Broadband CPS-fed Yagi-Uda antenna

K. Han, Y. Park, H. Choo and I. Park

A broadband coplanar stripline-fed Yagi-Uda antenna is presented. The antenna has a feedline structure that is much simpler than other Yagi-Uda antennas, and provides more design flexibility in arranging the reflector owing to the absence of a large ground plane. To improve the impedance match, a taper is inserted between the wide-line/small-gap and the narrow-line/large-gap CPS. The proposed antenna has a bandwidth of 3.9–5.9 GHz for a −10 dB reflection coefficient and a gain of 6.5–8.0 dBi. At the centre frequency of 4.9 GHz, the antenna has gain of 7.1 dBi, and a half-power beamwidth (HPBW) of 73° in the E-plane and 98° in the H-plane.

Introduction: In recent years, planar Yagi-Uda antennas have attracted much interest owing to their broad bandwidth, high gain, ease of fabrication and low cost [1]. These Yagi-Uda antennas can have several different feeding structures, such as a microstrip line feed with a microstrip-coplanar stripline (MS-CPS) transition [1, 2], coplanar waveguide (CPW) feed with a coplanar waveguide-coplanar stripline (CPW-CPS) transition [3], and a microstrip line feed without any transition structure [4]. They can be easily integrated with wireless communication systems because they are both small and broadband. However, the reflectors of the antennas cannot be well optimised since they utilise the ground plane as a reflector, and hence the radiation pattern is not as good as that of a conventional Yagi-Uda antenna.

A broadband CPS-fed Yagi-Uda antenna is described in this Letter. The proposed antenna has a simpler feedline structure than existing planar Yagi-Uda antennas. The antenna does not require a large ground plane on the substrate, so it provides more flexibility in designing the reflector than other Yagi-Uda antennas. However, it is difficult to design a 50 Ω matched CPS because the CPS has much higher characteristic impedance than a microstrip line or CPW. Therefore, an optimum reflector and feedline structure should be considered when designing the antenna. In the proposed antenna structure, a pair of reflectors is arranged at both sides of the CPS feedline for effective reflection of back-radiated electromagnetic waves. The optimum CPS is arrived at by inserting a tapered line between the wide line width CPS with a small gap size, and the narrow line width CPS with a large gap size.

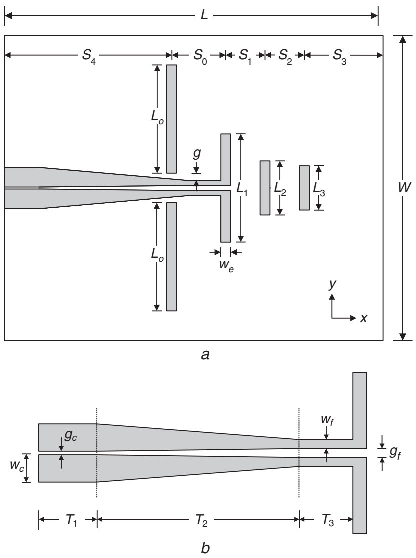

Fig. 1 *Schematic diagrams of proposed antenna*

a Top view
b CPS feed with driver

Antenna structure and characteristics: Fig. 1 shows the proposed antenna structure. The antenna is fed by a CPS, which is directly connected to the driver. The driver of the Yagi-Uda antenna does not operate well if it is directly connected to a 50 Ω matched CPS because the CPS is usually wider than the driver. Therefore, the width of the CPS must be reduced. The optimum CPS was arrived at by inserting a taper between the wide line width CPS with a small gap, and the narrow line width CPS with a large gap. CST Microwave Studio, which is a three-dimensional full-wave electromagnetic wave simulator based on the finite integral time-domain method, was used to design the proposed antenna. The antenna was designed on an 83 × 60 mm RT-Duroid 6010 substrate with a dielectric constant of $\varepsilon_r = 10.2$, and a thickness of 0.635 mm. The design parameters of the optimised antenna are given in Table 1.

Table 1: Design parameters of optimised antenna

Parameter	Value (mm)	Parameter	Value (mm)
L	83.0	W	60.0
L_o	22.0	T_1	8.0
L_1	22.0	T_2	29.0
L_2	11.6	T_3	10.0
L_3	8.0	g	1.0
S_o	10.0	g_c	0.13
S_1	4.0	g_f	0.63
S_2	7.0	w	2.0
S_3	24.0	w_c	4.0
S_4	38.0	w_f	1.7

The reflection coefficient of the simulated and measured antenna is shown in Fig. 2. The antenna was measured using an Agilent N5230A network analyser. The simulated bandwidth of the antenna was 4.1–6.0 GHz, and the measured bandwidth was 3.9–5.9 GHz for a −10 dB reflection coefficient. The measured radiation patterns at 4.1, 4.9, and 5.7 GHz are shown in Figs 3–5. At a frequency of 4.1 GHz, the gain of the antenna was 6.5 dBi, and the half-power beamwidth (HPBW) was 70° along the E-plane and 112.7° along the H-plane. At 4.9 GHz, the antenna showed a gain of 7.4 dBi, and an HPBW of 73° along the E-plane and 98° along the H-plane. At 5.7 GHz, the antenna showed a gain of 7.8 dBi, and an HPBW of 70.3° along the E-plane and 74.4° along the H-plane. The measured gain of the optimised antenna, shown in Fig. 6, was 6.5–8.0 dBi within the bandwidth, and showed a smaller gain variation than existing Yagi-Uda antennas [1–4]. Some discrepancy between the simulated and measured gain is due to a slight difference between the dielectric loss used in our simulation and the real value in the measurement. Therefore, the proposed Yagi-Uda antenna has a stable transmit and receive (T/R) power for a signal in broadband wireless communication systems that could be achieved with less T/R power variation than other antennas.

