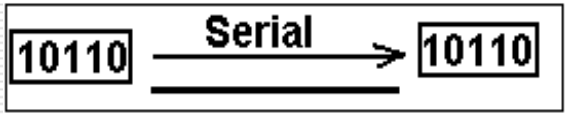
# Shift Registers

# Shift Register Applications

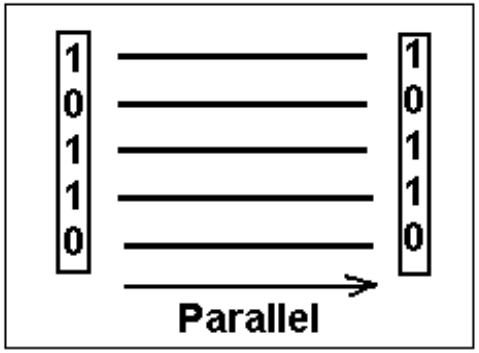
- Shift Registers are an important Flip-Flop configuration with a wide range of applications, including:
  - Computer and Data Communications
  - Serial and Parallel Communications
  - Multi-bit number storage
  - Sequencing
  - Basic arithmetic such as scaling (a serial shift to the left or right will change the value of a binary number a power of 2)
  - Logical operations

# Parallel versus Serial

- Serial communications: provides a binary number as a sequence of binary bits, one after another, through one data line.

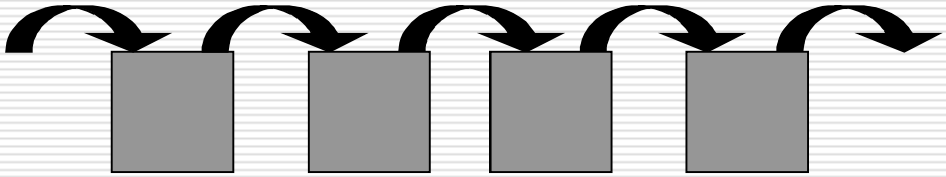



- Parallel communications: provides a binary number as binary bits through multiple data lines at the same time.

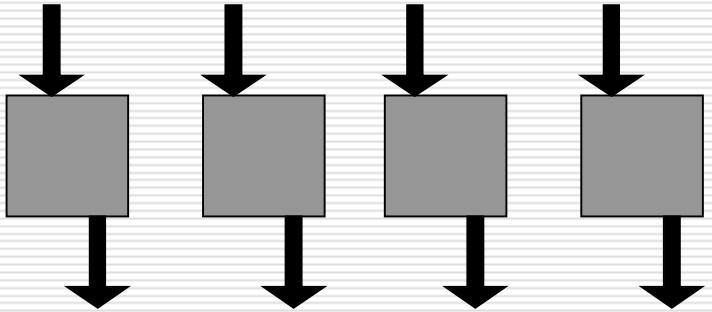


# Shift Registers

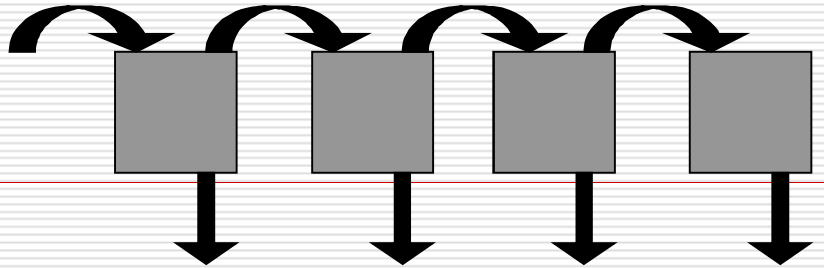
- Shift Registers are devices that store and move data bits in serial (to the left or the right),



- ..or in parallel,



- ..or a combination of serial and parallel.



# Configuration

- In Shift Registers, the binary bits transfers (shifts) from the output of one flip-flop to the input of the next individual Flip-Flop at every clock edge.

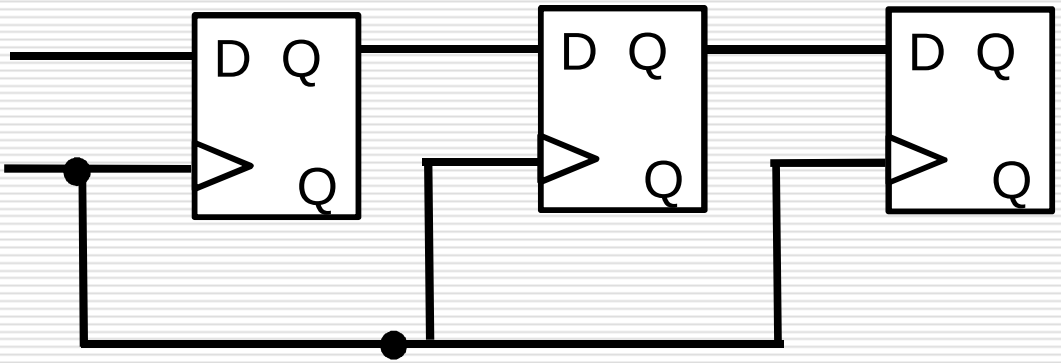
- Once the binary bits are shifted in, the individual Flip-Flops will each retain a bit, and the whole configuration will retain a binary number.

