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The Characteristics of the Temperature Sense Diodes

Prepared by
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R. Farley — Telescope Electronics — Date 2/3/03

ITAR Assessment Performed
Tom Langenstein — ITAR Control Required? Yes/No — Date 2/5/03

The Characteristics of the Temperature Sense Diode:

Prepared by Mesut Koç, August 19, 1997.

Objective:

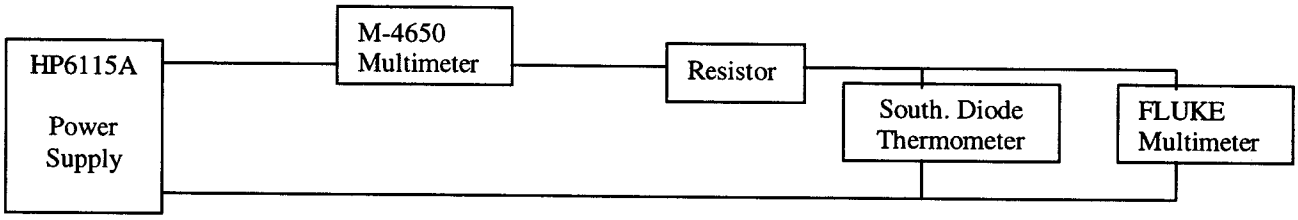
The Temperature-Current-Voltage Characteristics of the Southampton Miniature Diode Thermometer were not known clearly for us. For accurate determination of the temperature of the mount I performed this experiment which determined the effect of the current fluctuation in the diode.

Equipment:

- HP 6115A Precision Power Supply
- METEX M-4650 Multimeter
- Fluke 8842A Multimeter
- 1MΩ 1% resistor
- Southampton Miniature Diode Thermometer

Test Procedure:

After mounting the diode on the circuit mount prepared by Howard Demroff, I setup the following circuit for a current flow that can be accurately measured by the METEX multimeter.



The circuit allowed me to apply any desired current by adjusting the voltage source.

As the normal operating current of the diode was 10μA, the test was concentrated on the effect of a 10% fluctuation of the current. (i.e. Values from 9 to 11μA were tested.) And to understand the behavior of the circuit at low temperatures, that is the real operation temperature, I also tested the circuit at 77K besides 300K room temperature.

And to confirm the results I repeated the experiment once to have values that will be reliable for our purposes. The experiment results can be found in appendix 2.

After the experiment I started to analyze the results and in the process I completed three different graphs for each experiment. These graphs were: Current through diode vs. Voltage across diode, Apparent Temperature vs. Current through diode and Apparent temperature vs. Voltage across Diode. They can be found in appendix-4.

After the graphs were ready I calculated the slopes of the graphs which gave me the dependency of one variable on the other. These results can be found in appendix 3.

Conclusions:

The results of the test proved that the fluctuation in current could be considerable only if the fluctuation is bigger than 5% or so. The specification of the circuit that is providing the 10 μA current to the diode is much better than 5%. The total error margin would be at most 2% including the op-amp the resistor and the power source in the circuit. So the fluctuation would be at most 0.7 to 1.5K at 77K, and 1.5 to 4.5K at 300K.

METEX multimeter was used for current measurements. From my previous report we know that the multimeter is not accurate and that it needs calibration. Although the differential data would not be affected by this error, the absolute current measurements would be slightly different than the real current values.

Attachments:

Appendix 1: The Standard Calibration Data for Southampton miniature Diode Thermometer
Appendix 2: The experimental data for all four of the experiments performed.
Appendix 3: The slope and apparent temperature data for the experiments and the graphs
Appendix 4: The 12 graphs for the 4 experiments performed

Appendix 1:

