Translinear Circuits

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1 Experiments

1.1 Experiment 1: Bipolar Transistor Matching

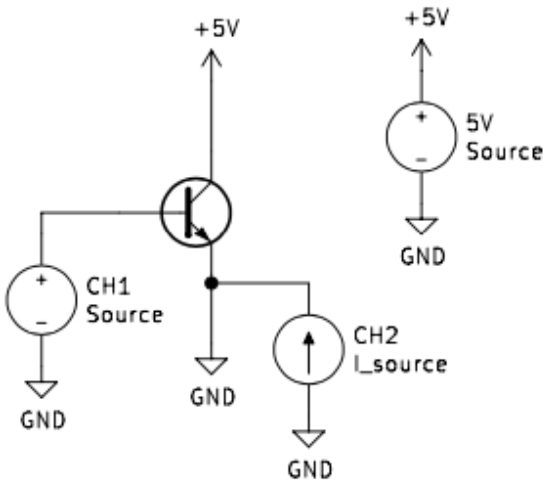

Figure 1: Schematic for Experiment 1

	Measured I_s	Measured β
BJT 1	3.702fA	114
BJT 2	3.509fA	115
BJT 3	3.61fA	115
BJT 4	3.30fA	114

Extracted I_s and β

Based on the extracted data and looking at the behaviour in Figure 4, we can say the transistors are reasonably well matched. In Figure 5 we can see large deviation before approximately $10^{-4}A$. After this value, the behaviour is well matched.

The BJT behavior lines up very well after 0.734 V. Under this value, the percent difference follows some non-linear behaviour.

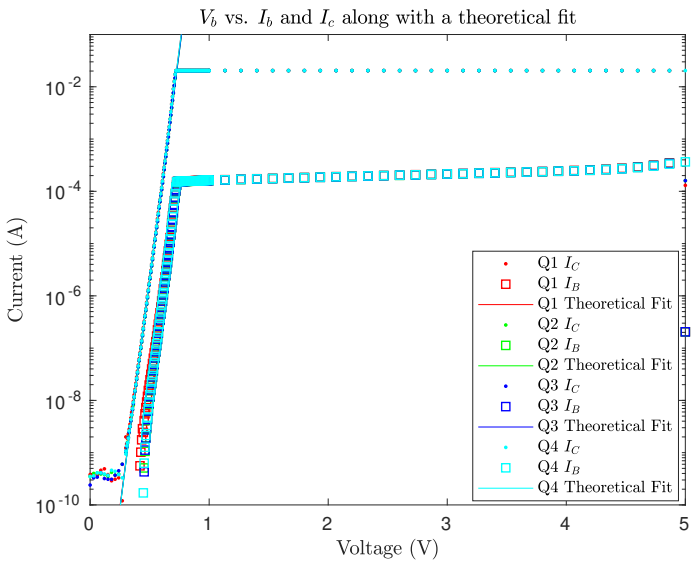

Figure 2: Base and Collector Current as a function of Base Voltage

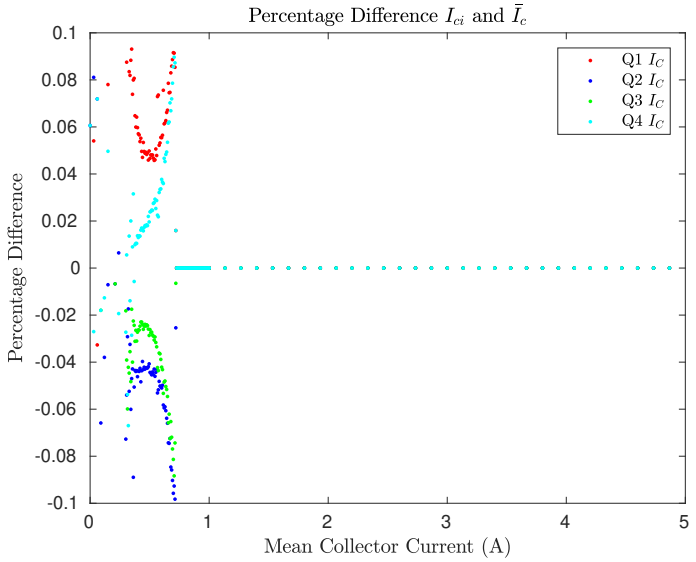

Figure 3: Percentage Different from Mean current

1.2 Experiment 2: Translinear Circuit 1

For Experiment 2, we used the circuit setup shown in Figure 7 - this data was taken via the SMU. Figures 9 and 10 show log-log plots of the output current I_z as a function of I_x and I_y at different levels of I_y and I_x, respectively. Along with the data we have plotted the analytically determined values for I_z. For the I_x sweep (Figure 9), we see that I_z's actual value is offset from the theoretical value by a certain manner until I_x as at least a tenth of I_y's value - we estimate this behavior is due to the base current's effect of drawing away a non-negligible current until higher values of I_x. Similarly, for the I_y sweep (Figure 10), I_z's actual value only begins matching the theoretical value when I_y is less than or equal to I_x. We again attribute this difference due to the base current effect.

