Pillbox Antenna for 5.6 GHz Band

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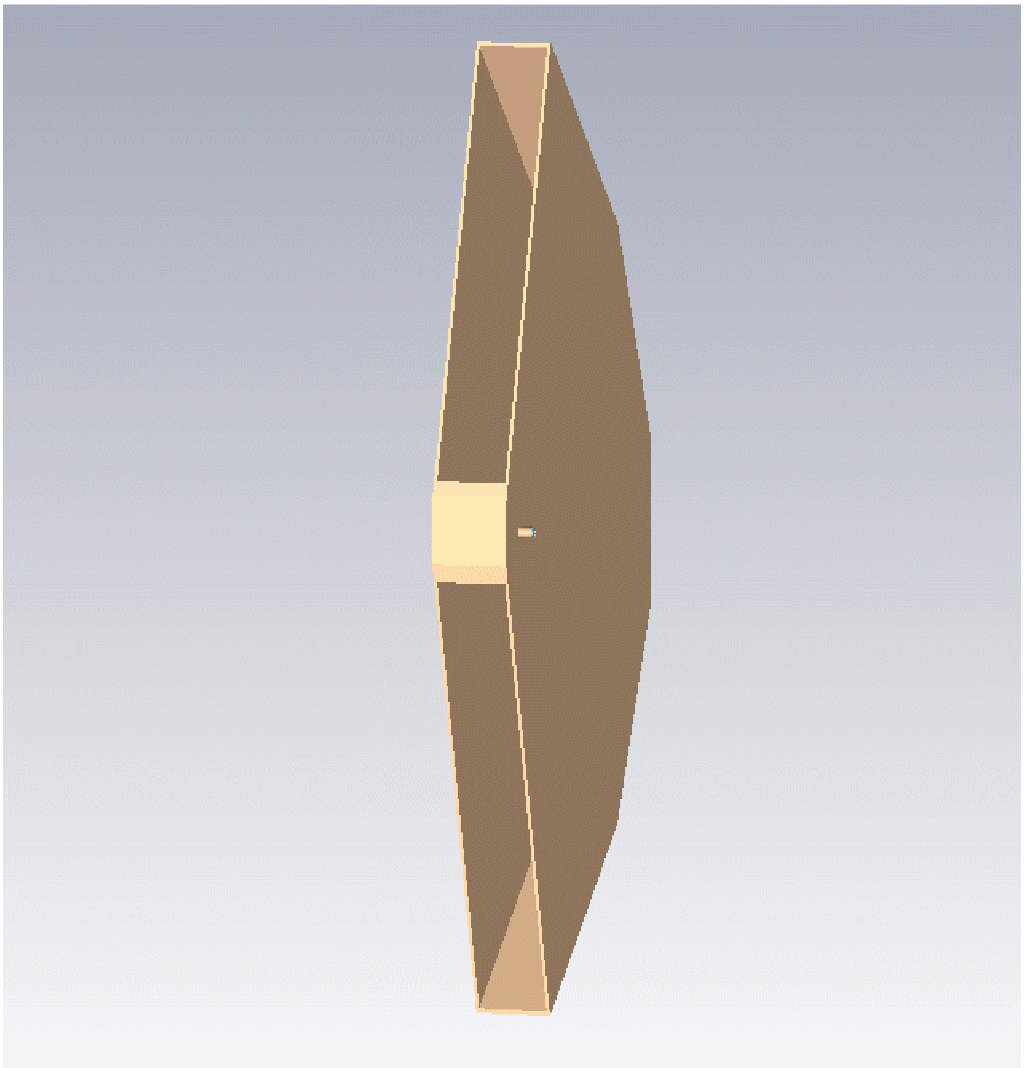

Introduction

The "pillbox" or "cheese" antenna is made of two parallel plates which are connected to the narrow strip of parabolic cylinder reflector. The side plates act as a parallel plane waveguide that guide radiation from feed to parabolic reflector. Distance between plates that form a parallel plane waveguide is usually small, half wavelength at the most, in order to restrict to principal or TEM mode of propagation and prevent supporting of higher modes of electromagnetic wave. The feed is placed at the focus point of parabolic cylinder reflector and it lies in the middle of radiating aperture **[1, 2].**

Such antenna construction is characterized with relatively narrow vertical and very wide horizontal angle of radiation. With simple feed situated at the focal region and consisting of quarter wavelength monopole, mounted perpendicularly to one of parallel plates in front of relatively small plane reflector, one gets very wideband, wide angle, horizontally polarized antenna.

