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Stacked Rectangular Microstrip Patch Antenna Loaded with Slot Using Microstrip Line Feed

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Abstract: A new, simple and slotted stacked microstrip patch antenna is design with parasitic patch element for wireless communication system. A U-shape slot has been loaded in lower patch of the rectangular microstrip antenna and rectangular slot has been loaded in parasitic patch element. Due to this the bandwidth of patch antenna is improved from 25.80-30.14%. The frequency of the conventional single layer antenna design lie in the range of 1.847-2.394 GHz with resonance frequency 2.203 GHz and proposed stacked antenna is resonating with multi band frequency range and fractional bandwidth of multi band proposed antenna is 30.14% (lower band), 0.4% (middle band) and 2.56% (upper band). A microstrip line feed of 50 Ω has been used in this proposed slotted microstrip antenna. The simulation process has been done by IE3D simulation software tool.

Key words: Stacked, slotted, parasitic, bandwidth, patch, line feed

INTRODUCTION

Due to rapid development of wireless communication systems, the demand for compact, wideband operation and high gain microstrip antenna has increased. Microstrip patch antenna possesses many advantages such as low profile, light weight, small volume and compatibility with Microwave Integrated Circuit (MIC) (Surjati *et al*., 2010). The narrow bandwidth and small gain are the major disadvantages of microstrip antenna. S-shaped multi-band stacked microstrip antenna has been designed for wireless communication applications including WiMax, WLAN, Bluetooth and C-band applications such as satellite communications, weather radar systems with coupling structure between the patches and a wide ground slot to improve antenna characteristics (Ankita *et al*., 2016). A trapezium shaped patch with T shape slot loaded circularly polarized microstrip patch antenna has been design for wireless application (Kumar and Srivastava, 2014).

In this study a wideband stacked patch antenna without air gap has been design for enhancing the bandwidth. Initially the bandwidth of microstrip antenna can be enhanced by loading U slot in lower radiating patch (Khan and Chatterjee, 2016) and further increased by stacked configuration with slotted parasitic patch element. The lower driven radiating patch is loaded with U shape slot and directly feed through 50 Ω microstrip line feed. The upper rectangular parasitic patch element is also loaded with rectangular slot. Due to this the proposed stacked antenna design resonates with multiband frequency which is lies in between 1.715-2.323, 2.453-2.463 and 2.696-2.766 GHz, respectively. This multiband frequency range is suitable for wireless communication applications (Nandgaonkar and Deosarkar, 2009; Egashira and Nishiyama, 1996; Roy and Bhunia, 2012; Rao and Chaitanya, 2013). The size and bandwidth of microstrip antenna also depends on substrate material. On increasing the dielectric constant, the size of antenna decreases as well as bandwidth and efficiency also decreases (Balanis, 2005).

MATERIALS AND METHODS

Antenna design specifications: The proposed single layer U slotted antenna design is shown in Fig. 1. Glass epoxy substrate is used for antenna design as a dielectric material with dielectric constant 4.4 (Pozar, 1992). The both dielectric substrate height h_1 and h_2 are 1.6 mm and 0.0013 is used as loss tangent. The lower driven radiating patch is feed through 50 Ω microstrip line feed. IE3D simulation software tool has been used for simulation work. All the specifications are given in the Table 1.

Antenna design procedure: Figure 1 shows the design of proposed single layer U slot loaded microstrip antenna. The patch width and length are 30 and 40 mm, respectively. The design has ground plane width 40 mm and length 50 mm. In designing of proposed antenna on IE3D tool ground plane is selected from (0, 0) at lower left corner (Table 2 and 3).

