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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017**

TERBUKA

COURSE NAME : ELECTROMAGNETIC
COMPATIBILITY

COURSE CODE : BEB41703

PROGRAMME CODE : BEE

EXAMINATION DATE : DECEMBER 2016 / JANUARY 2017

DURATION : 3 HOURS

INSTRUCTION : ANSWERS FIVE (5) QUESTIONS
ONLY

THIS QUESTION PAPER CONSISTS OF SIX (6) PAGES

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Q1 On May 4th, 1982, during the Falkland Islands War, the H.M.S. Sheffield's search radar was turned off due to electromagnetic interference problems with the ship's satellite communication system. This disabled the ship's anti-missile defense systems and enabled an Exocet missile to hit the ship resulting in the loss of the ship and 20 lives.

(a) What is the definition of electromagnetic compatibility (EMC) according to the International Electrotechnical Commission IEC?

(3 marks)

(b) Briefly explain what you understand by the term interference in terms of the following elements: “intentional emitters”, “intentional receptors”, “unintentional emitters” and “unintentional receptors”?

(8 marks)

(c) Briefly explain how does the problem encountered by the H. M. S Sheffield is related to EMC.

(5 marks)

(d) A large proportion of EMC problems can be addressed at the design stage of electronic systems. Propose and explain **TWO (2)** best practices in circuit design that can avoid the event above from taking place.

(4 marks)

Q2 You are an EMC test-Engineer working in a company producing switched-mode power supplies (SMPS). The R&D department has developed a new design of the device which must be marketed to European countries in 3 months time. Your main responsibility is to ensure that the products pass the necessary EMC tests within the stipulated time frame.

(a) State the scope of EMC tests should be conducted for the SMPS.

(2 marks)

(b) 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.

(6 marks)

(c) 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. Advise the best way on how the shielding should be implemented and the best technique to connect the input/output cables to the shield.

(12 marks)

- Q3** (a) Common-mode probe can be used to measure common-mode currents on a cable. Explain the operation of a common-mode probe. (5 marks)
- (b) The radiated emissions of a cable at 200MHz are measured as shown in **Figure Q3(b)**. The antenna factor at 200 MHz is 12 dB/m 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 meter length of RG58U coaxial cable with 0.25 dB/m loss at 200 MHz. The measurement is done in a semi-anechoic chamber in accordance to the MS CISPR 22 Class B standard.
- (i) Calculate the magnitude of the total electric field at the antenna due to the differential-mode and common-mode currents. (8 marks)
- (ii) Will the emission in part **Q3(b)(i)** pass the MS CISPR 22 Class B test? (2 marks)
- (iii) Calculate the magnitude of the voltage measured by the spectrum analyzer? (5 marks)
- Q4** (a) 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)
- (b) **Figure Q4(b)** shows the magnitude of impedance versus frequency for a passive component.
- (i) Based on the given impedance response, please identify the type of passive component. (2 marks)
- (ii) Estimate the value of the passive component. (3 marks)

- (c) A noisy circuit is connected to AC power mains. The AC power mains could be modeled as a AC power source with a source resistance of 25Ω . The noisy circuit could be modeled as a noisy voltage source with a source resistance of 5Ω . To attenuate the noise from the noisy circuit to the AC power mains, a low pass filter is added between the AC mains and the noisy circuit. Determine the filter attenuation characteristic using:
- (i) $0.1 \mu\text{F}$ shunt capacitor as low pass filter (5 marks)
 - (ii) 1 mH series inductor as low pass filter (5 marks)

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

- Q5** (a) You are required to provide credible arguments (equations and illustrations) to evaluate the following statements on electromagnetic shielding.
- (i) High permeable ferromagnetic material can provide shielding against low frequency magnetic fields. (3 marks)
 - (ii) A conductive shield placed around cable wires will not necessarily reduce the radiated emissions of the cable. (3 marks)
 - (iii) One long slot provides as much ventilation as do many small holes, but perturb the induced current more, thus reducing the shielding effectiveness. (3 marks)
- (b) A barrier made of copper ($\mu_r = 1$, $\epsilon_r = 1$, $\sigma = 5.8 \times 10^7 \text{ S/m}$) of thickness 1.2 mm is to be used as an enclosure to shield a digital circuit at 100 kHz . However the circuit has a shielded input-output cable connecting it to the outside world.
- (i) Suggest an effective method to terminate the shielded cable to the enclosure to avoid radiation due to common-mode current existing on the cable. (3 marks)
 - (ii) Calculate the skin depth and total loss (reflection loss + absorption loss + multiple reflection loss) of the barrier. Assume that the field incident on the barrier is a far field source and the effect of openings on the enclosure can be neglected. (8 marks)

