EXHAUSTIVE USER GUIDE

ManQ-PsyGate Engineering Reference

Complete Reference Manual & Parameter Guide for PsyGate v0.1.0

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1. System Architecture & Real-Time Safety Principles

ManQ-PsyGate is engineered from the ground up in native **Rust** as a zero-compromise real-time audio instrument. Built with the `nih-plug` framework and hardware-accelerated `egui` rendering, it provides extreme low-latency performance on modern 64-bit operating systems.

Core Real-Time Audio Constraints

Audio thread dropouts and jitter are catastrophic in live performance and heavy DAW arrangements. PsyGate adheres strictly to the four golden rules of real-time audio safety:

- **Zero Heap Allocation on Audio Thread:** No `Vec`, `Box`, `String`, or heap allocations occur inside `Plugin::process()`. All internal delay lines, Bezier lookup tables, and filter state buffers are pre-allocated during plugin instantiation.
- **Zero Thread Blocking:** Mutex locks, Read-Write locks, thread sleeping, file I/O, and disk logging are completely banished from the audio thread. Thread synchronization occurs exclusively via lock-free atomic arrays (`AtomicF32`, `AtomicBool`, `AtomicU32`).
- **Mandatory Parameter Smoothing:** All continuous host-automatable parameters are processed through 20 ms S-curve exponential smoothers, completely preventing zipper noise, pops, and DC clicks during aggressive DAW automation sweeps.
- **Zero-Latency DSP:** PsyGate reports 0 samples of internal lookahead latency to the host DAW, ensuring seamless integration with live MIDI controllers and multi-track audio bus inserts.

Figure 1.0: Master chassis interface architecture. Top dock header houses the preset browser, navigation tab bar, and UI scaling engine.

2. Master Chassis Layout & Navigation Controls

The user interface follows the unified ManQ Chassis Framework, organized into four primary functional docks:

Chassis Area	Screen Zone	Included Modules & Interactivity
Master Header Dock	Top Strip	Brand emblem, Preset Selector (with mandatory `INIT DEFAULT`), UI Scale Selector (75% to 200%), Main Workspace / Modulation Matrix Tab Bar, Master Output Gain & Mute, and Drawer View Toggles.
Central Synthesis Panel	Center View	64-Step Multi-Lane Sequencer Canvas, Lane Selector Tabs, Generative Mutation Tools, Filter Cutoff/Resonance/Drive/Slope dials, and Real-time Excursion Visualizer.

Chassis Area	Screen Zone	Included Modules & Interactivity
Bottom Modulator Drawer	Bottom Dock	Dynamic 8-slot modular rack housing LFOs, MSEGs, Chaos Attractors, Envelope Followers, and Sample & Hold modules with real-time vector oscilloscopes.
Contextual Inspector	Right Column	Focus-driven parameter diagnostics, exact floating-point OLED displays, value nudge steps (+/-0.1%, +/-1%, +/-5%), and active modulation route mappings.

3. 6-Lane Multi-Metric Step Sequencer Grid

The central sequencer engine allows editing up to 64 steps across 6 dedicated, parallel parameter lanes. Each lane operates with an independent loop length (2 to 64 steps), enabling complex polyrhythmic and polymetric phasing cycles that never repeat identically.

Lane Name	Range / Units	DSP Action & Routing
Gate / Vel	0% to 100%	VCA amplitude envelope gating. Lower edge contains a dedicated **Tie Indicator** (_ / ⌒) for binding adjacent steps into continuous legato notes.
Cutoff	20 Hz to 20 kHz	Step-sequenced analog filter cutoff frequency modulation with adjustable bipolar envelope depth.
Pan	-100% to +100%	Step-sequenced stereo balance placement using constant-power panning laws.
Drive	0% to 100%	Per-step harmonic saturation drive feeding into the analog non-linear filter core.
Pitch	-24 to +24 st	Monophonic pitch transposition with musical chromatic quantization for arpeggiated melodic sequences.

Lane Name	Range / Units	DSP Action & Routing
Probability	0% to 100%	Deterministic step trigger likelihood. At 100%, the step always triggers; at 50%, it acts as a generative coin-toss.

