

CHAPTER THREE

CIRCUIT DESIGN

3.1 Introduction

In this chapter we will discuss the circuit design and hardware components for smart car parking system. Which build in rotary shape to parking cars.

3.2 Circuit Components

The design of parking circuit main component:

- ✓ microcontroller AT MEGA 16L
- ✓ LCD 16*2
- ✓ driver ULN 2003
- ✓ stepper motor
- ✓ pushbutton
- ✓ keyboard 4*4

3.2.1 Microcontroller ATMEGA 16L

The ATmega16L is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

The pin configuration of ATMEGA 16L is showing in figure 3.1. And the pin Descriptions are:

- ✓ **VCC:** Digital supply voltage.
- ✓ **GND:** Ground.
- ✓ **Port A (PA7..PA0):** Port A serves as the analog inputs to the A/D Converter. Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pin scan provide internal pull-up resistors

(selected for each bit). The Port A output buffers have sym-metrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

- ✓ **Port B (PB7..PB0):** Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.
- ✓ **Port C (PC7..PC0):** Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5 (TDI), PC3 (TMS) and PC2 (TCK) will be activated even if a reset occurs.
- ✓ **Port D (PD7..PD0):** Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

- ✓ **RESET:** Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running.
- ✓ **XTAL1:** Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.
- ✓ **XTAL2:** Output from the inverting Oscillator amplifier.
- ✓ **AVCC:** AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.
- ✓ **AREF:** is the analog reference pin for the A/D Converter.

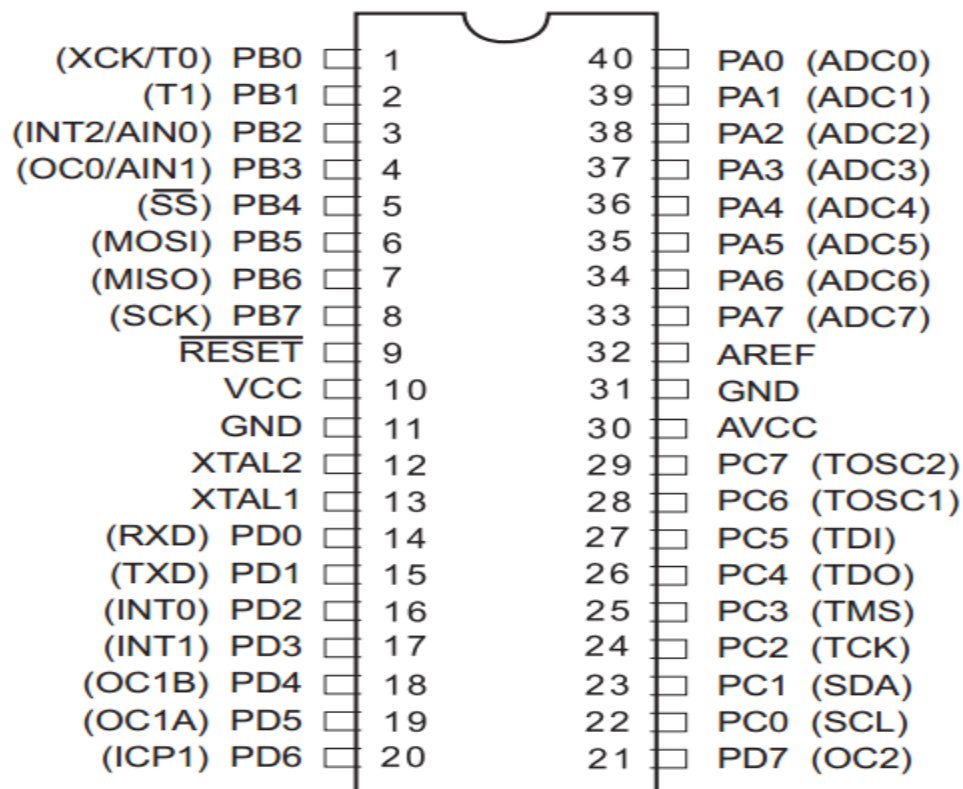


Figure 3.1 pins configuration of MC

The ATmega16L is used in embedded systems to receive signals from input devices and process them and send them to output devices.

