Course Name: Digital Hardware Design
Course Code: 17B1NEC741

Finite State Machine-6

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Number System

- Electronic and Digital systems use a variety of different number systems like Decimal, Hexadecimal, Octal, and Binary.
- Depending upon requirement numbers are converted from one system to another.
- The base for the digital system is a binary number (0,1).
- To easily handle a long sequence of binary numbers, it is converted into Binary Coded Decimal or BCD form.

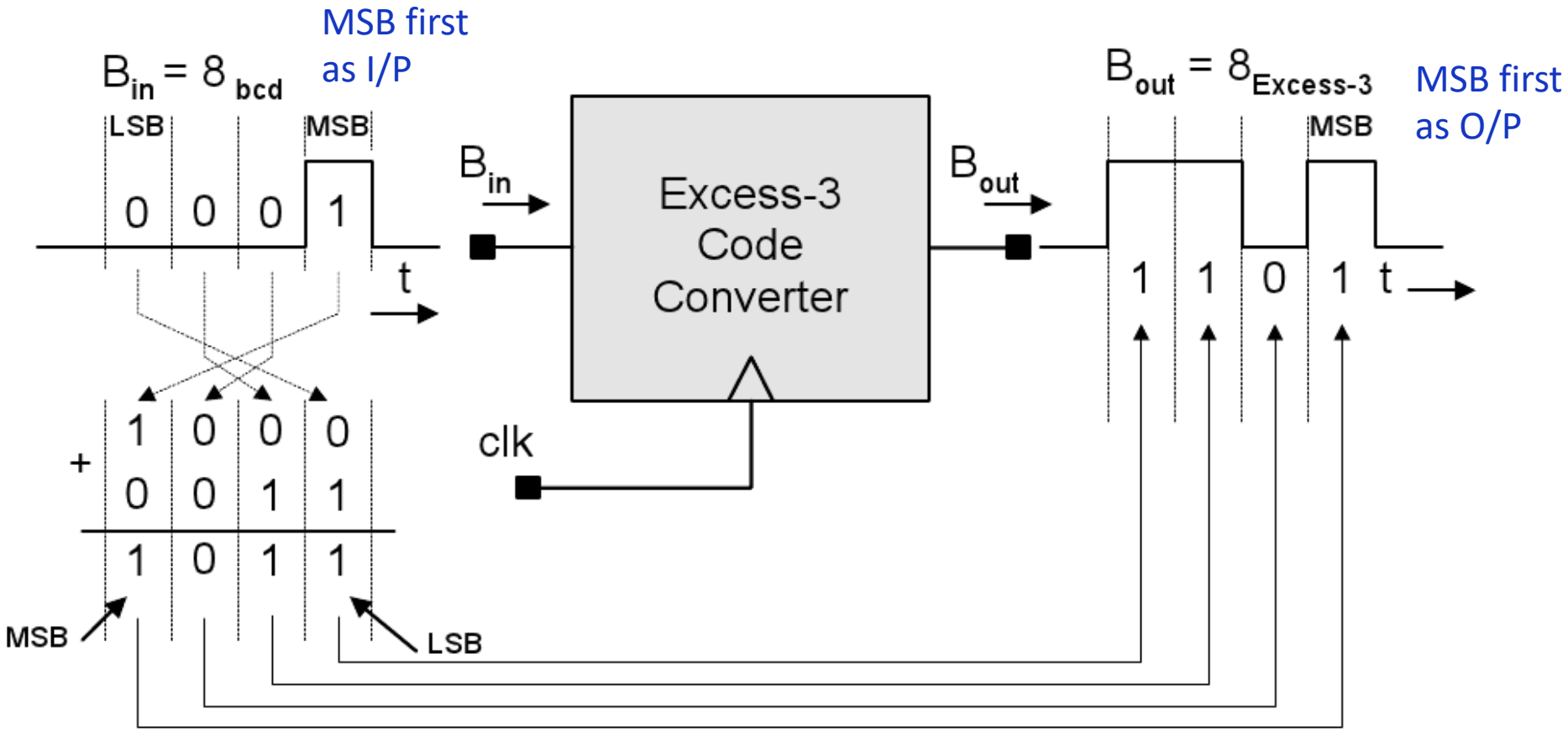
BCD to Excess -3 conversion

- A disadvantage of BCD is that only 10 of the possible 16 (2^4) codes that four bits can produce are used. Hence it is an inefficient code.
- The excess-3 code is another important BCD code used to overcome BCD limitations.
- In Excess-3 coding adds 3 to the original number. It is an unweighted self-complementary code.

