Printed Type Inverted F Antenna for Beam-steering

Hyung-Suk Ham, Young-Ro Kim, and Jong-Myung Woo
Department of Radio Sciences and Engineering,
College of Engineering, Chungnam National University, Daejeon, Korea
hsham@cnu.ac.kr, yr21sp@empal.com, and jmwoo@cnu.ac.kr

Abstract

To reduce a risk of damage from an exposure and the guarantee of a stable receive level, in case of the system of a wireless LAN, a printed type inverted F antenna for beam-steering is designed and its characteristic is measured. A parasitic element having the optimized length and interval is attached in both sides of the printed type inverted F antenna for beam-steering.

As a result of it, the first, when the antenna has a beam-steering to the front area, it obtained the vertical polarization gain of -1.02dBd, the ratio of the front and the back of 17.48dB. The second, when it has a beam-steering to the back, it obtained the vertical polarization gain of -1.66dBd, the ratio of the front and back of 17.03dB. The last, when it has no beam-steering, it maintains the original characteristic of the printed type inverted F antenna for beam-steering, and is appropriate for a antenna of a radio intelligence by having a horizontal polarization.

1. INTRODUCTION

Now a days, using the miniaturized radio intelligence that is emphasized a portable function is increased currently. therefore, users attempt a wireless information transfer without a limited amount of space and time.

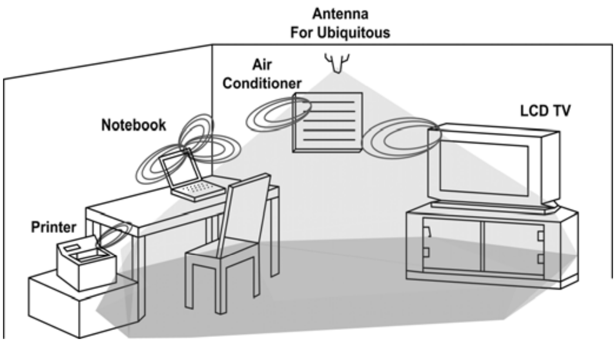
Generally, one of the antenna for a small radio intelligence is a monopole type. As a Fig.1.(a), a monopole antenna has a omni-directional beam pattern in the azimuth plane that is a horizontal. It causes degradation of a radio environment because it is consequently brought about the reduction of the gain and a multi-pass wave. That's why a printed monopole active Yagi-Uda antenna maintaining the finest level of transmitter/receiver is proposed for concentrating on the beam-oriented to the direction of a radio intelligence as a Fig.1.(b). It is possible that a passive element is attached in the printed monopole antenna and then the beam pattern is controlled actively after the changed level is acknowledged with the changed position of radio intelligence[4],[7].

However, as a Fig.1.(c), the proposed antenna cannot generate a horizontal polarization when the transceiver antenna of a horizontal polarization in a ceiling is attached and a receive level is depreciated by a polarization effect.

Hence, in this paper, the printed type inverted F antenna for beam-steering is designed that is available for not only beam-steering, but also the output of a horizontal polarization.

(a) Monopole antenna

(b) Printed type mono pole Yagi-Uda antenna for beam-steering



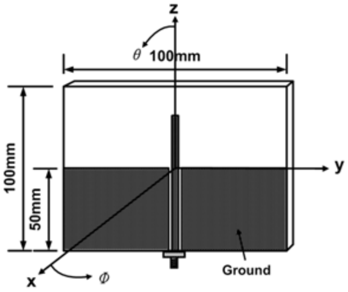
(c) Example of an indoor wireless LAN

Fig.1:Type of an antenna attached in a radio intelligence, the characteristic of a beam, and an example of an indoor wireless LAN.

