A Broadband T-Shaped Microstrip-line-fed Slot Antenna with Harmonic Suppression

D. H. Choi, Y. J. Cho, and S. O. Park
School of Engineering, Information and Communications University
103-6 Munji-dong, Yusong-Gu,
Daejeon, Korea

***Abstract*-In this paper, a slot antenna is proposed to achieve both harmonic suppression and wide bandwidth. To obtain these results, a T-shaped microstrip-line-fed slot antenna and U-shaped conductor line connected with the ground plane are applied. At the fundamental and harmonic frequencies, return loss and radiation characteristics are measured and compared with those of the conventional slot antenna. For the proposed antenna, the 10-dB return loss bandwidth could reach 1220 MHz (1730 ~ 2950 MHz), which is about 52 % with respect to the center frequency of 2340 MHz, and it is observed that the second and third harmonics of the proposed antenna is effectively suppressed.**

I. INTRODUCTION

Due to the advantages of compact sizes, high efficiencies, and low costs, active integrated antennas (AIAs) have attracted much attention in the applications of communication at the microwave and millimeter-wave frequencies [1]. In AIAs design, the antenna plays an important role not only as a radiator but also as a resonator and a filter for an oscillation circuit. But this configuration can easily occur the spurious radiation at the resonant frequency of the antenna. To overcome this problem, harmonic suppressed antenna (HAS) has been studied by many researchers, approaching the ways of photonic bandgap (PBG), circulator sector radiator, shorting pin, tuning stub, and split ground plane [2-4].

However, these types of antennas can't provide wide bandwidth due to high Q of antenna structure. To improve the bandwidth, various topologies were introduced such as CPW-fed loop slot antenna with some lattices along the feed line, dual-slot antenna, and stacked patch structure [5-7]. However, these techniques are attended by the complicated structure in common for obtaining the wide bandwidth.

In this paper, T-shaped microstrip-line-fed slot antenna [8], which has a modified slot in the ground plane and a merit for easy fabrication, is demonstrated with the comparison between the simulated and measured return losses. The measured radiation patterns at fundamental and harmonic frequencies are presented.

II. ANTENNA DESIGN

Figure 1 shows a schematic of the proposed slot antenna with a modified slot. It consists of a U-shaped conductor line connected with ground plane and T-shaped microstrip line on the other side. This antenna is fabricated on the FR-4 substrate with a thickness of H = 1.6 mm and a relative permittivity of ε_r = 4.6. The simulation was performed with CST software.

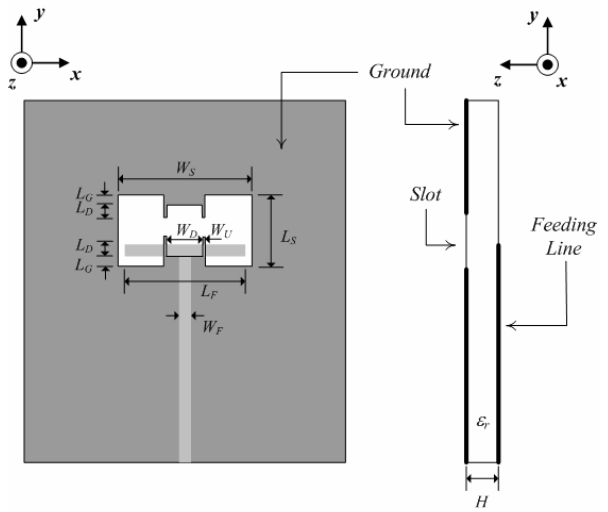

Figure 1. Geometry of the proposed antenna

TABLE I
OPTIMIZED PARAMETERS FOR THE PROPOSED ANTENNA

parameter	Value [mm]	parameter	Value [mm]
W_S	50	W_D	8.6
L_S	21.2	W_U	1
L_F	48.2	L_D	3.5
W_F	3	L_G	4.5

To obtain the wide bandwidth, we use the slot antenna fed by T-shaped microstrip antenna since this type antenna can achieve a good impedance match over a wide frequency range thorough the simple feed structure and also easily be implemented. To suppress harmonics, the U-shaped conductor line (WU x LD) connected with ground plane in the rectangular slot are applied. This conductor line and the gap (WD) act as the L-C resonator for filtering out the second and third harmonic frequencies. Since the length and width of the U-shaped conductor line are the critical parameters for suppressing the harmonics, we try to carefully adjust WU, WD,