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Table1: Antenna design specifications for single layer antenna

Parameters	Value (mm)
Dielectric constant ε_r	4.4
Substrate height h	1.6
Patch Width W_p	30.0
Patch Length L_p	40.0
Ground plane Width W_g	40.0
Ground plane Length L_g	50.0
Length of feed strip Q	3.0
Width of feed strip R	3.0

Table 2: Antenna parameters for single layer slotted antenna

Parameters	Value (mm)
AB	16.0
BC, PA	5.5
CD, EF	8.5
DE, NO	10.0
EF	8.5
FG, LM	5.0
GH, KL	2.5
HI, JK	18.0
IJ	11.0
MN	6.5
OP	5.5

Table 3: Antenna parameters for proposed stacked antenna

Parameters	Value (mm)
Parasitic patch length (X)	40.0
Parasitic patch width (Y)	30.0
Slot length (Z)	32.0
Slot width (W)	4.5

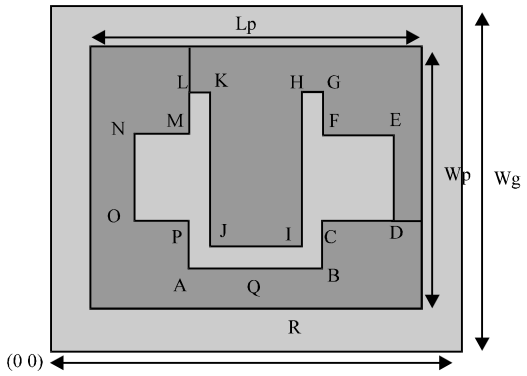

Fig. 1: Geometry of single layer U slotted microstrip antenna

This single layer antenna design is stacked with a parasitic patch element of length 40 mm and width 30 mm.The parasitic patch element is loaded with a rectangular slot of length 28 mm and width 4.5 mm. There is no air gap between driven patch and parasitic patch element. The centre of parasitic patch is at coordinate (30, 20). The proposed stacked antenna design is shown in Fig. 2 (Ali *et al*., 2017).

The microstrip line feed of 50 Ω is placed at lower middle of the driven patch through a strip of length 3 mm and width 3 mm to achieve maximum bandwidth. The side view of proposed stacked antenna is shown in Fig. 3.

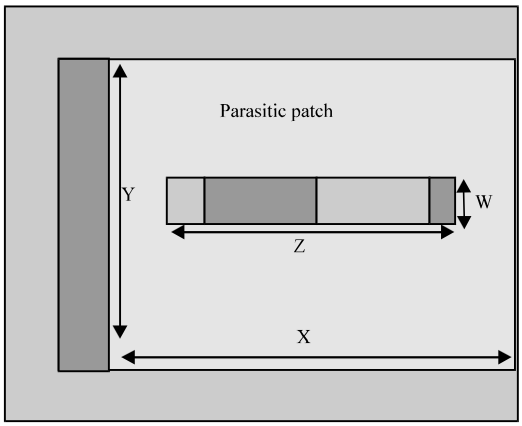

Fig. 2: Geometry of proposed stacked antenna

Fig. 3: Side view of proposed stacked antenna

RESULTS AND DISCUSSION

This study shows the enhancement of bandwidth of stacked rectangular microstrip patch antenna by loading U-slot. The fractional bandwidth of U slot loaded single layer antenna is 25.80% and antenna is resonating at 2.203 GHz with return loss -34.91 dBi. The proposed stacked antenna is resonating with multi band frequency range and fractional bandwidth of multi band proposed antenna is 30.14% (lower band), 0.4% (middle band) and 2.56% (upper band). The multi band frequency of the proposed antenna design lie in the range of 1.715-2.323, 2.453-2.463 and 2.696-2.767 GHz, respectively. This frequency band is suitable for wireless communication applications. The performance specifications of return loss, radiation pattern, VSWR, gain, antenna efficiency and directivity of proposed antenna is shown in Fig. 4-9.