This antenna can be used very efficiently for wireless LAN access points where wide angle coverage in horizontal plane is needed. Two such antennas placed "back to back" can produce pretty uniform omni directional pattern.

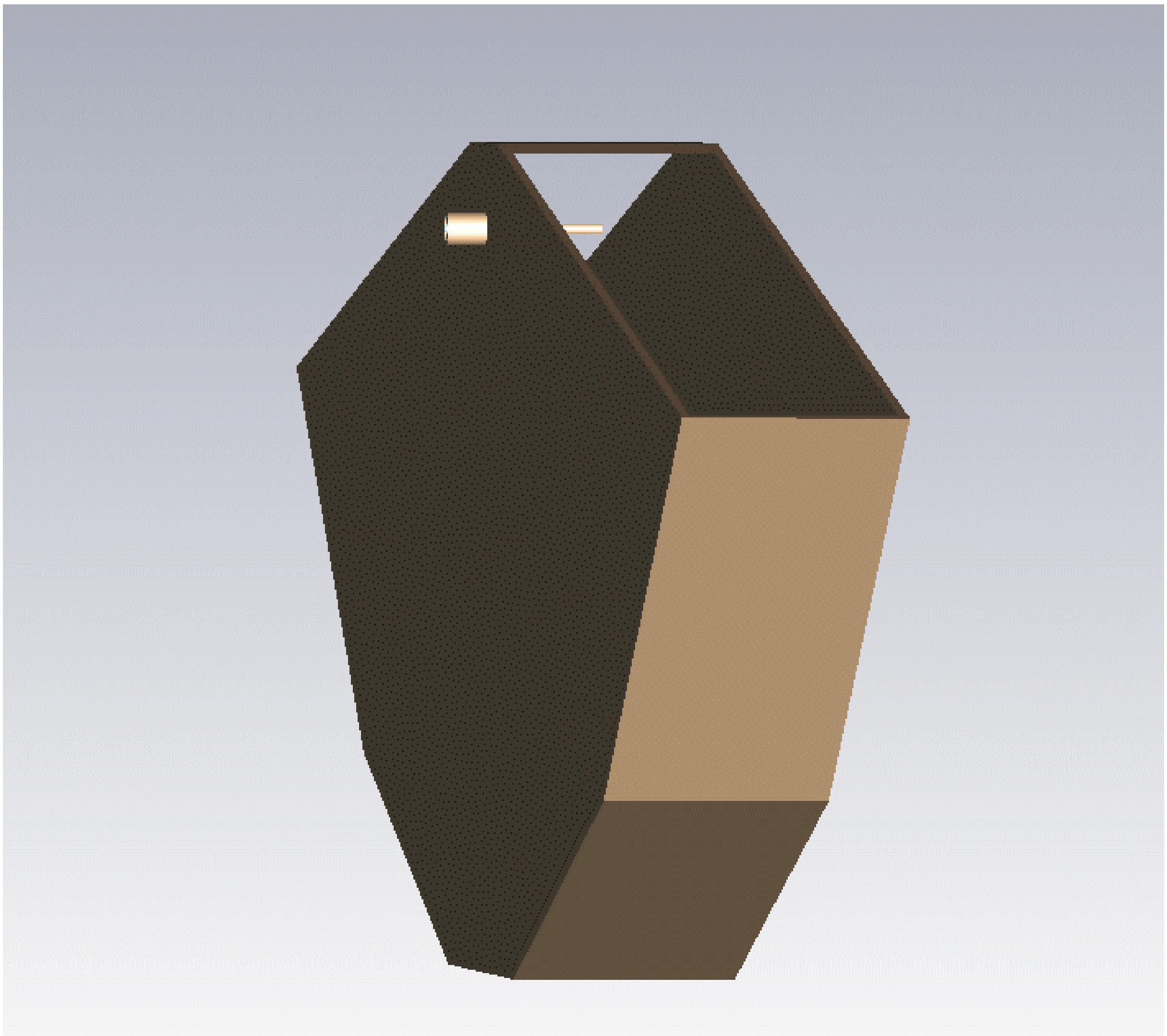

Fig. 1 Pillbox antenna

Construction

In order to make antenna construction and building as simple as possible I decided to make a simple but still relatively good approximation of parabolic curvature. It is done with a polygon whose dimensions were optimized so that antenna gain and side lobe levels stay very close to results that can be obtained with true parabolic curvature of reflector.

Pillbox antenna may have many different feed types depending on working frequency, polarization, input impedance, bandwidth and other aimed specific performances. I decided