电子技术
Introduction to Electronics

By Bao Qilian
鲍其莲

Chapter 9 Shift Registers

Objectives

- Registers
- Shift Registers
- Shift Register Counters
- Applications

Reading assignments

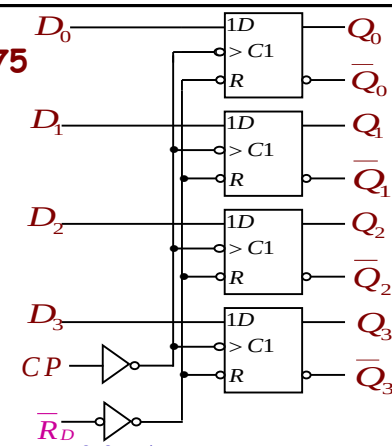
- P481~P508

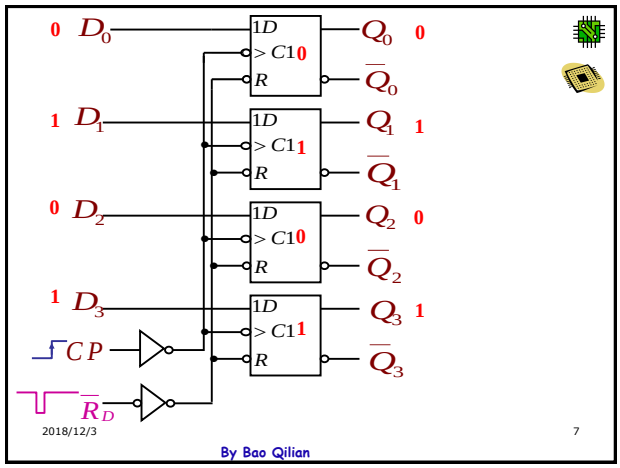
9.1 Register

- *A register* is a memory device that can be used to *store* more than one bit of information.
- A register is usually realized as several flip-flops with common control signals that control the movement of data to and from the register.

- A register is a generalization of a flip-flop. Where a flip-flop stores one bit, a register stores several bits
- The main operations on a register are the same as for any storage devices, namely
  - *Load* or *Store*: Put new data into the register
  - Read: Retrieve the data stored in the register (usually without changing the stored data)

- Control Signals
  - When they are asserted, they initiate an action in the register
  - *Asynchronous Control Signals* cause the action to take place immediately
  - *Synchronous Control Signals* must be asserted during a clock assertion to have an effect





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Shift Registers

- *A shift register* has two basic functions:
  - Data storage
  - Data movement

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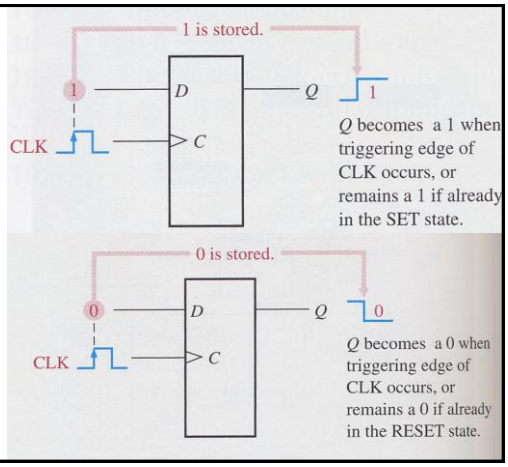
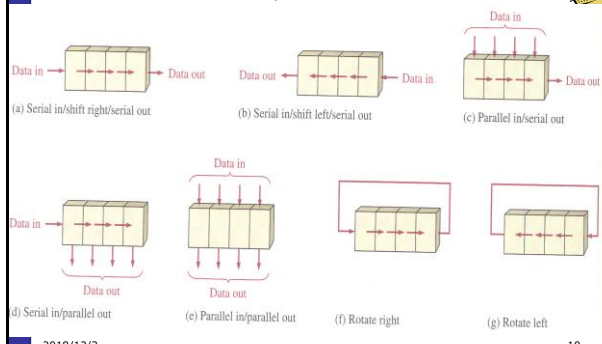
Data Storage



Data Movement



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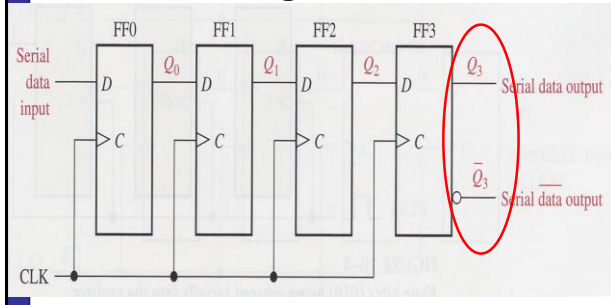
1 Serial in/Serial out Shift Register



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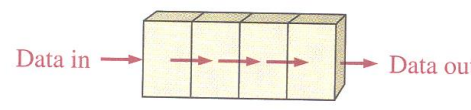