The experimental bandwidth of lower band is 28% in the frequency range 1.29-1.71 GHz and resonance frequency at 1.46 GHz with return loss -13.97 dB and band width of upper band is 8.62% in the frequency range 2.11-2.30 GHz and resonance frequency at 2.20 GHz with return loss -17.98 dB. The maximum gain of stacked antenna design has been enhanced up to 5.003 dBi at frequency 2.457 GHz and maximum antenna efficiency is 99.25% at frequency 1.744 GHz. The maximum directivity of the antenna is 6.444 dBi at frequency 2.447 GHz. The

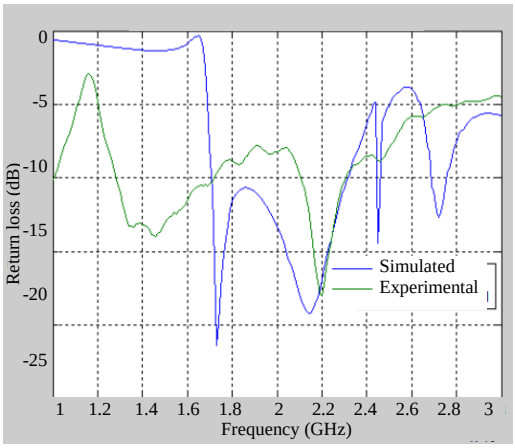

Fig. 4: Return loss vs. frequency graph

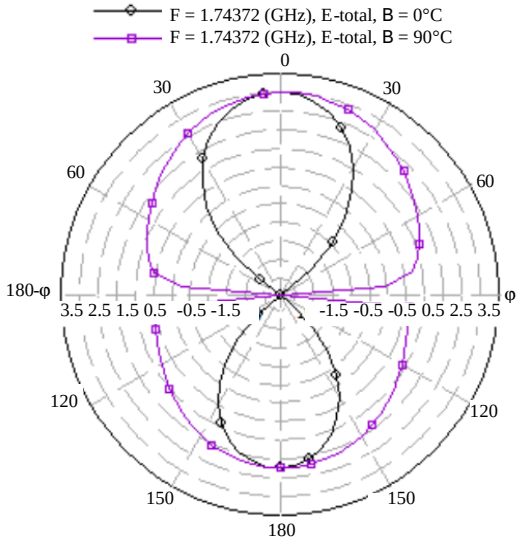

Fig. 5: 2D radiation pattern of antenna

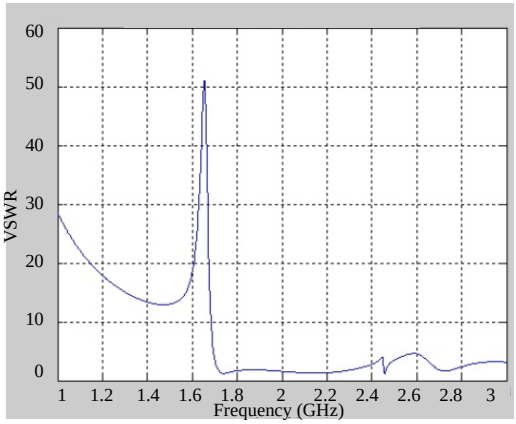

Fig. 6: VSWR of proposed antenna

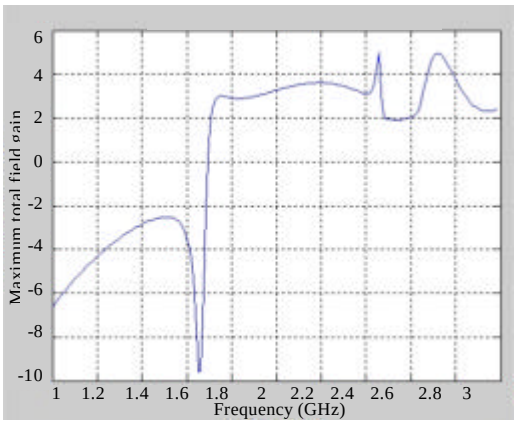

Fig. 7: Gain vs. frequency graph

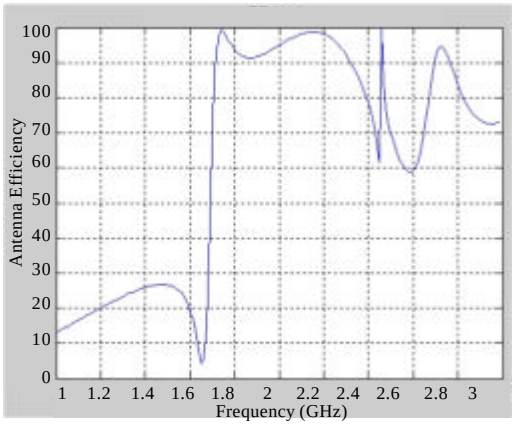

Fig. 8: Efficiency vs. frequency graph

