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Lab 7 : Finite State Machine

Objective

The purpose of this lab is to become familiar with finite state machine applications using integrated circuits on a breadboard. D-flip flops were used to achieve this purpose. It was monitored by putting LEDs on the outputs whether the result obtained was an finite state machine sample.

Methodology

Johnson counter was chosen for the design. Johnson counter is formed by combining D flip flops standing in a row. Each flip flop Q output is connected to the D input of the other. The Q' output of the last D flip flop is connected to the D input of the first D flip flop. All clocks in the circuit are connected to a common clock, so the circuit works synchronously. The 74HC74 dual D flip flop was used when designing the finite state machine. The voltage source is used to provide the 5V power needed to run the integrated circuits. With signal generator, a clock was created with signals at a frequency of 1 Hertz with a 5V V_{pp} value.

74HC74 Dual D-Flip Flop

74HC74 Dual D-Flip Flop allows to connect the input to a D-flip flop. It consists 2 D-flip flop. 14 and 7 pins are V_{cc} (5V) and GND respectively. It consist preset and clear functions. 3 and 11 pins are clock. The schematic is shown at Figure-1.

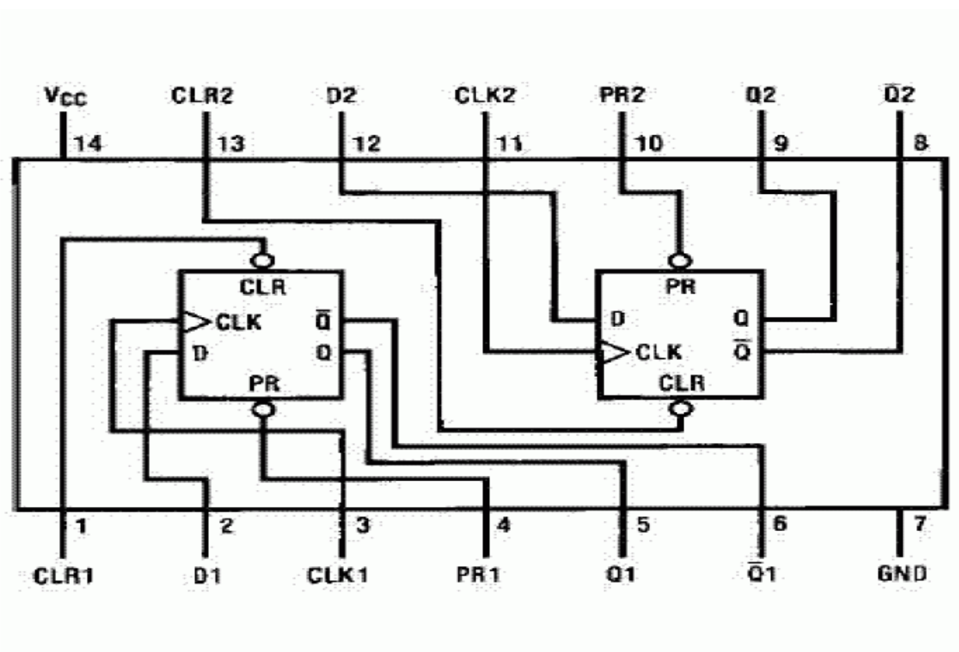

Figure 1 – 74HC74 Dual D-Flip Flop

Then a state diagram was created at the Johnson counter. It was shown that there are 8 states in total. When any of these states are given as input, the circuit starts to move from the current state to the next state. Since the circuit is not self corrected, when an incorrect input is given, it continues to give incorrect outputs and sends irregular outputs. After a correct input, it starts its sequential movement and does not stop until the electrical connections are cut. For example, when the circuit is first connected, no electrical signal goes to the D-flip flop, so the circuit starts from the "0000" state. After that, it continues to light as "1000" and "1100" respectively. If the input is given as "1111" at the beginning, the circuit starts to flash as "0111", "0011" respectively. The entire state table is shown in Table-1.

