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Scanned Quiet Zones In A Compact Antenna Test Range

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ABSTRACT

MBB has designed, built, and extensively tested their Compact Antenna Test Range (CATR). Ford Aerospace has entered into an agreement with MBB for the procurement of such a CATR for satellite testing at Space Systems Division in Palo Alto. During the procurement program some interesting testing has been conducted to investigate the generation of scanned quiet zones for custom applications involving satellite testing.

Due to the long effective focal length of the optics selected by MBB, excellent scanning performance is predicted for this geometry. This allows multiple CATR feeds to be used in scanned positions in the vicinity of the nominal focal position, which provide multiple simultaneous quiet zones. These quiet zones have demonstrated very good electrical characteristics and can be positioned to concentrate on specific antennas on the satellite, by translation of the CATR feeds. These quiet zones may be of different frequency bands depending upon feed selection, and multiple antenna testing is realized in a single raster scan of the satellite positioner. The satellite need not be translated to center a specific antenna in the nominal axial quiet zone so that convenience, expeditious data collection, and less danger to the satellite are realized.

Key Words: Compact Range, Scanning Performance, Satellite Test, Quiet Zone

1. INTRODUCTION

The MBB compact antenna test range (CATR) has been tested and verified in various frequency bands ranging from 3 GHz to 180 GHz for a feed located at the focus of the optics. Ford Aerospace, having entered into a procurement arrangement with MBB to build the optics of a CATR for satellite test, suggested that a variety of measurements be conducted to determine performance of quiet zones scanned from the axial quiet zone, by displacement of the feed from the nominal focal position. In addition to the obvious advantage of not having to move the satellite to center a specific antenna in the quiet zone, another interesting application of scanned quiet zones is air link testing of a satellite. In this test, a receive band feed transmits from the focal plane and creates a quiet zone for the receive antenna. The satellite receives this signal which couples through the repeater and radiates from the transmit antenna at a different frequency. This signal is received at a transmit band feed in the focal plane thus completing the air link. This configuration is shown in Figure 1.

2. CATR CONFIGURATION

The geometry of the CATR which is being built at Ford Aerospace, is shown in Figure 2. It can be seen that hyperboloid and paraboloid sections used as the subreflector and main reflector respectively, provide a very long effective focal length. The geometry of the optics of the Ford Aerospace CATR is identical to that at MBB and the only difference between the two facilities is the size of the room. The Ford Aerospace CATR room is somewhat larger to accommodate an alignment station. Since the electrical characteristics of the two facilities are expected to be quite similar, a measurement campaign was conducted at MBB to model the performance expected for the scanned quiet zones of the Ford Aerospace CATR. The following paragraphs describes the test configuration and the results which were measured.

3. AXIAL QUIET ZONE TESTS

The test article used for the measurement is an elliptical reflector, 40cm x 80cm, with a linearly polarized feed. The initial method of test was a collection of data with the antenna positioned in its nominal orientation, compared to that collected with the antenna rolled 180 degrees. For the latter azimuth pattern, the sense of the positioner rotation is reversed about the CATR axial pointing direction. In the absence of errors, the two patterns should be an overlay, and the deviation from an identical radiation characteristic is a measure of the CATR error level.

These tests were conducted for the feed positioned at the nominal CATR focus which generates the axial quiet zone. These patterns were collected for 3.7 GHz and 5.925 GHz which are the low frequencies of the C-Band transmit and receive satellite communication bands. The C-pol and X-pol data collected in this manner is shown in Figures 3 and 4 respectively for 3.7 GHz measurement. Similar data at 5.925 GHz is illustrated in Figures 5 and 6. These patterns were measured using vertical polarization on the unit under test, and show a very clear measurement environment for the nominal axial quiet zone.

