REPORT OF INDIVIDUAL DESIGN PROJECT

INTAKE 36

A COMPACT 'LEARNING BOARD' FOR HANDS-ON ELECTRONICS SYSTEMS EDUCATION OF DIFFERENT TYPES OF ASYNCHRONOUS COUNTER CIRCUITS

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ABSTRACT

This report presents the development of a Digital Counters Learning Board for hands-on electronics systems education of different types of asynchronous counters circuits. The developed prototype enables undergraduates, electronic enthusiasts, young researchers in academia to experiment with these counters circuits on a platform that is compact and portable so that the user can easily demonstrate and learn these concepts in a convenient place for them. The Learning board is inclusive of 12 different counter circuits which come along with a User's Guide that allows the user to gain knowledge on fundamental electronic components too. The user is required to refer to the User's Guide to learn the principles and identify the required common circuit modules to connect them accordingly with the given female-to-female jumper wires to complete the relevant circuit and obtain the output. 7-Segment displays and LEDs are provided to obtain the output and a clock pulse generator circuit to supply the required input to circuit combination to be implemented on the board. A successful attempt will result in getting the correct sequence of counting integers via the display of 7-segments or LEDs. It is hardly seen prototypes or devices like this product in recent history. However, there have been researches on many sophisticated and expensive designs in other fields of engineering but seldom from the field of electronics. The cost-effectiveness of this prototype dominates the market as it could be a go-to product for learning the basics of counters in electronics. Synchronous counters too can be incorporated at a broader scope with some modifications as to the next step of improving the prototype.

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1. INTRODUCTION

Citizens in Sri Lanka are currently facing many difficulties due to the pandemic outbreak that has imposed many restrictions on their daily life routines. This has affected undergraduates too in means of getting the required level of education in their degree programs, especially the necessary hands-on experiences on some theoretical concepts stipulated in their course curriculum. Also, it has been noted that engineering undergraduates in the fields of Electrical & Electronic, and Electronics & Telecommunication engineering of General Sir John Kotelawala Defence University (KDU), currently lack the means of getting hands-on education on Asynchronous Sequential Counters which is one of the main fundamentals that is been taught under the module 'Electronics Systems' in the first level of the degree program. It is an essential aspect of applications of electronics engineering, one must have mastery before becoming an expert in the field. Furthermore, many children living in rural areas of the country lack resources for primary and secondary education. Concurrently they lack resources to gain information on various aspects of interests due to many reasons such as poverty, inability to reach for informational resources and technologically developed devices/equipment, unawareness of a world filled with technological enhancements, etc. Therefore, there is a need to provide opportunities to obtain adequate hands-on education in Electronic Systems, and this context, on Asynchronous Counter circuits.

For this purpose, the Learning Board prototype has been developed to fulfill the required means and objectives by providing a platform to any undergraduate, enthusiast, and young researchers in academia to obtain hands-on education on asynchronous counters circuits. The development of this prototype was influenced by some previous researches done on more sophisticated learning boards in different fields of engineering [1], [2]. A detailed 'User's Guide' will be provided alongside the prototype for further details and to refer to the guidelines on operating and correctly maintaining the learning board **(See Annexure 1).** Information on Objectives, Aims, and the method of designing and developing this prototype is provided in the following chapters followed by a discussion with future improvements, and a conclusion.

2. PRODUCT SURVEY

This prototype is mainly focused on popularizing among the first-year and second-year undergraduates in the fields of Electronic, Electrical, and Mechatronic engineering. A quick survey was conducted among first and second year undergraduates of the aforementioned fields of KDU.

Out of the 27 responses obtained, the majority have an average knowledge of basic electronics.

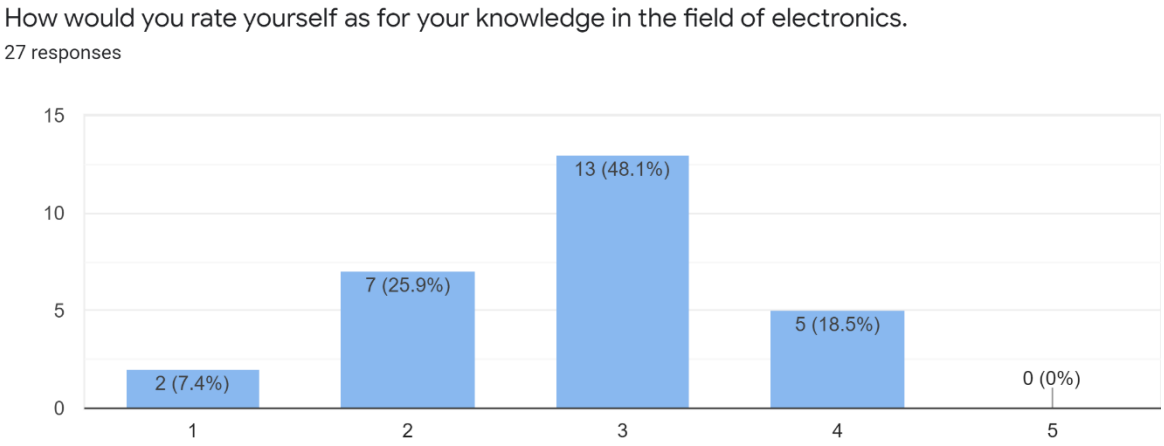


Figure 2-1: *Graph of students' opinion on their knowledge on electronics*

Even though the respondents seem to have adequate knowledge of electronics majority do not have basic knowledge and hands-on experience on asynchronous counters. This creates a huge opportunity for introducing a prototype as the "Digital Counters Learning Board" to the market, that could assist users to obtain relevant practice and experience in the particular subject area.

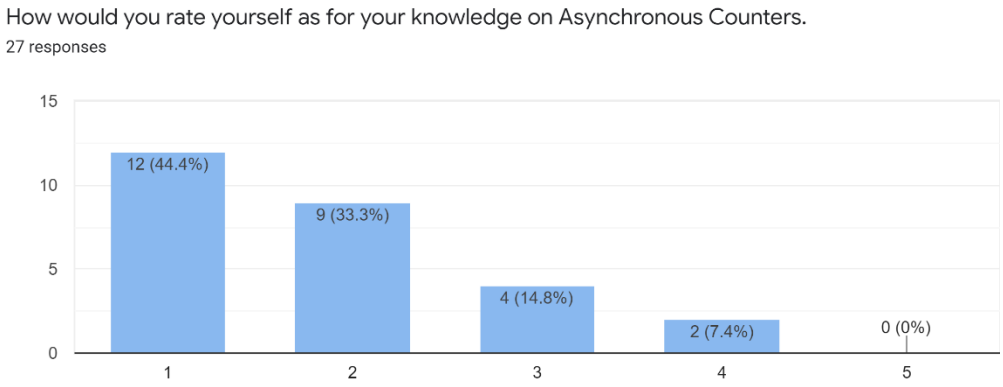


Figure 2-2: *Graph of students' opinion on their knowledge on electronics*

Most of the respondents did not have a good understanding of the specified circuit combinations that are to be included on the learning board as a majority were interested in learning all the concepts irrespective of their knowledge of electronics. As the learning board provides not only a platform to learn the counter circuits but also to get familiarized with electronic components and their functions, and learn functions of some other basic circuits such as 7-Segment display circuit and a clock pulse generator circuit, surely this all-in-one prototype would fulfill the market demand.

Following counter circuits can be demonstrated by the Learning Board.

Table 2-a: *Types of Circuits combinations available on the Learning Board*

Circuit No.	Asynchronous counter Circuit Type
1	Hexadecimal Up counter using JK Flip-Flops
2	Modulo 6 Up counter using JK Flip-Flops
3	Hexadecimal Down counter using JK Flip-Flops
4	Modulo 6 Down counter using JK Flip-Flops
5	Hexadecimal Up counter using Counter ICs
6	Modulo 6 Up counter using Counter ICs
7	Hexadecimal Down counter using Counter ICs
8	Modulo 6 Down counter using Counter ICs
9	Decade Up counter using Counter ICs
10	Decade Down counter using Counter ICs
11	Two-digit Up Counter using Counter ICs (Decimal 00-99 counter)
12	Two-digit Down Counter using Counter ICs (Decimal 99-00 counter)

Respondents seemed to be unclear on the actual value of the Learning Board as 55.6% were likely to spend less than Rs.4000 whereas the estimated first price of the product was ranged in between Rs.4000-Rs.6000 (approx. Rs.5000) which is still greatly affordable than many other similar products of more expensive prices. However, the confusion can be clarified further when marketing the product and raising awareness of the true worth of the product when compared to other sophisticated and expensive practical kits (learning kits).

'Digital Counters Learning Board kit' inclusive:

- Multi-Circuit Digital Counters Learning Board
- Detailed "User's Guide" with additional basic information on Electronics.
- 3x40 (20cm) Female-to-Female jumper wires
- 1x40 (30cm) Female-to-Female jumper wires

- 5V/1A Power Adapter

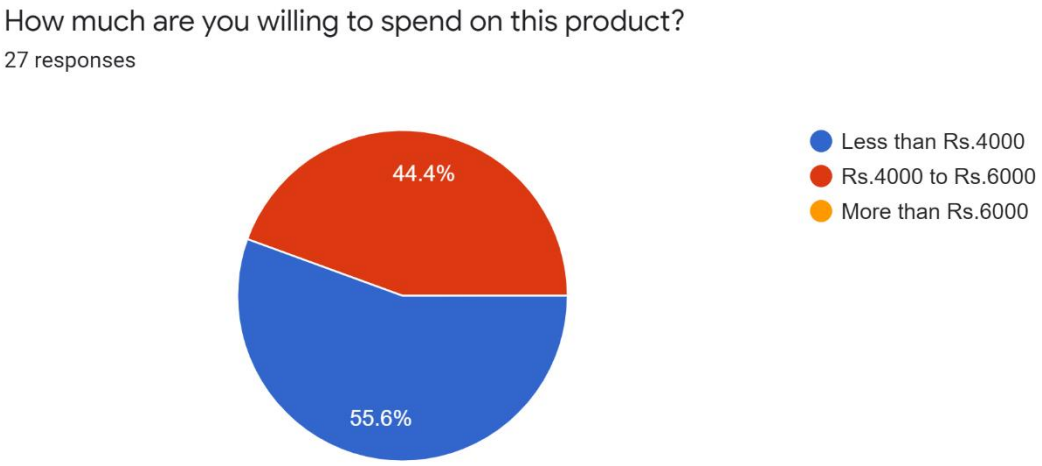


Figure 2-3: *Pie chart of price determination of the product*

As a detailed User Manual is provided along with the product, not only the engineering undergraduates that are learning this module in their course but also the beginners, enthusiasts, and young researchers in academia too will be able to get the maximum benefit out of this prototype, which indeed would widen the market demand and hence able to add a reasonable markup to the cost and sell it with an affordable price. With future improvements and modifications, the product can be customized according to the requirements of potential investors who are willing to invest in the mass production of this prototype.

3. OBJECTIVES AND AIMS

3.1. AIM:

To provide a platform to the undergraduates and electronic enthusiasts to improve their knowledge and obtain adequate hands-on experience on asynchronous counter circuits without the need and prior appointment to use laboratory facilities to conduct experiments.

3.2. OBJECTIVES:

- To provide comprehensive knowledge on Asynchronous circuits to the user.
- Introduce the fascinating fundamentals of the field of Electronics to undergraduates, beginners, young researchers in academia, and other interested parties.
- Introduce basic electronic components (ICs, LEDs, Resistors, Capacitors, 7 segment displays, etc.) and their functions.
- Raise awareness on available electronics simulation software and guide on using them. (Instructions on simulating circuits on 'Proteus 8 Professional' software)
- To provide access to basic electronic circuits learning devices to desiring hearts that are lacking such educational resources.
- Enhance the enthusiasm of undergraduates, students, and young adults, in the field of Electronics engineering.
- To provide a platform to practice theoretical concepts of asynchronous counters in a place convenient for the user amidst this pandemic outbreak.
- Assist in preventing the COVID-19 spread by making the product portable and compact, so users wouldn't have to travel seeking laboratory facilities.
- Produce a cost-efficient product that is affordable to all parties in society.
- Develop the prototype to the point where it is capable of being mass-produced in the future, with minor modifications.

4. METHODOLOGY

Initially, before starting work on the project, it was categorized into nine different phases to delegate work according to the timeline to make the process easier.

4.1. DESIGNING SCHEMATIC DIAGRAMS:

Firstly, an in-depth study on Asynchronous counters circuits was done and identified the necessary theoretical concepts to approach designing the schematics [3]. With the aid of Boolean expressions, truth tables, state diagrams, and timing diagrams, the foundation of schematics was constructed.

Clock signal	Outputs		
pulse	Q_2	Q_1	Q_0
Initial state	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1
8	0	0	0

Figure 4-1: *Truth table of count sequence [3].*

For Example, if we consider the theory of a modulo 8 counter circuit, Figure 4-1 shows the truth table of the counting sequence which is a mathematical table used in logic.

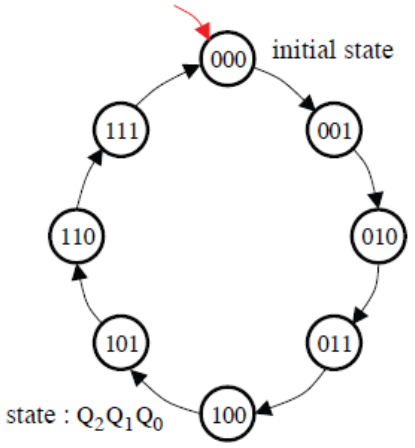


Figure 4-2: *State diagram of the Modulo 8 counter [3].*

The state diagram enables the identification of the correct sequence of the counter and the required states to deliver the output.

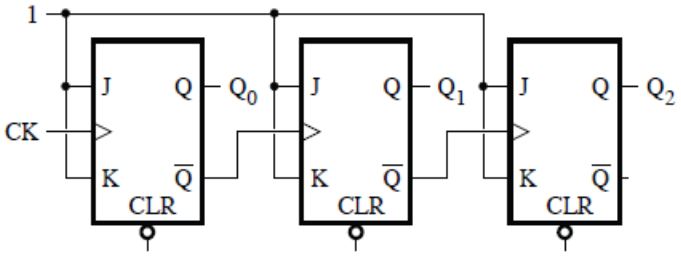


Figure 4-3: *Asynchronous modulo 8 counter logic circuit [3].*

Then the logic circuit is constructed according to the Boolean expression derived from the truth table and the state diagram. A timing diagram too can be derived to further verify the output of the logic circuit.

