Hochschule Bremen

City University of Applied Sciences

Computer Aided Data Acquisition

SoSe – 2019

Project Report

On

Development of an Automated Test System for Characterization of a 1N4002 Type Diode

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Abstract

This report presents the method of investigating and verifying the characteristic curve of diode on both software and hardware level. The experiment has been performed by collecting/measuring data in terms of Electrical signal (Voltage) with the help of diode circuit, measuring instruments, Programmable software (LABVIEW 8.6) and a Bus for the communication between measuring instruments and PC. The purpose of the experiment was to make a program with the help of Graphical Programming Software (LABVIEW 8.6) that automatically plots the I-V characteristic curve of diode by collecting data in terms of measuring voltage across diode. After that voltage across diode has been measured manually to get a manual plot so at the results should be compare on both hardware and software level.

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1. Introduction

Diode is a semiconductor component that allows the current to flow only in one direction. The diode is made up negative and positive doped semiconductor material known as P-TYPE (contain holes) and N-TYPE (contain electrons) are put together. The most common semiconductor materials that are used in diodes are Silicon, Germanium and selenium. Diodes are use in rectifier's circuit, a circuit that converts alternating current to direct current.

Right side of figure 1-1 shows the symbol of diode while on left side a real diode can be seen.

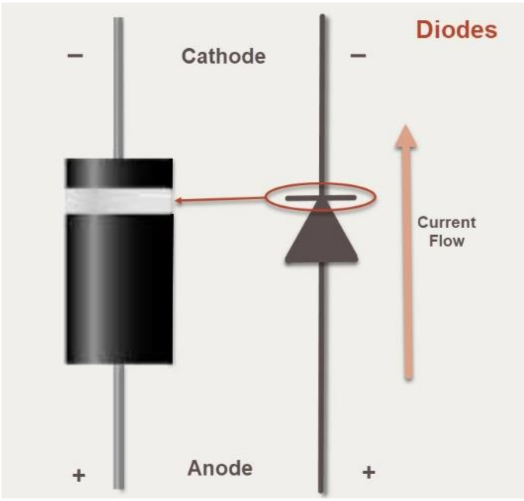

Figure 1-1 Layout of PN Junction Diode [1]

2. Current-Voltage Characteristics of Diode

Current-voltage characteristics curves or I-V curves of an electronic device or component are used to show the relationship between the current flowing through the component and voltage applied across its terminal.

In diode, P-type semiconductor material that contains holes which are acting as positively charged particles and N-type semiconductor material which contains electrons are put together. When these two semiconductor materials are put together, electrons from N-type material towards P-type positively charged holes. By this process the boundary of N-type become slightly positively charged and boundary of P-type become slightly negatively charged, in result an Potential barrier (Forward breakdown voltage) which is 0.7 for silicon or "Depletion layer" has been formed that resist the further motion of electrons and holes. In figure 2-1 we can see electrons moves from N-type towards P-type and a depletion region has been formed.

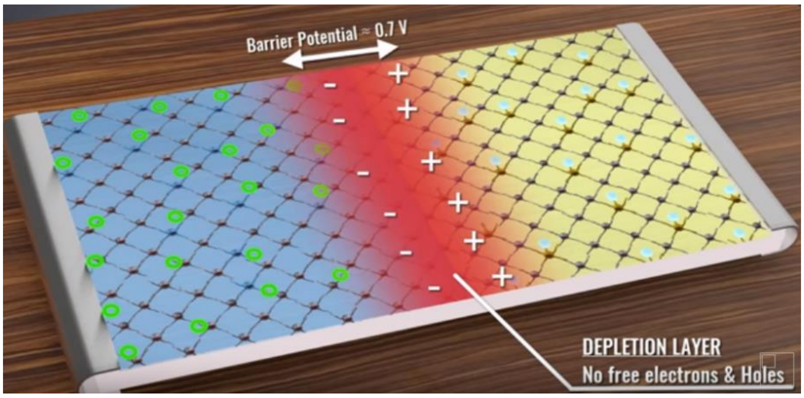

Figure 2-1 Electrons movement in diode [2]

Now in order to pass current through diode this potential barrier needs to be break. In order to break this barrier an external power source has been connected in such a configuration that N-type is connected with negative terminal of power source and P-type is connected with positive terminal of power source. This kind of configuration is known as “Forward Biased”. Now as soon as the power source has the enough voltage to break this barrier current starts flowing through diode.

