Elektrotechnisches Praktikum

Operationsverstärker

1. Invertierender Spannungsverstärker

1.1. $$\frac{U_2}{U_1} = -\frac{R_2}{R_1}$$

$$U_2 = -\frac{R_2 \cdot U_1}{R_1}$$

$R_1 = 10\,k\Omega \qquad R_2 = 50\,k\Omega \qquad U_1 = 1V$

$$U_2 = -\frac{50.000\,\Omega \cdot 1V}{10.000\,\Omega} = \underline{\underline{-5\,V}}$$

1.2)

U_{R1}	U_{R2}	U_1	U_2
1,002V	4,99V	1,003V	−5V

1.3)

U_1 [V]	U_2 [V]
14	−13,38
12	−13,38
10	−13,38
8	−13,39
6	−13,39
4	−13,39
2	−9,94
1	−5,00
0	0
−1	+4,99
−2	9,97
−4	13,99
−6	13,98
−8	13,98
−10	13,99
−12	13,98
−14	13,98

1.4)

U_3 [V]
13,28
13,28
13,28
13,28
13,28
13,28
9,83
4,85
0
−5,10
−10,09
−13,32
−13,32
−13,32
−13,32
−13,32
−13,32

2. Nicht invertierender Spannungsverstärker

2.1. $$\frac{U_2}{U_1} = 1 + \frac{R_2}{R_1}$$

$$\underline{\underline{U_2 = U_1 + \frac{R_2 \cdot U_1}{R_1}}}$$

$R_1 = 10\ k\Omega$ $\quad R_2 = 20\ k\Omega$ $\quad U_1 = 2V$

$$U_2 = 2V + \frac{20000\ \Omega \cdot 2V}{10.000\ \Omega} = \underline{\underline{6V}}$$

2.2)

U_1 [V]	U_2 [V]	U_{R1} [V]	U_{R2} [V]
2,003V	6,04	- 2,023	- 4,02

2.3)

U_1 [V]	14	10	6	4	3	2	1	0
U_2 [V]	13,96	13,96	13,96	12,00	9,03	6,04	3,05	0

	-1	-2	-3	-4	-6	-10	-14
	-2,93	-5,89	-8,89	-11,88	-13,38	-13,38	-13,38

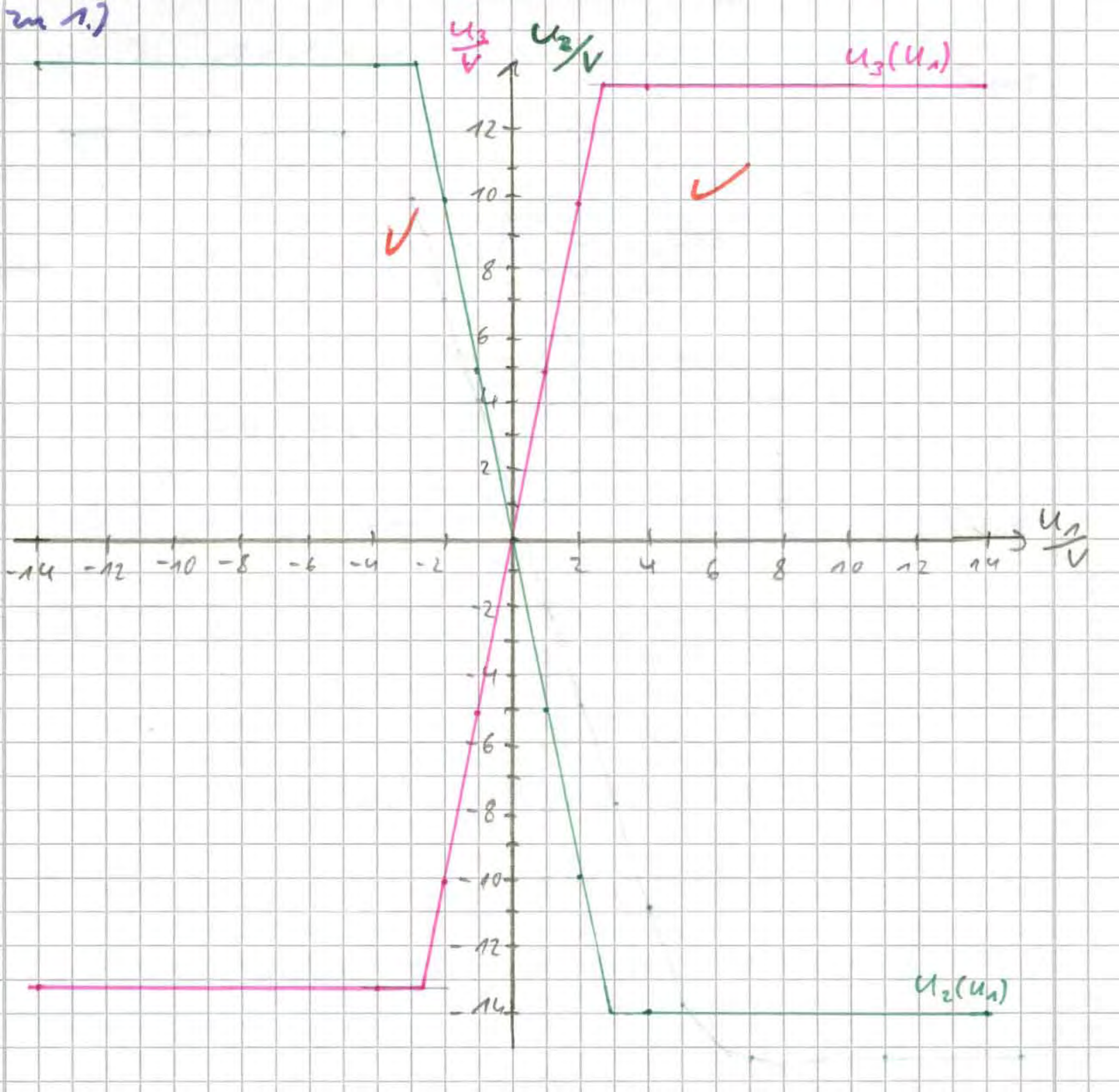
2.4) $1 = 1 + \frac{R_2}{R_1} \quad | \cdot R_1$