We also note that the data in the I_y sweep does not match the theoretical fit well, especially at higher values of I_x. When later taking data with the SMU, we noted that the op-amp was no longer functioning

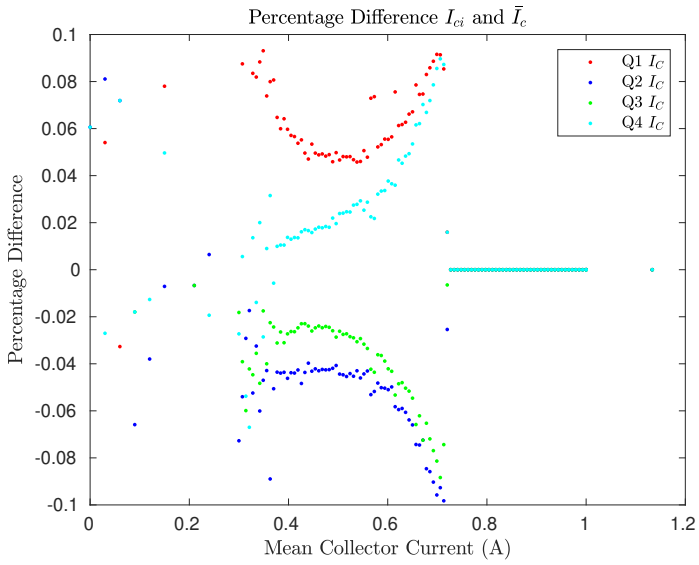

Figure 4: Zoomed into part with variation

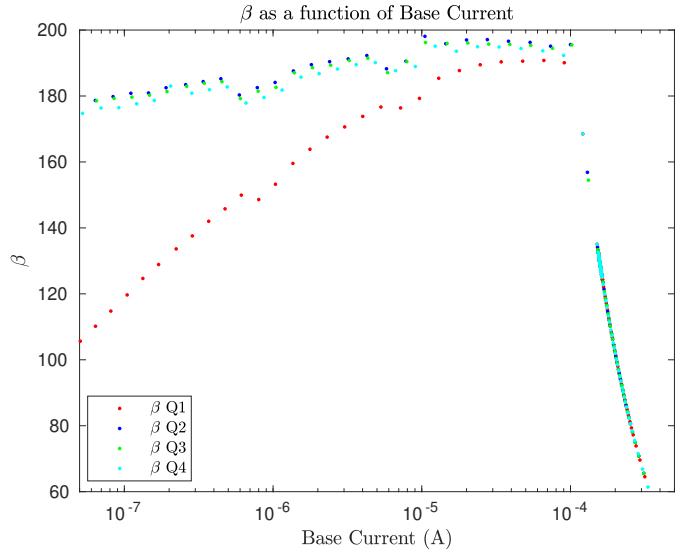

Figure 5: Beta as a function of Base Current

as expected, likely due to us forcing it to source too much current. As we started the sweep from smaller I_x values and went up, we believe that this breakdown of the op-amp must have started gradually, and become more prominent in our data with the higher values.

1.3 Experiment 3: Translinear Circuit 2

For Experiment 3, we used the circuit setup shown in Figure 11 - this data was taken via LTspice.

The data fits our expected results well aside from the smaller few decades in our sweep of I_x and the larger few decades in our sweep for I_y. We believe that we can attribute this bounce in the output current I_z in these ranges to effects from the base current. Since we ran this experiment in LTspice, our current sources were ideal, making our collected data cleaner at the extremes of our swept range.

