PROTOCOL

to laboratory exercise

Broad-Band-Amplifier

Group / Class	Secretary	Signature
5 / **4BHELS**	HOFSTÄTTER A.	
Exercise- / Delivery date 25. Nov. 2014 2. Dec. 2014	Employee HIRSCH L.	Signature
Teacher Tillich	Employee DÜRAUER J.	Signature
Grade	Employee	Signature

Transistor

2x BC546

Used Devices

Nr.	Device	Manufactor	Type	Place Nr.
1.	Oscilloscope	Tektronix	TDS 1001B	-
2.	Function generator	Hameg	HM 8035	-
3.	Power Supply	PS	2403D	-

Used Programs

Nr.	Name	Version
1.	Altium Designer	13
2.	Micro-Cap	11

1 Table of Contents

2 Tasks

The aim of this lab exercise was to build a broadband amplifier. All values were calculated and the broadband amplifier were dimensioned in all his circumstances, at last and finally the hole circuit was implemented and built.

The following tasks were achieved and implemented.

1. Dimensioning
2. Measuring construction
3. Measuring of the bias voltage
4. Measuring of output voltage
5. Bode diagram (amplitudes and phase response)

2.1 Given Values

The following Values were part of the individual tasks achievement and were taken firstly for dimensioning.

$\boldsymbol{U_b} = 15V$ $\boldsymbol{I_c} = 1mA$ $\boldsymbol{V_u} = 30\ dB$ $\boldsymbol{R_A} = 10k$ $\boldsymbol{B} = \boldsymbol{\beta} = 300$

3 Dimensioning

For all following calculations the values from 2.1 Given Values were taken as reference.

The first assumption was that the voltage U_{RE}. The range of this voltage was 1-2 V.
Assumption: U_{RE}=2V

Based on this value the emitter resistor $\mathrm{R_E}$ was calculated.

$$\mathrm{R_E} = \frac{\mathrm{U_{RE}}}{\mathrm{I_C}} = \frac{2\ \mathrm{V}}{1\ mA} = 2\ \mathrm{k\Omega} \rightarrow \mathrm{R_{E2}} = 1\mathrm{k}8\ \Omega$$

Afterwards the voltage U_{CE1} was chosen. The range for this voltage was 1-2.
Assumption: U_{CE1}=2V

$$U_{RC} = U_{CE_2} = \frac{U_b - U_{RE} - U_{CE_1}}{2} = \frac{15\ V - 2\ V - 2\ V}{2} = 5.5\ \mathrm{V}$$

$$R_C = \frac{U_{RC}}{I_C} = \frac{5.5\ V}{1mA} = 5.5\ \mathrm{k\Omega} \rightarrow \mathrm{R_C} = 5\mathrm{k}6\ \Omega$$

$$I_B = \frac{I_C}{B} = \frac{1mA}{300} = 3.3\ \mu A$$

Finally the current for the voltage divider was assumpted. The supposition for this current was 20 times bigger than I. From this it follows that: $I_Q = I_B * 20 = 3.3\ \mu A * 20 = 66\ \mu A$.

The so calculated value was a very important ingredient of the resistor calculation which set the bias voltage.

3.1 Calculation R3

$$U_{BE} = 0.7\ V$$

$$U_{B1} = U_{RE} + U_{BE} = 2.7\ V$$

$$R_3 = \frac{U_{B1}}{I_Q} = \frac{2{,}7\ V}{66\ \mu A} = 40.91\ k\Omega \rightarrow \mathrm{R_3} = 39\ \mathrm{k\Omega}$$

3.2 Calculation R2

$$U_{B2} = U_{B1} + U_{CE1} = 4{,}7\ V$$

$$R_2 = \frac{U_{B2} - U_{B1}}{I_Q} = \frac{2\ V}{66\ \mu A} = 30{,}303\ k\Omega \rightarrow \mathrm{R_2 = 33\ k\Omega}$$

3.3 Calculation R1

$$R_1 = \frac{U_B - U_{B2}}{I_Q} = \frac{15\ V - 4{,}7\ V}{66\ \mu A} = 156{,}06\ k \rightarrow \mathrm{R_1 = 150\ k\Omega}$$

$$r_F = \frac{U_I}{I_C} = \frac{26\ mV}{1mA} = 26\ \Omega$$

$$|V_u| = \left| \frac{\frac{1}{\frac{1}{R_C} + \frac{1}{R_2}}}{r_F + R_{E1}} \right| = \frac{3k5}{r_F + R_{E1}} = 30 = \rightarrow\ R_{E1} = \frac{3k5}{30} - 26 \rightarrow \mathrm{R_{E1} = 100\ \Omega}$$

