<u>**Answers Systems Engineering EEE115 2003-2004 Spring Semester**</u>

<u>Question 1</u>

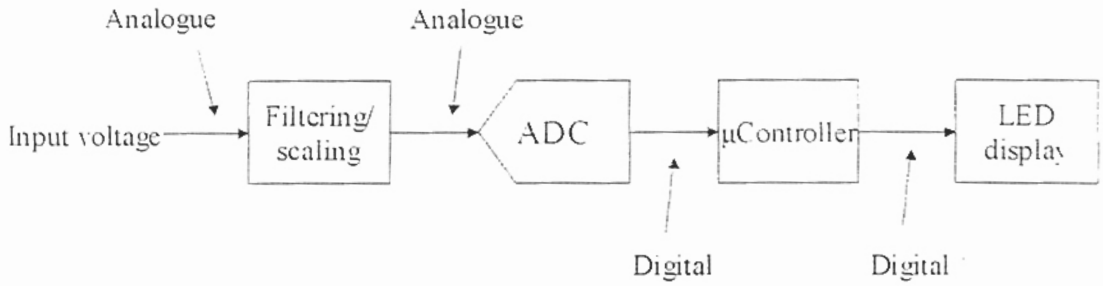
a)

Vital components of this diagram are:

Scaling, ADC, Microcontroller and the LED display.

There may be variations on this diagram where the input voltage passes through a multi-pole switch for the gain translation, as in a multimeter for example. Also, a buffer may be inserted between the microcontroller and the LED display to drive the extra current.

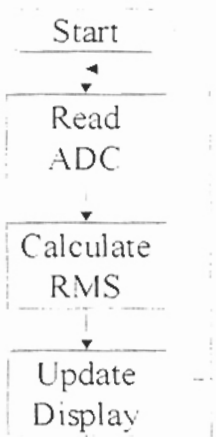
b)



c)

The basic functions of the RMS system are:

i) Read in analogue value
ii) Calculate RMS quantity
iii) Output number to display



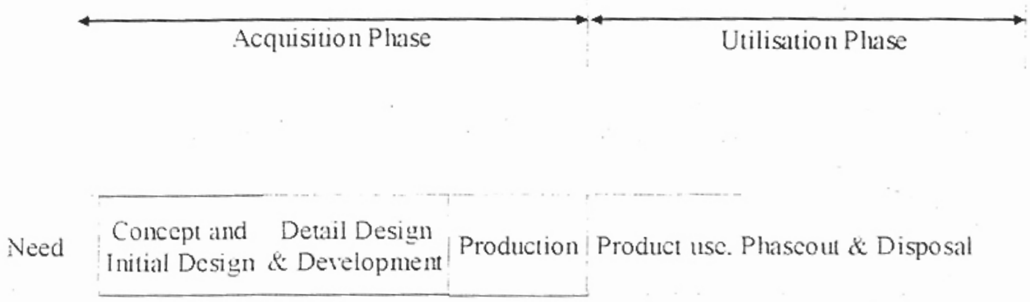
d)
$2^9=512$, $2^{10}=1024$ therefore 10-bit ADC minimum

e)

Voltage is $\frac{Vref}{2^n - 1} = \frac{5}{2^{10} - 1} = 4.9\text{mV}$

Question 2

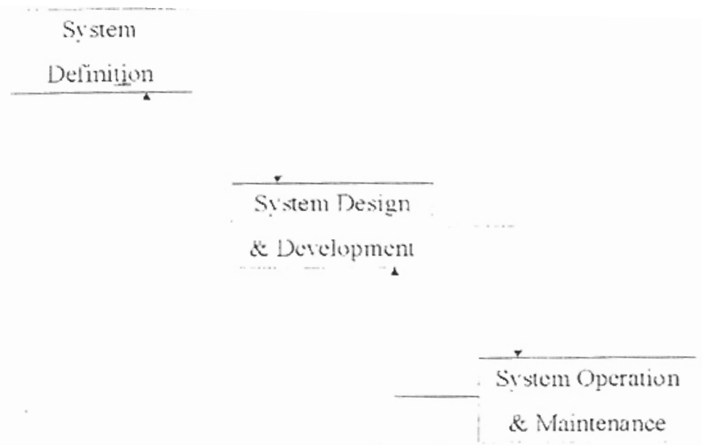
a)
The system life cycle is split into two main sections, the acquisition phase and the utilisation phase. The life cycle begins at the acquisition phase where a need is identified. From this need a concept and an initial design specification for a system is established. Using the specification a detailed system design is developed and finally the system is put into production. The product is then put into service, called the utilisation phase, and after a sufficient amount of time, the product is with drawn from service and disposed.



