Lab 2 – Feasibility Model Phase 2

ECE 298 – S2021

Lab Section: | Group: 50

{Switch}

Summary

Item	Description
Purpose	A switch is required to represent the collision switch and the door position limit switches, so it will stop the door movement when a collision occurs, or the door reaches its limit position.
Device physical domain and range	The physical domain and range are not applied to this device.
Device type chosen	The chosen switch is an on/off type.
Proteus Library component name	There is no direct Proteus push button component directly available, so ECE_GEN_PBUTTON is used in its place.
Device input / output properties	The device outputs a digital output. The type of the digital output is push/pull, but it requires a pull-down resistor.
Device input / output range	The input/out range is not applied to this device.
MCU connectivity details	The device will connect to an MCU digital input.
Device/MCU interfacing details	There is no interface provided for the switch because it can be connected to a 3.3V power directly.

Schematics and Simulations

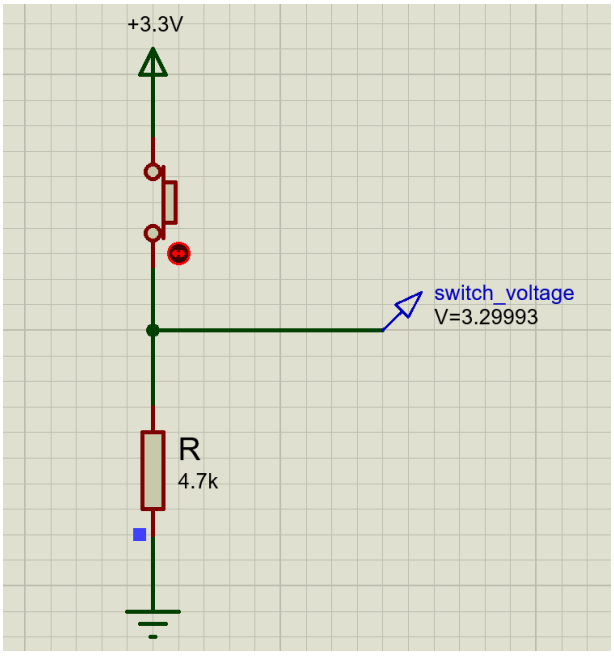


Figure 2.1.1 The schematic of ECE_GEN_PBUTTON -- Switch closed

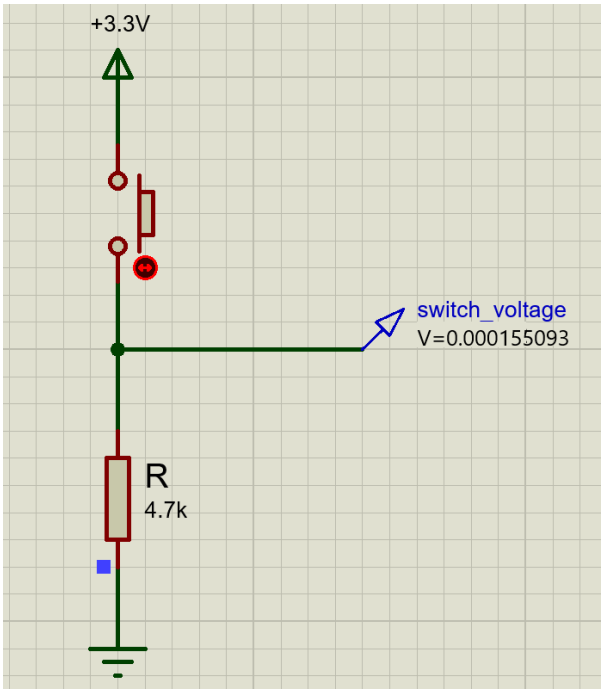


Figure 2.1.2: The schematic of ECE_GEN_PBUTTON -- Switch open

The schematic used for the switch is same as Lab1 because the switch can connect to a 3.3V power directly without voltage translation. The switch_voltage probe represents an MCU digital input. The probe shows 3.3V when the switch is closed and shows 0V when it is open.

{Distance Proximity Sensor}

Summary

Item	Description
Purpose	The distance proximity sensors are required to detect people and objects near the door from both directions.
Device physical domain and range	The distance range that the chosen distance proximity sensor support is 2cm - 500cm.
Device type chosen	The chosen distance sensor is an ultrasonic ranging module.
Proteus Library component name	HCSR04
Device input / output properties	The device receives a digital input as trigger signal and outputs the echo back signal which is a digital output.
Device input / output range	The device requires a digital active-high trigger signal and outputs a variable pulse width echo signal. The recommended cycle period is less than 50ms, and the echo pulse width is proportional to the measured distance. Other information such as maximum/minimum pulse width and V_{OH}/ V_{OL} / V_{IH} / V_{IL} is not available.
MCU connectivity details	The device uses an MCU digital output for the trigger input, and an MCU digital input for the echo signal.
Device/MCU interfacing details	The interfaces used are digital-to-digital. The first interface translates the 3.3V digital input from the MCU to a 5V digital input and pass it to trigger signal. The second interface translate the 5V digital output from the echo signal translate to a 3.3V digital output and pass it to an MCU digital input pin.

