RE-CPU Manual

Release 1.4.3

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Contents

1 Legal Disclaimer

1.1 Legal Disclaimer

We take no responsibility to any damage done to your machine during the installation of this product. It is assumed that you have the technical skills needed to do the installation, but any modification on existing machines will happen at your own risk! If in doubt, please seek a trained technician.

2 Introduction

Welcome to the RE-CPU! The installation should hopefully be quick and painless and should not take more than a coffee break.

This manual covers the hardware and software installation of the RE-CPU chip to a DIY DinSync RE-303 / TR-606 synthesizer and the software update procedure as well as additional features, not found in an original TB-303 or 606 (e.g. MIDI).

This manual is only meant for explaining the part revolving the RE-CPU chips hardware and software, but not for explaining the device this chip is installed into or its full software usage. However, the software in the RE-CPU will behave identical to the original TB-303 or TR-606 software, with the exception of a few added features (e.g. MIDI) that are explained in *Settings* (page 20). The operation of the sequencer can be studied by obtaining the original device manuals from Roland, which still can be found on the internet (e.g. an old TB-303 manual for the operation of your DinSync RE-303).

If you own a readily built RE-303 synthesizer you can skip the first few chapters, because the steps explained there have usually been done already by the person who built your device. In *Updating* (page 17) the optional firmware update procedure is explained and in *Settings* (page 20) the additional features, compared to an original TB-303/606 that the RE-CPU offers in its latest firmware version.

Thanks for supporting this product and hope you will have much fun with it.

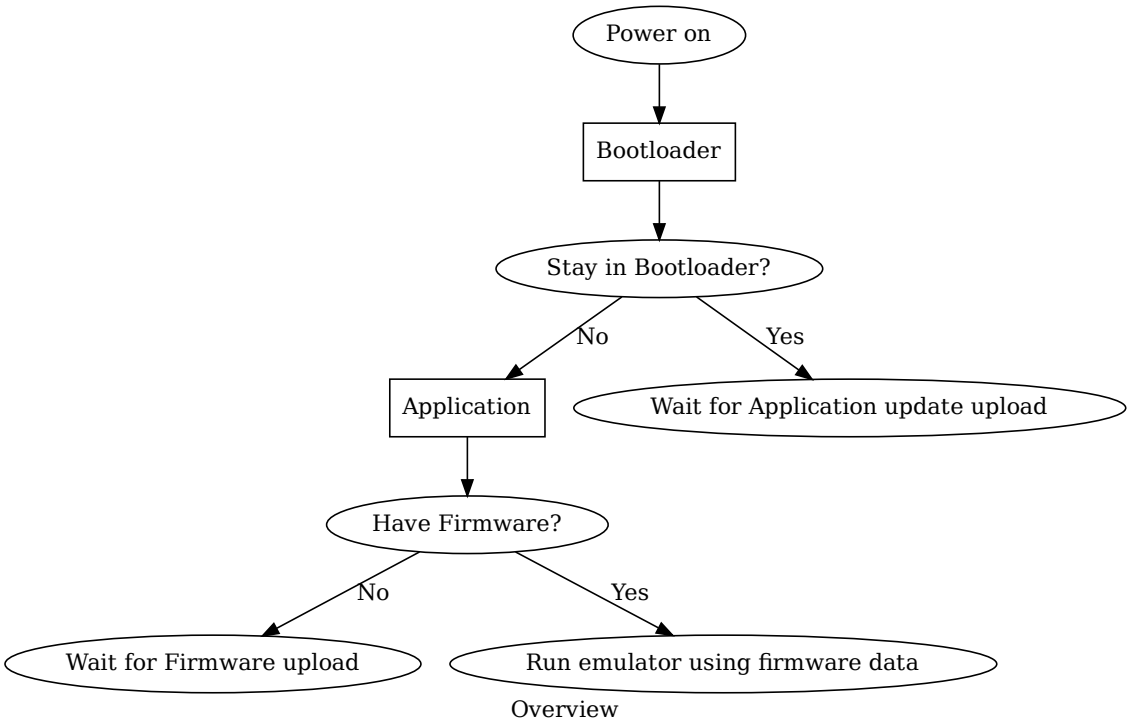
2.1 Software overview

RE-CPU is a replacement chip for the D650C chip which is not produced anymore and was used in different devices, including Roland TB303 and 606.

Bootloader will be mentioned through this manual. You can basically see it as the first stage of the software. It is a special software with only two purposes, to start the Application (RE-Emu) and to allow the user to update the application.

RE-Emu is the application software running on RE-CPU hardware that emulates the functionality of the original D650C chip. It is the software that makes your TB-303 and TR-606 sing.

Firmware is the instructions used by the emulator RE-Emu. RE-Emu reads this data file and interprets how to communicate with the hardware to make the sequencer works. I guess you could see RE-Emu as a chef and the firmware as recipe - the chef will never make the cake without the recipe!



Overview

3 Installation of the RE-CPU

3.1 Required parts for a complete installation

Note: The MIDI wiring should be compatible with Sonic Potions CPU, if you happen to have the wiring already setup for it, all you need is a to install a similar header on RE-CPU.

In order to have a complete install with working MIDI functionality you will need a few additional parts:

- 5 pieces of different colored (recommended) wires of around 20-30cm.
- 2 pieces of MIDI connectors (180 degree 5 pin male DIN Connector).
- (Optional) a 5 pin male and female header for easy connecting/disconnecting of the midi wiring.
- 40 (or 42[1]) pin IC socket or two 20 (or 21[1]) pin female pinheader for the target device.

[1] Depending on if you omit the unused pins or not.

3.2 Soldering the pinheaders

The RE-CPU comes with two 20 pin pinheaders that need to be soldered to the RE-CPU.

Note: RE-CPU just like the original NEC D650C CPU used in the TB-303 and TR-606 is a 42 pin IC with 21 pins on each side. Pin 1 and 42 is connected to the yellow coil used by the original CPU for clocking. This is not needed on the RE-CPU and can be omitted, hence why it is delivered with two 20 pin pinheaders.