3.4 Calculation C1 und C2

$$\mathrm{C_1} = \mathrm{C_2} = \frac{1}{2\pi * [R_2//R_3//\beta * (r_F + R_{E1})]} = \frac{1}{2\pi * [33k//39k//\beta * (26 + 39k)]} = 131{,}14\ nF$$

$$\rightarrow \mathrm{C_1 = C_2 = 100\ nF}$$

3.5 Calculation C3

$$\mathrm{C_3} = \frac{1}{2\pi * \mathrm{f_g} * (R_{E2}//R_{E1})} = \frac{1}{2\pi * \mathrm{f_g} * (1k8//100k\Omega)} = 16{,}8\ \mu F \rightarrow \mathrm{C_3 = 15\ \mu F}$$

3.6 Calculation C4

$$\mathrm{C_4} = \frac{1}{2\pi * \mathrm{f_g} * (R_A + R_C)} = \frac{1}{2\pi * 100\ Hz * (10k + 5k6)} = 102\ nF \rightarrow \mathrm{C_4 = 100\ nF}$$

4 Measuring construction

Following cicuit shows the used measuring construction inclusive all dimensioned und calculated values.

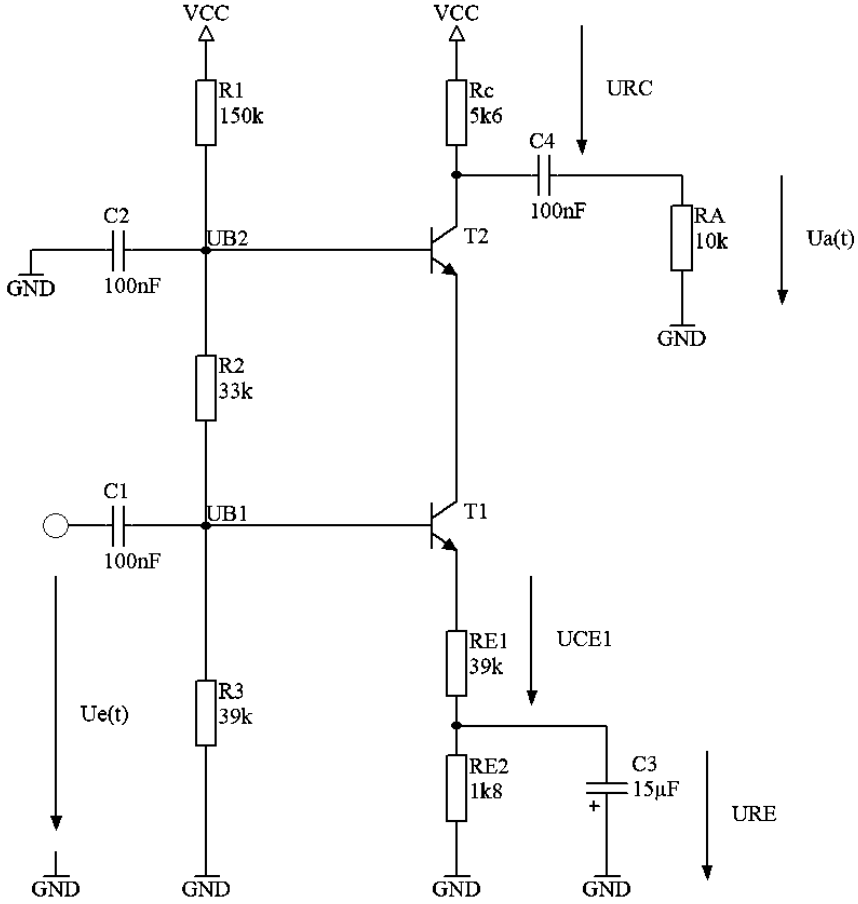

Figure 1. – Constructed measuring cicuit

5 Bias voltage

The measurement of the bias voltage was made and compared with the calculated values.
The results of the measurement from the bias voltage were following.

	Measured [V]	Calculated [V]
U_{B1}	2,56	2,7
U_{B2}	4,60	4,7
U_{RC}	5,80	5,5
U_{CE1}	2,10	2,0
U_{CE2}	5,05	5,5
U_{RE}	1,80	2,0

And additional measurement of the potentials UB1 and UB2 should exhibit in which range compared to the supply voltage the voltages were located.

On the measurement picture a GND and Vcc Line were drawn.