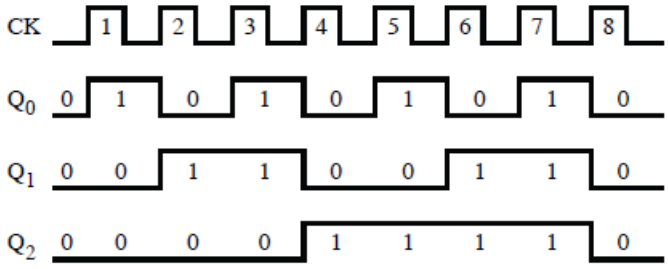


Figure 4-4*: Asynchronous modulo 8 counter timing diagram [3].*

Once the fundamentals for a particular circuit combination (out of the 12 counter circuits that can be demonstrated on the learning board) were analyzed and studied, a schematic diagram was designed using the "AutoCAD" design software. These diagrams were later included in the User's Guide as well. Following are some sample schematics of 3 counter circuits.

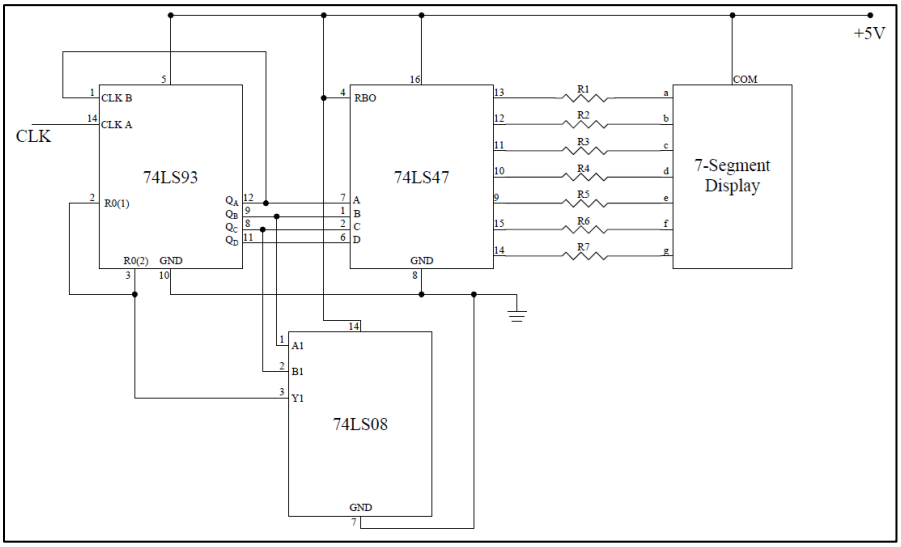


Figure 4-5: *Schematic of Modulo 6 Up counter using Counter IC*

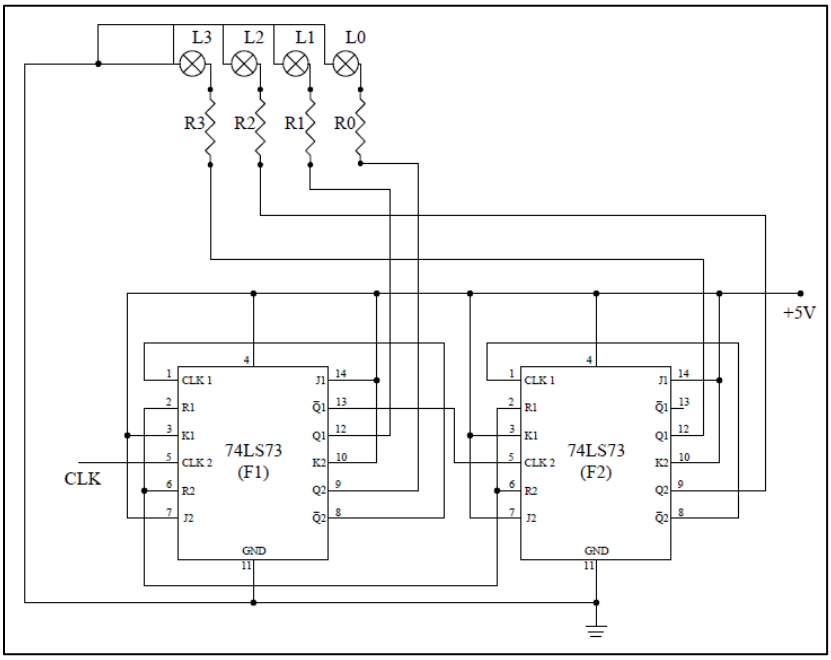


Figure 4-6: *Schematic of Hexadecimal down counter using JK flip-fops*

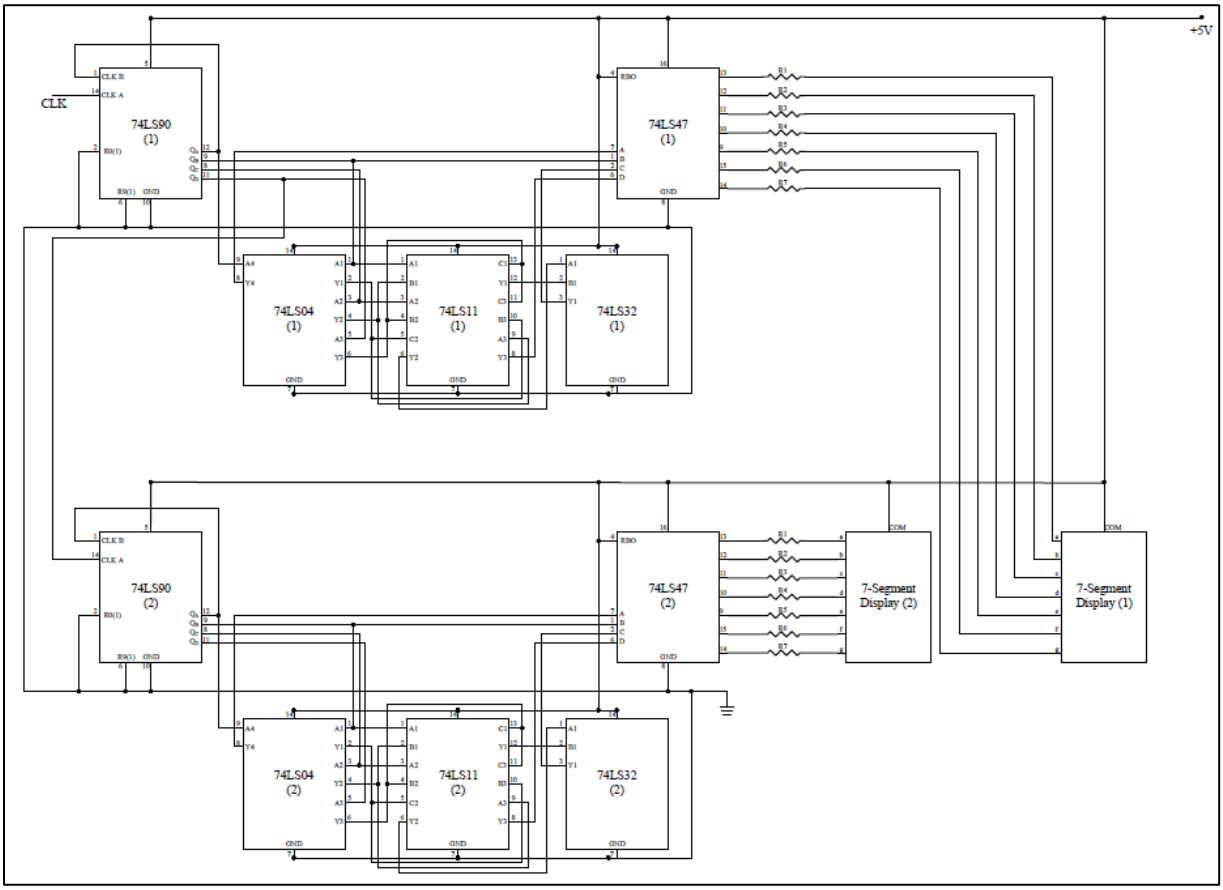


Figure 4-7: *Schematic of Two-digit Down counter using Counter ICs*

For Example: Schematic of Circuit. No. 10 – Decade Down counter using counter ICs was designed in 3 stages. Firstly, the requirement was identified. i.e. to convert the Decade Up counter in such a way that the output will be a Down counter sequence. The idea of converting the output of the 74LS90 decade Up counter IC which subsequently provides an input to the BCD to 7-Segment decoder IC (74LS47) as a down counting sequence, so that the 7-segment will display the Down counting integers even though the counter IC input is an Up counting sequence (which is not obtained via the displays). Secondly, two truth tables were designed to depict the desired output (Down counter) and the counter IC output (Up counter), hence obtain Boolean expressions to design the logic circuit for the converter part.

Table 4-a: *Truth table for Counter IC output*

	D	**C**	**B**	**A**
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Table 4-b: Truth table for desired Down counter output

	D*	**C***	**B***	**A***
9	1	0	0	1
8	1	0	0	0
7	0	1	1	1
6	0	1	1	0
5	0	1	0	1
4	0	1	0	0
3	0	0	1	1
2	0	0	1	0
1	0	0	0	1
0	0	0	0	0

A’B’C’D’+AB’C’D’

A’BC’D’ + ABC’D’ +AB’CD’ + A’B’CD’

A’

After comparing the above truth tables an expression for the inputs of desired outputs (A*, B*, C*, D*) in terms of A, B, C, D can be obtained as follows,

$$A^* = A' \quad (1)$$

$$B^* = B \quad (2)$$

$$C^* = A'BC'D' + ABC'D' + AB'CD' + A'B'CD' \quad (3)$$
$$= BC'D'(A' + A) + B'CD'(A' + A)$$
$$= BC'D' + B'CD'$$

$$D^* = A'B'C'D' + AB'C'D' \quad (4)$$
$$= B'C'D'(A' + A)$$
$$= B'C'D'$$

Lastly, the logic circuit is designed using the Boolean expressions received from the truth tables to design the converter circuit and then draw the schematic of the Decade down counter circuit depicting relevant IC modules.

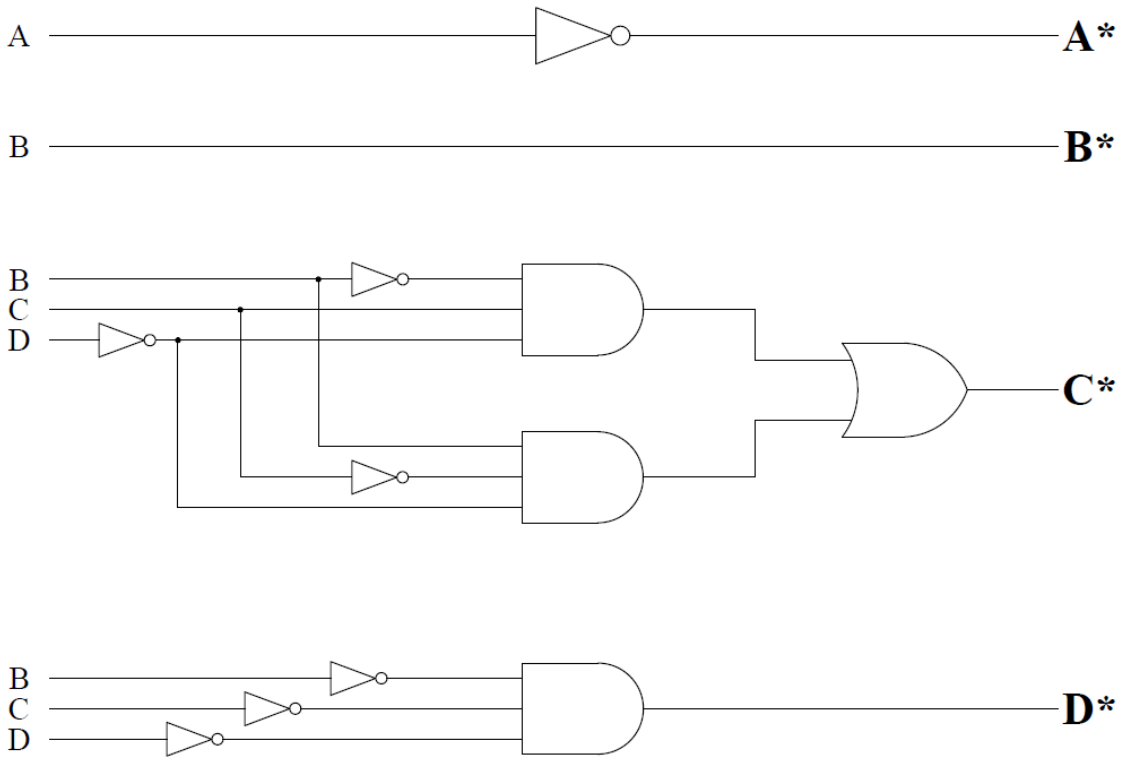


Figure 4-8: *Logic Circuits of derived expression*

The following diagram shows the schematic of the Circuit. No: 10 – Decade Down counter using counter ICs that was designed using the "AutoCAD" design software.