Previous State	Next State
“0000”	“1000”
“1000”	“1100”
“1100”	“1110”
“1110”	“1111”
“1111”	“0111”
“0111”	“0011”
“0011”	“0001”
“0001”	“0000”

Table 1 – State Table of Johnson Counter

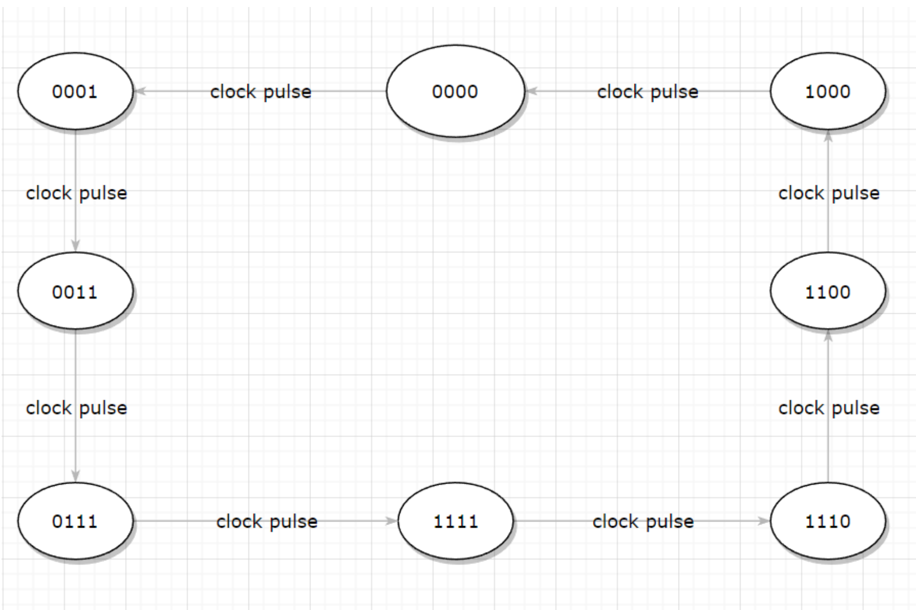

Figure 2 – State Diagram of Johnson Counter

After creating the state table, the components are connected to each other. A 330 ohm resistor is connected to the positive output of each D-flip flop and an LED is connected in series with the resistor to visualize the output. Then, by giving inputs, it was checked whether the system was working correctly by looking at the order in which the LEDs were lit.

Results

Finite state machine worked as expected. The states have changed only in the rising edges of the clock. In Figure 3 circuit is initialized with “1000” input and it completed the cycle at Figure 2.

