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DEVELOPMENT OF TRANSFER FUNCTION LIBRARY FROM ARDUINO® LIGHT SENSOR SYSTEM USING SCILAB XCOS SIMULATION

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Abstract. *The optimization and fine control of industrial process are important to improve the productivity, quality and reducing costs, considering the safety of factories and the competitiveness. The simulation processes are useful to anticipate the results of production systems used in industrial sites and to develop high fidelity control systems. The objective of this study was to find the transfer function of a light sensor (model LDR) and compare the results of this empirical equation simulated in Scilab with real results of the sensor in serial with a first order system. It was used a first order system as base to construct the empirical equation based on changes in the time constant (τ). After collection of the data with the sensor, τ was changed from 1×10^{-5} seconds to 1×10^{-1} seconds. The results shown that 1×10^{-2} seconds is the best value to represent the light sensor. It is suggested to develop another analysis with different measuring systems to find empirical transfer functions to create a databank of these instruments on Scilab to develop systems modelling for engineered applications.*

Keywords: *Arduino, simulation, process control, Scilab, Xcos.*

1. INTRODUCTION

Techniques used to identify parameters can be generally categorized into different classes, as analytical methods, numerical methods, experimental and hybrid methods. However, to minimize the difficulties of analytical method deterministic and stochastic numerical methods could be used to improve the parameters identification, minimizing the overall error between simulation and real data as cited by (Chen et al. 2016). Experimental studies are frequently a time-consuming and costly process (Zhang et al., 2017), however, computer aided simulation could be a good tool for designing and testing all types of chemical engineering processes (Vassilev-Galindo et al., 2016). In many applications it is needed to estimate the state of a dynamic system that is influenced by noises and other uncertainties (Nobahari et al., 2016). In this way, the Simplex method is a popular (Rutten et al., 2014), simple (Karimi; Siarry, 2012) and direct path to study and improve parameters of industrial systems (Da Ronco; Benini, 2013). This is an approach called “one at time” in which changing one control variable at a time holding other parameters static (Kumar et al., 2011). The method consists in tracking responses of the system caused by changes in the inputs (Xiao et al., 2014) to detect the best condition for a desired result.

Therefore, libraries of transfer functions from measurement systems are important to develop simulations and predict control systems to design real process controls. Thus, this work studied the response of a light sensor for a step function to describe the transfer function and create a library with the real data of the measurement device.

2. EXPERIMENTAL AND COMPUTATIONAL PROCEDURE

To develop the system, it was assembled in an Arduino Uno electronic board a data collection of LDR light sensor (Fig. 1) with a prototype board (protoboard). Connections were made in 5V output and ground output of Arduino board.

These connections were made for feeding the sensor. To protect the light sensor, it was used a 10 k Ω resistor in the connection with the 5V output of the Arduino board. After that, positive pole of the sensor was connected to the A0 analog input for data collection after pass through the resistor. The Arduino board was connected to the USB port of a laptop for data collection.

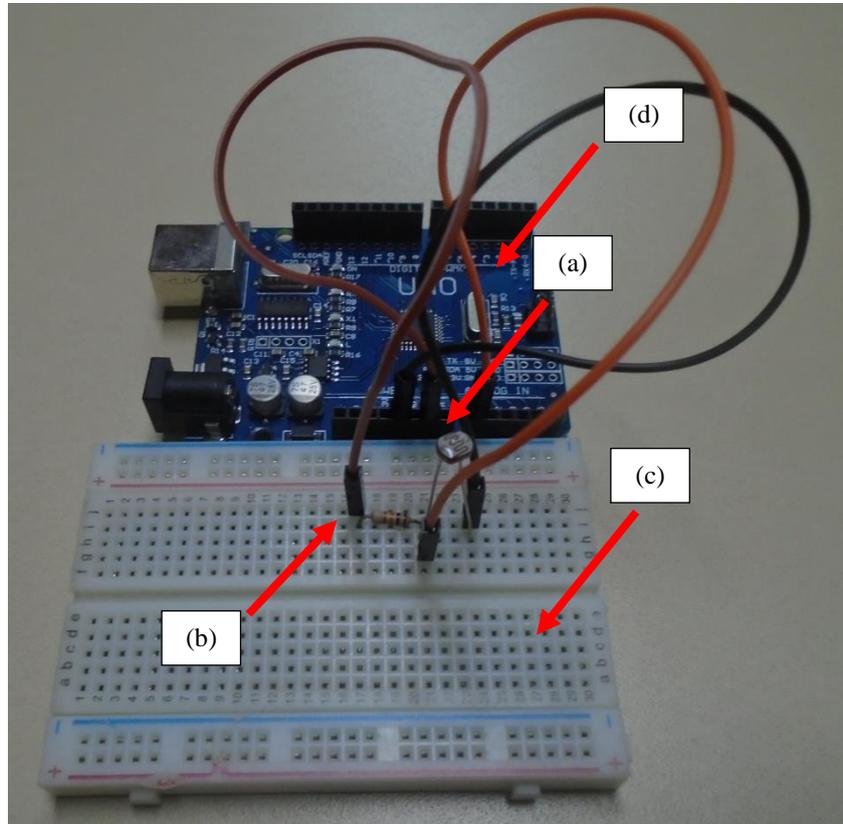


Figure 1: Prototype assembled with LDR sensor (a), 10 k Ω resistor (b) in protoboard (c) connected to an Arduino Uno board (d).

