Measurement Report: Balance Control
PRO-Q2

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Group 1

EQ2.a
EQ2.c

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Contents

1 The objective of the measurement

The objective of the measurement is to get more insight in how the balance control functions and to determine whether the balance control meets the specifications. The measurement is also a preparation for the assessment of the project.

2 Measurement setup

Figure 1 shows the schematic of the balance control. The schematic of the balance control in figure 1 is slightly different from the balance control as described in the project manual. The capacitors C_5 and C_6 are included and these capacitors prevent direct current flowing through the potentiometer and the wiper.

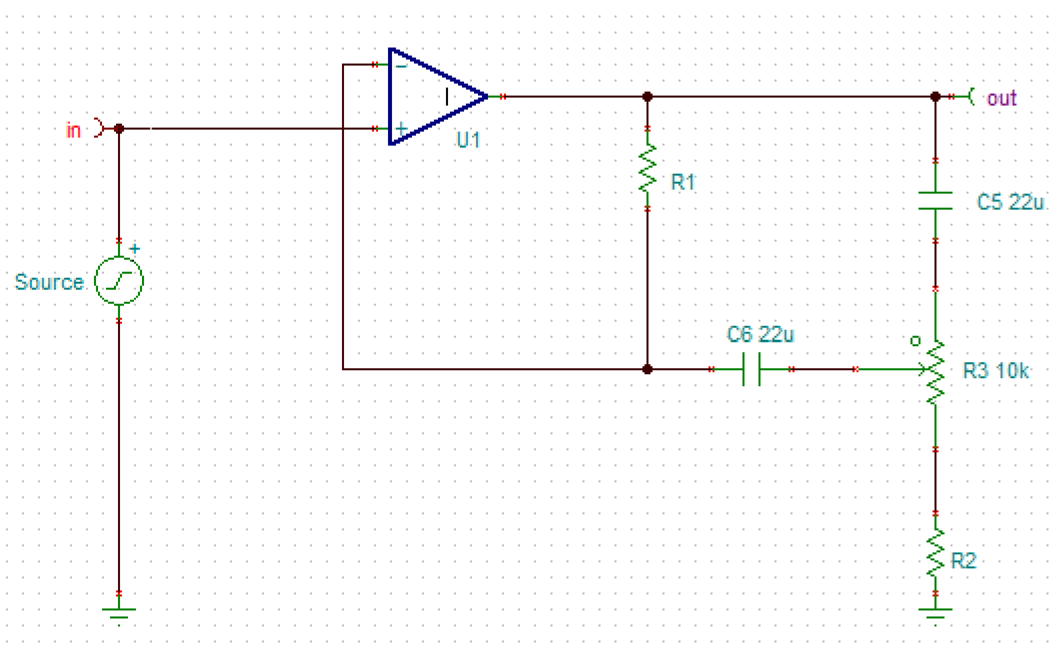

Figure 1: Balance control schematic

The balance control is soldered on a circuit board as seen in figure 2.

