

# Design a multi-purpose practice table for the digital electronics subject

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## ABSTRACT

*In this article, the author is going to present the steps to design a multi-purpose practice table for the digital electronics subject, this practice table is used for students to practice the contents of the digital electronic subject. Besides, the author also introduces the exercises written on this practice table. With each exercise, students will complete the steps to design a digital electronic circuit, including Ideation, state table, write and minimization Karnaugh map, writing state equations and building Build electronic circuits from logic elements and design real circuits on the practice table.*

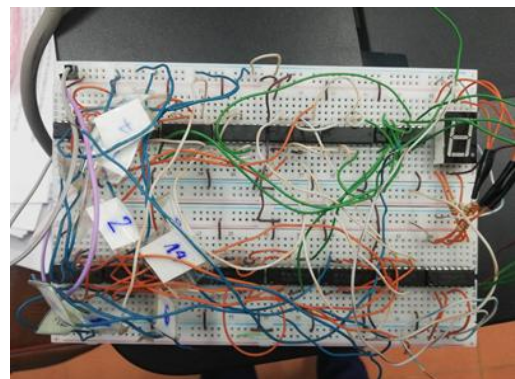
**Keywords:** Multi board, Digital electronic engineering, IC logic, Logic elements, Digital electronics practice.

## 1. INTRODUCTION

Digital electronics engineering is one of the compulsory subjects for all students in the electrical, electronics majors. This course is an introduction to counters; Boolean algebra; minimalist technique; basic logic gates; design techniques for sequential and combinational logic circuits, that knowledge is the basis for representing problems in fact into simple logic functions and implementing problems based on logic gates, based on hardware descriptions language. This course also introduces how to design some common combinational logic circuits in practice such as arithmetic logic circuits, encoders, decoders, demux circuits, mux circuits, counters, shift registers,

memory. Besides, the course also introduces AD/DA conversion methods to provide methods to solve electronic problems in both analog and digital directions [1-4].

In parallel with learning theory, the subject of digital electronics also requires students to practice designing logic circuits according to the given requirements using logic ICs. One of the simple methods to be able to practice logic circuit design is to use logic ICs in combination with test boards [5]. This option is simple and cheap, but it cannot be used in practice with many ICs because of the large number of wires connected, and the difficulty to test the circuit.



**Fig 1: Practice designing logic circuits using Board test**

To increase professionalism and make practice easier, people design practice tables containing logic ICs, then students will practice on these practice tables [6], [7]. However, the practice tables are very simple, few logic ICs and not many varieties. Therefore, it is necessary to design a practice table that contains all the logic ICs in the digital electronic engineering subject, a

variety of logic ICs and easy to manipulate when practicing.

In this article, we propose the design of a multi-purpose practice table for the digital electronics subject. The article is divided into 6 parts: (1) Introduction; (2) Design solutions for practice tables; (3) Detailed introduction of the practice table; (4) Designing exercises on the multi-purpose practice table for the digital electronic engineering subject; (5) Results and discussion; (6) Conclusion.

## 2. PRACTICE TABLE DESIGN SOLUTIONS

### 2.1 Design idea

In order for students to practice for the Digital Electronic subject, the practical desk must meet the following design requirements:

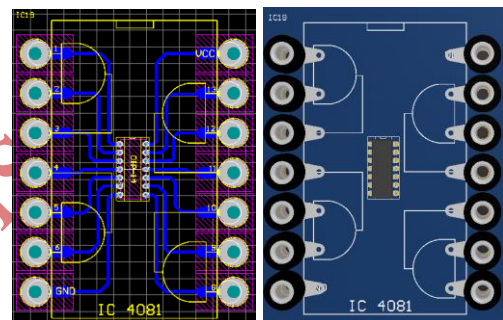
- Contains all logic ICs (containing logic elements) taught in the digital electronics course.
- ICs include TTL logic families and CMOS families.
- Available logic inputs, square pulse generator circuits.
- Led, seven-segment display outputs available.
- Power connection points are available on the practice table to easily connect the IC's power to the power supply.
- Connecting between pins of logic ICs is easy.
- Capable of expansion, allowing additional ICs when needed.

