第四章　组合逻辑电路

4.1 概述

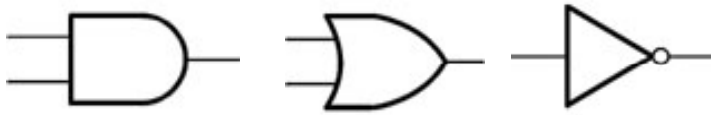
综合性组合逻辑电路
分析与设计

4.2 组合逻辑电路的
分析和设计方法

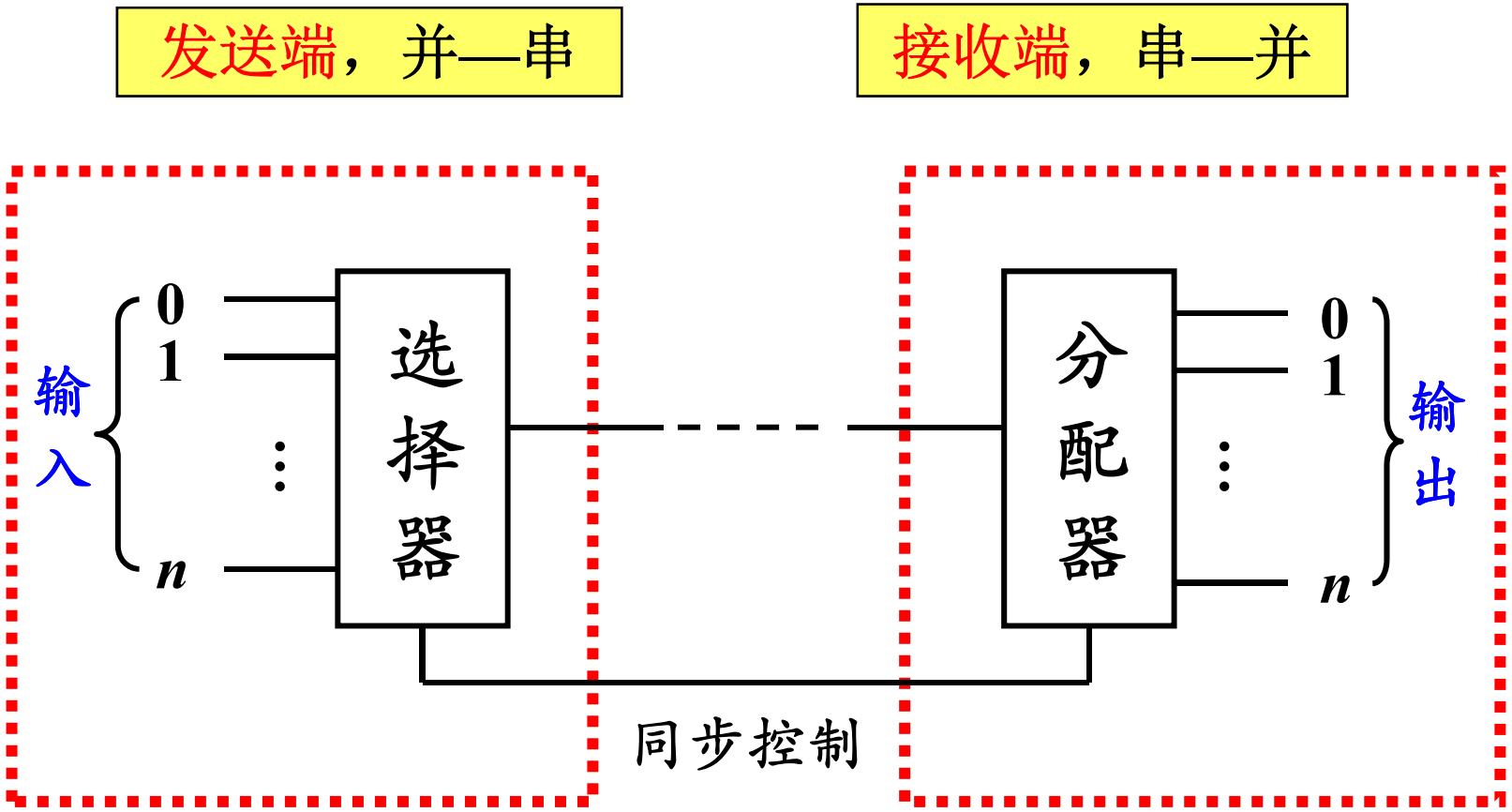
编码器，译码器，
比较器，选通器，
加法器

4.3 若干常用的组合逻辑电路

4.4 组合电路中的竞争与冒险



与门，　或门，　非门



串行传输数据示意图

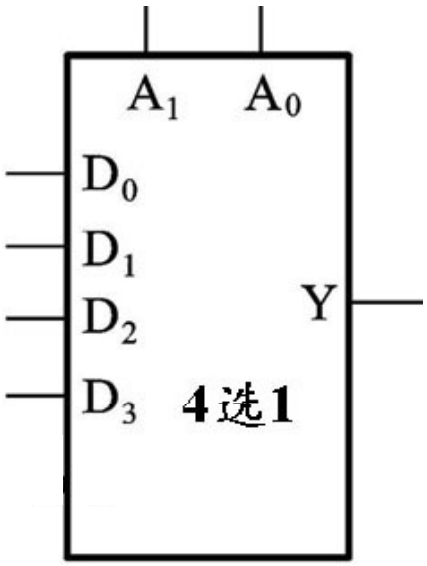
4.3.5 数据选通器

数据选择器类型

- 2选1 (1位地址)
- 4选1 (2位地址) ---74HC153，双4选1
- 8选1 (3位地址) ---74HC151，8选1
- 16选1 (4位地址) ---74HC150，16选1

2位地址选4个数

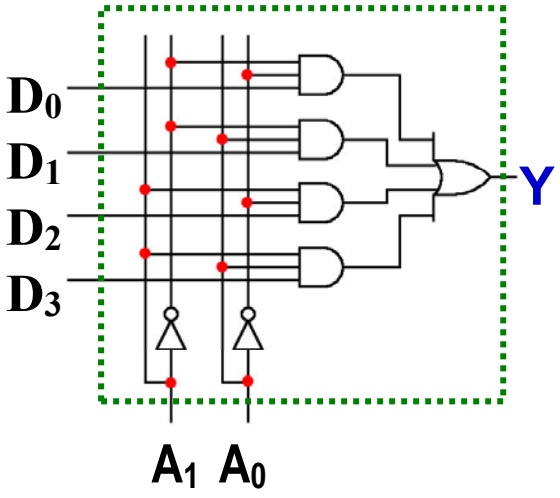
例1 设计4-1 MUX，功能要求如下表，写出最简逻辑函数及画电路图



功能要求

A_1A_0	Y
0 0	D_0
0 1	D_1
1 0	D_2
1 1	D_3

3) 电路图



1) 真值表

$A_1A_0D_3D_2D_1D_0$	Y
0 0 0 0 0 0	0
0 0 0 0 0 1	1
⋮	
0 0 1 1 1 1	1
0 1 0 0 0 0	0
0 1 0 0 0 1	0
⋮	
0 1 1 1 1 1	1
1 0 0 0 0 0	0
1 0 0 0 0 1	0
⋮	
1 0 1 1 1 1	1
1 1 0 0 0 0	0
1 1 0 0 0 1	0
⋮	
1 1 1 1 1 1	1

2) 根据真值表画 K 图及化简函数，或直接观察功能表写逻辑式

$$Y = (A_1'A_0')D_0 + (A_1'A_0)D_1 + (A_1A_0')D_2 + (A_1A_0)D_3$$

A_1A_0: 0 0 ; 0 1 ; 1 0 ; 1 1

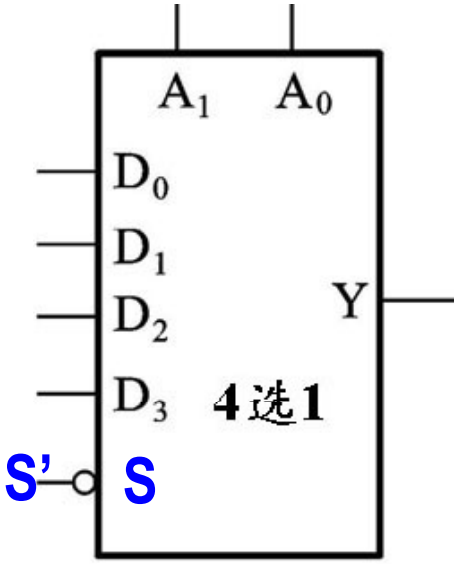
当$A_1A_0 = 00$时, $Y = (0'0')D_0 + (0'0)D_1 + (00')D_2 + (00)D_3 = D_0$

