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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016**

COURSE NAME : ELECTROMAGNETIC COMPATIBILITY
COURSE CODE : BEB 41703
PROGRAMME CODE : BEJ
EXAMINATION DATE : JUNE / JULY 2016
DURATION : 3 HOURS
INSTRUCTION : ANSWER FIVE (5) QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF SEVEN (7) PAGES

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- Q1** The computer power supply unit produced by company ABC has been withdrawn from the market with immediate effect. The product poses a risk of electromagnetic disturbance because it emits a higher intensity electromagnetic field than acceptable level. The product does not comply with the Directive 2004/108/EC on Electromagnetic Compatibility (EMC) and the relevant European standard EN 55022:2010. The R&D department needs to develop a revised design of the unit so that it can be marketed to Europe in 2 months time. Your main responsibility is to ensure that the power supply unit passes the EMC radiated emission test within the stipulated time frame.
- (i) List and explain **THREE (3)** possibilities why the power supply unit failed the radiated emission test.
(6 marks)
 - (ii) Explain the usage of the tool and measurement procedures to detect the existence of common-mode current on the cables attached to the power supply unit.
(8 marks)
 - (iii) It was found that the power supply unit radiated emission exceeds the EN 55022 Class A limit at 200 MHz. Propose two (2) countermeasures that you would suggest to the design engineer to reduce the emission?
(4 marks)
 - (iv) State EMC related precautions that should be published in the user-manual of the product.
(2 marks)
- Q2**
- (a) Common-mode probe can be used to measure common-mode currents on a cable. Explain how the common-mode probe works.
(5 marks)
 - (b) The radiated emissions of a cable are being measured as shown in **Figure Q2(b)** at 200 MHz. 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 Q2(b)(i) pass the MS CISPR 22 Class B test?
(2 marks)
- (iii) What is the magnitude of the voltage measured by the spectrum analyzer?
(5 marks)

Q3 (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 Q3 (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 (resistor, capacitor or inductor) and estimate the value of the passive component.
(5 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 Q3(c))

- Q4** (a) Describe the procedures to perform the field uniformity test as indicated in IEC 61000-4-3. (6 marks)
- (b) A 10 V/m, 100 MHz uniform plane wave is incident on a two-wire line as shown in **Figure Q4(b)**. The wire is surrounded by Teflon ($\epsilon_r = 2.1$) as insulation dielectric with spacing of 0.5 cm. The wires have a radius of 1.5 mm.
- (i) Determine the induced voltage V . State your assumptions. (10 marks)
- (ii) If the two wire line is susceptible to the induced voltage V calculated in part **Q4b(i)**, Propose the positions where V can be minimized by rotating the circuit along the x-axis. (4 marks)
- Q5** (a) You are required to provide credible arguments (equations and illustrations) to evaluate the following statements on electromagnetic shielding.
- (i) It is difficult to shield low-frequency magnetic field. (3 marks)
- (ii) A shield placed around cable wires will not necessarily reduce the radiated emissions of the cable. (3 marks)
- (b) A barrier made of copper ($\mu_r = 1$, $\epsilon_r = 1$, $\sigma = 5.8 \times 10^7$ S/m) of thickness 0.2 mm is to be used as an enclosure to shield a digital circuit at 3 MHz.
- (i) 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)
- (ii) An aperture of maximum linear dimension 4 cm is introduced on the barrier for the purpose of inserting cables. Calculate the shielding effectiveness of the aperture (in dB) and the effective shield of the barrier. (4 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 -

