ANECHOIC CHAMBER DIAGNOSTIC IMAGING

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Abstract

Traditional techniques for evaluating the performance of anechoic chambers, compact ranges, and far-field ranges involve scanning a field probe through the quiet zone area. Plotting the amplitude and phase ripple yields a measure of the range performance which can be used in uncertainty estimates for future antenna tests. This technique, however, provides very little insight into the causes of the quiet-zone ripple. NSI's portable near-field scanners and diagnostic software can perform quiet-zone measurements which will provide angular image maps of the chamber reflections. This data can be used by engineers to actually improve the chamber performance by identifying and suppressing the sources of high reflections which cause quiet-zone ripple.

SAR Imaging

The near-field measurement system can be used as a radio camera to identify multipath and leakage sources within an anechoic chamber or in a far-field measurement system. Representative applications include measuring the phase flatness in the quiet zone of a compact or far-field range and identifying various multipath and leakage sources. Another application is CW RCS measurements. A variation of this technique is described in reference (Mensa,1981). Small portable near-field measurement systems as described in chapter six are best suited for this application.

A conventional near-field measurement system can be considered to be a form of a two dimensional CW SAR radar. The grid of sampling points form a two dimensional synthetic aperture antenna array. The uniformly illuminated aperture used in near-field antenna measurements must be modified into a low sidelobe design by tapering the illumination at the aperture edges. This is handled by the additional step of applying a Kaiser-Bessel or similar window function (Harris, 1978) as a function of spatial position to the DUT measurements.

The scan pattern can be virtually any type including planar raster, plane polar, cylindrical and spherical. The sample positions correspond to element positions in a synthetic aperture phased array antenna.

The test is setup by placing the scanner in the quiet zone area with the scan plane with a slight tilt (5 degrees) in azimuth and elevation relative to the predicted phasefront to allow viewing of internal receiver leakages. The network analyzer is connected to make a S12 or S21 measurement between the source antenna and the scanner mounted probe antenna.

The test procedure is very similar to near-field processing with a few modifications. First, an XY planar grid of points is acquired. This raw data can be plotted in any form for use in the traditional quiet zone quality evaluation. The plots are typically scaled to a full scale range of a few dB as opposed to the typical 40 or 50 dB ranges when used for conventional antenna near-field measurements. The phase range also tends to be quite small (+/-15 degrees). X and Y cuts can be used to measure the phase curvature and amplitude ripple in the test region.

The far-field transform is then used to convert the measured phasefront into an angle or K space representation. As a significant difference from conventional near-field processing, the data into the Fourier transform must be tapered by a window function to suppress sidelobes. The window function used typically is a Kaiser-Bessel window with a relatively high coefficient value.

The output of the transform is the received energy in either angle or K space. An ideal anechoic chamber should show a small illuminated region slightly off boresight (see figure 8). A beam precisely on axis corresponds to a coherent on axis leakage source, receiver quadrature unbalance or often a LO leakage in a remote mixer configuration. Beams at other angles are caused by reflections from lights, supports, walls, etc.

If the transform output is in angle space, one can read the direction of an interference path and transfer the coordinates into a theodolite. The theodolite, when positioned at the scanner position and aligned with the scanner reference frame, will point along the interfering path. The K-space mapping is somewhat like a fisheye lens image of the same thing. There should be no energy outside a K space circle of radius one. If energy is present, it is created by a multipath mechanism.

Figure 3 shows the performance of a degraded anechoic chamber. The desired energy from the illumination horn is arriving from the upper right quadrant. The energy at the exact center corresponds to a severe RF leakage within the receiving system. The XY scanner was tilted intentionally to allow this leakage signal to be observed. The lower peaks correspond to reflections from a mounting panel, and the upper peaks correspond to the location of a light fixture.

Chamber imaging is based on the concept of creating a multibeam, synthetic aperture phased array antenna. The beamforming (in either angle or K-space) is accomplished by a modified Fourier transform. To achieve a low sidelobe in the synthetic aperture, the aperture is tapered with a window function. Holographic processing can be used to project the field to other locations in space.

