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Programme: Automotive Systems	Semester: ASM-SB
Module: Reliable Embedded Systems	
Lecture: <b>Real Time System Design</b>	Lecturer: Agrawal
Mode: closed book apart from 2 manually written sheets of paper DIN-A4	Duration: 60 minutes
Name:	Student number:

**Note:** Use the blank space underneath the questions to write your answers. Please use the time limit provided for each question as a hint as how elaborate your answer should be.

**Question 1:** (1 Min.)

Consider a combustion engine with an injection valve. The start point of fuel injection must be precise within 0.1 deg of the measured angular crankshaft position.

- 1.1 Calculate the temporal accuracy of the system if the crankshaft revolves with 6000 rpm.

**Question 2:** (1 Min.)

What is signal conditioning? How do you describe a device that encapsulates a sensor and a microcontroller in one housing?

**Question 3:** (1 Min.)

Show the relationship between error, faults and failures through a diagram.

**Question 4:** (2 Min.)

Calculate the overhead of a trigger task if the WCET of the trigger task is 200  $\mu$ sec and the laxity of the RT transaction is 10msec. Discuss the advantages and disadvantages of an application task activation by an interrupt versus that by a trigger task.

**Question 5:** (2 Min.)

The real time image in the controller is based on the sensor values. The sensors have their own bottlenecks with respect to time because of the conversion of the physical entities into the digital entities. These digital values are sent to the controller which would calculate the set point and send the value back to the actuator.

- 5.1 What are the two kinds of RT images based on the above constellation?
- 5.2 What is the relation between the temporal accuracy, execution times and the update period for both kinds of images?
- 5.3 In case the update period is not sufficient to update the RT image in the controller within the temporal accuracy period, how can this be achieved?

**Question 6:** (2 Min.)

Describe the successive approximation method for ADC conversion. Please draw the chart using a 3 bit, 5 V ADC convertor.

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### Question 7: (2 Min.)

Mention two different kinds of bus access methods as described in the lecture. Briefly describe how do they access the bus. Why do we need such a method in the distributed system?

### Question 8: (3 Min.)

According to the specification of a hard drive, its failure rate is 0.73 failures / year.

- 8.1 Please calculate lambda for the hard drive.
- 8.2 Please calculate Mean Time To Failure ( MTTF ) for the hard drive.
- 8.3 Please calculate the reliability of the hard drive immediately 1 hour after it has been connected to the computer.
- 8.4 Considering the Mean Time To Repair ( MTTR ) to be 24 hours. What is the Availability of the hard drive in hours.

### Question 9: (3 Min.)

The industrial plants alarm monitoring system which monitors the change in the pressure of an intake valve is connected to the other nodes in the plant through a bus system. However, since all the nodes are connected to a common bus, the alarm monitoring node should delay its action to set the alarm.

- 9.1 Please explain why is this important?
- 9.2 With the following parameters:  $d_{max} = 20$ ,  $d_{min} = 1$ ,  $g_{local} = 10\mu\text{sec}$  and  $g_{global} = 20\mu\text{sec}$ 
  - a Calculate the action delay when no global clock is available.
  - b Calculate the action delay when all the nodes are synchronized through a global clock.

### Question 10: (3 Min.)

Please implement a 10ms timer function and use the interrupt mechanism to toggle a GPIO port pin. To realize the program, please initialize the timer hardware, write an ISR for the timer peripheral, write a main function where you would register a callback function.

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### Question 11:

(5 Min.)

You are asked to design a system with local clocks at each node. The specifications of the ensemble is Latency jitter =  $20\mu\text{sec}$ , Clock drift rate =  $10^{-5}$  sec/sec,  $R_{int} = 1$  sec.

- 11.1 Calculate the precision based on the internal synchronizations algorithm for the clock constellations  $\mu(5,1)$  and  $\mu(5,0)$ .
- 11.2 For the above two clock constellations, which event set you would use through which the temporal order of the events can be definitely established?
- 11.3 Based on the precision calculated above, calculate the true value limits for both the clocks constellation, if the observed duration between two events is 1 millisecond.
- 11.4 What are the four fundamental limits of time measurement? In which case the fundamental limit of  $0/2g$  would fail? What is the possible solution for this?

### Question 12:

(10 Min.)

The customer is a big automotive giant and would like to develop an HMI ( Human Machine Interface ) using hard and soft keys. One of the functional requirement could be a fast scrolling of a phonebook when the user presses and holds a scroll down button for more than 2 seconds.