	1	0	0	0	0
CLK1		1	0	0	0
CLK2			1	0	0
CLK3				1	0
CLK4					1

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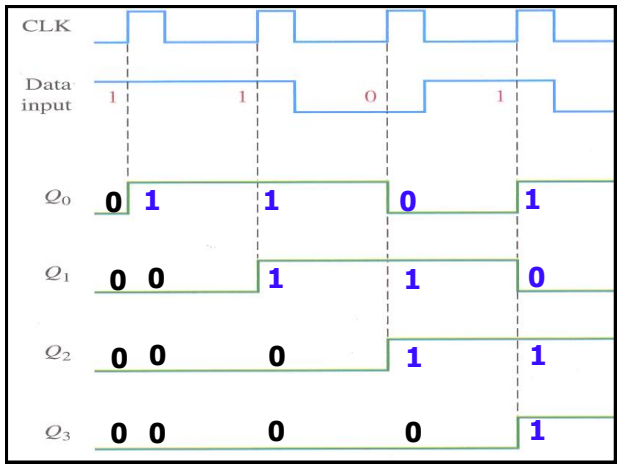
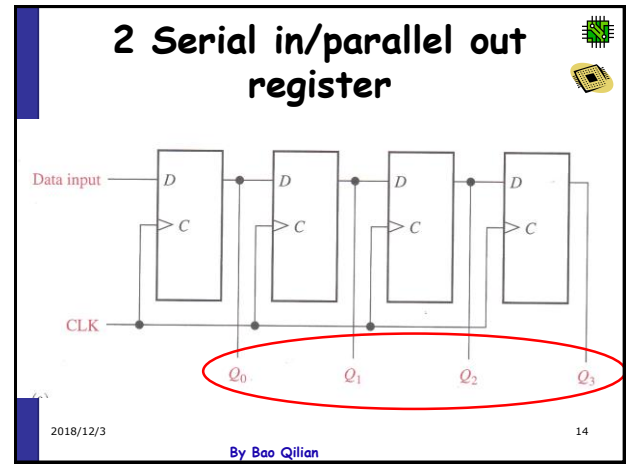

CLK
Data input
1
1
0
1
Q_0
Q_1
Q_2
Q_3


2 Serial in/parallel out register
Data input
D
C
CLK
Q_0
Q_1
Q_2
Q_3
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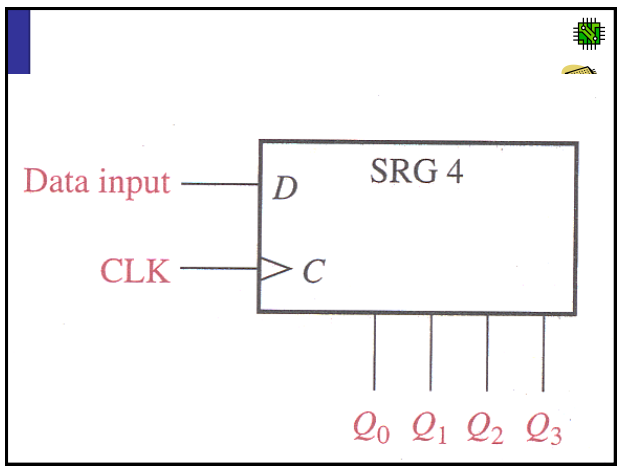
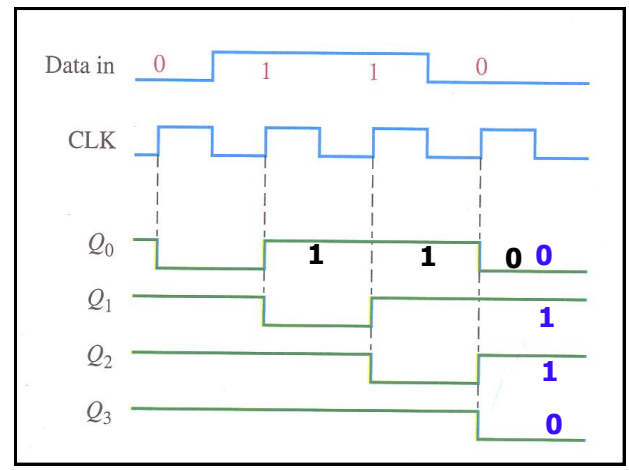
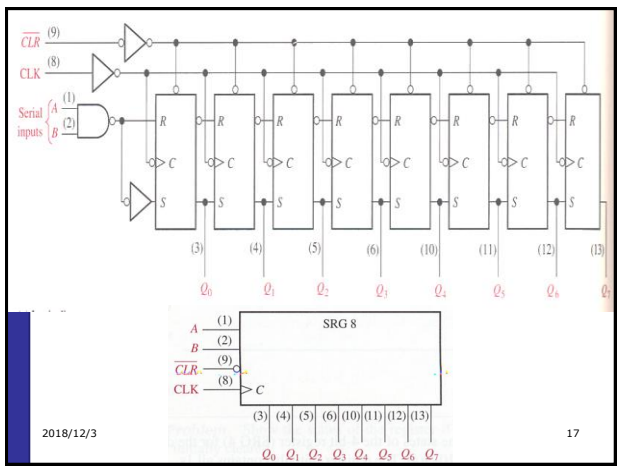

