DIGITAL IC LEARNING BOARD

USER'S GUIDE

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9-13-2021

1. TABLE OF CONTENTS

- In no event shall the seller be liable to anyone for special, collateral, incidental, or consequential damages in connection with or arising out of the purchase or use of this product and items that come with it.
- Moreover, seller shall not be liable for any claim of any kind whatsoever by any other party arising out of the use of this product and the items that come with it.

2. LIST OF FIGURES

3. LIST OF TABLES

4. ABOUT THIS MANUAL

- Comprehensive guidelines and instructions to operate the Learning Board with correct steps are provided herewith.
- Basic theories of Electronics systems, counters (asynchronous) and circuit components are included for beginners who are new to the field of electronics and other parties.
- Unless specifically stated, all sample operations in this manual assume that the device is in its default setup. Use the procedure under "Initializing the Learning Board" to return the device to its initial default setup.
- The Learning Board is much similar to a plug-and-play device except here, the user needs to connect circuits adequately to obtain relevant outputs.

5. INITIALIZING THE LEARNING BOARD

Perform the following procedure when you want to initialize the Learning Board to their default state.

1. Disconnect the supply terminal from the Learning Board.
2. Ensure all Jumper wires are disconnected/removed from the terminal pins.
3. Set all the switches to its "OFF" state referring the connection circuit diagrams provided in each case.

6. PRECAUTIONS

6.1 SAFETY PRECAUTIONS

⚠ **Electronic Components**

-Device should be strictly kept out of reach of infants and children below the age of 3.
-For replacement of any electronic component on the board please refer "Replacing Components" to safely conduct the procedure.

6.2 HANDLING PRECAUTIONS

- Supply should only be connected at the completion of circuit.

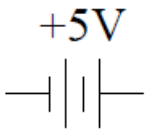
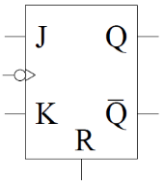
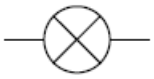
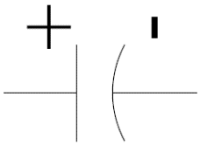
- Ensure the green light of the power adapter (if you are using the adapter provided by the seller) connected to the low voltage power supply is emitting, before conducting further modifications to power “ON” the circuit.
- Avoid use and storage of the device in areas subjected to temperature extremes and large amount of humidity and dust.
- Do not subject the Learning Board to excessive impact, pressure or bending.
- Do not try to remove components unless specified under the section “Replacing Components”.
- Surface of the board can be cleaned/dusted by a dry cloth and circuitry can be cleaned by a piece of cotton/cotton bud.

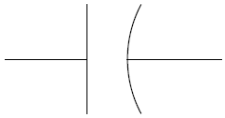
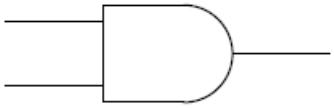
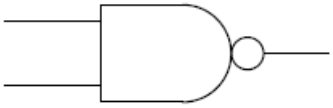
INCASE OF FIRE

1. Do not panic.
2. Cut off the electricity.
3. Do not use water to extinguish the fire.
4. Add some baking soda/any substance with sodium bicarbonate.
5. Remove the source of fire with a heavy blanket.

Even though the device is operated under very low (non-hazardous) voltages, small fire could occur due to unexpected reasons. In a situation as such please adhere to the procedure mentioned above.
Learning Board is constructed with minimal risk of fire and is safe to operate under normal conditions.

7. SYMBOLIC NOTATIONS

No.	SYMBOL	NOTATION
1.		5V DC Supply
2.		Ground
3.		JK Flip-Flop
4.		Bulb/LED
5.		Resistor
6.		Variable Resistor
7.		Polarized Capacitor

8.		Capacitor
9.		AND gate
10.		NAND gate
11.		NOT gate
12.		OR gate
13.	74LS00	Quad 2-Input NAND gates
14.	74LS04	Hex Inverter
15.	74LS08	Quad 2-Input AND gates
16.	74LS11	Triple 2-Input AND gates
17.	74LS32	Quad 2-Input OR gates
18.	74LS47	BCD to 7-Segment Decoder
19.	74LS73	Dual Negative-Edge Triggered JK Flip-Flops
20.	74LS90	Decade Counter
21.	74LS93	4-Bit Binary Counter
22.	NE555	Timer IC

8. INTRODUCTION TO DIGITAL ELECTRONICS & COUNTERS

Digital electronics is a field of electronics involving the study of digital signals and the engineering of devices that use them. There are many different aspects of digital electronics. The analysis and design of digital circuits with increasing complexity is facilitated using abstractions at the circuit and architecture levels. Consequently, there are three main categories.

1. Combinational Circuits
2. Sequential Circuits
3. Finite state machines

In this context we look at Sequential Circuits where the designing of Counters circuits falls under.

8.1 COUNTERS

Binary counters are circuits that generate binary sequences that can be associated with the number of clock signal pulses applied to the input. They are used in applications such as event synchronization and frequency measurement, estimation of angular position and the duration of an event. There are two main types of counters.

1. Asynchronous Counters
2. Synchronous Counters

An **asynchronous counter** is often called a *ripple counter*. The clock signal is only directly applied to the first flip-flop, and it is subsequently transmitted, with a propagation delay, from one flip-flop to another.

In a **synchronous counter**, all the flip-flops are triggered by the same clock signal. Thus, the outputs of the counter change state at the same time and there is no time lag between the different outputs.

A state diagram, which shows the states and possible transitions, is most often used to illustrate the counter operation. It is made up of circles with labels representing the states and with arrows symbolizing the transitions.

The following parameters can be used to characterize a counter:

- the number of different states (also called modulo).
- the direction of counting (up or down).
- the operating mode (asynchronous or synchronous).

❖ **In this context we focus on the designs of <u>Asynchronous Counter</u> circuits.**

9. BASIC CIRCUIT COMBINATIONS

The Learning board is designed to demonstrate 12 different types of asynchronous counter circuits.

Table 9-a: *Circuit 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 digits Up Counter using Counter ICs (Decimal 00-99 counter)
12	Two digits Down Counter using Counter ICs (Decimal 99-00 counter)

Each circuit will be further analyzed, and guidelines will be provided on how to obtain the output respectively in the section "Using the Learning Board". However, fundamental theories pertaining to above 12 circuits are provided under following categories.

1. Hexadecimal Up Counter (4-bit binary up counter)
2. Modulo 6 Up Counter
3. Hexadecimal Down Counter (4-bit binary up counter)
4. Modulo 6 Down Counter

9.1 HEXADECIMAL UP COUNTER

i. Description:

A hexadecimal (or four-bit) up counter has 16 ($2^4 = 16$) states and at least four flip-flops are required for its implementation. It can generate binary sequences corresponding to the numbers from 0 to 15 counting upwards. At each clock signal pulse, the counter moves from one number to the next (0, 1, 2, 3….14, 15, 0, 1, 2….). The counter is reset to 0 upon reaching the sequence 1111, that is the binary equivalent of number 15. Binary representation of the output number can be obtained by LEDs (L0, L1, L2, L3), L3 being the Most Significant Bit (MSB) and L0 being the Least Significant Bit (LSB).

ii. Components:

- 4x JK Flip-Flops
- 1x Clock Pulse Generator
- 4x LEDs
- 4x 220 Ω resistors

iii. Circuit Diagram:

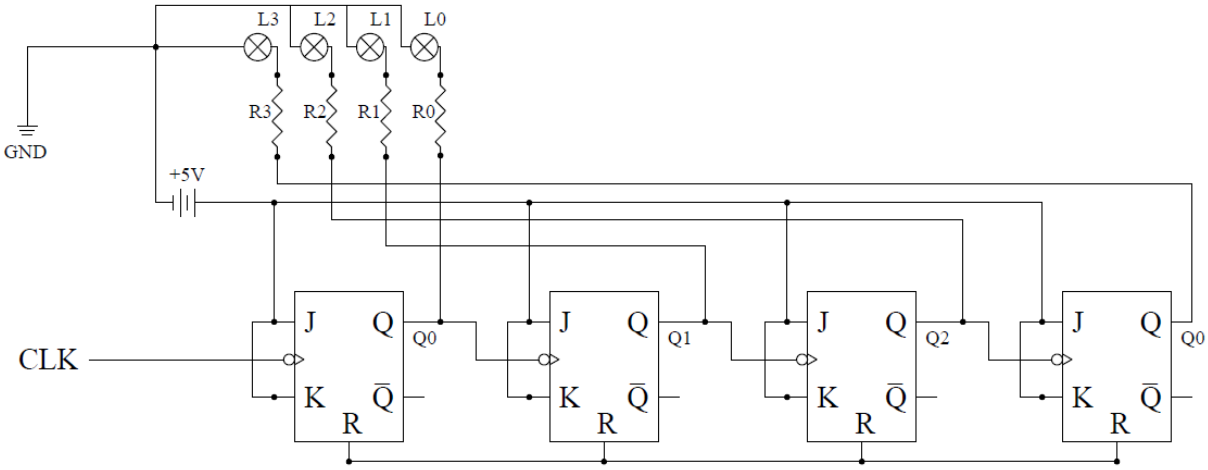


Figure 9-1: *Hexadecimal Up Counter using JK Flip-Flops*

9.2 MODULO 6 UP COUNTER

i. Description:

A modulo 6 (or two-bit) up counter has 6 different states. The output Q0 represents the least significant bit (LSB) and Q2 corresponds to the most significant bit (MSB). Initially, we have: Q0 = 0, Q1 = 0, and Q2 = 0. The counting is cyclic and once the state Q0 = 1, Q1 = 0, and Q2 = 1 is achieved (binary equivalent of decimal 5), the next pulse of the clock signal allows the counter to reset to its initial state. The implementation of a modulo 6 counter requires at least two flip-flops that can be configured for asynchronous operation, and Logic NAND (AND + NOT) as shown in Figure 2 to reset the flipflop when it detects the state 110 (binary equivalent of 6).

ii. Components:

- 3x JK Flip-Flops
- 1x Clock Pulse Generator
- 3x LEDs
- 3x 220 Ω resistors
- 1x NAND gate

iii. Circuit Diagram:

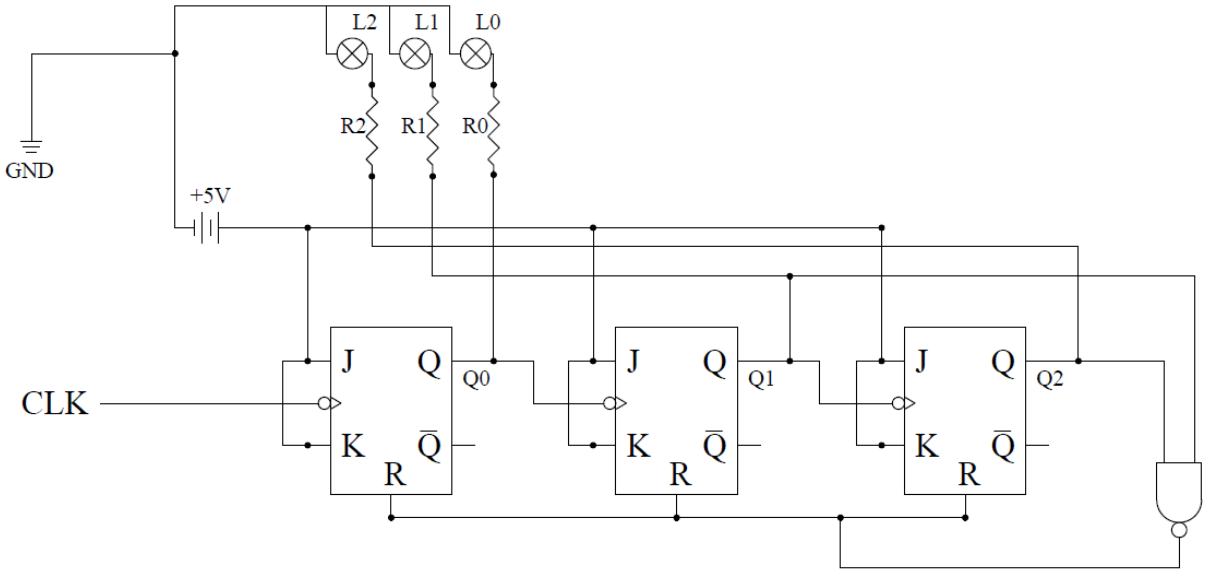


***Figure 9-2**: Modulo 6 Up Counter using JK Flip-Flops*

9.3 HEXADECIMAL DOWN COUNTER

i. Description:

A hexadecimal (or four-bit) down counter has 16 ($2^4 = 16$) states and at least four flip-flops are required for its implementation. It can generate binary sequences corresponding to the numbers from 15 to 0 counting downwards. At each clock signal pulse, the counter moves from one number to the next (15, 14, 13…..2, 1, 0, 15, 14….). The counter is reset to 15 (i.e. binary equivalent 1111) upon reaching the sequence 0000, that is the binary equivalent of number 0. Binary representation of the output number can be obtained by LEDs (L0, L1, L2, L3), L3 being the Most Significant Bit (MSB) and L0 being the Least Significant Bit (LSB).

ii. Components:

- 4x JK Flip-Flops
- 1x Clock Pulse Generator
- 4x LEDs
- 4x 220 Ω resistors

iii. Circuit Diagram:

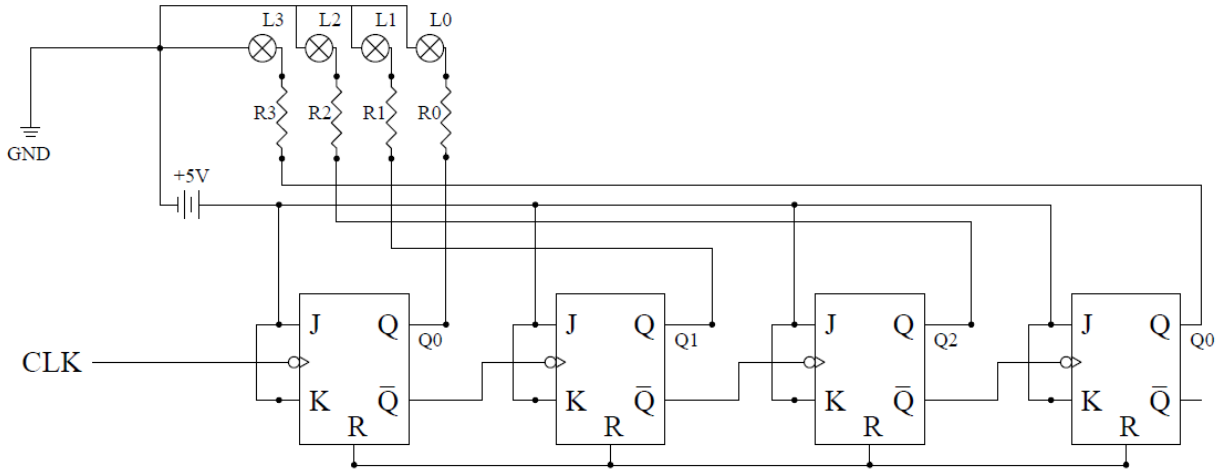


Figure 9-3: *Hexadecimal Down Counter using JK Flip-Flops*

9.4 MODULO 6 DOWN COUNTER

i. Description:

A modulo 6 (or two-bit) down counter has 6 different states. The output Q0 represents the least significant bit (LSB) and Q2 corresponds to the most significant bit (MSB). Initially, we have: Q0 = 1, Q1 = 0, and Q2 = 1 (binary equivalent of decimal 5). The counting is cyclic (5, 4, 3, 2, 1, 0, 5, 4, 3….) and once the state Q0 = 0, Q1 = 0, and Q2 = 0 is achieved, the next pulse of the clock signal allows the counter to reset to its initial state. The implementation of a modulo 6 down counter requires at least two flip-flops that can be configured for asynchronous operation, Logic AND, NOT gates and Logic NAND (AND + NOT) as shown in Figure 4. Here final output is received (via LEDs) after converting the Flip-Flop outputs with logic gates accordingly. However flip-flop outputs are similar to the case of modulo 6 up counter and fixed to reset when it detects the state 110 (binary equivalent of 6).

Let Q0, Q1, Q2 be outputs of flip-flops and A, B, C be the final outputs to be received via LEDs.

Table 9-b: *Truth Table for Flip-Flop output*

Decimal Value	C	B	A
5	1	0	1
4	1	0	0
3	0	1	1
2	0	1	0
1	0	0	1
0	0	0	0

Table 9-c: *Truth Table for final output*

Decimal Value	Q2	Q1	Q0
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1

Expressions:

$$A = Q0' \quad (1)$$

$$B = Q1 \quad (2)$$

$$C = Q2'Q1' \quad (3)$$

ii. Components:

- 3x JK Flip-Flops
- 1x Clock Pulse Generator
- 3x LEDs
- 3x 220 Ω resistors
- 1x NAND gate
- 1X AND gate
- 3x NOT gates

iii. Circuit Diagram:

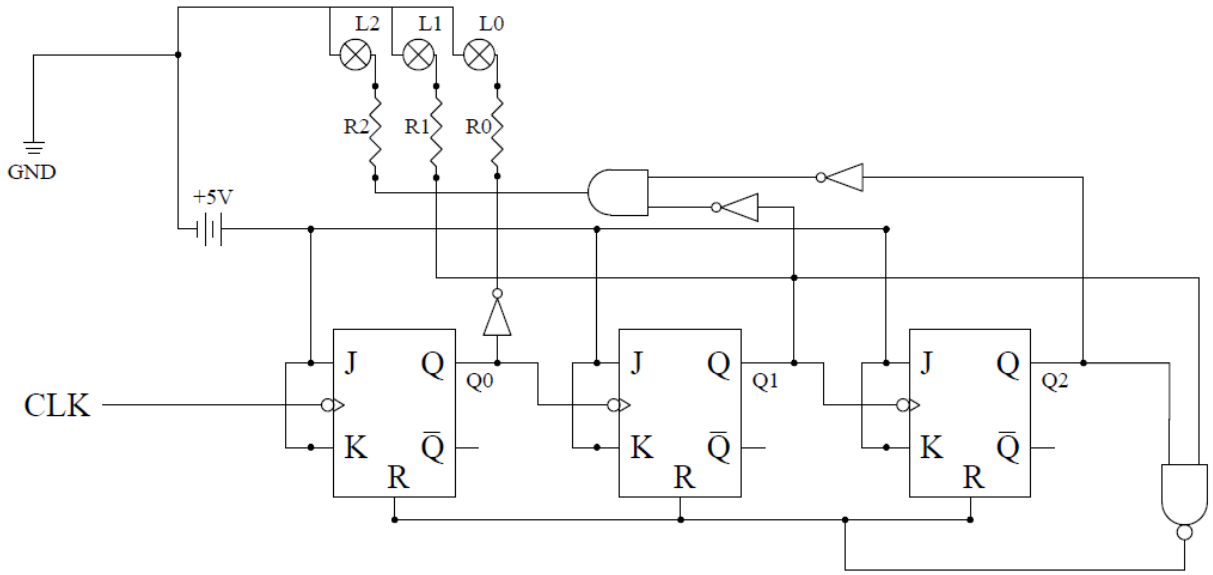


Figure 9-4: *Modulo 6 Down Counter using JK Flip-Flops*

10. LEARNING BOARD LAYOUT

Following figure shows the layout of the Learning Board and its common circuitry (counter1, counter 2, etc.) that will be used when implementing the counter circuits.