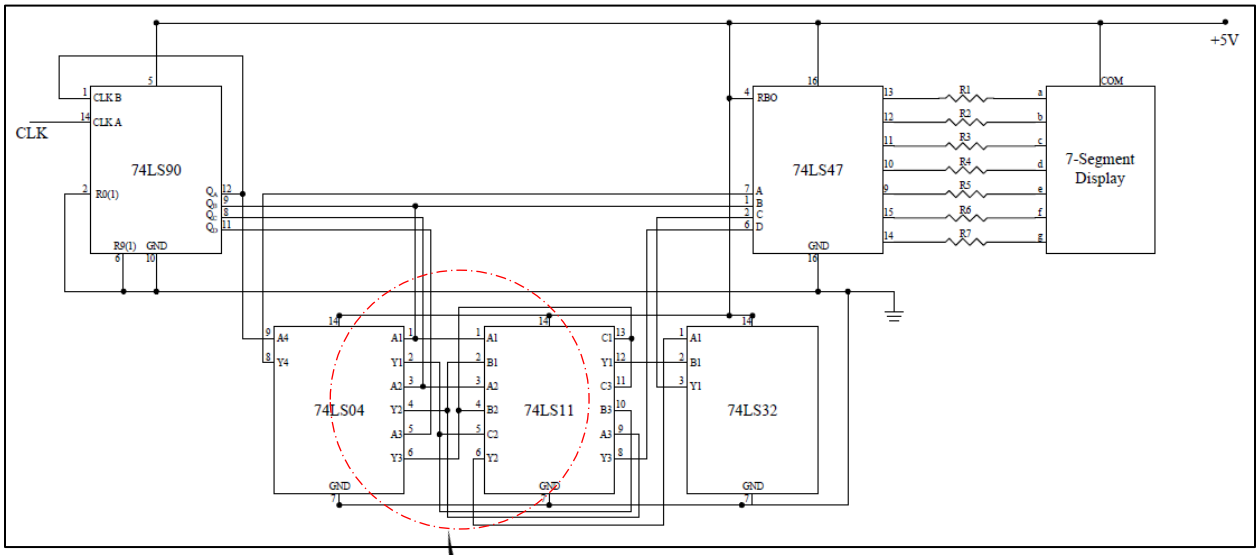
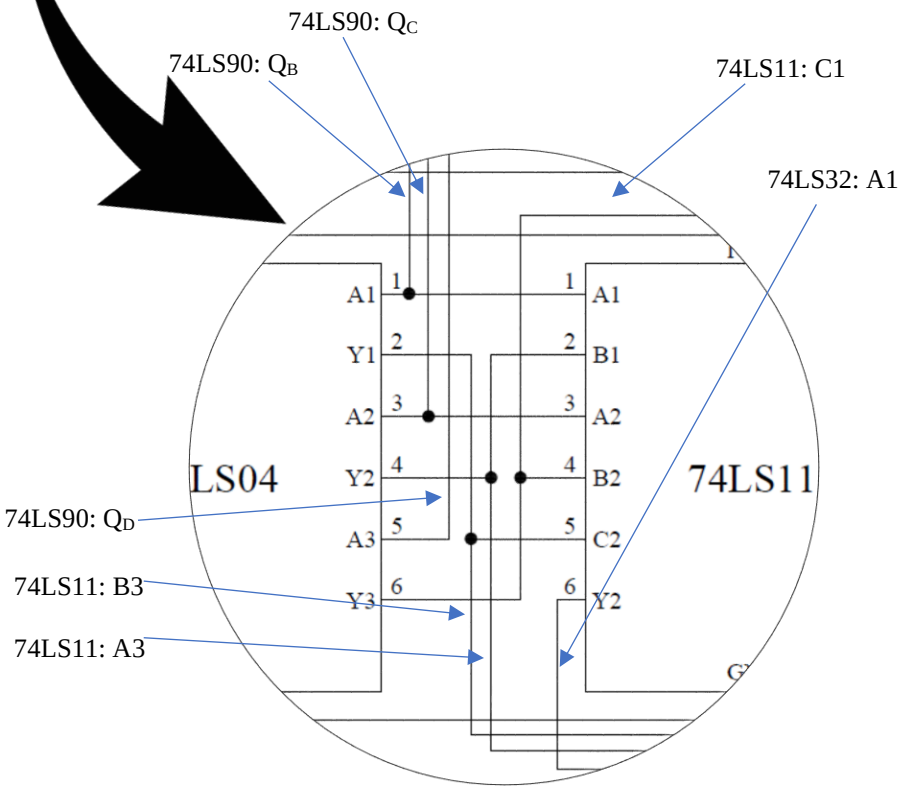


Figure 4-9: *Schematic of Decade Down counter using Counter IC*



Similarly, the above procedure was done to construct the schematics of all 12 counter circuits.

- **See <u>Appendix A</u> for schematics of all 12 counter circuits.**

4.2. RUNNING SIMULATIONS:

To verify designed schematics before soldering the components to obtain the outcomes, simulations were conducted through “Proteus 8” simulation software. Once again, the 12 circuits were designed within the software according to the pre-designed schematics and simulated consequently. All the circuits were verified by the software and the following are some sample simulation schematics designed prior to running the respective simulation. (Following are the relevant simulation schematics of the 3 sample schematic diagrams included in section 4.1. above)

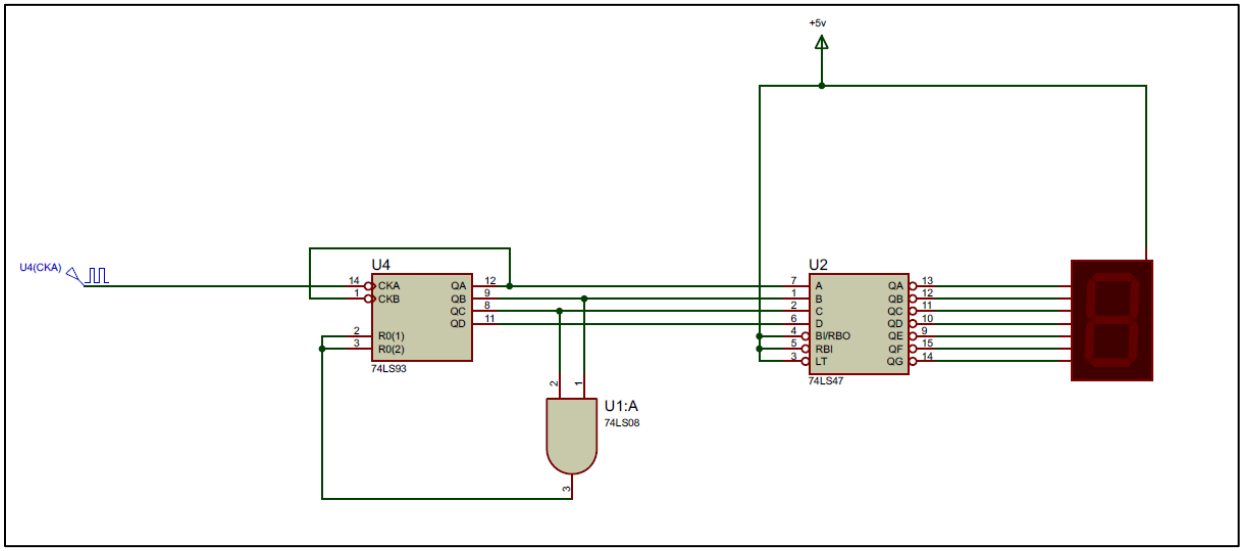


Figure 4-10: *Simulation schematic of Modulo 6 Up counter using Counter IC*

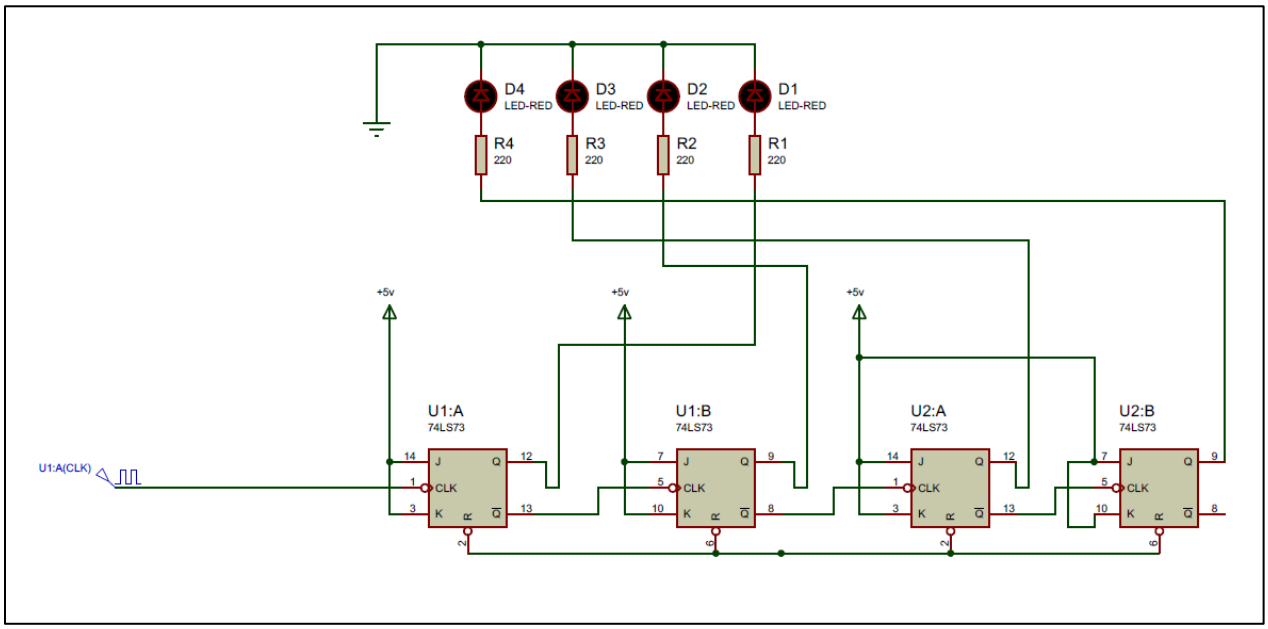


Figure 4-11: *Simulation schematic of Hexadecimal Down counter using JK flip-flops*

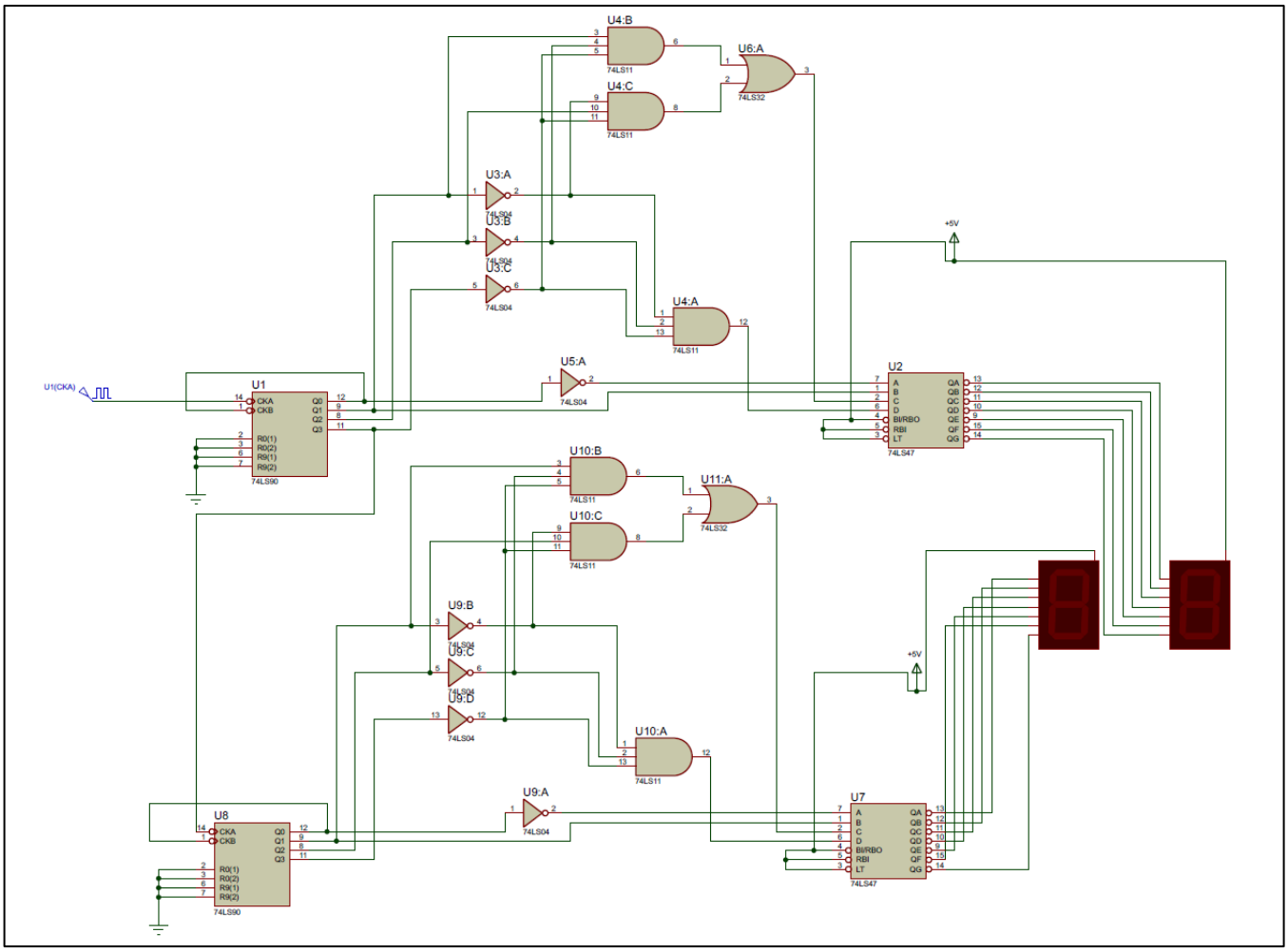


Figure 4-12: *Simulation schematic of Two-digits Down counter using Counter ICs*

- **See <u>Appendix B</u> for diagrams of all 12 Simulation schematics that produced accurate results.**

4.3. DESIGNING COMMON CIRCUIT MODULES:

After the 12 circuits were verified by the software, a way of embedding those circuits into the Learning Board was required, where the user would have to study (or refer to the manual) and select the necessary circuitry to connect them to obtain the relevant output. Therefore, 7 different "Common circuit modules" were designed for this purpose. Those circuits too were designed by "AutoCAD" design software.

