

LightSound Assembly Instructions

Introduction

These instructions for building your LightSound are organized into four main sections: (I) Chassis preparation, (II) Wiring/soldering, (III) Programming the Flora, and (IV) Final assembly. For Parts II and IV, there are accompanying step-by-step diagrams to aid with the wiring of the LightSound components. Please note that these instructions are written with the assumption that the reader is familiar with the basic safety practices in a workshop when using power tools and soldering/wiring. Safety glasses should be worn at all times.

At the start of each main section, a list of relevant materials and tools is provided. While specific tools and materials are listed, some are recommendations and may be substituted with another material, such using single insulated wires in lieu of ribbon cable wires or electrical tape in lieu of heat shrink. A comprehensive parts list for the LightSound is given after the introduction.

In the instructions, a list of the numbers of wires and heat shrinks needed are given for each step. These numbers reflect the *new* wires and heat shrinks that are needed and do not include wires/heat shrinks that have already been prepared or attached.

As previously mentioned, ribbon cables are recommended for wiring, although any type of standard, multi-stranded hookup wire can be used. The advantage of ribbon wire is that it keeps multiple wires organized when they are traveling from one component to another, but electrical tape and zip ties can be used to achieve a similar outcome. If you do choose to use ribbon cables for the wiring, single wires are unnecessary since you can pull off single, double, triple, and quadruple strands of wire from the ribbon (depending on the step). Ideally, the ribbon cable should be a minimum of four wires across.

Throughout the wiring and programming of the LightSound, there are several checkpoints to ensure that everything has been assembled correctly up to that step. In the event that the LightSound does not behave as expected at that step, Part V consists of a list of common problems and troubleshooting methods.

LightSound Comprehensive Parts and Tools List

Parts/tools marked with a single asterisk (*) are suggested but are **not essential**.

Parts/tools marked with a double asterisk (**) **are essential** but may be substituted with a comparable component or tool.

Adafruit components:

- FLORA - Wearable electronic platform: Arduino-compatible - v3
(<https://www.adafruit.com/product/659>)
- VS1053 Codec + MicroSD Breakout - MP3/WAV/MIDI/OGG Play + Record - v4
(<https://www.adafruit.com/product/1381>)
- High Dynamic Range Digital Light Sensor– TSL2591
(<https://www.adafruit.com/product/1980>)

Other electrical components:

- **Toggle switch (<https://www.adafruit.com/product/3221>)
- **Audio jack (soldered connections) (<https://www.adafruit.com/product/3692>)
- *7805 +5V voltage regulator (brand used in instructional pictures: Fairchild LM7805C)
- Wire (ribbon cable recommended, but any standard multi-stranded hookup wire works)
- **Heat shrinks

Additional parts:

- 9V battery
- 9V battery snap connector (if not included with the chassis)
- * Screw (ideally self-tapping) to secure voltage regulator
- **Chassis
(https://www.amazon.com/dp/B005T5GSFW/ref=cm_sw_r_cp_api_i_Sb4aBbD1FEVNH)
- **Telescope adaptor (for positioning LightSound over telescope objective)
(https://www.amazon.com/dp/B06Y6G8YQ7/ref=cm_sw_r_cp_api_i_933aBbGJZD5YY)

Items needed for LightSound programming:

- Computer
- Micro-USB cord with programming capabilities
- Adafruit-Arduino IDE
(<https://learn.adafruit.com/getting-started-with-flora/download-software>)
- Adafruit Arduino library
 - TSL2591 Library (https://github.com/adafruit/Adafruit_TSL2591_Library)
 - Adafruit Sensor Library (https://github.com/adafruit/Adafruit_Sensor)
- LightSound code

Tools needed for assembly and wiring:

- **Drill press
- *File
- Ruler and/or calipers
- Wire strippers/cutters
- Soldering iron and solder
- *Heat gun or blow dryer
- *Flush cutters
- *Hot glue gun and/or gaffer's tape and/or carpet tape
- *Adhesive rubber bumper

Instructions

I. Chassis preparation

Tools/materials needed:

- Drill press
 - File
 - Ruler and/or calipers (both are useful)
 - LightSound chassis
 - Power switch
 - Audio jack
1. Plan out placement of the different components in the chassis. Remember to leave space for wire connections and to place the micro-USB port near the outside of the chassis for the external connection from the Flora board.
 2. Using the planned layout, mark the locations of the 2 holes on the faceplate for the power on/off switch and the audio jack.
 3. With a drill press, drill the two holes to their appropriate diameters so that the switches and audio jack fit snugly and do not wiggle around. Twist in the power switch and audio jack. Suggested drill sizes for the hole diameters (based on the suggested switches and jack) are listed below:
 - a. Power switch – 0.221" bit
 - b. Audio jack – 0.221" bit (may have to file slightly for jack to screw in)
 4. On the bottom half of the chassis (the part with the battery enclosure), mark where the light sensor hole should be placed and bore a hole of the appropriate size with the drill press.
 - a. Make sure the light sensor board is clear of the faceplate groove and will not be pushed around when the faceplate is installed
 - b. Double-check that the sensor will not be obscured at all by the plastic.
 - c. Suggested drill size – 0.180" bit
 - d. Suggested hole placement – 0.85" from top of chassis to center of hole
 5. If you are using the suggested chassis, cut an opening for the battery snap wires in one corner of the battery partition.
 - a. Slot dimensions should be around 1/8" wide and at least 1/4" deep
 - b. Recommended tools: file and/or small handheld saw

II. Wiring/soldering

Tools/materials needed:

- Wiring Diagram
- Wire strippers/cutters
- Soldering iron and solder
- Heat gun or blow dryer
- Insulated wire (ribbon cable recommended)
 - Ribbon cable is useful since it keeps the wires organized between circuit boards
 - 7 single wires
 - 2 x 4-wire ribbon cable
 - 2 x 3-wire ribbon cable
 - 2-wire ribbon cable
- Heat shrinks
 - 8 to 11 lengths
 - One length should be a slightly larger diameter than the others (see step 6)
- LightSound chassis with switches and audio jack installed
- Battery snap connector
- Voltage regulator
- Flora board
- Lux Sensor board
- Codec board
- Audio jack

Connecting the power switch, battery, and voltage regulator

1. Check to make sure there will be enough slack in the wires from the battery snap connector so that the wires can connect to the power switch (at the top part of the chassis) and the voltage regulator. If the wires are not long enough, splice on additional lengths of wire, cover the splice with heat shrink or electrical tape, and proceed with step 2.
 - a. 1 wire, 1 heat shrink (for wire connection)
2. Prepare wires to connect the red (positive) battery wire to the switch, the ON lead of the switch to pin #1 (input) on the voltage regulator, pin #2 (ground) on the regulator to the Flora, and pin #3 (output) to the Flora. Cut lengths of heat shrink to cover the leads.
 - a. Pin numberings and wiring diagrams for the voltage regulator can be found online, but the component pins are typically numbered in ascending order from the left to right, with the metal tab oriented to the back of the component.
 - b. 4 wires, 4 heat shrink

3. Connect the red (positive) wire from the battery snap connector to the center (NONE) lead on the switch. Cut a length of heat shrink to cover the connection and slide it onto the wire. Solder the connection and position the heat shrink over the lead.
 - a. 1 heat shrink
4. Before connecting the wire that you connected to the ON lead on the switch to pin #1 on the voltage regulator, cut a length of heat shrink to cover the lead. Slide it onto the wire before soldering the wire to pin #1 on the regulator. Position the heat shrink over the lead.
 - a. 1 heat shrink
5. As in step 2, before connecting the black wire on the battery snap to the voltage regulator, make sure there is some slack in the connection. If the battery wire is not long enough, cut an additional wire and splice it with the black battery wire (via soldering). Cut a length of heat shrink and slide it over the connection, then proceed with step 6.
 - a. 2 wires, 1 heat shrink
6. Prepare a wire to connect pin #2 on the voltage regulator to the GND pad on the Flora. Both the black battery wire and this wire need to connect to pin #2 on the voltage regulator, so they should be soldered together first. Twist their tips together and then tin them. Cut a length of heat shrink for the connection (it will need to be a slightly larger diameter) and slide it over the two wires. Solder the joined wires to pin #2 on the voltage regulator. Position the heat shrink over the lead.
 - a. 1 wire, 1 heat shrink
7. Prepare another wire to connect pin #3 (5V out) on the voltage regulator to VBATT on the Flora. Cut a length of heat shrink to cover the lead on the voltage regulator. Solder the wire to pin #3 on the voltage regulator and slide the heat shrink onto the wire and over the lead.
 - a. 1 wire, 1 heat shrink
8. If desired, cut a length of heat shrink to cover the unused lead on the power switch and slide it on.
 - a. 1 heat shrink
9. Optional checkpoint: Check that the regulator works with the following steps:
 - a. Connect the battery, switch the power on, and touch the black probe to the pin 2 or the tab and the red probe to pin 1 (or the wire soldered to it). The voltmeter should read around 9V.
 - b. With the power still on, touch the red probe to pin 3 (or the wire soldered to it). The voltmeter should read around 5V.
 - c. Turn off power and disconnect battery before continuing to solder.

