External Loudspeaker Guidelines and Recommendations for Smart Speaker Applications

Design Guidelines

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Revision History

Document No.	Release Date	Change Description
008DGR00	12/20/16	Initial release

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Objective

This document provides developers and manufacturers with guidelines and recommendations for the use of external amplified loudspeakers in connection with smart speaker applications and evaluation kits.

The term "smart speaker" has been defined as a hands-free speaker that is capable of voice recognition and enables user voice interaction. The device can detect human voices from across the room with far-field voice recognition, even while music is playing. Processing is managed either locally or by use of voice-based services (typically available over a network connection) to provide assistance or a service to a user also by audible means (typically voice or media playback, including music).

This document is intended for Conexant Field Application Engineers (FAEs) and developers who are involved in development and evaluation of Conexant's smart speaker applications.

Introduction

The evaluations described in this document are intended to help identify potential candidate external loudspeaker systems that can be used with Conexant's Voice Input Processor solutions for playback of both speech and music. The focus was primarily on receive (or playback) path aspects, rather than on sending (or recording). Recording is very dependent on specific applications. These are highlighted within this document and should be considered as supplemental to recommendations expressed herein.

In using this document, the reader should consider the specific requirements or limitations unique to each application a product is designed for.

Evaluation Criteria

A set of commercial Off-The-Shelf portable speakers has been pre-selected. Important factors include:

- Unit cost
- Output power > 10W
- Line-in available
- Representative variety of acoustic design options

With respect to the factors listed above, the following (raw acoustic) criteria are recommended as appropriate metrics to assist in speaker selection:

- Frequency response and low corner frequency
- Total Harmonic Distortion (THD)
- Sound pressure level at low and mid-band frequencies
- Listening

Test Environment

Except for listening evaluation, which was performed in real-life environments such as a typical office room or a private residential room, all measurements were conducted in an anechoic chamber. The test setup used measurement microphones positioned on axis, 1 meter away from the loudspeaker under test, using the same line-in drive level across all speakers. That drive level had to be determined prior to the start of the evaluation.

Speaker Types

The following speaker models were evaluated in this study. One sample was applied for each, with a total of six different speaker types tested:

- JBL® *Flip3* Portable Bluetooth Speaker
- JBL® *Charge2+* Splashproof Portable Bluetooth Speaker
- DKnight *Big MagicBox* Bluetooth Portable Wireless Speaker
- UE *Boom* Wireless Bluetooth Speaker
- Bose *SoundLink Mini II* Bluetooth Speaker
- ARCHEER *A320* Bluetooth Home Speaker

Minimum Recommended Requirements

Recommended Response Mask

Figure 1 shows Conexant's recommended response mask.

