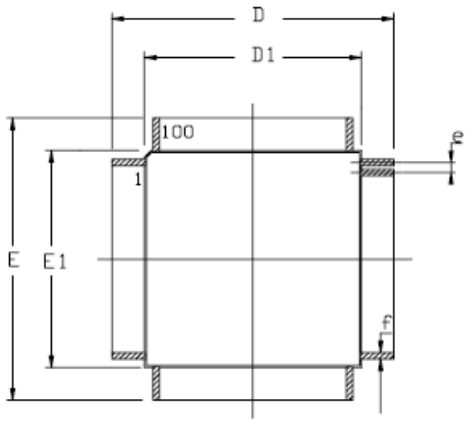
Application Note: Construction of an electrical model of a TQFP100 package with IC-EMC

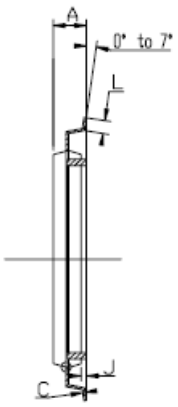
The following example compares the modelling results of a TQFP package given by the commercial tool Ansoft Maxwell Q3D and the tool Advanced Package Model provided by IC-EMC. Both software give models in terms of R, L, C lumped elements. An equivalent geometrical model is built under IC-EMC from basic mechanical data. Even if some differences exist between the geometrical models built with both software, simulation results are similar.
Please consult IC-EMC v2.0 User's Manual for more information about the tool Advanced Package Model.

I. Geometrical model of the package

1. General physical data of the package

Figure 1 describes external dimensions of the TQFP100 package.





COMMON DIMENSIONS IN MM

SYMBOL	Min	Max	NOTES
A	----	1.20	
A1	0.95	1.05	
C	0.09	0.20	
D	16.00 BSC		
D1	14.00 BSC		
E	16.00 BSC		
E1	14.00 BSC		
J	0.05	0.15	
L	0.45	0.75	
e	0.50 BSC		
f	0.17	0.27	

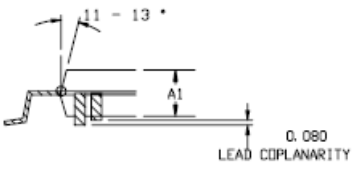


Figure 1 - External dimensions of the TQFP100 package

Figure 2 presents some general information concerning the package, as the bonding wire diameter, the package material, and some simulation parameter of Ansoft Maxwell Q3D.

Introduction

Package drawing	PLM# SM033926 / DWG# bd-m0-5716f_a.dwg
Target nets	Full nets
Model	Full nets
Simulation Tools	Ansoft Maxwell Q3D
Analysis frequency	100 MHz
Output Results	RLC matrix included mutual capacitance and inductance

Model Information

Package construction	
Package Type	TQFP
Lead count	100
Dimension	14 mm x 14 mm
Lead pitch	0.5 mm
Leadframe thickness	0.127 mm
Wire diameter	0.020 mm (HTS)

Material properties		
Material name	Properties	
	Rel.permittivity	Conductivity (S/m)
Leadframe - C194 ESH		3,77E+07
Mold	4	
Motherboard	4,4	

*** Motherboard ground plane is 254 um (10 mil) below the seating plane of the package.**

Figure 2 - General information of the TQFP100 package

Figure 3 provides a detailed view of the lead frame of the package, used for the Ansoft Maxwell Q3D simulation. Figure 4 gives a 3D view of the complete geometrical model used for the Ansoft Maxwell Q3D simulation. It can be noticed that double/triple bonding are used for some lead.