$R_1 = R_1 + R_2 \quad | - R_1$

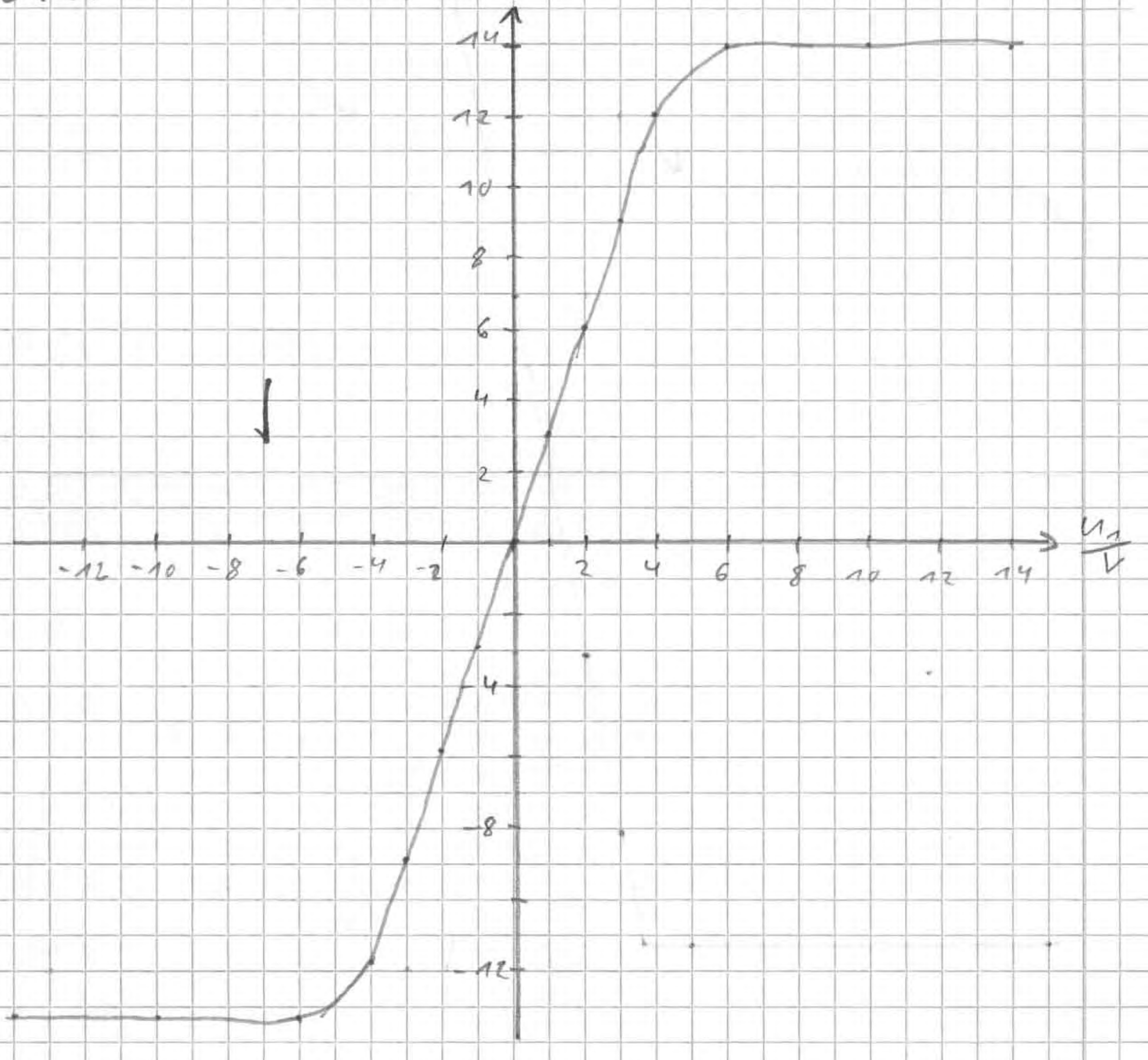
$0 = R_2$

$\Rightarrow R_2$ muss 0 sein, um Übertragungsfaktor 1 zu realisieren

zu 1.)


$\frac{U_3}{V}$
$\frac{U_2}{V}$
$U_3(U_1)$
$U_2(U_1)$
$\frac{U_1}{V}$
16
14
12
10
8
6
4
2
-2
-4
-6
-8
-10
-12
-14
-14
-12
-10
-8
-6
-4
-2
2
4
6
8
10
12
14

zu 2.



3. Addition von Signalen

3.1. $-\frac{U_2}{R_2} = \frac{U_{11}}{R_{11}} + \frac{U_{12}}{R_{12}}$

$$U_2 = -R_2\left(\frac{U_{11}}{R_{11}} + \frac{U_{12}}{R_{12}}\right)$$

$R_{11} = R_{12} = R_2 = R = 10\ k\Omega$

$U_{11} = +8\ V \qquad U_{12} = -2\ V$

$U_2 = -10\ k\Omega\left(\frac{8\ V}{10\ k\Omega} + \frac{-2\ V}{10\ k\Omega}\right)$

$U_2 = -6\ V$

3.2)

U_{11}	U_{12}	U_2	U_{R11}	U_{R12}	U_{R2}
8,03V	-1,998 V	6,00V	+2,0V	-8,03V	6,02V

3.3)

