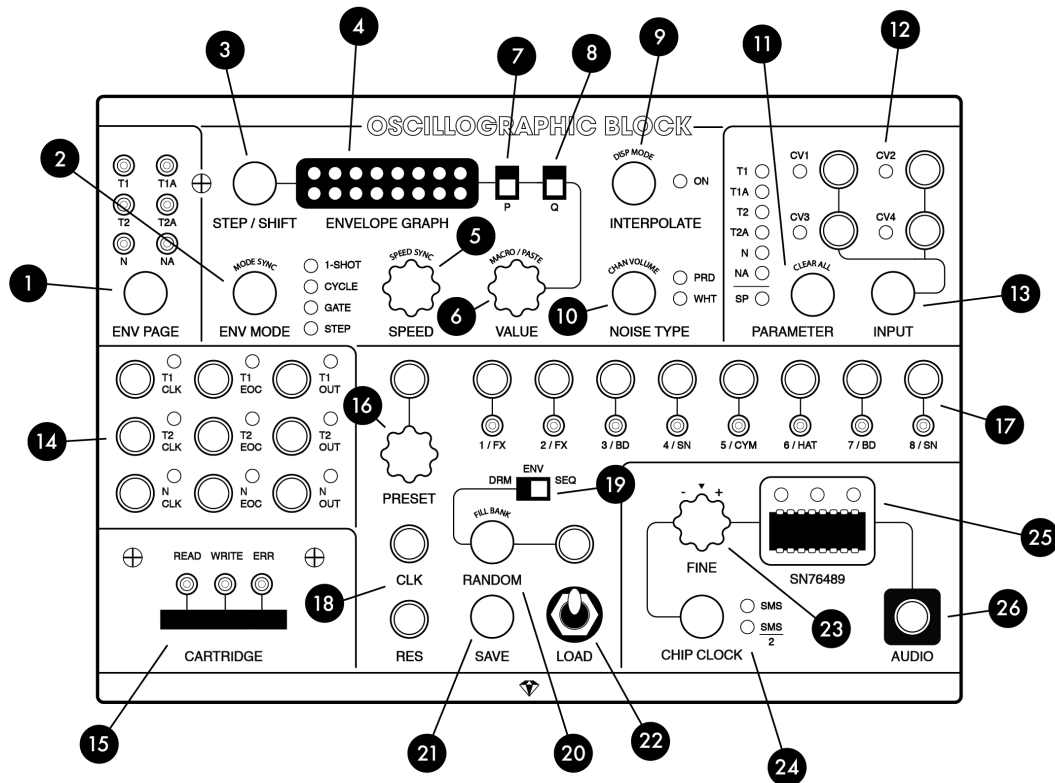


# OSCILLOGRAPHIC BLOCK USER'S GUIDE

## Module Map



1. ENVELOPE PAGE button and LEDS. Selects one of six ENVELOPES for editing via the ENVELOPE GRAPH controls.
2. ENVELOPE MODE button and LEDS. Selects one of four ENVELOPE MODES that determine looping and triggering behavior: 1-SHOT, CYCLE, GATE, and STEP.
3. STEP / SHIFT button. Used to advance the editing CURSOR and to access SHIFT MODES.
4. ENVELOPE GRAPH display. Visualizes ENVELOPE data and position.
5. SPEED knob. Sets current ENVELOPE SPEED.
6. VALUE knob. Edits current ENVELOPE STEP.
7. P Switch. Toggles PERFORMANCE MODE.

8. Q Switch. Quantizes the VALUE knob to semitones.
9. INTERPOLATE button and LED. Toggles between discreet and interpolated ENVELOPE output.
10. NOISE TYPE button and LEDS. Toggles between two noise modes: periodic and white.
11. PARAMETER button. Selects a PARAMETER for CV Input assignment.
12. Assignable CV Input jacks and LEDS. Volt per Octave scaled.
13. INPUT button. Assigns CV Input jacks to the currently selected PARAMETER.
14. OUTPUTS. Six gate outputs and 3 low-resolution CV outputs that follow ENVELOPE position and data.
15. CARTRIDGE slot and LED. Accepts FAT16 and FAT32 formatted SD Cards for PRESET storage.
16. PRESET knob and CV Input. Selects PRESETS.
17. PRESET gate inputs and SLOT LEDS. Selects PRESETS.
18. CLK and RES inputs. Sequences PRESETS.
19. RANDOM MODE. Selects between three randomization modes: DRM (drums), ENV (envelopes) and SEQ (sequences).
20. RANDOM button. Randomizes the currently selected PRESET.
21. SAVE button. Access the SAVE MENU for storing PRESETS.
22. LOAD switch. Reboots module and loads PRESETS.
23. FINE knob. Adjusts the fundamental frequency of the SN76489 sound chip in the cent range.
24. CHIP CLOCK button. Halves the fundamental frequency to achieve richer bass.
25. CHIP WINDOW. Displays the SN76489 chip and CHANNEL LEDS
26. AUDIO Output jack.

