EDISON

Electromagnetic Design of
flexIble SensOrs

FNP Team-Tech

Report 9 - DeEmbedding using Double-delay technique for blocks of simple microstrip lines

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1. Available blocks

In the following report, structures which consist of following blocks are considered. All of presented structures are two-port microstrip lines with the following parameters:

- height of substrate = 0.5 mm,
- width of the line = 2 mm,
- length of the absorption box = 10 mm,
- width of the absorption box = 10 mm,
- height of the absorption box = 5 mm,
- relative permittivity = 3.5,
- relative permeability = 1,
- loss tangent = 0.

All of presented structures are symmetric along at least one axis. The mesh parameters are set to **1 mm** for maximum mesh size and for **0.3 mm** for edges of microstrips. The number of frequency points equals to 101, and the analyzed band is 1-15 GHz.

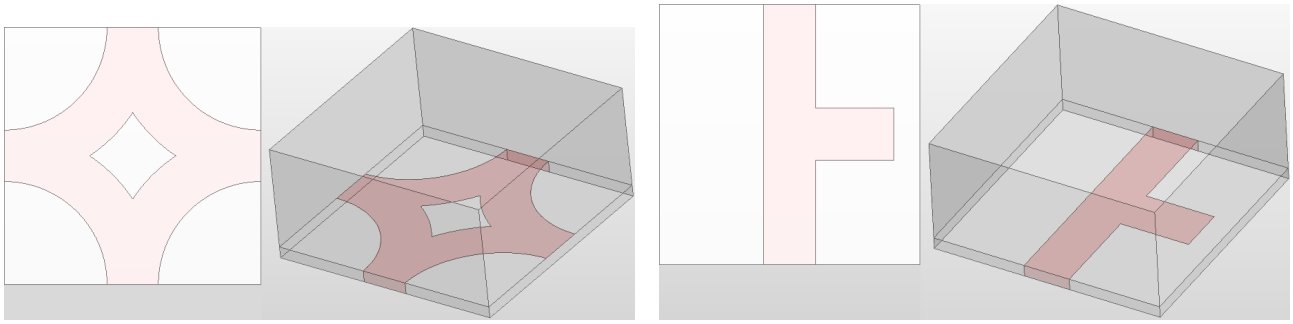

Figure 1: Structure on the left: **Luk**, N=53734. Structure on the right: **Sek**, N=36826.

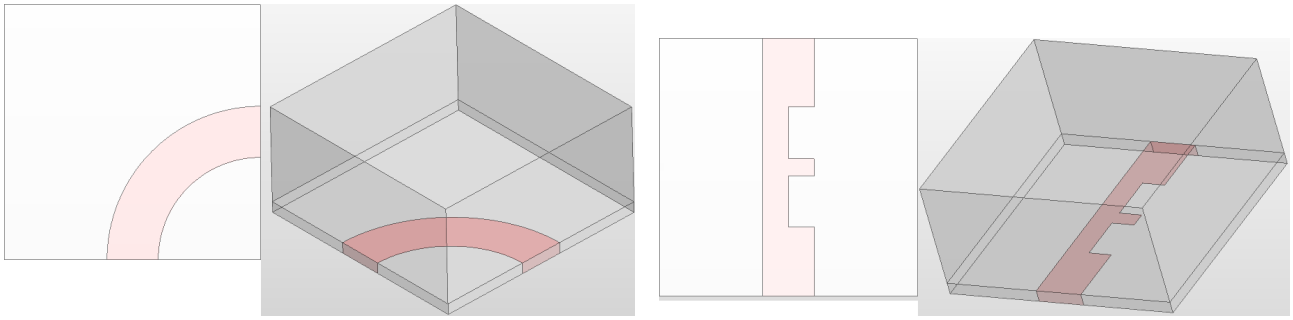

Figure 2: Structure on the left: **Curve**, N=24726. Structure on the right: **Wcieta**, N=39682.

2. Cloning basic structures

In this section results of cloned structures are presented. The multiplication is made using the S-parameters matrix, which are converted into ABCD parameters. All simulations are performed using **direct sweep**, however application of MOR techniques **does not increase the error** of S-parameters, which will be shown in the last section. The error is defined by:

$$s_{ij}^{\text{err}} = |s_{ij}^{\text{DeEmbedding}} - s_{ij}^{\text{Direct FEM}}| \tag{1}$$

The results are organized as follows:

- the first row correspond to S-parameters obtained with both, combination of deembedded blocks and direct simulation of combined blocks
- the second row correspond to error of above S-parameters obtained using formula (1).

