Time-Resolved Fluorescence Reader

SDSU College of Engineering

Ascential Medical & Life Sciences

Project Overview

Our time-resolved fluorescence reader will be used by biomedical researchers. These researchers need to measure the concentration of biological compounds, and will dye them with Europium; which makes them more easily measurable. These Europium-dyed samples are then pipetted into a standard 96-well microplate which our device then measures the Europium concentration of for each sample plate well.

Our device exploits Europium's property of being highly fluorescent to measure its concentration. When excited by ultraviolet light, Europium emits red light via fluorescence. By measuring this fluorescence through time-resolved fluorescence spectroscopy, our device can get a very accurate measurement of the Europium concentration. Researchers can then use this to evaluate the concentration of the underlying substance they are interested in.

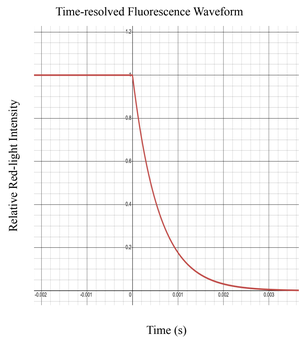
The primary function of our device is to shine ultraviolet light onto individual microplate well samples, to capture the red-light time-resolved fluorescence waveform emitted by the samples, and then to translate this data to a scalar Europium concentration.

Time-Resolved Fluorescence Physics

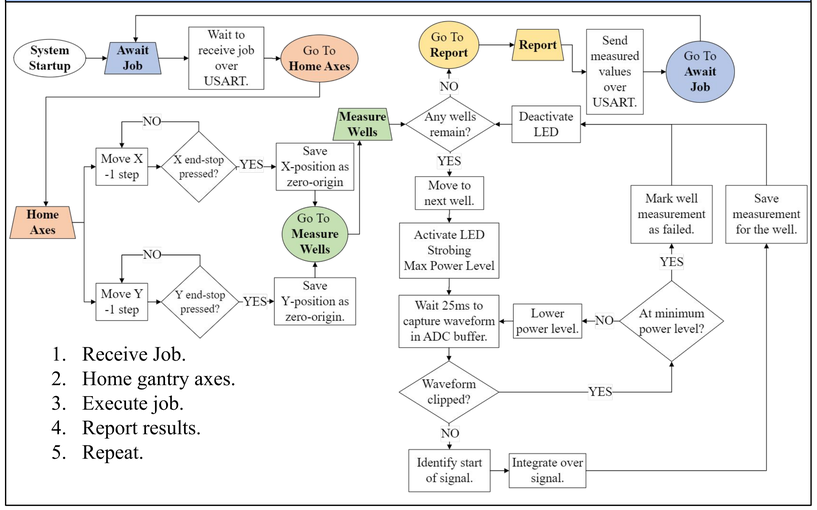
Fluorescence is when a high energy (short wavelength) photon is absorbed by an atom, and then a short time later, a lower energy (longer wavelength) photon is emitted as the electron returns to the low energy state.

There is a particular random distribution for the expected time for a new photon to be emitted after the first photon is absorbed, and this manifests as an exponentially decaying function of time.

This transient exponential decay of fluorescence emissions is called "time-resolved fluorescence." In our device, a strobing UV LED excites fluorescence, and then a photodiode captures the red light emitted during the off-period. Our device then integrates the fluorescence emission signal during the off period to measure concentration.



Software Flow Diagram



1. Receive Job.
2. Home gantry axes.
3. Execute job.
4. Report results.
5. Repeat.

Key Specifications

1. The device shall measure Eu(III) concentration within 5% of the true value.
2. The device shall have a Eu(III) detection limit of 500 fM or less.
3. The device must be capable of measuring all wells of a microplate in under 5 minutes.
4. The device must implement an external control interface.
5. The device must not expose the samples to bio-incompatible materials.
6. The device shall be designed for use with standard 96-well microplates.

Device CAD

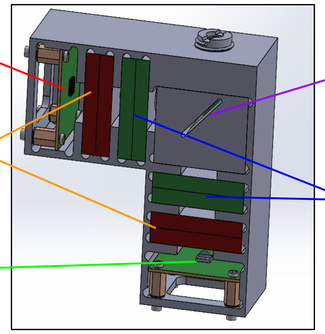
Project Video

Fluorescence Excitation and Sensing Subassembly

Photodiode Sensor
Captures the fluorescence emissions like a solar panel.

Lenses
Focuses light from/onto the LED, samples, and photodiode for increased optical efficiency.

UV LED
We strobe the UV LED to excite our sample and generate fluorescence emissions.



