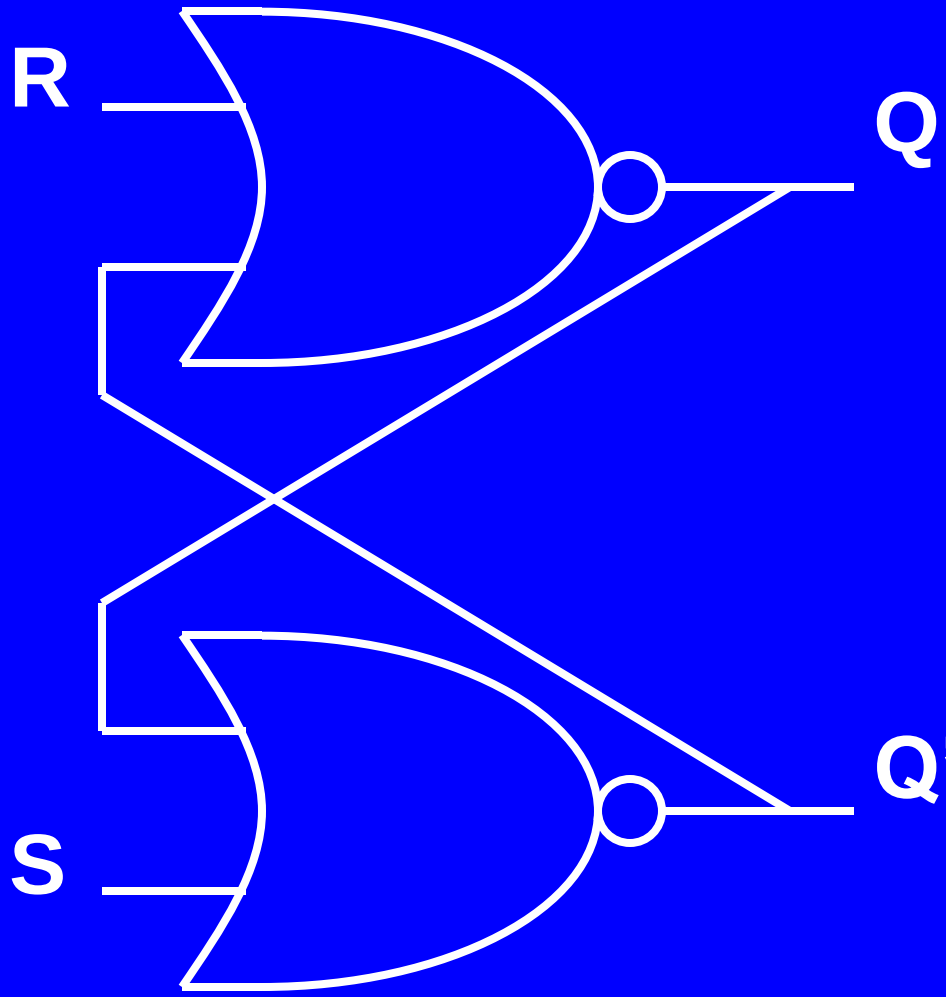
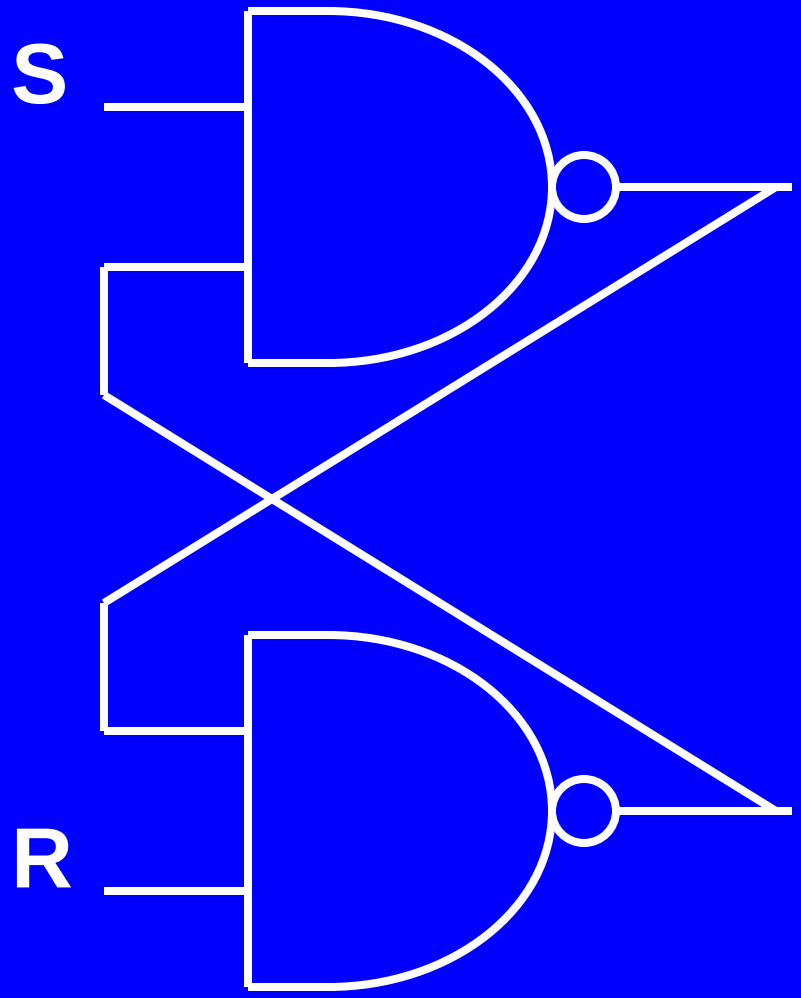
SR latch



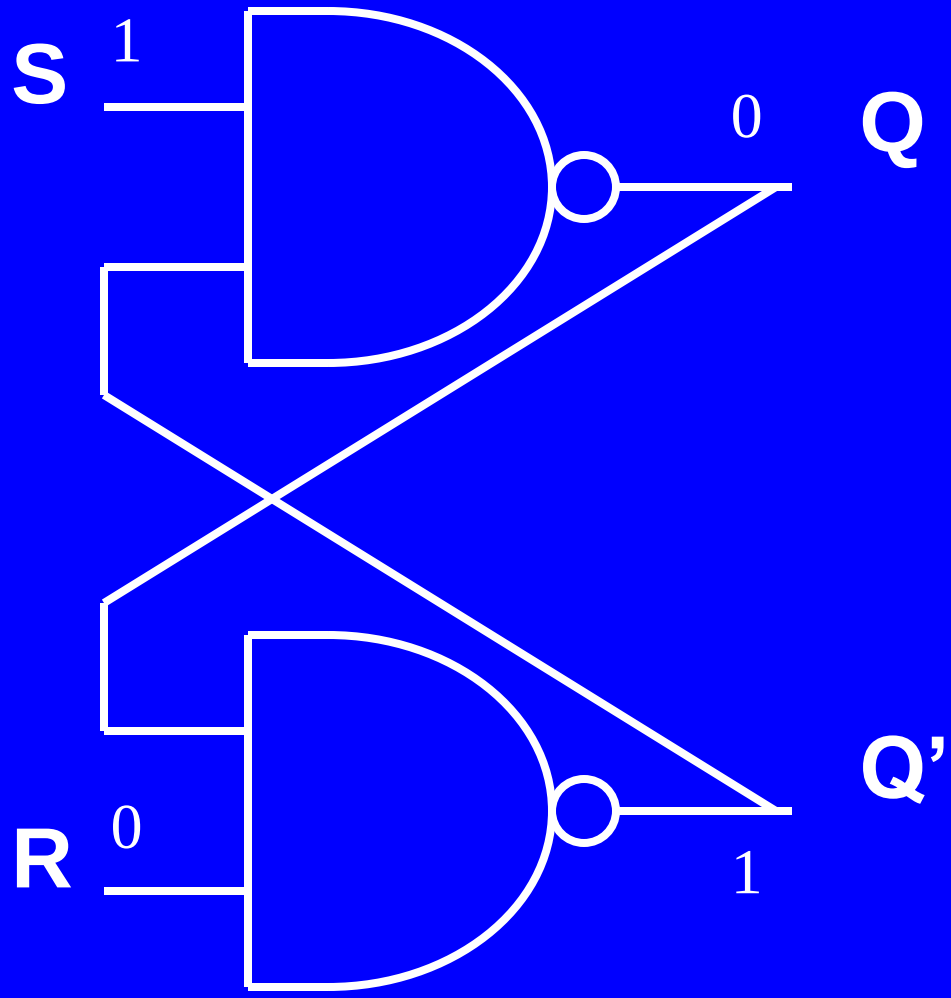
S	R	Q	Q'
1	0	1	0
0	0	1	0
0	1	0	1
0	0	0	1
1	1	0	0

SR latch



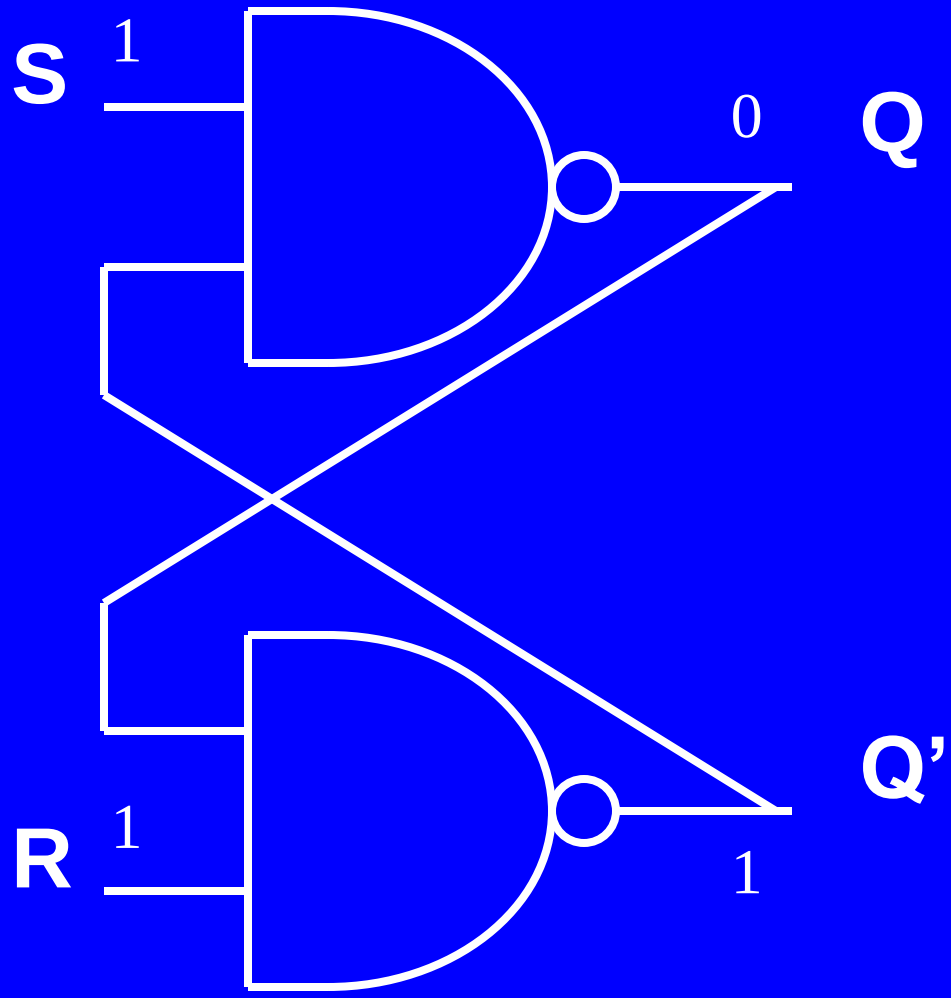
S	R	Q	Q'
1	0	0	1
1	1	0	1
0	1	1	0
1	1	1	0
0	0	1	1

