Report #5

Reduced size planar inverted-F antenna (PIFA)

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1. Planar inverted-F antenna (PIFA)

The planar inverted –F antenna was described in report #3. Here, we present its reduced-size version. The reduction in size of about 40% is achieved by keeping the same large bandwidth.

A distinct and inviting property of this antenna is an almost omnidirectional radiation pattern in the E-plane.

Simultaneously, the antenna becomes sensitive to the loading by human body. A tuning mechanism is suggested and realized, which may enable to compensate for this dependence.

2. Reducing the size of PIFA

In principle, the miniaturization of the PIFA can be achieved by several different approaches used by others:

1. using an additional shorting pin [1],
2. loading a dielectric material with high permittivity [2],
3. capacitive loading of the antenna structure [3],
4. using slots on the patch to increase the electrical length of the antenna [4].

However, using a high-epsilon dielectric material significantly reduces the bandwidth of the antenna structure, and, hence, it is not considered in the present case. The present report describes a PIFA structure that employs slots and capacitive loading in order to reduce the antenna size but still maintain the required operating bandwidth.

a. Design

Fig 1 shows the geometry of the new PIFA element optimized for 440 MHz. This design is essentially a modification of the original design explained in report #3. The capacitive load is formed by folding the open end of the PIFA toward the ground plane and adding a plate (parallel to the ground plane) to produce a parallel plate capacitor. The effective length of the patch is increased by introducing slots in its edges. The length of the slots, the number of slots, the vertical length of the capacitor plate, the location of the shorting plate and feeding point have been carefully optimized in order to achieve the best matching.

