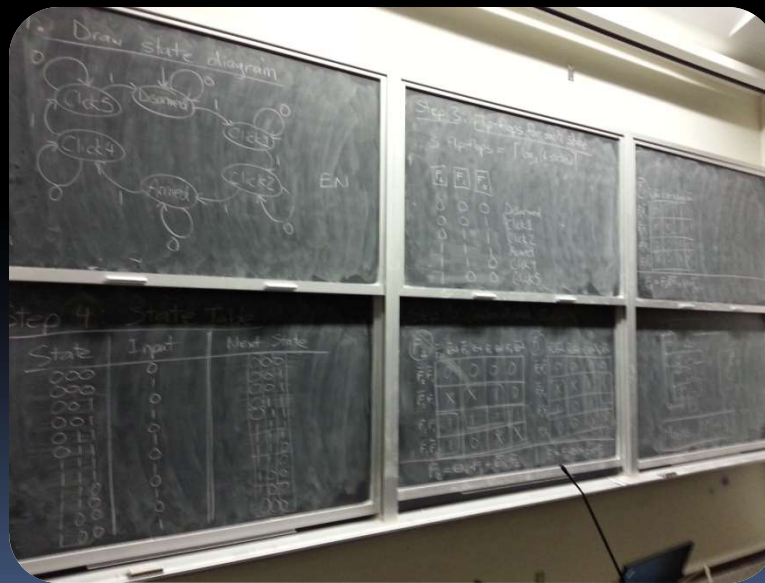


FSM example

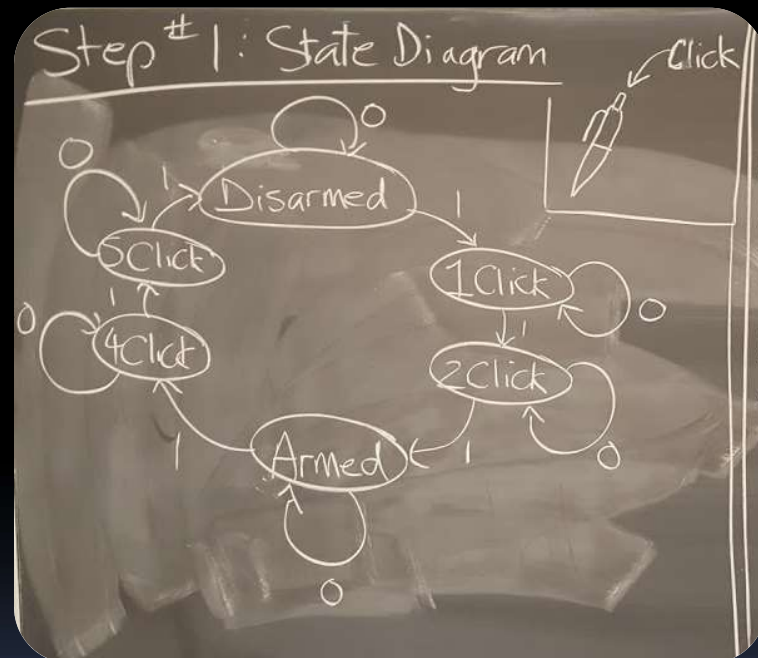
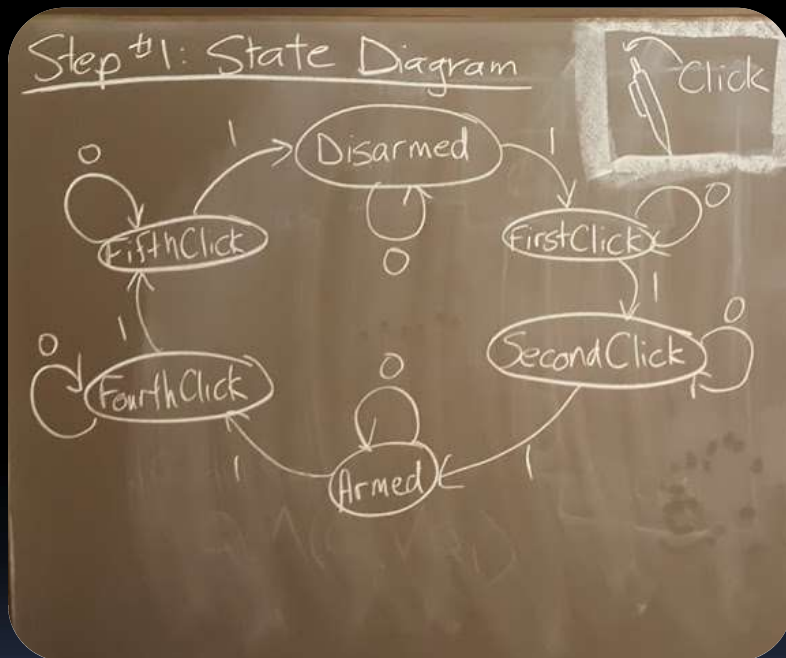
February 2017



FSM task

- Exploding pen from Goldeneye (James Bond)
 - Three clicks to arm,
 - Three clicks to disarm.
- Note how the design differs as a result of choosing different flip-flop assignments!