Systems Life Cycle

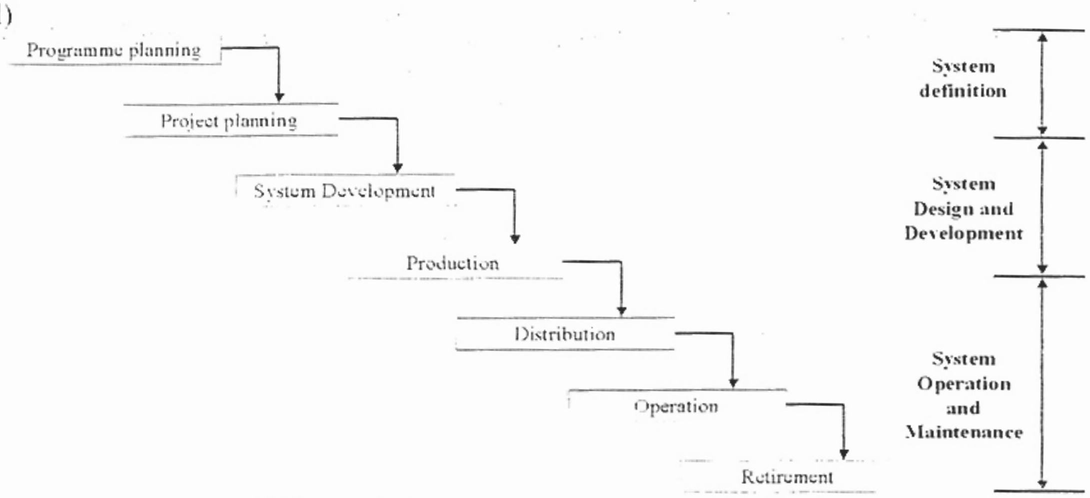
b)
Traditionally, systems engineering focused on the acquisition phase, i.e. the development of a product from concept to design, without the concern of manufacturing, operation and maintenance. Today systems are more complicated with a greater number of sub-systems being inter-related together therefore the systems engineer has to account for the limitation of the manufacturing processes (lead times, physical restrictions, cost, etc.). Also, particularly in electronic engineering, technology is advancing at a faster rate than ever before thus products are becoming obsolete in a shorter time period. Finally, although some products may be deemed to be finished when they leave the production line, often they are subject to after sales care, servicing and maintenance.

c)
The system definition phase is initiated by a need (the client wants a new product or service. Subsequently, system requirements are identified and a plan of action is produced. The system development phase is concerned with the design of the system/solution. Here, various components of the system are identified and numerous prototypes may be tested. Once a final system design has been established, it is built and tested to ensure the system components and the system as a whole meets the customers' requirements/specifications. Finally, the system is put into operation and at times may require maintenance.



3 phase systems engineering life cycle

d)



7 Phases in The Hall Engineering Life Cycle

1.Programme planning
Fundamentally the requirements capture phase, but results in the identification of actions and projects to support the development of the whole system. A specification of requirements for the whole system is produced along with associated programmes of work.

2.Project planning
Determination of suitable specifications for the identified projects together with a work programme and plan of action.

3.System development
This stage further refines the project plan specifications into detailed specifications, drawings and bills of materials for the manufacturer.

4.Production
Actual realisation of the system from specification (from section 3) to reality. Can involve a variety of techniques depending on the system. For example, the development of hardware or software for an electrical system to building of a warehouse for a factory.

