Very-Near-Field Testing of Large Antennas in Lab Environment

Kasra Payandehjoo
EMSCAN Corporation
Calgary, Alberta, Canada

Ruska Patton
EMSCAN Corporation
Calgary, Alberta, Canada

Abstract— **This article presents a compact set-up for characterization of large antennas. The proposed technique uses EMSCAN's RFxpert system. Multiple near-fields scans, 0.16m^2 each, are patched together to capture near-field radiation from large antennas. The effect of the width of the scan area and the lab environment is investigated herein for a base station antenna at 750MHz and 1850MHz. Far-field patterns show good agreement with chamber data in terms of shape, beamwidth, and directivity. Based on the investigations, the use of an absorber sheet for suppression of higher order interactions between the scanner and the antenna is strongly recommended. It is also demonstrated that a scan area as narrow as the width of the scanner itself is often sufficient to capture the fan-shaped radiation pattern of the base-station antenna.**

I. INTRODUCTION

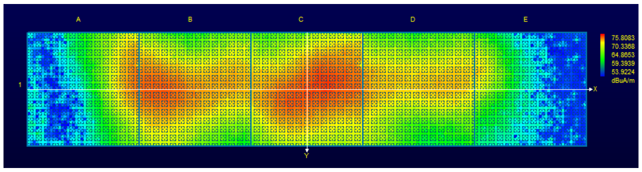
Characterization of large and/or low frequency antennas in far-field or compact range measurement systems is often too costly and in cases impractical [1, 2]. The specialized far-field test facilities needed for these measurements are often monumental, expensive to rent, and have long lead times to schedule testing. An alternative to direct far-field measurement exists based on very-near-field scanning. Very-near-field scanning method has already been successfully commercialized for small antennas in EMSCAN's RFxpert product [3]. An array of electronically switched probes eliminates the need for mechanical movement of the antenna and hence drastically reduces measurement time. The near-fields are then transformed to far-field in a hemisphere in a matter of 1-2 seconds. Theoretically, this technique is scalable to an arbitrarily large antenna. However, increasing the size of the array of probes has serious practical limitations. A method is developed herein to patch multiple scans together in order to virtually increase the scan area for larger antennas. RFxpert software combines the near-field scans together and applies the transformation to the far field. This article presents the set-up that is used to measure radiations from a base-station antenna. In section II, the RFxpert scanner is arranged in various array configurations and the measured near-field data is presented. The captured near-field data is then transformed into far-field and compared with chamber data in Section III.

II. TEST SET-UP

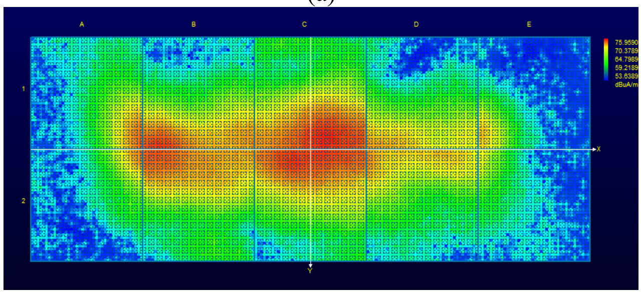
Fig. 1 shows a base-station antenna suspended over an RFxpert scanner on the lab floor. The near-field scanner is an array of H-field probes with an effective scan area of 40cm by 40cm (denoted by the grid on the surface of the scanner in Fig. 1). Therefore, multiple RFxpert scans are required to effectively capture radiations from the large 1.4m by 0.3m antenna. The scanner can easily be moved underneath the antenna to form patches of a larger scan area. Luckily, it is known that the base station antenna is a directive antenna with a fan shaped radiation pattern. Hence, most of the near-field emission is concentrated along the length of the antenna in order to achieve a narrow elevation beam-width. Two different measurement apertures are considered herein. First, the scanner is moved in 5 different positions right under the antenna to form a total scan area of 40cm by 200cm. In the second configuration, the scanner is placed in 10 different locations to double the scan area to 80cm by 200cm. Since the measurements are performed in an uncontrolled lab environment, reflections from the floor can introduce errors in the measurements. In order to suppress reflections from the floor, 6cm-thick multi-layer absorber sheets are placed on the floor around the scanner (the input impedance of the antenna is monitored to ensure minimal loading on the antenna). Moreover, in to investigate the effect of higher order interactions between the scanner board and the antenna (i.e., multiple reflections), the measurements are repeated with and without a half-inch absorber sheet (C - RAM MT - 20) placed on top of the scanner. Consequently, 4 different scenarios are investigated:

1. 1-by-5 array of scanners with no absorber sheet between the scanner board and the antenna.
2. 1-by-5 array of scanners with absorber placed between the scanner board and the antenna.
3. 2-by-5 array of scanners with no absorber sheet between the scanner board and the antenna.
4. 2-by-5 array of scanners with absorber placed between the scanner board and the antenna.

Fig. 1, Set-up showing base-station antenna hanging 8cm above the very-near-field scanner array.



