Samplerbox Mellotron Article

Craig A. Lindley Last Update: 05/28/2017

Introduction

I grew up in a golden age of rock music. Back then there wasn't the laser focus on only what music would sell so artists were free to experiment with just about anything and everything in pursuit of their art. Almost anything that could make a sound/noise was used in recording somewhere. With the advent of multi track recording, recorded passages were even reversed and fed back into mixes because that created a sound not heard before. Nothing was sacred as record producers strived for the “next new sound” that would hopefully be as exciting as the times. At the same time new effects that pushed aural boundaries were being developed including fuzz tones, reverbs, phasors, flangers, chorus, delays, talk boxes and more and these were quickly put to use in rock music. Initially these effects were used on guitars and basses but later they would be used on vocals, organs and most everything else.

Besides effects, entirely new, ground breaking musical instruments were developed during this time period including the analog synthesizer and the more obscure mellotron. The history of synthesizers is well documented in the literature but the mellotron, a unique beast indeed, seems to have been mostly forgotten over time. You may now be asking yourself if you have ever heard the sound of a mellotron before so I have prepared a short mellotron playlist for you comprised of some of the most famous songs in which it was used. If you are younger than 50 you may never have heard these songs before but that is an even better reason to check them out.

Group	Song	Link
King Crimson	The Court of the Crimson King	https://www.youtube.com/watch?v=gvCmtHDDuu0
Moody Blues	Tuesday Afternoon	https://www.youtube.com/watch?v=GEMuAnFH_IM
Beatles	Strawberry Fields Forever	https://www.youtube.com/watch?v=8UQK-UcRezE
Genesis	Watcher of the Skies	https://www.youtube.com/watch?v=57HicYcY4Ow
David Bowie	Space Oddity	https://www.youtube.com/watch?v=iYYRH4apXDo
Yes	And You and I	https://www.youtube.com/watch?v=H-rdL2KkvzY
Rolling Stones	2000 Light Years from Home	https://www.youtube.com/watch?v=wcy8o0gj-A0

Being a consummate tinkerer I have built just about every instrument/effect that has caught

my attention over the years; some in hardware, some in software and some using both. A few of these projects have been published in Nuts and Volts including:

- Building An Electric Guitar", in the June 2013 issue
- "MIDI Buddy", in the February 2015 issue.

I also wrote a four part series of articles for the now defunct Dr. Dobb's Journal about creating electronic music components in software. These are still available on-line at:

- Part One - http://drdobbs.com/java/229700113
- Part Two - http://drdobbs.com/java/230500178
- Part Three - http://drdobbs.com/java/231000557
- Part Four - http://drdobbs.com/java/231002076

if you are interested in reading them. Finally, I published a book about electronic musical effects in software called, "***Digital Audio with Java***" published by Prentice-Hall though now out of print.

One instrument that I haven't attempted to buy or build (until now) was a mellotron although I have very much appreciated its use in progressive rock music. It is possible to buy a mellotron these days but the cost is prohibitive for an amateur musician like myself.

This project began when I was reading a news group one evening and it mentioned that a mellotron digital sample set was available for free. I hadn't thought about a mellotron in years but this piqued my interest once again. A week or two later I was reading HackADay.com and it mentioned a Raspberry Pi sample player called SamplerBox, available as open source code from a person named Joseph Ernest. The code, written in Python, had incredible specs including 120 note polyphony so I immediately put the samples together with the sample player and the result is this project.

In this article I will present a digital version of a mellotron based upon the Raspberry Pi 3 and Joesph Ernest's SamplerBox software that can be built relatively inexpensively. Check out Figure One for a cost comparison.

So What is a Mellotron?

According to Wikipedia,

> "*The Mellotron is an electro-mechanical, polyphonic tape replay keyboard … that works by pulling a section of magnetic tape across a head*"

Figure Two shows a mellotron being played. A mellotron typically had 35 keys with each key coupled to a tape loop as shown in Figure Three. 35 keys meant 35 tape heads and 35 tape loops along with all of the capstans, pinch wheels, springs and rollers necessary to make things work.

Again according to Wikipedia:

> *"Pressing a key (1), causes two screws (2) to connect a pressure pad (3) with the tape head (5), and the pinch wheel (4) with the continuously rotating capstan (6). Tape is pulled at a gradual speed, counterbalanced by a tension spring (8 - 10) and stored temporarily in a storage bin (7) until the key is released."*

When the key is released, the tape is quickly retracted in preparation for another key press.

