Inspiring Excellence

Investigation of IV characteristic of Semiconductor Diode and Resistor using KEITHLEY 2450 Source Meter Operated by LabView programming

Internship report submitted in partial fulfilment of the requirements of the Degree of Bachelor of Science in Applied Physics and Electronics

By

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CANDIDATE'S DECLARATION

It is hereby declared that this report titled "Investigation of IV characteristic of Semiconductor Diode and Resistor using KEITHLEY 2450 Source Meter Operated by LabView programming", is submitted to the Department of Mathematics and Natural Sciences of BRAC University in partial fulfilment of the requirements for the degree of Bachelor of Science in Applied Physics and Electronics. This report is the very own work of my own and has not been submitted elsewhere. Every work that has been used as reference has been cited properly.

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Ultimately, I would mention my gratefulness for the support and constant inspiration provided by my parents.

Abstract

This internship report mainly focuses on Investigating the IV characteristic curve of diode and resistor using Keihley 2450 source meter operated by lab view programming. Using the Lab view programming such configuration was made where voltage is supplied and the corresponding current had been calculated for several points for both diode and resistor. A voltage versus Current graph was plotted using Origin lab according to the data from the setup and was investigated and compared with the theoretical properties of the diode and resistor with authentic reference. The measured data followed the theory and almost gave the same characteristic curves which proves that the programming in Labview and the setup in Keithley 2450 source meter was accurate for the measurement.

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Introduction

Investigating the characteristic curve for both diode and resistor by Keithly 2450 and then comparing it with the theoretical results was the main purpose of this internship. Theoretically every semiconductor diode has a knee voltage up to which it resist current flow and every resistor gives a straight line following Ohm's law when voltage is supplied. In this work we measured these characteristic by Keithley 2450 and operated it with Labview programming. In Labview a program was made so that it can increase voltage up to a limit and measure the currenponding current and then show the characteristic curve for several points. later on the experimental result was compared with the theoretical result.

Keithley 2450 source meter

The 2450 is Keithley's next-generation Source Meter source measure unit (SMU) instrument that truly brings Ohm's law (current, voltage, and resistance) testing right to your fingertips. Its innovative graphical user interface (GUI) and advanced, capacitive touchscreen technology allow intuitive usage and minimize the learning curve to enable engineers and scientists to learn faster, works marter, and invent easier. The 2450 is the SMU for everyone: a versatile instrument, particularly well-suited for characterizing modern scaled semiconductors, nano-scale devices and materials, organic semiconductors, printed electronics, and other small-geometry and low-power devices. All this combined with Keithley SMU precision and accuracy allows users to Touch, Test, Invent with the new favorite go-to instrument in the lab for years to come [1].

Keithley SourceMeter SMU Instrument Model 2450 is a four-quadrant flexible IV source and IVR measure solution for DC characterization of electronic components, modules, semiconductor devices, and advanced materials. Using the Touch, Test, Invent™ design philosophy this device seeks to meet today's emerging trends in test instrumentation use and design. With an intuitive Graphical User Interface with 5-inch touchscreen, icon-based control, and context sensitive help the Model 2450 allows engineers, researchers, and scientists to configure and run tests easily and quickly.

With a proven record in quality this Keithley product provides proven precision, accuracy, and low noise performance guaranteeing reliable test results including with low current and voltage ranges being useful in nanotechnology and low voltage semiconductor applications .

With embedded Test Script Processor Technology the Model 2450 provides unmatched throughput in automated test applications. GPIB, USB, and LAN/LXI interfaces enable the SourceMeter SMU instrument to be controlled via a PC.

Users of the popular and established SourceMeter SMU Model 2400 benefit from the model 2450's new features and functionalities and its full software compatibility with model 2400 for an easy drop in and run tests [2]

Reliable test results speeding your time to market with flexible four-quadrant IV source and IVR measure with any I-V characterization of electronic components.