The 7 Common circuit modules:

i. Clock Pulse Generator circuit
ii. 7-Segment Displays circuit

iii. COUNTER 1 circuit

iv. COUNTER 2 circuit

v. Converter & COUNTER 3 circuit

vi. COUNTER 4 circuit

vii. COUNTER 5 circuit

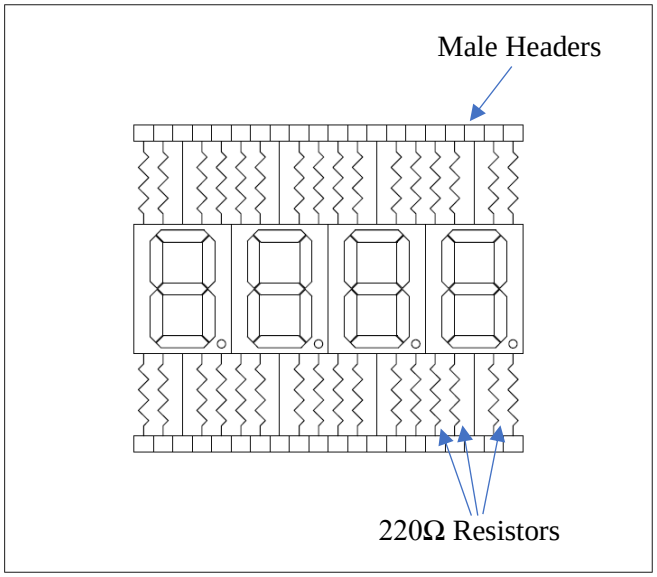


Figure 4-13: *7-Segment Displays Circuit*

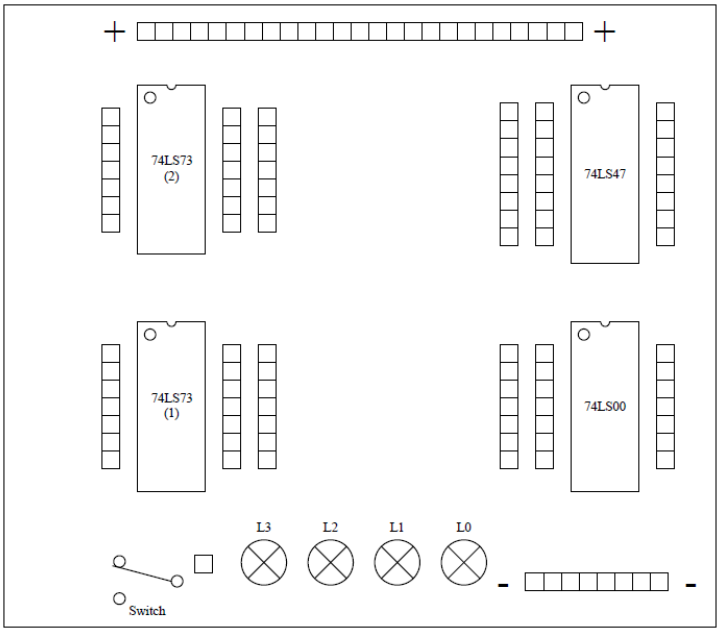


Figure 4-14: *COUNTER 1 circuit*

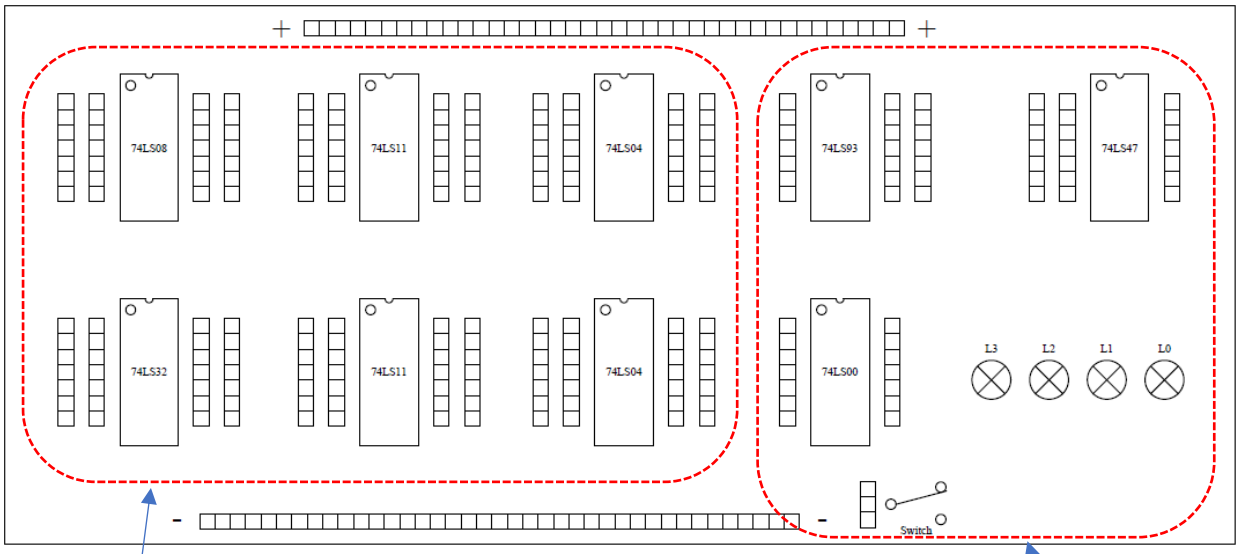


Figure 4-15: *COUNTER 3 & Converter circuit*

Converter circuit

COUNTER 3

In the Clock Pulse Generator circuit, the Time interval (frequency) in between two output integers can be set by the following equations,

$$f = \frac{1}{T} \quad (1)$$

$$T = 0.693(R1 + 2 \times VR)C1 \quad (2)$$

$$Ton = 0.693 \times R1 \times C1 \quad (3)$$

$$Toff = 0.693 \times 2 \times VR \times C1 \quad (4)$$

Where T = Cycle Time, f = frequency.

Since R1(10kΩ resistor) and C1(10μF electrolytic capacitor) are constant, by varying VR, the user can obtain the required cycle time.

And for example, if the user prefers to demonstrate Circuit. No. 4 – Modulo 6 Down counter using JK flip-flops, the user would need Clock Pulse Generator circuit, COUNTER 1 or COUNTER 2 circuit, COUNTER 3 & Converter circuit, and the 7-Segment displays circuit. Further information on how to connect them to obtain the relevant counter circuit and more details are provided in the User's Guide.

- **See <u>Appendix C</u> for diagrams of all 7 Common circuit modules.**

4.4. DESIGNING LEARNING BOARD LAYOUT:

The Learning Board layout was planned to design in a way that it fulfills some of the main objectives of this prototype, which is being compact and portable whilst being cost-effective. Therefore, a structure that includes all common circuit modules compactly was designed using the "AutoCAD" design software.

Dimensions in the following diagram are in centimeters (cm).

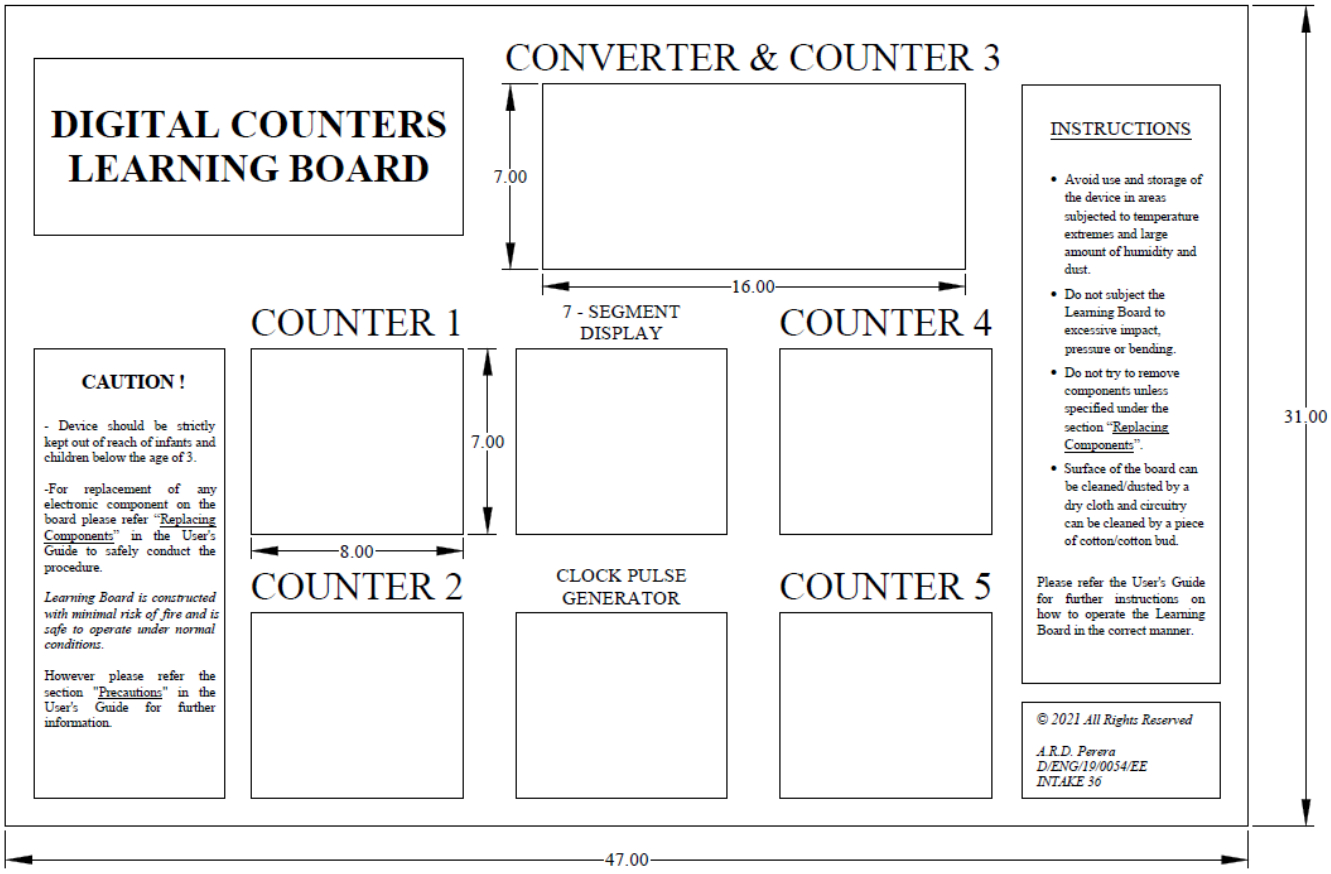


Figure 4-16: *Layout of the Digital Counters Learning Board*

4.5. PURCHASING ELECTRONIC COMPONENTS:

Once the designing stage was at its climax, a list of required electronic components to construct the final circuits was purchased.

Table 4-c: *Resources and components that were not purchased*

Item	Qty.
Electric Soldering Iron and Lead roll	1
10kΩ Resistors	2
100kΩ Variable Resistor	1
10nF Polyester Capacitor	1
10µF Polarized Capacitors	1
Copper circuit wires	2m

Table 4-d: *Budget of purchased items*

Item	Qty.	Unit Price (Rs.)	Total Price (Rs.)
74LS00	3	30	90
74LS04	2	30	60
74LS08	2	40	80
74LS11	2	45	90
74LS32	1	40	40
74LS47	5	85	425
74LS73	4	40	160
74LS90	2	45	90
74LS93	1	60	60
NE555	1	15	15
LEDs	16	3	48
7-Segment Displays	4	20	80
Vero line boards (14.5cm x 6.5cm)	4	60	240
8-pin IC bases	1	5	5
14-pin IC bases	17	5	85
16-pin IC bases	5	5	25
40x1 Male Headers SIL	15	15	225
Female-to-female jumper wires 1x40	3	150	450
2.1mm x 5.5mm Round panel mount female socket DC connector	1	15	15
5V 1A SMPS Power Adapter	1	360	360
Two-way 3 pin Sliding Switches	10	10	100
220Ω 1/4W Resistors pack (40pcs.)	1	30	30
10kΩ Resistors	2	1	2
100kΩ Variable Resistor	1	10	10
10nF Mylar Capacitor	1	4	4
10µF Electrolytic Capacitors	1	2	2
2.5mm Cast Acrylic Sheet 1'x1.5'	1	700	700
Total			**3491**

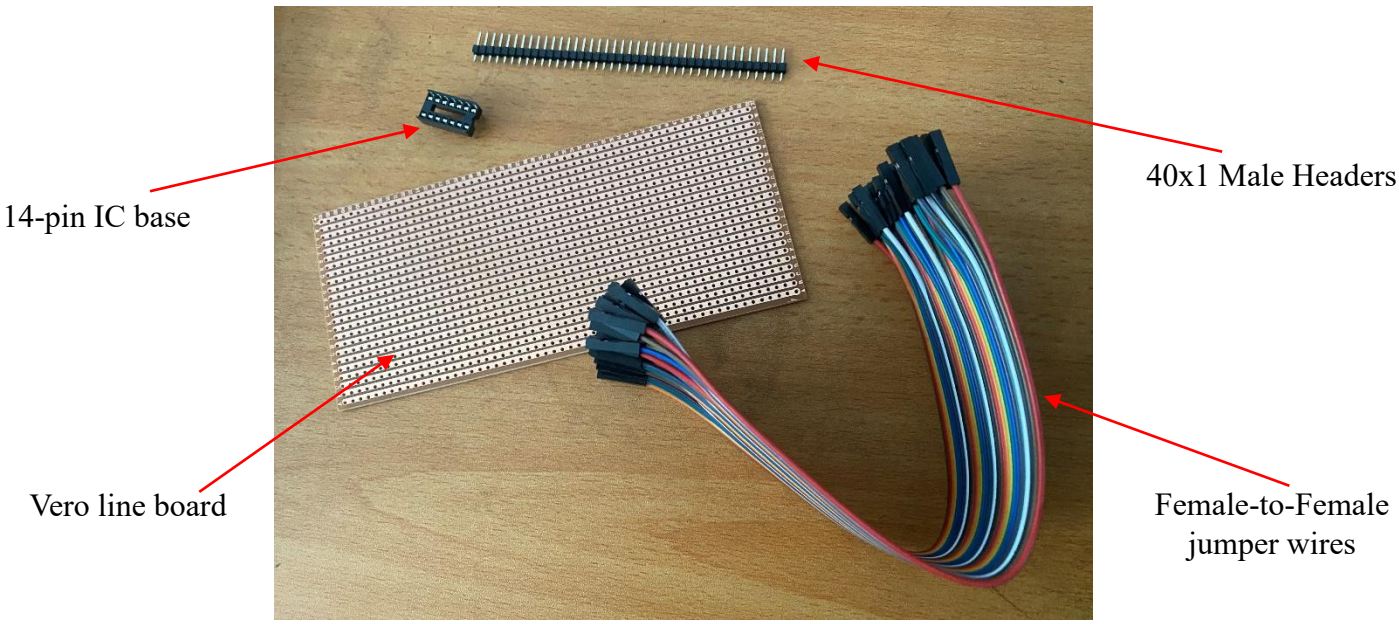


Figure 4-17: *Sample Electronic components purchased*

4.6. SOLDERING COMPONENTS:

Once the components were bought, the next was to put them together and construct the 7 common circuit modules. The following figure shows the final output of the common circuit modules.