The eight second length of the tape loops made playing the instrument problematic. If you pressed and held a key for more than eight seconds the sound would end as the tape would run out. If you wanted to hold a chord for longer than eight seconds you would have to continuously move your hands to play different chord inversions so that notes would still sound. This technique of playing the mellotron became known as the "crawling spider" because of the continuous movement of hands on the keyboard.

With some versions of the mellotron the tape loops had multiple tracks recorded onto them and a switch on the keyboard allowed selection of which tape loop track(s) to play. The individual tracks generally contained recording of different instruments so by switching the track different instrument sounds could be reproduced.

Playing a piece on a mellotron never sounded exactly the same twice because of wow and flutter (small changes in playback amplitude and pitch) as a result of the mechanics of the system. Sometimes during extended play periods, a mellotron would quit playing altogether. I remember reading somewhere that when a musician wanted to bring a mellotron along on tour they had to bring a mellotron expert along with them as the instrument was always in need of tweaking.

The mechanical marvel that is a mellotron can be seen in Figure Four. Imagine the difficulty in trying to synchronize 35 different tape decks at the same time in a machine that was meant to be portable.

Project Description

The mellotron project described in this article:

- runs on a Raspberry Pi 3 model B sporting a quad core 64 bit ARM processor running at 1.2 GHz with 1 GByte of SDRAM and built in WiFi and micro SD card interfaces.
- uses a modified version of the Raspbian Jessie Lite Linux operating system
- runs a customized version of SamplerBox software. SamplerBox has a growing user community (see *Resources*) that are enhancing its capabilities continuously in an open source manner.
- supports an unlimited number of sample sets up to 1 GByte each in size

- uses an inexpensive USB Digital to Analog Converter (DAC) for quality sound reproduction
- is capable of 120 note polyphony although that has been dialed back to 10 note polyphony to reduce latency in the version I supply with this article.
- stores sample sets on an inexpensive USB flash drive
- has a 20 character by 4 line LCD display
- support a traditional MIDI interface and the new USB MIDI specification
- depending upon the sample set used can be a grand piano, a mellotron, a drum set and anything else you can come up with a sample set for.
- uses wav sample files that are 16 or 24 bits at a 44.1 KHz (CD quality) sample rate either mono or stereo
- has buttons for incrementing and decrementing the current voice, a button for rebooting the RPi 3 and an, as yet unused, function button.

While the mellotron device I present here is a decent simulation it doesn't reproduce all of the subtleties of playing a real mellotron nor does it have its issues/problems. It does work for me in the recordings I do and that was/is its intended purpose.

Hardware

A schematic diagram of the SamplerBox electronics is shown in Figure Five and the parts list is shown below:

Quantity	Designation	Description	Source
4	Function Sw Increment Sw Decrement Sw Reset Sw	Normally open momentary contact pushbutton switch	eBay, Amazon, RadioShack
1	LCD	4 line by 20 character LCD display with HD44780 interface	Amazon, eBay
1	C1	1000 uF @ 35 VDC capacitor	RadioShack
1	C2	0.1 uF capacitor	RadioShack
1	C3	0.01 uF capacitor	RadioShack
2	R1, R2	2K ohm 10 turn trimmers	anywhere
2	R3, R4	220 ohm ¼ watt 5% resistor (required only if using traditional MIDI)	anywhere
1	Not shown on schematic	2 GByte USB flash drive for samples	Amazon
1	Not shown on schematic	4 GByte micro SD memory card for operating system	Amazon
1	Not shown on schematic	USB DAC PCM2704 Sound Card https://www.amazon.com/gp/product/B01MT46GYI/ref=oh_aui_detailpage_o05_s00?ie=UTF8&psc=1 Note: almost any USB sound card should work	Amazon

Quantity	Designation	Description	Source
1	RPi	Raspberry Pi 3 Model B	Mcmelectronics
1	OC	Lite-On LTV-816 optical coupler (required only if using traditional MIDI)	eBay, Arrow, Digikey, Mouser
1	D1	1N4148 diode (required only if using traditional MIDI)	RadioShack
1	CONN1	5 pin MIDI Female Connector (required only if using traditional MIDI)	Amazon. eBay
1	Not shown on schematic	5 Volt @ 2 amp Power Supply	Amazon, eBay, RadioShack

To make the hardware function the following steps are required:

