Musterlösung

Probeklausur ES 2010

Lösung Aufgabe 1

1.1

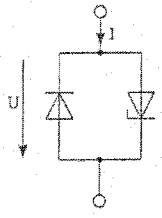
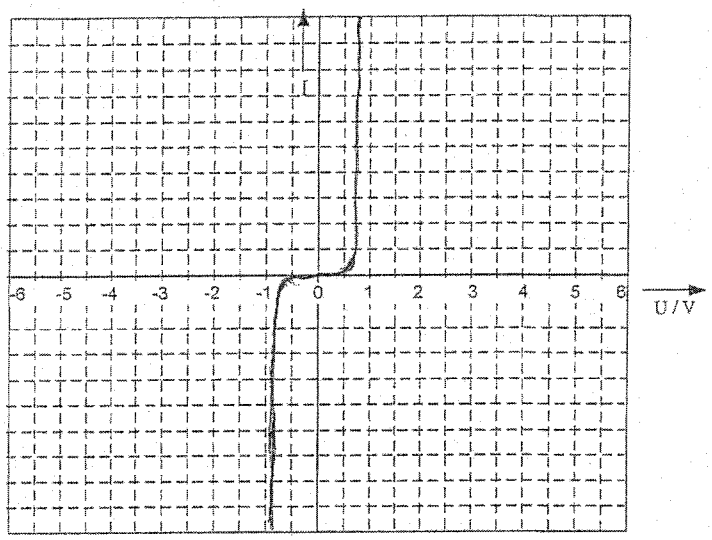
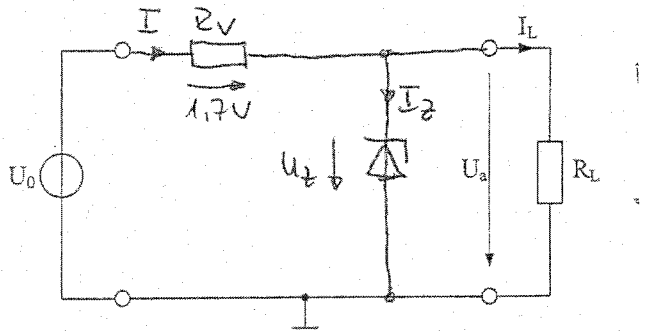


