Design and Implementation of a Mod-7 Asynchronous Counter

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Abstract

This lab report presents the design, implementation, and testing of a Mod-7 asynchronous counter using JK flip-flops. The counter operates with an external clock signal provided by an Arduino and its performance is verified using a Cathode Ray Oscilloscope (CRO).

1 Introduction

A Mod-7 counter is a sequential circuit that counts from 0 to 6 and then resets to 0. Using JK flip-flops in a toggle mode, the counter progresses through seven states. The asynchronous nature means that each flip-flop's clock input is triggered by the output of the previous flip-flop.

2 Components and Equipment

- JK Flip-Flops (e.g., 7476 IC)
- NAND gate(e.g. , 7410 IC)
- Arduino (as a clock source)
- 3 LED's
- Cathode Ray Oscilloscope (CRO)
- Resistors and Capacitors (as needed)
- Connecting Wires and Breadboard
- Power Supply (5V DC)

3 Circuit Design

The Mod-7 counter is implemented using three JK flip-flops. The JK flip-flops are configured in toggle mode by connecting both J and K inputs to logic HIGH (1). The clock for the first flip-flop is provided by the Arduino, while subsequent flip-flops receive their clock signal from the previous flip-flop's output.

3.1 Conversion of JK Flip-Flop to T Flip-Flop

A JK Flip-Flop can be converted into a T Flip-Flop by making the following modifications:

1. Connect both J and K inputs together.

2. Use a single toggle (T) input instead of separate J and K inputs.

3. The T input determines the flip-flop's behavior:

    - When $T = 0$, the output remains unchanged.
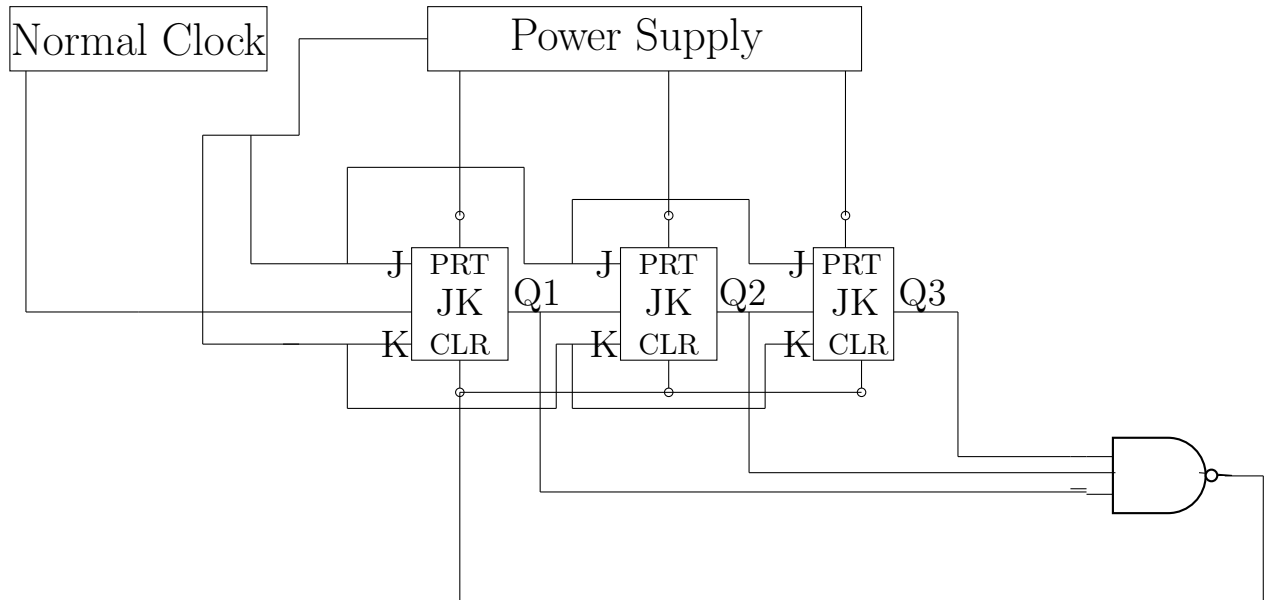   - When $T = 1$, the output toggles.

Since the Mod-7 counter requires toggle functionality, we connect J = K = 1 for each flip-flop, effectively making them act as T Flip-Flops.