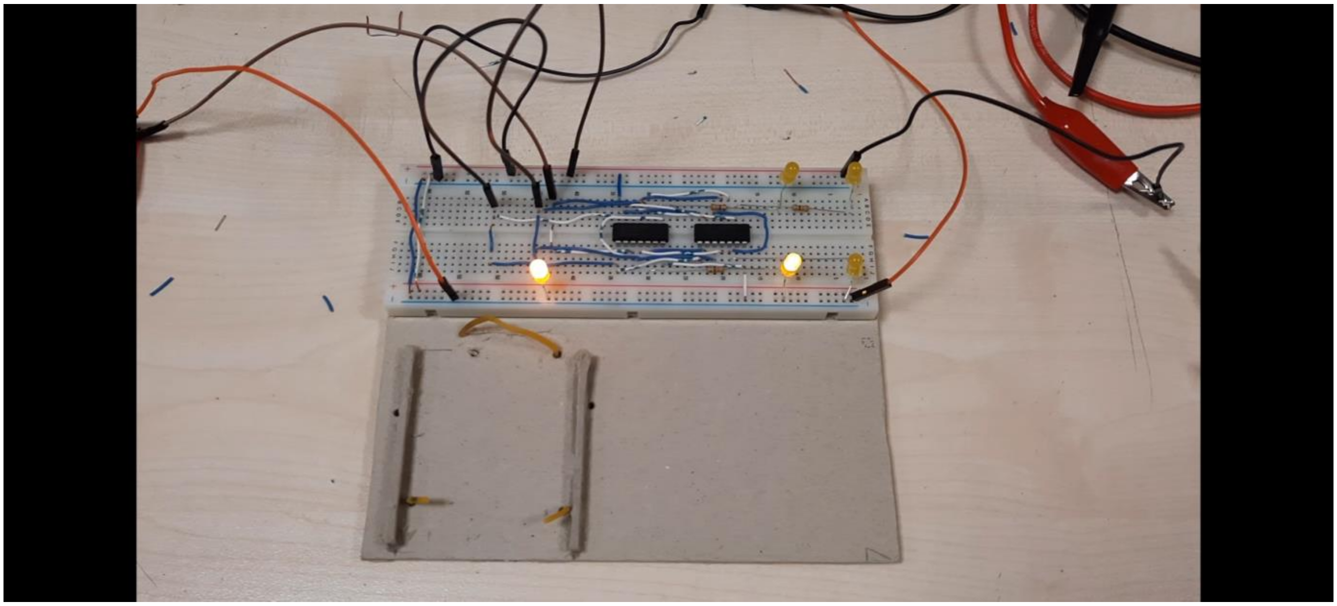

Figure 3 – Input is “1000” (First State)

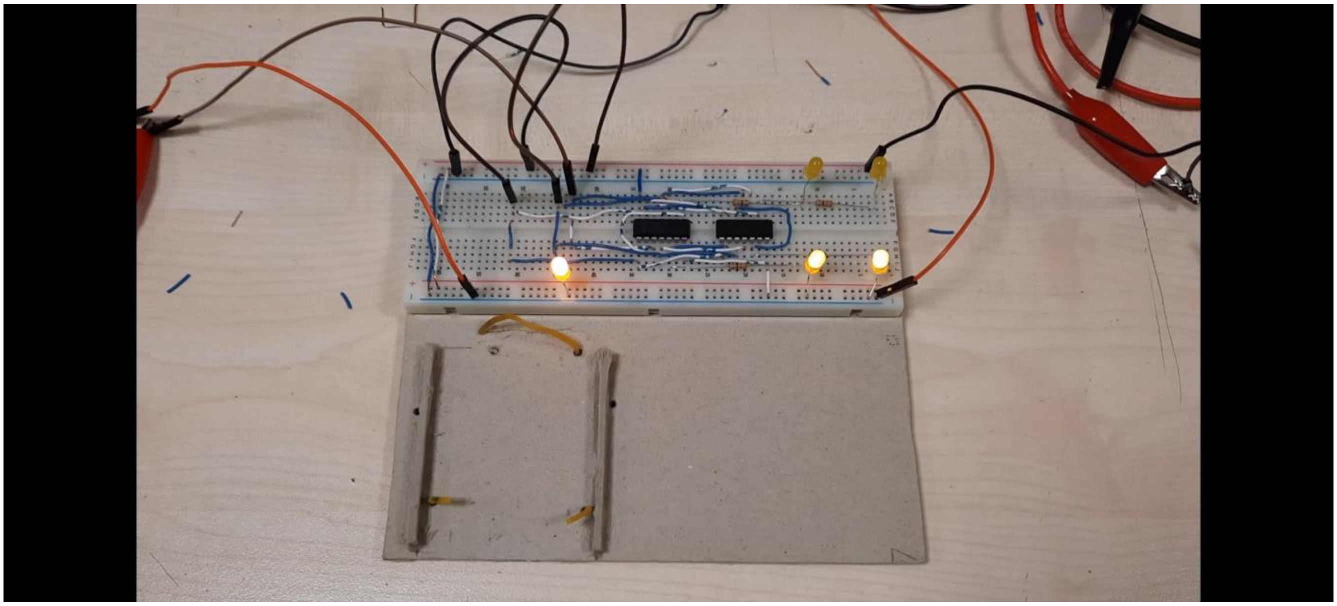

Figure 4 – Next state is “1100”

