Analysis of Vivaldi antenna etched with the circular patch and Complementary Split Ring Resonator slot

S. Sandhya Rani, K. K. Naik

Abstract: ***A Vivaldi antenna with circular patch and complementary split ring resonator (CSRR) slots etched has presented in this paper. The shape of the patch, defected ground structure, slots and feeding are considered to enhance the gain and bandwidth of proposed antenna. The triple frequency band operation over 5 GHz to 15 GHz frequency range with the return loss of -27.46, -11.23, and -13.61 dB at three operating frequencies 7.28GHz, 11.7 GHz and 14.44 GHz respectively are observed for the proposed design. The proposed Vivaldi antenna with slots can be used for satellite broadcasting applications.***

Index Terms**:** ***Vivaldi antenna, bandwidth enhancement***

I. INTRODUCTION

The Vivaldi antenna has drawn great attention from researchers, due to its ultra-wide band characteristics and can be applicable for all microwave systems. In the literature, several compact multi-band Microstrip Patch Antennas (MPA) with metamaterial structures and slots have been reported for various wireless communication applications such as Vehicular communication [1], a miniaturized implantable dual-band antenna for bio-medical applications at ISM band [2], dual circularly polarized metasurface antenna with artificial ground for dual band [3], a compact antenna with dual polarization for 5G Multi Input Multi Output application [4] , a high gain and low profile antenna for improved AR bandwidth for Wimax have been reported in [5]. An ultra wide impedance bandwidth and Omni directional polarized Vivaldi antenna array [6], a compact Vivaldi antenna with band-notched capability with two circular SRR (Split Ring Resonator) structures for WiMax band [7], with high frequency selectivity by loading resonator structures [8] was proposed. Improvement in gain of antipodal Vivaldi antenna [9] and improvement of directivity by adding metal patches [10] was reported.

A multi-band antenna with defected ground structure for ultra wideband [11] and a CPW fed slot and defected ground structure antenna with triple frequency bands for ultra wide band (UWB) frequency range [12] was reported. A dual polarized triple-band y-shaped monopole antenna for wireless applications WLAN/WiMAX [13] was reported.

Over the last few years, several antenna designs have been proposed, to mitigate the directivity problem of Vivaldi antenna. Hence, for enhancing the bandwidth, gain and return loss, etching method with complementary split ring resonator (CSRR) slot is proposed to Vivaldi antenna for tri-band applications. By etching the CSRR slot we observed the triple resonant frequencies with good return loss, gain and bandwidth.

II. DESIGN METHODOLOGY FOR VIVALDI ANTENNA WITH CIRCULAR PATCH AND CSRR SLOT

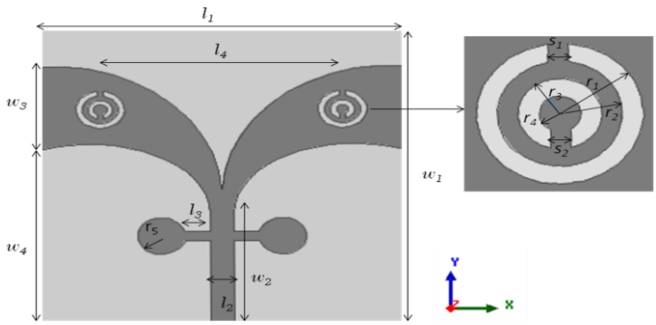

Fig. 1 Geometry of the CSRR slot circular patch Vivaldi antenna.

Vivaldi antenna with the circular patch and CSRR slot has shown in Fig. 1. The proposed antenna dimensions are 30 x 32 x 0.07 mm^3 with polyimide substrate having dielectric constant ε_r= 3.5, loss tangent of 0.008 and thickness of 0.07mm. The partial ground plane is considered with dimensions of 5 x 32 mm^2 at the center beneath the substrate as shown in Fig. 2. Two CSRR shaped slots are etched on the Vivaldi antenna with outer ring radii of r_1 and r_3 and inner radii of r_2 and r_4 respectively. Two circular stubs with radius of r_5 are attached to the microstrip feed line for impedance matching.