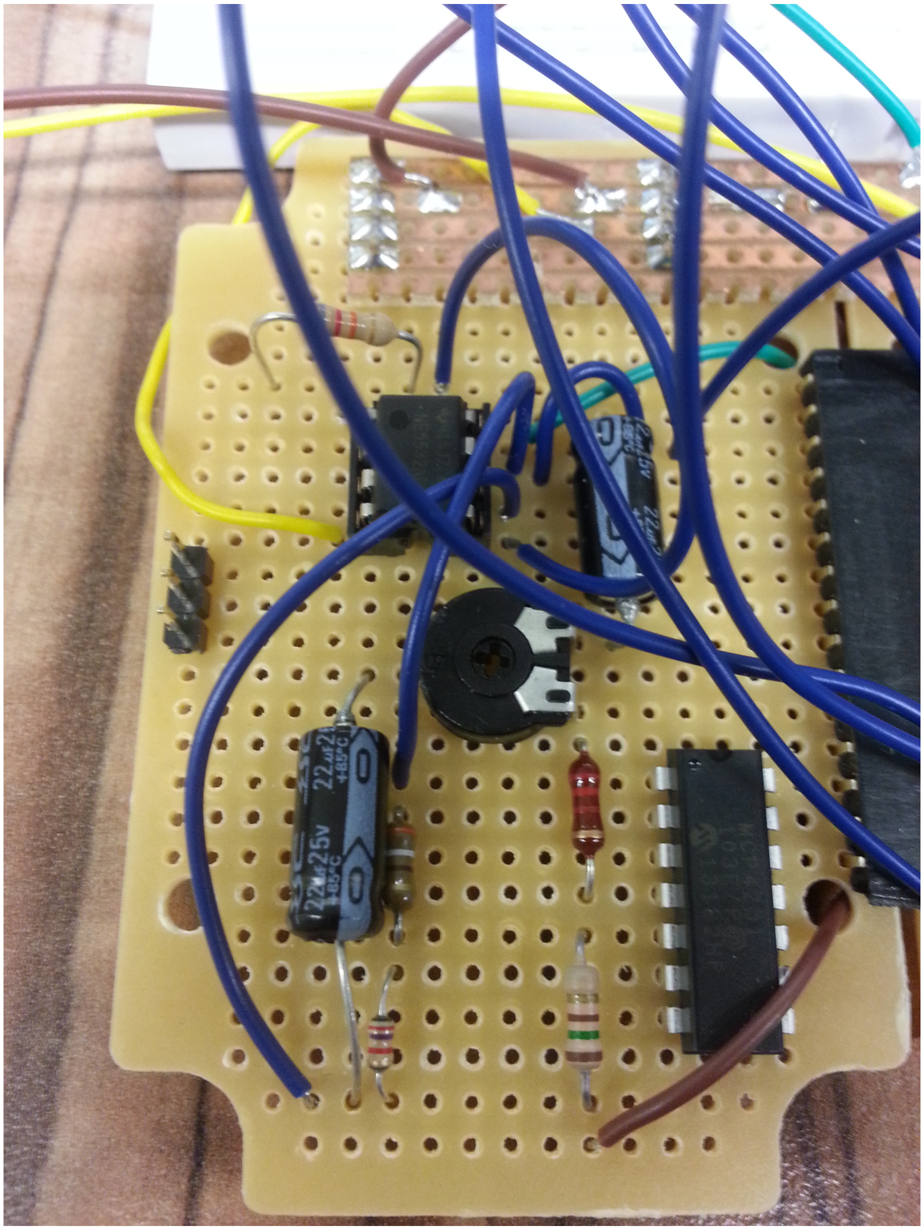

Figure 2: Balance control on a circuit board

The balance control is connected to the following equipment:

- The input of the balance amplifier is connected to a function generator, 'BK PRECISION 4052'. The input signal is a sine with an amplitude of $200mV_{\text{pk-pk}}$.

- A power supply is connected to the positive (+15V) and negative (-15V) terminals of the amplifier.
- The signals 'out' and 'in' are measured by using the oscilloscope, 'TEKTRONIX DPO2004B'.

3 Results

3.1 Balance control specifications

- Range ±6 dB (within ±0.5 dB) difference between right and left channels
- In flat position +2 dB (within ±0.5 dB)
- Approximate logarithmic control function
- No DC current through the potentiometer nor the wiper

3.2 Calculations

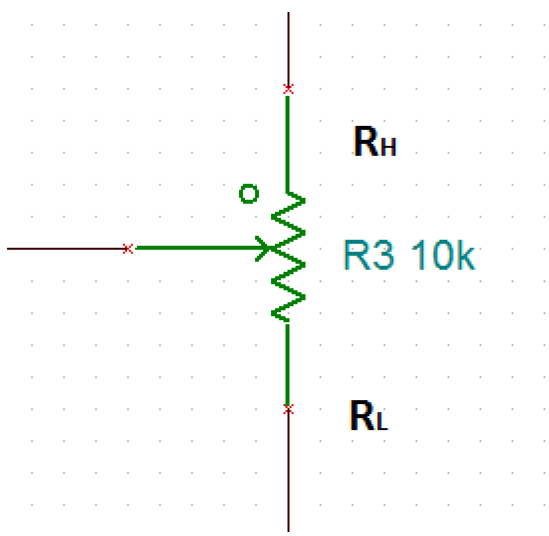

Figure 3: Positions of R_H and R_L of the potentiometer

The formula for the gain of the balance control is equal to:

$$Gain = \frac{R_1//R_H + R_L + R_2}{R_L + R_2} = 1 + \frac{R_1//R}{R_L + R_2} \tag{1}$$