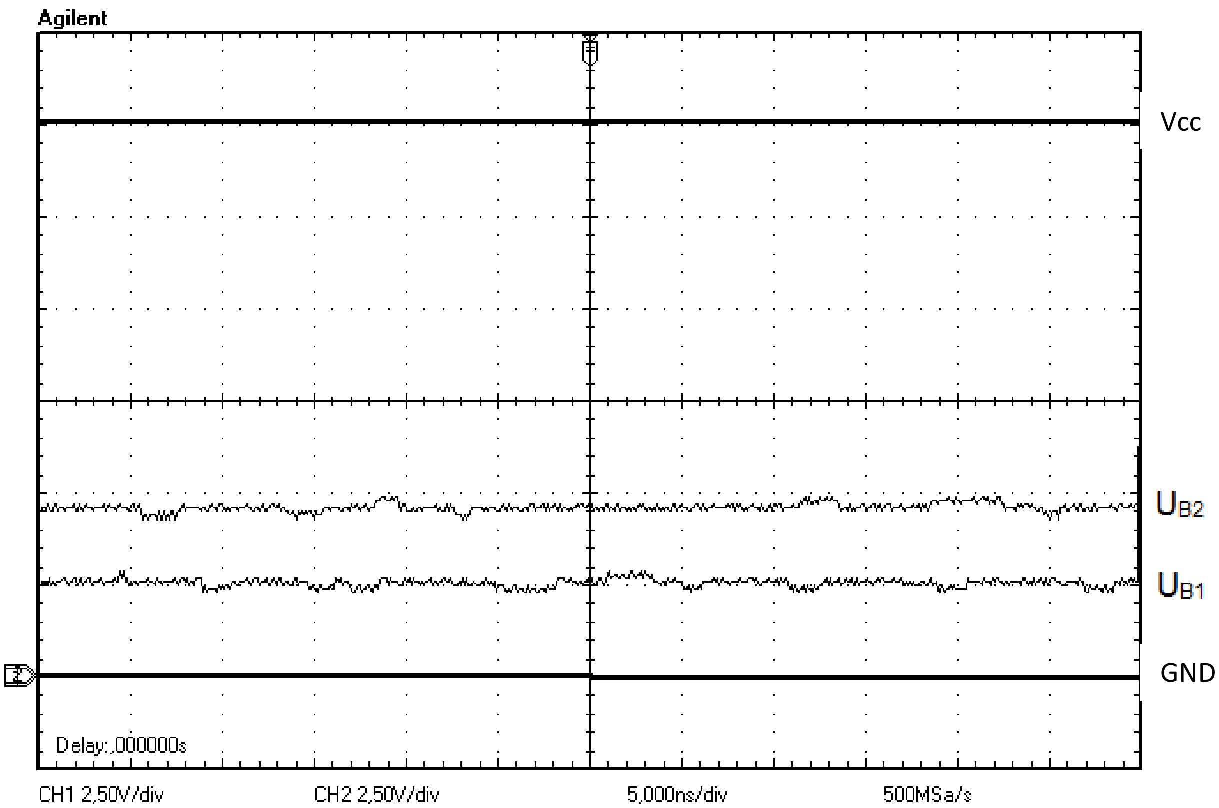

Figure 2. – Compare measurements

6 Output measurement

A sinus with a frequency of 1kHz and an amplitude of 100mVpp was supplied on the input pun of the broad-band-amplifier. The following picture shows the input signal (Ue – Ch2) and the output signal (Ua – Ch1).
Based on this picture the gain could be read and also seen that the amplifier inverts the output signal.

