Resistance Measurement for I/O Modules on a Zephyr IoT Platform

Students

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Initial Situation: An industrial partner is to renew its existing product range of I/O modules. As part of the renewal, a module which is especially designed for measuring low-resistance sensors using a 4-wire setup is to be replaced.
The goal of this semester thesis is to develop a functional prototype that is based on the hardware of a universal I/O module, which is shown in Figure 1. The capability of measuring low-resistance sensors with required accuracy must be fulfilled.
It must be ensured that the prototype implements the full functionality of the existing resistor module to guarantee a complete replacement.

Approach: Firstly, multiple concepts which implement the necessary measurement methods have been developed. The influence of various parasitic effects on the measurements was evaluated iteratively for each concept by performing error calculations. Based on the results of the error calculations, two concepts (2-wire and 3-wire) were chosen as suitable solutions which can fully replace the low-resistance sensor measurement functionality of the existing module.
Next, both concepts were integrated into an existing Zephyr driver running on the microcontroller (MCU), which interfaces with and controls the ASIC present on the modules. To further enhance measurement accuracy, a dedicated calibration method for low-resistance sensors was implemented. The software of the Zephyr IoT platform (see Figure 2) was then adapted to support the developed 2-wire and 3-wire measurement functions, as well as to perform calibration.
Finally, a functional prototype was assembled, commissioned, verified and calibrated at room temperature.
The performance of both concepts was validated through a proof-of-concept at ambient temperatures of 0°C, 25°C and 50°C.

Result: The result of this thesis is a functional prototype which is based on the hardware of a universal I/O module with a new MCU.
The proof-of-concept measurements demonstrate that both concepts meet the specified requirements for accuracy and robustness against noise. With an accuracy of ±0.15 Ω and a noise-free code resolution of < 50 mΩ over the entire sensor range (as shown in Figure 3) the 3-wire concept is proven suitable as a replacement for the 4-wire setup of the existing module.
The 2-wire concept was also successfully validated.
In conclusion, the prototype developed in this thesis fully satisfies all requirements for replacing the existing module, offering a robust and accurate solution for low-resistance sensor measurements, as well as providing universal functionality.

Figure 1: Architecture and Functionalities of an I/O Module.
Own presentment

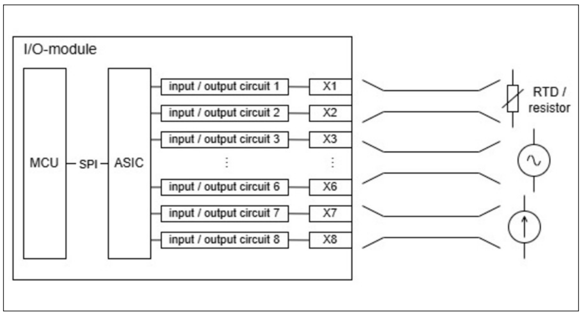


Figure 2: Software Architecture of Zephyr IoT Platform.
Own presentment

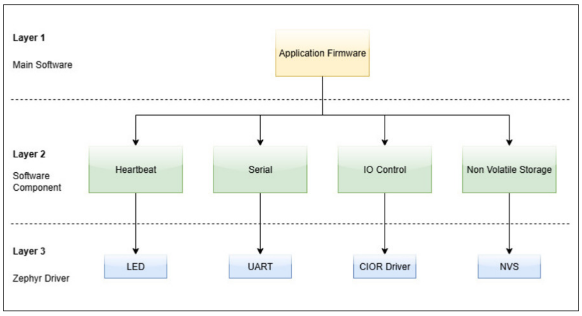
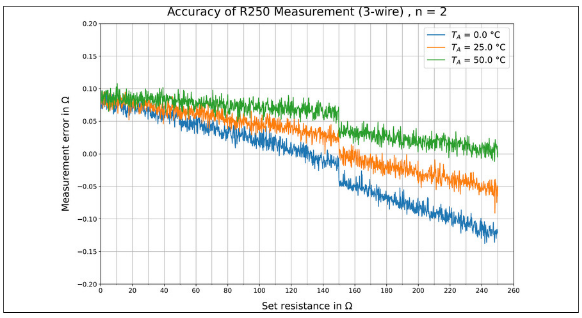


Figure 3: Measured Accuracy and Noise-Free Code Resolution of the 3-Wire Concept.
Own presentment



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