COBROS (Calibration and Operation Based on ROtational Symmetry)

FPGA implementation of a fast and accurate rotary encoder

Graduate Candidates

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Introduction: Rotary encoders are, like every other device, subject to non-ideal behaviour: mechanical imperfections, cross talk of coils etc. distort the sensor values. In order to detect those influences, the companies NM Numerical Modelling GmbH from Zug and maglab AG from Basel came up with the patented COBROS[1] algorithm that can compensate these influences and end up with an accurate angle signal.

Approach / Technology: In cooperation with maxon, the algorithm was implemented in an embedded system. The solution turned out to be slow, due to the sequential workflow of a microcontroller, the processor could only read one sensor at a time. This in turn created a time lapse and an information void, leading to unreliable results. Those issues could be addressed by using an ASIC[2] instead, which can parallelise many of the previously sequential tasks. As a first step in this direction, the algorithm shall be implemented on an FPGA[3].

Result: During the thesis, a functioning demo setup was produced. The result is a specialised hardware with the ability to communicate with a PC to exchange calibration data. The resource-demanding mathematical concepts such as matrix multiplication were implemented by utilising minimal hardware, while still reducing the processing time owing to the FPGA's nature.
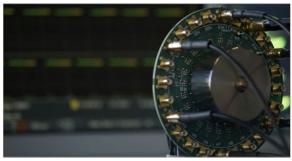
Measurements showed that the implemented COBROS algorithm is well within most desired specifications: less than 2° angle deviation were requested, depending on the configuration, as few as 0.57° were achieved. Only the target of a jitter value of less than 1 LSB was not surpassed, the measurements lie between 0.7 and 1.3 LSBs. The analysis of the output data showed, however, that this can likely be resolved with a reasonable amount of additional hardware.

1. Calibration and Operation Based on ROtational Symmetry
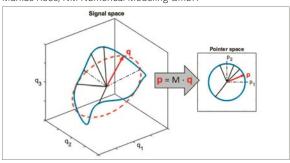2. Application-specific integrated circuit
3. Field-programmable gate array

Motor used in demo setup. The cables are directly linked to the position sensors which are evaluated by the FPGA.
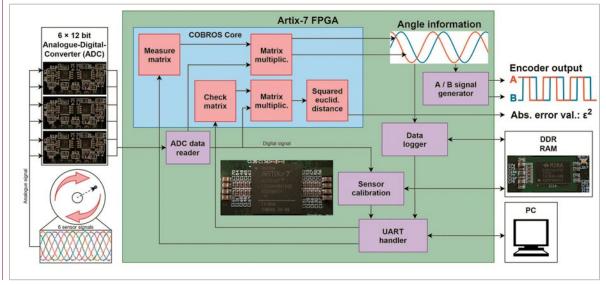Own presentment

COBROS: Distorted measurements (blue) from 3 sensors (q_n) get mapped onto the calibration (orange) circle.
Markus Roos, NM Numerical Modeling GmbH

The final implementation of the algorithm, the communication and its data, which can be saved on a DDR RAM are depicted.
Own presentment

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Subject Area
Microelectronics

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