

Design of a S/X band Dual-Polarized Microstrip Array Antenna for Radar Application

Juman Kim, Youngki Lee, Deukhyeon Ga, and Jaehoon Choi[#]

Department of Electronics and Computer Engineering, Hanyang University
17 Haengdang-Dong, Sungdong-Gu, Seoul, 133-791, Korea
Tel. +82-2-2220-0376, Fax. +82-2-2293-0377
Email: choijh@hanyang.ac.kr[#] (corresponding author)

Abstract

In this paper, the S/X band dual-polarized microstrip array antenna for an AMRFC radar application was proposed. By using a circular patch with modified L-probe feed for S-band and stacked diamond-shaped patch for X-band, a DBDP array with a frequency ratio of about 1:3 was achieved.

Keywords: Dual-band Dual-polarized Modified L-probe feed Array antenna AMRFC Radar

1. Introduction

Office of Naval Research (ONR) of U.S.A navy has been carrying out research about advanced multifunction radio frequency concept (AMRFC) to apply the Multifunction Electronic Warfare & Electronic Support (MFEW ES) system to the future navy battleship [1]. In order to that conventional radar and communication antennas need to be active phased array antennas that can provide multi-functions such as radar, electronic warfare, communication, and navigation [2]. In general, multiband operation is used to implement multi-functions while dual-polarization scheme is adopted to enhance the isolation between T_x and R_x . Many researchers have been trying to find dual-band dual-polarization phased array antenna techniques for satellite, wireless communications and synthetic aperture radar (SAR) applications [3]. In [4], dual-frequency dual-polarized antenna for airborne applications was proposed, but the bandwidth was below 2% at the desired S- and X-band. In [5], L/X dual-band dual-polarized planar array for SAR applications was proposed, but both L- and X-band bandwidth was also narrow. Another dual-band dual-polarized antenna for WLAN application was presented in [6]. However, it cannot be utilized for the dual-band dual-polarized (DBDP) radar application due to its complex structure. Although several DBDP antennas have been reported, it is still quite difficult to apply them to practical radar systems due to their narrow bandwidth and complex structure.

In this paper, a S/X band dual-polarized microstrip array antenna for an AMRFC radar application was proposed. By using a circular patch with modified L-probe feed for S-band and stacked diamond-shaped patch with parasitic element for X-band, a DBDP array with a frequency ratio of about 1:3 can be proposed.

2. Antenna structure

The array antenna is designed to operate at S-band (3.1 ~ 3.4 GHz) and X-band (9.0 ~ 10.5 GHz) and is depicted in Fig. 1. Since the bandwidth required for both bands are very wide, the proposed array antenna uses a multi-layer structure. The structure of the diamond-shaped 4×8 patch array was placed on the lower substrate. To achieve the wideband operation in X-band, parasitic elements were placed above the main patch. Fig. 2 shows the simulated S-parameter characteristics with and without parasitic elements. The impedance bandwidth can be satisfied by controlling the electromagnetic coupling between the main and parasitic patches. On the other hand, to obtain wideband operation in S-band, a modified L-probe feed is used. When the probe area (L) is increased, the impedance matching characteristics are improved by up to 40 dB, as shown in Fig.

3. Four diamond-shaped perforations were placed on the bottom of the layer 5 in the S-band circular patch to allow radiation from the X-band patches. The perforations in the S-band element should be large enough so that the effect of S-band element on the radiation from the X-band patches is relatively small.

