Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	ELECTROMAGNETIC COMPATIBILITY
COURSE CODE	:	BEB 41703
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2020
DURATION	:	24 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **(OPEN BOOK EXAMINATION)**

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Elaborate on each of the following statements:

(i) Electrostatic charges on a person can cause fire at a petrol station if he or she does not take extra precautions.

(6 marks)

(ii) An OATS is an alternative EMC facility as compared with TEM and GTEM cells. However, it has many disadvantages as compared with Semi-Anechoic Chamber and Reverberation Chamber.

(6 marks)

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 However, OJEU still using the previous standard that already withdrawn in IEC.

(8 marks)

(b) Most electronic circuits nowadays operate at high frequency. Hence the importance of studying the behavior of circuit elements when frequency increases are crucial to ensure its operation works as designed.

(i) What happens to the resistance of conductors when the frequency increases? Briefly explain why.

(4 marks)

(ii) Explain what happened to the wire conductor when frequencies increase in relation to the skin effect (δ).

(6 marks)

Q2 (a) Common-mode currents produce higher radiated emission than differential-mode currents. Justify this statement by using illustration and analytical formulation.

(5 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 the form of a flowchart on how the RE test is performed to obtain a list consisting of quasi-peak electric fields that exceed the limits of the CISPR 22 Class B standard.

(10 marks)

(c) The radiated emissions of a cable are being measured as shown in **Figure Q2(c)** at 200 MHz. The antenna factor at 200 MHz is 12 dB and the antenna is oriented parallel to and in the plane of the wires. The antenna is connected to a spectrum analyzer using a 3 m length of RG58U coaxial cable with 0.25 dB/m loss at 200 MHz.

(i) Calculate the magnitude of the radiated electric field due to the differential-mode component and due to the common-mode component at the antenna.

(10 marks)

(ii) Will the emission in **Q2(c)(i)** pass the EN 55022 Class B test?

(2 marks)

(iii) Indicate the magnitude of the voltage measured by the spectrum analyzer.

(3 marks)

Q3 (a) You are an EMC test-engineer working in a company producing switched-mode power supplies (SMPS). The Research and Development (R&D) department has developed a new design of the device which must be marketed to European countries in 3 months. Your main responsibility is to ensure that the products pass the necessary EMC tests within the stipulated time frame.

(i) Suggest a workflow in the form of a flowchart of the necessary EMC tests that should be conducted on the SMPS.

(10 marks)

(ii) 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 to overcome this situation.

(5 marks)

(iii) Shielding is normally implemented as the last resort to achieve EMC radiated emission compliance, although it would increase the cost and weight of the product. Please advise the design engineer on the best practices to implement shielding and the best technique to connect input/output cables to the shield.

(10 marks)

(b) Line Impedance Stabilization Network (LISN) is used to measure the noise currents that exit the product's AC power cord conductor for verification of compliance with FCC and CISPR 22 from 150 kHz to 30 MHz. However, these emissions can be simply measured with a current probe but repeatability is an issue.

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

(2 marks)

(ii) Illustrate the use of a LISN in the measurement of conducted emissions of a product.

(3 marks)

Q4 (a) You are required to provide credible facts (equations and figures) to support the following statements on electromagnetic shielding.

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

(2 marks)

(ii) Apertures considerably reduce the effectiveness of a shield.

(3 marks)

(b) A barrier made of copper ($\mu_r = 1$, $\varepsilon_r = 1$, $\sigma = 5.8 \times 10^7$ S/m) of thickness 0.1 mm is to be used as an enclosure to shield a digital circuit at 1 MHz.

(i) Calculate the skin depth and total loss (reflection loss, absorption loss and 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)

(ii) An aperture of maximum linear dimension 5 cm is introduced on the barrier for cables installation. Calculate the shielding effectiveness of the aperture.

(5 marks)

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

(i) 0.1 μF shunt capacitor as a lowpass filter, and

(5 marks)

(ii) 1 mH series inductor as a lowpass filter.

