Report : Simulation ACCO inductor

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Introduction

In the NANOCOPS project, test cases are foreseen to simulate device/circuit structures. As a particular choice for a device an inductor was selected by ACCO.

In a next stage this inductor will be used by FHO to set up combined circuit/device simulations. Moreover, it is foreseen that the time integration methods of FHO will be applied to the field state space description of the inductor. As a first step we will need to simulate the inductor in stand-alone mode. This already requires much of the work that is needed anyway at later stages. For example, the inductor must be uploaded in the MAGWEL software starting from the technology file and the gds file.

Device Uploading

We used the gds file as provided by ACCO and uploaded the device in the MAGWEL software, e.g. we made an xml structure file. Figure 1 shows the uploading up to layer E1
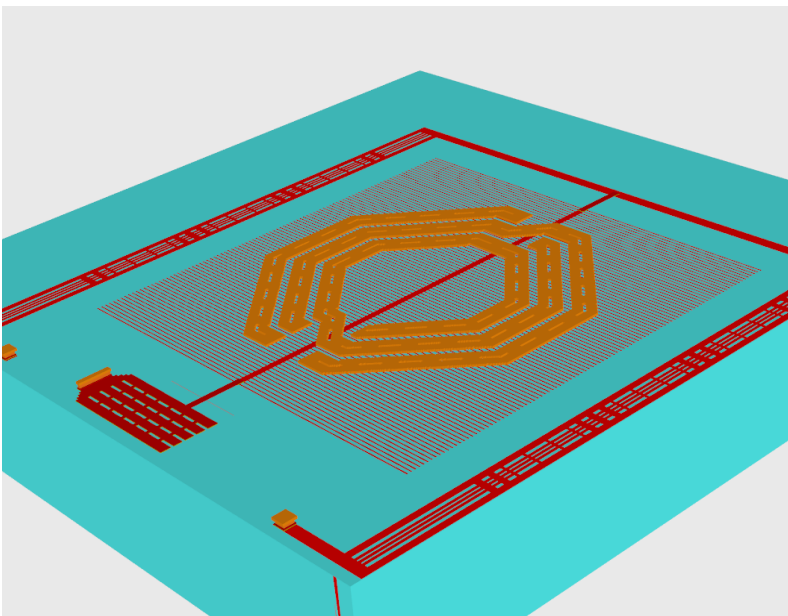

Fig.1 Uploading of the inductor up to layer E1
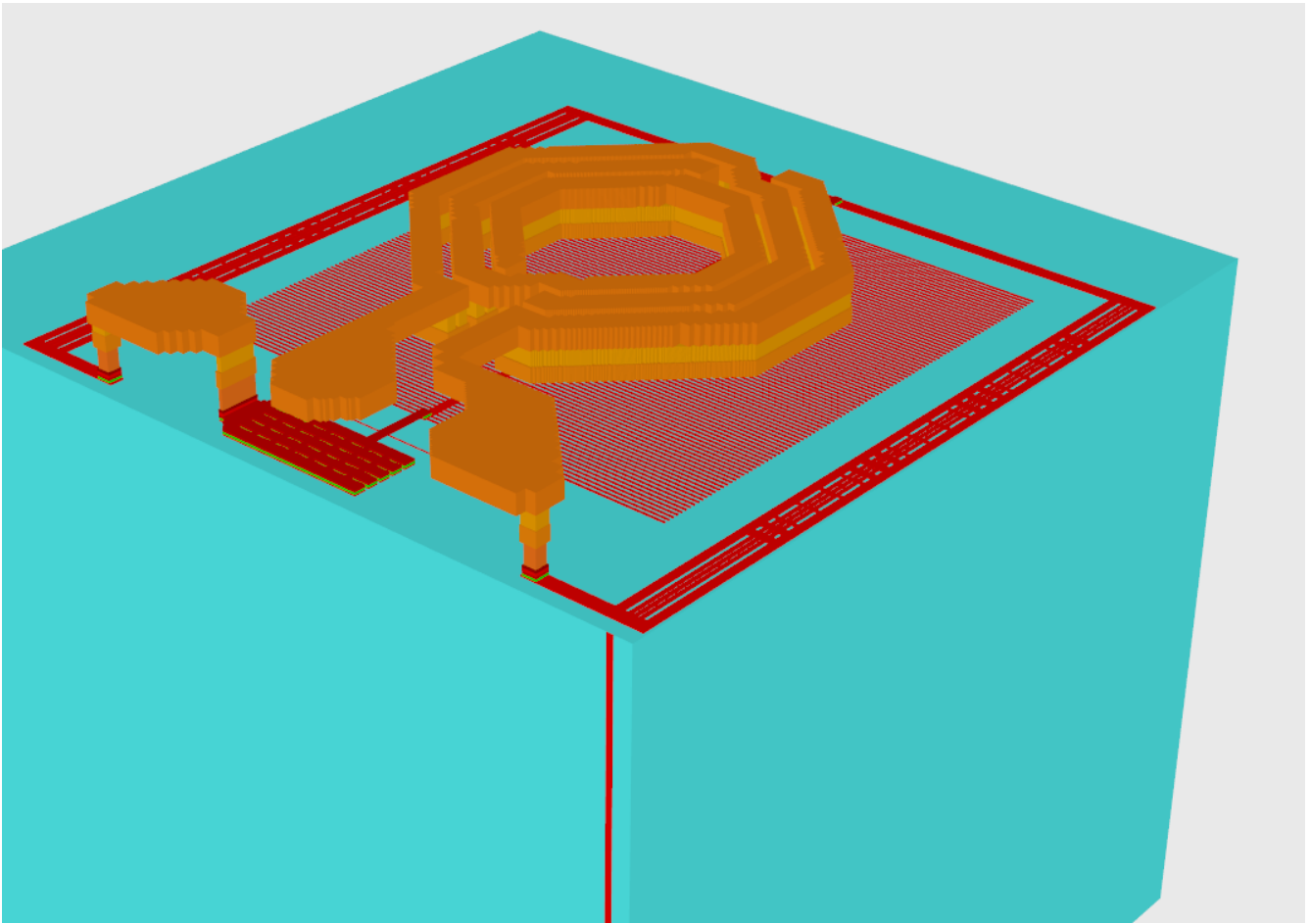
Figure 2 shows the uploading up to layer MA.

Fig.2 uploading up to layer MA.

We also added 50 microns of air on top of the simulation structure in order to create space for spreading out of the magnetic field.

