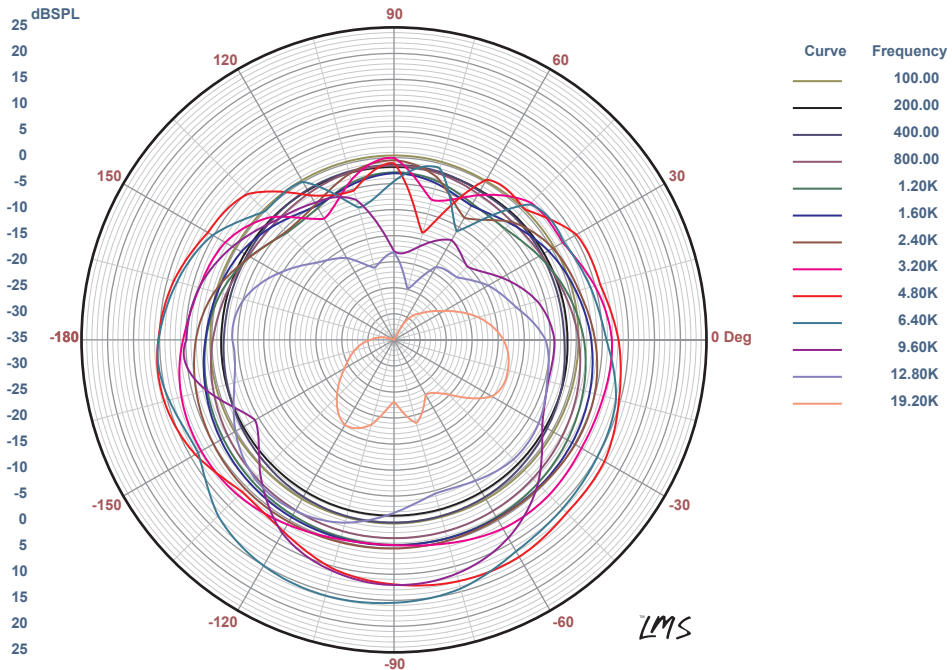


-30° Elevation

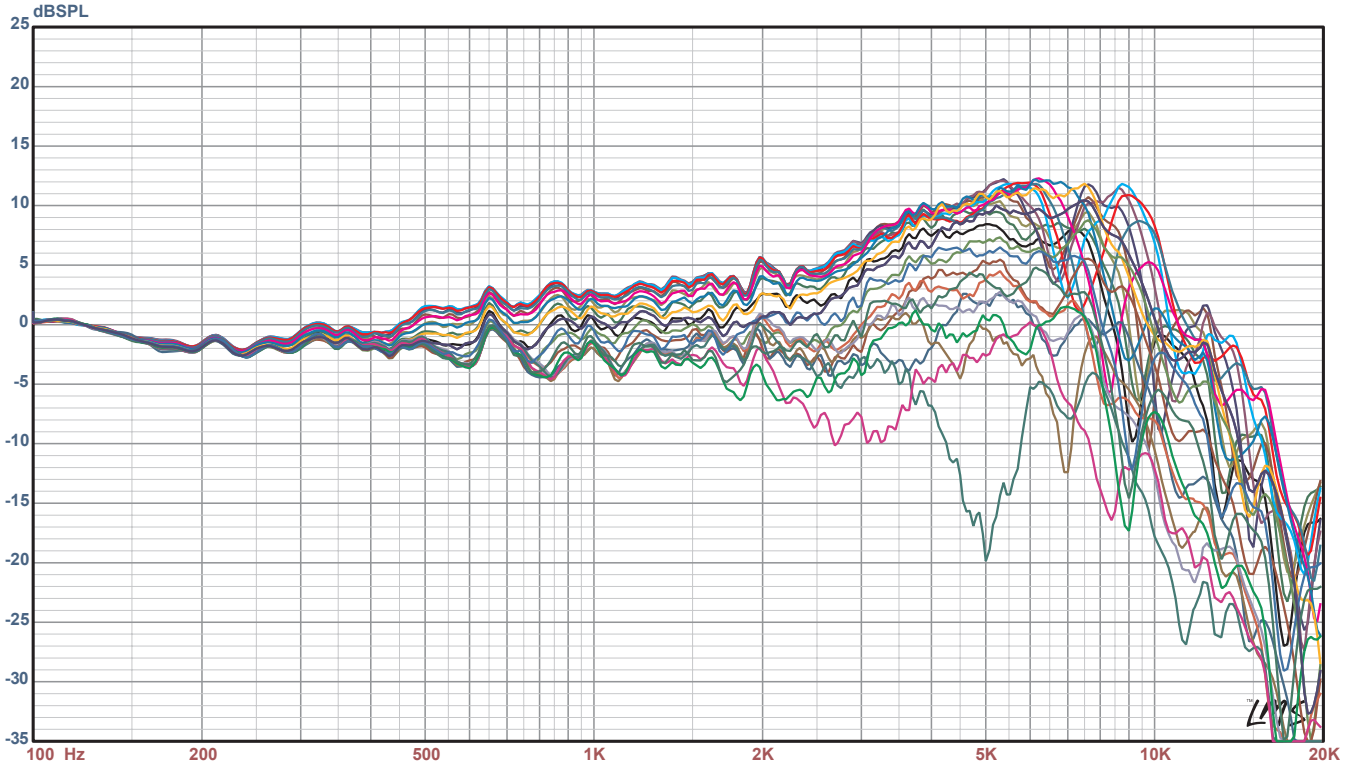


- | | | | |
|-------------------|-------------------|-------------------|-------------------|
| 1: -30E 0A.txt | 4: -30E 45A.txt | 7: -30E 90A.txt | 10: -30E 135A.txt |
| 2: -30E 15A.txt | 5: -30E 60A.txt | 8: -30E 105A.txt | 11: -30E 150A.txt |
| 3: -30E 30A.txt | 6: -30E 75A.txt | 9: -30E 120A.txt | 12: -30E 165A.txt |
| 13: -30E 180A.txt | 16: -30E 225A.txt | 19: -30E 270A.txt | 22: -30E 315A.txt |
| 14: -30E 195A.txt | 17: -30E 240A.txt | 20: -30E 285A.txt | 23: -30E 330A.txt |
| 15: -30E 210A.txt | 18: -30E 255A.txt | 21: -30E 300A.txt | 24: -30E 345A.txt |

-30° Elevation

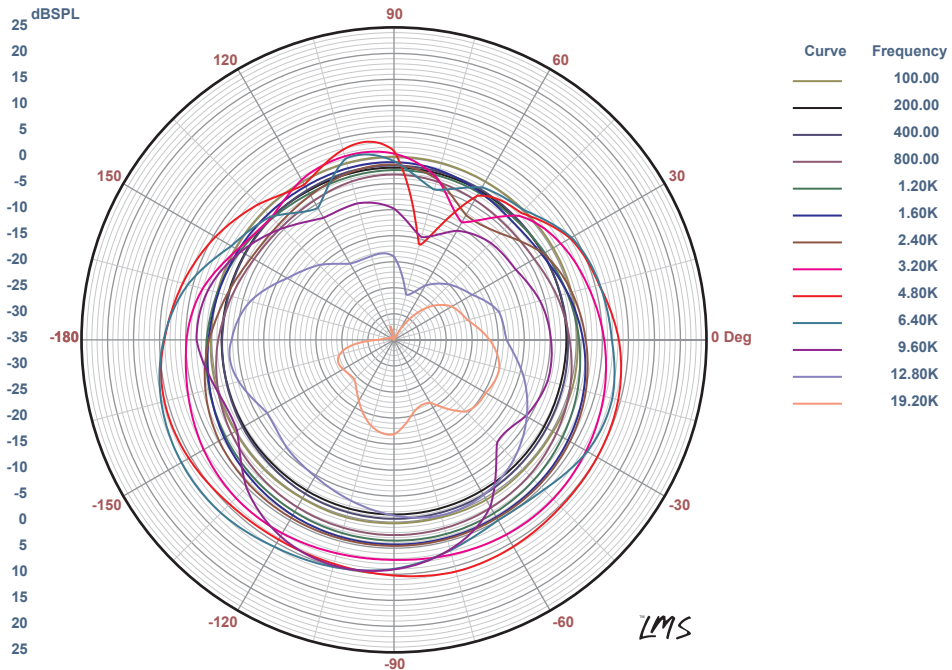


-45° Elevation



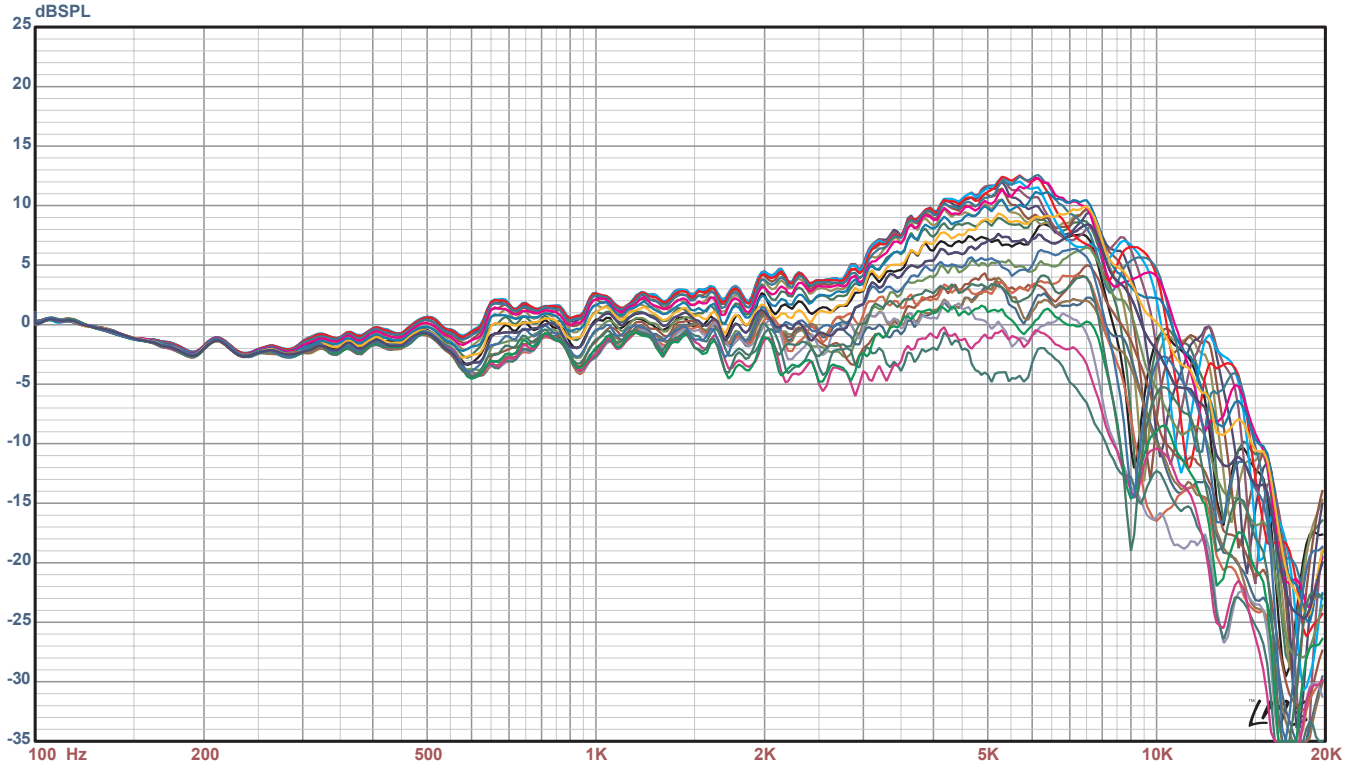
- | | | | |
|-------------------|-------------------|-------------------|-------------------|
| — 1: 0E 0A.txt | — 4: 0E 45A.txt | — 7: 0E 90A.txt | — 10: 0E 135A.txt |
| — 2: 0E 15A.txt | — 5: 0E 60A.txt | — 8: 0E 105A.txt | — 11: 0E 150A.txt |
| — 3: 0E 30A.txt | — 6: 0E 75A.txt | — 9: 0E 120A.txt | — 12: 0E 165A.txt |
| — 13: 0E 180A.txt | — 16: 0E 225A.txt | — 19: 0E 270A.txt | — 22: 0E 315A.txt |
| — 14: 0E 195A.txt | — 17: 0E 240A.txt | — 20: 0E 285A.txt | — 23: 0E 330A.txt |
| — 15: 0E 210A.txt | — 18: 0E 255A.txt | — 21: 0E 300A.txt | — 24: 0E 345A.txt |

-45° Elevation



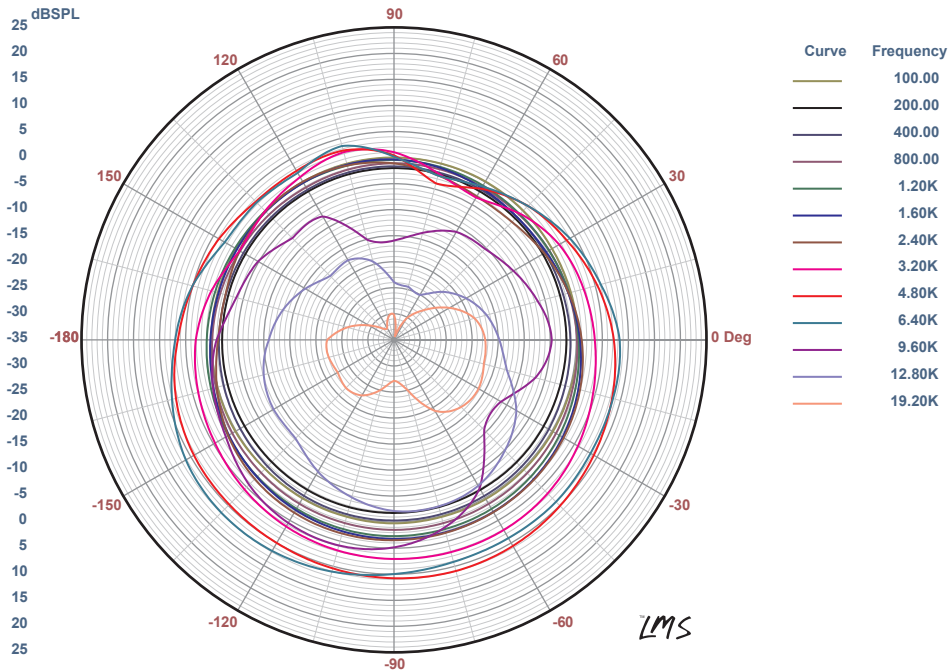
- | Curve | Frequency |
|-------|-----------|
| — | 100.00 |
| — | 200.00 |
| — | 400.00 |
| — | 800.00 |
| — | 1.20K |
| — | 1.60K |
| — | 2.40K |
| — | 3.20K |
| — | 4.80K |
| — | 6.40K |
| — | 9.60K |
| — | 12.80K |
| — | 19.20K |

-60° Elevation

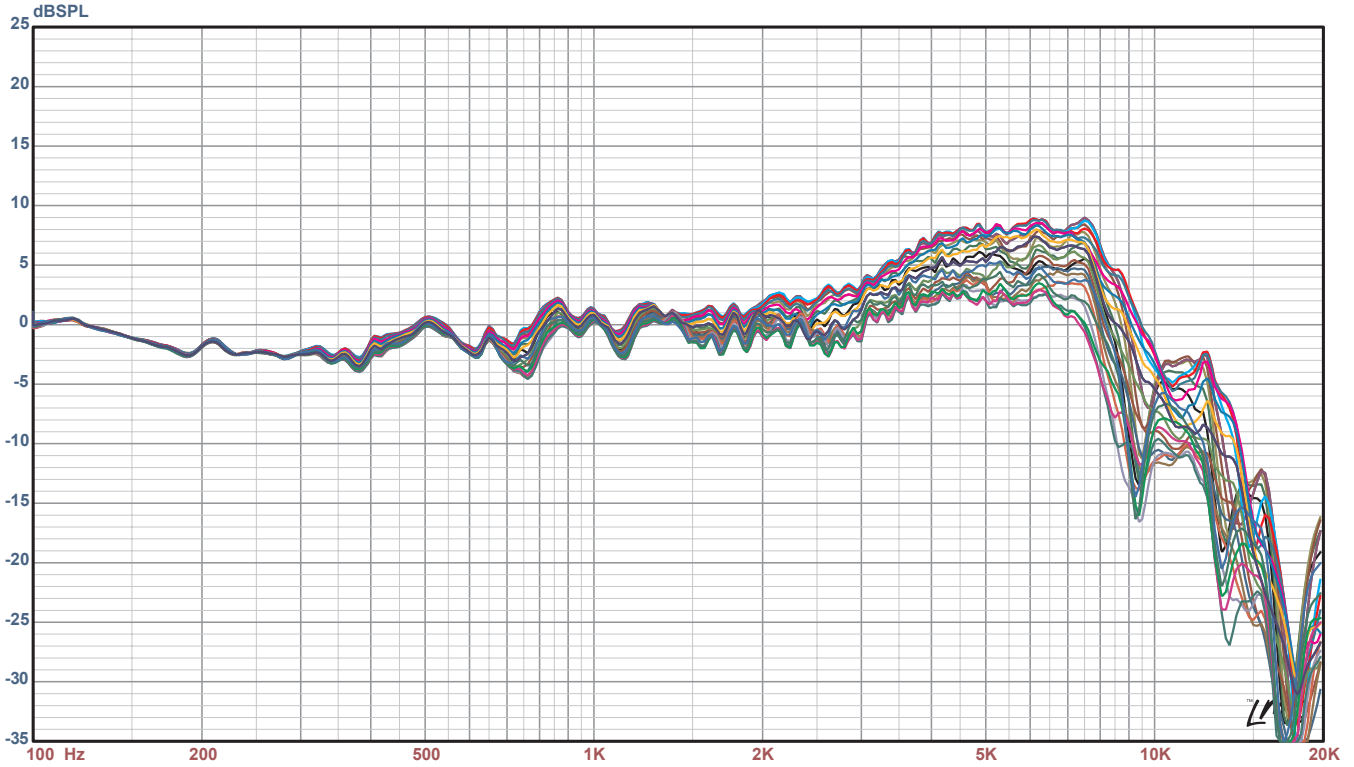


- | | | | |
|-------------------|-------------------|-------------------|-------------------|
| 1: -60E 0A.txt | 4: -60E 45A.txt | 7: -60E 90A.txt | 10: -60E 135A.txt |
| 2: -60E 15A.txt | 5: -60E 60A.txt | 8: -60E 105A.txt | 11: -60E 150A.txt |
| 3: -60E 30A.txt | 6: -60E 75A.txt | 9: -60E 120A.txt | 12: -60E 165A.txt |
| 13: -60E 180A.txt | 16: -60E 225A.txt | 19: -60E 270A.txt | 22: -60E 315A.txt |
| 14: -60E 195A.txt | 17: -60E 240A.txt | 20: -60E 285A.txt | 23: -60E 330A.txt |
| 15: -60E 210A.txt | 18: -60E 255A.txt | 21: -60E 300A.txt | 24: -60E 345A.txt |

