2B2-5

A Low-Cost Broadband Dual-Polarized Microstrip Array

Steven Gao, and Alistair Sambell
School of Engineering and Technology, Northumbria University,
Newcastle Upon Tyne, NE1 8ST, United Kingdom
Email: shichang.gao@unn.ac.uk

1. Introduction

Broadband dual-polarized microstrip antennas and arrays are needed in various wireless systems, including mobile communication base stations, satellite communications, radio frequency identification (RFID) system, and wireless local area network (WLAN). For example, in land mobile communication systems, polarization diversity using dual-polarized antennas may maximize the received signal and reduce the effects of multi-path fading. In satellite communication systems, the use of dual-polarized antennas can double the transmission capacity per frequency, thus greatly enhancing the channel throughput. Broadband dual-polarized antennas are also needed in RFID systems for reducing the cost, size and complexity.

The issue of obtaining dual polarizations by using a single patch has been of considerable interest, and a number of designs have been reported. A dual-polarized antenna can be realized by feeding the patch at two orthogonal edges, through edge-feed or probe feed [1]. Dual-polarized slot-coupled antennas have also been reported which use dual offset slots [1], or slots arranged in "T" configuration [2], or multiple slots [3]. In most of the previous designs, two feed network circuits for each polarization are placed on the same layer. However, it is very difficult to find enough space to accommodate two sets of feed networks on the same layer, when dual-polarized arrays or polarization-switching arrays are to be designed. Strong coupling between feed lines will occur if there is not enough space between them. The problem of limited space will become even more serious if we wish to integrate active (amplifiers, mixers, oscillators) and passive circuits (phase shifters, filters) into the feed network circuits for each polarization. To overcome this problem, we may put the feed networks on different layers under the ground plane [4]. However, this will lead to crossovers between feed lines on each layer, and strong coupling between them may occur, which lead to the deterioration of antenna performances. Broadband proximity-coupled microstrip antennas using an H-slot in the ground is given in [5].

In this paper, we propose a novel design of broadband dual-polarized microstrip array antennas. It uses the aperture-coupled feed for one polarization, while the microstrip line feed with slotted ground plane is used for the other polarization. The array antenna can make good use of the space on both sides of the ground plane, as the feed circuits for two orthogonal polarizations are placed on each side of the ground plane, respectively.

2. Antenna design

Figure 1 shows the configuration of the 4-element array antenna. It consists of three dielectric substrates (substrate 1, 2 and 3) and an air gap layer with a thickness of h_0. Four patches are etched on the back of substrate 1, which serves as a radome for protection. At port 1, the slot coupling is used and the feed circuits are below the ground plane. At port 2, the patch is fed by the microstrip line through proximity

ISBN: 4-88552-206-4 C3055©IEICE

coupling. For enhancing the coupling between the patch and feed line, a slot is cut in the ground plane below the feed line at port 2. Four patches are arranged in a square array. Under each patch, two H-shaped shots are arranged in "T" configuration, for achieving high isolation between two ports. The H slot is defined by the parameters *la1*, *la2*, *wa1* and *wa*2. A corporate feed network is designed to divide the power equally into each element in the array. Two orthogonal polarizations are produced from port 1 and 2, respectively. The simulation results are obtained by using "*Ensemble*" from Ansoft Corporation. The array designed at C band has the following parameters: L= 14 mm, W=13 mm, h_0=3.2 mm, d_x= d_y =37 mm. Port 1: *la1*=8 mm, *la2*=1 mm, *wa1*=1 mm, *wa*2=26 mm, *ds*1=2.5 mm; Port 2: *la*1=6 mm, *la*2=1 mm, *wa1*=1 mm, *wa*2=2.4 mm. Low-cost FR4 PCBs ($\varepsilon_r = 4.4, h = 1.6$ mm) are used for substrates 1, 2 and 3.

3. Results and discussions

Figure 2 gives the results of measured return loss at two ports. As we can see, the return loss is below –10 dB for port 1 within the frequency range between 5.13 GHz and 6.12 GHz, corresponding to a bandwidth of 18 %. At port 2, the return loss is below –10 dB within the frequency range between 5.45 GHz and 6.28 GHz, which corresponds to a bandwidth of 14 %. The results of measured isolation between two ports are given in Figure 3. It is seen the isolation is below –30 dB within the frequency bandwidth.

Figure 4 gives the measured radiation patterns of the array excited at port 2 at 5.8 GHz. Broadside radiation patterns are observed at both *E*- and *H*-planes, and the cross-polar levels are below –20 dB within the half space above the ground plane. The backward radiation is below –15 dB. The array is also measured at port 1 at several other frequencies, and it is observed that radiation patterns at two ports are similar and they are stable across the bandwidth.