# Construction

- Shift registers are constructed from flip-flops due to their characteristics:
  - Edge-triggered devices
  - Output state retention
- Each Flip-Flop in a shift register can retain one binary bit.
  - For instance, if a 5-bit binary number needs to be stored and shifted, 5 flip-flops are required.
- Each binary bit transfer operation requires a clock edge.
- Asynchronous inputs are useful in resetting the whole configuration.

# Shift Register Construction

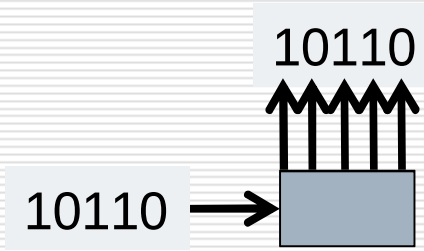
- Shift registers are comprised of D Flip-Flops that share a common clock input.



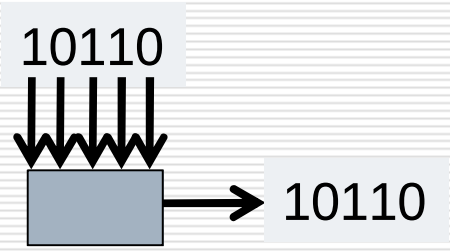
# Combinations of Data Transfer Methods

- SISO: Serial In, Serial Out

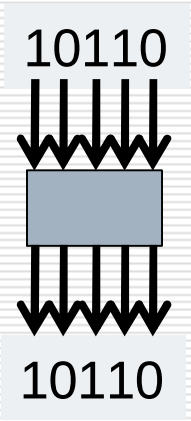

- SIPO: Serial In, Parallel Out




- PISO: Parallel In, Serial Out



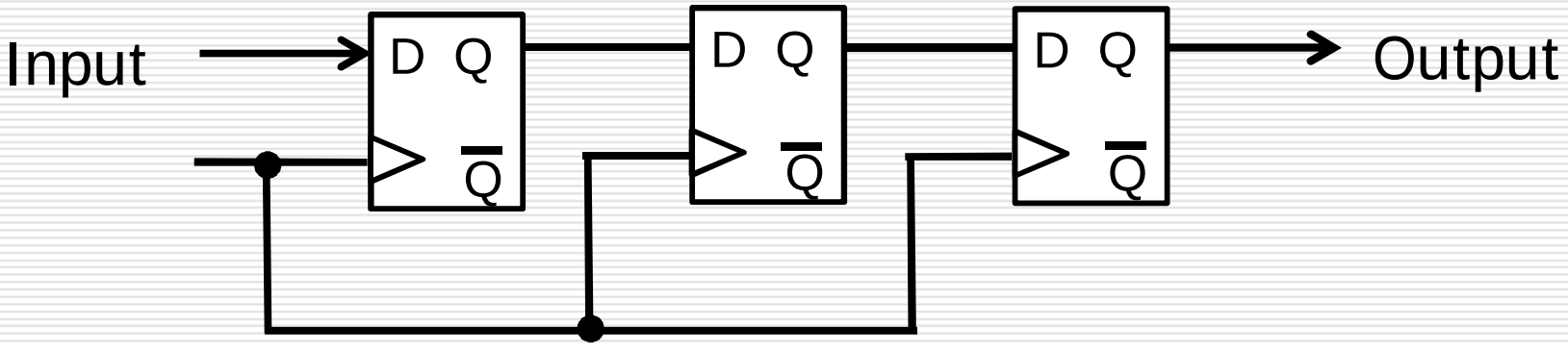

- PIPO: Parallel In, Parallel Out




How many clock edges are required for each operation?