1. Connect the components as shown on the schematic.
2. Download the Raspberry Pi software image from the Nuts and Volts website. The file is called Lindley_SamplerBox_Image.iso.zip and unzip the file.
3. Copy the .iso file to the micro SD card. How this is done depends upon the computer you will be using. Instructions for each type of computer are available at: *http://elinux.org/RPi_Easy_SD_Card_Setup* and many other places on the web.
4. Insert the SD card, insert the USB DAC/sound card, connect a set of headphones to the sound card output, insert the USB flash drive containing the sample sets, connect up your MIDI device either using a traditional MIDI cable or for newer MIDI keyboards a USB cable.
5. Connect the USB power supply to the Raspberry Pi and if all is well you should see the welcome message (Figure Nine) on the LCD display and if you press a key on the keyboard you should hear sounds. If you do, you should be good to go.
6. If your USB flash drive has multiple sample sets available you should be able to click the increment and decrement buttons to change the selected sample set. Be sure to wait until the sample set is completely loaded before playing the keyboard.
7. You may need to adjust one or both the contrast and brightness trimmers to make text displayed on the LCD visible.

NOTE: sometimes the USB DAC/sound card does not initialize correctly on power up which results in no sound when the keyboard is played. If this happens, press the reboot button and the Raspberry Pi will reboot but since the power is already up and stable, the USB sound card will initialize correctly.

Sample Sets

Sample sets are stored on a USB flash drive plugged onto the Raspberry Pi. Sample sets are stored in directories off of the root directory and are named as follows:

```
N Sample_Set_Name
```

Examples are:

0 Grand Piano
1 Mellotron-Strings
2 Mellotron-Cello
3 Mellotron-Choir
4 Angles
5 Funky Bass

and so on. Numbers in the directory names should increase incrementally and determine the order in which sample sets are selected. Sample sets come in a variety of formats and a file called *definition.txt* in each sample set directory describes the format of the sample files to SamplerBox. Space constraints prevent me from explaining this in detail so go to the SamplerBox website (see *Resources*) for the explanation.

Sample set are available from many sources with the SamplerBox web site alone providing 14 free ones for you to use. The free Grand Piano sample set is amazingly good and is listed first so it comes up when my device is first powered up. For my mellotron device I incorporated many free sample sets along with some I paid for for a total of 22 sample sets with room for many more. Unfortunately I cannot provide these to you because many are commercial and copyrighted. See *Resources* for a list of sample set providers.

As a final note, the SamplerBox web site has instructions for how to create sample sets for whatever instruments you want and make them work with the SamplerBox software.

Software

If you wire up the hardware exactly as I did and use exactly the same USB DAC and LCD display you probably won't need to modify the SamplerBox software to make it run. If, however, you are interested in modifying and/or enhancing the software you have some work to do. First off, you must connect an HDMI monitor to the Raspberry Pi to see what is going on and you will need to connect a keyboard and mouse as well. I used a Logitech wireless keyboard with track pad when I initially setup the software. The wireless keyboard requires that a small USB device be temporarily plugged onto the Raspberry Pi. Then on reboot you should be able to see the reboot process in action on the monitor and be able to log into the Raspberry Pi with the keyboard using the default user name *pi* with the default password *raspberry.*

Using a keyboard and monitor is OK for initial setup but I like to use SSH (Secured Shell) over WiFi on my finished device so I don't have to have a display and keyboard connected. Using SSH allows me to login from my computer and control and/or modify the SamplerBox code remotely.

To use SSH you first need to change WiFi credentials to enable connecting to your WiFi network. After logging in to your Raspberry Pi, run this command to begin editing:

```
sudo nano /etc/network/interfaces
```

Find the following lines in the file:

```
wpa-ssid CraigNet
wpa-psk craigandheather
```

and change them to the ssid (your WiFi network's name) and password for your WiFi network. When you are finished hit Control X and follow the prompts for saving your changes. Next, reboot using the following command:

```
sudo reboot
```

Towards the end of the reboot process you should now see a line on the display that indicates the IP address assigned to your Raspberry Pi. Using an SSH client on your computer you can now attempt to SSH into your Raspberry Pi using a command similar to the following:

```
ssh pi@YourIPAddress

ex. ssh pi@192.168.0.214
```

I have setup the SamplerBox software so it runs automatically on power up. To make changes to the software you must stop the instance that is running, make your changes and then restart SamplerBox.

To stop SamplerBox you must find its process ID using the following command:

```
ps -ef | grep samplerbox
```

you should then see something like:

```
root       104     1  0 15:02 ?        00:00:00 /bin/sh /home/pi/SamplerBox/samplerbox.sh
root       106   104  6 15:02 ?        00:00:09 python /home/pi/SamplerBox/samplerbox.py
pi         917   900  0 15:05 pts/0    00:00:00 grep --color=auto samplerbox
```

The process ID is the number in the second column or in this case 104. Next you must kill that process using:

```
sudo kill -9 104
```

You can now edit the SamplerBox Python code using the nano editor by typing:

```
nano SamplerBox/samplerbox.py
```

After you are done making your changes, start SamplerBox again using the following

command:

```
sudo SamplerBox/samplerbox.sh
```

and SamplerBox should start right up. Next time you reboot, SamplerBox should automatically come up with your changes operational. This is all Linux stuff and if you don't need to change anything you can safely ignore everything I just wrote.

