Lösungen

Thema: **Spannungsteiler – Seite 1**

Unbelasteter Spannungsteiler

1. $\mathbf{U_{20} = U \cdot \frac{R_2}{R_1 + R_2} = 12\,V \cdot \frac{5{,}5\,k\Omega}{1{,}5\,k\Omega + 5{,}5\,k\Omega} = 9{,}43\,V}$

2. $\mathbf{U_{20} = U \cdot \frac{R_2}{R_1 + R_2} = 15\,V \cdot \frac{90\,k\Omega}{25\,k\Omega + 90\,k\Omega} = 11{,}74\,V}$

3. $\frac{R_1}{R_2} = \frac{3}{5}$; $\frac{R_1}{R_2} = \frac{U}{U_{20}} - 1$; $\mathbf{U_{20} = \frac{U}{\frac{R_1}{R_2} + 1} = \frac{24\,V}{\frac{3}{5} + 1} = 15\,V}$

4. a) $\mathbf{U_{AB} = U \cdot \frac{R_{AB}}{R} = 150\,V \cdot \frac{200\,\Omega}{900\,\Omega} = 33{,}3\,V}$ b) $\mathbf{U_{AC} = U \cdot \frac{R_{AC}}{R} = 150\,V \cdot \frac{500\,\Omega}{900\,\Omega} = 83{,}3\,V}$

   c) $\mathbf{U_{BC} = U \cdot \frac{R_{BC}}{R} = 150\,V \cdot \frac{300\,\Omega}{900\,\Omega} = 50{,}0\,V}$ d) $\mathbf{U_{BD} = U \cdot \frac{R_{BD}}{R} = 150\,V \cdot \frac{700\,\Omega}{900\,\Omega} = 116{,}7\,V}$

   e) $\mathbf{U_{CD} = U \cdot \frac{R_{CD}}{R} = 150\,V \cdot \frac{400\,\Omega}{900\,\Omega} = 66{,}7\,V}$

5. $U_{20} = U \cdot \frac{R_2}{R_1 + R_2} \Rightarrow \mathbf{U = U_{20} \cdot \frac{R_1 + R_2}{R_2} = 6{,}0\,V \cdot \frac{2{,}7\,k\Omega + 8{,}1\,k\Omega}{8{,}1\,k\Omega} = 8{,}0\,V}$

6. $\frac{R_1}{R_2} = \frac{U}{U_{20}} - 1 \Rightarrow \mathbf{R_1 = \frac{U \cdot R_2}{U_{20}} - R_2 = \frac{24\,V \cdot 12\,k\Omega}{9\,V} - 12\,k\Omega = 20{,}0\,k\Omega}$

7. $N \triangleq R$; a) $\mathbf{N_2 = \frac{N \cdot U_{20}}{U} = \frac{640 \cdot 15\,V}{24\,V} = 400}$; b) $\mathbf{N_2 = \frac{640 \cdot 5\,V}{24\,V} = 133{,}3}$

   c) $\mathbf{N_2 = \frac{640 \cdot 3\,V}{24\,V} = 80}$; d) $\mathbf{N_2 = \frac{640 \cdot 6{,}3\,V}{24{,}V} = 168}$

8. $l \triangleq R$; a) $\mathbf{l_1 = \frac{l \cdot U_1}{U} = \frac{180\ mm \cdot 22{,}5\,V}{230\,V} = 17{,}6\,mm}$

   b) $\mathbf{l_2 = \frac{l \cdot U_2}{U} = \frac{180\,mm \cdot 75\,V}{230\,V} = 58{,}7\,mm}$

   c) $\mathbf{l_3 = \frac{l \cdot U_3}{U} = \frac{180\,mm \cdot 90\,V}{230\,V} = 70{,}4\,mm}$

9. $\frac{U_{20}}{U} = \frac{N_2}{N}$; $\mathbf{U_{20} = \frac{230\,V \cdot 1}{450} = 0{,}511\,V}$

10. $\mathbf{U_{20} = \frac{24\,V \cdot 1}{380} = 63{,}2\,mV}$

Lösungen

Thema: **Spannungsteiler – Seite 2**

Belasteter Spannungsteiler

1. **a)** $R_{2L} = \dfrac{R_2 \cdot R_L}{R_2 + R_L} = \dfrac{35\,\Omega \cdot 50\,\Omega}{35\,\Omega + 50\,\Omega} = 20{,}6\,\Omega$

$$U_2 = U \cdot \frac{R_{2L}}{R_1 + R_{2L}} = 30\,V \cdot \frac{20{,}6\,\Omega}{100\,\Omega + 20{,}6\,\Omega} = \mathbf{5{,}12\,V}$$

b) $I_L = \dfrac{U_2}{R_L} = \dfrac{5{,}12\,V}{50\,\Omega} = \mathbf{0{,}102\,A}$