After some structural cleaning the final result is shown in Fig. 3. After some structural cleaning the final result is shown in Fig. 3.
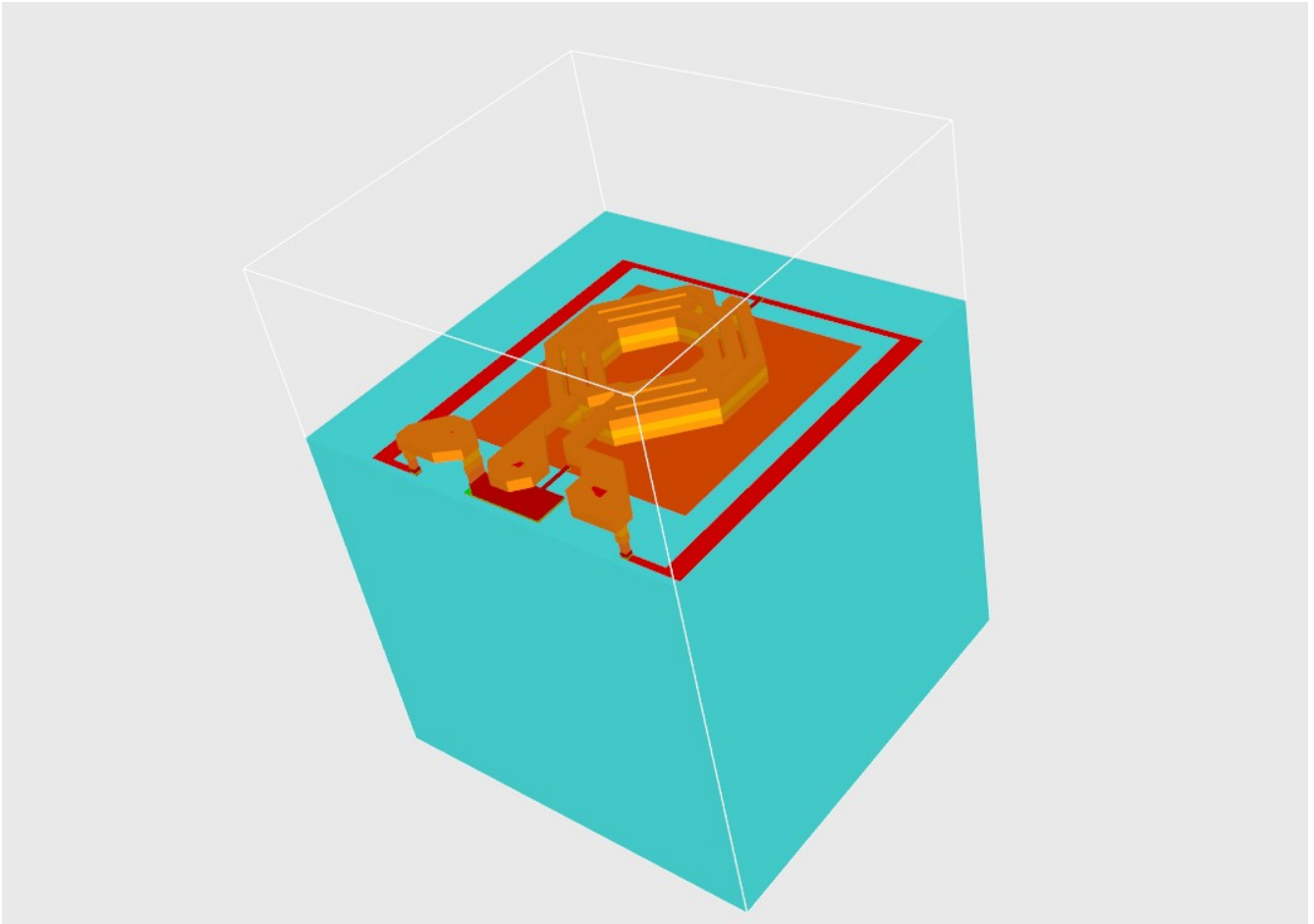
Fig. 3 final result of the uploading process.

An important issue is the treatment of metal1 (the fine metal grid below the inductor). Such details on this scale jeopardize the meshing. We have replaced this layer as is illustrated in Fig. 4.

Results

We did a 2-port simulation set up in the frequency regime using for port1={S1,G2} and port2={G1,G2}. We did a scan of the frequency from 1-5 GHz.

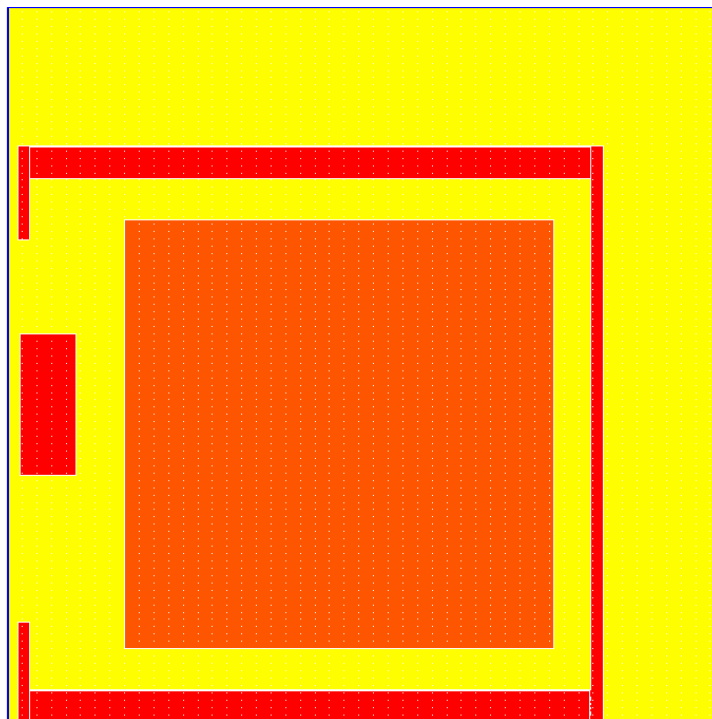In Fig. 5 we show the inductance plot. Fig. 6 shows the resistance plot and Fig.7 shows the Q-factor.
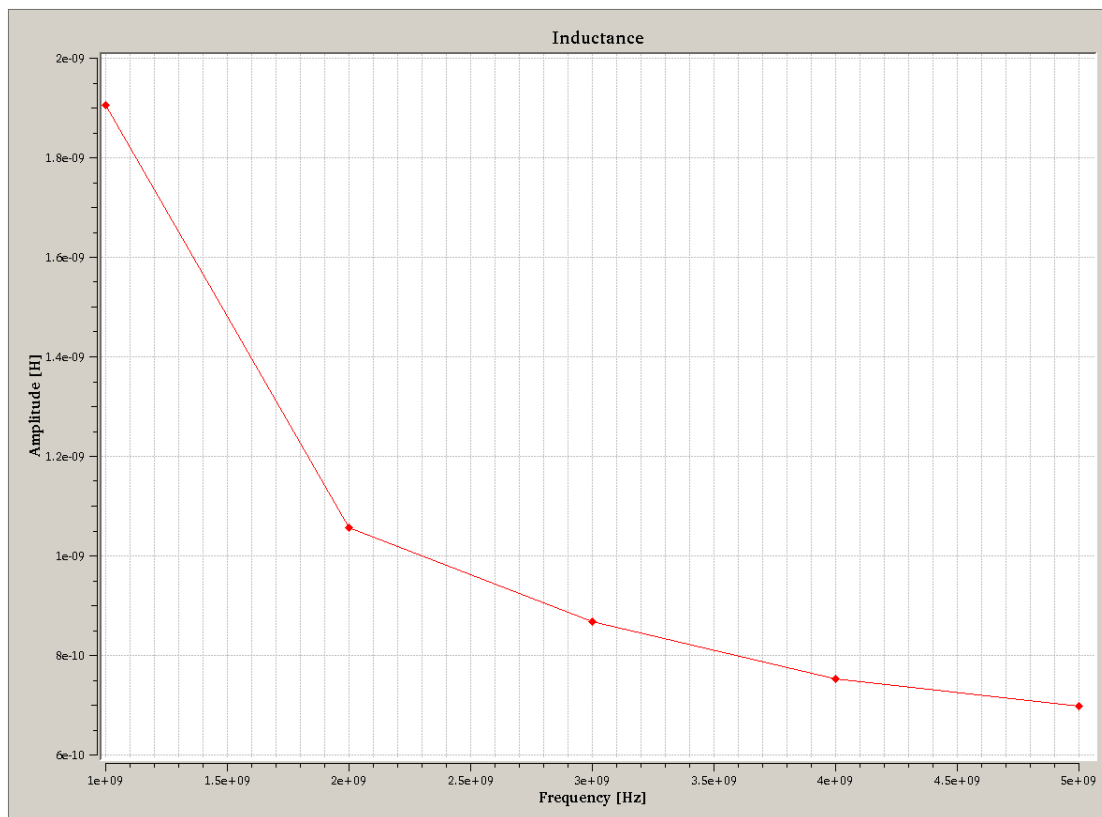
Fig. 4 Replaced metal1 plot