### 2.2 Design Solutions

To satisfy the design criteria in Section 2.1, the author offers the following solution:

- With each logic IC integrated on the practice table, because the actual distance between the

pins of the logic IC is small (usually 2.54 mm), it is difficult to perform operations, so the author will connect the pins of the IC to the connection points (using banana connectors). In figure 2, IC 4081 has 14 pins connected to a 2mm type banana connector. In order for students to easily connect, the logic ICs will be pin-ordered or drawn the symbol according to the datasheet of that IC [8]. In the practice table, there are always ICs with the same features but designed by TLL or CMOS technology, for example, AND ICs include IC 4081 and IC 74LS08, OR logic ICs include: IC 4071 and IC 74LS32...



**Fig 2: Logic IC image on the practice table: (a) connection diagram, (b) 3D image.**

- To easily connect between ICs, the author uses 2mm type banana connectors (Figure 3) [9] and the connection wires are already available with connection wires of different lengths: 20cm, 30cm, 50cm...(Figure 4) [10].

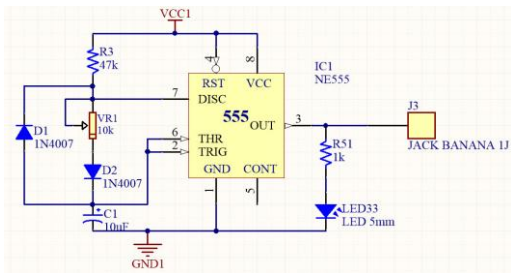


**Fig 3: The 2mm banana connector image**



**Fig 4: Connection wire image**

- Pulse generator circuits using op-amp ICs and 555 ICs are used. Figure 4 is the schematic diagram of the pulse generator circuit using IC 555.



**Fig 5: Circuit diagram of pulse generator using IC 555**

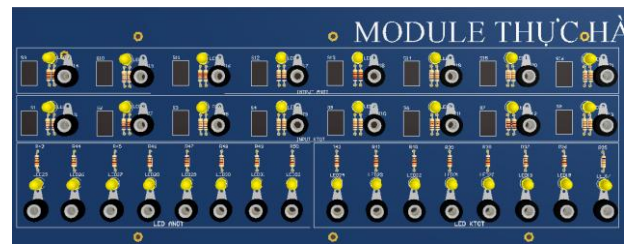
### 3. INTRODUCTION TO PRACTICE

#### TABLE IN DETAILS

Based on design ideas and solutions, the author used Altium Designer software to design the board before performing the actual circuit design and assembling the practice table. The multi-purpose practice table for digital electronics subject includes the following basic components:

#### 3.1 Input and output modules

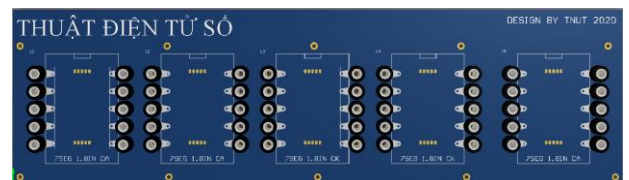
Containing 8 Anode (INPUT ANOT) and 8 Katot (INPUT KTOT) inputs, they help us to convention the input variables of logic circuits. In addition, this module also contains 8 Common Anode Output Leds (ANOT LED) and 8 Common Katot Output Leds (KTOT LED) used to convention the output functions of logic circuits as shown in Figure 6.



**Fig 6: 3D Module Input, Output image**

#### 3.2 Seven-segment display module

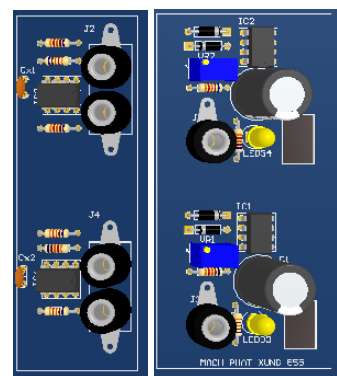
Contains available 7-segment display including 2 types of common Anode (CA) and common Katot (CK) for students to perform practical exercises in designing 7-segment decoders, counters, adders and subtractors.