(5 marks)

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

- END OF QUESTIONS

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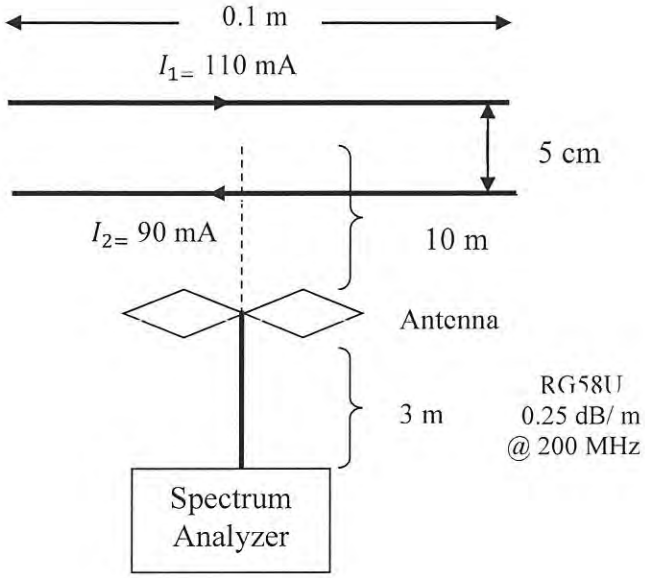

FIGURE Q2(c)

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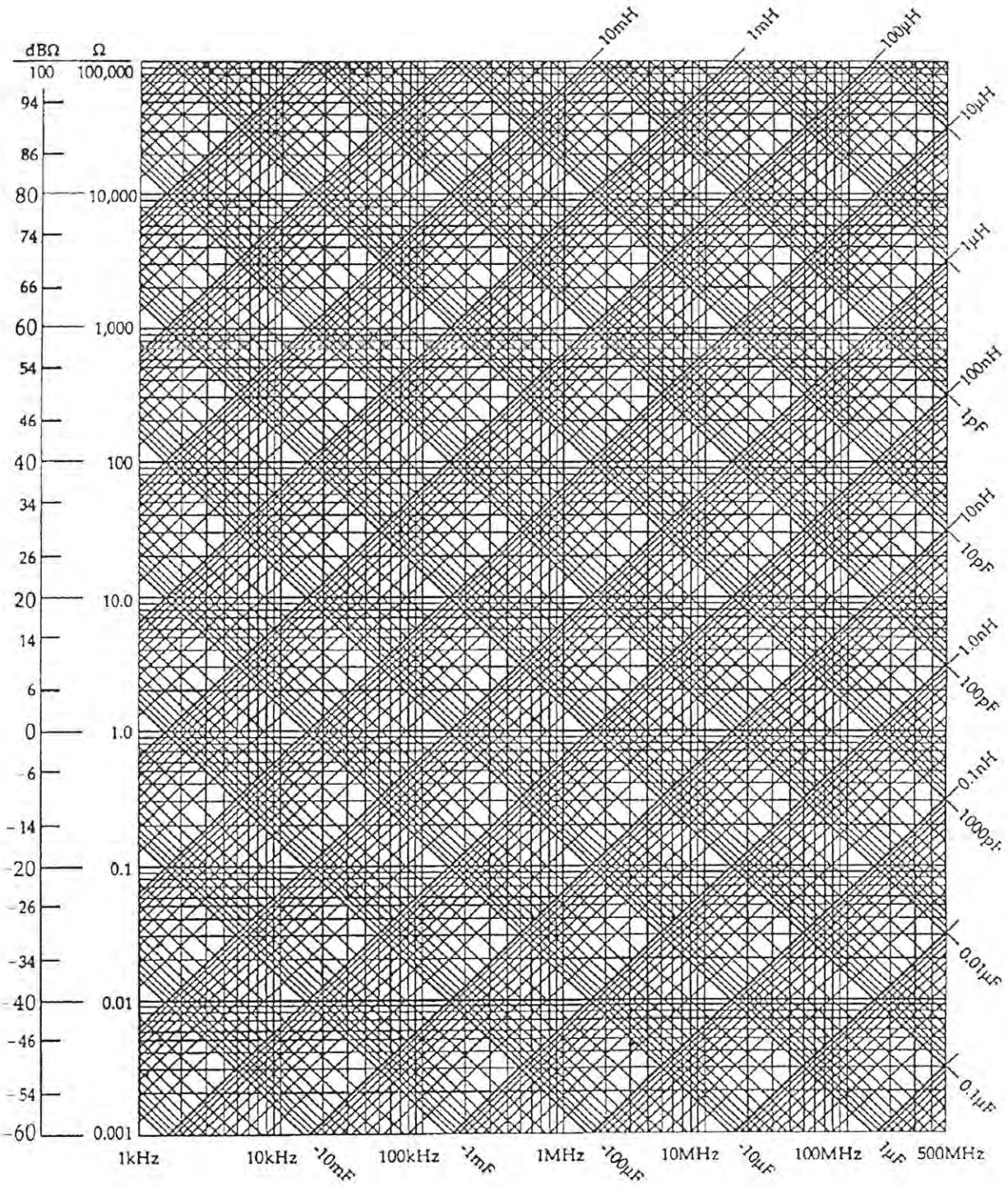

FIGURE Q4(c)