to use a very simple quarter wavelength monopole mounted on one of parallel plates, which also serves as ground plane mirror placed in front of a small reflector. Due to very specific construction of the antenna, the feed reflector was bent in concave form in order to conform to parallel plate shapes and also optimize illumination taper and minimize feed blockage.

Input matching

Suitable length of monopole and its distance from reflector are adjusted for good antenna input matching and optimum efficiency.

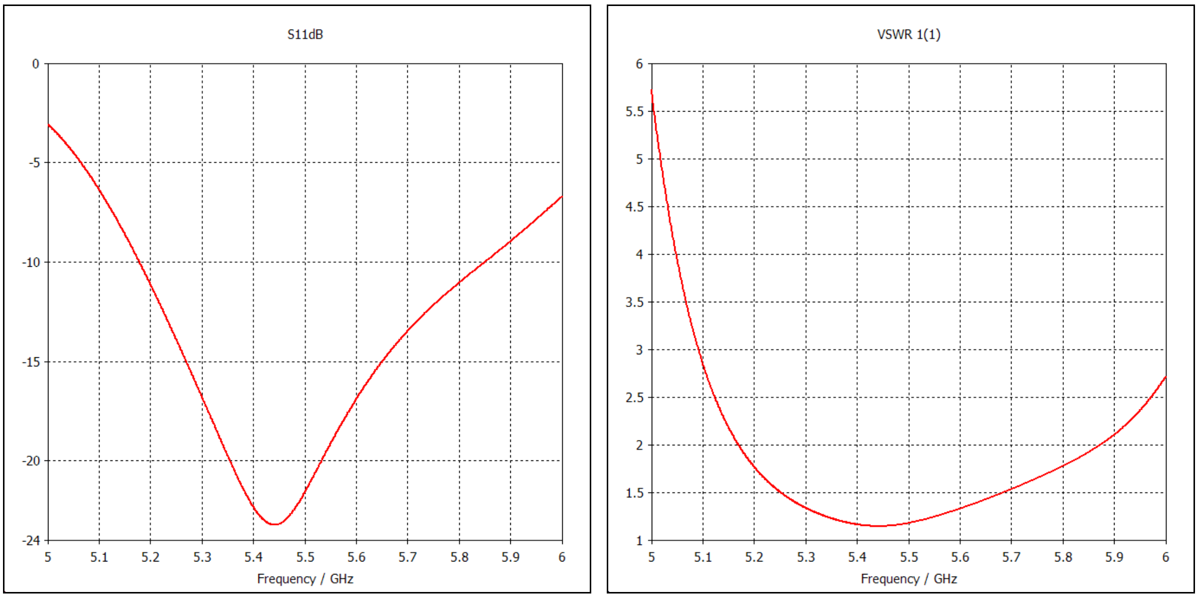

Fig. 2 Input return loss and SWR of pillbox antenna

As can be seen on the patterns, relatively good 50-ohm matching is obtained over the whole 5.2 to 5.8 GHz Wi-Fi band. SWR value in this band is less than 1.8, while SWR less than 3 is obtained in almost 1 GHz wide band.

