A Wideband Double Dipole Quasi-Yagi Antenna Using a Microstrip-slotline Transition Feed

Son Xuat Ta(1), **Jea Jin Han**(1), (2), **Hosung Choo**(3), **and Ikmo Park**(1)

(1) School of Electrical and Computer Engineering, Ajou University
5 Woncheon-dong, Youngtong-gu, Suwon 443-749, Korea
Email: ipark@ajou.ac.kr
(2) Danam Systems
799 Gwangyang2-dong, Dongan-gu, Anyang 431-767, Korea
Email: hjj123@danam.co.kr

(3) School of Electronics and Electrical Engineering, Hongik University
72-1 Sangsu-dong, Mapo-gu, Seoul 121-791, Korea
Email: hschoo@hongik.ac.kr

ABSTRACT: This paper describes a wideband double dipole quasi-Yagi antenna fed by a microstrip-to-slotline transition. The transition feed consists of a microstrip radial stub and a slot radial stub, each with the same angle of 90°, but with different radii to achieve wideband impedance matching. Double dipoles with different lengths are utilized as primary radiation elements to enhance bandwidth and achieve stable radiation patterns. The antenna has a bandwidth of 3.65–8.90 GHz for a –10 dB reflection coefficient, and a flat gain of 6.4–7.6 dB across the bandwidth. The proposed antenna could be widely applicable to wideband wireless communication systems due to wideband characteristics, planar structure, and stable radiation pattern.

I. INTRODUCTION

Nowadays, quasi-Yagi antennas are commonly used for many applications in the microwave and millimeter wave bands, due to their broad bandwidth, high gain, low cost, and high-radiation efficiency, as well as their ease of fabrication. These antennas can be fed by several types of feedlines, including microstrip lines (MS) [1–3], coplanar waveguides (CPW) [4, 5], coplanar striplines (CPS) [6], or slotlines [7]. Quasi-Yagi antennas utilize a regular dipole as the driver, so the bandwidths are approximately 50% or less, which may not be sufficient for some applications. Eldek introduced MS-fed planar antennas with double dipoles [8] and double rhombuses [9] as the main radiation elements to enhance the bandwidth. These antennas achieved a wide bandwidth with two parallel strip feedlines printed on opposite sides of the substrate. However, the radiation patterns were degraded due to the asymmetric structure of the antennas.

This paper presents a microstrip-to-slotline transition-fed quasi-Yagi antenna with wide bandwidth and flat gain. The transition consists of a microstrip radial stub and a slot radial stub, each with the same 90° angle, but with different radii for impedance matching between the microstrip line and the slotline [10]. The regular dipole driver is replaced by two parallel dipoles with different lengths to enhance the bandwidth. The double dipoles are connected to the slotline by a coplanar stripline, which is tapered to improve the impedance matching conditions. The antenna incorporates two parasitic strips as directors, and a truncated ground plane as the reflector, to achieve small gain variation across the operating bandwidth.

II. ANTENNA GEOMETRY AND CHARACTERSITICS

Figure 1 shows the geometry of the wideband microstrip-to-slotline transition-fed quasi-Yagi antenna. The antenna was designed on a 60 × 70 mm RT Duroid 6010 substrate with a dielectric constant of 10.2 and a thickness of 0.635 mm. It is comprised of a microstrip-to-slotline transition as the feed, two parallel dipoles as the main radiation elements, two printed strips as the directors, and a ground plane as the reflector. The microstripline was designed on the back side of the substrate with a characteristic impedance of 50 Ω. The slotline was designed with a characteristic impedance of approximately 70 Ω, due to a compromise between the narrow slot width required to obtain a characteristic impedance of 50 Ω and the limitations of the available fabrication technique. Therefore, a microstrip radial stub and a slot radial stub, each having the same angle of 90° but with somewhat different radii, were inserted into the transition for impedance matching between the microstripline and the slotline. Two parallel dipoles with different lengths were employed to achieve multi-resonances, and consequently the bandwidth was further enhanced. The slotline was directly connected to the parallel dipoles by a coplanar stripline, but the input impedances at the two dipoles were different. Hence, the coplanar stripline was tapered from a wide line width/small gap to a narrow line width/large gap to improve the impedance matching conditions.

