📡 Embedded System Design Report

STM32G030F6P + nRF24L01+ + MAX30102

> This report outlines the hardware configuration, software setup, and communication protocol design for a low-cost embedded system that collects biometric data and transmits it wirelessly using a minimal BOM design approach.

🔧 Project Components

1. STM32G030F6P6

- **Core**: ARM Cortex-M0+ @ 64 MHz
- **Flash**: 32 KB
- **RAM**: 8 KB
- **Package**: TSSOP20
- **Oscillator**: Internal HSI RC oscillator used (no external crystal)

2. nRF24L01+

- **Wireless transceiver** operating at 2.4 GHz
- Interface: **SPI**
- Application: Wireless data transmission to another node
- 📄 Datasheet
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3. MAX30102

- Integrated **pulse oximetry** and **heart-rate sensor**
- Interface: **I2C**
- 📄 Datasheet

🔌 Peripheral Configuration

SPI Interface (for nRF24L01+)

- **Clock speed**: 64 MHz system clock
- **Prescaler**: 8
- **SPI Speed**: 8 MHz
- Chosen for high-speed communication while staying within the nRF24L01+ supported SPI limits (~10 MHz max)

I2C Interface (for MAX30102)

- Internal **pull-up resistors** used in software
- **Clock speed**: 100 kHz
- MAX30102 I2C address (default): `0x57`

🛠️ I2C Pull-Up Problem and Solution

📍 Problem

I2C lines are **open-drain** and require pull-up resistors to define a logical HIGH state. Without them, the lines float, resulting in:

- Signal integrity issues
- Unstable or failed communication
- NACKs or device lockups

🧪 Solutions

Type	Description
Hardware	Use **external pull-up resistors** (2.2kΩ–10kΩ) — standard and recommended for production
Software	Enable **internal STM32 pull-up resistors** via GPIO settings — acceptable for prototyping

✅ **Chosen Approach**:

> Used the **software/internal pull-up resistors** for I2C in this prototype stage.
> Given the **short trace lengths** and **low-speed (100 kHz)** bus, this approach is functionally stable for now.
> However, **external pull-ups are recommended for final PCB** to ensure noise immunity and stronger drive capability.

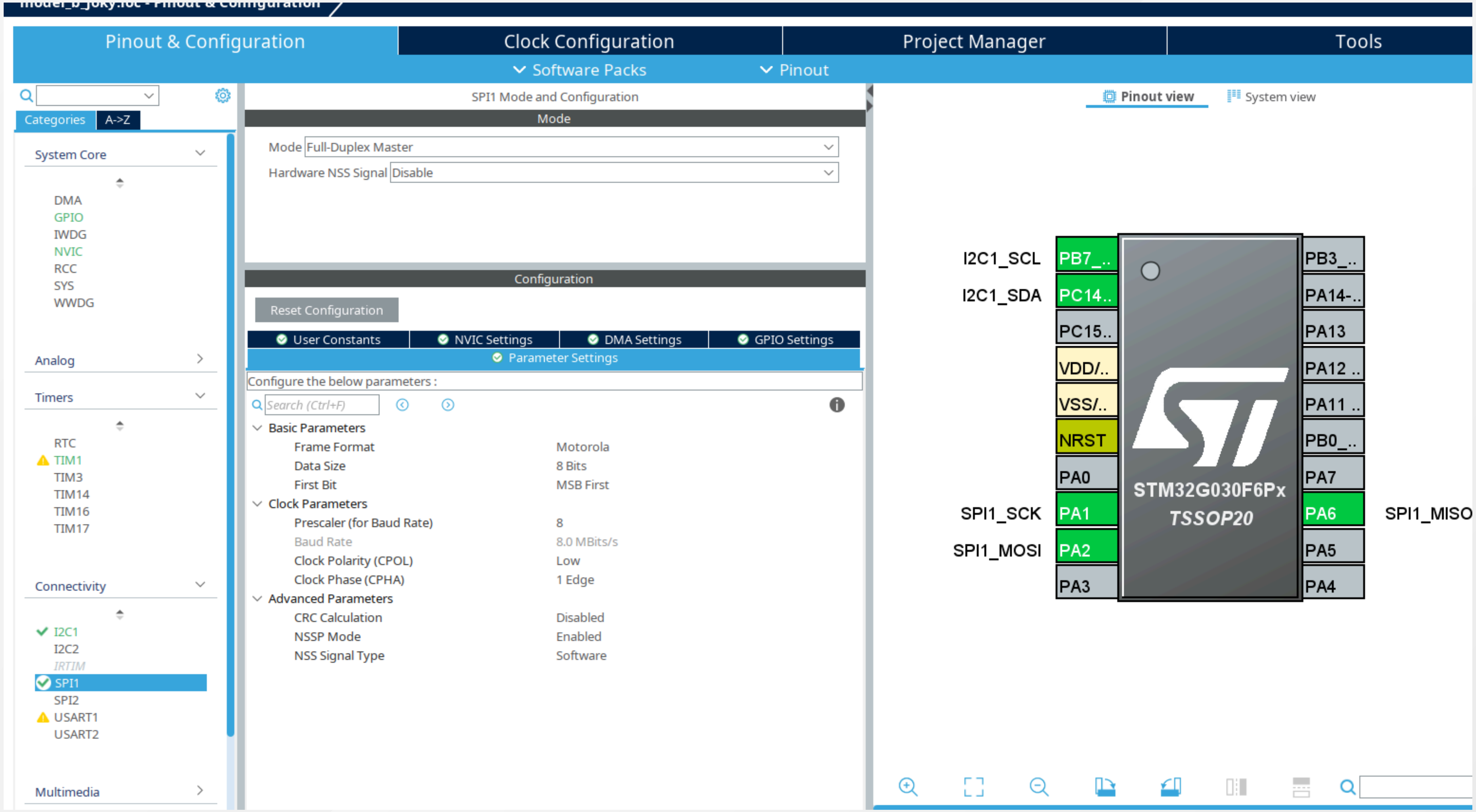
🕒 Clock Configuration

- **System Clock Source**: Internal HSI (High-Speed Internal RC oscillator @ 64 MHz)
- **External Crystal**: ❌ **Omitted**