It is important that you solder to the correct pins or else it will not work. Pinheader 1 should be soldered to Pin 2 through 20 and Pinheader 2 should be soldered to Pin 21 through 41. Pin 1 is easily identified as having a squared hole, Pin 42 is located at the same place on the second row. Please refer to Pinheader installation (Fig. 3.1) for correct installation.

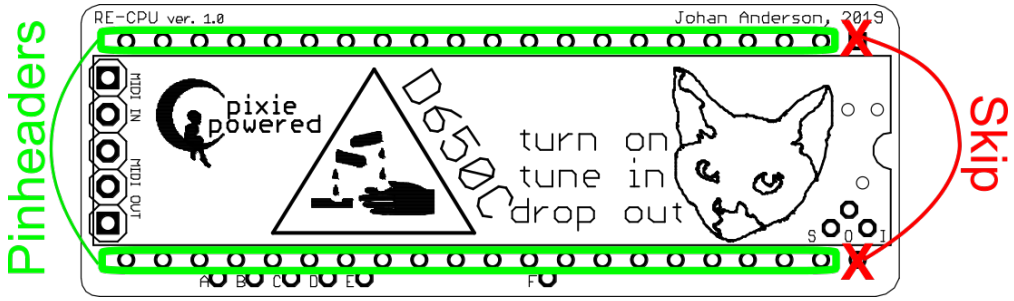


Fig. 3.1: Pinheader installation, skip pin 1 and pin 42.

3.3 MIDI wiring

In order to update and install the needed firmware for the emulation to work, it is recommended that you (at least temporarily while updating/installing) solder the MIDI IN connection, although it is recommended to solder both the MIDI IN and OUT connection to enjoy the full experience. Refer to MIDI installation (Fig. 3.2) for wiring.

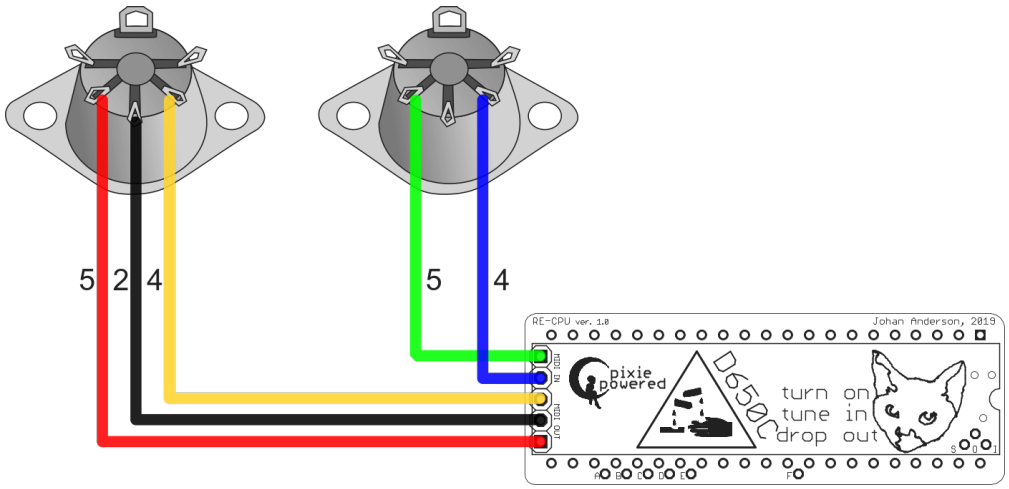


Fig. 3.2: MIDI Installation wiring.

3.4 Reference Photos

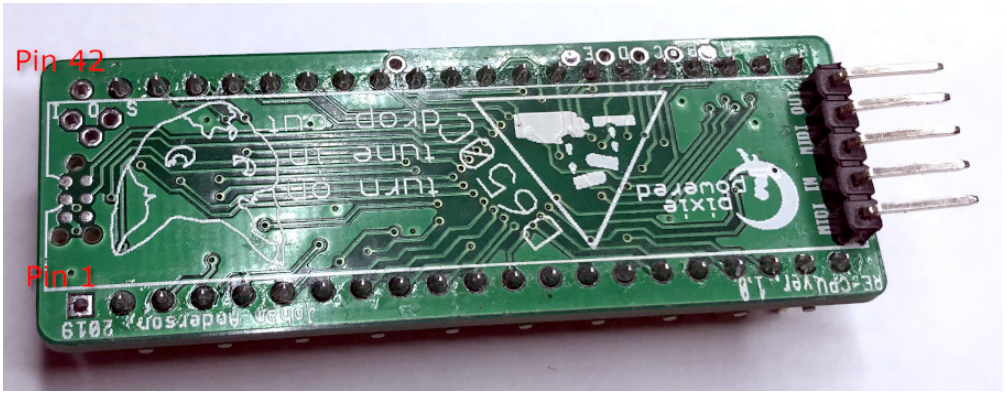


Fig. 3.3: CPU from above, notice pin 1 and pin 42

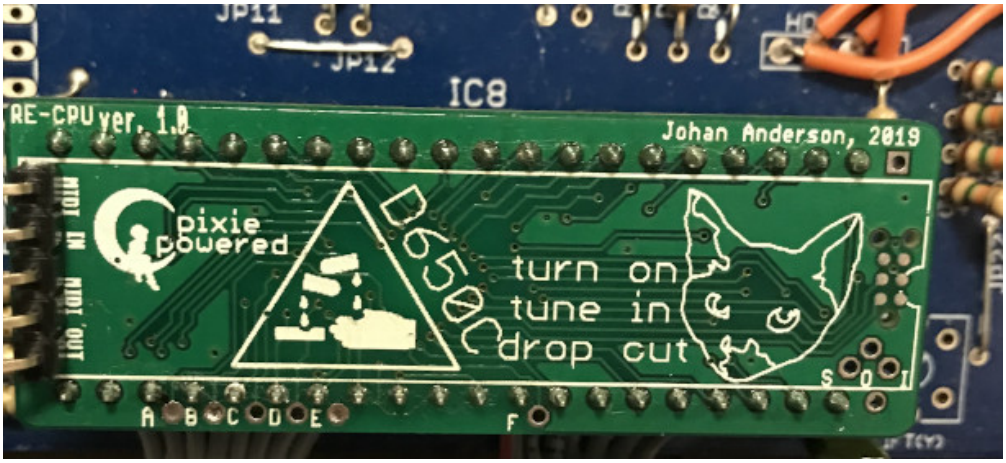


Fig. 3.4: CPU installed in a RE-303, MIDI should be pointing to the left.

