How to Build the Dementia Friendly Music Player Using a 3D Printed Case

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My Dad could not operate normal music players. But he could operate music player like this because it operates like a familiar two-knob radio. I was inspired by the documentary Alive Inside which shows the profound joy felt by some people with dementia when listening to their favorite music. I designed the insides and Trey Bagley designed the 3D printed case shown here.

It's easier than you think to make one. Everything is open source. This document contains all the information you need. Good project for kids. A 13 year old can do this with minimal assistance. Younger kids with more assistance.

Parts cost	~$60 + tax + shipping
Music cost	Minimal as you should use the recipient's existing music collection
Build time	About two hours, once you have the parts & music
Parts source	All parts can be mail ordered, links below
Soldering?	No
3D printer needed?	Yes, or work with a friend that has a 3D printer
3D printing time	About 24 hours
With a friend?	Good idea, especially if your friend has the basic tools required
Beverage?	I recommend a hoppy IPA while you are assembling

1 Preview of the build steps

1) Order parts 	2) 3D print pieces 	3) Stain the pieces (optional) 
4) Assemble recipient's favorite music 	5) Copy software to micro SD card 	6) Collect the parts & pieces 
7) Add Pi 	8) Install front panel components 	9) Glue it 
10) Wire it 	11) Screw on back 	12) Enjoy! 

2 No warranty

USE THESE DQMUSICBOX PLANS AND SYSTEM AT YOUR OWN RISK. THE DQMUSICBOX PLANS ARE PROVIDED AS IS WITHOUT WARRANTY OF ANY KIND EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PLANS AND SYSTEM IS WITH YOU. SHOULD THE PLANS OR SYSTEM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION. IN NO EVENT WILL ANY PARTY BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PLANS OR SYSTEM.

3 Acknowledgements

People were very generous with their time, and I really enjoyed the experience. This is certainly an incomplete list: Trey Bagley, Alex & Mike & others at Ada's, the super helpful crew at Seattle Makers, neighbor Randy, Stephen Christopher Phillips, Bob Rathbone, Stephen Rusk, Graham Hill, support at Ponoko, and my son.

4 What DQMusicBox does

4.1 For the person with dementia

Name	Description & implementation
Start song	Turning either of the knobs will start music playing.
Change song	Turn the songs knob.
Change volume	Turn the volume knob.
Pause	Tap the volume knob. Note that this also happens automatically – music pauses if there are no knob events in one hour.

4.2 For you

Name	Description & implementation
Shut down	Pull the power plug or long hold (15-30 seconds) on the volume knob.
Reboot	Pull the power plug and re-insert or long hold (15-30 seconds) on the songs knob.
Add/remove music	By adding/removing files on the USB memory stick.

5 Order the parts

You will be ordering these parts:

5.1 Order the parts - US

Item	Supplier	Cost (2018)	Notes & Alternatives
Raspberry Pi A+ single board computer	MCM/Newark	$20.00	Or buy from Allied or Amazon. Or use a Raspberry Pi 3 B+ or 3B or 2B.
Power supply	MCM/Newark	$5.99	This is the US model. Any micro USB 2A or better supply will do.
Female-female jumper wires	MCM/Newark	$3.56	Or buy Amazon B01L5ULRUA
Panel mount 3.5mm headphone jack	MCM/Newark	$2.69	Or buy Amazon B004JX64FE
M2.5 standoffs (screws)	MCM/Newark	$3.14	Or by Amazon B06XXV8RTR
Micro SD card 16GB	Amazon	$6.95	Any brand name micro SD card that is 8GB or larger will do.
USB thumb drive 16GB	Amazon	$6.97	While nearly any USB thumb drive will work, I recommend one that is physically tiny so it doesn't protrude much from the case.
Audio cable	Amazon	$5.29	Or find a short audio cable with a right angle bend.
#4 x 3/8" flat head wood screws	Amazon	$0.92	Or buy at your local hardware store
KY-016 indicator LED (note shipping time)	eBay	$1.62	The linked seller ships from China, takes 2-3 weeks. Or order as one piece of this kit - Amazon B013UL6LFS, which will arrive in a few days (assuming you live in the US).
KY-040 rotary encoders (knobs)	eBay	$5.39	You need two rotary encoders. The linked seller ships from the US. Or buy Amazon B06XQTHDRR. Or search eBay for KY-040, look carefully at the product photo - you need encoders with screw threads.
TOTAL		**$62.52**	Prices will vary. Does not include tax, shipping.

5.2 About headphones

Item	Cost $US, May 2017	Notes and alternatives
The recipient's existing headphone	$0.00	The best headphones are the headphones that the recipient is already used to. Not all headphones will sound great though. You want high sensitivity headphones as the Pi doesn't pump put much audio power.
Panasonic RP-HT21	$6.25	OK sound. Long cord.
AmazonBasics On-Ear Headphones	$14.99	Good sound. Cord is a bit short.
Sony MDR7506	$79.99	Amazing sound. High sensitivity, so a good match to the Pi. My Dad loved the sound. But he found the headphones to be a bit frustrating – they tend to fold themselves up.

5.3 Tools & supplies

You probably have some of these tools & supplies. If you don't, you have a spouse or child or friend that does. This project is exactly the sort of thing that a friend would be happy to help you with.

Link to order item	Notes & alternatives
Elmer's wood glue	Any wood glue will do
3/16th wrench or nut driver	Or needle-nosed pliers. Or really strong fingers
SD card reader/writer	Your computer may have an SD card reader/writer. If not, you probably have a friend that does. Or order a USB SD-card reader for your computer.
Painter's tape	Any tape that comes off easily will do. Painter's tape is great. Regular masking tape is probably fine too. I haven't tried Scotch tape.
PLA wood filament (optional)	This document assumes that you have a 3D printer, or you have a friend with a 3D printer. So you already have some regular PLA filament. I chose to use a PLA wood filament (see below for specifics).
Wood stain (optional)	If you print with PLA wood filament, you can optionally apply wood stain. I used a pre-stain, a stain, and a protective finish (see below for specifics).
Raspberry Pi 3 (optional)	This is in addition to the Pi that goes in the player. This is a completely optional step. If you are nerd like me, or you have nerdly friend, see details in the appendix 1.

6 3D print pieces

The key assumption is that you have a 3D printer, or you have a friend with a 3D printer. Thus, this document is not intended as an introduction to 3D printing.

You will be printing the pieces that you see below. On my basic 3D printer, the total print time was about 24 hours.

3D printed case designed by Trey Bagley

6.1 General instructions

1. Download the stl files from Thingiverse.
2. Print the files.

6.2 My experience

Trey Bagley designed the case. I think he did a great job. But I'm a novice at 3D printing. Nonetheless here is what I did, and I'm happy with the result:

- Monoprice Maker Select v2 3D printer
- Monoprice PLA wood filament
- Cura slicing software
- Key settings
    - Layer height: 0.2mm
    - Initial layer height: 0.3mm
    - Wall thickness: 0.8mm
    - Top/bottom thickness: 0.8mm
    - Infill: 10%
    - Print temp: 215C
    - Build plate temp: 60C
    - Diameter: 1.75mm
    - Flow: 100%
    - Enable retraction: yes
    - Retraction distance: 1.75mm
    - Retraction speed: 25mm/sec
    - Print speed: 40mm/sec
    - Infill speed: 50mm/sec
    - Travel speed: 80mm/sec
    - Initial layer speed: 10mm/sec
    - Enable print cooling: yes
    - Fan speed: 100%
    - Minimum layer time: 10 sec
    - Print sequence: all at once
- Post printing
    - My prints came out fairly clean, but I did use a tiny knife to extract extraneous strands from the lettering.