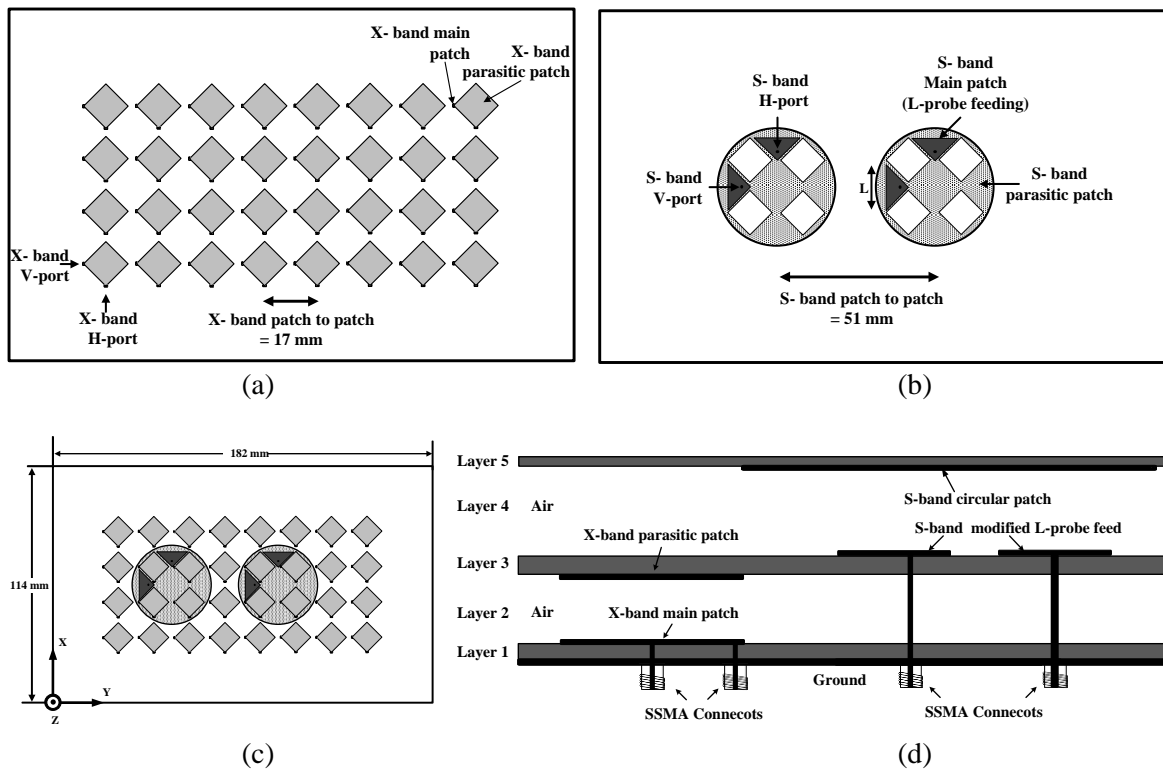


Fig.1. Geometry of the proposed S/X band dual-polarized array antenna. (a) X-band components, (b) S-band components, (c) top view, (d) side view

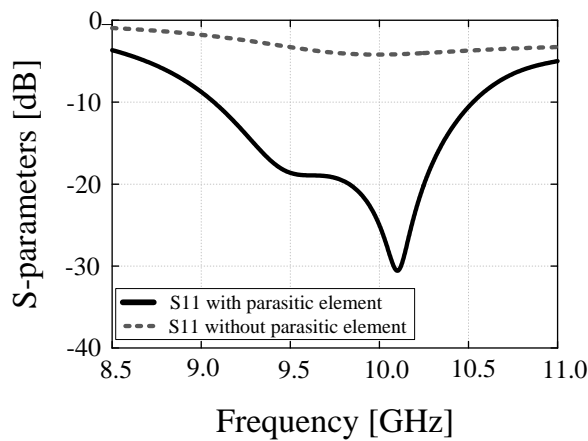


Fig. 2. Simulated S-parameter characteristics with and without parasitic elements.

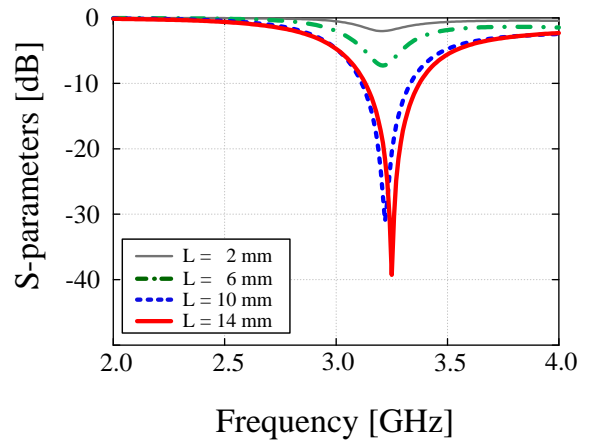


Fig. 3. Simulated S-parameter characteristics for various values of probe area (L).

3. Results

The simulated S-parameter characteristics of the S-band circular patch array with modified L-probe feed are shown in Fig. 4(a). The bandwidth for $VSWR \leq 2$ is 9.2 % from 3.1 GHz to 3.4 GHz. The isolation between the two orthogonal polarizations is higher than 20 dB for the required band. The simulated S-parameter characteristics of the X-band stacked diamond-shape patch

element are shown in Fig. 4(b). For the X-band array, the bandwidth for $VSWR \leq 2$ reaches 15.3 % from 9.0 GHz to 10.5 GHz.

