Compact planar multiband antenna for GPS, DCS, 2.4/5.8 GHz WLAN applications

R.K. Raj, M. Joseph, B. Paul and P. Mohanan

A compact single-feed multiband planar antenna configuration suitable for GPS, DCS, 2.4/5.8 GHz WLAN applications is presented. The antenna has dimensions 38 × 3 × 1.6 mm and offers good radiation and reflection characteristics in the above frequency bands. The antenna has a simple geometry and can be easily fed using a 50 Ω coaxial probe.

Introduction: The rapid progress in personal and computer communication technologies demands integration of more than one communication system into a single compact module. To comply with this requirement compact high-performance multiband planar antennas with good radiation characteristics are needed. A planar single-feed dual L antenna of dimensions 30.5 × 21.5 × 13 mm operating in GPS and DCS bands was proposed in [1]. The dual band antenna for the ISM band (2.4/5.8 GHz) using a backed microstrip line proposed in [2] has an overall dimension of 30 × 20 mm on FR4 substrate and offers a maximum gain of 4 dBi. The dual frequency antenna configuration proposed in [3] uses triple-stacked microstrip patch antennas with a slot in the middle patch, to achieve triple band operation. In this Letter a compact single-feed planar antenna with three wide 2 : 1 VSWR operating bands around 1.8, 2.4 and 5.8 GHz, covering four useful frequency bands, namely GPS (1575.4 MHz), DCS (1800 MHz), 2.4 GHz (2400–2485 MHz) and 5.8 GHz (5725–5825 MHz) WLAN, is presented.

Antenna design: Geometry of the proposed antenna is shown in Fig. 1. It is etched on FR4 substrate of relative permittivity $\varepsilon_r = 4.7$ and thickness $h = 1.6$ mm. The antenna has two arms of lengths $l_1 = 38$ mm, $l_2 = 33$ mm and widths $w_1 = w_2 = 1$ mm, placed symmetrically on either side of a middle element of length $l_3 = 17$ mm and width $w_3 = 1$ mm. The feed point of the antenna is optimised to be at the middle of edge AB. Good impedance matching is achieved by embedding a reflector of dimensions $L = 40$ mm and $W = 25$ mm on the bottom side of the substrate at an offset $d = 0.5$ mm from the edge AB, as shown in Fig. 1.

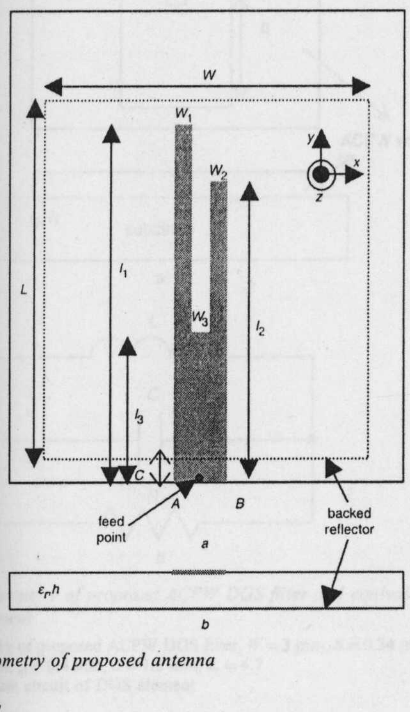

Fig. 1 *Geometry of proposed antenna*

a Top view
b Side view
$L = 40$ mm, $l_1 = 38$ mm, $l_2 = 33$ mm, $l_3 = 17$ mm, $W = 25$ mm, $w_1 = w_2 = w_3 = 1$ mm, $h = 1.6$ mm, $d = 0.5$ mm

From the experimental and simulation results, it is understood that the lower resonance can be tuned by varying the length l_1 of arm 1. Resonance in the 2.4 GHz band is influenced by the length $l_1 + l_2 - 2l_3$. When length l_3 of the middle element is increased, the second resonance shifts upwards, whereas it gets lowered when the length l_2 is increased. Dimensions of the reflector affect both the resonance frequency and impedance matching in the 5.8 GHz band. Another antenna with $l_1 = 79.4$ mm, $l_2 = 77.48$ mm and $l_3 = 60.54$ mm exhibits resonance at 940 MHz, 1.85 and 5.2 GHz, suitable for GSM/DCS/5.2 GHz WLAN applications.

Results: The measured return loss characteristic of the proposed antenna is shown in Fig. 2. Three resonant bands are observed at frequencies 1.75, 2.45 and 5.76 GHz with 2 : 1 VSWR bandwidths of 23, 5 and 4.5%, respectively. The lower resonant band with 406 MHz (1466–1872 MHz) bandwidth is wide enough to cover the GPS/DCS bands. The higher resonant bands with 124 MHz (2372–2496 MHz) and 260 MHz (5630–5890 MHz) bandwidths cover the 2.4 and 5.8 GHz WLAN bands, respectively.