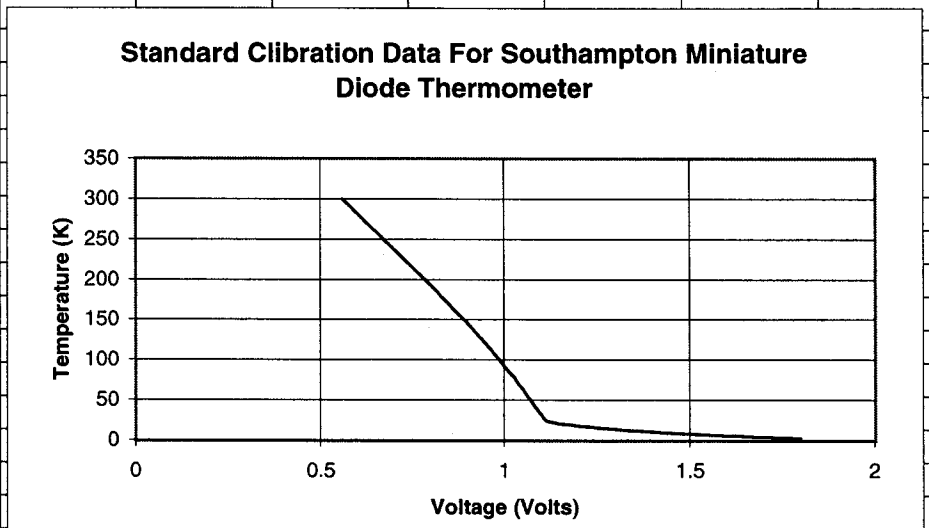
The Standard Calibration Data

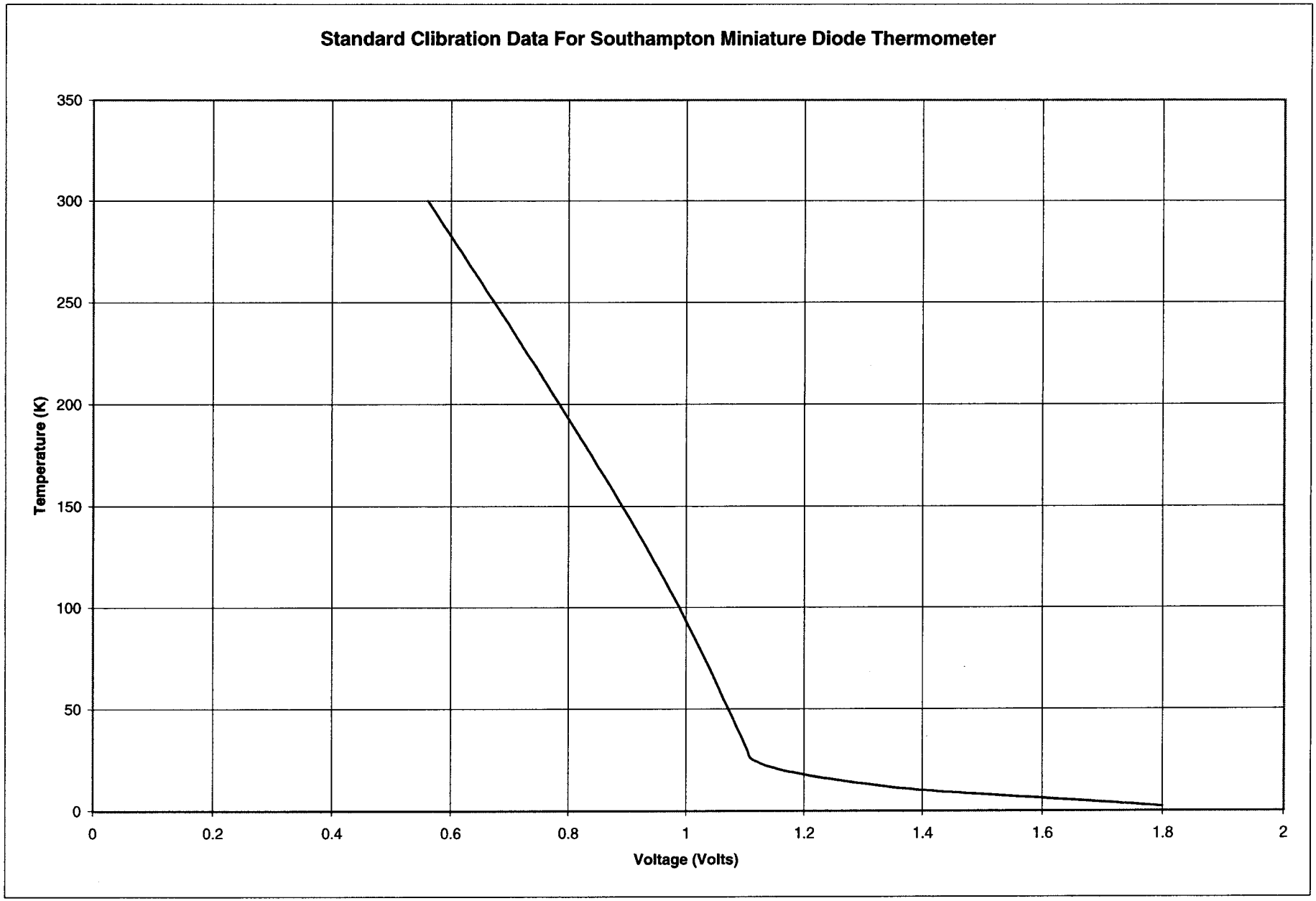
For

Southampton Miniature Diode Thermometer

		Diode voltage vs temperature						
		volts	Kelvin					
		volts	Kelvin		volts	Kelvin		
		0.560501	300		1.799523	2		
		0.571829	295		1.656401	5		
		0.583158	290		1.403041	10		
		0.594445	285		1.259053	15		
		0.605732	280		1.161717	20		
		0.617029	275		1.112858	25		
		0.628326	270		1.103737	30		
		0.639626	265		1.0955	35		
		0.650917	260		1.087377	40		
		0.662111	255		1.079313	45		
		0.673305	250		1.071373	50		
		0.684514	245		1.063468	55		
		0.695723	240		1.055573	60		
		0.706895	235		1.047527	65		
		0.718066	230		1.039477	70		
		0.729127	225		1.031141	75		
		0.740188	220		1.0228	80		
		0.751266	215		1.014227	85		
		0.762341	210		1.005651	90		
		0.77334	205		0.996794	95		
		0.784337	200		0.987935	100		
		0.795265	195		0.978786	105		
		0.806188	190		0.969636	110		
		0.816977	185		0.960197	115		
		0.827763	180		0.950756	120		
		0.838463	175		0.941077	125		
		0.849158	170		0.931396	130		
		0.859697	165		0.921429	135		
		0.870233	160		0.911459	140		
		0.880671	155		0.901283	145		
		0.891103	150		0.891103	150		
		0.901283	145		0.880671	155		
		0.911459	140		0.870233	160		
		0.921429	135		0.859697	165		
		0.931396	130		0.849158	170		
		0.941077	125		0.838463	175		
		0.950756	120		0.827763	180		
		0.960197	115		0.816977	185		
		0.969636	110		0.806188	190		
		0.978786	105		0.795265	195		
		0.987935	100		0.784337	200		
		0.996794	95		0.77334	205		
		1.005651	90		0.762341	210		
		1.014227	85		0.751266	215		
		1.0228	80		0.740188	220		
		1.031141	75		0.729127	225		

		1.039477	70		0.718066	230		
		1.047527	65		0.706895	235		
		1.055573	60		0.695723	240		
		1.063468	55		0.684514	245		
		1.071373	50		0.673305	250		
		1.079313	45		0.662111	255		
		1.087377	40		0.650917	260		
		1.0955	35		0.639626	265		
		1.103737	30		0.628326	270		
		1.112858	25		0.617029	275		
		1.161717	20		0.605732	280		
		1.259053	15		0.594445	285		
		1.403041	10		0.583158	290		
		1.656401	5		0.571829	295		
		1.799523	2		0.560501	300		




Standard Clibration Data For Southampton Miniature Diode Thermometer
Temperature (K)
350
300
250
200
150
100
50
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Voltage (Volts)

Appendix 2:

Experiment Results

For

77K and 300K environments

At 79.3F (starting temperature 79 end temperature reading 79.6)			At 74.1F (starting temperature 73.7 end temperature reading 74.5)	
Applied voltage(V)	**Current (microamp)**	**Voltage Across Diode(V)**	**Current (microamp)**	**Voltage Across Diode(V)**
9.40	8.89	0.555730	----------	----------
9.50	8.99	0.556050	8.98	0.562370
9.60	9.09	0.556280	9.08	0.562670
9.70	9.19	0.556560	9.18	0.562960
9.80	9.29	0.556850	9.28	0.563240
9.90	9.39	0.557130	9.38	0.563500
10.00	9.49	0.557390	9.48	0.563770
10.10	9.59	0.557660	9.58	0.564040
10.20	9.69	0.557930	9.68	0.564300
10.30	9.79	0.558190	9.78	0.564580
10.40	9.89	0.558440	9.88	0.564860
10.45	9.94	0.558510	9.93	0.564960
10.50	9.99	0.558700	9.98	0.565060
10.55	10.04	0.558820	10.03	0.565180
10.60	10.09	0.558890	10.08	0.565290
10.70	10.19	0.559140	10.18	0.565540
10.80	10.29	0.559390	10.28	0.565790
10.90	10.39	0.559640	10.38	0.566030
11.00	10.49	0.559900	10.48	0.566280
11.10	10.59	0.560160	10.58	0.566540
11.20	10.69	0.560400	10.68	0.566760
11.30	10.79	0.560650	10.79	0.567020
11.40	10.89	0.560890	10.88	0.567280
11.50	10.99	0.561110	10.98	0.567520
11.60	11.09	0.561350	11.08	0.567780
11.70	11.19	0.561580	----------	----------
At 77K				
Applied voltage(V)	**Current (micamp)**	**Voltage Across Diode(V)**	**Current (microamp)**	**Voltage Across Diode(V)**
9.40	8.41	1.02523	----------	----------
9.50	8.51	1.02533	----------	----------
9.60	8.61	1.02544	8.62	1.02533
9.70	8.72	1.02551	8.72	1.02542
9.80	8.81	1.02563	8.82	1.02548
9.90	8.92	1.02570	8.92	1.02555
10.00	9.02	1.02582	9.02	1.02565
10.10	9.12	1.02591	9.12	1.02573
10.20	9.22	1.02599	9.22	1.02586
10.30	9.32	1.02609	9.32	1.02594
10.40	9.42	1.02616	9.42	1.02598
10.50	9.52	1.02624	9.52	1.02610
10.60	9.62	1.02635	9.62	1.02618
10.70	9.72	1.02642	9.72	1.02626
10.80	9.82	1.02650	9.82	1.02633
10.85	9.87	1.02653	----------	---------
10.90	9.92	1.02658	9.92	1.02641
10.95	9.97	1.02660	9.97	1.02649
11.00	10.02	1.02668	10.02	1.02651
11.05	10.07	1.02670	10.07	1.02653
11.10	10.12	1.02676	10.12	1.02658
11.15	10.17	1.02678	----------	----------
11.20	10.22	1.02684	10.22	1.02665
11.30	10.32	1.02691	10.32	1.02673
11.40	10.42	1.02698	10.42	1.02680
11.50	10.52	1.02711	10.52	1.02688
11.60	10.62	1.02716	10.63	1.02696
11.70	10.73	1.02725	10.73	1.02704
11.80	10.82	1.02730	10.83	1.02710
11.90	10.93	1.02737	10.93	1.02720
12.00	11.03	1.02744	11.03	1.02726

Appendix 3:

The slope and Apparent Temperature Data

For

The Experiments and The Graphs

First experiment at 77K			Second exp. at 77K			At 74.3F (about 295.9K)		
current--->	Voltage	Temp.(K)	current--->	Voltage	Temp.(K)	current--->	Voltage	Temp. (K)
8.41	1.02523	78.54334	----------	----------	----------	----------	----------	----------
8.51	1.02533	78.4834	----------	----------	----------	----------	----------	----------
8.61	1.02544	78.41746	8.62	1.02533	78.4833953	----------	----------	----------
8.72	1.02551	78.37549	8.72	1.02542	78.4294449	----------	----------	----------
8.81	1.02563	78.30356	8.82	1.02548	78.393478	----------	----------	----------
8.92	1.02570	78.2616	8.92	1.02555	78.3515166	8.98	0.56237	299.1751
9.02	1.02582	78.18967	9.02	1.02565	78.2915718	9.08	0.56267	299.0426
9.12	1.02591	78.13572	9.12	1.02573	78.2436159	9.18	0.56296	298.9146
9.22	1.02599	78.08776	9.22	1.02586	78.1656876	9.28	0.56324	298.791
9.32	1.02609	78.02781	9.32	1.02594	78.1177317	9.38	0.56350	298.6763
9.42	1.02616	77.98585	9.42	1.02598	78.0937537	9.48	0.56377	298.5571
9.52	1.02624	77.9379	9.52	1.02610	78.0218199	9.58	0.56404	298.4379
9.62	1.02635	77.87196	9.62	1.02618	77.973864	9.68	0.56430	298.3232
9.72	1.02642	77.83	9.72	1.02626	77.9259082	9.78	0.56458	298.1996
9.82	1.02650	77.78204	9.82	1.02633	77.8839468	9.88	0.56486	298.076
9.87	1.02653	77.76406	9.92	1.02641	77.8359909	9.93	0.56496	298.0319
9.92	1.02658	77.73408	9.97	1.02649	77.788035	9.98	0.56506	297.9877
9.97	1.02660	77.7221	----------	----------	----------	----------	----------	----------
10.02	1.02668	77.67414	10.02	1.02651	77.776046	10.03	0.56518	297.9348
10.07	1.02670	77.66215	10.07	1.02653	77.7640571	10.08	0.56529	297.8862
10.12	1.02676	77.62618	10.12	1.02658	77.7340846	----------	----------	----------
10.17	1.02678	77.61419	----------	----------	----------	10.18	0.56554	297.7759
10.22	1.02684	77.57823	10.22	1.02665	77.6921232	10.28	0.56579	297.6655
10.32	1.02691	77.53627	10.32	1.02673	77.6441674	10.38	0.56603	297.5596
10.42	1.02698	77.49431	10.42	1.02680	77.602206	10.48	0.56628	297.4492
10.52	1.02711	77.41638	10.52	1.02688	77.5542501	10.58	0.56654	297.3345
10.62	1.02716	77.3864	10.63	1.02696	77.5062942	10.68	0.56676	297.2374
10.73	1.02725	77.33245	10.73	1.02704	77.4583383	10.79	0.56702	297.1226
10.82	1.02730	77.30248	10.83	1.02710	77.4223714	10.88	0.56728	297.0079
10.93	1.02737	77.26052	10.93	1.02720	77.3624266	10.98	0.56752	296.9019
11.03	1.02744	77.21856	11.03	1.02726	77.3264597	11.08	0.56778	296.7872
Slope I vs. V		1177.016	µA/V		1234.98731	µA/V		394.2494
Slope T vs. V		-599.449	°K/V		-599.448506	°K/V		-441.384
Slope T vs I		-0.50831	°K/µA		-0.48456407	°K/µA		-1.11858

$\frac{1}{1177} = 8.496E-4 \frac{V}{\mu A}$

$.849 \frac{mV}{\mu A}$ or $849\,\Omega$

$\frac{849\,\mu V}{\mu A} = \Omega$

At 79.3F (about 298.8K)			
current--->	Voltage	Temp. (K)	
---	---	---	
---	---	---	
---	---	---	
---	---	---	
8.89	0.55573	#VALUE!	
8.99	0.55605	#VALUE!	
9.09	0.55628	#VALUE!	
9.19	0.55656	#VALUE!	
9.29	0.55685	#VALUE!	
9.39	0.55713	#VALUE!	
9.49	0.55739	#VALUE!	
9.59	0.55766	#VALUE!	
9.69	0.55793	#VALUE!	
9.79	0.55819	#VALUE!	
9.89	0.55844	#VALUE!	
9.94	0.55851	#VALUE!	
9.99	0.55870	#VALUE!	
---	---	---	
10.04	0.55882	#VALUE!	
10.09	0.55889	#VALUE!	
10.19	0.55914	#VALUE!	
10.29	0.55939	#VALUE!	
10.39	0.55964	#VALUE!	
10.49	0.55990	#VALUE!	
10.59	0.56016	#VALUE!	
10.69	0.56040	#VALUE!	
10.79	0.56065	299.9342	
10.89	0.56089	299.8283	
10.99	0.56111	299.7312	
11.09	0.56135	299.6253	
11.19	0.56158	299.5237	
µA/V		395.1235	µA/V
°K/V		-441.384	°K/V
°K/µA		-1.02401	°K/µA

Appendix 4:

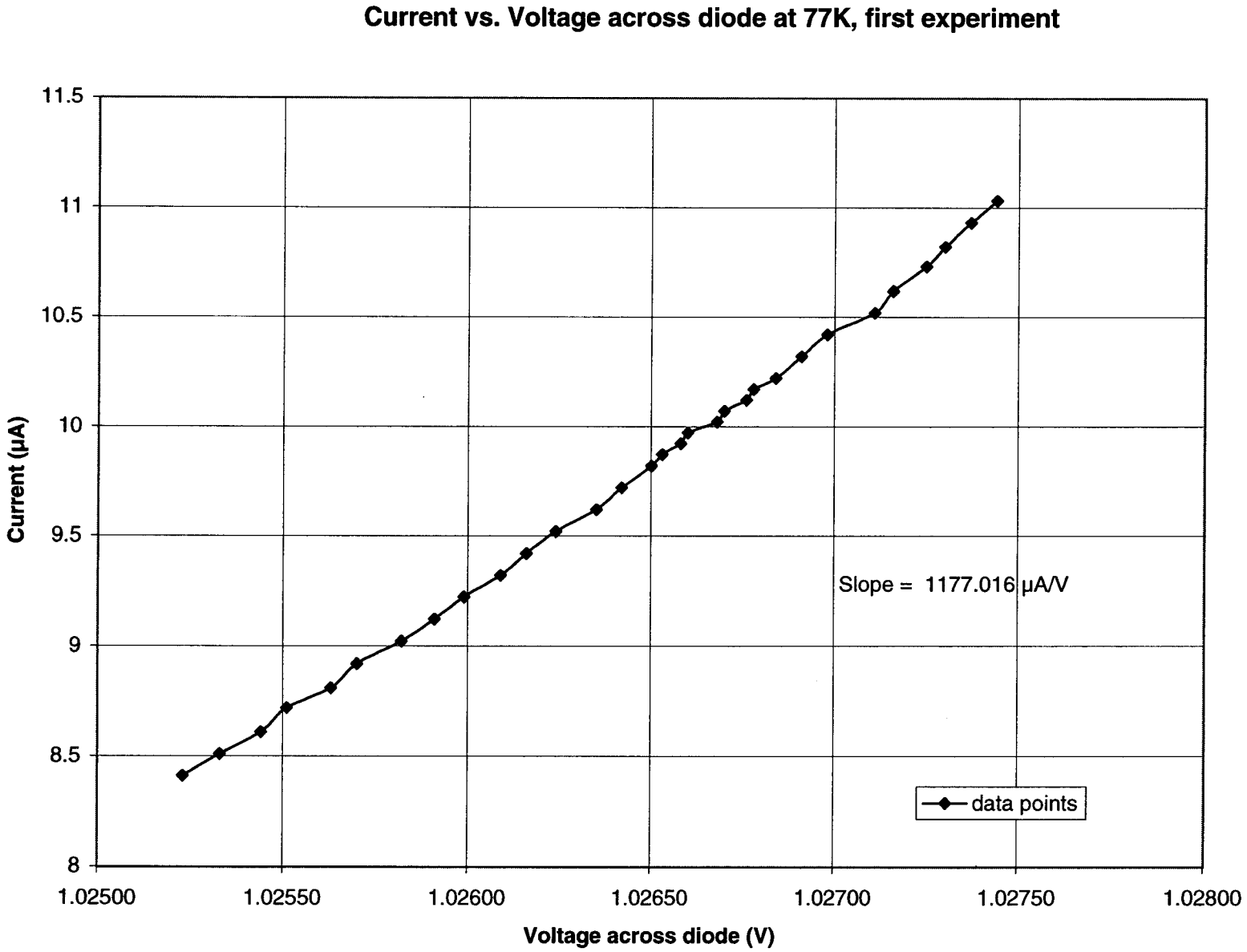
Graphical Interpretation of the Experiment Results