5-inch touchscreen with icon-based control

Proven precision, accuracy & low noise

Embedded Test Script Processor Technology (TSP)

Flexible test device adaptation with front and rear connections

GPIB, USB, and LAN/LXI PC interfaces and TSP-Link for I-V system setup [2]

LabView

Labview means Laboratory Virtual Instrument Engineering Workbench. It is mainly a programming software which creates interface with hardware and regulate many parameters such as voltage, current and temperature. It is a system-design platform and development environment for a visual programming language [4].

LabVIEW offers a graphical programming approach that helps to visualize every aspect of practical applications, including hardware configuration, measurement data, and debugging. This visualization makes it simple to integrate measurement hardware from any vendor, represent complex logic on the diagram, develop data analysis algorithms, and design custom engineering user interfaces [3].

LabVIEW was first launched 1986 as a tool for scientists and engineers to facilitate automated measurements - the aim was that it would be a tool that would be as productive for scientists and engineers as spreadsheets were for financial analysts. Says Jeff Kodowsky of National Instruments who came up with the initial idea and developed it: ”We weren't seeking to create a language but that's what we ended up doing because we needed that level of flexibility and control in order to deal with the kinds of IO and processing required.” In addition to this, Kodowsky had been using an early Apple Mac which utilised graphics more than any other computing system. Kodowsky wanted to be able to utilise this capability to enable quicker programming of the control for instruments [5].

LabVIEW integrates the creation of user interfaces (termed front panels) into the development cycle. LabVIEW programs-subroutines are termed virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector panel. The last is used to represent the VI in the block diagrams of other, calling VIs. The front panel is built using controls and indicators. Controls are inputs: they allow a user to supply information to the VI. Indicators are outputs: they indicate, or display, the results based on the inputs given to the VI. The back panel, which is a block diagram, contains the graphical source code. All of the objects placed on the front panel will appear on the back panel as terminals. The back panel also contains structures and functions which perform operations on controls and supply data to indicators. The structures and functions are found on the Functions palette and can be placed on the back panel. Collectively controls, indicators, structures, and functions are referred to as nodes. Nodes are connected to one another using wires, e.g., two controls and an indicator can be wired to the addition function so that the indicator displays the sum of the two controls. Thus a virtual instrument can be run as either a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the node through the connector panel. This implies each VI can be easily tested before being embedded as a subroutine into a larger program [4].

LabVIEW provides a powerful platform for undertaking a wide variety of different applications. It started as an environment for managing test programming, but since its inception, the applications for which it can be used have considerably expanded. It has expanded from being a graphical test management language to become a graphical system design environment.

This means that it can be used for an enormous variety of interesting and diverse applications. Not only can it be used for equipment control (including the control of the large Hadron Collider at CERN) and a variety of data acquisition applications (including car development simulation where Big Data monitoring is undertaken) to the system design arena where it has been used for development of projects from RF circuitry to biomedical equipment, green technology and much more [5].

Procedure

Physical configuration of Keithley 2450 sourcemeter

First of all Keithley 2450 source meter was connected to a power source and the power button was pressed to on, shown in Fig 2.1

