



Doctoral Thesis

Analogue four-quadrant multiplier in CMOS technology

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ANALOGUE FOUR-QUADRANT MULTIPLIER
IN CMOS TECHNOLOGY

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SWISS FEDERAL INSTITUTE OF TECHNOLOGY
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presented by

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Abstract

This thesis deals with the design, fabrication and analysis of new CMOS analogue-four-quadrant-multipliers. Such multipliers are useful in integrated circuits for signal filtering, modulation, and A/D and D/A conversion.

Prior to the presentation of the new multipliers, an overview will be given over the history of the development of analogue multiplier integrated circuits.

The CMOS multipliers developed in this thesis are based on MOS transistors operating in saturation, where there exists a quadratic relationship between the gate-source voltage and the drain-source current. According to this principle, three kinds of multipliers have been devised and realized in CMOS technology. They are the multiplier with resistors, the multiplier with switched capacitors and the multiplier consisting of MOS transistors only. These integrated multipliers have great dynamic ranges at their inputs extending almost to the supply voltages and a good linearity, but the output voltages are strongly dependent on the manufacturing process and temperature. Two improved circuits, namely the multiplier-divider with resistors and the multiplier-divider with switched capacitors which use active feedback techniques allow output voltages that are quite independent of the manufacturing process.

Another type of multiplier relies on lateral bipolar transistors with an exponential relationship between the emitter-base voltage and collector current. Their utilization of lateral bipolar transistors is consistent with MOS technology. This multiplier has a high precision. The distortion is smaller than 0.5% even when the input voltages are as large as one third of the supply voltages. Offset voltages are small ranging between zero and 50mV.

Details about CMOS process including process simulation by the computer program "SUPREM", the layout rules and performance data of the basic elements, namely the resistors, capacitors, MOS transistors and operational amplifiers complement this thesis.