ELectronics EXpress

A printed dual polarized array antenna element with a three layer structure

Lizhong Song[1a)] **and Yuming Nie**[2]

[1] *School of Information and Electrical Engineering Harbin Institute of Technology (Weihai), Weihai 264209, People's Republic of China*

[2] *Department of Electronics and Information Engineering Harbin Institute of Technology, Harbin 150001, People's Republic of China*

a) *songlizhonghit@gmail.com*

Abstract: A novel low-cost dual-polarized radiating element is presented for C-band multifunctional dual-polarized radar system: a compact three-layer configuration with reduced cross-polarized isolation enables frequency reuse using polarization diversity. Promising attributes are demonstrated with measured return loss of better than −10 dB from 4.8 to 5.2 GHz. The measured gain is larger than 6 dBi at 5 GHz, along with 29 dB cross-polarization discrimination, scanning capability and regular radiation patterns.

Keywords: printed antenna, dual polarization, monopole antenna, port isolation

Classification: Microwave and millimeter wave devices, circuits, and systems

References

[1] F. Mastrangeli, A. D. Luca, G. Valerio and A. Galli: Microwave and Optical Technology Letters **54** [3] (2012) 697.
[2] T. T. Ta, S. Yoshida, Y. Suzuki, S. Tanifuji, S. Kameda, N. Suematsu, T. Takagi and K. Tsubouchi: 2012 Asia-Pacific Microwave Conference Proceedings (APMC) (2012) 139.
[3] E. Moldovan, S. Tatu and S. Affes: Microwave and Optical Technology Letters **50** [5] (2008) 1371.
[4] M. Spella, A. de Graauw and S. Drago: 2012 IEEE Antennas and Propagation Society International Symposium (APSURSI) (2012) 1.
[5] N. V. Larsen and O. Breinbjerg: Microwave and Optical Technology Letters **48** [5] (2006) 873.
[6] R. Cox and W. Rupp: IEEE Trans. Antennas Propag. **18** [6] (1970) 804.
[7] C. Kumar, B. P. Kumar, V. S. Kumar and V. V. Srinivasan: IEEE Trans. Antennas Propag. **61** [2] (2013) 598.
[8] L. Schulwitz and A. Mortazawi: IEEE Trans. Antennas Propag. **54** [9] (2006) 2663.
[9] D. M. Pozar: Proc. IEEE **80** [1] (1992) 79.
[10] Y. Zheng, P. Wang, M. Hua and P. Gao: IEICE Electron. Express **10** [22] (2013) 1.
[11] H. Yoshioka, L. Yang and E. Tammam: IEICE Electron. Express **9** [3] (2012) 160.

DOI: 10.1587/elex.11.20140047
Received January 17, 2014
Accepted January 24, 2014
Publicized February 17, 2014
Copyedited March 10, 2014

IEICE Electronics Express, Vol.11, No.5, 1–6

[12] R. Kreutel Jr, D. Difonzo, W. English and R. Gruner: Proc. IEEE **65** [3] (1977) 370.
[13] D. Tallini, A. Galli, M. Ciattaglia, L. Infante, A. De Luca and M. Cicolani: EuCAP 2007 (2007) 1.
[14] A. Galli, G. Valerio, D. Tallini, A. De Luca and M. Cicolani: EuCAP 2009 (2009) 571.
[15] T. See and Z. N. Chen: Microwave and Optical Technology Letters **38** [2] (2003) 142.

1 Introduction

The capabilities of transmitting and receiving two orthogonal polarization lead dual-polarized antennas to act an important role in systems such as modern radar and wireless communication [1]. Various antenna have been investigated as the antenna element for the array, including 3-D horn antenna and 2-D microstrip antenna [2, 3, 4, 5, 6, 7, 8]. Microstrip antenna is one of the attractive candidates because of low-profile, low-weight, low-cost, easy integrability into arrays or with microwave integrated circuits, or polarization diversity [9]. Monopole antennas are widely used in communacation and radar systems for its simple structure [10, 11].

Frequency reuse using polarization diversity is useful where the same frequency band is used for two channels using orthogonal polarizations [7]. Besides low level of cross-polarization of the radiation pattern, high isolation between the two orthogonal linear polarizations is required for implementing frequency reuse, else it may lead to interchannel interference [1, 12]. In addition, low cost and light weight are taken into account due to the usual implementation of arrays with an extremely large number of elements [13, 14, 15].