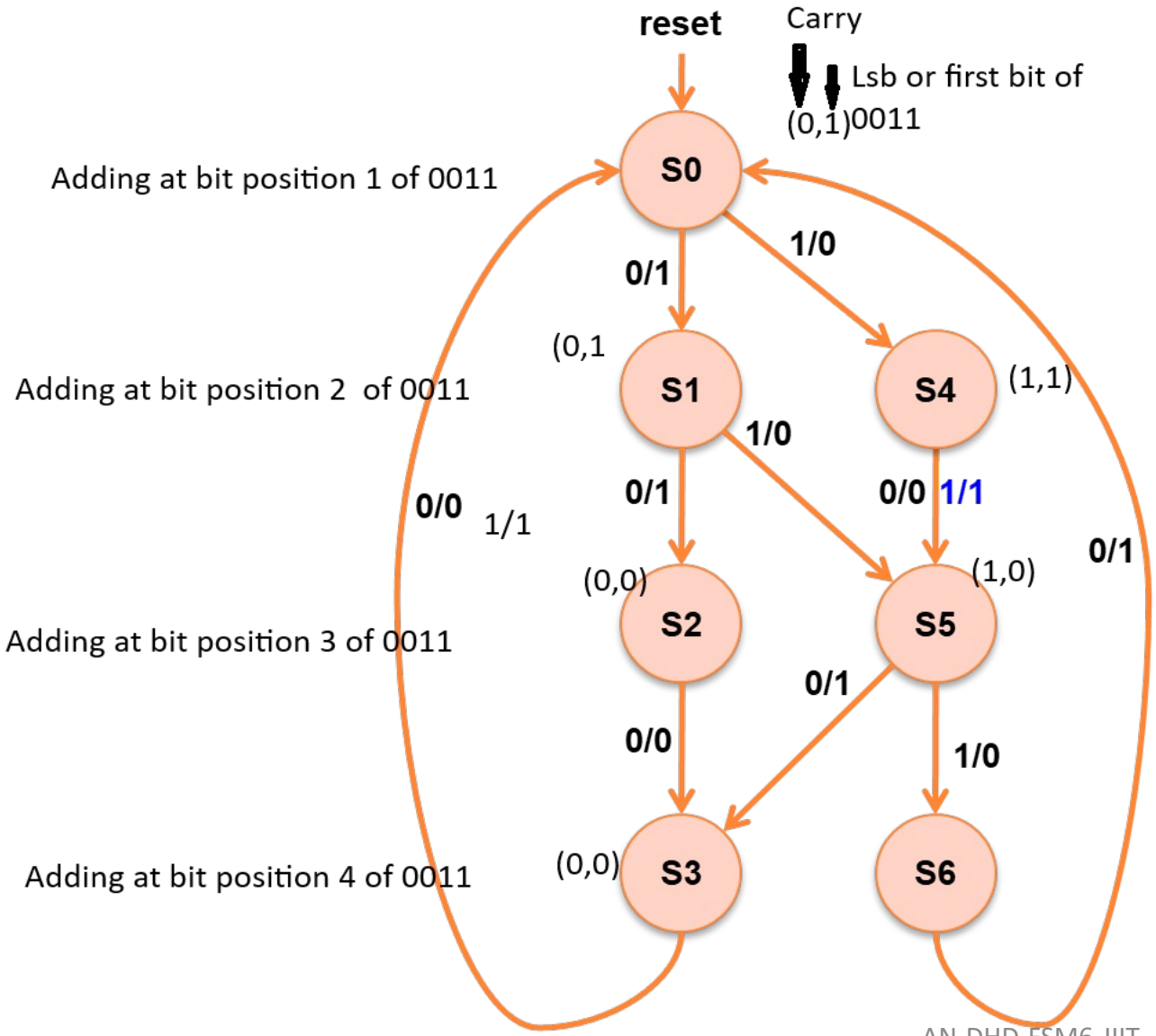
DECIMAL DIGIT	BCD CODE	EXCESS-3 CODE
0	0000	0011
1	0001	0100
2	0010	0101
3	0011	0110
4	0100	0111
5	0101	1000
6	0110	1001
7	0111	1010
8	1000	1011
9	1001	1100