Packaging

There are no requirements for packaging this project if you are only interested in experimenting with SamplerBox on the Raspberry Pi. An exposed Raspberry Pi with a bunch of protruding cables and USB modules does not a robust instrument make, however. Because I plan to keep my mellotron around for a long time and the fact that it will be moved around and probably even used in a live environment meant that I needed to package it up for its own protection.

To this end I built a 6 3/4” x 4 1/4” x 1 3/4” box made of 1/4” MDF and, of course, painted it a metal flake copper brown as shown in Figure Six. Figure Seven shows that the top of the box was made of 1/8” acrylic. I suspended some pref board from the acrylic top using 1/2” spacers and to that I mounted the Raspberry Pi 3 underneath and the LCD display on top. The MIDI interface circuitry is built on the pref board. Three pushbutton switches (Function, Increment and Decrement) are mounted directly to the acrylic top. On the right side of the box I have mounted a 1/4” phone jack that internally is wired to the output of the USB DAC module. On the rear of the box I have the power connector, reboot pushbutton switch, USB port connector and the MIDI connector. The output jack, reset switch and the power connector are glued to the box whereas the USB port connector and the MIDI connector are mounted to the pref board and protrude through holes machined in the back of the box. I left enough slack in the wiring so that the top with the suspended circuit board can easily be lifted out of the box for maintenance. The rats nest of wiring is shown in Figure Eight.

Figure Nine and Figure Ten show the operational SamplerBox.

Final Thoughts

Building the SamplerBox mellotron was challenging and fun but having a functional mellotron around is even better. I already know my next series of recordings will have the etherial sounds of the mellotron playing a prominent part.

Many maybe wondering why I didn't just buy a keyboard with a large number of sounds available. To this I have two answers. First I enjoy building the things I use and second I am not aware of any keyboard that has mellotron sounds built in.

Remember even though I use my SamplerBox mostly as a piano and mellotron you could use one you build for yourself for drum sounds, brass instruments, human voices or who knows

what. Surprise us !

Resources

Many versions of the open source SamplerBox code are available on the Internet including but not limited to:

Author	Web Site	Contact Addresses
Joseph Ernest	*http://www.samplerbox.org*	twitter: @JosephErnest mail: contact@samplerbox.org
Alex MacRae	*https://github.com/alexmacrae/SamplerBox*	mail: alex.finlay.macrae@gmail.com
Hans Hommersom	*http://homspace.xs4all.nl/homspace/samplerbox/index.html*	
Erik	*http://www.nickyspride.nl/sb2/*	

Sample sets are available from the following locations:

Description	Web Site
Free SamplerBox sample sets	*http://www.samplerbox.org/instruments*
A free mellotron sample set	*http://www.leisureland.us/audio/MellotronSamples/MellotronSamples.htm*
Commercial vintage keyboard sample sets	*http://www.vintagekeyboardsounds.com/*

A video of a SamplerBox device using mellotron flute sounds playing the intro to Strawberry Fields is available at: *https://www.youtube.com/watch?v=yz7GZ8YOjTw*

I did a short demo song using my newly built Samplerbox Mellotron device. The tune is a cover of a Sting song and is available here:

http://www.craigandheather.net/mp3/Fragile.mp3

There are two tracks of mellotron in this tune. Mellotron flutes and Mellotron combined choir.

Thanks to Paul and Judith for help with the demo song.

Figure One
Mellotron Cost Comparison
You Choose

Mellotron M4000D - White
from Vintage King Audio

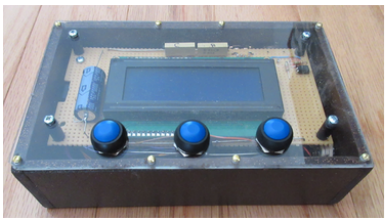
Basic · Polyphonic · MIDI Compatible

A painstaking digital recreation of the classic tape based mellotron, the M4000d looks plays and feels like the original. Why You Need the Mellotron M4000 Digital Mellotron: - ... more »

$2,799.00
Free shipping. No tax
Vintage King Audio
★★★★★ (303)
Shop

$2,799.00 Reverb.com
$2,799.00 eBay - vintagekingaudio
$2,799.00 eBay - altomusic
Compare prices from 5+ stores