5.Deployment
Delivering the system (product or services) to the user (or customer).

6.Operation
The system is in full service. This phase also includes activities such as maintenance and updating.

7.Retirement
After a period of operation the system is phased-out and possibly replaced by a new system.

Question 3

a)
Verification and validation are 2 distinct processes that are used to confirm that the system conforms to the Requirements Specification and the System Specification.

Validation ensures the final system meets the Requirements Specification (i.e. the user requirements).

Verification is the process of ensuring the system is being built according to the System Specification (or Design Specification).

b)
A whole system is not tested as a single, monolithic unit but in sections, often according to how the system has been partitioned during the design/partitioning phase phase.

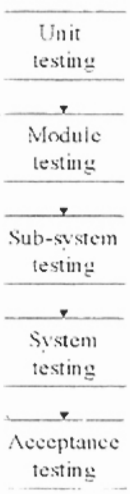
1. Unit/component testing
Individual components are tested isolation to ensure they operate correctly.

2. Module testing
A module or a set of related components are tested in isolation without the interaction of other modules.

3. Sub-system testing
Testing of several modules that have been integrated into a single sub-system. Effort in this process often concentrated on testing interfaces for consistency.

4. System testing
Sub-systems are combined to form the whole system and tested to find errors or unexpected interactions. This stage of testing is also concerned with validating the system against the Requirements Specification.

5. Acceptance testing
Final stage of the testing process before the system is put into operation. Involves testing the system with data supplied by the client.



c)

i) Combinatorial explosion is the rapid increase in output complexity (or logic states) with only a small increase in IC inputs. For example, a 2-input gate has 4 possible outputs and a 3-input gate has 8 possible outputs whereas a 64 input logic gate would have over 16 million outputs states requiring over million test vectors to completely test this single gate.

ii) Scan-paths are used for testing logic IC's and allowing indirect access to the input of logic gates permitting a test vector to be injected into the chips logic gates. Internally, flip-flops connected as shift registers are used to clock data into and out of the chip in a sequential manner. Errors are found by comparing the bit sequence from the device under test with a predefined test sequence.

d)

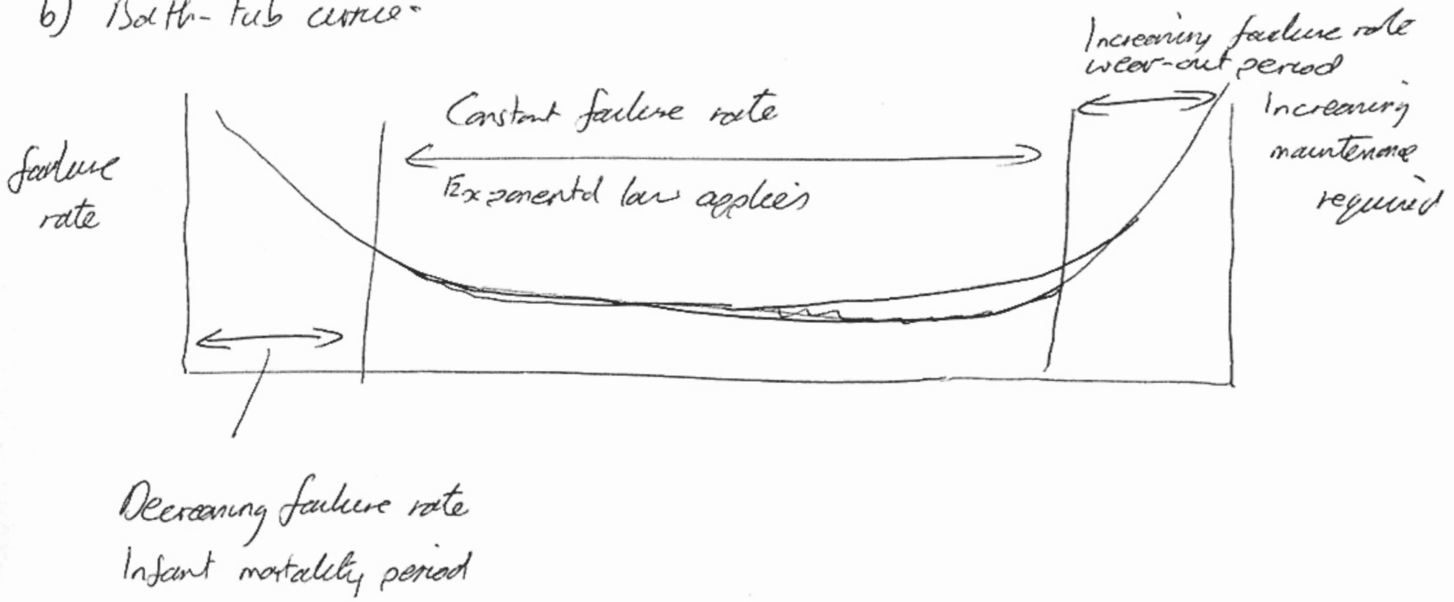
As more functionality is integrated onto digital IC's testing them becomes more complex due to the limited access to the logic cells used to make such devices and, therefore, testing such devices is difficult. Previously, scan-paths have been proposed for testing logic devices but today's current state-of-the-art devices are far too complex to use these techniques. JTAG (Joint Test Action Group) therefore proposed a boundary-scan test (BST) interface to simplify testing.

