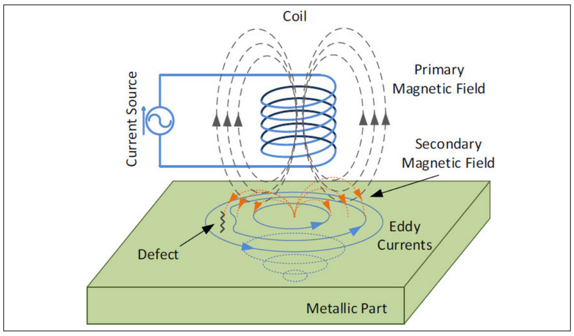
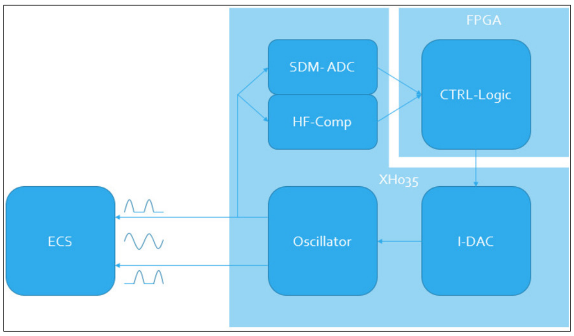
Student	Alex Braun
Examiner	Prof. Dr. Paul Zbinden
Subject Area	Sensor, Actuator and Communication Systems

Versatile Eddy Current Sensor Frontend ASIC



Eddy current sensor working principle
Ruben Filipe Daniel Abrantes, Master Thesis, Técnica Lisboa



Top-level blockdiagramm of the designed eddy current sensor frontend
Own presentment

Introduction: Eddy current sensors are non-contact, non-destructive testing probes using magnetic fields to detect materials, material flaws or measure distance with high precision. This is done by measuring the change of the complex impedance of an eddy current sensor probe. The aim of this project is to design a versatile eddy current sensor chip interface to be used with different eddy current sensor probes of variable impedance and operating frequencies. It should be able to measure the parallel resistance and inductance of a single coil eddy current sensor probe.

Approach / Technology: A study on existing single-ended eddy current sensor interfaces has led to a new approach using closed loop current control. The presented topology has been confirmed in a continuous-time high-level simulation. Optimal topologies for the different system blocks have been selected. Using mixed-simulation tools, an ASIC in a 350nm process was designed. It consists of a 6 bit thermometer current digital-to-analog converter, a cross-coupled differential transconductance oscillator, a 16 bit sigma-delta analog-to-digital converter and a digital control unit. The blocks were tested in separate testbenches for proper operation.

Result: The topology derived is simple, but it solves two problems with commonly available technologies. Using a closed loop current control to regulate the amplitude of the resonant circuit, it is able to react to impedance changes of 62 times the minimal real impedance of the eddy current sensor probe. The measurement of the equivalent resistance is independent of the resonant frequency of the eddy current sensor probe. The design was tested for sensor probes with an equivalent parallel resistance between 2kΩ and 100kΩ as well as for resonant frequencies from 3.5MHz up to 35MHz. No hard- or software reconfiguration is needed to fulfill the sensor range.
The presented work is able to measure differences in resistive load impedance with a resolution of up to 16 bit. It achieves this by selecting an ideal oscillator current and oversampling.