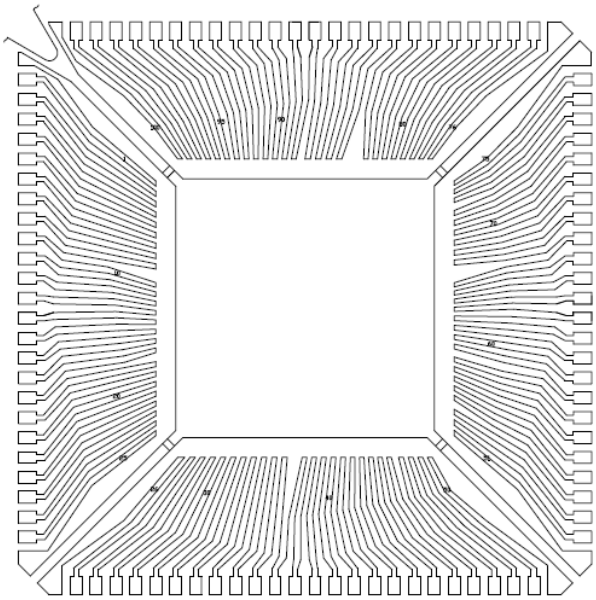


Figure 3 - Details of the lead frame of the TQFP100 package

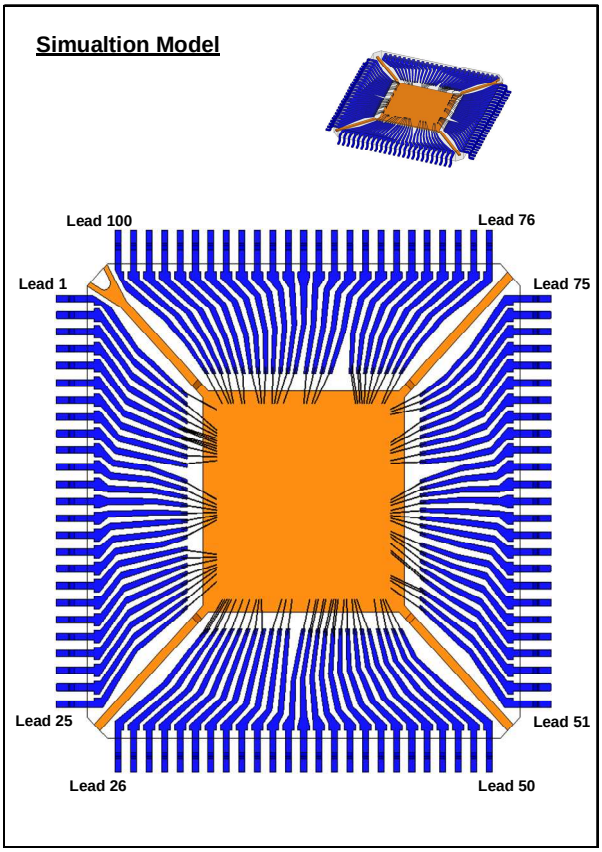


Figure 4 – Complete geometrical model of the package under Ansoft Maxwell 3D

2. Geometrical model construction with IC-EMC

The tool Advanced Package Model can build automatically geometrical model for QFP type package from a ten of mechanical parameters. Information concerning external dimensions are given by datasheet. Only information about cavity and die

sizes, and pad pitch are not known. However, approximated values can be deduced from the geometrical model done under Ansoft Mawell Q3D.
As the geometrical model built under IC-EMC is created automatically, it is an approximated model and is not fully similar to the model of Ansoft Maxwell Q3D. However, the construction of the model is simple and very fast.
Open IC-EMC and click on Tools/Advanced Package Model to launch the tool. The following figure detail the initial screen used to give basic geometrical data concerning the package.

