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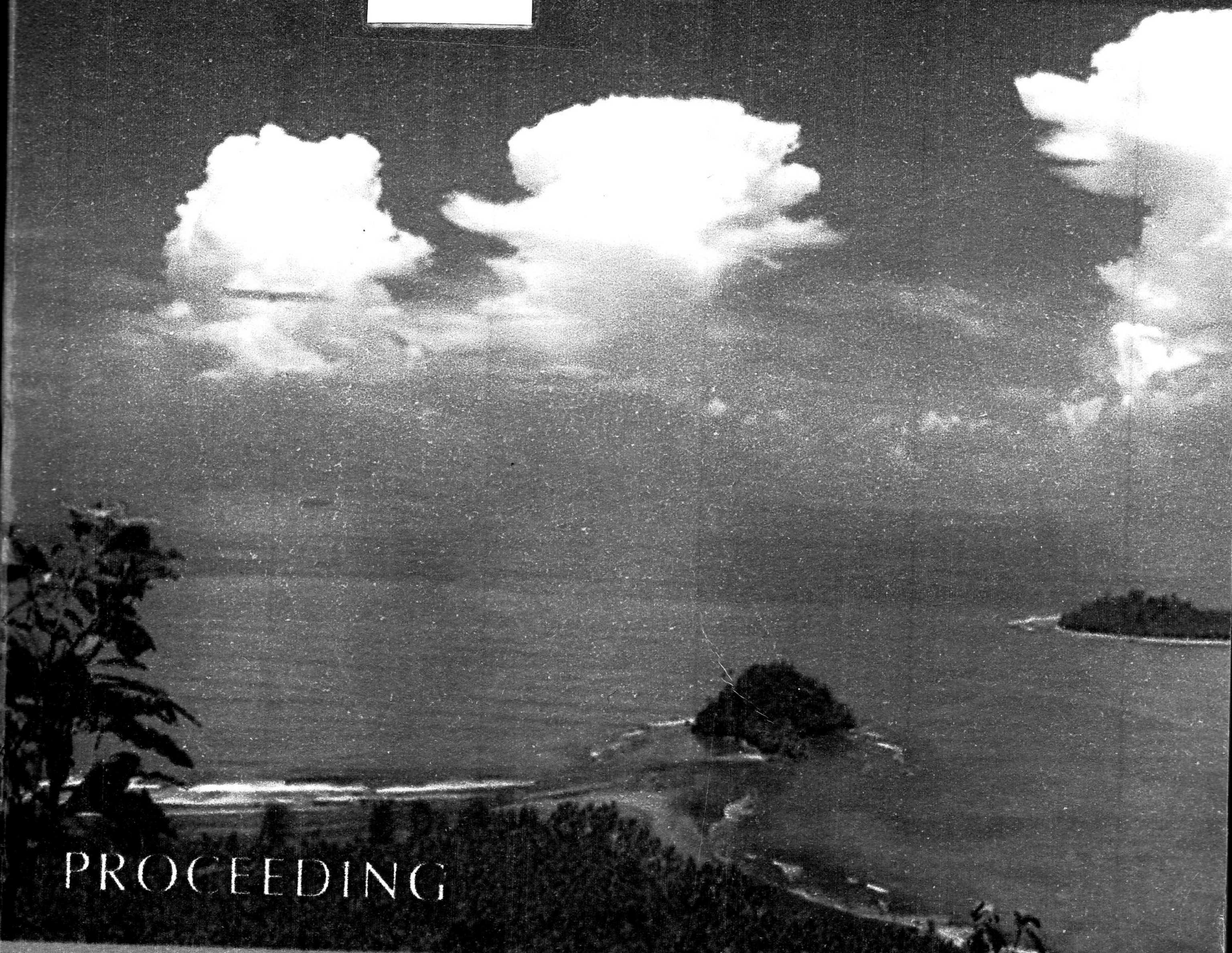

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An AT89S52 Microcontroller-Based Tool for Characterizing Light Emitting Diodes (LEDs)