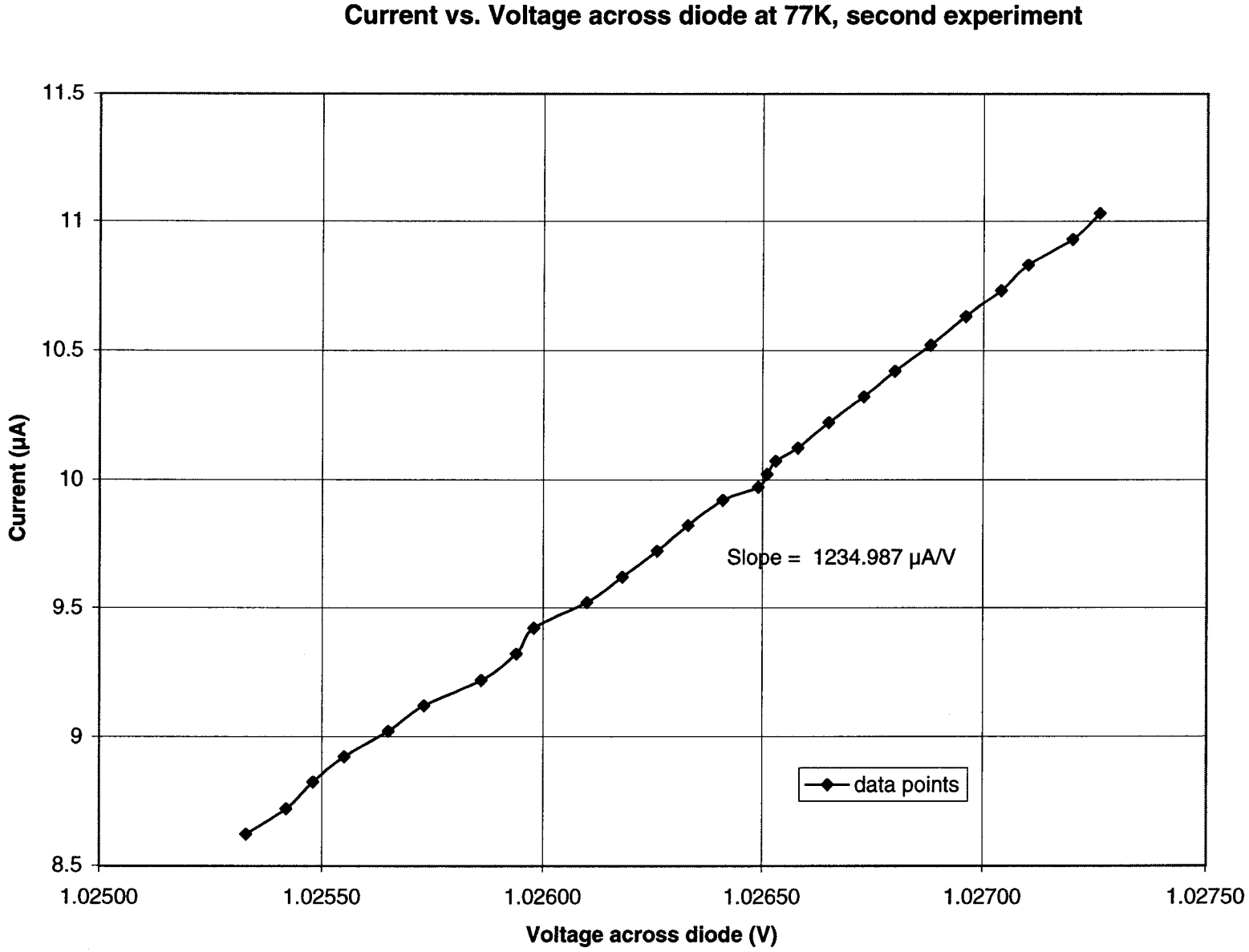
For

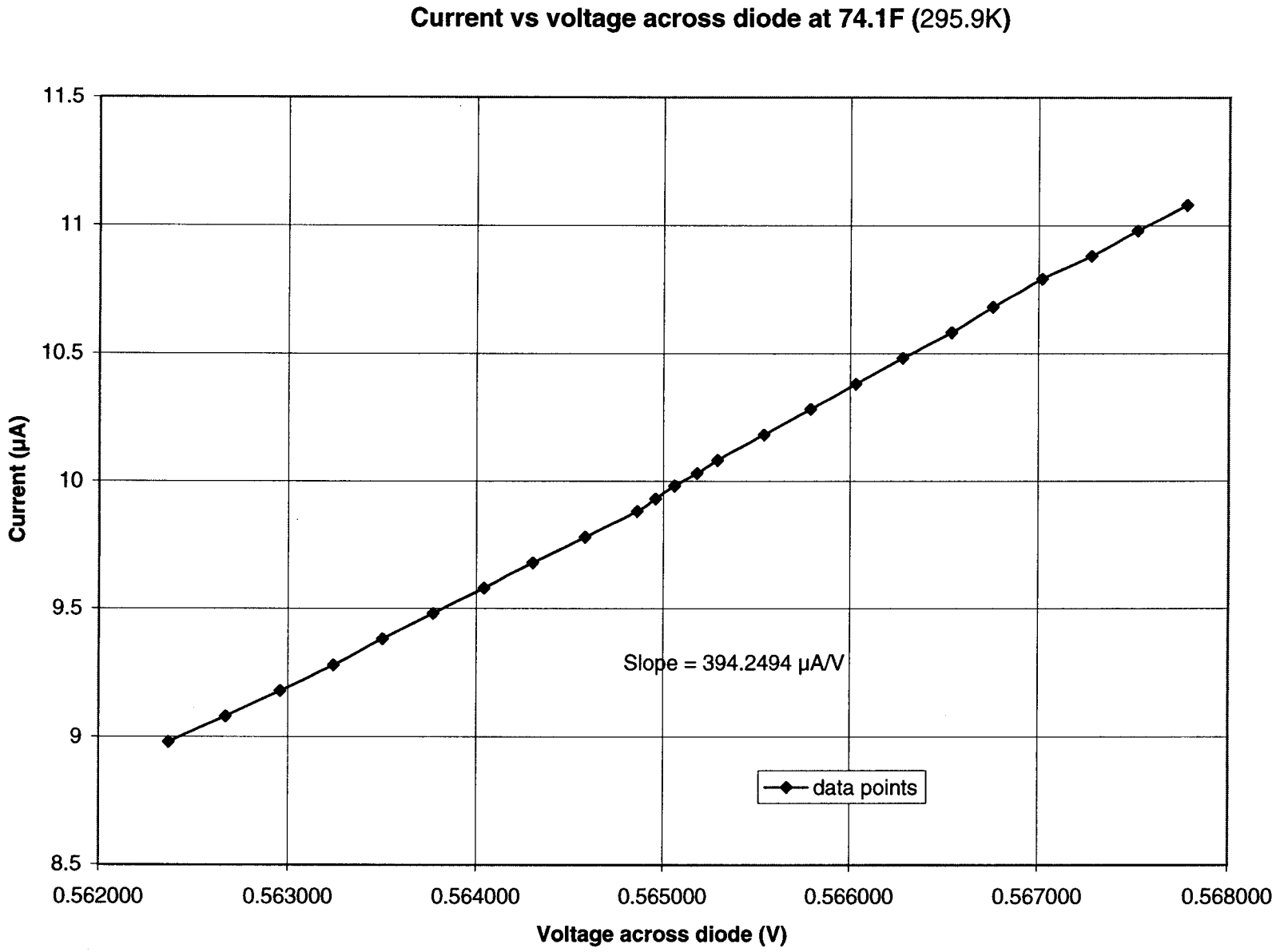
77K and 300K environments

For each experiment:

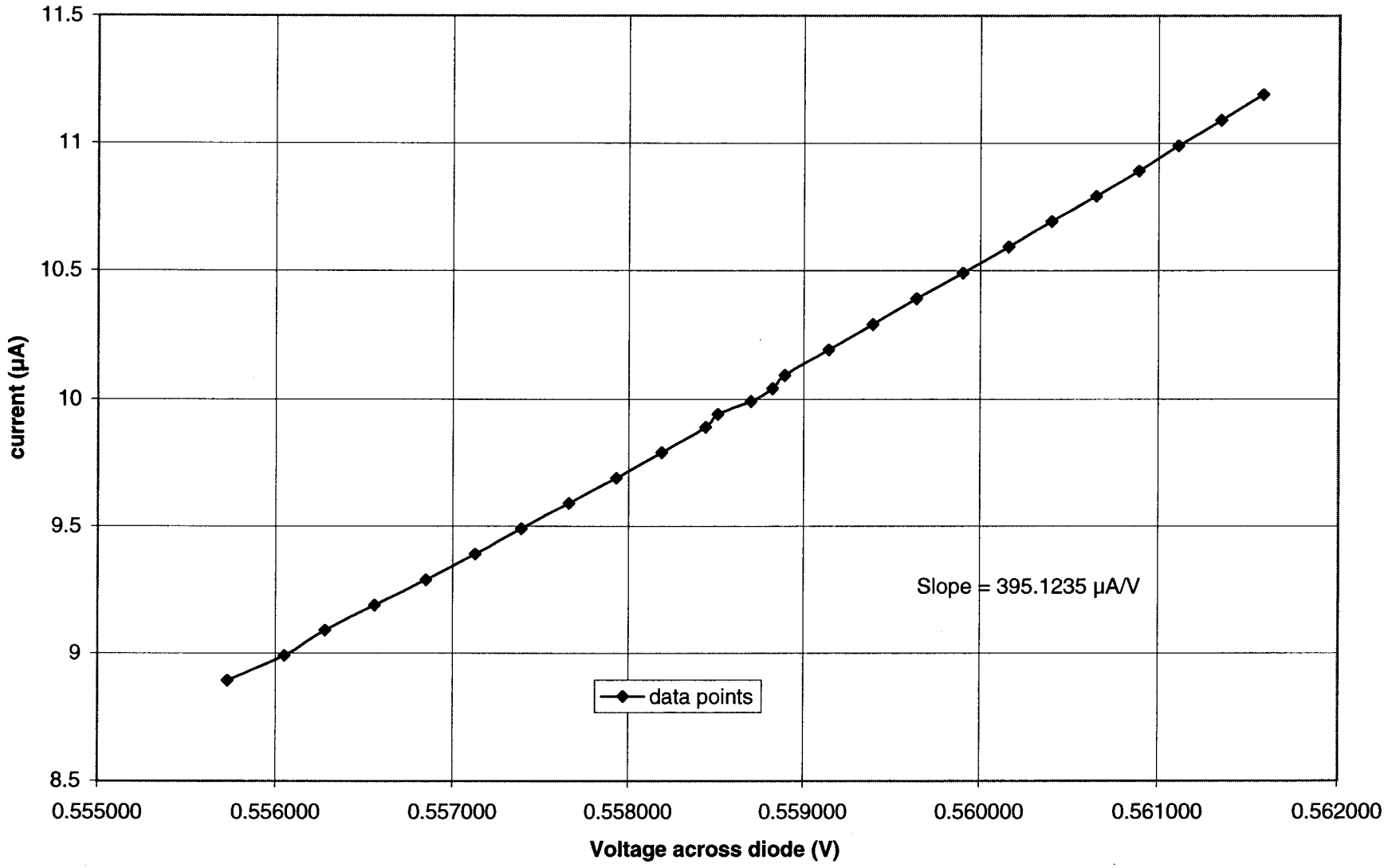
- Current through diode vs. Voltage across diode
- Apparent Temperature vs. Current through diode
- Apparent Temperature vs. Voltage Across Diode


Current vs. Voltage across diode at 77K, first experiment
11.5
11
10.5
10
9.5
9
8.5
8
Current (μA)
1.02500
1.02550
1.02600
1.02650
1.02700
1.02750
1.02800
Voltage across diode (V)
Slope = 1177.016 μA/V
data points

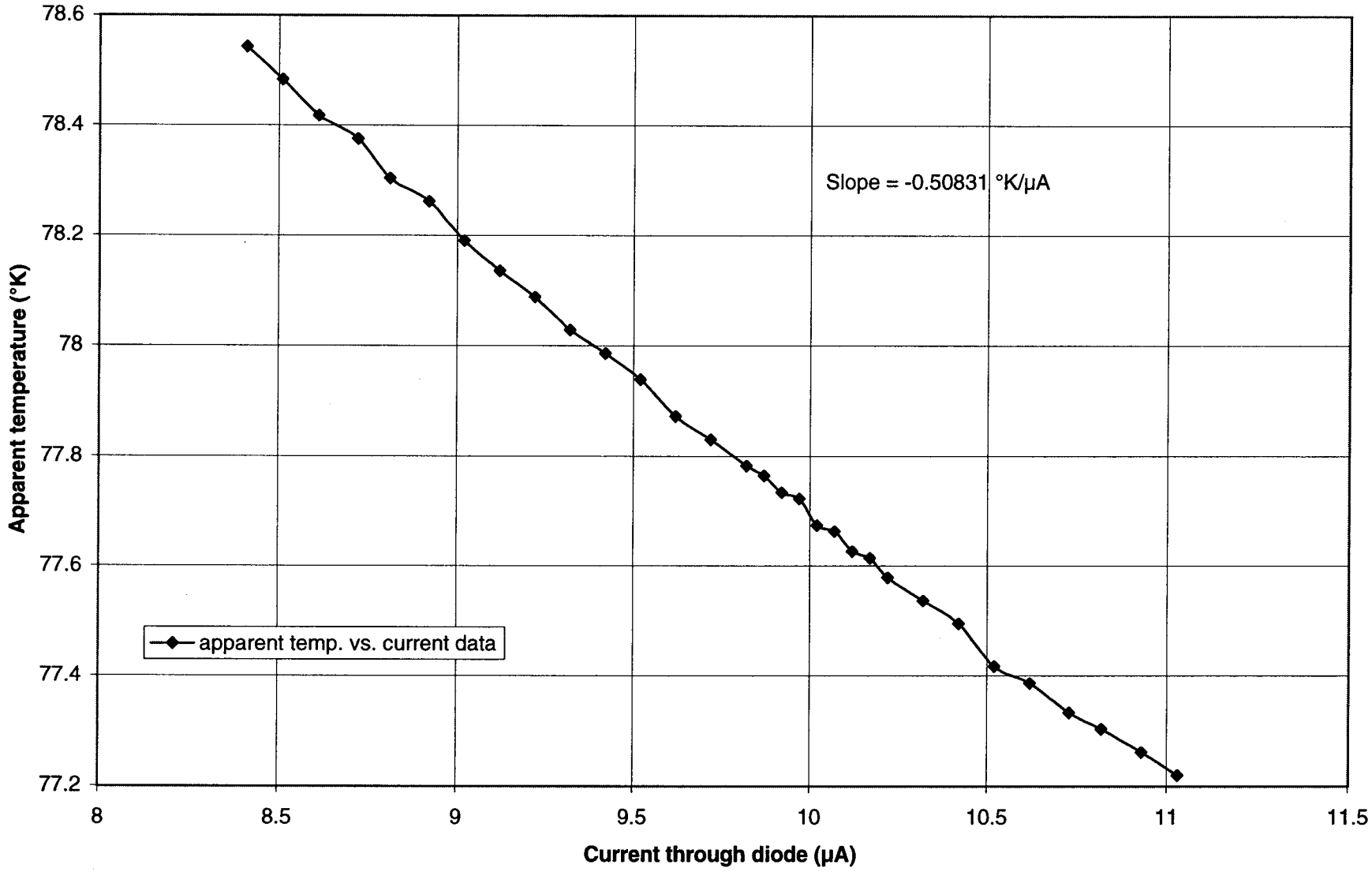

Current vs. Voltage across diode at 77K, second experiment
11.5
11
10.5
10
9.5
9
8.5
Current (μA)
1.02500
1.02550
1.02600
1.02650
1.02700
1.02750
Voltage across diode (V)
Slope = 1234.987 μA/V
data points


Current vs voltage across diode at 74.1F (295.9K)
11.5
11
10.5
10
9.5
9
8.5
Current (μA)
Slope = 394.2494 μA/V
data points
0.562000
0.563000
0.564000
0.565000
0.566000
0.567000
0.568000
Voltage across diode (V)

