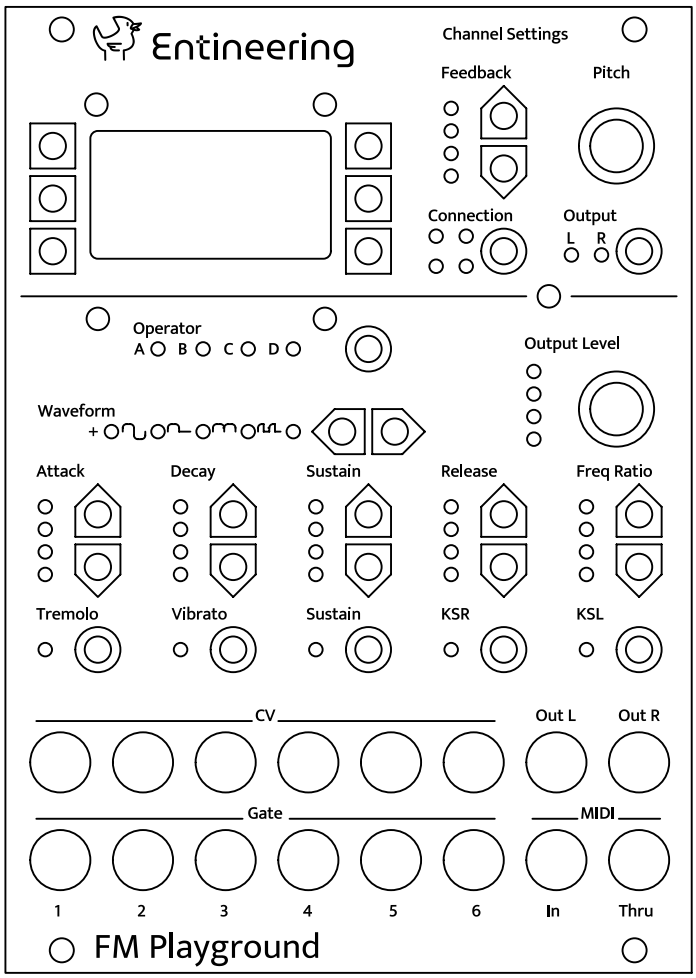
Entineering FM Playground

User Manual

v1.3



Introduction

Entineering FM Playground is a module for Eurorack synthesizers. It is a complete synthesizer doing a faithful emulation of the OPL3 chip, which was famously used in SoundBlaster and AdLib sound cards for the PC.

- 18 independent channels, 36 operators.
- Six channels can be configured to use four operators each, otherwise two operators per channel
- 6 CV inputs
- 6 gate inputs
- Two audio outputs
- MIDI In and Thru
- All channel and operator parameters accessible from the front panel
- Parameters are assignable to either gate or CV inputs
- Parameters are assignable to MIDI CC, Velocity and Aftertouch messages
- 99 program slots
- Polyphonic mode

Connecting the Module

Connecting Power

Your Eurorack synthesizer module comes equipped with a 10-pin keyed connector for power supply.

To connect the module:

1. Power Off Your System: Before connecting the module, ensure that your Eurorack case and power supply are turned off.
2. Locate the Power Connection on Your Case: Identify the power headers on your Eurorack case. These headers will have a 16-pin connector.
3. Use the supplied ribbon cable to connect the module to your Eurorack power supply. The red mark on the ribbon cable identifies the -12V supply line. On the module, the red mark points towards the bottom on the module.
4. Secure the Module: Once connected, mount your module into the case using the appropriate screws, ensuring it is securely in place.

