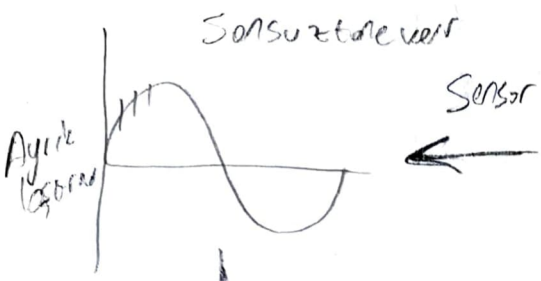
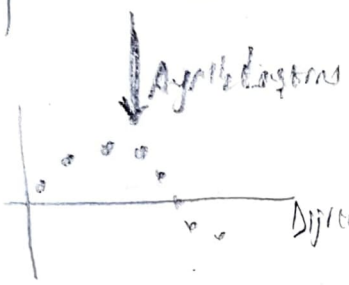
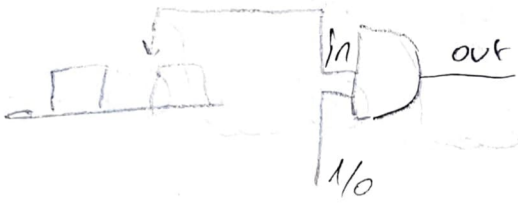
SDT

$A = 65 = 01000001$







1- Mantık Devreleri
Hüseyin Ekiz
(Değişkem yayınla)

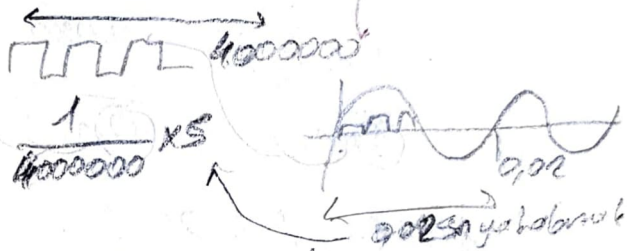
2- Lojik Devre Tasarımı
Bilal Coşkesen
(Paparya)

Sayı sistemleri (Konsept)

Kod sistemleri

Değişkenler

Mikroişlemci Min Kalbi → 4MHz



Sayı Sistemleri: Decimal, Binary, Okta, Hexadecimal

Onluk (Decimal) Sayı Sistemi:

$D = d_n \cdot 10^n + d_{n-1} 10^{n-1} + \dots + d_2 10^2 + d_1 10^1 + d_0 10^0, \; d_1 10^{-1} + d_2 10^{-2} + \dots$

$23,54 = 2.10^1 + 3.10^0, \; 5.10^{-1} + 4.10^{-2}$

İkilik Sayı Sistemi:

$D = d_n 2^n + d_{n-1} 2^{n-1} + \dots + d_1 2^1 + d_0 2^0, \; d_1 2^{-1} + d_2 2^{-2} + \dots$

$10101100 = 181$

(MSB) Most Significant Bit (En önemli bit)

(LSB) Least Significant Bit (En önemsiz Bit)

$\Rightarrow 1011$

$D = 1.2^4 + 1.2^3 + 0.2^2 + 1.2^1 + 1.2^0$

Onluk	Ikilik
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

$(110)_2 = (\#)_{10}$

$\# = 6 \quad 2 = 1.2^2 + 1.2^1 + 0.2^0$

Onluk Sayı sistemden İkilik Sayı Sistemine Geçiş

$\Rightarrow (23)_{10} = (x)_2$

Bölünen	Bölüm	Kalan
23/2	11	1
11/2	5	1
5/2	2	1
2/2	1	0

$x = 10111$

11000

Pratik Yol;

x_5	x_4	x_3	x_2	x_1	x_0
0	1	0	1	1	1
32	16	8	4	2	0

$\Rightarrow (23,540)_{10} = (x)_2$

10111,

0,540 · 2 = 1,080

0,080 · 2 = 0,160

0,160 · 2 = 0,320

0,320 · 2 = 0,640

0,640 · 2 = 1,280

10111, 10001 ...

$\Rightarrow (41,6875)_{10} = (x)_2$

101001, 0,6875 · 2 = 1,3750 (2)

0,3750 · 2 = 0,7500 (2)

0,7500 · 2 = 1,5000 (2)

0,5000 · 2 = 1,0000 (3)

$x = (101001,1011)_2$

Oktav (Sekizlik Sayı Sistemi)

$(N)_8 = d_n 8^n + d_{n-1} 8^{n-1} + \dots + d_1 8^1 + d_0 8^0$

$\Rightarrow (23)_8 = 2 \cdot 8^1 + 3 \cdot 8^0 = (19)_{10}$

$\Rightarrow (154)_{10} = (x)_8$

Bölünen	Bölüm	Kalan
154/8	19	2
19/8	2	3

$x = (232)_8$

$\Rightarrow (10111001)_2 = (x)_8$

2 7 1

$(271)_8$

[8'den 2'ye gelerken tam tersi yapılır]

[8'li sayı sisteminde en fazla 7 olduğundan yedide 111 temsil ediyor. Yani 3 bit. Bizde 3'lü paketler halinde gelmiştir]

$\Rightarrow (153,375)_{10} = (x)_8$

Bölünen	Bölüm	Kalan
153/8	19	1
19/8	2	3

0,375 · 8 = 3,000

$x = (231,3)_8$

Hexadecimal (Ondalıklı) Sayı Sistemi

0, 1, 2, 3, 4, ..., 8, 9, A, B, C, D, E, F
(A → 10, F → 15)

⇒ $(54)_{16} = (x)_{10}$
$= 5.16^1 + 4.16^0$
$= 84$

⇒ $(ABC)_{16} = (X)_{10}$
$= A.16^2 + B.16^1 + C.16^0$
(A → 10, B → 11, C → 12)

⇒ $(1233)_{10} = (x)_{16}$
1233/16 → 77, 1
77/16 → 4, 13

$x = (4D1)_{16}$

⇒ $10,975 = (x)_{16}$
10 → A

0,975 × 16 = 15,6
0,6 × 16 = 9,6
0,6 × 16 = 9,6

A,F99...

⇒ 0011101101110101 1110
(3 B 7 5 E $)_{16}$

[1111 = 15 olduğundan 4 bittir. Yani 4'lü paketler halinde]

8'li → 16'lı Sayı Sistemine Geçiş
1. Yöntem → 8 → 10'lu → 16
2. Yöntem → 8 → 2 → 16

⇒ $(645)_8 = (x)_{16}$
(110 100 $101)_2$

$(110100101)_2$
1 A 5
$(1A5)_{16}$

16'lı → 8'li Sayı Sistemine Geçiş

⇒ $(EOCA)_{16} = (x)_8$
1110 0000 1100 1010

$(1110000011001010)_2$
1 6 0 3 1 2
$x = (160312)_8$

İkili Sayı Sisteminde Toplama
0+0=0
0+1=1
1+0=1
1+1=0 (elde var 1)

```
if((a==5) || (c==2))
    Console.WriteLine("a");
if(true)        if(1)
```

veya işlemi → +
ve işlemi → *
ve

While (x<5) while(true)

İkilik Sayı Sisteminde Çıkarma

0-0=0
1-0=1
1-1=0
0-1=0 (elde var 1)

TÜMLEYENLER

1 r'nin tümleyeni
2 r-1'in tümleyeni

r'nin tümleyeni; r tabanlı bir sayı sisteminde, n basamaklı pozitif bir tam sayı N ile temsil edilirse, N sayısının r tümleyeni $r^n - N$ dir.

⇒ $(52520)_{10}$ r=10 10'a tümleyeni → $10^5 - 52520 = 47480$

⇒ $(0,3267)_{10}$ r=10 // // → $10^0 - 0,3267 = 0,6733$

⇒ $(25,639)_{10}$ r=10 // // → $10^2 - 25,639 = 74,361$

⇒ $(43)_5$ → r tümleyeni → $5^2 - (43)_5 =$

⇒ $(101100)_2$ → r tümleyeni (2ye tümleyeni) → $r^n - N$ → $2^6 - 101100$

1000000
- 101100
= 010100

Kısa Yol; En düşük değerlikli sıfırları ve sıfırdan farklı ilk hariçi olduğu gibi bırak diğer bitleri ters

⇒ $(0,0110)_2$ → 0,1010

"r" tümleyeni ile Çıkarma işlemi

M-N=?

1. Adım M'yi N sayısının r tümleyeni ile topla

2.adım a) Elde var ise eldeyi at (sonuç)

b) Elde yok ise sonucun r tümleyeni al ve başına (-) işaretini koy.

⇒ M=72532 , N=03250 (DİKKAT) M-N=? ⇒ $M+N^T$

$N^T = 10^5 - 3250 = 96750$

$M+N^T$ = 72532
+ 96750
= 1|69282

At ← 1

= 69282

⇒ $M = 3250$ $N = 72532$ $M - N = ?$

$N^T = 10^5 - 72532 = 27468$

$M + N^T = 03250$
$+ 27468$
$030718 = S$

$S^T = (-) 10^5 - 30718 = -69282$

⇒ $M = (1010100)_2$, $N = (1000100)_2$ $M - N = M + N^T$

$N^T = 0111100$
$+ M = 1010100$
$1|0010000$

Sonuç pozitif

$(84)_{10}$, $(68)_{10}$ > 2 tabanı çevirmece (2'lik tümleyen de bul)

$M = 1000100$
$N = 1010100$

$N^T = 0101100$
$M = 1000100$
$0|1110000$ = (-)0010000

Elde yok, Tümleyen al.

"r-1" Tümleyeni

$r^n - r^{-m} - N$ → ondalık basamak sayısı

⇒ $(52520)_{10} = 10^5 - 10^0 - 52520$
$= 47479$

[r-1 tümleyen demek bu sorular için 9'a tümleyen demek]

⇒ $(0,3267)_{10} = 10^0 - 10^{-4} - 0,3267$
$= 0,9999 - 0,3267$
$= 0,6732$

⇒ $(101100)_2$ r-1'e tümleyen → 1'e tümleyen
$= 2^6 - 2^0 - 101100$
$= (1000000 - 1) - 101100$
$= 111111 - 101100$
$= (010011)_2$

⇒ $(0,0110)_2$ → $(r-1)^T = ?$

$2^0 - 2^{-3} - 0,0110$

$(1 - 2^{-3}) - 0,0110$

$= 0,1111$

1'e tamleyen için kısa yol; Her haneyi tersle $\begin{cases} 1001100 \\ 0110011 \end{cases}$

r-1 ile çıkarma işlemi $M-N=?$

1-M'yi N sayısının (r-1) tamleyeni ile topla $M+N^T_{(r-1)}$

2-Elde varsa eldeyi at, En düşük değerlikli haneye +1 ekle
Elde yoksa r-1 tamleyeni al ve (-) koy

⇒ $M = 72532 \quad N = 03250$ (Dikkat)

99999

$N^T_{(r-1)} = 10^5 - 10^0 - 03250$

$= 96749$

$M + N^T_{(r-1)} = 72532 + 96749 = 169281$

$169281 + 1 = 69282$

⇒ $M = (1000100)_2 \quad N = (1010100)_2$ 1'e tamleyen ile çıkar

$M - N = M + N^T_{(r-1)}$

$N^T_{(r-1)} = 0101011$

$M = 1000100$

$0\,1101111$

eldeyi at (r-1) tamleyeni al

$= -(0010000)_2$

KODLAMA

a → 1000000
e → 88888
i →
⋮
x → 15

0
1
01
11
⋮

a sayısı / Tüm harfler = a'nın olasılığı

BCD KODU

Her basamak 4 bit ile temsil edilir

$(235)_{10} = (0010\ 0011\ 0101)_{BCD}$

"Binary Coded Decimal"

+3 KODU

4 haneli

$\Rightarrow (48)_{10} = (0111\ 1011)_{+3\text{ kodu}}$

+3 / +3

7 / 11

[Huffman Kodları ? Hareket dengelenoli ara derleme]

5'te 2 KODU {7, 4, 2, 1, 0}

	7	4	2	1	0		7	4	2	1	0
0	1	1	0	0	0	5	0	1	0	1	0
1	0	0	0	1	1	6	0	1	1	0	0
2	0	0	1	0	1	7	1	0	0	0	1
3	0	0	1	1	0	8	1	0	0	1	0
4	0	1	0	0	1	9	1	0	1	0	0

[Şart her sayıda iki tane 1 olacak (sıfır istisna)]

"Doğrulama kodu"

AIKEN KODU (2421)

	2	4	2	1		2	4	2	1
0	0	0	0	0	5	1	0	1	1
1	0	0	0	1	6	1	1	0	0
2	0	0	1	0	7	1	1	0	1
3	0	0	1	1	8	1	1	1	0
4	0	1	0	0	9	1	1	1	1

Sağ taraflı 1'le — Sol taraflı 1'le

GRAY KODU

AB \ CD	00	01	11	10
00	0	1	2	3
01	7	6	5	4
11	8	9	10	11
10	15	14	13	12

ABCD

0000 – 0
0001 – 1
⋮
0110 – 6
0111 – 7
⋮
1010 – 10

(Decimal) → GRAY kodu

0 → 0000
1
2 → 0011
3
4
5
9 → 1101
⋮
15 → 1000

[Haftaya sistemler]

İkili sistemden Gray kodu'na geçiş.
En başta 1 tane 0 olduğu kabul edilir. Her bit sağındaki ile toplanarak yazılır.

$0(10111010)_2$ — eldeyok

$(11100111)_{\text{gray kodu}}$

Gray kodundan 2'lik sisteme geçiş

$(11100111)_{gray}$

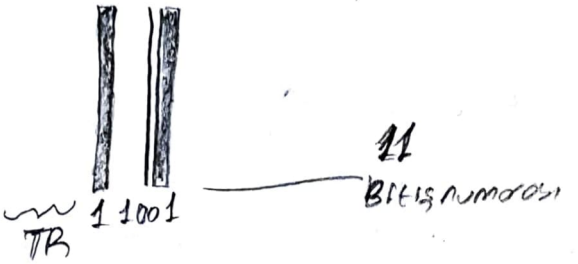
10111010

en soldaki bit aşağı indirilir. İndirilen bit bir sonraki bit ile toplanır.

eleyok

BARCODE

Geniş boşluk = 1
Geniş çubuk = 1
Dar çubuk = 0
Dar boşluk = 0



LOJİK KAPILAR

VE KAPISI (AND KAPISI) (7408 Entegresi)

İki biti çarpar

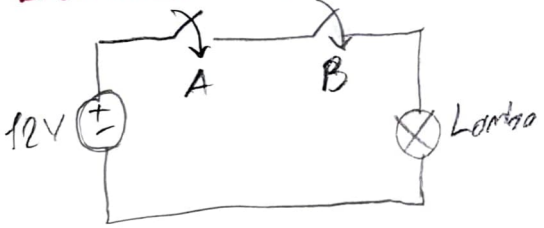
$Q = A \cdot B$

(Boolean ifadesi)

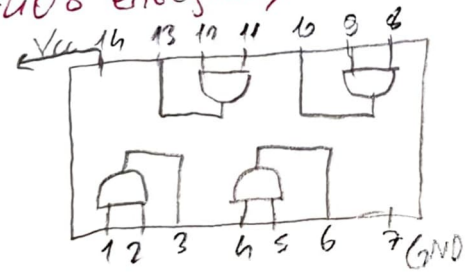
Doğruluk Tablosu

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

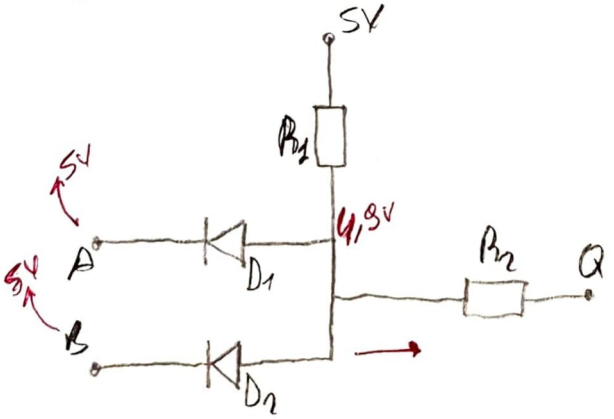
Elektriksel eşdeğer devresi;

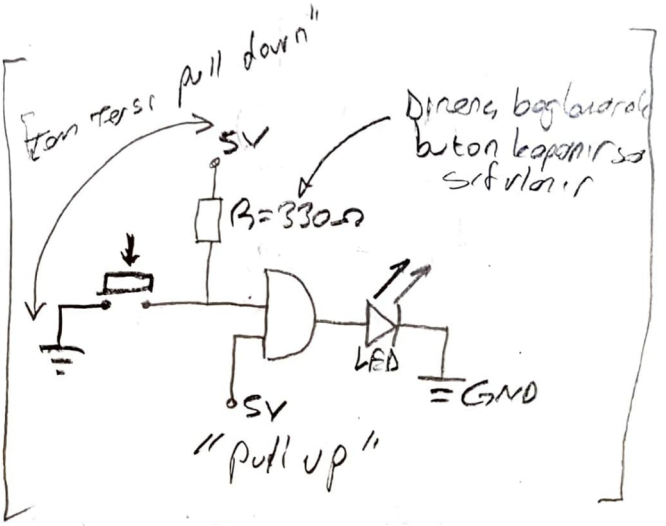


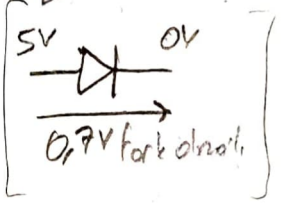
7408 entegresi;



Diyotlarla nasıl yapılır;

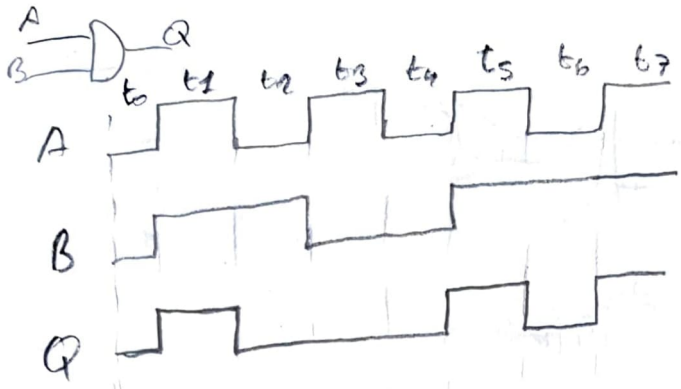






A	B	C	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

3 bacak!



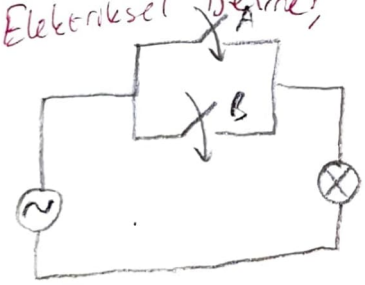

```
a=5; b=3;                    1
if[(a==5) ve ya (b==3)]
{
  Console.WriteLine(");
}
```

VEYA KAPISI (OR)

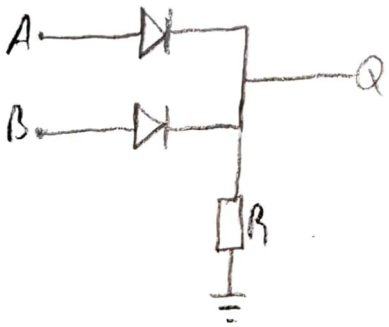
A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

Q = A + B
(Boolean ifadesi)

Elektriksel Devre;



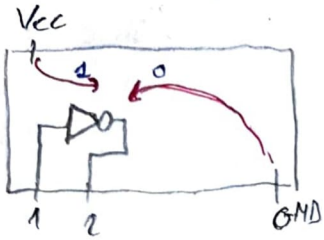
Diyotlar ile;



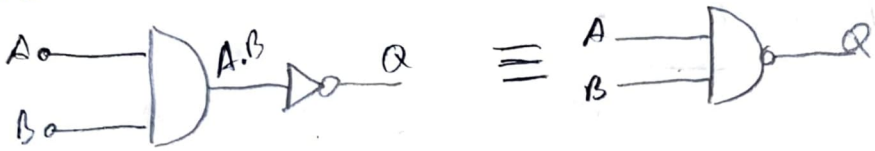
DEĞİL KAPISI (NOT) (7404)

A	Q
1	0
0	1

$Q = \overline{A} = A'$
(Boolean ifadesi)

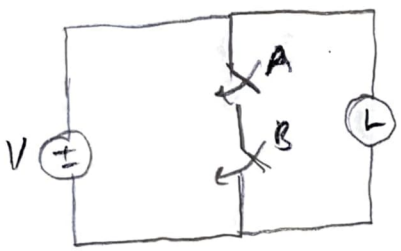


VE DEĞİL KAPISI (NAND)

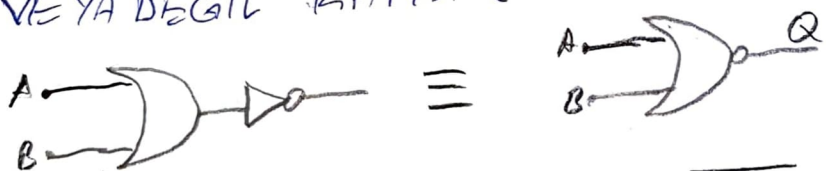


A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

$Q = \overline{AB}$
(Boolean ifadesi)

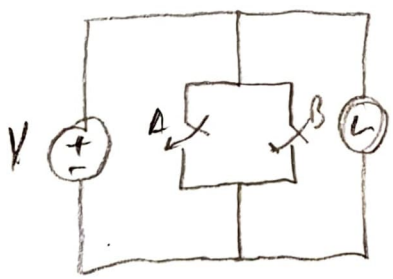


VEYA DEĞİL KAPISI (NOR)



A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

$Q = \overline{(A+B)}$
(Boolean ifadesi)

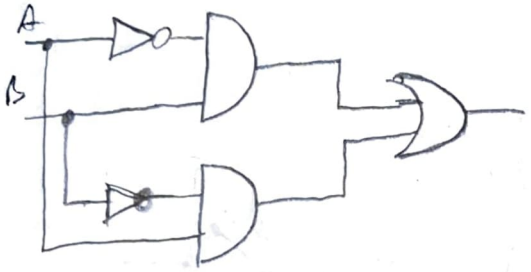


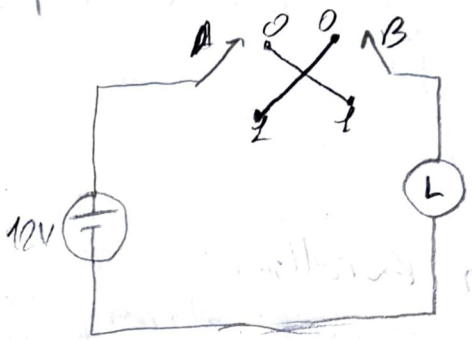
ÖZEL VEYA KAPISI (EXOR)

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

$Q = \bar{A}B + A\bar{B}$

$Q = A \oplus B$ özel gösterim

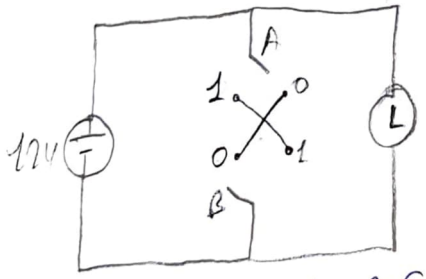




ÖZEL VEYA DEĞİL KAPISI (NEXOR)

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	1

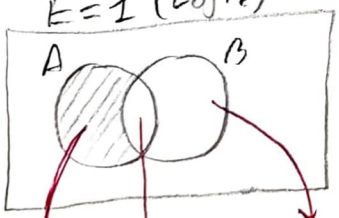
$Q = \bar{A}\bar{B} + AB$



LOJİKTE KÜME KAVRAMI

E = 1 (Lojik)

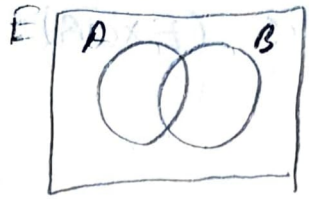
$A \cup B = A + B$



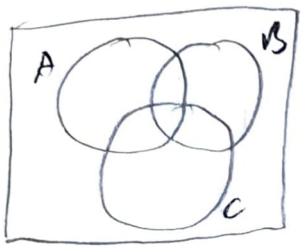
A/B $A \cap B$ B/A

$(A \cap \bar{B}) = A\bar{B}$ AB $B\bar{A}$

$A+\bar{A}=1$
$A.\bar{A}=0$
$1+A=1$
$1.A=A$
$0.A=0$



$AB+A=A$
$A(B+1)=A$
1



$AB+AC=A(B+C)$

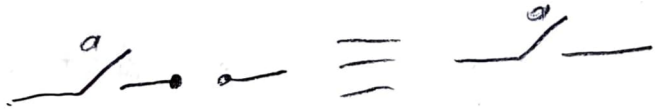
Boolean Kuralları

- Toplamda etkisiz eleman sıfırdır.

