T-MATRIX ANALYSIS OF ELECTROMAGNETIC WAVE
DIFFRACTION FROM A FOURIER GRATING

Makoto Ohki,1 Haruo Sakurai,2 and Shogo Kozaki1

1Department of Electronic Engineering
Faculty of Engineering
Gunma University
1-5-1 Tenjin-cho, Kiryu-shi 376
Gunma, Japan
2Department of Information and Computer Engineering
Gunma College of Technology
580 Toriba-machi, Maebashi 371
Gunma, Japan

Received July 22, 1997

Abstract

This paper is described for T-matrix analysis of the electromagnetic wave diffraction from a Fourier grating that the boundary value problem is treated by applying the extended boundary condition. The rigorous form of the expression of matrix elements is presented in the term of Bessel functions of the first kind. The error of power conservation versus the truncated number has been examined for mode number. Diffraction efficiencies versus groove depth and wavelength for a second or third harmonic wave of Fourier grating have been discussed. Numerical results are in good agreement with those obtained from other method and experimental values. Reasonable numerical results are presented for a groove depth per period of the Fourier grating less than 0.25.

Key words: electromagnetic wave diffraction, Fourier grating, T-matrix method, extended boundary condition

2031

0195-9277/97/000-2031$1.50 © 1997 Plenum Publishing Corporation
1. Introduction

The diffraction problem of electromagnetic wave from a sinusoidal grating is one of the basic problems in light wave technique and radio wave engineering. This important boundary value problem was investigated originally by Waterman[1] in the acoustic wave diffraction problem and Chuang and Kong[2] described an extensive literature survey. Recently, the Fourier grating as a kind of holographic grating has been developed by using holographic exposure process, and analysis of this grating has already been carried out by using the boundary element method[3] and mode matching method(MMM)[4],[5],[6]. We are interested in the diffraction problem from a metallic Fourier grating whose profiles are represented by a superposition two kinds of sinusoidal waves. When diffraction characteristics of the Fourier grating are analyzed in long wavelength region of light and microwave region, it was useful in an optimizing efficiencies so that amplitude of basic sinusoidal wave, a period, second or third harmonic wave amplitude and phase[3],[4],[7]. Otherwise, the diffraction efficiency versus wavelength for Fourier grating of third harmonic wave is also presented by Matsuda[5].

In this paper, the extended boundary condition method given by Chuang and Kong[2] was applied to analyze the Fourier gratings. This method is so called T-matrix method in the formulation of the problem and also it is regarded as an adjoint method to the MMM[8]. We obtained elements of T-matrix for Fourier grating with basic sinusoidal wave plus second or third harmonic wave newly, while an analysis of Chuang only basic sinusoidal wave is treated. Numerical results for the diffraction efficiency of the Fourier grating are presented for comparison with MMM[4] in second harmonic wave. For the other checking, we obtain a good agreement with the experiment value[9] and numerical results using by MMM[6] which depends on groove depth per period(h/P). Reasonable numerical results of the diffraction efficiency versus wavelength are described for a groove depth per period of the Fourier grating less than 0.25 on condition that the amplitude ratio of second or third harmonic wave is smaller than 0.3.

2. Basic formulation

Let us consider the electromagnetic wave diffraction by periodic varying surface(e.g. Fourier grating) illuminated by a plane wave. We assume a two-dimensional problem where the surface does not vary in the y direction and the plane of incidence is the x – z plane for incident angle $\theta_i$ as shown