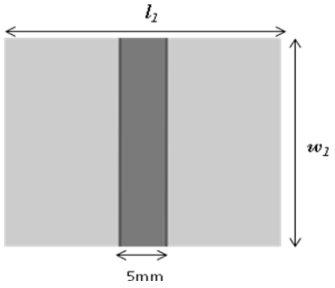

Fig. 2 Bottom view of the antenna with Partial ground plane.

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Table I. Antenna dimensions

Parameters	Values in (mm)	Parameters	Values in (mm)
l_1	30	w_4	19
w_1	32	r_1	2
l_2	2	r_2	1.5
w_2	12	r_3	1
l_3	2	r_4	0.5
w_3	2	r_5	2
l_4	20	s_1, s_2	0.5

III. RESULTS AND DISCUSSIONS

The CSRR slot Vivaldi antenna is designed with polyamide substrate having dielectric constant of ε_r=3.5 and a height of 0.07 mm. The dimensions of the simulated antenna are given in Table -I. Simulated results of this antenna are shown from Fig 3 to Fig 6. Three operating frequencies are obtained at 7.28GHz, 11.7 GHZ and 14.44 GHz frequencies with impedance bandwidths of (7.2-7.38GHz) 180 MHz, (11.66-11.73GHz) 70 MHz and (14.28-14.58) 300 MHz and return loss of -27.46dB, -11.23 dB and -13.61 dB respectively. The third operating frequency is observed more band width of 300 MHz compared to other frequencies.

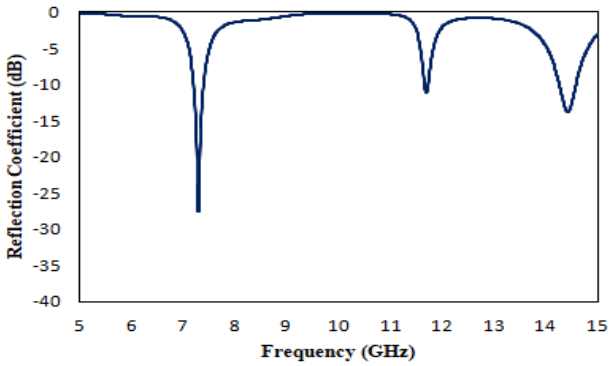
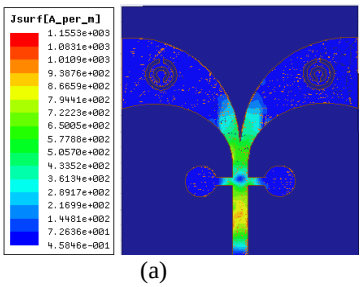
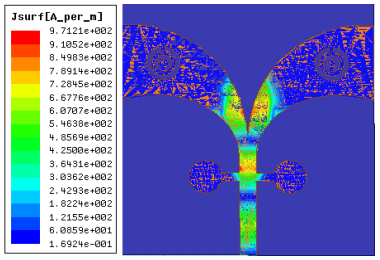


Fig. 2 Simulated Return Loss of the CSRR slot circular patch Vivaldi antenna

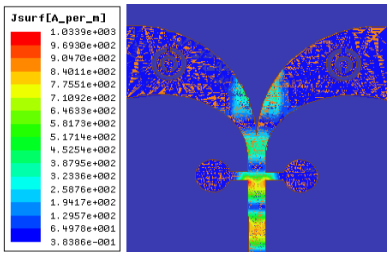
The surface current distributions of three operating frequencies are shown in fig. 4. The maximum current distribution of 71.76A/m is observed at the 11.7 GHz. The gain plots of the antenna are shown in fig 5. The gains of 3.13 dB, 3.63dB and 6.16 dB are obtained at 7.28 GHz, 11.7 GHz and 14.44 GHz frequencies respectively and it is observed that the maximum gain of 6.16 dB is obtained at 14.44 GHz frequency.