It is known that the gain must be 2dB in flat position. Therefore the gain can be derived:

$$20 \cdot log(A_{flat-position}) = 2dB$$

$$log(A_{flat-position}) = \frac{1}{10}$$

$$A_{flat-position} = 10^{\frac{1}{10}} \approx 1,26 \tag{2}$$

The gain must be 6dB if the balance control is in maximum position. Therefore the gain can be derived with the potentiometer in maximum position:

$$20 \cdot log(A_{high}) = 6dB$$

$$log(A_{high}) = \frac{3}{10}$$

$$A_{high} = 10^{\frac{3}{10}} \approx 2 \tag{3}$$

Equation 2can be substituted in 1 and $\mathrm{R_H}$ and $\mathrm{R_L}$ are 5,000Ω.

$$1,26 = \frac{5,000 \cdot R_1}{(R_1 + 5,000) \cdot (R_2 + 5,000)}$$

$$R_2 + 5000 = \frac{5,000 \cdot R_1}{1.26 \cdot (R_1 + 5,000)}$$

$$R_2 = \frac{3,700 \cdot R_1 - 6.5 \cdot 10^6}{1.26 \cdot R_1 + 1,300)} \tag{4}$$

3can be substitute in 1, R_H = 10,000Ω and R_L = 0Ω. The value of $R_L$is actually very small (±0,5Ω) but because the value is very small, R_L can be omitted.

$$2 = 1 + \frac{10,000 \cdot R_1}{(R_1 + 10,000) \cdot R_2}$$

$$R_2 = \frac{10,000 \cdot R_1}{(R_1 + 10,000)} \tag{5}$$

5can be substituted in 4 and therefore the value of R_1 can be calculated.

$$\frac{3,700 \cdot R_1 - 6.5 \cdot 10^6}{1.26 \cdot R_1 + 1,300)} = \frac{10,000 \cdot R_1}{(R_1 + 10,000)}$$

$$2,600R_1^2 + 13 \cdot 10^6 \cdot R_1 = 3,700 \cdot R_1^2 + 30.5 \cdot 10^6 \cdot R_1 - 6.5 \cdot 10^{10}$$

$$1,100R_1^2 + 17.5 \cdot 10^6 \cdot R_1 - 6.5 \cdot 10^{10} = 0$$

$$R_1 R_1 = \frac{17.5 \cdot 10^6 \pm 24,336,187}{2,200}$$

$$R_1 = 3,107.35 \approx 3,107\Omega \tag{6}$$

$$R_1 = -19,016\Omega \tag{7}$$

A resistor can never have a negative value so therefore R_1 is equal to 3,107Ω. To calculate R_2 , 6 can be filled in in 4 or 5.

$$R_2 = \frac{10,000 \cdot 3,107}{(3,107 + 10,000)} = 2,370\Omega \tag{8}$$

3.3 Simulations

The software 'Tina-TI' is used for the simulation of the balance control.

Figure 4 shows the bode plot of the balance control in maximum position.

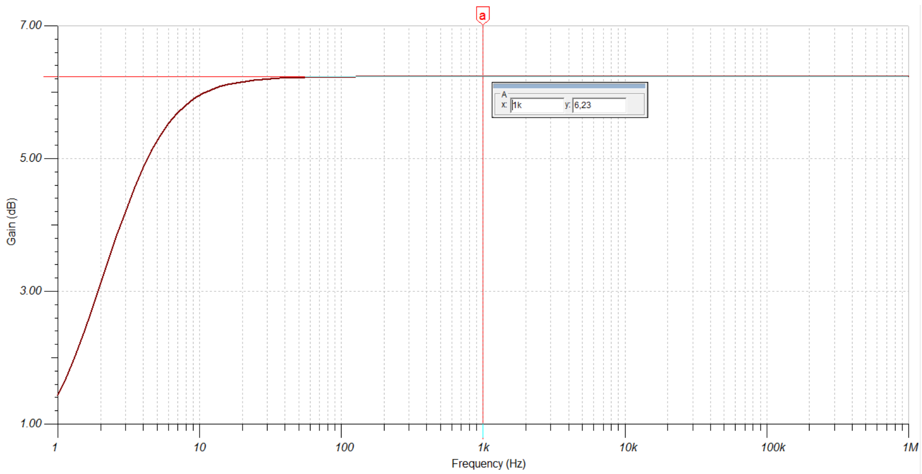

Figure 4: Simulation maximum position

Figure 5 gives the bode plot of the balancecontrol in flat position.