Bild 1.1



1.2



$$R_L = \frac{U_a}{I_L} = 66\Omega$$

$$\Rightarrow E24 : 68\Omega$$

$$\Rightarrow I_L = 48{,}5mA$$

$I_{min} = 48{,}5mA + 2mA$ und $I_{max} = 48{,}5mA + 6mA$

$$\frac{1{,}7V}{54{,}5mA} < R_v < \frac{1{,}7V}{50{,}5mA}$$

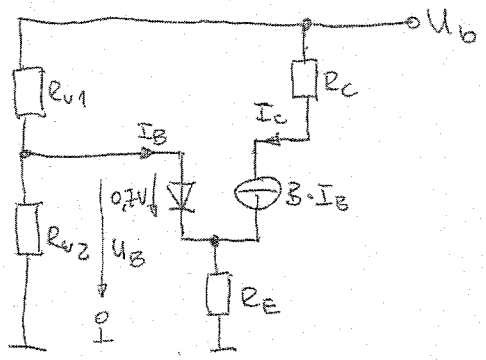
$$31{,}2\Omega < R_v < 33{,}66\Omega$$

→ E24: $R_v = 33\Omega$

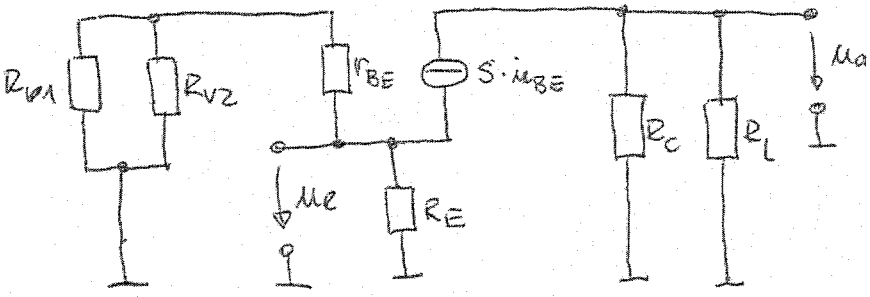
Lösung Aufgabe 2

2.1 Basisschaltung

2.2



2.3



2.4

$$U_B = R_{v2}\frac{U_b}{R_{v1}+R_{v2}} = 6V$$

$$U_E = U_B - 0{,}7V = 5{,}3V$$

$$I_E = \frac{U_E}{R_E} = \frac{5{,}3V}{1k\Omega} = 5{,}3mA = I_{c,A}$$

$$I_B = \frac{I_{c,A}}{B} = 13{,}25\mu A$$

$$U_{CE;A} = U_b - I_{C,A}\cdot(R_C + R_E) = 24V - 5{,}3mA\cdot(1{,}6k\Omega + 1k\Omega) = 10{,}22V$$

$$S = \frac{I_{C,A}}{U_T} = \frac{5{,}3mA}{26mV} = 204mS$$

2.5

$$r_e = R_E \parallel (\frac{1}{S} + \frac{R_{BV}}{\beta})$$

$$R_{BV} = \frac{R_{v1}\cdot R_{v2}}{R_{v1}+R_{v2}} = 2{,}25k\Omega$$

$$r_e = 1k\Omega \parallel \left(\frac{1}{204mS} + \frac{2{,}25k\Omega}{400}\right) \approx 10.5\Omega$$

$$r_a = R_C \parallel R_L = \frac{1{,}6k\Omega\cdot 30k\Omega}{1{,}4k\Omega + 30k\Omega} = 1{,}519k\Omega$$

$$A = \frac{\beta\cdot r_a}{r_{BE}+R_{BV}} = \frac{400\cdot 1519\Omega}{1960\Omega + 2250\Omega} = 144{,}3$$

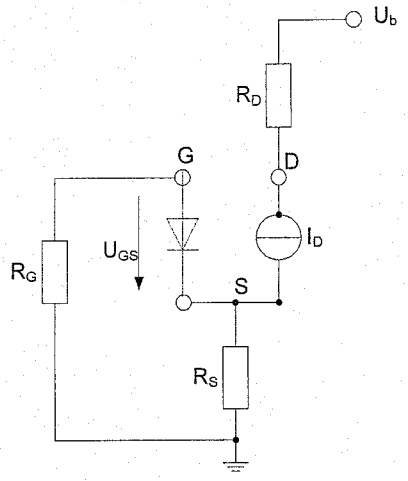
$$r_{BE} = \frac{\beta}{S} = \frac{400}{204mS} = 1{,}96k\Omega$$

Lösung Aufgabe 3

3.1 Sourceschaltung mit (Gleich-)Stromgegenkopplung

3.2 $I_{D0} = 12mA$

3.3



3.4

$$\beta = \frac{2I_{D0}}{U_{th}^2} = \frac{24mA}{16V^2} = 1{,}5\frac{mA}{V^2}$$

$$I_D = \frac{\beta}{2}(U_{GS} - U_{th})^2 = 0{,}75\frac{mA}{V^2}(-1{,}5V - (-4V)^2 = 4{,}69mA$$

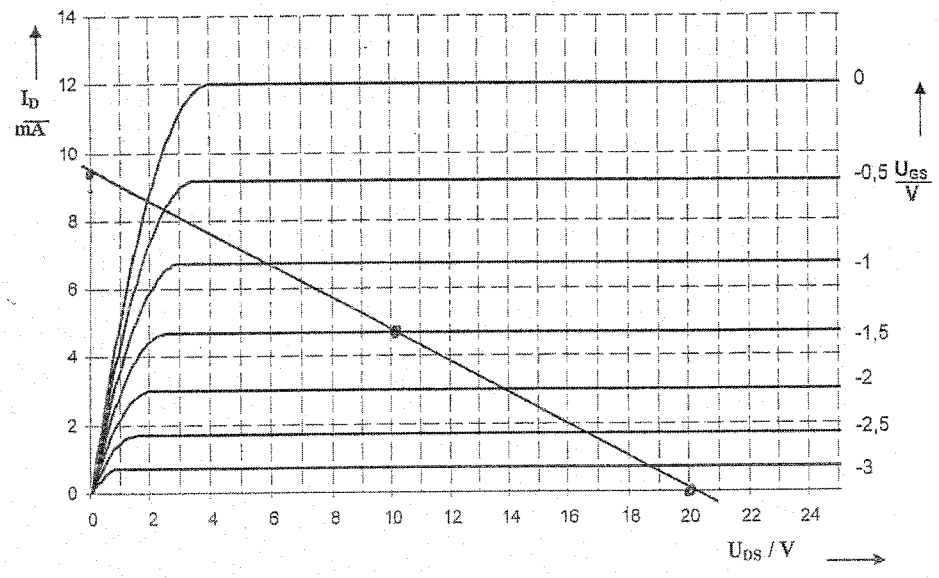
$$R_S = \frac{-U_{GS}}{I_D} = \frac{1{,}5V}{4{,}69mA} = 320\Omega$$

