

# MYNAH: DIY Audio Sampler

## User Manual

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## Hardware Overview

### Device Description

MYNAH is a powerful DIY 6-voice polyphonic audio sampler built around the ESP32-S3 microcontroller. It features a 16-step step sequencer, dual audio inputs (microphone and line-in), and comprehensive sound design tools including filters, delays, and reverb effects.

### Quick Feature Overview

#### **Core Audio Engine:**

- 6-voice polyphonic sampler with 16-step sequencer
- 32 kHz sample rate, 16-bit resolution
- Up to 16 samples per song (stored on SD card, cached in PSRAM as ADPCM)
- Real-time ADPCM decoding from PSRAM
- Total PSRAM sample capacity: ~123 seconds (~2 min 3 sec) across all 16 slots combined
- Per-slot maximum: up to ~27.6 sec; average ~7.7 sec each if equally divided

- Three sample play modes per voice: **SINGLE**, **SL 16** (16 equal slices), **SL TRS** (transient-detected slices)

### Sound Shaping:

- Per-voice: Pitch, Velocity, Pan, Delay Send, Reverb Send, **EQ (DJ-style LPF/HPF per voice)**
- Master Effects: Delay, Reverb, Low-pass Filter, Bit Crusher
- Master FX: Gater (16 rhythmic patterns), Filter, Phase/Chorus, Combo

### Sequencing:

- 16-step patterns with adjustable length (1-16 steps)
- Tempo: 30-240 BPM with swing control
- Step conditions for generative and deterministic pattern variation
- Pattern save/load (16 slots per song)
- **Song Sequencer**: arrange up to 128 bars by assigning pattern slots to each bar
- 16 songs per bank, 16 banks total

### Recording:

- Live recording from microphone or line-in
- Up to ~27.6 seconds per sample (hardware limit)
- Automatic input detection
- Streams direct-to-SD card, then imports to PSRAM as ADPCM (4:1 compression)

### Interface:

- 24 tactile buttons (16 step + 8 function)
- Single potentiometer with smart locking
- 128x64 OLED display
- 16 RGB NeoPixel LEDs (color-coded by voice)

### Storage:

- SD card support (FAT32, WAV/S16 files)
- File browser for sample loading
- Hierarchical folder navigation

## Main Components

### Processing Core

- **Microcontroller:** ESP32-S3 with dual-core processor
- **Audio Processing:** Real-time digital signal processing at 32 kHz sample rate
- **Memory:** 2MB PSRAM for sample and pattern storage
- **Voices:** 6-voice polyphonic playback

### Audio I/O Connections

- **Stereo Audio Output:** I2S digital audio interface with DAC
- **Dual Audio Inputs:**
  - **Microphone Input:** INMP441 omnidirectional MEMS microphone (via I2S data line)
  - **Line-In Input:** PCM1808 stereo ADC for external audio sources
- **Input Detection:** Automatic detection of active input source

### Control Interface

#### Display

- **OLED Screen:** 128x64 pixel display for real-time feedback on modes, values, and status

#### Input Controls

- **Shift Register Button Array:** 24 hardware buttons organized into a 74HC165 shift register
  - Button arrangement includes voice selectors, step buttons, function keys, and mode controls
  - Debouncing: 20ms debounce delay for stable input
- **Potentiometer:** Single analog potentiometer for parameter adjustment
  - Threshold: 8-step movement required for activation
  - Lock Time: 50ms unlock duration after motion detected
  - Averaging: 8-point running average for noise reduction
- **NeoPixel LED Strip:** 16 addressable RGB LEDs for visual feedback
  - Indicates active voice, step status, and recording state
  - Real-time pattern visualization

## Storage

- **SD Card:** MMC interface in 1-bit mode
  - Supports sample storage and pattern/bank saving
  - File system: FAT32 format
  - Sample paths: Nested folder support (up to 64 character paths)

## Effects Processing

- **Delay:** Full-featured delay effect with adjustable time and mix
  - Delay buffer: 32,000 samples (1 second at 32 kHz)
- **Reverb:** Algorithmic reverb with room size and damping controls
- **Filter:** Multi-mode filter with adjustable cutoff frequency and Q factor
- **Bit Crusher:** Digital distortion effect with adjustable bit depth

## Audio Specifications

- **Sample Rate:** 32 kHz (uncompressed) or variable with ADPCM compression
  - **Bit Depth:** 16-bit resolution
  - **Buffer Size:** 512 samples per processing block (16ms at 32 kHz)
  - **Maximum Recording:** 882,000 samples (~27.6 seconds at 32 kHz — per-slot upper limit)
  - **Audio Format:** WAV and S16 (raw 16-bit signed samples)
  - **PSRAM Sample Storage:** 2MB total; ~1.88MB available for samples after effect buffers
    - ADPCM compression (4:1): 16 KB per second of audio
    - **Total capacity across all 16 slots: ~123 seconds (~2 min 3 sec)**
    - Average per slot if equally divided: ~7.7 seconds each
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# Quick Start Guide

## Initial Setup

### 1. Hardware Assembly

- Ensure all audio connections are properly soldered to the PCB
- Connect SD card to the SD\_MMC interface
- Apply power to the device
- Wait for the startup logo to appear on the OLED screen

### 2. First Power-On

- The device will initialize all subsystems automatically

- If an SD card is present, it will be detected and enabled
- The display will show a logo confirmation

### 3. Load or Create Samples


#### Option A: Using Built-In Samples

- 16 default samples are included (samp01.s16 to samp16.s16)
- These are pre-loaded into the device at startup

#### Option B: Record New Samples

- See [Recording Audio](#) section below

#### Option C: Load Samples from SD Card

- Prepare WAV files on your SD card
- Use the File Manager mode to import samples
- Samples will be converted to the device's native format
-  The full file path must be 63 characters or fewer — shorten folder/file names if import fails silently

### 4. Play Your First Sample

1. Press a **Step Button** (A1-A8 or B1-B8) to enable that step
2. Press a **Voice Button** (F2-F7) to select the voice (F2=Voice 1, F3=Voice 2, etc.)
3. Adjust the **Potentiometer** to select a sample (1-16)
4. Press **F8** to start the sequencer

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## Controls & Interface

### Button Layout

#### Voice Selection Buttons (F2-F7)

- **Function:** Select which voice (polyphonic layer) to control
- **Single Press:** Selects the voice for editing (F2=Voice 1, F3=Voice 2, etc.)
- **Double Tap** (< 500ms between taps): Toggle voice mute/unmute
- **Held with Potentiometer:** Adjust per-voice volume (0-100%)
- **Status:** 6 total buttons for the 6 available voices

## Step Buttons (A1-A8, B1-B8)

- **Function:** Select which sequencer step to edit (A1-A8 for steps 1-8, B1-B8 for steps 9-16)
- **Primary Use:** Pattern programming in step sequencer
- **Secondary Use:** When held, shows which steps are active in current pattern
- **LED Feedback:** NeoPixels indicate active steps and play position
- **Button Layout:** Top row A1-A8, second row B1-B8

## Function Buttons (F1-F8)

- **F1:** Multi-purpose button for combos and fine-tuning:
  - F1 + A1-A8: Select per-voice modes (A-row)
  - F1 + B1-B8: Select extended per-voice modes (B-row)
  - F1 + F2: Decrease parameter value
  - F1 + F3: Increase parameter value
  - F1 + F4: Toggle Master FX 1 (Gater)
  - F1 + F5: Toggle Master FX 2 (Filter)
  - F1 + F6: Toggle Master FX 3 (Phase/Chorus)
  - F1 + F7: Toggle Master FX 4 (Combo FX)
  - F1 + F8: Enter Recording Mode
  - F1 alone in File Browser: Navigate up one folder
  - F1 + F2 in File Browser: Previous item
  - F1 + F3 in File Browser: Next item
- **F2-F7:** Voice selection buttons (see Voice Selection above)
- **F8:** Play/Pause and Master controls:
  - Single press (release): Toggle sequencer playback / reset to step 1
  - F8 + Potentiometer: Adjust master volume
  - F8 + A1-B8: Select master modes (16-31)
  - F8 + F7: Toggle live play mode (Keyboard / Pad / Step)
  - F8 + A4 in PATTERN/SONG/BANK\_SELECT mode: Enter Song Sequencer editor

## Mode Selection (No Dedicated Buttons)

- **F1 + A1-A8:** Select per-voice modes (A-row: SMP, PTC, TUN, VEL, PAN, DSND, RSND, VOL)
- **F1 + B1-B8:** Select extended per-voice modes (B-row: SST, SEN, MOD, SLC, ATC/DEC/SUS/REL, EQ, TRG, CON)
- **F8 + A1-B8:** Select master modes (16-31)
- Note: Mode selection is done through button combinations, not dedicated mode buttons

## Playback Control

- **F8 (release):** Toggle sequencer play/pause and reset to step 1

- **MIDI Clock Sync:** Enabled via software settings (no dedicated button)

## Potentiometer (Single Analog Input)

### Basic Operation

- **Sensitivity:** Threshold of 8 steps of analog movement before activation
- **Unlock Mechanism:** After movement detected, pot remains active for 50ms of inactivity
- **Averaging:** 8-sample moving average to reduce noise

### Current Mode Functions

- **Sample Select:** Choose which sample (1-16) plays for current voice/step
- **Sample Velocity:** Set note velocity/volume per step
- **Sample Pitch:** Adjust playback pitch/speed
- **Sample Pan:** Control stereo panning (left-right position)
- **Delay Send:** Amount of signal sent to delay effect
- **Reverb Send:** Amount of signal sent to reverb effect
- **Condition:** Step trigger condition (9 options from always-on to pattern-division logic)
- **Swing:** Timing offset for alternating steps
- **BPM:** Adjust sequencer tempo (beats per minute)
- **Pattern Length:** Set active pattern length (1-16 steps)
- **Delay Time:** Adjust delay effect timing
- **Delay Mix:** Balance between dry and wet delay signal
- **Filter Cutoff:** Adjust filter center frequency
- **Filter Q:** Control filter resonance/sharpness
- **Reverb Room Size:** Adjust reverb space simulation
- **Reverb Damping:** Control high-frequency damping in reverb
- **Bit Crusher:** Amount of digital distortion

## NeoPixel LED Display (16 addressable RGB LEDs)

### LED Feedback Information

- **Step Indicators:** LEDs 1-16 show current sequencer steps
- **Active Steps:** Show which steps have samples assigned for current voice
- **Playback Position:** Shows which step is currently playing
- **Pattern/Song/Bank Selection:** In PATTERN\_SELECT/SONG\_SELECT/BANK\_SELECT modes, indicates slot status and current position:
  - **White:** currently loaded slot
  - **Green:** slot has saved data on SD card

- **Dim purple** (PATTERN\_SELECT) / **Dim blue** (SONG\_SELECT) / **Dim red** (BANK\_SELECT): empty slot — colour varies by mode for instant visual identification
- **Orange blink**: save confirmation target
- **20% dimmed** version of the slot's colour: the step currently playing (sequencer running only)
- **Recording Status**: Visual feedback during recording
- **Voice Colors**: Each voice has a unique color for easy identification

### Voice Color Scheme

- **Voice 1**: Red (255, 0, 0)
- **Voice 2**: Green (0, 255, 0)
- **Voice 3**: Orange (255, 64, 0)
- **Voice 4**: Yellow (255, 255, 0)
- **Voice 5**: Magenta (255, 0, 64)
- **Voice 6**: Cyan (0, 255, 64)

### Usage:

- LEDs display in the current voice's color when showing active steps
- Playback position typically shows brighter/different intensity
- Pattern/Bank/Song select modes show availability indicators

### Complete Button Reference Table

Button	Action	Function	Context/Modifiers	Notes
<b>A1-A8, B1-B8</b>	Single Press	Toggle step ON/OFF	Normal operation	Turns sample on/off for current voice using voice's default sample
A1	Press	Sample Select	F1 + A1	SMP — selects which sample plays for current voice
A2	Press	Sample Pitch	F1 + A2	PTC — transpose playback pitch