SR latch



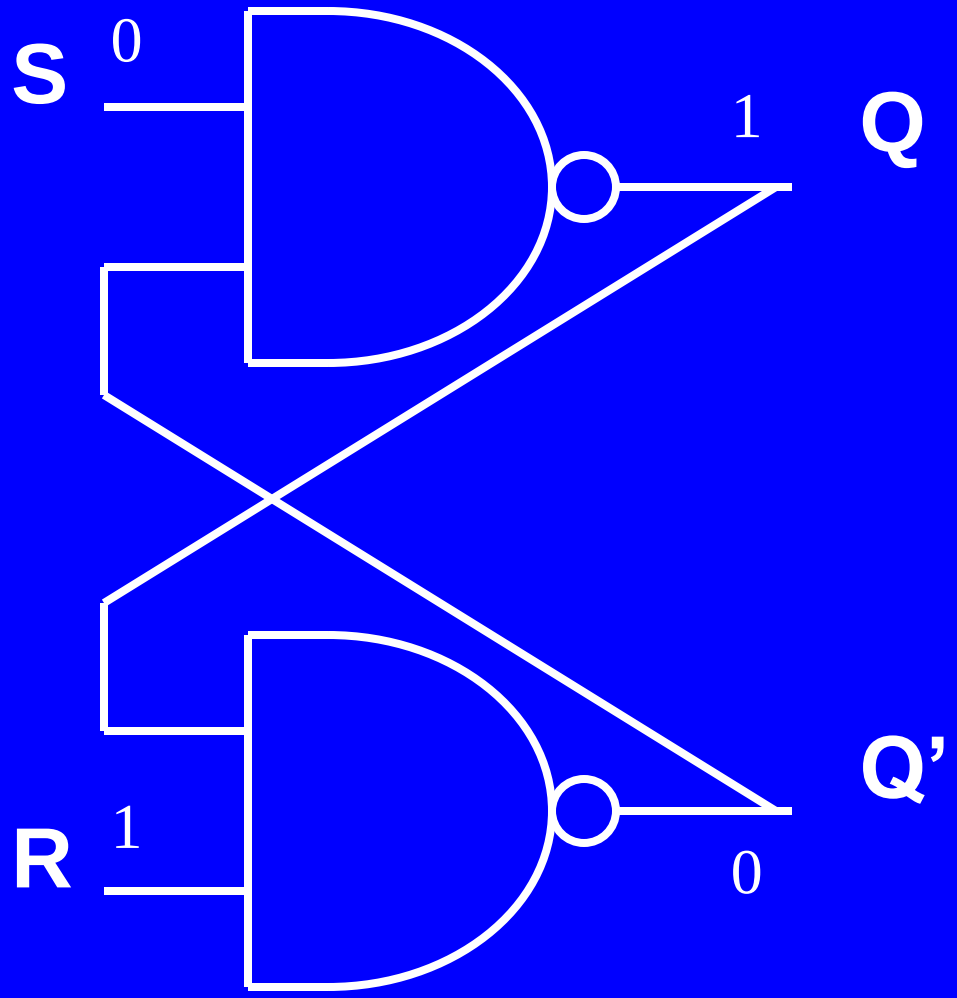
S	R	Q	Q'
1	0	0	1
1	1	0	1
0	1	1	0
1	1	1	0
0	0	1	1

SR latch



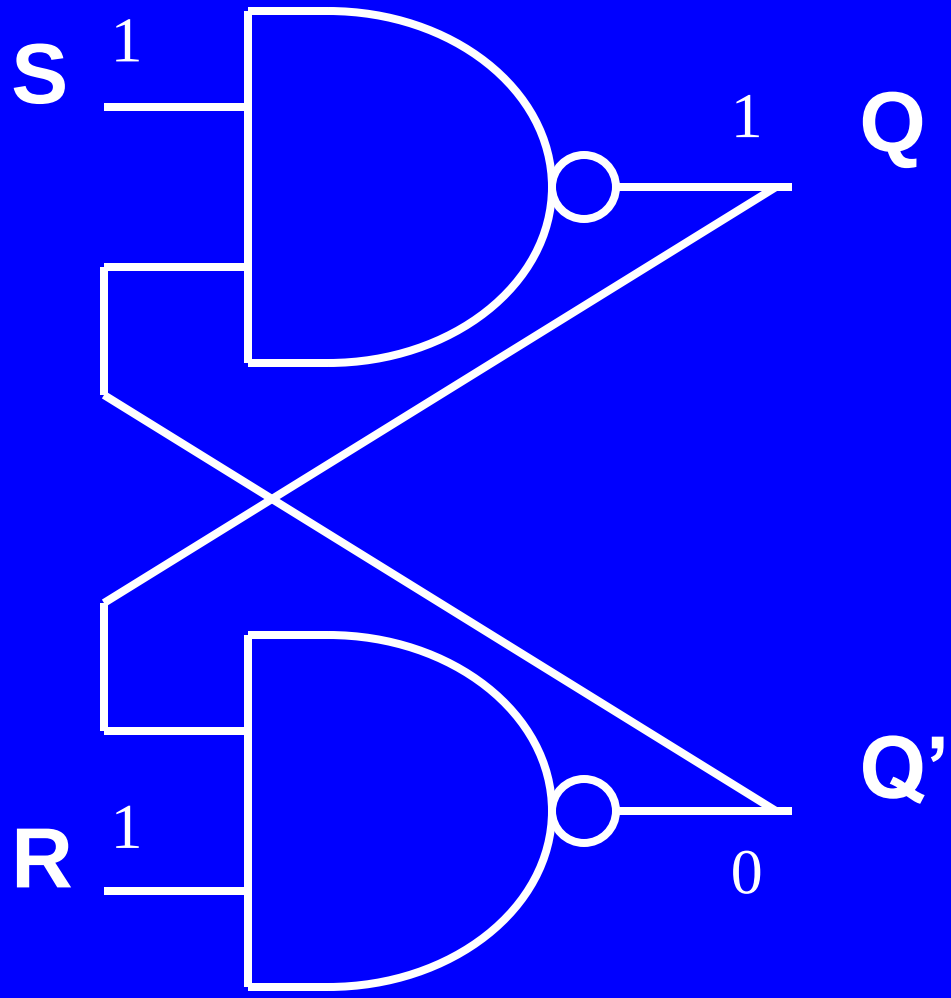
S	R	Q	Q'
1	0	0	1
1	1	0	1
0	1	1	0
1	1	1	0
0	0	1	1

SR latch



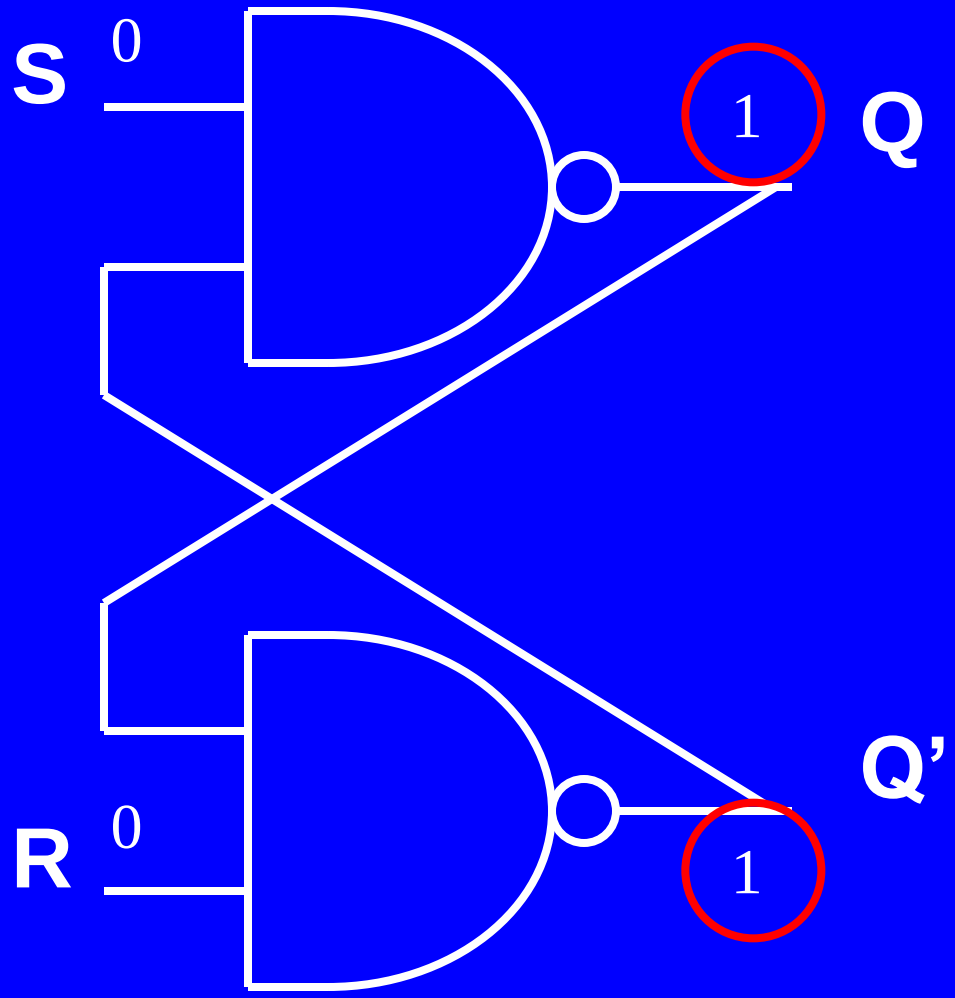
S	R	Q	Q'
1	0	0	1
1	1	0	1
0	1	1	0
1	1	1	0
0	0	1	1

SR latch



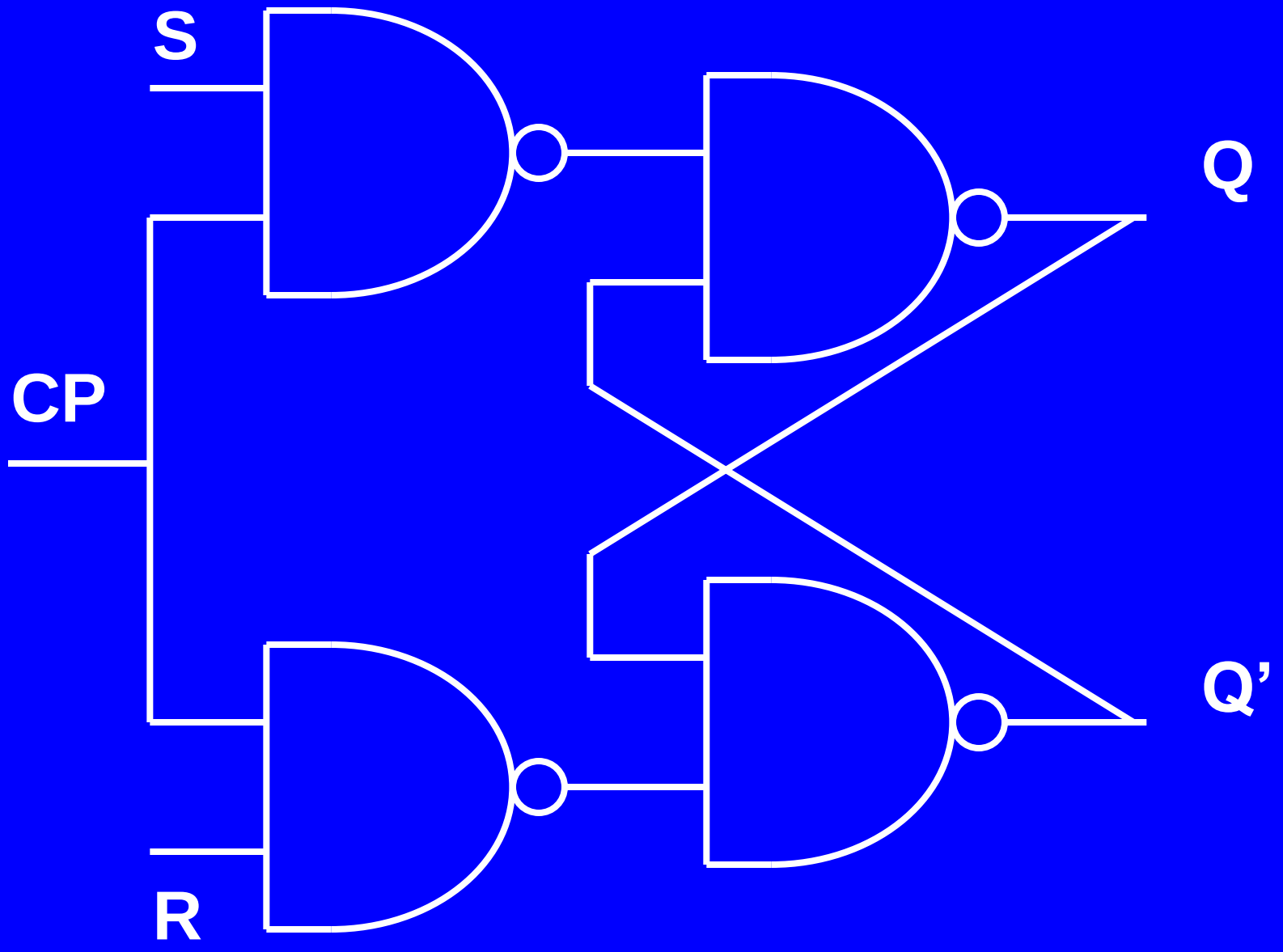
S	R	Q	Q'
1	0	0	1
1	1	0	1
0	1	1	0
1	1	1	0
0	0	1	1