$$U_{DS} = U_b - (R_S + R_D)I_D = 20V - 2120\Omega \cdot 4{,}69mA = 10{,}05V$$

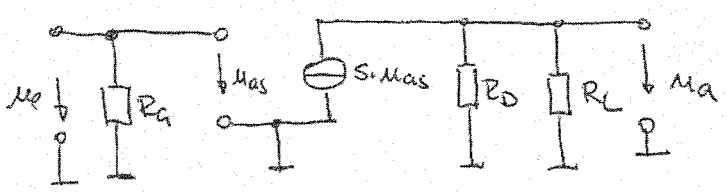
Lastgerade:

$$I_D = 0 \rightarrow U_{DS} = 20V$$

$$U_{DS} = 0 \rightarrow I_D = \frac{U_b}{R_D + R_S} = 9{,}43mA$$



3.5



3.6

$$r_E = R_G = 1M\Omega$$

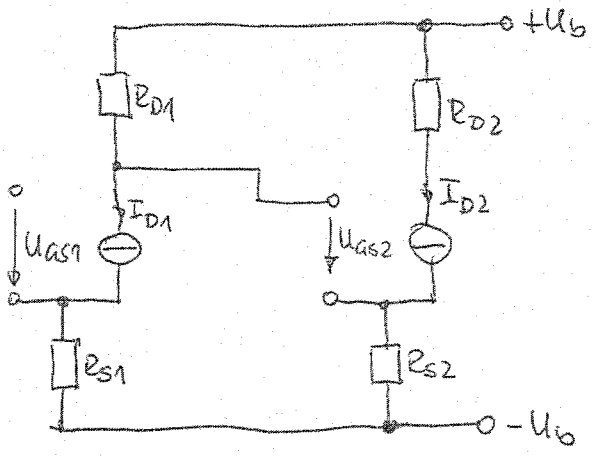
$$S = \frac{\partial I_D}{\partial U_{GS}} = 2\frac{\beta}{2}(U_{GS} - U_{th}) = 1{,}5\frac{mA}{V}\cdot\left(-1{,}5V - \left(-4\right)\right) = 3{,}75mS$$

$$A = -S\left(R_D \parallel R_L\right) \approx -S \cdot R_D = -6{,}75$$

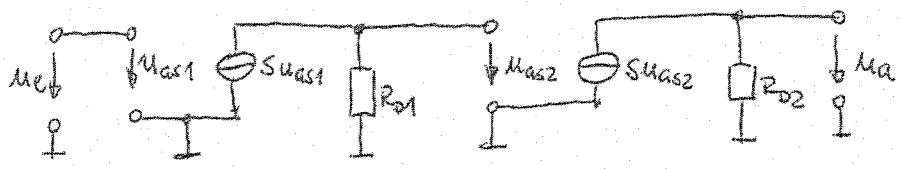
Da $R_L >> R_D$

Lösung Aufgabe 4

4.1



4.2



4.3

$$I_{D1} = \frac{\beta}{2}(U_{GS1} - U_{th})^2 = \frac{1{,}39mA}{2V^2}(7V - 4V)^2 = 6{,}255mA$$

