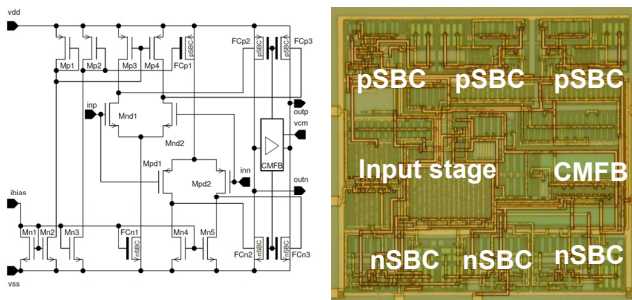
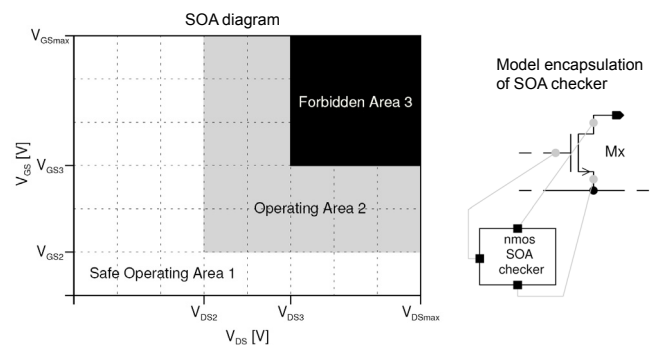
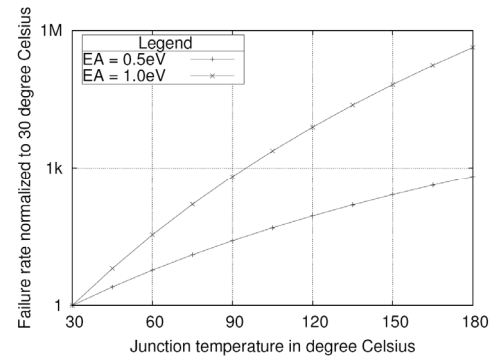


# Verification of Safe Operating Area (SOA) Constraints in Analog Circuits

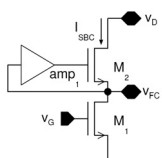
Udo Sobe, Karl-Heinz Roach, Dietmar Mörtl, Achim Graupner, André Lerch, Michael Pronath

Simulation of degradation effects of aging (e.g. negative bias temperature instability (NBTI), hot carrier stress (HC)) have been a topic of research for nearly two decades. These reliability models and corresponding simulation techniques are not yet widely available in current process development kits (PDK) and design flows. In general, process documentation contains information about safe operating areas (SOA) such as maximum current and voltage stress of the devices. The challenging lifetime standards of today's circuits for automotive and industrial applications are in the range of about 10,000 hours and about 100,000 hours respectively. Therefore, to ensure such a lifetime for high voltage and high temperature applications, the design development is using conservative techniques for design for reliability (DfR), like safe operating areas (SOA). Such DfR methods have to be continuously available for three circuit development phases: manual design, automated verification and tool supported optimization. Here the support by the process development kits (PDK) of the FABs and their adaption to the design flows by special departments inside a design center is important to make such methods and tools useful for circuit development.

	Criteria	Manually Defined Expression	Model Encapsulation	Simulator's built-in Device Check	Constraint Matrix
	Basis	Calculator Expression	HDL script	Spectre Assertion	WiCkeD Constraining
Application	Design	✓	✓	✓	
	Verification	✓	✓	✓	
	Optimization	✓			✓
Analysis	Results format	Cadence database	Log file	Cadence database	WiCkeD database
	Manual	ADE WF/Calc	Log file	ADE VD/Calc	WiCkeD
	Automatic	Calc/Ocean/Skill	Log parser	Calc/Ocean/Skill	WiCkeD internal

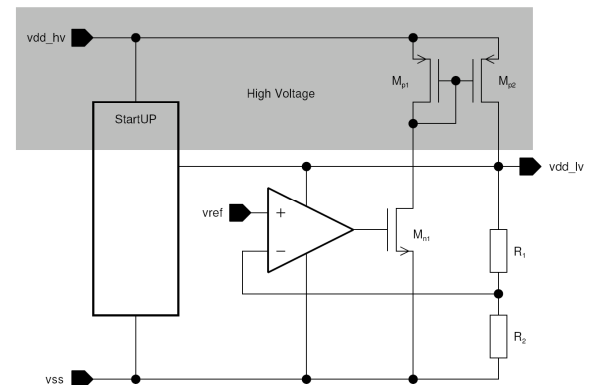


Simplified schematic and chip photograph of a fully differential folded cascode OTA



Self-biasing cascode with corresponding SOA constraints.

	geometrical	electrical
function	$L_1=L_2$	$V_{gs}-V_{th} > V_{limin}$ $V_{ds}-(V_{gs}-V_{th}) > V_{satmin}$ $ V_{ds,1}-V_{ds,2}  < V_{diffmax}$
robustness	$L > L_{min}$ $W > W_{min}$ $L*W > A_{min}$	
reliability		$V_{ds}-(V_{gs}-V_{th}) < V_{satmax}$



Voltage regulator circuit. High-voltage part is marked grey.

## About ZMD

Founded in 1961, ZMD AG is a leading supplier of analog and mixed-signal integrated circuits (ICs) for automotive, medical, and industrial applications. ZMD specializes in the design and marketing of high temperature, high voltage and ultra low power application-specific integrated circuits (ASICs) and application-specific standard products (ASSPs). Its advanced circuit-design expertise allow it to offer ICs with operating temperatures as high as +160°C, and voltages from as low as 0.85 V up to 40 V. Headquartered in Dresden, Germany, ZMD has 250 employees worldwide and serves customers from the company's offices in Melville, New York; Stuttgart, Germany; London, England; Paris, France; Tokyo, Japan and Hsinchu City, Taiwan. ZMD has design centers in Dresden, Stuttgart, Melville and Madison, Wisconsin. ZMD's product portfolio demonstrates the company's expertise in the four segments: automotive, medical, sensor signal-conditioning and standard analog & mixed-signal.

## About X-FAB Silicon Foundries

As the world's leading foundry group for mixed-signal semiconductor applications, X-FAB creates a clear alternative to typical foundry services by combining solid, specialized expertise in advanced analog and mixed-signal process technologies with excellent service, a high level of responsiveness and first-class technical support. These key elements allow X-FAB to optimally manage the flow of product development and the supply chain for its customers' semiconductor products. With its five manufacturing sites in Germany, Malaysia, the UK and the USA, X-FAB has a combined capacity of around 70,000 eight inch equivalent wafer starts per month and employs around 2,600 employees worldwide. Sales representatives in major countries in Asia, Europe and in the USA ensure that we stay in close contact with our customers all around the world.

## About MunEDA

MunEDA provides leading EDA technology for analysis and optimization of yield and performance of analog, mixed-signal and digital designs. MunEDA's products and consulting enable customers to reduce the design times of their circuits and to maximize robustness and yield. MunEDA's solutions are in industrial use by leading semiconductor companies in the areas of communication, computer, memories, auto-motive, and consumer electronics. WiCkeD is a comprehensive and powerful software tool for interactive, manual, semi- and fully automatic analysis, sizing, design centering and yield optimization of analog and mixed signal circuits.