7 Stain the pieces (optional)

This step is optional. I wanted to make something that seems familiar to someone with dementia i.e. make something that looks very much like a radio from the 1930s. These antique radios are made of wood and generally dark stained. Thus, I chose to print with a wood PLA filament and stain the print. You could choose to print with regular PLA filament. Or print with wood PLA but not stain it.

Here is the before and after of staining the front face:

I'm not a woodworker. Nonetheless, this is the process that I used:

1. Sand the parts with a fine grit sandpaper.
2. Apply Minwax Pre-Stain Wood Conditioner, let dry. Or a similar product. Minwax is what my neighborhood hardware store has…
3. Apply Minwax Wood Finish, Red Mahogany 225. I applied a thin even coat. Minwax suggests waiting 15 minutes then wiping off the excess stain. I found this removed too much of the stain. So I didn't do any wiping off and just let it dry overnight.
4. Apply Minwax Polycrylic Protective Finish, let dry.

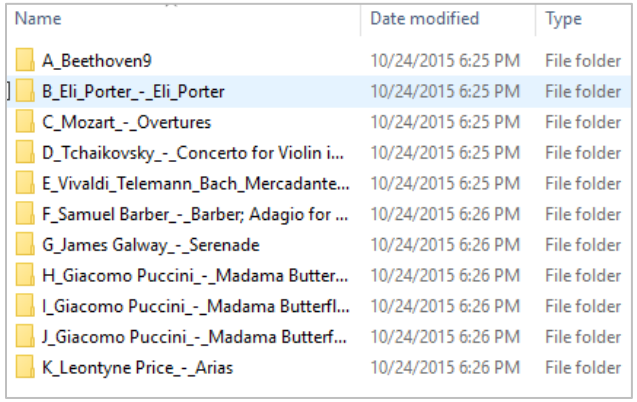
8 Assemble the personalized collection of music

8.1 Choosing the music – go for familiar favorites

This is the most important step. The personalized (familiar) music is the fundamental magic. You don't need much music, perhaps 6-10 albums. But only familiar favorites. In my case, my Mom mailed me my Dad's favorite CDs. It will take two weeks for the parts above to arrive, so you have time to do this well. Though it is easy to change the set of music later.

8.2 Put the music on the USB memory stick

Organize the digitized music into folders on the USB memory stick, one folder per album. MP3, iTunes, and FLAC files are supported i.e. files with extensions .mp3, .m4a, .flac. In the end, you should have a set of folders that looks something like this:

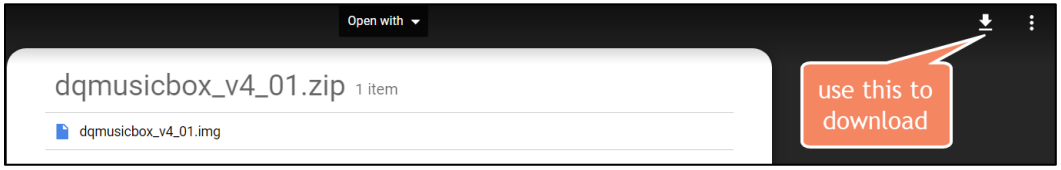


9 Prepare the micro-SD memory card

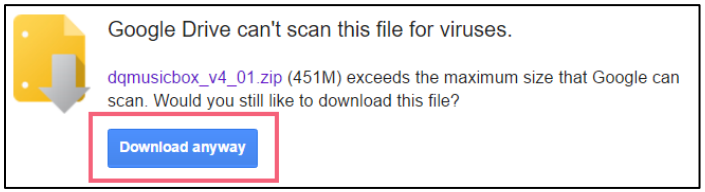
I prepared a disk image for you. It has all the required software. Your job is to download this disk image and then write it to the micro-SD card. The steps:

1. Install Etcher on your PC or Mac or Linux computer. Win32 Disk Imager also works.

2. Download the DQMusicBox disk image. 935MB.



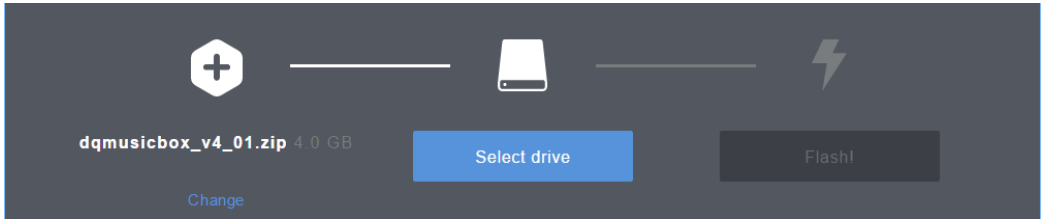
3. Confirm download – “Download anyway”