Figure 2.1 Keithley 2450 sourcemeter

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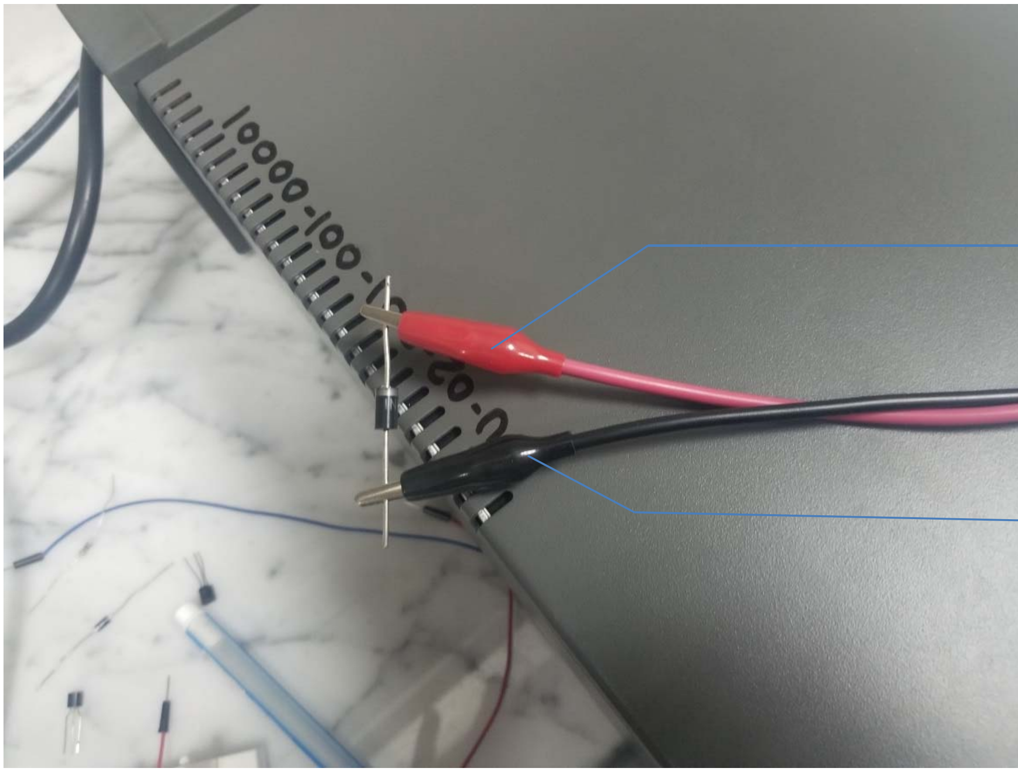
The Diode and Resistor were connected with the wire maintaining the positive and negative side shown in Fig 2.2

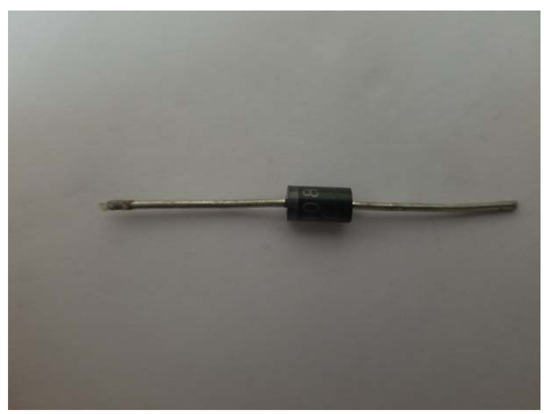


Positive wire

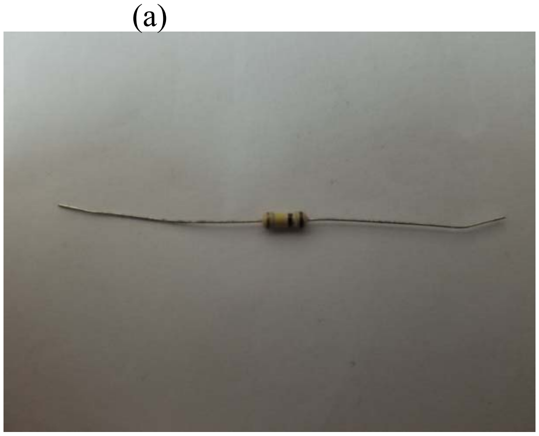
Negative wire

Figure 2.2 Wire Connection

(a)



(b)



(c)

