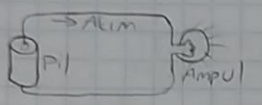
ELEKTRİK

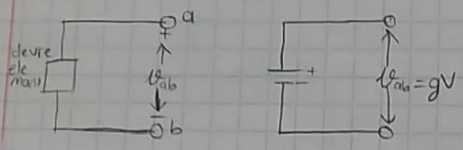
Elektrik devresi, elektrik elemanlarının birbirine bağlanmasıdır.



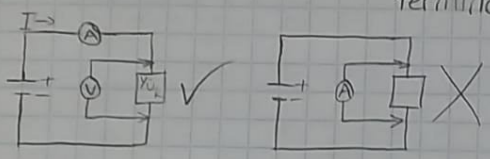
Uluslararası Birim Sistemi (SI):

Akım (A)	Çarpan	Örnek	Sembol
Voltaj (V)	10^{9}	giga	G
Yük (C)	10^{6}	mega	M
	10^{3}	kilo	k
	10^{0}	—	—
	10^{-3}	mili	m
	10^{-6}	mikro	μ
	10^{-9}	nano	n
	10^{-12}	piko	p

Yük Ve Akım: Yük, maddeyi oluşturan atomik parçacıkların bir özelliğidir. Coulomb (C) olarak ölçülür. q olarak gösterilir. $1e^{-} = 1{,}602 \cdot 10^{-19} C$



$v_{ba} = -gV$ Akım, devre elemanının üzerinden akar. Gerilim devre elemanının terminalleri arasında ölçülür.



✓ ✗

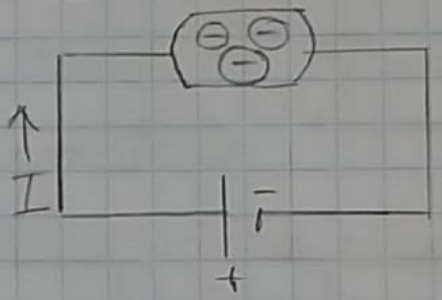
Güç Ve Enerji: Güç, harcanan ya da üretilen enerjinin zamana oranıdır. $P_{\text{Güç (W)}} \triangleq \frac{dw}{dt} \rightarrow \frac{\text{enerji (J)}}{\text{zaman (s)}}$ Watt

$$P = \frac{dw}{dt} = \frac{dw}{dq} \times \frac{dq}{dt} = VI$$

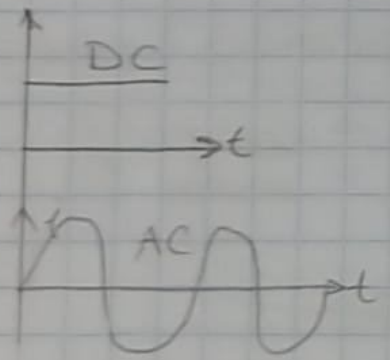
Pasif İşaretleme Yöntemi: Güç üreten cihazlarda akımın çıktığı terminal (+) terminaldir. Güç üreten devre elemanlarına akımın girdiği terminal (+) olarak işaretlenir.

Yükün Korunumu Kanunu: Yük yoktan vardır, vardan yok olamaz. Transfer edilebilir Bir sistemdeki toplam elektrik yükü değişmez.

Akım: Yüklerin hareketidir.



Elektrik akımı, yükün zamana karsı değişim miktarıdır.
$i \triangleq \frac{dq}{dt}$ Amper (A) ile ölçülür. I veya i ile ifade edilir.



Örn: Bir terminale giren yük miktarı $q = 5t \sin 4\pi t$ mC ise $t = 0{,}05$ s`deki akımı hesaplayınız.

Çöz: $i = \frac{dq}{dt} = \frac{d}{dt}(5t \sin 4\pi t) = 5 \sin 4\pi t + 20\pi t \cos 4\pi t$

2

@$t = 0{,}5$s $\quad i = 0 + 10\pi = 31{,}42$ mA

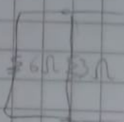
$0{,}3\,mV = 300\,\mu V$ $\quad 2\,mA = 2\times10^{-3}\,A$ $\quad \frac{V}{mA} = k\Omega$ $\quad \frac{V}{\Omega} = A$

$60\times10^{-3}\,mV = 60\,\mu V$ $\quad 0{,}0002\,V = 0{,}2\,mV$

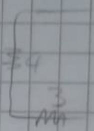
$400\,\Omega = 0{,}4\,k\Omega$ $\quad 3300\,\Omega = 3{,}3\,k\Omega$

$3\times10^{6}\,\Omega = 3\,M\Omega$

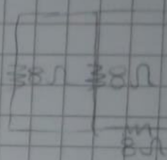
$\frac{\Omega}{M\Omega} = \frac{1}{10^6} = 10^{-6}$



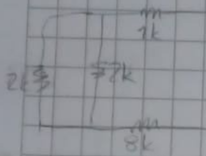
$\frac{6}{3} = 2\,\Omega$



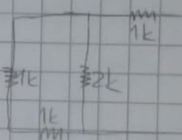
$4+3 = 7\,\Omega$



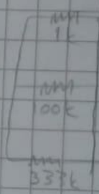
$\frac{8}{2} + 8 = 12\,\Omega$



$1 + \left(\frac{2}{2}\right) + 8 = 10k$



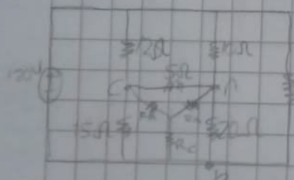
$\frac{(1+1)}{2} + 1 = 2k$



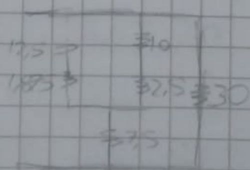
$R_{ab} = 3k$

$q = t\cos(4\pi t)\,mC$ $\quad t = 1{,}0\,s$ de $i = ?$ $\quad i = \frac{dq}{dt} = \frac{d}{dt}\left[t\cos(4\pi t)\right]$

$\cos(4\pi t) - 4\pi t\sin(4\pi t) = 1\,mA$



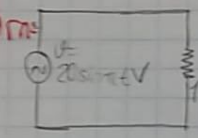
$\frac{R_1 R_2}{R_1+R_2+R_3}$ $\quad R_a = 1{,}875\,\Omega$ $\quad R_b = 2{,}5\,\Omega$ $\quad R_c = 7{,}5\,\Omega$



$R_{ab} = \left[(12{,}5+1{,}875)\,//\,(10+2{,}5)\right] + 7{,}5$

$\cong 9{,}632\,\Omega$ $\quad i = \frac{120}{R_{ab}} = 12{,}458\,A$

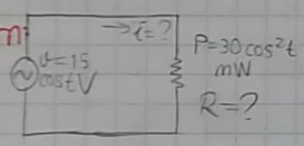
21

Örn: 

Çöz: $A\sin 2\pi ft$ $A=20$ $2\pi ft=\pi t$

$2f=1$ $f=0.5\,Hz$ $i=\frac{v}{R}=\frac{20\sin\pi t}{10k\Omega}=2\sin\pi t\,mA$

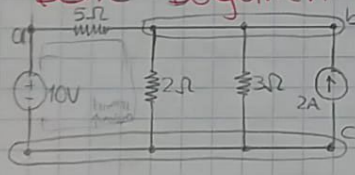
$P=iv=40\sin^2\pi t\,mW$

Örn: 

Çöz: $P=vi \Rightarrow i=\frac{P}{v}=\frac{30\cos^2 t\,mW}{15\cos t\,V}=2\cos\,mA$

$R=\frac{v}{i}=\frac{15\cos t\,V}{2\cos t\,mA}=7{,}5\,k\Omega$

Devre Düğümleri Ve Kolları:

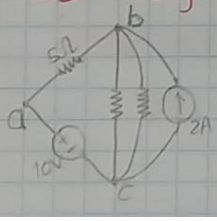


5 devre kolu → 2Ω, 3Ω, 2A, 10A, 5Ω

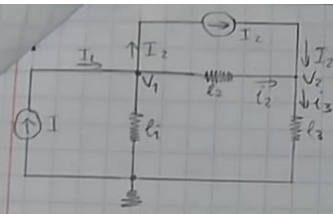
3 düğüm noktası → a, b, c

Seri Bağlantı:

10



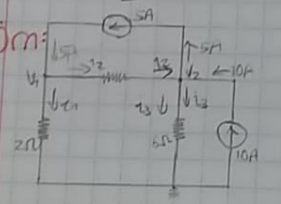
Eğer iki ya da daha fazla sayıdaki eleman, aynı düğümü paylaşarak, aynı akımı basıyorlarsa, bu elemanlar seri bağlıdır.