**Fig 7: 3D image of 7-segment module**

#### 3.3 Pulse generator circuit module

Contains 02 pulse generator circuits using op-amp IC and 02 pulse generator circuits using IC 555 for the purpose of creating Clock pulses for counter design circuits.



**Fig 8: 3D image of the pulse generator circuit module**

#### 3.4 Basic logic IC elements module

Contains basic logic ICs, which are AND, OR, NOT, NAND, NOR, Different Sign and Same Sign of 2 families of TTL and CMOS Ics.

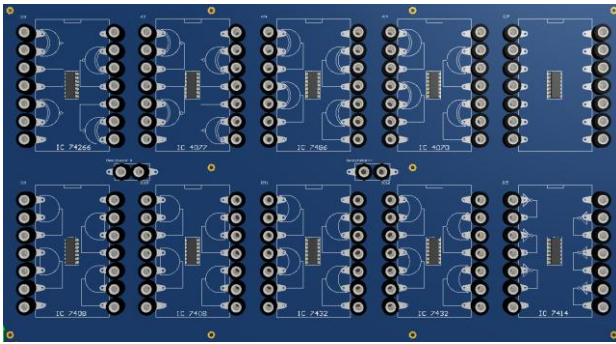


Fig 9: 3D image of the basic logic elements module

### 3.5 Dedicated ICs modules

The circuit is available with dedicated ICs used to design counters such as IC 74LS73 (JK trigger), IC 74LS90, 74LS193; Dedicated IC to design Demux, Mux circuits such as IC4051, IC74LS151; Dedicated IC to design adder such as IC 74LS138; Dedicated IC to design 7-segment decoding circuit such as IC 74LS47, IC 4511; Dedicated IC to design code converters such as IC 74LS138, IC74LS164....



Fig 10: Some dedicated ICs image

### 3.6 Expansion Ics modules

In addition to the practice table that contains the ICs introduced above, on the practice table there are also DIP 14, DIP16, and DIP18 feet to allow plugging in additional expansion ICs that are not available on the table. practice. In addition, there is space on the practice table to allow connection to external circuits or VHDL practice modules.

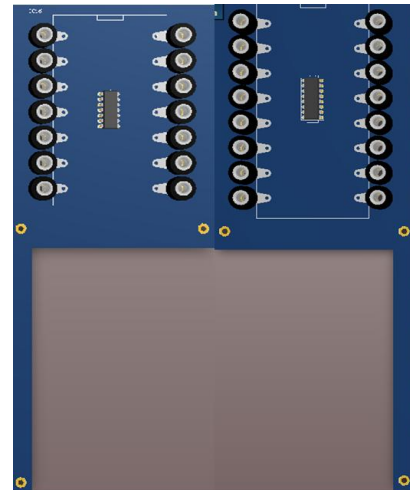


Fig 11: Hình ảnh 3D Modul các IC mở rộng

## 4. DESIGNING EXERCISE ON THE MULTI-PURPOSE PRACTISE TABLE FOR THE DIGITAL ELECTRONIC ENGINEERING SUBJECT

### 4.1 Contents of the exercises

Based on the results of the design of the digital electronics practice table, the authors wrote 05 practical tutorials covering the content of the digital electronics subject [11], including:

**Lesson 1:** Practice logical algebra and basic logic elements.

**Lesson 2:** Practice designing encoder and decoder circuits.

**Lesson 3:** Practice designing different types of counters.

**Lesson 4:** Practice designing mux and demux circuits

**Lesson 5:** Practice designing a blinking circuit according to the pre-requirements.

### 4.2 Basic content of the exercise

Each exercise will be presented according to the following basic contents:

**Purpose of the exercise:** Aim for students to understand the general content and meaning of each exercise

**Theoretical Foundations:** Re-presenting the basic theories related to the content of the practice exercises for the purpose of helping learners review the relevant knowledge they have learned.

### Contents of the exercise

#### a) Prepare equipment

Aim for learners to know the equipment that needs to be used for each exercise

#### b) Contents of the exercises

For each exercise, the document provides detailed instructions on the steps to perform the exercise, from state tabulation, write Karnaugh map, minimization Karnaugh map, transform equation of state, draw principle diagram, steps conduct the connection on the practice table and compare the practical results with the theory.

