Instrument for the Identification of Live and Dead Bacteria

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INTERFACE CONTROL DOCUMENT

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FOR

Instrument for the Identification of Live and Dead Bacteria

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1. Overview

The Interface Control Document (ICD) for the portable fluorescence spectrometer will provide additional detail on how the subsystems noted in the Concept of Operations (CONOPS) and the Functional System Requirements (FSR) documents will be produced. Namely, the ICD will include physical descriptions and specifications for each of the subsystems, in addition to providing details regarding the physical, thermal, electrical, and communication interfaces between the subsystems. To that effect, the document will thoroughly explain how the subsystems will successfully interface together to achieve the goals and functional requirements noted in the CONOPS and FSR documents for the overall system.

2. References and Definitions

2.1. References

Refer to Section 2.3 of the CONOPS document.

2.2. Definitions

CCA	Circuit Card Assembly
LED	Light-emitting Diode
mA	Milliamp
mW	Milliwatt
MHz	Megahertz (1,000,000 Hz)
PCA	Principal Component Analysis
TBD	To Be Determined
TTL	Transistor-Transistor Logic
UV	Ultraviolet
VME	VERSA-Module Europe

3. Physical Interface

3.1. Weight

3.1.1. Weight of control and display unit

The current control and display unit will be a Dell Precision 5510 Mobile Workstation Laptop. This laptop is rather compact and weighs less than five pounds. The weight specification for the unit is noted in Table 1 below.

Component	Weight
Dell Precision 5510 Mobile Workstation Laptop	4.4 lbs.
Total	4.4 lbs.

Table 1: Weight Specifications for the Control and Display Unit.

3.1.2. Weight of disinfection unit

The weight specifications for the disinfection subsystem are noted in Table 2 below. These specifications include the weight of the enclosure for the unit, as well as the weight of the UV LED and heatsink.

Component	Weight
Enclosure	Estimate: 1 lbs.
UV LED and Heatsink	0.1875 lbs.
Total	1.1875 lbs.

Table 2: Weight Specifications for the Disinfection Unit.

3.1.3. Weight of excitation monochromator

The weight specifications for the excitation monochromator subsystem are noted in Table 3 below. These specifications include the weights of the proposed monochromator itself (including its enclosure, mirrors, diffraction grating, and stepper motor), the stepper motor controller and driver, the UV LED excitation source and heatsink, the electronics project box for enclosing all components, and the aluminum plate for mounting all components in the project box.

Component	Weight
Monochromator (includes enclosure, mirrors, diffraction grating, and stepper motor)	1.9 lbs.
Controller and Driver	0.5 lbs.
UV LED and Heatsink	0.1875 lbs.
Electronics Project Box	Estimate: 1.5 lbs.
Aluminum Mounting Plate	Estimate: 0.5 lbs.
Total	4.5875 lbs.

Table 3: Weight Specifications for the Excitation Monochromator.

3.1.4. Weight of emission monochromator

The weight specifications for the emission monochromator subsystem are noted in Table 4 below. These specifications include the weights of the proposed monochromator itself (including its enclosure, mirrors, diffraction grating, linear CCD detector array, and control electronics), the electronics project box for enclosing all components, and the aluminum plate for mounting all components in the project box.

Component	Weight
Monochromator (includes enclosure, mirrors, diffraction grating, linear CCD detector array, and control electronics)	Estimate: 1 lbs.
Electronics Project Box	Estimate: 0.75 lbs.
Aluminum Mounting Plate	Estimate: 0.5 lbs.
Total	2.25 lbs.

Table 4: Weight Specifications for the Emission Monochromator.

3.1.5. Weight of overall system

The weight specifications for the overall system are summarized in Table 5 below. These specifications include the respective weights of each of the subsystems.

Subsystem	Weight
Control and Display Unit	4.4 lbs.
Disinfection Unit	1.1875 lbs.
Excitation Monochromator	4.5875 lbs.
Emission Monochromator	2.25 lbs.
Total	12.425 lbs.

Table 5: Weight Specifications for the Overall System.

Clearly, the overall system is quite portable and may easily be transported to the field.