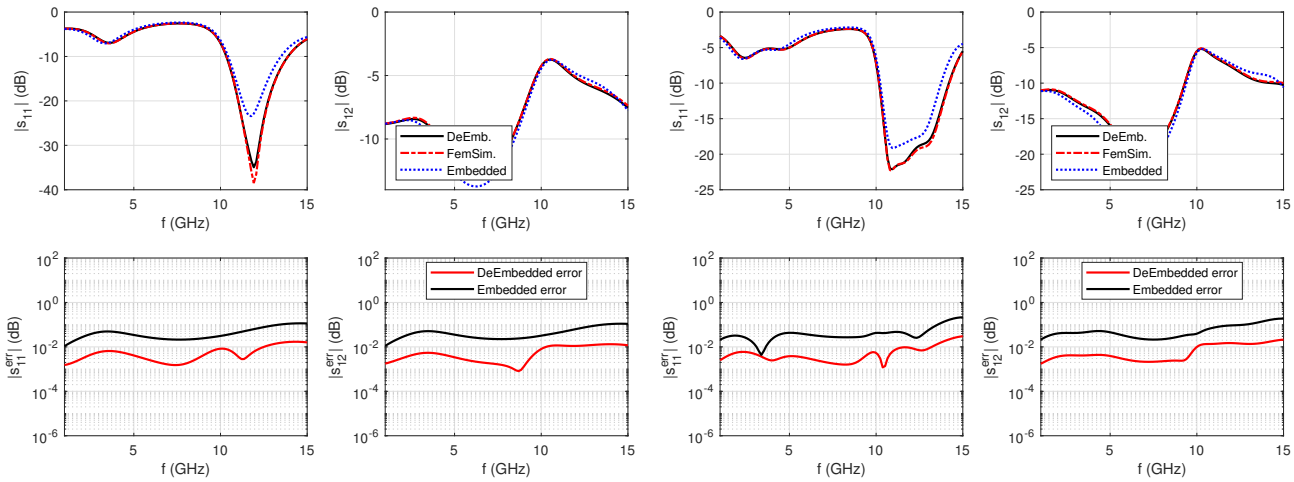

Figure 3: Structure on the left **Luk+Luk**. Structure on the right **Luk+Luk+Luk**.

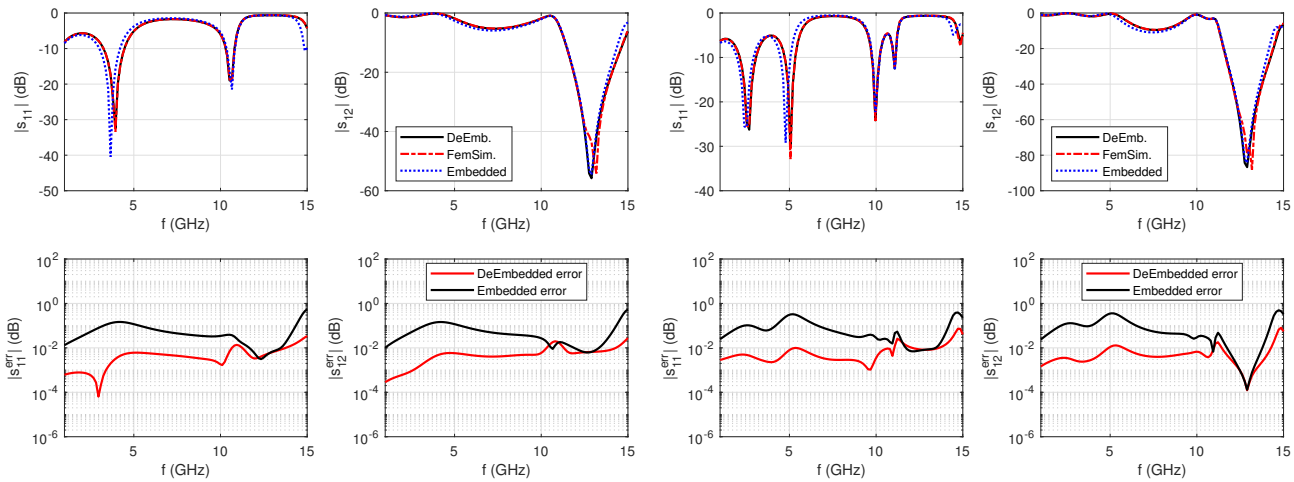

Figure 4: Structure on the left **Sek+Sek**. Structure on the right **Sek+Sek+Sek**.