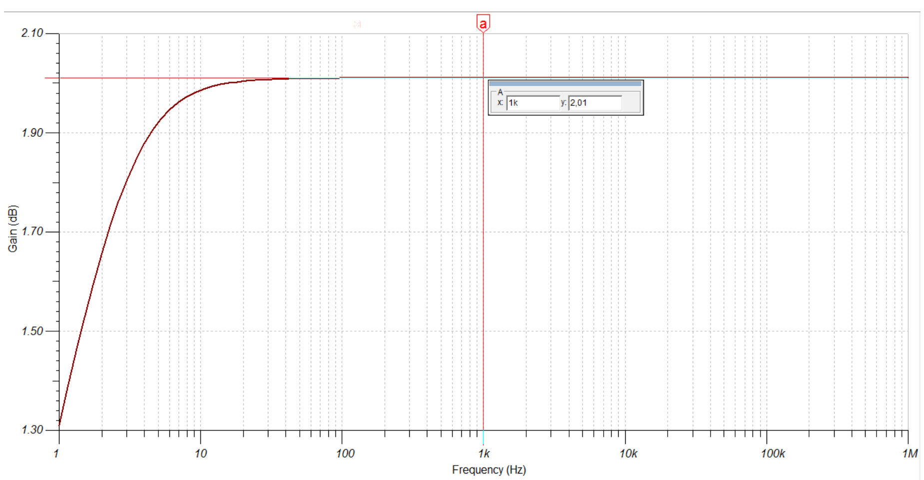

Figure 5: Simulation flat position

Figure 6 gives the bode plot of the balance control in minimum position.

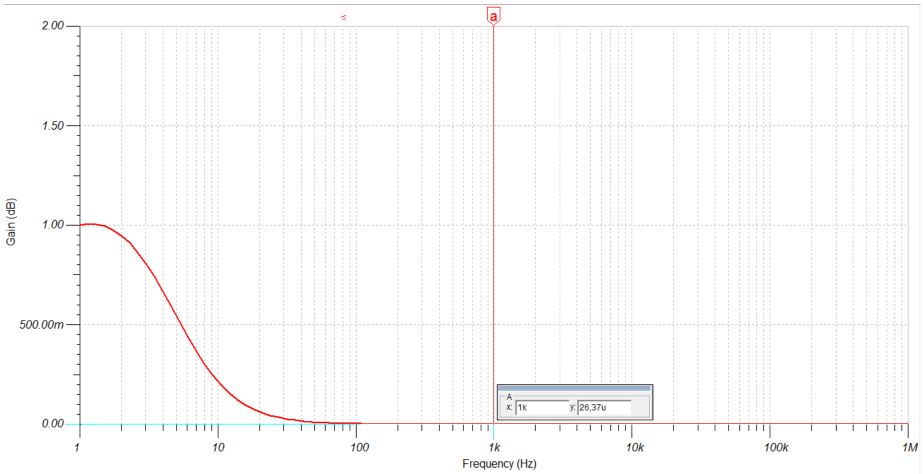

Figure 6: Simulation minimum position

3.4 Measurements

The results of the measurements can be found in the appendix.

