

# Written Exercise Sheet 4

(22 Punkte)

**Hints:** These assignments will be discussed at E23, from 10:15 am - 11:45 am on 14, Dec., 2016. You are not obligated to turn in the solutions.

## 1 FPGA (1 Punkt)

Many FPGAs use look-up tables for Boolean functions. Earlier FPGAs used look-up tables for 4 variables (memories with 4 address inputs). Configurations could be used to implement any Boolean function of 4 variables. How many Boolean functions of 4 variables exist? We ignore symmetries and also count simple functions like constant functions.

## 2 Memory hierarchy (2 Punkte)

What is the *memory wall* problem? How do scratchpad memory (SPM) and Cache memory work? What are the corresponding advantages of SPM and Cache, respectively?

## 3 Wandler-Auflösung (4 Punkte)

Betrachten Sie folgenden D/A-Wandler:

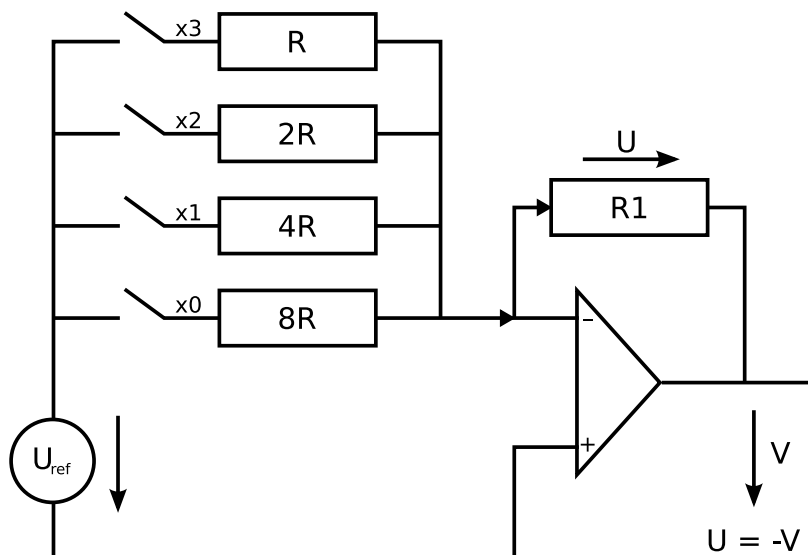


Abbildung 1: D/A-Wandler

Gegeben sei im Folgenden:  $U_{ref} = 5V$ ,  $R = 1k\Omega$

- Wie groß ist der Rückkopplungswiderstand  $R1$  zu wählen, wenn die Digitalwerte in einen Spannungsbereich von  $0V - 10V$  abgebildet werden sollen?
- Die Genauigkeit der D/A-Wandlung mittels Stromsummenwandler ist stark abhängig von der Genauigkeit (Toleranz) der verwendeten Widerstände. Bei zu großen Abweichungen vom Sollwert kann es vorkommen, dass der

für einen bestimmten Binärwert  $b$  gelieferte Strom geringer ist als der für den nächst geringeren Binärwert  $b - 1$  (Monotoniefehler).

- Bei welchem Binärwert ist die größte Auswirkung eines solchen Monotoniefehlers zu erwarten?
- Berechnen Sie für diese beiden Werte jeweils den Stromfluss.
- Um wieviel  $\Omega$  darf der Wert von Widerstand  $R$  maximal nach oben abweichen, damit kein Monotoniefehler auftritt?

**Hint:**  $1000_2$  bzw.  $0111_2$     **Hint:** Zur Musterloesung: dort nehmen wir 5V an, weil das die Referenzspannung ist.

Welcher der Widerstände am Eingang beeinflusst die Genauigkeit des Wandlers am meisten? Wie hoch darf die Toleranz dieses Widerstandes in Bezug auf die Wandlerauflösung maximal sein?

#### 4 Sampling Theorem (2 Punkte)

Suppose that we sample the signals at time 0, 1, 2, 3, 4, 5, 6, 7, 8 with the following values:

$t$	0	1	2	3	4	5	6	7	8
values	0	1.1	1	0.3	0	-0.2	-1	-1.2	0

Explain and draw the original signal by using the *sinc()* function.

#### 5 RTOS (2 Punkte)

- What are the requirements of an RTOS?
- Explain how an RTOS schedule real-time tasks under fixed-priority scheduling.
- Explain how to extend the standard OSES to have Real-Time extensions. In such cases, explain whether RT tasks can use all the system calls in the standard OSES or not?

#### 6 Interrupt Handling (2 Punkte)

RTOSes require to have bounded delay for handling interrupts. If an interrupt is detected, the processor performs a context switch (temporarily pauses the execution of the currently task and executes a designated interrupt service routine (ISR)). This may increase the response time. Explain how interrupts should be handled in RTOSes to reduce the influence to the real-time tasks in the system.

**Hint:** You can refer to Sec. 2 in the following article: Björn B. Brandenburg, Hennadiy Leontyev, James H. Anderson: An overview of interrupt accounting techniques for multiprocessor real-time systems. Journal of Systems Architecture - 57(6): 638-654 (2011)

#### 7 Aperiodic Scheduling (2 Punkte)

Consider a system with three tasks, all arriving at  $t=0$ :

- Task T1 has an execution time of 9 time units and an (absolute) deadline at time 25.
- Task T2 has an execution time of 3 time units and an (absolute) deadline at time 10.
- Task T3 has an execution time of 10 time units and an (absolute) deadline at time 15.

Which algorithm would you use to schedule the three tasks and why?

### 8 Schedulability tests (3 Punkte)

For the previous example, provide

- one necessary test
- and one exact test
- and one sufficient test

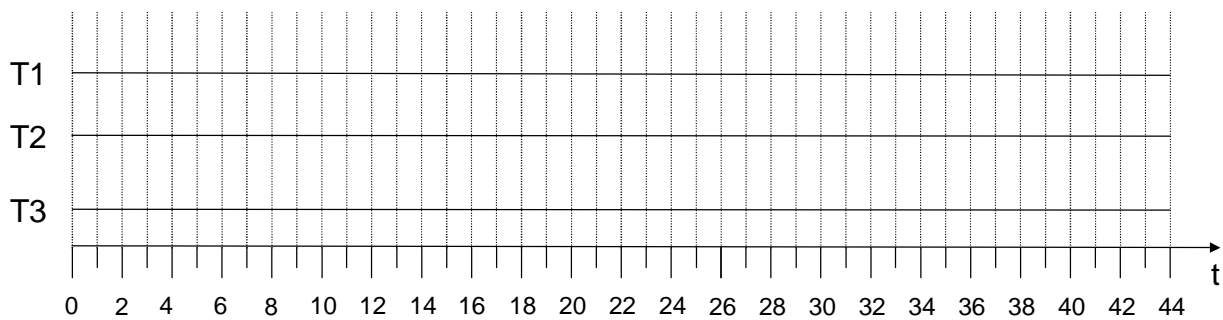
for schedulability!

### 9 EDF Scheduling (2 Punkte)

Consider a system with three tasks:

- Task T1 arrives at time 0, has an execution time of 9 time units and a deadline at time 35.
- Task T2 arrives at time 5, has an execution time of 3 time units and a deadline at time 27.
- Task T3 arrives at time 6, has an execution time of 10 time units and a deadline at time 29.

Generate a schedule for this task system using the earliest deadline first (EDF) scheduling policy!



### 10 Least Laxity Scheduling (2 Punkte)

Generate a schedule for the previous task system using the least laxity scheduling policy!