U_{12} [V]	14	10	6	4	3	2	1	0
U_2 [V]	13,32	13,32	13,32	11,95	10,95	9,96	8,95	7,96

-1	-2	-3	-4	-6	-8	-10	-12	-14
6,97	5,96	4,98	3,97	1,98	0	-1,99	-3,97	-5,98

3.4) $U_{11} = 8\ V$

U_{12} [V]	U_2 [V]
14	5,42
12	4,08
10	2,08
8	0,10
6	-1,90
4	-3,90
2	-5,88
0	-7,86
-2	-9,86

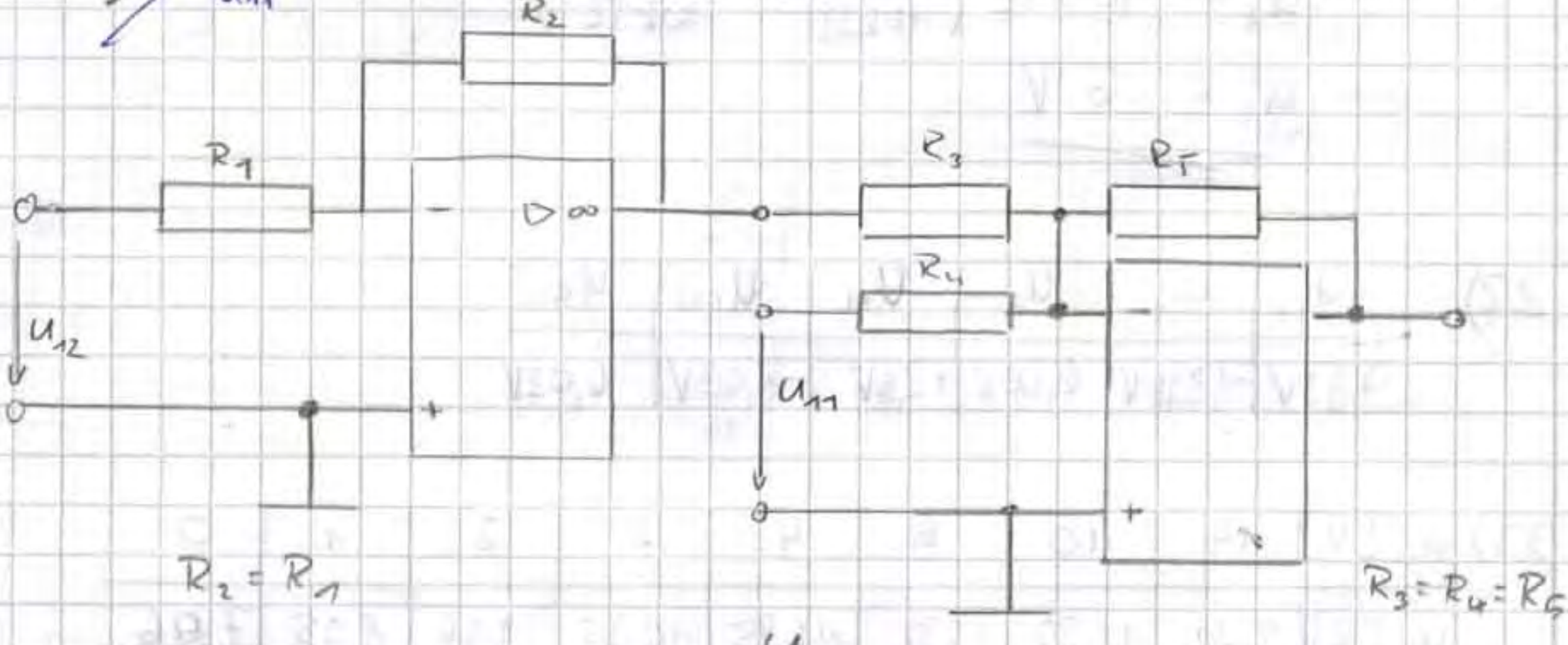
U_{12} [V]	U_2 [V]
-4	-11,87
-6	-13,33
-8	-13,32
-10	-13,32
-12	-13,32
-14	-13,32

4. Subtraktion von Signalen mit einem OPV

4.1. $\frac{U_2}{U_{12}-U_{11}} = \frac{R_{21}}{R_{11}}$ wenn $\frac{R_{21}}{R_{11}} = \frac{R_{22}}{R_{12}}$

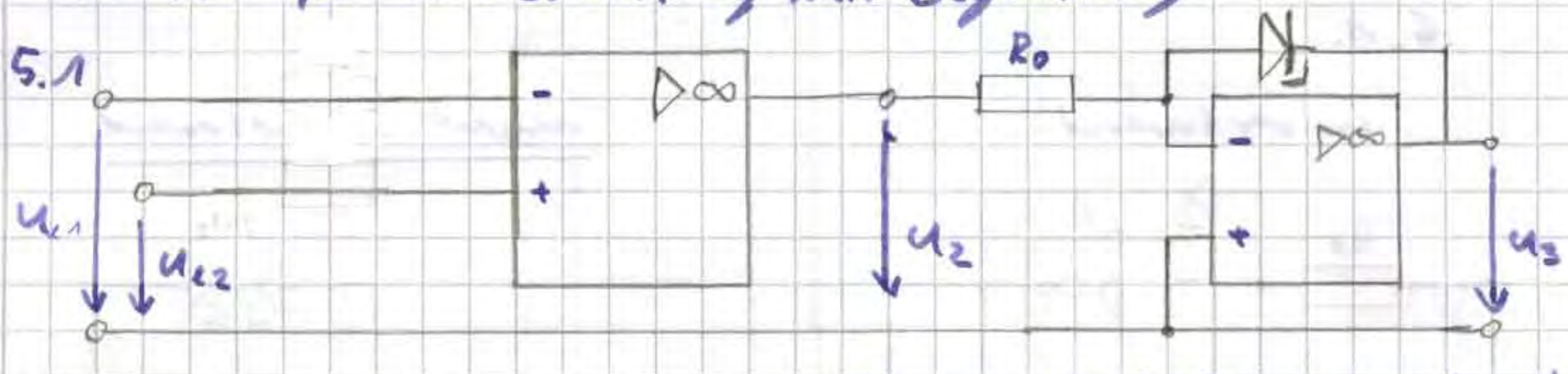
$$\underline{\underline{U_2 = \frac{R_{22}}{R_{11}}(U_{12}-U_{11})}}$$