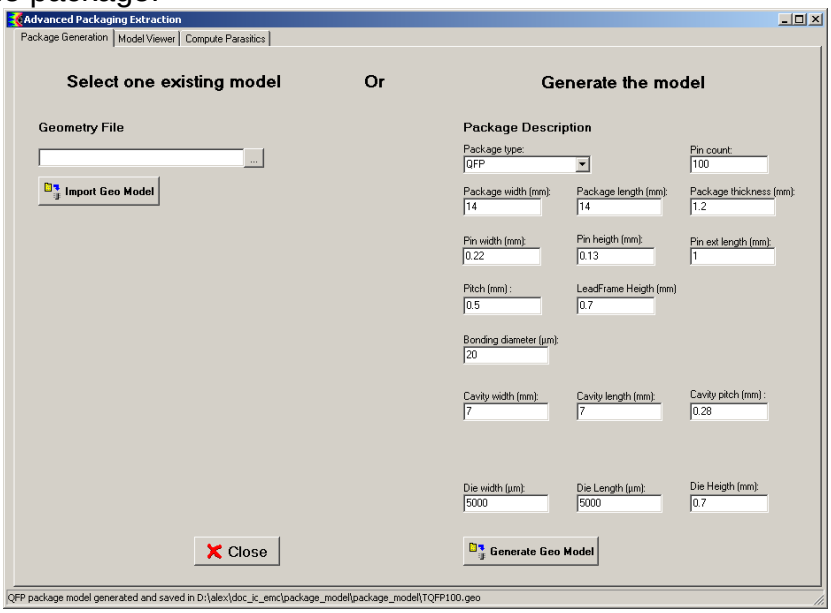
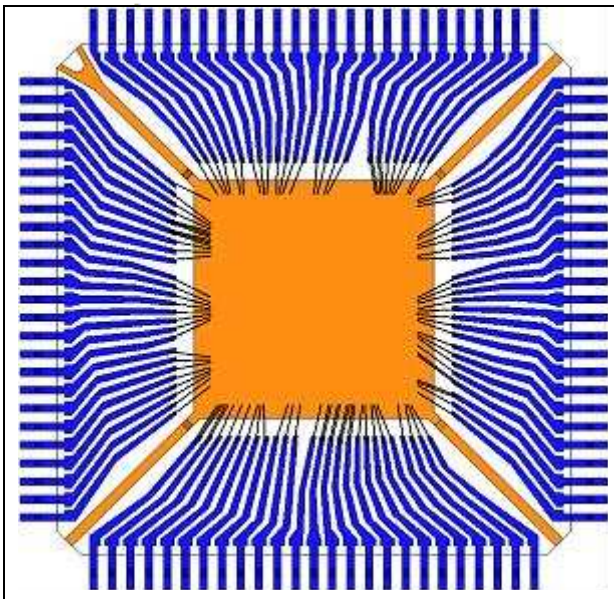
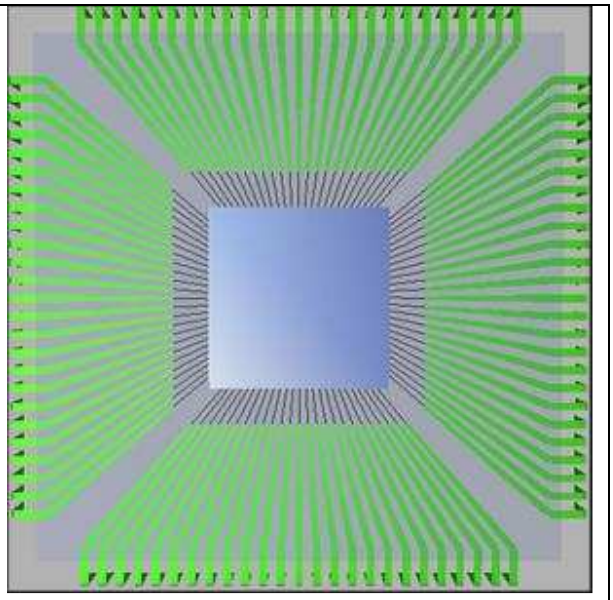


Figure 5 - Initial screen of the IC-EMC tool Advanced Package Model and input geometrical parameters for the TQFP100 package construction

Click on the button Generate Geo Model to build the geometrical model. A dialog box is opened to save geometrical information in a .geo file. Figure 6 compares the geometrical model built with Ansoft Maxwell Q3D (on the left) and IC-EMC (on the right). Models are similar. However, some differences exist and the Ansoft Maxwell Q3D model is more complex, especially for lead shape. Moreover, placement of bonding wires is not similar in both models. In IC-EMC, the placement of bonding wires is automatic so they are spread uniformly along the die.