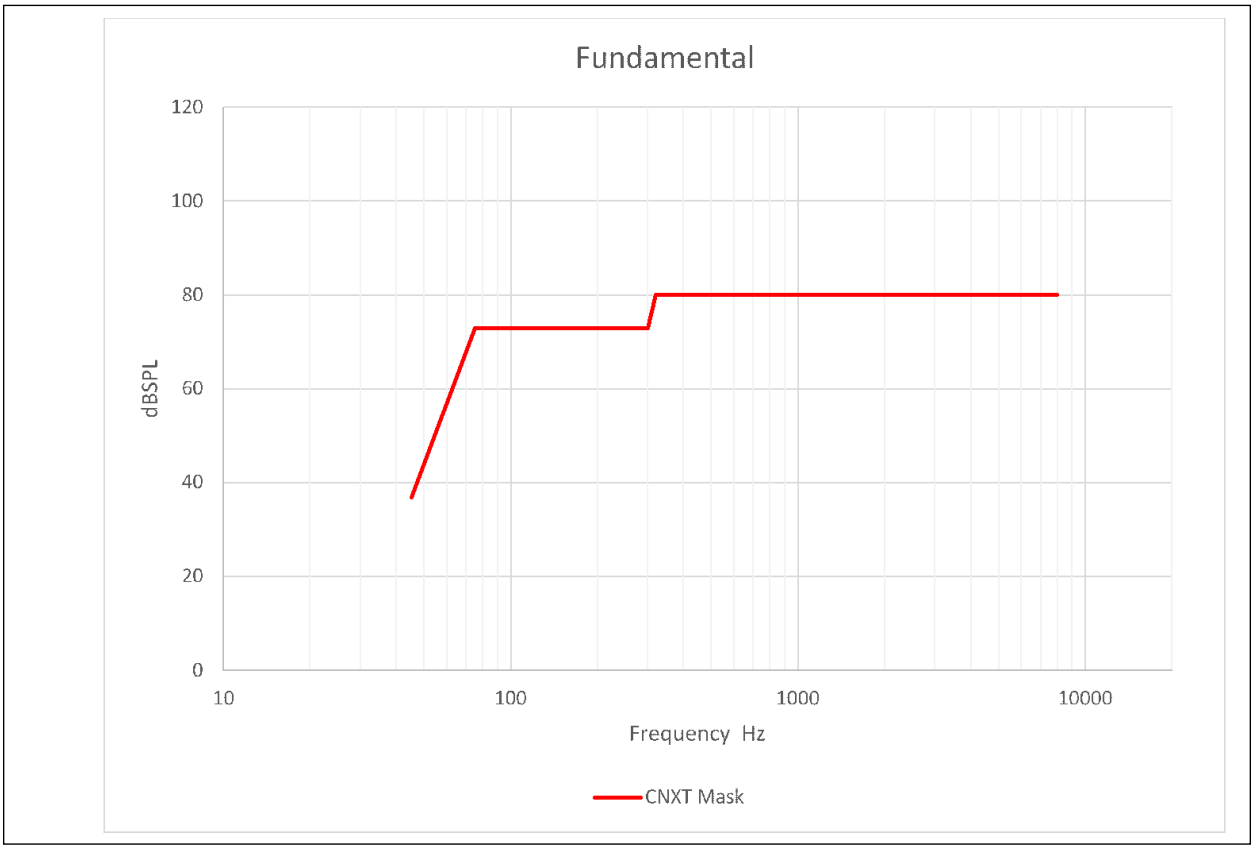

Figure 1: Recommended Limits for Loudspeaker Response

The mask shown in Figure 1 results from the limits shown in Table 1.

Table 1: Loudspeaker Response Mask Reference Points

Frequency (Hz)	SPL (@ 1m)
45	37
75	73
300	73
320	80
8000	80

THD Recommended Limits for External Loudspeakers

Figure 2 shows THD recommended limits.