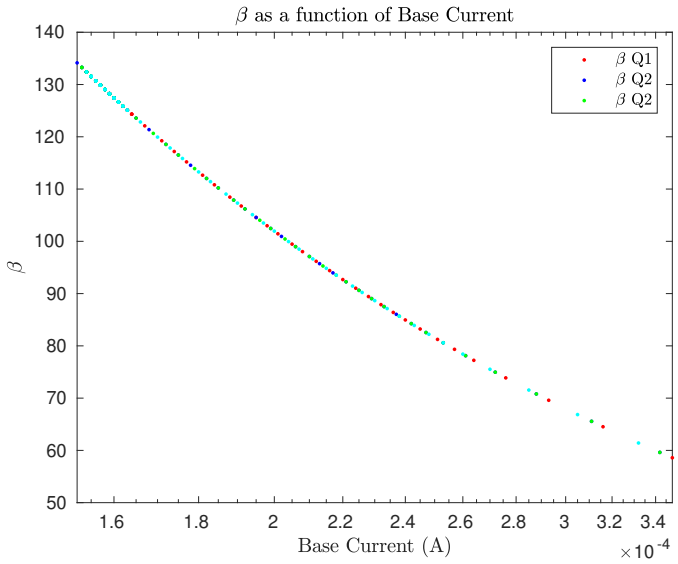

Figure 6: Beta as a function of Base Current zoomed in on well matched section

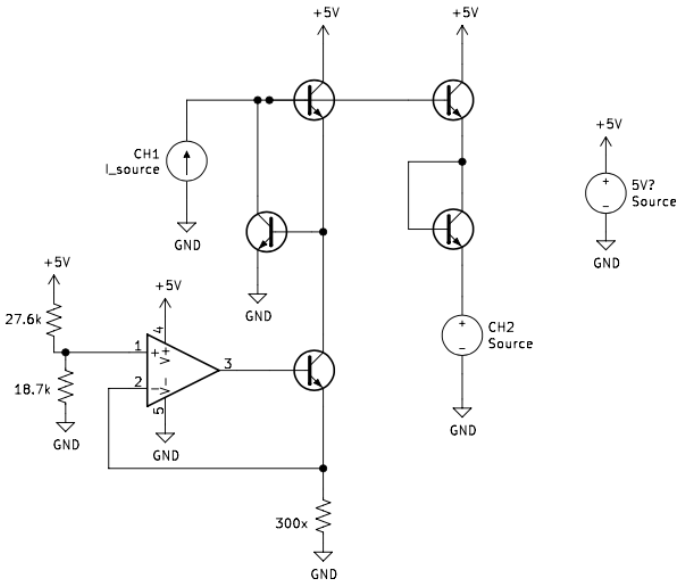

Figure 7: Schematic for Experiment 2a