Geometrical model under Ansoft Maxwell Q3D



Geometrical model under IC-EMC

Figure 6 - Comparison between geometrical models

II. Simulation configuration under IC-EMC

Once the geometrical model generated by IC-EMC is validated, the electrical parameter extraction has to be configured. The third window of the tool Advanced Package Model is dedicated to this configuration. Several parameters are configured:

- Placement of an ideal ground plane under the package
- Height of the package above the ground plane
- Dielectric constant of the package material
- Lead frame metal conductivity
- Frequency of the extraction (for the skin effect)

Figure 7 presents the parameters of the simulation.

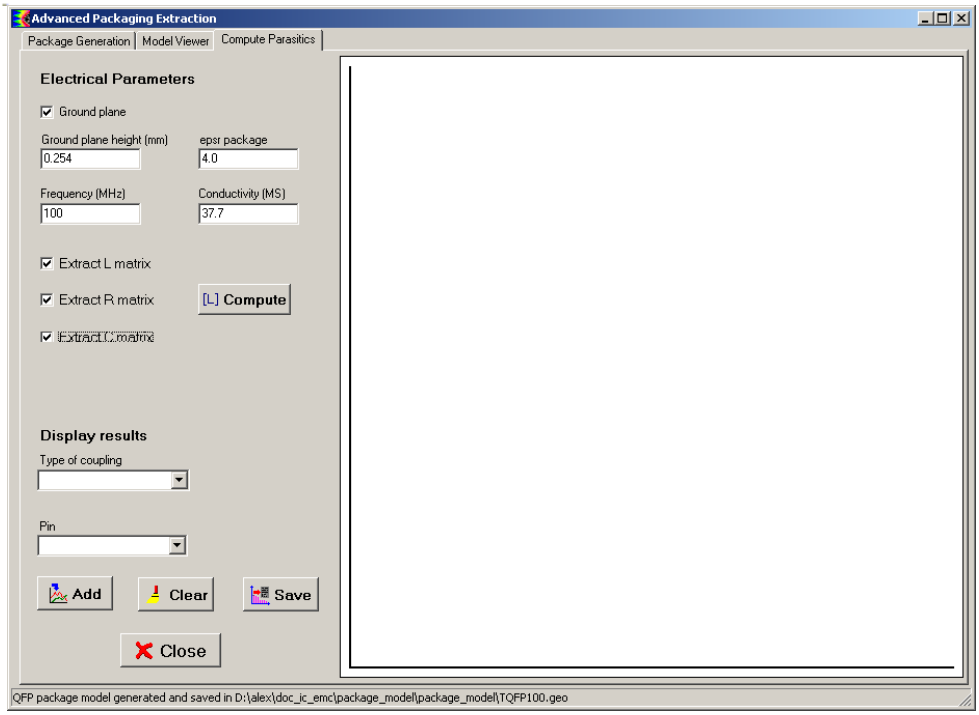
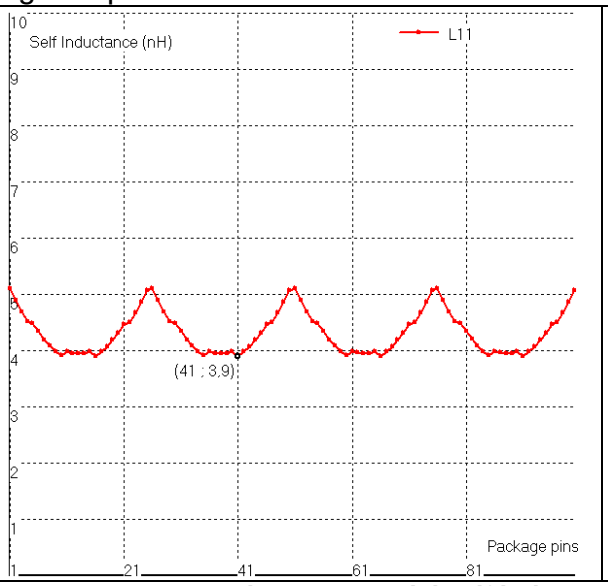


Figure 7 - Simulation parameters

Electrical elements to be computed are selected (R, L, C matrix) and the simulation is launched by clicking on the button Compute.

