

Design of a Modified L-Probe Fed Microstrip Patch Antenna

Jongkuk Park, *Member, IEEE*, Hyung-gi Na, *Member, IEEE*, and Seung-hun Baik

Abstract—A modified L-probe fed microstrip patch antenna is proposed. By replacing the bent part of an L-probe with a printed strip on a suspended substrate and by placing a radiating patch beneath the substrate, the proposed antenna can be more easily fabricated as a planar antenna. As an example, an antenna with this feed has been fabricated for operation near 2.2 GHz and was found to have a broad impedance bandwidth like a conventional L-probe antenna. In the whole frequency band, an average gain of 7.8 dBi is achieved. Also, the measured result shows that the proposed antenna has a nearly ideal radiation pattern although its feed shadows some part of a radiating patch.

Index Terms—Broadband patch antenna, modified L-probe feed.

I. INTRODUCTION

IN recent years, numerous techniques have been proposed in order to overcome the narrow impedance bandwidth of a microstrip patch antenna. Among the various kinds of broadband patch antennas, there have been the popular U-slot patch antenna [1], an E-shaped patch antenna [2], a stacked patch antenna [3], an L-shaped strip/probe antenna [4]–[6] and so on. In particular, an L-shaped strip/probe antenna has an excellent feeding structure suitable for wideband patch antennas with an air substrate. Since this L-strip/probe feed introduces capacitance between the feed and the radiating patch and this capacitance cancels out the inductance due to a feed strip/probe itself, this effect makes it possible to broaden the impedance bandwidth of the antenna. In general, this type of a feed can be easily implemented by bending a straight strip or probe into an L-shape. However, due to this procedure, it is sometimes inconvenient to insert a substrate such as foam in order to support a patch. Also, if the thick probe is formed from something such as a TNC connector, it is difficult to bend the stiff and rigid probe into the L-shape precisely.

Therefore, in this letter, a conventional L-shaped feeding structure is modified to be suitable for easy fabrication with its own good features preserved. In order to avoid the bending procedure, a vertical thick probe is soldered to a horizontal strip printed on the upper side of a suspended substrate and a radiating patch is printed on the lower side of the substrate. Hence, the horizontal feed strip is placed over the radiating patch contrary to a conventional L-probe antenna. Due to this peculiar geometry, it might be considered to have several disadvantages as follows. First, a soldering procedure is necessary for this feed while the conventional one avoids soldering the feed probe to another patch/strip, that is, it needs only the bending of a straight probe

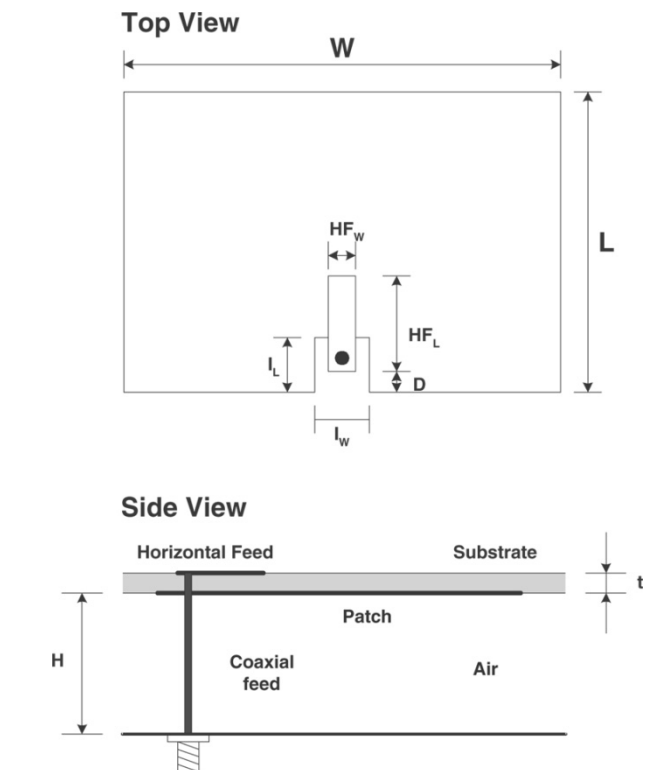


Fig. 1. Geometry of a modified L-probe antenna ($W = 72$ mm, $L = 50$ mm, $I_W = 20$ mm, $I_L = 10$ mm, $HF_W = 3$ mm, $HF_L = 11.5$ mm, $H = 10$ mm, $D = 3$ mm).

into the L-shape. However, when a thick probe is used, it is much easier to solder a vertical thick probe to the horizontal printed strip than to bend one thick and rigid probe to the L-shape precisely. Next, since the printed horizontal strip of an L-shaped feed is placed over the radiating patch, some shadowing effects might cause a radiation pattern to be degraded. However, the measured result shows a good and smooth radiation pattern over the whole operation band and, therefore, these effects can be regarded as very small. In addition, the spacing between the horizontal strip of the L-shaped feed and the radiating patch is exactly set to the thickness of a substrate and so it helps to keep the stable electrical performance and minimize the fabrication error, which may occur in bending a thick probe.