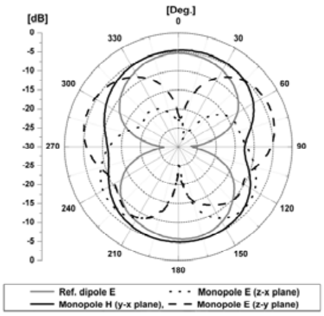
2. SUBJECTS

As a Fig.2.(a), the beam pattern of the printed monopole antenna based on the printed type inverted F antenna for beam-steering is measured. The printed monopole antenna is designed with the center frequency at 1.81GHz. It produced by a printed monopole consisted of a radiation element and the feeding structure of CPW(Coplanar Waveguide) in a substrate that is FR4($\varepsilon_r = 4.6$) with the size of 100mm×100mm. The length of the radiation element is

29mm from the ground. As a Fig.2.(b), in case of H-plane, the gain is 0dBd in the direction of the azimuth plane($\theta = 90°$). However, in case of E-plane, it is 1.52dBd in the direction of $\theta = 65°$. In this case, the gain of the azimuth plane is reduced. From the result, the printed type monopole Yagi-Uda antenna attached a director and a reflector is devised so that the gain of the azimuth plane is increased. This antenna is effective both the increase of the gain of a front area, 2.19dBd and restraint of it of a back area.



(a) Structure



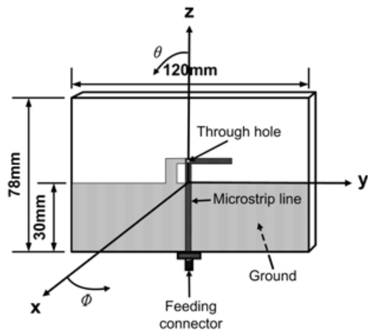
(b) Pattern

Fig.2:Printed type monopole antenna

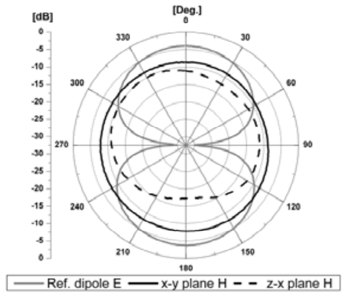
On a basis of this result, the printed type active monopole Yagi-Uda antenna is designed that is able to steer a beam to the areas of a front and a back changing the rule from a passive element to a director and a reflector with arranging a passive element in both sides of a feeding element and attaching a pin diode on it. The length and the interval of the parasitic element is optimized. The gain is 1.41dBd in the front area and 9.41dBd in the back area[7].

On the other hand, the printed type active monopole Yagi-Uda antenna is considered only a vertical polarization, so it is difficult to receive a horizontal polarization. To remove this weak point, the monopole antenna is alternated to a inverted F antenna that can receive a horizontal polarization and steer the beam of a vertical polarization with being a short or open state between a parasitic element and the ground for operating like a switch artificially in the parasitic elements added in both sides of a feeding element.

First of all, a printed type inverted F antenna based on the printed type inverted F antenna for beam-steering is designed with the center frequency at 1.81GHz. It produced by the structure of a printed inverted F radiation element and the feeding structure of a micostrip in a substrate that is FR4($\varepsilon_r = 4.6$) with the size of 120mm×77mm. The structure and the beam pattern show a Fig.3 [1],[2],[3] .



(a) Structure



(b) Pattern

Fig.3:Printed type inverted F antenna

As a Fig.3 (b), the H-plane pattern of the vertical element is omni-directional in a x-y plane and the gain is -4.74dBd. In addition to, the H-plane pattern of the horizontal element is also omni-directional in a z-x plane and the gain is -7.2dBd.

For beam-oriented of the vertical element, as a Fig.4, each parasitic element is attached in both sides of the middle of the inverted F antenna. To catch the finest ratio of the front and the back when the parasitic element is short and open states, the length(L) and the interval(d) is changed.

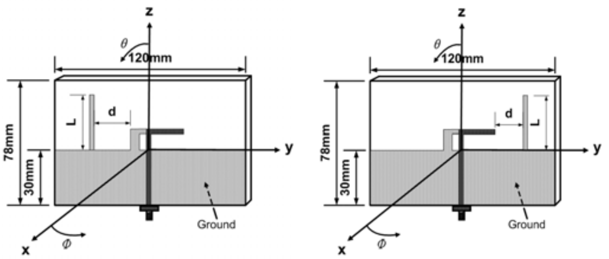


Fig.4:Printed type inverted F antenna attaching parasitic element in the front and the back areas

(In this experiment, it shows that the parasitic element a short state because the entire characteristic of the antenna is rarely influenced when it is an open state.)

