EVALUATION AND VALIDATION OF THE METHOD OF MOMENTS CODE NEC2 IN THE DESIGN OF LOG PERIODIC DIPOLE ARRAYS WITH LOW SIDELOBE LEVELS FOR BROADCAST APPLICATIONS

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ABSTRACT

The evaluation and validation of the Method of Moments Numerical Electromagnetics Code (NEC2) is undertaken by the comparison of measured and computed radiation patterns of Log Periodic Dipole Arrays. Emphasis is placed on the correspondence of the sidelobe levels -30 to -40 dB down from the major lobe. This paper is concerned with the evaluation of a single antenna in free space.

1. INTRODUCTION

The shortage of available frequencies for rebroadcasting relay links has resulted in the same frequency being used for adjacent links. Anomalous propagation conditions that sometimes occur produce co-channel interference effects at these relay sites [SABC, 1984]. Several methods, such as the use of complicated signal cancellation networks, exist to reduce the co-channel interference. The method under consideration in this paper involves computing and validating the radiation pattern for a single log periodic dipole antenna (LPDA) with the Moment Method program NEC2 running on a mainframe computer. Once the radiation pattern of the antenna can be accurately computed the method can be applied to two LPDA arrays and a mast. The combined array can then be phased and modelled on NEC2 to produce a pattern with a null in the direction of the interference source.

The complexity of analysis is increased from a single antenna in free space to an antenna array on a mast so that a comparison of the NEC2 computed radiation patterns and the measured patterns can be made for each step. This paper deals only with the evaluation of a single antenna in free space. Emphasis is placed on the correspondence of measured and computed patterns in the sidelobes -30 to -40 dB down from the major lobe where reradiation and scattering cause distortion in the patterns at these levels. The antennas are normally horizontally polarized and therefore the analysis concentrates on the E-plane pattern.

If this technique proves successful it would have application to world wide co-channel interference problems.

2. THE NUMERICAL ELECTROMAGNETICS CODE - NEC2

The Numerical Electromagnetics Code (NEC2) is a user-oriented computer code for analysis of the electromagnetic response of antennas and other metal structures. It is based on the numerical solution of integral equations by the Method of Moments for the currents induced on a structure by sources or incident fields. Any structure can be modelled either as a wire, grid of wires or by surface patches. The model may include non-radiating networks and transmission lines connected to part of the structure, perfect or imperfect conductors and lumped element loading [Burke and Poggio, 1981].

The input is in card image format. The data define the structure dimensions, frequency, excitation and other parameters. The output is in the form of a printout with the calculated currents, impedances and radiation patterns. The structure that is modelled is divided into wires, that are again divided into segments. Certain rules apply to the wire and the segment dimensions. These include limits on segment size and segment diameter to length ratio. General modelling guidelines are given in Burke and Poggio [1981], Section II.

3. PROBLEM INVESTIGATION

The basic antenna chosen for measurements and NEC2 analysis is a standard log periodic dipole antenna used for rebroadcasting by the South African Broadcasting Corporation (SABC). Full scale measurements had been carried out by the SABC on these antennas at a frequency of 220 MHz to determine an accurate array radiation pattern on a mast with guy ropes. The National Antenna Test Facility (NATF) [Baker 1983,1984] at Paardefontein north of Pretoria was used. Inconclusive results were then produced due to the high level of unwanted reflections from the Antenna Test Range. The failure of this early measurement program prompted the numerical and physical modelling reported in this paper. Subsequent investigation at the NATF revealed that a favorable frequency at which unwanted reflections were minimal would be above 1 GHz. Scaled measurements of the LPDA would thus have to be performed for validation purposes. The choice of the scaling factor was dictated by the availability of material from which the model antenna could be constructed. A scaling factor of 6.25 was chosen which resulted in the frequency of operation being scaled from 174 - 230 MHz to 1087 - 1437 MHz.

The original antenna had been constructed of galvanized steel. The scaled model antenna was constructed of brass with the elements butt soldered onto a boom. The use of brass enabled the conductivity to be scaled up from that of the original antennas. The LPDA was constructed with the dipole half elements alternately connected to the upper and lower booms [Smith, 1966]. All the elements are thus not in the same plane. The NEC2 model, however, simulates the LPDA as a linear array of logarithmically spaced dipoles decreasing logarithmically in size. These dipoles are connected at their centers by crossed transmission lines.