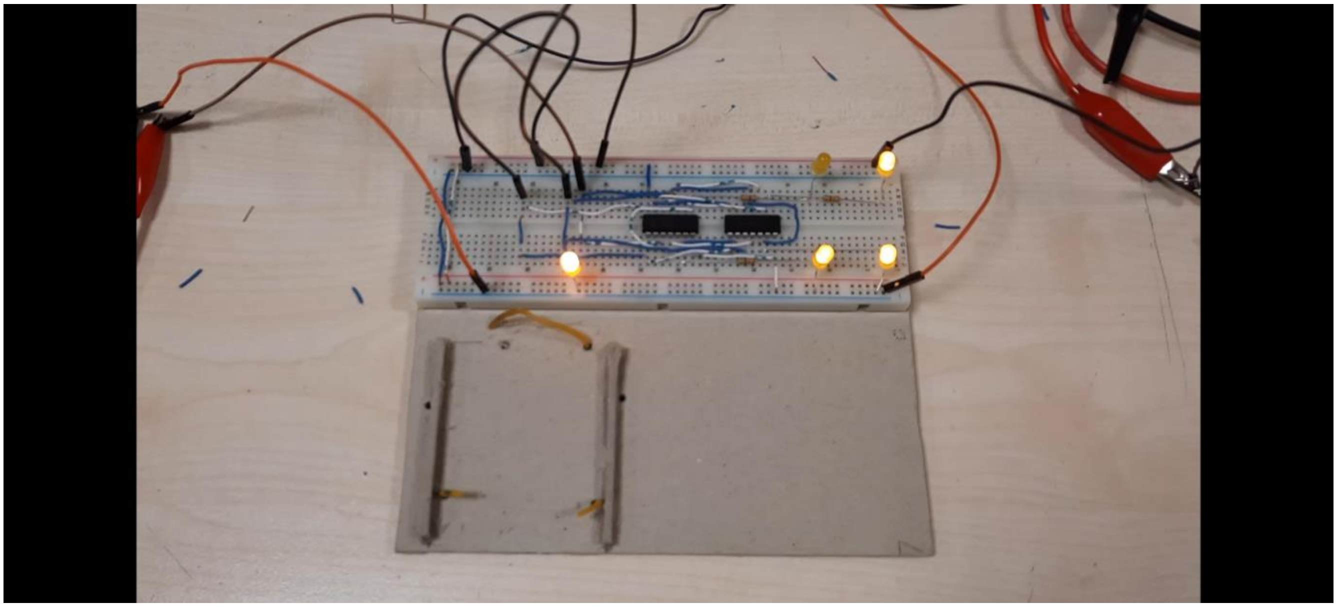
Figure 5 – Next state is “1110”

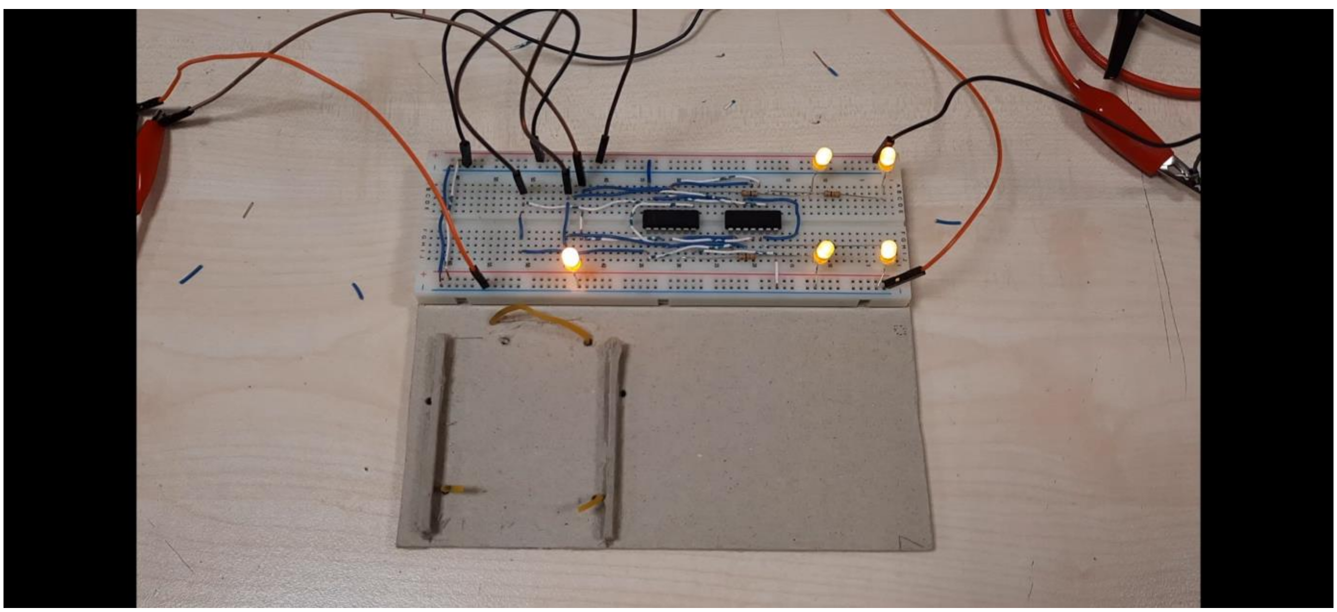
Figure 6 – Next state is “1111”