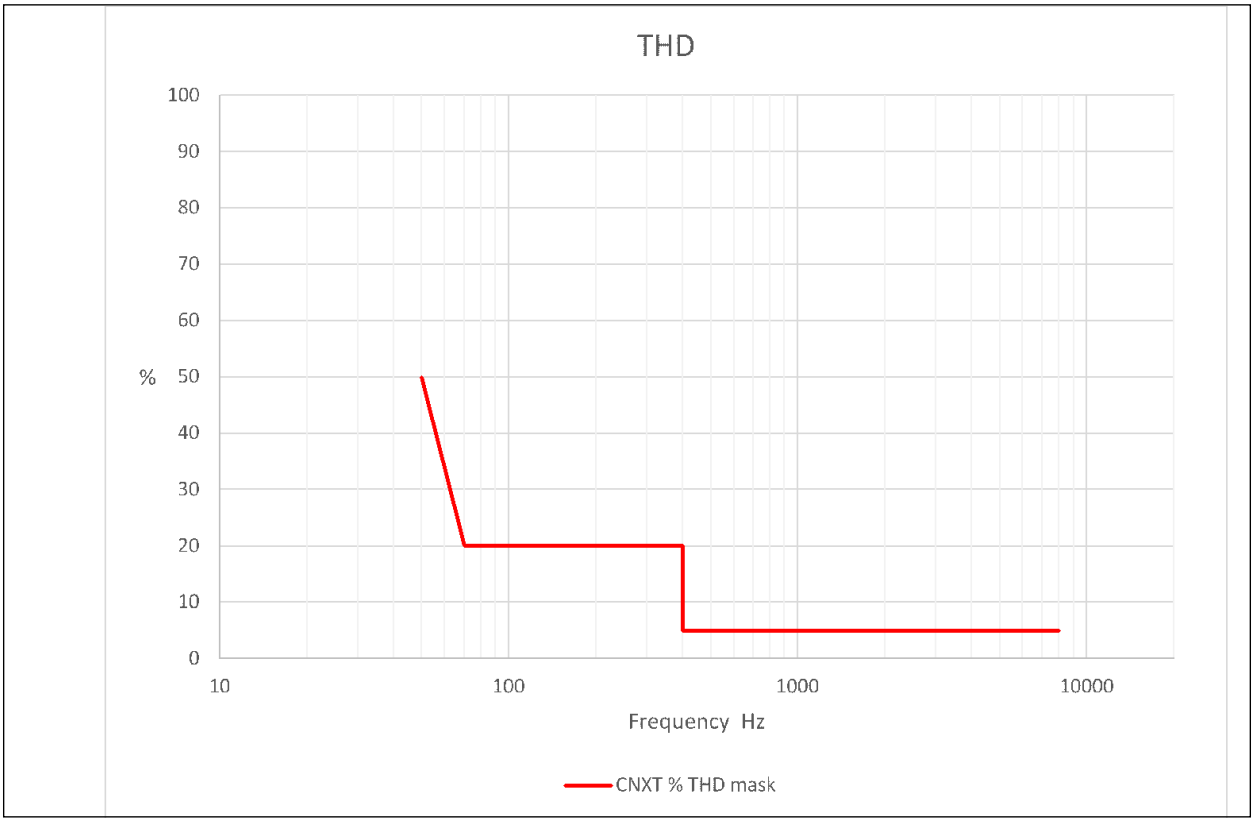

Figure 2: Total Harmonic Distortion Recommended Mask

The mask shown in Figure 2 results from the limits shown in Table 2.

Table 2: THD Reference Points

Frequency (Hz)	% THD
50	50
70	20
100	20
399	20
400	5
8000	5

Examples of Evaluated Speakers

Figure 3 shows the measured frequency response and level at 1 meter, on axis, for the two best performing sample speakers evaluated against the recommended mask.

- Bose *SoundLink (SL) Mini II*
- ARCHEER *A320*

Notice the comparative differences in drive levels at the line input. In one case, there is more headroom available when considering system sensitivity (acoustic output versus drive level), thus allowing for an adjustment in the tradeoff between output level and distortion.

Figure 3: Response Measured for Two Samples at 1 Meter, On-Axis

Figure 4 shows the measured THD at 1 meter, on axis, for the two best performing sample speakers evaluated, against the recommended mask.

- Bose *SoundLink (SL) Mini II*
- ARCHEER *A320*

One of the samples exhibits a lower THD based on a lower drive level. However, it has less margin from the level mask (see Figure 3 on page 4) at defined regions. Thus, it could potentially be operated at a slightly higher drive level with a higher THD and a comparable level as Figure 3 on page 4. In addition to this objective data, an expert listening test could be performed to determine if the end result is either acceptable or objectionable.