4. Put the micro-SD memory card into the SD card adapter that it came with i.e. put the tiny card into the larger card.

5. Put the SD card adapter into the SD reader/writer in your computer.

6. Start Etcher, instruct it to write the image file to the SD card:

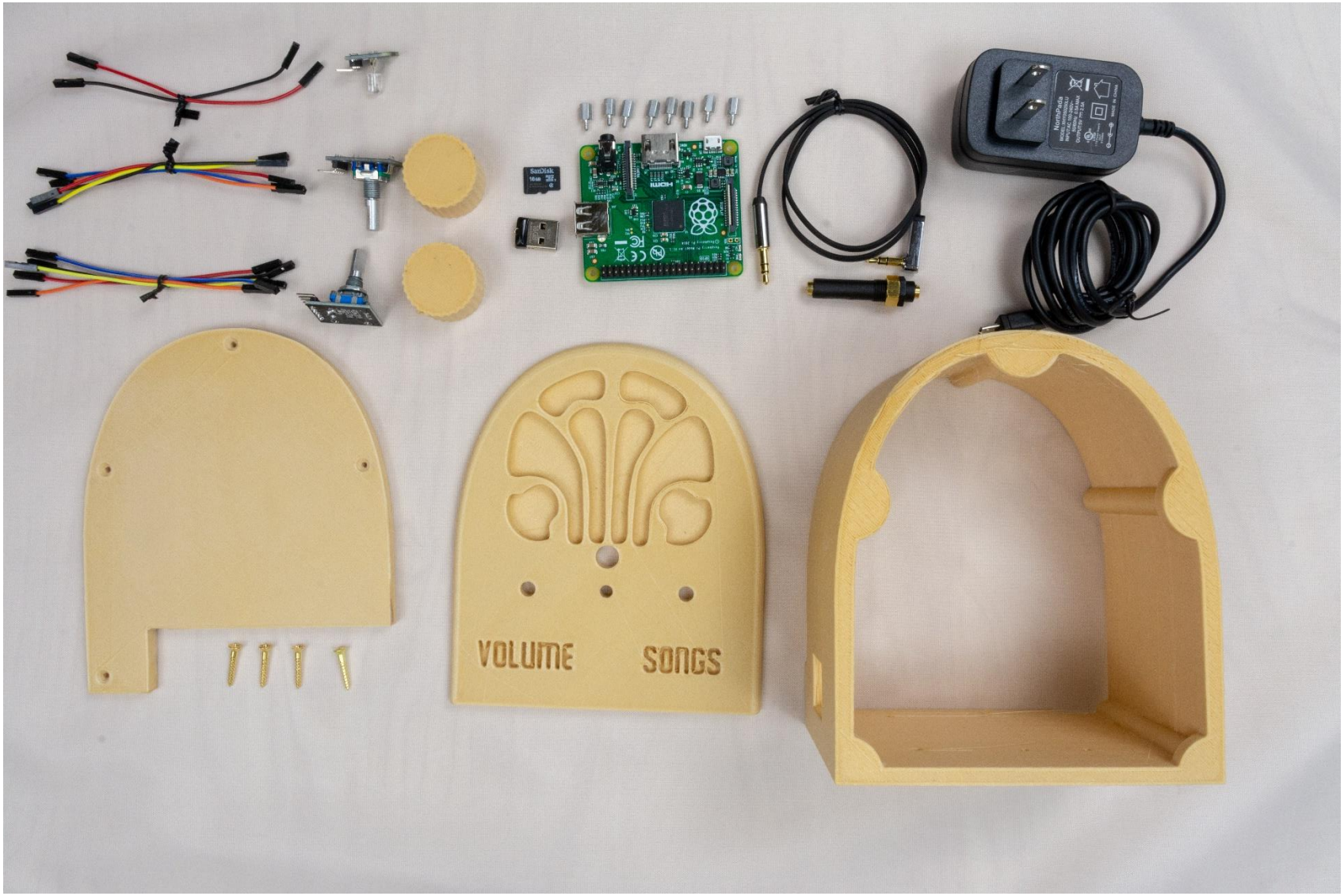


7. Wait for the writing to complete, ~10 minutes. This would be a good time to make a sandwich.

8. If you are a nerd or your friend is a nerd, see the optional step in Appendix 1.

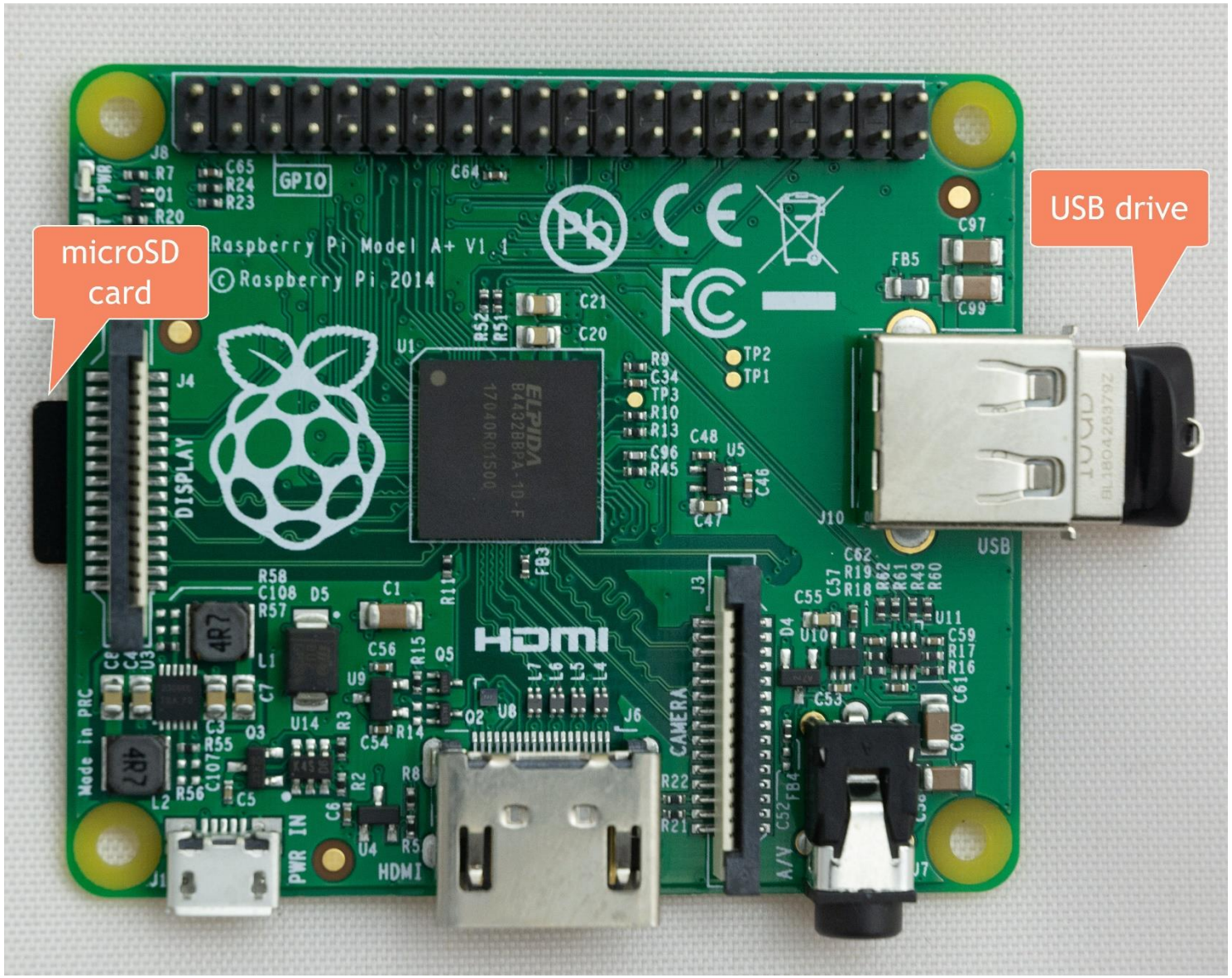
10 Collect the parts and pieces

You should now have the following:



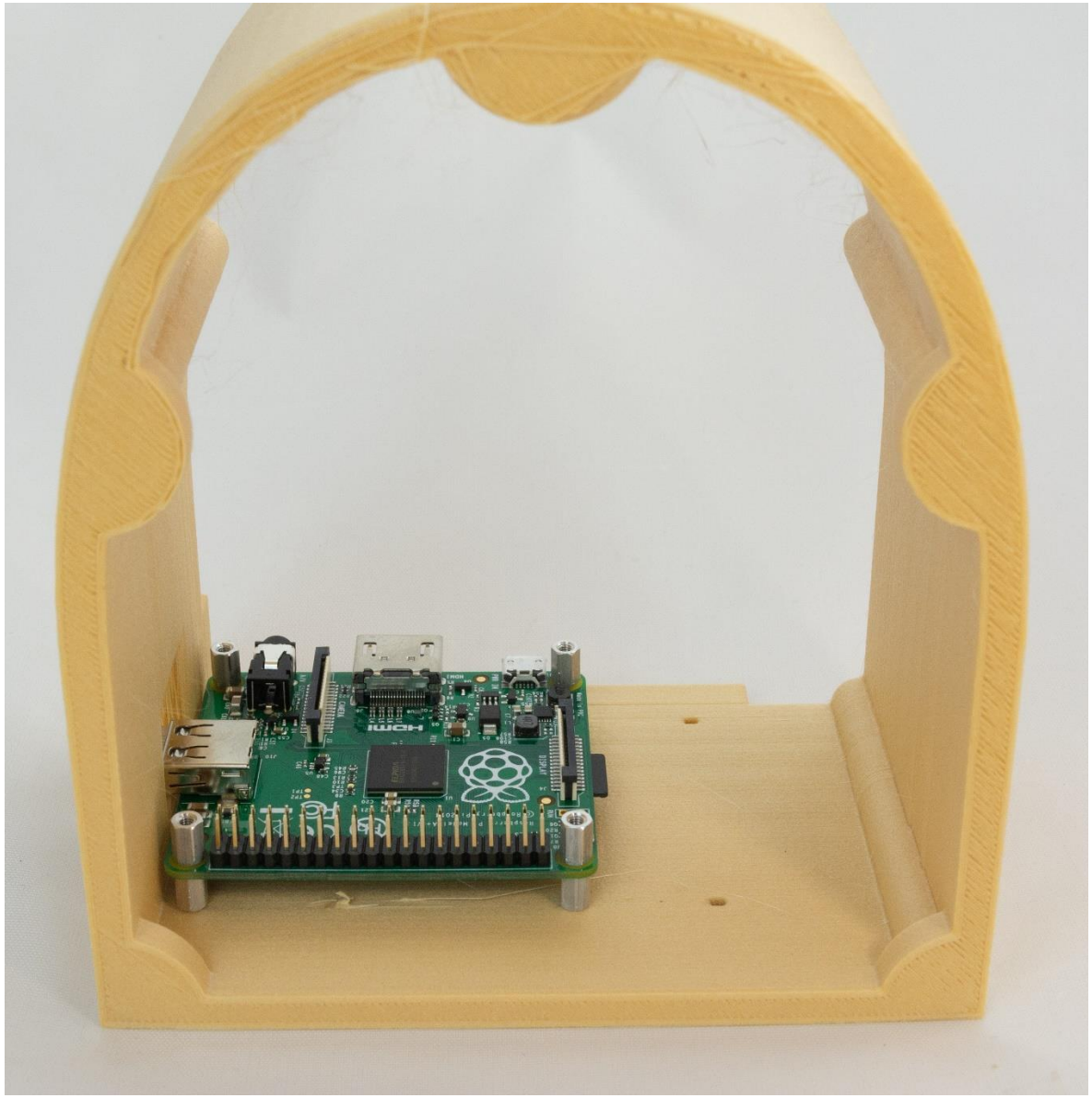
11 Add Pi

11.1 Put the MicroSD card and the USB drive into the Pi



11.2 Mount the Pi

Using the standoffs, mount the Pi in the body piece:

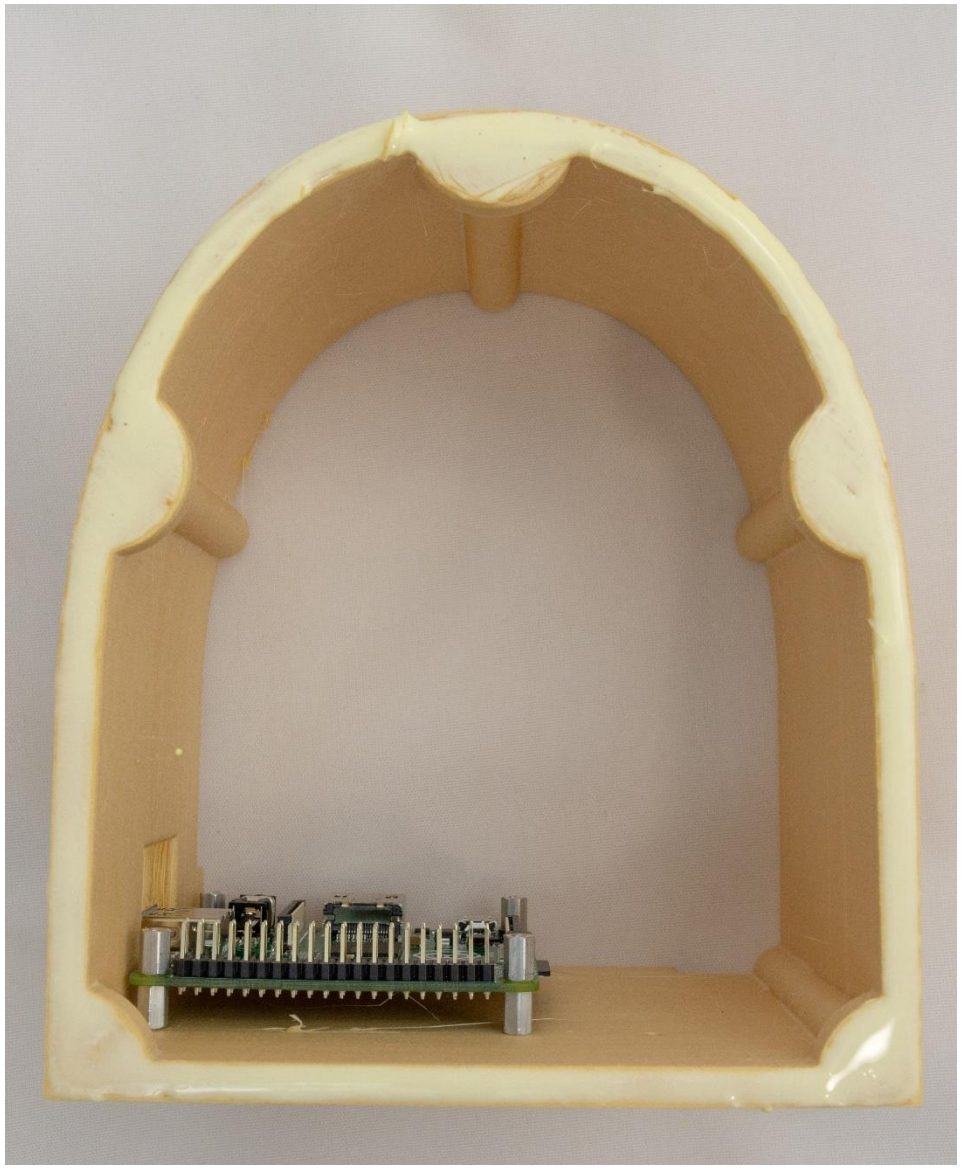


12 Install front panel components

Install the two rotary encoders (knobs), the LED, and the headphone jack. The rotary encoders need to be screwed in as far as they will go, or the button press won't work – test the rotary encoders to make sure they rebound from a button press.

13 Apply glue

Apply glue to the front of the body piece:



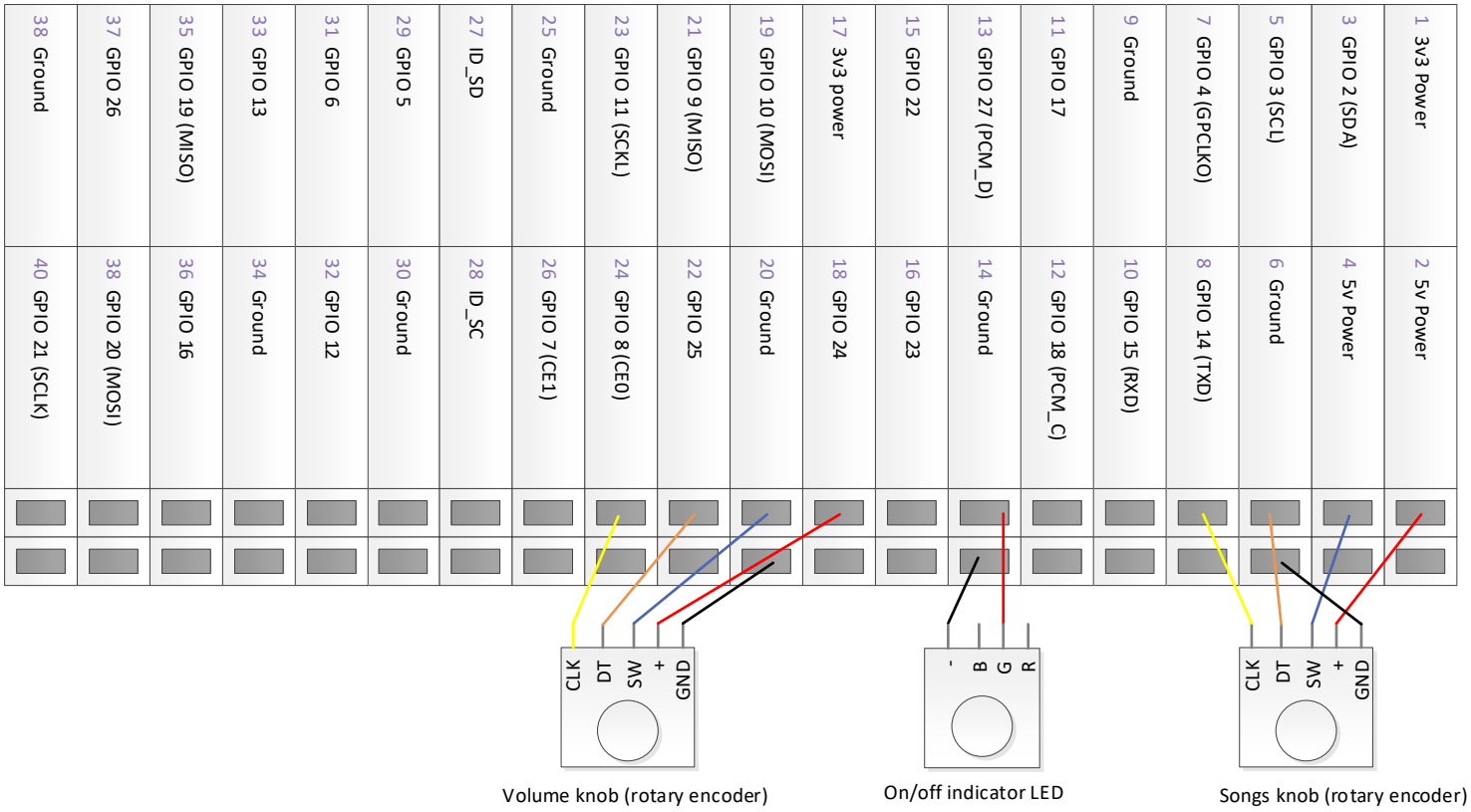
14 Glue on the face

Glue on the face, using painter’s tape to clamp:

15 Wire it

15.1 Wire the knobs & LED

Attach wires from the knobs and the LED to the Raspberry Pi as per the diagram and photos below. No soldering required – just press the wires into place. **This is where most build errors happen, so please carefully check your work.**

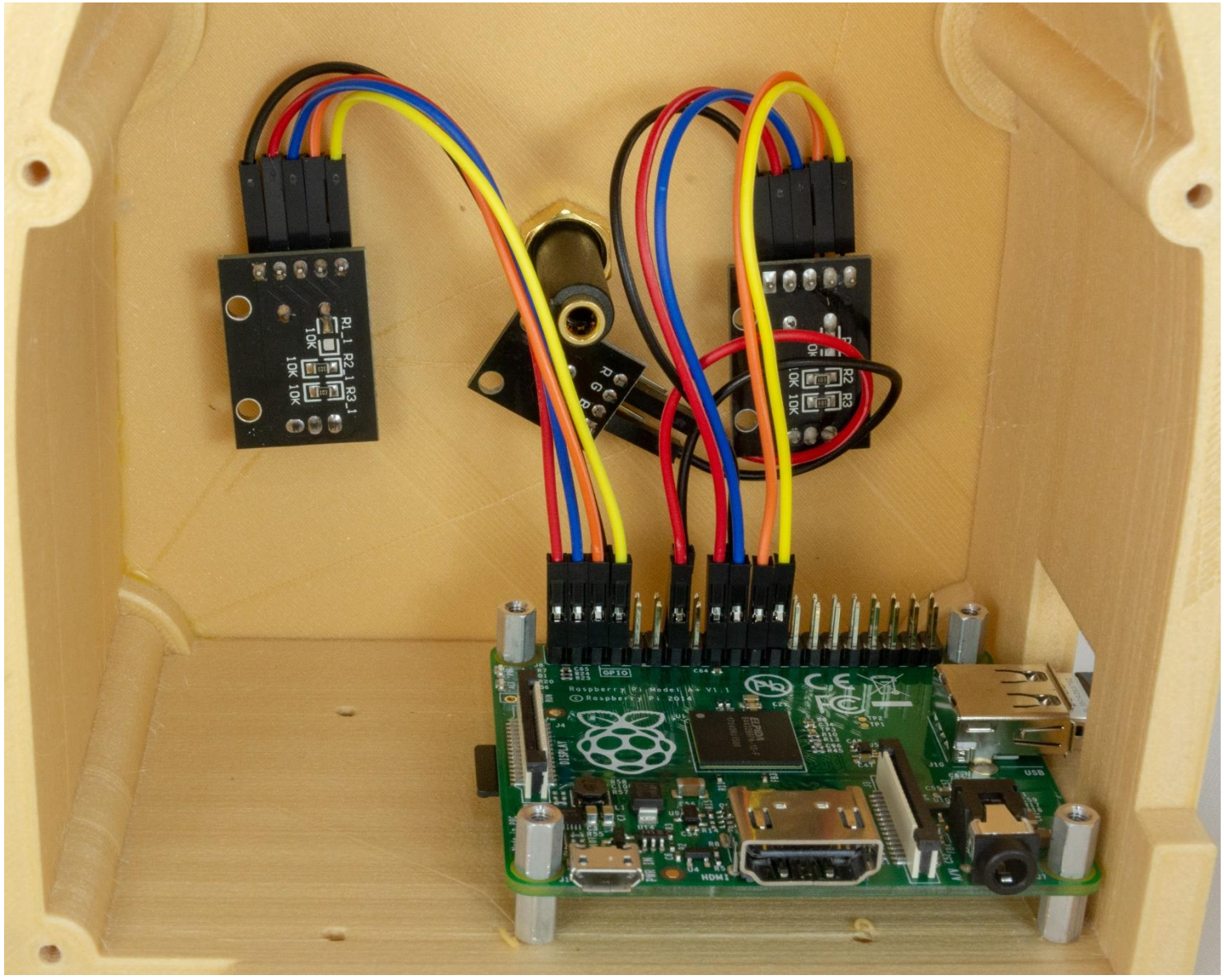


Volume knob (rotary encoder)

On/off indicator LED

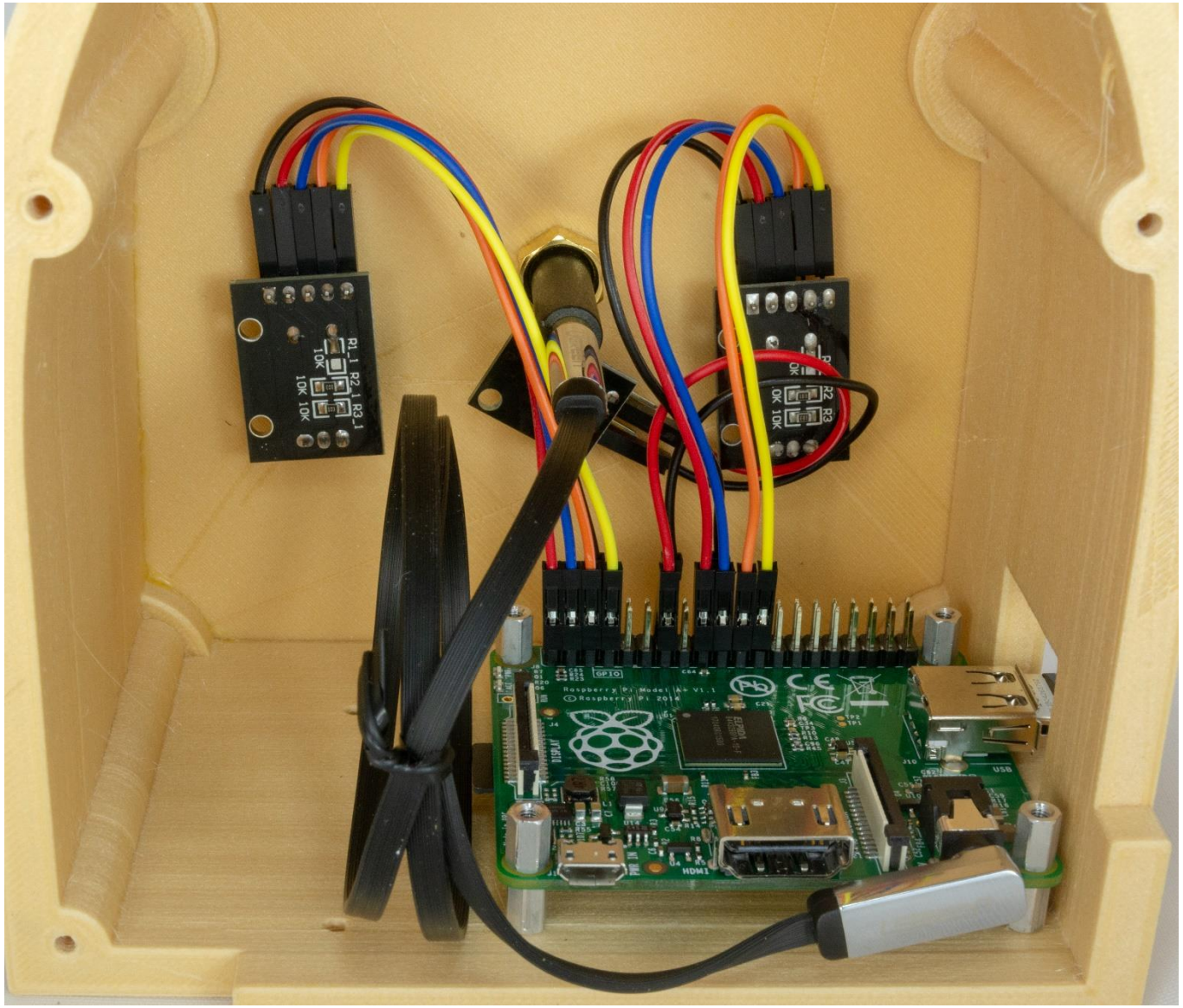
Songs knob (rotary encoder)