## Introduction

The Oscillographic Block (OB) is a chip-sound module that integrates oscillators, amplifiers, function generators, and preset memory into a single synth voice. Each unit features a physical SN76489AN sound chip, which provides the basic synthesis core. The SN76 is a sound generator designed and manufactured by Texas Instruments during the 1980's, and is found in classic systems like the Sega Master System, Sega Game Gear, BBC Micro, and ColecoVision. Occasionally described as having a “forlorn” sound by chip-tune connoisseurs, the SN76 lends the OB a nostalgic, [characteristic tone color](#).

(an excellent discussion of the SN76's history can be found on [this episode](#) of the Retro Game Audio podcast)

One of the joys of chip-audio lies in coaxing complexity out of fundamentally simple hardware. The SN76 offers only two fully functional square wave channels, and a single dual-mode noise channel. Yet composers like Yayoi Wachi managed to create [small masterpieces](#) that pushed the boundaries of the chip with meticulous and detailed programming. All the nuance of the sound had to be implemented in code, not in the hardware itself, and the creation of these complexity-generating “sound engines” became a major priority for studios and composers looking to distinguish their games with immersive sound and music.

This basic philosophy—the coupling of complex systems to simple aesthetic building blocks—inspires all of our designs at Special Stage, where we try to radicalize not only the “aesthetics” but also the “system dynamics” of videogame, sound, music, and image. For a general statement of our theory as it pertains to retro-historical computing, simulative cybernetics, and our work with E.P. Enterprises, see the forthcoming essay *Special Systems: Material Interfaces and Cybernetic Aesthetics*, to be published later this year in collaboration with systems analyst and philosopher Ezra Prime.

## Overview and System Architecture

Our ambition was to balance the simplicity and straightforward charm of the SN76 with a complex and powerful compositional system, capable of producing anything from looping musical fragments to digital percussion, sound effects, and entropic chip-soundscapes. Because of this, the OB is a large module, built out of many interacting “sub-modules” or functional units. This can seem daunting at first, but the generality and open-ended nature of the module reward experimentation with diverse, flexible, and at times surprising behavior.

### SN76

The SN76 is a strikingly minimal chip. It consists of only two square wave channels and one [Linear Feedback Shift Register](#) (LFSR) noise channel.

(Technically, the SN76 can generate three square waves, but since one of them cannot be controlled independently of the noise channel, we’ve omitted it on the OB for the sake of efficiency and usability. See the [SN76489 data sheet](#) for more information on its architecture.)

Each channel contains a Pitch (frequency) parameter and an Amp (amplitude) parameter, arranged as follows:

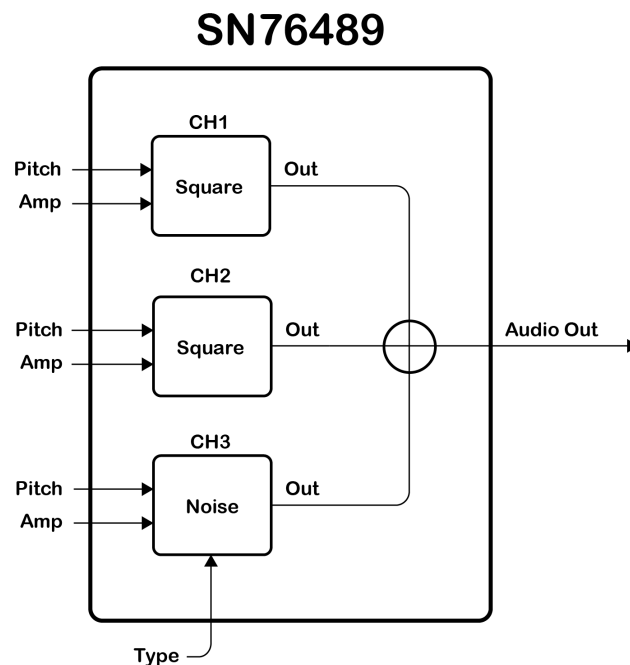
*CH1 — square wave*  
10-BIT Pitch register  
4-BIT Amp register

*CH2 — square wave*  
10-BIT Pitch register  
4-BIT Amp register

*CH3 — noise wave*  
10-BIT Pitch register  
4-BIT Amp register

CH 3 also contains a special 1-BIT register for selecting between two types of noise: a periodic wave, which is harmonic, and a white noise wave, which is pitched but non-harmonic.

All three channels can sound simultaneously, and are internally mixed into a single output.

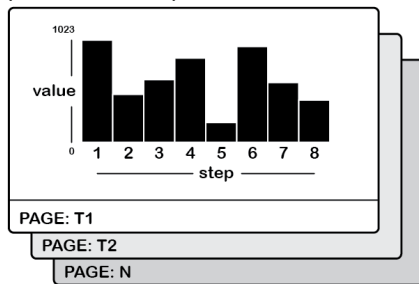


The physical SN76 can be seen in the chip window on the bottom right hand side of the module, where three *CHANNEL LEDS* light to indicate voice activity.