In this work, a new radiating element for multifunctional dual-polarized radar system is proposed, working in the reference frequency band 4.8∼5.2 GHz. Intense interest is focused on its double-polarization capabilities, low level of cross-polarization ($>$ 20 dB), high isolation ($>$ 25 dB), adequate gain at broadside ($>$ 5 dBi), suitable scanning capabilities and low-cost available materials.

2 Antenna design

The basic geometry of the novel radiation element proposed here is depicted in Fig. 1: it consists of two layered substrates and a layered copper reflector. Fig. 2 (a) and Fig. 2 (c) show the upper and lower layered substrates respectively. There are two orthogonal couples of bend monopole on each substrate to obtain a dual polarization of the radiation pattern. To grant an inexpensive realization, FR_4 with $\varepsilon_r = 2.2$ which is commercially has been chosen as the substrate. The top of the two substrates are shown as Fig. 2 (a) and Fig. 2 (c) as well as Fig. 2 (b) and Fig. 2 (d) for the bottom. Besides the

DOI: 10.1587/elex.11.20140047
Received January 17, 2014
Accepted January 24, 2014
Publicized February 17, 2014
Copyedited March 10, 2014

IEICE Electronics Express, Vol.11, No.5, 1–6

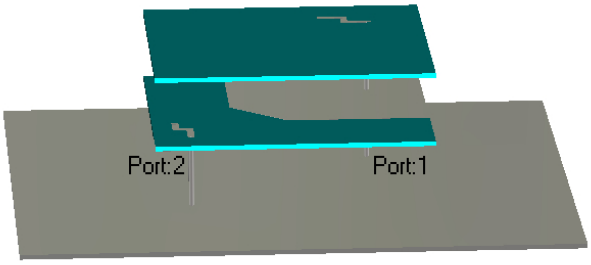
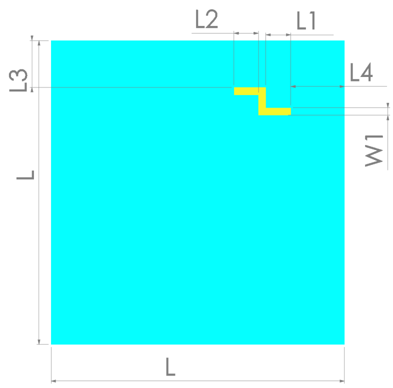
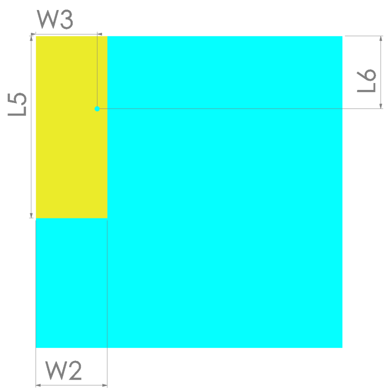


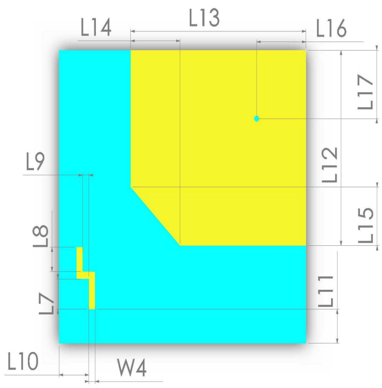
Fig. 1. Geometry of the dual polarized antenna element



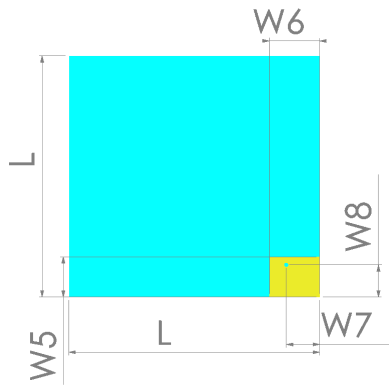
(a) Top view of the upper layered substrate



(b) Bottom view of the upper layered substrate



(c) Top view of the lower layered substrate



(d) Bottom view of the lower layered substrate

Fig. 2. Configuration of the upper ((a) and (b)) and lower ((c) and (d)) layered substrate

two layered substrates, one layered reflector is introduced to ensure regular pattern and high gain.

