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A DUAL-POLARIZED PROBE SYSTEM FOR NEAR-FIELD MEASUREMENTS

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Near-field measurements (planar, cylindrical or spherical) on large antennas require thousands of field values to be measured. Usually, two near-field scans are performed with the polarization of the probe antenna rotated 90° between the two scans. A probe which can receive two polarizations at the same time in connection with a three-channel phase/amplitude receiver halves the measurement time and eliminates the need for rotation of the probe. Further, a dual polarized probe system offers improved accuracy in measurements of near-field polarization. The system described in this paper has been designed for spherical measurements in particular, but may be used to advantage for planar and cylindrical measurements as well.

The measurement procedure and the data processing of spherical near-field measurements [1-4] are greatly facilitated by restricting the probe to receive spherical modes with azimuthal index m = ±1 only. If such a probe is rotated about the z-axis of its coordinate system, the received signal W will vary as

$$W(\chi) = W_{+1} e^{i\chi} + W_{-1} e^{-i\chi} \tag{1}$$

even when the probe is in the near field of the test antenna (time factor $e^{-i\omega t}$). Thus from measurements at $\chi = 0^o$ and $\chi = 90^o$ the received signal at any angle χ can be predicted. Assuming reciprocity, the radiation field of the probe will have the form

$$\bar{E}(r,\theta,\phi) = (E_\theta(r,\theta,0)\hat{\theta} + E_\phi(r,\theta,0)\hat{\phi}) \cos\phi$$
$$(E_\theta(r,\theta,90)\hat{\theta} + E_\phi(r,\theta,90)\hat{\phi}) \sin\phi \tag{2}$$

The probe antenna chosen here and sketched in fig. 1 is a conical horn excited by TE_{11}-modes in a circular waveguide. The waveguide is connected to an orthomode transducer (OMT) with two nominally perpendicular linear polarizations. However, the fields excited from the two ports of the OMT will in practice be slightly and differently elliptically polarized and the amplitudes and the phases in particular will be different. When the probe is receiving, the signal in port 2 will therefore not precisely correspond to the signal in port 1 when the probe is rotated 90°, as it is assumed in the usual near-field probe-correction algorithms.

The TE_{11}-mode excitation in connection with the rotational symmetry of the antenna yields

$$E_\theta(r,\theta,90) = pE_\theta(r,\theta,0) \quad \text{and} \quad E_\phi(r,\theta,0) = -pE_\phi(r,\theta,90) \tag{3}$$

where p is the complex polarization ratio E_y/E_x on the z-axis. Let port 1 be the one which nominally excites an x-polarized field on the z-axis. The field radiated from port 1 will be

$$\bar{E}_1(r,\theta,\phi) = (E_\theta(r,\theta,0)\hat{\theta} - p_1 E_\phi(r,\theta,90)\hat{\phi})\ \cos\phi\ +$$
$$(p_1 E_\theta(r,\theta,0)\hat{\theta} + E_\phi(r,\theta,90)\hat{\phi})\ \sin\phi \qquad (4)$$

with the deviation from linear polarization included. The polarization ratio p_1 is measured by a three-antenna method [5-7]. If one of the two other antennas is used for determining the $\phi = 0^o$ and $\phi = 90^o$ patterns of the probe, the functions E_θ and E_ϕ can be found in the far field correcting for the non-linear polarization of both antennas.

The field excited from port 2 which nominally should be y-polarized will have the form

$$\bar{E}_2(r,\theta,\phi) = A_2 \Big[(p_2 E_\theta(r,\theta,0)\hat{\theta} - E_\phi(r,\theta,90)\hat{\phi})\ \cos\phi$$
$$+ (E_\theta(r,\theta,0)\hat{\theta} + p_2 E_\phi(r,\theta,90)\hat{\phi})\ \sin\phi \Big] \qquad (5)$$

where A_2 is a complex phase and amplitude factor and p_2 is the polarization ratio E_x/E_y on the z-axis. Since $E_\theta(r,\theta,0)$ and $E_\phi(r,\theta,90)$ has been found by measurements with port 1, a knowledge of A_2 and p_2 is sufficient to predict the radiation pattern of port 2. A_2 and p_2 can conveniently be measured in connection with the three-antenna polarization measurement with both ports receiving. It is seen that if the two fields (4) and (5) are combined as

$$(\bar{E}_1 - \frac{p_1}{A_2}\bar{E}_2)\ \frac{1}{1+p_1 p_2} = E_\theta(r,\theta,0)\hat{\theta}\ \cos\phi + E_\phi(r,\theta,90)\hat{\theta}\ \sin\phi \quad (6)$$

$$(\frac{\bar{E}_2}{A_2} - p_2\bar{E}_1)\ \frac{1}{1+p_1 p_2} = E_\theta(r,\theta,0)\hat{\theta}\ \sin\phi - E_\phi(r,\theta,90)\hat{\phi}\ \cos\phi \quad (7)$$

the combined patterns correspond to a linearly polarized antenna in the two positions $\chi = 0^o$ and $\chi=90^o$, respectively. When the probe is used for near-field measurements, the signals measured by the two ports W_1 and W_2 shall also be combined as

$$W(0) = \frac{1}{1+p_1 p_2}\ (W_1 - \frac{p_1}{A_2}W_2) \quad \text{and} \quad W(90) = \frac{1}{1+p_1 p_2}\ (\frac{W_2}{A_2} - p_2 W_1) \quad (8)$$

and $W(0)$ and $W(90)$ can then be used in the near-field far-field transformation programs performing the probe correction as for a linearly polarized antenna with the pattern (6). If the calibration measurements are carried out with the total system assembled as shown in fig. 1, the coupling between the two ports and the internal reflections in the waveguides and cables are taken into account by (8) and the probe correction.