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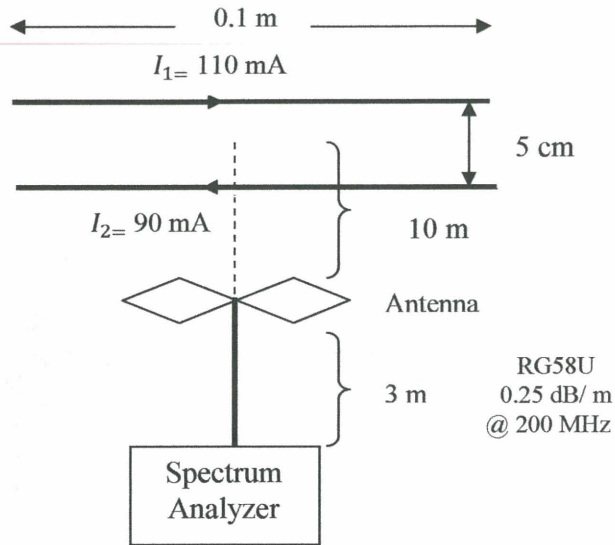


FIGURE Q2(b)

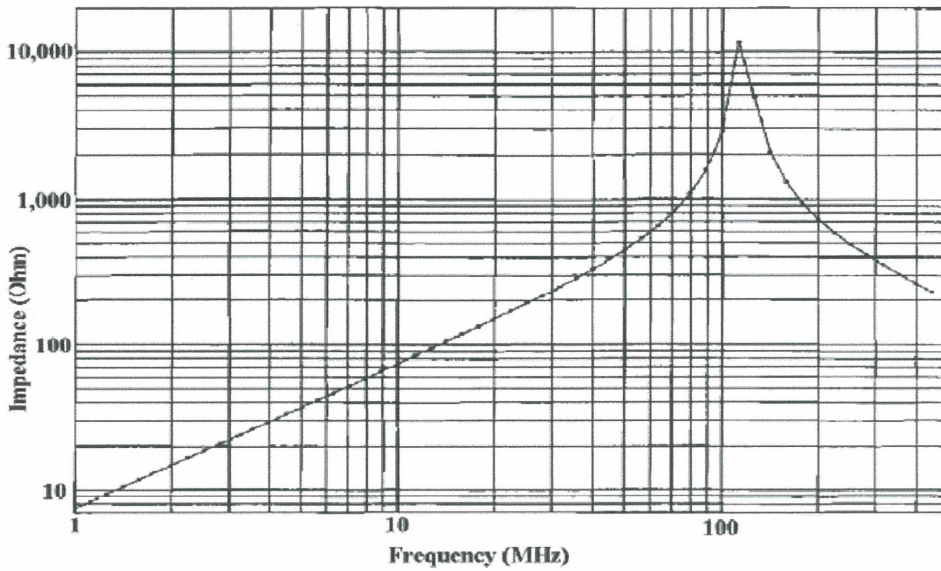


FIGURE Q3(b)

