separated from the edges of the pentagon in a length equal to 3*h*.

3.2 Simulation

Both cases of pentagonal patch were analyzed, the first one where the pentagonal patch is inscribed into a circle with a radius equal to the circular patch antenna, and the last one keeping the patches areas equivalents. As the last one give us better results, considering the symmetry of the electric far field around the operation frequency, we only present this case in this

section. Again, the operation frequency remains very near to 1.57 GHz (Figure 5), at 1.58 GHz. The antenna gain is of 3.43 dB (Figure 6), a little bit smaller than in the circular case.

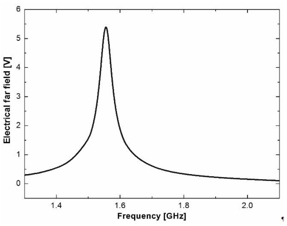

Figure 5. Electrical far field.

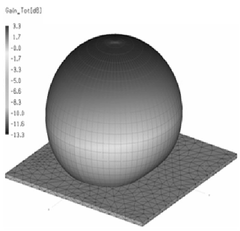

Figure 6. Patch antenna gain.

The beam widths at phi=0 and phi=90 are of 80° and 95°, respectively (Figure 7 and 8), showing a deviation of symmetry on the radiation pattern.

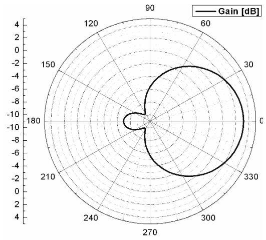

Figure 7. Beam width of patch antenna, at phi=0.

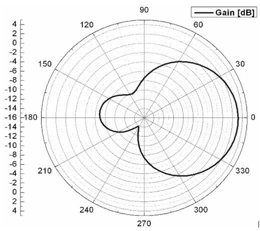

Figure 8. Beam width of patch antenna, at phi=90.

Finally in Figure 9, the return loss is presented considering a load of 50 Ω. As can be appreciated the corresponding bandwidth is of 650 MHz and the peak is obtained at 1.55 GHz, very near to the design operation frequency.

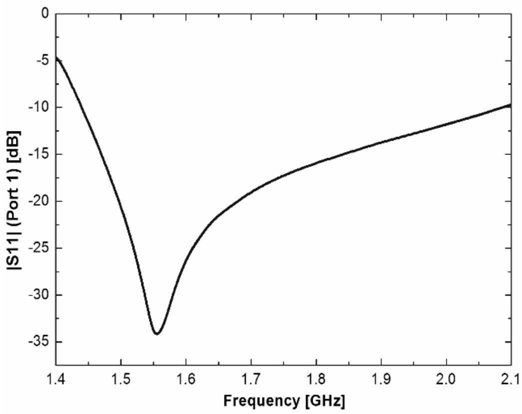

Figure 9. Return loss of the pentagonal antenna.

4. Comparison

The simulations of the gains of two cases where realized: 1) where the pentagonal radiating patch keeping equivalent the radius where it is inscribed and the circular patch, and 2) where the circular and pentagonal patches have equivalent areas. The first case shows severe asymmetries in shape of the electric far field near to the operation frequency, and a smaller gain compared to the case of equivalent areas (Figure 10). Considering the pentagonal antenna of bigger gain, a comparison between the pentagonal case and the circular one was realized (Figure 11).

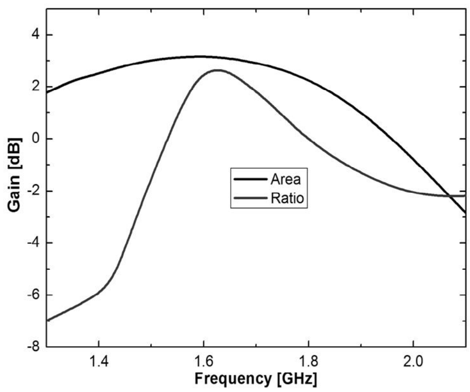

Figure 10. Gain of pentagonal antennas. In red, keeping an equivalent radio between the circular patch and the circle where the pentagonal patch is inscribed, and in black, keeping equivalent areas between the circle and the pentagonal patches.

As can be observed, in Figure 11, the pentagonal case shows a more defined symmetric curve considering at the center to the operation frequency, the same happen with the return loss and it is also almost imperceptible in the case of the electric far field. These facts constitute the main advantages of the pentagonal one, because the rest of the characteristics exhibit bigger symmetry in the case of the circular case.

Other advantage is the easier fabrication of straight sides instead of curves, which is even more economic for reducing costs of a complete GPS system.

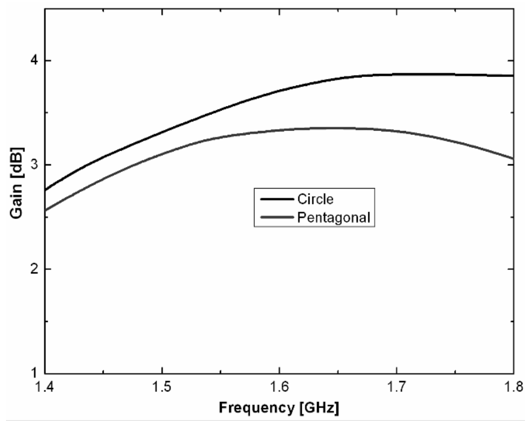

Figure 11. Gain of the pentagonal antenna (red) and of the circular one (black).

5. Conclusions

The approximation of the circular antenna design equation was enough ideal to obtain a circular patch antenna at GPS frequency with a satisfactory behavior, but for commercial purposes the substrate must be changed in order to obtain a bigger and competitive patch antenna gain.

As future work, it will be made prototypes with the sizes given by Equations (1) and (3), in order to observe its experimental behavior and corroborate the result obtained in the corresponding simulation.

The asymmetries on the response of the pentagonal antenna could be reduced implementing a circular substrate instead of the rectangular one. The purposed solution here demonstrates that different strategies can be realized with the aim to reducing global costs.

The location of the feed point also affects to the gain value, which increases as it is separated from the origin, as a consequence of the adjusting on impedance.

Additionally, on the base of the pentagonal antenna, the implementation of a dual antenna is under analysis. This has the purpose to show the high applicability of the pentagonal geometry for diverse uses.

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