FSM example :BCD to Excess -3 conversion

Serial code converter



FSM example :STG for Excess-3 convertor



Add 0011 to input bit by bit

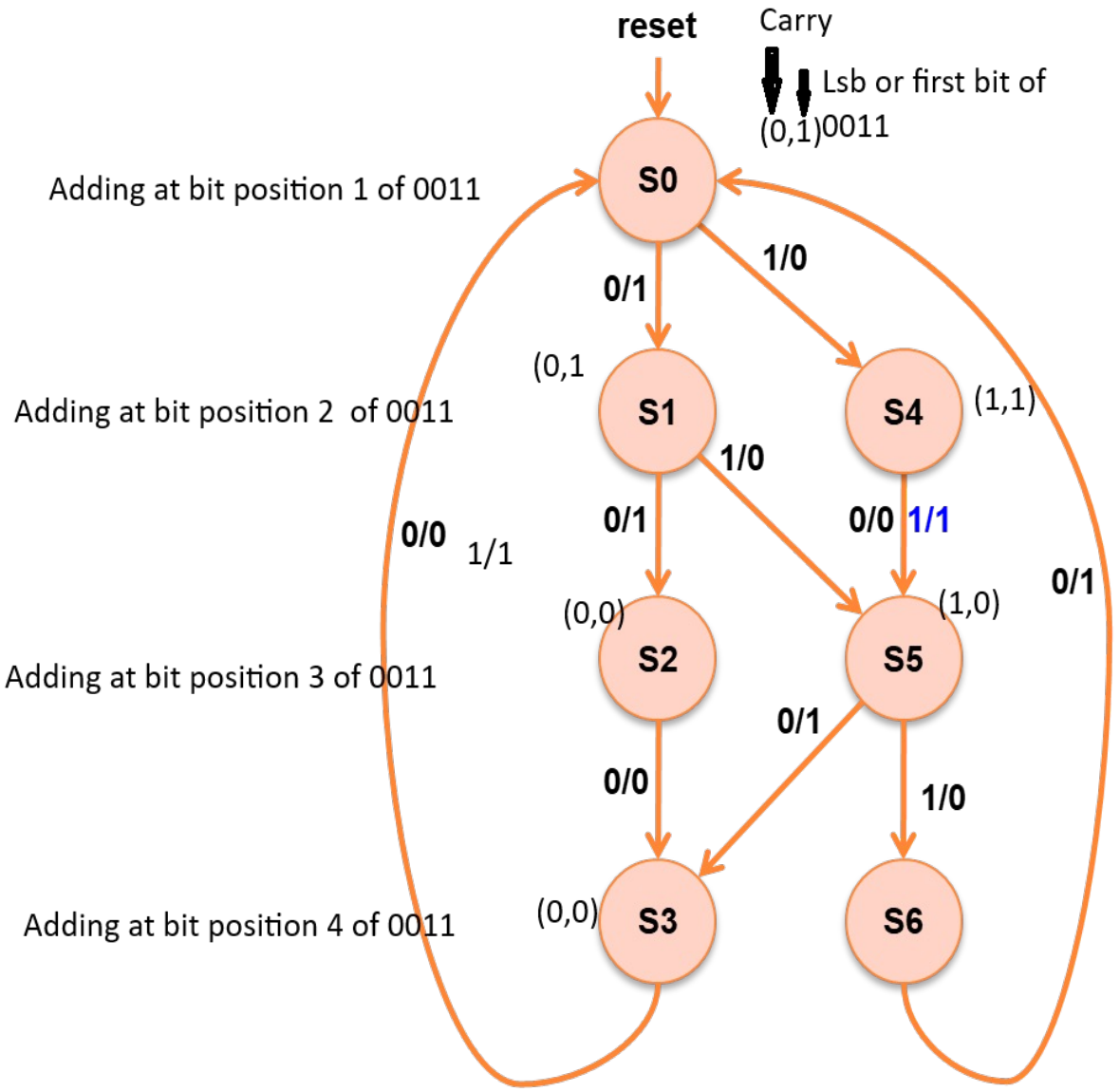
Level -0(LSB):Start with state S0 which means it is having no carry and LBS or first bit of 0011.

