University of Central Florida
Department of Electrical Engineering and Computer Engineering

EEL 4914| Senior Design 1| Summer 2022| Group 3 Creol
Initial Project Document Design and Conquer

Low-Cost Spectrometer & Grating Efficiency Station

Ecclezias Senat - EE

Carlos Irizarry - PSE

Christopher Robertson - CPE

Ryan Goff - CPE

Table of Contents

1.Project Descriptive

1.1 Introduction

Diffraction gratings play an integral role in spectroscopy and the efficiency can play a large factor in the output spectrum. Measuring the efficiency of a diffraction grating can be difficult as there are many variables that can affect the resulting light. This is why we aim to create not only a system that measures the efficiency of diffraction gratings, but a low cost spectrometer as well that can be utilized effectively to measure the efficiency by comparison. The important aspect of our design is not only the low-cost spectrometer, but also the semi-automated nature of the grating efficiency station. The user may input the characteristics of the grating and the system will account for the resulting spectrum and placement of the resulting light. This is important because light sources and diffraction gratings can cause large variations in the placement of a detector or lens necessary to have the system function. The applications for the grating efficiency station reach further than just the field of spectroscopy. There are a variety of industries that make use of diffraction gratings and having an automated system to measure efficiency would be greatly beneficial.

1.2 Motivation

Applications for diffraction gratings and spectroscopy are constantly growing. Knowing this, it is important to understand that ensuring that diffraction gratings are operating at the expected efficiency is incredibly important. Additionally, spectrometers can be very expensive in using a diffraction grating. For this reason, we aim to eliminate the need for incredibly expensive optical parts by offering a low cost spectrometer that does not feature a grating or optical mirrors. We believe that students and researchers who are not interested in spending a large sum of money can benefit from a relatively inexpensive, moderate resolution spectrometer. This solves two common issues in the optics field that are not actively being dealt with. With this project we aim to optimize the field of spectroscopy in two different ways.

1.3 Goals and Objectives

The end result of this project should be a quick and seamless method of measuring diffraction gratings, as well as a relatively inexpensive spectrometer which does not require a diffraction or mirrors in its design. To achieve this we will first consider the optical design that best suits our needs to carry out this task. Additionally ensuring that the electrical components provide automated focusing and placement through computer software are incredibly important to the fundamental idea of the efficiency station. With this automation it becomes significantly easier to measure the efficiency of gratings in a short period of time. The combination of the efficiency grating station as well as the low cost spectrometer provides several new avenues in the way of spectroscopy that can truly benefit the user. The end result should be two systems that can be used in a professional setting to enhance spectroscopy measurements and observations.

1.4 Project Functionality

Both the low-cost spectrometer and the grating efficiency station will operate through similar mechanisms. The low-cost spectrometer will use a prism as a dispersion element in both projects. However, the low-cost spectrometer will display a spectrum as the output variable and the grating efficiency station will have optical power as the output variable. Due to the fact that these two projects use similar mechanisms of action we believe it would be beneficial to combine the two projects in a concise way. The light source will be the input variable in both systems and will enter a prism as stated earlier. We will then have a slit to provide as a monochromator if necessary given that our light source is not monochromatic light. We will then have a collimating lens for the grating efficiency station in order to maintain coherent and collimated light through the system. The light will then travel through an aperture to limit the amount of light that can enter if necessary. Afterwards it will hit the grating to ultimately be diffracted and be measured by the detector.

2. Requirements and Specifications

2.1 Specifications

Feature	Spec
Power Supply	~5 V
Collimating Lens	Achromatic Doublet
Rotation Stage	Accurate within a ± 0.5mm margin of error
Collimating Lens Adjustment	Adjustment along 8 cm long rail, accurate within a ± 0.5mm margin of error
Graphical Display of Measurements	X-axis: wavelength (nm) Y-axis: count

Table 1 Engineering Requirements (Highlighted Features are Demonstrable)

2.2 **Requirements**

- Incorporates Accurate Semi-Automated calibration to ± 0.5mm
- Will not require the use of mirrors
- Will operate with a variety of light sources
- Power usage will be under 50 W
- Simple GUI
- Minimal setup requirements
- Measures light wavelengths within the visible light range (~740 nm to ~380 nm)

2.3 **Constraints**

- Must be relatively inexpensive compared to traditional spectrometers
- Completion by due date of senior design II

3. Project Diagrams

Teams Responsibilities	
Ryan Goff	
Christopher Robertson	
Carlos Irizarry	
Ecclezias Senat	

Figure 1 & 2: Teams Responsibilities For Block Diagram

- The block status of both the Hardware and Software Block Diagrams is currently being researched.

