

# Improvement Design High Frequency Wave Guide & Horn from Line Array Speaker VERA20

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**Abstract - Speaker is a common component at concerts, cinemas, and other event requires amplifier sound. The primary function fo speaker is to transmit sound from the sound source. When designing a speaker, analysis is require to achieve output sound frequency that closely resembles the source of sound, with even sound distribution and maximum of range. To create design can be done using Solidworks software to create and modify the design. Then, the design is analyzed through simulations using Ansys software. The simulation result are validate against existing product by examining the sound pressure relative to frequency and sound distribution pattern. After that, design changes are made to achieve more optimal result.**

**Keywords:** Speaker, design, frequency, pattern, High Frequency Wave Guide, Horn, Line Array Speaker.

## I. INTRODUCTION

Most loudspeakers today are conventional closed type or ventilated box, where they produce omnidirectional sound at low frequency and directional sound at high frequency (Solgård, 2011). Speaker works by converting electrical signals into sound wave, enabling listener to enjoy the sound produce. One key factor to determine sound quality produced by a speaker is the sound pressure level (SPL). The quality of sound pressure level generally depends on diameter of speaker up to the distance between speaker and listener (Adams, 2011). Sound pressure level of sound in decibel is 20 times base 10 logarithm of ratio between measured effective sound pressure and reference effective sound pressure (Beranek & Mellow, 2019).

Line array of loudspeakers are used by system designer to achieve a focus directional response, typically on vertical axis. A focuse directional response result in an increased gain, which is beneficial for event requiring coverage or an improve signal to echo ratio. Line array are create by stacking radiator or horn for perform effectively (Mark S., et al., 2001).

The function of waveguide and horns in history electro acoustics include two important aspects providing load on

speaker driver and controlling sound dispersion ( Kolbrek, 2008). Enclosures and horn commonly used in loudspeaker to control dispersion sound radiation. Sound radiated from source without using an enclosure will spread uncontrollably. It is necessary to define the radiation coverage angle of sound from speaker by designing the horn and speaker enclosure shape appropriately to achieve desired coverage angle (Spillmann & Riemersma, 2015).

In this research, a separator will be added to the waveguide leading to speaker output with aim of minimizing reduction or loss of high frequency due to turbulence at the speaker output. The simulation results will help to understanding fundamentals of acoustics.

## II. MATERIAL AND METHOD

### 2.1 Waveguide and Horn Model

The model used is replica product line array of TW Audio VERA20, created using 3D CAD software Solidworks and simplified as shown in Figure 1.

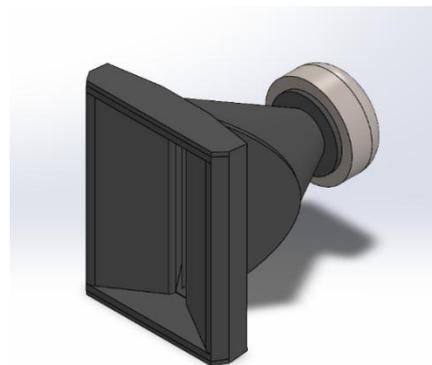


Figure 1: CAD Model Waveguide dan Horn High Frequency

The replica model will be modified to enhance frequency response in the high frequency range while maintaining same sound radiation result. To achieve expected result, Ansys software with harmonic acoustics feature will be used to perform acoustic modeling that closely resembles real world conditions. The constraints include speed of speaker membrane surface and distance between listener and speaker.

Polycarbonate, commonly used in speaker enclosures and suitable for molding, will be chosen as the material with its properties summarized in Table 1.

Table 1: Properties dari Polycarbonate

Density	1,2 g/cm <sup>3</sup>
Young's Modulus	2,4 GPa
Poisson's Ratio	0,36

### 2.2 Boundary Conditions

In Ansys harmonic acoustics, the boundary conditions are define into 2 domain which are acoustic domain set air and physical domain set speaker. The sound radiation dispersion is set for entire air region, with radius of 1 meter to observe the sound dispersion pattern (Russell, et al., 1998). The maximum speed of speaker membrane surface is set to 50 m/s in the simulation.

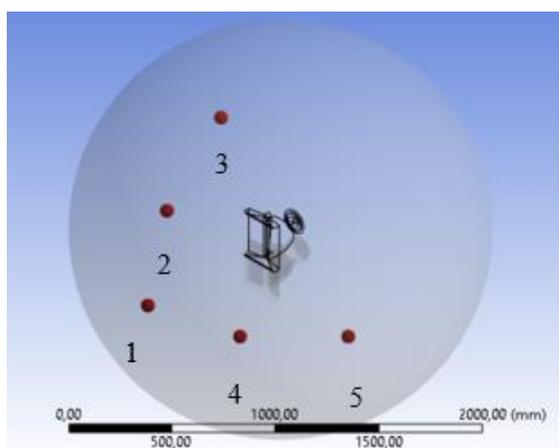


Figure 2: Point Location of Mic for measure dispersion sound

To observe sound dispersion, several points are set: point 1 is located 1 meter in front of the horn; point 2 is 30° angle above point 1 and point 3 30° angle above point 2. Similarly for point 4 and 5 are positioned to the left of point 1. The angles are used to facilitate the comparison of speaker output at each point (Solgård, 2011). Placement of mic shown in Figure 2.

### 2.3 Validation

To validate the model created with CAD software against actual product, several sample data points comparing frequency to far field SPL were taken from both product and CAD model. As shown Figure 3, the largest error from sample data is 5.67%, resulting in a similarity index of 0.94. This margin of error is acceptable, as a result above 0.9 is considered very good (Naef, et al., 2022).