To proceed the simulation the module Xcos of Scilab free software (Scilab Enterprises) was used with the Arduino Atom module, that is a toolbox from Arduino that provides communication blocks for Xcos through serial port in Windows platform.

To analyze the transfer function from LDR sensor, variations on the time constant (τ) of a first order transfer function (Equation 1) were made from 1×10^{-4} seconds to 1×10^{-1} seconds.

$$\frac{1}{\tau \cdot s + 1} \quad (1)$$

The block diagram of the evaluated system is shown in Figure 2(a). Because the high sensitivity of the LDR sensor, a block with first order system was arranged in serial with the sensor data collection and the theoretical blocks for simulation (Figure 2b). The used blocks for set up the experiment were Analog Read, used for capturing the data from the sensor, CLR, used for transfer function definition, CSCOPE to collect and analyze the processed data and CLOCK, used to control the simulation time. All the blocks were connected to set up the real system of data collection. To develop the simulated system it was used a block of Step Function, 2 CLR blocks, used for simulating the LDR sensor and the serial transfer function to provide a delay in the reading, MUX box to aggregate the different simulations, CSCOPE and CLOCK for data collection and time control.

Simulation time was defined as 30 seconds, $y_{\min} = 500$ mV and $y_{\max} = 850$ mV. Refresh period was established as 30 seconds to avoid multiple screens of graphs. Step function was configured with step time = 10; initial value = 530 and Final Value = 830. These configurations were chosen after running a first time the real system to check the range of values. After assembling the system on Scilab, it was run the simulation to produce the data for comparison. Collected data from Scilab were analyzed with Minitab 17 software to plot the graphs. The curves were plotted in a scatterplot to show the response behavior.

