

Wideband Dual Linearly Polarized Patch Array Antenna

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1. Introduction

Rectangular patch excited in one dominant mode provides a single LP radiation [1]. In various communication environments, dual-polarized antenna is required. For example, mobile communication systems to deal with the multi-path fading environment use dual-polarized antennas. There are several ways to realize dual-polarized microstrip antennas that the antenna may maximize the received signal, reduce the effects of multi-path fading or to provide other receiving paths. The most popular practice is to locate two feed points on the center of two perpendicular edges of a rectangular patch and a visual isolation of nearly 20dB can be achieved for the square patch [2]. Dual-polarized aperture-coupled microstrip antennas have also been proposed in [3] where an isolation of 18dB is reported. Many dual-polarized microstrip arrays have also been reported [4]. Microstrip antenna has narrow bandwidth characteristic. For this reason, many elements with enhanced bandwidth have been investigated [5,6,7]. In this paper, broadband impedance-matching technique is proposed for improving the bandwidth of microstrip antennas. First, the microstrip patch antenna is fed so that the size of the impedance locus is small, which represents an under-coupled situation. Then the impedance is matched, and the impedance bandwidth is improved by using a tuning stub connected in shunt with the feed line. Second the microstrip patch antenna is fed so that the size of the impedance locus is large, which represents an over-coupled situation. Then the impedance is matched, and the impedance bandwidth is improved by using a transfer connected in series with the feed line.

2. Wideband dual linearly polarized radiating element

Geometry of the dual linearly polarized element (LPL) is shown in Fig.1, and to realize dual LP, Aperture and proximity coupling feeding techniques are applied on patch antenna. Each feed line is placed in different layers for an array structure. To increase impedance bandwidth in aperture coupling feeding (V port), under-coupling is performed by adjusting slot size. In case of under-coupled situation, the fact that impedance variation according to frequency variation is reduced causes impedance locus small in smith chart. If the central impedance of the locus is matched, the frequency around center will be matched and then the impedance bandwidth is improved. To increase impedance bandwidth in proximity-coupling feeding (H port), over coupling is performed. In case of over-coupled situation, the impedance variation followed by frequency variation has particular pattern where the real part of impedance is constant and the image part is the same constant and contrary sign in detuned open position therefore. Using the matching circuit ($\lambda/2$ transformer) of contrary characteristic, the image part of impedance is cancelled to improve impedance bandwidth [8]. For using the theory, one dual linearly polarized element is designed. The length of patch is 7.7 x 8.2mm. The substrate used is form ($\epsilon_r=1.1$, $h=1$ mm) and film (Rogers R/flew9000). Fig. 2 shows the reflection, and isolation of one dual linearly element. The bandwidth (VSWR<2) of H port and V port by using matching circuit is 17% and 18%, respectively. The isolation between two polarization ports is 40dB in operating band.

