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ENGS124 Electricity and Magnetism Lab Section B
Investigating the behavior of semiconductor devices

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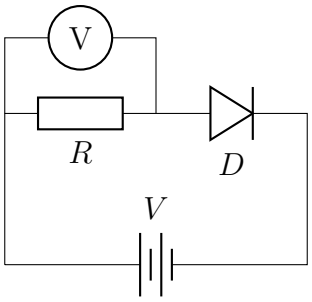
November 9, 2024

1 Diode I-V characteristics

A diode is a semiconductor device, that lets current through one direction and not the other. A simple diode consists of n and p typed doped semiconductors. A p-type has a abundance of free spaces electrons can go to, while an n-type has extra electrons. So when they the two parts are connected to each other, some electrons from the n-type go to the p-type and create a depletion region. To conduct electricity, this region has to be broken down, which requires some energy, thus there is a threshold voltage.

A diode and a resistor were connected in series to a variable power supply. The voltage was varied and the voltage drop was measured on the resistor.



Instrument or material	Description
Voltmeter	A voltmeter
Lab bench power supply	With sufficient voltage range
Resistors	In the range of kilo ohms
Diode	A diode
Cables	For the multimeter and power supply

Table 1: List of instruments and materials

Variable	Value	Resolution
Supply voltage	Controlled	$0.01V$
Voltages across resistor	Measured	$0.01V$

Table 2: List of variables

Source of error	Type of error	Countermeasures
Power Supply Inaccuracy	Random	Since we are dealing with low voltages across the diode, an error of only $0.01V$ produces a significant random noise in our data.

Table 3: Estimated errors

V_{all} (V)	V_R (V)	V_{diode} (V)	R (Ω)	I (mA)
-1.00	0.00	-1.00	9850	0.00
-0.50	0.00	-0.50	9850	0.00
0.00	0.00	0.00	9850	0.00
0.50	0.06	0.44	743	0.08
0.60	0.14	0.46	743	0.19
0.65	0.18	0.48	743	0.24
0.70	0.22	0.48	743	0.30
0.75	0.26	0.49	743	0.34
0.80	0.30	0.50	743	0.35
0.85	0.35	0.50	743	0.40
1.00	0.48	0.52	743	0.47
1.05	0.53	0.52	743	0.65
1.10	0.58	0.52	743	0.71
1.15	0.63	0.52	743	0.78
1.20	0.67	0.53	743	0.85
1.30	0.77	0.53	743	0.97
1.40	0.86	0.54	743	1.09
1.45	0.91	0.54	743	1.16
1.50	0.95	0.55	743	1.22
1.55	1.01	0.54	743	1.28
1.60	1.06	0.55	743	1.36
1.80	1.25	0.56	743	1.43
2.00	1.43	0.57	743	1.68
5.00	4.38	0.62	743	5.90
10.00	9.33	0.67	743	11.88
14.00	13.32	0.68	743	17.93