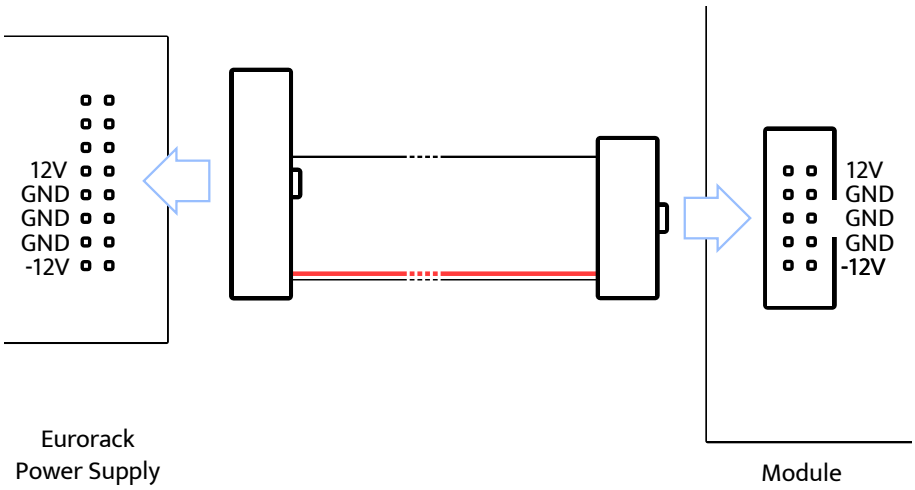


Figure 1: Connecting Power

Only use proper Eurorack power supplies with voltages of -12V and +12V.

Connecting MIDI

To connect a device with a 5-pin DIN connector to the module, you need a MIDI DIN-to-TRS adapter. The TRS jacks on the module use the A pinout that is now included in the official MIDI standard.

To be able to send MIDI data to the module, connect the MIDI Out or MIDI Thru port of your MIDI keyboard, audio interface or similar, to the MIDI In jack of the module.

Introduction to the Emulated OPL3 Chip

The heart of the FM Playground module, and the original OPL3 chip, lies in its unique approach to sound generation: FM (Frequency Modulation) synthesis. This is orchestrated through a combination of operators and channels, which work together to create its distinctive sound palette. Understanding how these operators and channels function is key to mastering the FM Playground module.

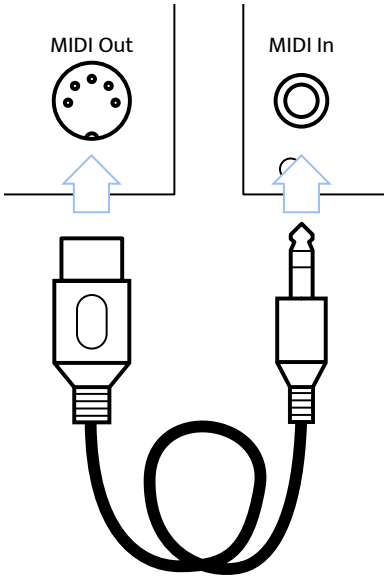


Figure 2: Connecting MIDI

Operators: The Building Blocks

1. **Definition**: In FM synthesis, an operator is essentially a sine wave generator. Each operator in the OPL3 chip can act as either a carrier (producing audible sound) or a modulator (modifying the frequency of another operator).
2. **Characteristics**: Operators in the OPL3 have several parameters:
    - **Waveform**: In additional to a normal sine wave, three (in OPL2 mode) or seven (in OPL3 mode) additional waveforms are available, most of which are variations of the sine pattern.
    - **Frequency**: Determines the pitch of the sound. This is derived from the channel frequency and a factor of 0.5 or 1 to 15.
    - **Amplitude**: Controls the loudness.
    - **Envelope**: Shapes the sound over time, with parameters like attack, decay, sustain, and release.
    - **Additional parameters**: Vibrato, tremolo, etc.
3. **Modulation**: By modulating one operator with another, complex timbres and textures can be created, ranging from simple bell-like tones to intricate evolving sounds.

Channels: The Organizational Framework

The emulated OPL3 chip features multiple channels, each capable of handling multiple operators. In the FM Playground module, this structure is preserved, allowing for intricate patching possibilities.

Properties of a Channel

- **Operator Capacity**: Each channel can control two or four operators. The latter requires enabling the OPL3 mode.
- **Feedback Control**: Channels have a feedback mechanism, where the output of a carrier operator can be routed back into its modulator, affecting the timbre and harmonic content.
- **Modulation Routing**: Channels allow for different modulation routings, including series (FM chain), parallel, and mixed modes.
- **Stereo Output Assignment**: Channels can be assigned to left, right, or both stereo outputs, enabling spatial sound placement.
- **Frequency Control**: Each channel has independent frequency control for its operators, determining the pitch of the sound.
- **Note On**: This signal engages the envelope generators of all operators in the channel.