$R_{11} = R_{12} = R_{21} = R_{22} = R = 10\,k\Omega$



5. Komparatorschaltung mit Begrenzung

5.1



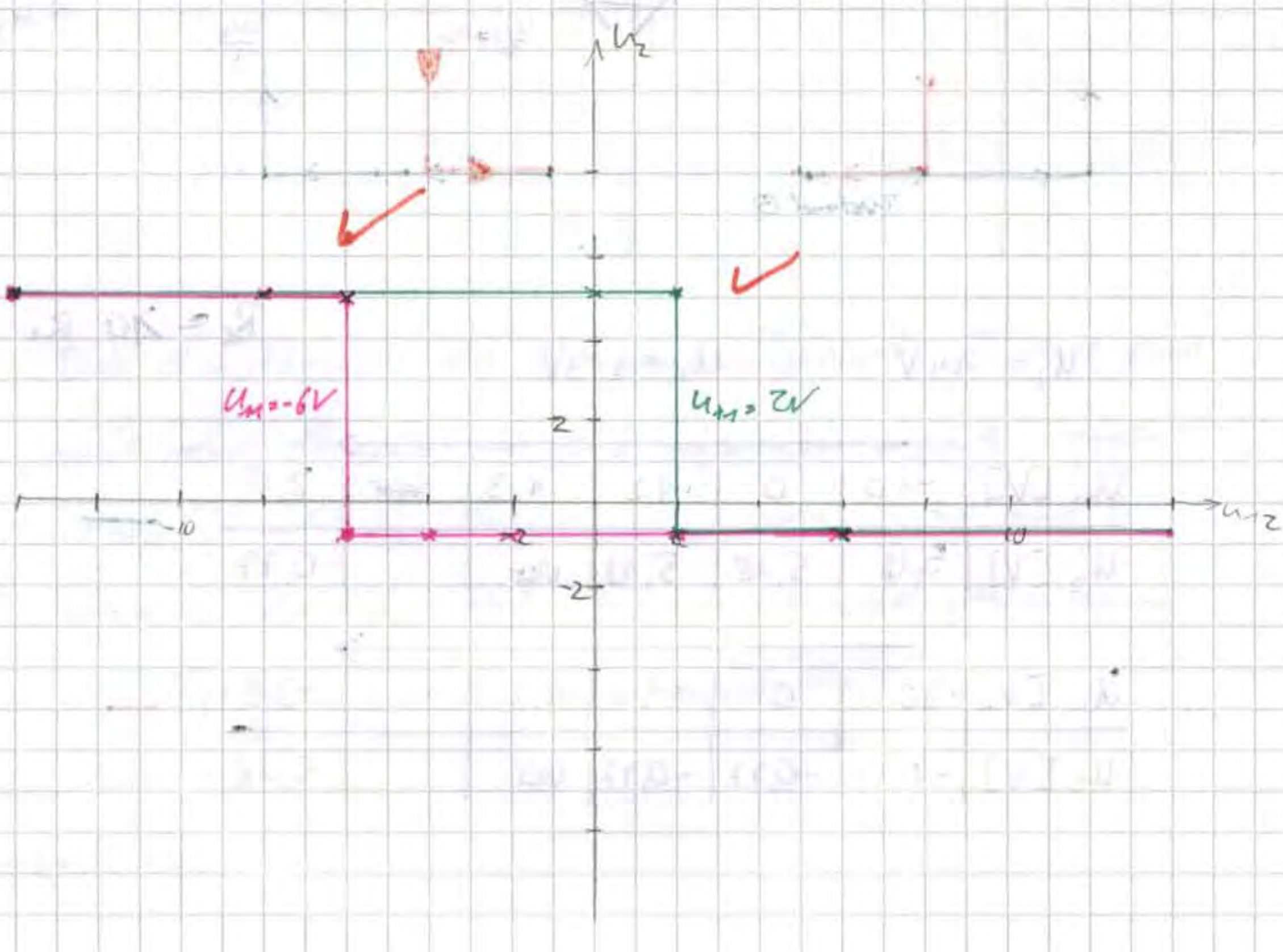
$R_0 = 1\,k\Omega$ (Schutzwiderstand)

5.3) $U_{11} = -6V$

U_{12} [V]	-14	-8	-6	-4	-2	2	6	14
U_2 [V]	5,18	5,18	-0,77	-0,77	-0,77	-0,77	-0,77	-0,77

$U_{11} = +2V$

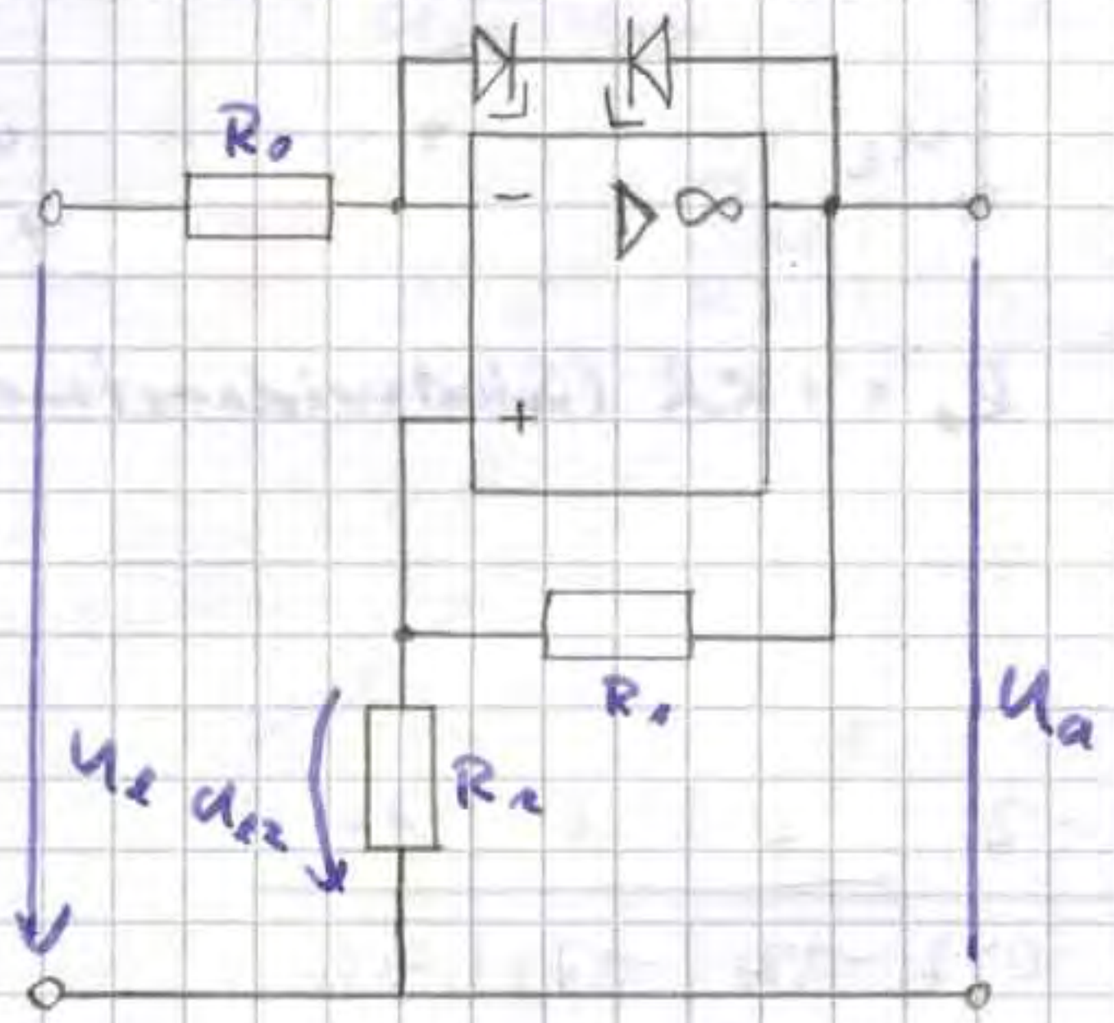
U_{12} [V]	-14	-8	-6	0	2	6	14
U_2 [V]	5,18	5,18	5,18	5,18	-0,77	-0,77	0,77