3 Antenna performance

The design parameters of the proposed antenna have been optimized by using the CST. The design parameters investigated are: W1=1.5 mm, W2=14 mm, W3=12 mm, W4=1.5 mm, W5=10 mm, W6=12 mm, W7=8 mm, W8=8 mm, L=60 mm, L1=5 mm, L2=5 mm, L3=9 mm, L4=11 mm, L5=35 mm, L6=14 mm, L7=6.2 mm, L8=5 mm, L9=1.5 mm, L10=7.2 mm, L11=7 mm, L12=

DOI: 10.1587/elex.11.20140047
Received January 17, 2014
Accepted January 24, 2014
Publicized February 17, 2014
Copyedited March 10, 2014

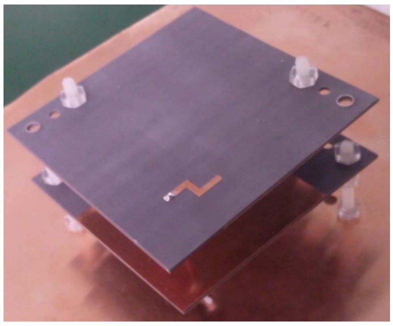


Fig. 3. Photograph of the fabricated antenna

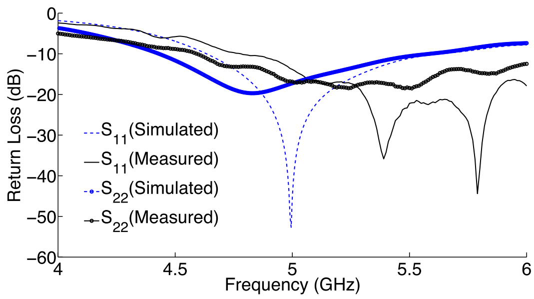
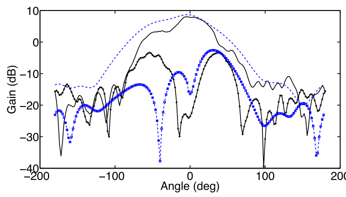
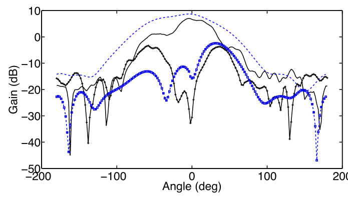


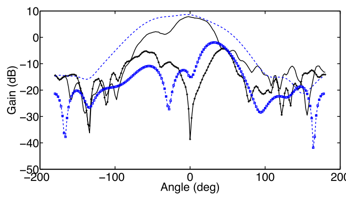
Fig. 4. Simulated and measured return loss for both ports of the dual polarized antenna