Figure 2-2 shows the flow of current when the diode is connected in Forward biased configuration. Figure 4 shows the I-V curve of diode in which V_D is the diode voltage and I_D the diode current, as voltage increases above the potential barrier (e.g. 0.7 for silicon) current rapidly start flowing through diode. If we reverse the connection of power source that is N-type connected with positive terminal and P-type connected with negative terminal than no amount of current will flow through the diode and the configuration is known as “Reversed Biased”. That’s how current can only flow in one direction.

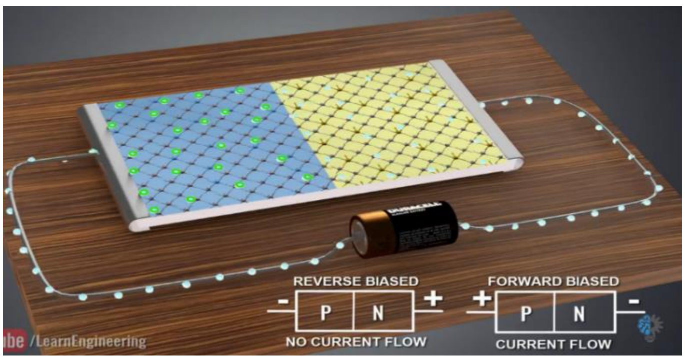

Figure 2-2 Biasing of Diode [3]

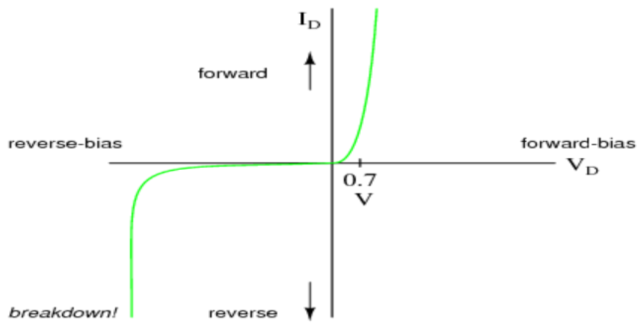

Figure 2-3 VI Characteristics of Diode [4]

3. Experimental Setup

The experiment is carried out in Measurement and Instrumentation laboratory in the Faculty of Electrical Engineering, Hochschule Bremen. The following apparatus are used for the experiment.

i. Power Supply
ii. Multimeter
iii. GPIB Interface
iv. Diode IN 4002
v. Computer with Lab View 8.6

i. Power Supply

A PN-300 Programmable Power Supply (figure 3-1) is used which can be controlled by lab view program through GPIB interface. All the settings are carried out using only a few keys. The instrument supplies two variable voltages of 0 – 30 V/ 0-2.3 A and a fixed voltage of 5 V / 2 A. The variable output voltages can be adjusted separately in tracking mode or in parallel. In parallel operation a maximum of 30 V and 4.6 A is possible to supply. The minimum increment for voltage and current settings are 10 mV and 1 mA respectively. The operating voltages and frequency of the Power Supply are 230V/115V and 50-60Hz [5].

Figure 3-1: PN 300 Programmable Power Supply

ii. Multimeter

The HP 34401A is a high-performance digital multimeter shown in figure 3-2. Its combination of bench-top and system features makes this multimeter a versatile solution for measurement. It can measure up to 1000 volts, 0.0015% basic dc V accuracy, 0.06% basic ac V accuracy, 3 A max current input and 3 Hz - 300 kHz AC bandwidth. It can send 1000 readings/s direct to GPIB.

Figure 3-2 HP 34401A Multimeter

iii. GPIB

The GPIB (General Purpose Interface Bus) or IEEE 488 bus (figure 3-3) is an interface standard used for enabling electronics test equipment to be controlled remotely. GPIB is a bit-parallel (byte-serial) communication interface with 8 bits, which allows data transfer rates of up to 1 MByte/s. It has 8 lines for data bus width, 3 lines and 5 Bus management lines.

