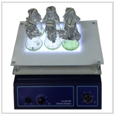

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Illuminated Orbital Shaker for Microalgae Culture

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ABSTRACT

Microalgae are grown for the research on photosynthesis, biotechnology, and water-environment ecology. Specialized laboratories typically use calibrated commercial equipment, which agitates the microalgae culture by shaking or bubbling, controls the irradiance, temperature, and CO_2 content. Such commercial incubators may be out of reach for some laboratories, like those not specializing in microalgae research, teaching laboratories, or laboratories in low resource settings. Our research uses microalgae cultures during the development and validation of advanced microscopy techniques. We lacked access to and the budget for a commercial incubator. We solved the problem by building a stand-alone orbital shaking incubator with an in-built variable light source and a 24-hour timer. The shaker features a homogeneously illuminated growth area of 20 cm × 15 cm, which is suitable for three T75 tissue culture flasks or four 100 ml Erlenmeyer flasks. The overall material cost was around £300 and assembly time of about two days. We tested the shaker with fresh-water microalgae *Desmodesmus quadricauda* and *Chlorella vulgaris*. Both microalgae cultures have been grown continuously for seven months in the incubator. We studied their growth under different light conditions to validate the function of the shaker. The protocol outlines the step-by-step process to the building of this microalgae shaker.

Here, we describe an illuminated orbital shaker designed for culture of microalgae suspensions. It was optimized for production cost, simplicity, low power consumption, design flexibility, and consistent and controllable growth light intensity. The instrument agitates and illuminates microalgae suspensions grown inside flasks. The agitation speed is variable while the light intensity is both variable and programmable (24-hour light/dark diurnal cycle).

The instrument offers a vastly cheaper alternative to commercial instruments for many laboratory applications, making it especially well suited for teaching and poorly-resourced research laboratories. It improves on home-built microalgae growth systems by offering consistent and well characterized illumination light intensity, low power consumption and heat dissipation. The illuminated growth area is 20 cm × 15 cm, which is suitable for three T75 tissue culture flasks or six 100 ml Erlenmeyer flasks. The photosynthetic photon flux density, measured inside an Erlenmeyer flask, is variable in eight steps (26–800 $\mu mol \cdot m^{-2} \cdot s^{-1}$). The overall material cost is around £300 (including an entry-level orbital shaker). The build takes about two days, requiring electronics assembly and machine workshop skills. The instrument build is documented in a set of protocols, design files, and source code. Its design can be readily modified, scaled, and adapted for other orbital shakers and specific experimental requirements.

The illuminated orbital shaker is ideal for growing small volumes of microalgae for research and teaching. It can readily replace commercial systems in many common microalgae culture application for a fraction of their cost. It outperforms typical home-made systems by offering consistent and predictable illumination light intensity and low power consumption.

EXTERNAL LINK

https://app.labstep.com/sharelink/221d4460-8591-4ab5-ac0c-70b54c93532a

GUIDELINES

This document brings an overview of the steps required to build and assemble the algal shaker. It is a high-level document that explains the process and links to more detailed protocols, which describe the step-by-step procedures.

SAFETY WARNINGS

The work on this project involves a number of hazards. The risks are low with appropriate safety precaustions in place. The warnings are discussed in details in the individual protocols. In general, the hazards involved in electronics soldering, mechanical workshop tools use, and optional laser cutter and 3D printer use. The risks include exposure to fumes, solvents, hot surfaces, electrical current, and potentially lead during soldering; cutting or bruising and dust during mechacial workshop works; exposure to fumes, hot surfaces, and potentially solvents during optional 3D printing; and exposure to fumes and laser irradiation during optional laser cutting.

BEFORE STARTING

Project Steps

Building the algal shaker requires the following major steps:

- Procuring Parts for Algal Shaker
- Assembling LED Controller Electronics
- 3D Printing Case for LED Controller
- Assembling Cooled LED Illuminator
- Cutting and Drilling Clear Acrylic Sheet
- Assembling Algal Shaker

The steps outlined above are superficially described in this protocol. Detailed step-by-step description of each is in the linked protocols.

Required Skills

Building requires electronics assembly skills, including soldering of surface mount components. Basic mechanical workshop skills and equipment are also required. Optional 3D printer and laser cutter simplify the process. The custom printed circuit board needs to be ordered from a suitable supplier.