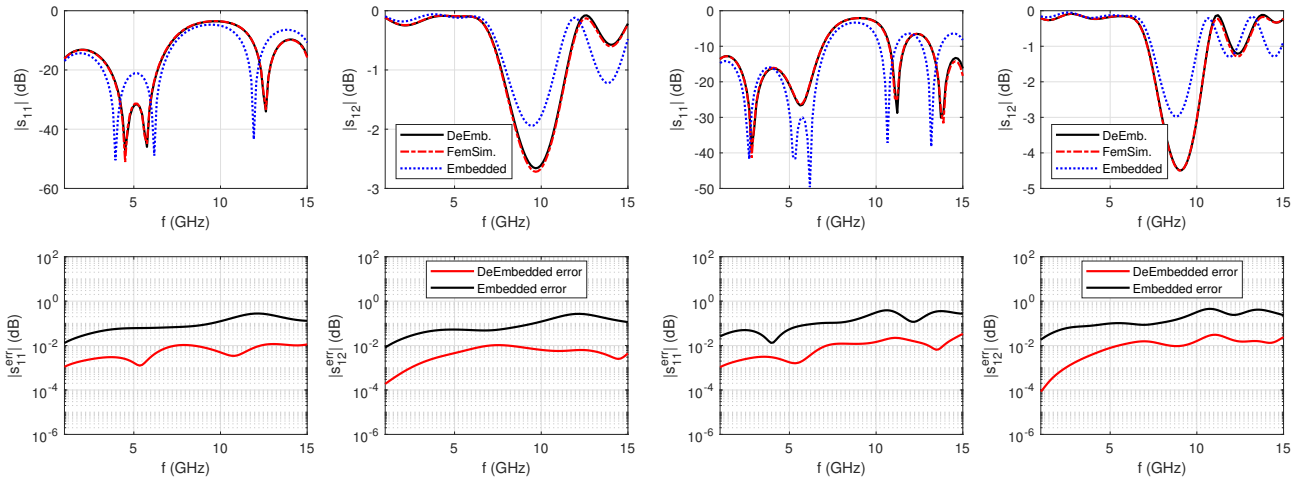

Figure 5: Structure on the left **Wcieta+Wcieta**. Structure on the right **Wcieta+Wcieta+Wcieta**.

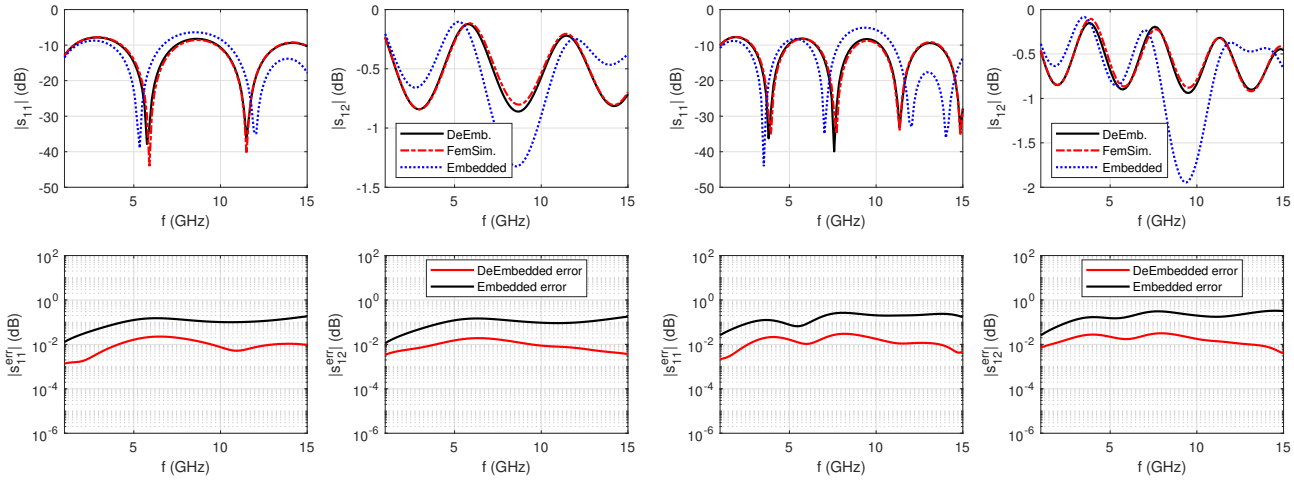

Figure 6: Structure on the left **Curve+Curve**. Structure on the right **Curve+Curve+Curve**.