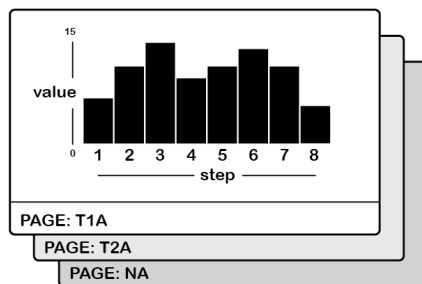
## ENVELOPES

The SN76's six primary parameters are split across three channels, each one containing a Pitch /Amp pair. Each parameter is directly controlled by one of the OB's *ENVELOPES*. Following SN76 convention, the square wave pitch envelopes are labeled *T1* and *T2* for Tone 1 and Tone 2, and the noise wave pitch envelope is simply labeled *N*. The corresponding amplitude envelopes are labeled *T1A*, *T2A*, and *NA*, respectively.

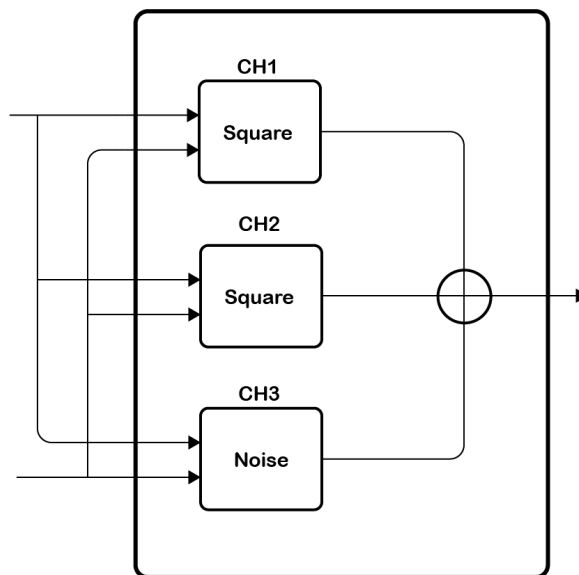
### pitch envelopes



### amplitude envelopes



### SN76489



*CH1 — square wave*

**T1 ENV** — controls Pitch register

**T1A ENV** — controls Amp register

*CH2 — square wave*

**T2 ENV** — controls Pitch register

**T2A ENV** — controls Amp register

*CH3 — noise wave*

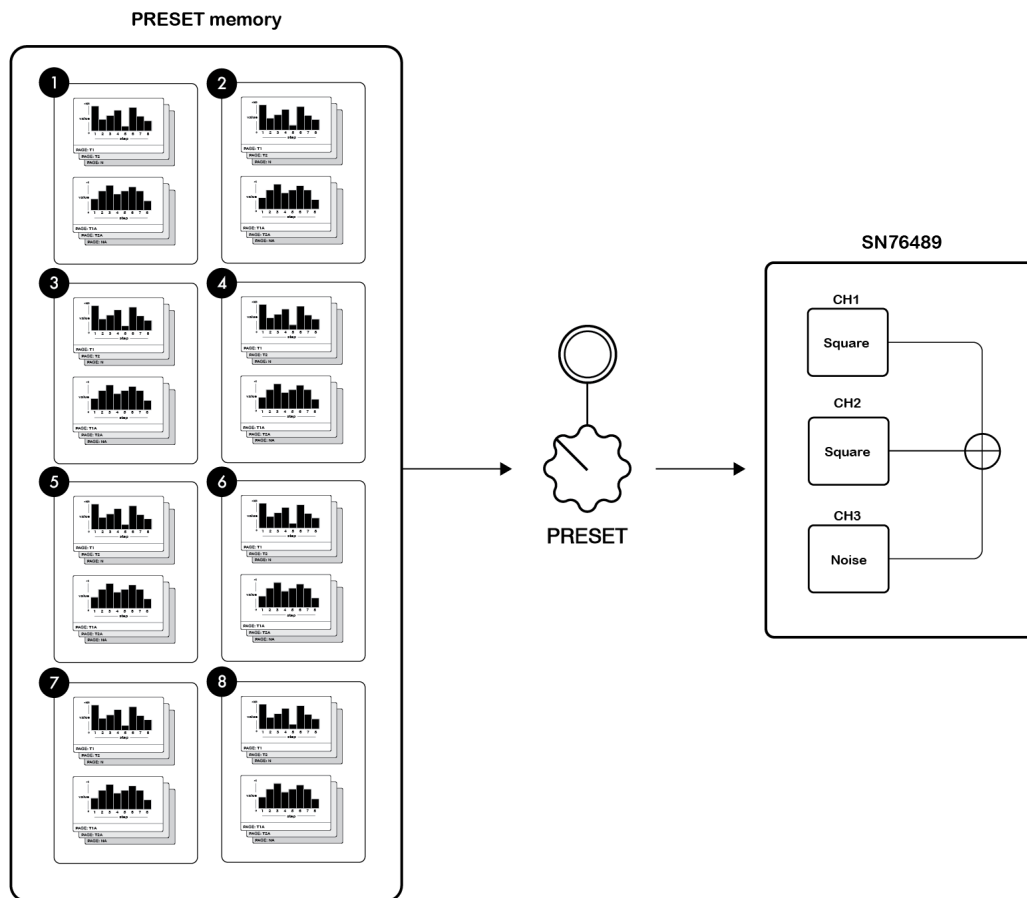
**N ENV** — controls Pitch register

**NA ENV** — controls Amp register

Envelopes are selected using the *ENV PAGE* button, which cycles through each envelope sequentially. The ENV PAGE button doesn't trigger or otherwise effect the behavior of the envelopes, but simply displays the selected envelope for editing on the ENVELOPE GRAPH. The envelopes are edited using the *SPEED*, *VALUE*, *INTERPOLATION*, and *ENV MODE* controls, described in the next chapter.

## PRESETS

The entire system state—including all six envelopes and their various settings and modes— is stored in one of eight *PRESET* memory slots. This allows for complete OB patches to be saved and recalled across power cycles, as well as modulated during operation. Presets are stored onto removable SD Cards for maximum portability and flexibility, but are completely loaded into RAM on boot. Since the comparatively slow process of accessing the SD Card only occurs during boot, preset