

INFO0064 - Embedded Systems
Examination session of August 2015

Notes or documents of any kind forbidden. Duration: 3 h 30.

Questions must be answered on different sheets, annotated with your name and section.

1. [4 points]

- (a) Describe briefly the notion of reentrancy.
- (b) Describe the problem of priority inversion. How can this problem be avoided?
- (c) In the context of real-time operating systems, what is the role of the scheduler? What are its principles of operation?
- (d) If a set of tasks fully uses the processor, is it still possible to execute additional tasks? Justify.

2. [8 points] A portable audio player is equipped with a microcontroller that has to react to user actions, display messages on a small screen, and send audio data to an MP3 decoder.

The function of the MP3 decoder is to convert audio data into analog signals. This decoder is connected to a dedicated digital input of the microcontroller, on which it signals whether it is ready or not to receive data.

The microcontroller needs to run the following tasks:

- A task τ_1 checking the state of the keyboard 25 times per second. Its execution time is negligible.
- A task τ_2 sending a fixed number of characters to the screen, at most 25 times per second. This task requires 3 ms to complete.
- A task τ_3 sending audio data to the MP3 decoder whenever it is ready to receive it. Sending data can take up to 80 ms. In the worst case, this operation might be requested 10 times per second. The microcontroller is the master of the transaction; it can pause the data transfer in order to perform other tasks, provided that the duration of this pause does not exceed 10 ms.

Note: The input of the microcontroller connected to the decoder can be configured to trigger interrupts.

- (a) What is the best software architecture for this system ? Justify.
- (b) Using pseudocode, give the global structure of this software.

3. [8 points] When the sluice gates of a dam are closed, the water level in the reservoir rises at the rate of 0.4 m/h if it is between 10 m and 20 m , and of 0.2 m/h between 20 m and 30 m . Above 30 m , a spillway drains the extra water. When the sluice gates are open, the water level decreases at the rate of 0.5 m/h , independently from the water level.

A sensor constantly measures the water level in the reservoir, and sends a signal each time that this level changes by 1 m . The sluice gates must be opened when the level exceeds 25 m , and closed when it drops below 15 m . Each opening or closing operation of the gates needs 120 seconds to complete.

- (a) Construct an hybrid system modelling this problem. Initially, the water level is at 17 m , and the sluice gates are open.
- (b) Give the first 3 steps of the state-space exploration of this system.