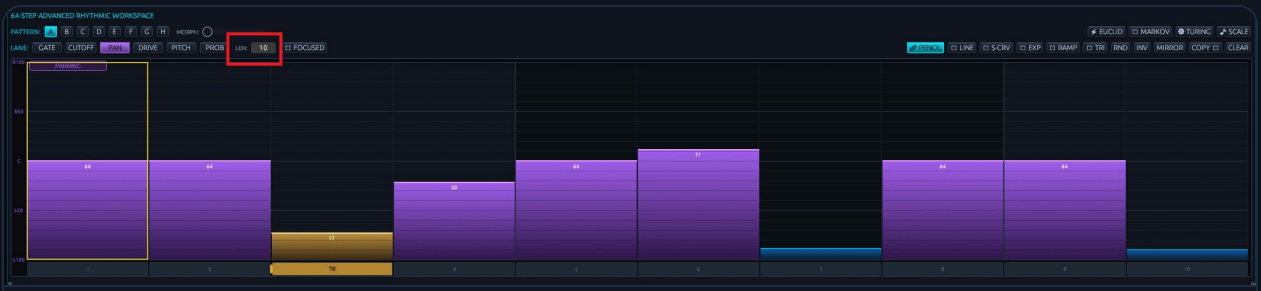

Figure 3.1: Polyrhythmic multi-lane sequencer workspace displaying independent step lengths and per-lane modulation curves.

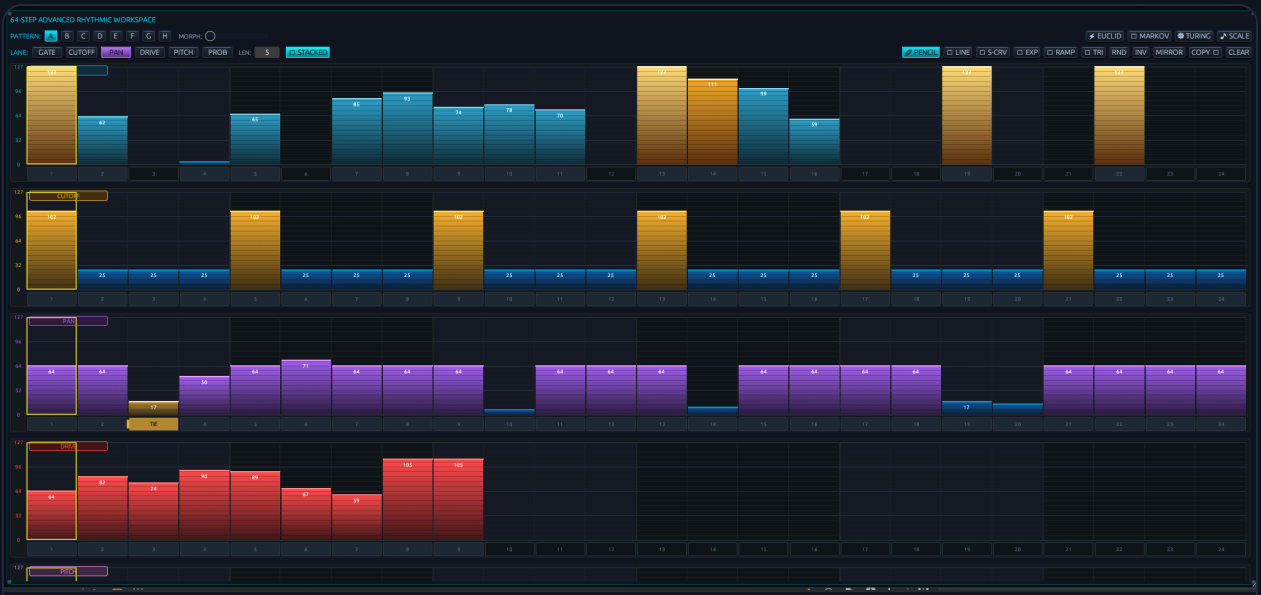

Figure 3.2: Detailed multi-lane editor view showing velocity levels, legato tie nodes, and real-time step playhead tracking.

