PROJECT TITLE

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ECE 362 Microprocessor Interfacing and System

Date: ___4/26/2025___

Executive Abstract (≤ 200 words)

This was a “Bring Your Own Idea” (BYO Idea) project. This project is a “Hat” module for the STM32 Nucleo-32 board that would allow the STM32 to send a file wirelessly between two devices using the LoRa protocol. The objectives were a full Schematic of the “hat”, the ability for the “hat” to be powered from the SD card port of a computer, and the ability to send a text file from one device to another. So far, a schematic and PCB design have been created. The PCB was manufactured, and I also soldered the components together, so, I have physical hardware. To test if the computer could read the SD card in the “Hat”, I plugged it in and could see that it was indeed accessible. The STM 32 Nucleo-32 dev board is also powered from the SD card port. However, with all the hardware tasks, I have not had time yet to develop the Software and the board cannot, currently, send a text file between devices. Therefore, two of the three objectives of the project have been met.

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1. Introduction & Objectives

1.1 Background / Motivation

I chose this project because I am very interested in designing and programing embedded devices and sensors with Long-Range (LoRa) connectivity. I also believed that the SD card reading, and SD-port power feature would be an interesting way to challenge myself in PCB design.

1.2 Problem Statement

My project should bring Long Range (LoRa) connectivity to laptops and personal computers. This could be used to download data from field sensors or to transfer text files in the field.

1.3 Project Objectives

1. Full Schematic of the STM32 Hat module.
2. Ability to power the module and the STM32 Nucleo-32 dev board from the computer's SD card port.

3. Ability to send a text file from one device to another.

1.4 Scope & Success Criteria

In-scope: [features, tests, deliverables]

- Use of STM32 microcontroller.
- Hardware consists of a PCB "hat" for the STM32 to connect SD card slot and LoRa card.
- Features software to drive/read LoRa device (using UART) and save to the SD card (using the default SPI interface)
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- PCB footprint that can be plugged directly into the SD card reader on a laptop so that we can read the data from the SD card immediately (lines on the PCB should be hardwired to the SD card reader). Power should be drawn from the VDD and VSS lines on the SD card interface.

Out-of-scope: [deferred items]

- Connection to field sensors or other useful devices.

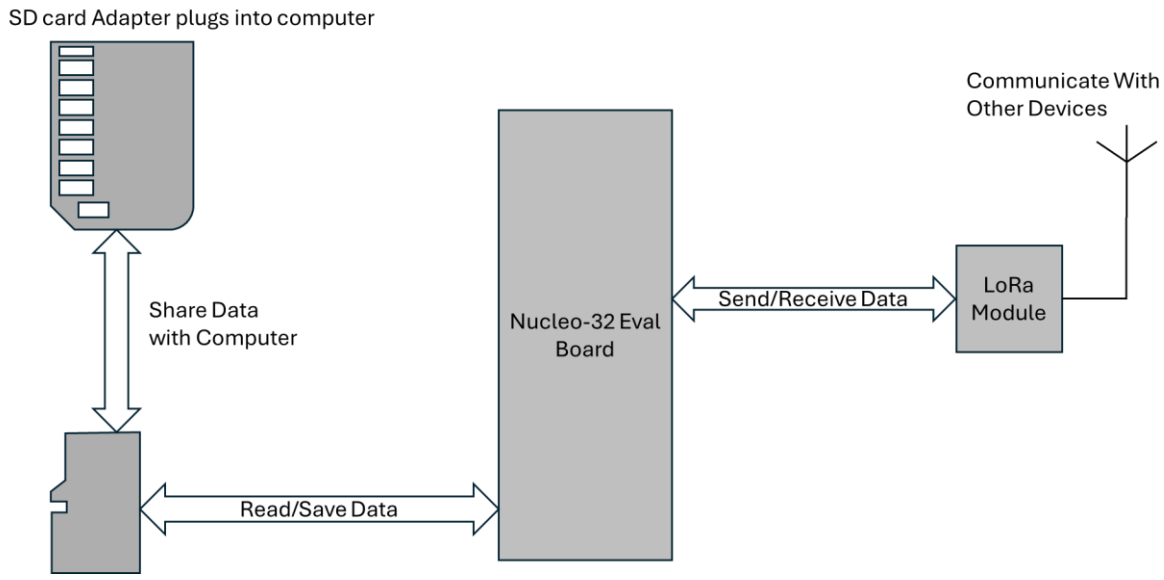
Success if: [quantifiable metrics]

- A PCB is created that can provide power to the microcontroller via the SD card interface.
- Data can be transferred between the computer and the module by plugging the module's PCB directly into the SD card slot.
- Can transfer data from one device to another using LoRa communication.