KAK: $I_1 = I_2 + i_1 + i_2$ $\quad I_2 + i_2 = i_3$

$I_1 = I_2 + \frac{V_1 - 0}{R_1} + \frac{V_1 - V_2}{R_2}$ $\quad I_2 + \frac{V_1 + V_3}{R_2} = \frac{V_2 - 0}{R_3}$

Örn:

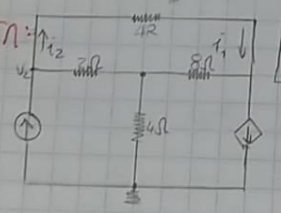


KAK@V_1: $5 = i_1 + i_2$ $\quad \frac{V_1 - 0}{2} - \frac{V_1 - V_2}{4} = 5$ $\quad 3V_1 - V_2 = 20$

KAK@V_2: $i_2 + 10 = 5 + i_3$ $\quad i_3 - i_2 = 5$ $\quad \frac{V_2 - 0}{6} - \frac{V_1 - V_2}{4} = 5$

$3V_1 - 5V_2 = -60$ $\quad V_1 = 20V$ $\quad V_2 = 13,3V$

Örn:



$$\begin{bmatrix} 3 & -2 & -1 \\ 4 & -7 & 0 \\ -2 & 3 & -1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 12 \\ 0 \\ 0 \end{bmatrix}$$

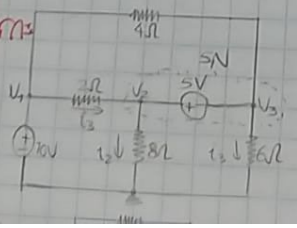
KAK@V_1: $i_1 + i_2 = 3$ $\quad \frac{V_1 - V_3}{4} + \frac{V_1 - V_2}{2} = 3$

$3V_1 - 2V_2 - V_3 = 12$

@V_2: $i_1 = i_2 + i_3$ $\quad \frac{V_1 - V_2}{2} = \frac{V_2 - V_3}{8} + \frac{V_2 - 0}{4}$ $\quad 4V_1 - 7V_2 + V_3 = 0$

@V_3: $i_1 + i_2 = 2i_3$ $\quad \frac{V_1 - V_3}{4} + \frac{V_2 - V_3}{8} = 2\,\frac{V_1 - V_2}{2}$

Örn:

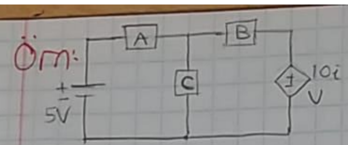


17

$V_1 = 10V$ $\quad i_1 = -10A$ $\quad i_1 + i_4 = i_2 + i_3$

$\frac{V_1 - V_2}{2} + \frac{V_1 - V_3}{4} = \frac{V_2 - 0}{8} + \frac{V_3 - 0}{6}$ $\quad V_2 = V_3 + 5$

Örn:



i	V
1A	10V
1mA	10mV

Direnç: Maddenin üzerinden akan yüke karşı koya-bilme kabiliyetidir. R ile gösterilir. Birimi ohm (Ω)'dur.

$R = \rho \frac{\ell}{A}$

- R: direnç (Ω)
- ρ: direnç katsayısı (Ω.m)
- ℓ: uzunluk (m)
- A: kesit alan (m^2)

Materyal	Direnç Katsayısı	
Gümüş	$1{,}64 \cdot 10^{-8}$	İletken
Bakır	$1{,}72 \cdot 10^{-8}$	İletken
Alüminyum	$2{,}8 \cdot 10^{-8}$	İletken
Altın	$2{,}45 \cdot 10^{-8}$	İletken
Karbon	$4 \cdot 10^{-5}$	Y. iletken
Germanyum	$4{,}7 \cdot 10^{-3}$	Y. iletken
Silikon	$6{,}4 \cdot 10^{-2}$	Y. iletken
Kağıt	10^{10}	Yalıtkan
Mika	$5 \cdot 10^{11}$	Yalıtkan
Cam	10^{12}	Yalıtkan
Teflon	$3 \cdot 10^{12}$	Yalıtkan

Örn: Çapı 10mm olan 45 km uzunluğunda bakır telin iki ucu

7 arasındaki direnci nedir?

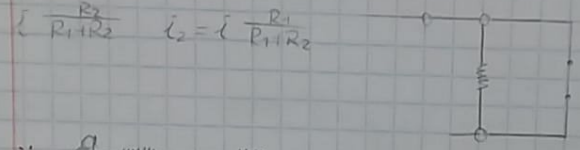
Çöz: $D = 10mm \Rightarrow A = \pi r^2 \quad \pi\left(\frac{10mm}{2}\right)^2 = 78 \times 10^{-6}\, m^2$

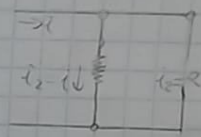
$R = \rho \frac{\ell}{A} = 1{,}72 \cdot 10^{-8} \cdot \frac{45 \cdot 10^{3}}{78 \cdot 10^{-6}} \approx 9{,}9\,\Omega$

KAK: $i = i_1 + i_2$ $\frac{U}{R_1} + \frac{U}{R_2} = \frac{U}{R_1} + \frac{U}{R_2}$ $U\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

$\frac{1}{R_{es}} = \frac{1}{R_1} + \frac{1}{R_2}$ $R_{es} = \frac{R_1 R_2}{R_1 + R_2}$ $U = i R_{es}$ $i_1 = \frac{U}{R_1} = i \frac{R_2}{R_1}$ $= i \frac{R_1 + R_2}{R_1}$

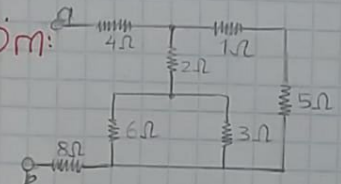
$i \frac{R_2}{R_1 + R_2}$ $i_2 = i \frac{R_1}{R_1 + R_2}$



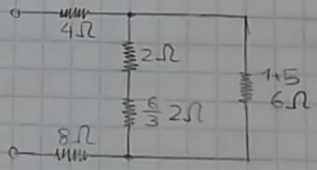


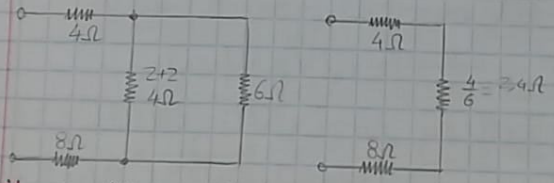
$i_2 = i$ $i_1 = 2 R_2 = \Omega$

Öm:



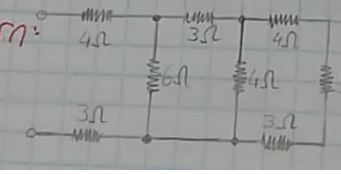
Res=?





$R_{es} = 4 + 8 + 2{,}4 = 14{,}4\,\Omega$

Öm:

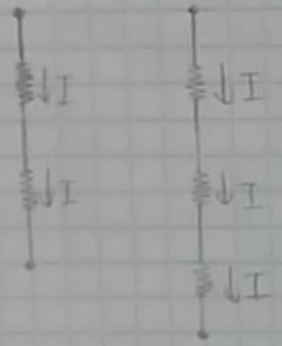


Res=?

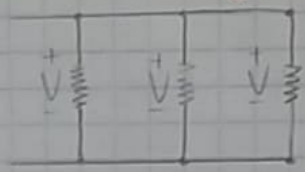
$[(4+3+5)\,//\,4)+3]\,//\,6]+4+3 =$

12

15



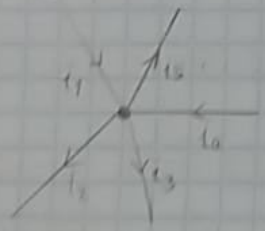
Paralel Bağlantı:



Eğer iki yada daha fazla sayıdaki eleman aynı iki düğüme bağlıysa ve üzerinde aynı gerilim varsa, bu devre elemanları paraleldir.

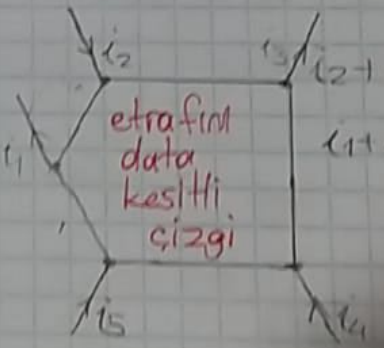
Kirchoff Akım Kanunu (KAK):

Bir düğüm noktasına giren akımların toplamı, bu düğüm noktasından çıkan akımların toplamına eşittir.

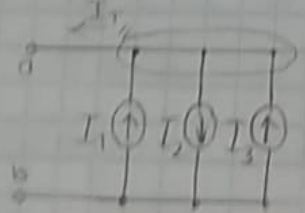


$i_1 + i_4 = i_2 + i_3 + i_5$

$(i_1 + i_4) - i_2 - i_3 - i_5 = 0$



$i_2 + i_3 + i_5 = i_1 + i_4$



$I_1 + I_3 = I_1 + I_2$

$I_1 = I_1 - I_2 + I_3$

11

Örn: Bir terminalden geçen akım $i = 3t^2 - t$ A ise $t = 1s$ ve $t = 2s$ aralığında bu terminale giren yük miktarı nedir?

Çöz: $q = \int i\,dt = \int_{1s}^{2s} (3t^2 - t)\,dt \quad \left(t^3 - \frac{t^2}{2}\right)\Big|_{t=1}^{2} \quad 6 - 0.5 = 5.5\ C$

Örn: Bir devre elemanı üzerindeki akım $i = \begin{cases} 4A, & 0 \le t \le 1s \\ 4t^2 A, & t > 1s \end{cases}$ olarak veriliyor. Bu devre elemanına $t = 0s$ ile $t = 2s$ aralığında giren yük nedir?

Çöz: $q = \int i\,dt = \int_0^1 4\,dt + \int_1^2 4t^2\,dt \cong 13.3\ C$

Gerilim: Gerilim yada potansiyel fark, devre elemanları üzerinde, yükü hareket ettirmek için gerekli olan elektromotor kuvveti temsil eder.

