Self-ID scanning and Temperature Checking Machine

By Alfred Jason R. Abanto

Introduction

During this ongoing pandemic, one of the biggest challenges facing both private and public institutions is the logistics of contact tracing. To address these challenges, we propose an automatic temperature sensor that doubles as a contact tracing station. This Self-ID scanning and temperature checking machine will check the user's temperature and then proceed to log the user's personal information using the RFID feature of their UP-ID. This information, including the time and date of their login will then be stored in a SD card for gathering and post processing.

Device Layout

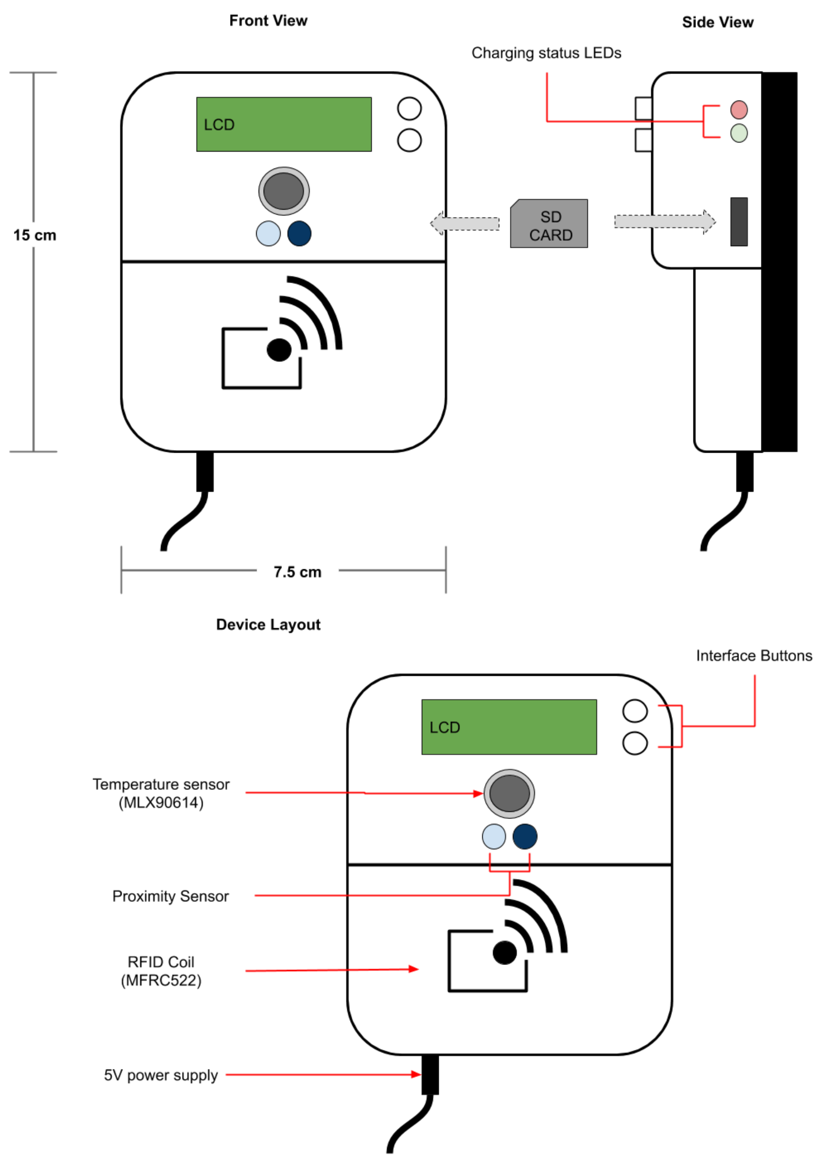


Figure 1. Device layout and estimated dimensions

Hardware Implementation

Peripherals and components

Board mounted Infrared Sensor

For the device to detect the presence of a user, a built in proximity sensing circuit will be implemented, consisting of an infrared LED coupled with a photodiode. This should allow the device to have an idle state in which no data will be logged then decide when to move from the idle state into the next states in which communication with the other peripherals will commence and thus data will be logged.

The proximity circuit functions by emitting some constant infrared light via the mentioned IR LED and measuring the amount of infrared light reflected back into the photodiode which will tell the microcontroller whether there is a surface near the device.

