Counter and Registers

- Counters
  - Asynchronous Counters
  - Synchronous Counters
  - Design of Synchronous Counters
  - 74163 devices
- Registers
  - Shift Registers
    - SISO, SIPO, PISO, PIPO
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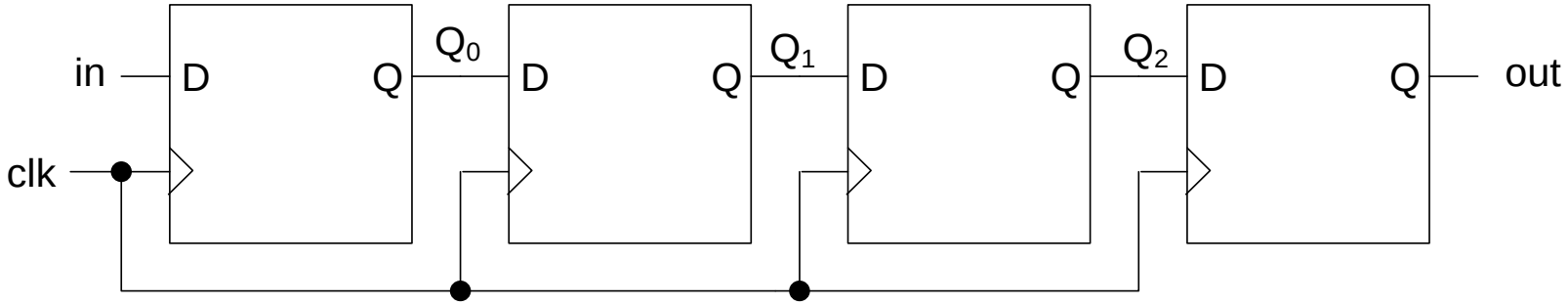
  - 74164, 74165, 74194, and 74195 devices

Shift Registers

- Shift registers are used primarily for storage and data movement
- There are four types of shift registers
  - Serial In Serial Out (SISO)
  - Serial In Parallel Out (SIPO)
  - Parallel In Serial Out (PISO)
  - Parallel In Parallel Out (PIPO)
- All the shift registers are arrays of flip-flops, arranged in certain ways

Serial In Serial Out (SISO)

- 4-bit SISO shift register
  - Each clock pulse will move an input bit to the next flip-flop



when clk = ↑

Q_0 <= in,

Q_1 <= Q_0

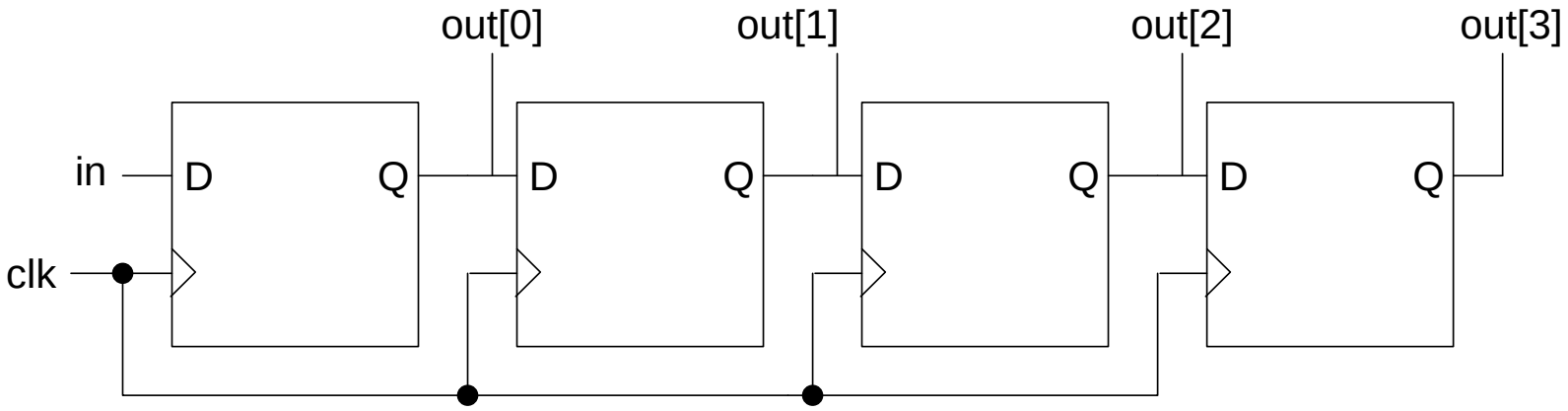
Q_2 <= Q_1

out <= Q_2

Input is 1-bit *in*, and output is 1-bit *out*

Serial In Parallel Out (SIPO)