Dedy Hamdani
Physics Education of Faculty of Teacher Training and Education
University of Bengkulu
Jalan W.R Supratman, Bengkulu, Indonesia
E-mail: dedyham@yahoo.com

Abstract

A tool for characterizing light emitting diodes (LEDs) was made by using an AT89S52 microcontroller, an Analog to Digital Converter (ADC) ADS7822 and a Digital to Analog Converter (DAC) MCP4921. Characterization of LED, which means to obtain I-V curve of the LED, can be performed by applying current to the LED and measure the voltage from the LED. An LED is a p-n junction diode that can emit light when its threshold voltage, where the current raises rapidly, is given. The characterization of red, orange, yellow, green and blue LEDs are displayed in this paper and it is found that the threshold voltages for each LEDs were 1.54, 1.43, 1.54, 1.60 and 2.26 V respectively. Therefore, the tool can be used in learning process for physics undergraduate students.

Keywords: AT89S52 microcontroller, light emitting diode, threshold voltage

1. Introduction

Electronics is one of the compulsory courses that must be taken by undergraduate students in physics study program of Faculty of Teacher Training and Education at University of Bengkulu. This course gives a good understanding in characterizing LED as a kind of electronic components and measuring its threshold voltage. The characterization of the LED can be performed by applying current to the LED and measure the voltage from the LED. In order to conform the competence standard of the course, it is needed to design and produce a tool for characterizing LED.

In this research, the tool is designed to produce the voltage from 0V through 9.6 V, and current from 10 μA to 7 mA. An Atmel AT89S52 microcontroller [1], an ADS7822 analog to digital converter (ADC) [2] and an MCP4921 digital to analog converter (DAC) [3] are used to produce the tool. The tool was used to characterize red, orange, yellow, green and blue LEDs. The characterization of those LEDs are shown in this paper. The treshold voltage for the LED is determined when the LED emits light for the first time.

2. Theory

An LED consists of two regions known as p- (with hole as majority carrier) and n-types (with electron as majority carrier) as seen in Fig. 2.1. If a forward bias is applied to the LED, electrons in the conduction band at the n region and holes in the valence band at the p region

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will have sufficient energy to across to the junction. In the junction, electrons and holes will recombine and emit photon with energy [4]

$$E = h\nu = \frac{hc}{\lambda}, \qquad (2.1)$$

where h is Planck's constant (6,626 x 10^{-34} J.s), c is speed of light in vacuum, ν and λ are frequency and wavelength of the photon, respectively.

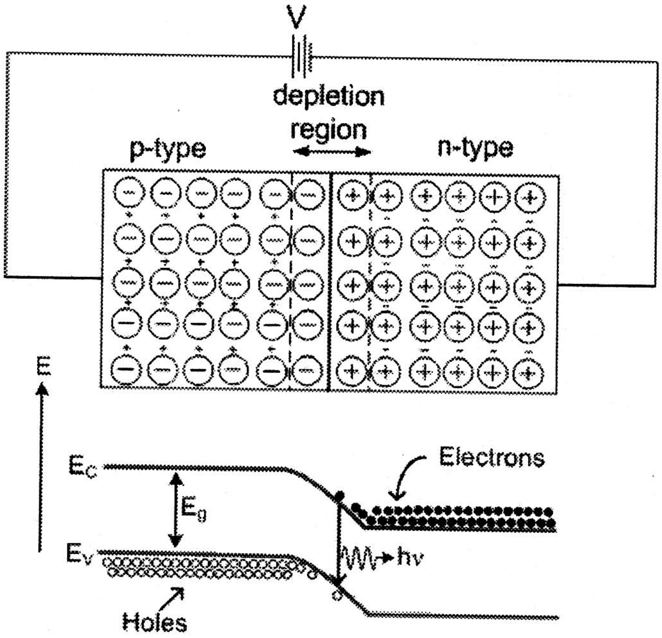

Figure 2.1. Recombination process of electrons and holes
in the junction.

