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Design of Electromagnetic Wave Absorber Using Periodic Structure and Equivalent circuit-based Analysis

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***Abstract* - In this paper, new electromagnetic wave absorber based on periodic structure and equivalent circuit-based analysis are presented. The proposed structure shows a broadband characteristic, and its bandwidth is improved by generating additional resonance through the reasonable approach based on impedance analysis and equivalent circuit. For the verification of this approach, the functionality of the absorber, the proposed technique, and the experimental results are demonstrated along with analytical and computational results.**

***Index Terms* — Electromagnetic wave absorber, periodic structure, Microwave absorber.**

I. INTRODUCTION

Generally, it is well known that a planar resonant-type absorbing structure such as the Salisbury screen [1] is one of the simplest absorbers. The reason is that it doesn't lead to the complexity of the manufacturing compared to the conventional material-based absorber depending on the complex process of controlling the manufacturing conditions. To compensate for the main disadvantage of Salisbury screen, which is a thickness limit of a quarter-wavelength above the conducting plane, several planar resonant absorbers using a period structure have been reported [2]-[4].

In this paper, a new electromagnetic wave absorbing structure based on a periodic surface and a technique to generate additional resonance for bandwidth improvement through the equivalent circuit-based analysis are proposed. The final structure consists of an array of two simple unit cells to practically realize the proposed structure and technique. The impedance of the structure is investigated in detail by using the proposed equivalent circuits. To verify this approach, the experimental results of the constructed prototypes are demonstrated along with computational results.

II. PROPOSED CONFIGURATION

The geometry of the proposed absorptive structure and unit cell are shown in Fig. 1. The structure consists of a grounded dielectric slab and a periodic surface. Considering the hybrid unit cell structure created by a combination of two unit structures, which are a modified square patch and cross dipole patch, the proposed unit cell structure is also depicted in the same figure. The square patch and cross dipole patch are well-known structure as a unit cell of a fundamental Frequency Selective Surface (FSS) [5]. The amount of space required for periodically positioning cross dipole patches was reserved, and slots (slot1 and slot2) were inserted to the square patch for improving the impedance matching characteristic. Considering the normal incidence, the equivalent circuit for the overall absorbing structure is equal the parallel connection between the parallel *LC* resonant circuit (Z_S = jX_1) and the series *RLC* circuit (Z_F = R+jX_2), as shown in Fig. 2. From full wave simulation results of the grounded dielectric slab and periodic surface [6], the circuit parameters can be determined, and logical values of the lumped resistance, *R*, and the input impedance satisfying the

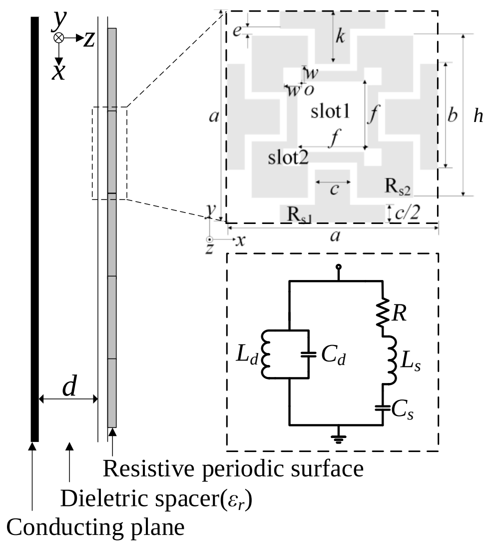

Fig. 1. The unit cell geometry and equivalent circuit model of the proposed absorber (L_d = 5.53 nH, C_d = 18.38 fF, L_s = 0.14 nH, and C_s = 0.13 pF).

TABLE I
DESIGN PARAMETERS OF THE PROPOSED ABSORBER

Parameter and Length (mm)		Parameter and length(mm)		Parameter and value	
a	30	*h*	23	$R_{s1,2}$	40 Ω /sq
b	15	*k*	7.5	ε_r	1
c	5	*w*	2.5		
d	4.7	*k*	7.5		
e	1				

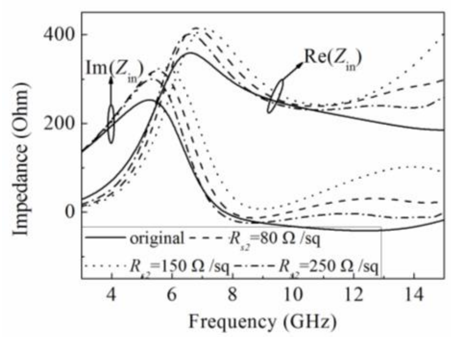

Fig. 2. Input impedance of the proposed structure (R_{s1}= R_{s2}= 40 Ω /sq) and its hybrid one (R_{s1}= 40 Ω /sq, R_{s2}= 80, 150, 250 Ω /sq).

resonance condition can be computed. Through a good estimate [5], the corresponding sheet resistance, R_s, also can be obtained. Through a simple parametric study for better reflectivity performance, the final design parameters and the obtained circuit ones are listed in Table 1 and Fig. 2, respectively. We have investigated the impedance of the proposed structure when the sheet resistance (R_{s2}) of the center loop patch is different from that (R_{s1}) of the half-cross dipole patches as a hybrid structure. From the results of Fig. 2, it can be ascertained that additional resonance can be generated in addition to original resonance at approximately 7 GHz and then the whole absorption bandwidth can be increased. The final sheet resistances for the hybrid structure, R_{s1} and R_{s2}, are 40 Ω/sq and 130 Ω/q, respectively, and the corresponding equivalent circuit is shown in Fig. 3.

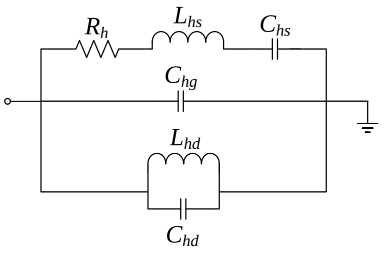

Fig. 3. The equivalent circuit model of the hybrid structure (L_{hd}=5.53 nH, C_{hd}=18.38 fF, R_h=241 Ohm, L_{hs}=4.96 nH, C_{hs}=59.53 fF, C_{hg}=24.82 fF).

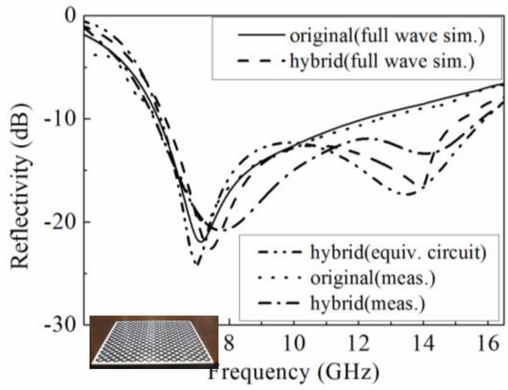

Fig. 4. The simulated and measured reflectivity of the proposed structure (R_{s1} = R_{s2} = 40 Ω/sq) and its hybrid one (R_{s1} = 40 Ω/q, R_{s2} = 130 Ω/sq).

III. EXPERIMENTAL RESULTS

The simulated and the measured results of the proposed structure and the hybrid one are plotted together in Fig. 4. The measured results of the hybrid structure showed an increase of 17% of the bandwidth compared to the original structure and a broadband characteristic with a fractional bandwidth of approximately 93% below -10 dB.

IV. CONCLUSION

A new EM wave absorbing structure using a periodic surface was proposed, and a design technique to enhance the absorption bandwidth of the proposed structure has been proposed with simple equivalent circuits. The objectives have been successfully demonstrated using simulations and measurements.

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