A WIRE GRID MODEL FOR THE ANALYSIS OF
VHF ANTENNAS MOUNTED ON THE
BHASKARA SATELLITE

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1. Introduction

Analysis of radiation patterns of antennas in the presence of obstacles is of interest in the design of quasi-isotropic antenna systems for satellite applications. The wire-grid modelling technique has been employed in the present paper for the analysis of radiation patterns of the VHF antenna assembly mounted on the Indian satellite BHASKARA-I. The results have also been compared with those obtained by measurement.

The BHASKARA satellite has the shape of a quasi-spherical polyhedron with 26 flat faces. The VHF antenna assembly is an array of four monopoles mounted parallel to the spin axis and operating in the frequency range of 136 to 149 MHz. The monopoles are fed in a turnstile fashion with a progressive phase difference of 90 degrees. Since the largest dimension of the satellite is of the order of 0.725 wavelengths, the asymptotic techniques may not be well suited for the pattern computation. The analysis therefore calls for a numerical solution of the electric or magnetic field integral equations for the current distribution on the entire structure. Many of such methods can often be conveniently explained by the unifying theory of the method of moments[1]. Two options may be available to the designer. They are (a) the surface patch modelling technique [2] or (b) the wire grid modelling technique [3]. Although surface patch models would be expected to yield more accurate results as compared to wire grid models, a problem arises due to the antenna configuration where the monopoles are mounted directly on the edges. Such a configuration becomes difficult to handle in the surface patch modelling technique. The wire-grid model on the other hand can handle such a configuration and has therefore been employed in the present work.

2. Analysis

The mathematical model has been derived from the actual satellite model by making certain simplifications (Fig.1). The structure is considered as a generalised polygon assembled from straight perfectly conducting wire segments. The radius of the monopoles is of the order of 0.002 wavelengths (which is well within the limits valid for the thin wire assumption) and is also taken as the radius of all the segments of the grid. The end points of each segment are defined and care is taken to ensure that the segment length does
not greatly exceed 0.1 wavelengths. On each thin wire a set of
terminals or current sampling points are defined. Terminals are also
defined at each corner or bending point and at each junction where
several wires intersect. With several terminals defined in this manner
the wire structure is treated as a multiport system. A piece-wise
sinusoidal expansion is used for the current distribution on each
segment. Richmond's[3] sinusoidal reaction formulation is employed in
the solution of the electric field integral equation. The matrix
equation \[ Z[I] = [V] \] is generated by enforcing reaction tests with a set
of sinusoidal dipoles located in the interior region of the wire, a
procedure similar to that of the Galerkins method. The elements of the
impedance matrix \[ Z \] are generated by computing the mutual impedance
between the wire segments. This segmentation procedure resulted in a
total of 214 sinusoidal modes on the entire structure. The elements of
the exitation matrix are calculated by assuming a unit voltage delta
gap feed. This set of simultaneous equations are then solved for the
current distribution \[ I \] from which the radiation pattern is computed.

3. Numerical results and discussion

The normalized radiation pattern is computed over the entire
sphere and is shown in the form of a contour plot in Fig.2a. The
experimental \[ 4 \] results with the contour levels expressed in dBd are
also shown in Fig.2b for comparison. These results are at a frequency
of 137.4 MHz for a right handed circular polarization. The overall
agreement between the results may be seen to be good. The present
method has also predicted reasonably accurate input impedances. For the
example illustrated in Fig.2, the computed value of the input impedance
was 85.0-j16.2 Ohms as compared to the measured value of 63.5-j11.5
Ohms. Similarly the performance index isotropy[5] computed from the
theoretical results was 0.701 as compared to 0.706 computed from the
measured values of the radiation pattern. It is thus illustrated that
the wire grid model even with a moderately large grid size provides a
reasonably accurate method for the analysis of satellite mounted
antennas.

4. References

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1. THE WIRE GRID MODEL (all dimensions in mm)
2. POWER PATTERN AT FREQUENCY 1374 MHz AND RHC POLARIZATION
   a) THEORETICAL (NORMALIZED) dB (b) EXPERIMENTAL (dBi)