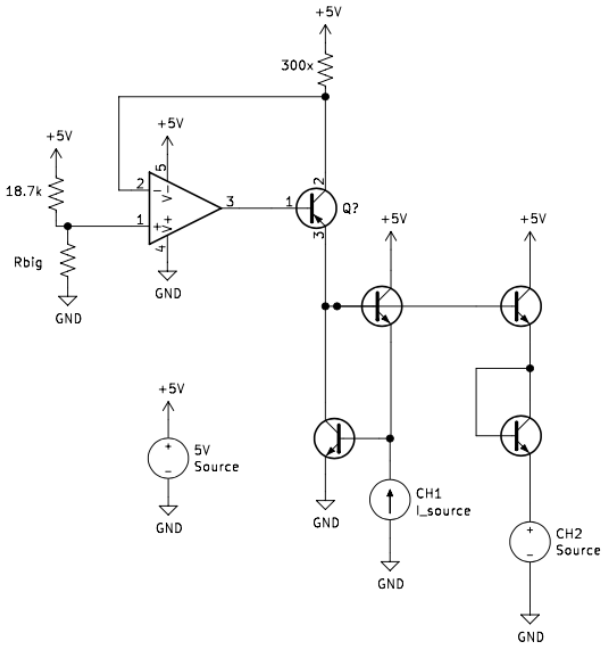

Figure 8: Schematic for Experiment 2b

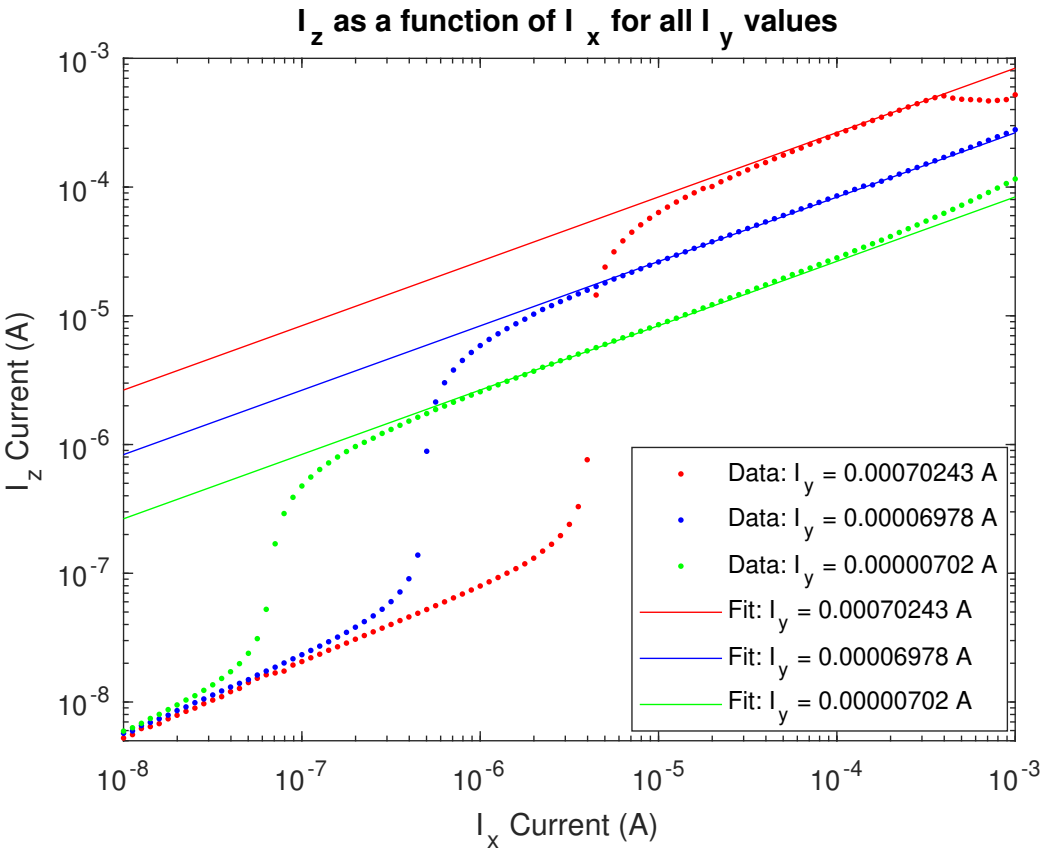

Figure 9: I_z as a function of I_x for Experiment 2