Practical Applications

- **Recreating Classic Sounds**: Use the 2-operator mode for classic FM sounds reminiscent of early PC games and synthesizers.
- **Complex Sound Design**: Leverage the 4-operator mode for creating intricate and evolving textures.
- **Percussive Elements**: (Not present in the current firmware version.) Utilize the rhythmic mode to add unique percussive sounds to your modular setup.

In summary, the operators and channels of the emulated OPL3 chip form the basis of its sound generation capabilities. By understanding and experimenting with these elements, users of the FM Playground module can explore a vast range of sonic possibilities, from retro-inspired tones to innovative soundscapes.

Module Description

Buttons

The functions of the FM Playground module are controlled through push buttons on the front. These serve different functions: - **Soft Buttons**: Marked by a rectangle around them. These are located left and right of the screen and have different functions depending on screen contents. - **Up/Down Buttons**: Marked by an arrow around them. These control parameters with up to 16 steps. An LED bar graph next to them shows the current value of the parameter - **Toggle/Cycle Buttons**: Marked by a circle around them. These toggle parameters (On/Off) or cycle through up to four options. LEDs next to the button indicate the current value of the parameter.

Rotary Encoders

There are two high-precision rotary encoders on the module. One of the knobs also has a push function.

OLED Screen

The screen is used to display selected programs and channels, parameter values, as well as a menu system. The functions of the user interface can be triggered with the soft buttons described earlier.

Using the Module

The inputs on the front panel of the module are divided in two sections: Channel parameters and operator parameters. The channel controls influence the parameters of the currently selected channel (in monophonic mode) or all channels (in polyphonic mode).

The operator controls let you change the parameters of the currently selected operator. The operator can be selected at the top of the operator control section. In a two-operator channel, only operators A and B can be selected. In a four-operator channel, operators A through D can be selected.

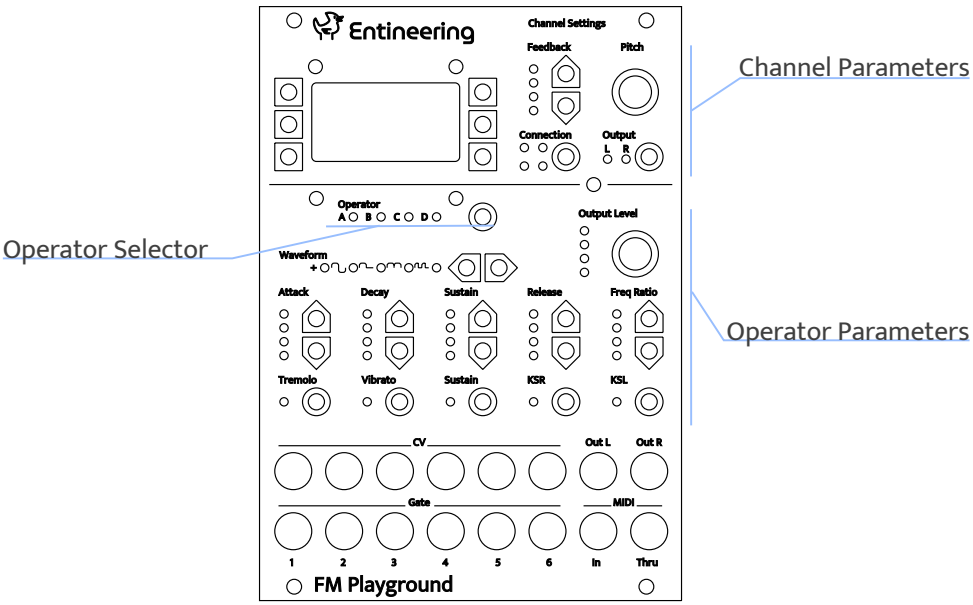


Figure 3: Front Panel Description

Channel Parameters

Feedback

One of the distinctive features of a channel in the OPL3 architecture is the feedback mechanism. Feedback occurs when the output of a carrier operator is routed back into its modulator. This can significantly alter the sound, adding complexity and harmonic content. In the OPL3-Euro Module, feedback is adjustable, offering a range from subtle coloration to aggressive, almost distorted tones.

