Project Report: Electric wheelchair control unit

Group 7

Abstract

Our group project is dedicated to the design of a digital system of electric wheelchair control unit. Circuit for that was designed in Logisim with standard library. In addition to that, several counters, timer, and binary-to-7-segment decoder were designed in order to ensure desired work of the system. The system also includes IDLE - mode, which allows the wheelchair to save energy when not in use. After constructing circuit, operation and behavior of the system was tested, and performance was assessed.

Contents

1.Introduction

What our group chose as the topic is the electric wheelchair control unit. Electric wheelchair control unit looks like the following image.

Control unit consists of the following:

- Power button
- Speed decrease and increase buttons
- Joystick
- Speed indicator

We decide to make it’s essential parts and they are power, speed, direction.

First of all, power is needed to activate an electric wheelchair. This is not only for an electric wheelchair, but also other electronic devices. Also, we want to put in some kind of battery saving system. We named it “IDLE - mode”. If we do not use an electric wheelchair for a while, it will go to “IDLE - mode”.

Next one is speed. When we drive the electric wheelchair, we need to be able to change its speed. Otherwise, there will be a problem. For example,if we drive too fast on the sidewalk, we’ll hit people. On the other hand, if we drive too slow on the road, the car will hit us.

Therefore, we need an option to run at an appropriate speed. Otherwise, there will be an accident.

Last one is direction. To get to the destination we want, we have to be able to change the wheelchair's destination.

In order to implement the above functions, we designed an up/down counter, synchronous counter, 7-segment display , etc and put it on circuit.

Now, we will explain each part in the below.

2.Development process

4 / 30 - selected the topic <control unit of electronic wheelchair>

5 / 2 ~ 5 / 10 - maked initial presentation material

1. investigated the topic
2. overall circuit initiative
3. maked ppt

5 / 12 - initial presentation

5 / 17 - maked power part

5 / 20 - maked speed and direction part

1. used Up/Down counter in speed part
2. used D flip - flop in direction part

5 / 24 - maked IDLE - mode

1. added NAND - LATCH in power part to connect with IDLE - mode

5 / 26 - maked real output

1. mode indicator
2. speed indicator
3. motor

5 / 28 - tested the circuit

1. There are too much speed
2. It would be better to use the 7 - segment we learned in lecture
3. Speed indicator displays the speed even if power is off (waste of energy)
4. We have to deactivate the IDLE - mode not by controlling power inputs but controlling speed or direction inputs

5 / 29 ~ 5 / 30 - modified the circuit

1. maked speed limit (0 ~ 5)
2. modified speed indicator to hex digit display to 7 - segment display
3. modified speed indicator to display the speed only when the power input is on
4. changed IDLE - mode’s deactivating condition

5 / 31 - final circuit test

6 / 1 ~ 6 / 5 - maked final report and presentation material

3.Explanation of system

3 - 1.Power

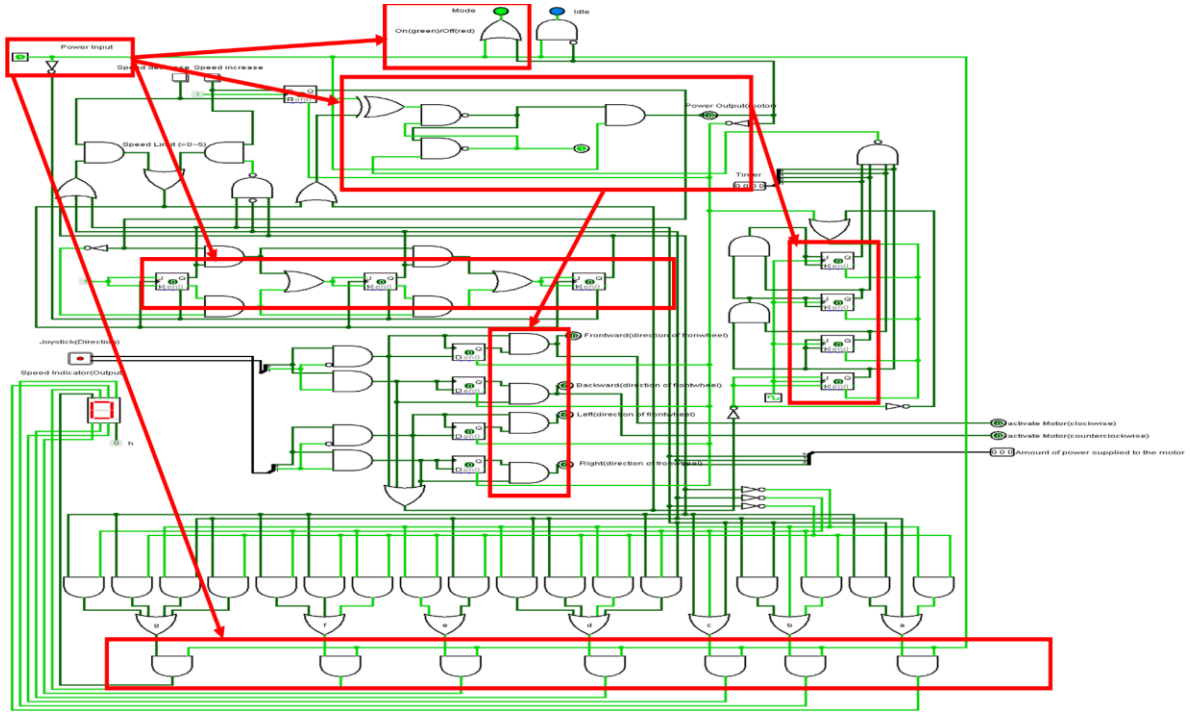

Figure 1: Power Unit Parts

Power is the premise of all outputs. It means, power is connected with all other parts.

First we can see the power button is connected with two LEDs. First one is an on/off indicator, and the second one is an IDLE-mode indicator. We will describe IDLE-mode in the next chapter. If power is on, the on/off LED turns to green. And the power is off, the LED turns to red.