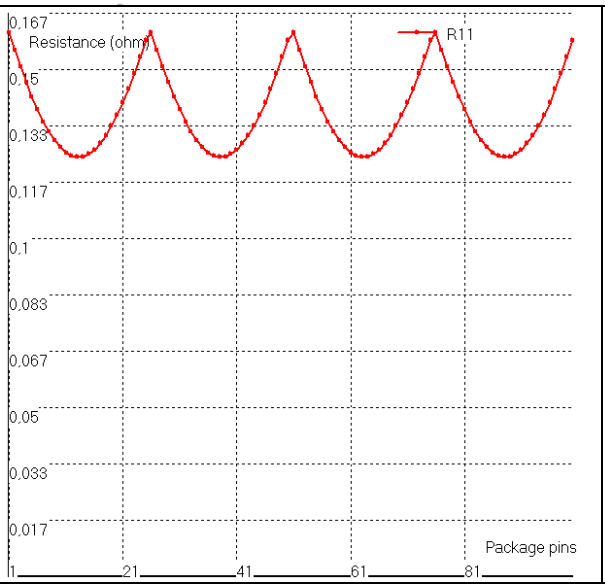
III. Simulation results

The simulation time required to extract the R, L, C parameters for the 100 pins of the package does not exceed 22 seconds (on a Intel Core 2 Duo, 2.4 GHz). At the end of the simulation, results are saved in .R, .L and .C files in the form of partial elements matrix. Min, Typ and Max value are given in the header of these files. The following figures present the simulation results.



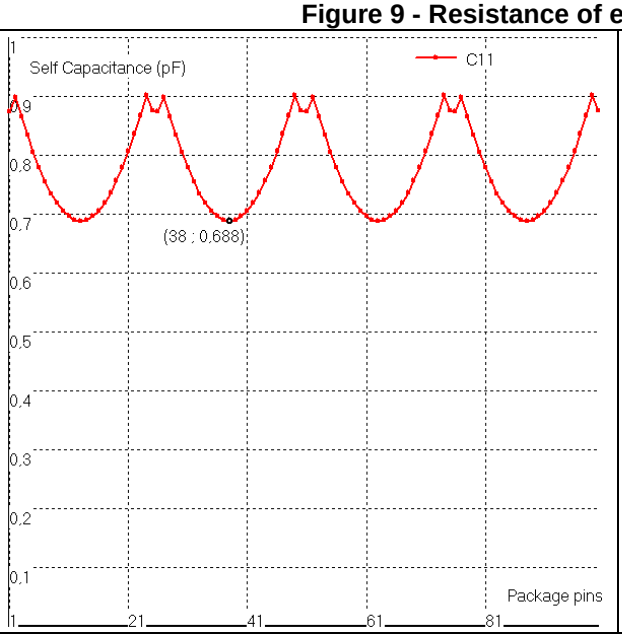
Min = 3.9 nH
Typ = 4.32 nH
Max = 5.11 nH

Figure 8 - Partial self inductance of each pin of the package



Min = 124 mΩ
Typ = 138 mΩ
Max = 161 mΩ

Figure 9 - Resistance of each pin of the package



Min = 0.69 pF
Typ = 0.78 pF
Max = 0.9 pF

Figure 10 - Partial capacitor of each pin of the package

IV. Comparison with Ansoft Maxwell Q3D results

1. Inductance extraction

Figures 11 and 12 compare the extraction results of partial inductance (self and mutual inductances respectively) for the 25 first pins as the IC-EMC geometrical model is symmetrical. Results of self inductance provided by IC-EMC are very similar to those given by Ansoft Maxwell Q3D. However, there are differences for mutual inductances; IC-EMC tends to under estimate mutual inductance. They are certainly due to differences in geometrical models. Separation between leads is smaller in Ansoft Maxwell Q3D model than in IC-MC model.

