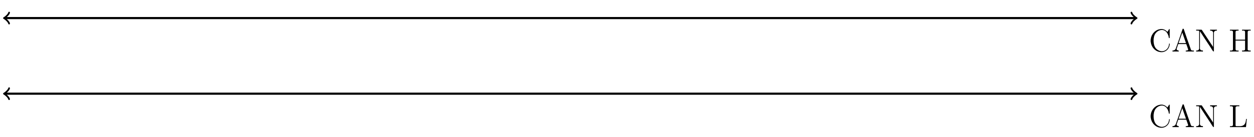
University of Applied Sciences Esslingen **Faculty Graduate School**

Summer Term 2016		Page No.:	1 of 8
Programme:	Automotive Systems	Semester:	ASM-SB
Module:	Reliable Embedded Systems		
Lecture:	**Distributed Real-Time Systems**	Lecturer:	Agrawal
Mode:	closed book apart from 2 sheets of DIN-A4 paper	Duration:	60 minutes
Name:		Student ID:	

Note: Use the blank pages to write your answers. Please number the pages before submitting them. Please follow the time limit provided against each question as a hint as how elaborate your answer should be.

Question 1: Attempt any 10 questions (20 Min.)

You are asked to design a real time distributed network with 3 nodes. All the nodes are equipped with a low speed CAN controller (TJA1054T) and a host CPU as shown in the figure. Pin Number 16 and Pin number 17 are the Can Rx and Can Tx pins on the host CPU respectively.



1. Draw how a real time node looks like and list the main components in such a node.
2. In the fig above, connect the CAN receive and transmit pins on the host CPU with those on the communication controller.
3. In the fig above, connect the communication bus with the appropriate pins on the communication controller.
4. Now, in the page below, make a new distributed network diagram with 3 nodes by connecting all of them with each other via the communication bus.
5. Assign a CAN ID to each node and discuss how the nodes access the bus in case of collisions?

4

Each node is connected in parallel to a 12V DC battery with a capacity of 5400 mAh. Each node has an energy consumption of 100 mAh in operational mode and 1 mAh in standby mode.

6. Extend your block diagram above by connecting the battery unit to the nodes.
7. Assuming that the car has no charger unit, how much energy does the battery still have after 20 hours, if the car is in the operational mode for 15 hours and in standby mode for 5 hours ?

Please sketch a model here

Assuming Node 3, starts sending Error Frames on the bus.

8. How does the CAN driver know about the error frames on the bus and what measures would you take to make sure that all the nodes can still communicate with each other? Hint > Please see the chip diagram.
9. Discuss why a terminating resistance is important in a multi-node communication network system.

Please sketch a model here

The two farthest nodes are 5 m away from each other. The low speed CAN transciever can transmit and receive messages with a bandwidth of 125 KBit / second. The speed of the transmission of the bits is 2/3 of the speed of the light and the message length is 100 bits.

10. What is the bit length of the two farthest nodes?
11. Calculate the best channel utilization in percentage.

Please sketch a model here

TDMA is Time Division Multiple Access and CSMA/CA is Carrier Sense Multiple Access / Collision Avoidance.

12. Name 5 important parameters which you would need to know, before choosing the right protocol such as the one above

Please sketch a model here

Question 2: (10 Min.)

You are given a quartz which oscillates at the rate of 32768 ticks per second.

Your job is to make 3 local clocks each with a macro-granularity of 512 ticks. Each clock drifts differently at a drift rate ρ 10^{-9} s/s, $2 * 10^{-9}$ s/s, $3 * 10^{-9}$ s/s respectively.

1. What is the granularity of the reference clock?
2. What is the granularity of the local clock?
3. What is the minimum time and the maximum time that can be measured in one of the local clock with a 32 bit variable?
4. What is the precision of the clock ensemble over an interval of interest of 1 second?

Please sketch a model here

The clocks are synchronized to the reference clock via a communication bus. The latency jitter between the the reference clock and the local clock is 10^{-12} s. The formula for drift offset is $\Gamma = 2 * \rho * R_{int}$

5. Calculate the synchronization interval according the central master algorithm of one of the local clock of your choice.

Please sketch a model here

Question 3: (10 Min.)

Consider a combustion engine with an injection valve. The start point of fuel injection must be precise within 2° of the measured angular crankshaft position.

1. Calculate the temporal accuracy of the system, if the crankshaft revolves with 6000 rpm.

Please sketch a model here

Considering an update rate d_{update} of 10 μs, WCET of the sender as 500 ns and the WCET of the receiver as 1500 ns and the worst case latency of the communication bus as 18 μs, discuss the type of the image derived (phase sensitive or phase insensitive).

2. Discuss the type of the image if the high level PAR protocol of the RT transaction between the sender and the receiver allows a maximum of 2 retry.
3. How can you solve the problem of phase insensitive images?

Please sketch a model here

Question 4: (20 Min.)

Consider a task set T composed of the following three periodic tasks:

- T1(0, 1, 6) (release time, computation time, deadline)
- T2(0, 2, 10)
- T3(0, 5, 15)

1. Compute the major cycle of the task set.
2. Verify the schedulability under the EDF algorithm.
3. Build the schedule.

Consider the following aperiodic tasks:

- T4(1, 2, 29) (release time, computation time, deadline)
- T5(13, 2, 10)
- T6(21, 4, 9)

4. **All** aperiodic tasks are scheduled in the background together with the main tasks. Compute the response times of tasks T4, T5, and T6.
5. Do you think that any of the aperiodic task would not be able to meet the deadline?