RESULTS OF PLANAR NEAR-FIELD MEASUREMENTS ON A COMPACT RANGE AT 18 and 54 GHz

Andrew G. Repjar and Douglas P. Kremer
National Bureau of Standards
Boulder, Colorado 80303

Significant progress in recent years has been made on planar near-field measurements for antenna calibrations(1). Such measurements are also useful in the alignment and evaluation of compact ranges because they provide more information than a limited number of analogue plots in one dimension. Contour plots of amplitude and phase data obtained from more complete 2-dimensional measurements precisely and accurately locate sources of problems in the range reflector, with phase contour plots being more useful as diagnostic tools.

The goal of the compact range under test was to provide an approximate plane wave illumination over a measurement zone 120 cm square with less than 0.5 dB amplitude variation and less than 10 degree phase variation at any frequency in the 12 to 100 GHz range. The results of the planar near-field measurements were to determine if the goal could be achieved.

A precision reflector is one of the most critical factors in compact range design(2). The range under test utilizes a portion (16 panels) of a precision 10-meter diameter reflecting surface, originally part of a prototype telescope for millimeter and sub-millimeter astronomy(3). Each hexagonal panel has a surface accuracy of about 50 μm rms. Since the reflector support frame can be disassembled and reassembled and the panels reattached, the original parabolic surface accuracy can be obtained by adjusting 24 panel-support screws. The focal length of the reflector is 412.32 cm.

The parabolic reflecting surface, approximately 396 cm high and 475 cm wide was mounted on the azimuth over elevation rotator at the NBS near-field facility in Boulder (see Figure 1). In this configuration, the rotator was used to align the reflector with its axis normal to the plane of the scanner, and then the scanner was used to measure the field uniformity in a plane. The dimensions of the measurement plane of the scanner were set at 373 cm in the x direction and 378 cm in the y direction. The z variation of the scanner area was previously measured to be ± 127 μm. The 120 cm square measurement zone of the compact range under test was centered at x = 185 cm and y = 165 cm. Two scalar feeds designed to satisfy the 0.5 dB amplitude variation specification were utilized to illuminate the reflecting surface and planar near-field measurements were conducted at 18.0 and 54.75 GHz. The probes used in the planar scanner included a KU band horn (12.4-18.0 GHz) and a V band horn (50.0-75.0 GHz), and their nominal gains are 24.7 dB and 25.5 dB respectively. They were chosen for the alignment and reflector evaluation because, due to their narrower beamwidths (when compared to the beamwidths of open-ended waveguide probes) they attenuate variations caused by edge diffraction and feed spillover, and focus on the data showing reflector surface errors.

Alignment of the compact range requires measuring the electromagnetic field, both amplitude and phase, in a zone approximately 150 cm behind the feed as shown in Figure 1. Since a planar wavefront is desired in the test zone, it is advantageous for the measurement plane of the planar near-field scanner to coincide with a measurement plane of the test zone. First, the nominal axis of the reflector is set parallel to the normal of the scanner plane and the feed is positioned at the nominal focal point of the reflector. Then, in small increments, the feed is translated in x and rotated in azimuth and the reflector is rotated in azimuth for maximum symmetry in x for both amplitude and phase plots in the <u>entire</u> measurement plane of the near-field scanner. Then, again in small increments, the feed is translated in z until the phase measurements are nearly constant in x. These results for y = 335 cm are shown in Figure 2 where the effect of the amplitude taper of the feed on the shape of the amplitude curve is also evident. The reflector is then rotated in elevation and the feed is adjusted in y and elevation angle, all in small increments, until the phase is nearly constant in y. Final adjustments can then be made to optimally satisfy all the above conditions simultaneously.

With the above alignment procedure, and at 18 GHz, both symmetry in x of the electromagnetic field amplitude, and constant phase for a number of x scans were achieved over the upper (see Figure 2) and lower portions of the near-field scanner measurement area. However, amplitude symmetry and constant phase in x over the middle portion was not present and is the subject of the following discussion. After the initial compact range alignment, contour plots of amplitude and phase were obtained from the complete 2-D data spaced 2.54 cm in both x and y, and the latter is presented in Figure 3. Note the unexpected concentric phase contours at the left center positions. Furthermore, from the amplitude contour plot, it was evident that the symmetry in x did not exist in this middle region. The overlaying of the reflector diagram onto the phase plot makes it apparent that the errors are in the vicinity of a specific support screw and are the result of the reassembly of the reflector. However, since this support screw is adjustable (304.8 μm per turn) as are all 24 support screws, adjustments were made. The final amplitude and phase contour plots are shown in Figure 4 and 5 respectively. At this point it should be noted that the alignment of this reflector using only a limited number of analogue plots at various y positions in the middle region would have been difficult if not impossible!