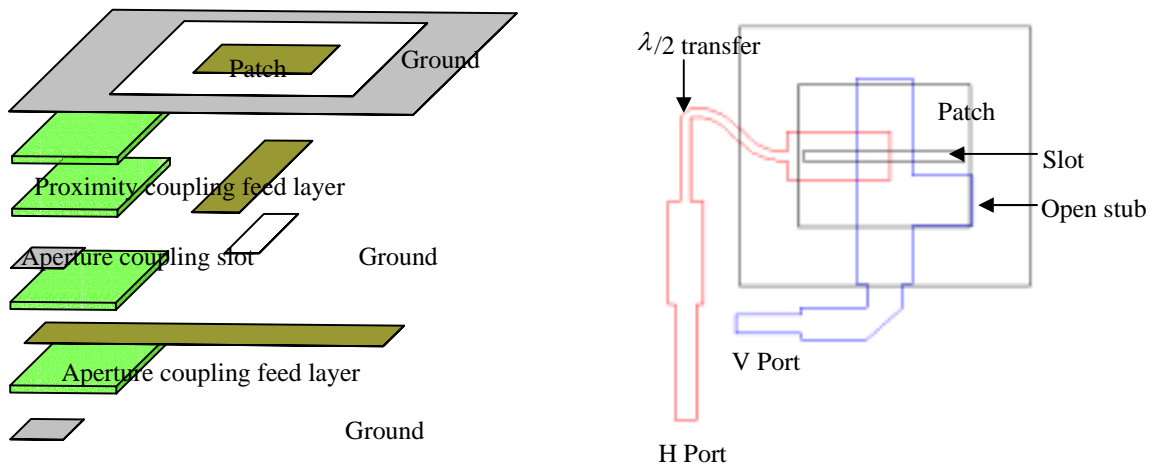


Fig. 1 Dual linearly polarized antenna element

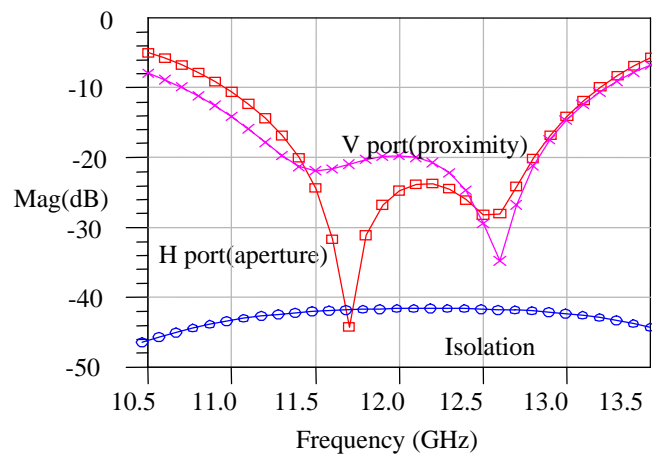


Fig. 2 Return loss at port V and H and isolation

3. Wideband Dual Linearly Polarized Patch Array

3.1 Array description

Fig. 3 shows the proposed four elements wideband dual linearly polarized array. The strip feed-line network is formed parallel feeding method. The characteristic of parallel feed method is that as the number of array increases, the bandwidth decreases because the reflected waves from each element of antenna are added to each other in power combiner [9]. For wide bandwidth, multi-transformer is used in power combiner. This array is designed at 11.7GHz and then fabricated. The relative dielectric constant of substrate and thickness is same that of single patch. The spacing between two adjacent patches is $0.9 \lambda_0$ at center frequency, and array antenna is enlarged by 16x16(256) element.

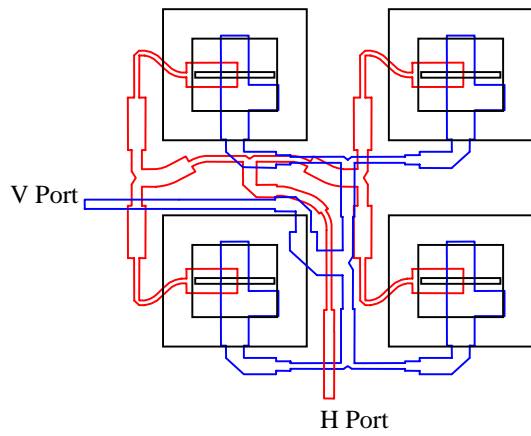


Fig. 3 Dual LP patch array

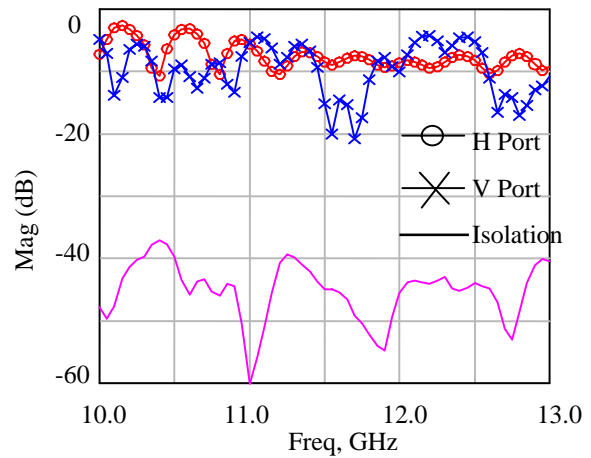


Fig. 4 Return loss at port V and H and Isolation

3.2 Array performance

The measured results of return loss and isolation at port V and H of the array are presented in Fig 4. The highest isolation of 38dB is obtained. The high isolation characteristics of this dual linearly polarized array are desirable for practical dual-polarized application where the two polarizations operate over the same frequency band. The measured E-plane radiation pattern of port V is presented in Fig.5. The cross-polarization components are also illustrated. The cross-polarization levels are 30dB down from the co-polarization component on bore-sight in E-plane. The measured E-plane radiation pattern of port H is presented Fig. 6.