It can be also noticed that mutual inductance values given by IC-EMC are systematically positive as the tool provides only absolute value.

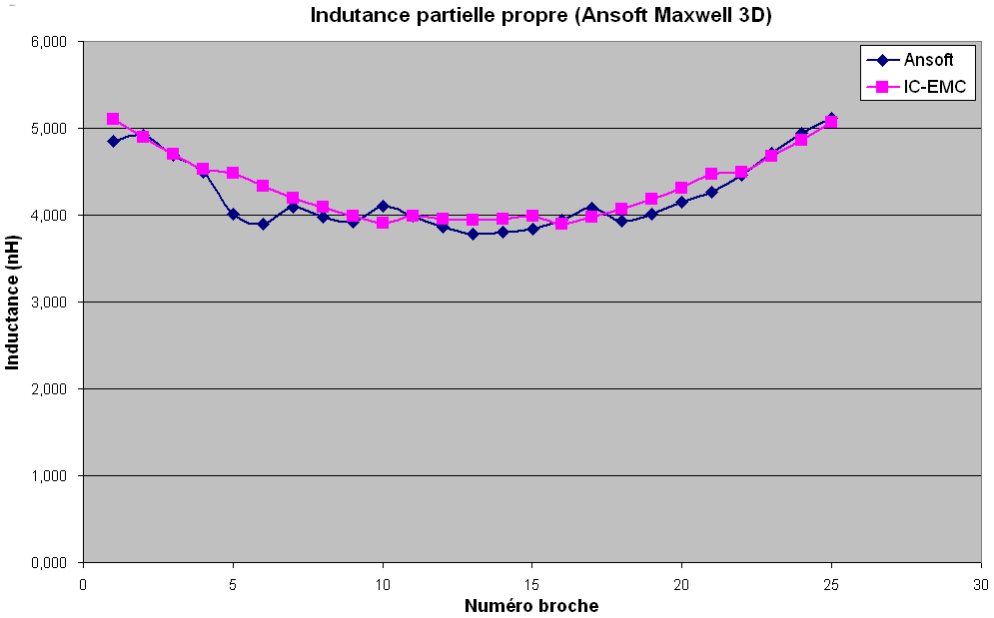


Figure 11 – Comparison of self inductance results provided by both model

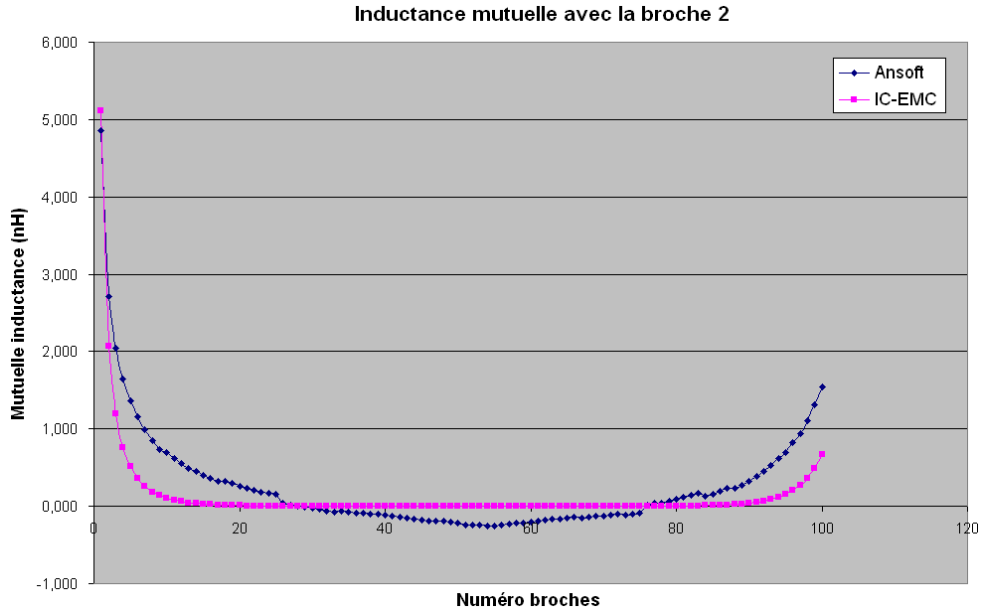


Figure 12 – Comparison of mutual inductance results provided by both model

2. Resistance extraction

Figure 13 compares the resistance extraction results provided by IC-EMC and Ansoft Maxwell Q3D. IC-EMC provides resistance values similar to those given by Ansoft Maxwell Q3D. However, some discontinuities in the Ansoft