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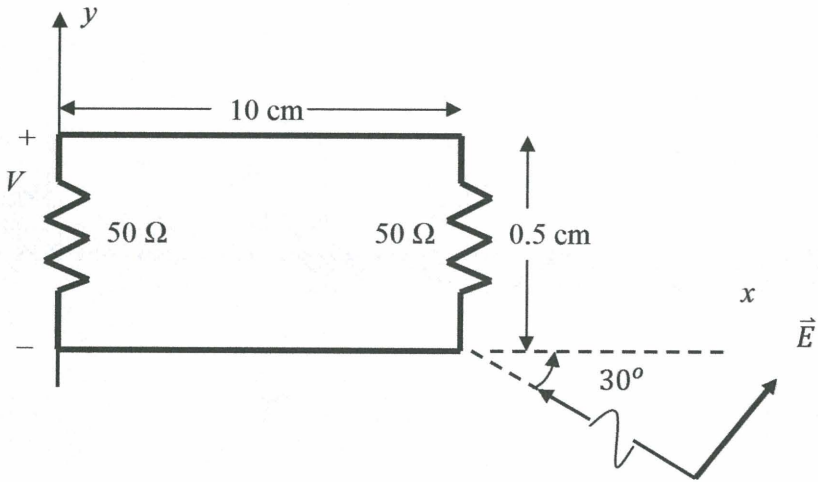
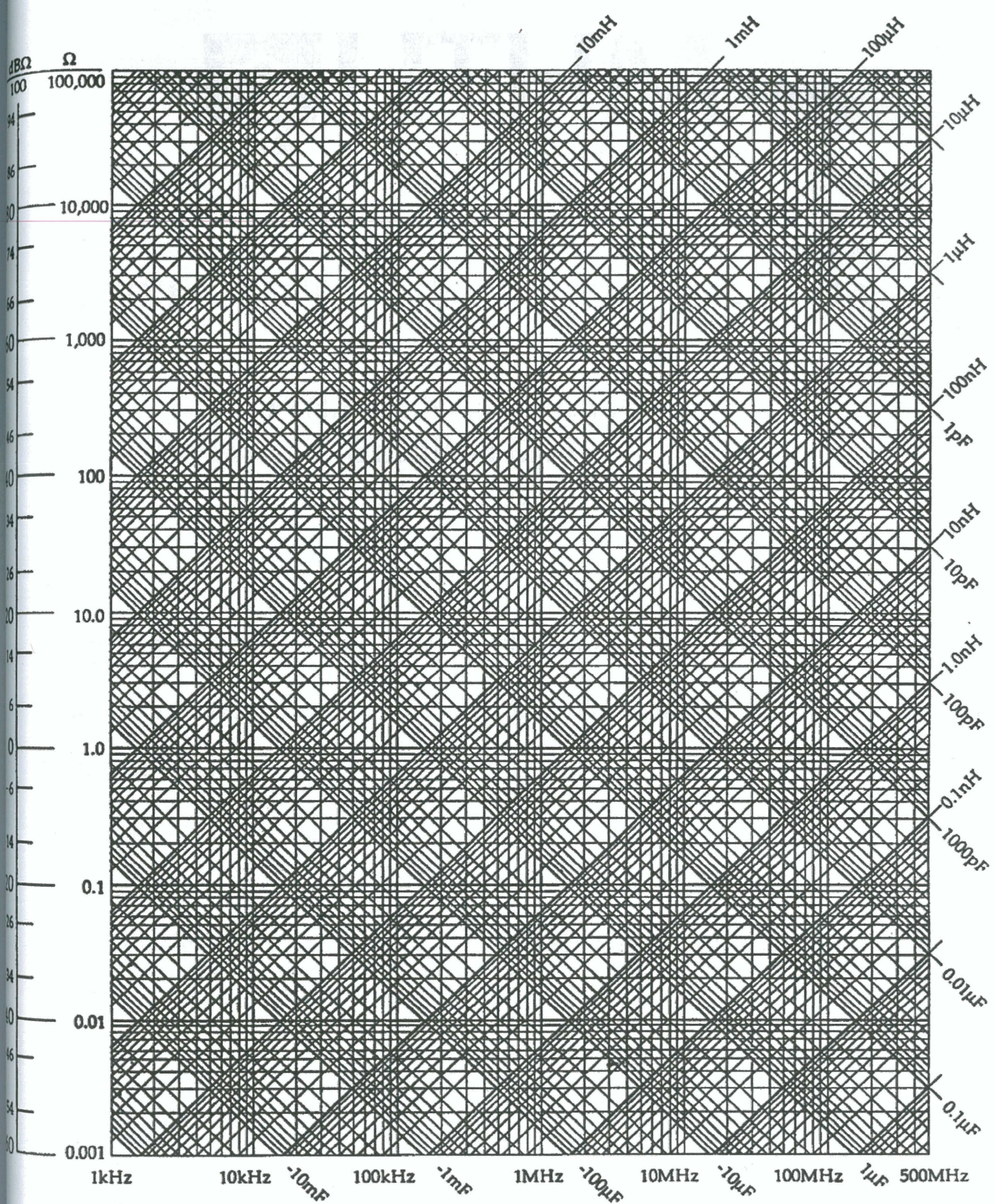


FIGURE Q4(b)

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