Design and production of a low cost thermal cycler

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Abstract

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There is a need for low cost, high precision thermal cyclers accessible to students and universities for the purpose of amplifying DNA. Producing a reliable and accurate device that can be produced at any makerspace for around $300.00 will eliminate a huge barrier to entry for those wishing to do more in the biotechnology field. During the process of building the thermal cycler, a custom designed circuit board using only off the shelf low cost components was developed. All control is executed through custom code that is purposely kept as user friendly as possible. The casing was modeled in SolidWorks and ran through simulation to determine how it will open and operate before being 3D printed. A simple user interface was developed and the thermal cycler has been tested to achieve DNA amplification.

Affordable biotechnology focus

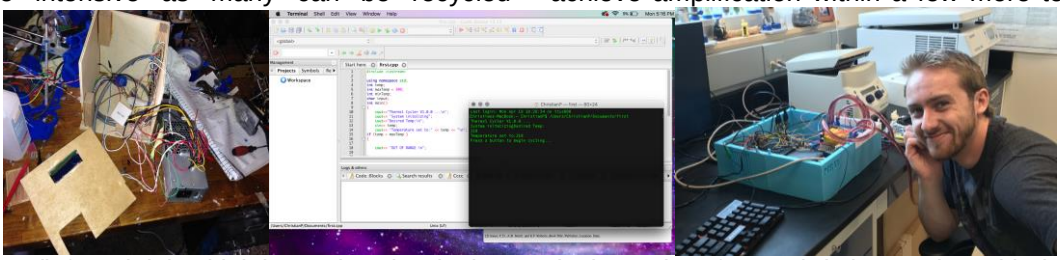
An innovator's best friend is cheap and accessible technology. While technology revolving around robotics has become drastically more available for the low budget student, fields such as microbiology and genetics are still tough to enter. Items such as a thermal cycler are hard to find at low cost and are often complex requiring special training to use; hindering typical student or young scientist access to the equipment needed for microbiology research. An increased emphasis on microbial survival in high-altitude balloon experiments has prompted the development of this device. The $300.00 cost of this unit is a safe estimate and should be reasonable to bring a final product to schools for around that price. Primary sources of cost stem from the water cooling heat management system. The rest of the parts are not as price intensive as many can be recycled materials such as a computer power supplies, while no longer efficient enough for today's systems are perfect for such DIY products.

Metrics for Success

Before any actual assembly was to take place, a checklist needed to be created which would include goals that need to be met to classify my design a success or a failure. The first and perhaps most important criteria is functionality, if the device is unable to correctly fluctuate temperature and produce results than the underlying project will have been a failure. The second most criteria is reliability. In the beginning this appeared to be the most difficult goal and the first version had a buffer of 60% repeatable data. The third and most exciting criteria for the cycler is the cost, after discussing this with my faculty advisor I decided to set a goal of $300.00 for total cost. Though initial tests did not produce the desired results, a second round of testing is scheduled.

Conclusions

Initial tests show no amplification, primarily due to the time period for temperature ramping being too large, so the device was not able to run through all 30 cycles. Given that each cycle produces exponentially more DNA it is possible that the last test was successful, just not visible on the gel. In order to combat the ramping issue, steps have been taken to reduce mass from the thermal block which holds the PCR tubes and improve cooling to the water system. The device exterior is entirely 3d printed, therefore redesign and modification to implement an isolated ice reservoir for the radiator is not an issue. These modifications should yield desired results and allow the thermal cycler to achieve amplification within a few more test runs.



Figures (left to right) Initial thermal cycler design, typical user interface, Christian posing with the final design