

Open source and DIY hardware for DNA nanotechnology labs

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File S1. Construction instructions and parts lists for the devices described.

Parts list for homogenizer:

3D printed 2-tube holder

NIH 3-D print repository Model ID 3DPX-001227

<https://www.shapeways.com/product/3CJW7TFSZ/>

and/or 3D printed 6-tube holder

NIH 3-D print repository, Model ID 3DPX-001748)

<https://www.shapeways.com/product/KTJPSFR2X/>

DEWALT DWE357 10-Amp Compact Reciprocating Saw

Reciprotools RCT-A10 Reciprocating Saw Adapter

Neiko 20753A 1/4-Inch Shank Keyless Chuck Conversion Tool

TruePower Electronic Stepless Speed Controller

(Optional) Digital tachometer, Tondaj 6234P+

Instructions for open homogenizer:

Clamp 3D printed tube holder into the Keyless Chuck Conversion Tool

Plug the Keyless Chuck Conversion Tool into the Reciprocating Saw Adapter

Add 1 ml of liquid/suspension to be homogenized to a 2 ml conical tube

Add a ¼ inch steel ball bearing to the conical tube

Place tube into the 3D printed tube holder

Homogenize by pulsing 10 times with the trigger for ~1 sec each time

Minimum speed on TruePower speed controller is ~20 Hz (based on tachometer)

Adjust speed and pulse length to achieve desired results

Parts list for horizontal PAGE gel rig:

3D printed gel casting mold

NIH 3-D print repository model ID 3DPX-001228 and 3DPX-001229

<https://www.shapeways.com/product/KHYF72RR5/>

<https://www.shapeways.com/product/5YRNDGG2F/>

Biorad Mini-Sub® Cell GT kit (catalog # 170-4406)

Instructions for horizontal PAGE rig adapter:

Using a long piece of lab tape, surround the tray portion of the mold

Prepare 50 ml of acrylamide prepolymer to desired density

Example:

17 ml Acrylamide/bis-acrylamide (19:1) solution (30%) from Biorad.

5 ml 10x SB buffer

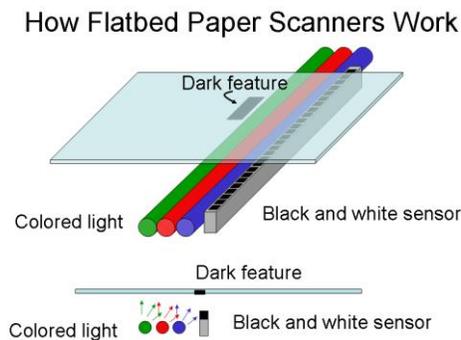
- 10 ml 50% glycerol
- Initiate polymerization
 - Add 44 μ l of TEMED (Biorad) and 168 μ l of 10% ammonium persulfate
- Add this mixture to the taped tray-mold
- Slowly lower 3D printed lid/comb diagonally into the prepolymer
- Excess prepolymer will be displaced onto the top of the lid
- Allow this to sit at room temperature for 1 hour to polymerize
- Remove tape
- Remove the excess polyacrylamide from the top of the lid
- Pull the lid/comb away from the polyacrylamide using the handle
- To scan the gel, remove it from the tray

Parts list for modifying a commercial flatbed scanner for fluorescence

1. Canoscan LiDE 110 scanner
2. Conductive ink pen (Radioshack Bare Conductive Pen Catalog #2760267)
3. Kodak wratten number 15 filter (ideally, 100mm x 100mm square)
4. Laboratory tape
5. Small sized Phillips head screwdriver
6. Utility knife
7. Multimeter
8. Test leads
9. AA battery
10. Suguru or epoxy paste

Instructions for modifying the Canoscan LiDE 110 scanner for fluorescence detection:

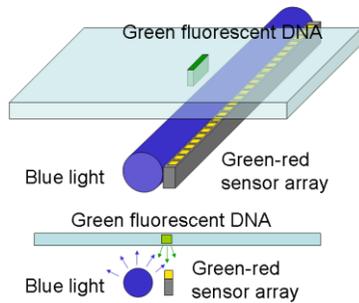
1. As delivered, the color flatbed scanner operates by sequentially flashing red, green, and blue light and recording a straight of reflected intensity data. Reconstructing the stripes of red green and blue reflections yields a two dimensional RGB image.



