

Design of Wideband Pattern Diversity Antenna for Mobile Communications

Introduction

The great success of the mobile communication services has fostered the development of various wireless communication systems, which require complex antenna systems to achieve high quality performance. For this, the multiple antenna approach has received much attention in both antenna and wireless communications communities. In particular, the diversity antenna is compared to increase system capability [1]. There are different types of diversity antennas including spatial diversity antenna, frequency diversity antenna [2], polarization diversity antenna [1] [3] and pattern diversity antenna [4-5]. The pattern and polarization diversity techniques can be used to solve the multipath-fading effects in modern wireless systems [2]. Comparing with the classical antennas with a single radiation mode, the pattern diversity antennas, which are capable of radiating and receiving signals from different radiation modes, has the advantages of less installation space, low coupling effect and low installation costs [4]. Several antenna structures offering pattern and polarization diversities have been proposed in the literature [4]-[5]. Unfortunately, the available pattern and polarization diversity antennas suffer from narrow bandwidth [4] and incomplete pattern diversity modes [5]. Thus their applications are limited.

Recently, a wideband complementary antenna designated as the magneto-electric dipole was proposed [6]. Excellent electrical characteristics such as low back radiation, stable antenna gain across the operating band, and symmetric E- and H-plane radiation patterns were demonstrated. These attracting features can mitigate the problems of the microstrip patch antennas. Recently, based on the basic magneto-electric dipole, a new dual-polarized planar antenna excited by two Γ -shaped strips has been proposed[7]. The antenna has about 67% (SWR<2) impedance bandwidth and its isolation is more than 36dB over the whole impedance bandwidth. In this paper, a wideband four-port diversity antenna radiating four different shapes of patterns will be presented. It produces two orthogonal broadsides and two orthogonal conical patterns at overlapped operating band.

Antenna Description and Geometry

The geometry of the proposed antenna operated at around 2.4 GHz is shown in Fig.1-2, with detailed dimensions shown in TABLE I. The dimensions were selected after a detailed parametric study for good performance. For the proposed antenna, it consists of four magneto-electric dipoles in a ring configuration. The configuration of each magneto-electric dipole is a combination of an electric dipole and a magnetic dipole. The upper part of each magneto-electric dipole, which is an electric dipole, is constructed by a pair of sectorial-shape horizontal plates. The electric dipole is connected to the lower part of antenna, which is

equivalent to a folded magnetic dipole. The magnetic dipole is due to a pair of vertically-oriented shorted patch antenna with height of $H=29$ mm, coupled by an L-shaped strip feed to produce a magnetic current along the edge of the two vertical walls. The separation between two vertical walls is $G=10$ mm. The strip act like the transmission line. The L-shaped strip can be adjusted for impedance matching [8]. The vertical wire is located above the center of the ground plane to generate a vertically polarized conical beam radiation patterns separately.

The feeding network consisting of two hybrid rings and one Wilkinson power divider is located under the ground plane. And it is fabricated on a microwave substrate with thickness of 1.57 mm and relative permittivity of 2.33. The feeding network consists of two stages for mode decomposition. At first stage, both input ports of two hybrid rings are connected to four coupled strips of magneto-electric dipole elements. And both isolation ports produce two orthogonal broadside resonant modes. And two summation output ports are connected the Wilkinson power divider. And the output port produces horizontally polarized conical beam radiation patterns.

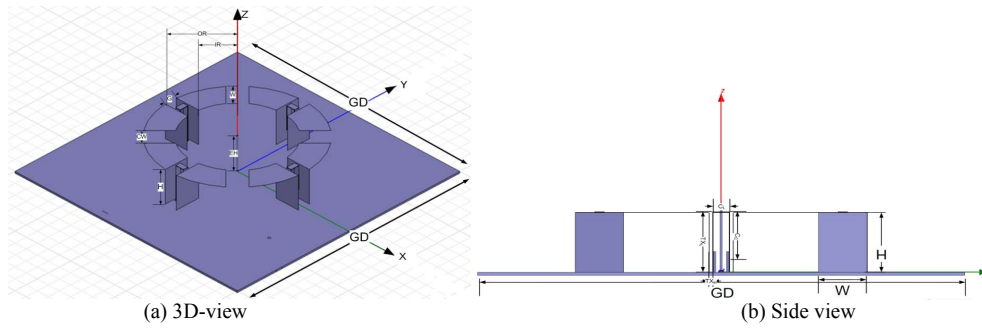


Fig. 1. Geometry of the proposed antenna

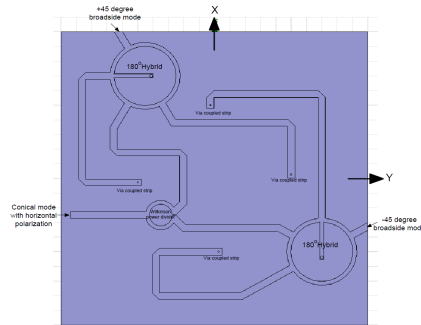


Fig. 2. The feeding network

TABLE I
Dimensions of proposed antenna

Parameters	GD	H	EH	CW	W
Values/mm	200 ($1.6\lambda_0$)	29 ($0.232\lambda_0$)	30 ($0.024\lambda_0$)	15 ($0.12\lambda_0$)	1.0 ($0.008\lambda_0$)
Parameters	G	IR	OR	C_L	C_C
Values/mm	10 ($0.08\lambda_0$)	40 ($0.32\lambda_0$)	60 ($0.48\lambda_0$)	7 ($0.056\lambda_0$)	20 ($0.16\lambda_0$)
Parameters	TX_L	TX_H			
Values/mm	29 ($0.232\lambda_0$)	1.5 ($0.012\lambda_0$)			