II. ANTENNA CONFIGURATION

Fig. 1 represents the simple geometry of the proposed antenna. As shown in the Fig. 1, the rectangular patch with inset (I_W by I_L) is printed on the lower side of a suspended substrate with a width W and a length L . The horizontal strip feed with a width HF_W and a length HF_L is printed on the upper side of

Manuscript received January 2, 2004; revised April 1, 2004.
The authors are with R&D Group, LG Innotek Company Ltd., Yongin City, 449-910 Kyonggi-do, Korea (e-mail: jkparke@lginnotek.com).
Digital Object Identifier 10.1109/LAWP.2004.829999

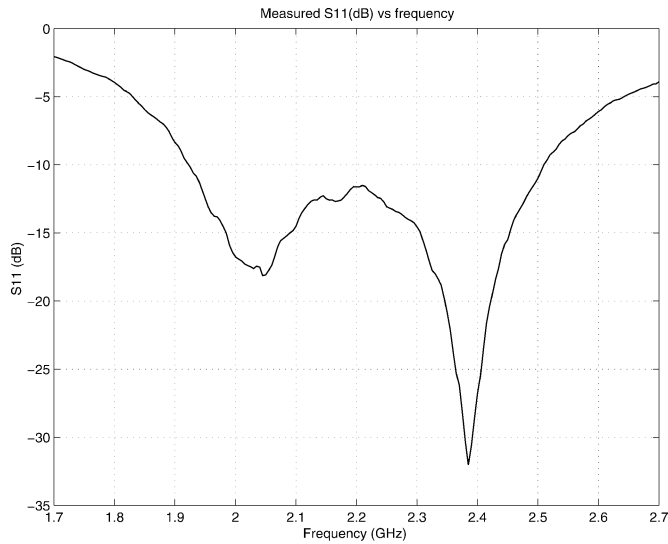


Fig. 2. Measured S-parameter (S_{11}).

the substrate and soldered to the inner conductor (2.1 mm diameter) of a 50- Ω standard TNC launcher. For the substrate where the patch and the horizontal strip are printed, we used a 62 mil (t in Fig. 1) RT Duroid 5880 with a dielectric constant of 2.2. In order to support this substrate and suspend it in the air, four Teflon spacers are used with a height of H . Alternatively, a foam substrate of a thickness H can be inserted between the dielectric substrate and the ground plane. However, the measured result shows no difference between the two methods.

As mentioned above, the spacing between the horizontal strip feed and the patch is limited to the dielectric substrate thickness values that are commercially available. Hence, when the capacitance value between the patch and the horizontal feed must be adjusted in the given dielectric substrate, it is possible to change the horizontal feed width (HF_W) and length (HF_L) or move the position of the feed. However, if some custom-made substrates are available, the dielectric thickness could be also used as another capacitance tuning parameter.

All the values of design parameters given in Fig. 1 are determined for the given substrate through extensive numerical simulations. Since the effect of each parameter is similar to the case of a conventional L-probe fed antenna [5], it is omitted in this letter for brevity.

III. MEASUREMENT RESULTS

Fig. 2 represents the measured reflection coefficient of the fabricated antenna. As shown in this figure, the antenna can be operated from 1.92 to 2.51 GHz, which corresponds to a bandwidth of 26.5% ($VSWR < 2$). This value is slightly smaller than that of a conventional L-probe patch antenna with its spacing H relatively small ($H = 0.064\lambda_0 - 0.084\lambda_0$) [6]. The reason for the slight decrease in the bandwidth is likely that the spacing H is optimized to a somewhat smaller value because the substrate dielectric constant and thickness are fixed commercially. Through numerical simulations, it can be easily verified that a larger bandwidth is obtained by selecting other substrates of different dielectric constant and thickness such that the spacing is increased.