Data input
CLK
D
C
SRG 4
Q_0 Q_1 Q_2 Q_3


Data in
0
1
1
0
CLK
Q_0
Q_1
Q_2
Q_3

74HC164


CLR
CLK
Serial inputs
SRG 8
2018/12/3
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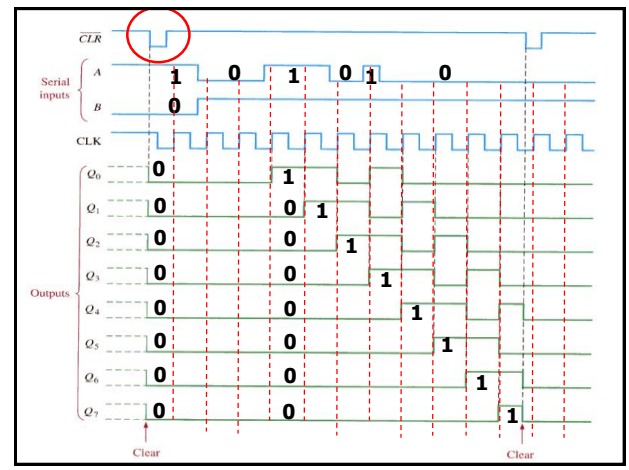
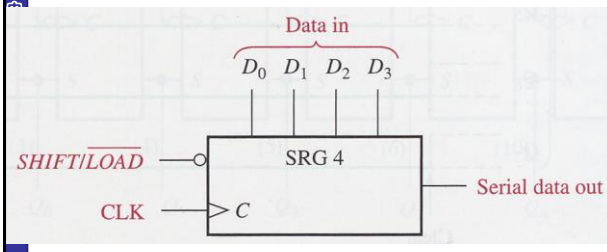

CLR
Serial inputs
CLK
Outputs
Clear
Clear

3 Parallel in/Serial out Register



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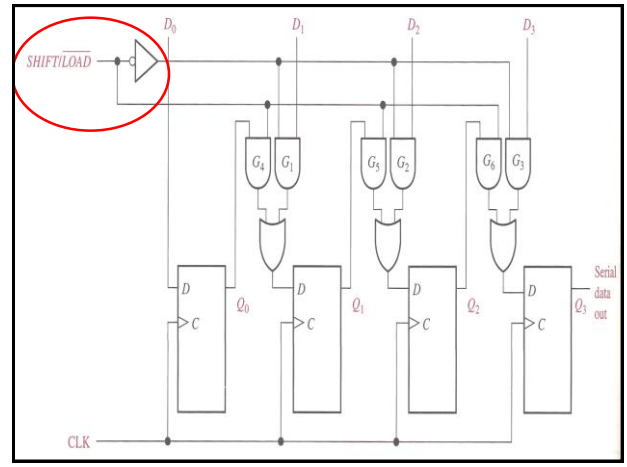
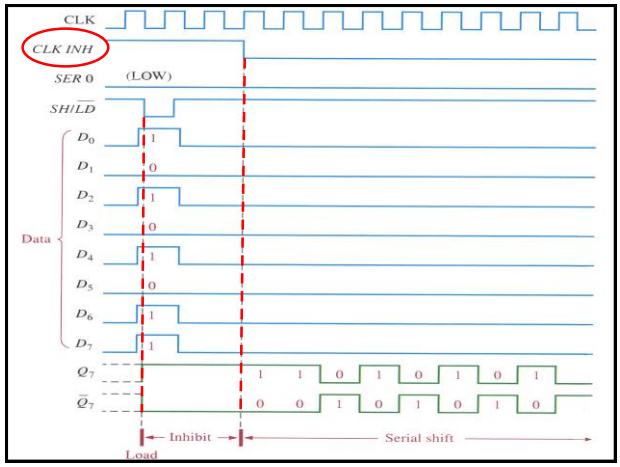
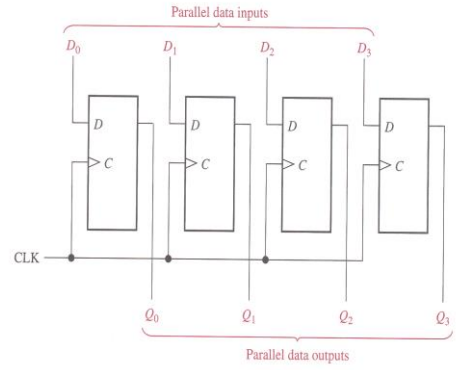
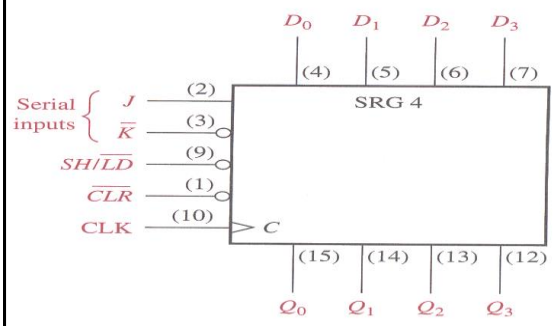




4 Parallel in/Parallel out register



4 Parallel in/Parallel out register



74HC195: Function Table

- This device is obsolete.

INPUTS									OUTPUTS				
$\overline{CLEAR}$	SHIFT/$\overline{LOAD}$	CLOCK	SERIAL		PARALLEL				Q_A	Q_B	Q_C	Q_D	$\overline{Q}_D$
			J	$\overline{K}$	A	B	C	D					
L	X	X	X	X	X	X	X	X	L	L	L	L	H
H	L	↑	X	X	a	b	c	d	a	b	c	d	$\overline{d}$
H	H	L	X	X	X	X	X	X	Q_A	Q_B	Q_C	Q_D	$\overline{Q}_D$
H	H	↑	L	H	X	X	X	X	Q_A	Q_A	Q_B	Q_C	$\overline{Q}_C$
H	H	↑	L	L	X	X	X	X	L	Q_A	Q_B	Q_C	$\overline{Q}_C$
H	H	↑	H	H	X	X	X	X	H	Q_A	Q_B	Q_C	$\overline{Q}_C$
H	H	↑	H	L	X	X	X	X	$\overline{Q}_A$	Q_A	Q_B	Q_C	$\overline{Q}_C$

$J = L, \overline{K} = L$
$J = H, \overline{K} = H$
$\Big\} J = \overline{K} = D \Rightarrow$ D-type flip-flop

$J = L, \overline{K} = H$
$J = H, \overline{K} = L$
$\Big\} J = K = T \Rightarrow$ T-type flip-flop: T= L, no change; T= H, toggle.