SR latch

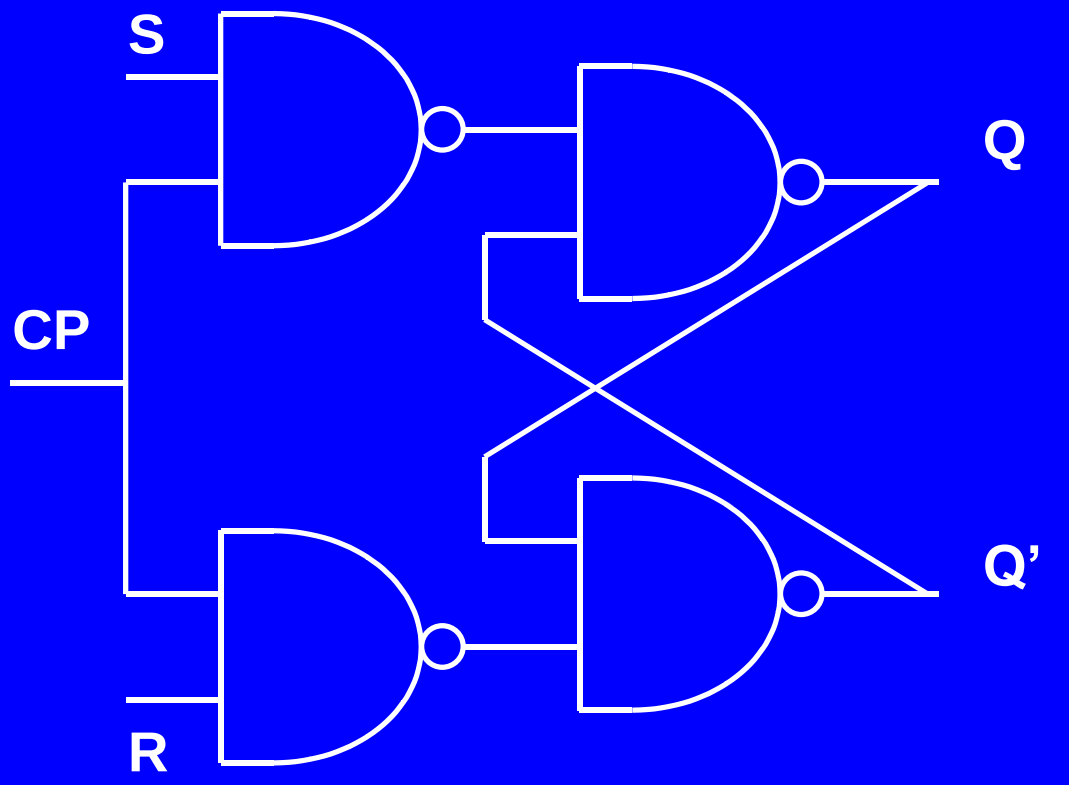


S	R	Q	Q'
1	0	0	1
1	1	0	1
0	1	1	0
1	1	1	0
0	0	1	1

Clocked SR latch

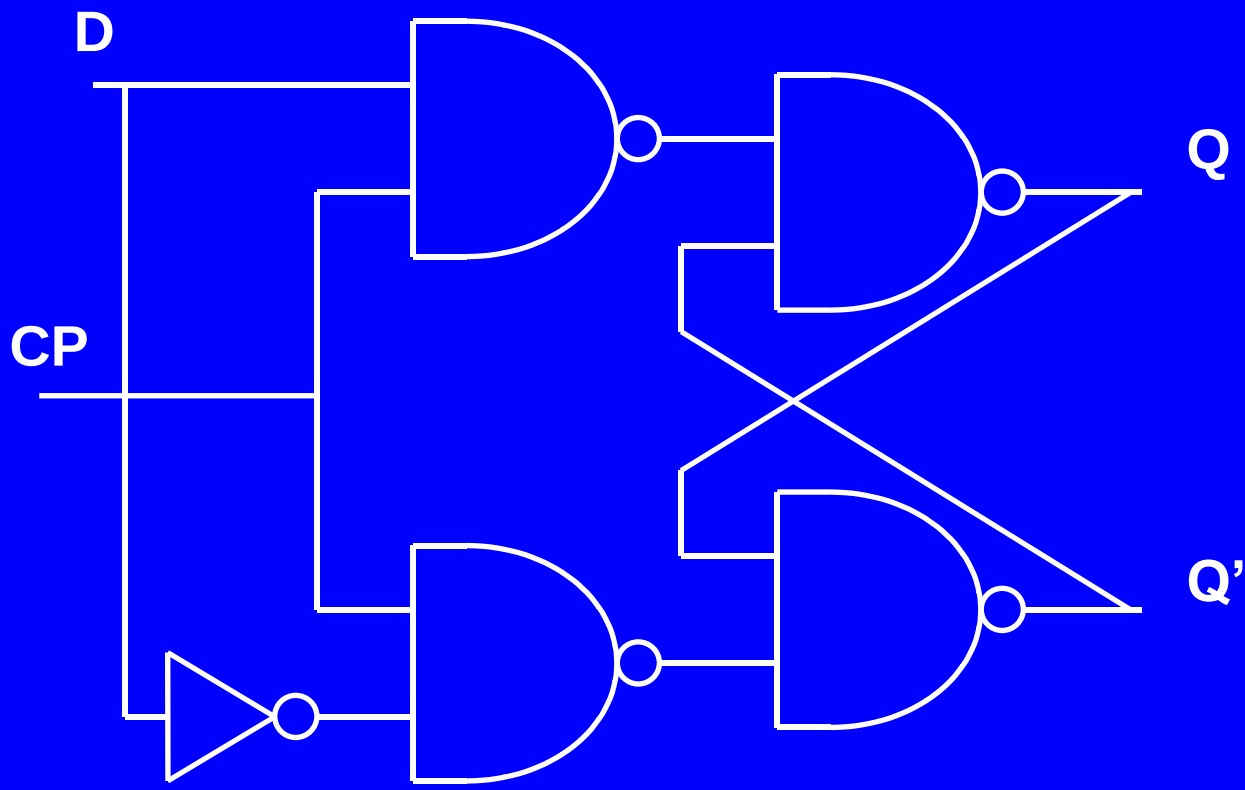


Clocked SR latch



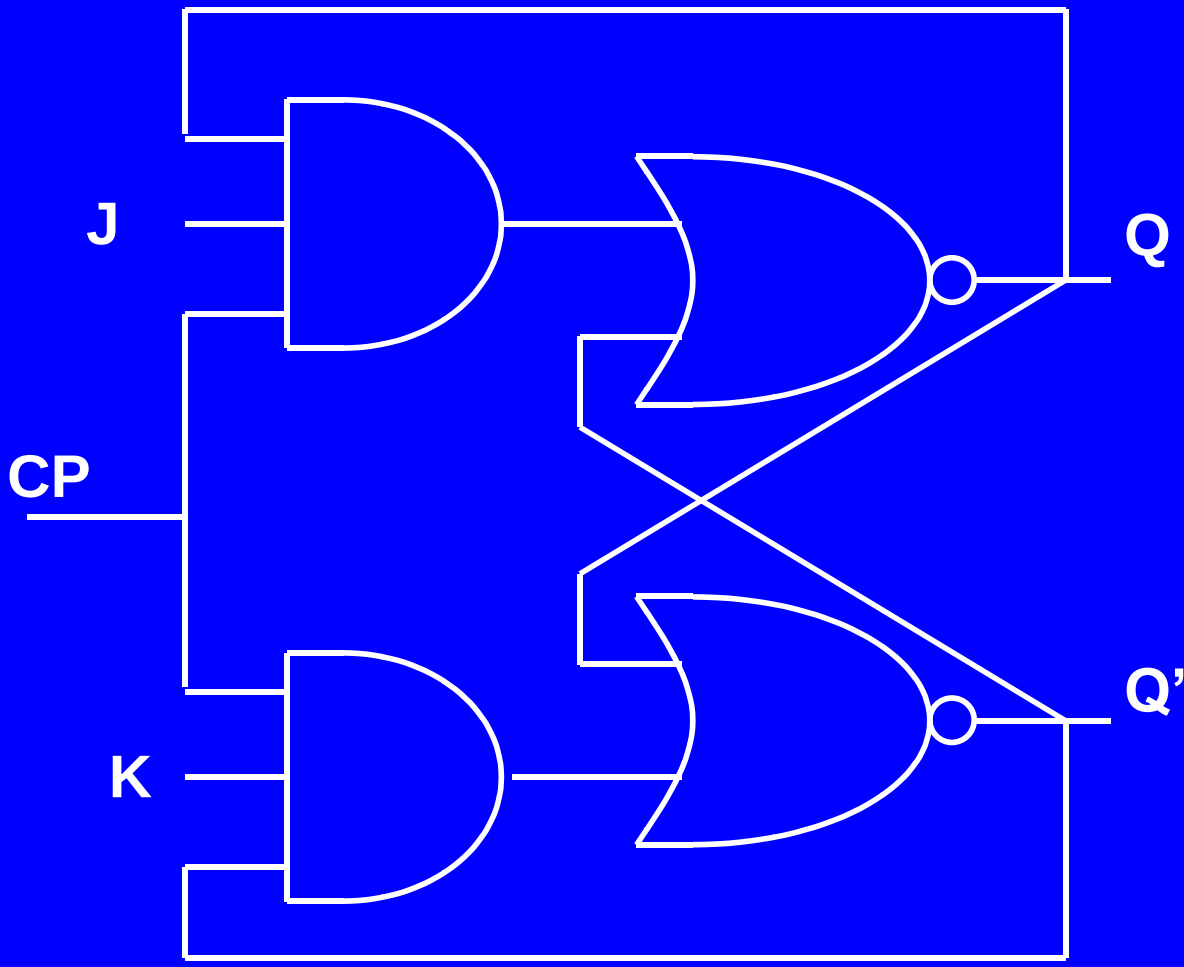
Q	S	R	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	X
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	X

