# Sparrow Design Requirements

Sparrow is the name of a set of products intended to enable a developer to explore the use of the Notecard as a gateway, operating in conjunction with a cluster of minimalist LoRa-based ‘sensor nodes’ based on the STM32WL integrated MCU/Radio.

In this document, “Sparrow Sensor” refers to a very simple product that generally contains only the STM32WL and a simple sensor, such as a temperature sensor or motion detector, with some sort of battery and antenna.

One or many Sparrow Sensors will then communicate with a “Sparrow Gateway”, which again contains at a minimum an STM32WL and a Notecard, again with some sort of line power and antennas.

The purpose of this project is to produce the following deliverables:

1. A core “Sparrow Board” that acts as the radio and MCU for both the Sparrow Sensor and the Sparrow Gateway. We’re opting for this design so that we can make investments with Fractus/Ignion on a top-notch RF design that will work in both. This Sparrow Board has numerous components that can be populated or depopulated for different purposes. The core functions of this board that may not be depopulated are:
   1. STM32WL (TOP)
   2. Low-profile DIP switch enabling selection of frequency band (TOP)
   3. Antenna, with good sized ground plane and antenna matching network (TOP)
   4. 3V3 Regulator with 1.8v-5.5v input, with voltage level monitoring (TOP)
   5. 2 rows of twelve 0.1” holes and castellations used to access all functions (THRU)
   6. CONTROLS: Three LEDs and a PB-SKRPADE010 Button used for pairing and activity monitoring (DUAL)
   7. PCB form factor is designed precisely to fit deeply inside the deep cover of the Takachi TWF5-3-9W (datasheet page 3 “recommended PCB design”)
2. Multiple ‘personalities’ of this Sparrow Board are populated differently. (If something is not mentioned, it means that it is not populated.)
   1. Sparrow Core Board (offered in our store with 100 MOQ)
      1. CONTROLS (top)
   2. Sparrow Essentials Board (offered in our store)
      1. CONTROLS (TOP)
      2. FTSH105-01-F-DV-K-P-TR connector plus PB-SKRPADE010 RESET and BOOT buttons (TOP)
      3. JST-PH 2 vertical LiPo jack (TOP)
      4. Keystone 3034 Coin Cell Battery jack (BOT)
      5. ­­Qwiic connector for I2C (TOP)
      6. 4UCON Short Female Headers (BOTTOM / THT)
   3. Sparrow Reference Sensor Board
      1. CONTROL (BOT)
      2. FTSH105-01-F-DV-K-P-TR connector plus PB-SKRPADE010 RESET and BOOT buttons (BOT)
      3. Keystone 2468 Dual-AAA Battery Pack (BOT)
      4. ­­PYQ1548/7659 Motion Sensor (TOP / THT)
      5. BME280 Temp/Humid Sensor (TOP)
3. A “Sparrow Reference Sensor” that is a Sparrow Reference Sensor Board packaged as a *final product* that can be used as either a low power temperature sensor or motion detector. The packaging is a Takachi TWF5-3-9W enclosure. This would be offered in our store.
4. A core “Sparrow Gateway Board” acts as the gateway for these sensors, and
   1. The board’s dimensions are designed so it fits on the back side of the cover of the Takachi WSC10-14-5W enclosure.
   2. Sparrow Essentials Board plugs into 4UCON short male headers, powered by the LiPo battery, and is secured with dual snap-lock spacers such as the Keystone 8890
   3. On the rear of the board are duplicates of the Button and Red, Blue, and Green indicators, so that they can be viewed through a laser-cut front panel of the enclosure.
   4. A Notecarrier design derived from the Notecarrier-AL, but with no GPS antenna or LNA, using the Fractus antenna, with the Solar LiPo charger replaced by a less expensive generic chip with a yellow Charge LED, and with a vertically-mounted USB connector. The LiPo charger should route to the 18650 battery and also to a JST-PH 2 pin LiPo jack, so that the developer can choose which one they wish to use.
   5. Keystone 54 secure dual-clips for an 18650 LiPo battery
   6. A five-pin male header on the edge marked 3V3 EN GND TX RX which expose the AUX-EN, AUX-TX, AUX-RX functions of the Notecard for debugging and expansion, with a shunt jumper preinstalled between AUX-EN and GND.
5. A “Sparrow Reference Gateway” is a *final product* that can be used as a gateway for Sparrow Sensors. It would be offered in our store, and comes with
   1. Takachi WSC10-14-5W enclosure, modified via laser-cut so that the front panel has the PAIR button and the PAIR, RX, and TX LEDs. Also, on the rear is the Micro USB.
   2. A Sparrow Gateway Board mounted to the rear of the cover
   3. A Notecard NOTE-WiFi Notecard
   4. An 18650 LiPo battery
   5. A Micro USB panel mount extension cable that is an inexpensive generic equivalent of the Adafruit 3258 (but which clears the 18650 on the inside) with the USB flat side up.
   6. A generic 5V Micro USB AC Adapter of at least 1A
6. A “Sparrow Development Kit” contains
   1. 2 Sparrow Reference Sensors
   2. 1 Sparrow Reference Gateway
   3. 6 Sparrow Essentials Boards
   4. 1 Sparrow Gateway Board with four rubber feet so that the button on the rear of the board doesn’t touch the desk
   5. 1 NOTE-NBGL for the Sparrow Gateway Board
   6. 7 inexpensive LiPo batteries (the one in the Airnote?), one for each Sparrow Essentials Board and one for the Sparrow Gateway Board
   7. 1 STLINK-V3 MINI for debugging and loading firmware
   8. 1 FTDI TTL-232R-RPI serial cable for viewing debug output
   9. 1 small package male-to-male header jumpers for connecting the FTDI cable to the female headers of the sensor, consisting of either a full or partial bag of the equivalent of Sparkfun PRT-14284