Table 4: Diode data

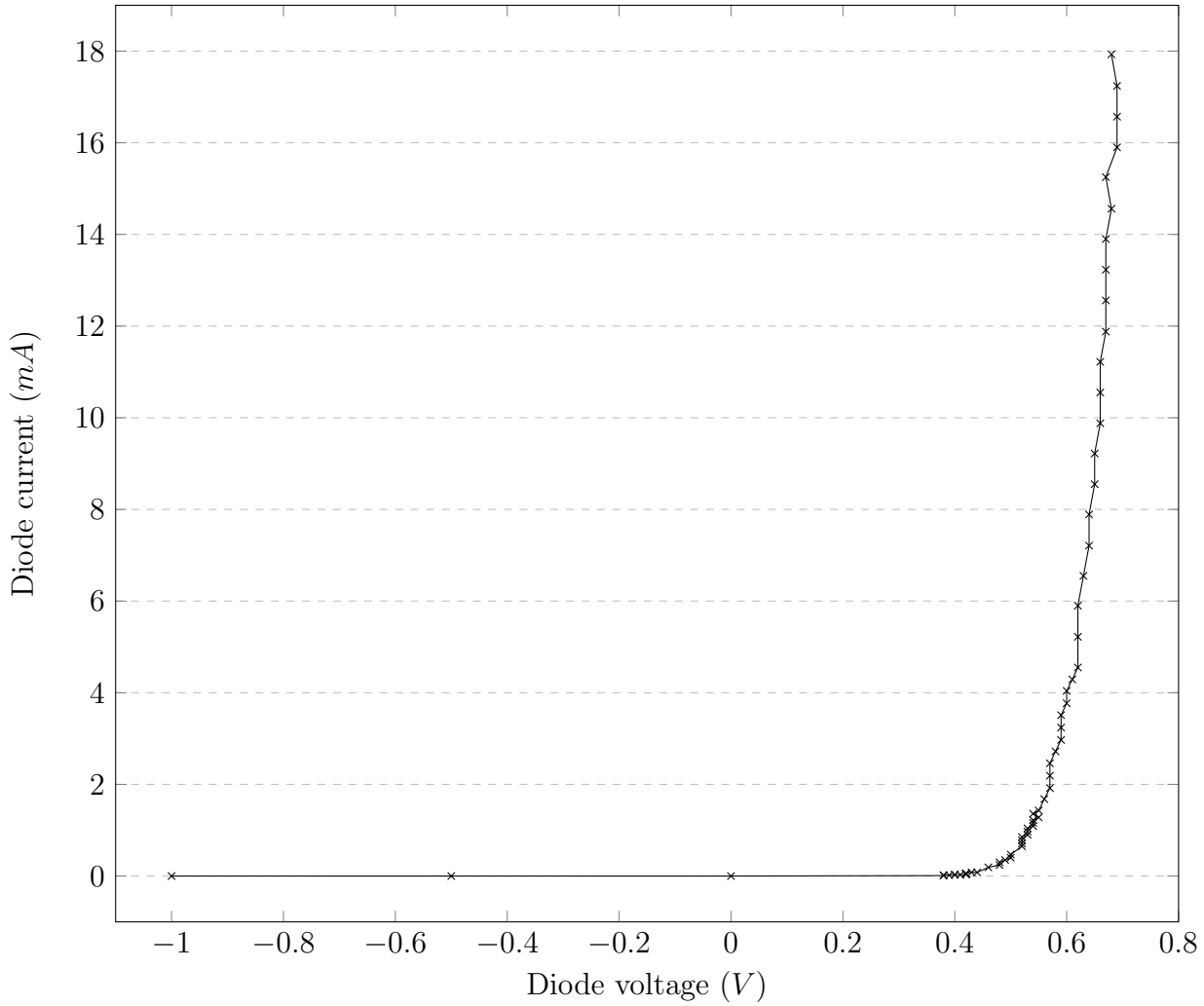


Figure 1: Plot of dependence of current in a diode from voltage across the diode

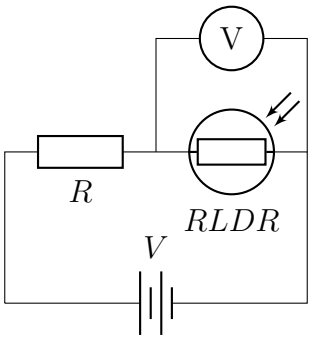
When negative voltage was connected, the diode blocked the current. When positive voltage was connected, the diode slowly started to let current at around $V_{\text{diode}} = 0.4V$, reaching a maximum at around $V_{\text{diode}} = 0.7V$.

2 Light dependent resistor (LDR)

A light dependent resistor (LDR) changes its resistance based on the amount of light that falls on it. A resistor ($R = 9800\Omega$) and an LDR were connected in series to a power source. A small paper cup was made with multiple sheets and was placed on top of the LDR. A light source was positioned above the LDR, the circular opening was closed with different areas and the resulting voltage across the LDR was measured.