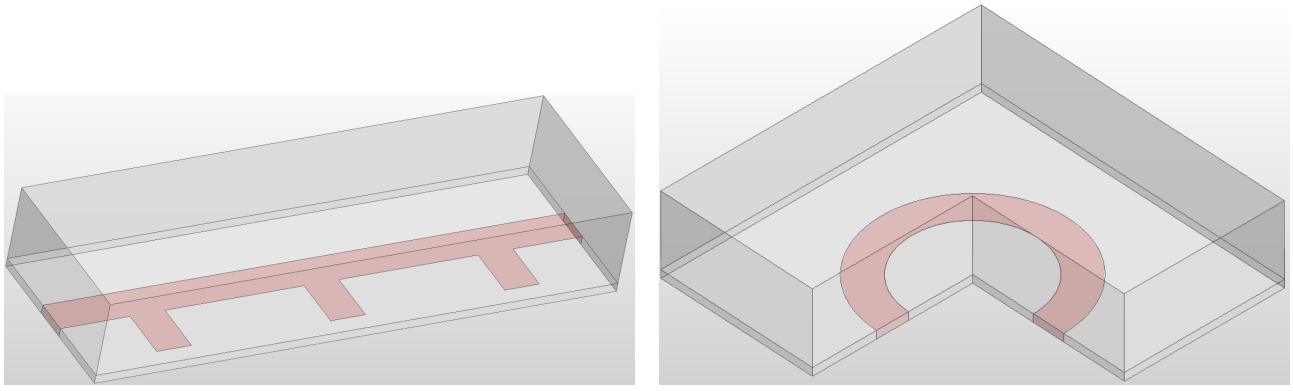

Figure 7: Structure on the left **Sek**×3. Structure on the right **Curve**×3.

3. Combination of basic blocks

In this section following structures are presented obtained using single blocks introduced in section 1:

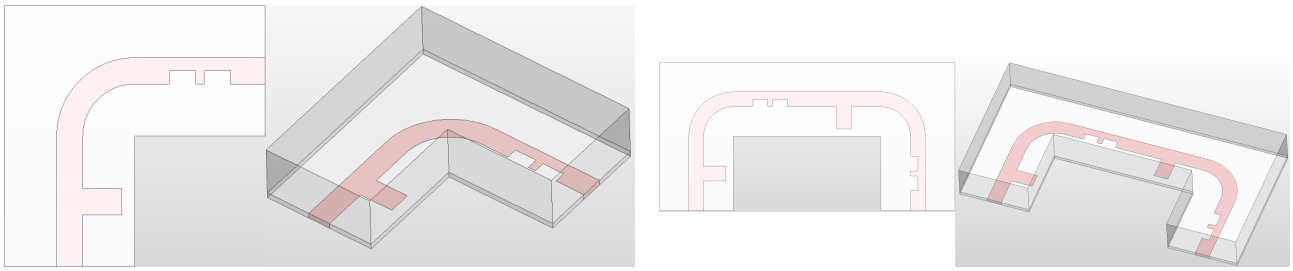

Figure 8: Structure on the left **Sek+Curve+Wcieta**.
Structure on the right **Sek+Curve+Wcieta+Sek+Curve+Wcieta**.

Direct sweep for both, combined and combination of single blocks.

