CURVE TRACER USING MICROCONTROLLER

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Special dedication to my beloved parents, Ahmat Tahir Bin Ismail and Faezah Binti Musran, my siblings, my friend Amar „Asif, and all my dearest friends and my kind hearted supervisor Professor Abdul Hamid Bin Hamidon .

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ABSTRACT

This project is to design a semiconductor characteristic curve tracer using microcontroller. General purpose microcontroller as they are called is a very handy computer-on-chip that can be used to simplify digital design. A curve tracer requires a sawtooth and a staircase waveform to trace the characteristic curves of a semiconductor device on an LCD or oscilloscope screen. The microcontroller simplifies the design of these required waveform. Thus, using a microcontroller programming developed in arduino a cheap, portable and reliable curve tracer can be developed.

The curve tracer is a useful tool for looking at semiconductor characteristic and obtain their parameters. Curve tracer are useful for technician for detecting good and suitable devices for circuit design. The microcontroller used is ATmega2560 and software is based on arduino.

ABSTRAK

Projek ini bertujuan untuk mereka penyurih lengkung cirian semikonduktor menggunakan mikropengawal. Mikropengawal tujuan umum merupakan sebuah komputer di cip yang boleh digunakan untuk memudahkan reka bentuk digital. Penyurih lengkung memerlukan gelombang gerigi dan gelombang tangga untuk mengesan lengkung ciri satu peranti semikonduktor di LCD atau di skrin osiloskop. Mikropengawal memudahkan reka bentuk gelombang tersebut. Oleh itu, menggunakan pengaturcaraan mikropengawal yang dibangunkan dalam arduino, satu penyurih lengkung yang murah, mudah alih dan boleh dipercayai boleh dibangunkan.

Penyurih lengkung ialah satu alat yang berguna untuk melihat cirian semikonduktor dan mendapatkan parameter mereka. Penyurih lengkung berguna untuk juruteknik untuk mengesan komponenyang baik dan sesuai untuk rekabentuk litar. Mikropengawal yang digunakan ialah ATmega2560 dan perisian berdasarkan kepada arduino.

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LIST OF ABBREVIATIONS

PCB	-	Printed Circuit Board
RF	-	Radio Frequency
Rx	-	Receiver
Tx	-	Transmitter
IC	-	Integrated Circuit
LED	-	Light Emitting Diode
ADC	-	Analog Digital Converter
I/O	-	Input/ Output
RAM	-	Random Access Memory
EEPROM	-	Electrically Erasable Programmable Read-Only Memory
PSM	-	Projek Sarjana Muda

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CHAPTER I

INTRODUCTION

This chapter is a brief about the introduction of the project. It states the purpose, objective of the project. The scope of project, problem statements and advantages to be acquired from the project is also mentioned.

1.1 Introduction of the project

A semiconductor curve tracer is a specialised piece of electronic test equipment used to analyse the characteristics of discrete semiconductor devices such as diodes, BJT, FETs and thyristors. The device contains voltage and current sources that can be used to stimulate the device under test (DUT) and display the characteristic curve on an oscilloscope.

The basic operating principle of the device is to apply a swept (automatically varying) voltage to the main terminals of the DUT while measuring the amount of current that the device permits to flow. This so-called V-I (voltage versus current) graph is displayed on an oscilloscope screen. The operator can control the maximum amount of voltage applied to the device, the polarity of the voltage applied (including the automatic application of both positive and negative polarities), and the load resistance inserted in series with the device.

For two terminal devices (such as diodes and DIACs), this is sufficient to fully characterize the device. The curve tracer can display all of the interesting parameters such as the diode's forward voltage, reverse leakage current, reverse breakdown voltage, and so on. For triggerable devices such as DIACs, the forward and reverse trigger voltages will be clearly displayed. The discontinuity caused by negative resistance devices (such as tunnel diodes) can also be seen. The main terminal voltage can often be swept up to several thousand volts with load currents of tens of amps available at lower voltages. Three-terminal devices require an additional connection; this is usually supplied from a stepped voltage or current source attached to the control terminal of the DUT. By sweeping through the full range of main terminal voltages with each step of the control signal, a family of V-I curves can be generated. This family of curves makes it very easy to determine the gain of a transistor or the trigger voltage of a thyristor or TRIAC. For most devices, a stepped current is used. For field effect transistors (FET), a stepped voltage is used instead.

Curve tracers usually contain convenient connection arrangements for two- or three-terminal DUTs, often in the form of sockets arranged to allow the plugging-in of the various common packages used for transistors and diodes. Most curve tracers also allow the simultaneous connection of two DUTs; in this way, two DUTs can be "matched" for optimum performance in circuits (such as differential amplifiers) which depend upon the close matching of device parameters. This can be seen in the image to the right where a toggle switch allows the rapid switching between the DUT on the left and the DUT on the right as the operator compared the respective curve families of the two devices.

I-V curves are used to characterize devices and materials through DC source-measure testing. These applications may also require calculation of resistance and the derivation of other parameters based on I-V measurements. For example, I-V data can be used to study anomalies, locate maximum or minimum curve slopes, and perform reliability analyses. A typical application is finding a semiconductor diode’s reverse bias leakage current and doing forward and reverse bias voltage sweeps and current measurements to generate its I-V curve.

The curve tracers are professional and specialized instruments. They are indispensable for the research and development of new and better electronic equipment. This means that these instruments are required for the laboratories and engineers, but also for the electronic enthusiast. With this kind of instrument the designer will get the best results ever obtained but the price of a good curve traver are very expensive, its burden to a electronic enthusiast and students. By introducing Curve Tracer Adapter using Microcontroller, it will ensure a good news to whom seeks a reliable, compact and cheaper curve tracer for equipment troubleshooting.