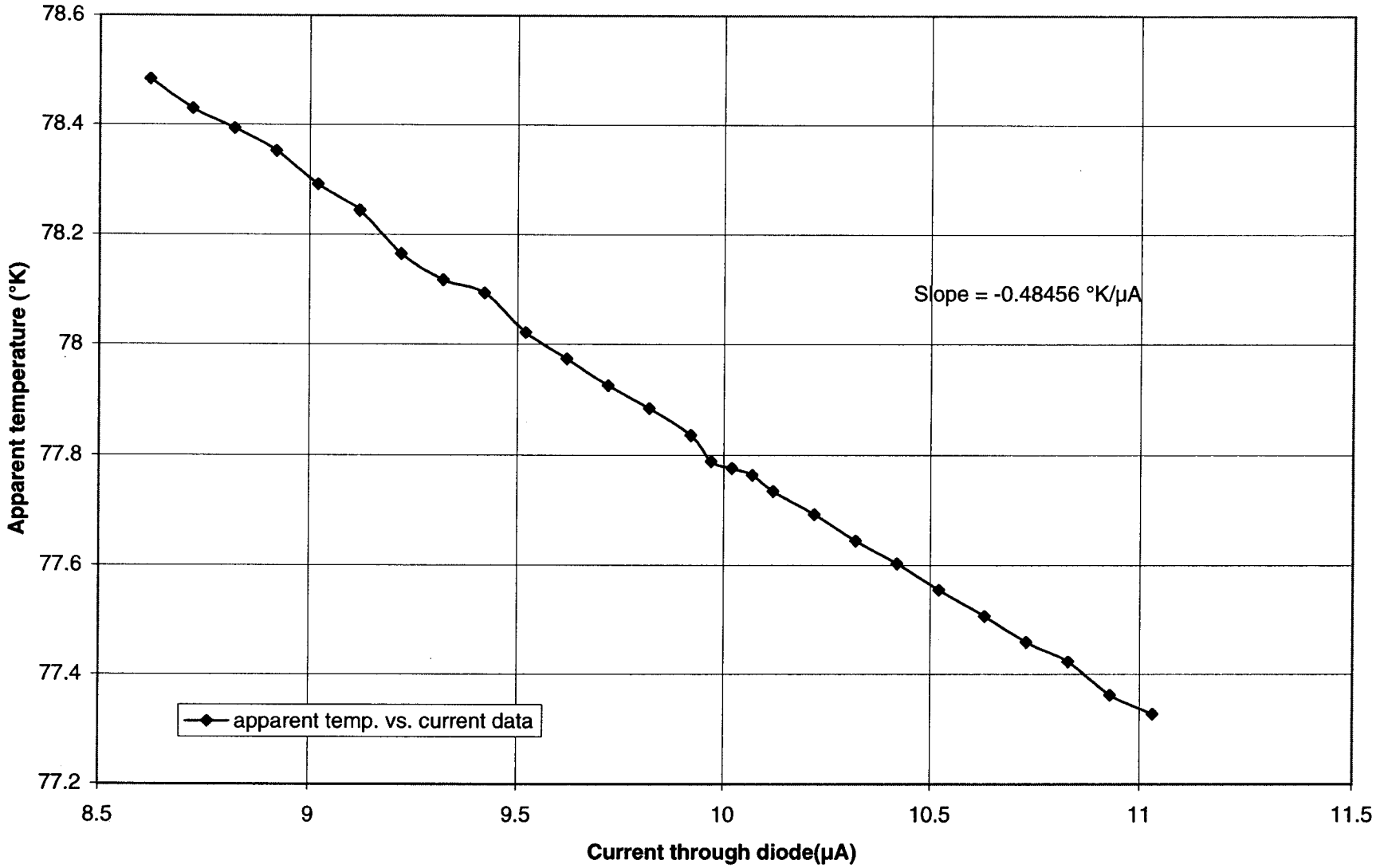
Current vs. voltage across diode at 79.3F (298.8K)



Apparent temperature vs. Current Data for 77K fixed temperature environment.
(first experiment)



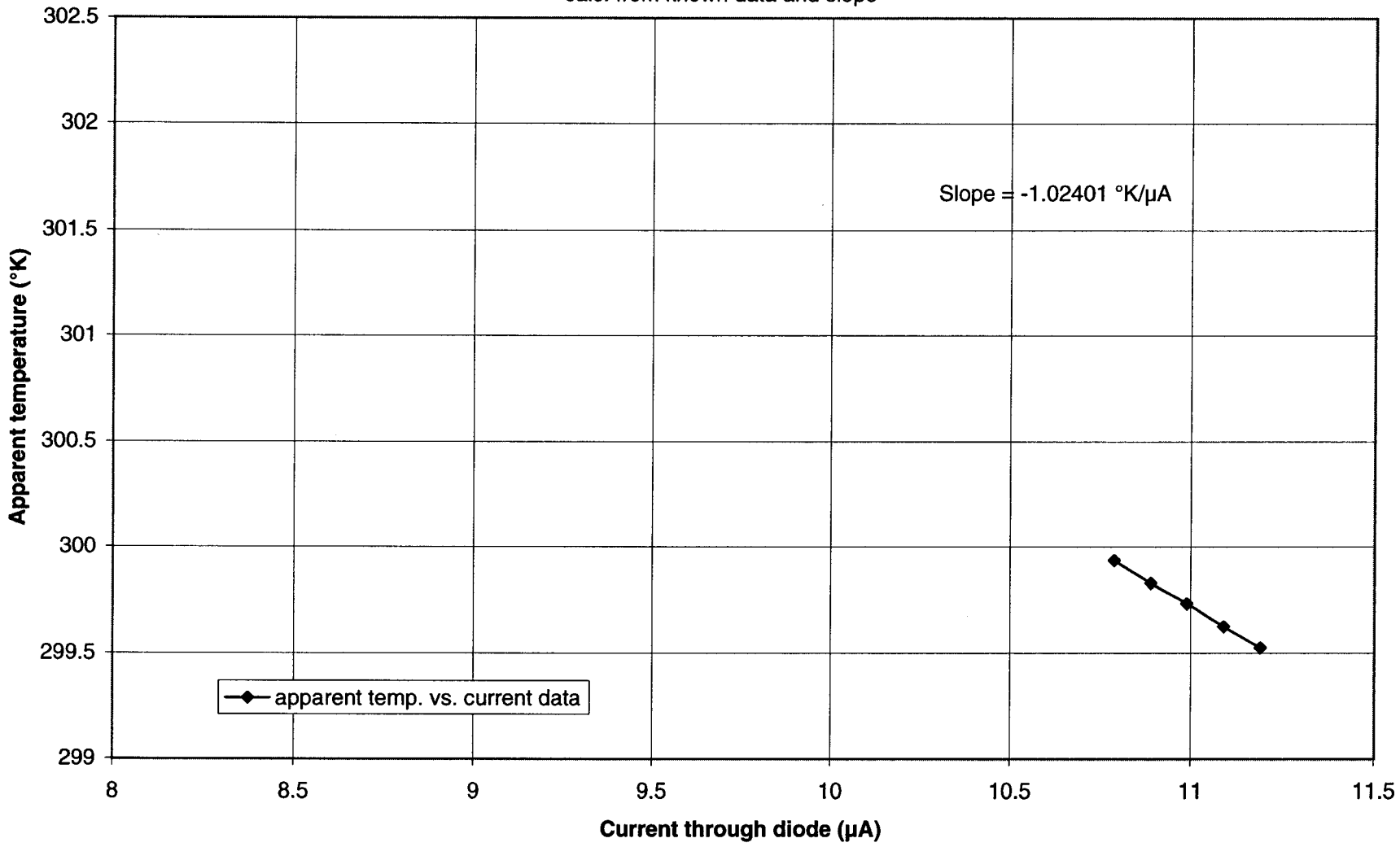
Apparent Temp. vs. Current Data for 77K fixed temperature environment.
(second experiment)