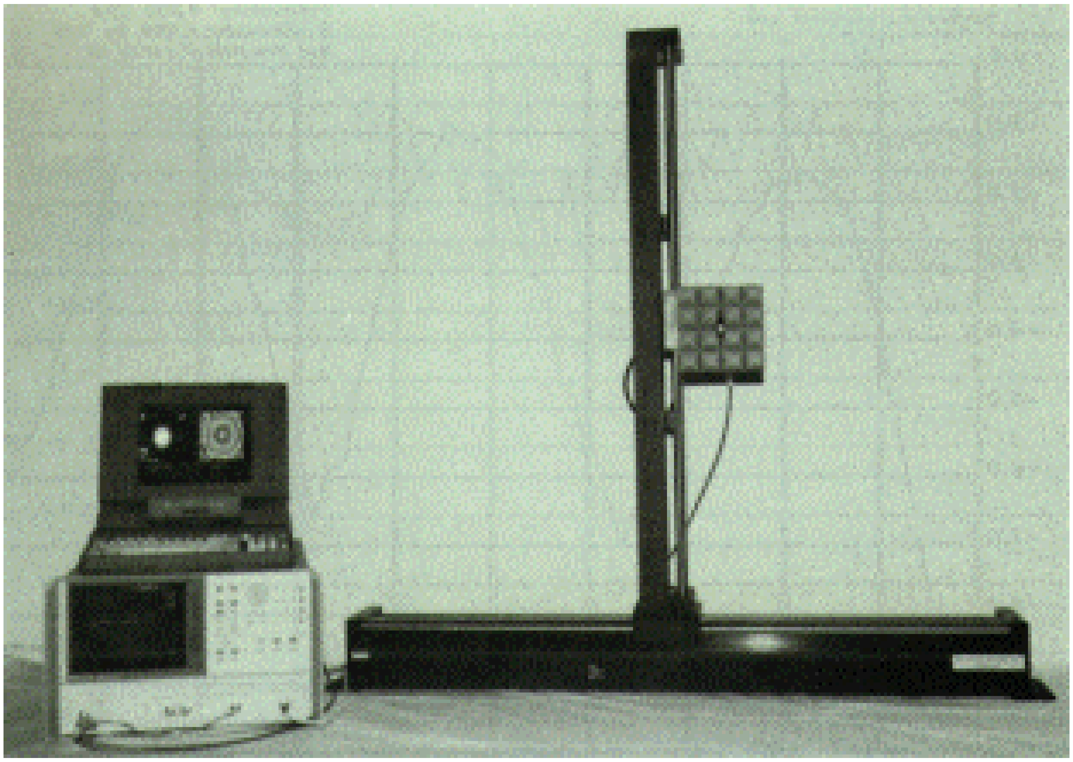

Figure 1 - Portable Near-Field Scanner To Detect Multipath And Leakage Effects In An Anechoic Chamber

