

UNIVERSITÀ DEGLI STUDI DI PALERMO

EMBEDDED SYSTEMS

# **Door Alarm System on Raspberry Pi 4**

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## 1 Introduction

The project is a Door Alarm System. The System is able to monitor the open or closed status of a door using a hall sensor to detect the presence of a magnet; if the latter is far from the sensor, it is emitted a sound alert with a buzzer. Using two LEDs and a LCD display 16x2 the status of the door is shown. In addition there is a button that can be used to turn off the alarm when the door is closed.

In the following sections is described in detail the hardware and the software used to implement the project.

## 2 Hardware

### 2.1 Raspberry PI 4

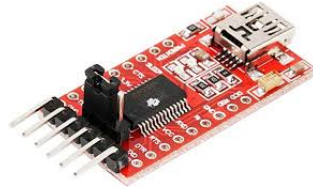


The chosen target for this project is the Raspberry Pi 4 Model B, a single board computer developed by the Raspberry Pi Foundation and released in 2019. The tech specs include:

- Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5Ghz
- 1GB, 2GB, 4GB, or 8GB LPDDR4-3200 SDRAM (depending on model)
- 2.4 GHz and 5.0 Ghz 802.11ac wireless
- Gigabit Ethernet
- Bluetooth 5.0, BLE
- 2 USB 3.0 ports, 2 USB 2.0 ports
- Raspberry Pi standard 40 pin GPIO header

- 2 micro-HDMI ports (up to 4kp60 supported)
- 2-lane MIPI DSI display port
- 2-lane MIPI CSI camera port
- 4-pole stereo audio and composite video port
- H.265 (4kp60 decode), H.264 (1080p60 decode, 1080p30 encode)
- OpenGL ES 3.1, Vulkan 1.0
- Micro-SD card slot for loading operating system and data storage
- 5V DC via USB-C connector (minimum 3A)
- 5V DC via GPIO header (minimum 3A)
- Power over Ethernet (PoE) enabled (requires separate PoE HAT)
- Operating temperature 0 - 50 °C ambient

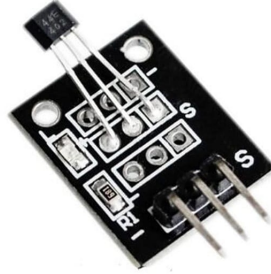
## 2.2 FT232-AZ USB to TTL serial UART adapter



The FT232-AZ USB to TTL serial UART adapter is used to connect the PC used during the development of the project to the target in order to send and receive data between the PC and the Raspberry Pi 4. The PC is connected through a USB port, the target is connected through GPIO pins according to the following table.

GPIO	Function	UART adapter
14 (Tx)	Output	Rx
15 (Rx)	Input	Tx
Ground	Ground	Ground

### 2.3 KY-003 Hall sensor



The KY-003 hall sensor allows to detect a magnetic field. When the magnetic field at the Hall sensor exceeds the operate point threshold (BOP) the output of the device switches low. When the magnetic field is reduced to below the release point threshold (BRP) the device output switches high. BOP and BRP may vary respectively from 1 mT to 33 mT and from 5 mT to 35 mT at operating temperature  $T = 25^{\circ}\text{C}$  depending on the sensor model. This sensor is used to trigger the alarm when the magnet is far from the sensor.

### 2.4 KY-012 Buzzer



The KY-012 Buzzer is an active piezoelectric buzzer, it generates a sound of approximately 2.5kHz when input signal (S) is high. The Buzzer is activated when the Hall sensor does not detect the magnet.

### 2.5 LEDs



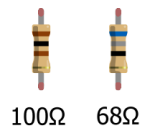
The LEDs are used to show the alarm status. When the Hall sensor does not detects the magnet the green LED turns off and the red LED turns on. When the Hall sensor detect the magnet and the push button is pressed, the green LED turns on and the red LED turns off.

## 2.6 Push Button



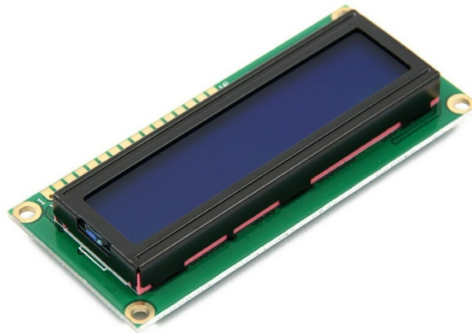
The push button can be used to turn off the alarm when the hall sensor detects the magnet.

