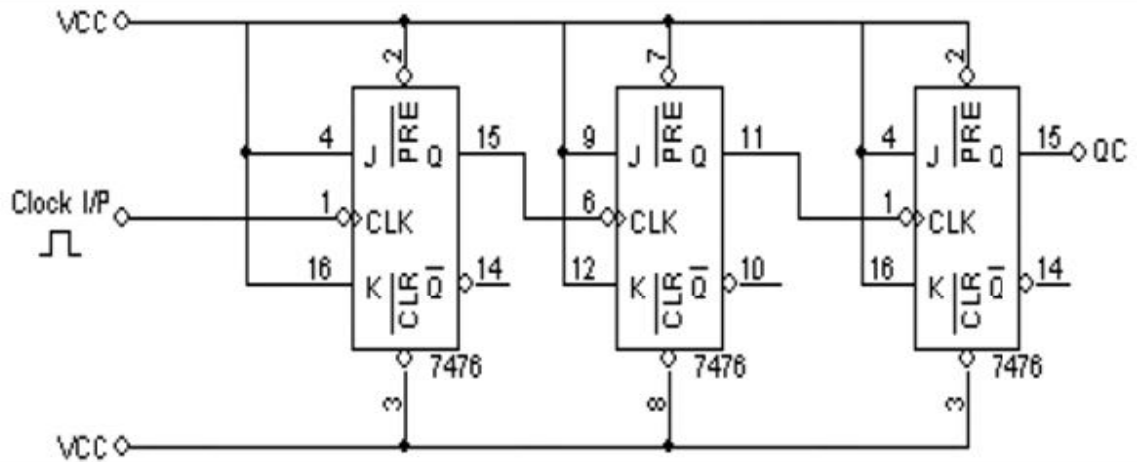
Hardware Exp#7: Design and Construction of Counters: Synchronous and asynchronous (Up & Down) using flip-flops and counter ICs.

In digital logic and computing, a **counter** is a device which stores (and sometimes displays) the number of times a particular event or process has occurred, often in relationship to a clock signal. In electronics, counters can be implemented quite easily using register-type circuits such as the flip-flop, and a wide variety of classifications exist:

- Asynchronous (ripple) counter – changing state bits are used as clocks to subsequent state flip-flops
- Synchronous counter – all state bits change under control of a single clock
- Decade counter – counts through ten states per stage
- Up/down counter – counts both up and down, under command of a control input
- Ring counter – formed by a shift register with feedback connection in a ring
- Johnson counter – a *twisted* ring counter
- Cascaded counter
- modulus counter.

Each is useful for different applications. Usually, counter circuits are digital in nature, and count in natural binary. Many types of counter circuits are available as digital building blocks, for example a number of chips in the 4000 series implement different counters.
Occasionally there are advantages to using a counting sequence other than the natural binary sequence—such as the binary coded decimal counter, a linear feedback shift register counter, or a Gray-code counter.

