Lab 7: Counters

ECE218-L01

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Introduction

Purpose

Design a 2-bit Gray Code counter using D flip-flops and combinational logic and design a specialized counter using a counter chip.

Scope

Observe the output counters using LEDs. The 2-bit Gray Code counter should output all digits from 0-3 in 2-bit Gray Code. The specialized counter should output different sequences depending on the input variables C_0 and C_1.

Theory

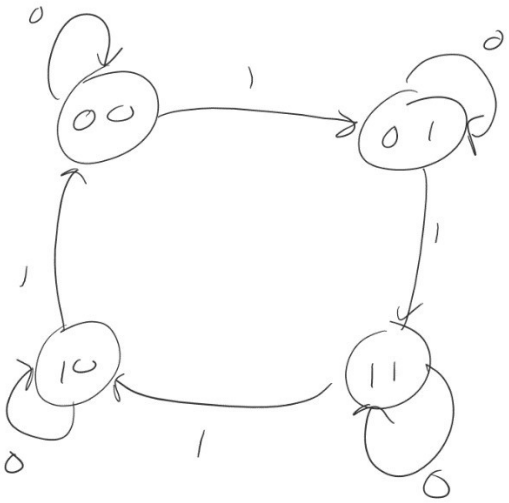
Theoretical Basis

More about theory

A counter is a sequential logic circuit that goes through a specific set of states. Most counter used today have a common clock for all the elements in the counter, these are called synchronous counters, which were used in this lab. A good way to design a counter is to create a state diagram and a state table to visualize the procedure of the counter get the logic needed to create the counter.

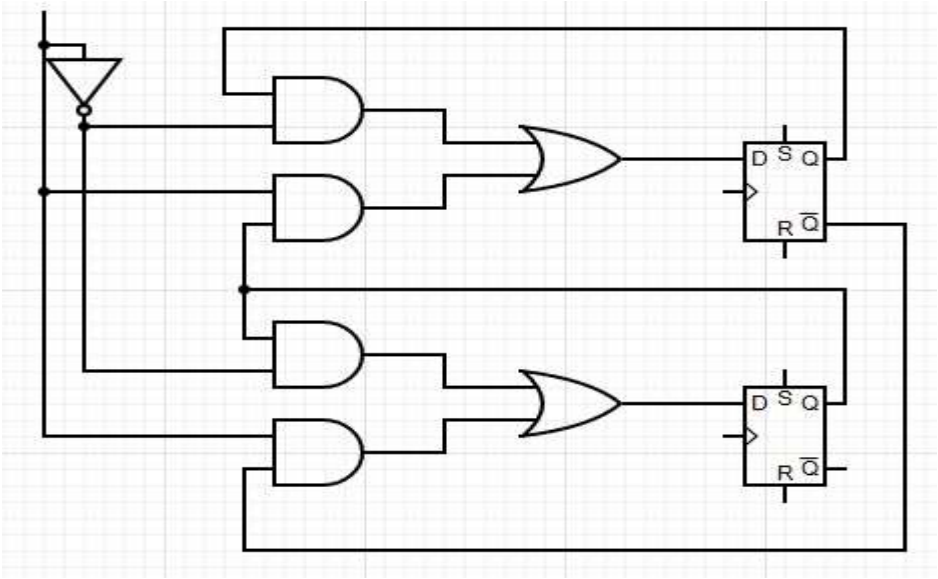
Preliminary Work

To prepare for this lab a state diagram and table were designed for the 2-bit Gray Code counter which can be seen below. A state diagram was also created for the specialized counter but, as it was optional and not created in the lab it will not be shown here.

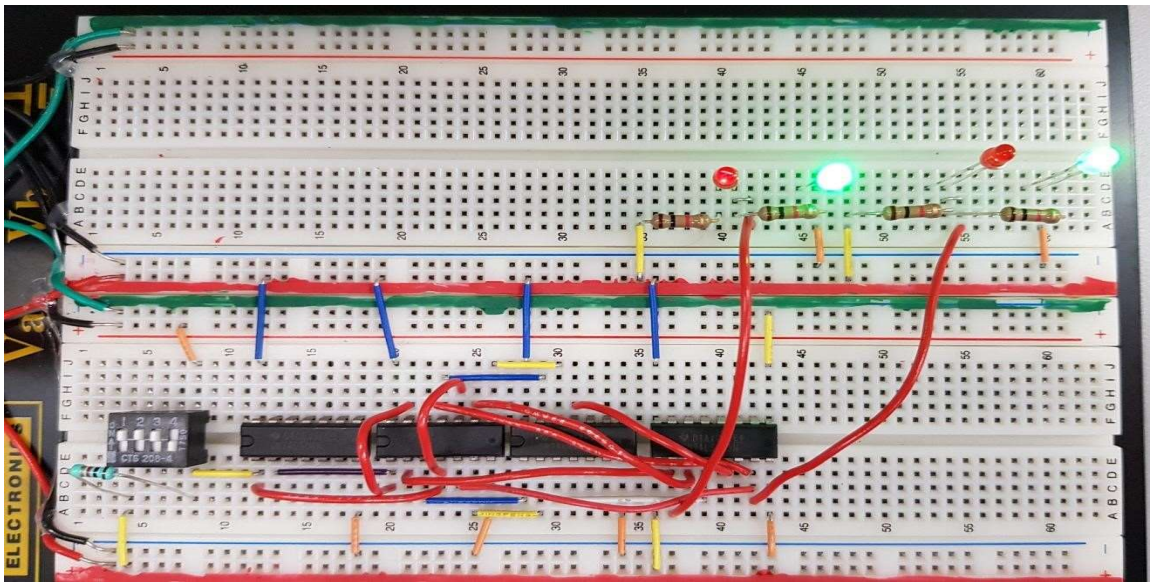


Present State		Next State (AB)	
a	b	EN=0	EN=1
0	0	00	01
0	1	01	11
1	1	11	10
1	0	10	00