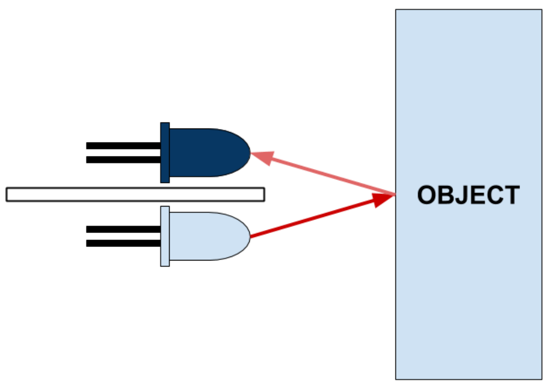


Figure 2. Infrared proximity sensing

The circuit is constructed according to Figure 3 below. When picking out the specific components for the sensing circuit, we must take into account the wavelength range that the photodiode can detect and make sure that we pick an appropriate IR LED that emits light within said range. For this application we picked a photodiode and IR LED that operates in the 940nm wavelength range. Namely we picked 1540031EC4590 (D6) for the photodiode and the 15400394F3590 (D5) for the IR emitter [13][14].

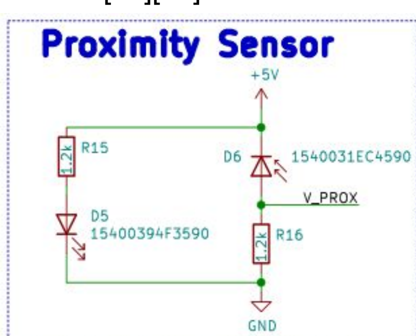


Figure 3. Proximity sensing circuit

The voltage level measured at V_prox will represent the sensor data which will be read by the microcontroller using the ADC peripheral.

Board mounted infrared temperature sensor

In order to measure the user's temperature. We will make use of a non-contact infrared temperature sensor. Specifically, we will use one of the sensors from the MLX90614 family. This sensor will be mounted directly to the pcb and will communicate with the pic microcontroller using an i2c interface [7][10].

Figure 4. MLX90614 temperature sensor

Realtime Clock

Since the end goal of this device would be to conduct contact tracing. A RTC integrated circuit will be used to provide time and date information which is to be stored by the SD card after the temperature and RFID has been scanned. Specifically we will be using the MAX31341CETB+ which will also be connected to the i2c bus interface as a slave [5][10].

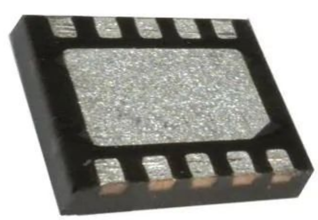


Figure 5. MAX31341CETB+ RTC IC

LCD Module

To provide a means of post launch configuration and also to prompt the user with instructions for logging in, a 16x2 LCD module with an IO expander circuit (PCF8574) will be used. This module will be controlled with the use of an i2c bus which some other peripherals will also be connected to.We will be using the LCD module with the I/O Expander (PCF8574) module since we want to avoid consuming too many gpio pins which could be used for buttons and status LEDs [4][10].

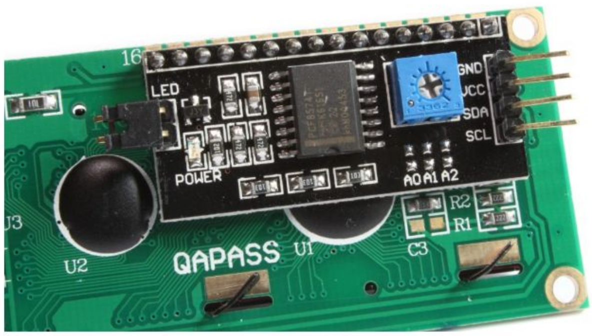


Figure 5. Back side of the LCD module (green PCB)
with the PCF8574 I/O expander module (black PCB)

SD Card

To actually store the contact tracing data we intend to collect we will use a SD card (specifically a Micro SD card) which will be connected in SPI Bus mode to the microcontroller.The SD card operates at 3.3V voltage but since we intend to use a PIC24F microcontroller, we won't need to worry about lowering the voltage levels using resistors since it also operates at a 3.3V logic level range [1].