Figure 3-3: GPIB IEEE 488 [7]

iv. Diode

A diode is a device which allows current flow through only one direction, the current should always flow from the Anode to cathode. The cathode terminal can be identified by using a grey bar as shown in the figure 3-4.

1N4002 Diode Features:

- Average forward current is 1A
- Non-repetitive peak current is 30A
- Reverse current is 5uA.
- RMS reverse voltage is 70V
- Peak repetitive reverse voltage is 100V

Figure 3-4 1N 4002 diode

For 1N4002 Diode, the maximum current carrying capacity is 1A, withstands peaks up to 30A. Hence, we can use this in circuits that are designed for less than 1A. The reverse current is 5uA which is negligible. It can withstand reverse voltage peak up to 100V.

v. LabVIEW 8.6

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a system-design platform and development environment for a visual programming language from National Instruments. LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of operating systems (OSs). Lab View 8.6 software is used in windows 7 operating system for this experiment.

4. Block Diagram of Hardware Setup

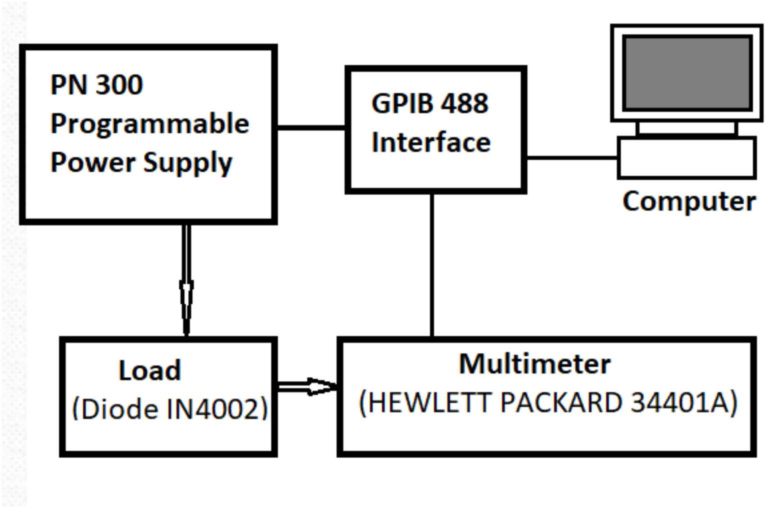

Figure 4 -1 Block diagram of hardware setup

The block diagram of experimental setup is shown in figure 4-1. A computer with Labview 8.6 software is connected to the Power Supply and the Multimeter as well through GPIB 488 Interface. This power supply is programmable and can be controlled by the instructions given by the user through LabVIEW program. The diode is connected with power supply and also connected to multimeter in parallel to measure the voltage drop across the diode.

5. Program explanation

5.1 Front Panel

The front panel of this project has been showed in Figure 5-1.