4. MEASUREMENT RESULTS

The first set of measurements was conducted at the NATF with a single LPDA mounted on top of a fibreglass pole on the microwave ground reflection test range. An E-plane cut of the radiation pattern was made at 1375 MHz and the results recorded graphically. The measured results are compared with the NEC2 computations in Figure 1. It will be noticed that the measured radiation pattern exhibits an oscillation of nearly 10 dB peak to peak at the -30 to -40 dB level. This is due to unwanted range reflections [IEEE, 1979].

The second set of measurements was conducted at the NATF on a different test range in an attempt to reduce the range reflections which were causing distortions in the sidelobe patterns. This was done on a slant range [Arnold, 1966] with the source (a 10 ft. dish) at ground level and the antenna under test on a positioner on a high building. The antenna height above ground was 26 ft. These results are compared with those predicted by NEC2 in Figure 2. The measured sidelobes display oscillations, with variation in the measurement angle, similar in magnitude to those of the first test.

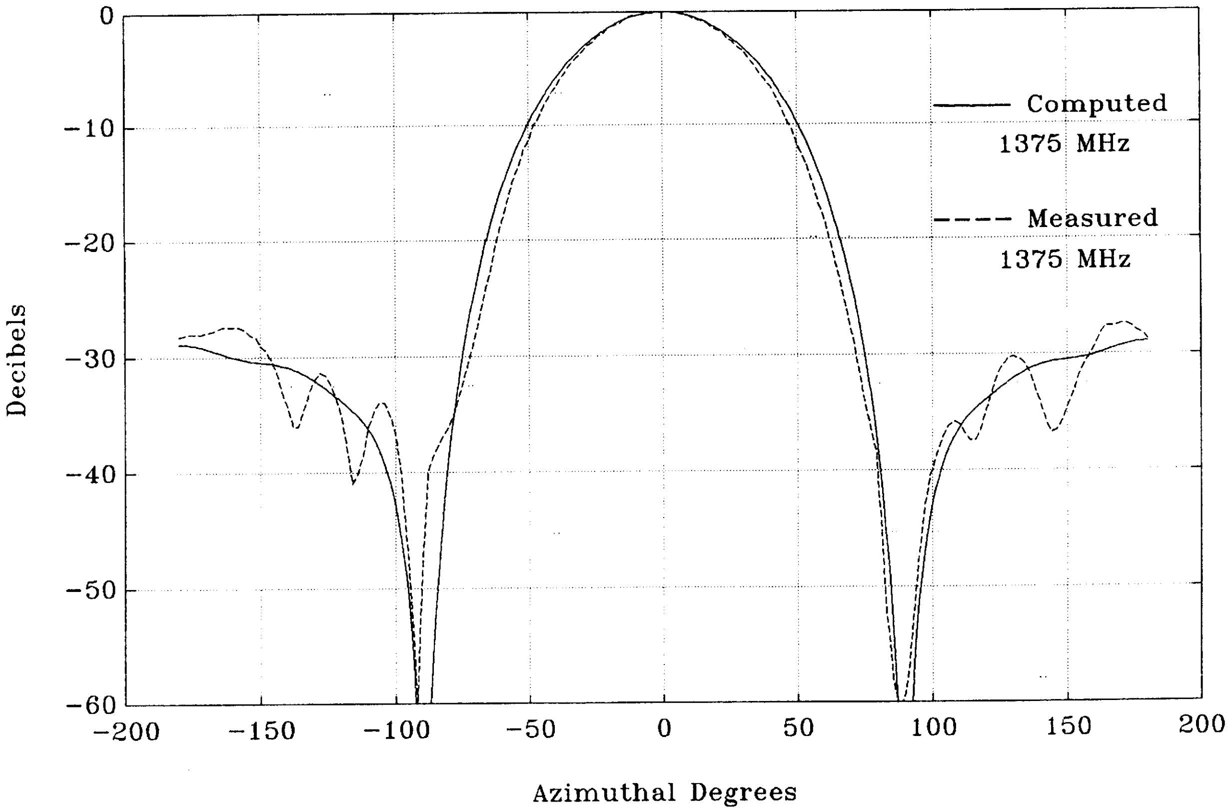

Fig. 1. Comparison of NEC2 and Measured results at 1375 MHz for a Single Antenna in Free Space measured on Ground Reflection Range.

