PIC-1

Autonomous Inventory Checking

Project Specifications - v. 0.1

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2023/2024 – 2º Semester Group 36

1 General characteristics

1.1 Key Features

- RFID tag reader with BLE (Bluetooth Low Emission) connection to an external device
- UI via WebApp
- WebApp-reader connection via BLE through host
- 5V Supply Voltage
- Power Consumption under 10W (peak)
- Maximum range of 2m
- ISO18000-6C (EPC Gen2) protocol

1.2 Bill of Material

	Quantity	Description
AS3992 "ROGER" UHF RFID Reader System	1	RFID reader reader with an associated microcontroller, providing protocol support for ISO18000-6C
RF SOLUTIONS ANT-PCB4242-FL	1	UHF antenna with 50Ω impedance matching and MMCX connector
USB-A to mini-USB-B cable	1	
Avery Dennison RF100286 RFID Tags	10	UHF RFID EPC Gen 2 transponder tags
Raspberry Pi 4 Model B	1	Single-board computer with wireless LAN and Bluetooth connectivity
Raspberry Pi 4 power supply	1	
Female-Female jumper connectors	3	

1.3 System Description

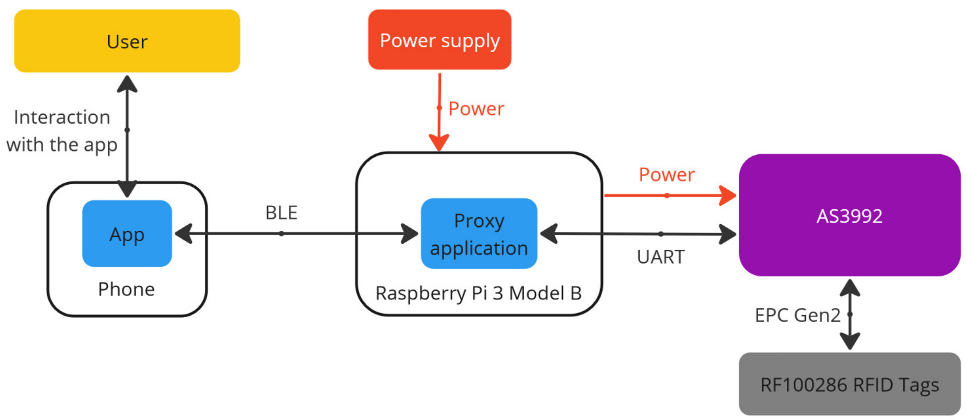

Figure 1: System Description block diagram

This system's goal is to allow easier inventory checking in closed-spaces using RFID tag detection. Using the Raspberry Pi 4 Model B as a host for the system, two data connections are established, one between the host and the AS3992 RFID Reader (via UART, with power been supplied via USB), and the second via BLE (Bluetooth Low Emission) with a smartphone, or any other device able to connect via BLE.

After a succesful BLE connection between the host and the phone, the user selects (through the WebApp) a list of items already logged into the server, and associate to an ID and to the serial number (EPC Gen 2) of the a certain tag. That list is sent to the host, who checks the input sent by the RFID reader. Then, a list of all detected tags is sent to the host, who will compare it with the list sent by the phone. The host will mark which items are detected and which are not, send that information to the phone, relaying that information to the WebApp, informing the user of any changes.

It is required that the system is connected at all times to a power supply, able to supply 5V, at peak 1A (5W).

2 Electrical characteristics

2.1 Electrical connections

Component	Connection
AS3992 UHF Reader	mini USB-B port → USB-A port, Raspberry Pi 4
	Tx → GPIO 15 (Rx$_d$0 - pin 10), Raspberry Pi
	Rx → GPIO 14 (Tx$_d$0 - pin 8), Raspberry Pi
	GND → GND (pin 25), Raspberry Pi
	MMCX antenna connector → RF SOLUTIONS ANT-PCB4242-FL
Raspberry Pi 4 Model B	USB-A port → mini USB-B port, AS3992
	GPIO 15 (pin 10) → Tx, AS3992
	GPIO 14 (pin 8) → Rx, AS3992
	USB-C → Power Supply (230V @ 50Hz)

2.2 Electrical specifications

Supply Voltage (V_s)	5V (maximum 6V)
Working power (peak)	8.4W
Working power (standby)	4.2W
Reading Distance	1.90m (max.)
Tag Protocol	ISO18000-6C (EPC Gen. 2)
Tag Area	60mm x 4mm
Working Frequency	(915 ± 3%)MHz
RF power	20dBm (0.5W) max.
RFID reader receive sensitivity	-86dBm ($2.51 \times 10^{-12} W$)
Minimum power supply requirements	5V @ 3A (15W)
Antenna Gain	5dBi @ 915MHz
Antenna Area	49.5mm x 49.5mm