2. **a)** Stellung A: $\Rightarrow$ Kurzschluss von R_{L1}, R_{L2} und R_2 $\Rightarrow$ $\mathbf{U_2 = 0\,V}$

b) Stellung E:

$$R_L = \frac{R_{L1} \cdot R_{L2}}{R_{L1} + R_{L2}} = \frac{2{,}2\,k\Omega \cdot 1{,}2\,k\Omega}{2{,}2\,k\Omega + 1{,}2\,k\Omega} = \mathbf{0{,}78\,k\Omega}$$

$$U_2 = \frac{U}{\dfrac{R_1 \cdot (R_L + R_2)}{R_L \cdot R_2} + 1} = \frac{6\,V}{\dfrac{820\,\Omega \cdot (780\,\Omega + 390\,\Omega)}{780\,\Omega \cdot 390\,\Omega} + 1} = \frac{6\,V}{3{,}15 + 1} = \mathbf{1{,}44\,V}$$

3. **a)** $I_{q1} = q_1 \cdot I_B = 3 \cdot 1{,}0\,mA = 3{,}0\,mA$

$$R_2 = \frac{U_2}{I_{q1}} = \frac{0{,}72\,V}{3{,}0\,mA} = \mathbf{240\,\Omega}$$

$$R_1 = \frac{U - U_2}{I_{q1} + I_B} = \frac{12{,}00\,V - 0{,}72\,V}{3{,}0\,mA + 1{,}0\,mA} = \mathbf{2820\,\Omega}$$

b) $I_{q2} = q_2 \cdot I_B = 4 \cdot 1{,}0\,mA = 4{,}0\,mA$

$$R_2 = \frac{U_2}{I_{q2}} = \frac{0{,}72\,V}{4{,}0\,mA} = \mathbf{180\,\Omega}$$

$$R_1 = \frac{U - U_2}{I_{q2} + I_B} = \frac{12{,}00\,V - 0{,}72\,V}{4{,}0\,mA + 1{,}0\,mA} = \mathbf{2260\,\Omega}$$

c) $I_{q3} = q_3 \cdot I_B = 5 \cdot 1{,}0\,mA = 5{,}0\,mA$

$$R_2 = \frac{U_2}{I_{q3}} = \frac{0{,}72\,V}{5{,}0\,mA} = \mathbf{144\,\Omega}$$

$$R_1 = \frac{U - U_2}{I_{q3} + I_B} = \frac{12{,}00\,V - 0{,}72\,V}{5{,}0\,mA + 1{,}0\,mA} = \mathbf{1880\,\Omega}$$

$$R_2 = R_L \cdot \frac{U}{U_2} \cdot \left(\frac{U_{20} - U_2}{U - U_{20}}\right) = 250\,\Omega \cdot \frac{100\,V}{20\,V} \cdot \left(\frac{25\,V - 20\,V}{100\,V - 25\,V}\right) = \mathbf{83{,}3\,\Omega}$$

$$R_1 = R_2 \cdot \left(\frac{U}{U_{20}} - 1\right) = 83{,}3\,\Omega \cdot \left(\frac{100\,V}{25\,V} - 1\right) = 83{,}3\,\Omega \cdot 3 = \mathbf{250\,\Omega}$$

4. **a)** $R_1 = \dfrac{R \cdot 3}{3 + 1} = \dfrac{280\,\Omega \cdot 3}{4} = \mathbf{210\,\Omega}$; $R_2 = \dfrac{R \cdot 1}{3 + 1} = \dfrac{280\,\Omega}{4} = \mathbf{70\,\Omega}$

b) $U_{20} = \dfrac{R_2}{R_1 + R_2} \cdot U = \dfrac{70\,\Omega}{280\,\Omega} \cdot 24\,V = \mathbf{6\,V}$

c) $$U_2 = \frac{U}{\dfrac{R_1 \cdot (R_L + R_2)}{R_L \cdot R_2} + 1} = \frac{24\,V}{\dfrac{210\,\Omega \cdot (200\,\Omega + 70\,\Omega)}{200\,\Omega \cdot 70\,\Omega} + 1} = \frac{24\,V}{4{,}05 + 1} = \mathbf{4{,}75\,V}$$

d) $I_q = \dfrac{U_2}{R_2} = \dfrac{4{,}75\,V}{70\,\Omega} = \mathbf{0{,}068\,A}$

e) $I_L = \dfrac{U_2}{R_L} = \dfrac{4{,}75\,V}{200\,\Omega} = \mathbf{0{,}0238\,A}$

f) $q = \dfrac{I_q}{I_L} = \dfrac{I_q}{U_2/R_L} = \dfrac{0{,}068\,A}{0{,}0238\,A} = \mathbf{2{,}9}$

Lösungen

Thema: **Spannungsteiler – Seite 3**

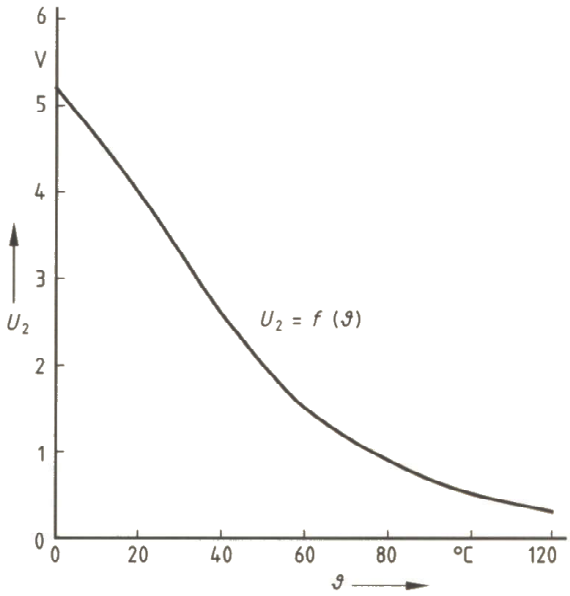
5. a)