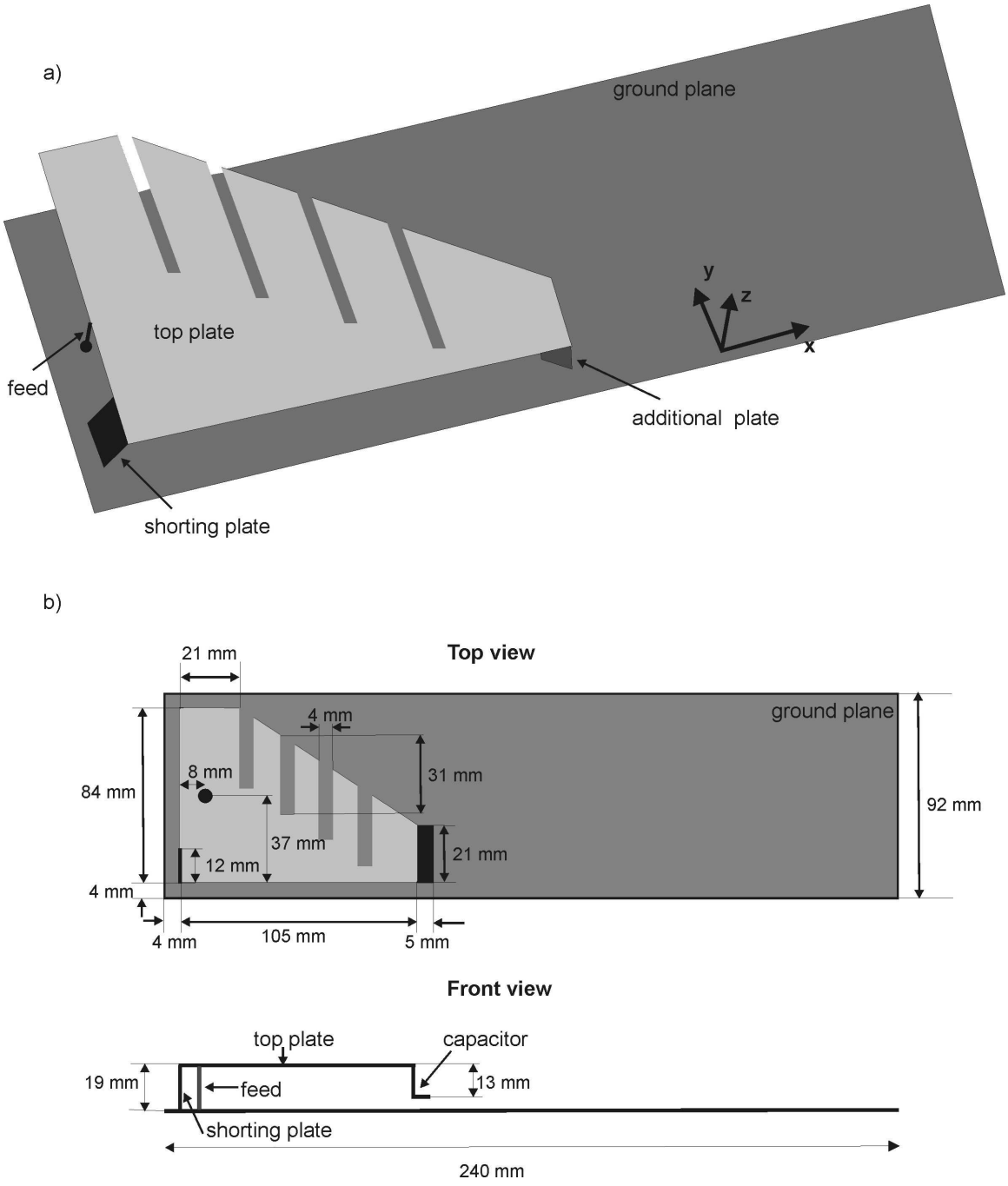

Fig.1. Reduced-size PIFA structure optimized for 440 MHz. a) - the isometric view; b) - top view and front view of the antenna.

b. Bandwidth performance

As shown in Fig. 2, the maximum return loss is -26.10 dB at 443 MHz. The upper and lower band frequencies are 420 MHz and 480 MHz, respectively, giving the absolute impedance bandwidth of 60 MHz. Therefore, the bandwidth obtained for the proposed PIFA is 13.65%. The bandwidth can be further increased by increasing the length of the ground plane [5].