Figure 2.3. (a) 1N4007 Diode (b) 1N5408 Diode (c) 10M Ohm Resistor

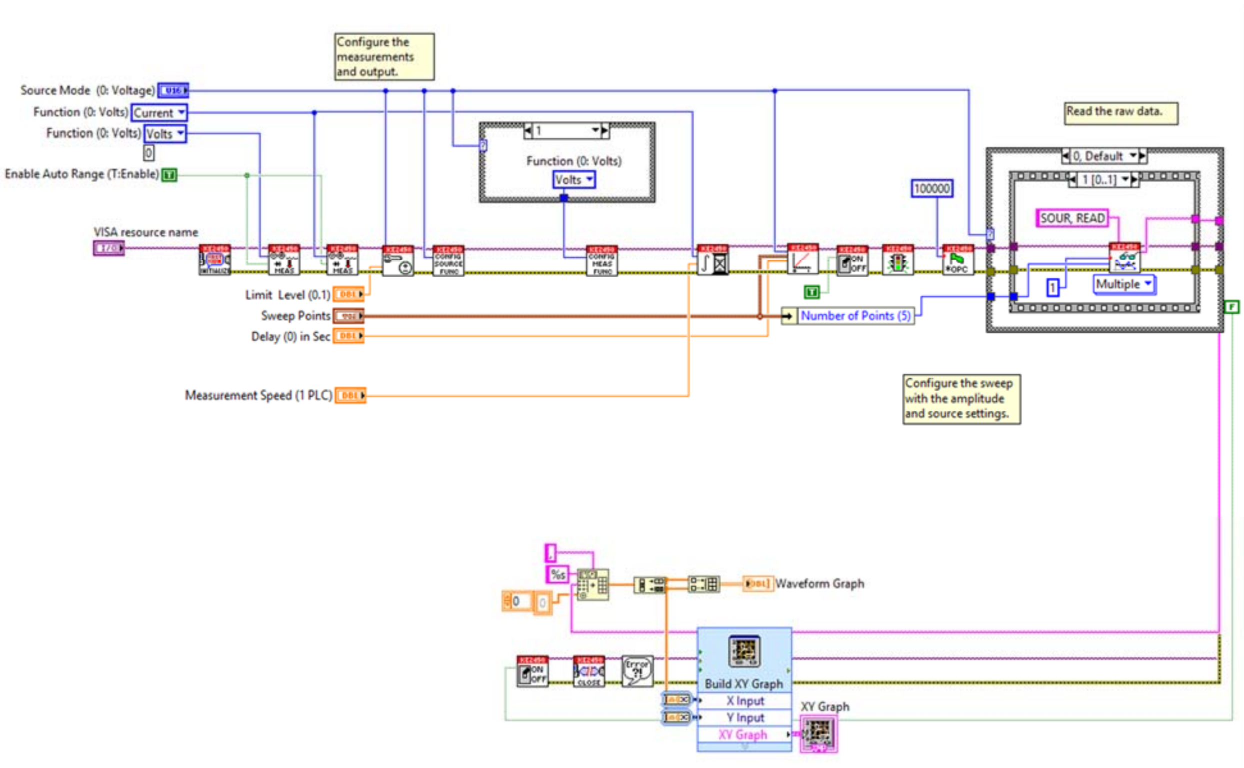


Figure 2.4. LabVIEW block diagram for I-V characteristic measurement

A LabVIEW program was made for the measurement of I-V characteristic , Fig 2.4. later on some parameter was set on the LabVIEW VI interface according to the measurement. The parameters are source mode, voltage limit, starting point, ending point and the number of points. Shown in Fig 2.5.

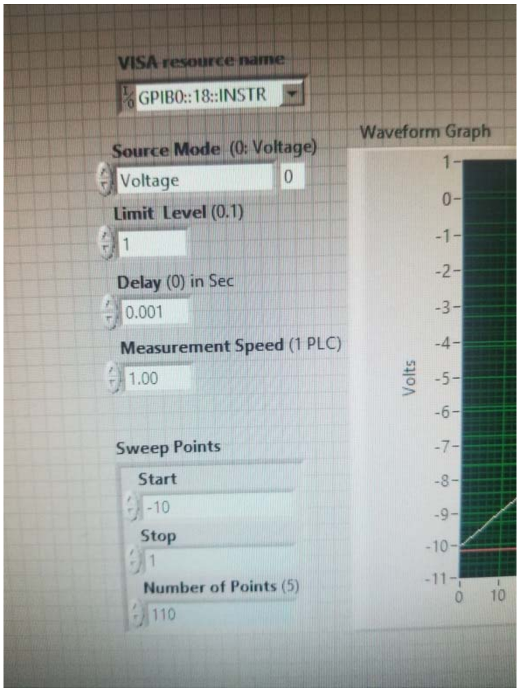


Figure 2.5. Parameters of measurement

After connecting the device properly and running the LabVIEW program the I-V characteristic for different diodes and a 10 M Ohm resistor were measured.