(a)



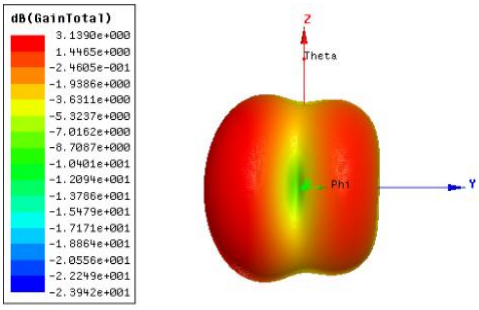
(b)



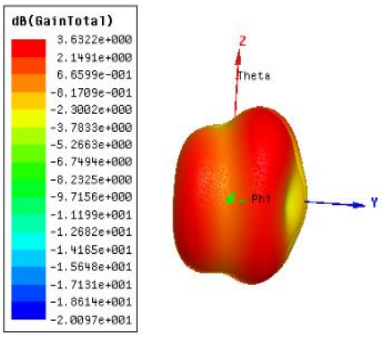
(c)

Fig. 4 The current distribution on the surface of the Vivaldi antenna at (a) 7.28GHz (b) 11.7GHz and (c) 14.44 GHz frequency

The normalized radiation patterens of the antenna for E-plane and H-plane at the three operating frequencies are shown in Fig 6. Nearly omnidirectional radiation patterns are observed in E-plane and butterfly shaped directional radiation patterns are observed in H-plane for all the three resonant frequencies.



(a)



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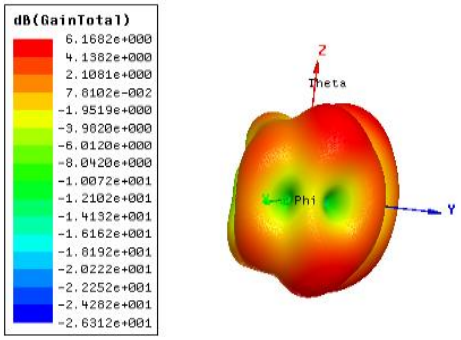
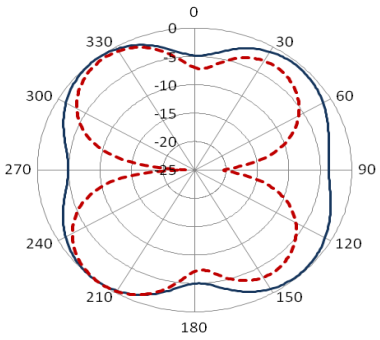
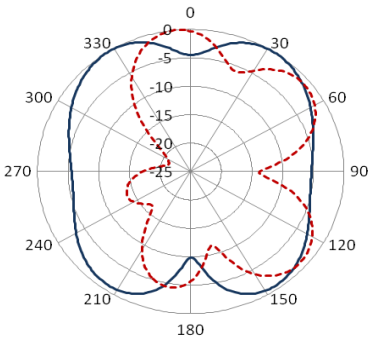


(c)

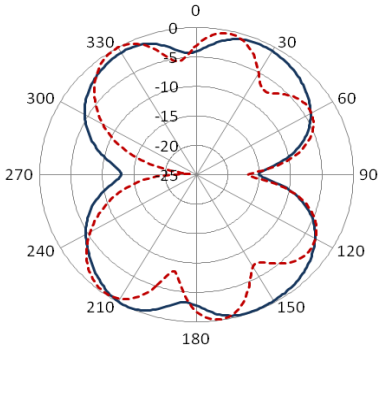
Fig. 5 Gain plot of the Vivaldi antenna at (a) 7.28 GHz, (b) 11.7GHz and (c) 14.44GHz frequency



(a)



(b)



(c)

Fig. 6 E-Plane and H-Plane Radiation patterns of the Vivaldi antenna (a) 7.28GHz, (b) 11.7GHz and (c) 14.44GHz frequency

IV. CONCLUSION

The Vivaldi antenna has etched with the circular patch and CSRR slot method. Due to etching of CSRR slot on the radiating patch and adding the circular patches on either side of feed line, the gain and bandwidth of the antenna are enhanced moderately. Hence, the antenna can be very useful in satellite applications for broad banding purpose.

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