Connecting the voltage regulator to the Flora

10. Connect (via screw terminal) or solder the free wire that you soldered to pin #2 on the voltage regulator to the GND pad on the Flora.
11. Connect or solder the wire from pin #3 on the regulator to the VBATT pad on the Flora.
12. Checkpoint: Connect battery and turn on power to make sure that lights on the Flora board turn on.
13. Turn off power and disconnect battery before continuing to solder.

Connecting the Lux Sensor to the Flora

14. Prepare wires for the Lux Sensor/Flora GND, SCL, SDA, and 3V/3.3V connections and prepare wires of appropriate lengths (ribbon cable recommended here). Connect/solder the appropriate wires to the GND, SCL, SDA, and Vin holes on the Lux Sensor.
 - a. 4 wires (ribbon cable recommended)
15. Connect/solder the other ends of the wires to the appropriate pads on the Flora (i.e. GND to GND, SCL to SCL, SDA to SDA, and Vin to 3.3V).

Connecting the Codec (MIDI) board to the Flora and audio jack

16. Prepare wires (ribbon cable recommended) for D9/RST, D10/RX, 3.3V, and GND connections from Codec board to Flora, as well as two jumpers to connect GND/0 and 3V3/1 on the Codec board.
 - a. 4 wires (ribbon cable recommended), 2 jumper wires
 - b. There are multiple 3V3 pads, so you can connect the 3V3/1 jumper on the opposite side of the board as the Codec/Flora 3V3/3.3V connection
17. Take the GND/0 jumper and GND wire and tin them together so that junction can be soldered into the GND hole on the Codec board.
18. Solder the following wires to the Codec board:
 - a. Jumper and wire pair (from step 2) – jumper end to 0 pad and jumper/wire junction to GND pad on other side of board
 - b. Second jumper between 3V3 and 1 pads
 - c. Wires to RX, RST, and 3V3 pads (for Codec/Flora connection)
19. Prepare wires (ribbon cable recommended) to connect LOUT, ROUT, and AGND (on Codec board) to the leads numbered 2 (L), 3 (R), and 1 (ground, the longer lead) pins on the audio jack. Cut lengths of heat shrink for each connection on the jack.
 - a. 3 wires (ribbon cable recommended), 3 heat shrinks
20. Solder the wires to the LOUT, ROUT, and AGND pads on the Codec board

21. Solder the following wires on the Codec board to the Flora board:
 - a. RX wire to the #10 pad
 - b. RST wire to the #9 pad
 - c. 3V3 wire to the 3.3V pad
 - d. GND wire to the GND pad
22. Slide the 3 heat shrinks onto the LOUT, ROUT, and AGND wires.
23. Solder the following wires on the Codec board to the audio jack:
 - a. LOUT wire to lead #2 (L)
 - b. ROUT wire to lead #3 (R)
 - c. AGND wire to lead #1 (GND, longest lead)
24. Slide the heat shrinks over the audio jack leads.

III. Programming the Flora

Tools/materials needed:

- Computer
 - Micro-USB cord with programming capabilities
 - Adafruit-Arduino IDE (<https://learn.adafruit.com/getting-started-with-flora/download-software>)
 - Adafruit Arduino library
 - TSL2591 library (https://github.com/adafruit/Adafruit_TSL2591_Library)
 - Adafruit Sensor library (https://github.com/adafruit/Adafruit_Sensor)
 - Supplied *Software Instructions*
 - Supplied LightSound code
 - LightSound chassis with assembled/wired components
1. If you have not already done so, download/install the Adafruit-Arduino IDE (using the link above) and follow the directions in the separate *Software Instructions* (supplied). There are some additional steps that Windows, Mac OSX, and Linux users need to take when installing and setting up the Adafruit-Arduino IDE.
 - a. Windows: <https://learn.adafruit.com/adafruit-arduino-ide-setup/windows-driver-installation>
 - b. Mac OSX: <https://learn.adafruit.com/adafruit-arduino-ide-setup/mac-osx-setup>
 - c. Linux: <https://learn.adafruit.com/adafruit-arduino-ide-setup/linux-setup>
 2. Install the TSL2591 Lux Sensor and Adafruit Sensor libraries by following the directions at the following link: <https://learn.adafruit.com/adafruit-tsl2591/wiring-and-test#install-adafruit-tsl2591-library-4-4>
 3. Open the LightSound code in the Adafruit-Arduino IDE
 4. Connect the micro-USB cord to the LightSound
 5. Set the IDE's board setting to "Adafruit Flora" by going to Tools > Board and selecting "Adafruit Flora" under the Adafruit Boards sections of the drop-down menu.
 - a. If you don't see the option, make sure that you have installed Adafruit AVR Boards by Adafruit (see Step 4 of *Software Instructions*)
 6. Under Tools > Port, select correct port. It should say "Adafruit Flora" on it somewhere. On Windows computers, this port should be a numbered form of "COM." On Mac OSX computers, it should be labeled as a serial port.
 7. Upload the LightSound code to the Flora.
 - a. For issues uploading, see "Software-specific Troubleshooting" in Part V
 8. Checkpoint: Plug speakers or headphones into the audio jack, connect the battery, and test if the LightSound works and that the outputted sound varies with light intensity!