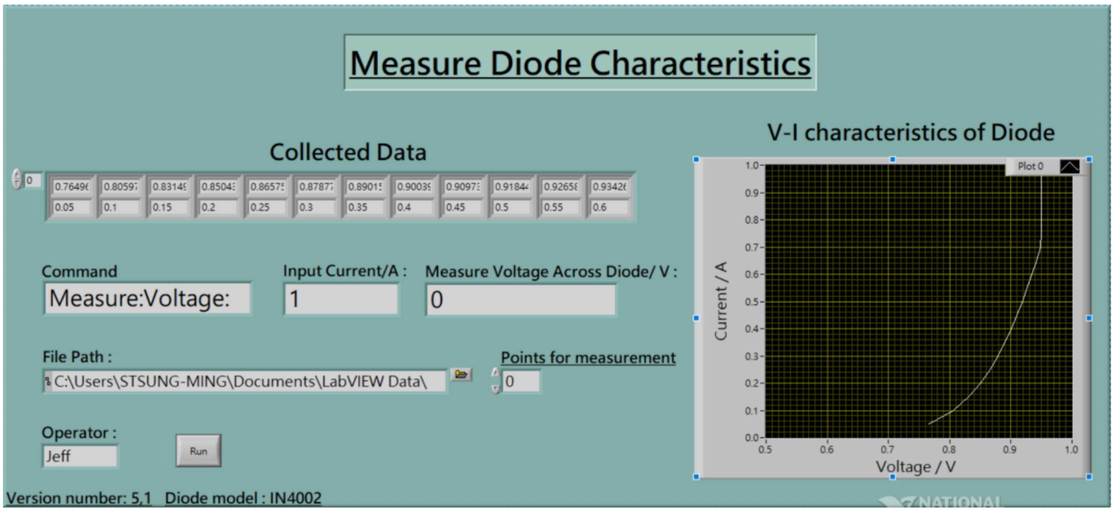

Figure 5-1: Front Panel

In the front panel, the functions of collected data, instantly input current, and instantly Voltage Across the diose has been added in this program. In the collected data area, the user can inspect all experiment data. Also, the instantly data will show below. When the experiment finished, the diode characteristic figure will show at the monitor.

The user can adjust the output file path and also add the operator's name in the output file. The user can run the program in front of the panel, and also change to points for measurement.

Below the front panel, it shows the software version number and the recommended diode model.

5.2 Block Diagram

Let's see the detail of the program. In this program, there are 4 main flat sequence. Flat sequence is consisting of one or more sub diagrams, or frames, that execute sequentially. And the appearance of flat sequence is shown in Figure 5-2.

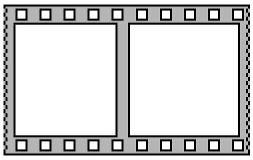

Figure 5-2 Flat Sequence

Now, let's talk about the function of first sequence and its structure is shown in Figure 5-3. In this sequence, we use visa open, visa write and visa read to help us to communicate with the instrument. At the visa open part, selecting which instrument you want to connect is need. Here, we connect "GPIB::10::INSTR", the "GPIB::10::INSTR" is the interface name of PN300(power supply). After that, we setup the timeout value as 1000 milliseconds. Then, using visa write to send a "Vset 1" command to the PN300, and close the visa. With this sequence, the initial voltage of power supply is set as 1 volt.

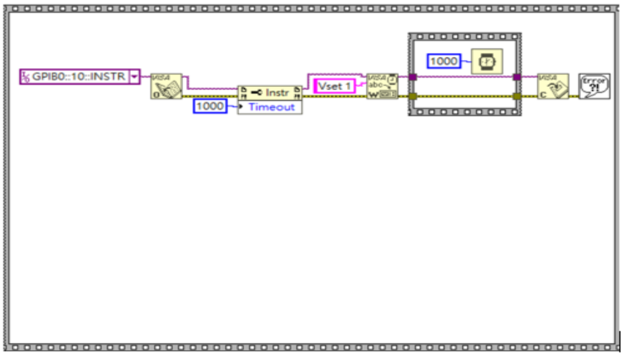

Figure 5-3 Flat sequence 1

At the flat sequence 2, the procedure is almost the same. The only different is just sending different command" Out_ON". This sequence can help us to open the output function of the power supply, then the voltage and current will start to apply on the diode. The structure of flat sequence 2 is shown as Figure 5-4.

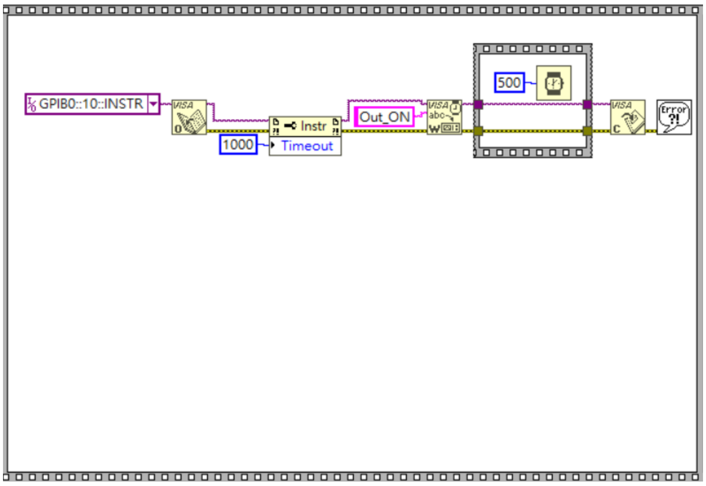

Figure 5-4 Flat sequence 2

Next, the flat sequence 3 is the main part of our program. The main function is creating the output file, setting the continuously measurement and display the characteristic curve on the monitor. The structure of Flat sequence 3 is shown as Figure 5-5.