Two inputs possible

1. Input bit =‘0’; ADD 0011+0 => gives O/P =1, carry =0 and next state S1.
2. Input bit =‘1’;

3. Repeat same process for 2,3,4 bit position of 0011.
4. At last state if carry is generated, it is ignored.

FSM example :STG for Excess-3 convertor



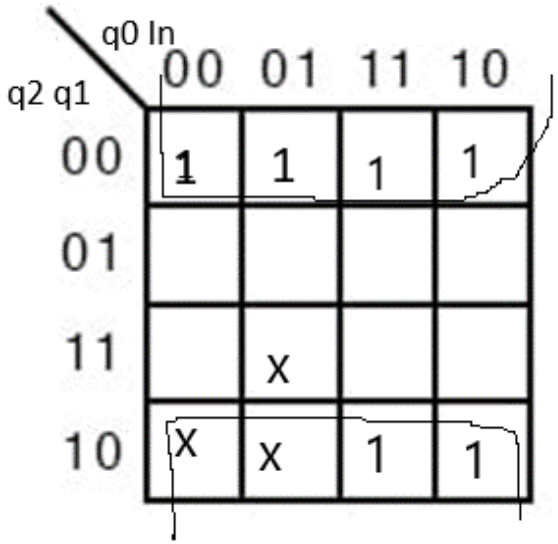
Prepare State transition table
3 bits are required to code 6 states.

	PS			NS							
				In= 0			In= 1			In= 0	In= 1
	q2	q1	q0	q2+	q1+	q0+	q2+	q1+	q0+	O/P	O/P
S0	0	0	0	0	0	1	1	0	1	1	0
S1	0	0	1	1	1	1	0	1	1	1	0
S2	1	0	1	0	1	1	0	1	1	0	1
S3	1	1	1	1	1	0	1	1	0	0	1
S4	0	1	1	1	1	0	0	1	0	1	0
S5	1	1	0	0	0	0	0	0	0	0	1
S6	0	1	0	0	0	0	x	x	x	1	x

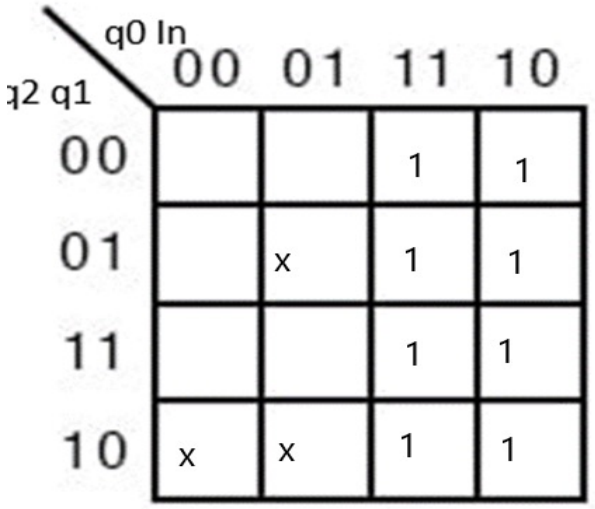
FSM example :Circuit for Excess-3 convertor

