

# Exam TI2720-C Embedded Software

Monday January 28 2013 (14.00 - 17.00)

In order to avoid misunderstanding on the syntactical correctness of code fragments in this examination, we will always assume that we are dealing with pseudo-code, although we might have syntactically correct code in some cases. We assume that the required variables, semaphores, tasks, timers, etc. are always declared and initialized correctly.

Further, we assume the following abbreviations to be known: RR = Round Robin, RRI = Round Robin with Interrupts, FQS = Function Queue Scheduling, RTOS = Real-Time Operating System, IR = interrupt and ISR = interrupt service routing. One system clock tick = 10 ms (if not stated otherwise).

In this exam, we use the following definitions, unless stated otherwise:

```
void delay(int ms) {
    !! do some CPU computation to the amount of ms milliseconds
}
```

```
char getchar() {
    while (!! UART rx buffer empty);
    !! return c from UART rx buffer
}
```

```
void gets(char *s) {
    !! fill string s using getchar
}
```

```
void putchar(char c) {
    while (!! UART tx buffer not empty);
    !! send c to UART tx buffer
}
```

To pass this written exam, you need to answer correctly at least 18 questions. The relationship number of correctly answered questions and your mark is given below.

Nr. Correct Answers	18	19	20	21	22	23	24	25	26	27	28	29	30
Mark	6	6.5	6.5	7	7.5	7.5	8	8.5	8.5	9	9.5	10	10

Question 1
Which of the following statements is correct? An interrupt is a. a synchronous signal from hardware to indicate processor attention b. an asynchronous signal from hardware to indicate processor attention c. a synchronous signal from the processor to indicate hardware attention d. an asynchronous signal from the processor to indicate hardware attention
Question 2
Which of the following statements is correct? The non-maskable interrupt a. may introduce a data sharing bug b. can be disabled when other interrupts occur c. cannot be disabled d. none of the above
Question 3
Which of the following statements is correct? Interrupts can be disabled in order to a. protect a critical section b. enable context switches c. protect other interrupts d. disable a critical section
Question 4
Which of the following statements is correct? Interrupts can be disabled in order to a. protect a task's code from shared data b. disable a critical section c. protect task code from execution d. resolve a shared data problem
Question 5
Which of the following statements is correct? An interrupt service routine is supposed to a. disable the non-maskable interrupt b. restore the context and return c. restore the lowest-priority interrupt d. increase the program counter
Question 6
Which of the following statements is correct? An interrupt vector a. contains a pointer to an ISR b. points to a table with interrupt routines c. contains the addresses of interrupts d. contains interrupt routines
Question 7
Which of the following statements is correct? An interrupt service routine supposed to a. disable the non-maskable interrupt b. increase the priority of the lowest-priority interrupt c. increase the program counter d. restore the registers
Question 8
Which of the following statements is correct? The X32 platform a. employs an interrupt controller b. has one interrupt priority level c. is not equipped with an interrupt vector d. prohibits interrupt preemption
Question 9
Which of the following statements is correct? The shared data problem can be solved through a. enabling interrupts b. using the extern keyword c. using semaphores d. using the static keyword
Question 10
Which factor determines the worst response time of a system reacting on an interrupt? a. The longest period of time during which lower-priority interrupt routines are executed. b. The longest period of time during which the context of the current task is restored. c. The longest period of time during which another high-priority task is executing. d. The longest period of time during which the interrupt is disabled.