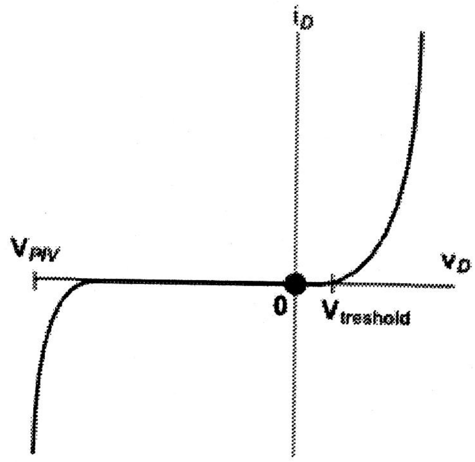

Figure 2.2 Characteristic curve of LED.

The current-voltage curve (I-V curve) of the LED is shown in fig. 2.2 [5]. While there is no external voltage given to the LED, $V_D = 0$, is applied to the LED, the LED current will be zero, $I_D = 0$. If a forward bias is applied, $V_D > 0$, the LED current initially has $I_D = 0$. When the forward bias equals to the treshold voltage, $V_D = V_{treshold}$, the current raises rapidly to the bias applied. If reverse biased, $V_D < 0$, is applied, the LED current is very small. When peak inverse voltage (PIV) is aplied, the LED current will drop rapidly.

3. Methodology

Figure 3.1 shows the diagram block of characterization system of LEDs, which comprises a computer, an electrometer, an RS232 serial interface, and an LED as the device to be characterized. The electrometer consists of a programmable voltage source and a current meter. The programmable voltage source is built from an Atmel AT89S52 microcontroller, an MCP4921 digital to analog converter (DAC), and a signal conditioning circuit, while the

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current meter includes a current (I) to voltage (V) converter, an ADS7822 analog to digital converter (ADC), and an LCD display. The computer is used as a main control to drive the overall system. It is also used to process and store measurement data. The communication between the computer and the microcontroller is using the RS232 serial interface.

The microcontroller is used to control the measurement system under the computer supervision. In order to provide an analog voltage, the microcontroller gives a digital value to the DAC and signal conditioning circuit. The analog voltage is displayed by the LCD and used to bias the LED. The current flowing through the LED is read by the I to V converter and is converted by the ADC so that the current value can be stored into the microcontroller and displayed on the LCD.

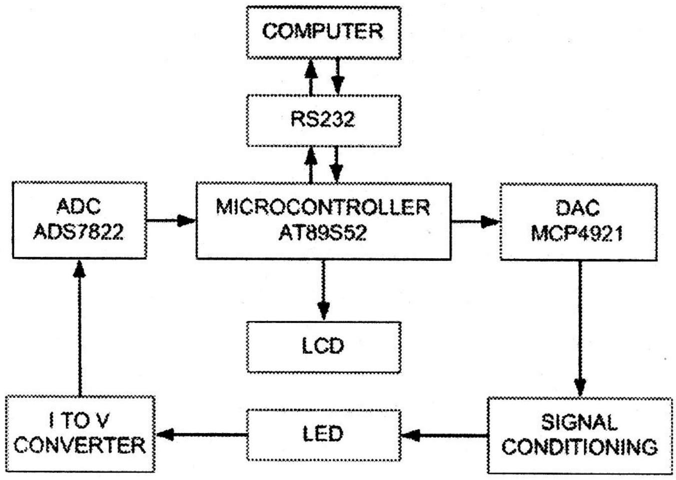

Figure 3.1. Diagram block of a characterization system of an LED.

The flowchart of the characterization program is depicted in Fig. 3.2. The program starts with initialization of serial, LCD and calculation parameters. The microcontroller awaits data transmitted by the computer. After it received the data, the data will be sent to the DAC and the conditioning circuit to provide an analog voltage. The analog voltage is then fed to the LED so that there is a current that passes through it. Next, the microcontroller will read digital data, which is the output of the I to V converter and ADC. Finally, the microcontroller saves the measured current and the applied voltage and displays them to the LCD.