Schematics and Simulations

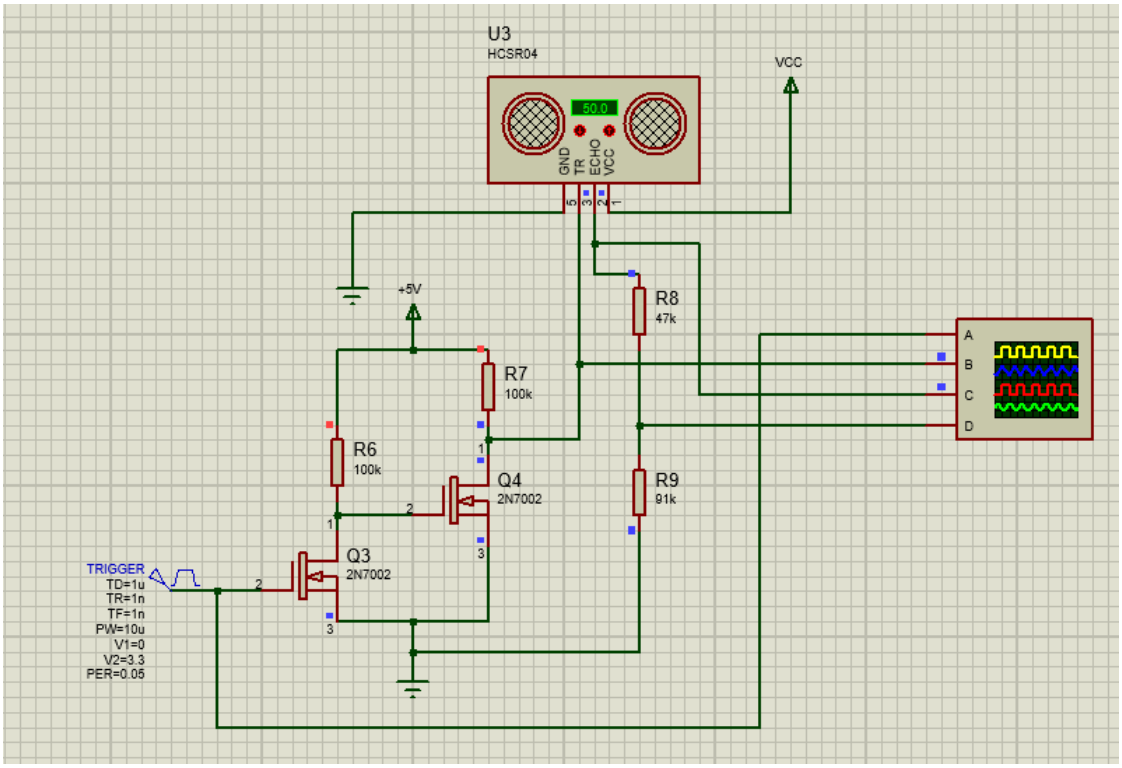


Figure 2.2.1: The schematic of HCSR04 ultrasonic ranging module with distance = 50cm

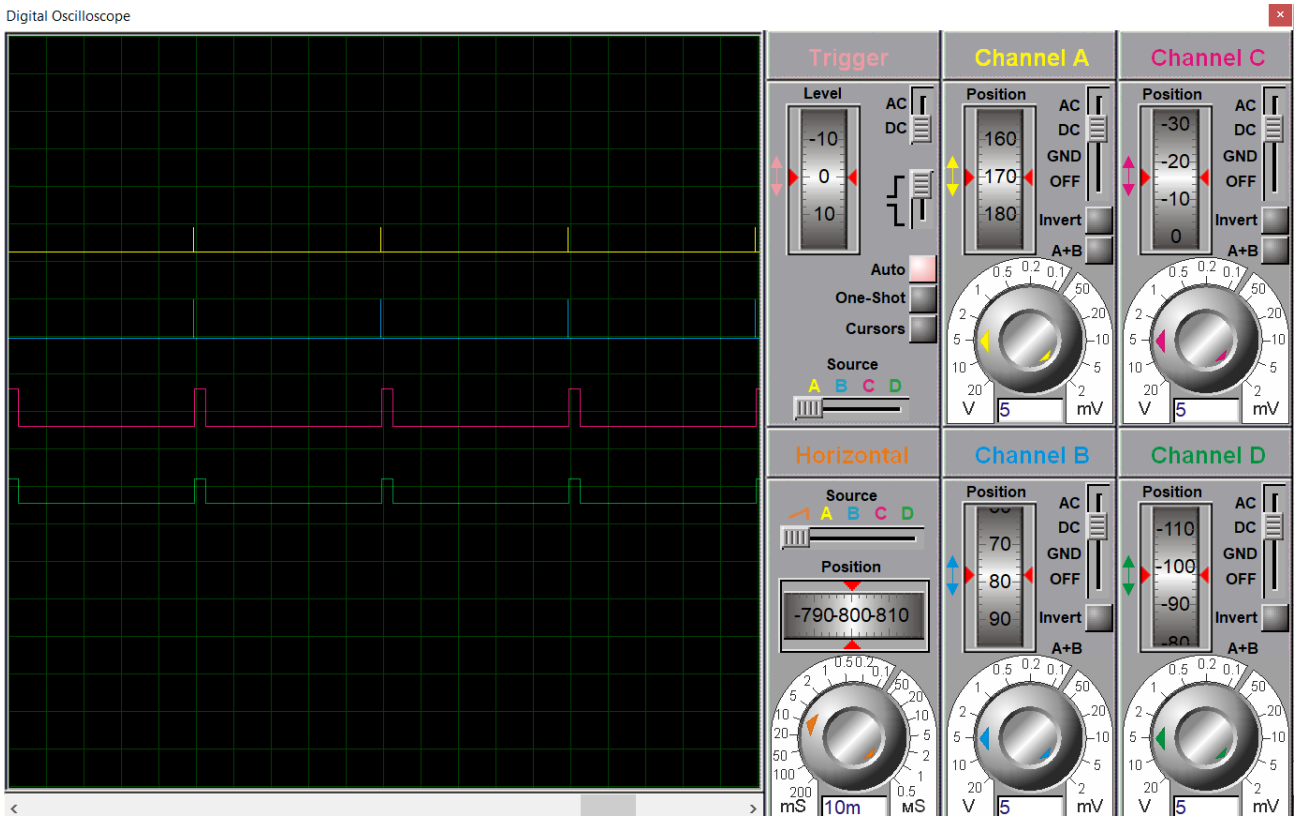


Figure 2.2.2 The signals displayed by the oscilloscope with distance = 50cm (Yellow: original MCU input, Blue: trigger input after translation, Pink: original echo output, Green: echo output after translation)