当$A_1A_0 = 01$时, $Y = (0'1')D_0 + (0'1)D_1 + (01')D_2 + (01)D_3 = D_1$

当$A_1A_0 = 10$时, $Y = (1'0')D_0 + (1'0)D_1 + (10')D_2 + (10)D_3 = D_2$

当$A_1A_0 = 11$时, $Y = (1'1')D_0 + (1'1)D_1 + (11')D_2 + (11)D_3 = D_3$

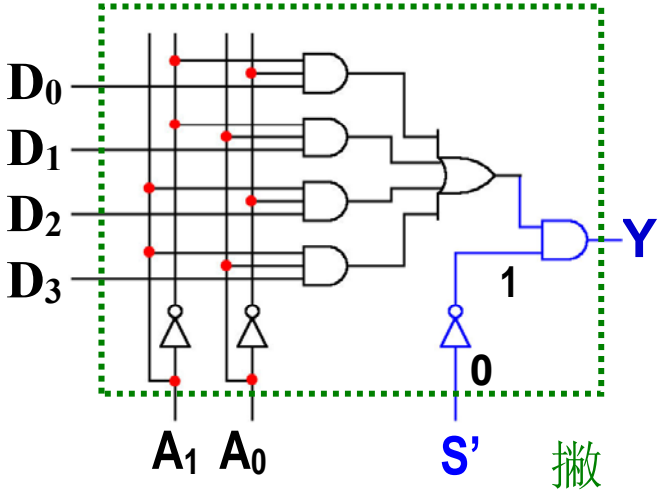
4) 增加“片选”控制端Select),



功能

S' A1A0	Y
0 0 0	D0
0 0 1	D1
0 1 0	D2
0 1 1	D3
1 x x	0

6) 电路图,增加片选控制



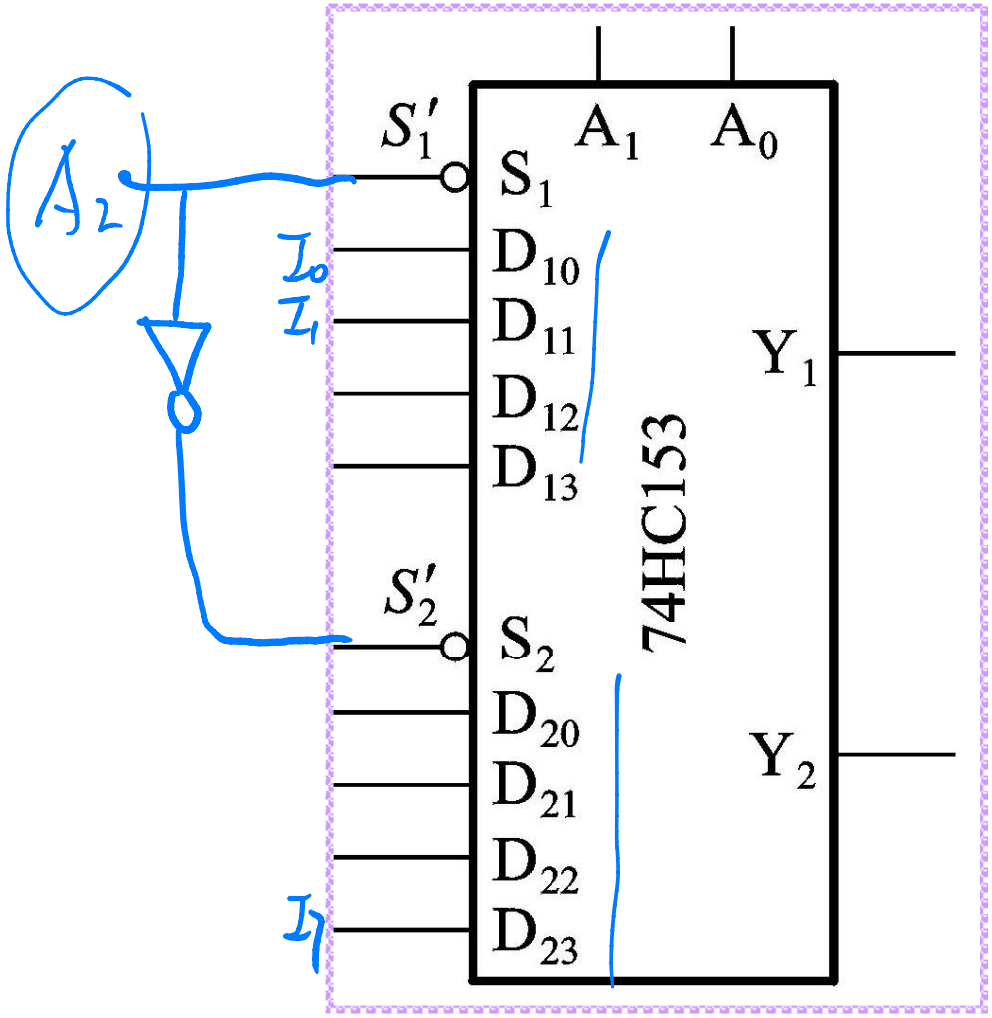
5) 修改逻辑函数，增加片选控制信号S’

$$Y = (S')'\,((A_1'A_0')D_0 + (A_1'A_0)D_1 + (A_1A_0')D_2 + (A_1A_0)D_3)$$

当S’有效时, 即S’= 0时, $Y = (A_1'A_0')D_0 + (A_1'A_0)D_1 + (A_1A_0')D_2 + (A_1A_0)D_3$

当S’无效时, 即S’= 1时, Y = 0

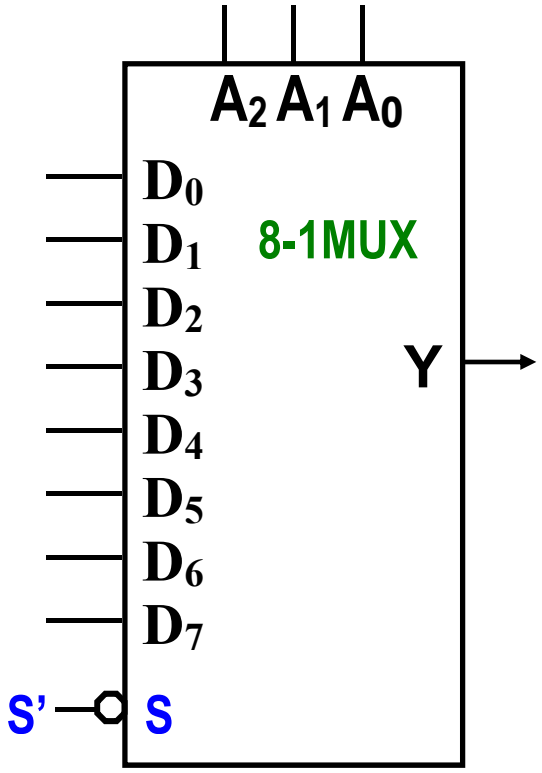
7) 实用芯片 74HC153,双4-1选通器(4-1MUX)



- 公共的地址输入端(A_1A_0)
- 独立的数据输入和输出端

A_2 A_1 A_0

练习1　设计8-1选通器(8-1MUX) 功能如下，写出Y的逻辑式。



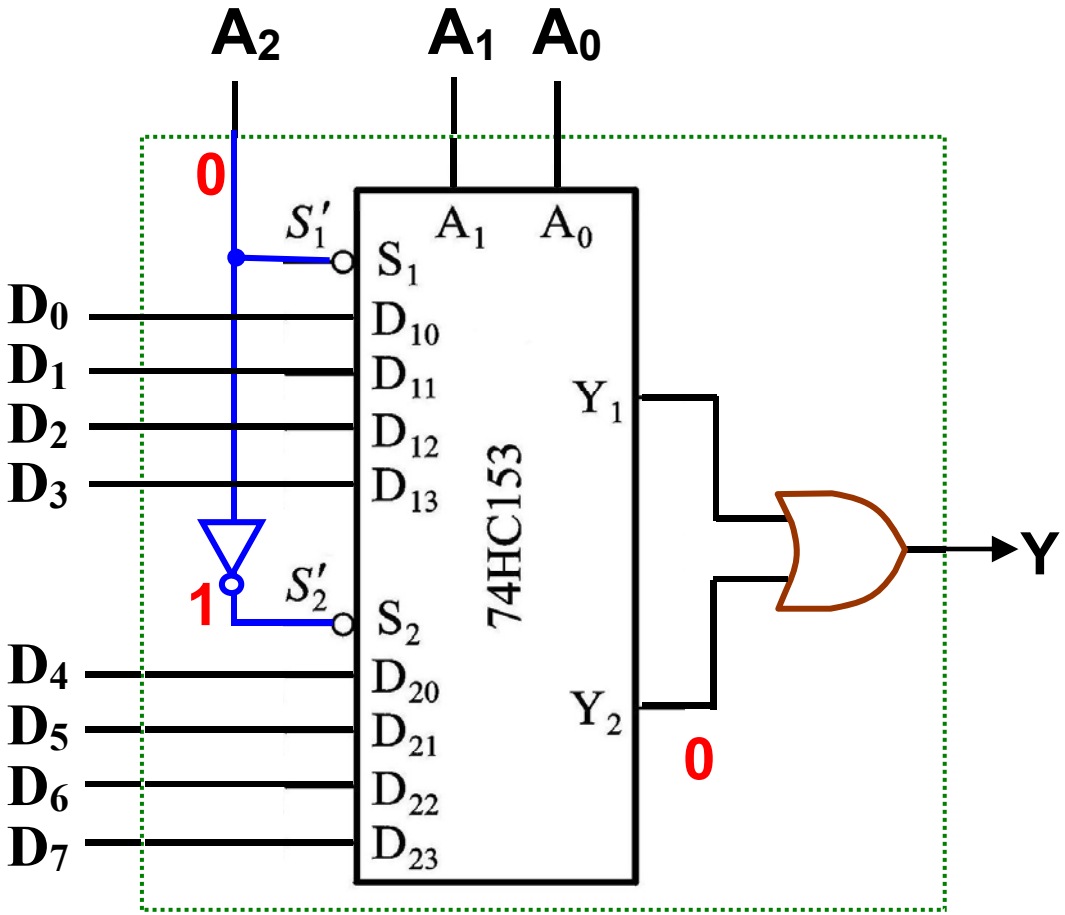
功能要求

S' $A_2A_1A_0$	Y
0 000	D_0
0 001	D_1
0 010	D_2
0 011	D_3
0 100	D_4
0 101	D_5
0 110	D_6
0 111	D_7
1 xxx	0

$$Y = (S')'\,(\underbrace{(A_2'A_1'A_0')D_0}_{000} + \underbrace{(A_2'A_1'A_0)D_1}_{001} + \underbrace{(A_2'A_1A_0')D_2}_{010} + \underbrace{(A_2'A_1A_0)D_3}_{011}$$

$$+ \underbrace{(A_2A_1'A_0')D_4}_{100} + \underbrace{(A_2A_1'A_0)D_5}_{101} + \underbrace{(A_2A_1A_0')D_6}_{110} + \underbrace{(A_2A_1A_0)D_7}_{111})$$