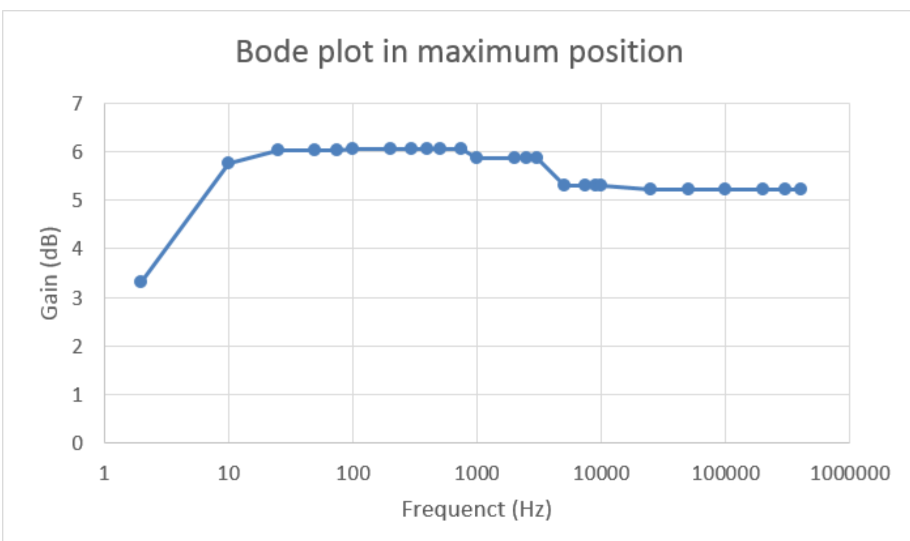

Figure 7: Bode plot of the measurement in maximum position

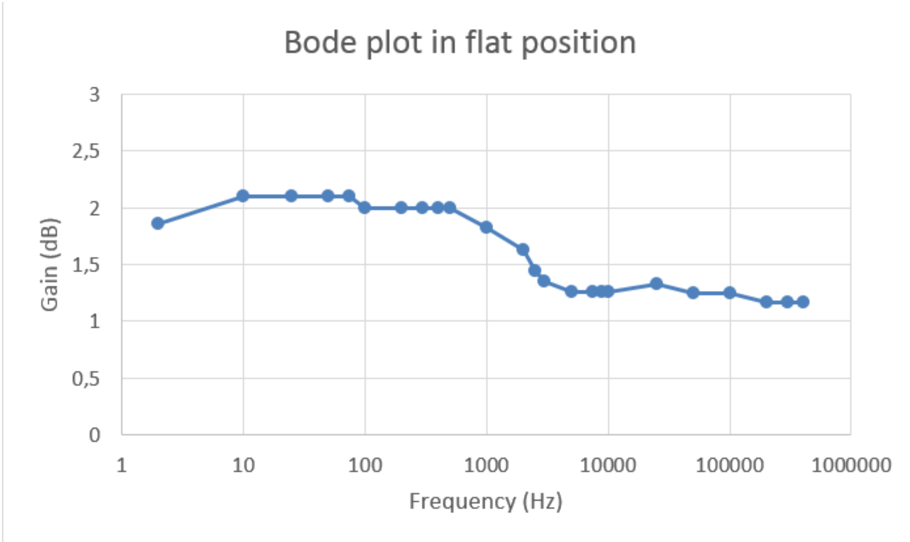

Figure 8: Bode plot of the measurement in flat position

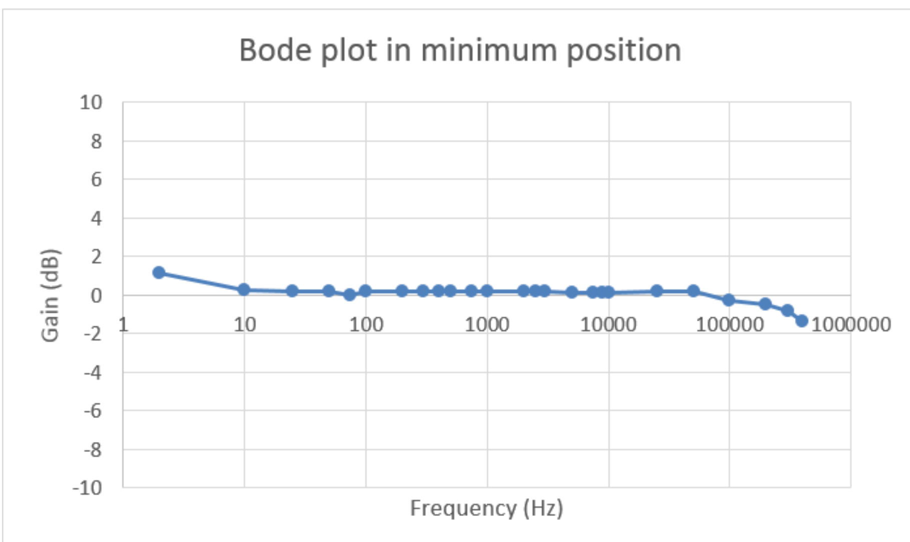

Figure 9: Bode plot of the measurement in minimum position

4 Conclusion

The bode plot of the measurement in minimum position closely approaches the bode plot of the simulation in minimum position. There is however differences between the bode plots in flat position and maximum position.