2. In order to modify this scanner for fluorescence detection, we must illuminate in the blue only (in order to excite fluorescein-like dyes) and record the light intensity in the green and red spectrum. In order to avoid collecting bright reflections in the green and

red, the scanner is modified to emit blue light only. In order to collect appropriate fluorescent light, a filter is applied to the sensor array.

How Fluorescence Scanners Work

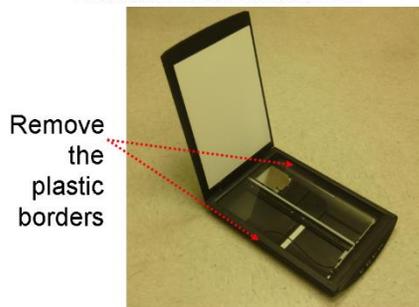


3. The Canoscan LiDE 110 scanner is disassembled in the following manner:

3a. The plastic borders on the sides of the bed of the scanner are removed using a razor blade or utility knife.

Disabling the Red and Green light

Disassemble the scanner



Disabling the Red and Green light

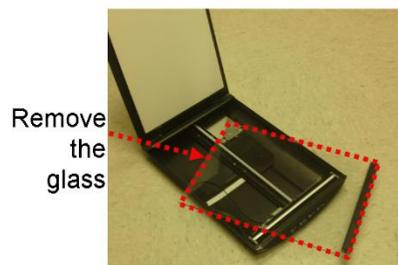
Disassemble the scanner



3b. The glass scanner bed slides toward the back of the scanner and the glass can then be lifted out with the aid of a small screwdriver

Disabling the Red and Green light

Disassemble the scanner

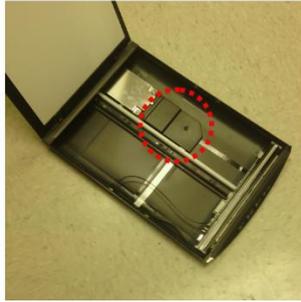


4. The red and green illumination sources are disabled in the following manner:

4a. The ribbon cable cover is removed using a Phillips screwdriver

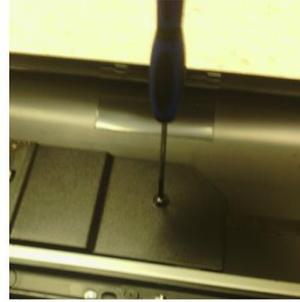
Disabling the Red and Green light

Uncover the ribbon cable connections



Disabling the Red and Green light

Uncover the ribbon cable connections



4b. The ribbon cable connection is located and probed with an AA battery to determine which pins correspond to ground and the red and green LED illumination pins

Disabling the Red and Green light

Uncover the ribbon cable connections

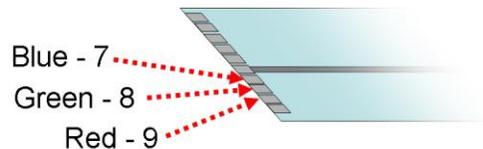


4c. in the case of the CanoScan LiDE 110 scanner, these are pins 8 and 9

Disabling the Red and Green light

Tape over RGB pins

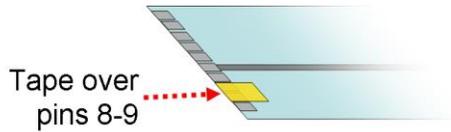
(#8-9 on CanoScan LiDE 110)



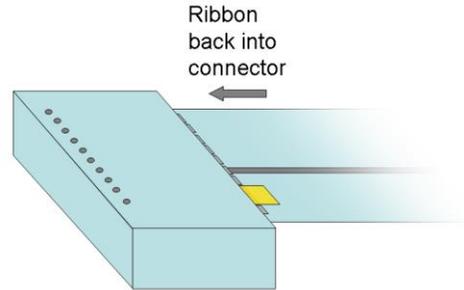
4d. Kapton tape is applied to pins 8 and 9 (or whichever pins correspond to the red and green illumination) and the ribbon cable is plugged back into its connector

Disabling the Red and Green light

Tape over RGB pins
(#8-9 on CanoScan LIDE 110)