Clocked D latch



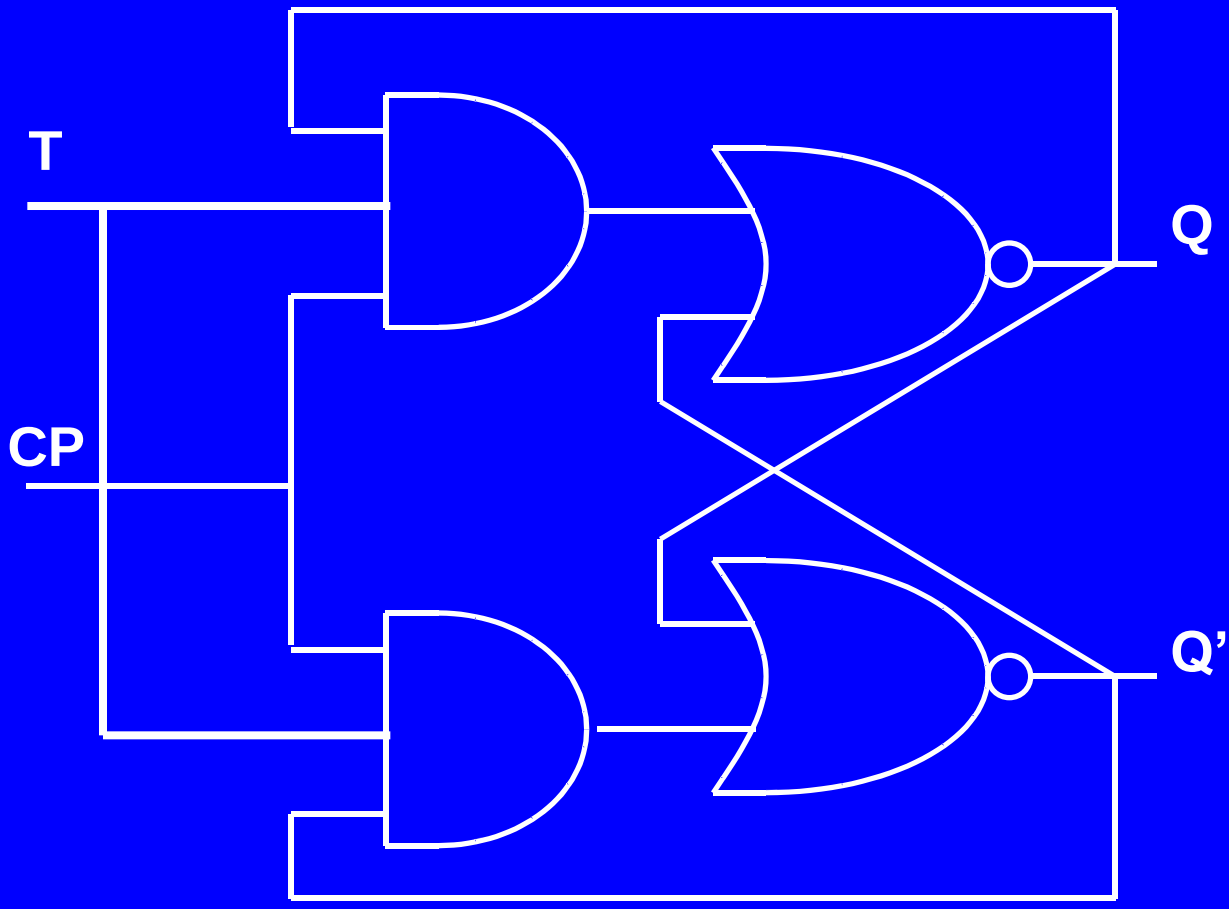
Q	D	Q(t+1)
0	0	0
0	1	1
1	0	0
1	1	1

Clocked JK latch



Q	J	K	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Clocked T latch



Q	T	Q(t+1)
0	0	0
0	1	1
1	0	1
1	1	0

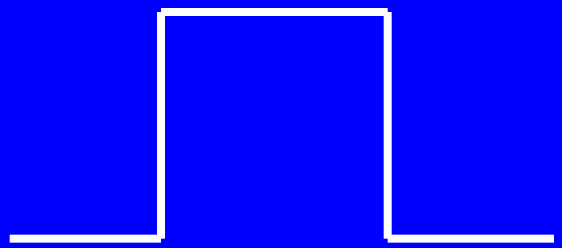
Κατηγορίες ακολουθιακών στοιχείων

- Latches
  - level-sensitive
  - edge triggered
- Flip-flops

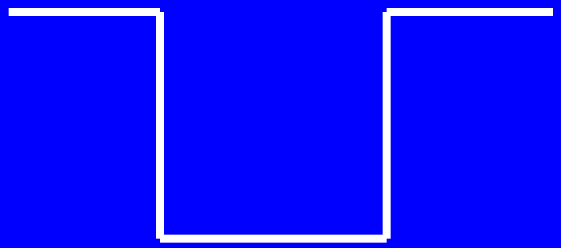
- Με σύγχρονο/ασύγχρονο reset ή enable

Χρονισμός

Θετικός παλμός



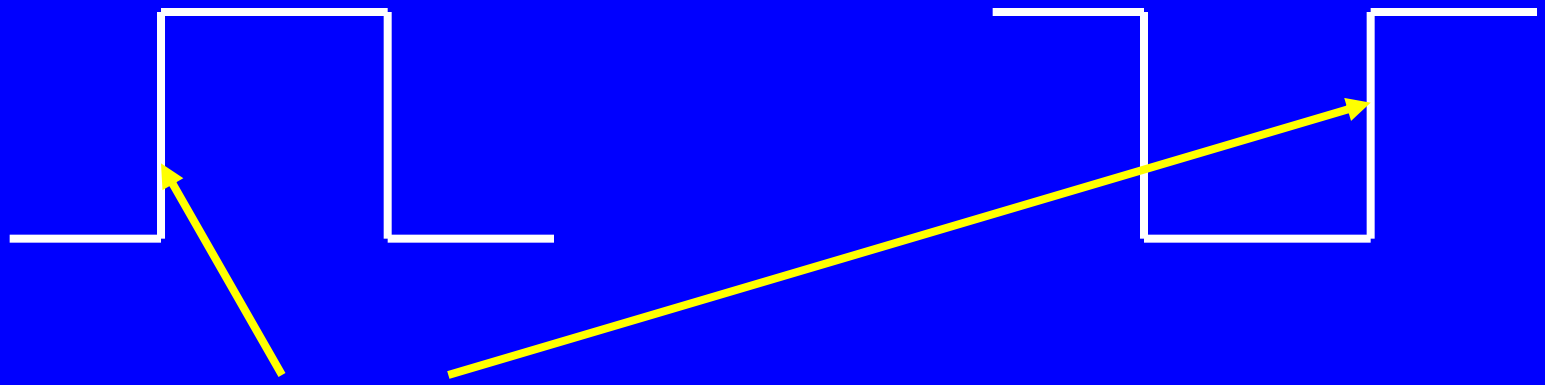
Αρνητικός παλμός



Χρονισμός

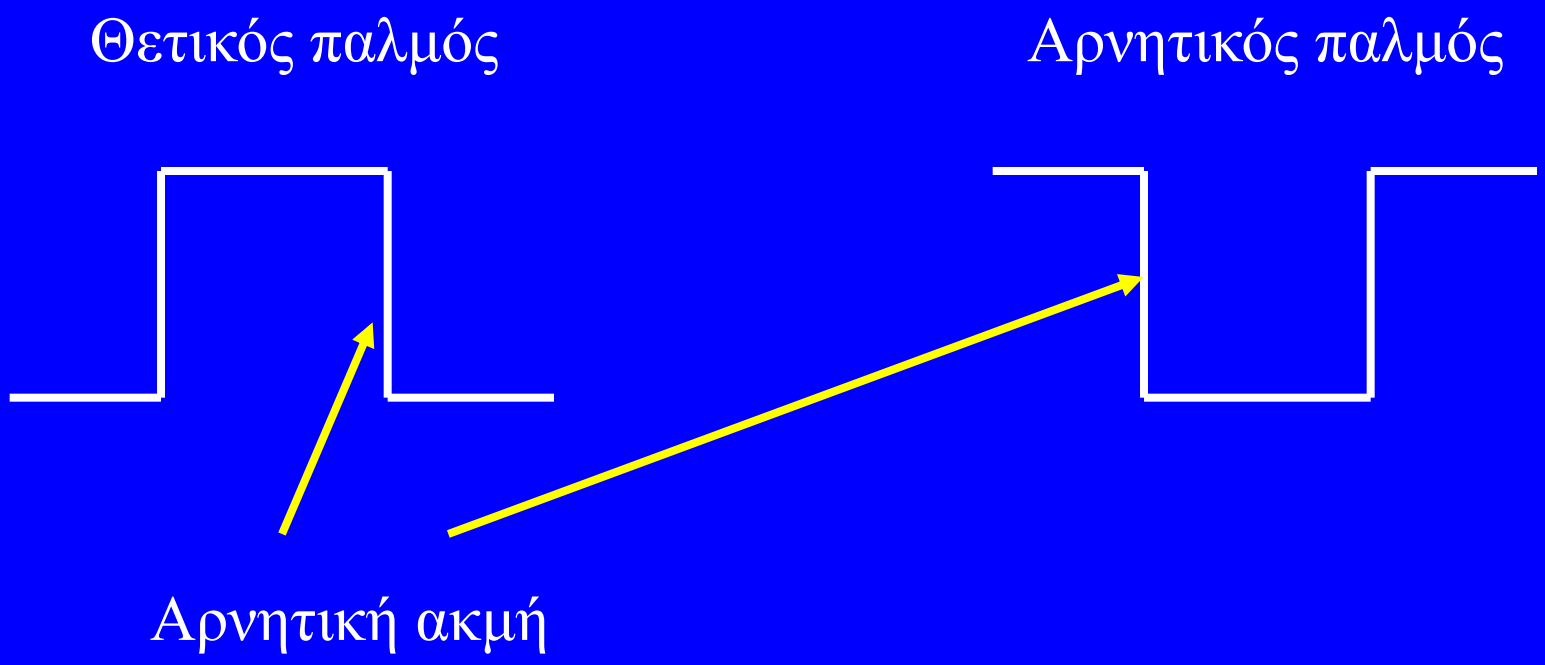
Θετικός παλμός

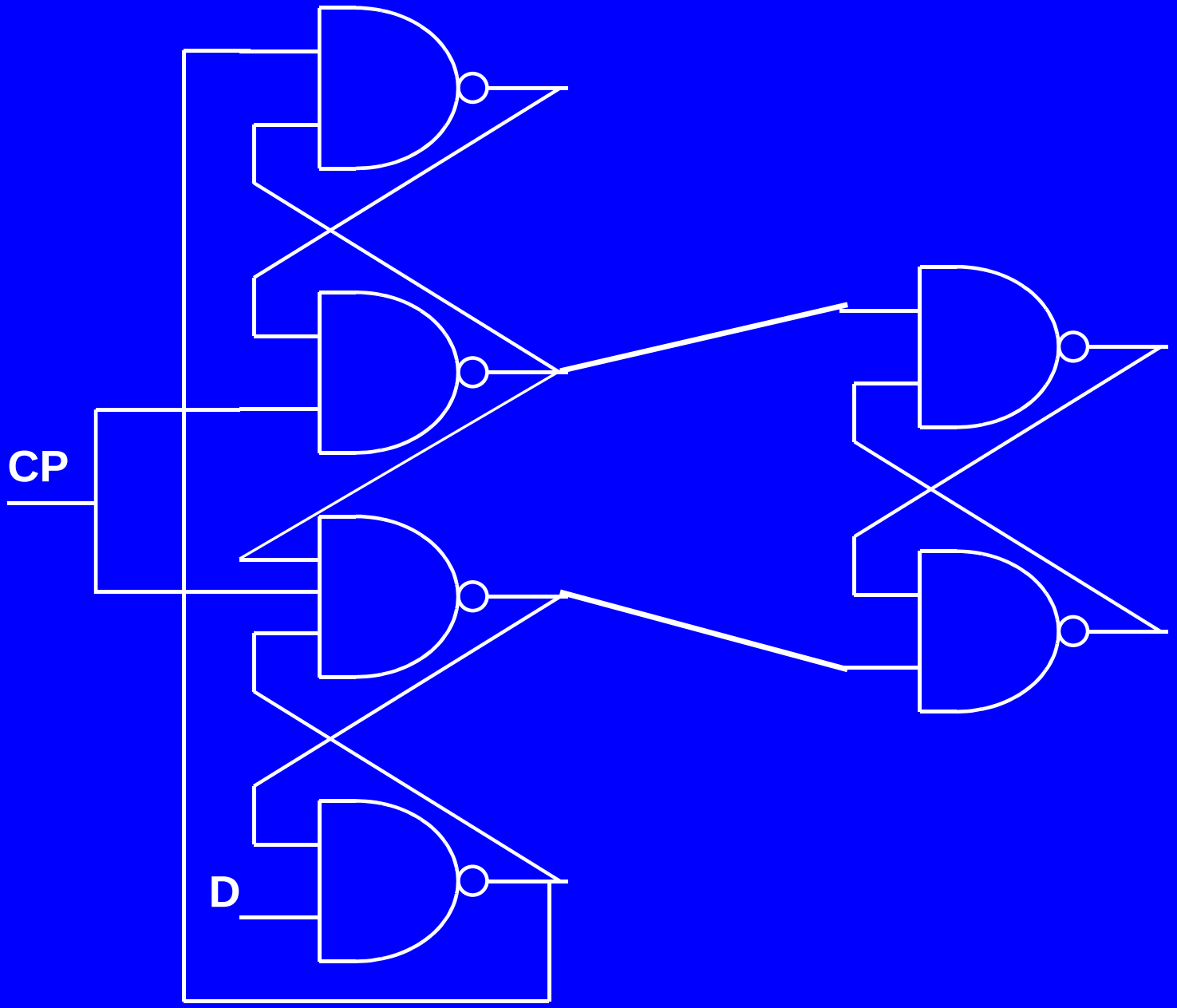
Αρνητικός παλμός



Θετική ακμή

Χρονισμός

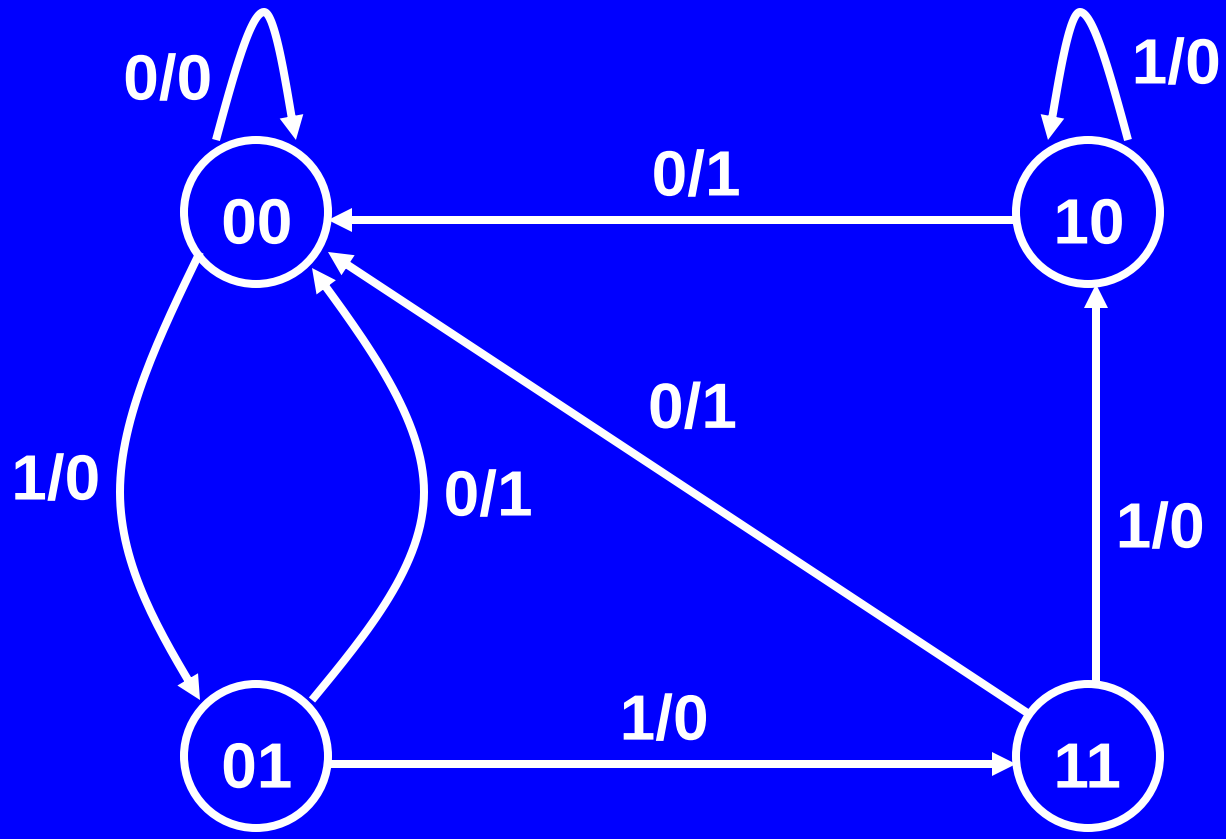



CP
D

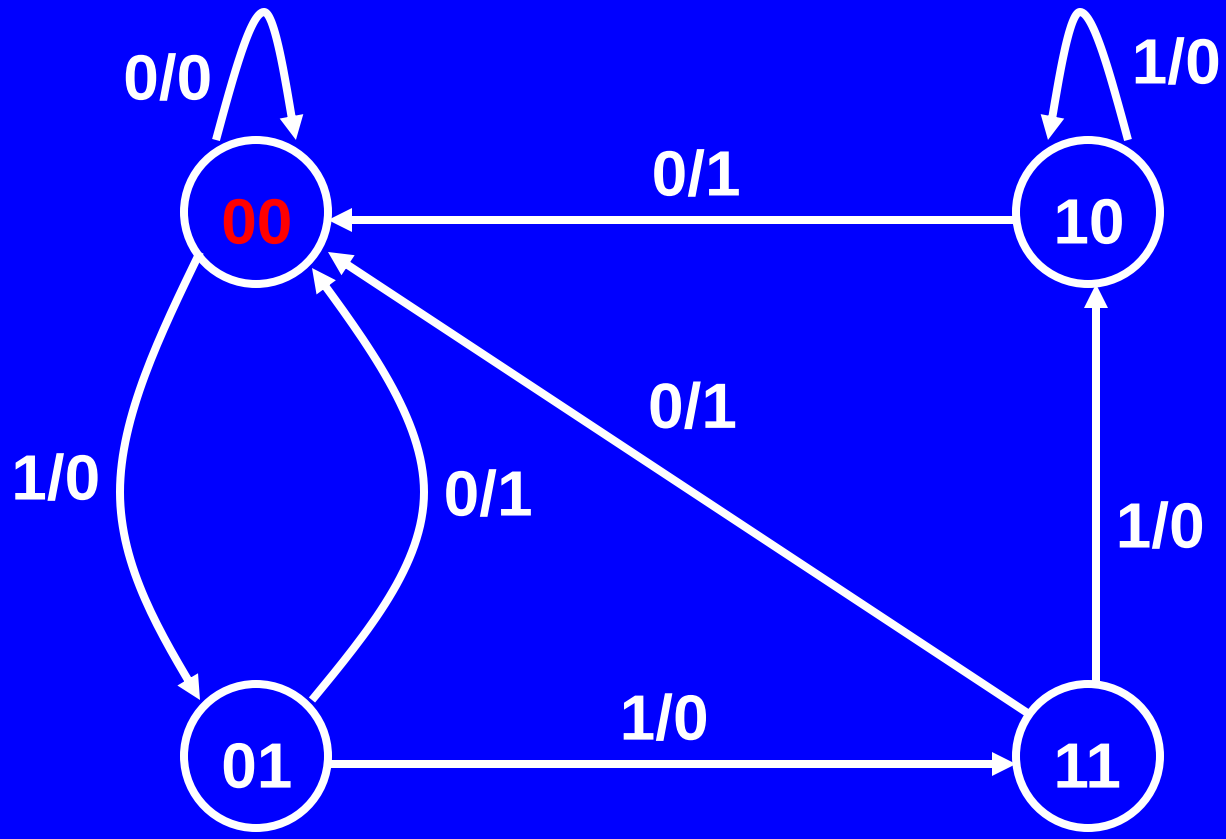
Πίνακας καταστάσεων

Αρχική		Είσοδος	Επόμενη		Έξοδος
A	B	X	A	B	Y
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	0	1
0	1	1	1	1	0
1	0	0	0	0	1
1	0	1	1	0	0
1	1	0	0	0	1
1	1	1	1	0	0