3.2. Dimensions

3.2.1. Dimensions of control and display unit

As noted previously, the current control and display unit will be a Dell Precision 5510 Mobile Workstation Laptop. The dimensions of the unit are noted in Table 6 below.

Subsystem	Length (inches)	Width (inches)	Height (inches)
Control and Display Unit	14.06	9.27	0.66

Table 6: Dimensions of the Control and Display Unit.

3.2.2. Dimensions of disinfection unit

The dimensions of the disinfection unit will be determined by the dimensions of the enclosure for the unit. The dimensions of the unit are noted in Table 7 below.

Subsystem	Length (inches)	Width (inches)	Height (inches)
Disinfection Unit	Estimate: 3	Estimate: 3	Estimate: 3

Table 7: Dimensions of the Disinfection Unit.

3.2.3. Dimensions of excitation monochromator

The dimensions of the excitation monochromator will be determined by the dimensions of the electronics project box enclosing the entire subsystem. The dimensions of the subsystem are noted in Table 8 below.

Subsystem	Length (inches)	Width (inches)	Height (inches)
Excitation Monochromator	Estimate: 10	Estimate: 6	Estimate: 4

Table 8: Dimensions of the Excitation Monochromator.

3.2.4. Dimensions of emission monochromator

The dimensions of the emission monochromator will be determined by the dimensions of the electronics project box enclosing the entire subsystem. The dimensions of the subsystem are noted in Table 9 below.

Subsystem	Length (inches)	Width (inches)	Height (inches)
Emission Monochromator	Estimate: 8	Estimate: 5	Estimate: 3

Table 9: Dimensions of the Emission Monochromator.

3.2.5. Dimensions of overall system

The dimensions for the overall system are summarized in Table 10 below. These specifications include the respective dimensions of each of the subsystems.

Subsystem	Length (inches)	Width (inches)	Height (inches)
Control and Display Unit	14.06	9.27	0.66
Disinfection Unit	Estimate: 3	Estimate: 3	Estimate: 3
Excitation Monochromator	Estimate: 10	Estimate: 6	Estimate: 4
Emission Monochromator	Estimate: 8	Estimate: 5	Estimate: 3

Table 10: Dimensions of the Overall System.

3.3. Mounting Locations

3.3.1. Mounting of UV LED in Disinfection Unit

The UV LED in the disinfection unit will be mounted on either the side or bottom surface of the disinfection unit. Owing to the rather compact size of the UV LED, it is not necessary to affix it with nails or screws. Mounting will instead be accomplished through sticky thermal adhesive tape. This will serve the dual purpose of mounting the UV LED in the disinfection unit and promoting efficient heat dissipation.

3.3.2. Mounting of Excitation Monochromator Components

The excitation monochromator subsystem components will all be mounted in a common electronics project box. This includes the excitation monochromator itself (including its enclosure, mirrors, diffraction grating, and stepper motor), the stepper motor controller and driver, and the UV LED excitation source and heatsink. This will be accomplished by drilling threaded holes in an aluminum mounting plate and utilizing set screws to mount and secure components in the project box.

3.3.3. Mounting of Emission Monochromator Components

The emission monochromator subsystem components will all be mounted in a common electronics project box. This includes the emission monochromator itself, along with its enclosure, mirrors, diffraction grating, linear CCD detector array, and control electronics. This will be accomplished by drilling threaded holes in an aluminum mounting plate and utilizing set screws to mount and secure components in the project box.

3.3.4. Mounting of Subsystems

The disinfection unit, excitation monochromator, and emission monochromator subsystems may also be mounted together. This may be accomplished through either double-sided tape or set screws. It is expected that the disinfection unit and emission monochromator subsystems will be mounted on top of the excitation monochromator subsystem, which has the largest dimensions. The subsystems may also simply be detached from each other, depending on the use case.

4. Thermal Interface

4.1.1. Cooling and Air Circulation

Cooling and air circulation shall be provided for the linear CCD detector array of the emission monochromator subsystem. This will be accomplished by means of a miniature fan, which will be powered through a +5 VDC input, situated on the optical bench by the detector. This is necessary in order to reduce the so-called “dark noise” associated with the detector, which increases as the detector overheats. Providing cooling and air circulation for the detector will therefore increase the signal-to-noise ratio (SNR) of the emission monochromator.