2. System-Level Overview

2.1 Block Diagram

Covers Technical Complexity



2.2 Data / Power Flow Description

Covers Layout

Positive voltage is supplied from the VCC port on the SD card adapter PCB. The Ground also comes from the SD card adapter and powers the STM Nucleo-32

The PCB is designed such that the STM Nucleo-32 will communicate with the SD card using SPI mode and the computer can communicate with it using the standard SD card protocol. The table below outlines the connections for SPI communication:

Micro SD card	**Nucleo-32**
Pin 2 (SSEL)	PB_0 (SPI1_SSEL)
Pin 3 (MOSI)	PA_12 (SPI1_MOSI
Pin 5 (SCLK)	PA_1 (SPI1_SCLK)
Pin 7 (MISO)	PA_6 (SPI1_MISO)

The UART lines of the LoRa module are connected to the TX and RX pins (pins PA_9 and PA_10) of the Nucleo-32 board.

The LoRa module also connects to a chip antenna via Pin 15 (RFIO).

There is also a three-state switch on the PCB. Each state connects to a different pin on the Nucleo-32. This is intended to change the mode of the device.

2.3 Bill of Materials (if applicable)

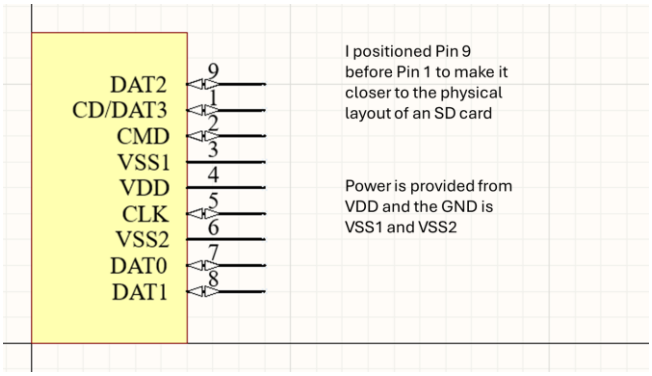
Quantity	Part	Function	Key Specs	Source
1	317990687	LoRa module		DigiKey
1	1140084168	Micro SD card reader		DigiKey
1	ACAG1204-915-T	915 MHz Antenna	915MHz	DigiKey
1	CUS-13TB	Slide Switch		DigiKey
1	FK18X5R1A475KR020	Capacitor for LoRa Vin	4.7 uF	DigiKey
1	GJM1555C1H3R9BB01D	0201 Capacitor	0201, 19 pF	DigiKey
1	LQW15AN4N7C00D	Inductor	0402 4.7nH	DigiKey
2	MMF25SFRE20R	20 Ohm Resistor	No Description Available	DigiKey
1	NUCLEO-L432KC	Nucleo-32 Dev board	32-Bit Embedded Evaluation Board	DigiKey

3. Schematic & PCB Library Design

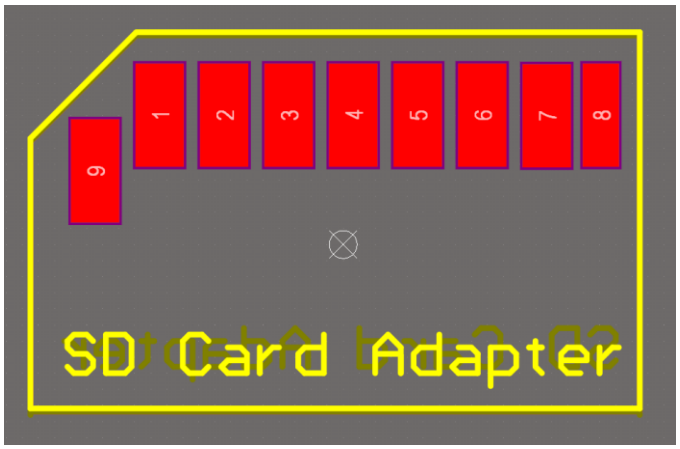
Covers Schematic & PCB Library

The main design principle of this project was to make a device with a similar form factor to the STM Nucleo-32 that could act as a “Hat” module.

