A Circuit Extraction Tool for Full Custom Designed MEMS Sensors

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In MEMS sensor design, there is a maximum demand for robustness and reliability as well as ambitious requirements for cost reduction which include mainly more area reduction. To comply with these conflicting objectives, it is necessary to make extensive use of all available degrees of design freedom. This level of optimization requires a polygon based design approach. It cannot be achieved with today's library-based MEMS design approaches due to the limited precision of their component models. In consequence, geometry and net information of a sensor are only given by polygons and text labels.

Additional problems arise from the fact, that the mechanical MEMS core can only be electrically connected at its bottom side. Therefore the wiring is realized in a conductive layer under the MEMS core, which leads to serious parasitic RC effects. Hence, the parasitic electrostatic RC effects have to be analyzed and optimized in detail during the design phase. This requires an exact understanding of which parasitic value corresponds to which topology element (e.g. spring, mass, ...) of the sensor. Unfortunately, this is in conflict with the polygon based design strategy which does not provide any information about the topology elements of the sensor. So commercial parasitic extraction tools can only analyze the entire MEMS structure as a black box which contains only the polygons of the sensor. The extracted circuit is reduced to the coupling capacitances between the nets defined by the external contact pins of the sensor. Figure 1 shows the extracted circuit of an acceleration sensor, which has three external pins. The extracted circuit neither contains any information about the sensor topology elements nor a geometrical mapping between the extracted capacitances to the sensor polygons.

A precondition of a detailed electrostatic analysis is a structure recognition of the sensor's topology elements, derived from the polygon representation of the sensor. Based on this a commercial parasitic extraction tool can analyze the extracted lumped elements.

Our tool is able to extract a circuit out of a MEMS sensor designed in a polygon based design flow. The key feature of this tool is a rule based structure recognition algorithm which identifies sensor topology elements, starting from an user defined initial segmentation. Thereafter, the electrostatic RC-extraction is performed by a commercial field solver.

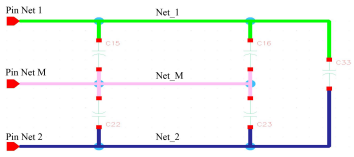

Fig. 1. Black box parasitic extraction of an acceleration sensor.

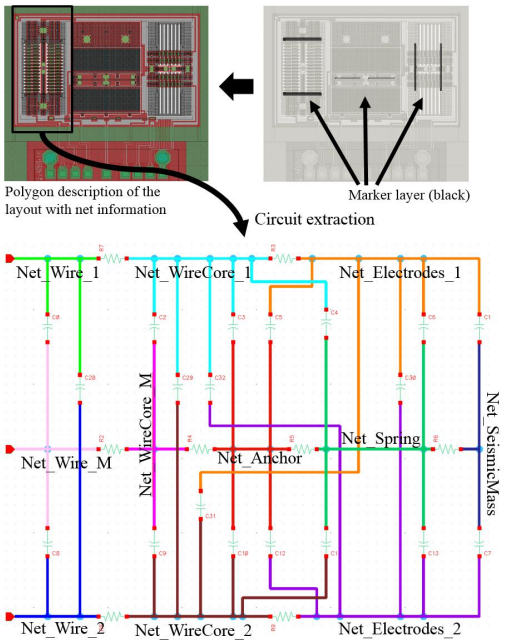

Fig. 2. Circuit extraction of the x-core of a three-axis-acceleration sensor designed by the Robert Bosch GmbH.

The identified sensor topology elements are represented by additional nets in the extracted circuit. So there is a geometrical mapping between the extracted capacitances and the sensor polygons (Fig. 2). The extracted lumped elements now correspond to the topology elements of the sensor and can be used for further simulation and optimization tasks during the design phase.

This work has been developed in the project RoMulus (project label 16 ES 0363) which is partly funded within the Research Program ICT 2020 by the German Federal Ministry of Education and Research (BMBF).