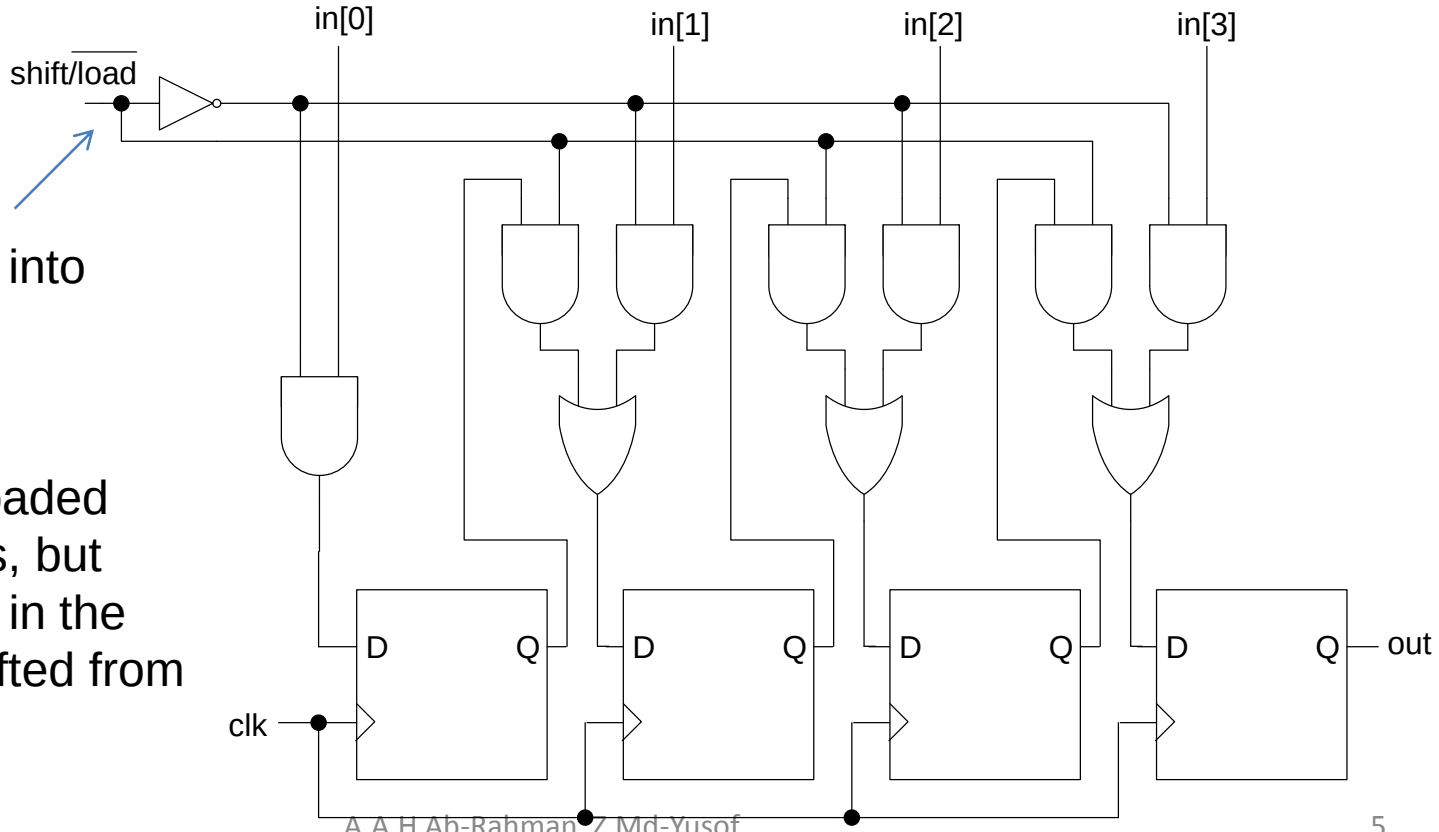
- 4-bit SIPO shift register
  - 1-bit input *in*, and 4-bit output *out[3:0]*



when clk = ↑
  out[0] <= in,
  out[1] <= out[0]
  out[2] <= out[1]
  out[3] <= out[2]

