Application of WIPL-D Pro CAD to Flexible Antennas

Introduction

For quite some time there is a noticeable trend to expand the scope of applications that are regarded as standard, classic electronics to novel, innovative areas, such are flexible or wearable circuits. Apparently, the software tools traditionally used to design standard circuits must conform with the most recent developments. For RF/microwave circuits in particular, the conformity means that electromagnetic (EM) simulators used to design standard circuits, such as antenna, antenna arrays, different transmission line circuits etc., must be expanded to accurately model and analyze various flexible circuits, or in general, circuits of complex shape.

This document describes powerful Wrap command recently introduced into WIPL-D Pro CAD environment which enables the simple and effective transformation of flat sheet bodies to bodies wrapped over arbitrary complex developable surfaces. The associated modeling, e.g., assigning the ports, and EM analysis are performed in a usual way. The Wrap command will be demonstrated using two relatively simple examples of wrapping a flat microstrip patch antenna shown in Figure 1 around a cylinder. One example deals with a cylinder aligned along x axis, while the other example deals with a cylinder aligned along y axis. The coordinate system is orientated as shown in Figure 1.

Wrap Command in Brief

Wrap command enables wrapping of a flat sheet body over an arbitrary developable surface. Working with this command is straightforward and user friendly. The Wrap operation becomes active when a flat sheet body, in remaining text referred to as a tool body, is selected. Then, after the Wrap option is chosen, the tool body is deselected, and the user should select a target body which has at least one developable face. After the target body is selected, the reference points on tool and target bodies should be defined. Before the wrapping is performed, the tool body is automatically translated in such a manner that the reference point on the tool body is aligned with the reference point on the target body. Once reference points are set, wrapping is performed after a click on the OK button. The tool body is deleted, while the corresponding shape is created on the target body. A detailed explanation of particularities related to the use of the Wrap command can be found in WIPL-D Pro CAD 2023 User Manual.

Flat Microstrip Patch Antenna

An original structure to be modified using the Wrap command can be for example a flat microstrip patch antenna presented in Figure 1. The particular antenna operates approximately at 1 GHz.

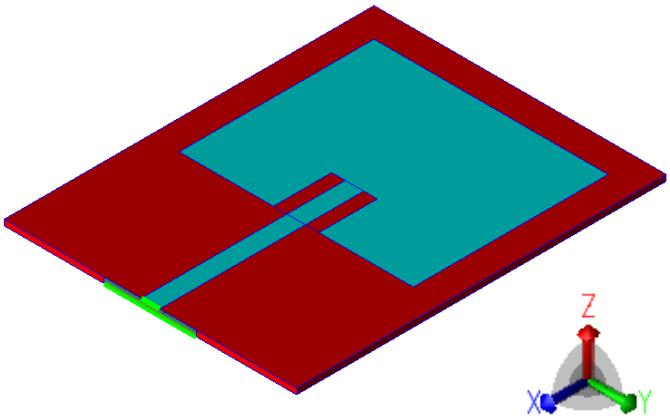

Figure 1. Flat microstrip patch antenna.

Wrapped Microstrip Patch Antenna

The flat microstrip patch antenna from Figure 1 wrapped around a cylinder aligned along x axis is presented in Figure 2, while the effect of the wrapping on S_{11} parameter of the antenna is illustrated in Figure 3. Comparing with S_{11} of the flat microstrip antenna from Figure 1, also presented in the same figure, it can be concluded that wrapping around x axis has a mild effect on the antenna performance.

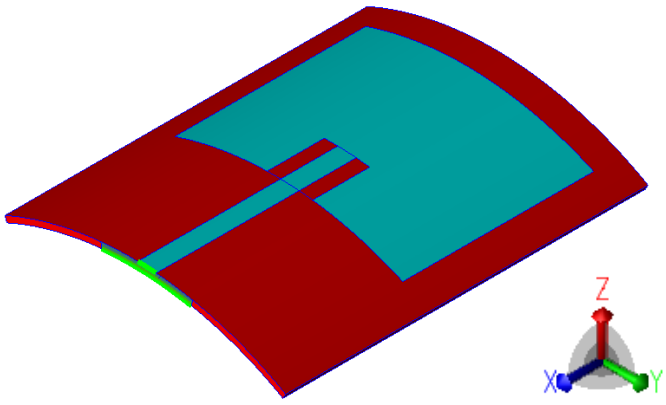

Figure 2. Microstrip patch antenna wrapped around the cylinder aligned along x axis.

Antenna wrapped around the cylinder aligned along y axis is presented in the Figure 4, while the effect of the wrapping on S_{11} parameter of the antenna is given in Figure 5.

Comparing the performance of the antenna wrapped around the cylinder aligned with y axis with the performance of the antenna from Figure 2, it can be concluded that wrapping around y axis has a more pronounced effect on the antenna performance.

