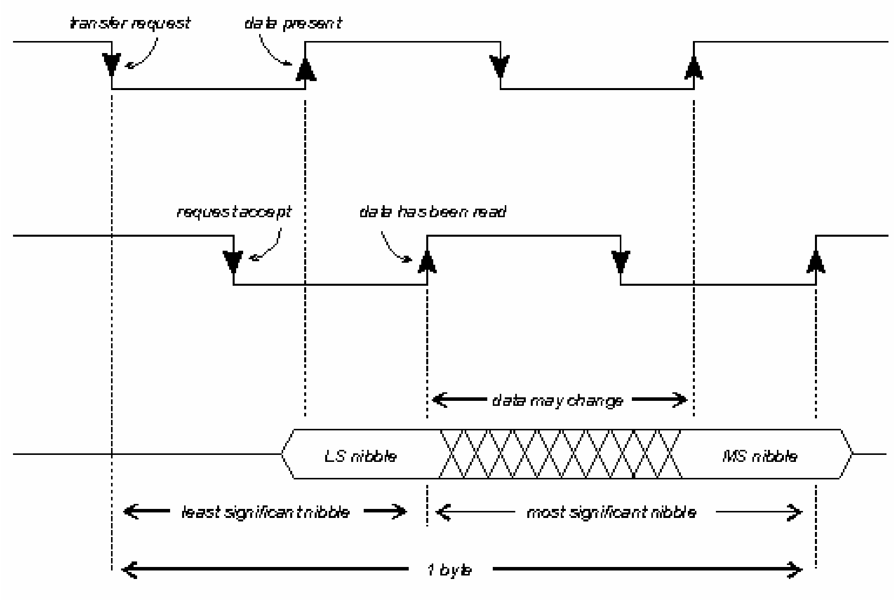
Electrical, Electronic & Computer Engineering
School of Engineering & Physical Sciences

Digital Design : Tutorial

1. Minimise the following using Karnaugh maps

a. $F(a,b,c) = \sum m(0,1,3,4,6)$
b. $F(a,b,c,d) = \sum m(2,3,7,9, 11,12,15)$
c. $F(a,b,c,d,e) = \sum m(5,6,7,9,11,17,19,21,25,26,27,30,31)$