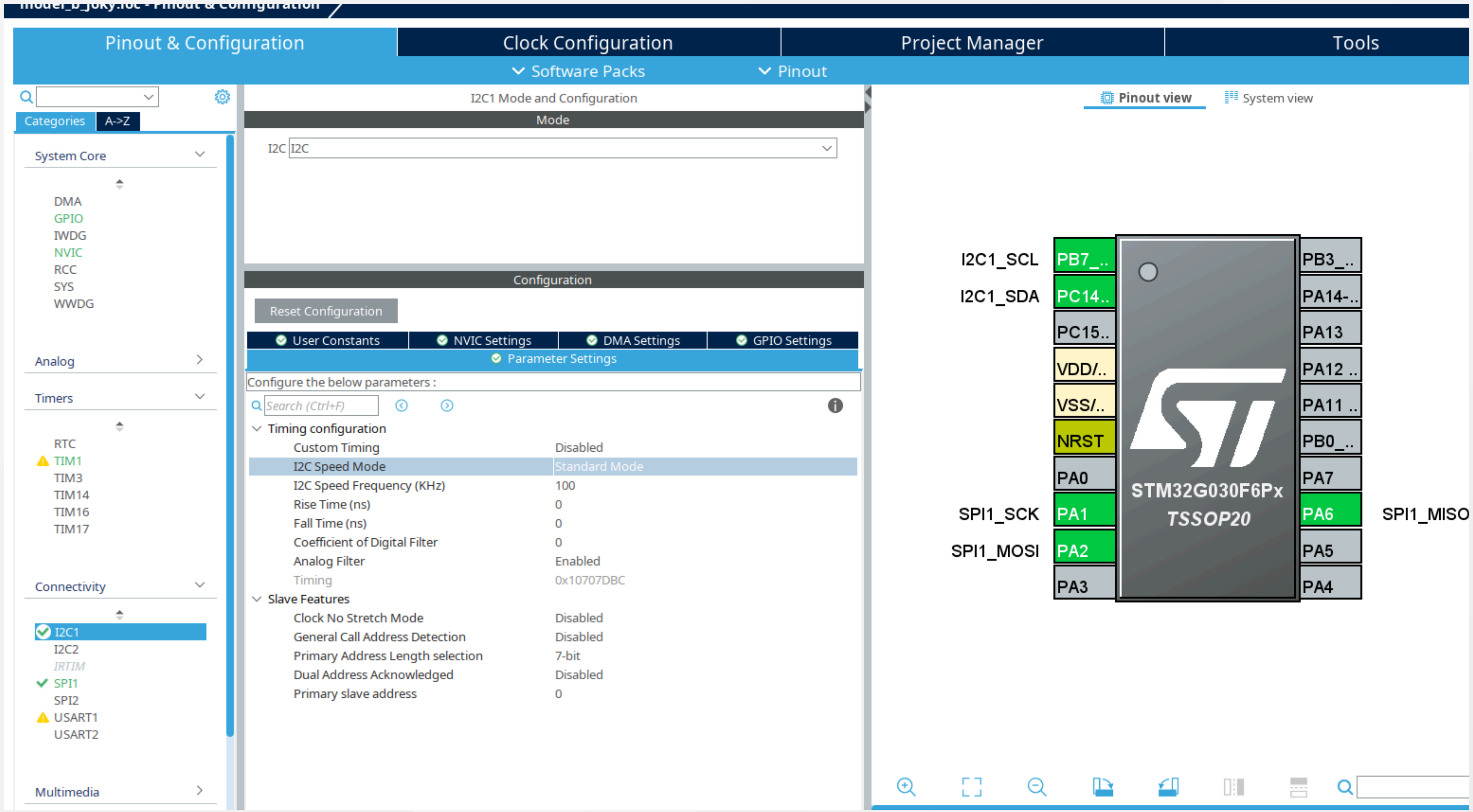
> Decision made to **reduce component count** and simplify PCB layout.
> For this application (SPI at 8 MHz and I2C at 100 kHz), the **internal RC oscillator provides sufficient timing accuracy**.
> If wireless timing drift or USB support is needed later, we can revise and add a crystal.

Configuration Screenshots

STM32CubeMX: SPI Configuration (nRF24L01)



STM32CubeMX: I2C with Internal Pull-Up (MAX30102)



💰 Bill of Materials (BoM)

Estimated Hardware Cost for 1 Unit

Component	Part Number	Quantity	Unit Price (USD)	Total (USD)
MCU	STM32G030F6P6	1	$0.60	$0.60
Wireless Module	nRF24L01+	1	$1.20	$1.20
Sensor	MAX30102	1	$2.80	$2.80

🧾 **Total Estimated Cost (Prototype)**: **~$x.xx**

END Conclusion

This embedded setup is designed for **wireless transmission of heart rate and temperature data** using a cost-effective and low-power solution:

- STM32G030F6P runs at 64 MHz using its **internal HSI** oscillator
- Communicates wirelessly using **nRF24L01+** over SPI @ 8 MHz
- Collects health data via **MAX30102** over I2C with **internal pull-ups**

The design is optimized for:

- Low BOM cost
- Simple PCB layout (no external crystal or I2C resistors)
- Wireless + biometric sensing

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