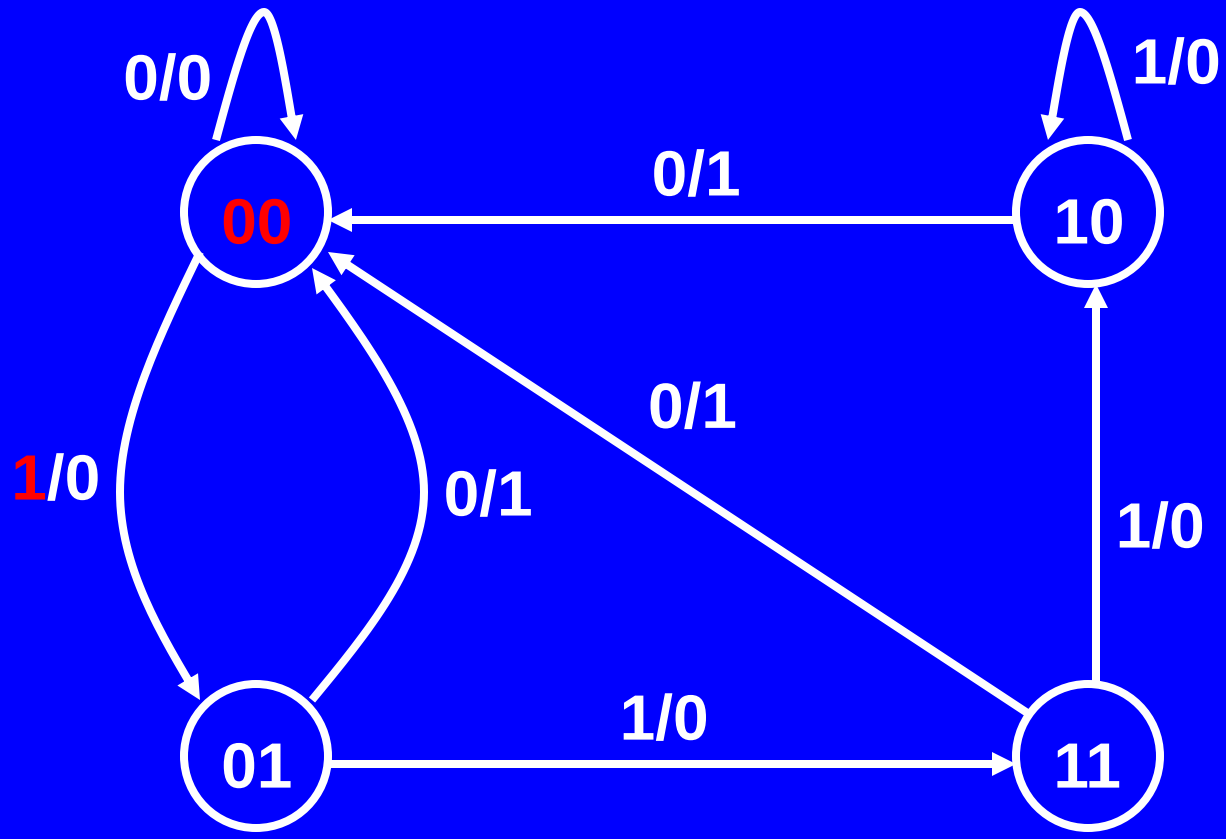
Διάγραμμα καταστάσεων



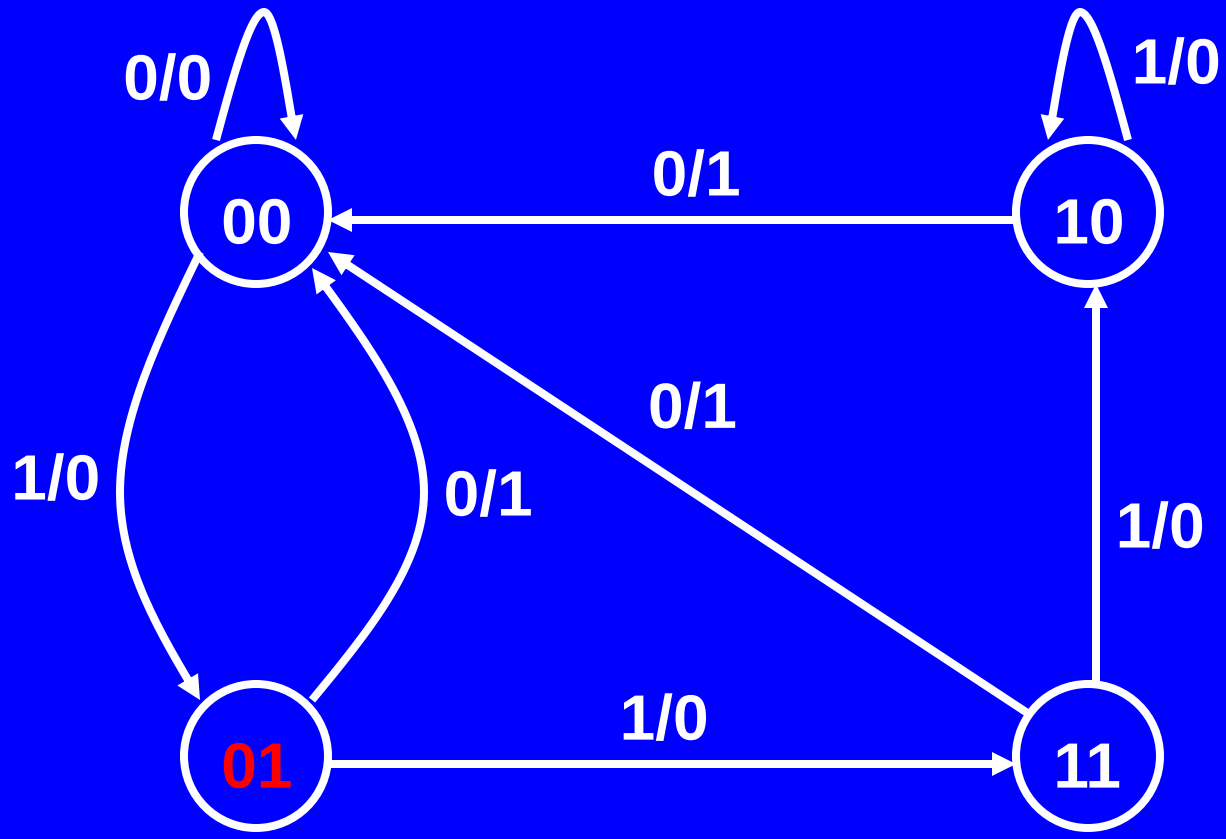
Διάγραμμα καταστάσεων



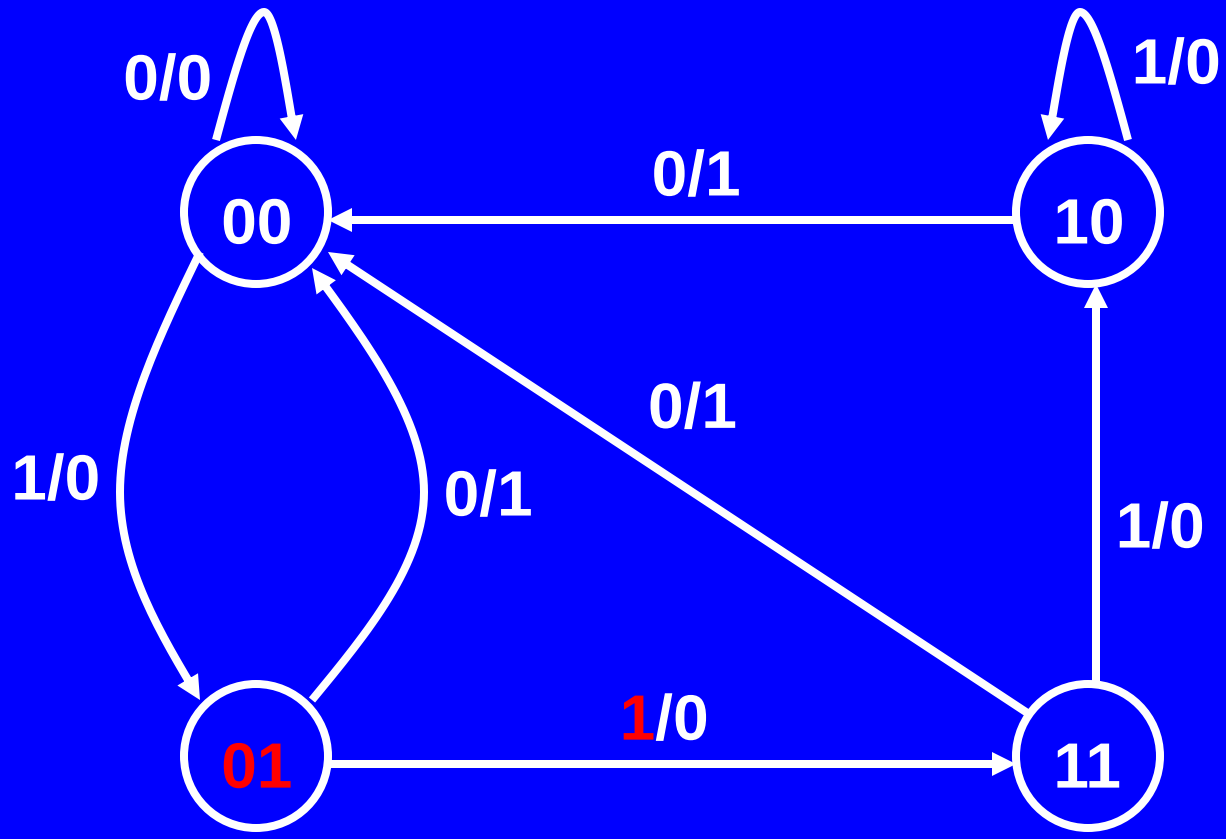
Διάγραμμα καταστάσεων



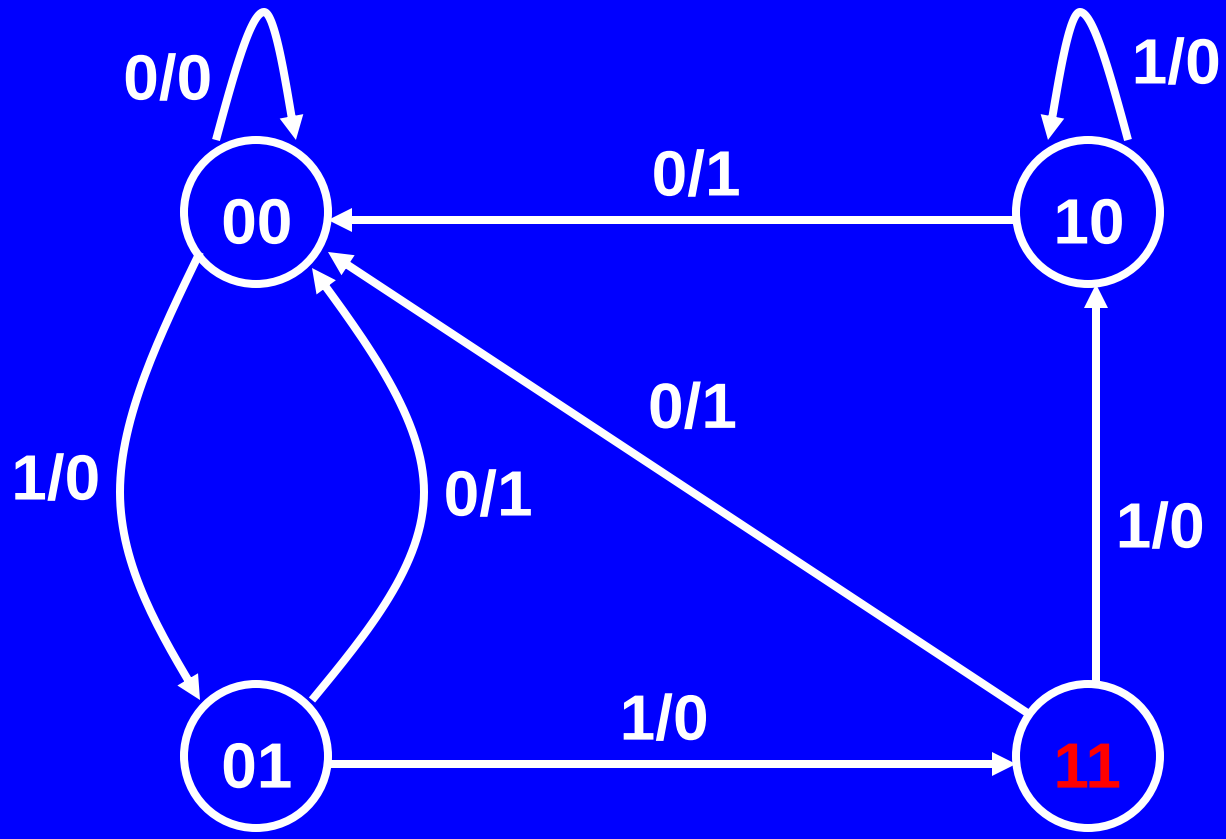
Διάγραμμα καταστάσεων



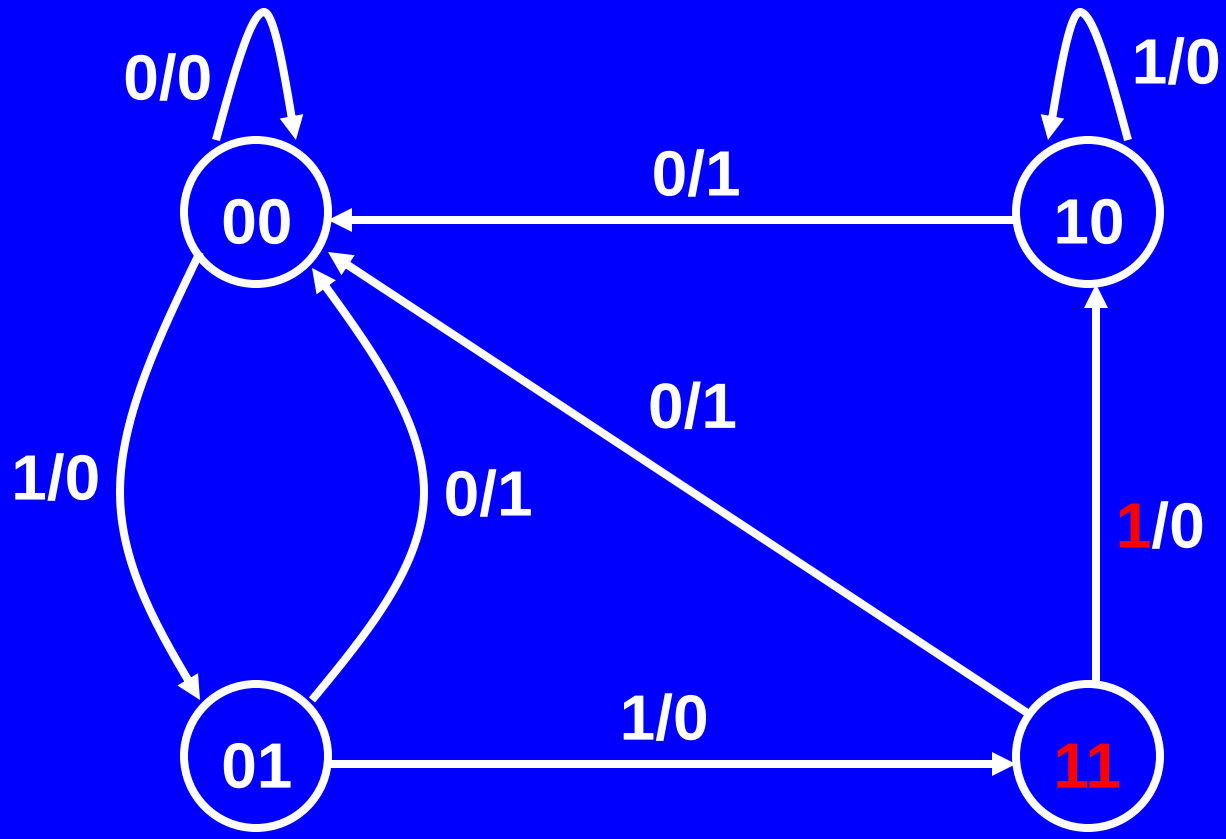
Διάγραμμα καταστάσεων



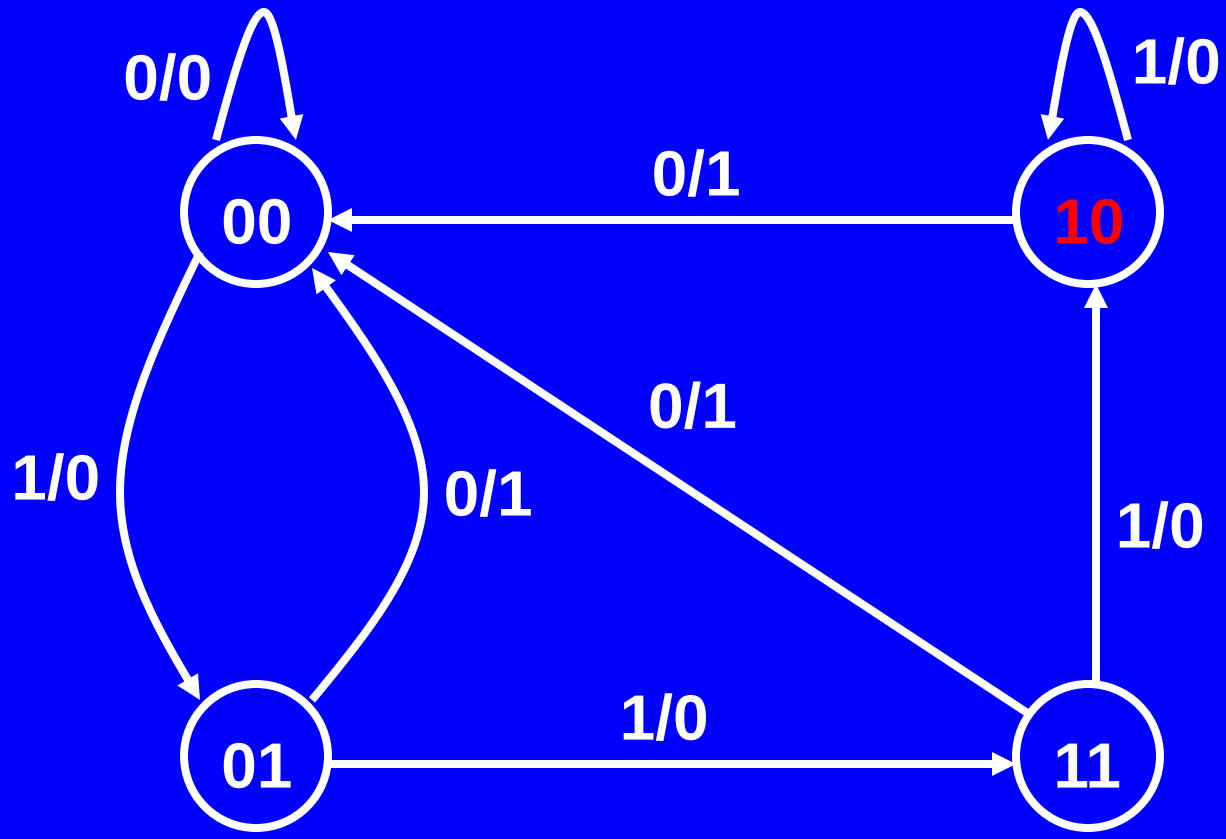
Διάγραμμα καταστάσεων



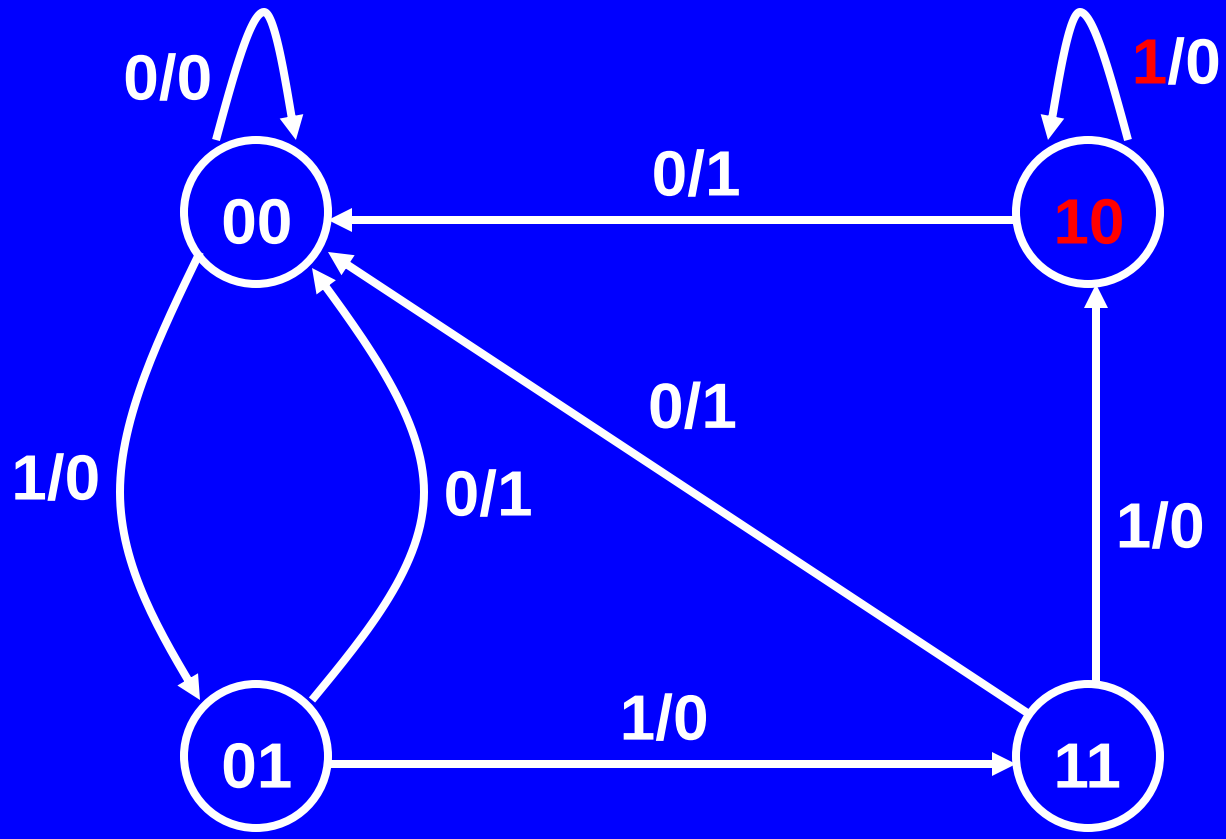
Διάγραμμα καταστάσεων



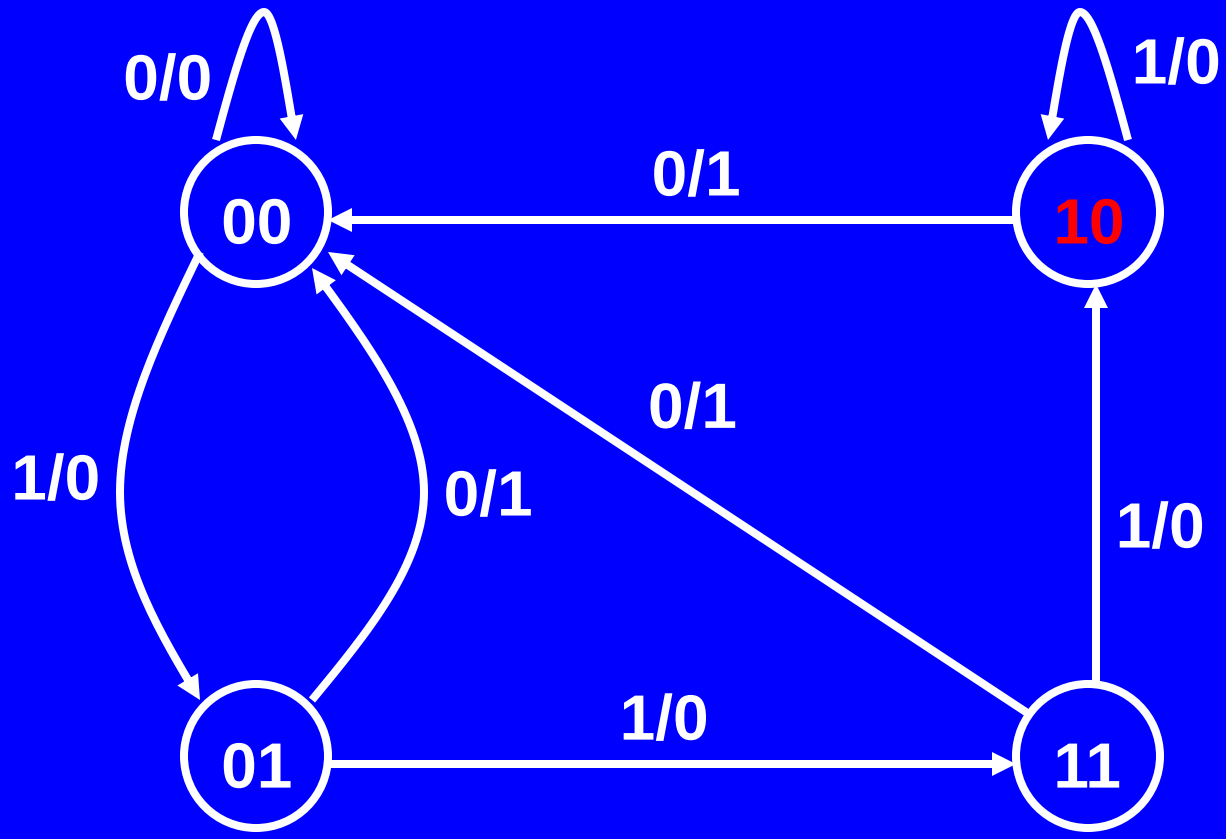
Διάγραμμα καταστάσεων



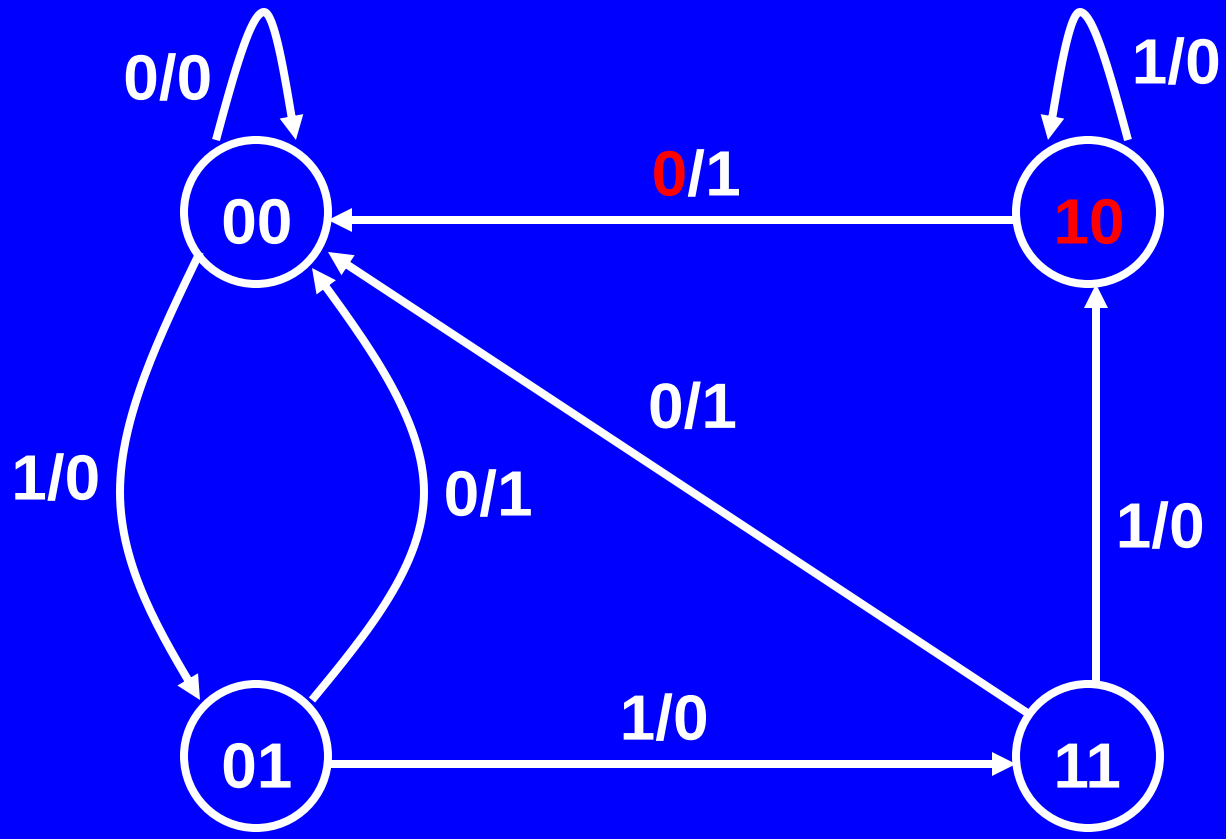
Διάγραμμα καταστάσεων



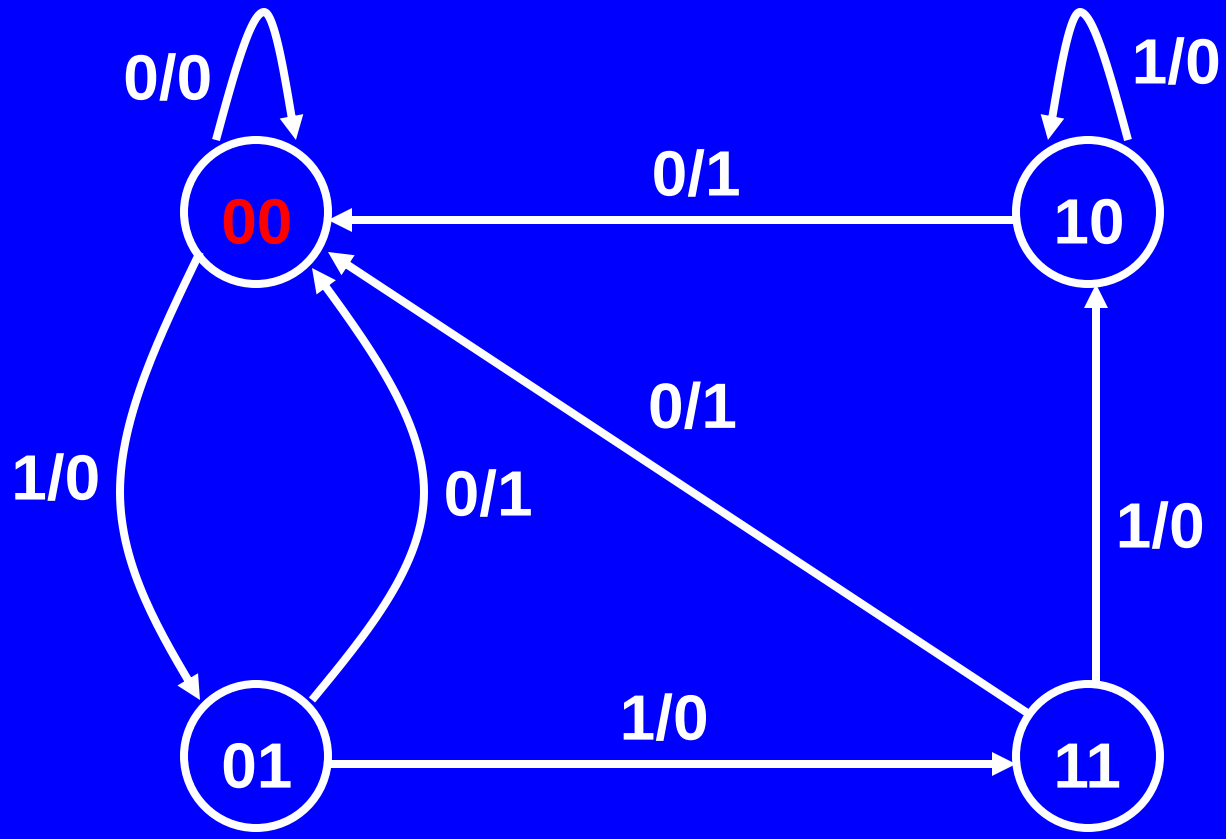
Διάγραμμα καταστάσεων



Διάγραμμα καταστάσεων



Διάγραμμα καταστάσεων



