2 The course of the exercise

2.1 Determination of transition characteristics

Determine the transition characteristics $U_{wy} = f(U_{we})$ for:

- voltage follower,
- non-inverting system,
- the inverting system.

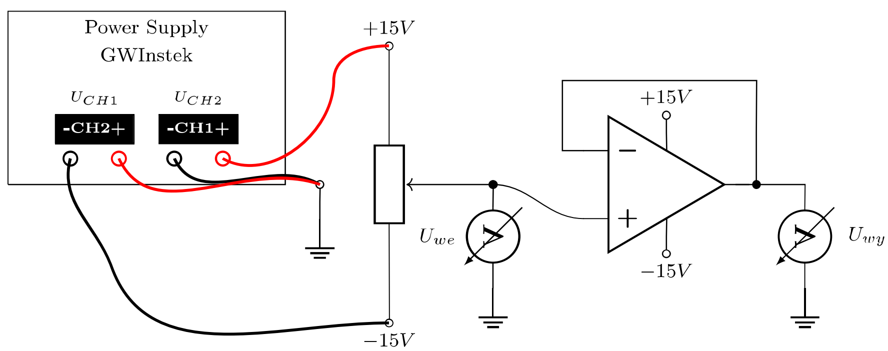


Figure 1: Measuring system for testing the voltage follower

To take measurements:

- connect the circuit as shown in the picture 1,
- set the voltage on the first and second channels of the power supply $\boldsymbol{U_{CH1} = U_{CH2} = 15V}$ and current limitation $\boldsymbol{I_{CH1max} = I_{CH2max} = 100mA}$,
- changing the voltage $\boldsymbol{U_{we}}$ at the input with a potentiometer in the range $\boldsymbol{U_{we} \in (-15; 15)V}$ measure the voltage $\boldsymbol{U_{wy}}$ at the output,
- record the results in a tables 1 and 2,
- similarly perform the measurements for the systems shown in the drawing 2 and 3 for various resistor configurations R_1 i R_2.

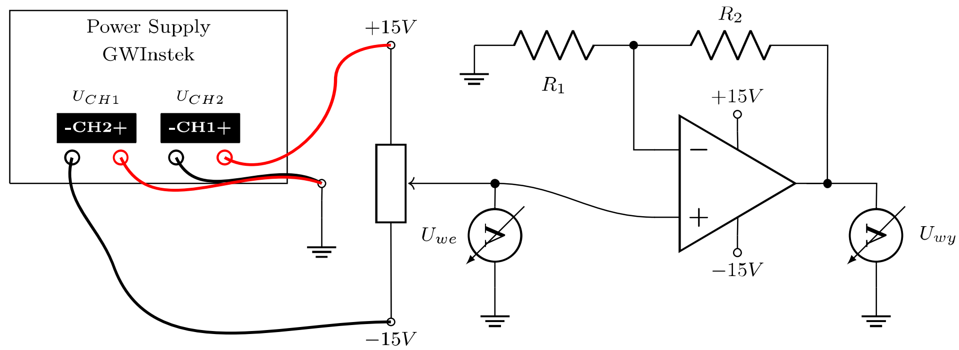


Figure 2: Measurement scheme for testing the non-inverting system

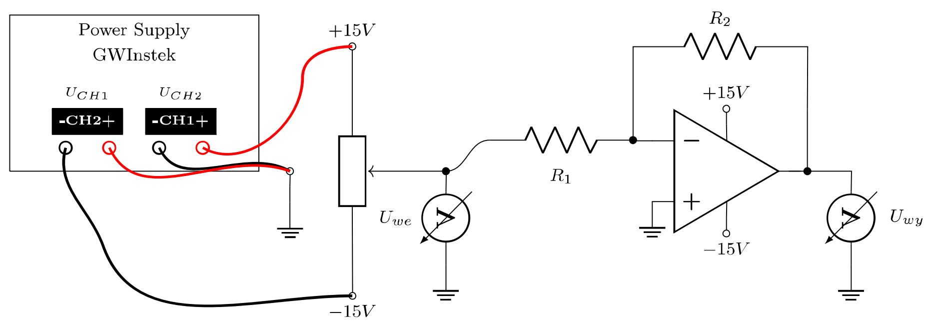


Figure 3: Measurement scheme for testing the inverting system

2.2 Study of the differentiating and integrating systems

Integrating circuit. Connect the circuit as shown in the picture 4. Determine the frequency characteristics for the given parameters R and C by the teacher. Record the results in the table 3 and mark it on the drawing 9. Then apply a square wave at the input of the system. Record input and output voltage waveforms.