Button	Action	Function	Context/Modifiers	Notes
A3	Press	Tuning	F1 + A3	TUN — fine-tune sample pitch
A4	Press	Sample Velocity	F1 + A4	VEL — set note velocity per step
A5	Press	Sample Pan	F1 + A5	PAN — stereo pan position
A6	Press	Delay Send	F1 + A6	DSND — signal level sent to delay
A7	Press	Reverb Send	F1 + A7	RSND — signal level sent to reverb
A8	Press	Volume	F1 + A8	VOL — per-voice volume
B1	Press	Sample Start / Sample End	F1 + B1	Cycles [1]SST (sample start point) → [2]SEN (sample end point) on each press
B2	Press	Per-Voice LFO	F1 + B2	Cycles [1]LFO SHAPE → [2]LFO RATE → [3]LFO DEPTH → [4]LFO TARGET on each press
B3	Press	Sample Mode	F1 + B3	MOD — cycles SINGLE → SL 16 → SL TRS

Button	Action	Function	Context/Modifiers	Notes
B4	Press	Slice Select	F1 + B4	SLC — assigns slice index to steps
B5	Press	ADSR Envelope	F1 + B5	Cycles through [1]ATTACK → [2]DECAY → [3]SUSTAIN → [4]RELEASE on each press
B6	Press	Voice EQ	F1 + B6	EQ — DJ-style filter per voice (LPF ↔ FLAT ↔ HPF)
B7	Press	Trigger Mode	F1 + B7	TRG — sets per-step trigger type (FWD / REV / LOOP / LPND / FL2 / FL3 / ROLL)
B8	Press	Condition	F1 + B8	CON — step trigger condition
A1-B8	Press	Select Master Mode	F8 + A1-B8	Selects master modes 16-31
A1-B8	Press	Set Default Sample	F2-F7 (voice) + A1-B8	Sets default sample (1-16) for selected voice
A1-B8	Short Press	Load Pattern	PATTERN_SELECT mode	Loads pattern from slot (0-15)
A1-B8	Long Press (800ms)	Save Pattern	PATTERN_SELECT mode	Saves current pattern to slot; confirms if slot occupied

Button	Action	Function	Context/Modifiers	Notes
A1-B8	Press	Select Song/Bank	SONG_SELECT or BANK_SELECT mode	Immediate selection
A1-B8	Hold	Start Recording	REC_MODE	Press and hold to record
A1-B8	Release	Stop Recording	REC_MODE (while recording)	Stops recording and imports to PSRAM
A1-B8	Hold	Select Effect Pattern	Master FX modes	Hold to activate pattern while in GATER/FILTER/PHASE/COMBO modes
<b>F2</b> (Voice 1)	Single Press	Select Voice 1	—	Sets Voice 1 as active editing voice
F2	Double Tap	Toggle Mute Voice 1	< 500ms between taps	Mutes/unmutes Voice 1
F2	Hold + Pot	Adjust Voice 1 Volume	—	Displays and adjusts Voice 1 volume (0-100%)
<b>F3</b> (Voice 2)	Single Press	Select Voice 2	—	Sets Voice 2 as active editing voice
F3	Double Tap	Toggle Mute Voice 2	< 500ms between taps	Mutes/unmutes Voice 2
F3	Hold + Pot	Adjust Voice 2 Volume	—	Displays and adjusts Voice 2 volume (0-100%)

Button	Action	Function	Context/Modifiers	Notes
<b>F4</b> (Voice 3)	Single Press	Select Voice 3	—	Sets Voice 3 as active editing voice
F4	Double Tap	Toggle Mute Voice 3	< 500ms between taps	Mutes/unmutes Voice 3
F4	Hold + Pot	Adjust Voice 3 Volume	—	Displays and adjusts Voice 3 volume (0-100%)
F4	Press	Toggle Gater FX	F1 + F4	Toggles Master FX 1 (Gater) on/off
<b>F5</b> (Voice 4)	Single Press	Select Voice 4	—	Sets Voice 4 as active editing voice
F5	Double Tap	Toggle Mute Voice 4	< 500ms between taps	Mutes/unmutes Voice 4
F5	Hold + Pot	Adjust Voice 4 Volume	—	Displays and adjusts Voice 4 volume (0-100%)
F5	Press	Toggle Filter FX	F1 + F5	Toggles Master FX 2 (Filter) on/off
<b>F6</b> (Voice 5)	Single Press	Select Voice 5	—	Sets Voice 5 as active editing voice
F6	Double Tap	Toggle Mute Voice 5	< 500ms between taps	Mutes/unmutes Voice 5
F6	Hold + Pot	Adjust Voice 5 Volume	—	Displays and adjusts Voice 5

Button	Action	Function	Context/Modifiers	Notes
				volume (0-100%)
F6	Press	Toggle Phase FX	F1 + F6	Toggles Master FX 3 (Phase/Chorus) on/off
<b>F7</b> (Voice 6)	Single Press	Select Voice 6	—	Sets Voice 6 as active editing voice
F7	Double Tap	Toggle Mute Voice 6	< 500ms between taps	Mutes/unmutes Voice 6
F7	Hold + Pot	Adjust Voice 6 Volume	—	Displays and adjusts Voice 6 volume (0-100%)
F7	Press	Toggle Combo FX	F1 + F7	Toggles Master FX 4 (Combo) on/off
<b>F1</b>	Press	Decrease Parameter	F1 + F2	Decrements current parameter
F1	Press	Increase Parameter	F1 + F3	Increments current parameter
F1	Press	Previous Item	F1 + F2 in FILE_BROWSE R	Moves selection to previous item
F1	Press	Next Item	F1 + F3 in FILE_BROWSE R	Moves selection to next item

Button	Action	Function	Context/Modifiers	Notes
F1	Press	Toggle File Browser	F1 + A1 in SAMPLE_SELECT	Enters FILE_BROWSE R for current voice's sample slot
F1	Press	Exit File Browser	F1 + A1 in FILE_BROWSE R	Returns to SAMPLE_SELECT mode
<b>F8</b>	Release	Play/Pause/Reset	—	Toggles sequencer playback; resets to step 1
F8	Hold + Pot	Adjust Master Volume	—	Displays and adjusts master volume (0-100%)
F8	Press	Enter Song Sequencer	F8 + A4 in PATTERN/SONG/BANK_SELECT	Opens Song Sequencer editor
F8	Press/Release	Play/Pause (Song Seq)	SONG_SEQUENCE mode	Single press toggles sequencer; double-tap rewinds to bar 1
<b>B1 (Step 9)</b>	Release	Navigate Up	FILE_BROWSE R mode	Goes up one folder level
<b>B8 (Step 16)</b>	Press	Select/Enter	FILE_BROWSE R mode	Load selected file or enter folder
<b>F8 + F7</b>	Press Both	Toggle Live Play Mode	Any voice mode	Cycles: off → Keyboard

Button	Action	Function	Context/Modifiers	Notes
				(SINGLE) / Pad (sliced) → off
<b>F1 double-tap</b>	Two quick presses	Toggle Live Recording	Live play mode, sequencer running	REC ON / REC OFF; alert SEQ OFF if sequencer paused
<b>Any F1–F8</b>	Press	Cancel Live Recording	Live recording active	Stops recording immediately
<b>F1 + F8</b>	Press Both	Enter Recording Mode	From voice modes (0-15) only	Displays "REC:MIC" or "REC:LIN"
<b>Any F1-F8</b>	Press	Exit REC_MODE	REC_MODE (not recording)	Returns to previous mode
<b>Any Button</b>	Release	Lock Potentiometer	Any mode	Prevents accidental parameter changes

#### Notes:

- All button combinations are press-and-hold (hold first button, then press second)
- Pattern save in PATTERN\_SELECT requires 800ms hold to distinguish from load
- Double-tap detection window is 500ms
- Master FX modes use step buttons for pattern selection while active
- FILE\_BROWSER navigation: **B1 release** = up folder, **B8 press** = select/enter, **F1+F2** = prev, **F1+F3** = next, **Pot** = scroll list, **F2–F7** = exit to that voice's SAMPLE\_SELECT
- FILE\_BROWSER entry: **F1+A1** from SAMPLE\_SELECT (same combo exits); F8 in FILE\_BROWSER mode falls through to sequencer toggle
- SONG\_SEQUENCE: **F8** = play/stop; **F8 double-tap** = rewind to bar 1; **A1–A8** = assign patterns 0-7; **B1–B8** = assign patterns 8-15; **Pot** = navigate bars; **F1+F2/F3** = nudge bar; **F2–F7** = exit to PATTERN\_SELECT

## Complete Potentiometer Reference Table

Mode	Mode Name	Function	Range	Notes
0	SAMPLE_SELECT	Choose sample to play	1-16	Selects which sample plays for current voice
1	DELAY_SEND	Delay effect send	0-255	Per-voice delay send amount
2	REVERB_SEND	Reverb effect send	0-255	Per-voice reverb send amount
3	SAMPLE_PITCH	Transpose pitch	Semitone steps	Real-time pitch adjustment
4	SAMPLE_VELOCITY	Note velocity	0-255 (0-100%)	Step volume/loudness
5	SAMPLE_PAN	Stereo position	0-255	0=left, 127=center, 255=right
6	EFFECTS_SEND	Fine pitch control	Variable	Micro-tuning adjustment
7	CONDITION	Step trigger condition	9 options	Pot CW = 100% (always); CCW = 1/4 repeat
8-15	SELECT_SAMPLE_1-8	Quick sample select	Varies	Reserved for quick sample access
16	PATTERN_SELECT	Pattern selection	—	Use step buttons to select
17	SONG_SELECT	Song selection	—	Use step buttons to select
18	BANK_SELECT	Bank selection	—	Use step buttons to select

Mode	Mode Name	Function	Range	Notes
19	COPY_PATTERN	Copy pattern	—	Implementation varies
20	CLEAR_PATTERN	Clear pattern	—	Resets pattern
21	BPM_SET	Tempo control	30-240 BPM	Sequencer tempo; nudge $\pm 1$ BPM
22	SWING	Shuffle timing	0-100%	Groove amount (0=straight); nudge $\pm 1$
23	PATTERN_LENGTH	Active steps	1-16 steps	Loop length; nudge $\pm 1$ step
24	FILTER_Q	Filter resonance	0-255	Q factor; nudge $\pm 5$
25	FILTER_CUTOFF	Filter frequency	50-16000 Hz	Log-scale; nudge steps through same scale
26	DELAY_TIME	Delay timing	20-999 ms	Repeat interval; nudge $\pm 10$ ms
27	DELAY_MIX	Delay wet/dry	0-100%	Effect blend; nudge $\pm 5$
28	REVERB_ROOM_SIZE	Reverb size	0-100%	Space simulation; nudge $\pm 5$
29	REVERB_DAMPING	Reverb damping	0-100%	High-frequency absorption; nudge $\pm 5$
30	BITCRUSH	Bit reduction	0-15	0=off, 15=maximum crush; nudge $\pm 1$

Mode	Mode Name	Function	Range	Notes
31	VOLUME	Master volume	0-100%	Overall output level
38	SAMPLE_PLAY_MODE	Sample playback mode	3 options	CCW=SINGLE; mid=SL 16; CW=SL TRS (see Extended Voice Modes)
39	SLICE_SELECT	Slice assignment	0=auto, 1-N	Force a slice index per step; 0=sequential auto
40	ATTACK [1]ATC	ADSR attack time	0=OFF, 1–255	Linear fade-in ramp; 1 step ≈ 0.5 ms (max 255 ≈ 127 ms); F1+B5 enters this stage
45	ENV_DECAY [2]DEC	ADSR decay time	0=OFF, 1–255	Fall from peak to sustain level; 1 step ≈ 4 ms (max 255 ≈ 1020 ms)
46	ENV_SUSTAIN [3]SUS	ADSR sustain level	0–255 (0–100%)	Amplitude held after decay completes; only active when decay > 0
47	ENV_RELEASE [4]REL	ADSR release time	0=OFF, 1–255	Fade-out; 1 step ≈ 4 ms (max 255 ≈ 1020 ms); behaviour differs for looping vs non-looping (see Extended Modes)