Result and Discussion

For diode the I-V graph was plotted in Origin lab from the out put result of LabVIEW program, for both diode 1N4007 and 1N5408 the result matched with the theory. Up to knee voltage both the diode was resistant to current , after knee voltage current increased exponentially. Fig.3.1 (a), and 3.2.

For the 10M Ohm resistor the grapgh followed Ohm's law at room temparature the current increased proportionally with the voltage, and the graph appears a straight line as expected. Fig 3.3

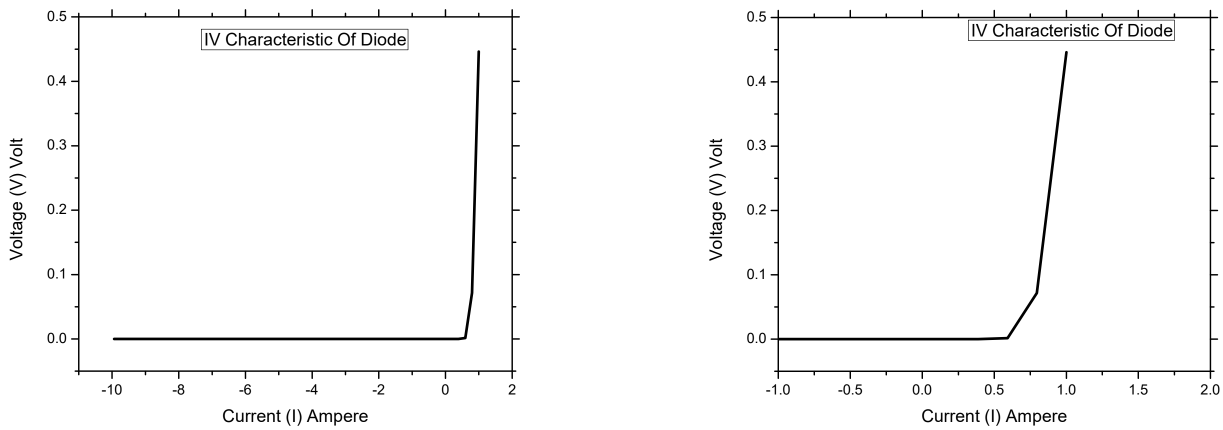


Figure 3.1. I-V characteristic of Diode 1N4007

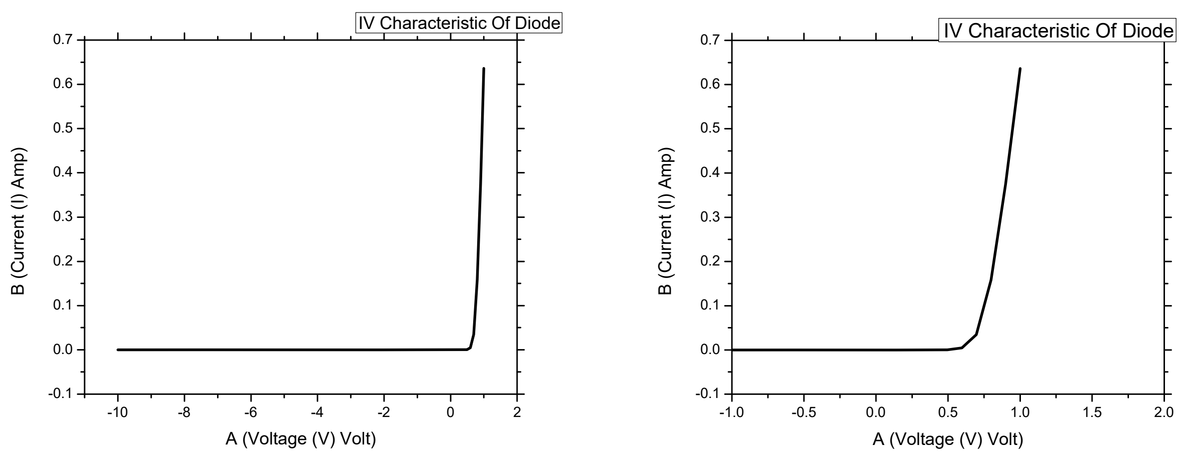


Figure 3.2. I-V characteristic of Diode 1N5408

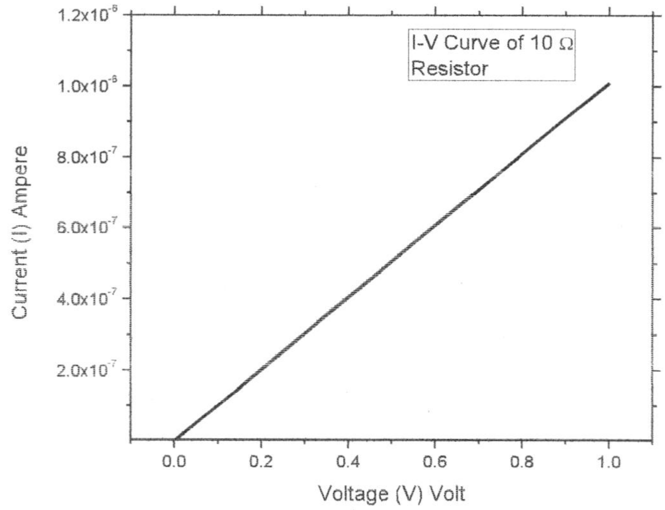


Figure 3.3 I-V characteristic of 10M Ohm resistor.