- **Low Feedback**: Subtle changes in timbre, adding slight richness or "body" to the sound.
- **High Feedback**: More pronounced effects, creating metallic or bell-like tones, and can lead to aggressive, distorted textures at extreme settings.

Operator Connections

Also known as "Algorithm". Controls the connections between modulators and carriers.

- **2-Operator Channels**: The simplest form, and the only one available in OPL2 mode.
  - Series: One operator acts as the modulator, shaping the timbre of the other operator, which acts as the carrier.
  - Parallel: Both operators act as carriers, and their outputs are mixed.
- **4-Operator Channels**: Only available in OPL3 mode. More complex, allowing for a variety of configurations:
  - Series: Operators are arranged in a chain, with each modulating the next.
  - Parallel: Operators work in pairs, each pair modulating a separate carrier.
  - Hybrid: A combination of series and parallel configurations, allowing for intricate sound designs.

You can change between two and four operators for a channel in the "OPL Settings" menu item.

Pitch

This controls the base frequency of the channel. This can be helpful if you don't want to control the pitch externally (for example for percussive instruments) or to quickly

test a patch.

Pushing the knob triggers the “Note On” signal for this channel, making the channel audible.

Output Channels

In OPL3 mode, this lets you select the output channel. Options are left, right, both or off. In polyphonic mode, You can select between all voices on both channels (mono) and half of the voices left and half of the voices right (stereo).

In OPL2 mode, this button has no effect. You can switch between OPL2 and OPL3 modes in the “OPL Settings” menu item.

Operator Parameters

Waveform

In OPL2 mode, four waveforms are available: Sine, half-sine, abs-sine and pulse-sine. In OPL3 mode, four additional waveforms are available: Sine in even periods only, abs-sine in even periods only, square and derived square.

Output Level

This controls the output amplitude of the operator. Changing the output level of a modulator changes the modulation depth, while changing the output level of a carrier changes the output volume.

Attack

This parameter controls the rate at which an operator’s sound reaches its maximum level after a key is pressed. A faster attack results in the sound starting more abruptly, while a slower attack means the sound ramps up more gradually, creating a softer onset.

Decay

Decay controls the time taken for the sound to transition from the attack's peak level to the sustain level. A quicker decay results in a rapid reduction to the sustain level, whereas a slower decay allows for a more gradual descent.

Sustain

The sustain level sets the volume at which the sound remains after the initial decay phase and before the key is released. A high sustain level means the sound maintains a louder volume during sustain, while a lower level results in a quieter sustain phase.

Release

Release determines how quickly the sound fades to silence after the key is released. A short release time will stop the sound abruptly, whereas a longer release time allows the sound to decay slowly, creating a lingering effect.

Frequency Ratio

The frequency factor or ratio is used to set the frequency of an operator relative to the base frequency of the channel. These factors are crucial in defining the harmonic content and timbral characteristics of the sound produced.

The frequency ratio can be half, one, or any integer between two and 15.

Factor	Meaning
0.5	One octave below (Perfect Octave Down)
1	Unison (Same Pitch)
2	One octave above (Perfect Octave Up)
3	One octave plus a perfect fifth above
4	Two octaves above
5	Two octaves plus a major third above
6	Two octaves plus a perfect fifth above

Factor	Meaning
7	Two octaves plus a minor seventh above
8	Three octaves above
9	Three octaves plus a major second above
10	Three octaves plus a major third above
11	Three octaves plus a major third plus a microtonal amount above
12	Three octaves plus a perfect fifth above
13	Three octaves plus a perfect fifth plus a microtonal amount above
14	Three octaves plus a major seventh above
15	Three octaves plus a major seventh plus a microtonal amount above

Tremolo

Located on the last row of buttons on the far left. The tremolo effect modulates the amplitude of the sound at a regular rate, creating a pulsating effect. Tremolo depth can be adjusted in two steps in the chip settings.