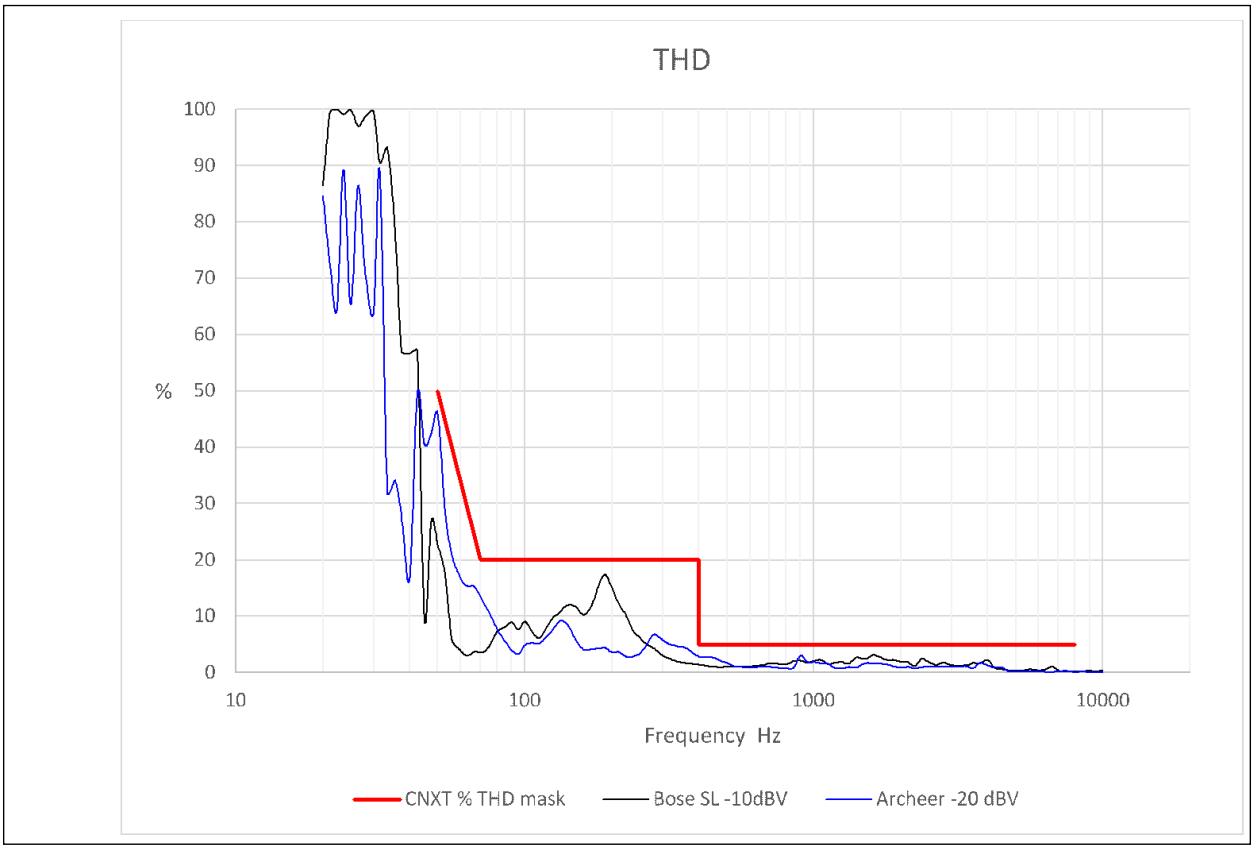

Figure 4: THD of Measured Samples at 1 Meter, On-Axis

Additional Considerations

As described in "Minimum Recommended Requirements" on page 2, and using the sample evaluation data shown, the recommended limits should be used as guidelines. This means that some tradeoffs may be necessary so that a reasoned selection may be made for each particular application.

Form Factor and Spatial Response

Other aspects of the selected external speaker can also play a significant role. For example, form factor and spatial response. As an illustration of the latter, consider a case where the device is positioned in the middle of a room. Chances are that the typical design intent is to cover as much area as possible while radiating sound energy from the source. In such a case, a spatial response that resembles an Omni source is preferred as opposed to a more directional pattern.

In other applications, where the source is to be placed near a wall for instance, it is likely that the design intent is to have a source wherein most of the radiated sound energy is concentrated in the half frontal hemisphere.

Polar Response Diagramming

To assist with this type of evaluation, a polar response diagram can be used. Figure 5 and Figure 6 on page 7 show the polar responses for the two samples evaluated.