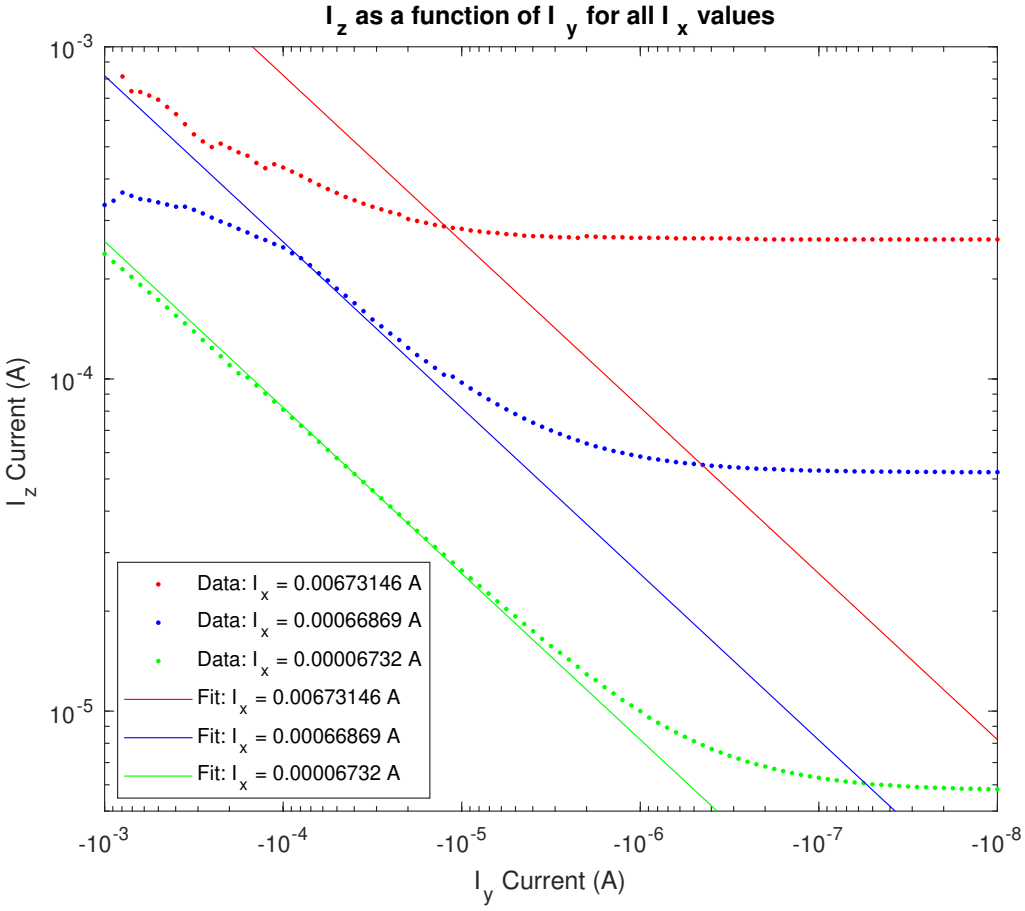

Figure 10: I_z as a function of I_y for Experiment 2

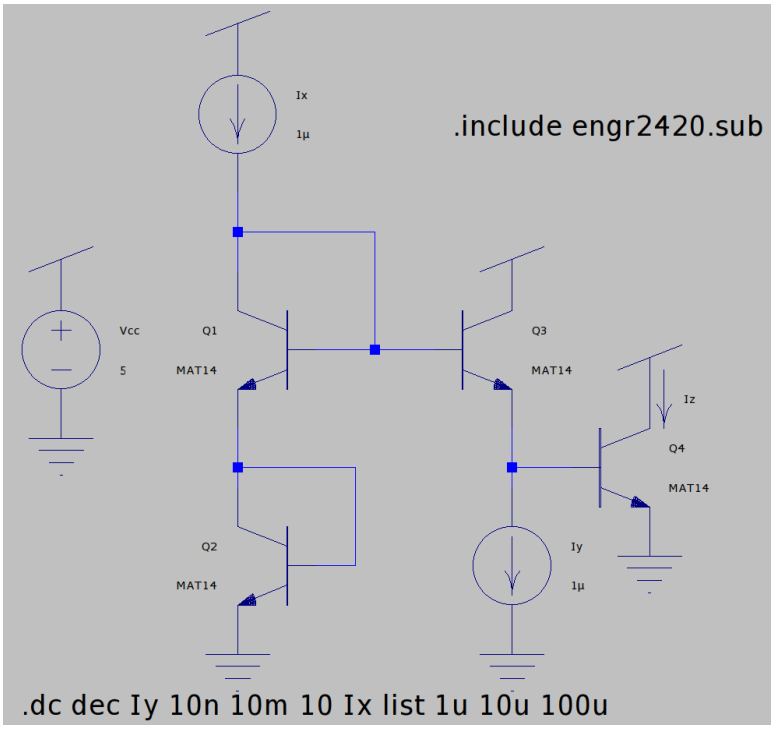

Figure 11: Schematic for Experiment 3

