State Machine Design

State Machine Design

This presentation will

- Define a state machine.
- Provide several examples of everyday items that are controlled by state machines.
- Illustrate the block diagram for a state machine.
- Review the design steps in the state machine design process.
- Provide an example of a simple state machine design.

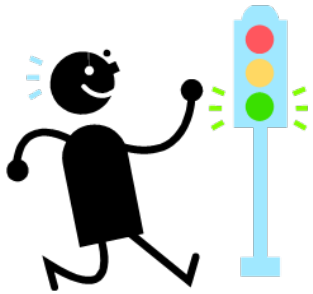
Definition of a State Machine

State Machine

A synchronous sequential circuit, consisting of a sequential logic section and a combinational logic section, whose outputs and internal flip-flops progress through a predictable sequence of states in response to a clock and other input signals.*

Examples of State Machines

Many everyday devices are controlled by state machines.

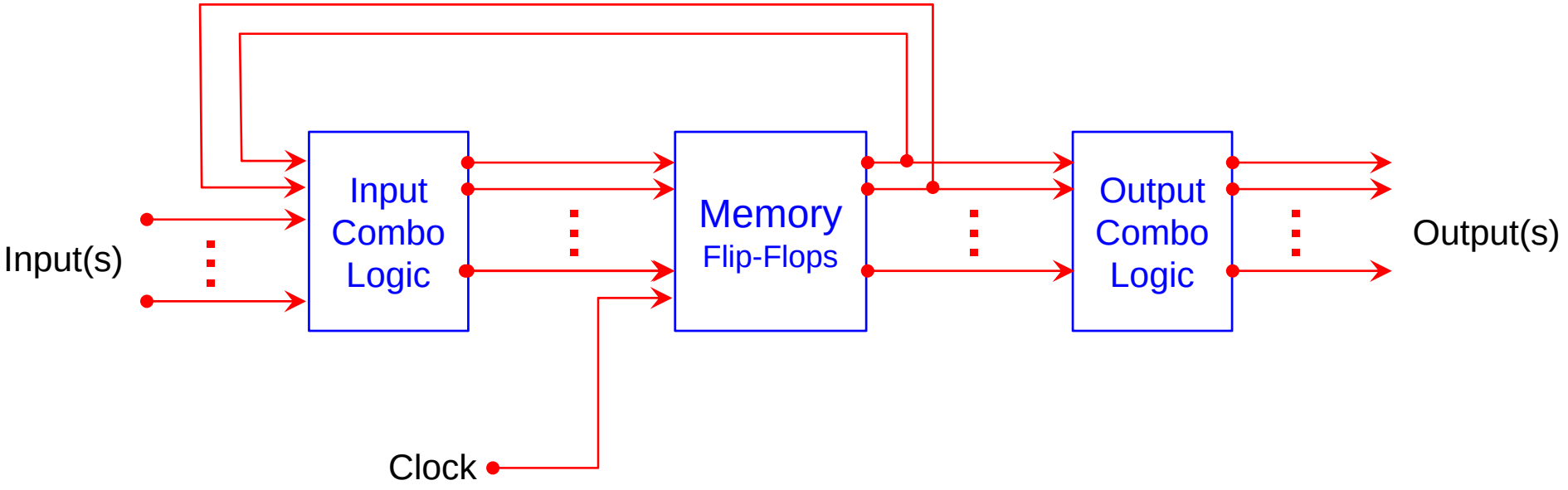


Traffic Light

Garage Door Numeric Keypad

Vending Machine

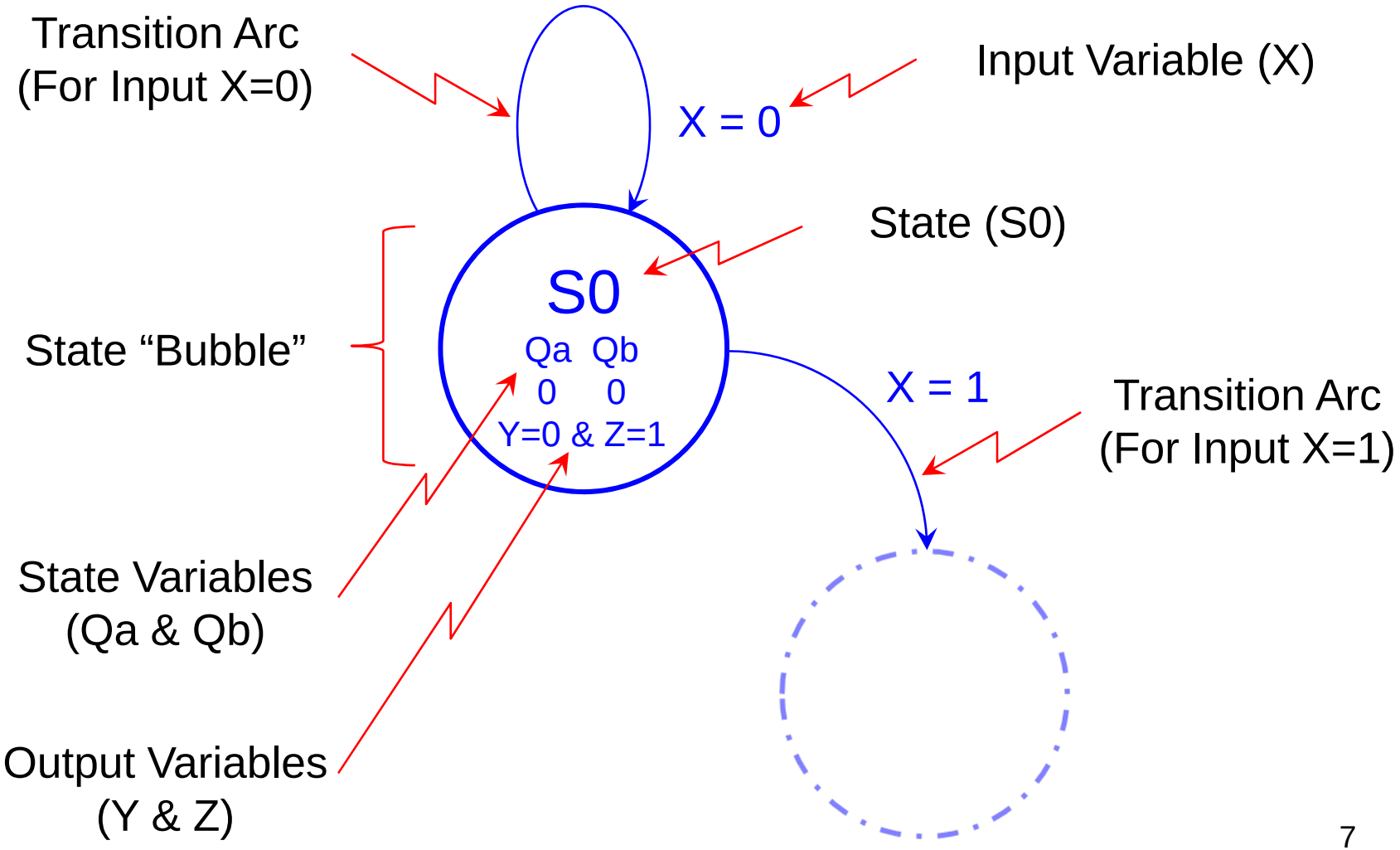
State Machine Block Diagram



State Machine Design Steps

1. Create State Graph
2. Determine State Variables and Assign
3. Encode Outputs to States
4. Create State Transition Table
5. Write and Simplify Design Equations
6. Design Circuit

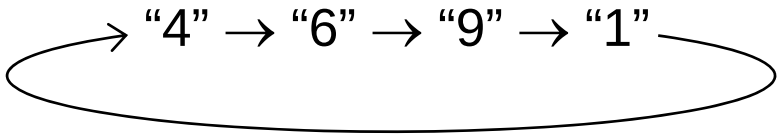
Anatomy of a State Graph



State Machine Design Example

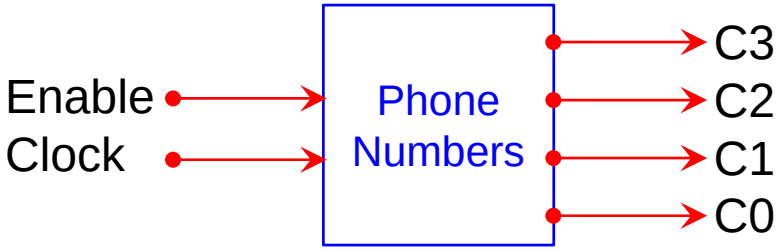
Example:

Design a state machine that will count out the last four digits of the phone number 585-476-4691.