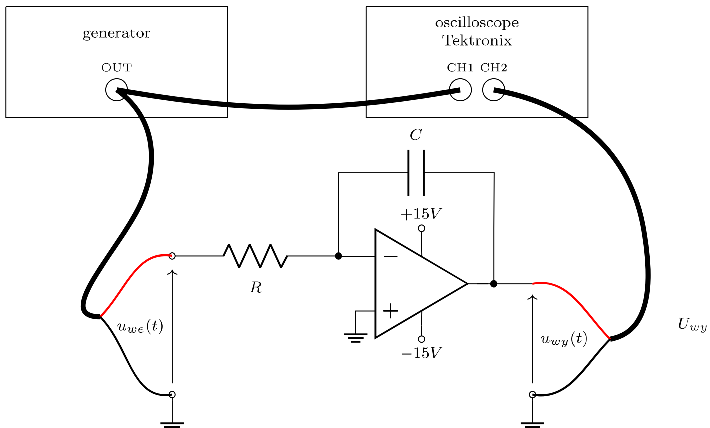


Figure 4: Measurement diagram for the integrator

Differential system. Connect the circuit as shown in the picture 5. Determine the frequency characteristics for the given parameters R and C by the teacher. Record the results in the table 3 and mark it on the drawing 9. Then apply the triangular waveform at the input. Record input and output voltage waveforms.

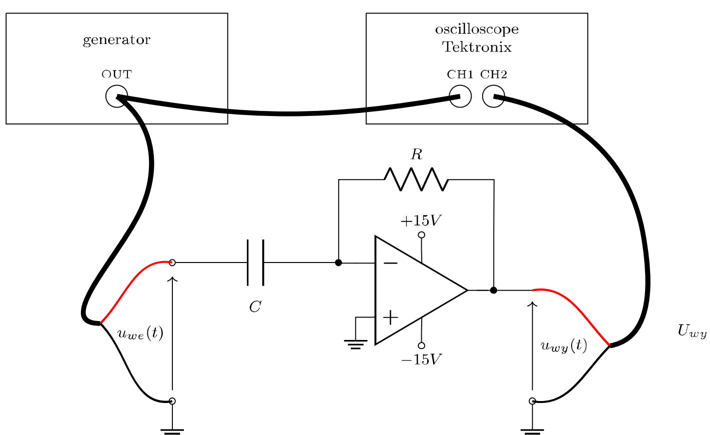


Figure 5: Measurement scheme for the differentiator

2.3 Determination of the bandwidth of an operational amplifier

Connect the circuit as shown in the picture 6. Enter a sinusoidal wave as input. By changing the frequency of the input waveform, determine the frequency response of the amplifier. Then give a square wave to the input and determine the maximum rate of voltage change at the output (SR - Slew Rate).