Table 1:The Characteristic of the length(L) and the interval(d) of the parasitic element in the front area

Charateristic	d \ L	28mm	30mm	32mm	34mm
FBR(dB)	16mm	3.69	0.16	4.52	11.12
Gain(dBd)		-0.77	-0.77	0.53	0.23
HPBW		139	96	115	140
FBR(dB)	18mm	0.73	3.42	9.41	16.38
Gain(dBd)		-1.67	-0.57	-0.27	-0.57
HPBW		115	127	144	157
FBR(dB)	20mm	2.23	6.75	15.97	19.51
Gain(dBd)		-0.77	-0.17	-0.37	-0.67
HPBW		114	128	146	159
FBR(dB)	22mm	2.45	5.72	11.06	22.3
Gain(dBd)		-1.37	-0.67	-0.47	-0.77
HPBW		130	133	144	161
FBR(dB)	24mm	4.42	8.18	15.69	**25.32**
Gain(dBd)		-0.97	-0.77	-0.77	**-0.97**
HPBW		133	141	154	**165**

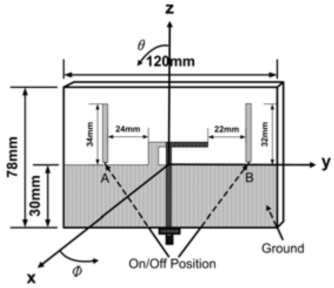
Charateristic	d \ L	36mm	38mm	40mm	42mm
FBR(dB)	16mm	8.37	11.99	10.41	9.27
Gain(dBd)		-0.17	-0.47	-0.67	-0.87
HPBW		152	161	166	172
FBR(dB)	18mm	14.1	11.61	9.96	8.7
Gain(dBd)		-0.87	-1.07	-1.17	-1.27
HPBW		169	177	-	-
FBR(dB)	20mm	14.19	11.07	9.41	8.44
Gain(dBd)		-0.97	-1.17	-1.37	-1.47
HPBW		169	177	-	-
FBR(dB)	22mm	14.72	12.07	10.43	8.78
Gain(dBd)		-1.07	-1.17	-1.37	-1.57
HPBW		172	179	-	-
FBR(dB)	24mm	18.69	13.19	11.32	9.81
Gain(dBd)		-1.07	-1.27	-1.37	-1.47
HPBW		171	179	-	-

Table 2:The Characteristic of the length(L) and the interval(d) of the parasitic element in the back area

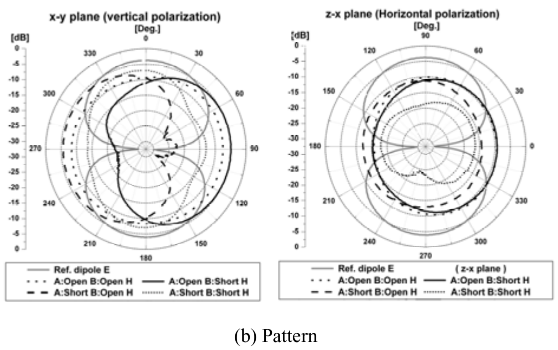
Characteristic	d \ L	28mm	30mm	32mm	34mm
FBR(dB)	16mm	5.7	10.81	2.83	12.93
Gain(dBd)		-0.57	-0.97	-1.17	-1.47
HPBW		151	169	-	-
FBR(dB)	18mm	5.39	10.26	16.32	13.25
Gain(dBd)		-0.87	-1.07	-1.37	-1.57
HPBW		150	169	-	-
FBR(dB)	20mm	5.65	10.5	17.46	13.57
Gain(dBd)		-1.17	-1.27	-1.47	-1.57
HPBW		155	174	-	-
FBR(dB)	22mm	4.97	10.21	18.39	14.68
Gain(dBd)		-1.37	-1.37	-1.47	-1.57
HPBW		153	175	-	-
FBR(dB)	24mm	5.23	9.56	**19.8**	17.21
Gain(dBd)		-1.57	-1.57	**-1.67**	-1.67
HPBW		159	178	**-**	-