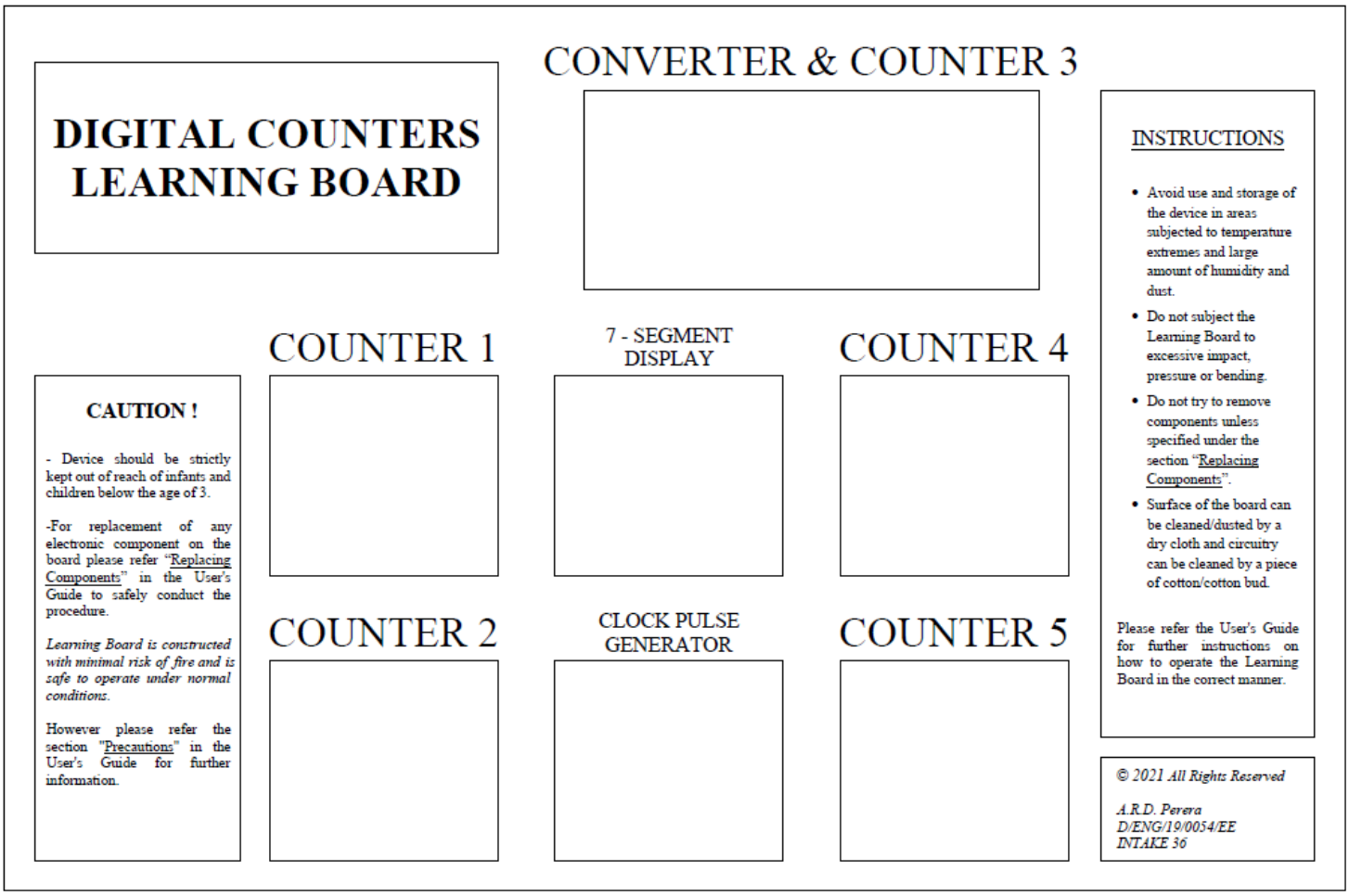


Figure 10-1: *Layout of the Learning Board*

11. COMPONENTS IDENTIFICATION

11.1 COMMON CIRCUITRY IN THE LEARNING BOARD

11.1.1 Counter 1:

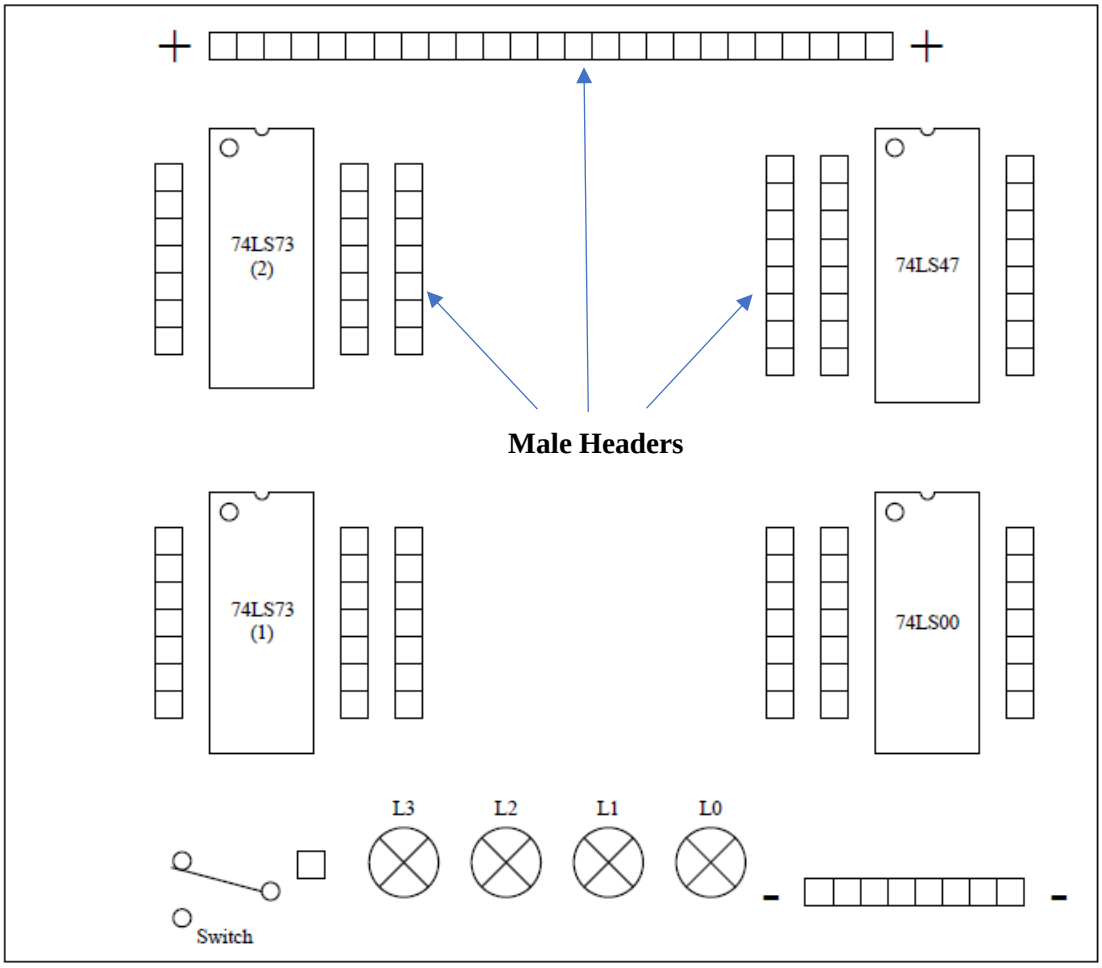


Figure 11-1: *COUNTER 1 circuit diagram*

This circuit diagram can be used to demonstrate the counters that are implemented by JK flip-flops (circuit no. 1,2,3,4). However, to receive the output via a 7-segment display this circuit needs to be connected to the "7-Segment Display" circuit. DC supply is connected to the row of male headers named with "+" and "-" signs. There's a Two-way 3 pin switch connected to the board. It is used to calibrate the starting point of the counter circuit (make the 'Reset' terminal of the IC "High" or "Low" with +5V and 0V respectively). Function of the switch will be further explained in the section "Using the Learning Board". LEDs are represented by L3, L2, L1, L0 (binary equivalents of LEDs are $L0=2^0=1$, $L1=2^1=2$, $L2=2^2=4$, $L3=2^3=8$). Ex: Decimal 6 will be represented by L3=OFF, L2=ON, L1=ON, L0=OFF.

NOTE:

Following switch configurations in each common circuitry can be connected to obtain a controlled output. i.e. to ensure counting starts from 0, and to reset the counter whenever as per the preference of user.

Firstly the switch should be connected by a jumper wire as shown in the following diagrams to supply a Zero potential to the middle pin (2) of the 2-way 3 pin slide switch. Reset (R) terminal of the IC is connected to pin 3 and pin 1 is opened in the 2-way switch

In the "OFF" position as shown in Figure 11-2, 0V is not supplied to pin 3. Therefore, Reset is not set to 0.

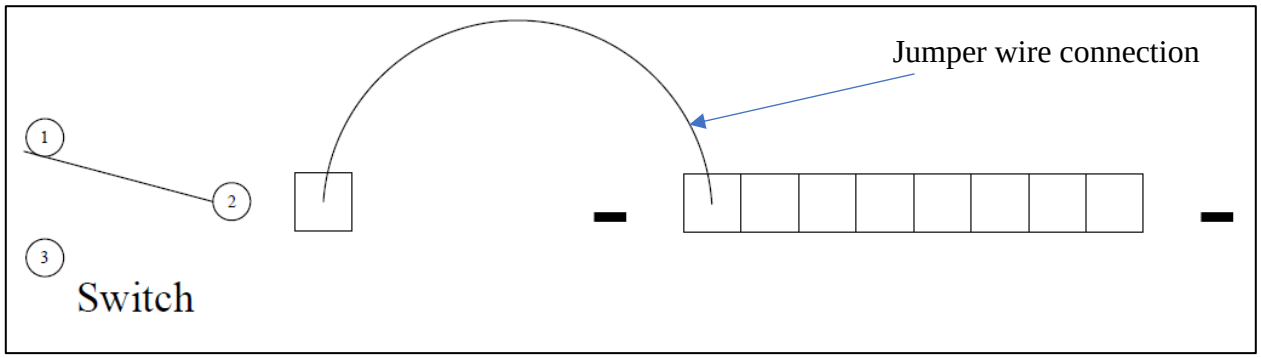


Figure 11-2: *OFF position of the switch*

In the "ON" position as shown in Figure 11-3, 0V is supplied to pin 3. Therefore, Reset is set to 0. Hence the counter output is 0.

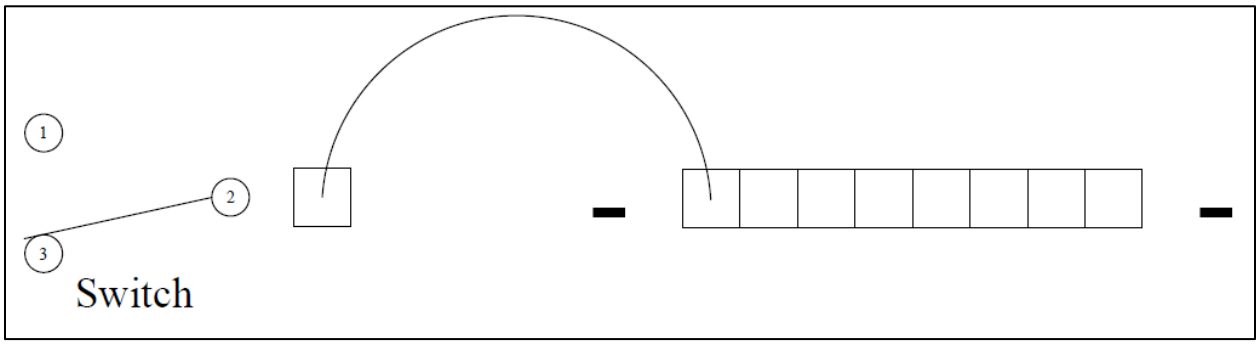


Figure 11-3: *ON position of the switch*

11.1.2 Counter 2:

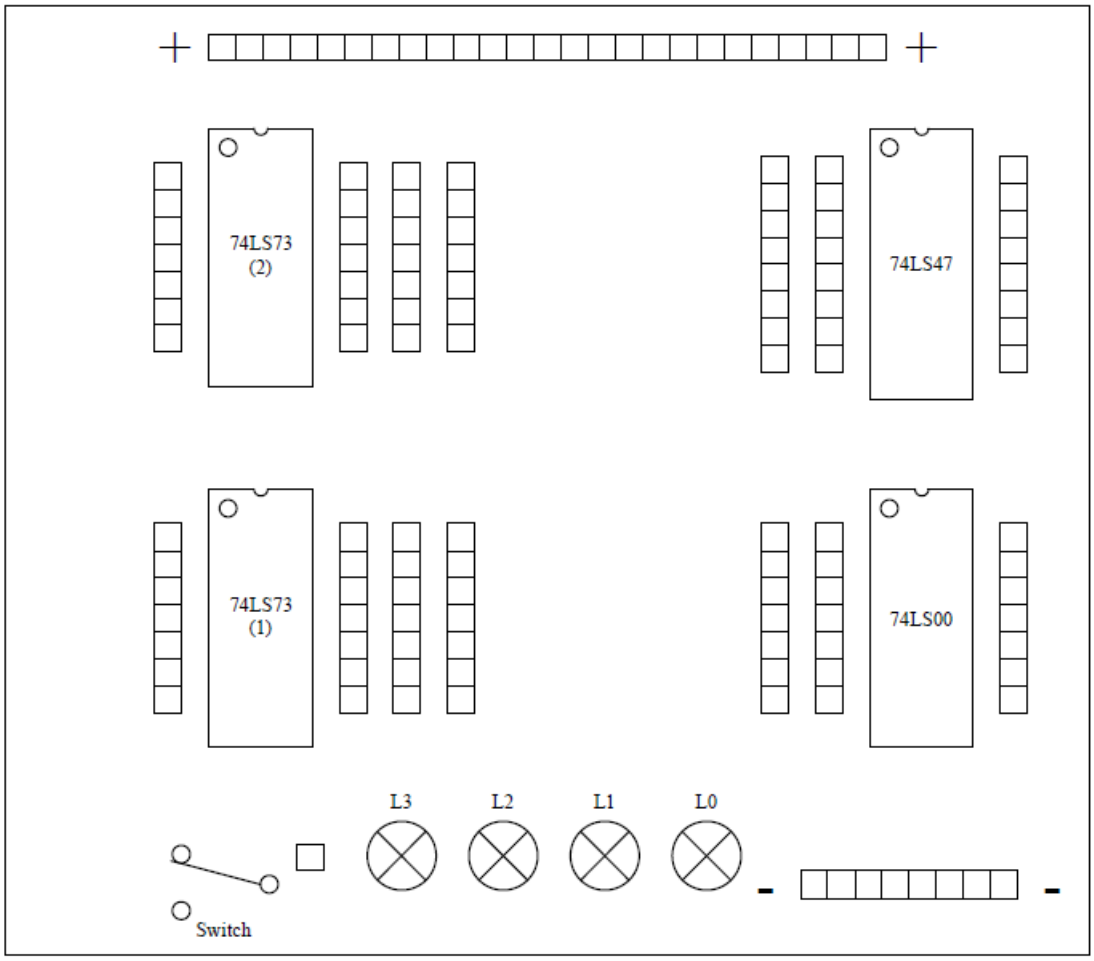


Figure 11-4: *COUNTER 2 circuit diagram*

Same circuit as COUNTER 1. User can demonstrate the counters that are implemented by JK flip-flops (circuit no. 1,2,3,4) on this circuit as well. However, when demonstrating two or more digits counters this circuit can be used. Same components as mentioned in the COUNTER 1 circuit is used here with an additional row of male headers added to the two 74LS73 ICs.

11.1.3 Converter & Counter 3:

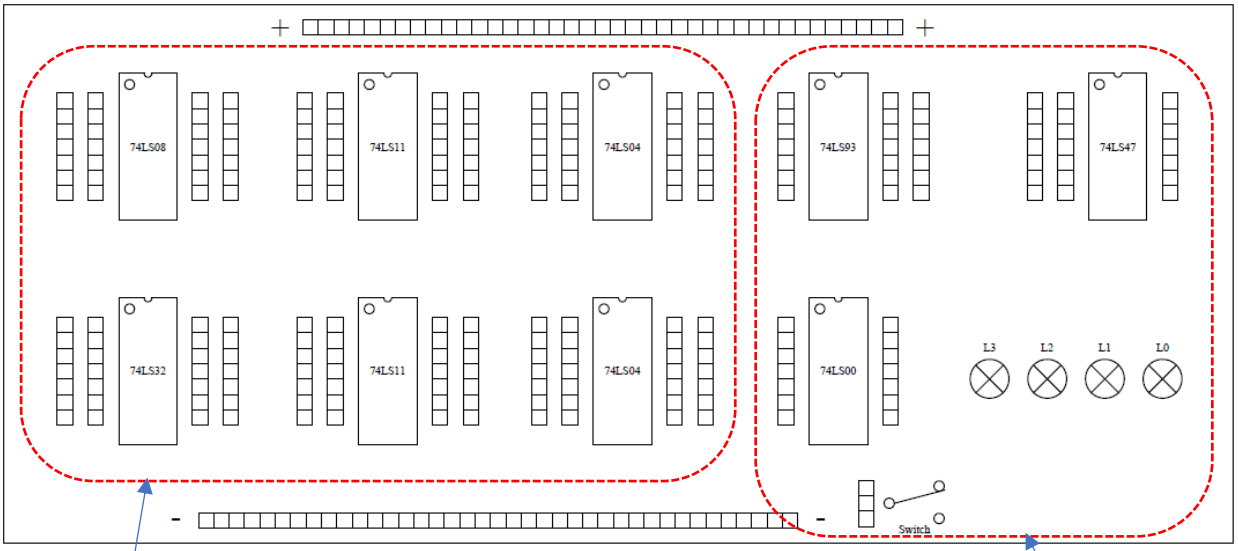


Figure 11-5: *Converter & COUNTER 3 circuit diagram*

Converter circuit

Counter 3

COUNTER 3 circuit can be used to demonstrate the counters that are implemented by 4-bit binary counter ICs (circuit no. 5,6,7,8). However, to receive the output via a 7-segment display this circuit needs to be connected to the "7-Segment Display" circuit. DC supply is connected to the row of male headers named with "+" and "-" signs. Switch and LEDs have their usual notations and functions as explained under the section 11.1.1.

Converter circuit is mainly used to implement down counters. Output of the original counter ICs are connected accordingly to the converter circuit prior connecting to the decoder IC (74LS47) to obtain the output via the 7-segment displays. Connection process is explained under later sections.

