Suspended Patch Antenna with Z-Type Strip Plate as Broadband Impedance Transformer

C. Karakuş[1] M. F. Demirkol[2]

Abstract **– A wideband Suspended Plane Antenna (SPA) design is proposed. The design uses a suspended Z-type Strip Plate (ZSP) that serves as a radiator and impedance matching part, a thin air gap between the feed connector, and a radiator plane that serves as broadband impedance matching and main radiator part. The resulting impedance bandwidth is from 1.6 to 3 GHz. The horizontal and vertical radiating patterns of the antenna have the same behavior across this band.**

1 INTRODUCTION

Rapid developments in wireless communication systems bring up the need for the antennas with wideband radiating characteristics. Wideband radiating antenna support is important particularly in indoor Distributed Antenna Systems (DAS) used for in-building base station (BS) sites, where, typically 20 to 200 antennas are installed per site. This paper presents a low-profile, light-weight wideband radiating antenna design to be used specifically in indoor BS sites. The design supports GSM-1800MHz, 3G, WIFI and LTE/WI-MAX bands simultaneously.

A major challenge of designing a broadband SPA is the length of the feed probe when the ground plane and the radiator are separated and the height of the radiator is increased. This long probe brings a high inductance and makes it difficult to achieve impedance matching. Studies have been made to compensate for the large inductance by adjusting the location of a feed point [1-6]. In parallel, studies in [7-10] have used vertical or inclined L-type impedance-matching strip plates between radiator and the feed connector to provide broad impedance bandwidth.

In this paper, an SPA design is presented that uses a novel suspended Z-type Strip Plate (ZSP) for broadband impedance matching [10, 11]. The ZSP stands between the feed connector and the radiator. In addition, there is an air gap between the radiator and the ground plane.

The proposed design is both simulated in Ansoft HFSS and verified experimentally on a prototype. An impedance bandwidth from 1.6 to 3 GHz is achieved. The horizontal and vertical radiating patterns of the antenna have the same behavior across this band.

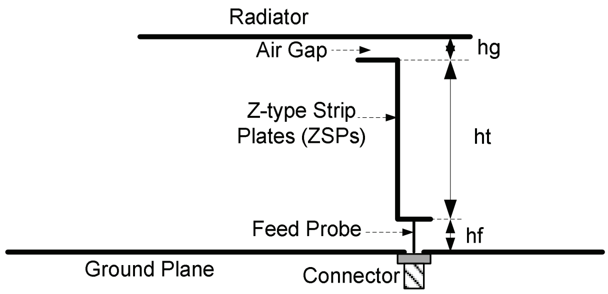


Fig. 1: Cross-section view of proposed suspended antenna configuration.

The rest of the paper is organized as follows. Section II presents the designed antenna structure, including the ZSP and the antenna dimensions. Section III shows both the simulated and measured performance characteristics of the antenna. Section IV concludes the paper.

2 ANTENNA STRUCTURE

2.1 Overall structure

The cross-sectional antenna structure is shown in Figure 1. The antenna comprises of a ground plane, a feed probe, suspended radiator and ZSP for broadband impedance matching and radiator. The radiator is fabricated on a thin air gap.

The ZSP is soldered to the probe of a connector through a tapered feeding strip. A 50 Ω coaxial line is used as a feed probe. The outer conductor of the coaxial line is soldered, riveted or screwed on the ground plane.

The ZSP is used to achieve good impedance matching by the thin air gap. A metal patch (ZSP) is suspended in the air gap above a ground plane. The combination of the ZSP and the air gap results in large impedance bandwidth characteristics.

[1] Istanbul Kultur University, Istanbul, Turkey,
e-mail: cahitkarakus@gmail.com, tel.: +90 (555) 255 1919.
[2] AVEA İletişim Hizm., A. Ş., Istanbul, Turkey,
e-mail: mehmetfatih.demirkol@avea.com.tr, tel.: +90 (555) 255 9153.