4. SCANNED QUIET ZONE TESTS

To investigate the performance of a quiet zone scanned 2.45 meters from the axial quiet zone, in the direction of the satellite receive antenna, the feed was displaced 0.9 meters from the nominal focus. Figures 7 and 8 plot the measured C-pol and X-pol patterns measured at this position. It can be seen from an overlay of these, with the corresponding pattern measured at the center of the axial quiet zone, that good correlation is achieved. It is realized that the 0, 180 degree roll azimuth pattern test is indicative of error levels but may not include the worst case. It was decided that amplitude and phase ripple would be measured in the transmit band as the probe is continuously moved from -1.1 meter to -4.1 meter relative to the center of the axial quiet zone. This 3 meter quiet zone centered at -2.6 meters is the nominal position of the C-Band transmit antenna on the satellite when it is centered on the range axis. The measured amplitude and phase characteristics are plotted in Figures 9 and 10 respectively, and smooth probe data is seen which indicates an accurate measurement environment. The test antenna was used to collect an azimuth pattern at eight horizontal locations along the 3m scanned quiet zone. An overlay of these patterns is shown in Figure 11 for 3.7 GHz. The antenna has been disassembled and reassembled in the time since the axial quiet zone measurement so that exact sidelobe and null structure cannot be correlated, due to the feed being located in a different position. A measure of the error would however be the envelope of values measured at a given point. It can be seen that with the exception of one extraneous pattern measured at the edge of the quiet zone, accuracy of ±0.9 dB at the 32 dB level is maintained. This corresponds to an error level of 51 dB.

5. SUMMARY

Scanned quiet zones have been demonstrated to be a useful measurement tool. Due to the long effective focal length of the MBB and Ford Aerospace Compact Ranges, performance in these scanned quiet zones is virtually the same as that in the axial quiet zone. This phenomenon has particular merit for testing communication satellites because they typically have large reflector antennas located on either side of the satellite mainbody. This allows for rapid collection of antenna data which minimizes risk to the satellite due to relocation of the test article.