Instrument or material	Description
Voltmeter	A voltmeter
Lab bench power supply	With sufficient voltage range
Resistors	In the range of kilo ohms
Photoresistor	LDR
Cables	For the multimeter and power supply

Table 5: List of instruments and materials



Variable	Value	Resolution
LDR area portion with light	Controlled	0.25
Voltages across LDR	Measured	$0.01V$

Table 6: List of variables

Source of error	Type of error	Countermeasures
Illuminance variance	Random	The paper cup was not stable, the cross-sectional area was not a perfect circle and shading parts of it were inaccurate
Movements	Random	A different light source and paper cup was used to prevent movements from changing the results

Table 7: Estimated errors

Area ratio	V_{LDR} (V)	V_{supply} (V)	V_R (V)	R_{LDR} (Ω)	$\frac{1}{R_{LDR}}$ Ω^{-1}
1.00	2.32	10.01	7.69	2956.57	3382.30
0.75	3.14	10.01	6.87	4479.18	2232.55
0.50	4.26	10.01	5.75	7260.52	1377.31
0.25	5.00	10.01	5.01	9780.44	1022.45
0.00	10.00	10.01	0.01	9800000.00	1.02

Table 8: LDR lumminance variance data

Area ratio	V_{LDR} (V)	V_{supply} (V)	V_R (V)	R_{LDR} (Ω)
1.00	0.52	0.99	0.47	10776.17
1.00	1.05	2.01	0.96	10653.13
1.00	1.58	3.02	1.44	10686.94
1.00	2.10	4.01	1.91	10708.90
1.00	2.63	5.01	2.38	10763.11
1.00	3.16	6.01	2.85	10799.44
1.00	3.69	7.01	3.32	10825.48
1.00	4.21	8.00	3.79	10819.37
1.00	4.73	9.00	4.27	10789.27
1.00	5.24	10.00	4.76	10722.18

