Trans cranial antenna design

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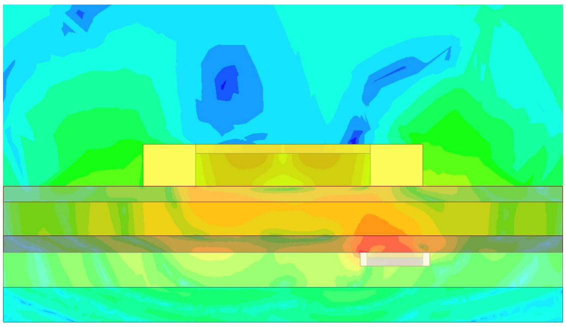
The number of applications for implantable or ingestible sensors has been continuously growing over the past years, especially in eh medical domain. These elements very often require a wireless communication module for control or telemetry, leading to the request for heavily miniaturized antennas. Many examples of such antennas can be found in the literature (see for instance [1]).
In this contribution, we concentrate on the antenna design for a cranial implant communicating with a node placed on the surface of the skin. The aim is to optimize as far as possible the transmission from the implant to the node. To this aim, we will present and discuss the different steps we considered in the design phase in order to perform the latter efficiently.

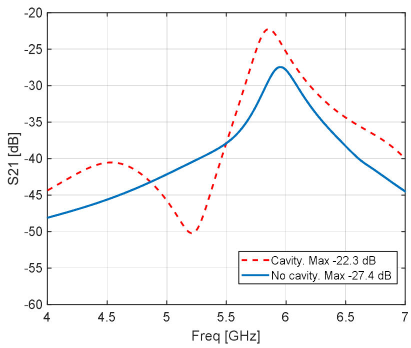
The requirements for the implanted antenna are as follows: The maximal dimensions of the antenna are 8 x 8 x 2 mm3, including the biocompatible encapsulation on the top. The frequency is 5.8GHz with a bandwidth of 100MHz. The implant is placed in the bone layer of the skull, flush with the fat layer on the top of it. The wearable antenna will consist of a simple patch covered by a biocompatible spacer layer placed directly on the wearer's skin.

For the simulations, we used a simple multilayered parallepiped phantom consisting of a cerebrospinal fluid layer, the bone layer a fat layer and the skin layer. The importance of lateral dimensions of this phantom were studied, and found to be of little importance as long as absorbing boundary conditions laterally terminates the simulation box. This is important, as the strong contrast between the dielectric properties of the different layers will cause a non-negligible part of the power to be guided laterally in each layer.

The design selected for the implanted antenna is a PIFA placed in a box, and covered by a layer of PEEK. The transmission coefficient to the wearable node was found to be better than -25dB in the desired frequency band. This result was confirmed on measurements made on a phantom made pig's fat and skin sewn together and using lossy foams for the bone and the cerebrospinal fluid layers.

Finally, the effect of different thicknesses of the layers and of the relative positioning of the implanted and the node antenna were studied. These effects are very relevant in practice, as the head of different patients can be greatly differ from each other. An example of results is given in the Figure 1, showing the electric filed distribution in the phantom and the transmission coefficient between the implant and the wearable node for the simple node or the cavity backed node.





References

[1] A. Kiourti, K.A. Psathas and K.S. Nikita, "Implantable and ingestible medical devices with wireless telemetry functionalities: a review of current status and challenges," Wiley Bioelectrom., vol. 35, pp.1-15, Jan. 2014.