$A+0=A$
$0+0=0$
$1+0=1$

- Çarpmada etkisiz eleman birdir.

$A.1=A$
$0.1=0$
$1.1=1$

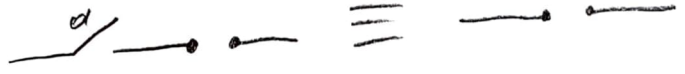


- Toplamada birim eleman

$A+1=1$
$0+1=1$
$1+1=1$

- Çarpmada yutan eleman

$A.0=0$
$0.0=0$
$1.0=0$



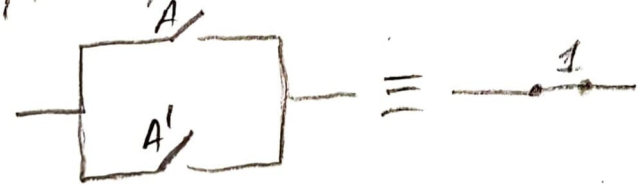
- Ters eleman

$\bar{0}=1$ $\quad \bar{1}=0$
$\bar{E}=0$

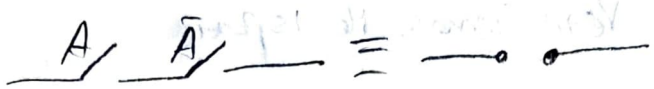
$(A')'=A$

- Toplama ve Çarpma işlemleri

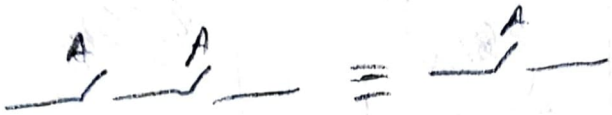
$A+\bar{A}=1$
$0+1=1$
$1+0=1$



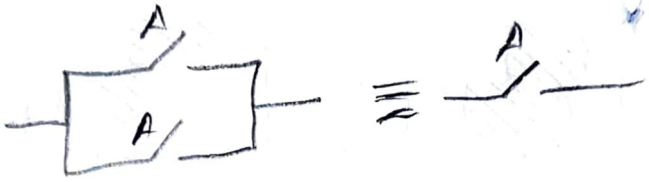
$A.\bar{A}=0$
$0.1=0$
$1.0=0$



$A.A=A$
$0.0=0$
$1.1=1$



$A+A=A$
$0+0=0$
$1+1=1$



Özellikler

1-) Sabit Kuvvetlilik
$A+A=A \quad (A+A+A+\dots+A)=A$
$A.A=A \quad (A.A.A.\dots.A)=A$

2-) Değişim Kanunu
$AB=BA$
$A+B=B+A$

3-) Birleşme Kanunu
$A+(B+C)=(A+B)+C$
$A.(B.C)=(A.B).C$

4-) Dağılma Kanunu
$A.(B+C)=AB+AC$
$*(A+B)(A+C)=A+(B.C)$

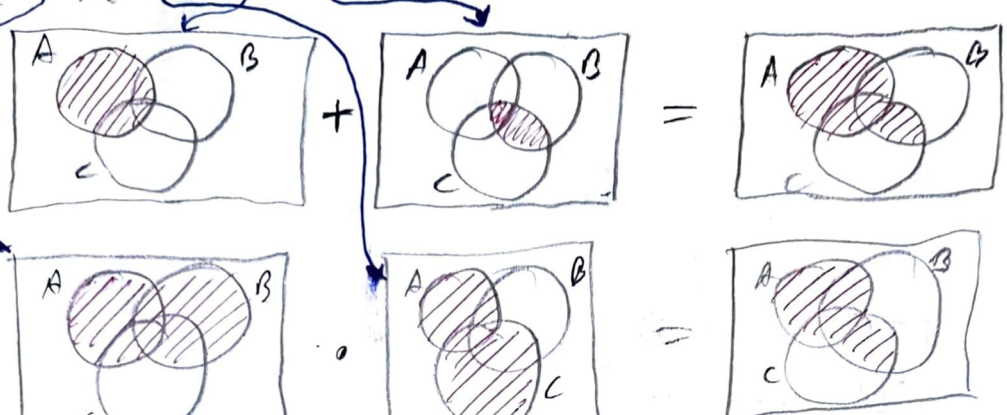
5-) Yutma Kanunu
$A+AB=A(\underbrace{1}_{1}+B)=A$

6-) Basitleşterme Kanunu
$A+\bar{A}B=A+B$
$A(\bar{A}+B)=AB$

7-) De Morgan Kuralı (Eleman sayısın. arttırılabilir)
$\overline{AB}=\bar{A}+\bar{B}$
$\overline{(A+B)}=\bar{A}.\bar{B}$
$\overline{A.B.C}=\bar{A}+\bar{B}+\bar{C}$

Dağılma Özelliğinin Venn Şeması ile İspatı

- $(A+B)(A+C) = A+BC$



$(A+B)(A+C) = A.A + A.C + AB + BC$

$= A(\overbrace{1}^{1} + C + B) + BC$

$= A + BC$

- $\overline{\overline{A+\bar{A}B}}$ iki kez de Morgan al

$\bar{\bar{A}} = A$

$\overline{A+B} = \bar{A}.\bar{B}$

$\overline{AB} = (\bar{A}+\bar{B})$

$\overline{\overline{A+\bar{A}B}} = \overline{\bar{A}.(\overline{\bar{A}B})}$

$= \overline{\bar{A}.(A+\bar{B})}$

$= \overline{\bar{A}.A + \bar{A}\bar{B}}$

$= \overline{\bar{A}\bar{B}}$

$= \bar{\bar{A}} + \bar{\bar{B}}$

$= A+B$

[Bir soru Burada] [Amaç 1'e ulaşmak]

- $\bar{A}\bar{B}C + \bar{A}BC + A\bar{B}$

$= \bar{A}C(\underbrace{\bar{B}+B}_{1}) + A\bar{B}$

$= \bar{A}C + A\bar{B}$

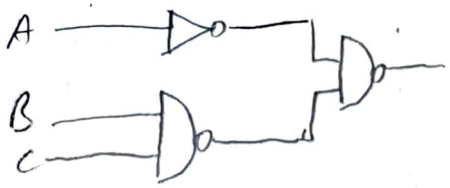
- $AB + \bar{A}C + BC.(\overbrace{A+\bar{A}}^{1})$

$= AB + \bar{A}C + ABC + \bar{A}BC$

$= AB(1+C) + \bar{A}C(1+B)$

$= AB + \bar{A}C$

- Y= $\overline{A(\overline{BC})}$ Sağlık diyagramını çiz, doğruluk tablosunu oluşturun ve de Morgan kurallını uygulayınız?

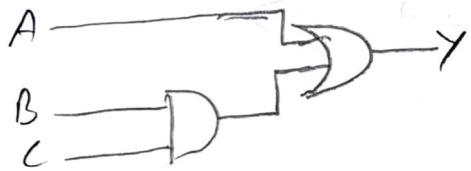


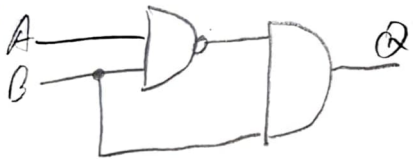
(Lojik diyagramı)

A	B	C	$\bar{A}$	$\bar{B}\bar{C}$	Y
0	0	0	1	1	0
0	0	1	1	1	0
0	1	0	1	1	0
0	1	1	1	0	1
1	0	0	0	1	1
1	0	1	0	1	1
1	1	0	0	1	1
1	1	1	0	0	1

(Doğruluk Tablosu)

$$Y = \overline{\bar{A}(\bar{B}\bar{C})} = \bar{\bar{A}} + \overline{(\bar{B}\bar{C})} = A + BC \quad \text{(De Morgan)}$$



- 

Devreyi sadeleştirin.

$$(\bar{A}.B)B = (\bar{A}+\bar{B}).B$$
$$= \bar{A}B + B.\bar{B}$$
$$= \bar{A}B$$

- $Q = \overline{\bar{A}+\bar{B}+\bar{C}}$
  $= ABC$
- $X = \overline{A\bar{B}(A+C)} + (\bar{A}B).\overline{(A+\bar{B}+\bar{C})}$

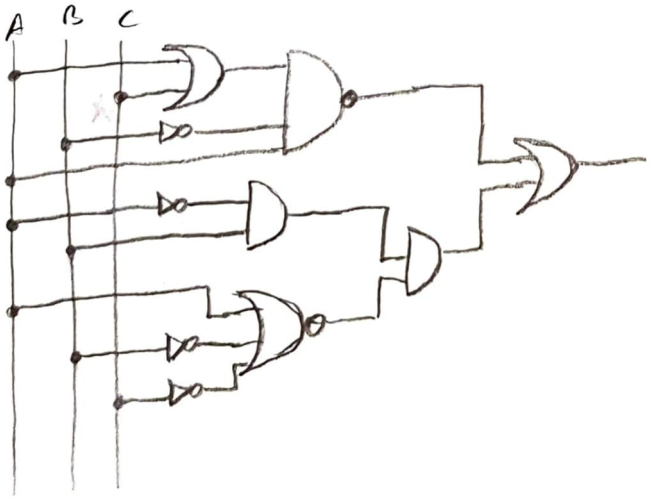
de morgan ile sadeleştirin.

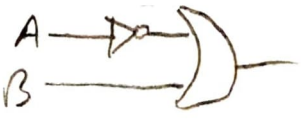
$$X = \bar{A} + B + (A+C) + (\bar{A}B)(\bar{A}.B.C)$$
$$X = \bar{A} + B + \bar{A}\bar{C} + \bar{A}.\bar{A}.B.\bar{B}.C$$
$$\bar{A}B.C$$

$\bar{A}\bar{C} \neq \bar{A}\bar{C}$

$$X = \bar{A} + B + \bar{A}\bar{C} + \bar{A}BC$$
$$X = \bar{A}(1 + \bar{C} + BC) + B$$

$$\boxed{X = \bar{A} + B}$$





Minterm ve Maksterm

X	Y	minterm	İndis	maksterm	İndis
0	0	$\bar{X}\bar{Y}$	m_0	$X+Y$	M_0
0	1	$\bar{X}Y$	m_1	$X+\bar{Y}$	M_1
1	0	$X\bar{Y}$	m_2	$\bar{X}+Y$	M_2
1	1	XY	m_3	$\bar{X}+\bar{Y}$	M_3
		karakterli		değişkenli	

Minterm → carp → 1 olsun
Maksterm → topla → 0 olsun

Minterm indis bulmak için X ve Y nin değerine 1 bak
Maksterm için ise 0 bak
$\bar{X}Y \Rightarrow \bar{1}1 = 01 = 1 \rightarrow m_1$

A	B	C	minterm	İndis	maksterm	İndis
0	0	0	$\bar{A}\bar{B}\bar{C}$	m_0	$A+B+C$	M_0
0	0	1	$\bar{A}\bar{B}C$	m_1	$A+B+\bar{C}$	M_1
0	1	0	$\bar{A}B\bar{C}$	m_2	$A+\bar{B}+C$	M_2
0	1	1	$\bar{A}BC$	m_3	$A+\bar{B}+\bar{C}$	M_3
1	0	0	$A\bar{B}\bar{C}$	m_4	$\bar{A}+B+C$	M_4
1	0	1	$A\bar{B}C$	m_5	$\bar{A}+B+\bar{C}$	M_5
1	1	0	$AB\bar{C}$	m_6	$\bar{A}+\bar{B}+C$	M_6
1	1	1	ABC	m_7	$\bar{A}+\bar{B}+\bar{C}$	M_7

⇒ Veya işlemine ait minterm kanonik biçimini elde edin?

A	B	Q=F	minterm
0	0	0	$\bar{A}\bar{B} \rightarrow m_0$
0	1	1	$\bar{A}B \rightarrow m_1$
1	0	1	$A\bar{B} \rightarrow m_2$
1	1	1	$AB \rightarrow m_3$

1 1 0 0 A
1 0 1 0 B
→ F

$F = \bar{A}B + A\bar{B} + AB$

(Çarparsak sadece 11 kalır olur)

$F = \sum(m_1, m_2, m_3) = \sum(1,2,3)$

$F = m_1 + m_2 + m_3$

- Minimum terimlerin kanonik biçimine ilişkin ifade yazdırılan işlem sonucunun lojik ifadesinde 1 olan minterimler değerlendirilir ve bu terimlerin toplamı kanonik biçimini oluşturur.

A	B	Q
0	0	0
0	1	0
1	0	1
1	1	1 → AB

$F = A\bar{B} + A\bar{B}$

$F = \sum(2,3) = \sum(m_3, m_2)$

⇒ $F = \bar{a}b + \bar{a}c$ mintermleri kanonik biçimde elde edin?

A	B	C	F
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

m_0
$m_1 = \bar{A}\bar{B}C$
m_2
$m_3 = \bar{A}BC$
m_4
m_5
$m_6 = AB\bar{C}$
$m_7 = ABC$

$F = \sum(1,3,6,7)$ ★

$F = \bar{A}\bar{B}C + \bar{A}BC + AB\bar{C} + ABC$

⇒ Ve işlemine ait Maxterm kanonik biçimini elde edelim.

A	B	Q	
0	0	0	$M_0 = A+B$
0	1	0	$M_1 = A+\bar{B}$
1	0	0	$M_2 = \bar{A}+B$
1	1	1	$M_3 = \bar{A}+\bar{B}$

- Maksterlerin kanonik biçimine ilişkin ifade yazılırken işlem sonucunun lojik ifadesinde sıfır olan maksterimler değerlendirilir ve bu terimlerin çarpımı maxtermlerin kanonik biçimini oluşturur.

$$F = (A+B)(A+\bar{B})(\bar{A}+B)$$

$$F = \Pi(0,1,2)$$

$$F = \Pi(M_0, M_1, M_2)$$

⇒ Bir önceki sorunun maxterm kanonik biçimini oluşturun.

$$F_{md} = \Pi(0,2,4,5) \star$$

$$F_{MD} = (A+B+C).(A+\bar{B}+C)(\bar{A}+B+C)(\bar{A}+B+\bar{C})$$

⇒ $F = A+\bar{B}C$ doğruluk tablosu oluşturmadan eleman ekleyerek minterimlerin kanonik biçimini oluşturunuz.

$F = A + \bar{B}C$

$A = A.(B+\bar{B}) = AB+A\bar{B}$ ($B+\bar{B} = 1$)

$\bar{B}C = \bar{B}C(A+\bar{A}) = A\bar{B}C + \bar{A}\bar{B}C$ ($A+\bar{A} = 1$)

$(AB+A\bar{B})(C+\bar{C}) = ABC+AB\bar{C}+A\bar{B}C+A\bar{B}\bar{C}$

$F = ABC+AB\bar{C}+A\bar{B}C+A\bar{B}\bar{C}+\bar{A}\bar{B}C$

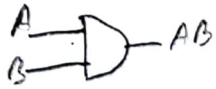
$F = \Sigma(7,6,5,4,1)$

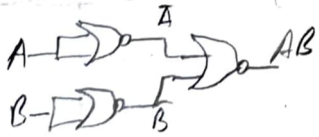
Temel lojik elemanların ve değil / veya değil ile oluşturulması

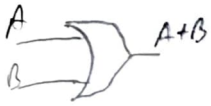
Temel Lojik Elemanların vedeğil / veyadeğil ile oluşturulması.

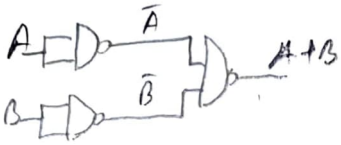
TLE | **NAND** | **NOR**

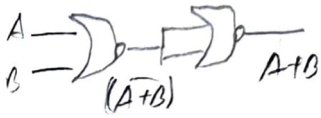
$(\bar{A}+\bar{B}) = AB$

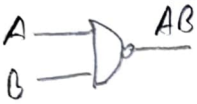


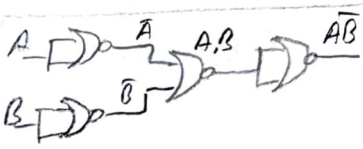


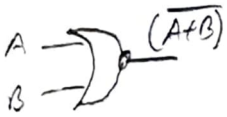


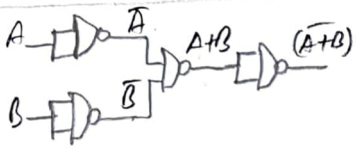






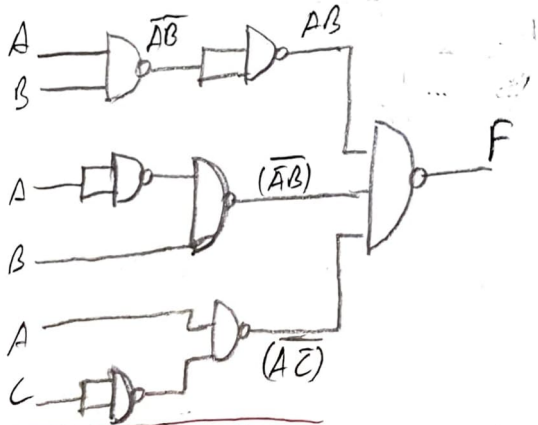






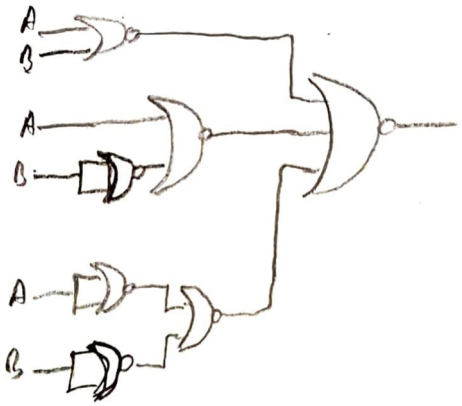
$\Rightarrow F = \overline{(\bar{A}B) + (\bar{A}\bar{B}) + (A\bar{C})}$ vedeğil kapılarıyla gerçekleştirilmek 2 kez değil (1 kez de morgan)

$F = \overline{(AB).(\bar{A}\bar{B})\,(\bar{A}\bar{C})}$



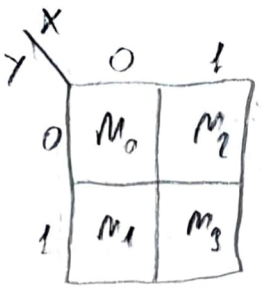
$\Rightarrow F = \overline{(A+B)\,(A+\bar{B}).(\bar{A}+\bar{B})}$ veyadeğil

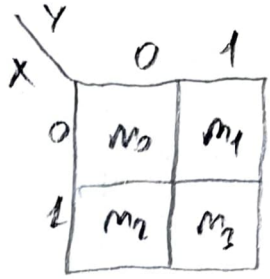
$\bar{\bar{F}} = \overline{(\overline{A+B}) + (\overline{A+\bar{B}}) + (\overline{\bar{A}+\bar{B}})}$

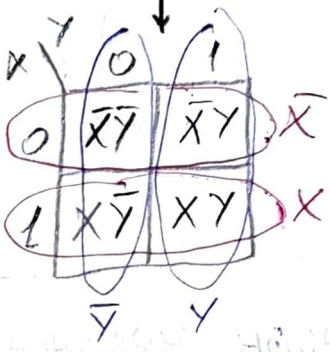


KARNAUGH HARİTALARI

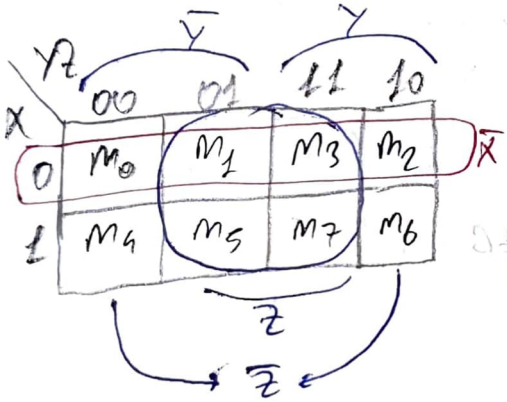
X	Y	minterm	
0	0	$\bar{X}\bar{Y}$	m_0
0	1	$\bar{X}Y$	m_1
1	0	$X\bar{Y}$	m_2
1	1	XY	m_3

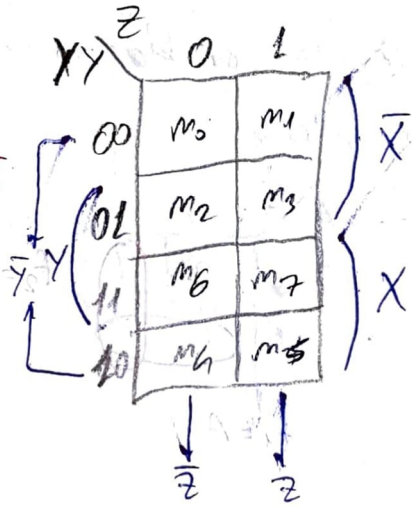






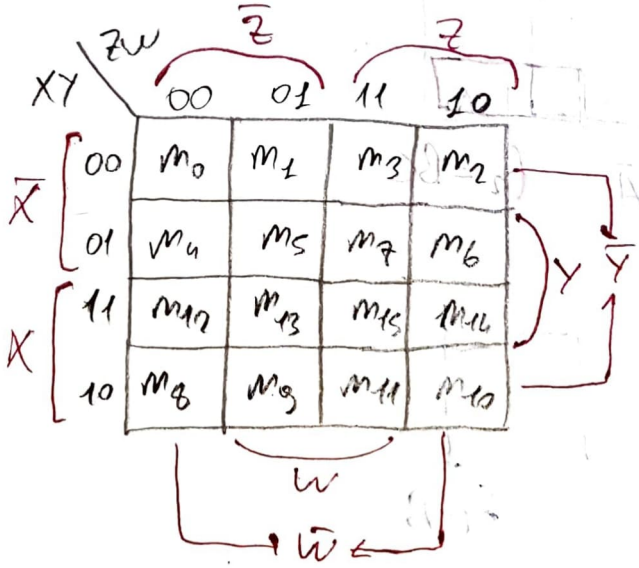
X	Y	Z	F	
0	0	0		m_0
0	0	1		m_1
0	1	0		m_2
0	1	1		m_3
1	0	0		m_4
1	0	1		m_5
1	1	0		m_6
1	1	1		m_7





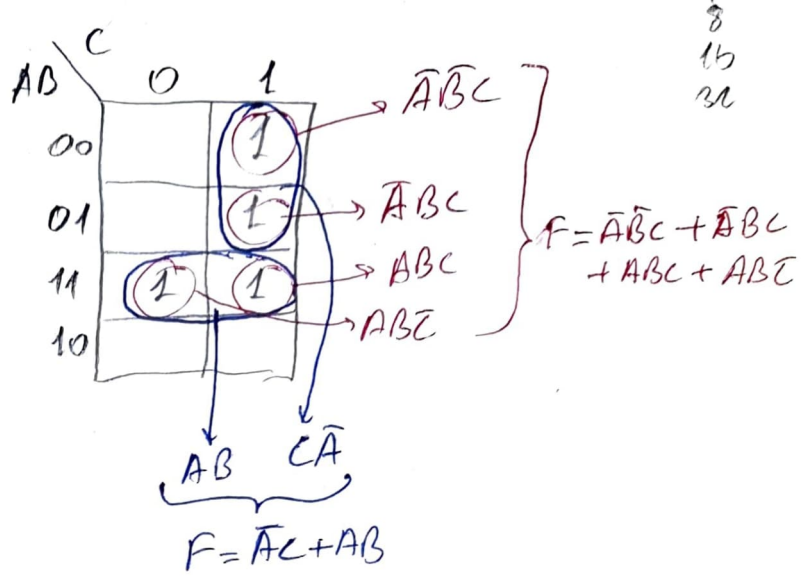
X	Y	Z	W	
0	0	0	0	$m_0 \rightarrow \bar{X}\bar{Y}\bar{Z}\bar{W}$
0	0	0	1	m_1
0	0	1	0	m_2
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	$m_7 \rightarrow \bar{X}YZW$
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	$m_{15} \rightarrow XYZW$

0 ← 7 ← 12 ← 15 ←



⇒ $Q = AB\bar{C} + \bar{A}B\bar{C} + BC$ karnaugh haritasına indirgeyim.