Power is directly connected with the speed control part and its indicator. If the power input is off, then even if we control the speed increase or decrease button, we can't get the output. We connect the power button and the CLR of flip - flops of speed inversely. So if we turn off the power, the CLR of the flip-flops of the speed circuit are activated. But if we turn the power on, then the CLR of flip - flops of speed.

Power input is used as enable input in the speed indicator circuit. It is connected with a 7-segment display with AND gates. So if the power input is off, the indicator doesn't display the speed. And if the power input turns on, the basic speed is 0, so the indicator displays speed 0.

Also the direction circuit is connected with power. But it is not connected to power directly. Look at the picture below.

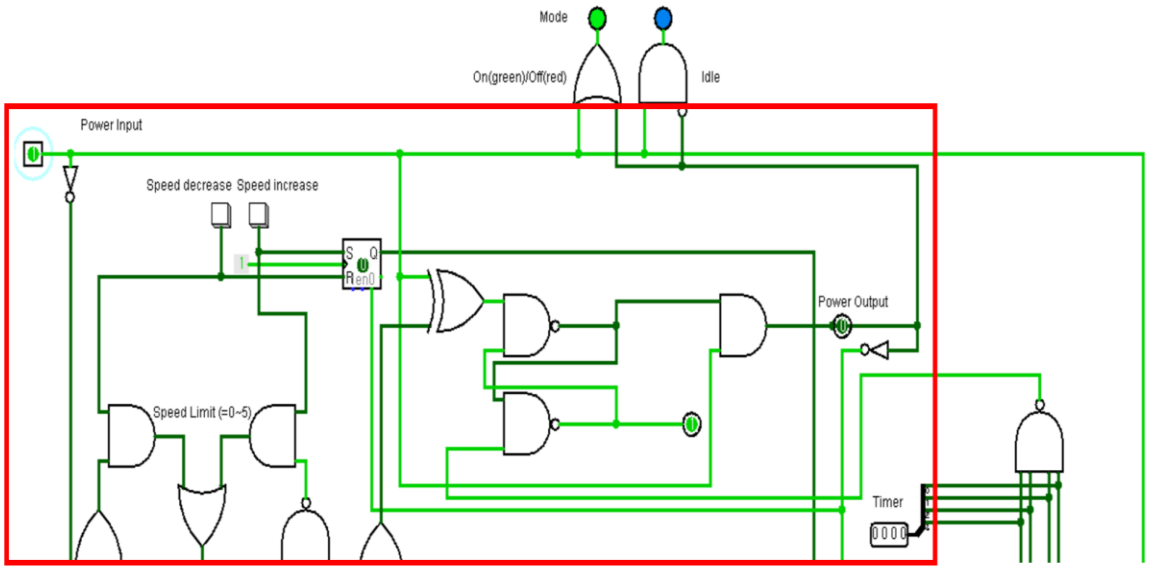

Figure 2: Power Unit Parts : Connected with NAND Latch

Power button is connected to NAND - LATCH by using XOR gates. NAND - LATCH connects power and the IDLE MODE part. As you can see, the output Q of NAND - LATCH is ANDed with power input, and it's output will be power output. And power output is connected with the Direction part and the IDLE-mode part. As you can see from the above, It is connected with the CLR of flip-flops. So when we turn on the power, we can get speed or direction outputs by controlling the button or joystick.

3 - 2.IDLE - mode

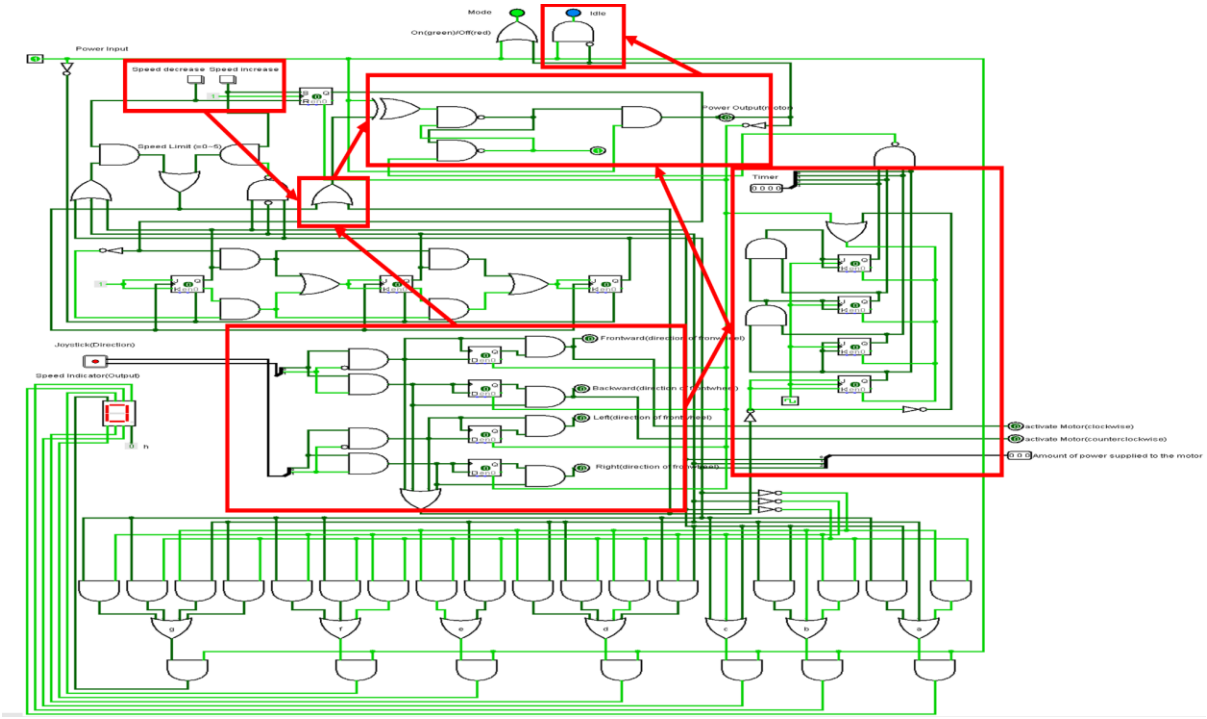

Figure 3: IDLE Mode

IDLE - mode is a kind of power saving system. We designed it to enter the IDLE - mode if the wheelchair is not operated for a certain period of time after turning on power. It is similar with ISG(Idle Stop & Go) system of automobiles. As you can see from above, the IDLE - mode part is connected with power input. If IDLE - mode is on, there is no power output to the motor. So It saves energy.