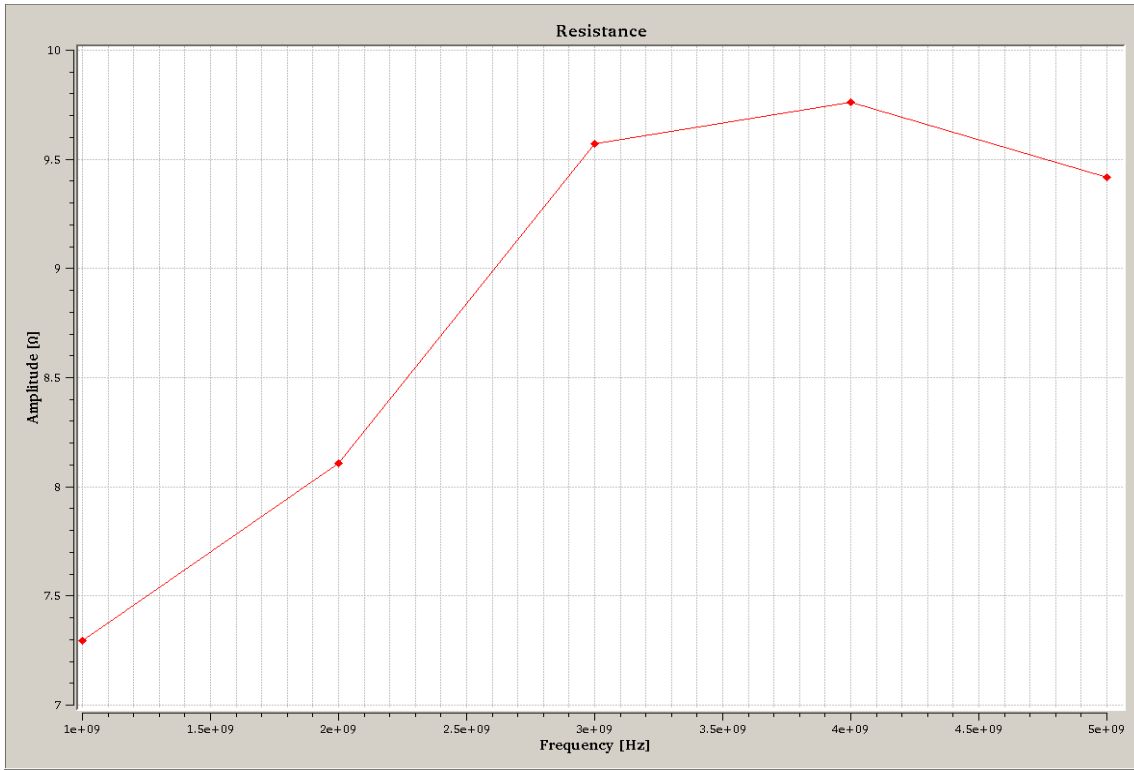Fig. 5. Inductance plot from 1-5 GHz. The maximum = 1.9 nH.
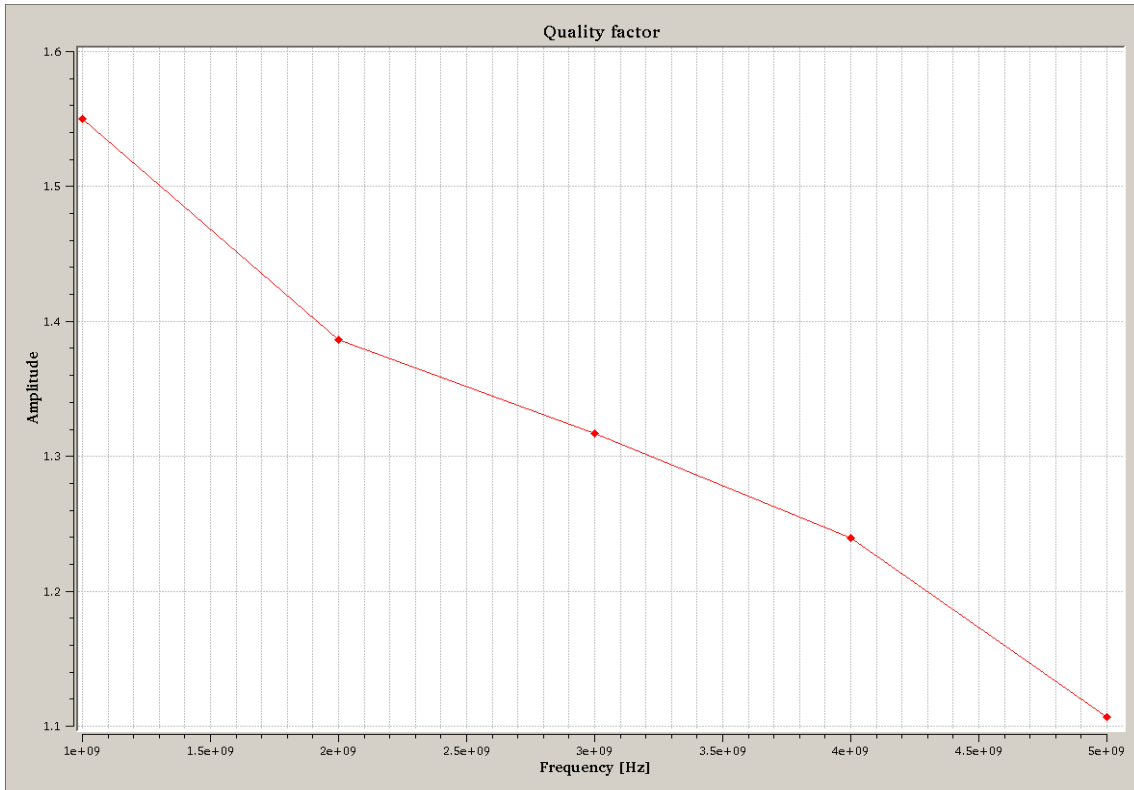
Fig. 6 Resistance plot.