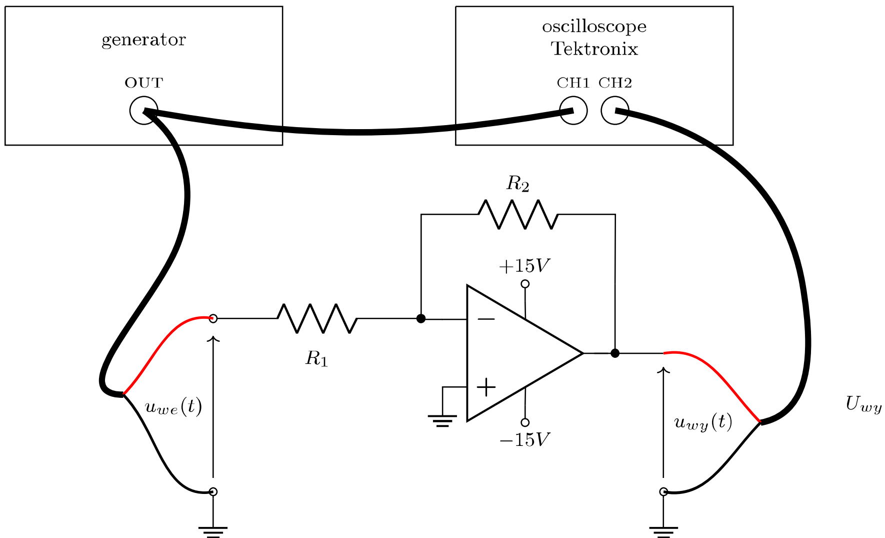


Figure 6: Measurement system for determining the frequency response

2.4 Application of the comparator (extracurricular tasks)

2.4.1 Generating a square wave with variable fill

At the input of the integrator, give the square wave from the generator installed on the test board. Connect the output of the integrator with the input of the comparator, and apply the signal from the potentiometer to the second input of the comparator. For different positions of the potentiometer, register the waveforms at inputs and at the output of the comparator.

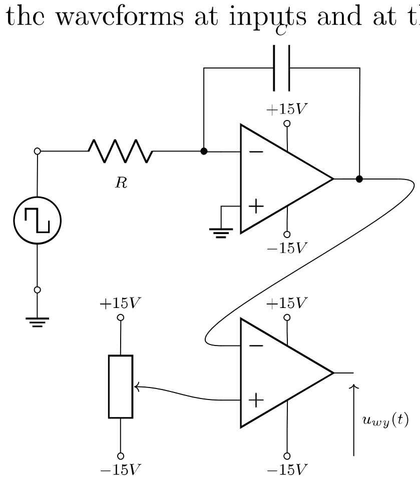


Figure 7: Measuring system

2.4.2 Sinusoidal modulation

At the input of the integrator, give the square wave from the generator installed on the test board. Connect the output of the integrator with the input of the comparator, and apply the sinusoidal signal from the NDN generator to the second input of the comparator. Record the waveforms at the inputs and output of the comparator.

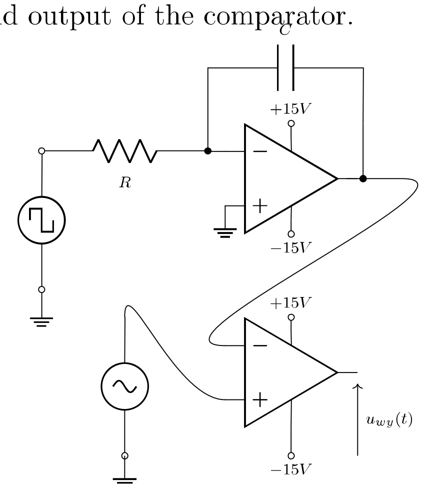


Figure 8: Measuring system

Conclusion

In this experiment, we studied the behavior of operational amplifiers in three different configurations: voltage follower, non-inverting amplifier, and inverting amplifier. By plotting and analyzing the input and output voltages for each setup, we observed the following:

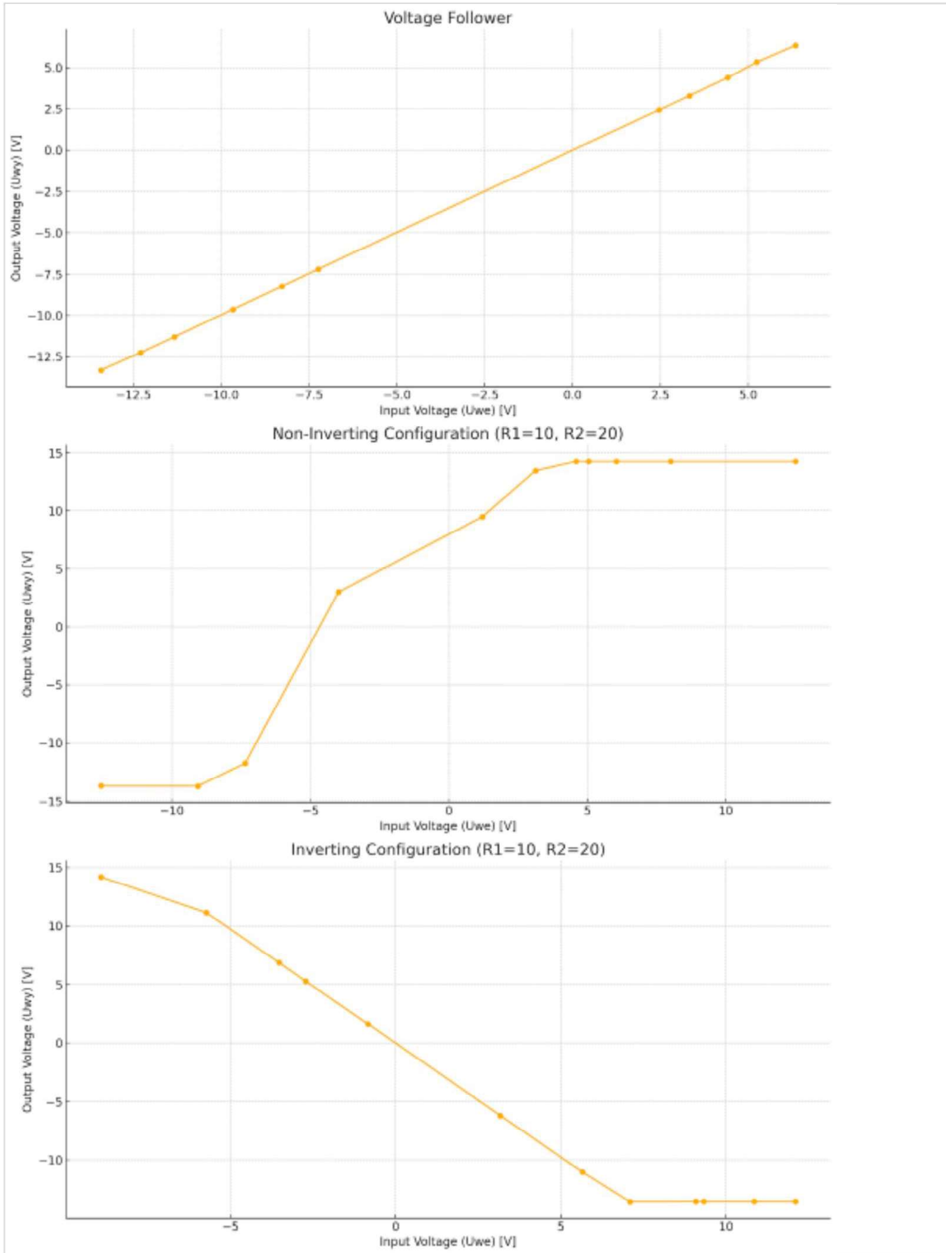
- Voltage Follower: The output voltage closely follows the input voltage. This configuration is useful for buffering signals without amplification, providing high input impedance and low output impedance.
- Non-Inverting Amplifier: The output voltage is a magnified version of the input voltage, increasing according to a gain factor determined by the resistor values. The output saturates at the power supply limits, demonstrating the amplifier's limitation in handling higher input voltages.
- Inverting Amplifier: The output voltage is both inverted and amplified. The relationship between input and output voltages shows that the output changes polarity and also saturates at the power supply limits.

Tabela 1: Transient characteristics Uwy = f (Uwe)