4.1.2. Heatsinks

Heatsinks shall be provided for most, if not all, onboard UV LEDs. This includes the UV LED in the disinfection unit, as well as the UV LED(s) present in the excitation monochromator subsystem. A heatsink may not be required if a relatively small voltage is being applied to the UV LED, which may be the case if the induced bacterial fluorescence is sufficiently intense for detection. The UV LEDs will be coupled with the heatsinks by means of either thermal adhesive tape or thermal paste to promote efficient heat conduction and dissipation. Therefore, no extra cold wall is required for the heatsinks. Finally, a heatsink shall be utilized for the stepper motor controller and driver as well to prevent overheating. This heatsink may be pasted directly on the IC itself.

5. Electrical Interface

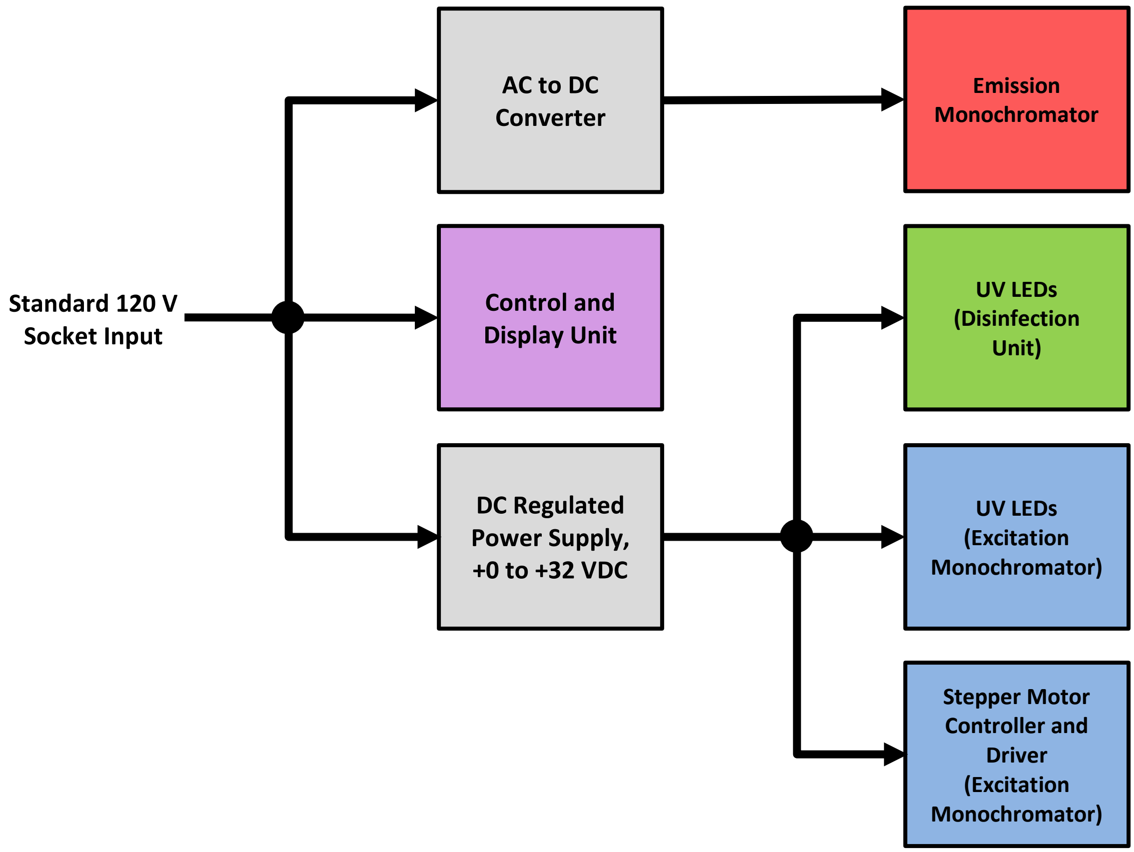

Figure 1: Electrical Interface Diagram.