It was also found that the knee voltage for both the diode was around 0.7 Volt, as these were silicon diodes, their theoretical knee voltage is 0.7 So it fitted with the theory. Knee voltage for 1N4007 and 1N5408 was 0.59233 and 0.59627 respectively where the current started to increase exponentially. Shown in Fig 3.4.(a) and 3.4.(b)

(a) 1N5408		**(b) 1N4007**	
Volts - Plot 0	Amps - Plot 0	Volts - Plot 0	Amps - Plot 0
-10.0001	-5.22E-08	-9.94047	-4.38E-09
-9.89882	-5.22E-08	-9.79658	-4.48E-09
-9.7979	-5.20E-08	-9.53762	-4.16E-09
-9.69687	-5.17E-08	-9.33372	-4.38E-09
-9.59667	-5.16E-08	-9.18512	-4.13E-09
-9.49568	-5.12E-08	-8.92698	-4.30E-09
-9.39442	-5.11E-08	-8.7778	-4.11E-09
-9.29339	-5.07E-08	-8.5199	-4.08E-09
-9.19249	-5.05E-08	-8.37029	-4.19E-09
-9.09157	-5.01E-08	-8.11473	-3.97E-09
-8.9909	-5.00E-08	-7.96316	-4.21E-09
-8.88996	-4.96E-08	-7.70751	-3.87E-09
-8.7889	-4.93E-08	-7.50563	-4.10E-09
-8.68799	-4.91E-08	-7.35185	-3.91E-09
-8.58696	-4.87E-08	-7.09729	-3.88E-09
-8.4861	-4.85E-08	-6.94442	-4.01E-09
-8.3854	-4.79E-08	-6.68727	-3.74E-09