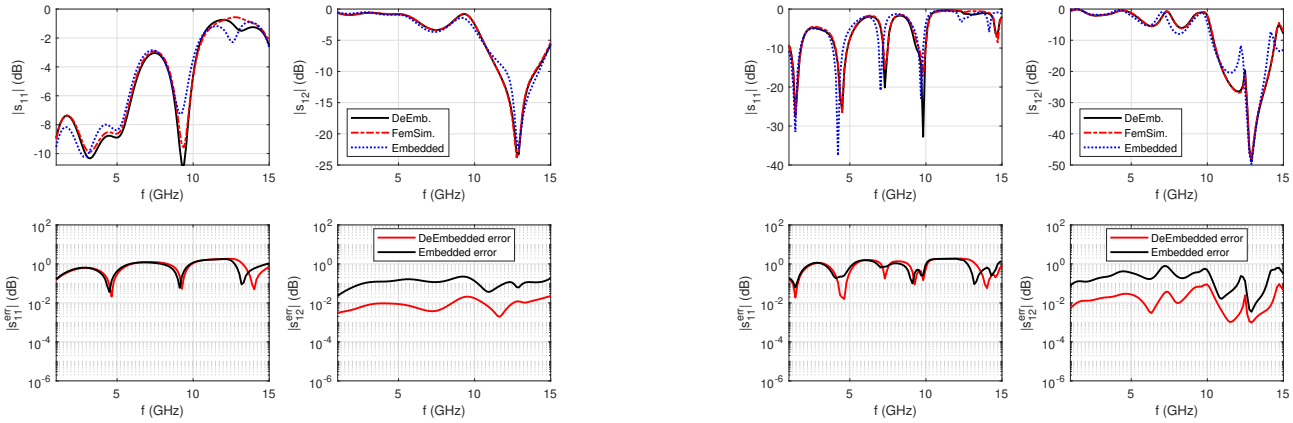

Figure 9: Structure on the left **Sek+Curve+Wcieta**.
Structure on the right **Sek+Curve+Wcieta+Sek+Curve+Wcieta**.

Application of MOR technique (normal->SAPOR) to single blocks (reference unchanged, deembedding changed).

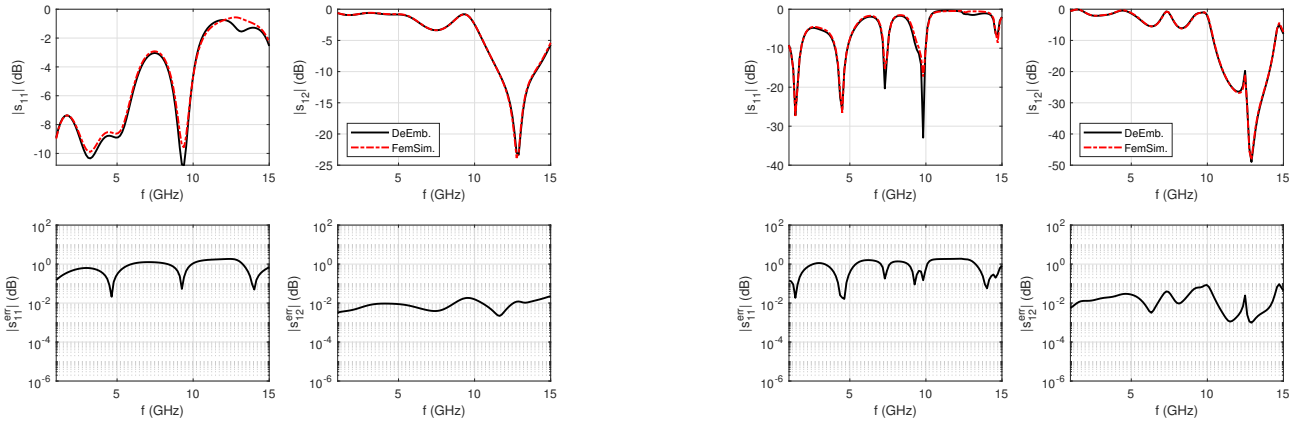

Figure 10: Structure on the left **Sek+Curve+Wcieta**.
Structure on the right **Sek+Curve+Wcieta+Sek+Curve+Wcieta**.

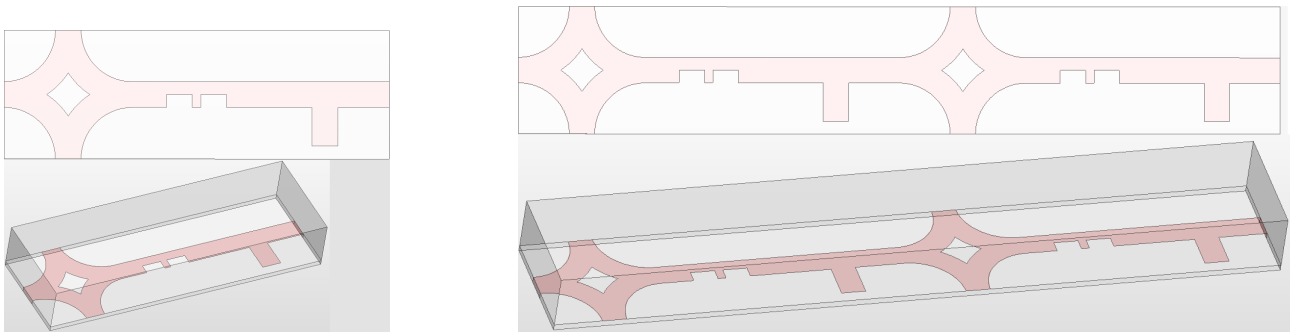

Figure 11: Structure on the left **Luk+Wcieta+Sek**.
Structure on the right **Luk+Wcieta+Sek+Luk+Wcieta+Sek**.

