PROCEEDINGS OF ISAP2005, SEOUL, KOREA

CHARACTERISTICS OF GUIDED-WAVE ELECTROMAGNETIC BANDGAP STRUCTURE

Guan-Yu Chen and Jwo-Shiun Sun
Department of Electronic Engineering, National Taipei University of Technology
Microwave & Wireless Components Laboratory
1, Sec.3, Chung-Hsiao E. Rd. Taipei 106, Taiwan,
E-mail: s1669012@ntut.edu.tw & jss@en.ntut.edu.tw

1. Abstract

The performances of the periodic surface structures (PSS) of different geometric shapes on the ground plane are studied. Simulated results with full wave electromagnetic analyses are in good agreement with those experimental data. The optimal structure of PSS bringing about the perturbation electromagnetic waves and power loss will be determined. The proposed wideband PBG microstrip line has defect tapered ground surface with the characteristics of lowpass, bandstop and leaky wave characteristics, respectively.

2. Introduction

The periodic surface structure (PSS) is like frequency selective surfaces (FSS) [1] or photonic bandgaps (PBG) [2] structures are effective in microwave application that provides an effective control of electromagnetic waves along specific direction. Controlling the periodic distance of PBG that exist band reject characteristic. Periodic ground surface (PGS) have some excellent performance applied microwave transmission line guide such as the microstrip PBG [3], coplanar waveguide PBG [4], coplanar-stripline PBG [5], uniplanar compact PBG [6] and multiplayer PBG [7]. The perforation patterns of PBG on the ground surface with band-stop and slow wave characteristics are studied. The PGS show great promise in improving the power added efficiency and radiation pattern in high power amplifiers [8], increase the Q value of planar inductor [9] or high efficiency planar antenna [10] application to suppress unwanted sub-harmonic compared to conventional harmonic turning techniques. Some papers also report a new tunable technique on traditional planar filter [11] or DR filter [12] to reject undesired resonator modes. In this paper, a 50Ω microstrip-line placed at center the PGS with various PBG structures are studied, then proposed novel wide reject low pass characteristic on tapered PBG microstrip line. By the way of measurement and simulation to detect this structure exist obvious passband, stopband and leaky wave band region then compare with interrelate research papers[13~16]. Final via measurement to calculate electromagnetic patten on leak wave region, then find this tapered PBG structure can as a leak wave antenna that hold leaky power loss and radiation wave performance, and have super wide reject band characteristic as a perfect lowpass filter circuit.

3. Design methodology

Some effective approach, which used any shapes lattice of PGS on PBG microstrip line, has been proposed. However, this is the first study to compare efficiency of various PBG microstrip line in this paper. The PBG microstrip line implemented with periodic perforation on ground surface for PGS of different geometric shapes are studied as showed in Fig. 1. Design methodology [17] based on periodic structure then co-operate by using moment method [18] and physic EM current propagates sense to implement.

4. Effective perturbation of PBG structures

A 50Ω microstrip-line placed at center PSS above the different hole’s structure on the ground surface with 1D periodic holes array by the perturbation of electromagnetic waves are studied. Simulation [19] based on method of moment, which the electromagnetic problem is based on spectral domain method applied to three-dimensional circuits, was applied for graphical

ISBN: 89-86522-78-0 94460©KEES

environment to analyze the EM performances of various PSS on ground surfaces. An FR4 substrate (dielectric constant 4.4, loss $\tan\delta$ =0.015 and height 1.6 mm) was used for this design. Fig.1 shows the layout of the designed PSS with a 50Ω microstrip line at the center position above the periodic square, polygon, triangle and spider unite cells of the perforation on the ground surface with 1D periodic holes array called PBG microstrip line, respectively. L=W=8 mm with periodic distances D=2L=16 mm of the ground surface plane. The distance between the periodic holes on ground plane is calculated by (1) and the center frequency of stop-band is about 5GHz.

$$D = \frac{c}{2 \times f \times \sqrt{\varepsilon_e}} \quad (1)$$

where

D : distance between the periodic holes on ground plane

f : center frequency of wanted stop-band

c : velocity of light

ε_e : effective dielectric constant for Microstrip line

Fig.2, 3 and 4 shows the measured results for an evident maximum energy perturbed by periodic holes for the 50Ω microstrip line above the periodic square and polygon with 1D periodic holes array. Obviously, the 50Ω microstrip line above the periodic triangle and spider with 1D periodic holes array that have minimum energy perturbed an high power loss characteristic, receptivity. It also demonstrates the fairly good agreement with those design results.

5. Tapered periodic defect ground surface and antenna radiation measurement

For microwave applications of the designed PGS structure, the measured results can be defined as a stop-band region to reject harmonic responses that permutation with tapered defect ground surface, as seen in Fig.5. As the same substrate shows the layout of the designed with a 50Ω microstrip line at the center position above the periodic tapered square holes are approach 3*3, 6*5, 9*9, 15*15 mm of the ground surface plane with gap is equal to 3 mm. Measured data as shown in Fig.6, some characteristics for 0.1 GHz ~ 10.1 GHz as good lowpass filter type which wide rejection band, and below 11GHz PBG microstrip line exist 12.7 GHz, 15.4GHz and 18.4 GHz high order antenna mode is like a slot antenna. This structure by measured data exist obvious passband、stopband characteristic as a perfect wideband lowpass filer and exist leak wave region which high power loss factor in 9.23 GHz, 10.6 GHz, 12.7 GHz, 15.4GHz and 18.4 GHz, as seen in Fig.7. Measured radiation patten is proportional to the radiation electric field as shown in table.1 and Fig.9.