978-1-4577-0048-4/11/$26.00 ©2011 IEEE

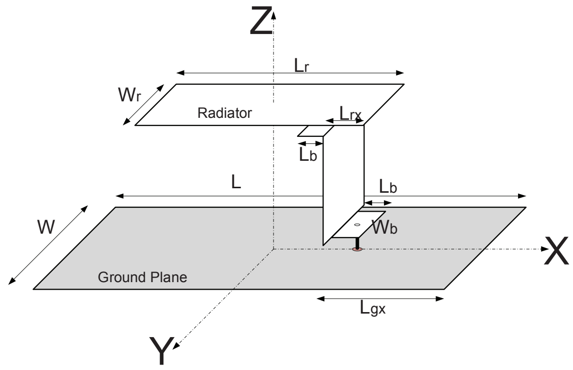


Fig. 2: Geometry suspended antenna configuration.

Table I: Units for magnetic properties.

Component	Parameter	Dimension
Ground plane	W	0.6*λ
	L	0.6* λ
Feed probe	W_b	0.006* λ
	h_f	0.022* λ
	L_{gx}	0.18* λ
	h_t	0.16* λ
	W_b	0.1* λ
	L_b	0.03* λ
Air gap	h_g	0.003* λ
Radiator	W_r	0.165* λ
	L_r	0.3* λ
	L_{rx}	0.07* λ

2.2 Antenna dimensions

Figure 2 shows the 3-D geometry and size parameters. Radiator and the ground plane are oriented horizontally in the X-Y plane.

The dimensions of the antenna components are given in Table I, as a function of the wavelength, $\lambda = C/f_c$, in meters; f_c, being the center operating frequency (Hz) and C, the speed of light.

The total profile of the antenna ($h_g + h_t + h_f$) is less than quarter a wavelength. Thus, it is suitable to be used in proposed applications.

3 SIMULATION AND EXPERIMENTAL STUDIES

For verification of the proposed design, simulations using Ansoft HFSS are performed. Also, a prototype of the proposed design is fabricated for f_c = 2.5 GHz.

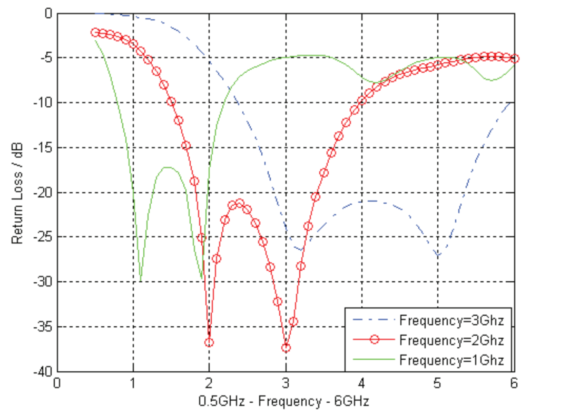


Fig. 3: Return loss calculations for 3 different sizes of the proposed antenna: f_c = 3GHz, 2 GHz, and 1 GHz.

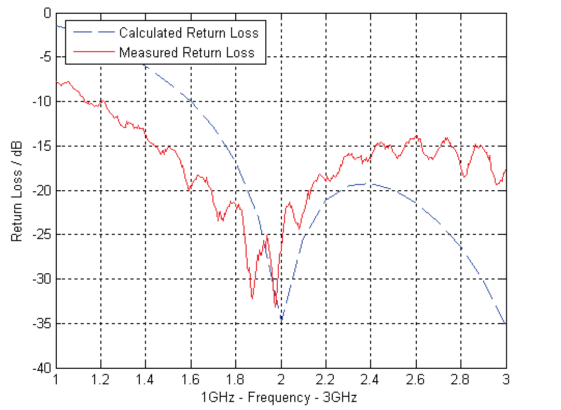


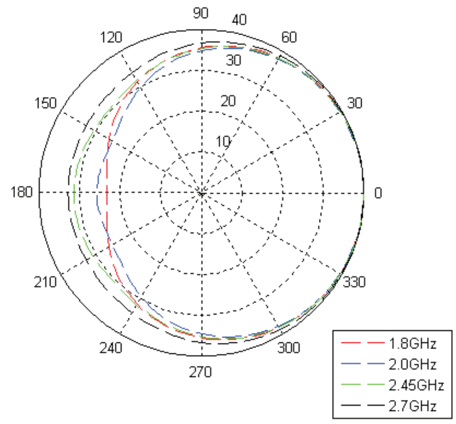
Fig. 4: Simulated and measured return loss values.

Measurements are performed to verify the simulated characteristics such as the return loss and the antenna gain. The return loss is measured using Agilent E4403B (9KHz – 3GHz) ESA-L Series analyzer.