-60° Elevation

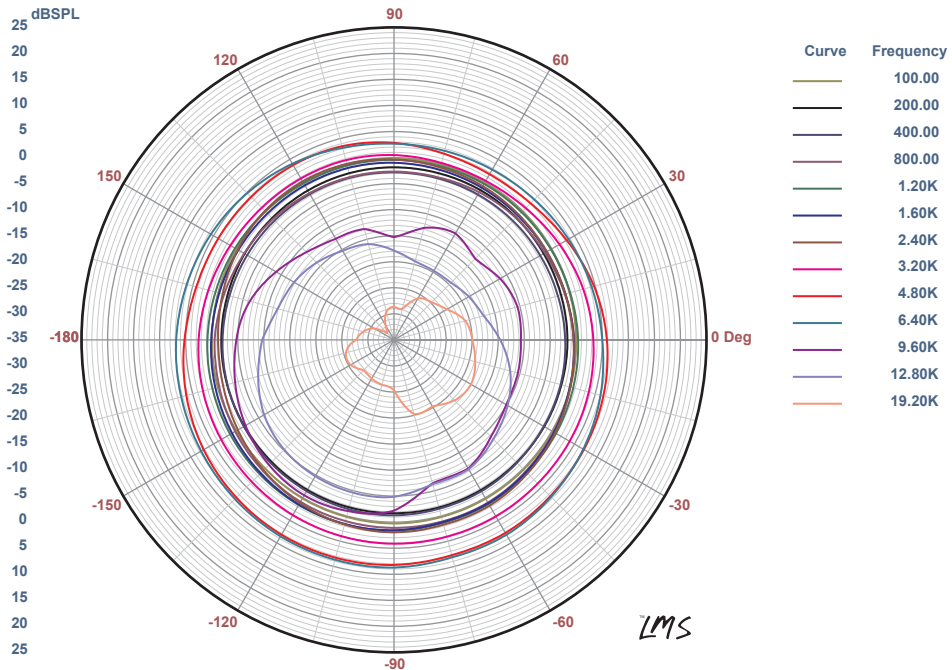


-75° Elevation

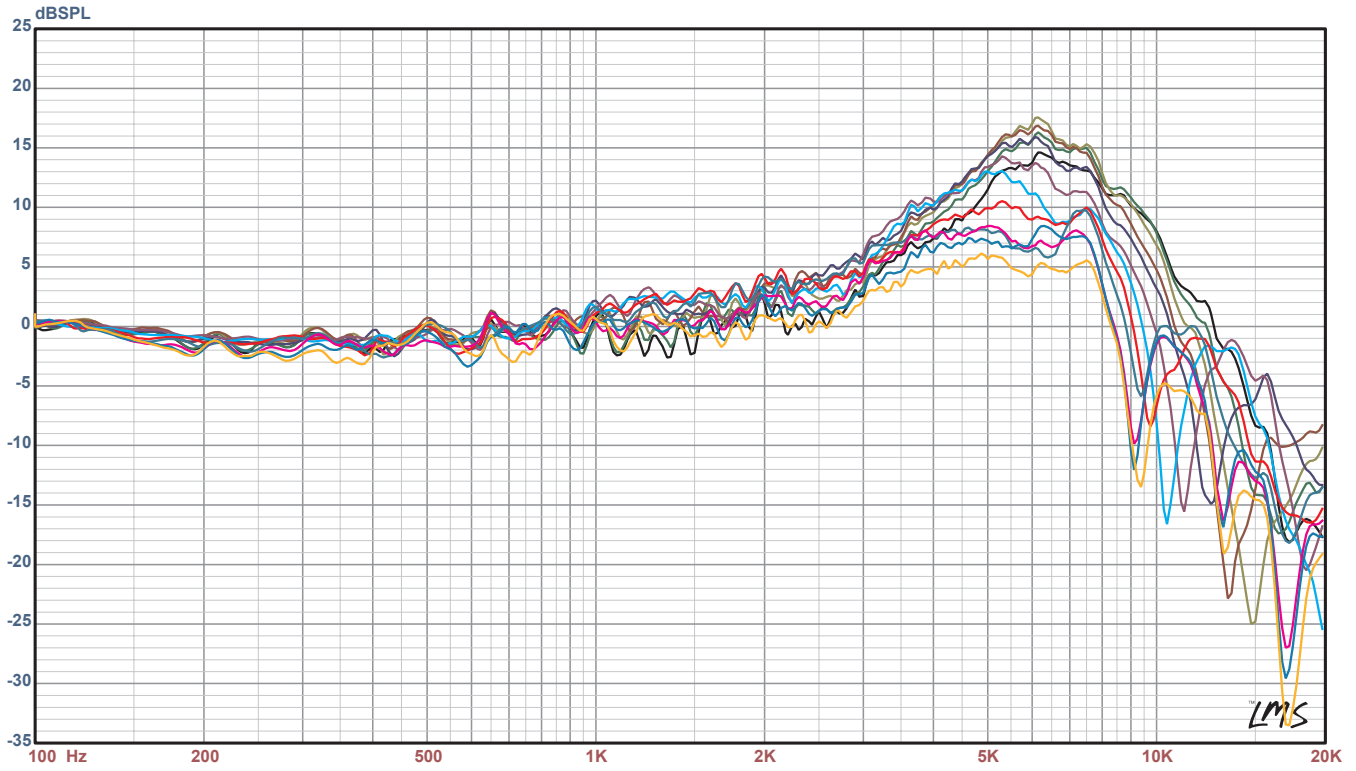


- | | | | |
|-------------------|-------------------|-------------------|-------------------|
| 1: -75E 0A.txt | 4: -75E 45A.txt | 7: -75E 90A.txt | 10: -75E 135A.txt |
| 2: -75E 15A.txt | 5: -75E 60A.txt | 8: -75E 105A.txt | 11: -75E 150A.txt |
| 3: -75E 30A.txt | 6: -75E 75A.txt | 9: -75E 120A.txt | 12: -75E 165A.txt |
| 13: -75E 180A.txt | 16: -75E 225A.txt | 19: -75E 270A.txt | 22: -75E 315A.txt |
| 14: -75E 195A.txt | 17: -75E 240A.txt | 20: -75E 285A.txt | 23: -75E 330A.txt |
| 15: -75E 210A.txt | 18: -75E 255A.txt | 21: -75E 300A.txt | 24: -75E 345A.txt |

-75° Elevation

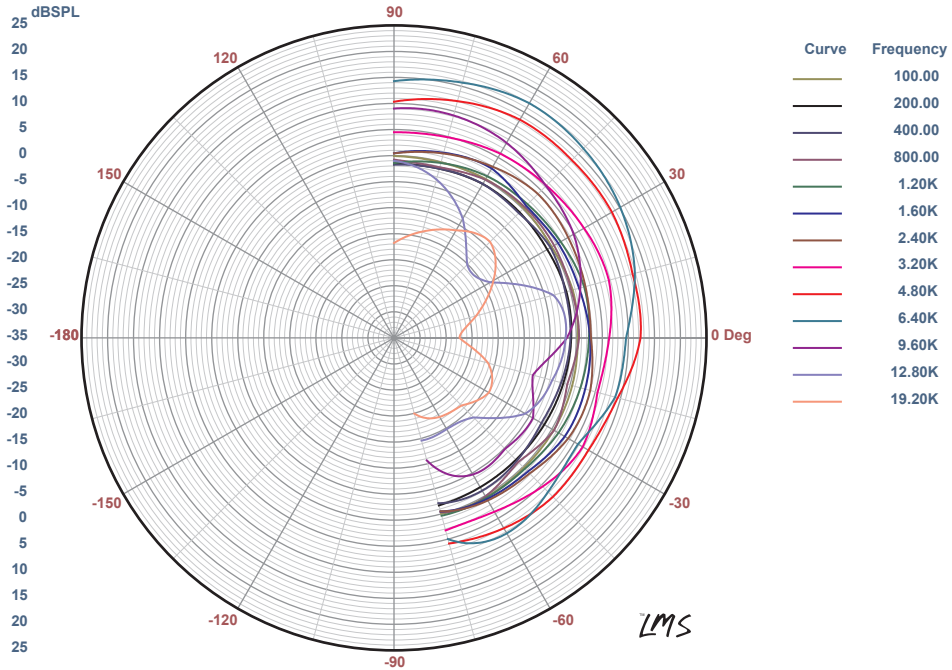


0° Azimuth

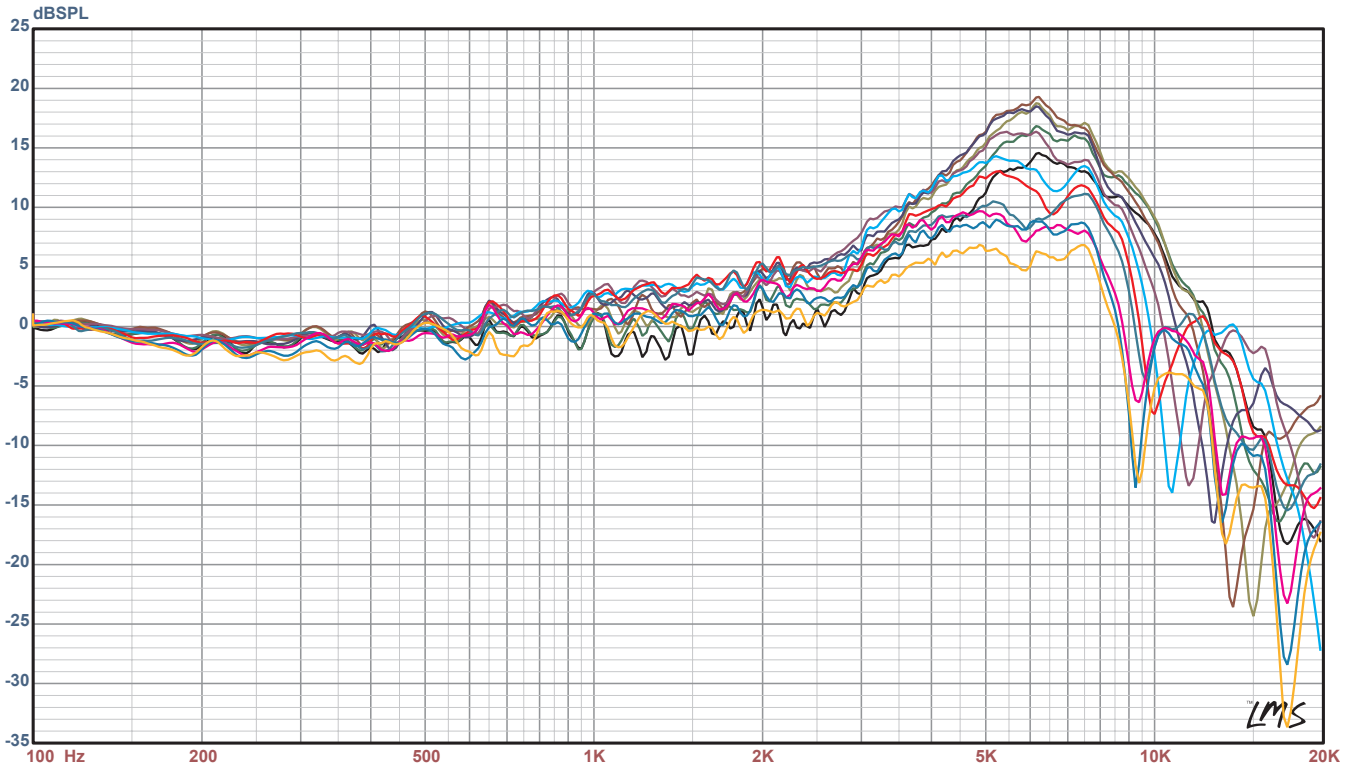


- | | | | |
|---------------|---------------|----------------|-----------------|
| 1: 90E 0A.txt | 4: 45E 0A.txt | 7: 0E 0A.txt | 10: -45E 0A.txt |
| 2: 75E 0A.txt | 5: 30E 0A.txt | 8: -15E 0A.txt | 11: -60E 0A.txt |
| 3: 60E 0A.txt | 6: 15E 0A.txt | 9: -30E 0A.txt | 12: -75E 0A.txt |

0° Azimuth

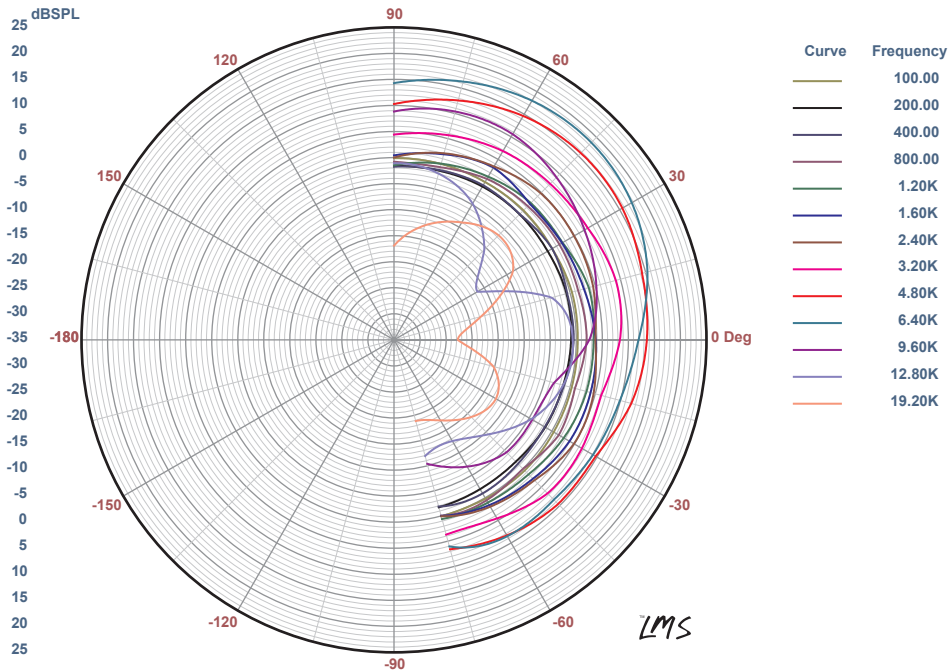


15° Azimuth

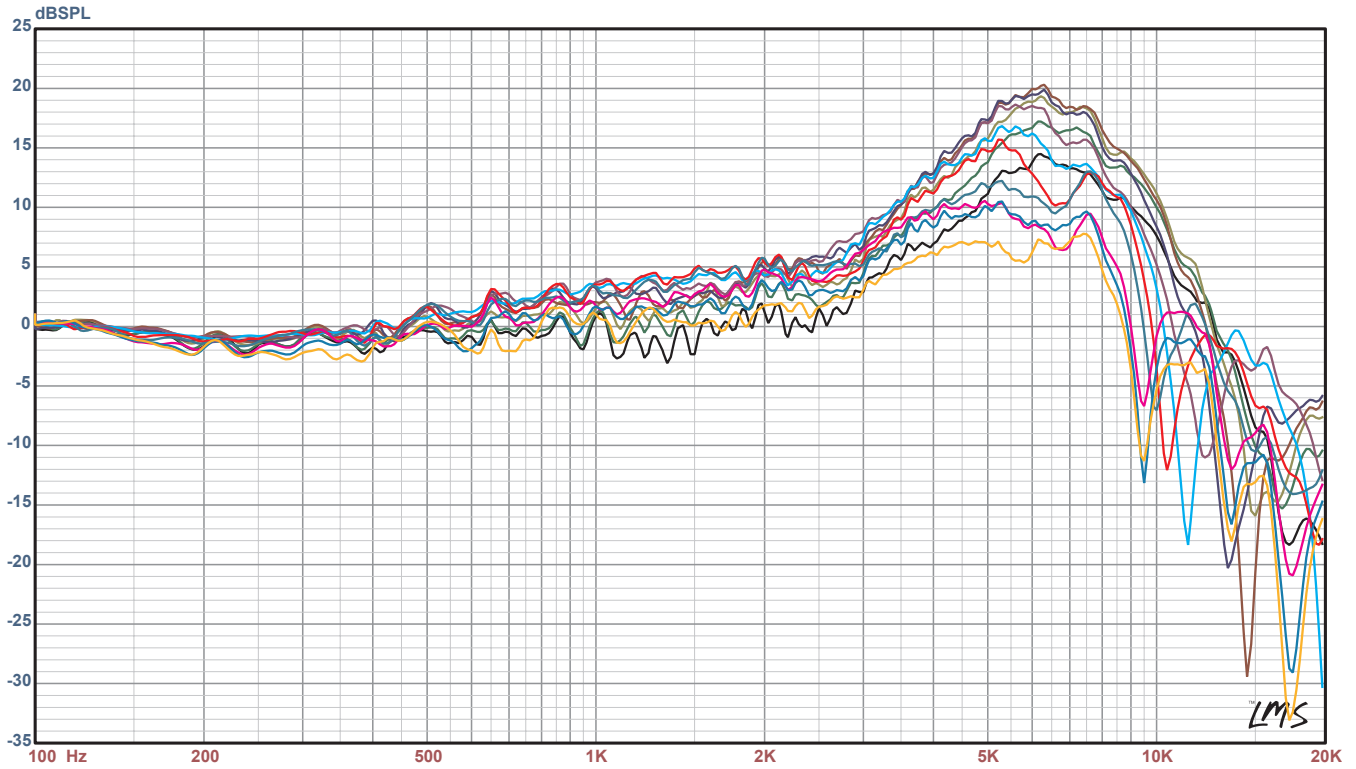


- | | | | |
|----------------|----------------|-----------------|------------------|
| 1: 90E 15A.txt | 4: 45E 15A.txt | 7: 0E 15A.txt | 10: -45E 15A.txt |
| 2: 75E 15A.txt | 5: 30E 15A.txt | 8: -15E 15.txt | 11: -60E 15A.txt |
| 3: 60E 15A.txt | 6: 15E 15A.txt | 9: -30E 15A.txt | 12: -75E 15A.txt |

15° Azimuth

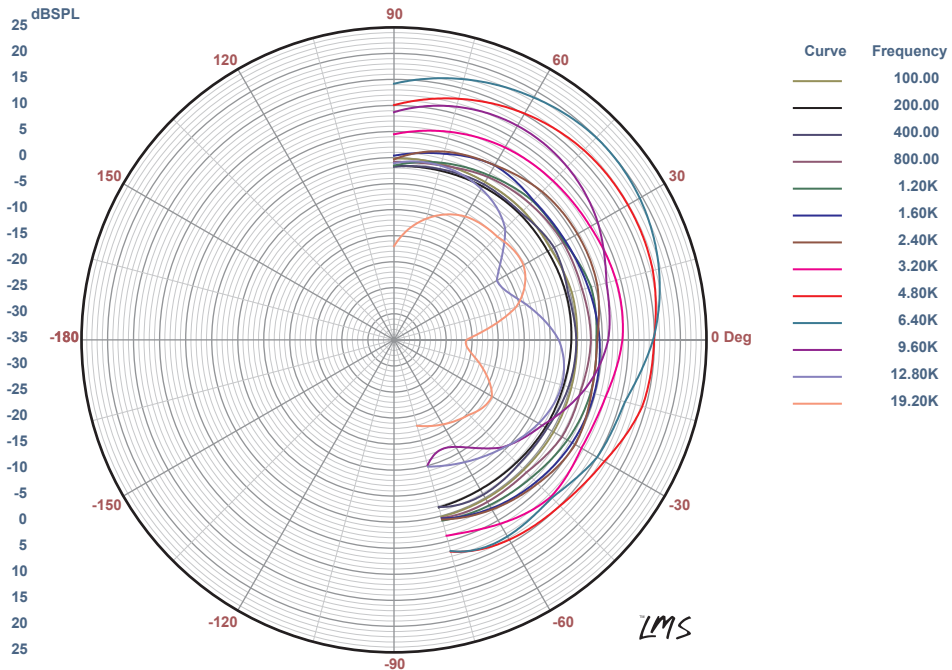


30° Azimuth

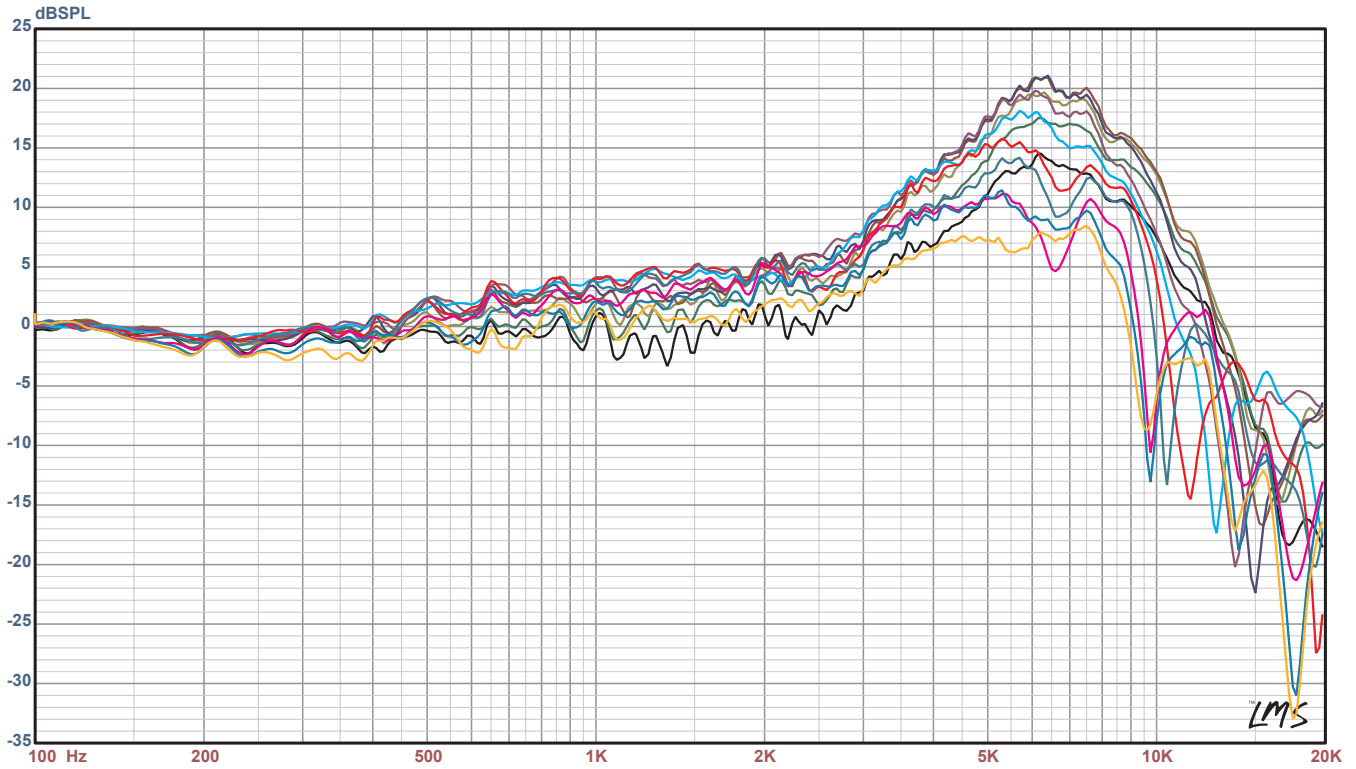


- | | | | |
|----------------|----------------|-----------------|------------------|
| 1: 90E 30A.txt | 4: 45E 30A.txt | 7: 0E 30A.txt | 10: -45E 30A.txt |
| 2: 75E 30A.txt | 5: 30E 30A.txt | 8: -15E 30A.txt | 11: -60E 30A.txt |
| 3: 60E 30A.txt | 6: 15E 30A.txt | 9: -30E 30A.txt | 12: -75E 30A.txt |