11.1.4 Counter 4:

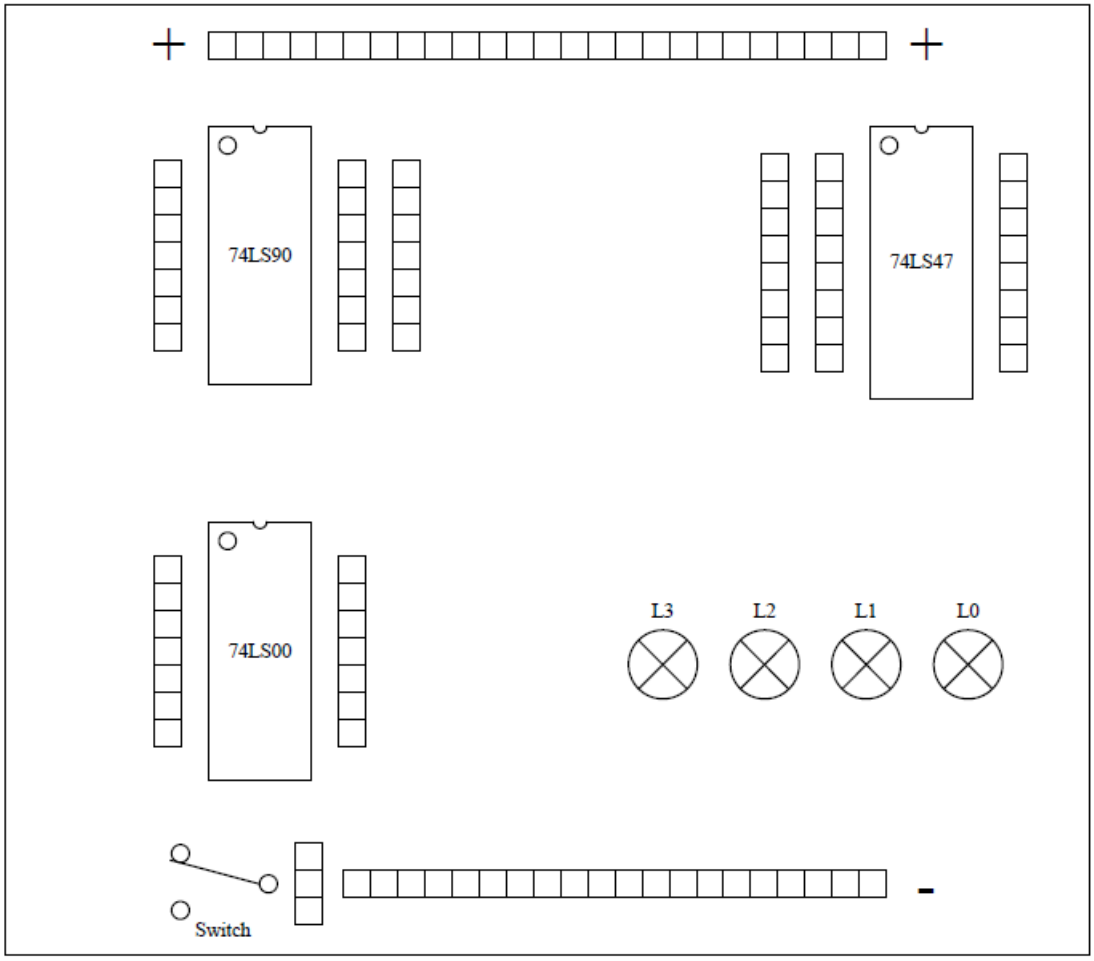


Figure 11-6: *COUNTER 4 circuit diagram*

COUNTER 4 circuit can be used to demonstrate the counters that are implemented by Decade Counter ICs (circuit no. 9,10,11,12). However, to receive the output via a 7-segment display this circuit needs to be connected to the "7-Segment Display" circuit. DC supply is connected to the row of male headers named with "+" and "-" signs. Switch and LEDs have their usual notations and functions as explained under the section 11.1.1. Modulo counters too can be implemented using this circuit.

11.1.5 Counter 5:

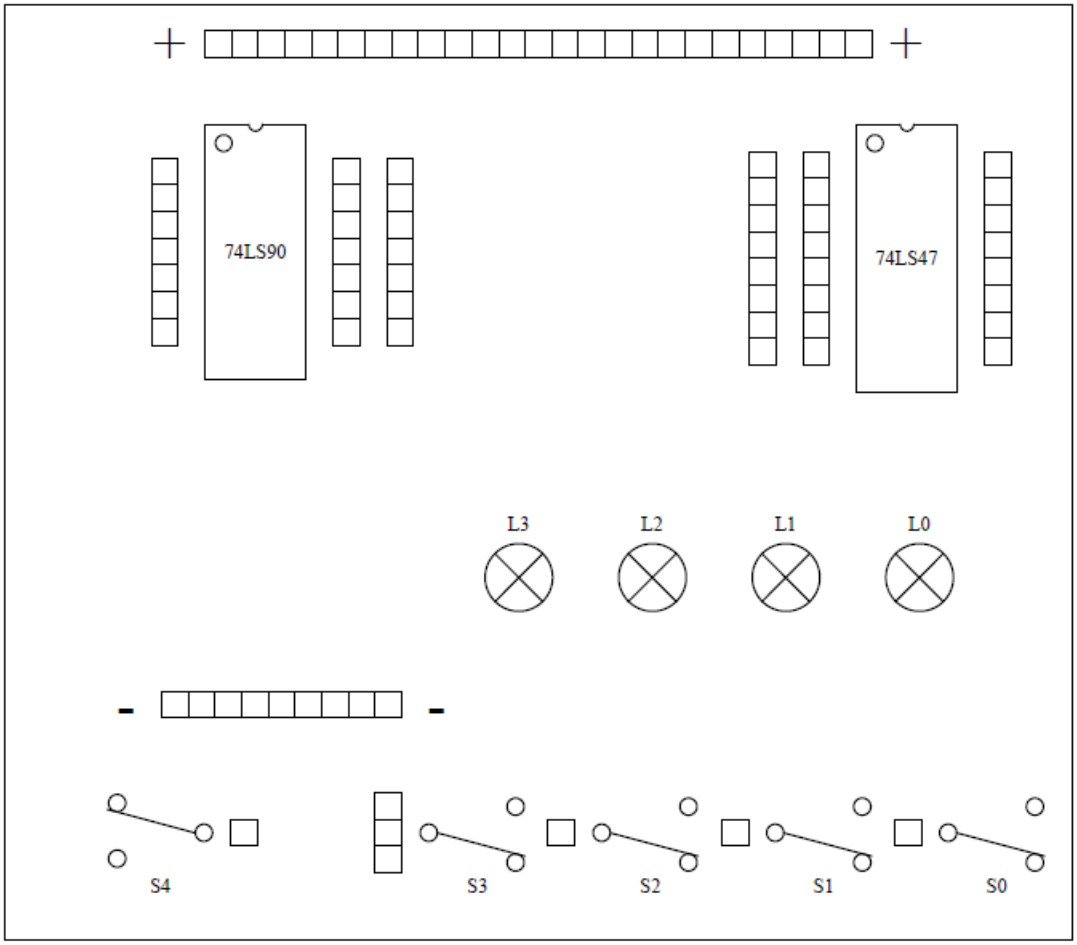


Figure 11-7: *COUNTER 5 circuit diagram*

COUNTER 5 circuit too can be used to demonstrate the counters that are implemented by Decade Counter ICs (circuit no. 9,10,11,12). However, to receive the output via a 7-segment display this circuit needs to be connected to the "7-Segment Display" circuit. DC supply is connected to the row of male headers named with "+" and "-" signs. Switch and LEDs have their usual notations and functions as explained under the section 11.1.1. Additionally this circuit is mainly used to implement 2-digits or more counters.

- **7-segment display circuit and Clock pulse generator circuit are explained in detail under the subsections 12.1 and 12.2.**

11.2 PIN DIAGRAMS OF INTEGRATED CIRCUITS (ICs)

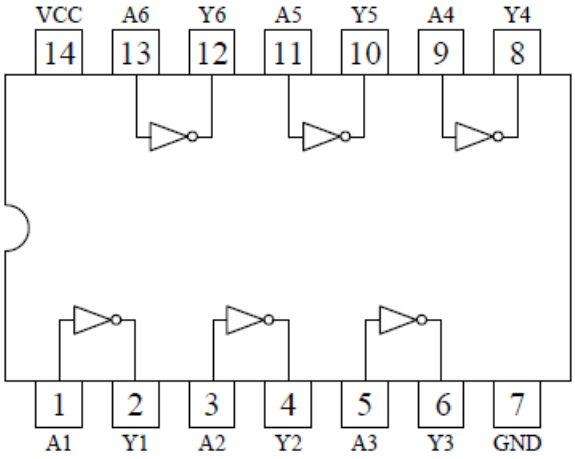


Figure 11-8: *74LS04 Hex Inverter*

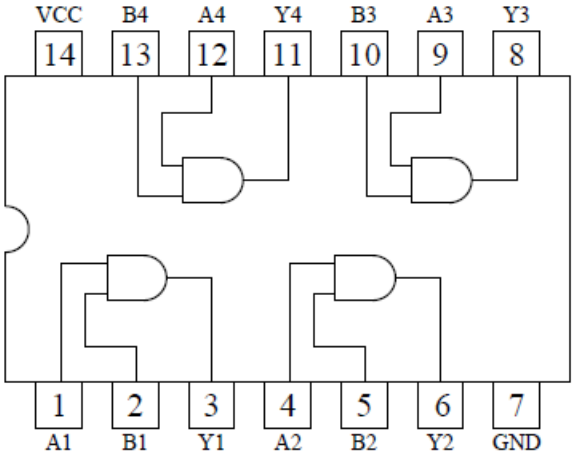


Figure 11-9: *74LS08 Quad 2-Input AND gates*

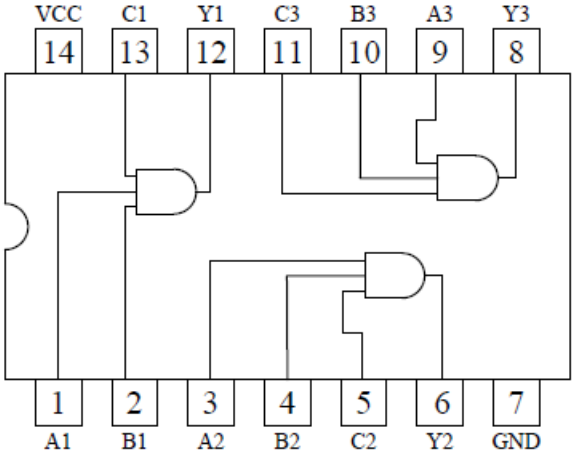


Figure 11-10: *74LS11 Triple 3-Input AND gates*

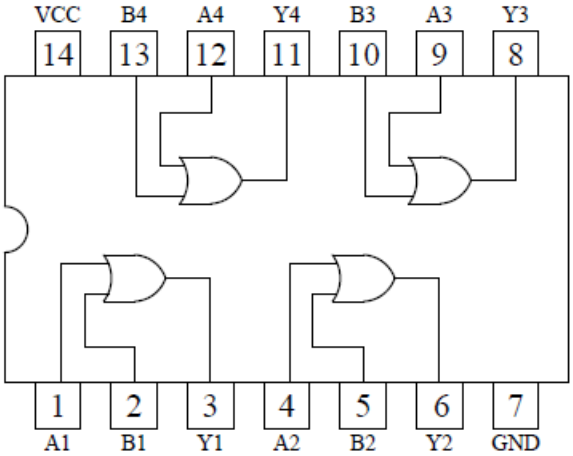


Figure 11-11: *74LS32 Quad 2-Input OR gates*

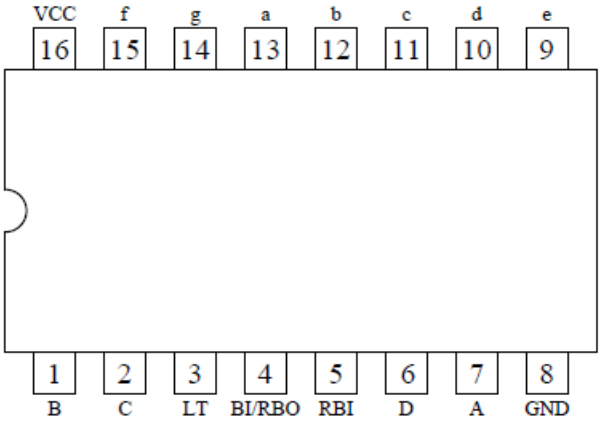


Figure 11-12: *74LS47 BCD to 7-Segment Decoder*

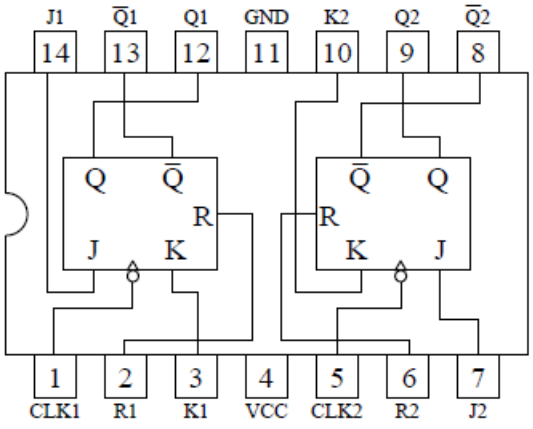


Figure 11-13: *74LS73 Dual Negative-Edge Triggered JK Flip-Flops*

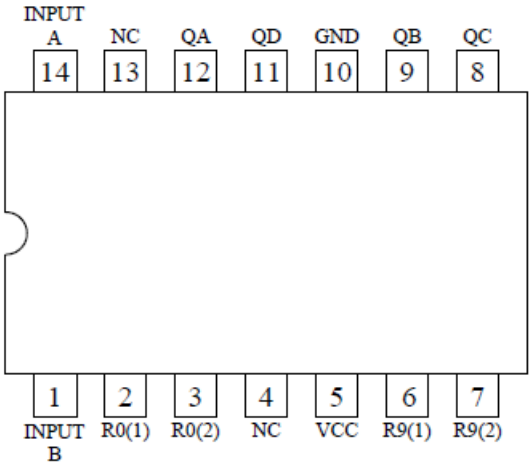


Figure 11-14: *74LS90 Decade Counter*

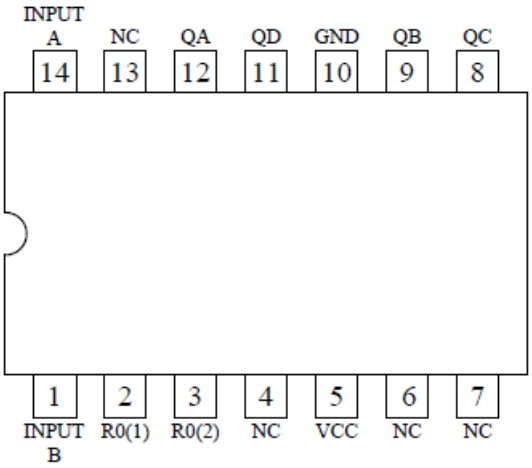


Figure 11-15*: 74LS93 4-Bit Binary Counter*

12. USING THE LEARNING BOARD

12.1 FUNCTION OF A CLOCK PULSE GENERATOR

A Clock Pulse Generator is used to send an input signal to the Counter ICs to start the counting. Frequency of the clock pulse generator can be adjusted according to user preference on how they wish to make the counter outputs change. (i.e., to change output integers with a period of pre set time intervals).

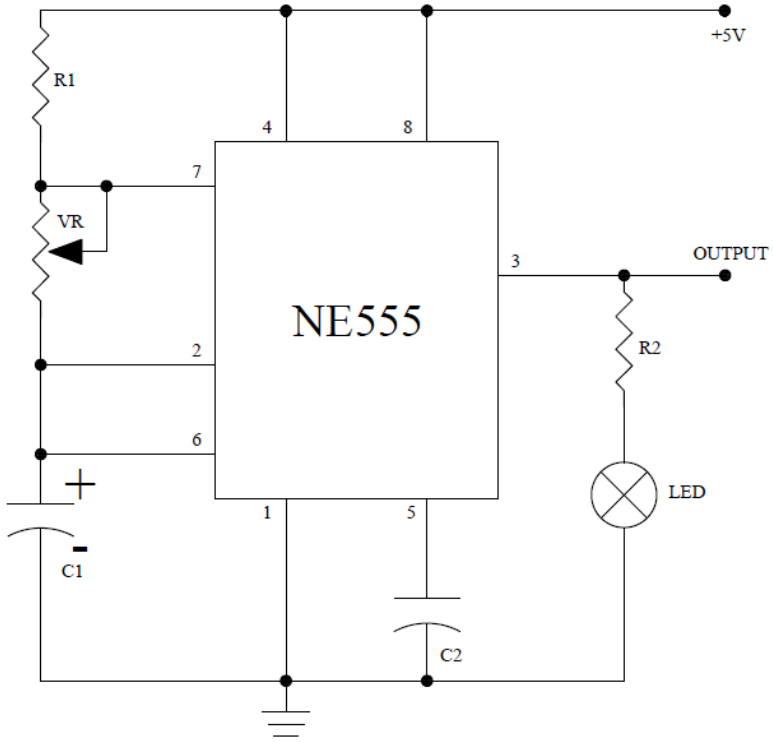


Figure 12-1: *Clock Pulse Generator circuit diagram*

Time interval (frequency) in between two output integers can be set by following equations,

$$f = \frac{1}{T} \tag{4}$$

$$T = 0.693(R1 + 2 \times VR)C1 \tag{5}$$

Where T = Cycle Time, f = frequency.

Since R1 and C1 are constant by varying VR user can obtain the required cycle time.

Following diagram shows circuit connection on the Learning Board.

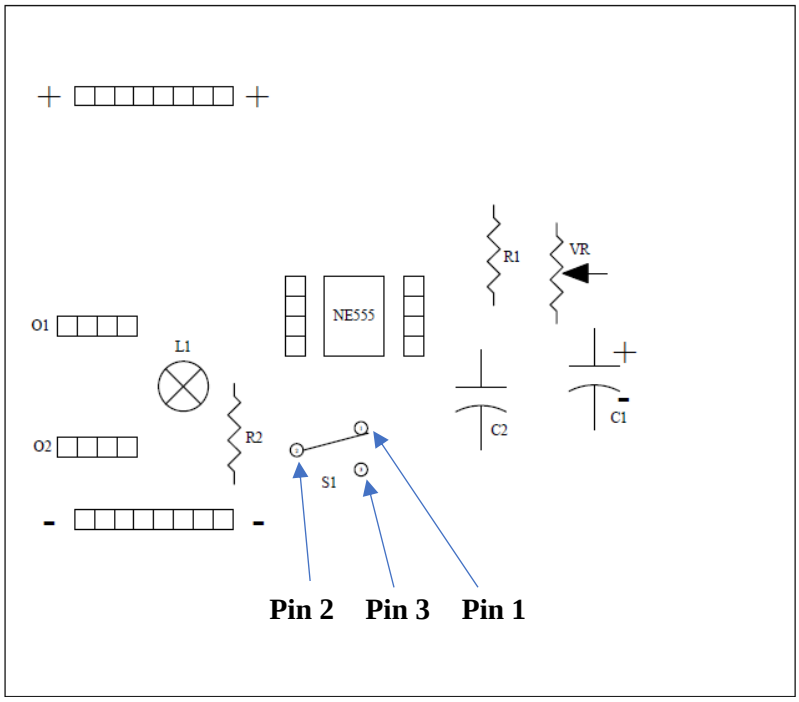


Figure 12-2: *Clock Pulse Generator common circuit on the Learning Board*

If the user prefer to toggle the pulses the output jumper wire should be connected to O2 terminal. Then by toggling the switch to "ON" and "OFF" position user can control the input signal to the counter ICs. When the switch is in "OFF" position (connected to pin 1), no input signal is given to the counter IC. When the switch is in "ON" position (connected to pin 3), input signal is given to the counter IC and the counting starts. If the output jumper wire is connected to O1 terminal input clock pulses are sent to the counter IC as soon as the supply voltage is provided to the circuit.