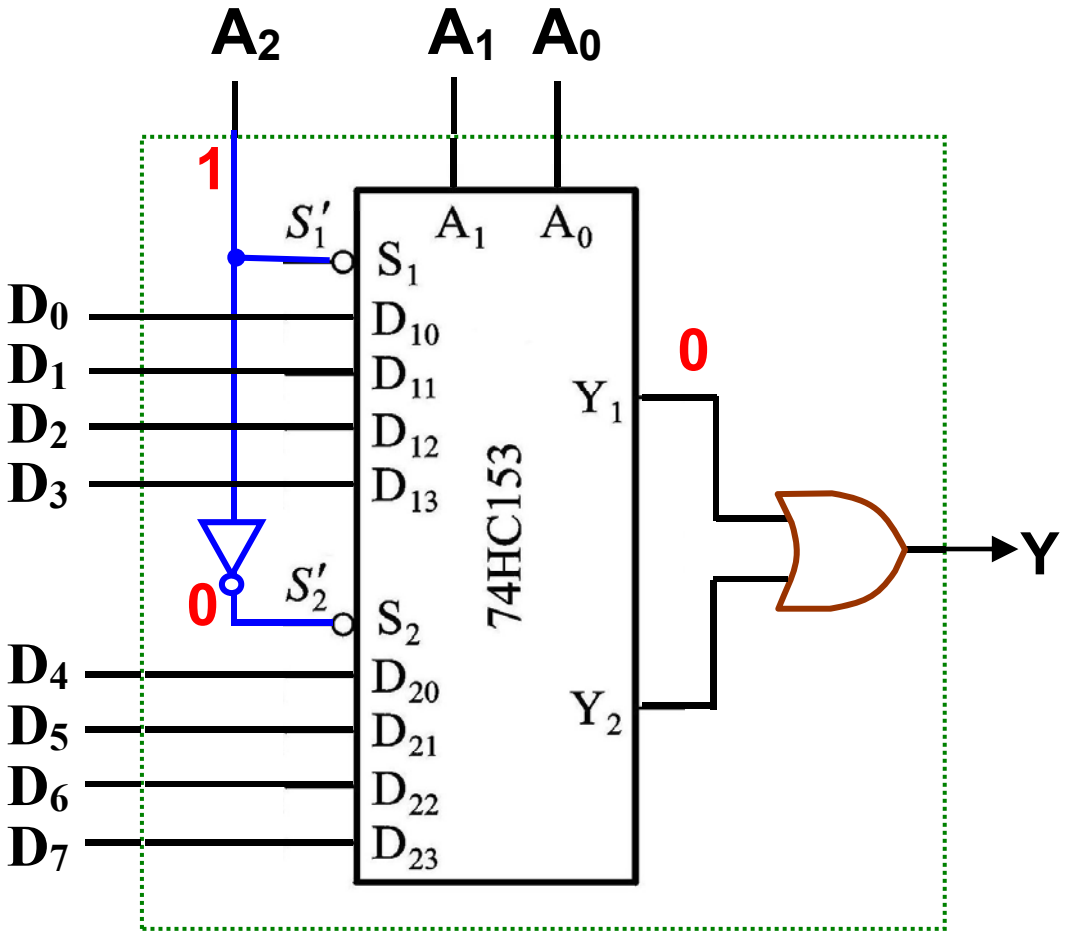
例2　用两个“4选1”接成一个“8选1”



8-1MUX 功能表

$A_2A_1A_0$	Y
0 0 0	D_0
0 0 1	D_1
0 1 0	D_2
0 1 1	D_3
1 0 0	D_4
1 0 1	D_5
1 1 0	D_6
1 1 1	D_7

例2　用两个“4选1”接成一个“8选1”



功能要求

$A_2A_1A_0$	Y
0 0 0	D_0
0 0 1	D_1
0 1 0	D_2
0 1 1	D_3
1 0 0	D_4
1 0 1	D_5
1 1 0	D_6
1 1 1	D_7

例3 用数据选择器实现逻辑函数，用8—1MUX实现Y(A,B,C),真值表已知

$$Y=(A_2'A_1'A_0')D_0+(A_2'A_1'A_0)D_1+(A_2'A_1A_0')D_2+(A_2'A_1A_0)D_3$$
$$+(A_2A_1'A_0')D_4+(A_2A_1'A_0)D_5+(A_2A_1A_0')D_6+(A_2A_1A_0)D_7$$
$$=m_0D_0+m_1D_1+m_2D_2+m_3D_3+m_4D_4+m_5D_5+m_6D_6+m_7D_7$$