4. Conclusion

A novel design of low-cost broadband dual-polarized microstrip array antennas is presented. It uses the aperture-coupled feed for one polarization, while the microstrip line feed with slotted ground plane is used for the other polarization. The array antenna can make good use of the space on both sides of the ground plane, as the feed circuits for two orthogonal polarizations are placed on each side of the ground plane, respectively. The prototype 4-element array antenna designed at C band yields a bandwidth over 14 % at both ports, and isolation below –30 dB is obtained. The cross-polar levels are below –20 dB at both *E*- and *H*-panes. As more space is available now at the feed layers, the current work is to realize the dual-polarized active arrays by accommodating the active and passive components into the passive array. The array is simple in structure and low in lost. The findings are promising for RFID, mobile communication base station, and satellite communication applications.

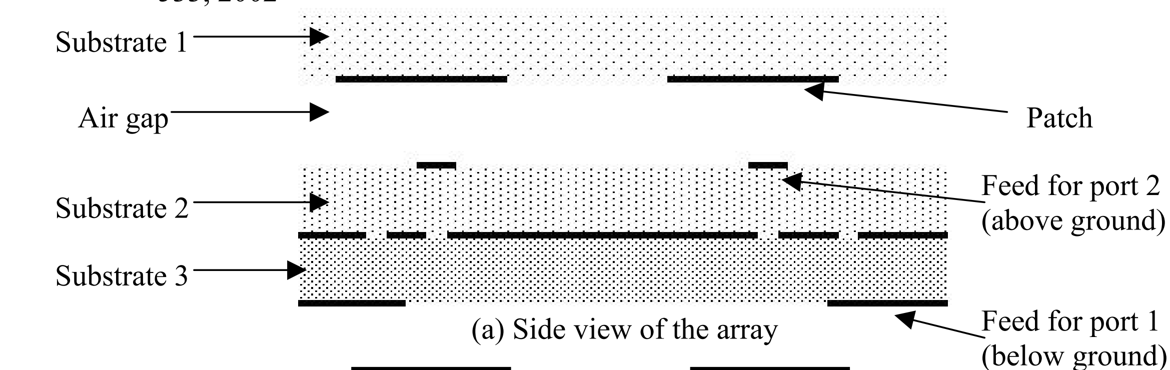
Acknowledgement

The work was supported by EPSRC (UK) under the grant GR/S42538/01.

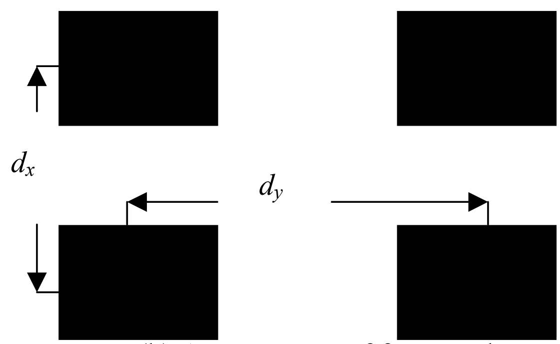
References:

[1] P.S. Hall, Review of techniques for dual and circularly polarized microstrip antennas, D.M. Pozar and D.H. Schaubert, (Eds.), *Microstrip antennas*: *The analysis and design of microstrip antennas and arrays*, IEEE Press, NY, 1995