12.2 FUNCTION OF A 7-SEGMENT DISPLAY

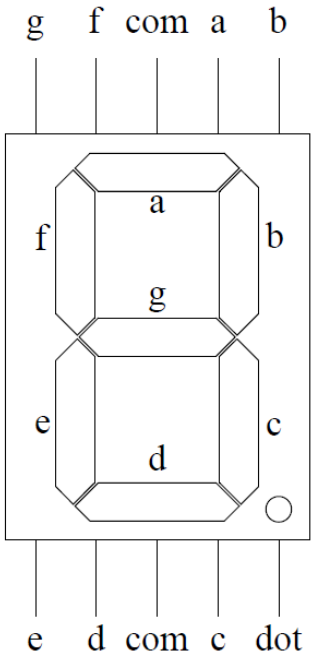


Figure 12-3: *7-Segment Display*

Above figure depicts the basic pin diagram of a 7-segment display. User should connect the terminal pins accordingly with the 74LS47 IC output terminal pins. There are 10 possible numerical outputs (0,1,2,3,4,5,6,7,8,9) that can be displayed by a 7-segment display. In order to display an integer (0-9) as an output for the display we need to ensure relevant segments have a "HIGH" potential (binary 1).

For Example: If the user wish to display the digit "2", user should provide "HIGH" state to segments a,b,g,e,d.

Following diagram shows the relevant segments to be switched ON to obtain an integer output displayed.

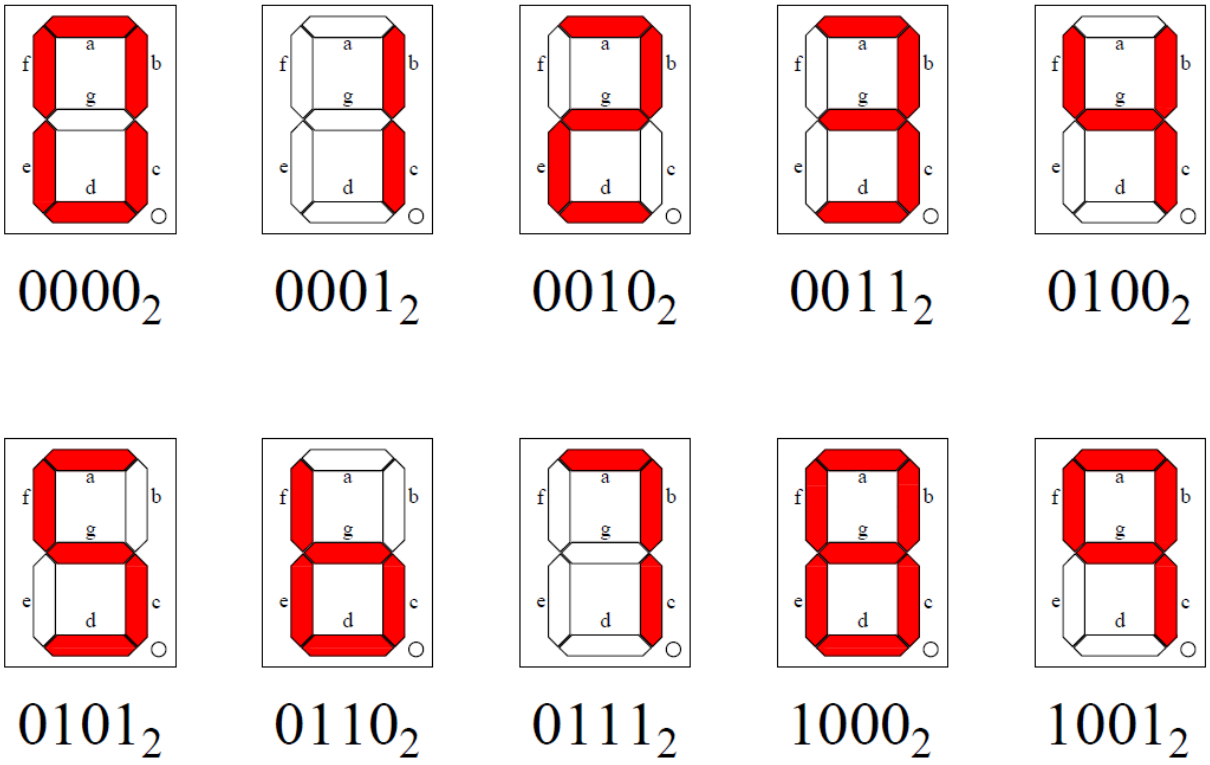


Figure 12-4: *Numerical integers of 7-segment displays*

A '7-Segment Displays circuit' consisting of 4 nos. 7-segment displays is provided in the Learning Board as common circuitry. Even though there are 4nos. of displays we will be working with 2nos. of displays to learn the fundamental concepts. However, user can further demonstrate circuits using all 4 displays using 4 different counter circuits. Few examples are given under the section "Other Possible Connections" to try out by yourself.

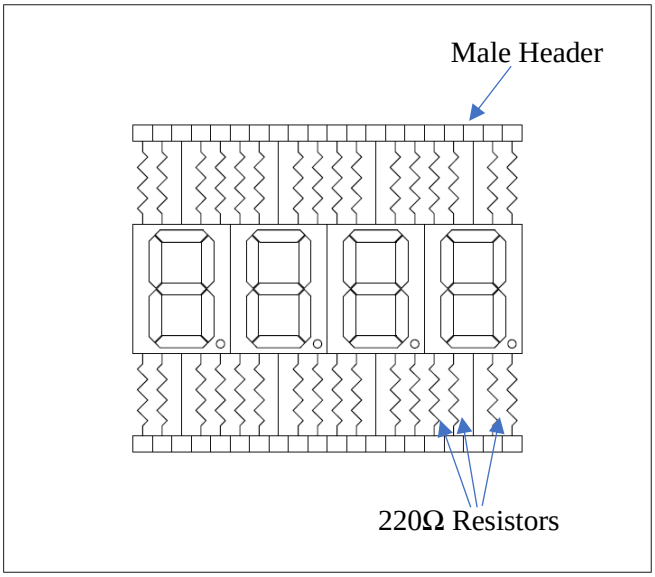


Figure 12-5: *7-Segment Displays common circuit on Learning Board*

12.3 IMPLEMENTING COUNTER CIRCUITS

This section provides the user in depth detail on how to connect the circuits and use it in the correct manner minimizing the errors. There are 5 main types of common circuitry on the Learning Board to assist in implementing the asynchronous counter circuits available. Each circuit is explained under following categories,

i. Components
ii. Steps to connect the circuit
iii. Circuit diagram
iv. Proteus Simulation
v. Block diagram
vi. Final Output

12.3.1 Hexadecimal Up counter using JK Flip-Flops

i. Components

- 2x 74LS73 ICs
- 4x LEDs
- 4x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- COUNTER 1 or COUNTER 2

STEP 2: Refer Figure 12-3 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

- **LEDs are connected to relevant IC terminals internally,**
- **Reset terminals within a flip-flop are connected internally,**
- **J-K terminals within a flip-flop are connected internally,**

to avoid the number of jumper wires on the board as they have same potentials separately.

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and 'J-K' terminal pins accordingly and complete the connections of two flip-flops to complete the basic connections of the circuit.

STEP 5: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of flip-flop 1 in the COUNTER 1 circuit (Figure 11-1) as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 1 circuit to maintain the same supply potentials at both circuits.

STEP 6: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 7: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

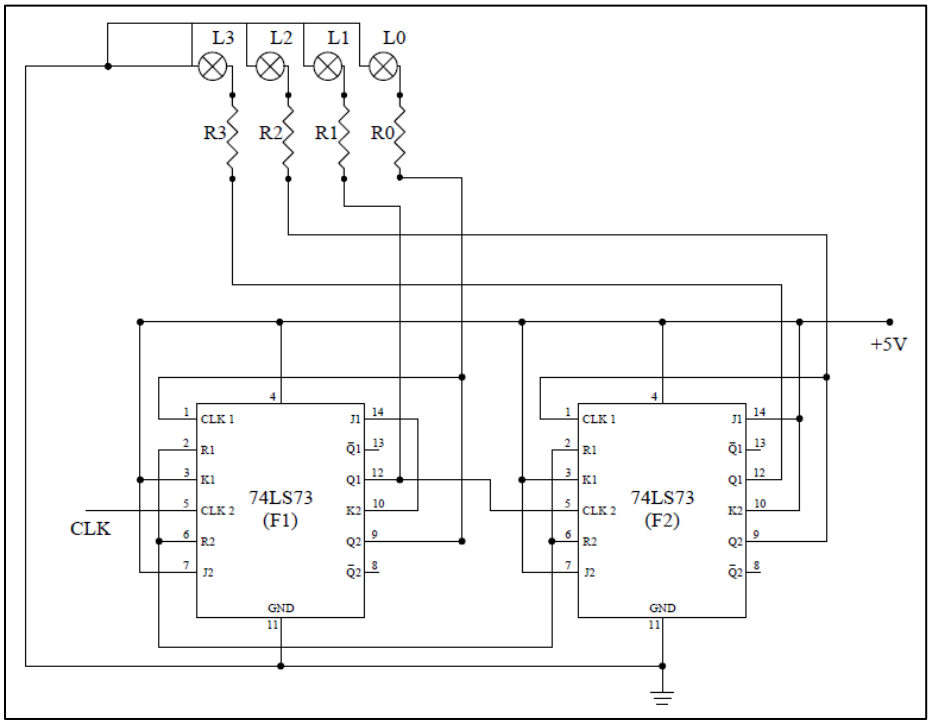


Figure 12-6: *Hexadecimal Up counter using JK Flip-Flops*

iv. Proteus Simulation

Note: 7-Segment display is not connected here. It may be connected through a BCD to 7-segment decoder IC (sample connection shown in Figure 12.3.5-2) but the output after decimal digit '9' will not be displayed. Refer section "Errors" for further clarifications.

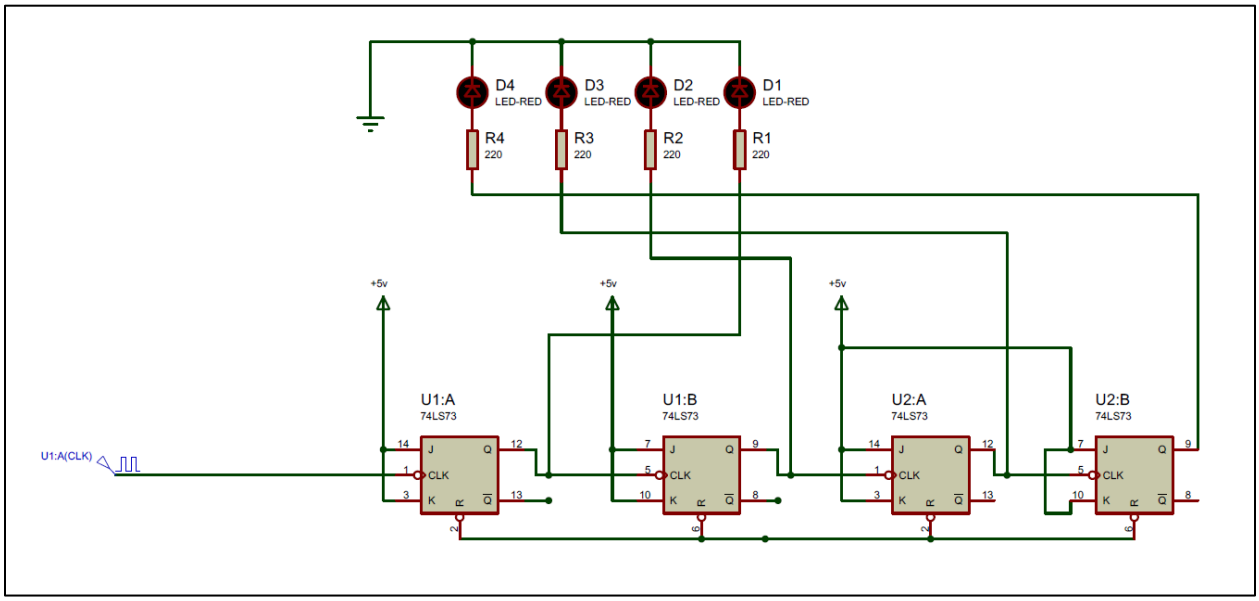


Figure 12-7: *Simulation Circuit diagram of Hexadecimal Up counter using JK Flip-Flops*

v. Block diagram

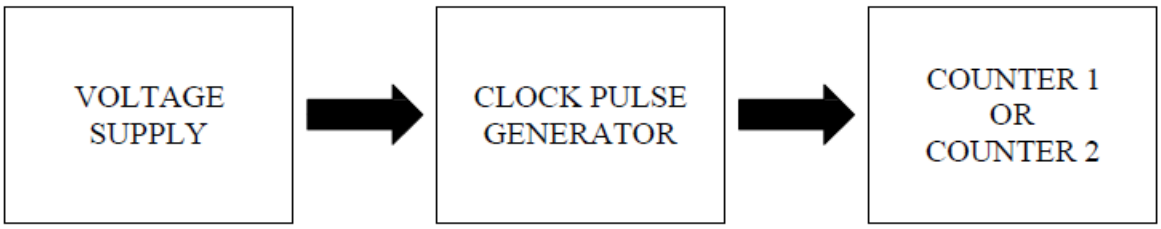


Figure 12-8: *Connection of common circuitry for 12.3.1*

vi. Final Output

(include common cct external connections & final preview of the real output of the Learning Board)

12.3.2 Modulo 6 Up counter using JK Flip-Flops

i. Components

- 2x 74LS73 ICs
- 1x 74LS00 IC
- 1x 74LS47 IC
- 1x 7-segment display
- 7x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.
- Clock Pulse Generator
- COUNTER 1 or COUNTER 2
- 7-segement displays

STEP 2: Refer Figure 12-5 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**
- **Reset terminals within a flip-flop are connected internally,**
- **J-K terminals within a flip-flop are connected internally,**

to avoid the number of jumper wires on the board as they have same potentials separately.

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and 'J-K' terminal pins accordingly to complete the connections of two flip-flops and connect 7-segment display circuit (Figure 12-2) with COUNTER 1 (Figure 11-1) circuit to complete the basic connections of the circuit.

STEP 5: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of flip-flop 1 in the COUNTER 1 circuit as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 1 circuit to maintain the same supply potentials at both circuits.

STEP 6: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment display (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 7: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

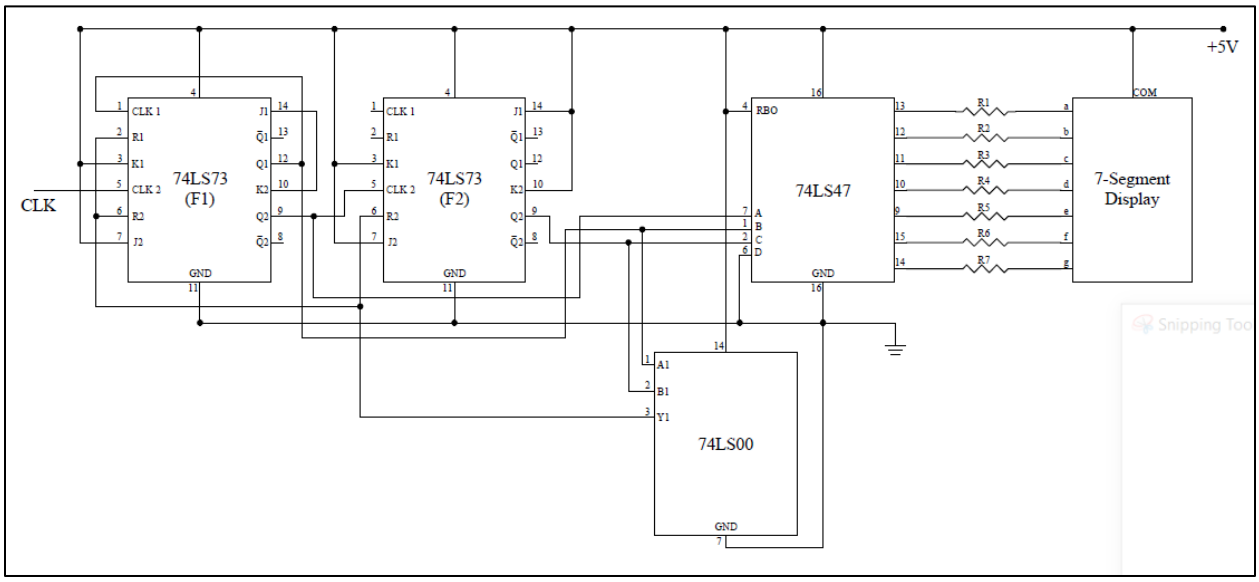


Figure 12-9: *Modulo 6 Up counter using JK Flip-Flops*

iv. Proteus Simulation

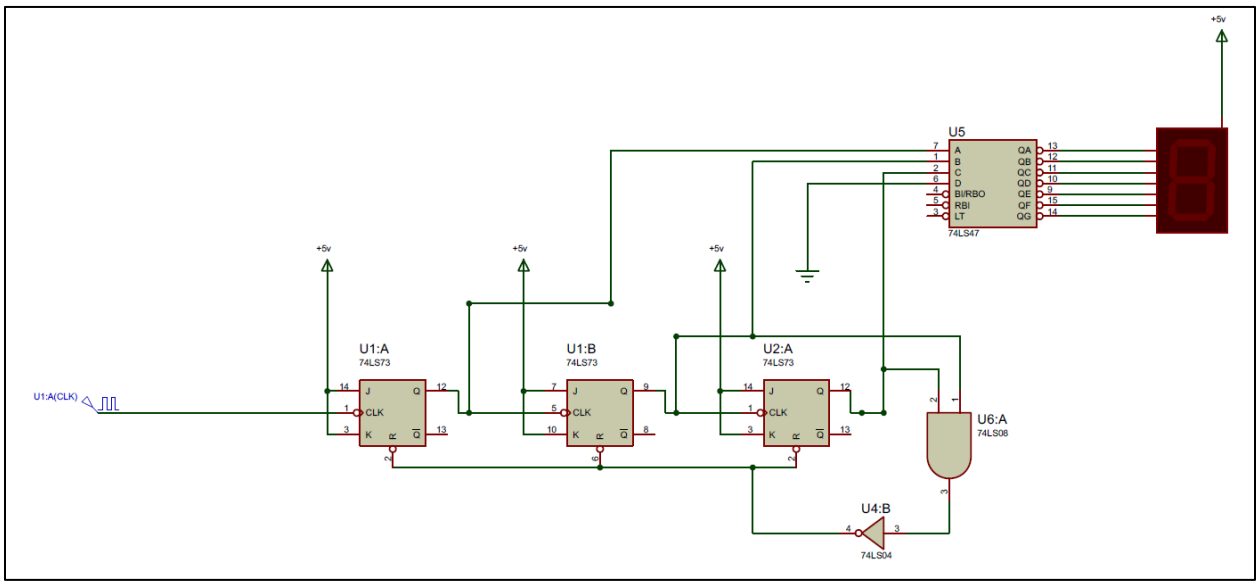


Figure 12-10: *Simulation circuit diagram of Modulo 6 Up counter using JK Flip-Flops*

v. Block diagram

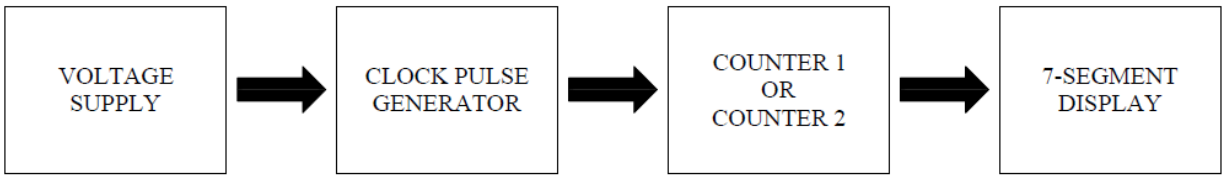


Figure 12-11: *Connection of common circuitry for 12.3.2*

vi. Final Output

12.3.3 Hexadecimal Down counter using JK Flip-Flops

i. Components

- 2x 74LS73 ICs
- 4x LEDs
- 4x 220 Ω resistors

ii. **Steps to connect the circuit**

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- COUNTER 1 or COUNTER 2

STEP 2: Refer Figure 12-7and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

- **LEDs are connected to relevant IC terminals internally,**
- **Reset terminals within a flip-flop are connected internally,**
- **J-K terminals within a flip-flop are connected internally,**

to avoid the number of jumper wires on the board as they have same potentials separately.

