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**AN AUDIO ENGINEERING SOCIETY PREPRINT**

# A Generalized Horn Design to Optimize Directivity Control & Wavefront Curvature

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*A new horn design is presented. This approach yields good loading characteristics and reduced harmonic distortion. The new horns polar patterns are that of a constant directivity type horn. The novel feature of this new horn is that its apparent apices for the horizontal and vertical planes are in the same physical location regardless of coverage angle for the horizontal or vertical plane.*

## 0. Introduction

Horns have been used in loudspeaker systems for decades. Their use can be attributed to two main factors: 1) increased output for a given input and 2) directivity control. The latter has been seen to be the more dominant reason in recent years. A good degree of loading of the loudspeaker driver must still be accomplished for the horn to be useful. However, with higher power handling and increased efficiency available from typical compression drivers today, horn designers can concentrate more on the directivity response of a horn.

In recent years Geddes<sup>1</sup> and Putland<sup>2</sup> have put forth works on horns that have the properties of propagating a one-parameter acoustic wave. The motion of such a wave can be described by a single spatial coordinate. These types of horns have been referred to as waveguides. A good differentiation between a horn and a waveguide can be thought of as a horn being primarily concerned with the optimal loading of its driver, while a waveguide is primarily concerned with its directional characteristics<sup>3</sup>.

There are a several terms that will be used later. Their definition is as follows.

$r$   $\equiv$  radius of connecting arc

$y_t$   $\equiv$  diameter of throat entrance

$r_H$   $\equiv$  radius of horizontal plane connecting arc

$r_V$   $\equiv$  radius of vertical plane connecting arc

$\theta_H$   $\equiv$  horizontal coverage half - angle

$\theta_V$   $\equiv$  vertical coverage half - angle

## 1. Constant Directivity

In 1975 Keele<sup>4</sup> outlined a concept whereby a horn could be constructed of essentially separate, but joined, sections. The first section of this type of horn has a cross sectional area that expands exponentially. The second section has a cross sectional area that expands in a manner similar to that of a simple cone. This combined horn had two very sought after traits. It presented good loading to the driver to which it was attached allowing for an increase in the efficiency of the horn. It also maintained good directivity control over a wide range of frequencies.

## **6. Conclusions**

It can be surmised that the Quadratic Throat waveguide has a large reduction of 3<sup>rd</sup> harmonic distortion, while having a significant, yet smaller, reduction of 2<sup>nd</sup> harmonic distortion when compared to a conical horn or a conventional constant directivity horn comprised of an exponential section followed by a conical section.

Due to the design of the throat section, this new waveguide will admit and propagate a one-parameter wave when it is driven at its throat entry by a plane wave. The astigmatism typically found in conventional horns is eliminated in this new type of waveguide. This has a definite advantage when multiple horns are employed in an array as the apparent apex of the wavefront is in the same place for any given orientation of the waveguide. This feature makes spatial alignment of the individual elements in the array much easier. Once placed in the array these waveguides may be rotated, pitched or yawed as needed without affecting the spatial orientation of the wavefront, as it is truly spherical. With conventional horns, a change in orientation results in a change in the orientation of the wavefront curvature, as it is not spherical.

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## **8. References**

1. Earl R. Geddes, "Acoustic Waveguide Theory", presented at the 83<sup>rd</sup> AES Convention, Oct. 1987
2. Gavin R. Putland, "Every One-Parameter Acoustic Field Obeys Webster's Horn Equation", *Journal of the AES*, Vol. 41, No. 6, pp. 435-448 (June 1993)
3. David Gunness, email correspondence, Jan. 6, 1999
4. D. B. Keele, Jr., "What's So Sacred About Exponential Horns", presented at the 51<sup>st</sup> AES Convention, May 1975
5. Clifford A. Henricksen & Mark S. Ureda, "The Manta Ray Horns", *Loudspeakers Vol. 2 An Anthology*, pp. 30-35
6. David Gunness, "Instantaneous Flare Rate", notes from Synergetic Audio Concepts - Loudspeakers Workshop, June 1997
7. D. B. Keele, Jr., "Optimum Horn Mouth Size", presented at the 46<sup>th</sup> AES Convention, Sept. 1973