LOW COST BIOLUMINESCENCE DETECTION

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Background

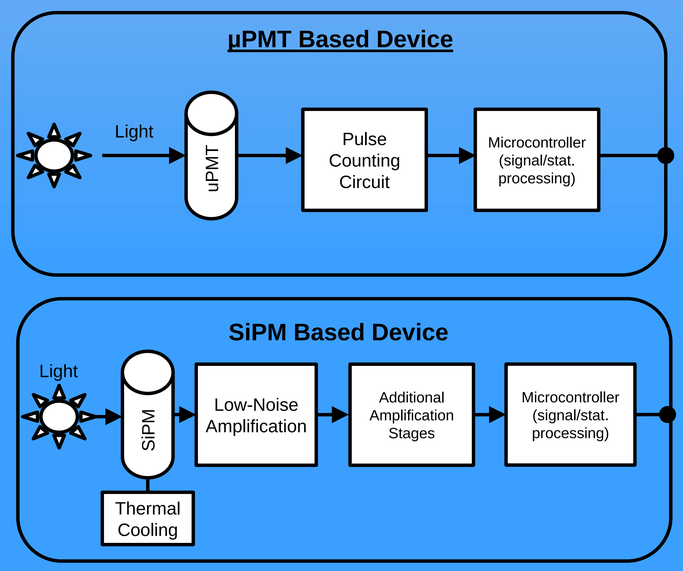
Antibiotic resistant bacteria is one of modern medicine's greatest challenges. GeneWEAVE (a Roche subsidiary) has developed a faster diagnostic method based on an induced bioluminescent reaction in bacteria. The current technology relies on expensive photomultiplier tubes that make this system too cost prohibitive outside of large hospital environments. We've designed sensors based on cheaper, state-of-the-art SiPM/µPMT technologies that can achieve single-photon detection (sub-attojoule) at under $500.

Overview/Design Specs

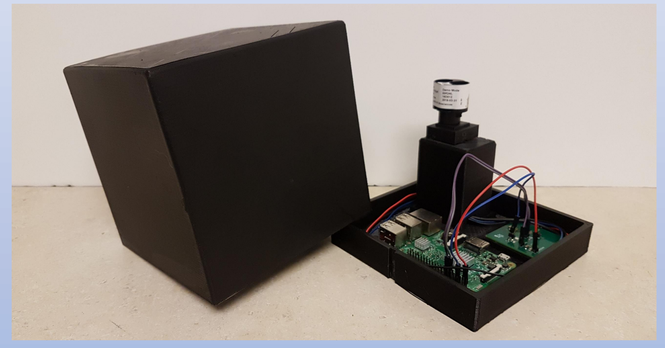
Our project focuses on the design of the light detection system for use in GeneWEAVE's VivoDX diagnostic tool. The trade-offs of two different sensors, a Silicon Photomultiplier (SiPM) and a Micro Photomultiplier (µPMT), were evaluated to find the best balance between:

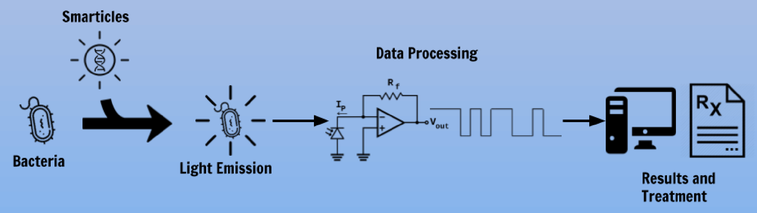
- Cost
- Light Detection Capability
- Compatibility with current VivoDX

System Block Diagrams



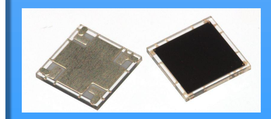
Overview





The system we created can very accurately measure low levels of light emitted from a bioluminescent reaction. By analyzing these measurements over time, bacterial antibiotic resistance and vulnerability can be determined quickly and cheaply.

Hardware / Key Components



Silicon Photomultiplier (SiPM)

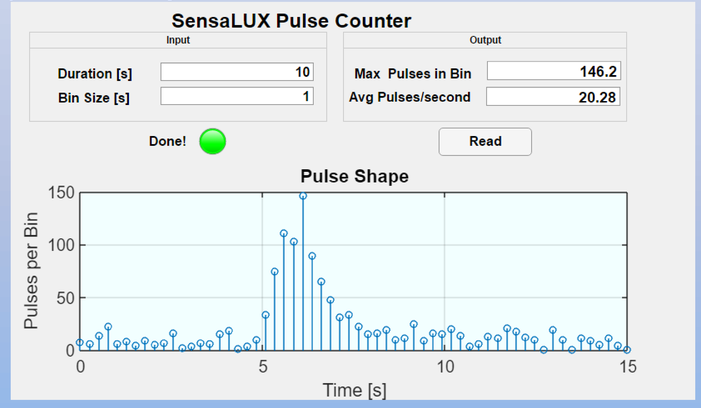
- 1mm^2 array of photodiodes
- Dark count of 30kHz
- Requires signal conditioning and cooling
- Cheapest component (<$100 at all unit pricing)

Micro Photomultiplier Tube (µPMT)

- Miniature PMT
- Dark count of ~5Hz
- Simpler signal conditioning and no cooling required
- Cheaper than PMT, more expensive than SiPM (<$500 at over 5k units)

µPMT System Performance

This implementation of the system worked exceptionally well. With simple circuitry and no thermal cooling required, this system is reliable and robust.



This image displays the user interface of the µPMT based design during a simulated bioluminescent reaction. This user interface plots the transient response of the luminescent reaction, as well as providing important statistics about the light entering the system.

SiPM System Performance

The SiPM system required much more precise circuitry and an excessive amount of thermal cooling. Ultimately, the system failed to produce any significant results. The main issues we ran into were:

- Still excessive amounts of thermal noise, even with significant efforts to cool the device using a Peltier cooler.
- Complexity of the system overall is not convenient and would be more prone to malfunctioning in practice

Conclusions

The Micro-PMT based system is much more reliable, precise, and robust than the SiPM based system. The fact that the circuit requires no thermal cooling and a relatively simple design make the Micro-PMT system well worth the comparatively larger price tag while still fulfilling the cost and size specifications. We believe this system will allow Roche to reach a larger international market and continue to make strides against antibiotic resistant bacteria.

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