**LAB REPORT: 5**

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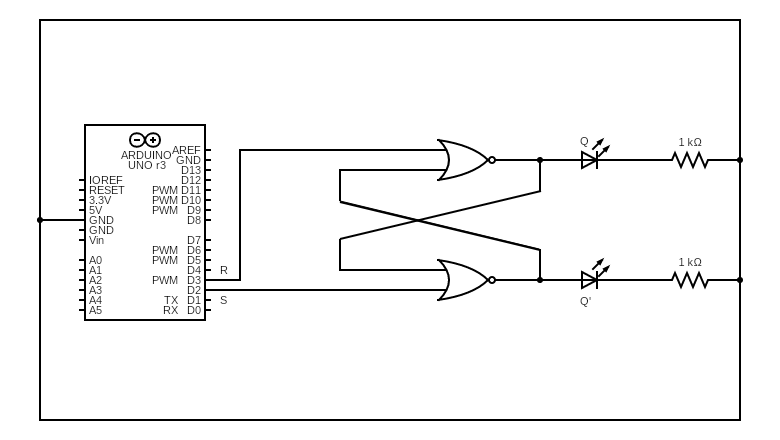
Group: 8

**Part A: SR Latch**

Aim/Objective of the experiment: To design an SR latch

Electronic components used: 1 Arduino board, two 1 kilo ohm resistors, 2 LEDs, 1 breadboard, 2 NOR gates(74HC02), 1 pushbutton, wires

Reference Circuit:



Procedure:

1. A NOR latch is assembled using two NOR gates, as shown in the reference figure above, on the breadboard.
2. R and S are taken as inputs from the user.
3. Outputs Q and Q’ are displayed on two LEDs.
4. An Arduino code is written to give different combinations of inputs as input.
5. The observed outputs of the latch are tabulated.

The code:

int r,s;

void setup()

{

pinMode(2,OUTPUT);

pinMode(3,OUTPUT);

Serial.begin(9600);

}

void loop()

{

if(Serial.available()>0)

{

s=Serial.read();

s=s-'0';

digitalWrite(2,s);

}

if(Serial.available()>0)

{

r=Serial.read();

r=r-'0';

digitalWrite(3,r);

}

delay(100);

}

Conclusion:

|  |  |  |  |
| --- | --- | --- | --- |
| **S** | **R** | **Q** | **Q’** |
| 0 | 1 | 0 | 1 |
| 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 0 | 0 | 0 | 1 |
| 1 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 |

Q. When given the above inputs, explain till when the latch can be expected to operate correctly and why?

Ans. The latch can be expected to operate correctly until both S and R inputs are 1. The 11 input is a forbidden input for NOR implementation of SR latch since if it followed by a 00 input, we may not get the previous state though that is expected.

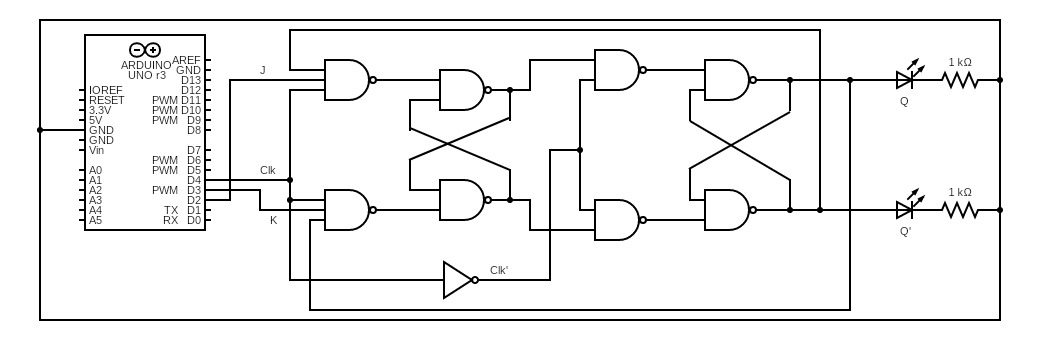
TinderCAD simulation: [https://www.tinkercad.com/things/5K34xg6Fmvq-arghya-lab-5-part-a-sr-latch/](https://www.tinkercad.com/things/5K34xg6Fmvq-arghya-lab-5-part-a-sr-latch/editel?sharecode=bESer4RMPdN7vi-rkbteQpKyB9mUSwFV5GxcsxERsG0)