switching during operation is instantaneous and gapless, making it possible to sequence preset changes in perfect rhythmic time. If each preset slot is loaded with a percussive (i.e. 1-shot based) patch, the preset system can be used like a drum machine, triggering each preset in response to incoming gate or CV signals.



## CV Inputs

The OB uses a simple INPUT MATRIX that maps four physical CV input jacks onto twelve module parameters. The inputs accept a 0-5V signal and are calibrated for 1 Volt per Octave when mapped onto Pitch parameters. All six chip parameters (Pitch and Amp registers) are accessible, as well as the SPEED parameter for each envelope.

### CV Outputs

The OB features six trigger outputs and three CV outputs. All outputs feature a 0-10V range (approximate).

The *Clock* outputs fire one pulse per envelope step:

T1 CLK  
T2 CLK  
N CLK

The *End of Cycle* outputs fire one pulse each time the envelope cycles in its entirety:

T1 EOC  
T2 EOC  
N EOC

The *CV Out* outputs generate a low resolution (roughly 7-bit) 0-10V control voltage that follows the envelope contour:

T1 OUT  
T2 OUT  
N OUT

Tip: if you own a Ming Mecca system, try patching the CV Outs into the World Core's SPRITE positions—the OB can double as a lo-fi animation generator.



## Using the ENVELOPE GRAPH system

### Main Controls

Each ENV PAGE contains the following parameters, accessible via the ENVELOPE GRAPH controls at the top of the module:

SPEED knob — controls the rate at which the envelope progresses.

VALUE knob — edits the value of the current ENV STEP, as selected by the STEP / SHIFT button.

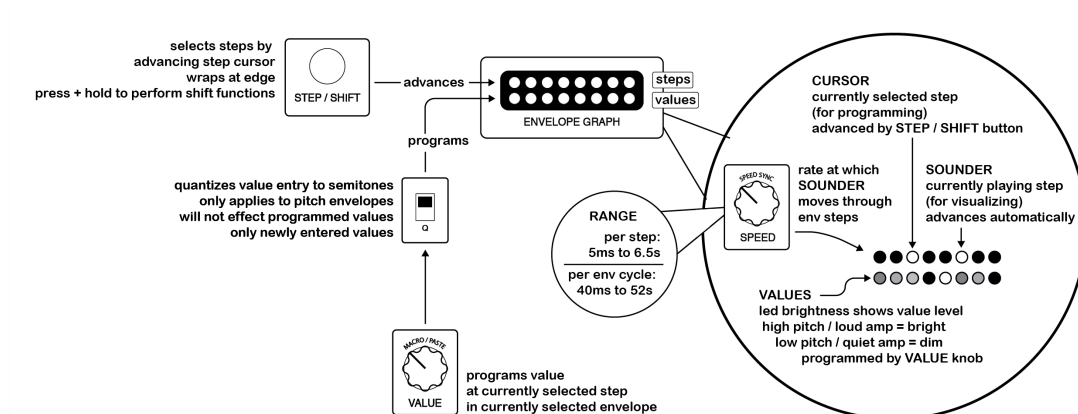
INTERPOLATION — toggles between a stepped or smooth output.

ENV MODE — selects between four different trigger modes: 1-SHOT, CYCLE, GATE, and STEP.

