

“Cell-free biosensors for rapid detection of water contaminants”

**Jung, Alam, *et al.* (2020)**

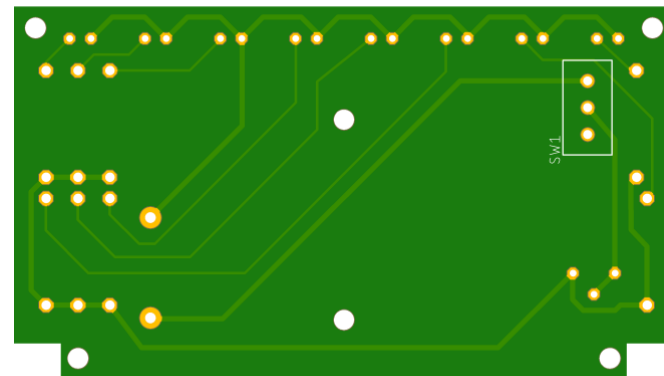
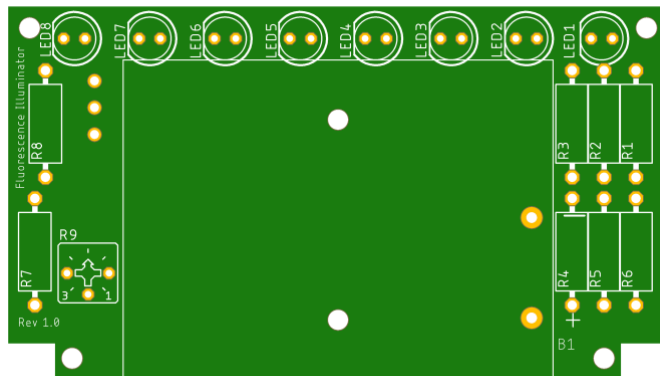
Supporting Data File

## Handheld Fluorescence Illuminator Instructions

3D print the following .STL files using fused filament fabrication (also known as fused deposition modeling, FDM). For the illuminators described here, we have had success using a Stratasys Fortus 250MC printer with black ABS plastic, 0.007 inch (0.178 mm) layer thickness. We have included our CAD files for anyone to develop and customize their own illuminator on top of our design.

- Front case: 786018-2\_rev2-logo.STL
- Back case: 786018-3.\_rev1.STL
- Battery cover: 786018-4\_rev1.STL
- Window frames (print 2): 786018-5 WINDOW FRAME.STL

We have also provided .gbr files for manufacturing a printed circuit board (PCB) for easy assembly of the electronic components. For the illuminators described here, we had our PCBs manufactured by JLBPCB.com as 2-layer boards. The EPF file for the board is available at this [link](#) and can be opened using Eagle (free download from [Autodesk](#)).



Top view of the board (left). Bottom view of the board (right). The switch (“SW1”) goes on the bottom side of the board.