3.2 State Transition Table

Current State			Next State		
Q3	Q2	Q1	Q3	Q2	Q1
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	0	1	1
0	1	1	1	0	0
1	0	0	1	0	1
1	0	1	1	1	0
1	1	0	0	0	0

Table 1: State Transition Table for Mod-7 Counter

3.3 Circuit Diagram

Circuit Diagram for Mod-7 Counter using JK Flip-Flops

4 Implementation

The Arduino generates a clock signal using the following code:

```
#define CLOCK_PIN 8
void setup() {
    pinMode(CLOCK_PIN, OUTPUT);
}

void loop() {
    digitalWrite(CLOCK_PIN, HIGH);
    delay(100);
    digitalWrite(CLOCK_PIN, LOW);
    delay(100);
}
```
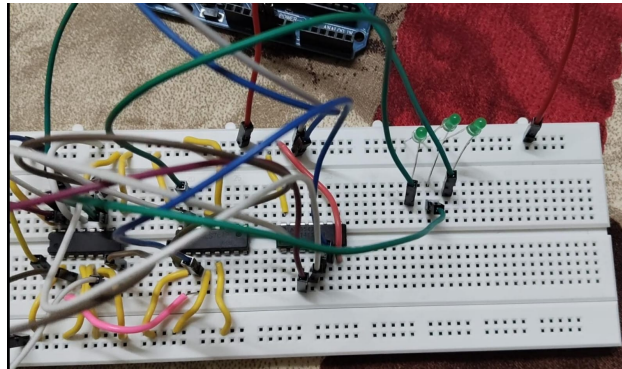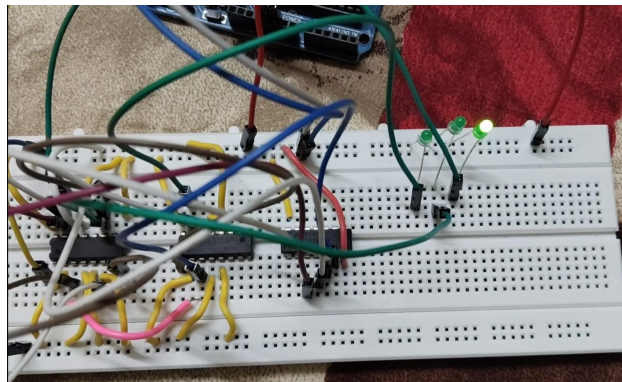
5 Observations and Results

The counter output was verified using a Cathode Ray Oscilloscope (CRO), showing the expected sequence from 000 to 110 before resetting. The wave-

form analysis confirmed the correct operation of the Mod-7 counter. The below pictures are of the LED counter:
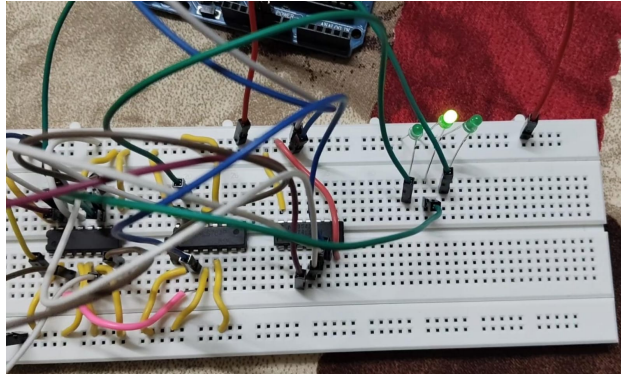
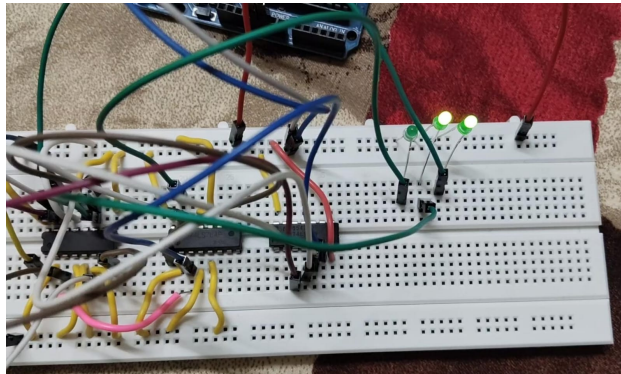**The LED blinking represents 1 and the order is Q3, Q2, Q1 from left to right:**
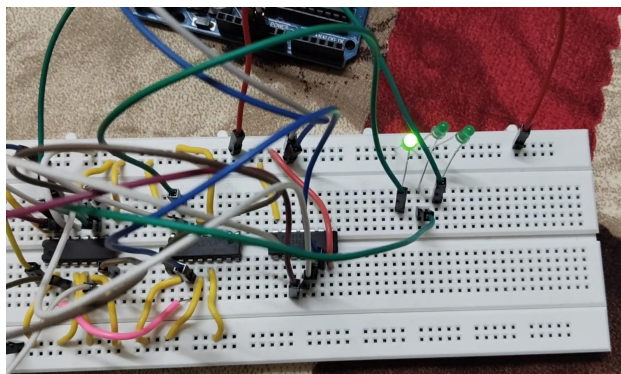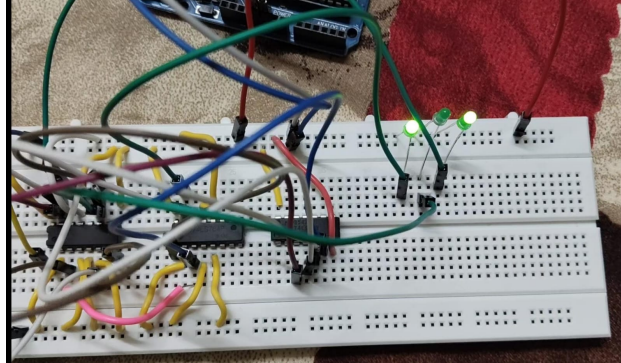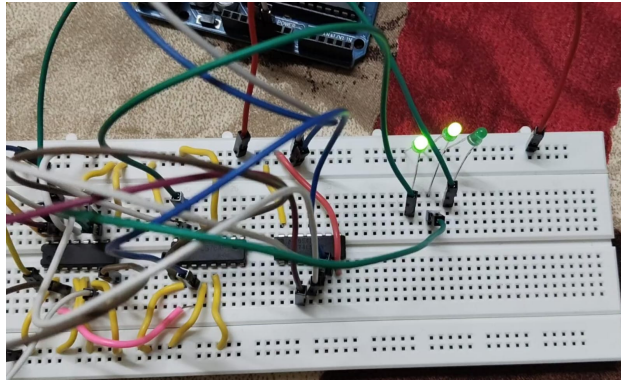