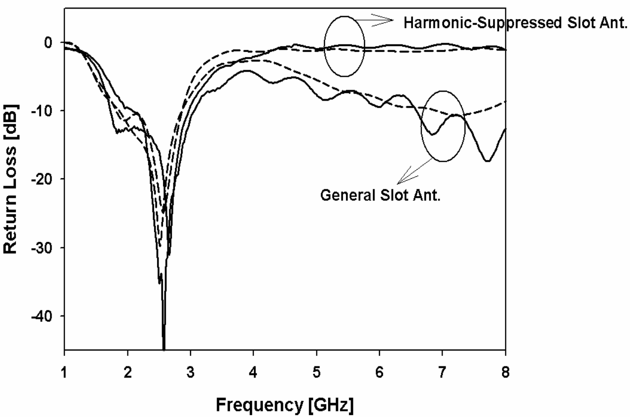

Figure 2. Simulated (dashed line) and measured (solid line) return losses for the proposed antenna

and LD to achieve that L-C resonator has the wide band-stop characteristics. The optimized parameters are listed in Table I.

III. EXPERIMENT

The simulated and measured return losses of the proposed antenna are shown in Figure 2. For the comparison, the graph of a conventional slot antenna fed by T-shaped microstrip line is also shown in the same figure. The basic structural parameters of the conventional slot antenna are the same as those of the proposed antenna except for the U-shaped conductor line. The center frequency of the conventional slot antenna has been designed around 2500 MHz. The bandwidth of about 960 MHz is reached and the bandwidth of the higher order mode is about 2326 MHz. However, by fabricating the proposed antenna, these harmonics are completely suppressed, and also we obtain the 10-dB bandwidth of 1220 MHz (1730~2950 MHz), which is about 52 % with respect to the center frequency of 2340 MHz. In this experiment, attaching U-shaped conductor line on the ground plane does not result in deterioration of bandwidth but enhancing the bandwidth on the contrary.

Next, the co- and cross-polarization patterns at resonant frequencies were measured for the proposed slot antenna. The cross-polarized radiation patterns were normalized to the maximum value of co-polarization level. In the fundamental frequency, co-polarization patterns for the proposed antenna are similar to those of the y-directed dipole antenna, as shown in Figure 3. Both the second and third harmonics are measured to be approximately less than -25 dB and -30 dB, respectively. This means that, at the harmonic frequencies, the radiation patterns of the proposed antenna are drastically diminished.

In Figure 4, E- and H-plane cross-polarization patterns for the proposed antenna are presented. The H-plane cross-polarization levels compared to the E-plane one are somewhat increased due to the unwanted current of the U-shaped conductor line. The measured maximum gains of the antenna

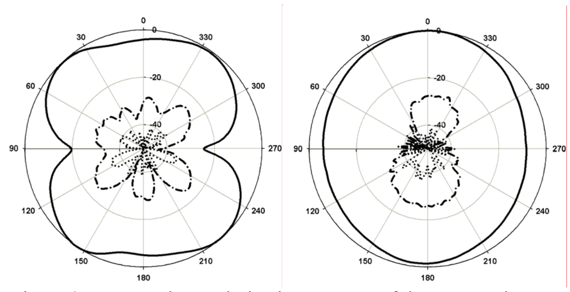

Figure 3. Measured co-polarization patterns of the proposed antenna (solid line : 2500 MHz, dash-dot line : 5000 MHz, dot-dot line : 7500 MHz)

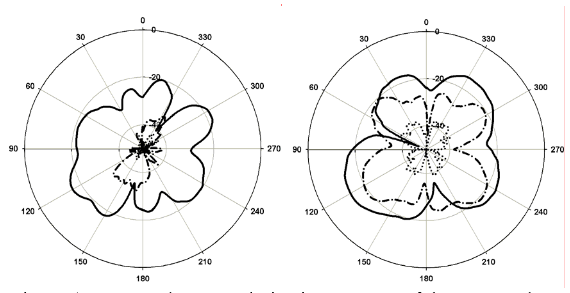

Figure 4. Measured cross-polarization patterns of the proposed antenna (solid line : 2500 MHz, dash-dot line : 5000 MHz, dot-dot line : 7500 MHz)

are 4.3 dBi, 5.4 dBi, and 3.5 dBi at the frequencies of 2.0 GHz, 2.5 GHz, and 3.0 GHz, respectively.

IV. CONCLUSIONS

A rectangular slot antenna fed by T-shaped microstrip line is presented for achieving both harmonic suppression and wide bandwidth. Since this proposed antenna consists of the U-shaped conductor line connected ground plane inside the rectangular slot, it is easily fabricated. Experimental results indicate that the proposed antenna is quite effective for suppressing the harmonics and enhancing the simultaneously.

ACKNOWLEDGMENT

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