Color Arduino Assembly Instructions

Introduction

These instructions for building your Color Arduino are organized into four main sections: (I) Chassis preparation, (II) Wiring/soldering, (III) Programming the Flora, and (IV) Final wiring and assembly. For Parts II and IV, there are accompanying step-by-step diagrams to aid with the wiring of the Color Arduino 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. In the pictures provided with these instructions, 0.1-inch screw terminals were installed on all of the Adafruit components to reduce the amount of soldering needed but are by no means essential. A comprehensive parts list for the Color Arduino is given after the introduction.

In both the written and diagrammed steps, 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 Color Arduino, there are several checkpoints to ensure that everything has been assembled correctly up to that step. In the event that the Color Arduino does not behave as expected at that step, Part V consists of a list of common problems and troubleshooting methods.

Color Arduino 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 – $14.95 (https://www.adafruit.com/product/659)
- VS1053 Codec + MicroSD Breakout - MP3/WAV/MIDI/OGG Play + Record - v4 – $24.95 (https://www.adafruit.com/product/1381)
- RGB Color Sensor with IR filter and White LED - TCS34725 – $7.95 (https://www.adafruit.com/product/1334)
    - Make sure you get the breakout (square) version, not the wearable (circular) one
- Flora RGB Smart NeoPixel version 2 - Pack of 4 – $7.95 (https://www.adafruit.com/product/1260)

Other electrical components:

- **Mini ON-OFF toggle switch (for power) – $2.19 (http://www.youdoitelectronics.com/catalog/product/view/id/926/s/philmore-mini-on-off-toggle-spst-30-10007/category/592/?___SID=U)
- **Sub-Mini ON-OFF toggle switch (for LED) – $2.12 (http://www.youdoitelectronics.com/philmore-on-off-sub-mini-toggle-30-10030)
- **Alternative toggle switch (can be used for both power and LED) – $0.95 (https://www.adafruit.com/product/3221)
- **Audio jack (screw terminals) – $2.50 (https://www.adafruit.com/product/2791)
- **Alternative audio jack (soldered connections) – $0.75 (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
- *Screw terminals for Adafruit components

Additional parts:

- 9V battery
- 9V battery snap connector (if not included with the chassis)
- **Chassis – $12.85 (https://www.amazon.com/dp/B005T5GSFW/ref=cm_sw_r_cp_api_i_Sb4aBbD1FEVNH)

- **Telescope adaptor (for positioning Color Arduino over telescope objective) – $16.99 (https://www.amazon.com/dp/B06Y6G8YQ7/ref=cm_sw_r_cp_api_i_933aBbGJZD5YY)

Items needed for Color Arduino programming:

- Computer
- Micro-USB cord with programming capabilities
- Adafruit-Arduino IDE (https://learn.adafruit.com/getting-started-with-flora/download-software)
- Adafruit Arduino library
    - NeoPixel Library (https://github.com/adafruit/Adafruit_NeoPixel)
    - TCS34725 Color Sensor Library (https://github.com/adafruit/Adafruit_TCS34725)
- Color Arduino 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

Instructions

I. Chassis preparation

Tools/materials needed:

- Drill press
- File
- Micro-USB cord (recommended)
- Ruler and/or calipers (both are useful)
- Color Arduino chassis
- Power switch
- LED 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.
2. Using the planned layout, mark the locations of the 3 holes on the faceplate for the power and sensor LED on/off switches and the audio jack.
3. With a drill press, drill the three holes to their appropriate diameters so that the switches and audio jack fit snugly and do not wiggle around. Suggested drill sizes for the hole diameters (based on the suggested switches and jack) are listed below:
    a. Power switch –
    b. White LED switch – 0.173” (about 0.439 cm)
    c. Audio jack – 0.344” (about 0.874 cm)
4. On the top half of the chassis (the part without the battery enclosure), use the drill press to bore a hole for the NeoPixel RGB LED indicator. Placement is not essential, but ideally it should be centered and located near the top (faceplate-side) of the chassis.
    a. Suggested drill size – 0.25” (0.635 cm)
    b. Check that the NeoPixel LED is unobscured. You may need to file the hole to a 0.25” by 0.25” (0.635 cm by 0.635 cm) square