6. Conclusion

PBG on the different ground-perforated cells and tapered defect ground surface are implemented. The PBG microstrip structure exhibit band-stop filter character due to perturbation of current distribution on periodic holes array. The microstrip line incorporated with the suitable PGS show quite clear band-stop character to reject unwanted frequencies. The PBG microstrip line can be applied for microwave different applications such as antenna, amplifier, surface wave suppression and filter design, etc. Finally, Simulated results show fairly good agreement with those experimental data.

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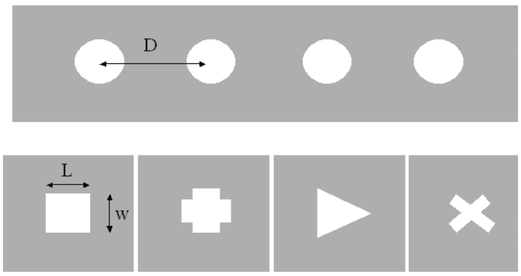

Fig. 1. PBG microstrip line & various ground surface structures

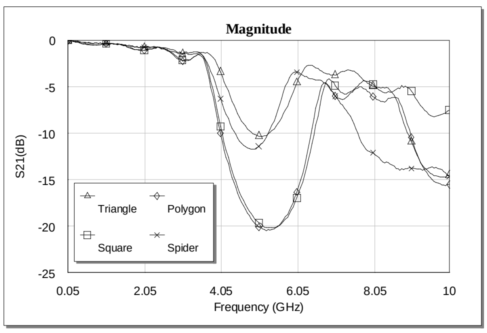

Fig. 2. Measured return loss data of the four PBG microstrip line

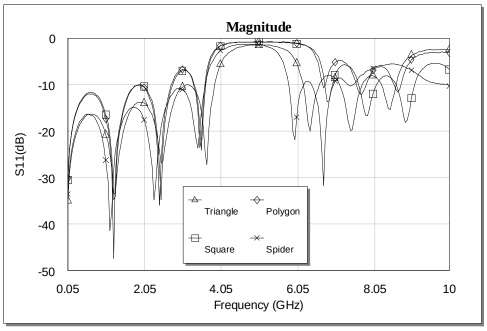

Fig. 3. Measured insertion loss of the four PBG microstrip line

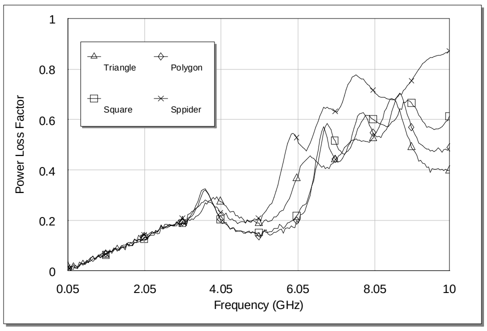

Fig. 4. Measured power loss of the four PBG microstrip line

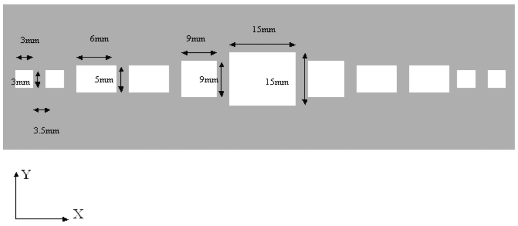

Fig. 5. Proposed tapered PBG microstrip line

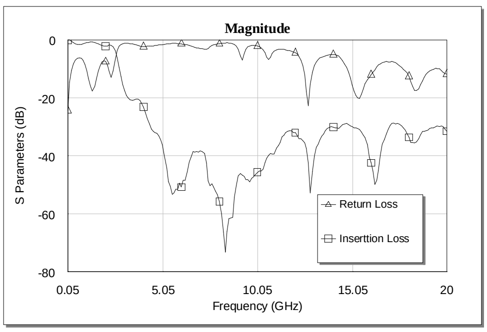

Fig. 6. Measured return loss and insertion of the tapered PBG microstrip line

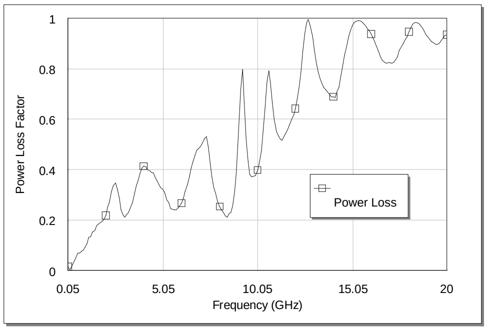

Fig. 7. Measured power loss of the tapered PBG microstrip line

Frequency GHz	9.23	10.6	12.7	15.4	18.4
Peak Gain dBi	1.51	1.02	1.25	1.12	1.43

Table. 1 Antenna peak gain measured by taperd PBG microstrip line

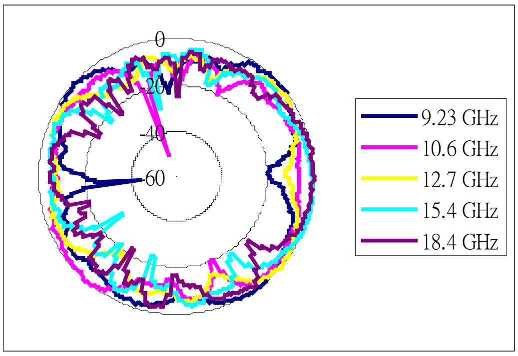

Fig. 9 Radiation patterns of peak gain