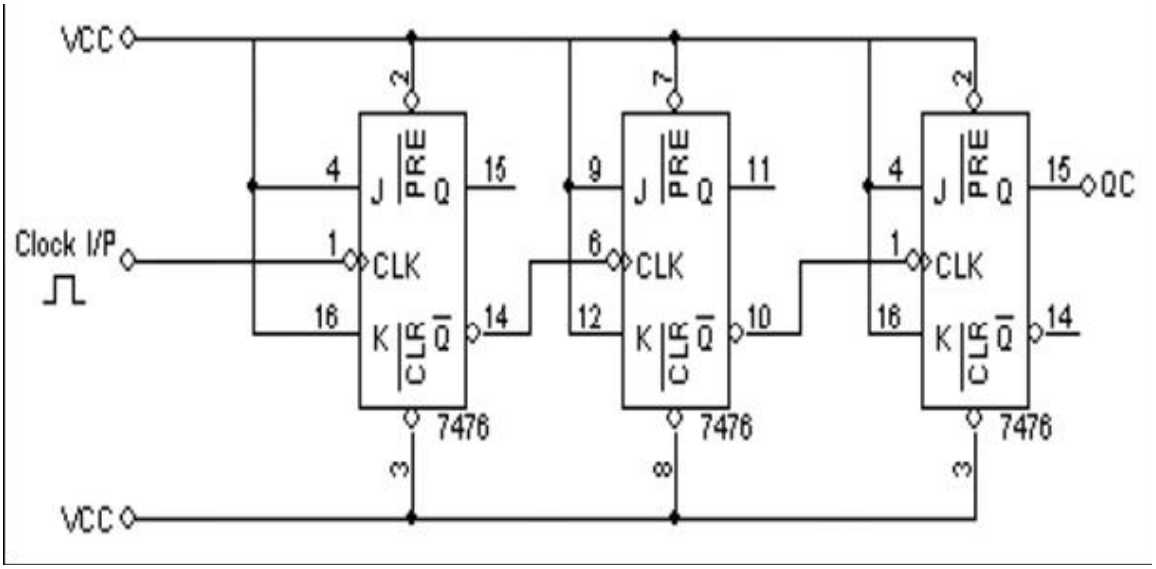
Task-1: 3-bit Asynchronous/ripple Up counter:
Asynchronous counters are a series of flip-flops each clocked by the previous state, one after the other. Since all the stages of the counter are not clocked together, a ripple effect propagates as various flip-flops are clocked. For this reason they are called ripple counters. The modulus of a counter is the number of different output states the counter may take.



Truth Table:

CLK	Q_2	Q_1	Q_0
1	0	0	1
2	0	1	0
3			
4			
5			
6			
7			
8			
9			
10			

Task-2: 3-bit Asynchronous/ripple Down counter:

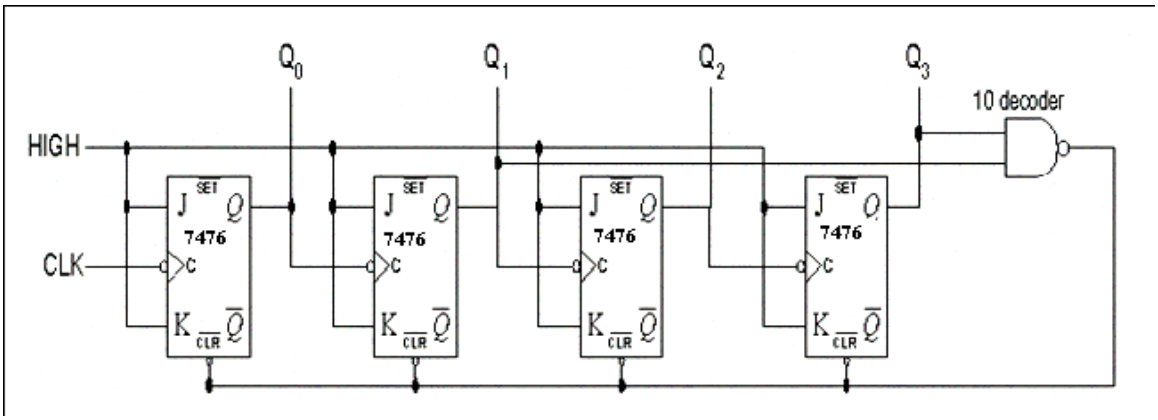


Truth Table:

CLK	Q_2	Q_1	Q_0
1	1	1	1
2	1	1	0
3			
4			
5			
6			
7			
8			
9			
10			

Task-3: Decade Counter:

A decade counter is a binary counter that is designed to count to 1010b (decimal 10).



