

# "Microcontrollers Explained: Build a Legal WiFi Detector with ESP32"

## What is a Microcontroller?

### 1. Definition

A microcontroller is a small computer built into a single integrated circuit (chip). It contains:

- A processor (CPU)
- Memory (RAM and Flash)
- Input/Output (I/O) pins
- Communication modules (WiFi, Bluetooth, UART, etc.)

Unlike a desktop computer, a microcontroller is designed to control specific tasks inside electronic systems.

Examples used in this module:

- **ESP32** (by Espressif Systems)
- **M5Stack Core** (ESP32-based development kit by M5Stack)

### 2. What Does a Microcontroller Do?

A microcontroller:

1. Reads inputs (buttons, sensors, WiFi signals)
2. Processes data using programmed instructions
3. Controls outputs (LEDs, screens, motors)

In this project:

- The ESP32 scans WiFi networks
- It counts detected networks
- It turns on:
  - Green LED (Normal)
  - Yellow LED (Caution)
  - Red LED (Alert)

It is acting as a decision-making controller

### 3. Microcontroller vs Microprocessor

Feature	Microcontroller	Microprocessor
Purpose	Embedded control	General computing
Memory	Built-in	External required
Example	ESP32	Laptop CPU

Used in IoT devices, robotics, PCs, servers

Microcontrollers are used in:

- Washing machines
- Cars
- Smart TVs
- Medical devices
- IoT systems

### 4. Internal Components of ESP32

The ESP32 contains:

- Dual-core processor

- WiFi module
- Bluetooth module
- GPIO pins (General Purpose Input Output)
- ADC (Analog to Digital Converter)
- Flash memory

This makes it ideal for:

- Wireless detection
- Sensor monitoring
- Smart automation

## 5. Why ESP32 is Used in This Project

We use the ESP32 because:

- It has built-in WiFi
- It supports scanning nearby networks
- It can control LEDs
- It is affordable and educational
- It supports programming in Arduino IDE

Most importantly:

It performs PASSIVE detection only.

It does NOT transmit interference.

## 6. Step-by-Step: How the Microcontroller Works in This Project

1. Power is supplied through USB.
2. The program starts running.

3. WiFi scan begins.
4. Number of networks is counted.
5. Conditional logic checks thresholds.
6. LED color output is activated.
7. Process repeats every 5 seconds.

This is called a control loop.

## 7. Teaching Explanation (Instructor Notes)

When explaining to students:

- Compare a microcontroller to a “tiny brain” of a device.
- Explain that it follows instructions written in code.
- Emphasize embedded systems concept.
- Reinforce that detection is legal, jamming is illegal.

## Student Module

- **Wireless Interference Detection Project**
- **LEGAL NOTICE – DETECTION ONLY:** This module describes a wireless interference DETECTION system. It does NOT transmit signals and MUST NOT be modified into a jammer. Jamming communications is illegal in most countries and may result in severe penalties.

## What You Will Learn

- How WiFi scanning detects nearby networks.
- Difference between detection and illegal jamming.

- How LEDs/LCD provide status feedback.

## *Color Meaning*

- GREEN
- Normal wireless environment
- YELLOW
- Caution – increased signal activity
- RED
- Alert – strong interference detected

## *Lab Activity*

- Measure signal levels in 3 different locations.
- Record number of networks detected.
- Explain why results differ.

## *Worksheet Questions*

- Why is wireless jamming illegal?
- What does GREEN indicate?
- What environment produced RED? Why?
- How can interference affect communication systems?

# **Experiment Activity**

**LEGAL NOTICE:** This project is a WIRELESS JAMMING DETECTOR ONLY. It is designed strictly for legal spectrum monitoring and educational purposes. It DOES NOT transmit interference and MUST NOT be modified into a jammer. Jamming communications is illegal in most countries and punishable by law.

### **Discussion Questions**

- What is wireless interference?
- Why is jamming illegal?
- How does WiFi scanning detect activity?
- What does each color represent?

*Wireless Jamming Detection (LEGAL DETECTOR ONLY)*

**LEGAL NOTICE – DETECTION ONLY:** This module describes a wireless interference DETECTION

system. It does NOT transmit signals and MUST NOT be modified into a jammer.  
Jamming

communications is illegal in most countries and may result in severe penalties.

### Course Objectives

- Explain wireless interference vs illegal jamming.
- Demonstrate safe WiFi spectrum monitoring.
- Build ESP32 and M5Stack detection systems.
- Interpret signal thresholds using LED/LCD alerts.

Color Alert System GREEN Normal wireless environment

YELLOW Caution – increased signal activity RED Alert – strong interference  
detectedPlatform Option 1 – ESP32

Materials: ESP32 board, 3 LEDs (Green/Yellow/Red),  $220\Omega$  resistors, breadboard, jumper wires.

GPIO 25 → Green ,LED →  $220\Omega$  → GND ,GPIO 26 → Yellow ,LED →  $220\Omega$ , →  
GND GPIO 27 → ,Red LED →  $220\Omega$  → GND

```
#INCLUDE <WIFI.H>
INT G=25,Y=26,R=27;
VOID SETUP(){
PINMODE(G,OUTPUT); PINMODE(Y,OUTPUT); PINMODE(R,OUTPUT);
WIFI.MODE(WIFI_STA);
}
VOID LOOP(){
INT N=WIFI.SCANNETWORKS();
IF(N>5){DIGITALWRITE(R,1);DIGITALWRITE(Y,0);DIGITALWRITE(G,0);}
ELSE IF(N>2){DIGITALWRITE(Y,1);DIGITALWRITE(R,0);DIGITALWRITE(G,0);}
}
```

```
    ELSE{DIGITALWRITE(G,1);DIGITALWRITE(R,0);DIGITALWRITE(Y,0);}  
    DELAY(5000);  
}
```

## Teacher Guide & Assessment

LEGAL NOTICE: This project is a WIRELESS JAMMING DETECTOR ONLY. It is designed strictly for legal spectrum monitoring and educational purposes. It DOES NOT transmit interference and MUST NOT be modified into a jammer. Jamming communications is illegal in most countries and punishable by law. Teaching Guide Emphasize that this is a detection-only project. Review spectrum laws in your country. Never demonstrate or simulate jamming.

## Assessment Rubric

- Correct circuit assembly (25%)
- Successful code upload (25%)
- Accurate data recording (25%)
- Understanding of legal implications (25%)