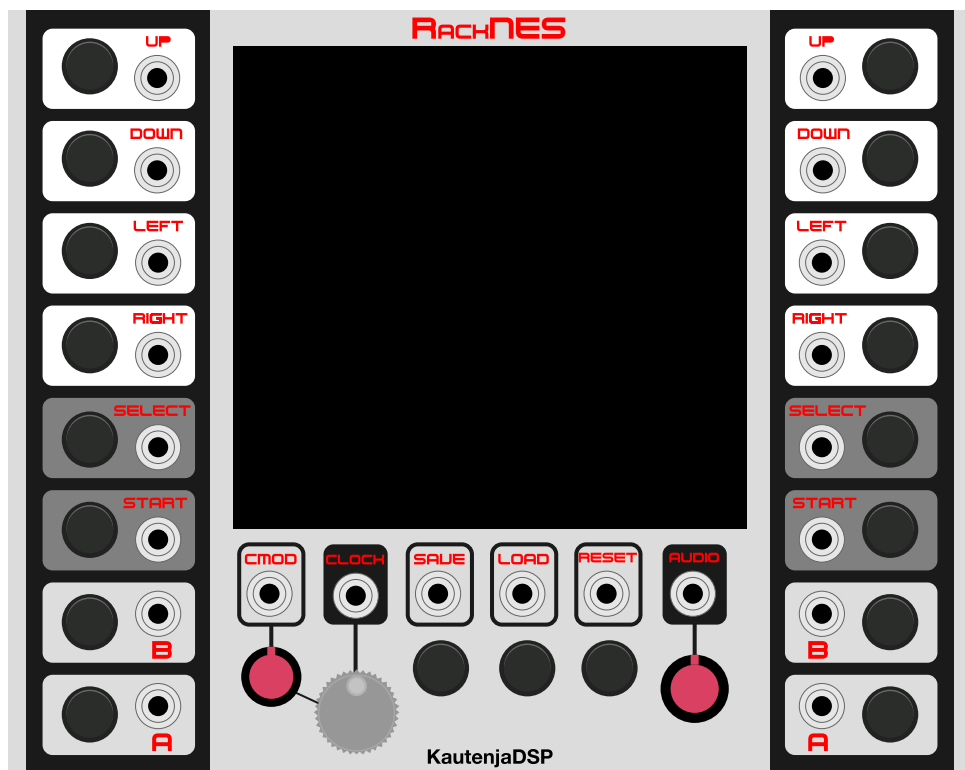# RackNES

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1 Overview

RackNES is a Nintendo Entertainment System (NES) emulator for VCV Rack with control voltage inputs and outputs. RackNES offers several key features, namely,

- **Clock Source:** Use NES frame-rate (FPS) as a clock source for downstream modules;

- **Clock Rate Modulation:** Control the clock rate of the NES with direct knob and CV;

- **NES Audio Output:** Sample audio from the NES in real-time at any sampling rate;

- **Sampling/Ratcheting:** Save and restore the NES state for interesting musical effects; and

- **Full CV Control:** CV inputs for Reset, Player 1, Player 2, and more.

2 Loading ROMs

To load a game into RackNES:

1. acquire a ROM dump of the desired game in the iNES format, the file-type will be `.NES` or `.nes`;

2. bring up the RackNES context menu by right-clicking the module and selecting "**Load ROM**";

3. use the resulting file explorer to locate the ROM file from (1) and load it into RackNES[1];

4. if the ROM file is invalid or cannot be loaded, RackNES will inform you using a pop-up dialog.

3 Mappers

NES cartridges contain application specific integrated circuits (ASICs), called mappers, to provide special functionality for certain games. Oftentimes, these mappers provide some additional resources, like ROM or RAM. These mappers must be accounted for in the NES emulation in order to support the games that use them, otherwise the logic of the game will not execute correctly, if at all. RackNES supports many of the common mappers, with plans to support more in the future. Table 1 outlines which mappers are supported by the current stable release of RackNES.

ID	Name
0	NROM
1	MMC1
2	UNROM
3	CNROM

Table 1: NES mappers supported by the current release of RackNES.