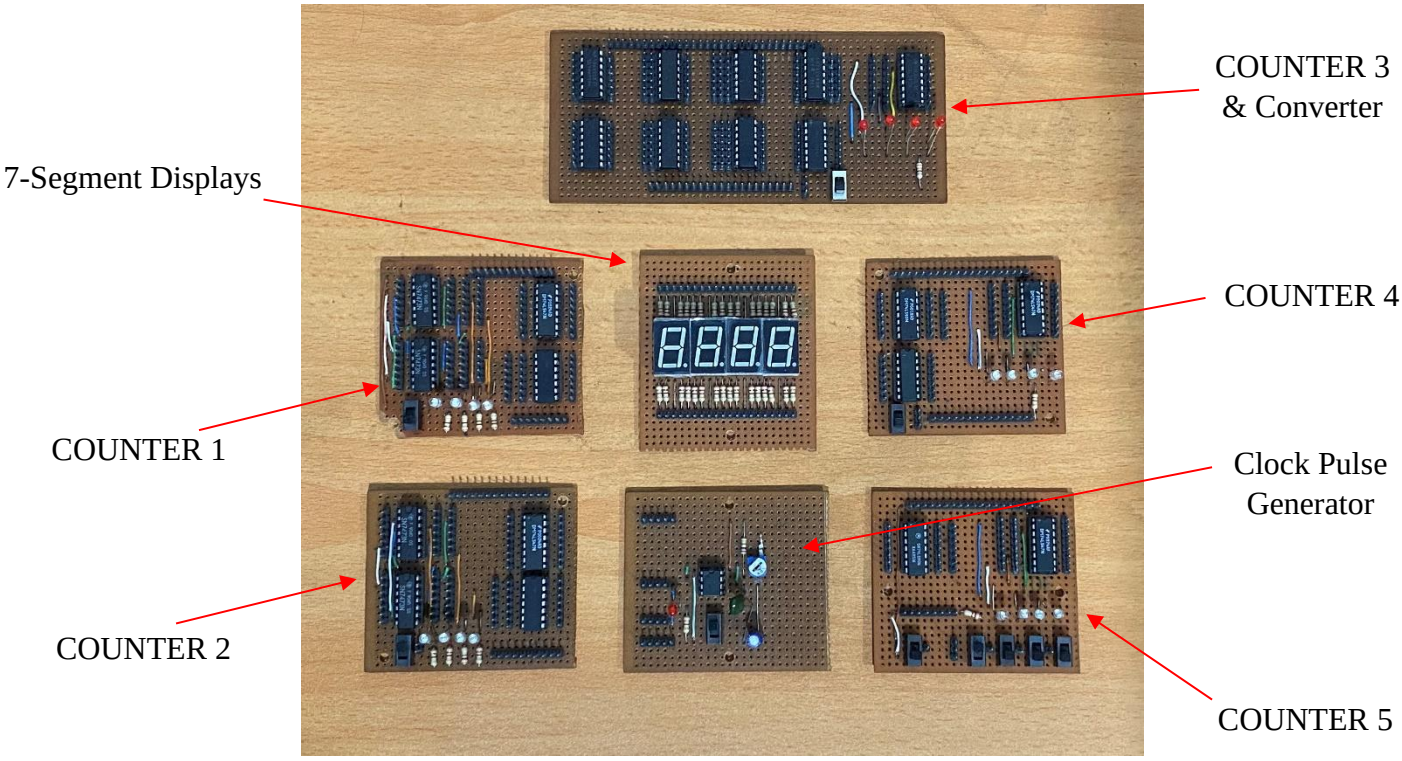


Figure 4-18: *Finalized 7 Common circuit modules*

4.7. CONDUCTING TEST RUNS:

Before fixing the common circuit modules to the acrylic board, test runs were done to verify the functionality of circuits in case modifications and other developments needed to be done. All 12 circuit combinations were tested with the use of common circuit modules before further proceedings.

4.8. FINALIZING THE LEARNING BOARD:

Finally, all the components were fixed to the acrylic board and final test runs were done on the board to finalize the prototype. The following figure shows the final layout of the Learning Board.

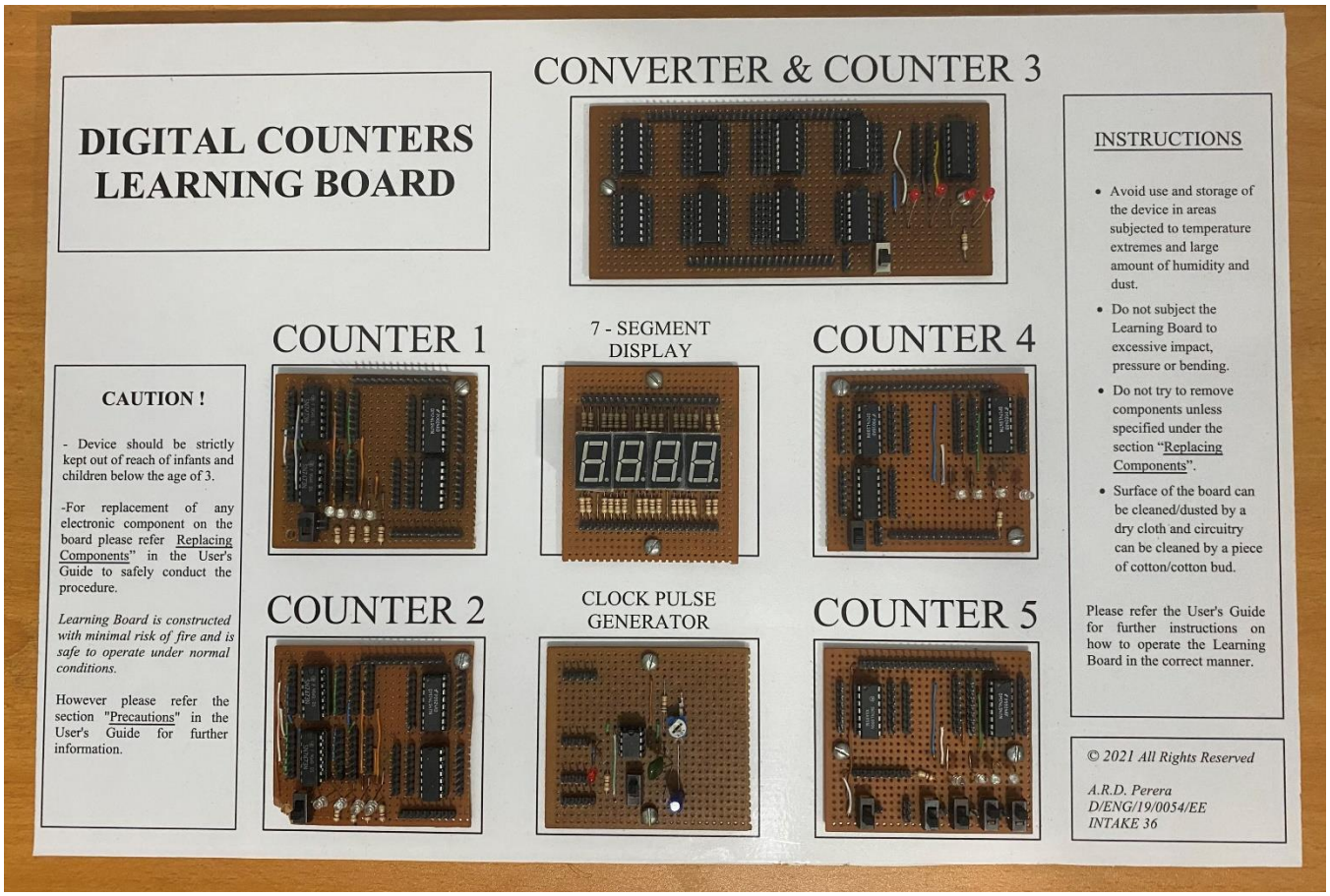


Figure 4-19: *Final layout of the prototype*

5. FINAL OUTCOME AND DISCUSSION

The Digital Counters Learning Board which consists of 7 Common circuit modules could produce accurate outputs of the 12 counters circuits combinations stipulated for this prototype which were previously verified by the simulations conducted via 'Proteus 8' simulation software. The prototype was fabricated to limit the surface area to a pre-planned value of 31cm x 47cm (1457cm^2, i.e. 0.1457m^2) to enhance the compactness. Accordingly, the User's Guide to correctly operating the Learning Board too was designed in such a manner that the user not only gets to refer to the steps to connect the circuits and obtain the output but also learn the fundamentals of Electronics, as information on basic electronic components, basic electronic circuits, and details about Integrated Circuits (ICs) were printed on it. The following figure shows an output obtained from one of the sample counter circuits demonstrated on the board whilst conducting final test runs.

(include picture of a two digit counter)

In the first couple of test runs some of the circuits failed to display the correct output. When further analyzing it was found that some of the ICs purchased were of low quality and having internal issues. After replacing them with a relatively better set of ICs, the issues were rectified, and correct output was

guaranteed. Also, the 7-segment displays are not capable of displaying the hexadecimal equivalent of the decimal outputs 10,11,12,13,14,15 (binary equivalent of 1010_2, 1011_2,…, 1111_2) in the instances of demonstrating hexadecimal counters (Cct. No.: 1,3,5,7), as counters are connected via 74LS47 IC (i.e. BCD to 7-Segment Decoder IC) which is built to decode the outputs of integers 0-9. However, this can be neglected as displaying two digits counters can be implemented by other circuits stipulated in the User's Guide.

6. CONCLUSION AND FUTURE WORK

The main objective of developing a compact, user-friendly Learning Board that can be used as a platform to get the hands-on experience of the counter circuits wherever convenient for the user, was achieved by managing to limit the surface area of the board to just $0.1457m^2$ (approx. 1' x 1.5') and providing a detailed yet user-friendly User's Guide. Not only the user gets comprehensive knowledge on asynchronous counters circuits but also an introduction to fundamental electronic components and their functions as well as provide a basic idea of what a simulation software is about and its structure by the printed User's Guide. That way it is beneficial to all users of different beginner's knowledge (undergraduates, enthusiasts, and young researchers in academia). The product can be sold at an affordable price in the market securing cost-effectiveness. This is best suited for undergraduates to minimalize the time to seek laboratory facilities to conduct experiments (especially during this period of a pandemic).

This prototype can be further upgraded into a trilingual product where the instructions and User's Guide will be printed in the three main languages in Sri Lanka (Sinhalese, English, and Tamil) so that it is possible to distribute this product, partnering with a funding associate or a charitable organization who are willing to serve the community in empowering the young innovative minds all over the country (especially the underprivileged children in rural areas) to assist them in obtaining technologically advanced educational resources as the "Digital Counters Learning Board", and to motivate them into broadening their enthusiasm to excel in fields of technology. And, by incorporating more fundamental theories of Digital Electronics such as synchronous counters, shift registers, etc. to the Learning Board with adequate modifications and acquiring investors, this prototype can be developed into a level of mass production which can even obtain a patent for its novelty.

REFERENCES

[1] M. Biglarbegian, I. Mazhari, H. Jafarian, N. Kim, B. Parkhideh, and J. Enslin, “Multi-purpose generic board for hands-on power electronics education of different power converter topologies in PV applications,” *Conf. Proc. - IEEE Appl. Power Electron. Conf. Expo. - APEC*, vol. 2018-March, pp. 1147–1154, 2018, doi: 10.1109/APEC.2018.8341161.

[2] N. Kim, C. Roy, R. Cox, and B. Parkhideh, “A Plug and Play Power Electronics Education Board for Hands-on Learning of Power Converters Incorporating WBG Semiconductor,” *ICPE 2019 - ECCE Asia - 10th Int. Conf. Power Electron. - ECCE Asia*, pp. 2807–2813, May 2019, doi: 10.23919/ICPE2019-ECCEASIA42246.2019.8796999.

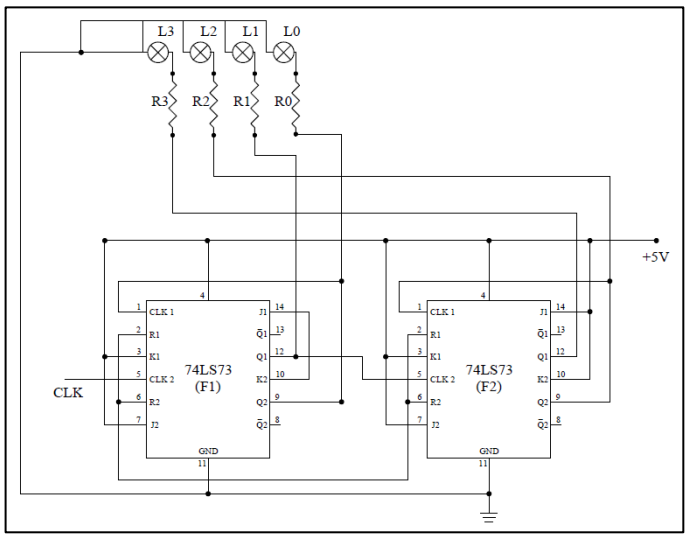
[3] T. Ndjountche, *Digital Electronics 2: Sequential and Arithmetic Logic Circuits*, 1st editio. Wiley-ISTE, 2016.

[4] P. Karunanayake. EE1212. Class Lecture, Topic:"Counters" General Sir John Kotelawala Defence University, Sri Lanka. 2019.

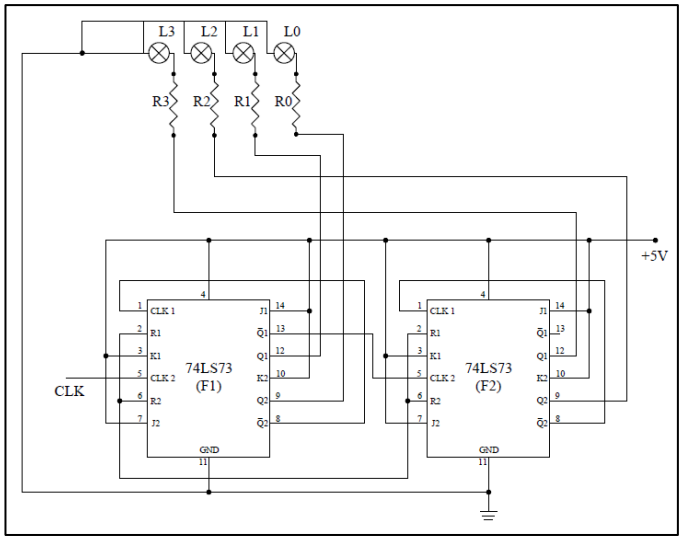
APPENDIX

APPENDIX A: SCHEMATIC DIAGRAMS

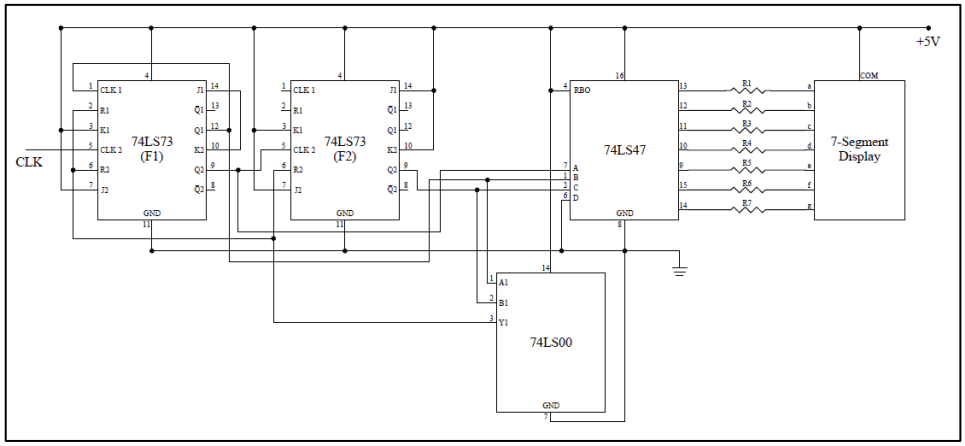
All circuits are labeled according to Table 2-a.