Simulation Results

Simulation results of SWR, radiation pattern and gain were obtained by the commercial EM software HFSS. As shown in Fig. 3, the simulated and impedance bandwidths for electric monopole (conical mode with vertically polarization) are about 38.3% (SWR<2) ranging from 1.9GHz to 2.83GHz. Similarly, the impedance bandwidths for magnetic monopole (conical mode with horizontal polarization) are ranging from 2.15GHz to 2.7GHz (~23%). Simulated

impedance bandwidths for -45° polarized dipole and $+45^\circ$ polarized dipole are ranging from 1.9GHz to 2.9GHz ($\sim 42\%$) Therefore, the overlapping operating band is from 2.15GHz to 2.7GHz ($\sim 23\%$). The isolations of four ports shown in Fig. 5 are less than -30 dB.

Fig. 6 shows the simulated radiation patterns of two orthogonal broadside modes and two orthogonal conical modes over the operating band. For electric monopole (conical mode with vertically polarized), the radiation patterns in the elevation plane are symmetric across the operating band. The levels of cross polarization are less than -30 dB. The radiation patterns of electric monopole in the azimuth plane are circular with about 3 dB variation. For magnetic monopole (conical mode with horizontal polarization), the radiation patterns in the elevation plane are symmetric. The cross polarization levels of magnetic monopole are less than -20 dB. For two orthogonal broadside modes, the co-polarization patterns are symmetric. The cross polarization and back lobe levels are all below -30 dB and -20 dB respectively. As shown in Fig.4, The two orthogonal broadside modes exhibit about 10 dBi average gain. While for the two orthogonal conical modes, an average gain of 6 dBi can be achieved.

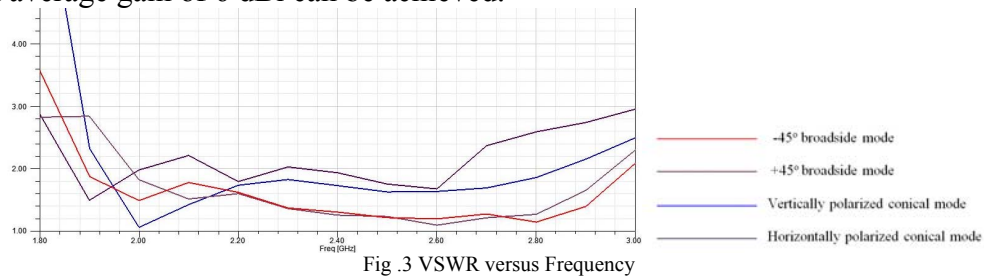


Fig. 3 VSWR versus Frequency

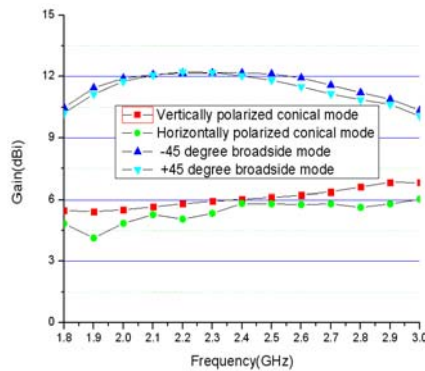
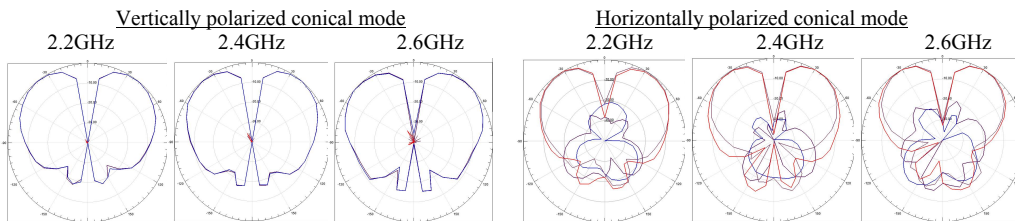


Fig. 4 Antenna gain versus Frequency



Fig. 5 Isolation versus Frequency



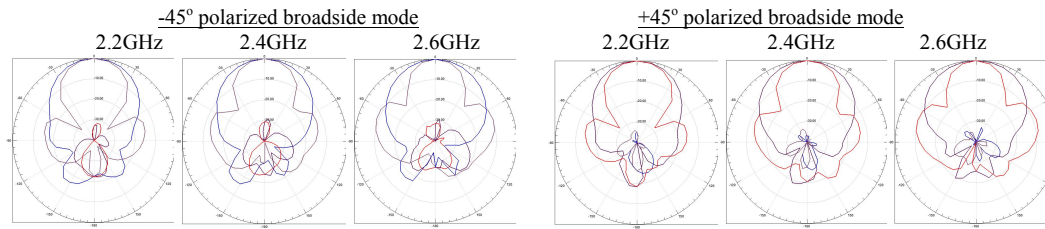


Fig.6 The radiation patterns at 2.2GHz,2.4GHz and 2.6GHz

Conclusion

A wideband four-port diversity antenna that is capable of exciting four different radiation modes is presented. This kind of antenna can greatly improve the system performance by providing a full coverage both in E- and H- plane. It also introduces additional degrees of freedom in steering and beam. The measurement results will be presented at the conference.

References

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