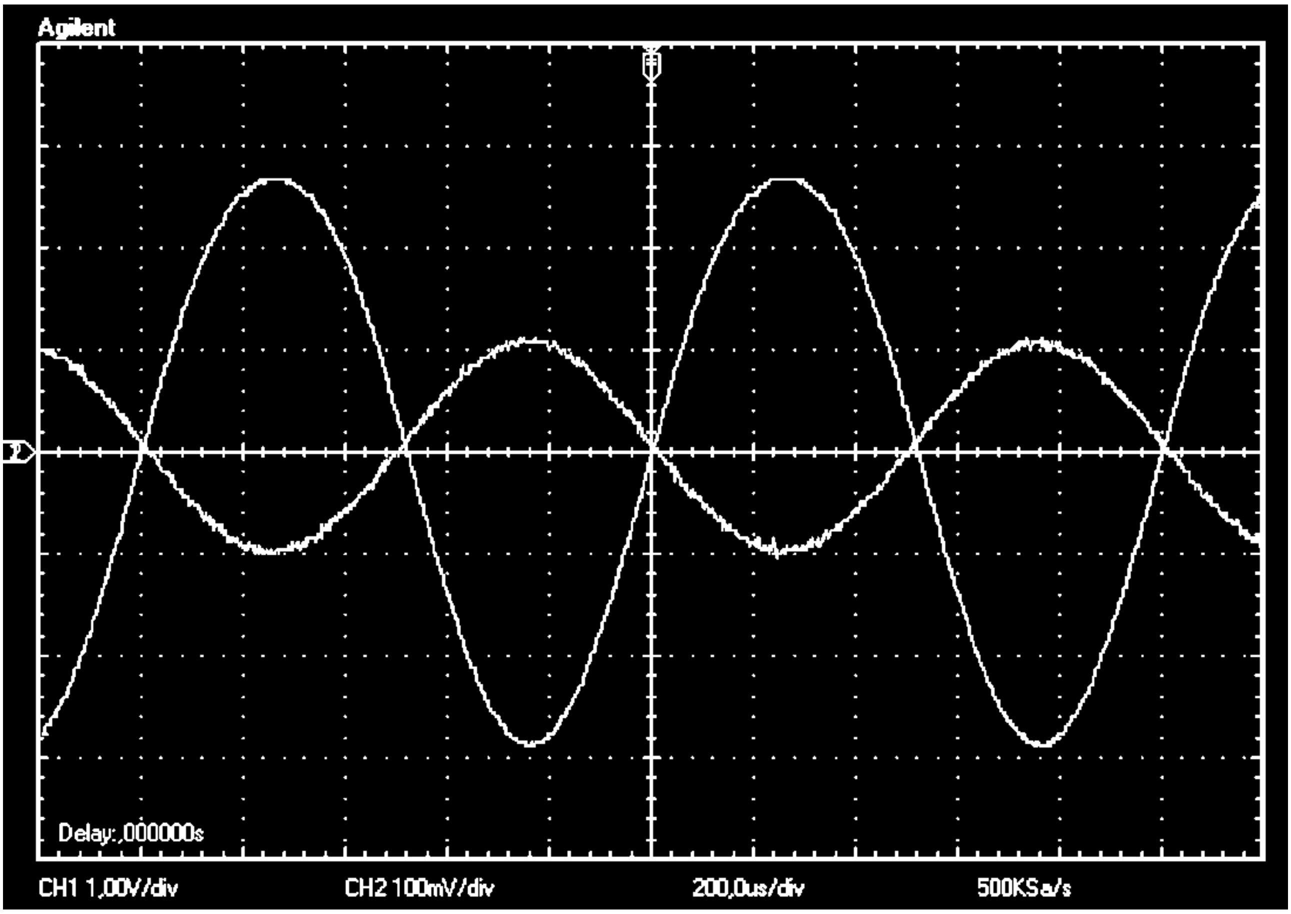

Figure 3. – Input signal with 100 mVpp and 1 kHz

6.1 Dynamic Range

The following measurements showed the dynamic range of the amplifier.
By all following three signals an input signal of 1 kHz was used. The amplitude varies from 100mVpp to 300 mVpp.

Based on the following measurements it was recognizable that the amplifier works probably in the range of 1-100mVpp without saturation.

With the measured values the gain could be recalculated.

$$V_u = -\frac{U_A}{U_E} = -\frac{2{,}7\ V}{0{,}1\ V} = -27\ dB \cong 28{,}6\ dB$$

6.1.1 Measurement results (100mVpp)

The first measurement was executed with an input signal with an amplitude from 100mVp.
The Signal is not much damped and available in it´s origin form.

