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VIRTUAL INSTRUMENT SOFTWARE FOR PLOTTING V-I CHARACTERISTICS OF SILICON DETECTOR USING 6487PICOAMMETER

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Abstract

In this paper, a PC-based virtual instrument (VI) that has been developed for plotting VI characteristics of silicon detector using a high resolution bus-programmable (RS-232 and IEEE-488) picoammeter (model 6487) is demonstrated. The virtual instrument can be used to test a silicon detector. While performing semiconductor device testing it is able to produce and analyze Voltage Vs. current (V-I) characteristics of electronic device and also to store the measured data in a file specified by user for future processing and analysis. The proposed VI is based on the Lab VIEW (Laboratory Virtual Instrument Engineering Workbench) language under the workbench of the MS Windows 95/98 operating system. The capability of the proposed method can be expanded according to the requirements of users

INTRODUCTION

LabVIEW (National Instruments, Austin, TX) is a data acquisition and programming environment that allows flexible acquisition and processing of analog and digital data. The main feature that distinguishes LabVIEW from other data acquisition programs is its highly modular graphical programming language, “G,” and a large library of mathematical and statistical functions. The advantage of graphical programming is that the code is flexible, reusable, and self-documenting. Subroutines can be saved in a library and reused without modification in other programs. This dramatically reduces development time and enables researchers to develop or modify their own programs. LabVIEW uses a large amount of processing power and computer memory, thus requiring a powerful computer. A large-screen monitor is desirable when developing larger applications. LabVIEW is excellently suited by testing new monitoring paradigms, analysis algorithms, or user interfaces. [1] The best virtual instrumentation system that has been developed so far is LabVIEW. LabVIEW is an application development program that was developed by National Instruments in 1986 to integrate science and engineering tasks by interfacing computers with instruments for collecting, storing, analyzing, and transmitting data while, at the same time, providing an effective user interface. Different from other development software such as C/C++, FORTRAN, Basic, etc., LabVIEW utilizes its own integrated programming language known as the Graphical Programming Language, which uses graphics as code sequences in the application being developed, making the software development process significantly easier.[2] LabVIEW is powerful programming software that can interface with over 7,000 instruments to provide data acquisition, industrial measurement, automated testing, and instrument control. [5]

GPIB (General Purpose Interface Bus) is an essential tool in computer-controlled instrumentation. National Instruments' LabVIEW provides an effective alternative to conventional text based languages by utilizing a graphical programming environment to control GPIB instruments. From a pedagogical perspective, it offers an interesting new approach to programming, particularly for visual learners. [2]

I. INSTRUMENT COMMUNICATION USING VARIOUS METHODS

There are different types of communication methods available for controlling laboratory instruments as well as optical components. These methods are serial, parallel, GPIB, VXI, PXI and others, which the choice is mainly based on the applications. Two most common instrument communication methods are GPIB and serial port communication. In 1965, Hewlett Packard designed the Hewlett-Packard Interface Bus (HP-IB) to connect their line of programmable instruments to their computers. Because of its high transfer rates (nominally 1 MB/s), this interface bus quickly gained popularity. It was later accepted as IEEE Standard 488-1975. Today, the General Purpose Interface Bus (GPIB) is more widely used than the HP-IB. This is due to its ability to connect to different devices to the same GPIB bus.

Any devices must have a unique GPIB address between 0 and 30, so that the data source and destinations can be specified by this number. Address 0 is assigned to the GPIB interface board. The GPIB has one Controller, usually a computer that controls the bus management functions. The LabVIEW GPIB VI automatically handles the addressing and most other bus management functions, saving user from the hassle of low-level programming. To use GPIB as part of in any virtual instrumentation systems, the GPIB driver software is required and can be installed in our computer according to the directions that accompany LabVIEW or the board. [4]. IEEE-488 connector is shown in figure 1.

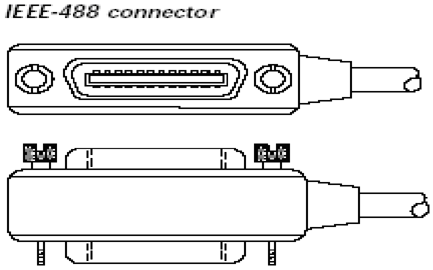


Figure 1: IEEE-488 connector

II. INTERACTING WITH 6487 PICCOAMMETER THROUGH PC

The Model 6487 is a high-resolution bus-programmable (RS-232 and IEEE-488) picoammeter. The Model 6487 has the following current measurement ranges: 8 ranges, from 20mA down to the 2nA range. The Model 6487 also has a built-in ±500V DC voltage source.