A	B	C	F
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1



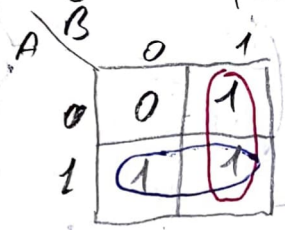
1 2 4 8 16 32

KARNAUGH HARITALARINDA GRUBLAMA

- Gruplama 2^n sayısına uygun yapılır. n sıfırdan başlar
- Çapraz gruplama olmaz (Kendi içinde çapraz olmaz)
- Dışarıda eleman olmayacak şekilde gruplandırılır.
- Maximum eleman içeren gruplar yapılmaya çalışılır.

⇒ veya işleminin K ile indirgenmesi $f = A + B$

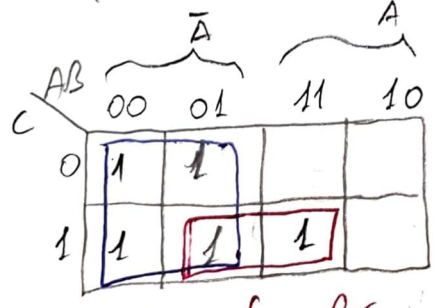
A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1



$f_1 = A$

$f = f_1 + f_2 = A + B$ minterme göre

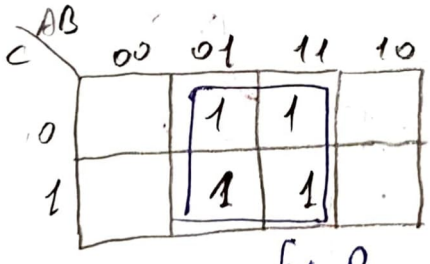
⇒



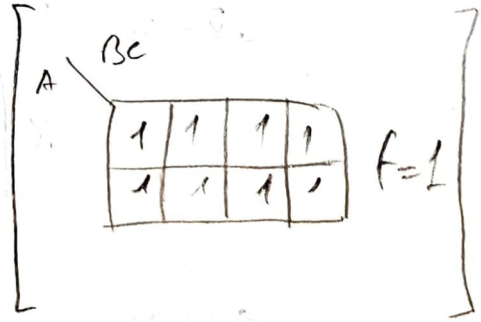
$f_1 = \bar{A}$ $f_2 = BC$

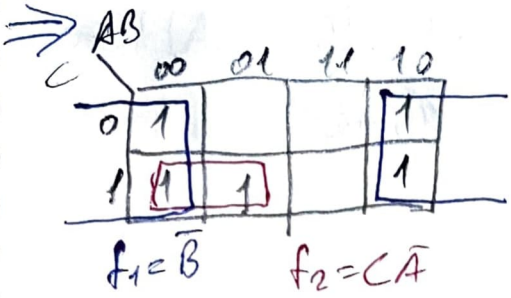
$f = f_1 + f_2 = \bar{A} + BC$

⇒

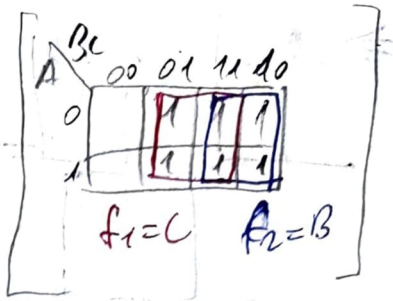


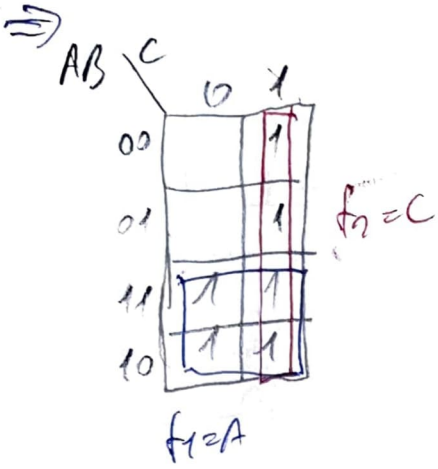
$f_1 = B$

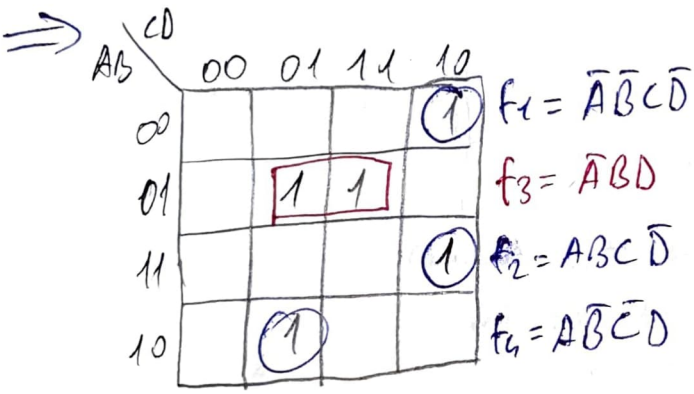


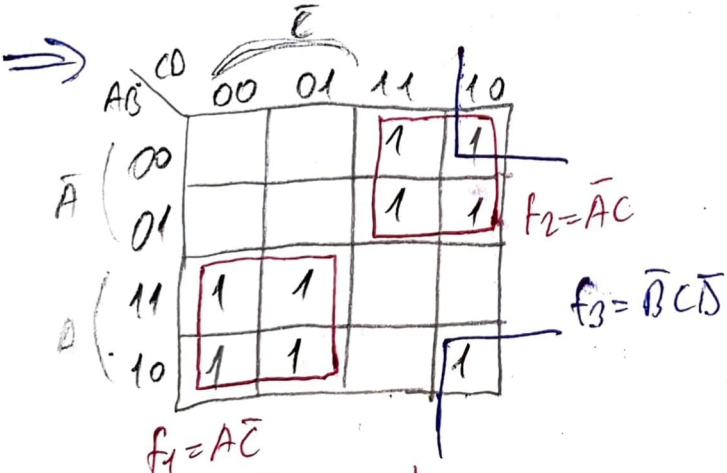


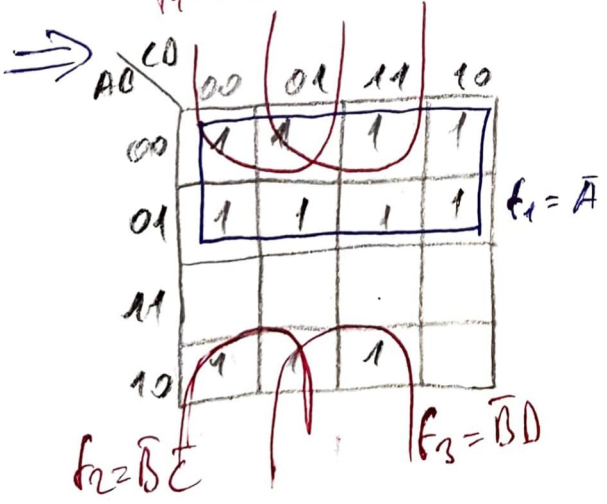
$f = f_1 + f_2 = \bar{B} + C\bar{A}$







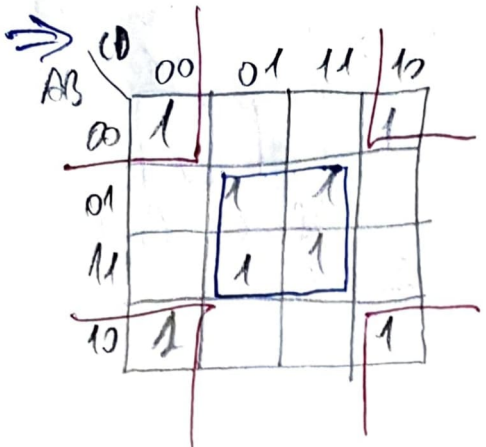




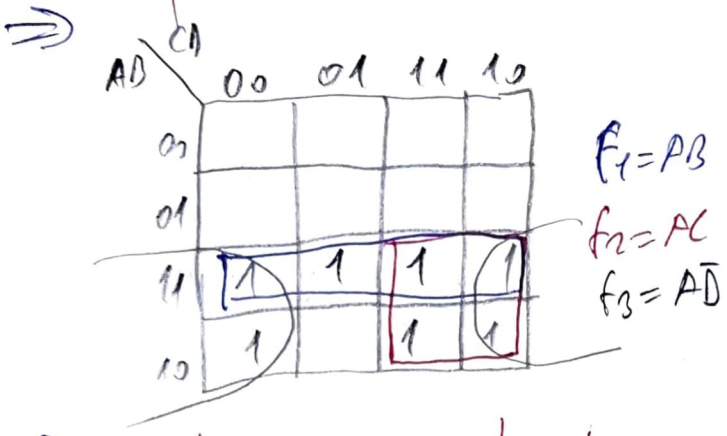
$f = f_1 + f_2 + f_3$

$f = \sum (f_1, f_2, f_3)$

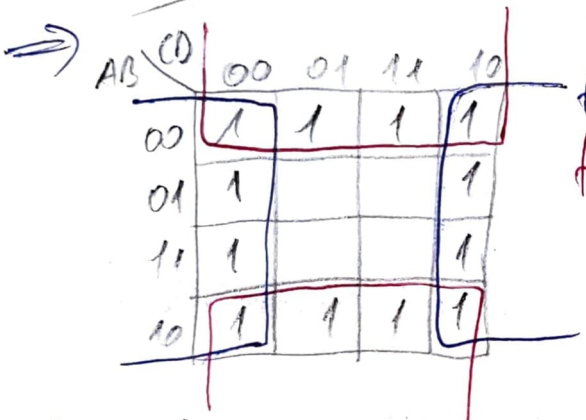
$f = \bar{A} + \bar{B}\bar{C} + \bar{B}D$

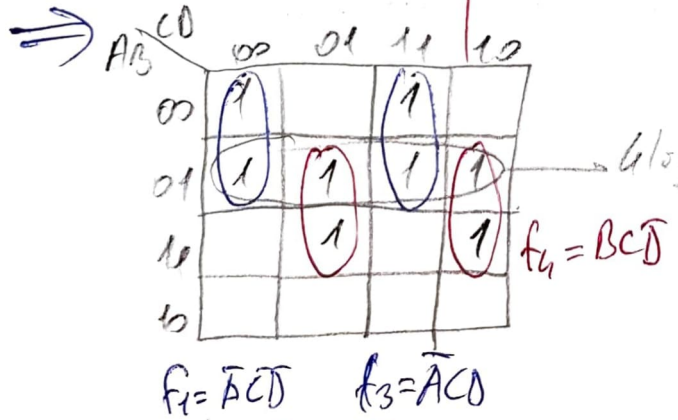


$f = f_1 + f_2 = \bar{B}\bar{D} + B\bar{D}$



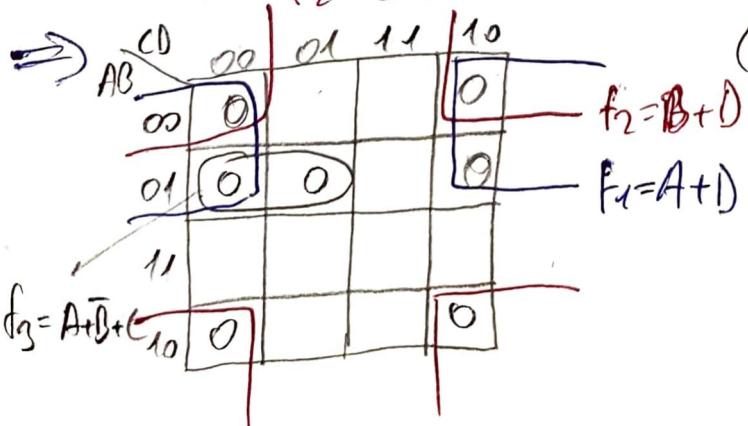
$f = f_1 + f_2 + f_3$
$= AB + AC + A\bar{D}$





$f_1 = \bar{A}C\bar{D}$ $f_3 = \bar{A}CD$

$f_2 = B\bar{C}\bar{D}$



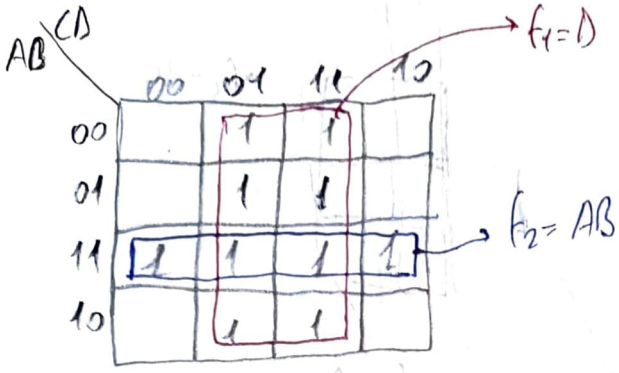
(maxterme göre)

$f = f_1 \cdot f_2 \cdot f_3$

$f = (A+D)(B+D)\cdot(A+\bar{B}+C)$

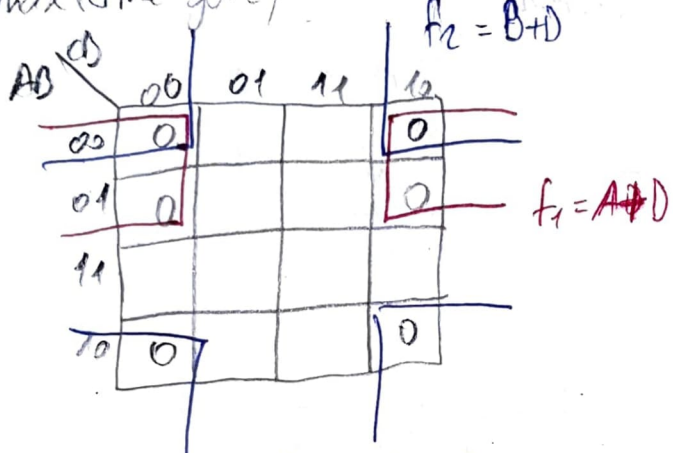
⇒ $f(A,B,C,D) = \Pi(0,2,4,6,8,10)$ maxterimlerine göre indirgeyin.

$f = \sum(1,3,5,7,9,11,12,13,14,15)$ ← minterm



$f = f_1 + f_2 = D + AB$

maxterme göre;

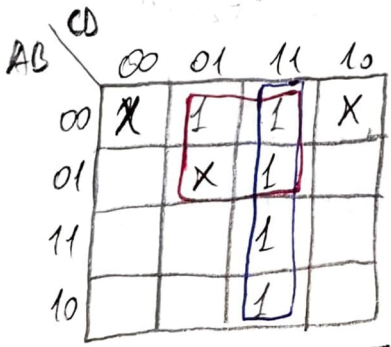


$f_1 = f_1 \cdot f_2 = (A+D).(B+D)$

Fark Etmeyen Durumlar için Karnaugh Haritaları

X'i minimum olacak şekilde fonksiyonları arttırmayacak şekilde indirgemede kullan. En az X i kullan

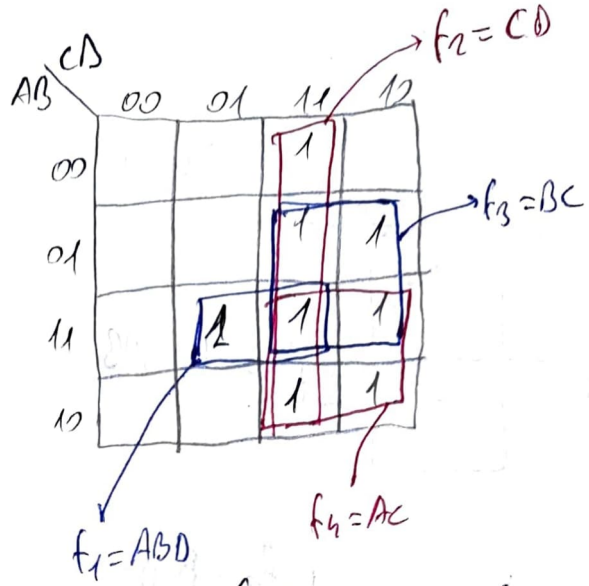
⇒ $f(A,B,C,D) = \sum(1,3,7,11,15)$ $\quad X = d = \sum(0,2,5)$



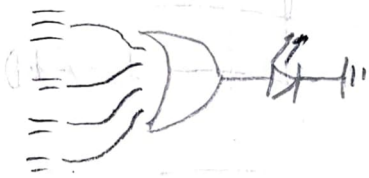
⇒ Bir meclise 560 milletvekili ve 4 parti. A partisi 105
B partisi 125
C partisi 202
D partisi 128

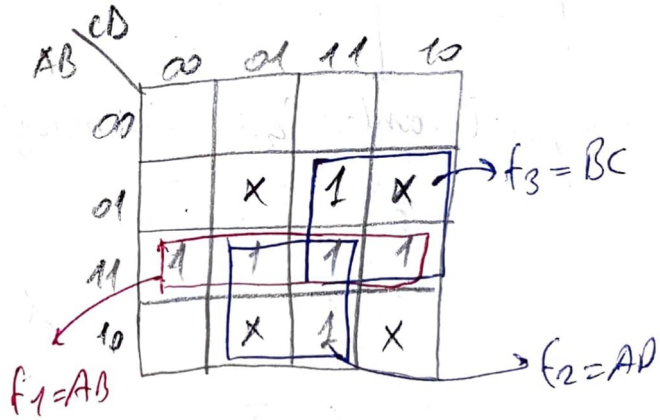
Çoğunluğun sağlandığı durumlarda bir lamba yanacak. Çoğunluğun sağlandığı durumlardaki işaret eşitliği karnaugh haritasında sağlayınız.

A	B	C	D	f	f_2
0	0	0	0	0	0
0	0	0	1	0	0
0	0	1	0	0	0
0	0	1	1	1	0
0	1	0	0	0	0
0	1	0	1	0	X
0	1	1	0	1	X
0	1	1	1	1	1
1	0	0	0	0	0
1	0	0	1	0	X
1	0	1	0	1	X
1	0	1	1	1	1
1	1	0	0	0	1
1	1	0	1	1	1
1	1	1	0	1	1
1	1	1	1	1	1
105	125	202	128		
~~150~~	~~150~~	100	100		



$f = f_1 + f_2 + f_3 + f_4$





Kombinasyonel Lojik Devre

Temel lojik kapılardan oluşan ve devrenin çıkışı doğrudan girişlerin anlık durumlarına göre belirlenen birleşik mantık devreleri denir.

- Kombinasyonel Lojik Tasarım Esasları
  1. Problem belirlenir.
  2. Giriş ve çıkış değişken sayıları tespit edilir.
  3. Doğruluk tablosu oluşturulur.
  4. Çıkışlar için boolean fonksiyonu oluşturulur.
  5. Sadeleştirme yapılır.
  6. Lojik Devre çizilir.

1- Kodlayıcı, Kod çözücü / 2- Gideleyici (Veri seçiciler) Multiplexer / 3- Ayrıştırıcı

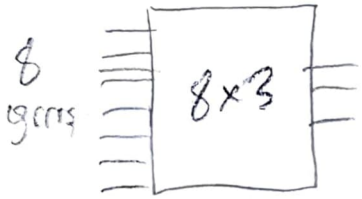
4- Karşılaştırıcı (Comparator) / 5- Aritmetik İşlem (Toplayıcı ...)

ENCODER (Kodlayıcı)

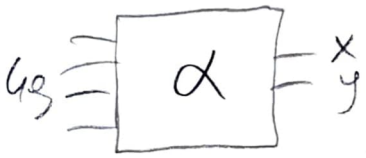
Kodlayıcı devrelerde herhangi bir anda girişlerden sadece 1 tanesi aktif olur.

↔ 4 girişli 2 çıkışlı Kodlayıcı Devre

D_3	D_2	D_1	D_0	X	Y	
0	0	0	1	0	0	11
0	0	1	0	0	1	00
0	1	0	0	1	0	01
1	0	0	0	1	1	10



8 girişte



D_3D_2 \ D_1D_0	00	01	11	10
00		0		0
01	1			
11				
10	1			

$X = \bar{D_3} D_2 \bar{D_1} \bar{D_0} + D_3 \bar{D_2} \bar{D_1} D_0$

$Y =$

[Youtube → computerphile
entropi → yeşil]

Öncelikli Kodlayıcı

D_3	D_2	D_1	D_0	X	Y
0	0	0	(1)	0	0
0	0	(1)	1X	0	1
0	(1)	1X	1X	1	0
(1)	1X	1X	1X	1	1

en soldaki en önemli bit

D_3D_2 \ D_1D_0	00	01	11	10
00				
01	1	1	1	1
11	1	1	1	1
10	1	1	1	1

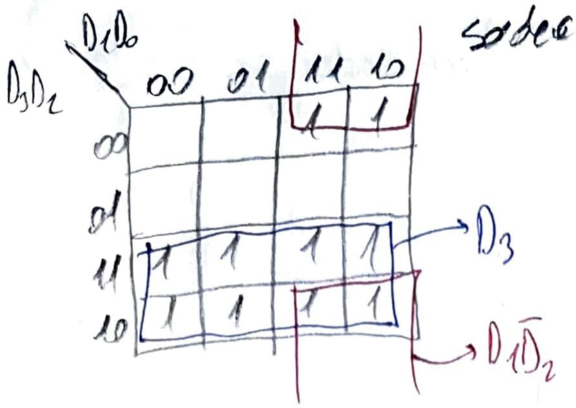
sadece X için; (X'lerin 1 olduğu yerler)

$F_1 = D_2$

$F_2 = D_3$

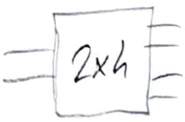
$F_X = D_2 + D_3$

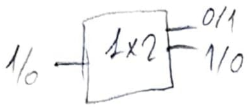
sadece Y için



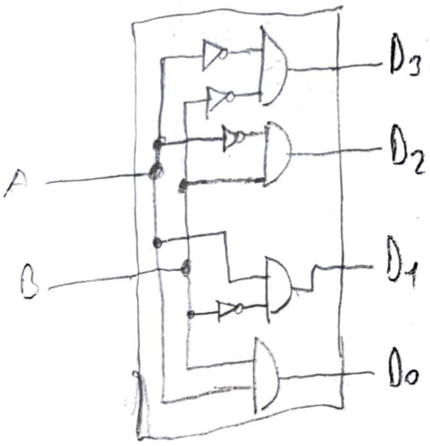
$$f_y = D_1\bar{D}_2 + D_3$$

DEKODER (Kod çözücü)

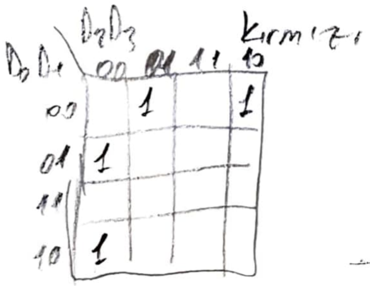




A	B	D_0	D_1	D_2	D_3
0	0	0	0	0	1
0	1	0	0	1	0
1	0	0	1	0	0
1	1	1	0	0	0

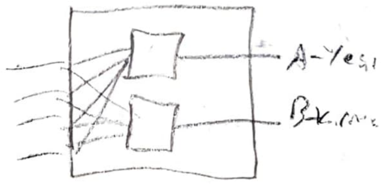


Enkoder;

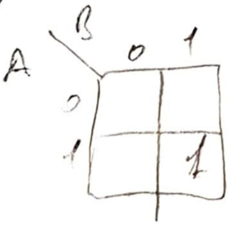


Yeşil Kırmızı

A	B	D_0



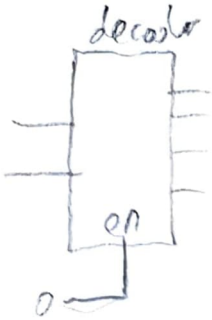
Dekoder;



girişte karnaugh haritası ile indirgeme

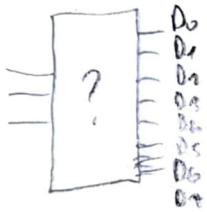
Enable;

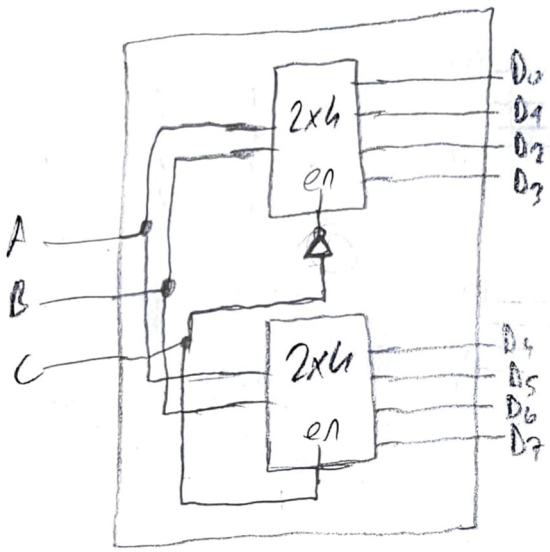
1 den fazla olabilir. genelde en çok 3 tane
Entegrenin çalışıp çalışmadığına bakar



Enable → Yetkilendirme girişi

⇒ Yetkilendirme girişli 2x4 kod çözücüler ile 3x8 kod çözücü elde ediniz?