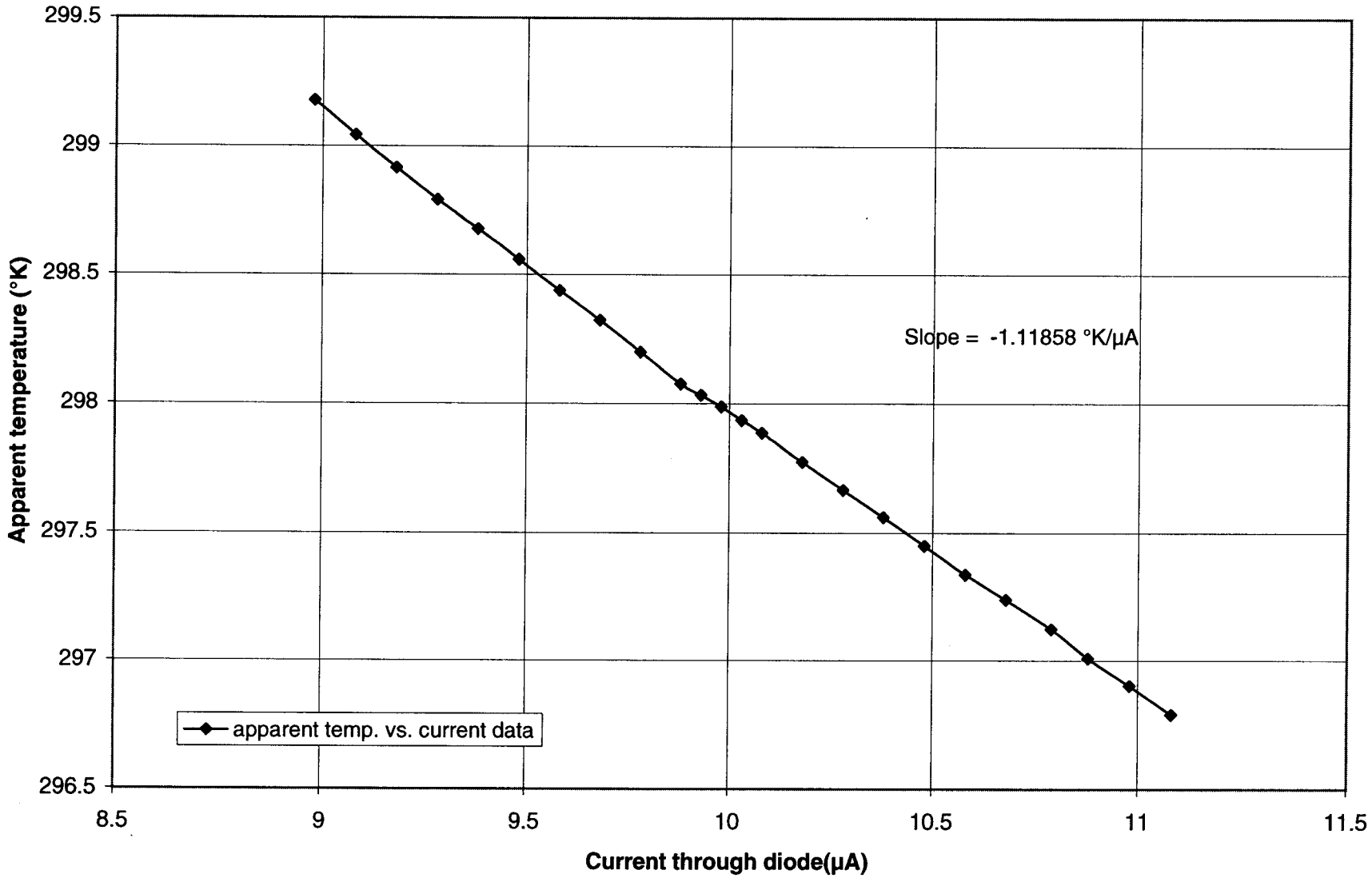
Apparent temperature vs. Current Data for 298.8K fixed temperature environment.

(First experiment)

Because of the lack of data in Standard Calibration Data 20 data points couldn't be shown on the graph, but they can be calc. from known data and slope

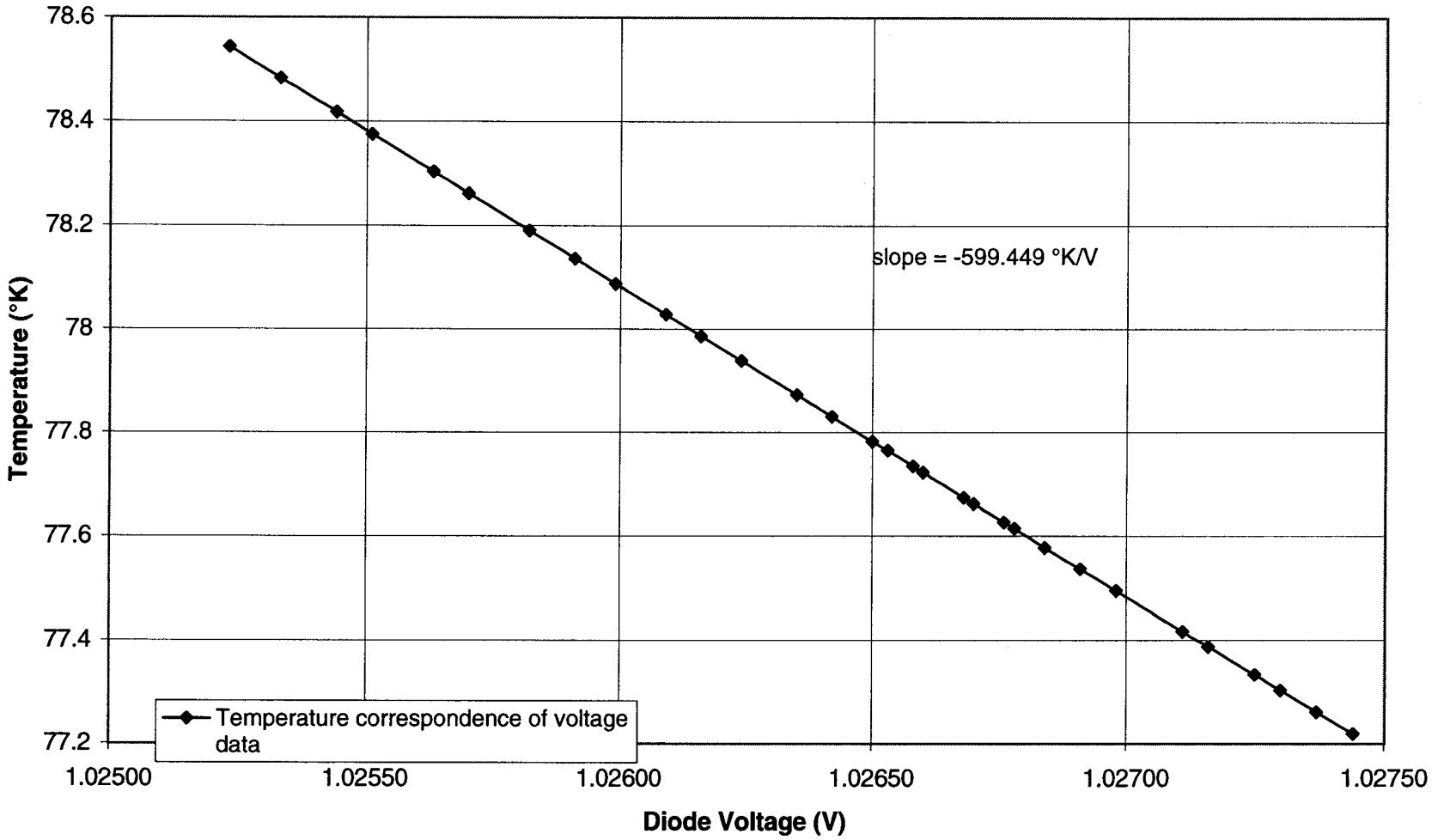


Apparent Temp. vs. Current Data for 295.9K fixed temperature environment.
(Second experiment at 300K)