This



Or This
< $150

Figure Two
A Mellotron being played
By Buzz Andersen from San Francisco, California, United States - Mellotron | NAMM 2007, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=2801145

Figure Three
The Mellotron Mechanism

By Fred the OysteriThe source code of this SVG is valid.This vector graphics image was created with Adobe Illustrator., GFDL, https://commons.wikimedia.org/w/index.php?curid=36119734

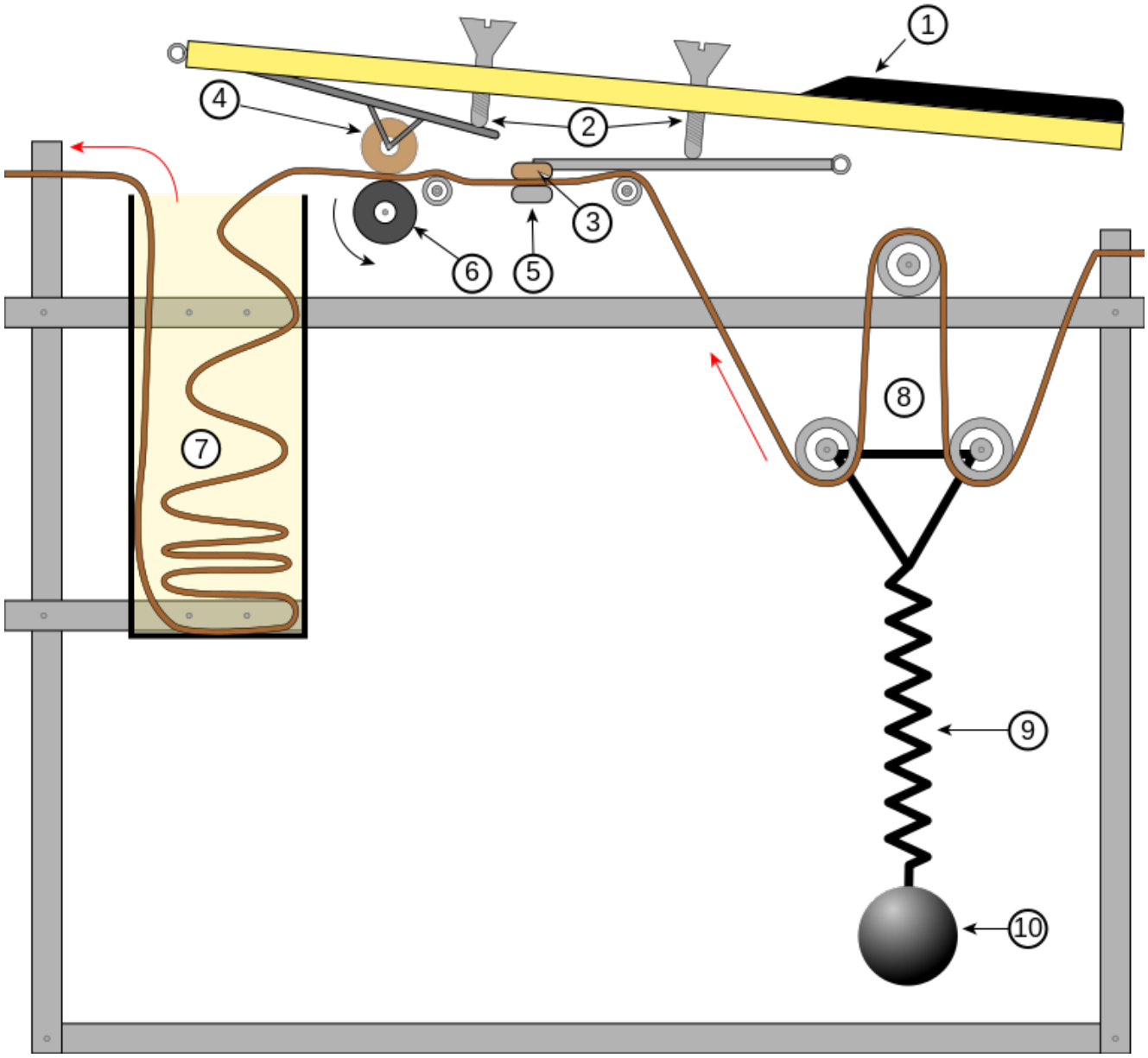


Figure Four
Mellotron Internals – Mechanical Marvel or Monstrosity ?

