Ansteuerung eines Ventils über einen CAN-Bus

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Graz, October 7, 2024

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Abstract

For a student team rocket built by the Aerospace Team Graz (ASTG) and launched at the European Rocketry Challenge (EuRoC) 2023, a printed circuit board (PCB) was designed to measure various sensor types (thermocouples, pressure sensors, strain gauges) and to control both simple solenoid and more complex servo valves. The gathered data is necessary for controlling the fluid systems of the propulsion in both the rocket and the filling station that fuels the aformentioned rocket before launching. The node will communicate with the flight computer in the rocket and its accompanying filling station via a CAN bus.

The development of the rocket involved multiple stages, resulting in three versions of these nodes named CANary V0.0, V1.0, and V2.0. This thesis begins with the requirements for the CANaries and provides a brief overview of the various types of analog to digital converters (ADCs) considered. It then discusses the different versions and their design criteria. Finally, the performance of the latest version (V2.0) used during the flight at EuRoC 2023 is evaluated, and potential changes for future versions are explored.

While a few design errors were found in all versions, the primary functions were achieved, and only some "nice to have" features couldn't be completed due to the short development time. This enabled the rocket's successful launch and nominal flight in October 2023, earning multiple awards at that year's EuRoC.

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1 Introduction

Figure 1: The rocket HALCYON

As part of the larger HALCYON rocket project conducted by the student team ASTG, it was necessary to develop a test stand to evaluate planned propulsion concepts and measure their performance. To achieve this, various sensors need to be read, and at least two ball valves need to be actuated. All these functions should be integrated into one or more PCBs that communicate via a CAN bus with another system that controls the test sequence. This control system is referred to as the flight computer (FC) because it is derived from the flight computer used in previous rocket projects.

The initial iteration of this measuring and controlling system, internally named CANary, was essentially a prototype comprising a development board, a CAN transceiver, and a voltage regulator. Its sole purpose was to actuate a valve, either the main valve or the vent valve, upon receiving the corresponding command via a CAN bus. This simplicity was necessary because tests were scheduled shortly after the project began, leaving no time for more complex designs to be developed.

Following this, the first iteration of the PCB was developed, retaining the same micro controller unit (MCU) but adding an ADC to measure up to eight sensors. Depending on how the schematic was assembled, these sensors could be thermocouples, strain gauges, or pressure sensors. We selected a form factor already in use in the test stand to ensure that it fits its intended purpose.

Next, version 2.0 was designed for use in HALCYON, as depicted in Figure 1, as well as the filling station. This version required a smaller form factor while maintaining similar input and output requirements. The key additions included a power supply to directly power hobby servos from the board and the option to add reference junction compensation for the measured thermocouples.

Figure 2: The team with the awards at the EuRoC

Subsequently, these PCBs were integrated into their respective positions and used for the rocket launch in October 2023 at that year's EuRoC. This launch earned the overall EuRoC award and the flight award in the category (H3 Award), both of which are being held by team members in Figure 2.

Because the focus of this work only lies on the hardware, the software written for the prototype version will not be discussed. The more intricate firmware for all other PCBs is intended to be thoroughly described in a separate thesis.[1]