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and 'J-K' terminal pins accordingly and complete the connections of two flip-flops to complete the basic connections of the circuit. (similar connection as 12.3.1 circuit except here the clock inputs are *Q'* where as in 12.3.1 the clock input was *Q*.)

STEP 5: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of flip-flop 1 in the COUNTER 1 circuit (Figure 11-1) as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 1 circuit to maintain the same supply potentials at both circuits.

STEP 6: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 7: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

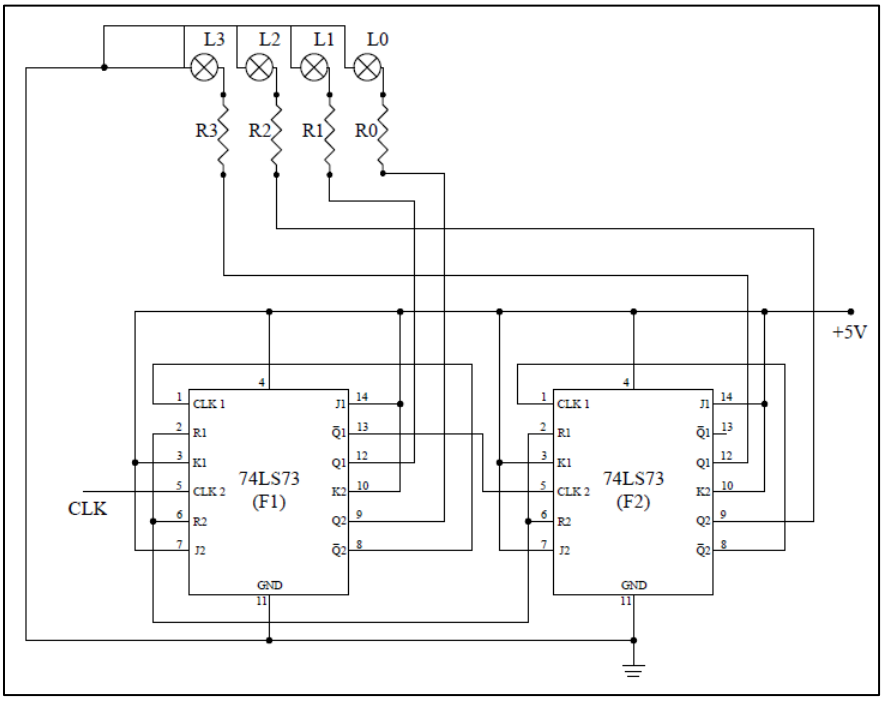


Figure 12-12: *Hexadecimal Down counter using JK Flip-Flops*

iv. Proteus Simulation

Note: 7-Segment display is not connected here. It may be connected through a BCD to 7-segment decoder IC (sample connection shown in Figure 12.3.5-2) but the output after decimal digit '9' will not be displayed. Refer section "Errors" for further clarifications.

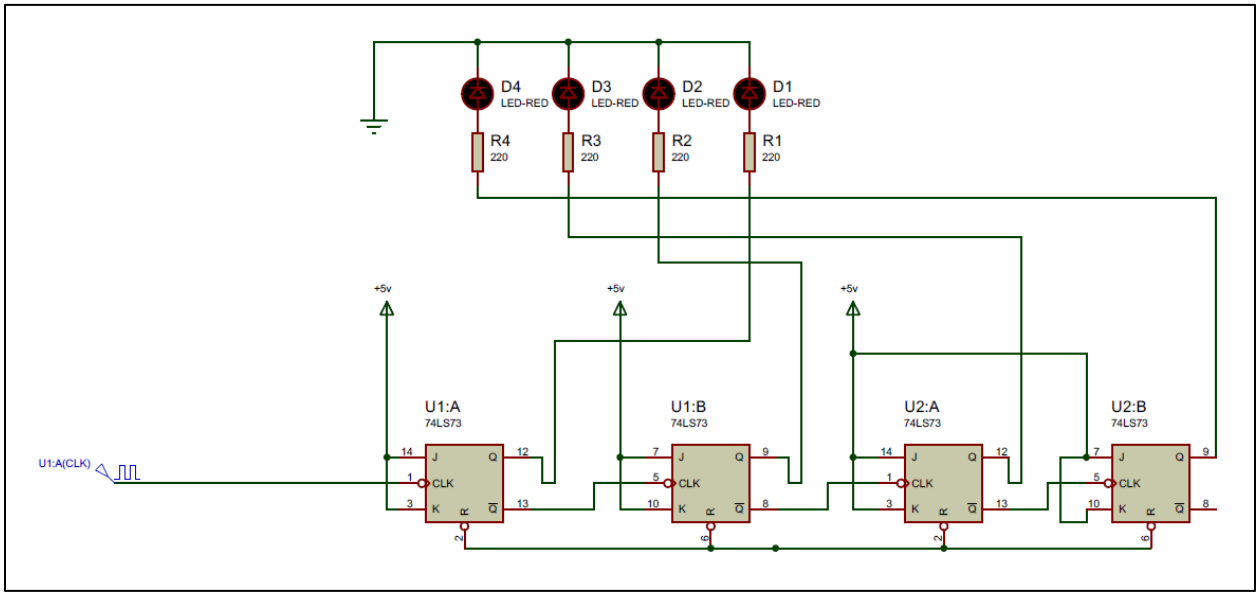


Figure 12-13: *Simulation circuit diagram of Hexadecimal Down counter using JK Flip-Flops*

v. Block diagram

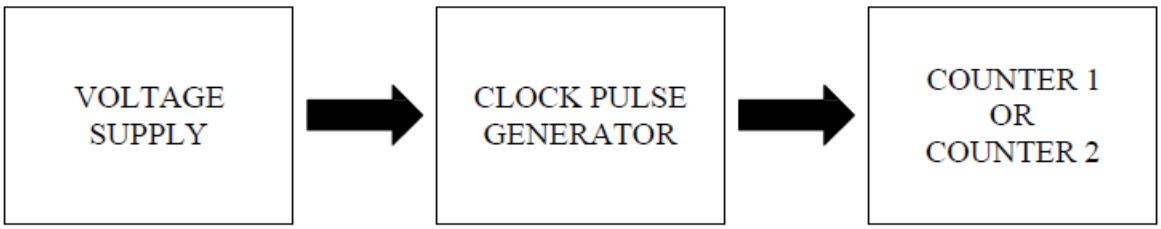


Figure 12-14: *Connection of common circuitry for 12.3.3*

vi. Final Output

12.3.4 Modulo 6 Down counter using JK Flip-Flops

i. Components

- 2x 74LS73 ICs
- 1x 74LS04 IC
- 1x 74LS08 IC
- 1x 74LS47 IC
- 1x 7-segment display
- 7x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- COUNTER 1 or COUNTER 2
- Converter & COUNTER 3
- 7-segement displays

STEP 2: Refer Figure 12-9 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

- **Reset terminals within a flip-flop are connected internally,**
- **J-K terminals within a flip-flop are connected internally,**

to avoid the number of jumper wires on the board as they have same potentials separately.

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and 'J-K' terminal pins accordingly to complete the connections of two flip-flops

STEP 5: Use the Converter part of the Converter & Counter 3 circuit (Figure 11-5) to convert the output of counter ICs and provide input to the decoder IC (74LS47), and connect 7-segment display circuit (Figure 12-2) with COUNTER 1 (Figure 11-1) circuit to complete the basic connections of the circuit.

STEP 6: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of flip-flop 1 in the COUNTER 1 circuit as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 1 circuit to maintain the same supply potentials at both circuits.

STEP 7: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment display (Function of Clock Pulse Generator circuit was

explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 8: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

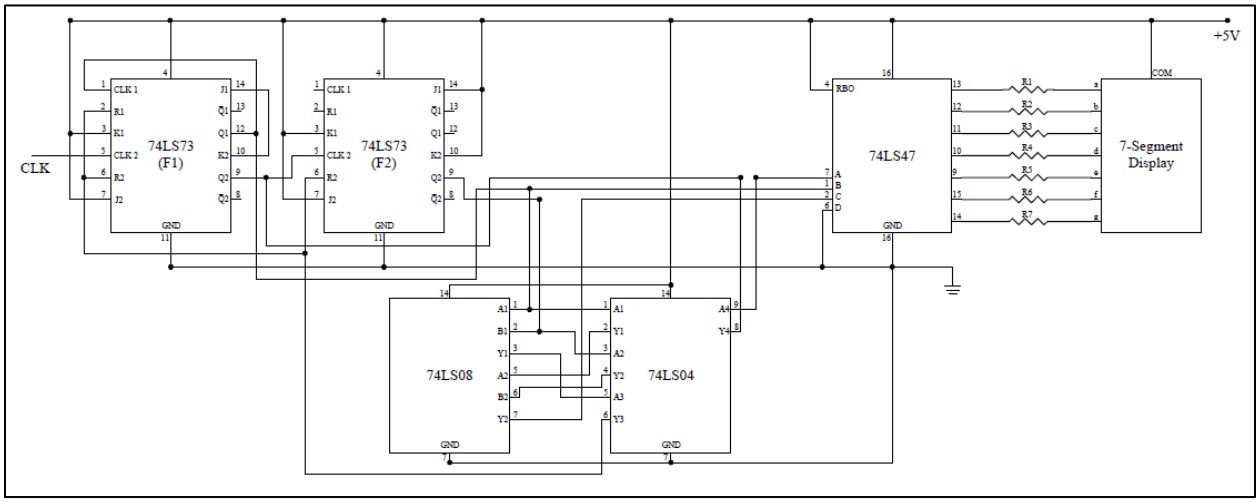


Figure 12-15: *Modulo 6 Down counter using JK Flip-Flops*

iv. Proteus Simulation

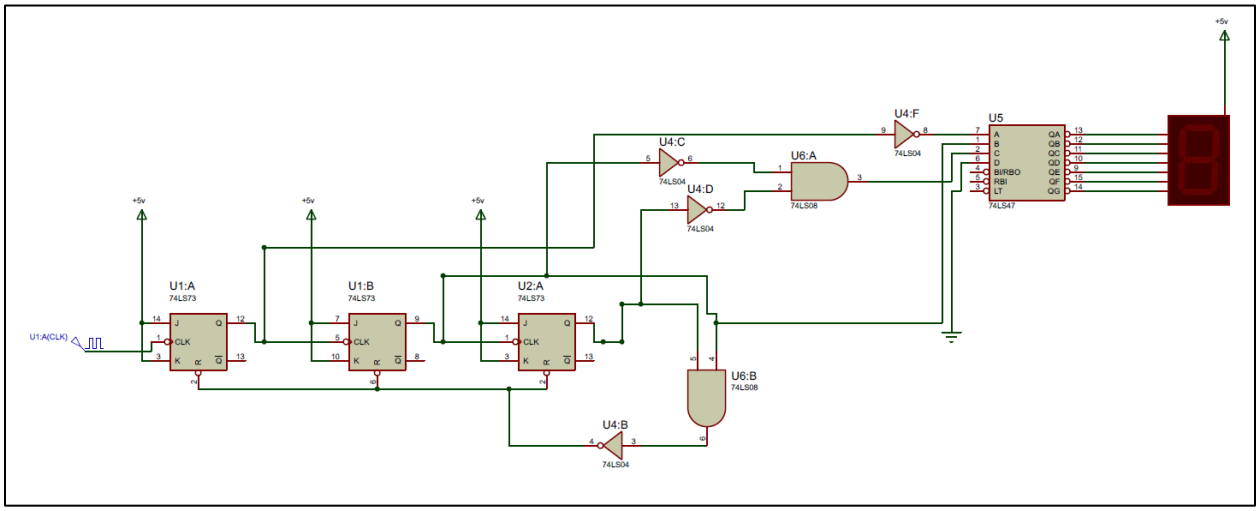


Figure 12-16: *Simulation circuit diagram of Modulo 6 Down counter using JK Flip-Flops*

v. Block diagram

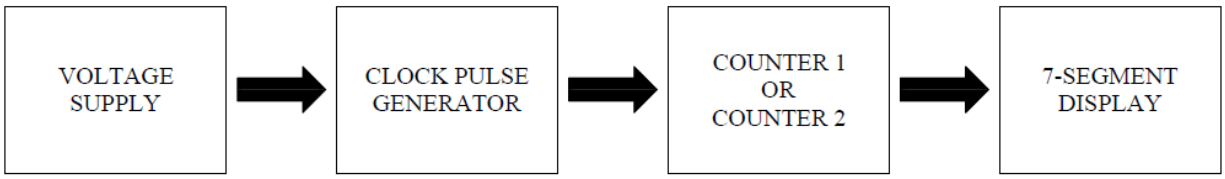


Figure 12-17: *Connection of common circuitry for 12.3.4*

vi. Final Output

12.3.5 Hexadecimal Up counter using Counter ICs

i. Components

- 1x 74LS93 IC
- 1x 74LS47 IC
- 1x 7-segment display
- 4x LEDs
- 11x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- Converter & COUNTER 3
- 7-segement displays

STEP 2: Refer Figure 12-11 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

- **LEDs are connected to relevant IC terminals internally,**

to avoid the number of jumper wires on the board as they have same potentials separately.

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and output terminals accordingly in the COUNTER 3 part of the Converter & COUNTER 3 circuit (Figure 11-5) and connect 7-segment display circuit (Figure 12-2) with COUNTER 3 circuit to complete the basic connections of the circuit.

STEP 5: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of 74LS90 IC in the COUNTER 3 circuit as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 3 circuit to maintain the same supply potentials at both circuits.

STEP 6: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment displays and LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 7: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

OBSERVATION: *Here you will observe that 7-segment display will not show the digits pertaining to integers 10,11,12,…,15 but the LEDs will signify their binary equivalent. The reason is explained under the section "Errors".*

iii. Circuit diagram

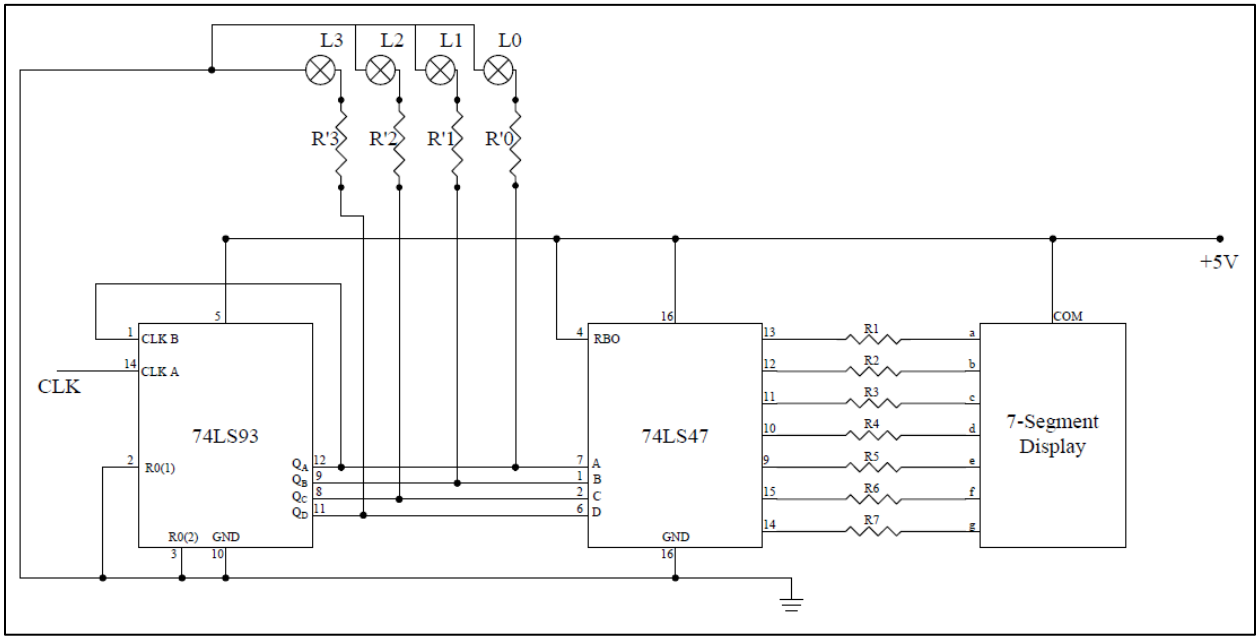


Figure 12-18: *Hexadecimal Up counter using Counter ICs*

iv. Proteus Simulation

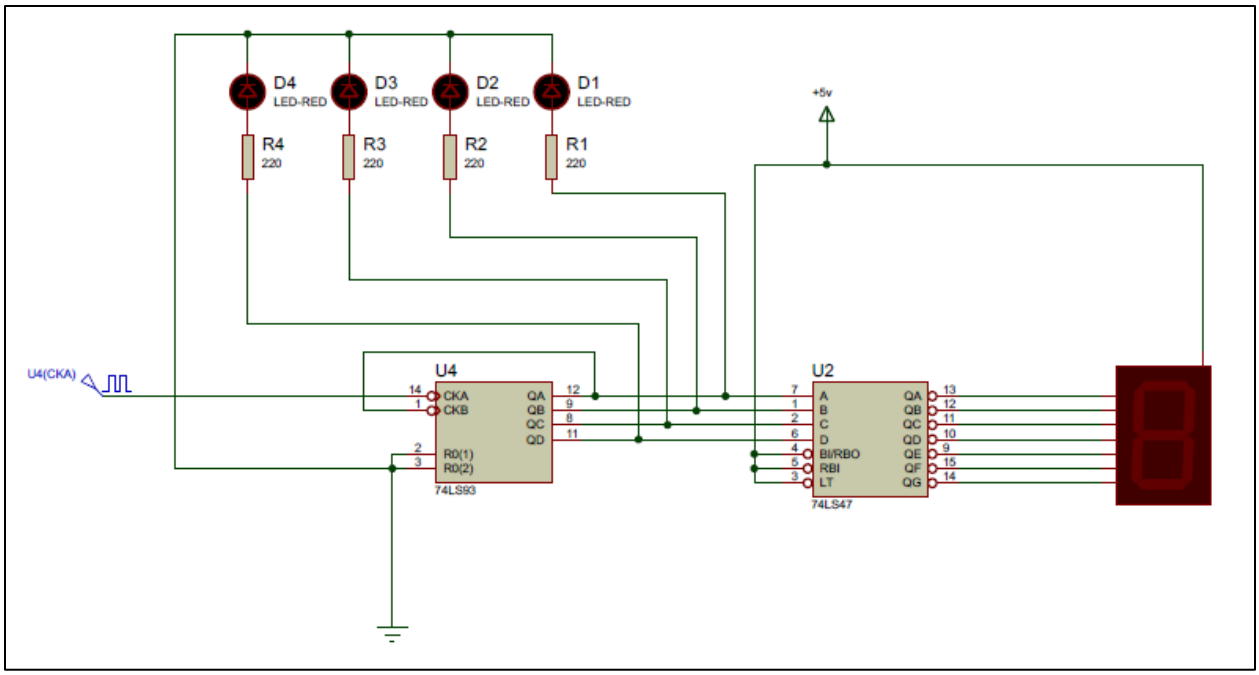


Figure 12-19: *Simulation circuit diagram of Hexadecimal Up counter using Counter ICs*

v. Block diagram

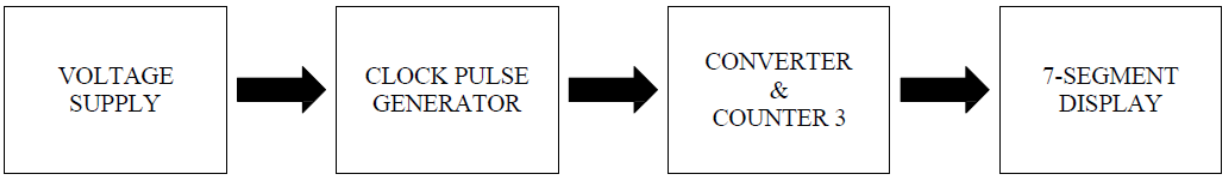


Figure 12-20: *Connection of common circuitry for 12.3.5*

vi. Final Output

12.3.6 Modulo 6 Up counter using Counter ICs

i. Components

- 1x 74LS93 IC
- 1x 74LS47 IC
- 1x 74LS08 IC
- 1x 7-segment display
- 7x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- Converter & COUNTER 3
- 7-segement displays

STEP 2: Refer Figure 12-13 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and output terminals accordingly in the COUNTER 3 part of the Converter & COUNTER 3 circuit (Figure 11-5), and connect 7-segment display circuit (Figure 12-2) with COUNTER 3 circuit to complete the basic connections of the circuit.