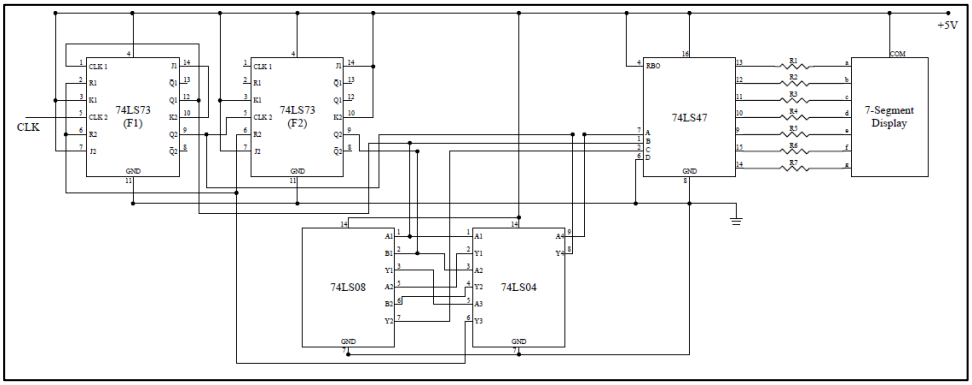
Circuit No. 1



Circuit No. 3



Circuit No. 2



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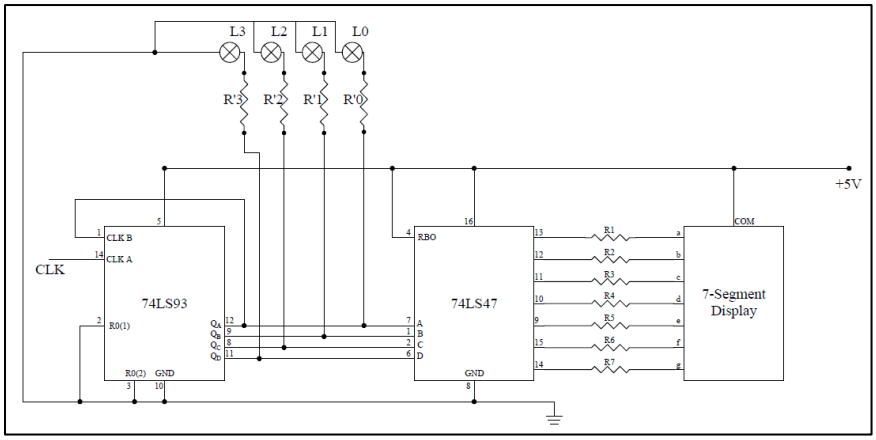

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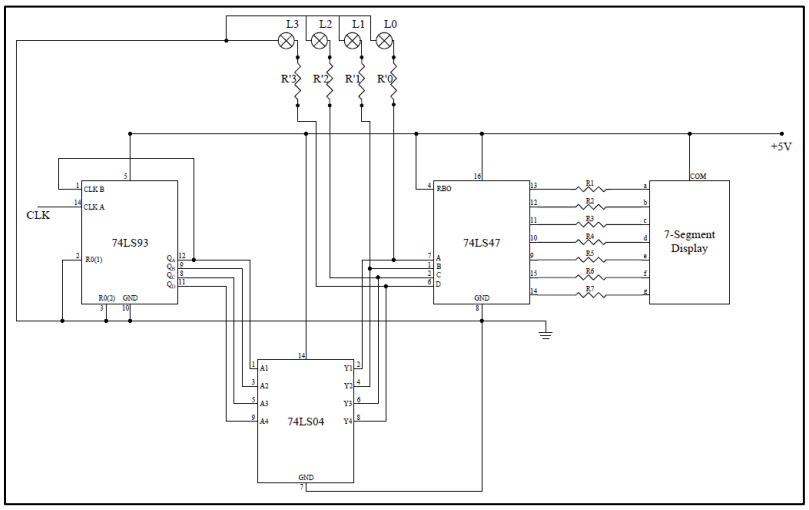

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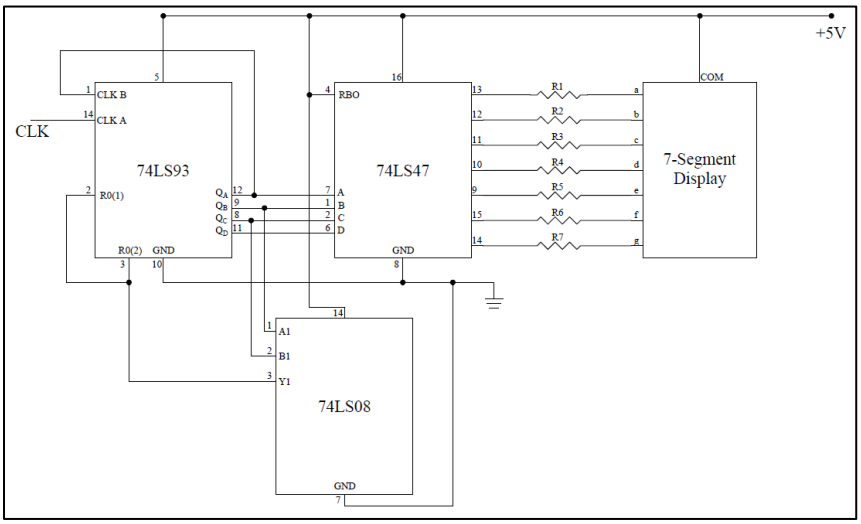
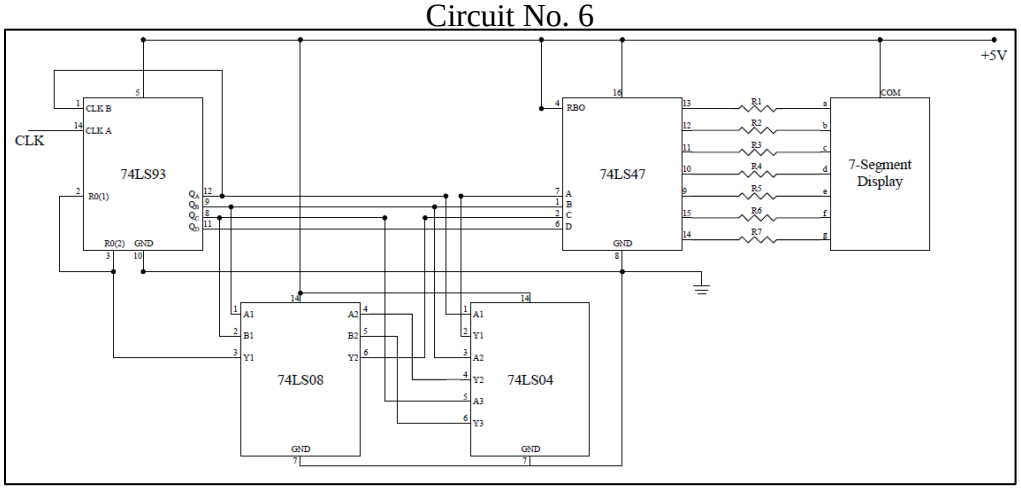


II

Circuit No. 6



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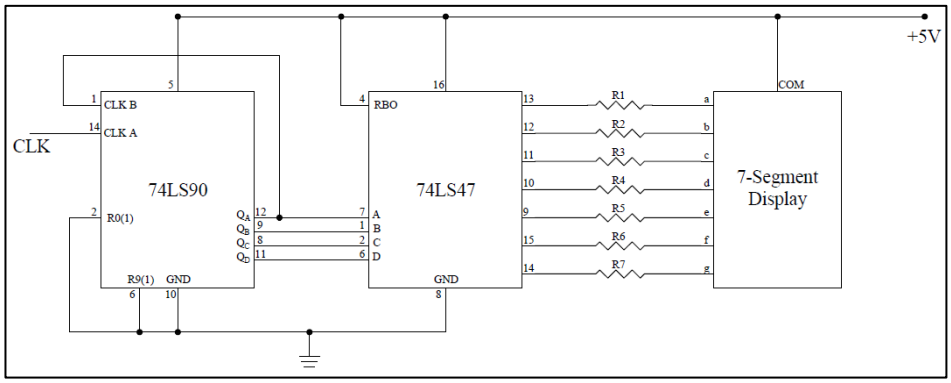

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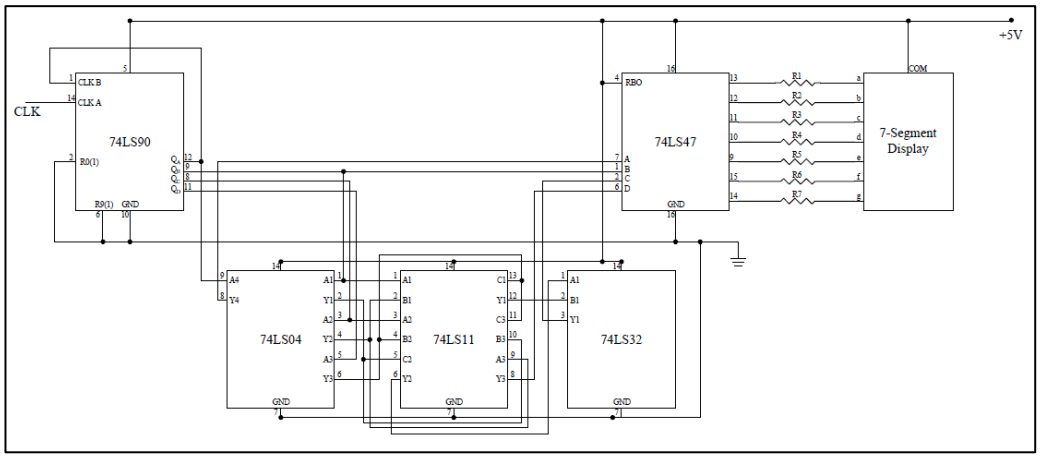

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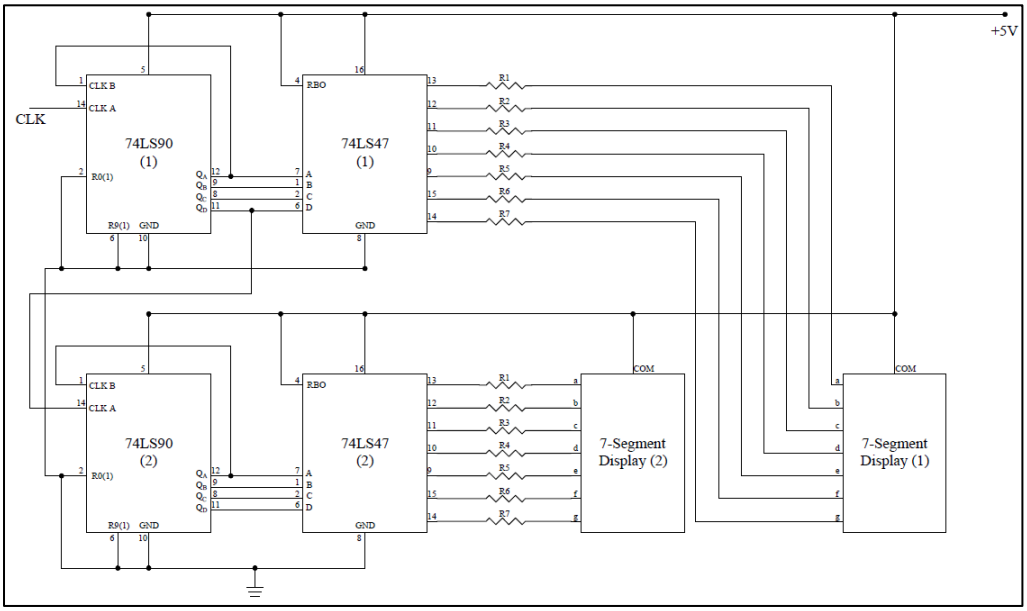

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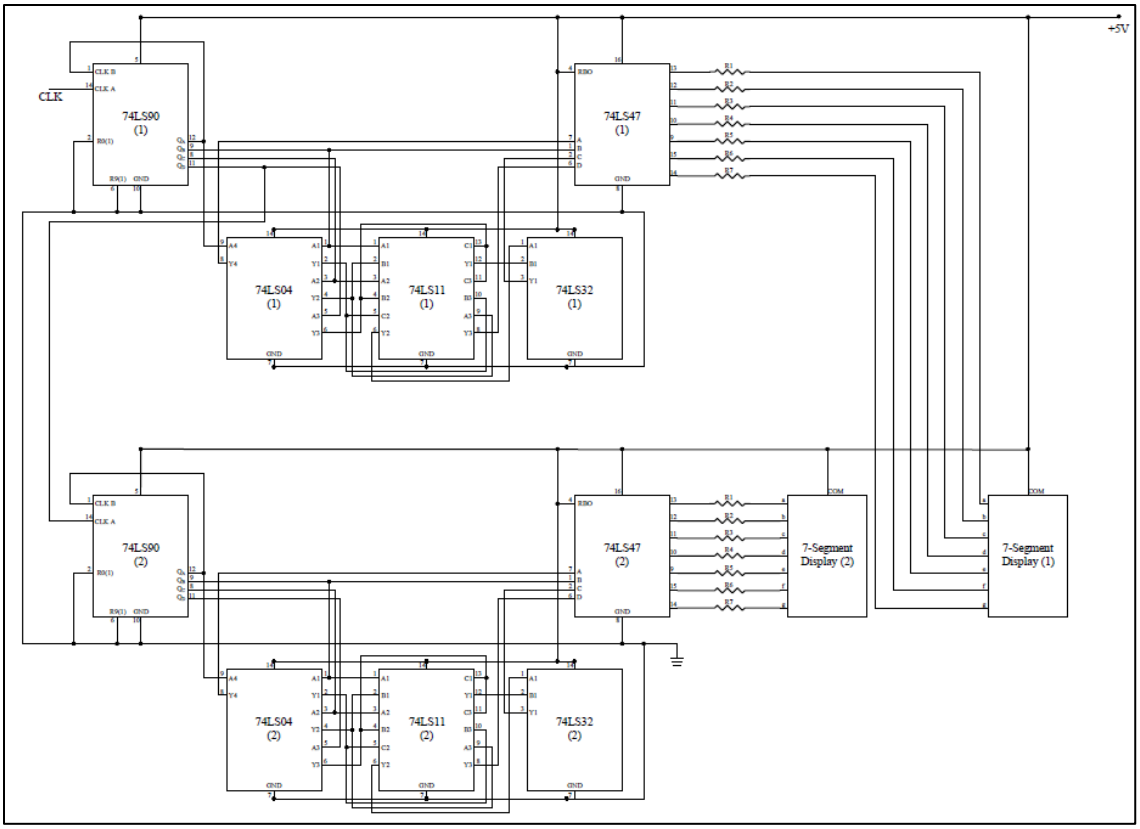
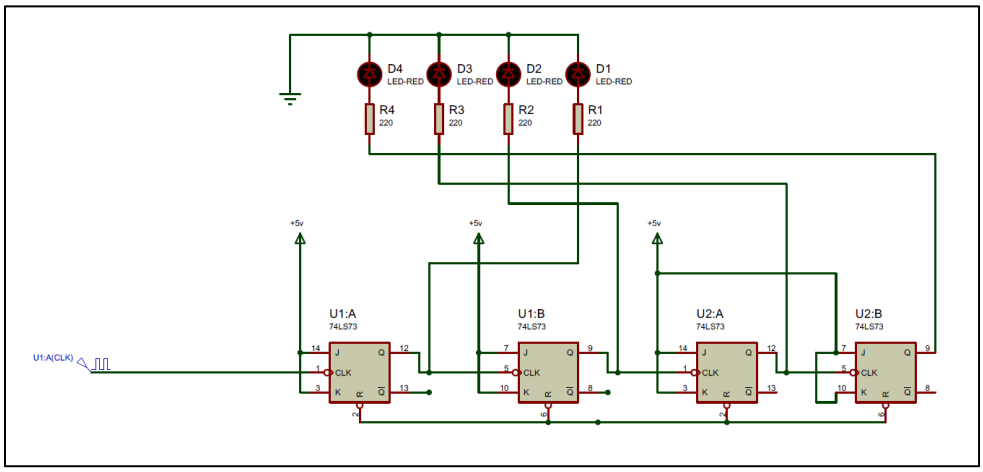


Circuit No. 12

APPENDIX B: SIMULATION SCHEMATICS

All circuits are labeled according to Table 2-a.