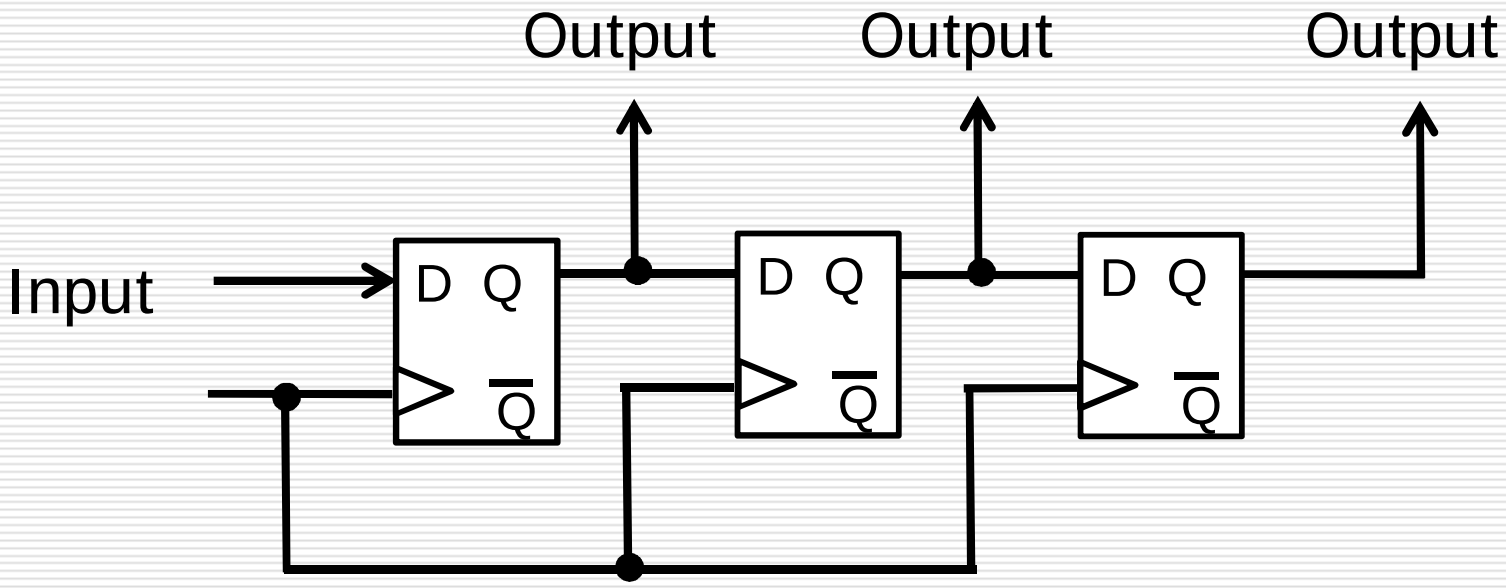
# SISO Flip-Flop Shift Register

- a **Serial In Serial Out** shift register has a single input and a single output