Vibrato

Vibrato is the modulation of pitch at a steady rate. Vibrato depth can be adjusted in two steps in the chip settings. Higher vibrato settings will cause more noticeable pitch fluctuations, adding a quivering effect to the sound.

Sustain Enable

KSR (Key Scale Rate)

This parameter affects how the attack, decay, and release times of an operator are modified based on the pitch of the note being played. Enabling KSR results in shorter envelope times for higher-pitched notes, mimicking the behavior of many acoustic instruments.

KSL (Key Scale Level)

KSL adjusts the overall output level of an operator based on the pitch of the note. This helps to balance the loudness across different pitches, as higher notes can be perceived as louder. Lowering the KSL value makes the sound more consistent across the keyboard, while higher values accentuate the level differences between high and low notes.

KSL can be chosen between none, 1.5 dB, 3.0 dB and 6.0 dB per octave.

Saving and Loading Programs

All parameters of all channels and operators are retained during module power-off. Additionally, sets of parameters can be saved as "programs" and recalled later. 99 program slots are available.

Saving a Program

If parameters have been modified compared to the currently loaded program, the "Save" button appears in the upper right corner of the screen. Press the upper right soft button. Now use the center-right and bottom-right soft buttons to choose a program slot. Press "Save" to complete the operation or "Cancel" to exit and not modify any program slots.

When saving a program into a slot, the program previously in this slot is overwritten and cannot be recovered.
Factory programs can be recovered using the "Restore" item under the "Program" menu, or by doing a factory reset.

Loading a Program

While on the main screen, pressing the center-right or bottom-right soft buttons loads the next or previous program into the current channel, respectively. When in polyphonic mode, the program is loaded into all voices.

Loading a program can also be done using MIDI PC (Program Change) commands. In monophonic mode, PC commands on MIDI channels 1 to 16 load programs into OPL

channels 1 to 16 respectively. Channels 17 and 18 cannot be controlled via MIDI. In polyphonic mode, the MIDI channel to listen on can be configured in the menu.

Loading a program will discard any changes made to the parameters of the current channel and overwrite them with the contents of the program.

Program Load Fail

If, after loading a program, the program slot number is striked through, it means that the program could not be loaded. The reason is one or multiple of the following:

- The program uses a waveform only available in OPL3 mode, but OPL3 mode is currently disabled.
- The program uses four operators, but OPL3 mode is currently disabled.
- The program uses four operators, but the current channel is only configured for two operators, or vice versa. This does not happen in polyphonic mode, since the channels are automatically switched between two and four operators on program load.

Controlling Parameters Externally

Almost every parameter for channels and operators can be controlled externally via CV/Gate inputs or via MIDI.

CV inputs have a range of -7 to 7 volts. This range can be freely mapped to the available range of the parameter and even be inverted.

Whenever you change a parameter from the front panel, the display shows the current value of that parameter along with buttons to assign this parameter to CV, Gate or MIDI.

Assigning to a Gate Input

Parameters that only have an on/off state can be assigned to a gate input. After pressing the “Gate Assign” soft button, a screen appears where you can select the gate input to be used.

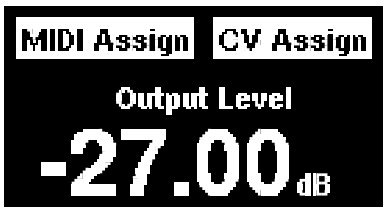


Figure 4: Parameter assignment buttons. Press "MIDI Assign" to assign this parameter to a MIDI message. Press "CV Assign" to assign the parameter to a CV input. Some parameters can be assigned to a gate input instead.

If you have configured gate and CV inputs to be used for polyphonic voices, those inputs are not available to be assigned to a parameter anymore. Use the menu to configure the number of inputs to be used for polyphonic voices.

Assigning to a CV Input

Parameters that can take a range of values can be assigned to CV inputs. Additionally to the input number 1 to 6, you can now also configure how input voltages should be mapped to parameter values. By default, 0 Volts refer to 0% of the parameter value and 5 Volts to 100%. Use the soft buttons to adjust these voltages. Press the soft button marked with a right arrow to complete the assignment.