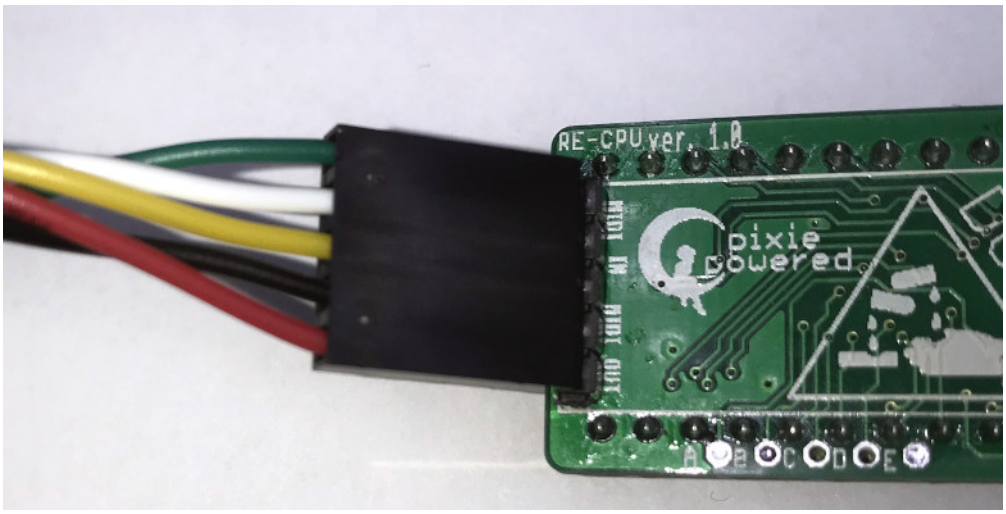


Fig. 3.5: Example MIDI wiring from CPU, notice coloring

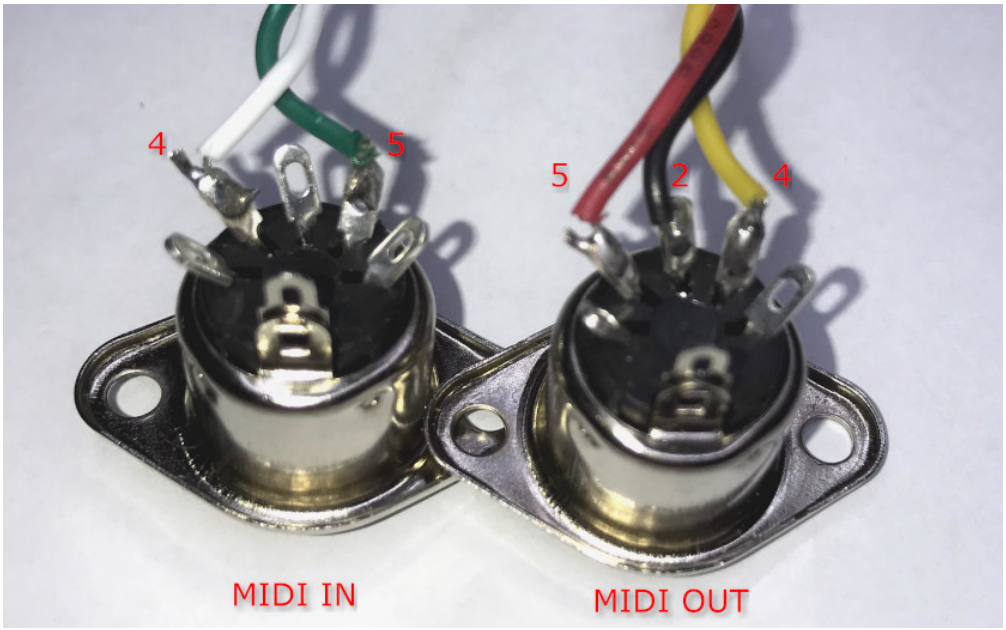


Fig. 3.6: Example MIDI wiring to connectors, notice coloring

4 First start-up

First time you start the RE-CPU the pre-installed emulator will be missing the much needed firmware. The LEDs will look very similar to Fig. 4.1. You will need to install this firmware file yourself and you can read about the procedure in the following section.

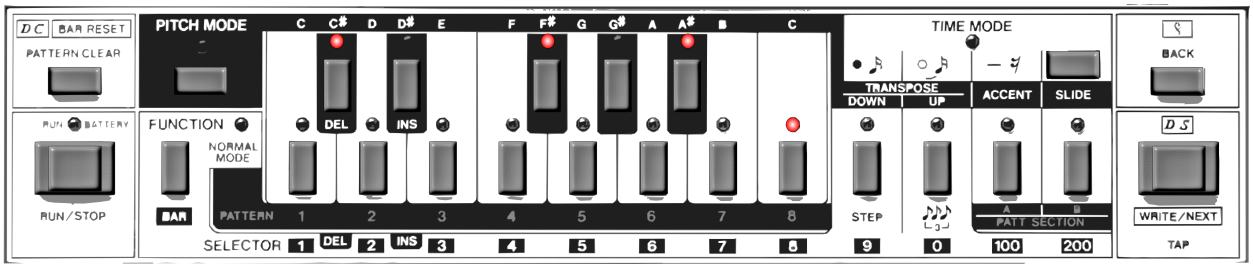


Fig. 4.1: Missing emulator firmware status message.

4.1 Installing the Emulator firmware

Attention: The emulator code requires the original TB-303 / TR-606 firmware in order to run. This is not installed on the device when you receive it. In order to install it you will need to first convert the firmware file to a MIDI SysEx file (.syx) and then send it to the RE-CPU over MIDI SysEx.

