Bandwidth Improvement Technique for a U-slotted Rectangular Patch Antenna using Coupled Slots

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บทคัดย่อ

บทความนี้นำเสนอเทคนิคการปรับปรุงแบนด์วิดธ์สายอากาศแพตช์สี่เหลี่ยมผืนผ้าที่เจาะช่องแคบเปิดรูป U โดยเพิ่มโหลดช่องแคบเปิดขนานกับแขวนของช่องแคบเปิดรูป U เพื่อเพิ่มขนาดแบนด์วิดธ์ สายอากาศที่นำเสนอถูกสร้างและจำลองผลจากโปรแกรม IE3D™ และ Sonnet™ โดยใช้ซับเสตรทเป็นโฟม ($\varepsilon_r \approx 1$) ความหนา 0.1 และ 0.12 เท่าของความยาวคลื่น ผลลัพธ์มีอิมพีแดนซ์แบนด์วิดธ์ (VSWR $\leq$ 2) 56% ความถี่กลางประมาณ 5 GHz ค่าไดเร็คติวิตี้สูงสุด 8.72 dBi รูปแบบการแพร่คลื่นลักษณะดีตลอดแบนด์

ABSTRACT

This paper presents a new technique for a bandwidth improvement of a U-slotted rectangular patch antenna. This technique is a modified version of a U-slotted patch antenna. Coupled slots parallel to both ends, arms, of the U-shaped slot are added to enhance the bandwidth. The proposed structure is simulated using IE3D™ and Sonnet™, commercial software packages, and implemented using a foam substrate ($\varepsilon_r \approx 1$). The results for substrate thickness of 0.1 wavelength and 0.12 wavelength are presented. An impedance bandwidth of 56% for VSWR less than 2:1 are obtained at a center frequency of 5 GHz. A good antenna pattern with a directivity of 8.72 dBi is observed.

Keywords: microstrip antenna, U-slot patch antenna, Bandwidth widening

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I. INTRODUCTION

Microstrip antennas are widely used in wireless applications because of their advantages of low profile and non-complexity. However, a main disadvantage of this type of antenna is a narrow bandwidth about 1-5%. Bandwidth improvement techniques have been extensively investigated by many researchers. Huynh and Lee (1995) presented a new kind of a wideband patch antennas with an impedance bandwidth of 47% at center frequency around 900 MHz. The antenna was probe fed at its center with an internal U-shaped slot a unity permittivity substrate was used. The U-slotted patch antenna was reported in Lee (1997) at a higher frequency with the result of 32.4% bandwidth at a centre frequency of 4.5 GHz.

This paper presents a new technique for a bandwidth improvement based on a U-slotted rectangular patch antenna. Coupled slots parallel to both ends, arms, of the U-shaped slot are added to enhance the bandwidth. This technique gives a better bandwidth than the ones reported in both Lee (1997) and Ooi (2002) with a simpler structure.

II. ANTENNA STRUCTURE

The proposed structure is shown in Fig. 1. A foam layer ($\varepsilon_r \approx 1$) is used as a supporting substrate, a radiation patch and a ground plane are made by use copper sheet with the thickness 0.1 and 0.2 mm respectively. Coupled slots and the arms are in same length. Dimension U-shaped slot provided in Lee (1997) as a basis for a parametric study. The parameters of interest include both width of coupled slot and spacing between arms and coupled slots.