30° Azimuth

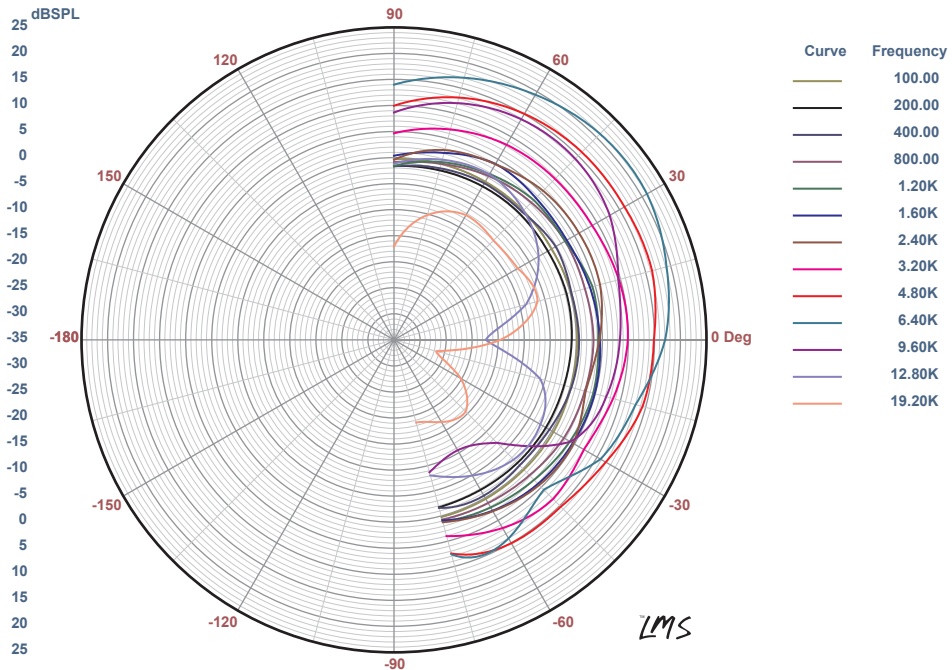


45° Azimuth

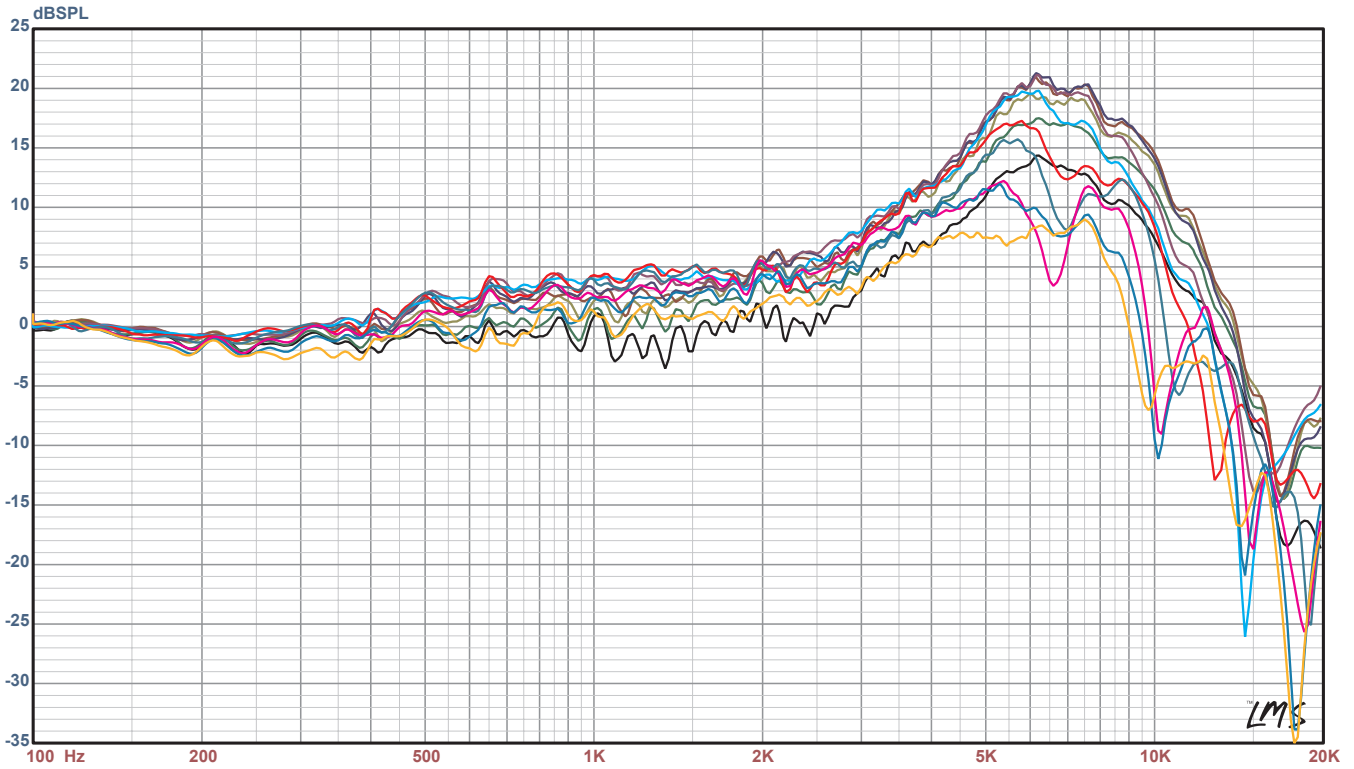


- | | | | |
|----------------|----------------|-----------------|------------------|
| 1: 90E 45A.txt | 4: 45E 45A.txt | 7: 0E 45A.txt | 10: -45E 45A.txt |
| 2: 75E 45A.txt | 5: 30E 45A.txt | 8: -15E 45A.txt | 11: -60E 45A.txt |
| 3: 60E 45A.txt | 6: 15E 45A.txt | 9: -30E 45A.txt | 12: -75E 45A.txt |

45° Azimuth

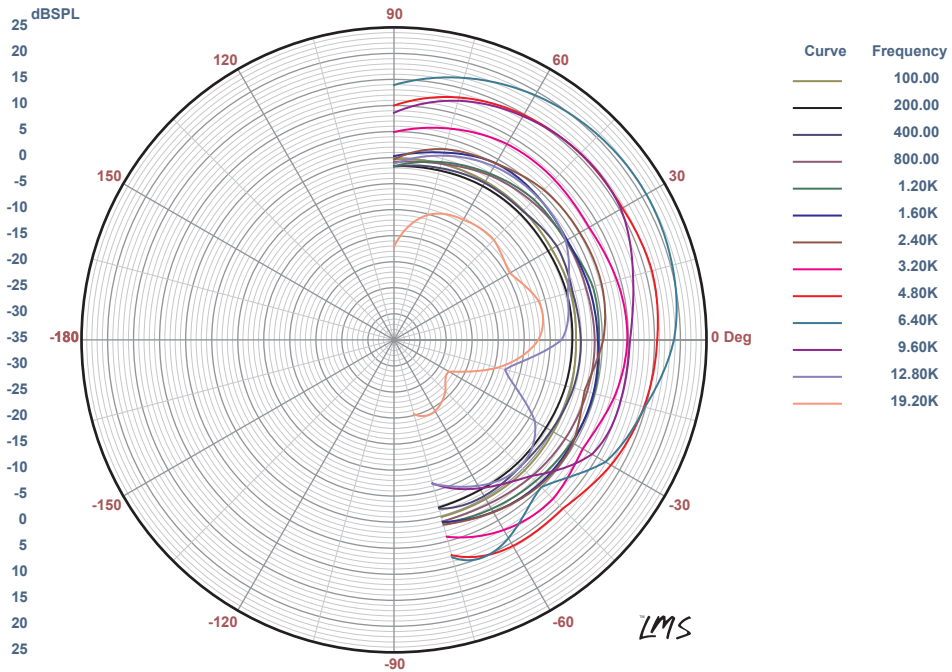


60° Azimuth

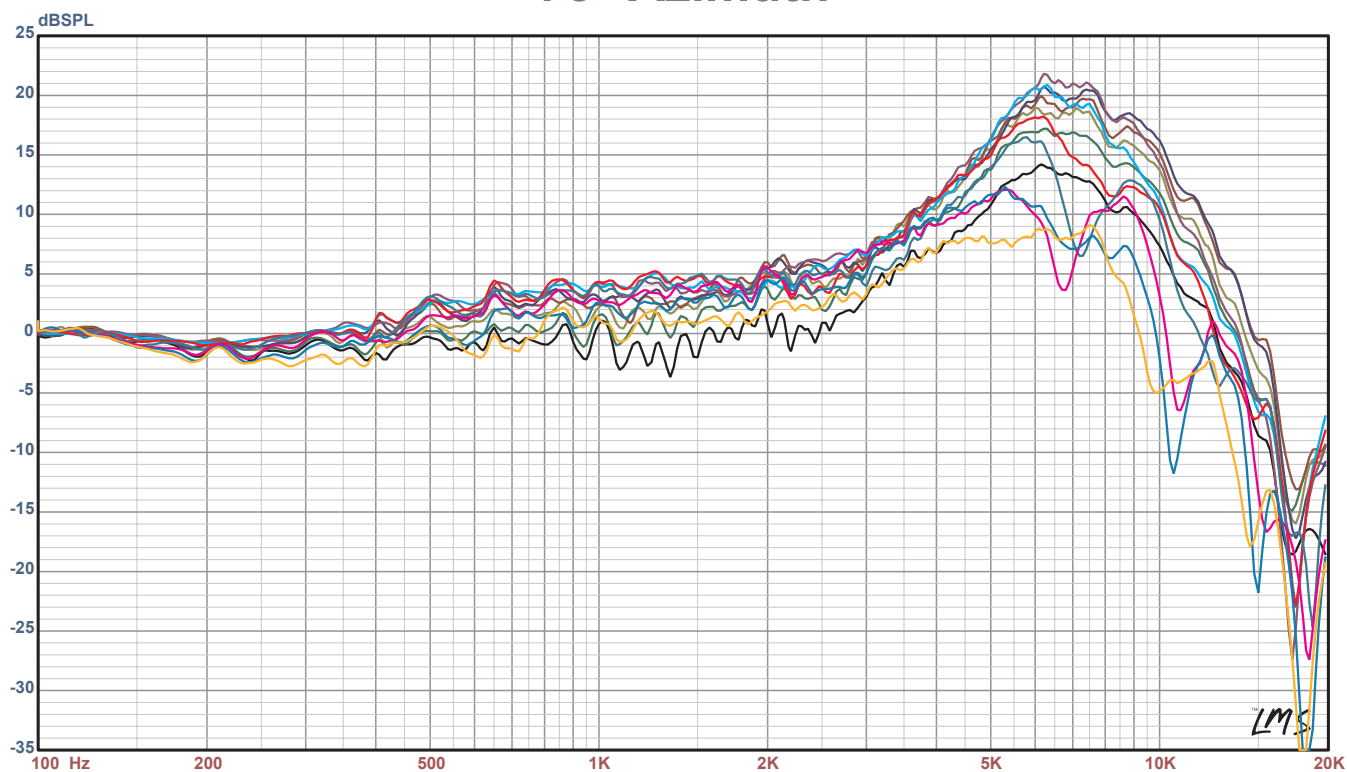


- | | | | |
|------------------------|------------------------|-------------------------|--------------------------|
| 1: Import: 90E 60A.txt | 4: Import: 45E 60A.txt | 7: Import: 0E 60A.txt | 10: Import: -45E 60A.txt |
| 2: Import: 75E 60A.txt | 5: Import: 30E 60A.txt | 8: Import: -15E 60A.txt | 11: Import: -60E 60A.txt |
| 3: Import: 60E 60A.txt | 6: Import: 15E 60A.txt | 9: Import: -30E 60A.txt | 12: Import: -75E 60A.txt |

60° Azimuth

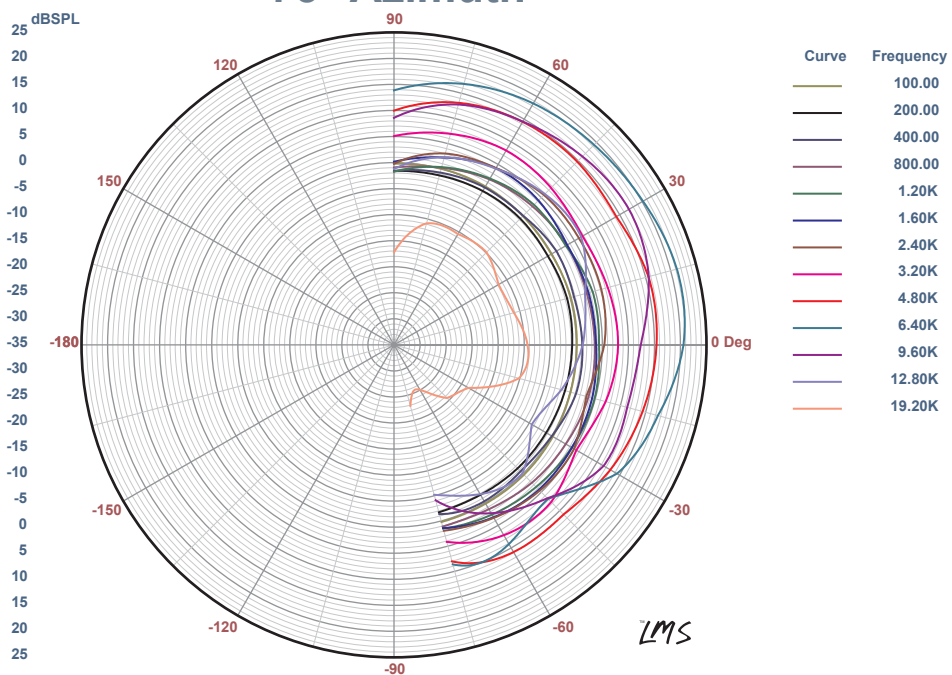


75° Azimuth

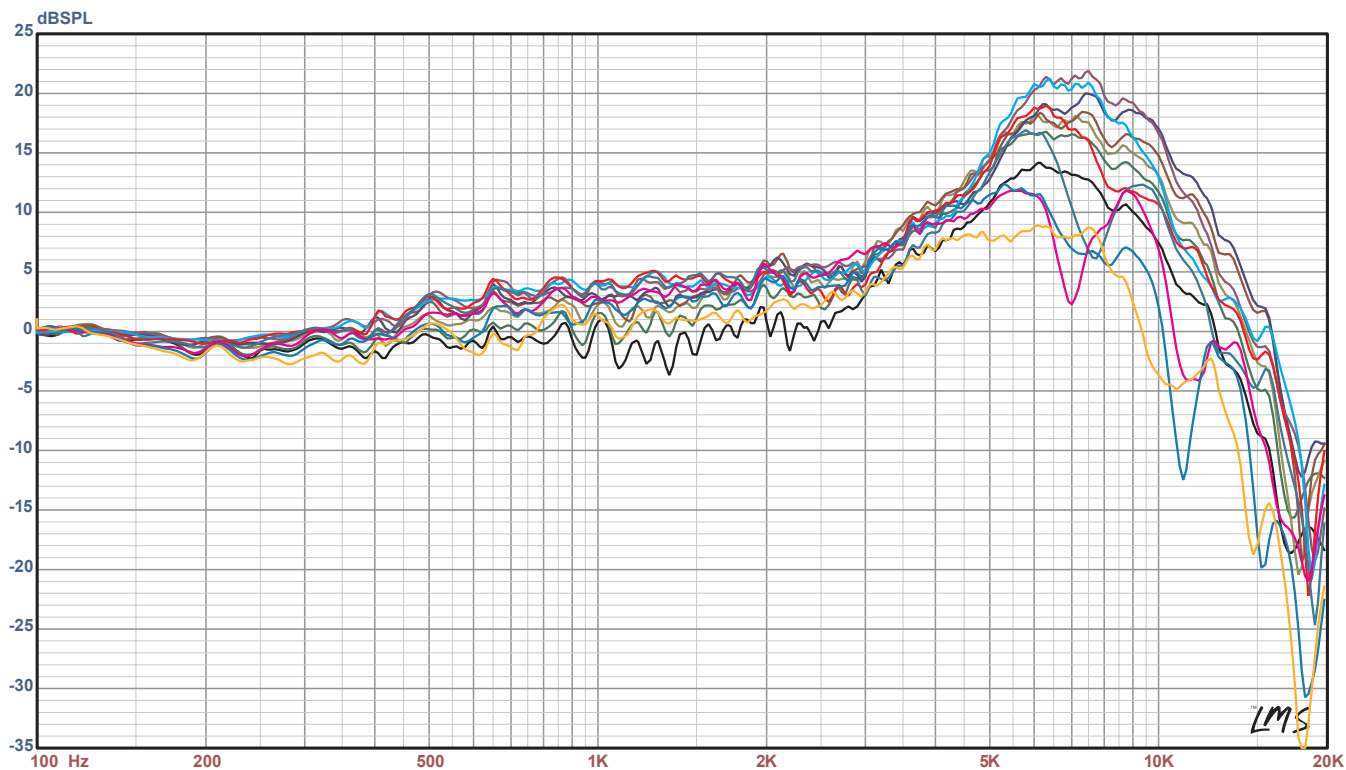


- | | | | |
|----------------|----------------|-----------------|------------------|
| 1: 90E 75A.txt | 4: 45E 75A.txt | 7: 0E 75A.txt | 10: -45E 75A.txt |
| 2: 75E 75A.txt | 5: 30E 75A.txt | 8: -15E 75A.txt | 11: -60E 75A.txt |
| 3: 60E 75A.txt | 6: 15E 75A.txt | 9: -30E 75A.txt | 12: -75E 75A.txt |