Fig. 7 Q-factor

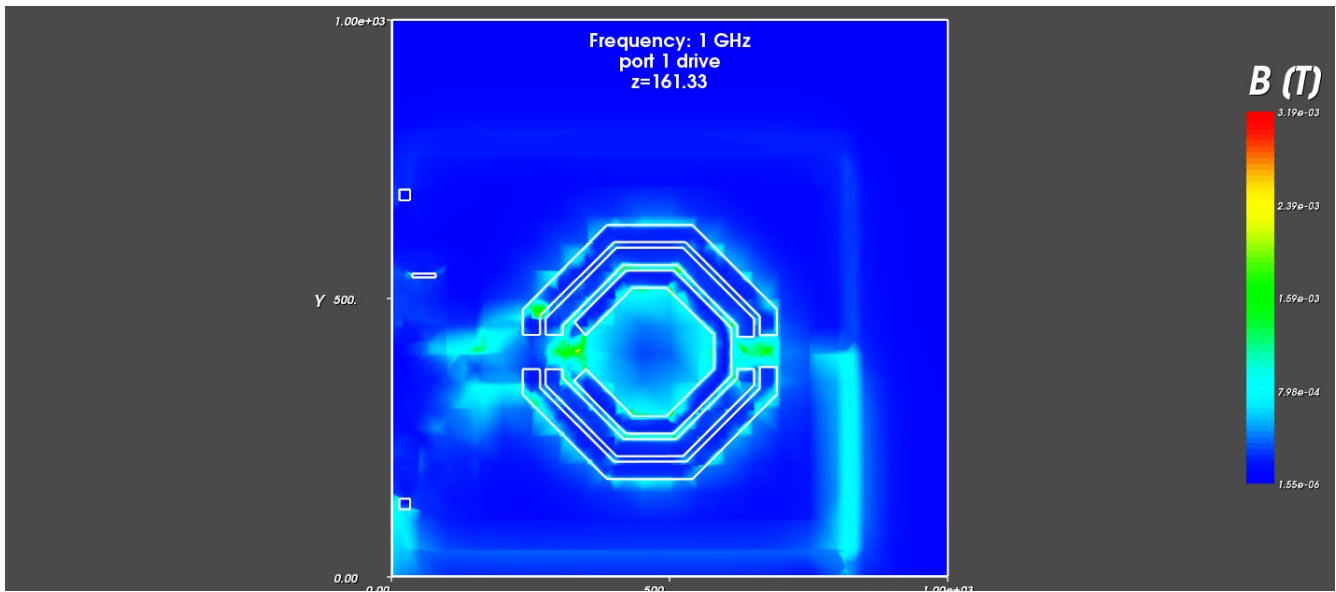In figures 8, 9 and 10 some field plots are shown.

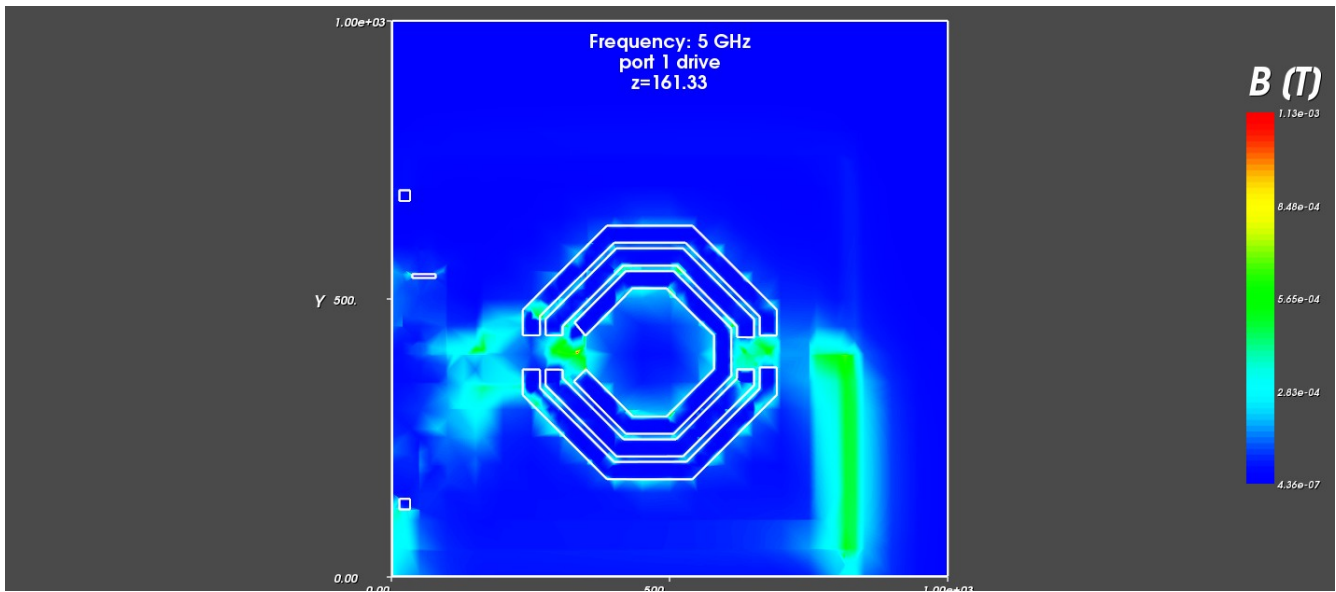Fig. 8 Magnetic field at 1 GHz and layer E2