STEP 5: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of 74LS90 IC in the COUNTER 3 circuit as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 3 circuit to maintain the same supply potentials at both circuits.

STEP 6: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment displays and LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 7: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

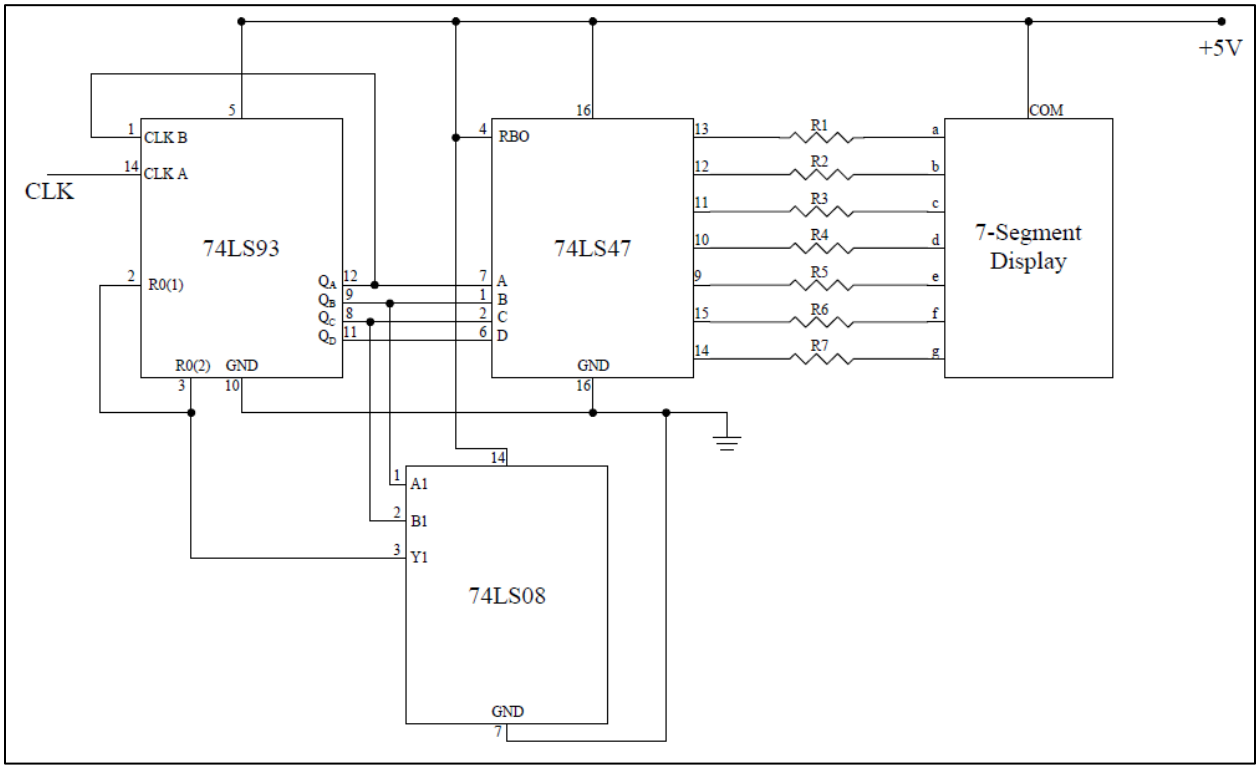


Figure 12-21: *Modulo 6 Up counter using Counter ICs*

iv. Proteus Simulation

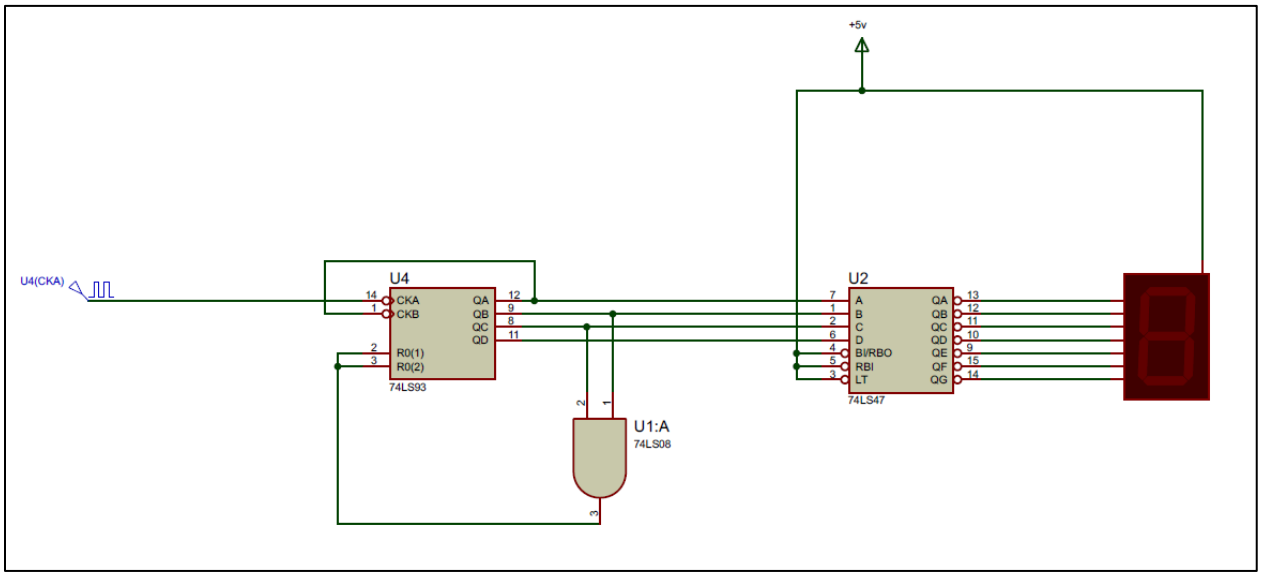


Figure 12-22: *Simulation circuit diagram of Modulo 6 Up counter using Counter ICs*

v. Block diagram

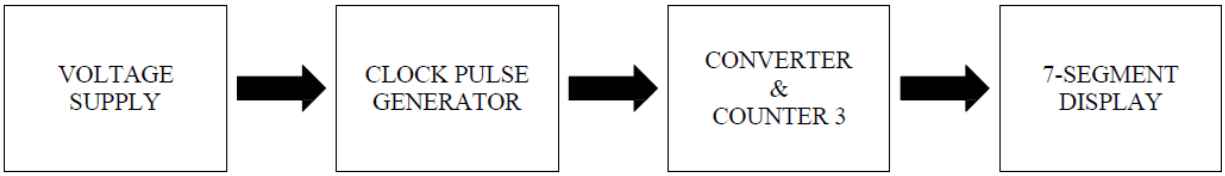


Figure 12-23: *Connection of common circuitry for 12.3.6*

vi. Final Output

12.3.7 Hexadecimal Down counter using Counter ICs

i. Components

- 1x 74LS93 IC
- 1x 74LS47 IC
- 1x 74LS04 IC
- 1x 7-segment display
- 4x LEDs
- 11x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- Converter & COUNTER 3
- 7-segement displays

STEP 2: Refer Figure 12-15 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and output terminals accordingly in the COUNTER 3 part of the Converter & COUNTER 3 circuit (Figure 11-5).

STEP 5: Use the Converter part of the Converter & Counter 3 circuit (Figure 11-5) to convert the output of counter ICs and provide input to the decoder IC (74LS47), and connect 7-segment display circuit (Figure 12-2) with COUNTER 3 circuit to complete the basic connections of the circuit.

STEP 6: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of 74LS90 IC in the COUNTER 3 circuit as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 3 circuit to maintain the same supply potentials at both circuits.

STEP 7: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment displays and LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 8: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

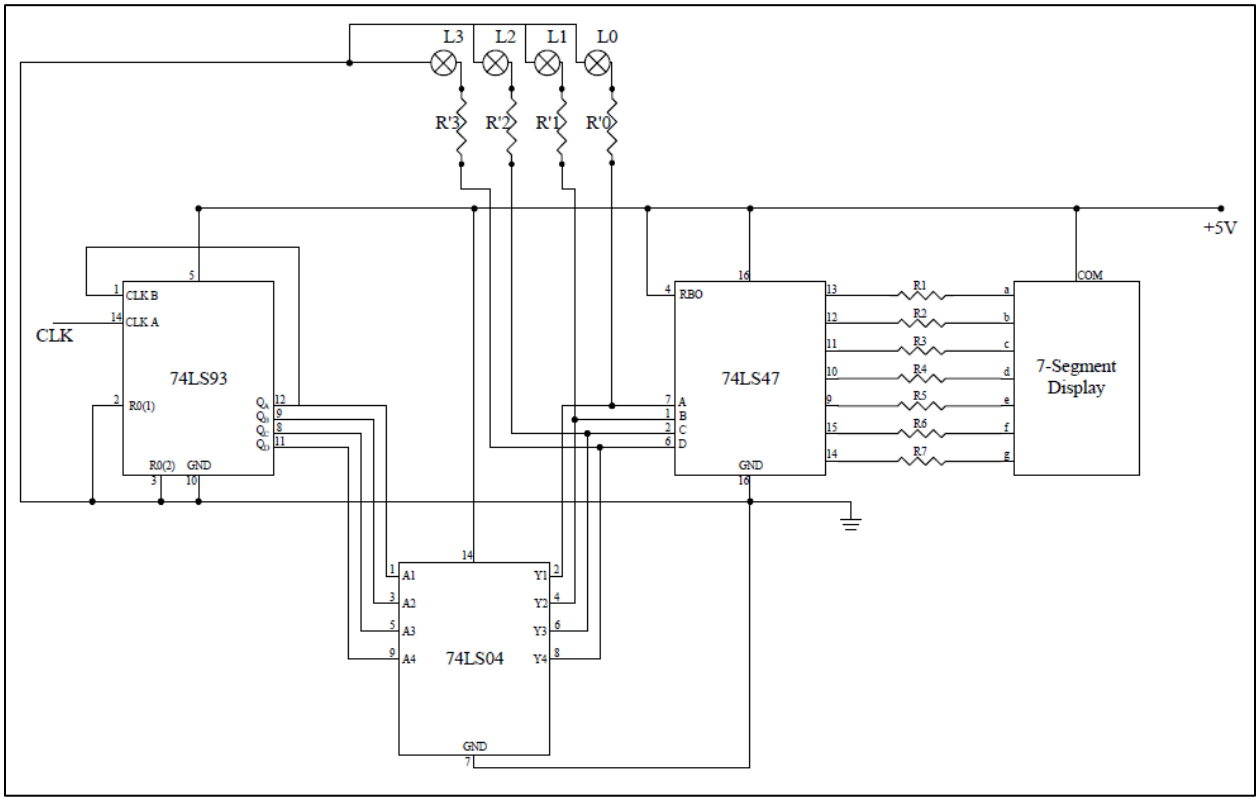


Figure 12-24: *Hexadecimal Down counter using Counter ICs*

iv. Proteus Simulation

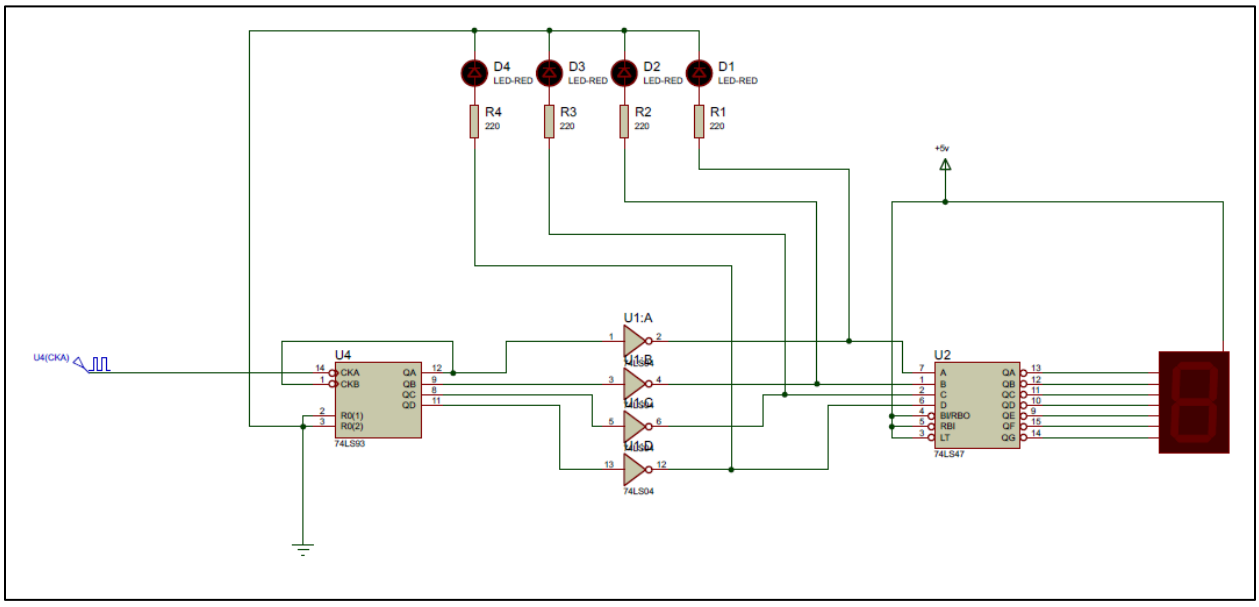


Figure 12-25: *Simulation circuit diagram of Hexadecimal Down counter using Counter ICs*

v. Block diagram

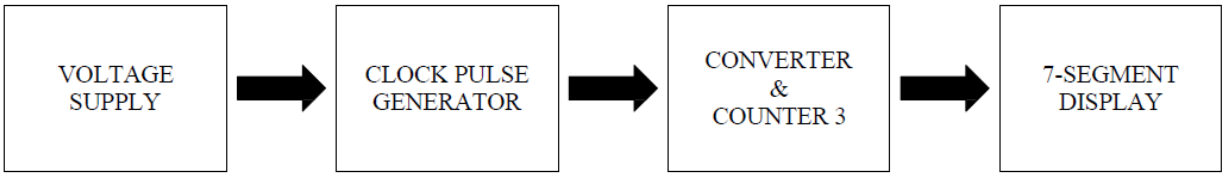


Figure 12-26: *Connection of common circuitry for 12.3.7*

vi. Final Output

12.3.8 Modulo 6 Down counter using Counter ICs

i. Components

- 1x 74LS93 IC
- 1x 74LS47 IC
- 1x 74LS04 IC
- 1x 74LS08 IC
- 1x 7-segment display
- 7x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- Converter & COUNTER 3
- 7-segement displays

STEP 2: Refer Figure 12-17 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and output terminals accordingly in the COUNTER 3 part of the Converter & COUNTER 3 circuit (Figure 11-5).

STEP 5: Use the Converter part of the Converter & Counter 3 circuit (Figure 11-5) to convert the output of counter ICs and provide input to the decoder IC (74LS47), and connect 7-segment display circuit (Figure 12-2) with COUNTER 3 circuit to complete the basic connections of the circuit.

STEP 6: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of 74LS90 IC in the COUNTER 3 circuit as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 3 circuit to maintain the same supply potentials at both circuits.

