Part I

1. The circuits below all use TTL gates with two voltage levels 0 and 5 volts. Prepare a Boolean truth table and find the logic function for each of the circuits, where the input and output variables are all asserted HIGH (i.e. logic 1 is represented by 5V and logic 0 is represented as 0V). Asserted HIGH’s are often written as A(H), B(H), C(H), .. etc.

2. For each of the following functions give (i) the Karnaugh map representation, (ii) the truth table representation and (iii) the circuit diagram representation

\[ F(X,Y,Z) = \overline{X}Y\overline{Z} + \overline{X}YZ + \overline{X}Y\overline{Z} \]
\[ G(A,B,C,D) = \overline{A}B\overline{C}D + \overline{A}B\overline{C}\overline{D} + \overline{A}BCD + \overline{A}BCD + A\overline{B}CD + A\overline{B}CD \]
\[ H(A,B,C,D) = \Sigma(0,5,7,8,9,14,15) \]
\[ J(W,X,Y,Z) = \overline{W}(X + \overline{Y}\overline{Z}) + \overline{W}XY \]

3. Implement the following functions with a minimal amount of hardware using only NAND gates

\[ F(A,B,C,D) = (\overline{A} + B + D).(A + \overline{C}).(A + B + \overline{D}).(A + \overline{B} + C + D) \]
\[ G(A,B,C,D) = \Sigma(1,2,3,5,6,11,12) + D(7,8,10,14) \]
4. Convert the following circuit to a NOR gate only implementation

![Circuit Diagram]

**Part II**

**Design**

**Answer two out of three questions**

**Question 1**

By connecting 8 cells together, show how an 8-bit parallel adder can be constructed to perform addition of two 8 bit numbers. How fast will the circuit perform one addition, based on the propagation delay of one cell?

**Question 2**

Using full adder circuits, and other gates show how a 4 bit parallel multiplier can be constructed. Hence, or by any other means, design a standard multiplier cell and show the design for an 8 bit multiplier.

**Question 3**

You are required to build a simple logic circuit to control a fire-alarm system. The fire alarm will sound if the logic input to a terminal T is 5V. If the input to this terminal is 0V then the alarm will not sound.

The alarm system consists of the following sensors and inputs:

1. A heat sensor which sends 5V to the terminal H if the nearby temperature exceeds 140 degrees and 0 V otherwise.
2. A panic button which if pressed sends a 5 volts signal to a terminal P and 0V if the button is not pressed.
3. Two infrared sensors at opposite ends of a room which send a 5V signal if fire is detected to terminal I and J respectively, and 0V if not. For the alarm to sound, both sensors must also detect fire.