Widely Tunable Multiband Reconfigurable Patch Antenna for Wireless Applications

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***Abstract*— A design of a low profile reconfigurable microstrip patch antenna is presented. The antenna consists of four sup-patches connected to one feed line, each sub-patch generates a single band. By placing a variable capacitor at the input of the sub-patches, the impedance matching frequency of the antenna can be tuned over a wide range starting from 0.92 GHz to 2.98 GHz with total tunability rang of 2060 MHz. The proposed antenna designed to operate in the Global System for Mobile communication (GSM900, 880-960 MHz)/ Digital Communication System (DCS1800, 1710-1880 MHz)/ Universal Mobile Telecommunication System (UMTS, 1920-2170 MHz)/ Wireless Local Area Network (WLAN, 2400-2483.5 MHz)/ and Worldwide Interoperability for Microwave Access (WiMAX, 2495-2700 MHz). The total size of the proposed antenna is 50 x 50 mm^2 which is suitable for small wireless devices.**

***Index Terms*— Reconfigurable Antenna, Multiband Antenna, Tunable Antenna, Small Antenna, wide tunability range**

I. Introduction

Antennas for wireless application are currently requires operation in a number of bands. Antennas are the most important components of any communication systems. Sometimes their inability to adjust to new operating frequency can limit system performance. Therefore, by making antennas able to reconfigure its operation and can adapt with changing system requirements or environmental conditions can improve these restrictions and provide additional levels of functionality. There are different techniques investigated by researchers to reach multiband operations. These includes, applying different shaped-slots to create multiband and wideband [1]-[3].

A reconfigurable antenna can reuse its entire volume at different operating bands so the physical size of the multiband antenna can be reduced, to allow the operating frequencies to be reconfigurable, switching component must be used. Varactor and PIN diodes are the most commonly used to tune the operating frequencies in RF and front-end application [4]-[5]. In [6] PIN diodes were used to switch single band. In [7] a dual band with wide tuning range has been achieved by introducing varactor diodes to a chassis antenna. In [8] a wide tuning range is also achieved by using varactor diodes in a large ground plane to cover the frequencies between1.3 GHz to 2.670 GHz.

The design presented in this paper aims to combat the high profile and large size usually occur when designing antennas for low frequencies. The antenna occupies a total size of 50 x 50 x 1.57 mm = 2590.5 mm^3 including the ground plane. The antenna can be used in different wireless applications.

II. Configuration and Design procedure

Fig.1 shows the structure of the proposed reconfigurable antenna. The main dimensions are listed in Table I. The antenna consists of 4 sub-patches with varactor diode at the input of each sub-patch, feed line, ground plane, 10 pF chip capacitor and 1K ohm current limitation. The antenna is designed on a 1.57 mm-thick FR-4 substrate with a dielectric constant of 4.4. The varactor diode of the BB184 from Philips was used; the capacitance of the diode can be changed from 2 pF (10V) to 14 pF (1V). The operating frequencies can be tuned over a wide range.

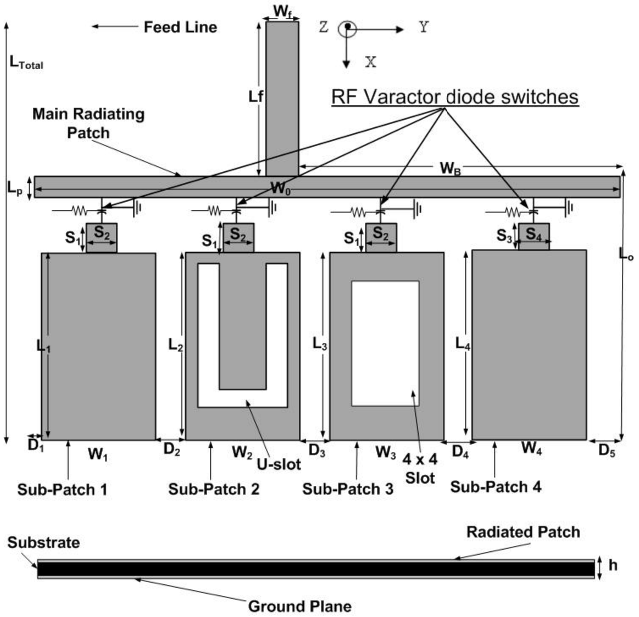


Fig. 1 The structure of the proposed antenna

TABLE I
THE DIMENSIONS OF THE PROPOSED ANTENNA (UNITS IN MM)