Mode	Mode Name	Function	Range	Notes
41	VOICE_EQ	Per-voice DJ filter	0-255	0=max LPF; 128=FLAT/bypass; 255=max HPF; dead-band snaps to FLAT
—	SAMPLE_START [1]	Sample start point	0-100%	F1+B1 (first press or cycle); sets playback start position
—	SAMPLE_END [2]	Sample end point	0-100%	F1+B1 (second press); sets playback end position
—	LFO_SHAPE [1]	LFO waveform	0–5	F1+B2 (first press); SINE / TRI / SAWUP / SAWDN / SQ / RNDM
—	LFO_RATE [2]	LFO tempo-sync rate	0–7	F1+B2 (second press); 1/32 → 4BAR
—	LFO_DEPTH [3]	LFO modulation depth	0–255	F1+B2 (third press); 0 = LFO off
—	LFO_TARGET [4]	LFO modulation target	0–14	F1+B2 (fourth press); VEL/PAN/PTC/TUN/DLY/RVB/EQ/FLQ/VOL/ATK/DEC/SUS/REL/SST/SEN
—	VOICE_VOLUME	Per-voice volume	0-127	Hold F2-F7 + pot

Mode	Mode Name	Function	Range	Notes
<b>SONG_SEQUENCER</b>	Bar Select	Navigate song bars	0-127 bars	Pot maps full travel to 128 bars
<b>FILE_BROWSER</b>	List Scroll	Browse file list	Item index	Pot position maps directly to list position

### Shortcuts:

- **F8 + Pot**: Master volume (any mode)
- **F2-F7 + Pot**: Per-voice volume (Voices 1-6)
- **Pot Locking**: Automatically locks when any button is released

## OLED Display (128x64 pixels)

### Display Modes

#### Voice Mode Display (modes 0-15)

- Shows: **V[1-6]: [MODE\_NAME]** (example: **V1:TRG**)
- Line 2: Current parameter value or status

#### Master Mode Display (modes 16-31)

- Shows: **M: [MODE\_NAME]**
- Line 2: Current parameter value or status

### Volume Control Display

- When F2-F7 held: **V[1-6]: VOL** with percentage shown
- When F8 held: **M: VOL** with percentage shown
- Muted voices show: **MUTED**

### Recording Mode Display

- Shows recording status, input source (MIC or LIN), and level
- Real-time recording time and sample information

### Bank/Song/Pattern Select Display

- Shows available slots and current selection
  - Indicates which slots contain saved data
- 

## Operating Modes

### Voice-Specific Modes

These modes control individual voice parameters. Select a voice with F2-F7 buttons (Voice 1-6), then use F1 + Step buttons to access modes.

#### A-Row Modes (F1 + A1–A8)

##### F1+A1: Sample Select (SMP)

- **Purpose:** Choose which sample (1-16) plays for this voice/step
- **Potentiometer:** Adjust sample number
- **Range:** 1-16 (0 = off/silent)
- **Display:** Shows current sample index
- **Special:** F8 in this mode enters File Browser for loading samples from SD card
- **Quick Assign:** Hold F2-F7 + press A1-B8 to set default sample for that voice

##### F1+A2: Sample Pitch (PTC)

- **Purpose:** Transpose playback pitch up/down
- **Potentiometer:** Adjust pitch offset
- **Range:** Semitone steps
- **Scale:** Chromatic steps
- **Tempo Sync:** Pitch change maintains audio quality

##### F1+A3: Tuning (TUN)

- **Purpose:** Fine pitch control for micro-tuning
- **Potentiometer:** Adjust fine pitch adjustment
- **Range:** Fine pitch steps
- **Effect:** Precise pitch tuning beyond semitone steps

##### F1+A4: Sample Velocity (VEL)

- **Purpose:** Set note velocity (loudness) per step
- **Potentiometer:** Adjust velocity amount
- **Range:** 0-255 (0 = silent, 255 = maximum)
- **Percent Display:** Shown as 0-100%
- **Effect:** Combines with voice volume for final level

### F1+A5: Sample Pan (PAN)

- **Purpose:** Position sound in stereo field (left/right)
- **Potentiometer:** Adjust pan position
- **Range:** 0-255 (0 = left, 127 = center, 255 = right)
- **Display:** Center position indicated on OLED

### F1+A6: Delay Send (DSND)

- **Purpose:** Set the amount of signal sent to the delay effect for this voice
- **Potentiometer:** Adjust delay send amount
- **Range:** 0-255 (0 = no delay, 255 = full send)
- **Effect:** Per-voice delay send level

### F1+A7: Reverb Send (RSND)

- **Purpose:** Set the amount of signal sent to the reverb effect for this voice
- **Potentiometer:** Adjust reverb send amount
- **Range:** 0-255 (0 = no reverb, 255 = full send)
- **Effect:** Per-voice reverb send level

### F1+A8: Volume (VOL)

- **Purpose:** Set the output volume for this voice
- **Potentiometer:** Adjust voice volume
- **Range:** 0-255 (0 = silent, 255 = maximum)
- **Shortcut:** Also accessible by holding F2-F7 (voice select) + potentiometer

### B-Row Modes (F1 + B1–B8)

#### F1+B1: Sample Start / Sample End (SST / SEN)

- **Access:** Press **F1 + B1** to cycle between the two sample boundary modes:
  - First press (or if not already in this group): enters **[1] SAMPLE START**
  - Next press: advances to **[2] SAMPLE END**
  - The OLED header shows **[1]** or **[2]** to indicate which sub-mode is active

#### [1] Sample Start (SST)

- **Purpose:** Set the playback start position within the sample
- **Potentiometer:** Adjusts start point (0-100% of sample length)
- **Display:** Shows **SST** alert on entry; OLED shows current value
- **Per-step:** Hold a step button while adjusting to set start point for that step only
- **Use:** Chop into a sample, skip silences, or create stutter effects

## [2] Sample End (SEN)

- **Purpose:** Set the playback end position within the sample
- **Potentiometer:** Adjusts end point (0-100% of sample length)
- **Display:** Shows **SEN** alert on entry
- **Per-step:** Hold a step button while adjusting to set end point for that step only
- **Use:** Shorten samples, isolate a region, or combined with start point to isolate a segment

## F1+B2: Per-Voice LFO (LSHP / LRAT / LDEP / LTGT)

- **Purpose:** Apply a tempo-synced Low Frequency Oscillator to continuously or trigger-time modulate a per-voice parameter
- **Access:** Press **F1 + B2** to cycle through the four LFO sub-modes:
  - [1] LFO SHAPE → [2] LFO RATE → [3] LFO DEPTH → [4] LFO TARGET
  - The OLED header shows [1]–[4] to indicate the active sub-mode
- **Per-voice:** Each voice has its own independent LFO with its own shape, rate, depth, and target
- **Enable/Disable:** Set [3] **LFO DEPTH** to 0 to disable the LFO for the selected voice; any depth > 0 activates it

## [1] LFO Shape (LSHP)

- **Purpose:** Select the waveform that drives the modulation
- **Potentiometer:** Selects one of 6 shapes across the pot travel
- **Display:** Shows shape label (**SINE**, **TRI**, **SAWUP**, **SAWDN**, **SQ**, **RNDM**)

Shape	Label	Description
Sine	<b>SINE</b>	Smooth, rounded oscillation — natural-sounding vibrato, tremolo
Triangle	<b>TRI</b>	Linear up/down ramp — similar to sine but with harder corners
Sawtooth Up	<b>SAWUP</b>	Ramps up smoothly then resets — one-directional sweeps
Sawtooth Down	<b>SAWDN</b>	Ramps down smoothly then resets — falling sweeps

Shape	Label	Description
Square	SQ	Abrupt on/off switching — gating, trill, stepped modulation
Smooth Random	RNDM	Linearly interpolates between random values each half-cycle — organic, unpredictable modulation

### [2] LFO Rate (LRAT)

- **Purpose:** Set how fast the LFO oscillates, locked to sequencer tempo
- **Potentiometer:** Selects one of 8 musical divisions
- **Display:** Shows division label
- **Tempo-sync:** Rate is always relative to the current BPM — changing tempo adjusts LFO speed automatically

Division	Label	Pulses per cycle (at PPQN=48)	Speed at 120 BPM
1/32 note	1/32	6	~26.7 Hz — very fast
1/16 note	1/16	12	~13.3 Hz
1/8 note	1/8	24	~6.7 Hz
1/4 note	1/4	48	~3.3 Hz
1/2 note	1/2	96	~1.7 Hz
1 bar	1BAR	192	~0.83 Hz
2 bars	2BAR	384	~0.42 Hz
4 bars	4BAR	768	~0.21 Hz — very slow sweep

### [3] LFO Depth (LDEP)

- **Purpose:** Set the modulation intensity
- **Potentiometer:** Full pot travel maps to 0–255 depth
- **Range:** 0 = LFO off (no modulation); 1–255 = modulation depth (roughly 0–100%)
- **Display:** Shows current depth value (or OFF at 0)
- **Tip:** Start with a low depth (around 20–40) and increase gradually to taste

#### [4] LFO Target (LTGT)

- **Purpose:** Select which voice parameter the LFO modulates
- **Potentiometer:** Selects one of 15 targets
- **Display:** Shows target label

LFO targets fall into two categories:

**Continuous targets** — modulation is applied every sequencer pulse while the voice is active:

Target	Label	Parameter modulated
Velocity	VEL	Per-step velocity level
Pan	PAN	Stereo pan position
Fine Tune	TUN	Fine-pitch offset (micro-pitch wobble)
Delay Send	DLY	Per-voice delay send amount
Reverb Send	RVB	Per-voice reverb send amount
Voice EQ	EQ	DJ-style per-voice filter position
Filter Q	FLQ	Per-voice filter resonance
Volume	VOL	Per-voice volume level

**Trigger-time targets** — modulation is sampled once at the moment a step fires and applied as an offset to the trigger value for that note:

Target	Label	Parameter modulated
Pitch (semitone)	PTC	Semitone pitch offset at trigger
Attack	ATK	ADSR attack time at trigger
Decay	DEC	ADSR decay time at trigger
Sustain	SUS	ADSR sustain level at trigger

Target	Label	Parameter modulated
Release	REL	ADSR release time at trigger
Sample Start	SST	Sample start point at trigger
Sample End	SEN	Sample end point at trigger

**Notes:**

- The LFO phase resets when the LFO Rate is changed (re-locks to sequencer grid)
- Changing LFO Rate while the sequencer is running takes effect immediately
- Trigger-time targets (PTC, ATK, DEC, SUS, REL, SST, SEN) only apply at the moment a step fires; they do not continuously modulate a playing voice
- The LFO phase is **not** reset on each trigger — it runs continuously relative to the sequencer clock, giving evolving variation across loops

F1+B3: Sample Mode (MOD)

- **Purpose:** Choose how the sample is subdivided and triggered for the active voice
- **Potentiometer:** Selects one of three modes across the pot travel:

Pot position	OLED display	Behaviour
Left third (CCW)	SINGLE	Plays the whole sample (or start/end region) as one continuous note
Middle third	SL 16	Divides the sample into <b>16 equal slices</b> ; each step can target any slice
Right third (CW)	SL TRS	Detects up to 16 <b>transient onsets</b> automatically and places slice boundaries there

- **On mode change:** Slice boundaries are (re)calculated immediately
- **Display:** Alert shows SINGLE, SL 16, or SL TRS on change
- **Saved:** Play mode is stored per voice in the pattern

F1+B4: Slice Select (SLC)

- **Purpose:** Assign a specific slice to one or more sequencer steps (requires SL 16 or SL TRS mode)

- **Potentiometer:** Selects slice number or auto:
  - **Auto (0):** Steps cycle through slices sequentially (OLED shows 1-16 or 1-N)
  - **SL1–SL16:** Force all affected steps to always trigger that specific slice
- **Scope of assignment:**
  - **F1 held:** Applies to the currently playing step only (automation)
  - **Step button held:** Applies to that specific step
  - **Neither held:** Applies to all active steps for the current voice
- **In SINGLE mode:** Pot has no effect; OLED shows N/A
- **Display:** Alert shows SL1–SL16 or 1-N (auto range)
- **Creative use:** Address individual hits in a drum break, or map different drum sounds from one sample to different steps