Here in this project ATmega16L is connected with LCD, motors, and keyboard. And it is loaded with a program (set of instruction); to control of enter and exit of cars.

3.2.2 Liquid crystal display (LCD 16 x 2)

An HD44780 Character LCD is a de facto industry standard liquid crystal display (LCD) display device designed for interfacing with embedded systems. These screens come in a variety of configurations including 8x1, which is one row of eight characters, 16x2, and 20x4. The most commonly manufactured configuration is 40x4 characters, which requires two individually addressable HD44780 controllers with expansion chips as the HD44780 can only address up to 80 characters. Figure 3.2 shows LCD 16x2.



Figure 3.2 LCD 16X2

These LCD screens are limited to text only and are often used in copiers, fax machines, laser printers, industrial test equipment, networking equipment such as routers and storage devices. Character LCDs can come with or without backlights, which may be LED, fluorescent, or electroluminescent. Character LCDs use a standard 14-pin interface and those with backlights have 16 pins as showing in figure 3.3. The pin outs are as follows:

- ✓ Ground
- ✓ VCC (+3.3 to +5V)
- ✓ Contrast adjustment (VO)

- ✓ Register Select (RS). RS=0: Command, RS=1: Data
- ✓ Read/Write (R/W). R/W=0: Write, R/W=1: Read
- ✓ Clock (Enable). Falling edge triggered
- ✓ Bit 0 (Not used in 4-bit operation)
- ✓ Bit 1 (Not used in 4-bit operation)
- ✓ Bit 2 (Not used in 4-bit operation)
- ✓ Bit 3 (Not used in 4-bit operation)
- ✓ Bit 4
- ✓ Bit 5
- ✓ Bit 6
- ✓ Bit 7
- ✓ Backlight Anode (+)
- ✓ Backlight Cathode (-)

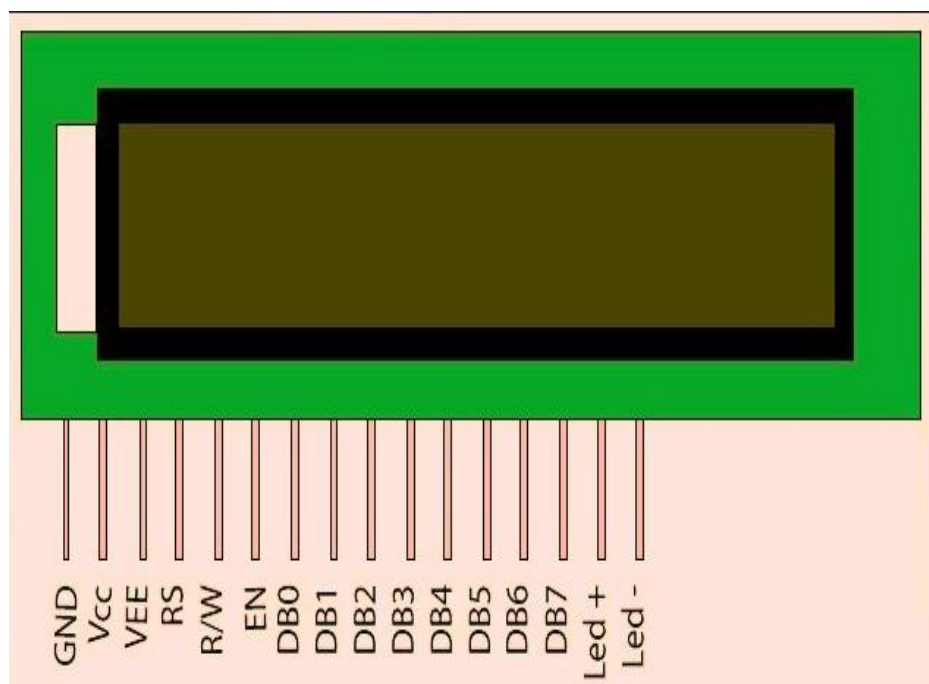


Figure 3.3 pins configurations of LCD16X2

The LCD connected with microcontroller as showing in figure 3.4, in this project LCD is used to display some messages which is useful to car owners like:

- ✓ Enter your password
- ✓ Re enter your password

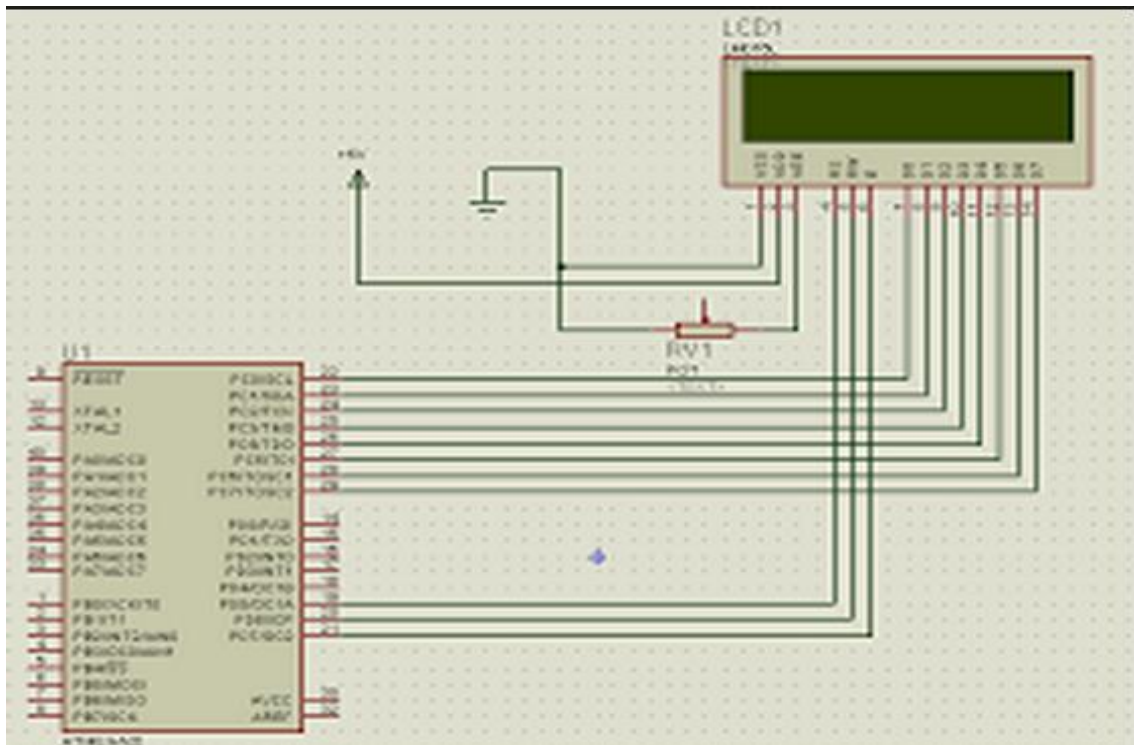


Figure 3.4 LCD connected with microcontroller

3.2.3 The drive type (ULN2003)

The ULN2003 is a monolithic IC consists of seven NPN Darlington transistor pairs with high voltage and current capability. It is commonly used for applications such as relay drivers, motor, display drivers, led lamp drivers, logic buffers, line drivers, hammer drivers and other high voltage current applications. It consists of common cathode clamp diodes for each NPN Darlington pair which makes this driver IC useful for switching inductive loads as shown in Figure 3.5 below.