$$Y=\sum_{i=0}^{2^k-1}m_iD_i \quad (k\text{位地址})$$

n个变量的逻辑函数可表示为：$Y=\sum_{i=0}^{2^n-1}m_ia_i$

设：k为数据选择器的地址输入端数，n为逻辑函数的变量数。

a）$n=k$

b）$n<k$

c）$n>k$

例3 用数据选择器实现逻辑函数，用8—1MUX实现Y(A,B,C),真值表已知

对比

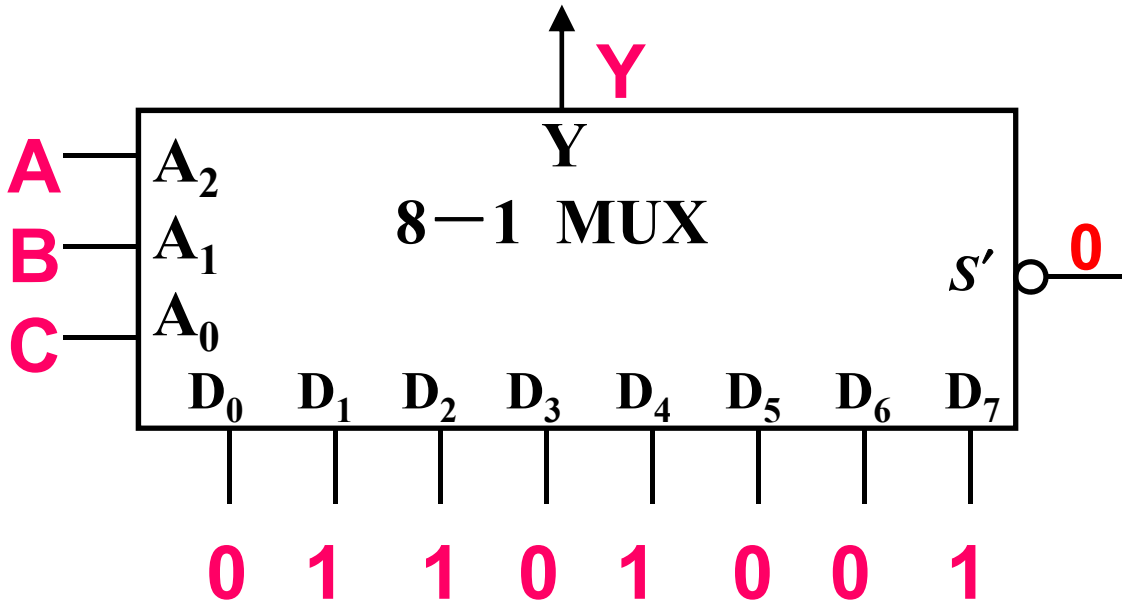
Y函数
真值表

ABC	Y
000	0
001	1
010	1
011	0
100	1
101	0
110	0
111	1

8-1MUX功能表

$A_2A_1A_0$	Y
000	D_0
001	D_1
010	D_2
011	D_3
100	D_4
101	D_5
110	D_6
111	D_7

1） 列8-1MUX功能表
2） 对比Y函数真值表和8-1MUX功能表
3） 连接对应输入输出信号
4） 给控制信号正确的值



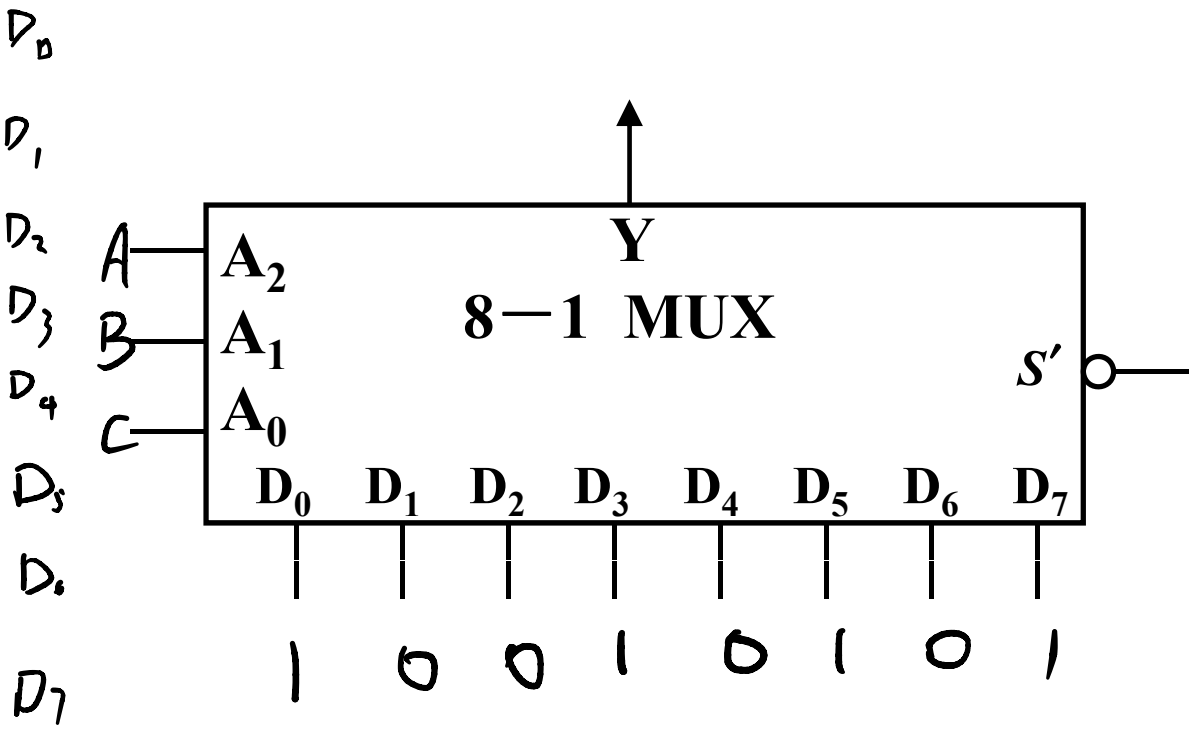
注意地址的高低位之分

练习2　用8－1MUX实现三变量逻辑函数 Y=A'B'C'+AC+A'BC

1）列函数Y的真值表
2）对比Y函数真值表和8-1MUX功能表
3）连接对应输入输出信号
4）给控制信号正确的值

Y函数真值表

ABC	Y
000	1
001	0
010	0
011	1
100	0
101	1
110	0
111	1

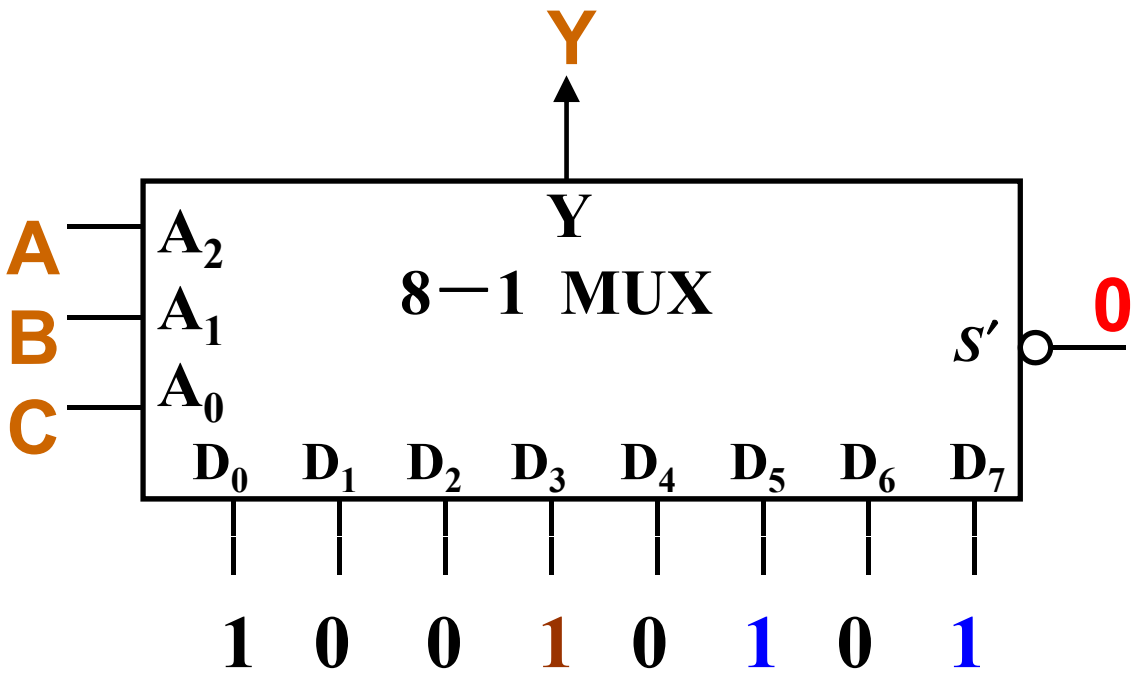


练习2　用8－1MUX实现三变量逻辑函数 Y=A'B'C'+AC+A'BC

1）列函数Y的真值表
2）对比Y函数真值表和8-1MUX功能表
3）连接对应输入输出信号
4）给控制信号正确的值

Y函数
真值表

ABC	Y
000	1
001	0
010	0
011	1
100	0
101	1
110	0
111	1



例4　用8－1MUX实现Y=X1+X0

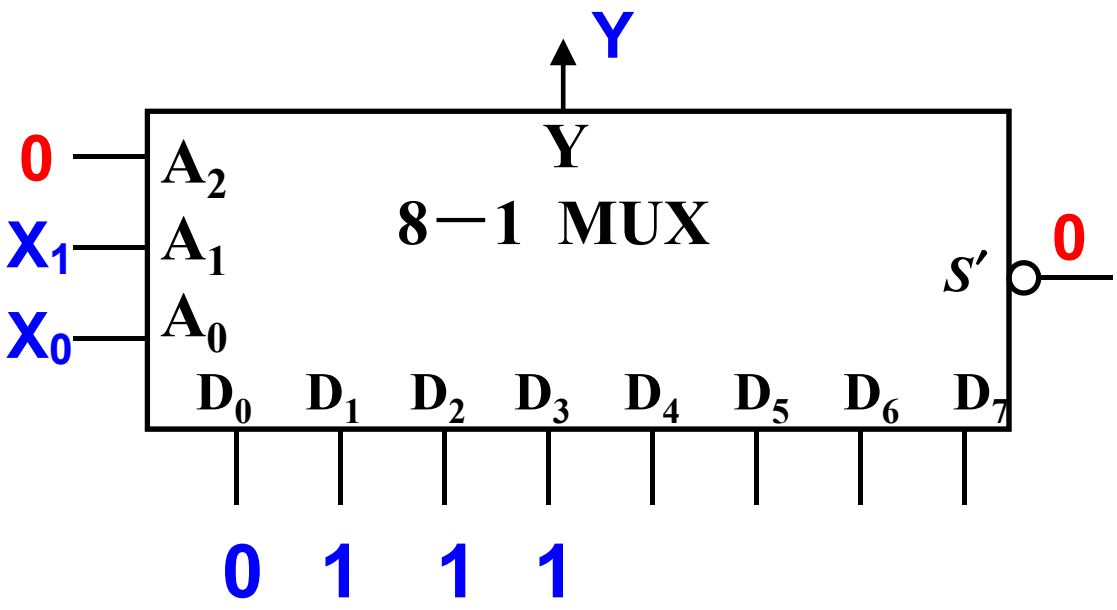
1）列函数Y的真值表
2）对比Y函数真值表和8-1MUX功能表
3）连接对应输入输出信号
4）给控制信号S及多余信号A2赋正确的值

Y函数真值表

X_1X_0	Y
0 0	0
0 1	1
1 0	1
1 1	1

8-1MUX功能表

$A_2A_1A_0$	Y
0 0 0	D_0
0 0 1	D_1
0 1 0	D_2
0 1 1	D_3
1 0 0	D_4
1 0 1	D_5
1 1 0	D_6
1 1 1	D_7



例5　用8－1MUX实现

$Y(A,B,C,D) = \sum m(1,5,6,7,9,11,12,13,14)$

方法I：扩展选通器法

1) Y函数真值表

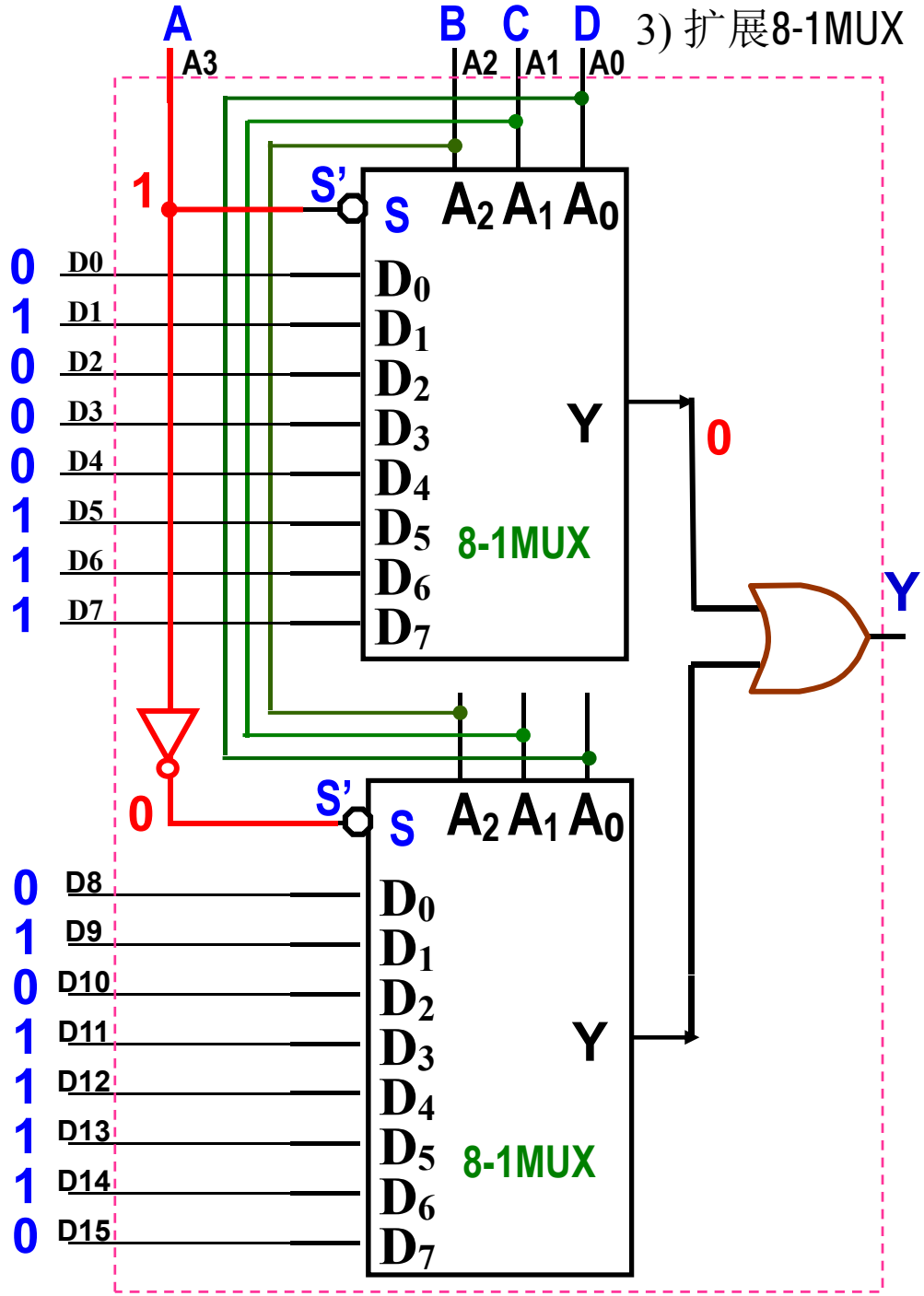
A B C D	Y
0 0 0 0	0
0 0 0 1	1
0 0 1 0	0
0 0 1 1	0
0 1 0 0	0
0 1 0 1	1
0 1 1 0	1
0 1 1 1	1
1 0 0 0	0
1 0 0 1	1
1 0 1 0	0
1 0 1 1	1
1 1 0 0	1
1 1 0 1	1
1 1 1 0	1
1 1 1 1	0

