Compact asymmetric coplanar waveguide filter

S.K. Menon, K. Vasudevan, C.K. Aanandan and P. Mohanan

The design and implementation of a novel asymmetric coplanar waveguide (ACPW) band rejection filter using defected ground structure (DGS) is presented. The proposed ACPW DGS technology provides bandgap characteristics with only one cell in the lateral ground plane. The equivalent circuit model of the proposed DGS unit section is described. Measurements of ACPW DGS showed good agreement with simulation and the proposed model.

Introduction: Rejection of undesired frequencies in microstrip designs can be accomplished with electromagnetic bandgap (EBG) structures [1]. Usually EBG structures occupy a large circuit area as the number of cells used determines the bandgap characteristics. EBG structures, also termed defected ground structure (DGS), can be applied to coplanar waveguides (CPW) [2] for effective filtering of undesired frequency components.

In this Letter a unit cell of DGS is applied to an asymmetric coplanar wave guide (ACPW) to attain band rejection characteristics. Equivalent circuit parameters of the proposed ACPW DGS unit cell are extracted. Experimental results are validated by simulation. The proposed structure is more compact as only one ground plane of CPW is used and can be highly suitable for MMIC applications.

ACPW DGS unit cell and characterisation: A 50 Ω ACPW with slot width $S = 0.34$ mm and signal strip width $W = 3$ mm was fabricated on a substrate with thickness $h = 1.6$ mm and dielectric constant $\varepsilon_r = 4.7$. A square lattice with dimension $a = 5$ mm was etched on the lateral ground plane of the ACPW with gap length $l = 1$ mm and gap width $g = 0.4$ mm. The geometry of the proposed ACPW DGS unit cell is shown in Fig. 1*a*.

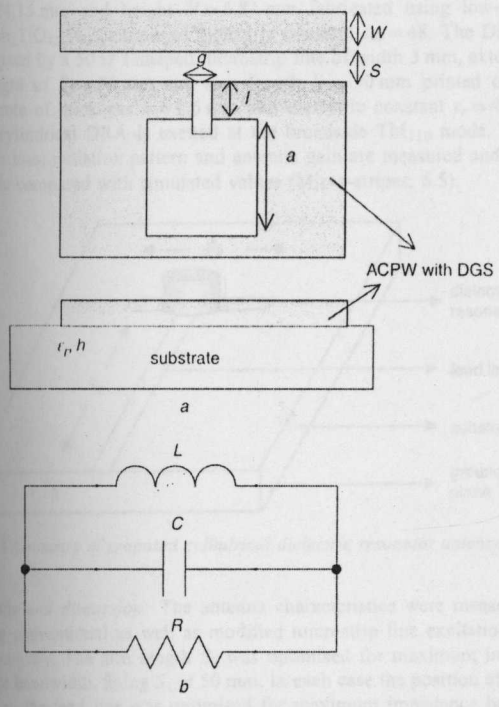

Fig. 1 *Geometry of proposed ACPW DGS filter and equivalent circuit of DGS element*

a Geometry of proposed ACPW DGS filter, $W = 3$ mm, $S = 0.34$ mm, $a = 5$ mm, $l = 1$ mm, $g = 0.4$ mm, $h = 1.6$ mm, $\varepsilon_r = 4.7$

b Equivalent circuit of DGS element

The lattice shape etched in the ground plane disturbs the current distribution, thus increasing the effective capacitance and inductance of the signal strip. Thus, the proposed DGS circuit can be represented by an equivalent LCR circuit [3]. Following [3] we can obtain the capacitance and inductance of the equivalent circuit of ACPW DGS as shown in Fig. 1*b*.

For a parallel LCR circuit at the resonant frequency:

$$R = 2Z_o\left(\frac{1}{S_{11}^2 - 1}\right) \tag{1}$$

$$C = \frac{\sqrt{S_{11}^2(R + 2Z_o)^2 - 4Z_o^2}}{2Z_o R\sqrt{1 - S_{11}^2}(f_2 - f_1)} \tag{2}$$

$$L = \frac{1}{4\pi^2 f_o^2 C} \tag{3}$$

In these equations C is the capacitance, L the inductance, Z_o characteristic impedance of the coplanar line, f_o the pole frequency and $f_2 - f_1$ the -10 dB bandwidth of the S_{21} curve. The lumped element values are extracted from the simulation. The frequency response of this ACPW DGS filter obtained from IE3D simulation, experiment and extracted equivalent circuit are in good agreement and shown in Fig. 2.

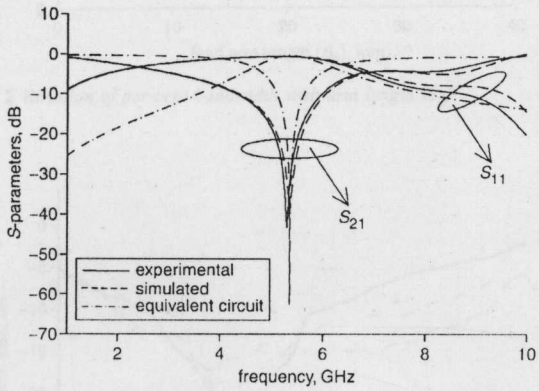

Fig. 2 *Frequency response of proposed ACPW DGS filter*

Results: An ACPW with DGS in the lateral ground for filter applications is presented. The equivalent circuit of the unit cell is also presented. Simulated, equivalent circuit and measured results are found to be in good agreement. Moreover, as there is only one lateral ground plane, suppression of parasitic mode is assured.

Acknowledgment: S. K. Menon acknowledges the Council of Scientific and Industrial Research (CSIR) India for awarding a Senior Research Fellowship.

14 March 2005
Electronics Letters online no: 20050941
doi: 10.1049/el:20050941

S.K. Menon, K. Vasudevan, C.K. Aanandan and P. Mohanan (*Centre for Research in Electromagnetics and Antennas (CREMA), Department of Electronics, Cochin University of Science & Technology, Kochi 682 022, India*)

E-mail: drmohan@cusat.ac.in

References

1 Radisic, V., Qian, Y., Coccioli, R., and Itoh, T.: 'Novel 2-D photonic bandgap structure for microstrip lines', *IEEE Microw. Guid. Wave Lett.*, 1998, **8**, pp. 69–71

2 Fu, Y., Zhang, G., and Yuan, N.: 'A novel PBG coplanar waveguide', *IEEE Microw. Wirel. Compon. Lett.*, 2001, **11**, pp. 447–449

3 Chang, C.C., Caloz, C., and Itoh, T.: 'Analysis of a compact slot resonator in the ground plane for microstrip structures'. Proc. APMC 2001, pp. 1100–1103