State Machine Encoding Example

Last updated 1/22/21

State Machine Encoding Examples

- These slides provide examples of various encoding formats

State Machine Encoding Example

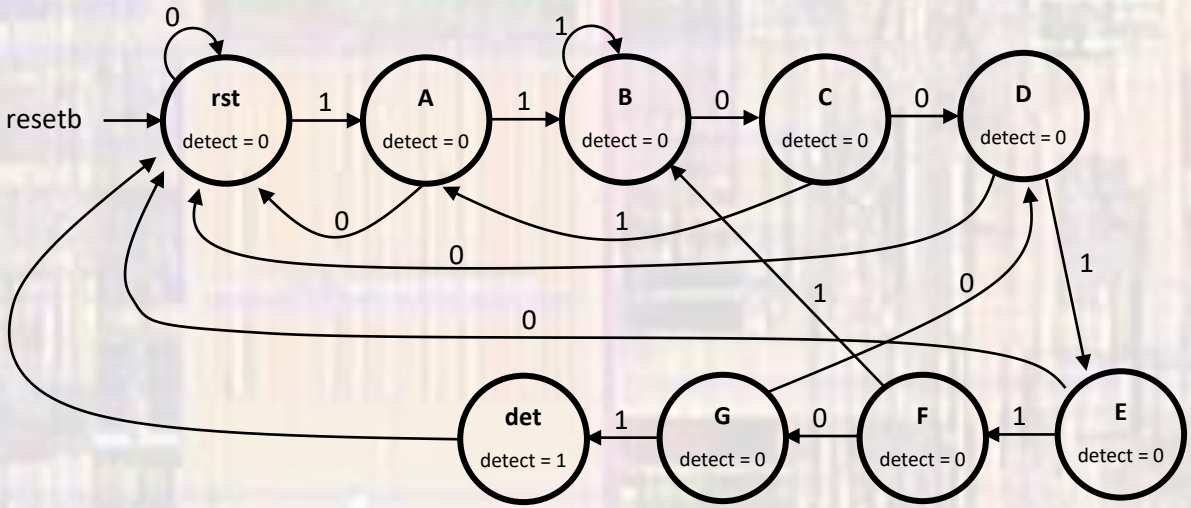
- Encoding
  - Comparison – considerations
    - Memory elements (bits) → area or fit
    - Coding / Decoding logic → area or fit
    - Speed
      - Shorter logic chains → faster maximum clock speeds
    - Power
      - P = v * i
      - P = v * c * dv/dt
      - dv/dt represents a transition 0 → 1
      - Fewer transitions → lower power

State Machine Encoding Example

- Sequence Detector
  - Create a state machine that can detect when a specific bit sequence is transmitted on a communications channel
  - Common in coded channels
  - Start sequence: 11001101
    - time →
  - Pulse a bit when the sequence is detected

State Machine Encoding Example

- State Diagram
  - Sequence detector 11001101

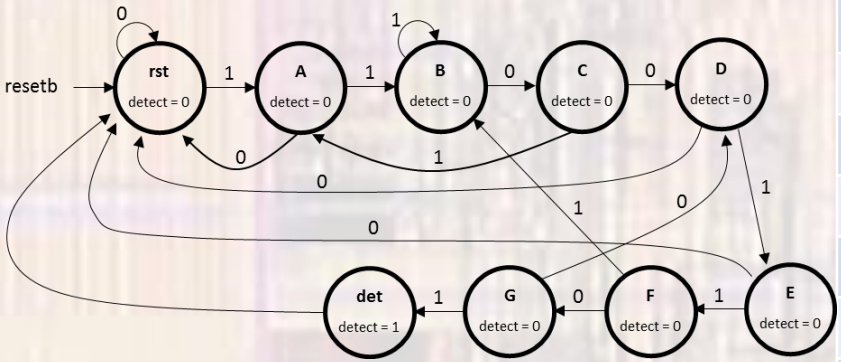


State Machine Encoding Example

- State Diagram

State	Din	Next State
rst	0	Rst
rst	1	A
A	0	Rst
A	1	B
B	0	C
B	1	B
C	0	D
C	1	A
D	0	Rst
D	1	E
E	0	Rst
E	1	F
F	0	G
F	1	B
G	0	D
G	1	Det
Det	X	rst