The ENVELOPE GRAPH display consists of two rows of eight LEDs. The top row shows STEP position, and contains a *CURSOR* and a *SOUNDER* indicator. The *SOUNDER* visualizes the currently playing step, and advances automatically as the envelope plays.

The SPEED knob controls the rate at which the *SOUNDER* position moves through the ENV steps—in other words, the envelope speed. It ranges from approximately 5ms to 6.5s per step, or 40ms to 52s per cycle.

The *CURSOR* visualizes the currently selected step and is used to isolate the step for editing. *CURSOR* position is advanced using the STEP / SHIFT button, as shown in the diagram below:



Once a step has been selected for editing, individual step values are programmed using the VALUE knob. The value of the current step is visualized by the brightness of the LED.

Note: the internal process used to control the brightness of the ENVELOPE GRAPH display can, depending on the module settings, generate a slight hum in the audio output. To counteract this, the OB automatically switches off all GRAPH LEDs except for the currently played and/or edited step. If you would prefer to see the entire envelope visualized at once (for instance, to quickly check the general shape of an envelope) the display mode can be set accordingly. See the chapter on *SHIFT MODES* for more information.

## ENVELOPE MODES

The ENVELOPE MODE button cycles through four different modes: *1-SHOT*, *CYCLE*, *GATE*, and *STEP*. Each mode changes not only the behavior of the currently selected envelope, but also how it responds to triggering.

Envelopes are triggered in one of two ways:

- 1) When a preset is first loaded, either via the PRESET CV knob / input, or using the PRESET GATE inputs.
- 2) When a preset is generated using the RANDOM button, so that the randomly generated preset can be immediately auditioned. This behavior can be overridden using the P switch if necessary.

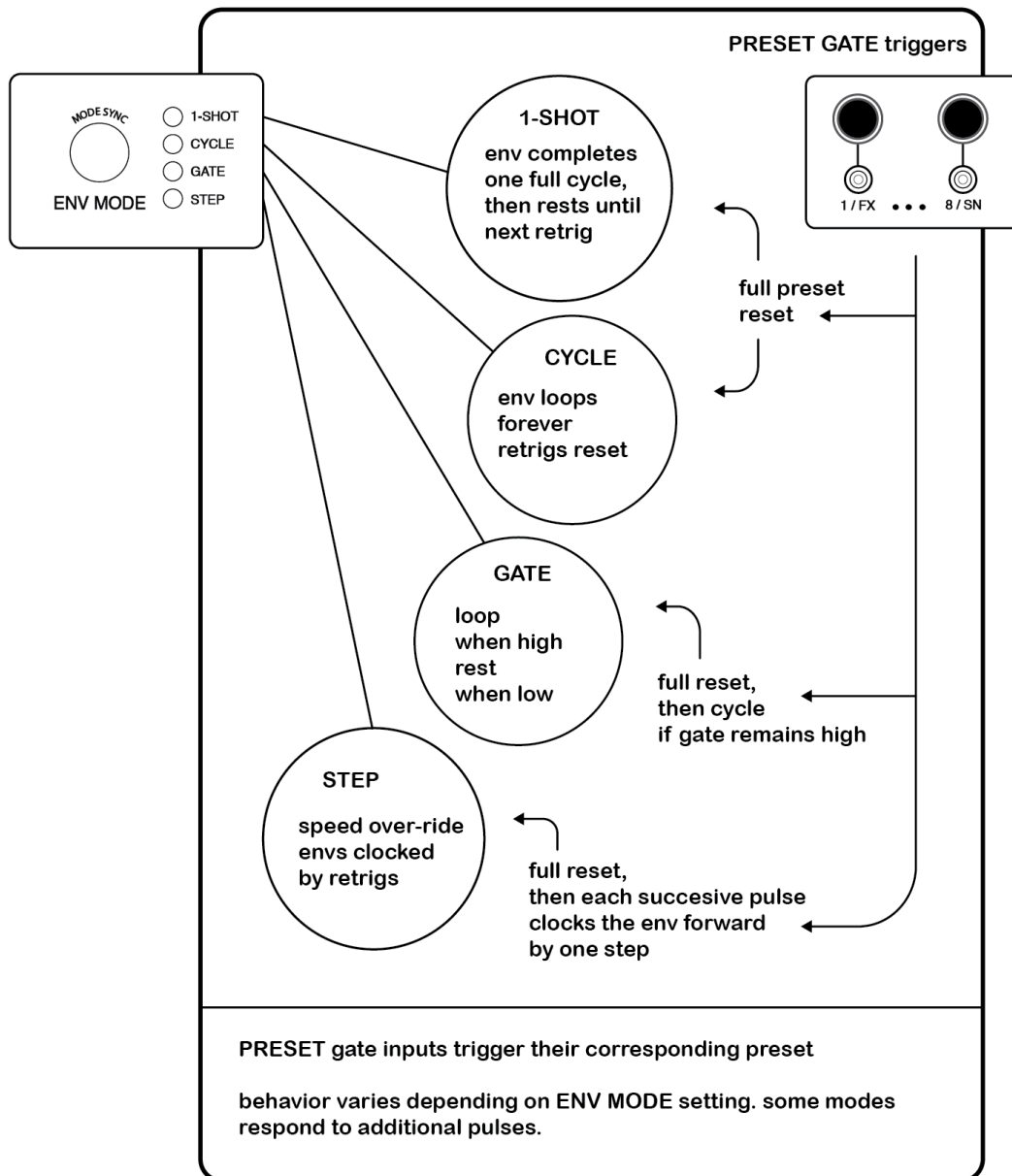
When a preset is selected using the CV knob / input, the preset (and the envelopes it contains) cannot be retriggered unless the CV is first increased or decreased (to select a higher or lower preset) and then returned to its original value.

