Wideband and Compact Bandstop Filter Structure Using Double-Plane Superposition

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***Abstract*—A novel bandstop filter (BSF) structure is proposed and measured for wideband and compact circuit applications. The proposed BSF realizes the wide stopband (2-octave) characteristics by superposing two different photonic bandgap (PBG) structures into a coupled double-plane configuration. Only three cells of the proposed structure are enough for the measured 10 dB stopband from 4.3 to 16.2 GHz. We expect this novel BSF structure is widely used for compact and wideband circuit applications, such as compact high-efficiency power amplifiers using harmonic tuning techniques.**

***Index Terms*—Bandstop filter (BSF), Bragg condition, DGS, PBG.**

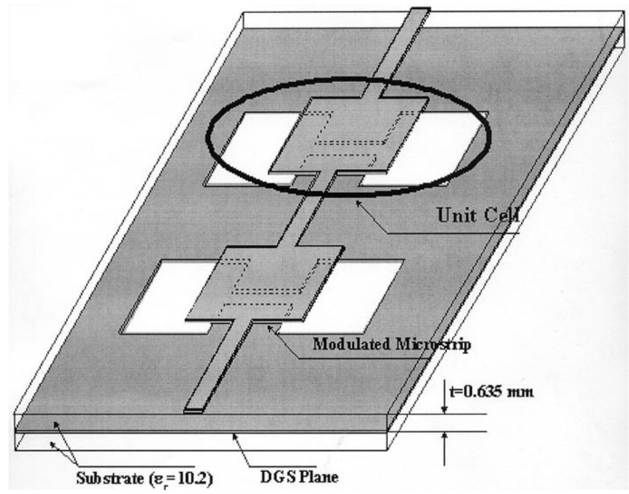
I. Introduction

PHOTONIC bandgap structures emerged to control electromagnetic-waves propagation by constructing artificial periodic discontinuities, which satisfy the Bragg condition [1]. For the past few years, the PBG concepts have been widely applied to microwave and millimeter-wave circuits using multilayered planar techniques, such as low noise oscillators, high-efficiency power amplifiers and wide bandstop filters [2]–[5]. Naturally, wider stopband at a compact size became an important issue for the practical aspect of the PBG applications. Wider bandgap is required to suppress the harmonics generation in active circuits [3] and the spurious modes or leakage generation of the filter applications [6]. Simple increments of the PBG cells and the wave impedance difference, however, result in inherent problems of the increasing size and the passband degradation [4].

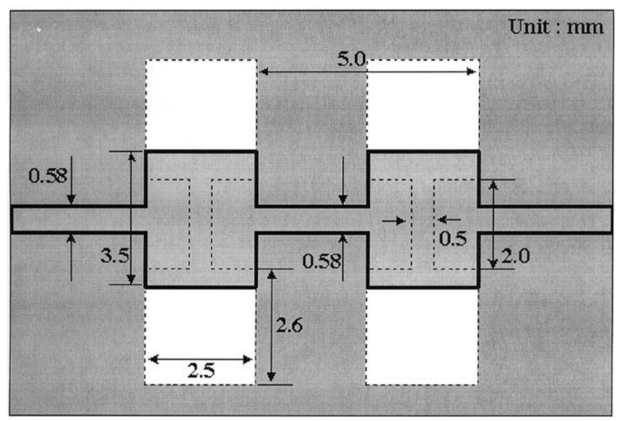
This letter proposes a high performance and compact BSF structure with ultra-wide stopband using a new double-plane configuration, in which two types of well-known PBG cells having different center frequencies are superposed and strongly coupled to expand the bandwidth. A BSF fabricated using 3-period of the proposed cells shows 2-octave 10 dB stopband from 4.3 to 16.2 GHz and 0.2 dB insertion loss in the passband. The compactness and wider bandwidth will be very useful for various integrated microwave circuits.

II. Novel Bandstop Filter Structure

Fig. 1 shows the proposed BSF structure, in which a modulated strip is overlapped on a defected ground plane structure (DGS) [2], [7]. The longitudinal resonant modes of the strip



(a)



(b)

Fig. 1. Proposed bandstop filter (BSF) structure: (a) 3-D view and (b) top-view.

and the transverse resonant modes of the DGS are strongly coupled through the DGS gap fields. Therefore, the multiple resonant modes effectively increase the bandwidth characteristics. We fabricated a modulated microstrip unit cell on a common ground and a common microstrip on a DGS unit cell in addition to the proposed BSF unit cell using a Duroid 6010 substrate (10.2 ε_r and 0.635 mm thickness). The structures shown in Fig. 1 are designed for 10 GHz Bragg condition of the modulated microstrip and 6 GHz resonant frequency of a DGS cell. In order to effectively increase the DGS gap capacitance, an additional supporting substrate is attached under the DGS ground as shown in Fig. 1. All the fabricated devices fed by a 50 Ω microstrip, are measured using a universal test fixture (UTF) with V-connectors.

