Single-Post Inductive Obstacle in Rectangular Waveguide

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Abstract — A rapidly converging moment solution for electromagnetic scattering by a single inductive post in a rectangular waveguide is obtained. The numerical results show good agreement with Marcuvitz's data as far as this data goes. Furthermore, Marcuvitz's curves are extended to cover data for large posts. This new data should allow one to design a simply constructed new type of narrow bandpass filter, namely, a filter consisting of large single posts. The successful use of this straightforward moment solution in solving the single-post problem suggests that this technique should prove useful in solving a variety of microwave discontinuities such as those involving thin or thick irises and posts of arbitrary shape.

I. INTRODUCTION

In designing bandpass filters for rectangular waveguides, one usually utilizes a number of sections, each of which comprises a high-Q resonant cavity. Such a cavity is formed of two obstacles nearly half a guide wavelength apart followed by a connecting length that is an odd multiple of a quarter-guide wavelength long. Of all conventional obstacles, a single cylindrical post, placed across the guide parallel to the narrow wall and parallel to the electric field of the dominant mode, is the most attractive from a fabrication point of view.

Schwinger had originally solved the single-post problem during World War II for small posts and his data is given in Marcuvitz's Waveguide Handbook [1]. One may think of the post problem simply in terms of the current which is induced on the post. Current is longitudinally directed (along the post axis) and varies circumferentially. The variation on each post may be represented by a Fourier series. Schwinger had taken into account the zeroth and first-order terms of the series. This had limited the results to posts which were of moderate size and were distant from the walls and from each other. Those interested in microwave filter design soon found out that when narrow bandpass filters were desired they needed larger posts. Mariani [2] recognized the need for larger posts, but, because data was lacking, decided to analyze the triple-post configuration consisting of three small posts, each within the range of Schwinger's analysis. Also available is a work by Bradshaw [3] who derived improved variational expressions for scattering from a round metal post with gap.

This paper develops a moment solution [4] for the single-post problem and extends Marcuvitz's curves to cover data for large posts. This new data should allow one to design a simply constructed new type of narrow bandpass filter, namely, a filter consisting of large single posts.

In treating the single-post problem, we use a multipole representation of the current. The field due to each filament is then expanded in terms of waveguide modes. This leads to a slowly converging series which is not convenient for computation. Fortunately, this severe drawback can be overcome by converting the series to a rapidly converging one. Subsequently, a multiple point-matching of the boundary condition is applied and the unknown filamentary currents are readily obtained. Finally, we calculate the scattering matrix for the post two-port junction, and then obtain the equivalent T network for that junction. We also use the unitary condition of the scattering matrix, which is equivalent to the power conservation law, to estimate how good our approximate solution is.

In addition, we employ another independent method of moment procedure to provide a check against the first one in regions where no experimental data or other analytical results are available. The other method uses a multipole representation of the current and a Galerkin procedure for the boundary condition. The method uses an infinite series of images rather than the waveguide-mode representation, and we found a way of summing the series analytically. A detailed analysis of the second method will appear in a forthcoming paper.

The computer results for the single post from the two dissimilar methods agree with each other within a fraction of one percent and plot right on top of Marcuvitz's data as far as this data goes. Furthermore, we extend Marcuvitz's curves to cover data for large posts. The results obtained from both methods for large posts also show a remarkable agreement. Apparently these methods both can provide an accurate solution. It also appears likely that the first method can be applied to other classes of problems such as those involving thin or thick irises and posts of arbitrary shape.

II. PROBLEM SPECIFICATION AND EQUIVALENT SITUATION

The physical configuration of the problem under study is shown in Fig. 1, together with the coordinate system used.