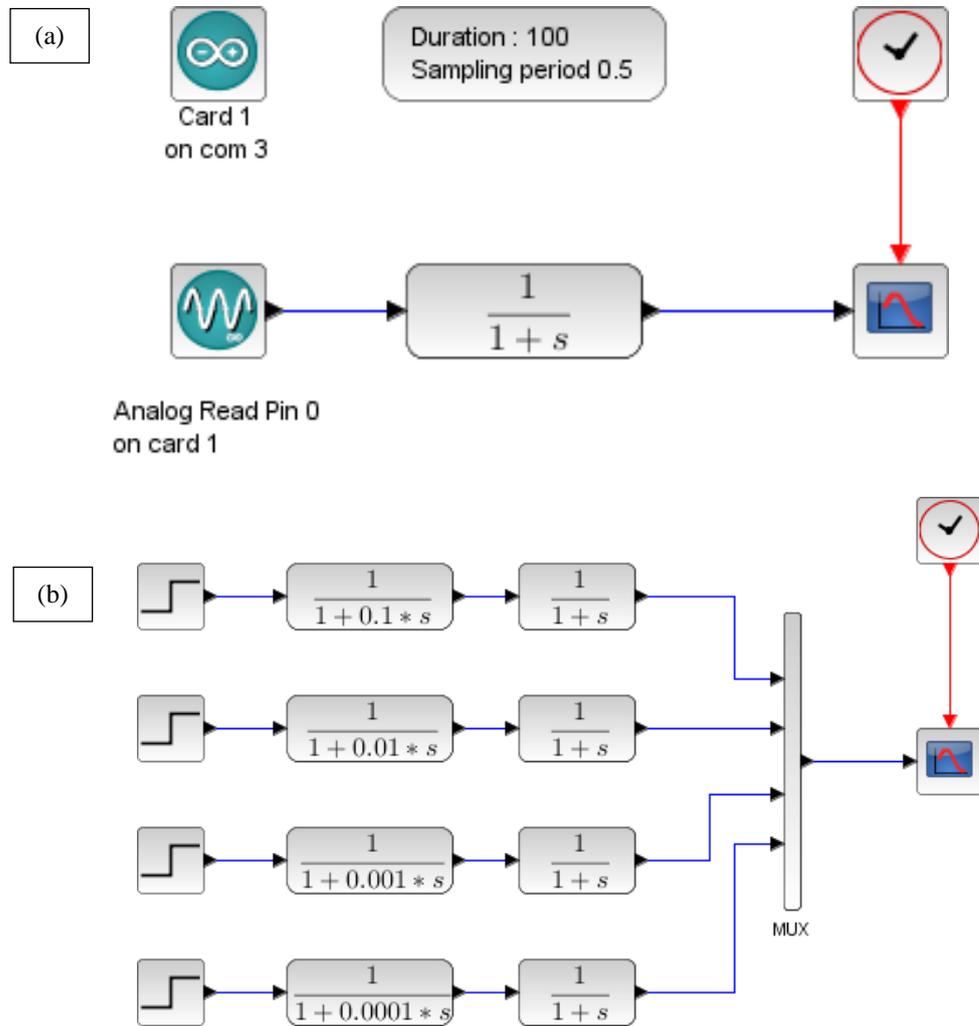


Figure 2: (a) Evaluated system a first order transfer function in serial with the LDR sensor (real system). (b) Simulation process with different values of time constant.

To select the best curve, it was calculated in MS-Excel® 2016 software the accumulated relative error comparing the real data with the simulated data. Student t-test was made to verify the differences between the real data and simulated process.

3. RESULTS AND DISCUSSION

The simulation shown that the sensor has a characteristic behaviour of first order system. The results of accumulated relative errors, p-values and correlations are shown in Table 1.

Table 1 – Accumulated relative error (ΣRE) and p-value of Student t-test from simulated curves compared with the real data from LDR sensor.

Measure	$1 \times 10^{-1} s$	$1 \times 10^{-2} s$	$1 \times 10^{-3} s$	$1 \times 10^{-4} s$
ΣRE	0.463%	0.429%	0.445%	0.463%
p-value	0.299	0.402	0.413	0.415
Correlation	0.997	0.997	0.997	0.997

All the time constant parameters showed closer values to the real data collected from the LDR sensor, with no statistic differences for 95% of confidence interval (p -value > 0.05). The curve using $\tau=1 \times 10^{-2}$ s as time constant accumulated the lower error with similar correlation with the other three situations, that increase errors in the system. It is suggested that the use of this time constant is suitable to simulate the real process. A library of this study was constructed and will be available in the project website: ctrlpq.wixsite.com/ctrlpq. All curves were plotted and shown in Figure 3.

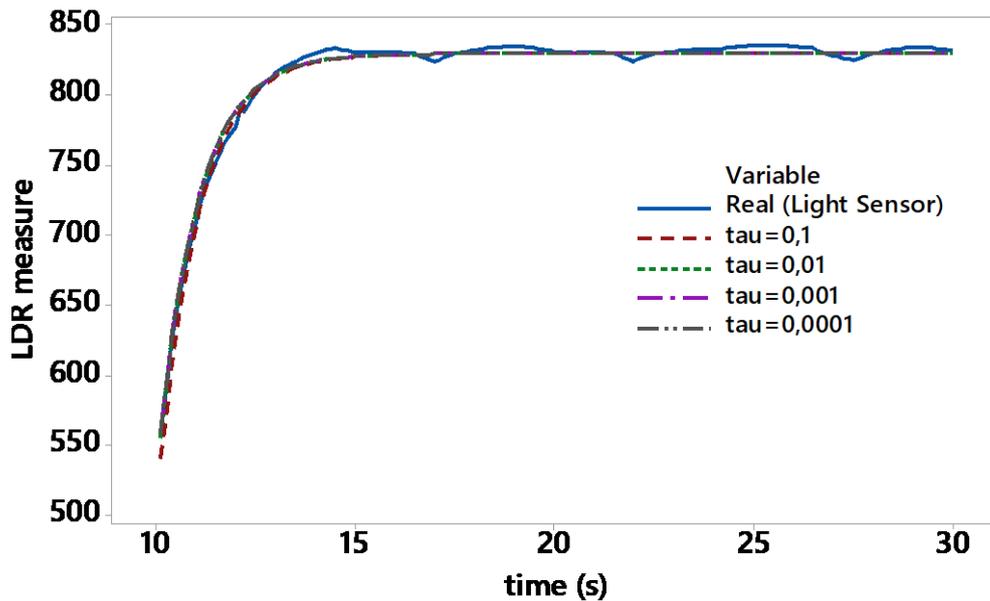


Figure 3: Real and simulated curves with different values of time constant (τ)

CONCLUSIONS

The empiric method used for simulation was suitable to develop first order libraries of measuring instruments with low accumulated error. The use of a serial system with a first order block was important to reduce the speed of response from the LDR sensor system, then it is suggested that other sensors could be evaluated in the same way. Temperature, pH, level, pressure and other sensors are important to develop industrial applications and it is important to create a complete library of these measurement devices to develop simulation of industrial processes using Scilab software.

4. ACKNOWLEDGEMENTS

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