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Professor Dr.-Ing. Stefan Kowalewski
Julius Kahle, M.Sc. RWTH

Informatik 11 Embedded Software | RWTH AACHEN UNIVERSITY

Exercise for

Embedded Systems

Summer Term 2025

Sheet 1: Embedded Systems and Microcontrollers

Exercise 1: Questions

a) What is an embedded system?

b) What is the source of requirements for an embedded system?

c) Embedded systems can be categorized into two groups.

(1) What are these categories?
(2) What are their characteristics?
(3) What kind of hardware is typically used for these categories?
(4) Which programming languages are most dominant in these categories?
(5) Name at least one example for each category!

d) What is a microcontroller?

Exercise 2: Digital I/O

For this and the following exercises we refer to the Atmel ATmega16 microcontroller. A datasheet can be found in the Moodle room.
Assume 8 buttons are connected to Port A and GND. Also assume 8 LEDs are connected to Port B and VCC (using fitting resistors) such that they can be lit.

a) What are the registers that control these ports?

b) How should these registers be initialized?

c) Write a loop that allows control over the LEDs via the buttons:

   (1) On a 1-to-1 basis (pushing button 4 causes LED 4 to be lit).

   (2) Priority encoder: show the binary coding for the number of the highest button pushed.

d) What is bouncing? Implement a debouncing method.

Exercise 3: Interrupts and Polling

a) Choose Interrupts or Polling for the following scenarios and explain your choice.

   (1) The "change input"-button on a monitor

   (2) The wireless-reciever of a garage-opener

   (3) The keyboard on a standard desktop

   (4) The temperature-sensor of a weather-station

b) When is an ISR called and how is it done?

Exercise 4: Timers and Counters

a) What is a counter? What is a timer?

b) What components does timer 1 of the ATmega16 have? How are they configured?

c) How is the reading and writing of a 16 bit value made atomic?

d) What is a watch dog?

e) Why might it be necessary to temporarily disable interrupts when reading 16 bit values?

Exercise 5: Analog Devices

a) What analog devices can be found on a ATmega16?

b) What is PWM and how does it work?

c) Sketch a successive approximation converter and explain how it works.

d) Imagine you only have 1 Ohm Resistors available, which cost 10 cents each. What is the minimum achievable cost for a 4Bit R-2R and a 4Bit binary weighted resistor circuit respectively if you can only combine resistors in serial?

e) What are the disadvantages of the binary weighted resistor circuit?