🖱️ Sequencer Mouse Gestures

- `Left Click + Drag`: Paint step velocity/level values smoothly across multiple steps.
- `Right Click on Step`: Toggles step active state (0% to 100%).
- `Click on Step Bottom Bar`: Toggles **Legato Tie** with the subsequent step.

- `Shift + Drag`: Precision fine-adjustment mode (+/-0.1%).

4. Algorithmic Generators & Generative Mutation Toolbar

Directly above the step sequencer grid sits the Generative Mutation Toolbar, providing instant mathematical transformations of the active pattern lane:

- 🎲 **Randomize:** Generates musically weighted random velocity curves constrained to rhythmic sub-grids.
- 🔁 **Invert:** Flips the step values vertically across the center axis.
- ◀ **Shift / Shift ▶:** Circularly rotates the active pattern one step backward or forward in time.
- 🌊 **Euclidian Generator:** Evenly distributes pulses across the active lane length using the Euclidean algorithm.
- 🧬 **Turing Machine Shift Register:** Generates evolving, semi-repeating probabilistic sequences based on linear-feedback shift register (LFSR) entropy with controllable lock/mutate rates.
- **Markov Groove:** Generates organic velocity accents based on transition probability matrices modeled from real human rhythm performances.
- 🧹 **Clear:** Resets all steps in the active lane to clean zero baseline.

5. Zero-Delay Feedback (ZDF) Multi-Mode Filter & Saturation Core

PsyGate includes a zero-delay feedback (ZDF) state-variable filter modeled after classic analog synthesizer ladders and circuits:

Filter Type	Available Slopes	Characteristics & Sonic Profile
Low-Pass (LP)	6, 12, 24, 36, 48 dB/Oct	Warm analog roll-off with self-oscillating resonance peak for deep psytrance squelches.
High-Pass (HP)	6, 12, 24, 36, 48 dB/Oct	Cuts sub frequencies and mud, allowing rhythmic gating of sparkling top-end transients.
Band-Pass (BP)	12, 24, 36 dB/Oct	Isolates a focused frequency band for telephone, radio, and laser-like rhythmic sweeps.
Notch	12, 24 dB/Oct	Surgically scoops a narrow notch, creating sweeping phaser-style hollow textures.
Peak	12, 24 dB/Oct	Resonant parametric boost that highlights specific musical harmonics.
Formant Vowel	A-E-I-O-U Morph	Dual parallel vocal resonator filters producing robotic, talking vowel sweeps.

6. Universal Cross-Point Modulation Matrix & Transfer Curves

Navigating to the ⚡ `MODULATION MATRIX` tab exposes the master cross-point grid routing any of the 8 modular sources to all synthesis targets.

Figure 6.1: Universal Modulation Matrix cross-point grid with real-time animated excursion needles, depth percentage readouts, and neon transfer shape selectors.

Cross-Point Socket Controls

- **Top Dial Region:** Left-drag vertically to adjust bipolar modulation depth (-100% to +100%). Single left-click toggles route active state (+50% / 0%). Double-click resets to 0%. Right-click opens the contextual transfer menu.
- **Bottom Dedicated Curve Button:** Single left-click instantly cycles through the 6 mathematical transfer curves with dedicated neon color badges:

Curve Acronym	Formula Shape	Behavior & Sonic Result
LIN ∿	Linear 1:1	**Linear 1:1:** Direct proportional transfer. Output tracks the modulator value linearly.
EXP ²	Cubic Exponential (x^3)	**Exponential:** Soft, subtle response at low levels with sudden, intense peak punches. Ideal for snappy percussive envelopes.
LOG √	Cube Root (x^0.33)	**Logarithmic:** Instantaneous attack rise that dwells in a broad upper plateau. Ideal for rapid gate opening and sustained body.

