A Dual-Band Slot Antenna with Two Pairs of Slot Patches for Cross-Polarization Reduction

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***Abstract* - A dual-band slot antenna with an asymmetrical tuning stub added two pairs of symmetrical slot patches inside the slot is proposed for reducing the peak cross-polarization level. The asymmetrical tuning stub can be used to tune the input impedance matching for the bandwidth improvement but possess very high cross-polarization levels. The two pairs of symmetrical slot patches are used to reduce the peak cross-polarization level, and the suppression is about 9 dB lower than that of the design without slot patches. Details of the design are presented, and simulated and measured results are also presented and discussed.**

***Index Terms* —Slot antenna, dual-band, cross-polarization reduction.**

I. Introduction

In very recent years, there has been a growing research activity on the asymmetrical tuning stub study for miniaturized broad-band slot antenna designs [1]-[2]. These asymmetrical tuning stubs can be used to tune the input impedance matching or excite multi-resonant modes but possess very high cross-polarization levels. The literature survey shows that there are several valuable technologies for the better polarization purity [3]-[4]. However, these papers only focus on the symmetrical structure investigation. In this paper, we propose an uncomplicated method to reduce the peak cross-polarization level by adding two pairs of symmetrical slot patches. By properly choosing the suitable dimensions of symmetrical slot patches, the peak cross-polarization level is suppressed to about 9 dB lower than that of the conventional design, and the overall cross-polarization levels of E-plane and H-plane are both reduced.

II. Antenna Design

As shown in Fig. 1, the configuration of the proposed slot antenna with ground size of W = 40 mm consists of a square slot of L = 22 mm inserted two ring-type metallic strips and two pairs of symmetrical slot patches. The square slot inserted with two ring-type metallic strip radii R_1 and R_{11}, and widths g_1 and g_{11}. The feeding structure shown in Fig. 1 consists of two parts. One is the feed-line and the other is the tuning stub. The feed-line section based on 0.8-mm FR-4 substrate is a 50-Ω microstrip line with a width (W_f) of 1.5 mm. The tuning stub section has two branches. After first ring-type strip is inserted into the slot, two resonant bands are excited. The second metallic ring generates a new

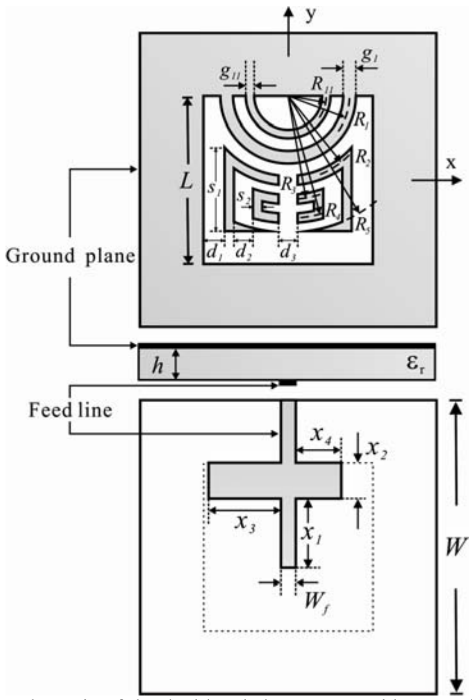

Fig. 1. The schematic of the dual-band slot antenna with two pairs of slot patches for cross-polarization reduction.

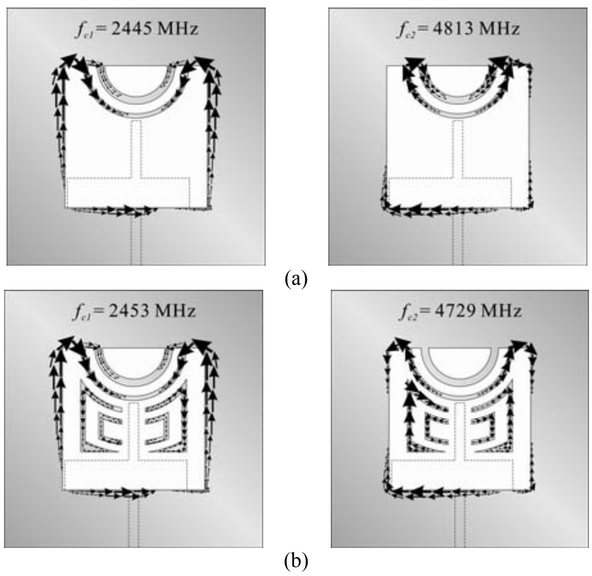

Fig. 2. Simulated current distribution of (a) A slot antenna with an asymmetrical tuning stub and (b) The proposed antenna modified by adding two pairs of symmetrical slot patches inside the slot.

