INTRODUCTION

During our research, we are going to study a type of antenna called Dielectric Resonator Antennas (DRA). We want to look at it's design and radiation characteristics, and their possible applications.

DRAs are used more and more because they have many advantages in relation to other type of antennas. They are very easy to design, cheap and very efficient. For these reasons, this type of antenna are used in mobile terminals, due to the fact that they are small and efficient.

At the moment, the wireless communication systems have specific characteristics: they increase in bandwidth, in spectral efficiency, in capacity and, maybe the most important, the continuous miniaturization of radiation systems to be able to integrate into the new mobile devices. A very efficient solution for these characteristics is MIMO.

MIMO (Multiple Input Multiple Output) is the use of multiple antennas in the transmitter and in the receiver in wireless communications. This use of MIMO solves multipath propagation, which is the biggest problem with wireless communications.

MIMO is starting to be used in the new mobile communication systems. It appeared for the first time in HSPA+ (High Speed Packet Access). However, it´s in LTE (Long Term Evolution) where is really important. For example, in Release 8 it has a maximum of 4x4 in Downlink (DL) and a maximum of 2x2 in Uplink (UL). In Release 9 it´s not given the maximum antenna´s number, in spite of the fact that there are examples with 8.

DRAs, being small and efficient, are a good solution as they are be able to integrate into small devices, like a Smartphone, rather than one antenna to use the MIMO solutions.

The work structure to analyze DRA antenna is the following:

First of all, we are going to do a small introduction about DRA antennas, summarizing briefly the beginnings of the investigations into this field that haven't been explored yet and then explaining the different structures that exist and the different advantages that they offer.

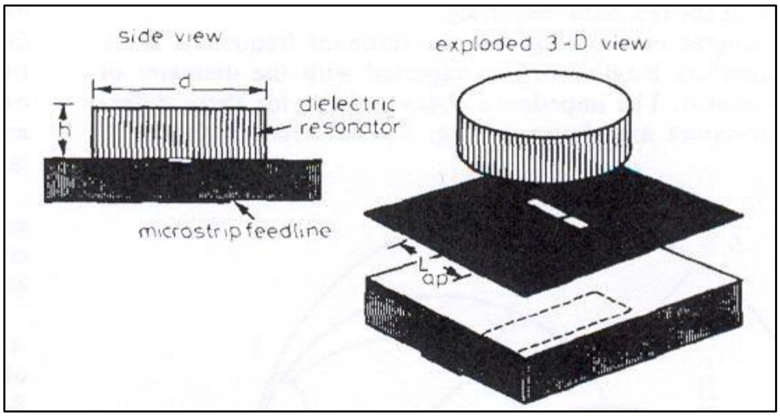
Secondly, once we know the different structure, we are going to choose a DRA design to analyze by simulations the radiation characteristics and the effects that the variations of parameters have in the adaptation and in the radiation pattern of the DRA.

Next, we are going to design possible real application where we can use our antenna. Antenna directivity is one of the most important ideas, so we are going to try to increase this directivity with these applications.

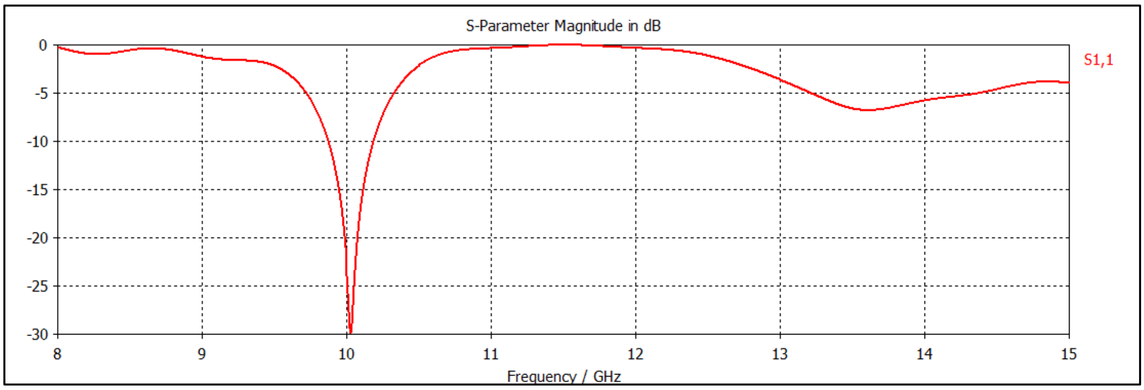
Finally, we are going to make the design and the measures of a real prototype, made of fiberglass material (ε_r = 4.5). We haven´t done the simulations with fiberglass, therefore we are going to redesign all the structure for the new glass fiber material antenna broadcasts properly. Once the antenna is made, we are going to do all the measures that are necessary.

