Remote-Controlled Digital Electronics Trainer Board (RCDET)

Research · April 2020

DOI: 10.13140/RG.2.2.28602.34245

4 authors, including:

Vincent Mulwa Mutuku
South Eastern Kenya University

Mutwiri Joseph
Tharaka University College

Joshua Mwema
South Eastern Kenya University

ISSN No:-2456-2165

Remote-Controlled Digital Electronics Trainer Board (RCDET)

Vincent Mulwa[1],
Department of Physical Science, South Eastern Kenya University,Kitui,Kenya

Mutwiri Joseph[2],
Department of Computer Science and ICT, Tharaka University College, Tharaka, Kenya

Joshua M. Mwema[3]
Directorate of ICT, South Eastern Kenya University, Kitui, Kenya

Antony Gitonga[4]
Department of Physical Science, Chuka University, Chuka, Kenya

Abstract:- A remote-controlled digital electronics trainer device has been designed and implemented based on ATmega328 QFN microcontroller, logic gate integrated circuits (ICs) and an infrared (IR) detector. On the board face are light emitting diodes (LEDs) that indicate logic state of various logic inputs and outputs. A remote transmitter completes the set up and is used to send infrared signals to the receiver. This prototype presents a novel approach of designing teaching aids to help reach a larger number of learners when demonstrating certain concepts during learning sessions. The wireless control integration in the device enables a technologist or a lecturer to demonstrate to learners how logic gates respond to logic inputs by a press of button on the transmitter. Various combinations of inputs have been tested and it's been found that the board has a maximum power consumption of 1.85W. It's expected to solve the challenge of having many learners and less teaching aids especially in developing countries. The design procedure, implementation, testing and verification of the device is discussed in this paper.

Keyword:- *Remote-Controlled, Infrared, Logic Gates, Logic State, Logic Input, Logic Output, Teaching Aid.*

I. INTRODUCTION

Teaching and learning activities take different methods defined by tools used to help the learner grasp the concept. LCD projectors, interactive learning TVs, cameras, video conferencing and the internet are some of the latest teaching materials in learning arena [1]. The risen demand of education in developing countries has seen large number of students in classrooms, lecture halls and laboratories in quest for knowledge and skills. There is a need to develop teaching materials that can cater for large numbers and supplement the small sized equipment meant for use by a small group of students. It is well known that at introductory levels of science and engineering-based courses, there are usually big numbers of students taking mandatory common units in the area of digital electronics. While there is still a challenge in handling them in lecture halls, it is harder to arrange enough laboratory sessions and set ups for the students to appreciate the practical bit of the courses. Access to a subject's laboratory materials and thereof use has a strong link with performance of students in a particular subject [2]. The present work introduces an innovative way of designing laboratory training equipment by integrating wireless control with infrared signals. Infrared remote-control systems find applications in industries like consumer electronics, automation and even aerospace. Just like the way a user toggles a television set on or off, laboratory equipment can have the same capability if the technology is integrated in the design. In microprocessor or micro-controlled devices, remote control normally has the transmitting and the receiving ends. When the signal is received, it is decoded and with help of an embedded program, the right action is performed for that specific signal. This concept is captured in the current design to toggle the logic states at the inputs of logic gates using different keys on a remote transmitter.

A. Review of Common Digital Electronics Kits

Like most electronics training kits, jumper wires are used to make various connections for testing. The method in this work is not a complete replacement of the current kits but a supplementary approach for technologists and lecturers when dealing with large number of students. Checking manufacturer's catalogues, a description of some of the kits related to this development are reviewed as follows;

Tesca presents a logic gate trainer shown in Fig.1 below. The different logic gates are drawn on front testing face which emulate how the gates work through an underneath integrated circuit. The inputs to the physical gates are on the surface of the face as hole contacts where jumper wires can be connected for testing. Logic states are toggled with and indicated by onboard switches and red LEDs respectively.

Fig 1:- Tesca 38691 [3]

XL-104 shown in fig.2 and manufactured by Xeltronix features 2 AND gates, 2NOT gates, 2 EXOR gates and 1 OR gate on the board with physical contact inputs and a presumed beneath circuit. Three 14 DIP ICs three LEDs and logic switches are also embedded on top of the board representing some of the logic gates. The kit is essentially used as a half and full adder or subtractor.