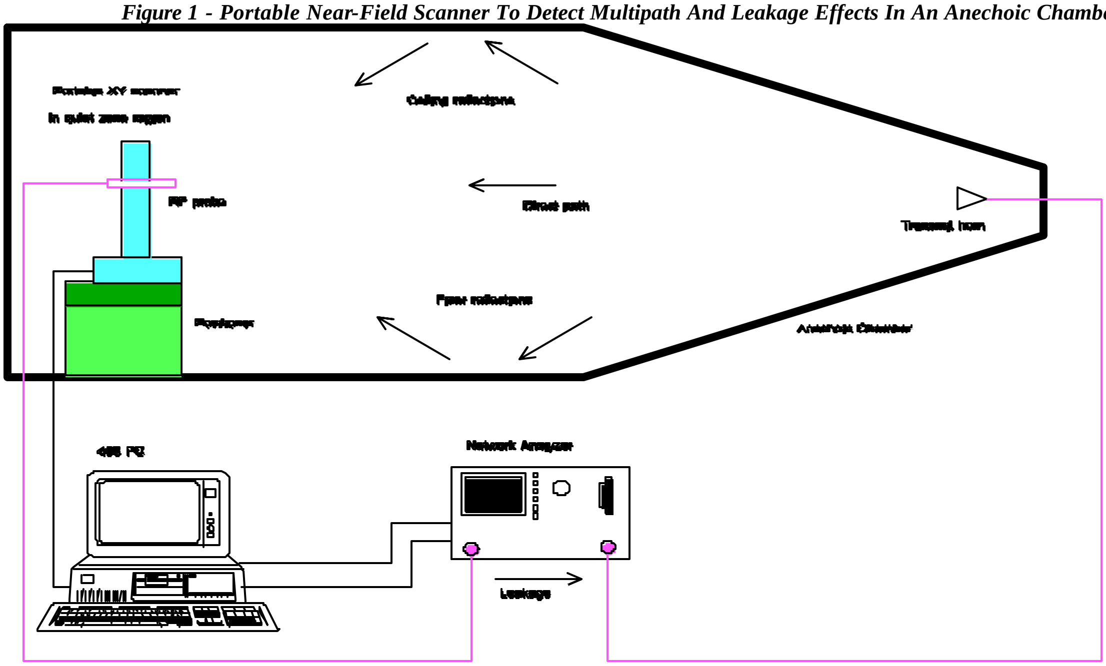

Figure 2 - NSI Model 233T Portable Scanning System

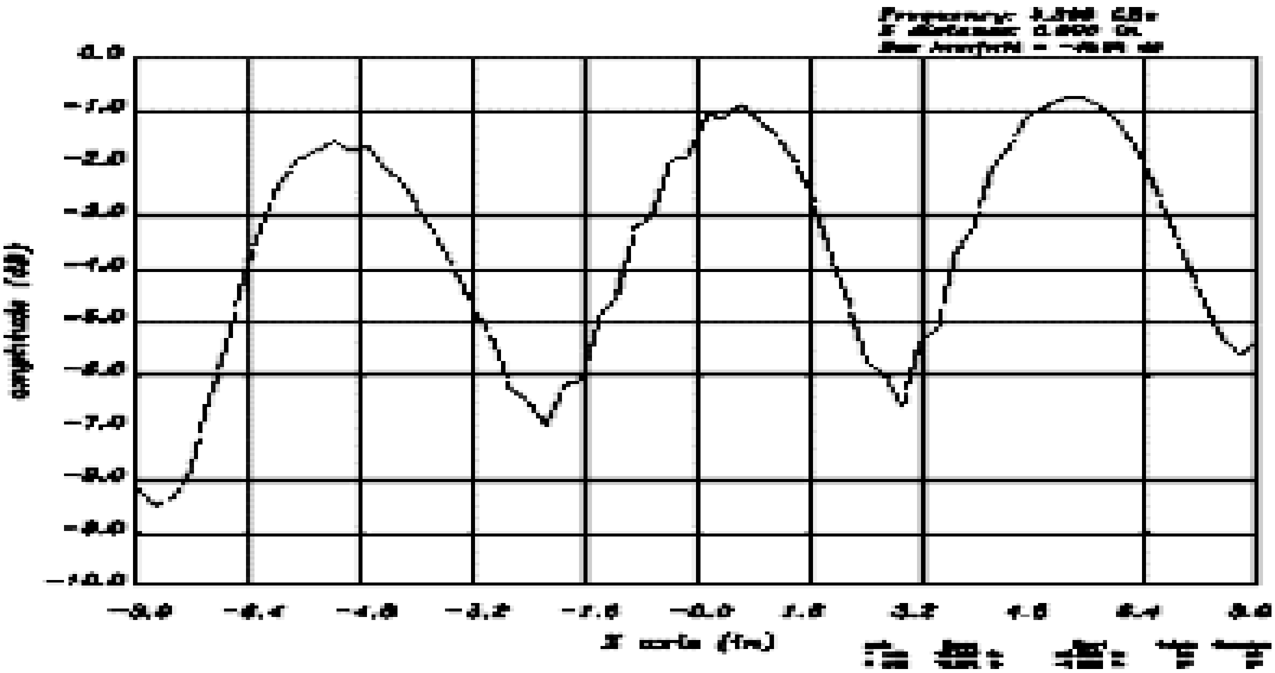

