The University Of Sheffield.

Data Provided: Statistical tables A and B

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2007-2008 (2 hours)

Electromagnetic Compatability 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. a. Describe briefly, with the aid of diagrams, the various types of antenna and other transducer which might be used in the measurement of radiated emissions. **(6)**

b. Show that the antenna factor, AF, of a receiving antenna is given by

$$AF = \frac{2}{\lambda}\sqrt{\frac{\pi Z_0}{G_R R_R M}}$$

where λ is the operating wavelength, Z_0 is the characteristic impedance of free-space, G_R is the antenna gain, R_R is the antenna input resistance and M is the impedance mismatch factor. **(6)**

c. Why, in practice, does the antenna factor need to be measured rather than calculated? **(2)**

d. A log-periodic antenna is designed to operate over the frequency band 200 - 1000 MHz. Using the antenna factor data given below and assuming that the coaxial cable connecting the antenna to the measurement receiver has a loss of 0.5 dB at 200 MHz, calculate the incident field strength at the antenna at 200 MHz and at 1000 MHz when the voltage at the receiver input is 10 dBμV.

Frequency (MHz)	Antenna Factor (dB)
200	17.0
1000	25.1

(6)

2. a. Explain why random sample testing is used in industry and define the so-called X% / Y% rule. **(3)**

b. The radiated emissions level at a certain frequency was measured for a batch of six randomly selected energy saving light bulbs. The results were as follows:

Sample No.	1	2	3	4	5	6
dBμV/m	118	102	108	112	104	116

Using the 80% / 80% rule, does the production run from which this sample of bulbs was taken meet the required maximum emission level of 120 dBμV/m ? **(7)**

c. Describe briefly the various types of detector which are used for radio frequency emissions measurements. Discuss the phenomenon of detector overload and explain why it is important in practical measurement scenarios. **(5)**

d. Write short descriptive notes on ***one*** of the following:

(i) Line impedance stabilisation network

(ii) GTEM cell **(5)**

3. a. A co-axial cable is approximated by two concentric cylinders. Given that the relative permittivity of the insulator between the cylinders (ε_r) is 2, and the relative permeability of the insulator (μ_r) is 1, calculate the diameter of the outer conductor needed to provide a characteristic impedance of 50Ω. Calculate the capacitance and inductance per unit length of the cable. Assume the inner conductor has a diameter of 1mm ($\mu_o = 4\pi \times 10^{-7}$ H/m, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m). **(5)**

b. Draw a lumped parameter model for two wires in close proximity, highlighting the coupling mechanisms between the wires. **(5)**

c. A drive system has the sensor wires from the motor Hall-effect sensor running next to the main drive output cables for 2m along one side of the enclosure. It is known that the mutual inductance between the two cables varies with the separation between the cables, and the value of the mutual inductance may be found from Figure 1. The rate of change of current in the drive output cables is 5A/μsec during the drive switching transients, and you may assume that the source and load impedances are equal to the characteristic impedance of the cables. Calculate the magnitude of the noise voltage induced at the input to the drive electronics given that the cables are initially 1mm apart. (Assume that any capacitive coupling between the cables is negligible). **(5)**

d. How far apart do the cables need to be, in section (b) above, to ensure that the magnitude of any induced voltage at the input to the drive remains below a logic level threshold of 0.4V? **(5)**

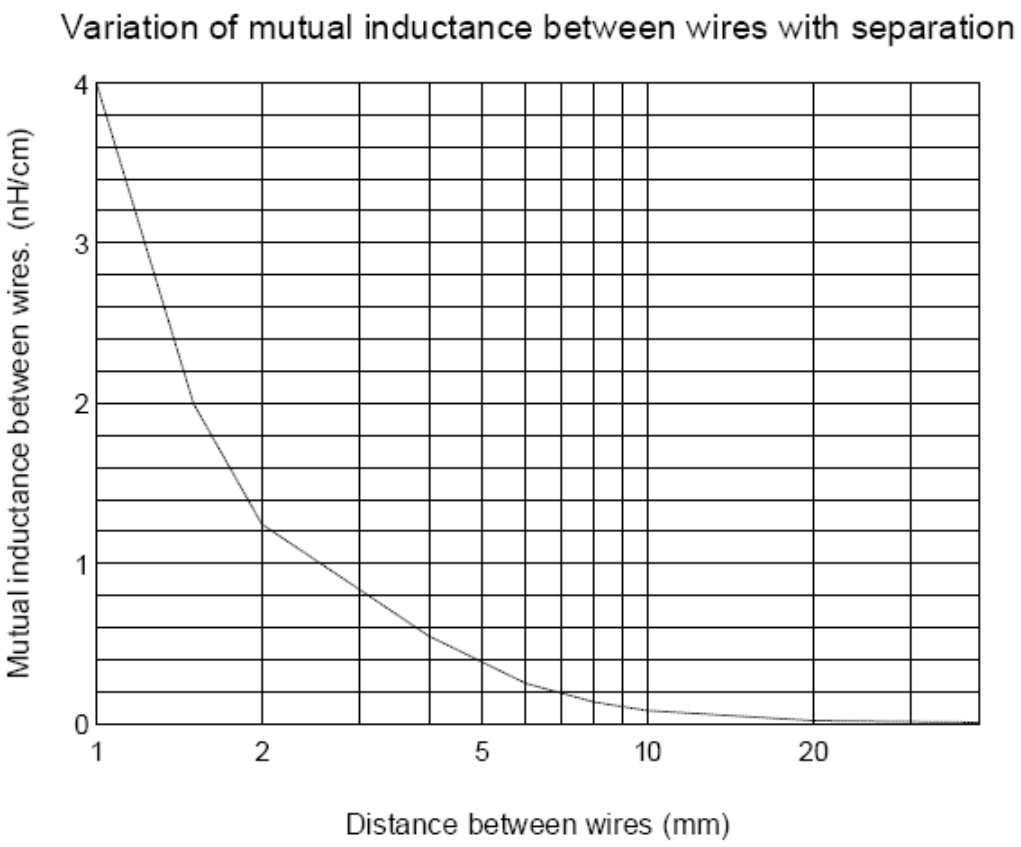
Variation of mutual inductance between wires with separation
Mutual inductance between wires. (nH/cm)
4
3
2
1
0
1
2
5
10
20
Distance between wires (mm)

Figure 1.

4. **a.** With the aid of a diagram, explain the 3 modes in which screening material prevents interference passing into an enclosure. As part of your answer, give the equation expressing screening effectiveness. **(6)**

b. Ignoring the loss due to multiple scattering, and the effect of any apertures, calculate the shielding effectiveness for a 0.3mm thick mild steel computer casing at 50MHz, given that the relative permeability of the mild steel, $\mu_r = 1$, and the relative conductivity of mild steel is $\sigma_r = 0.1$ ($\sigma_{cu} = 5.8 \times 10^7$ S/m, $\mu_o = 4\pi \times 10^{-7}$ H/m). **(8)**

c. Discuss the effect of poor joints between the sections of the casing, and suggest three ways to increase the shielding at the joint over that given by a simple butt joint. **(6)**

BC-LF / SKK