Fig 2:- XL 104 Half and Full Adder/Subtractor Kit [4]

Nvis technologies is the manufacturer of the kit shown in fig. 3. The kit has provision of logic gates; AND, NAND, NOT, OR, NOR, EXOR and XOR experimentation with the inputs on the board face. Logic switches and indicators are also included on the board. The logic gates are represented by drawings and physical input ports on top of the board face. Respective logic and power circuits are embedded beneath the surface of the board.

Fig 3:- Nvis6551 Logic Gates Kit [5]

B. Previous Studies

A trainer kit named E-Logic Trainer kit was implemented using Arduino Mega, a display and a keypad to aid electrical engineering students in simulating combinational logic circuits [6]. The timing diagram for input and output was displayed on a TFT LCD screen. The 4x4 matrix keypad was used to navigate menu options between assessment and simulation mode for AND, OR, XOR, AND and NOT combinational logics. The kit got a 60% acceptance and shows its usefulness in laboratory use.

Lack of understanding practical electronics is strongly linked with the methodology used to deliver the concept [7]. The researchers implemented a logic gate trainer by emulation using Atmel 8955 microcontroller. An embedded C program was used to achieve emulation of logic gates which required enough memory, the reason why Atmel 8955 was selected. Emulation of the logic gates is a good approach as it reduces the number of physical components required to implement a multi-gate experiment as well as the duration taken.

It is important for a leaner in certain areas of science and engineering to understand how digital systems work. Meeting this need is sometimes hindered by high cost of purchasing the training equipment [8]. This motivated the researchers to design and locally fabricate a digital logic trainer for laboratory use. A patch panel, printed circuit board, logic gate integrated circuits and plug connectors were the main components used to make a logic trainer that didn't require soldering the components. Their work resulted to an improvised training module which proved to be useful in practical training at early stages of digital logic design courses.

II. MATERIALS AND METHOD

The heart of the device is an avr microcontroller unit (MCU) ATmega328PU TQFP package. It has been chosen because of its small size to minimize the size of the board and that it has several IO pins compared to its dual in line package (DIP-28). When a certain key is pressed on the infrared transmitter, a pulse train is produced and detected by the receiver if the transmitter is pointed towards the detector. The signal at the output pin of the infrared receiver is decoded by the MCU. This is accomplished through a C++ embedded program in the microcontroller which was written in Atmel Studio 7. Different signals from the transmitter are assigned different tasks in the program to toggle the outputs of certain MCU pins. Inputs to the logic gates are in turn connected to outputs of the MCU pins for detection of the logic states.

At the outputs of the logic gates are LEDs used as logic indicators. The board is powered by +5V dc source but with its onboard voltage regulator it can work with a voltage range of 6.5V-12V.A data bus carrying logic signals from the microcontroller connects it to the logic gates and logic state detector circuits.

The design process started with drawing the schematic on Proteus ISIS. Simulation of its working was done to test the idea and point out any technical problems that would emerge at hardware level. It also gave an opportunity to visualize pinout usage on the microcontroller and select the appropriate one. Using Proteus ARES for PCB layout, the schematic components footprints and connections were converted into PCB layout. The PCB size was optimized by manual placement of components on the PCB area which resulted to a 7cmx5cm board. Gerber files for manufacturing were then generated awaiting fabrication of the board.

Before the files were sent to manufacturer, circuit connections were first done on solderless and soldered prototyping circuit boards and tested following the schematic drawn in Proteus design suite.

ISSN No:-2456-2165

The functionality of the system was verified and PCB fabricated for assembly. An improvised light weight casing for the kit has been made with locally available materials to host the controller board whilst holding the logic indicators on the face of the board at designated points. The block design of the device and program flow chart are shown in the next page.