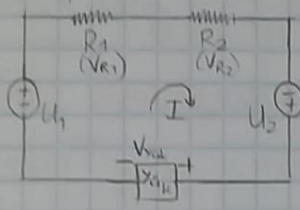
Volt(V) olarak ölçülür. V(DC) ya da v(AC) ile temsil edilir. $v_{ab} \triangleq \frac{dw}{dq}$ → enerji (J), yük

$v_{ab} = -9V$ Akım

Örn: Bir 2A d

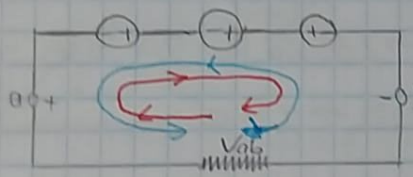
Kirchoff Gerilim Kanunu (KGK):

Kapalı bir devre üzerindeki gerilimlerin toplamı 0



$-V_1+V_{R_1}+V_{R_2}-V_2+V_{yük}=0$

$V_1+V_2=V_{R_1}+V_{R_2}+V_{yük}$

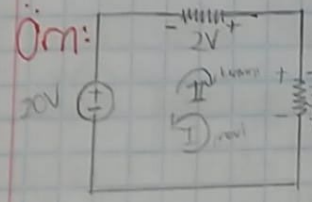


$-V_1-V_2+V_3-V_{ab}=0$ $V_{ab}-V_3+V_2+V_1=0$

$V_{ab}=-V_1-V_2+V_3$ $V_{ab}=-V_1-V_2+V_3$

(12)

Örn:



$V_1+V_2=?$ $-20+V_1+V_2=0$

Ohm: $V_1=I\times 2\Omega$ $V_1=4A\times 2\Omega=8V$

$V_2=I\times 3\Omega$ $V_2=4A\times 3\Omega=12V$

$-20+2I+3I=0$ $5I=20$ $I=4A \rightarrow V_1=4A\times 2\Omega=8V$

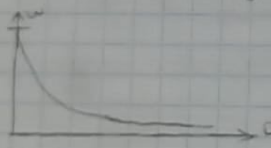
$V_2=4A\times 3\Omega=12V$

Devre Elemanları:

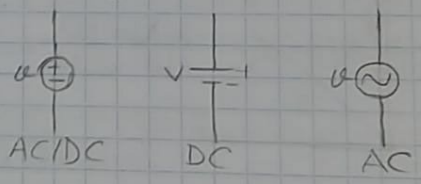
1) Pasif Devre Elemanları: Güç tüketirler, direnç vardır. İndüktör / Bobin vardır kondansatör vardır.

2) Aktif Devre Elemanları: Güç üretirler. jeneratörler, pil/aku, ışınsel kuvvetlendirici (Op-Amp) vardır.

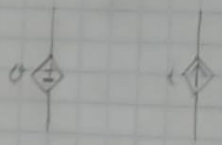
Güç Kaynakları
- Gerilim kaynakları
- Akım kaynakları

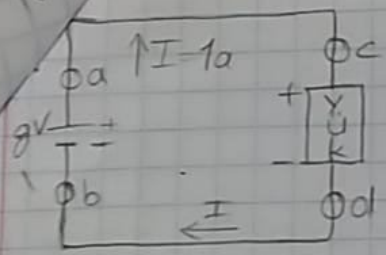


Kaynaklar
- Bağımsız güç kaynakları



6 Kontrollü Güç Kaynakları



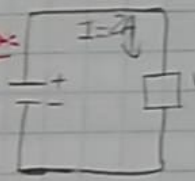


$V_{ab} = gV \quad V_{cd} = gV \quad P_{üretilen} = V_{ab} \times I$

$P_{yük} = V_{cd} \times I \quad P_{üretilen} = P_{yük}$

Örn: Bir güç kaynağına bağlı lamba üzerinden 10s boyunca 2A akım geçiyor. Eğer lambada ısı ve ışık olarak 2,3 kJ'lük bir enerji tüketiliyor. Lamba üzerindeki gerilim?

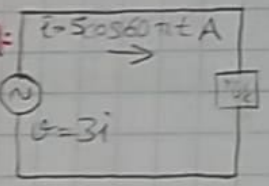
Çöz:



$i = \frac{\Delta q}{\Delta t} \quad \Delta q = i\,\Delta t = 2A \times 10s = 20C$

$V_k = \frac{\Delta w}{\Delta q} = \frac{2,3kj}{20C} = 115\ V$

Örn:



$P_{yük} = ?$ @$t = 3ms$ Çöz: $v = 3i = 3 \times 5 \cos 60\pi t =$

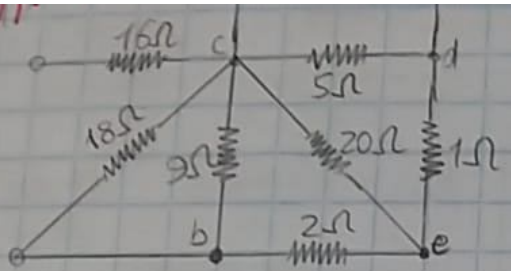
$15 \cos 60\pi t\ V \quad P = vi = 75 \cos^2 60\pi t\ W$

@$t = 3ms \Rightarrow 75 \cos^2 60\pi\ 3 \times 10^{-3} \cong 53,48W$

5

Örn: 100 W'lık bir ampul 2 saatte ne kadar enerji harcar?

Çöz: $P = \frac{\Delta w}{\Delta t} \Rightarrow \Delta w = P\,\Delta t = 100W \times (2 \times 60 \times 60)s = 720000\ j = 720kj$

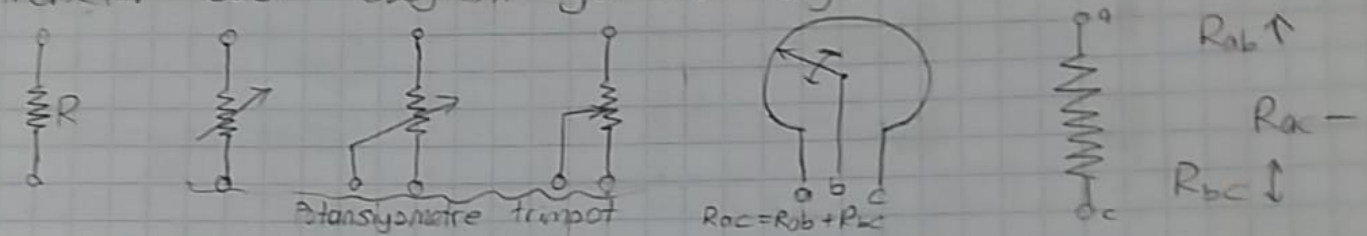


Düğüm Analiz Yöntemi:

Gerilim kaynağı içermeyen n düğüm noktası olan bir devre için;

1) Düğüm noktalarından birisi referans (0V) kabul edilir.
2) KAK, referans düğümü hariç, tüm düğümlere uygulanır.
3) KAK ile elde edilen denklem, düğüm gerilimleri cinsinden tekrar yazılır ve çözülür.

Dirençler sabit değerli ya da ayarlanabilir olur.



İletkenlik (G): $G = \frac{1}{R}$ (mho (℧) / Siemens (S); R ohm (Ω))

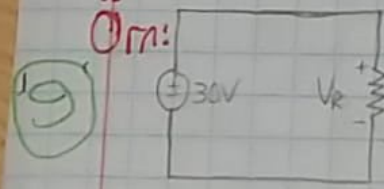
Direnç Ve Güç: $P = vi \quad iRi = i^2R \quad v\frac{v}{R} = \frac{v^2}{R}$

Örn: 220 V ile çalışan bir ütü, 2A akım çekiyor ise ütünün direnci nedir?

Çöz: $R = \frac{V}{I} = \frac{220V}{2A} = 110\Omega$

Örn: Tost makinesinin direnci 40 Ω ise 220 V ile çalıştığında ne kadar akım çeker.

Çöz: $i = \frac{v}{R} = \frac{220V}{40\Omega} = 5.5\,A$

Örn: 

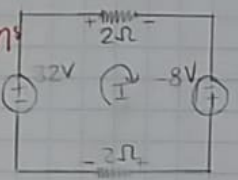
P=? Çöz: $V_R = 30V \quad I = \frac{V_R}{R} = \frac{30V}{5k\Omega} = 6mA$

$P = I^2R = (6mA)^2 \times 5k\Omega = 180mW$

$0 + V_2 + V_1 - 0 \quad 5I = -20 \quad I = -4A \Rightarrow V_1 = -4 \times 2 = -8V$

$V_2 = -4 \times 3 = -12V$

Örn:

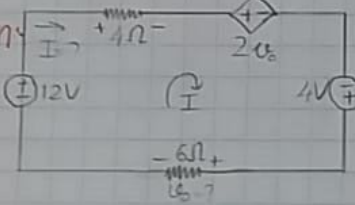


$V_1, V_2 = ?$ $-32V + V_1 - (-8) + V_2 = 0$ $V_1 + V_2 = 24$

Ohm: $V_1 = I \times 4\Omega$ $V_2 = I \times 2\Omega$ $4I + 2I = 24$

$6I = 24$ $I = 4A$ $V_1 = 4 \times 4 = 16V$ $V_2 = 4 \times 2 = 8V$

Örn:



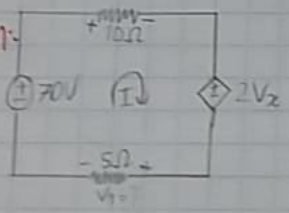
$I, v_0 = ?$ $-12 + V_{4\Omega} + 2v_0 - 4 + V_{6\Omega} = 0$

Ohm: $V_{4\Omega} = I \times 4\Omega$ $V_{6\Omega} = I \times 6\Omega$ $v_0 = -I \times 6\Omega$

$4I + 2 \times (-6I) + 6I = 16$ $10I - 12I = 16$

$I = 8A$ $v_0 = -6I$ $-6 \times -8 = 48V$

Örn:

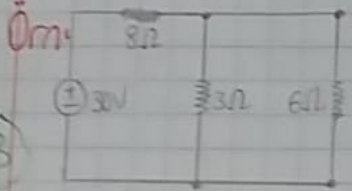


$V_1, V_x = ?$ $-70 + V_x + 2V_x + V_1 = 0$

Ohm: $V_x = I \times 10\Omega$ $V_1 = I \times 5\Omega$ $3 \times (10I) + 5I = 70$

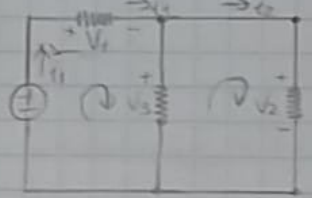
$35I = 70$ $I = 2A$ $V_x = 2 \times 10 = 20V$ $V_1 = 10V$

