

# Smart Parking Barrier System Proposal

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## 1. Project Overview

The Smart Parking Barrier System is an embedded automation project designed to control the access of electric vehicle (EV) charging areas. The system ensures that only authorized EV users can access charging spots, preventing unauthorized parking and increasing charging efficiency. The project is implemented on an STM32F407 Discovery microcontroller using CMSIS register-level programming. The system includes:

- RFID authorization (MFRC522 – SPI)
- Ultrasonic obstacle & vehicle detection
- Weight sensor (Load cell analog input)
- Servo-controlled automatic barrier
- ESP32 ESP-NOW wireless remote control
- OLED display (I<sup>2</sup>C)
- LED and buzzer indicators



Figure 1 Project Picture

The system supports the smart city concept and demonstrates real-world embedded system design integrating sensors, actuators, and communication modules.

## 2. System Architecture and Hardware Components

During power-up, the STM32 initializes all connected peripherals (RFID, ultrasonic sensor, servo, display, wireless module). The system enters **System Ready** mode until a vehicle approaches. If an RFID tag is authorized, the barrier opens automatically. Safety mechanisms such as obstacle detection and weight sensing ensure reliable operation. Wireless commands via ESP-NOW allow remote open/close operations.

This architecture demonstrates:

- Multi-protocol communication (SPI, I<sup>2</sup>C, UART, PWM, ADC)
- Real-time interrupt-based operation
- Modular and maintainable embedded software design

## 3. System Line Diagram

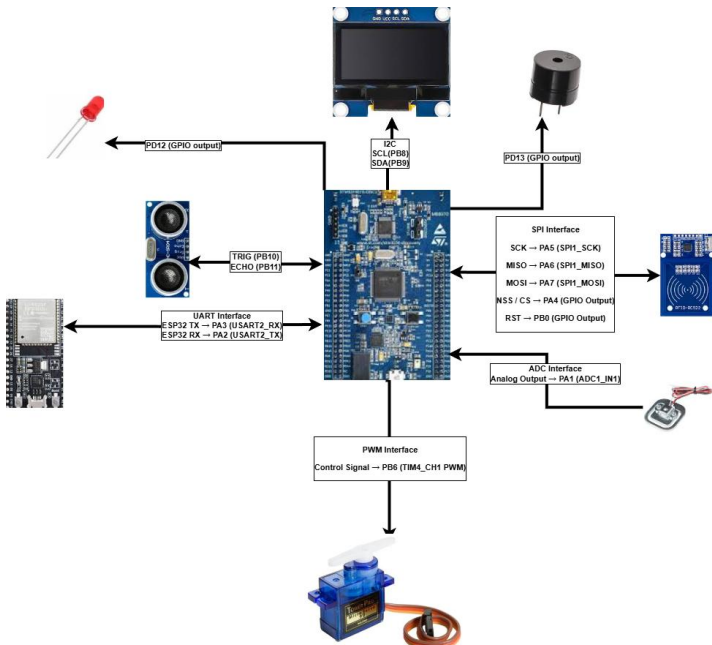


Figure 3 System Line Diagram

## 4. Hardware Components

Component	Function
STM32F407 Discovery	Main MCU, CMSIS-based embedded controller
RFID Reader (MFRC522)	User authentication via SPI
Ultrasonic Sensor (HC-SR04)	Vehicle distance & obstacle detection
Load Cell + Amplifier	Detects whether a car is parked (ADC)
ESP32 Module	Wireless ESP-NOW remote operation
OLED Display (SSD1306)	Status messages and system feedback
Servo Motor (SG90/MG90)	Controls the barrier movement
LED (PD12)	Status indicator
Buzzer (PD13)	Warning / notification sound

Figure 2 Hardware Components

Pin Mapping Table				
Peripheral	Pin(s) on STM32	Interface	Direction	Description
OLED Display	PB8 (SCL), PB9 (SDA)	I <sup>2</sup> C1	In/Out	System status display
RFID Reader (MFRC522)	PA5 (SCK) PA6 (MISO) PA7 (MOSI) PA4 (NSS / CS) PB0 (RST)	SPI1	In/Out	RFID authentication module
Ultrasonic Sensor	PB10 (TRIG) PB11 (ECHO)	GPIO + Timer	Out / In	Distance & obstacle detection
Load Cell (Analog)	PA1 (ADC1_IN1)	ADC	In	Vehicle presence via weight
ESP32 (Wireless)	PA3 (USART2_RX) PA2 (USART2_TX)	UART	In/Out	ESP-NOW communication
Servo Motor	PB6 (TIM4_CH1 PWM)	PWM	Out	Barrier control
LED	PD12	GPIO Output	Out	System indicator
Buzzer	PD13	GPIO Output	Out	Warning tone

Figure 4 Pin Mapping Table