# Design Notes for Sparrow Board

1. **PCB LAYOUT**

The starting point for the Sparrow Board is twofold. First, the conceptual design is taken from The Things Industry’s Generic Node. I would suggest that you start out with the basic layout of the STM32WL, the entire HI/LO power matching networks, the matching network for the Fractus antenna, the power supply, and the antenna. We will not be using their secure element, accelerometer, temp/humidity sensor, NOR flash.

<https://github.com/TheThingsIndustries/generic-node-se/tree/develop/Hardware/sch>

<https://github.com/TheThingsIndustries/generic-node-se>

<https://thethingsindustries.github.io/generic-node-docs/hardware/se-board/>

Our board will be larger, of course, because the Fractus people strongly recommended doing so for performance reasons. We’ll also use the 4UCON short headers, which are 0.1” headers but which are much shorter than usual. (These are the headers we’re now using on Notecarrier-AL.)

Note that although the Things Network design allows either internal or external antenna and has a u.FL, we do not need this. We only want it to support the internal Fractus antenna.

1. **STM32**

All of my software development has been done by using the Nucleo-WL55JC1, and you will find the reference and the schematics for both the Nucleo and the STM32 in the Sparrow repo “datasheets” folder. There are also some immensely interesting documents with RF design hints.

Note that we will be using the UFQFPN48 version of the STM32WL. Knowing that there may be availability issues, we can feel free to use any of these four chips which will work interchangeably:

<https://octopart.com/search?q=STM32WLE5CCU6>

<https://octopart.com/search?q=STM32WLE5CCU7>

<https://octopart.com/search?q=STM32WL55CCU6>

<https://octopart.com/search?q=STM32WL55CCU7>

This is very minor, but repeating what we learned on the Notecard, please connect the STM32 VBAT pin to VDD with a 100nF decoupling capacitor, and connect VDDA to VIO.

1. **FREQUENCY SELECTION**

The LoRa technology operates in different frequency bands in different parts of the world. I do not want to have a different software build or configuration on a per-region basis, which is difficult to maintain, and so I created firmware that automatically senses the band to use by using a DIP switch connected to the lines RFSEL\_0 through RFSEL\_3. Please design the board with a very low-height 4-position switch such as CTS 218-4LPSJ. (See Datasheets folder.)

But also, in parallel with this switch, please design the PCB so that if I wish to omit the switch I can install 0R resistors for a set of boards being manufactured for a specific region.

1. **ANTENNA**

I worked with Fractus to determine the correct antenna to use, and we have already negotiated pricing with them. Do not use the one on the Things Industries board, but instead use the Fractus NN02-224 part (see the Datasheets folder). After you complete your first pass at the layout we will resume the Fractus engagement and will have them review and make recommendations about matching network and layout revisions.