Örn:



13)

Kollardaki akım ve gerilimi bulunuz



KGK: $-30 + V_1 + V_3 = 0 \Rightarrow$

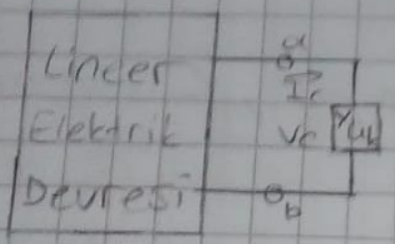
$-30 + 8i_1 + 3i_3 = 0$

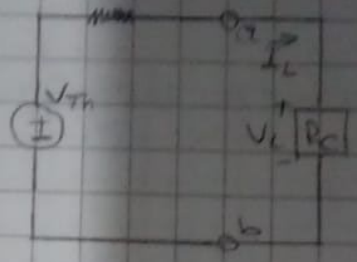
$-V_3 + V_2 = 0 \Rightarrow -3i_3 + 6i_2 = 0$

$i_1 - i_2 - i_3 = 0$ $(i_1 = i_2 + i_3)$ $V_1 = i_1 \times 8\Omega$ $V_2 = i_2 \times 6\Omega$ $V_3 = i_3 \times 3\Omega$

$i_1 = 3A$ $i_2 = 1A$ $i_3 = 2A$ $V_1 = 24V$ $V_2 = 6V$ $V_3 = 6V$

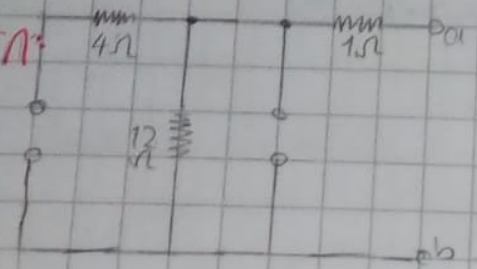
Thevenin Teoremi:



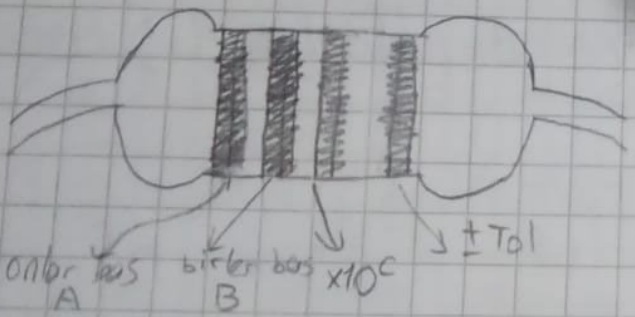


$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

Örn:



$$R_{Th} = \left(\frac{4}{12}\right) + 1 = 4\Omega$$

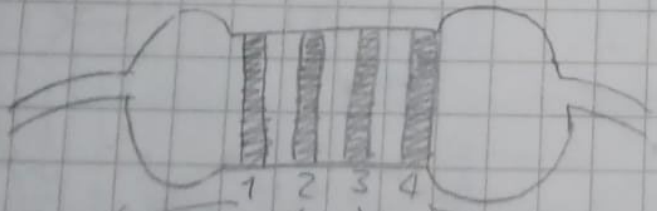


$AB \times 10^C \pm \%D$

0	1	2	3	4	5	6	7	8	9
Siyah	Kahve	Kırmızı	Turuncu	Sarı	Yeşil	Mavi	Mor	Gri	Beyaz

%10 ← Gümüş } Tolerans
%5 ← Altın } ve çarpan

5Ω ± %1
10N



Kahve	Siyah	Kırmızı	1%
Sarı	Mor	Turuncu	1%
Kırmızı	Kırmızı	Kırmızı	1%
Kahve	Siyah	Siyah	1%
Turuncu	Beyaz	Yeşil	1%
Yeşil	Mavi	Kahve	1%

E24 direnç seri
$\frac{1}{4}$ W

R

$10 \times 10^7 \pm \%5\Omega = 1000\Omega \pm \%5 = 1k\Omega \pm \%5$

$47 \times 10^3 \pm \%5\Omega = 47k\Omega$

$22 \times 10^2\ \Omega = 2,2k\Omega$

$10 \times 10^0\Omega = 10\Omega$

$39 \times 10^5\Omega = 3,9M\Omega$

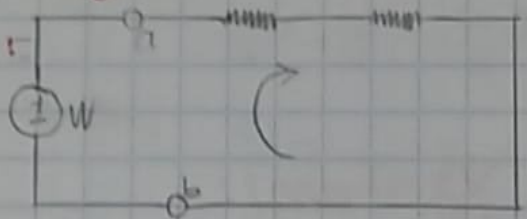
$56 \times 10^1\Omega = 560\Omega$

$i_1 - i_2 - i_3 = 0 \quad (i_1 = i_2 + i_3) \quad V_1 = i_1 \times 8\Omega \quad V_2 = i_2 \times 6\Omega \quad V_3 = i_3 \times 3\Omega$

$i_1 = 3A \quad i_2 = 1A \quad i_3 = 2A \quad V_1 = 24V \quad V_2 = 6V \quad V_3 = 6V$

Dirençlerin Seri Bağlanması:

1) Gerilim Bölücüler:



$R_{es} = R_1 + R_2 \quad v = i(R_1 + R_2)$

$i = \frac{v}{R_1 + R_2} = \frac{v}{R_{es}}$

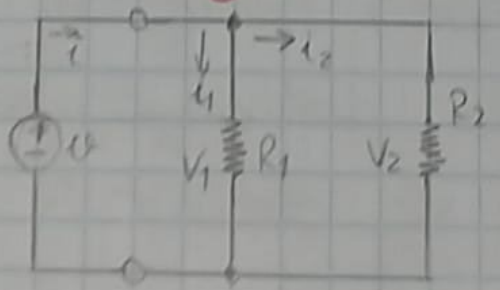
$v_1 = iR_1 = v \frac{R_1}{R_1 + R_2}$

$v_2 = iR_2 = v \frac{R_2}{R_1 + R_2}$ KGK: $-v + v_1 + v_2 = 0 \quad v = v_1 + v_2 = iR_1 + iR_2 = i\underbrace{(R_1 + R_2)}_{R_{es}}$

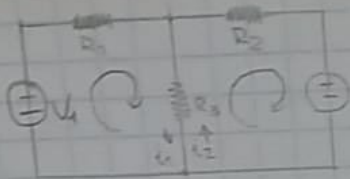
OHM: $v_1 = iR_1 \quad v_2 = iR_2 = iR_{es}$

Dirençlerin Paralel Bağlanması:

1) Akım Bölücüler:



$v_n = v \left(\frac{R_n}{\sum_k R_k} \right) R_{es} \quad v_1 = v_2 = v$



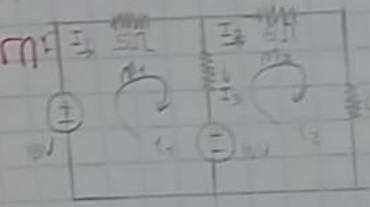
KGK @M1: $-V_1 + i_1 R_1 + R_3(i_1 - i_2) = 0$

$i(R_1 + R_3) - i_2 R_3 = V_1$

KGK @M2: $R_3(i_2 - i_1) + R_2 i_2 + V_2 = 0$

$-i_1 R_3 + i_2(R_2 + R_2) = -V_2$

Örn:



I_1, I_2 ve I_3 = ?

Çöz: $M_1: -15 + 5i_1 + 10(i_1 - i_2) + 0 = 0$

$3i_1 - 2i_2 = 1$

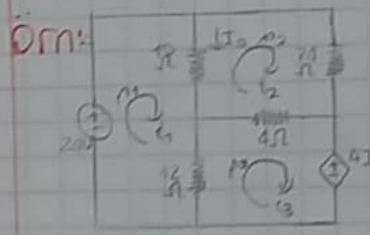
$M_2: -10 + 10(i_2 - i_1) + 6i_2 + 4i_2 = 0$ $\quad i_1 - 2i_2 = -1$

$$\begin{bmatrix} 3 & -2 \\ 1 & -2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

$i_1 = 1A$ $\quad i_2 = 1A$ $\quad I_1 = i_1 = 1A$

$I_2 = i_2 = 1A$ $\quad I_3 = i_1 - i_2 = 0A$

Örn:



I_0 = ? Çöz: $M_1: -24 + 10(i_1 - i_2) + 12(i_1 - i_3) = 0$

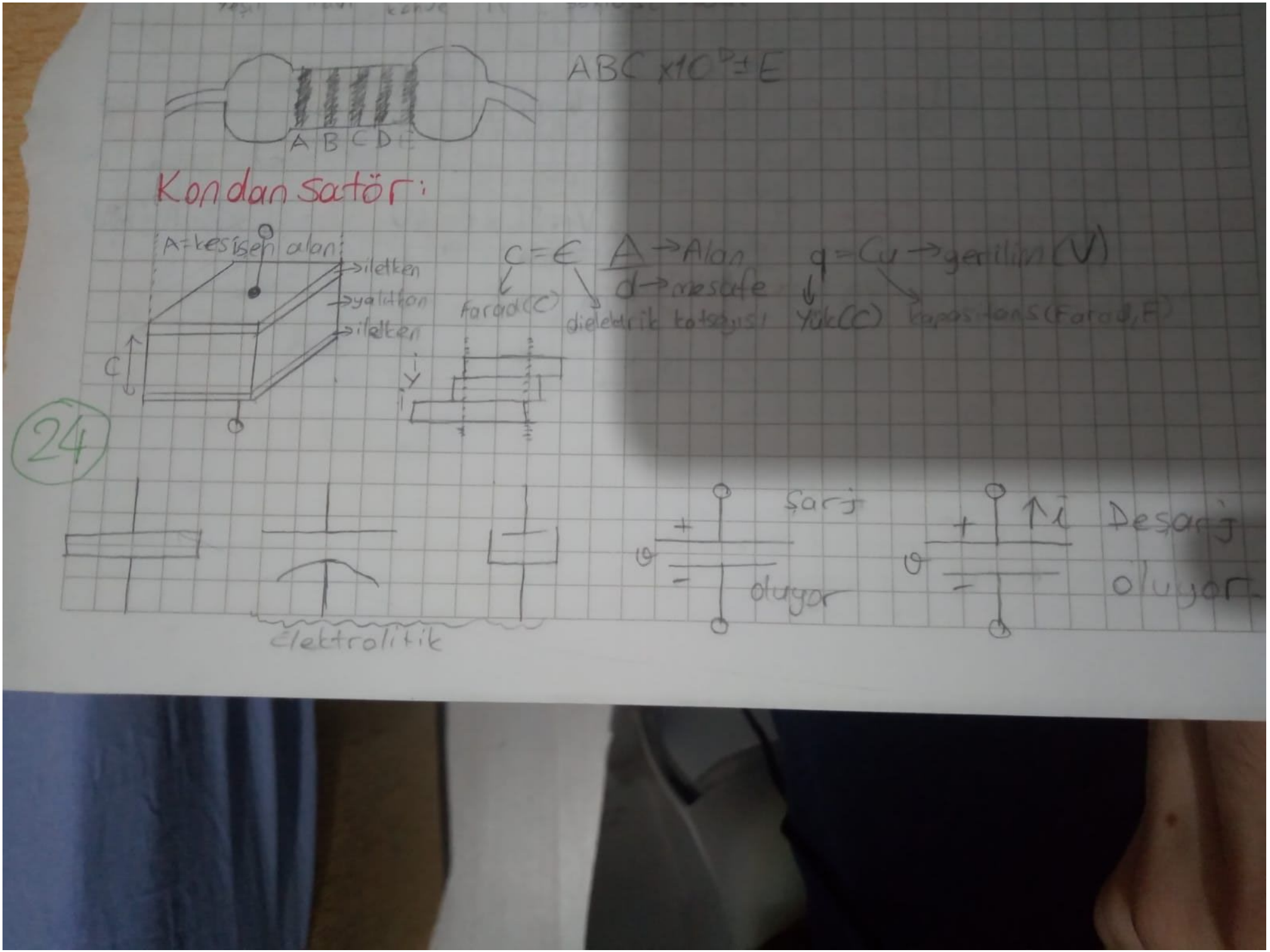
$11i_1 - 5i_2 - 6i_3 = 12$

$M_2: 10(i_2 - i_1) + 24i_2 + 4(i_2 + i_3) = 0$

$-5i_1 + 19i_2 - 2i_3 = 0$

19) $M_3: 12(i_3 - i_1) + 4(i_3 - i_2) + 4I_0 = 0$ $\quad I_0 = i_1 - i_2$

$-i_1 - i_2 + 2i_3 = 0$ $\quad i_1 = 2,25A$ $\quad i_2 = 0,75A$ $\quad i_3 = 1,5A$ $\quad I_0 = 1,5A$

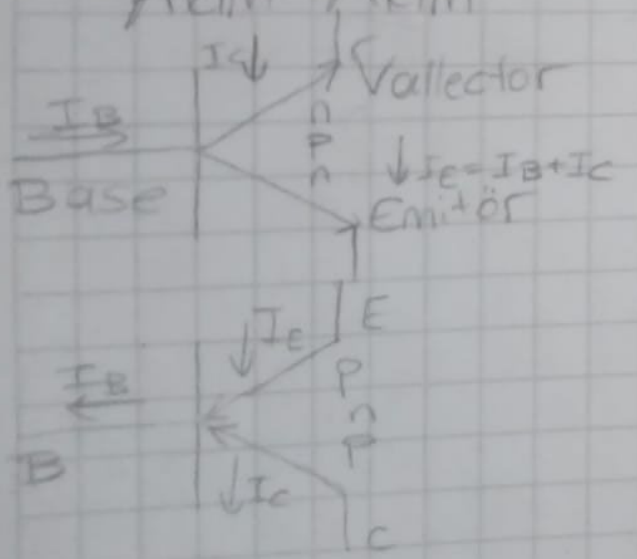

ABC x10^D = E
A B C D E
Kondansatör:
A=kesişen alan
iletken
yalıtkan
iletken
C
Y
C = ε A/d
A → Alan
d → mesafe
ε → dielektrik katsayısı
Farad (C)
q = Cu → gerilim (V)
q → Yük (C)
C → Kapasitans (Farad, F)
24
Şarj
+
-
oluyor
Deşarj
+
-
i
oluyor
Elektrolitik

31

Transistör

BJT

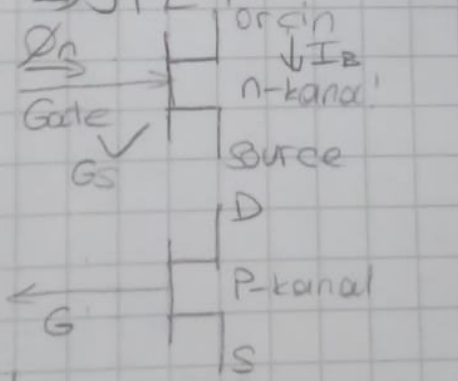
Akım - Akım



FET

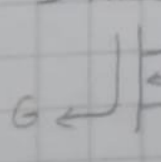
Gerilim - Akım

↳ JFET

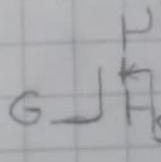


↳ MOSFET

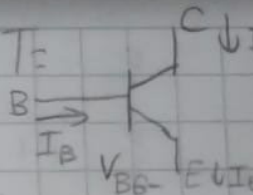
D-MOSFET



E-MOSFET

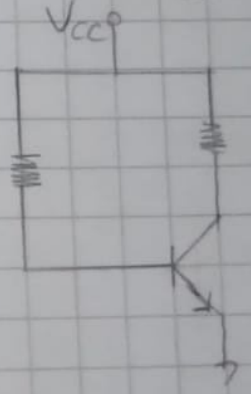


BJT:

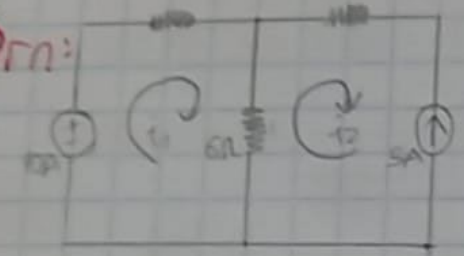


$I_C = \beta I_B$

$V_{BE} = 0{,}7\,V$



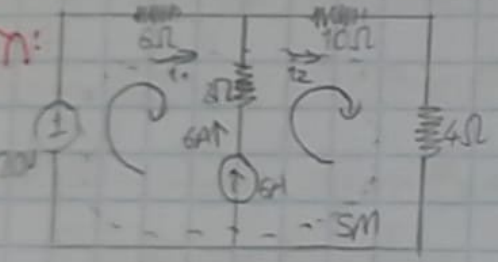
Örn:



$i_2 = -5A$

$-10 + 4i_1 + 6(i_1 - i_2) = 0 \quad i_1 = -2A$

Örn:



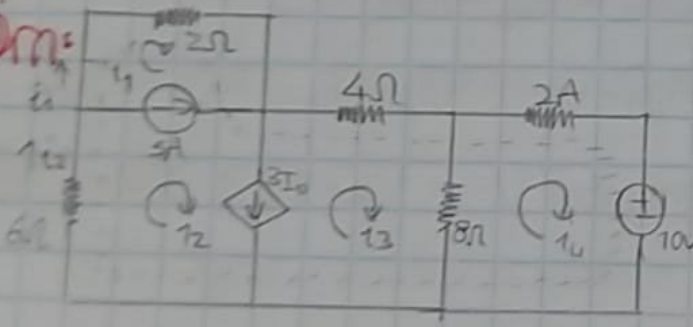
SM: $-20 + 6i_1 + 10i_2 + 4i_2 = 0$

$6i_1 + 14i_2 = 20 \quad 6A = i_2 - i_2$

$i_1 = 3,2A \quad i_2 = 2,8A$

SM: Süper meşinil

Örn:



SM: $2i_2 + 4i_3 + 8(i_3 - i_4) + 6i_2 = 0$

$i_1 + 3i_2 + 6i_3 - 4i_4 = 0$

$M_4 = 8(i_4 - i_3) + 2i_4 + 10 = 0$

$4i_3 - 5i_4 = 5 \quad 5A = i_2 - i_1 = 5$

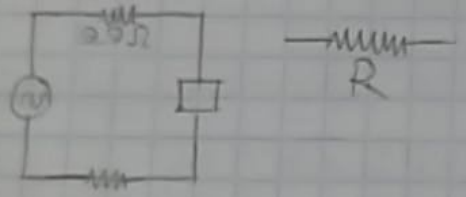
(20)

$3I_0 = i_2 - i_3 = 3I_0 \quad I_0 = -i_4 \quad i_2 - i_3 + 3i_4 = 0$

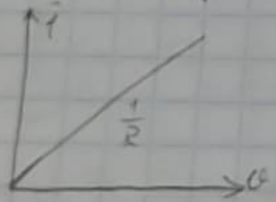
$i = -7,5A \quad i_2 = -2,5A \quad I_0 = -i_4 = -2,143A$

$R = \rho \frac{A}{} = 1{,}72 \cdot 10^{-8} \cdot \frac{}{} \approx 9{,}9\,\Omega$

NOT: Materyalin akımın karsı koyabilme özelliklerini modellemekte kullanılan devre elemanlarına direnç denir.