Parallel In Serial Out (PISO)

- 4-bit PISO shift register
  - 4-bit input *in[3:0]* and 1-bit output *out* with *shift/load* functions

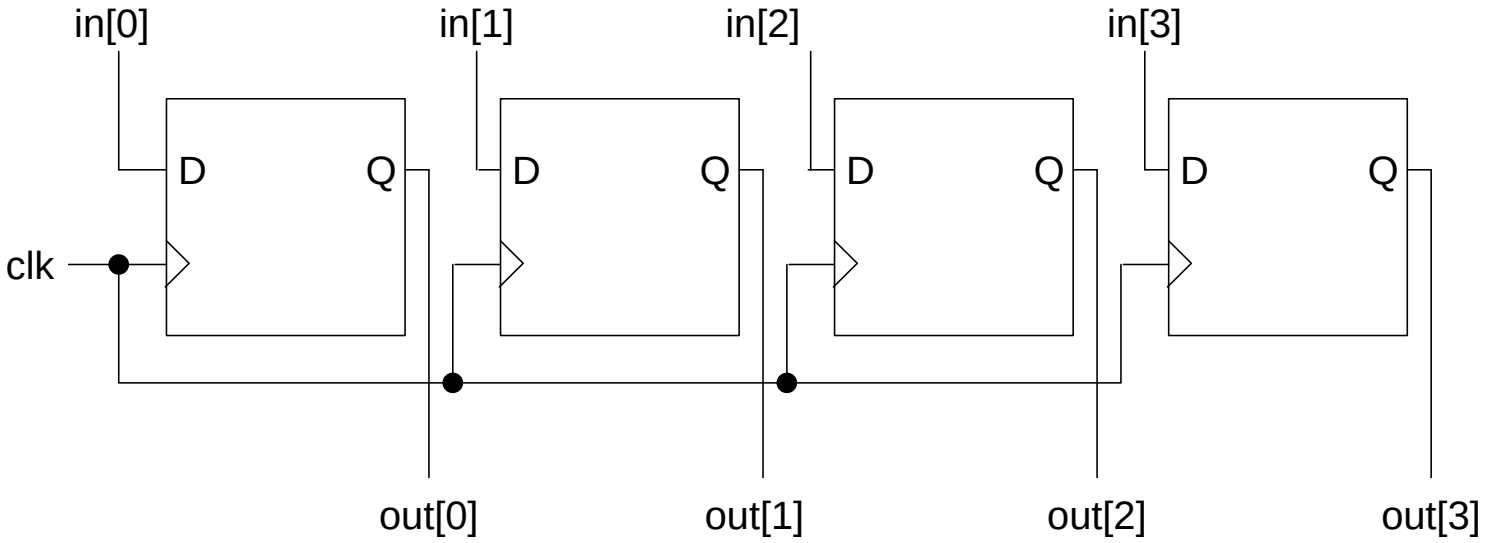


If *shift/load* = 0, *in[3:0]* is loaded into the flip-flops

If *shift/load* = 1, *in[3:0]* is NOT loaded into the flip-flops, but the current data in the flip-flops are shifted from left to right

Parallel In Parallel Out (PIPO)

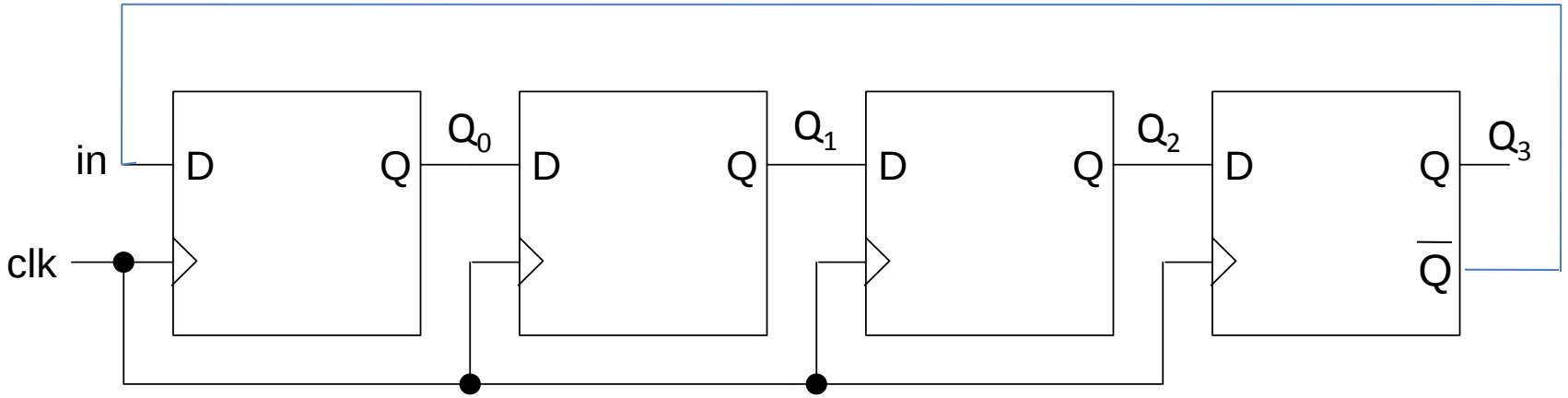
- 4-bit PIPO shift register
  - 4-bit input *in[3:0]* and 4-bit output *out[3:0]*