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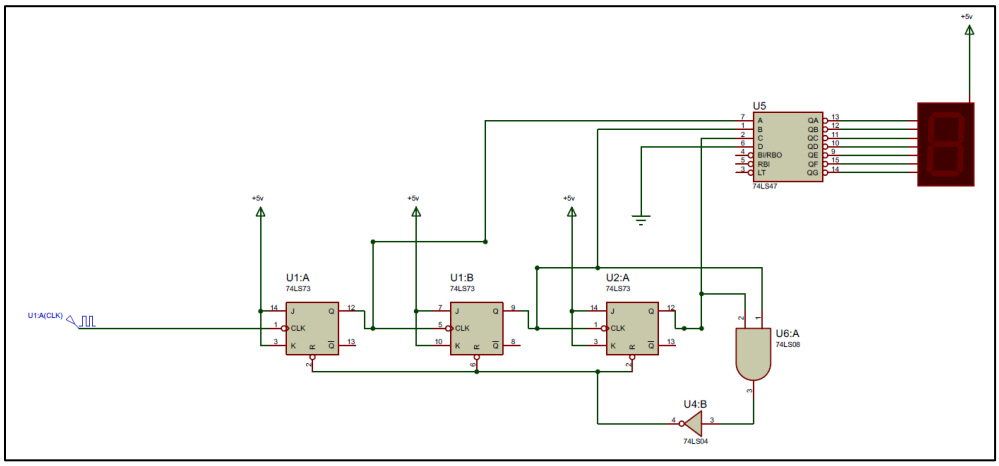

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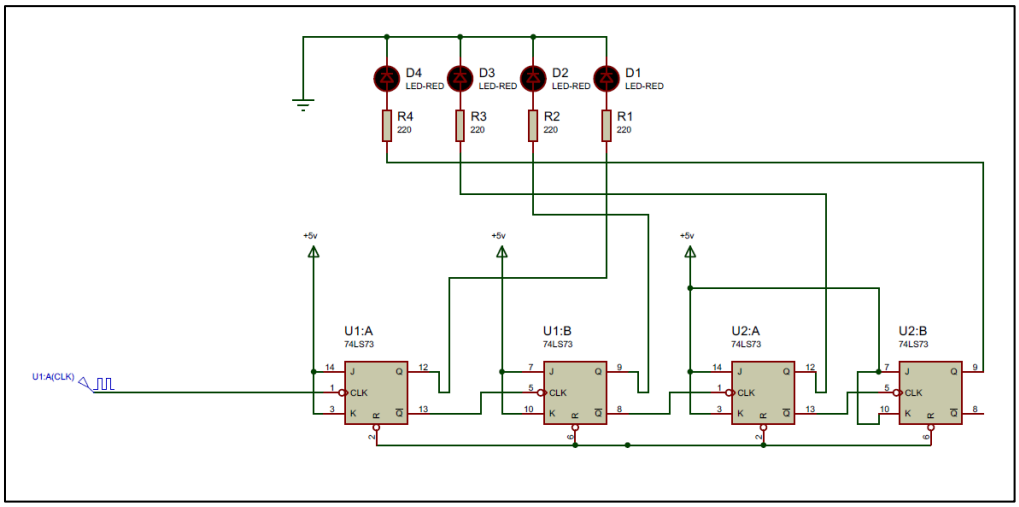

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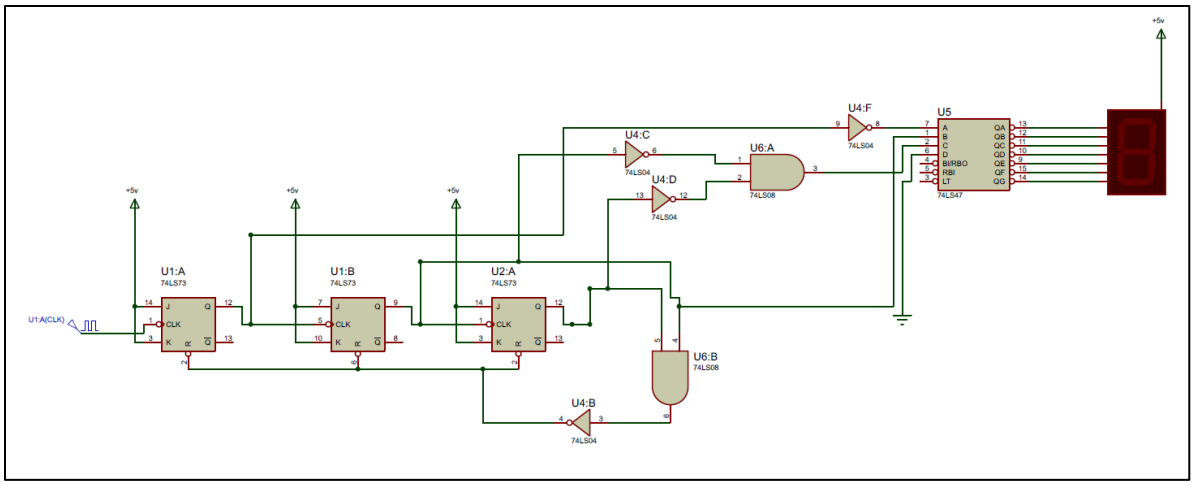

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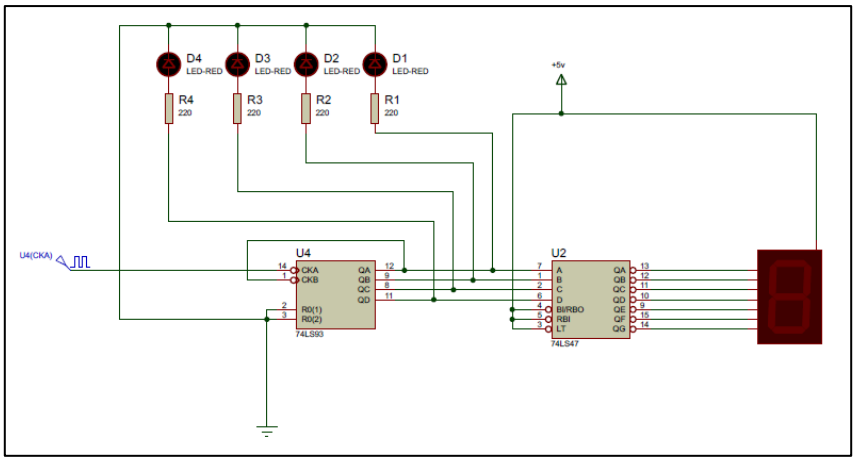

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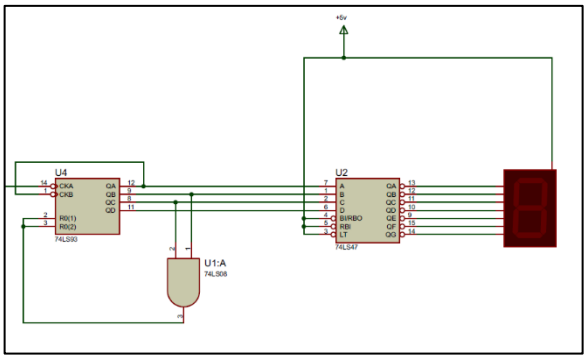

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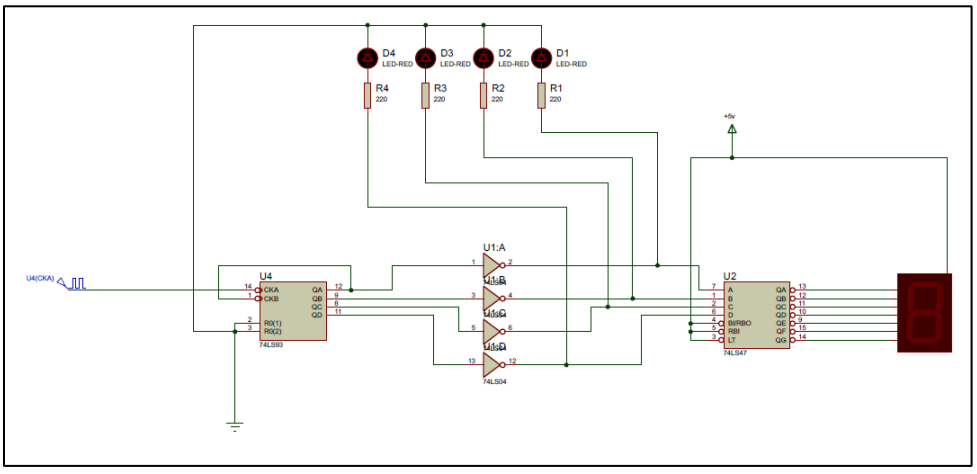

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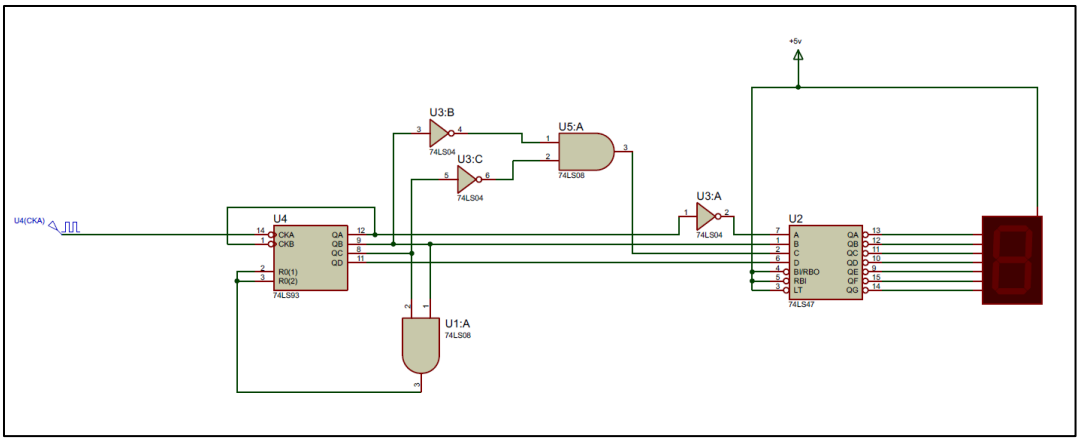

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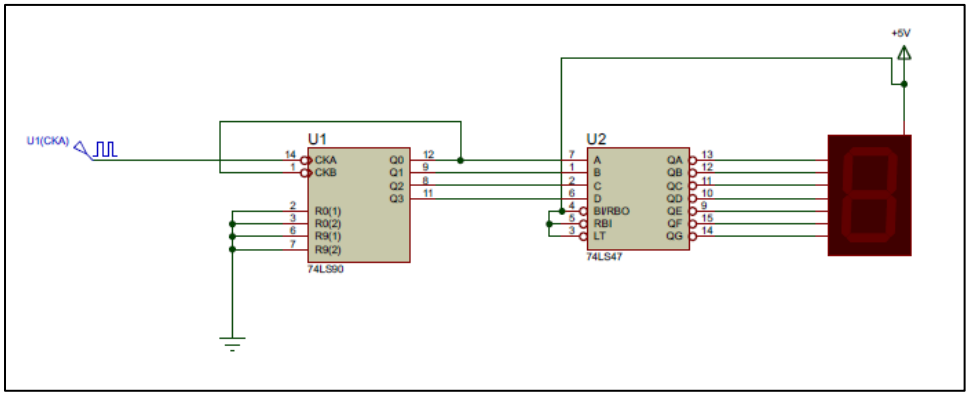

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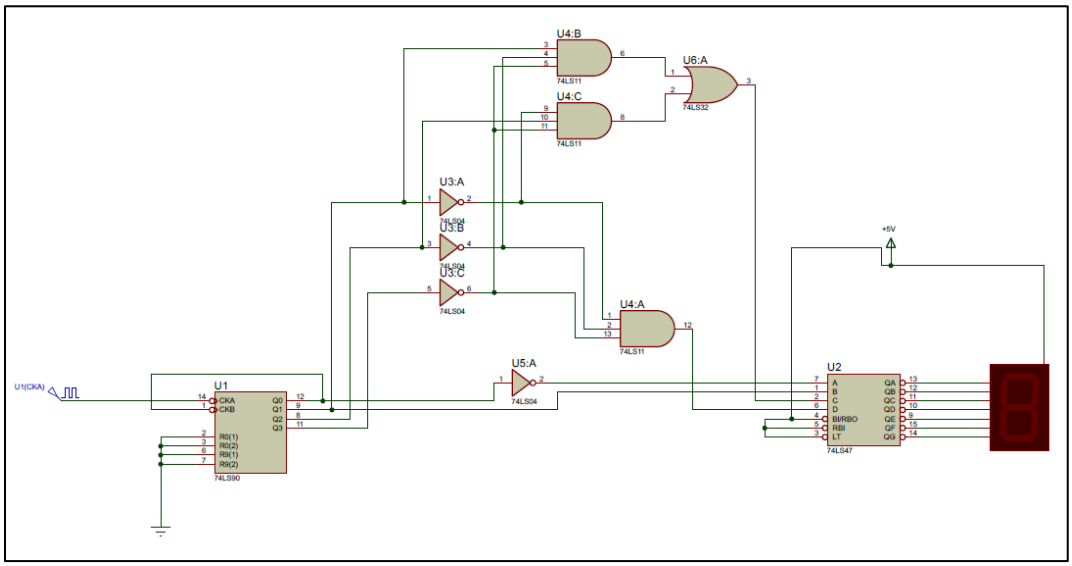