2) 16-1MUX功能表

$A_3A_2A_1A_0$	Y
0 0 0 0	D_0
0 0 0 1	D_1
0 0 1 0	D_2
0 0 1 1	D_3
0 1 0 0	D_4
0 1 0 1	D_5
0 1 1 0	D_6
0 1 1 1	D_7
1 0 0 0	D_8
1 0 0 1	D_9
1 0 1 0	D_{10}
1 0 1 1	D_{11}
1 1 0 0	D_{12}
1 1 0 1	D_{13}
1 1 1 0	D_{14}
1 1 1 1	D_{15}

4) 对比Y真值表和16-1MUX 真值表,连接对应信号

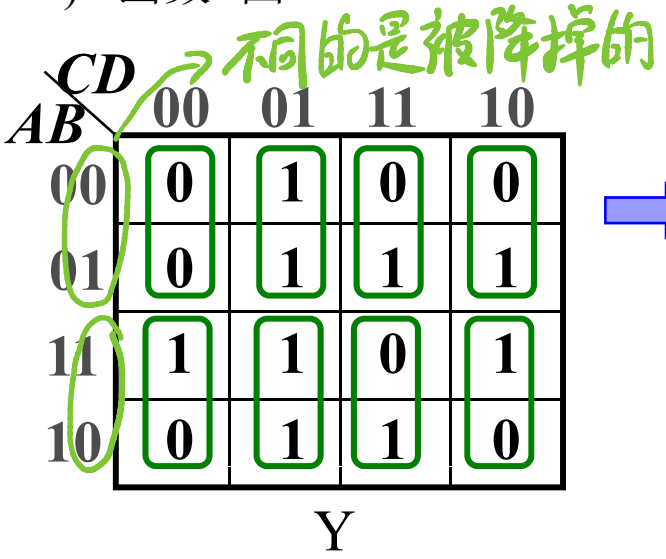
3) 扩展8-1MUX



例5　用一片8-1 MUX 实现Y(A,B,C,D) =∑m(1,5,6,7,9,11,12,13,14)

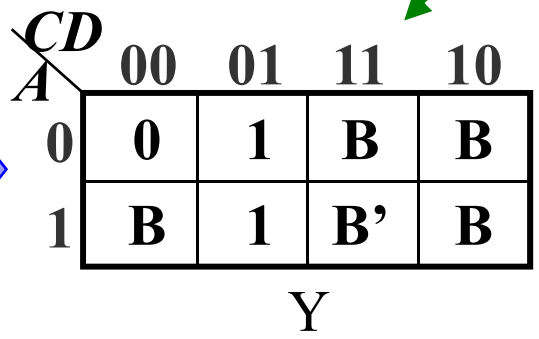
方法II：K图降维法 (用一片8-1 MUX 实现)

1) Y函数K图



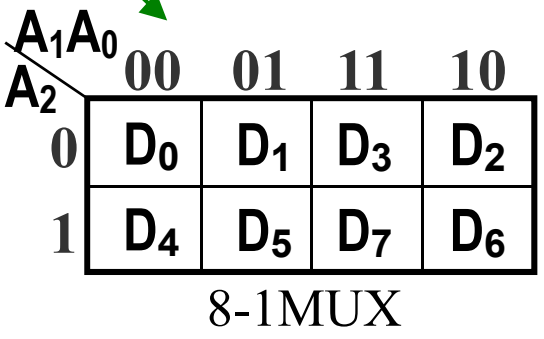
不同的是被降掉的

2)Y函数 K图降维



对比

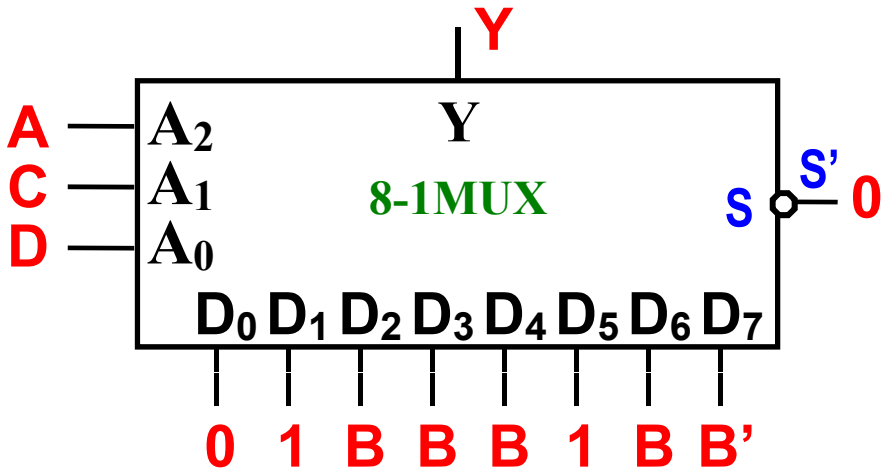
3) 8-1MUX功能 K 图



4) 对比Y函数K图和8-1MUX功能K图，连接对应信号

A →A2
C →A1
D →A0
Y →Y

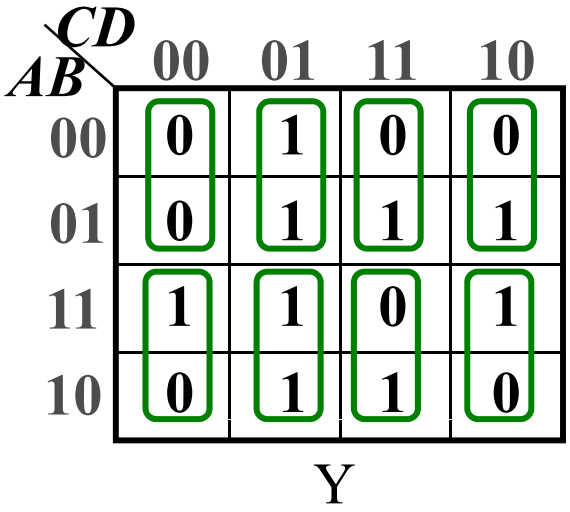
0 → D0
1 → D1
B → D2
B → D3
B → D4
1 → D5
B → D6
B′ → D7



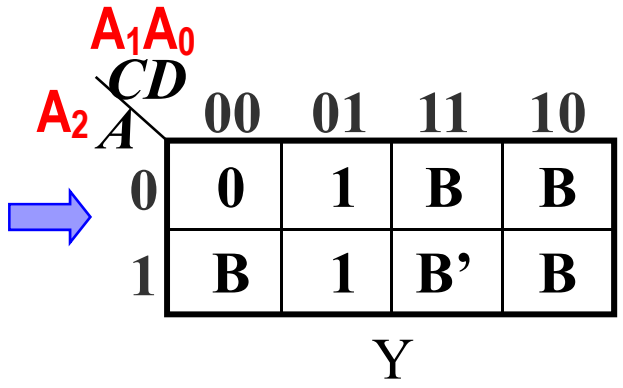
例5　用一片8-1 MUX 实现Y(A,B,C,D) =∑m(1,5,6,7,9,11,12,13,14)

方法II：K图降维法 (用一片8-1 MUX 实现)

1) Y函数K图



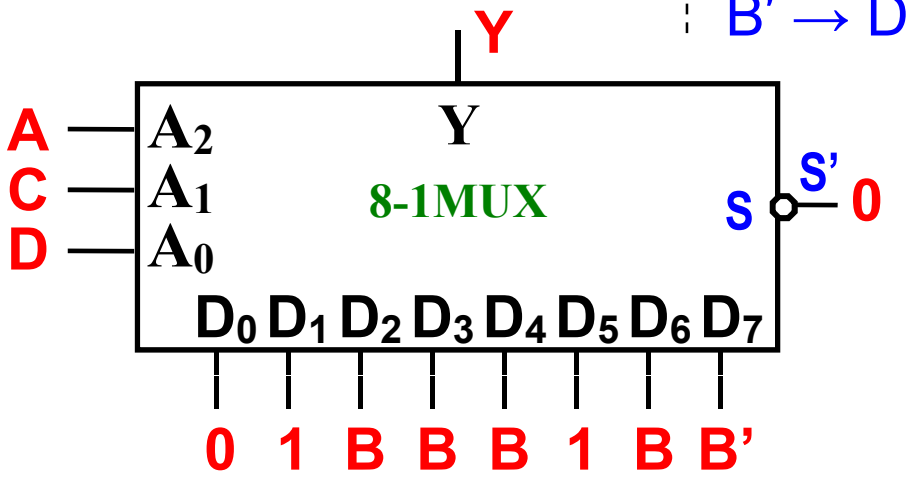
2)Y函数 K图降维



4) 对比Y函数K图和8-1MUX功能K图
连接对应信号

A → A2
C → A1
D → A0
Y → Y

0 → D0
1 → D1
B → D2
B → D3
B → D4
1 → D5
B → D6
B′ → D7



例5　用一片4-1 MUX 实现Y(A,B,C,D) =∑m(1,5,6,7,9,11,12,13,14)

方法III:K图降维法 (用一片4-1 MUX 实现)

1) Y函数K图

AB \ CD	00	01	11	10
00	0	1	0	0
01	0	1	1	1
11	1	1	0	1
10	0	1	1	0

Y

2)Y函数 K图降维第1次

A \ CD	00	01	11	10
0	0	1	B	B
1	B	1	B'	B

Y

3)Y函数 K图降维第2次

C \ D	0	1
0	AB	1
1	B	A'B+AB'

Y

对比

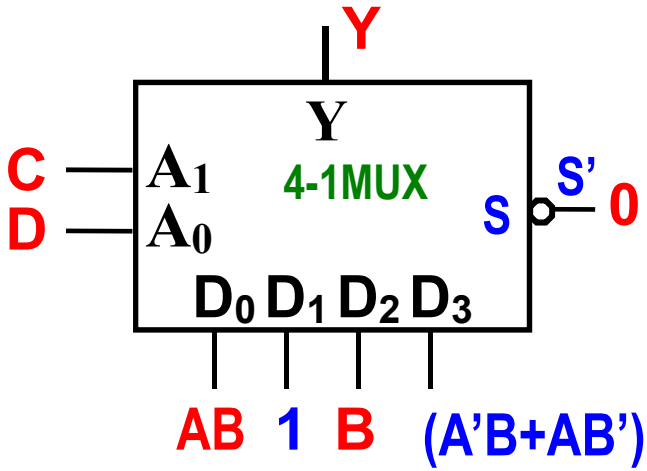
4）4-1 MUX功能表

A_1 \ A_0	0	1
0	D_0	D_1
1	D_2	D_3

4-1 MUX

5) 对比Y函数K图和4-1MUX功能K图，连接对应信号

C → A_1
D → A_0
AB → D0
1 → D1
B → D2
(A'B+AB') → D3
Y → Y



用设计的复杂度换取资源.