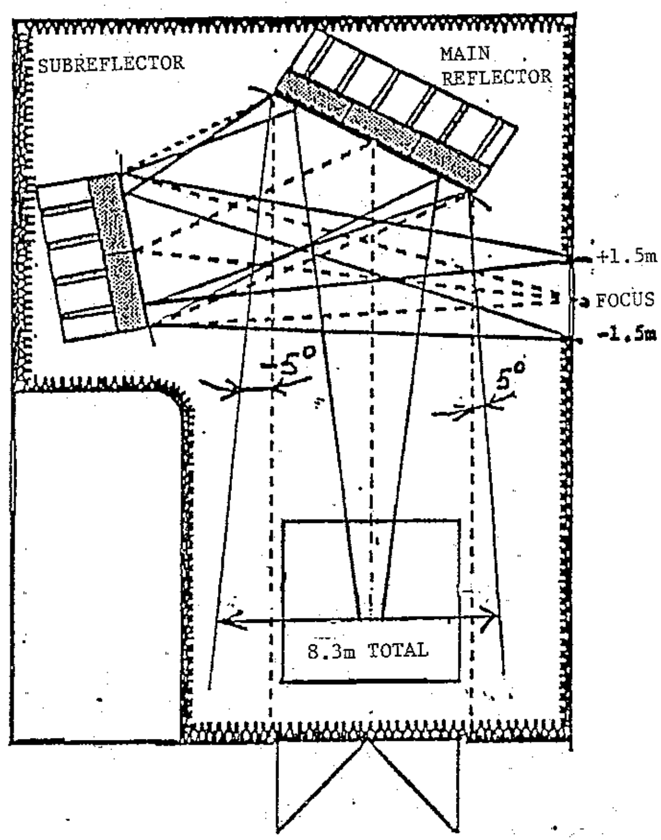

FIGURE 1: SCANNED QUIET ZONES FOR SATELLITE AIR LINK TEST

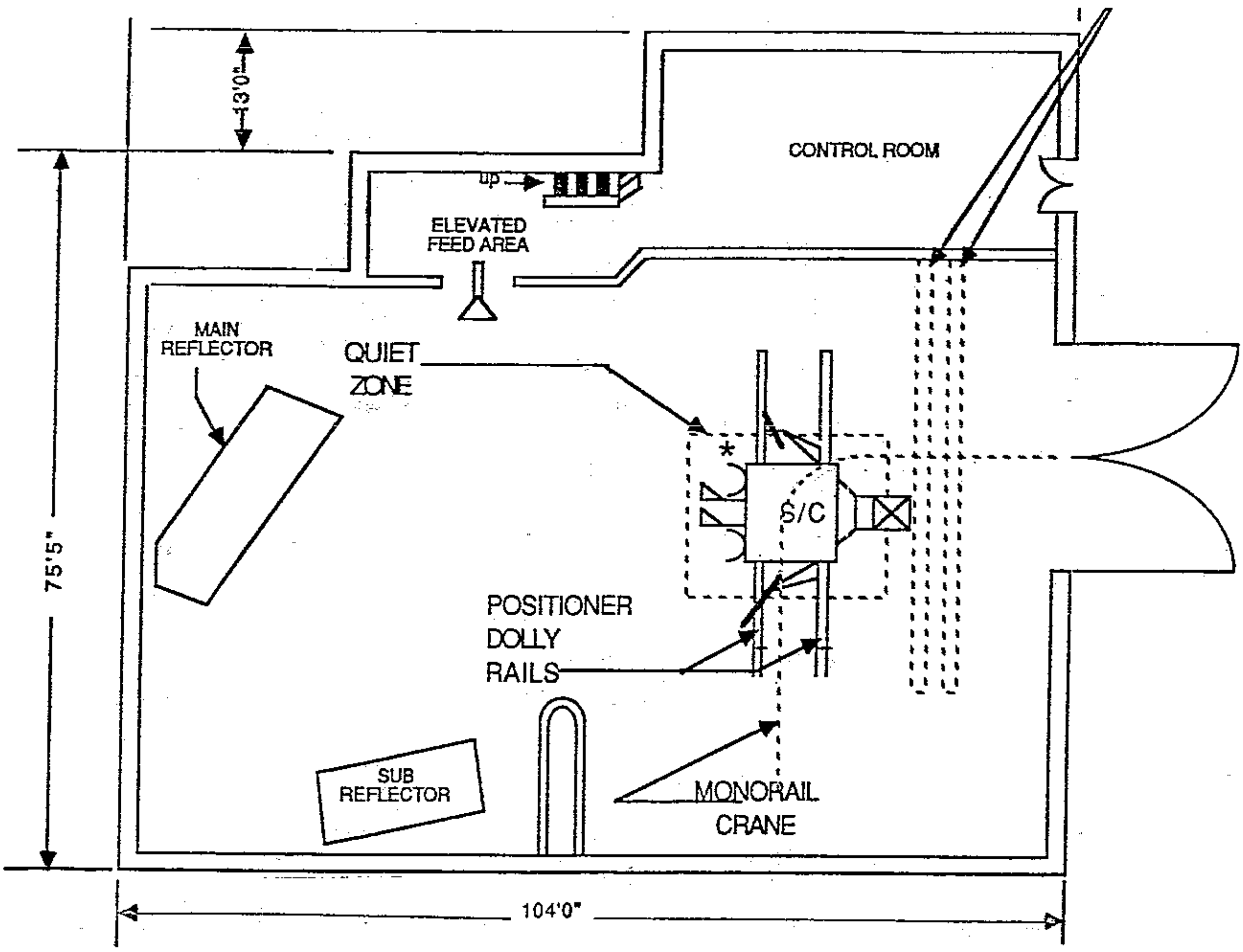

FIGURE 2: FORD AEROSPACE CATR GEOMETRY

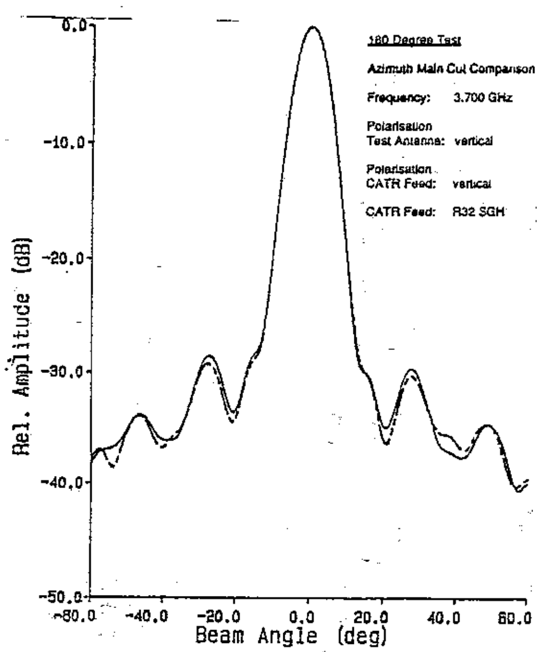