A third set of measurements was then conducted using a totally different technique on a roof range at the Council for Scientific and Industrial Research (CSIR) in Pretoria. An HP 8510 Network Analyzer was selected, as it is able to implement a pseudo-time gating function. The time gating limits the frequencies to values corresponding to a selected bandwidth which is adjusted to eliminate reflections that arrive at the antenna later in time than the direct signal. [Boyles, 1985, HP 8510B Operating Manual, 1987]. The antenna is rotated in one degree steps. The frequency is swept across the antenna bandwidth at each step. The active

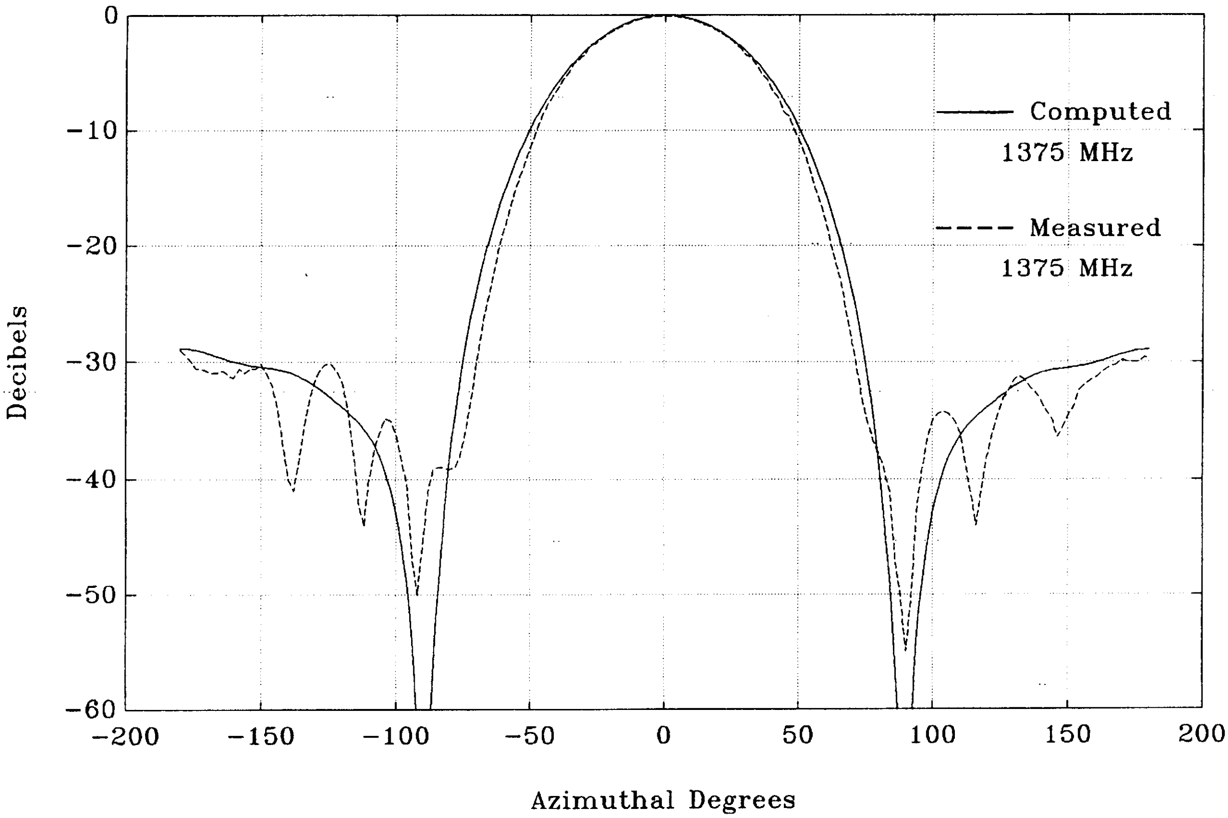

Fig. 2. Comparison of NEC2 and Measured results at 1375 MHz for a Single Antenna in Free Space measured on the Slant Range.

region of the LPDA thus moves along the antenna and is not restricted to that corresponding to 1375 MHz. Results of these measurements are compared with NEC2 computations in Figure 3. Oscillations were still present at the -30 to -40 dB level which indicates that either all the reflections were not gated out, or that the filtering bandwidth was not large enough.