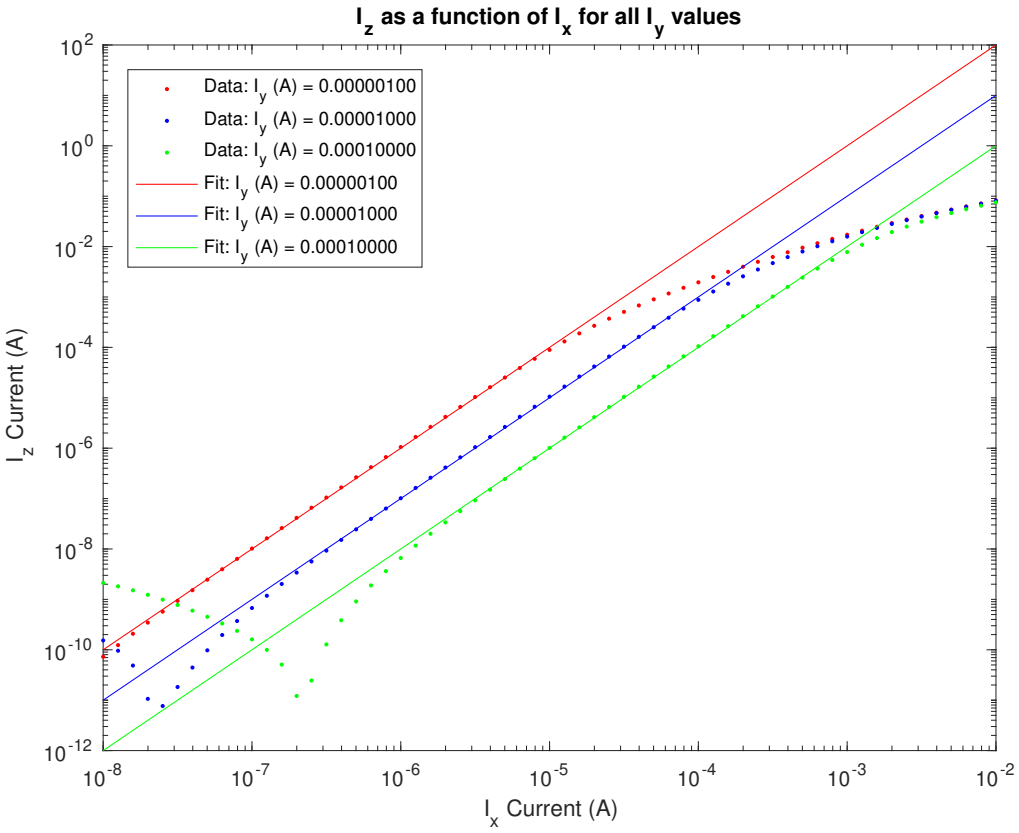

Figure 12: I_z as a function of I_x for Experiment 3

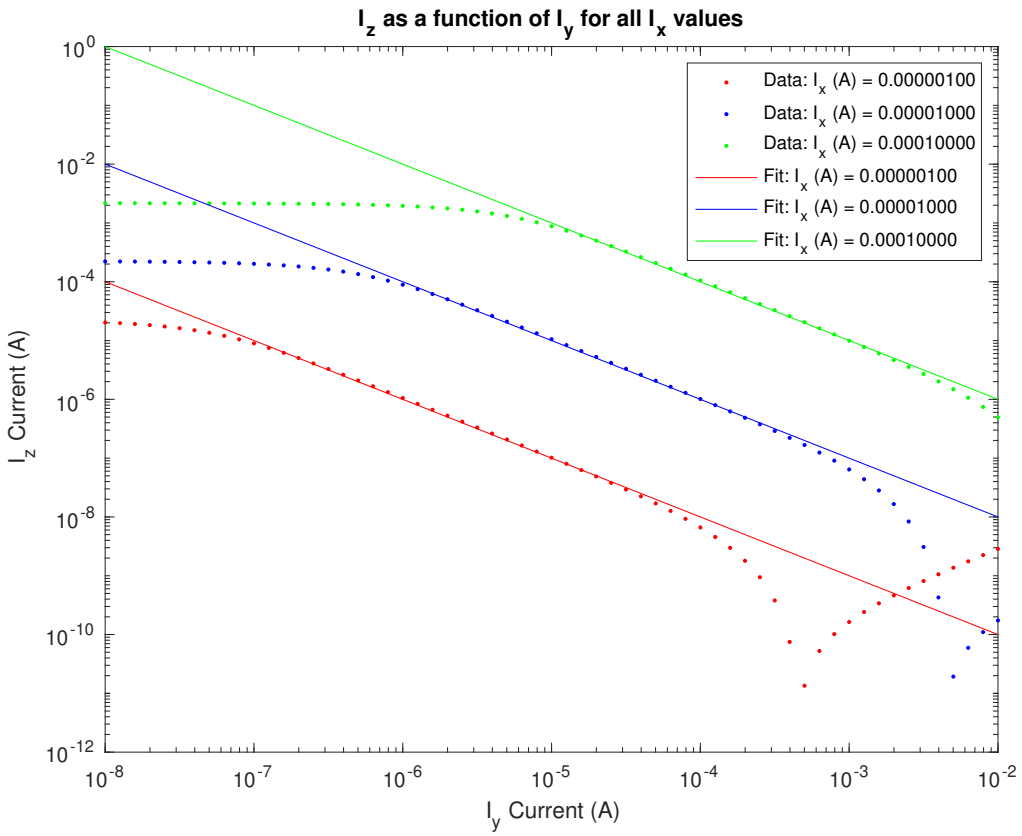

Figure 13: I_z as a function of I_y for Experiment 3