At 54.75 GHz, the V band feed was installed and the range was aligned. As expected the phase contours varied more rapidly, by a factor of approximately 3, when compared to those obtained at 18 GHz. In addition, after the reflector diagram was overlaid on the phase plot, small adjustments which would also improve the KU band results were determined and made for a small number of support screws.

This measurement program shows that planar near-field measurements are indeed practical and valuable in aligning and evaluating compact ranges. In addition the planar technique provides a convenient way to precisely and accurately measure cross polarization levels. It will only be mentioned here that cross component levels in the order of 28 and 33 dB below the main component were measured in the 120 cm measurement plane of the test zone at 18.0 and 54.75 GHz respectively. Future work, both analytical and experimental, needs to be done on compact range evaluations. In particular, compact range studies should include other probes such as the broad-beam, open ended waveguide, which due to its broader beamwidth (when compared to the beamwidth of a horn), does not attenuate variations caused by edge diffraction and feed spillover. Some results have been obtained for this case.

REFERENCES

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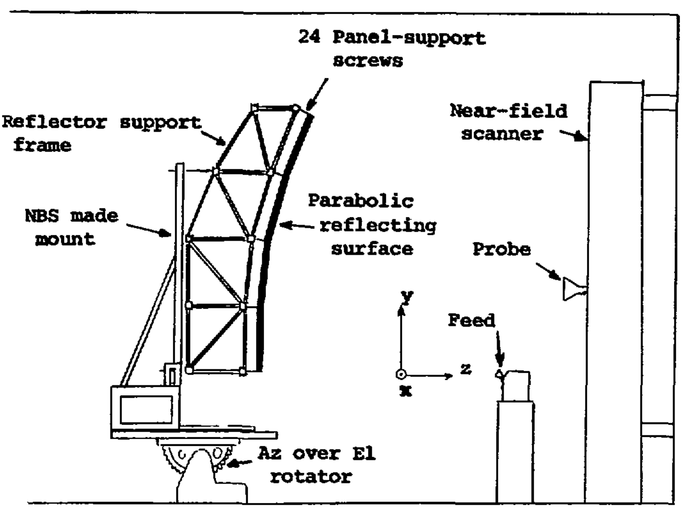

Figure 1. Measurement facility schematic and coordinate system compact range, NBS, Boulder, Colorado

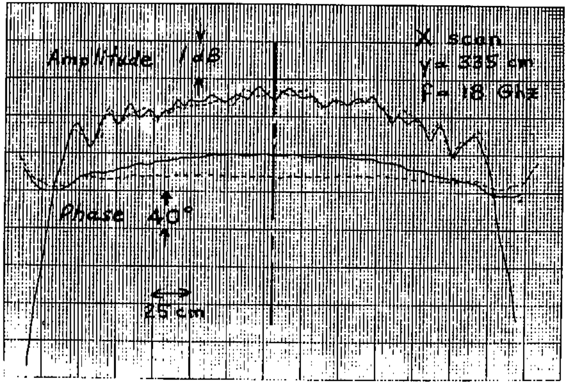

Figure 2. Main component amplitude and phase
Initial and final alignment, compact range.

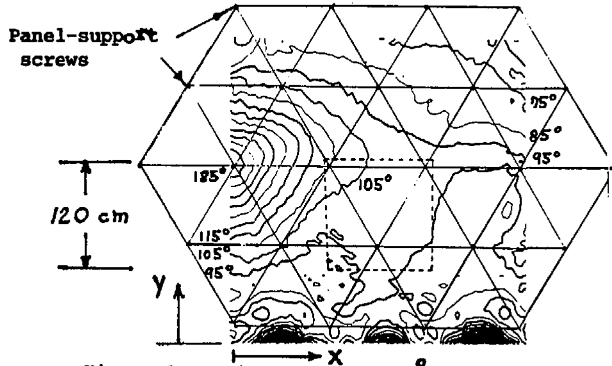

Figure 3. Main component 10° phase contours
Initial alignment, compact range
Reflector support overlay.

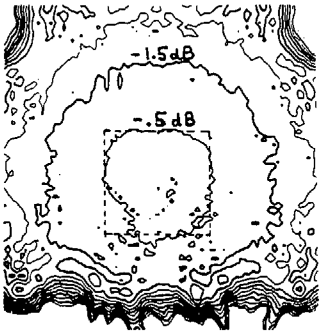

Figure 4.
Main component
1 dB amplitude contours
Final alignment
Compact range.

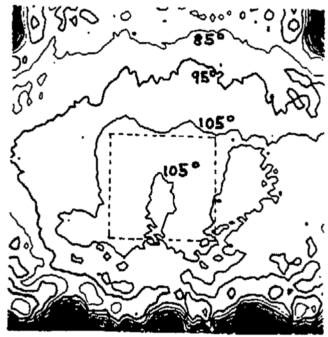

Figure 5.
Main component
10° phase contours
Final alignment
Compact range.