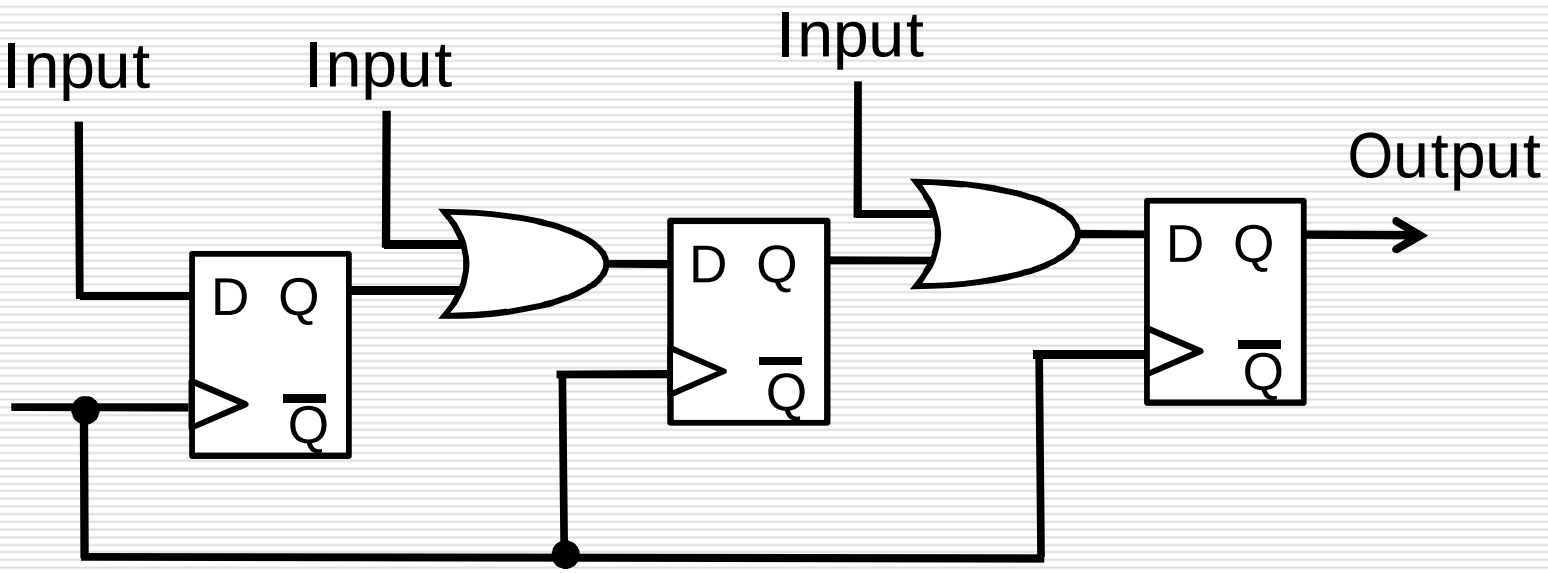
# SIPO Flip-Flop Shift Register

- a Serial In Parallel Out shift register has a single input and access to all outputs



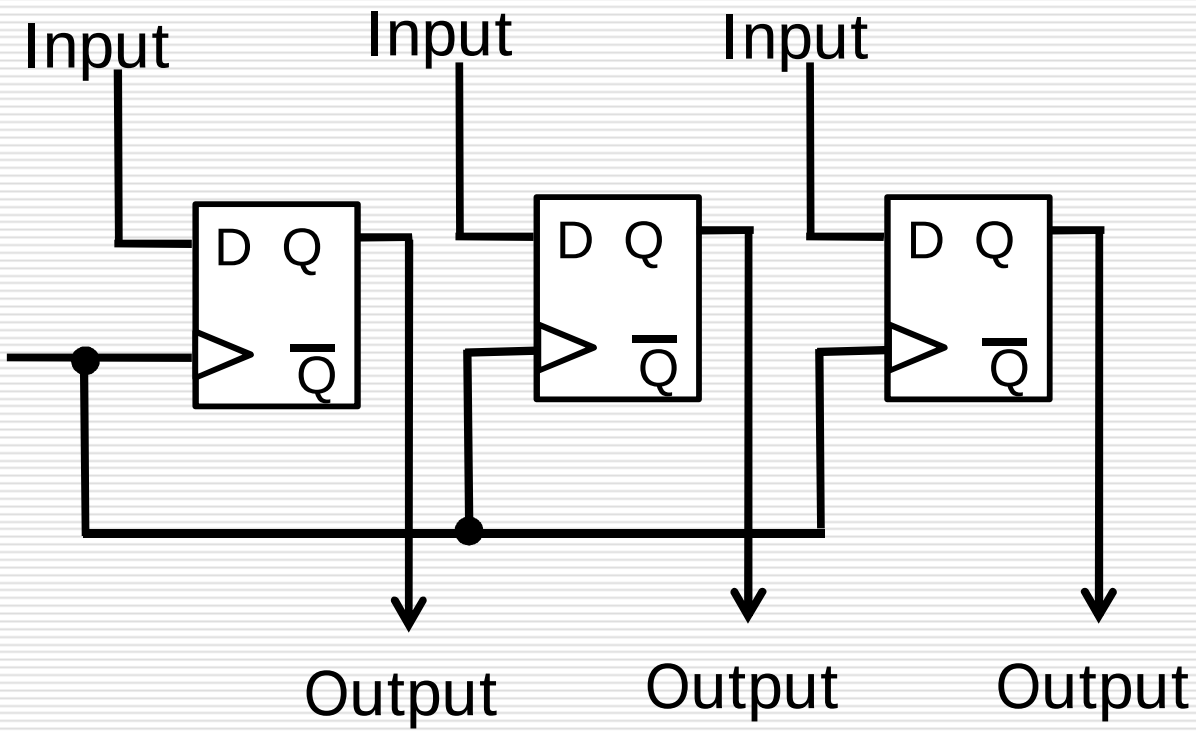
# PISO Flip-Flop Shift Register

- a **Parallel In Serial Out** shift register requires additional gates, and the parallel input must revert to logic low.



# PIPO Flip-Flop Shift Register

- a **Parallel In Parallel Out** register has the simplest configuration. It represents a memory device.



# Universal Shift Registers

- Universal Shift Registers can be configured to operate in a variety of modes. For instance, they can be configured to have either Serial or Parallel Input/Output.

- Internally use steering gates to determine:
  - Serial input/output direction
  - Parallel input (load)
  - Hold

- Refer to the manufacturer specification sheets for more information.