A. System Block Diagram

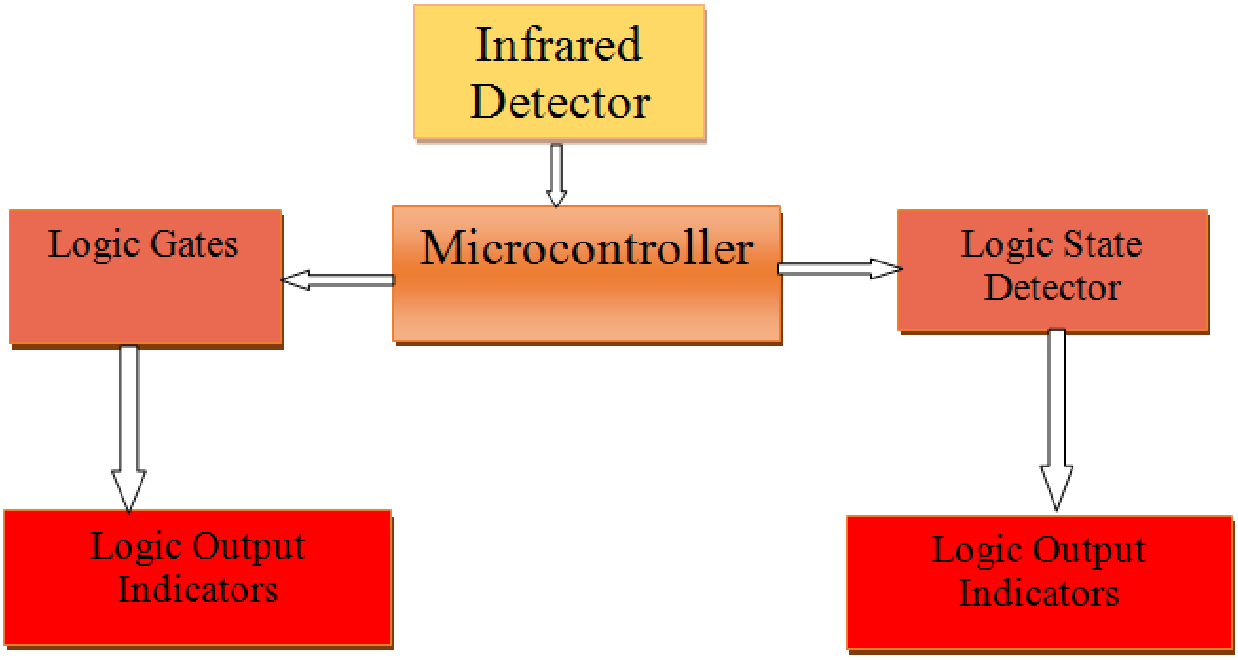

Fig 4

B. Program Flowchart

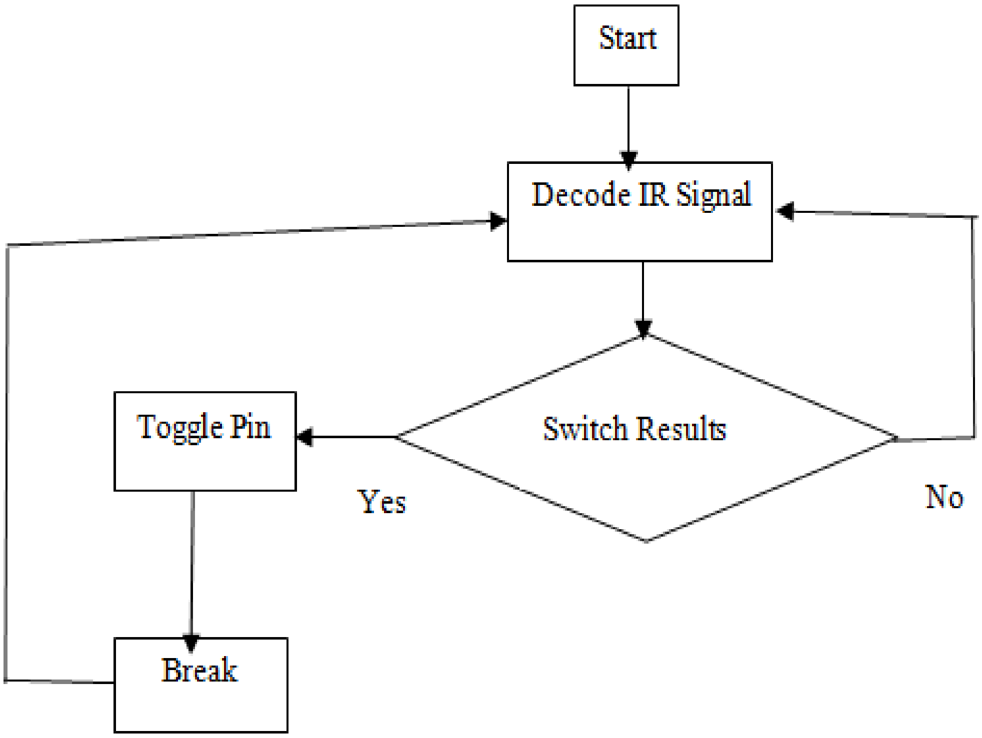

Fig 5

III. RESULTS

A prototype of a remote-controlled logic trainer has been fabricated and tested. Using different combinations of logic states at gates inputs, it has been found that the maximum power consumption of the kit is 