ABSTRACT

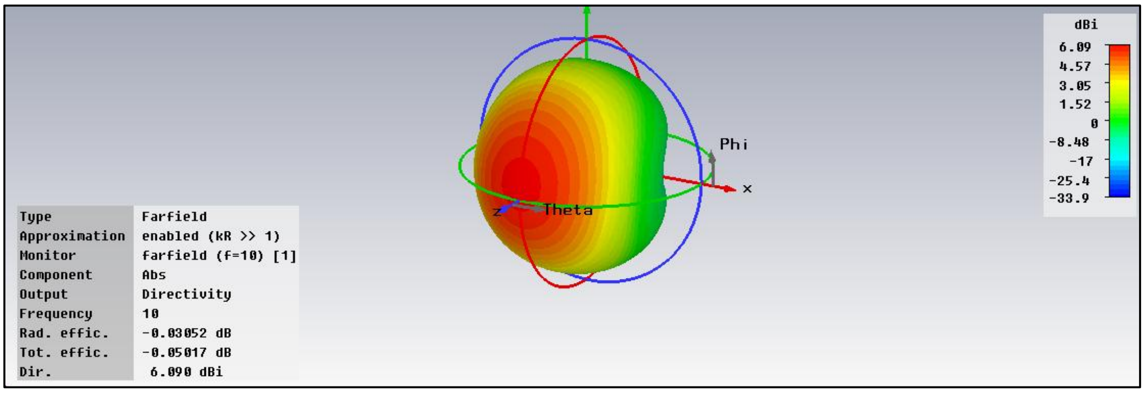
The aim of our research is to build a DRA antenna which we can use for different applications.Firstly, we are going to try to design a cylindrical DRA suggested by Pozar, as is shown in the figure below:



The problem is that this antenna with its parameters broadcasts in 14 GHz approximately, so we have had to change the parameters to adapt the s11 parameter to the 10 GHz that we need. This adaption is shown in the figure below:



Once we get the correct s11 parameter, we will be able to analyze the radiation pattern.

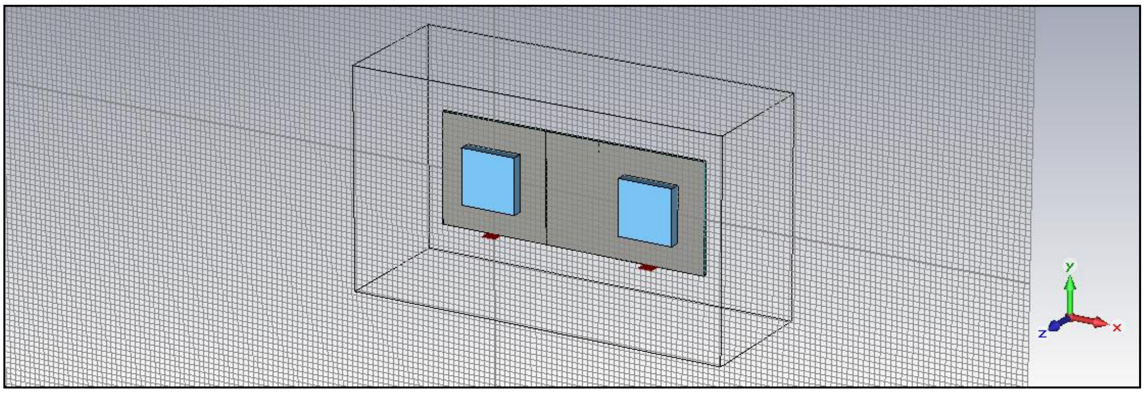


As the figure shows, the efficiency is correct and we discovered that there was 6.09 dBi of directivity. After that, we are going to try to increase this directivy by using a different application, for example in array.