We use the half-bit timer to implement this function. If the power output is on and there are no direction inputs, the timer is activated. And when the timer output is 1111, by the NAND - LATCH, power output turns to off and IDLE - mode is activated. It resets and deactivates the timer.

IDLE - mode is interconnected with speed and direction parts. When IDLE - mode is on, if there are any speed inputs or direction inputs, then by the NAND - LATCH, power output turns on and IDLE - mode is deactivated.

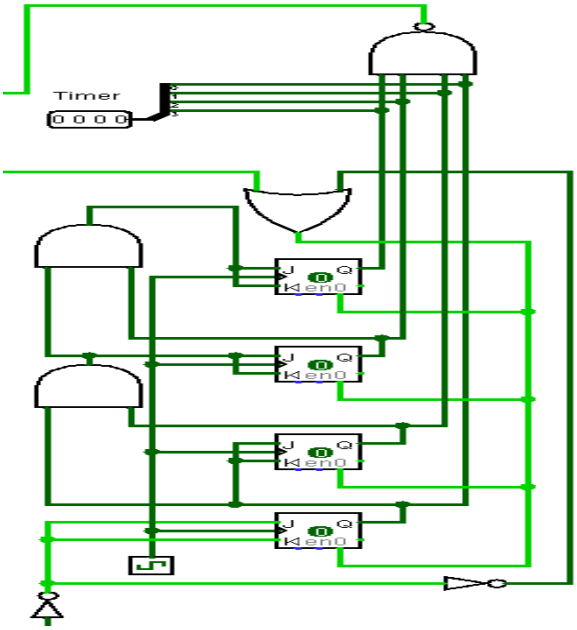

Figure 4: IDLE Mode : Timer

In this circuit, we tested the timer with 0.25 Hz clock signal frequency. On the assumption that there are no direction inputs, it takes almost two minutes to activate IDLE - mode. When the power is on and there are any direction inputs, it resets the timer. Timing diagram for timer is shown in Figure 5.

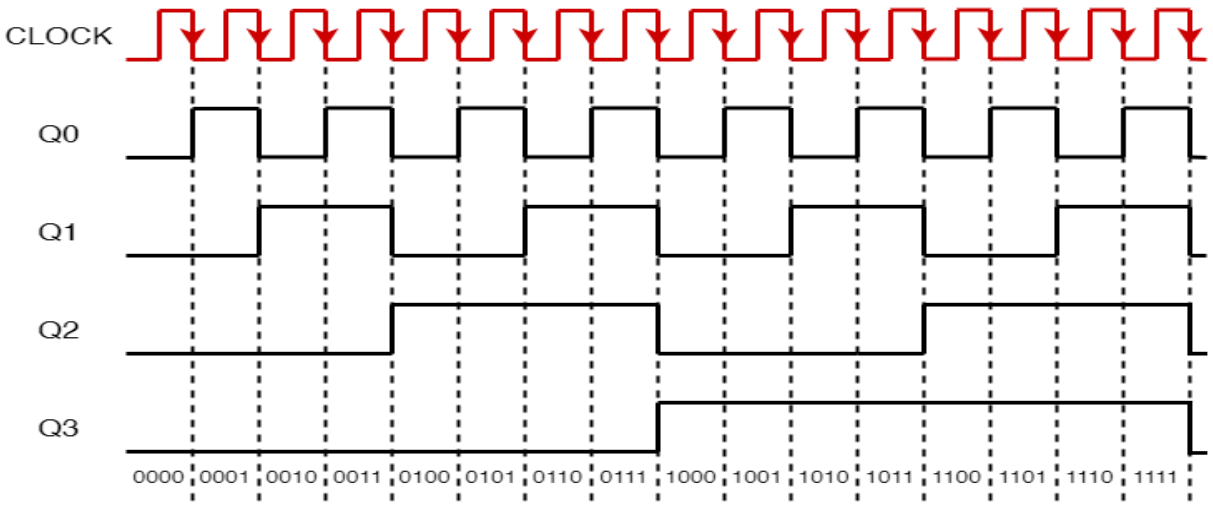

Figure 5: Timing diagram of IDLE timer

We have created a circuit where speed input can be used to deactivate IDLE - mode, but can't reset the timer. Because no matter how fast speed exists, the wheelchair doesn’t actually move without direction input. No matter how much we controlled the speed, the timer couldn’t be reset because the wheelchair doesn’t move.

3 - 3.Speed

Speed control unit consists of two buttons used to increase or decrease the speed, a 7-segment display used to show speed value in decimal format, and a synchronous Up/Down counter used to control changes of speed. They are shown in Figure 6. It also depends on power and will not respond to inputs without power supply.

Moreover, there is a speed limit, and user is allowed to choose among only 6 speed levels from 0 to 5.