This shows that the antenna is pretty wideband and that it can cover the entire Wi-Fi band without readjusting feed dimensions or position.

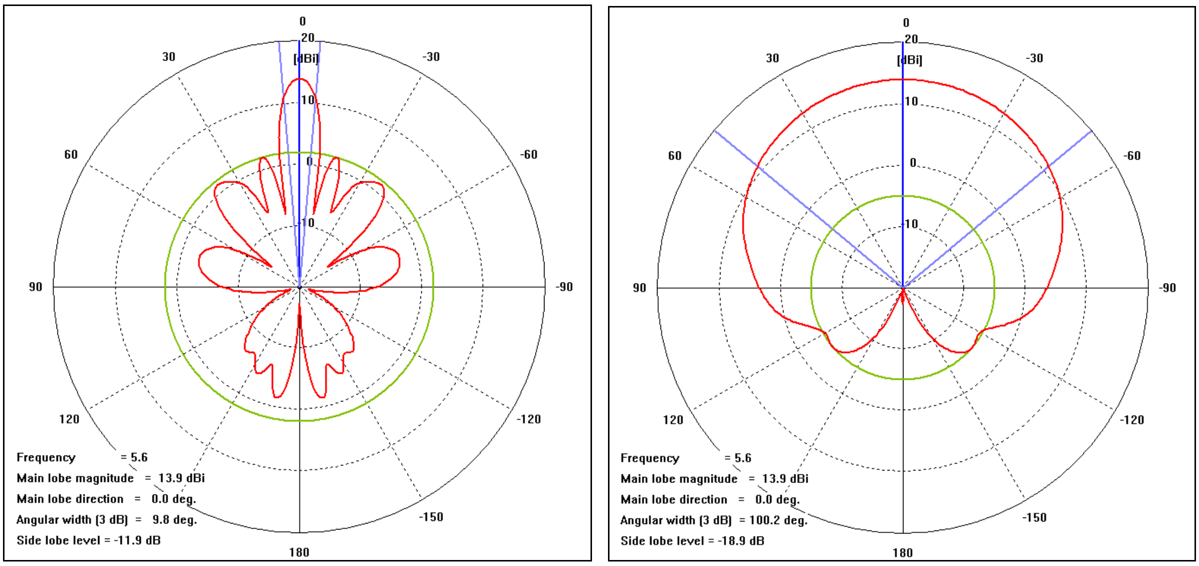

Fig. 3 Vertical and horizontal diagram of pillbox antenna

Antenna pattern

Due to the very narrow strip of parabolic cylinder that is used as a reflector, the horizontal pattern of the antenna is very wide. Angle between -3 dB points is as wide as 100 deg. On the other side, the vertical pattern is quite narrow and -3dB angle is only about 10 deg.

Antenna gain is close to 14 dBi which is also close to theoretical and practical maximum that can be obtained for given antenna radiating aperture. Gain loss due to approximation of parabolic curvature by polygon is less than 0.2 dB. The level of all antenna side lobes was kept below about -12 dB.

The Pillbox antenna is known for its higher back lobe levels due to its construction **[1]** and in this one the back lobes level is about -16 dB. Some very small increase of side and back lobes have been paid to antenna construction simplification and approximation of parabolic curve by polygon.

