Using of High-end Design Tools in Education

Kay Hammer, Steffen Heinz, Hendrik Zeun, Gunter Ebest
Chemnitz University of Technology, Faculty of Electrical Engineering and Information Technology,
Chair Electronic Devices

1 Introduction

Analogue circuits are essential components of integrated circuits. Nowadays, most integrated circuits are prepared in CMOS technology. Advantages of CMOS circuits are lower power loss and favourable manufacturing costs according to bipolar circuits. For this reason, the later introduced practical training is based on a CMOS process.
Simultaneous to the growing scale of integration a lot of new applications are opened. At the same time, the desire for short development times and savings in sophisticated test circuits is growing. For integrated analogue circuits the selection of an appropriate production process is very important also. Statements about the efficiency of a designed circuit are only possible with the help of prototypes produced in the same process scheduled for serial production.
The design of these circuits is performed with the help of design tools like MENTOR and CADENCE. For students, who are working as an integrated circuit designer later, it is important to understand the context between theoretical knowledge of circuit design, production process and the influence of specific layouts. The knowledge about working with a design software is means for the purpose only.

2 Integrated Analogue Design Flow

During a design flow, many decisions influence characteristics of the design. One aim of the practical training is the understanding of these coherences. Fig. 1 shows a typical design flow for integrated circuits. In the practical training, students are responsible for all design steps.
The first task in the integrated circuit design is a draft of the circuit (design specification). Hereby, function and performance of the circuit are defined. After this step, the calculated transistor dimensions and the chosen design process form the design specifications. These include restrictions like the allowed power loss, the supply voltages and other technology parameters. Afterwards, the draft has to be feed into the design tool as a netlist (schematic entry). In general, netlists are created with the help of the design tool through a graphical editor. The resulting netlist is used in the next step of the design flow. With a first simulation of the circuit, the properties and functionality of the designed circuit can be confirmed. Dependent on the circuit, different simulators for analogue, digital or mixed signal applications are available. After the first simulation, one can change some circuit parameters like transistor dimensions to improve the circuit parameters. Understanding and testing the circuit with suitable test circuits is an important part of the practical training too.

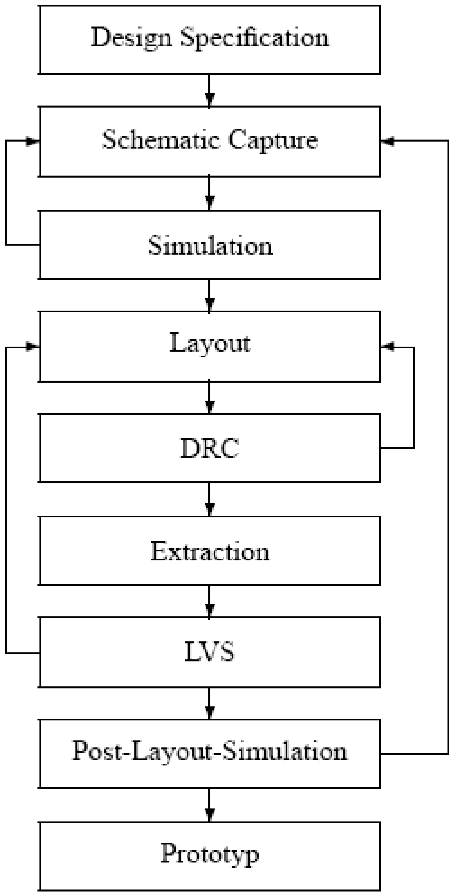

Fig. 1: Integrated Circuit Design Flow

Using a layout editor, one feeds the positions and dimensions of each circuit element into the design tool. For integrated analogue circuits, the

layout, determining the circuit's efficiency, is a very important step during the design flow.
The layouts of circuits have to fulfil many restrictions. Their number depends on the process. The design rule checker (DRC) checks the layout whether the rules are fulfilled or not. If there are any rule violations, they are listed.
Afterwards, one has to compare the layout with the netlist of the schematic capture. For this reason, the design tool extracts a netlist from the layout. Additional information about parasitic elements like parasitic capacities is extracted also.
Now, the layout versus schematic checker (LVS) checks whether the two netlists represent the same circuit or not. Anyway, this tool allows no statement about the performance of the circuit.
Afterwards, the electrical characteristics of the layout are simulated during the post layout simulation. Because of the more detailed netlist with included parasitic elements, the results of this simulation allow a good prediction about the real circuit. Restrictions in the performance of the simulator are the used non ideal models.
After a satisfying simulation result, the designed circuit can be produced as a prototype.