The Micro SD card will be mounted on a soldered SD card slot like in figure 6 .Reading and writing will be done using the pre-existing FAT_Fs library which will abstract away the complications of file system management [1][11] .

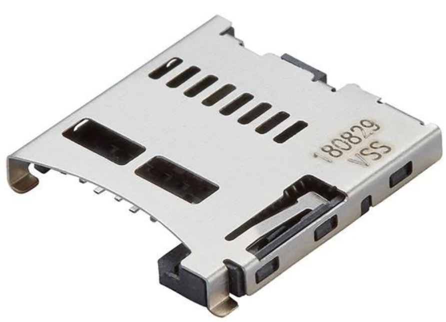


Figure 6. Board mounted micro sd card slot

RFID sensor module

To read the RFID tag on the user's UP ID, the project will be using a MFRC522 RFID IC which will be integrated into the main PCB with a custom PCB antenna-coil. The MFRC522 will be configured as a slave and will communicate with the microcontroller through the i2c bus which the LCD display module is also connected to [10][6]. Note that the specifications of the PCB antenna-coil and the encryption protocol of the RFID tag will not be discussed in this paper and considered out of scope.

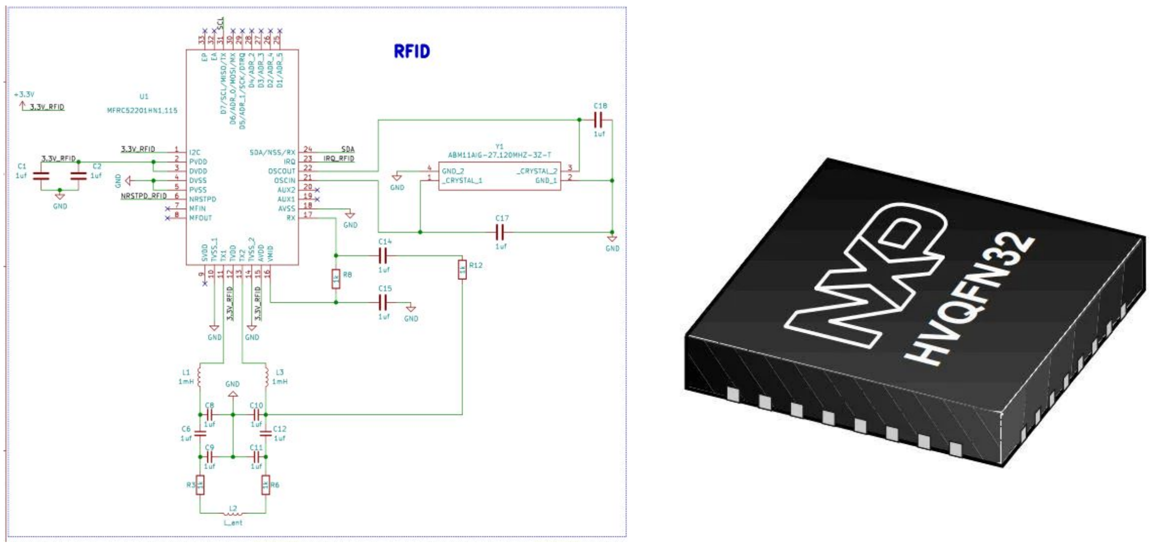


Figure 7. RFID circuit (left) featuring the NXP MFRC522 (right)

Miscellaneous Hardware

User feedback

To give some user/operator some feedback during operation we will use an active buzzer component with an arbitrary NPN transistor to switch it on and off. In Particular we chose the CMI-1295IC-0585T since it already has an onboard driver circuit which will drive the piezo when powered on. This buzzer is also convenient since it can operate on +5V supply voltage [8].