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Table 1: Design parameters of the optimized antenna

Parameter	*Value (mm)*	*Parameter*	*Value (mm)*	*Parameter*	*Value (mm)*
D	10	L_4	6	S_2	5.4
g_0	0.2	R_m	2.8	T_{cps}	20
g_1	0.8	R_s	3	W_{ms}	0.56
L_1	22	S_f	10	W_s	2
L_2	16	S_0	11.2	W_e	0.6
L_3	7	S_1	4.4	W_c	2.4

An Ansoft high-frequency structure simulator (HFSS) was used to investigate the characteristics of the proposed antenna. Simulations indicate that the lengths of the dipoles (L_1 and L_2) and directors (L_3 and L_4) mainly determine the lower and upper resonant frequencies, respectively, whereas the radiation patterns can be controlled by varying the spaces between the elements of the antenna (S_f, S_0, S_1, and S_2). The design parameters of the optimized antenna, chosen for their wideband characteristics and small gain variation, are listed in Table 1.

As shown in Figure 2, the bandwidth of the optimized antenna roughly covered the 3.65–8.90 GHz frequency range for a –10 dB reflection coefficient. The radiation patterns of the antenna in the *E*- and *H*-planes at 4, 6, and 8 GHz are illustrated in Figure 3. At a frequency of 4 GHz, the peak gain was 6.96 dB, and the half-power beam widths (HPBWs) were 83° along the *E*-plane and 132° along the *H*-plane. At a frequency of 6 GHz, the peak gain was 6.9 dB, and the HPBWs were 79° along the *E*-plane and 125° along the *H*-plane. At a frequency of 8 GHz, the peak gain was 7.02 dB, and the HPBWs were 89° along the *E*-plane and 79° along the *H*-plane. A plot of the peak gain of the optimized antenna versus frequency is shown in Figure 4. The gain ranged from 6.4–7.6 dB, and exhibited only a small variation (1.2 dB) within the impedance bandwidth. Therefore, the antenna should be stable for transmitting and receiving applications in a wideband wireless communication system.

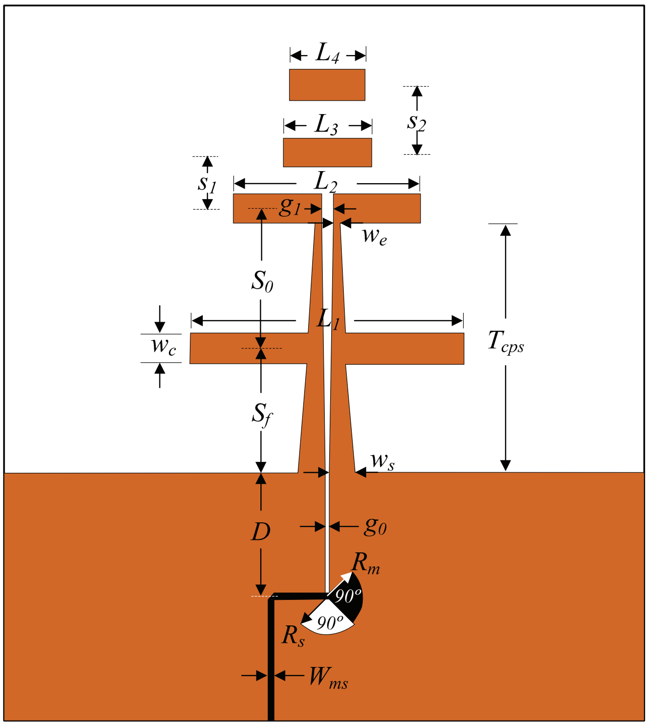

Figure 1. Geometry of the proposed antenna.