Curve Acronym	Formula Shape	Behavior & Sonic Result
SIG	Hermite S-Curve	**Sigmoid S-Curve:** Dwells quietly at minimum, executes a sudden transitional jump across the center threshold, and clamps at maximum.
ST4	Quantized 4-Step	**Stepped 4-Level:** Quantizes the continuous modulation signal into 4 discrete staircase steps (0%, 33%, 66%, 100%).
ST8	Quantized 8-Step	**Stepped 8-Level:** Quantizes the modulation signal into 8 rhythmic micro-steps for retro sample-and-hold stepping.

7. Bitwig-Style Modular Drawer & Deep Studio Popups

The bottom drawer houses up to 8 dynamic modulator slots. Clicking `+ ADD MODULATOR` allows inserting any generator type:

- **Wave Morph LFO:** Multi-waveform oscillator (Sine, Triangle, Saw, Square, Exponential, Random Sample & Hold) with pulse-width modulation, phase offset, and tempo sync (4/1 to 1/64).
- **MSEG (Multi-Segment Envelope):** Vector spline curve editor with drag-and-drop Bezier curvature tension nodes, looping sustaining regions, reverse, normalize, and smoothing tools.
- **Chaos Attractor:** Non-linear deterministic dynamical systems based on Lorenz, Rossler, and Duffing equations for organic, never-repeating modulation drift.
- **Envelope Follower:** Sidechain-capable peak amplitude tracker with independent Attack (0.5 to 500 ms) and Release (5 to 2000 ms) ballistics.

- **Sample & Hold / Slew:** Clock-sampled noise with variable slew limiter rate for smooth organic drifting or stepped glides.

8. Contextual Parameter Inspector & High-Precision Diagnostics

Clicking any knob or slider across the interface immediately focuses the parameter inside the **Right Inspector Column**:

- **OLED Numerical Readout:** High-precision numerical value display in exact musical units (Hz, dB, ms, %, st).
- **Value Nudge Strip:** Instant step increment/decrement buttons (+/-0.1%, +/-1.0%, +/-5.0%).
- **Modulation Mapping List:** Lists every modulator actively routed to the focused parameter with individual depth meters and quick mute toggles.
- **Host DAW Automation:** All primary macro parameters are registered as native 64-bit automatable DAW parameters. Pattern banks (A–H) can be automated seamlessly via the host parameter `pattern_bank`.

9. Preset Management Architecture & Pattern Banks (A–H)

PsyGate features an integrated bank of 8 in-memory pattern memory slots (A–H). Producers can switch instantly between different rhythmic variations during a live performance or drop. To avoid host freezes and DAW undo flooding, individual step cells are stored in fast in-memory buffers while the active pattern bank is exposed as the automatable parameter `pattern_bank` (0 to 7).

Every preset library includes a mandatory `INIT DEFAULT` state to restore all engine controls to clean baseline defaults.

10. Inter-Plugin Communication Bus (IPC) & Channel Synchronization

PsyGate incorporates a global lock-free 16-channel Inter-Plugin Communication (IPC) bus. When multiple ManQ plugins are loaded across different tracks in a DAW project, assigning them to the same IPC Channel (1 to 16) allows:

- **Shared Transport Coordinates:** Exact beat position and sub-sample tempo synchronicity.
- **Cross-Plugin Envelope Following:** Track 1 (e.g. Kick Drum) can broadcast its audio envelope follower into Channel 1, allowing PsyGate on Track 2 (e.g. Synth Pad) to duck or gate automatically without complex DAW sidechain routing.

11. Audio Specifications, Host Automation Etiquette & Safety Invariants

Specification	Value / Rating	Operational Notes
Latency	0 Samples (Zero-Latency)	Fully zero-latency operation. Safe for live stage performance and real-time tracking.
Sample Rate Support	44.1 kHz to 192.0 kHz	Internal filters automatically compensate and re-scale coefficient cutoff calculations.

Specification	Value / Rating	Operational Notes
Parameter Smoothing	20 ms S-Curve Ramp	All continuous automatable parameters are filtered with lock-free smoothers to eliminate zipper noise.
Inter-Plugin Bus (IPC)	16 Shared Global Channels	PsyGate can broadcast or receive tempo, gate triggers, and modulation envelopes from other ManQ plugin instances across the same project.