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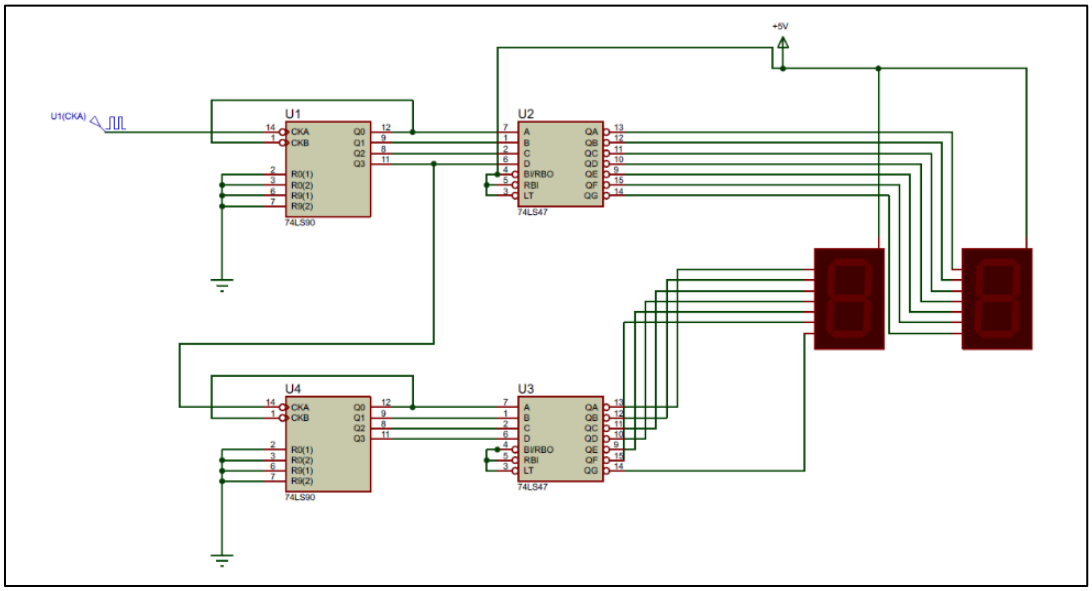

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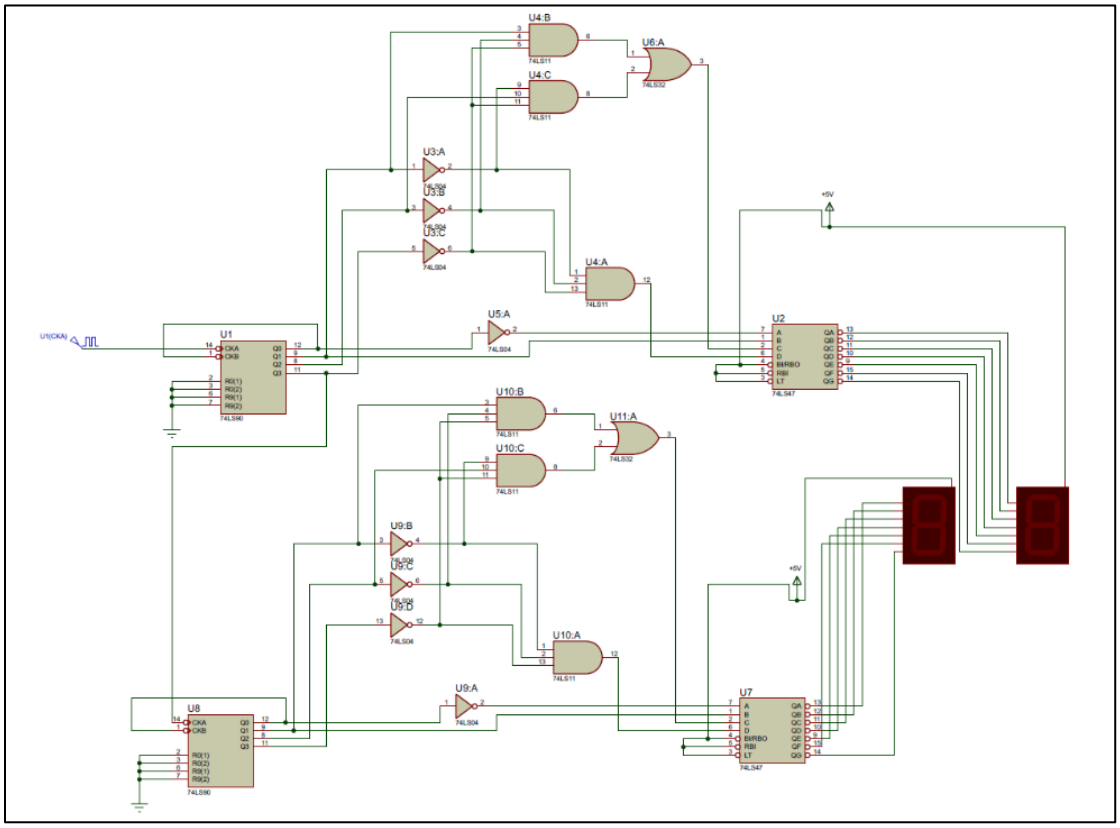
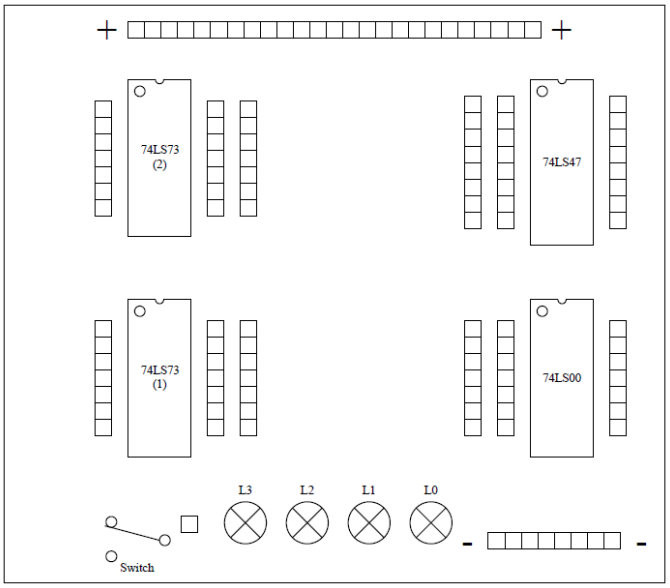
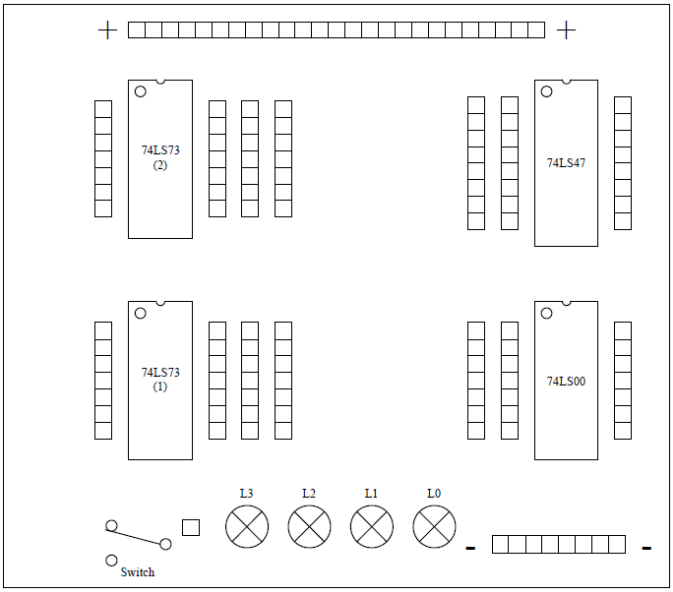


Circuit No. 12

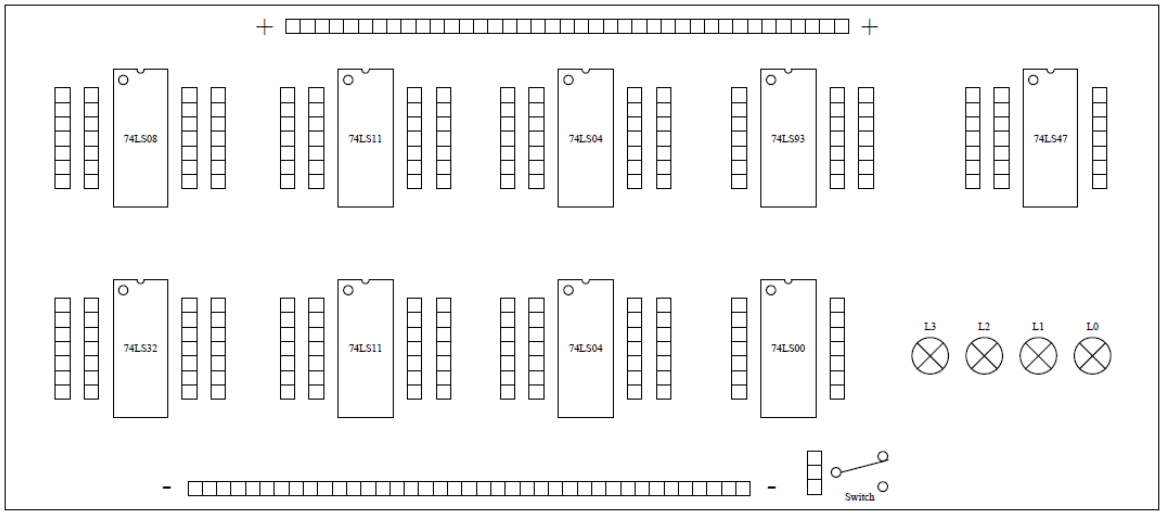
APPENDIX C: COMMON CIRCUIT MODULES



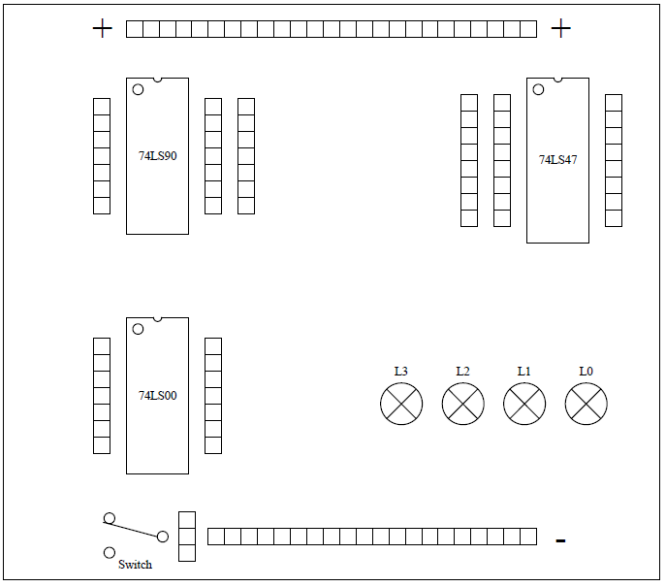
COUNTER 1



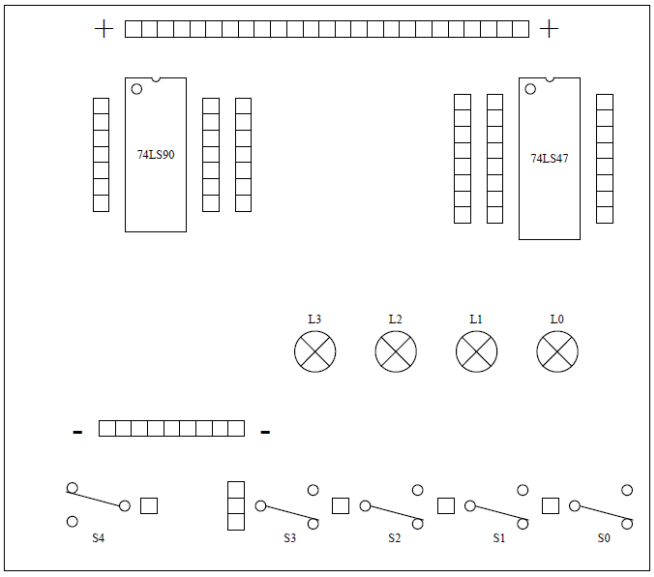
COUNTER 2



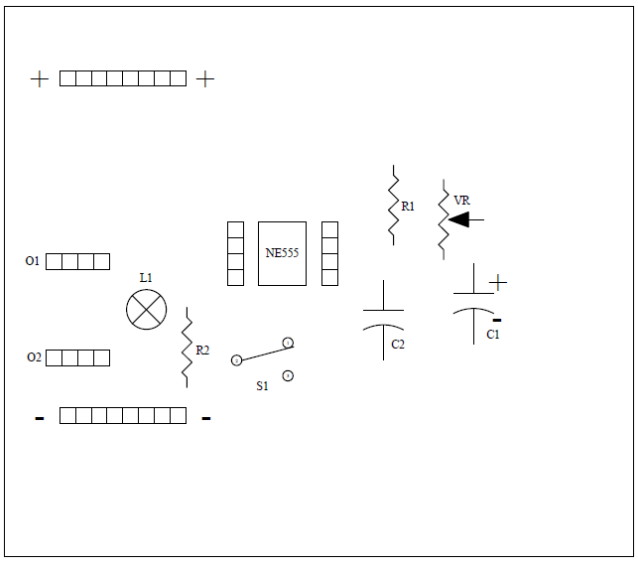
Converter & COUNTER 1



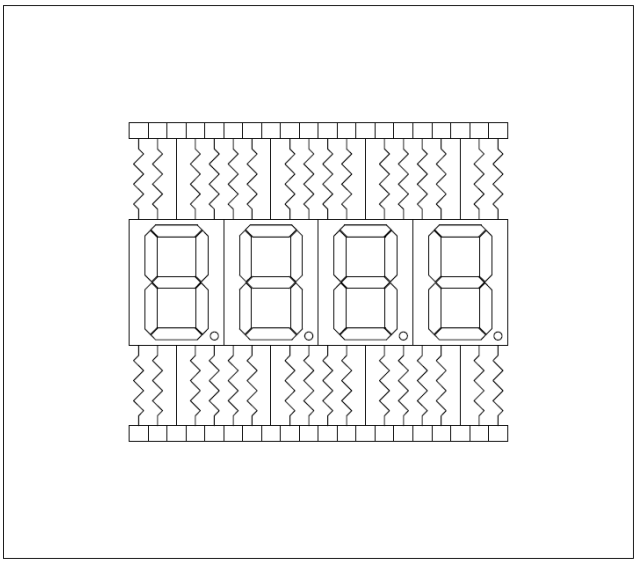
COUNTER 4



COUNTER 5



Clock Pulse Generator



7-Segment Displays

ANNEXURES

ANNEXURE A: USER'S GUIDE

The User's Guide document it attached separately to this report.