**Content evaluate:** This content contains 15 to 20 exercises for students to practice on their own and evaluate based on the results achieved.

## 5. RESULTS AND DISCUSSION

From the design idea, designing the circuit board using Altium Designer software, then proceed to assembly, the results of the practice table are shown as shown in Figure 12. The practice table has dimensions of 1.2m x 0.8m.



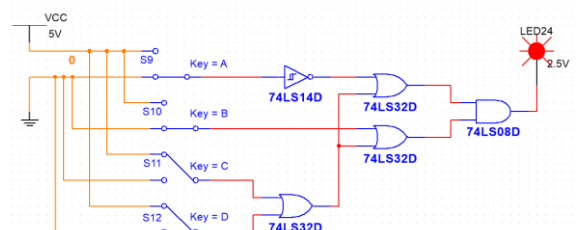
**Fig. 12: The image of the multi-purpose practice table for the digital electronics subject has been completed**

Included with each practice table is a connection wire box, the connection wires have different lengths and colors to facilitate the connection and distinction of signal wires, GND wires, and VCC wires.

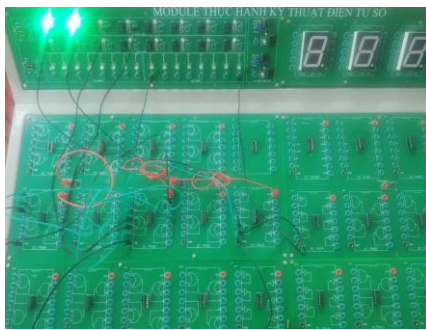


**Fig 13: Connection wire box image**

Figure 15 is the result image of the circuit design practice using AND, OR, and NOT logic elements according to the logic function F described in the schematic diagram of Figure 14.



**Fig. 14: The schematic diagram of the function F**



**Fig. 13: Actual connection diagram of function F on the practice table**

## 6. CONCLUSION

In this article, the author presented the design of a multi-purpose practice table for the digital electronics subject: From design ideas, design solutions, to designing boards using Altium Designer software and designing real circuits. Besides, the author introduces the exercises and the basic content of the exercises applied on this versatile practice table. The results of the practice table met the design goals and were applied at the laboratory of electronic engineering, Thai Nguyen university of technology.

## ACKNOWLEDGMENTS

This research was supported by a grant for the university research from the TNUT (Thai Nguyen University of Technology). We thank our colleagues from the TNUT who provided insight and expertise that greatly assisted the research.

## 7. REFERENCES

- [1]. Bộ môn Kỹ thuật điện tử, “Đề cương chi tiết học phần kỹ thuật Điện tử số”, Thai Nguyen University of Technology, 2019.
- [2]. Thomas L. Floyd, “Digital Fundamentals”, 10th Edition, Prentice-Hall, 2009.
- [3]. Stephen Brown and Zvonko Vranesic, “Fundamentals of Digital Logic with VHDL Design”, 3rd edition, McGraw-Hill, 2008.
- [4]. John Crowe and Barrie Hayes – Gill, “Introduction to Digital Electronic”, Butterworth-Heinemann, 1998.
- [5]. <https://www.linhkientot.vn/breadboard-mini-mb-102-400lo-8-5cm-5-5cm-test-board>
- [6]. <https://2tctech.vn/san-pham/module-dien-tu-so-and-or-xor-not/>
- [7]. <https://2tctech.vn/san-pham/bo-thuc-hanh-dien-tu-so/>
- [8]. Datasheetspdf. IC 4081, Data sheet, 2014
- [9]. <https://www.indiamart.com/proddetail/2mm-banana-socket-plug-terminal-connector-20957776662.html>
- [10]. <https://www.fuelcellstore.com/2mm-4mm-banana-plug-cables>.
- [11]. Bộ môn Kỹ thuật điện tử, “Tài liệu hướng dẫn thực hành kỹ thuật điện tử số”, Thai Nguyen University of Technology, 2019.