When a preset is selected via the dedicated PRESET GATE inputs however, it is possible to retrigger the preset by sending additional pulses to its PRESET GATE jack. How each envelope responds to retriggers varies depending on the ENVELOPE MODE. A description of each mode's behavior, including triggering and retriggering, is shown on the following page.

Note 1: retrigger behaviors are a somewhat difficult to describe textually. A good way to experiment with the different modes is to connect a manual gate source (such as a button or switch) to one of the PRESET GATE inputs (for instance, PRESET 1 / FX). Make sure that channels 2 and 3 are effectively muted (either by filling their T2A and NA envelopes with zero's, or by using the *CHANNEL VOLUME* shift mode to directly silence them). Set T1A to CYCLE, then navigate back to the T1 using the ENV PAGE button. Fill T1 with some arbitrary pitches (or

program a little melody), and then select each ENV MODE in turn, each time sending the 1 / FX jack manual gates in order to observe the behavior in each mode.

Note 2: remember that each envelope can have a unique mode. By combining different modes, it's possible to achieve interesting effects.



## Secondary Controls

### *—Quantizing*

When the *Q* switch is down, the *VALUE* knob controls the full parameter range: a raw 10-bit number for pitch, or a 4-bit number for amplitude. When editing Pitch parameters, the *Q* switch can be used to quantize the values to semitones; it applies to any newly entered value, but will not effect previously programmed values (i.e., simply toggling the *Q* switch will not retroactively quantize steps).

### *—Performance Mode*

The *P* switch toggles *PERFORMANCE MODE*. When the *P* switch is down, *PERFORMANCE MODE* is off. In this mode, the *OB* is optimized for envelope editing. When the *P* switch is up, *PERFORMANCE MODE* is engaged, and the *OB* is optimized for live playing.

#### *PERFORMANCE MODE OFF:*

- When using the *VALUE* knob, all six *ENVELOPES* will pause, and the current channel / step will be isolated, making it easier to focus on the current edit
- When using the *SPEED* knob, the current channel / step will be isolated, and the current envelope will be temporally set to *CYCLE MODE*, making it easy to hear changes to its playback speed.

#### *PERFORMANCE MODE ON:*

- Neither knob affects playback or isolates channels. This is particularly useful for performing patches that loop continuously — edits can be made to the envelope values and rates without interrupting playback.

### — *Interpolation*

The *INTERPOLATE* button toggles between two states. When interpolation is off, the envelope will move in discreet units, snapping to each new value like a step sequencer; when interpolation is on, the envelope will smoothly glide between steps, creating a continuous waveform.



### — *Noise Type*

The *NOISE TYPE* button toggles between PRD (periodic) and WHT (white noise) modes for the noise channel. Since it only affects channel N, it's the only control in the ENVELOPE GRAPH section that is not stored per ENV PAGE (i.e., it is a global parameter, stored per preset slot).

## Assigning CV Inputs

The OB's four CV input jacks can be freely assigned to any of twelve parameters. The assignments are stored with each preset, so incoming CVs can be dynamically routed without physical re-patching. For instance, the same external LFO could be used to modulate the speed of Channel 3 in PRESET 1, shift to modulating the pitch of Channel 1 in PRESET 2, and so on.

The PARAMETER button selects one of the twelve available parameters. Each press of the PARAMETER button moves through the six chip registers (Pitch and Amp for each Channel), visualized by the LED column to its left. Once all six parameters have been displayed, the *SP* (speed) LED will light. The PARAMETER button then advances through the same LED column with the SP LED lit, indicating the SPEED setting for each envelope. Once all twelve parameters (the six chip registers and their corresponding envelope speeds) have been displayed, the SP LED will extinguish, and the cycle begins again.

The CV1 – CV4 LEDs indicate which CV Input jacks, if any, are active for the currently selected parameter. The INPUT button cycles through the jacks. Each parameter can only be assigned to a single jack (i.e., you cannot sum jacks to a single parameter), but each jack can be assigned to as many parameters as you like (i.e., the same physical input can control multiple parameters simultaneously). If a jack is not in use, it can be turned off by cycling the INPUT button until no jack LEDs are lit. Since the CV Input jacks generate a slight offset when not connected to anything, it's best to disable them when not in use.