The software (Bootloader and RE-Emu) as well as any needed data (Firmware) for the RE-CPU chip has to be transferred by the MIDI SysEx protocol. Therefore files needs to be prepared into

special SysEx files with the file extension .syx. This chapter explains how to prepare your own MIDI .syx files. Luckily, the software releases usually include pre-made .syx files ready to be uploaded. If you have the files *bootloader.syx* and *reemu.syx* available, you can skip this chapter and continue reading the next chapter. If, however, you do not want to use the pre-generated .syx files and prefer generating this files yourself for some reason, you can read in this chapter how to do this.

To convert the firmware to a MIDI SysEx file there is two tools provided (and a online version):

- RE-CPU official tool PixieDust[2]
- RE-CPU official tool PixieDust (Online version)[3]
- A python script named sysextool.py[4]

4.1.1 Converting using PixieDust

When you start the PixieDust you will be at the home screen (Fig. 4.2).

[2] https://github.com/sunflowr/pixiedust/releases
[3] https://sunflowr.github.io/pixiedust/
[4] https://github.com/sunflowr/recpu/releases

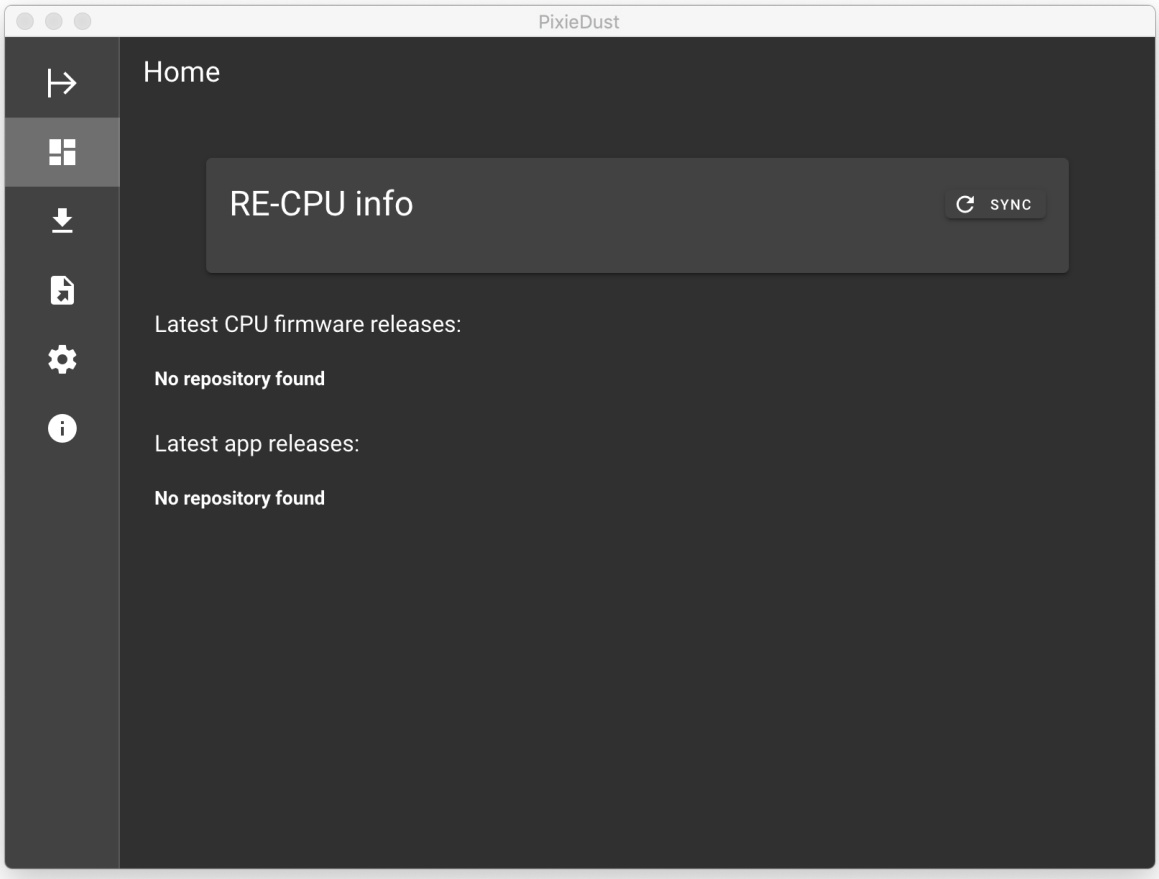


Fig. 4.2: PixieDust home screen.

Go to the SysEx Tool screen (Fig. 4.3).