ctor 11001101



State	Detect
Rst	0
A	0
B	0
C	0
D	0
E	0
F	0
G	0
Det	1

State Machine Encoding Example

- State Diagram
  - Binary encoding
  - 9 states → 4 bits

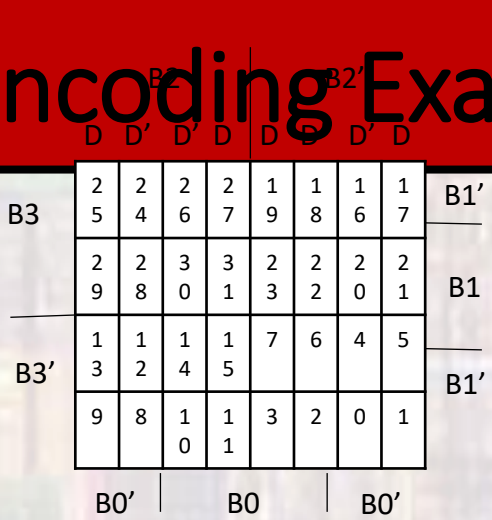
State	Code
Rst	0000
A	0001
B	0010
C	0011
D	0100
E	0101
F	0110
G	0111
Det	1000

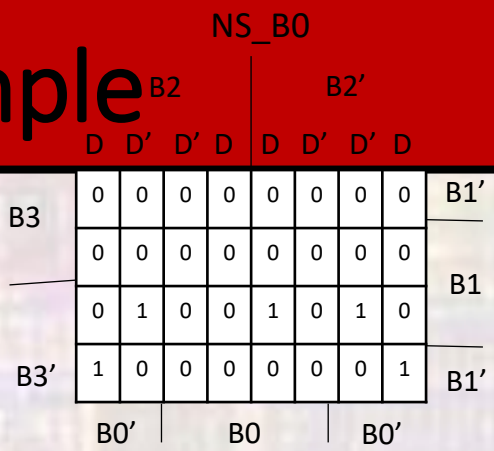
State	Din	Next State
0000	0	0000
0000	1	0001
0001	0	0000
0001	1	0010
0010	0	0011
0010	1	0010
0011	0	0100
0011	1	0001
0100	0	0000
0100	1	0101
0101	0	0000
0101	1	0110
0110	0	0111
0110	1	0010
0111	0	0100
0111	1	1000
1000	X	0000

State	Detect
0000	0
0001	0
0010	0
0011	0
0100	0
0101	0
0110	0
0111	0
1000	1

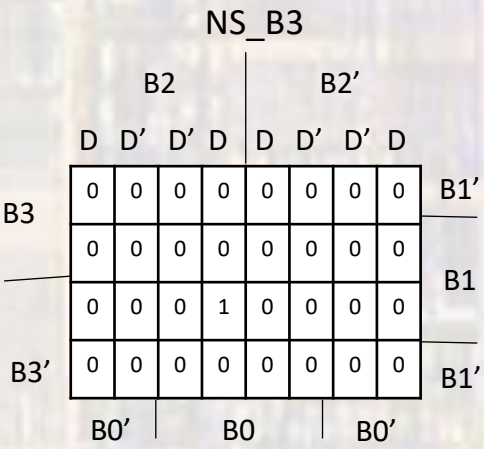
State Machine Encoding Example

- State Diagram
  - Binary encoding
  - 9 states → 4 bits

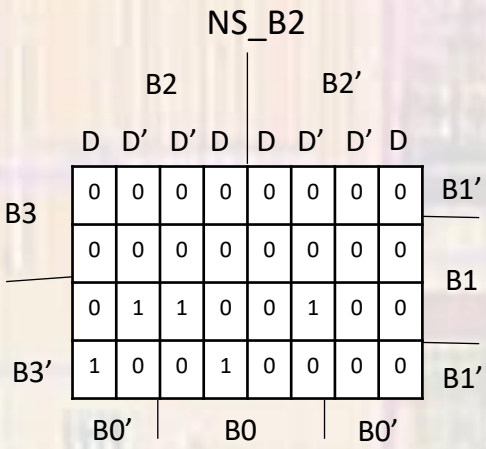




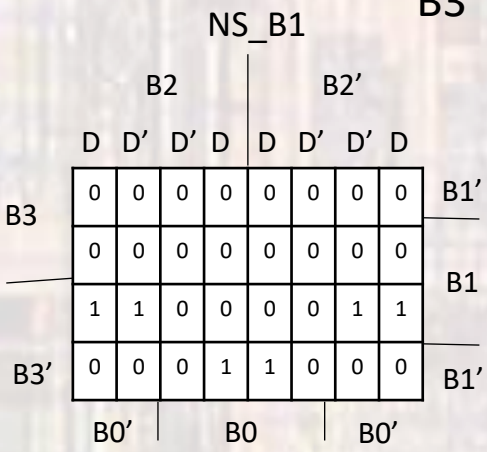
B3' B1' B0' D +
B3' B2 B1 B0' D' +
B3' B2' B1 B0 D