#### F1+B5: ADSR Envelope (ATC / DEC / SUS / REL)

- **Purpose:** Shape the amplitude envelope for each triggered step using a four-stage Attack–Decay–Sustain–Release envelope
- **Access:** Press **F1 + B5** repeatedly to cycle through the four stages in order: [1]ATTACK → [2]DECAY → [3]SUSTAIN → [4]RELEASE → back to [1]ATTACK
- **Potentiometer:** Sets the value for the currently active stage
- **Scope of assignment** (applies to all four stages):
  - **F1 held:** Records automation to the currently playing step only
  - **Step button held:** Applies to that specific step
  - **Neither held:** Applies to all steps for the current voice
- **Saved:** All four ADSR values are stored per-voice, per-step in the pattern
- **Defaults:** Attack = 0 (OFF), Decay = 0 (OFF), Sustain = 255 (100%), Release = 0 (OFF) — envelope is effectively bypassed on fresh patterns

#### [1] Attack (ATC)

- **Range:** 0–255; 0 = OFF (no fade-in — voice starts immediately at full level)
- **Timing:** each increment adds 16 PCM samples at 32 kHz ≈ 0.5 ms; max (255) ≈ 127 ms
- **Effect:** Linearly ramps amplitude from silence to full level at the start of each triggered step
- **Display:** Alert shows ATC OFF or ATC {N}ms; OLED header V#:ATC

#### [2] Decay (DEC)

- **Range:** 0–255; 0 = OFF (voice holds at full level after attack — no decay)
- **Timing:** each increment adds 128 PCM samples at 32 kHz ≈ 4 ms; max (255) ≈ 1020 ms
- **Effect:** After the attack phase completes, amplitude ramps down to the Sustain level over the set duration
- **Display:** Alert shows DEC OFF or DEC {N}ms; OLED header V#:DEC

### [3] Sustain (SUS)

- **Range:** 0–255 displayed as 0–100%; default = 255 (100%)
- **Effect:** The amplitude level held continuously after the Decay phase completes, until the Release phase begins. Only meaningful when Decay > 0; if Decay is 0, this value has no effect and the voice plays at full level throughout
- **Display:** Alert shows **SUS {N}%**; OLED header **V#:SUS**

### [4] Release (REL)

- **Range:** 0–255; 0 = **OFF** (no fade-out — voice ends abruptly at its natural end)
- **Timing:** each increment adds 128 PCM samples at 32 kHz ≈ 4 ms; max (255) ≈ 1020 ms
- **Effect:** Linearly ramps amplitude from the Sustain level down to silence over the set duration; the starting level of the ramp is the Sustain level (or full level if Decay = 0)
- **Display:** Alert shows **REL OFF** or **REL {N}ms**; OLED header **V#:REL**
- **Behavior differs by trigger mode:**
  - **Non-looping voices (FWD, REV, FL2, FL3, ROLL):** Release begins automatically the correct number of samples before the natural end of the sample play region — the voice fades out just as the sample finishes. If the Release duration is longer than the play region, it starts immediately at trigger time.
  - **Looping voices (LOOP, LPND):** Release is deferred; the voice holds at the Sustain level indefinitely while looping. The release phase is triggered when an **empty step** is encountered for that voice in the sequencer — the voice then fades out over the set Release duration and stops. If Release = 0, a looping voice will loop indefinitely (until retriggered or the sequencer stops).

### F1+B6: Voice EQ (EQ)

- **Purpose:** Apply a per-voice DJ-style single-pole filter — low-pass (dark), bypass (flat), or high-pass (bright)
- **Potentiometer:** Sweeps the filter character:
  - **CCW half (0–127):** Low-pass filter; deeper left = more bass-heavy rolloff
  - **Centre dead-band (≈ 124–132):** Bypass — no filtering (**FLAT**); the pot snaps cleanly to bypass in this zone
  - **CW half (129–255):** High-pass filter; deeper right = more treble-heavy rolloff
- **Display:** Shows **LP x%**, **HP x%**, or **FLAT** as the pot moves; alert shows **EQ FLAT**, **LP x%**, or **HP x%**
- **Scope of assignment:**
  - **No step held:** Sets the per-voice default EQ and resets all steps of that voice to the same value
  - **Step button held:** Sets an EQ override for that specific step only (**stepEQ**)
  - **F1 held:** Records EQ automation to the currently playing step
- **Saved:** Per-voice EQ value stored in the pattern; step-level EQ overrides also saved

- **Default:** 128 (FLAT / bypass on fresh patterns)

#### F1+B7: Trigger Mode (TRG)

- **Purpose:** Set per-step trigger type — controls playback direction, looping, and flam/roll multi-hit performance articulations
- **Potentiometer:** Selects one of 7 trigger types across equal sevenths of the pot range
- **Nudge shortcuts (F1+F2 / F1+F3):** Step backward/forward through all 7 types one at a time
- **Display:** Shows TRG alert on entry; value feedback shows the mode label

Pot position	Label	Behaviour
Leftmost (CCW)	FWD	Forward one-shot playback (default)
	REV	Reverse one-shot playback
	LOOP	Loop sample region until next step retriggers the voice
	LPND	Pendulum loop: bounces forward↔reverse between loop points
	FL2	<b>Grace-note flam:</b> 2 hits — main hit at full velocity + ghost note ~1.5 pulses later at 55% velocity
	FL3	<b>Open ruff:</b> 3 hits spaced ~3.5 pulses apart, velocities descending 100% → 65% → 35%
Rightmost (CW)	ROLL	<b>Machine-gun roll:</b> 4 evenly-spaced hits across ~¾ of a 16th note, all at 80% velocity

#### Notes on flam/roll types:

- All timing intervals are tempo-relative — flam spacing automatically tightens at higher BPM

- A new step firing always cancels any in-flight flam hits for that voice
- Flam velocity layers are fixed and independent of per-step velocity (the base velocity scales all hits proportionally)
- **LOOP** and **LPND** modes require the sequencer to stop or retrigger the voice to end; flam/roll modes do not sustain
- **Scope of assignment:**
  - **F1 held:** Applies to the currently playing step only (automation)
  - **Step button held:** Applies to that specific step
  - **Neither held:** Applies to all active steps for the current voice
- **OLED Header:** Voice pages use **V#:MODE** format (for example **V1 :TRG**)

#### F1+B8: Condition (CON)

- **Purpose:** Set the trigger condition for each step — from always-on to probability-based to pattern-division logic
- **Potentiometer:** Selects one of 9 discrete conditions (fully clockwise = 100%, fully counter-clockwise = 1/4)
- **Encoder:** Step through conditions one at a time
- **Display:** Shows condition label on OLED (e.g. **100%**, **W/LST**, **1/2**)

Pot position	Label	Behaviour
Fully CW (default)	100%	Always triggers
	90%	90% probability
	75%	75% probability
	50%	50% probability
	25%	25% probability
	10%	10% probability
	W/LST	Only triggers if the previous active step on this voice triggered

Pot position	Label	Behaviour
	1/2	Only triggers on the 1st of every 2 full pattern loops
Fully CCW	1/4	Only triggers on the 1st of every 4 full pattern loops

- **Loop counters** (1/2, 1/4) reset to zero when the sequencer is started or a new pattern is loaded, so these conditions always fire on the very first loop.
- **Use Cases:** Probabilistic fills, call-and-response sequences, slow-evolving patterns, and polyrhythmic layering

## Master Modes (16-31)

These modes control global device parameters. Access using F8 + Step buttons:

### Mode 16: Pattern Select (PATTERN\_SELECT) - F8 + A1

- **Purpose:** Load/save sequencer patterns
- **Step Buttons:** Press A1-B8 to select pattern slot (short press = load, long press = save)
- **Long Press:** Hold step button for 800ms to save current pattern to that slot
- **Storage:** 16 pattern slots per song, saved to SD card
- **Working Memory:** Pattern 255 is temporary (not saved)
- **Voice Selection:** Press F2-F7 to exit pattern select and return to voice modes
- **LED Color Code:** White = current pattern; Green = saved slot; Dim purple = empty slot; Orange blink = save target; 20% dimmed = currently playing step (if sequencer running)

### Mode 17: Song Select (SONG\_SELECT) - F8 + A2

- **Purpose:** Switch between song arrangements
- **Step Buttons:** Press A1-B8 to select song (immediate selection)
- **Range:** 16 songs per bank
- **Effect:** Loads different set of patterns and samples
- **LED Color Code:** White = current song; Green = saved slot; Dim blue = empty slot; 20% dimmed = currently playing step (if sequencer running)

### Mode 18: Bank Select (BANK\_SELECT) - F8 + A3

- **Purpose:** Switch between sample banks
- **Step Buttons:** Press A1-B8 to select bank (immediate selection)
- **Range:** 16 banks available
- **Effect:** Changes which songs and patterns are active
- **LED Color Code:** White = current bank; Green = saved slot; Dim red = empty slot; 20% dimmed = currently playing step (if sequencer running)

### Mode 19: Song Sequencer (SONG\_SEQUENCE) - F8 + A4 (from PATTERN/SONG/BANK\_SELECT)

- **Purpose:** Arrange patterns into a song by assigning them to bars in a 128-bar sequence
- **Access:** Press **F8 + A4** while in PATTERN\_SELECT, SONG\_SELECT, or BANK\_SELECT mode
- **Step Buttons:**
  - **A1–A8** (steps 1–8): Assign pattern slots 0–7 (**A1–A8**) to the selected bar
  - **B1–B8** (steps 9–16): Assign pattern slots 8–15 (**B1–B8**) to the selected bar
  - Press the same step again to **clear** the assignment for that bar
- **Potentiometer:** Navigates across all 128 bars (full pot travel = bars 0–127)
- **F1 + F2 / F1 + F3:** Nudge selected bar one position left or right
- **F8 (release):**
  - Single press: Toggle sequencer play / stop
  - Double-tap (within 500 ms): Rewind to bar 1 — works whether stopped or playing
- **F8 + Pot:** Master volume (still works inside Song Sequencer)
- **F2–F7:** Exit Song Sequencer and return to PATTERN\_SELECT
- **Display:** Shows current Bank / Song header, a 4×2 grid of 8 bars per page, selected bar highlighted with a double border; playing bar shows a small filled square in its cell
  - **Uppercase label** (A1–B8): explicitly assigned pattern
  - **Lowercase label** (a1–b8): bar inherits the pattern from the nearest preceding assigned bar
  - **--:** no pattern assigned and none inherited (bar will be skipped)
- **Auto-save:** Song sequence is saved to SD card automatically after each change
- **Per-song:** Each song has its own song sequence; switching songs resets the playback position

### Mode 20: Clear Pattern (CLEAR\_PATTERN) - F8 + A5

- **Purpose:** Clear/initialize current pattern
- **Effect:** Resets all steps and parameters to default

### Mode 21: BPM Set (BPM\_SET) - F8 + A6

- **Purpose:** Set sequencer tempo
- **Potentiometer:** Adjust tempo (full sweep = 30–240 BPM)
- **Range:** 30–240 BPM (beats per minute)
- **Nudge (F1+F2/F3):** Step ±1 BPM
- **Sync:** Can be synchronized to MIDI clock
- **Display:** Shows current BPM value

### Mode 22: Swing (SWING) - F8 + A7

- **Purpose:** Add shuffle/swing timing to sequencer

- **Potentiometer:** Adjust swing amount
- **Range:** 0-100% (0 = straight, 100 = maximum triplet swing)
- **Nudge (F1+F2/F3):** Step  $\pm 1\%$
- **Effect:** Delays alternate (upbeat) steps for groove feel

#### Mode 23: Pattern Length (PATTERN\_LENGTH) - F8 + A8

- **Purpose:** Set active sequencer length
- **Potentiometer:** Adjust pattern length
- **Range:** 1-16 steps
- **Nudge (F1+F2/F3):** Step  $\pm 1$
- **Default:** 16 steps
- **Effect:** Loop repeats after specified step

#### Mode 24: Filter Q (FILTER\_Q) - F8 + B1

- **Purpose:** Set filter resonance/sharpness
- **Potentiometer:** Adjust Q factor (0-255 internal)
- **Nudge (F1+F2/F3):** Step  $\pm 5$
- **Effect:** Emphasizes frequencies near cutoff
- **Sound:** Can self-oscillate at extreme values