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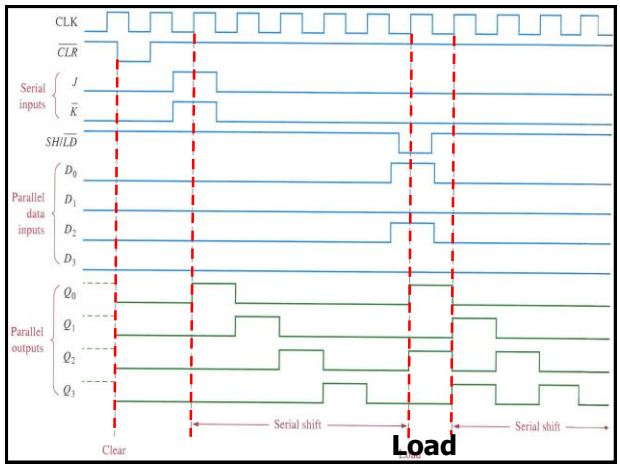
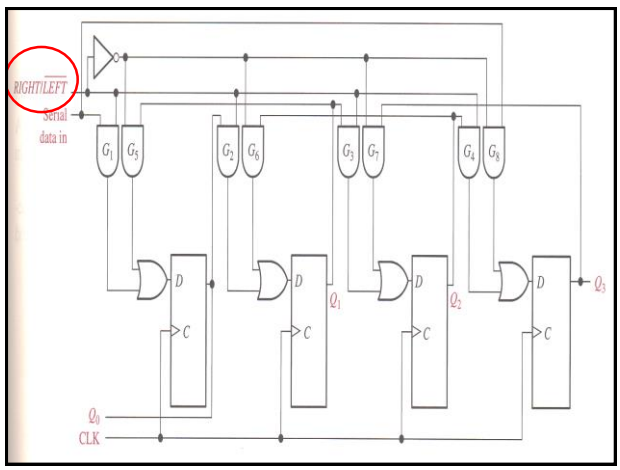
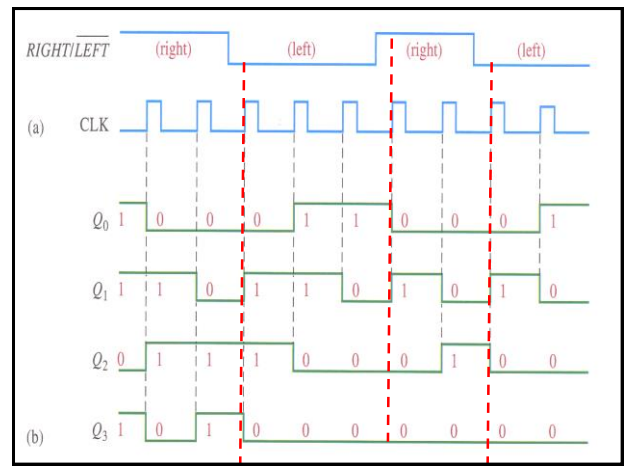
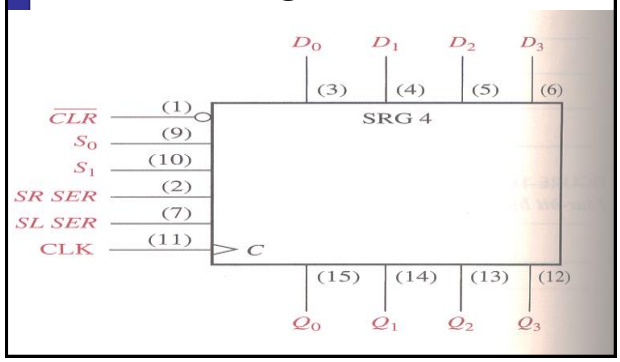


5 Bi-directional Register





74HC194: 4-bit Universal Register

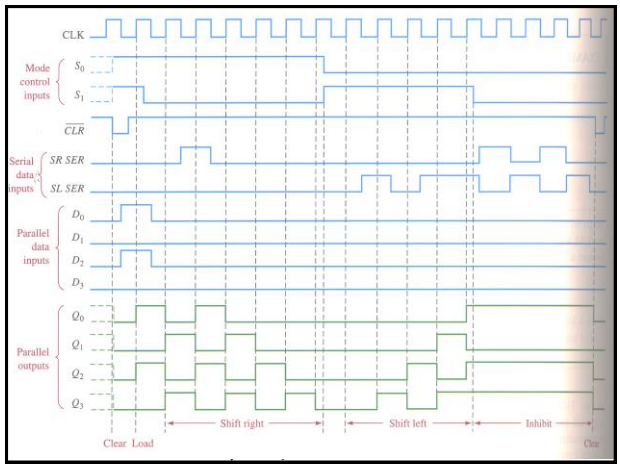


74HC194: Function Table

- S1 and S0 are mode control
- There are five possible operations
  - Clear
  - Parallel loading
  - Right shifting
  - Left shifting