The Model 6487 conforms to these standards:

- IEEE-488.1-1987
- IEEE-488.2-1992

These standards define a syntax for sending data to and from instruments, how an instrument interprets this data, what registers should exist to record the state of the instrument, and a group of common commands.

- SCPI 1996.0 (Standard Commands for Programmable Instruments)

This standard defines a command language protocol. It goes one step further than IEEE-488.2-1992 and defines a standard set of commands to control every programmable aspect of an instrument.

A. *Instrument control*

All the instruments are connected through a GPIB bus. A simple piece of LabVIEW software is used to access each instrument either for configuration or data retrieval. Other means of hardware communication can be used for this system; however, since GPIB ports were already incorporated in all of these instruments, GPIB was selected for instruments communication and control. A test is selected on the front panel. These test are predefined in the software, however, the instrument setup must be changed manually in order to retrieve meaningful data. During a test cycle, current and voltage are measured and retrieved trough the GPIB port at predefined increments [3]. Figure 2 and 3 show front and rear panel of model 6487.

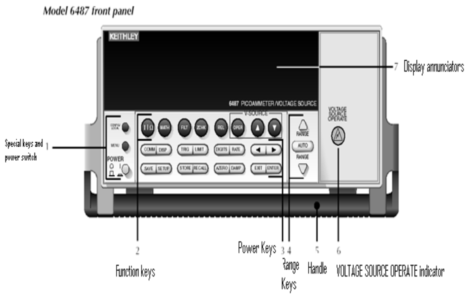


Figure 2: Model 6487 Front Panel

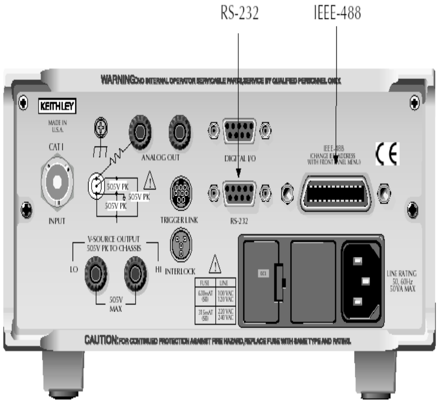


Figure 3: Model 6487 IEEE-488 and RS-232 connector locations

B. *Configuring the GPIB interface*

We select the GPIB interface from the COMM menu structure (access by pressing the COMM key while in local). After selecting the GPIB interface, we press the CONFIG key and then the COMM key to configure the GPIB address and language. From this menu we can check or change the following settings:

- Primary address: 0–30
- Language: SCPI (SCPI 1996.0 which includes 488.2), 488.1, or DDC

We press the RANGE keys to scroll through ADDress and LANGuage available. To make changes to a setting, we press the cursor right key.

Then use the RANGE keys and the cursor keys to select and modify the value as desired. ENTER is pressed to save the changes and stay in the menu (pressing EXIT also saves the changes but leaves the menu).

III. VIRTUAL INSTRUMENT SOFTWARE FOR PLOTTING V-I CHARACTERISTICS OF SILICON DETECTOR

A. *Front Panel Control*

All the instruments are connected through a GPIB bus. To control the instrument 6487 first front panel is designed. In the front panel we provide input as given below:

- Start voltage
- End voltage
- Strip current limit
- Numbers of steps
- Instrument name
- File path and
- Output file name.

To pass these parameters to instrument we are using **SCPI commands.** The front panel control is shown in figure 4.

B. *Steps followed*

Computation of Voltage and current require start and end voltage divided into predefined steps. To measure voltage and current following steps have to be followed:

1. Initialize the instrument
2. Set ranges for the various parameters
3. Give voltage to instrument
4. Read value of current measured from instrument
5. Compare strip current limit with measured current If current exceeds limit then step down the instrument

