EE 4910 WEEKLY REPORT: 3

2/25/2026 – 3/3/2026

***Group number:* 06**

***Project title:* Developing a Cost Effective NIR VIS Spectrometer**

***Client &/Advisor:* Avishek Das & Manojit Pramanik**

***Team Members/Role:* Ryan Majstorovic, Evan Tamer, Dawson Posekany, Samar Gill**

Weekly Summary

Over the last week, the team finalized the initial optical design direction for our 400–1000 nm spectrometer and pushed through another procurement order to keep hardware progress moving. With the microcontroller units still in transit, we shifted focus to the optics subsystem to make progress in parallel.

On the optics side, we selected an AR-coated 1-inch lens (LA 1134-AB-ML) to improve light throughput by minimizing reflection losses at optical surfaces. For dispersion, we chose a 25 mm reflective grating with 600 grooves/mm (GR 25-0605), which offers a practical balance between dispersion and efficiency for broadband, unpolarized sources. We discussed the tradeoffs between transmission and reflective grating layouts, and confirmed that post-mounted hardware will be used throughout to simplify breadboard alignment.

Rather than purchasing a precision slit assembly at this stage, the team decided to prototype aperture control using existing translation and adjustment hardware. Avishek has the relevant components available in the lab, so we will use those for initial aperture testing before committing to a dedicated purchase. We also reviewed concave mirror options; since most readily available parts are circular, we will proceed with standard mirrors for initial testing and revisit packaging choices once the layout is locked in.

As a quick sanity check, we ran a simple diffraction demo and observed multiple orders, confirming that dispersion is visible and that first-order alignment will be our practical target going forward.

The ETG order for the lens and grating was approved by Professor Manojit Pramanik. The team picked up the original Digi-Key order and found an issue with the digital inverter where the wrong package type was ordered. A new order was placed for the inverters with the correct package. For next session, we will mount the optics and run a full alignment procedure using a lab laser. In parallel, STM32 bring-up will continue so we can begin capturing CCD output during early optical tests.

Past week accomplishments

Dawson completed analytical verification for the PNP BJT (2SA1015) buffer circuit that interfaces our CCD to the STM32 MCU. For accurate DC analysis, my load line equations used the CCD's internal output impedance and assumed a typical transistor gain of 200. The math confirms that impedance reflection creates a massive effective input impedance of roughly 440kOhms, which isolates the CCD output from distortion. The emitter output to the MCU will sit at approximately 3.2V in the dark state and drop ~2.6V at maximum brightness. This translates the CCD's data into a clean swing that perfectly preserves the sensor's dynamic range for our ADC. The analysis can be downloaded below. All parameters were taken from normal values of the CCD and BJT. Some parameters like the BJT gain vary significantly, but this is not terribly important as the input impedance will be high enough regardless. The documentation is in the Appendix below.

Ryan worked on understanding the CubeIDE and some testing to prepare for the coding meeting. However, due to the microcontrollers not arriving the team shifted focus and talked about integration of the optics subsystem. Choosing a 60mm focal point lens and a reflective diffraction grating to separate the wavelengths. Additionally, Ryan ordered the lens and grating along with reordering the digital inverters due to a package mixup.

Samar and Evan worked on the microcontroller setup in the CubeMX developer environment. This included enabling the ADC, timers, and USB connection (see appendix for pin assignment). A github repository was also created so that the code for the microcontroller can be shared between group members as they perform their own test on the microcontrollers.

Pending issues

1. We need to solidify our understanding of our users. We struggled to identify clear cut users outside of ISU biomedical researchers. We believe there could be educational or medical applications, but a lot goes into getting a device verified to be in a setting like that. We still need to discuss this with Dr. Avishek.
2. The microcontrollers haven't come in quite as quick as we'd hoped from ETG. This made us pivot what we did during our weekly meeting/work session. It turned out to be fine because we accidentally ordered through hole inverters instead or surface mount, so the circuits wouldn't be ready to put together anyway, but we want our microcontrollers so we can start testing.