注意高低位间的连接

例5　用一片4-1 MUX 实现Y(A,B,C,D) =∑m(1,5,6,7,9,11,12,13,14)

方法III:K图降维法 (用一片4-1 MUX 实现)

1) Y函数K图

AB \ CD	00	01	11	10
00	0	1	0	0
01	0	1	1	1
11	1	1	0	1
10	0	1	1	0

Y

2)Y函数 K图降维第1次

A \ CD	00	01	11	10
0	0	1	B	B
1	B	1	B'	B

Y

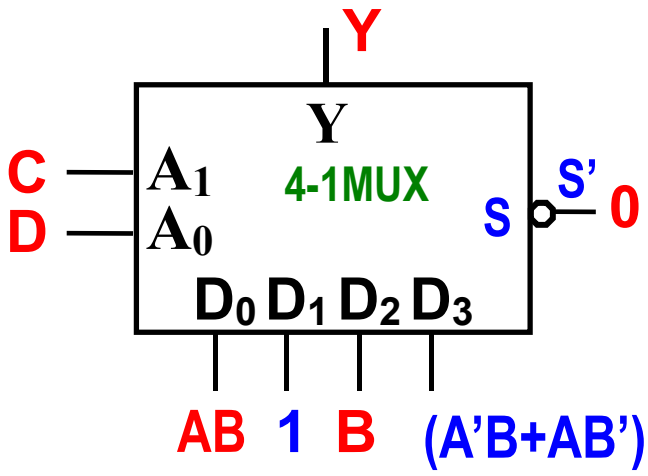
3)Y函数 K图降维第2次

C \ A_0D	0	1
0	AB	1
1	B	A'B+AB'

(A_1)

Y

4) 对比Y函数K图和4-1MUX功能K图，连接对应信号



C → A_1
D → A_0
D0 → AB
D1 → 1
D2 → B
D3 →(A'B+AB')
Y →Y

例5　用一片8-1 MUX 实现$Y(A,B,C,D)=\sum m(1,5,6,7,9,11,12,13,14)$

方法IV 代数法 (用一片8-1 MUX 实现)

$Y(A,B,C,D)$

$=(A_2'A_1'A_0')D_0+(A_2'A_1'A_0)D_1+(A_2'A_1A_0')D_2+(A_2'A_1A_0)D_3+(A_2A_1'A_0')D_4+(A_2A_1'A_0)D_5+(A_2A_1A_0')D_6+(A_2A_1A_0)D_7$

$=(A'B'C')D_0+(A'B'C)D_1+(A'BC')D_2+(A'BC)D_3+(AB'C')D_4+(AB'C)D_5+(ABC')D_6+(ABC)D_7$

$=m0D_0+m1D_1+m2D_2+m3D_3+m4D_4+m5D_5+m6D_6+m7D_7$

$Y(A,B,C,D)=A'B'C'D+A'BC'D+A'BCD'+A'BCD+AB'C'D+AB'CD+ABC'D'+ABC'D+ABCD'$

0001　0101　0110　0111　1001　1011　1100　1101　1110

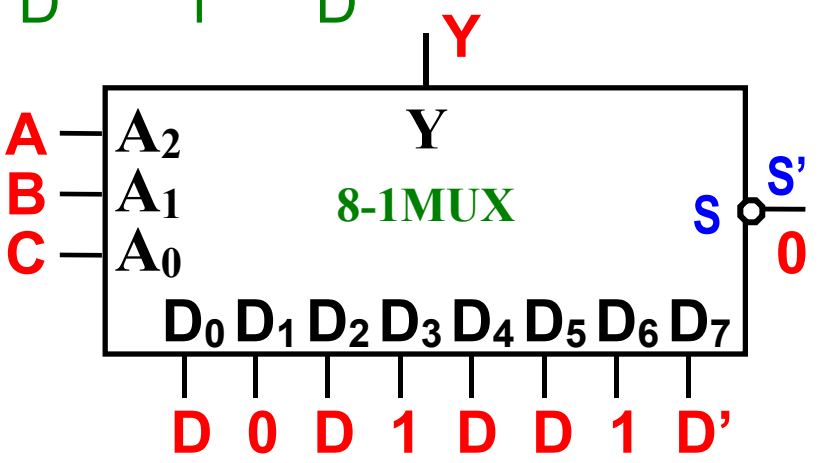
$=m_0D+m_2D+m_3D'+m_3D+m_4D+m_5D+m_6D'+m_6D+m_7D'$

$=m_0D+m_2D+m_3(D'+D)+m_4D+m_5D+m_6(D'+D)+m_7D'$

$=m_0D_0+m_1D_1+m_2D_2+m_3D_3+m_4D_4+m_5D_5+m_6D_6+m_7D_7$

D　0　D　1　D　D　1　D'

3位地址选8个地址



例3 用数据选择器实现逻辑函数，用8—1MUX实现Y(A,B,C),真值表已知

$$Y=(A_2'A_1'A_0')D_0+(A_2'A_1'A_0)D_1+(A_2'A_1A_0')D_2+(A_2'A_1A_0)D_3$$
$$+(A_2A_1'A_0')D_4+(A_2A_1'A_0)D_5+(A_2A_1A_0')D_6+(A_2A_1A_0)D_7$$
$$=m_0D_0+m_1D_1+m_2D_2+m_3D_3+m_4D_4+m_5D_5+m_6D_6+m_7D_7$$

$$Y=\sum_{i=0}^{2^k-1}m_iD_i \quad (k\text{位地址})$$

n个变量的逻辑函数可表示为：$Y=\sum_{i=0}^{2^n-1}m_ia_i$

设：k为数据选择器的地址输入端数，n为逻辑函数的变量数。

a）$n=k$

b）$n<k$

c）$n>k$

练习3 用一片8-1 MUX 实现Y(A,B,C,D) =∑m(1,5,6,7,9,11,12,13,14)，
A2A1A0已经连接好，要求填写D0~D7的输入端