3.1 **Hardware Diagram**

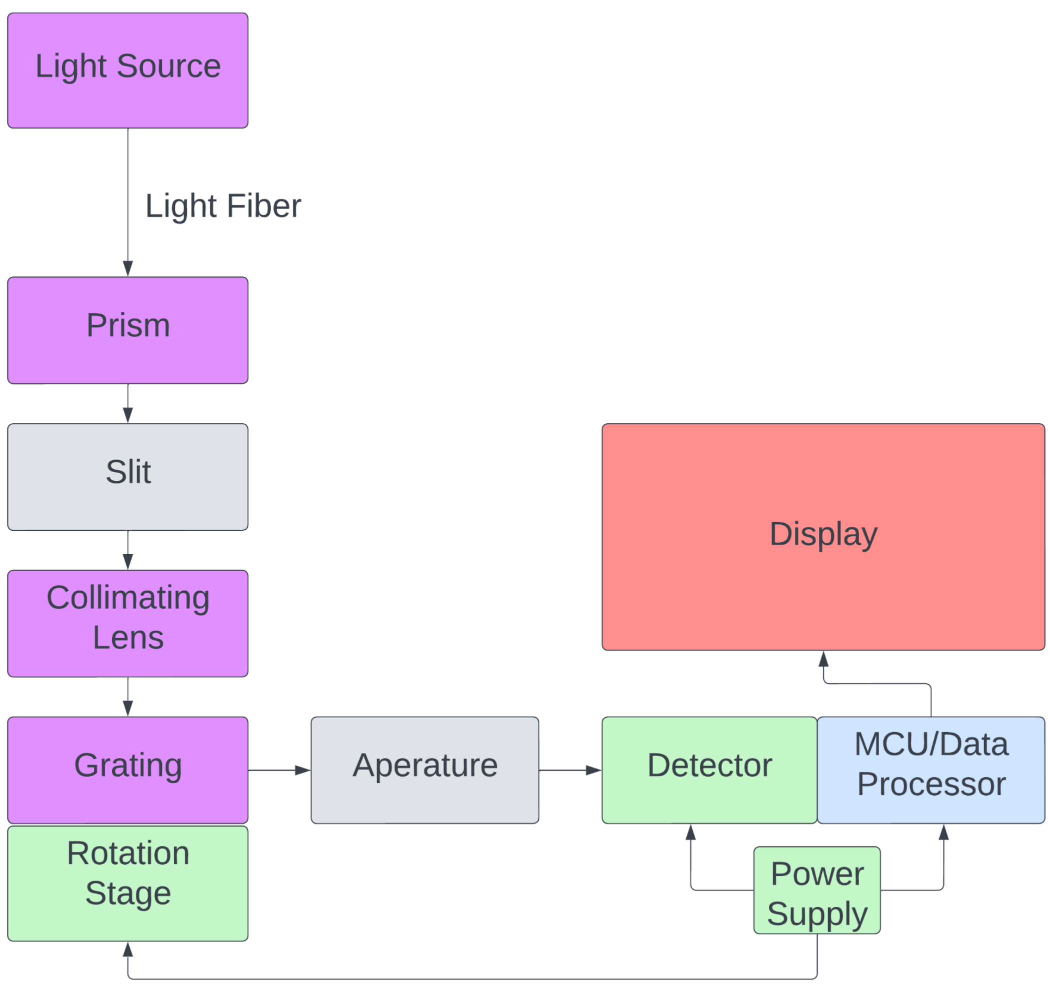


Figure 1: Hardware Block Diagram

3.2 **Software Diagram**

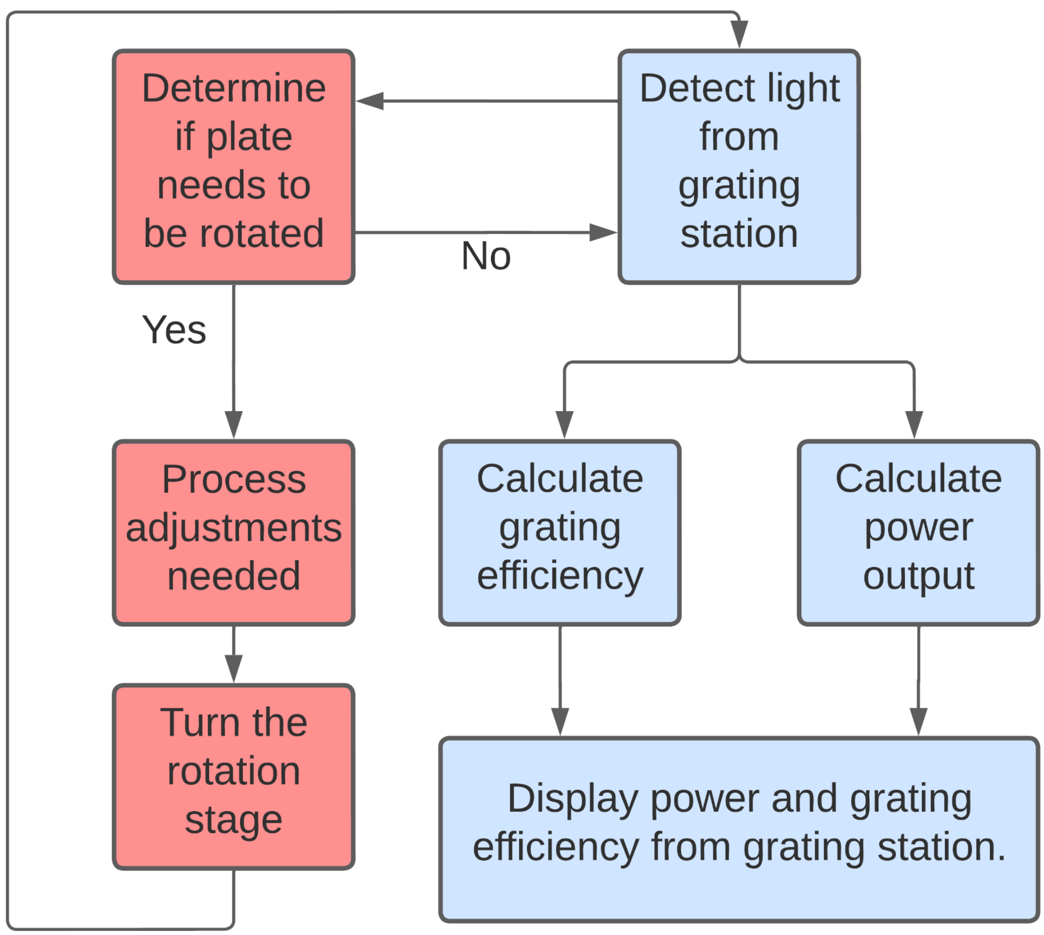


Figure 2: Software Block Diagram

3.3 **Prototype Illustration**

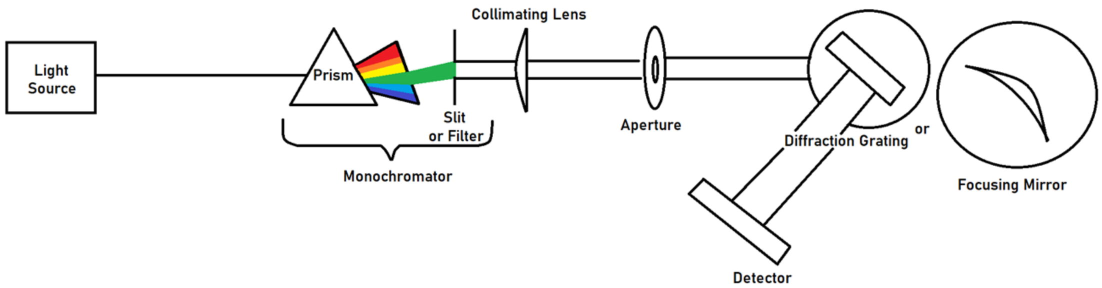
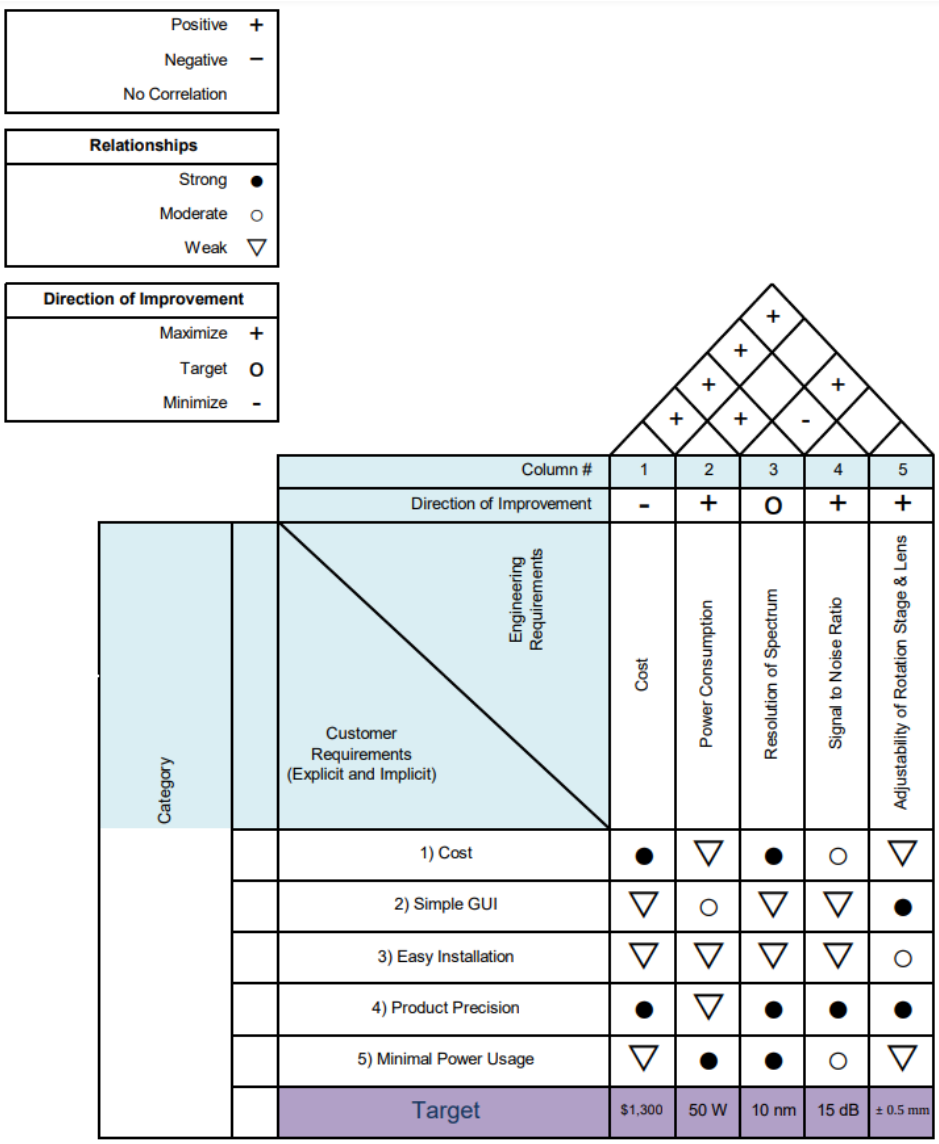


Figure 3: Project Graphic

3.4 House of Quality Diagram



Column #	1	2	3	4	5
Direction of Improvement	-	+	O	+	+
Customer Requirements (Explicit and Implicit) / Engineering Requirements	Cost	Power Consumption	Resolution of Spectrum	Signal to Noise Ratio	Adjustability of Rotation Stage & Lens
1) Cost	●	▽	●	○	▽