Πίνακες διέγερσης

Q(t)	Q(t+1)	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

Q(t)	Q(t+1)	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Q(t)	Q(t+1)	D
0	0	0
0	1	1
1	0	0
1	1	1

Q(t)	Q(t+1)	T
0	0	0
0	1	1
1	0	1
1	1	0

Σχεδίαση με D latches

Αρχική		Είσοδος	Επόμενη		Είσοδοι D		
A	B	X	A	B	DA	DB	Y
0	0	0	0	1	0	1	0
0	0	1	0	0	0	0	0
0	1	0	1	1	1	1	1
0	1	1	1	0	1	0	0
1	0	0	1	1	1	1	1
1	0	1	1	0	1	0	0
1	1	0	0	0	0	0	1
1	1	1	1	1	1	1	0

DA

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

DB

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

Y

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

DA

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

DA=AB’+AX+A’B

DB

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

Y

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

DA

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

DA=AB’+AX+A’B

DB=B’X’+A’X’+ABX

DB

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

Y

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

DA

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

DA=AB’+AX+A’B

DB=B’X’+A’X’+ABX

Y=AX’+BX

DB

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

Y

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

Πίνακες διέγερσης

Q(t)	Q(t+1)	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

Q(t)	Q(t+1)	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Q(t)	Q(t+1)	D
0	0	0
0	1	1
1	0	0
1	1	1

