SmartButton Electrical Design Description

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1. Introduction

This document aims to elaborate on the electrical design of the SmartButton project. The SmartButton is a low-power Bluetooth smart button device based on the Nordic Semiconductor nRF52840 System on a Chip (SoC). This device is designed to provide users with a convenient and customizable wireless control method through Bluetooth communication. This document will provide a comprehensive analysis and explanation of the circuit design based on the project's schematic diagram.

2. System Overview

The core of the SmartButton is an nRF52840 microcontroller that integrates an ARM Cortex-M4F processor and a 2.4 GHz radio. The entire system design revolves around this core controller, including power management, clock circuits, user interaction interfaces (buttons and LEDs), and interfaces for firmware programming and debugging. In addition, the design includes a set of configuration pins to differentiate the device's different operating modes at the firmware level.

The following table summarizes the main components of the system and their functions:

Component	Model/Specification	Function Description
Main Controller (MCU)	Nordic nRF52840	The core of the system, responsible for handling all logic, communication, and I/O control.
Power Management	Power Protection Circuit	Prevents reverse polarity and undervoltage.
Clock Circuit	32.768kHz Crystal	Provides a low-frequency clock source for the MCU, used for the Real-Time Clock (RTC) and low-power modes.
User Input	Mechanical Buttons	Provides multiple physical buttons for users to trigger

		specific operations.
User Feedback	LED Indicators	Provides feedback to the user on the device's status through different colored LED lights.
Debugging Interface	SWD (Serial Wire Debug)	Provides a Serial Wire Debug interface for firmware programming and debugging.

3. Detailed Circuit Design

3.1. Main Controller (MCU)

The core of the circuit is U1, a Nordic nRF52840 Bluetooth SoC. This chip, in a 64-pin QFN package, integrates powerful processing capabilities and a rich set of on-chip peripherals. Its main functions and connections are as follows:

- **Processor Core:** ARM Cortex-M4F, providing the device with sufficient computing power to run complex applications and the Bluetooth protocol stack.
- **Wireless Communication:** The built-in 2.4 GHz radio supports the Bluetooth Low Energy (BLE) protocol, ensuring reliable communication between the device and other Bluetooth devices.
- **GPIO:** A large number of general-purpose input/output pins are used to connect buttons, LEDs, and other external components.
- **Analog Interface:** Some pins (such as P0.28-P0.31) are configured as analog inputs for functions like voltage detection.
- **Debugging and Programming:** Through the SWDIO and SWCLK pins, the chip can be debugged online and its firmware can be updated.

3.2. Power Supply Design

The device's power system is designed to be simple and efficient. The power is primarily supplied from the USB bus power V_BUS_NRF, which is filtered to provide a stable 3.3V operating voltage (V3V) for the system.

- **Filter Capacitors:** Multiple capacitors (C19, C20, C21) are used in the circuit to filter the power supply, ensuring a clean and stable power supply for the nRF52840. Among them, C19 (10uF) and C20 (0.1uF) are a typical decoupling capacitor combination used to filter out power supply noise at different frequencies.

3.3. Clock Circuit

To achieve precise timing and low-power operation, the system uses an external 32.768kHz crystal oscillator, B1. This crystal is connected to the XTAL1 and XTAL2 pins of the nRF52840 and is equipped with two 12pF load capacitors (C22, C23) to ensure stable startup and accurate frequency output of the oscillator. This low-frequency clock

is crucial for the sleep management of the Bluetooth protocol stack and the low-power standby of the device.

3.4. Input/Output Interfaces

3.4.1. Button Input

The device provides multiple physical buttons, including BTN_SET, BTN_PAIR, BTN_CHANNEL, BTN_STOP, BTN_UP, and BTN_DOWN. These buttons are directly connected to the GPIO pins of the nRF52840. By configuring the internal pull-up or pull-down resistors, the firmware can detect the press and release events of the keys, thereby triggering the corresponding functions.

3.4.2. LED Indication

Four LED indicators (LED1_GREEN, LED2_GREEN, LED1_RED, LED2_RED) are used to provide visual feedback to the user. These LEDs are also driven by the GPIO pins of the nRF52840 and can display the device's pairing status, battery information, or operational feedback.

3.4.3. Debugging Interface

A 6-pin connector, J2, provides a standard Serial Wire Debug (SWD) interface. Through the DBG_SWDIO and DBG_SWCLK signal lines, developers can connect a debugger (such as a J-Link) to the device for firmware programming, code debugging, and performance analysis.

3.5. Configuration Pins

The schematic specifically marks a set of jumper pins: SET, PAIR, CHANNEL, STOP, MODE, 5V_DET. These pins are set to different logic levels in hardware through pull-up or pull-down resistors. When the firmware starts, it reads the status of these pins to identify whether the current device should operate as a "remote control" or a "button" device, thus realizing the design idea of a single hardware platform supporting multiple product forms.

4. Conclusion

The electrical design of the SmartButton is a highly integrated, low-power solution centered on the nRF52840 SoC. This design meets the functional requirements while also considering cost-effectiveness and manufacturability. The simple power management, reliable clock circuit, and flexible I/O configuration together form a stable and powerful hardware platform. The SWD interface facilitates firmware development and iteration, while the design of the configuration pins provides a hardware basis for product diversification. Overall, this design solution is mature and reliable, and can meet the market demand for smart button products.

References:

[1] SmartButton Schematics, PCB-000051PCB-BUTTONRev.B_Schematics.pdf, RYSE Inc., 2024.03