1.2 Problem Statement

Curve tracer, even adapters, are rather bulky and costly. In fact, good standalone curve tracers are very expensive. This are the problems that make people think twice in buying a realible curve tracer. Generally, the solutions to the problems that were carried out in this project are:

- To innovate a new form of curve tracer design
- Can be constructed at a very low cost
- Apply circuit knowledge and implement using newest technology

1.3 Objective of the Project

The objectives of this investigation are:

- To design a curve tracer using a Microcontroller
- To use the curve tracer to display semiconductor characteristic on computer and standalone display

1.4 Scope of the Project

In order to achieve the objective of the project, there are several scope had been outlined. The scope of this project includes using arduino compiler to program microcontroller ATmega2560, build hardware for the system, and interface the hardware to computer by using serial port communication and Graphic LCD. A graph of Collector to Emitter voltage versus collector current obtained by using Visual Basic 2010.

1.5 Scope of Study

The scope of study consists of review about curve tracer that available in market. The ways of the curve tracer plotting the characterization curve of semiconductor. Design a simple circuit for curve tracer. Finding a way to generate ramp and staircase waveform by using Microcontroller. Designing a program using Visual Basic to plot the graph of characterization curve of semiconductor.

CHAPTER II

LITERATURE REVIEW

In this chapter, it will discuss about the literature review which it contains the information gathered to gain knowledge and ideas in completing the project. There are several sources that have been taken as a resource such as Books, Thesis, Journal and Website.

It is included the operation of the circuit, the hardware and software which is useful in the project.

2.1 CURVE TRACER

A semiconductor tracer basically functions as a signal generator. It apply a test signal to the semiconductor under test and display the curves on a scope.

Figure 2.1: The B1505A Agilent Curve Tracer

The B1505A is the only single-box solution that can function as a curve tracer replacement due to its ability to accurately evaluate and characterize power devices at up to 3000 volts and 20 amps. It also has the ability to perform capacitance measurements at high voltage biases. For the benefit of traditional curve tracer users, the B1505A includes a curve tracer mode that combines familiar curve tracer functionality with the convenience of a PC-based instrument. The net result is improved ease of use, better data analysis and simplified data management
for the measurement of power devices and power circuitry.

2.2 B1505A Features and Benefits

A single-box solution with 3000 V/20 A capability

The B1505A is the only single box solution available today with the capability to characterize high power devices from the sub-picoamp level up to 3000 volts and 20 amps. The B1505A has separate modules that support high-current (HCSMU) and high-voltage (HVSMU). The B1505A also supports a high-power SMU (up to 1 A/200 V) and a multifrequency capacitance measurement unit (up to 5 MHz).

Accurate force/measure capability up to 3000 volts

Power devices using new materials such as SiC or GaN require higher breakdown voltage measurement capabilities than do conventional power device. In addition, there are no solutions available that can measure leakage currents at high voltage biases with sufficient resolution and accuracy. The B1505A's HVSMU supports breakdown measurements up to 3000 V, and its ability to also measure leakage currents in the sub picoamp range at 3000 V bias is far superior to existing solutions that can only measure down to the microamp level.

50 microsecond current pulse width at high current

Device self-heating due to large applied currents distorts measurement results and it is a big concern for power devices such as PMICs. Proper characterization of device on-resistance (Ron) requires high measurement accuracy and resolution, but device self-heating can completely distort this sensitive measurement. The B1505A's HCSMU can force a 20 A current pulse as narrow as 50 microseconds, which is sufficient to avoid the deleterious effects of device self-heating thereby enabling the user to perform these sensitive measurements.

Capacitance measurement at up to 3000 V bias

In order to properly evaluate the switching characteristics of power devices, it is important to measure drain-source capacitance and junction capacitance, and to extract the basic physical parameters of the device. Using a high-voltage bias-T (available from Agilent), the HVSMU and MFCMU can be used together to perform capacitance measurements at biases of up to 3000 V. This makes the B1505A the first solution in the industry capable of performing capacitance measurements at this level of voltage bias.

Quick measurement via the curve tracer mode

The B1505A software environment allows users to check device characteristics and detect device faults with the easy convenience of a curve tracer. Just like on a curve tracer, the B1505A supports rotary knob control of the independent sweep variable for intuitive and real-time evaluation of parameters such as breakdown voltage. The measurement setup information and data can be automatically stored to the B1505A's built-in hard disk drive and transferred to USB memory sticks as well as other portable storage devices. It is also easy to print graphical measurement data and to copy and paste it into reports when the analysis results are summarized.

Easy-to-use Windows PC-based

EasyEXPERT software incorporates data management functions The B1505A, which uses the same PC-based EasyEXPERT software as Agilent's popular B1500A Semiconductor Device Analyzer, allows users to get measurement results quickly and easily. Device parameters can be automatically analyzed using the auto-analysis function and displayed on the screen when the measurement is done. Application tests for power device characterization are also included with the EasyEXPERT software.

On-wafer testing and prober control

On-wafer power device testing faces many obstacles. The need to disable interlock in order to connect cables from equipment to the wafer prober creates many safety concerns. It is also highly desirable that the measurement instrument have a prober driver to permit automated testing in conjunction with the on-wafer measurements. The B1505A provides both a standard cable and interlock mechanism (to permit safe prober connections) and driver support for a variety of semiautomatic wafer probers. These features make it possible to replace time consuming packaged device testing with safe and efficient on-wafer testing, thereby drastically reducing the TAT (turnaround- time) and decreasing overall cost.