Q(t)	Q(t+1)	T
0	0	0
0	1	1
1	0	1
1	1	0

Σχεδίαση με JK latches

Q(t)	Q(t+1)	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Αρχική		Είσοδος	Επόμενη		Είσοδοι JK			
A	B	X	A	B	JA	KA	JB	KB
0	0	0	0	1	0	X	1	X
0	0	1	0	0	0	X	0	X
0	1	0	1	1	1	X	X	0
0	1	1	1	0	1	X	X	1
1	0	0	1	1	X	0	1	X
1	0	1	1	0	X	0	0	X
1	1	0	0	0	X	1	X	1
1	1	1	1	1	X	0	X	0

JA

A \ BX	00	01	11	10
0	0	0	1	1
1	X	X	X	X

KA

A \ BX	00	01	11	10
0	X	X	X	X
1	0	0	1	0

JB

A \ BX	00	01	11	10
0	1	0	X	X
1	1	0	X	X

KB

A \ BX	00	01	11	10
0	X	X	1	0
1	X	X	0	1

JA

A \ BX	00	01	11	10
0	0	0	1	1
1	X	X	X	X

JA=B

KA

A \ BX	00	01	11	10
0	X	X	X	X
1	0	0	1	0

KA=BX

JB

A \ BX	00	01	11	10
0	1	0	X	X
1	1	0	X	X

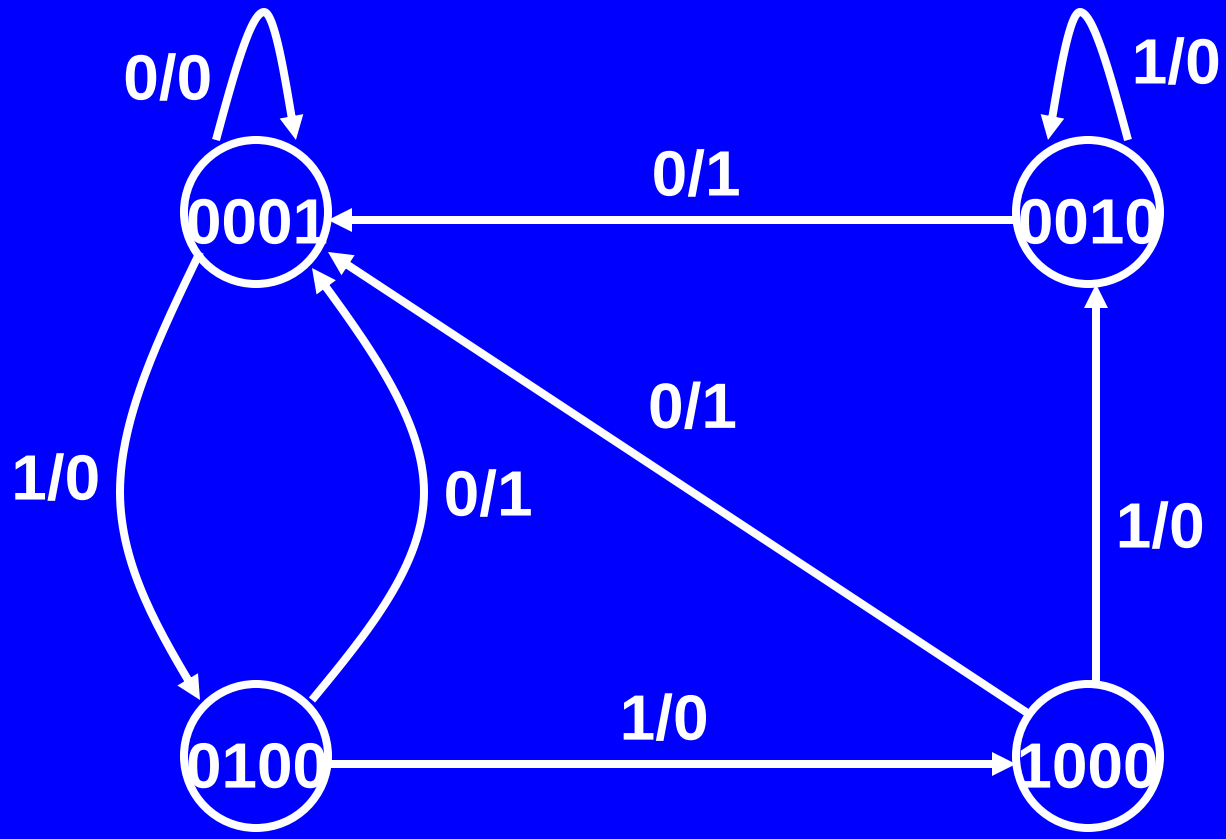
JB=X’

KB

A \ BX	00	01	11	10
0	X	X	1	0
1	X	X	0	1

KB=A’X+AX’

Διάγραμμα καταστάσεων one-hot



Σχεδίαση one-hot

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
0	0	0	1	0	0	0	0	1
0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	1
0	0	1	0	1	0	0	1	0
0	1	0	0	0	0	0	0	1
0	1	0	0	1	1	0	0	0
1	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	1	0

Σχεδίαση one-hot

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
0	0	0	1	0	0	0	0	1
0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	1
0	0	1	0	1	0	0	1	0
0	1	0	0	0	0	0	0	1
0	1	0	0	1	1	0	0	0
1	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	1	0

DA=BX

Σχεδίαση one-hot

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
0	0	0	1	0	0	0	0	1
0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	1
0	0	1	0	1	0	0	1	0
0	1	0	0	0	0	0	0	1
0	1	0	0	1	1	0	0	0
1	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	1	0

DA=BX

DB=DX

Σχεδίαση one-hot

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
0	0	0	1	0	0	0	0	1
0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	1
0	0	1	0	1	0	0	1	0
0	1	0	0	0	0	0	0	1
0	1	0	0	1	1	0	0	0
1	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	1	0

DA=BX

DB=DX

DC=CX+AX

Σχεδίαση one-hot

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
0	0	0	1	0	0	0	0	1
0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	1
0	0	1	0	1	0	0	1	0
0	1	0	0	0	0	0	0	1
0	1	0	0	1	1	0	0	0
1	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	1	0

DA=BX

DB=DX

DC=(C+A)X

Σχεδίαση one-hot

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
0	0	0	1	0	0	0	0	1
0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	1
0	0	1	0	1	0	0	1	0
0	1	0	0	0	0	0	0	1
0	1	0	0	1	1	0	0	0
1	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	1	0

DA=BX

DB=DX

DC=(C+A)X

DD=AX'+BX'
+CX'+DX'

Σχεδίαση one-hot

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
0	0	0	1	0	0	0	0	1
0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	1
0	0	1	0	1	0	0	1	0
0	1	0	0	0	0	0	0	1
0	1	0	0	1	1	0	0	0
1	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	1	0

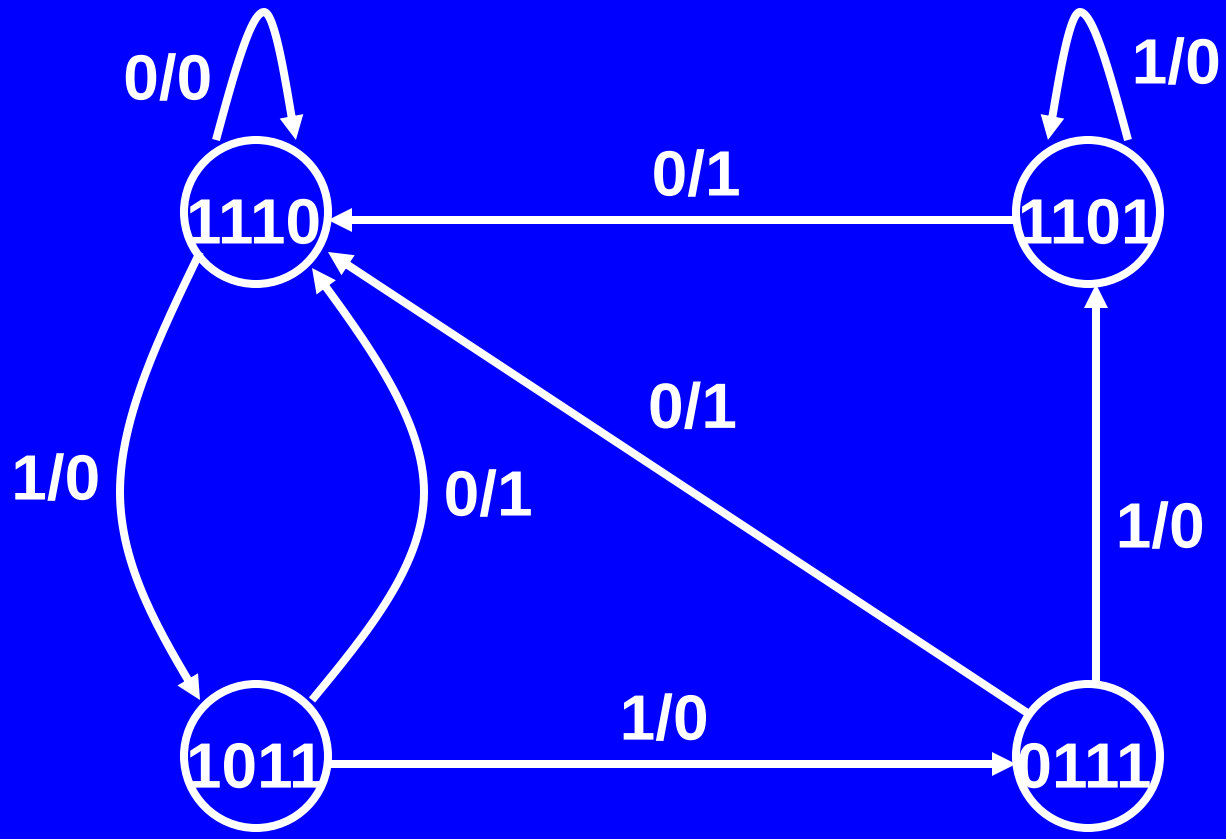
DA=BX

DB=DX

DC=(C+A)X

DD=X’

Διάγραμμα καταστάσεων one-cold



Σχεδίαση one-cold

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
1	1	1	0	0	1	1	1	0
1	1	1	0	1	1	0	1	1
1	1	0	1	0	1	1	1	0
1	1	0	1	1	1	1	0	1
1	0	1	1	0	1	1	1	0
1	0	1	1	1	0	1	1	1
0	1	1	1	0	1	1	1	0
0	1	1	1	1	1	1	0	1

Σχεδίαση one-cold

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
1	1	1	0	0	1	1	1	0
1	1	1	0	1	1	0	1	1
1	1	0	1	0	1	1	1	0
1	1	0	1	1	1	1	0	1
1	0	1	1	0	1	1	1	0
1	0	1	1	1	0	1	1	1
0	1	1	1	0	1	1	1	0
0	1	1	1	1	1	1	0	1

DA=B+X’

Σχεδίαση one-cold

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
1	1	1	0	0	1	1	1	0
1	1	1	0	1	1	0	1	1
1	1	0	1	0	1	1	1	0
1	1	0	1	1	1	1	0	1
1	0	1	1	0	1	1	1	0
1	0	1	1	1	0	1	1	1
0	1	1	1	0	1	1	1	0
0	1	1	1	1	1	1	0	1

DA=B+X’

DB=D+X’

Σχεδίαση one-cold

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
1	1	1	0	0	1	1	1	0
1	1	1	0	1	1	0	1	1
1	1	0	1	0	1	1	1	0
1	1	0	1	1	1	1	0	1
1	0	1	1	0	1	1	1	0
1	0	1	1	1	0	1	1	1
0	1	1	1	0	1	1	1	0
0	1	1	1	1	1	1	0	1

DA=B+X’

DB=D+X’

DC=(C+X’)
(A+X’)

Σχεδίαση one-cold

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
1	1	1	0	0	1	1	1	0
1	1	1	0	1	1	0	1	1
1	1	0	1	0	1	1	1	0
1	1	0	1	1	1	1	0	1
1	0	1	1	0	1	1	1	0
1	0	1	1	1	0	1	1	1
0	1	1	1	0	1	1	1	0
0	1	1	1	1	1	1	0	1

DA=B+X’

DB=D+X’

DC=X’+AC

Σχεδίαση one-cold

Αρχική					Επόμενη			
A	B	C	D	X	A	B	C	D
1	1	1	0	0	1	1	1	0
1	1	1	0	1	1	0	1	1
1	1	0	1	0	1	1	1	0
1	1	0	1	1	1	1	0	1
1	0	1	1	0	1	1	1	0
1	0	1	1	1	0	1	1	1
0	1	1	1	0	1	1	1	0
0	1	1	1	1	1	1	0	1

DA=B+X’

DB=D+X’

DC=X’+AC

DD=X