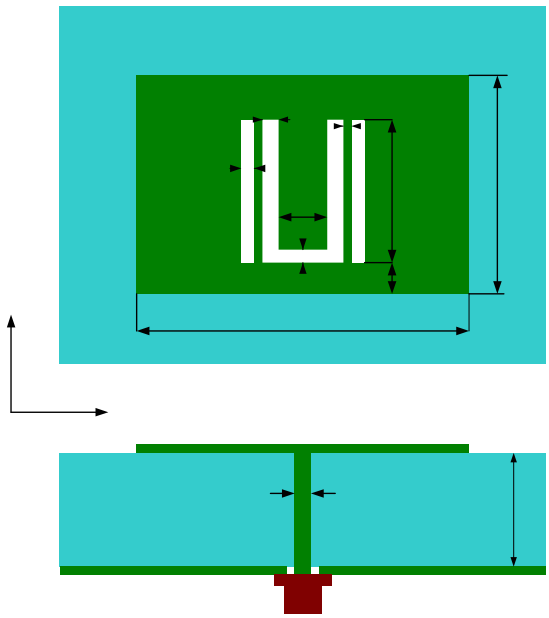


Fig. 1 Geometry of the proposed antennas

Table1. Physical dimensions of the proposed antennas in millimeter

	W	L	a	b	c	d
Antenna # 1	36	26	2	20	8	3
Antenna # 2	36	26	2	20	8	3.5
U-slotted patch	36	26	2	20	8	2
	e	f	g	offset	h	dp
Antenna # 1	1	0.5	2	(0,-2)*	6.2	2.2
Antenna # 2	2	0.5	2	(0,-2)*	7.4	2.2
U-slotted patch	-	-	2	(0,-2)*	6.2	1

*(0,0) is a centre of patch.

III. SIMULATED AND MEASURED RESULTS

The computer simulation is performed by using IE3D and Sonnet. The parameters of the proposed antennas is measured using Agilent 8719ES network analyzer. The simulated results of the proposed antennas are compared with the U-slotted patch antenna in Fig. 2.

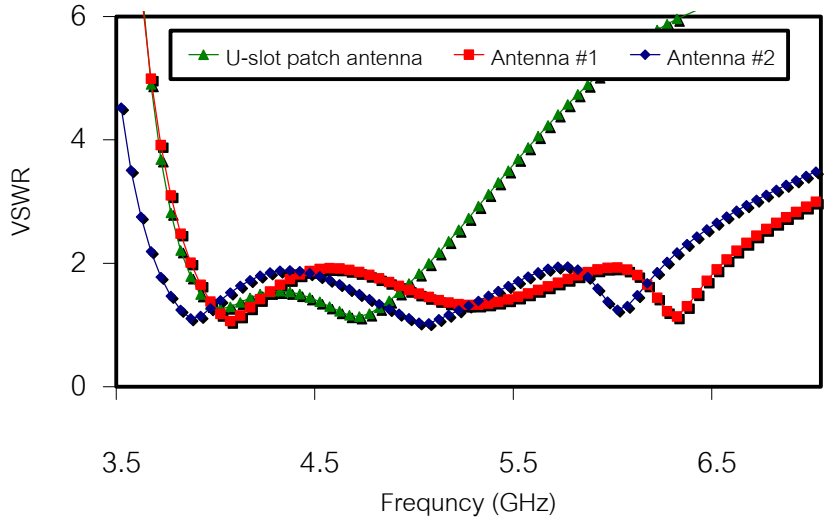
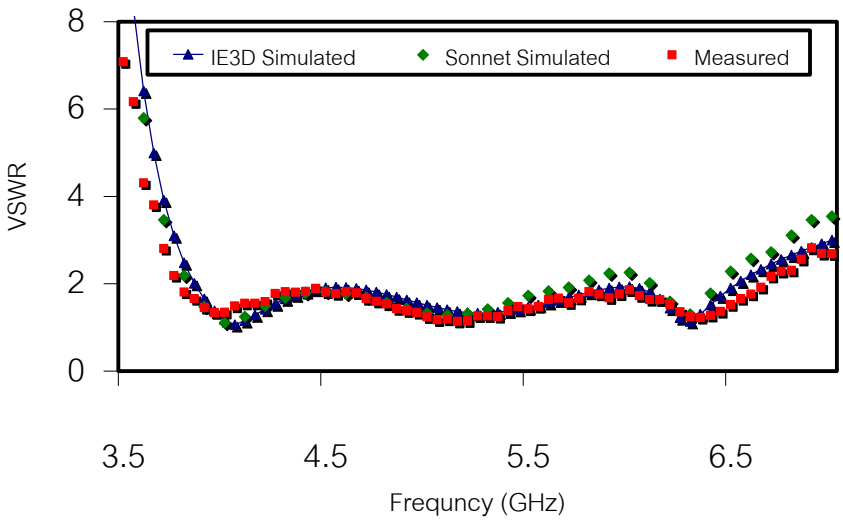
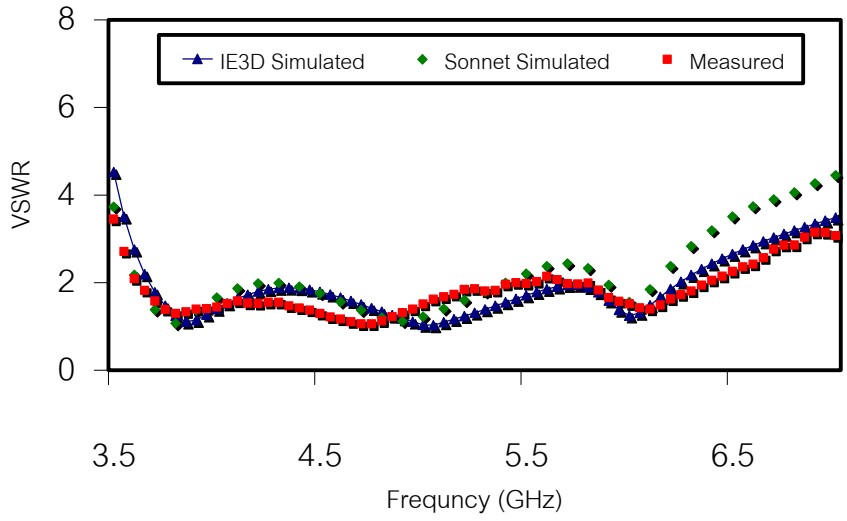