Figure 3 - Amplitude Ripple Due To Reflections

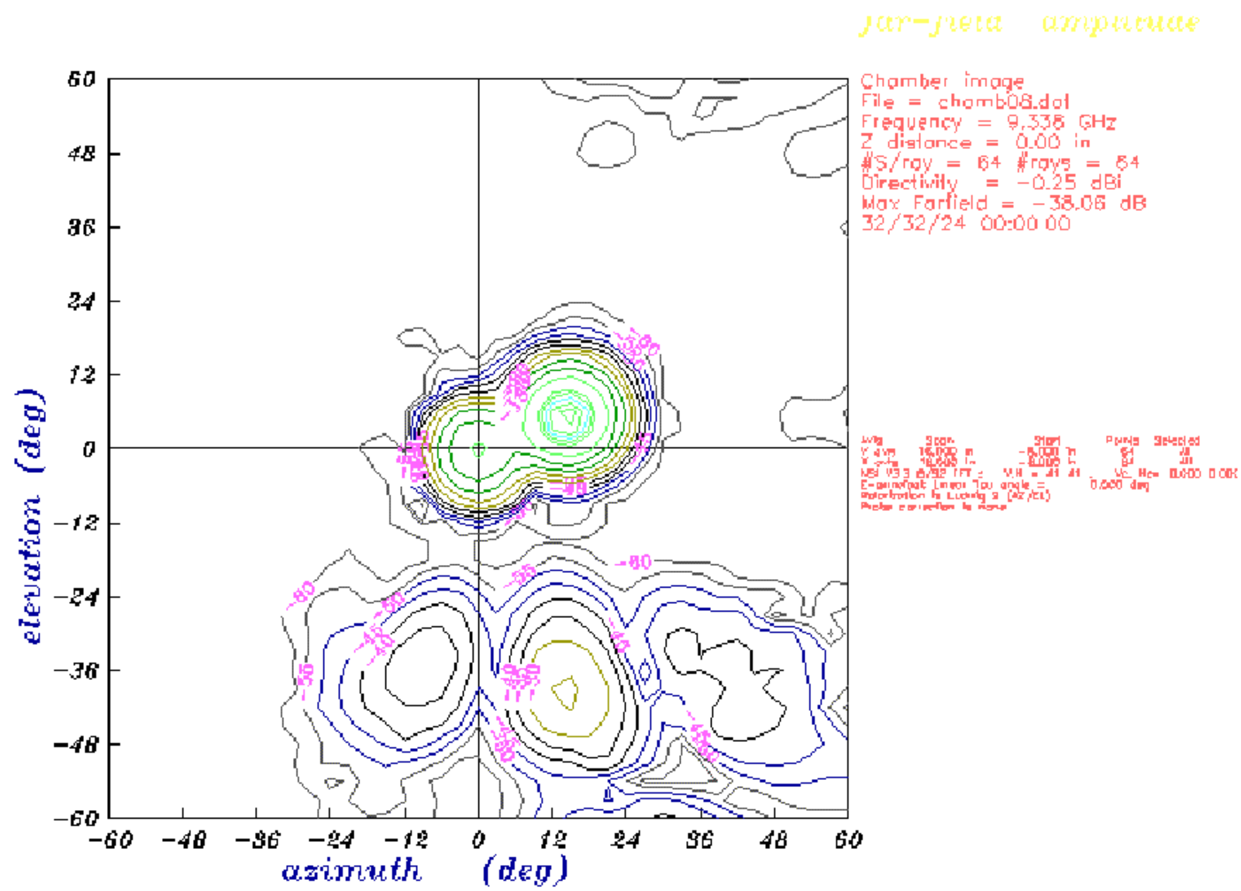

Figure 4 - CW SAR Image Of "Dirty" Chamber