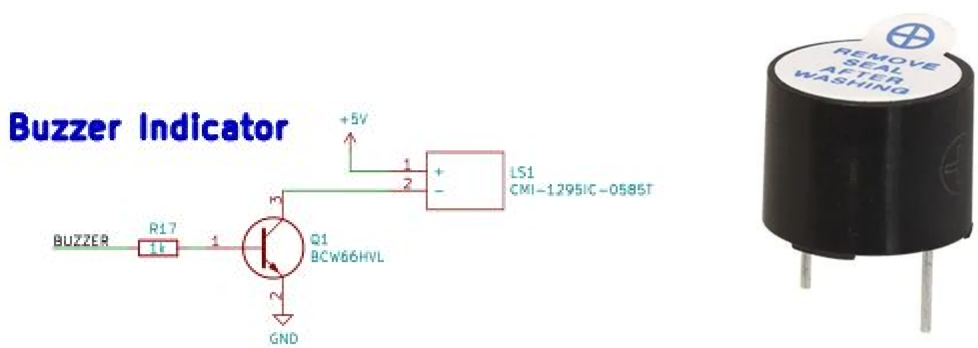


Figure 8. Buzzer indicator circuit (left) featuring the CMI-1295IC (right)

Battery backup

For portability and flexibility, a battery back-up circuit will be included. Specifically we will use two 18650 lithium ion batteries which will be charged by the TP4056 chip. The TP4056 chip is a popular charging solution and is normally available in small breakout modules for personal projects. This will allow us to charge the two 18650 batteries in parallel to their nominal voltage of 4.7 volts [12]. Since the rest of the components are meant to operate on a 5 volts regulated supply, we will use the MT3608 buck-boost regulator to step up the battery voltage to the desired 5 volts [9].

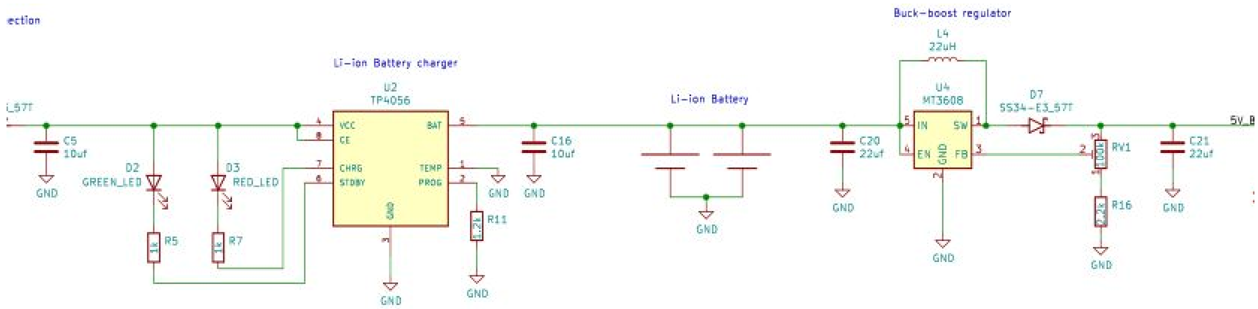


Figure 9. Battery backup circuit

Automatic battery Backup switch-over

Since the device is designed to be flexible and portable, a battery back-up switch-over feature is added so that the device can be plugged when an outlet is available, otherwise it can operate on the battery back-up. This feature is accomplished using the ICL7673 chip which is very straightforward to implement and perfect for low-current applications like this project [3].