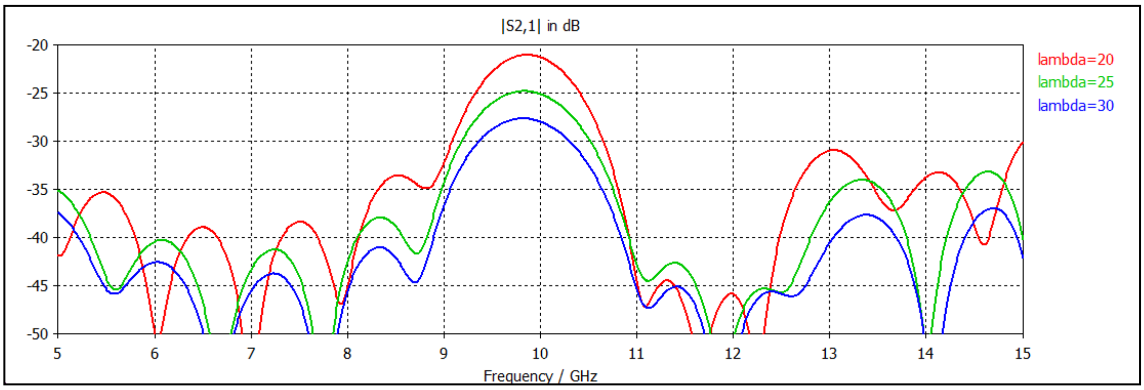
After designing our cylindrical DRA, we are going to anazlyze the same DRA, but with square structure. The only change we have made is to put the side square as the cylinder diameter. With these parameters, we have come to the conclusion that both structures broadcast in a similar way, so we are going to choose the square DRA, because it's easier to build.

Once we have chosen the square DRA, we are going to use it in two possible applications: application as array element and application as directive antenna using it as feed of a Fabry-Perot cavity.

In the array application, we have put two square DRAs as is shown in the figure below:

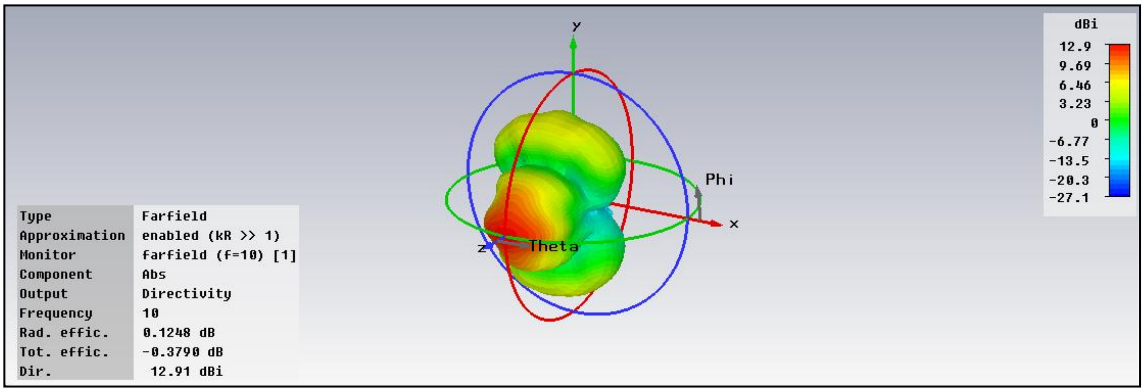


The most important parameter to analyze in this application is the mutual coupling, because it´s has to be low. Changing the distance of both elements, we obtain these mutual couplings:



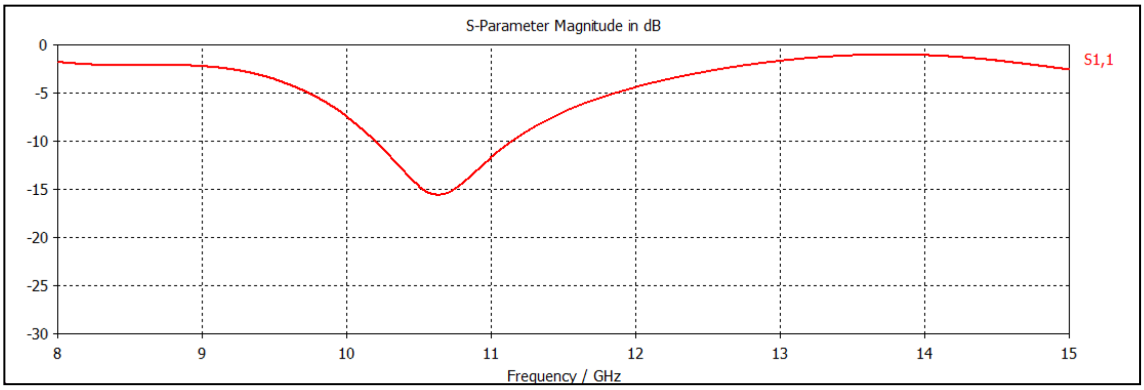
In general, the mutual coupling between these antennas is low in relation to usual values, so it's possible to build an array with these antennas without worrying about this critical parameter.

