Software Development for a Smart Radiator Thermostat

Exposé for a Master Project

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1 Problem description

Heating is one of the most CO_2-intensive areas of human life. In Germany, around 210 million tons of $CO2$ of the general total of 762 million tons of CO_2 equivalents emitted in 2021 came from heating private living spaces. [1] [2]

Effective heating control has an average saving potential of between 8 and 19%, which can be achieved through the use of intelligent heating controllers and smart home systems [3].

Whereas such control systems are sophisticated and widespread in developed countries such as Germany, most of them are fully proprietary. There is currently no project of public domain, which could be used as a base for research, development and production of smart heating controllers.

2 Objectives and concept presentation

The focus of the presented master project is the development of a modern software for a Micro Controller Unit (MCU)-based radiator thermostat and its contribution to the public domain. The master project will be realized as a part of a bigger interdisciplinary development, which includes:

- **Mechanics**: Development of the thermostats power transmission for proper function with commonly used radiator valves, followed by the design of an enclosure. This work will be presumably realized by Anton Surikov and advised by Prof. Dr. Tobias Müller.

- **Control algorithms**: Engineering of control algorithms to be used by the thermostat.

- **Electronics**: Development of the thermostats Printed Circuit Board (PCB) and its integration with mechanical components, presumably realized by Thomas Schneider and advised by Prof. Dr. Daniel Schönherr.

- **Software**: The subject of this work, development of the thermostats software and its integration with PCB components. It will be presumably realized by Alexander Menzel and advised by Prof. Dr. Uwe Werner.

In the first part of this project, a basic software for the device should be implemented including hardware drivers, main state machines and tasks. At the end of this part a scientific paper will be written as an Institute of Electrical and Electronics Engineers (IEEE) report, describing the developed software architecture and design decisions.

The software should be designed ready for prospective integration of the control algorithms and Bluetooth Low Energy (BLE). The latter feature is supposed to be used for smart home applications, specifically for the integration of the thermostat in Home Assistant and/or for provisioning of a Hypertext Transfer Protocol (HTTP) Application Programming Interface (API) using a gateway.

The following points are consequently objectives of this master project:

- Development or integration of drivers for all radiator thermostat components.
- Design of the software according to basic consumer functions and hardware features.
- Implementation and tests of the designed software.
- Writing of an IEEE report describing program design.

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3 Theoretical foundations and state of the art

Descriptions of common thermostats such as eQ-3 eqiva Bluetooth from [4] and eQ-3 MAX! [5] will be used as a reference for functional scope of the software to develop. For example they implement following functions:

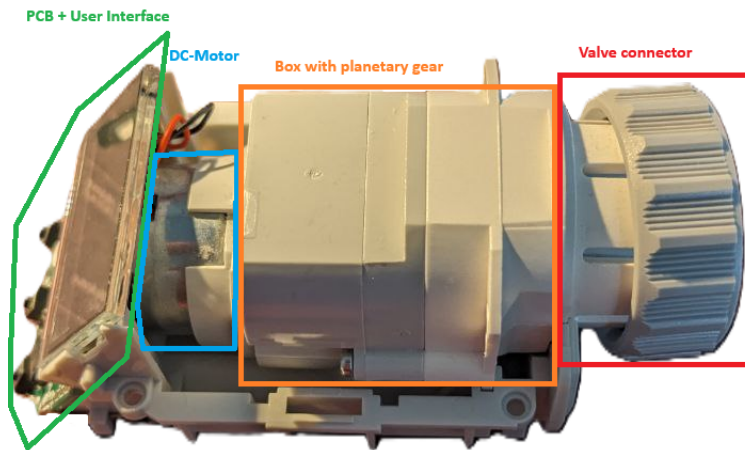- temperature adjustment, mode selection, open-window function