FIGURE 3: 3.7 GHz CO-POL, AXIAL QUIET ZONE

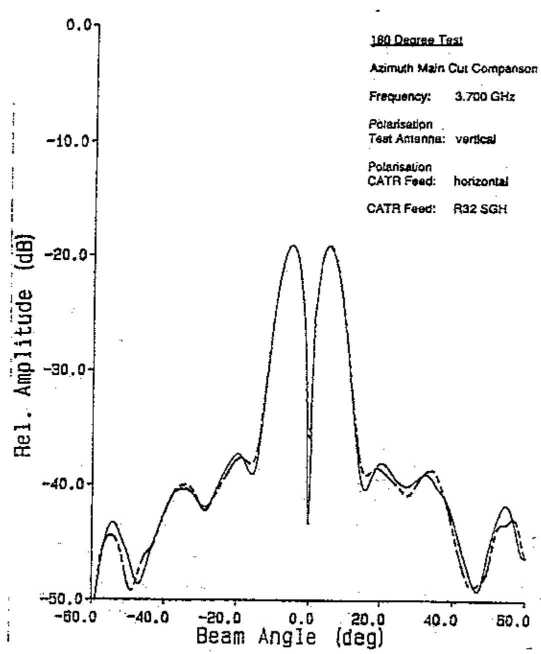

FIGURE 4: 3.7 GHz X-POL, AXIAL QUIET ZONE

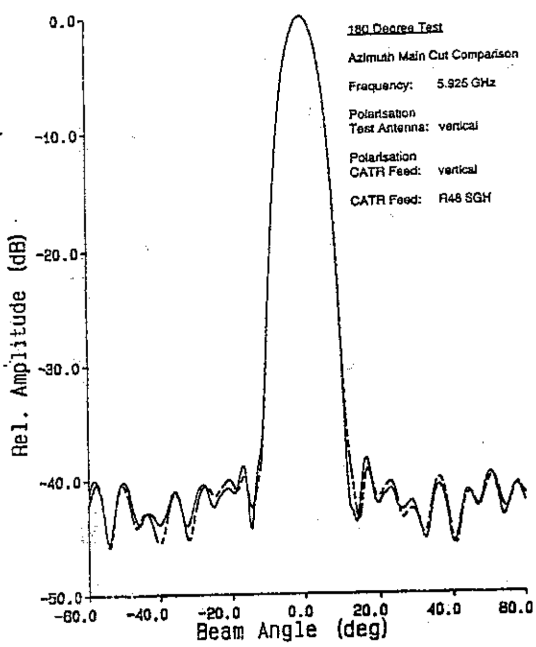

FIGURE 5: 5.925 GHz CO-POL, AXIAL QUIET ZONE

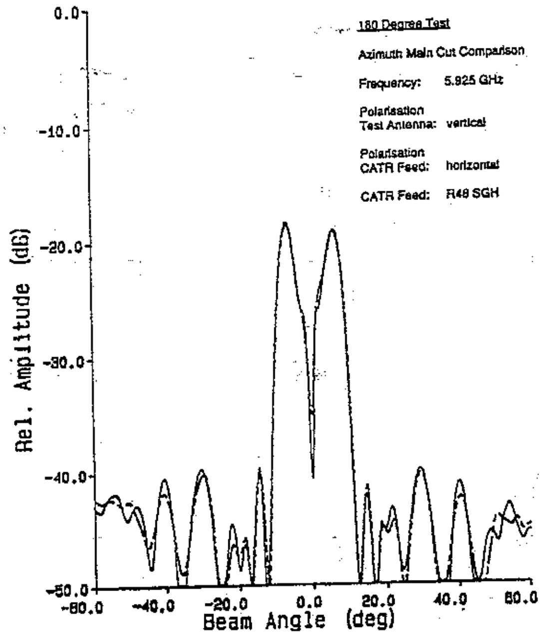