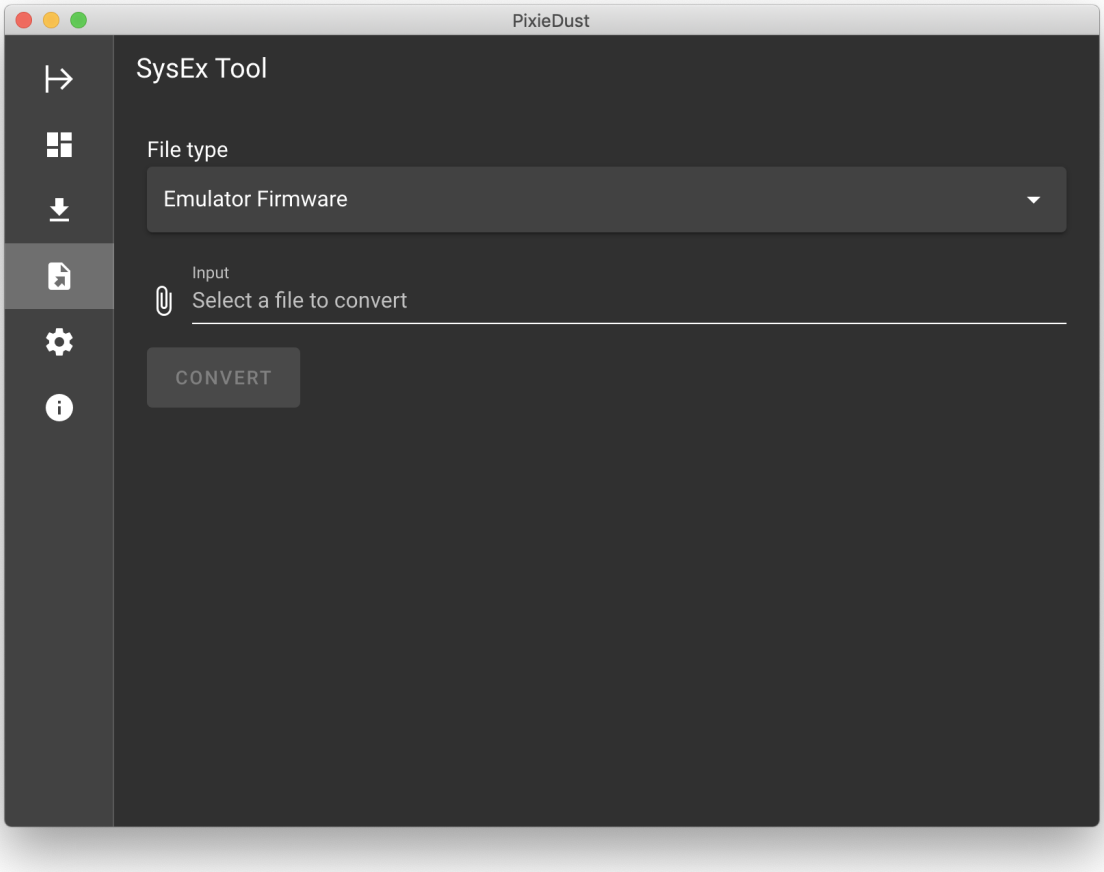


Fig. 4.3: PixieDust SysEX Tool screen

Select the firmware file (Fig. 4.4). If it is recognized it will display the identified file (e.g. "TB-303 firmware). Click on the Convert button to continue.

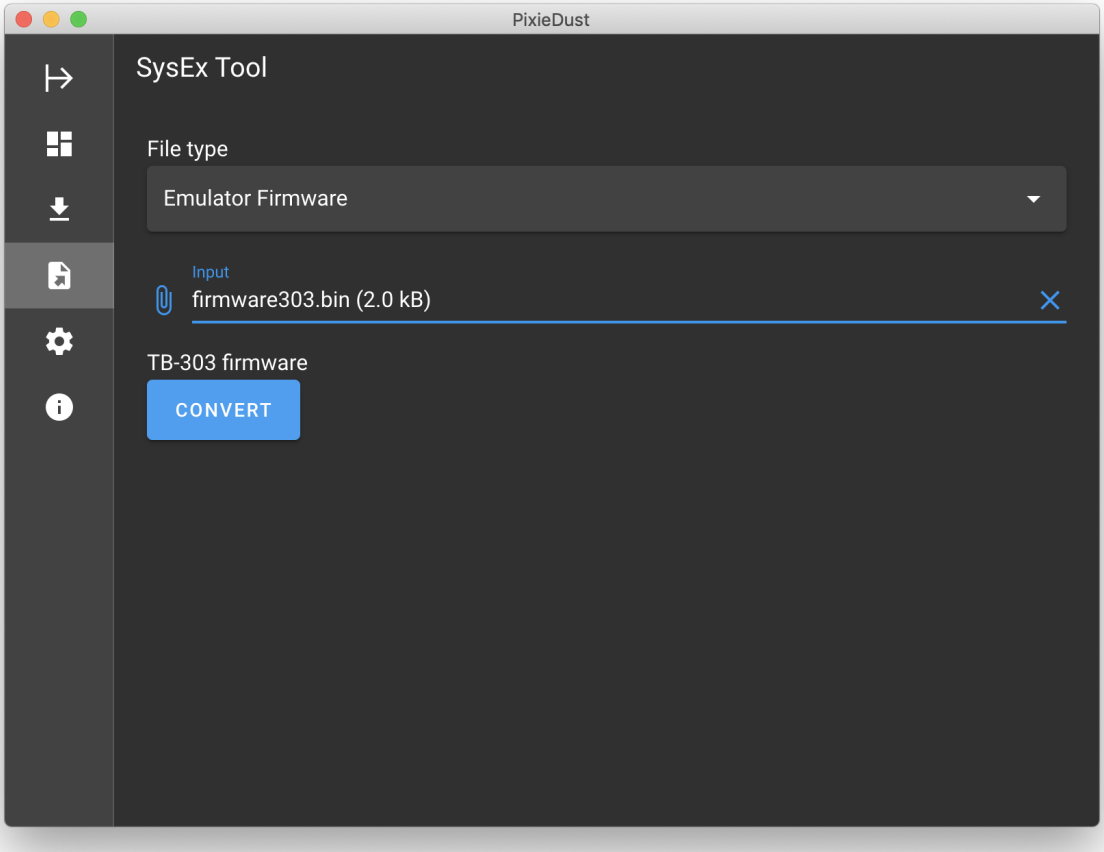


Fig. 4.4: Select the firmware file and click Convert.

Remember to Save the file (Fig. 4.5).