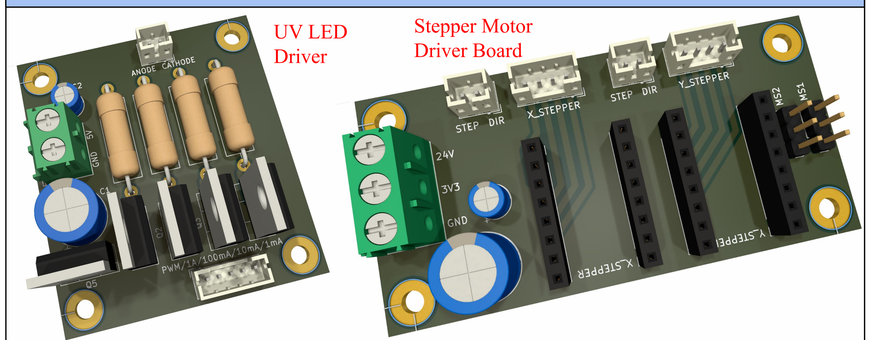
Dichroic Mirror
Allows UV light to pass through toward the samples, but reflects the red emissions at a 90 degree angle towards the photodiode sensor.

Filters
Filters red or ultraviolet light to reduce signal interference.

Core PCBs

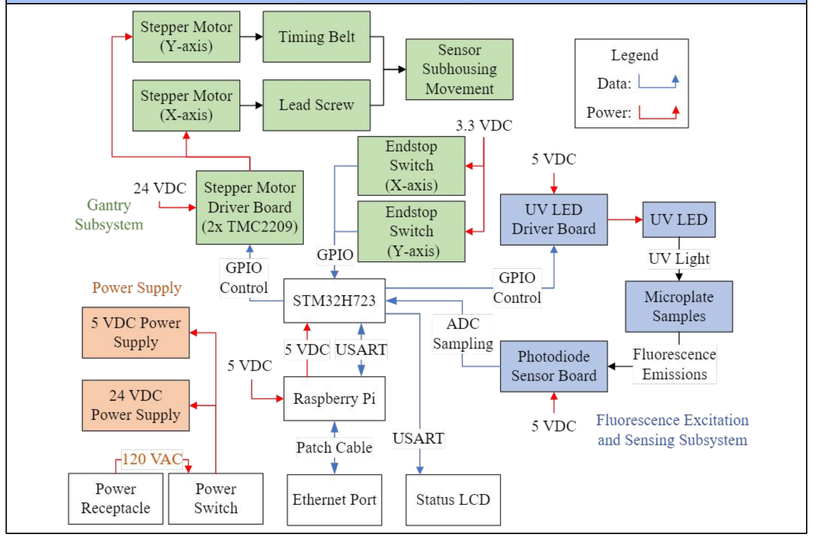
UV LED Driver

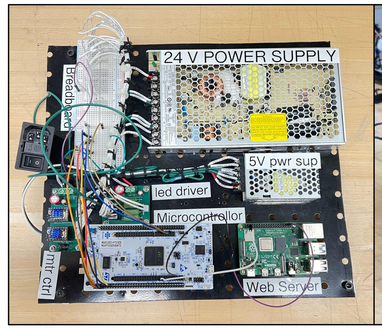
Stepper Motor Driver Board

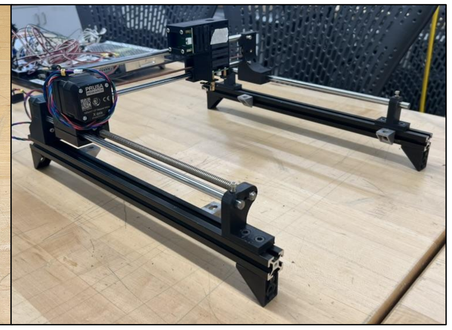


- The UV LED driver provides GPIO-drivable inputs for the STM32 microcontroller to control the power level of the UV LED and enable strobing, as well as a connector for the UV LED and a screw terminal for power.
- The stepper motor driver board houses two BIGTREETECH TMC2209 boards and provides connectors for the stepper motors, GPIO inputs to control each motor, and a power screw terminal.
- All of our PCB designs implement JST connectors to make the electrical subsystems easily interchangeable without excessive resoldering.

System Diagram







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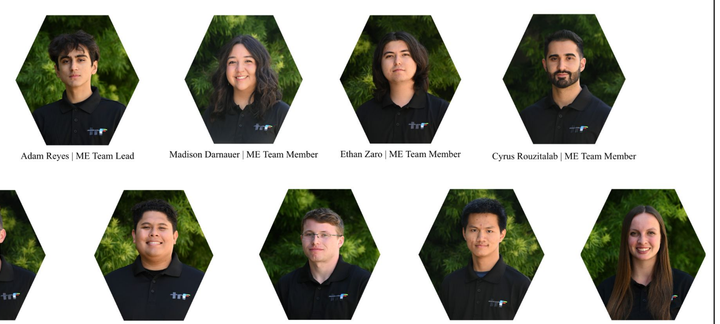
Meet the Team

Joint ECE/ME Team



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