A Compact Size Reconfigurable PIFA Antenna for Use in Mobile Handset

I.T.E.Elfergani[1], R. A. Abd-Alhameed[1], C.H.See [1] , T.sadeghpour[1] ,YAS Dama[1], SMR Jones[1] and P. S. Excell[2]

[1]Mobile Satellite Communications Research Centre, University of Bradford, Bradford, BD7 1DP, UK
Email: {i.t.e.elfergani, r.a.a.abd, c.h.see2, t.sadeghp, s.m.r.jones, y.a.s.dama} @bradford.ac.uk
[2]School of Computing and Communications Technology, Glyndŵr University, Wrexham, LL11 2AW, UK
Email: p.excell@ glyndwr.ac.uk

Abstract

A planar inverted-F type reconfigurable antenna with slot is presented. The antenna can cover frequency bands which include Digital Cellular Service (DCS: 1710–1880 MHz), Personal Communication Service (PCS: 1850–1990 MHz), and Universal Mobile Telecommunications System (UMTS: 1900–2200 MHz). Initially, the reconfigurability of the proposed antenna is achieved by attaching lumped capacitor over the slit of the radiator with values range from 1.5- 4pf. The measured and simulated results reveal that the fabricated proposed antenna is capable of obtaining tunable frequency ratio from 1850MHz to 2200MHz with overall size of $21\times13.5\times5$ mm^3 that makes it suitable for handset applications and can be easily integrated inside commercial mobile handsets.

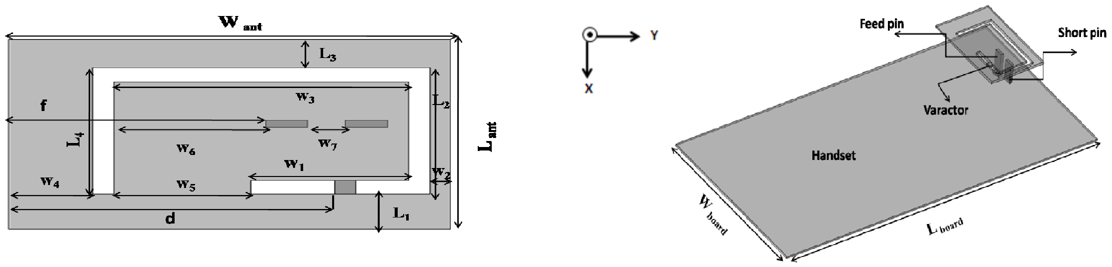
1. INTRODUCTION

With the revolution of info-communication era, broadband operations from a compact and low profile electronic gadget are demanded. In this regard the utmost constraint is the availability of low profile planar antenna from which getting adequate bandwidth is a big challenge. Both the bandwidth and gain constraints on microstrip patches have been addressed, and several techniques used to overcome or improve these criteria have been applied, with particular reference to PIFA structures [1].

They are compact in size, having omni-directional patterns, improved average power in the urban area where cross polarization is relatively large [2]. Basically, Simple PIFA consists of rectangular planar element, shorting pins and a ground plane. Numerous methods can be utilized to make a dual-band PIFA; commonly a slot is used [3]. But using slots may not be a choiceable option since they only can generate very narrowband resonances at two or three frequencies depending on the number of perturbations or resonators. In this regard, PIFA antenna is loaded with PIN and varactor diodes to operator over a very wide frequency band [4-10]. This frequency tuning generates a large dynamic range of frequencies. But switches are seldom used because its reactive load may affect the bandwidth of the PIFA either to make it better or worse [11].This paper presents a new reconfigurable PIFA-slot type antenna which covers the operating ranges of DCS, PCS and UMTS. The antenna is designed iteratively using a frequency domain finite element analysis (Ansoft HFSS), and work bench results. The final design optimisation was cross validated using CST Microwave Studio, and a representative prototype was constructed on this basis.

2. ANTENNA DESIGN

Figure 1 shows the geometry of the antenna. The antenna is placed on the ground plane of dimension L_{board} = 80mm,W_{board} = 42 mm and thickness 0.5 mm by means of shorting pin height of 5mm and width of 2mm.



a b

Figure1. Basic antenna structure; (a) Top view (b) 3D.

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The antenna is fed by vertical plate of maximum height 4.5mm and width of 2 mm, in which it is connected to the feeding probe through the slot in the ground plane and the effective substrate being air. The slot has a uniform width of 1mm. The detailed dimensions of the radiator patch are illustrated in table I. The structural and lumped element parameters were simulated using both high frequency structure simulator (HFSS) and MW Studio [12] [13].The tuning range was investigated initially through manipulating lumped capacitance parameters (1.5-4pF).