1) Y函数K图

AB \ CD	00	01	11	10
00	0	1	0	0
01	0	1	1	1
11	1	1	0	1
10	0	1	1	0

Y

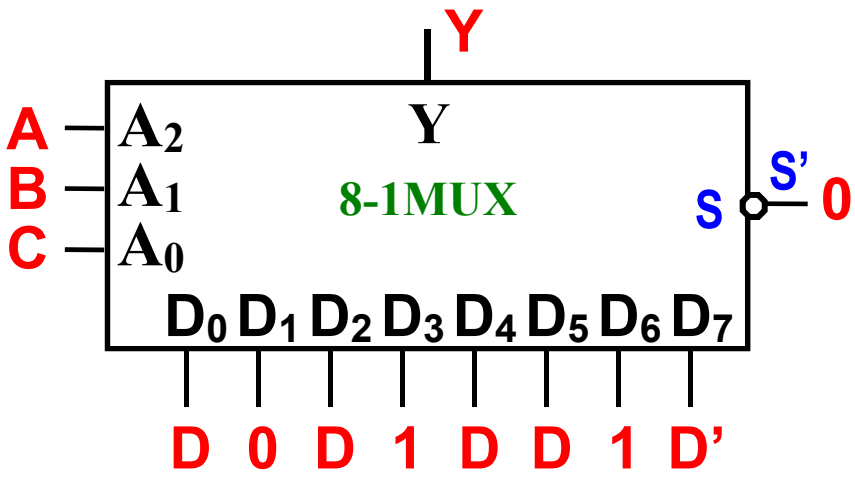
AB \ C	0	1
00	D	0
01	D	1
11	1	D'
10	D	D

Y

AB \ C	0	1
00	D	0
01	D	1
11	D	D'
10	D	D

2)Y函数 K图降维

3）对应8-1MUX的K图,连接信号线



将-任变成D前取值

A →A2
B →A1
C →A0
Y →Y

D → D0
0 → D1
D → D2
1 → D3
D → D4
D → D5
1 → D6
D' → D7

练习4 用一片8-1 MUX 实现Y(A,B,C,D) =∑m(1,5,6,7,9,11,12,13,14)，A2A1A0已经连接好，要求填写D0~D7的输入端

1) Y函数K图

AB \ CD	00	01	11	10
00	0	1	0	0
01	0	1	1	1
11	1	1	0	1
10	0	1	1	0

Y

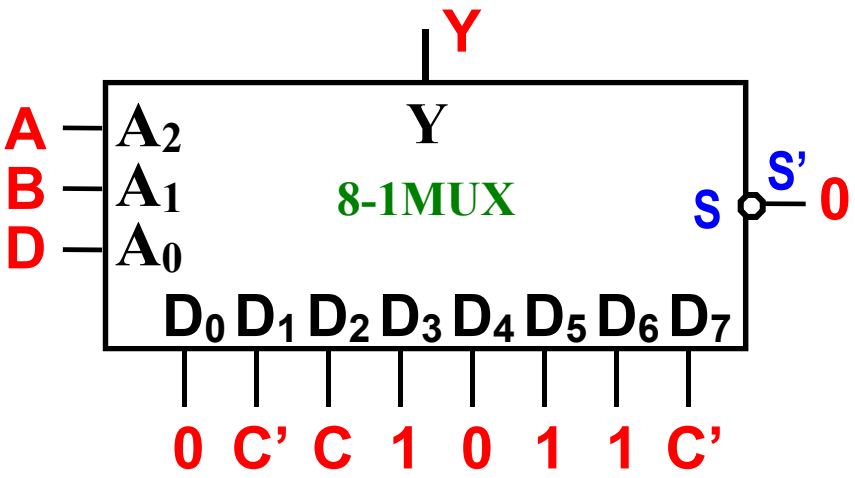
2)Y函数 K图降维

A_2A_1 \ A_0D	0	1
00	0	C’
01	C	1
11	1	C’
10	0	1

Y

AB \ D	0	1
00	0	C’
01	C	1
11	1	C’
10	0	1

3）对应8-1MUX的K图,连接信号线



A →A_2
B →A_1
D →A_0
Y →Y

0 → D_0
C′ → D_1
C → D_2
1 → D_3
0 → D_4
1 → D_5
1 → D_6
C′ → D_7

练习5　用一片4-1 MUX 实现函数Y(A,B,C)，真值表已知

Y函数真值表

ABC	Y
000	0
001	1
010	1
011	0
100	1
101	0
110	0
111	1

方法I　1) Y函数K图

A \ BC	00	01	11	10
0	0	1	0	1
1	1	0	1	0

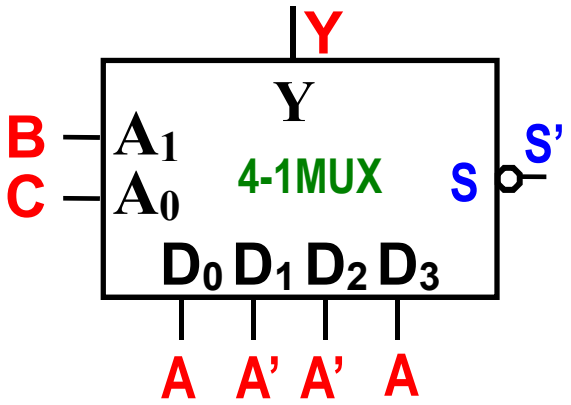
Y

2) K图降维

B \ C	0	1
0	A	A'
1	A'	A

Y

3）对应连接信号线



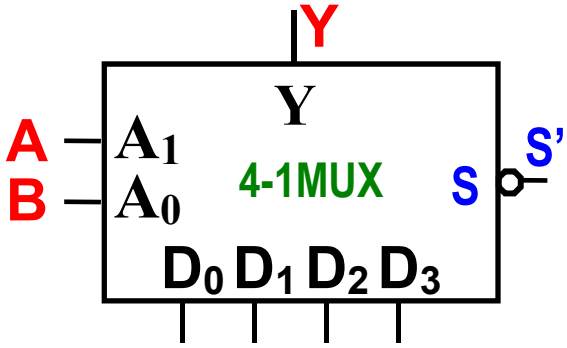
方法II

A \ BC	00	01	11	10
0	0	1	0	1
1	1	0	1	0

Y

B \ A	0	1
0	C	C'
1	C'	C

Y



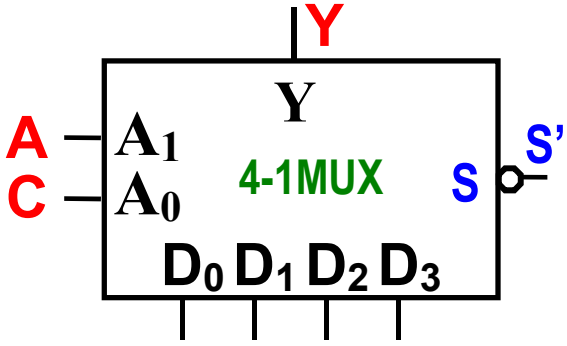
方法III

A \ BC	00	01	11	10
0	0	1	0	1
1	1	0	1	0

Y

C \ A	0	1
0	B	B'
1	B'	B

Y

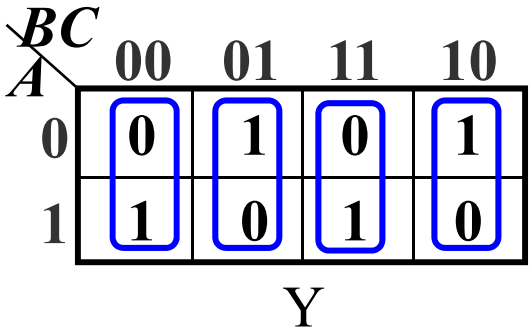