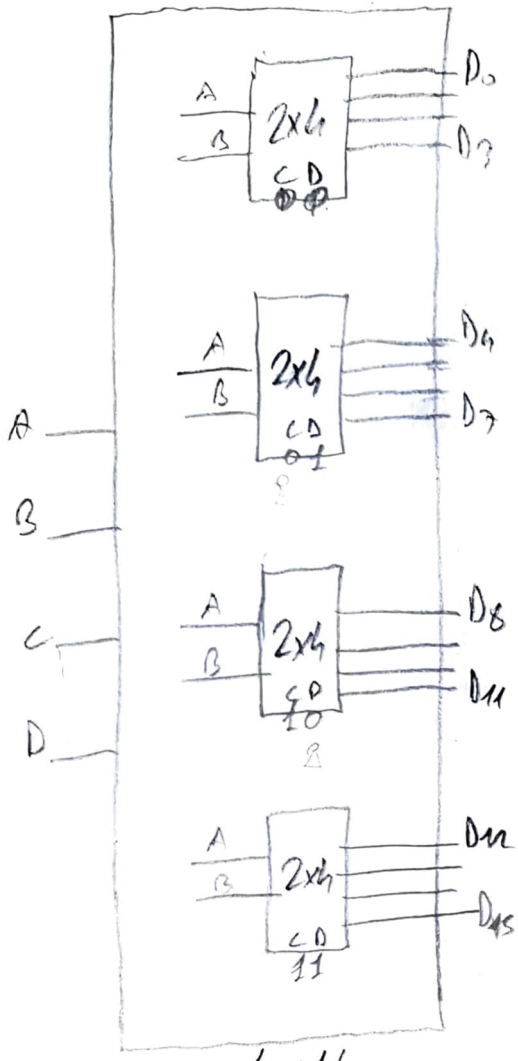




	C	A	B	D_0	D_7
I	0	0	0	1	
	0	0	1		
	0	1	0		
	0	1	1		
II	1	0	0		
	1	0	1		
	1	1	0		
	1	1	1		1

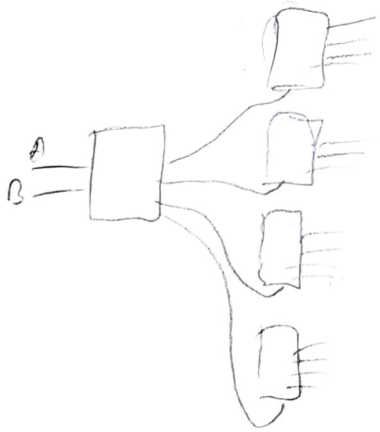
C girişi enable için kullandık

⇒ 2x4 ten 4x16 elde et?



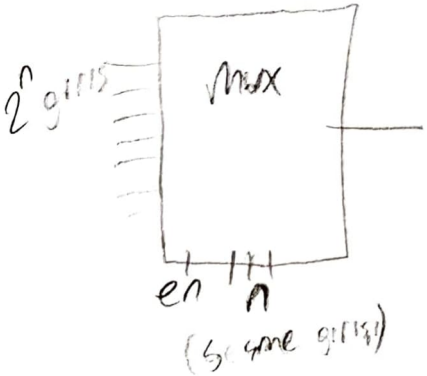
D	C	B	A	D_0	D_4	D_8	D_{12}
0	0	0	0				
0	0	0	1				
0	0	1	0				
0	0	1	1				
0	1	0	0				
0	1	0	1				
0	1	1	0				
0	1	1	1				
1	0	0	0				
1	0	0	1				
1	0	1	0				
1	0	1	1				
1	1	0	0				
1	1	0	1				
1	1	1	0				
1	1	1	1				

78X72_0 } Aynı entegre bitti değilse
78X72_1 }

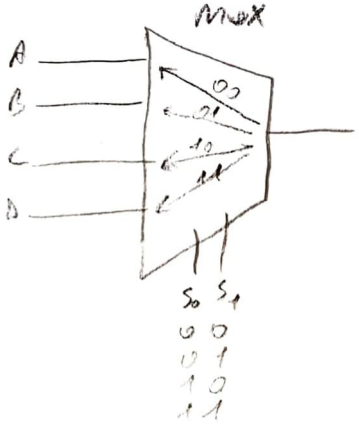


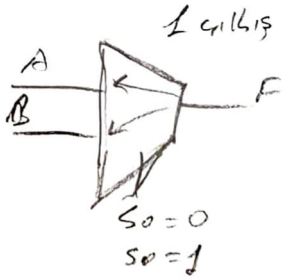
Dekoder-Mux-demux
Tasarım Servisi
Basitleştirme (Boolean)

MUX (GÖSTAYICILAR)



4x1 MUX



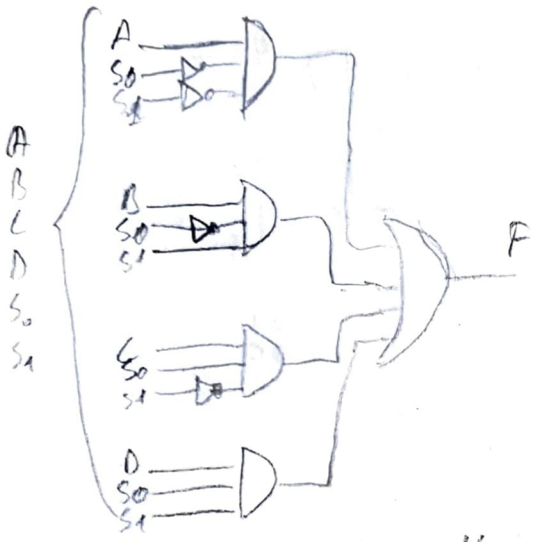


S_1	S_0	F
0	0	A
0	1	B
1	0	C
1	1	D

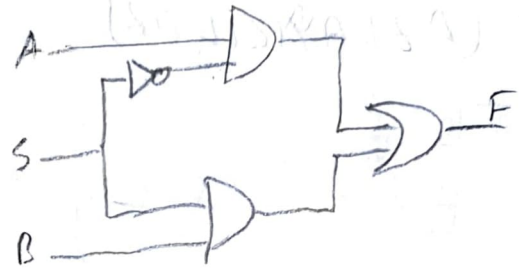
S	F
0	A
1	B

Seçme girişine göre

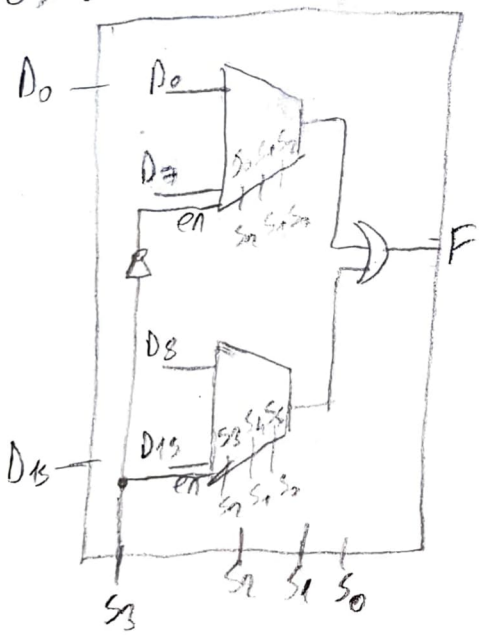
4x1 mux



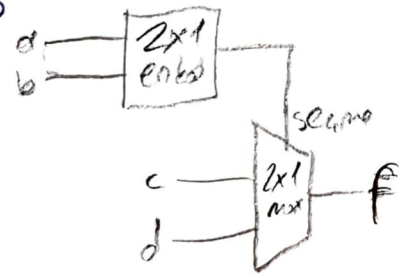
2x1 mux



⇒ 8x1 mux ile 16x1 mux elde edelim.



Yine



01 → c 0

10 → d 1

f sonucunu a, b, c, d cinsinden bul?

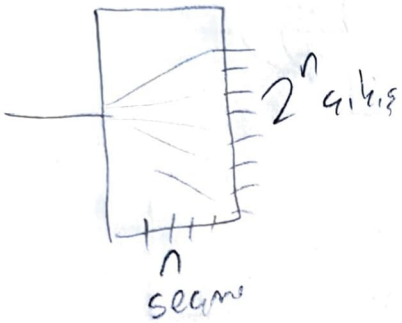
A	B	C	D	f
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	1
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	1
1	1	1	1	1

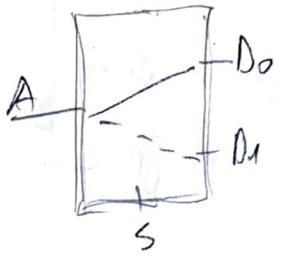
→ Karnaugh ile devam

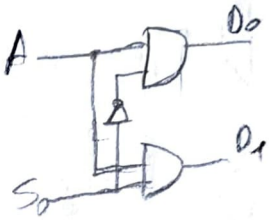
AB \ CD	00	01	11	10
00				
01			1	1
11				
10		1	1	

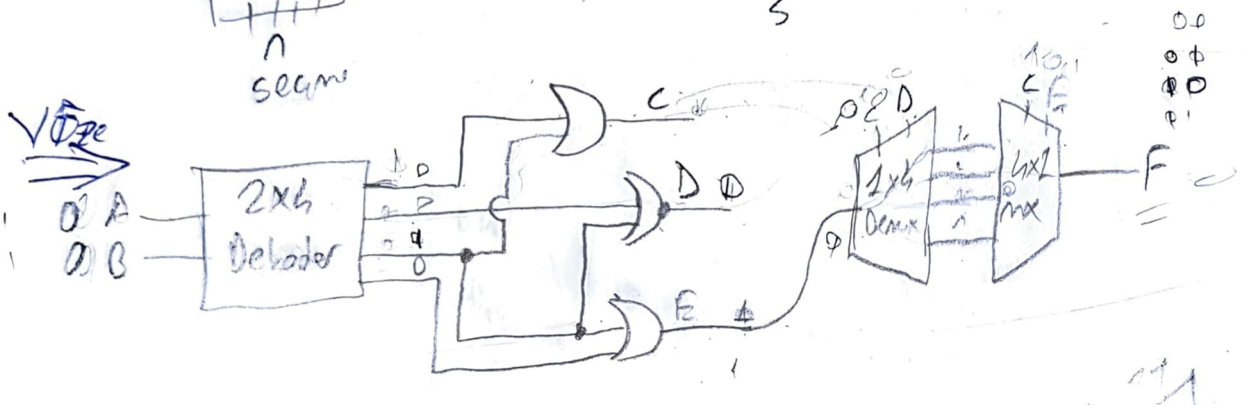
$f = f_1 + f_2$

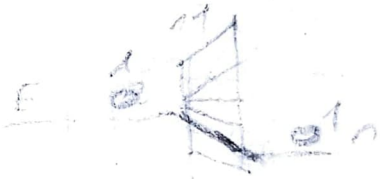
DEMUX (AZLAYICILAR)







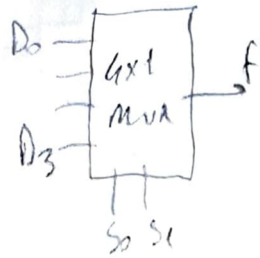




A	B	D_0	D_1	D_2	D_3	C	D	E	F
0	0	1	0	0	0	1	1	0	0
0	1	0	1	0	0	0	1	0	0
1	0	0	0	1	0				
1	1	0	0	0	1	0	0	1	0

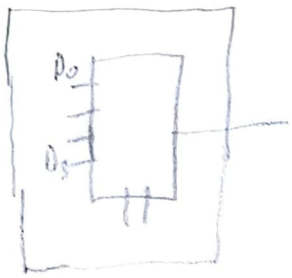
A	B	D_0	D_1	D_2	D_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

LAB3 $f(A,B,C) = \sum(0,2,1,6,7)$ cadece mux ile yap



Kanaugh haritasında $\Rightarrow f = \bar{C}$

A	B	C	f
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1



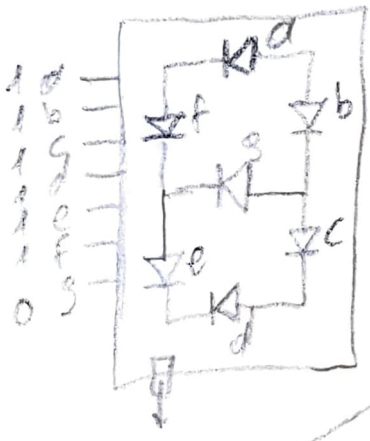
Ā	0	1	2	3
A	4	5	6	7

$f = \bar{A}\,\bar{A}\,1\,A$

→ Parçalı Gösterge (7 Segment Display)

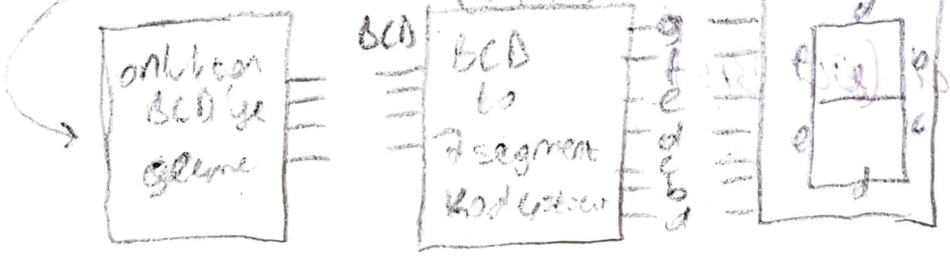
00 11 1111

(3 F) Hex



Key Pad

1	2	3
4	5	6
7	8	9
	0	



Mikroişlemcide Bellekten ve Peripheral Birimlerden Veri Okuma

Onluk	A	B	C	D	g	f	e	d	c	b	a
0	0	0	0	0	0	1	1	1	1	1	1
1	0	0	0	1	0	0	0	0	1	1	0
2	0	0	1	0	1	0	1	1	0	1	1
3	0	0	1	1	1	0	0	1	1	1	1
4	0	1	0	0	1	1	0	0	1	1	0
5	0	1	0	1	1	1	0	1	1	0	1
6	0	1	1	0	1	1	1	1	1	0	1
7	0	1	1	1	0	0	0	0	1	1	1
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	0	1	1	1	1

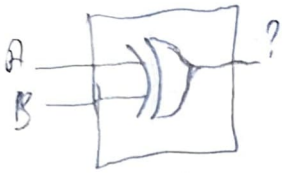
BCD | 7447

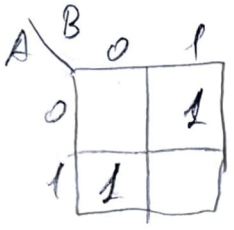
Karşılaştırıcılar

2 Bit Karşılaştırıcı

A	B	A=B	A≠B	A>B	A<B
0	0	1	0	0	0
0	1	0	1	0	1
1	0	0	1	1	0
1	1	1	0	0	0

A≠B





$\rightarrow f = \bar{A}B + A\bar{B} = A \oplus B$

Aritmetik İşlem Devreleri

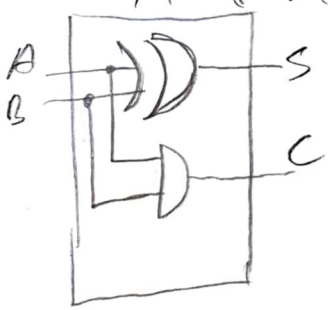
Yarım Toplayıcı (İki Bit)

A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

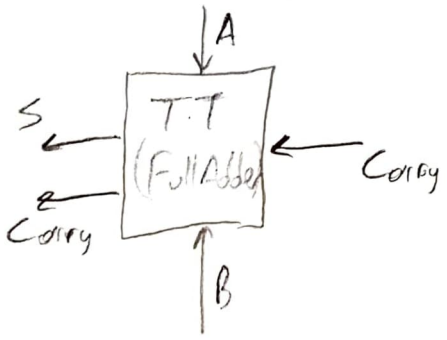
S ← exor, C ← ve

Carry → elde
Sum → Toplam

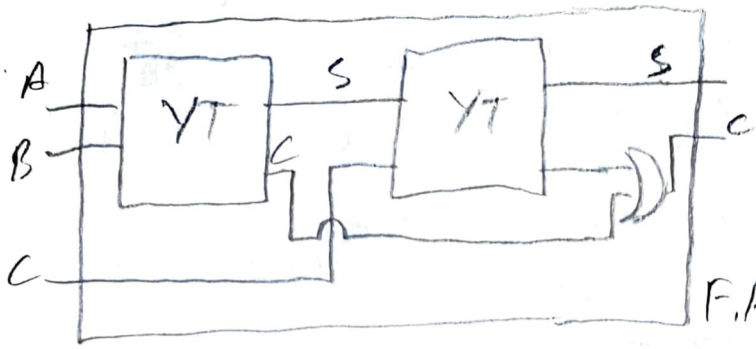
YT (HA) (Half Adder)



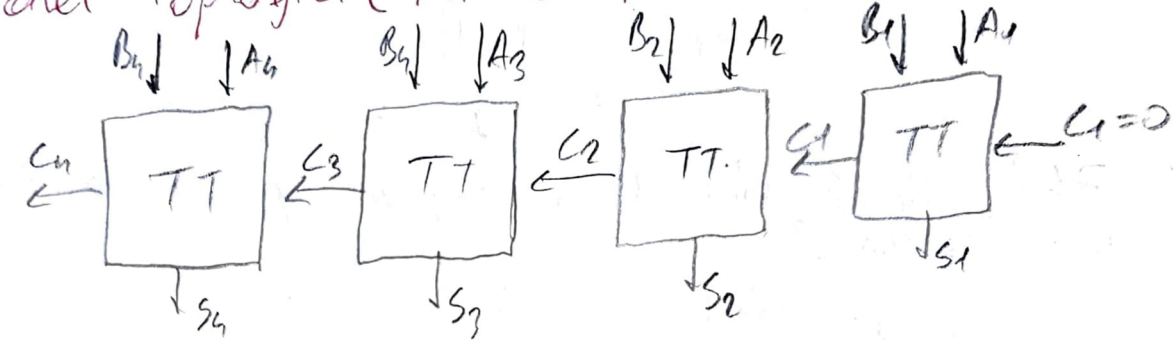
Tam Toplayıcı (Üç Bit)



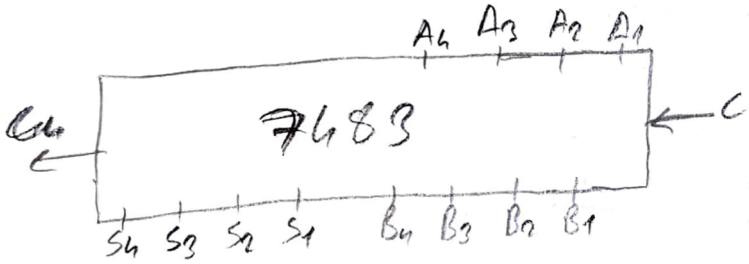
A	B	C	S	C
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



Paralel Toplayıcı (74HC283, 7483, 74LS83, 74LK83)



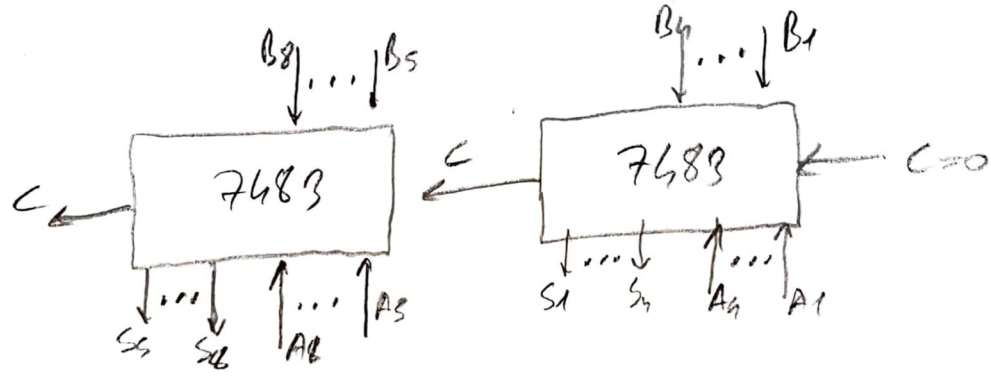
$$\begin{array}{cccccc} & B_4 & B_3 & B_2 & B_1 \\ + & A_4 & A_3 & A_2 & A_1 \\ \hline C_4 & S_4 & S_3 & S_2 & S_1 \end{array}$$



2 tane 4 bitlik toplayıcı

$$\begin{array}{cccccccc} & B_8 & B_7 & B_6 & B_5 & B_4 & B_3 & B_2 & B_1 \\ + & A_8 & A_7 & A_6 & A_5 & A_4 & A_3 & A_2 & A_1 \\ \hline & S_8 & S_7 & S_6 & S_5 & S_4 & S_3 & S_2 & S_1 \end{array}$$

C_8 ← C



BCD Toplayıcı

$$\begin{array}{r} 4 \\ +3 \\ \hline 7 \end{array} \qquad \begin{array}{r} 0100 \leftarrow \text{BCD} \\ +0011 \leftarrow \text{BCD} \\ \hline 0111 \leftarrow \text{BCD} \end{array}$$

$$\begin{array}{rr} 6 & 0110 \\ +7 & 0111 \\ \hline 13 & 1101 \\ & +0110 \\ \hline & 10011 \end{array}$$

1 → 3

$9+6=15$

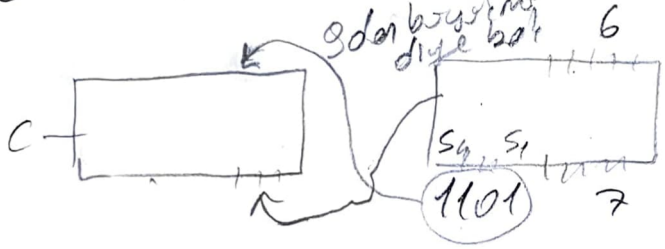
↑

Sonucu 6 ile topla (DA komutu)

$6+7 \rightarrow$ 

1 3

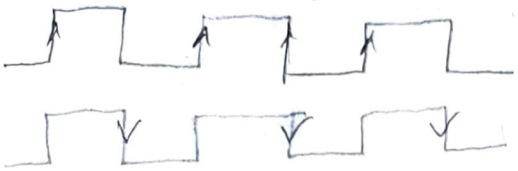
ÖDEV 7483 ile 2 adet BCD sayıyı toplayan devreyi gerçekleştiriniz?



