Project Report: Wireless Power Receiver with ESP32 Integration

1. Introduction

This project focuses on developing a wireless power receiver using the BQ51050B IC and an ESP32 microcontroller. The system is designed to receive power wirelessly, monitor its parameters, and communicate status to a host controller. Key functionalities include power monitoring, over/under voltage alerts, and thermal management.

2. Objectives

1. Implement a wireless power receiver circuit capable of delivering 5W-15W.
2. Integrate the ESP32 microcontroller to monitor power, temperature, and charging status.
3. Provide alerts for power anomalies and ensure efficient communication.

3. Schematic Overview

Key Components:

1. IC (BQ51050BRHL):

The BQ51050BRHL was chosen for its integration of a wireless power receiver and a battery charger, simplifying the design and reducing external components. Its compliance with the Qi standard ensures compatibility with common wireless chargers, while features like foreign object detection (FOD), overvoltage protection, and thermal monitoring provide safety and reliability. The IC’s power range of up to 15W aligns perfectly with the project requirements, and its efficient power management capabilities make it ideal for pairing with the ESP32 microcontroller.

2. Coil (Würth Elektronik 760308101):

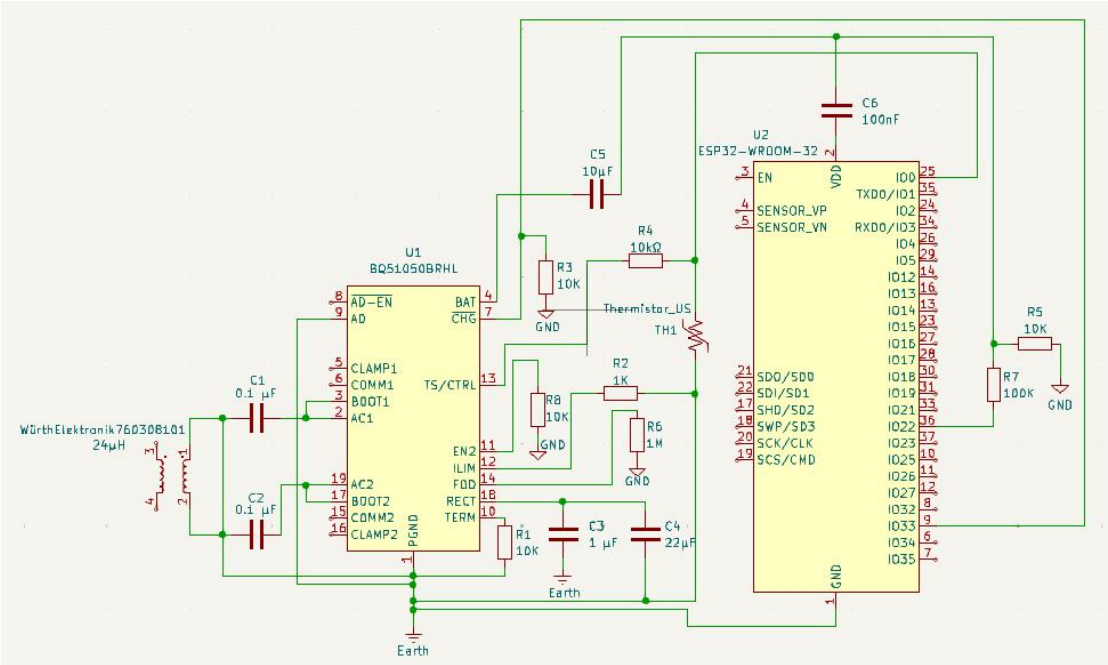
The Würth Elektronik 760308101 wireless power receiver coil was selected for its inductance of 24 µH, which meets the IC’s recommended range. Its compact size, low resistance, and high Q-factor make it efficient for power transfer, ensuring optimal performance in this application.

3. ESP32-WROOM-32:

The ESP32-WROOM-32 microcontroller was chosen for its dual-core processor, built-in Wi-Fi and Bluetooth capabilities, and low power consumption. Its versatility in interfacing with sensors and the BQ51050B, combined with its robust GPIO configuration, makes it ideal for monitoring and control in the wireless power receiver system.

Schematic Diagram:

Refer to the attached schematic for detailed connections.



4. Component Selection(Specifications)

A. IC: BQ51050BRHL

- **Functionality**: Qi-compliant wireless power receiver with integrated Li-Ion/Li-Polymer battery charger.
- **Input Voltage Range**: 4.5V to 10V (AC input).
- **Output Voltage**: 4.2V (regulated for battery charging).
- **Output Current**: Up to 1.5A (programmable via ILIM resistor).
- **Features**: Foreign object detection (FOD), thermal protection, overvoltage protection, integrated rectification, and dynamic efficiency optimization.
- **Applications**: Wireless charging for portable devices and battery-operated systems.

B. Coil: Würth Elektronik 760308101

- **Inductance**: 24 µH
- **DC Resistance**: 0.2 Ω
- **Current Rating**: Suitable for up to 5W-15W power range.
- **Compatibility**: Verified to meet the specifications of the BQ51050B datasheet.

C. ESP32-WROOM-32

- **Processor**: Dual-core Xtensa LX6, clocked up to 240 MHz.
- **Memory**: 520 KB SRAM, 16 MB flash storage (variant dependent).
- **Connectivity**: Wi-Fi (802.11 b/g/n) and Bluetooth (v4.2, BR/EDR/LE).
- **Operating Voltage**: 3.3V.
- **GPIO Pins**: 34, supporting ADC, DAC, UART, I2C, SPI, PWM, and capacitive touch.
- **ADC Resolution**: 12-bit, up to 18 channels.
- **Applications**: IoT devices, wireless monitoring, and control systems.

D. Passive Components:

- Resistors and capacitors selected based on the BQ51050B datasheet recommendations for stable operation.

5. Software Implementation

Code Overview:

A. Header File: PowerReceiver.h

Defines constants, pin mappings, and function prototypes.

B. Source File: PowerReceiver.cpp

Implements functionality for:

1. Pin initialization
2. Battery voltage and thermistor readings
3. Charge status monitoring
4. Power range checking and alert handling

C. Test File: TestCode.ino

Runs the main loop to:

1. Monitor power and temperature
2. Display status on the serial monitor
3. Trigger alerts for power anomalies

Key Functionalities:

1. **Battery Voltage Monitoring**: Uses ADC on IO22 with a voltage divider.
2. **Temperature Monitoring**: Reads thermistor voltage via IO0.
3. **Charge Status**: Reads CHG pin status on IO33.

Sample Output:

```
============================
Battery Voltage: 3.7 V
Thermistor Voltage: 0.85 V
Charge Status: Charging
Received Power: 7.4 W
============================
```

6. Simulation Status

Due to a number of constraints, a complete simulation of the circuit was not done. Firstly, in the KiCAD library, there isn't a SPICE model simulation for this BQ51050B IC. Once again, no suitable SPICE file for that kind of IC was found online. Therefore, it will be very challenging to make good wireless power receiver simulation using the same. Also, all other circuit simulation software either lacked compatibility or support for advanced features of the BQ51050B IC, further limiting options for simulation. In this regard, I tested ESP32 code internally by using default values in order to simulate expected inputs from the IC. This would at least ensure that the firmware is tested for functionality, although a complete simulation of the circuit is not possible.