Table I THE PARAMETERS OF THE PROPOSED DUAL-BAND SLOT ANTENNA FOR REDUCING CROSS-POLARIZATION LEVEL (UNIT: mm)

x_1	x_2	x_3	x_4	R_1	R_{11}	R_2	R_3	R_4	R_5
8.5	6.0	10.5	7.1	8	6	9.5	11	14	15.25
g_1	g_{11}	d_1	d_2	d_3	s_1	s_2			
0.5	1	3	2	4	10	0.5			

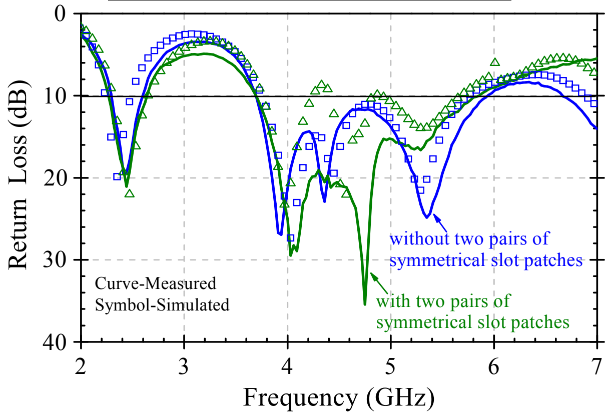

Fig. 3. The simulated and measured return losses of the proposed slot antennas against frequency.

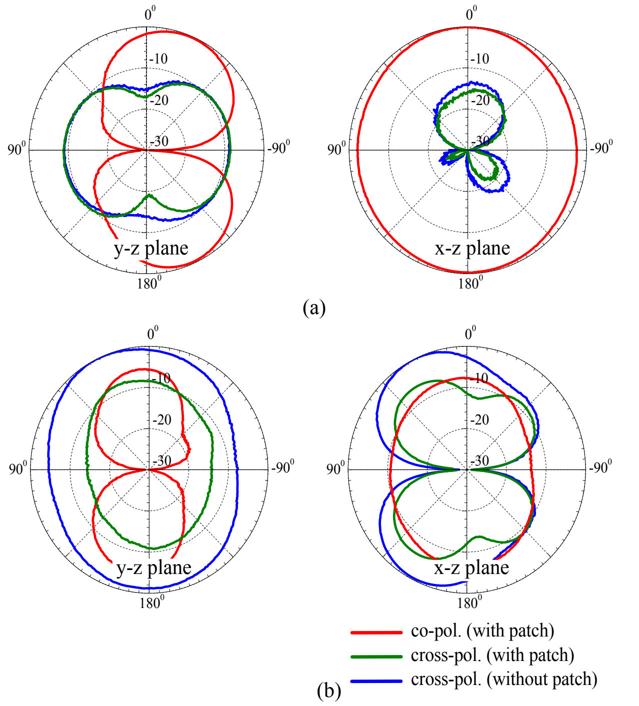

Fig. 4. Measured E-plane and H-plane radiation patterns of prototype. (a)At the low-band. (b) At the high-band.

resonant mode in the high-band, and makes the bandwidth improvement. A comprehensive analysis has been done to understand the effects of various dimensional parameters and to optimize the performances of the designed antennas [5]. By properly selecting and tuning their dimensions (x_{1}-$_{4}$) of tuning stub to be an asymmetric shape ($x_3 \neq x_4$), a large operating bandwidth is obtained.

In order to reduce the cross-polarized radiation levels caused by asymmetrical tuning stub, two pairs of symmetrical slot patches are added in the slot and all the dimensions are detailed in Table I. Figs. 2(a) and 2(b) show the schematic diagrams for the surface electric current distribution of the proposed slot antennas. Fig. 2(a) shows the asymmetrical currents along slot are the main causes of the high-level cross-polarized radiation. Fig. 2(b) shows that the proposed antenna with slot patches has the similar electric current distribution in the low-band. The proposed antenna has the approximate symmetrical electric current distribution in the high-band due to the slot patches. One can see from the right figure (high-band case) of Fig. 2(a) that the x-directed electric currents near the lower edge of the main slot are responsible for the co-polarized radiation in the high-band, while the bilaterally symmetric current distribution along the ring-type strips would cancel out in the far field. Therefore, the antenna radiates x-polarized waves, not the y-polarized radiation when operating in the high-band.

III. RESULTS AND DISCUSSION

The design without symmetrical slot patches shown in Fig. 3 indicates that the bandwidth of high-band is 46.5%. The design with symmetrical slot patches shows the similar bandwidths and center frequencies of dual-band to that of design without slot patches, indicating two operating resonant bandwidths of 372 MHz (15.2%) and 2068 MHz (43.7%), respectively. The normalized radiation patterns measured across E- and H-plane at their center frequencies are presented in Fig. 4, respectively. The cross-polarization levels of E- and H-planes of the design without symmetrical slot patches at the second resonant frequency (4813MHz) are very high due to asymmetrical tuning stub. One can observe that the proposed antenna possesses lower cross-polarization levels in both principle planes at center frequency of the high-band, especially in the E-plane pattern. Consequently, the overall cross-polarizations levels of E- and H-plane are significantly decreased. The maximum reduction in the peak cross-polarization level is about 8 dB in the E-plane and 9 dB in the H-plane. Simultaneously, at the low-band, the cross-polarization level is also decreased slightly.

IV. CONCLUSION

The printed dual-band slot antenna with slot patches was successfully designed and implemented. Numerical simulations have been validated experimentally and show very good agreements. With two pairs of slot patches, the reduction is about 9 dB in peak cross-polarization level and the overall cross-polarizations of E-plane and H-plane are significantly decreased.

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