For schematic prints, I only needed to make one of my own parts. I designed the SD card adapter schematic print. This part allows the computer to access the on-board SD card in the LoRa File transfer hat module.



The Footprint for this part looks and measures exactly like the pads on a real SD card. This allows the pins in the SD card reader on the computer to make proper contact with the pads and read and save data.

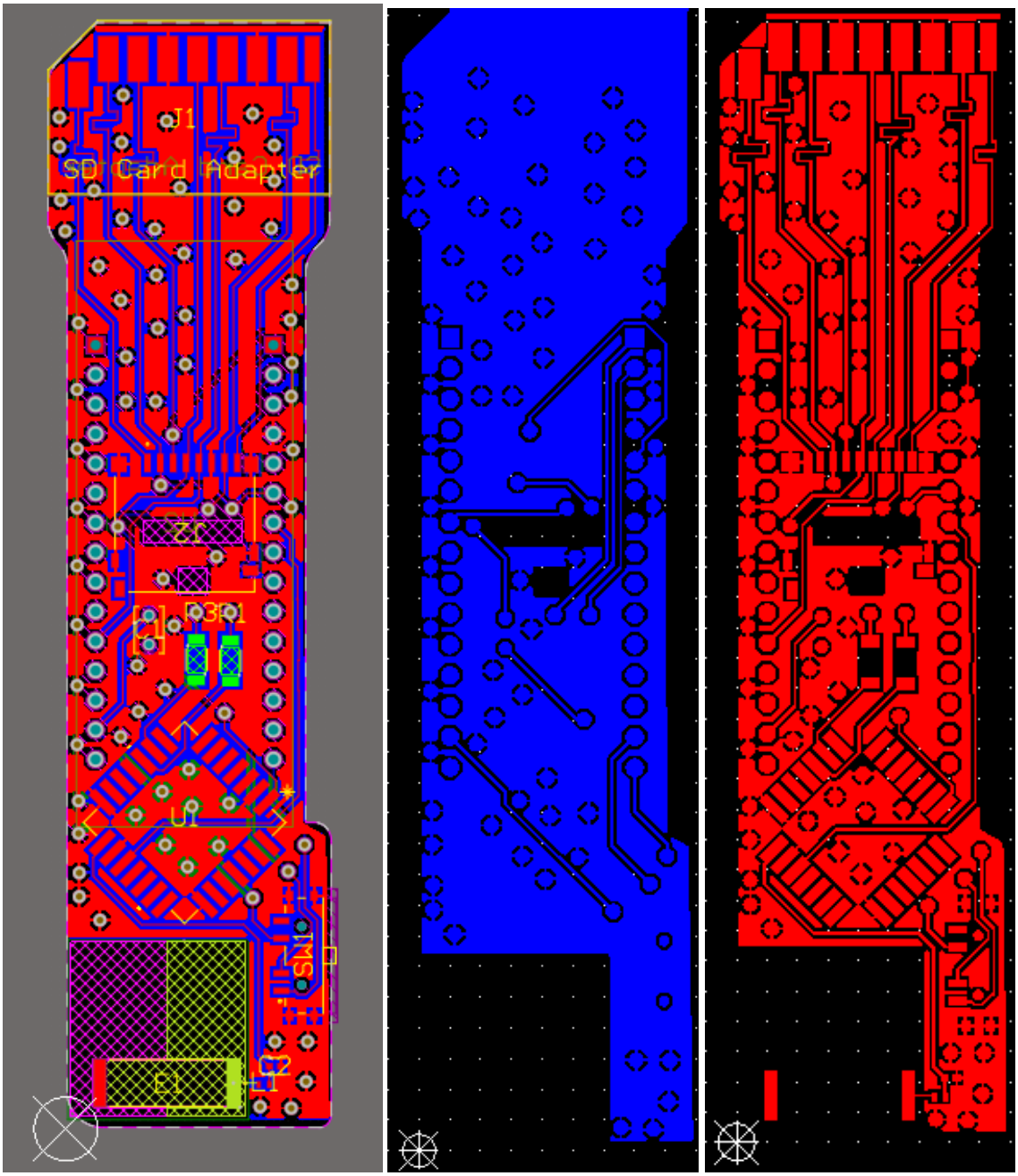


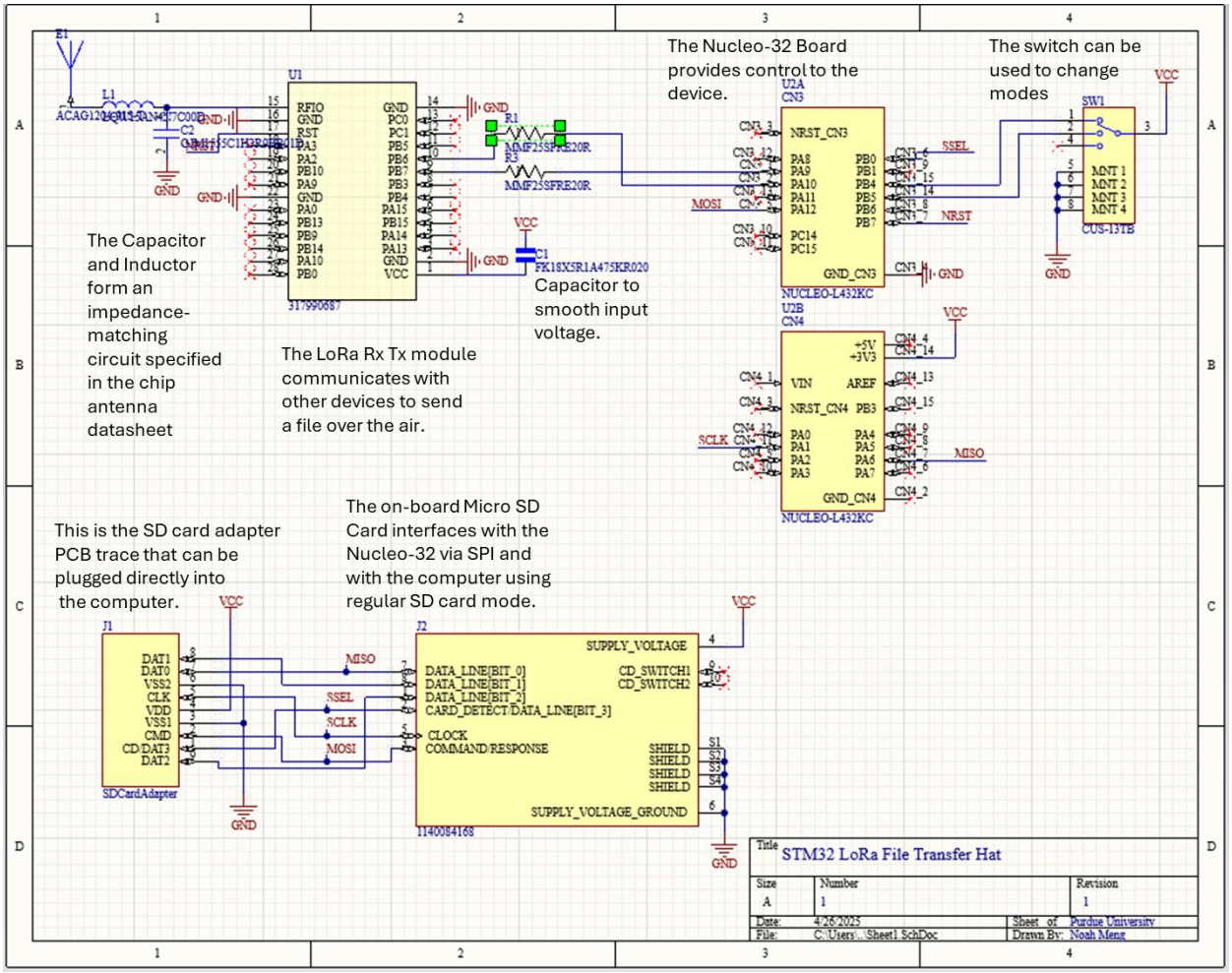
The full Schematic is in Appendix A.

4. PCB Layout (if applicable)

Covers PCB Layout and Schematic Print

Combined Layer View Bottom Layer Top Layer


J1
SD Card Adapter
ZR
D3
U1
SW1
E1



5. Code (if applicable)

N/A. The code is currently not implemented.