STEP 7: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment displays and LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 8: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

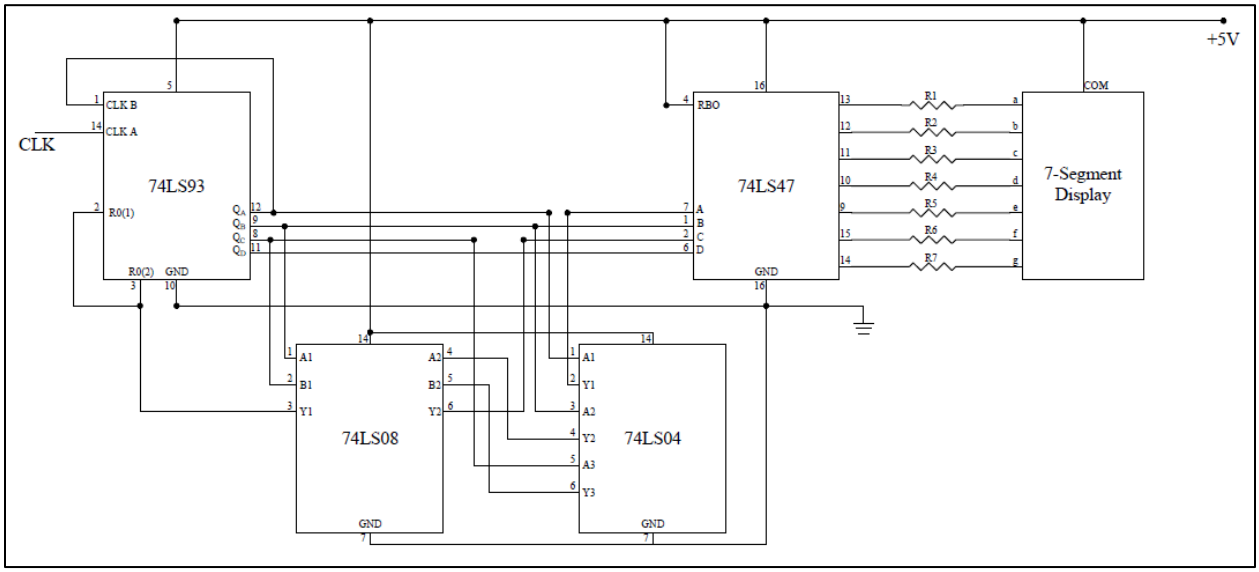


Figure 12-27: *Modulo 6 Down counter using Counter ICs*

iv. Proteus Simulation

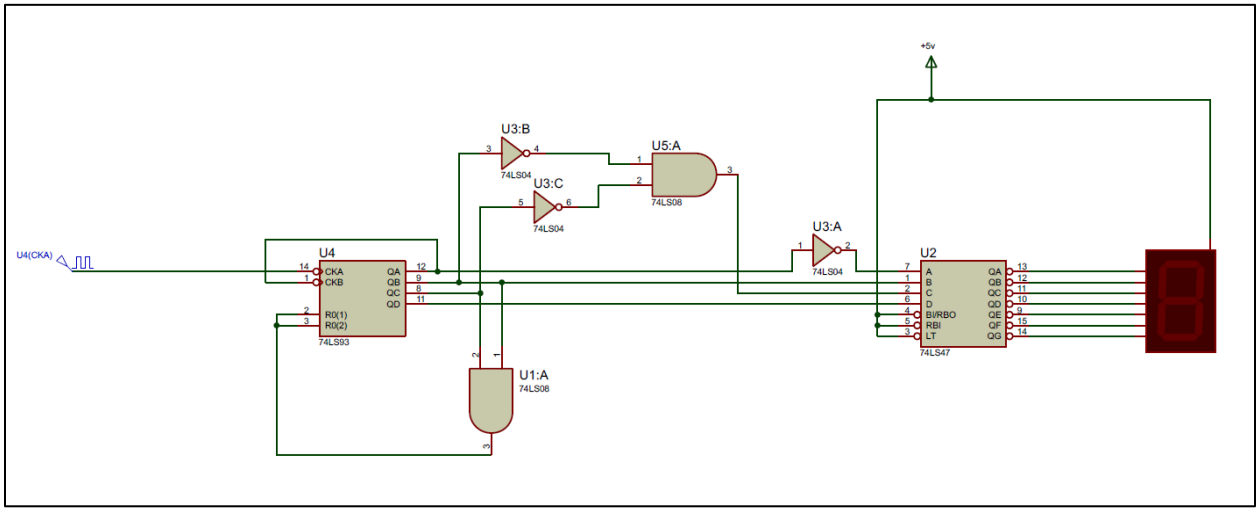


Figure 12-28: *Simulation circuit diagram of Modulo 6 Down counter using Counter ICs*

v. Block diagram

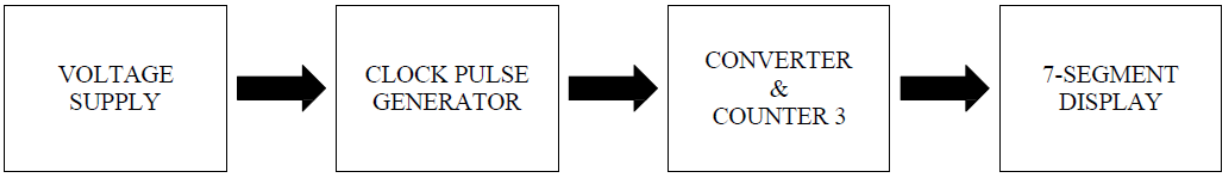


Figure 12-29: *Connection of common circuitry for 12.3.8*

vi. Final Output

12.3.9 Decade Up counter using Counter IC

i. Components

- 1x 74LS90 IC
- 1x 74LS47 IC
- 1x 7-segment display
- 7x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- COUNTER 4
- 7-segement displays

STEP 2: Refer Figure 12-19 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and output terminals accordingly in the COUNTER 4 circuit (Figure 11-6), and connect 7-segment display circuit (Figure 12-2) with COUNTER 3 circuit to complete the basic connections of the circuit.

STEP 5: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of 74LS90 IC in the COUNTER 4 circuit as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 4 circuit to maintain the same supply potentials at both circuits.

STEP 6: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment displays and LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 7: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

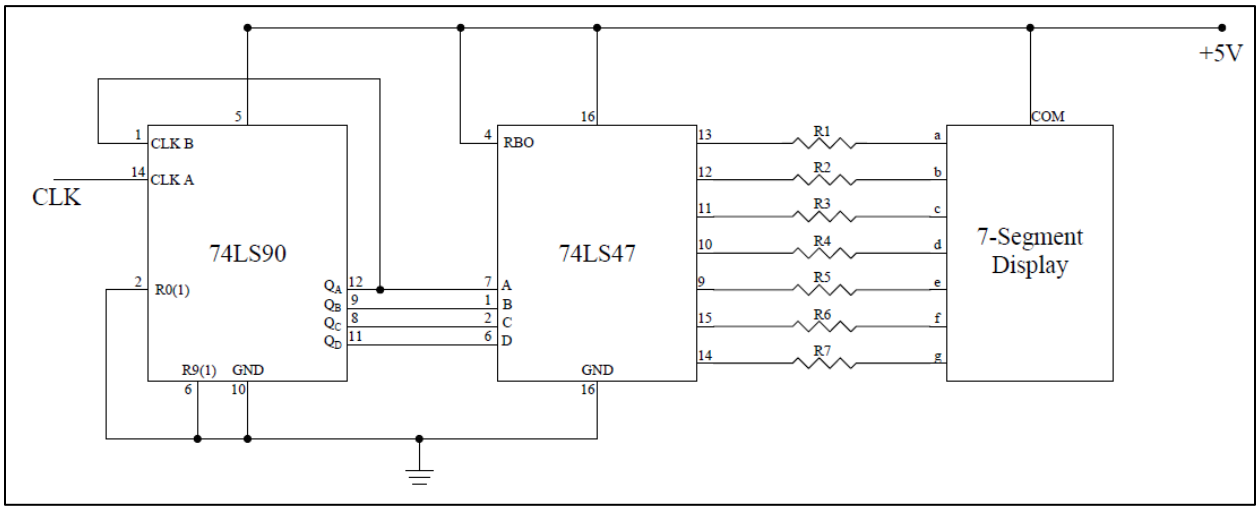


Figure 12-30: *Decade Up counter using Counter ICs*

iv. Proteus Simulation

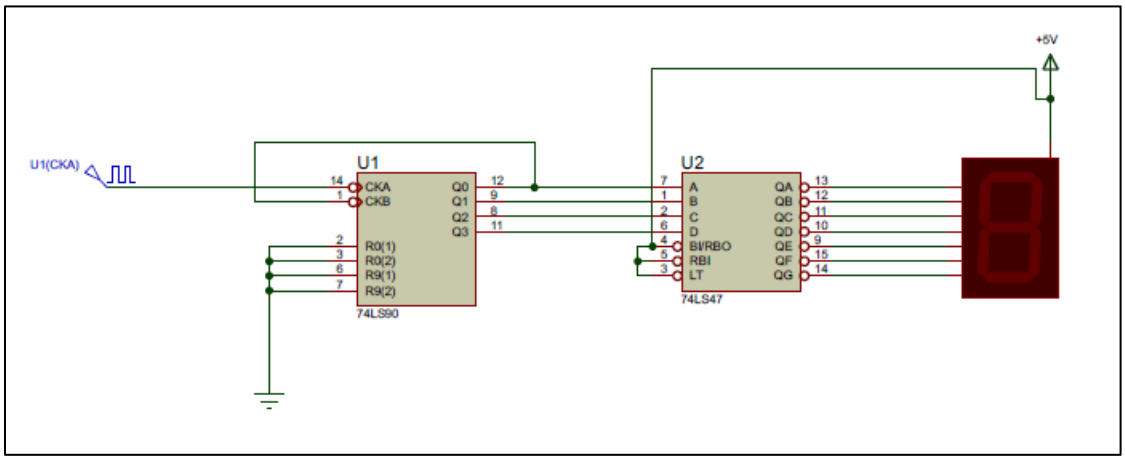


Figure 12-31: *Simulation circuit diagram of Decade Up counter using Counter ICs*

v. Block diagram

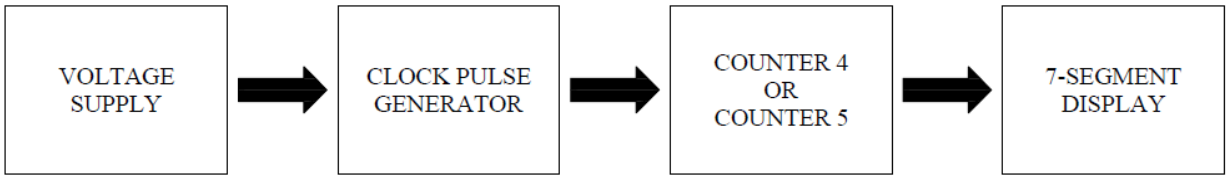


Figure 12-32: *Connection of common circuitry for 12.3.9*

vi. Final Output

12.3.10 Decade Down counter using Counter IC

i. Components

- 1x 74LS90 IC
- 1x 74LS47 IC
- 1x 74LS04 IC
- 1x 74LS11 IC
- 1x 74LS32 IC
- 1x 7-segment display
- 7x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- COUNTER 4 or COUNTER 5
- 7-segement displays

STEP 2: Refer Figure 12-21 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and output terminals accordingly in the COUNTER 4 circuit (Figure 11-6).

STEP 5: Use the Converter part of the Converter & Counter 3 circuit (Figure 11-5) to convert the output of counter ICs and provide input to the decoder IC (74LS47), and connect 7-segment display circuit (Figure 12-2) with COUNTER 3 circuit to complete the basic connections of the circuit.

STEP 6: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of 74LS90 IC in the COUNTER 4 circuit as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 4 circuit to maintain the same supply potentials at both circuits.

STEP 7: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment displays and LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 8: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

iii. Circuit diagram

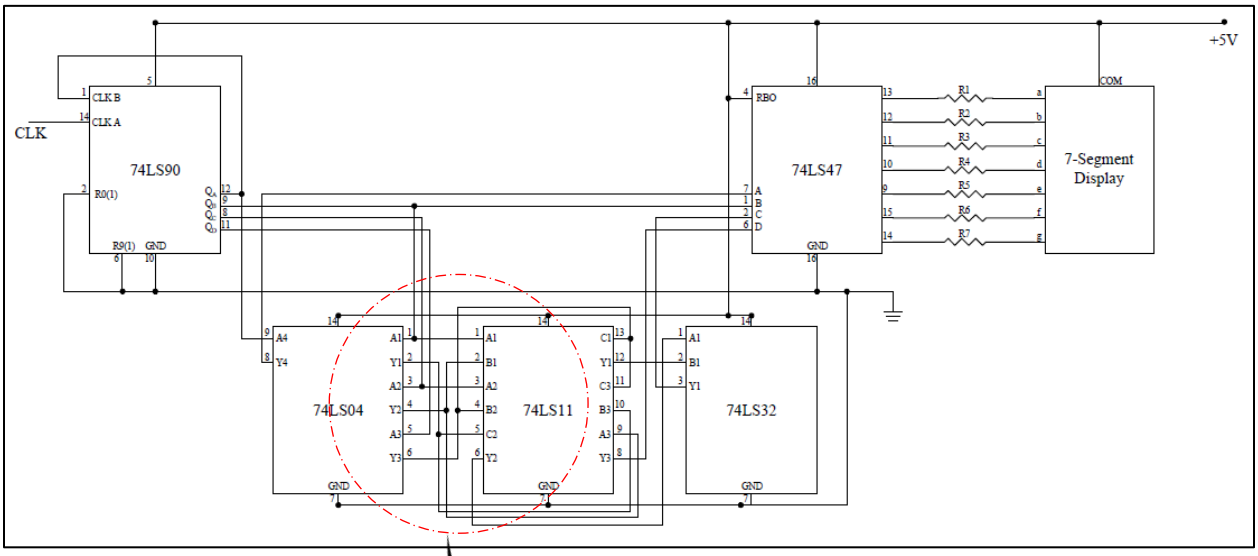
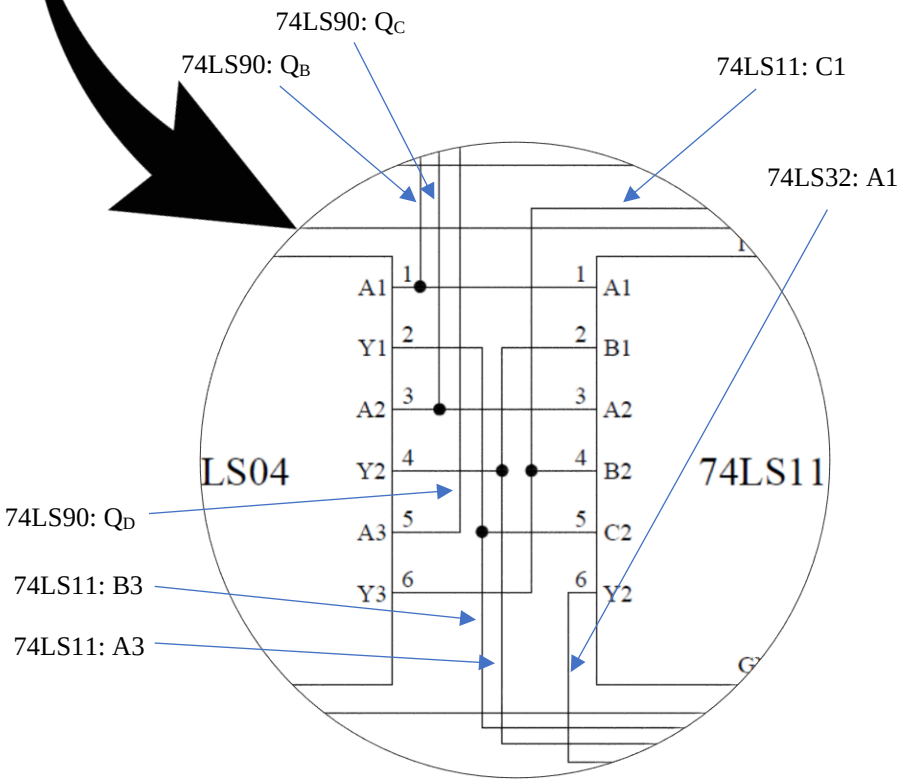


Figure 12-33: *Decade Down counter using Counter ICs*



iv. Proteus Simulation

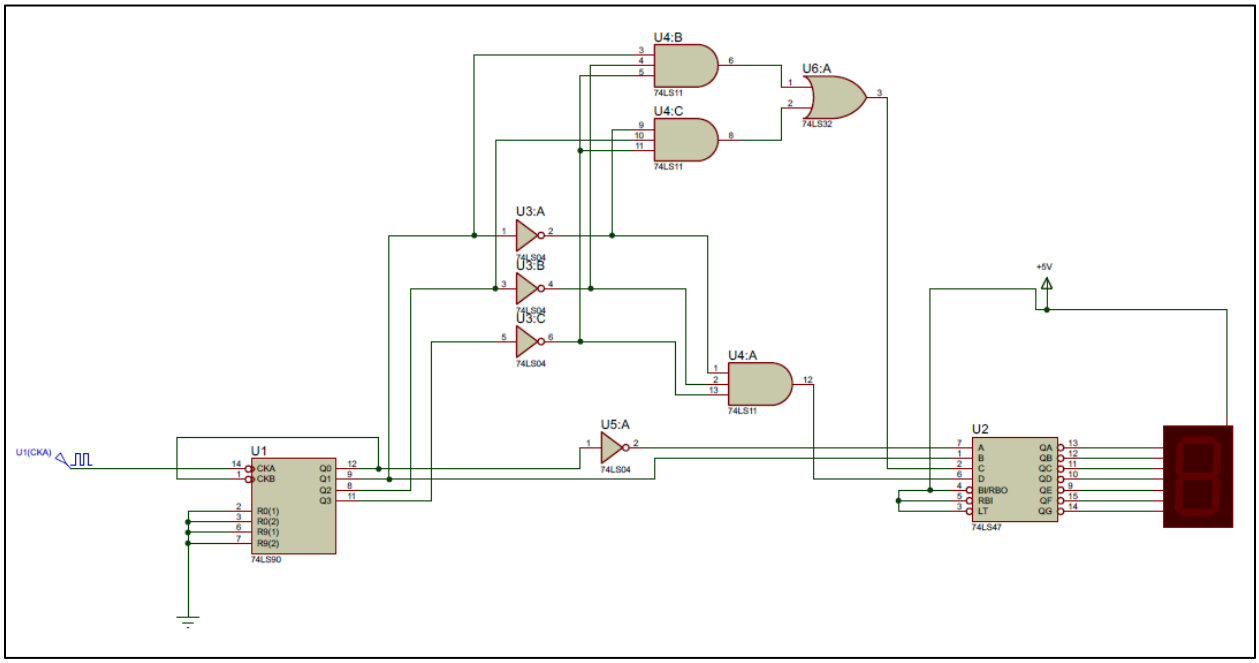


Figure 12-34: *Simulation circuit diagram of Decade Down counter using Counter ICs*

v. Block diagram

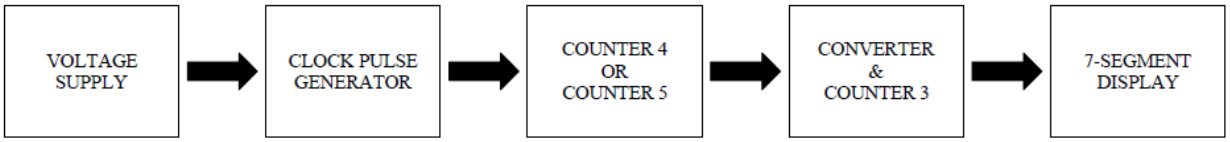


Figure 12-35*: Connection of common circuitry for 12.3.10*

vi. Final Output

12.3.11 Two digits Up Counter using Counter ICs

i. Components

- 2x 74LS90 IC
- 2x 74LS47 IC
- 2x 74LS32 IC
- 2x 7-segment display
- 14x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.
- Clock Pulse Generator
- COUNTER 4
- COUNTER 5
- 7-segement displays

STEP 2: Refer Figure 12-23 and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and output terminals accordingly in the COUNTER 4 circuit (Figure 11-6), and in the COUNTER 5 (Figure 11-7) circuit separately.

STEP 5: Connect 2x 7-segment display circuit (Figure 12-2) with COUNTER 4 and COUNTER 5 circuit separately to complete the basic connections of the circuit.

STEP 6: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of 74LS90 IC in the COUNTER 4 circuit and connect the QD terminal of 74LS90 (1) IC to the input CLK terminal of 74LS90 (2) IC as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 4 & 5 circuits to maintain the same supply potentials at all 3 circuits.