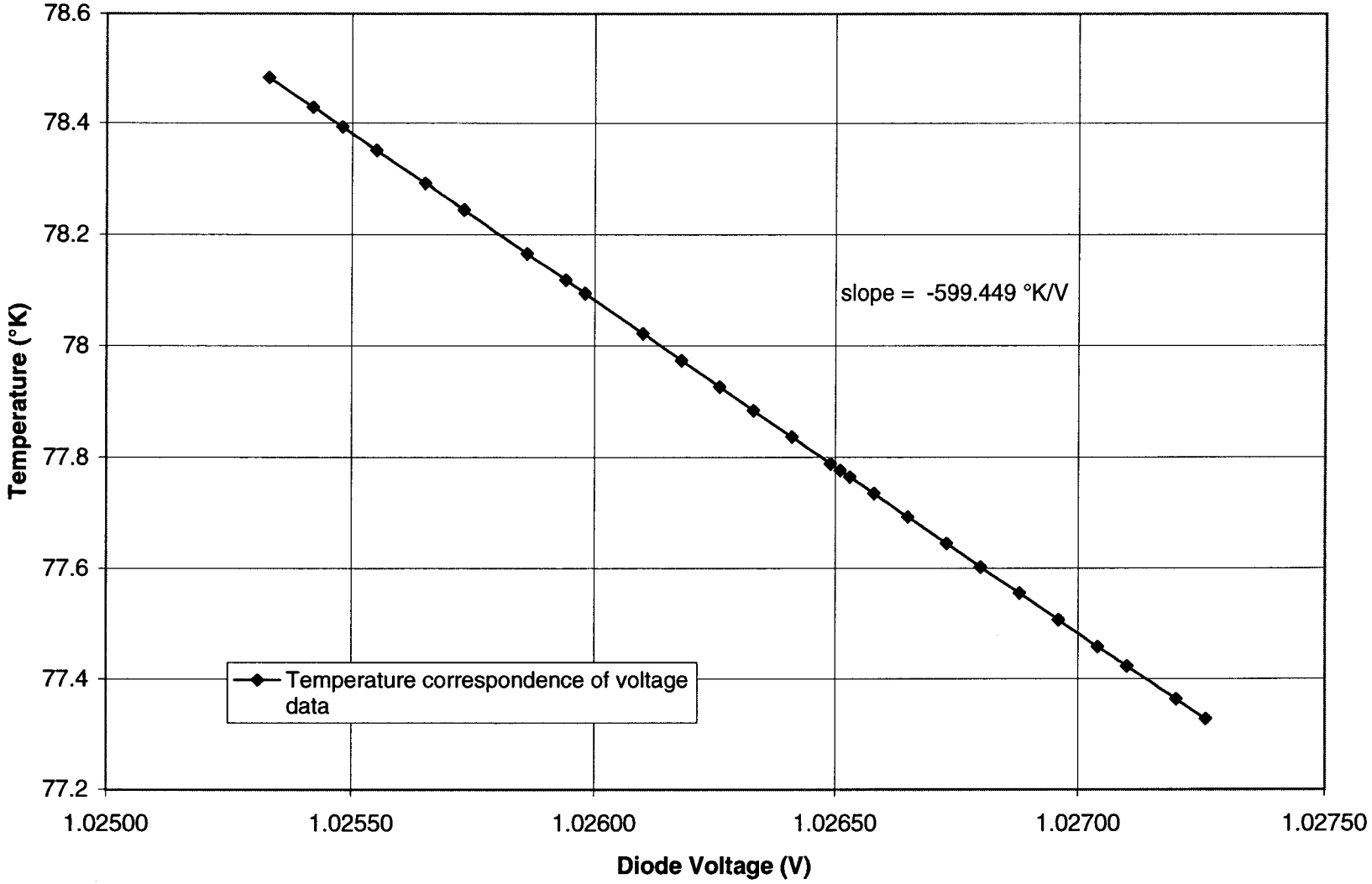
Apparent Temperature vs. Diode Voltage (77K, first experiment)

Temperature is fixed. Despite this; changing current forms an apparent temperature fluctuation. And the apparent temperature vs. voltage across diode forms a graph as follows.



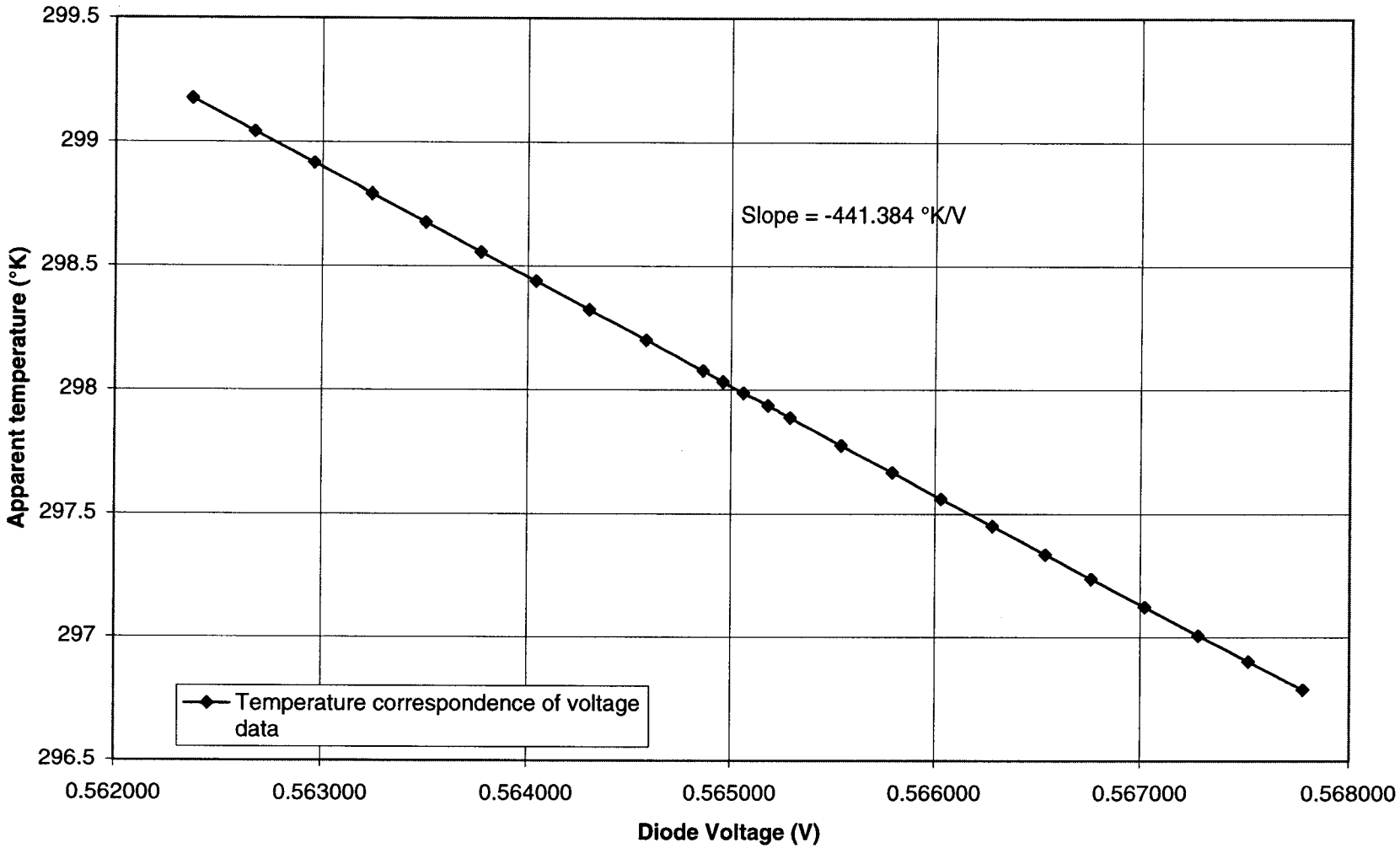
Apparent Temperature vs Diode Voltage (77K, second experiment)

Temperature is fixed. Despite fixed temperature, changing the current forms an apparent temperature fluctuation. And the apparent temperature vs. voltage across diode forms a graph as follows.



Apparent Temperature vs. Diode Voltage (295.9K second experiment)

Temperature is fixed at 295.9K. Despite the fixed temperature, changing the current forms an apparent temperature fluctuation. The graph of Temperature vs. Diode Voltage forms as follows...



Temperature vs. Diode Voltage (298.8K, first experiment)

Temperature if fixed at 298.8K. Because of the lack of data above 300K, 20 data above 300K could not be represented on the graph. The first voltage reading was .55573 micA. Values can be calculated