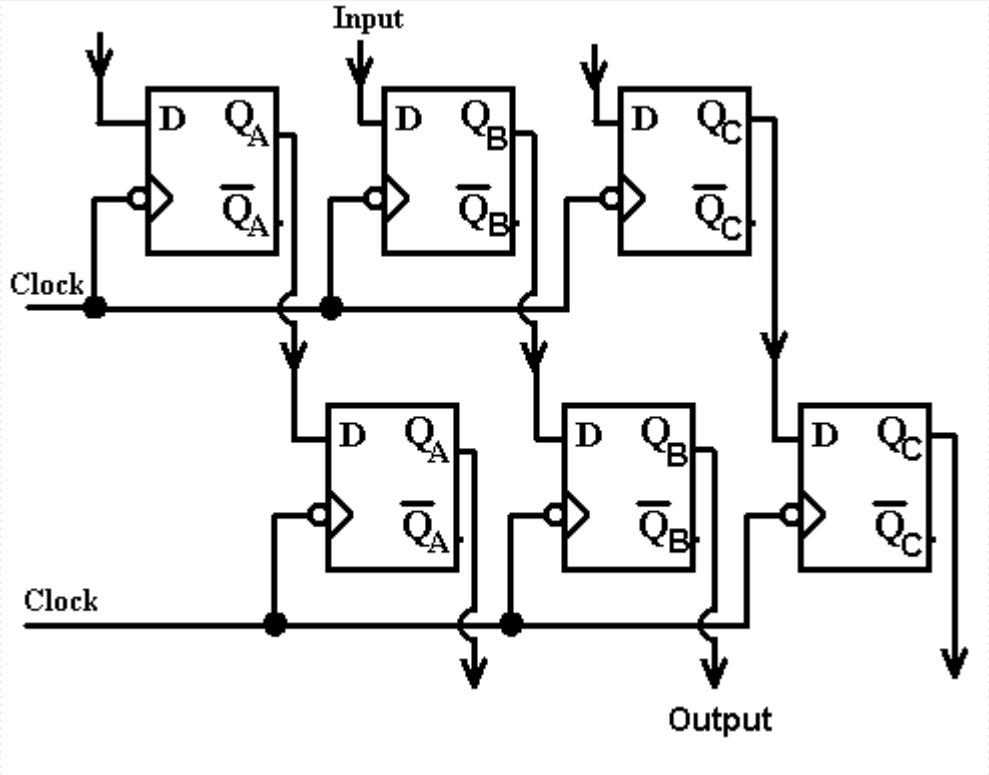
# Universal Shift Registers

- Look up the 74LS194 and describe its function by looking at the schematic. Fill in the table.

| S0 | S1 | Mode |
|---|---|---|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |

In-class exercise

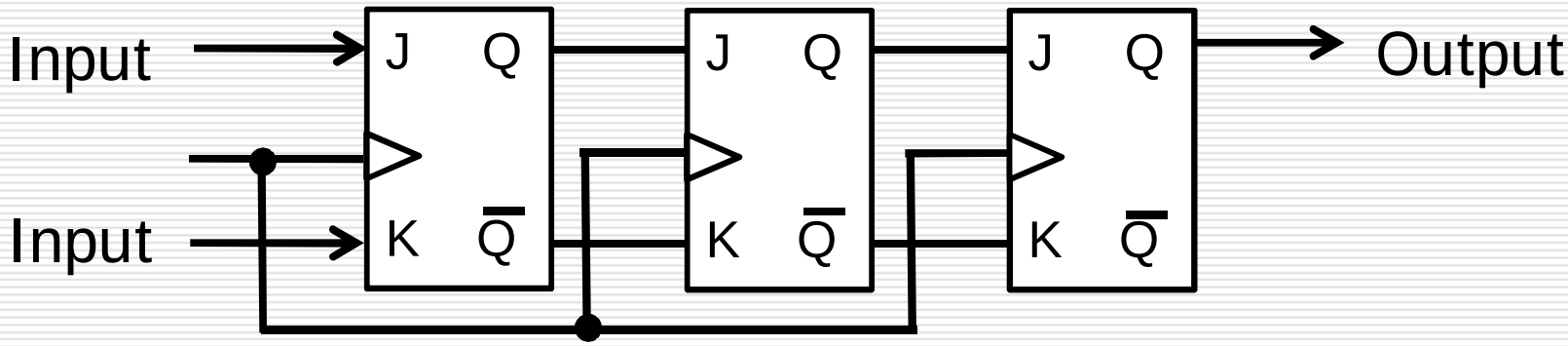
# Application: Parallel transferring the contents of a Register to another register.




Describe where this circuit combination may be used.