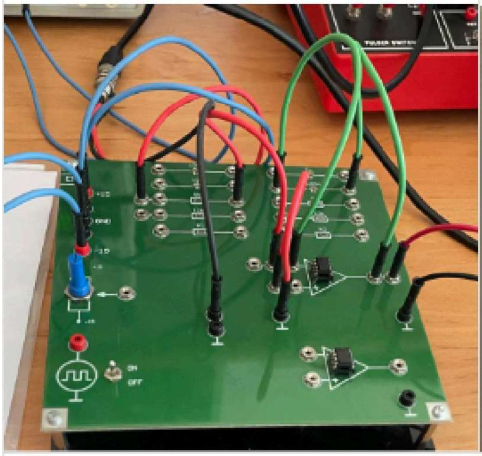
Voltage follower		Non-inverting: R1 = 10 R2 = 20		Non-inverting: R1 = . . . R2 = . . .	
Uwe[V]	Uwy[V]	Uwe[V]	Uwy[V]	Uwe[V]	Uwy[V]
-13.43	13.31	-12.57	-13.7		
-12.3	-12.24	-9.07	-13.71		
-11.34	-11.29	-7.36	-11.74		
-9.67	-9.63	-3.99	3		
-8.28	-8.23	1.21	9.48		
-7.24	-7.39	3.12	13.44		
2.46	2.44	4.59	14.26		
3.32	3.3	5.05	14.26		
4.41	4.38	60.4	14.26		
5.24	5.33	8	14.26		
6.34	6.33	12.51	14.26		

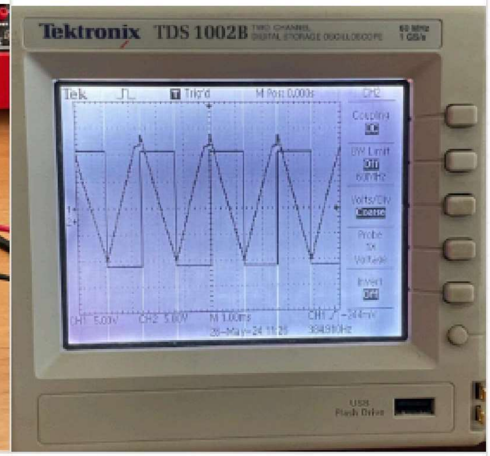
Tabela 2: Transient characteristics Uwy = f (Uwe)

Inverting: R1 = 10 R2 = 20		Inverting: R1 = . . . R2 = . . .		. . .	
Uwe[V]	Uwy[V]	Uwe[V]	Uwy[V]	Uwe[V]	Uwy[V]
-8.92	14.19				
-5.73	11.15				
-3.53	6.88				
-2.72	5.29				
-0.838	1.63				
3.17	-6.19				
5.65	-11.01				
7.09	-13.57				
9.09	-13.56				
9.33	-13.56				
10.85	-13.56				
12.1	-13.56				

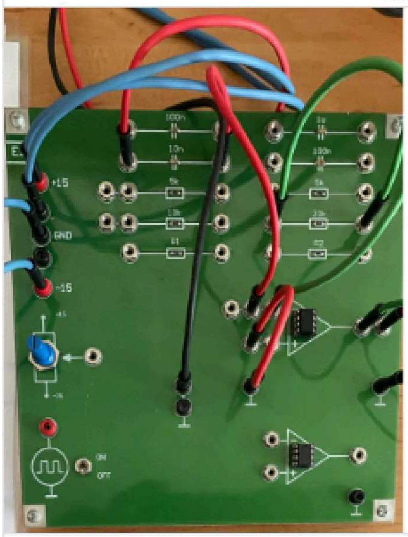

Voltage Follower
Output Voltage (Uwy) [V]
Input Voltage (Uwe) [V]
Non-Inverting Configuration (R1=10, R2=20)
Output Voltage (Uwy) [V]
Input Voltage (Uwe) [V]
Inverting Configuration (R1=10, R2=20)
Output Voltage (Uwy) [V]
Input Voltage (Uwe) [V]

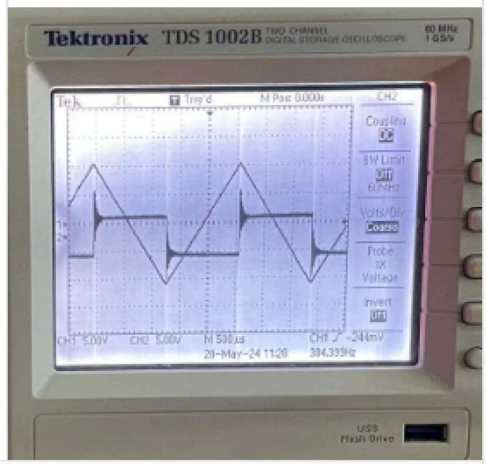
Integrating circuit





Differential system





The bandwidth of an operational amplifier