C	S_4	S_3	S_2	S_1	
	0	0	0	0	
			⋮		
	1	0	0	1	→ 9
	1	0	1	0	+
	1	0	1	1	
	1	1	0	0	
	1	1	0	1	
	1	1	1	0	
	1	1	1	1	
1	0	0	0	0	

AK-223

Tetikleme Sinyali (Clock Pulse)



Yükselen Kenar Tetikleme

Düşen Kenar Tetikleme

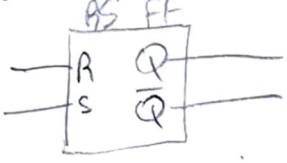
Flip-Flop

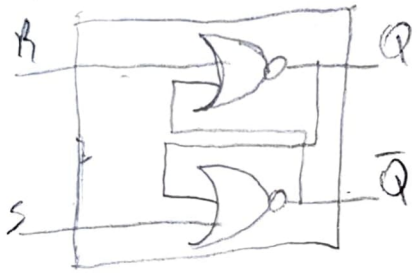
Bellek elemanlarıdır. Tek başına bilgi saklayamazlar. Kapı devreleri ile birleştirilerek bilgi saklama kapasiteleri oluşturulabilir.

4 tip flip-flop çeşidi vardır. RS, JK, T, D

RS Flip-Flop

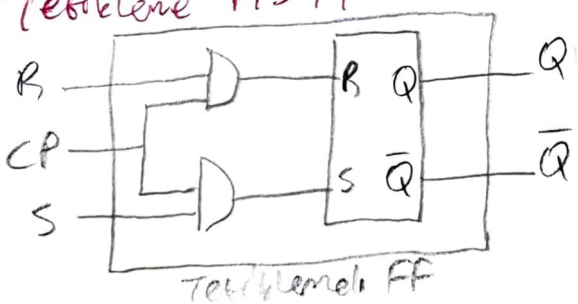
Set-Reset





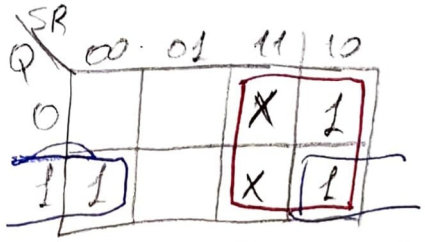
S	R	Q	$\bar{Q}$
0	0	Q_t	$\bar{Q}_t$
0	1	0	1
1	0	1	0
1	1	Tanımsız	

Tetiklemeli RS FF



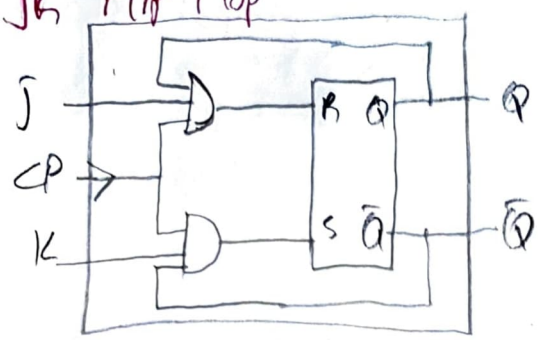
CP	S	R	Q_{t+1}	$\bar{Q}_{t+1}$
↓	X	X	Q_t	$\bar{Q}_t$
↑	0	0	Q_t	$\bar{Q}_t$
↑	0	1	0	1
↑	1	0	1	0
↑	1	1	Tanımsız	

Q_t	S	R	Q_{t+1}
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	Tanımsız (X)
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	Tanımsız (X)

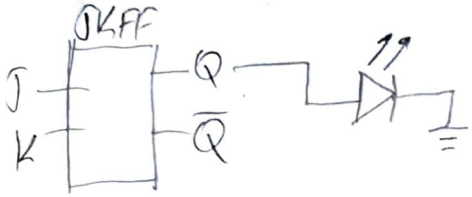


$$Q_{t+1} = S + \bar{R} Q_t$$

JK Flip-Flop

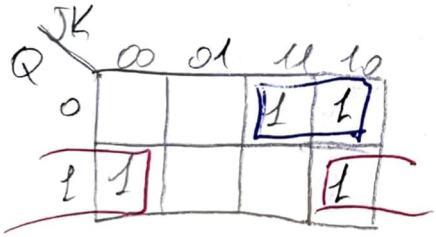


CLK	J	K	Q_t	$\bar{Q}_t$
↓	X	X	Q_t	$\bar{Q}_t$
↑	0	0	Q_t	$\bar{Q}_t$
↑	0	1	0	1
↑	1	0	1	0
↑	1	1	$\bar{Q}_t$	Q_t



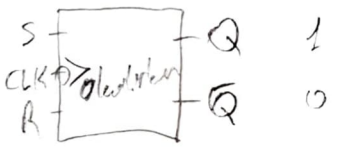
Q_t	J	K	Q_{t+1}
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

// Girişi tersle (11 de yap)
// Durumu muhafaza et (00 da yap)



$$f = J\bar{Q} + \bar{K}Q$$

RS

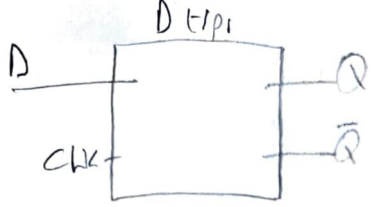


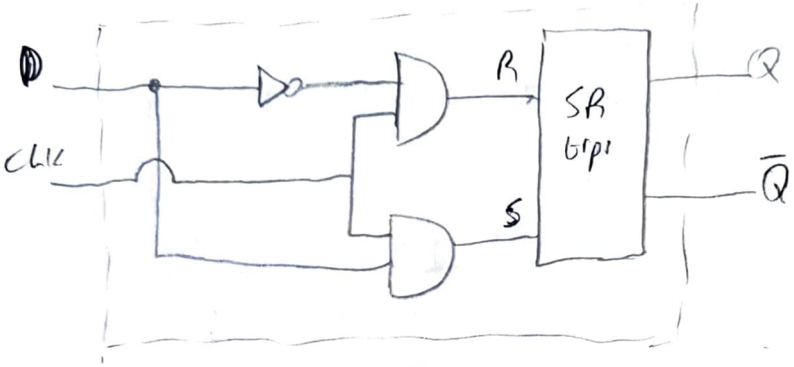
R,S 0 0 olursa yine aynı kalır

R	S	Q	$\bar{Q}$
0	0	Q	$\bar{Q}$
0	1	1	0
1	0	0	1
1	1	—	—

aynısı kalır.

D tipi Flip Flop





JK da da var.

CLK	D	Q	$\bar{Q}$
X	X	...	
↑	0	0	1
↑	1	1	0

T tipi Flip Flop (Toggle)

CLK	T	Q	$\bar{Q}$
son yok	X	Q	$\bar{Q}$
↑	0	Q	$\bar{Q}$
↑	1	$\bar{Q}$	Q

Durum Geçiş Tablosu

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

JK	son
00	
10	

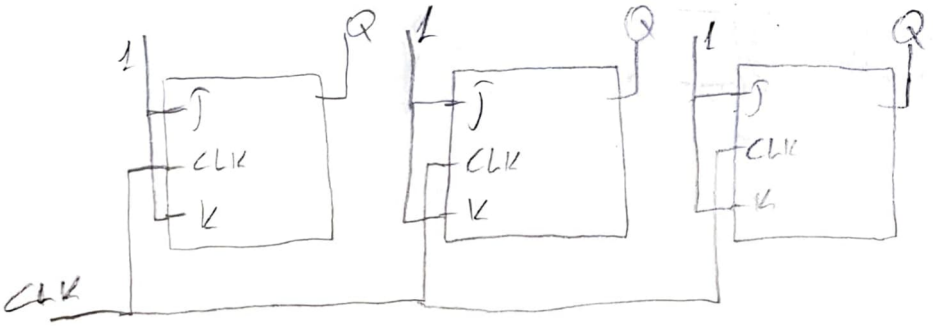
Q(t)	Q(t+1)	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

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

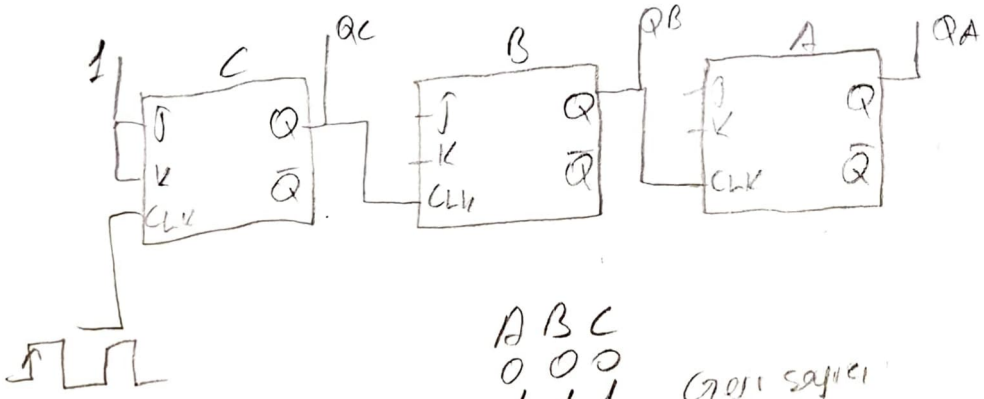
önceki durum önemsiz

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

ARDIŞIL DEVRELER



senkron



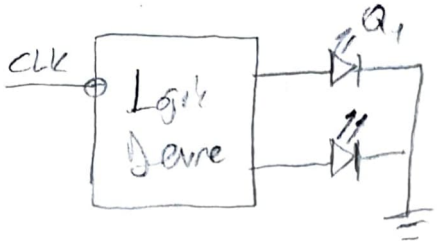
A senkron

A	B	C
0	0	0
1	1	1
1	1	0
1	0	1

Geri sayıcı

İleri sayıcı için Q̄ ini bağla

⇒



CLK	Q_1	Q_2
↓	0	1
↓	0	0
↓	1	0
↓	1	1
↓	0	1

→ en başlarda durumlarla et

Şekildeki blok şeması ve çalışma programı verilen devreyi flip-flop-lar kullanarak (RS-JK-D-T) ile ayrı ayrı tasarla?

2 çıkış için 2 tane FF var.

Q_1	Q_2	S_1	R_1	S_2	R_2
0	1	0	X	0	1
0	0	1	0	0	X
1	0	X	0	1	0
1	1	0	1	X	0
0	1				

F_1 F_2

S_1 /

Q_1 \ Q_2	0	1
0	1	0
1	X	0

$S_1 = \bar{Q}_2$

R_1 /

Q_1 \ Q_2	0	1
0	0	X
1	0	1

$R_1 = Q_2$

S_2 /

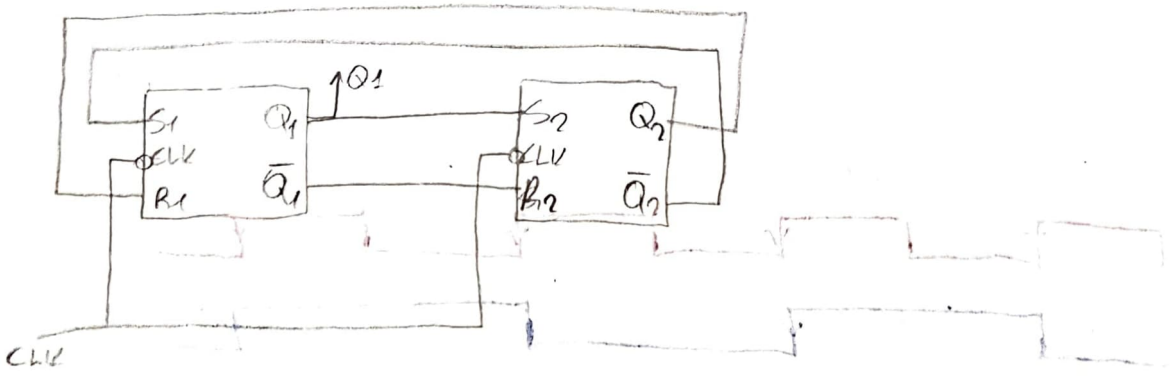
Q_1 \ Q_2	0	1
0	0	0
1	1	X

$S_2 = Q_1$

R_2 /

Q_1 \ Q_2	0	1
0	0	0
1	1	X

$R_2 = \bar{Q}_1$



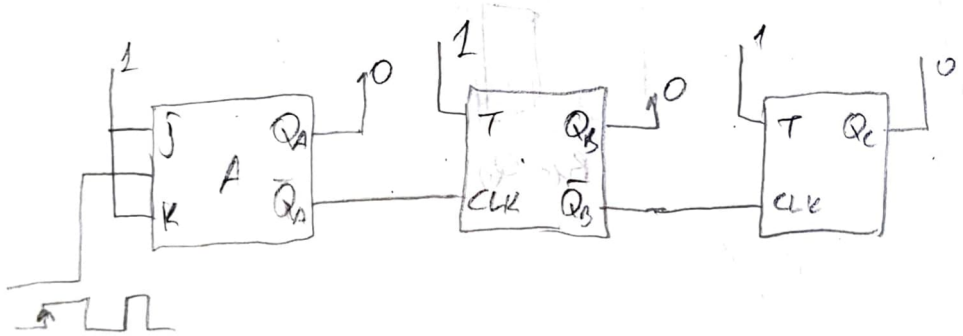
J-K için aynı

Sayıcılar (Asenkron)

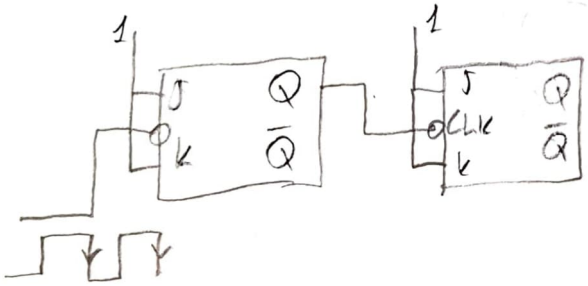
Sayıcılar
- Tetikleme işaretine göre
  - Senkron
  - Asenkron
- Sayma yönüne göre
  - İleri
  - geri
  - İleri-geri
- Sayma kodlamasına göre
  - BCD
  - İkilik
  - onluk
  - moda göre

İki Bitlik Asenkron Sayıcı.

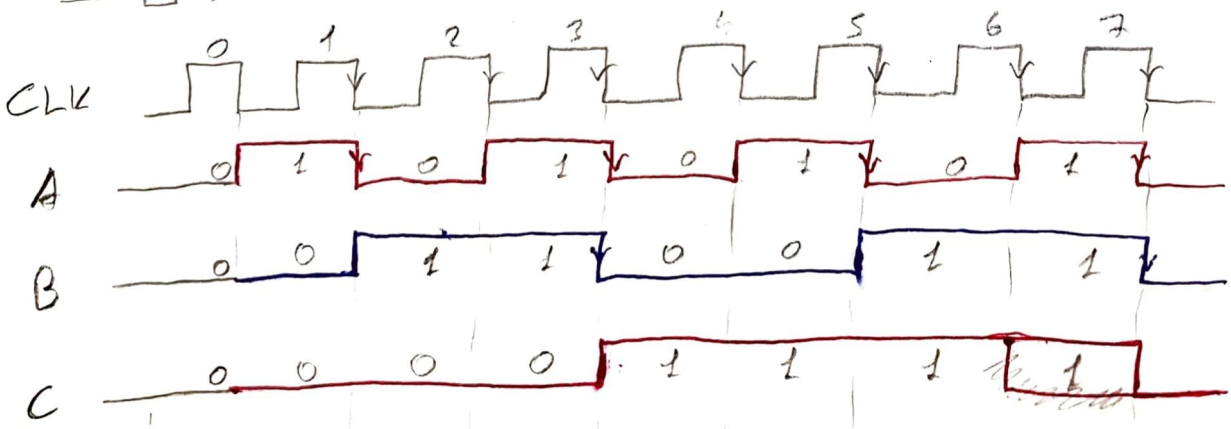
	CLK	Q_B	Q_A
0	1	0	0
1	1	0	1
2	1	1	0
3	1	1	1



Yükselen kenar için ileri sayıcı

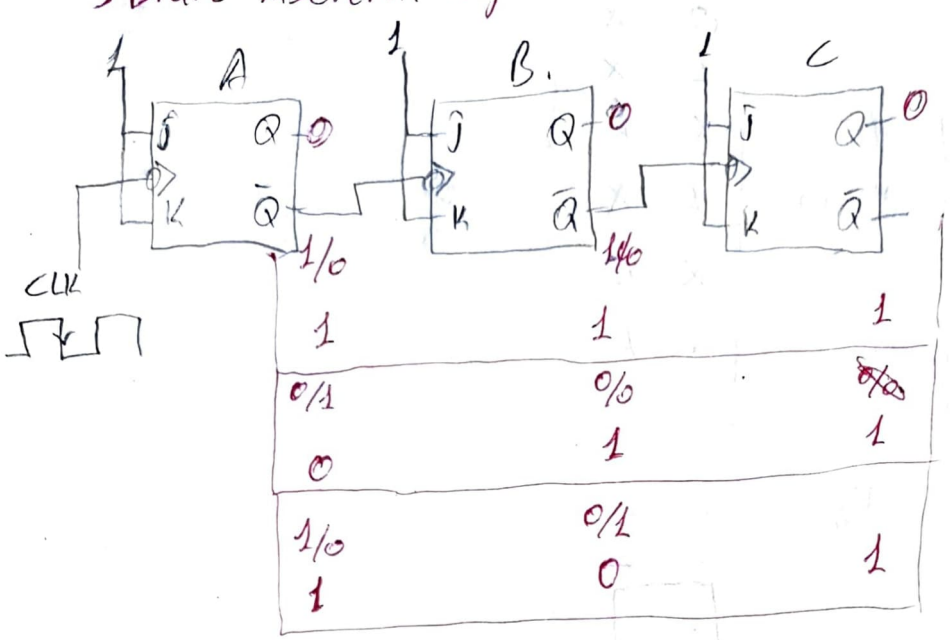


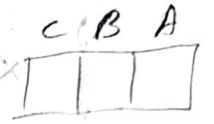
Düşen kenar için ileri sayıcı



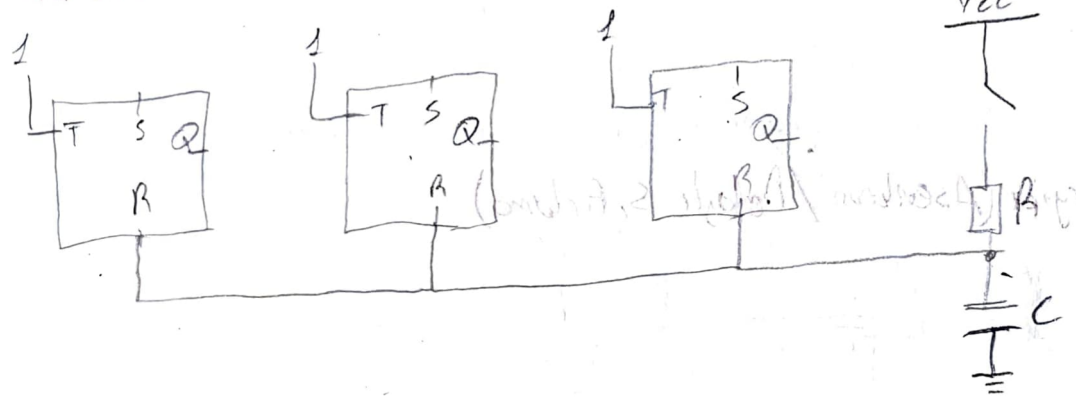
İleri düşen kenarda A kendini tersliyor

3 Bitlik Asenkron Sayıcı

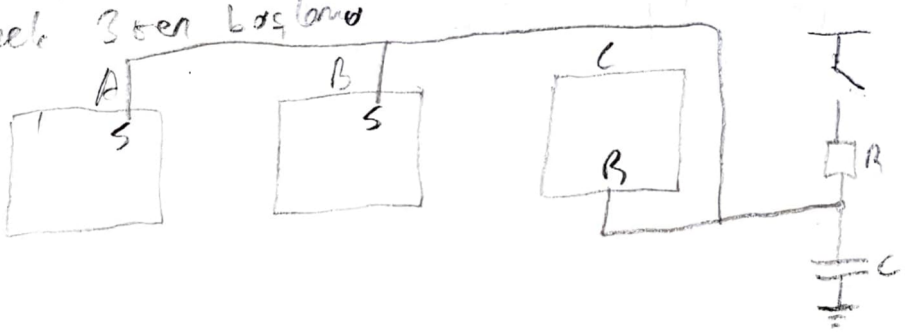




Sıfırlamalı Asenkron Sayıcı

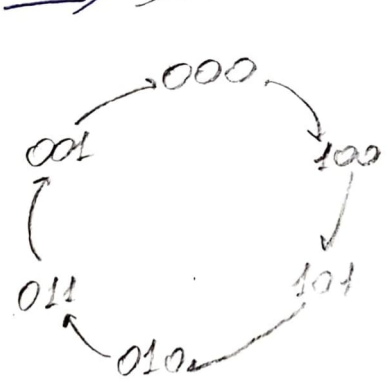


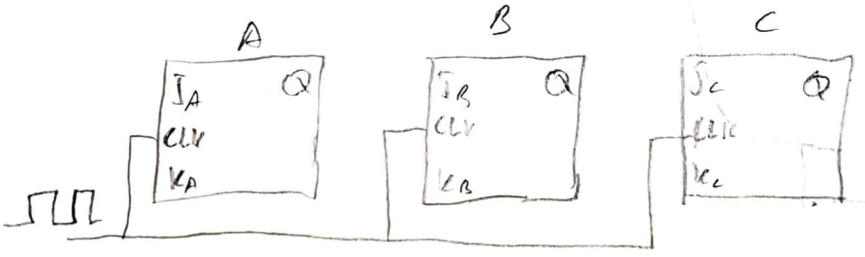
Örnek 3 ten Küçük



C B A
0 1 1

⇒ Senkron 3 ten örnek





Q_C	Q_B	Q_A	J_C	K_C	J_B	K_B	J_A	K_A
0	0	0	1	X	0	X	0	X
1	0	0	X	0	0	X	1	X
1	0	1	X	1	1	X	X	1
0	1	0	0	X	X	0	1	X
0	1	1	0	X	X	1	X	0
0	0	1	0	X	0	X	X	1
0	0	0						

J	K	Q
0	0	Q
0	1	0
1	1	1
1	0	$\overline{Q}$

J_A

Q_C \ $Q_B Q_A$	00	01	11	10
0	0	X	X	X
1	1	X	X	X

$J_A = Q_C + Q_B$

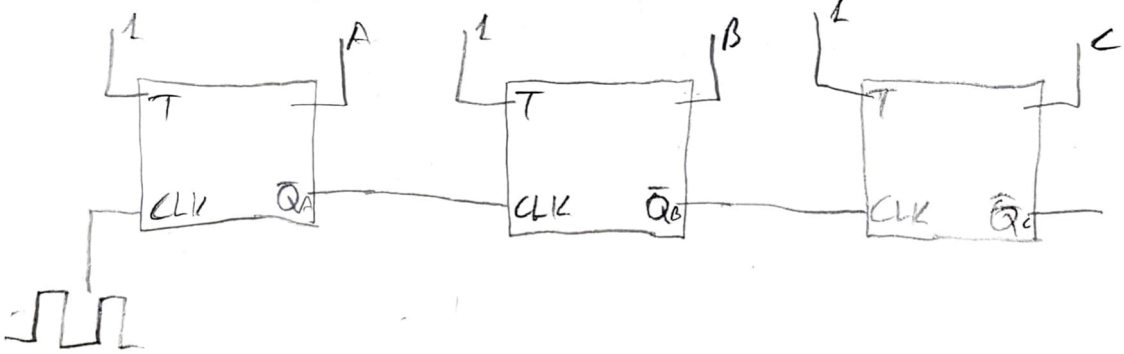
K_A

Q_C \ $Q_B Q_A$	00	01	11	10
0	X	1	0	X
0	X	1	X	X

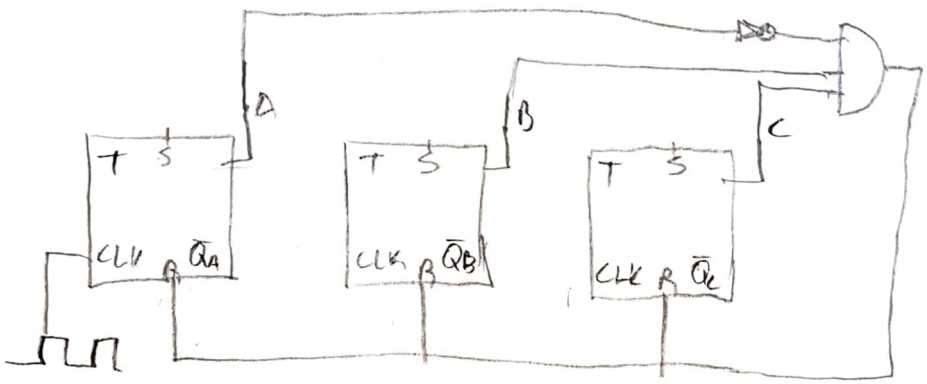
$K_A = \overline{Q}_B$

J_B, J_C, K_B, K_C için de aynı şeyleri yap devreyi kur.