**Part B: JK Master-Slave Flip-Flop**

Aim/Objective of the experiment: To design a JK Master-Slave Flip-Flop

Electronic components used: 1 Arduino board, two 1 kilo ohm resistors, 2 LEDs, 3 breadboards, 1 triple 3-input NAND gate (74HC10), 1 hex inverter(74HC04), 5 Quad NAND gates(74HC00), 1 push button, wires

Reference Circuit:



Procedure:

1. The circuit is set up, as shown in the reference figure above, on the breadboard.
2. Power supply is added to it.
3. An Arduino code is written to give different combinations of inputs as input.
4. The observed outputs of the JK flip-flop are tabulated.

The code used:

int j,k,c;

void setup()

{

pinMode(2, OUTPUT);

pinMode(3, OUTPUT);

pinMode(4, OUTPUT);

Serial.begin(9600);

}

void loop()

{

c=1;

if(Serial.available()>0)

{

j=Serial.read();

j=j-'0';

digitalWrite(2,j);

}

if(Serial.available()>0)

{

k=Serial.read();

k=k-'0';

digitalWrite(3,k);

digitalWrite(4,c);

delay(100);

c=0;

digitalWrite(4,c);

}

delay(100);

}

Conclusion:

|  |  |  |  |
| --- | --- | --- | --- |
| **J** | **K** | **Q** | **Q’** |
|  |  |  |  |
| 1 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 0 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |
| 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 |

Thus, the outputs are tabulated and verified.

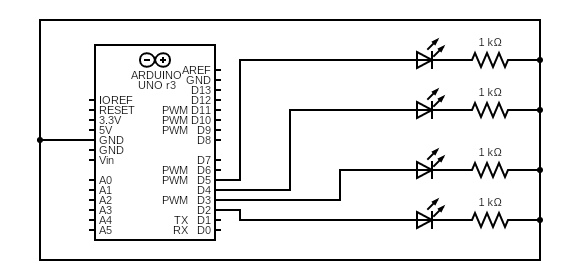
TinkerCAD Simulation: <https://www.tinkercad.com/things/2pjyaPqrPTw-arghya-lab-5-part-b-jk-flip-flop/>

**Part C: 4-bit Up-Down Counter**

Aim/Objective of the experiment: To implement a 4-bit counter

Electronic components used: 1 Arduino board, four 1 kilo ohm resistors, 4 LEDs, 1 breadboard, wires

Reference Circuit:



Procedure:

1. The circuit is set up, as shown in the reference figure above, on the breadboard.
2. An Arduino code is written to implement a 4-bit counter with LEDs using the Timer library.
3. Each of the bit outputs are represented by an LED.

The code used:

/\*

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\*/

/\* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \*

Code by Simon Monk

http://www.simonmonk.org

\* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \* \*/

#ifndef Event\_h

#define Event\_h

#include <inttypes.h>

#define EVENT\_NONE 0

#define EVENT\_EVERY 1

#define EVENT\_OSCILLATE 2

class Event

{

public:

Event(void);

void update(void);

void update(unsigned long now);

int8\_t eventType;

unsigned long period;

int repeatCount;

uint8\_t pin;

uint8\_t pinState;

void (\*callback)(void);

unsigned long lastEventTime;

int count;

};

#endif

#ifndef Timer\_h

#define Timer\_h

#include <inttypes.h>

#define MAX\_NUMBER\_OF\_EVENTS (10)

#define TIMER\_NOT\_AN\_EVENT (-2)

#define NO\_TIMER\_AVAILABLE (-1)

class Timer

{

public:

Timer(void);

int8\_t every(unsigned long period, void (\*callback)(void));

int8\_t every(unsigned long period, void (\*callback)(void), int repeatCount);

int8\_t after(unsigned long duration, void (\*callback)(void));

int8\_t oscillate(uint8\_t pin, unsigned long period, uint8\_t startingValue);

int8\_t oscillate(uint8\_t pin, unsigned long period, uint8\_t startingValue, int repeatCount);

/\*\*

\* This method will generate a pulse of !startingValue, occuring period after the

\* call of this method and lasting for period. The Pin will be left in !startingValue.