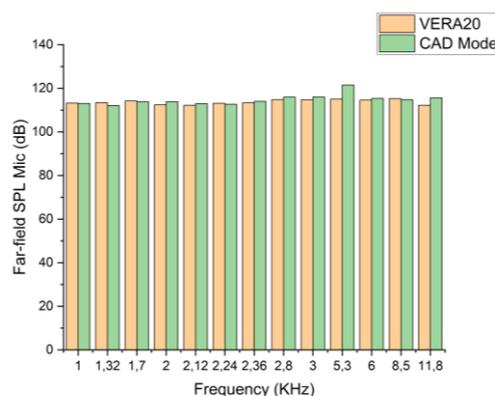


Figure 3: Validation sample data VERA20 compare CAD Model

## III. RESULT AND DISCUSSION

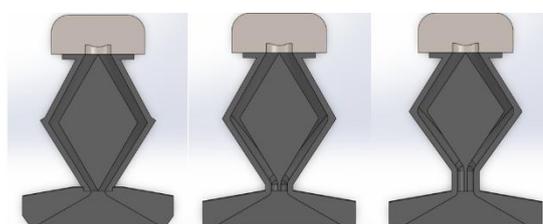


Figure 4: CAD Model left (Clone), center (separator 2 cm), dan right (separator 3 cm)

In Figure 4, three models are presented. The model on left is the validated model, while following two models are modified with separator in waveguide. The far field SPL measurements against frequency for these models is shown in Figure 5.

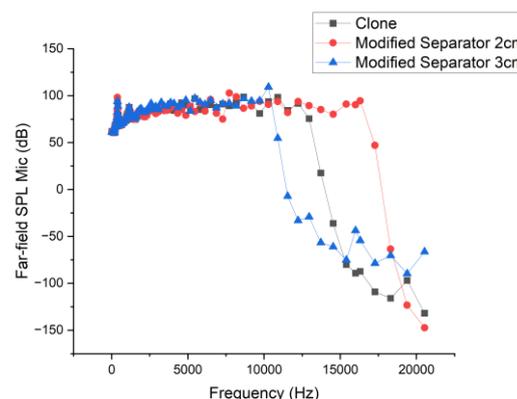


Figure 5: Comparison Design Clone against Modified Separator 2cm and 3cm

The simulation results of clone model in Figure 5 shown a reduction or loss of high frequency at 14,538 Hz. When a 2 cm separator is introducing in design, the reduction occurs at 18,302 Hz. With 3 cm separator, the reduction is found occur at 11,548 Hz.

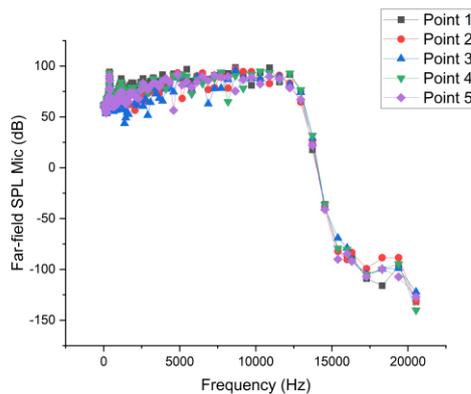


Figure 6: Sound Dispersion on Clone

Sound dispersion results from VERA20 clone in Figure 6 shown that sound dispersion pattern is consistent, with only slight difference. This result indicates that the existing product has very good sound dispersion.

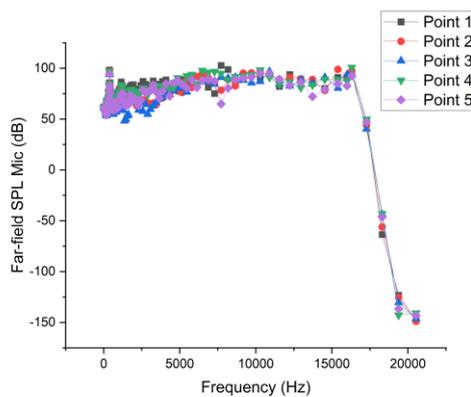


Figure 7: Sound Dispersion on Modified Separator 2cm

The sound dispersion results for modified separator 2 cm shown in figure 7 exhibit a pattern similar to the clone. This pattern indicates that modification made do not cause any distortion in sound dispersion pattern.

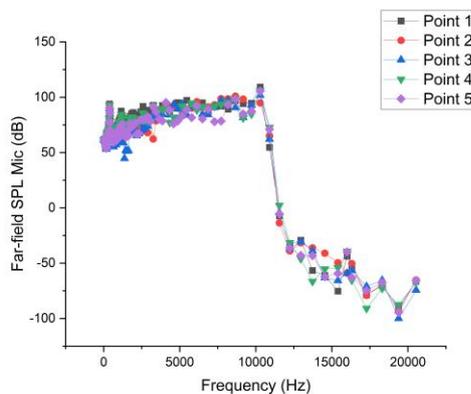


Figure 8: Sound Dispersion on Modified Separator 3cm

The sound dispersion results for modified separator 3 cm in Figure 8 show a pattern that is close to uniform. The lack of uniformity in results may be due to changes in the waveguide shape made to adjust the enclosure, which could have caused turbulence.

#### IV. CONCLUSION

In this research was found that the design of TW Audio VERA20 product is already excellent in terms of the sound quality produced, as well as the control of sound dispersion, which is quite uniform at different angles. With slight modifications, different results were obtained which is 2 cm separator produced slightly better higher frequency performance than existing product, while 3 cm separator resulted in worse sound quality than original product. The geometry of the waveguide and horn plays a crucial role in determining sound quality and dispersion.

By aligning the air and sound waves using waveguide, a uniform quality can be achieved without the loss of frequency at certain points, ensuring better clarity for listener.

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