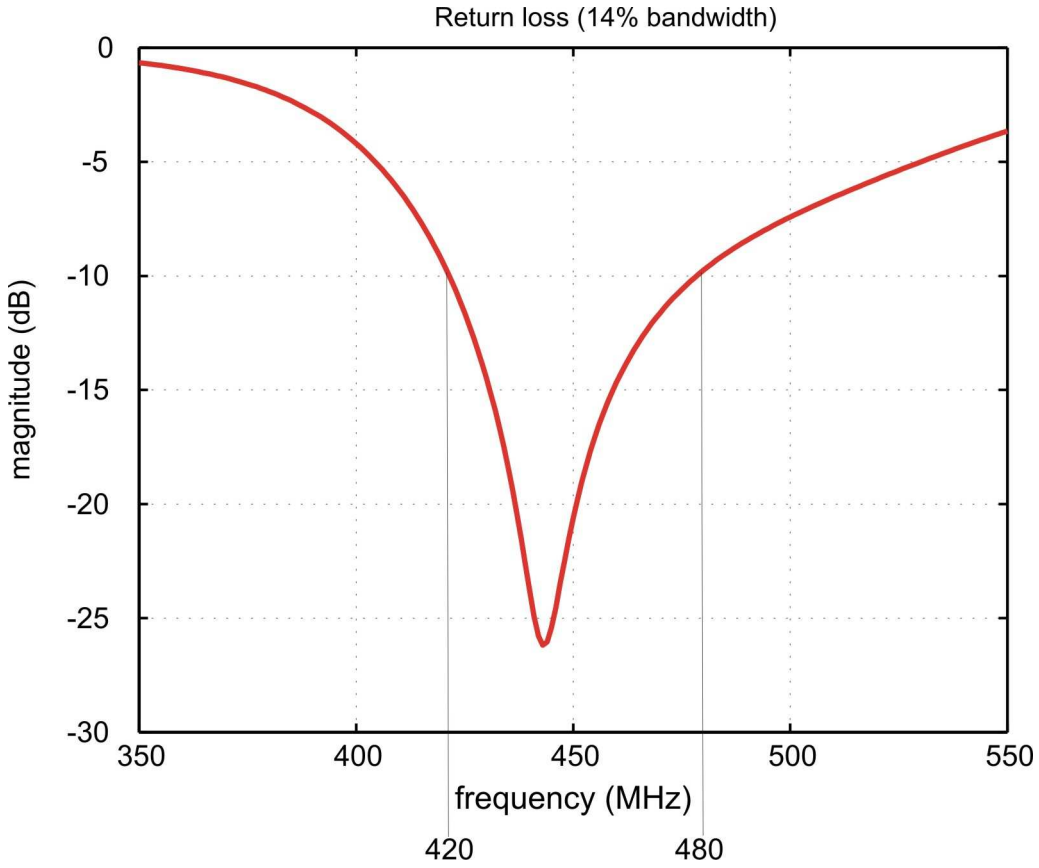

Fig.2. Return loss for the PIFA structure shown in Fig 1.

c. Radiation patterns

The 3D radiation pattern for absolute gain (real gain in the lossy case is very close to this value) is shown in Fig. 3. The antenna has a near omni-directional pattern with a maximum gain of about 2.7 dB along the vertical z-axis (the axes are shown in Fig. 1). Fig. 4 shows the gain variation of the antenna in the *xz* plane (the E-plane of the antenna).

The new PIFA is thus a nearly omnidirectional, linearly-polarized antenna, with an acceptable front-to-back ratio. Fig.5 shows the polarization isolation plot in the E-plane.

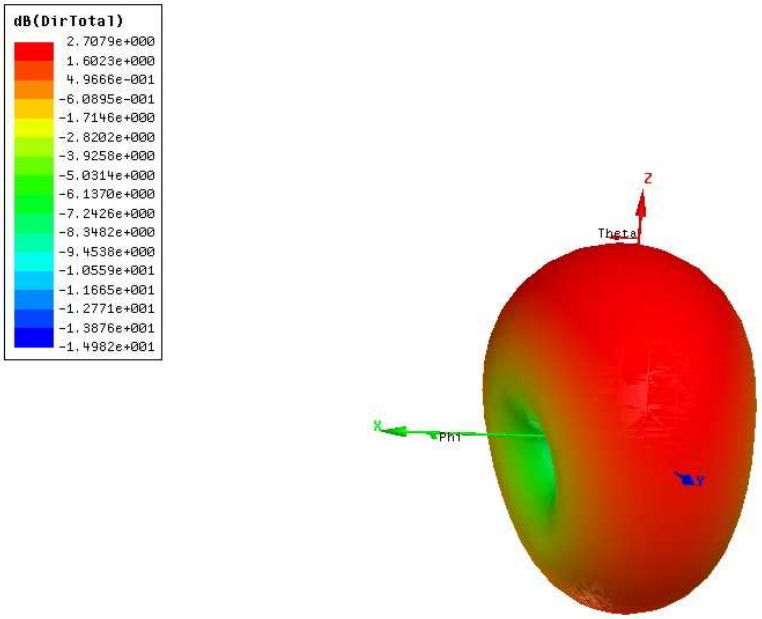

Fig.3. 3D radiation pattern (absolute gain).

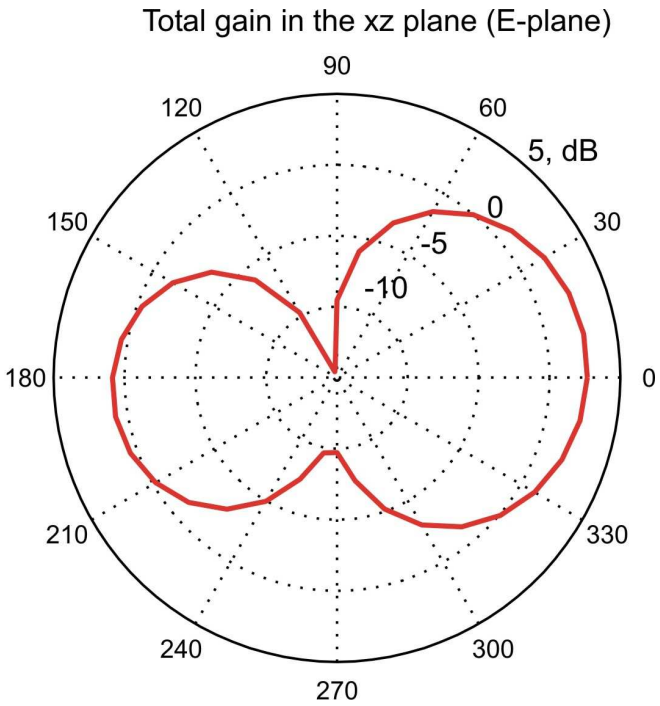

Fig.4. 2D radiation pattern in the *xz* plane (absolute gain).