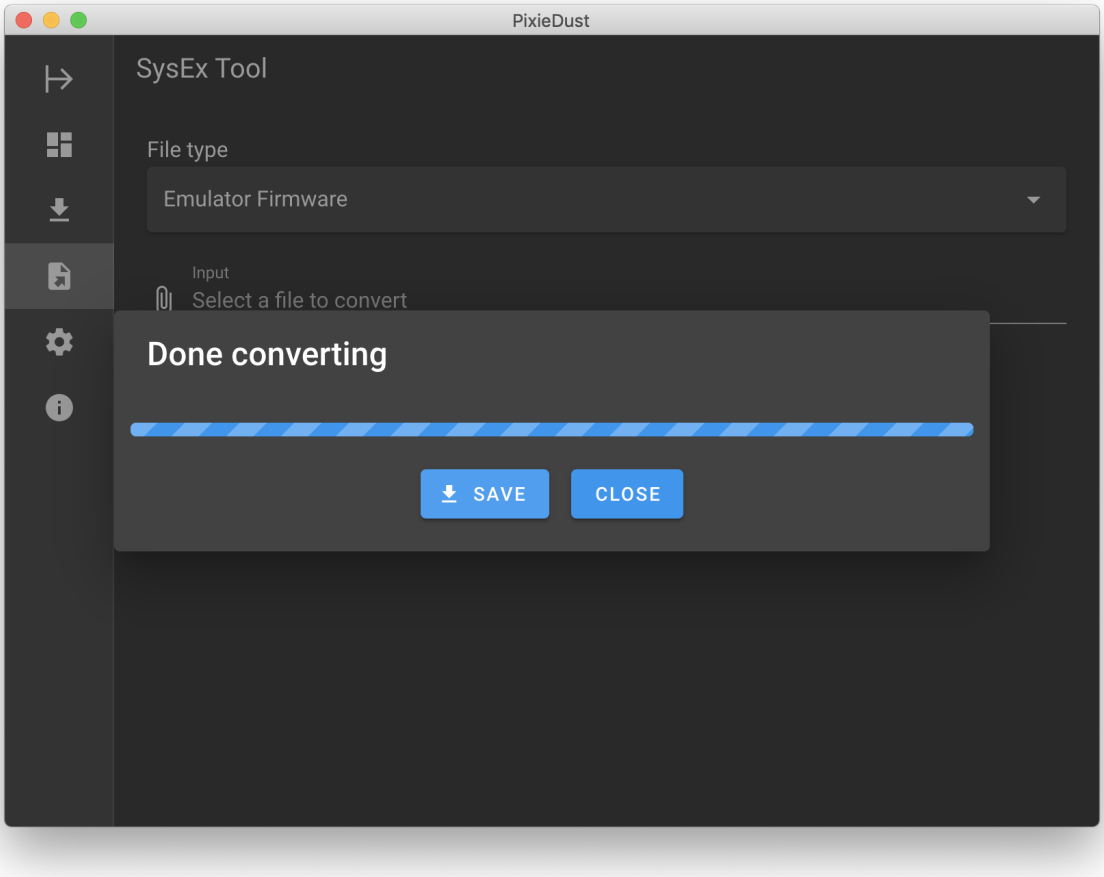


Fig. 4.5: Remember to Save the file.

4.1.2 Converting using sysextool.py

This is intended for people familiar with the terminal and prefer text-based tools. It requires Python to be installed. It also depends on the python package *mido*. To install mido execute:

```
pip install mido
```

To convert a firmware file to MIDI SysEx:

```
python sysextool.py --type=emulator_firmware --syx -o firmware.syx␣
↪path/to/your/firmware_file.bin
```

4.1.3 Upoading the firmware file

Once you have your firmware file converted to a MIDI SysEx file you can upload it to the RE-CPU using your favorite SysEx tool. If you do not have any I can recommend SysEx Librarian[5] for Mac or MIDI-OX[6] for Windows.

Note: Make sure the MIDI wiring is installed correctly and a MIDI cable is connected to the MIDI IN port.

If you are experience problems with uploading please refer to the *Troubleshooting* (page 23).

Power up the device and confirm you are seeing the missing firmware message (Fig. 4.1). Select the .syx file in your program and start uploading it. When the uploading starts the device will lit up the LED above *C* on TB-303 or *Step 1* on TR-606 as well as the *Time Mode* LED on TB-303 or *Step 16* on TR-606. If however no LED or any other note/step (e.g. A#) is lit and C/Step-1 is never lit alone, the procedure needs to be repeated after a power cycle. Do not worry, the transfer of the firmware as well as *reemu.syx* can be re-tried after a power-cycle in the Bootloader as often as needed until it succeeds.

Once the file have been uploaded, the device should reboot and start running the emulator with the uploaded firmware.

Congrats, you have now successfully installed the firmware. Have fun!

[5] https://www.snoize.com/SysExLibrarian/
[6] http://www.midiox.com/

5 Bootloader

The Bootloader is accessed[7] by holding the *C* button on TB-303 or *Step 1* button on TR-606. In this mode you can update the RE-CPU Application code.

More info later!

[7] If you are using the original Bootloader, you need to hold Function on TB-303 or set the Instrument selector in a specific positions on TR-606 to access the Bootloader. This have been changed in later versions of the Bootloader.

6 Updating

Updating of the Application as well as the Bootloader is done over MIDI SysEx. You will need a MIDI interface in order to upload the file. Most pro-level external audio interfaces provides this. If you do not already have a MIDI interface there is also stand alone USB MIDI interfaces you can buy. But beware of the cheap once, they can sometime have bad support for the SysEx protocol and will corrupt the upload. I recommend either go with a well known brand or reading reviews and ask around prior to ordering.

Once you have your MIDI interface, connect its MIDI OUT port to the MIDI IN port as well as the MIDI IN port to the MIDI OUT port of your device installed with a RE-CPU. OUT goes to IN, IN goes to OUT.

You will also need software to upload the SysEx file, you can either use the official tool PixieDust[8] or SysEx Librarian[9] for Mac or MIDI-OX[10] for Windows.

If you have problems uploading please refer to the section *Troubleshooting* (page 23).

[8] https://github.com/sunflowr/pixiedust/releases
[9] https://www.snoize.com/SysExLibrarian/
[10] http://www.midiox.com/

6.1 Updating Application

Updating the Application (RE-Emu) cannot be done while the device is normally running. The Bootloader mode needs to be entered:

1. Make sure you have connected your MIDI interface MIDI OUT port to the middle MIDI jack labeled MIDI IN.
2. Hold the *C* button on TB-303 or the Step 1 button on TR-606 and keep it held.[11]
3. Power-cycle the TB-303 / TR-606 device.