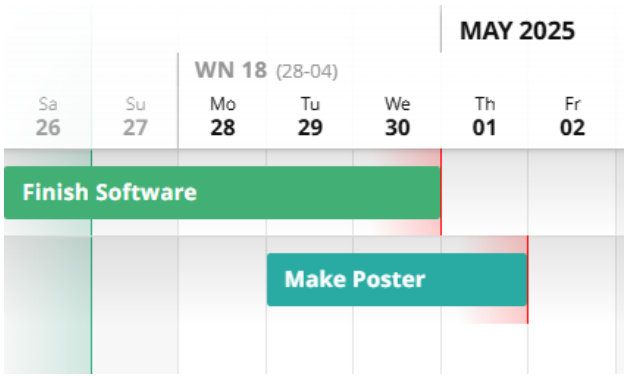
5. Firmware / Software

N/A. The firmware is currently not implemented.

6. Project Management & Progress

Partially Covers Objectives Met and Intermediate Checkpoints, weekly progress.

The Gantt chart below outlines how I plan to finish the rest of the project on time and be ready for the ECE Spark challenge and the final demo.

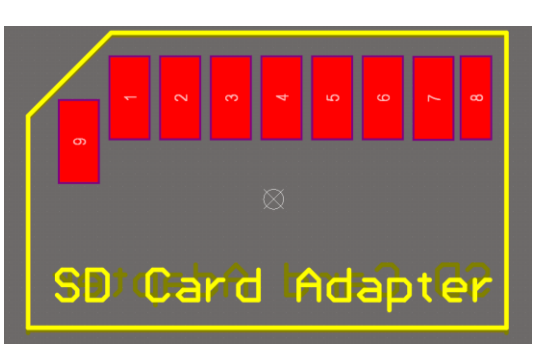


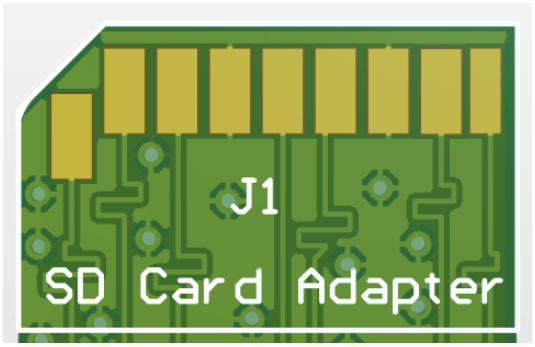
Week	Planned Milestone	Actual Outcome
07 – 13	Confirm design concept	Confirmed design concept.
14 – 20	Finish Schematic	Finished Schematic and PCB design
21 - 27	Finish Software & Submit Report	Fabricated PCB and finished hand-soldering one full device.

7. Innovation & Design Enhancements

Covers Innovation and Creativity

I designed my own adapter for the SD Card port. The squiggly traces are length-matched so that the data read-write signals all arrive in-sync.





Since the design comes with an RF component (the antenna for the LoRa module), I added many many vias in the ground pours to keep a consistent ground voltage and avoid RF problems.

8. Conclusions & Future Work

Two of the objectives are met because the device powers the Nucleo-32 from the SD card port alone, and the computer can access the internal SD storage. Sadly, the major feature of this project (transferring a file between devices) is not implemented.

In this project, I learned to aim high with project goals, because of the potential to learn so much more while trying to implement them. I have learned an incredible amount from this project. And I ain't done yet 😉.

The next step for me is to solder a second board together and implement the software to transfer a file across two of the two devices. I plan to have this finalized before the Inaugural ECE Spark Challenge at Purdue Indianapolis on May 2nd.

9. References

Please see the "Datasheets" section in the GitHub Repo at the URL for a to retrieve the PDF references.

https://github.com/mutantmuskrat/STM-Nucleo-32-File-Transfer-Hat.git

For LoRa module:

- LoRa-E5 module datasheet_V1.0.pdf
- LoRa-E5 AT Command Specification_V1.0 .pdf

For Antenna:

- ACAG1204-915-T.PDF
- AppCAD

For STM32 Nucleo:

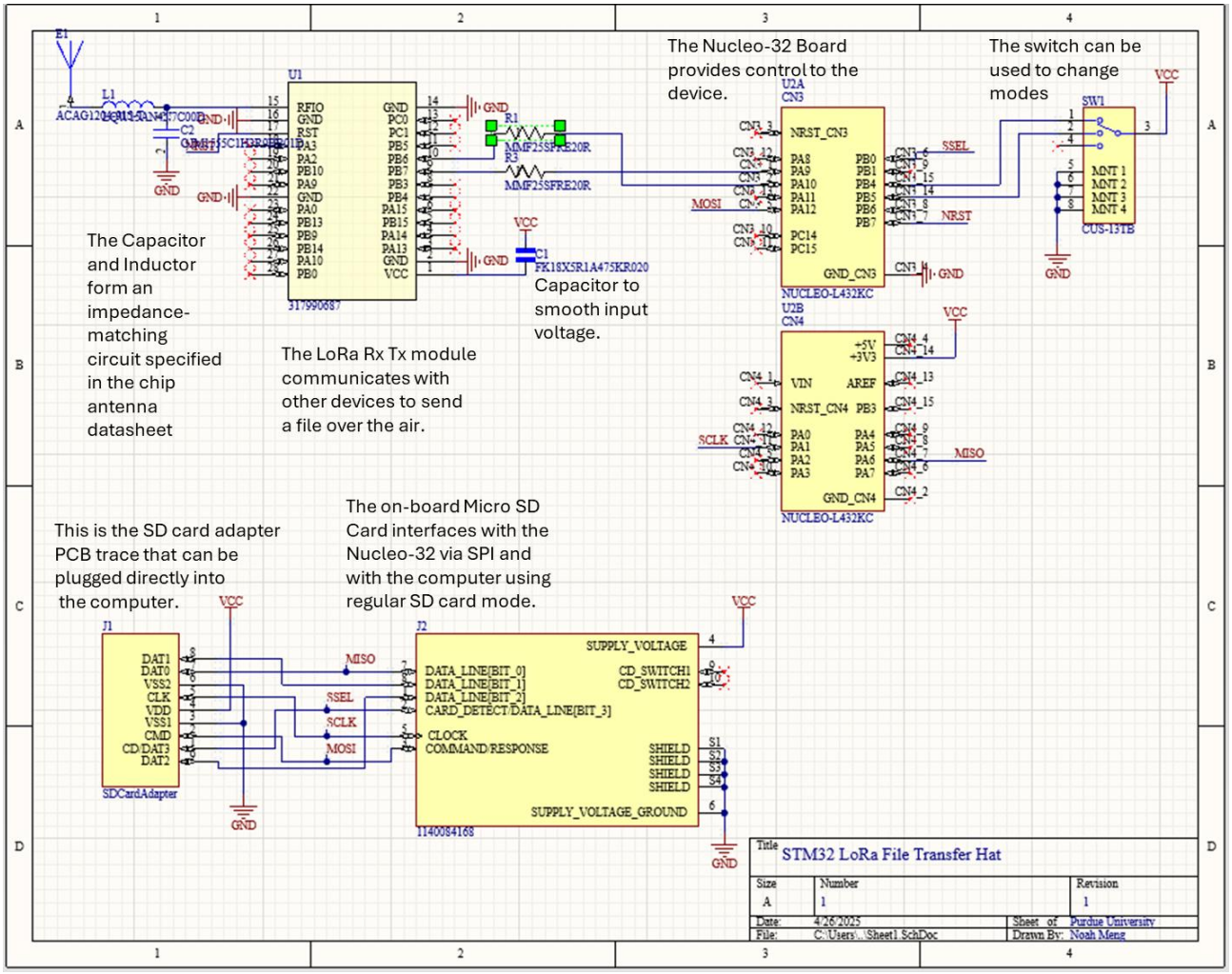
- Datasheet.pdf
- DDI0484C_cortex_m0p_r0p1_trm.pdf
- Programming Manual.pdf
- Reference Manual.pdf
- User Manual.pdf
- https://os.mbed.com/platforms/ST-Nucleo-L432KC/

10. Appendices

Appendix A: Full Schematics (PDF)

