[ENG23]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

MSc ENGINEERING (Various Pathways)

SEMESTER ONE EXAMINATION 2023/2024

SMART ENGINEERING SYSTEMS

MODULE NO: MSE 7003/MSE7013

Date: Friday 12th January 2024 **Time: 10:00 – 12:30**

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions.

Answer any FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Formulae sheet is attached at the end of the paper.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

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Question 1

(a) Ethernet relies on CSMA/CD for collision management. Draw the block diagram to illustrate how CSMA/CD works (7 marks)

(b) Explain why Collision Detection would not work well for Wireless LAN protocols (6 marks)

(c) How is Collision Management improved for wireless LAN using the IEEE802.11 standard (8 marks)

(d) What does IP standard for in the Network layer, what is the key difference between version 4 and version 6 (4 marks)

Total Marks: 25

Question 2:

(a) What are the key security issues associated with Smart Systems (5 marks)

(b) Explain the concept of Big Stream and how it differs to big data (6 marks)

(c) Rationalise the role of configuration in the growth of IOT, state the key benefits of self-configurable IoT systems. (7 marks)

(e) With the use of an example, briefly explain what the Physical Layer is. (5 marks)

Total Marks: 25

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Question 3:

(a) Using simple ray theory, describe the mechanism for the transmission of light within an optical fiber. Briefly discuss with the aid of a suitable diagram what is meant by the acceptance angle for an optical fiber. Show how this is related to the fiber numerical aperture and the refractive indices for the fiber core and cladding. (7 marks)

(b) Draw the general block diagram of the optical fibre communication system (6 marks)

(c) Briefly indicate with the aid of suitable diagrams the difference between meridional and skew ray paths in step index fibers. (6 marks)

(d) An optical fiber has a numerical aperture of 0.20 and a cladding refractive index of 1.59. Determine:

(i) the acceptance angle for the fiber in water which has a refractive index of 1.33;
(ii) the critical angle at the core–cladding interface.

(6 marks)

Total Marks: 25

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Question 4

(a) Draw a UML Use Case Diagram for the for the Elevator Software System described in Figure Q4 (10 marks)

(b) Draw a UML Class Diagram for the Elevator Control Software System described in Figure Q4. Show classes, and relationships between classes on your diagram. Give attributes and methods for the classes. (15 marks)

A software system must control one elevator for a building with 20 floors. The elevator contains a set of buttons, each corresponding to a desired floor. These are called floor request buttons, because they indicate a request to go to a specific floor. The elevator also has a current floor indicator above the door. Each floor (except the highest and lowest) has two buttons for requesting elevators, called elevator request buttons, because they request the elevator.

Each floor has a sliding door for the shaft arranged so that two door halves meet in the centre when closed. When the elevator arrives at the floor, the door opens at the same time the door on the elevator opens; these two sets of doors can be treated as one door since the two only ever open together. The door has both pressure and optical sensors to prevent closing when an obstacle is between the two door halves. If an obstruction is detected by either sensor, the door shall open. The door shall automatically close after a timeout period of five seconds after the door opens. The detection of an obstruction shall restart the door closure time after an obstruction is removed. There is a speaker on each floor that "pings" in response to the arrival of an elevator.

On each floor (except the highest and lowest), there are two elevator request buttons, one for UP and one for DOWN. On each floor, above the elevator door, there is an indicator that specifies the floor the elevator is currently at and another indicator for its current direction. The system shall respond to an elevator request by sending the elevator if it is already going in the requested direction, or if the elevator is idle. If the elevator is travelling in the opposite direction, the request shall pend until the elevator meets the above criterion. Once pressed, the request buttons are backlit to indicate that a request is pending. Pressing an elevator request button when a request for that direction is already pending shall have no effect. When an elevator arrives to handle the request, the backlight shall be removed. If the button is pressed when the elevator is on the floor to handle the request, then the door shall stop closing and the door closure timer shall be reset.

To enhance safety, a cable tension sensor monitors the tension on the cable that controls the elevator. In the event of a failure in which the measured tension falls below a critical value, then four external locking clamps connected to running tracks in the shaft stop the elevator and hold it in place.

Figure Q4

Total (25 marks)

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Question 5

(a) Draw a typical bathtub curve for the hardware component. Identify the three important parts of your diagrams (8 marks)

(b) Explain, in a few sentences, what a functional requirement is and what a non-functional requirement is, and give an example of each, for a passenger plane system. (6 marks)

(c) Explain what SysML is and how it differs to UML. (6 marks)

(d) Considering the six general principles of Design for Reliability: Element/component selection, De-Rating, Environment, Minimum complexity, Redundancy and Diversity. Give an example of a system which should be designed using De-Rating, and explain how Diversity could be designed into this system. (5 Marks)

END OF QUESTION

Formulae sheets follow over the page

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Formulae List

Snell's law: $\frac{\sin\theta_i}{\sin\theta_r} = \frac{n_2}{n_1} = n = \text{constant}$

Numerical Aperture, $NA = n_0 \sin\theta_a = \left(n^2{}_1 - n_2{}^2\right)^{\frac{1}{2}}$

The relative refractive index difference, $\Delta = \frac{n_1^2 - n_2^2}{2n_1^2} \simeq \frac{n_1 - n_2}{n_1} for \Delta \ll 1$

$NA = n_1(2\,\triangle)^{\frac{1}{2}}$

The Rayleigh scattering coefficient:

$$\gamma_R = \frac{8\pi^3 n^8 p^2 \beta_c K T_F}{3\lambda^4}$$

where:

$\beta_c -$ the isothermal compressibility

$K -$ Boltzmann's constant $= 1.381\times10^{-23}\ J/K$

$p -$ the average photoelastic coefficient

$T_F -$ fictive temperature.

Transmission loss factor, $\mathcal{L}_{km} = \exp\left(-\gamma_R L\right)$

The attenuation due to Rayleigh scattering *in dB/km*, $Attenuation = 10\log_{10}(1/_{km})$

The optical power generated internally by the LED, $P_{\text{int}} = \eta_{\text{int}} \frac{hic}{\lambda e}$

where: –

$h -$ Planck's const $= 6.625\times10^{-34}\ Js$

$c = 3\times10^8\ m/s$

$e -$ the charge on an electron $= 1.602\times10^{-19}\ coulomb$

The total recombination lifetime, $\tau = \frac{\tau_r \times \tau_{nr}}{\tau_r + \tau_{nr}}$

The internal quantum efficiency, $\eta_{\text{int}} = \frac{\tau}{\tau_r}$

The external power efficiency, $\eta_{ep} = \frac{P_e}{P}\times100\%$

$P -$ power provided in device

The optical power emitted externally, $P_e = \frac{P_{\text{int}} F n^2}{4n_x^2}$

END OF PAPER