5. On the bottom half of the chassis (the part with the battery enclosure), mark where the sensor/white LED hole should be placed and bore a hole of the appropriate size with the drill press.
    a. Make sure the color sensor board is clear of the faceplate groove and will not be pushed around when the faceplate is installed
    b. Double-check that neither the LED nor the sensor will be obscured at all by the plastic. Since the ideal hole shape to expose the white LED and the sensor is rectangular, this can be accomplished by boring a slightly larger hole than the rectangle or by boring a slightly smaller hole and filing it to a rectangle.
    c. Suggested drill size – 0.25” (0.635 cm)
    d. Suggested placement of hole – at least 0.5” (1.3 cm) from top of chassis to top of hole
6. To create the hole for the micro-USB connection, mark where the port on the Flora meets the chassis and cut the opening with a file or similar instrument. On our chassis, we were able to cut primarily into the bottom half of the chassis.
    a. Make sure the micro-USB port sits flush with the outside of the chassis for a good connection
    b. Double-check that the micro-USB cable will fully connect to the port on the Flora when the chassis is closed.

II. Wiring/soldering

Tools/materials needed (will also be needed for Part IV):

- 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
    - 4-wire ribbon cable
    - 3-wire ribbon cable
    - 2-wire ribbon cable
- Heat shrinks
    - 8 to 10 lengths
    - One length should be a slightly larger diameter than the others (see step 6)
- Color Arduino chassis with switches and audio jack installed
- Battery snap connector
- Voltage regulator
- Flora board
- NeoPixel board
- Color Sensor board

Connecting the power switch, battery, and voltage regulator

1. Prepare the appropriate lengths of wire to connect the ON lead of the on/off switch to pin #1 (input) on the voltage regulator. Cut a length of heat shrink to cover the switch lead and solder the wire onto the lead. Slide on the heat shrink length to cover the lead.
    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. 1 wire, 1 heat shrink
2. Before connecting the red wire on the battery snap connector to the switch, make sure there is some slack in the connection, since you will need to be able to remove the battery when the chassis is closed. If the battery wire is not long enough, cut an additional wire and splice it with the red battery wire (via soldering). Cut a length of heat shrink and slide it over the connection, then proceed with step 3.
    a. 2 wires, 1 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. Make sure all of the heat shrinks are positioned correctly. Using a heat gun or blow dryer, heat the tubings until they shrink to form.

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.

Connecting the Color Sensor to the Flora

12. Assign various colors to the Color 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 3.3V pad on the color sensor.
    a. 4 wires (ribbon cable recommended)
13. 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 3V to 3.3V).
14. Checkpoint: Connect battery and make sure indicator lights turn on with Flora.
    a. Turn off power/disconnect battery before continuing to solder

Connecting the LED switch to the Color Sensor and the Flora

15. Prepare two wires (ribbon cable recommended) to connect the left (ON) lead of the white LED on/off switch to the LED pad on the color sensor and the center lead (NONE) of the switch to GND on the Flora. Cut two lengths of heat shrink for the LED switch leads.
    a. Ideally, the off position of LED switch should point in the same direction as the off position of the power switch
    b. 2 wires (ribbon cable recommended), 2 heat shrinks
16. Solder the two wires to their respective leads on the switch. Thread the heat shrinks onto the wires and position over the switch leads. Heat up the heat shrinks with a heat gun.
17. Connect or solder the wire on the left lead of the switch to the LED pad on the color sensor.
18. Connect or solder the wire on the center lead of the switch to a GND pad on the Flora.
19. Checkpoint: Connect battery and make sure indicator lights turn on with Flora and that white LED can be switched on/off
    a. Turn off power/disconnect battery before continuing to solder

Connecting the NeoPixel (RGB LED) to the Flora

20. To connect the NeoPixel to the Flora, assign three colors to the –/GND, +/VBATT, and ▽ /D6 connections. Cut and prepare wires (ribbon cable recommended).
    a. 3 wires (ribbon cable recommended)
21. Connect/solder the appropriate wires to the – (GND), + (V+), and ▽ (in) pads on the NeoPixel.
22. Connect/solder the – wire to the GND pad on the Flora, the + wire to the VBATT pad on the Flora, and the ▽ wire to the D6 pad on the Flora.