Fig.2 Simulated VSWR of the proposed antennas and U-slotted patch antenna

Fig. 3 shows that the measured VSWR and simulated VSWR for the proposed antennas are in good agreement. The broad side radiation pattern observed over operating frequency band. The simulated patterns of the proposed antennas at frequency of 4, 5, and 6 GHz are shown in Fig.4.

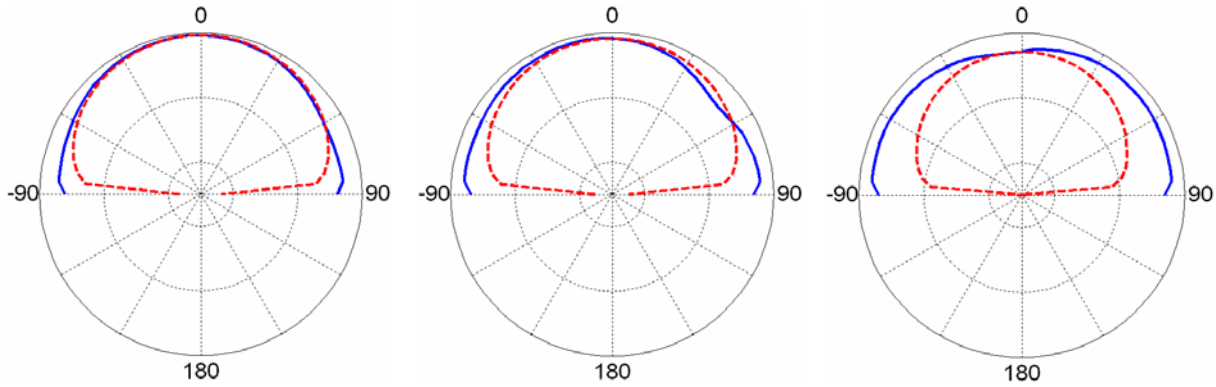


(a) Antenna #1



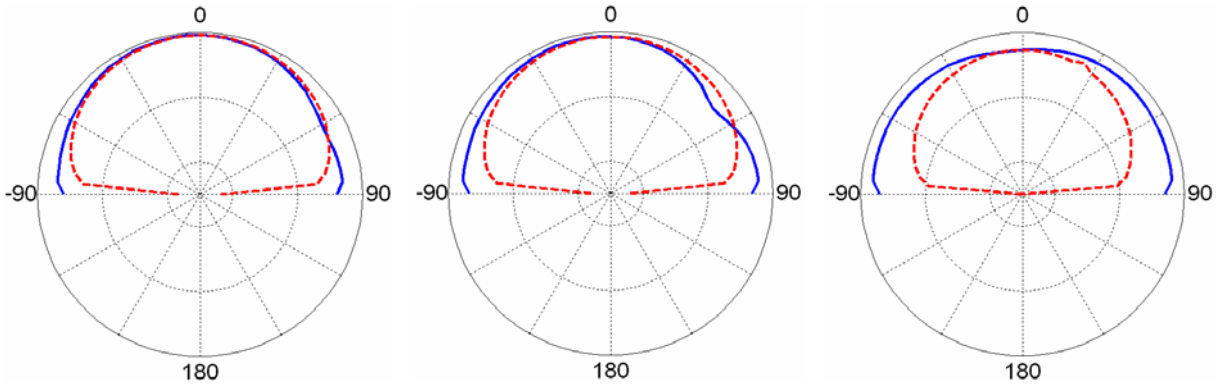
(b) Antenna #2

Fig.3 Simulated and measured VSWR (a) antenna #1 (b) antenna #2



4 GHz 5 GHz 6 GHz

(a) Antenna #1



4 GHz 5 GHz 6 GHz

(b) Antenna #2

H-Plane
E-Plane

Fig. 4 (a) Simulation radiation pattern of proposed antenna # 1 at 4, 5, and 6 GHz.
(b) Simulation radiation pattern of proposed antenna # 2 at 4, 5, and 6 GHz.

Table2. Operating frequency band and bandwidth of the proposed antennas (GHz)

		f_l	f_c	f_u	BW	BW (%, VSWR≤2)
Antenna # 1	Simulated	3.85	5.20	6.55	2.70	52.00
	Measured	3.77	5.23	6.68	2.91	55.64
Antenna # 2	Simulated	3.65	4.95	6.25	2.60	52.53
