

Wideband circularly polarised planar monopole antenna array

W.S. Lee, S.Y. Cha, K.S. Oh and J.W. Yu

A simple design for a wideband circularly polarised planar monopole antenna array is presented. The attractive characteristics of the proposed antenna array are the wide impedance bandwidth of 87.3% (1 to 2.55 GHz), the 3 dB axial ratio (AR) bandwidth of 95% (1.05 to 2.95 GHz), and the maximum gain within the 3 dB AR bandwidth of about 4 dBi.

Introduction: With the rapid progress of wireless technology in recent years, various wireless systems such as GSM, WCDMA/UMTS, Bluetooth, WLANs, and GPS have been highly integrated into mobile devices, and in order to fulfil the RF system requirements, an antenna is required to have wideband characteristics. A planar monopole antenna is a good competitive solution for the wireless systems owing to a simple structure and wide impedance bandwidth [1]. Also, wireless systems employ antennas having a circular polarisation (CP) characteristic because it is strong for the reflection and absorption of the radio signal [2]. To achieve wideband CP, design techniques have been published on these. A stacked configuration [3], a single-patch CP antenna with dual feeds [4], or a dielectric resonator antenna [5] is employed, and their bandwidths are around 30%. Previously studied CP antennas have the narrowband antenna element with a narrowband or wideband feeding network. It causes degraded wideband performance owing to the limit of the impedance bandwidth. Therefore, to improve the enhanced wideband characteristic, this Letter presents the wideband planar monopole antenna array (PMAA) with a wideband feeding network. Details of the proposed antenna array and its performance in such areas as impedance bandwidth, axial ratio, and radiation pattern are presented and discussed.

Antenna configuration: The geometry of the proposed wideband CP antenna is shown in Fig. 1. The antenna array is fabricated on an RF35 substrate with a dielectric constant of 3.5 and thickness of 0.5 mm. The size of the ground plane is $150 \times 150 \text{ mm}^2$. The proposed antenna array is assembled by the four planar monopole antenna elements which are fixed on the ground plane. The PMAA has the bevelled structure owing to a wideband characteristic. The height of the planar monopole antenna element is $H_1 = 31.5 \text{ mm}$ ($0.21\lambda_0$, where λ_0 is the free-space wavelength at the centre of the 3 dB axial ratio bandwidth). Its height depends on the lower side frequency band, whereas the width of the antenna element ($W_1 = 20 \text{ mm}$) decides the wideband characteristic. In the bottom layer of the ground plane, the wideband feeding network is formed and composed of the wideband planar balun [6] and LTCC hybrid couplers. To generate good circular polarisation, the proposed wideband bevelled PMAA has a symmetrical configuration, and it is fed by equal amplitude power and quadruple phase differences. From port 1 to ports 2, 3, 4, and 5 in Fig. 1, the sequential phases of 0° , 90° , 180° , and 270° are achieved. To improve system performance in the antenna part, the configuration of the PMAA has the bevelled technique for wideband bandwidth. An optimised antenna angle in the antenna element is $\alpha = 12^\circ$. Table 1 summarises the dimensions of the proposed antenna array for wideband characteristics.

Results and discussion: To investigate the electrical characteristics of the proposed antenna array, it has been designed and optimised using a 3D electromagnetic solver (SEMCAD X by SPEAG). Fig. 2 shows that the proposed antenna array has measured an impedance bandwidth of 1.0–2.55 GHz (87.3%) using a vector network analyser. It also shows that the reflection coefficient of the proposed antenna array (case B) depends on that of the feeding network with 50Ω terminations (case A). Fig. 3 shows the measured gain and 3 dB axial ratio (AR) with regard to the frequency compared to the simulated results for the proposed antenna array. The use of the bevelled PMAA leads to a maximum gain of 4.02 dBi. It also shows the 3 dB AR bandwidth of 1.05–2.95 GHz (95%). The degradation of measured gain compared to the simulated results at the upper frequency band is caused by the increase of reflection coefficient in Fig. 2. Fig. 4 shows the measured radiation patterns of the proposed antenna array at 2.0 GHz. It produces

right-hand circular polarisation (RHCP), and also represents satisfactory axial ratio for the z-axis direction.

