Medium Power Amplifier Interface and Firmware

Degree programme: BSc in Electrical Engineering and Information Technology
Specialisation: Communication Technologies, Embedded Systems
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Kontron Transportation Schweiz AG is developing a new Medium Power Amplifier designed to enhance their mission-critical communication systems while improving cost efficiency. Since the firmware of the amplifier will be used in different hardware platforms, a flexible concept is designed and implemented to enable reliable operation through status monitoring and embedded safety mechanisms, while a streamlined user interface simplifies access to calibration and product data.

Objectives

The primary goal of the project is to design and implement firmware for an RF amplifier for use in railway communication systems. The key objectives are:

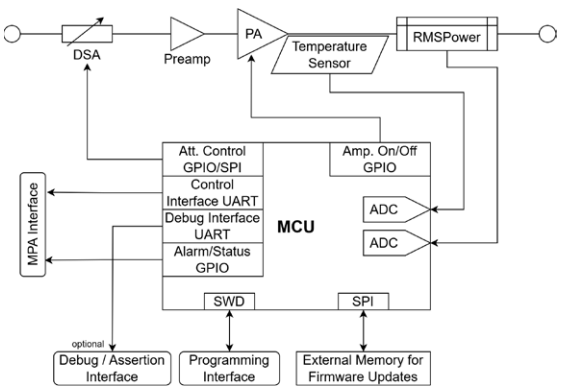
- Evaluate a set of microcontrollers to see which suits the usage case best.
- Develop a firmware platform for measurement, calibration and control.
- Ensure thermal protection and automated power adjustment.
- Design a mock-up prototype using an ST Nucleo board to validate the firmware.
- Enable serial communication for integration, remote monitoring and calibration.
- Provide a robust concept for firmware updates.

Concept

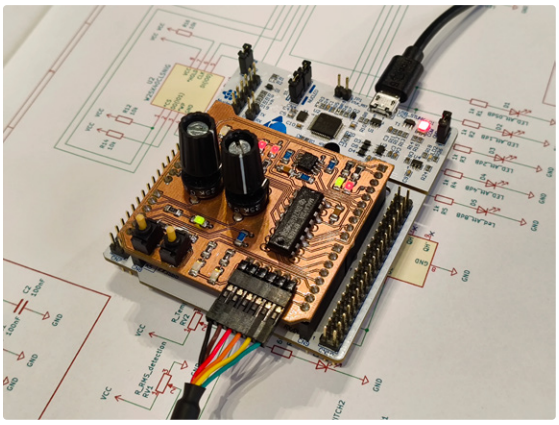
To enable parallel development with the power amplifier hardware, a mock-up prototype was implemented using an ST Nucleo development board. This prototype simulates the amplifier environment with potentiometers (for temperature and RF power sensors), shift registers and LEDs (for simulating the digital attenuator and amplifier control), and a variety of switches. Serial connectors simulate external communication interfaces. The firmware is designed to continuously monitor system parameters, apply calibration data from non-volatile memory, and control the attenuator and amplifier accordingly. A robust communication interface over UART enables read/write operations of calibration and measurement data, status flags and error reports. This allows the MPA to operate as a standalone module or integrate into a larger system. A concept for firmware updates was also developed, accounting for challenges such as transmission failures or power loss during the update process, as well as the ability to fallback to a previous version, in case the new firmware does not function properly. Given the amplifier's intended modularity, the firmware implements a scalable, hardware-agnostic design that abstracts low-level hardware dependencies while maintaining robust error management through structured exception handling.

Results

The implemented software architecture combines robustness and flexibility, ensuring reliable operation while remaining adaptable to future requirements. The codebase follows a structured implementation adhering to the Google C++ Style Guide. A Python script provides seamless serial communication, enabling full control of the hardware. In addition, the system features an extensively documented update concept with basic components already implemented.



Block diagram of the implemented system



Mock-up hardware of the medium power amplifier

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