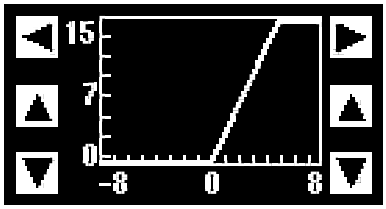


Figure 5: CV value mapping. Horizontal axis shows the input voltage, vertical axis shows parameter value. Up/down buttons in the left control lower input voltage, up/down buttons on the right control upper input voltage. Right arrow button confirms, left arrow button returns to main screen.

Assigning to a MIDI Value

Parameters can also be assigned to different MIDI messages. The messages that can be used are:

- Velocity

- Controller (e.g. mod wheel)
- Channel Aftertouch
- Polyphonic Aftertouch

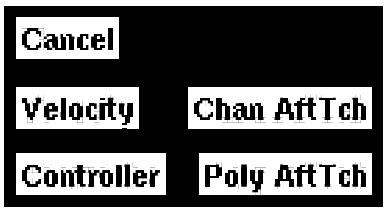


Figure 6: MIDI message assignment. Press one of the message types, or "Cancel" to return to the main screen.

Value ranges can be mapped in the same way as with CV inputs, but with MIDI input values 0 to 127 instead of voltages.

In monophonic mode, OPL channels 1 to 16 are controlled with MIDI channels 1 to 16. OPL channels 17 and 18 cannot be controlled via MIDI. In polyphonic mode, the MIDI channel can be configured in the settings menu.

Main Menu

From the main channel/program screen, pressing the upper left button labeled "Menu" opens the main menu. Pressing the upper left button again exits out of the menu. Left center and left bottom buttons let you select the previous or the next menu item respectively. The meaning of the buttons on the right depend on the selected menu item.

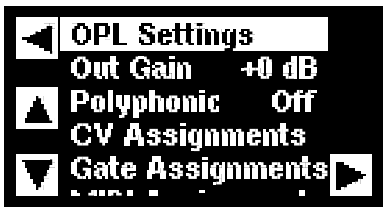


Figure 7: Main menu.

OPL Settings

These are global settings for the emulated OPL3 chip. Please note that programs saved with a certain set of settings may be unable to load with a different set of

settings. For example, if saving a program with four operators, it cannot be loaded if the chip is in OPL2 mode or the selected channel is not configured to have four operators.

Tremolo

This sets the tremolo depth for all operators on all channels where tremolo is enabled. Set it to either 1.0 dB or 4.8 dB.

Vibrato

This sets the vibrato depth for all operators on all channels where vibrato is enabled. You can choose either 7 cents or 14 cents.

OPL3 Mode

Switch between OPL2 and OPL3 mode here. OPL3 mode enables channels with four operators and additional waveforms.

4-Operator Channels 1 through 3 and 10 through 12

Enable four-operator mode for the respective channel. Note that channels 4, 5, 6 and 13, 14, 15 can't be used if four-operator mode is enabled on channels 1, 2, 3 and 10, 11, 12 respectively, since their operators become part of the primary channel.

With polyphonic mode enabled there is only one setting that controls all channels used for polyphony at once.

Output Gain

The output levels of the emulated OPL chip may seem too low in some circumstances. In these cases, you can increase the output level with this setting. If you experience clipping, lower the setting instead.

Since firmware version 1.3, the output gain can be adjusted in 1 dB steps.

This is initalized to +6 dB to help new users who start exploring FM Playground with a single channel. Once you start using multiple channels or the polyphonic mode, lower this to 0 dB.

Polyphonic Mode

When turned off, all channels of the emulated OPL chip are handled separately. They all can have different parameters, and channels 1 to 16 can be controlled with MIDI channels 1 to 16.

However, when polyphonic mode is turned on, only one set of parameters is applied to six channels simultaneously. The six voices are controlled via a single MIDI channel (configured below) and/or a number of CV/Gate inputs (also configured below).

CV Assignments

This lists all parameters currently assigned to one of the CV inputs. It also allows for deleting one or all CV assignments.

Gate Assignments

This lists all parameters currently assigned to one of the gate inputs. It also allows for deleting one or all gate assignments.