As described in the summary table, a step-up interface and a step-down interface are used in the schematic. The step-up interface uses two N-FET and translates the 3.3V digital input from the MCU to a 5V digital input and pass it to trigger signal. Channel A of the oscilloscope shows the original 3.3V input from MCU, and channel B shows the digital input after translation. The step-down interface uses two resistors with resistance 47k and 91k and translates the 5V digital output from the echo signal translate to a 3.3V digital output. Channel C shows the 5V digital output, and Channel D shows the signal after translation. The signal displayed in Channel D is the output that will be passed to an MCU digital input.

{Keypad}

Summary

Item	Description
Purpose	A keypad is required to select mode of operation and input parameter values.
Device physical domain and range	The keypad is an array of switches, so the physical domain and range are not applied to it.
Device type chosen	The keypad is an array of switches, and the switches are on/off type. When a key is pressed, the corresponding switch is closed; when a key is not pressed, the corresponding switch is open.
Proteus Library component name	KEYPAD - PHONE
Device input / output properties	The device receives three digital inputs for pins representing columns and outputs four digital outputs from pins representing rows. The type of the digital output is push/pull, but it requires a pull-down resistor.
Device input / output range	The keypad is an array of switches, so the input/out range is not applied to this device.
MCU connectivity details	The device uses three MCU digital outputs connecting to pins representing columns and four MCU digital inputs for pins representing rows.
Device/MCU interfacing details	The keypad is an array of switches, so there is no interface provided for the switch because it can be connected to a 3.3V digital signal directly.

