TECHNICAL BULLETIN

Unique Application of Chebyshev Absorbers

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ABSTRACT

The purpose of this paper is to report on the application of Chebyshev absorbers in the design of a multi use anechoic chamber. The requirement was for a chamber which allowed for evaluation of various wireless devices to be evaluated in a multi use chamber. The purpose of the chamber is to support multiple programs and allow for the evaluation of both complete handsets as well as individual components of the wireless devices.

Due to the dual purpose applications that were to be evaluated in this chamber neither a standard" antenna range" nor a "classic wireless" chamber fit the bill. In order to optimize the use of this chamber a unique design was developed which incorporates the best of both classical chamber designs.

To improve the low frequency response of the chamber a Chebyshev pattern was designed for chamber termination wall. Due to the short length of the chamber in comparison to the target length a Chebyshev pattern was designed for the specular patches on the sidewalls, floor and ceiling to improve the "off angle" performance of the chamber.

Keywords: Absorber Material, Anechoic Chamber, Antenna Measurements, Range Equation, Phase Taper, Chebyshev Absorber, Off-Angle Performance,CTIA.

SECTION 1: **introduction**

This paper describes a joint effort between Advanced ElectroMagnetics, Inc and Qualcomm, Inc. to develop and build an antenna measurement facility for the development of mobile communication antennas in a pre-commercial engineering environment for their own use as well as the use of their customers.

This paper will focus on the use of a Chebyshev design in the anechoic foam in order to achieve the desired performance in restrictive size constraints and the requirement of the chamber to perform for both a far-field emissions testing and antenna performance measurements.

Due to the fact that Qualcomm was in a leased facility and was growing at an incredible rate laboratory space was at a premium. The space made available for the Anechoic Chamber was smaller that what would be ideal for the frequencies to be tested.

The unique Chebyshev design was incorporated in order to provide improved performance for lower frequencies under test while sustaining the required physical dimensions of the chamber itself.

SECTION 2: **chamber performance criteria**

This chamber is designed to be used in a primarily engineering (pre-commercial) environment for both far-field emissions testing and antenna performance measurements. The dynamic engineering environment requires the chamber to be used for a broad band of frequencies to encompass the various mobile technologies used in Qualcomm's testing. The minimum operating frequency requirements for the chamber were based as at least 800 MHz to 2.1 GHz.

It is important that this chamber should meet CTIA (Cellular Telecommunications & Internet Association) certification program requirements for evaluating CDMA mobile devices. However t he chamber does not need official certification since its purpose is only for use in an internal engineering environment. A primary concern would be the ability to take reliably reproducible measurements throughout the operating frequency range.

Physical constraints were placed on this chamber based on the site in which it was to be located. The chamber design was required to fit height and weight constraints for the pre-existing lab that it was built in, as well as having enough room for a multi-axis positioner system in order to automate testing. The final configuration's dimensions measure 20'x10'x9'6" (LxWxH).

SECTION 3: **chamber description**

Based on the requirements listed in Section 2, Qualcomm contacted Lindgren RF Enclosures to build the 100 dB shielded enclosure. Utilizing standard modular shielded construction techniques, which incorporate a hat and flat clamp mechanism to join together double skin panels. The modular panel construction consists of zinc coated, 60 gauge steel laminated to both sides of a high-density particleboard core. The hat and flat clamping mechanism consists of cold rolled steel, which is designed to provide uniform clamping pressure along the whole perimeter of the attached panel. The fasteners used to clamp the shield together are hardened zinc plated TORX screws placed on nominal 100mm centers. The corner intersections of the enclosure are finished and sealed with cast bronze caps that are precision machined to match the framing members. The enclosure is assembled on an underlayment consisting of a polyethylene vapor barrier and 3 mm thick dielectric hardboard. This construction can be seen in Figure 1.

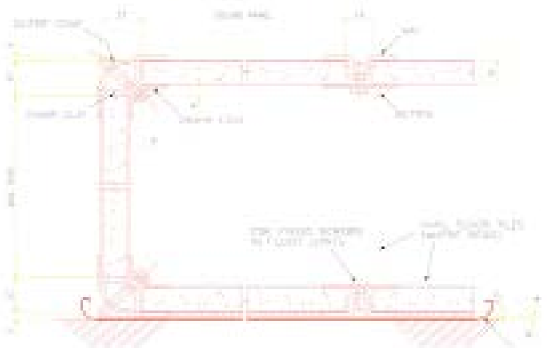


Figure 1 – Shielded Enclosure Construction

SECTION 4: **absorber performance**

Microwave absorbing materials come in various different configurations. The first absorbers were literally “horsehair” mat impregnated with a lossy carbon mixture. These early absorbers had limited application due to the low performance that was achieved. These materials typically were limited to – 20 dB of attenuation. To make up for the low performance of these materials the early chamber designs utilized various baffle designs in order to provide Quiet Zone performance higher that the limited performance of the absorbers.

