High-gain Triple-Band Reconfigurable Vivaldi Antenna

C. Borda Fortuny*

K. F. Tong†

K. Chetty‡

P. Brittan§

Abstract — A frequency agile Vivaldi antenna whose operating frequency band can be switched is proposed. High-performance radio-frequency micro-electromechanical system (RF-MEMS) switches allow tuning of the operational band between 2.0 GHz, 3.7 GHz and 5.2 GHz. The average gains of the antenna for the low, mid and high bands are 8.5 dBi, 12.5 dBi and 13.7 dBi, respectively. This reconfigurable antenna offers improved performance over multiple, wideband and multiband antennas without increases in cost and size.

1 INTRODUCTION

The growth of reliable wireless communications demands higher antenna capabilities. Frequency reconfigurable antennas are a feasible solution since they can operate in one frequency band while rejecting other bands, thereby increasing signal-to-noise ratio (SNR) [1]. Although some work has been done in the field of reconfigurable antennas, most of the designs can only operate in a narrow range of frequencies [2]. The use of a Vivaldi antenna allows working in a wide range of frequencies.

Some work has been reported on Vivaldi reconfigurable antennas in [3, 4]. In [3] several rings are introduced in a Vivaldi antenna for resonance at different frequencies. As it resonates in specific frequency bands, some energy is accumulated in the rings diminishing the overall gain of the antenna down to 3.27 dBi, making it not suitable for spectrum monitoring [5]. A tuneable stop band in a Vivaldi antenna is proposed in [4]. Three varactors are distributed on a microstrip line resonator which couple to the tapered slot. The varactors are used to change the electrical length of the resonator, achieving several reconfigurable stop bands. But the maximum gain obtained is 7 dBi.

This paper proposes a high-gain frequency reconfigurable antenna that can be switched between three frequency bands. In order to improve the SNR of the antenna, quarter-wavelength stubs are

used to control the operating frequency. Given that the Vivaldi antenna is frequency-independent, the radiation characteristics are going to be maintained in its whole band.

2 ANTENNA GEOMETRY AND DESIGN

The proposed antenna is designed on a single microwave substrate, as shown in Figure 1. The dielectric substrate used is Taconic RF-43 with thickness 0.76 mm. The top layer is a tapered microstrip feed-line of the antenna. The taper matches the impedance at 50 Ω at the input port to the optimum impedance in the back slot. The transition from microstrip to slot line is formed by two quarter-wave stubs. Two RF-MEMS switches are introduced in each stub. The positions of these switches determine the effective length of the stubs, as shown in equations 1 and 2, where λ_o is the free-space wavelength, λ_g is the guided wavelength in the microstrip line, HB indicates the high band and MB indicates the mid band. These distances are optimised for maximum signal coupling at the transition at each reconfigurable band.

Figure 1: Antenna geometry and switches position.

$$L_1 = \frac{\lambda_{g,HB}}{4} \quad , \quad L_2 = \frac{\lambda_{g,MB}}{4} \quad (1)$$

$$L_3 = \frac{3}{4} \cdot \lambda_{o,HB} \quad , \quad L_4 = \frac{3}{4} \cdot \lambda_{o,MB} \quad (2)$$

*University College London, Torrington Place, London, WC1E 7JE, UK, e-mail: cristina.borda.12@ucl.ac.uk

†University College London, Torrington Place, London, WC1E 7JE, UK, e-mail: k.tong@ucl.ac.uk

‡University College London, 35 Tavistock square, London, WC1H 9EZ, UK, e-mail: k.chetty@ucl.ac.uk

§L-3 TRL Technology, Severn Drive, Tewkesbury, Gloucestershire, GL20 8DN, UK, e-mail: Paul.StJohnBrittan@L-3Com.com

3 RESULTS AND DISCUSSION

The simulated S_{11} parameter and gain at broadside direction, i.e. $(\theta, \phi) = (90^\circ, 90^\circ)$ of the antenna at the different operating bands are shown in Figure 2. The gain is stable within each band and drops rapidly in the immediate proximity of the ends of the band. As the electrical size of the radiating aperture varies with operating frequency, the maximum gain variation is 2.2 dB within a band. The gain tends to increase in frequency with a lineal trend. Table 1 presents the results obtained.

Figure 2: Simulated S_{11} parameter and realised gain of the proposed design.

	<i>Center freq.</i>	<i>Bandwidth</i>	<i>Gain</i>
Low band	2.0 GHz	600 MHz	8.67 dBi
Mid band	3.7 GHz	600 MHz	12.20 dBi
High band	5.2 GHz	460 MHz	13.84 dBi

Table 1: Simulated results for the proposed antenna.

Figures 3 and 4 show the radiation pattern for the E-plane and H-plane, respectively. The direction of the main lobe is constant in all bands. The 3dB beamwidth is decreasing significantly in H-plane, but it is stable in the E-plane. Overall the radiation pattern is maintained for all bands. In Table 2 the simulated results of the radiation pattern in all bands are presented.

	<i>Center freq.</i>	3dB beamwidth	
		<i>E-plane</i>	<i>H-plane</i>
Low band	2.0 GHz	63.6°	77.5°
Mid band	3.7 GHz	28.3°	41.2°
High band	5.2 GHz	25.1°	22.6°

Table 2: Simulated radiation pattern results for the proposed antenna.

Figure 3: Simulated E-plane radiation pattern for all bands of the proposed design.

Figure 4: Simulated H-plane radiation pattern for all bands of the proposed design.

4 CONCLUSION

A tri-band reconfigurable antenna based on a Vivaldi antenna is presented. RF-MEMS switches are used to tune the antenna to the different operational bands. The switches can be placed in different positions, where other configurable frequency bands can be created, to accommodate each system requirements. This design minimizes the effects of the switches because only two switches are working at the same time. There is high isolation between the bands, which is suitable for spectrum surveillance. The proposed antenna is currently being fabricated and will be tested to validate the simulation results. The measured results will be presented in the conference.

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