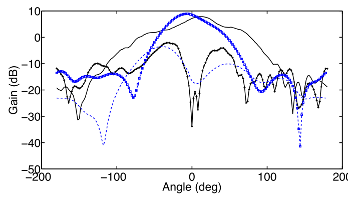
(a) E-plane for 4.8G



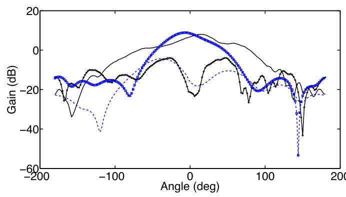
(b) E-plane for 5G



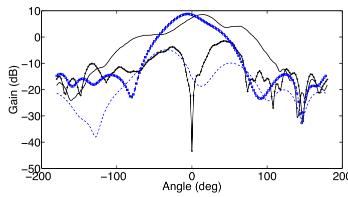
(c) E-plane for 5.2G



(d) H-plane for 4.8G



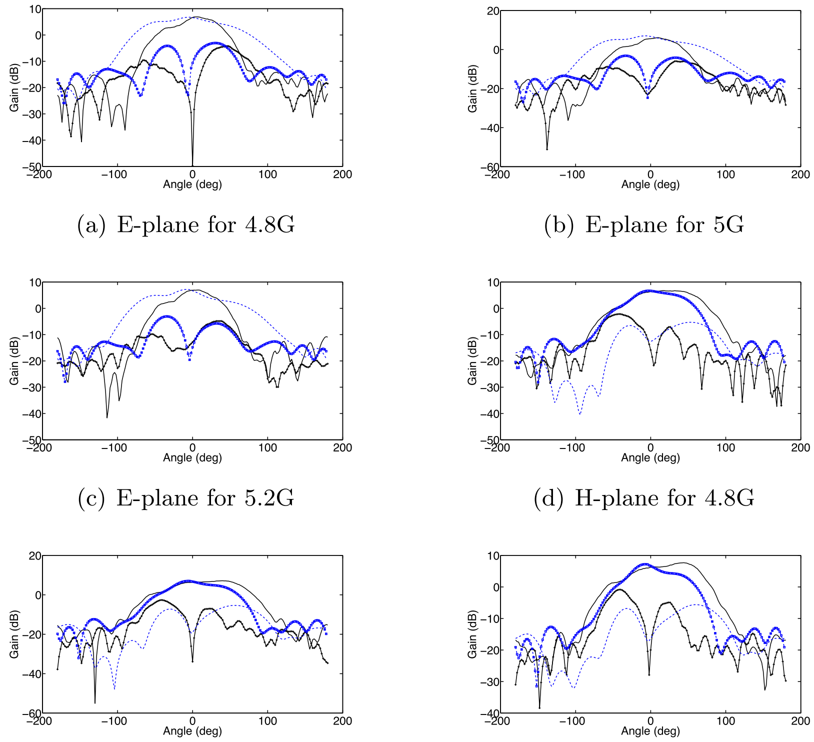
(e) H-plane for 5G



(f) H-plane for 5.2G

Fig. 5. Simulated (blue dashed) and measured (black solid) radiation patterns in the E-plane of port 1 for (a) 4.8 G (b) 5 G (c) 5.1 G, as well as in the H-plane for (d) 4.8 G (e) 5 G (f) 5.2 G

DOI: 10.1587/elex.11.20140047
Received January 17, 2014
Accepted January 24, 2014
Publicized February 17, 2014
Copyedited March 10, 2014



(a) E-plane for 4.8G

(b) E-plane for 5G

(c) E-plane for 5.2G

(d) H-plane for 4.8G

(e) H-plane for 5G

(f) H-plane for 5.2G

Fig. 6. Simulated (blue dashed) and measured (black solid) radiation patterns in the E-plane of port 2 for (a) 4.8 G (b) 5 G (c) 5.1 G, as well as in the H-plane for (d) 4.8 G (e) 5 G (f) 5.2 G

40 mm, L13=42.6 mm, L14=12 mm, L15=12 mm, L16=12 mm, L17=14 mm. The height between substrates and copper reflector is $\frac{1}{4}\lambda$ at designed middle frequency. The copper reflector is 120 mm×120 mm.

The antenna discussed above has been realized, and a photograph of the antenna is shown in Fig. 3. To characterize the return loss as well as isolation for the two individual ports, two port S-parameter measurements have been conducted with Agilent E8363B vector network analyzer. The simulated and measured return loss results for two ports are shown in Fig. 4. As expected, the proposed antenna offers a bandwidth from 4.8 GHz to 5.2 GHz for 2:1 VSWR. Differences between the measured and simulated return losses are attributed to the additional losses that are associated with the inaccuracy of height between the substrates and the reflector.

The isolation between the two ports is also measured, where better than 25 dB isolation is observed throughout the designed frequency range. Co-polarized and cross-polarized patterns have been measured for both the E and H planes. Both simulated and measured results are shown in Fig. 5 and Fig. 6. As expected, a broad beamwidth is observed, where in the E plane, the half power beamwidth for port 1 is 46°, and that for port 2 is 52°. For the H plane, port 1 has a 56° beamwidth, while that for port 2 is 98°. The co-polarized gain of both ports have also been measured over the designed frequency range, which is 7.8 dBi, 7.1 dBi, and 8.4 dBi at 4.8 GHz, 5 GHz and

DOI: 10.1587/elex.11.20140047
Received January 17, 2014
Accepted January 24, 2014
Publicized February 17, 2014
Copyedited March 10, 2014

ELectronics EXpress

5.2 GHz for port 1 as well as 6.9 dBi, 6.2 dBi, 7.5 dBi for port 2.

4 Conclusions

The radiation and reflection characteristics of a new dual-polarized radiating element for C-band radar systems have been investigated and presented in this paper. The cost and fabrication have been taken into account for usual implementation of phased arrays with an extremely large number of elements. The whole structure is compact and low profile, which can be easily arranged in large arrays. The results show the dual-polarized antenna can provide satisfactory wide impedance bandwidth, low level of cross-polar discrimination, high isolation and regular radiation pattern with simple structure. The promising features of the antenna element make it a potential candidate for multifunctional dual-polarized radar systems.

Acknowledgments

This work is supported by the National Natural Science Foundation of China (Grant No.61171181).

DOI: 10.1587/elex.11.20140047
Received January 17, 2014
Accepted January 24, 2014
Publicized February 17, 2014
Copyedited March 10, 2014