Maxwell Q3D appears, which are due to the presence of double or triple bonding on some pins. This type of bonding is not modelled with IC-EMC.

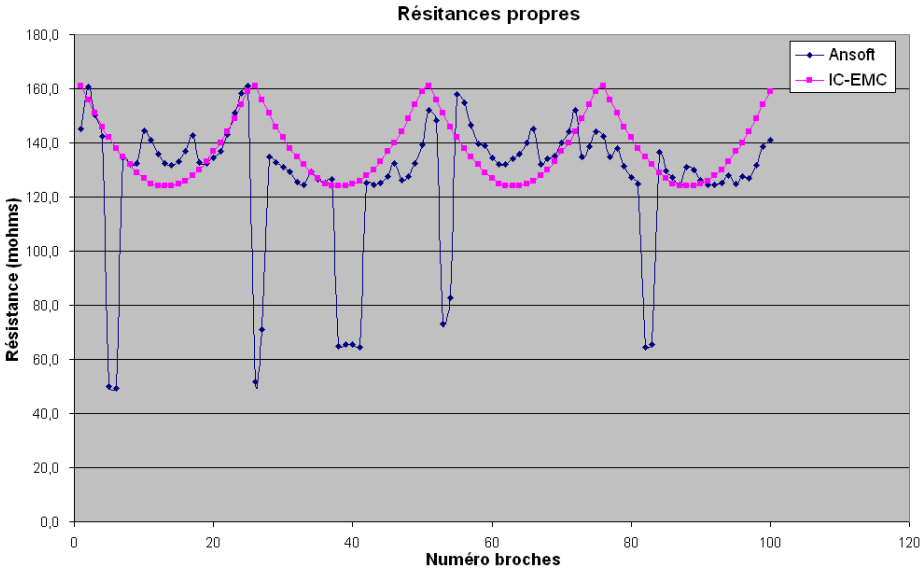


Figure 13 – Comparison of resistance results provided by both model

3. Capacitance extraction

Figures 14 and 15 compare results of partial capacitance extraction (only the 25 first pins). Both software gives similar results. The same conclusion as inductance extraction can be formulated. IC-EMC tends to under estimate mutual capacitor between neighbour pins. Differences between geometrical models can be explained these discrepancies.