# JK Shift Registers

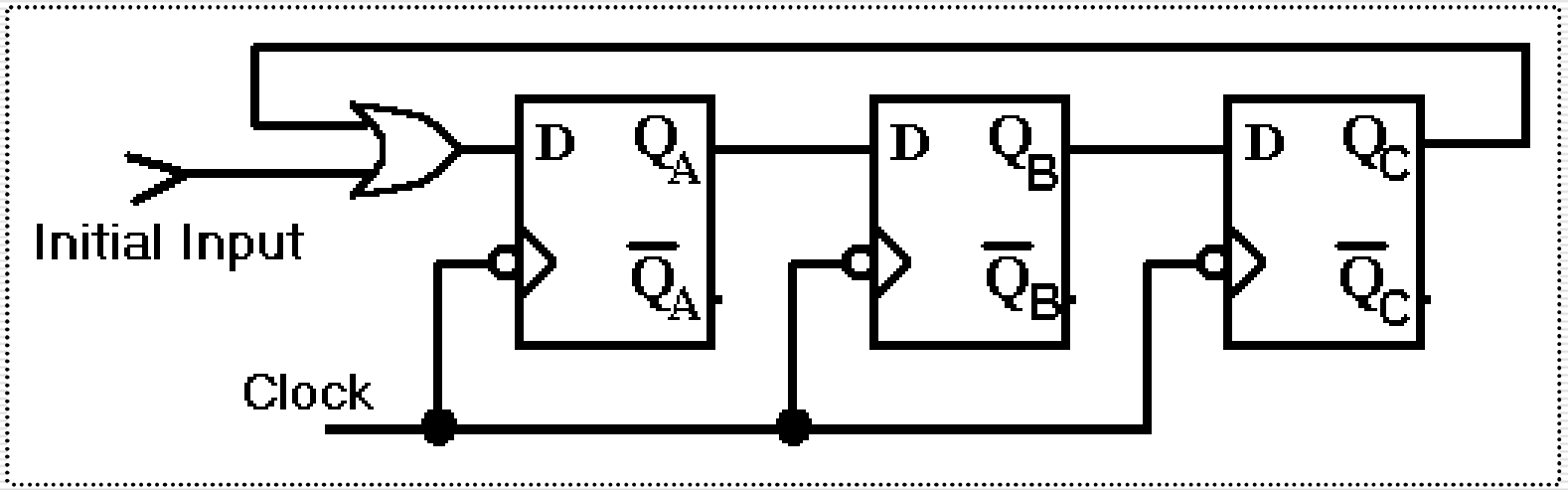
J-K Shift registers are seldom used, as two inputs (J,K) are required to load the first flip-flop (note all others receive only set or reset inputs).



# Ring Counter

- A ring counter takes the serial output of the last Flip-Flop of a shift register and provides it to the serial input of the first Flip-Flop.
- Ring Counters are also known as re-circulating shift registers.
- The display characteristics will be familiar…

# Ring Counter



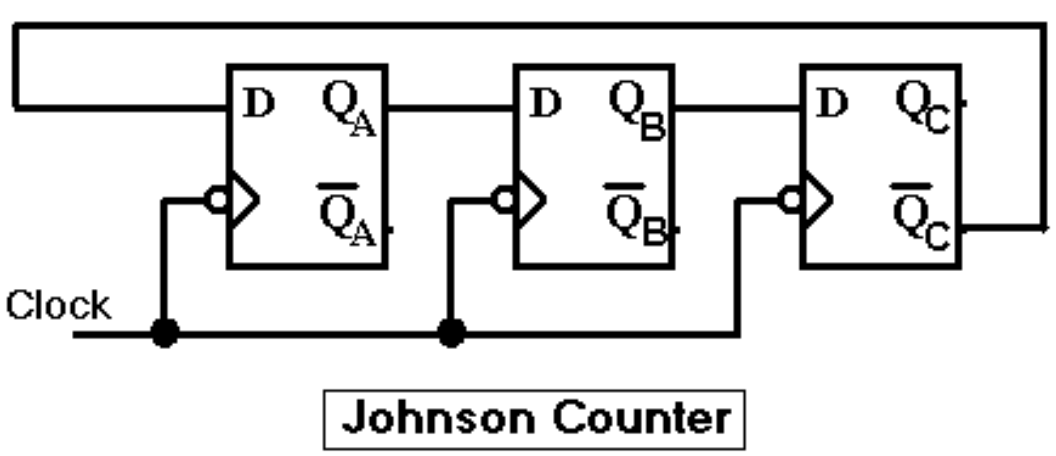

In Class: Build a ring counter using electronics simulation tools

# Self-Starting or Load on Power-up

- There are several ways of loading values into a ring counter on power-up:
  - RC circuit
  - Logic detection (similar to truncating a counter)