-8.28444	-4.79E-08	-6.53695	-4.01E-09
-8.18346	-4.75E-08	-6.28151	-3.67E-09
-8.08249	-4.73E-08	-6.0791	-3.90E-09
-7.98157	-4.69E-08	-5.92603	-3.69E-09
-7.8806	-4.67E-08	-5.67131	-3.63E-09
-7.78001	-4.64E-08	-5.51854	-3.80E-09
-7.67892	-4.61E-08	-5.26532	-3.50E-09
-7.57806	-4.58E-08	-5.11103	-3.77E-09
-7.47707	-4.55E-08	-4.85902	-3.43E-09
-7.37615	-4.53E-08	-4.65657	-3.62E-09
-7.27509	-4.49E-08	-4.49977	-3.47E-09
-7.17449	-4.47E-08	-4.25059	-3.34E-09
-7.07351	-4.42E-08	-4.09272	-3.56E-09
-6.97251	-4.41E-08	-3.84439	-3.20E-09
-6.8716	-4.36E-08	-3.64187	-3.44E-09
-6.77062	-4.35E-08	-3.48148	-3.20E-09
-6.6697	-4.31E-08	-3.23559	-3.21E-09
-6.56897	-4.28E-08	-3.07392	-3.27E-09
-6.46811	-4.25E-08	-2.82955	-3.02E-09
-6.36716	-4.21E-08	-2.6664	-3.27E-09
-6.26623	-4.20E-08	-2.42348	-2.88E-09
-6.16521	-4.15E-08	-2.22207	-3.05E-09
-6.06392	-4.13E-08	-2.05562	-2.91E-09
-5.96357	-4.09E-08	-1.81568	-2.73E-09
-5.86259	-4.07E-08	-1.64815	-2.95E-09
-5.76169	-4.03E-08	-1.41056	-2.54E-09
-5.66069	-3.98E-08	-1.2087	-2.75E-09
-5.55945	-3.98E-08	-1.0369	-2.46E-09
-5.45836	-3.93E-08	-0.803986	-2.38E-09
-5.35811	-3.90E-08	-0.629322	-2.35E-09
-5.25707	-3.86E-08	-0.402049	-1.95E-09
-5.15622	-3.84E-08	-0.221745	-1.96E-09
-5.0549	-3.79E-08	-0.0152782	-1.55E-10
-4.95392	-3.77E-08	0.18464	9.04E-08
-4.85294	-3.73E-08	0.388655	1.53E-05
-4.75266	-3.71E-08	0.592328	0.00146335
-4.65177	-3.66E-08	0.796117	0.0716217
-4.55033	-3.63E-08	0.999807	0.446097
-4.44947	-3.60E-08		
-4.34839	-3.56E-08		
-4.24747	-3.53E-08		
-4.14713	-3.49E-08		
-4.04594	-3.47E-08		

-3.9449	-3.42E-08	
-3.84393	-3.40E-08	
-3.743	-3.36E-08	
-3.64203	-3.31E-08	
-3.54147	-3.28E-08	
-3.4404	-3.25E-08	
-3.33958	-3.22E-08	
-3.23842	-3.17E-08	
-3.13749	-3.16E-08	
-3.0365	-3.10E-08	
-2.93594	-3.07E-08	
-2.83496	-3.02E-08	
-2.73397	-3.00E-08	
-2.63299	-2.94E-08	
-2.53201	-2.91E-08	
-2.43111	-2.87E-08	
-2.33046	-2.81E-08	
-2.22955	-2.79E-08	
-2.1285	-2.73E-08	
-2.02759	-2.70E-08	
-1.92659	-2.63E-08	
-1.82561	-2.61E-08	
-1.72497	-2.55E-08	
-1.62403	-2.51E-08	
-1.52305	-2.45E-08	
-1.42201	-2.40E-08	
-1.32109	-2.35E-08	
-1.22012	-2.27E-08	
-1.11954	-2.23E-08	
-1.01851	-2.14E-08	
-0.917534	-2.09E-08	
-0.816582	-2.00E-08	
-0.715652	-1.93E-08	
-0.614403	-1.83E-08	
-0.513978	-1.73E-08	
-0.412994	-1.62E-08	
-0.312028	-1.47E-08	
-0.211058	-1.28E-08	
-0.0664966	-5.91E-09	
-0.00540656	-8.19E-10	
0.0912045	4.36E-08	
0.192108	4.10E-07	
0.293023	4.11E-06	

0.394253	5.15E-05	
0.495178	0.00057091	
0.59627	0.00471212	
0.696589	0.0344436	
0.797956	0.158692	
0.898857	0.37548	
0.999803	0.635976	

Figure 3.4. Excel data collected from the experiment (a) Diode1N5408 (b) Diode 1N4007

Conclusion

The internship was a practical experience for comparing the characteristic of circuit elements with their theoretical data using Keithley 2450 device and LabVIEW programming. The device can calculate efficiently and calculate data for many points in less amount of time. Also it can provide graphical data with less error and more accuracy. Using this device we found the knee voltage for diodes and it almost fitted with the theoretical data. I have learned the basic of measuring I-V characteristic for other circuit element and also the graphical programming of LabVIEW with this set up and configuration.

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