

# Mixed-mode S parameters modeling

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**INTRODUCTION:** The project aims to purpose a tool to optimize the process of development of electrical connectors. These connectors are designed to meet communication protocols.



We are interested here in the simulation of the mixed-mode S parameters. Once the model is appropriate, a Comsol application is developed.

It will allow engineers to build simplified connectors and simulate S parameters.



Figure 1. CAD of electrical connector

## COMPUTATIONAL METHODS:

### Definition of mixed-mode S parameters

#### 4-port Differential S-parameters

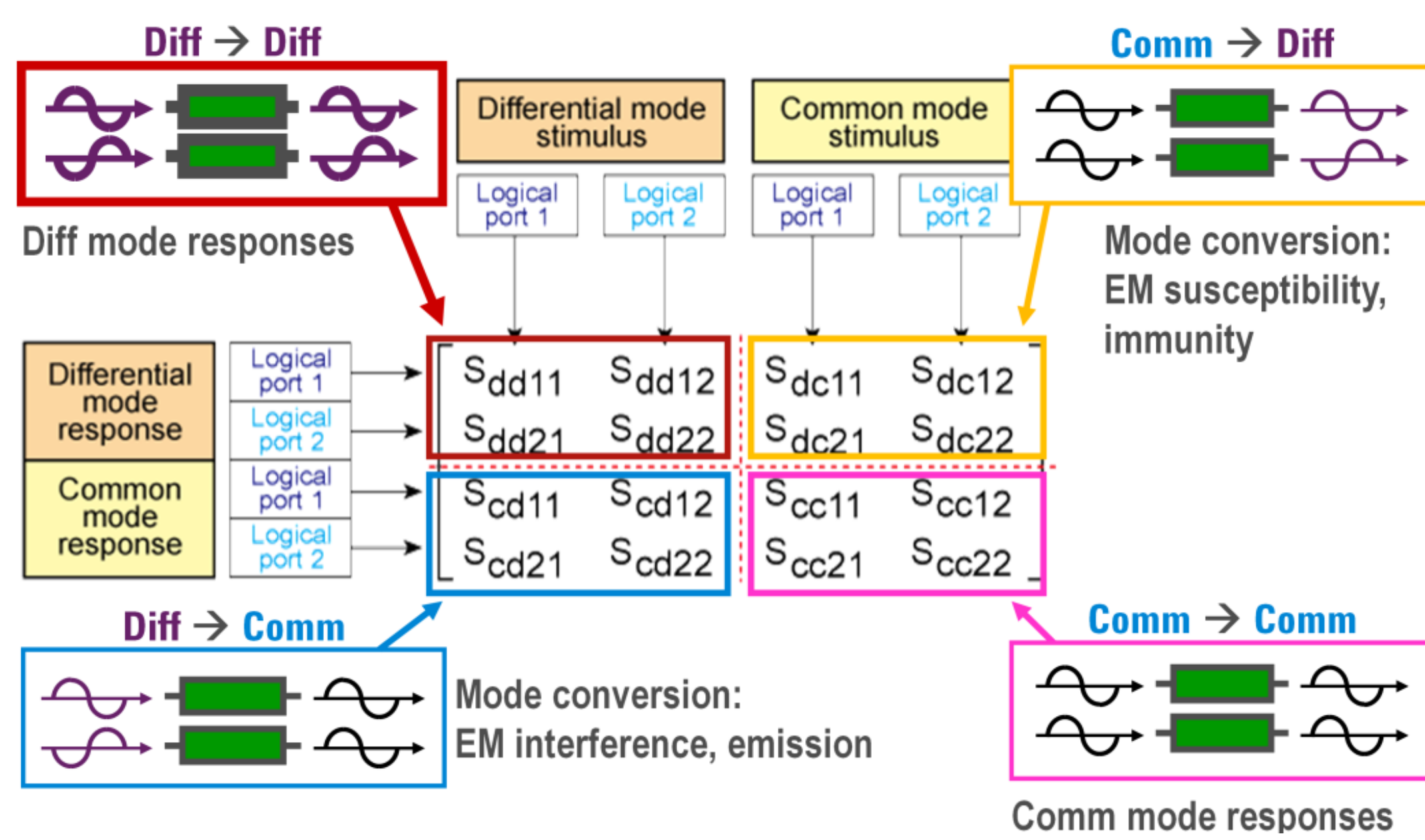


Figure 2. Mixed-mode S parameters

The parameters of interest presented here are :