2.2W. Fig. 6 with thirteen LEDs on, the regulated DC power source shows that at 7.5V, the device draws 0.25A consuming approximately 1.875W.

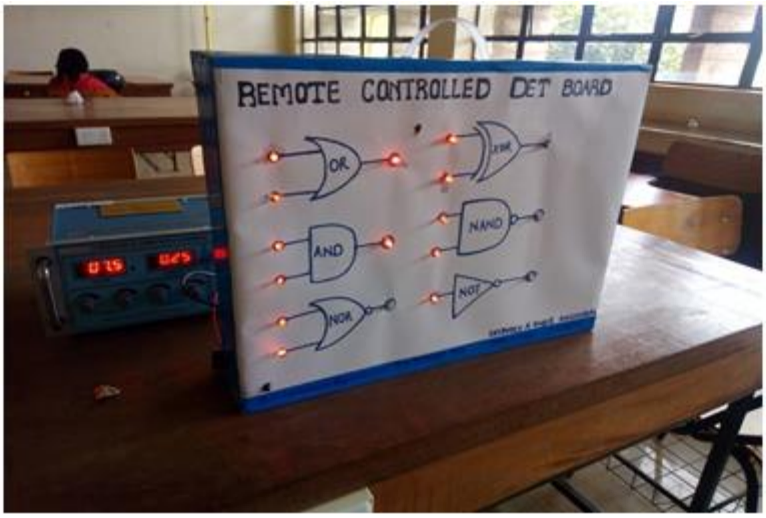

Fig 6:- RCDET on a Lab test bench

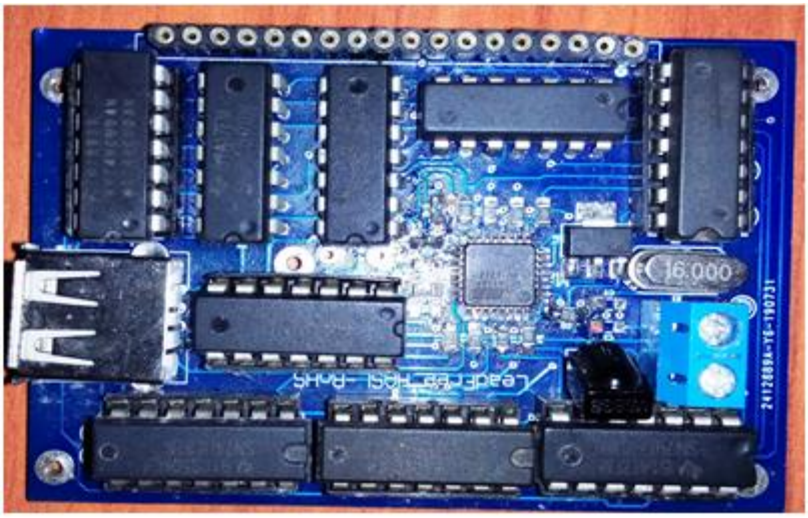

Fig 7:- RCDET Controller Board

To test the functionality of the board, data in Table 1shown below has been verified