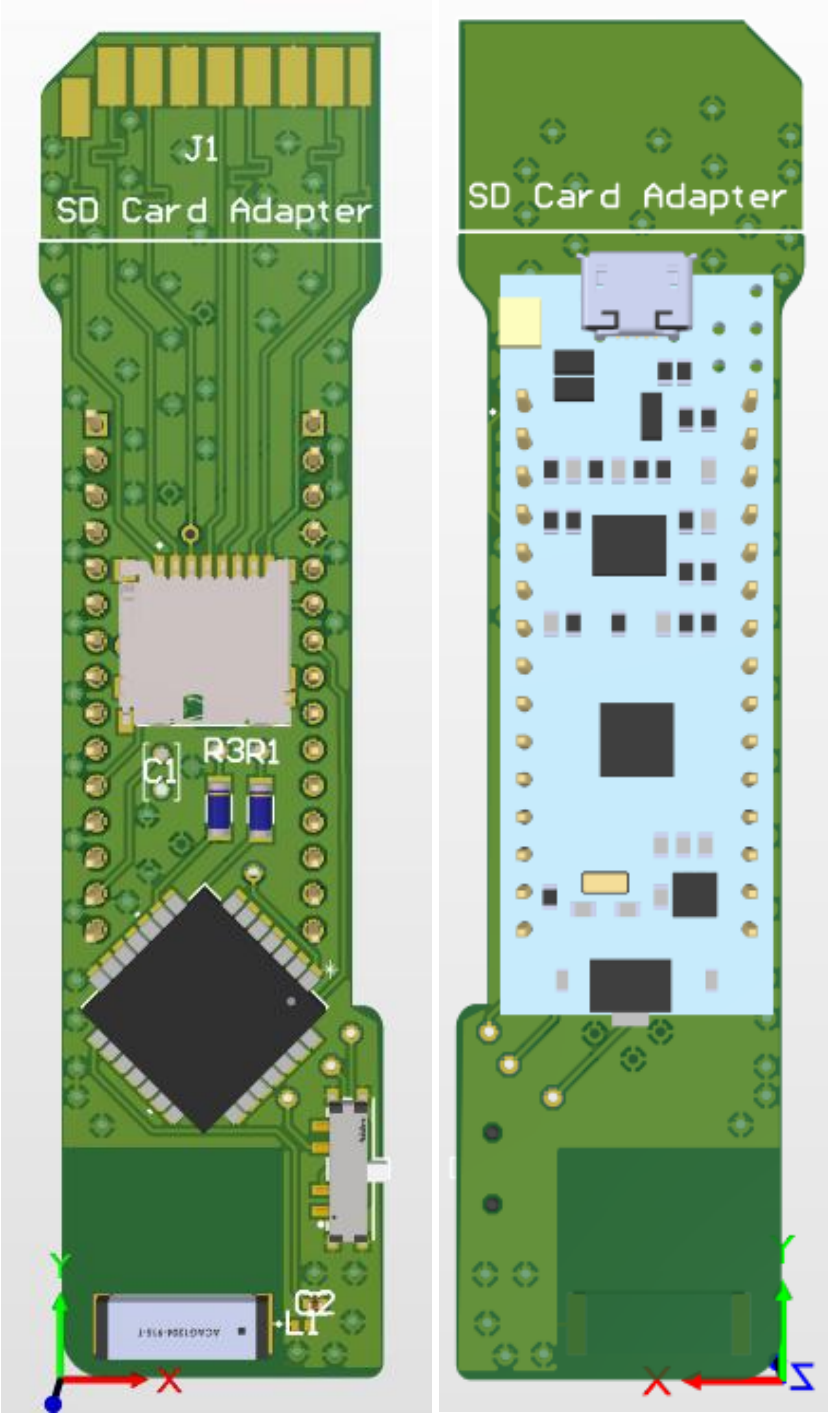
Covers Schematic Print and Schematic and PCB Layout

