Quarter-wave patch antenna with 35% bandwidth

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Abstract

A small quarterwave patch antenna with the impedance bandwidth of 35% was constructed for the frequency of about 2 GHz. The antenna has a probe feed with an integrated capacitor to compensate for the probe inductance and produce a dual-resonant structure. The radiation pattern of the proposed antenna is fairly omnidirectional and the polarization separation is low, so it is suitable for certain applications in mobile communications.

1 Antenna structure

The proposed antenna is a quarterwave rectangular microstrip patch antenna with a thick air substrate (Figure 1). The antenna has a capacitor in the middle of the probe. The capacitor is a matching capacitor to compensate for the inductance of the long feed probe. The capacitance and probe combination is in resonance near the patch resonance.

Two possible configurations have been studied. In the first version the capacitor was made of a piece of common low-permittivity substrate having metal on both sides, therefore the structure of the antenna resembles a stacked patch antenna. In the second version the capacitor consisted of two chip capacitors on top of the probe and almost similar behaviour was obtained as with the large capacitor.

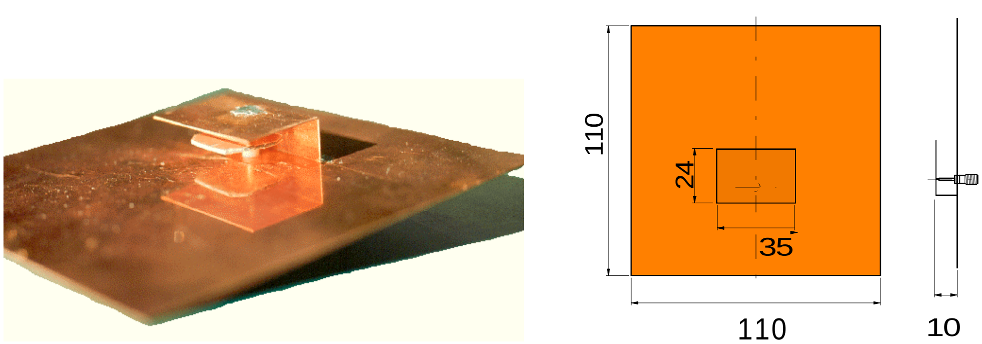


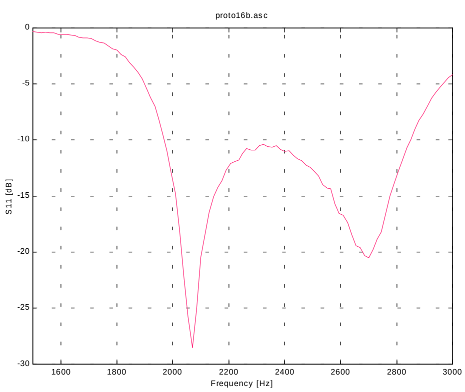
Figure 1. *Structure and dimensions of the prototype antenna (in mm).*

The antenna has two resonances: one patch resonance (parallel resonance) and one loop resonance (series resonance). The resulting combination of resonances is the source of the wide bandwidth. Comparable impedance bandwidths from 20% to 35% have been obtained with aperture coupled antennas [1], but sometimes the additional PCB layer of the aperture feed is not desirable. There are also similarities between the proposed structure and that in [2] and [3]. The main differencies are the short-circuited quarterwave structure and that the planar stacked-type structure is only one implementation option of the dual-resonant principle.

Because of the position, size and material of the large capacitor, the capacitor may have also some electrical coupling effect with the patch, but this needs further study.

2 Measured properties

The reflection coefficient for the antenna version with the large capacitor is given in Figure 2 and the input impedance in Figure 3.



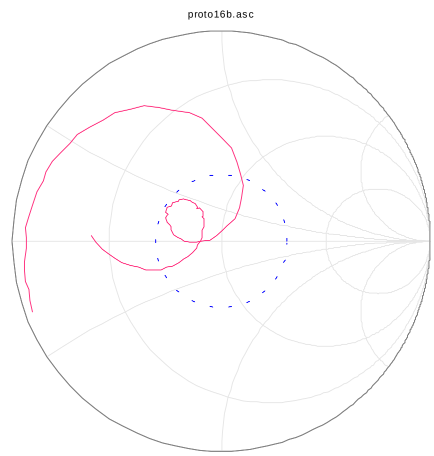


Figure 2. *Measured reflection coefficient.* ***Figure 3.*** *Measured input impedance.*

The impedance bandwidth for the 10dB return loss is about 35 %. From Figure 3 it can be noticed that the matching was not totally optimal and somewhat larger bandwidth can be obtained by tuning the matching.

From a measurement without the capacitor the inductance of the probe was estimated to be about 7nH. Thus at the 2400 MHz resonance frequency the respective capacitance is 0.55 pF. When a 0.67pF (+/-20%) chip capacitor was used to replace the large capacitor a 10dB bandwidth of 31% was obtained.

The measured radiation pattern (Figures 4 and 5) show fairly omnidirectional pattern. Gain is 3±1 dBi. The cross-polar value is almost as high as the copolar value except in the boresight direction.