Mod-6 Sayıcı (Asenkron / Dokaylı Sıfırlama)

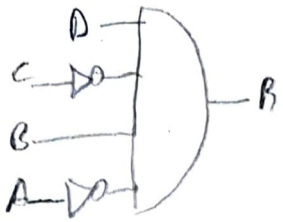


	C	B	A
0 ←	0	0	0
	0	0	1
	0	1	0
	0	1	1
	1	0	0
5 ←	1	0	1
-			
6 ←	1	1	0

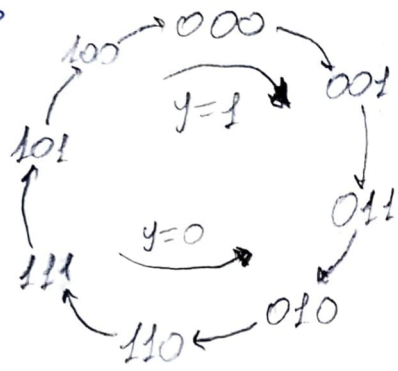


Mod-10 sayıcı

D	C	B	A
0	0	0	0
0	0	0	1
⋮			
1	0	0	0
1	0	0	1
1	0	1	0



⇒



Senkron $Q_C Q_B Q_A$

Y	Q_C	Q_B	Q_A	J_C	K_C	J_B	K_B	J_A	K_A
1	0	0	0	0	X			1	X
1	0	0	1	0	X			X	0
1	0	1	1	0	X			X	1
1	0	1	0	1	X			0	X
1	1	1	0	X	0			1	X
1	1	1	1	X	0			X	0
1	1	0	1	X	0			X	1
1	1	0	0	X	1			0	X

Y	Q_C	Q_B	Q_A	J_C	K_C	J_B	K_B	J_A	K_A
0	0	0	0					0	X
0	1	0	0					1	X
0	1	0	1					X	0
0	1	1	1					X	1
0	1	1	0					0	X
0	0	1	0					1	X
0	0	1	1					X	0
0	0	0	1					X	1

J_A

$Y Q_C$ \ $Q_B Q_A$	00	01	11	10
00	0	X	X	1
01	1	X	X	0
11	0	X	X	1
10	1	X	X	0

$$J_A = \bar{Y}\bar{Q}_2 Q_1 + \bar{Y} Q_2 \bar{Q}_1 + Y Q_2 Q_1 + Y \bar{Q}_2 \bar{Q}_1$$

Y'yi anahtar kabul edilir

KAYDEDİCİLER

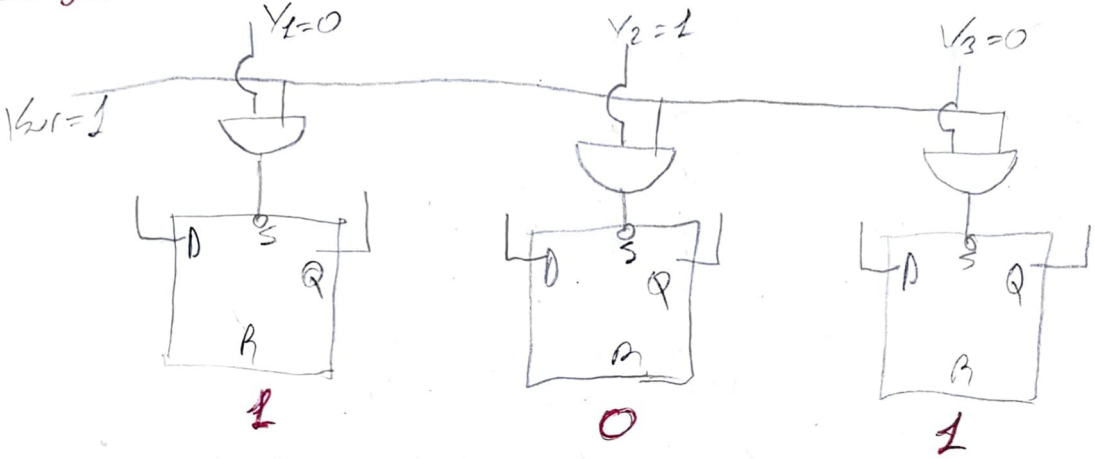
I- Bilgi Yüklenmesine Göre

- Paralel Kaydedici
  - Senkron
  - Asenkron
- Seri kaydedici
  - Sağa
  - Sol

II- Bilgi Çıkışına Göre

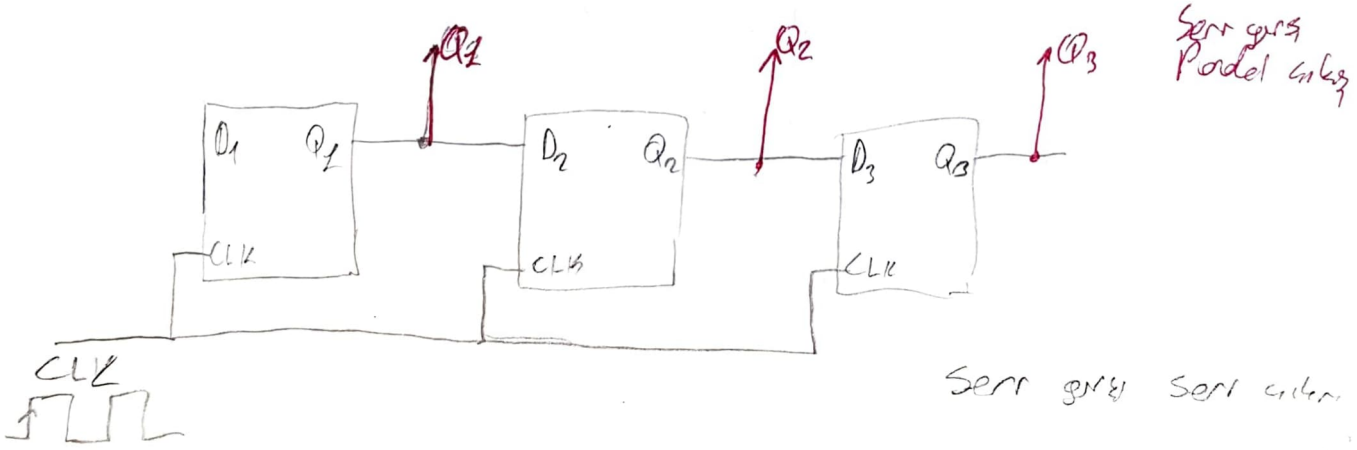
- Seri giriş Seri çıkış
- Seri giriş Paralel çıkış
- Paralele giriş seri çıkış
- Paralel giriş Paralel çıkış

Paralel giriş Paralel çıkış



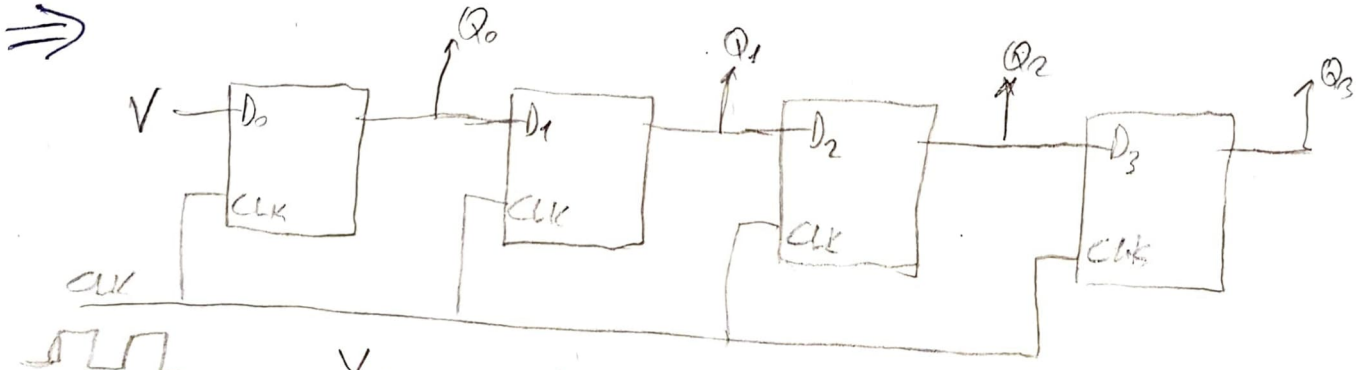
1101 yapmak için kaydedici

Senkron Sağa doğru Kaydedici



Seri giriş Paralel çıkış

Seri giriş seri çıkış

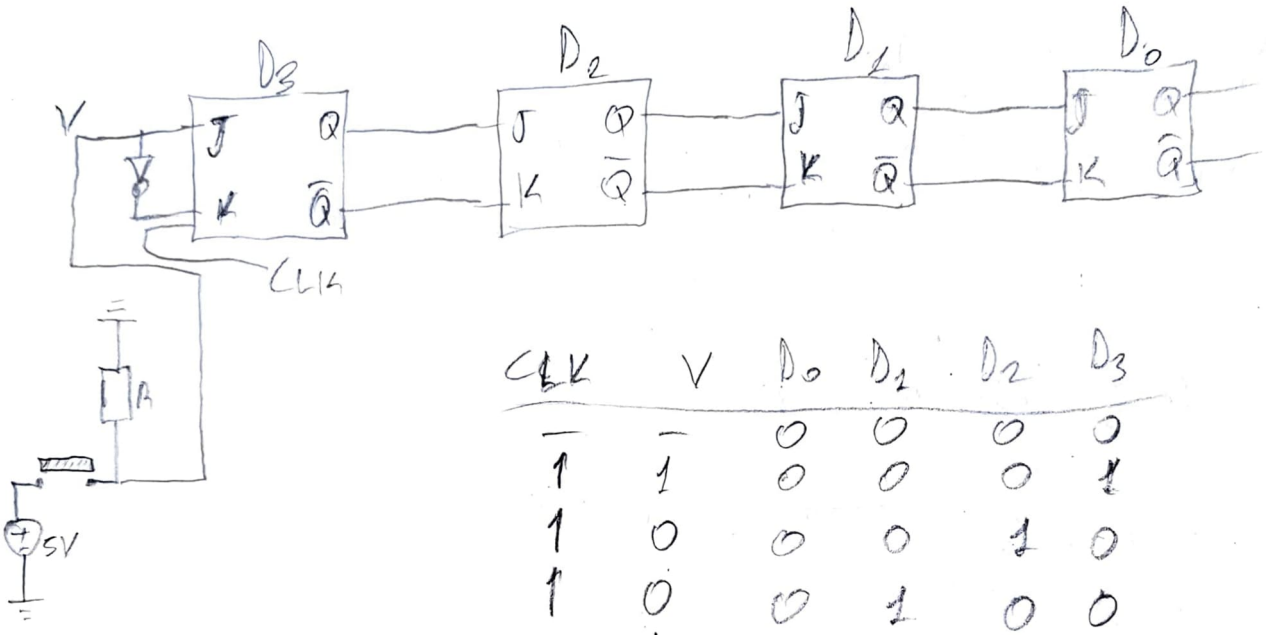


V 1010 bilgisini bu FF'a yükle?

CLK	V	D_0	D_1	D_2	D_3
—	—	0	0	0	0
↑	0	0	0	0	0
↑	1	1	0	0	0
↑	0	0	1	0	0
↑	1	1	0	1	0

4 bitlik Sağa Kaymalı Kaydedici Devresini Çiziniz (JK ile) (senkron)
1001 değerinin uygulanması durumunda 6. kaydırma pulse sonucunda FF'lerde oluşacak değeri gösteriniz?

$D_3 D_2 D_1 D_0$
1 0 1 0



CLK	V	D_0	D_1	D_2	D_3
—	—	0	0	0	0
↑	1	0	0	0	1
↑	0	0	0	1	0
↑	0	0	1	0	0
↑	1	1	0	0	1
↑	0	0	0	1	0
(6.) ↑	0	0	1	0	0

0 0 0 0 0

1 0 0 0 1

1 0 0 1 1

0 0 1 1 0

0 1 1 0 0

0 1 0 0 1

SAYISAL DEVRE TASARIMI

Sayı Sistemleri

Digital Fundamentals
Hüseyin Ekiz
Sayısal Devre

1- Onluk sayı sistemi $0 \rightarrow 9$

$$D_n = d_n 10^n + d_{n-1} 10^{n-1} + \dots + d_0 10^0 + d_{-1} 10^{-1} + \dots$$

virgülden sonra

- Flip-Flop
- Kronoloji
- Devre Sentezi

2- Binary (Hikili) Sayı Sistemi

$n$bit $\rightarrow 2^n$

MSB ↓ (0 1 1 0 0 1)$_2$ ↓ LSB

$(23)_{10}$ | 2 → $= (1\,0\,1\,1\,1)_2$

$(23,6)_{10} \rightarrow (\quad)_2$

$(A1F)_{16} = (?)_{10}$

$256A + 16 + F = 2560 + 16 + 15 = 2591$
(A = 10, F = 15)

Bölme ve Çarpma (2'lik Sistem)

0/0	$0 \cdot 0 = 0$
0/1	$01 = 0$
1/0	$10 = 0$
1/1	$11 = 1$

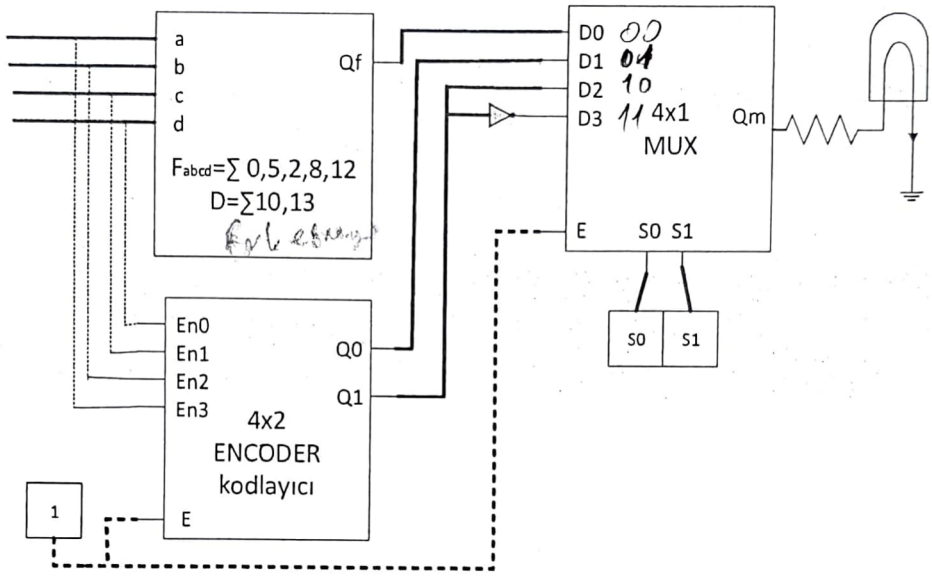
SAKARYA ÜNİVERSİTESİ

MÜHENDİSLİK FAKÜLTESİ ELEKTRİK-ELEKTRONİK MÜHENDİSLİĞİ BÖLÜMÜ

29.03.2017

SAYISAL DEVRE TASARIMI - ARASINAV

ÖĞRENCİNİN	PUAN CETVELİ										SON NOTU
Adı Soyadı :	1	2	3	4							
Numarası :											
Soruların Program Çıktısı İlişkisi	P.Ç.1	P.Ç.2	P.Ç.1	P.Ç.1							



Soru1: a,b,c,d girişlerine sahip şekildeki ilk blokta verilen f fonksiyonunu mintermleri dikkate alarak yazınız ve karnough yöntemiyle sadeleştirerek mintermler şeklinde yazınız ve sadeleştirilmiş fonksiyonun devresini çiziniz. **25p**

Soru2: Devre çıkışına bağlanmış LEDin yanmasını sağlayan Qm çıkış fonskiyonunu, S0 ve S1 seçme girişlerini ve a,b,c,d yi içerecek şekilde yazınız. (Qm çıkış fonksiyonunu boolen olarak yazınız.) **25p**

Soru3:

$$K=(7F)_{16} \quad L=(172)_8 \quad M=(0101)_{\text{GRAYkodu}} \quad N=(01010)_{\text{5 te 2 kodu}}$$

$$R=K-L \quad T=M+N$$

R sonucunun ikili sayı sistemindeki karşılığındaki 4 biti ($R_3R_2R_1R_0$),

T sonucunun ikili sayı sistemindeki karşılığındaki 4 biti ($T_3T_2T_1T_0$),

T ve R değerlerinin ikili sayı sistemi karşılıklarını bulunuz. (R=K-L , T=M+N) K-L işlemini 1'e tümleyen metoduyla hesaplayınız. **25p**

Soru4: $F = AC'D + A'BD + A'B' + BCD + A'BD' + BCD'$ fonksiyonunu boolean cebri kullanarak sadeleştiriniz ve sadeleştirilmiş fonksiyonu sadece VE-DEĞİL kapıları kullanarak devresini çiziniz. **25p**

Yrd.Doç.Dr. Ahmet KÜÇÜKER / Yrd.Doç.Dr. Burhan BARAKLI

Sınav Süresi **90** dakikadır. Hesap makinesi, Cep telefonu vb. araçların kullanımı kesinlikle yasaktır. Sınav sırasında cep telefonlarının tamamen kapalı ve sınav evraklarından uzakta tutulması zorunludur. Sınav kurallarına uymayanlar hakkında tutanak tutulacaktır. Soru kağıdı öğrencide kalacaktır. Cevap kağıtları gözetmen tarafından kimlik kontrolü ile paraflanmalıdır

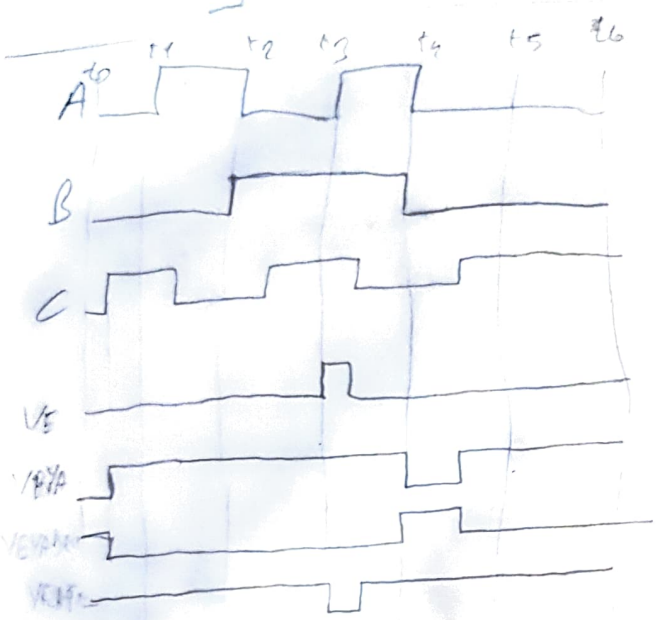
YAZ #3 OKULU

$M = 72532$ $N = 03250$ $M - N \equiv M + N^T$

$N^T = 10^5 - 3250 = 96750$

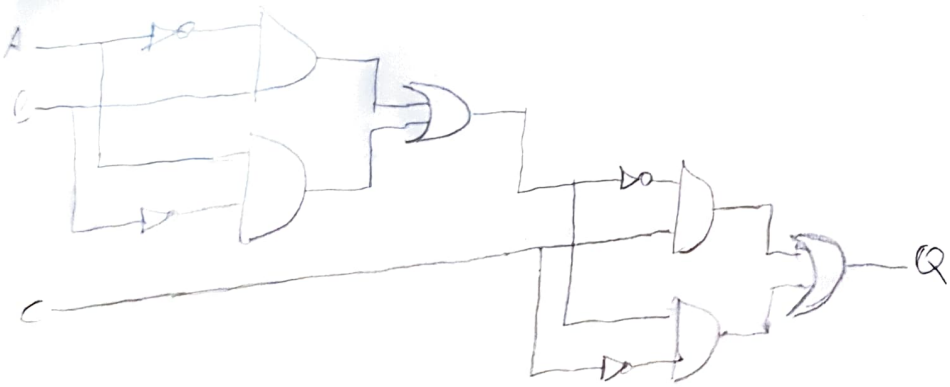
$72532 + 96750 = 169282$

sağlar → $72532 - 3250 = 69282$



A, B, C ye göre sinyal şekilleri çiz

A	B	C	Q
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1



A, B, C ye göre Z grafiği çiz?

