Novel high frequency components with non-conventional shape employing smooth geometry deformation of 3D solid with FFD.

The project aims to investigate the possibility of developing and manufacturing novel high frequency devices having non-standard geometries, allowing for improved electromagnetic performance over what is achievable with currently available design tools.. The non-conventional geometry will be obtained by employing the free-form deformation technique (FFD) and 3D printing technology.

The process of microwave & radio frequency devices design differs significantly from the design of low frequency electronic devices. In the case of low frequency components, the designer uses lumped elements, such as resistors, capacitors or inductors as well as active elements such as diodes or transistors. The design process is based on circuit analysis according to Kirchhoff's laws. When it comes to high frequency components and systems, the wavelength of the electric signals is comparable to the dimensions of the design, which imposes the use of specific tools to analyze them, called electromagnetic field simulators. The electrical parameters of the system also depend on its shape, as it affects the distribution of the electric and magnetic field inside it.

The proposed application of the FFD technique in the process of designing microwave components will allow to overcome the existing limitations resulting from the approach to modeling geometry used in commercial simulators of electromagnetic fields. The currently available tools allow for constructing models from simple basic build blocks, like boxes, cylinders, cones, and performing basic logical operations leading to geometry modification. This approach is known as constructive solid geometry (CSG).

The use of free-form deformation method will open the possibility of modeling an almost unlimited space of unconventional shapes with smooth profiles, as well as their easy modification, giving the designer additional degrees of freedom in the design process. Such an approach opens up new possibilities for the development of completely new devices. The resulting structures will have smooth surfaces, eliminating the presence of sharp edges, which is preferred when the device is manufactured by 3D printing. Such approach will allow to manufacture devices with improved electrical parameters, which are not achievable by the CSG approach.

During this project, a new software toolchain will be developed and used for designing novel microwave passive components for applications in modern telecommunications and radar systems, with improved electrical performance over the commonly used devices available today. As a result, new high frequency passive components will be developed employing the FFD method, and prototypes will be manufactured with the use of 3D printing technology. During the process of designing and producing the prototypes, the advantages and limitations of the proposed methods will be examined.