#### Mode 25: Filter Cutoff (FILTER\_CUTOFF) - F8 + B2

- **Purpose:** Set filter center frequency
- **Potentiometer:** Adjust cutoff frequency
- **Range:** 50-16000 Hz
- **Nudge (F1+F2/F3):** Steps through the same logarithmic scale as the pot
- **Effect:** Low-pass filter removes frequencies above cutoff
- **Resolution:** Logarithmic frequency steps

#### Mode 26: Delay Time (DELAY\_TIME) - F8 + B3

- **Purpose:** Set delay repeat timing
- **Potentiometer:** Adjust delay time
- **Range:** 20-999 ms (milliseconds)
- **Nudge (F1+F2/F3):** Step  $\pm 10$  ms
- **Effect:** Controls timing of delay repeats
- **Buffer:** 1 second maximum delay time

#### Mode 27: Delay Mix (DELAY\_MIX) - F8 + B4

- **Purpose:** Balance between dry and delayed signal
- **Potentiometer:** Adjust wet/dry mix
- **Range:** 0-100%
- **Nudge (F1+F2/F3):** Step  $\pm 5$  ( $\approx 2\%$ )

- **Effect:** 0% = no delay heard, 100% = only delay heard

#### Mode 28: Reverb Room Size (REVERB\_ROOM\_SIZE) - F8 + B5

- **Purpose:** Control reverb space simulation size
- **Potentiometer:** Adjust room size
- **Range:** 0-100%
- **Nudge (F1+F2/F3):** Step  $\pm 5$  ( $\approx 2\%$ )
- **Effect:** Larger values create longer reverb tail
- **Sound:** Simulates different room acoustics

#### Mode 29: Reverb Damping (REVERB\_DAMP) - F8 + B6

- **Purpose:** Control high-frequency absorption in reverb
- **Potentiometer:** Adjust damping
- **Range:** 0-100%
- **Nudge (F1+F2/F3):** Step  $\pm 5$  ( $\approx 2\%$ )
- **Effect:** Higher values remove more brightness from reverb tail
- **Sound:** Creates more natural, less metallic reverb

#### Mode 30: Bit Crusher (BITCRUSH) - F8 + B7

- **Purpose:** Add digital distortion effect
- **Potentiometer:** Adjust bit depth reduction
- **Range:** 0 (off) to 15 (maximum crush)
- **Nudge (F1+F2/F3):** Step  $\pm 1$
- **Effect:** 0 = no effect, 15 = maximum lo-fi degradation
- **Sound:** Lo-fi, crunchy, digital degradation

#### Mode 31: Master Volume (VOLUME) - F8 + B8

- **Purpose:** Set overall output volume
- **Potentiometer:** Adjust master volume
- **Range:** 0-100%
- **Effect:** Controls overall device output level
- **Note:** Also accessible via F8 + Potentiometer shortcut

### Master FX Modes (Special Toggle Modes)

These are special effect modes that work differently from other modes. They are toggled on/off using F1 combos and use step buttons to select patterns while active:

#### Master FX 1: Gater (MASTER\_FX\_1)

- **Access:** F1 + F4 (toggle on/off)
- **Purpose:** Rhythmic gating effect that mutes/unmutes audio in patterns
- **Step Buttons (while active):** Press and hold A1-B8 to select gating pattern

- **Patterns:** 16 different gate patterns available (64th note resolution)
  - 0: 32nd Note Gate (Standard)
  - 1: 16th Note Gate
  - 2: 64th Note Trill (Fast!)
  - 3: Gallop 64ths
  - 4: Machine Gun 64ths
  - 5: Single 64th click per beat
  - 6: Drop last 32nd
  - 7: Cut Middle
  - 8: Swing-ish 64ths
  - 9: Skip 64ths
  - 10: Offbeat 64ths
  - 11: Glitch A (Fast)
  - 12-15: Various complex patterns
- **Effect:** Gates are synchronized to the sequencer (32 steps per half-bar)
- **Display:** Shows "GTR" mode name

#### Master FX 2: Filter (MASTER\_FX\_2)

- **Access:** F1 + F5 (toggle on/off)
- **Purpose:** Rhythmic filter sweeping effect
- **Step Buttons (while active):** Press and hold A1-B8 to select filter pattern
- **Patterns:** Different filter cutoff frequencies per step
- **Effect:** Creates rhythmic filter movement synchronized to sequencer
- **Display:** Shows "FLT" mode name

#### Master FX 3: Phase/Chorus (MASTER\_FX\_3)

- **Access:** F1 + F6 (toggle on/off)
- **Purpose:** Modulation effects (flanger/chorus)
- **Step Buttons (while active):** Press and hold A1-B8 to select phase pattern
- **Patterns:** 16 different modulation patterns
- **Effect:** Adds stereo width and movement to the sound
- **Buffers:**
  - Flanger: 512 samples (~16ms @ 32kHz)
  - Chorus: 1024 samples (~32ms @ 32kHz)
- **Display:** Shows "PHC" mode name

#### Master FX 4: Combo FX (MASTER\_FX\_4)

- **Access:** F1 + F7 (toggle on/off)
- **Purpose:** Combined/layered effects
- **Step Buttons (while active):** Press and hold A1-B8 to select combo pattern
- **Patterns:** Combinations of multiple effects
- **Effect:** Complex multi-effect processing

- **Display:** Shows "CMB" mode name

### Note on Master FX Usage:

- Master FX modes operate independently of voice modes
- While in a Master FX mode, step buttons control effect patterns instead of sequencer steps
- Press F1 + the same F-key again to toggle the effect off
- Effects remain active until explicitly turned off
- No step button = effect bypassed automatically

## Special Modes

### File Browser Mode (FILE\_BROWSER)

- **Access:** Press F8 while in SAMPLE\_SELECT mode
- **Purpose:** Browse and load samples from SD card
- **Navigation:**
  - **F1 (release):** Navigate up one folder level
  - **F1 + F2:** Move selection up (previous item)
  - **F1 + F3:** Move selection down (next item)
  - **F8 (press):** Enter folder or load selected file
- **File Types:** WAV and S16 files
- **Path Support:** Nested folders up to 64 characters
- **Display:** Shows current folder and file list on OLED
- **Exit:** Select a file to load, or switch modes with F1 + Step buttons
- **Sample Slot:** Loaded file is assigned to the sample slot of the current voice

#### **Path Length Limit — 63 characters maximum**

The full file path (folder + filename, e.g. /SAMPLES/MY\_FOLDER/MYFILE.WAV) must be **63 characters or fewer** (including the leading /). If the path is longer, the file will preview correctly but will silently fail to import — the browser will return to SAMPLE\_SELECT without loading anything.

#### **Example of a path that is too long:**

/SAMPLES/AUTHENTIC\_VINYL\_BREAKS\_DEMOS/AUTHENTIC\_VINYL\_BREAKS\_DE... ← truncated, import fails

**Fix:** Shorten your folder and file names on the SD card. A safe rule of thumb:

- Keep folder names under 20 characters
- Keep filenames under 30 characters

- Avoid deeply nested subfolders

### Recording Mode (REC\_MODE)

- **Access:** F1 + F8 (from any voice mode 0-15, not from master modes)
- **Purpose:** Record new samples from microphone or line-in
- **Input Detection:** Automatic detection of active input source
  - Shows "REC:MIC" for microphone input
  - Shows "REC:LIN" for line-in input
- **Recording Steps:**
  1. Press F1 + F8 to enter REC\_MODE
  2. Press and HOLD any Step button (A1-B8) to start recording
  3. Release the Step button to stop recording
  4. Sample is automatically imported to PSRAM for that slot (1-16)
  5. Returns to previous voice mode after recording completes
- **Exit (without recording):** Press any F-key (F1-F8) to cancel and return
- **Maximum Duration:** ~27.6 seconds (882,000 samples at 32kHz)
- **Levels:** Real-time input level display on OLED
- **Note:** Cannot enter REC\_MODE from master modes (16-31)
- See [Recording Audio](#) section for more details

### Live Play Mode

- **Access:** F8 + F7 (global toggle — survives voice switches)
- **Purpose:** Turn the 16 step buttons into a real-time instrument for live performance — either a chromatic keyboard or a multi-pad drum trigger
- **Exit:** F8 + F7 again; display shows **STEP** when returning to normal step-edit mode

When live play is enabled, the active **sub-mode** is determined automatically by the current voice's sample play mode (the one set with **F1 + B3**):

Voice sample play mode	Live sub-mode	Alert shown
SINGLE	Keyboard	KEYBOARD
SL 16 or SL TRS	Drum Pad	PAD MODE

Switching voices while live play is active re-evaluates the sub-mode instantly, so you can flip between keyboard and pad behaviour by selecting a different voice.

### Keyboard Mode (voice sample play mode = SINGLE)

- The 16 step buttons form a two-octave chromatic layout centred on the voice's default pitch:

- **A1–A8:** -8, -7, -6, -5, -4, -3, -2, -1 semitones (lower octave, left to right)
- **B1–B8:** 0, +1, +2, +3, +4, +5, +6, +7 semitones (upper octave, B1 = root pitch)
- Each press immediately triggers the voice's default sample at the corresponding transposed pitch
- Velocity is derived from the voice volume setting

### Drum Pad Mode (voice sample play mode = **SL 16** or **SL TRS**)

- Each step button directly fires the corresponding slice (button 1 → slice 0, button 2 → slice 1, ...)
- For **SL 16**: button index maps directly to one of the 16 equal slices
- For **SL TRS**: button index is clamped to the number of detected transient slices
- Velocity is derived from the voice volume setting
- Useful for playing drum hits, chops, or any multi-sample mapped to a single sliced sample

### Tips

- Combine Keyboard Mode with pitch/tuning to shift the root note before entering live play
- Use Drum Pad Mode on a transient-sliced drum loop to improvise fills over the running sequencer
- The sequencer keeps running in live play mode — triggered notes layer on top of the pattern
- Use voice mute (double-tap F2–F7) to silence a sequencer voice while jamming live through a different voice

### Live Recording

While in live play mode you can record your performance directly into the running pattern in real time.

- **Start recording:** Double-tap **F1** while in live play mode (the sequencer must be running). The alert **REC ON** is shown and a blinking dot appears next to the mode icon on the OLED.
- **Stop recording:** Double-tap **F1** again. Alert shows **REC OFF**.
- **Cancel immediately:** Press any F-button (F1–F8). Cancels without a second double-tap.
- **Requirement:** The sequencer must be playing. If it is paused when you double-tap F1, the alert **SEQ OFF** is shown and recording does not start.

### What gets written

Each time you press a step button while live recording is active, the **current sequencer step** ( $\text{stepCount} \bmod \text{pattern length}$ ) is written with that note's data:

Sub-mode	Data stamped into the step
Keyboard	Step activated with the voice's default sample; pitch offset set to the semitone of the key you pressed
Drum Pad	Step activated with the voice's default sample; slice index locked to the pad you pressed (1-based)

The pattern is updated immediately and marked as modified. The sequencer continues to play — on the next loop the newly recorded steps will fire in the normal playback pass.

### OLED feedback

- A blinking middle-dot appears to the left of the mode icon (grid/note) on line 2 while recording is active
- If the live-play preview screen is open (F8 held), a small **REC** label is shown at the bottom

### Tips

- Record fills or variations over a running groove without stopping the sequencer
- Switch voices mid-recording to layer material across multiple voices in one take
- The sequencer keeps cycling — a step is only overwritten when you press the corresponding pad or key, so unplayed steps are left intact
- Erase unwanted steps afterwards in normal step-entry mode (toggle them off)

---

## Audio Features

### Sample Playback

- **Polyphonic Voices:** 6 simultaneous samples can play
- **Sample Selection:** 16 samples per voice
- **Pitch Shifting:** Real-time pitch adjustment without sample rate conversion
- **Looping:** Optional looping support for sustained notes

- **Start/End Position:** Set custom playback region per step (F1+B1 cycles [1]SST / [2]SEN)

## Sample Slicing

MYNAH can divide any loaded sample into up to 16 slices and address them independently per step. This turns a single long recording (e.g. a drum loop or a chord stab) into a playable multi-timbral instrument.