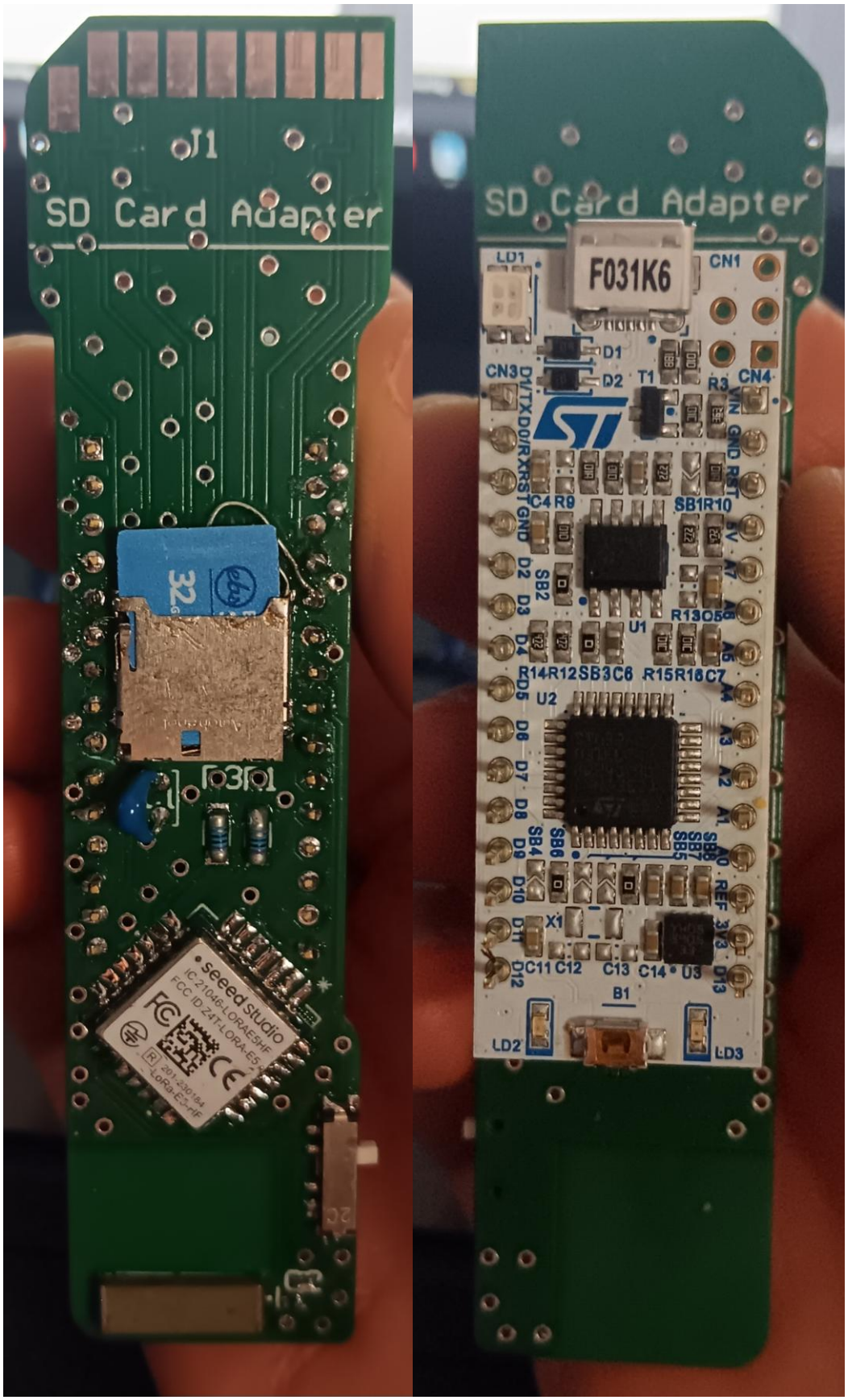
The full Schematic design for the device is shown below.



Appendix B: 3-D PCB Views

Covers PCB layout


J1
SD Card Adapter
R3R1
C1
C2
L1
SD Card Adapter


J1
SD Card Adapter
SD Card Adapter
F031K6
LD1
CN1
CN3
CN4
D1
D2
T1
R3
U1
U2
X1
B1
LD2
LD3
seeed studio

Appendix C: Source Code (ZIP link)

Appendix D: Fabrication Outputs

Please see the Gerber files here:

https://github.com/mutantmuskrat/STM-Nucleo-32-File-Transfer-Hat/tree/main/PCB/Gerber

Please see the NC Drill Files Here:

https://github.com/mutantmuskrat/STM-Nucleo-32-File-Transfer-Hat/tree/main/PCB/NC%20Drill

Please see the ODB files here:

https://github.com/mutantmuskrat/STM-Nucleo-32-File-Transfer-Hat/tree/main/PCB/ODB

Please see the board stack here:

https://github.com/mutantmuskrat/STM-Nucleo-32-File-Transfer-Hat/tree/main/PCB/Report%20Board%20Stack