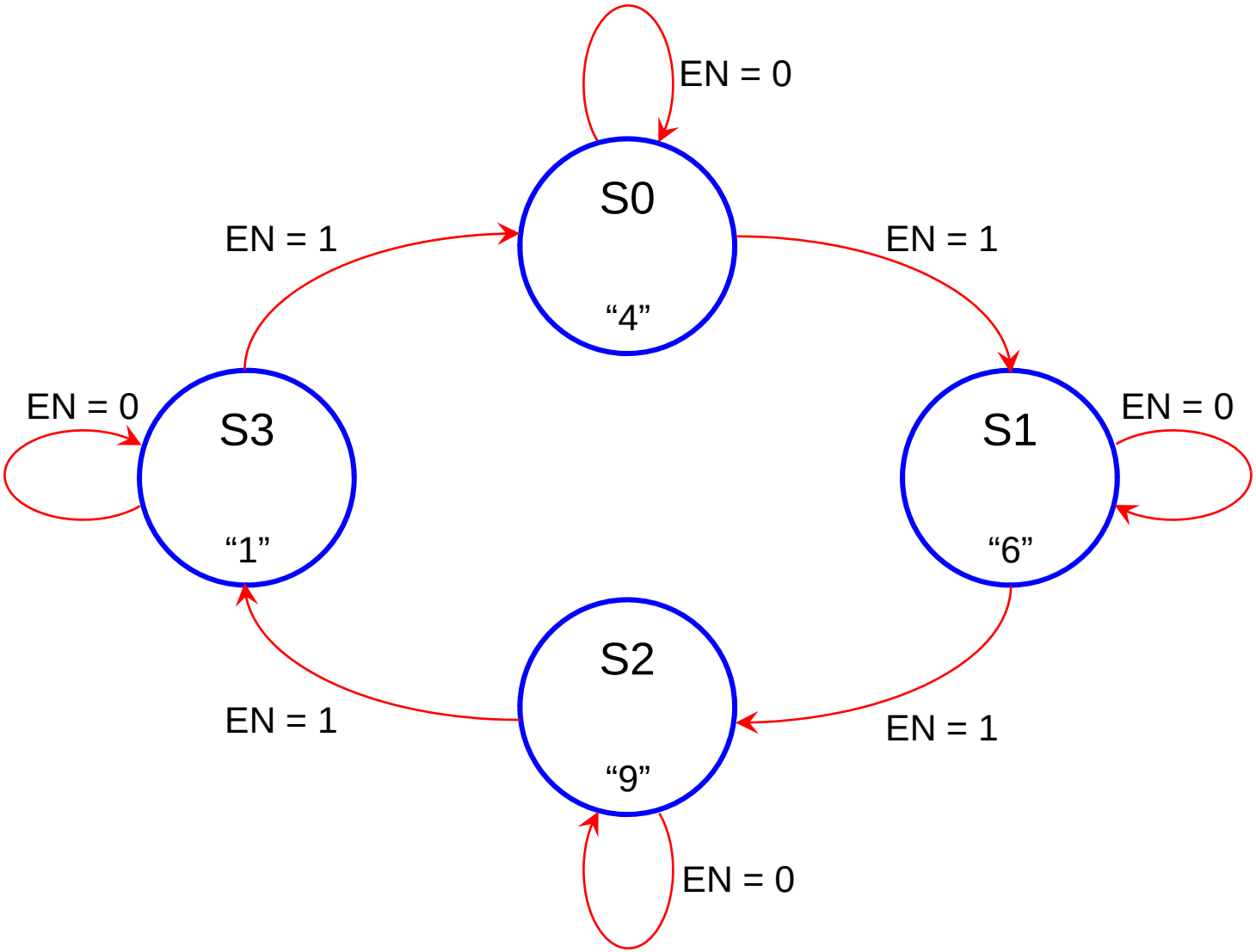


In addition to the clock input, this design has a second input called Enable (EN). Whenever the Enable is a logic (1), the outputs will continuously cycle through the four values 4,6,9,1. Whenever the Enable is a logic (0), the outputs will hold at their current values.