## 2.7 Resistors

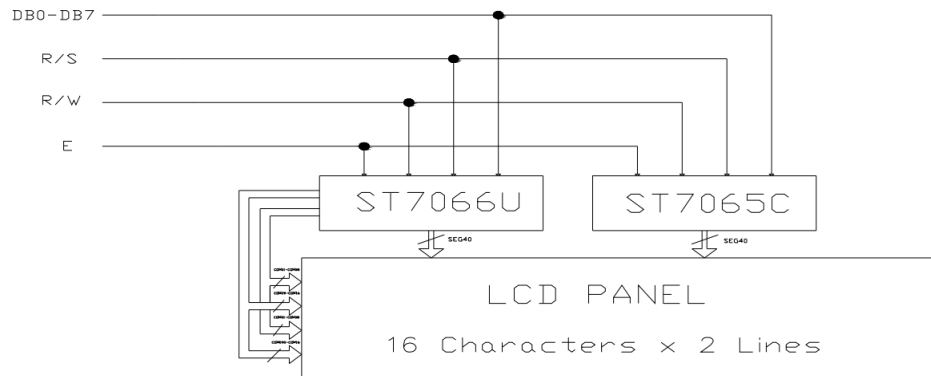


The resistors are connected in series to the LEDs to limit the current flowing through the LED and to ensure that the supplied voltage does not exceeds the maximum voltage of the LED. The 100  $\Omega$  resistor is connected to the red LED, the 68  $\Omega$  resistor is connected to the green LED.

## 2.8 LCD 1602



The LCD 1602 is an industrial character LCD that can display 16x02 or 32 characters at the same time. The LCD 1602 is controlled through a parallel interface with 8-bit / 4-bit data bus and 3 control signals. The interface signals reach the two controller chips that drive the LCD panel as shown in the following block diagram.



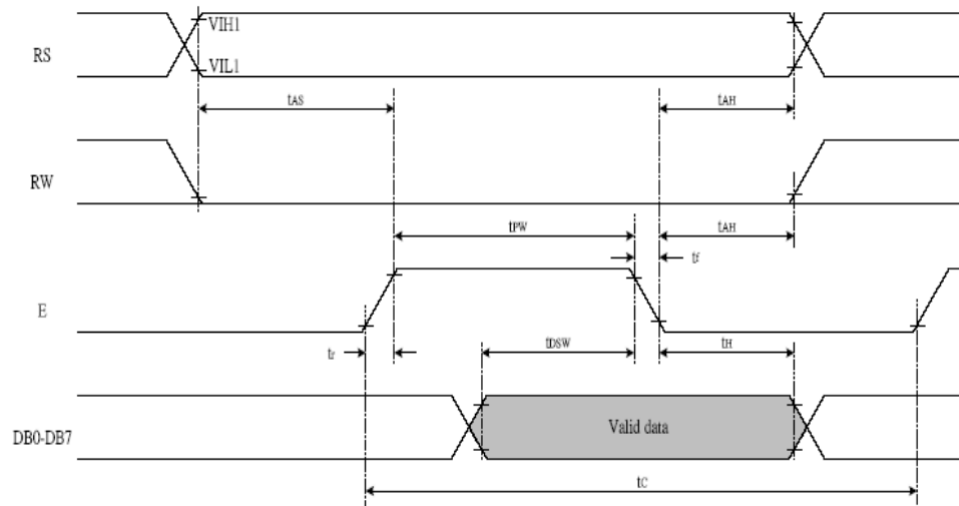
The following table describes the pin assignment

No.	Symbol	Level	Function
1	Vss	--	0V
2	Vdd	--	+3.3V
3	V0	--	for LCD
4	RS	H/L	Register Select: H:Data Input L:Instruction Input
5	R/W	H/L	H--Read L--Write
6	E	H,H-L	Enable Signal
7	DB0	H/L	Data bus used in 8 bit transfer
8	DB1	H/L	
9	DB2	H/L	
10	DB3	H/L	
11	DB4	H/L	Data bus for both 4 and 8 bit transfer
12	DB5	H/L	
13	DB6	H/L	
14	DB7	H/L	
15	BLA	--	BLACKLIGHT +3.3V
16	BLK	--	BLACKLIGHT 0V-

The LCD module is controlled through instructions to set display format, data length, scrolling modality, internal RAM address, to perform data transfer from/to internal RAM and to access status flag. The following table describes the instructions.

Instruction	Instruction Code										Description	Description Time (270KHz)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear Display	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRAM, and set DDRAM address to "00H" from AC	1.52 ms
Return Home	0	0	0	0	0	0	0	0	1	x	Set DDRAM address to "00H" from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed.	1.52 ms
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	37 us
Display ON/OFF	0	0	0	0	0	0	1	D	C	B	D=1:entire display on C=1:cursor on B=1:cursor position on	37 us
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	x	x	Set cursor moving and display shift control bit, and the direction, without changing DDRAM data.	37 us
Function Set	0	0	0	0	1	DL	N	F	x	x	DL:interface data is 8/4 bits N:number of line is 2/1 F:font size is 5x11/5x8	37 us
Set CGRAM address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address counter	37 us
Set DDRAM address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter	37 us
Read Busy flag and address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Whether during internal operation or not can be known by reading BF. The contents of address counter can also be read.	0 us
Write data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM)	37 us
Read data from RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM)	37 us