The result should be as you see it below. The front of the LED should be flush with the front of the face. If the LED is a bit loose, just use some glue.



15.2 Add the audio cable

The audio cable goes from the back of the Pi to back of the front panel's headphone jack:



16 Screw on the back

17 Enjoy!

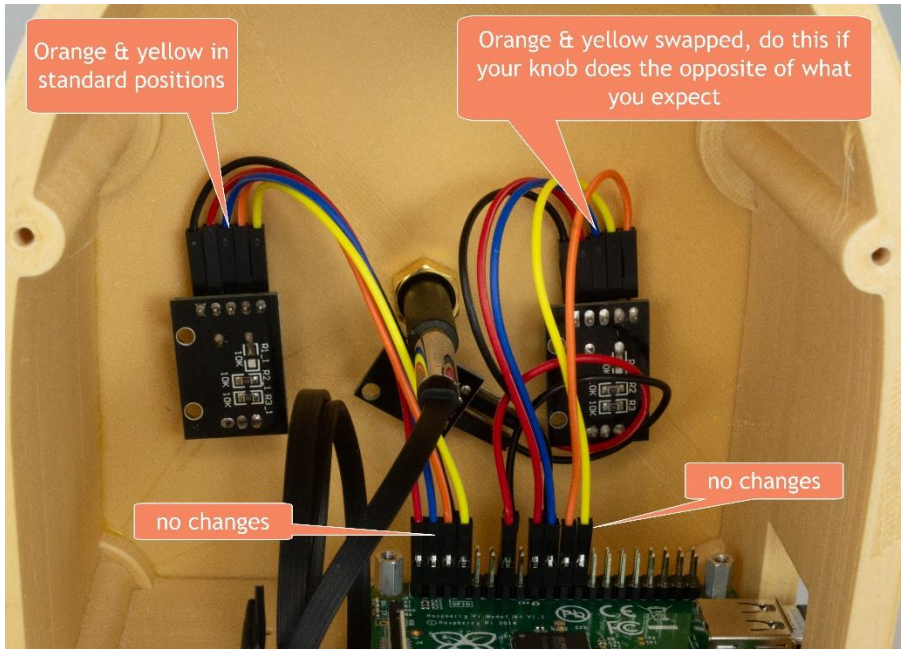
17.1 Test it

Now that you have assembled everything, it is time to test.

Test	Description & Expectation
Light 20sec after power on	The indicator LED turns on when DQMusicBox is ready to play music, which is generally about 15 seconds after power on.
Start song	Turning either of the knobs will start music playing.
Change song	Turn the songs knob. If you go forward and backward through the song list as expected, then all is well.
Change volume	Turn the volume knob. If the volume goes up and down as expected, then all is well.
Pause	Tap the volume knob, song should pause. Tap the songs knob, this should also pause the song.
Unpause	Tap a knob

17.2 If one or both knows do the opposite of what you expect

Once assembled, you may find your knobs doing the opposite of what you expect e.g. a clockwise turn decreases the volume. This is because there are two kinds of rotary encoders out there. Happy, the fix is easy, just switch the orange and yellow wires on the misbehaving knob(s) (don't touch the Pi itself):



17.3 If the knobs are loose on the metal shafts

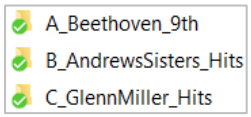
Just glue the knobs to the metal shafts. But only if it is really necessary. Once the knobs & shafts are glued, it's harder to dissemble the box to fix any problems.

17.4 Tape instructions

Print this page and tape the instructions in the box below to the bottom of your new DQMusicBox:

To create personalized music

Organize the music on your computer



One folder per album. Use MP3 files, must have .mp3 file extension. Or iTunes files (.m4a). Or FLAC files (.flac). Optionally, use folder names prefixes to specify the play order e.g. A_, B_

Copy the music to the USB thumb drive

1. Unplug your DQMusicBox.
2. Remove the USB thumb drive and place in your computer.
3. Copy music files from your computer to the USB thumb drive.
4. Put the USB thumb drive back in the DQMusicBox.
5. Plug in your DQMusicBox.

17.5 Congratulations

Congratulations! You should have a fully functional DQMusicBox.

17.6 Let me know how it went

I'd love to hear how your build process went and if it was useful for the recipient. rosswesleyporter@gmail.com

18 Appendix 1: Write protect the SD card

18.1 About SD card write protection TMP_WRITE_PROTECT

This step is optional. It will increase the durability of the system. If you or your friend already work with Raspberry Pis, you may find this fun. If you don't then you might find this frustrating and it's perfectly OK to skip this optional step.

About TMP_WRITE_PROTECT:

- Raspbian and DietPi, don't generally like to be rudely shut down i.e. having the power plug pulled.
- Rude power downs can interrupt writes to the micro SD card and potentially corrupt the OS.
- But we have a special case here, because DQMusicBox does not need to be online and does not need to be updated. In other words, it is safe to write protect the micro SD card.
- The SD card standard has a rarely used feature known as TMP_WRITE_PROTECT (which is a useful google search term) i.e. temporary write protection.
- When in this mode, the SD accepts write accepts write requests, but any such writes are made to temporary storage and are deliberately lost upon reboot or power loss.
- In other words, if you pull the plug on a DQMusixBox you are effectively doing a factory reset. Music stored on the USB thumb drive is unaffected.
- To enable this, set the TMP_WRITE_PROTECT bit in the Card Specific Data on micro-SD card (more on this below).
- Here is the SD Association's official description of TMP_WRITE_PROTECT from the SD Specifications Part 1 Physical Layer Simplified Specification Version 6.00: *Temporarily protects the entire card content from being overwritten or erased (all write and erase commands for this card are temporarily disabled). This bit can be set and reset. The default value is 0, i.e. not write protected.*
- For the curious, here are some of the other fields in the Card Specific Data, chart taken from the same document linked just above:

File format group	FILE_FORMAT_GRP	1	xb	R/W(1)	[15:15]
copy flag	COPY	1	xb	R/W(1)	[14:14]
permanent write protection	PERM_WRITE_PROTECT	1	xb	R/W(1)	[13:13]
temporary write protection	TMP_WRITE_PROTECT	1	xb	R/W	[12:12]
File format	FILE_FORMAT	2	xxb	R/W(1)	[11:10]
reserved		2	00b	R/W	[9:8]
CRC	CRC	7	xxxxxxxb	R/W	[7:1]
not used, always'1'	-	1	1b	-	[0:0]

Table 5-4 : The CSD Register Fields (CSD Version 1.0)

- References:
  - SD Card Write Protection
  - Build the SD Locker and Make Your SD Cards More Secure

18.2 Option 1: Build the SD locker project

There are several ways to implement TMP_WRITE_PROTECT. I was originally inspired by the SD locker project on Hackaday and by its successor. Both of which look like fun. But I ended up using Option 2 below as it is more consistent with Raspberry Pi work.