OHM Kanunu: Bir direnç üzerindeki gerilim (V), bu direnç üzerinden geçen akım (I) ile doğru orantılıdır.



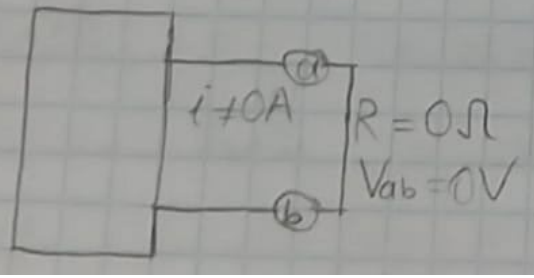
$V = IR$ (Volt, Amper, Ohm)

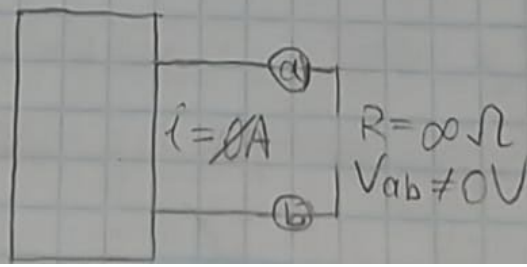
Direnç $0\,\Omega$ ile $\infty\,\Omega$ aralığında bir değer alır.

$R = 0\,\Omega$: kısa devre $\Rightarrow v = iR \quad i \times 0 = 0V$

$R = \infty\,\Omega$: açık devre $\Rightarrow v = iR \quad i \times 0 \Rightarrow i = \frac{v}{\infty} = 0A$

(8)



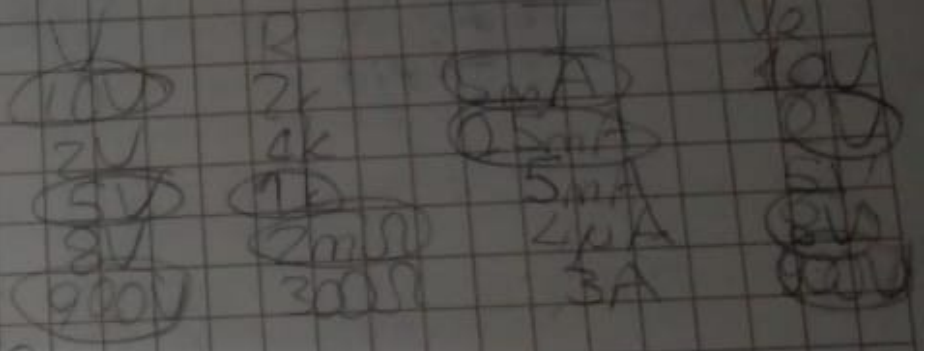


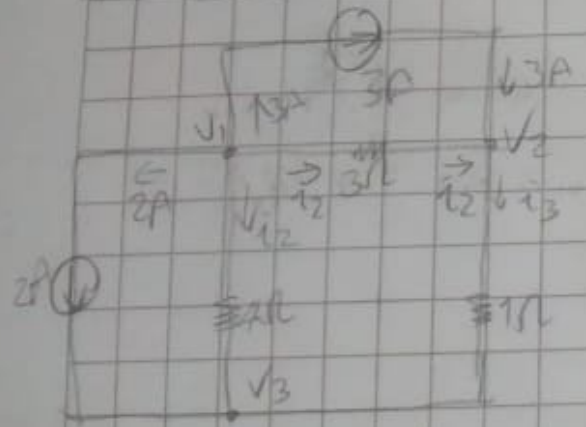
(21)

$r = 2mm$ $l = 0,1mm$ $\rho_{Si} = 6,4 \times 10^{2}$ $A = \pi r^2 = \pi (2 \times 10^{-3})^2 = 12,56 \times 10^{-6} m^2$

$R = \rho_{Si} \frac{l}{A} = 6,4 \times 10^{2} \frac{0,1 \times 10^{-3}}{12,56 \times 10^{-6}} \approx 5 k\Omega$

$-V + V_e = 0 \quad V_e = V$





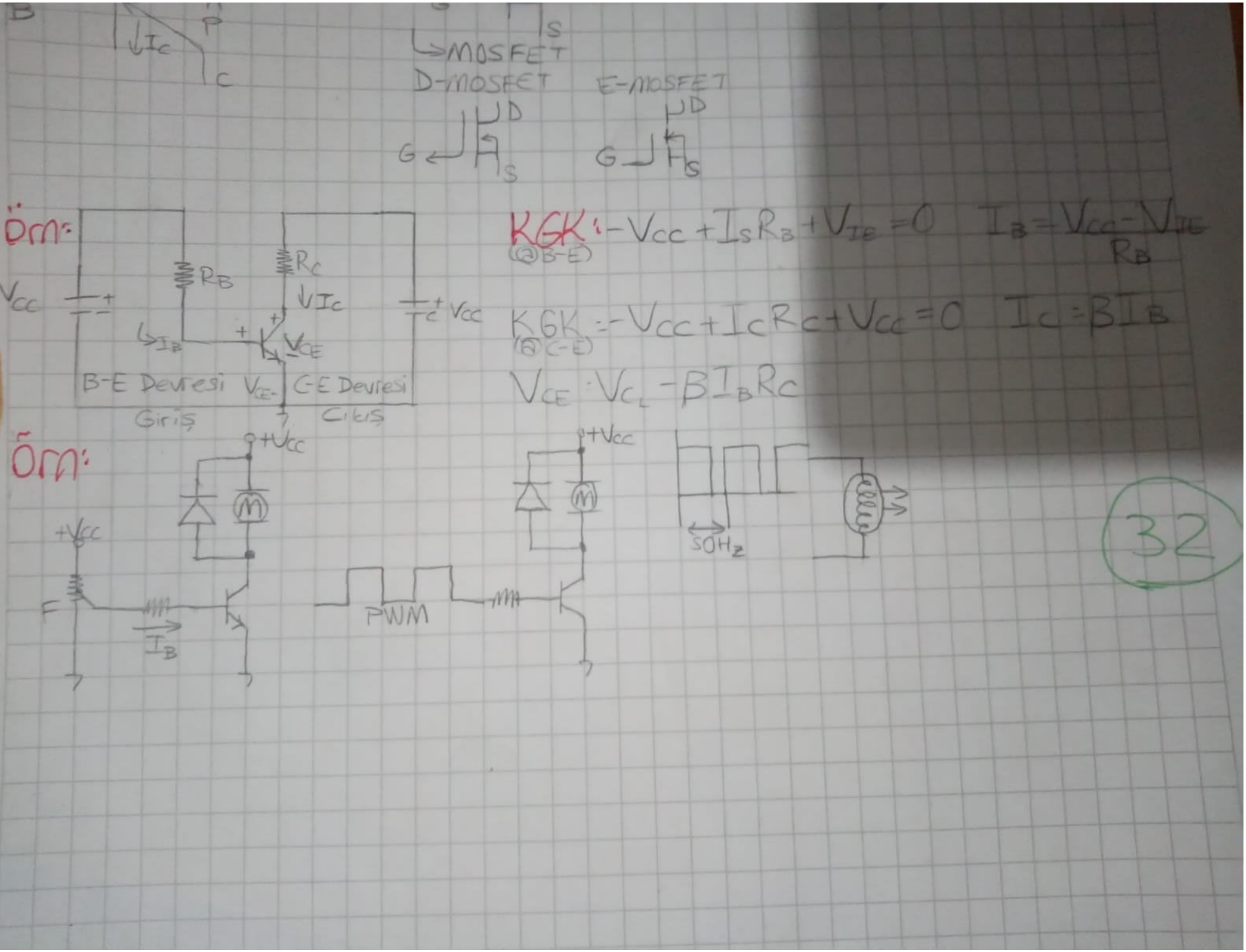
$V_1 = i_1 + i_2 + 2 + 3 = 0$

$i_1 + i_2 = -5$

$\frac{V_1}{1} + \frac{V_1 - V_2}{3} = -5$

$7V_1 - V_2 = -60$

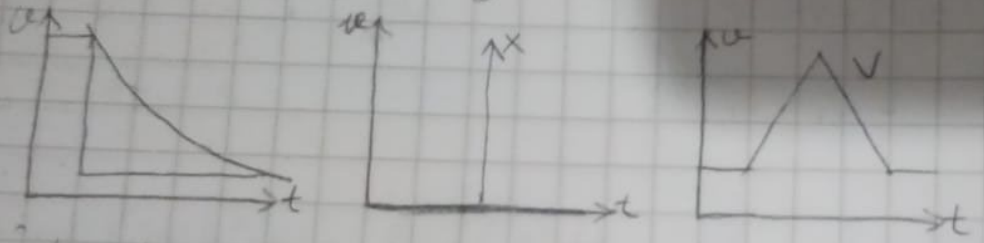
(22)


B
I_C
C
S
↳MOSFET
D-MOSFET
E-MOSFET
D
G
S
Örn:
V_{CC}
R_B
R_C
V_{IC}
I_B
V_{CE}
V_{CC}
B-E Devresi
V_{CE}
C-E Devresi
Giriş
Çıkış
KGK: $-V_{CC}+I_BR_B+V_{BE}=0$ $I_B=\frac{V_{CC}-V_{BE}}{R_B}$
(@B-E)
KGK: $-V_{CC}+I_CR_C+V_{CE}=0$ $I_C=\beta I_B$
(@C-E)
$V_{CE}=V_{CC}-\beta I_BR_C$
Örn:
+Vcc
F
I_B
PWM
50Hz
32

$i = C\frac{du}{dt}$ $v(t) = \frac{1}{C}\int_{t_0}^{t} i(t)\,dt + v(t_0)$

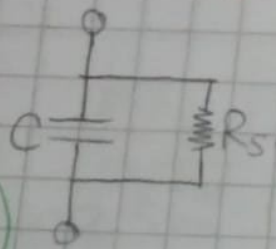
Eğer C üzerindeki gerilim değişmiyorsa, C üzerinden akım akmaz.