- Return Loss (RL, Sdd)
- Near End Crosstalk (NEXT, Sdc)

### Modeling

- Two contact blocs (male and female). All blocs made of flat cylinders
- Electrical contacts are simplified

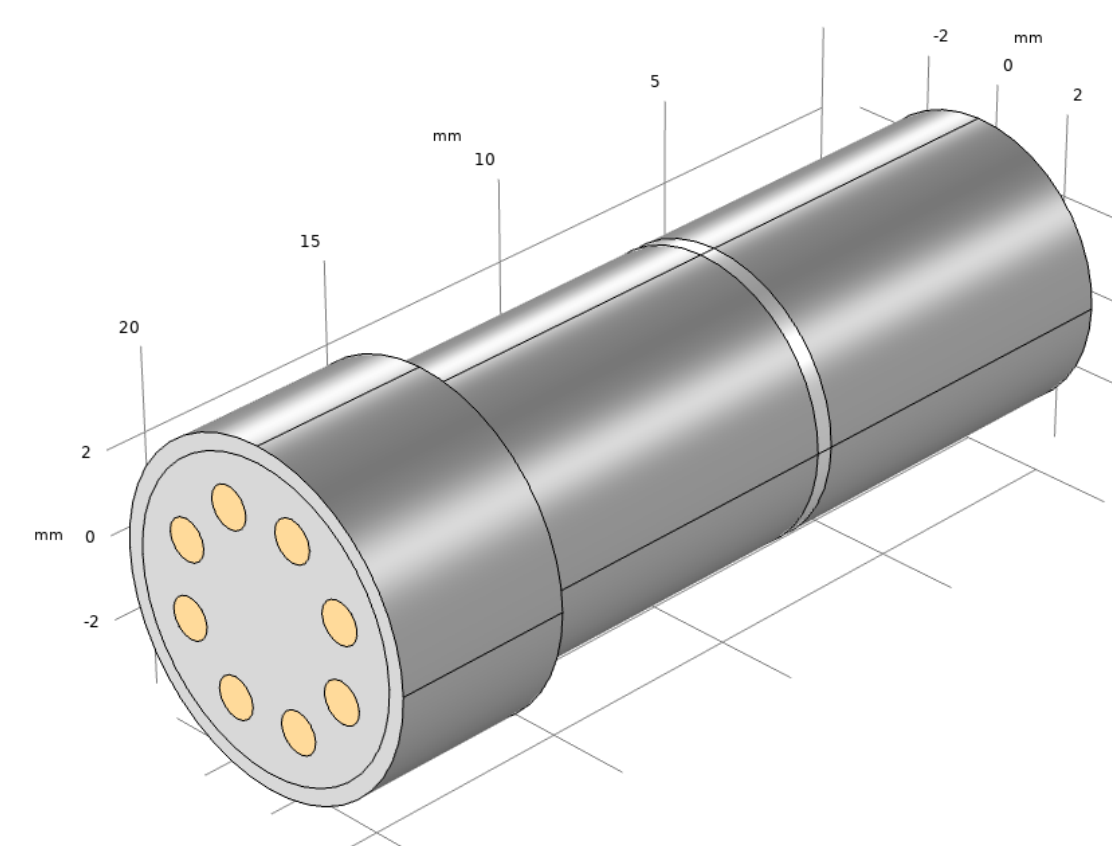


Figure 3. Simplified model of figure 1

- Comparison between a complete model (CAD with all details) and his simplified model (less details without losing physical properties) as in Figure 3.

### Boundary condition : Port

In order to find the optimal boundary conditions, two models are developed for each compared model :

- "All ports" : Port for each contact, then mixed-modes are manually computed.
- "MMc" : use of "mixed-mode" function available in Comsol 5.5, where a Port is added for the ports of interest. Mixed-modes are computed by the software.

In both cases, single modes (S) are simulated and then, mixed-modes are obtained with the conversion matrix (M) :

$$S_{mm} = M \cdot S \cdot M^{-1}$$

## RESULTS:

RL curves (Figure 4) show that the "MMc" is applicable. The simplified model is shifted, but it's still representative of the complete model.