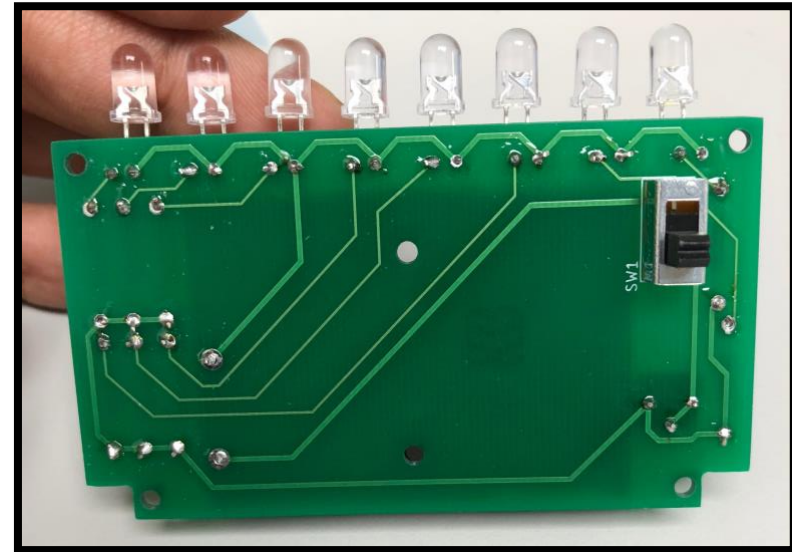
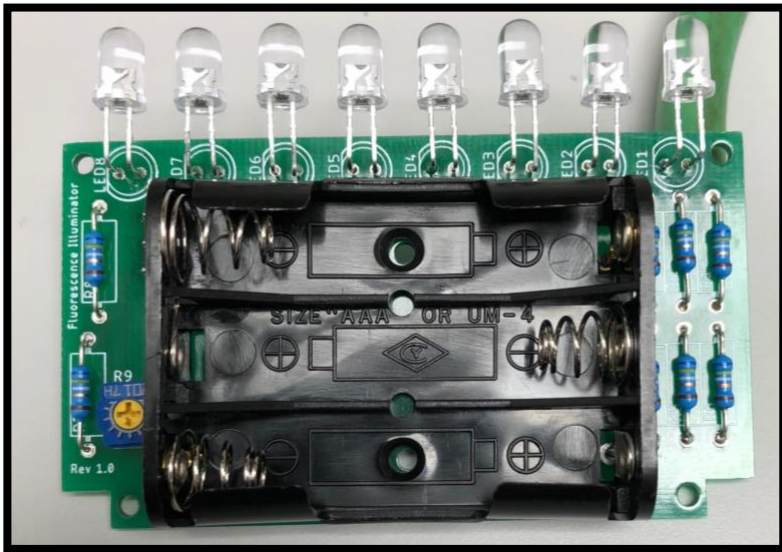
Additional parts needed to assemble the illuminator include: 3 AAA batteries, 8 LEDs (LED1-LED8 in the illustration), 8 resistors (R1-R8), a trim potentiometer (R9) that allows you to easily adjust the brightness of the LEDs, and a switch (SW1). You will also need a set of electronics tools (T6 Torx driver, No. 1 Phillips driver, small wire clippers, etc.), a soldering iron and solder.

Part	Supplier	Manufacturer	Supplier Part Number	Cost (April 2020)	Quantity	Details
5 mm Standard Through Hole LED, 470 nm Blue	Mouser	Cree, Inc.	941-C503BBANCZ0A0451	\$0.23/each	8	15° viewing angle, 11000 mcd, $I_F = 20$ mA, $V_F = 3.2$ V
Through Hole Axial Resistor	Digi-Key	Yageo	64.9XBK-ND	\$0.10/each	8	64.9 Ohms, 1/4W
Through Hole Trimmer Potentiometer	Digi-Key	Nidec Copal Electronics	CT6EP201-ND	\$0.78	1	200 Ohm, 1/2W
Through Hole Slide Switch	Digi-Key	Nidec Copal Electronics	360-2131-ND	\$2.25	1	
3 Cell AAA Battery Holder	Digi-Key	Memory Protection Devices (MPD)	BC3AAAPC-ND	\$1.71	1	
Phillips Rounded Head Thread-Forming Screws for Plastic (#1 Phillips)	McMaster-Carr		99461A710	\$0.243/each (sold in pack of 50)	6	18-8 Stainless Steel, Number 2 Size, 3/16" Long
Flat Head Thread-Forming Screws for Plastic (T6 Torx)	McMaster-Carr		95893A550	\$0.266/each (sold in pack of 50)	4	18-8 Stainless Steel, Number 2 Size, 1/4" Long

Assembly of the board can be tricky, especially if you're not familiar with electronics and soldering. Be prepared to make mistakes (order some extra LEDs). Although the tolerances are fairly generous, it still takes a certain level of skill to put this together. Your local research shop, core facility, maker space, etc. should have hobbyists and experts who can help you throughout this process.