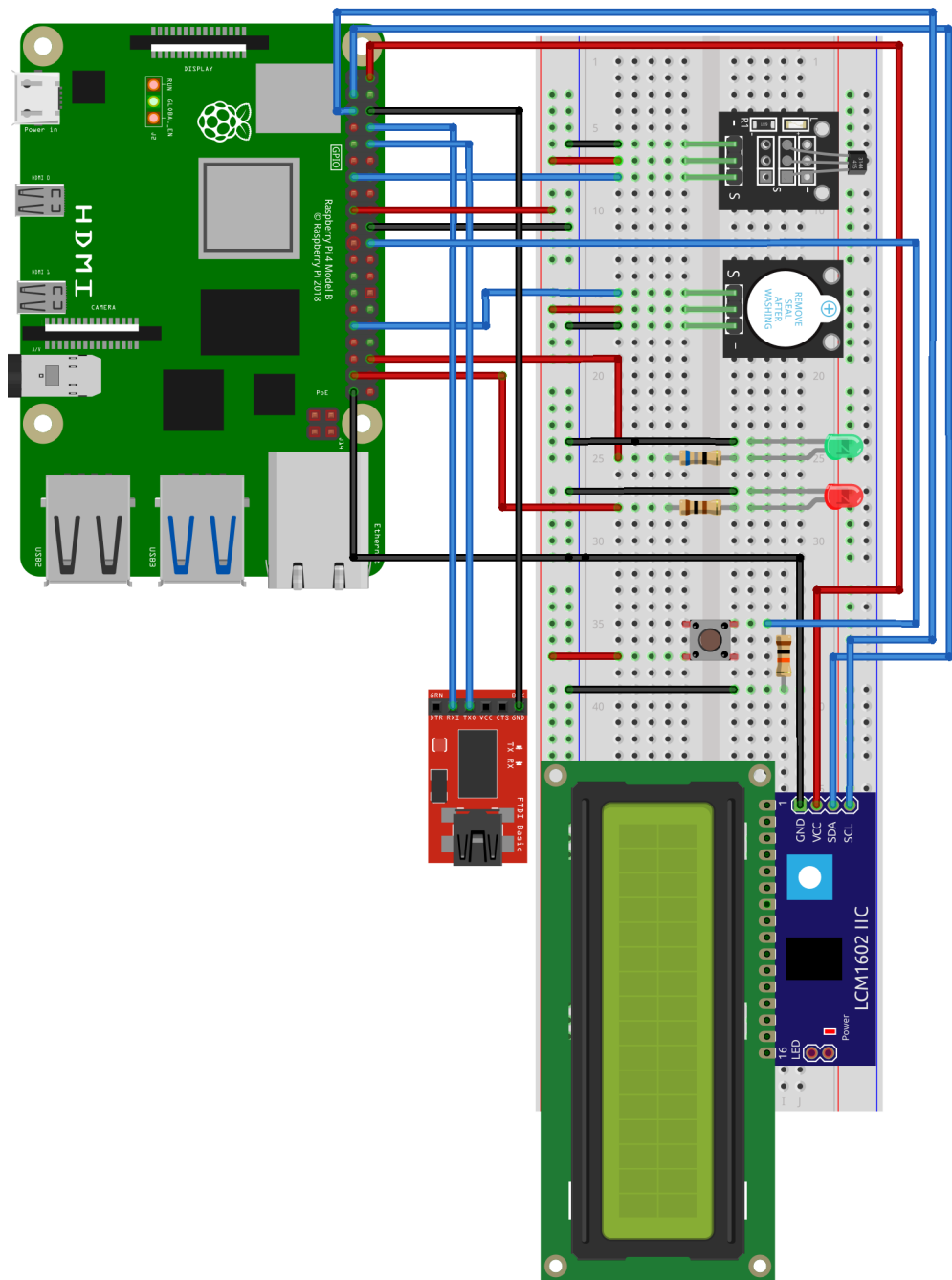
In order to write to the controller chips we need to set properly the control bits: the R/W bit must be set to 0 for writing, the RS bit must be set to 1 for data input and to 0 for instruction input, the E bit must be set to 1 before the start of the data transmission and must be set to 0 before the end of the data transmission as shown in the following figure





## 2.9 PCF8574AT 8-bit I/O expander for I2C bus

## 2.10 GPIO wiring diagram



fritzing

The following table is the GPIO wiring diagram.

GPIO	Function	Connection
2	SDA	SDA (I/O expander)
3	SCL	SCL (I/O expander)
6	Output	S (Buzzer)
16	Output	Anode (Green LED)
25	Input	Button
26	Output	Anode (Red LED)
27	Input	S (Hall sensor)
5V	Power	VCC (I/O expander)
3V3	Power	Breadboard
Ground	Ground	Breadboard

### 3 Environment

#### 3.1 pijForthos

#### 3.2 Minicom, Picocom

### 4 Software

### 5 References

- [raspberrypi.com/products/raspberry-pi-4-model-b/specifications](https://raspberrypi.com/products/raspberry-pi-4-model-b/specifications)
- [cdn.shopify.com/s/files/1/1509/1638/files/FT232-AZ\\_Adapter\\_Datenblatt\\_AZ-Delivery-Vertriebs\\_GmbH.pdf](https://cdn.shopify.com/s/files/1/1509/1638/files/FT232-AZ_Adapter_Datenblatt_AZ-Delivery-Vertriebs_GmbH.pdf)
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