B3' B2 B1 B0 D



B3' B2 B1 D' +
B3' B2 B1' D +
B3' B2' B1 B0 D'



B3' B1 B0' +
B3' B1' B0 D

State Machine Encoding Example

- State Diagram
  - binary encoding
  - 9 states → 4 bits

State	Detect
0000	0
0001	0
0010	0
0011	0
0100	0
0101	0
0110	0
0111	0
1000	1

detect = B3B2’B1’B0’

State Machine Encoding Example

- State Diagram
  - One hot encoding
  - 9 states → 9 bits

State	Code
Rst	000000001
A	000000010
B	000000100
C	000001000
D	000010000
E	000100000
F	001000000
G	010000000
Det	100000000

State	Din	Next State
000000001	0	000000001
000000001	1	000000010
000000010	0	000000001
000000010	1	000000100
000000100	0	000001000
000000100	1	000000100
000001000	0	000010000
000001000	1	000000010
000010000	0	000000001
000010000	1	000100000
000100000	0	000000001
000100000	1	001000000
001000000	0	010000000
001000000	1	000000100
010000000	0	000010000
010000000	1	100000000
100000000	X	000000001

State	Detect
000000001	0
000000010	0
000000100	0
000001000	0
000010000	0
000100000	0
001000000	0
010000000	0
100000000	1

State Machine Encoding Example

- State Diagram
  - One hot encoding
  - 9 states → 9 bits

ns8 = b7 D
ns7 = b6 D'
ns6 = b5 D
ns5 = b4 D
ns4 = b3 D' + b7 D
ns3 = b2 D'
ns2 = b1 D + b2 D
ns1 = b0 D' + b3 D
ns0 = b0 D' + b1 D' + b4 D' + b5 D' + b8

State	Din	Next State
000000001	0	000000001
000000001	1	000000010
000000010	0	000000001
000000010	1	000000100
000000100	0	000001000
000000100	1	000000100
000001000	0	000010000
000001000	1	000000010
000010000	0	000000001
000010000	1	000100000
000100000	0	000000001
000100000	1	001000000
001000000	0	010000000
001000000	1	000000100
010000000	0	000010000
010000000	1	100000000
100000000	X	000000001

State Machine Encoding Example

- State Diagram
  - One hot encoding
  - 9 states → 9 bits

State
000000001
000000010
000000100
000001000
000010000
000100000
001000000
010000000
100000000

detect = b8

State Machine Encoding Example

- State Diagram
  - Johnson encoding
  - 9 states → 5 bits

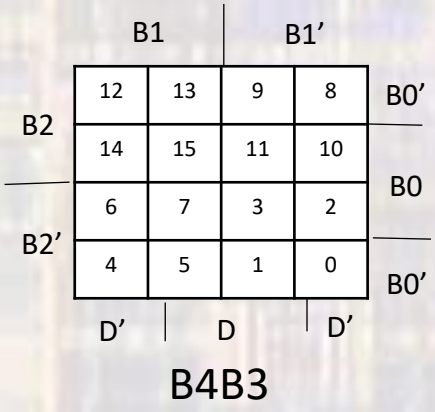
State	Code
Rst	10000
A	11000
B	11100
C	11110
D	11111
E	01111
F	00111
G	00011
Det	00001

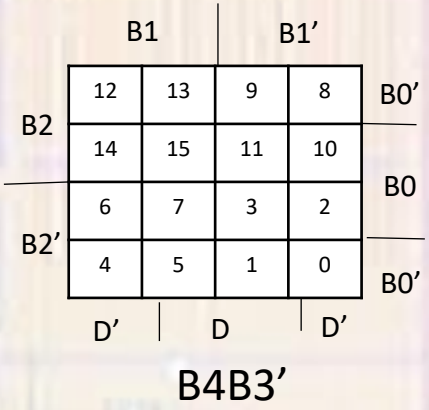
State	Din	Next State
10000	0	10000
10000	1	11000
11000	0	10000
11000	1	11100
11100	0	11110
11100	1	11100
11110	0	11111
11110	1	11000
11111	0	10000
11111	1	01111
01111	0	10000
01111	1	00111
00111	0	00011
00111	1	11100
00011	0	11111
00011	1	00001
00001	X	10000