Parameter	Value mm	Parameter	Value mm
L1	2.5	W4	4
L2	9	W5	6.5
L3	14	W6	7.5
L4	9	W7	1.8
W1	7.5	d	15.5
W2	1	f	12.5
W3	14	Want, Lant	21,13.5

Table I. Detailed Dimensions of Radiator Patch

3. RESULTS AND DISCUSSION

The impact of the loaded capacitor basically would be investigated on the fabricated antenna parameters such as return loss, radiation pattern and gain as well. This study would be carried out through comparison with the performance of a reference antenna not incorporating the varactor. The reference antenna without the loaded capacitors would be only resonated at 2.36 GHz as shown in Figure 2.However, one loaded capacitor with values of 1.5pf, 2pf, 3pf and 4pf on one fixed location along the slot of the radiator would make the proposed antenna resonate at frequency range from 1.85GHz to 2.2GHz

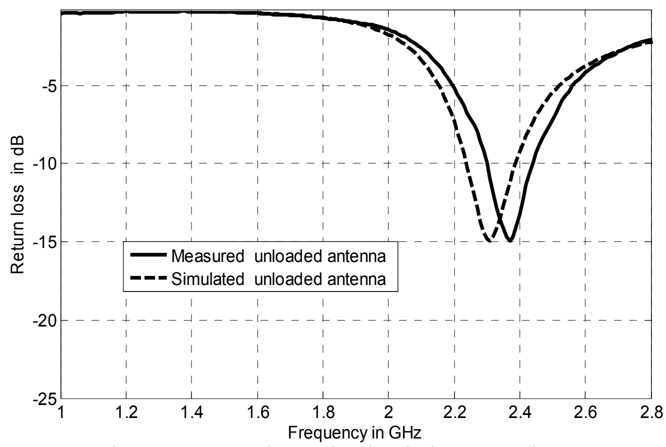
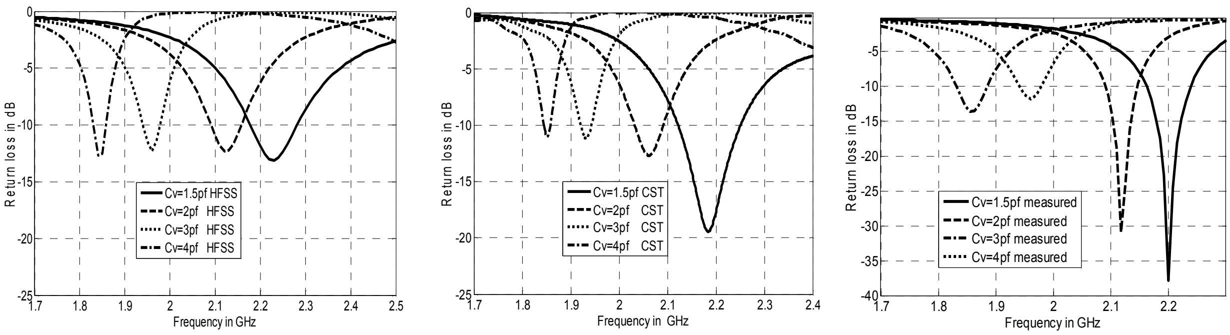


Figure 2. return loss of unloaded proposed antenna

The fabricated tuned antenna design relies on the introduction of the slot on the radiator arm, and a varactor diode is attached at fixed a location over the slot to achieve the required tuning. As the capacitance is varied, tuning is exhibited over frequency range from 1850MHz to 2200MHz.

The two packages were used to permit cross-confirmation that the simulation results were obtained with reasonable accuracy. In order to verify the practical characteristics of the prototype antennas, a vector network analyser was used for return loss measurement as shown in Figure (3, c).Both the predicted and measured return loss results of this antenna are presented for different values of capacitors (varactor) as shown in Figure 3.

The simulated and measured maximum gain of the proposed tuned PIFA antenna across desirable bands 1,85,1,95,2.1 and 2.2GHz is illustrated in Figure (4,a).



a b c

Figure3. Input return loss at the input port; (a) HFSS output (b) CST output (c) measured

The simulated maximum gains across the mentioned band were 1.61dBi, 1, 98dBi, 2.4dBi and 2.25dBi respectively, whereas the measured gain were 2.02dBi, 1.72dBi, 2.71dBi and 2,81dBi. Figure 4,b,c shows the input impedance of the proposed antenna, where the real part of the impedance is more or less 50 Ω over the targeted bandwidth (i.e., 1.85 to 2.2 GHz)