OR			XOR	AND	NAND	NOR	NOT
A	B	Y_a	Y_b	Y_c	Y_d	Y_e	Y_f
1	1	1	1	1	0	0	0
0	1	1	0	0	1	0	1
1	0	1	0	0	1	0	0
0	0	0	1	0	1	1	1

Table 1:- Truth Tables of Logic Gates

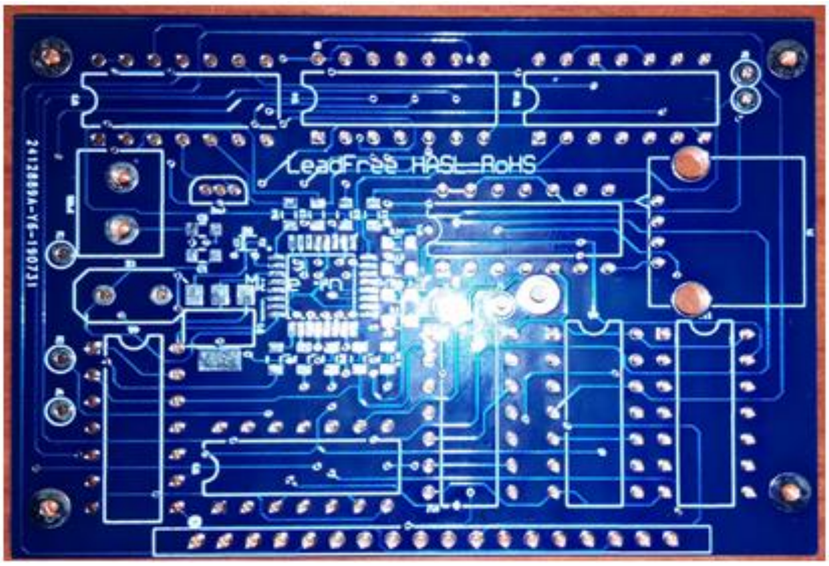

Fig 8:- PCB top view

IV. CONCLUSION

A Remote-controlled digital electronics trainer (RCDET) has been designed, its prototype fabricated, tested and found to work properly. The experimental results match the truth tables of the logic gates as shown above. This board will ease the challenge of many students crowding over one board and manually connecting the board to inputs. Every student also gets a chance to directly see the results through observations and making truth tables of the gates at the same time. Logic levels are indicated by brightly lit LEDs at the inputs and outputs. This kit does not give a learner the hands-on experience of manually connecting the logic gates to inputs an testing them. It is therefore not a replacement of the existing technology. RCDET is a supplementary kit and is recommended for use by instructors where the number of learners is overwhelming. The instructor just needs to place the board facing towards the learners on a raised bench then use remote transmitter to show how logic gates work. With this board, students can verify truth tables of logic gates in real time and though wireless transmission technology presented in this work. It is highly recommended for use in laboratories of institutions of learning where electronics courses are taught.

REFERENCES

[1]. K. Serhat, "Educational Technology: An Overview," Educational Technology, 18 November 2015. [Online]. Available: https://educationaltechnology.net/educational-technology-an-overview/. [Accessed 21 January 2020].

[2]. T. ,. Bello, "Effect of Availability and Utilization of Physics Laboratory Equipment on Students' Academic Achievement in Senior Secondary School Physics," World Journal of Education, vol. 2, no. 5, pp. 1-7, 2012.

[3]. Xeltronix, "Digital Electronic Trainer Kits," 2005. [Online]. Available: http://www.xeltronix.com/digital-electronic-trainer-kits.html. [Accessed 22 May 2019].

[4]. Tesca, "Products & Services," Tesca Technologies Private Limited, 2013. [Online]. Available: https://www.tescatech.com/digital-electronics-trainers.html. [Accessed 16 April 2019].

[5]. Nvis, "Products," Nvis Technologies Pvt. Ltd, [Online]. Available: https://www.nvistech.com/images/pdf/Nvis6551.pdf. [Accessed 11 March 2019].

[6]. Z. Mohammad, F. Z. Amar and H. Syahrul, "E-Logic Trainer Kit: Development of an Electronic Educational Simulator and Quiz Kit for Logic Gate Combinational Circuit by Using Arduino as Application," International Journal of Online and Biomedical Engineering, vol. 15, no. 14, pp. 67-77, 2019.

[7]. O. A. Ogungbenro, G. A. Chukwudebe, F. K. Opara and G. N. Ezeh, "Design and implementation of logic gate emulator," in 2017 IEEE 3rd International Conference on Electro-Technology for National Development (NIGERCON),, Owerri, Nigeria, 2017.

[8]. A. O. Ajao, K. Kadiri and O.O.Bamgboye, "Local Fabrication of Digital Logic Trainer forLaboratory Demonstration," International Journal of Science and Mathematics, vol. 2, no. 1, pp. 43-46, 2014.