\*/

int8\_t pulse(uint8\_t pin, unsigned long period, uint8\_t startingValue);

/\*\*

\* This method will generate a pulse of pulseValue, starting immediately and of

\* length period. The pin will be left in the !pulseValue state

\*/

int8\_t pulseImmediate(uint8\_t pin, unsigned long period, uint8\_t pulseValue);

void stop(int8\_t id);

void update(void);

void update(unsigned long now);

protected:

Event \_events[MAX\_NUMBER\_OF\_EVENTS];

int8\_t findFreeEventIndex(void);

};

#endif

//// YOUR CODE STARTS HERE

Timer t;

/\*

int pin0 = 2;

int pin1 = 3;

int pin2 = 4;

int pin3 = 5;

\*/

int flag = 0;

int eventId1,eventId2,eventId3,eventId4;

void setup() {

Serial.begin(9600);

pinMode(2, OUTPUT);

pinMode(3, OUTPUT);

pinMode(4, OUTPUT);

pinMode(5, OUTPUT);

eventId1 = t.oscillate(2, 500, flag);

//if (eventId1<0){Serial.println("Could not initialize timer");}

eventId2 = t.oscillate(3, 1000, flag);

// if (eventId2<0){Serial.println("Could not initialize timer");}

eventId3 = t.oscillate(4, 2000, flag);

//if (eventId3<0){Serial.println("Could not initialize timer");}

eventId4 = t.oscillate(5, 4000, flag);

// if (eventId4<0){Serial.println("Could not initialize timer");}

t.after(8000, after);

}

void after()

{

t.stop(eventId1);

t.stop(eventId2);

t.stop(eventId3);

t.stop(eventId4);

flag = !flag;

//Serial.println(flag);

eventId1 = t.oscillate(2, 500, flag,8);

//if (eventId1<0){Serial.println("Could not initialize timer");}

eventId2 = t.oscillate(3, 1000, flag,4);

// if (eventId2<0){Serial.println("Could not initialize timer");}

eventId3 = t.oscillate(4, 2000, flag,2);

//if (eventId3<0){Serial.println("Could not initialize timer");}

eventId4 = t.oscillate(5, 3000, flag,1);

// if (eventId4<0){Serial.println("Could not initialize timer");}

t.after(8000, after);

}

// 1 unit of your timer = 500ms in real time

void loop() {

t.update();

}

// "every" X milliseconds

//// YOUR CODE ENDS HERE

// For Arduino 1.0 and earlier

// #if defined(ARDUINO) && ARDUINO >= 100

// #include "Arduino.h"

// #else

// #include "WProgram.h"

// #endif

Event::Event(void)

{

eventType = EVENT\_NONE;

}

void Event::update(void)

{

unsigned long now = millis();

update(now);

}

void Event::update(unsigned long now)

{

if (now - lastEventTime >= period)

{

switch (eventType)

{

case EVENT\_EVERY:

(\*callback)();

break;

case EVENT\_OSCILLATE:

pinState = ! pinState;

digitalWrite(pin, pinState);

break;

}

lastEventTime = now;

count++;

}

if (repeatCount > -1 && count >= repeatCount)

{

eventType = EVENT\_NONE;

}

}

Timer::Timer(void)

{

}

int8\_t Timer::every(unsigned long period, void (\*callback)(), int repeatCount)

{

int8\_t i = findFreeEventIndex();

if (i == -1) return -1;

\_events[i].eventType = EVENT\_EVERY;

\_events[i].period = period;

\_events[i].repeatCount = repeatCount;

\_events[i].callback = callback;

\_events[i].lastEventTime = millis();

\_events[i].count = 0;

return i;

}

int8\_t Timer::every(unsigned long period, void (\*callback)())

{

return every(period, callback, -1); // - means forever

}

int8\_t Timer::after(unsigned long period, void (\*callback)())

{

return every(period, callback, 1);

}

int8\_t Timer::oscillate(uint8\_t pin, unsigned long period, uint8\_t startingValue, int repeatCount)

{

int8\_t i = findFreeEventIndex();

if (i == NO\_TIMER\_AVAILABLE) return NO\_TIMER\_AVAILABLE;

\_events[i].eventType = EVENT\_OSCILLATE;

