A HIGH EFFICIENT COMPACT CPW FED MIMO ANTENNA FOR WIRELESS APPLICATIONS

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ABSTRACT

In this paper, a compact, high efficient CPW (co-planar waveguide) fed MIMO antenna which is used for various wireless applications is proposed. In this work, the proposed antenna is evaluated using IE3D simulation software. The proposed antenna has the compact size of 16.55mm x 20.05mm x 1.6 mm and the substrate is RT_Duroid 5880 used ($\varepsilon_r$ is 2.2 and $\tan\delta$ is 0.0009). The antenna resonates at 8.5 to 8.7 GHz frequency, with a return loss value of proposed antenna shows -48dB at 8.64 GHz. The gain obtained is 5.5 dBi, VSWR of around 1.1 at 8.64 GHz. The antenna is found to have 80% efficiency.

Key words: Coplanar wave guide, MIMO antenna, hexagonal slot structure & wireless applications.


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1. INTRODUCTION

In recent years, most of the wireless mobile and communication systems, the Multiple-Input-Multiple-Output (MIMO) antenna has been used. To increase the quality factor, use higher data rate, and increase the quality of signal [1]. This technology particularly used in 3G and 4G devices. In this method, several antennas are connected in single board at both receiver and transmitter and operating in same resonant frequency.

However, such a technique adds additional challenges to the antenna design where; the required MIMO specifications should be achieved, including overall MIMO antenna size (practical constrain) and the mutual couplings between individual antennas on one PCB (signal quality design constrain). These constrains should be achieved simultaneously to design a good MIMO antenna. Lots of researches have been done to design a MIMO antenna having the required size and minimum coupling for a specific application, including many approaches to minimize the coupling under size constrain. In 2010, Zhou et al. proposed MIMO antenna array for mobile handset operating in the band (1.6–2.6) GHz with −11 dB coupling [2].
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In 2011, a novel multiband antenna was proposed and reported with dual-broadband (0.8–1.2 & 1.6–2.7) GHz [3]. This antenna can be used for MIMO design and has wide range of applications including wireless mobile and sensors devices. A broadband microstrip MIMO antenna having multi-slots (two orthogonal E-shapes patch antennas) was used for WiMax applications (5.2–6) GHz, and it was reported in [4]. In April 2012, See et al. proposed a wideband printed monopole MIMO antenna for WiFi and WiMax applications (2.2–4.2) GHz [5]. Another wideband MIMO antenna was proposed and reported for WiMax and 4G applications (2.4–6.55)GHz [6]. Two-monopole-antenna system decoupled by using the neutralization-line technique was proposed and reported for wireless module card-solution in the band (2.2–2.5) GHz [7]. Also, a high gain (3.5 dBi), high isolation (−15 dB) and compact MIMO slot array antenna (55 × 95mm2) for handheld devices (2–3) GHz was proposed in 2012 by Ayatollahi et al. and reported in [8]. Defective ground structure (DGS) concept was used to provide high isolation (−22.5 dB) over a wideband for mobile handset MIMO antenna (0.5–3) GHz [9].

In 2013, other microstrip MIMO antennas covering LTE mobile (0.7–0.85) GHz and mobile terminals (2.2–6.5) GHz were reported in [10]. Recently, many MIMO antennas for WiFi&LTE (1.7–3.8) GHz, WLAN (2–8) GHz, WiMax (4.8–6.5) GHz and handheld devices (0.7–0.9) GHz applications were proposed and reported in [11]. In 2015, Li et al. proposed and analyzed a wideband indoor WLAN/WiMax MIMO base station array (5.2/5.5/5.8 GHz) consisting of sixteen elements of folded dipoles excited by an E-shaped microstrip feed line [12].

A dual band microstrip antenna (2.37–2.48 GHz) and (3.46–3.56 GHz) was proposed and reported by Kadu et al. for ISM and WiMax MIMO system [13]. Other publications include design and analysis of microstrip antenna using modified slotted ground plane for mobile phone handsets [26–28]. Slotted ground plane was used either to control the antenna resonance frequency(s) or to reduce the mutual coupling between MIMO antenna ports. In fact, to design a good MIMO antenna, isolation, overall MIMO size and MIMO antenna parameters (pattern, gain, efficiency, bandwidth, VSWR, and polarization) should be taken into account simultaneously. Such a task represents the actual challenge facing the antenna designers.