Individual contributions

NAME	**Individual Contributions** *(Quick list of contributions. This should be short.)*	**Hours this week**	**HOURS cumulative**

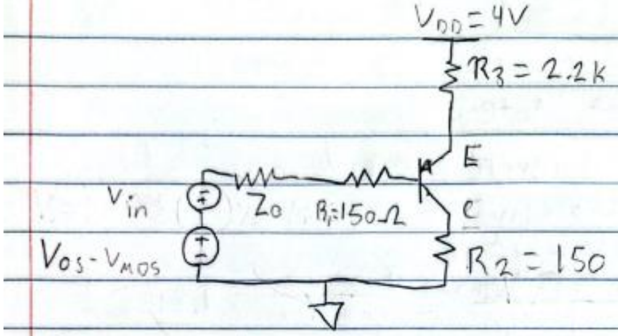
Ryan Majstorovic	Lens and grating ordering. Tested timer setups for CubeIDE. Order monitoring from ETG.	5	20
Dawson Posekany	BJT analysis, Familiarizing with CubeIDE	7	19
Samar Gill	Continued setup of the CubeMX software and early testing of the serial monitor.	5	17
Evan Tamer	Worked on CubeMX code for MCU	6	18

Comments and extended discussion

Plans for the upcoming week

- Ryan Majstorovic & Dawson Posekany: Support coding lab next week and then focus on building the python GUI once the data acquisition is understood.
- Samar Gill & Evan Tamer: Finalize the code for initial testing and debugging within the CubeIDE and push the changes to GitHub. Include documentation for handling pin assignment and timers.

Appendix:



TCD Characteristics:

$V_{s,max} = V_{os} - V_{MDK} = 2.5 - 0.002 \simeq 2.5V$

$V_{sat} \simeq 0.6V$

$Z_o = 0.5\,k\Omega$ so $R_B = R_i + Z_o = 650\,\Omega$

$V_{cc} = V_{s,max} - V_{in} \simeq 2.5 - V_{in}$, $2.5 - 0.6 \leq V_{cc} \leq 2.5$

2SA BJT: $130 < \beta < 400$

We will have to test it, but I will take $\beta = 200$ for this analysis.

Analysis:

$V_{DD} - I_E R_3 - V_{EB} - I_B R_B - V_{cc} = 0$

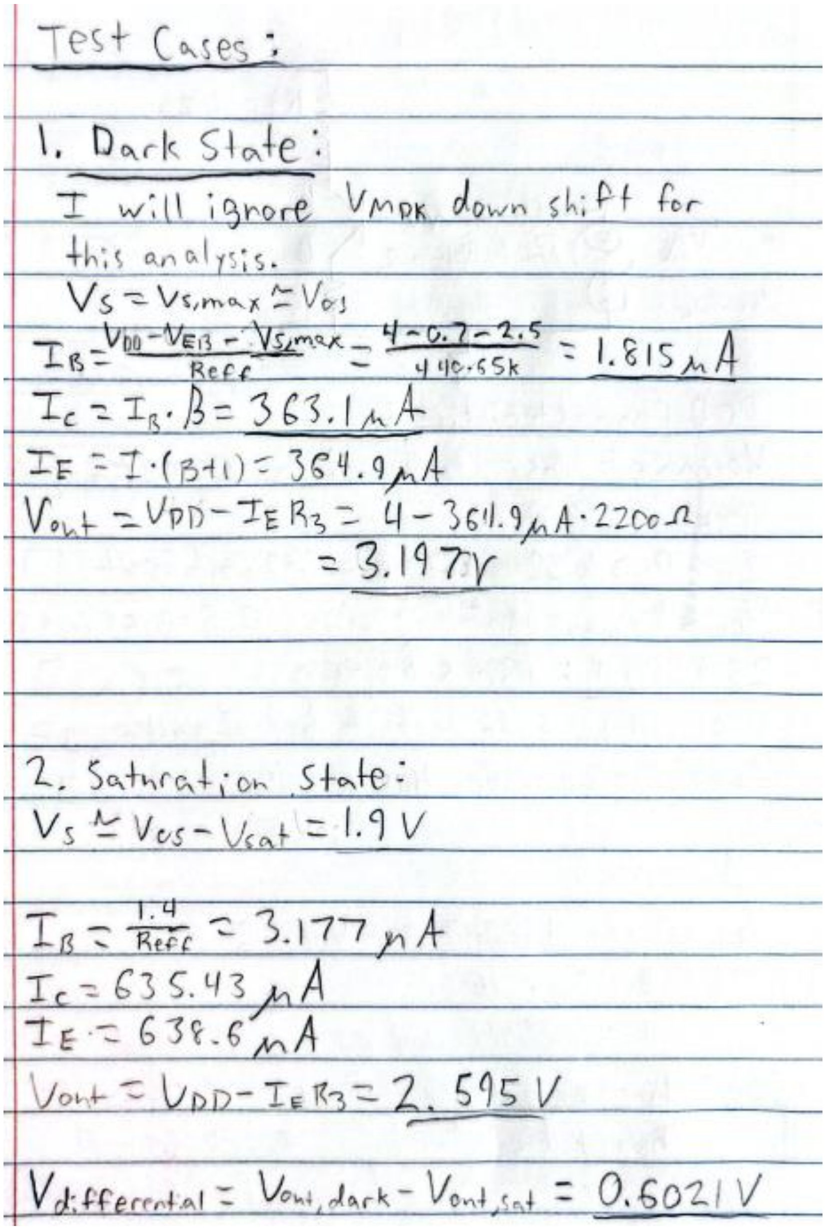
$I_E = (\beta + 1) I_B \simeq \beta I_B$