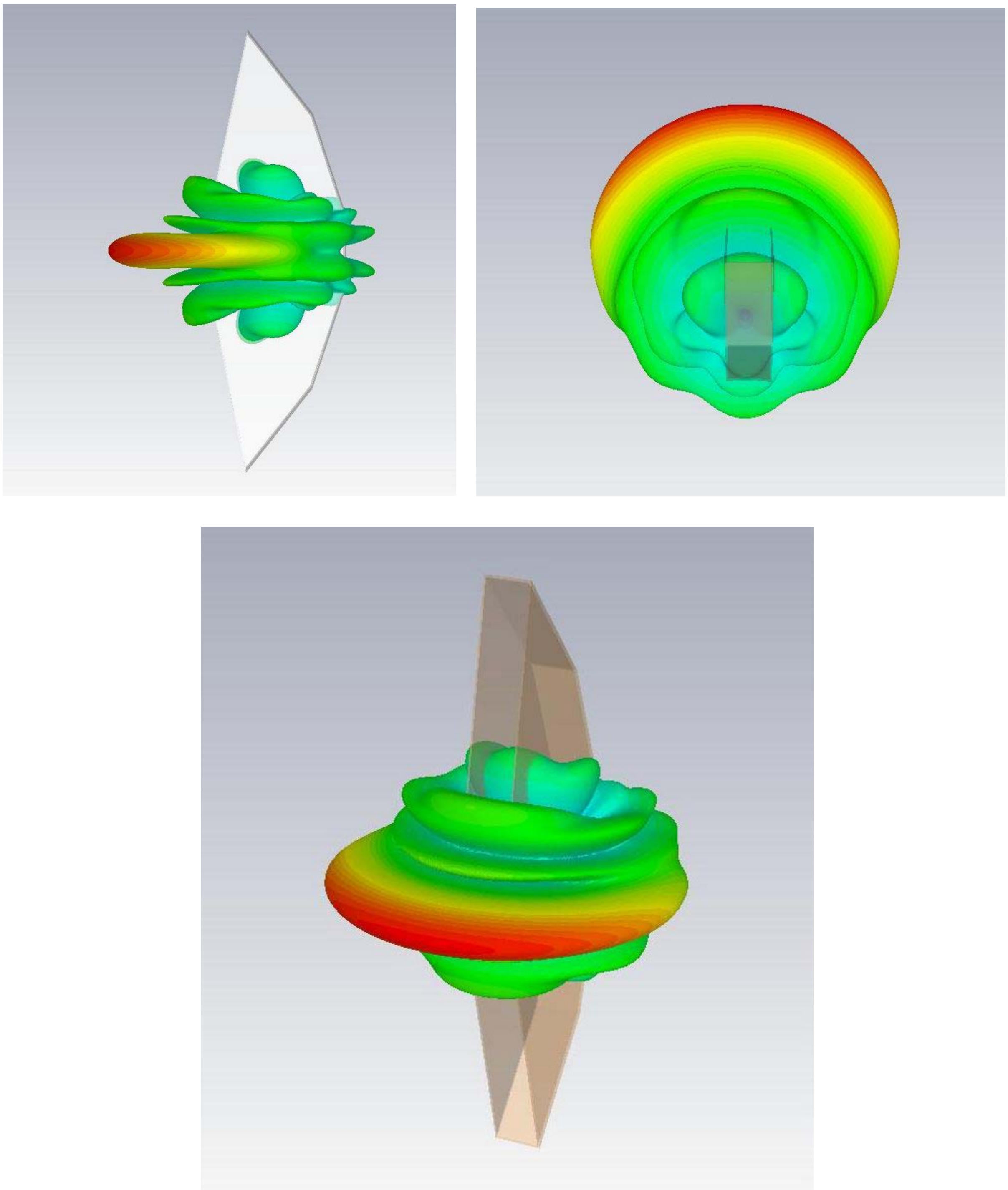

Fig. 4 Vertical, horizontal and perspective 3D diagram of pillbox antenna

Mechanical construction

The antenna should be made of copper or brass tin sheet about 0.5 mm thick. Side plates must be cut out precisely according the drawing given on Fig. 5. Two identical side plates and two reflectors, one large main reflector and other small feed reflector, both bent on appropriate shape to make the side plates conform, are soldered or welded together for good contact. All given dimensions are **inside** dimensions of antenna in **millimeters**.