- Q6** (a) Proper grounding system is essential to ensure compliance to EMC. Discuss the followings which are related to grounding system.
- (i) Common impedance coupling. (3 marks)
 - (ii) Differences between safety ground and signal ground. (2 marks)
- (b) You are employed by company XYZ which produces low-cost digital devices and you are a member of that company's EMC team. The company has had numerous situations where inattention to EMC design principles has caused disastrous schedule delays and cost overruns. The company management has ordered an EMC awareness campaign. Your manager has given you a task to present a seminar on EMC to the technical personnel in the company. Your task is to develop a presentation that will educate on how to design, manufacture and market their product with EMC as top priority. The presentation may include:
- (i) A list of learning objectives of the seminar. (5 marks)
 - (ii) Outline of the seminar. (5 marks)
 - (iii) Sample of two slides on important sub-areas in your outline. (5 marks)

-END OF QUESTIONS -

FINAL EXAMINATION

SEMESTER / SESSION : SEM I 2016/2017
COURSE NAME : ELECTROMAGNETIC FIELDS
COMPATIBILITY

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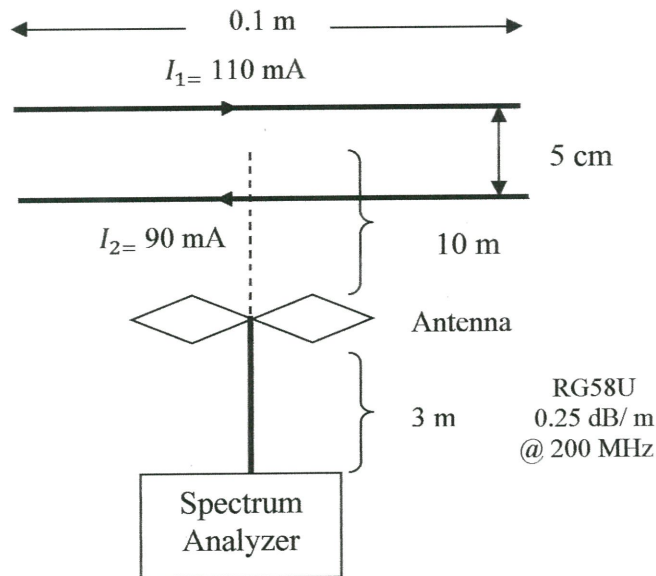


FIGURE Q3(b)