Table 9: LDR voltage variance data

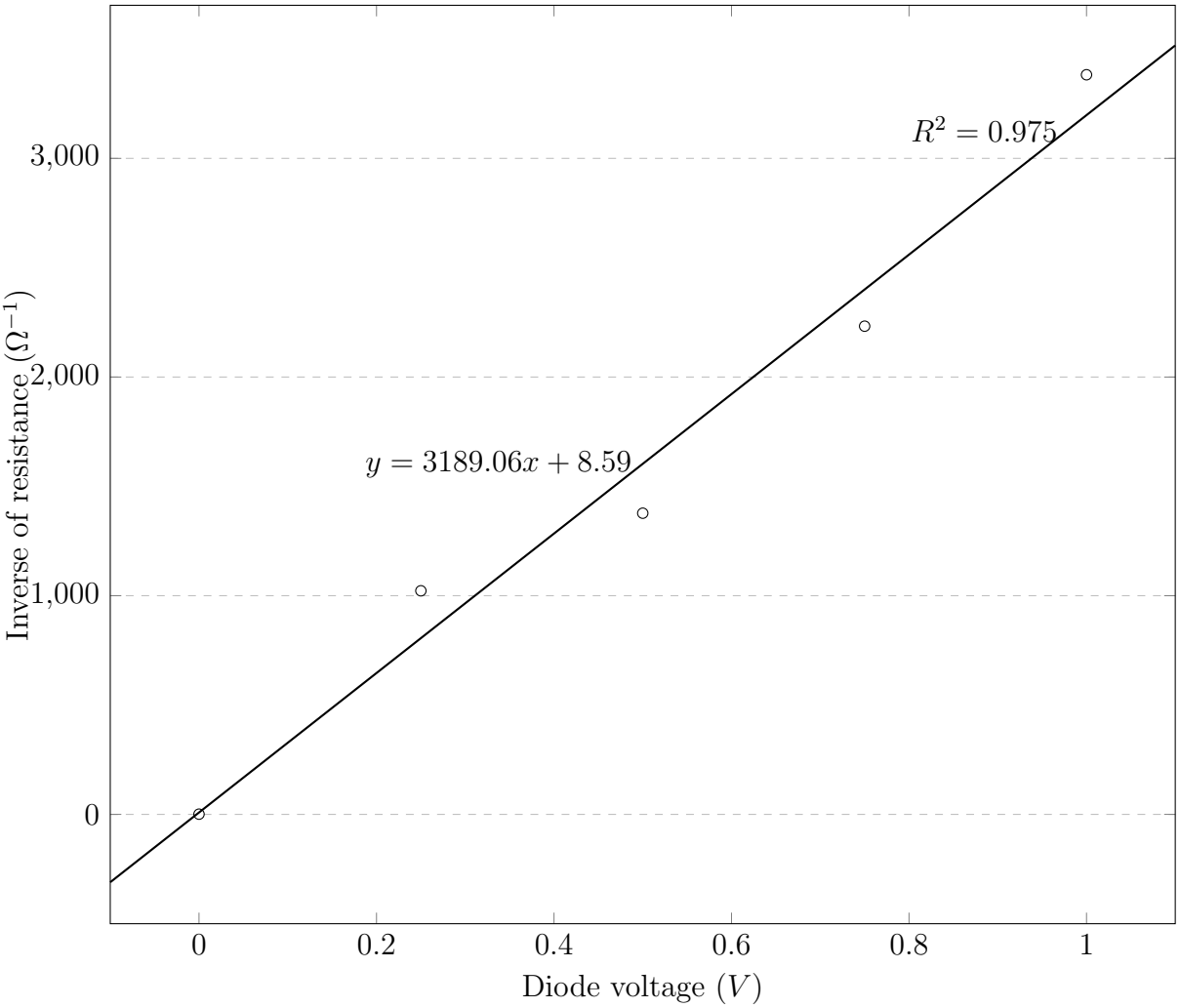


Figure 2: Plot of illuminance and inverse of LDR resistance

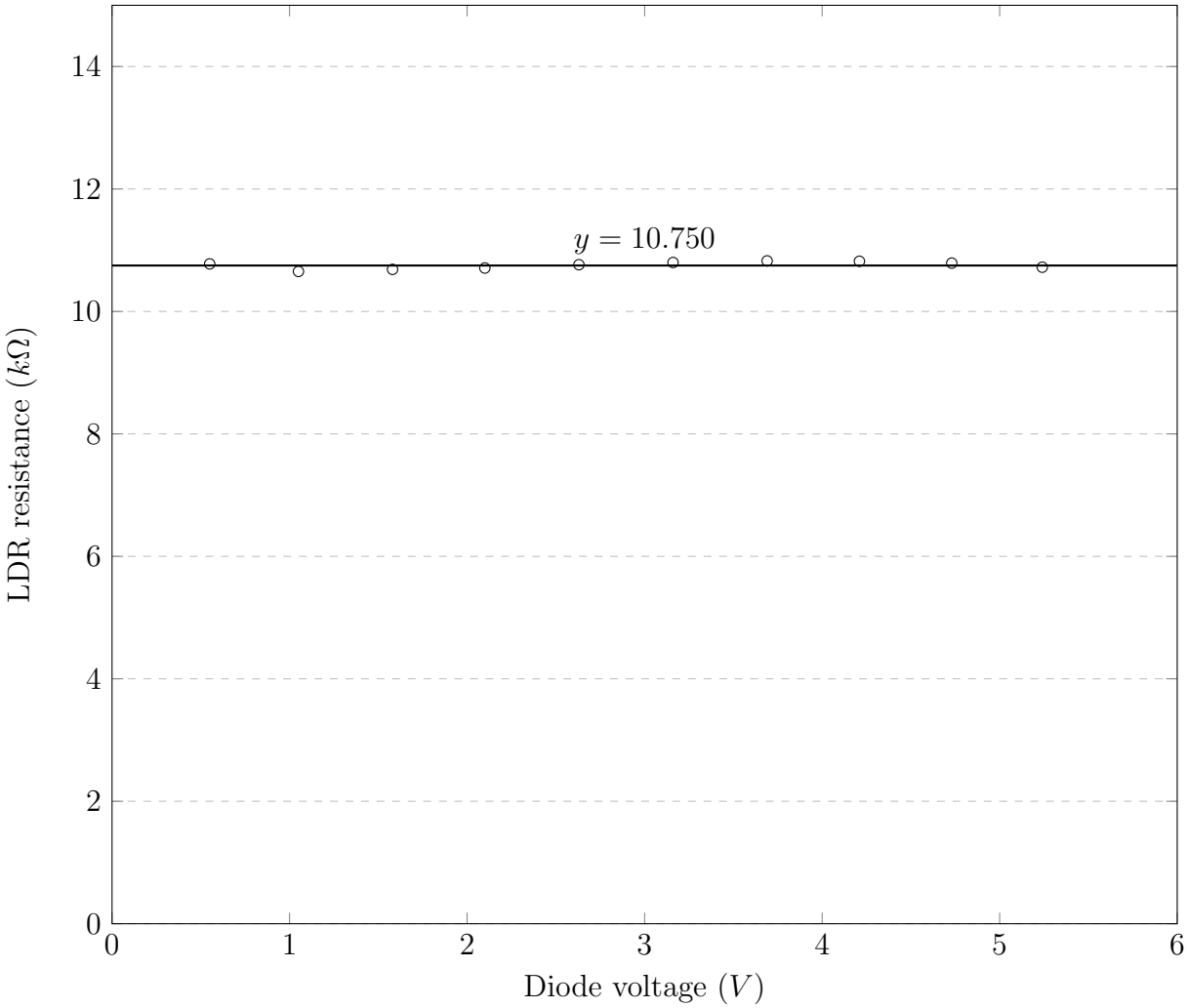


Figure 3: Plot of voltage and LDR resistance

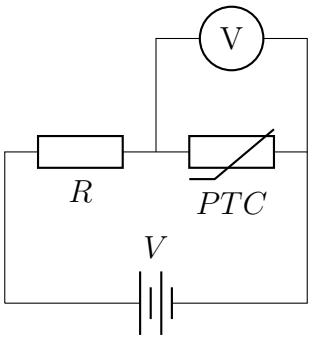
The resistance of an LDR is inversely proportional from the illuminance, independent from the supply voltage.

3 Thermistor I-V characteristics

A thermistor changes its resistance based on the heat applied. A PTC thermistor and a resistor ($R = 97\Omega$) were connected to power source, the voltage was varied, the PTC was left to reach equilibrium and the voltage across the resistor was measured.

Instrument or material	Description
Voltmeter	A voltmeter
Lab bench power supply	With sufficient voltage range
Resistors	About 100Ω
Thermistor	PTC
Cables	For the multimeter and power supply

Table 10: List of instruments and materials



Variable	Value	Resolution
Supply voltage	Controlled	$0.01V$