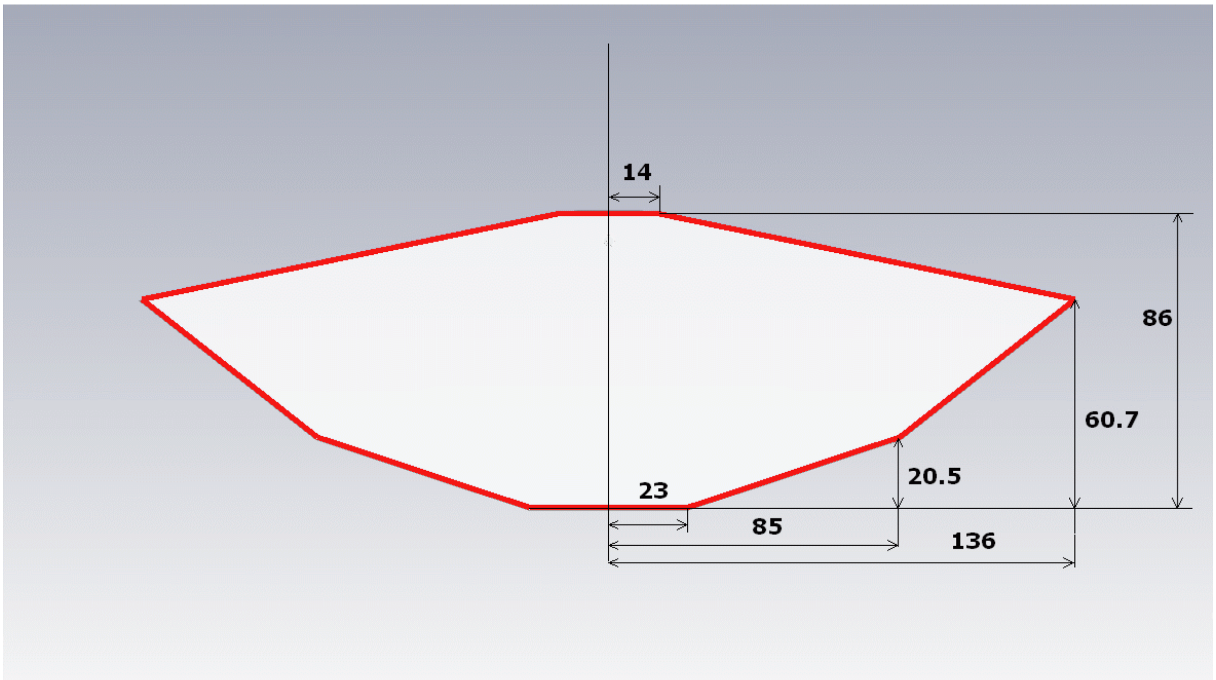

Fig. 5 Cut out pattern for side plates of pillbox antenna

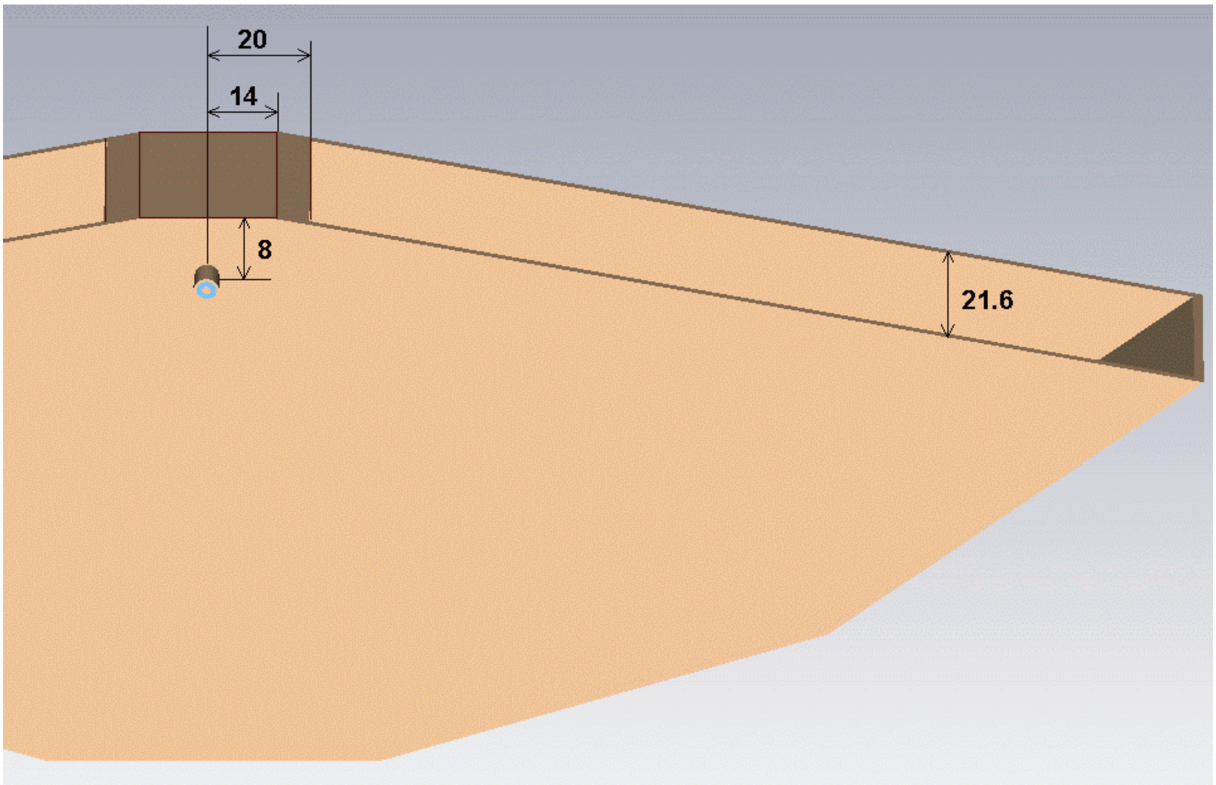

Fig. 6 Connector position and feed reflector dimensions of pillbox antenna

On one antenna side plate it is necessary to drill an appropriate hole for RP-SMA, SMA or N female connector. The best way for connector fastening to the antenna is soldering its ground plate to antenna side plate all around the connector ground plate. Very good electrical contact of connector ground to antenna side plate is mandatory for the antenna's good operation and for obtaining predicted performances.

Active monopole made of bare copper wire 1.2 mm in diameter is soldered directly to the female connector central pin. Before soldering the monopole wire, it is good to cut the central pin in order to be a bit shorter. Then solder the monopole and cut the wire length so that its tip is exactly 11.5 mm above the antenna's side plate surface that is serving as a ground plane mirror. This is very similar way of monopole mounting as in my previous published antennas **[3, 4, 5]**. Monopole **axis** distance from feed reflector surface is 8 mm.