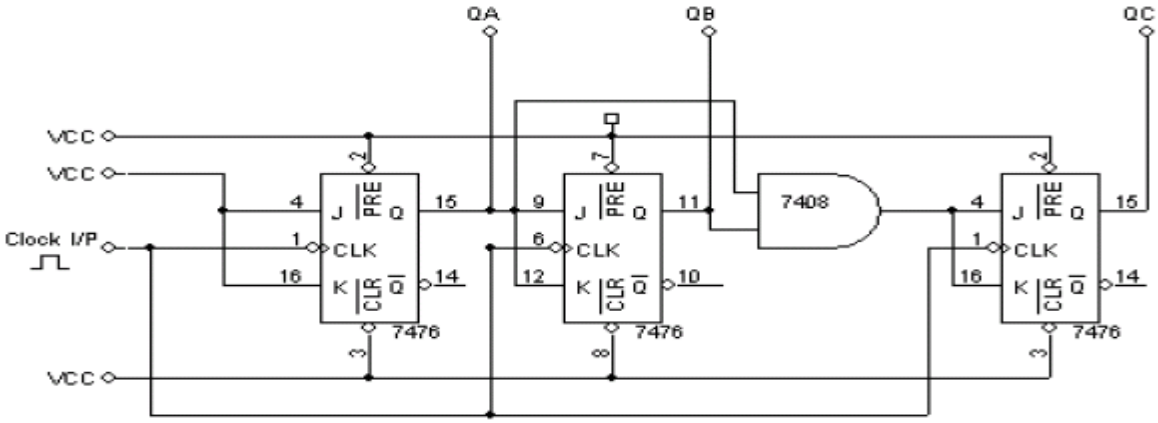
Truth Table:

CLK	Q_3	Q_2	Q_1	Q_0
1	0	0	0	1
2	0	0	1	0
3				
4				
5				
6				
7				
8				
9				
10				

Task-4: 3-bit synchronous Up counter

Synchronous counters have all clock lines tied to a common clock causing all flip-flops to change at the same time. The count sequence of a counter can be analyzed by placing the counter into every possible number in the sequence and determining the next number in the sequence state diagram is developed as the analysis proceeds.

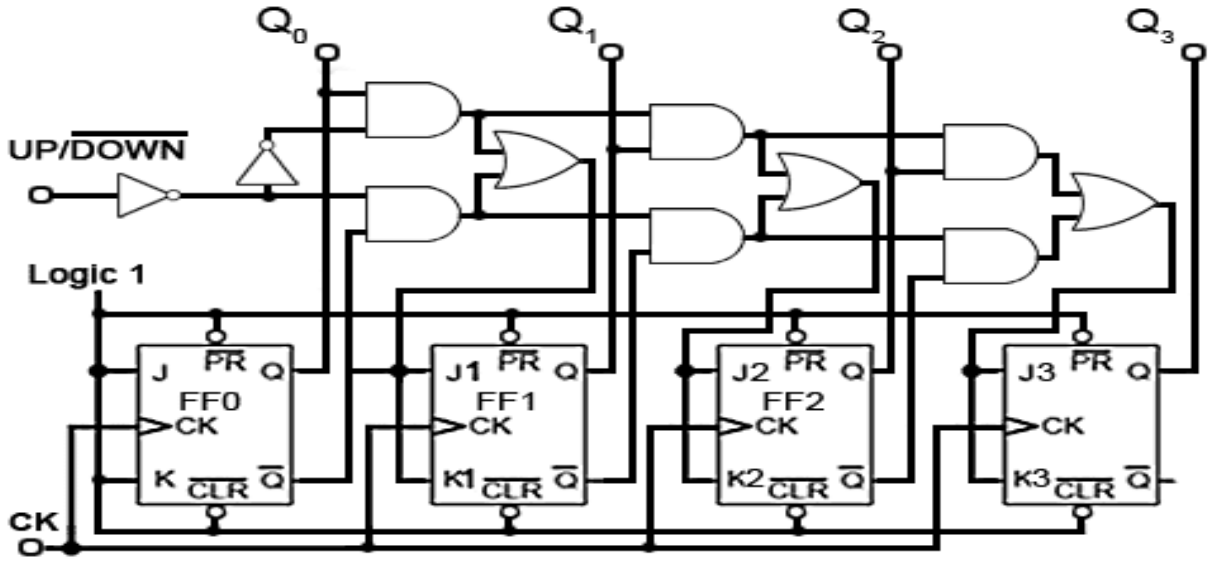
3-bit Synchronous Counter:-



Truth Table:

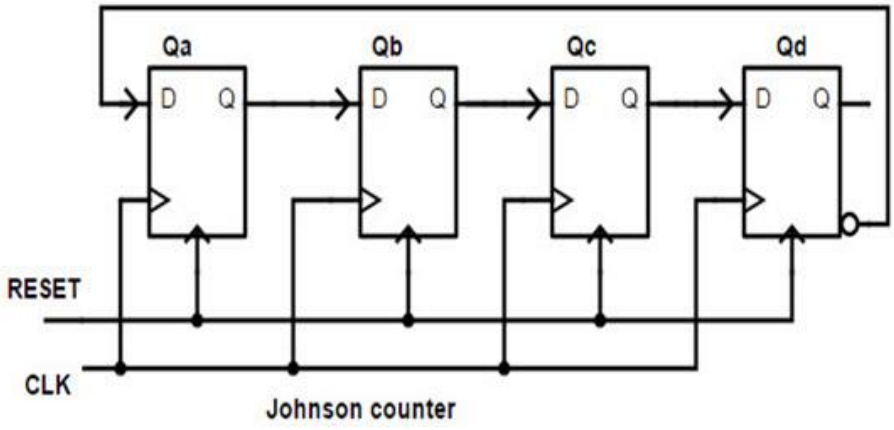
CLK	Q_2	Q_1	Q_0
1	0	0	1
2	0	1	0
3			
4			
5			
6			
7			
8			
9			
10			

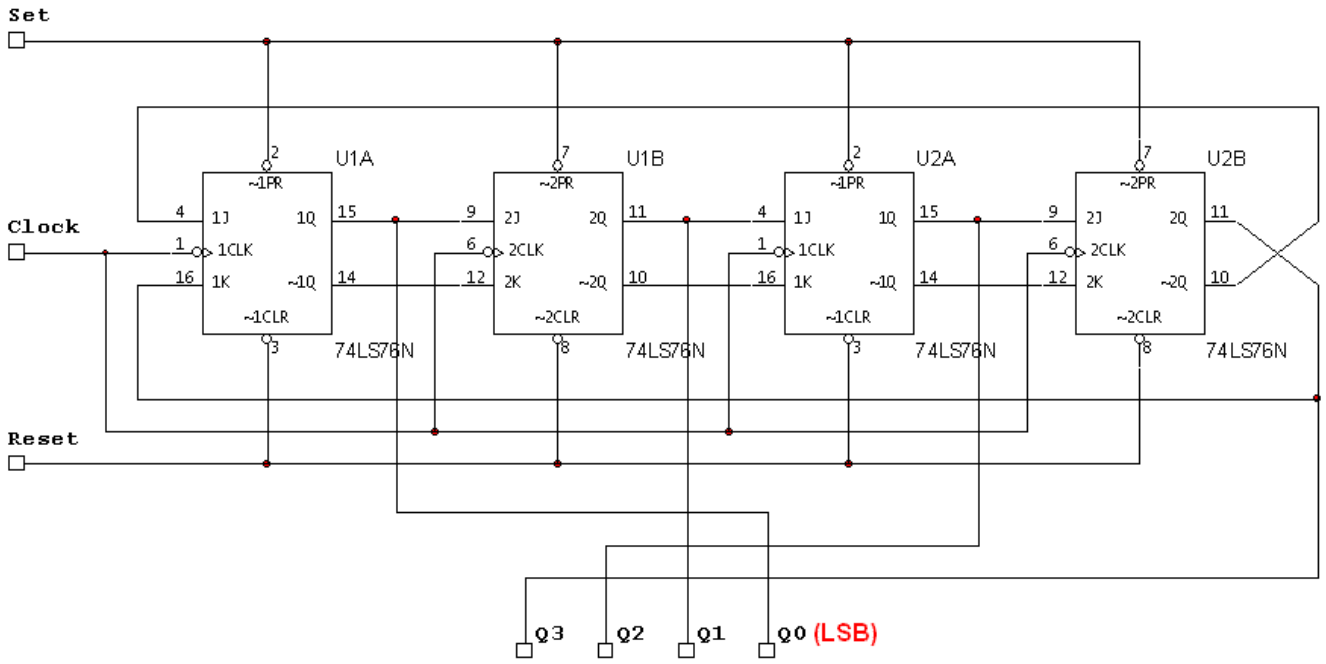
Task-5: 3-bit synchronous Up/Down counter