S_1S_0	Function
00	inhabit
01	Shift right
10	Shift left
11	Load

CLR	S1	S0	CLK	SL SER	SR SER	D0	D1	D2	D3	Q0	Q1	Q2	Q3
L	X	X	X	X	X	X	X	X	X	L	L	L	L
H	X	X	L	X	X	X	X	X	X	Q0	Q1	Q2	Q3
H	H	H	↑	X	X	a	b	c	d	a	b	c	d
H	L	H	↑	X	r	X	X	X	X	r	Q0	Q1	Q2
H	H	L	↑	l	X	X	X	X	X	Q1	Q2	Q3	l
H	L	L	X	X	X	X	X	X	X	Q0	Q1	Q2	Q3



小结：移位寄存器

移位功能：

指寄存器里存储的代码能在移位脉冲的作用下依次左移或右移。

因此，移位寄存器不但可以用来寄存代码，还可以用来实现数据的串行-并行转换、数值的运算及数据处理等

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9.2 Shift Register Counter（移位寄存器型计数器）

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Shift Register Counter

- ***Johnson Counter***（扭环型计数器）：**the complement of the output of the last FF connected back to the first FF**
- ***Ring Counter***（环型计数器）：**the output of the last FF connected back to the first FF**

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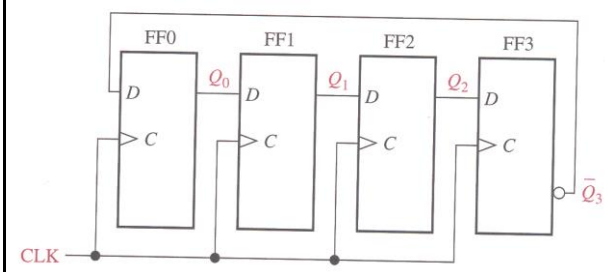
1 Johnson Counter



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Clock Pulse	Q_0	Q_1	Q_2	Q_3
0	0	0	0	0
1	1	0	0	0
2	1	1	0	0
3	1	1	1	0
4	1	1	1	1
5	0	1	1	1
6	0	0	1	1
7	0	0	0	1

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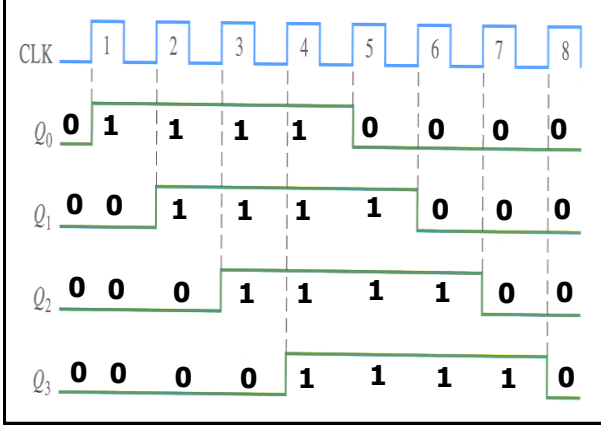

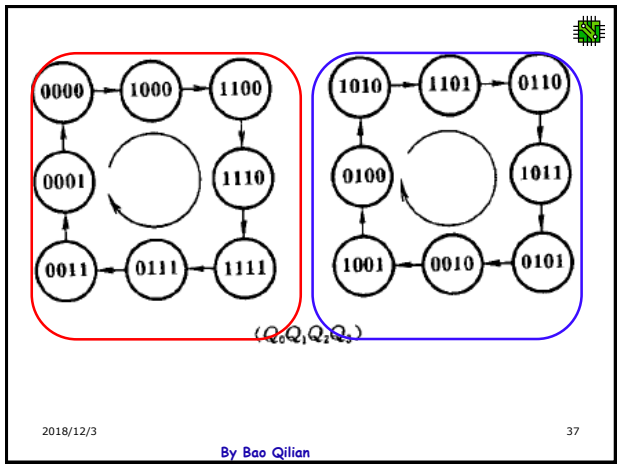

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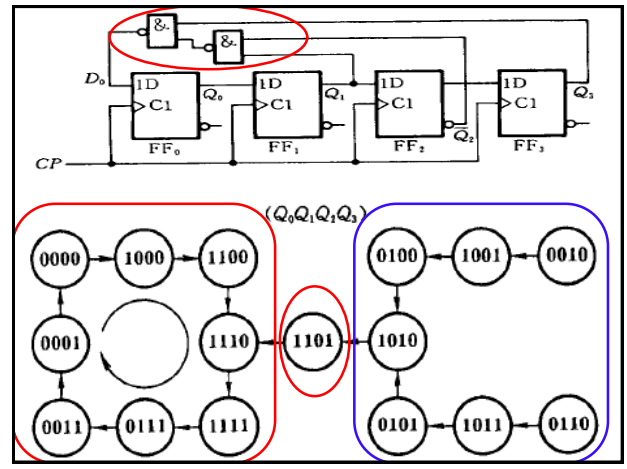
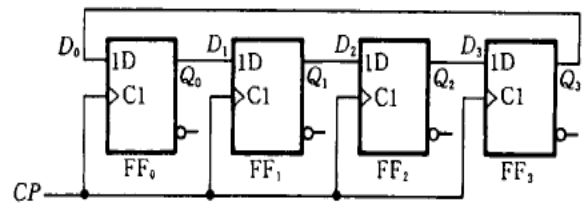