Time to Build

Once all the parts are secured, the assembly should take a day or two in total. The lead time of the parts will depend on their local availability and price. Custom-made printed circuit boards and the orbital shaker are likely to be the components with the longest lead times.

Cost

We found the overall cost to be about £300. The price will vary according to local prices and fluctuate with time.

Citation: Jakub Nedbal (03/18/2020). Illuminated Orbital Shaker for Microalgae Culture. https://dx.doi.org/10.17504/protocols.io.bdubi6sn

1 **Procurement of Parts**

The components for the algal shaker can be sourced from four types of suppliers.

- Laboratory equipment supplier
- Electronics parts distributor
- Printed circuit board manufacturer
- 3D printing service (or in-house 3D printer)

The orbital shaker can be sourced from laboratory equipment suppliers. The orbital shaker described in this protocol was bought on ebay.

All electronics components and mechanical fixings can be bought from electronics parts distributors. In the described case, it was Farnell. The clear acrylic sheet can be bought from specialist local supplier of sheet plastic or can be ordered laser cut to size and shape local laser-cut service providers.

The custom-made printed circuit board (PCB) simplifies and speeds up the assembly and results in a smaller, more robust circuit. Here, Seeed Technology was used for their low-cost, high-quality PCBs production service.

The electronics is housed in a custom case. It can be produced on a fused-deposition modelling 3D printer - in-house or outsourced to third-party manufacturers. An in-house Stratasys Uprint SE Plus was used here.

Go to: Procuring Parts for Algal Shaker

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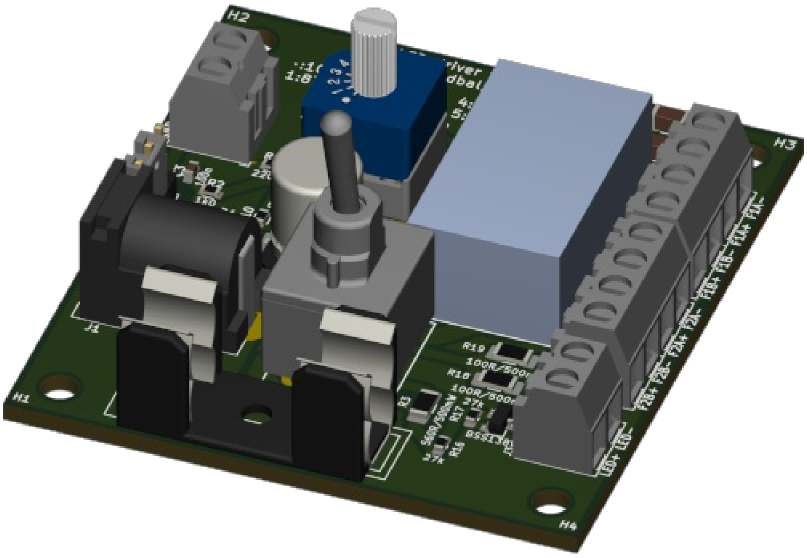
2 Assembling the LED Controller

The LED controller electronics regulates the LED current, adjusting the irradiance of the sample according the experimental needs. It also powers the fans cooling down the LEDs. The electronic circuit assembly requires surface-mount component soldering equipment and skills. The smallest parts used are in 0603 package. This size allows soldering with a decent soldering station, flux, watch-makers tweezers, an a bit of experience. The soldering should take no more than 1-2 hours. It is followed by testing the circuit and finally cleaning any excess flux.

Consider the safety of the soldering process and observe local regulations. Soldering creates risks of fire, exposure to hazardous fumes, and skin exposure to the soldering flux. Take all necessary precautions. Keep the work area tidy, especially devoid of any combustible materials. Never leave the soldering iron unattended while hot. Use fume extractor during soldering and laboratory gloves when handling the flux-stained PCB.