# Johnson Counter

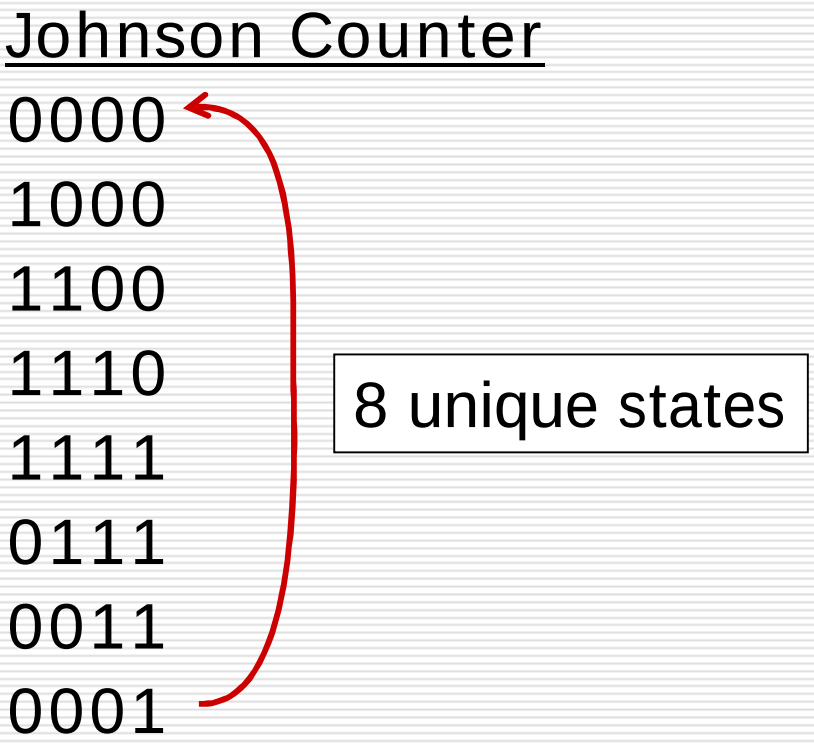
- A Johnson Counter re-circulates the last flip-flop Q (inverted) output back to the input of the first Flip-Flop. It doesn't require an initialization value, and will provide a predictable output state sequence.




Johnson Counter

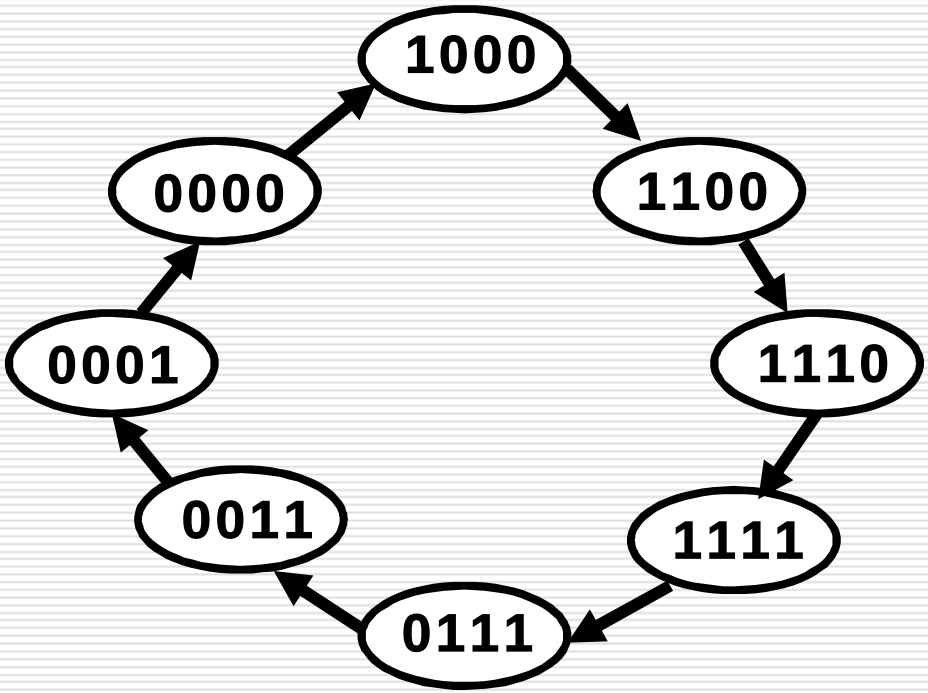
# Re-Circulating Counters

A **4-bit** Johnson counter has a **modulus** of **8**, meaning there are 8 unique output states.



