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A GSM-based method for the electromagnetic analysis and design of truncated periodic structures

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ABSTRACT

The research activity, illustrated in this work, has been developed in the area of applied electromagnetics and it concerns the development and the improvement of a hybrid numerical method combining the Mode Matching (MM) and the Finite Element (FE) specifically derived for the study of complex microwave devices. Firstly, the optimization problem of unconventional Frequency Selective Surfaces (FSSs), obtained by using NURBS curves, is analyzed. A genetic algorithm is used in order to address the optimization of a multiparametric structure such as the FSS. The hybrid method MM-FE is used to evaluate the frequency behaviour of this kind of structures. The hybrid technique is therefore applied to the study of large finite arrays of open-ended or iris-loaded waveguide apertures or horn antennas. The finite dimensions are taken into account by using a Spectral Decomposition (SD) approach that allows us to reduce the finite problem to a summation of infinite periodic ones. A similar procedure, now based on the Method of Moments (MoM) and the spectral decomposition approach, is applied to the analysis of finite thin frequency selective surfaces. Finally the hybrid methodology MM-FEM-SD, combined with an MoM, is used to study finite arrays of rectangular waveguide cascaded with a finite thin FSS. In order to prove the effectiveness of this methodology, several numerical results are compared with that obtained through a commercial software or available in literature.

SOMMARIO

Obiettivo dell'attività di ricerca scientifica, svolta nel settore dell'elettromagnetismo applicato, consiste nell'impiego e nell'estensione di un metodo numerico Mode Matching - Finite Element Method (MM-FEM) per l'analisi di dispositivi a microonde. In una prima fase, è stato affrontato il problema dell'ottimizzazione di superfici selettive in frequenza (Frequency Selective Surfaces - FSSs) non convenzionali ottenute mediante curve NURBS (Non Uniformal Rational B-Spline). Data la natura multiparametrica delle strutture in esame, il problema dell'ottimizzazione è stato affrontato mediante l'impiego di una tecnica evoluzionistica, di natura stocastica, nota come algoritmo genetico. Per l'analisi delle prestazioni e del comportamento in frequenza di tali strutture, è stato impiegato il metodo ibrido Mode Matching- Finite Elements Method. Tale metodo è stato inoltre utilizzato per l'analisi di array finiti di guide d'onda open-ended o iris-loaded e antenne horn. Le dimensioni finite delle strutture in esame sono state considerate mediante il metodo Spectral Decomposition (SD). Tale tecnica consente di ricondurre l'analisi del problema finito, a quella di una combinazione di problemi equivalenti di tipo infinito, più semplicemente analizzabili.

Una procedura basata sulla decomposizione spettrale e su un metodo dei momenti (Method of Moments - MoM) per strutture periodiche sottili è stata applicata allo studio di superfici sottili selettive in frequenza di dimensioni finite. Infine, la metodologia impiegata nelle attività sopra descritte è stata utilizzata per lo studio di sistemi compositi, costituiti dalla cascata di un array di guide d'onda o antenne horn e una o più FSS entrambi di dimensioni finite e diversa periodicità.

La correttezza della metodologia impiegata nelle attività descritte è stata verificata mediante esempi presenti in letteratura o mediante software commerciali.

LIST OF ACRONYMS

AMC: Artificial Magnetic Conductor;

DFT: Discrete Fourier Transform;

EFIE: Electric Field Integral Equation;
EBG: Electromagnetic Band Gap;

FEM: Finite Element Method;
FFT: Fast Fourier Transform;
FSS:Frequency Selective Surface;

GA: Genetic Algorithm;
GAM: Generalized Admittance Matrix;
GIM: Generalized Impedance Matrix;
GSM: Generalized Scattering Matrix;

MM: Mode Matching;
MoM: Method of Moments;

NURBS: Non Uniform Rational B-Spline;

PEC: Perfect Electric Conductor;
PMC: Perfect Magnetic Conductor;

SD: Spectral Decomposition;

TE: Transverse Electric;
TEM: Transverse ElectroMagnetic;
T(FW)2: Truncated Floquet Wave Full-Wave;
TM: Transverse Magnetic;

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