1. **POWER SUPPLY**

I like their RP605 and its operating parameters, so let’s use this. However, instead of running at 2V8 as they do (I don’t know why), run it instead at 3V3 by using the RP605Z333B. (See doc in the Datasheets folder in repo.) Unlike the Things Industries design where they have a GPIO to control battery monitoring, tie CE2 to VOUT and tie BM to B\AT\_ADC. Given that the battery monitoring takes 100nA and the STM32 still takes more than 3uA in STOP2, I think it's probably ok to leave \it connected.

1. **USER CONTROLS**

For BUTTON1 use PB-SKRPADE010. Note that the LEDs must be ordered RED ("TX"), GREEN ("RX"), BLUE ("PAIR"), BUTTON ("PAIR"), or exactly the reverse. On the gateway where there is a charging LED, use a yellow that must be distinguishable from green. Where the Red, Green, and Blue LEDs are present, please make sure that the brightness of LEDs is roughly comparable. For economy reasons please drive LED’s directly off of GPIOs rather than adding mosfets.

1. **SENSORS**

There are two sensors to be mounted in one of the SKUs. You’re already familiar with the BME280 and I only selected it so we use a part that we will stock.

However, I am also using an extremely low-power PIR sensor as a motion detector. I have already acquired, prototyped, and have written the firmware for this exact sensor.

The sensor part number is the Excelitas PYQ1548/7659 and the docs are in the Datasheets folder.

This is a THT sensor, and so please make sure it is positioned so that it can be installed on the front even when the battery pack is mounted. I also believe it is smart to put the BME280 immediately next to it so that a single hole can be drilled that provides air flow and sensor visibility.

BME280 should be powered by PA5. The PYQ should be 3V3-powered and should use PA6 for the SERIAL\_IN pin and PA7 for the DIRECT\_LINK pin.

1. **HEADER PINOUTS**

We will be using two sets of 12 short 0.1” headers on either side of the board, centered. When I refer to “left” or “right” I am referring to what the board looks like when the antenna is on top.

|  |  |
| --- | --- |
| Left Edge | Right Edge |
| LPTX (LPUART1\_TX)  LPRX (LPUART1\_RX)  <RED (LED\_RED)  <GRN (LED\_GREEN)  <BLUE (LED\_BLUE)  >BTN# (BUTTON1)  <VIO  SWCLK  SWDIO  BOOT  RST#  GND | (USART1\_TX) TX  (USART1\_RX) RX  (I2C2\_SCL) SCL  (I2C2\_SDA) SDA  (SPI1\_MISO) MISO  (SPI1\_MOSI) MOSI  (SPI1\_SCK) SCK  (SPI1\_CS) CS  A3  A2  A1  (no diode protection – INPUT/OUTPUT) VBAT |

1. **STM32 PINS & NET NAMES**

PB3 1 NET: RFSEL\_0

PB4 2 NET: BAT\_ADC

PB5 3 NET: RFSEL\_1

PB6 4 NET: USART1\_TX

PB7 5 NET: USART1\_RX

PB8 6 NET: RFSEL\_2

PA0 7 NET: BUTTON1

PA1 8 NET: LED\_BLUE

PA2 9 NET: LPUART1\_TX

PA3 10 NET: LPUART1\_RX

PA4 12 NET: SPI1\_CS

PA5 13 NET: SPI1\_SCK

PA6 14 NET: SPI1\_MISO

PA7 15 NET: SPI1\_MOSI

PA8 16 NET: FE\_CTRL1

PA9 17 NET: FE\_CTRL2

PB2 31 NET: A1

PB12 32 NET: LED\_GREEN

PA10 33 NET: FE\_CTRL3

PA11 34 NET: I2C2\_SDA

PA12 35 NET: I2C2\_SCL

PA13 36 NET: SWDIO

PC13 38 NET: RFSEL\_3

PA14 42 NET: SWCLK

PA15 43 NET: LED\_RED

# Reference with 3D Design Docs

Takachi TWF5-3-9W

<https://www.takachi-enclosure.com/products/TWF>

<https://www.takachi-enclosure.com/assets/attachments/images/TWF5-3-9W_20201104154210.pdf>

Takachi WSC10-14-5W

<https://www.takachi-enclosure.com/products/WSC>

<https://www.takachi-enclosure.com/assets/attachments/images/WSC10-14-5W_20201104154816.pdf>

# PCB concept

Diagram, schematic

Description automatically generated