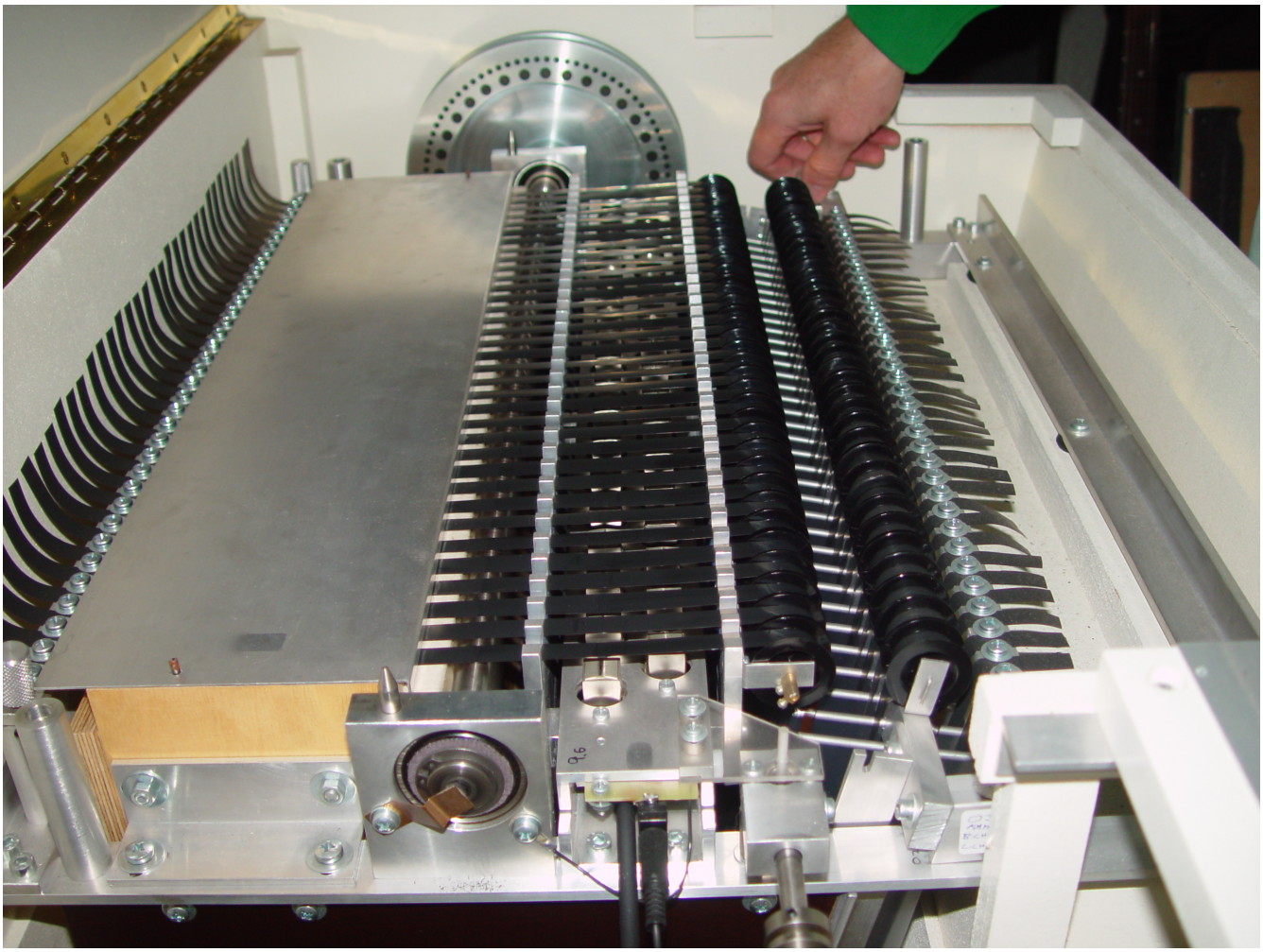


Figure Five
Schematic Diagram

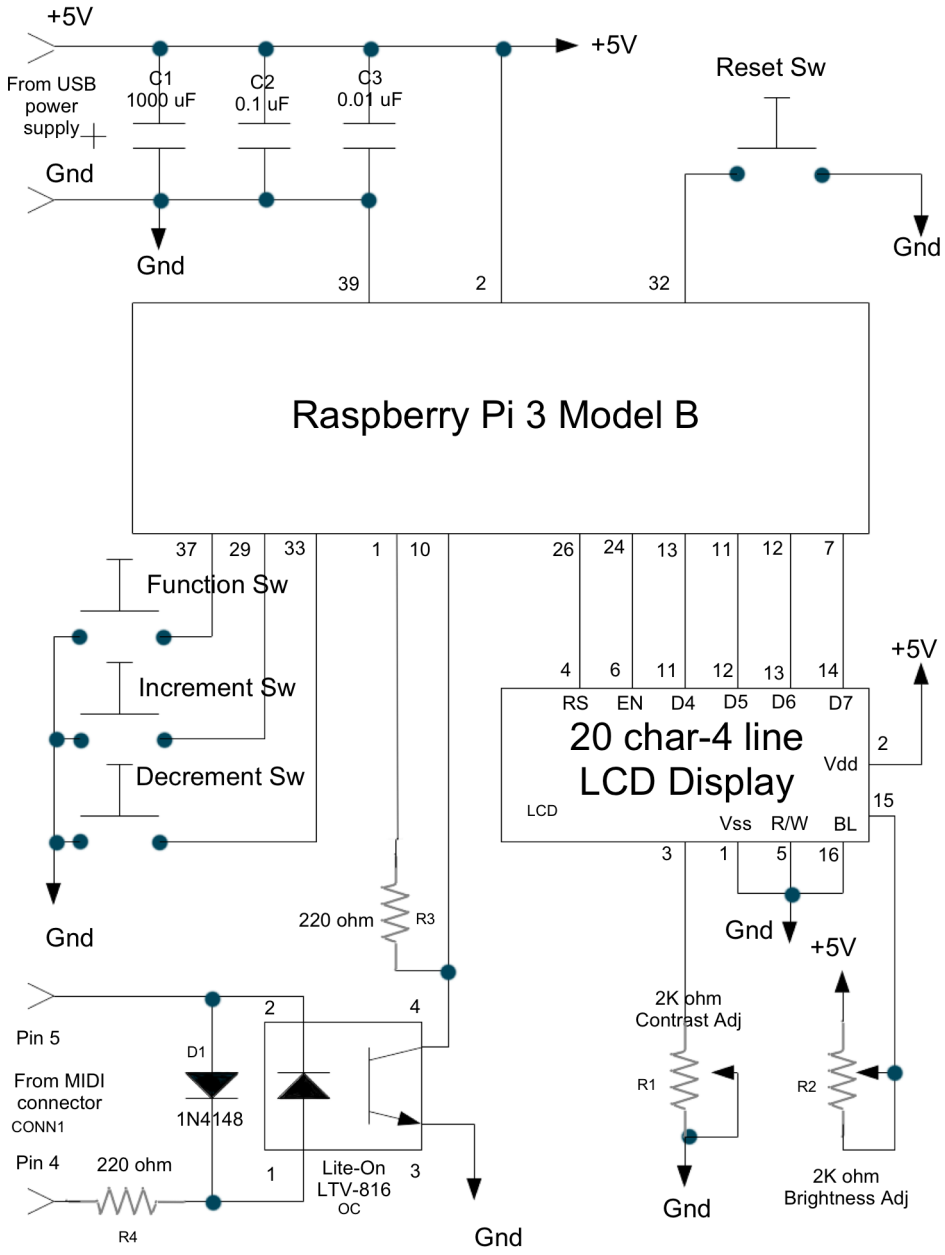


Figure Six
Painted Box with machined holes

Figure Seven
Packaging Planning
Display on front side of pref board and the Raspberry Pi 3 on the back side