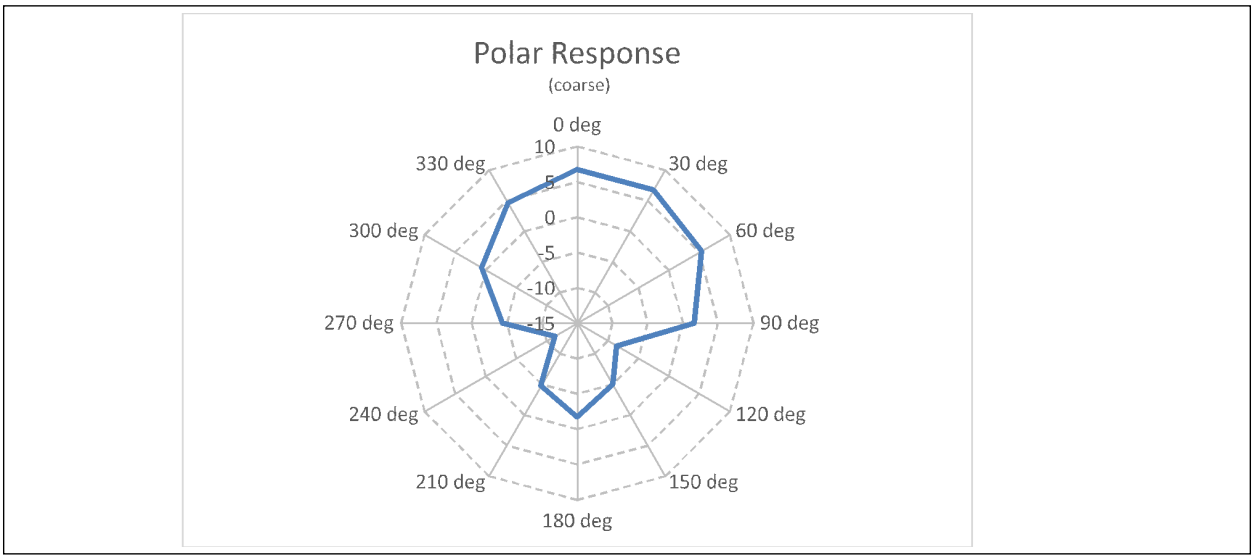

Figure 5: Polar Response: Bose SoundLink (SL) Mini II

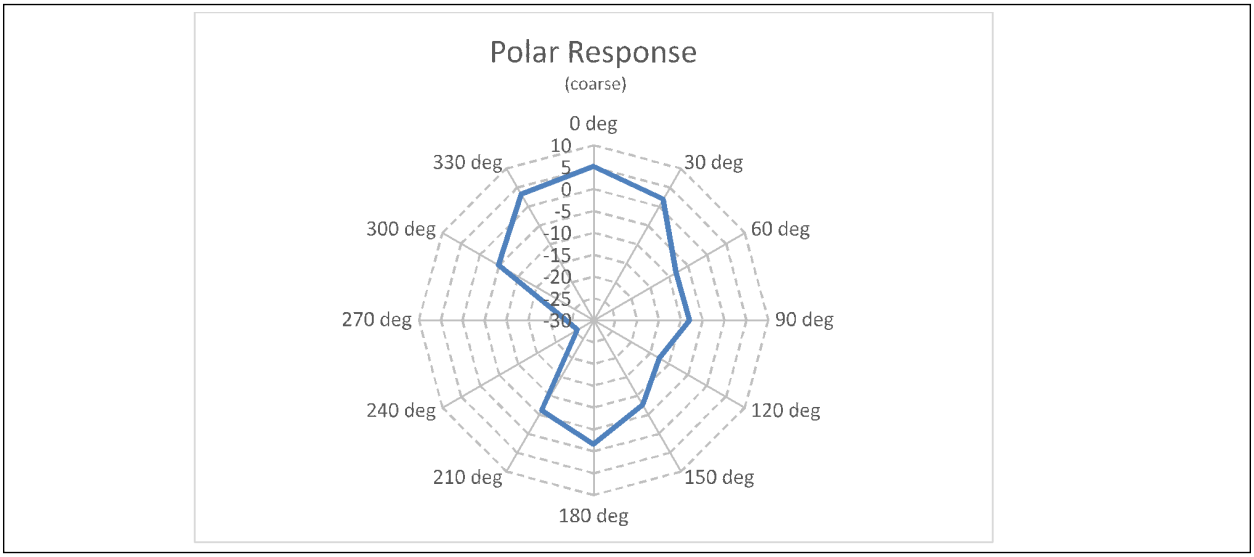

Figure 6: Polar Response: ARCHEER A320

Notice the different patterns between the two samples. Another use for measuring the polar response of a speaker enclosure at development time is that the location of nulls in the spatial response could be considered in the definition of microphone placement on the product.

Regarding microphone placement, microphones must not be placed directly facing loudspeaker(s) as this will greatly impact the echo canceler, thus degrading its ability to properly attenuate or eliminate echo.

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