In the Fabry-Perot cavity application, we have achieved a better directivity. We have put a superstrate with ε_r = 7 and a size of 5λx5λ. The radiation patter is shown in the next figure:



As we have explained, we have increased the directivity to approximately 13 dBi.

Finally, we designed a real prototype. As we had fiberglass material to build the antenna, we had to redesign all the parameters to adapt the DRA to 10 GHZ. After doing many simulations, we obtained the correct parameter s11 shown in the figure:



CONCLUSIONS

The aim of our research has been the analysis of the DRA, a new type of antenna which is very efficient and small and that we are integrating in the technological world.

The continuous advance of communications in the world means that it'2 more necessary to investigate radiation themes; because it's necessary to integrate a bigger amount of antennas into a smaller area of the new mobile devices. New mobile terminals are being introduced into market with the new standard LTE (Long Term Evolution), because it introduces the use of MIMO to be able to use multiple antennas in transmission and reception. For this reason, there is a special interest in the investigation of these type of antennas because of its small size and high efficiency, as we have already explained.

In our research, we started to briefly explain the beginnings of the investigation in this type of antenna, with the main advantages that they offer in relation to other antennas, like wire antennas or printed antennas. Afterwards, we talked about the different structures that we normally use to build DRAs. There are three main structures: spherical, cylindrical and rectangular. The cylindrical antennas offer better freedom than the spherical antennas; and the rectangular antennas, in addition, offer better freedom than the cylindrical antennas. In practice, the easiest antenna to make is the rectangular DRA.

After this, we chose a design of a DRA suggested by Pozar. This design is made to work in 14.5 GHz, so we had to redesign all the parameters in order for our antenna to work in 10 GHz. For this, we used CST STUDIO, a program which we achieved, by many simulations, to obtain the correct frequency that we needed.

Once we achieved the necessary adaptation, we obtained the radiation pattern with all the information it has. In addition, we made different simulations to achieve an understanding of how our antenna operated when we change some of the parameters.

After we made the entire analysis of the DRA, we did the same study for the same square DRA, where we chose as square side the same size as the cylinder diameter. We obtained the results and they showed us that they produced the same results. So the best and the easiest option is the square structure beacuse it's easier to make.

After we chose the square DRA, we studied two possible applications for this antenna to increase the directivity.

Firstly, we used the DRA in an array of two elements, the target was to analyze the mutual coupling between each of them, a critical parameter in an array design. To understand this parameter we have changed the distance between both elements and we came to the conclusion that the mutual coupling is low in relation to the usual values. It´s important to emphasize that we had to redesign all the antenna structure to build the array with a λ/2 distance between both elements because it was impossible to build with the original measures due to there was overlapping between each of them. λ/2 is a typical distance in arrays because we secure to not have grating lobes.

Secondly, we used the DRA as feed of a Fabry-Perot cavity. It consists of put a superstrate (in our case size 5λx5λ) to λ/2 distance from the antenna with a thickness $\lambda\varepsilon_r/4$, depending on de material permittivity. Firstly, we analyzed the radiation pattern of this case and we come to the conclusion that the directivity increased enough. After that, we modified some parameters of the structure to investigate if we could achieve more directivity. We changed the distance between the antenna and the superstrate (0.4λ and 0.6λ); the superstrate size (3λx3λ and 6.5λx6.5λ); and the permittivity value (ε_r = 4 and ε_r = 10).

In conclusion, after we made all the possible simulations, we made the design of a real prototype so that we could build it. Because the material we have is fiberglass (ε_r = 4.5), we had to redesign all the antenna structure to adapt to 10 GHz that we needed. In this way, after we made the simulations and adapted the line impedance to 50 Ω, we achieved the correct parameters to build our fiberglass DRA. Once the antenna was built, we made the measures to prove that it works properly.