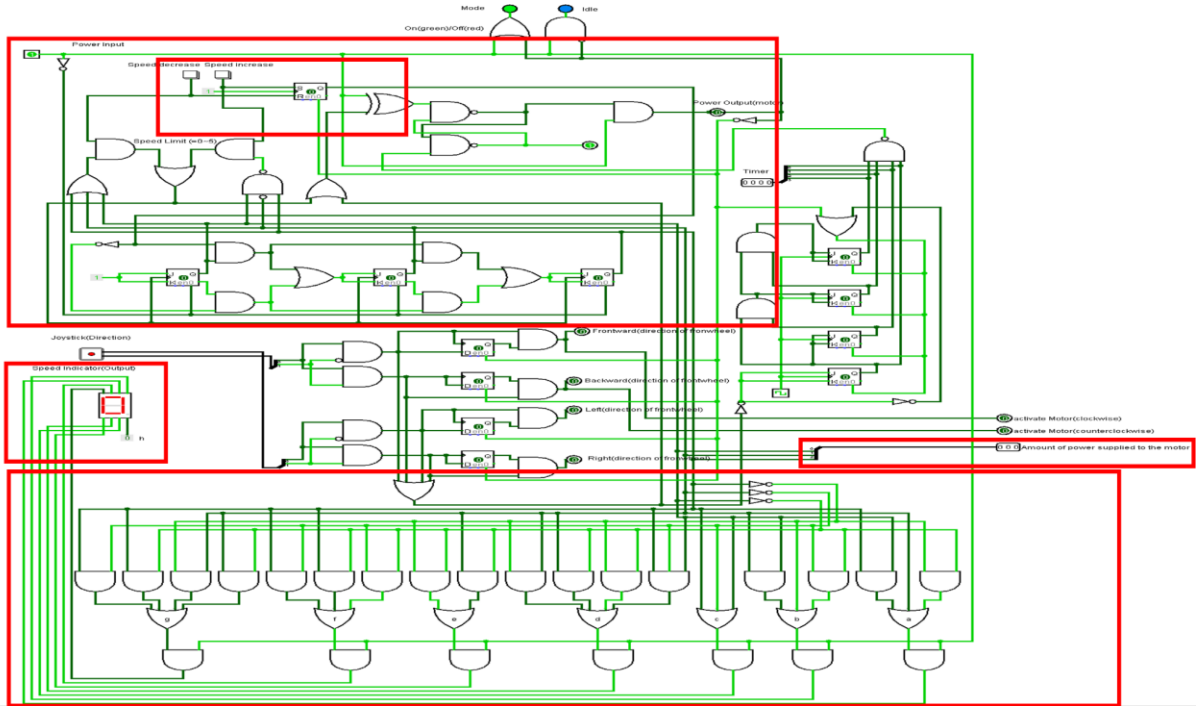

Figure 6: Speed control unit parts

In real world there are generally two cases: one, when user of an electric wheelchair wants to slow down, and the second, when user wants to accelerate. This change of speed is implemented using two logisim standard buttons. Logisim button outputs HIGH when pressed, and LOW all the rest of the time. The left button is responsible for decreasing speed, and the right one for increasing.

Speed limit is implemented by ANDing left button with ORed output of 3 speed J-K FFs, and ANDing right button with NANDed output of the same speed J-K FFs. Initially, when Power is set HIGH, output of speed counter will be 000 (0 speed level). Since FFs outputs are ORed together, it is impossible to decrease the level of speed below 0. In the case of increasing speed, NAND gate takes output of 1st and 3rd speed FFs, and inverted output of 2nd FF as input. When output of speed counters becomes 101 (or 5 in decimal), output of NAND gate becomes LOW, and it is not possible to further increase speed.

Synchronous Up/Down MOD-6 counter design is shown in Figure 7. It includes three J-K FFs. All FFs are triggered on negative going transition, and clock input is connected to ORed output of buttons - when any of buttons is pressed, FFs will respond to input. CLR input is connected to the inverse of power, so when there is no power supply FFs are cleared. FFs are not cleared after entering IDLE - mode, so the last speed level is saved.

Buttons act here as Up/Down control inputs. When left is pressed this control input is held LOW and counter performs count-down operation. When right is pressed this control input is held HIGH and counter performs count-up operation. Left button and right button are connected to R and S inputs of the S-R Flip-flop, respectively. This FF is HIGH-level triggered, so clock input is connected to constant 1. Using S-R FF allows Up/Down input to remain at the appropriate level. In addition to working as Up/Down control input, these buttons also act as a clock for triggering FFs.

J and K inputs to the first FF (Q0) are connected to 1, and will output 1 and 0 after each button click. Second FF (Q1) will perform its counting operation only if Up/Down input and Q0 are HIGH for counting-up, or if Up/Down input and Q0 are LOW for counting-down. The third FF (Q2) will perform counting operation only if Up/Down input, Q0, and Q1 are all HIGH for counting-up, or if Up/Down input, Q0, and Q1 are all LOW for counting-down. Timing diagram for counter is shown in Figure 8, and state transition diagram is shown in Figure 7.

Speed output is connected to the binary-to-7-segment converter, used to display current speed level in user-friendly manner, and also connected to the motor, providing amount of power to be supplied to the motor in order to change wheelchair speed. This is shown in the rightmost red rectangle in Figure 6.

It is also necessary to say how changing speed affects IDLE - mode .Buttons output is ORed with ORed direction output, so when any of these become HIGH, and the wheelchair is in IDLE - mode, IDLE - mode will be disabled.