BST is an industry standard testing interface developed for testing digital IC's, associated circuitry and the PCB based on boundary scan test techniques. Using a 4-wire interface test data is loaded onto the IC under test. A predefined serial bit-pattern is then applied to each input pin of the IC and corresponding output pins are then clocked out to test machine or PC using a shift register. The interface also provides facility for cascading a number of IC with JTAG interfaces together so that several chips can be tested using just one interface thereby simplifying the testing of more complex systems.

Question 4

a) Reliability may be defined as the probability that a system or product will perform in a satisfactory manner for a given period when operated under specified conditions.

b) Bath-tub curve.

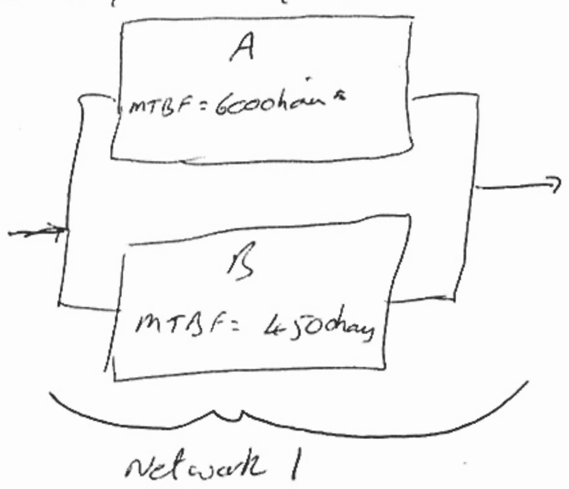


c) Failure rate $= \lambda = \dfrac{F_h}{T_h - F_h D_h}$ $\Rightarrow$ $MTBF = \dfrac{1}{\lambda} = \dfrac{T_h - F_h D_h}{F_h}$

For this system $= \dfrac{169 - 6}{6} = \underline{\underline{27.167 \text{ hours}}}$

Reliability for 10 hours of operation is $e^{-10/27.167} = \underline{\underline{0.692}}$

d) For 1st parallel component



Failure rate of A $= \dfrac{1}{6000} = 166.67\times10^{-6} = \lambda_A$

" " B $= \dfrac{1}{4500} = 222.22\times10^{-6} = \lambda_B$

Reliability of Network 1 is:

$R_1 = R_A + R_B - R_A R_B$

$R_1 = e^{-\lambda_A t} + e^{-\lambda_B t} - e^{-(\lambda_A+\lambda_B)t}$

$= 0.846 + 0.8 - 0.678 = \underline{\underline{0.968}}$