75° Azimuth

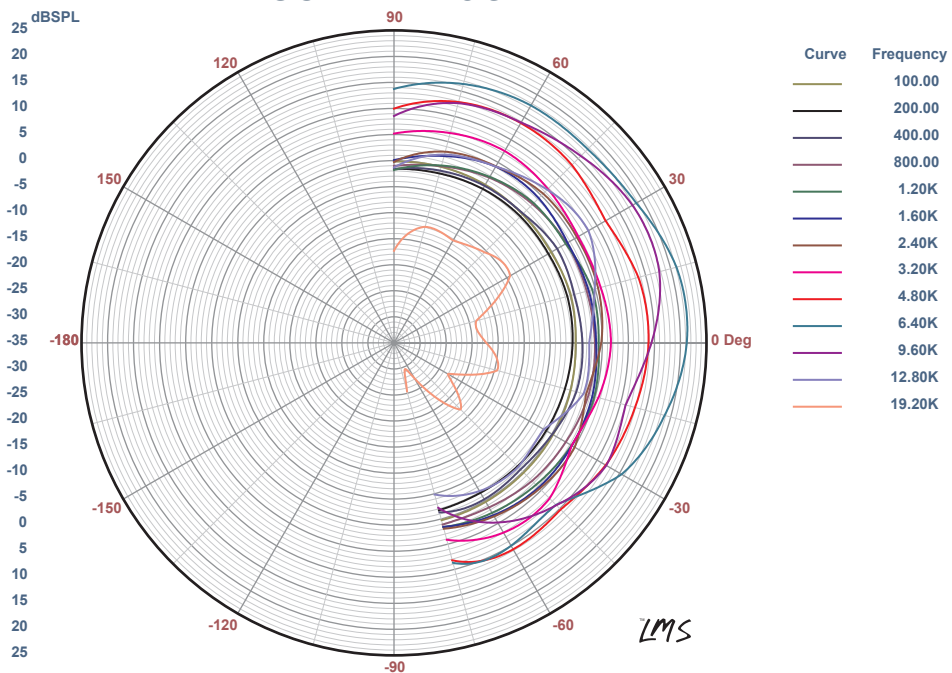


90° Azimuth

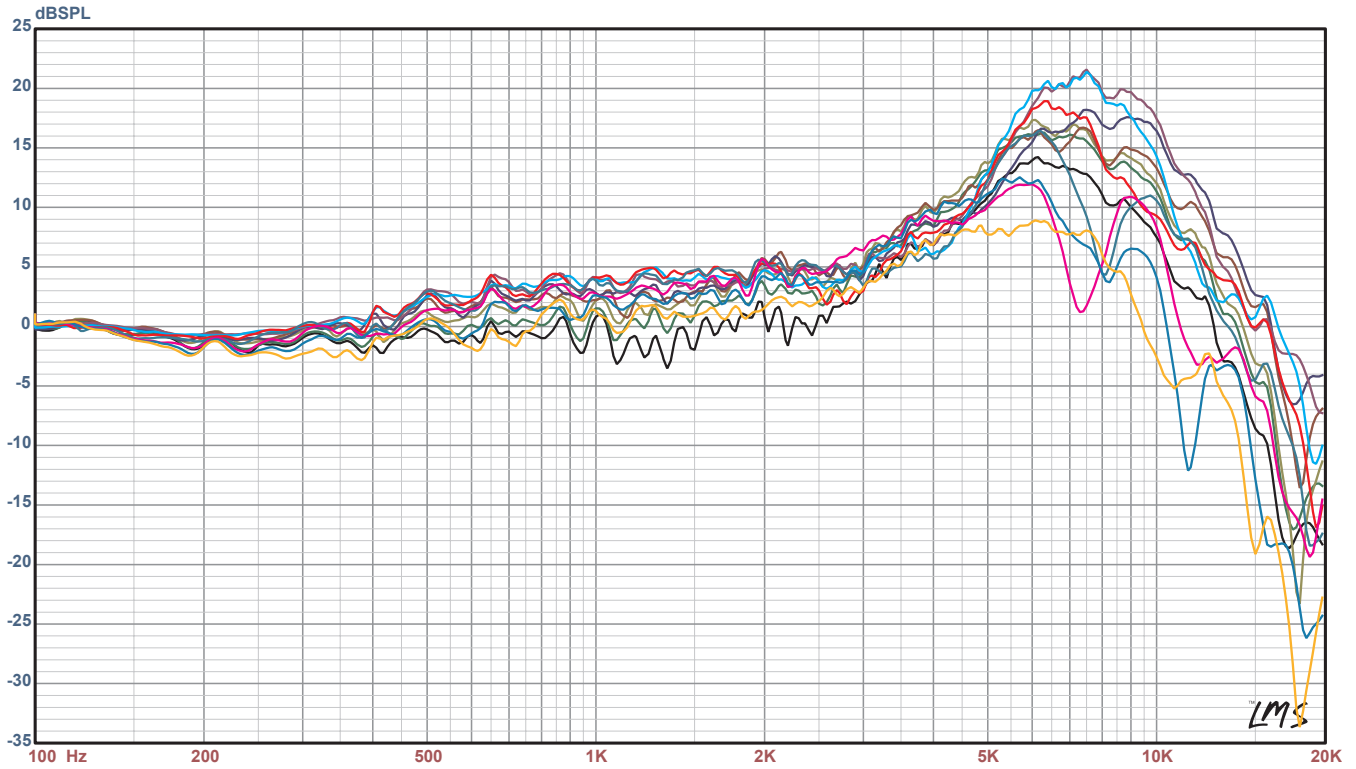


- | | | | |
|----------------|----------------|-----------------|------------------|
| 1: 90E 90A.txt | 4: 45E 90A.txt | 7: 0E 90A.txt | 10: -45E 90A.txt |
| 2: 75E 90A.txt | 5: 30E 90A.txt | 8: -15E 90A.txt | 11: -60E 90A.txt |
| 3: 60E 90A.txt | 6: 15E 90A.txt | 9: -30E 90A.txt | 12: -75E 90A.txt |

90° Azimuth

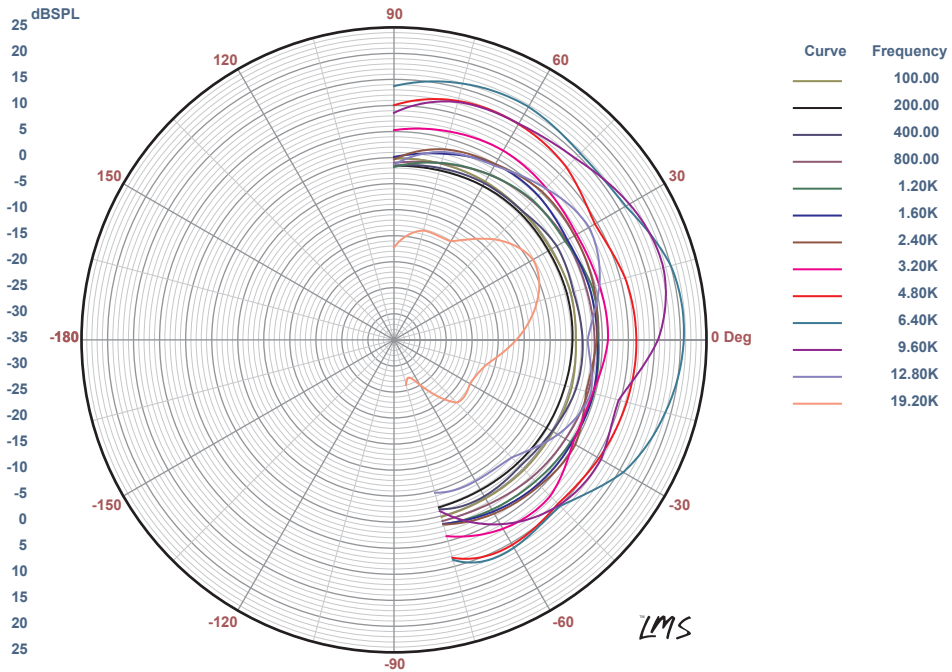


105° Azimuth

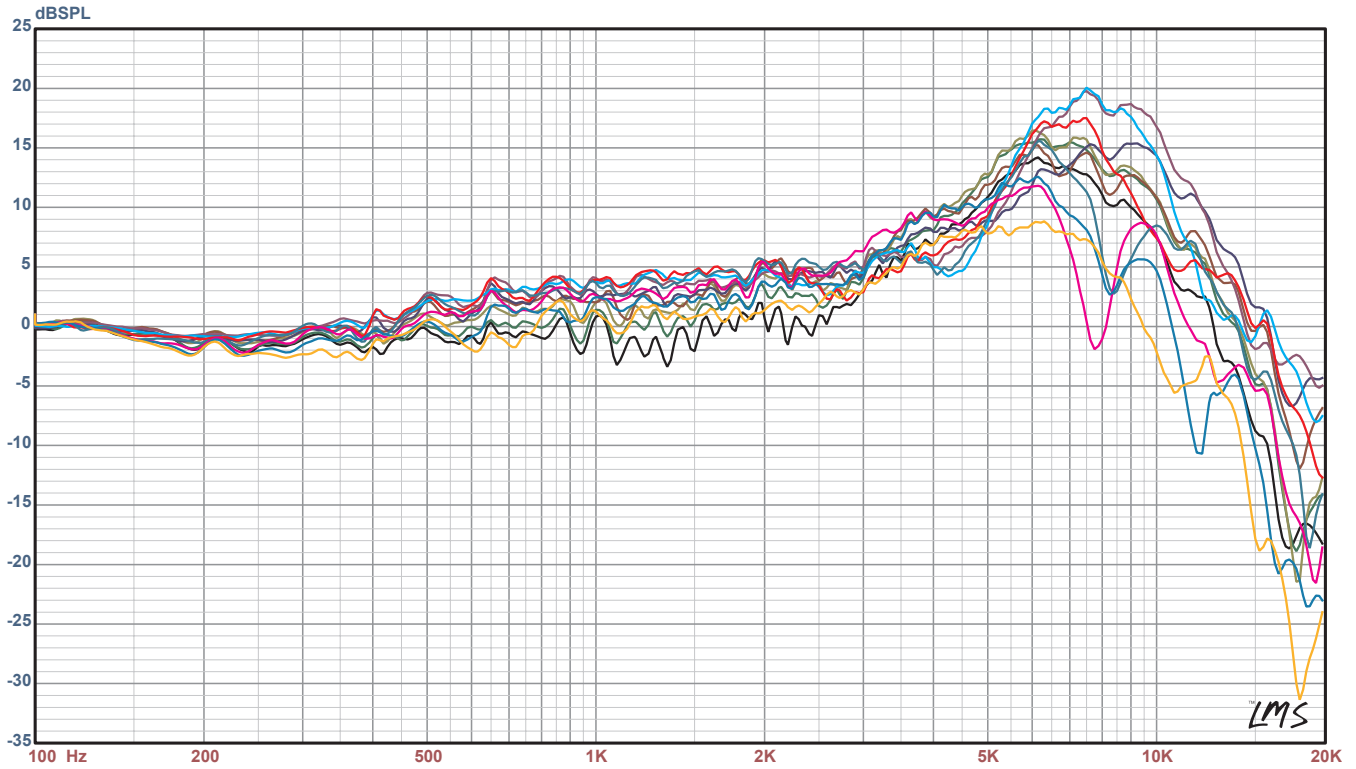


- | | | | |
|-----------------|-----------------|------------------|-------------------|
| 1: 90E 105A.txt | 4: 45E 105A.txt | 7: 0E 105A.txt | 10: -45E 105A.txt |
| 2: 75E 105A.txt | 5: 30E 105A.txt | 8: -15E 105A.txt | 11: -60E 105A.txt |
| 3: 60E 105A.txt | 6: 15E 105A.txt | 9: -30E 105A.txt | 12: -75E 105A.txt |

105° Azimuth

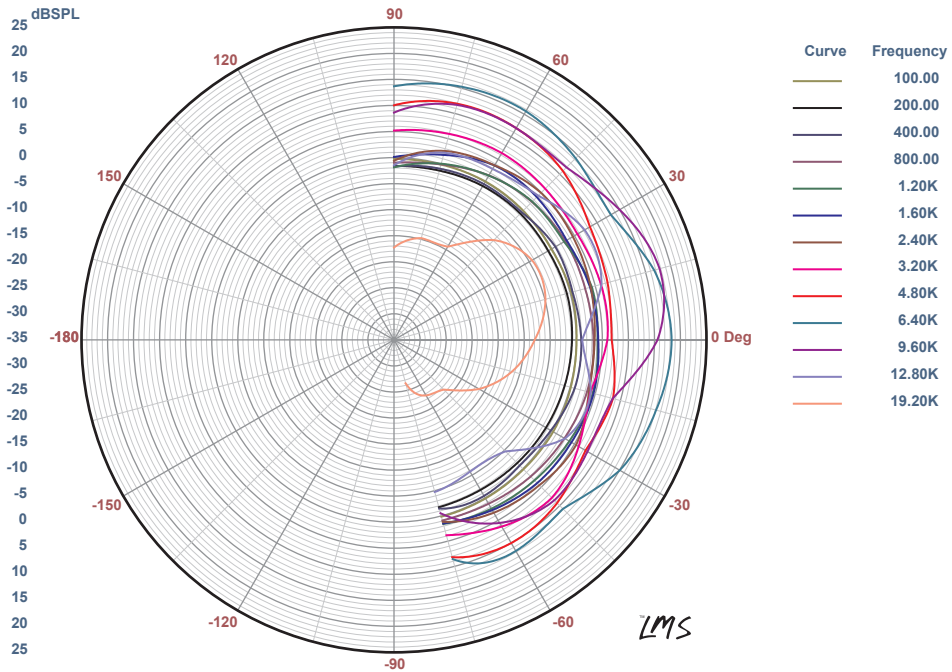


120° Azimuth

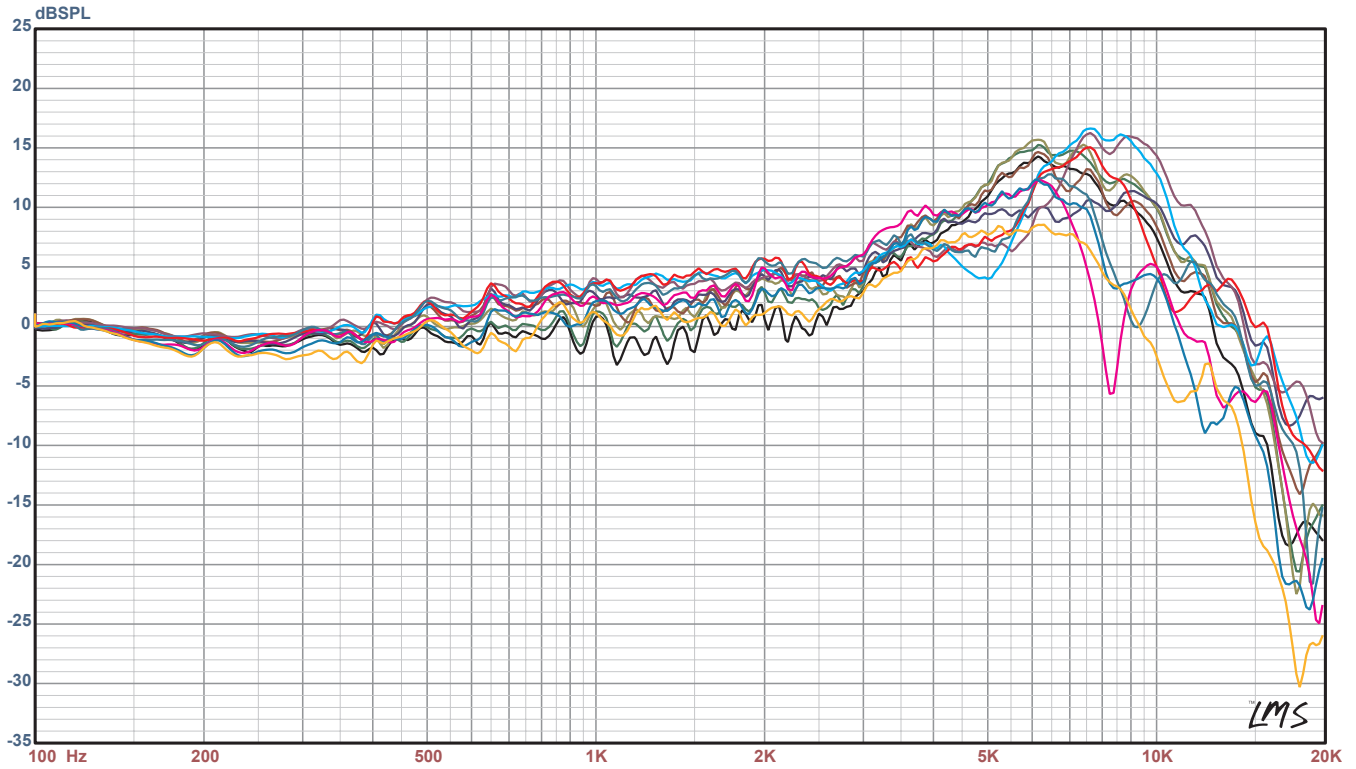


- | | | | |
|-----------------|-----------------|------------------|-------------------|
| 1: 90E 120A.txt | 4: 45E 120A.txt | 7: 0E 120A.txt | 10: -45E 120A.txt |
| 2: 75E 120A.txt | 5: 30E 120A.txt | 8: -15E 120A.txt | 11: -60E 120A.txt |
| 3: 60E 120A.txt | 6: 15E 120A.txt | 9: -30E 120A.txt | 12: -75E 120A.txt |

120° Azimuth

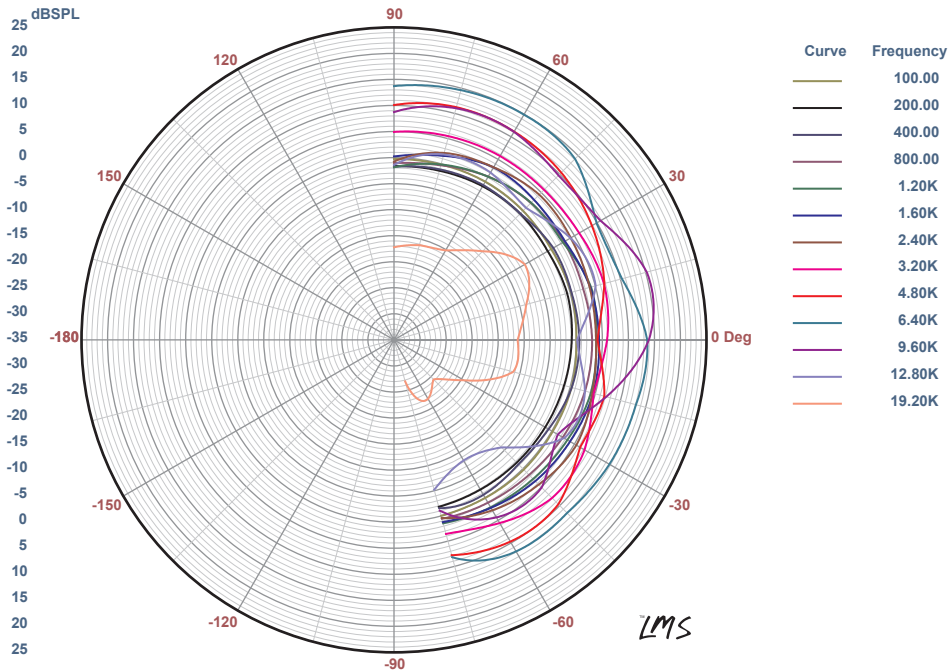


135° Azimuth

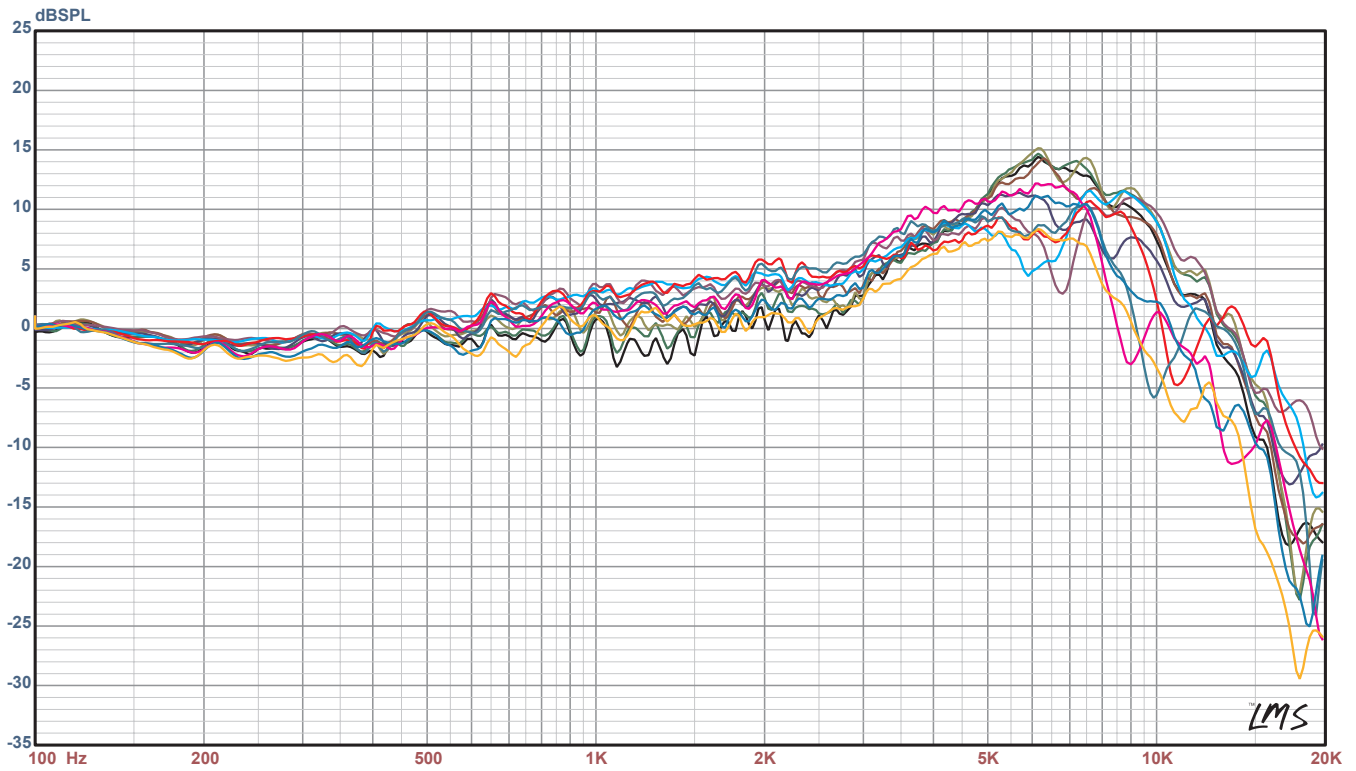


- | | | | |
|-----------------|-----------------|------------------|-------------------|
| 1: 90E 135A.txt | 4: 45E 135A.txt | 7: 0E 135A.txt | 10: -45E 135A.txt |
| 2: 75E 135A.txt | 5: 30E 135A.txt | 8: -15E 135A.txt | 11: -60E 135A.txt |
| 3: 60E 135A.txt | 6: 15E 135A.txt | 9: -30E 135A.txt | 12: -75E 135A.txt |