MIDI Assignments

This lists all MIDI assignments. It also allows for deleting one or all MIDI assignments.

Programs

Different operations on stored user programs can be performed in this submenu.

Figure 8: Programs menu.

This menu was added in firmware version 1.3.

SysEx Export

With this, all 99 programs can be transferred via MIDI to a host PC running the appropriate software for recording SysEx messages. One example on macOS is SysEx Librarian. It is also possible to transfer programs to another FM Playground module.

SysEx Import

Here you can import previously exported programs via MIDI SysEx. Optionally, a range of programs to import can be specified. Programs outside of that range will be ignored during the import process.

Figure 9: Program SysEx import menu.

After selecting “Import”, the module waits for MIDI SysEx messages containing program data. It will wait for all programs in the specified range, unless you press “Cancel”.

Programs within the specified range will be overwritten with the imported programs!

Copy

Here, a program can be copied to a different slot. Choose the source and destination program slot, then select “Copy”.

The program selected by “Destination” will be overwritten!

Swap

Here, two programs can be swapped between slots.

Restore

Here you can restore a subset of programs to their factory default. Only the programs between “First” and “Last” will be restored once you select the “Restore” item.

Programs within the specified range will be overwritten with the factory programs!

Advanced

Advanced settings and functions can be found here.

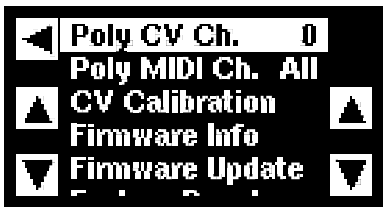


Figure 10: Advanced menu.

Polyphonic CV Channels

Sets the number of CV/Gate inputs which are used as Volts/Octave and Gate inputs in polyphonic mode. Between zero and six inputs can be dedicated for pitch and “note on” this way. The other inputs can be assigned to any of the other parameters.

Polyphonic MIDI Channel

With polyphonic mode turned off, MIDI channels 1 to 16 control OPL channels 1 to 16. With polyphonic mode turned on however, a single MIDI channel controls six of the OPL channels. The MIDI channel number can be configured here.

CV Calibration

Your FM Playground module is calibrated from the factory. However, if you find that Volts/Oct tracking is not precise enough, you can calibrate the CV inputs.

After selecting the menu item, you are requested to do three calibration steps per input:

1. Calibrate zero. Unplug any cable from the CV input being calibrated and press the button with the round symbol. Press the right arrow button to proceed to the next step.
2. Calibrate positive voltage. Feed a precise, known positive voltage into the CV input. Around 5 Volts works best. Now press and hold the up and down buttons until the displayed voltage matches the one being fed into the module. Press the right arrow button to proceed to the next step.
3. Calibrate negative voltage. Feed a known negative voltage inte the input. Around -5 Volts works best. Press and hold the up and down buttons until the displayed voltage matches the voltage being fed into the module. Press the right arrow to calibrate the next CV input.

Figure 11: CV calibration screen. Press the round button to calibrate the zero point. Press the right arrow to proceed to the next step. Press the left arrow button to return to the previous step.

After completing these steps for every CV input, you are asked to either save or discard the new calibration.

Firmware Info

Displays the version of the currently installed firmware. Visit https://entineering.eu to see if there is a newer version available for your module.

Firmware Update

Use this option to update the firmware on your module. See the chapter on updating the firmware for details.

Factory Reset

This restores the settings and programs to their default state. Optionally you can also clear the CV calibration, although this is not recommended.

Resetting the calibration does **not** restore the calibration done at the factory. Instead, it sets the calibration to generic default values. A calibration is probably needed after this.

Updating the Firmware

The firmware of the module can be updated by sending a firmware update file via MIDI SysEx messages. Please find firmware update files at https://entineering.eu. For installing the update, you first have to enter firmware update mode, and then send then new firmware via MIDI from a host PC.

Entering Update Mode

To enter update mode, while on the main screen, press the top left soft button to enter the menu. Using the center left and bottom left soft buttons, navigate to the “Advanced” submenu and press the bottom right soft button to enter this submenu. In the same manner, select the “Firmware Update” menu item.

