(Till tentamensvakten: engelsk information behövs)

Exam

Embedded Systems I, DVA316
Västerås, 2013-11-04

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Exam duration:	08:10 – 12:30
Help allowed:	calculator, language dictionary, ruler
Points:	90 p + extra lab points

Grading:

Swedish grades:		ECTS grades:	
0 – 54	→ failed	0 – 54	→ failed
55 – 76 p	→ 3	55 – 65	→ D
77 – 90 p	→ 4	66 – 80	→ C
91 – 100 p	→ 5	80 – 90	→ B
		91 – 100	→ A

Instructions:

- Answers should be written in English.
- Short and precise answers are preferred. Do not write more than necessary.
- If some assumptions are missing, or if you think the assumptions are unclear, write down what do you assume to solve the problem.
- Write clearly. If I cannot read it, it is wrong.

Good luck!!

Assignment 1: (18 points)

```
int sum;

int getSum(int a, int b){
   sum = a + b;
   return sum;
}

int main (void) {

   int x=5;

   return (getSum(x,20));
}
```

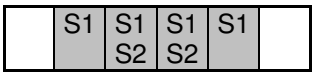
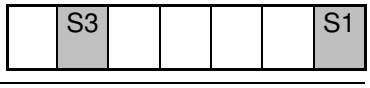
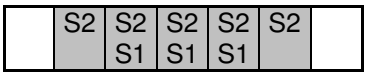
a) Is the above function `getSum(...)` re-entrant? (3p)
b) If yes, explain why it is re-entrant. If no, explain why it is not re-entrant and give a suggestion how to make it re-entrant. (8p)
c) In general terms describe how non-re-entrancy and race-conditions occurs.(7p)

Assignment 2: (18 points)

You have written a program consisting of 2 c-files *main.c* and *foo.c*, and an assembler file *bar.asm*. Explain the process of downloading and getting the program to run on your target HW. Your explanation should contain description and purpose of the following terms: *debug monitor, object file, cross-compiler, linker, library, locator,* and *memory map*.

Assignment 3: (18 points)

Consider a real-time system consisting of 3 tasks, A,B,C, that share 3 resources protected by semaphores S1,S2,S3. The tasks have different priorities and they are released at different times (see table below). Moreover, all tasks use their semaphores as illustrated in the column "execution sequence" below (clock tick are counted relatively to the start of the system). The execution times of tasks A=6 ticks, B=7 ticks and C=7 ticks as illustrated in the table below (in the "execution sequence" column).

Task	Priority	Deadline relative	Release time	Execution sequence
A	3 (highest)	12	3	
B	2 (middle)	19	2	
C	1 (lowest)	25	0	
			Clock tick:	1 2 3 4 5 6 7

For example, we can see in the table that task C has the lowest priority, it is released at time t=0, and, once released, it will execute like described below:

- *tick 1*: executes one clock tick without any semaphores.
- *tick 2*: tries to lock S2, and if ok, it enters its critical section and executes one tick with S2 locked.
- *tick 3*: tries to lock S1, and if ok, it enters its critical section and executes one tick with S1 and S2 locked
- *tick 4*: executes one tick with S1 and S2 locked
- *tick 5*: executes one tick with S1 and S2 locked
- *tick 6*: releases S1 and executes one tick with S2 locked
- *tick 7*: releases S2 and executes one tick without any semaphores.

The same reasoning applies to all other tasks.

Note that the execution scenarios for the tasks will be equal to the ones illustrated in the table above *only under the assumption* that the required semaphores are *free* when requested by a task, and the task is not pre-empted by a high-priority task. However, from the release times above we can see that the task will interfere with each other. Besides, the semaphores will not be always available when requested by tasks.