135° Azimuth

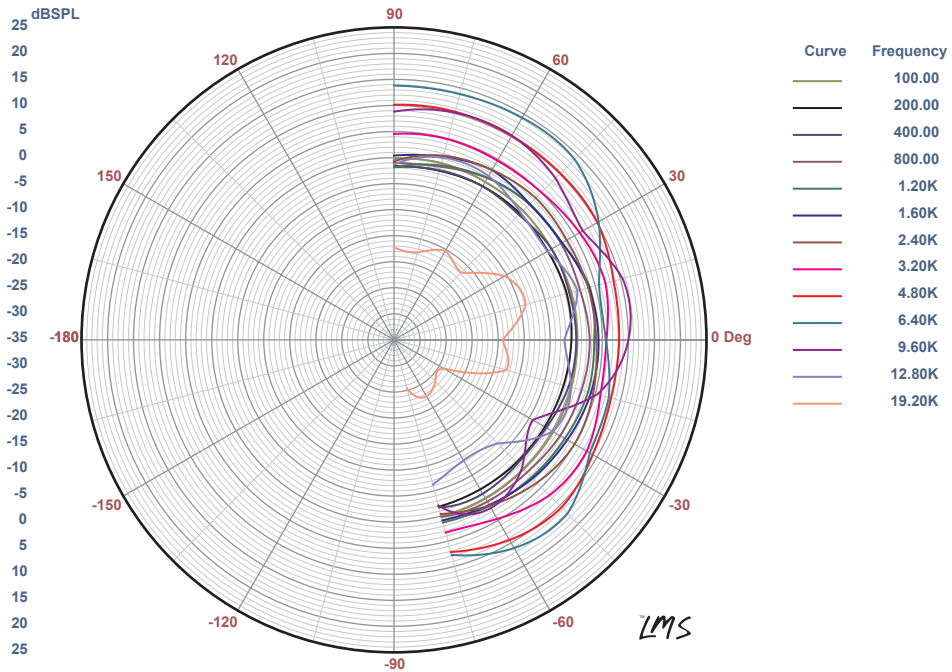


150° Azimuth

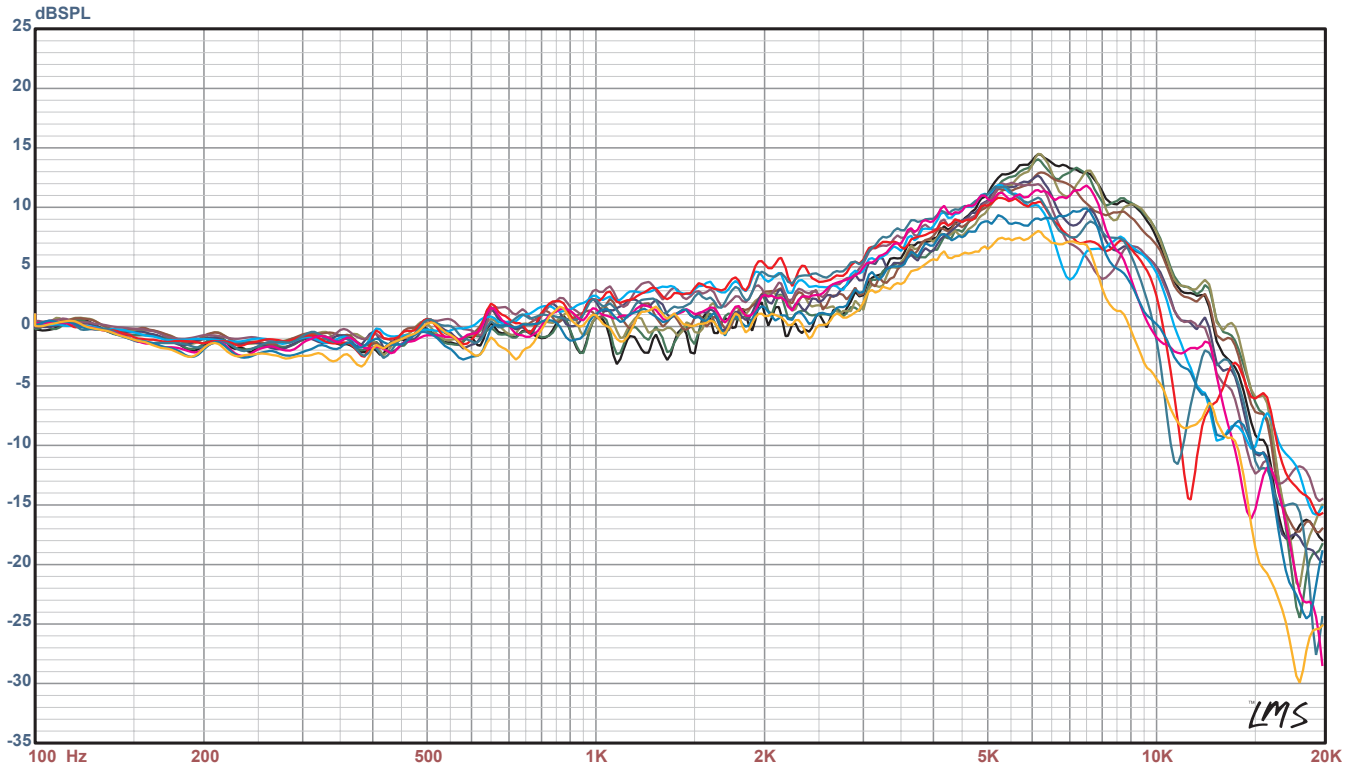


- | | | | |
|-----------------|-----------------|------------------|-------------------|
| 1: 90E 150A.txt | 4: 45E 150A.txt | 7: 0E 150A.txt | 10: -45E 150A.txt |
| 2: 75E 150A.txt | 5: 30E 150A.txt | 8: -15E 150A.txt | 11: -60E 150A.txt |
| 3: 60E 150A.txt | 6: 15E 150A.txt | 9: -30E 150A.txt | 12: -75E 150A.txt |

150° Azimuth

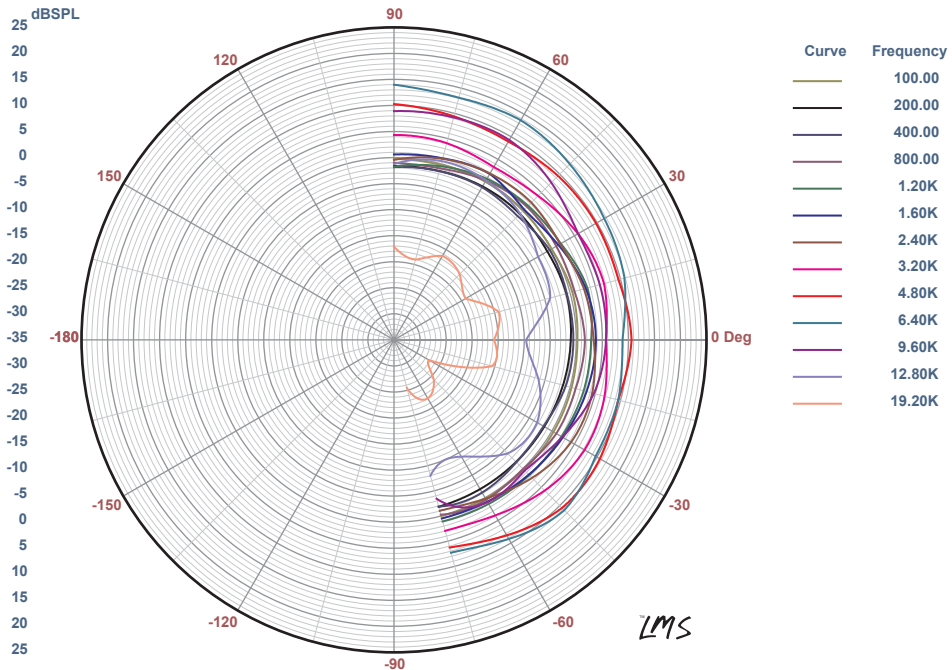


165° Azimuth

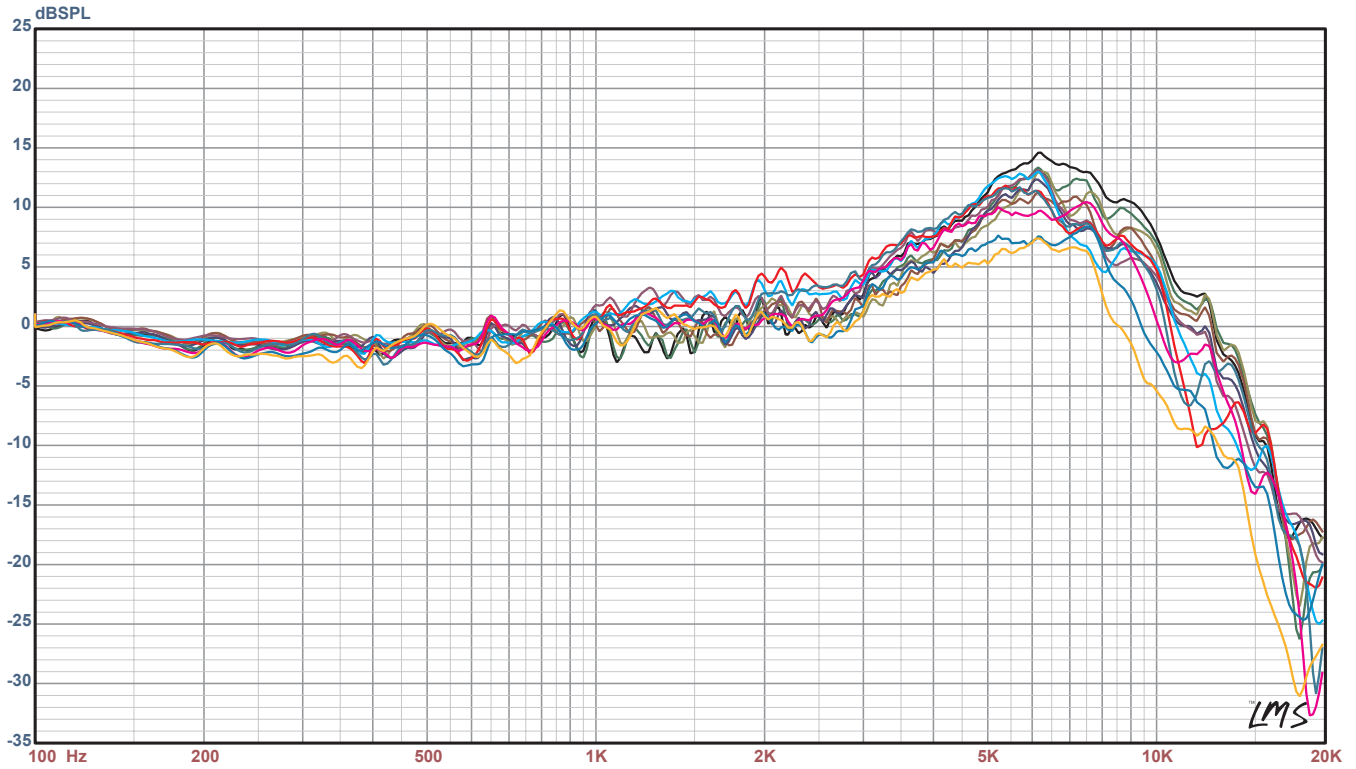


- | | | | |
|-----------------|-----------------|------------------|-------------------|
| 1: 90E 165A.txt | 4: 45E 165A.txt | 7: 0E 165A.txt | 10: -45E 165A.txt |
| 2: 75E 165A.txt | 5: 30E 165A.txt | 8: -15E 165A.txt | 11: -60E 165A.txt |
| 3: 60E 165A.txt | 6: 15E 165A.txt | 9: -30E 165A.txt | 12: -75E 165A.txt |

165° Azimuth

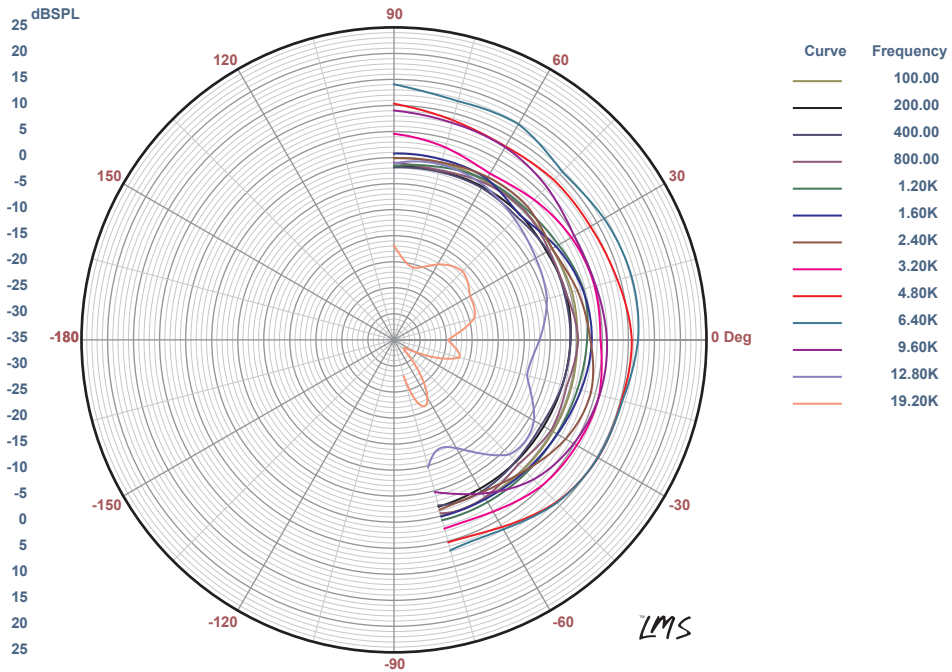


180° Azimuth

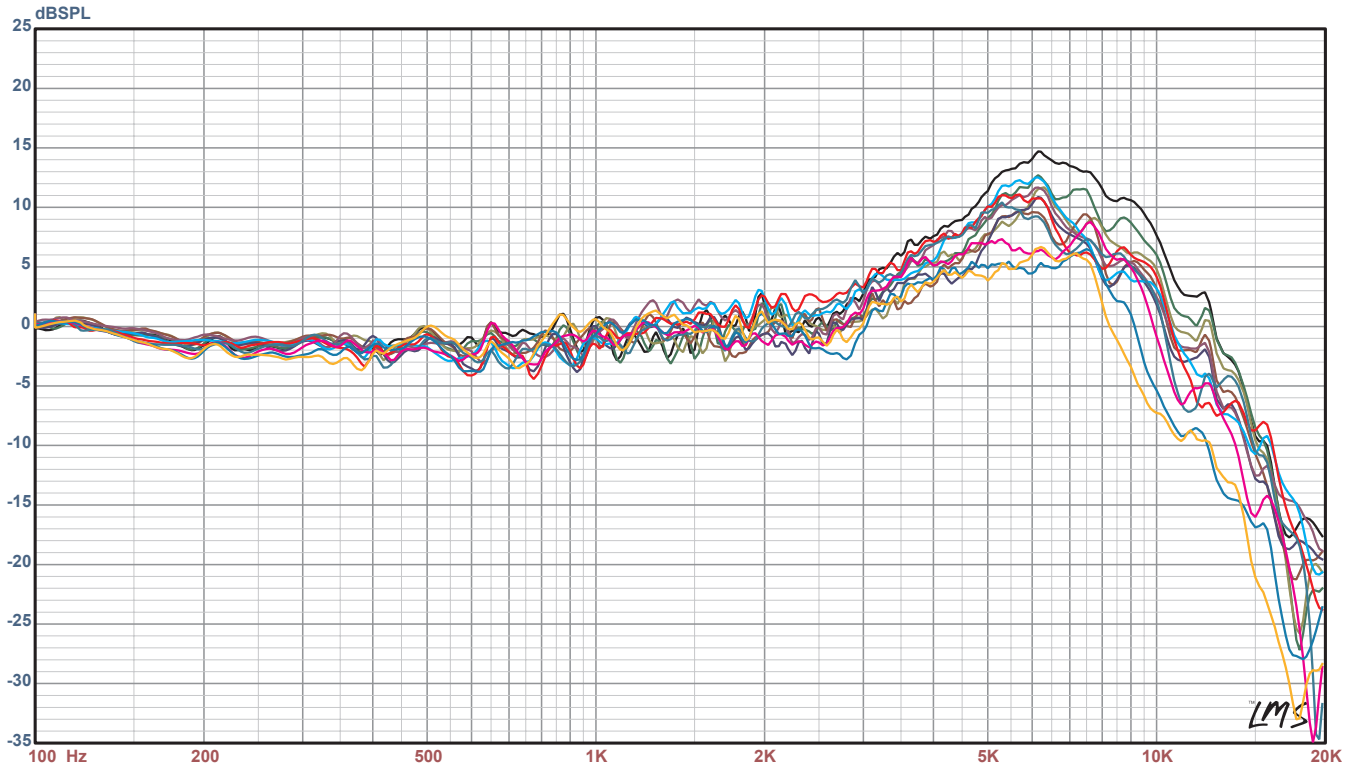


- | | | | |
|-----------------|-----------------|------------------|-------------------|
| 1: 90E 180A.txt | 4: 45E 180A.txt | 7: 0E 180A.txt | 10: -45E 180A.txt |
| 2: 75E 180A.txt | 5: 30E 180A.txt | 8: -15E 180A.txt | 11: -60E 180A.txt |
| 3: 60E 180A.txt | 6: 15E 180A.txt | 9: -30E 180A.txt | 12: -75E 180A.txt |

