

# ZMD-ZFoundry Circuit Design-for-Yield (DFY) using WiCkeD: 110dB Op-Amp for Automotive and Sensor Applications

The scope of this reference case is to show how tools for analog design automation can assist a modern topology design on the example of a High Gain Operational Transconductance Amplifier (OTA). The design method involved a combination of topology improvements and yield optimization by utilizing the tools zmdAnalyser and WiCkeD. The circuit design was sized interactively for an exhaustive analysis of a hierarchical circuit as well as to understand limitations of different circuit topologies. Finally a topology with a high simulated parametric yield could be achieved.

The OTA is designed for ZMD's 0.6µm standard CMOS technology. The design contains about 130 active devices and measures 300x300µm<sup>2</sup>. Taking into account process variation, mismatch, the large automotive temperature range and a supply voltage range of 5V ±10%, a dc gain of more than 110dB and a unity-gain frequency greater than 50MHz for a 9pF load were achieved. The settling time is less than 100ns with an accuracy finer than 0.01%. The consumed supply current is about 2.5mA.

## OTA Circuit Description, Flow & Results\*

Main Steps	Applied Tools
Feasibility of Main Topology	<b>Feasibility Optimization (FO):</b> satisfy all saturation constraints inside the SBCs. <b>Deterministic Nominal Optimization (NO)</b> on variation of the topology showed that high gain specification can also be achieved with fewer SBC, and that most SBCs can be sized identically.
Optimization of the SBC sub-blocks	<b>NO, FO:</b> Find essential saturation constraints and sensitivities to parasitics.
Optimization of Main Circuit	<b>NO, FO:</b> Improve circuit parameters, detect instability of CMFB loop.
Yield Analysis and Yield Optimization	<b>Monte Carlo analysis (MC)</b> showed yield down to 30%. Improvement was realized by additional RC filter inside the CMFB. <b>Yield Optimization (YO)</b> to improve the setting time, focusing on the input stage.
Final centering, rounding and verification	<b>YO</b> on all performance parameters including operating conditions. Design parameters were adjusted to technology grid and the performance was checked by <b>MC</b> and <b>Worst-Case Diagnosis (WCD)</b> to estimate yield.

\* Detailed results published at ANALOG2006 Conference in Dresden

- zmdAnalyser is a verification environment driven by analog/mixed signal designers
- standard analyses (e.g. corner, Monte Carlo) are improved and expanded e.g. parametric corner/MC analysis, automatic corner generation, output protocol (cpk), trimming analysis, ...
- the optimization flow of WiCkeD completes our design flow by modern optimization algorithms
- for this example the zmdAnalyser was used to estimate parametric yield, analyze sensitivity and mismatch ... document results and finally to check topology changes

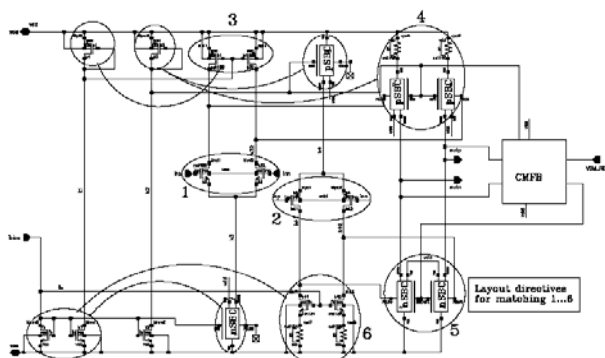
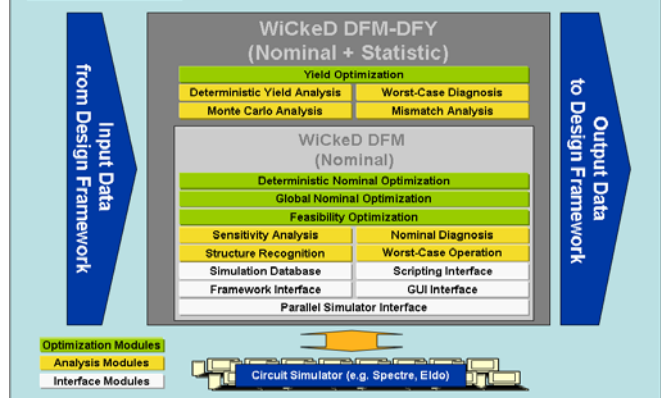


Figure 1: Simplified schematic of the fully differential folded cascode OTA

## WiCkeD Features



Performance	Specification	Result
DC Gain	> 110dB	✓
Settling time	< 100ns	✓
Settling time error	< 0.01%	✓
Area	300 x 300 µm <sup>2</sup>	✓
Load Capacitance	3pF ... 9pF	✓
Temperature	-40°C ... +150°C	✓
Yield Prediction	> 98%	✓

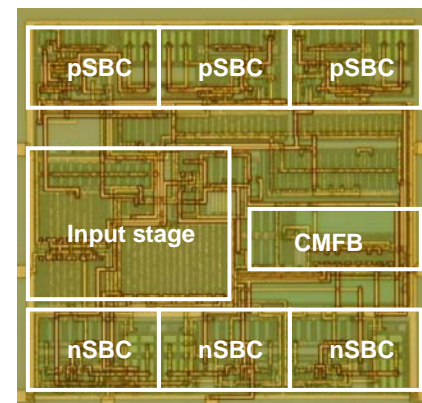


Figure 2: Chip photograph of the realized OTA

### About ZMD-ZFoundry

Founded in 1961, ZMD AG specializes in the expert design, production, and marketing of mixed-signal application-specific integrated circuits (ASICs) and application-specific standard products (ASSPs) for automotive, industrial, and medical applications. Focused on high-precision signal conditioning and high-performance wireless communication, ZMD ensures an integrated foundation for robust sensor networks. With corporate headquarters in Dresden, Germany, ZMD also services customers from offices worldwide including: Melville, NY; San Diego, CA; Santa Clara, CA; Stuttgart, Germany; London, England; and Taipei, Taiwan. For more information, please visit the ZMD and ZFOUNDRY web site at [www.zmd.de](http://www.zmd.de) and [www.zfoundry.com](http://www.zfoundry.com).

### 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, automotive, and consumer electronics. WiCkeD is a comprehensive and powerful software tool for interactive, manual, semi- and full automatic analysis, sizing, design centering and yield optimization of analog and mixed signal circuits. WiCkeD is marketed also under the trademark DesignMD®.