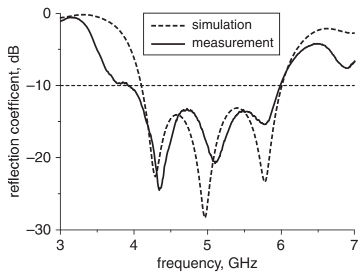

Fig. 2 *Reflection coefficient of optimised antenna*

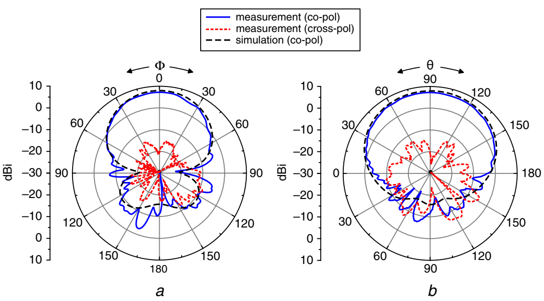

Fig. 3 *Radiation patterns at 4.2 GHz*

a E-plane
b H-plane
Simulated cross-polarisation is excluded because value is too small to show in Figure

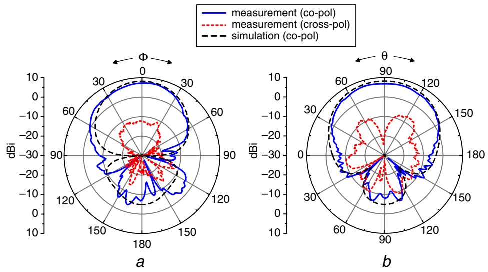

Fig. 4 *Radiation patterns at 4.8 GHz*

a E-plane
b H-plane
Simulated cross-polarisation is excluded because value is too small to show in Figure

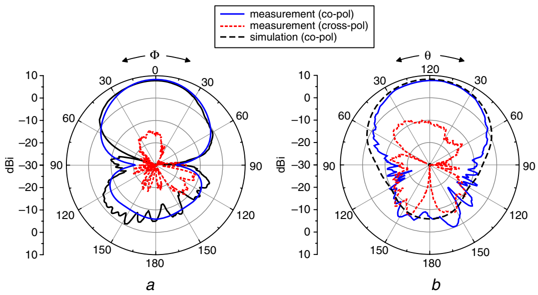

Fig. 5 *Radiation patterns at 5.4 GHz*

a E-plane
b H-plane
Simulated cross-polarisation is excluded because value is too small to show in Figure

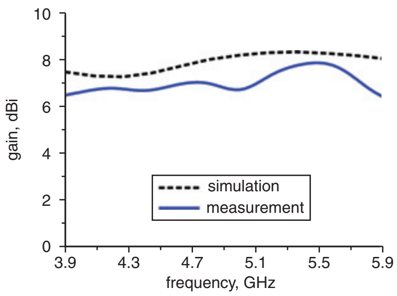

Fig. 6 *Gain of optimised antenna*

Conclusions: A broadband CPS-fed Yagi-Uda antenna is presented with a simpler feedline structure than other Yagi-Uda antennas with MS-CPS or CPW-CPS transition. The proposed antenna provides more design flexibility in arranging the reflector since it does not require a large ground plane on the substrate. For effective reflection of back-radiated electromagnetic waves, a pair of reflectors was placed at both sides of the CPS. The optimised CPS feed was arrived at by inserting a taper between the wide line and the narrow line. The proposed Yagi-Uda antenna has a measured bandwidth of 3.9–5.9 GHz with −10 dB reflection coefficient and a measured gain of 6.5–8.0 dBi within the impedance matched bandwidth.

12 May 2009
doi: 10.1049/el.2009.1330

K. Han, Y. Park and I. Park (*Department of Electrical and Computer Engineering, Ajou University, 5 Wonchon-dong, Youngtong-gu, Suwon, 443-749, Korea*)

E-mail: ipark@ajou.ac.kr

H. Choo (*School of Electronic and Electrical Engineering, Hongik University, 72-1 Sangsu-dong, Mapo-gu, Seoul 121-791, Korea*)

References

1 Kaneda, N., Deal, W., Qian, Y., Waterhouse, R., and Itoh, T.: 'A broadband planar quasi-Yagi antenna', *IEEE Trans. Antennas Propag.*, 2002, **50**, (8), pp. 1158–1160
2 Avila-Navarro, E., Segarra-Martinez, A., Carrasco, J., and Reig, C.: 'A low-cost compact uniplanar quasi-Yagi printed antenna', *Microwave Opt. Tech. Lett.*, 2008, **50**, (3), pp. 731–735
3 Kan, H., Waterhouse, R., Abbosh, A., and Bialkowski, M.: 'Simple broadband planar CPW-fed quasi-Yagi antenna', *IEEE Antennas Wirel. Propag. Lett.*, 2007, **6**, pp. 18–20
4 Zheng, G., Kishk, A., Glisson, A., and Yakovlev, A.: 'Simplified feed for modified printed Yagi antenna', *Electron. Lett.*, 2004, **40**, (8), pp. 464–466