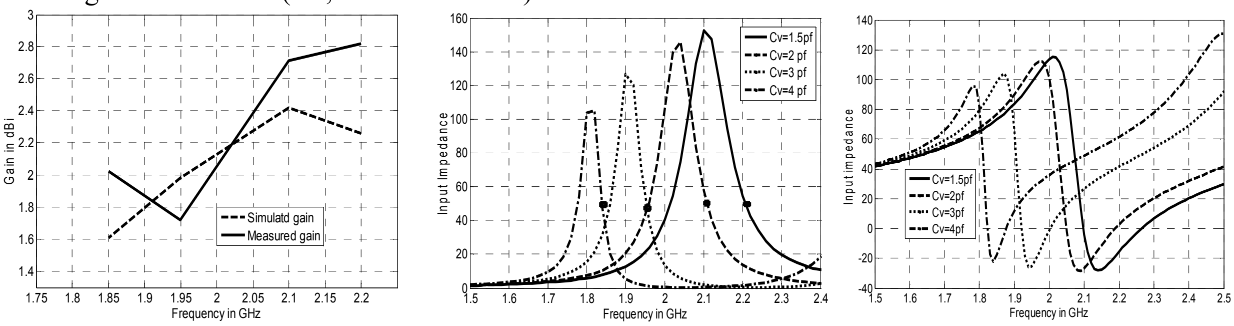


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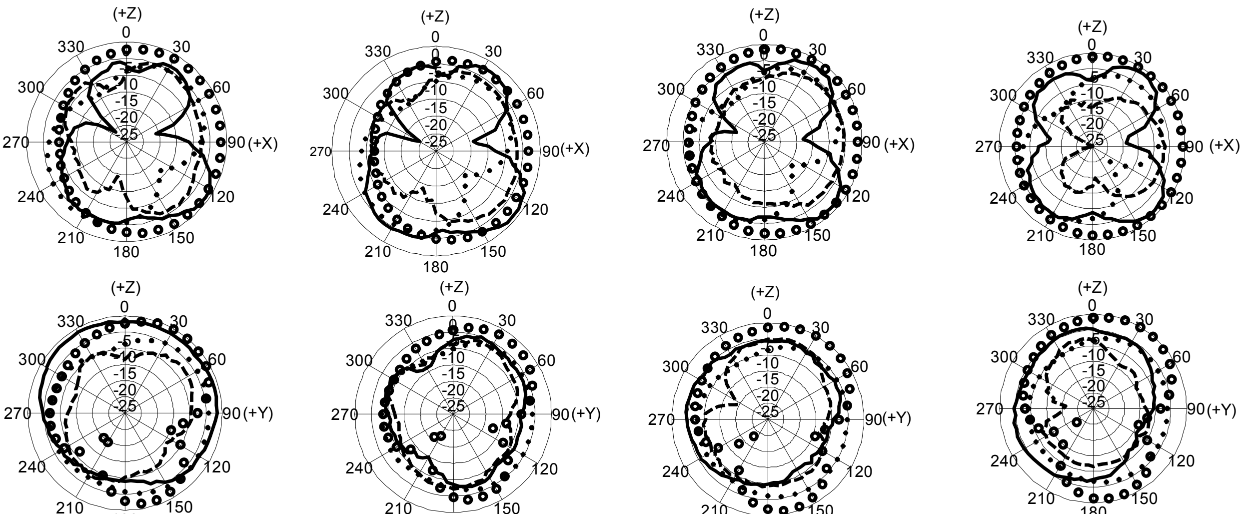
Figure4. (a) measued and simulated gain (b) input impedenace{Real} ,(c){Imaginary}



2200MHz 2100MHz 1950MHz 1850MHz

Figure 5. Measured and simulated radiation field patterns of the proposed antenna for various operating frequencies; left: xz plane, right: yzplane'ooo': Simulated co-polar, '***': Simulated cross-polar, '——': Measured co-polar, '- - - - ': Measured cross-polar.

Figure 5 shows simulated and measured radiation patterns. Both results are more or less similar and slight variations in these field patterns may be attributed in inaccuracies introduced during fabrication, and construction. The measurements of the far field radiation patterns were carried out inside an anechoic chamber in which the reference antenna used was a calibrated broadband horn EMCO type 3115. The spacing between the test antenna and the horn was kept at 4 m. Two pattern cuts (H-plane and E-plane) were considered for a range of frequencies that covered the entire target bandwidth. The simulated patterns were generated using HFSS for the same two cuts planes.

4. CONCLUSION

A compact reconfigurable PIFA antenna for single band applications is studied and investigated. The generated bands can be easily controlled by varying the capacitance of the varactor diode. The antenna design targeted DCS, PCS, and UMTS frequency bands. The performances of the proposed antenna were measured and are in good agreements with simulated results. Overall volume of the antenna is small enough that makes it suitable for compact and slim handsets.

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