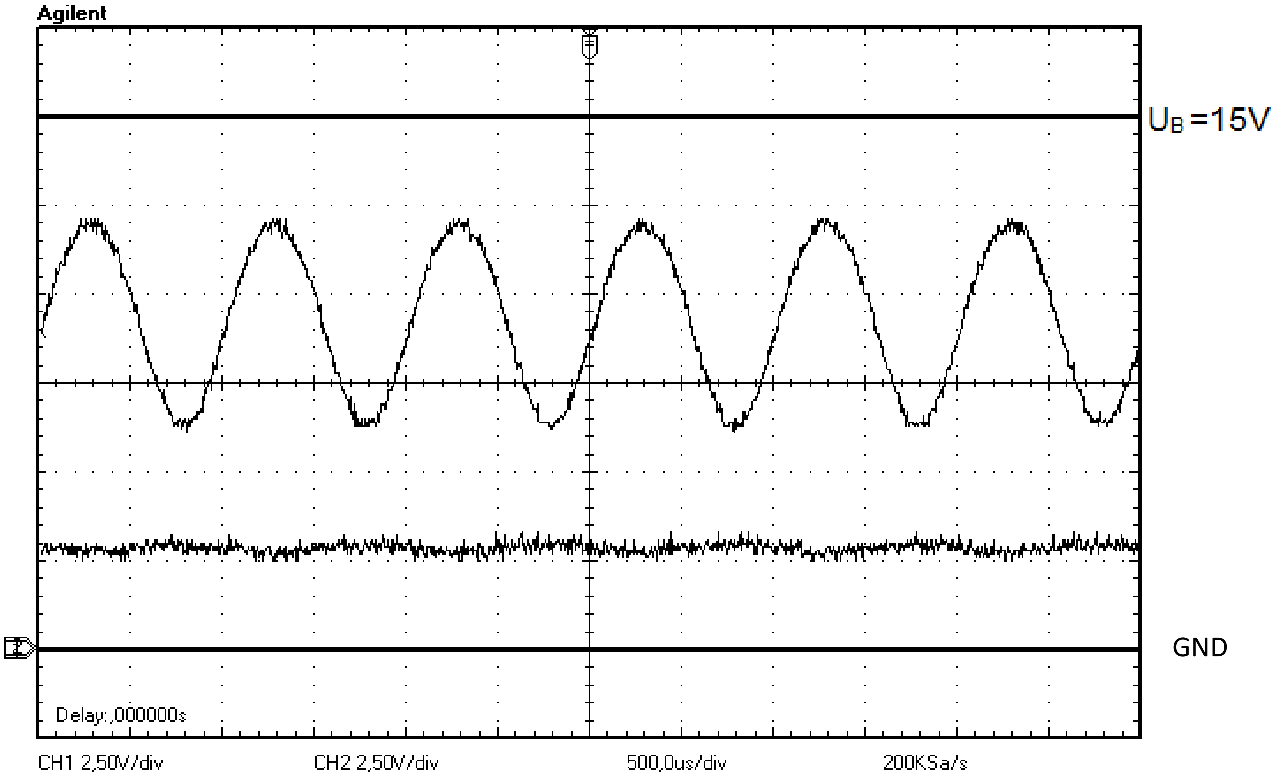

Figure 4. – Dynamic range (100mVpp)

6.1.2 Measurement results (200mVpp)

The first measurement was executed with an input signal with an amplitude from 200mVp.
The output signal is already not very symmetric and a little bit cut off.