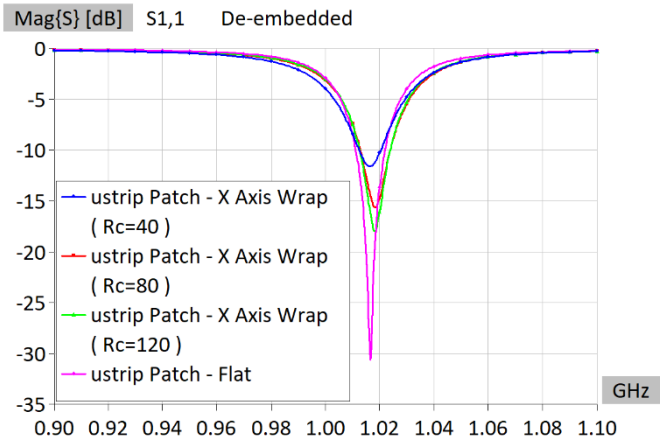

Figure 3. S_{11} of microstrip patch antenna wrapped around the cylinder aligned along x axis as a function of wrapping radius Rc.

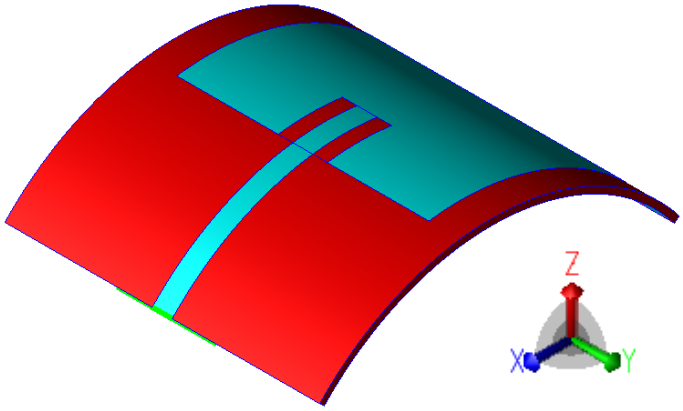

Figure 4. Microstrip patch antenna wrapped around the cylinder aligned along y axis.

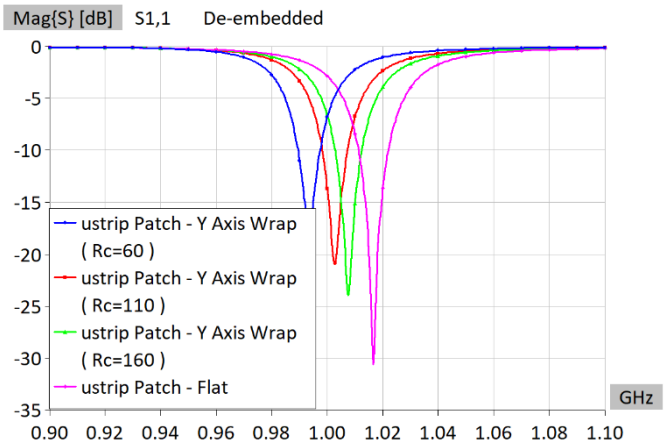

Figure 5. S_{11} of microstrip patch antenna wrapped around the cylinder aligned along y axis as a function of wrapping radius Rc.

Simulations

All of the antenna models have been created and the simulations carried out using WIPL-D software suite. WIPL-D Pro is a cutting-edge full wave 3D electromagnetic Method-of-Moments (MoM) based software which applies Surface Integral Equations (SIEs). It is well suited for versatile and demanding antenna simulations. WIPL-D Pro CAD is a modeling and simulation environment where geometry modelling is simplified, speed-up and based on various built-in modelling entities and Boolean operations. Import of different CAD file formats is also supported.

Computer used for the simulations of the three variants of the patch antenna is outlined in the Table 1.

Table 1. Workstation used for the simulations

Hardware	Description
Processor	Intel® Core™ i7-7700 CPU @ 3.60GHz 3.60 GHz
RAM	64 GB

All matrix operations are performed on CPU. Number of elements, number of unknowns and average simulation time per frequency are given in the Table 2. Frequency band in which each simulation is performed starts from 0.9 GHz and ends at 1.1 GHz. The band is subdivided into 21 frequency discrete points. The wrapped antennas are simulated with values for mesh elements size and surface and angle tolerance which are lower than default. That way, curvatures are modeled more precisely.

Table 2. Number of elements, number of unknowns, and average simulation time per frequency in seconds

Model	Number of elements	Number of unknowns	Average simulation time per frequency [sec]
Flat antenna	356	1,924	6.0
Wrapping cylinder aligned along x axis (Rc=120 mm)	4,095	6,456	23.7
Wrapping cylinder aligned along y axis (Rc=160 mm)	3,914	6,316	21.5

Conclusion

In order to conform with the modern trends in electronics, the recent release of WIPL-D CAD Pro EM simulator has been equipped with the powerful Wrap command which enables the analysis of flexible and wearable circuits. The command is versatile, user friendly and allows easy conversion of flat sheet bodies to different wrapped shapes.

The application of the Wrap command has been demonstrated on the example of a patch antenna wrapped around the cylinder. Comparing the two ways to wrap the antenna, it has been concluded that wrapping around the y axis has more pronounced effect on antenna performance.