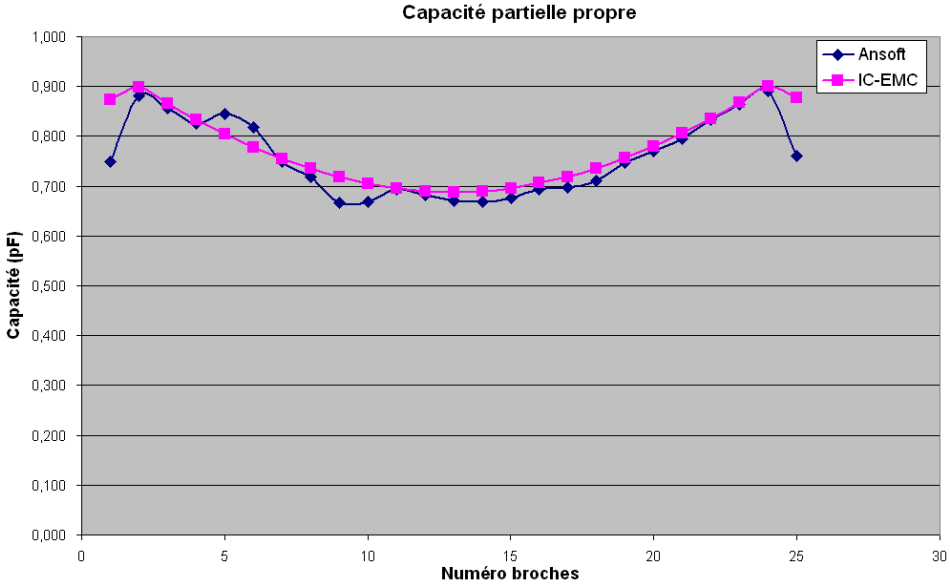


Figure 14 – Comparison of capacitances results provided by both model

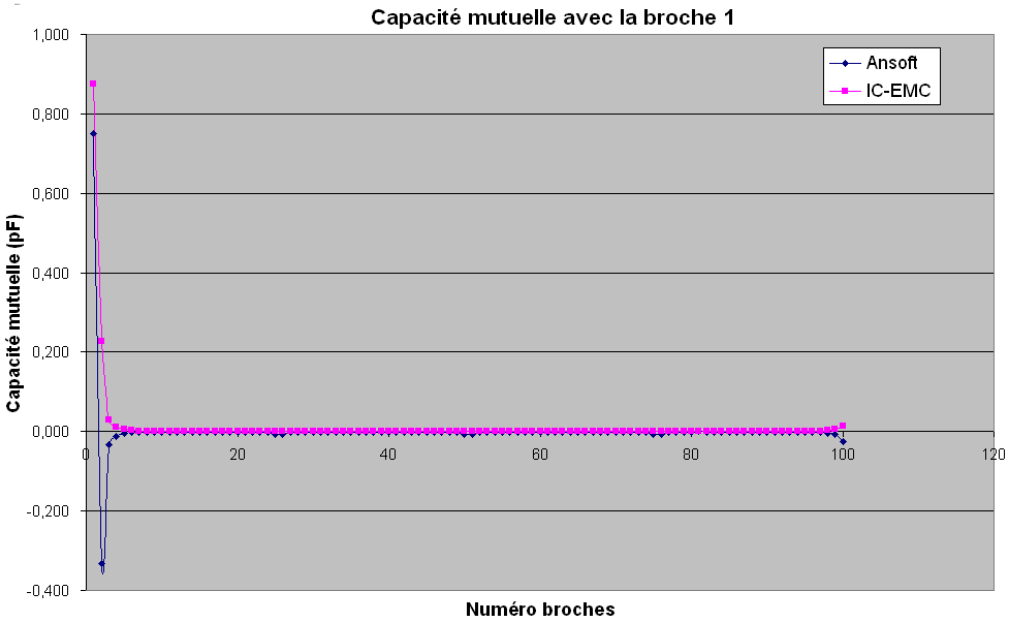


Figure 15 – Comparison of mutual capacitance results provided by both model

V. Conclusion

This application note has shown an example of modelling of a package with the tool Advanced Package Model of IC-EMC. Results provided by IC-EMC are compared with those given by a commercial tool, Ansoft Maxwell Q3D, in order to validate IC-EMC. Both software give electrical models in terms of lumped electrical parameters (R, L, C partial elements). Results given by both tools are similar. Some differences exist especially for mutual inductances and capacitances. These differences can be explained by the differences of geometrical models. As IC-EMC reconstructs a geometrical model automatically from a reduced set of parameters, it can not create a geometrical model as accurate as the one construct manually under Ansoft Maxwell Q3D. However, the automatic construction is very fast and simple which can compensate the slight loss of accuracy for an estimation of package electrical model.