(a)



(b)

Fig. 2, (a): measured $|H_x|$ at 750MHz for Scenario 2, (b): measured $|H_x|$ at 750MHz at 750MHz for Scenario 4.

Fig. 2 shows the magnitude of the measured H-field emissions from the antenna at 750MHz. For simplicity, only the x-component of the H-field is plotted ($|H_x|$). Moreover, only measurement Scenarios 2 and 4 are depicted in Fig. 2. According to the plots of Fig. 2, the measured fields in Scenarios 2 and 4 are almost identical, except for the fact that the measurements of Scenario 2 are truncated beyond ±20cm (i.e., outside scanner area).

III. PROJECTION TO FAR-FIELD

Once the orthogonal H-field components (magnitude and phase) are captured, they are transformed to far-field pattern in a hemisphere using a plane-wave-spectrum expansion [4]. Figs. 3 and 4 show the extracted far-field radiation pattern in azimuth and elevation planes for all four scenarios at 750MHz and 1850MHz, respectively. Table I summarizes important far-field parameters for different scenarios at low and high bands. Based on the values reported in these tables, Scenario 4 seems to give a generally more accurate prediction of the total directivity. The predicted vertical 3dB beamwidth is close to the data sheet values for all scenarios and the horizontal beamwidth is within ±25°. The high band radiation patterns in the Azimuth cut of Fig. 4 demonstrate that the effect of multiple reflections between the scanner and the antenna appear as ripples in the radiation patterns of Scenarios 1 and 3. Therefore, especially at higher frequencies, the use of an absorber sheet between the scanner and the antenna is highly recommended. The far-field patterns in Scenarios 2 and 4 are fairly close to the radiation patterns measured directly in far-field. However, Scenario 4 results in a more accurate pattern as the angle move from broadside to end-fire direction. This is mainly due to the fact that in planar near-field measurement systems, the solid angle within which the far-field patterns are accurate depends on the width of the scan area as radiations beyond a certain angle are not captured by the scanner.

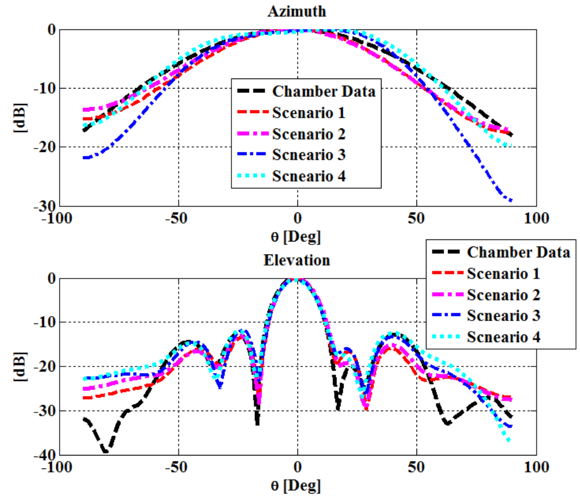


Fig. 3. Far-field radiation patterns at 750MHz.

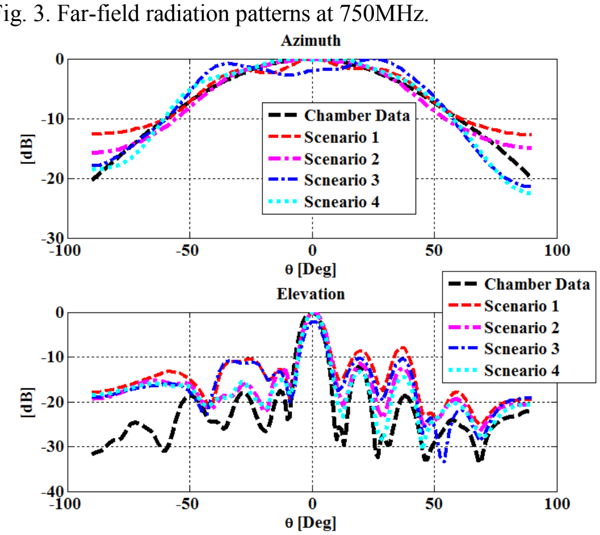


Fig. 4. Far-field radiation patterns at 1850MHz.

TABLE I. FAR-FIELD PARAMETER, RFX2 VS. DATASHEET.

	Directivity	Vertical 3dB Beamwidth	Horizontal 3dB Beamwidth
750MHz			
Datasheet [5]	14.3 dBi	15°	68°
Scenario 1	16.1 dBi	14°	57°
Scenario 2	15.9 dBi	14.3°	58°
Scenario 3	15.5 dBi	13.7°	70°
Scenario 4	14.7 dBi	13.8°	81°
1850MHz			
Datasheet [5]	17.3 dBi	7.5°	61°
Scenario 1	16.8 dBi	7.5°	73°
Scenario 2	17.5 dBi	7.5°	65°
Scenario 3	16.6 dBi	7.5°	86°
Scenario 4	17.0 dBi	7.3°	72°

REFERENCES

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