Note 1: When assigned to any of the six chip registers, the incoming CV is summed with the corresponding envelope output. When assigned to any of the envelope speeds, the incoming CV simply overrides the internal speed setting.

Note 2: When assigned to a Pitch register, the incoming CV is scaled for 1V per Octave.

Tip: Since the CV Inputs are summed to the envelope outputs, they can be used to offset cycling Pitch envelopes. If the envelope is set to cycle through a harmonic progression (for instance, a major or minor triad) very quickly, the CV Input can be used to transpose the root of the chord. This is a quick way to get classic videogame-style “broken chord” effects.

## Selecting, Saving, Loading, and Randomizing Presets

Presets can be selected using either the PRESET knob / CV Input, or the dedicated PRESET GATE inputs.

Presets can also be advanced using the *CLK* input. Each successive pulse applied to the CLK input advances the OB to the next Preset; after PRESET 8 has been reached, the next pulse will wrap to PRESET 1.

A pulse at the *RES* input resets the OB to the preset last selected by the PRESET knob. To reset to PRESET 1, make sure the PRESET knob is fully counter clockwise.

The following parameters are saved with presets:

- Envelope data
- Envelope speeds
- Envelope modes
- Interpolation settings
- Noise type setting
- CV Input assignments
- Chip Clock setting
- Channel volume settings

### To save a preset:

1. Insert a FAT16 or FAT32 formatted SD Card.
2. Press and release the SAVE button once.
3. The OB will now enter the SAVE MENU, and play a short major sequence followed by a slow ticking sound to confirm that it's awaiting input.\*
4. Use the PRESET knob to select a PRESET SLOT to save to. The SLOT LED will light to indicate which SLOT is selected.
5. Once you've selected a SLOT, press the SAVE button again to complete the operation. The OB will automatically exit the SAVE MENU and return to normal operation.

\*If the ERROR LED lights instead (located directly above the CARTRIDGE slot) then there is a problem with the SD Card. Try a different card or check it's formatting.

### To cancel a save operation:

1. Once in the SAVE MENU, turn the PRESET knob fully counter clockwise until no PRESET SLOT LEDS are lit.
2. Press the SAVE button once. The OB will exit the SAVE menu without saving.

To save all eight presets at once:

1. Once in the SAVE MENU, turn the PRESET knob fully clockwise until all eight PRESET SLOT LEDS are lit.
3. Press the SAVE button once. The OB will save each PRESET into its respective slot and then exit the SAVE menu automatically

To load previously saved presets:

1. Insert an SD Card with previously saved presets.
2. Pull and release the LOAD switch to reboot the OB. Note that this will erase all presets not previously saved.
3. The OB will now check the SD Card for content and load any presets it finds into memory. The SLOT LEDS will light to indicate which presets have been loaded.

Note 1: presets are saved as small individually numbered .OBP files on the SD Card for easy sharing and management.

Randomizing Presets

The *RANDOM* button can be used to generate presets algorithmically. The OB contains three randomization systems, selected using the RANDOM MODE switch:

**DRM** generates drum sounds and percussive effects (i.e., fast patches utilizing 1-SHOT mode)

**ENV** generates ENVELOPE DATA but leaves all other settings alone

**SEQ** Generates looping patches (i.e., slower patches utilizing CYCLE mode)

Each press of the RANDOM button randomizes the currently selected preset according to the RANDOM MODE switch.

Once a preset has been randomized, it can be edited as usual using the ENVELOPE GRAPH controls.

The RANDOM gate input performs the same function as the RANDOM button.



## Global Chip Settings

Traditionally, the SN76 was tuned to a relatively high frequency that prevented it from sounding low bass notes. In order to overcome this limitation (shared by virtually all of the consoles and computers that utilized the SN76) the OB features a CHIP CLOCK button that can be used to shift the fundamental frequency of the chip into a lower range.

The CHIP CLOCK button has two settings:

**SMS:** tuning used by the original Sega Master System. The lowest note that the SN76 can sound in this tuning is A2.

**SMS/2:** half the frequency of the original SMS tuning. The lowest note that the SN76 can sound in this tuning is A0.

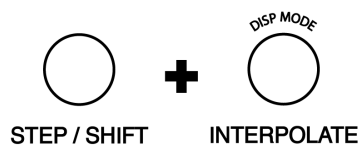
Additionally, the FINE knob can be used to adjust tuning up or down by a few cents or semitones. This allows for the chip's fundamental frequency to be subtly adjusted to match harmonic content originating from other sources.

Note 1: the SN76 uses 10-bit registers for controlling pitch. This means that semitone values drift slightly out of tune as frequency increases. High octave content will appear subtly detuned relative to lower octave content. This is a normal characteristic of the chip, and is no cause for alarm.