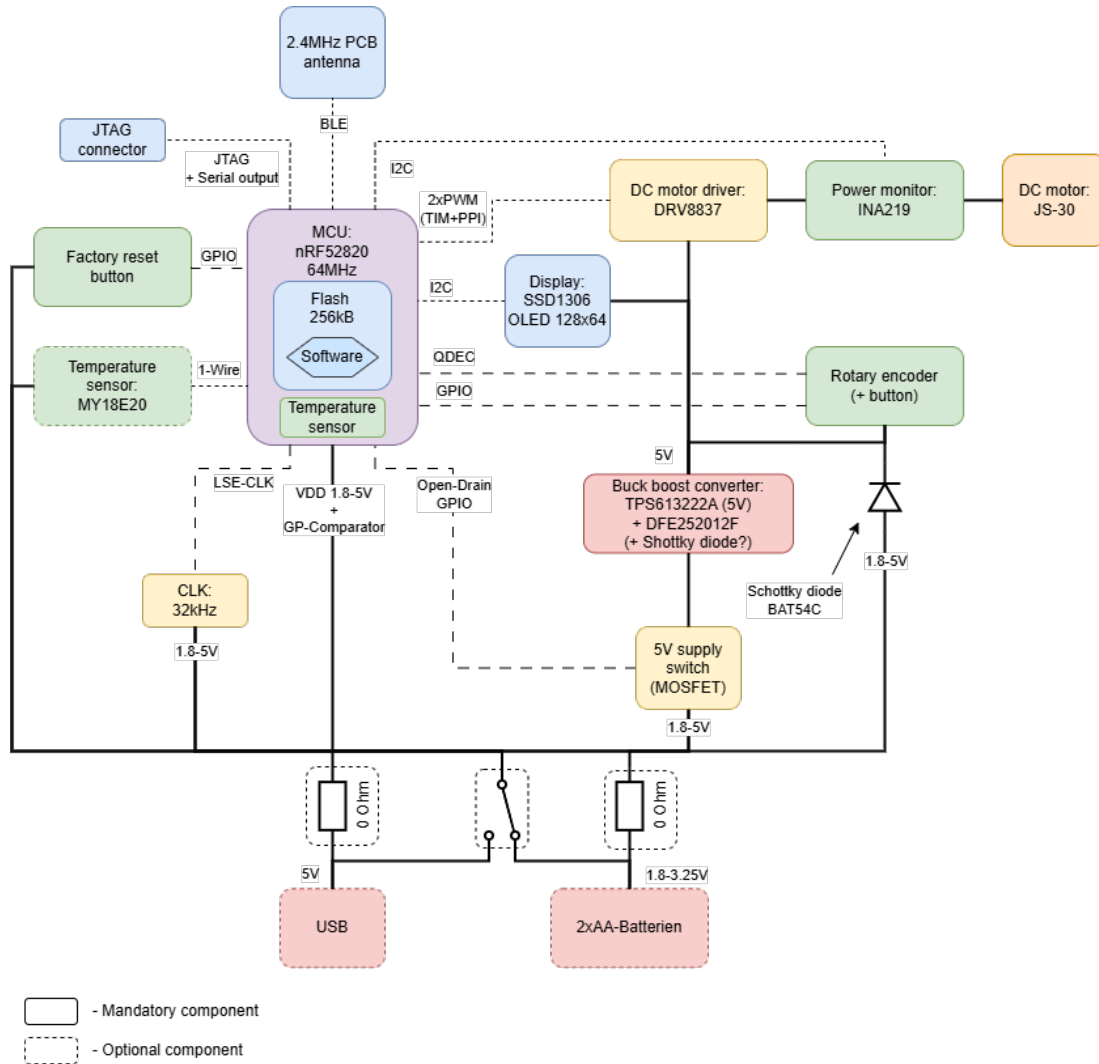Figure 3.1: Photo of a partially disassembled radiator thermostat eQ-3 eqiva (version without Bluetooth).

Figure 3.2: Current version of the block diagram for the radiator thermostat (draft)

4 Provisional outline

5 Time plan

...To Do...

Bibliography

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[3] M. Kersken, H. Sinnesbichler, and H. Erhorn, "Analyse der Einsparpotenziale durch Smarthome– und intelligente Heizungsregelungen," *Bauphysik*, vol. 40, no. 5, pp. 276–285, 2018.

[4] eQ-3 AG, *Operating Manual BLUETOOTH® Smart Radiator Thermostat UK eqiva CC-RT-M-BLE-EQ*, 5.2018.

[5] ELVjournal, "MAX! Heizkörperthermostat als ARR-Bausatz," no. 2, 2012.

List of Figures

List of Abbreviations

MCU   Micro Controller Unit
PCB   Printed Circuit Board
API   Application Programming Interface
BLE   Bluetooth Low Energy
HTTP   Hypertext Transfer Protocol
IEEE   Institute of Electrical and Electronics Engineers