Pseudo-Laboratory Project Write-up: Design of an LED Display Driver

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***Abstract*-This report describes experiments to characterize an LED and a display driver circuit for the LED. The LED is found to have a turn-on voltage of approximately 1.4 V, and the driver circuit uses a 330 Ω resistor with a 12 V source.**

I. Introduction

LED's are ubiquitous in modern electronic equipment from thumb drives to automobiles. Schokley's law [1] describes diodes of many types, including LED's:

$$i = I_s\left(e^{v/V_T} - 1\right) \tag{1}$$

where

i	≡	current through diode in Amps
v	≡	voltage across diode in Volts
I_s	≡	reverse saturation current in Amps
V_T	≡	thermal voltage = kT/q in Volts ≈ 26 mV at room temperature
k	≡	Boltzmann constant = $1.38 \cdot 10^{-23}$ J/°K
T	≡	temperature °K (293 °K = 68°F, 300°K = 80.6°F)
q	≡	electronic charge = $1.602 \cdot 10^{-19}$ C

When plotted as an i–v curve, Schokley's law appears to have a "knee" at a so-called "turn-on voltage". In a simple approximation to the i–v curve, a diode is treated as being non-conducting below the turn-on voltage and as a voltage drop (equal to the turn-on voltage) above the turn-on voltage. This model is adequate for design purposes and is used in this report for a driver circuit operating on a 12 V supply.

The first part of this report discusses experiments that precisely identify the parameters of the Schokley model for an LED, and the latter part of this report discusses the design of the 12 V driver circuit.

II. Linear Regression Model for LED

As described in Section C of Appendix A, an LED's voltage and current were measured with a simple experimental setup consisting of a 12 Volt power supply across a potentiometer in series with the LED. By adjusting the potentiometer, the voltage across—and current through—the LED were varied. Table I lists results measured with a digital current/voltage meter in the laboratory.

TABLE I
TYPE SIZES FOR CAMERA-READY PAPERS

voltage (V)	current (mA)
1.30	0.6
1.35	2.2
1.40	13.6
1.41	21.1

We use the data in Table I to fit a Shockley's law model (1) describing the relationship between current and voltage for diodes. Because we wish to use linear regression to find parameters for the model, we reduce (1) to a linear approximation. Our first step is to ignore the –1 term in (1).

$$i = I_s e^{v/V_T} \tag{2}$$

Our second step is to take the natural log of both sides of (2):

$$\ln(i) = \ln(I_s) + \frac{v}{V_T} \tag{3}$$

We observe that (3) has a linear form

$$\ln(i) = a_0 + a_1 v \tag{4}$$

where

$$a_0 \equiv \ln(I_s)$$
$$a_1 \equiv 1/V_T$$

The Matlab™ script "lin_reg_diode.m" in Appendix B finds the values of a_0 and a_1 that give the best fit, (in the least-squares sense), of the data in Table I to the line described by (4). Note that lin_reg_diode.m employs the Matlab™ backslash, \, operator to compute the optimal linear regression (or least-squares) fit. Fig. 1 shows the fit obtained. Table II lists the values of a_0 and a_1, as well as the values of I_S and V_T obtained from a_0 and a_1 by the following equations:

$$\ln(i) = a_0 + a_1 v \tag{5}$$

$$\ln(i) = a_0 + a_1 v \tag{6}$$

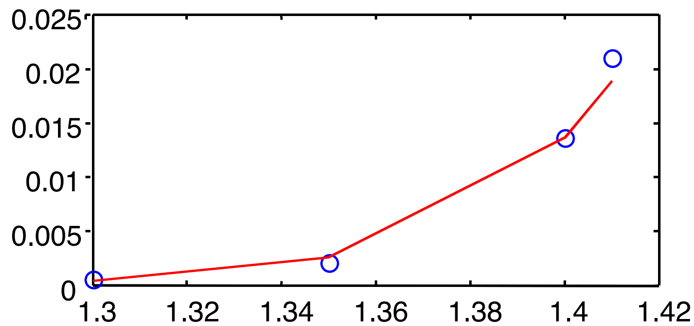

Fig. 1. Linear regression fit (solid line) to LED data (circles) in *i*-*v* format. Horizontal axis =voltage (V); vertical axis = current (A).

TABLE II

LED LINEAR REGRESSION PARAMETERS

parameter	value
a_0	0.6
a_1	2.2
I_s	2.52e-22 (A)
V_T	357 (˚K)

III. "FMINS" NONLINEAR OPTIMIZATION MODEL FOR LED

... Continue the report in the above fashion. Include figures where appropriate...

IV. LED DRIVER CIRCUIT DESIGN

... Derive the driver resistor value here. Include a circuit diagram. The last section is the Conclusion. It is a brief factual summary of your results. Appendices follow Conclusion. (I have left out Appendices. You will include appendices in your report if you have detailed items such as Matlab® code that lends itself to tabulation and would interrupt the flow of the report.) For example, you might put the lab handout, Matlab® listings, and other reference items in appendices...

V. CONCLUSION

The parameters for the LED Shockley law model, (found by linear regression and the Matlab® "fmins" function), differ slightly, (see Tables II and III). For both sets of parameters, however, we obtain nearly the same resistor value of 330 Ω for the driver circuit shown in Fig. 2.

REFERENCES

[1] M. J. Moloney, Justifying the simple diode equation, Am. J. Phys. 54, 914-916.

APPENDIX I

Title of Appendix in Bold, Centered

Appendix information, if any, goes here. Appendices should be enumerated with roman numerals. Code listings, lengthy derivations, or other material that would disrupt the flow of a paper but are essential to its content may be placed in appendices.