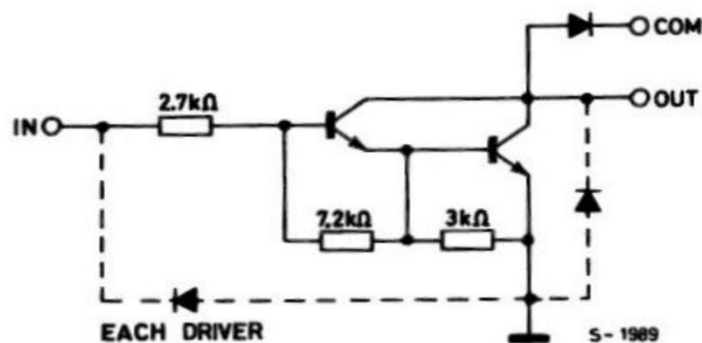


Figure 3.5: Schematic diagram of each Darlington pair – ULN2003

The output of the driver is open collector and the collector current rating of each Darlington pair is 500mA. Darlington pairs may be paralleled if higher current is required. The driver IC also consists of a 2.7K Ω base resistor for each Darlington pair. Thus each Darlington pair can be operated directly with TTL or 5V CMOS devices. This driver IC can be used for high voltage applications up to 50V.

Note that the driver provides open collector output, so it can only sink current, cannot source. Thus when a 5V is given to 1B terminal, 1C terminal will be connected to ground via Darlington pair and the maximum current that it can handle is 500A. From the above logic diagram shown in Figure 3.6, we can see that cathode of protection diodes are shorted to 9th pin called COM. So for driving inductive loads, it must connect to the supply voltage.