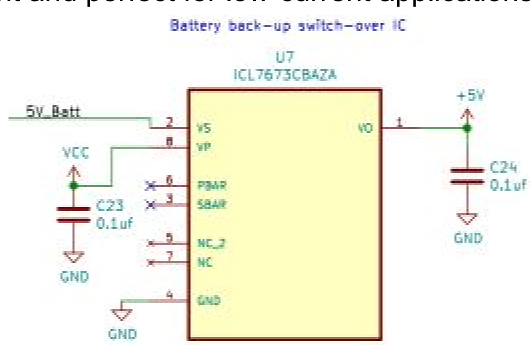
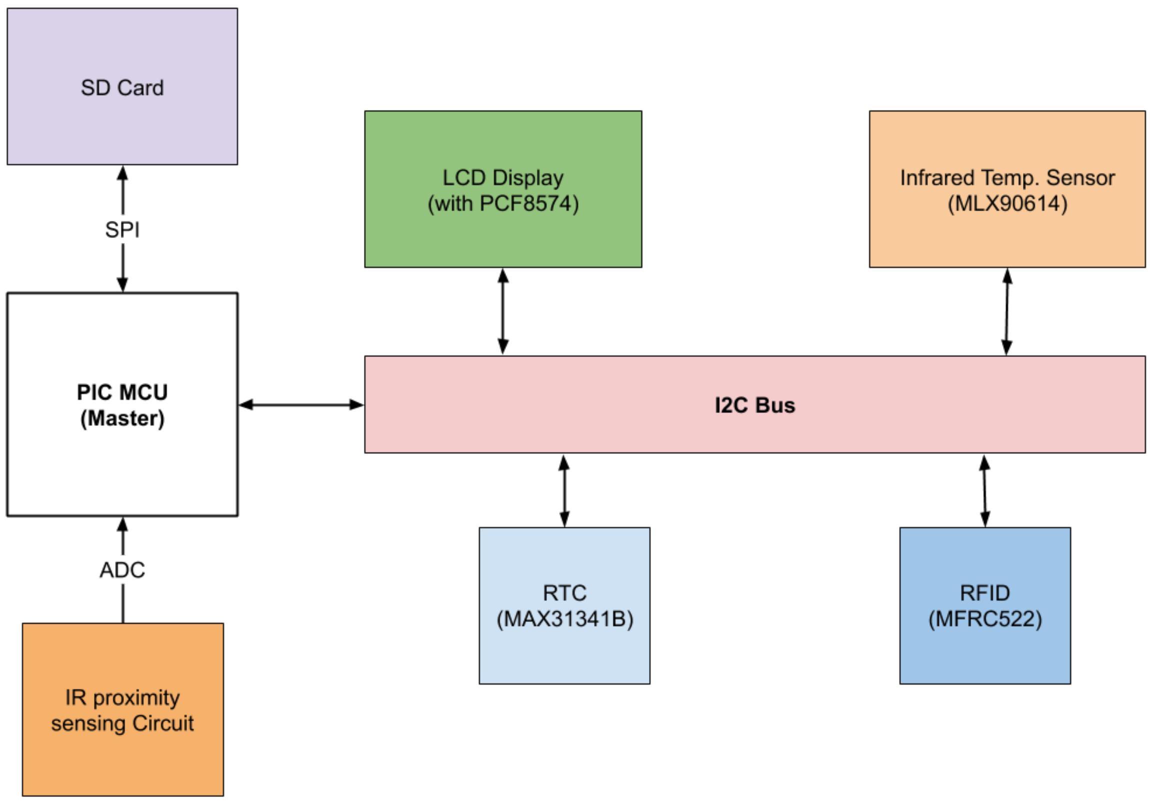