5.1. Primary Input Power

5.1.1. Primary Input Power for Control and Display Unit

The control and display unit, a compact laptop, may be directly powered by a standard 120 V socket input. Alternatively, the unit may be charged before usage and therefore utilized without any charging cable.

5.1.2. Primary Input Power for Emission Monochromator

Owing to the fact that the emission monochromator will require the lowest input DC voltage, +5 VDC, an AC to DC converter will be utilized to power the subsystem directly from a standard 120 V socket input. The DC voltage will be regulated to ensure stability in the subsystem operation.

5.1.3. Primary Input Power for Disinfection Unit and Excitation Monochromator

A DC regulated power supply, capable of delivering DC voltages as high as +32 VDC, shall be utilized with the disinfection unit and excitation monochromator subsystems due to the higher nominal DC voltages of the stepper motor controller and driver and UV LEDs. Alternative components, such as batteries and boost converters, may be explored as more compact means of powering the system.

5.2. Voltage and Current Levels

Component	Voltage (V)	Current (mA)
UV LED (Disinfection Unit)	Estimate: 32	Estimate: 300
UV LED (Excitation Monochromator)	Estimate: 32	Estimate: 300
Stepper Motor Controller and Driver (Excitation Monochromator)	Estimate: 24	Estimate: 200
Emission Monochromator	Estimate: 5	Estimate: 600

Table 11: Absolute maximum voltage and current values for system components.

The excitation monochromator and disinfection unit subsystems are expected to consume more power than the emission monochromator and will therefore utilize a DC regulated power supply in the range of +0 to +32 VDC. Alternative means of powering the subsystems, perhaps with even only batteries, may be explored during the course of the project.

5.3. Signal Interfaces

5.3.1. Emission Monochromator Signal Interface

The emission monochromator control electronics will include a serial port which will be coupled with a USB to Serial adapter for interfacing with the onboard computer. Through this serial communication link, spectral data may be read and stored from the emission monochromator subsystem.

5.3.2. Stepper Motor Controller and Driver Signal Interface

The stepper motor controller and driver will include a serial port which will be coupled with a USB to Serial adapter for interfacing with the onboard computer. Through this serial communication link, commands may be issued for rotating the excitation grating and performing synchronous fluorescence measurements.

5.3.3. Excitation Monochromator Signal Interface

The excitation monochromator will house a DB9 connector which will be coupled with the stepper motor controller and driver for rotating the excitation grating of the monochromator. Control signals will be sent from the controller and driver to the connector based on user commands issued through the serial communication link between the controller and driver and onboard computer.

5.4. User Control Interface

The user control interface will be a GUI, executing on the onboard computer, which is responsible for receiving inputs from users, communicating with both the excitation monochromator and emission monochromator subsystems, and ultimately processing and displaying recorded data. This unit will interface with both the excitation monochromator and emission monochromator subsystems by means of a serial communication link, or cable, which may allow commands to be easily issued. Relevant inputs from users may include the following: (1) the type of spectrum (normal fluorescence or synchronous fluorescence) to record, (2) the initial and final excitation wavelengths of the spectrum, (3) the number of spectra to record, and (4) the range of fluorescence data to subject to PCA, among others. Following these user inputs, the unit will issue control signals for initializing the excitation and emission monochromators and initiating the spectrum acquisition. Furthermore, this unit will be responsible for receiving, processing, and displaying spectral data recorded by the emission monochromator.

6. Communications / Device Interface Protocols

6.1. Serial Communication

Serial communication will be achieved between the onboard computer and excitation and emission monochromator subsystems by means of a serial communication link. Through this serial communication link, spectral data may be read and stored from the emission monochromator subsystem. In addition, commands may be issued for rotating the excitation grating and performing synchronous fluorescence measurements.

6.2. RS-232 Communication Protocol

RS-232 is expected to be the standard protocol utilized for the serial communication process. All relevant practices regarding this protocol shall be enforced and followed. The serial port will be configured as needed to follow this particular communication protocol.

6.3. DB15 Connector

A DB15 connector will be utilized to interface the stepper motor controller and driver with the excitation monochromator. All relevant practices regarding this connector shall be enforced and followed. In particular, appropriate connectors will be utilized to interface these components together.