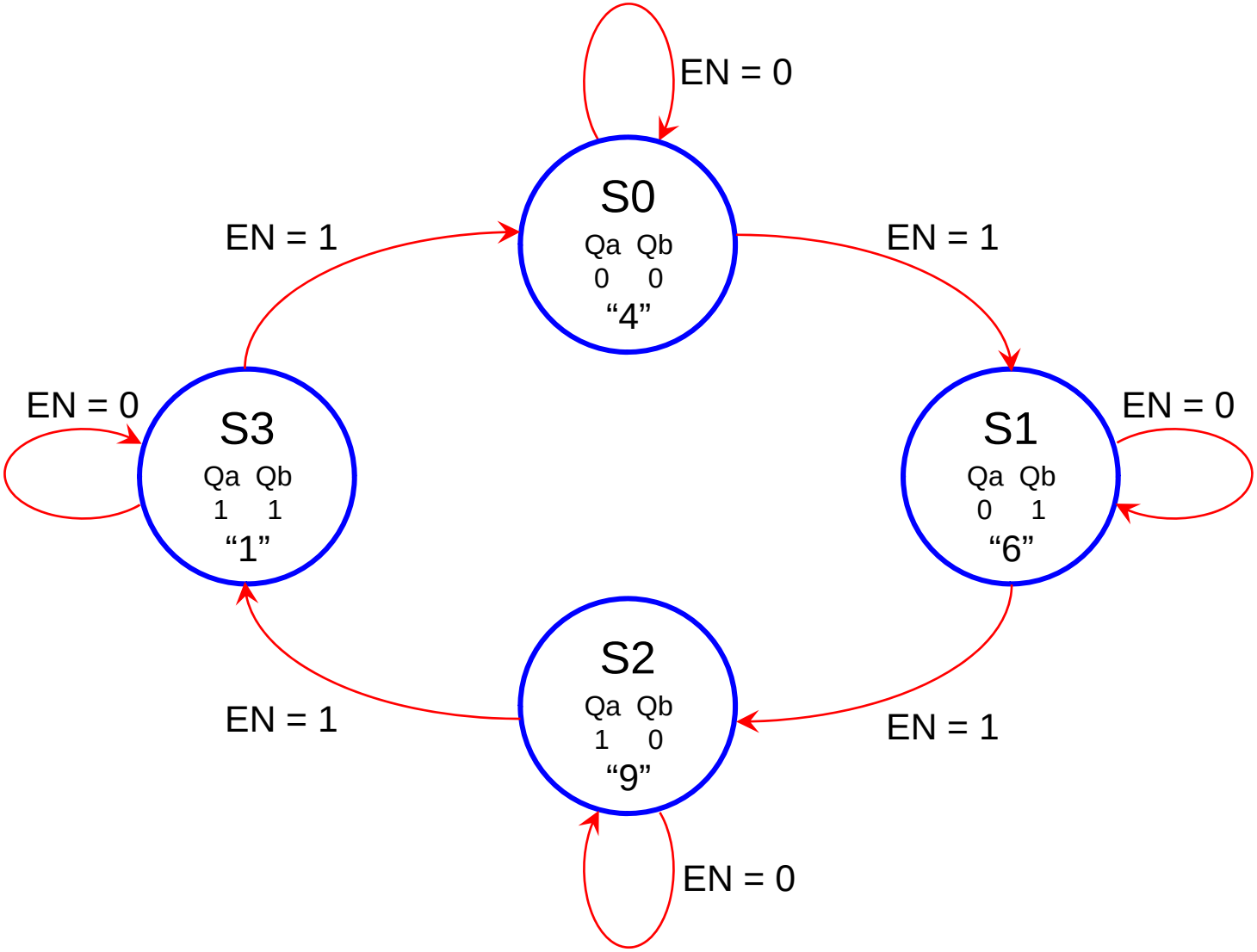
For this design any form of combinational logic may be used, but the sequential logic must be limited to D flip-flops.