2 Ring Counter



1000 ⇨ 0100 ⇨ 0010 ⇨ 0001 ⇨ 1000

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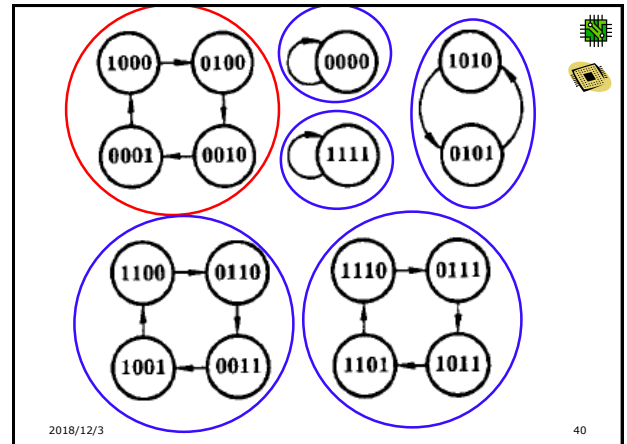

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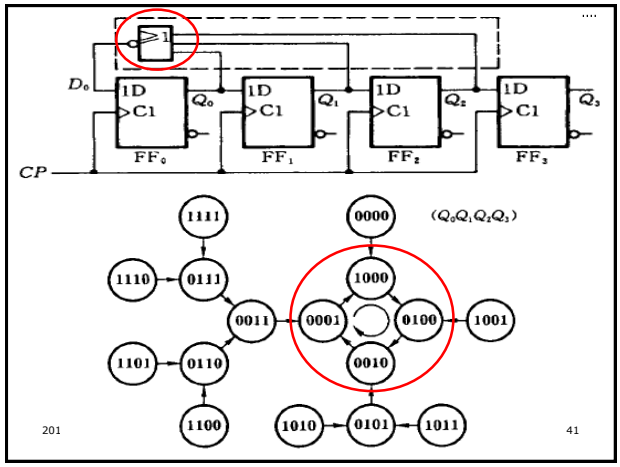
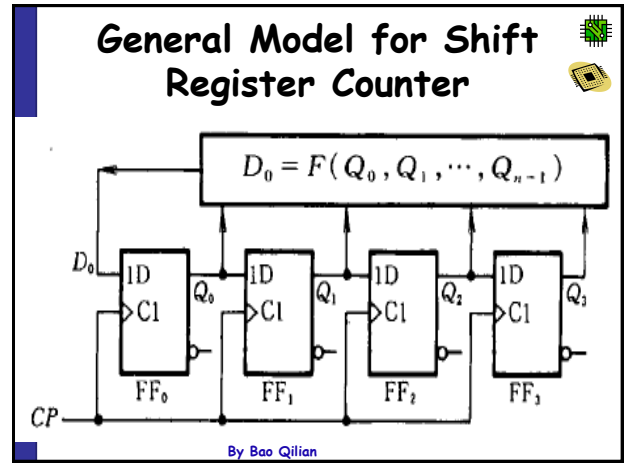


General Model for Shift Register Counter



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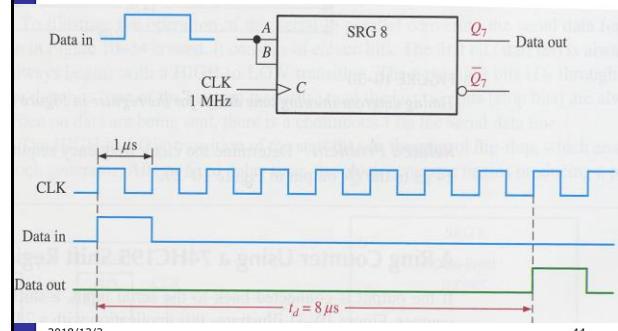
9.3 Applications of Shift Register Counters

Time Delay



For output Q_i:

Time delay=(i+1)×$Period_{CLK}$

e.g.Q_1:

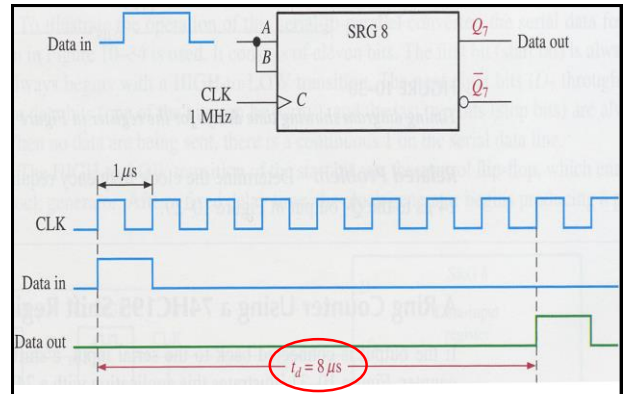
Time delay=(1+1)×$Period_{CLK}$

=2×$Period_{CLK}$

=2 ×1/1MHz

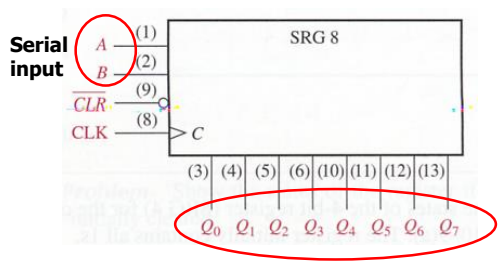
=2 ×1μs

=2 μs

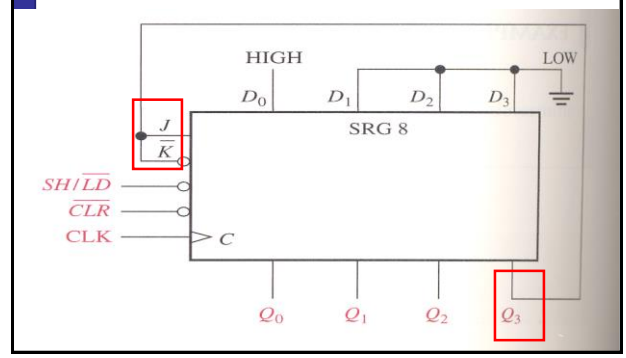


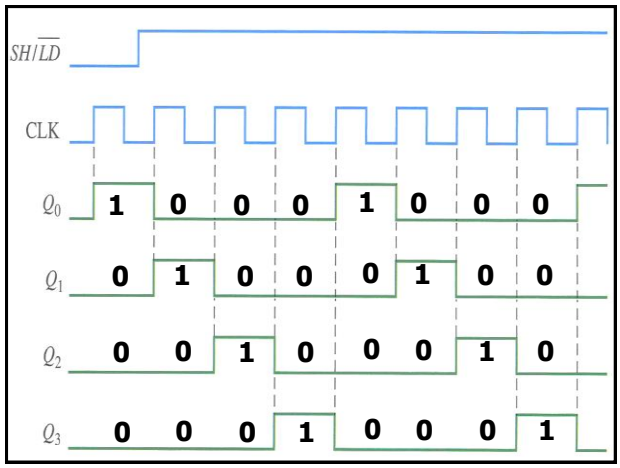
Time delay=8×$Period_{CLK}$ =8 μs

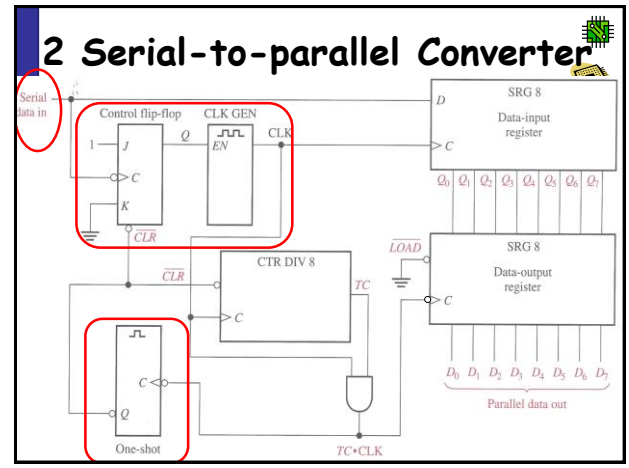
74HC164: 8-Bit serial in/parallel out shift register

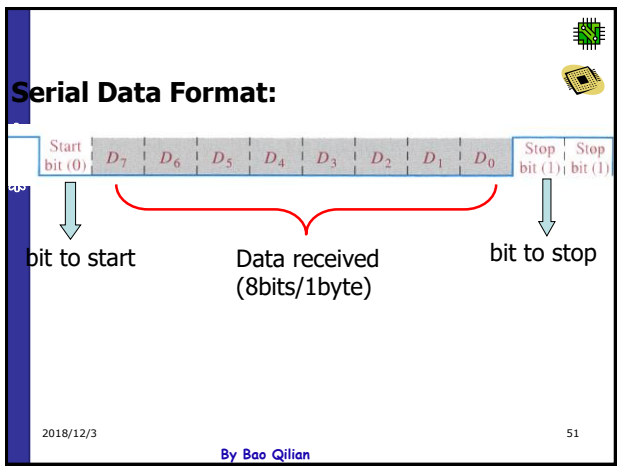


2 Ring Counter Using 74HC195 (4-bit shift register)




SH/LD
CLK
Q0 1 0 0 0 1 0 0 0
Q1 0 1 0 0 0 1 0 0
Q2 0 0 1 0 0 0 1 0
Q3 0 0 0 1 0 0 0 1


2 Serial-to-parallel Converter
Serial data in
Control flip-flop
CLK GEN
SRG 8
Data-input register
CTR DIV 8
SRG 8
Data-output register
One-shot
Parallel data out
TC•CLK