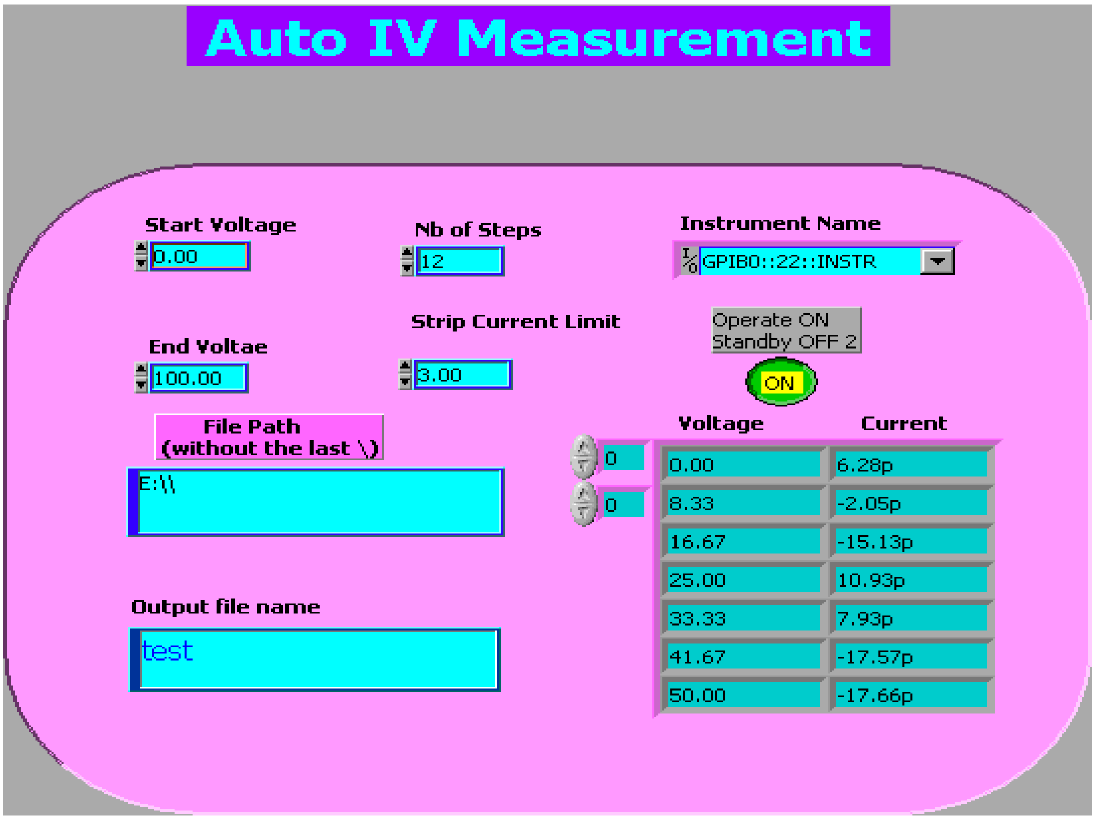
voltage to zero and abort the program's execution Else repeat the process for next voltages.

6. Save the value of voltage and corresponding measured current in a file
7. Plot the VI characteristics in graph and display values in an array
8. Step down instrument's voltage to zero.

C. ***List of subVIs***

In order to complete the processing this virtual instrument will be divided into many sub Vis. Hierarchy of VIs is shown in figure 5. List of these sub VIs along with their functions is given below:

- Find First Error1.vi: Tests the error status of one or more low-level functions or subVIs that produces a numeric error code as output.
- Open_Create_ReplaceFile1.vi: Opens an existing file, creates a



Auto IV Measurement

Start Voltage: 0.00
Nb of Steps: 12
Instrument Name: GPIB0::22::INSTR
Strip Current Limit: 3.00
End Voltae: 100.00
Operate ON Standby OFF 2: ON
File Path (without the last \): E:\\
Output file name: test

	Voltage	Current
0	0.00	6.28p
0	8.33	-2.05p
	16.67	-15.13p
	25.00	10.93p
	33.33	7.93p
	41.67	-17.57p
	50.00	-17.66p

Figure 4: 6487 Front Panel user interface for Plotting VI characteristics of silicon detector

New file or replaces an existing file, programmatically or interactively using a file dialog box.

- Write File1+ (string).vi: Write a string of characters to a byte stream file at a specified location; the default location is at the end of file. The VI does incoming and internal error checking and does not write if an incoming error occurs.
- V-RAMP-64871.vi: Passes the given voltage to instrument.
- 6487 -read-1CHNL1.vi: This VI reads the measured current from instrument
- XY Chart Buffer_new.vi: This reentrant VI uses an XY graph to mimic the behavior of an XY chart, in that it plots a stipulated amount of the most recently acquired data points. The chart data is stored in a static local variable of the output XY chart indicator.
- I-allStrip-pA@V12.vi: This VI plots the measured current in a graph at each of given voltage.