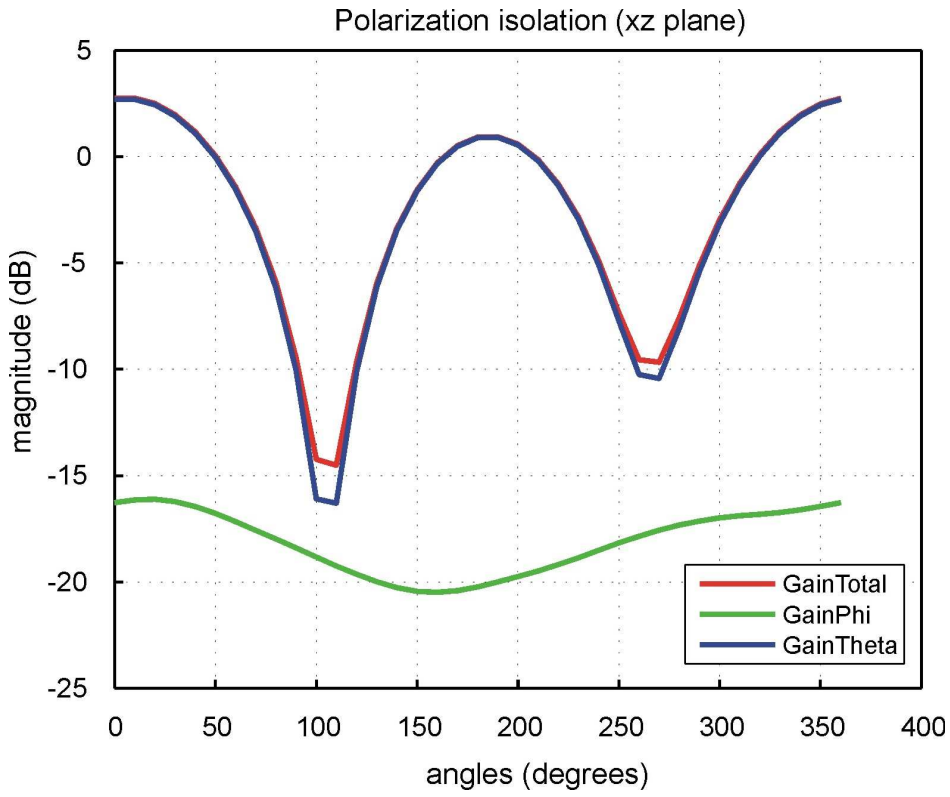

Fig.5. Co-polarization and cross-polarization radiation patterns in the E-plane.

3. References

1. L. Zaid and R. Staraj, "Miniature circular GSM wire patch on small ground plane", *Electronic Letters*, vol. 38pp. 153 – 154, Feb. 2002.

2. T. K Lo and Y. Hwang, "Bandwidth enhancement of PIFA loaded with very high permittivity material using FDTD," *IEEE Antennas and Propagation Society International Symposium*, vol.-2, pp. 798-801, June 1998.

3. T. K Lo, J. Hoon and H. Choi, "Small wideband PIFA for mobile phones at 1800 MHz," *Vehicular Technology Conference*, vol.-1, pp. 27-29, May 2004.

4. C. R. Rowell and R. D. Murch, "A capacitively loaded PIFA for compact mobile telephone handsets," *IEEE Trans. Antennas and Propagation*, vol.-45, no. 5, pp. 837-842, May 1997.

5. M. C. Huynh and W. Stutzman, "Ground plane effects on the planar inverted- F antenna (PIFA) performance," *IEE Proc. Microwave Antennas and Propagation*, vol.-150, no. 4, pp. 209-213, August 2003.