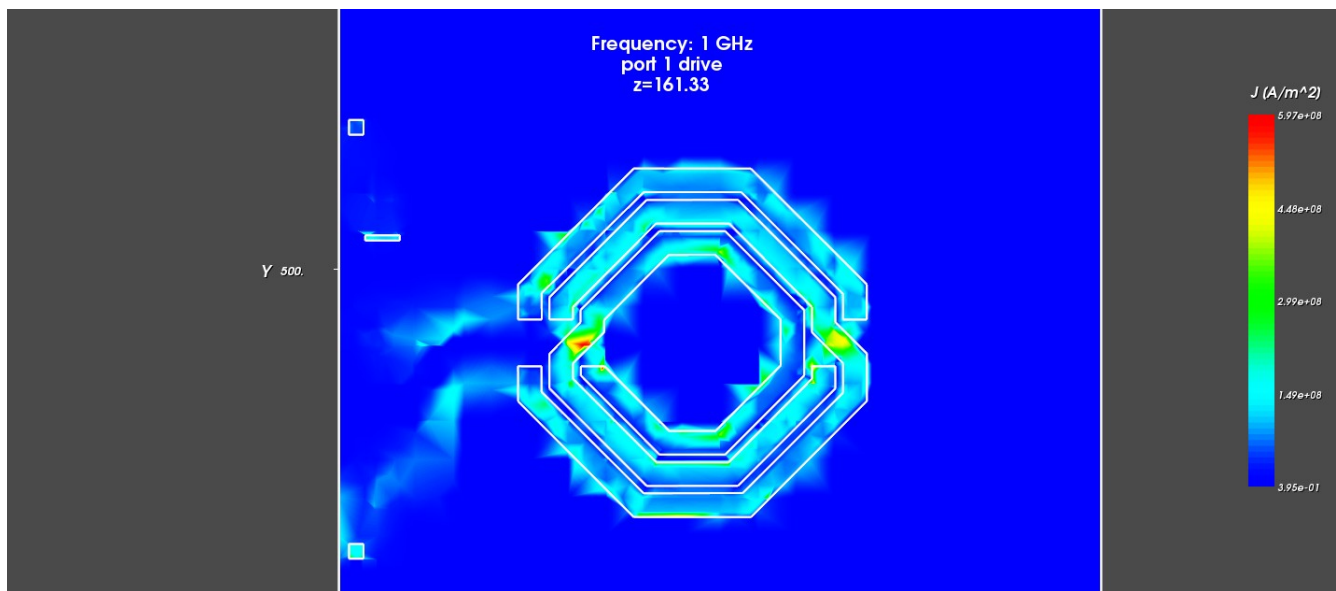Fig. 8 Magnetic field at 5 GHz and layer E2.

Fig. 9 . current density at 1 GHz and layer E2

Summary – first simulation run

A first simulation sweep was performed on the ACCO inductor. A number of assumptions have been made concerning the structure cleaning, the selection of port contacts. In a sense it is a 'blind' simulation without designer feed back into the set up. The primary goal of this simulation was to demonstrate that the inductor simulation is feasible.

Simulations – second run

In the next simulation run we move the complete structure away from the edge of the simulation domain. Furthermore we did some further structure cleaning in order to get a more efficient mesh. The inductance is done using the same port set up as before. e.g. it is a two-port set up.
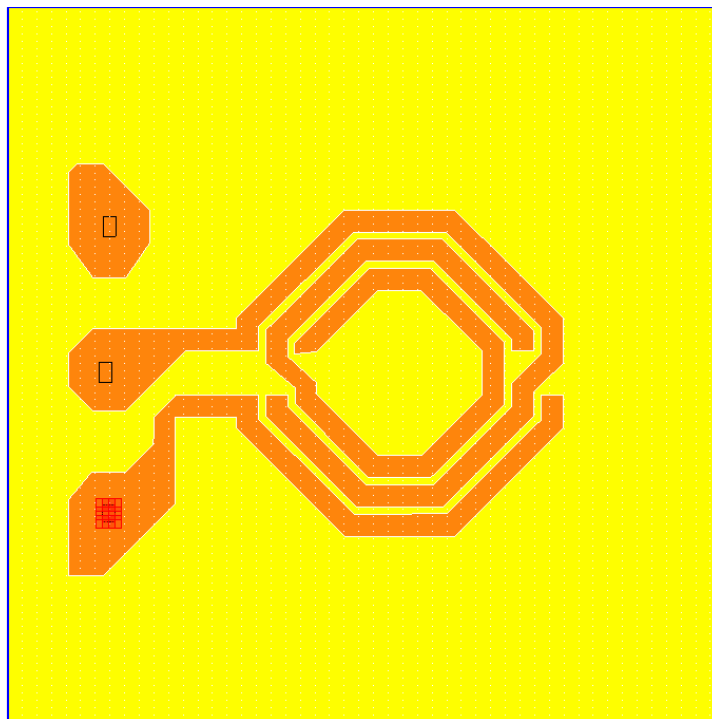
Fig. 10 There are 3 contacts to excite the structure. The contacts are located at the left side of the structure. The contacts are G2 (top-left) S1 (middle-left) and G1 (bottom-left). See Fig. 11.
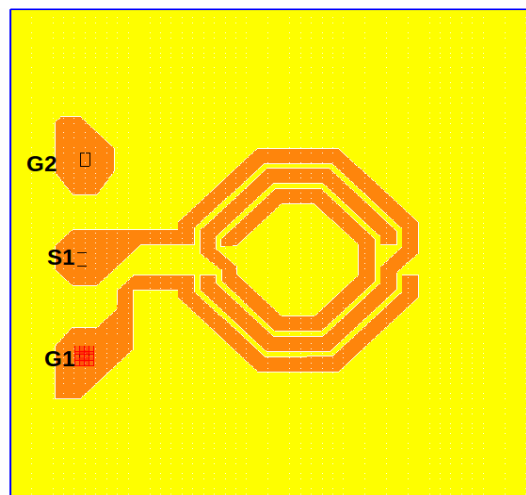
Contact set up

Fig. 11 contact names and their location.