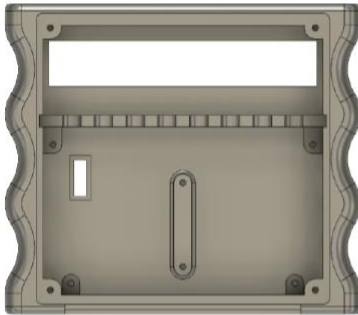
#### Tips:

- Test all of your components before soldering them onto the board.
- Start with the LEDs, then add the resistors, the switch, the trim potentiometer, and finally the battery holder.
- Position the LEDs so that they first extend away from the board, and then bend 90° upwards. This is one of the challenging parts of assembling the board. We found that bending the legs around a small cylindrical rod helped to consistently position all of the LEDs. Test fit the board in the case throughout the process.
- Start with LED1, then LED8, LED2, LED7, etc. Alternating in this manner results in a more consistent build.
- The legs of the LEDs, resistors, battery holder, and switch must be trimmed as close to the board as possible. Failing to do so will make it more difficult to mount the board inside the illuminator.
- Remember that the switch mounts on the other side of the board.
- Test the board before mounting it into the illuminator.

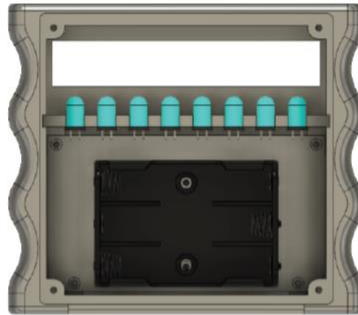


**Assembly of the handheld fluorescence illuminator.** (A) Place the front case flat on a solid surface with the backside facing towards you. (B) Gently place the fully-assembled printed circuit board (PCB), without batteries, into the back of the front case. Be careful to make sure that the switch on the PCB is aligned with the switch hole in the front case. Make any final adjustments (e.g. LED positioning) before moving onto the next step. (C) Place 6 round head Phillips screws into the positions shown by the arrows and secure into place with a #1 Phillips driver. (D) Gently place the back case onto the the front case. Do not force into position! If you are unable to place the back case on, you may need to adjust the PCB or sand down the 3D printed pieces. (E) Screw the back case on using 4 of the flat head screws with a T6 Torx driver. Add batteries and slide battery cover up to close.