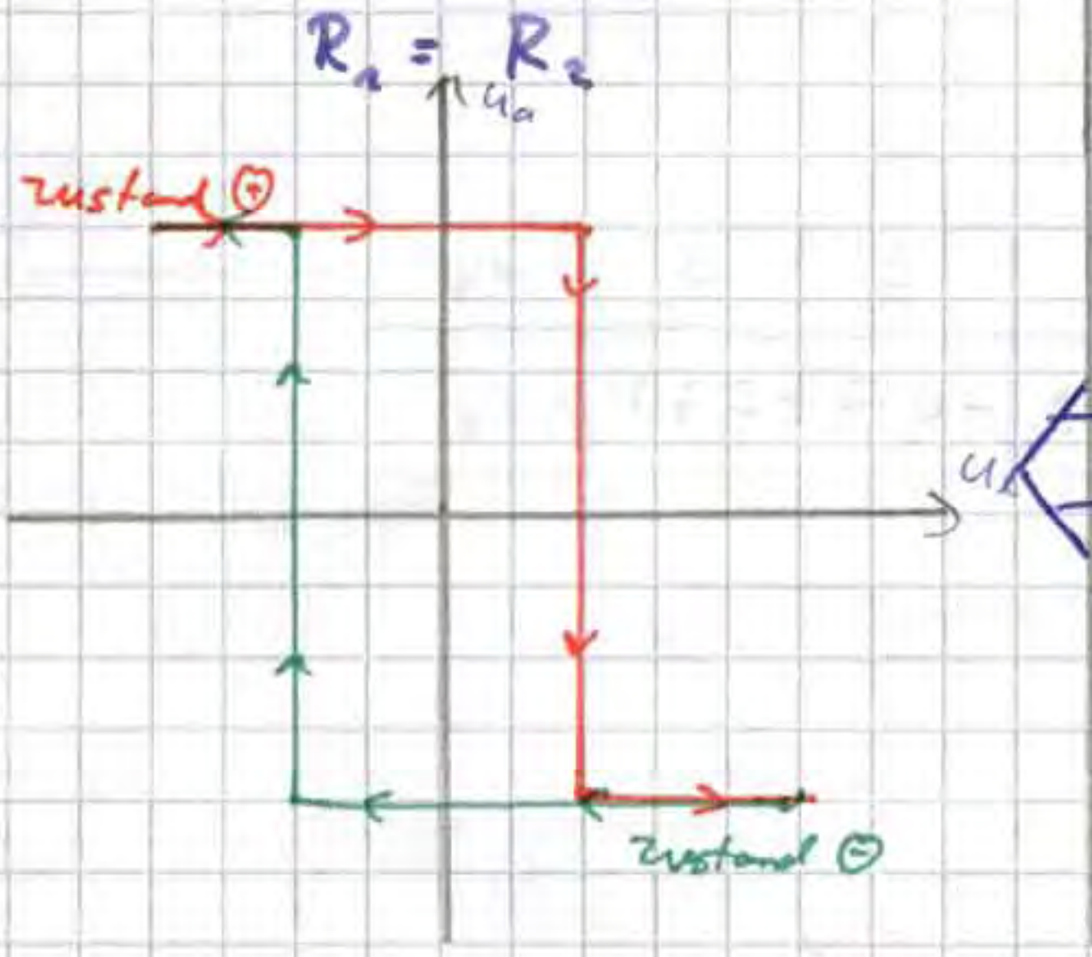
6. Schmitt-Trigger

6.1.