When the Bootloader has been successfully entered you see the keyboard lights flashing from left to right and back again, also a little bassline is played via the audio output. Now you can release the *C* / *Step1* button and send an updated application from your computer via MIDI. If, however, no flashing lights are shown the device is not ready yet and the attempt to enter the Bootloader needs ro be repeated by a new power-cycle until you see the flashing lights. Now the file can be send by a MIDI using a protocol called SysEx using any SysEx tool of your choice. It is perfectly safe to send the file *reemu.syx* in this state, and should the upload fail you can always try again. Do not send the file *bootloader.syx* while inside the Bootloader, it will not work.

Now using your SysEx uploading tool of choice, start uploading the file *reemu.syx*.

Once the upload start, depending on the version of Bootloader you have, the *Time Mode* LED should be lit, ori f you are on version 1.2.0 or later you should see a progress bar of the upload using the LEDs on the device.

The device should reboot once the upload have finished.

Tip: To pass some time while waiting for the upload to finish, feel free to play with the six knobs on top.

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[11] Old versions of the Bootloader requires you to hold Function on TB-303 or set the Instrument selector in a specific positions on TR-606 to access the Bootloader. This have been changed in later versions of the Bootloader. For more information, refer to *Bootloader* (page 16).

6.2 Updating Bootloader

Caution: Version 1.2.0 includes additional safety measures against bricking. Once you start the update procedure the Application will redirect the start up code to skip the Bootloader until it has successfully been installed, this should in theory make updating of the Bootloader as safe as updating the Applicaion. In reality there is always edge-cases and bad luck. But over all you should be able to feel more safe updating the Bootloader from now on. The caution message is only left as a reminder for users updating from a version prior to 1.2.0

This is the only time there is a risk of bricking your RE-CPU, please be certain your MIDI interface is working properly and do not abort the process once it have started.

I recommend to first upload the Application or Emulator Firmware once prior to updating the Bootloader to confirm the MIDI interface is working properly.

In the event of a failed update there is a risk the RE-CPU need to be send back for reprogramming.

Updating the Application (reemu.syx) like described in the prior chapter gives the RE-CPU all new features. This chapter describes the update of the Bootloader (bootloader.syx), which is dangerous, because unlike the application update the bootloader update cannot be repeated if it fails and brick (i.e. more or less damage) your RE-CPU. Usually updating only the Application (reemu.syx, as described above) is sufficient to get all latest device features. Skip the bootloader update and continue reading the next chapter unless there is a very specific reason for updating also the bootloader.

Updating the bootloader is done while inside the Application. Just start your device like normal. Once it is running just upload the Bootloader SysEx file *bootloader.syx* over MIDI using your favorite SysEx tool. If you are on version 1.2.0 or later you should see a progress bar updating using the LEDs on the device being updated.

7 Settings

To enter the settings mode to configure MIDI inside the Application, hold the *Function* button and press the *Clear* button on TB-303 or TR-606. To exit back to normal mode just press *Function* again.

On TR-808 you enter Settings mode by setting *Mode* switch to *Manual Play* and pressing the *Clear* button. To exit back to normal mode press *Clear*.

7.1 Clearing settings

When in Settings mode you can clear the settings by pressing the *Clear* button on TB-303 and TR-606 (currently not working on TR-808).

7.2 MIDI In channel

To change MIDI In channel, press *Octave Down* on TB-303 or *Step 10* on TR-606 and TR-808. You will now go to a sub-screen where you select channel using Step buttons on TR-606 and TR-808.

On TB-303 you first select channel group 1-8 using *C#* or channel group 9-16 using *D#* buttons. Then you select channel 1-8 (or 9-16) using the pattern 1-8 buttons.

> To exit back to Settings press *Function* on TB-303 and TR-606. On TR-808 press *Clear*.

7.3 MIDI thru

RE-CPU can tunnel MIDI from the MIDI In to Out through software. To toggle this behavior, press *Accent* on TB-303 or *Step 11* on TR-606/TR-808. The LED associated with the button will be lit when enabled.

7.4 MIDI Out channel

To change MIDI Out channel, press *Octeve Up* on TB-303 or *Step 12* on TR-606/TR-808. You will now go to a sub-screen where you select channel using Step buttons on TR-606/TR-808, for TB-303 look at table above. To exit back to Settings press *Function*.

7.5 Send note

This settings is reserved for future use.

7.6 MIDI In Omni mode

Makes the RE-CPU listen on all MIDI In channels. To enable, press *Slide* on TB-303 or *Step 14* on TR-606/TR-808. The LED associated with the button will be lit when enabled.

7.7 Remote mode

Makes it possible to trigger the device voice(s) over MIDI. To enable, press *Pitch Mode* on TB-303 or *Step 15* on TR-606/TR-808. The LED associated with the button will be lit when enabled. Still work in progress.

A velocity of 100 or more makes note accented.

TB-303 recognize notes in the range of C1-C6. Two overlapping notes create a slide.

Note values on TR-606

Instrument	Note value
Accent	35 (B1)
Bass Drum	36 (C2)
Snare Drum	38 (D2)
Low Tom	47 (B2)
High Tom	50 (D3)
Cymbal	49 (C#4)
Open Hi-hat	46 (A#3)
Closed Hi-hat	42 (F#3)

Note values on TR-808

Instrument	Note value
Accent	35 (B1)
Bass Drum	36 (C2)
Snare Drum	38 (D2)
Low Tom	47 (B2)
Mid Tom	48 (C3)
High Tom	50 (D3)
Rimshot	37 (C#2)
Handclap	39 (D#2)
Cowbell	56 (G#3)
Cymbal	49 (C#4)
Open Hi-hat	46 (A#3)
Closed Hi-hat	42 (F#3)

7.8 MIDI sync mode

To toggle between master/slave MIDI-sync, press *Time Mode* on TB-303 or *Step 16* on TR-606/TR-808. The LED associated with the button will be lit when in master sync.

8 Troubleshooting

8.1 Problem uploading SysEx files

A few users hav reported problem uploading SysEx files to RE-CPU. In all the cases it was solved by using MIDI-OX[12] on Windows and experimenting with the *Buffer Size* (in some case setting it as low as 8 Bytes, but 128 Bytes have also solved it for some).