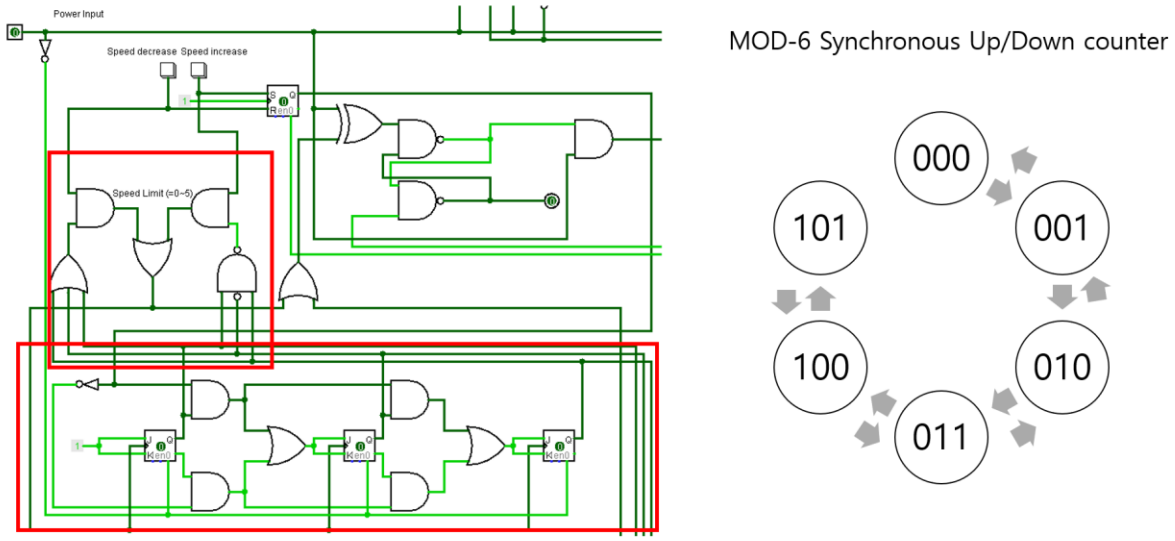

Figure 7: Up/Down synchronous counter

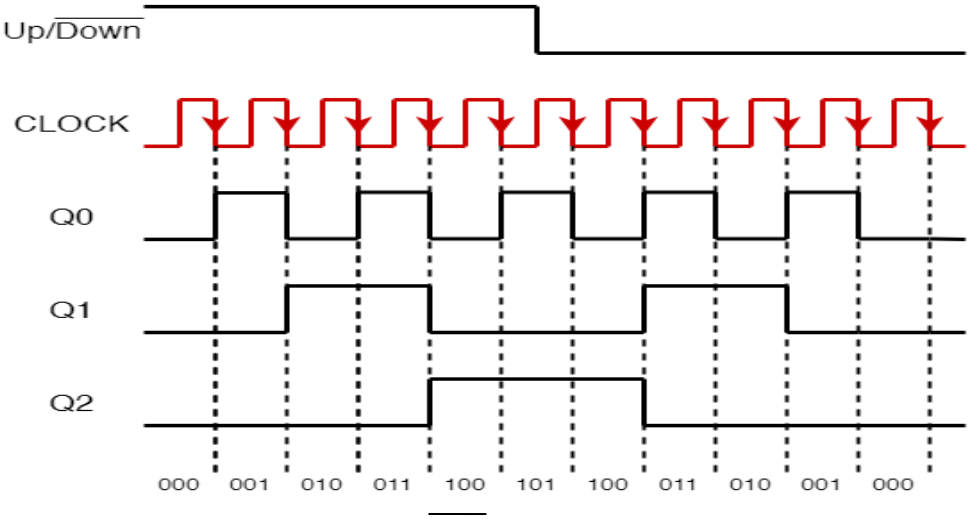

Figure 8: Timing diagram of MOD-6 Up/Down synchronous counter

Speed indicator (Figure 9) consists of a 7-segment display, which is connected to binary-to-7-segment converter. This converter includes 7 AND gates and enable inputs, each of which is responsible for a specific segment. They are numbered a-g. The h is held constantly LOW since our speed levels are integers. Since speed level is conserved after entering IDLE mode, speed indicator also retains its value. And, as said earlier, even though speed level is conserved, there will be no movement in IDLE mode as there is no power supply.