K-map to get equations

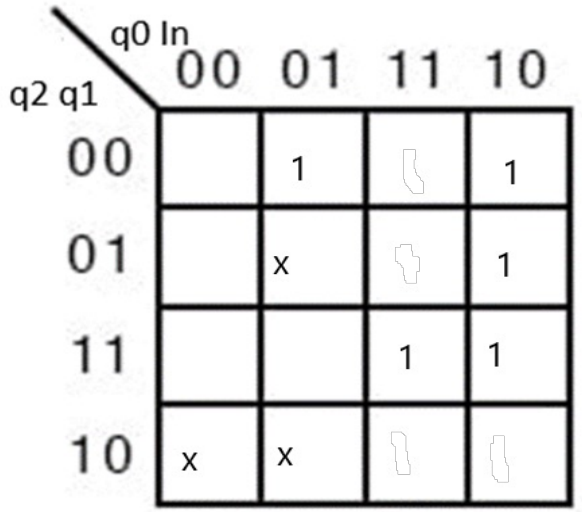
Prepare State transition table
3 bits are required to code 6 states.



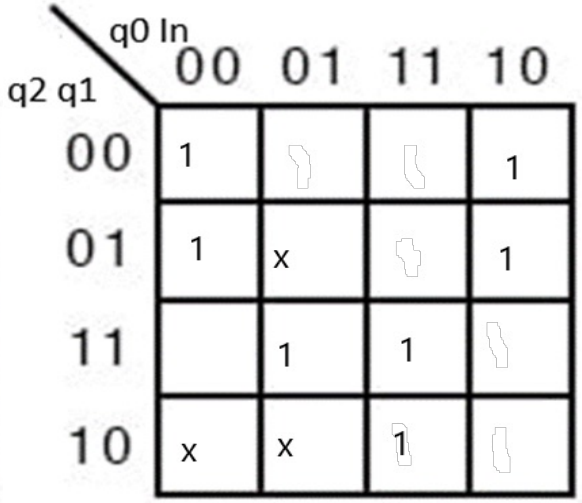
$q_0^+ = q_1'$



$q_1^+ = q_0$



$q_2^+ = q_2' q_{0\,In}' + q_2 q_1 q_0 + q_1' q_0'_{\,In}$



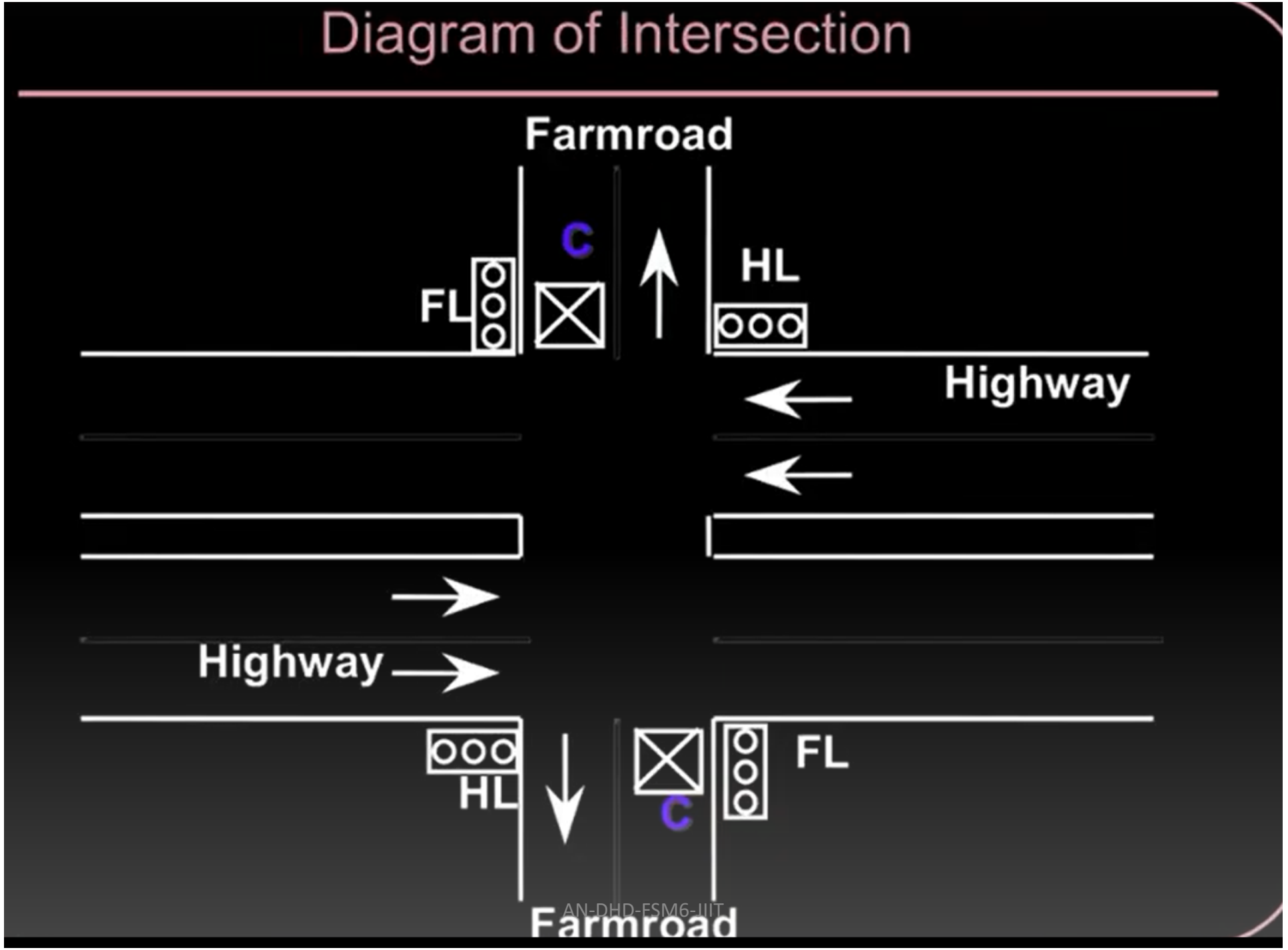
$out = q_{2\,In}'' + q_{2\,In}$

Using above equation circuit can be made for BCD to excess 3 converter

FSM Example- Traffic Light Controller