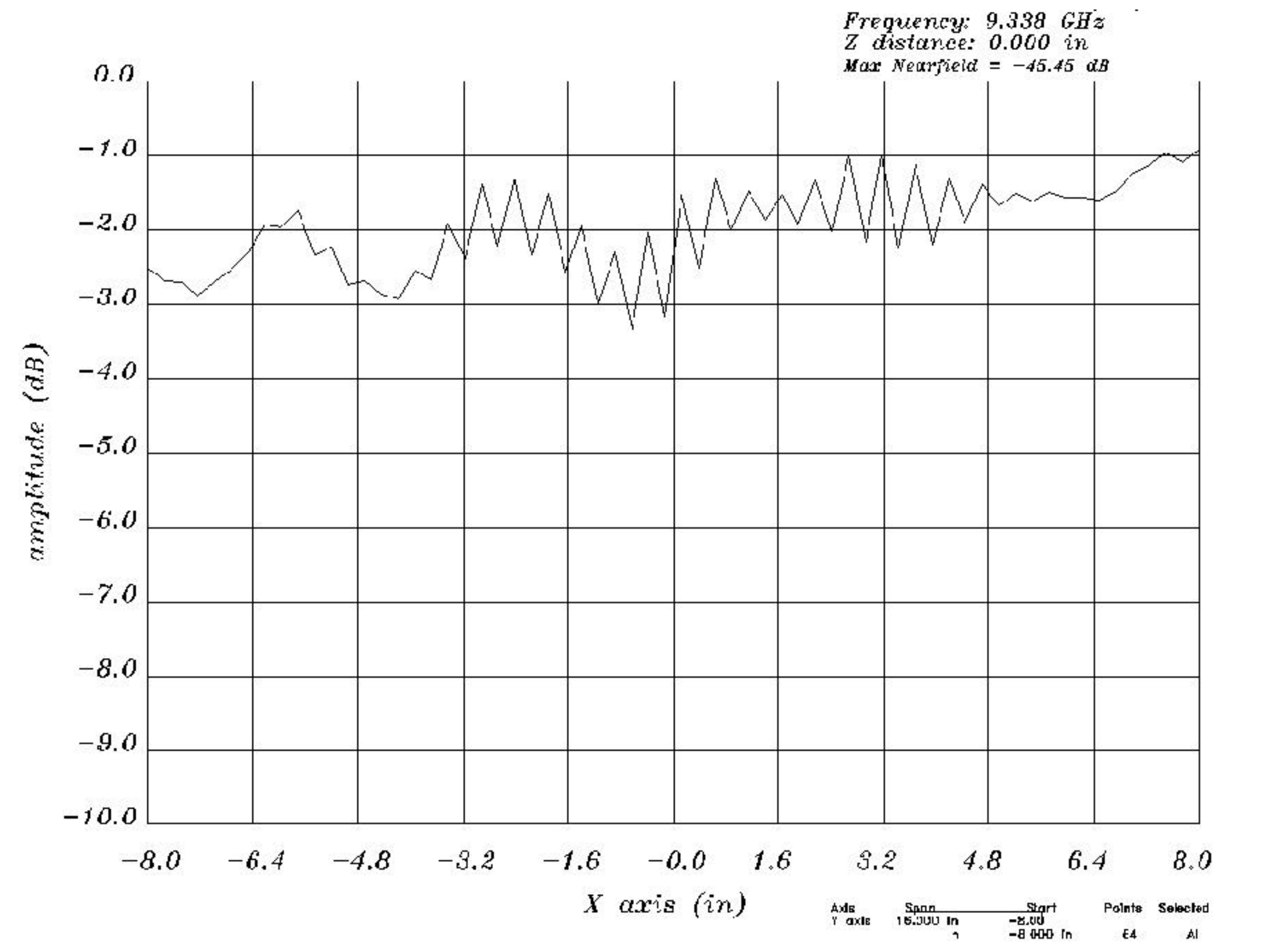

Figure 5 - Amplitude Ripple Due To Large Leakage Signal

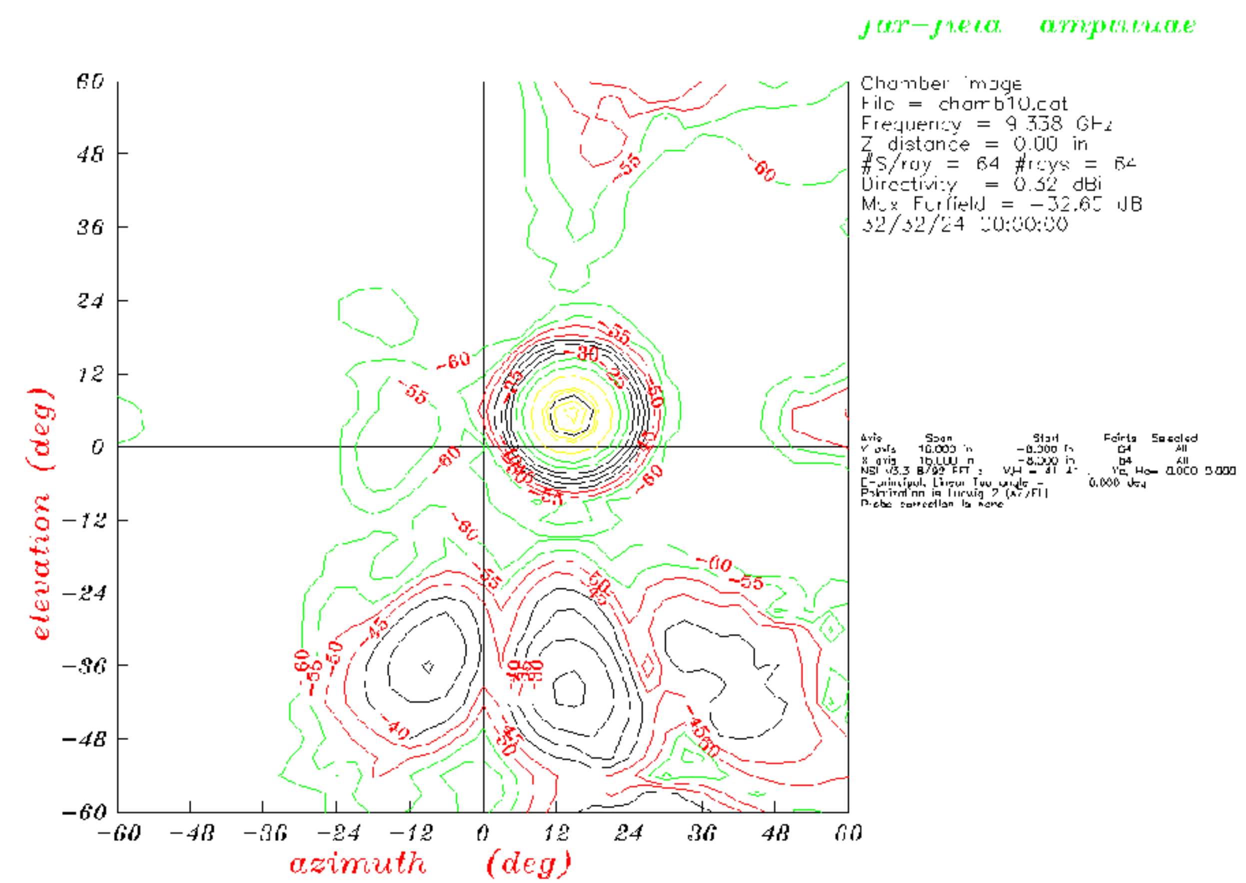