Assembled LED controller printed circuit board

Go to: Assembling LED Controller Electronics

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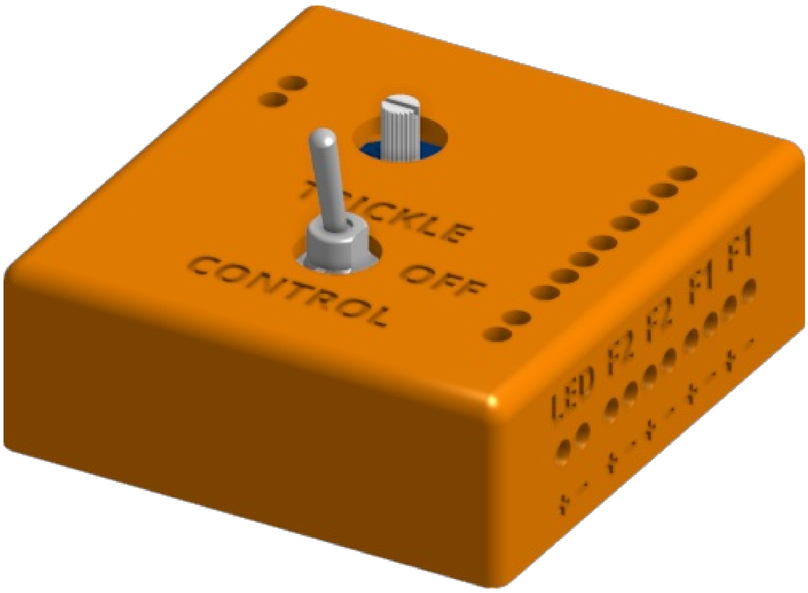
3 3D Printing the Case

The electronics circuit is housed inside a case, which protects the circuit from damage and the users from exposure to live voltage. The case for the LED controller can be 3D printed in-house or outsourced to a specialist supplier. I used Stratasys Uprint SE Plus, a fused-deposition modeling printer. The finishing is rough, but serves the purpose. A laser-sintering printer would produce a more detailed and premium finish.



Assembled case for the LED controller

Go to: 3D Printing Case for LED Controller

4 Assembling Cooled LED Illuminator

The LED illuminator is built from LED strips mounted on top of a heatsink. The heat sink is passively cooled when the LEDs are operated at low current. It is actively cooled by small fans at higher current to avoid overheating the algal cultures. The assembly of the cooled LED illuminator consists of glueing the LED strips to the underside of the heat sink and soldering them in a daisy-chain fashion for connection to the LED controller. The fans are also glued to the heatsink and connected to the LED controller.

Cooled LED illuminator

Go to: Assembling Cooled LED Illuminator

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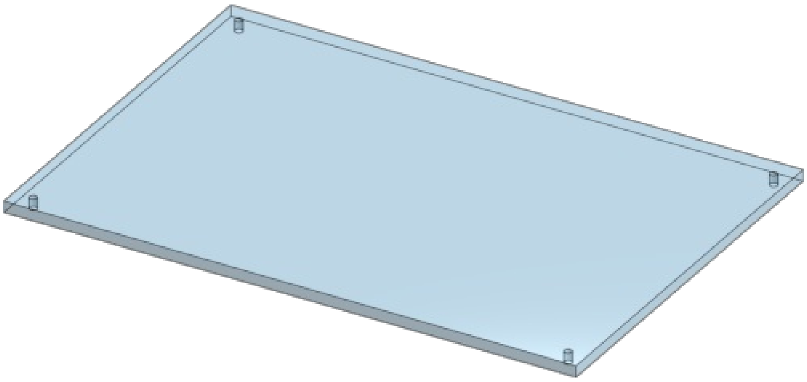
5 **Cutting and Drilling Clear Acrylic Sheet**

A clear acrylic sheet is mounted over the LEDs and serves as the platform on which the algal cultures are placed for shaking. The acrylic can be cut out and drilled using a hack saw and a drill in a workshop. Alternatively, it can be cut using a laser cutter in-house or externally.



Cut and drilled clear acryilic sheet serving as a transparent orbital shaker platform

Go to: Cutting and Drilling Clear Acrylic Sheet

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6 **Assembling the Algal Shaker**

Assembling the Algal Orbital Shaker is the last an most rewarding step. The acrylic sheet is mounted on top of the orbital shaker on metal stand-offs. The cooled LED illuminator is laid underneath the acrylic. The antislip silicon mat supplied with the orbital shaker is placed on top of the acrylic. The LED controller is connected to a socket through a 24-hour timer with the day/night cycle programmed. Once powered, the algal shaker should be working.

Assembled and functioning illuminated orbital shaker

Go to: Assembling Algal Shaker

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