$$I_B = \frac{4V - V_{EB} - V_{cc}}{R_B + \beta R_3}$$

$R_{eff} = 650 + 200 \cdot 2.2k$
$= 440.65\,k\Omega$

(Varies from 286k to 880k
Based on β.)

Appendix 1.1: BJT Modelling



Test Cases:

1. Dark State:

I will ignore V_{MPK} down shift for this analysis.

$V_S = V_{S,max} \simeq V_{os}$

$I_B = \frac{V_{DD} - V_{EB} - V_{S,max}}{R_{eff}} = \frac{4 - 0.7 - 2.5}{440.55k} = \underline{1.815 \mu A}$

$I_C = I_B \cdot \beta = \underline{363.1 \mu A}$

$I_E = I \cdot (\beta + 1) = 364.9 \mu A$

$V_{out} = V_{DD} - I_E R_3 = 4 - 364.9 \mu A \cdot 2200 \Omega$

$= \underline{3.197 V}$

2. Saturation State:

$V_S \simeq V_{os} - V_{sat} = \underline{1.9 V}$

$I_B = \frac{1.4}{R_{eff}} = 3.177 \mu A$

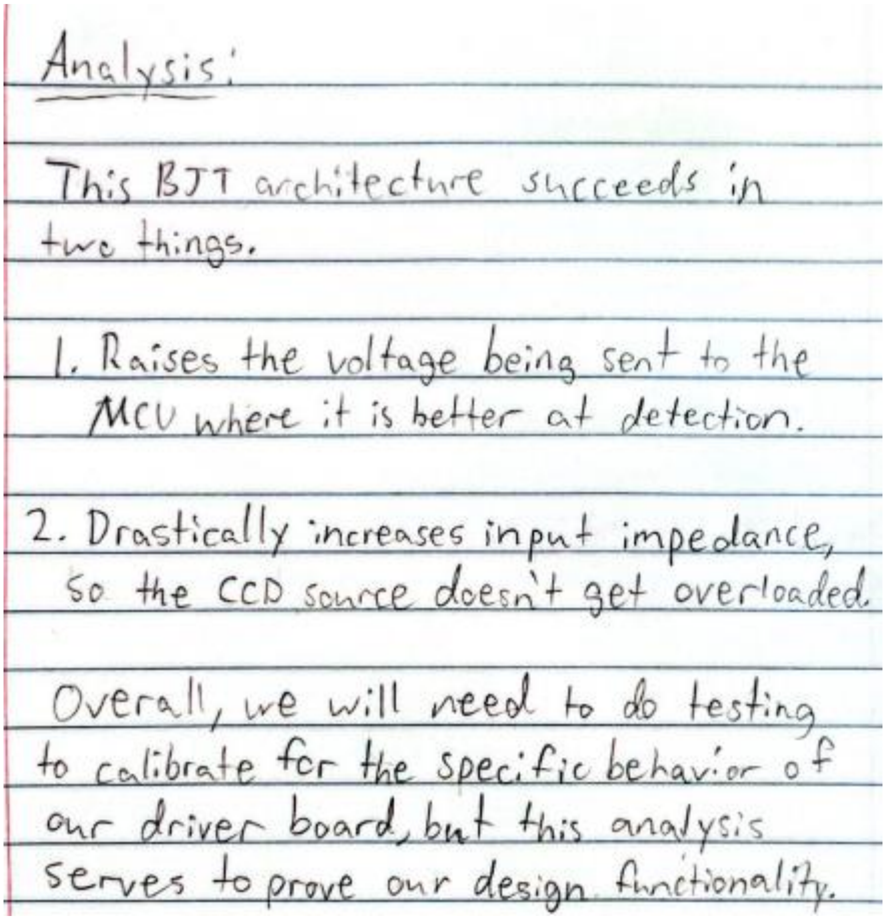
$I_C = 635.43 \mu A$

