ELEC-E8001 Embedded Real-Time Systems

EXAM 21.3.2016

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1. Are the following claims true (**T**) or false (**F**)? Every correct answer gives you +1 p, every incorrect –1 p, and an empty answer is worth 0 p. The minimum amount of total points is 0 p and maximum 6 p.

   a) The basic von Neumann computer architecture does not contain any explicit I/O element.
   b) DRAM and SRAM belong to the group of nonvolatile memories.
   c) Low-end microcontrollers with CPU clock frequencies below 10 MHz do not suffer the CPU–memory bottleneck.
   d) A benefit of using an instruction cache in hard real-time systems is that the effective access time is deterministic.
   e) The best possible instruction completion time of an N-stage pipeline is $1/N^2$ times the completion time of the nonpipelined case.
   f) A large number of concurrent interrupt requests may sporadically lead to excessive response times in a real-time system.

2. Given an analog signal whose voltage ranges from –10 to +10 V, and an 8-bit A/D converter, calculate the A/D output for 2.6 V, (2 p.) and then trace the successive-approximations method to find the output value. (4 p.)

3. Consider an RTOS with preemptive priority scheduling. Draw a general state diagram that shows the possible task states and allowed transitions between them. (3 p.) Besides, define all the states and transitions. (3 p.)

4. Priority inversion may occur in a real-time system under certain conditions. Why is it harmful? (1 p.) Illustrate with an appropriate execution scenario how the priority inversion occurs in a three-task system under the control of an RTOS with preemptive priority scheduling. (3 p.) What is the common solution to such a priority inversion problem, and how would it work in your scenario? (2 p.)

5. An embedded real-time system with three periodic tasks has the execution periods of p_i and execution times of e_i as follows:

   - p_1 = 250 ms and e_1 = 1,000,000/f_c
   - p_2 = 50 ms and e_2 = 200,000/f_c
   - p_3 = 10 ms and e_3 = 40,000/f_c

   where f_c is the CPU clock frequency.

   You are designing a low-cost system with short lifetime, and intend to use a 32-bit microcontroller. This microcontroller is available in three versions, which have different clock frequencies, f_c = 10 MHz, f_c = 20 MHz, and f_c = 50 MHz. And the unit prices in desired quantities are 1.25 €, 2.40 €, and 4.99 €, respectively.

   Which one of those versions would you choose for the application and why? (6 p.)