Step 1: State Diagram



Step 2: State Table

Step #2: State Table

State	Click	Next State
Disarmed	0	Disarmed
Disarmed	1	FirstClick
FirstClick	0	FirstClick
FirstClick	1	SecondClick
SecondClick	0	SecondClick
SecondClick	1	Armed
Armed	0	Armed
Armed	1	FourthClick
FourthClick	0	FourthClick
FourthClick	1	FifthClick
FifthClick	0	FifthClick
FifthClick	1	Disarmed

Step #2: State Table

State	Click	Next State
Disarmed	0	Disarmed
Disarmed	1	1Click
1Click	0	1Click
1Click	1	2Click
2Click	0	2Click
2Click	1	Armed
Armed	0	Armed
Armed	1	4Click
4Click	0	4Click
4Click	1	5Click
5Click	0	5Click
5Click	1	Disarmed

Step 3: Flip Flop Assignments

Step #3: Flip-Flops

of flip-flops: 3

$\lceil \log_2(\# \text{ states}) \rceil$

3 FFs \rightarrow 8 states
> 6 needed

State	Flipflop values
Disarmed	0 0 0
FirstClick	0 0 1
SecondClick	0 1 1
Armed	1 1 1
FourthClick	1 1 0
FifthClick	1 0 0

Step #3: Flip-Flops

6 states needed

$\rightarrow \lceil \log_2(\# \text{ of states}) \rceil$

\rightarrow 3 flip-flops

State	F ₂	F ₁	F ₀
Disarmed	0	0	0
1Click	0	0	1
2Click	0	1	1
Armed	1	1	1
4Click	1	1	0
5Click	1	0	0

Step 4: State Table, updated

Step #3: Flip-Flops

of flip-flops: 3

$\lceil \log_2(\# \text{states}) \rceil$

3 FFs \rightarrow 8 states
 > 6 needed

State	Flipflop values
Disarmed	0 0 0
FirstClick	0 0 1
SecondClick	0 1 1
Armed	1 1 1
FourthClick	1 1 0
FifthClick	1 0 0

Step #4: Redraw State Table

Current State	Click	Next State
0 0 0	0	0 0 0
0 0 0	1	0 0 1
0 0 1	0	0 0 1
0 0 1	1	0 1 1
0 1 1	0	0 1 1
0 1 1	1	1 1 1
1 1 1	0	1 1 0
1 1 1	1	1 0 0
1 1 0	0	1 1 0
1 1 0	1	1 0 0
1 0 0	0	1 0 0
1 0 0	1	0 0 0

Step #3: Flip-Flops

6 states needed

$\rightarrow \lceil \log_2(\# \text{of states}) \rceil$

\rightarrow 3 flip-flops

State	F_2	F_1	F_0
Disarmed	0	0	0
1Click	0	0	1
2Click	0	1	1
Armed	1	1	1
4Click	1	1	0
5Click	1	0	0

Step #4: Rewrite State Table

Current State	Click	Next State
0 0 0	0	0 0 0
0 0 0	1	0 0 1
0 0 1	0	0 0 1
0 0 1	1	0 1 1
0 1 1	0	0 1 1
0 1 1	1	1 1 1
1 1 1	0	1 1 0
1 1 1	1	1 0 0
1 1 0	0	1 1 0
1 1 0	1	1 0 0
1 0 0	0	1 0 0
1 0 0	1	0 0 0

Step 5: Circuit Design

F_2

	$\overline{F_0} \text{Click}$	$\overline{F_0} \overline{\text{Click}}$	$F_0 \text{Click}$	$F_0 \overline{\text{Click}}$
$\overline{F_2} \overline{F_1}$	0	0	0	0
$\overline{F_2} F_1$	X	X	1	0
$F_2 \overline{F_1}$	1	1	1	1
$F_2 F_1$	1	0	X	X

F_1

	$\overline{F_0} \text{Click}$	$\overline{F_0} \overline{\text{Click}}$	$F_0 \text{Click}$	$F_0 \overline{\text{Click}}$
$\overline{F_2} \overline{F_1}$	0	0	1	0
$\overline{F_2} F_1$	X	X	1	1
$F_2 \overline{F_1}$	1	0	1	1
$F_2 F_1$	0	0	X	X

$F_2 = \overline{F_0} \text{Click} + F_2 \text{Click}$
 $F_1 = \overline{F_0} \text{Click} + F_1 \overline{\text{Click}}$
 $F_0 = \overline{F_2} \text{Click} + F_0 \text{Click}$

F_2

	$\overline{F_0} \text{Click}$	$\overline{F_0} \overline{\text{Click}}$	$F_0 \text{Click}$	$F_0 \overline{\text{Click}}$
$\overline{F_2} \overline{F_1}$	0	0	0	0
$\overline{F_2} F_1$	X	X	1	0
$F_2 \overline{F_1}$	1	1	1	1
$F_2 F_1$	1	0	X	X

F_0

	$\overline{F_0} \text{Click}$	$\overline{F_0} \overline{\text{Click}}$	$F_0 \text{Click}$	$F_0 \overline{\text{Click}}$
$\overline{F_2} \overline{F_1}$	0	1	1	1
$\overline{F_2} F_1$	X	X	1	1
$F_2 \overline{F_1}$	0	0	0	1
$F_2 F_1$	0	0	X	X

$F_2 = F_1 \text{Click} + F_2 \overline{\text{Click}}$
 $F_1 = \overline{F_0} \text{Click} + F_1 \overline{\text{Click}}$
 $F_0 = \overline{F_2} \text{Click} + F_0 \text{Click}$

Step 5 (cont'd)