Dr. Elery Buckley utilized this “baffle design” to convert an old barn in Canton Mass. Into a large anechoic chamber. In an effort to improve the performance of absorbers shaped materials were used in place of the old “horsehair” mat. One of the first shapes to be tried was the “convoluted” material which was derived from packing materials and is best described as an “egg crate” surface. These material lead to the use of wedge and pyramidal shaped materials which are the mainstay of shaped absorbers even today.

Shown in Figure 2 is the typical geometry of pyramidal absorbers for microwave use.

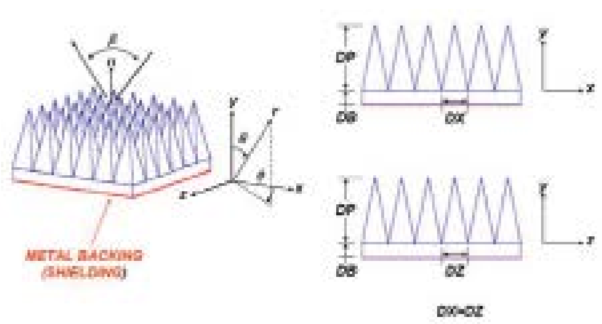


Figure 2 – Pyramidal Absorber Geometry

Shown in Figures 3 is the typical wide angle performance level of standard pyramidal absorbers that is commonly used in the design of Anechoic Chambers. This graph has been used for many years and has resulted in many, many chamber designs.

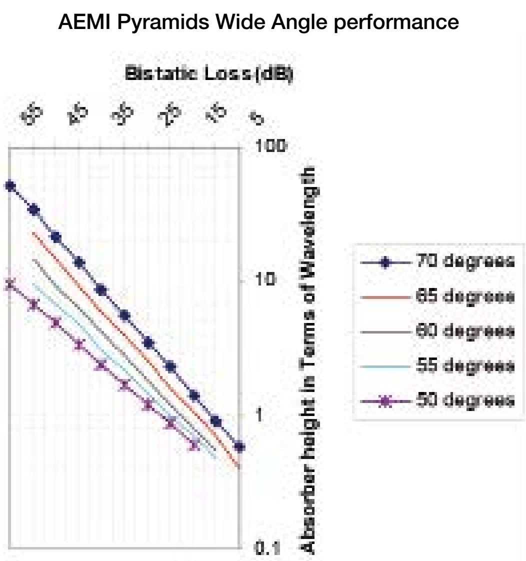


Figure 3 – Specular Angle VS Performance Graph

This graph is normalized to performance in relationship to the materials thickness in terms of wavelength.

Figure 4 and Figure 5 show measured absorber performance for various angles of incidence on the absorbers. As can be seen from this data the absorbers perform reasonably well to angles approaching 600 and are consistent with the graph of Figure 2.

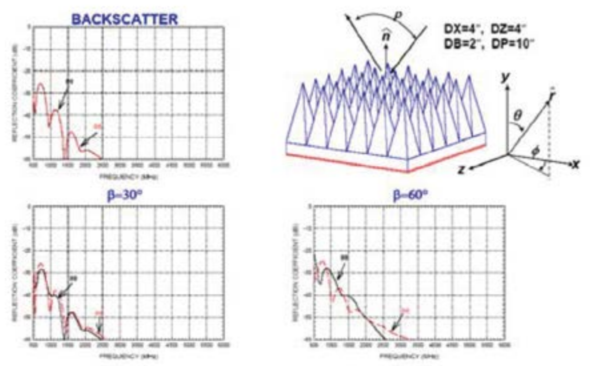


Figure 4 – Specular Angle VS Performance Graph

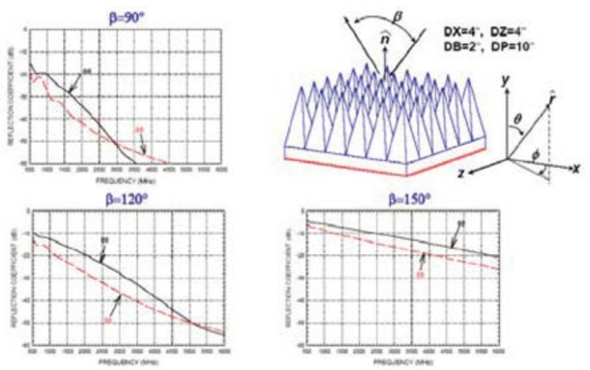


Figure 5 – Specular Angle VS Performance Graph

In order to improve the off angle performance of these pyramidal shaped absorbers work was conducted at The Ohio State University on Chebyshev absorber designs. These designs have proven to increase overall material performance by -10 dB to -25 dB. These material designs have been used in a number of chambers ranging fro typical Tapered Chambers, to Compact Range Chamber and even specialized Hardware-In-The-loop Chambers with great success. Shown in Figure 6 is typical performance improvement of a 12" Chebyshev absorber design.