\_events[i].pin = pin;

\_events[i].period = period;

\_events[i].pinState = startingValue;

digitalWrite(pin, startingValue);

\_events[i].repeatCount = repeatCount \* 2; // full cycles not transitions

\_events[i].lastEventTime = millis();

\_events[i].count = 0;

return i;

}

int8\_t Timer::oscillate(uint8\_t pin, unsigned long period, uint8\_t startingValue)

{

return oscillate(pin, period, startingValue, -1); // forever

}

/\*\*

\* This method will generate a pulse of !startingValue, occuring period after the

\* call of this method and lasting for period. The Pin will be left in !startingValue.

\*/

int8\_t Timer::pulse(uint8\_t pin, unsigned long period, uint8\_t startingValue)

{

return oscillate(pin, period, startingValue, 1); // once

}

/\*\*

\* This method will generate a pulse of startingValue, starting immediately and of

\* length period. The pin will be left in the !startingValue state

\*/

int8\_t Timer::pulseImmediate(uint8\_t pin, unsigned long period, uint8\_t pulseValue)

{

int8\_t id(oscillate(pin, period, pulseValue, 1));

// now fix the repeat count

if (id >= 0 && id < MAX\_NUMBER\_OF\_EVENTS) {

\_events[id].repeatCount = 1;

}

return id;

}

void Timer::stop(int8\_t id)

{

if (id >= 0 && id < MAX\_NUMBER\_OF\_EVENTS) {

\_events[id].eventType = EVENT\_NONE;

}

}

void Timer::update(void)

{

unsigned long now = millis();

update(now);

}

void Timer::update(unsigned long now)

{

for (int8\_t i = 0; i < MAX\_NUMBER\_OF\_EVENTS; i++)

{

if (\_events[i].eventType != EVENT\_NONE)

{

\_events[i].update(now);

}

}

}

int8\_t Timer::findFreeEventIndex(void)

{

for (int8\_t i = 0; i < MAX\_NUMBER\_OF\_EVENTS; i++)

{

if (\_events[i].eventType == EVENT\_NONE)

{

return i;

}

}

return NO\_TIMER\_AVAILABLE;

}

Conclusion:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time** | **A** | **B** | **C** | **D** |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 1 |
| 3 | 0 | 0 | 1 | 0 |
| 4 | 0 | 0 | 1 | 1 |
| 5 | 0 | 1 | 0 | 0 |
| 6 | 0 | 1 | 0 | 1 |
| 7 | 0 | 1 | 1 | 0 |
| 8 | 0 | 1 | 1 | 1 |
| 9 | 1 | 0 | 0 | 0 |
| 10 | 1 | 0 | 0 | 1 |
| 11 | 1 | 0 | 1 | 0 |
| 12 | 1 | 0 | 1 | 1 |
| 13 | 1 | 1 | 0 | 0 |
| 14 | 1 | 1 | 0 | 1 |
| 15 | 1 | 1 | 1 | 0 |
| 16 | 1 | 1 | 1 | 1 |
| 17 | 1 | 1 | 1 | 1 |
| 18 | 1 | 1 | 1 | 0 |
| 19 | 1 | 1 | 0 | 1 |
| 20 | 1 | 1 | 0 | 0 |
| 21 | 1 | 0 | 1 | 1 |
| 22 | 1 | 0 | 1 | 0 |
| 23 | 1 | 0 | 0 | 1 |
| 24 | 1 | 0 | 0 | 0 |
| 25 | 0 | 1 | 1 | 1 |
| 26 | 0 | 1 | 1 | 0 |
| 27 | 0 | 1 | 0 | 1 |
| 28 | 0 | 1 | 0 | 0 |
| 29 | 0 | 0 | 1 | 1 |
| 30 | 0 | 0 | 1 | 0 |
| 31 | 0 | 0 | 0 | 1 |
| 32 | 0 | 0 | 0 | 0 |

We observe that the ripple counter first goes up from 0 (0000) to 15 (1111), then goes down from 15 to 0, then goes up again, and this cycle keeps on repeating until the simulation is stopped.

TinkerCAD Simulation: <https://www.tinkercad.com/things/9303yjXZhLE-arghya-lab-5-part-c-4-bit-counter/>