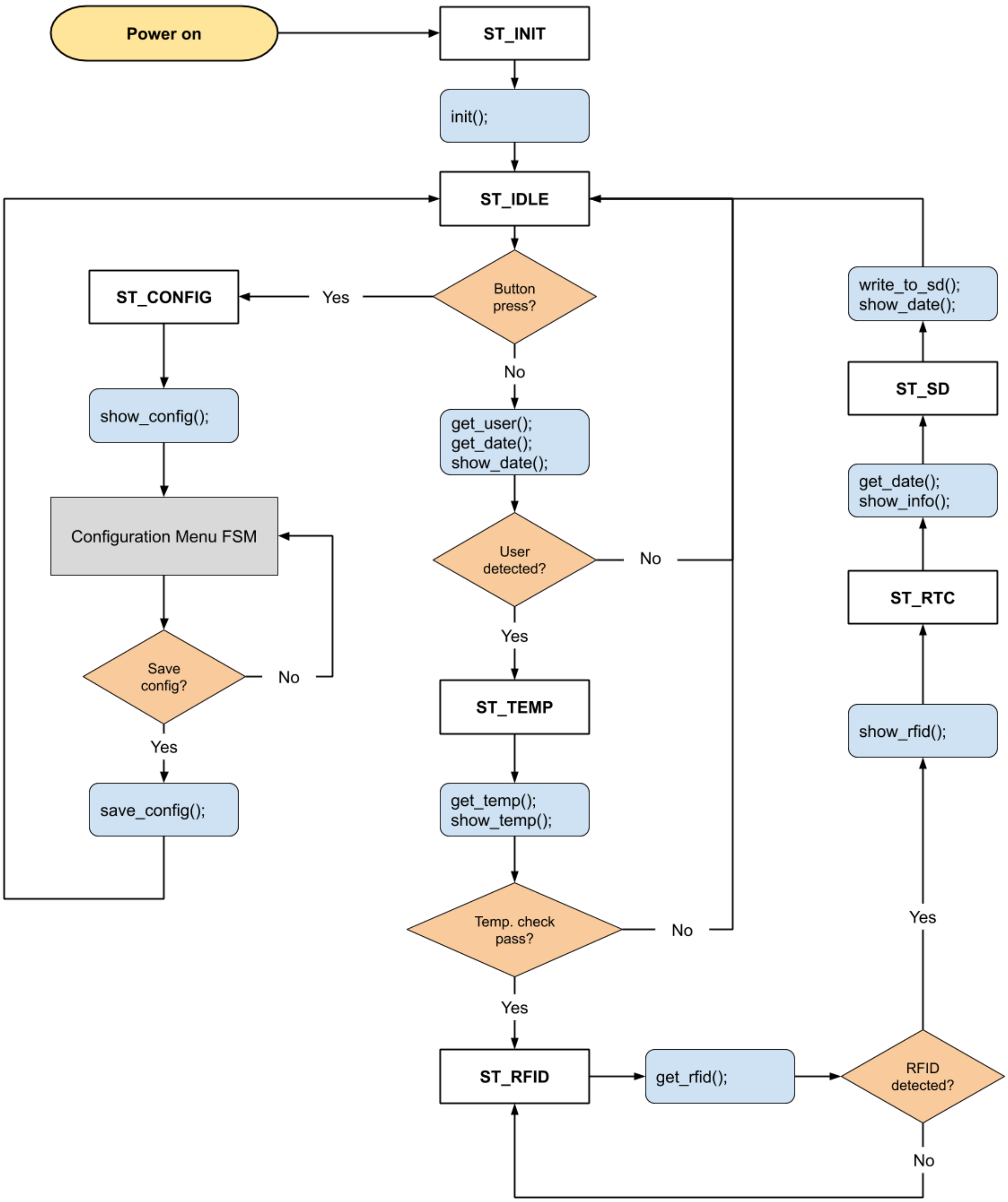
Figure 10. Battery backup switch-over circuit

Block diagram



Pseudocode and program flowchart

Program State Diagram



Pseudocode/Program description

State Machine

Since the device will only perform a simple routine we can implement the entire operation using a finite state machine. To be specific there will be two state machines, one for the main functions and one for configuring the device through the use of mechanical buttons on the pcb. For the purposes of this paper we will be focusing on the fsm of the main functionalities. The states in said fsm are as follows:

- ST_INIT
    - After powerup the device immediately starts in this state. This is when some modules will be initialized such as the lcd and sd-card. The device will also set measurement thresholds for the proximity sensing circuit to detect users. Error checking will also be done in this state before proceeding with normal operation. During this state, the device will check the existence of two files on the SD card. Those files will be the *“config.txt”* or the *“log.txt”* file for the current date. The files will be created if missing however if *config.txt* exists, all configurations shall be read and loaded to the device accordingly.
- ST_IDLE
    - In this state, the device acts almost in a low-power mode in which all other peripherals are ignored except for the ADC that measures the Proximity sensing circuit. If the resulting measurements reach a certain threshold, we will assume that the user is present.
- ST_TEMP
    - Since a user is present, we will immediately communicate with the temperature sensor via the i2c bus and read the user’s temperature.
- ST_RFID
    - After taking the temperature, the device will then communicate with the rfid module (MFRC522) in order to detect and read the rfid chip on the user’s UP ID then extract the necessary information such as student number and name [6].
- ST_RTC
    - As the last source of information, the real time clock module (RTC) will be read and time and date information will be extracted before it is displayed onto the LCD.
- ST_SD
    - Lastly the read information will be logged onto the mounted SD card in a csv file format.
- ST_CONFIG
    - This state will allow the operator of the device to change the settings such as current time and date, session time-out ,and the like without re-uploading the device program. The Device is designed to have 2 interface buttons which ,if either is pressed during ST_IDLE state, will enter the device into the config menu. The two buttons will be used as an enter and scroll button respectively, meaning one will be used to enter/exit a setting screen and the other used to

modify the values, similar to that of a rotary encoder with a mechanical button. After exiting the configuration tree all changes will be saved onto the config.txt file in the SD card.