### Slice Mode: SL 16 (16 Equal Slices)

- The sample is divided into **16 equal-length segments**
- Slice boundaries are calculated once on mode change
- ADPCM decoder state is cached at every boundary for zero-latency triggering
- Use the pot in **SLICE\_SELECT** mode to lock a step to a specific slice (1-16) or leave it on **auto** (sequential cycling)

### Slice Mode: SL TRS (Transient-Detected Slices)

- The firmware analyses the loaded sample for **amplitude onsets** (transients) using a dual-envelope detector:
  - Fast envelope (~5 ms time constant) rises quickly on attack
  - Slow envelope (~200 ms time constant) tracks the background energy level
  - An onset is detected when  $fast > 3.5 \times slow$  (or noise floor)
- Up to **16 transient boundaries** are placed, with a minimum 50 ms gap between slices
- Silence before the first hit is skipped automatically
- The number of detected slices is shown on the OLED as 1-N in auto mode
- Ideal for drum loops: each detected hit becomes a individually addressable slice

### Slice Assignment per Step

- **Auto (0):** Each step triggers the next slice in order (wrap-around), creating rhythmic cycling through the sample
- **Force (1-16):** Lock a step to always trigger a specific slice — use this to compose patterns from individual hits
- The F7 button can be used for live/per-step automation of slice assignment

### Accessing Slice Modes

1. Select a voice (F2-F7)
2. Press **F1 + B3** (SAMPLE\_PLAY\_MODE) and turn the pot to choose **SL 16** or **SL TRS**
3. Press **F1 + B4** (SLICE\_SELECT) to assign slices to steps
4. The sequencer immediately plays using the new slice mode

## Effects Processing

### Delay Effect

- **Type:** Tape-style digital delay
- **Parameters:**
  - Time: 50-1000ms
  - Mix: Dry/wet balance (0-100%)
  - Feedback: Regeneration amount
- **Per-Voice Send:** Individual control for each voice
- **Stereo:** Separate delay for left and right channels
- **Buffer:** 32,000 sample internal buffer

### Reverb Effect

- **Type:** Algorithmic convolution reverb
- **Parameters:**
  - Room Size: 0-100 (space simulation)
  - Damping: 0-100 (high-frequency absorption)
  - Wet/Dry Mix: Balance between original and reverb
- **Per-Voice Send:** Individual control for each voice
- **Decay:** Natural tail-off of reverb reflections

### Filtering

- **Type:** Multi-mode filter (Low-pass default)
- **Parameters:**
  - Cutoff Frequency: 100 Hz - 16 kHz
  - Q Factor (Resonance): 0.5-32
- **Real-Time Control:** Adjustable without clicking
- **Self-Oscillation:** Can generate sine tone at extreme Q values
- **Global:** Applied after all voice mixing

### Bit Crusher Effect

- **Purpose:** Reduce audio resolution for lo-fi sound
- **Range:** 0-16 bits (16 = no effect, 8 = very aggressive)
- **Characteristics:** Digital distortion, aliasing at high settings
- **Creative Use:** Adds grit and character to samples

## Volume Control

### Master Volume

- **Control:** F8 button + Potentiometer

- **Range:** 0-100% (0-255 internally)
- **Purpose:** Overall output level
- **Display:** Shown as percentage on OLED

#### Per-Voice Volume

- **Control:** F2-F7 buttons (for voices 1-6) + Potentiometer
- **Range:** 0-127 per voice
- **Muting:** Voices can be muted individually
- **Status:** Muted voices show "MUTED" on display

#### Step Velocity

- **Control:** Velocity mode per voice
- **Range:** 0-255 per step
- **Combines With:** Voice volume for final level
- **Smooth:** Velocity ramps between steps

## Pattern & Sequencer Guide

### Sequencer Overview

- **Type:** 16-step step sequencer
- **Voices:** 6 polyphonic voices (can play simultaneously)
- **Clock:** Internal timing or MIDI clock sync
- **Sample Rate:** 32 kHz
- **Timing:** PPQN (Pulses Per Quarter Note) = 48

### Step Programming

#### Basic Step Entry

1. Press desired **Step Button** (A1-A8 or B1-B8) to select step
2. Press **Voice Button** (F2-F7) to select voice (F2=Voice 1, F3=Voice 2, etc.)
3. Use **Potentiometer** in Sample Select mode to choose sample (1-16)
4. Adjust velocity, pitch, pan as desired
5. Press **F8** to start the sequencer and hear the pattern

#### Multi-Voice Steps

- Each step can trigger samples on multiple voices simultaneously
- Press Voice button to switch voice without changing step
- Different sample can be set for each voice at same step

- All will play together when step is triggered

## Step Parameters

For each step on each voice, you can set:

- **Sample:** Which of the 16 samples to play (0 = off)
- **Velocity:** Volume for this step (0-255)
- **Pitch:** Pitch offset for sample
- **Pan:** Left/right stereo position
- **Condition:** Trigger condition for this step (see Condition mode for the 9 options)

## Pattern Management

### Pattern Slots

- **Working Memory:** Slot 255 (temporary, not saved)
- **Saved Patterns:** Slots 0-15 (can be saved to SD card)
- **Multiple Banks:** 4 banks of patterns (0-3)
- **Multiple Songs:** 4 song arrangements (0-3)

### Saving Patterns

1. Create pattern in Working Memory
2. Press **Pattern Select** button
3. Use Step Buttons to choose destination slot (0-15)
4. Press **Save** (or mode-specific save button)
5. Confirm save on OLED with F1/F8 buttons

### Loading Patterns

1. Press **Pattern Select** button
2. Use Step Buttons to choose source slot
3. Pattern automatically loads
4. Return to normal playing mode to hear pattern

## Sequencer Timing

### Internal Timing

- **Clock Source:** Device's internal timer
- **BPM Control:** Master BPM mode (mode 16)
- **Tempo Range:** 30-300 BPM
- **Tap Tempo:** Optional feature for manual tempo

## MIDI Clock Synchronization

- **Clock Input:** MIDI port on device
- **Sync Speed:** PPQN = 48 (24 clocks per quarter note)
- **Enable/Disable:** Sync button toggles MIDI clock mode
- **Advantage:** Lock tempo to external sequencer or DAW

## Swing & Timing

### Swing Parameter

- **Purpose:** Add shuffle/swing feel to timing
- **Range:** 0-24 (higher = more swing)
- **Effect:** Delays every other step for groove
- **Triplet Feel:** Creates syncopated rhythm

### Timing Accuracy

- **Jitter:** Minimized through high-resolution timing
  - **Catch-Up:** Automatic catch-up if timing falls behind
  - **Guard Band:** 5ms protection against jitter artifacts
- 

## Advanced Features

### Recording Audio

#### Record Modes

- **Microphone Recording:** Direct from onboard INMP441 MEMS microphone
- **Line-In Recording:** From external audio source via PCM1808 stereo ADC

#### Input Detection

- **Automatic Detection:** Device automatically detects which input source is active
- **Display Indication:** Shows "REC:MIC" or "REC:LIN" on OLED when entering recording mode

#### Recording Process

##### 1. Enter Recording Mode

- From any voice mode (0-15), press **F1 + F8** simultaneously
- Display shows "REC:MIC" or "REC:LIN" with input level indication

- Note: Cannot enter REC\_MODE from master modes (16-31)

## 2. Select Sample Slot and Record

- Press and HOLD any **Step button (A1-B8)** to start recording to that sample slot
- Red indicator shows recording is active
- Sequencer automatically pauses during recording if it was playing

## 3. Monitor Input Level

- Real-time input level meter shown on OLED display
- Ensure levels are not clipping (too loud)
- No manual gain control - adjust source volume externally

## 4. Stop Recording

- Release the Step button to stop recording
- Audio is automatically imported to PSRAM for that sample slot (1-16)
- Returns to previous voice mode automatically
- Sample is immediately available for playback in the sequencer

## 5. Exit Without Recording

- Press any F-key (F1-F8) to cancel and return to previous mode
- No recording is saved

## Recording Specifications

- **Sample Rate:** 32 kHz
- **Bit Depth:** 16-bit signed PCM
- **Channels:** Mono (microphone) or Stereo (line-in, mixed to mono)
- **Maximum Duration:** 882,000 samples (~27.6 seconds at 32 kHz per slot)
- **Recording Workflow:** Streams directly to SD card as WAV, then converts and imports to PSRAM as ADPCM
- **ADPCM Compression:** 4:1 ratio — a 27.6-second recording uses ~431 KB of PSRAM
- **Total PSRAM Budget for Samples:** ~1.88 MB (~123 seconds total across all 16 slots)
- **File Format:** WAV written to `/SAMPLES/RECORDINGS/` on SD, then ADPCM copy held in PSRAM

## Tips for Best Results

- For microphone: Speak/play clearly at a consistent distance
- For line-in: Set source output to moderate level to avoid clipping
- Hold Step button firmly during entire recording

- Keep recordings under 20 seconds for best performance
- Samples are automatically normalized on import

## File Management

### Sample Organization

- **Default Samples:** Pre-loaded samples 1-16
- **Sample Paths:** Support nested folders (up to 64 characters)
- **File Formats:** WAV, S16 (raw 16-bit signed samples)
- **Storage:** Primarily on SD card, can be cached in RAM

### Banks & Songs

- **Bank 0-15:** Different sets of samples and songs
- **Song 0-15:** Different sequencer pattern arrangements per bank
- **Selection:**
  - Access BANK\_SELECT mode via F8 + A3
  - Access SONG\_SELECT mode via F8 + A2
  - Press A1-B8 to select bank/song
- **Persistence:** Saved to SD card for recall on power-up

### Importing Samples

1. Prepare WAV or S16 files on SD card
2. Enter SAMPLE\_SELECT mode (F1 + A1)
3. Press **F1 + A1** to open File Browser (same combo exits)
4. Navigate using:
  - **Potentiometer:** Scroll through the file list (direct position mapping)
  - **F1 + F2:** Move to previous item
  - **F1 + F3:** Move to next item
  - **B1 (Step 9) release:** Navigate up one folder level
  - **B8 (Step 16) press:** Enter folder or load selected file
  - **F2-F7:** Exit browser and switch to that voice's SAMPLE\_SELECT
5. Selected sample is loaded to current voice's sample slot
6. Available for immediate playback

**Note:** A downward arrow is shown on the SAMPLE\_SELECT display as a reminder that the browser is accessible from that mode.

## Master FX Effects

The MYNAH includes four Master FX modes that apply rhythmic, synchronized effects to the entire mix. These are separate from the per-voice effects and provide creative, performance-oriented sound design tools.

