A Multi-application Compact Ultra Wideband Vivaldi Antenna for IoT, 5G, ITS, and RFID

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***Abstract*—A miniaturized wideband Vivaldi antenna is presented in this paper. The proposed antenna is compact in size, has wide bandwidth and high radiation efficiency. The proposed antenna is simulated and fabricated on FR-4 substrate with overall dimensions of 20×17 mm^2. The resonating frequency of the reported design is observed as 5.8GHz and impedance bandwidth is 2.67GHz (4.94GHz - 7.61GHz). The simulated radiation efficiency and gain are approximately 98.9% and 3.66dBi, respectively. The proposed design finds its applications in IoT, 5G, Wireless LAN (WLAN), Intelligent Transportation System (ITS) and Radio Frequency IDentification (RFID).**

***Index Terms*—Vivaldi, Miniaturized, ITS, RFID.**

I. Introduction

In the last few years, the development of wireless communication systems have received a great attention and progress in the field of antennas. To cater the demand of smart life, large number of wireless devices are required. Hence, taking limited space into consideration, these devices need to have certain properties i.e. compact size, large bandwidth, high efficiency, cost efficient and moderately high gain. Microstrip antennas posses most of these properties and therefore gained high attention in last few decades [1], [2].

The wireless devices have many applications such as WLAN, Bluetooth, ITS, RFID, 5G, and Internet of things (IoT).The IoT devices involve remote monitoring, tracking, data collection, manufacturing, and media and entertainment applications. These specific applications have far-field and near-field communication with radio frequency and requires large bandwidth and high data rate to mitigate the transmission delay. These are the major reasons that makes Vivaldi antenna as one of the potential candidates for IoT applications. In literature, various techniques are reported to design wideband antennas such as defected ground structure (DGS), slotted radiating patch, etc [3].

In this paper, a compact, radiation efficient Vivaldi antenna with slotted semi-circular DGS ground plane is reported. The evolution of the antenna is discussed in Section II. Section III comprises simulated results and discussion. The paper is concluded in Section IV.

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II. Proposed Vivaldi antenna

The layout of the proposed wide-band Vivaldi antenna is shown in Fig. 1 which consists tapper shape microstrip patch and a partial DGS ground plane. A low cost FR4

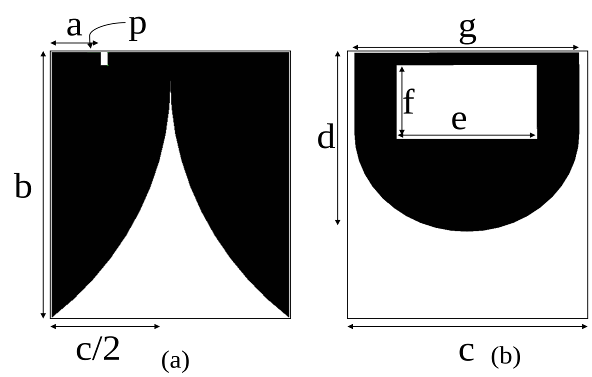


Fig. 1. Layout of the proposed antenna (a) Top view (b) bottom view.

substrate having (ε_r=4.4, $tan\delta$=0.02, thickness(h)=1.54mm) with copper cladding of 35 microns was selected for designing the proposed Vivaldi antenna. The evolution of antenna starts with designing basic Vivaldi antenna. Further a slot in the patch and a rectangular slotted circular DGS ground plane has been introduced to miniaturized the size and also to enhance the performance of Vivaldi antenna. The curve of Vivaldi patch and slot in ground plane causes a significant increase in gain at 5.2 GHz, 5.8 GHz and 7 GHz as well as improves the antenna efficiency in the proposed size of antenna. The optimized parameters of the design are listed in Table I. The antenna

TABLE I
Optimized parameters of the proposed antenna

Parameter Name	a	b	c	d	e	f	g
Dimension(mm)	5	20	17	14.5	10	6	16

is fed at point p as shown in Fig. 1. The proposed Vivaldi antenna is simulated using commercially available EM tool. The results are presented subsequently.

III. Results and discussion

The S_{11} Performance of the Vivaldi antenna is shown in Fig. 2, simulated in Ansys HFSS. The observed impedance bandwidth at S_{11}=-10 dB is found over the frequency band 4.94 -7.61 GHz. The Proposed antenna is designed to operate at four different frequencies 5.2, 5.8, 5.81 and 7 GHz (S_{11}=-23dB, -30dB, -29dB and -37dB, respectively) covering WLAN, ITS, IoT, RFID, 5G communication, and satellite band.