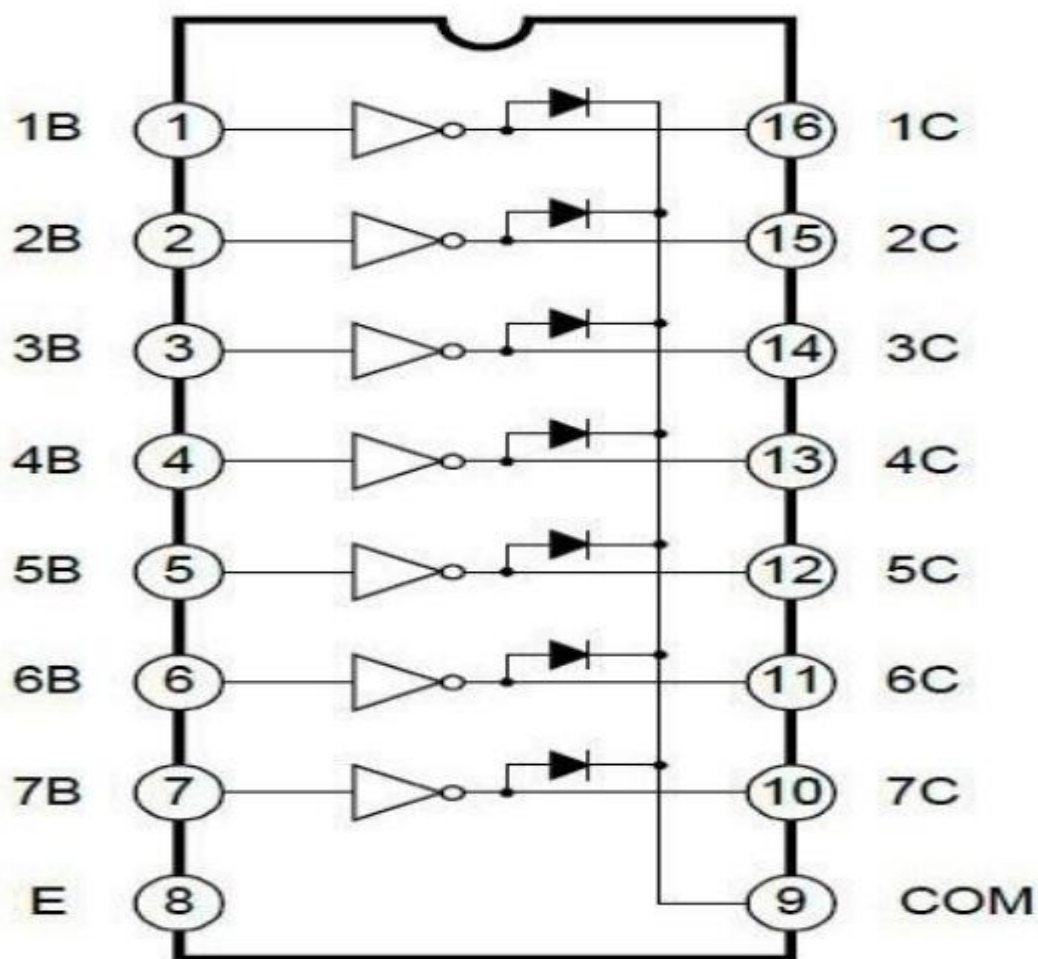


Figure 3.6 Logic diagram of ULN2003

The driver it connects between microcontroller and motor, the driver received the signal from MC and sending it to motor.

3.2.4 Stepper motor

Stepper Motor is a motor controlled by a series of electromagnetic coils. The center shaft has a series of magnets mounted on it, and the coils surrounding the shaft are alternately given current or not, creating magnetic fields which repulse or attract the magnets on the shaft, causing the motor to rotate.

✓ Types of winding

There are two basic winding arrangements for the electromagnetic coils in a two phase stepper motor: bipolar and unipolar. The unipolar stepper motor has five or six wires and four coils (actually two coils divided by center connections on each coil) as shown in Figure 3 .7. They are wiring together and used as the power connection. They are called unipolar steppers because power always comes in on this one pole. Stepper motors fall somewhere in between a regular DC motor and a servo motor. They have the advantage that they can be positioned accurately, moved forward or backwards one 'step' at a time, but they can also rotate continuously. Stepper motors use a cogged wheel and electro magnets to nudge the wheel round a 'step' at a time.

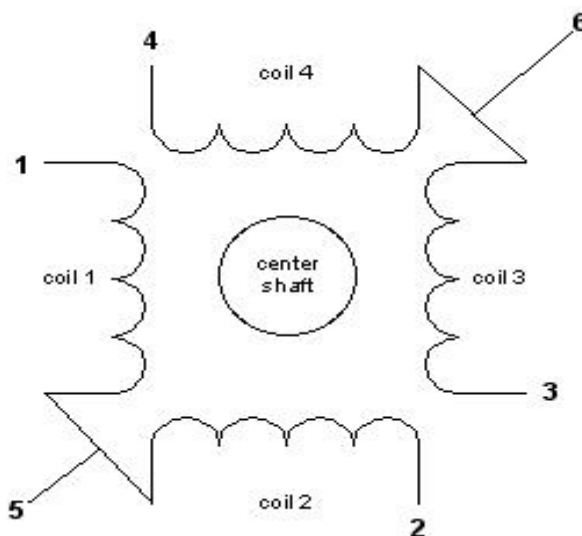


Figure 3 .7 Wiring diagram of stepper motor

By energizing the coils in the right order, the motor is driven round. The number of steps that the stepper motor has in a 360 degree rotation is actually the number of teeth on the cog.

✓ Stepper phasing

A unipolar stepper requires that a sequence of four pulses be applied to its various windings for it to rotate properly. By their nature, all stepper motors are at least two-phase. Many are four-phase; some are six-phase. Usually, but not always, the more phases in a motor, the more accurate it is. As shown in Figure