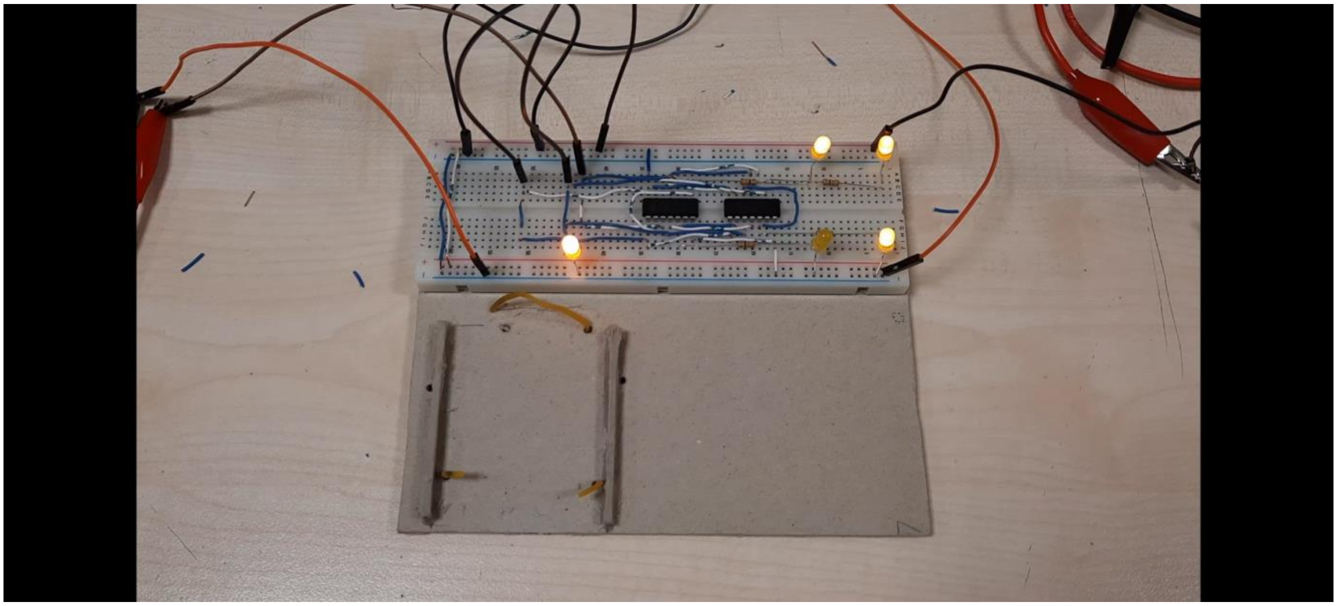

Figure 7 – Next state is “0111”