## How Master FX Work

- **Toggle On/Off:** Each Master FX can be toggled independently using F1 + F4/F5/F6/F7
- **Pattern Selection:** While active, hold Step buttons (A1-B8) to select effect patterns
- **Synchronized:** All patterns sync to the 64th note resolution (32 steps per half-bar)
- **Real-time:** Effect patterns can be changed during playback
- **Multiple FX:** Multiple Master FX can be active simultaneously
- **Bypass:** Release all step buttons to bypass the effect

## Master FX 1: Gater (F1 + F4)

**Purpose:** Rhythmic amplitude gating that creates chopping, stuttering, and glitch effects

**Patterns** (16 available):

- **Pattern 0:** 32nd Note Gate (Standard 4x4 pattern)
- **Pattern 1:** 16th Note Gate (Slower rhythmic gate)
- **Pattern 2:** 64th Note Trill (Rapid fire flutter)
- **Pattern 3:** Gallop 64ths (Triplet-like gallop feel)
- **Pattern 4:** Machine Gun (Sparse 64th note hits)
- **Pattern 5:** Single 64th Click (Minimal click per beat)
- **Pattern 6:** Drop Last 32nd (Builds tension)
- **Pattern 7:** Cut Middle (Creates breaks in phrases)
- **Pattern 8:** Swing-ish 64ths (Shuffled gate pattern)
- **Pattern 9:** Skip 64ths (Skippy, syncopated)
- **Pattern 10:** Offbeat 64ths (Emphasizes off-beats)
- **Pattern 11:** Glitch A (Fast, complex glitching)
- **Patterns 12-15:** Various complex rhythmic patterns

**Usage:** Great for creating breakbeat effects, glitch textures, and rhythmic variation

## Master FX 2: Filter (F1 + F5)

**Purpose:** Rhythmic low-pass filter sweeping synchronized to sequencer steps

**Patterns** (A1-B8):

- Hold different step buttons to select different cutoff frequencies
- **Pattern 0 (A1):** Deep Bass (400 Hz)
- **Pattern 1 (A2):** Low (600 Hz)
- **Pattern 2 (A3):** Low-Mid (900 Hz)
- **Pattern 3 (A4):** Mid (1400 Hz)
- **Pattern 4 (A5):** Mid-High (2200 Hz)
- **Pattern 5 (A6):** High (3500 Hz)

- **Pattern 6** (A7): Very High (6000 Hz)
- **Pattern 7** (A8): Almost Open (10000 Hz)

**Usage:** Creates rhythmic filter movement, useful for techno-style filter sweeps and dubstep wobbles

Master FX 3: Phase/Chorus (F1 + F6)

**Purpose:** Modulation effects including flanger and chorus for stereo width and movement

**Features:**

- Dual delay lines: Flanger (512 samples, ~16ms) and Chorus (1024 samples, ~32ms)
- Stereo processing with 90° phase offset for width
- LFO modulation: Triangle, Sine, and Square waveforms
- Feedback control for resonant flanger sounds

**Usage:** Adds stereo width, creates psychedelic sweeps, thickens sounds

Master FX 4: Combo FX (F1 + F7)

**Purpose:** Combined effects for complex, layered processing

**Features:**

- Combines multiple effect types
- 16 different combination patterns
- Experimental/creative effect combinations

**Usage:** For maximum sound mangling and creative sound design

Master FX Tips

1. **Layer Effects:** Try enabling multiple Master FX simultaneously for complex textures
2. **Performance Tool:** Use Master FX as a live performance element, switching patterns in real-time
3. **Start Simple:** Begin with Gater to understand the rhythmic sync behavior
4. **Automation:** Patterns change immediately, so you can "play" the effects like an instrument
5. **Combined with Voice FX:** Master FX stack with per-voice delay/reverb sends for deep sound design

## Per-Voice LFO

Each of the 6 voices has an independent Low Frequency Oscillator (LFO) that can continuously modulate a chosen parameter in sync with the sequencer tempo.

### Overview

- **Per-voice:** All 6 voices can run independent LFOs simultaneously with different shapes, rates, depths, and targets
- **Tempo-synced:** Rate divisions (1/32 through 4BAR) are always locked to the current BPM — change the tempo and all LFOs automatically track
- **Enable/Disable:** Set **LFO DEPTH** (F1+B2 third press) to 0 to disable; any value above 0 activates the LFO
- **Saved:** All LFO settings (shape, rate, depth, target) are stored per-voice in the pattern

### Accessing LFO Parameters

1. Select a voice with **F2–F7**
2. Press **F1 + B2** to enter the LFO sub-mode group
3. Each press of F1+B2 cycles to the next sub-mode: [1]LFO SHAPE → [2]LFO RATE → [3]LFO DEPTH → [4]LFO TARGET
4. Adjust the **potentiometer** to set the parameter for the current sub-mode

### LFO Shapes

Six waveforms are available. See [F1+B2 LFO SHAPE](#) for the full table.

### LFO Rates

Eight tempo-synced divisions from 1/32 note to 4 bars. See [F1+B2 LFO RATE](#) for the full table.

### LFO Targets

Fifteen modulation targets are available, split into two categories:

- **Continuous** (PAN, TUN, DLY, RVB, EQ, FLQ, VOL, VEL): applied every sequencer pulse, creating smooth real-time movement while the voice is sounding
- **Trigger-time** (PTC, ATK, DEC, SUS, REL, SST, SEN): the LFO value is sampled once at the moment a step fires and applied as an offset to that step's value — adding expressive variation from note to note

See [F1+B2 LFO TARGET](#) for the full table with descriptions.

## Creative Uses

- **Vibrato:** Target **TUN** with SINE shape at 1/4 note rate, low depth (~15) for subtle pitch wobble
- **Tremolo:** Target **VOL** or **VEL** with TRIANGLE shape at 1/8 or 1/4 note rate
- **Auto-pan:** Target **PAN** with SINE or SAWUP shape at 1 or 2 bar rate
- **Rhythmic filter:** Target **EQ** with SQUARE shape at 1/4 or 1/8 note rate for a gating filter effect
- **Random pitch:** Target **PTC** with RNDM shape at 1/4 or 1/8 note rate for an unpredictable melody variation
- **Evolving texture:** Target **SST** with SAWUP or RNDM at 2BAR or 4BAR for slowly shifting sample start positions
- **Pumping reverb:** Target **RVB** with SAWDN at 1/4 note to duck and swell reverb with each beat

## Notes

- The LFO phase is **not** reset on each note trigger — it runs continuously against the sequencer clock, so modulation evolves independently of pattern length
- Changing LFO Rate resets the phase to keep the LFO in sync with the new division
- Trigger-time targets work entirely independently of per-step automation: if both are set for the same parameter, the automation value is used as the base and the LFO offset is added on top at trigger time

## MIDI Control

### MIDI Input

- **Port:** Serial MIDI via MIDI input connector
- **Clock Sync:** Receive MIDI clock for tempo sync
- **Sync Format:** PPQN = 48 (standard MIDI clock)

### MIDI Clock Synchronization

- **Enable:** Press Sync button to toggle MIDI sync mode
- **Disable:** Return to internal timing
- **Advantage:** Lock device to external sequencer/DAW
- **BPM Derived:** MIDI clock rate determines effective BPM

### Clock Calculation

- MIDI clock = 24 PPQN standard
- Device divides by 4 = 6 clocks per 16th note
- Step advances on every 6 MIDI clocks

## Multicore Processing

- **Dual Core:** ESP32-S3 uses both cores efficiently
  - **Core 0:** Audio processing (real-time critical)
  - **Core 1:** UI updates and file management (lower priority)
  - **Separation:** Ensures audio doesn't stutter during UI updates
- 

## Song Sequencer

The Song Sequencer lets you chain patterns into a full song arrangement — up to **128 bars** per song, each bar playing a single pattern slot.

### Overview

- **Bars:** 128 bars per song, numbered 1–128 (internally 0–127)
- **Pattern assignment:** Each bar can be assigned any of the 16 saved pattern slots (A1–A8 = patterns 1–8; B1–B8 = patterns 9–16), or left empty
- **Inheritance:** An empty bar automatically plays the pattern from the nearest preceding assigned bar (shown in lowercase on the display). This lets you repeat sections without explicitly assigning every bar.
- **Skipped bars:** If a bar has no assignment and no predecessor to inherit from, it is silently skipped
- **Auto-save:** Any change to the song sequence is saved to SD immediately

### Accessing the Song Sequencer

1. Enter **PATTERN\_SELECT** (F8+A1), **SONG\_SELECT** (F8+A2), or **BANK\_SELECT** (F8+A3)
2. Press **F8 + A4** to enter **SONG\_SEQUENCE** mode
3. The OLED switches to a 4×2 bar grid showing 8 bars per page

### Layout & Display

The OLED shows two rows of four bar cells per page (8 bars per page, 16 pages total):

B01S01          1/16

+----+----+----+----+

| A1 | A2 |[A3]| -- |

+---+---+---+---+

| a3 | a3 | b5 | -- |

+---+---+---+---+

- **Header:** Current Bank (**B##**) and Song (**S##**), and current page (**##/16**)
- **Uppercase** cell labels (e.g. **A3**, **B5**): explicitly assigned pattern
- **Lowercase** labels (e.g. **a3**): bar inherits the pattern from the preceding bar
- **--**: no assignment and no inherited pattern
- **Double border** around a cell: that bar is currently selected (cursor)
- **Filled 3×3 square** in the bottom-right of a cell: that bar is currently playing (sequencer running)

## Controls Summary

Control	Action
Pot	Navigate bars (full sweep = all 128 bars)
A1–A8	Assign pattern slot 0–7 to selected bar (press again to clear)
B1–B8	Assign pattern slot 8–15 to selected bar (press again to clear)
F1 + F2	Nudge cursor one bar left
F1 + F3	Nudge cursor one bar right
F8 (single)	Toggle sequencer play / stop
F8 (double-tap)	Rewind to bar 1 (works stopped or playing)
F8 + Pot	Adjust master volume
F2–F7	Exit Song Sequencer → return to PATTERN_SELECT

## Workflow

1. **Save your patterns** first — patterns must be saved to slots to be assignable (use PATTERN\_SELECT long-press to save)
2. **Select a bar** using the pot or F1+F2/F3 nudge
3. **Assign a pattern** by pressing a step button (A1–A8 for slots 0–7; B1–B8 for slots 8–15)

4. Move to the next bar and repeat
5. Press **F8** to play the song from the selected bar
6. Press **F8 double-tap** at any time to rewind to bar 1

## Tips

- Use **inheritance** (leave bars empty) to repeat sections without re-assigning; change one bar and all following empty bars update automatically
  - The sequencer respects pattern lengths — a 4-step pattern will loop 4 steps before the bar advances
  - MIDI clock sync works inside the Song Sequencer; bar advances happen at pattern boundaries
  - Switching songs (SONG\_SELECT) resets the song sequence and playback position
- 

## Troubleshooting

### No Audio Output

#### Check Audio Connections

- Verify stereo cables connected to audio output
- Check for loose connections on PCB
- Try different speaker/headphone system

#### Check Output Volume

- Press F8 button and adjust potentiometer to increase master volume
- Verify no voices are muted
- Check per-voice volume levels (F2-F7)

#### Reset Audio System

1. Press device reset button
2. Wait for startup sequence to complete
3. Return to play mode and test

#### I2S Configuration

- Ensure I2S pins (BCLK, LRC, DOUT) are properly soldered
- Check for continuity on audio lines with multimeter
- Verify DAC chip is seated properly

## Recording Issues

### No Sound Being Recorded

#### **Microphone Input Not Detected**

- Check INMP441 microphone connection
- Verify MIC\_SD line (GPIO 9) is soldered correctly
- Test with audible sound (clapping, talking)
- Check automatic input detection (should show "MIC" on display)

#### **Line-In Not Working**

- Verify PCM1808 ADC connections
- Check input cables from external source
- Ensure PCM1808 receives MCLK when needed
- Display should show "LIN" when detected

### Recording Cuts Off

- Pattern may be paused automatically during recording
- Maximum duration: 27.6 seconds - check recording length
- Try shorter recordings and save frequently
- Restart device if recording crashes

### Input Level Too Low

- Check external audio source volume
- Microphone may be too quiet - speak louder
- Verify input path connections
- Consider external preamp for line-in signal

## Button Not Responding

### Single Button Issue

- Check button connection on shift register PCB
- Verify shift register is properly seated
- Test with adjacent buttons to isolate problem
- Check GPIO pins (3, 4, 5) for shift register control

### Multiple Buttons Not Working

- Shift register IC may be faulty
- Verify shift register power supply

- Check clock and latch pin signals with oscilloscope
- Replace shift register IC

## Debouncing Issues

- If buttons appear to double-trigger, increase debounce delay
- Current debounce: 20ms
- Reduce sensitivity threshold if needed

## Potentiometer Issues

### Pot Not Responding

- Check analog input on GPIO 1 (POT\_PIN)
- Verify potentiometer power and ground connections
- Test with multimeter - should vary 0-4095 as turned

### Pot Too Sensitive/Insensitive

- **Too Sensitive:** Increase POT\_THRESHOLD (currently 8)
- **Insensitive:** Decrease threshold or check potentiometer condition
- **Averaging:** 8-point moving average reduces noise

### Pot Stuck or Scratchy

- May need physical cleaning
- Check solder joints on potentiometer pins
- Replace potentiometer if damaged