FIGURE 6: 5.925 GHz X-POL, AXIAL QUIET ZONE

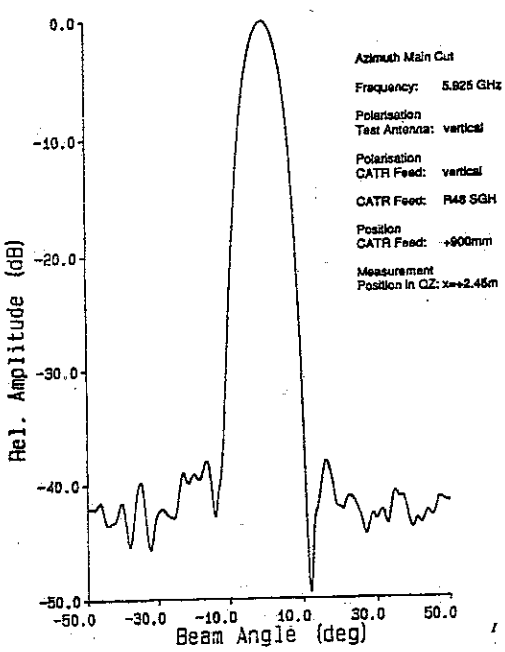

FIGURE 7: 5.925 GHz CO-POL, SCANNED QUIET ZONE

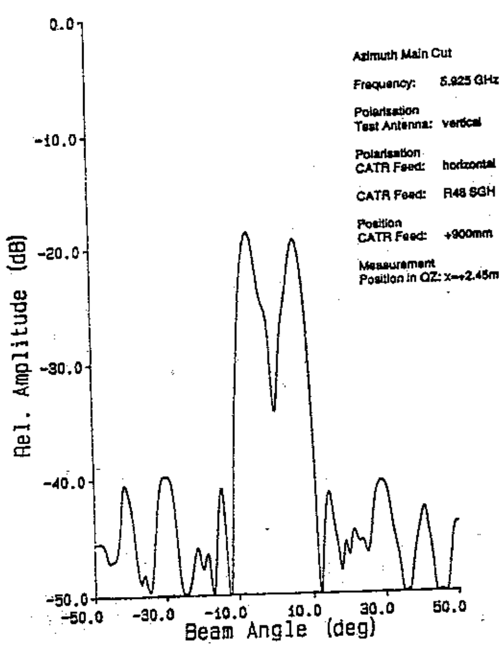

FIGURE 8: 5.925 GHz X-POL, SCANNED QUIET ZONE

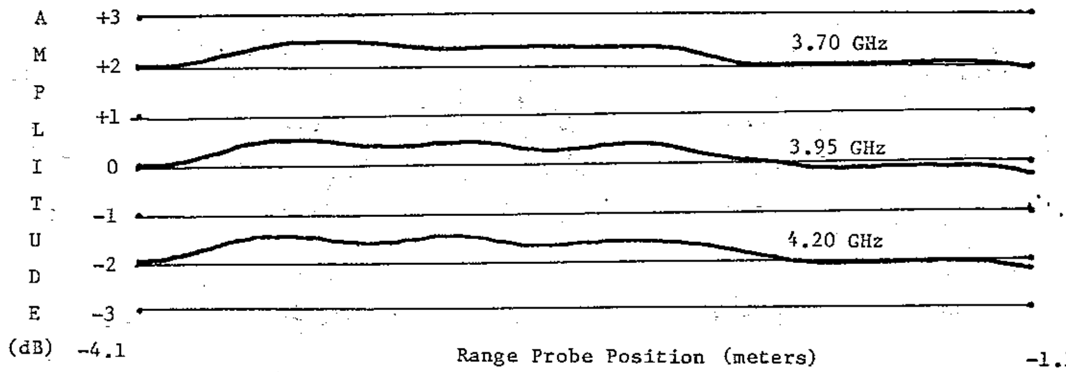