IV. Final assembly

Tools/materials needed:

- Heat gun or blow dryer
 - File
 - Micro-USB cord (recommended)
 - Flush cutters (recommended for removing unnecessary posts in the chassis)
 - Hot glue gun and/or gaffer's tape and/or carpet tape
 - * Screw (ideally self-tapping) to secure voltage regulator
 - * Adhesive rubber bumper (to secure Flora at the right height in the chassis)
 - LightSound chassis (with switches and audio jack installed and Flora, Color Sensor and NeoPixel already wired in)
 - Codec board
1. Disconnect LightSound from micro-USB and turn off power for final assembly.
 2. Make sure all of the heat shrinks are positioned correctly. Using a heat gun or blow dryer, quickly heat the tubings until they shrink to form.
 3. To create the hole for the micro-USB connection to the Flora, mark where the port on the Flora meets the chassis and cut the opening with a file or similar instrument.
 - a. In order to minimize the amount of material we had to cut away from the chassis, we raised our Flora by attaching an adhesive rubber bumper to the bottom of the board and then hot-gluing it to the chassis.
 - b. Make sure the micro-USB port sits flush with the outside of the chassis for a good connection
 - c. Double-check that the micro-USB cable will fully connect to the port on the Flora when the chassis is closed.
 - d. Make sure to carve out a hole that accounts for the rubber/plastic molding around the micro-USB end.
 4. Tack down components of LightSound inside the chassis with hot glue, carpet tape, or gaffer's tape. If there is a spare chassis post available, use a screw to secure the voltage regulator to the chassis (through the hole in the tab).
 - a. Use flush cutters to remove any unnecessary posts from chassis
 - b. Check that the sensor on the Lux Sensor board is not obscured before tacking
 - c. Check that the micro-USB port is aligned with the bored hole before tacking
 5. Close up chassis
 - a. Make sure no wires will be pinched by the chassis or its screws before closing
 6. Your LightSound is ready to use!

V. Troubleshooting

General Troubleshooting

1. Check for continuity in soldering connections (on pads and in wires, especially if screw terminals are used on some of the components)
2. Check for cold solder joints
3. If you are using screw terminals, make sure the wires are making contact in the terminal (i.e. insulation is not interfering)
4. Check for pinched or severed wires
5. Double-check that the battery has charge and the clip is fully snapped on

Checkpoint-specific Troubleshooting

1. Part II, Step 12
 - a. Check wiring of power switch, voltage regulator, and Flora
 - b. See General Troubleshooting for more suggestions
2. Part III, Step 8
 - a. Check the Adafruit-Arduino IDE settings and try re-uploading the LightSound code to the Flora
 - b. Check that the Lux Sensor is not obscured
 - c. See General Troubleshooting for more suggestions
 - d. Make sure audio jack, Codec board, and Flora are wired correctly
 - e. Check if headphones/sound system work with another audio player
 - f. See General Troubleshooting for more suggestions

Software-specific Troubleshooting

1. All users
 - a. Check that the micro-USB cord is capable of data transfer
 - b. Try changing USB ports on the computer
 - c. Check the Adafruit-Arduino IDE installation page for more help (<https://learn.adafruit.com/adafruit-arduino-ide-setup/overview>)
2. Windows users
 - a. Check that you installed the Adafruit Windows Driver (<https://learn.adafruit.com/adafruit-arduino-ide-setup/windows-driver-installation>)
 - b. Try using a self-powered USB 2.0 hub that plugs into an outlet
 - c. Try installing the Adafruit-Arduino IDE 1.6.4 or earlier (<https://learn.adafruit.com/adafruit-arduino-ide-setup/arduino-1-dot-6-x-ide#all-in-one-installation-not-recommended-2-18>)
 - d. If you are using Windows 7 or earlier, you may need to find a Windows 10, Mac, or Linux computer to use