C üzerindeki gerilim aniden değişemez.



ideal C güç tükelmez. Depolar ve depoladığını aktarır.

Pratikt:



$X_C = \frac{1}{2\pi f C}$

↓ kapasitif reziztans (Ω)

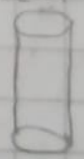
↓ frekans (Hz, $\frac{1}{s}$)

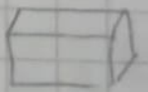
↓ kapasi tans

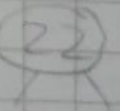
uf elektrolitik

nf plastik kağıt

pf seramik





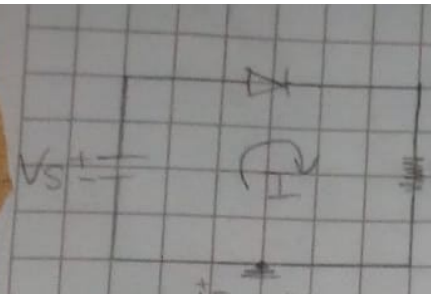


(25) (22)

1V 100 $\frac{f}{C}$ $\frac{}{\text{volt}}$ $\frac{}{\text{tol}}$ 4n7V 80C 223⇒22nf 104...→10×10^4 pf = 100nF

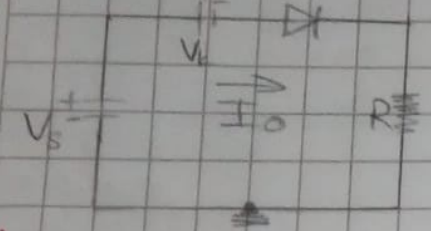
Örn: C = 200nF $v(t) = 50t$ V $0 \le t \le 1$

$100 - 50t$ V $1 < t < 3$



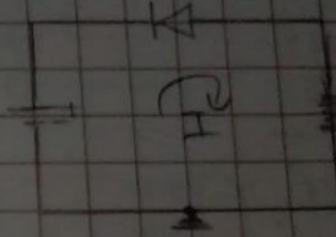
Diyot Yönü = Akım yönü

diyot iletimde olabilir.



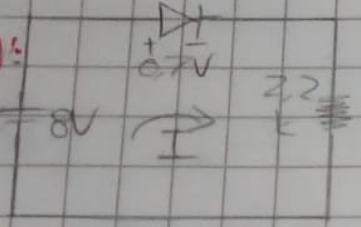
$V_S > V_k$ = Diyot iletimde

$V_S \leq V_k$ = Diyot kesimdedir



Diyot kesimde

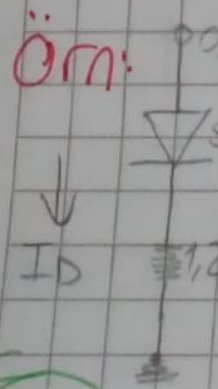
Örn: V_D, V_R, I_D ? Çöz: $8V > V_k = 0,7V$ diyot iletimde



$KGK: -8 + 0,7 + I_D \cdot 2,2k = 0$ $I_D = 3,32mA$

$V_R = I_D \cdot 2,2k = 7,3V$

Örn: V_D, V_R, V_I, V_S, V_k = ? Çöz: $0,5V < 0,7V$ diyot kesimde



$I_D = 0A$ $V_R = I_D \cdot 1,2k = 0V$, $KGK: -0,5 + V_D + V_R = 0$

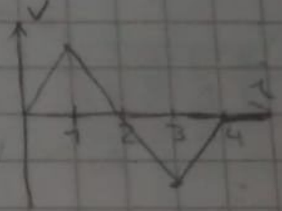
$V_D = 0,5V$

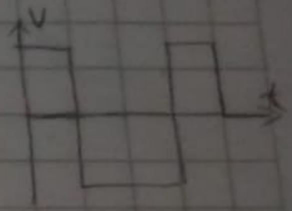
28

223 ⇒ 22 nf   104 → 10×10^4 pf = 100 nf

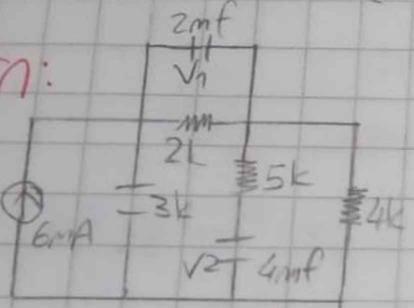
Örn: C = 200 μF $v(t) = \begin{cases} 50t\ V & 0 \le t \le 1 \\ 100-50t\ V & 1 < t \le 3 \\ -200+50t\ V & 3 < t \le 4 \\ 0\ V & 4 < t \end{cases}$

$$i(t) = C\frac{dv(t)}{dt} = \begin{cases} 200\times10^{-6}\times\frac{d}{dt}50t = 10\ mA \\ 200\times10^{-6}\times\frac{d}{dt}(100-50t) = -10\ mA \\ 200\times10^{-6}\times\frac{d}{dt}(-200+50t) = 10\ mA \\ 0\ mA \end{cases}$$

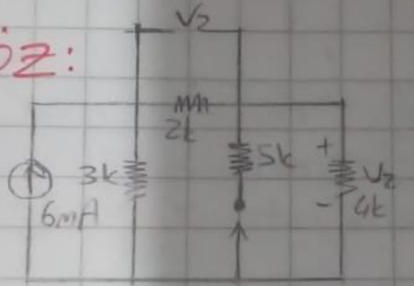




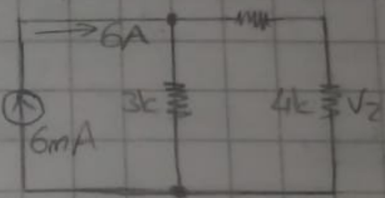
Örn:



Çöz:



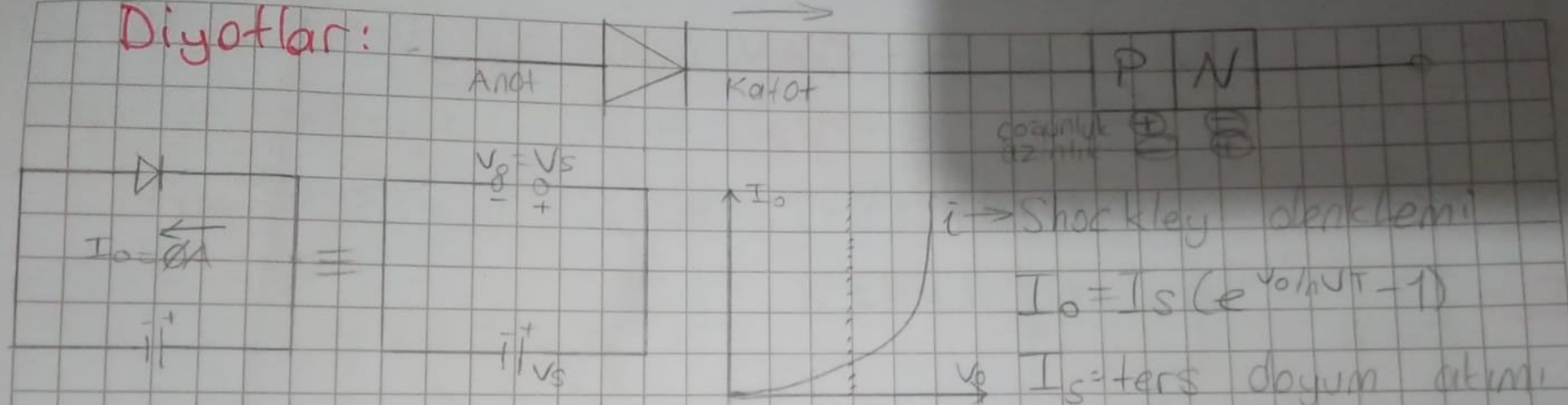
$V_1 = 2k \times i = 4V$ $V_2 = 4k \times 2mA = 8V$



$i = 6mA \dfrac{3k}{3k+(2k+4k)} =$ 2mA

Paralel C'ler:

Diyotlar:



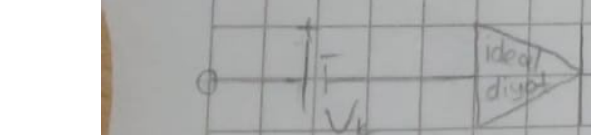
i → Shockley denklemi

$I_D = I_S(e^{V_D/\eta V_T} - 1)$

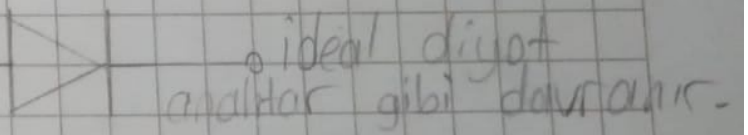
I_S = ters doyum akımı

η = ideallik faktörü $V_T = \frac{kT_k}{q}$ k = Boltzmann sabiti T_k = mutlak sıcaklık

$V_k = \{0,7V, Si, 0,3V, Ge\}$ q = e^- yükü

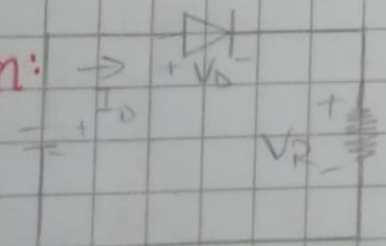


} basitleştirilmiş model



} ideal diyot anahtar gibi davranır.