The probe system described offers a particular advantage for plane

polar near-field measurements [8], where it is usually necessary to keep the x and y axes of the probe parallel to the x and y axes of the test antenna in order to perform probe correction. When the probe is mounted on a rotating arm it must be rotated synchronously backwards relative to the arm in order to keep its axes parallel to the axes of the test antenna. However, with the probe system described here, the received signal for any polarization angle χ can be found by

$$W(\chi) = W(0)\cos\chi + W(90)\sin\chi \tag{9}$$

Thus the probe can be fixed to the arm and the counter rotation can be accurately done in the computer.

References

[1] F. Jensen, "On the Probe Compensation for Near-Field Measurements on a Sphere", Archiv für Elektronik und Übertragungstechnik (Electronics and Communication), Vol. 29, No. 7/8, pp. 305-308, July/August 1975.

[2] P.F. Wacker, "Non-Planar Near-Field Measurements: Spherical Scanning", Report NBSIR 75-809, Electromagnetics Div., Institute for Basic Standards, Nat. Bureau of Standards, Boulder, Colorado, USA, June 1975.

[3] Fl. Holm Larsen, "Probe Correction of Spherical Near-Field Measurements", Electronics Letters, Vol. 13, No. 14, pp. 393-395, July 1977.

[4] Fl. Holm Larsen, "Spherical Near-Field Transformation Program with Probe Correction", Report R 201, Electromagnetics Institute, Tech. University of Denmark, October 1978.

[5] A.C. Newell and D.M. Kerns, "Determination of both Polarization and Gain of Antennas by a Generalized 3-Antenna Measurement Method", Electronics Letters, Vol. 7, pp. 68-70, Feb. 1971.

[6] E.B. Joy and D.T. Paris, "A Practical Method for Measuring the Complex Polarization Ratio of Arbitrary Antennas", IEEE Trans. Antennas & Prop., Vol. AP-21, No. 4, pp. 432-435, July 1973.

[7] Fl. Jensen, "On Microwave Antenna Polarization", Ph.D. Thesis, LD 29, Electromagnetics Institute, Tech. University of Denmark, July 1976.

[8] V. Galindo-Israel, Y. Rahmat-Samii and R. Mittra, "Plane-Polar Technique for Far-Field Computation from Near-Field Measurements", URSI Meeting, Helsinki, 1978.
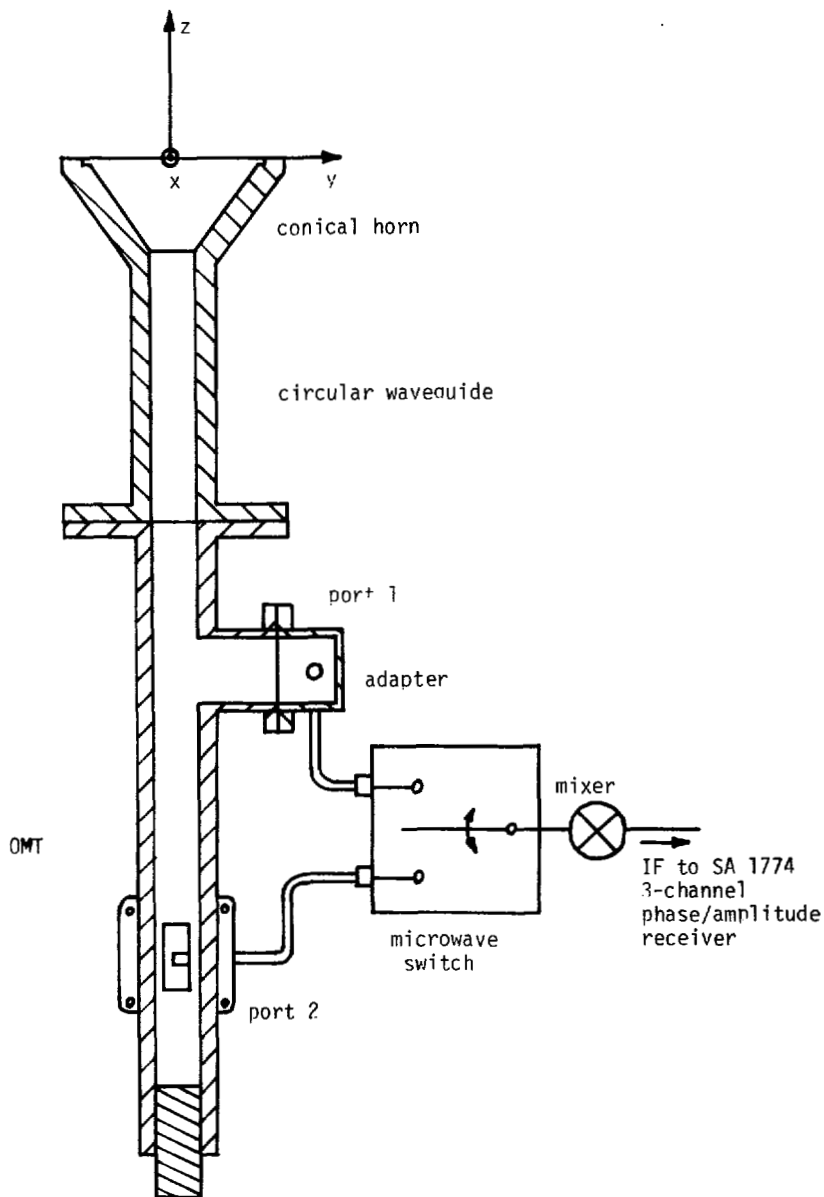
Fig. 1 Probe system with conical horn, **OMT**, microwave switch and time-shared mixer.

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