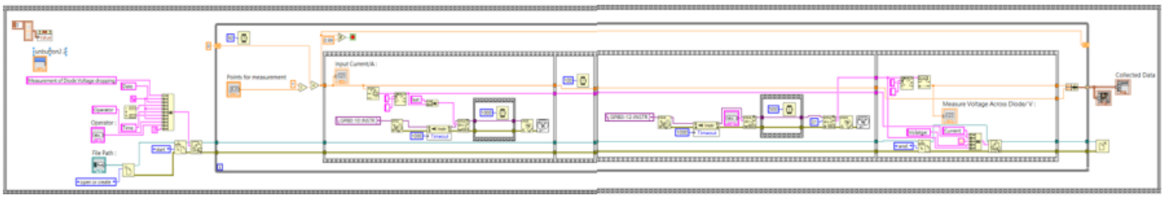

Figure 5-5 Flat sequence 3

Let's look into the detail of flat sequence 3.

In the red part of Figure 5-6, the zero array is sent to the value of monitor. This function can clear the monitor and make sure the obtained curve is plot by the latest data. Also, the runbutton2 is the Xcontrol program of the LabVIEW, we create a start button icon and function at that subprogram and apply on this program.

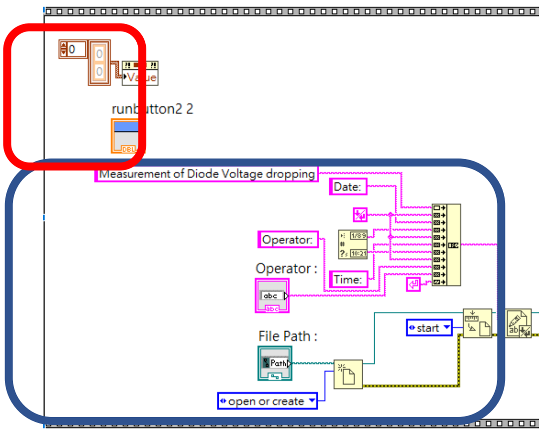

Figure 5-6 First part of Flat sequence 3

In the blue part of Fig 5-6, we create a text file, and putting some experiment date and time at the beginning. Also, the operator and file path are “control” which controlled at the front panel.

In the Figure 5-7, the second part of flat sequence 3, we add a while loop to increasing the voltage automatically, the while loop would start from 0, add several volts every times and end up at 0.99 volt. The number for the adding is calculated by points of measurement. If we want to have 2 points for measurement, we will add 0.5 volts each time, and it will only add two times to achieve 0.99 volt then the while loop stop.

The value of voltage will be sent into the flat sequence and changing the type of the number into the string. The reason Changing “.” to “,” is because at the LabVIEW system, the decimal point is “.”, but at the instrument system, the decimal point is “,”. If the decimal point is not changed, the command would have an error and the program would not work. At the end, we combine the number with the string” Iset ” and send this command to the PN300, the voltage will start changing automatically.