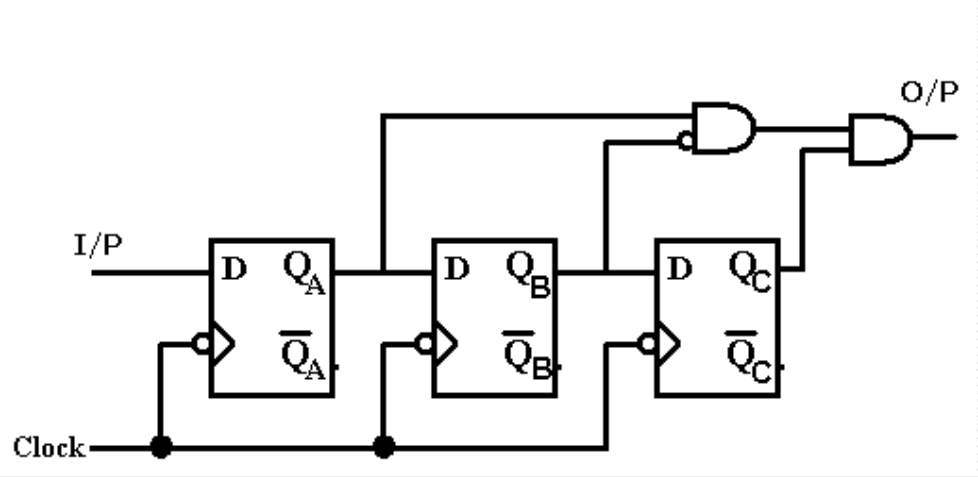
# State Diagram

- A State Diagram is used to describe the sequence of output states of a circuit.
- The state diagram for the previous Johnson counter looks like this:



# State Recognition

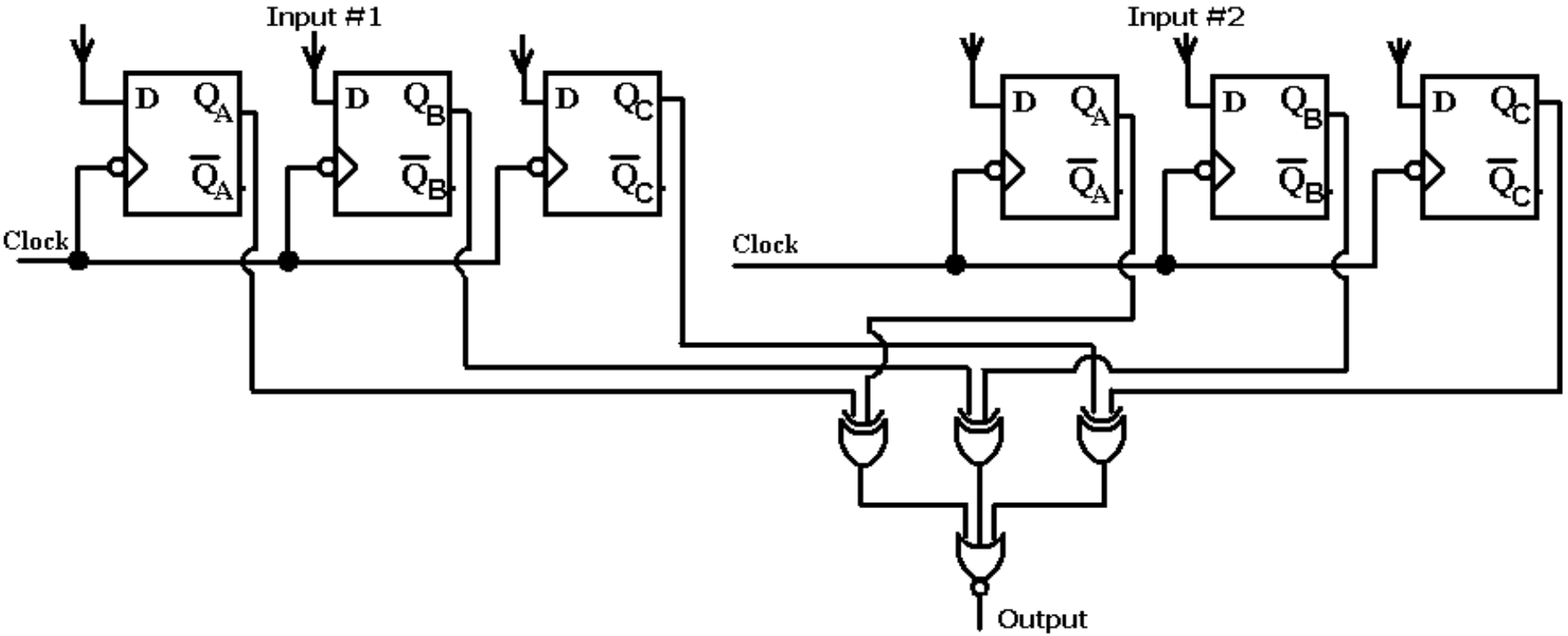
- One application of registers is to recognize a specific binary number. Sequences of bits are loaded in series into a register. External detection gates will identify if the value matches a predetermined value:




What value will this circuit detect?
Will this work with a Johnson counter?

# Comparison of two values

- Values stored in shift registers can be compared by using the following circuit :




What is the output be if both binary inputs are the same?