1100 | 101
101 | 1
0010
101
0
100
101
0
1000
101
1
011

1100 | 101
101 | 1
0010
101
0
100
101
0
1000
101
1
0011

$(225)_8 = (\quad)_{BCD}$

$(\quad)_{10}$

$2\times64+2\times8+5=149$

$(149)_{10} = (000101001001)_{BCD}$

(11 0011 1011 1011)$_{BCD}$

3 3 11 11

9'dan Büyük olanlar (yazılamaz)

→ (11 0011 1001 1001)$_{BCD}$

3 3 9 9

yazılabilir

ASCII / BARCODE / GRAY KODU → işledi!!!
(minimum bit değişimi ile sıralama gerçekleşir.
böylece kodlama hızlı olur.

r tamlayan

$(11\,0100\,1011\,100)_2$

$(0010\,1101\,0010\,0)_2$

Undergraduate 14 SAAT

$y = \overline{\overline{A} \cdot \overline{BC}}$

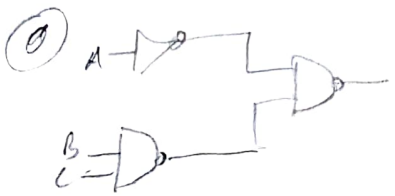
(a) Lojik kapı
(b) De Morg.
(c)

A

$A + A'B = A + B$

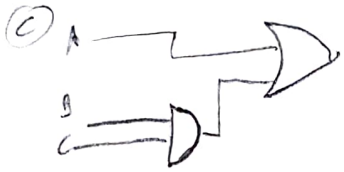
$A(A' + B) = AB$

(a)

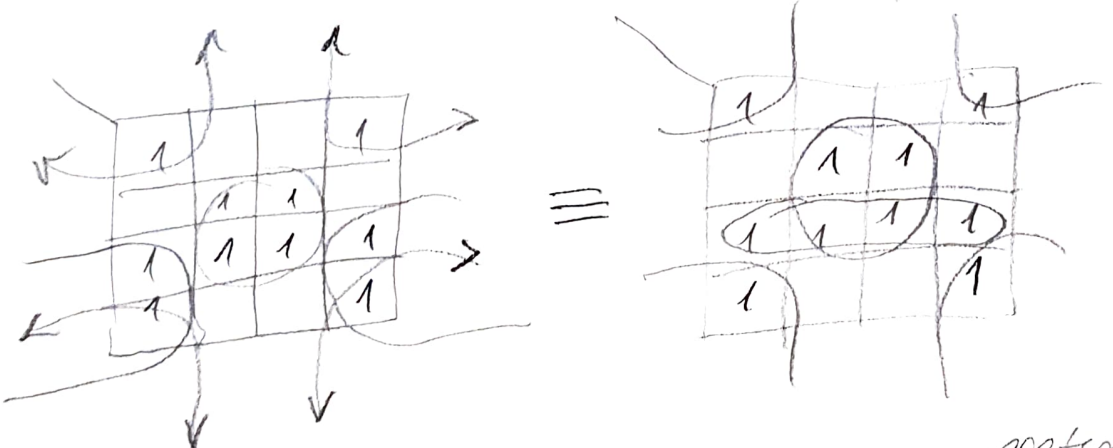


(b) $\overline{\overline{A}} + \overline{\overline{BC}} = A + BC$

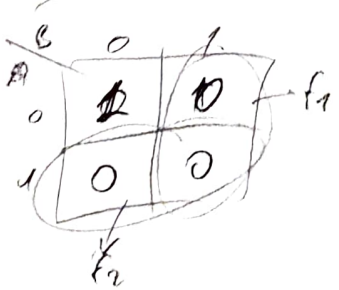
(c)



- $Q = AB + B\bar{C} + \bar{A}\bar{B}C$ ⟶ Toplayıcı çıkışı
- $f = (\bar{A} + B)(A + C)(B + C)$ ⟶ maxterm ile



Minterm

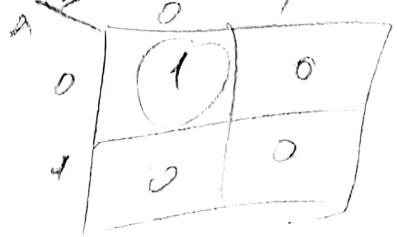


$F = f_1 \cdot f_2$

$= \bar{B} \cdot \bar{A}$

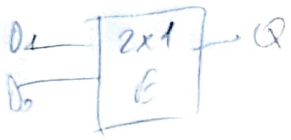
$F = \bar{A}\bar{B} = (A + B)$

Minterm



$F = f_1$

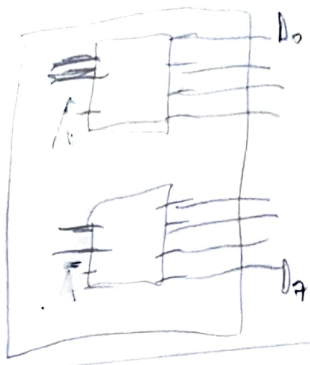
$= \overline{AB}$

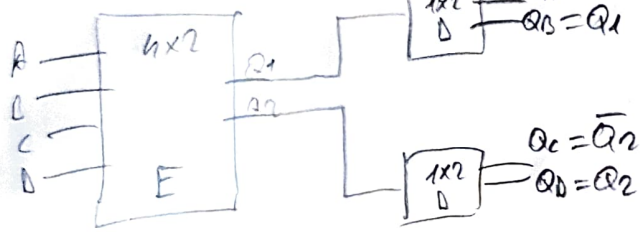


D_1	D_0	Q
0	1	0
1	0	1

- Yetkilendirme girişli 2x4 kod çözücüler ile 3x8 kod çözücü tasarımı

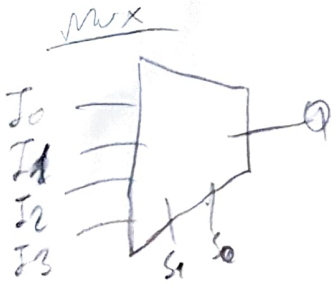
A	B	C
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1





D_3	D_2	D_1	D_0	Q_1	Q_2
0	0	0	1	0	0
0	0	1	0	0	1
0	1	0	0	1	0
1	0	0	0	1	1

$$Q_1 = \bar{D}_3 D_2 \bar{D}_1 \bar{D}_0 + D_3 \bar{D}_2 \bar{D}_1 \bar{D}_0$$
$$Q_2 = \bar{D}_3 \bar{D}_2 D_1 \bar{D}_0 + D_3 \bar{D}_2 \bar{D}_1 \bar{D}_0$$



S_1	S_0	Q
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

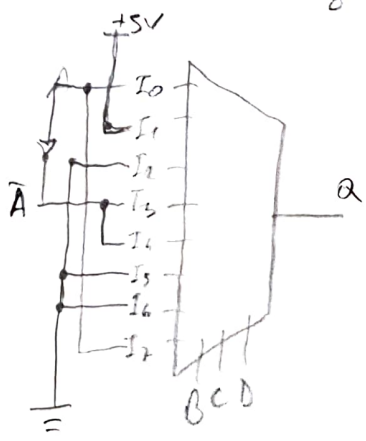
$$Q = \bar{S}_1 \bar{S}_0 I_0 + \bar{S}_1 S_0 I_1 + S_1 \bar{S}_0 I_2 + S_1 S_0 I_3$$

$f_{ABCD} = \sum(1, 3, 4, 8, 9, 15)$

8x1 mux ile gerçekleştirin

	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7
$\bar{A}$	0	(1)	2	(3)	(4)	5	6	7
A	(8)	(9)	10	11	12	13	14	(15)

A 1 0 $\bar{A}$ $\bar{A}$ 0 0 A

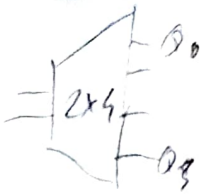


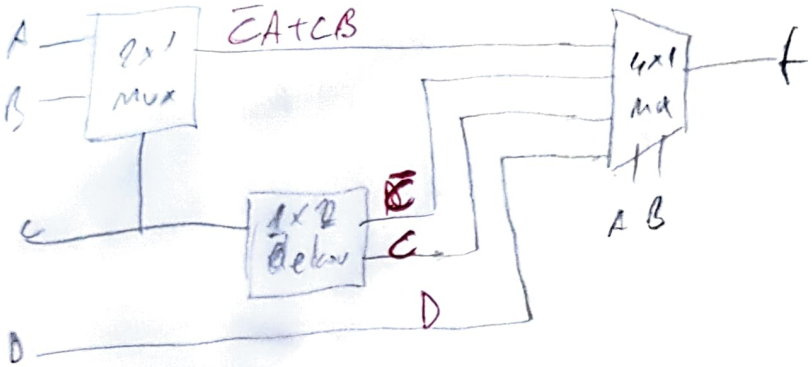
$Q_0 = \bar{S}_1 \bar{S}_2 D$

$Q_1 = S_1 \bar{S}_2 D$

$Q_2 = \bar{S}_1 S_2 D$

$Q_3 = S_1 S_2 D$





$f = \underbrace{\bar{A}\bar{B}(\bar{C}A+CB)}_{0} + \bar{A}B\bar{C} + A\bar{B}C + ABD$

3 bitlik bir ifade 4 kullanıcıya dağıtılacaktır. Bu işlem her kullanıcının seçilmesi ve bilginin sadece istenilen kullanıcıya iletilmesi şeklinde olacaktır. Demux ile gerçekleşir.

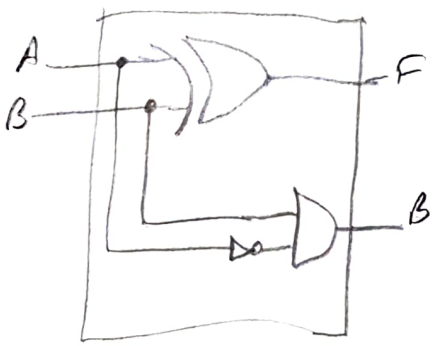
Tel Sarı

7483 (x2 adet) BCD toplayıcı devresi tasarla (ÖDEV)

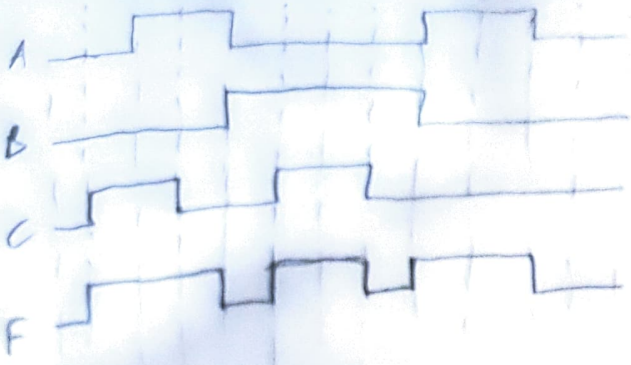
Giriş Çıkışlı Devreler

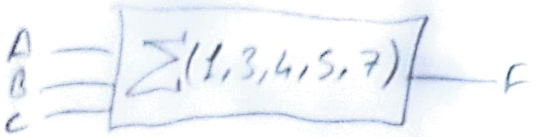
A	B	Fark	Borç
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0
		↓	↘ $\bar{A}B$
		exor	

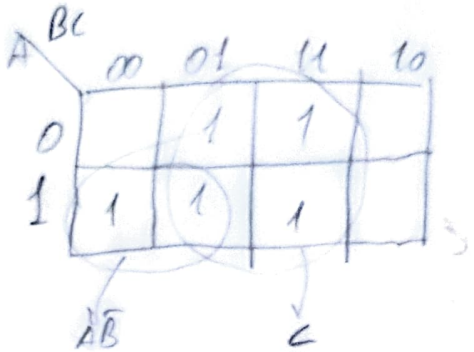
Half Subb (HS)



A	B	C	F	B
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1







$F = C + A\overline{B}$

Reset Bağlı

R	S	Q	$\bar{Q}$
1	1	0	1

Set Bağlı

R	S	Q	$\bar{Q}$
1	1	1	0

Durum Geçiş Tabloları

Q_t	Q_{t+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	R
0	X
1	0
0	1
X	0

D
0
1
0
1

T
0
1
1
0

- 23,540

$23 \mid 2$ → 11 → 1
$11 \mid 2$ → 5 → 1
$5 \mid 2$ → 2 → 1
$2 \mid 2$ → 1 → 0

$10111,10001$

$0,540 \times 2 = 1,080$

$0,080 \times 2 = 0,160$

$0,160 \times 2 = 0,32$

$0,32 \times 2 = 0,64$

$0,64 \times 2 = 1,28$ ...

- $A + \bar{A} = 1$
  $A \cdot \bar{A} = 0$
  $1 + A = 1$
  $1 \cdot A = A$
  $0 \cdot A = 0$

$(A+B)(A+C) = A+(BC)$

$\overline{AB} = \bar{A} + \bar{B}$

$\overline{(A+B)} = \bar{A} \cdot \bar{B}$

Shorter Machines

$J_1 = Q_3$ ~~$K_1 = Q_3$~~

~~$J_2 = \bar{Q}_1 \bar{Q}_2 \bar{Q}_3$~~ $K_2 = Q_1 Q_3$

~~$J_3 = \bar{Q}_1 \bar{Q}_2$~~ $K_3 = Q_1 \bar{Q}_2 Q_3$

$S = \bar{A}B + A\bar{B}$

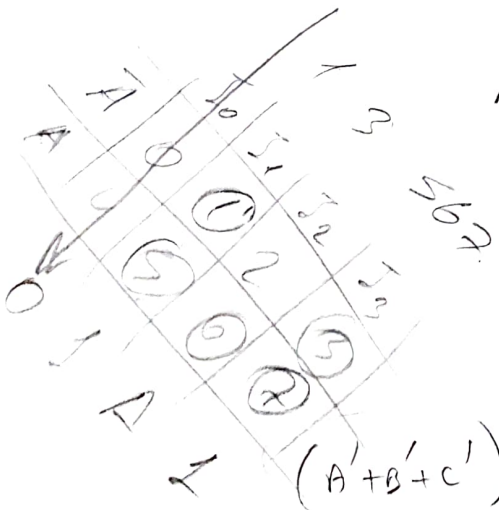
$C_0 = AB$

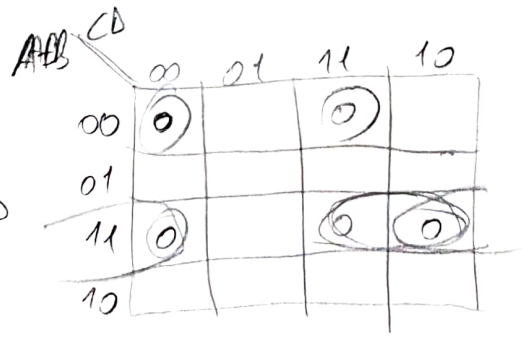
$F = \bar{C}D + C\bar{D}$

$B_0 = \bar{A}B$

$F_2 = \overline{AB}(\bar{C}D + C\bar{D}) + AB(\bar{A}B)$

A	B	C	D	S	C_0	F	B_0	F_1	F_2	F_3
0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	1	1	0	1	1
0	0	1	0	0	0	1	0	0	1	1
0	0	1	1	0	0	0	0	0	0	0
0	1	0	0	1	0	0	0	1	0	1
0	1	0	1	1	0	1	1	1	1	1
0	1	1	0	1	0	1	0	1	1	1
0	1	1	1	1	0	0	0	1	0	1
1	0	0	0	1	0	0	0	1	0	1
1	0	0	1	1	0	1	1	1	1	1
1	0	1	0	1	0	1	0	1	1	1
1	0	1	1	1	0	0	0	1	0	1
1	1	0	0	0	1	0	0	0	0	0
1	1	0	1	0	1	1	1	0	1	1
1	1	1	0	0	1	1	0	0	0	0
1	1	1	1	0	1	0	0	0	0	0





$A + B + C + \bar{D}$

$(A' + B' + C') \cdot (A' + B' + D) \cdot (A + B + C + D) \cdot (A + B + C' + D')$

Fatih Yıldız

- JK-FF (7476 x2 ədəd)
- Delikli perfinax və ya PCB
- Pil
- Buton x1
- Kondensator
- Yoğurdan və ya Dəsmal Vəsait
- BCD kod göstərici & 7 seqmentli displey (7447)

→	J	K
0 0	0	x
0 1	1	x
1 0	x	1
1 1	x	0

B1501.00037

1	5	0	3	7
0	1	2	3	4

ilkin sayğa

	Q_1	Q_2	Q_3	
0	0	0	1	↓
1	1	0	1	↓
2	0	0	0	↓
3	0	1	1	↓
4	1	1	1	↓
0	0	0	1	↓

S_1	R_1
1	0
0	1
0	x
1	0
0	1

S_2	R_2
0	x
0	x
1	0
x	0
0	1

S_3	R_3
x	0
0	1
1	0
x	0
x	0

S_1 / Q_1 \ Q_2Q_3

	00	01	11	10
0	0	1	1	
1		0	0	

$S_1 = \bar{Q}_1 Q_3$

R_1 / Q_1 \ Q_2Q_3

	00	01	11	10
0	x	0	0	
1		1	1	

$R_1 = Q_1 Q_3$

S_2 / Q_1 \ Q_2Q_3

	00	01	11	10
0	1	0	x	
1		0	0	

$S_2 = \bar{Q}_1 \bar{Q}_2 \bar{Q}_3$

R_2 / Q_1 \ Q_2Q_3

	00	01	11	10
0	0	x	0	
1		x	1	

$R_2 = Q_1 Q_3$

$R_1 = R_2$

S_3 / Q_1 \ Q_2Q_3

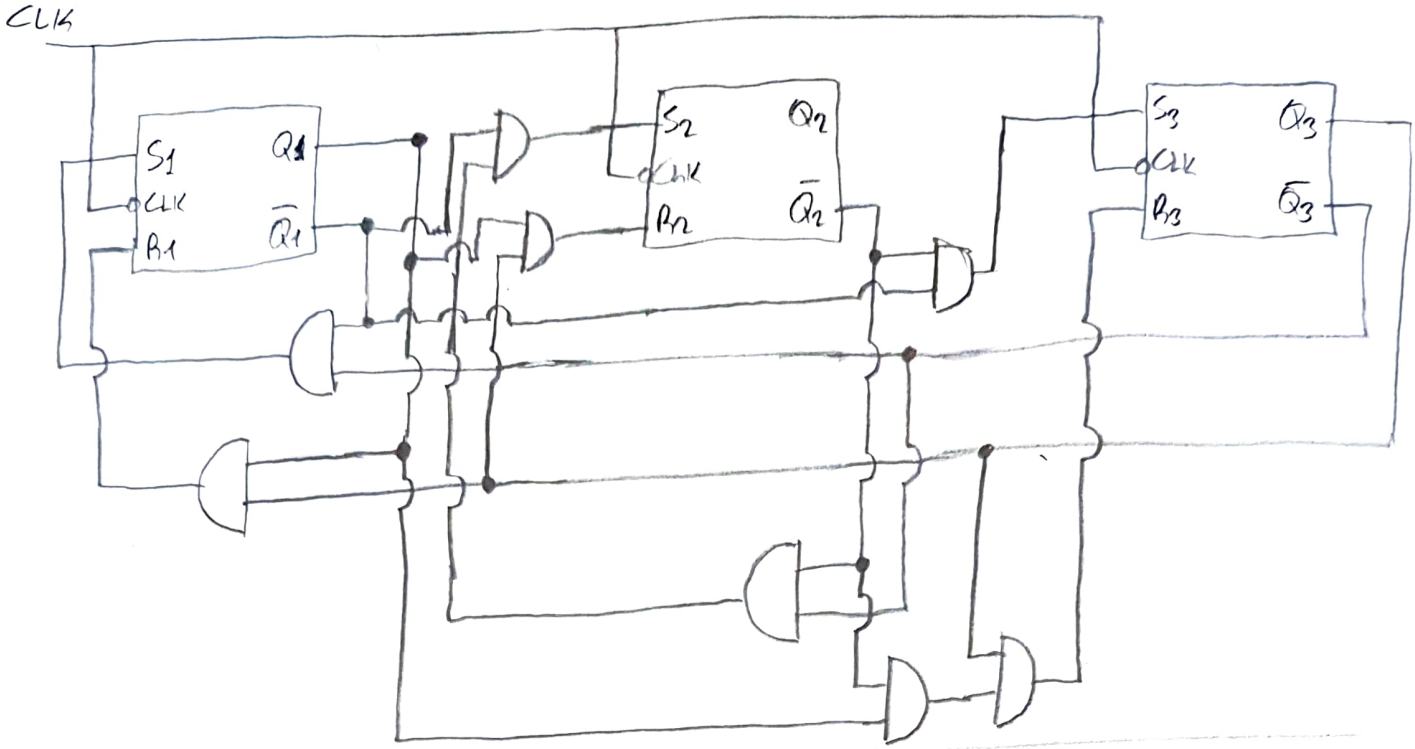
	00	01	11	10
0	1	x	x	
1		0	x	

$S_3 = \bar{Q}_1 \bar{Q}_2$

R_3 / Q_1 \ Q_2Q_3

	00	01	11	10
0	0	0	0	
1		1	0	

$R_3 = Q_1 \bar{Q}_2 Q_3$



Q_1	Q_2	Q_3
0	0	1
1	0	1
0	0	0
0	1	1
1	1	1
0	0	1

J_1	K_1
1	X
X	1
0	X
1	X
X	1

J_2	K_2
0	X
0	X
1	X
X	0
X	1

J_3	K_3
X	0
X	1
1	X
X	0
X	0

J_1 / Q_1 \ Q_2Q_3

Q_1 \ Q_2Q_3	00	01	11	10
0	0	1	1	
1		X	X	

$J_1 = Q_3$

K_1 / Q_1 \ Q_2Q_3

Q_1 \ Q_2Q_3	00	01	11	10
0	X	X	X	
1		1	1	

$K_1 = Q_3$

J_2 / Q_1 \ Q_2Q_3

Q_1 \ Q_2Q_3	00	01	11	10
0	1	0	X	
1		0	X	

$J_2 = \bar{Q}_1 \bar{Q}_2 \bar{Q}_3$

K_2 / Q_1 \ Q_2Q_3

Q_1 \ Q_2Q_3	00	01	11	10
0	X	X	0	
1		X	1	

$K_2 = Q_1 Q_3$

J_3 / Q_1 \ Q_2Q_3

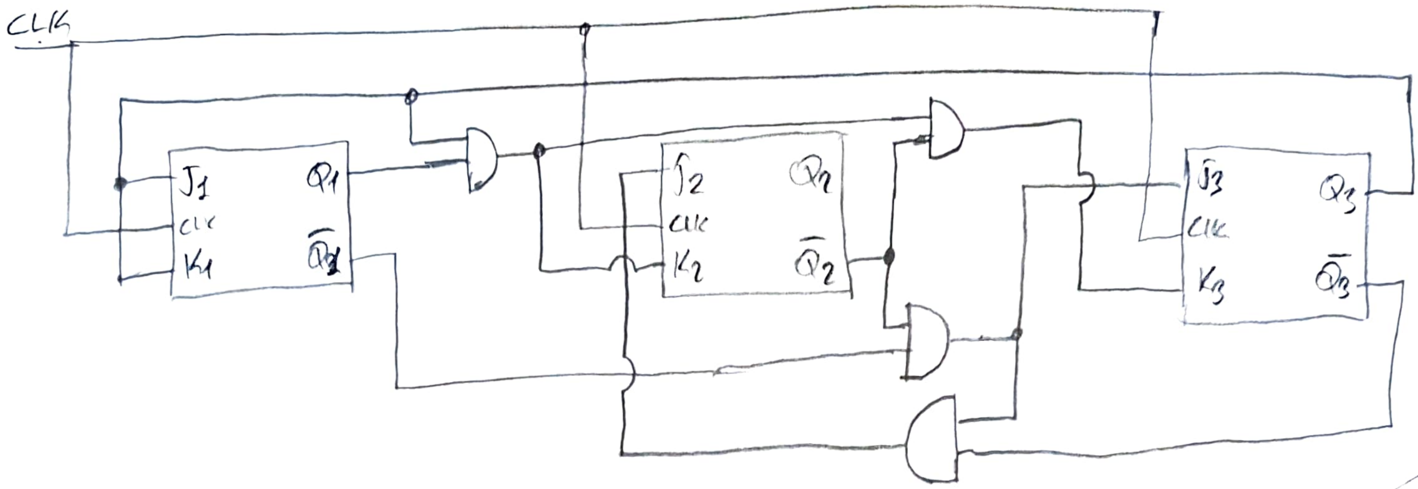
Q_1 \ Q_2Q_3	00	01	11	10
0	1	X	X	
1		X	X	

$J_3 = \bar{Q}_1 \bar{Q}_2$

K_3 / Q_1 \ Q_2Q_3

Q_1 \ Q_2Q_3	00	01	11	10
0	X	0	0	
1		1	0	

$K_3 = Q_1 \bar{Q}_2 Q_3$



✓ 2 tane 7476 (JK FF)

✓ 1 tane 7447 (BCD/Dekoder)

Soketler

— 1 ve (8 parça)

— 9V pil 8 (pil yatağı)

Kısa Direnç

1 buton

1 Switch

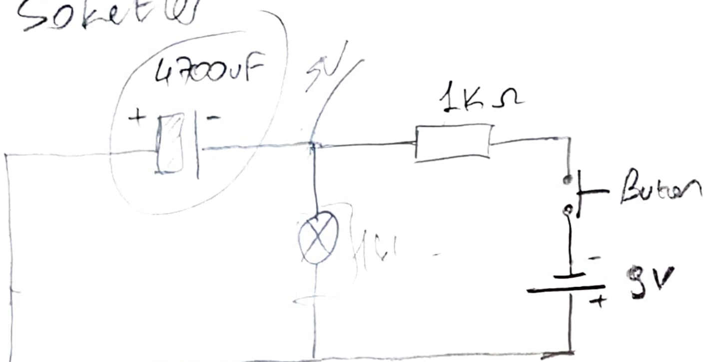
delikli

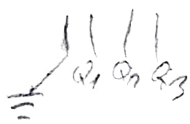
200 ve ya 100 µF

— 220 Ω

— 330 Ω

1k Ω

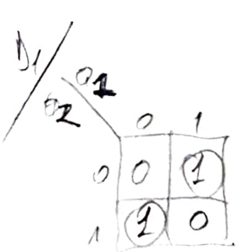


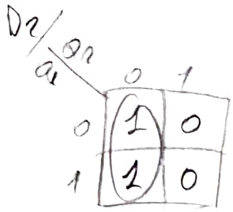


Note: D FF ile 0 1 2 3 ... baştan dön (asenkron sayıcı)