Serial Data Format:
Start bit (0)
Stop bit (1)
Stop bit (1)
bit to start
Data received (8bits/1byte)
bit to stop
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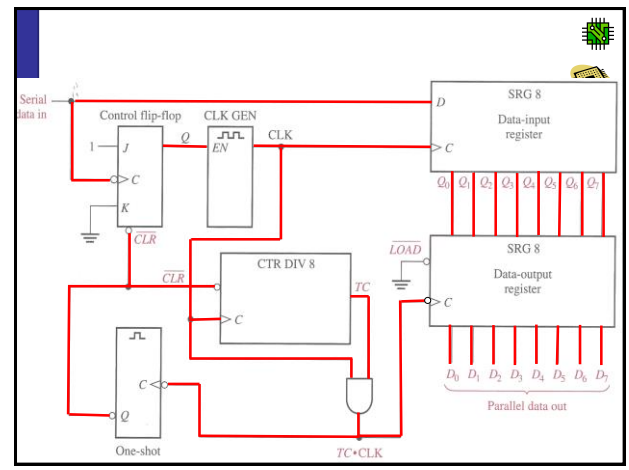
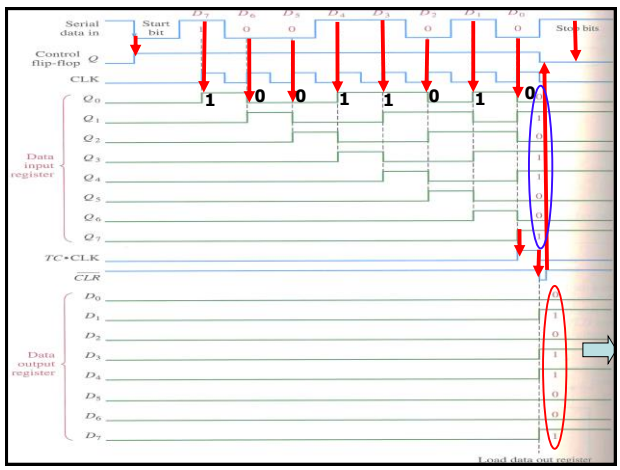
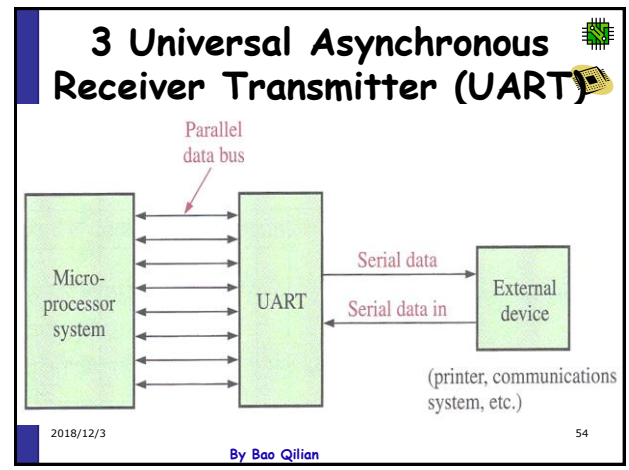

Serial data in
Control flip-flop
CLK GEN
SRG 8
Data-input register
CTR DIV 8
SRG 8
Data-output register
One-shot
Parallel data out
TC•CLK


Serial data in
Start bit
Stop bits
Control flip-flop
CLK
Data input register
Data output register
1 0 0 1 1 0 1 0


3 Universal Asynchronous Receiver Transmitter (UART)
Parallel data bus
Micro-processor system
UART
Serial data
Serial data in
External device
(printer, communications system, etc.)
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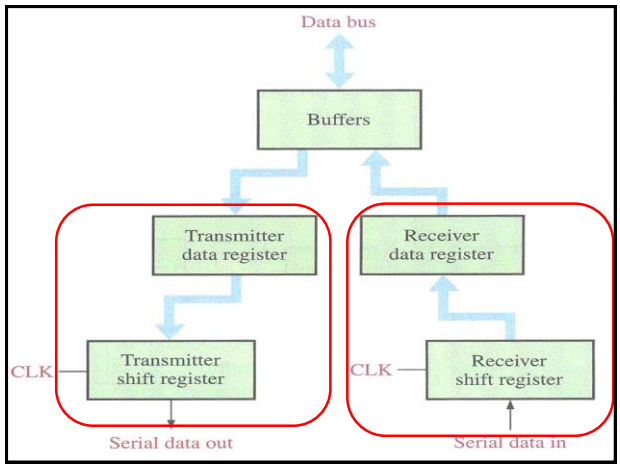
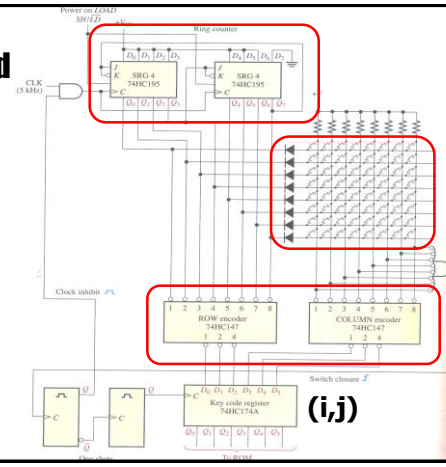
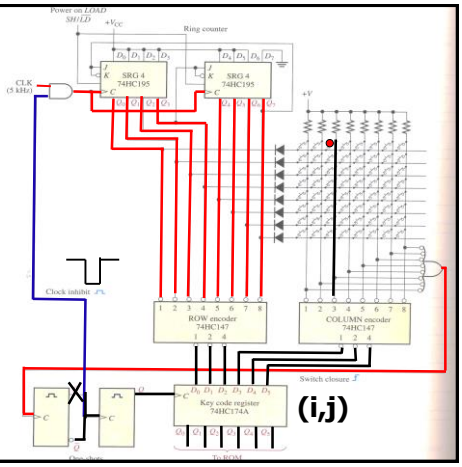


4 Keyboard Encoder



Data flow



Summary

- Registers: storage
- Shift Registers: storage+movement
  - Serial in/serial out
  - Serial in/parallel out
  - Parallel in/parallel out
  - Parallel in/serial out
  - Bidirectional shift register
- Shift Register Counters
  - Johnson shift register counter
  - Ring counter
- Applications

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