

# Alternative Sequential Logic Design

- Large regular structures can be designed using alternative methods to avoid large state diagrams and K-maps
  - Good candidates are:
    - Registers
    - Counters
- Basic approach:
  - Design a single bit of an  $N$ -bit structure
    - Consider only inputs/outputs for that bit
  - Replicate design  $N$  times to create  $N$ -bit structure

# Register Examples

- Recall registers

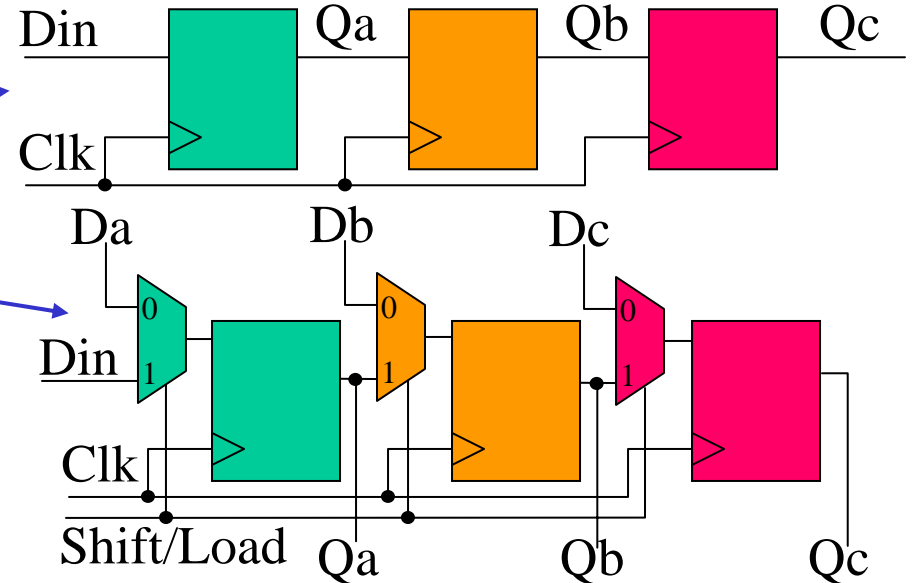
- Serial shift register

- Also serial-to-parallel

- Universal shift register

- Serial-to-parallel
    - Parallel-to-serial

- Parallel load register



*Note that each bit of register is identical*

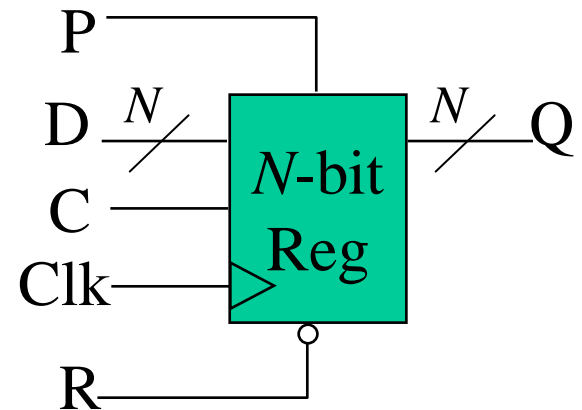
# Design Example

- Assume an rising-edge triggered  $N$ -bit register with following functions and order of precedence:

- Synchronous active low reset (R)
- Synchronous active high preset (P)
- Active high clock enable (C)

- This assumes parallel load of data per register bit ( $D_i$ )

- Common control signals = R, P, and CE
  - And Clock (of course)
- Individual signals =  $D_i$  and  $Q_i$



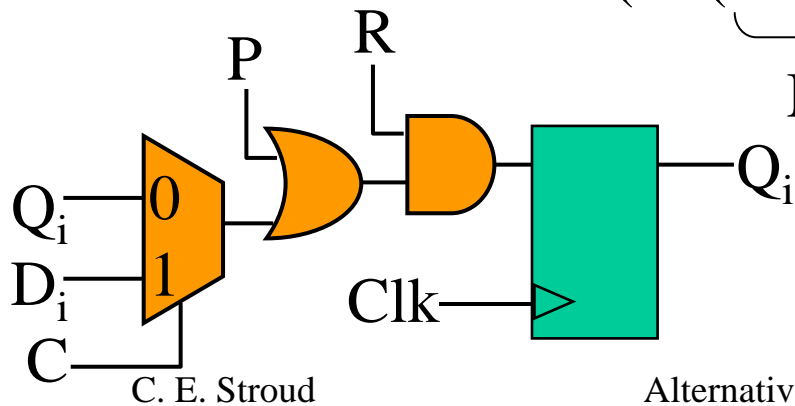
# Design Example

- Begin with function table
- Populate K-map
  - Obtain minimized SOP
  - Use BA T&P if desirable
- Draw logic diagram for  $i^{\text{th}}$  bit
- Replicate design  $N$  times

R P C	$Q_i^+$
0 X X	0
1 1 X	1
1 0 0	$Q_i$
1 0 1	$D_i$

$$\begin{aligned}
 Q_i^+ &= RP + RC'Q_i + RCD_i \\
 &= R(P + C'Q_i + CD_i) \\
 &= R(P + \underbrace{(C'Q_i + CD_i)}_{\text{MUX}})
 \end{aligned}$$

RP \ C	00	01	11	10
0	0	0	1	$Q_i$
1	0	0	1	$D_i$



MUX

*Note: we can obtain same design working out from FF input by order of precedence:  
 Active low Reset implies AND  
 Active high Preset implies OR  
 Clock enable implies MUX*

# Accumulator Register Example

- Accumulator in PSIM

- Functions controlled by combinational logic design

- Including holding data when no operations are specified

- ✓ Via feedback of  $AC_i$

- Only need a flip-flop at output of MUX

- AC register (8-bits)
    - C register (1-bit)

- ✓ Similar to  $AC_i$  design shown here