Schematics and Simulations

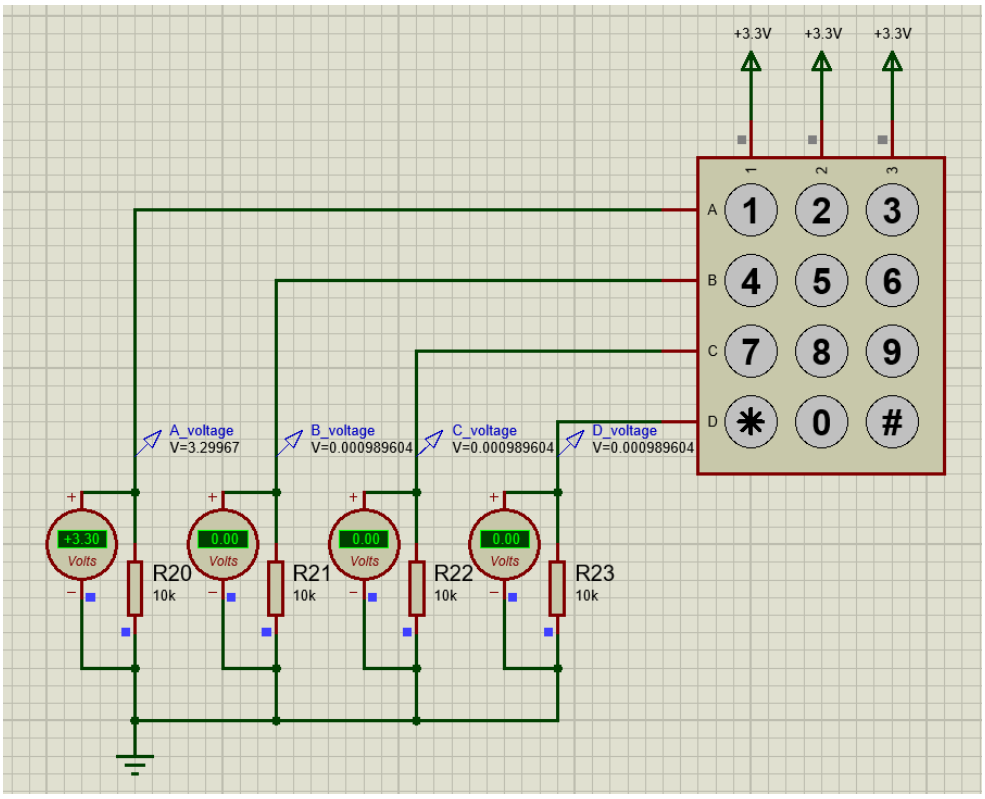


Figure 2.3.1: The schematic of KEYPAD_PHONE when key '1' is pressed

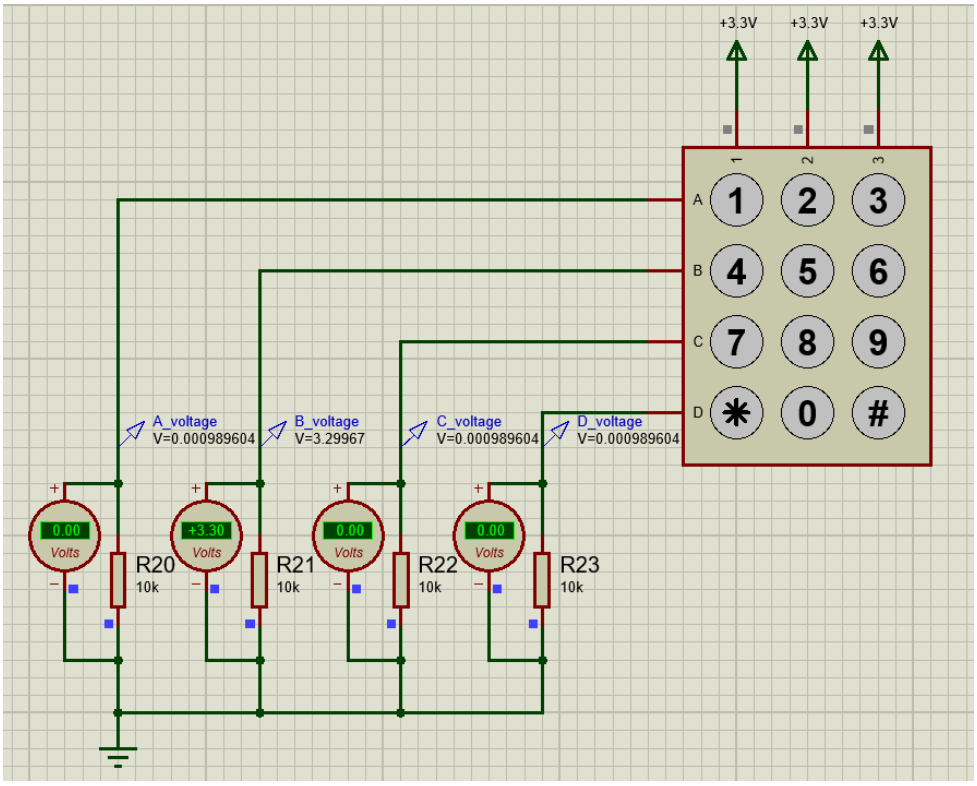


Figure 2.3.2: The schematic of KEYPAD_PHONE when key '5' is pressed

The keypad doesn't require voltage translations because it's simply an array of switches. The two figures above show the schematic when the key '1' and '5' is pressed, and it shows that the voltage of the corresponding pin turns to 3.3V when the key is pressed. The 3.3 voltage power represents the digital signal of '1' receiving from MCU digital output, and the probes labeled A_voltage, B_voltage, C_voltage, D_voltage represent the signal will be passed to MCU digital inputs.

{LED}

Summary

Item	Description
Purpose	Different color of LEDs are used to indicate different status of door motor.
Device physical domain and range	LED's maximum brightness will depend on the specific LED.
Device type chosen	Normal LED
Proteus Library component name	LED-RED, LED_GREEN, LED_YELLOW
Device input / output properties	The device will receive the digital signal from MCU as digital input.
Device input / output range	We setup the current through LED to be 10mA.
MCU connectivity details	The LED will use an MCU digital output for the trigger signal.
Device/MCU interfacing details	The interface is digital to digital, if MCU inputs a '1' (3.3v), the circuit of LED will connect to 5v voltage source and groud to generate a 10mA current for LED to work, the LED will light up; if MCU inputs a '0' (0v), the LED will not light up.

Schematics and Simulations

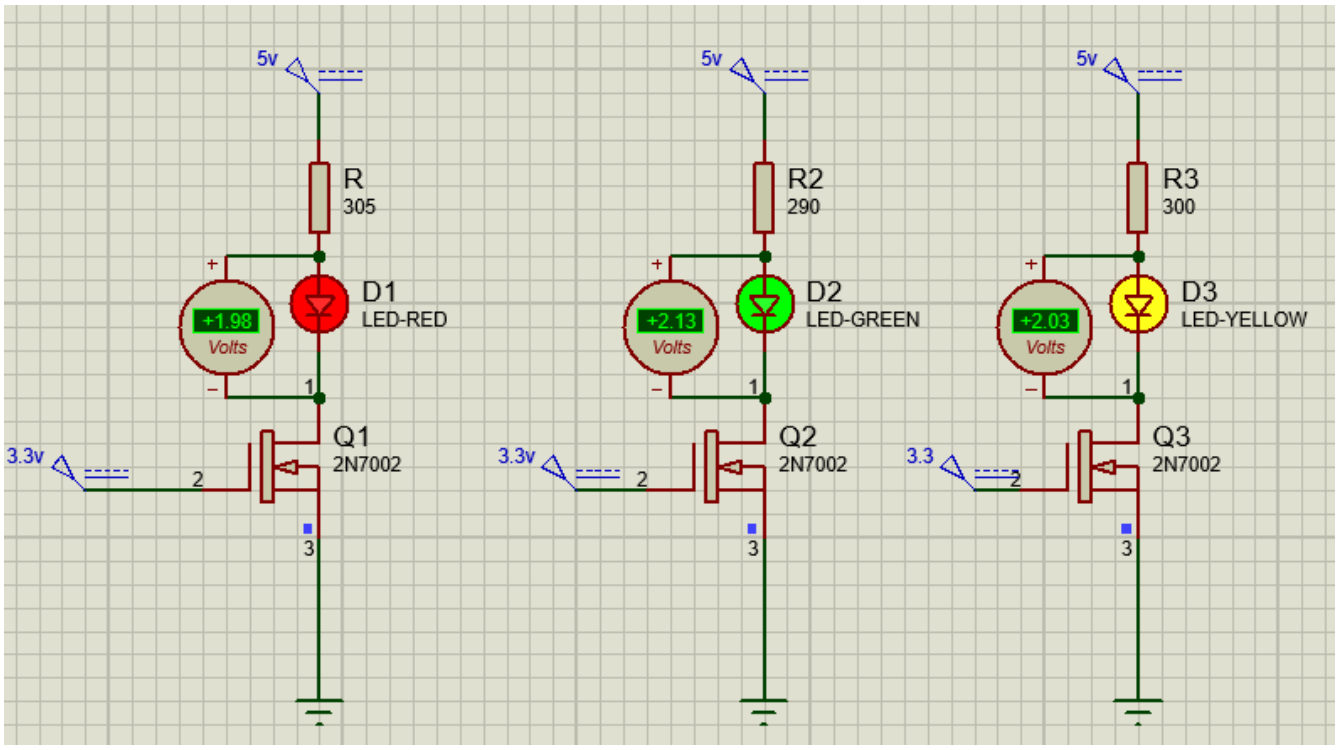


Figure 2.4: Schematics of converting digital input to voltage range for LEDs.