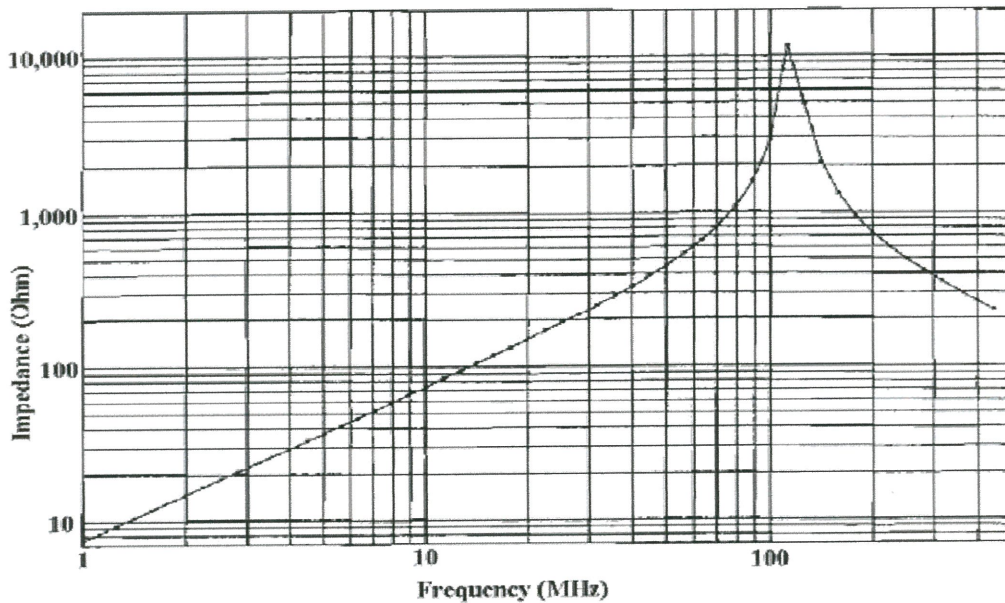
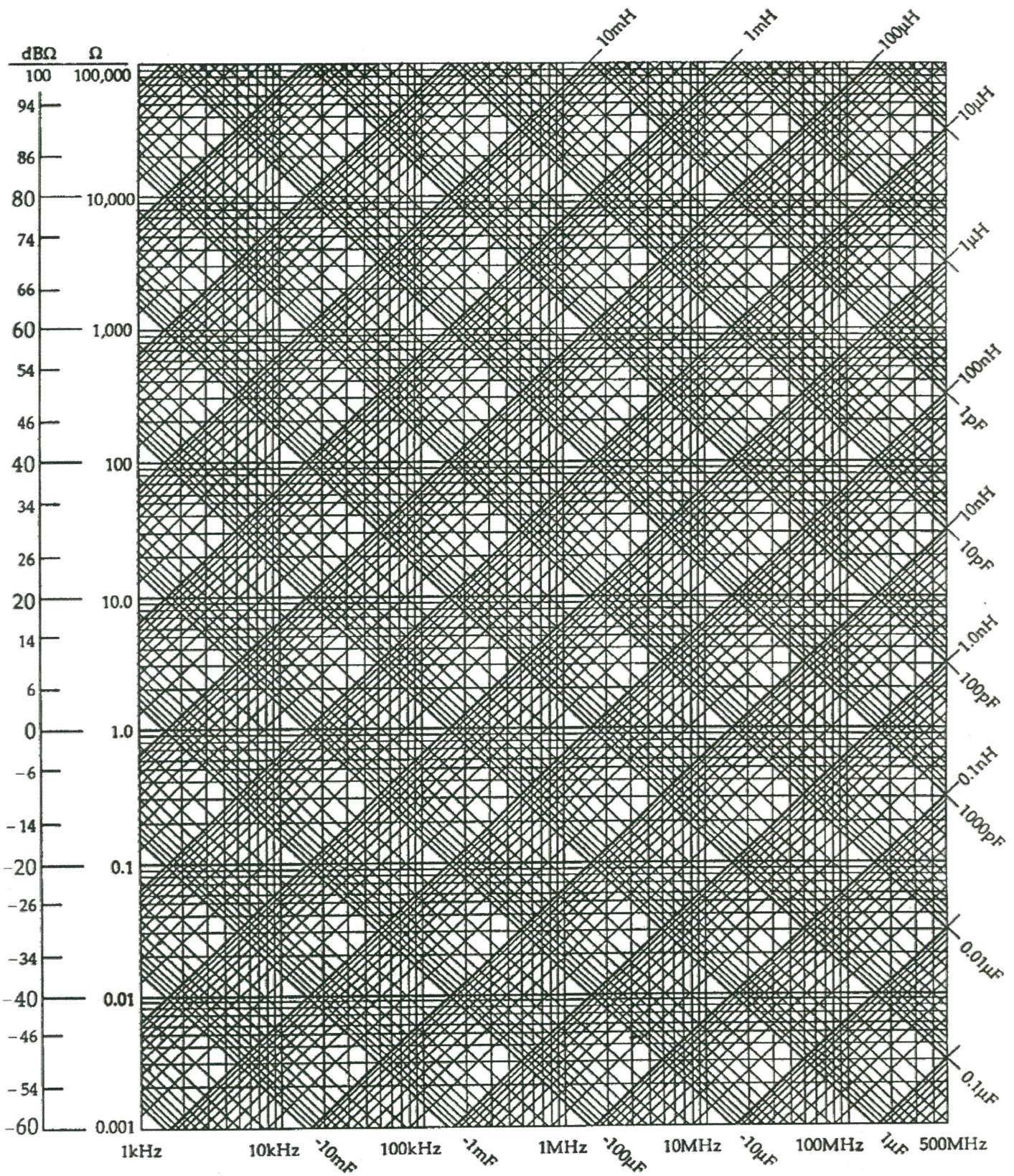


FIGURE Q4(b)



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