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
    - NeoPixel Library (https://github.com/adafruit/Adafruit_NeoPixel)
    - TCS34725 Color Sensor Library (https://github.com/adafruit/Adafruit_TCS34725)
- Supplied *Software Instructions*
- Supplied Color Arduino code
- Color Arduino 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. Open the Color Arduino code in the Adafruit-Arduino IDE
3. Connect the micro-USB cord to the Color Arduino
4. 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*)
5. 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.
    a. For issues uploading, see "Software-specific Troubleshooting" in Part V
6. Upload the Color Arduino code to the Flora.
    a. For issues uploading, see "Software-specific Troubleshooting" in Part V
7. Checkpoint: Make sure the NeoPixel RGB indicator changes color with the illuminated/incident light (i.e. white LED on/off)
    a. Turn off power/disconnect battery before continuing to solder

IV. Final wiring and assembly

Tools/materials needed:

- Wire strippers/cutters
- Soldering iron and solder
- Heat gun or blow dryer
- Flush cutters (recommended for removing unnecessary posts in the chassis)
- Hot glue gun and/or gaffer's tape
- Insulated wire (ribbon cable recommended)
    - Ribbon cable is useful since it keeps the wires organized between circuit boards
    - 4-wire ribbon cable
    - 3-wire ribbon cable
    - 2 jumper wires
- Heat shrinks
    - 3 lengths
- Color Arduino chassis (with switches and audio jack installed and Flora, Color Sensor and NeoPixel already wired in)
- Codec board

Connecting the Codec (MIDI) board to the Flora

1. Assign colors and prepare wires (ribbon cable recommended) for D9/RST, D10/RX, 3.3V, and GND connections from Flora to Codec board, 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
2. Connect/solder the appropriate wires to the RX and RST pads on the Codec board.
3. Connect/solder the 3V3 wire and one end of a jumper to the 3V3 pad on the Codec board.
4. Connect/solder the other end of the 3V3/1 jumper to the 1 pad on the Codec board.
5. Connect/solder the GND wire and one end of the other jumper wire to the GND pad on the Codec board.
6. Connect/solder the other end of the GND/0 jumper to the 0 pad on the Codec board.
7. Connect/solder the RX wire to the D10 pad on the Flora.
8. Connect/solder the RST wire to the D9 pad on the Flora.
9. Connect/solder the 3V3 wire to the 3.3V pad on the Flora.
10. Connect/solder the GND wire to the GND pad on the Flora.

Connecting the Codec (MIDI) board to the audio jack

11. Prepare wires (ribbon cable recommended) to connect LOUT, ROUT, and AGND (on Codec board) to L, R, and ground (respectively) pins on the audio jack. If your audio jack uses soldered connection rather than screw terminals, cut lengths of heat shrink for each connection on the jack.
    a. 3 wires (ribbon cable recommended), 3 heat shrinks (if audio jack uses soldered connections)
12. Connect/solder the LOUT, ROUT, and AGND wires to their respective pads on the Codec board. If your audio jack uses soldered connections, thread the heat shrinks onto their respective wires.
13. Connect/solder the LOUT wire to the L terminal on the audio jack. Position heat shrink over connection (if applicable).
14. Connect/solder the ROUT wire to the R terminal on the audio jack. Position heat shrink over connection (if applicable).
15. Connect/solder the ANGD wire to the ⍰ (ground) terminal on the audio jack. Position heat shrink over connection (if applicable).
16. Checkpoint: Plug in speakers or headphones into the audio jack, connect the battery, and test to see if the Color Arduino works and that the outputted sound varies with color!
17. Make sure the three heat shrinks are positioned correctly. Using a heat gun or blow dryer, heat the tubings until they shrink to form.

Assembly

18. Disconnect Color Arduino from micro-USB and turn off power for final assembly.
19. Tack down components of Color Arduino inside the chassis with gaffer's tape or hot glue. 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 color sensor and white LED are not obscured before tacking
    c. Check that the NeoPixel RGB indicator is visible before tacking
    d. Check that the micro-USB port is aligned with the bored hole before tacking
20. Close up chassis
    a. Make sure no wires will be pinched by the chassis or its screws before closing
21. Your Color Arduino 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 14
    a. Check wiring of power switch, voltage regulator, Flora, and Color Sensor
    b. See General Troubleshooting for more suggestions
2. Part II, Step 19
    a. Check wiring of LED switch to Color Sensor and Flora
    b. See General Troubleshooting for more suggestions
3. Part III, Step 5
    a. If the NeoPixel is not changing color, check the sensor display on the Adafruit-Arduino IDE to determine if the color sensor is functioning. If it is not, check the connections of the Flora, Color Sensor, and NeoPixel.
    b. Check the Adafruit-Arduino IDE settings and try re-uploading the Color Arduino code to the Flora
    c. Check that the Color Sensor is not obscured
    d. Test to see if the NeoPixel functions correctly when shining a bright colored light directly onto the Color Sensor
    e. See General Troubleshooting for more suggestions
4. Part IV, Step 16
    a. Make sure audio jack, Codec board, and Flora are wired correctly
    b. Check to see if headphones/sound system work with another audio player
    c. 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