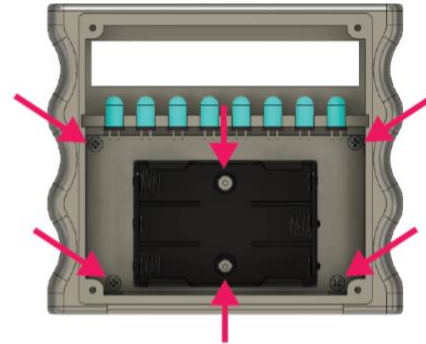
a



b



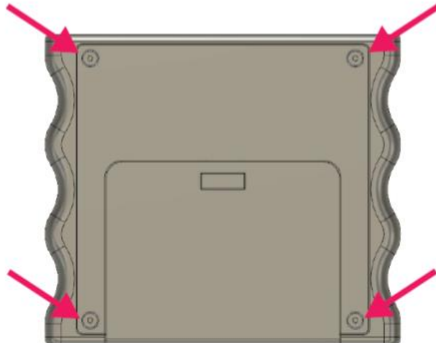
c

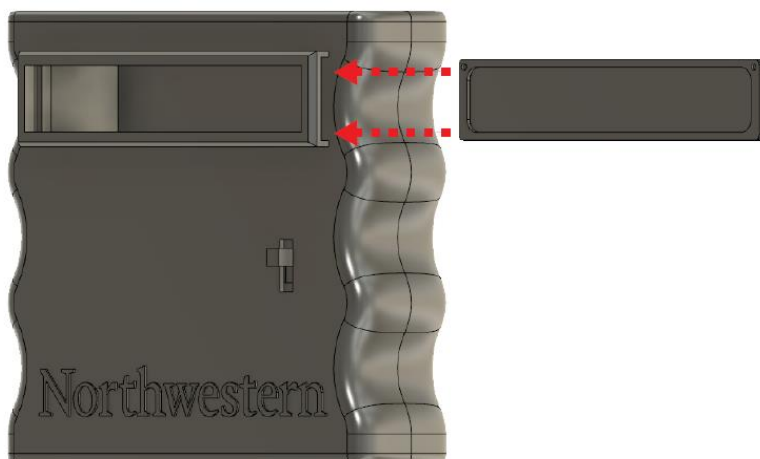


d



e





The window assembly consists of two identical frames, so make sure you print two of them. They are designed to sandwich a piece of stage light film between them and slide as a single unit into the window on the front case of the illuminator. Test fit the frames and adjust as needed before gluing the filter and frames together. We recommend using a small amount of a strong and clear adhesive (e.g. cyanoacrylate, a.k.a. “superglue”). Once assembled, the framed filter should easily slide into the window.

For visualizing green fluorescence, we recommend using Roscolux #12 Straw as a lighting filter. A poster size roll can be purchased online for ~\$10 (before shipping and handling). It efficiently transmits light at wavelengths longer than 500 nm, while blocking a sufficient amount of blue light across 380–480 nm. This makes it a practical solution for blocking the blue light generated by the LEDs, but not the green fluorescence generated in ROSALIND reactions. An additional layer of film can improve the blue light blocking but will also result in lower transmittance of green light.

A benefit of having a removable window is that you can easily try several different filters until you find something that works best for your application.

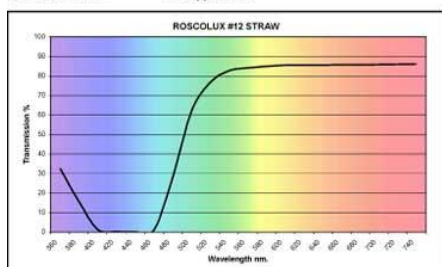


#### COLOR FILTER TECHNICAL DATA SHEET

SWATCHBOOK:  
COLOR FILTER:  
DESCRIPTION:  
TRANSMISSION =  
MIREL SHIFT =  
CC EQUIVALENT =

ROSCOLUX  
#12 STRAW  
Color Effects Lighting Filter.  
88% or -0.2 stop loss  
Not Applicable.  
Not Applicable.

COLORIMETRIC DATA  
OBSERVER: CIE 1964 10°  
SOURCE: \* 'A' (tungsten)  
\* 'D65' (daylight)

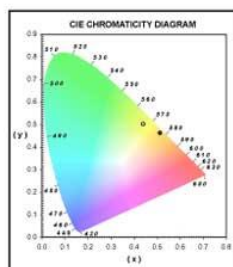


HUNTER LAB	
SOURCE A	
L*	91.307
A*	1.079
B*	0.735

HUNTER LAB	
SOURCE D65	
L*	89.449
A*	-12.272
B*	96.136

CIE 1964	
SOURCE A	
Y	80.496
(x)	0.512
(y)	0.483

CIE 1964	
SOURCE D65	
Y	75.162
(x)	0.440
(y)	0.553



nm.	360	380	400	420	440	460	480	500	520	540	560	580	600	620	640	660	680	700	720	740
trans %	55	15	1	0	0	1	20	62	77	83	84	85	86	86	86	86	86	86	86	86

#### MATERIAL SPECIFICATIONS:

General Description: Deep-Dyed Polyester Film  
Substrate: PET (Polyethylene Terephthalate)  
Thickness: 1.5 mil (.0015" or 38 micron)  
Manufactured in: U.S.A.

#### AVAILABLE SIZES:

✓ 20 in. x 24 in. sheets (50cm x 60cm)  
✓ 24 in. x 25 ft. rolls (60cm x 7.62m)  
✓ 48 in. x 25 ft. rolls (121cm x 7.62m)  
60 in. x 20 ft. rolls (152.4cm x 6.10m)  
13.5 in. Diameter Glass (34.3cm) - Cut to order





Contact the Lucks Lab (<http://luckslab.org>) with any questions. Post and share your builds with us by tagging us on Twitter @Luckslab!

**Acknowledgements:** We acknowledge the work of Northwestern University's Research Shop for the CAD designs and development of the PCB, and Northwestern's Rapid Prototyping facility for manufacturing them.