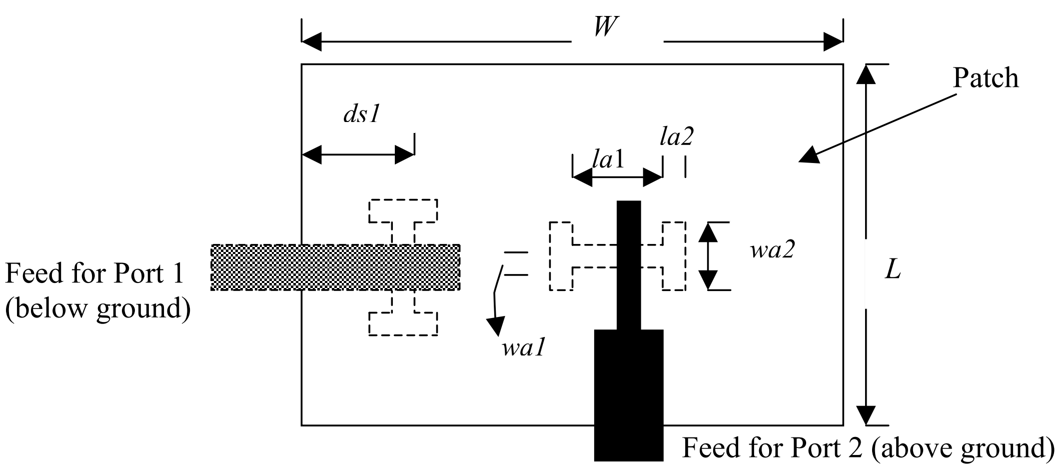
[2] B.G. Porter, L.L. Rauth, J.R. Mura and S.S. Gearhart, Dual-polarized slot-coupled patch antennas on duroid with teflon lensens for 76.5-GHz automotive radar systems, *IEEE Trans.*, Vol. AP-47, pp.1836-1842, 1999
[3] K.L. Wong, H.C. Tung and T.W. Chiou, Broadband dual-polarized aperture-coupled patch antennas with modified H-shaped coupling slots, *IEEE Trans.*, Vol. AP-50, No. 2, pp. 188-191, 2002
[4] C.H. Tsao, Y.M. Hwang, F. Kilburg and F. Dietrich, Aperture-coupled patch antenna with wide-bandwidth and dual-polarization capabilities, *IEEE Antennas and Propagation Symp. Dig.,* pp. 936-939, 1988
[5] S.Y. Ke, Broadband proximity-coupled microstrip antennas with an H-shaped slot in the ground plane, *IEEE Antennas and Propagation Symp. Dig.,* pp. 530-533, 2002



(a) Side view of the array



(b) Arrangement of four patches



(c) Top view of an element

Fig. 1 Antenna configuration

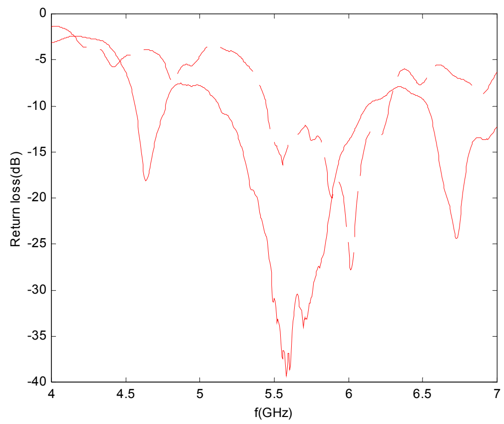


Figure 2. Measured return loss results at two ports
(Solid line: port 1; dashed line: port 2)

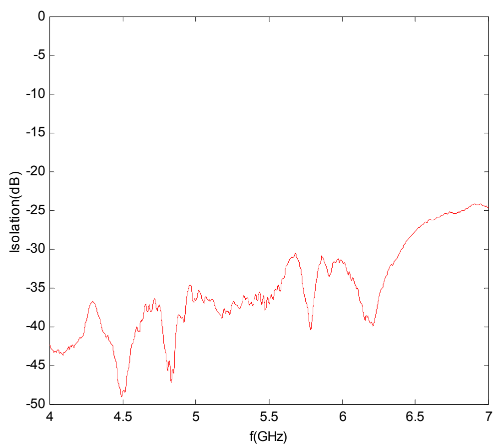
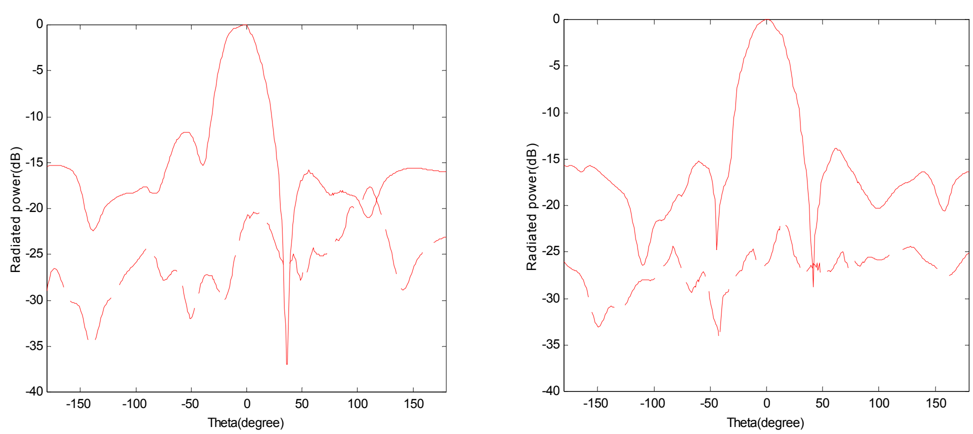


Figure 3. Measured isolation between two ports



(a) *E* plane (b) *H* plane
Figure 4 Measured radiation patterns at 5.8 GHz for port 2
(Solid line: co-polar; dashed line: cross-polar)