Characteristic	d \ L	36mm	38mm	40mm	42mm
FBR(dB)	16mm	10.1	8.35	7.21	6.12
Gain(dBd)		-1.57	-1.77	-1.77	-1.87
HPBW		-	-	-	-
FBR(dB)	18mm	10.42	8.65	7.14	6.6
Gain(dBd)		-1.67	-1.87	-1.87	-1.97
HPBW		-	-	-	-
FBR(dB)	20mm	10.33	8.21	6.79	6.03
Gain(dBd)		-1.67	-1.77	-1.87	-1.87
HPBW		-	-	-	-
FBR(dB)	22mm	10.32	8.3	6.74	6.01
Gain(dBd)		-1.67	-1.77	-1.87	-1.87
HPBW		-	-	-	-
FBR(dB)	24mm	11.37	8.16	6.61	5.54
Gain(dBd)		-1.77	-1.77	-1.87	-1.87
HPBW		-	-	-	-

As Table 1 and 2, the finest ratio of the front and the back areas is in below. In the front area(the left side) of the parasitic element, the gain and it are -0.97dBd and 25.32dB at d=22mm and L=32mm. Also, in the back area(the right side) of the parasitic element, the gain and it are -1.47dBd and 18.39dB at d=24mm and L=32mm. Therefore, as a Fig.5, the beam pattern of the inverted F antenna is measured when it has the finest ratio of the front and the back areas.



(a) Structure



(b) Pattern

Fig.5:Printed type inverted F antenna attaching parasitic elements

As a Fig.5, according to the rule of a feeding element, the beam pattern of the H-plane in a x-y plane is changed. The first, the gain and the ratio of the front and the back areas are -1.02dBd and 17.48dB when the parasitic element of the front and the back areas are open and short states. The second, the gain and the ratio of the front and the back areas are -1.66dBd and 17.03dB when the parasitic element of the front and the back areas are short and open states. It distinguishes the increase of the gain that is 2.25dB and 1.61dB to steer to the front and the back areas comparing to the prior inverted F antenna. Moreover, its original characteristic is maintained since two of parasitic elements are open states and the beam pattern in a horizontal polarization is omni-directional that is almost identical about the printed inverted F antenna, as a Fig.5.(b).

3. CONCLUSION

In this paper, the state between the parasitic elements of the printed inverted F antenna and the ground is changed from open to short or in the crossed condition for beam-steering to the direction of a horizontal plane with maintaining the characteristic of an omni-directional horizontal plane.

From the result, the gain and the ratio of the front and the back areas are -1.02dBd and 17.48dB with steering to the front area. Also, these are -1.66dBd and 17.03dB with steering to the back area. It means that beam-steering is available to the direction of a horizontal plane of the fonrt and the back areas. Especially, it is possible to receive a horizontal polarization from the ceiling in terms of maintaining the omni-directional beam characteristic of a horizontal polarization.

Consequently in this paper, the printed type inverted F antenna for beam-steering is adequate for a radio intelligence that is capable of the control of the beam by its switch and the characteristic of a horizontal polarization.

REFERENCES

[1] Ho-Sun Lee, Jong-Myung Woo, Jong-Chan Kim, "Printed Type Inverted F Antenna", *Proc. of 1999 KEES Microwave and Electromagnetic wave communication conference*, Vol.22 pp. 253-256 Sept. 18, 1999, Korea

[2] Jong-myung Woo, "Printed Type Inversed F Antenna", *Antenna Technology workshop* Apr. 2000, Korea.

[3] Ho-Sun Lee, Jong-Myung Woo, "A Study of Dipole Antenna on a Finite Reflector Using Physical Optics", *Proceedings of KEES Microwave and Electromagnetic wave communication conference*, Vol.22, pp. 284-287 May. 29, 1999, Korea

[4] Sang-Man Moon, Moo-Ha Song, Jong-Myung Woo, Hun-Chul Shin, "Monopol Yagi-Uda antenna on prited board", *Proceedings of KEES Microwave and Electromagnetic wave communication conference*, Vol.24 No.1 pp.362-365, May. 12, 2001, Korea

[5] An Yi Lv Xin, Gao Benqing, "Developing a kind of microstrip array antenna with beam squit", *ISAPE2000 proceedings*, pp.443~446, Aug. 2000

[6] Rodney Vaughan "Switched parasitic elements for antenna diversity". *IEEE transaction. on antennas and prop.* vol. 47, No 2. Feb. 9, 1992.

[7] Sung-Min Lee, Jong-Myung Woo, Nak-En Sung, "Printed Type Active Yagi-Uda Antenna", *Proceedings of KEES Microwave and Electromagnetic wave communication conference*, Vol. 25, No. 1, pp. 169-172, May. 25, 2002, Korea