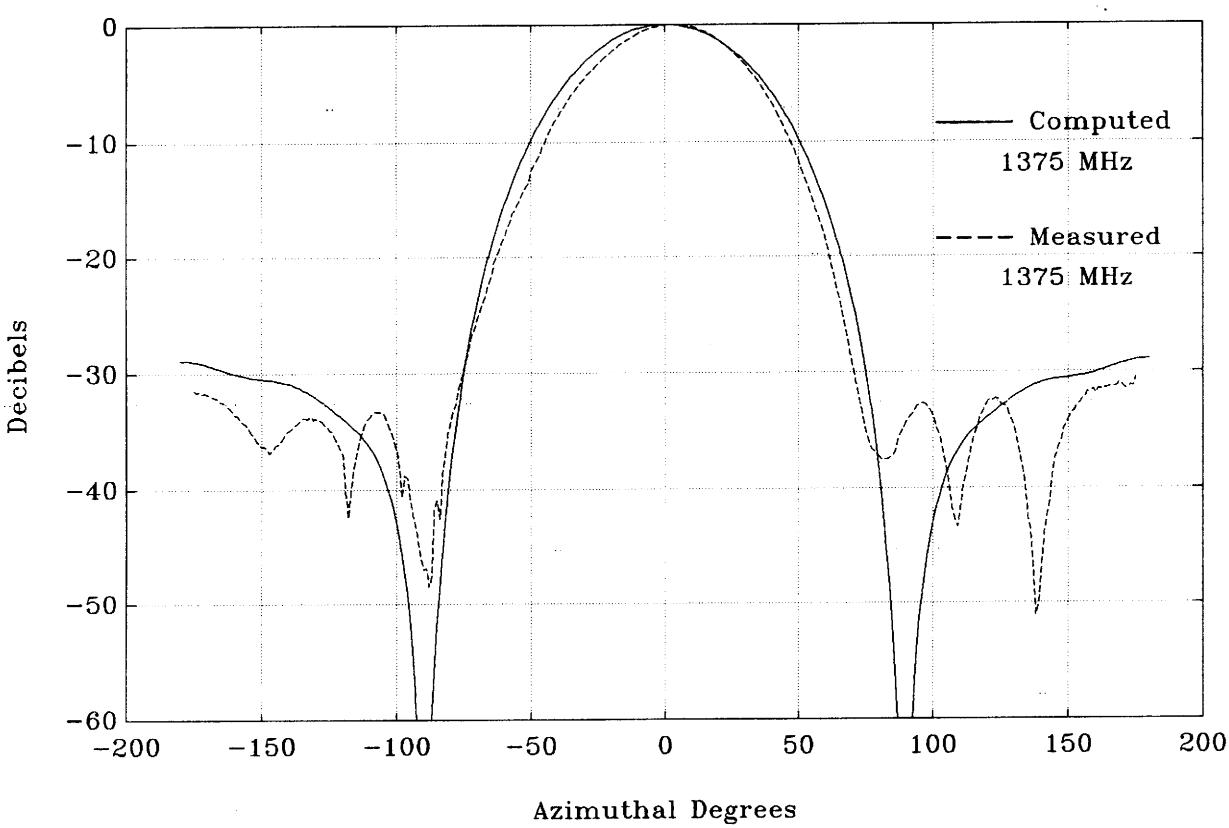

Fig. 3. Comparison of NEC2 and Measured results at 1375 MHz for a Single Antenna in Free Space measured on the Roof Test Range with pseudo-time gating.

5. CONCLUSIONS

The results shown in Figures 1, 2 and 3 are for a single LPDA in free space. It is clear that the measurement of low sidelobe levels (-30 to -40 dB down from the major lobe) is extremely sensitive to unwanted reflections from the test range. This can be concluded from the constant presence of oscillatory sidelobes with three different measurement techniques. If a reflected wave is incident at a certain angle and the test antenna is oriented so that its major lobe is pointing toward the source, the reflected wave is then received on a side lobe and has negligible effect on the measured magnitude of the major lobe. When the antenna is rotated so that the major lobe is pointing in the direction of the incoming reflected wave the apparent level of the sidelobe can deviate significantly from that obtained in the absence of the reflected wave [IEEE, 1979]. The magnitude of the reflected signals in the measurement setup can be estimated by observing that the sidelobe oscillations in Figure 2 have an 11 dB swing at approximately -140 degrees. A simple calculation shows that the scattered signals are thus approximately -40 dB down from the major lobe. In order to conduct accurate measurements the scattered signals should preferably be at least -50 or more dB down.

Considering the major lobe pattern, the correspondence of measurement with the NEC2 computation is good for all three cases. There is however a 2 dB discrepancy at -20 dB down which is probably due to differences between the actual LPDA construction and the NEC2 model.

The sidelobe interference posed the greatest problem in the verification of the measurements with NEC2 computations at low sidelobe levels. The measurement asymmetries confirm the presence of multipath signals. It is noted, however, that in Figures 1 and 2 the NEC2 predictions agree reasonably well with the "average" measured sidelobe levels, but in the pseudo-time gated measurements of Figure 3 additional complications result in poor sidelobe correspondence. It is suspected that the time gate moved as the antenna was rotated. Work is continuing to reduce the range reflections, re-evaluate the NEC2 antenna model and extend the analysis to validation of a pair of LPDA arrays on a mast.

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