UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	ELECTROMAGNETIC COMPATIBILITY
COURSE CODE	:	BEJ 41703
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2022
DURATION	:	4 HOURS
INSTRUCTION	:	1. ANSWER **ALL QUESTIONS** 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSISTS OF **TENTH (10)** PAGES

Q1 (a) You are working as an EMC engineer in a company producing electrical and electronic devices and systems. Your primary function is to ensure that your company's products comply with the relevant EMC standards.

(i) What is the definition of electromagnetic compatibility (EMC) according to the IEC?

(2 marks)

(ii) Explain the importance of achieving EMC compliance to your company?

(4 marks)

(b) Discuss the following statements:

(i) It is difficult to shield a low-frequency magnetic field.

(4 marks)

(ii) As an engineer, you need to ensure that an equipment and system for fix installation comply with EMC standard in intended environment. IEC just published a new standard and has been adopted by British Standard (BSI). However, OJEU still using previous standard that already withdrawn in IEC.

(iii) (6 marks)

(b) Most electronic circuits nowadays operate at high frequency. Hence, studying the behavior of circuit elements when frequency increases to ensure that operation works as designed is important. Explain what happened to the wire conductor as frequency increases related to the skin effect (δ).

(4 marks)

Q2 (a) Describe the difference between common-mode (CM) current and different-mode (DM) current.

(4 marks)

(b) Radiated emission (RE) test is one of the important tests for EMC compliance. Nowadays, an automated system is used to perform the RE test to control the antenna, turntable and other instruments. Present a description in a flowchart on how the RE test is performed to obtain a list consisting of quasi-peak electric fields measurement.

(8 marks)

(c) A PCB with an interface cable is shown in **FIGURE Q2(c).** Analyze whether the radiated emission of the PCB and cable will comply with FCC part 15 class B limit?

FCC part 15 class B limit

Frequency (MHz)	Limits at 3m(dBμV/m)
30-88	40
88-216	43.5
216-960	46
>960	54

(8 marks)

Q3 (a) You are an EMC test-engineer working in a company producing Air-conditioner. The R&D department has come up with a new design of the air-conditioner which must be marketed to United Kingdom (UK) in 3 months. Your main responsibility is to ensure that the product passes all the EMC tests within the stipulated time frame.

(i) Describe all the EMC tests that should be conducted on the Air-Conditioner
(4 marks)

(ii) Determine the relevant EMC standards to comply with during the testing.
(4 marks)

(iii) If it was found that the SMPS radiated emission exceeds the permitted limit at 50 MHz. Recommend two (2) EMC best practices in the design of the SMPS circuit in order to overcome this situation

(4 marks)

(b) Line Impedance Stabilization Network (LISN) is used to measure the noise currents that exit the product's AC power cord conductor to verify compliance with FCC and CISPR 22 from 150 kHz to 30 MHz.

(i) Explain briefly why LISN is needed for a conducted emission measurement.
(5 marks)

(ii) Illustrate the use of a LISN in measuring conducted emissions of a product.
(3 marks)

Q4. (a) A barrier made of copper ($\mu_r = 1$, $\epsilon_r = 1$, $\sigma = 5.8 \times 10^7$ S/m) of thickness 0.1 mm is to be used as an enclosure to shield a digital circuit at 1 MHz. Calculate the skin depth and total loss (reflection loss + absorption loss + multiple reflection loss) of the barrier (in dB). Assume that the field incident on the barrier is a far-field source, and the effect of openings on the enclosure can be neglected.

(10 marks)

(b) A noisy circuit is connected to AC power mains. The AC power mains could be modelled as an AC power source with a source resistance of 25 Ω. The noisy circuit could be modelled as a noisy voltage source with a source resistance of 5 Ω. A lowpass filter is added between the AC mains and the noisy circuit to attenuate the noise from the noisy circuit toward the AC power mains. Discuss the filter attenuation characteristic using:

(i) 0.1 μF shunt capacitor as a lowpass filter

(5 marks)

(ii) 1 mH series inductor as a lowpass filter

(5 marks)

(Note: You may refer to the Impedance Graph in **Figure Q4(c)**)

Q5. (a) Discuss the importance and difference between EMC product level/stage andEMC system design.

(3 marks)

(b) Discuss the difference between PCB and circuit design in **Figure Q5 (b)** Explain which PCB design is better in terms of EMC design.