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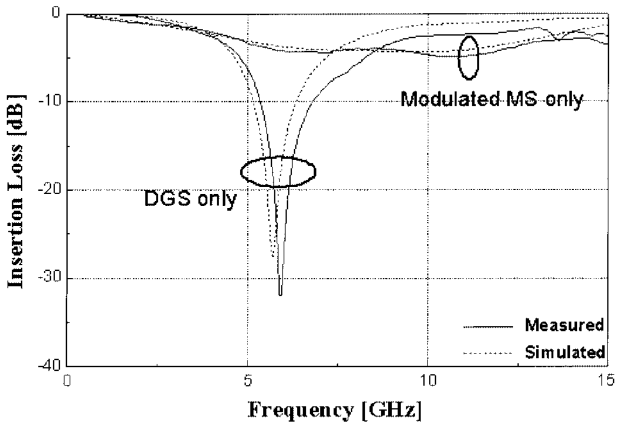

Fig. 2. Measured and calculated insertion losses of the single modulated microstrip and the single DGS cell ——— Measured; ············· Simulated.

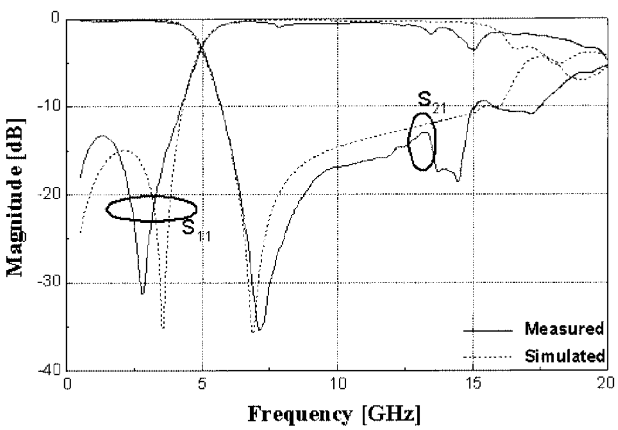

Fig. 3. Measured and calculated S-parameters of the proposed unit cell. ——— Measured; ············· Simulated.

III. Numerical and Measurement Results

We characterized the proposed BSF structure using the FEM calculations and experimental measurements. Fig. 2 compares the calculated and measured data of the single modulated microstrip cell and the single DGS cell. The single DGS cell shows a highly-resonant behavior while the single modulated microstrip cell has wideband characteristics. Fig. 3 shows S-parameters of a unit cell of the proposed BSF structure. The resonant frequency is slightly moved to higher frequency due to the coupling effect of the resonant modes. The most important feature of the proposed BSF is about 2-octave bandwidth of the 3 dB stopband from 5 to 18 GHz in addition to the negligible insertion loss throughout the passband. The low frequency and the high frequency characteristics of the stopband are, respectively, related to the DGS resonance and the period of the proposed structure. The calculated results also agree very well with the measured data except small fluctuations associated with the ports discontinuity of the test fixture.

The proposed BSFs are measured for different cell numbers as shown in Fig. 4. The 3 and 5 cells filters, respectively, have the measured 10 dB stopband width of 11.9 GHz and 12.1 GHz and also the insertion loss at the stopband center (10 GHz) of 51 dB,

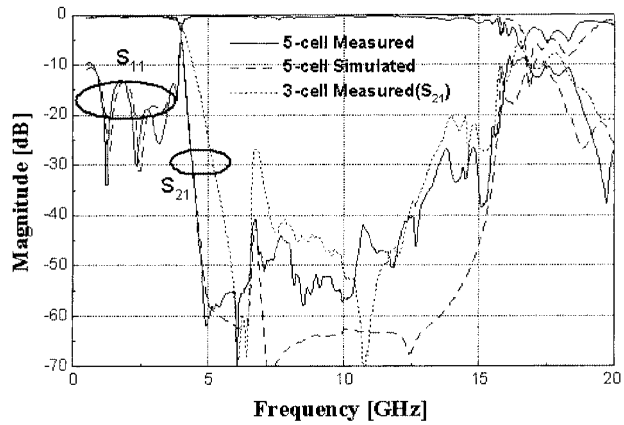

Fig. 4. Measured and calculated S-parameters of the proposed BSFs ——— 5-cell Measured; - - - - 5-cell Simulated ·············; 3-cell Measured (S_{21}).

and 56 dB. The minimum stopband flower is mostly limited by the test-ports reflection loss and, hence the stopband level can be lower in actual circuits. Very low insertion loss (0.3 dB) and flat passband characteristics of the proposed filters are kept for different cell numbers and periods while common PBG structures [4], [5] exhibit higher passband loss and ripples as the bandwidth and the cell numbers increase. The lower and higher corner frequencies of the stopband can be independently controlled by the DGS structure and the period of the modulated microstrip without passband degradation.

IV. Conclusions

A novel bandstop filter structure using double-plane superposition technique is proposed and implemented. A bandstop filter fabricated using three cells of the proposed structure shows 2-octave stopband from 4.3 to 16.2 GHz and 0.2 dB insertion loss without ripples in the passband. The compactness and wider bandwidth will be very useful for various integrated microwave circuits.

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