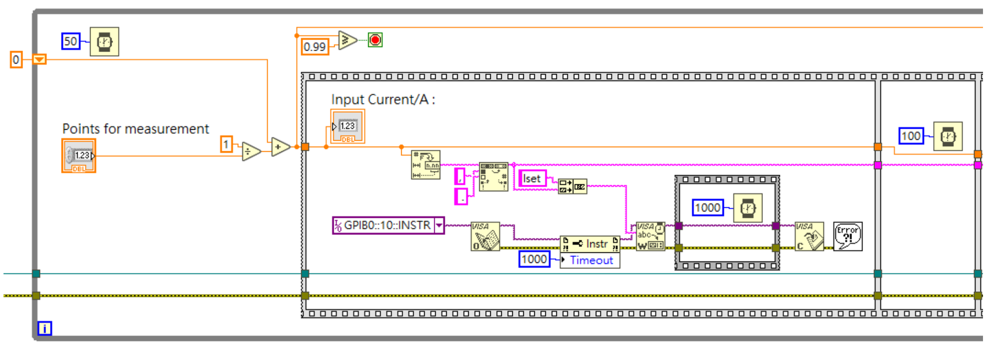

Figure 5-7 Second part of flat sequence 3

In Figure 5-8, the third part of sequence 3, the aim is collected the data from the multimeter, then the instrument name should be changed into” GPIB0::12::INSTR”. The voltage across diode is the read buffer of VISA read, and this number will also change”,” into”.”, and write the data into the text file.

Outside of the while loop, there are collected data array and the graph of diode characteristic. If the while loop stop, the data which collected inside of the while loop will deliver through the indexing tunnel to the collected data array and plot the characteristic graph.

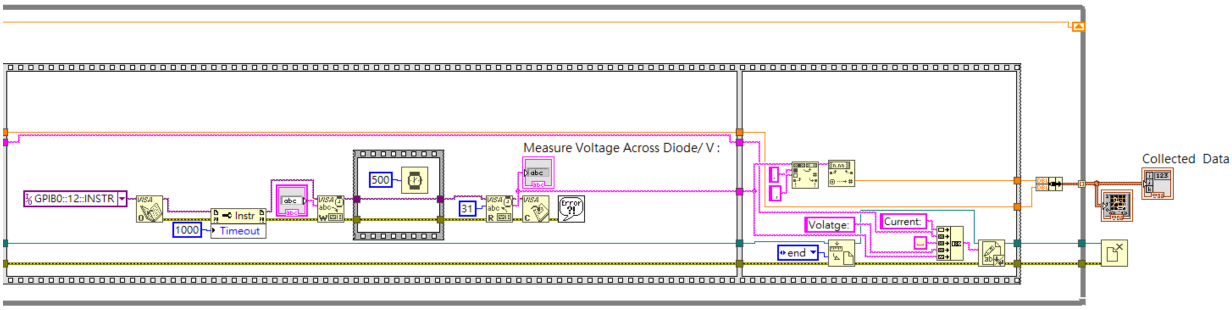

Figure 5-8 Third part of flat sequence 3

Finally, at the last flat sequence, it also same as flat sequence 2. The only different is just changing the command to “Out_off”. This function can turn off the output of power supply and avoid to apply the voltage and current continuously on the diode. The structure of flat sequence 4 is shown as Figure 5-9.

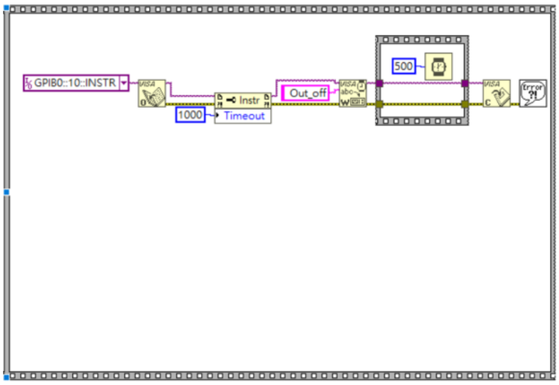

Figure 5-9 Flat sequence 4

6. Data Analysis

6.1 Automatic measurements

The collected data of the text file is shown in Fig.10. At the beginning, we have our program name, the date, the time and the operator. Each current and relative voltage is recorded at the below.