Question 11
Which factor determines the best response time of a system reacting on an interrupt? a. The shortest period of time during which the interrupt is enabled. b. The shortest period of time during which the interrupt is disabled. c. The shortest period of time during which the context of the current task is restored. d. The shortest period of time during which another high-priority task is executing.
Question 12
Which of the following statements is correct? a. We cannot have a shared data problem in an RR architecture. b. We cannot have a shared data problem in an RRI architecture. c. We cannot have interrupt vectors in an FQS architecture. d. We cannot have atomic sections in an RTS architecture.
Question 13
Which of the following statements is correct? a. An RR architecture provides interrupts and interrupt priorities. b. We cannot have a shared data problem in an RRI architecture. c. An FQS architecture has a better response time than an RRI architecture. d. An RTOS provides interrupt preemption whereas an FQS architecture does not.
Question 14
Which type of requirements determines the choice of a software architecture for embedded systems? a. Dependability requirements b. Robustness requirements c. Availability requirements d. Timing requirements
Question 15
For which kind of software architecture for embedded systems is the worst response time for task code the execution time for the longest task code plus the execution time for interrupt routines? a. Round-robin without interrupts b. Round-robin with interrupts c. Function-queue-scheduling d. Real-time operating system
Question 16
For which kind of software architecture for embedded systems is the worst response time for task code the total execution time for all task code plus the execution time for interrupt routines? a. Round-robin without interrupts b. Round-robin with interrupts c. Function-queue-scheduling d. Real-time operating system
Question 17
Which of the following statements is correct? A reentrant function a. may never call other reentrant functions b. may only use hardware in an atomic way c. may not be shared by different tasks d. cannot be stored on the stack
Question 18
Which of the following statements is NOT correct? An Embedded System ... a. has always interactions with the physical world b. is always controlling a technical entity c. is always embedded in a context d. has always safety requirements
Question 19
Which of the following principles of RTOS-based design is false? a. short interrupt routines are needed for a responsive system b. more tasks help sometimes encapsulate data more efficiently c. turning time-slicing off decreases the throughput of the processor d. it is recommended to use just the minimum necessary functionality from an RTOS

Question 20

Given is the following RTOS (pseudo) code.

```
...
void isr_buttons(void) // arrive here if a button is pressed
{
    x = X32_PERIPHERALS[PERIPHERAL_TEMP1];
    y = X32_PERIPHERALS[PERIPHERAL_TEMP2];
}
...
while (1) {
    DISABLE_INTERRUPT(INTERRUPT_BUTTONS);
    temp1 = x; temp2 = y;
    ENABLE_INTERRUPT(INTERRUPT_BUTTONS);
    X32_display = ((temp1 & 0xff) << 8) | (temp2 & 0xff);
    if (temp1 != temp2)
        ;; shutdown plant
}
```

Which of the following statements is correct?

- There is a potential deadlock problem in this code.
- There is a potential shared data problem in this code.
- There is a potential problem with respect to reentrancy in this code.
- There is no potential problem in this code.

Question 21

Given is the following (pseudo) code:

```
int main() {
    ...
    while (1) {
        task_1();
        task_2();
        if (print_flag == 1) print();
        if (finit_flag == 1) break;
    }
    ...
    return 0;
}
```

Which of the following statements is correct? This code represents a

- round-robin architecture.
- round-robin with interrupts architecture.
- function-queue scheduling architecture.
- real-time operating system architecture.

Question 22

Given is the following (pseudo) code:

```
int done;

void isr_button (void) // arrive here when button pressed/released
{
    if (!button pressed)
        done = 1;
}

void main (void)
{
    done = 0;
    while (!done) {
        printf ("Hello World\r\n");
        delay(10000);
    }
    printf ("done\r\n");
}
```

The program is uploaded onto the embedded system in the conventional way. Which of the following statements is correct?

- Sometimes, the program does not end if the button is not debounced.
- The program does not always show the same output if it is restarted without uploading it.
- Sometimes, the program does not end.
- The program ends always as soon as the button is pressed.