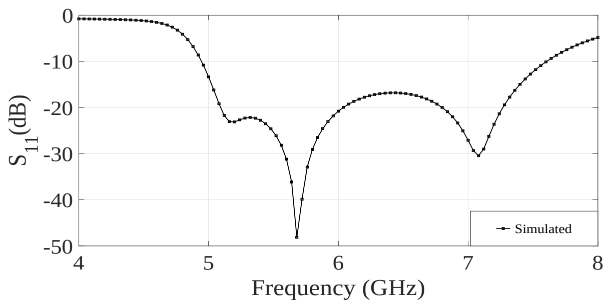
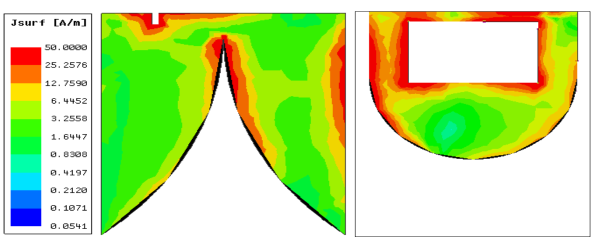
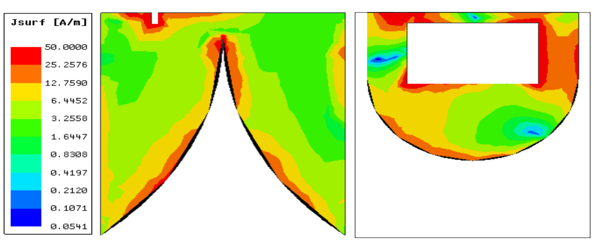


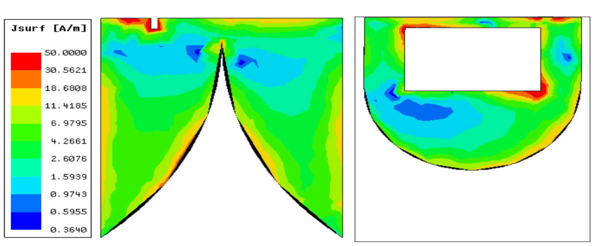
Fig. 2. Simulated S_{11} performance of Vivaldi antenna.



(a)



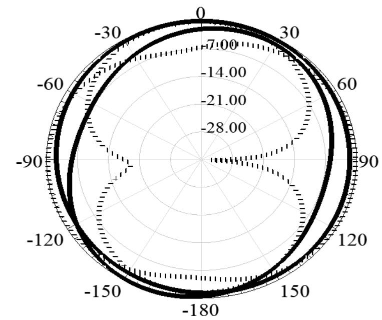
(b)



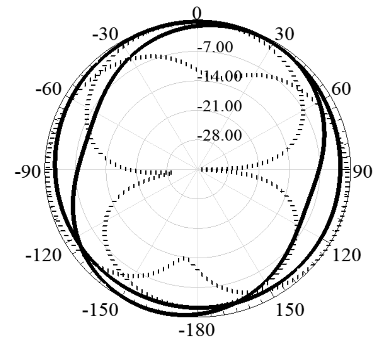
(c)

Fig. 3. Simulated current distribution patterns (a) 5.2 GHz (b) 5.8 GHz (c) 7 GHz.

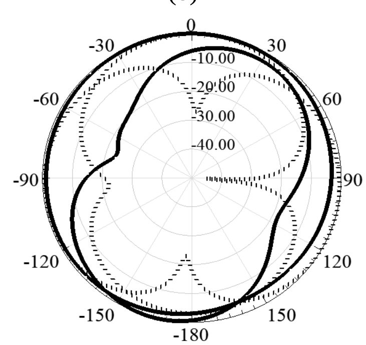
The surface current distribution of the proposed antenna and slotted DGS ground plane at (a) 5.2 GHz, (b) 5.8 GHz, (c) 7 GHz is shown in Fig. 3. The normalized far field co and cross patterns in elevation plane at 5.2, 5.8, and 7 GHz are shown in Fig. 4 (a), (b), and (c) respectively. The gain of the antenna at 5.2 GHz is found to be 2.78 dBi in elevation plane, at 5.8 GHz the observed maximum gain is 3.1 dBi, and at 7 GHz the gain is 2.9 dBi.



(a)



(b)



(c)

Fig. 4. Simulated normalized E-phi and theta patterns (a) 5.2 GHz (b) 5.8 GHz (c) 7 GHz. Solid line: $\phi = 0^0$, and dashed line : $\theta = 90^0$.

TABLE II
Comparison of the Proposed design with previous antennas

Reference	Size (mm)	Bandwidth(GHz)	Material
[4]	45×40	6	FR-4
[5]	135×100	8	TP-2
[6]	72×70	6	TLY-5
[7]	60×40	7.5	ROGERS-4350
Proposed design	20×17	2.67	FR-4

The comparison of the proposed antenna with previously reported designs is displayed in Table II. It is evident from the Table, designs reported in [4]–[7] are having higher size and also not economic compared to the proposed design.

IV. Conclusion

A compact Ultra Wideband Vivaldi antenna has been reported with satisfactory performance. The proposed antenna is operating from 4.94GHz - 7.61GHz and having an impedance bandwidth of 2.67GHz and has size of $20 \times 17mm^2$. The simulated gain of the antenna is 3 dBi at 5.8 GHz. The proposed antenna is a suitable candidate for IoT, 5G, ITS, WiMax, WLAN, and RFID applications.

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