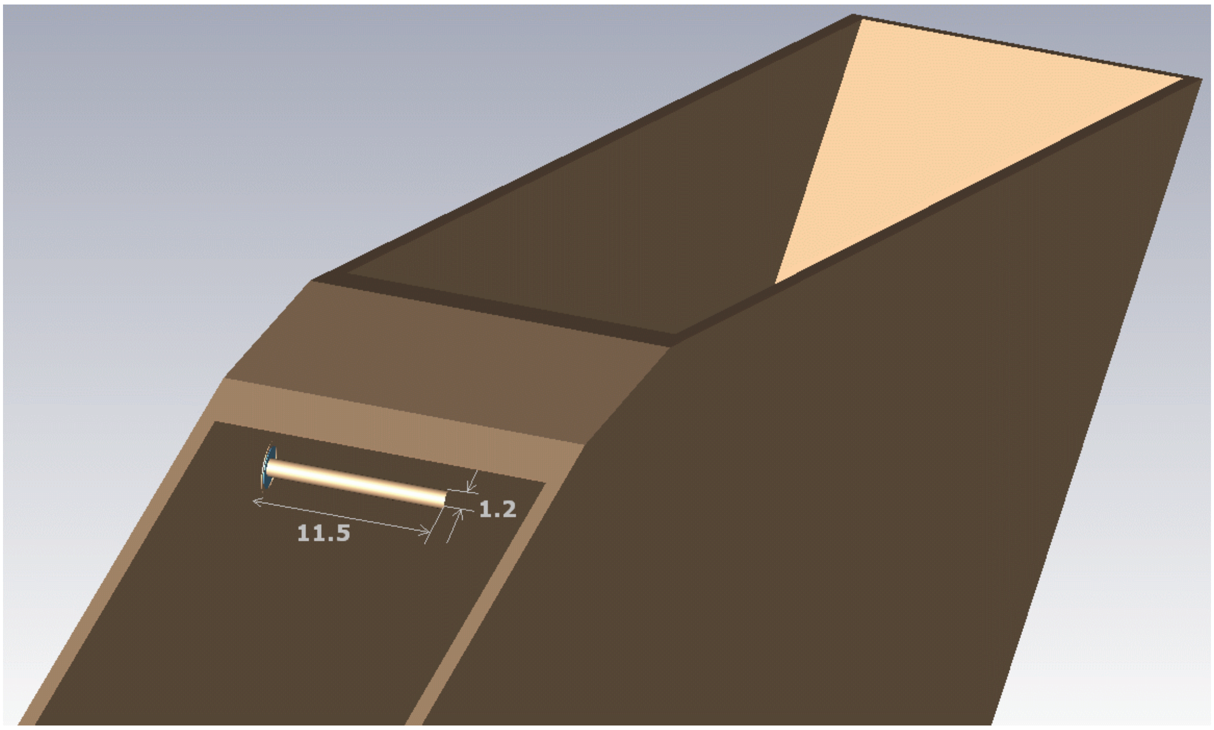

Fig. 7 Monopole position and dimensions

Conclusion

In this paper I presented wireless LAN access point antenna for 5 GHz band. With very wide horizontal and very narrow vertical angle it represents very efficient horizontal polarized antenna that is very well harmonized with Wi-Fi LAN access point demands.

Antenna performances results can be compared to the gain of the same 100% efficiently illuminated surface area: *Go=4*PI*A*, where *A* is the cross section (aperture) of the parabolic surface area given in square wavelengths. Then we can calculate illumination efficiency as antenna gain ratio: *Eff= G/Go*, where *G* is gain of antenna in numbers, not in dB.

For this antenna, gain of 100% efficient radiation aperture is:

$$Go=4*PI*A/\lambda^2 =4*PI*2*136*21.6/53^2 = 73829.94/2867.4=25.75 \text{ or } 14.1 \text{ dBi}$$

The presented antenna, in spite of parabolic curvature approximation and feed reflector blockage gives gain *G=13.9 dBi or 24.547 times*. During simulations I set metal loss as that antenna is made of copper.

Efficiency of this antenna can be calculated as ratio of its gain to the gain of an ideal 100% illuminated aperture:

Eff=G/Go=24.547/25.75=0.953 or 95.3 %.

This is a 25-30 % better efficiency than usually good illuminated parabolic antennas which are in order of 60-65 %. In spite of its simplifications, this antenna preserved its good performances and very high efficiency. **-30-**

References:

1. Henry Jasik, **Antenna Engineering Handbook**, First Edition, McGraw-Hill Book Company, Inc. 1961. Pages 12-16 to 12-18.
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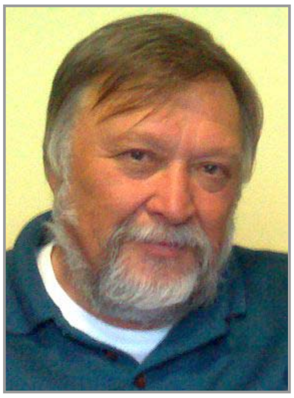
BRIEF BIOGRAPHY OF THE AUTHOR

Dragoslav Dobričić, YU1AW, is a retired electronic Engineer and worked for 40 years in Radio Television Belgrade on installing, maintaining and servicing radio and television transmitters, microwave links, TV and FM repeaters and antennas. At the end of his professional career, he mostly worked on various projects for power amplifiers, RF filters and multiplexers, communications systems and VHF and UHF antennas.



For over 40 years, Dragan has published articles with different original constructions of power amplifiers, low noise preamplifiers, antennas for HF, VHF, UHF and SHF bands. He has been a licensed Ham radio since 1964. He is married with two grown up children, a son and a daughter.