ϑ in °C	R_ϑ in kΩ	$R_2 \parallel R_\vartheta$ in kΩ	U_2 in V
0	32	11,5	5,2
20	12,5	7,4	4,0
40	5,4	4,2	2,6
60	2,5	2,2	1,5
80	1,3	1,2	0,9
100	0,7	0,67	0,52
120	0,4	0,39	0,31

R_ϑ aus Diagramm ablesen:

$$R_{2\vartheta} = \frac{R_2 \cdot R_\vartheta}{R_2 + R_\vartheta} = \frac{18\,\text{k}\Omega \cdot 32\,\text{k}\Omega}{18\,\text{k}\Omega + 32\,\text{k}\Omega} = 11{,}5\,\text{k}\Omega$$

$$U_2 = \frac{U \cdot R_{2\vartheta}}{R_1 + R_{2\vartheta}} = \frac{12\,\text{V} \cdot 11{,}5\,\text{k}\Omega}{15\,\text{k}\Omega + 11{,}5\,\text{k}\Omega} = 5{,}2\,\text{V}$$



6. a) Siehe Schaltskizze

b) $$U_{20} = \frac{R_2}{R_1 + R_2} \cdot U = \frac{6{,}2\,\text{k}\Omega}{(47\,\text{k}\Omega + 6{,}2\,\text{k}\Omega)} \cdot 50\,\text{V} = \mathbf{5{,}83\,V}$$

c) **P1:** $$R_m = R_L = r_k \cdot U = 666\,\frac{\Omega}{\text{V}} \cdot 6\,\text{V} = 4\,\text{k}\Omega$$

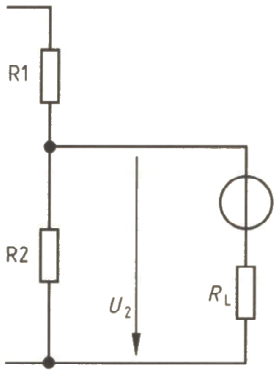
$$U_2 = \frac{U}{\frac{R_1 \cdot (R_L + R_2)}{R_L \cdot R_2} + 1} = \frac{50\,\text{V}}{\frac{47\,\text{k}\Omega \cdot (4\,\text{k}\Omega + 6{,}2\,\text{k}\Omega)}{4\,\text{k}\Omega \cdot 6{,}2\,\text{k}\Omega} + 1} = \mathbf{2{,}46\,V}$$

P2: $$R_m = R_L = r_k \cdot U = 3333\,\frac{\Omega}{\text{V}} \cdot 6\,\text{V} = 20\,000\,\Omega = 20\,\text{k}\Omega$$

$$\mathbf{U_2} = \frac{50\,\text{V}}{\frac{47\,\text{k}\Omega \cdot (20\,\text{k}\Omega + 6{,}2\,\text{k}\Omega)}{20\,\text{k}\Omega \cdot 6{,}2\,\text{k}\Omega} + 1} = \mathbf{4{,}57\,V}$$

P3: $$R_m = R_L = r_k \cdot U = 20\,\frac{\text{k}\Omega}{\text{V}} \cdot 6\,\text{V} = 120\,\text{k}\Omega$$

$$\mathbf{U_2} = \frac{50\,\text{V}}{\frac{47\,\text{k}\Omega \cdot (120\,\text{k}\Omega + 6{,}2\,\text{k}\Omega)}{120\,\text{k}\Omega \cdot 6{,}2\,\text{k}\Omega} + 1} = \mathbf{5{,}57\,V}$$



d) **Messfehler bei P1:** $\Delta U = U_{20} - U_2 = 5{,}83\,\text{V} - 2{,}46\,\text{V} = \mathbf{3{,}37\,V}$

$$\Delta U_\% = \frac{3{,}37\,\text{V} \cdot 100\%}{5{,}83\,\text{V}} = \mathbf{58\%}$$

bei P2: $\Delta U = U_{20} - U_2 = 5{,}83\,\text{V} - 4{,}57\,\text{V} = \mathbf{1{,}26\,V}$; $\Delta U_\% = \frac{1{,}26\,\text{V} \cdot 100\%}{5{,}83\,\text{V}} = \mathbf{22\%}$

bei P3: $\Delta U = U_{20} - U_2 = 5{,}83\,\text{V} - 5{,}57\,\text{V} = \mathbf{0{,}26\,V}$; $\Delta U_\% = \frac{0{,}26\,\text{V} \cdot 100\%}{5{,}83\,\text{V}} = \mathbf{4{,}5\%}$