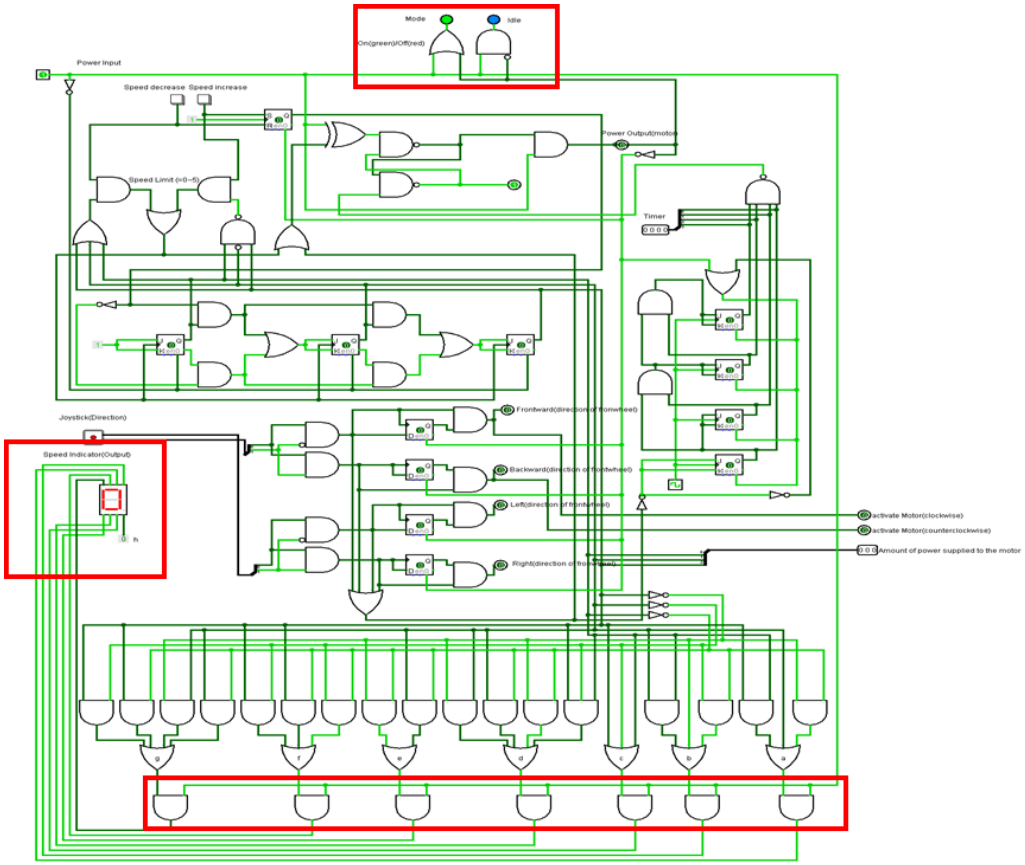

Figure 9: Speed indicator

3 - 4. Direction

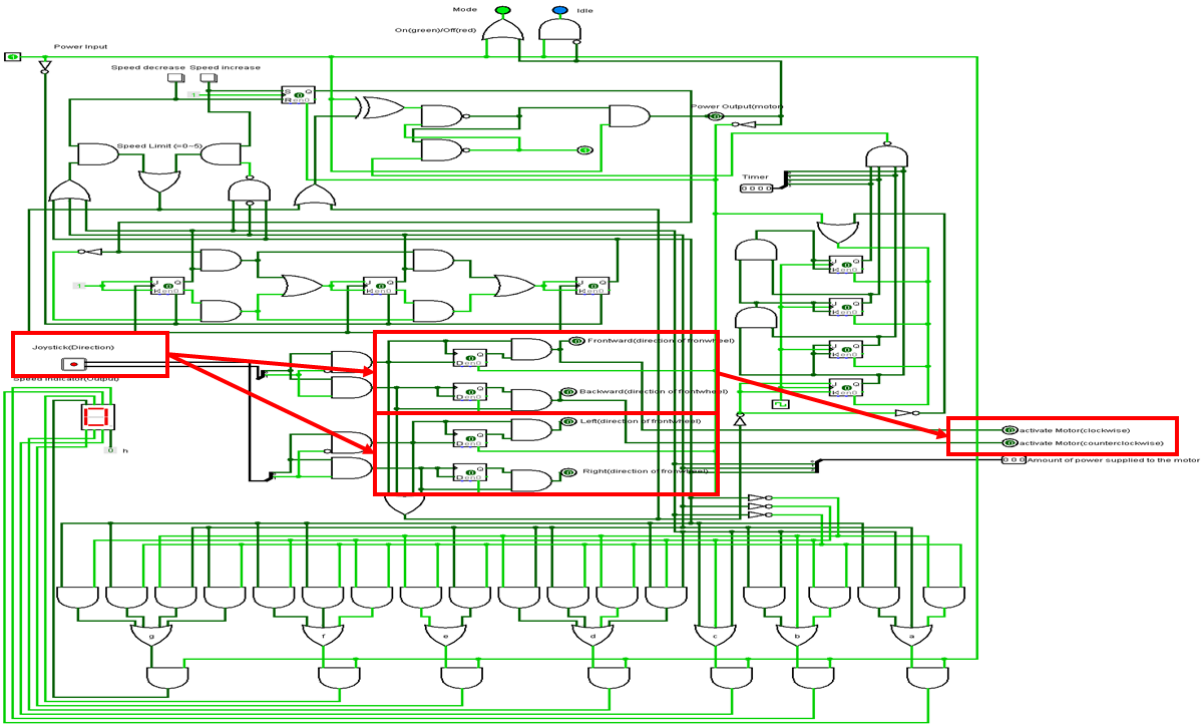

Figure 10: Direction control unit parts

Direction input means the actual moving of the wheelchair. It connected with frontwheel's direction and motors. Even if power input and speed input above 1 exist, the wheelchair won't move unless direction output exists.

Joystick can make direction outputs by pushing or pulling it when power is on. There are eight direction inputs and no input. Each input is decided by where the joystick is.

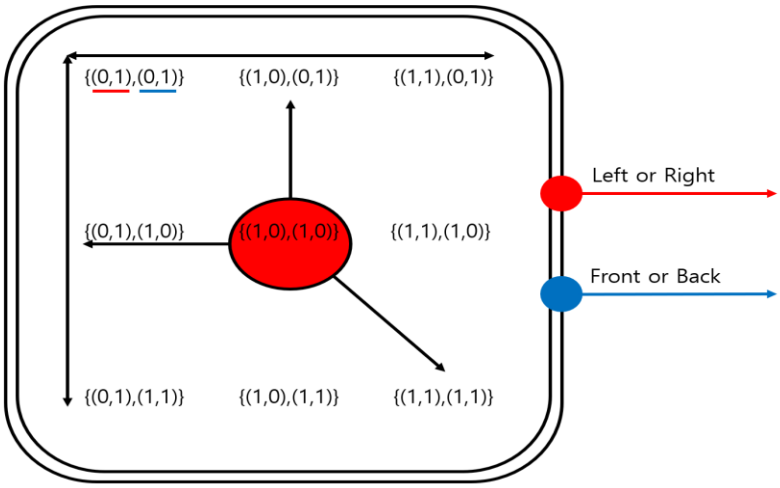

Figure 11: Direction control unit parts - Joystick

Actually, there are only two outputs in the joystick. One is about left or right, and another one is about front or back. And each output has a type of coordinate. The range of the joystick can be divided into nine spaces and each space can be represented by X and Y

coordinates. X coordinate is connected with output of left or right, and Y coordinate is connected with output of front or back.

If the input is front, then output is 1, 0 and 0, 1. If the input is left, then the output is 0, 1 and 1, 0. And if the input is right back, then the output is 1, 1 and 1, 1. So we can check the output by its coordinates.

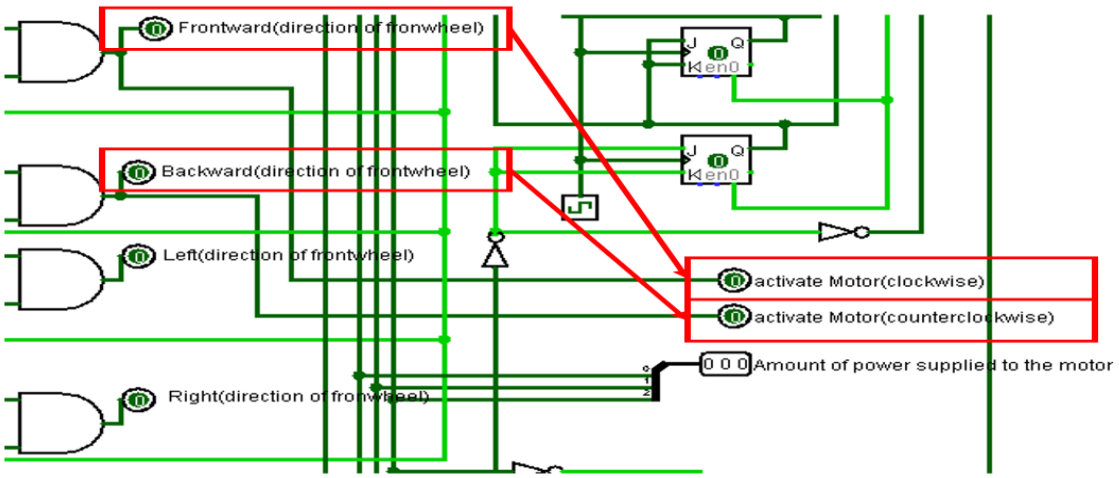

Figure 12: Direction control unit parts - output

If the direction input includes frontward, it activates the motor clockwise. So the wheelchair can roll its front wheel forward. And if the direction input includes backward, it activates the motor counterclockwise. So the wheelchair can roll its front wheel backward.