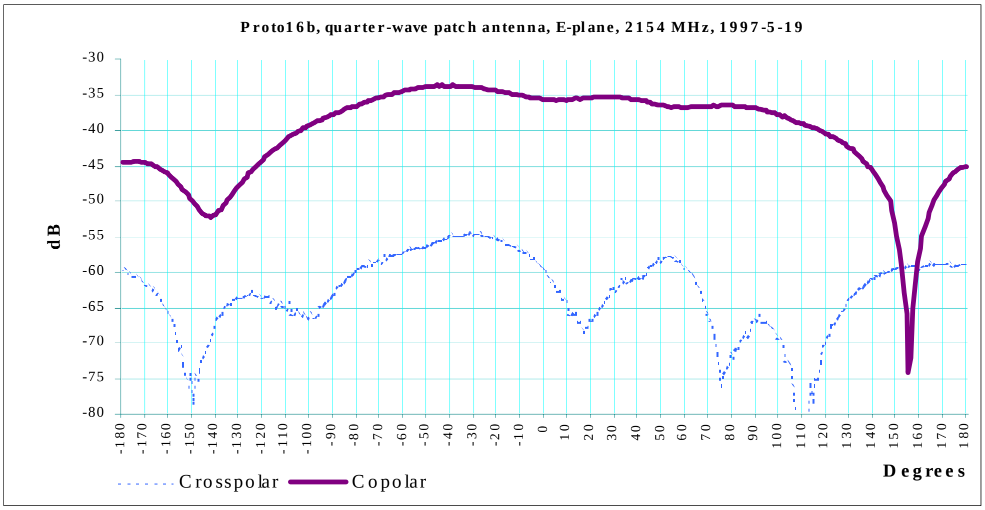


__Figure 4.__ Measured radiation pattern in E-plane, 0dBi at –37dB.

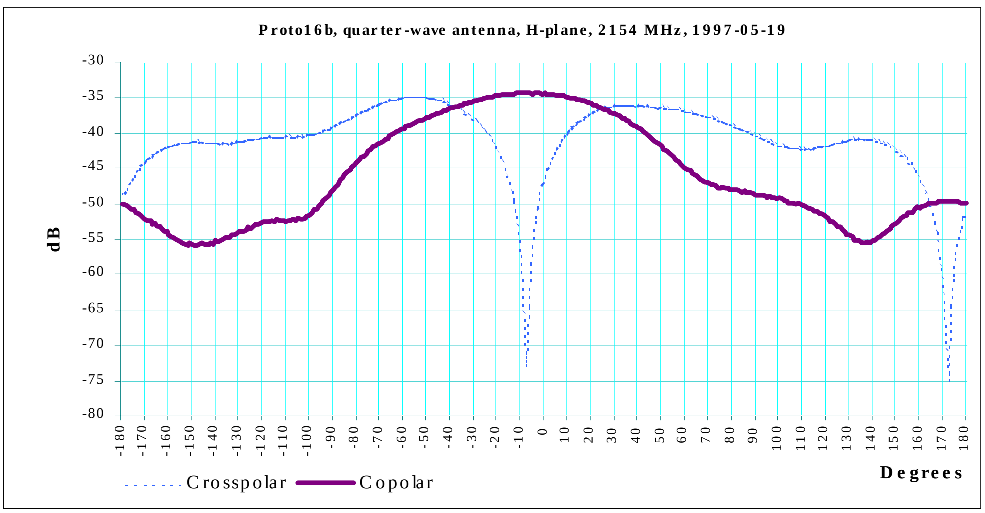
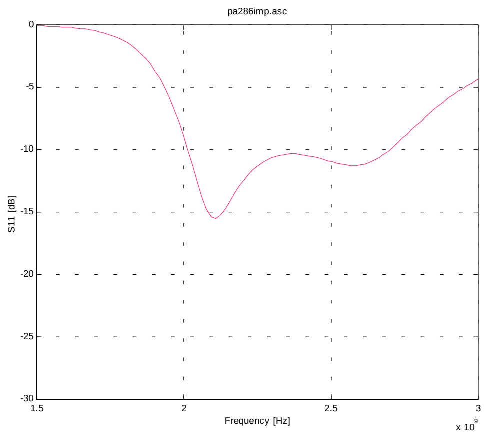


__Figure 5.__ Measured radiation pattern in H-plane, 0dBi at –37dB.

3 Computer simulations

In FDTD simulations, 28.8% 10dB bandwidth was reached, see Figures 7 and 8. Here the input impedance was closer to optimum than for the prototype.



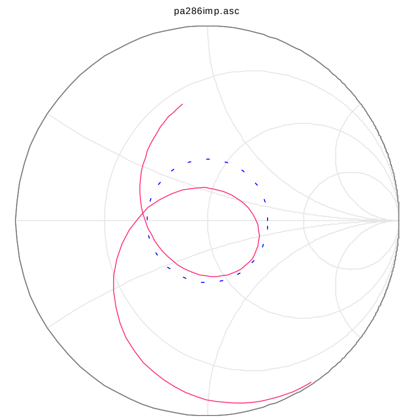


Figure 6. *Simulated reflection coefficient (frequency in GHz).*

Figure 7. *Simulated input impedance*

4 Conclusions

In this paper we presented our first measured and simulated results for a resonant-fed thick quarterwave patch. The bandwidth obtained in the measurements was 35 %. Further improvement of the performance can be expected by optimising the dual-resonant input impedance. The simulated bandwidth was clearly lower than the measured.

The antenna could be used in cellular base stations when wide bandwidth is required and polarization separation is not necessary. The antenna could be modified for mobile handsets e.g. by using a substrate material of higher permittivity or by reducing the height. These modifications would shrink the size of the antenna but would also reduce the bandwidth. Widening of the antenna could be used to reclaim some of the bandwidth.

References

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[2] G.A.E. *Vandenbosch*, ***"Capacitive matching of microstrip antennas,"*** *Electronics letters*, vol. 31, no. 18, 31st August 1995, pp. 1535-1536

[3] G.A.E. *Vandenbosch*, A.R.Van de Capelle "***Study of the capacitively fed microstrip antenna element***," *IEEE Transactions on Antennas and Propagation*, vol. 42, no.12, December 1994, pp. 1648-1652