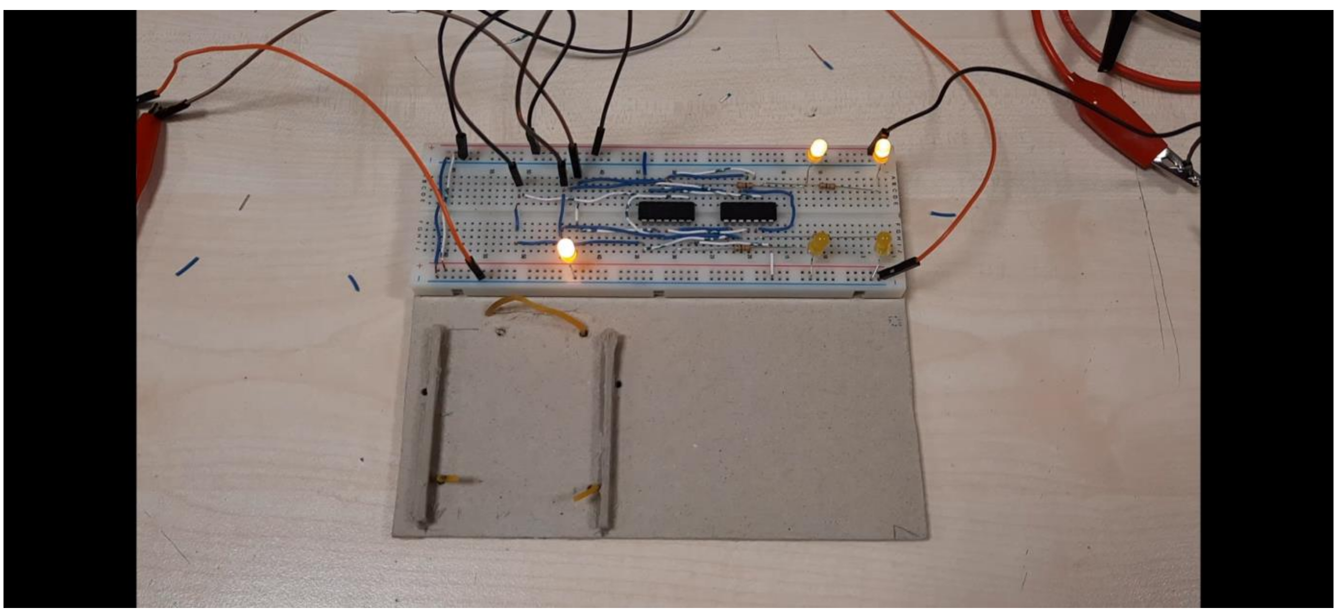

Figure 8 – Next state is “0011”

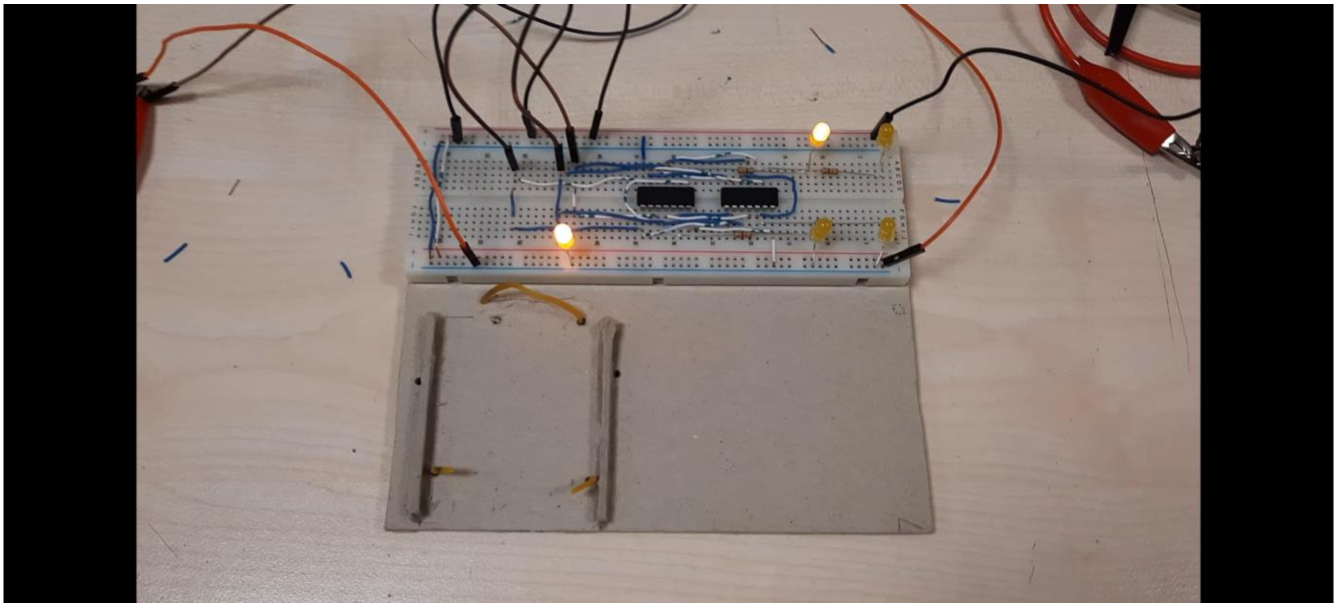
Figure 9 – Next state is “0001”

Conclusion

As a result, I learned how finite state machines work and how to design them in this lab. The finite state machine I designed worked in accordance with the expected situations. In addition, I learned how to use D-flip flop integrated circuits.