2) Simple GUI	▽	○	▽	▽	●
3) Easy Installation	▽	▽	▽	▽	○
4) Product Precision	●	▽	●	●	●
5) Minimal Power Usage	▽	●	●	○	▽
Target	$1,300	50 W	10 nm	15 dB	± 0.5 mm

Figure 4: House of Quality Diagram

4. Budget & Financing

Item	Cost
MCU	$35
PCB	$50
Light Source	$0-$100
Linear Variable Filter	$200
Light Prism	$500
Power Supply	$20
Optical Sensor	$200
Optical Fiber	$75
LCD Display	$10
Diffraction Grating	$30
Collimating Lens	$20
Rotation Stage	$100
Total	$1340

Table 2 Budget & Financing Breakdown

5. Milestones

5.1 Senior Design I

Due Date	Deliverable	Steps to complete
06/03/22	Divide and Conquer 1.0	Team meets to discuss the scope of the project
06/13/22	Meeting with Dr wei and Dr Kar	Team Meet with Dr Wei and Dr Kar to go over our initial 1.0
6/17/22	Divide and Conquer 2.0	Independent research and team meets to collaborate
06/24/22	New Assign. On Standards	TBD
07/08/22	60 Page Draft SD1 Doc	TBD
07/22/22	100 Page Report	TBD
08/02/22	Final Document	TBD

Table 3 Senior Design I Milestones

5.2 Senior Design II

Due Date (Estimations)	Deliverable	Steps to Complete
September	Initial PCB design begin	TBD
October	Finalize Design for PCB	TBD
November	Testing project	TBD
December	Give final presentation	TBD

Table 4 Senior Design II Milestones