2. Describe the different graphical aspects of this waveform diagram. Ignore the purpose of the diagram.



3. Convert the following 4 variable function to a standard Karnaugh map.

$$F(a,b,c,d) = \sum m(1,2,4,5,7,9,11,12,13,15)$$

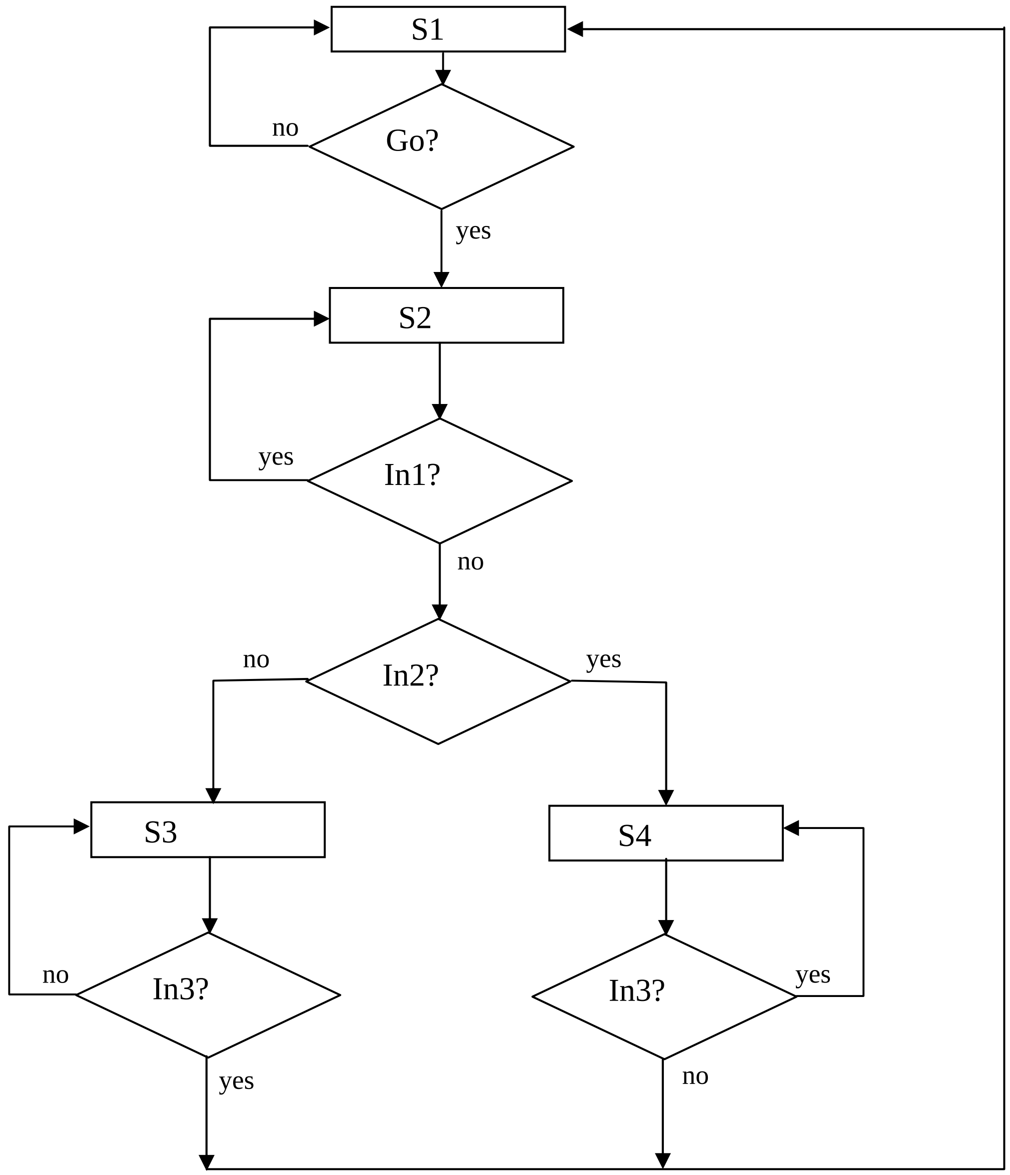
Convert this 4 variable Karnaugh map to a 3 variable map entered Karnaugh map with **d** as the map entered variable.

4. Answer the following questions

a. Show how a glitch pulse can be created by a race condition setup by a single input signal.
b. Describe the operation of a D-type flip-flop.
c. Draw the structure of a Moore state machine.
d. Outline the problem of state consistency.
e. State the "asynchronous rule" for state assignment and indicate why it is important when dealing with asynchronous input signals.

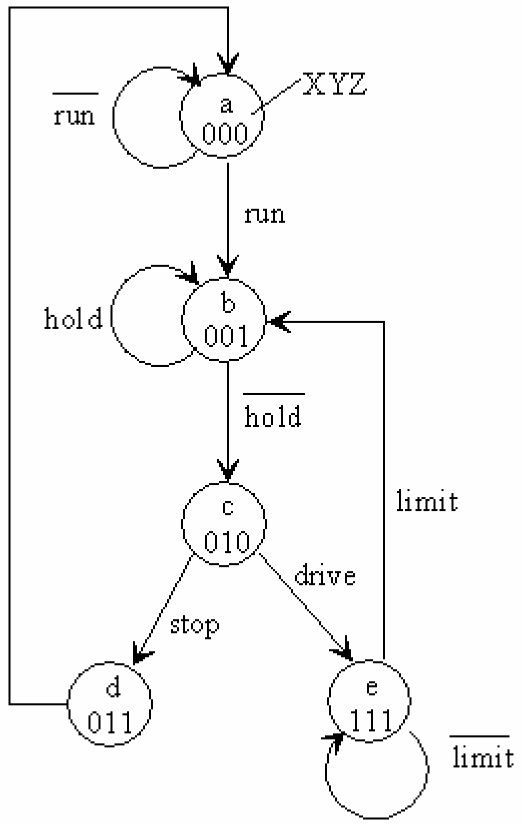
5. What are the rules to produce a mapping from a Variable Entered Karnaugh Map (VEM).