0 0 0 = 0

0 0 1 = 1

0 1 0 = 2

0 1 1 = 3

1 0 0 = 4

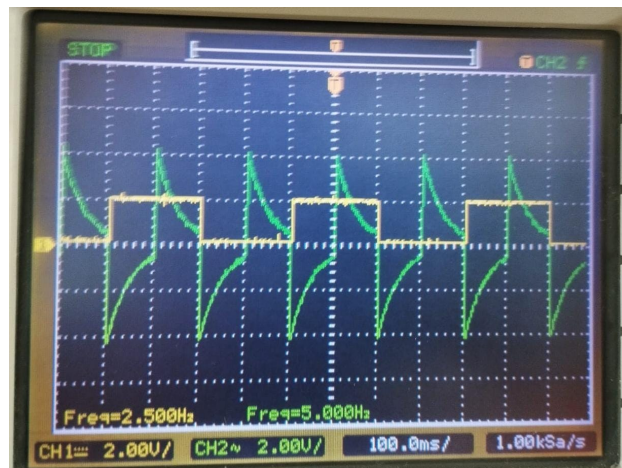$1\ 0\ 1 = 5$

$1\ 1\ 0 = 6$

Figure 1: frequency of Clock and Q1 where $f_{Q1} = \frac{f_{clk}}{2}$

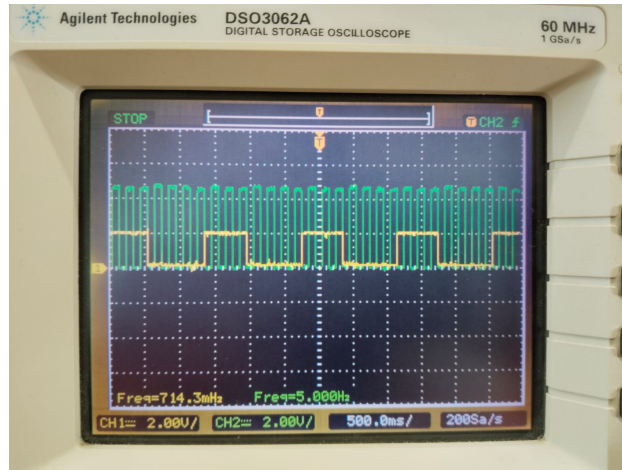Figure 2: frequency of Clock and Q2 where $f_{Q2} = \frac{f_{clk}}{4}$

Figure 3: frequency of Clock and Q3 where $f_{Q3} = \frac{f_{clk}}{8}$

6 Conclusion

The Mod-7 asynchronous counter was successfully designed and tested using JK flip-flops. The circuit counted correctly through seven states and reset as expected. The Arduino provided a stable clock signal, and the output was verified using a CRO.