$$R_{S1} = \frac{5V}{I_{D1}} = 799{,}3\Omega \approx 800\Omega$$

$$U_{DS1} = 24V - I_{D1}(R_{D1} + R_{S1}) = 24V - I_{D1}(R_{D1} + R_{S1}) = 9{,}62V$$

$$I_{D2} = \frac{1{,}39mA}{2V^2}(9{,}62V - 4V)^2 = 21{,}95mA$$

$$R_{S2} = \frac{5V}{21{,}95mA} = 229\Omega$$

$$R_{D2} = \frac{12V}{21{,}95mA} = 546\Omega$$

4.4

$$A_{ges} = A_1 \cdot A_2$$

$$A_1 = -S_1 R_{D1} = -\beta(U_{GS1-}U_{th}) \cdot R_{D1} = -1{,}39\frac{mA}{V^2} \cdot 3V \cdot 1500\Omega = -6{,}255$$

$$A_2 = -S_2 \cdot R_{D2} = -\beta(U_{GS2} - U_{th})R_{D2} = -1{,}39\frac{mA}{V^2} \cdot 5{,}62V \cdot 546\Omega = -4{,}265$$

$$A_{ges} = -6{,}255 \cdot (-4{,}265) = 26{,}7$$

4.5

Ja, da U_{DS2} = 7V > (U_{GS2} – U_{th}) = 5,62V ist

Lösung Aufgabe 5

5.1

Eingangswiderstand gegen unendlich.
Ausgangswiderstand gegen 0.
Leerlaufverstärkung gegen unendlich.

5.2

OP1: invertierender Integrierer
OP2: nichtinvertierender Verstärker
OP3: Subtrahierer