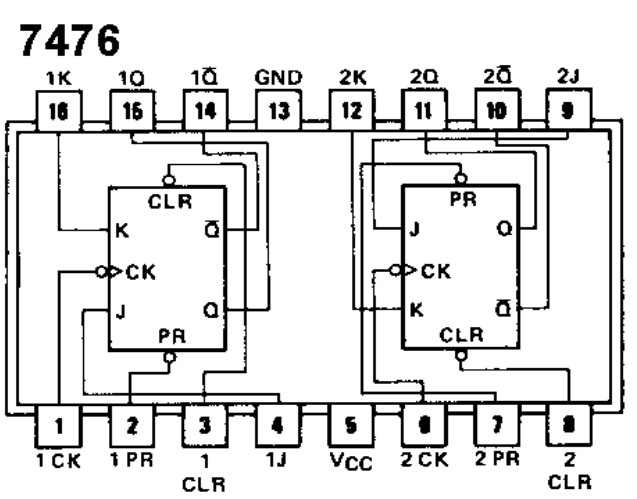
Task-6: 4-bit Johnson counter

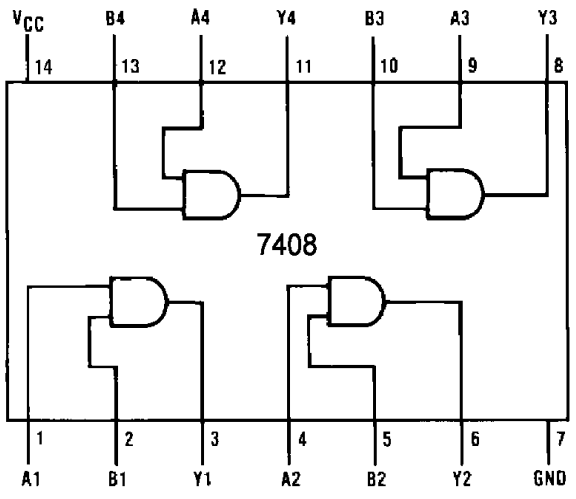
Q_A	Q_B	Q_C	Q_D
0	0	0	0
1	0	0	0
1	1	0	0
1	1	1	0
1	1	1	1
0	1	1	1
0	0	1	1
0	0	0	1
repeat			

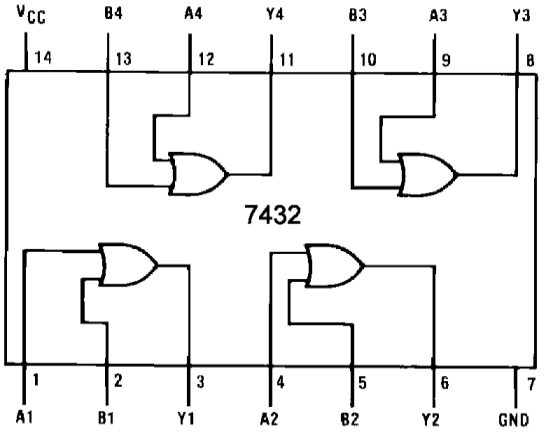




Johnson Counter







7400 Quad 2-input NAND Gates