## Utilizing Shift Modes and Macros

The OB features a number of SHIFT MODES that provide advanced functions and control. Shift modes are accessed by pressing and holding the STEP / SHIFT BUTTON, and then manipulating a shift-enabled control (either a button or a knob). On the front panel, a given control's shift mode is listed directly above it in small rounded print. A full list of modes and their descriptions are provided below:

### DISPLAY MODE



*DISPLAY MODE* toggles between two different ENVELOPE GRAPH visualization modes.

In Mode 1, only the active VALUE LED in the ENVELOPE GRAPH will display. This eliminates stray PWM noise in the module and provides the highest fidelity audio output possible.

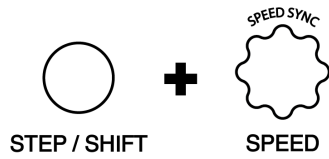
In Mode 2, all VALUE LEDs remain continuously lit. This has the advantage of displaying the full envelope data for a given page, but results in slightly noisy audio output. For many patches (especially non-drum patches) the noise is often a non-issue.

### MODE SYNC



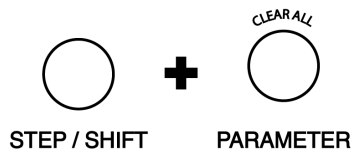
*MODE SYNC* adjusts the ENVELOPE MODE for all six envelopes simultaneously. Useful for quickly setting all envelopes to CYCLE or 1-SHOT when constructing looping patches and drum patches, respectively.

## SPEED SYNC



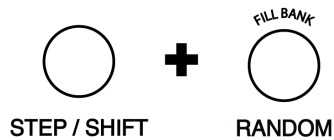
*SPEED SYNC* adjusts all ENVELOPE SPEEDS simultaneously. Useful for creating perfectly tempo-synchronized looping envelopes.

## CLEAR ALL



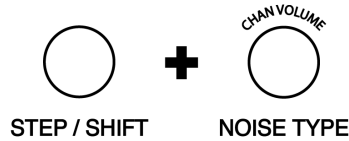
*CLEAR ALL* turns off all CV Input assignments on all twelve parameter pages.

## FILL BANK



*FILL BANK* randomizes all eight presets simultaneously. When randomizing presets in DRM MODE, each slot is assigned a unique drum model. This allows for complete drum kits to be generated in a consistent way (i.e., PRESET 8 will always contain some sort of snare drum, PRESET 7 will always contain some kind of bass drum, etc.). On the front panel, the assigned drum model is listed under the SLOT LEDS.

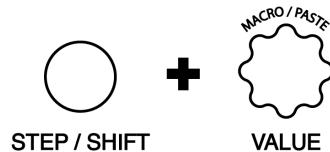
## CHANNEL VOLUME



*CHANNEL VOLUME* sets the total volume level for each Channel:

1. Enter the CHANNEL VOLUME menu by pressing and holding STEP / SHIFT, then pressing the NOISE TYPE button once.
2. With STEP / SHIFT still held down, press the ENV PAGE button to navigate to the desired Channel. Only the T1A, T2A, and NA pages are active when in the CHANNEL VOLUME menu.
3. With STEP / SHIFT still held down, turn the VALUE knob to set the desired volume level for the currently selected Channel. The volume level is visualized by the ENVELOPE GRAPH LEDS.

## MACRO / PASTE













The *MACRO / PASTE* system provides two functions:











1. Instantly filling an envelope with a number of preset shapes and patterns
2. Pasting a shape or pattern from a previously edited envelope into the currently selected envelope

When the STEP / SHIFT button is held down, the VALUE knob no longer edits individual steps, but instead overwrites the entire envelope with data stored in memory. The first seven patterns are preset shapes, and the final three patterns are user data drawn from the other envelope in the currently selected PRESET. The full table of macros is provided below:

## PITCH MACROS

- |    |   |                         |
|----|---|-------------------------|
| 1  |    | Static pitch (A2)       |
| 2  |    | Static pitch (A4)       |
| 3  |    | Static pitch (A6)       |
| 4  |    | Exp. slope (descending) |
| 5  |    | Exp. slope (ascending)  |
| 6  |    | Major arpeggio          |
| 7  |   | Minor arpeggio          |
| 8  |  | User envelope T1        |
| 9  |  | User envelope T2        |
| 10 |  | User envelope N         |

## VOLUME MACROS

- |    |   |                         |
|----|---|-------------------------|
| 1  |    | Static volume (mute)    |
| 2  |    | Static volume (max)     |
| 3  |    | Lin. slope (descending) |
| 4  |    | Exp. slope (descending) |
| 5  |    | Lin. slope (ascending)  |
| 6  |    | Exp. slope (ascending)  |
| 7  |   | Triangle wave           |
| 8  |  | User envelope T1A       |
| 9  |  | User envelope T2A       |
| 10 |  | User envelope NA        |