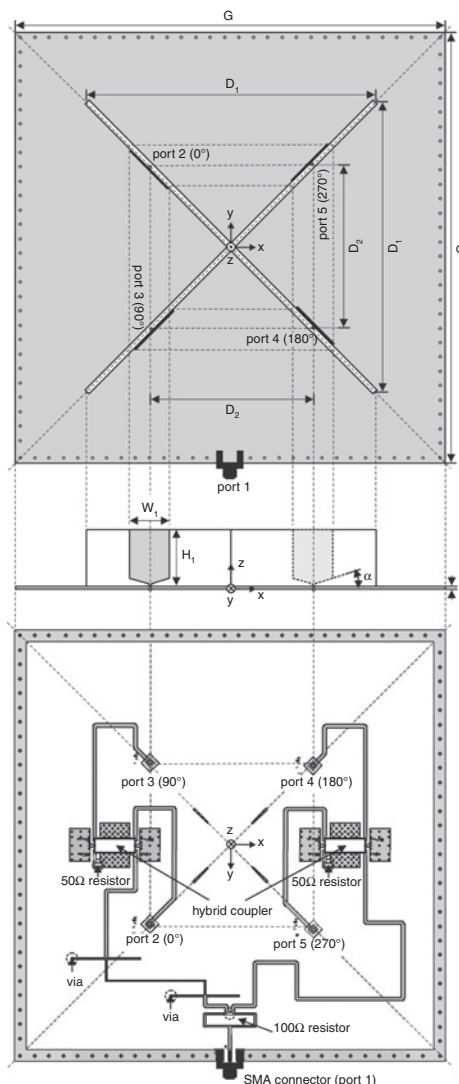


Fig. 1 Geometry of proposed antenna array having wideband feeding network

Table 1: Dimensions of proposed antenna array configuration

Parameters	Label	Dimension
Antenna width	W_1	20 mm
Antenna height	H_1	31.5 mm
Antenna beveling	α	12
Dielectric length	D_1	100 mm
Substrate thickness	t	0.5 mm
Antenna port gap	D_2	56.6 mm
Ground plane length	G	150 mm

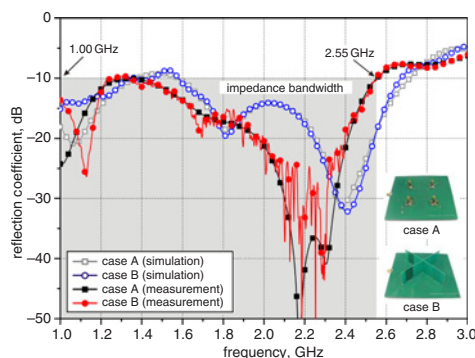


Fig. 2 Simulated and measured reflection coefficient of proposed antenna array

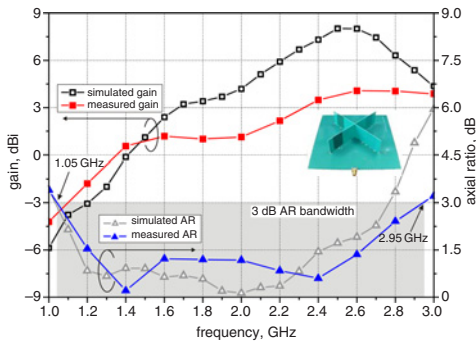


Fig. 3 Measured gain and axial ratio compared to simulated results against frequency for proposed antenna array

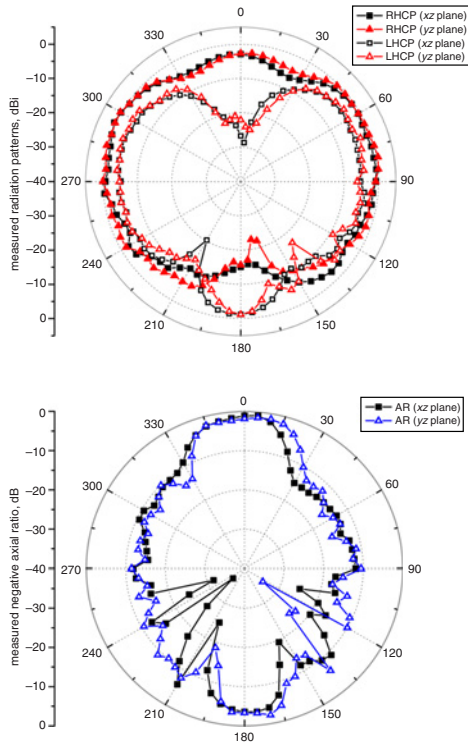


Fig. 4 Measured radiation patterns in xz and yz planes at 2 GHz
 a Measured radiation
 b Axial ratio

Conclusion: A bevelled wideband PMAA with a wideband feeding network for outstanding circular polarisation characteristic is presented in this Letter. Although the antenna array and ground size are smaller than the wavelength, the superior wideband 3 dB axial ratio bandwidth of 95% and maximum gain of 4.0 dBi are achieved. Because of the favourable antenna performance, the proposed antenna array can be useful for many modern wireless communication systems that require wideband circularly polarised radiation patterns.

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One or more of the Figures in this Letter are available in colour online.

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