FIGURE 9: SCANNED QUIET ZONE AMPLITUDE RIPPLE

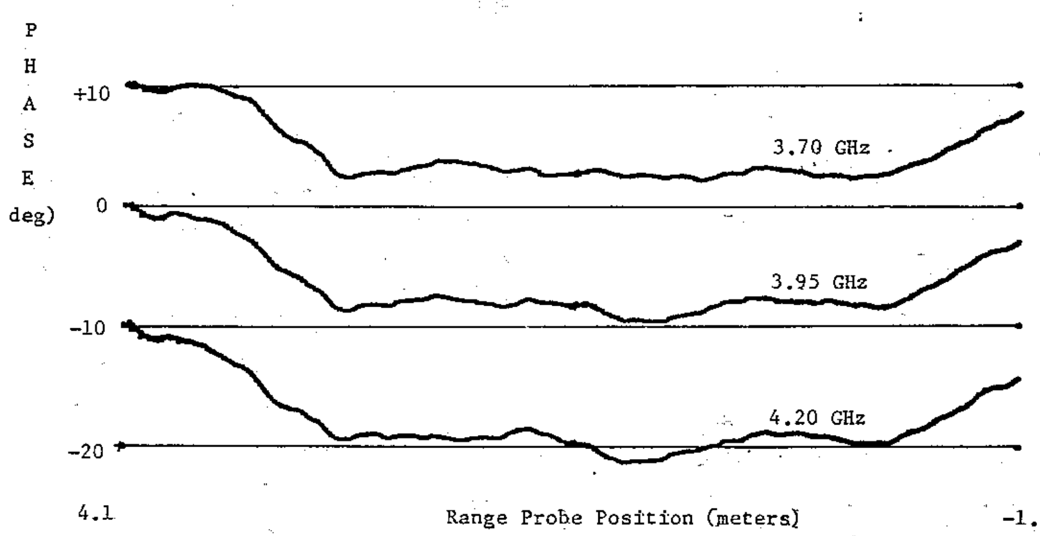

FIGURE 10: SCANNED QUIET ZONE PHASE RIPPLE

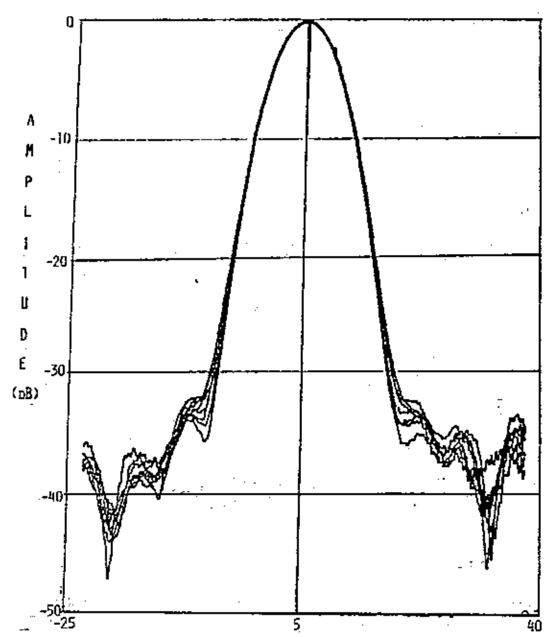

FIGURE 11: 3.7 GHz PATTERN ENVELOPE, SCANNED QUIET ZONE