Table 6-1 Automatic measurement data

```
Measurement of Diode Voltage dropping
Date: 28.06.2019
Time: 11:43
Operator: Jeff
Current: 0.050000 Volatge: +7.64967110E-01
Current: 0.100000 Volatge: +8.05973120E-01
Current: 0.150000 Volatge: +8.31492770E-01
Current: 0.200000 Volatge: +8.50438570E-01
Current: 0.250000 Volatge: +8.65758090E-01
Current: 0.300000 Volatge: +8.78776430E-01
Current: 0.350000 Volatge: +8.90151350E-01
Current: 0.400000 Volatge: +9.00393160E-01
Current: 0.450000 Volatge: +9.09735480E-01
Current: 0.500000 Volatge: +9.18445770E-01
Current: 0.550000 Volatge: +9.26585340E-01
Current: 0.600000 Volatge: +9.34264320E-01
Current: 0.650000 Volatge: +9.41775120E-01
Current: 0.700000 Volatge: +9.48897990E-01
Current: 0.750000 Volatge: +9.50127890E-01
Current: 0.800000 Volatge: +9.50162270E-01
Current: 0.850000 Volatge: +9.50318200E-01
Current: 0.900000 Volatge: +9.50336740E-01
Current: 0.950000 Volatge: +9.50126130E-01
Current: 1.000000 Volatge: +9.50120120E-01
```

6.2 Manual Measurements

The input current is given manually by the power supply and voltage drop across the diode is measured in the multimeter directly. The automatic measured data and manually measured data both are plotted in graph to compare (figure 6-1). Almost the same curve is found for both measurements. The current input step size was larger that’s why the manual measurement data curve is not much sharp as automatic measurement.

Table 6-2 Manual Measurement Data

Current (A), Voltage (V)		Current (A), Voltage (V)		Current (A), Voltage (V)	
0.005	0.658	0.060	0.778	0.400	0.892
0.010	0.688	0.065	0.782	0.500	0.908
0.015	0.708	0.070	0.786	0.600	0.923
0.020	0.722	0.075	0.790	0.700	0.934
0.025	0.733	0.080	0.793	0.800	0.946
0.030	0.742	0.085	0.796	0.900	0.957
0.035	0.750	0.090	0.800	1.00	0.967
0.040	0.757	0.095	0.803	1.10	0.973
0.045	0.763	0.100	0.805		
0.050	0.769	0.200	0.846		
0.055	0.773	0.300	0.872		

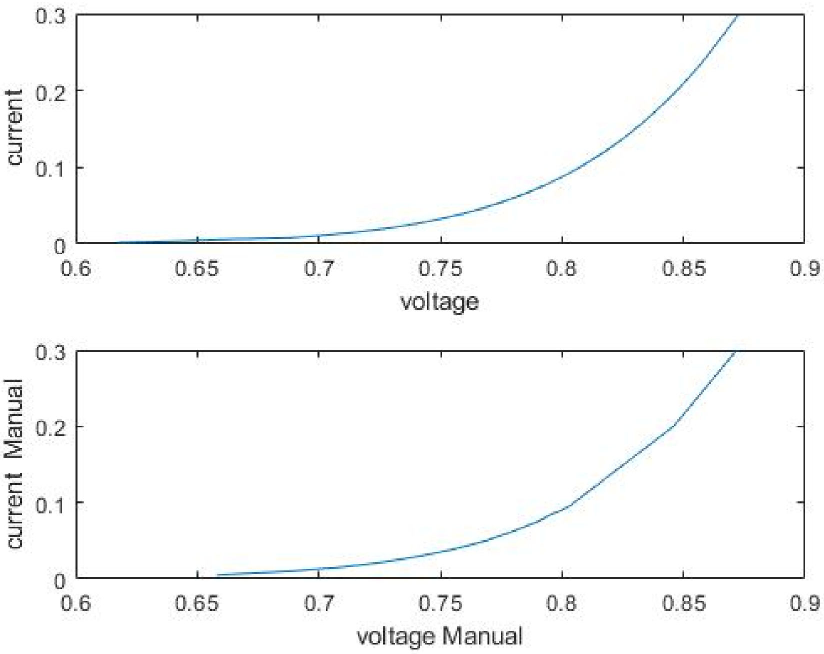

Figure 6-1 Comparison of Automatic Data and Manual Data

7. Conclusion

Learning and experimental goals have been achieved successfully. Results have checked on both hardware and software level for the verification of results. Using our previous knowledge of LabView we have learned some new concepts like looping, structuring and how to communicate with measuring instruments through Lab view and using buses and at the end data has been collected successfully. A customer friendly system and industrial approach has been considered throughout the experiment. We have tried to make a user interface that shows all the required and important information.

At the end we really appreciate all the efforts and are thankful for the guidance from Professor and Lab attendant throughout the course.

References

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