练习5　用一片4-1 MUX 实现函数Y(A,B,C)，真值表已知

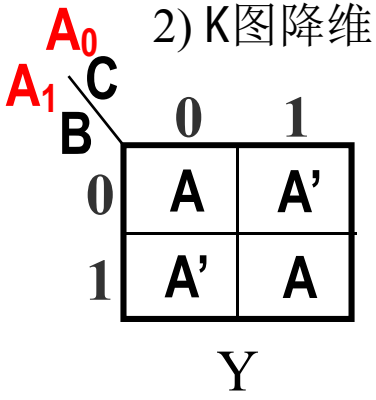
Y函数真值表

ABC	Y
000	0
001	1
010	1
011	0
100	1
101	0
110	0
111	1

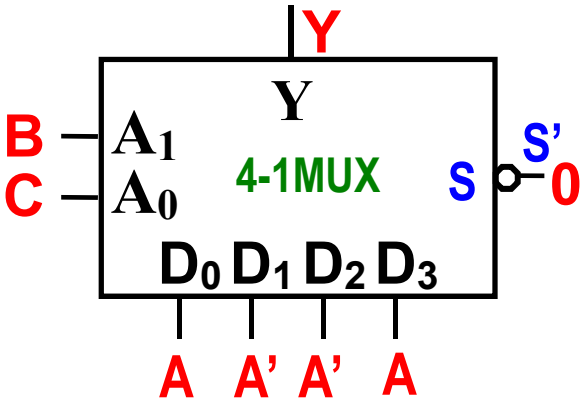
方法I　1) Y函数K图



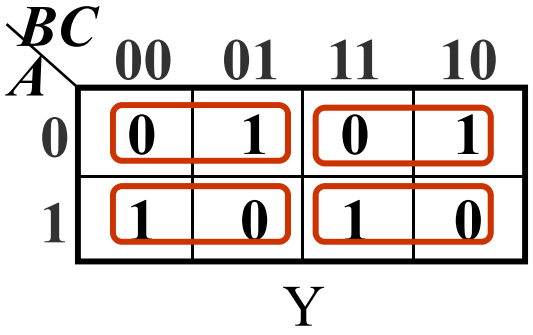
2) K图降维

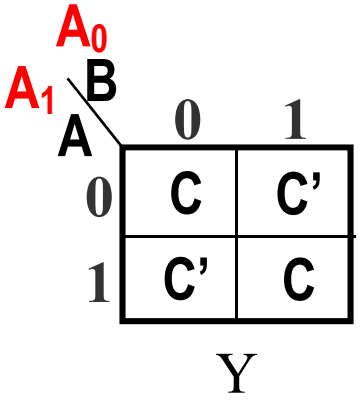


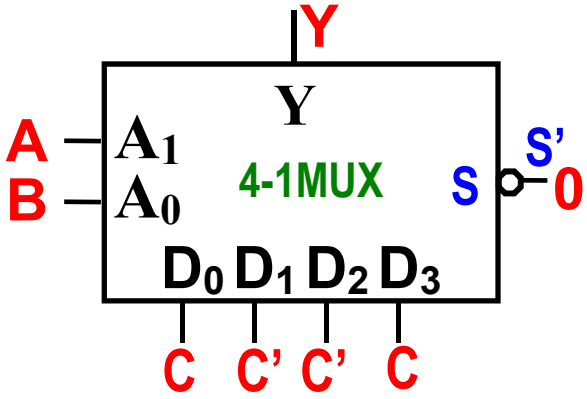
3）对应连接信号线



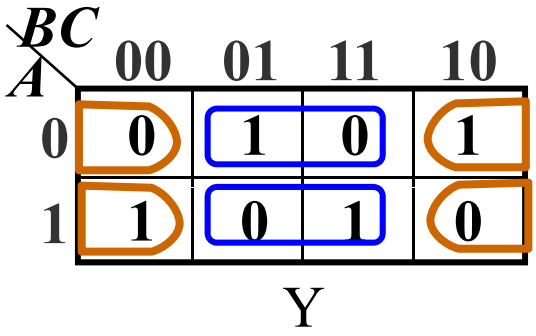
方法II

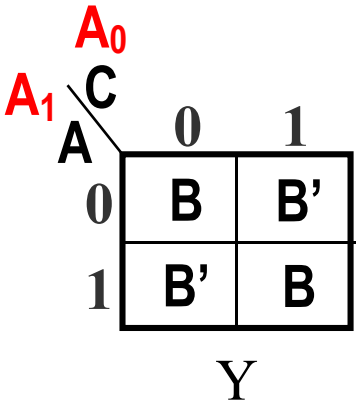


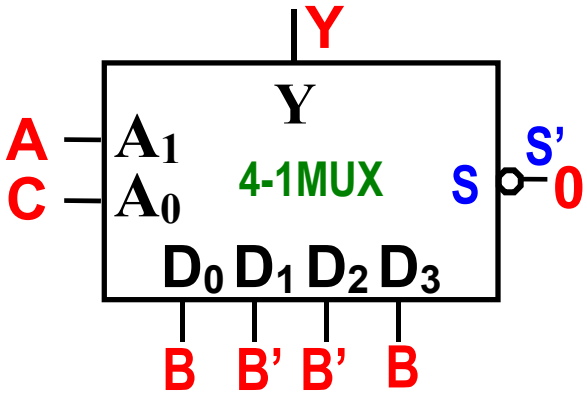




方法III

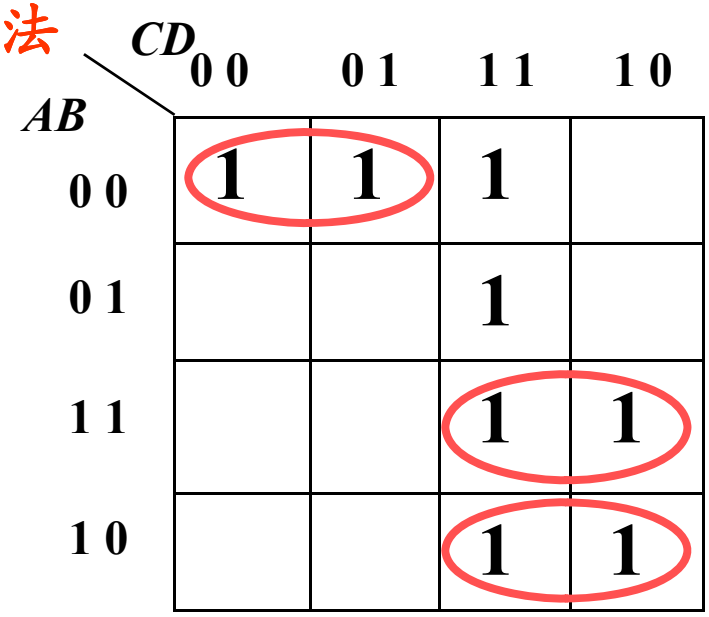


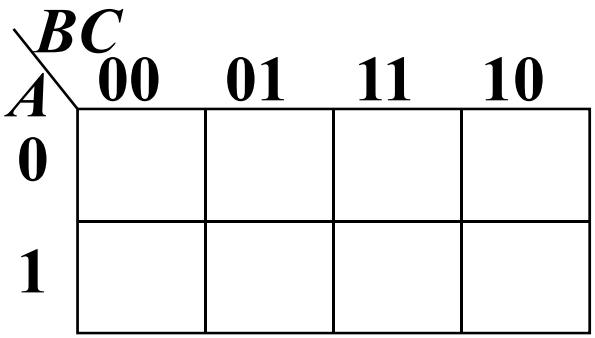




例：试用1片8-1数据选择器实现函数 $Z = A'B'C' + CD + ACD'$

- 卡诺图法





- 代数法

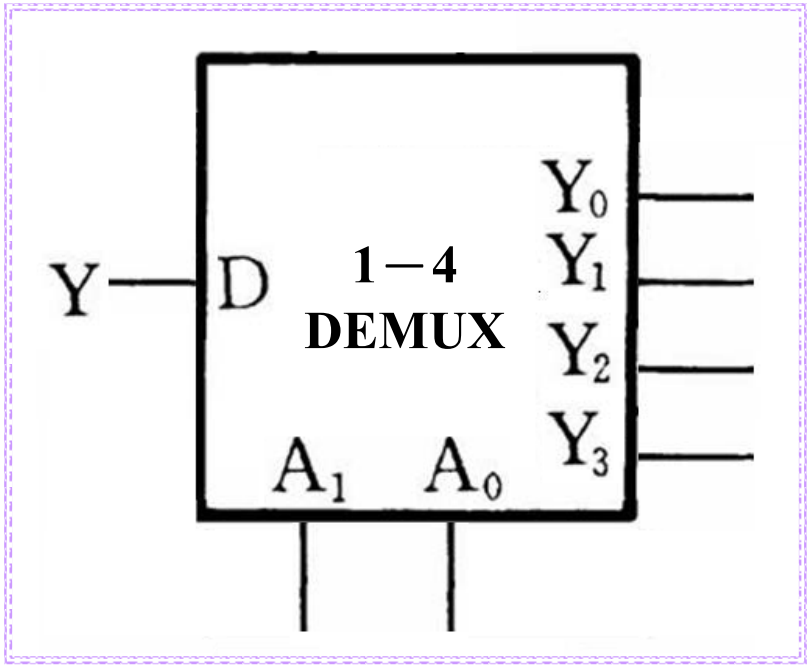
$$Z = A'B'C' + (A'B' + A'B + AB' + AB)CD + A(B + B')CD'$$

$$Z = A'B'C' + (A'B'C + A'BC)D + AB'C + ABC$$

$$D_0 = D_5 = D_7 = 1 \qquad D_1 = D_3 = D \qquad D_2 = D_4 = D_6 = 0$$

选择 并行→串行

4.3.6 数据选通器 ⇒ 串行数据→并行数据

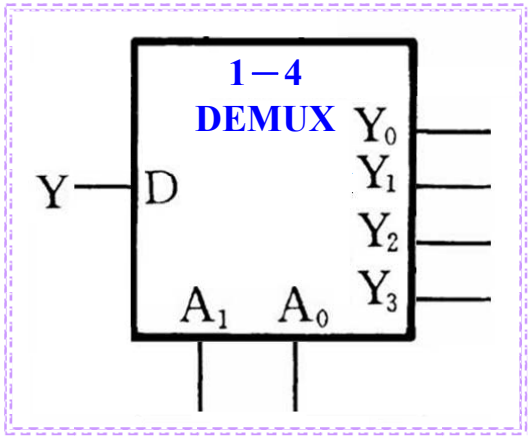


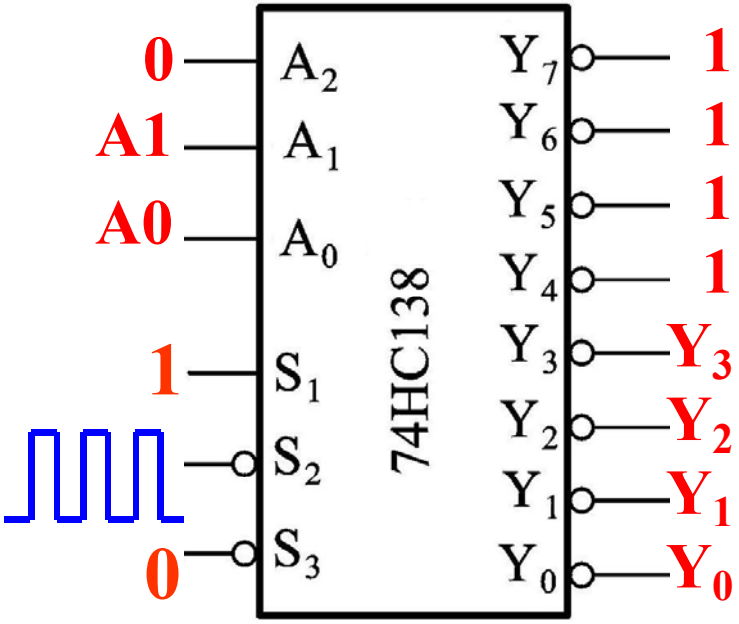
A_1	A_0	Y_0	Y_1	Y_2	Y_3
0	0	*D*	0	0	0
0	1	0	*D*	0	0
1	0	0	0	*D*	0
1	1	0	0	0	*D*

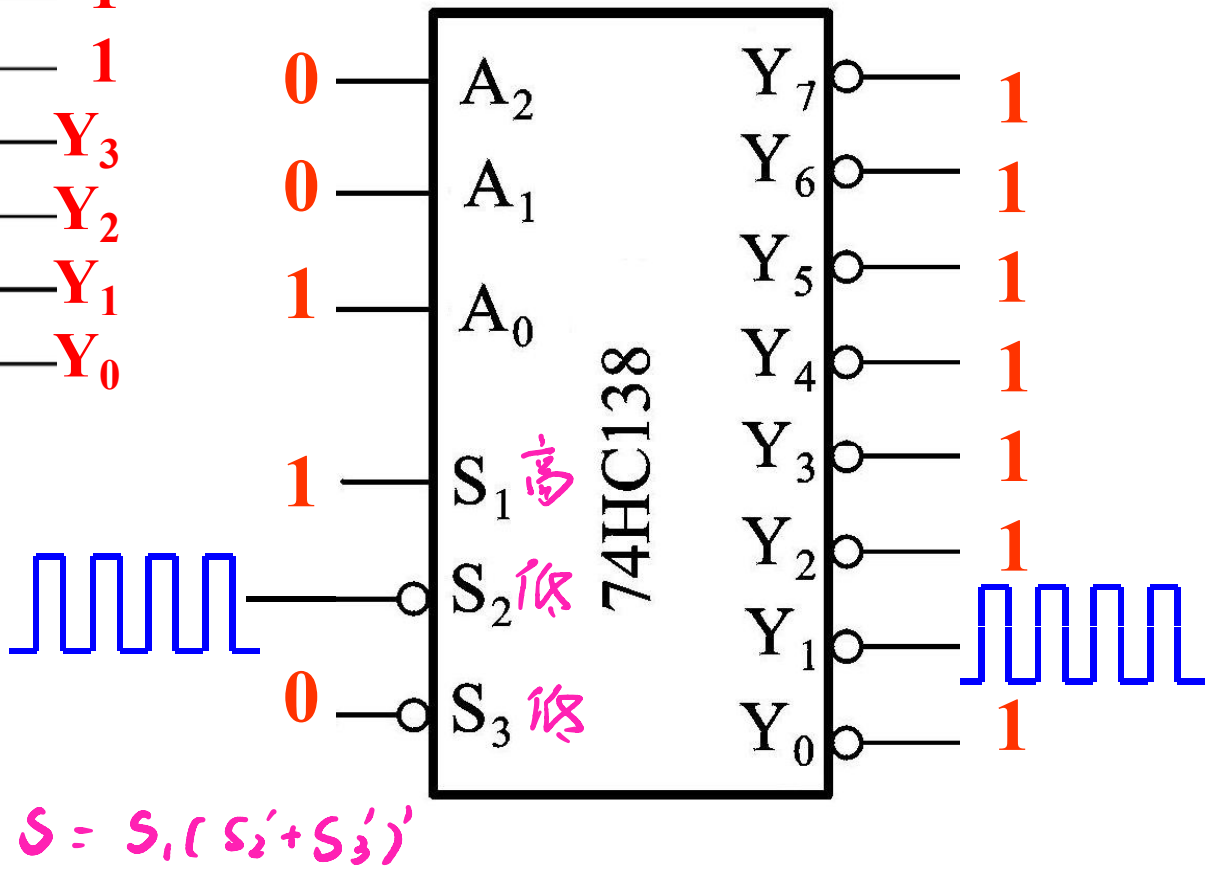
$$Y_0 = A_1' A_0' D, \quad Y_1 = A_1' A_0 D, \quad Y_2 = A_1 A_0' D, \quad Y_3 = A_1 A_0 D$$

0 0　　0 1　　1 0　　1 1

例6：用译码器构成数据分配器







作业

4.15
4.17
4.18
4.19
4.20
4.24

4-1MUX, 8-1MUX