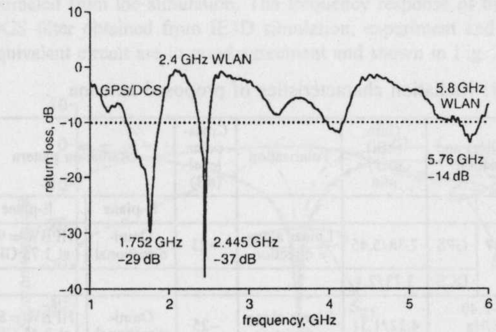

Fig. 2 *Return loss characteristics of antenna*

The normalised E-plane and H-plane radiation patterns measured at the centre frequencies of the respective bands are shown in Fig. 3. The patterns are observed to be nearly omnidirectional in the H-plane, with a cross-polar level better than −15 dB in the boresight direction. The antenna exhibits similar radiation characteristics in all the desired bands. The measured antenna gain against frequency is presented in Fig. 4. The antenna offers a peak gain of 7.38 dBi in the GPS band. The maximum gains observed in the DCS, 2.4 GHz WLAN, 5.8 GHz WLAN bands are 3.73, 4.22 and 4.65 dBi, respectively. The radiation performance of the antenna in all the above bands is summarised in Table. 1. It is observed that all bands except the 5.8 GHz band are linearly polarised along *y* direction. The 5.8 GHz band is orthogonal to the other bands.

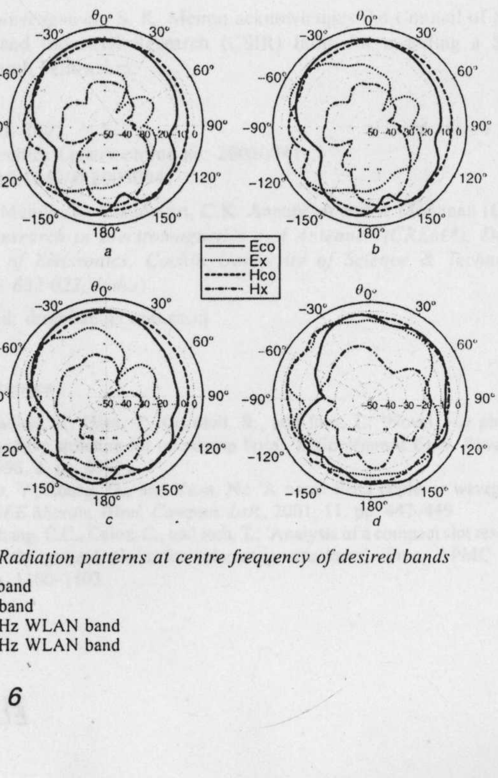

Fig. 3 *Radiation patterns at centre frequency of desired bands*

a GPS band
b DCS band
c 2.4 GHz WLAN band
d 5.8 GHz WLAN band

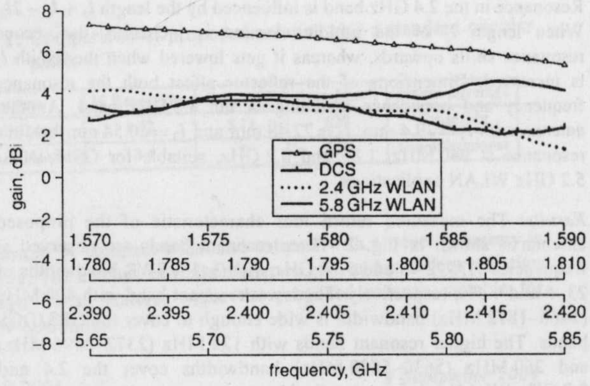

Fig. 4 *Antenna gain in desired bands*

Table 1: Radiation characteristics of proposed antenna

Band (GHz) and application		Gain (dBi) max/min	Polarisation	Cross-polar level (dB)	Radiation pattern	
					H-plane	E-plane
1.46–1.87	GPS	7.38/5.45	Linear along *y* direction	−23	Omni-directional	HPBW = 90° at 1.75 GHz
	DCS	3.73/2.1				
2.37–2.49 2.4 GHz WLAN		4.22/1.31	Linear along *y* direction	−25	Omni-directional	HPBW = 80° at 2.45 GHz
5.63–5.89 5.8 GHz WLAN		4.65/3.12	Linear along *x* direction	−19	Omni-directional	HPBW = 126° at 5.76 GHz

Conclusions: A compact multiband planar antenna with reflector backing suitable for GPS/DCS/2.4 GHzWLAN/5.8 GHzWLAN applications is proposed. The wide 2 : 1 VSWR bandwidths at the three resonant bands, along with moderate gain and radiation characteristics, make the proposed antenna an ideal choice for multiband wireless communication gadgets.

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R.K. Raj, M. Joseph, B. Paul and P. Mohanan (*Centre for Research in Electromagnetics and Antennas, Department of Electronics, Cochin University of Science and Technology, Kochi 682022, Kerala, India*)

E-mail: drmohan@ieee.org

References

1 Chen, Z., Ganjara, A.D., and Chen, X.: 'A dual-L antenna with a novel tuning technique for dual frequency applications', *IEEE Trans. Antennas. Propag.*, 2002, **50**, (3), pp. 402–403

2 Choi, S.H., Park, J.K., Kim, S.K., and Kim, H.S.: 'Design of dual-band antenna for the ISM band using a backed microstrip line', *Microw. Opt. Technol. Lett.*, 2004, **41**, (6), pp. 457–460

3 Ryu, H.-C., Ahn, H.-R., Lee, S.-H., and Park, W.S.: 'Triple-stacked microstrip antenna for multiband system', *Electron. Lett.*, 2002, **38**, (24), pp. 1496–1497