In this paper, a novel compact and broadband CPW fed MIMO antenna are designed, analyzed, investigated, fabricated, and measured. The proposed MIMO antennas resonate within the 3G/4G band and have a wide range of applications in wireless communication systems. Section 2 presents a detailed description of the proposed CPW fed antennas. The proposed CPW fed MIMO antennas are fully described and presented in Section 3. Simulation results are presented and discussed in Section 4. Finally, the paper is concluded in the last section.

2. ANTENNA DESIGN METRICS

CPW fed antenna has the dimensions with a compact size of 16.55mm x 20.05mm x 1.6 mm and the substrate used here is RT/Duroid 5880(εr is 2.2 and tanδ is 0.0009. The fabrication has to be done on single surface of the substrate, since the antenna here is CPW fed ground and the conducting part has to be fabricated on single surface only. The conductor width is 1.5mm and the gap from the coplanar ground plane to the patch is 1.225mm.
The length and width of the CPW fed slot is 17.05mmx 10.8 mm. Ports were defined, meshing was done. An automatic generation of uniform and non-uniform mesh with rectangular, triangular cells is obtained. Then simulation process was carried out using IE3D software. The return loss, resonant frequency, VSWR etc., vary accordingly with the variations in the size of the slot, increasing or decreasing the length, width of the patch, coplanar ground plane dimensions. The design metrics are shown in the Fig.1.

3. RESULTS AND DISCUSSIONS

The proposed CPW fed slot antenna is simulated using Mentor Graphics IE3D simulator version14.0. The return loss characteristic of proposed antenna shows lower return loss value of -48dB at 8.64GHz. Return loss of the proposed antenna is shown in Fig.2.

![Figure 1 Geometrical view of proposed antenna](image1)

![Figure 2 Frequency vs. return loss](image2)

The VSWR characteristic for the proposed antenna is shown in Fig.3. The azimuth and elevation patterns are displayed in Fig.4 and Fig.5. The surface current distribution and the
radiation pattern at the resonant frequency are shown in Fig. 6. Total gain verses frequency plot is exhibited in Fig. 7 and the gain of the antenna is 5.5dBi at resonant frequency.

![VSWR Display](image)

**Figure 3 VSWR vs. Frequency**

- $f=8.645\,\text{GHz}$, E-total, phi=0 (deg)
- $f=8.645\,\text{GHz}$, E-total, phi=90 (deg)

![Elevation Pattern Gain Display](image)

**Figure 4 Elevation pattern**
A High Efficient Compact CPW Fed MIMO Antenna for Wireless Applications

Figure 5 Azimuth pattern

Figure 6 Surface current distribution

Figure 7 Gain vs. Frequency
The efficiency of the designed antenna is found to be 80%, and the gain is 5.5 dBi. The plots for efficiency, directivity, and gain are shown in Fig. 9.

4. CONCLUSIONS
Two novel designs of compact and dual-broadband MIMO antennas have been proposed and presented. The single MIMO element is a CPW fed antenna type with transmission line feed. A detailed parametric study has been conducted using IE3D to optimize the parameters as well as dimensions of the proposed CPW fed antennas and MIMO antennas. In addition, MIMO antennas have been fabricated on an RT Duroid substrate, and their parameters have been measured. Simulation results show that good MIMO antenna parameters have been achieved, including high port-to-port isolations (22–27 dB), gains (2.5–5.5 dBi), bandwidths (225–480 MHz), efficiencies (58–84%), VSWR (1.06–2.0) and compact size module (16.5×20mm2). The proposed MIMO antennas have many wireless applications including LTE and WLAN/WiMax and with high port-to-port isolation. Finally, a compact array size composed of four MIMO antenna modules can be designed to achieve high gain (5.5 dBi) for standard Wireless devices.

REFERENCES


