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# **Applications of Embedded Sensors in Loader Crane Positioning and Rotor RPM Measurement**

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## **AKADEMISK AVHANDLING**

För avläggande av filosofie doktorsexamen vid fakulteten för naturvetenskap, teknik och medier vid Mittuniversitetet, Campus Sundsvall, som offentligen kommer att försvaras i sal O111 , fredagen den 9, december 2011, kl 09.00.

Opponent är Prof. Dr. Arno Ruckelshausen, lärosäte Hochschule Osnabrück, Tyskland

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## **Abstract**

In this thesis, two novel applications involving embedded sensors are studied, one dealing with loader crane positioning and the other involving rotor Revolutions Per Minute (RPM) measurement. The thesis presents a general introduction to the embedded sensor, its architecture and its use in mechanical industry, and provides the reader with an overview of conventional sensor technologies within the fields of angle sensors and angular speed sensors, covering their working principles, features, advantages and disadvantages and typical applications. The particular problems associated with the use of conventional sensors in both loader crane positioning and rotor RPM measurement are described and these problems provided the motivation for the designs of the embedded sensor systems developed in this thesis.

In the case of the loader crane positioning, the origins of the project and the special requirements of the application are described in detail. In addition, a preliminary study is conducted in relation to the idea of a contactless joint angular sensor using MEMS inertial sensors in which four different methods, namely, the Common-Mode-Rejection with Gyro Integration (CMRGI), Common-Mode-Rejection (CMR), Common-Mode-Rejection with Gyro Differentiation (CMRGD) and Distributed Common-Mode-Rejection (DCMR), are conceived, modeled and tested on a custom-designed prototype experimental setup. The results gathered from these four methods are compared and analyzed in order to identify the differences in their performances. The methods, which proved to be suitable, are then further tested using the prototype sensor setup on a loader crane and the performance results are analyzed in order to make a decision in relation to the two most suitable methods for the application of the loader crane positioning. The results suggested that the two most suitable were the CMRGD and the DCMR. The practical design issues relating to this sensor system are highlighted and suggestions are made in the study. Additionally, possible future work for this project is also covered.

In the first case for the rotor RPM measurement, the thesis presents the modeling and simulation of the stator-free RPM sensor idea using the Monte Carlo method, which demonstrated the special features and performance of this sensor. The design aspects of the prototype sensor are described in detail and the prototype is tested on an experimental setup. The conclusions for the stator-free RPM sensor are then made from the analysis of the experimental results and future work in relation to this sensor is also proposed.

In the second case of the rotor RPM measurement, the thesis presents another idea involving the laser mouse RPM sensor and the main focus of the study is on the performance characterization of the laser mouse sensor and the verification of the RPM sensor idea. Experiments are conducted using the test setup and results are gathered and analyzed and conclusions are drawn. Possibilities in relation to future work for this laser mouse RPM sensor are also provided.

The summary and the conclusion form the final chapter of the thesis and several important aspects of the designs relating to both the loader crane positioning project and the rotor RPM measurement project are discussed.

## **Keywords:**

Industrial electronics; Microelectromechanical devices; Intelligent sensors; Mechanical variable measurement