Direct sweep for both, combined and combination of single blocks.

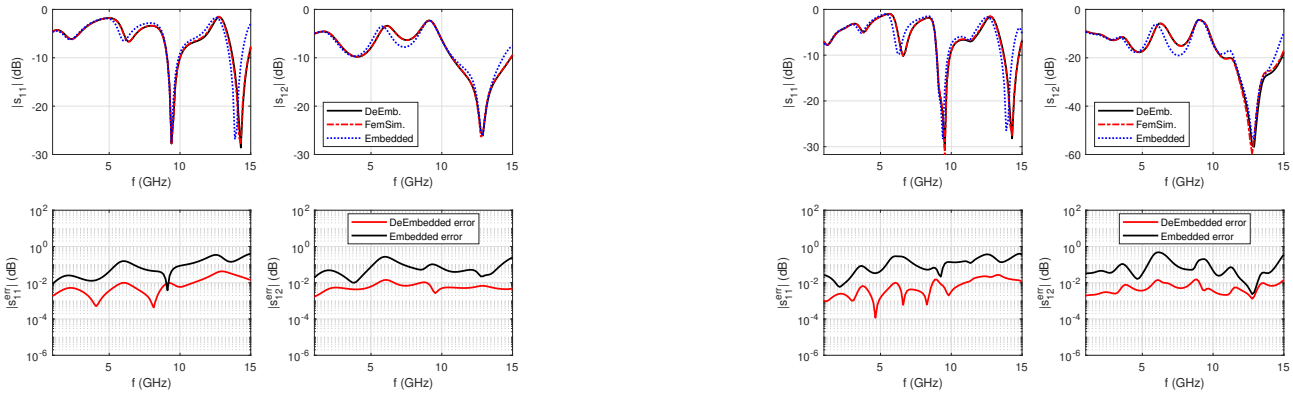

Figure 12: Structure on the left **Luk+Wcieta+Sek**.
Structure on the right **Luk+Wcieta+Sek+Luk+Wcieta+Sek**.

Application of MOR technique (normal->SAPOR) to single blocks (reference unchanged, deembedding changed).

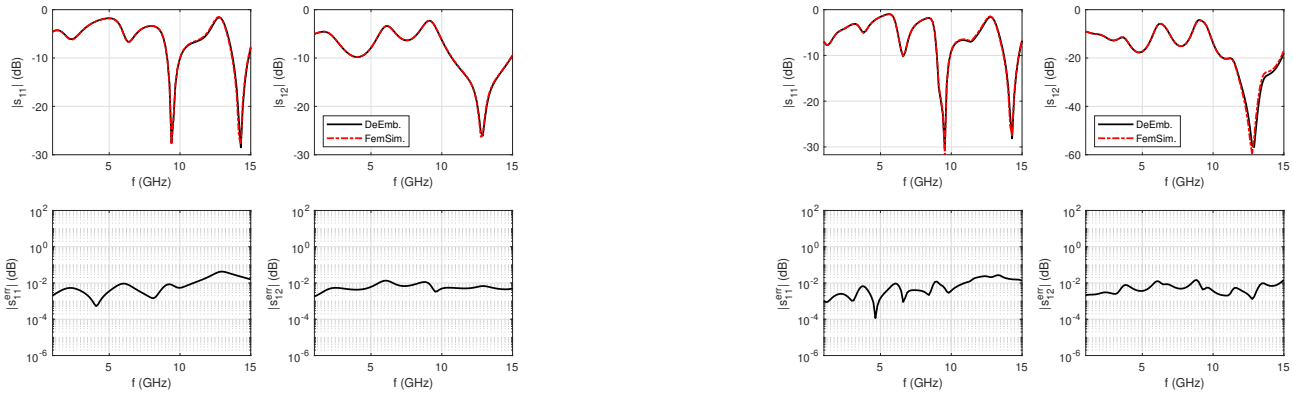

Figure 13: Structure on the left **Luk+Wcieta+Sek**.
Structure on the right **Luk+Wcieta+Sek+Luk+Wcieta+Sek**.

4. Conclusions

Above tests prove that Double delay technique may have a chance to be reliable technique in combination of various microstrip blocks. Application of MOR technique does not increase the error significantly. In presented cases, there is no difference, however the number of frequency points is rather low for such wide band. Probably the error will differ at level of simulation tolerance (currently is set to 1e-3).