invertierend



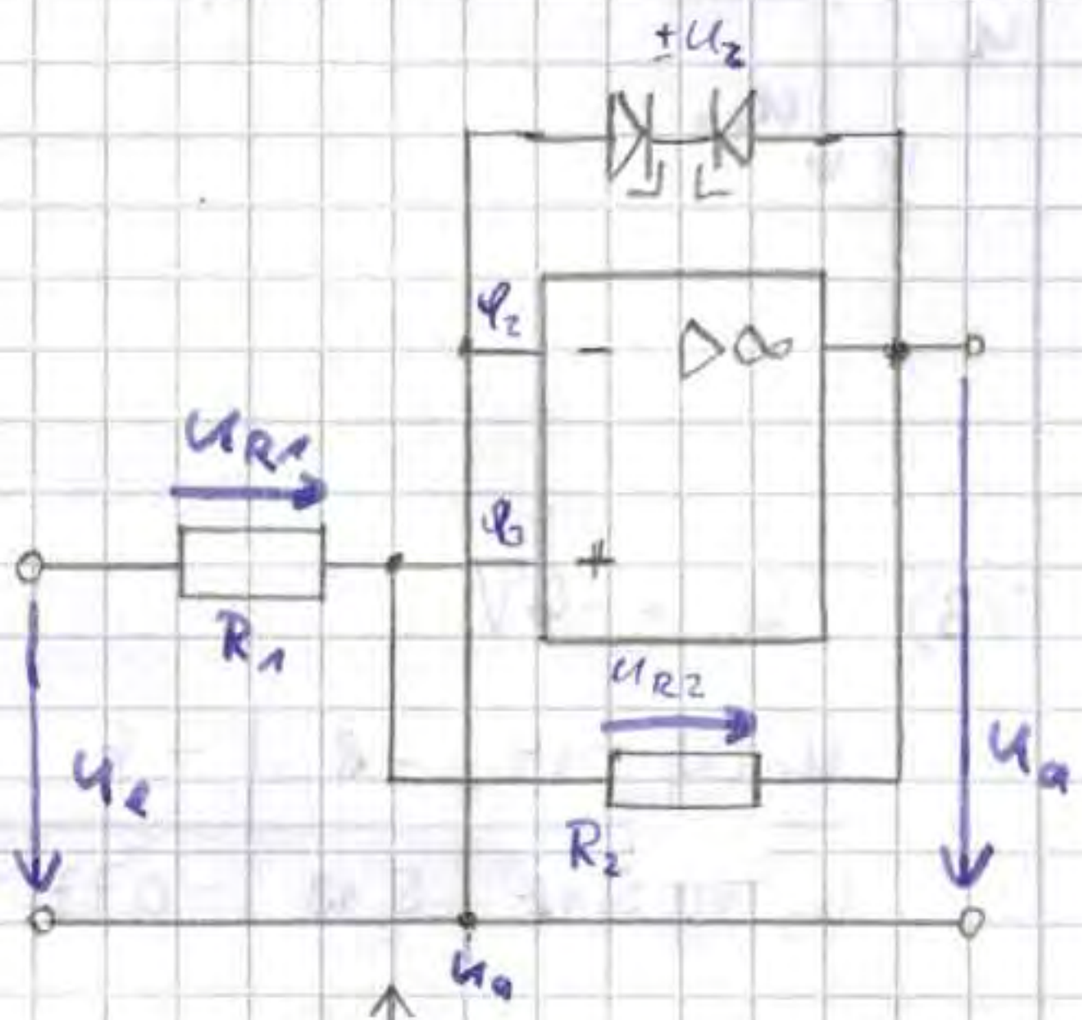
$R_1 = R_2$

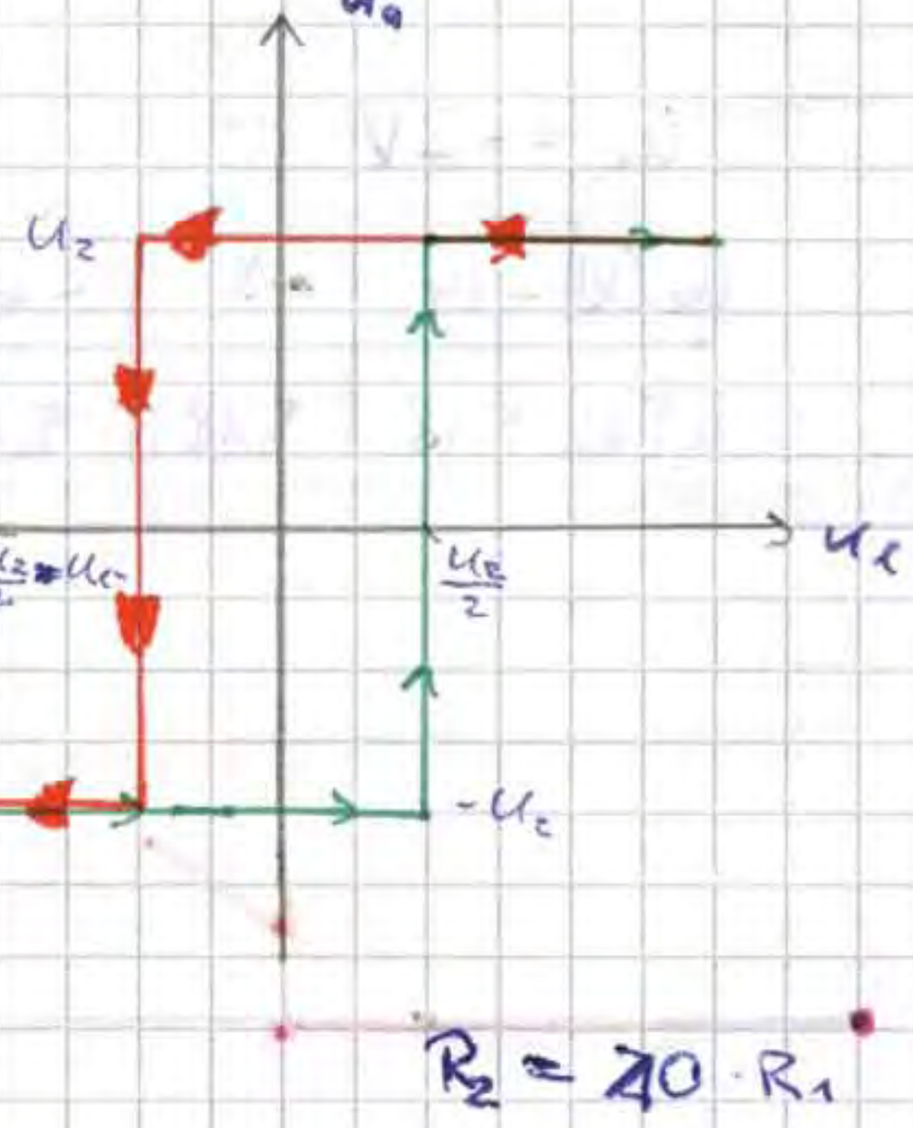


$U_2 = 14V$

$U_H = 1,3V$

nicht invertierend



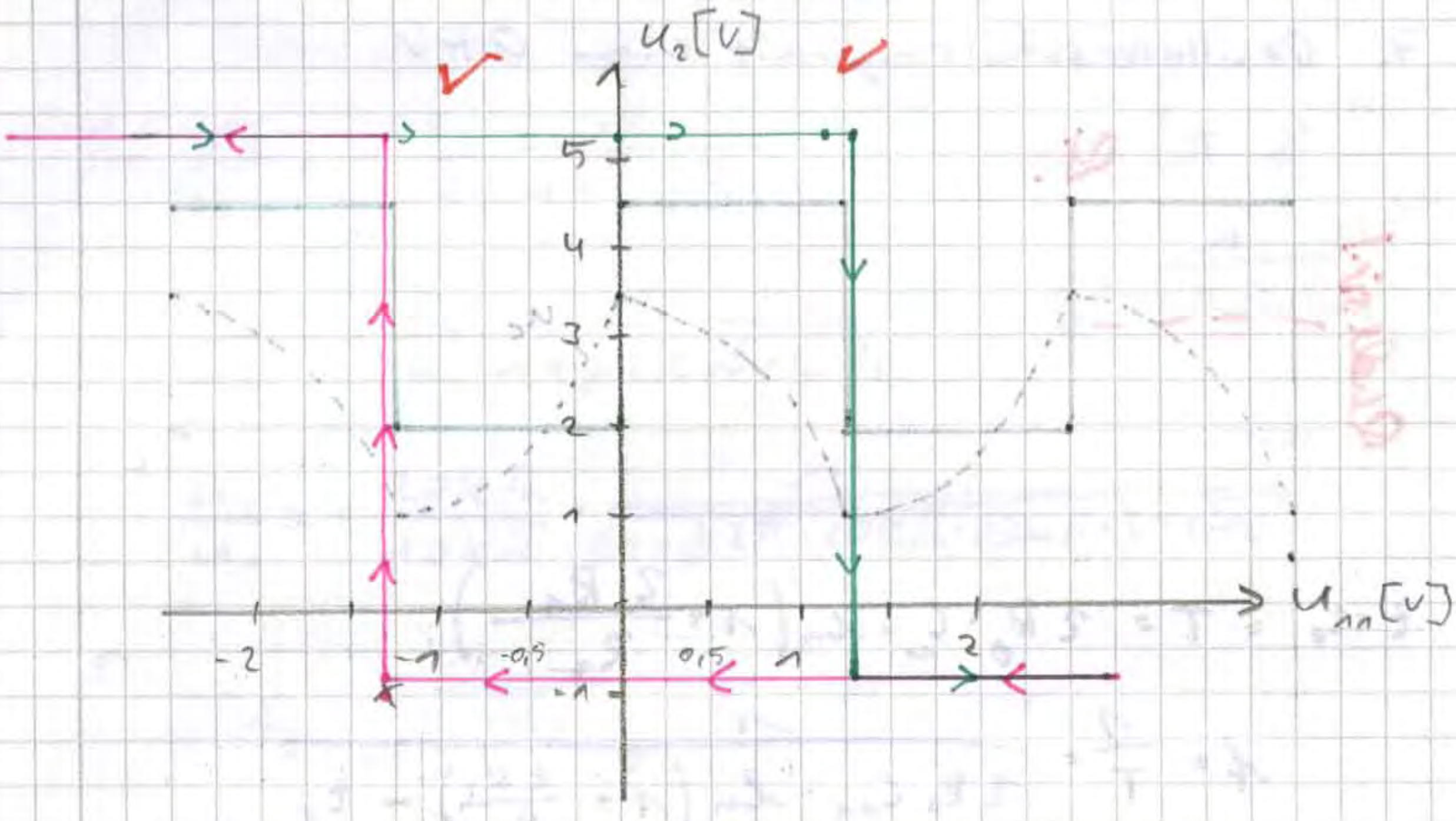


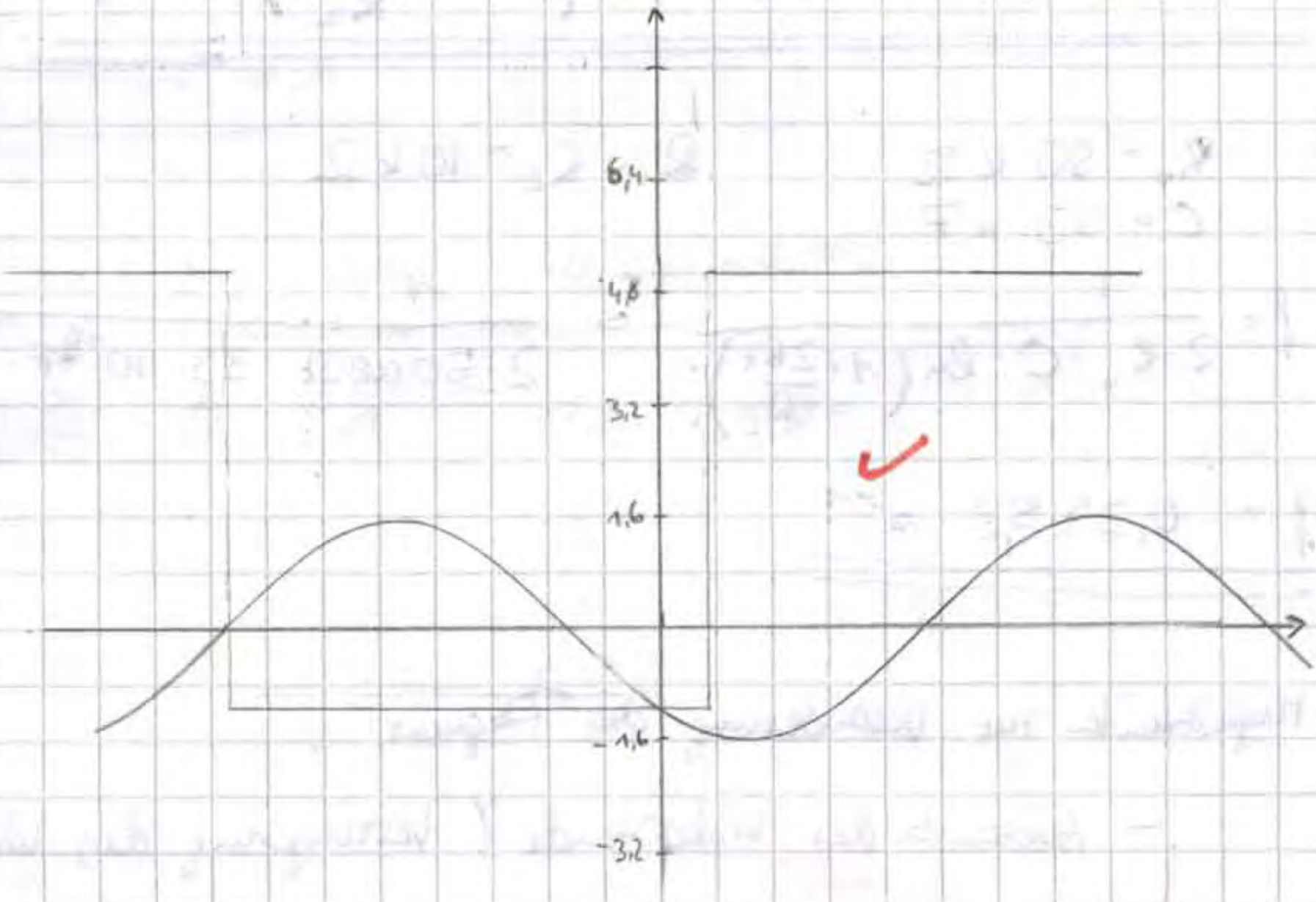
$R_2 = 20 \cdot R_1$

U_{11} [V]	-1,0	0	1,2	1,3	~~1,4~~	2,0
U_2 [V]	5,18	5,18	5,18	Ues.		-0,77

U_{11} [V]	+2,0	0	-1,2	-1,3	-	-2,0
U_2 [V]	-0,77	-0,77	-0,77	Ues		5,18

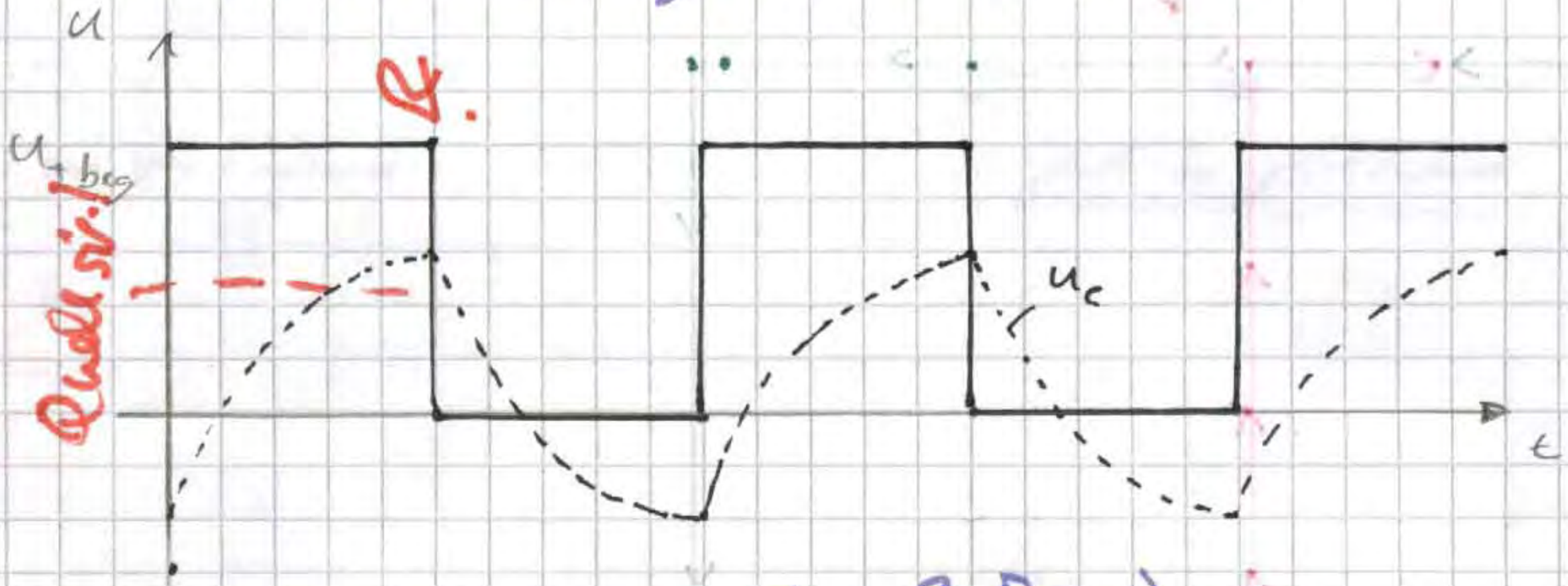
s.o. Diagramm





- Die Amplitude des Ausgangssignals ändert sich mit der Amplitude des Eingangssignals nicht
- Amplitude des Ausgangssignals geht auf 0, wenn endlos Schwelle (Minimum) mit Minimum des Eingangssignals zusammenfällt