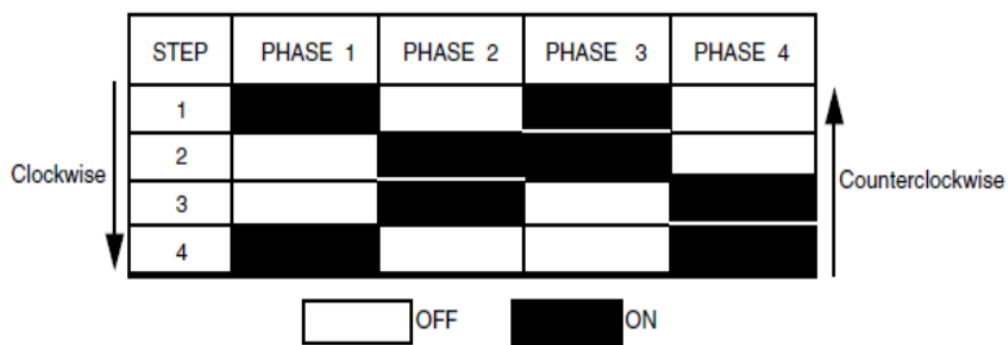


Figure 3.8: step sequence of a unipolar stepper motor

✓ Step angle

The angle through which the motor shaft rotates for each command pulse is called the step angle. Smaller the step angle, greater the number of steps per revolution and higher the resolution or accuracy of positioning obtained. The step angles can be as small as 0.72° or as large as 90° . But the most common step sizes are 1.8° , 2.5° , 7.5° and 15° . The value of step angle can be expressed either in terms of the rotor and stator poles (teeth) N_r and N_s respectively or in terms of the number of stator phases (m) and the number of rotor teeth.

$$\beta = (N_s - N_r / N_s * N_r) \times 360 \quad (3.1)$$

$$\beta = 360 / m N_r = 360 / \text{No. of stator phases} \times \text{No. of rotor teeth} \quad (3.2)$$

Witch:

β = step angle.

N_s = number of stator phases.

Nr = number of rotor teeth

For example, if $N_s = 8$ and $N_r = 6$, $\beta = (8 - 6) \times 360 / 8 \times 6 = 15^\circ$

Resolution is given by the number of steps needed to complete one revolution of the rotor shaft. Higher the resolution, greater the accuracy of positioning of objects by the motor

$$\therefore \text{Resolution} = \text{No. of steps / revolution} = 360 / \beta \quad (3.3)$$

A stepping motor has the extraordinary ability to operate at very high stepping rates (up to 20,000 steps per second in some motors) and yet to remain fully in synchronism with the command pulses. When the pulse rate is high, the shaft rotation seems continuous. Operation at high speeds is called 'slewing'.

When in the slewing range, the motor generally emits an audible whine having a fundamental frequency equal to the stepping rate. If f is the stepping frequency (or pulse rate) in pulses per second (PPS) and β is the step angle, then motor shaft speed is given by:

$$n = \beta \times f / 360 \text{ rps} = \text{pulse frequency resolution} \quad (3.4)$$

Witch:

n = motor shift speed.

If the stepping rate is increased too quickly, the motor loses synchronism and stops. Same thing happens if when the motor is slewing, command pulses are suddenly stopped instead of being progressively slowed. Stepping motors are designed to operate for long periods with the rotor held in a fixed position and with rated current flowing in the stator windings. It means that stalling is no problem for such motors whereas for most of the other motors, stalling results in the collapse of back EMF (EB) and a very high current which can lead to a quick burn-out.[3]

✓ operation and connecting to micro controller

There are two motors in this circuit, one of them its operation is to control open and close the door, second motor its operation is to control for moving the location of parking. Each motor connected to driver ULN 2003.

3.2.5 Pushbutton

A push-button is a simple switch mechanism for controlling some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal.

There is one pushbutton, connected with MCU, and motor doesn't work to close the door if user doesn't push it.

3.2.6 Keyboard 4*4

The keyboard is an input device. It is component contains a set of library routines that enable scan of 4*4 switch array and return the data associated with the switch pressed, it use to enter a text or numeric data.

It connect with microcontroller with port A, it use in the circuit to enter data and send it to the MCU.