The lower the "buffer size" setting in your SysEx tool is, the longer the update will take. Time will vary from several seconds with a high up to a few minutes with a very low buffer size setting.

8.2 First time I start nothing works and some LEDs are lit

This is normal and means you need to install the emulators Firmware Data. Refer to *First start-up* (page 9).

[12] http://www.midiox.com/

9 Links

9.1 Important Links

- Buy the hardware[13]
- RE-CPU support forum[14]
- RE-CPU firmware updates[15]
- RE-CPU official tool PixieDust[16]
- RE-CPU official tool PixieDust Online version[17]

9.2 Recommended SysEx Tools

- SysEx Librarian[18] for Mac
- MIDI-OX[19] for Windows.

[13] https://shop.re-303.com/
[14] http://23.235.199.139/~re303c5/forum/forum/10-pixie-powered-cpu/
[15] https://github.com/sunflowr/recpu/releases
[16] https://github.com/sunflowr/pixiedust/releases
[17] https://sunflowr.github.io/pixiedust/
[18] https://www.snoize.com/SysExLibrarian/
[19] http://www.midiox.com/

10 Changelog

This project adheres to Semantic Versioning[20].

10.1 1.4.3

10.1.1 General

- Updated version number.
- Updated changelog.

10.1.2 Core

- Fixed a bug in MIDI parser on Note messages
- Added optional MIDI thru support.

10.1.3 Bootloader

- Added output of version info over serial.
- Added test serial command 'r' to reboot.

[20] https://semver.org/spec/v2.0.0.html

10.1.4 RE-Emu

- Fixes to MIDI note out
- Small fix to port e output
- Added output of version info over serial.
- Added output of target cpu being emulated over serial.
- Fixes to upd444 memory emulation
- Improved TR-808 support thanks to some memory fixes.
- Added MIDI-thru support.
- Reverted D650C port initialization value to fix issue https://github.com/sunflowr/recpu/issues/8
- Added some serial status logging.
- Fixes to Settings version updating.
- Added MIDI in/out channel, send note, omni mode, and remote mode to config menu.
- Fixes to memory IC selection in TR-606 emulation.
- Added MIDI in note support on TR-606 (remote mode).
- Added support for MIDI omni mode message
- Fixed pin assignment of PE0 and PE1 on TR-808
- Changed how MIDI channel is selected on 303
- Added option to reset Settings in settings menu.
- Added option to enable/disable midi thru in settings.
- Added remote mode to 303, 606 and 808 (work in progress)
- Fix in note stack on TB-303

10.1.5 Documentation

- Added note about bug fix to sysex max size
- Spell fix on bug note in changelog
- Updated MIDI implementation chart for
- Updated changelog
- Updated TR-606 MIDI implementation chart
- Updated settings to reflect changes in RE-Emu

10.2 1.3.0

Important change! A bug related to max update size on SysEx files was found when adding TR-808 support. Due to this bug being fixed you need to update the bootloader prior to uploading reemu.syx.

10.2.1 General

- Updated version number.

10.2.2 Core

- Identified and fixed a bug in the SysEx memory handling.
- Added flush to end of SysEx data to make sure all data is send.
- Fixes to large SysEx files having SysEx package id overflowing.

10.2.3 Documentation

- Started on MIDI specs for RE-Emu.

10.2.4 Bootloader

- Added output of version info over serial.

10.2.5 RE-Emu

- Added output of version info over serial.
- Added output of target cpu being emulated over serial.
- Discovered and fixed a bug in the emulation of D650C internal RAM emulation.
- Started on MIDI Out support.
- Small correction to I/O port reading/writing.
- Started on TR-808 support (basic hardware support and memory emulation).
- Fixes to MIDI note out

10.3 1.2.0

10.3.1 General

- Added a pre-upload MIDI message describing the upload data. This in order to make the update process a bit more safe.

10.3.2 Manual

- Added suggestions from GitHub user RoelofBerg thank you! :)
- Fixed some misspellings.
- Added a System Overview in an attempt to visualize explain the different parts of the software.

10.3.3 Bootloader

- Updated the update code to use the new pre-upload MIDI message.
- The updater now make sure the entire application have been uploaded before allowing the user to run it.
- Added a upload progress animation.
- Deprecated old way of requesting version number.
- Added sysex requests for version.

10.3.4 RE-Emu

- Updated the update code to use the new pre-upload MIDI message.
- The updater now make sure the entire bootloader have been uploaded before allowing the user to run it (if the bootloader is corrupt, the CPU jumps right in to the application instead wait for the bootloader to be uploaded again).
- Optimizations in D650C emulation.
- Added a upload progress animation.
- Started on a settings system, currently only contain MIDI related settings. Will be able to configure settings through PixieDust software later.
- Deprecated old way of requesting version number.
- Added sysex requests for version, settings and memory dump.

- Fixes to MIDI note output from sequencer, still not perfect.
- SysEx support for requesting reboot in to bootloader mode (will be used for full system update later).

10.3.5 Tools

- Updated sysextool to add support for the new pre-upload MIDI message.
- Added option to select MIDI output device in sysextool.
- Added option to list available MIDI devices in sysextool.

10.4 1.1.0

10.4.1 Manual

- Fixed size of a few images.
- Added settings, updating and troubleshooting section.

10.4.2 RE-Emu

- Improved support for TR-606 emulation, now there's no need for uPD444C memory ICs.
- Some small optimizations.
- Timing experiments to get closer to original CPUs timing.
- Settings mode for configuring MIDI.
- Initial experiments with MIDI In sync. There seem to be a small delay of a few ms when starting the sync at the moment that need to be compensated for, currently investigating this.

10.4.3 Bootloader

- Changed button used to enter bootloader from *Function* on TB-303 to *C* on TB-303 and *Step 1* on TR-606 as the original button caused problems on TR-606.

10.5 0.1.1

- Fixed a few typos in the manual.
- Added additional installation photos in the install part of the manual.

10.6 0.1.0

First release. Contains the MIDI SysEx python script and the manual.