3 High end design tools in a practical training

Nowadays, it is very important for students to be trained with the same design tools used in industry. For a prospective employee as an analogue designer, the relation between layout and performance of a circuit has to be trained. For this reason, an early practical training with a high-end design tool like CADENCE is advisable.
During the practical training, the students have to be responsible for the complete design flow. It is important to demand and support an autonomous work of the student. A possible task is the design an operational amplifier with a specific performance. The demands for a good slew rate or a rail to rail output stage are possible optimising criteria.
The first step will be the design specification. Beginning with a simple two stage amplifier, students have to get into the operation of the design tool.
During the design flow, students will improve the first circuit to fulfil the given requirements. By adding a nulling resistor and an AB output stage like shown in Fig. 2, the simulation results will improve (Fig. 3). It is important that the students have the ability to try things out on their own to get a sense how to get the best design results.

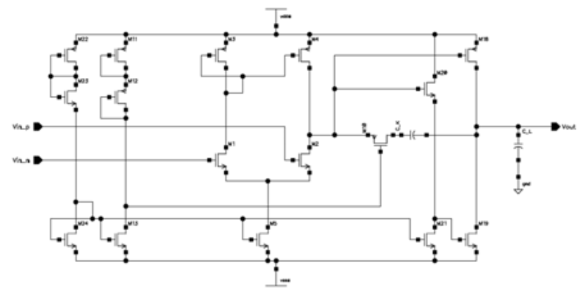

Fig. 2: Two Stage Amplifier with AB Output Stage

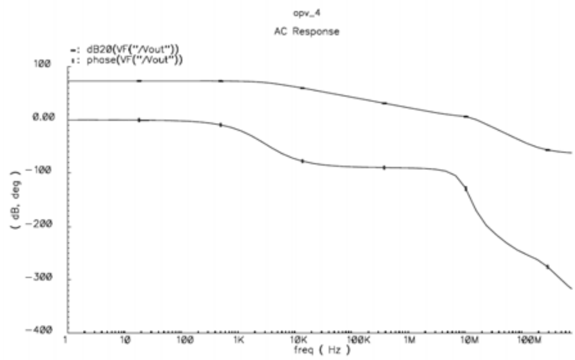

Fig. 3: AC Response of the Circuit from Fig. 2

The most important part of the practical training should be the layout. For good results, the students need an experienced instructor and a good knowledge about mask layout. The practical training can help to understand the effects of reducing serial resistance of the circuit elements, the importance of dummy elements and the design of protective circuits.

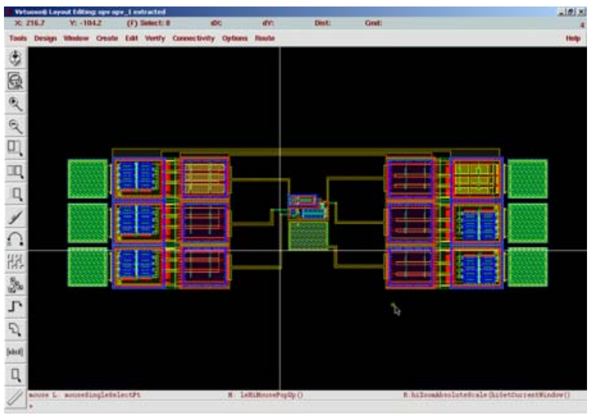

Fig. 4: Complete Layout with Protection Circuits

After the complete design flow, including many iteration steps to get the best design results, the students have designed their first own circuits (Fig. 4). A post layout simulation now gives a good prediction of the performance of the designed circuit.

Now, the possible production of a prototype enlarges the possibilities of a practical training. The students have already designed test circuits to prove the performance of their designs. With real hardware, the students can compare simulation results with measurement results.

4 Conclusion

A practical training with a design tool like CADENCE is very attractive for students. Beside the necessary licence for the design software, it is important to have an up-to-date design kit (high performance interface tool kit) from a semiconductor manufacturer. The higher expenditure in preparation and realisation the practical training results in a better understanding of analogue circuit design by students.

5 References

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