Transfer New Firmware

Connect a MIDI cable from a PC-MIDI interface to the module. Now send the firmware file in .syx format from your PC to the module. You can disable any delays between messages for faster transfer.

Some low-cost USB-to-MIDI adapters do not properly support SysEx messages, in particular those based on the CH345 chip.

Table 2: Recommendations for Software that can be used for sending SysEx files.

Operating System	Software	Where to Get
macOS	SysEx Librarian	https://www.snoize.com/sysexlibrarian/
Linux Command Line	`amidi`	`alsa-utils` package
Windows	MIDI SysEx Transfer Utility	https://apps.microsoft.com/detail/9pfd4ddwgktn

SysEx Librarian

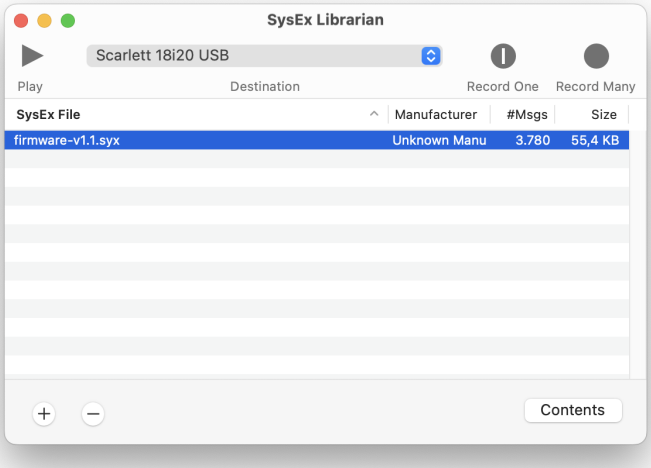


Figure 12: SysEx Librarian

Follow these steps to transmit a new firmware file to the module using SysEx Librarian:

- Add the firmware file to the list of SysEx files in SysEx Librarian.
- Select your MIDI interface in the drop-down menu at the top.
- To speed up the transfer, go to “Settings” under the “SysEx Librarian” menu and set the pause between messages to 0 milliseconds.
- Press the “Play” button in the top left.
- Wait until the file was fully transferred.

`amidi`

Follow these step to transmit a new firmware file to the module using `amidi` on Linux:

- Open a terminal.
- Type `amidi --list-devices` to get a list of your MIDI devices. Note the descriptor in the "Device" column.
- Type `amidi --send=/path/to/firmware-v1.1.syx --port=hw:1,0,0`, where the argument to `--send` is the path to the firmware file, and `--port` is the MIDI device descriptor from the previous step.
- Wait until the file was fully transferred.

MIDI SysEx Transfer Utility

Follow these step to transmit a new firmware file to the module using MIDI SysEx Transfer Utility on Windows:

- Select your MIDI interface in the drop-down menu labelled "MIDI Output Port".
- Press the button "Pick SysEx File to Send" and choose the downloaded firmware file.
- In the field "Transfer Delay", enter 0.
- Press "Validate and Send SysEx"
- Wait until the file was fully transferred.

Complete the Update

After the new firmware file has been transferred completely, you are prompted with a message asking you if the firmware should be written to module. Choose "yes" to complete the installation.

Ensure a stable power supply during this last phase of the update! If power gets interrupted while the firmware file is written to the module, the module will no longer be operational. Additional tools and knowledge are required to recover from this state.

Appendix A: Attributions

The firmware of FM Playground uses several open source libraries which are listed here, along with their licenses.

Nuked-OPL3

FM Playground uses the Nuked-OPL3 software library, copyright by Nuke.YKT, licensed under the terms of the GNU Lesser General Public License version 2.1. Please visit http://entineering.eu to get a special firmware package that allows you to replace the Nuked-OPL3 source code.

This firmware package is for advanced users only and requires additional software and hardware tools to install. Installing custom firmware can potentially damage the FM Playground module. Damages caused by custom firmware is not covered by warranty.

specially designated software packages--typically libraries--of the Free Software Foundation and other authors who decide to use it. You can use it too, but we suggest you first think carefully about whether this license or the ordinary General Public License is the better strategy to use in any particular case, based on the explanations below.

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