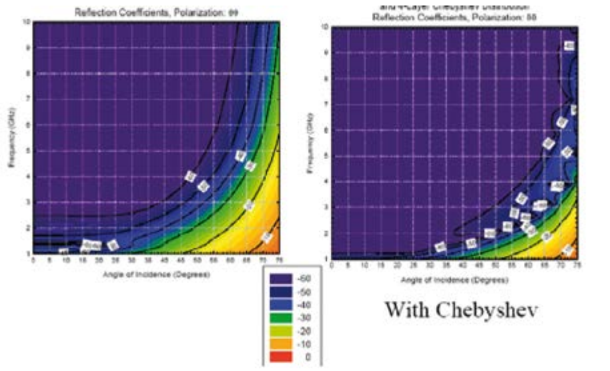


Figure 6 – Standard VS Chebyshev Performance

Figure 7 shows a typical Chebyshev absorber configuration for use in the specular regions of a chamber design to maximize the off angle attenuation performance of the chamber.

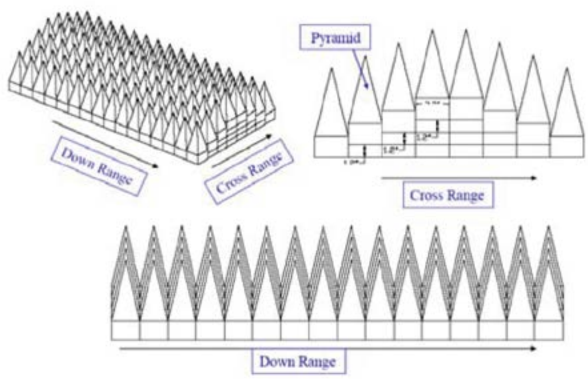


Figure 7 –Typical Chebyshev Absorber Configuration

SECTION 5: **absorber configuration**

In an effort to make this chamber as universal as possible the design has incorporated the Chebyshev treatment to all of the pyramidal absorbers used in the construction of the chamber. The back wall was treated with 24" Chebyshev absorbers and the sidewalls. Floor and ceiling were treated with 18" Chebyshev absorbers and 18" wedge absorbers. This configuration is shown in Figures 8, 9, and 10.

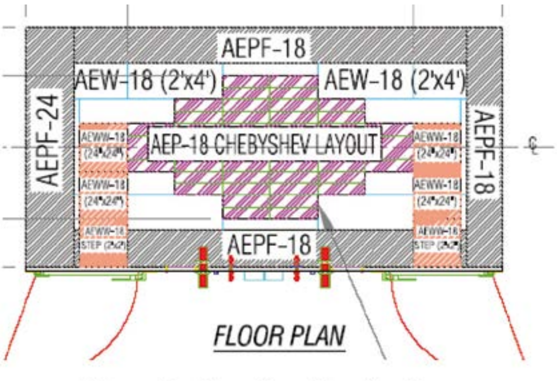
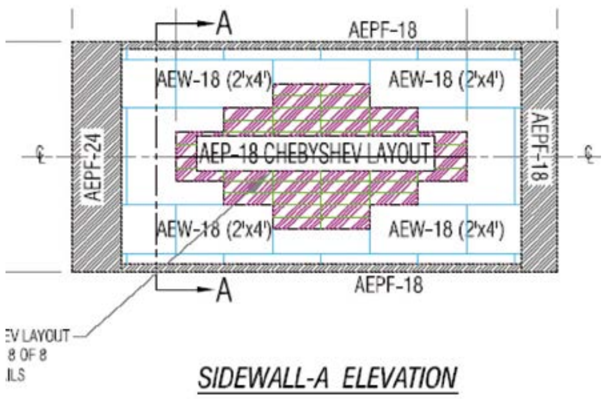


Figure 8 – Chamber Absorber Layout



.Figure 9 – Chamber Absorber layout

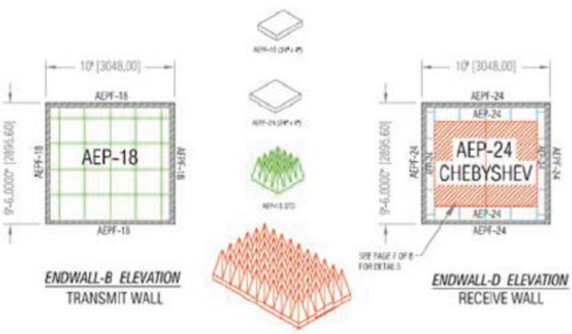


Figure 10 – Chamber Absorber layout

SECTION 6: **summary**

Due to the urgency to put this chamber into full time use we have not had the opportunity to do a full analysis of the chambers performance we had hoped to include some preliminary measurements in this paper but time has not allowed us to do so. We hope to be able to report on the chambers performance at the next meeting.

SECTION 7: **references**

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