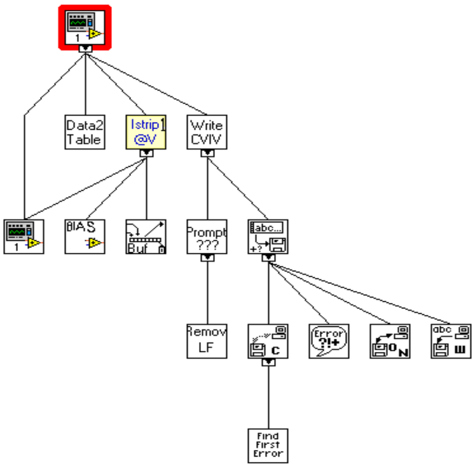


Figure 5: Hierarchy of VIs.

IV. OUTPUT DISPLAY

In this program output comes in two forms, one as a graph display and another as a data saved in a notepad file. For displaying output as a graph subVI I-allStrip-pA@V12.vi is used. I-allStrip-Pane VI will plots the measured current in a graph at each of given voltage. This VI takes Bias voltage control, number of steps and step number as a input and display strip current, strip current exceed limit as a output. The connector pane of this Sub-VI is shown in figure 6.

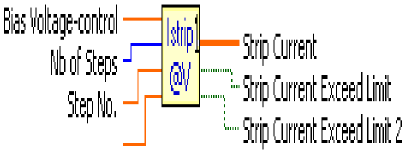
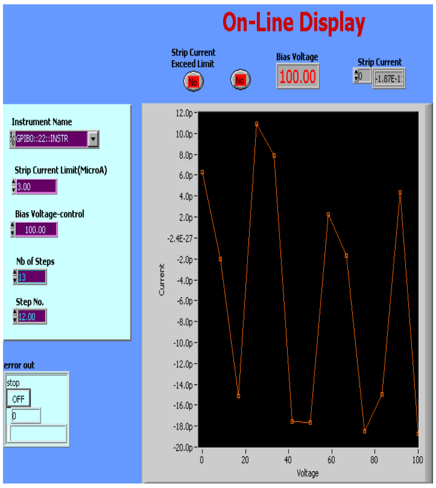


Figure 6: Connector Pane

This sub VI is directly connected to main VI and gets the input from main VI. When all inputs are passed, this subVI plots a graph for measured current at each step of given voltage. This on line display graph is shown in figure 7.


On-Line Display

Strip Current Exceed Limit: No

No

Bias Voltage: 100.00

Strip Current: 0 -1.87E-1

Instrument Name: GPIB0::22::INSTR

Strip Current Limit(MicroA): 3.00

Bias Voltage-control: 100.00

Nb of Steps: 13

Step No.: 12.00

error out

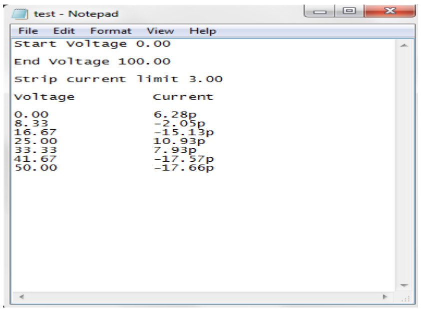
stop: OFF

0

Figure 7: Online graph display

At the same time this voltage and corresponding measured current is also saved in a notepad file. File location and name is specified by user at the time of executing this program. Output stored for this program is shown below:

At the same time this voltage and corresponding measured current is also saved in a notepad file. File location and name is specified by user at the time of executing this program. Output stored for this program is shown below:



```
Start Voltage 0.00

End Voltage 100.00

Strip current limit 3.00

Voltage             Current

0.00                6.28p
8.33                -2.05p
16.67               -15.13p
25.00               10.93p
33.33               7.93p
41.67               -17.57p
50.00               -17.66p
```

V. CONCLUSION

LabVIEW is a wonderful tool to initiate a simple approach to evaluate VI characteristics of semiconductor devices. The software has a high potential for the analysis of device characteristics and displaying output. The uses of the built-in functions of LabVIEW help to test basic of these devices. Online graph display is one of the advantage over normal output. In this paper, a PC-based virtual instrument (VI) that has been developed for plotting VI characteristics of silicon detector using a high resolution bus-programmable (RS-232 and IEEE-488) picoammeter(model 6487) is demonstrated. Measured current for each voltage step is displayed in the form of graph and notepad output.

VI. FUTURE SCOPE

In this paper we have used one 6487 picoammeter is used to test VI characteristics of a silicon detector. VI characteristics of a transistor also can be tested using two 6487 picoammeter. For that we have to provide two voltages as gate voltage and drain voltage and corresponding current can be measured.

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