18.3 Option 2: Use a Raspberry Pi 3

This is the option that I used. In brief, the write protection process is:

1. Write the DQMusicBox image to a micro-SD card, as per the instructions above.
2. Boot a Raspberry Pi 3 from a USB thumb drive.
3. Once booted, insert a micro-SD card and issue the following command:
   `sudo ./sdtool/static/arm-sdtool /dev/mmcblk0 lock`

This is my setup for doing so:

The slightly tricky bit is to get the Raspberry Pi 3 to boot from USB. See below for the process that I used to create to create the setup above. You will only have to do this once.

1. You'll need:
   a. **A Raspberry Pi 3**. I keep a Pi 3 just for this purpose i.e. I don't use this Pi 3 inside a DQMusicBox.
   b. **A good USB thumb drive.** I keep a thumb drive just for this purpose. Apparently this won't work with some low performance USB thumb drives, although it worked with my old 2GB thumb drive (pictured above). I now use a SanDisk Extreme 32GB thumb drive.
   c. **A micro-SD card.** You will only need for 30 minutes to complete the steps below, then you can use the card for other purposes.

2. Download DietPi.

3. Write the DietPi image to the micro-SD card (using Etcher or Win32diskimager).

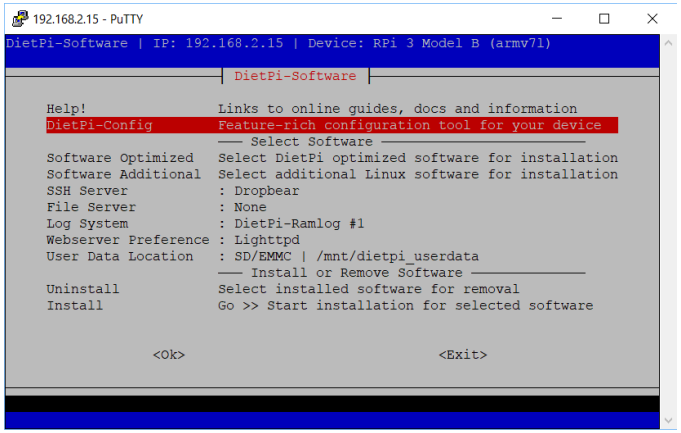
4. Write the same DietPi image to the USB thumb drive.

5. Attach Ethernet to your Raspberry Pi 3.

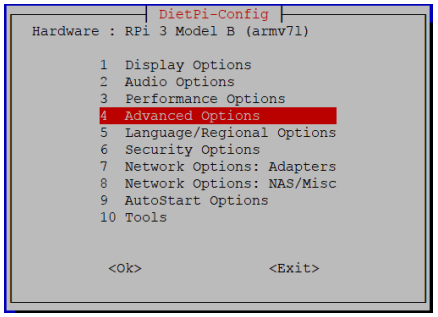
6. Insert the micro-SD card.

7. Start the DietPi installation process i.e.:
    a. Boot the Pi 3 from the micro-SD card
    b. Connect to the Pi 3 over the network with Putty or something similar, login with username=root password=dietpi

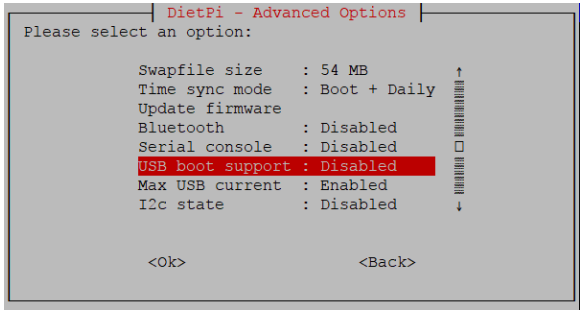
8. After a while, you will get to this screen, choose DietPi-Config



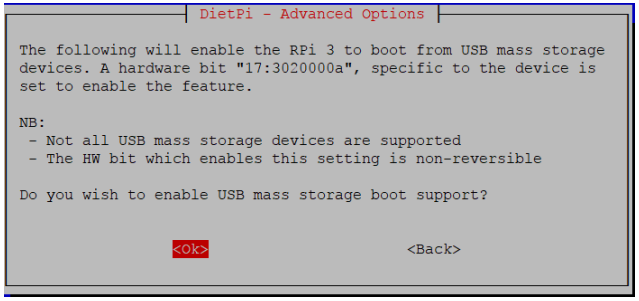
9. Choose Advanced Options:



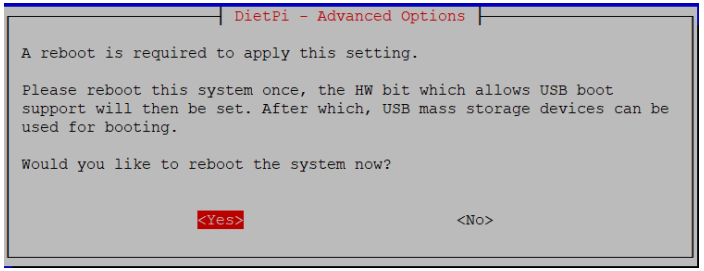
10. Choose USB boot support and choose to **enable** it:



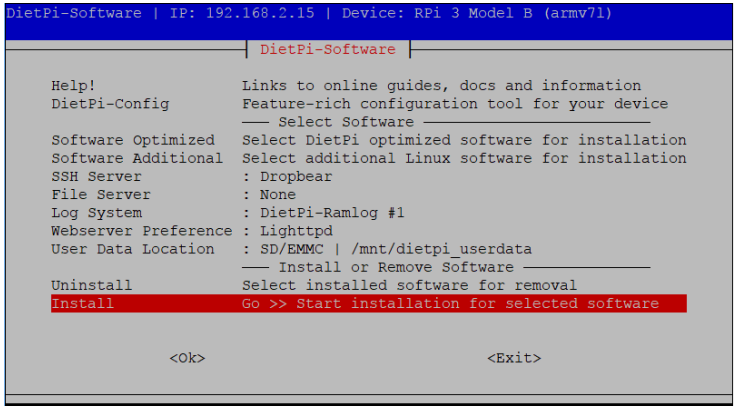
11. Choose OK (read the full message first):



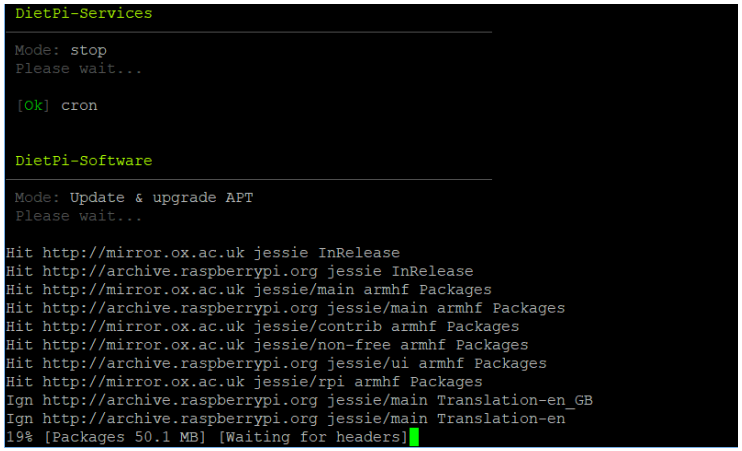
12. Choose Yes to reboot:



13. After rebooting, choose Install:

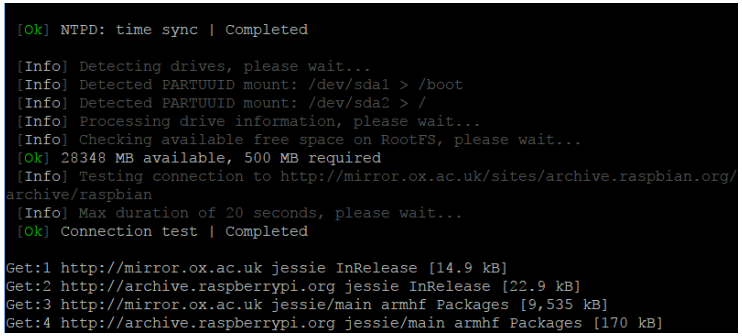


14. Let the installation run and finish.

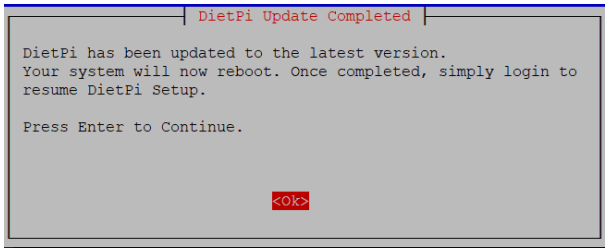


15. Once the installation is complete, switch to a USB setup:
    a. Unplug the Pi.
    b. Remove the micro-SD Card.
    c. Insert the USB thumb drive.
    d. Plug the Pi back in and boot.

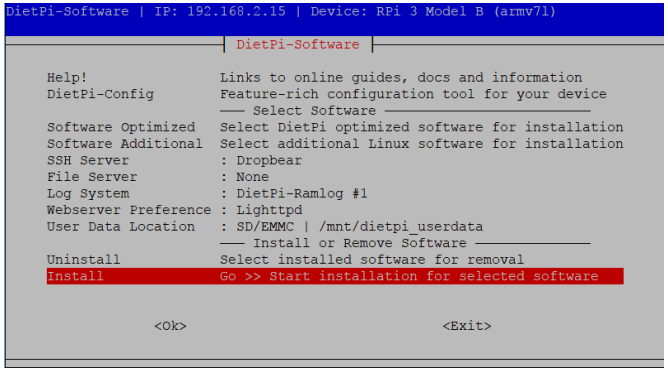
16. Install DietPi on the USB thumb drive. Start by letting DietPi update itself:



17. When prompted, restart your Pi:

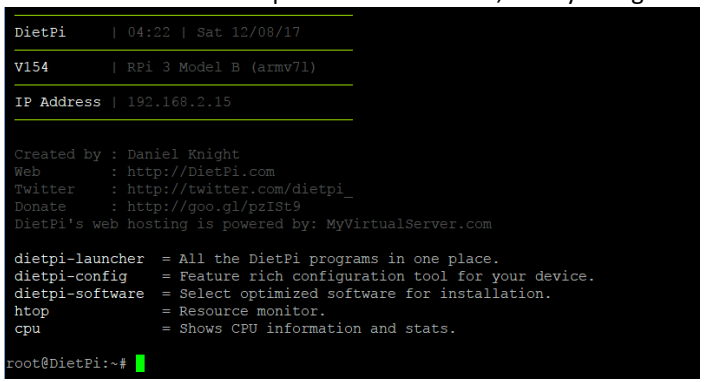


18. Install:



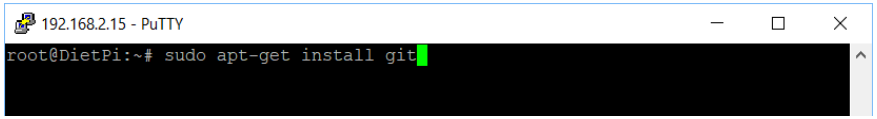
19. Let DietPi do more updating:

20. DietPi will reboot to complete the installation, then you'll get a normal command prompt:



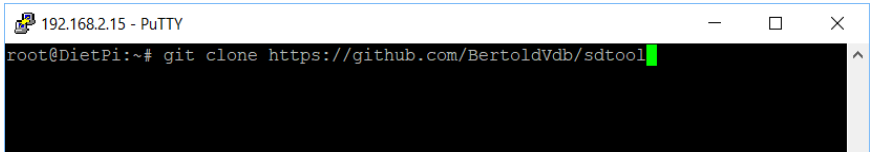
21. Install git with

```
sudo apt-get install git
```

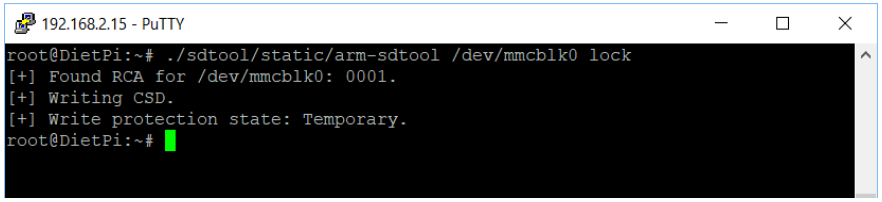


22. Get the write protection tool [sdtool]() with

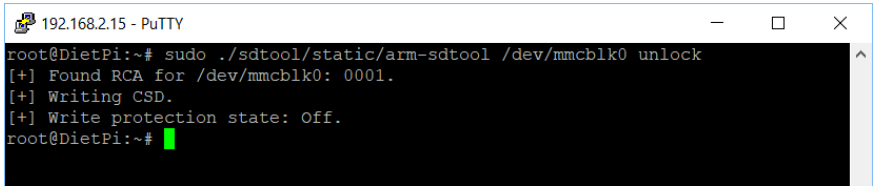
```
git clone https://github.com/BertoldVdb/sdtool
```



23. Put an micro-SD card in the slot, practice enabling TMP_WRITE_PROTECT:
    `sudo ./sdtool/static/arm-sdtool /dev/mmcblk0 lock`



24. Now practice reversing the above:
    `sudo ./sdtool/static/arm-sdtool /dev/mmcblk0 unlock`



25. You are done!

19 Appendix 2: Change log

v1, November 2015	Original release
v2, September 2016	• Changed music storage from a micro-SD memory card to a conventional USB memory stick. • Changed the base Operating System from full Raspbian to DietPi – much smaller, so faster to boot, and less to go wrong.
v3, January 2017	• Changed from USB audio to Pi built-in audio, including a firmware update for excellent audio quality.
v4, May 2017	• Switched to bamboo for durability and use of standoffs. • Switched to Pi A+ to lower cost. • Made USB thumb drive externally accessible, to make it easier for the caregiver to organize music.
v4.01, 25 June 2017	• Minor edits.
v4.01_1, 20 July 2017	• Minor edits.
v4.01_2, 11 August 2017	• Added links for ordering parts in the UK. • Added detailed instructions for write protecting a micro-SD card.
v4.01_3, 12 August 2017	• Minor edits
v4.01_4, 12 August 2017	• Minor edits
v4.01_5, 14 October 2017	• Edited text and updated photographs to reflect the change from an HDD-style LED to a KY-016 LED module.
v4.01_6, 26 February 2018	• Updated the links for purchasing the parts. No changes to the parts themselves, just the links. • Minor change to the instructions, noting how the build can be accomplished in one sitting, if desired.
v4.1, 7 April 2018	• Reflects that the software has been updated to support the new Raspberry Pi 3 B+. No new software features.
v4.1_1, 23 April 2018	• Updated to reflect the new bamboo case design.
V4.1_1, 6 May 2018	• Adapted the existing instructions to match the new 3D printed case design.