Assume the release times of tasks, their priorities and the execution sequences from the table above:

a) Will all tasks meet their deadlines? If not which task will miss its deadline and why? Draw the actual execution trace. (6p)

b) If *Priority Ceiling Protocol* PCP is used, will all tasks meet their deadlines? Draw the actual execution trace. (6p)

c) What will be the difference in the execution of tasks if the *Immediate Priority Ceiling Protocol* IPCP is used? (3p)

d) Is it possible to use *Priority Inheritance Protocol* PIP without introducing any further problems? Please motivate your answer? (3p)

Assignment 4: (18 points)

a) What is the difference between preemptive and non-preemptive scheduling? What are advantages and disadvantages of each scheduling approach? (8p)

b) There are different types of real-time tasks, for example periodic tasks and aperiodic tasks.
   - Explain the difference between these two types. (2P)
   - Suppose that a task is developed to read a room temperature from a temperature sensor. Which type of real-time task fits better (periodic or aperiodic)? Please motivate your choice. (2P)
   - If a task is responsible to react whenever an alarm push button is pressed. Which type of real-time tasks fits better? Please motivate your choice. (2P)

c) Deadline Monotonic DM, Shortest Job First SJF, First Come First Served FCFS and Earliest Deadline First EDF are 4 different scheduling algorithms. Which scheduling algorithms among them are more suitable for real-time systems? Please motivate your answer. (4P)

Assignment 5: (18 points)

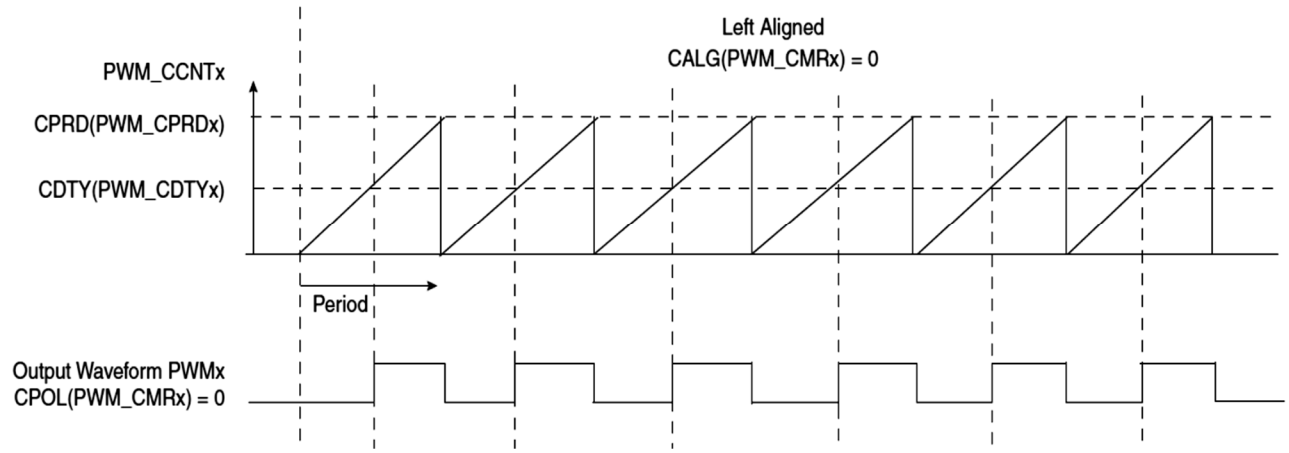
a) (6p)
Describe the main strategies used in embedded systems to protect the electronic boards and the IC's from: over current, over voltage, DC power supply polarity inversion, noisy DC power supply. Sketch one example of each one.

b) (6p)
Explain the concept of the "Open collector"/"Open Drain" mode to drive a digital output. Describe its role in the WIRED AND configuration and its working principle in the TWI communication bus.

c) (6p)
Suppose to work with an AT32 microcontroller that has a 12Mz Oscillator master clock (MCK). Design a PWM signal, like the one shown in the picture, having 10Hz frequency and 30% duty cycle, by computing the following parameters:

- CPRD (period value to be written in the CPRDx register)
- CDTY (duty cycle value to be written in the CDTYx register)
- DIV (master clock frequency linear divider to be set: 2-255)

Consider that the timer used in the PWM modules is 20 bit.



$$\boldsymbol{period(sec)} = \frac{\boldsymbol{CPRD * DIV}}{\boldsymbol{MCK}}$$

$$\boldsymbol{duty}(\%) = \mathbf{100} * (\boldsymbol{period} - \frac{\boldsymbol{DIV}}{\boldsymbol{MCK}} * \boldsymbol{CDTY}) / \boldsymbol{period}$$

Assignment 6: (extra lab points)

You do not need to do anything here. This is for the extra points earned at the labs. Your extra lab points will be automatically added to your total exam score.