	Measured	3.60	5.00	6.40	2.80	56.00
U-slotted patch	Simulated	3.8	4.03	5.05	1.25	31.06

Fig.5 shows the simulated the directivity of the proposed antennas. Fig.6 shows the photograph of the proposed antenna # 1. The operating frequency bands and the bandwidths of the proposed antennas are shown in Table 2.

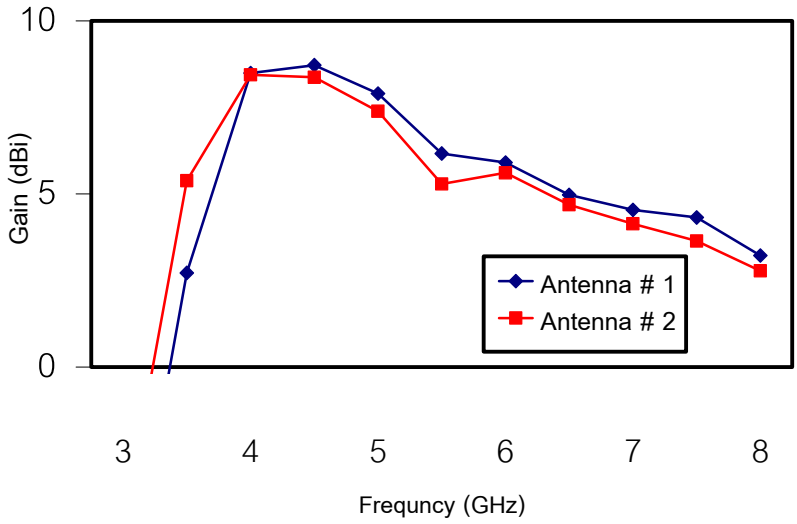


Fig. 5 Simulated antenna gain of proposed antennas

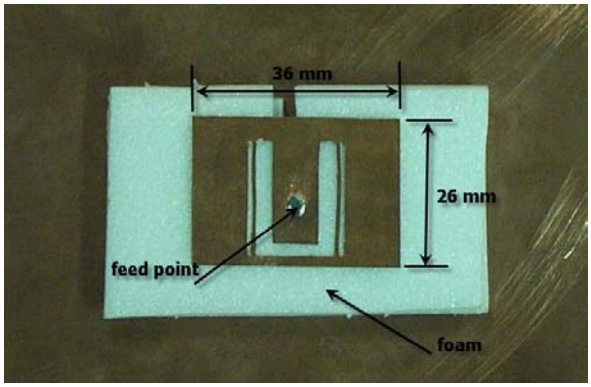


Fig. 6 photograph of proposed antenna # 1

IV. CONCLUSION

A novel technique for enhancing bandwidth of wideband patch microstrip antennas is successfully demonstrate in this paper with impedance bandwidth 56 %. Using slot load coupled arm of U-slot technique, two example are provided to have impedance bandwidth improvement substantially. For thickness of propose antennas remain changed from 5 to 6.2 mm. for first example and 7.4 mm. for second example. When compared to the reference Lee (1997) better than 23.6% and Ooi (2002) better than 17.59%.

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