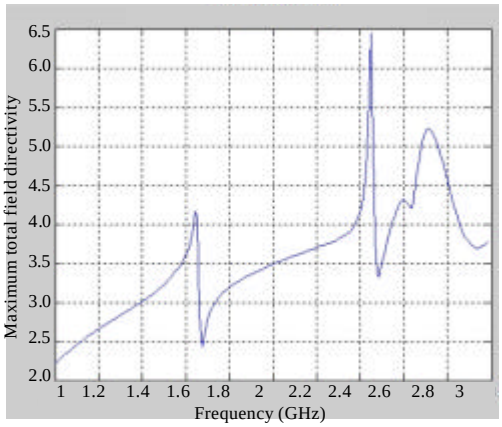

Fig. 9: Directivity vs. frequency graph

VSWR of the antenna is in between 1-2 in entire resonance frequency band. The simulation analysis of design patch antenna has been used by IE3D software tool.

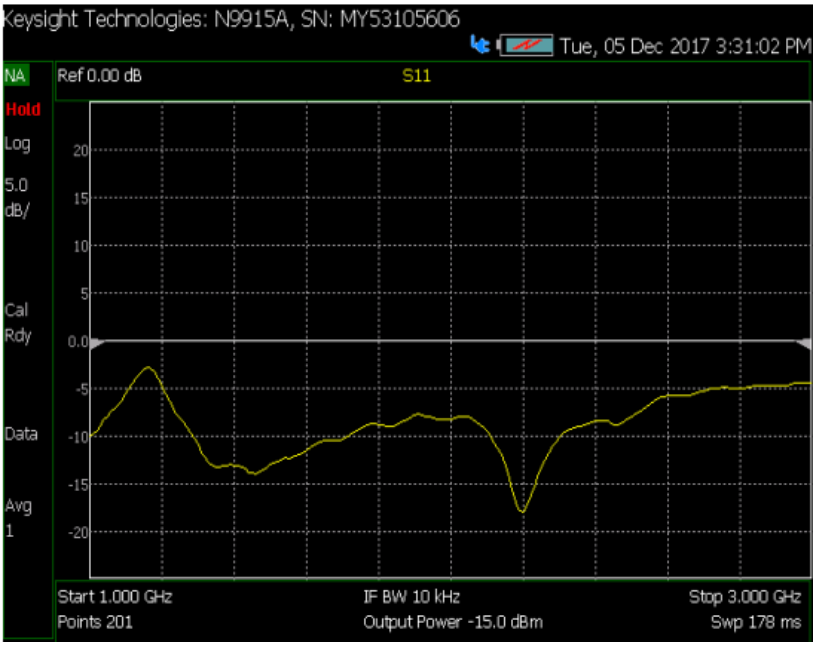

Fig. 10: Return loss vs. frequency graph of experimental result

CONCLUSION

The different characteristics of U slot stacked microstrip antenna have been studied. The fractional bandwidth of the stacked designed antenna has been enhanced upto 30.14%. The proposed stacked antenna is resonating with multi band frequency range at resonance frequency 1.740, 2.457 and 2.726 GHz with return loss -21.55, -22.60 and -12.72 dBi, respectively. The VSWR of the proposed antenna at different resonance frequency are 1.826, 1.160 and 1.602, respectively. This proposed antenna can be used in wireless communication system.

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