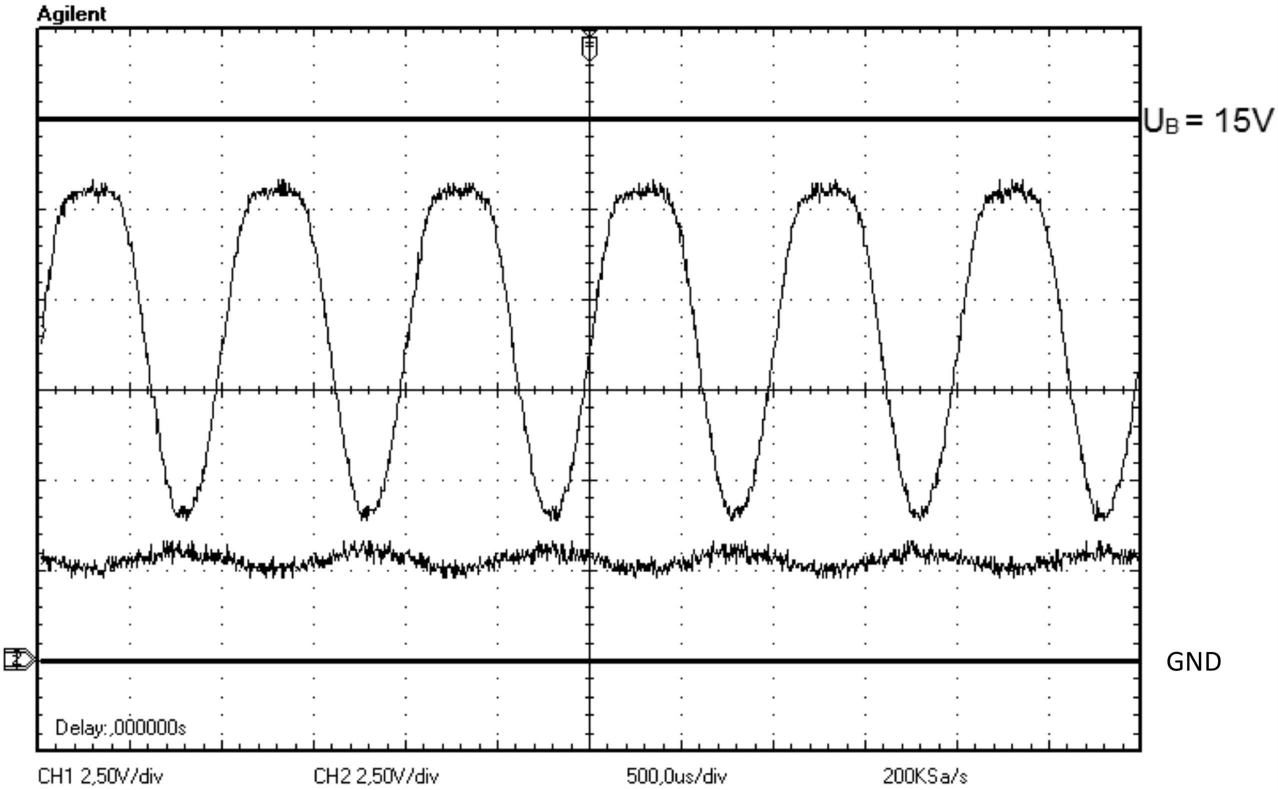

Figure 5. – Dynamic range (200mVpp)

6.1.3 Measurement results (300mVpp)

The first measurement was executed with an input signal with an amplitude from 300mVp.
In this measurement the amplifier is already in a heavy saturation.

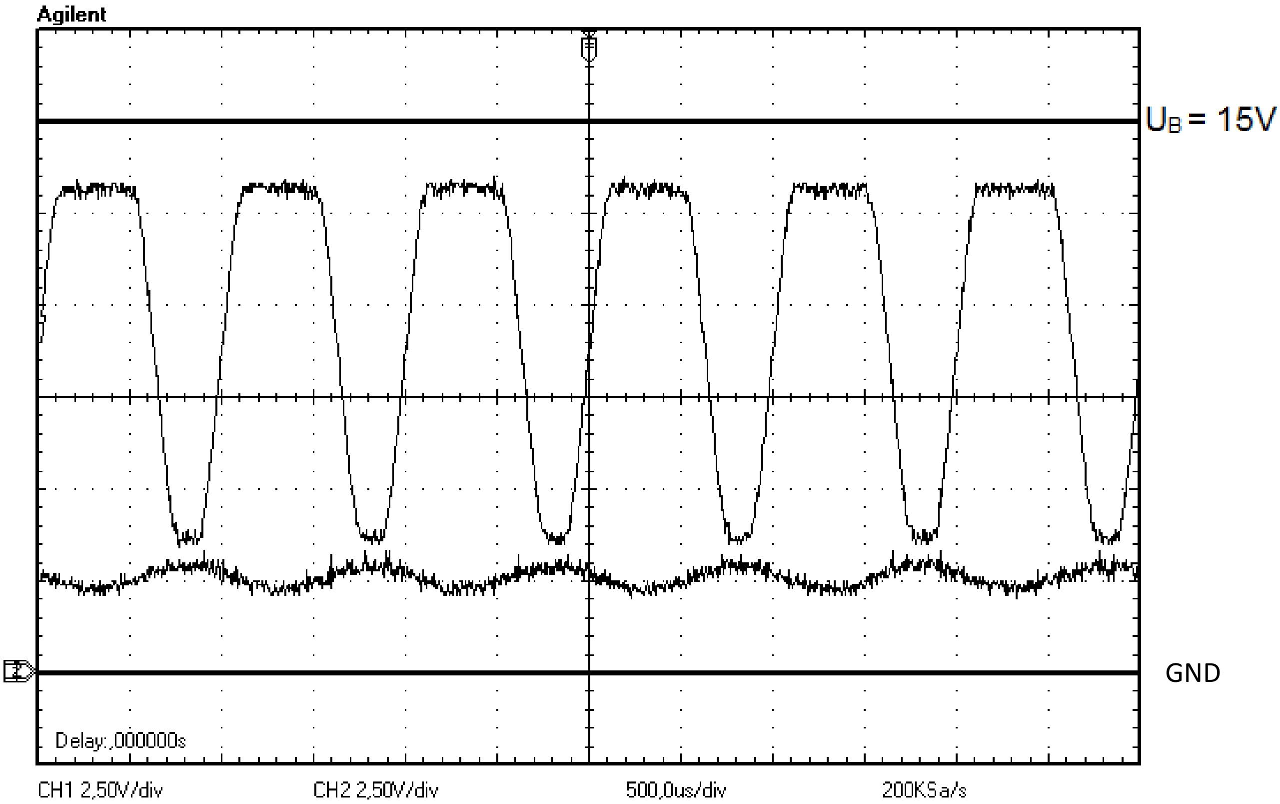

Figure 6. – Dynamic range (300mVpp)