(4 marks)

(c) A High Voltage (HV) power transmission line (Alternate Current, AC) produces a strong magnetic field that varies with time and induce a dangerous voltage on the adjacent cable (victim) near the transmission line. Future new railway track will be developed near the Power transmission line as shown in **Figure Q5 (c)(i).**
In addition, the new Control cable is laid parallel with the power transmission line at a distance, L = 2 km, and the distance between the Control cable and its ground is 10 cm, as shown in **Figure Q5 (c) (ii)**

(i) Represent the cable induced voltage in a complete equivalent circuit. Label your figure.

(2 marks)

(ii) Calculate the total induce voltage (Vemf) on the victim cable if the magnetic field (H-field) produced by the AC Power transmission line at the intended location is 0.99 uT.

(6 marks)

(iii) As an engineer, decide if the control cable is safe placed at the intended location based on ITU standards and regulations.

(2 marks)

(iv) 33kV AC Power cable has been replaced with 750 VDC. Discuss why the DC power cable will not interrupt and induce high voltage on the victim control cable.

(3 marks)

END OF QUESTIONS

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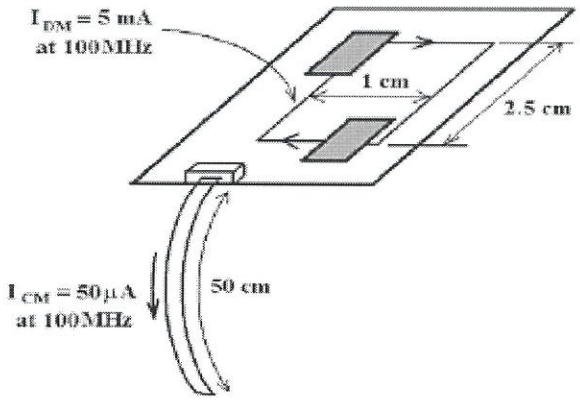

FIGURE Q2 (c)

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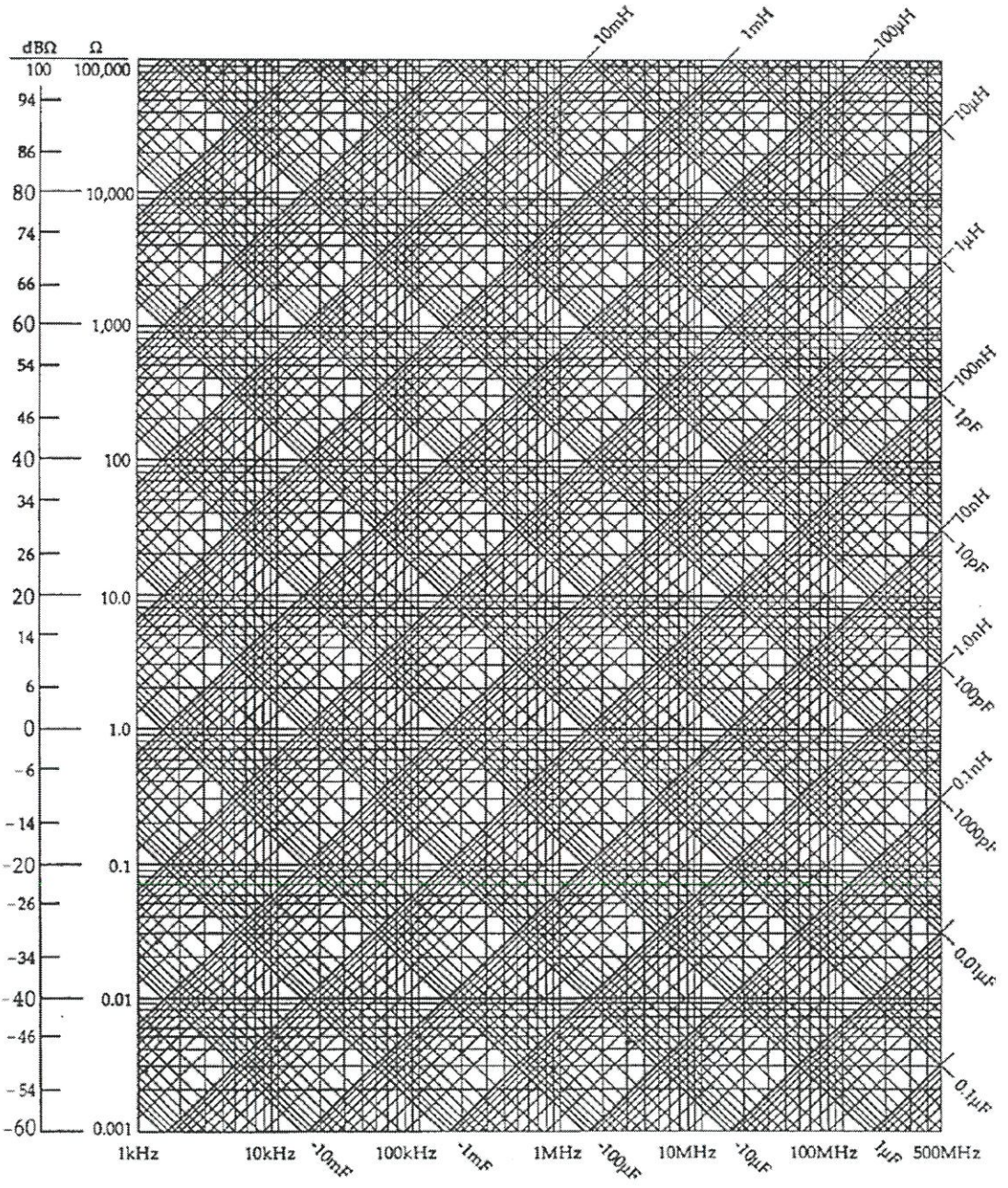