Voltages across resistor	Measured	$0.01V$

Table 11: List of variables

Source of error	Type of error	Countermeasures
Wind	Random	Any little wind from movement caused the thermistor to cool down and ruin the experiment. Movements were kept minimal.

Table 12: Estimated errors

V_{total} (V)	V_R (V)	V_PTC (V)	I (mA)	P (mW)	R (Ω)
1.01	0.26	0.75	2.68	2.01	0.28
2.02	0.51	1.51	5.26	7.94	0.29
3.02	0.77	2.25	7.94	17.86	0.28
4.00	1.02	2.98	10.52	31.34	0.28
5.01	1.27	3.74	13.09	48.97	0.29
6.00	1.49	4.51	15.36	69.28	0.29
7.00	1.67	5.33	17.22	91.76	0.31
8.01	1.83	6.18	18.87	116.59	0.33
8.51	1.86	6.65	19.18	127.52	0.35
9.00	1.88	7.12	19.38	138.00	0.37
9.51	1.91	7.60	19.69	149.65	0.39
10.01	1.92	8.09	19.79	160.13	0.41
10.50	1.90	8.60	19.59	168.45	0.44
11.00	1.84	9.16	18.97	173.76	0.48
11.50	1.80	9.70	18.56	180.00	0.52
12.00	1.80	10.20	18.56	189.28	0.55
13.00	1.71	11.29	17.63	199.03	0.64
14.00	1.66	12.34	17.11	211.18	0.72
15.00	1.55	13.45	15.98	214.92	0.84