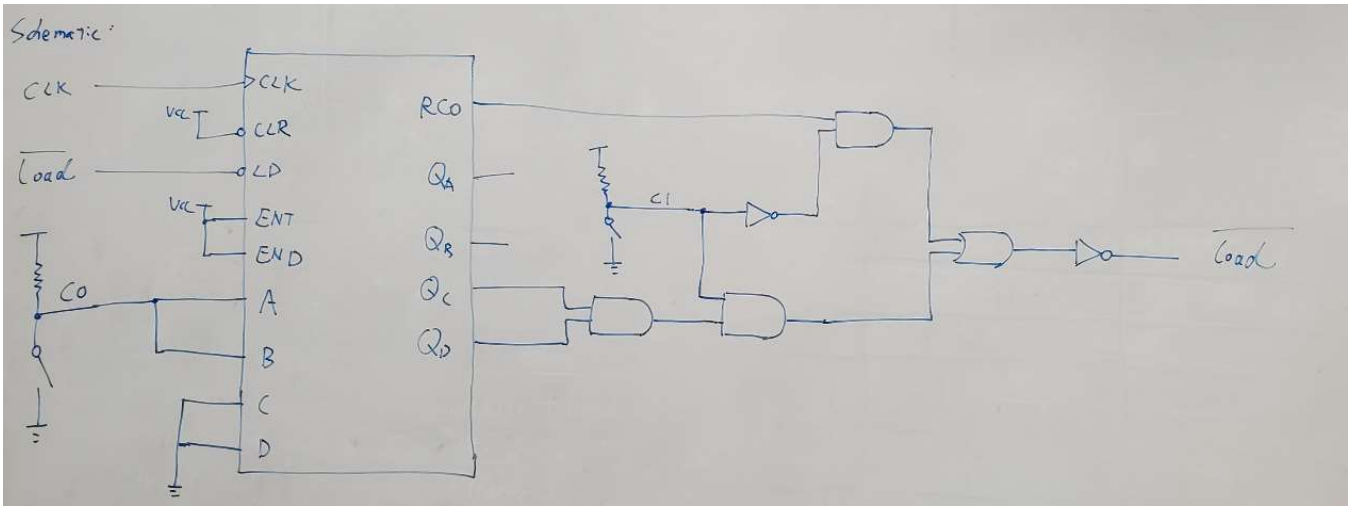
Experimental Procedure



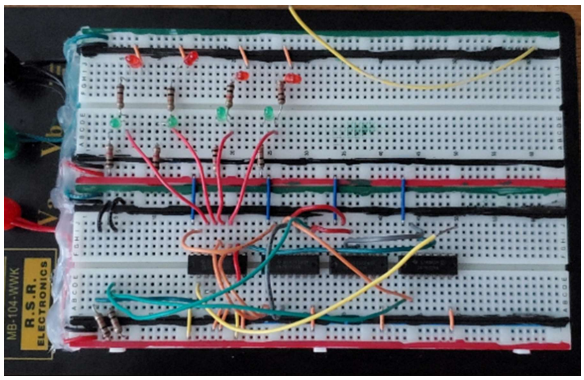
2-bit gray Code Counter Schematic



2-bit Gray Code Breadboard



Specialized Counter



Specialized Counter Breadboard

Equipment:

- Copper wire
- SN74LS175 Quad D Flip-Flop
- SN74LS04 Inverter
- SN74LS32 Quad OR Gate
- SN74LS08 Quad AND Gate
- DIP SPST Switch
- 1kΩ±5% Resistors
- Green and red LEDs

Procedure

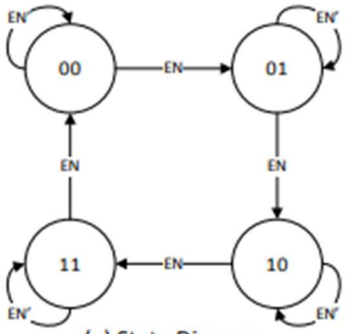
1. Set up the circuit depicted in the circuit diagram on the breadboard.
2. Connect breadboard to desktop voltage source and set to 5V.
3. Connect breadboard to waveform generator and set to 1Hz pulse wave with an amplitude of 5V and set to 1 pulse per trigger.
4. With switch off observe output as you trigger the generator, the output should not change.

5. With switch on observe output as you trigger the generator, the output should now cycle through the states shown in the state diagram.
6. Troubleshoot as necessary and demonstrate results to the TA.

Result

The results obtained are as expected. For the binary counter, the counting sequence goes from 00 to 01 to 11 and finally to 10, after which it returns to 00. Similarly, for the specialized counter, Table 3 is followed. The state diagram for the binary counter and the function table for the specialized counter are given below.

Fig.5 State diagram of Gray code counter



(a) State Diagram

Table 3. Logic of specialized counter

C0	C1	Counting Sequence
0	0	0-15
0	1	0-12
1	0	3-15
1	1	3-12

Interpretation

This experiment conclusively proves that any form of counting sequence can be realized using a binary counter and the required logic gates, with the logical functions that are derived from the excitation table and state table.

Conclusion

Counters are utilized to keep a tab on the inputs to detect/change the state of the machine. Such counters are used for counting the clock cycles, inputs or any other subject that can be counted in order to keep the machine functioning properly.

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