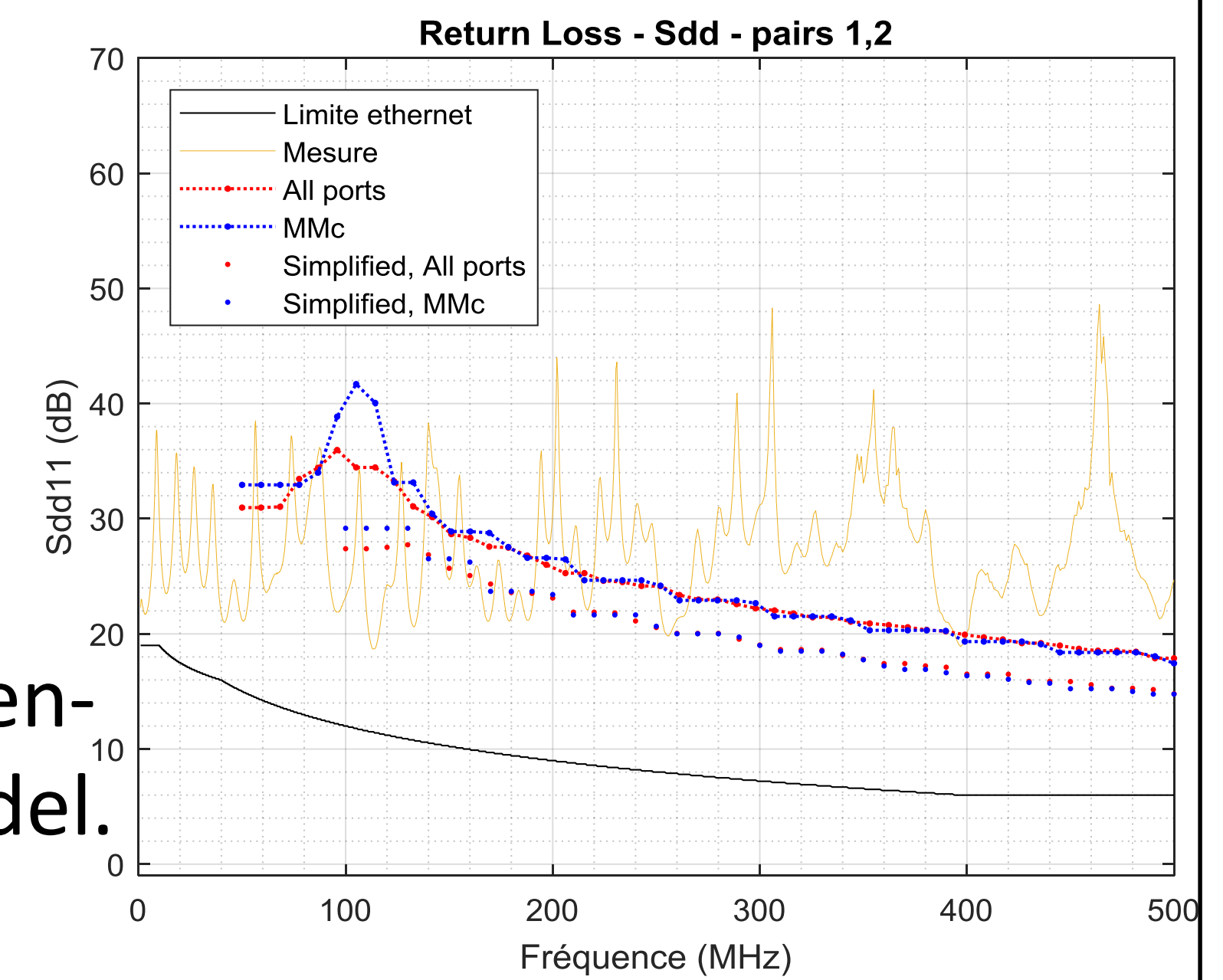


Figure 4. RL for ethernet

NEXT curves (Figure 5) show that the models (simplified and complete) are not well appropriate. This can be explained by the conditions, that don't take into account the dielectric effect.

