[ENG27]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

MSC ENGINEERING

SEMESTER ONE EXAMINATION 2021/22

SMART ENGINEERING SYSTEMS

MODULE NO: MSE 7003

Date: Tuesday 11th January 2022 Time: 14:00 – 16:30

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions.

Answer ANY FOUR questions.

All questions carry equal marks.

Scientific calculators without programmable functions are permitted.

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.

Question 1

a) What is the difference between Smart devices and WSNs (7 marks)

b) Explain how the Network Layer can influence the development of IoT (8 marks)

c) What are the key problems with app based IoT smart objects (5 marks)

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

Total (25 marks)

Question 2:

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

b) What is Big Stream and how does it differ from big data (6 marks)

c) Compare the key differences between Symmetric-key LWC Algorithms and Tiny Encryption Algorithm (8 marks)

d) With the use of a diagram, explain the Fog Computing paradigm (6 marks)

Total (25 marks)

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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) 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;

(3 marks)

(ii) the critical angle at the core–cladding interface.

(3 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)A step index fiber with a suitably large core diameter for ray theory considerations has core and cladding refractive indices of 1.44 and 1.42 respectively.
Calculate the acceptance angle in air for skew rays which change direction by 150°at each reflection.

(6 marks)

Total (25 marks)

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Question 4:

(a) Describe the different properties of Tchebycheff, Butterworth and Bessel filters.

(10 Marks)

(b) Refer to table one, calculate the component values for a low pass filter of order five used in a smart transducer interface. **The Butterworth** filter should have 3dB frequency of 500MHz and will be used in a 50Ω circuit sketch the design.

(7 Marks)

k ↓ n →	2	3	4	5	6
1	1.4142	1.0000	0.7654	0.6180	0.5176
2	1.4142	2.0000	1.8478	1.6810	1.4142
3		1.0000	1.8478	2.0000	1.9319
4			0.7654	1.6810	1.9319
5				0.6810	1.4142
6					0.5176

Table One

(c) Refer to table one, design a high pass filter with corner frequency 500MHz and to be used in 50Ω circuit, sketch the design. (8 Marks)

Total (25 marks)

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Question 5:

(a) A smart signal conditioning circuit is shown in Figure 6, derive the transfer function for Vo/Vs in the Laplace domain. (10 marks)

(b) For the transfer function derived in part(a) sketch the frequency plots, magnitude, and phase labelling all axis and corner frequencies. (8 marks)

(c) If the signal conditioning circuit shown in Figure 6 has poles and zeros, sketch the pole-zero diagram and comment on stability. (5 marks)

(d) State an application for the circuit shown Figure 6. (2 marks)

Components; R1=R2=R3= 100kΩ and C1 =10nF

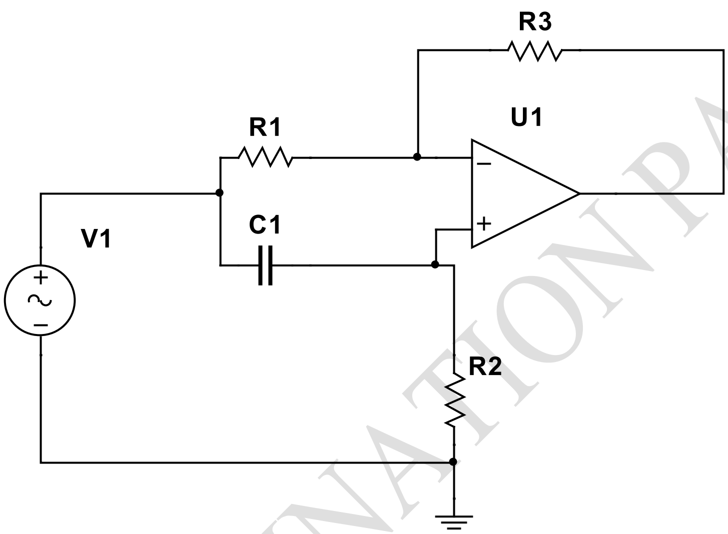

Figure 6

Total (25 marks)

END OF QUESTIONS

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Formulae List

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

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

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

$NA = n_1\left(2\Delta\right)^{\frac{1}{2}}$

$The\ Rayleigh\ scattering\ coefficient:$

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

$where:$

$\beta_c -$ 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, $\mathscr{L}_{km} = \exp\left(-\gamma_R L\right)$

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

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

$where:-$

$h -$ 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, $\tau = \dfrac{\tau_r \times \tau_{nr}}{\tau_r + \tau_{nr}}$

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

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

$P -$ power provided in device

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

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