Subroutines/Functions

Since most of the peripherals are connected via a communication protocol (i2c and spi) we will assume that each of the functions/subroutines will use the appropriate communication protocol to send and receive data from target registers.

- Void init()
    - This function is responsible for initializing all relevant registers for the adc, the lcd module via the PCF8574 and also the sd card for spi communication [1][4]. Additionally it will measure a reference threshold voltage where there is assumed to be no user interacting with the device. Before proceeding exiting execution, it will check whether there is an SD card present in the SD card slot, if not it will enter an infinite loop, prompting the operator to insert a SD card to proceed.If SD card is present, it will check the existence of *config.txt* and *log.txt* which would contain the configuration settings and the current log data for the date. Both files will be created if they do not already exist, otherwise configuration data will be loaded from *config.txt* and new log data will be appended to the existing *log.txt* file.
- Int get_user()
    - In this function the microcontroller will use the adc to measure the voltage at the voltage divider circuit with the photodiode. It will then compare the measurement with the threshold to decide if a user is detected.This will return 1 if a user is detected and -1 if otherwise.
- Void get_date()
    - This function is responsible for retrieving date and time data from the RTC [5]. This assumes that the delay introduced by the execution time of the function is negligible thus the data received is still trustworthy. This function will overwrite a global variable with the latest data received each time it is called.
- Int get_rfid()
    - This function is responsible for communicating with the MFRC522, first reading the *status2reg* to determine the current status of the RFID receiving state machines whether it is still awaiting data [6]. If the MFRC522 has readily available data then it will overwrite the current RFID data global variable and return 1 otherwise if it is still idle then it will return -1.

- Void write_to_sd()
    - This function is intended to be used to mount the sd card using the provided fat_fs library and append new data to an existing log.txt file. This will be called as a final step before the device goes back into idle state. The sd card/volume shall be mounted and unmounted during the execution of this function, this is to free up as much ram for other processes.
- Void show_rfid() / show_date() / show_info()/show_temp()
    - These functions will be responsible for writing characters to the LCD display. functionally they should be similar in that they will access the relevant global variables that contain the data to be sent and will communicate with the PCF8574 to actually display it [4].
    - During the ST_TEMP state, once this function is called and the temperature of the user exceeds that of the set threshold, then the operator will be notified using the buzzer indicator and the state machine will reset back to ST_IDLE where it will wait for another user.
- Void show_config() / save_config()
    - These functions will be used as an additional feature so that the operator of the device will be able to change settings such as the current time and date for the RTC module without having to upload the main program itself. Additional configurations can be added and saved into the SD card each time the configuration is changed.

References

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Bill of Materials

Reference	Quantity	Value	Price per unit	Total cost	Footprint
C28 C18 C17 C2 C15 C14 C8 C10 C9 C11 C6 C12 C1	13	1uf	₱8.90	₱115.70	Capacitor_SMD:C_0603_1608Metric_Pad1.05x0.95mm_HandSolder
C19	1	1nf	₱22.75	₱22.75	Capacitor_SMD:C_0603_1608Metric_Pad1.05x0.95mm_HandSolder
C20 C21	2	22uf	₱19.71	₱39.42	Capacitor_SMD:C_0603_1608Metric_Pad1.05x0.95mm_HandSolder
C23 C24 C27 C26 C13 C7 C4 C22 C25	9	0.1uf	₱17.59	₱158.31	Capacitor_SMD:C_0603_1608Metric_Pad1.05x0.95mm_HandSolder
C3	1	100uf	₱12.49	₱12.49	Capacitor_SMD:CP_Elec_8x10
C5 C16	2	10uf	₱18.20	₱36.40	Capacitor_SMD:C_0603_1608Metric_Pad1.05x0.95mm_HandSolder
D1 D7	2	SS34-E3_57T	₱29.32	₱58.64	SS34-E3_57T:DIOM7959X262N
D2	1	GREEN_LED	₱15.97	₱15.97	LED_THT:LED_D3.0mm
D3	1	RED_LED	₱18.20	₱18.20	LED_THT:LED_D3.0mm
D4	1	LED	₱7.33	₱7.33	LED_SMD:LED_0603_1608Metric
D5	1	15400394F3590	₱20.22	₱20.22	LED_THT:LED_D3.0mm
D6	1	1540031EC4590	₱31.85	₱31.85	LED_THT:LED_D3.0mm
J1	1	5V_power_conn	₱0.00	₱0.00	Connector_PinSocket_1.27mm:PinSocket_1x02_P1.27mm_Vertical
J2	1	PICkit_conn	₱0.00	₱0.00	Connector_PinHeader_1.27mm:PinHeader_1x06_P1.27mm_Vertical
J3	1	47352-1001	₱180.96	₱180.96	SamacSys_Parts:47352