$I_E = 638.6 \mu A$

$V_{out} = V_{DD} - I_E R_3 = \underline{2.595 V}$

$V_{differential} = V_{out,dark} - V_{out,sat} = \underline{0.6021 V}$

Appendix 1.2: Test Cases



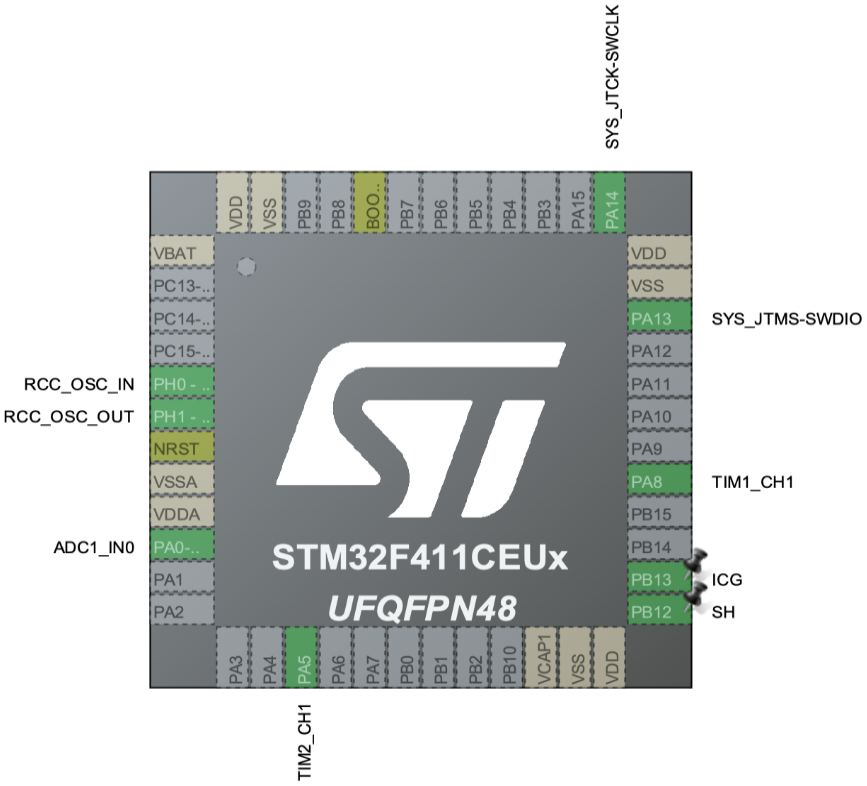
Analysis:

This BJT architecture succeeds in two things.

1. Raises the voltage being sent to the MCU where it is better at detection.
2. Drastically increases input impedance, so the CCD source doesn't get overloaded.

Overall, we will need to do testing to calibrate for the specific behavior of our driver board, but this analysis serves to prove our design functionality.

Appendix 1.3: Results Analysis



Appendix 2: MCU pin assignments

Appendix 3: optics meeting diagram - Possible integration of a lens to expand the 650-1000nm range across the sensor.