7 Bode plot

7.1 Amplitude plot

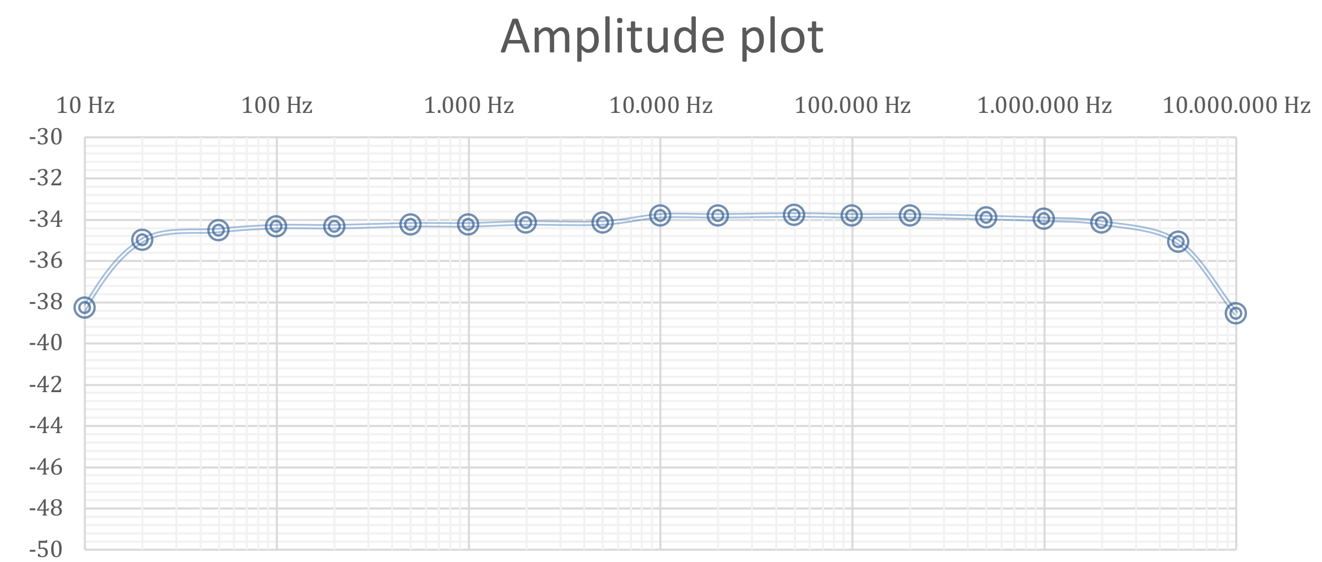

Figure 7. – Measured Amplitude Response

7.2 Phase plot

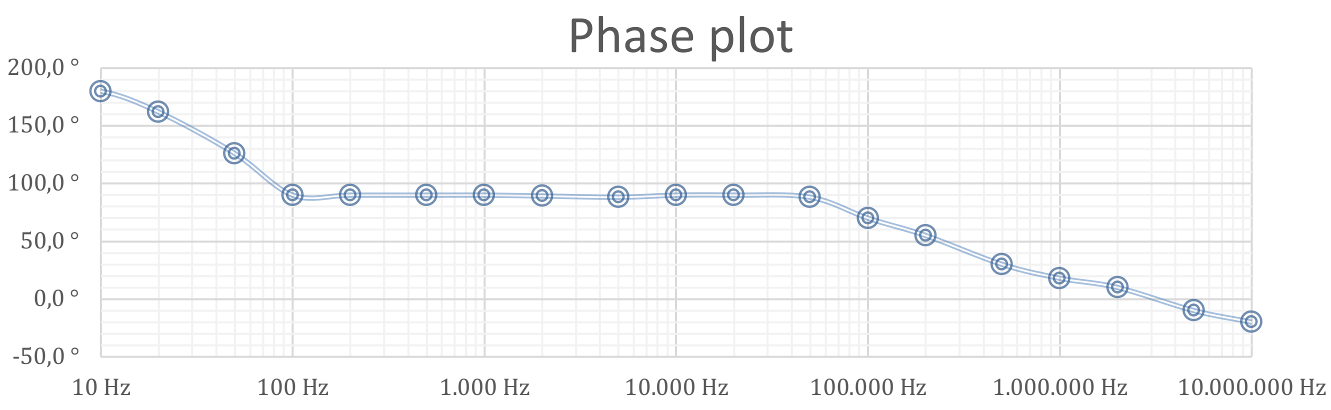

Figure 8. – Measured Phase Response

8 Simulation

To consolidate the measured and calculated circuit the whole circuit was in addition to the built up simulated in Micro-Cap.