To step up the voltage to the input range of LED, we add a N-FET. The #1 pin connects to the 5v and LED, #2 pin connects to the digital output of MCU, and #3 connects to ground. When MCU outputs a '0', which means that V2 = 0v and V23 = 0v, then circuit between #1 pin and #3 pin is open circuit, the led would not work well. When MCU outputs a '1', which means that V2=3.3v and V23=3.3v, then #1 pin and #3 pin is connected, and there is a 10mA current through the LED to support.

Through the Lab1 piazza, we knew that LEDs with different colors have different work voltage: 1.95v for red LED, 2v for yellow LED, and 2.1v for green LEDs. The current for LEDs to work is 10mA. The resistance connect to LED should be 5v-V(work)/I(work). Therefore, the resistance for red LED is 305 ohm, for yellow LED is 300 ohm, and for green LED is 290 ohm.

{LCD}

Summary

Item	Description
Purpose	LCD is used to indicate the Mode, Parameter Name and Parameter Value in Setup Mode, and it is also used to display the status of the automatic door.
Device physical domain and range	Operating temperature should be 0 – 50 degrees.
Device type chosen	A character display LCD
Proteus Library component name	LM016L
Device input / output properties	The LCD will receive a digital input and convert it to characters by Ascii table to display required characters.
Device input / output range	The LCD accepts input range from 0v to 5v.
MCU connectivity details	LCD receives the digital outputs from MCU and converts the digital signal (which always present as ‘0’ or ‘1’) to the characters by Ascii table and display the received characters.
Device/MCU interfacing details	The interface is digital to digital, MCU will send a serial of digital signals and LCD receive and translate these signals.

Schematics and Simulations

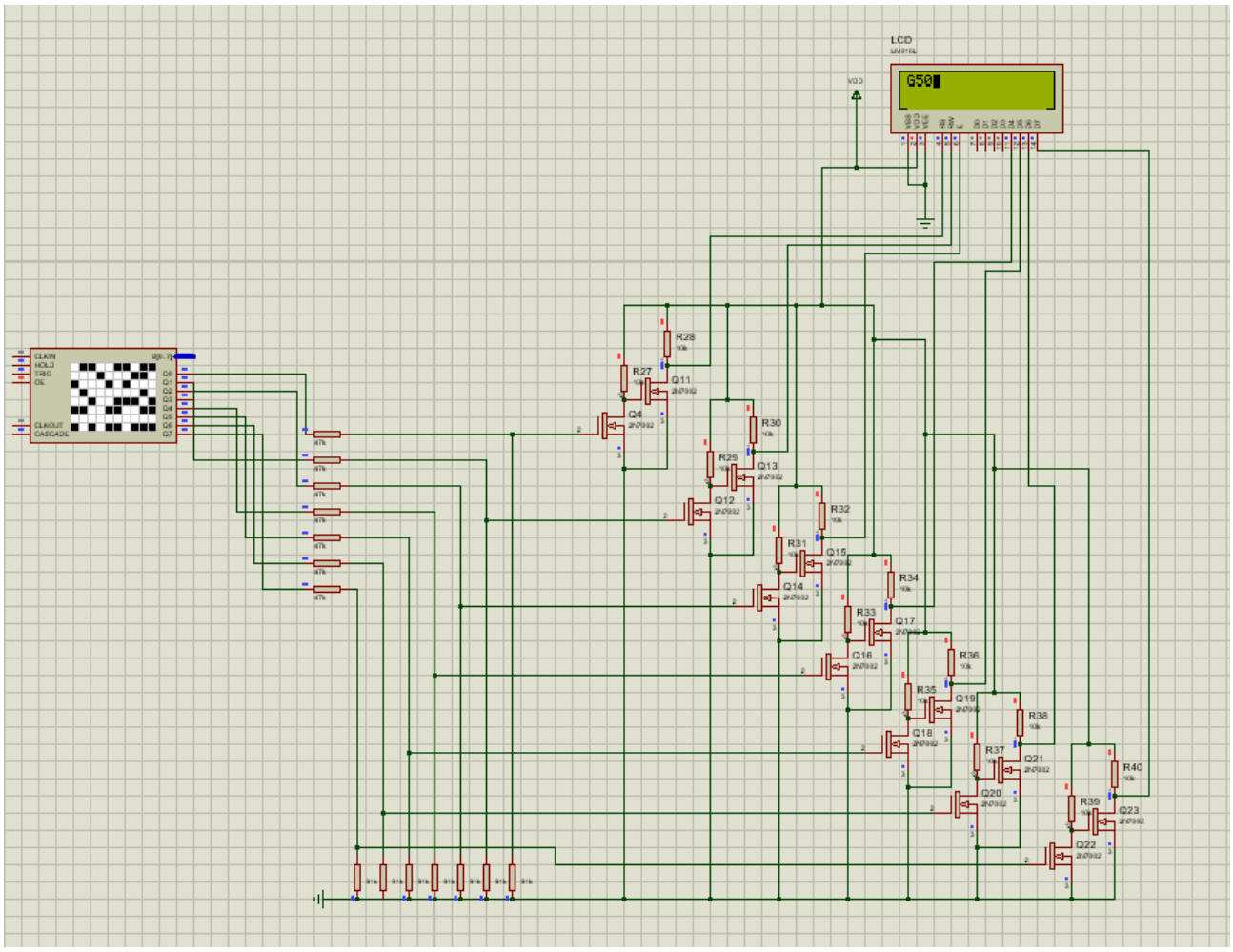
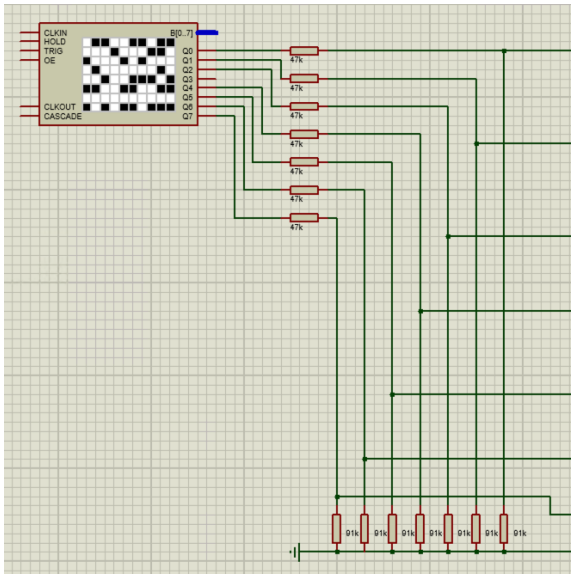