180° Azimuth

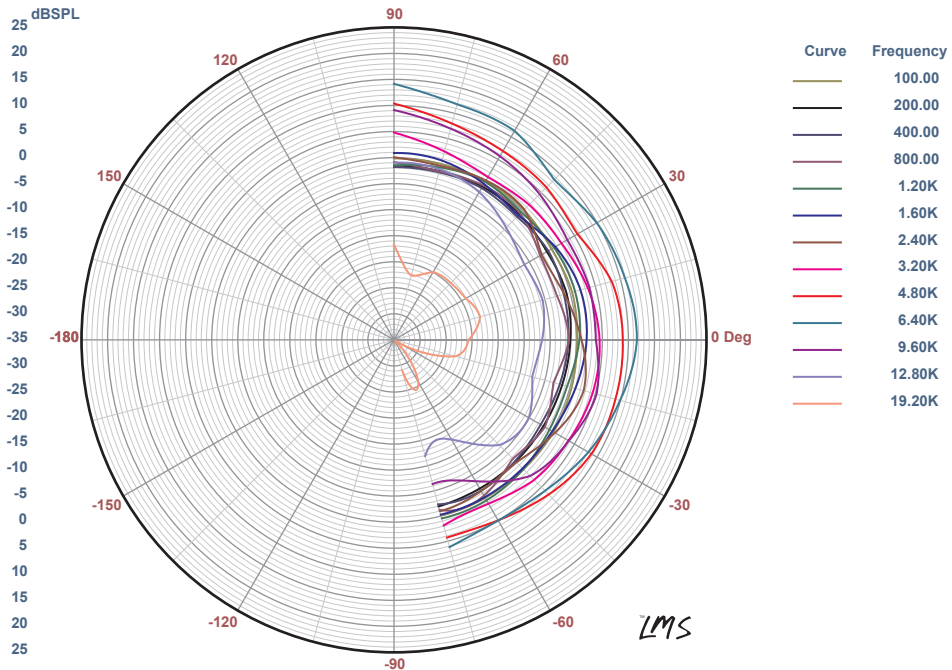


195° Azimuth

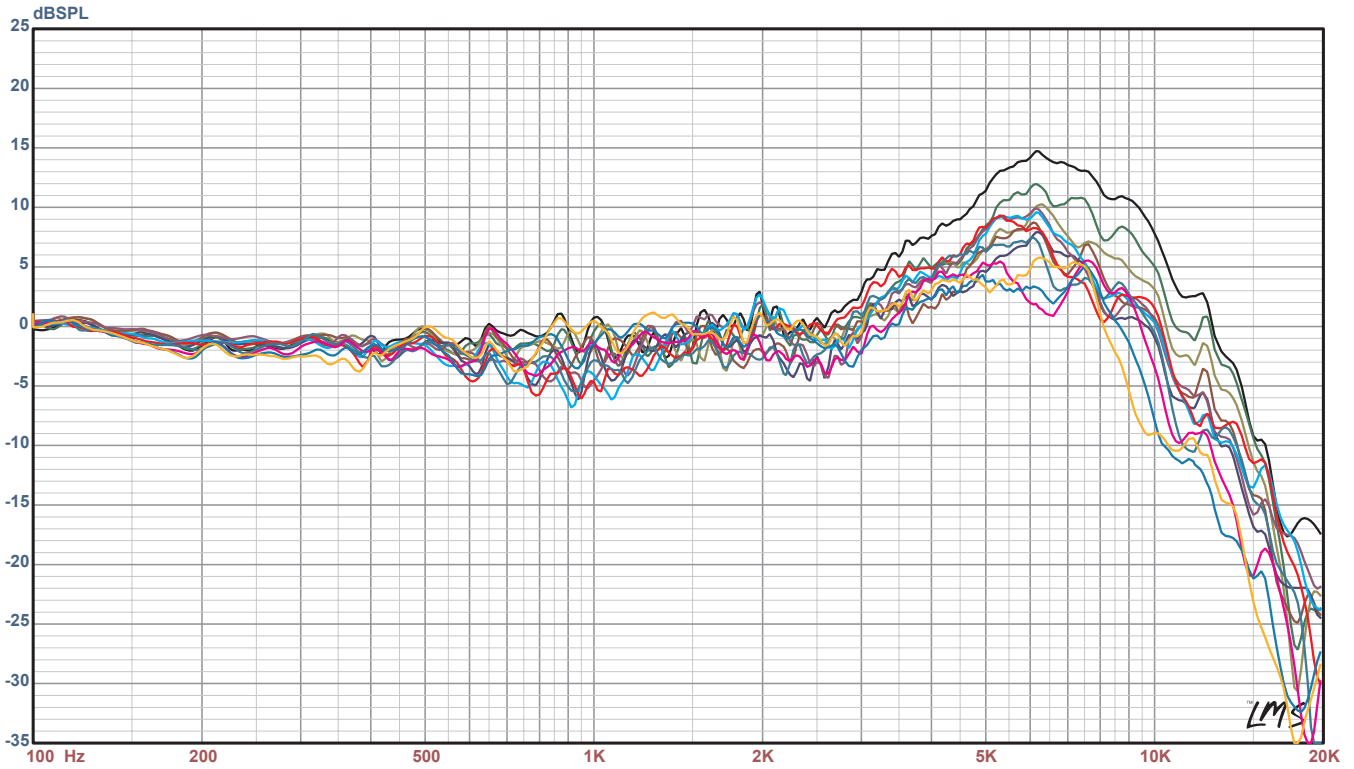


- | | | | |
|-----------------|-----------------|------------------|-------------------|
| 1: 90E 195A.txt | 4: 45E 195A.txt | 7: 0E 195A.txt | 10: -45E 195A.txt |
| 2: 75E 195A.txt | 5: 30E 195A.txt | 8: -15E 195A.txt | 11: -60E 195A.txt |
| 3: 60E 195A.txt | 6: 15E 195A.txt | 9: -30E 195A.txt | 12: -75E 195A.txt |

195° Azimuth

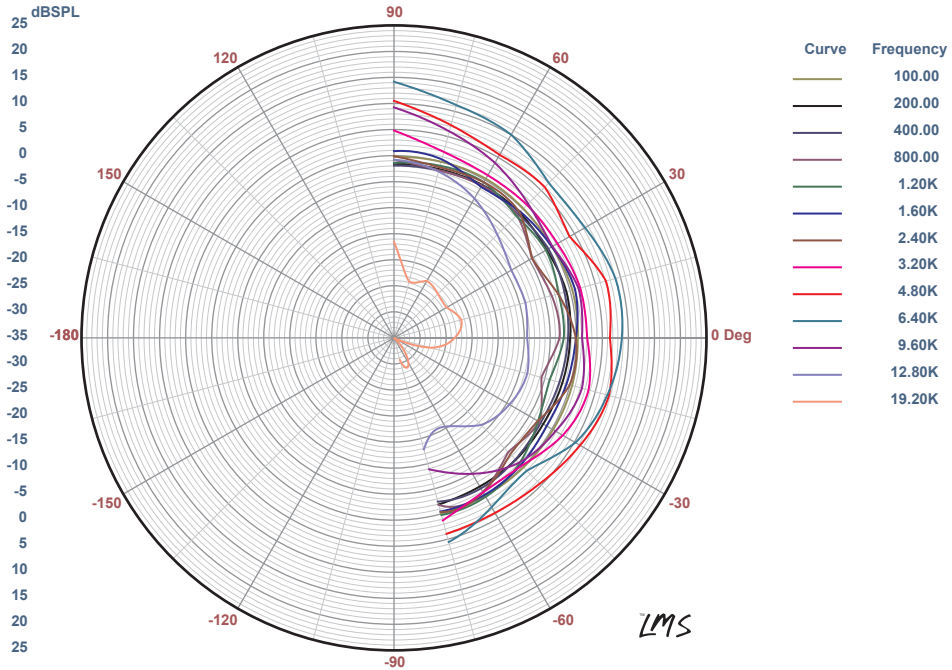


210° Azimuth

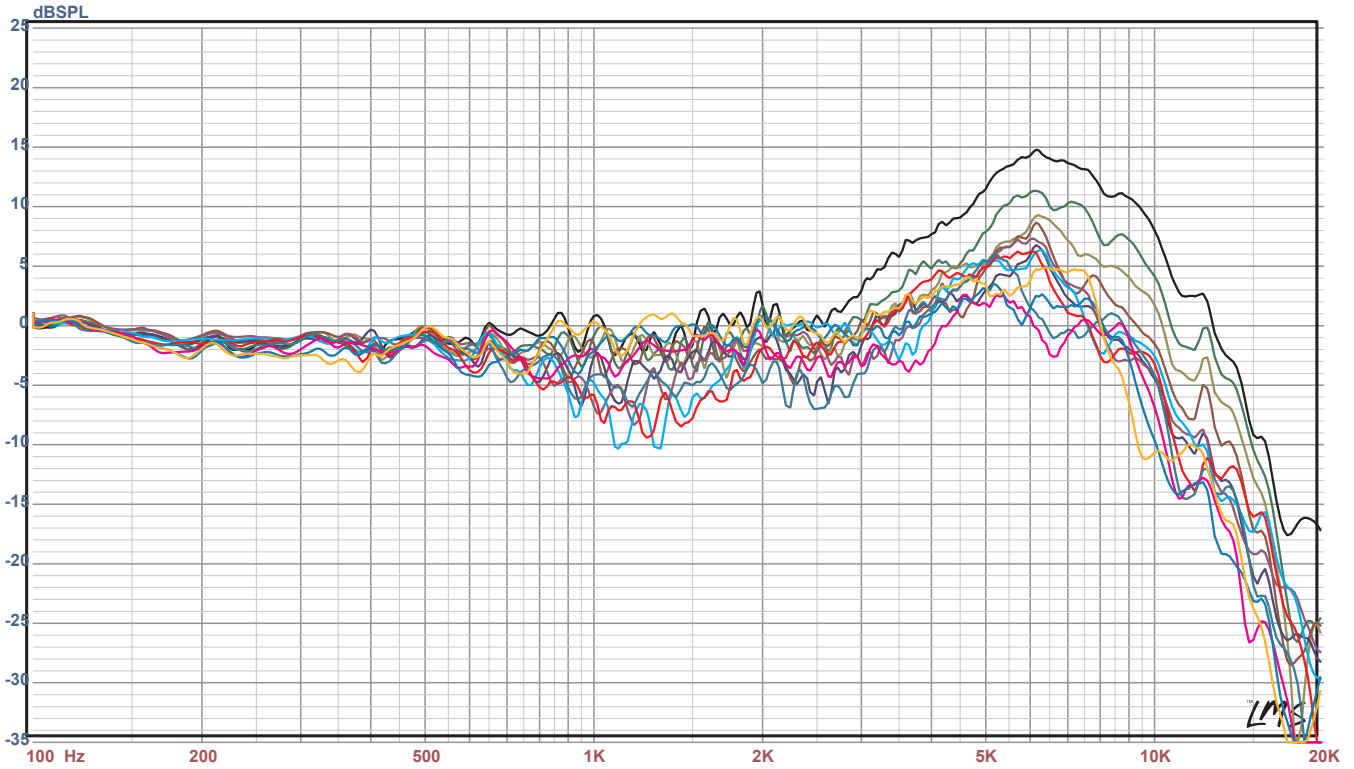


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|-----------------|-----------------|------------------|-------------------|
| 1: 90E 210A.txt | 4: 45E 210A.txt | 7: 0E 210A.txt | 10: -45E 210A.txt |
| 2: 75E 210A.txt | 5: 30E 210A.txt | 8: -15E 210A.txt | 11: -60E 210A.txt |
| 3: 60E 210A.txt | 6: 15E 210A.txt | 9: -30E 210A.txt | 12: -75E 210A.txt |

210° Azimuth

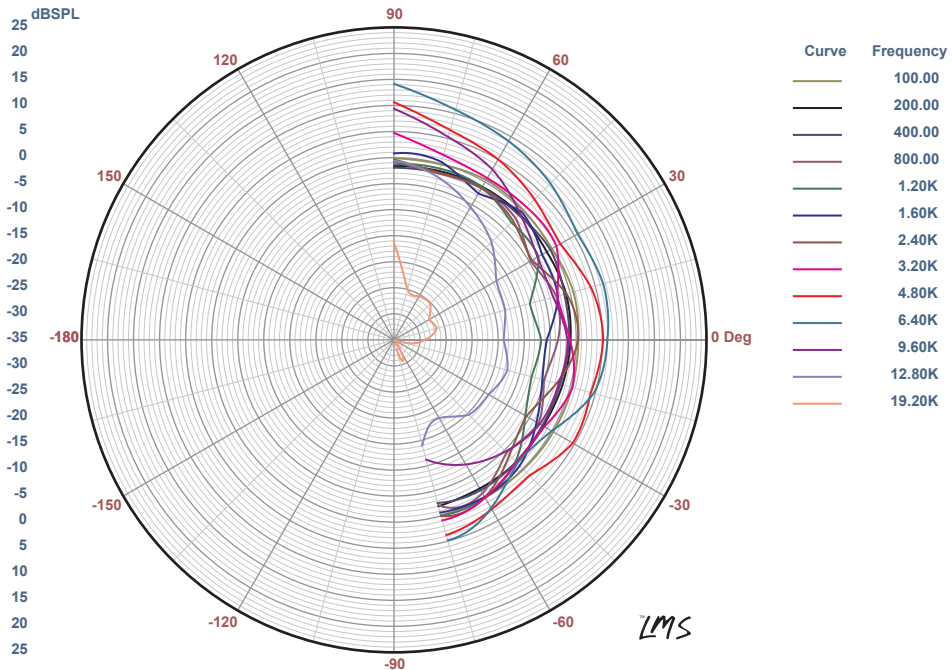


225° Azimuth

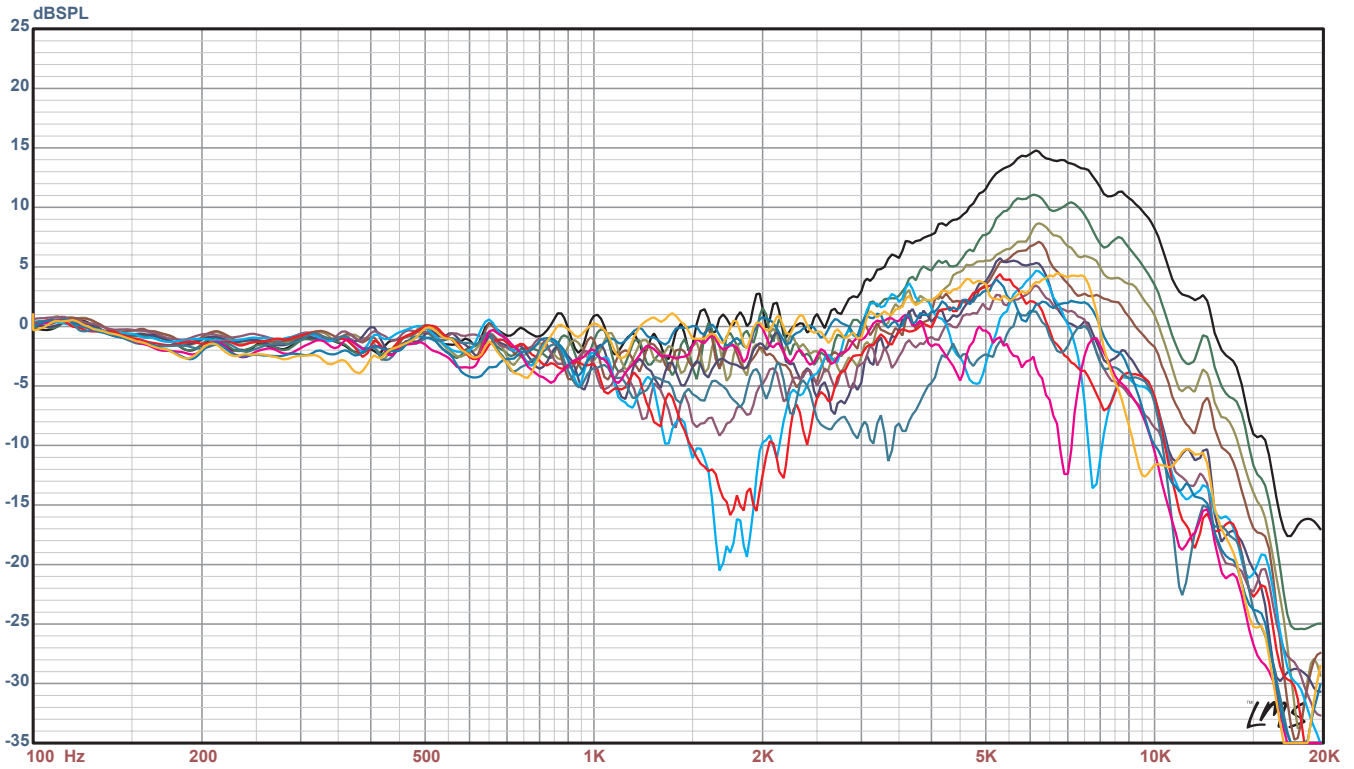


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|-----------------|-----------------|------------------|-------------------|
| 1: 90E 225A.txt | 4: 45E 225A.txt | 7: 0E 225A.txt | 10: -45E 225A.txt |
| 2: 75E 225A.txt | 5: 30E 225A.txt | 8: -15E 225A.txt | 11: -60E 225A.txt |
| 3: 60E 225A.txt | 6: 15E 225A.txt | 9: -30E 225A.txt | 12: -75E 225A.txt |