FIGURE Q4 (c)

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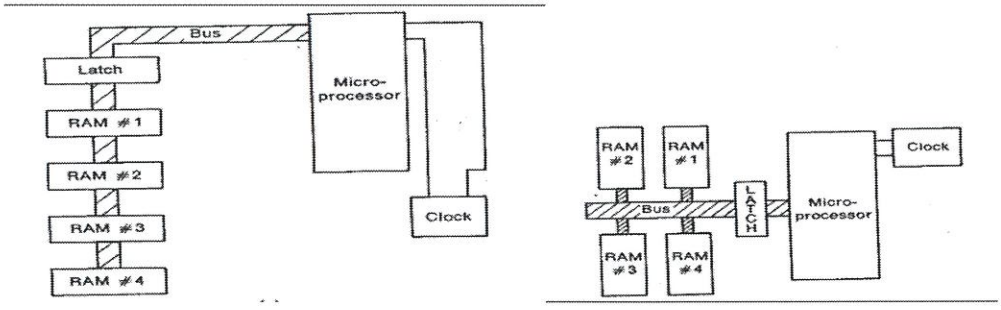

(a) (b)

FIGURE Q5 (b)

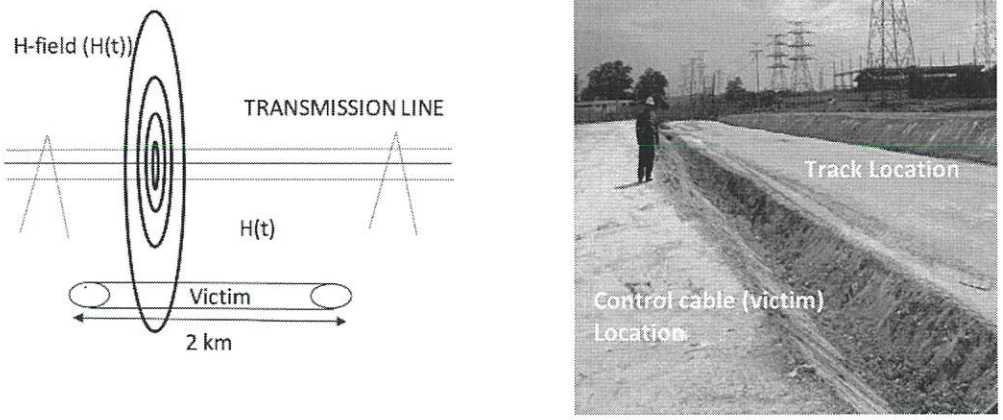

FIGURE Q5 (c)(i)

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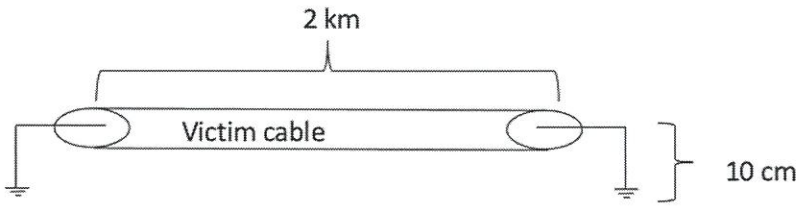

FIGURE Q5 (c) (ii)