**Data Provided: None**

**The University of Sheffield**

**DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING**

**Spring Semester 2003-2004 (2 hours)**

**Systems Engineering**

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.** You work for an electricity supply company as a project design engineer. Another department within your company approaches you to design a true RMS voltmeter for incorporation within new piece of equipment.

They issue you with the following requirements:

1.) Input to the system is a bipolar analogue voltage.

2.) Unit must have a 7-segment L.E.D. based numerical display.

3.) Unit should be based around a microcontroller.

4.) The microcontroller should perform the RMS calculation.

5.) The microcontroller drives the display directly.

6.) Since the input voltage to the unit can vary over a wide range the unit should automatically scale the input voltage to obtain the best accuracy. The RMS voltage ranges are: 0V to 5V, 5V to 50V, 50V to 250V, 250V to 1000V.

From the specification:

**a.** Draw a block diagram of the RMS voltage meter showing the main elements given above. **(6)**

**b.** On the same diagram illustrate the different types of signals/interfacing used in the voltage meter (e.g. analogue/digital). **(2)**

**c.** Identify the basic functions (at the highest level) that the microcontroller needs to perform to calculate the RMS voltage from the input voltage. Draw a simple flowchart showing the interactions between these functions, and the order in which each should be performed. **(6)**

**d.** Your manager requests that on each range the meter should have a minimum resolution of 1/1000. What is the minimum resolution of ADC (analogue-to-digital converter) that should be used? **(3)**

**e.** Using your previous answer, what voltage does the ADC least significant bit represent on the 0 to 5V range? **(3)**

2. Most systems follow a typical life cycle (whether they are biological, mechanical, electrical or software). Systems engineers use the key stages identified in the life cycle to develop fundamental systems engineering concepts.

**a.** With the aid of diagrams explain a typical systems life cycle. **(4)**

**b.** Using the systems life cycle as a basis for your argument, explain why systems engineering is vital in today's society? **(4)**

**c.** With the aid of a diagram, describe the steps taken during the 3 Phase Design Cycle, drawing parallels with the systems engineering life cycle. **(6)**

**d.** Describe the Hall Systems Engineering 7 Phase Design Cycle and how it relates to the simpler 3 Phase Design Cycle. Use diagrams in your explanation. **(6)**

**3.** Verification, validation and testing are fundamental to the systems engineering process.

**a.** Explain the difference between verification and validation. **(4)**

**b.** With the aid of diagrams explain the testing hierarchy. **(4)**

**c.** Explain:

i. What is meant by the combinatorial explosion with regard to IC' testing.

ii. How scan-paths are used test logic IC's. **(6)**

**d.** Briefly explain what JTAG is and why it is used. **(6)**

4. a. Provide an appropriate definition of reliability. **(4)**

b. Draw a typical bath-tub curve describing the failure rate of an electronic component. Identify the three main regions of your curve and clearly explain the typical characteristics of each region. **(4)**

c. If the time-to-failure of a system can be described by an exponential density function, then the reliability of the system at time, t, is given by:

$$R = e^{-\lambda t} = e^{-t/MTBF}$$

where MTBF is the mean-time-between-failures and λ is the failure rate,

$$\text{where } \lambda = \frac{\text{number of failures}}{\text{total operating hours}}$$

Consider a system that has to operate for $T_h$ hours and during that time $F_h$ failures are expected to occur. On each failure, the down-time of the system is $D_h$ hours. Write an expression for the failure rate λ in terms of $T_h$, $F_h$ and $D_h$. For the specific example of a system that operates for 169 hours and during this time has 6 failures, calculate the failure rate (λ) <u>and</u> MTBF if the down-time after each failure is 1hour.

What is the reliability of the system for 10hours of operation. **(6)**

d. Consider the system comprising of 4 components shown in Fig. 4.1. Each component has an associated MTBF as given in the figure.

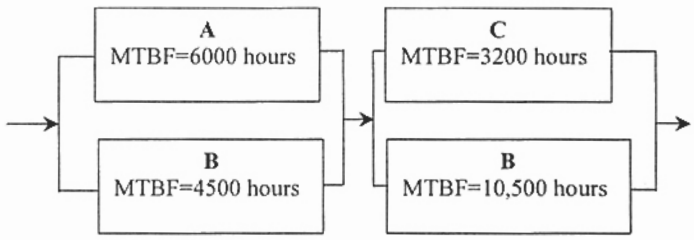


Figure 4.1

Determine the reliability, $R$, of the system in Fig. 4.1 if it is expected to operate for 1000 hours. **(6)**

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