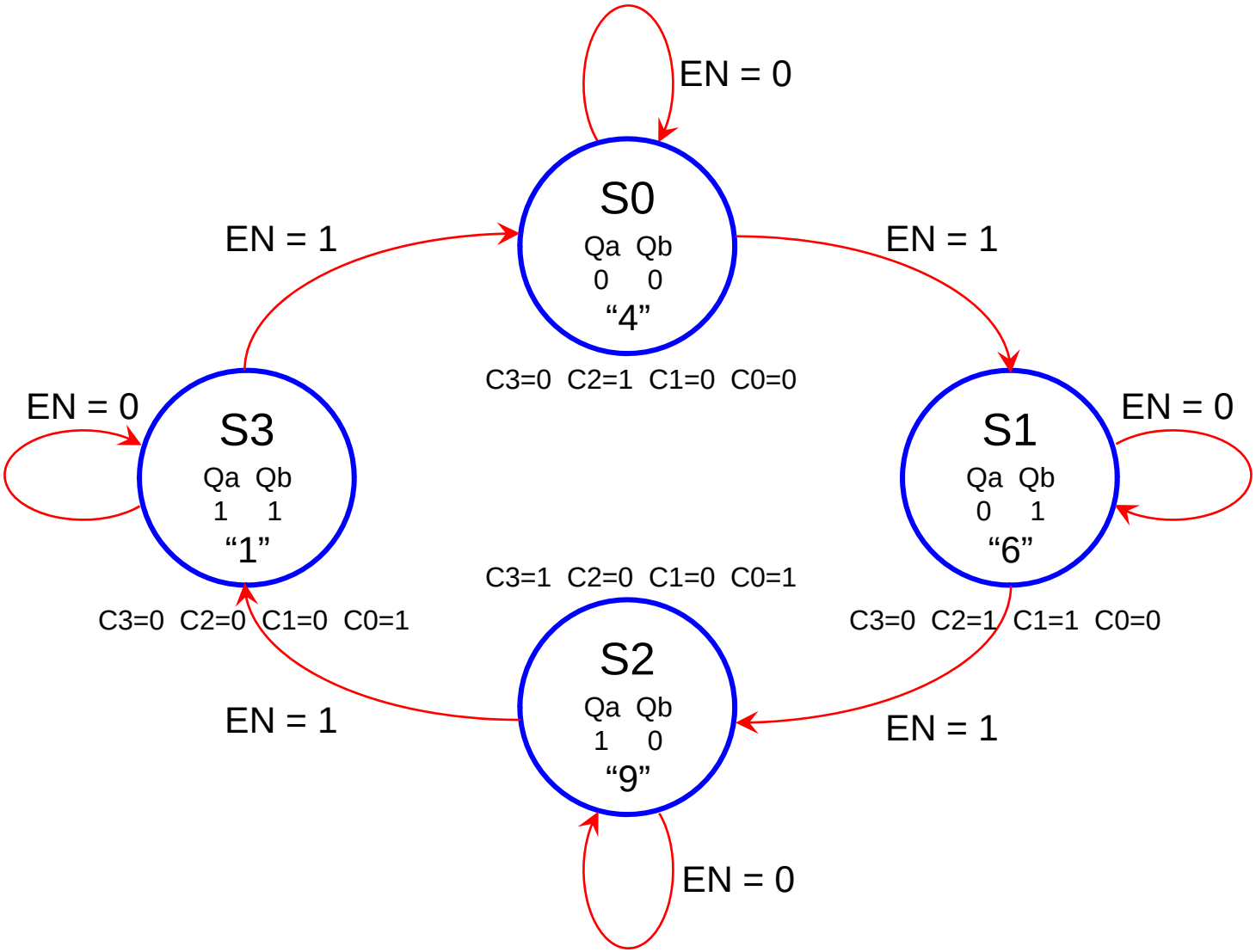
Step #1: Create State Graph



Step #2: Determine State Variables and Assign



Step #3: Encode Outputs to States



Step #3: Create State Transition Table

State	Inputs			State	Outputs							
	Present State		Input		Next State		F/F Inputs		Encoded Outputs			
	Qa	Qb	EN		Qa*	Qb*	Da	Db	C3	C2	C1	C0
S0	0	0	0	S0	0	0	0	0	0	1	0	0
S0	0	0	1	S1	0	1	0	1	0	1	0	0
S1	0	1	0	S1	0	1	0	1	0	1	1	0
S1	0	1	1	S2	1	0	1	0	0	1	1	0
S2	1	0	0	S2	1	0	1	0	1	0	0	1
S2	1	0	1	S3	1	1	1	1	1	0	0	1
S3	1	1	0	S3	1	1	1	1	0	0	0	1
S3	1	1	1	S0	0	0	0	0	0	0	0	1

Step #4: Write and Simplify Design Equations

$$Da = \overline{Qa}\,Qb\,EN + Qa\,\overline{Qb}\,\overline{EN} + Qa\,\overline{Qb}\,EN + Qa\,Qb\,\overline{EN}$$

$$Da = \overline{Qa}\,Qb\,EN + Qa\,\overline{EN} + Qa\,\overline{Qb}$$

$$Db = \overline{Qa}\,\overline{Qb}\,EN + \overline{Qa}\,Qb\,\overline{EN} + Qa\,\overline{Qb}\,EN + Qa\,Qb\,\overline{EN}$$