8.1 Simulation results

8.1.1 Transient analysis

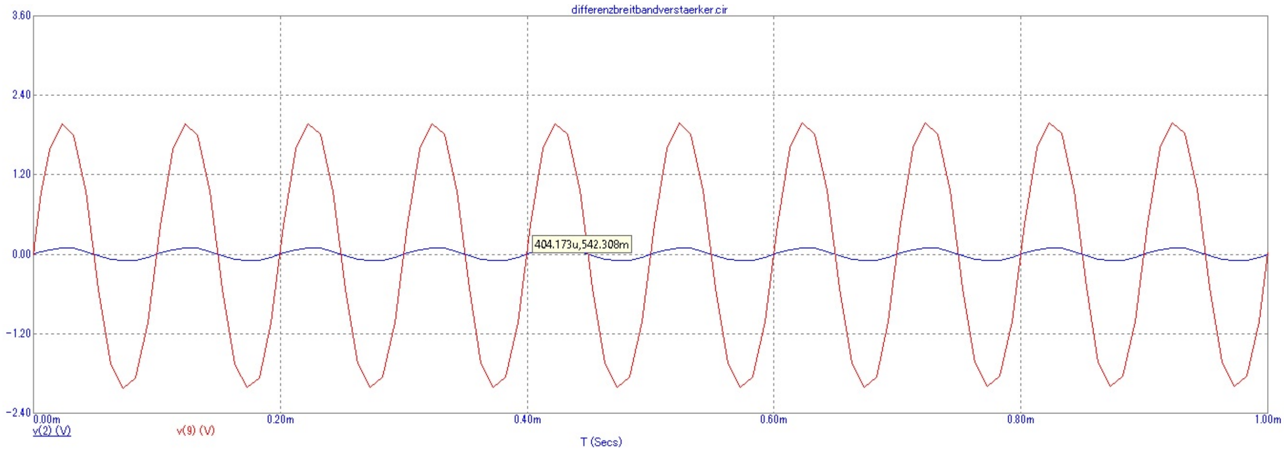

Figure 9. – Simulation of the Transient analysis with Micro-Cap

8.1.2 Bode plot (Amplitude and Phase)

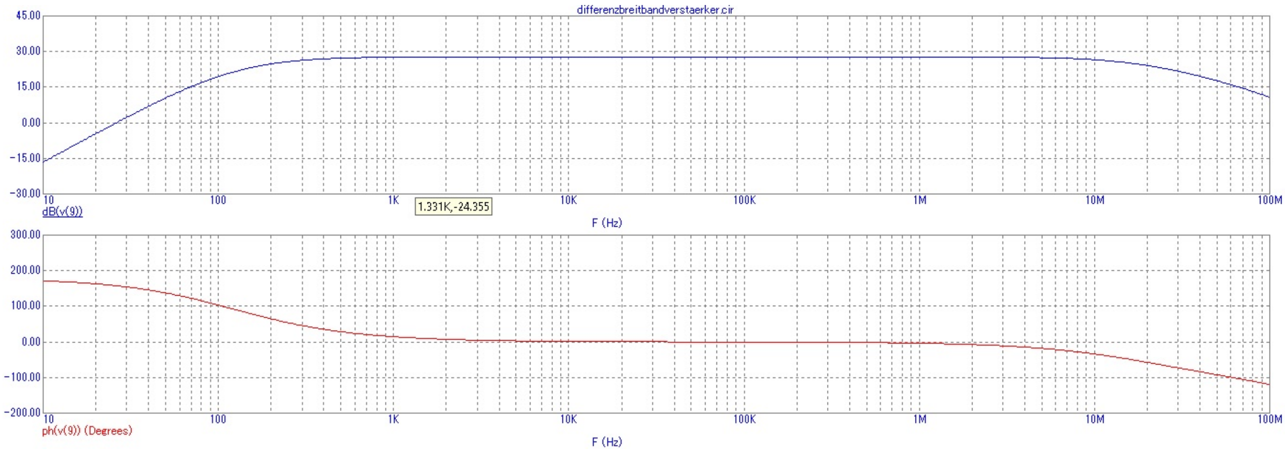

Figure 10. – Simulation of the bode plot with Micro-Cap

9 List of Figures