6. Convert the following ASM chart to a state diagram. There are 4 states and 4 input signals

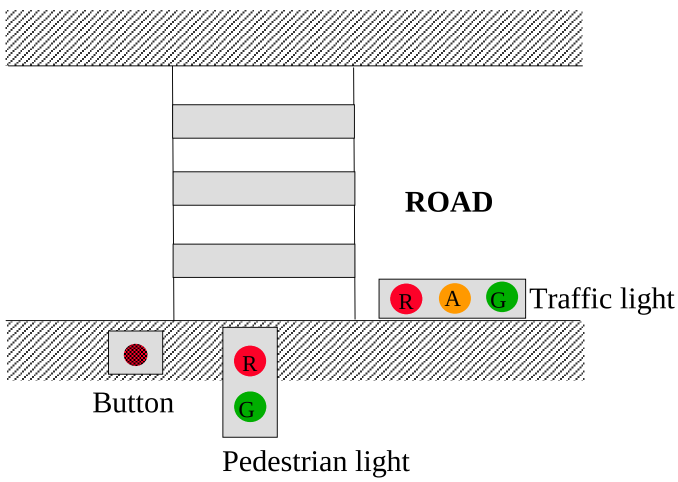


7. Convert the state diagram of question 6 to a set of excitation equations for a D-type implementation of the state machine.

8. Convert the following state diagram to a set of D-type excitation equations.



9. Design a state machine to control a simple. "pedestrian crossing".

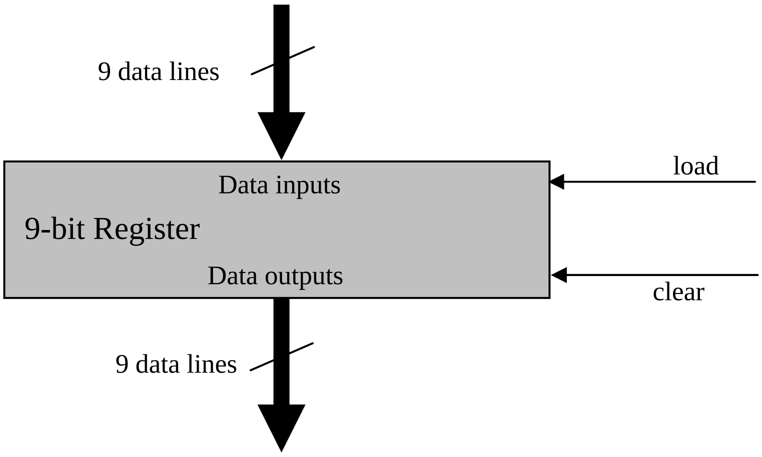


10. Design a state machine to detect the value '10101' in a serial stream of data.

11. List the steps requires to solve a state machine problem that starts with a specification and finishes with a D-type flip-flop implementation.

12. List a general set of data components that can be used for digital system design.

13. Design a state machine based system to count the number of '1's in a register of length 9 bits. The starting point for your design is as follows



There are two control inputs – load and clear

14. (Exam question from 2003)

A manufacturer of vacuum cleaners wishes to experiment with robotic cleaners. They plan to design a cheap model that has little intelligence that bumps its way around a room in an almost random manner. It is proposed to build a series of test versions to evaluate the concept.

This initial version has the following hardware features

- A start button
- Motors can drive forward, backwards, turn left, turn right, and stop
- Three bump sensors, front left, front right, and rear provide detection of the environment
- An on-board timer, when triggered, gives a signal after 2 seconds

The operational requirements are

- On start drive forward.
- If left bump activated , turn right for 2 seconds then drive forward.
- If right bump activated, turn left for 2 seconds then drive forward.
- If both left and right bump activated, reverse for 4 seconds, turn right for 2 seconds, then drive forward.
- If rear bump, drive forward for 2 seconds, turn left for 2 seconds, then drive forward.

The control system is to be built as a state diagram.

a) Draw a system block diagram showing the various subsystems and the relevant signals.
b) Create a state diagram for the vehicle controller.
c) From the state diagram derive a set of excitation equations for a D-type flip-flop implementation.
d) Suggest changes to the hardware and state diagram to allow the following modification

- If both left and right bump activated, reverse for 2 seconds, increment a 3-bit counter.
    - If counter is less than 4 turn right for 2 seconds, then drive forward
    - If counter is greater than 4 turn left for 2 seconds, then drive forward

      (note : when counter is at 7 the next count sets count to zero)