$$Db = Qb\,\overline{EN} + \overline{Qb}\,EN$$

$$Db = Qb \oplus EN$$

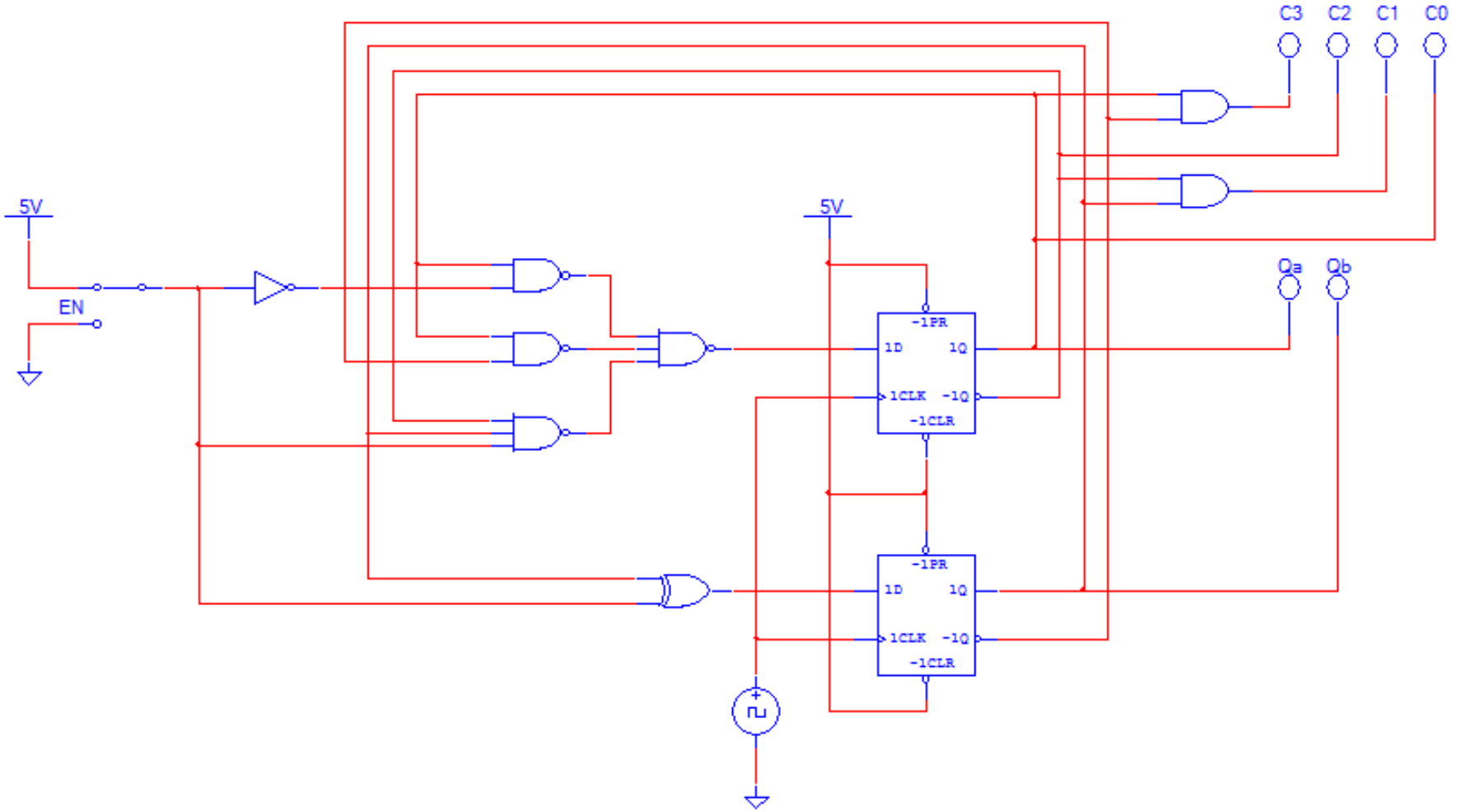
$$C3 = Qa\,\overline{Qb}\,\overline{EN} + Qa\,\overline{Qb}\,EN = Qa\,\overline{Qb}$$

$$C2 = \overline{Qa}\,\overline{Qb}\,\overline{EN} + \overline{Qa}\,\overline{Qb}\,EN + \overline{Qa}\,Qb\,\overline{EN} + \overline{Qa}\,Qb\,EN = \overline{Qa}$$

$$C1 = \overline{Qa}\,Qb\,\overline{EN} + \overline{Qa}\,Qb\,EN = \overline{Qa}\,Qb$$

$$C0 = Qa\,\overline{Qb}\,\overline{EN} + Qa\,\overline{Qb}\,EN + Qa\,Qb\,\overline{EN} + Qa\,Qb\,EN = Qa$$

Step #5: Circuit Design



Block Diagram / Schematic