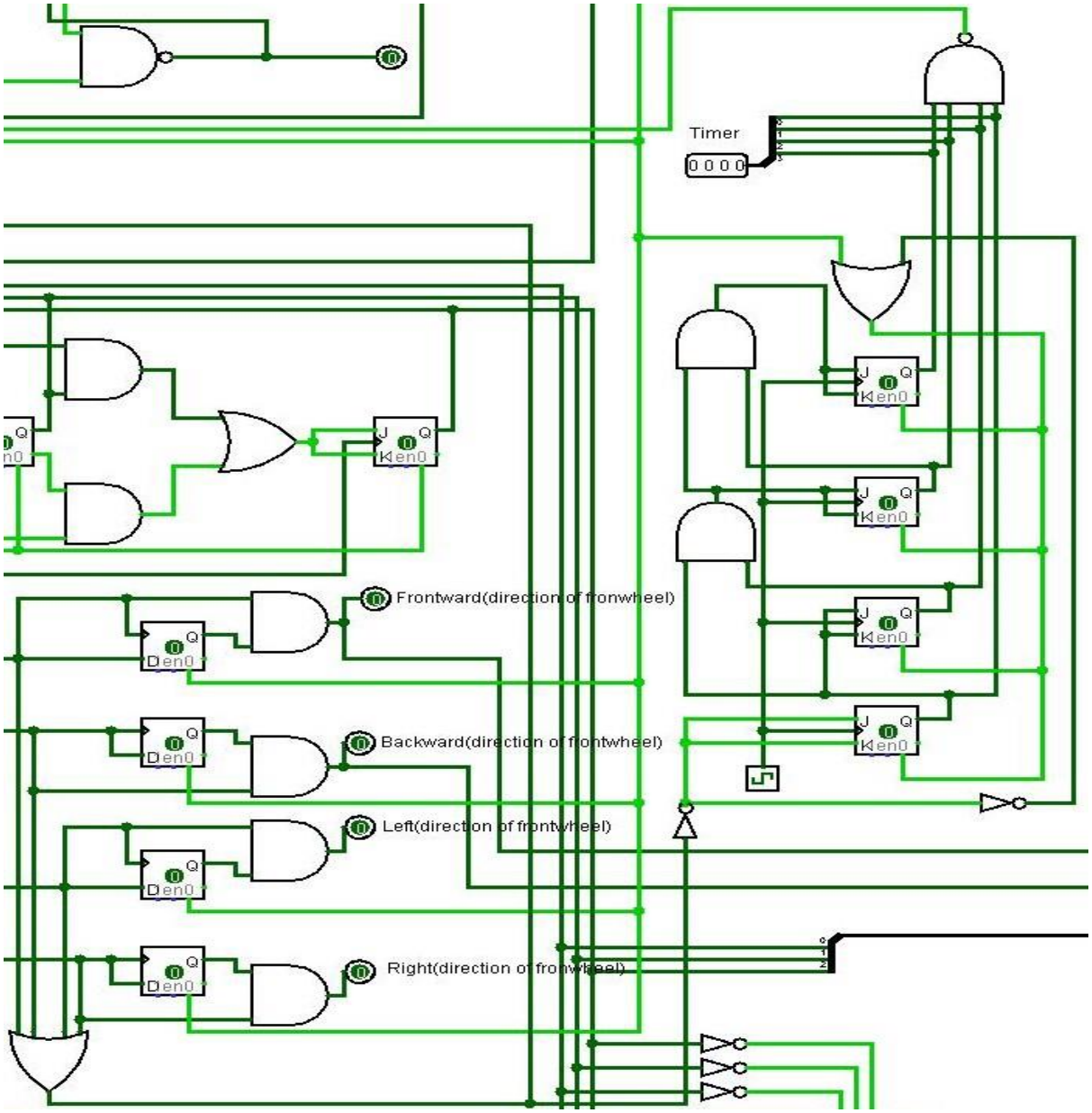

Figure 13: Direction Control Unit Parts - Connection with IDLE Mode

As we mentioned earlier, the direction input is ORed and the output of the OR gate is connected to the first J - K FF's input J0, and K0 through the NOT gate. It is also connected to the OR gate with power output, and the output of the OR gate is connected to the CLR of four J - K FFs. So if there are any direction inputs, then the timer is reseted and deactivated.