The simulated co- and cross-polarization radiation patterns of the S-band array, at the center frequency (3.25 GHz) of the S-band, are shown in Figs. 5(a) and 5(b), respectively. The cross-polarization levels in both E- and H-planes are lower than -20 dB and the side lobe levels are lower than -20 dB. The maximum antenna gain is about 11 dBi. For the X-band array, the co- and cross-polarization radiation patterns of the horizontal and vertical polarizations at the center frequency (9.75 GHz) of X-band, are plotted in Figs. 6(a) and 6(b), respectively. In both E- and H-planes, the cross-polarization levels are lower than -25 dB and the side lobe levels are lower than -10 dB. The maximum array antenna gain is 20 dBi.

4. Conclusion

In this paper, the S/X band dual-polarized microstrip array antenna for an AMRFC radar application was proposed. By using a circular patch with modified L-probe feed for S-band and stacked diamond-shaped patch for X-band, a DBDP array with a frequency ratio of about 1:3 was achieved. Simulated bandwidths for $VSWR \leq 2$ were 9.2 % from 3.1 GHz to 3.4 GHz for S-band and 10.5 % from 9.0 GHz to 10.0 GHz for X-band, respectively. The isolation characteristic between the two orthogonal polarizations was about 20 dB at 3.25 GHz while that at 10 GHz band was over 15 dB.

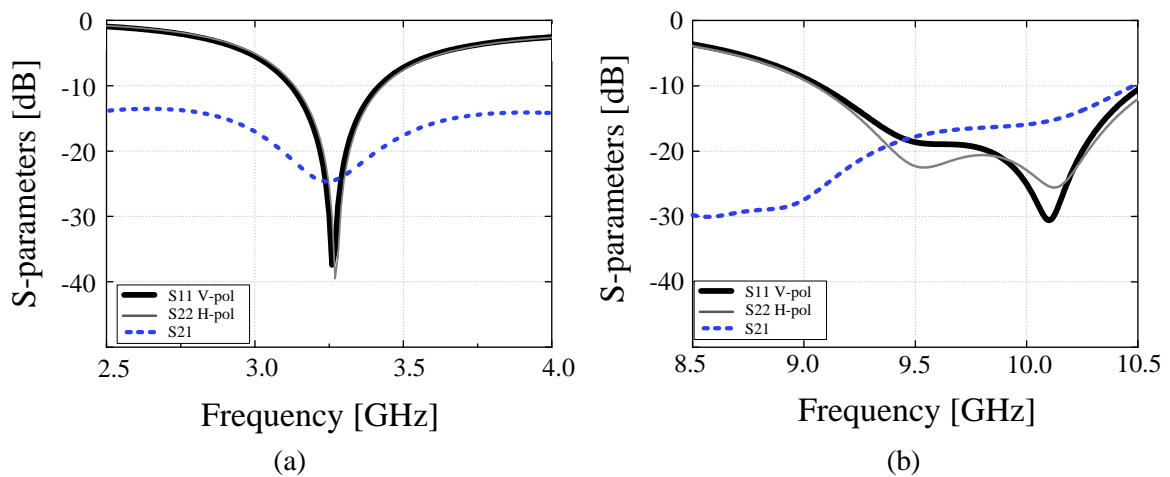


Fig.4. Simulated S-parameter characteristics. (a) S-band, (b) X-band

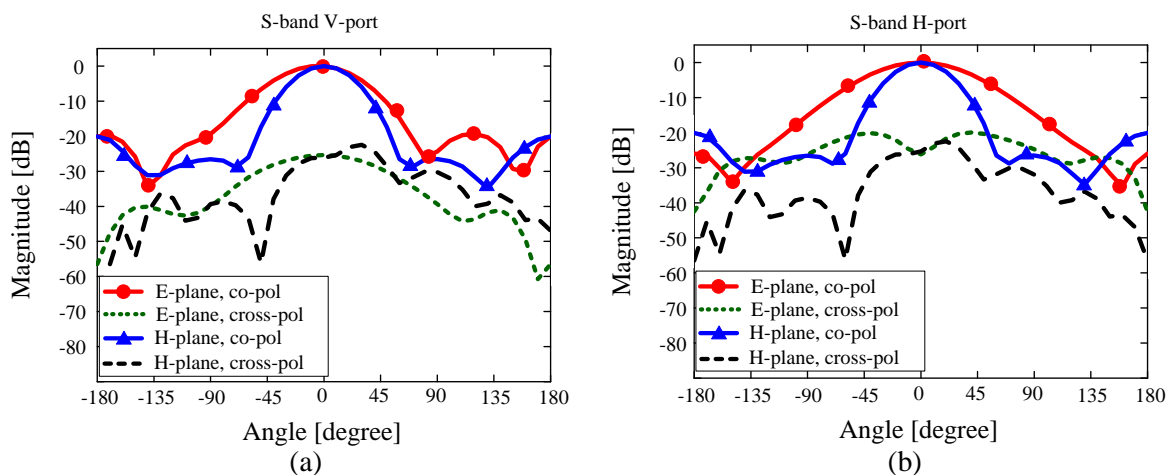


Fig. 5. Normalized radiation patterns of the S-band 2x1 array antenna at 3.25GHz. (a) V-port, (b) H-port