L_o	L_1	L_2	L_3	L_4	L_f	L_P
33	24	24	24	24	12.5	5
W_o	W_1	W_2	W_3	W_4	W_f	W_B
50	8	10	10	12	3	27
S_1	S_3	S_2	S_4	D_1	D_2	D_3
3	3	2	2.5	1	2	2
D_4	D_5	L_{Total}	h	Ground Plane		
3	2	45.5	1.57	50 x 50		

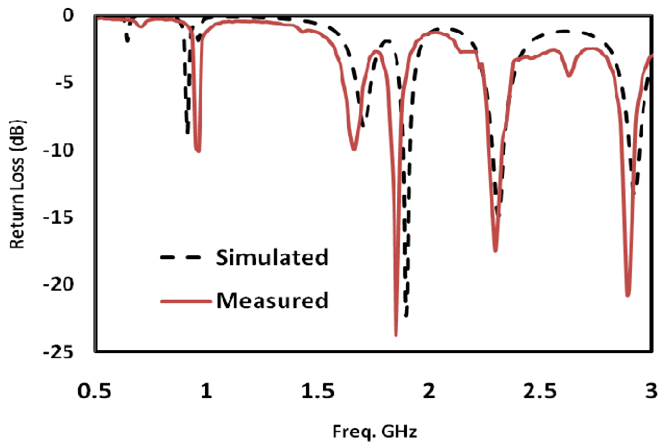


Fig. 2 (a) The measured (solid) and simulated (dashed) return loss (S_{11}) when the antenna is not biased (i.e. V=0).

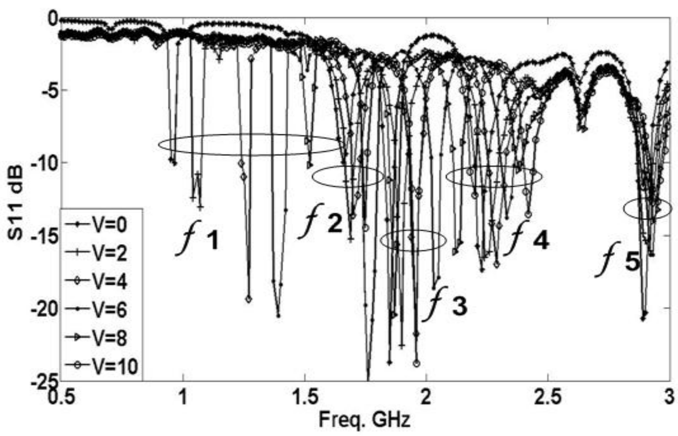


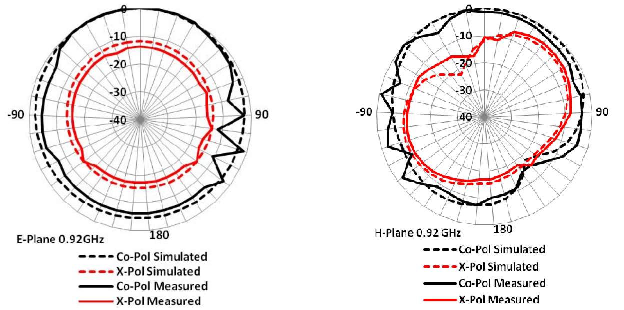
Fig. 3 The measured return loss S11 when applying equal voltages to the four switches

III. SIMULATED EXPERIMENTAL RESULTS

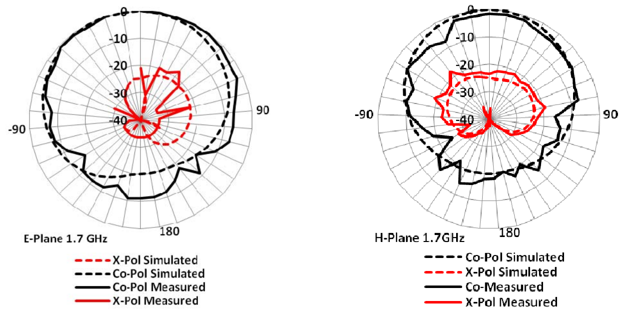
The antenna was simulated using HFSS software. In the simulation model, the capacitance was changed from 2 pF to 14 pF while the return loss was obtained from each value. Fig.2 shows the return loss (S_{11}) when the antenna is not biased. Fig.3 shows the measured S_{11} when applying equal voltages to the switches. By applying equal voltages to the four switches the frequency of the 0.92 GHz, 1.7 GHz, 1.95 GHz 2.4 GHz and 2.9 GHz can be tuned over wide range.