Figure 6 - CW SAR Image Showing Reflections From Floor And Ceiling

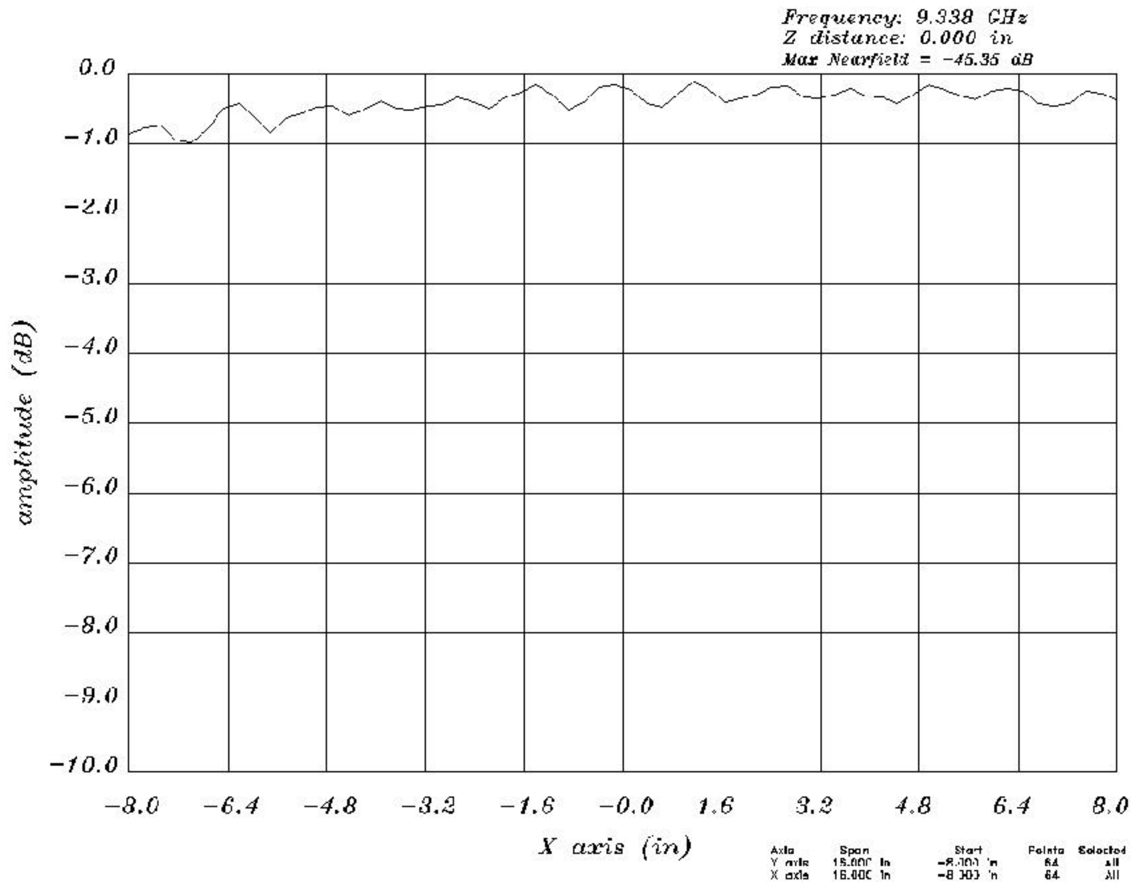