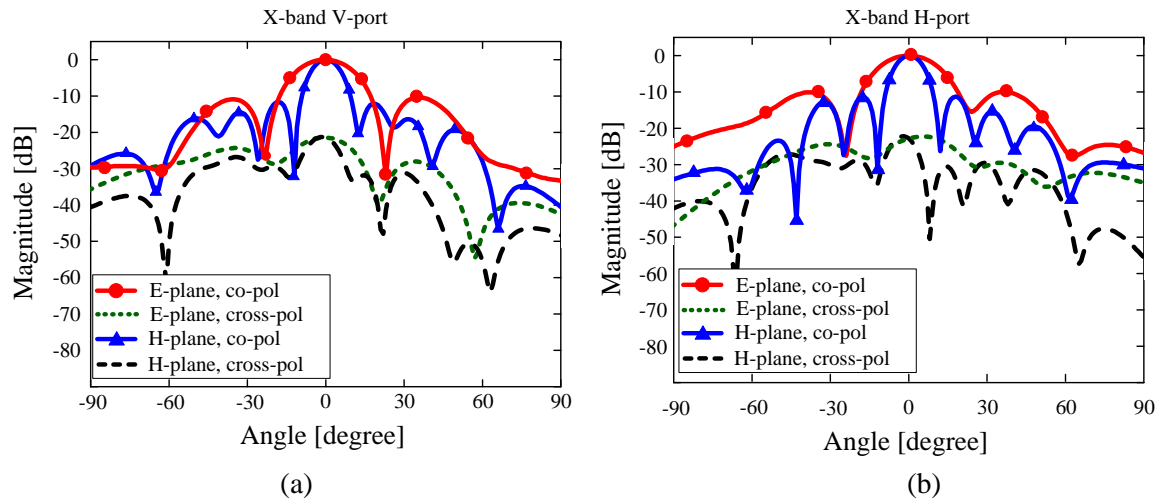


Fig. 6. Normalized radiation patterns of the X-band 4x8 array antenna at 9.75GHz. (a) V-port, (b) H-port

The cross-polarization levels were less than -20 dB for the S-band and less than -25 dB for the X-band, respectively. The results verify that the proposed DBDP antenna array with a flexible frequency ratio can be a good candidate for future phased array antenna such as synthetic aperture radar and AMRFC radar applications.

Acknowledgments

This work was supported by a grant-in-aid of Samsung Thales.

References

- [1] G. V. Trunk, "Advanced multifunction RF system (AMRFS) preliminary design considerations," NRL, Washington, DC, Formal Rep. 5300-01-9914, Dec. 10, 2001.
- [2] S. Lindenmeier, J. F. Luy, and P. Russer, "A multifunctional antenna for terrestrial and satellite radio applications," in *IEEE MTT-S Int. Microwave Symp. Dig.*, vol. 1, pp. 393–396, May 20–25, 2001.
- [3] R. Pokuls, J. Uher, and D. M. Pozar, "Dual-frequency and dual-polarization microstrip antennas for SAR applications," *IEEE Trans. Antennas Propagat.*, Vol. 46, No. 9, 1289–1296, 1998.
- [4] S. -H Hsu, Y.-J. Ren, K. Chang, "A Dual-Polarized Planar-Array Antenna for S-Band and X-Band Airborne Applications," *Antennas and Propagation Magazine, IEEE*, vol.51, no.4, pp.70–78, Aug. 2009.
- [5] D.M. Pozar, and S.D. Targonski, "A shared-aperture dual-band dual-polarized microstrip array," *Antennas and Propagation, IEEE Transactions on*, vol.49, no.2, pp.150-157, Feb 2001
- [6] J. M. Steyn, J. W. Odendaal, and J. Joubert, "Dualband dual-polarized array for WLAN applications," *Progress in Electromagnetics Research C*, vol. 10, pp. 151-161, 2009.