- 12.1 Please mention more functional, temporal and dependable requirements of the above mentioned system.
- 12.2 Draw a block diagram to detect the press of the buttons through CAN Messages. Please use interrupts. ( the messages are queued in a FIFO ).
- 12.3 Draw a block diagram to detect the press of a button using a potentiometer. Please use polling.
- 12.4 Draw an architecture starting from the press of the button till the realization of the functional requirement of the button.
- 12.5 Please include:
  - a Diagnostic task ( every 50 ms ) to check for a fault on the hard keys.
  - b Driver task ( 100 ms ) to detect the CAN messages using polling.
  - c Driver task ( 1 ms ) to detect the press of a button based on a potentiometer.
  - d Application task ( event task ) to realise the functional requirements.

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### Question 13:

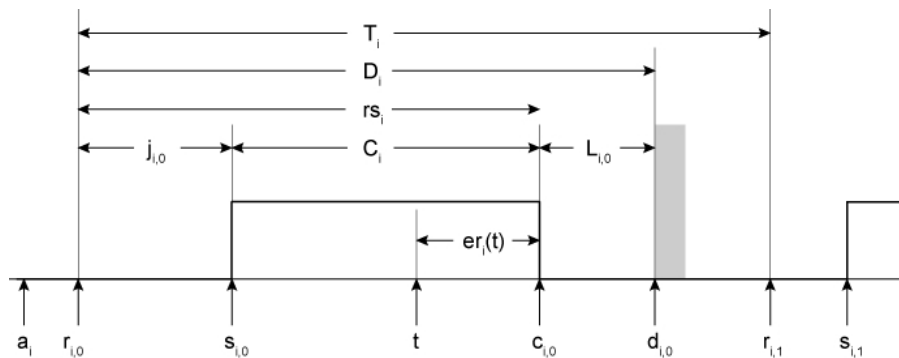
(5 Min.)

You have been given a task to select a real time operating system which would govern an industrial plant. For that you have been invited in the meeting to discuss the various criterias which are important in the proper selection of the product.

13.1 Please mention 5 important criterias what you would present in the meeting?

13.2 One of the criteria is scheduling. Describe the scheduling problem in one line?

13.3 Describe T, D, rs, C, and L in the below diagram.



13.4 In the rate monotonic algorithm, the task with the ..... gets the highest static priority.  
( Please fill in the blank )

13.5 In the earliest deadline algorithm, the task with the ..... gets the highest dynamic priority.  
( Please fill in the blank )

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### Question 14:

(10 Min.)

14. The rate monotonic algorithm is a static priority scheduling algorithm and the earliest deadline first is a dynamic priority scheduling algorithm. Using  $T1 = (1, 4)$ ;  $T2 = (2, 6)$ ;  $T3 = (3, 8)$ ; where the value in parantheses are ( C, T ). Please assume the deadline to be the same as the period.

- 14.1 Calculate the processor utilization factor of the tasks for both the alorithms. Does the calculated factor suffice the schedulability test? Please answer why?
- 14.2 Compute the hyperperiod of the tasks.
- 14.3 Fill in the chart to draw the schedulability of the tasks for both the algorithm.

### Question 15:

(5 Min.)

Using  $T1 = (1, 4)$ ;  $T2 = (2, 8)$ ;  $T3 = (3, 12)$ ; where the value in parantheses are ( C, T ), please

- 15.1 Calculate the processor utilization factor of the task using RM algorithm.
- 15.2 Compute the hyperperiod of the task set.
- 15.3 Fill in the chart to draw the schedulability of the tasks using the RM algorithm.
- 15.4 Can an aperiodic task with the release time of 2, deadline of 20 and computation time of 3 fit in this algorithm? Please calculate the response time of this aperiodic task.

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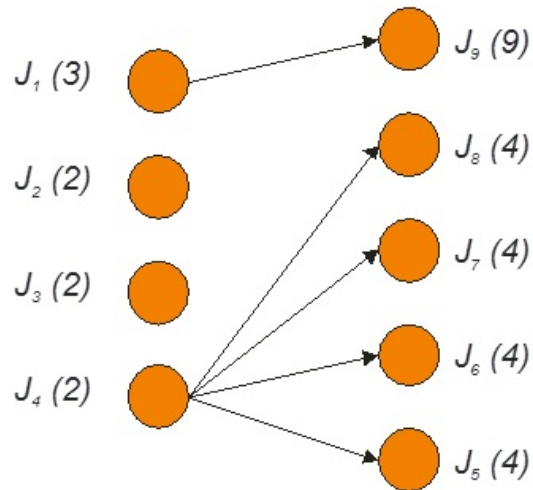
### Question 16:

(5 Min.)

In the below precedence tasks with 9 tasks, please fill in the chart in accordance to the priority.

16.1 For a three processor system.

16.2 For a four processor system.



$$priority(J_i) > priority(J_j) \quad \forall i < j$$

values in parantheses are execution times