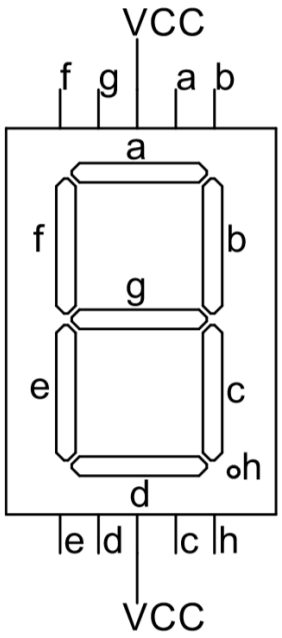
Decade Counter using D Flip Flops

February 18, 2016

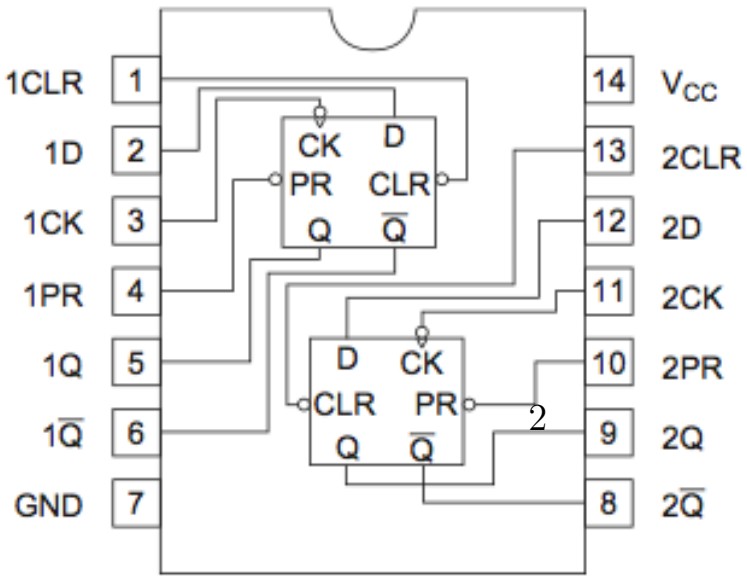
1 AIM:

To make a decade counter using D-Flip Flops and an Arduino.The counter will be synchronous ie. all the flip flops will have a common clock. The Arduino will be used to provide the clock pulses and to perform logical operations.