## Display Issues

### OLED Not Showing

- Verify I2C connections (SDA on GPIO 12, SCL on GPIO 11)
- Check OLED power supply (3.3V)
- Try I2C scan to detect OLED address
- Check contrast setting (should be adjustable in code)

### Display Flickering

- Reduce display update frequency
- Check I2C bus pull-up resistors
- Ensure stable 3.3V power supply
- Verify no EMI from audio lines

## Wrong Characters or Corrupted Display

- Check I2C clock frequency
- Verify correct OLED library version (U8g2lib)
- Confirm pin assignments are correct
- Try factory reset procedure

## LED Issues

### NeoPixels Not Lighting

- Check GPIO 10 (LED\_PIN) connection to NeoPixel data line
- Verify NeoPixel strip power supply (5V)
- Confirm data line has proper voltage levels
- Try single LED test first

### Colors Incorrect

- Check color format (RGB vs. GRB)
- Verify NeoPixel library version
- Test color values individually
- Check for electrical noise/interference

### LEDs Flickering or Dim

- Power supply may be insufficient (need robust 5V supply)
- Check power distribution on LED strip
- Add capacitor across NeoPixel power
- Reduce LED brightness if supply is limited

## SD Card Problems

### SD Card Not Detected

- Verify MMC connections (CLK, CMD, D0)
- Check SD card is properly inserted
- Confirm SD card is formatted FAT32
- Try different SD card to isolate issue

### Files Not Found

- Check file paths in pattern data
- Verify sample files are in expected directories
- Check for typos in filenames (case-sensitive)
- Rebuild file cache on device

## Saving/Loading Fails

- Verify SD card has free space
- Check write-protect tab on SD card
- Try reformatting SD card (erases data)
- Test with simple text file to verify read/write

## MIDI Problems

### MIDI Clock Not Syncing

- Check MIDI cable connections
- Verify MIDI input is set to correct serial port
- Confirm external device is sending MIDI clock
- Enable MIDI clock sync with Sync button

### Timing Drifts

- Check MIDI clock accuracy on external device
- Verify device isn't processing too much data
- Try disabling UI updates during timing-critical sections
- Reduce other processing load

### No MIDI Connection

- Check serial port configuration (Serial1)
- Verify MIDI IN connector has proper 5V pull-up
- Test with known MIDI controller
- Check MIDI library is properly initialized

## Performance Issues

### Audio Dropouts/Clicks

- Reduce number of simultaneous voices playing
- Disable reverb or delay temporarily
- Reduce UI update frequency
- Check for inefficient filter settings

### UI Sluggish/Slow

- UI updates are lower priority (Core 1)
- Audio processing is highest priority
- Reduce OLED refresh rate if possible
- Simplify display updates

## Memory Issues

- Check available PSRAM for sample storage
- Limit recording duration to available memory
- Reduce number of samples kept in memory
- Clear unused patterns/banks

## Power Issues

### Device Won't Start

- Check USB power supply (minimum 2A recommended)
- Verify power connector is properly seated
- Check for short circuits on PCB
- Try different USB cable

### Intermittent Crashes

- Power supply may be unstable (get better supply)
- Add larger capacitors across power rails
- Check for thermal issues (device hot)
- Reduce processing load

### Battery Drain (if applicable)

- Check for continuously powered peripherals
- Verify WiFi/Bluetooth disabled (enabled in code)
- Profile power consumption with multimeter
- Consider low-power modes

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## Technical Specifications

### Processing & Memory

- **Microcontroller:** ESP32-S3 Dual-Core (240 MHz each core)
- **SRAM:** Dual-port RAM for real-time audio
- **PSRAM:** 2MB total
  - Delay buffers (L+R): ~128 KB
  - Available for 16 ADPCM sample slots: ~1.88 MB
  - **Total sample duration capacity: ~123 seconds (~2 min 3 sec) across all 16 slots**
  - Average per slot: ~7.7 seconds; maximum per slot: ~27.6 seconds

- **Flash:** 4MB internal flash for firmware and default samples

## Audio Specifications

- **Sample Rate:** 32 kHz
- **Bit Depth:** 16-bit signed integer
- **Voices:** 6 polyphonic voices
- **Buffer Size:** 512 samples (16ms at 32 kHz)
- **DMA Buffers:** 8 buffers for I2S streaming
- **Maximum Recording per slot:** ~27.6 seconds (882,000 samples at 32 kHz)
- **ADPCM Compression:** 4:1 (4 bits per sample = 16 KB per second of audio in PSRAM)

## I/O Specifications

### Audio I/O

- **I2S Port:** I2S\_NUM\_0
- **Output BCLK:** GPIO 6
- **Output LRC:** GPIO 7
- **Output DOUT:** GPIO 8
- **Input DIN:** GPIO 9 (shared microphone/I2S input)
- **MCLK:** GPIO 2 (for PCM1808 when needed)

### SD Card Interface

- **Mode:** SDMMC 1-bit mode via GPIO Matrix
- **CLK:** GPIO 18
- **CMD:** GPIO 17
- **D0:** GPIO 16
- **File System:** FAT32 (up to 32GB cards supported)

### OLED Display

- **Interface:** I2C
- **SDA:** GPIO 12
- **SCL:** GPIO 11
- **Resolution:** 128x64 pixels
- **Voltage:** 3.3V

### Buttons

- **Count:** 24 buttons
- **Interface:** 74HC165 Shift Register (SPI-style)
- **Data:** GPIO 3
- **Clock:** GPIO 5
- **Latch:** GPIO 4

- **Debounce:** 20ms software debounce

## Potentiometer

- **Input:** GPIO 1 (ADC1 channel)
- **Range:** 0-4095 (12-bit ADC)
- **Threshold:** 8 steps movement to activate
- **Lock Time:** 50ms after movement

## NeoPixel LEDs

- **Count:** 16 addressable RGB LEDs
- **Interface:** Digital GPIO
- **Data Pin:** GPIO 10
- **Voltage:** 5V
- **Protocol:** WS2812B (one-wire serial)

## MIDI

- **Interface:** Serial MIDI
- **Port:** Serial1 (UART)
- **Baud Rate:** 31,250 bps (standard MIDI)
- **Clock Format:** PPQN = 48

## Effects Processing

### Delay Effect

- **Buffer Size:** 32,000 samples (1 second at 32 kHz)
- **Time Range:** 50-1000ms
- **Feedback:** Adjustable regeneration
- **Stereo:** Separate left/right processing

### Reverb Effect

- **Type:** Algorithmic (Freeverb-style)
- **Room Size:** 0-100 parameter range
- **Damping:** 0-100 parameter range
- **Decay:** Natural tail-off

### Filter

- **Type:** Multi-mode (IIR)
- **Cutoff:** 100 Hz - 16 kHz range
- **Q Factor:** 0.5-32
- **Fixed-Point Math:** Q8.24 format for precision

## Bit Crusher

- **Bit Depth:** 0-16 bits adjustable
- **Sample & Hold:** Optional sample rate reduction
- **Aliasing:** Intentional digital artifacts

## Synchronization

### Internal Timing

- **Base Clock:** Microsecond-resolution timer
- **Quantization:** PPQN = 48 for 16th note steps
- **Tempo Range:** 30-300 BPM
- **Resolution:** Floating-point pulse timing

### MIDI Sync

- **Standard:** 24 PPQN (6 clocks per 16th note)
- **Derivation:** Automatically calculates BPM from clock rate
- **Jitter:** Minimized through high-resolution timing

## Performance Targets

- **Audio Loop Time:** < 5ms (Real-Time Critical)
  - **UI Update Time:** < 100ms (Low Priority)
  - **Display Refresh:** ~60Hz (16.7ms interval)
  - **Button Response:** < 50ms (with debounce)
- 

## Appendix

### Default Key Bindings Summary

Control	Function	Range/Options
F2-F7	Voice Select	6 voices (F2=V1, F3=V2, F4=V3, F5=V4, F6=V5, F7=V6)
F2-F7 (double tap)	Mute/Unmute Voice	Toggle mute for each voice
F2-F7 + Pot	Voice Volume	0-127 per voice

<b>Control</b>	<b>Function</b>	<b>Range/Options</b>
A1-B8	Step Select/Toggle	16 sequencer steps (toggle sample on/off)
F1 + A1	Sample Select (SMP)	Choose sample 1-16 for this voice
F1 + A2	Sample Pitch (PTC)	Transpose pitch in semitone steps
F1 + A3	Tuning (TUN)	Fine-tune pitch
F1 + A4	Sample Velocity (VEL)	Set note velocity 0-255
F1 + A5	Sample Pan (PAN)	Stereo pan 0 (L) - 127 (C) - 255 (R)
F1 + A6	Delay Send (DSND)	Per-voice delay send 0-255
F1 + A7	Reverb Send (RSND)	Per-voice reverb send 0-255
F1 + A8	Volume (VOL)	Per-voice volume 0-255
F1 + B1	Sample Start (SST)	Sample playback start point
F1 + B2	Sample End (SEN)	Sample playback end point
F1 + B3	Sample Mode (MOD)	SINGLE / SL 16 / SL TRS
F1 + B4	Slice Select (SLC)	Assign slice to steps
F1 + B5	Attack (ATC)	Per-step amplitude attack time
F1 + B6	Nudge (NDG)	Reserved — not yet implemented
F1 + B7	Trigger Mode (TRG)	Per-step trigger type (FWD / REV / LOOP)
F1 + B8	Condition (CON)	Step trigger condition (9 options)
F8 + A1-B8	Select Master Mode	Modes 16-31 (global parameters)

Control	Function	Range/Options
F1 + F2	Decrease Parameter	Fine adjustment (decrement)
F1 + F3	Increase Parameter	Fine adjustment (increment)
F1 + F4	Toggle Gater FX	Master FX 1 (rhythmic gating)
F1 + F5	Toggle Filter FX	Master FX 2 (rhythmic filter)
F1 + F6	Toggle Phase FX	Master FX 3 (flanger/chorus)
F1 + F7	Toggle Combo FX	Master FX 4 (combined effects)
F1 + F8	Enter Recording Mode	Record from mic or line-in
F8 (release)	Play/Pause/Reset	Toggle sequencer playback
F8 + Pot	Master Volume	0-100% overall output
F8 (in SAMPLE_SELECT)	File Browser	Load samples from SD card
F2-F7 + A1-B8	Quick Sample Assign	Set default sample for voice
Potentiometer	Adjust Parameter	Current mode's parameter

## Glossary of Terms

**ADPCM:** Adaptive Differential PCM - compressed audio format for sample storage **BPM:** Beats Per Minute - sequencer tempo measurement **DAC:** Digital-to-Analog Converter - converts digital audio to analog signal **DMA:** Direct Memory Access - high-speed data transfer without CPU intervention **I2S:** Inter-IC Sound - digital audio interface standard **MIDI:** Musical Instrument Digital Interface - protocol for music data control **PPQN:** Pulses Per Quarter Note - MIDI clock resolution (48 on this device) **Q-Factor:** Filter resonance/peak sharpness at cutoff frequency **Swing:** Rhythmic timing offset for alternate steps (shuffle feel) **Velocity:** Note volume/loudness per step (0-255 range)

## Safety & Maintenance

### Electrical Safety

- Device runs on low-voltage DC power
- Never attempt repair while powered
- Avoid static electricity when handling electronics
- Do not expose to water or moisture

## Audio Signal

- Keep audio cables away from power supplies
- Shield audio lines from RF interference
- Ensure proper grounding of audio equipment
- Avoid audio feedback by monitoring speaker volume

## Storage

- Store in cool, dry location (avoid humidity)
- Protect from physical damage and impacts
- Do not store with magnetic objects
- Backup important patterns to SD card regularly

## Firmware Updates

- Check project repository for latest firmware
- Always backup patterns before updating
- Follow update procedure carefully to avoid corruption
- Test on new firmware with simple pattern first

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## Support & Resources

For additional help, questions, or bug reports:

- Check the project repository documentation folder
- Review code comments in source files for technical details
- Test individual components in isolation if troubleshooting
- Keep backups of important patterns and samples on SD card

**Enjoy your MYNAH Audio Sampler!**

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*Last Updated: March 2, 2026 Manual Version: 2.1 Firmware Version: Current (with Master FX support)*