Figure 7 - Amplitude Ripple In "Clean" Chamber

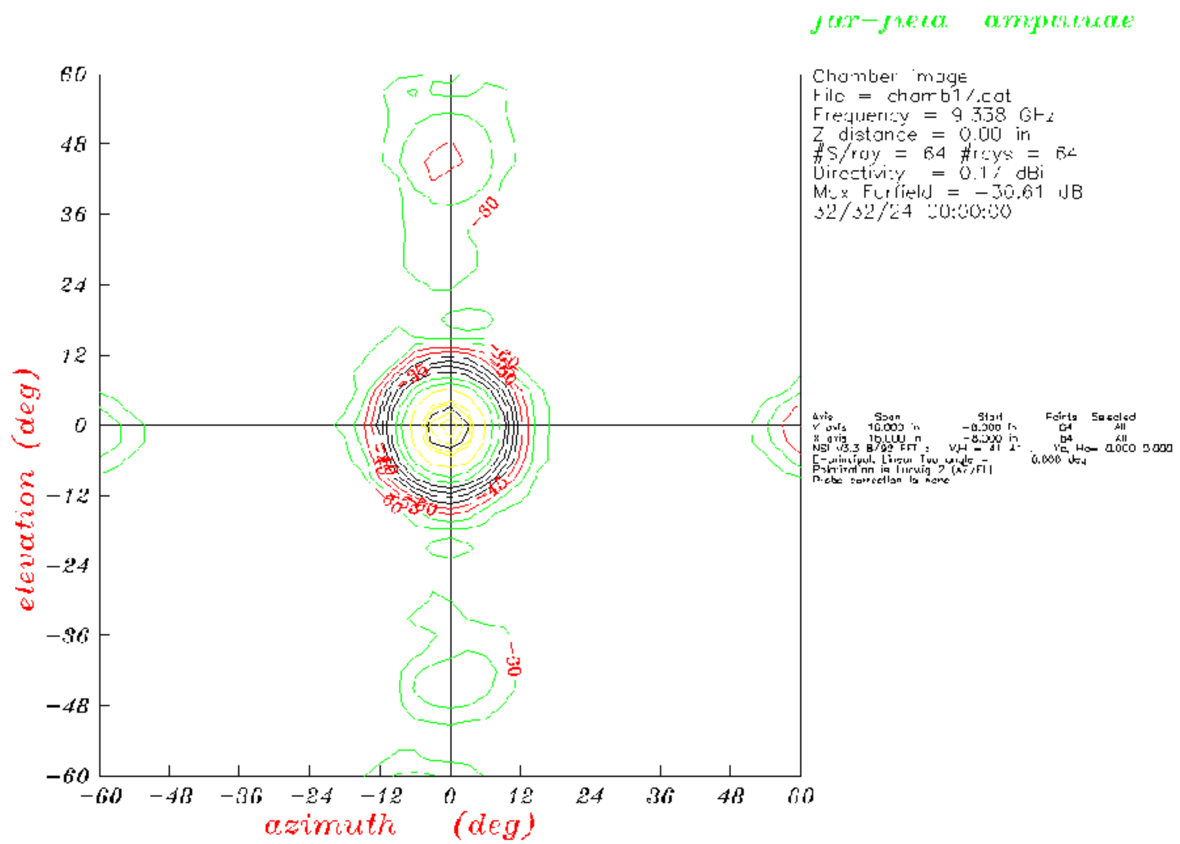

Figure 8 - CW SAR Image Of "Clean" Chamber