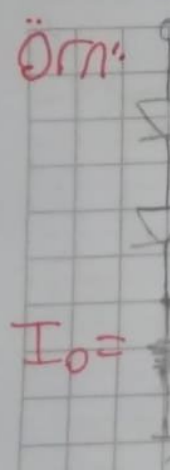
Örn:



$-V_S + V_D + V_R = 0 \quad V + I_D R = V_S \quad I_D = \frac{V_S - V_D}{R}$

$I_D = \frac{V_S - V_K}{R}$ } Basitleştirilmiş $I_D = \frac{V_S}{R}$ } ideal diyot

27

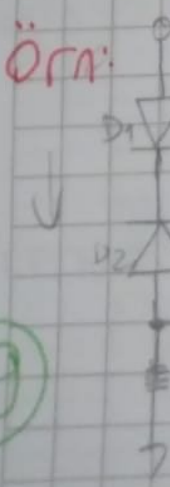
Örn: 

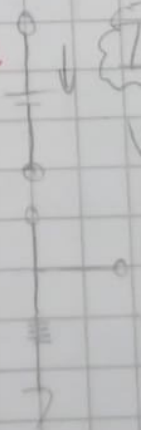
V_S=?, I_D=? Çöz: V_{LED}=1,8V V_S>(V_{K-S}+V_{LED})

12V>(0,7+1,8)V diyotlar iletimde

KGK: −12+0,7+1,8+I_D·680=0 I_D=13,97 mA

I_D= V_0=I_D·680Ω=9,5Ω

Örn: 

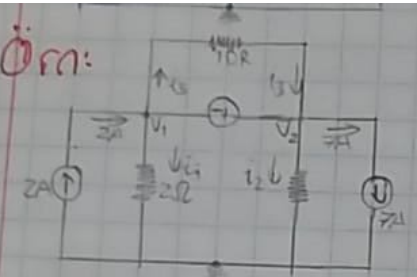
V_{D1}, V_{D2}, V_0=? Çöz: 

{I_D=0A} V_K=0,7V=V_{D1}

V_{D2}=19,3V {V_0=0V}

29

Örn:

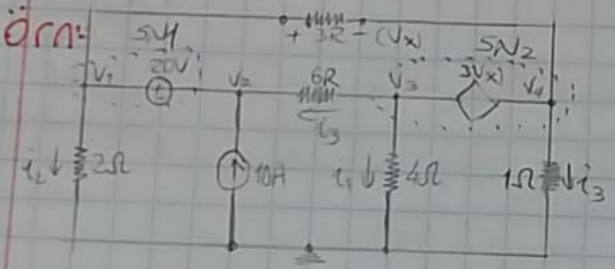


$2+i_3=i_1+i_2+7+i_3 \quad 2=i_1+i_2+7 \quad \frac{V_1}{2}+\frac{V_2}{4}=-5$

$2V_1+V_2=-20 \quad V_2-V_1=2 \quad V_1=-7.333V$

$V_2=-5{,}333V$

Örn:



KAK $5N_1: 10+i_3=i_1+i_2$

$\frac{V_1-V_4}{3}+\frac{V_1}{2}-\frac{V_3-V_2}{6}=10 \quad 5V_1+V_2-V_3-2V_4=60$

$5N_2: i_1=i_3+i_4+i_5 \quad \frac{V_1-V_4}{3}=\frac{V_3-V_2}{6}+\frac{V_3}{4}+\frac{V_4}{1}$

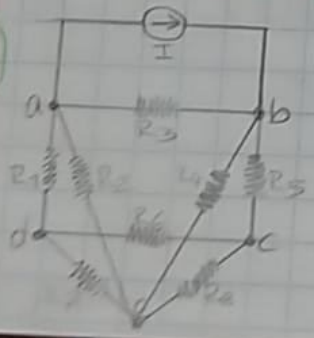
$4V_1+2V_2-5V_3-16V_4=0$

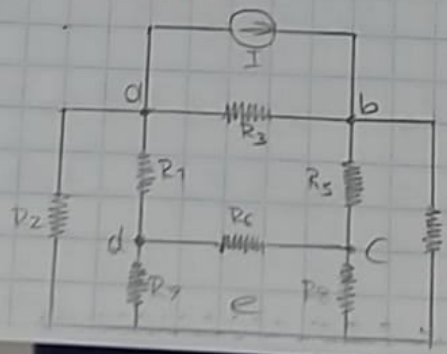
$5N_1: V_1-V_2=20 \quad V_3-V_4=3V_x \quad V_x=V_1-V_4 \quad V_3-V_4=3V_1-3V_4$

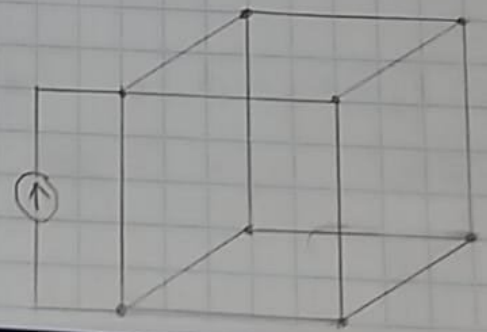
$3V_1-V_3-2V_4=0 \quad V_1=26{,}67V \quad V_2=6{,}67V \quad V_3=173{,}33V \quad V_4=46{,}67V$

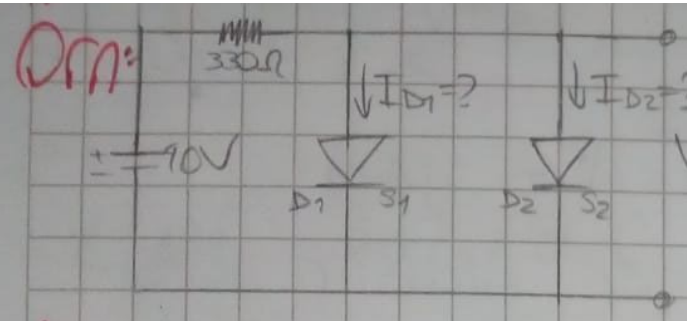
Göz Analizi Yöntemi:

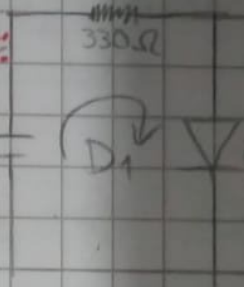
(18)







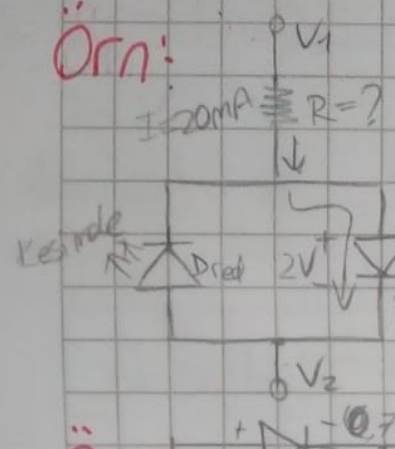
Örn: 

Çöz: 

V_0 = 0,7V 10V > 0,7V

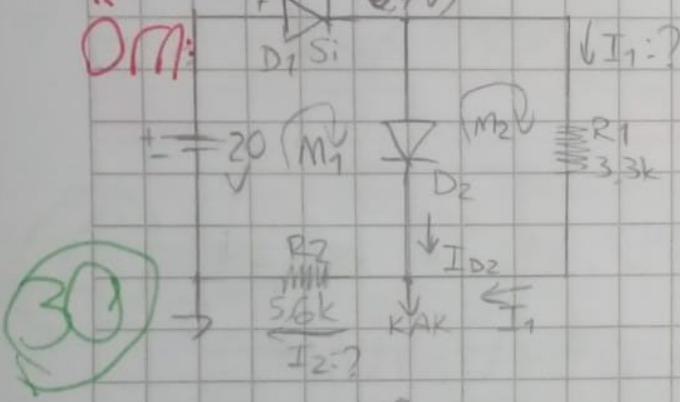
$I_1 = \frac{10-0,7}{330} = 28,18$ mA

$I_{D1} = I_{D2} = \frac{I_1}{2} = 14,09$ mA

Örn: 

Çöz = $V_{K.LED}$ = 2V KGK: −8+IR+2=0

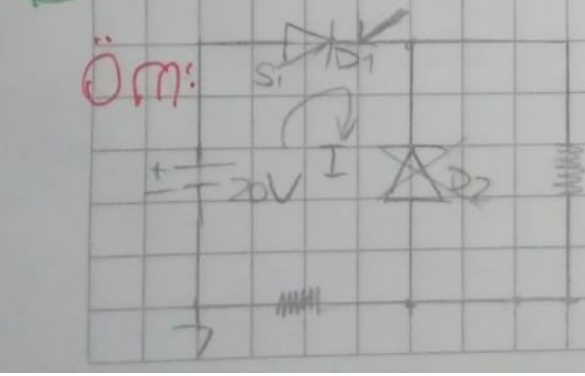
$R = \frac{8+2}{I} = 300\Omega$

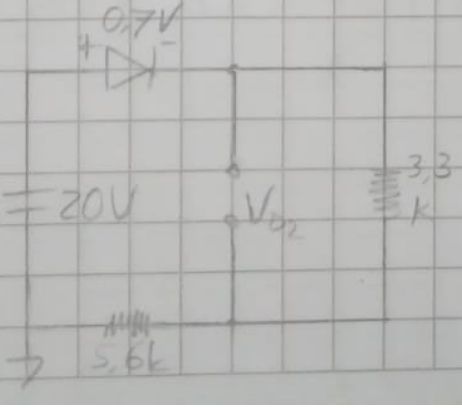
Örn: 

I_1, I_2 = ? Çöz: M_1: −20+0,7+0,7+I_2 . 5,6k = 0

I_2 = 3,32 mA M_2: −0,7+I_1 . 3,3k = 0

I_1 = 0,212 mA $I_2 = I_1 + I_{D2}$ 3,32 − 0,212 = I_{D2} = 3,108 mA

Örn: 



$I = \frac{20-0,7}{8,9k}$ V_{D2} = 3,3k × I