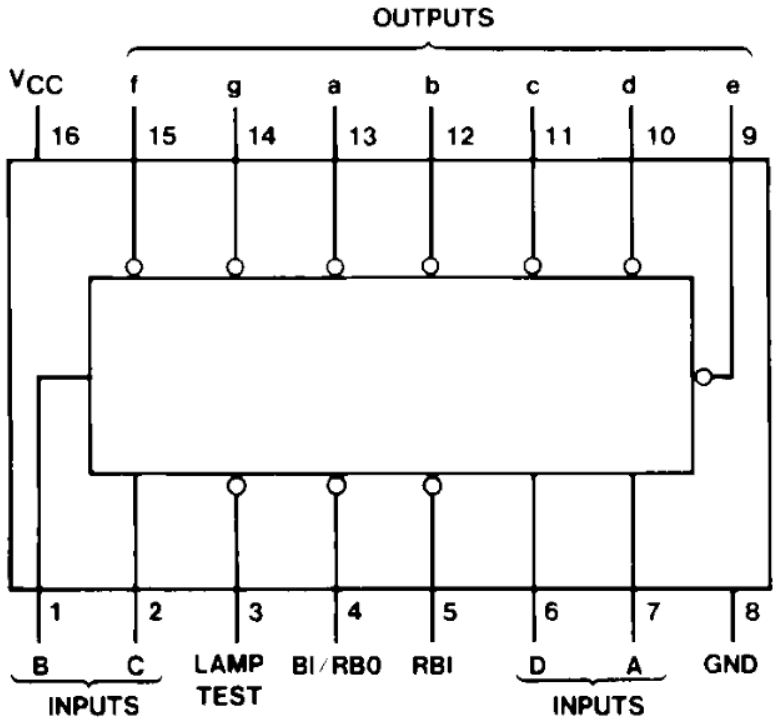
2 Components and their Pin Layouts



7 Segment Display Pin Layout

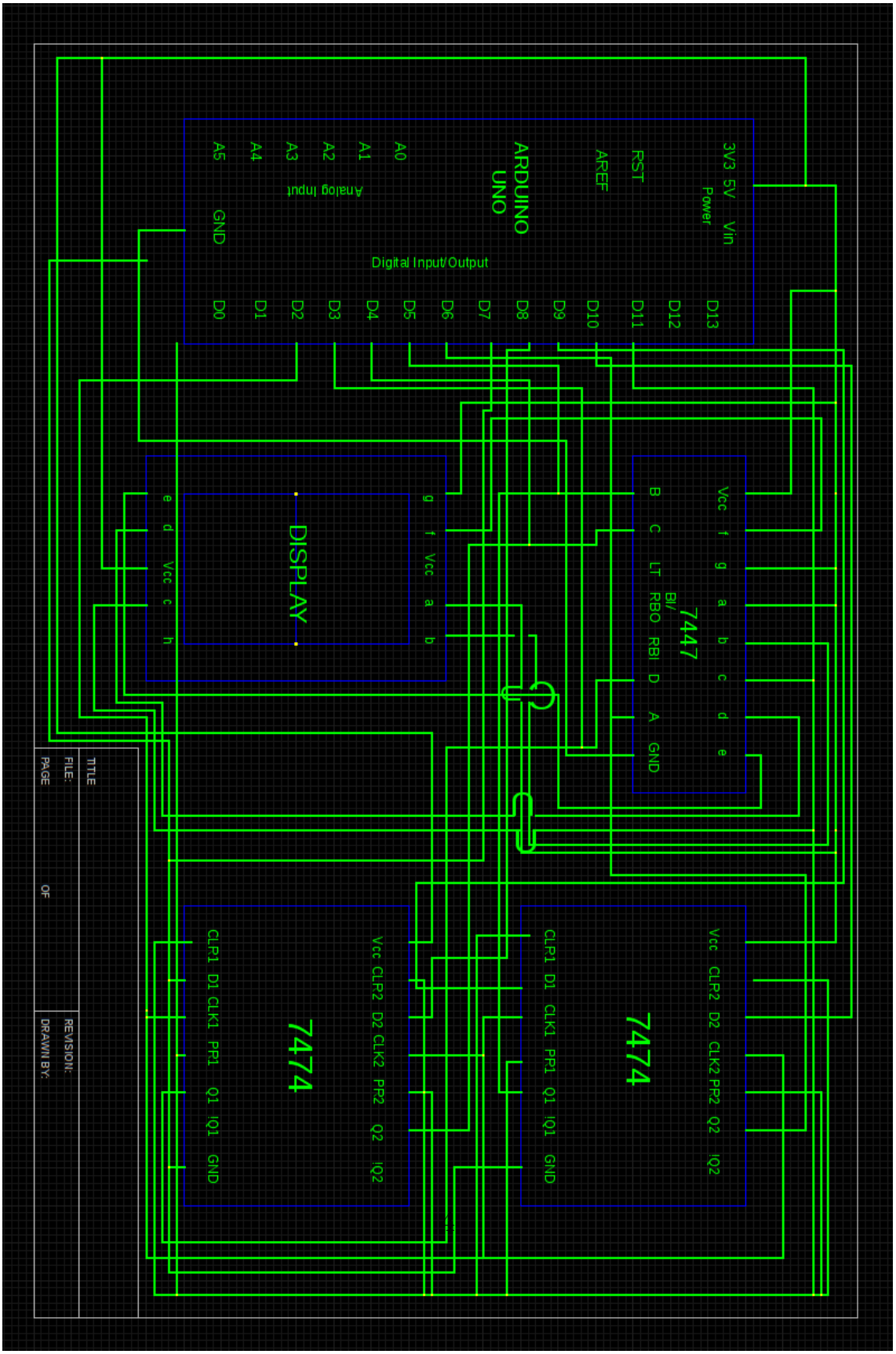


D Flip Flop (7474) Pin Layout



BCD-7-Segment Decoder(7474

3 Circuit Diagram:



4 Arduino Code:

```
int d_1=2,d_2=3,d_3=4,d_4=5,q_1=6,q_2=7,q_3=8,q_4=9,clock_pin=10;
//1:LSB,4:MSB ie. d_4 is the data input for the flip flop storing MSB

void setup() {
  pinMode(d_1,OUTPUT);
  pinMode(d_2,OUTPUT);
  pinMode(d_3,OUTPUT);
  pinMode(d_4,OUTPUT);
  pinMode(clock_pin,OUTPUT);
  pinMode(q_1,INPUT);
  pinMode(q_2,INPUT);
  pinMode(q_3,INPUT);
  pinMode(q_4,INPUT);
  Serial.begin(9600);
}

void loop() {
  //The clock_pin is the common clock for all flip flops
  digitalWrite(clock_pin,HIGH);
  bool a=digitalRead(q_4);
  bool b=digitalRead(q_3);
  bool c=digitalRead(q_2);
  bool d=digitalRead(q_1);
  //Boolean expressions for the next state:
  //For the truth table, please check the Working Section.
  bool D=(!d);
  bool C=((c&&(!d))||((!a)&&(!c)&&(d)));
  bool B=((b && (!d)) || (b && (!c)) || ((!b) && c && d));
  bool A=((a && (!d)) || (b && c && d));
  Serial.println(a);
  Serial.println(b);
  Serial.println(c);
  Serial.println(d);
```

```
  Serial.println("\n");
  Serial.println(A);
  Serial.println(B);
  Serial.println(C);
  Serial.println(D);
  Serial.println("\n");
  digitalWrite(d_1,D);
  digitalWrite(d_2,C);
  digitalWrite(d_3,B);
  digitalWrite(d_4,A);
  digitalWrite(clock_pin,LOW);
  delay(1000);

}
```

5 Working:

A decade counter displays the integers between 0 and 9 and resets to 0 after displaying 9. As there are 10 unique values to display, the counter requires 4 bits (because $2^3 < 10 < 2^4$) of storage. Four D-flip flops are used for this purpose. The decade counter can be conceptualized as a Finite-state machine which has 10 states mapping to the 10 values to display. In each state, the flip flops hold a bit corresponding to the Boolean representation of the integer to display, with flip flop D holding the least significant bit and flip flop A holding the most significant bit.

The output Q and the data input D for each flip flop is connected to the arduino which contains code to trigger the next state. The states are computed from the following truth table:

a_{prev}	b_{prev}	c_{prev}	d_{prev}	A_{next}	B_{next}	C_{next}	D_{next}
0	0	0	0	0	0	0	1
0	0	0	1	0	0	1	0
0	0	1	0	0	0	1	1
0	0	1	1	0	1	0	0
0	1	0	0	0	1	0	1
0	1	0	1	0	1	1	0
0	1	1	0	0	1	1	1
0	1	1	1	1	0	0	0
1	0	0	0	1	0	0	1
1	0	0	1	0	0	0	0
1	0	1	0	X	X	X	X
1	0	1	1	X	X	X	X
1	1	0	0	X	X	X	X
1	1	0	1	X	X	X	X
1	1	1	0	X	X	X	X
1	1	1	1	X	X	X	X

We obtain minimized Boolean expressions for A_{next}, B_{next}, C_{next} and D_{next} from the state table. These will be the data inputs for the respective flip flops which will trigger the next state of the decade counter. The Output Q of each flip flop is also connected to the BCD-7 segment decoder which makes the appropriate segments of the 7-segment display to glow, showing the integer value for each state.