Abstract

Multiple Cavity Modeling Technique (MCMT) has been used to analyze a class of rectangular waveguide based circuits and radiators. The methodology involves in replacing all the apertures and discontinuities of the rectangular waveguide based structures, with equivalent magnetic current densities so that the given structure can be analyzed using only Magnetic Field Integral Equation (MFIE). To make the MFIE applicable to the generalized waveguide structure problem, the given structure is modeled using rectangular cavities. As it is necessary to use a number of such cavities in order to study these complicated waveguide structures, the present method is named as MULTIPLE CAVITY MODELING TECHNIQUE (MCMT). The interfacing apertures between different regions (waveguide – cavity, cavity – cavity, cavity –half space) are then replaced by equivalent magnetic current densities. The magnetic field scattered inside the cavity region due to this source is determined by using cavity Green's function of the electric vector potential. The cavity Green's function has been derived by solving the Helmholtz equation for the electric vector potential for unit magnetic current source. The scattered magnetic fields in the waveguide region due to the presence of the transverse magnetic current densities are solved by rigorous mode matching technique. The scattered field inside the waveguide due to slots in the broad / narrow wall of the waveguide has been derived using the Green's function for the electric potential for such a slot. From the field existing at the aperture fed by a waveguide, the radiated field can be evaluated using plane wave spectrum approach. The radiated field is obtained by expanding the spherical waves in terms of plane wave spectrum in the vector potential formulation. By applying the continuity condition of the tangential magnetic field at the interfacing apertures, and expanding the unknown magnetic current densities in terms of piecewise linear (triangular) basis function by using the Method of Moments, the problem is reduced to solving the simultaneous linear equations.

Using the methodology some of waveguide based structures corresponding to two port, three port and four port networks are studied. This includes

1. *Analysis of waveguide discontinuities and two, three and four port passive circuits.*
2. *Even and Odd mode analysis of waveguide based circuits.*
3. *Study the effect of closely spaced matched load on waveguide circuits.*
4. *Analysis of waveguide aperture radiator.*
5. *Analysis of waveguide aperture as EMI sensor.*
6. *Study the behavior of a matched transmitter in receiving mode.*
7. *Analysis of broad wall slot radiator.*
8. *Estimation of EMI from waveguide joints.*

Waveguide discontinuities include waveguide step and right angle waveguide bend. The two port waveguide circuit consists of interacting thick irises and resonant iris band-pass filter whereas the three port waveguide circuits include power divider / combiner, folded E-plane Tee-junction. The four-port circuit consists of longitudinal / transverse slot coupled crossed waveguide junction. An aperture fed by a waveguide is studied among waveguide aperture radiator. The thesis provides a complete and accurate analysis of these problems. Algorithms have been developed for the determination of the S-

parameters and hence to determine equivalent network model parameters. The thesis is broadly divided into following heads:

CHAPTER 1 presents an extensive survey of literature on the different methodologies used for the analysis of different two port, three port and four port networks which includes both the waveguide circuit elements as well as waveguide based aperture radiator and slot radiators. It also discusses the shortfalls of different methods and the requirement for carrying out the present work.

CHAPTER 2 presents the derivation of the cavity Green's function for the electric vector potential and hence the cavity scattered fields. The evaluation of fields scattered within the waveguide and into the free space due to different types of waveguide discontinuities, in the form of apertures are presented in the same chapter.

The analysis of two basic building blocks of the waveguide based structures a) Waveguide step discontinuity and b) Waveguide bend have been presented in ***CHAPTER*** *3. Details theory of even and odd mode analysis of a symmetric two port circuit has been presented with the example of symmetric interactive inductive irises in waveguide.*

The analysis of different class of 1: 2 power divider and 2:1 power combiner has been studied in ***CHAPTER 4****. These include a) Folded E-plane Tee- junction b) E-plane and H-plane joint power divider / combiner.*

CHAPTER 5 presents the analysis of a waveguide resonant iris band pass filter assuming a matched termination. This assumption is a reasonable if there is sufficient length of waveguide section between the output of the filter and the load point to let the existing higher order modes to be died out. In absence of sufficient length of waveguide section the higher order modes, existing at the filter end, see a complex load at the end of the filter which in turn affects the insertion / return loss characteristics of the filter. An attempt has been made to analyze such case subject to the worst condition where all the higher order modes get totally reflected from the load.

A very important class of waveguide fed radiator, namely the radiating rectangular window excited by a rectangular waveguide is studied in ***CHAPTER 6****. Primarily, the axes of the radiating aperture are assumed to be parallel to that of the waveguide axes. Next the effect of the window inclination has been studied. Finally a generalized analysis for the receiving characteristics of waveguide probes for measurement of EMI has been presented. The equivalent circuit of the open end of the waveguide contains a frequency dependent resistor equal to the radiation resistance of this antenna and in addition a frequency dependent reactive component which can be approximated as capacitive for metal waveguides. So this antenna can be matched by a small inductive inhomoginity, such as thin metal diaphragms with vertical slots. The performance of both the matched and unmatched radiator has been compared both in transmitting and receiving mode. A moment method analysis of an arbitrary length broad wall longitudinal slot radiator is presented in* ***CHAPTER 7****. A generalized network model is proposed.*

*End to end waveguide joints often have a scope of leaving small gap due to defects in manufacturing, through which radiated emission is possible. Such gaps can easily be modeled as waveguide transverse slot, with the thickness being equal to the height of the waveguide flange. A moment method analysis to estimate the EMI produced due to defects in mechanical joints between waveguides is presented in **CHAPTER 8**.*

***CHAPTER 9** presents a moment method analysis of a broad wall slot coupled crossed rectangular waveguide junction. The coupling slot is longitudinal / transverse and offset from the centre lines of the guides.*

The theoretical results obtained for the above waveguide based passive circuits / antennas have been verified by comparing with theoretical / measured / commercially available software simulated data.

Key Words

Multiple Cavity Modeling Technique, Method of Moments, Galerkin's Technique, Entire Domain Basis Function, Piece-wise Triangular Basis Function, Green's Function, Vector Potential Approach, Fourier Transform, Modal Expansion, Spectral Domain, Waveguide Step, Waveguide Bend, Waveguide Diaphragm, Even Mode and Odd Mode, Push-Push and Push-Pull Port Excitation, Waveguide Power Divider, E-Plane Tee-junction, Resonant Iris Band-pass Filter, Matched Load, Window Radiator, Electromagnetic Interference, Electromagnetic Compatibility, EMI Sensor, Antenna Factor, Longitudinal Slot, Transverse Slot, Waveguide Joint, Longitudinal / Transverse Slot Coupled Crossed Waveguide Junction.