Table 13: PTC data

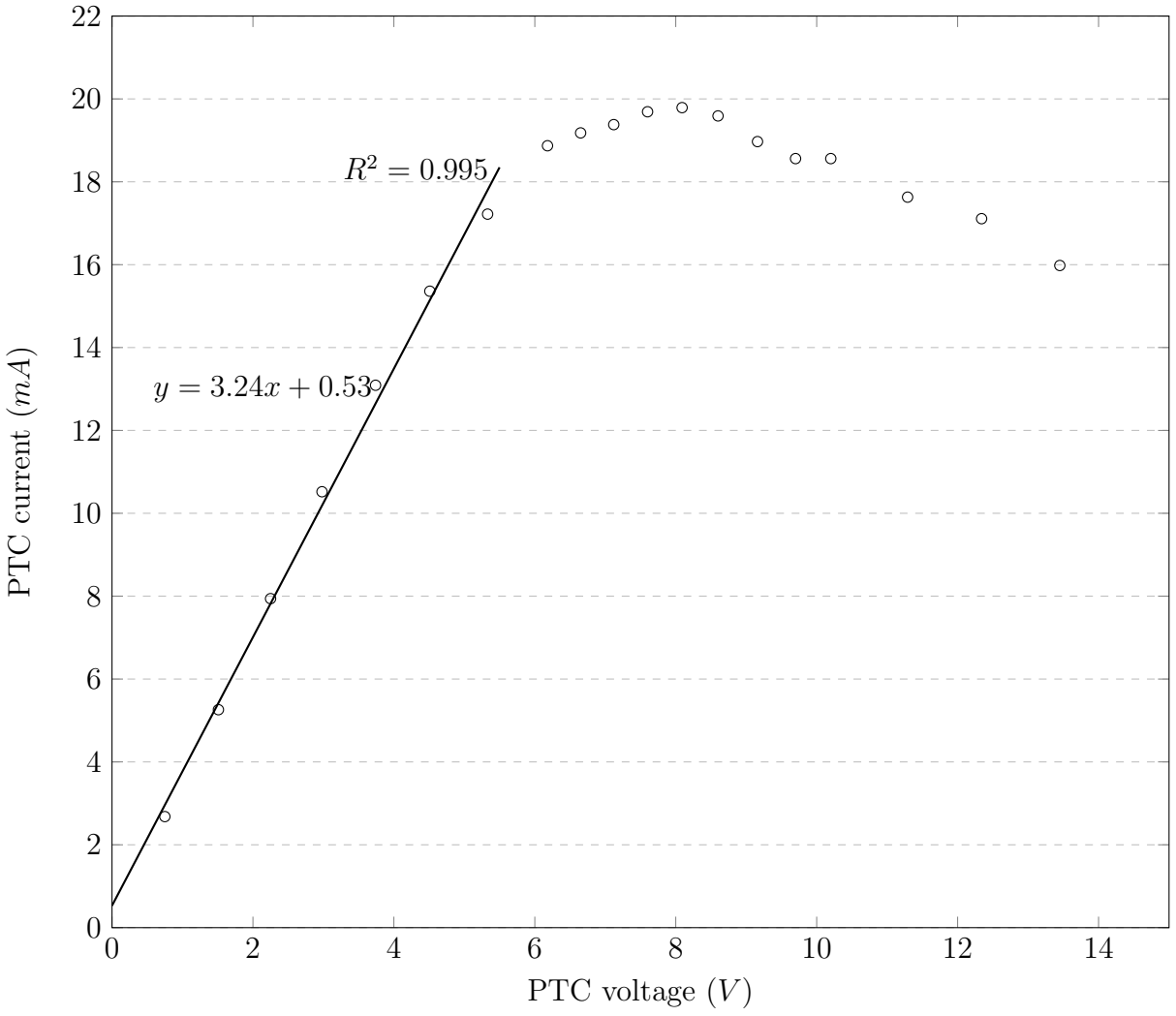


Figure 4: Plot of dependence of current in a PTC from voltage across the PTC

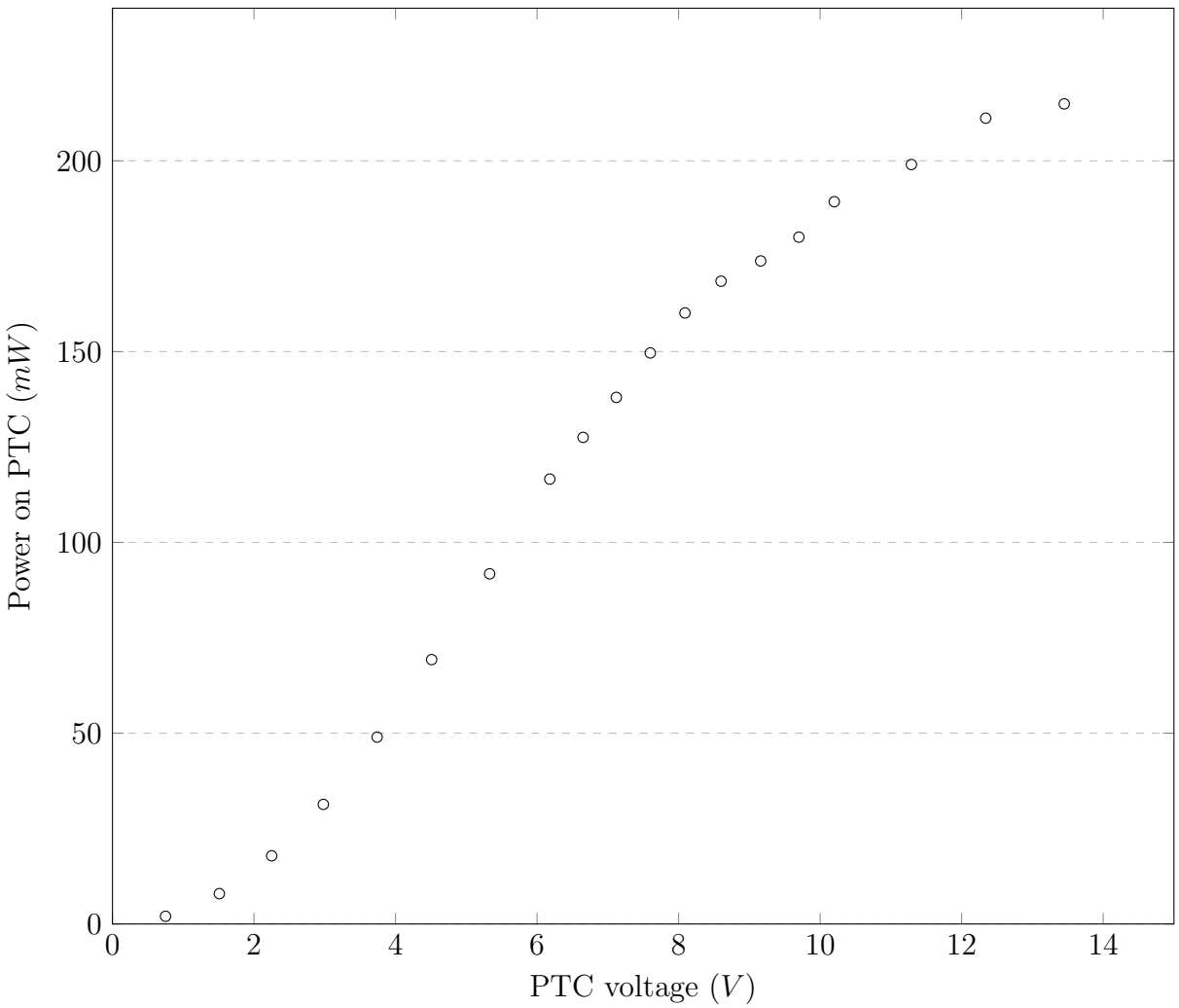


Figure 5: Plot of dependence of power from voltage across the PTC

