

ESD 505 Principles of Embedded Systems

Discussion Assignment (11th Aug 2014)

1. Reading assignment: "A symbolic analysis of Relay and Switching circuits" by C.E.Shannon available on the web or in IITB Learning Management System (LMS) at (<http://lms.iitb.ac.in/moodle/login/index.php>) course module ESD505. This paper is based on Shannon's Master's Thesis at MIT which won Alfred Nobel Prize. It helped to change digital design from an art to a science.
2. Given an embedded system with a clock frequency of 100MHz, a memory size of 1Kbytes with read/write time of 1ms and a CPU speed on the average 3 cycles per operation, calculate the time needed to find maximum of a set of N, 16 bit positive numbers.
3. Design an Embedded system (specify memory size, memory access time, CPU functions, average number of cycles and Clock speed) required to meet the following specs. Input to the system is a sequence of 16 bit signed numbers given at a speed of 1 mega numbers per second. Output is a sequence of numbers at the same input speed and is equal to the corresponding input number divided by 1024. If the input is less than 1024 then the output is zero.
4. Show that we make an adder using resistors and operational amplifiers to add any two numbers in the range of 1 to 100? Make a diagram of the system which can be built and which works if implemented in the lab.
5. Make a circuit using Operational amplifier to generate the signal $y(t) = \cos(t)$.
6. Given an operational amplifier find and sketch the output waveform with a sine wave as input when, a) input is applied on the non-inverting pin and output pin of the Opamp is connected to the inverting input pin b) input is applied on the inverting pin and output pin of the Opamp is connected to the non- inverting input pin
7. Show that we can realize any combinational switching function using only AND, OR and NOT gates. A combinational switching function depends only on the present value of its arguments.
8. How many switching functions of n variables are possible? How many switching functions of n variables are there which actually involve all the variables? Note that $f(x,y) = x+y$ is a function of both x and y. While $f(x,y) = x$ involves only x.
9. Design a logic circuit which takes 3 inputs X,Y and Z and gives NOT(X), NOT(Y) and NOT(Z) as outputs using only two NOT gates and any number of AND and OR gates.
10. Given only addition, subtraction and multiplication give a method to find good approximation to the square root of a real number and inverse of a real number between 0 and 1 using finite number of instructions.

11. Let $x(1), x(2) \dots x(n)$ be binary variables. A function $f(x(1), x(2), \dots, x(n))$ is called a threshold switching function iff,

$$\begin{aligned} f(x(1), x(2), \dots, x(n)) &= 1 \text{ if } x(1)a(1) + x(2)a(2) + \dots + x(n)a(n) > T \\ &= 0 \text{ if } x(1)a(1) + x(2)a(2) + \dots + x(n)a(n) \leq T \end{aligned}$$

Where $a(1), a(2) \dots a(n)$ and T are real numbers called weights and threshold (T). Show that threshold switching functions can be used to realize any combinational switching function. Hint: Realize AND, OR and NOT gates using proper threshold functions.