The characteristics of the simulated results can be verified by fabricating the antenna and measure its performance. The antenna was fabricated on a PCB, the thickness of the substrate is 1.57 mm, the dielectric substrate is FR-4 with a relative permittivity εr = 4.4. The measured and simulated results are in good agreements.

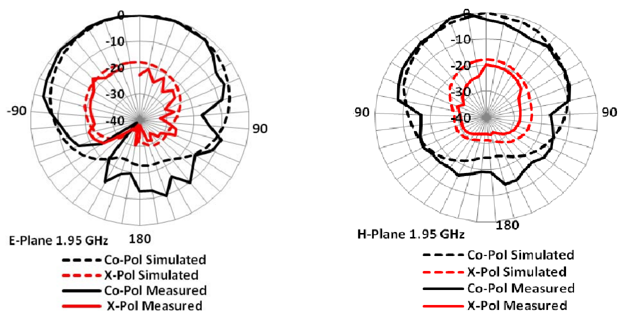
The measurements for the radiation patterns were conducted at the Small Antenna Radiated Testing Range (SMART) at the National Physical Laboratory (NPL). After measuring the co and cross polar, the results were normalized to the maximum value. The normalized measured and simulated radiation patterns for the co- and cross polar far field E-plane and H-plane at 0.92, 1.70, 1.95, 2.4 and 2.9 GHz are shown in Fig. 4(a)-(e) respectively.



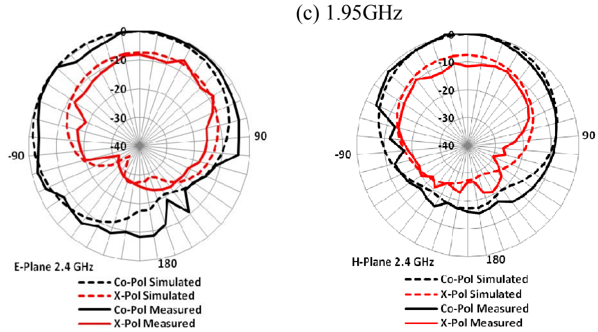
(a) 0.92 GHz



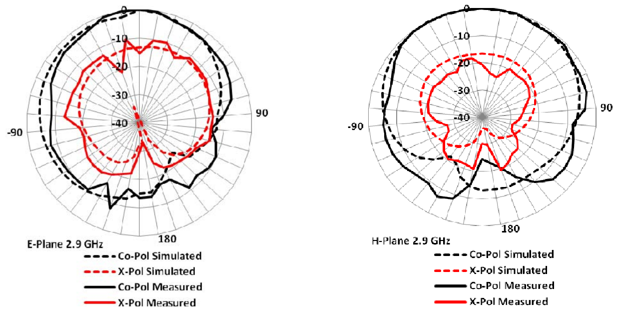
(b) 1.7GHz



(c) 1.95GHz



(d) 2.4GHz



(e) 2.9GHz

Fig.4 Measured versus simulated Co-Pol and X-Pol radiation patterns for E and H planes when all switches set to be 0V at (a) 0.92 GHz (b) 1.7 GHz (c) 1.95 GHz (d) 2.4 GHz and (e) 2.9 GHz

Conclusion

A compact Reconfigurable five-band microstrip patch antenna was proposed. The proposed antenna can cover more than 12 applications. Measurements of the return loss and radiation patterns are in good agreement with simulated results at the different frequencies. The total size of the antenna is suitable for slim devices or small wireless system.

Acknowledgment

The measurements at the NPL SMART chamber were supported by the Measurements for Innovators (MFI) program and the National Measurement Office, an Executive Agency of the Department for Business, Innovation and Skills.

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