225° Azimuth

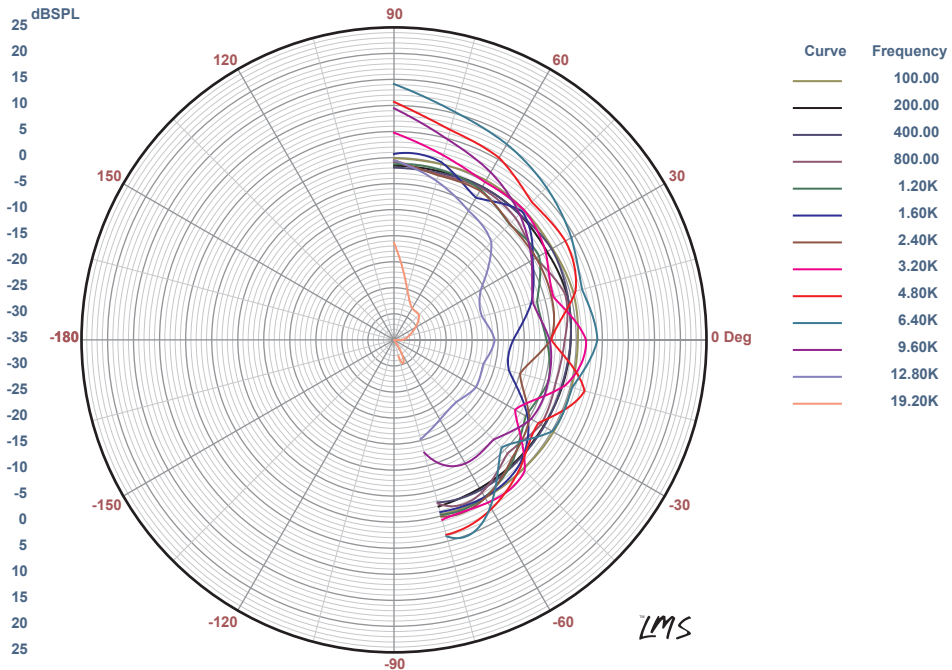


240° Azimuth

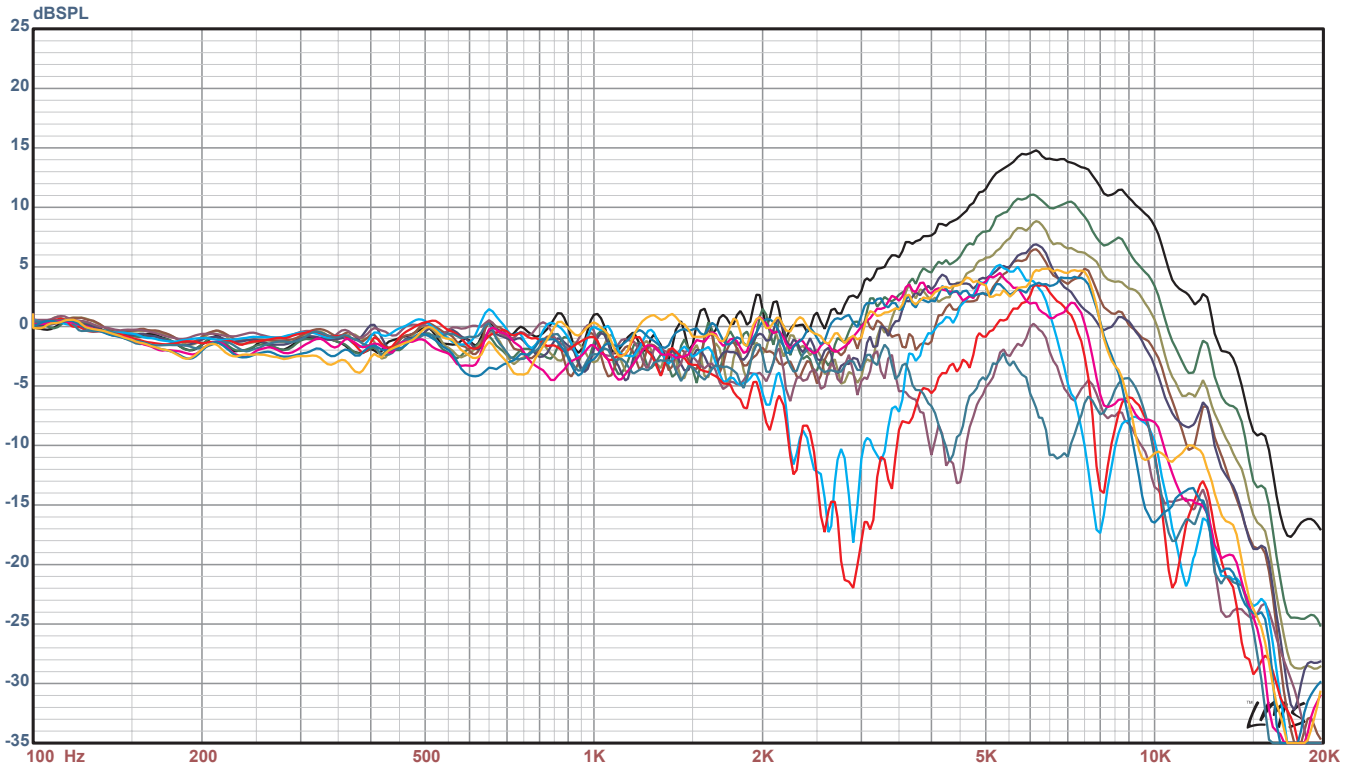


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|-------------------------|-------------------------|--------------------------|---------------------------|
| 1: Import: 90E 240A.txt | 4: Import: 45E 240A.txt | 7: Import: 0E 240A.txt | 10: Import: -45E 240A.txt |
| 2: Import: 75E 240A.txt | 5: Import: 30E 240A.txt | 8: Import: -15E 240A.txt | 11: Import: -60E 240A.txt |
| 3: Import: 60E 240A.txt | 6: Import: 15E 240A.txt | 9: Import: -30E 240A.txt | 12: Import: -75E 240A.txt |

240° Azimuth

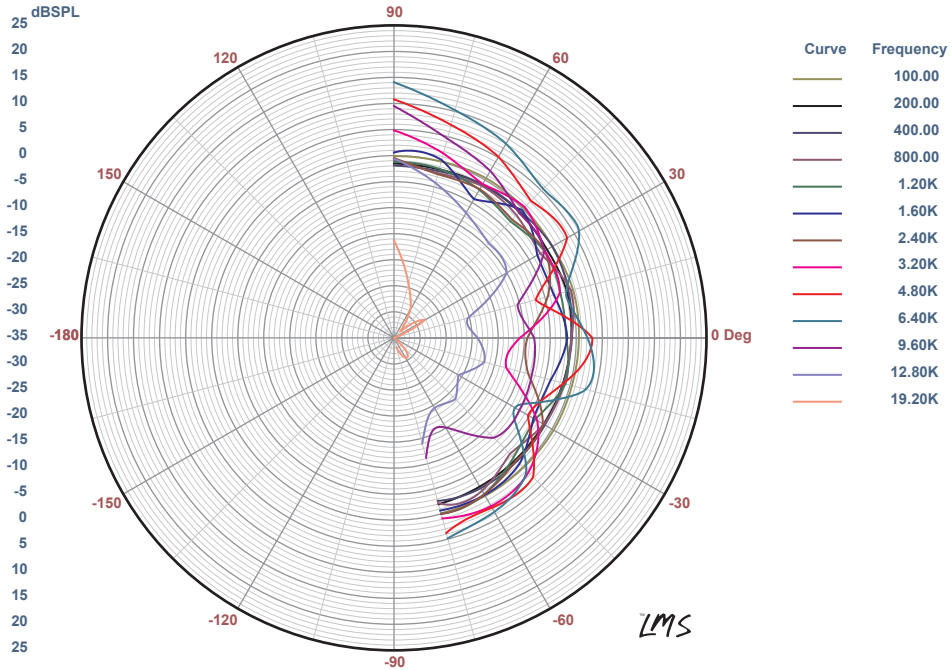


255° Azimuth

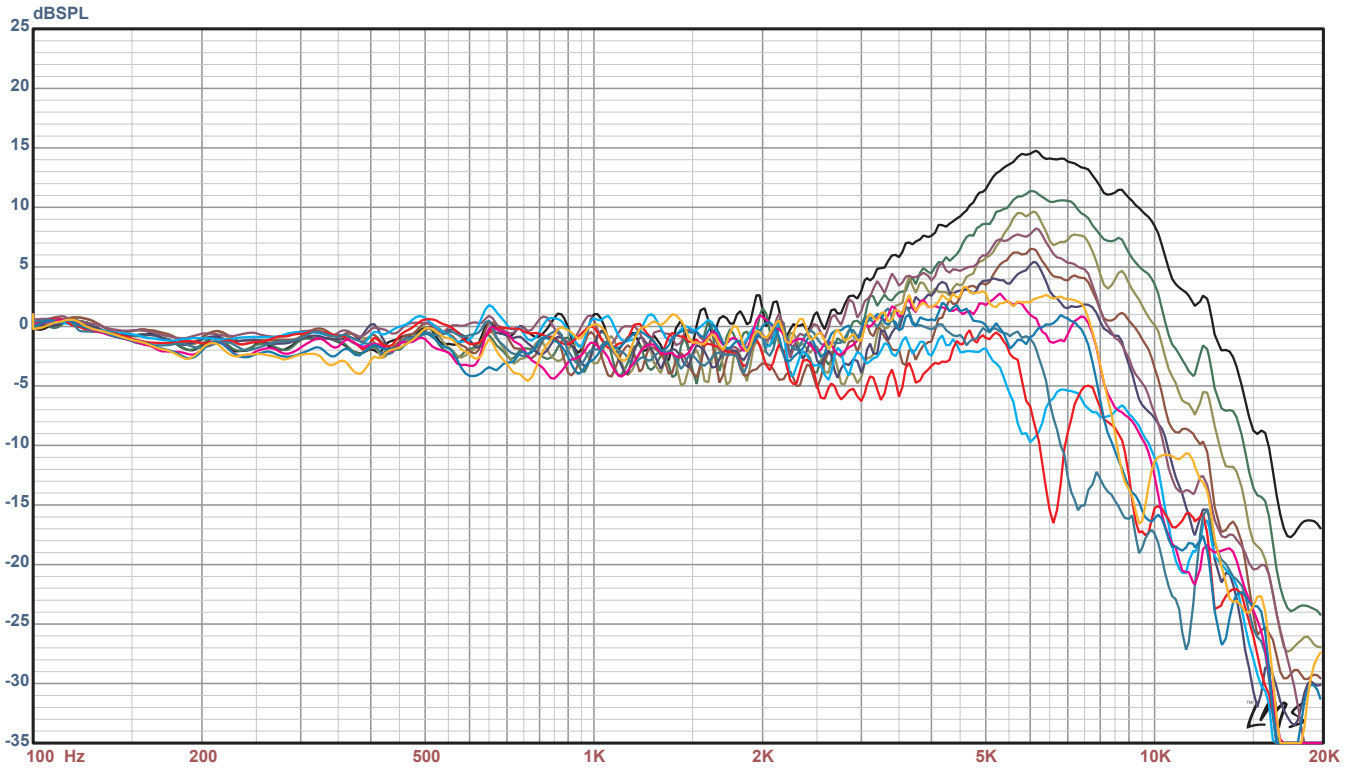


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|-----------------|-----------------|------------------|-------------------|
| 1: 90E 255A.txt | 4: 45E 255A.txt | 7: 0E 255A.txt | 10: -45E 255A.txt |
| 2: 75E 255A.txt | 5: 30E 255A.txt | 8: -15E 255A.txt | 11: -60E 255A.txt |
| 3: 60E 255A.txt | 6: 15E 255A.txt | 9: -30E 255A.txt | 12: -75E 255A.txt |

255° Azimuth

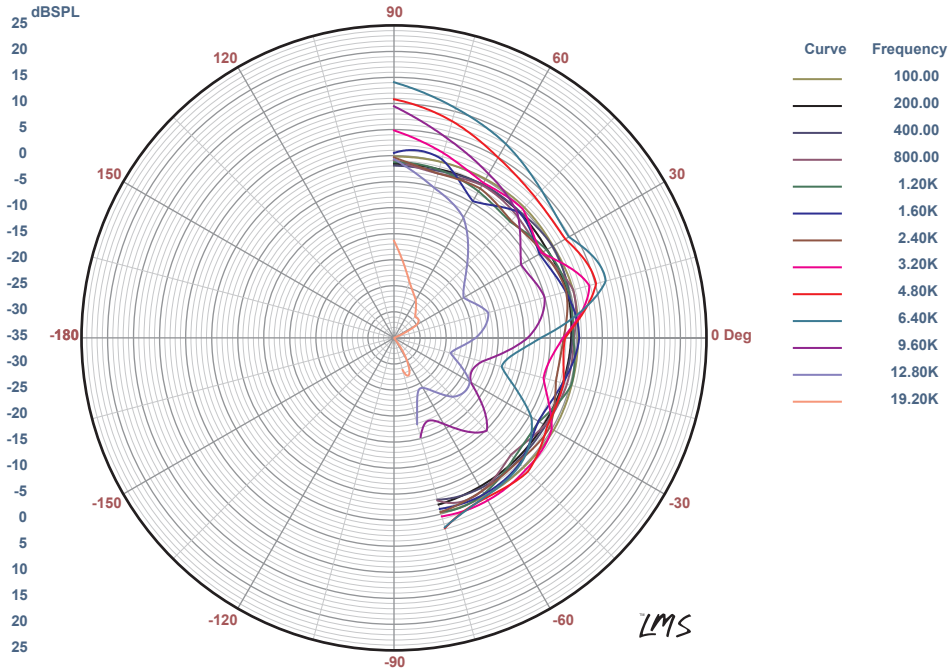


270° Azimuth

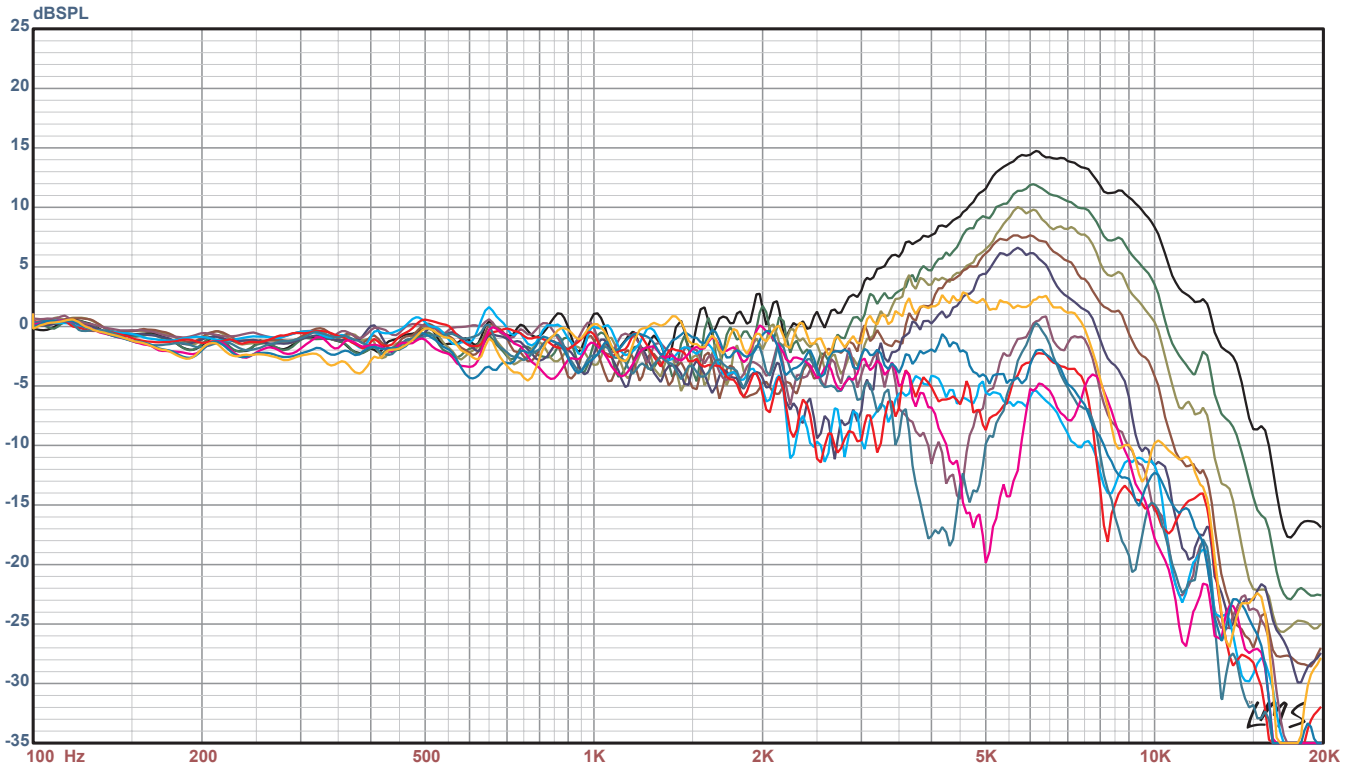


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|-----------------|-----------------|------------------|-------------------|
| 1: 90E 270A.txt | 4: 45E 270A.txt | 7: 0E 270A.txt | 10: 45E 270A.txt |
| 2: 75E 270A.txt | 5: 30E 270A.txt | 8: -15E 270A.txt | 11: -60E 270A.txt |
| 3: 60E 270A.txt | 6: 15E 270A.txt | 9: -30E 270A.txt | 12: -75E 270A.txt |

270° Azimuth

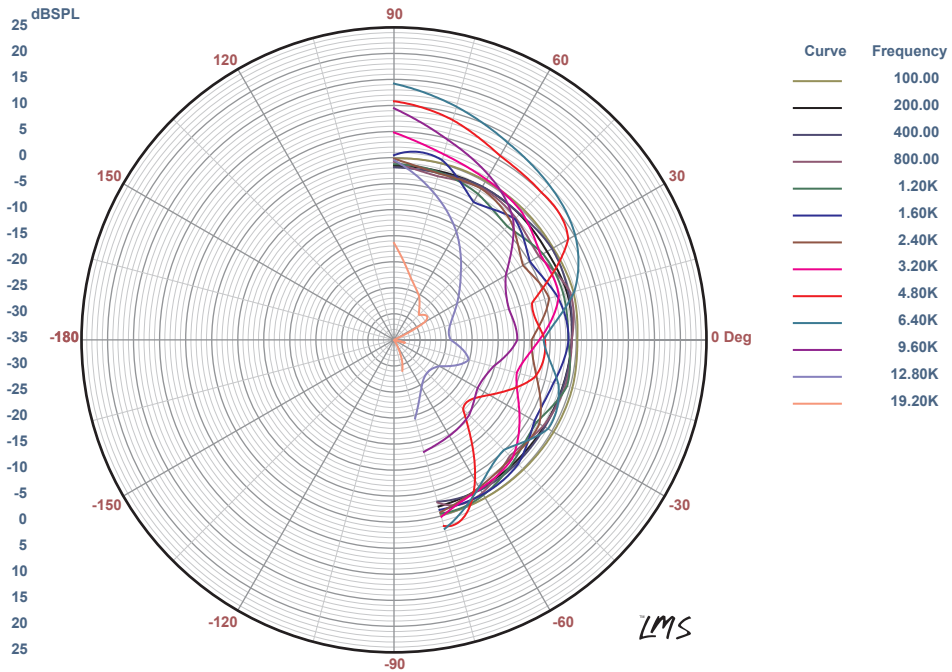


285° Azimuth

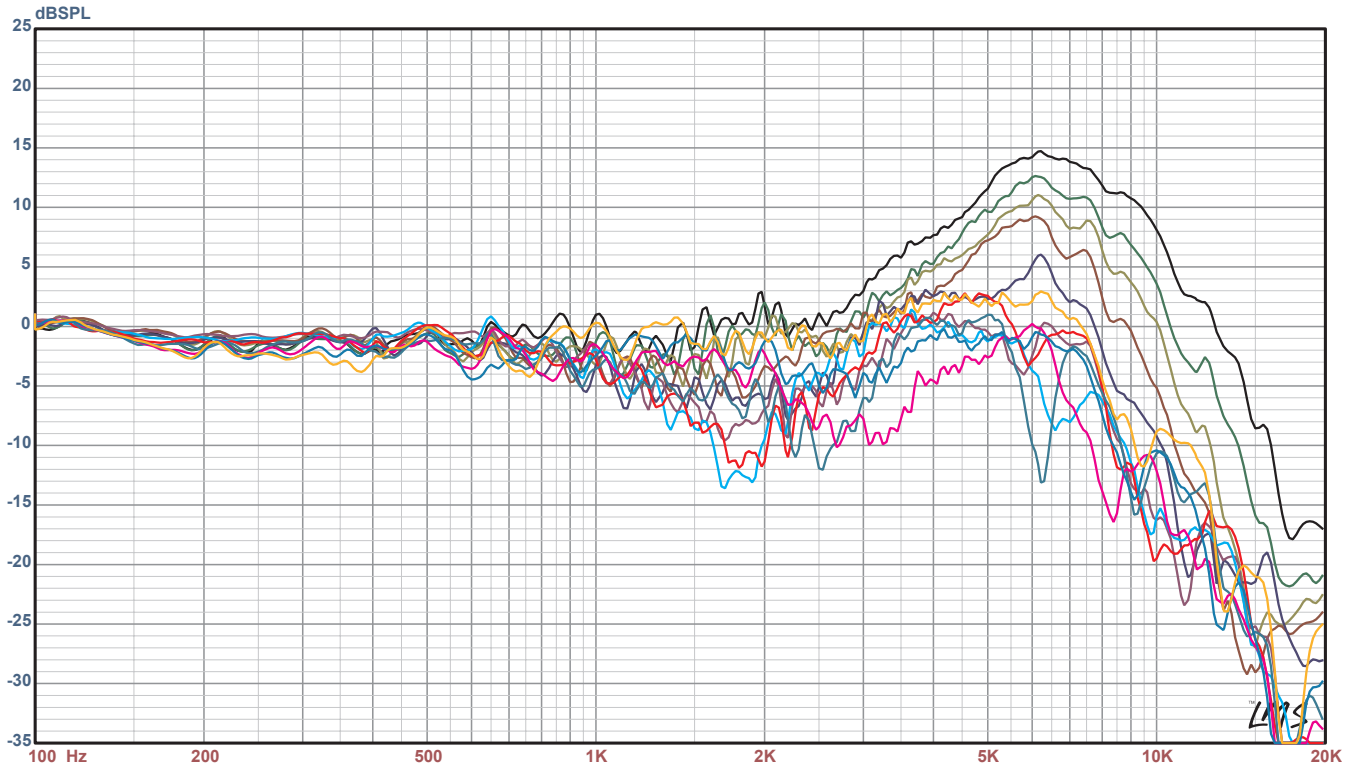


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|-------------------------|-----------------|------------------|-------------------|
| 1: Import: 90E 285A.txt | 4: 45E 285A.txt | 7: 0E 285A.txt | 10: -45E 285A.txt |
| 2: 75E 285A.txt | 5: 30E 285A.txt | 8: -15E 285A.txt | 11: -60E 285A.txt |
| 3: 60E 285A.txt | 6: 15E 285A.txt | 9: -30E 285A.txt | 12: -75E 285A.txt |