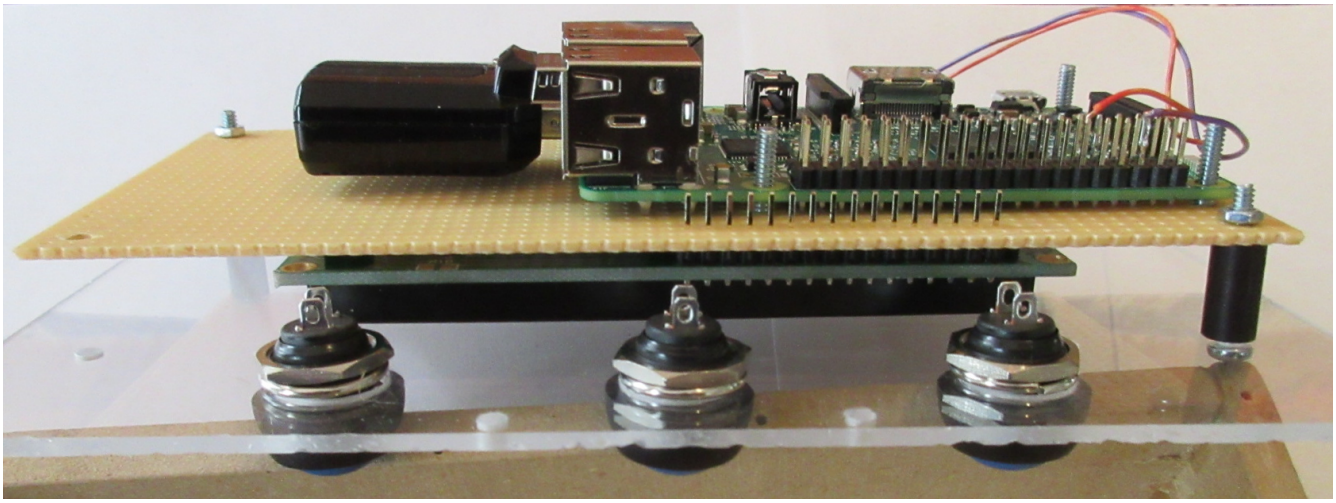


Figure Eight
A Rats Nest of Wires
Point to point wiring used

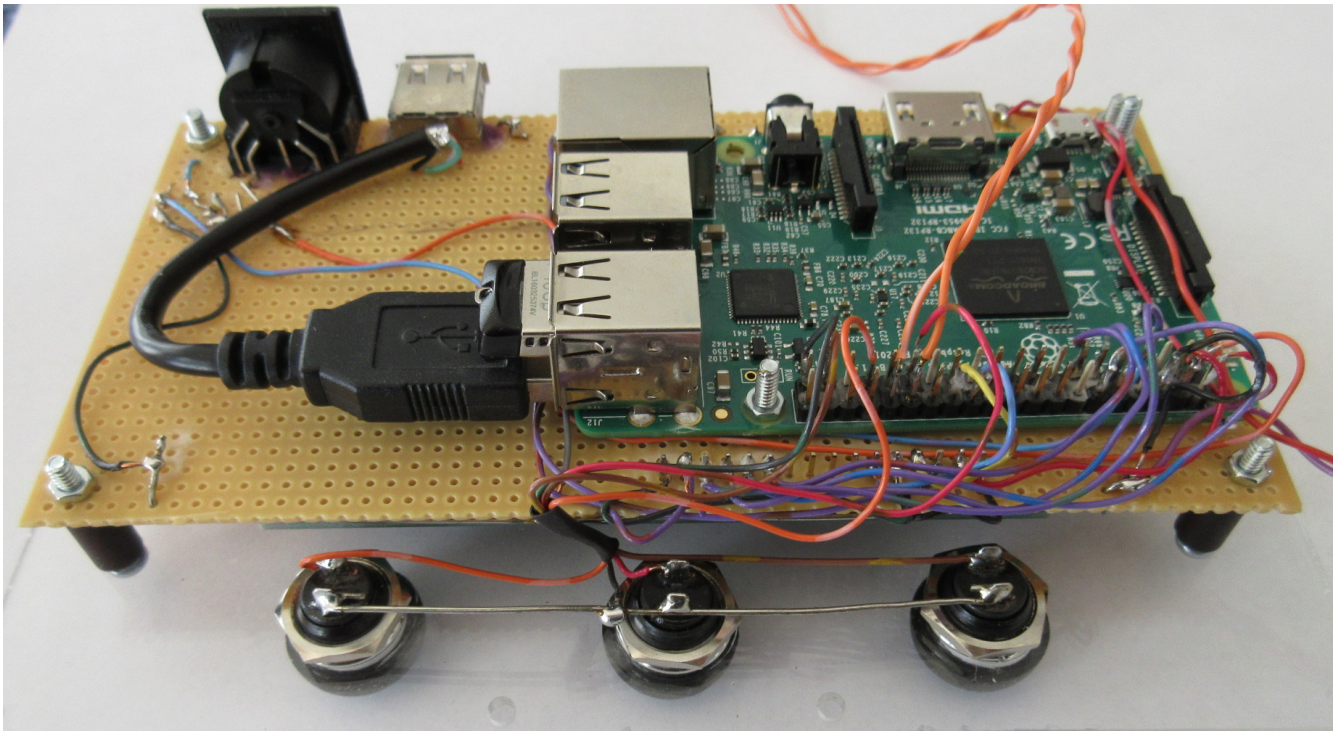


Figure Nine
Working SamplerBox with Welcome Message
The contrast and brightness adjustment trimmers are at the top
and the MIDI circuitry on the upper right.
From left to right the buttons are function, increment and decrement

Figure Ten
Working SamplerBox with Mellotron Voicing Selected