4.Conclusion

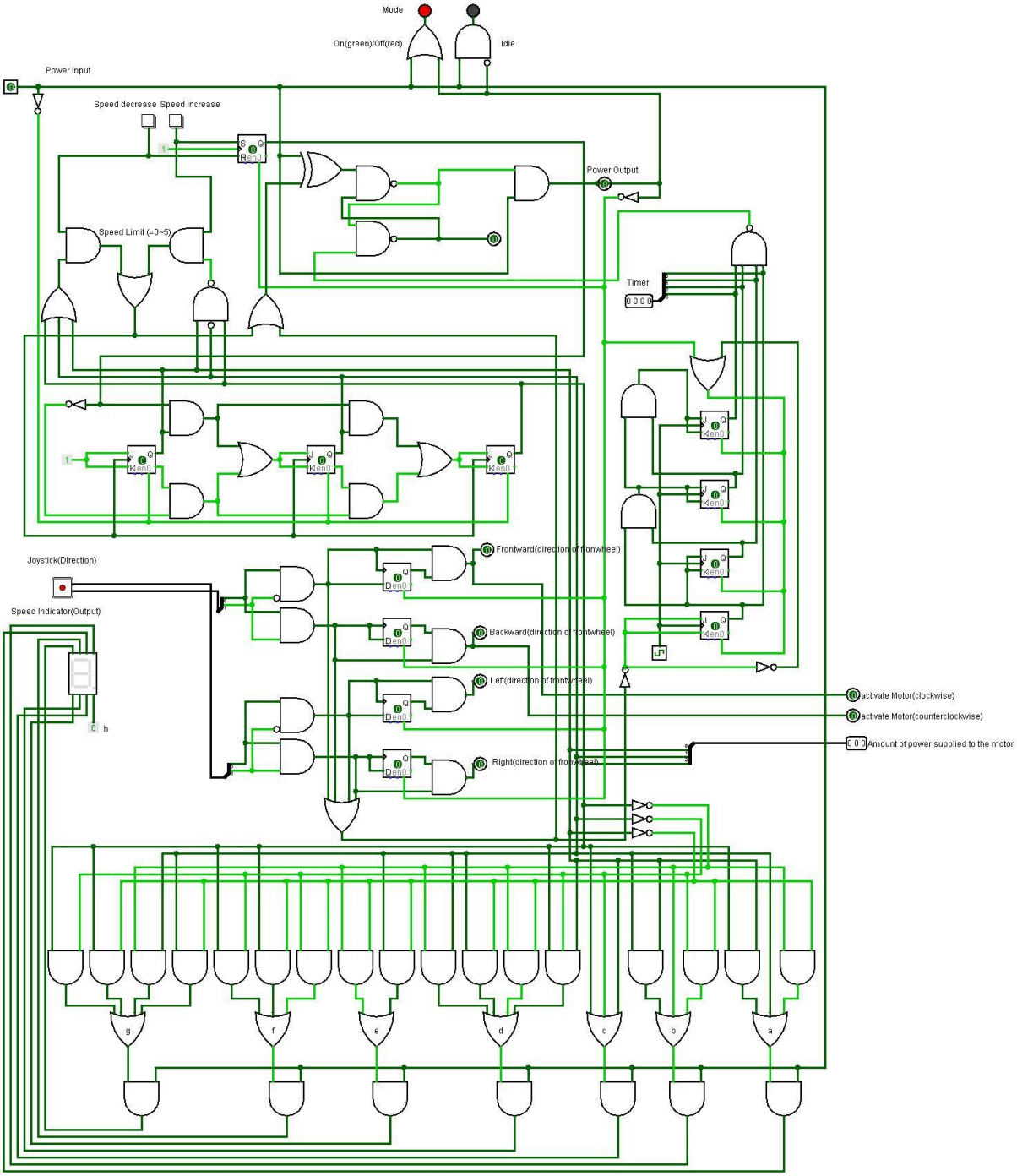

Figure 14: Whole Circuit

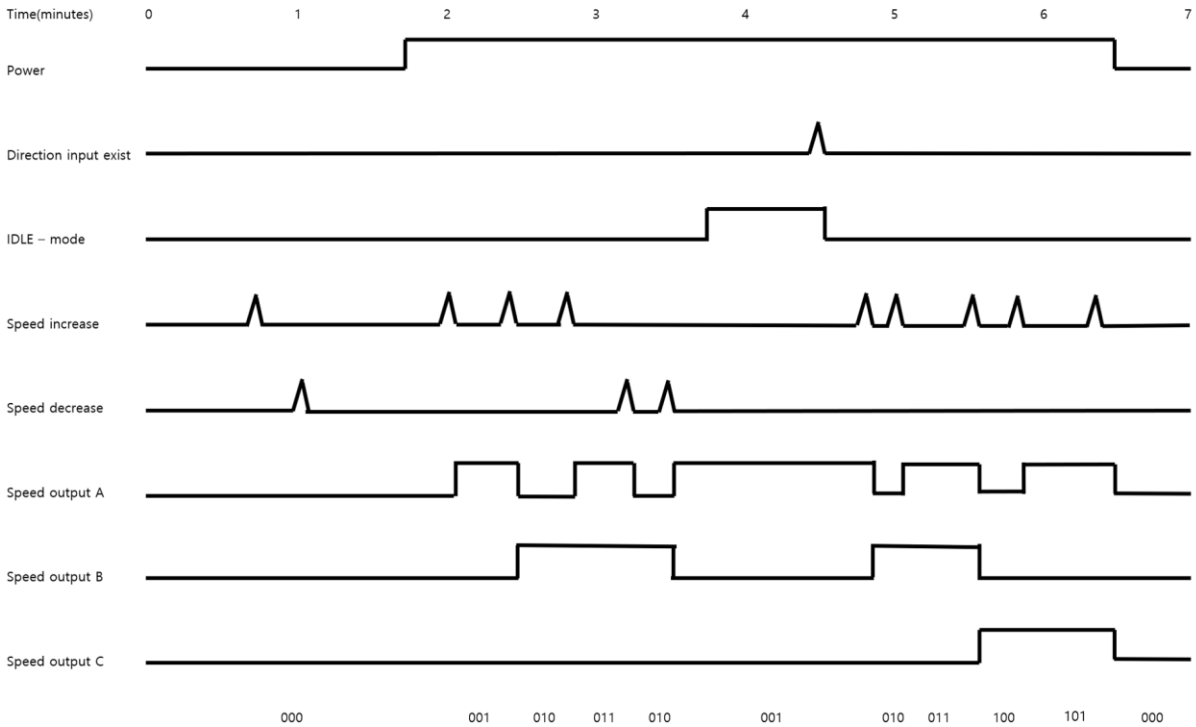

Figure 15: Whole Circuit Timing Diagram

We can see through figure 14 and figure 15 that the circuit we created works just as well as we intended.

1. When power is off, the mode indicator's on / off LED is red, speed indicator doesn't display the speed, we can't get any speed or direction outputs, and the timer is deactivated.
2. When power is on, the mode indicator's on / off LED is green, speed indicator displays the speed, we can get any speed or direction outputs, and the timer is activated if there are no direction inputs.
3. When the timer output is 1111, IDLE - mode is activated and the timer is reseted. The mode indicator's IDLE - mode LED turns blue. We can reset the timer by direction inputs, and we can deactivate IDLE - mode by speed or direction inputs. And the value of speed is maintained even if IDLE - mode is activated, so we can deactivate IDLE - mode and move the wheelchair at the same time.
4. If the power is on, we can change the speed from 0 to 5 by pushing the speed increase or decrease button. And if the power goes off, then the up / down counter is CLRed and speed goes to 000.