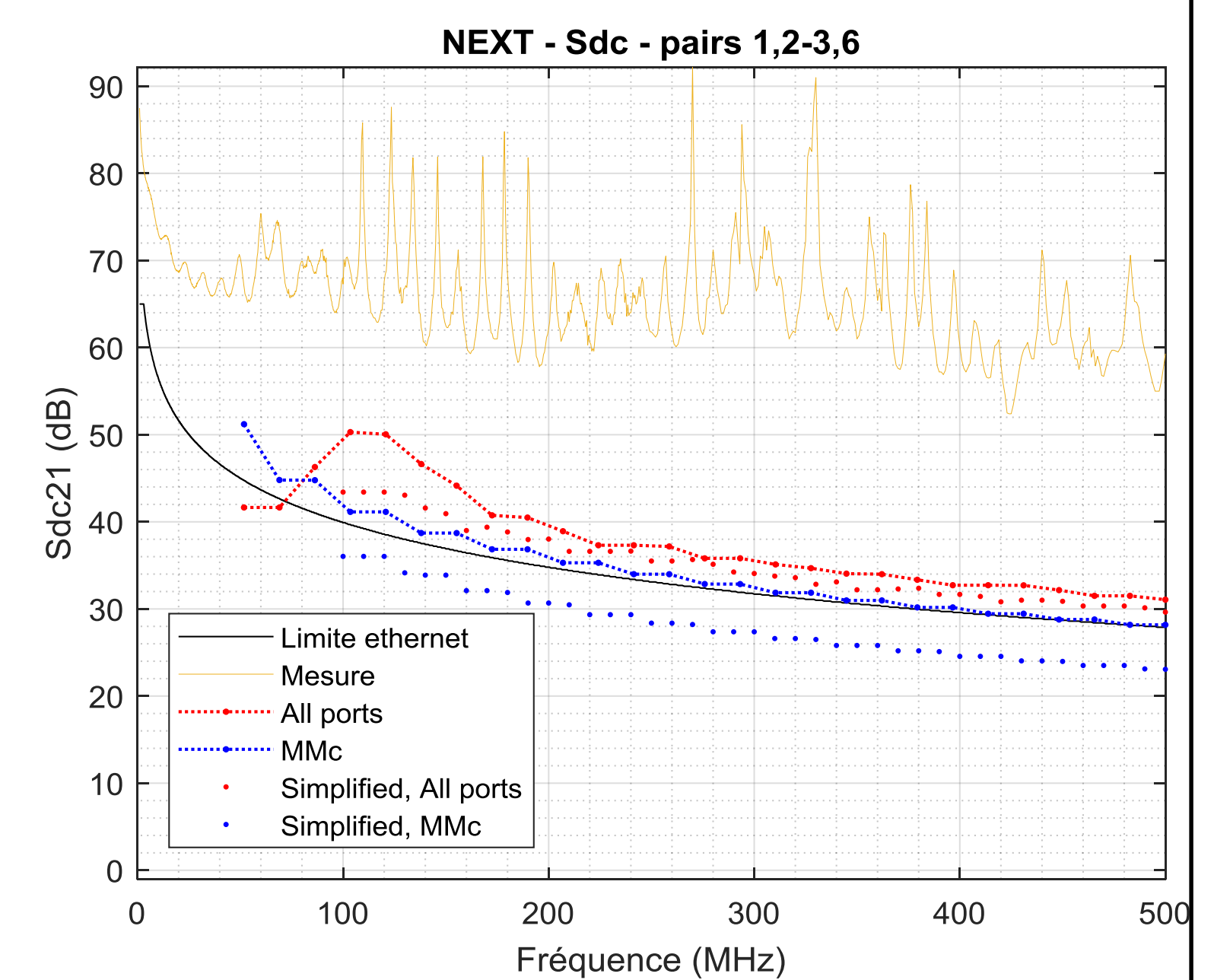


Figure 5. NEXT for ethernet

In both cases, the results of the simplified model are similar to the complete 3D model, that's confirm our choices taken for the model.