The gain is not 2dB throughout the entire frequency range (2Hz-400kHz) in the measurement in flat position. In the simulation in flat position, the gain is approximately 2dB in the frequency range of 10Hz-400kHz.

The gain is not 6dB throughout the entire frequency range (2Hz-400kHz) in the measurement in maximum position. In the simulation in maximum position, the gain is approximately 6dB in the frequency range of 10Hz-400kHz.

The similarity between the bode plot of the measurement in flat position and the bode plot of the measurement in maximum position is that the gain decreases by approximately 1dB at a frequency of approximately 2kHz. Disturbances in the surrounding area of the circuit or noise are possible reasons why this phenomenon occurs.

Despite the differences between the measurements and simulations, the balance control still meets the specifications.

5 Appendix

Table 1: Measurements balance control minimum position

Frequency (Hz)	V_{in}	V_{out}	Gain (dB)
2	0.088	0.1	1.110346557
10	0.088	0.092	0.287956414
25	0.088	0.09	0.195196746
50	0.088	0.09	0.195196746
75	0.088	0.088	0
100	0.088	0.09	0.195196746
200	0.088	0.09	0.195196746
300	0.088	0.09	0.195196746
400	0.088	0.09	0.195196746
500	0.088	0.09	0.195196746
750	0.088	0.09	0.195196746
1,000	0.088	0.09	0.195196746
2,000	0.088	0.09	0.195196746
2,500	0.088	0.09	0.195196746
3,000	0.088	0.09	0.195196746
5,000	0.088	0.089	0.09814669
7,500	0.088	0.089	0.09814669
9,000	0.088	0.089	0.09814669
10,000	0.088	0.089	0.09814669
25,000	0.088	0.09	0.195196746
50,000	0.088	0.09	0.195196746
100,000	0.088	0.085	-0.301274929
200,000	0.088	0.083	-0.508091595
300,000	0.088	0.08	-0.827853703
400,000	0.088	0.075	-1.388428175

Table 2: Measurements balance control flat position

Frequency (Hz)	V_{in}	V_{out}	Gain (dB)
2	0.088	0.109	1.858876516
10	0.088	0.112	2.09470701
25	0.088	0.112	2.09470701
50	0.088	0.112	2.09470701
75	0.088	0.112	2.09470701
100	0.089	0.112	1.996560321
200	0.089	0.112	1.996560321
300	0.089	0.112	1.996560321
400	0.089	0.112	1.996560321
500	0.089	0.112	1.996560321
1,000	0.09	0.111	1.821609387
2,000	0.092	0.111	1.630703029
2,500	0.094	0.111	1.443902504
3,000	0.095	0.111	1.35198747
5,000	0.096	0.111	1.261034915
7,500	0.096	0.111	1.261034915
9,000	0.096	0.111	1.261034915
10,000	0.096	0.111	1.261034915
25,000	0.097	0.113	1.326134184
50,000	0.097	0.112	1.248925768
100,000	0.097	0.112	1.248925768
200,000	0.097	0.111	1.17102489
300,000	0.097	0.111	1.17102489
400,000	0.097	0.111	1.17102489

Table 3: Measurements balance control maximum position

Frequency (Hz)	V_{in}	V_{out}	Gain (dB)
2	0.088	0.129	3.322140763
10	0.088	0.171	5.770268765
25	0.088	0.176	6.020599913
50	0.088	0.176	6.020599913
75	0.088	0.176	6.020599913
100	0.088	0.177	6.069811884
200	0.088	0.177	6.069811884
300	0.088	0.177	6.069811884
400	0.088	0.177	6.069811884
500	0.088	0.177	6.069811884
750	0.088	0.177	6.069811884
1,000	0.09	0.177	5.874615138
2,500	0.09	0.177	5.874615138
5,000	0.096	0.177	5.314040666
7,500	0.096	0.177	5.314040666
9,000	0.096	0.177	5.314040666
10,000	0.096	0.177	5.314040666
25,000	0.097	0.177	5.224030642
50,000	0.097	0.177	5.224030642
100,000	0.097	0.177	5.224030642
200,000	0.097	0.177	5.224030642
300,000	0.097	0.177	5.224030642
400,000	0.097	0.177	5.224030642