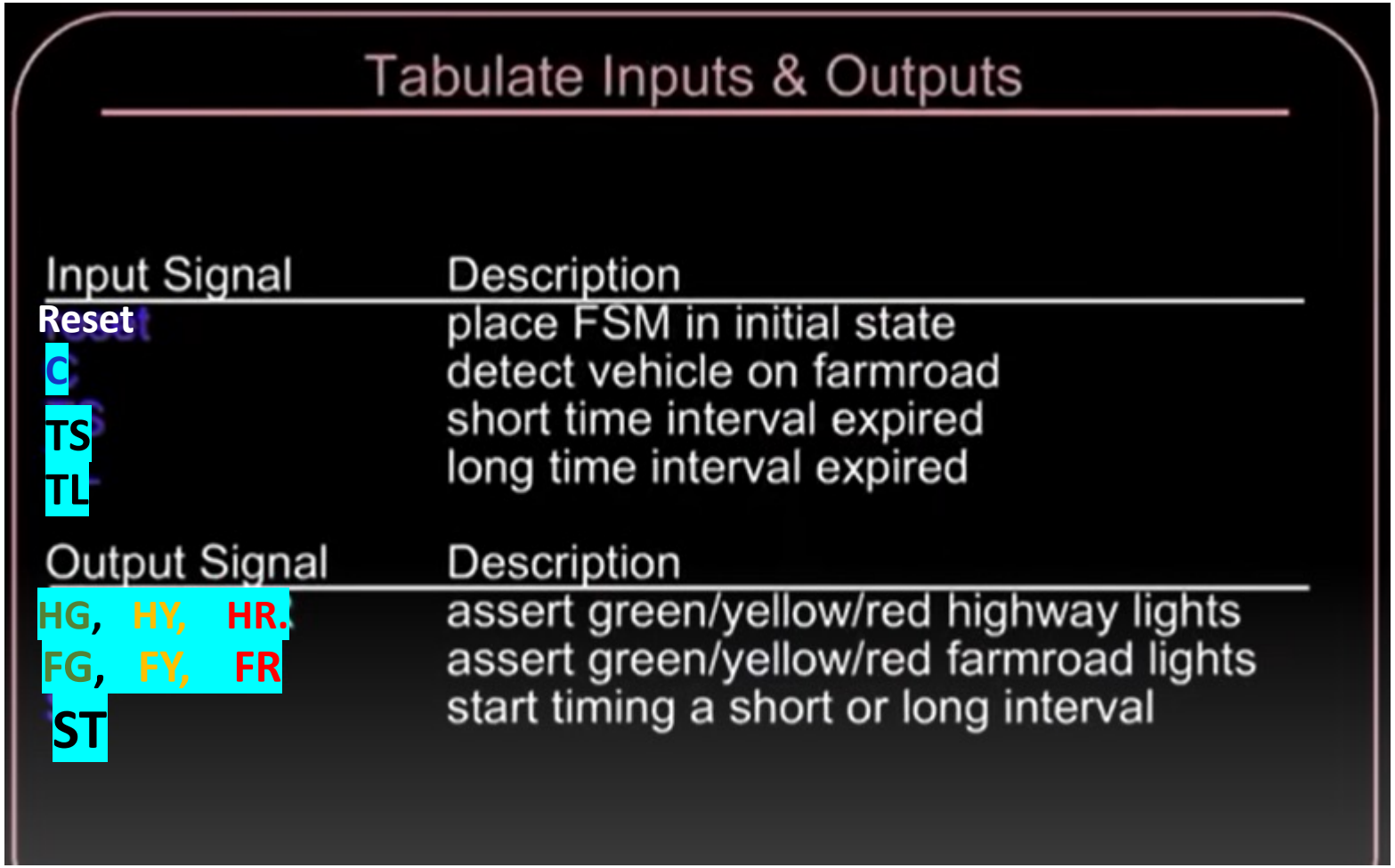
- A busy highway is intersected by a little used farmroad.
- Detectors C sense the presence of cars waiting on the farmroad.
- With no car is on farmroad, the lights remain Green in the highway direction.
- If vehicle is on the farmroad, highway lights go from Green to Yellow to Red, allowing the farmroad lights to become Green.
- These stay Green only as long as a farmroad car is detected but never longer than a set interval.
- When conditions are met, farm lights transition from Green to Yellow to Red, allowing highway to return to Green.
- Even if farmroad vehicles are waiting, the highway gets at least a set interval as Green.

Diagram of Intersection



Available Timers

- Assume you have an interval timer that generates a short time pulse (TS) and a long time pulse (TL) in response to a start timer (ST) signal.
- TS is to be used for timing Yellow lights and TL for Green lights