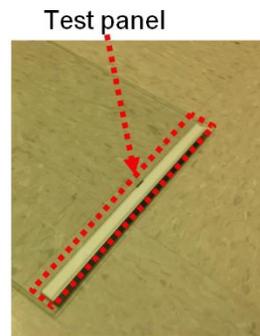


Disabling the Red and Green light



5. The Canoscan LiDE 110 scanner performs a self-check upon startup. During the self-check, it uses green illumination to scan a small test panel attached to the scanner bed. Disabling the green illumination prevents this from occurring and effectively disables the scanner. In order to solve this, the power for the green LED array must be rerouted to the blue LED array.

The scanner does a self-test when it is first plugged in
It scans a panel under the glass (see image) to test the LED, sensor and motor
It uses green channel for this
If you disable the green completely, the scanner fails to boot



This can be accomplished with a conductive ink pen. Conductive ink is applied to bridge pins seven, eight, and nine on the ribbon cable connector.

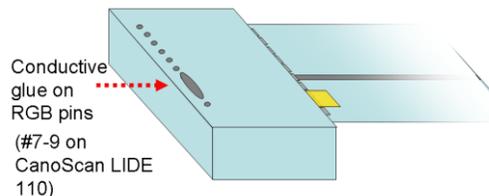
Conductive pen

- Put a bit of conductive ink on a piece of paper
- Transfer ink to pins with a needle or a pipette tip



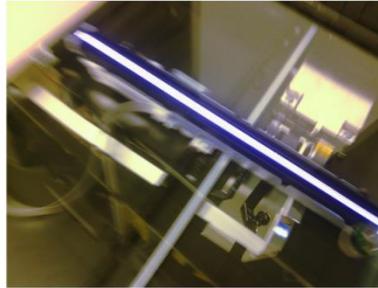
Re-routing the green channel

- With conductive paint or glue, we can re-route the green (and red – why not) channel to the blue LED

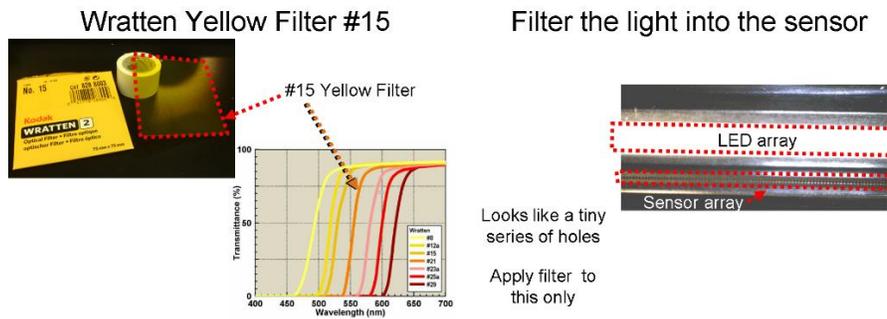


6. The scanner should be tested at this point by partially reassembling, connecting, and attempting to scan.

Test it out after putting the glass back in place – should be **Blue**



7. A Kodak wratten #15 filter limits the reflected blue light from reaching the detector array. This filter can be taped to the sensor array which is directly adjacent to the LED illuminator.



8. In order to satisfy the scanner's self-check, the central region of the aforementioned test panel must not be covered by the yellow filter. Additionally, the wratten filter is only 75 mm wide. As a consequence, only a 75 mm stripe of the scanner is used. The unfiltered region of the scanner bed must be blacked out. This can be accomplished with cardboard or black spray paint. This is a good opportunity to black out the reflective white scanner bed cover as well.

To satisfy self-check

- Use only right 75mm of the scanner
– This is the stock width of the Wratten filter
- Do not filter the test panel notch region
- Mask the unused regions of scanner bed

Test fluorescence with highlighter on paper

In white light, the words are barely visible

Under fluorescence, writing is very clear.

9. Blue illumination from the blue LED built into the scanner is inadequate for sensitive detection of bands of DNA embedded in a gel. The bands are several mm away from the

relatively low-powered LED. An array of bright LEDs can be directed onto the gel from the side to improve the LOD.

Affix a blue LED array to the side
for better sensitivity