## Comsol application

- Many tabs allow the user to choose material, design each component (insulator, contacts and their positions)
- Users can then choose the pairs of interest and which S parameter to compute
- Other windows display the geometry, the electromagnetic field and the results

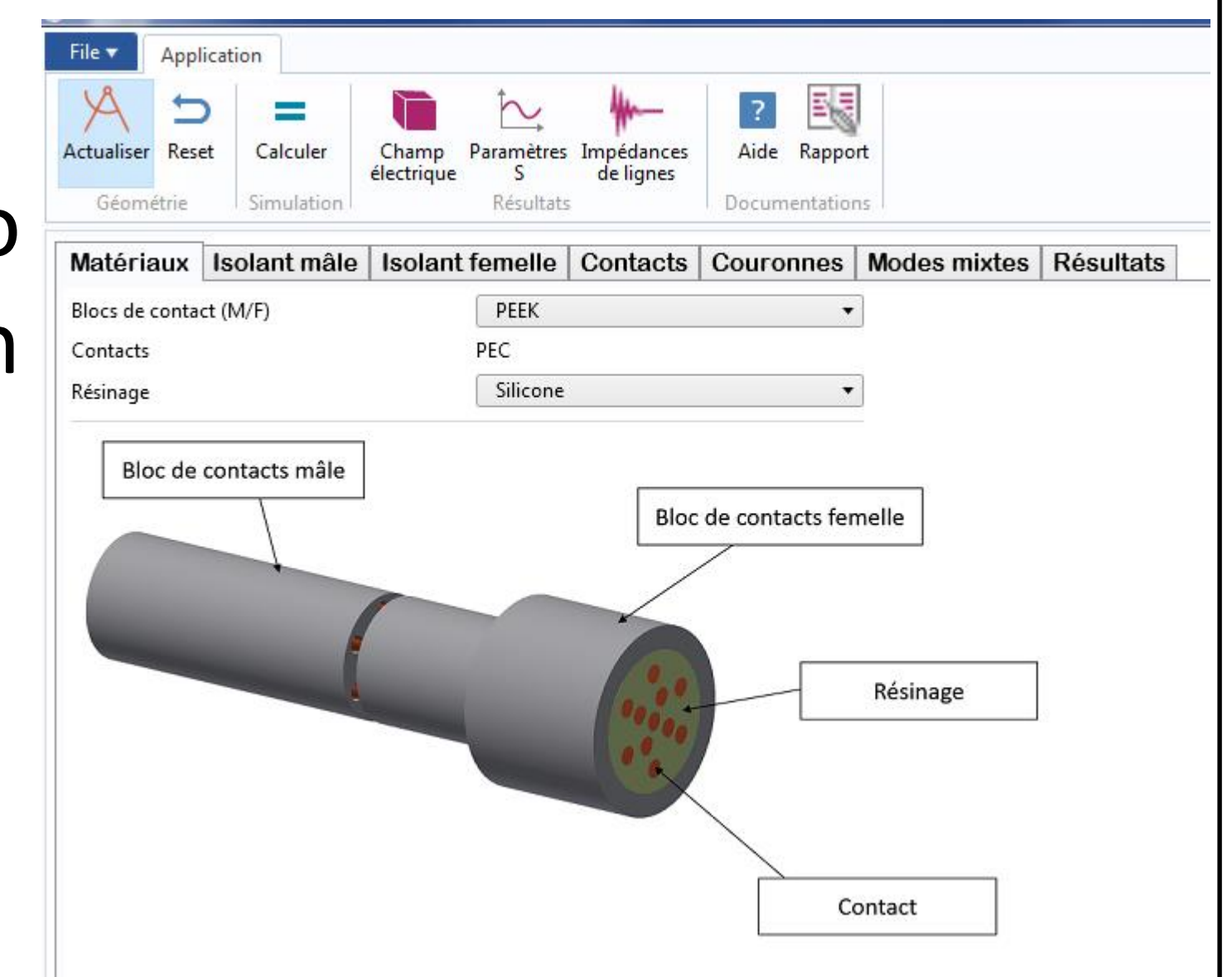


Figure 6. Interface of application

## CONCLUSIONS:

- The user interface allows an easy and rapid building and study of connectors. Moreover, the simplified model allow an important diminution of time of computation
- The model might be improved by adding other physical aspects, such as loss induced by electromagnetic or thermal effects

## REFERENCES:

1. Agilent, "S-Parameter Measurements Basics for High Speed Digital Engineers", Jan 2014