Besides moving the structure more centered in the simulation domain, we also approximate the shield by a plane cut in 4 segments (Fig.12).
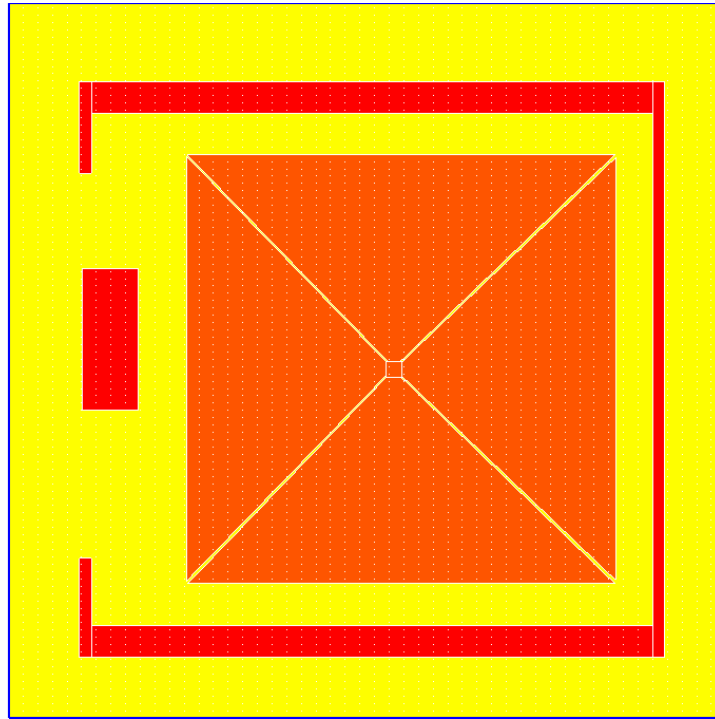
Fig. 12 Approximation of the shield by plane cut in 4 segments.

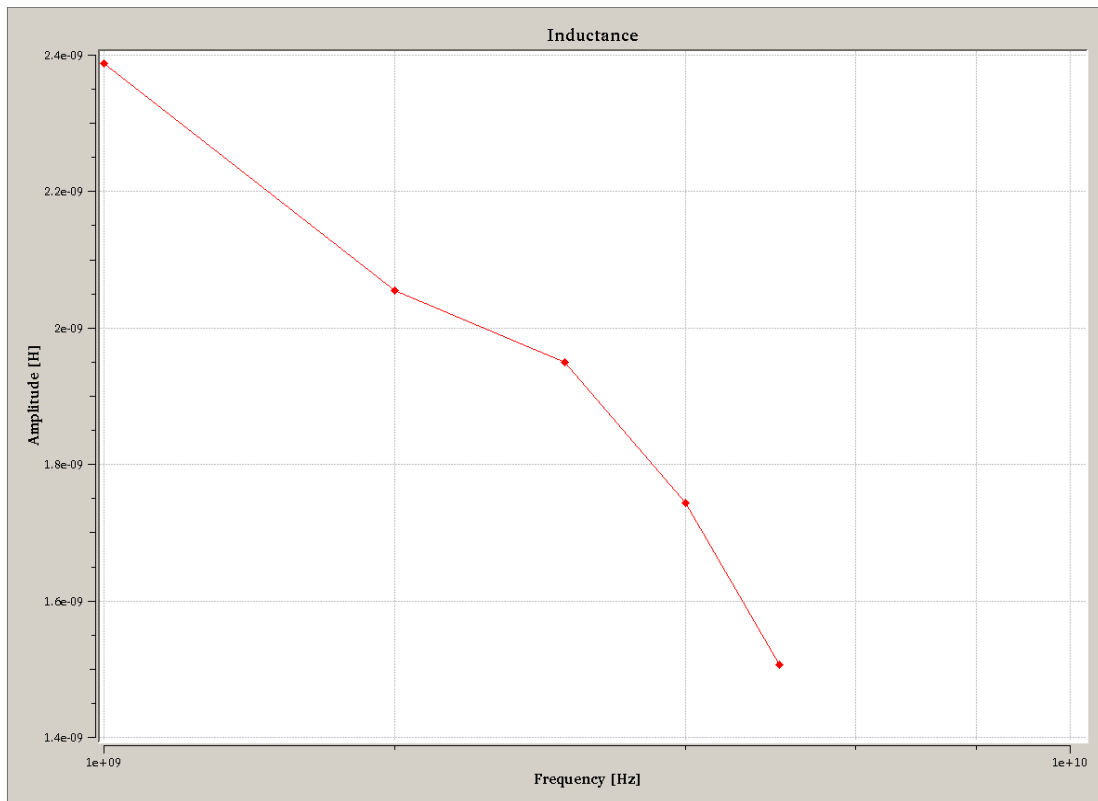The results of the simulation for L,Q and R are shown in Fig. 13, 14 and 15.
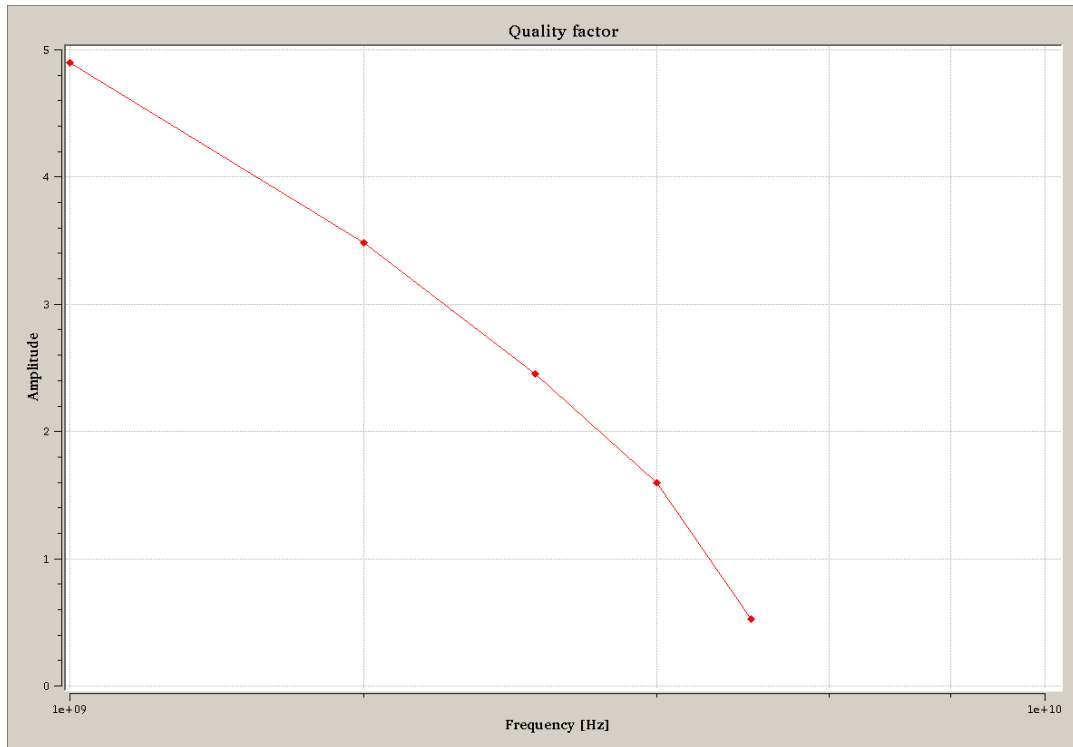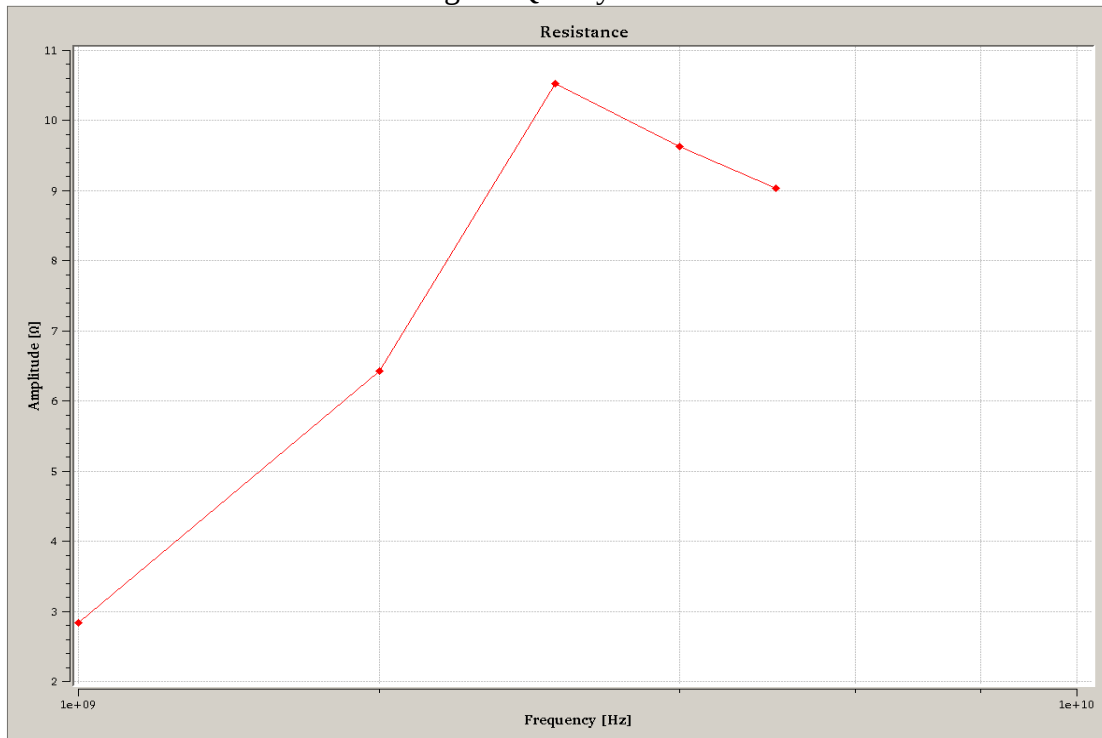