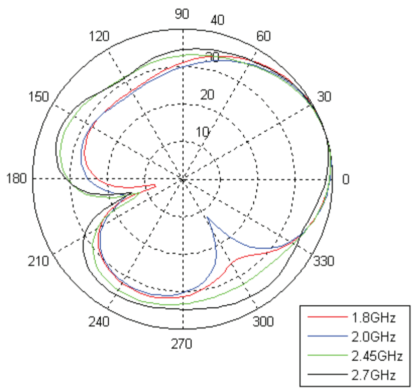
Figure 3 shows the return loss calculations of the proposed antenna for f_c = 3GHz, 2 GHz, and 1 GHz. The dimensions are calculated according to Table I and the designs pertaining to each frequency is simulated in HFSS. The results are as expected; with broad impedance bandwidth for each case.

Figures 4 shows a comparison of simulated and measured the return loss (dB) characteristics of the proposed antenna. Within the frequency range of the measurement setup (1-3 GHz), the simulated and measured results are in good match. The return loss of the prototype is less than -10 dB.

Horizontal and vertical radiation patterns obtained using HFSS are shown in Figure 5, for f = 1.8, 2, 2.45 and 2.7GHz. Both the horizontal and vertical patterns have the same behavior at each frequency. The antenna maximum gain direction does not change.



(a)



(b)

Fig. 5: Radiation patterns: (a) vertical, (b) horizontal.

4 CONCLUSION

A wideband antenna design that uses an Z-type Strip Plate (ZSP) as broadband impedance transformer has been presented in this paper. The antenna is designed to be compact, easy-to-fabricate and low cost.

Simulation and measurement results are presented. The ZSP, in combination with a thin air gap yields an impedance bandwidth from 1.6 to 3 GHz. The horizontal and vertical patterns of the antenna have the same behavior below 3GHz. The antenna maximum gain direction does not change. The gain of the proposed antenna is calculated and measured to be 6 dB at 2GHz.

References

[1] N. Herscovici, "A Wide-Band Single-Layer Patch Antenna," IEEE Transactions on Antennas And Propagation, Vol. 46, No. 4, April 1998, pp. 471–474.

[2] X. N. Low, Z. N. Chen, W. K. Toh, "Ultra wideband Suspended Plate Antenna With Enhanced Impedance and Radiation Performance," IEEE Trans. Antenna Propagation, Vol. 56, No. 8, 2008, pp. 2490–2495.

[3] F. J. Wang and J. S. Zhang, ''Wide Band Cavity-Backed Patch Antenna For PCS/IMI2000/2.4GHz WLAN,'' Progress In Electromagnetics Research, PIER 74, 39–46, 2007.

[4] W. K. Toh, Z. N. Chen, and X. Qing., ''A Planar UWB Antenna With a Broadband Feeding Structure,'' IEEE Trans. Antenna Propagation, Vol.57, No. 7, 2009, pp. 2172-2175.

[5] Z. N. Chen, "Broadband Suspended Plate Antenna With Concaved Center Portion," IEEE Trans. Antenna Propagation, Vol. 53, No. 4, 2005, pp. 1550–1551.

[6] W. K. Toh and Z. N. Chen, "Dual Broadband Folded Antenna Embedded into Access-Point Devices," Proc. 'EuCAP 2006', Nice, France, 6–10 November 2006 (ESA SP-626, October 2006).

[7] B. Gokce, C. Karakus, F. Akleman, "Microstrip Patch Antenna Design for UMTS Handsets," DIPED-2009 Proceedings.

[8] M. Abbak, C. Karakus "A Novel Broadband and High Gain Antenna for GSM, UMTS, and LTE Wi-MAX Applications", European Conference on Antennas and Propagation 2010, 12-16 April 2010, Barcelona.

[9] M. Ding, R. Jin, J. Geng, "A Frequency Notched Inverted-trapezoid UWB Antenna," PIERS ONLINE, Vol. 3, No. 7, 2007.

[10] T. S. P. See and Z. N. Chen, "An electromagnetically coupled UWB plate antenna," IEEE Trans on Antennas an Propagation, vol. 56, no. 5, May 2008.

[11] K. M. Lunk, A. K. Shackelford, K. F. Lee, "Design of small-size Wide-bandwidth microstrip-patch antennas," IEEE Antennas and Propagation Magazine, vol. 45, no. 1, February 2003.