STEP 7: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment displays and LEDs (Function of Clock Pulse Generator circuit was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 8: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

***NOTE:* Two similar decade UP counter circuits are connected together here.**

iii. Circuit diagram

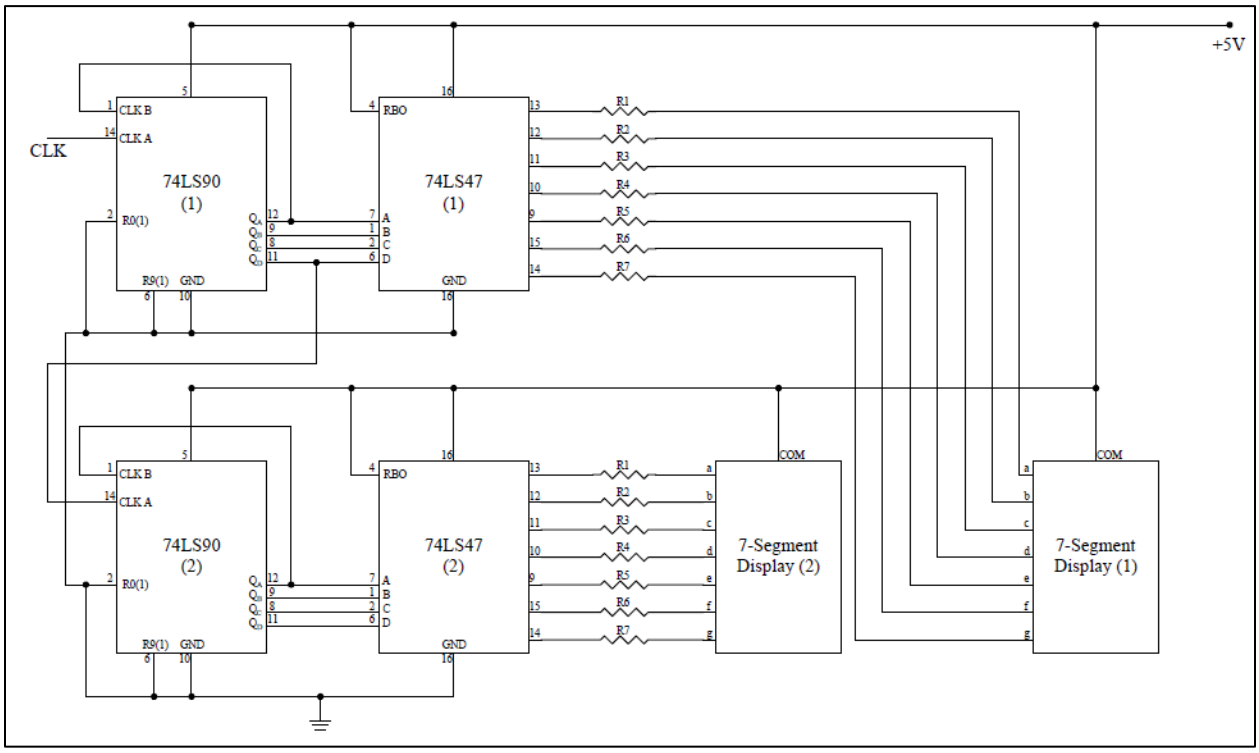


Figure 12-36: *Two digits Up Counter using Counter ICs*

iv. Proteus Simulation

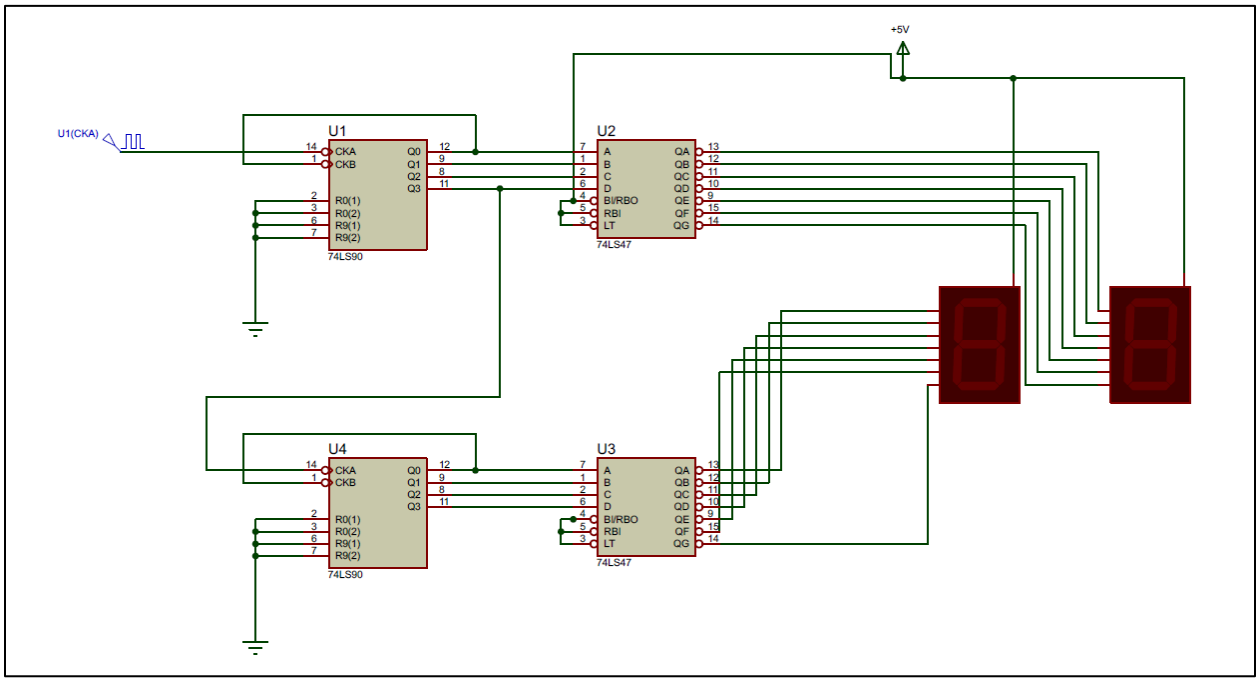


Figure 12-37: *Simulation circuit diagram of Two digits Up Counter using Counter ICs*

v. Block diagram

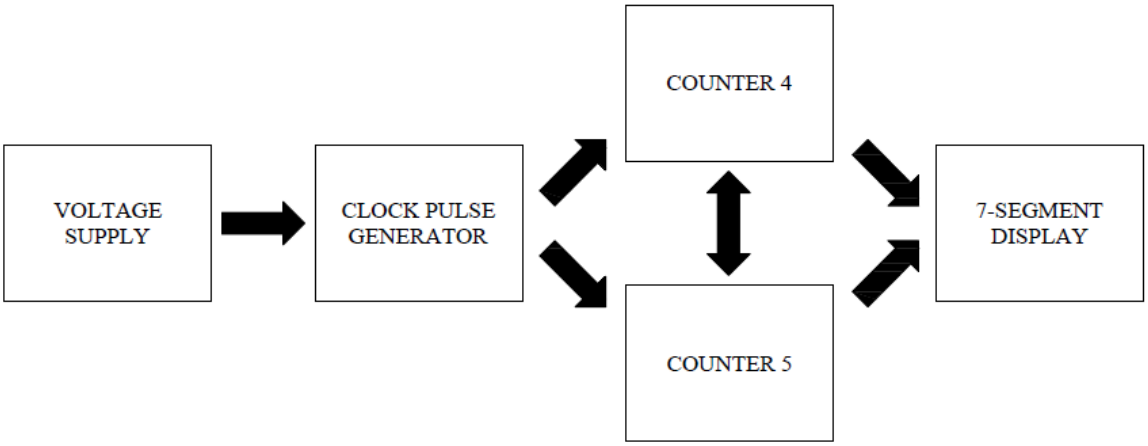


Figure 12-38: *Connection of common circuitry for 12.3.11*

vi. Final Output

12.3.12 Two digits Down Counter using Counter ICs

i. Components

- 2x 74LS90 IC
- 2x 74LS47 IC
- 2x 74LS04 IC
- 2x 74LS11 IC
- 1x 74LS32 IC
- 2x 7-segment display
- 14x 220 Ω resistors

ii. Steps to connect the circuit

STEP 1: Locate the following common circuitry on the Learning Board.

- Clock Pulse Generator
- COUNTER 4
- COUNTER 5
- 7-segement displays

STEP 2: Refer Figure 12-25P and study the circuit diagram and its connections. (Proteus simulation circuit diagram too is provided for user's ease of understanding the circuit and as an assistance to conduct simulations using Proteus software)

❖ **Note that user is required only to connect the terminal pins of ICs via male headers using female-to-female jumper wires.**

STEP 3: First connect the 'Vcc'(+5V) and 'GND' terminals of ICs to the common rows where the supply will be provided.

STEP 4: Then connect 'Reset(R)' and output terminals accordingly in the COUNTER 4 circuit (Figure 11-6), and in the COUNTER 5 (Figure 11-7) circuit separately.

STEP 5: Use the Converter part of the Converter & Counter 3 circuit (Figure 11-5) to convert the output of counter ICs and provide input to the two decoder ICs (74LS47) separately for COUNTER 4 & 5 to complete the basic connections of the circuit.

STEP 6: Connect 2x 7-segment display circuit (Figure 12-2) with COUNTER 4 and COUNTER 5 circuit separately to complete the basic connections of the circuit.

STEP 7: Connect the output of Clock Pulse generator circuit (Figure 12-1) to the relevant terminal of 74LS90 IC in the COUNTER 4 circuit and connect the QD terminal of 74LS90 (1) IC to the input CLK terminal of 74LS90 (2) IC as shown in the diagram below. And connect the supply header rows of Clock Pulse Generator circuit with the COUNTER 4 & 5 circuits to maintain the same supply potentials at all 3 circuits.

STEP 8: Finally provide the supply to the Clock Pulse Generator circuit to obtain the output from the 7-segment displays and LEDs (Function of Clock Pulse Generator circuit

was explained before. Figure 12-1). **Refer page 14 for switch configuration of the common circuitry.**

STEP 9: Once you obtain the output make sure to disconnect the supply before removing the jumper wires on the Learning Board.

NOTE: ***Two similar decade down counter circuits are connected together here.***

iii. Circuit diagram

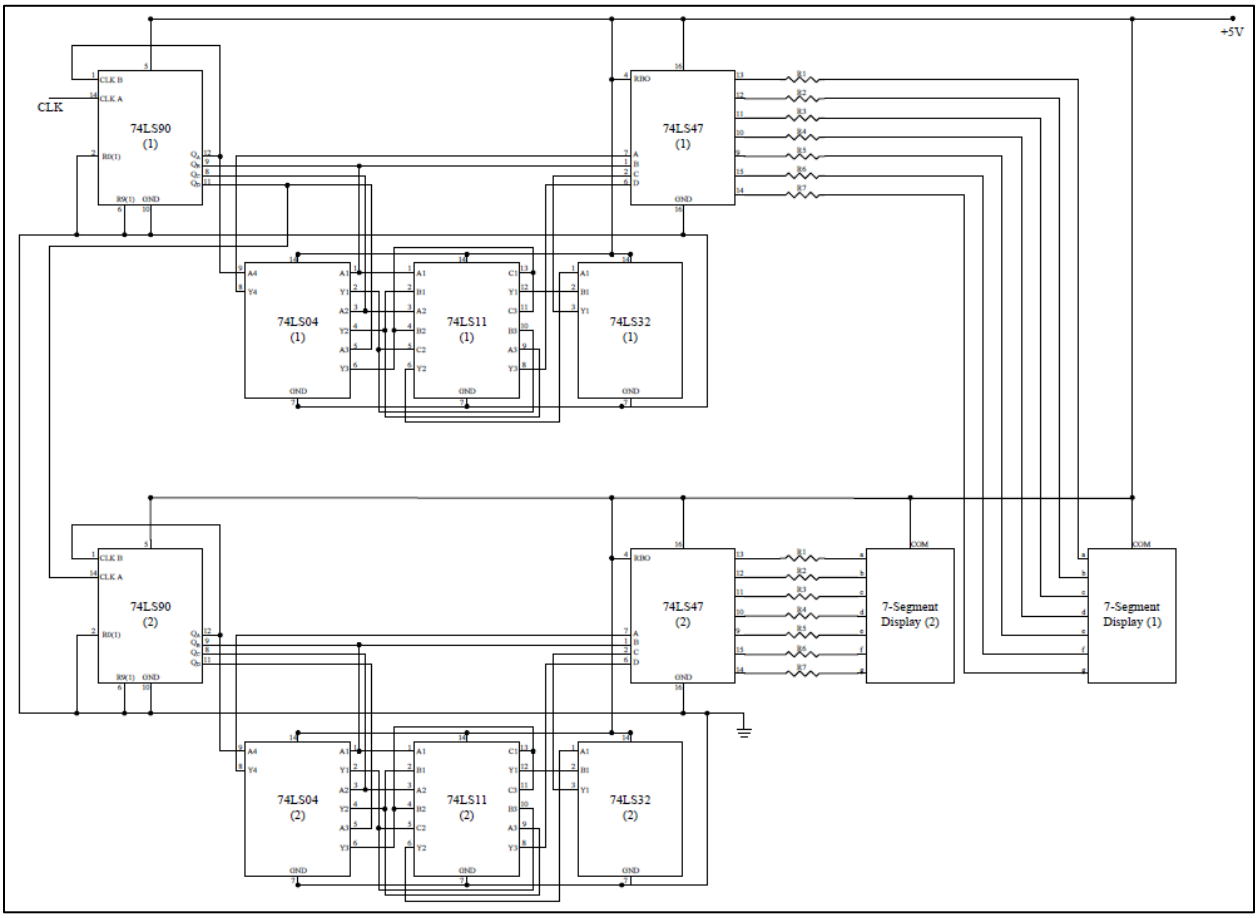


Figure 12-39: *Two digits Down Counter using Counter ICs*

iv. Proteus Simulation

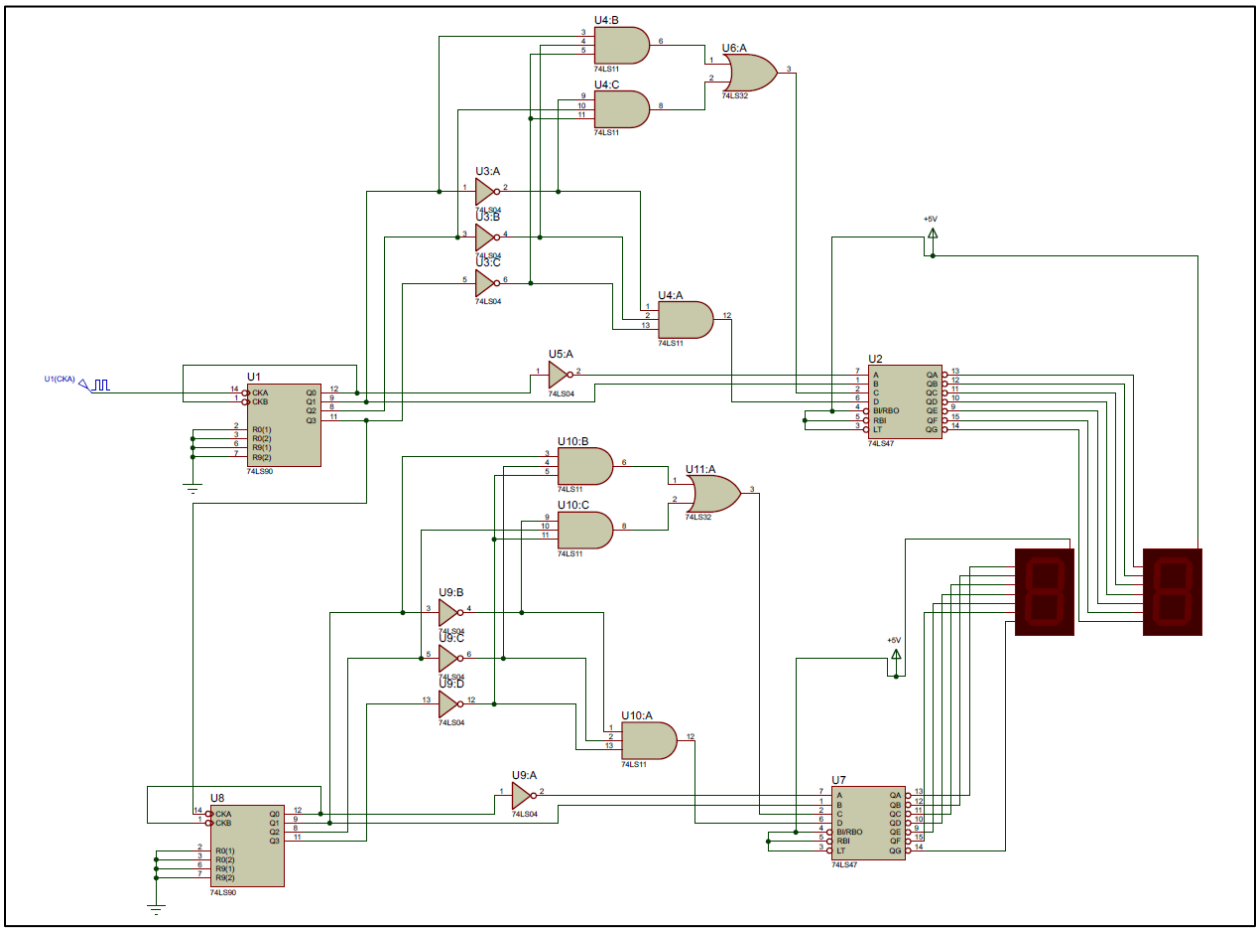


Figure 12-40: *Simulation circuit diagram of Two digits Down Counter using Counter ICs*

v. Block diagram

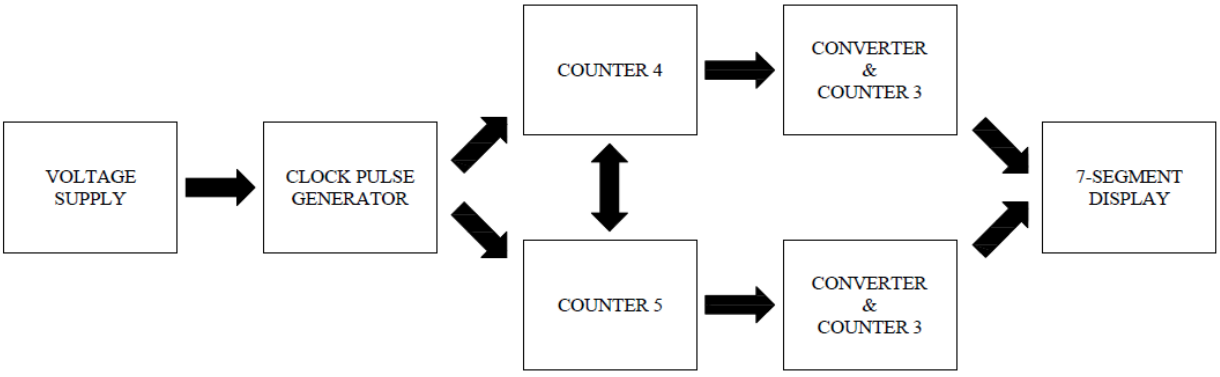


Figure 12-41: *Connection of common circuitry for 12.3.12*

vi. Final Output

13. OTHER POSSIBLE CONNECTIONS

- 3 digits Up Counter
- 4 digits Up Counter
- ODD integer counter using Decade counter
- EVEN integer counter using Decade counter
- Simultaneous Up and Down counter

14. ERRORS

- BCD to 7-Segment decoder IC (74LS47) is built in such a way that when it is connected the output will count from 0 to 9 and then reset to 0 and repeat. Therefore, when a 4-bit binary counter IC or a 4-bit binary counter circuit made from JK Flip-flops is connected to 74LS47 IC which is connected to the 7-segment display, it will only display integers from 0-9 only and display error figures for the remaining integers 10-15.
  However, this can be rectified using microcontrollers instead of counter ICs to program the hexadecimal equivalent of binary output to be displayed.
  If the user needs to obtain two-digit output refer section 12.3.11 under "Implementing counter circuits".

15. REPLACING COMPONENTS

ICs can be replaced in an instant where a malfunction occurs.

STEP 1: Refer the guidelines again and construct the circuit to check if the LEDs of the particular common circuitry works or not.
STEP 2: If the LEDs are working do not replace the IC. If they're not working replace it with a similar IC according to its code printed on the surface.
STEP 3: When removing the IC make sure to insert a thing and narrow tip of a utensil in between the IC and its base to lift it from both sides without damaging the pins and circuitry.
STEP 4: Once it is removed you may further test its function by other means.
STEP 5: When fixing a new IC to the base please make sure to insert it to the base without damaging the IC pins, which would not properly function otherwise.
STEP 6: Connect the circuit and provide a supply to check for the IC's function.

❖ **Strictly adhere to the safety guidelines provided at the beginning of this manual at all times.**

16. FAQs