UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	ELECTROMAGNETIC COMPATIBILITY
COURSE CODE	:	BEB 41703
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SIX** (6) PAGES

Q1 You are an EMC test-engineer working in a company producing switched-mode power supply (SMPS). The R&D department has come up with a new design of the equipment which must be marketed to USA in 3 months time. Your main responsibility is to ensure that the product pass all the EMC tests within the stipulated time frame.

(i) List three (3) EMC tests that should be conducted on the SMPS.

(5 marks)

(ii) Explain the measurement procedures for one (1) of the tests in Q1(i).

(5 marks)

(iii) It was found that the SMPS emission exceeds the permitted limit at 200 MHz. What countermeasures that you would suggest to the design engineer?

(5 marks)

(iv) What are your EMC related advices on the packaging of the SMPS?

(5 marks)

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

(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 and the antenna is oriented parallel to and in the plane of the wires. The antenna is connected to a spectrum analyzer using a 3m length of RG58U coaxial cable with 0.25dB/m loss at 200 MHz.

(i) Calculate the magnitudes 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(b)(i) pass the EN 55022 Class B test?

(2 marks)

(iii) What is the magnitude of the voltage measured by the spectrum analyzer?

(3 marks)

Q3 (a) Power supply filters are normally employed in most electronic products to reduce conducted emissions so as to comply with regulatory requirements.

(i) Sketch and label clearly a typical power supply filter topology.
(5 marks)

(ii) Show graphically the importance of each component of the filter with regard to reducing the conducted emission noise by showing the changes in the noise spectrum from 150 kHz to 30 MHz.
(5 marks)

(b) A Line Impedance Stabilization Network (LISN) is to be used to measure the conducted emission from a Class B product which has an oscillator circuit. The phase current I_P is found to have the following Fourier series:

$$I_P = 2.5 + \frac{10}{\pi}\sin(2\pi 2\times 10^6 t) + \frac{10}{3\pi}\sin(2\pi 6\times 10^6 t) + \ldots \quad (\mu A)$$

(i) Sketch and label the expected output of the spectrum analyzer connected to the LISN. Assume the power line has a 50 Ω impedance and all losses can be neglected.
(7 marks)

(ii) Explain how a common-mode choke can be used to reduce the conducted emission.
(3 marks)

Q4 (a) Elaborate on each of the following statements:

(i) Electrostatic charges can cause fire at a petrol station.
(3 marks)

(ii) Problems caused by an electrostatic discharge event can be prevented by creating an inherent immunity to the ESD event in the electronic circuitry through software (i.e software immunity).
(3 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 (ϵ_r = 2.1) as insulation dielectric with spacing of 0.5 cm. The wires have a radius of 1.5 mm.

(i) Calculate the induced voltage V. State your assumptions.

(10 marks)

(ii) If the two wire line is susceptible to the induced voltage V calculated in Q4(b)(i), find the positions where V can be minimized by rotating the circuit along the y-axis.

(4 marks)

Q5 (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 low-frequency magnetic field.

(3 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 1.5 mm is to be used as an enclosure to shield a digital circuit at 100 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 5 cm is introduced on the barrier for the purpose of inserting cables. Calculate the shielding effectiveness of the aperture (in dB).

(4 marks)

Q6 (a) Proper grounding system is essential to ensure compliance to EMC. Discuss the followings which are related to grounding system.

(i) Single point grounding is effective at low frequency (below 100 kHz) while multipoint grounding is used at high frequency.

(3 marks)

(ii) The return path for high frequency current is the path with least inductance.

(4 marks)

(iii) Many ground system problems occur as the result of common impedance coupling.

(3 marks)

(b) You are given a task by your manager to design the layout of the PCB of a new product which consists of digital and analog circuits. The circuits have clock, amplifier, microprocessor, RAM, controller, ASIC, connectors, power supply and grounding. The clock is generating pulses at 3 GHz. Suggest the layout of the PCB by taking into consideration most aspects of EMC to ensure compliance to international standards and satisfaction to customers.

(10 marks)

END OF QUESTIONS

FINAL EXAMINATION

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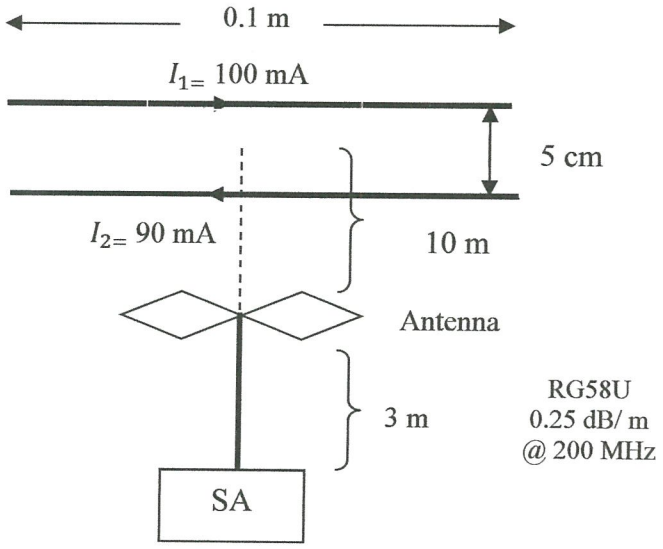

FIGURE Q2(b)

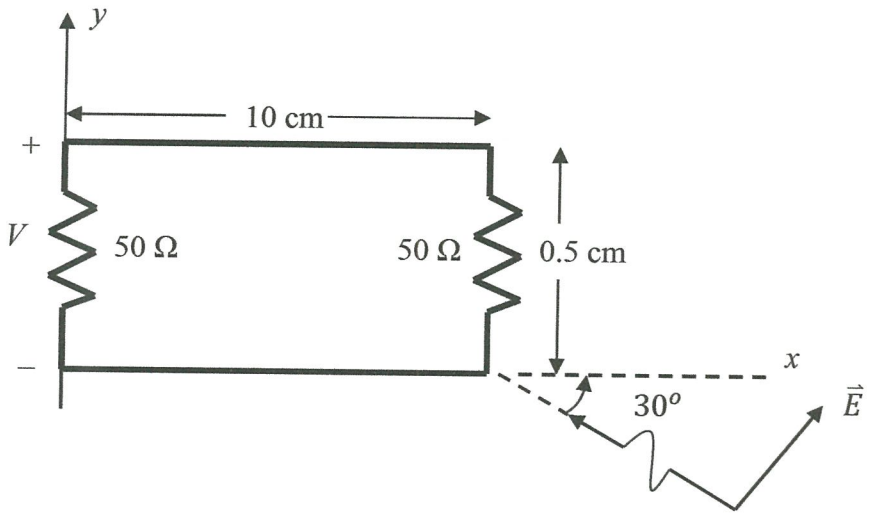

FIGURE Q4(b)