Fig 13. Inductance plot

Fig. 14 Quality factor.

Fig. 15 Resistance plot.

Simulations – third run

This set up will do the compact model extrantion in a *1-port* set up.

The 1-port S-parameters are

!S-parameter file generated by solvEM, http://www.magwel.com
HZ S RI R 50
!freq ReS11 ImS11
1000000000 -0.757836222616 0.49053566489
2000000000 -0.369564946793 0.691575385147
3000000000 0.0159481556509 0.67817229115
4000000000 0.335199312988 0.497752761972
5000000000 0.530816601116 0.186204572205

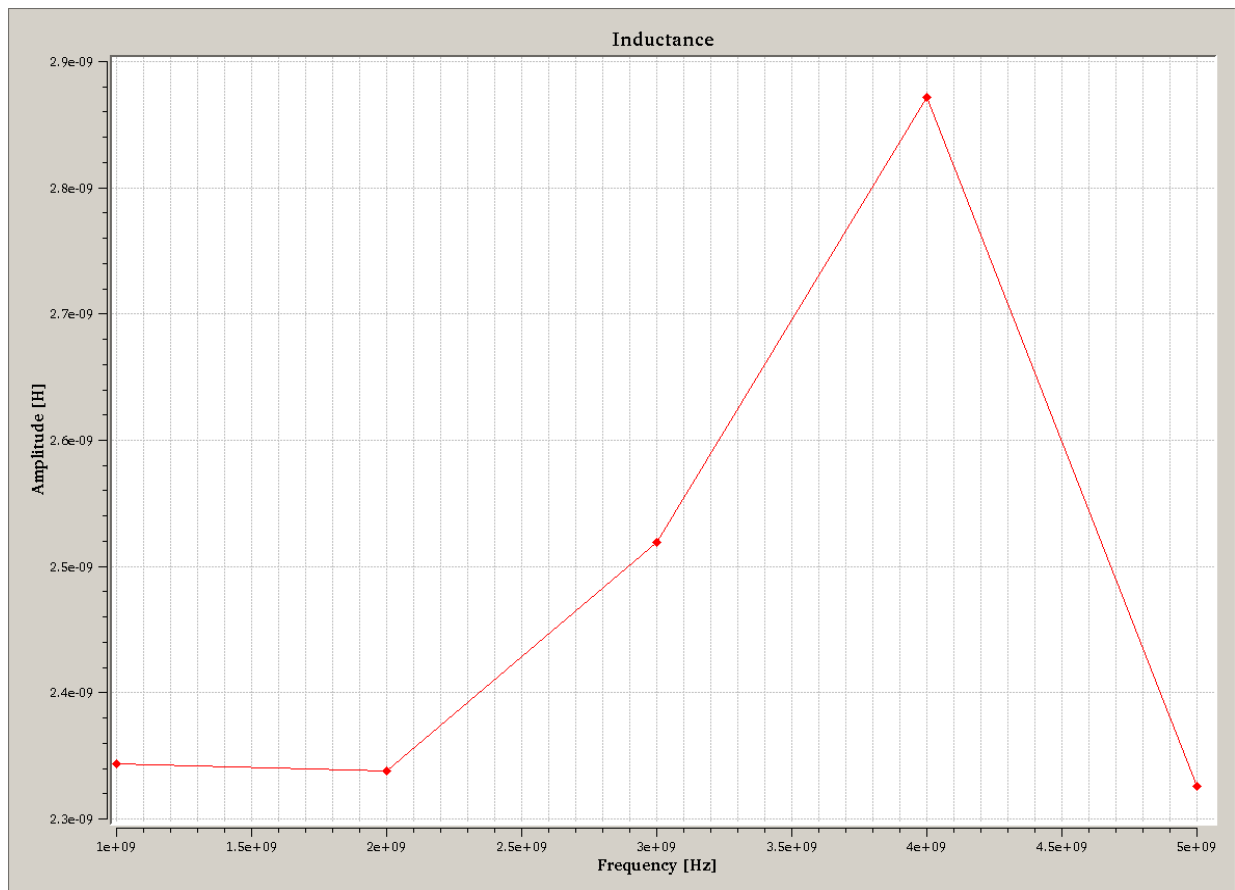The L,Q,R plots are given in Fig. 16,17 and 18.
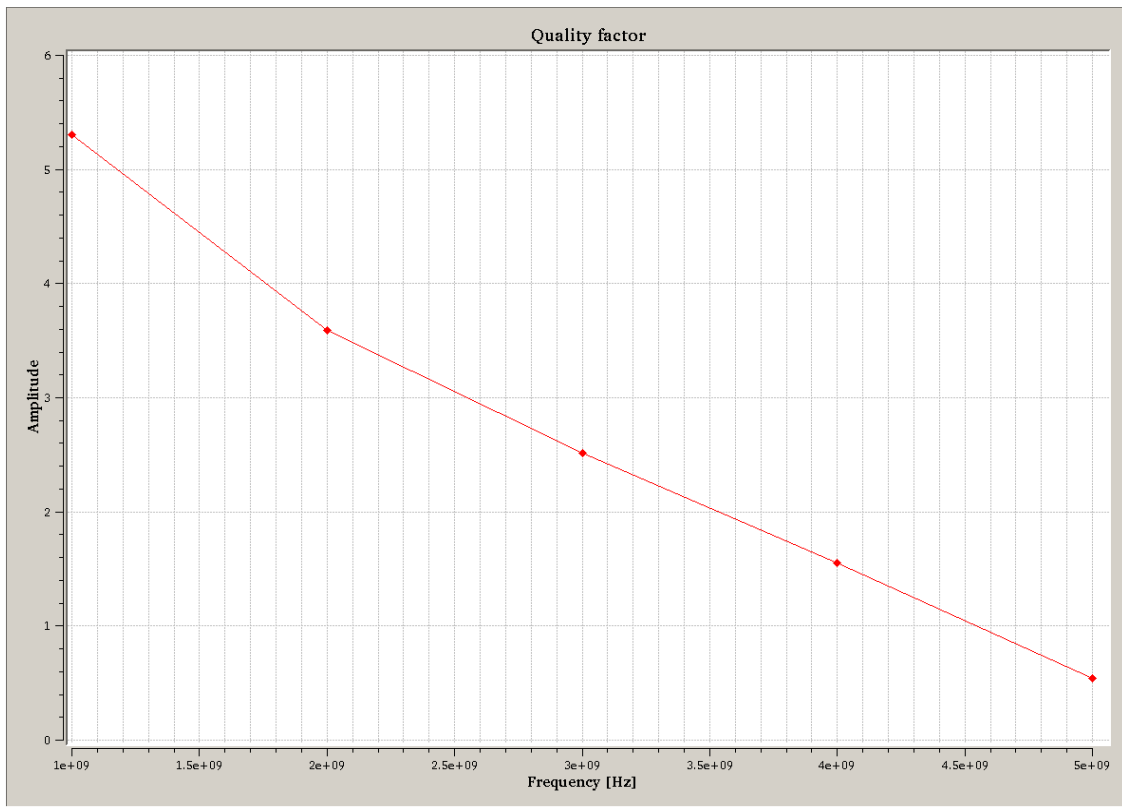

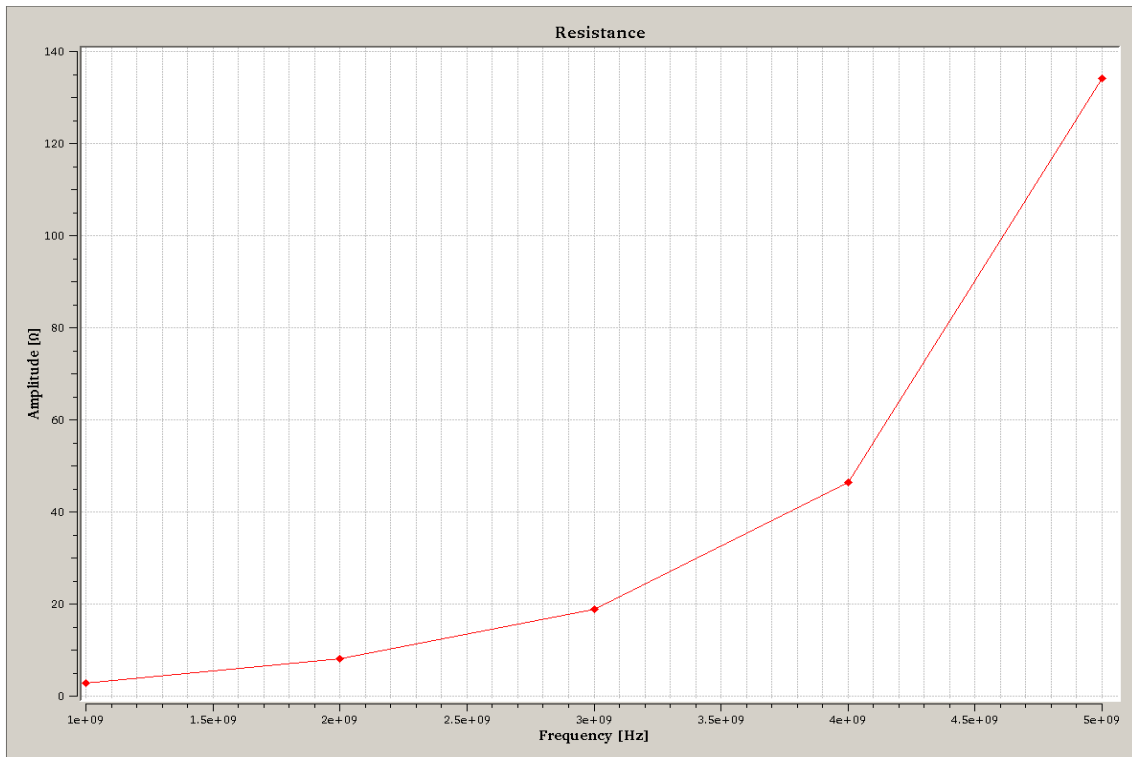Fig.16 L-plot 1-port analysis

Fig. 17 Q plot 1-port analysis

Fig. 18 R-plot 1-port analysis

Static parameters

We also performed a static field analysis. This resulted into the following values

R = 0.432 Ohm
L = 2.387 nH
C = 0.405 pF