3 Maximum Values

3.1 Maximum reading distance

The maximum reading distance can be found using the radar equation (or Friis formula)[1], giving:

$$P_r = A_{e_{Reader}} \cdot P_{back} \tag{1}$$

P_{back} and $A_{e_{Reader}}$ can be calculated using:

$$P_{back} = \frac{P_t \cdot G_{Reader} \cdot \sigma}{(4\pi r^2)^2} \tag{2}$$

$$A_{e_{Reader}} = \sigma \tag{3}$$

Where σ is the radar cross-section. For a $\lambda = \frac{c}{f} = 0.328m$ (with $f = 915MHz$), since there is antenna matching ($50\Omega@915MHz$), and $\sigma = \frac{4\pi A^2}{\lambda^2}$ ($\sigma_{tag} = 6.733 \times 10^{-6} m^2$), we get the final equation for the maximum distance[2]:

$$r_{max} = \left[\frac{P_{t_{antenna}} G_{antenna} A_{antenna} \sigma_{tag}}{(4\pi)^2 P_{r_{antenna_{min}}}} \right]^{\frac{1}{4}} = 1.90m \tag{4}$$

With $P_{t_{antenna}}$ being the peak RF power ($0.5W$), $P_{r_{antenna_{[min]}}}$ being the receive sensitivity ($2.51 \times 10^{-12} W$).

3.2 Peak and standby power consumption

The total power consumptions can be calculated by adding the individual power consumption of both the AS3992 and the Raspberry Pi, as defined in the datasheets and databases and benchmarks of usage[1]. As such, the peak power consumption is:

$$P_{peak} = P_{max_{AS3992}} + P_{max_{Raspberry}} = 2 + 6.4 = 8.4W \tag{5}$$

And the standby power consumption:

$$P_{standby} = P_{standby_{AS3992}} + P_{standby_{Raspberry}} = 1.7 + 2.5 = 4.2W \tag{6}$$

3.3 BLE maximum distance

For the maximum distance of the BLE connection, it

4 BLE communication protocol

The protocol used for describing the communication between the host and the BLE device (in the host side) is described by:

[1] As mentioned in https://www.pidramble.com/wiki/benchmarks/power-consumption

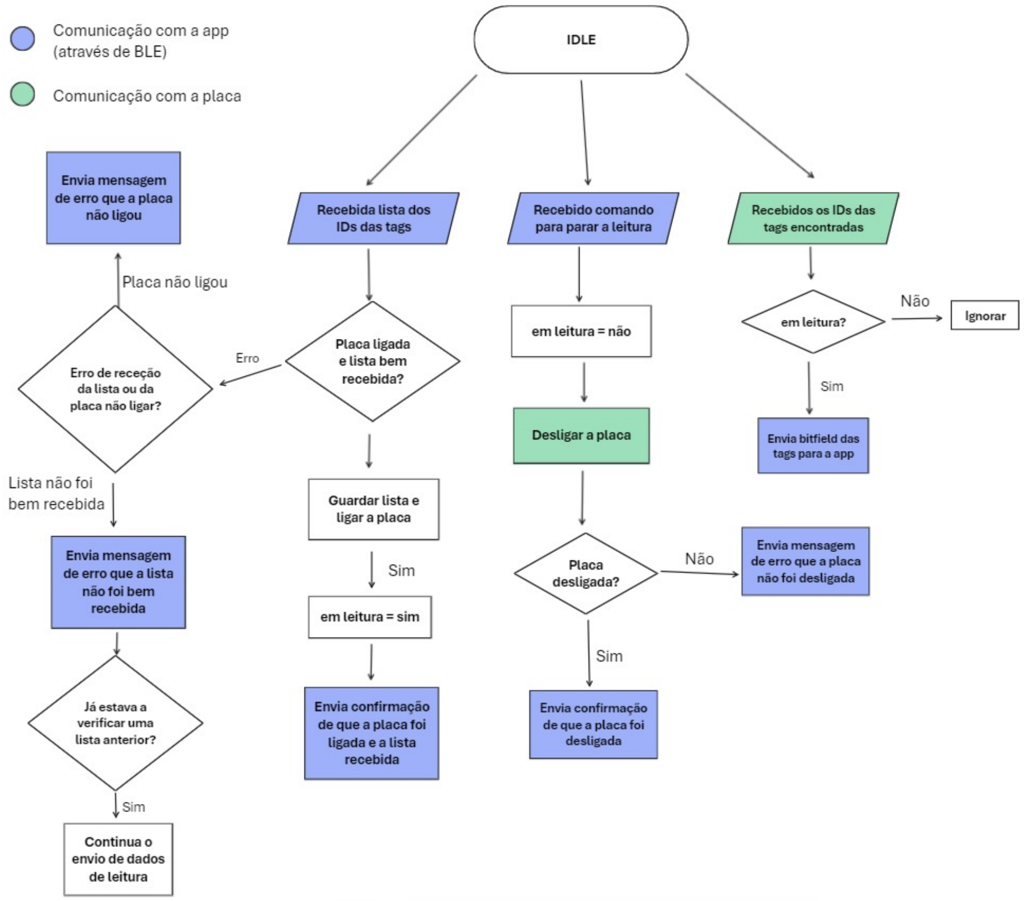

Figure 2: BLE algorithm fluxogram

References

[1] Klaus Finkenzeller. *RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communications.* Wiley and Sons, 3rd edition, 2010.

[2] Sophocles J. Orfanidis. *Electromagnetic Waves and Antennas.* Rutgers University, 1st edition, 1999.