Antenna Design Based on the Conductor-Backed Asymmetry CPW Structure with Finite Ground Planes and Substrate

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***Abstract* —Based on the conductor-backed asymmetry CPW structure with finite ground planes and substrate, a printed antenna resulting from equivalent magnetic current loop is proposed. At 2.4GHz, the proposed antenna can be designed inside an area of 10 mm x 10mm. Binary particle swarm optimization and square metal mesh are employed to optimize the $|S_{11}|$. Antenna efficiency can be further improved by including this parameter into the cost function of the optimization[1].**

Background

Body area sensor networks (BASN) are emerging as a popular research area due to the dramatically increasing interests in mobile healthcare (m-Health) applications. In m-Health, it is usually required to provide small sensor nodes including MCU, RF transceiver, sensor, and antenna. These sensor nodes are usually worn or stuck on a portion of human body. The total area of the whole sensor node can be as small as 10 mm x 10 mm and the circuit layout and design of printed antenna become more difficult. To pack those ICs and printed antenna on such small area, four-layer PCB is suggested, the printed antenna is designed on top layer, and ICs are located on the bottom layer. Based on conductor-backed (CB) asymmetry coplanar waveguide (CPW) Structure with finite ground planes and substrate, a printed antenna design is proposed in this paper.

Proposed Method

For conventional finite width CBCPW structure, the source is at the center of one edge, the symmetry fed. Either or both of the CPW mode and the microstrip-like (MSL) mode dominate below a critical frequency. On the contrary, a leaky wave, in the form of surface wave, will occur in CPW line structure if the frequency is large than the critical frequency [1]. Similar to the mcrostrip leaky-wave antenna, a leaky-wave one based on CBCPW structure can be developed. However, the working frequency of this type of antenna is usually above 10GHz if the size of CBCPW is around 10mm x 10mm.

In order to design a CBCPW-based antenna at 2.4GHz, a magnetic current loop antenna resulting from the MSL modes is proposed and designed. According to Table I, an offset-fed CBCPW structure is first constructed to have EM radiation around 5 to 6 GHz and 10 to 14 GHz, respectively. The radiation at higher frequency results from the surface current on the side planes and that at lower frequency from the equivalent magnetic current shown in Fig. 1(c). Second, the original rectangle structure is extended by a semi-circle substrate with back PEC. The $|S_{11}|$ and efficiency are not changed too much for this substrate extension. The binary particle swarm optimization (PSO) is then employed to find the optimized mesh pattern of metal squares on the top surface of the semi-circle substrate. To find the optimized mesh pattern quickly, only the $|S_{11}|$ is considered in the cost function.

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TABLE I
THE DISTANCE TO THE MAXIMUM EFFICIENCY

Offset (mm)	$f_{min\|S11\|}$ / Efficiency	f_{maxEff} (GHz) / Efficiency	Distance	min$\|S_{11}\|$ (dB)
1.0	5.1 / 0.1154	5.1 / 0.1154	0	-0.9999
1.5	5.1 / 0.1486	5.2 / 0.1735	0.1031	-2.1727
2.0	5.2 / 0.2245	5.3 / 0.2580	0.1055	-3.7150
2.5	5.4 / 0.3449	5.5 / 0.3572	0.1008	-5.9109
3.0	5.5 / 0.4335	5.8 / 0.5040	0.3082	-9.4520
4.0	5.9 / 0.7462	6.5 / 0.8066	0.6030	-13.4450

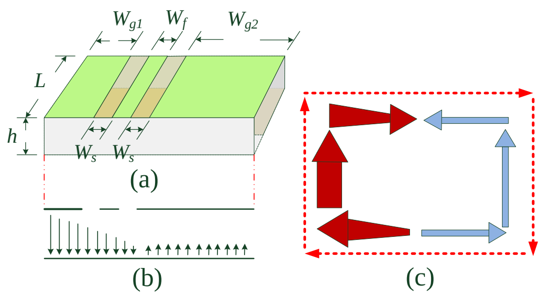

Fig. 1 The modified CBCPW structure. (a) The dimensions, (b) the first MSL higher mode excited in this structure, and (c) the equivalent magnetic current resulting from (b).

Results

The $|S_{11}|$ and radiation efficiency of the optimized antenna, based only on the magnitude of the S_{11}, is shown in Fig. 2. The efficiency from 2.4 GHz to 2.5 GHz is around 45% since the efficiency is not implemented in the cost function. However, it takes much longer time to calculate radiation efficiency than that to S_{11} in HFSS simulation. A computational efficient cost function including the radiation efficiency is to be further studied.

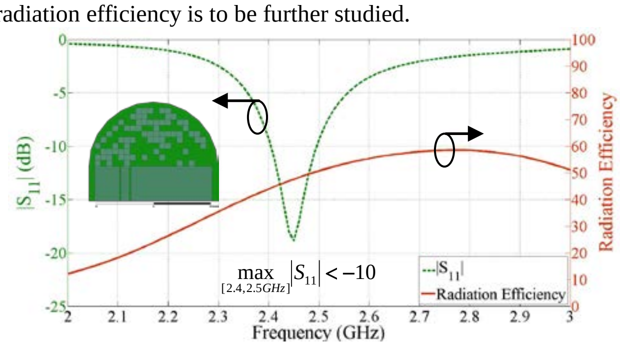

Fig. 2 The $|S_{11}|$ and radiation efficiency of the optimized antenna based only on the magnitude of the S_{11}.

References

[1] C.-C. Tien, C.-K. C. Tzuang, S.-T. Peng and C.- C. Chang, "Transmission Characteristics of Finite-Width Conductor-Backed Coplanar Waveguide," *IEEE Trans. Microwave Theory and Tech.*, vol. 41, no. 9, pp. 1616-1623, Sept. 1993.

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