<p><b>Questions 23 – 25</b></p> <p>Given is the following (pseudo) code, which reads the current values of 4 different buttons and acts accordingly. The 4 buttons are all mapped to bits 0..3 of the register button. The buttons are already debounced.</p> <pre> void f1(void) { delay(1000); } void f2(void) { delay(2000); } void f3(void) { delay(3000); } void f4(void) { delay(4000); }  void main (void) {     while (1) {         if (buttons &amp; 0x01) f1();         if (buttons &amp; 0x02 ) f2();         if (buttons &amp; 0x04 ) f3();         if (buttons &amp; 0x08 ) f4();         delay(1000);}} </pre>
<p><b>Question 23</b></p> <p>None of the buttons has been pressed. Which of the following statements is correct? The longest time that button #3 must be pressed in order to activate f3() once is</p> <p>a) 1 second b) 2 seconds c) 3 seconds d) 4 seconds</p>
<p><b>Question 24</b></p> <p>None of the buttons has been pressed. 500 ms after button #3 has been pressed, button #1 and button #4 are pressed (in this sequence) and held down. Which of the following statements is correct? The sequence of executed functions is</p> <p>a) f3(), f1(), f4() b) f3(), f4(), f(1) c) f3(), and the remaining sequence cannot be determined d) arbitrary</p>
<p><b>Question 25</b></p> <p>At a given moment in time, the system is in an arbitrary state. Which of the following statements is correct?</p> <p>a) Button #1 must be pressed at most 9 s in order to activate f1(). b) Button #1 must be pressed at least 10 s in order to activate f1(). c) Button #1 must be pressed at most 10 s in order to activate f1(). d) Button #1 must be pressed at most 11 s in order to activate f1().</p>
<p><b>Questions 26 – 27</b></p> <p>Given is the following RTOS (pseudo) code with decreasing priorities <math>T1 &gt; T2 &gt; T3</math>:</p> <pre> void T1(void) {     while (1) {         OSSemPend(s_status);         !! control chemical process according to status         OSSemPost(s_status);}}  void T2(void) {     while (1) {         OSSemPend(s_temp);         !! read and update plant temperatures         OSSemPost(s_temp);}}  void T3(void) {     while (1) {         OSSemPend(s_status);         !! calculate and update the status         OSSemPost(s_status);}} </pre>
<p><b>Question 26</b></p> <p>Which of the following statements is correct? There is ...</p> <p>a) a potential deadlock between T1 and T2 b) a potential deadlock between T1 and T3 c) a potential deadlock between T2 and T3 d) no potential deadlock</p>
<p><b>Question 27</b></p> <p>Imagine that the priorities are exchanged, so that <math>T1 &lt; T2 &lt; T3</math>. Which of the following statements is correct? There is ...</p> <p>a) a potential deadlock between T1 and T2 b) a potential deadlock between T1 and T3 c) a potential deadlock between T2 and T3 d) no potential deadlock</p>

## Question 28-30

Given is the following RTOS (pseudo) code. The priority of T2 is higher than the priority of T1, the time for putchar and context switching is negligible:

```
void T1() {
    char x='a';
    while (1) {
        putchar(x++);
        OSTimeDly(10);
    }
}

void T2() {
    char x='1';
    while (1) {
        putchar(x++);
        OSTimeDly(10);
    }
}
```

## Question 28

Which of the following statements is correct? The display shows:

- a) abcdefgh ...
- b) 1a2b3c4d ...
- c) 12345678 ...
- d) a1b2c3d4 ...

## Question 29

The OSTimeDly(10) call is replaced by a delay(10) call. Which of the following statements is correct? The display shows:

- a) a1b2c3d4 ...
- b) 1a2b3c4d ...
- c) 12345678 ...
- d) abcdefgh ...

## Question 30

Consider the original fragment of code. Which of the following sentences is correct?

- a) Renaming the variable "x" to "y" in T2 removes the data sharing problem between T1 and T2.
- b) The addition of the keyword "volatile" in front of the definition "char x='1';" in T2 removes the data sharing problem between T1 and T2.
- c) The addition of the keyword "volatile" in front of both definitions "char x=..." removes the data sharing problem between T1 and T2.
- d) There is no data sharing problem between T1 and T2.