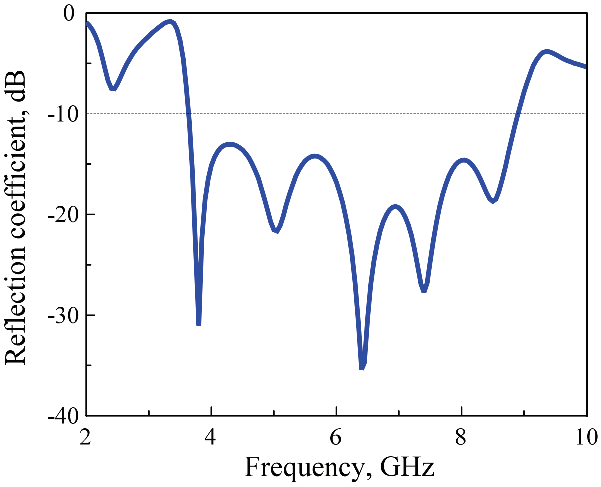

Figure 2. Reflection coefficient of the proposed antenna.

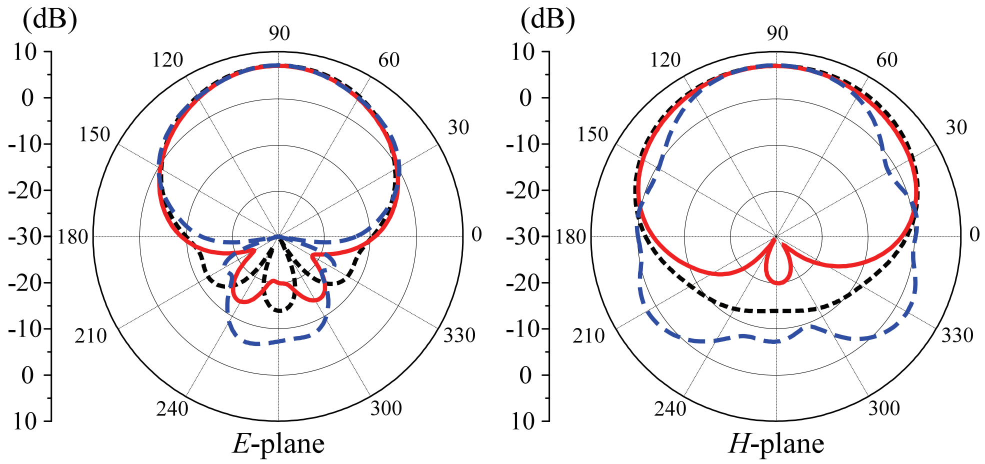

Figure 3. Radiation patterns of the antenna: ┅ 4 GHz, ━ 6 GHz, and ╍ 8 GHz.

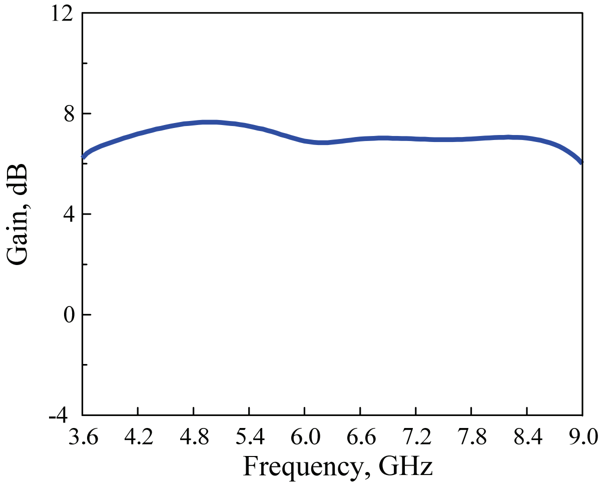

Figure 4. Gain of the proposed antenna.

III. CONCLUSIONS

This paper introduced a microstrip-to-slotline transition-fed quasi-Yagi antenna with a wide bandwidth of 3.65–8.9 GHz and a flat gain of 6.4–7.6 dB. To achieve wideband characteristics and stable radiation patterns, the regular dipole driver was replaced by two parallel dipoles with different lengths, which were directly connected to the slotline by a tapered coplanar stripline. With its wideband characteristics, planar structure, stable radiation pattern, and small gain variation, the proposed antenna could be widely applicable to wideband wireless communication systems.

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