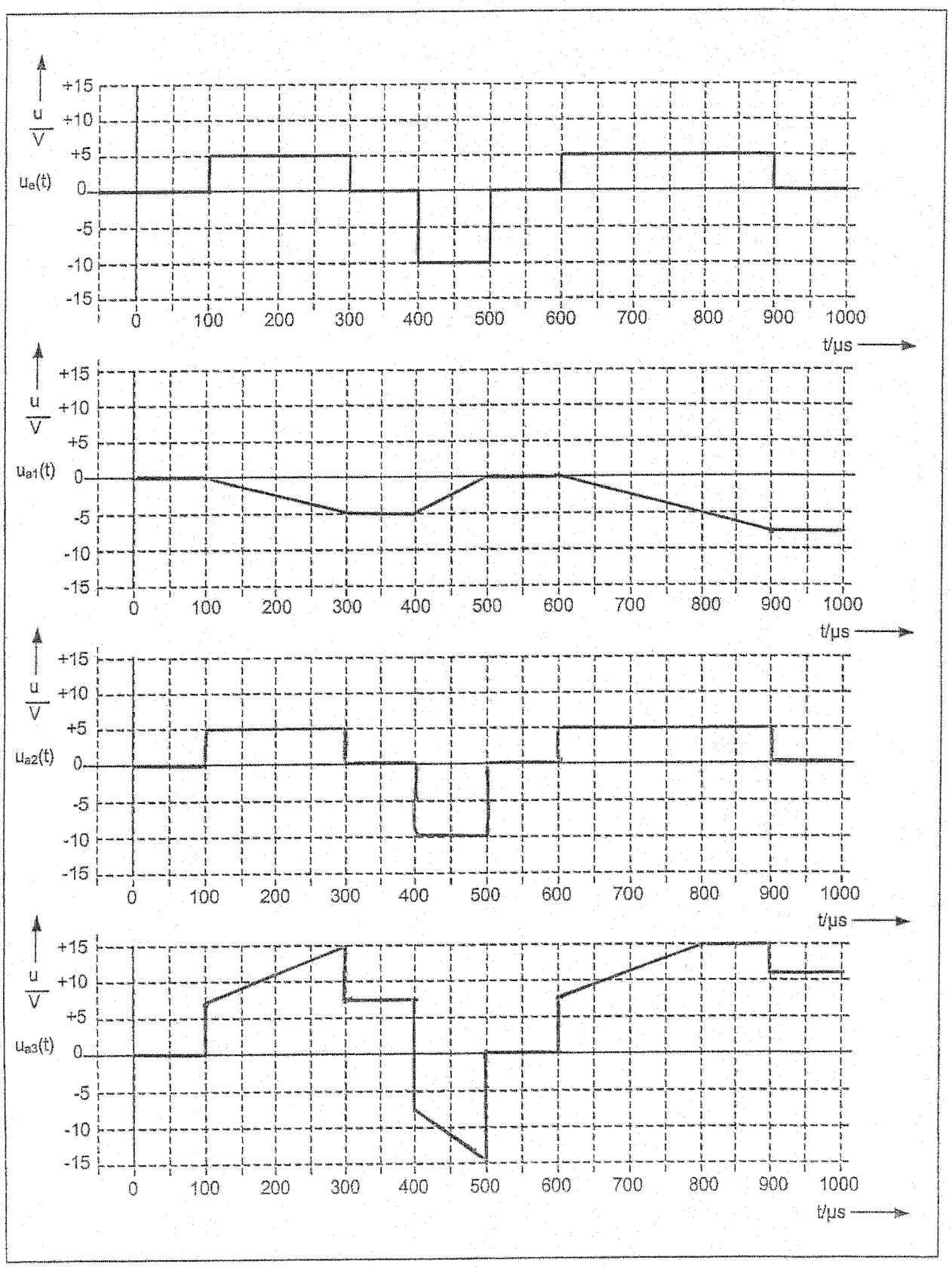
5.3

$$u_{a1}(t) = -\frac{1}{R_1 C_1}\int u_e dt + u_{a1}(t=0) \qquad \text{Mit } \frac{1}{R_1 C_1} = \frac{1}{200\ \mu s}$$

$$u_{a2}(t) = \frac{R_2}{2R_2}\left(\frac{R_2}{R_2} + 1\right)u_e = \frac{1}{2} \cdot 2 \cdot u_e = u_e$$

$$u_{a3}(t) = \frac{R_4}{R_3}(u_{a2} - u_{a1}) = 1{,}5(u_{a2} - u_{a1})$$

5.4


u
V
+15
+10
+5
0
-5
-10
-15
$u_e(t)$
$u_{a1}(t)$
$u_{a2}(t)$
$u_{a3}(t)$
0
100
200
300
400
500
600
700
800
900
1000
t/µs

Lösung Aufgabe 6

6.1 Nichtinvertierender Schmitt-Trigger

6.2

$$\textit{Eingangsseite}: \quad R_1 \cdot I + U_D - u_e = 0 \;\Rightarrow I = \frac{u_e}{R_1}$$

$$\textit{Ausgangsseite}: \quad R_2 \cdot I + u_a = 0 \;\Rightarrow I = -\frac{u_a}{R_2}$$

$$\Rightarrow \quad \frac{u_e}{R_1} = -\frac{u_a}{R_2} \Rightarrow u_e = -\frac{R_1}{R_2} u_{a\max}$$

$$u_e = -\frac{R_1}{R_2} \cdot (\pm u_{\max}) = -\frac{1}{2} \cdot (\pm 12V) = \mp 6V$$

6.3

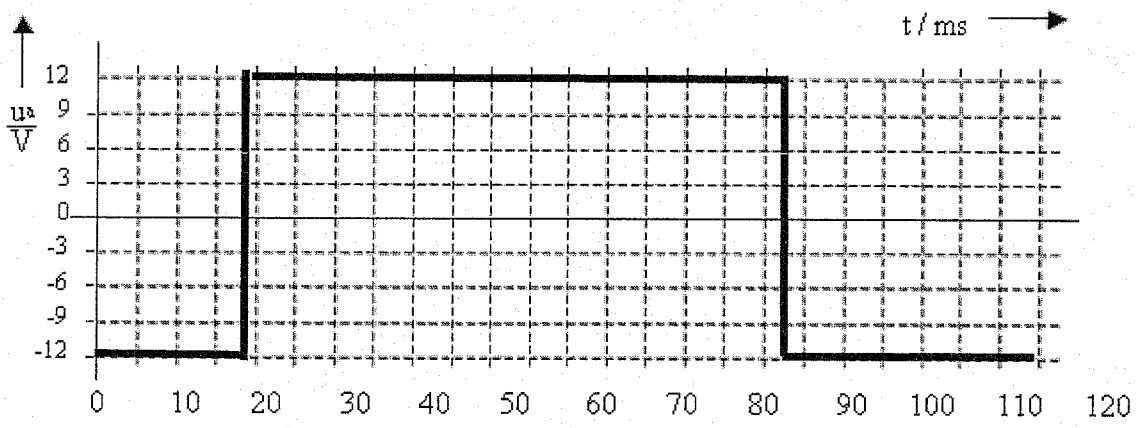


Bild 6.2

6.4