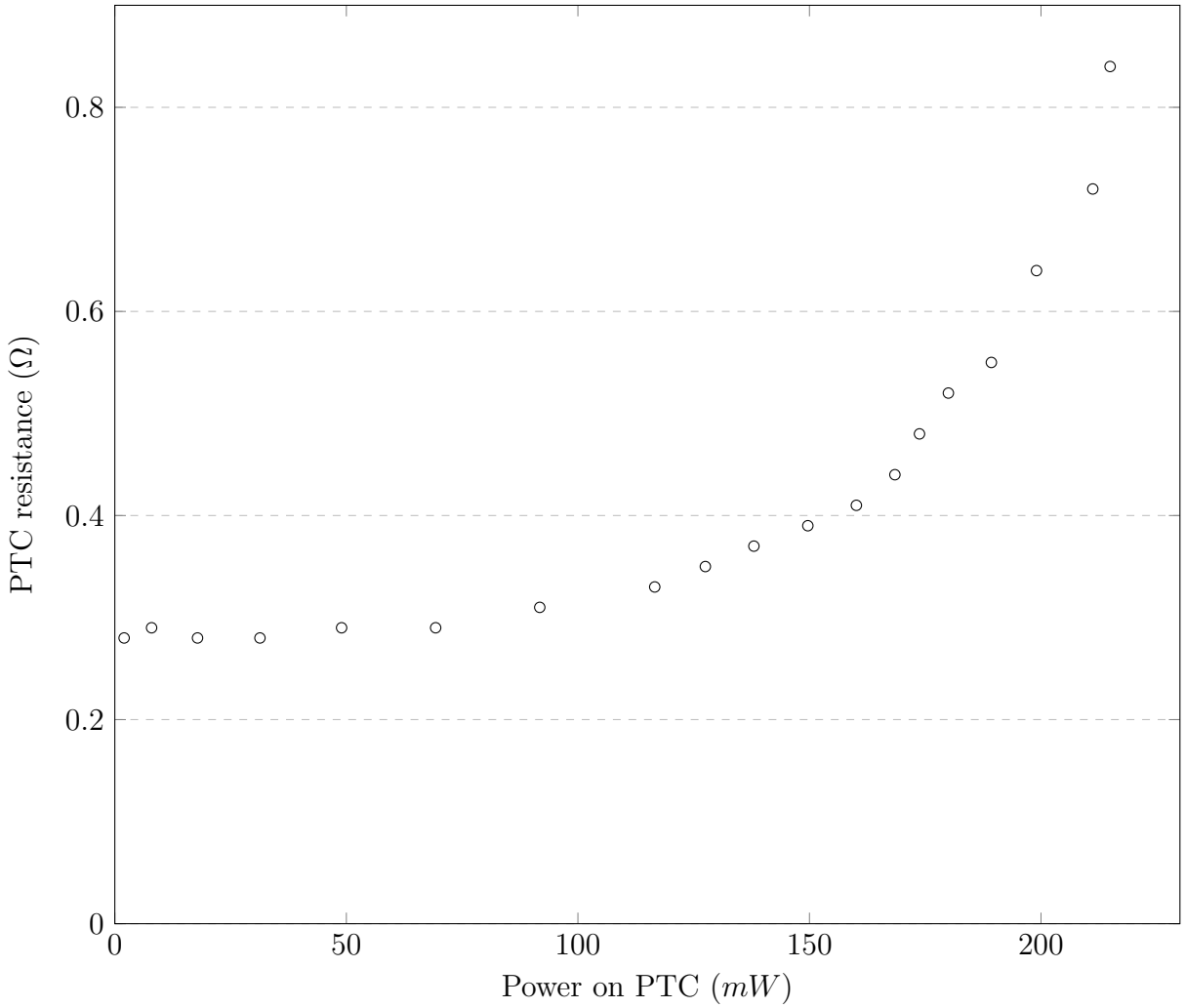


Figure 6: Plot of dependence of resistance from power on the PTC

The ohm's law does not hold for the thermistor, because it changes its resistance, depending on temperature. At the beginning it was somewhat constant, however from the point $V = 6.18V$ the resistance stops being constant and at the point $V = 8.60V$ $I = 19.59mA$ the plot reached a maximum, at which point the resistance suddenly jumps. The curie temperature is reached at the voltage of $8.60V$.