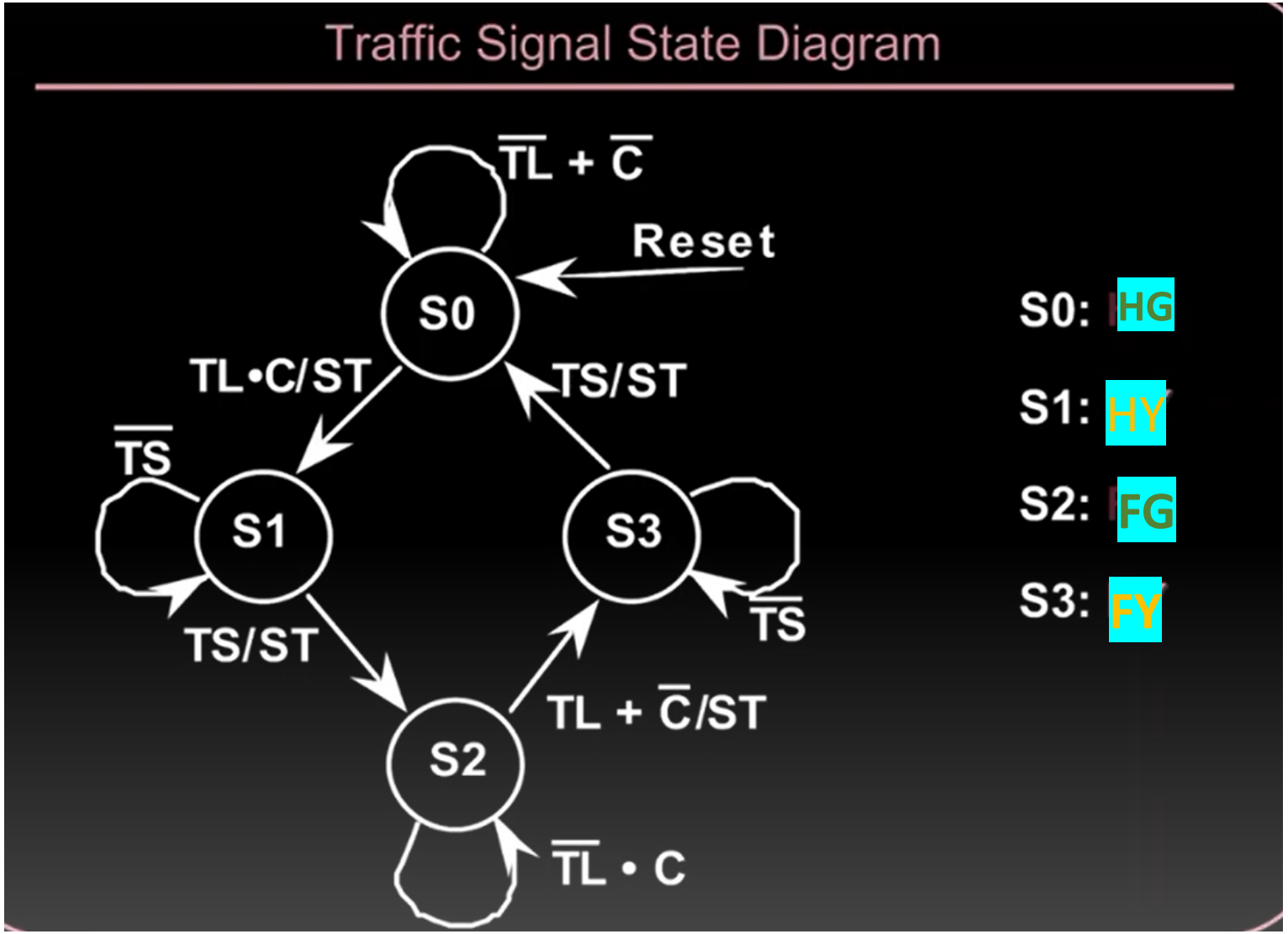

Tabulate Inputs & Outputs
Input Signal
Description
Reset
place FSM in initial state
C
detect vehicle on farmroad
TS
short time interval expired
TL
long time interval expired
Output Signal
Description
HG, HY, HR.
assert green/yellow/red highway lights
FG, FY, FR
assert green/yellow/red farmroad lights
ST
start timing a short or long interval

Tabulate Unique States

- Some light configurations imply others.

State	Description
S0	Highway Green (farmroad Red)
S1	Highway Yellow (farmroad Red)
S2	Farmroad Green (highway Red)
S3	Farmroad Yellow (highway Red)

- Reset places timer in S0, highway Green and farmroad Red.
- Reset also starts the timer.
- Stay in S0 as long as no one is on the farmroad.
- Even if there is a farmroad vehicle, the highway stays Green at least long as the long time interval.
- (Unstated in problem spec) There will never be a bicycle or pedestrian on the farmroad.



From STG, a state transition table and circuit can be designed.