4   Panel Layout
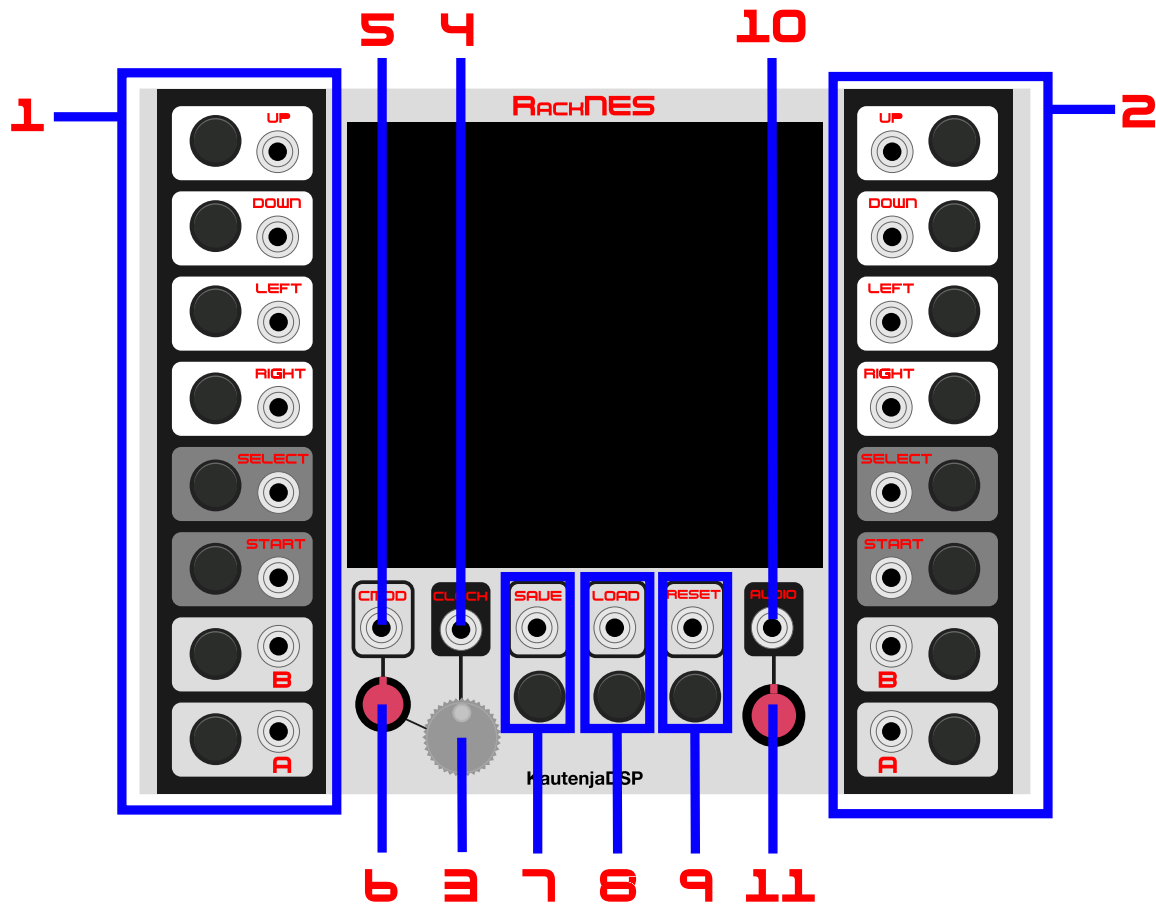
1. Player 1 controller input triggers; high at $2V$

2. Player 2 controller input triggers; high at $2V$

3. NES Clock rate control. Controls the clock rate of the NES starting at a base rate of $f_{clock} = 1.7898MHz$.

4. NES Clock output. A pulse wave with 50% duty cycle; high at $10V$, low at $0V$. Rising edge follows the frame-rate of the NES where a frame occurs once every 29781 CPU cycles, i.e., $f_{output} = \frac{f_{clock}}{29781}$

5. NES Clock rate CV modulation. Modulates the clock rate parameter according to CV with half the range of the clock rate control knob.

6. NES Clock rate CV attenuverter. Controls strength and polarity of clock rate CV input.

7. Save state trigger; high at $2V$. Saves the current state of emulation.

8. Load state trigger; high at $2V$. Loads the existing save state back into the emulation.

9. Reset emulator trigger; high at $2V$. Equal to pressing "Reset" on the NES, resets the game.

10. NES Audio output; $10V_{pp}$. Audio output from the internal mixer of the NES.

11. NES Audio output volume level; $[0\%, 200\%]$. Controls the gain of the audio output signal. 100% is $\approx 2.5V_{pp}$ and 200% is $\approx 5V_{pp}$.

References & Acknowledgments

Green, S. (2003). Nes_Snd_Emu. `http://www.slack.net/~ant/libs/`.

Naidu, A. (2016). SimpleNES. `https://github.com/amhndu/SimpleNES`.

Nyffenegger, R. (2017). cpp-base64. `https://github.com/ReneNyffenegger/cpp-base64`.