					-1001
J4	1	i2c_lcd	₱0.00	₱0.00	Connector_PinSocket_1.27mm:PinSocket_1x06_P1.27mm_Vertical
L1 L3	2	1mH		₱0.00	Inductor_SMD:L_1206_3216Metric
L2	1	L_ant	₱0.00	₱0.00	
L4	1	22uH		₱0.00	Inductor_SMD:L_10.4x10.4_H4.8
LS1	1	CMI-1295IC-0585T	₱63.69	₱63.69	SamacSys_Parts:CMI1295IC0585T
Q1	1	BCW66HVL	₱9.10	₱9.10	SamacSys_Parts:SOT95P230X110-3N
R1	1	0	₱1.47	₱1.47	Resistor_SMD:R_0603_1608Metric
R11 R15 R14	3	1.2k	₱20.07	₱60.21	Resistor_SMD:R_0603_1608Metric
R13	1	10k	₱7.58	₱7.58	Resistor_SMD:R_0603_1608Metric
R16	1	2.2k	₱11.17	₱11.17	Resistor_SMD:R_0603_1608Metric
R18	1	330	₱5.71	₱5.71	Resistor_SMD:R_0603_1608Metric
R19	1	560	₱11.17	₱11.17	Resistor_SMD:R_0603_1608Metric
R21 R22 R20	3	4.7k	₱20.07	₱60.21	Resistor_SMD:R_0603_1608Metric
R5 R7 R8 R12 R3 R6 R10 R9 R4 R2 R17	11	1k	₱14.86	₱163.46	Resistor_SMD:R_0603_1608Metric
RV1	1	100k	₱164.28	₱164.28	Potentiometer_THT:Potentiometer_Bourns_3266W_Vertical
SW1	1	PB_1	₱19.97	₱19.97	Button_Switch_THT:SW_PUSH_6mm
SW2	1	PB_2	₱19.97	₱19.97	Button_Switch_THT:SW_PUSH_6mm
SW3	1	PB	₱19.97	₱19.97	Button_Switch_THT:SW_PUSH_6mm
SW4	1	PB_MCLR	₱19.97	₱19.97	Button_Switch_THT:SW_PUSH_6mm

U1	1	MFRC52201HN1,115	₱270.43	₱270.43	SamacSys_Parts:QFN50P500X500X100-33N-D
U10	1	BAT-HLD-001-THM	₱14.66	₱14.66	SamacSys_Parts:BATHLD001THM
U2	1	TP4056	₱25.00	₱25.00	Package_SO:SOP-8_3.9x4.9mm_P1.27mm
U3	1	BK-18650-PC4	₱64.00	₱64.00	BK-18650-PC4:18650-PC4
U4	1	MT3608	₱10.50	₱10.50	Package_TO_SOT_SMD:SOT-23-6
U5	1	MLX90614ESF-DCI-000-SP	₱2,234.73	₱2,234.73	SamacSys_Parts:MLX90614ESFDCI000SP
U6	1	PIC24FJ64GB002-I_SS	₱172.37	₱172.37	SamacSys_Parts:SOP65P780X200-28N
U7	1	ICL7673CBAZA	₱131.42	₱131.42	SamacSys_Parts:SOIC127P600X175-8N
U8	1	MAX31341CETB+	₱66.22	₱66.22	SamacSys_Parts:SON50P300X300X80-11N
U9	1	LM317_SOT-223	₱44.48	₱44.48	Package_TO_SOT_SMD:SOT-223-3_TabPin2
Y1	1	ABM11AIG-27.120MHZ-3Z-T	₱36.39	₱36.39	SamacSys_Parts:ABM11AIG27120MHZ3ZT
Y2	1	ECS-.327-9-34QN-TR	₱33.87	₱33.87	SamacSys_Parts:ECS327934QNTR
Total Cost				**₱4,460.24**	

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