7. Oszillatorschaltung mit einem OPV



$$t + t_0 = T = 2R_0 \cdot C_{on} \cdot \ln\left(1 + \frac{2R_1}{R_2}\right)$$

$$f = \frac{1}{T} = \frac{1}{2R_0 C_{on} \cdot \ln\left(1 + \frac{2R_1}{R_2}\right)}$$

$R_0 = 50\ k\Omega$ $\qquad R_1 = R_2 = 10\ k\Omega$

$C = 33\ nF$

$$f = \frac{1}{2 \cdot R_0 \cdot C \cdot \ln\left(1 + \frac{2R_1}{R_2}\right)} = \frac{1}{2 \cdot 50.000\Omega \cdot 33 \cdot 10^{-9} F \cdot \ln\left(1 + \frac{2 \cdot 10k\Omega}{10k\Omega}\right)}$$

$$f = 275{,}8\ s^{-1}$$

7.3) Möglichkeiten zur Veränderung der Frequenz

- Austausch des Widerstande (Verringerung des Widerstandes R_0 → Erhöhung der Frequenz)
- Austausch des Kondensator (in der Experimentieranordnung nicht möglich)

8. Tiefpass - Integrator

8.1 $\frac{U_2}{U_1} = -\frac{R_2}{R_1} \cdot \frac{1}{1 + j\omega C}$ $\quad \omega = 2\pi \cdot f$

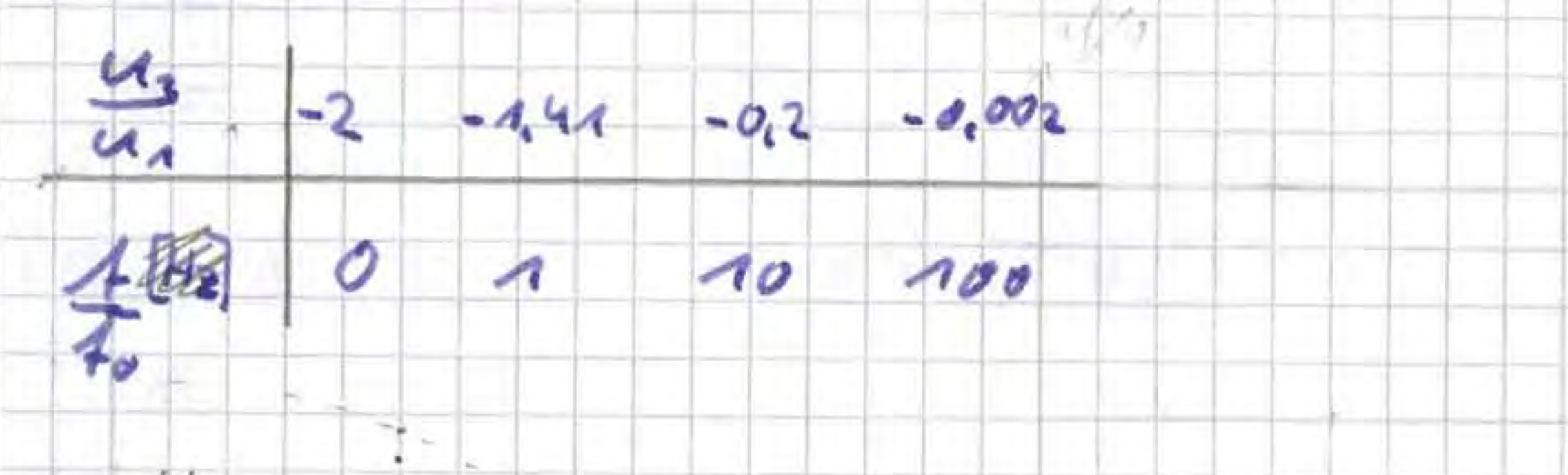
$\frac{U_2}{U_1} = -\frac{R_2}{R_1} \cdot \frac{1}{1 + j 2\pi f \cdot C R_2}$ $\quad f_0 = \frac{1}{2\pi R_2 C_{12}}$

$\frac{U_2}{U_1} = -\frac{20k\Omega}{10k\Omega} \cdot \frac{1}{\sqrt{1 + (2\pi \cdot 20k\Omega \cdot 33nF \cdot 241Hz)^2}}$

$f_0 = \frac{1}{2\pi \cdot 20k\Omega \cdot 33nF} = 241\ Hz$

$\frac{U_2}{U_1} = 1,41$

$\frac{U_2}{U_1}$	-2	-1,41	-0,2	-0,002
$\frac{f}{f_0}$	0	1	10	100



8.2)

f [Hz]	10	100	240	1000	2000	10000
φ [°]	90°	63,3°	36,4°	23,3°	15°	9,0°
ω	62,8	628,3	1507	6283	12566	62831
G	11	0,7	1,2			