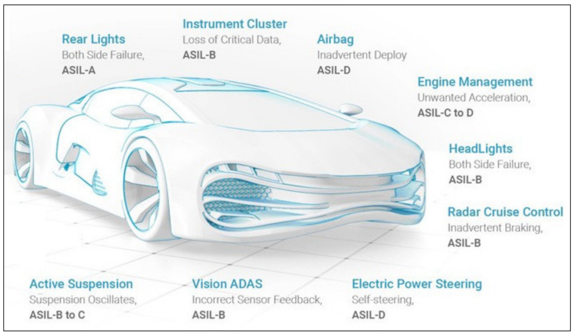
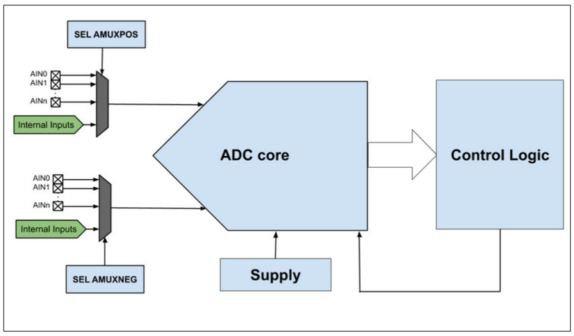
Leonz Bamert

Graduate Candidate	Leonz Bamert
Examiner	Prof. Guido Keel
Co-Examiner	Robert Reutemann, Miromico AG, Zürich, ZH
Subject Area	Sensor, Actuator and Communication Systems
Project Partner	Microchip Technology Norway AS, Trondheim, Norway

Functional safety in analog integrated circuits for automotive applications



Automotive Safety Integrity Levels (ASIL) of different automotive systems
https://www.synopsys.com/automotive/what-is-asil.html



ADC connectivity within the microcontroller
Own presentment

Circuit	$M_{SPFM,Opt}$	$M_{SPFM,Pes}$	M_{LFM}	$M_{PHFM,Opt}$	$M_{PHFM,Pes}$
AMUX	97.4%	49.4%	100%	$5 \cdot 10^{-7}$ FIT	$1 \cdot 10^{-5}$ FIT
ADC core	90%	28.3%	NC*	$6 \cdot 10^{-4}$ FIT	$4 \cdot 10^{-3}$ FIT

*Not considered

Evaluated optimistic (Opt) and pessimistic (Pes) values for the ISO 26262 metrics of the AMUX and the ADC core
Own presentment

Introduction: Today's cars are equipped with an ever-growing number of assistance systems. Especially around advanced driver assistance systems, there is currently an evolution taking place. This evolution leads to more autonomous systems, which should make driving more comfortable and safer. However, to ensure the proper function of these ever more complex systems, functional safety is fundamental. Traditionally, functional safety has been addressed by car manufacturers. However, as more and more systems on a chip are being used in cars today, functional safety is becoming an issue for chip manufacturers as well. For these, functional safety in the digital domain is already well-known and well supported within the design tools. In the analog and mixed-signal environment, where according to a study by Mentor, close to 80% of the breakdowns in today's mixed-signal ICs occur, these techniques are not that well integrated yet.

Objective: This thesis focuses on providing an insight into the functional safety area in the analog and mixed-signal domain. In the course of this project, a software tool is evaluated, that can inject faults and generate ISO 26262 compliant reports. Then an analog component out of an 8-bit microcontroller is modified with safety mechanisms and its compliance with the ISO 26262 standard is evaluated.

Conclusion: A 12-bit successive approximation register Analog to Digital Converter (ADC) was selected for the functional safety modification. The ADC with the corresponding analog multiplexers (AMUX) for the input signal selection was modified with four safety mechanisms. The ISO 26262 metrics were then analysed with a fault injection campaign carried out with the evaluated CustomFault® tool from Synopsys®. In the fault injection campaign, mainly random hardware failures with open and short faults of MOSFETs, resistors and capacitors were considered. The ADC was only simulated at the nominal corner to reduce the fault injection campaign setup and simulation time. This approach resulted in that the final metrics can differ from the evaluated ones. To account for this uncertainty, an optimistic and pessimistic value for the metrics was introduced. When considering the optimistic metrics, the modified circuit would be ASIL B compliant, while in the pessimistic case, no compliance level would be reached. In order to finalise the compliance report, further investigations into the operating corners must be carried out. Overall, the modified ADC became more resilient against the considered random hardware failures.