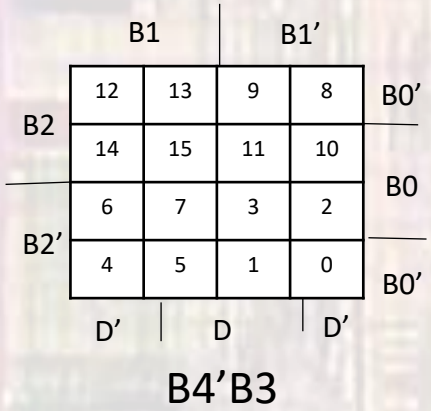
State	Detect
10000	0
11000	0
11100	0
11110	0
11111	0
01111	0
00111	0
00011	0
00001	1

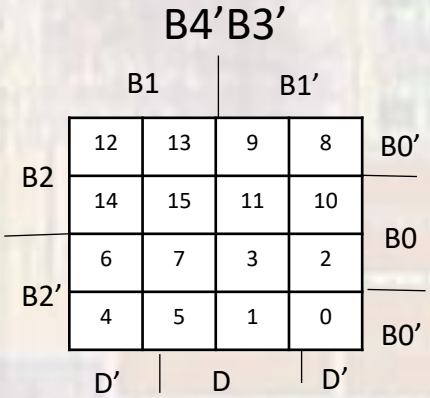
State Machine Encoding Example

- State Diagram
  - Johnson encoding
  - 9 states → 5 bits







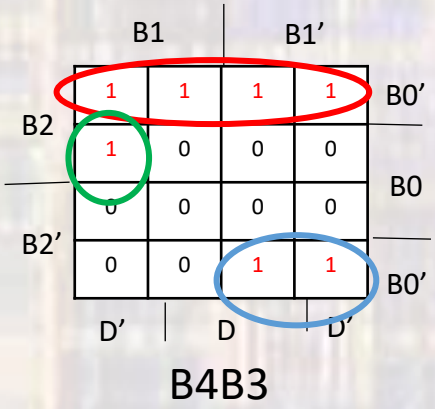


State Machine Encoding Exa

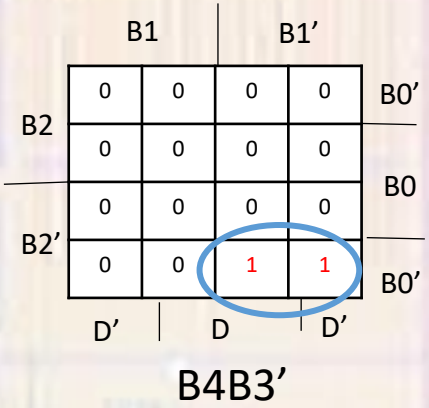
- State Diagram
  - Johnson encoding
  - 9 states → 5 bits

State	Din	Next State
10000	0	10000
10000	1	11000
11000	0	10000
11000	1	11100
11100	0	11110
11100	1	11100
11110	0	11111
11110	1	11000
11111	0	10000
11111	1	01111
01111	0	10000
01111	1	00111
00111	0	00011
00111	1	11100
00011	0	11111
00011	1	00001
00001	X	10000

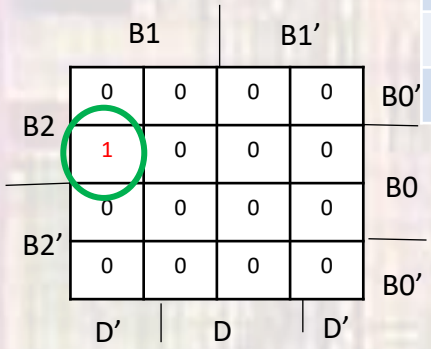
NS_4



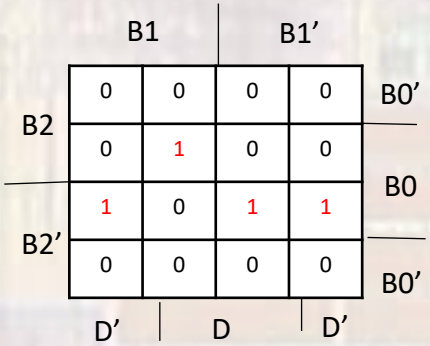
B4B3



B4B3'



B4'B3



B4'B3'

B4B3B2B0' + B4B2'B1'B0' + B3B2B1B0D' +
B4'B3'B2'B1'B0 + B4'B3'B2'B1B0D' +
B4'B3'B2B1B0D

State Machine Encoding Example

- State Diagram
  - Johnson encoding
  - 9 states → 5 bits

State	Detect
10000	0
11000	0
11100	0
11110	0
11111	0
01111	0
00111	0
00011	0
00001	1

detect = b4’b3’b2’b1’b0