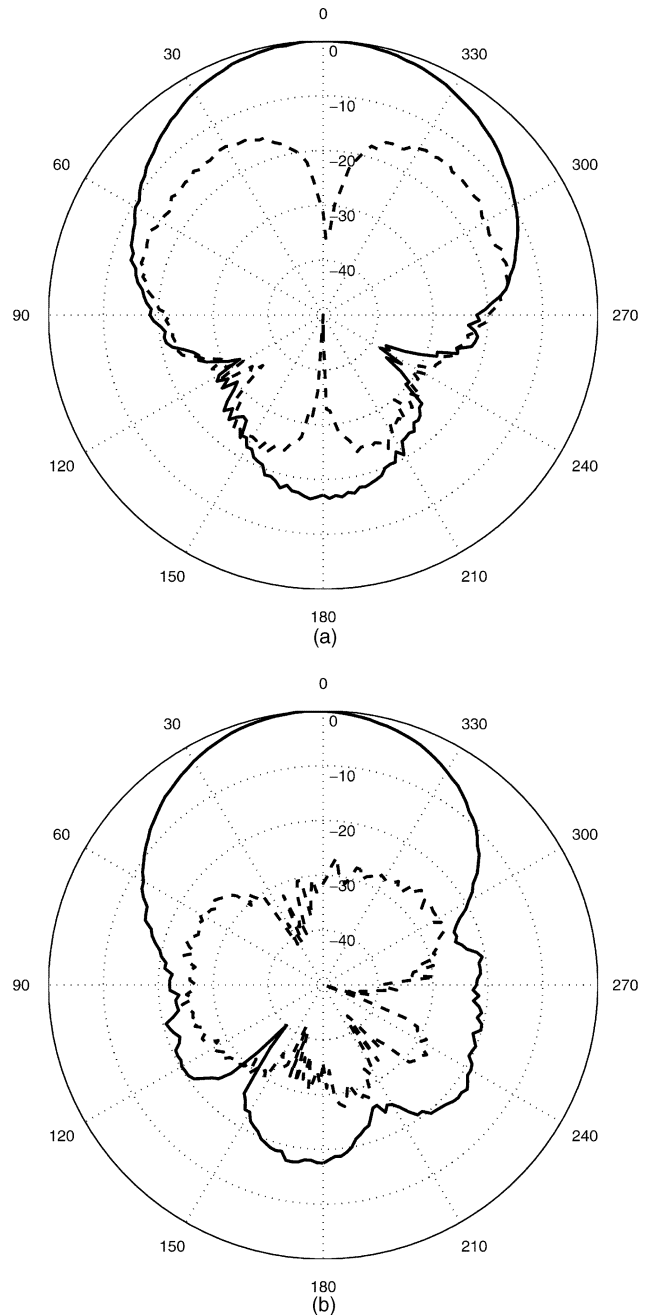


Fig. 3. Measured radiation patterns at 2.2 GHz (solid line: copolarization; dashed line: cross polarization). (a) H-plane pattern. (b) E-plane pattern.

Fig. 3 shows copolarized and cross-polarized radiation patterns measured at 2.2 GHz. As mentioned above, the results show that no degradation is observed in the radiation pattern although the positions of the feed and patch are inverted. Together with a smooth radiation pattern, the average measured gain is 7.8 dBi in the operation band.

IV. CONCLUSION

In this letter, a conventional L-probe fed microstrip patch antenna is modified so that it may be more easily fabricated with its own good features preserved. Instead of bending a probe into the L-shape, an L-shaped feed is implemented by soldering a vertical thick probe to a horizontal strip printed on a suspended

substrate and by placing a radiating patch beneath the substrate. The measured results show that the proposed antenna has a relatively large bandwidth like a conventional L-probe design. Although the positions of a feed and a patch are inverted, this fact is found to have little effect on the radiation pattern of the proposed antenna.

REFERENCES

- [1] K. F. Lee, K. M. Luk, K. F. Tong, S. M. Shum, T. Huynh, and R. Q. Lee, "Experimental and simulation studies of the coaxially fed U-slot rectangular patch antenna," *Inst. Elect. Eng. Microwave Antennas Propagation*, vol. 144, no. 5, pp. 354–358, Oct. 1997.
- [2] F. Yang, X. X. Zhang, X. Ye, and Y. Rahmat-Samii, "Wideband E-shaped patch antennas for wireless communications," *IEEE Trans. Antennas Propagat.*, vol. 49, pp. 1094–1100, July 2001.
- [3] S. D. Targonski, R. B. Waterhouse, and D. M. Pozar, "Design of wideband aperture-stacked patch microstrip antennas," *IEEE Trans. Antennas Propagat.*, vol. 46, pp. 1245–1251, Sept. 1998.
- [4] C. L. Mak, K. M. Luk, and K. F. Lee, "Wideband L-strip fed microstrip antenna," in *Proc. IEEE Antennas and Propagation Society Int. Symp.*, Orlando, FL, July 1999, pp. 1216–1219.
- [5] Y. X. Guo, C. L. Mak, K. M. Luk, and K. F. Lee, "Analysis and design of L-probe proximity fed-patch antennas," *IEEE Trans. Antennas Propagat.*, vol. 49, pp. 145–149, Feb. 2001.
- [6] K. M. Luk, C. L. Mak, Y. L. Chow, and K. F. Lee, "Broadband microstrip patch antenna," *Electron. Lett.*, vol. 34, no. 15, pp. 1442–1443, 1998.