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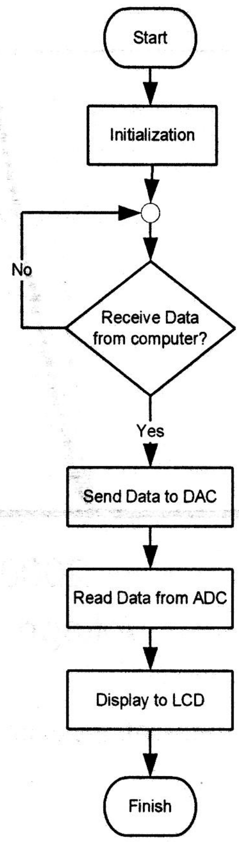

Figure 3.2. Flowchart of characterization program.

4. Results and Discussion

Five LEDs with various colors, which are red (λ= 700 nm) orange (620 nm), yellow (585 nm), green (565 nm) and blue (470 nm), were characterized. The I-V curves of the LEDs are shown in Fig 4.1. The threshold voltage for each LED determined when the LED emits light for the first time. It was found that the threshold voltages are 1.54, 1.43, 1.54, 1.60 and 2.26 V for the red, orange, yellow, green and blue LEDs, respectively.

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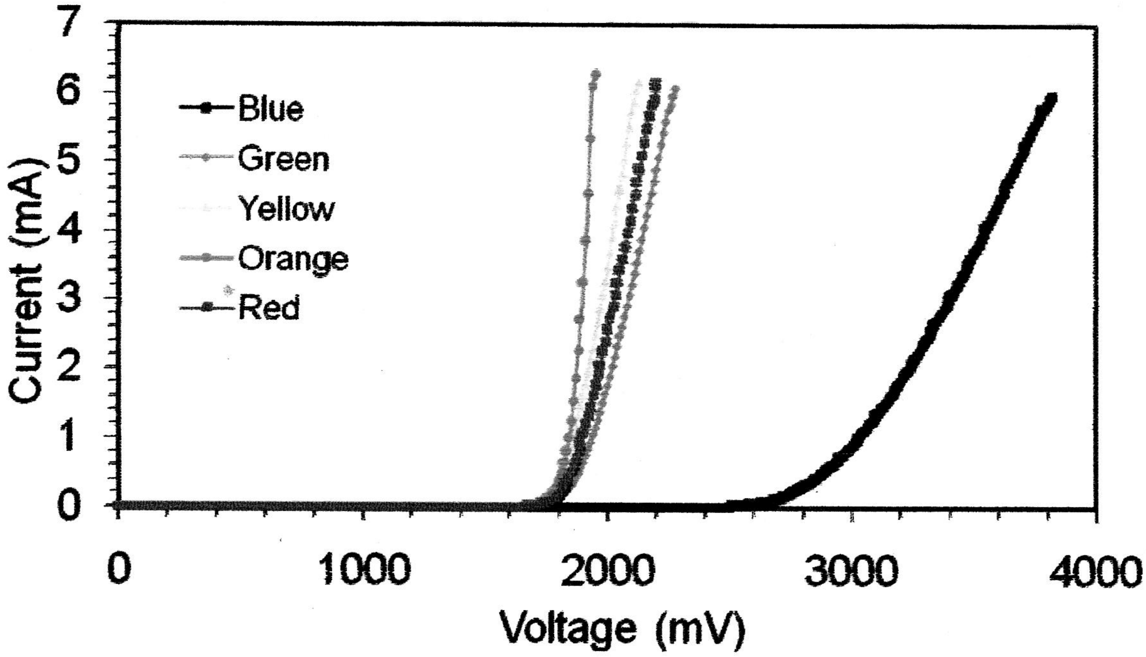

Figure 4.1 Current-voltage characteristics of LEDs.

5. Conclusion

It has been designed and implemented a tool for characterizing LEDs. The tool was implemented by using an Atmel AT89S52 microcontroller, an ADS7822 analog to digital converter (ADC) and an MCP4921 digital to analog converter (DAC). The tool was used to characterize red, orange, yellow, green and blue LEDs. It was obtained that the threshold voltages are 1.59, 1.57, 1.60, and 2.40 V for orange (λ =620 nm), yellow (585 nm), green (565 nm) and blue (470 nm) LEDs, respectively.

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