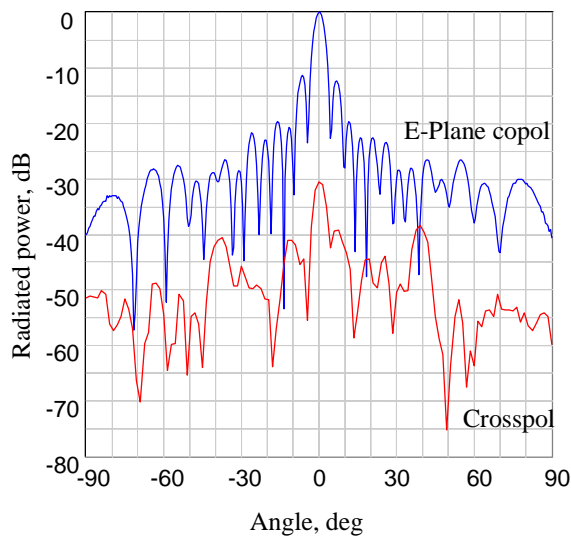


Fig. 5 Radiation patterns at 11.7GHz for port V of dual LP array

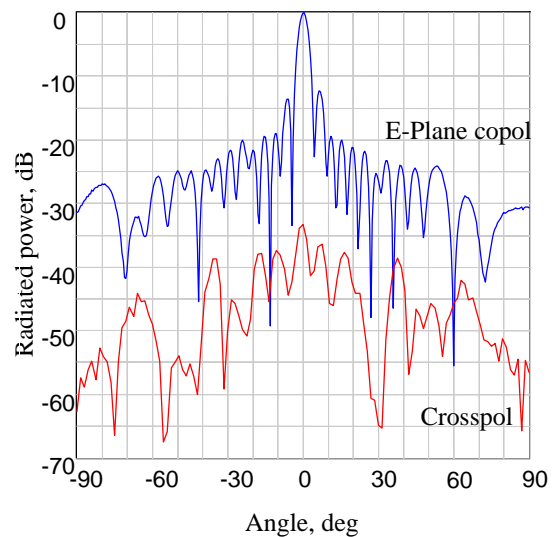


Fig. 6 Radiation patterns at 11.7GHz for port H of dual LP array

The cross-polarization components are also illustrated. The cross-polarization levels are 32dB down from the co-polarization component on bore-sight in E-plane. All these patterns are measured at 11.7GHz.

4. Conclusion

The proposed dual linearly polarized patch is designed and developed. Aperture and proximity coupling feed methods are used. To obtain wideband in an aperture-coupling feed method, under-coupling is performed by using smaller coupling slot and matching circuit (open stub) increased the impedance bandwidth. In a proximity coupling feed method, over-coupling is performed to obtain wideband and matching circuit ($\lambda/2$ transfer) increased the impedance bandwidth. The smaller ground slot used for under-coupling leads better isolation in aperture coupling feed method, and narrower $\lambda/2$ transfer line of matching circuit leads better isolation in proximity coupling feed method. When array is formed, the two feed lines are completely separated from the ground and it gives a good isolation characteristic.

References

- [1] JAMES, JR., and HALL, P.S. (Eds.): 'Handbook of microstrip antennas' (Peter Peregrinus, 1989)
- [2] 2. POZAR, D.M., and SCHAUBERT, D.H. (Eds): 'Microstrip antennas, the analysis and design of microstrip antennas and arrays' (IEEE Press, New York, NY, 1995)
- [3] 4. ADRIAN, A., and SCHAUBERT, D.H.: 'Dual aperture-coupled microstrip antenna for dual or circular polarisation', *Electron. Lett.*, 1987, 23, pp. 1226-1228
- [4] 5. HUANG, J.: 'Dual-polarised microstrip array with high isolation and low cross polarisation', *microw. Opt. Technol. Lett.*, 1991, 41, (3), pp. 99-103
- [5] T. Huynh and K. F. Lee, "Single-layer single-patch wideband microstrip antenna," *Electronics. Lett.*, Vol 31, pp 1310-1312, 1995.
- [6] K. F. Lee, K. M. Luk, K. F. Tong, S. M. Shum, T. Huynh, and R. Q. Lee, "Experimental and simulation studies of coaxially fed U-slot rectangular patch antenna," *IEE-Pro.-Microw., Antennas Propaga.*, Vol 144, pp 354-358, 1997.
- [7] H. F. Pues and A. V. Van De Capelle, "An impedance-matching technique for increasing the bandwidth of microstrip antennas," *IEEE Trans., Antennas and Propaga.*, Vol 37, pp 1345-1354, Nov. 1989.
- [8] Edward L. Ginzton,,: 'Microwave Measurement' MCGRAW-HILL, 1957, PP391-421.
- [9] Tasuku TESHIROGI, Masato TANAKA, and Wataru CHUJO, "Wideband circularly polarized array antenna with sequential rotations and phase shift elements", ISAP, 1985, Aug, pp117-120