Figure 2.5.1: Schematics of LCD for simulation



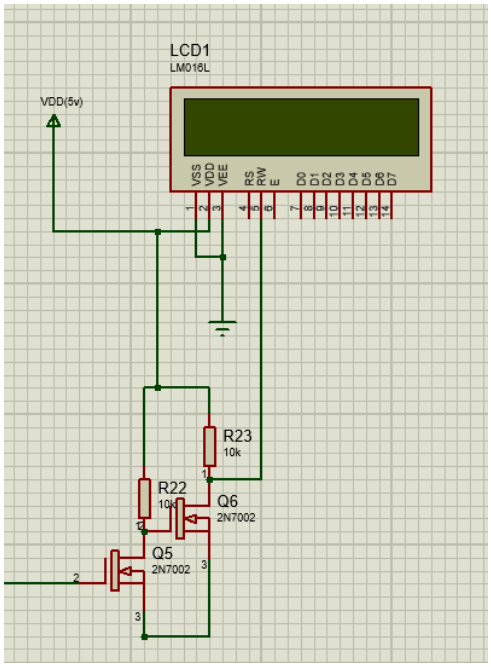


Figure 2.5.2: Simulation the output signal of MCU *Figure 2.5.3: Converting to LCD input range*

We used the step-down voltage interface and generator to simulate the digital output of MCU as Figure 2.5.2. The schematics showed in Figure 2.5.2 is converting an 5v digital signal to 3.3v digital signal to simulate the actual MCU digital output.

To convert the digital signal to the range of LCD, we connected the circuit as Figure 2.5.3. Two N-FETs are used to convert the 3.3v digital to 5v. The left N-FET (Q5) connect to the 3.3 digital signal with #2 pin. When the MCU output '1' (3.3v), The voltage at #1 pin of Q4 N-FET is 0v, thus the circuit between Q6 N-FET's #1 and #2 pins are open circuit, then the voltage at #1 pin of Q6 is equal to VDD = 5v. If MCU output '0' (0v), the circuit between #1 and #3 pins of Q5 is open circuit, and then #1 and #3 of Q6 is connected, so the voltage at #1 pin of Q6 is 0v.

{Motor}

Summary

Item	Description
Purpose	The Door Motor is used to open and close the door.
Device physical domain and range	The motor rpm is unknown, because the motor model we use does not have a specific datasheet. The rpm of most motors is 0 to 800, we assume the same is true for the motor model we use
Device type chosen	Brushed DC Motor
Proteus Library component name	ECE298_DCMOTOR_ENCODER (Actuators)
Device input / output properties	The motor will receive analog voltage input.
Device input / output range	An analog DC motor accepts 0v to 12v.
MCU connectivity details	The MCU will output a digital signal to the motor driver, then the motor driver will convert the digital signal to PWM signal for motor.
Device/MCU interfacing details	For the MCU to motor driver part, it converts digital to analog by adding a VDD voltage and map the digital signal to PWM voltage to supply motor.