when clk = ↑
out[3:0] <= in[3:0]

Johnson Counter

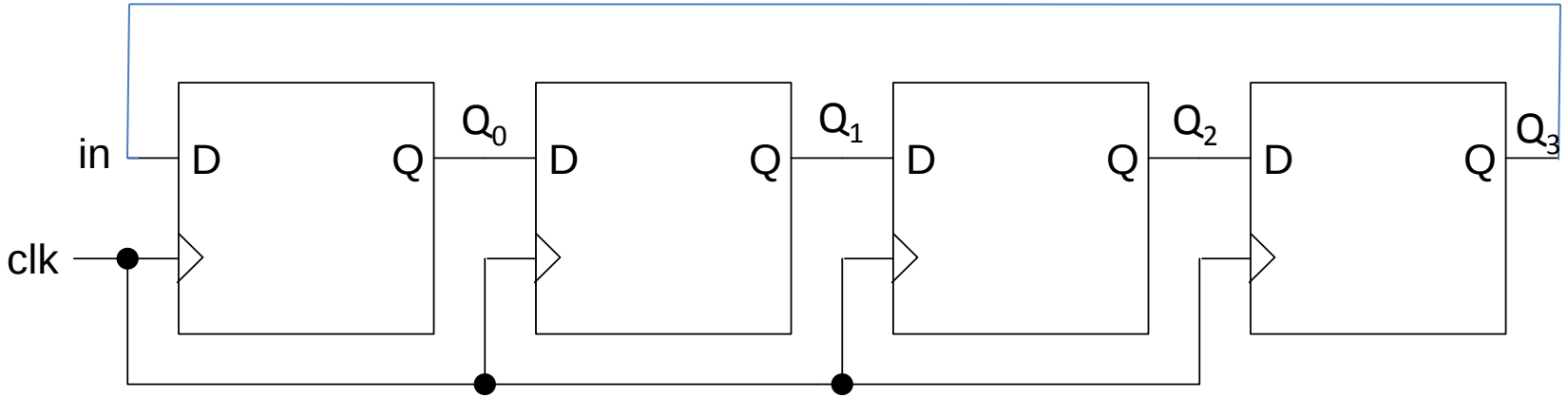
- Recall the SISO shift register
  - By connecting the complementary output of final stage to the input of the SISO shift register, we get the Johnson counter



Assume initially $Q_0 = 0$, $Q_1 = 0$ and $Q_2 = 0$, and $Q_3 = 0$
Determine the values of Q_0, Q_1, Q_2, and Q_3 after 8 clock cycles

Ring Counter

- Again from the SISO shift register,
  - By connecting the output of final stage to the input of the SISO shift register, we get the Ring counter



Assume initially $Q_0 = 0$, $Q_1 = 0$ and $Q_2 = 0$, and $Q_3 = 0$
At first clock we set in = 1
Determine the values of Q_0, Q_1, Q_2, and Q_3 after 8 clock cycles

Shift Register IC

- Some of the IC's available for shift registers include
  - 74164 – 8-bit SISO shift register
  - 74165 – 8-bit PISO shift register
  - 74194 – 4-bit PIPO shift register
  - 74195 – 4-bit Universal shift register (can be used for SISO, SIPO, and PIPO operations)
  - Refer to datasheet for details