	Q_2Q_1	D_1	D_2
0	00	0	1
1	01	1	0
2	10	1	1
3	11	0	0
	00		

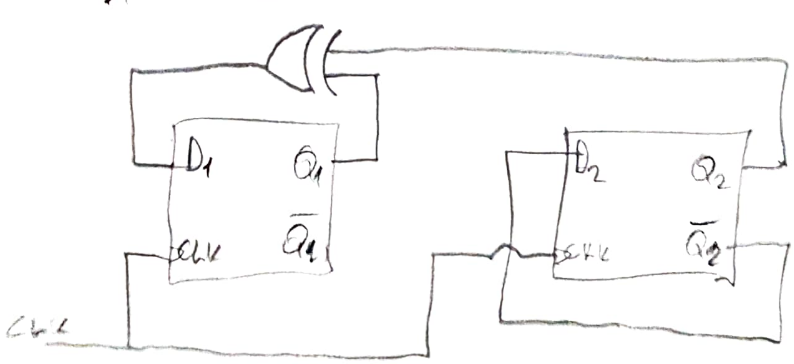
	D
00	0
01	1
10	0
11	1





$D_1 = Q_1\overline{Q_2} + \overline{Q_1}Q_2$

$D_2 = \overline{Q_2}$



$\tau = \frac{1}{RC}$ R↑ C↑ τ↓

22μF

22μF ✓

4700μF ✓

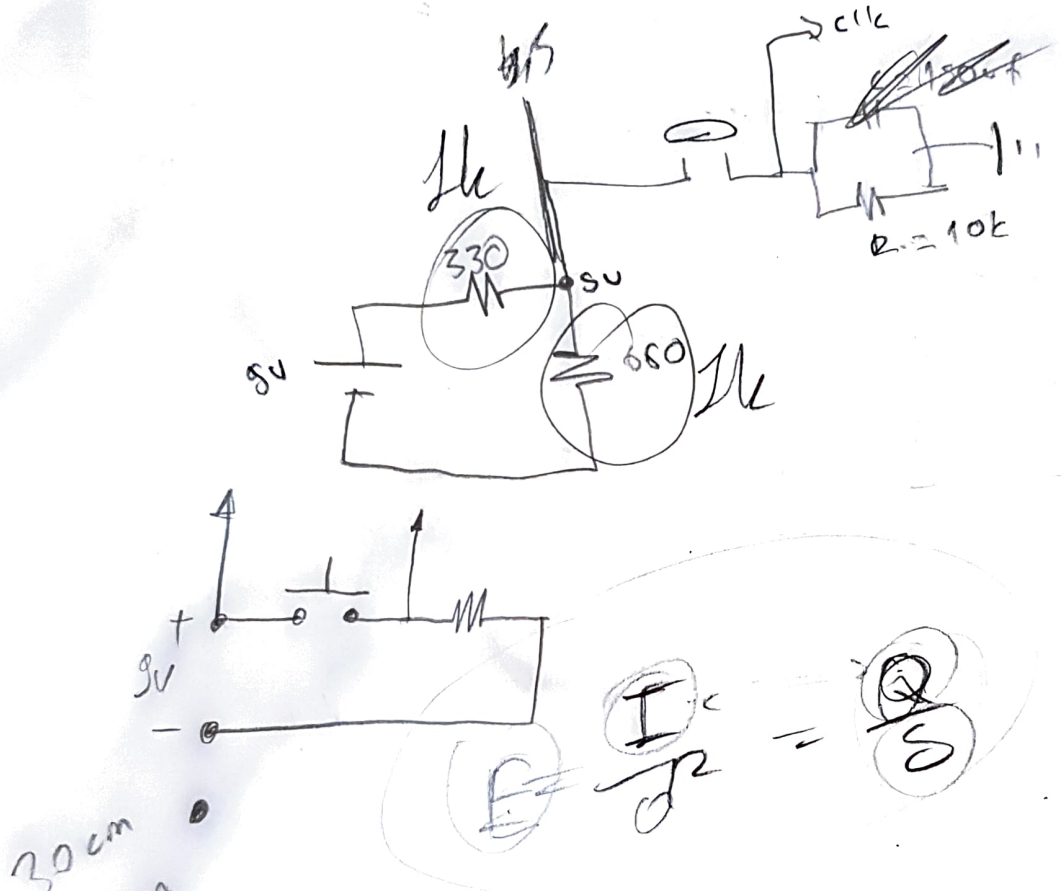
μ → 10^{-6} ✓

n → 10^{-9}

p → 10^{12}

X	Q_A	Q_B
0	0	0
0	1	0
0	1	1
0	0	0
1	1	1
1	0	1
1	0	0
1	1	1

010



$\frac{I}{r^2} = \frac{Q}{S}$

30cm
29cm

$\frac{4\pi r^2}{2}$ ... $2\pi r^2$

10k

1000

clock

660

Klaxons

955

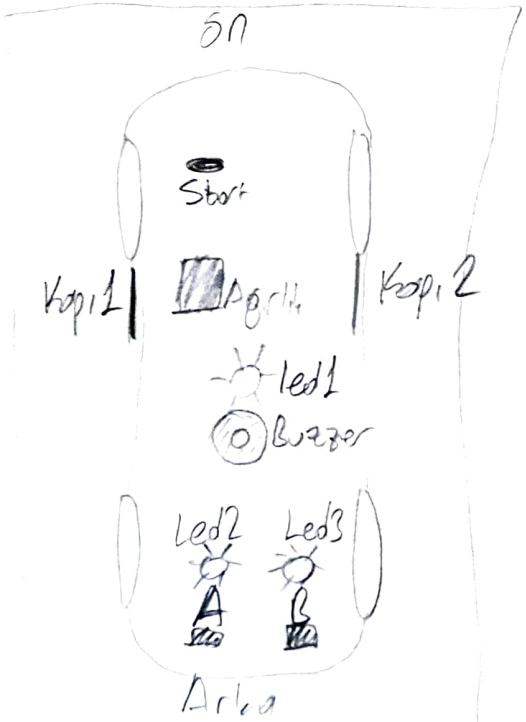
1 start/stop (Anahtar)
1 ağırlık sensörü (Buton)
2 on kapılar (Buton)
1 orta kapı (B. Led)
1 Alarm (Buzzer)
1 Pil
2 Bağlı Led (M ve K)

↓
A ve B buton

XY ⇒ 37
X = 0011
Y = 0111

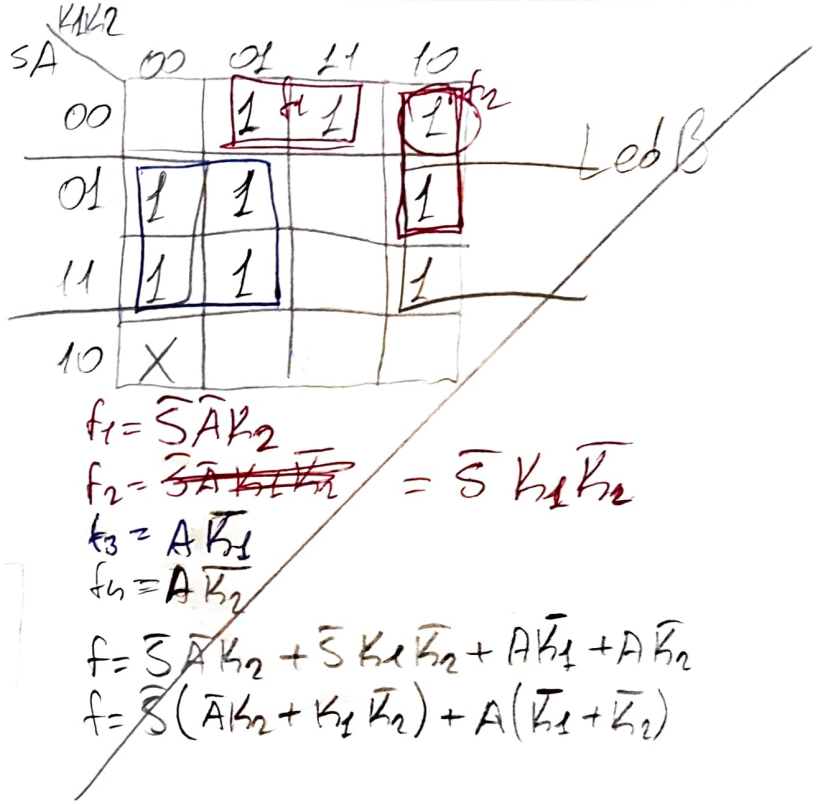
Buton A
Buton B
Kapı 1 = C
Kapı 2 = D

$ABCD < (Y)_2$
$ABCD > (X)_2$



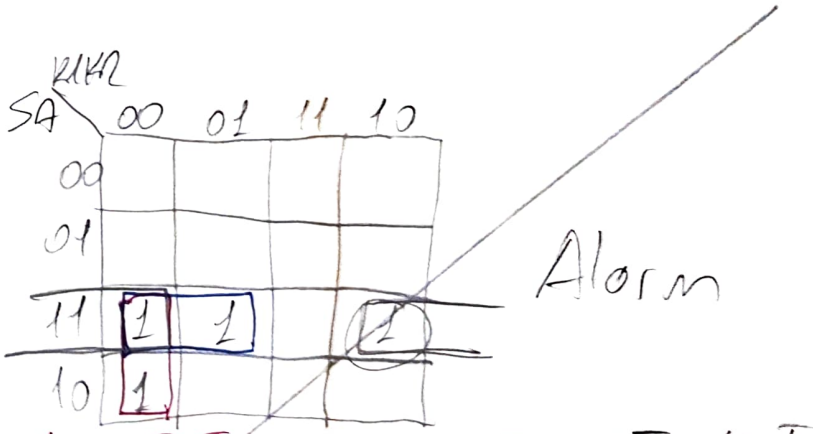
Kapı kapalı = 0

S	A	K1	K2	B led	Alarm
S/S	Ağırlık Buton	Kapı 1	Kapı 2		
0	0	0	0	* 0	
0	0	0	1	1	
0	0	1	0	1	
0	0	1	1	1	
0	1	0	0	* 0	
0	1	0	1	1	
0	1	1	0	1	
0	1	1	1	1	
1	0	0	0	* X	1
1	0	0	1		
1	0	1	0		
1	0	1	1		
1	1	0	0	0	0
1	1	0	1	1	1
1	1	1	0	1	1
1	1	1	1	1	1



$f_1 = \bar{S}\bar{A}K_2$
$f_2 = \bar{S}\bar{A}K_1\bar{K_2}$ $= \bar{S}K_1\bar{K_2}$
$f_3 = A\bar{K_1}$
$f_4 = A\bar{K_2}$

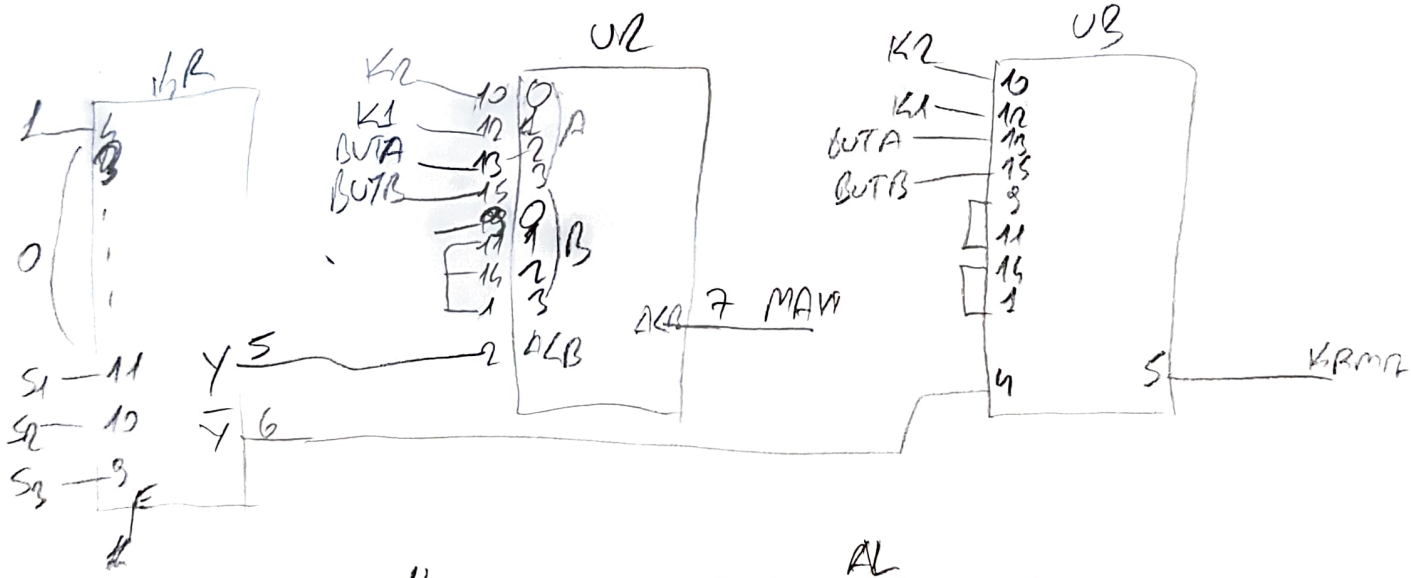
$f = \bar{S}\bar{A}K_2 + \bar{S}K_1\bar{K_2} + A\bar{K_1} + A\bar{K_2}$
$f = \bar{S}(\bar{A}K_2 + K_1\bar{K_2}) + A(\bar{K_1} + \bar{K_2})$

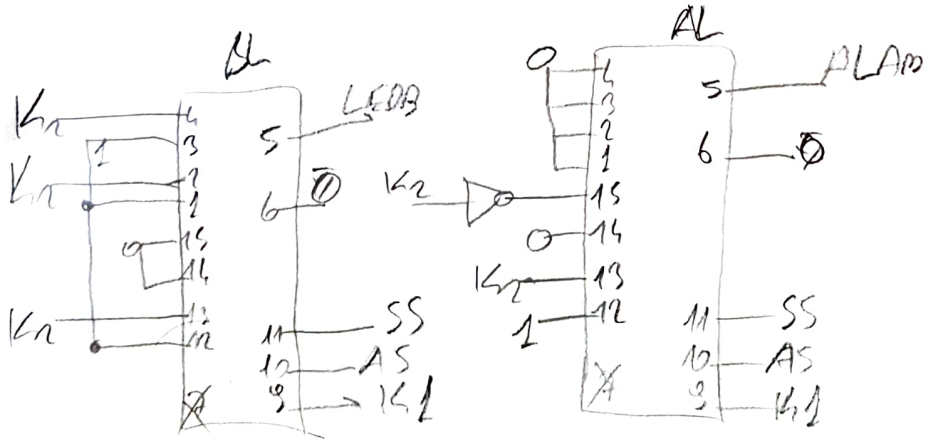


$f_1 = S\bar{K_1}\bar{K_2}$
$f_2 = SA\bar{K_1}$
$f_3 = SA\bar{K_2}$

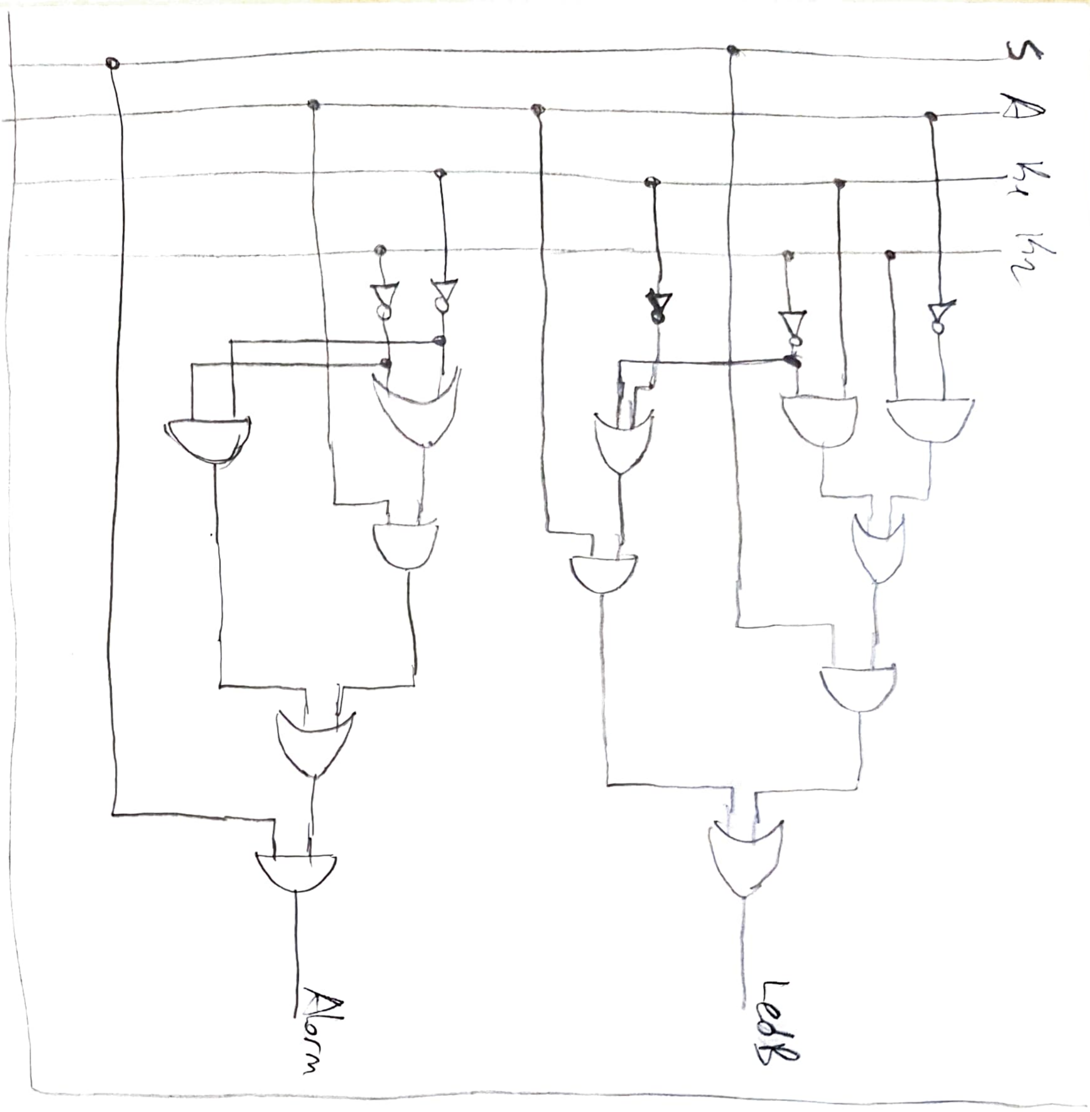
$f = S\bar{K_1}\bar{K_2} + SA\bar{K_1} + SA\bar{K_2}$
$f = S\bar{K_1}\bar{K_2} + SA(\bar{K_1} + \bar{K_2})$
$f = S(\bar{K_1}\bar{K_2} + A(\bar{K_1} + \bar{K_2}))$

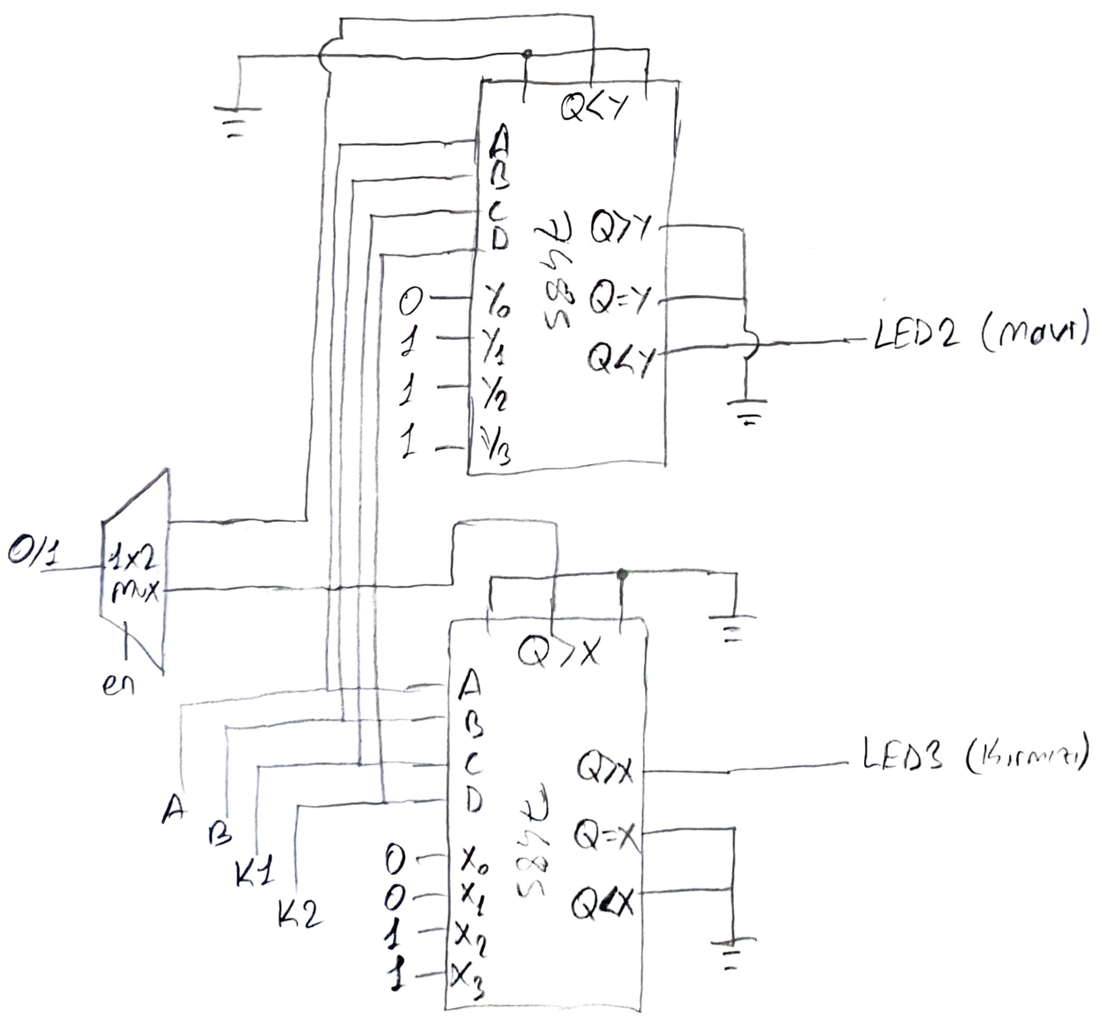
D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	S
1	1	1	1	0	0	0	0	A
1	1	0	0	1	1	0	0	K1
1	0	1	0	1	0	1	0	K2
1	0	0	X	1	1	1	0	Bed
1	0	0	1	0	0	0	0	Alarm
1	K_1	0	0	1	K_2	1	K_2	f_1
1	K_1	0	K_1	0	0	0	0	f_2





7406 → Değil
7408 → Ve
7432 → Veya
7486 → özel veya
74153 → mux
7485 → karşılaştırma
74138 → demux





$f_1 = \overline{A+B+C'} + A'BC' + (A'B + AB')$

$f_1 = \underbrace{A'B'C}_{fx} + \underbrace{A'BC'}_{fy} + \underbrace{A'B}_{fz} + \underbrace{AB'}_{fw}$

A	B	C	fx	fy	fz	fw	f_1
0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	1
0	1	0	0	1	1	0	1
0	1	1	0	0	1	0	1
1	0	0	0	0	0	1	1
1	0	1	0	0	0	1	1
1	1	0	0	0	0	0	0
1	1	1	0	0	0	0	0

$f_2 = \overline{AB+C} + (A'+C')(AB).(B'C)$

$f_2 = \underbrace{(A'+B').C'}_{fx} + \underbrace{A'ABB'C}_{fy} + \underbrace{ABB'CC'}_{fz}$

A	B	C	fx	fy	fz	f_2
0	0	0	1	0	0	1
0	0	1	0	0	0	0
0	1	0	1	0	0	1
0	1	1	0	0	0	0
1	0	0	1	0	0	1
1	0	1	1	0	0	1
1	1	0	0	0	0	0
1	1	1	0	0	0	0

$f_3 = \underbrace{ABC}_{fx} + \underbrace{AB'C}_{fy} + \underbrace{ABC'}_{fz}$

A	B	C	fx	fy	fz	f_3
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	1	0	0	0	0	0
0	1	1	0	0	0	0
1	0	0	0	0	0	0
1	0	1	0	1	0	1
1	1	0	0	0	1	1
1	1	1	1	0	0	1

$f_4 = \overline{A+B+C'} + (A'+B')C' + AC$

$f_4 = \underbrace{A'B'C}_{fx} + \underbrace{A'C'}_{fy} + \underbrace{B'C'}_{fz} + \underbrace{AC}_{fw}$

A	B	C	fx	fy	fz	fw	f_4
0	0	0	0	1	1	0	1
0	0	1	1	0	0	0	1
0	1	0	0	1	0	0	1
0	1	1	0	0	0	0	0
1	0	0	0	0	1	0	1
1	0	1	0	0	0	1	1
1	1	0	0	0	0	0	0
1	1	1	0	0	0	1	1

$\bar{A}\bar{B}C + \bar{A}B(1+\bar{C}) + A\bar{B}$

$\bar{A}\bar{B}C + \bar{A}B + A\bar{B}$