285° Azimuth

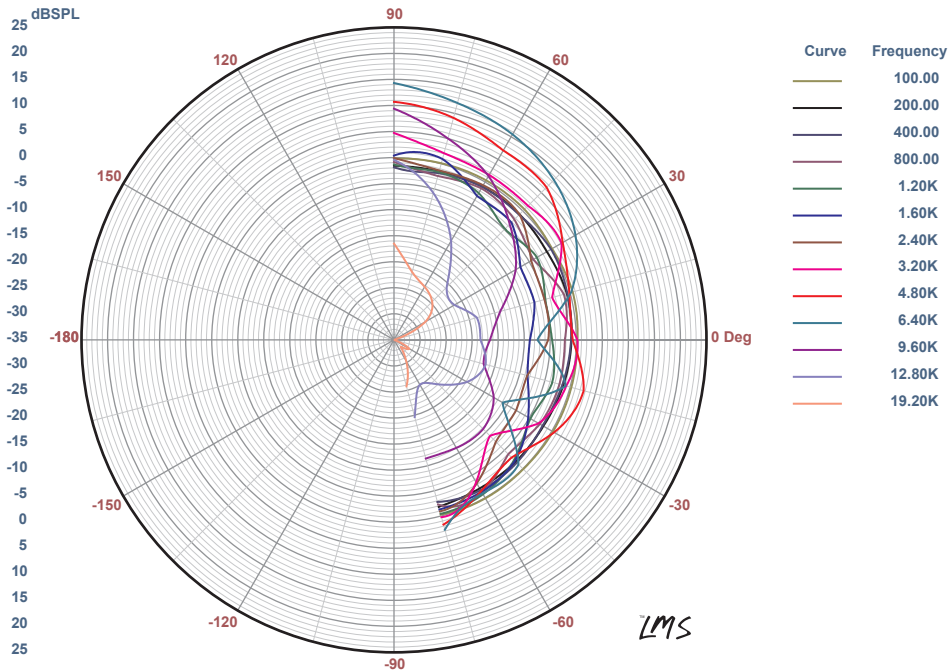


300° Azimuth

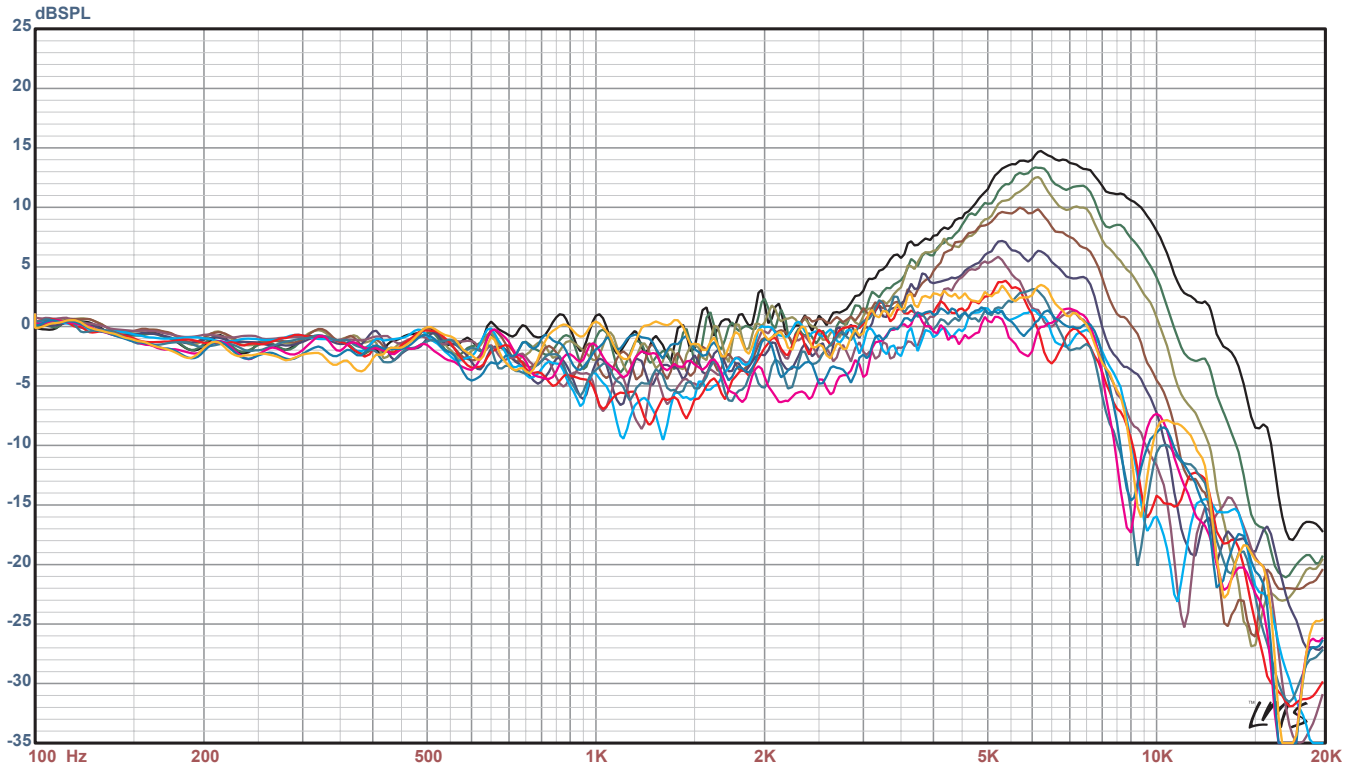


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|-----------------|-----------------|--------------------------|---------------------------|
| 1: 90E 300A.txt | 4: 45E 300A.txt | 7: 0E 300A.txt | 10: Import: -45E 300A.txt |
| 2: 75E 300A.txt | 5: 30E 300A.txt | 8: Import: -15E 300A.txt | 11: Import: -60E 300A.txt |
| 3: 60E 300A.txt | 6: 15E 300A.txt | 9: Import: -30E 300A.txt | 12: Import: -75E 300A.txt |

300° Azimuth

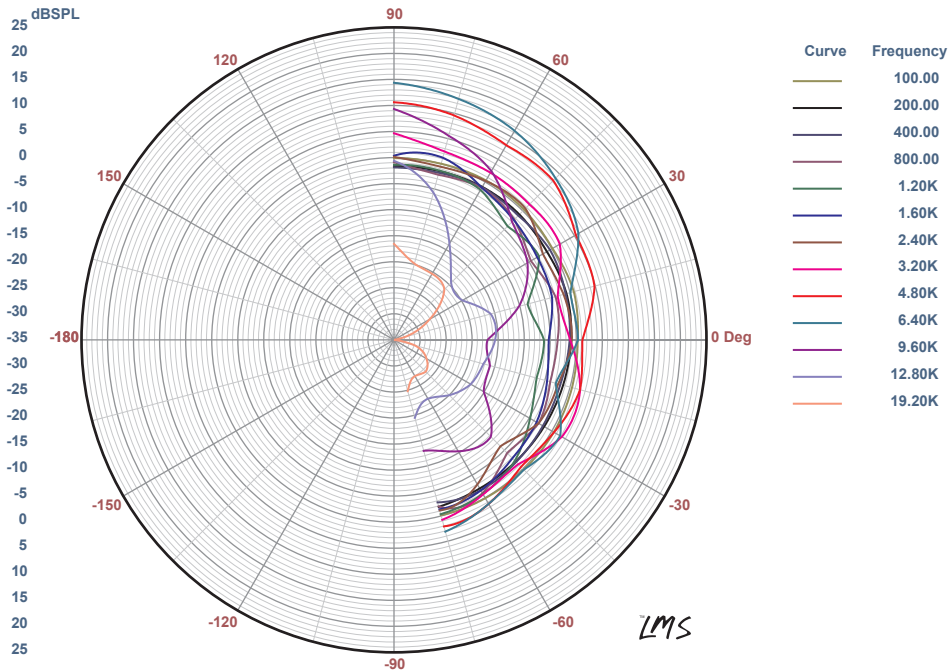


315° Azimuth

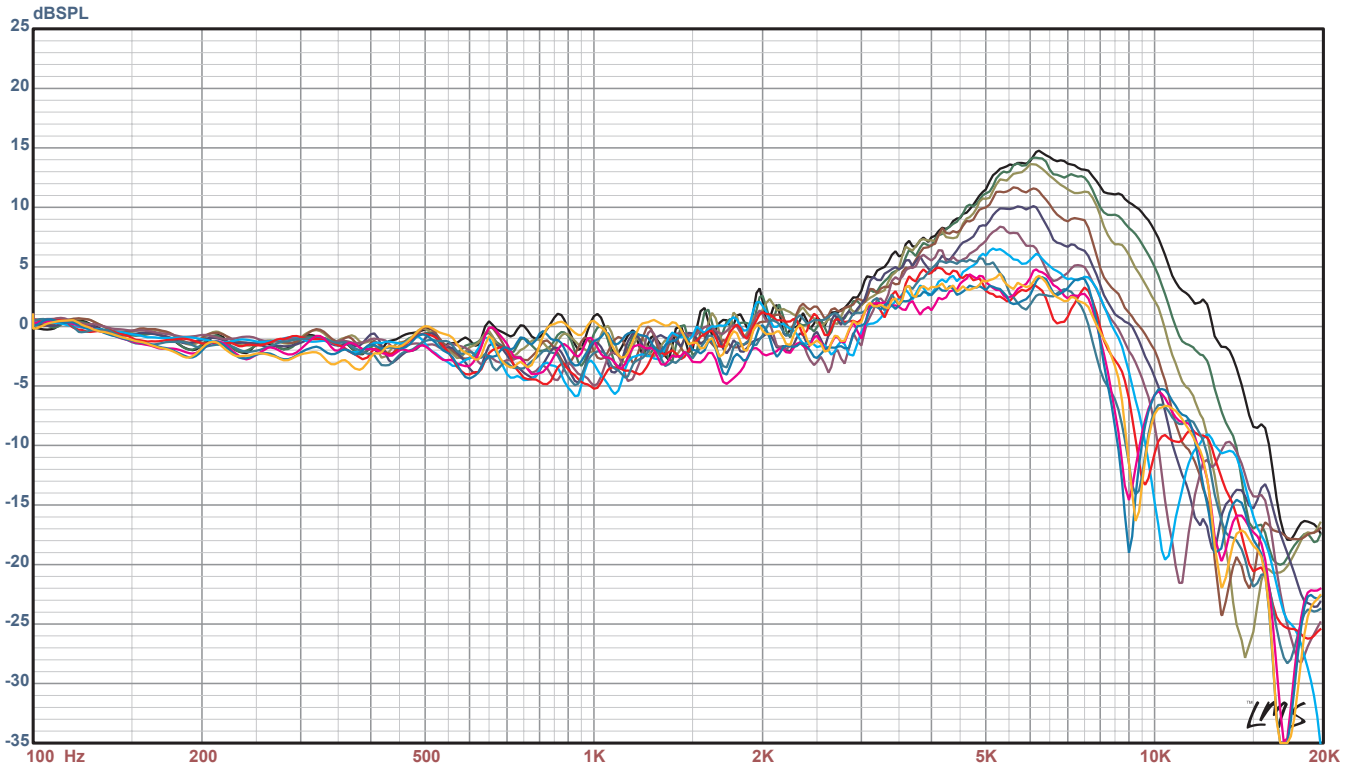


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|-----------------|-----------------|------------------|-------------------|
| 1: 90E 315A.txt | 4: 45E 315A.txt | 7: 0E 315A.txt | 10: -45E 315A.txt |
| 2: 75E 315A.txt | 5: 30E 315A.txt | 8: -15E 315A.txt | 11: -60E 315A.txt |
| 3: 60E 315A.txt | 6: 15E 315A.txt | 9: -30E 315A.txt | 12: -75E 315A.txt |

315° Azimuth

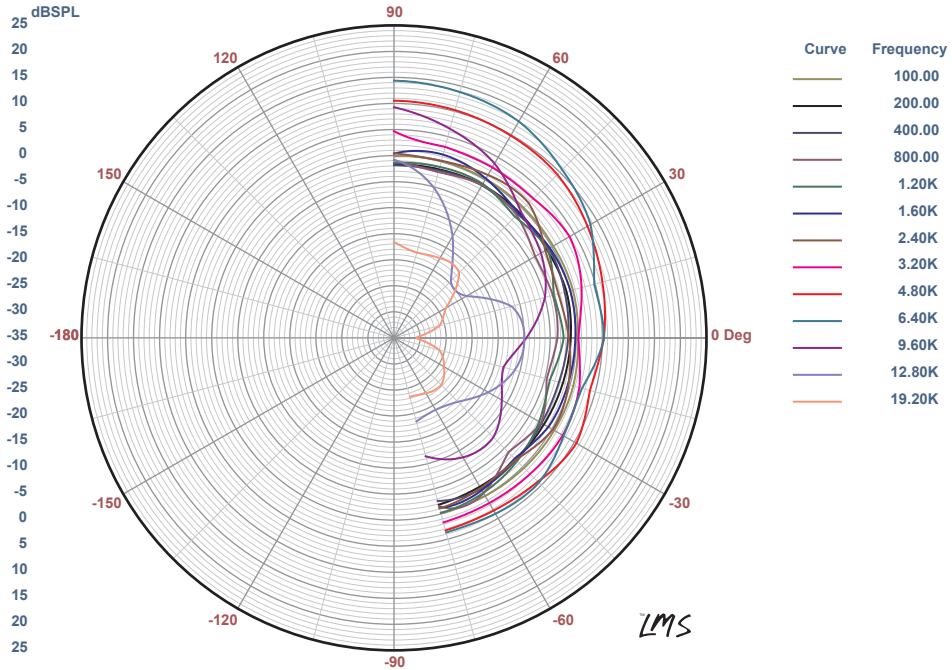


330° Azimuth

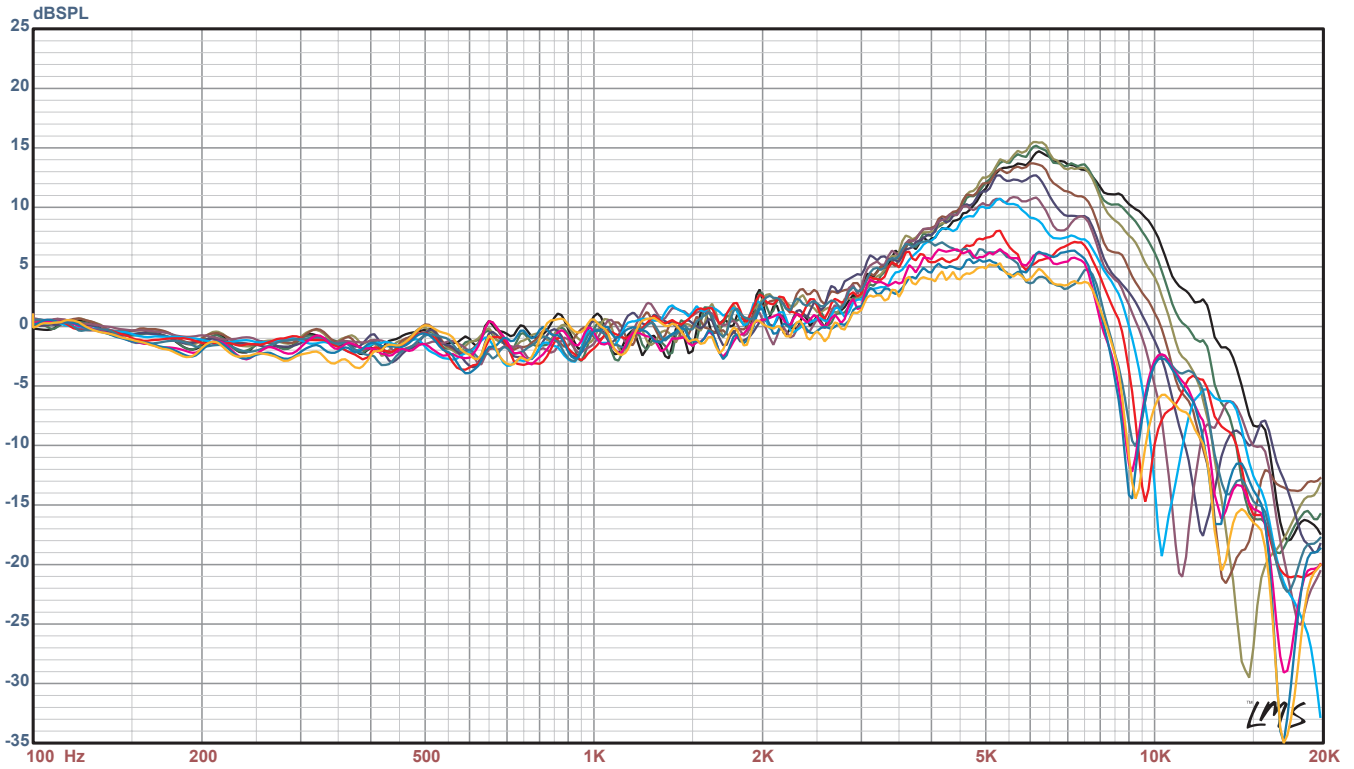


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|-----------------|-----------------|------------------|---------------------------|
| 1: 90E 330A.txt | 4: 45E 330A.txt | 7: 0E 330A.txt | 10: Import: -45E 330A.txt |
| 2: 75E 330A.txt | 5: 30E 330A.txt | 8: -15E 330A.txt | 11: Import: -60E 330A.txt |
| 3: 60E 330A.txt | 6: 15E 330A.txt | 9: -30E 330A.txt | 12: Import: -75E 330A.txt |

330° Azimuth

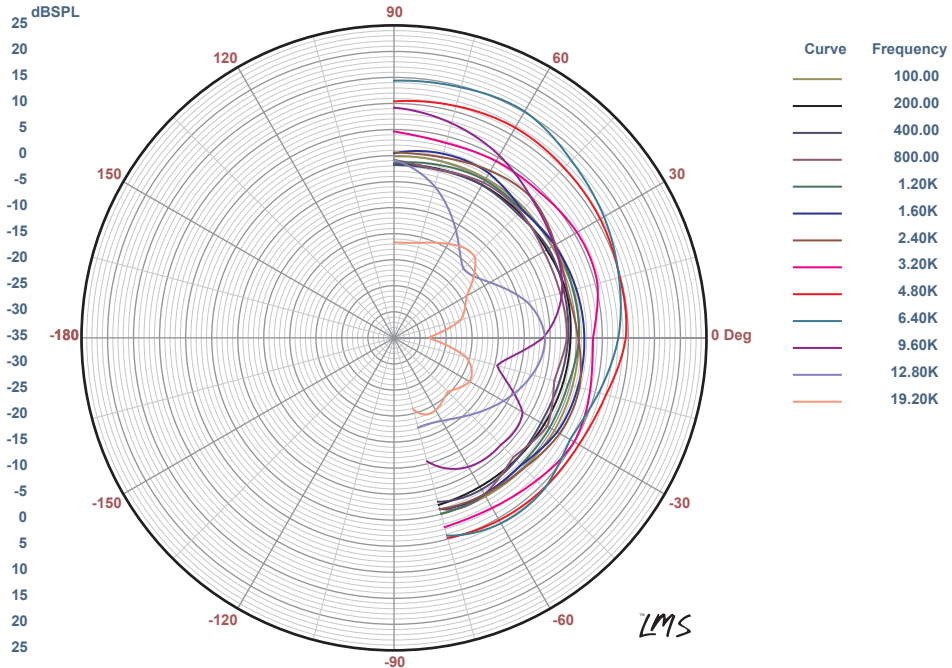


345° Azimuth



- | | | | |
|-------------------------|-------------------------|--------------------------|---------------------------|
| 1: Import: 90E 345A.txt | 4: Import: 45E 345A.txt | 7: Import: 0E 345A.txt | 10: Import: -45E 345A.txt |
| 2: Import: 75E 345A.txt | 5: Import: 30E 345A.txt | 8: Import: -15E 345A.txt | 11: Import: -60E 345A.txt |
| 3: Import: 60E 345A.txt | 6: Import: 15E 345A.txt | 9: Import: -30E 345A.txt | 12: Import: -75E 345A.txt |

345° Azimuth





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