Schematics and Simulations

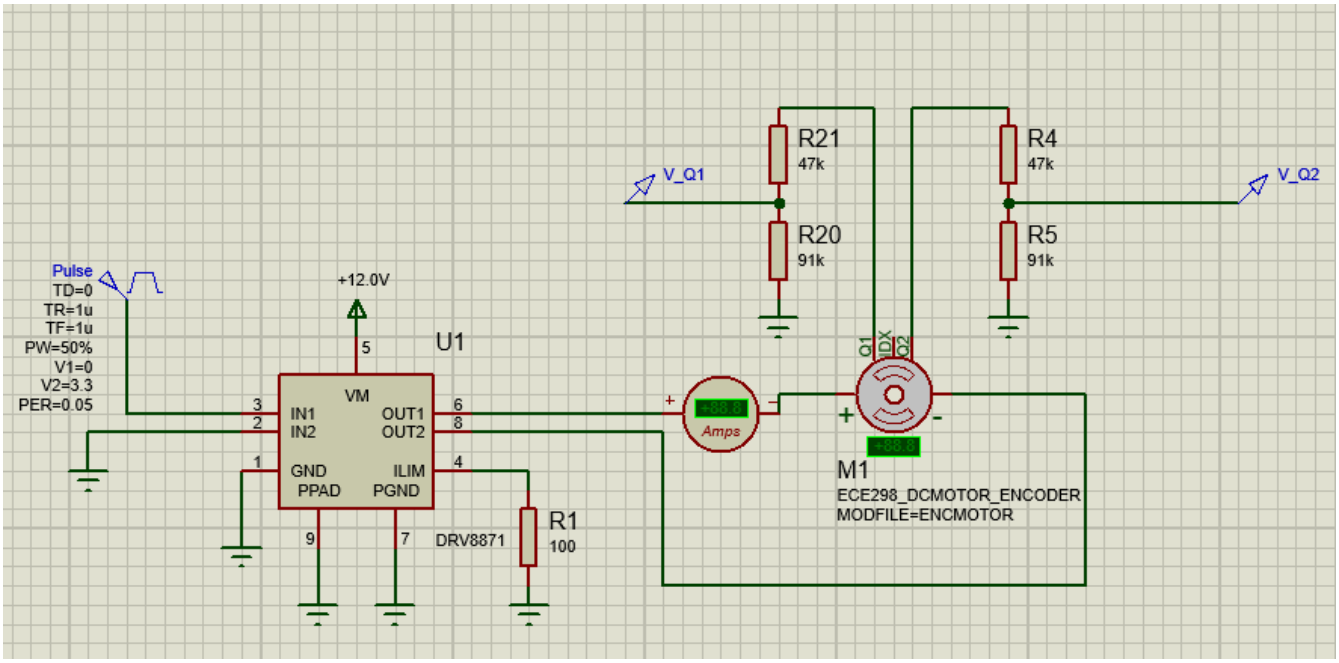


Figure 2.6.1: Schematics of motor and motor sensor simulation

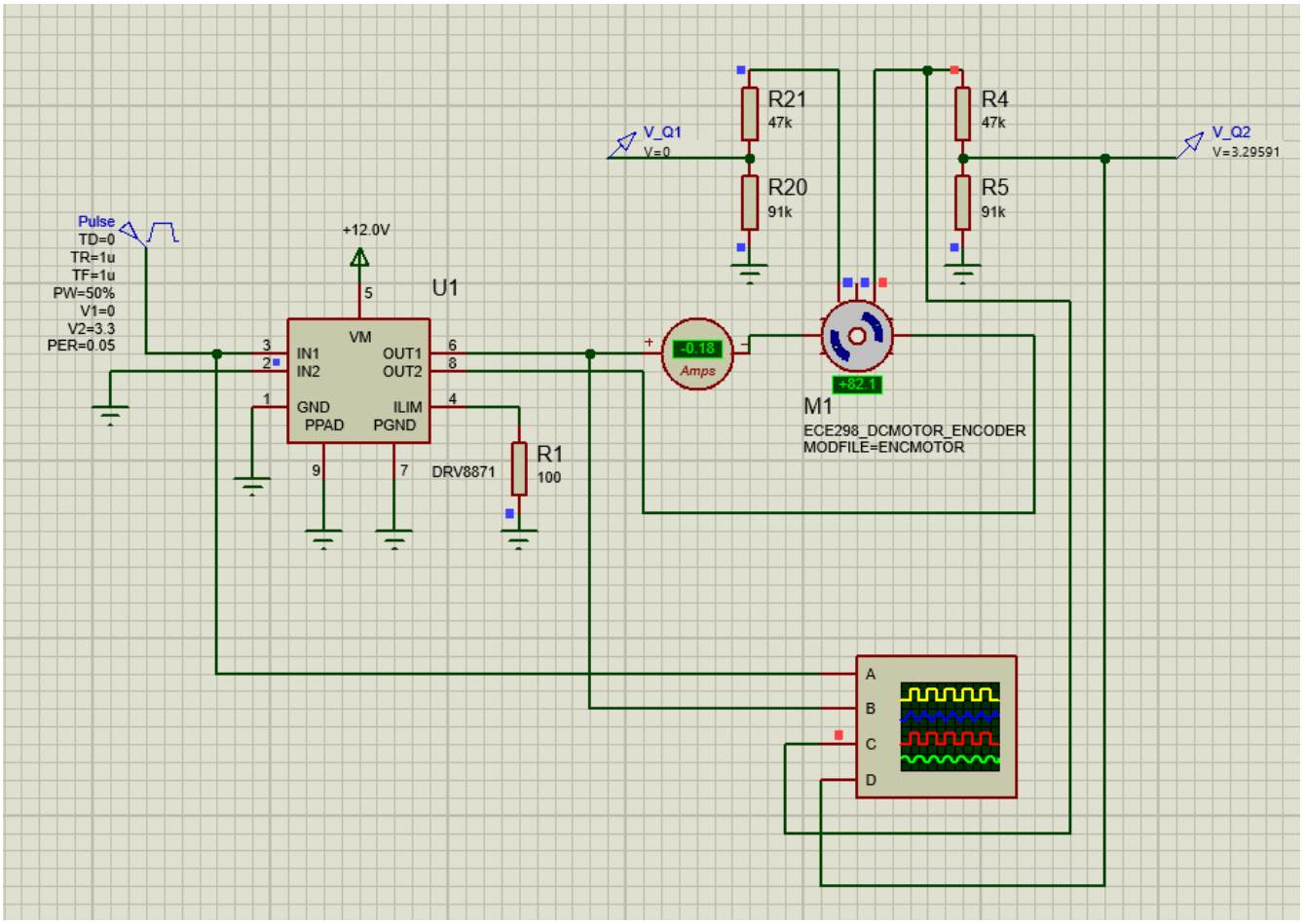


Figure 2.6.2: Add oscilloscope to the circuit for testing

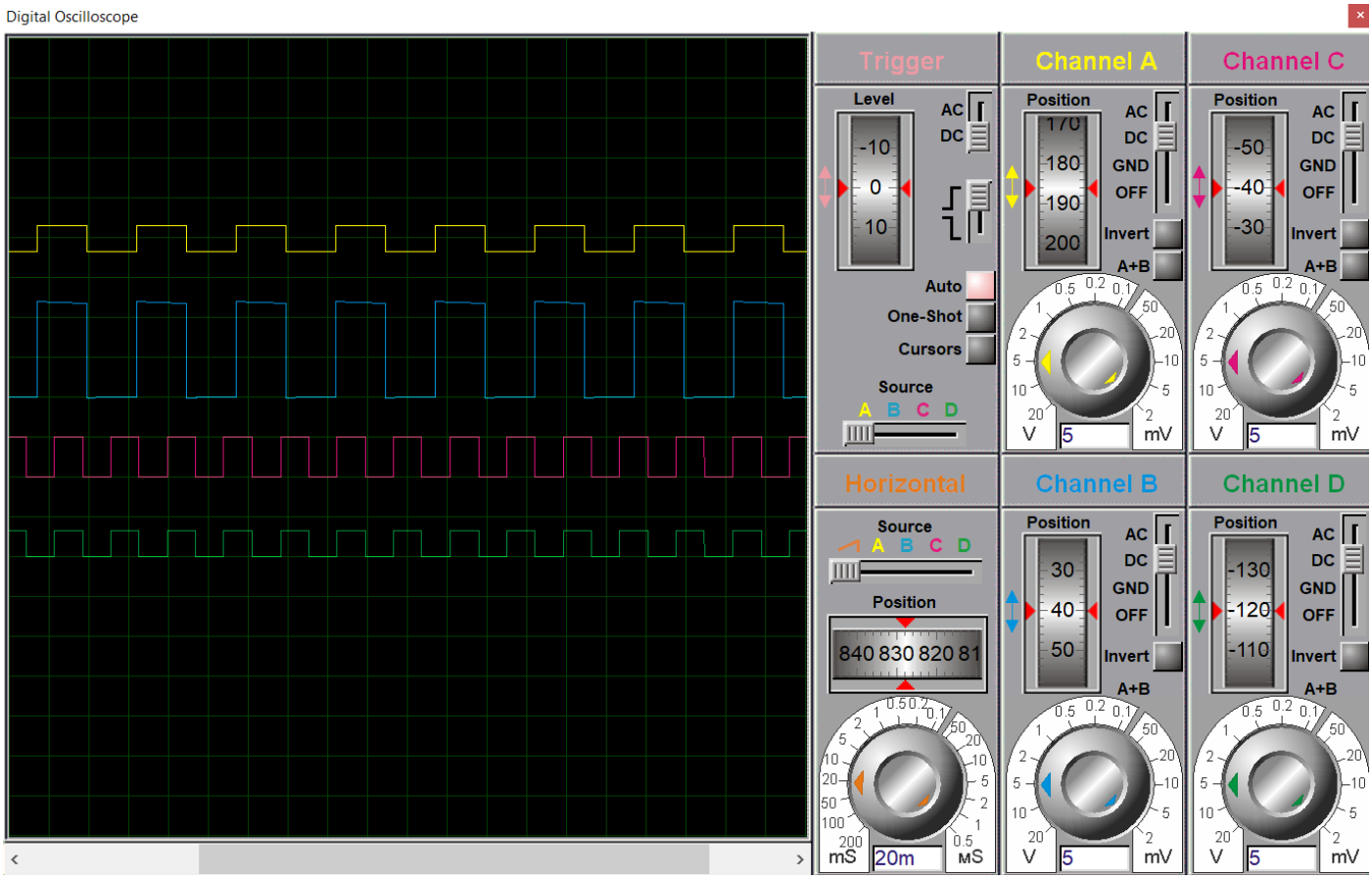


Figure 2.6.3: Display of oscilloscope.

We used the pulse source to simulate the digital output from MCU. The IN1 pin of motor driver connects to the digital signal, VM pin connect to motor work voltage 12v, OUT1 and OUT2 connect to the motor to supply voltage. The motor driver (DRV8871) converts the received digital signal to PWM within 0v to 12v. We could confirm the signal by oscilloscope, channel A shows the input digital signal from MCU (0 - 3.3v); channel B shows the output signal from motor driver to motor, we could see the height of wave is much higher, which means the voltage has step up to 0v – 12v for motor.

{Motor Sensor}

Summary

Item	Description
Purpose	Door motor sensor is used to monitor the door travel, including position, speed, and acceleration.
Device physical domain and range	The physical domain and range are not applied to this device.
Device type chosen	Internal motor encoder
Proteus Library component name	ECE298_DCMOTOR_ENCODER (Encoder)
Device input / output properties	The digital outputs of motor sensor are modelled as being TTL compatible.
Device input / output range	The output signal of motor sensor is 0v to 5v
MCU connectivity details	The motor sensor output a digital signal to MCU.
Device/MCU interfacing details	Hidden VCC of the encoder is 5v, we need to step down the voltage range to 0 – 3.3v for MCU input.

Schematics and Simulations

The motor sensor is encoded by the motor, we could see the how the motor sensor works from schematic of motor.

The VCC of motor sensor is 5v, channel C shows the output signal from encoder, the range of this output is 0v-5v. Then we add step down voltage interface (one 47k ohm and one 91k ohm) to reduce the voltage range to 0v –3.3v to fit the input signal range of MCU. Oscilloscope's Channel C and D shows the signal before step down and after, we could see the height of wave decreased. The point probe V_Q1 and V_Q2 located will connect to the MCU.