Enhanced 4-Oscillator Psy Trance Synthesizer

Complete Feature Documentation v1.0

PDF-Ready Version with Interface Screenshots

Interface Overview

The synthesizer features a professional dark-themed interface with bright green accents, optimized for studio environments and long production sessions. The main interface consists of several key sections:

Main Interface Layout (Current Version Screenshot)

Top Control Bar:

- Four oscillator enable buttons (OSC1-4) with visual status indicators
- Sync OSCs toggle for oscillator mixing mode
- Master Pitch control slider (-8 to +8 semitones)
- BPM control (60-200) with current value display
- Envelope trigger/release controls for all oscillators
- Audio engine start/stop controls
- Real-time visualization toggles (Filter Spectrum, Oscilloscope)

Preset Management Section:

- Available presets list with scroll capability showing:
    - Danger, forest, leadbreaksecret, Psybreaksecret, Psybreak, Deep presets
- Load Preset, Delete, Info, Refresh control buttons
- Save New Preset input field and save button

Negative Matrix (Modulation System):

- Source selection dropdown (None, LFO1-4)
- Target parameter selection with comprehensive routing options
- Amount control slider with bipolar range (-100% to +100%)
- Reset All button for clearing modulation connections

Real-Time Visualization:

- **Left Panel - Oscilloscope:** Live waveform display showing signal amplitude over time
- **Right Panel - Filter Spectrum:** Real-time frequency response analysis with cutoff frequency markers

Oscillator Control Tabs:

- Four individual tabs (OSC 1-4) for detailed parameter control
- Currently showing OSC 1 with comprehensive parameter sections:
    - Waveform selection (Sine currently selected)
    - Frequency control (271 Hz shown)
    - Filter type (Lowpass selected)
    - Cutoff frequency control
    - Resonance control
    - ADSR Envelope with Trigger/Release buttons
    - Delay section with On/Off toggle
    - LFO controls with mode selection
    - Extended parameter sections (scrollable interface)

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System Architecture

The Enhanced Psy Trance Synthesizer is a comprehensive 4-oscillator digital synthesizer specifically designed for psytrance production. It features advanced modulation capabilities, psychedelic effects, real-time visualization, and a complete preset management system.

Key Features

- **4 Independent Oscillators** with full parameter control
- **Advanced Modulation Matrix** (Negative Matrix by Gabriel Trentini)
- **Comprehensive Psy Effects Suite** (Distortion, Chorus, Gate, FM, Noise)
- **Real-time Audio Visualization** (Oscilloscope & Filter Spectrum)
- **Complete Preset Management System**
- **Professional ADSR Envelopes**
- **Multi-mode Filters**
- **Synchronized LFOs and Arpeggiators**

Audio Engine

- **Sample Rate**: 44.1 kHz (configurable)
- **Bit Depth**: 32-bit float processing
- **Buffer Size**: 512 samples
- **Latency**: ~12ms (depending on system)
- **Channels**: Mono output (expandable)

Dependencies

- **NumPy**: DSP and mathematical operations
- **SciPy**: Advanced filter design
- **sounddevice**: Real-time audio I/O
- **tkinter**: GUI framework
- **matplotlib**: Real-time visualization
- **json**: Preset data storage

Master Controls

Global Parameters

Control	Range	Function
Master Pitch	-8 to +8 semitones	Global pitch shift for all oscillators
BPM	60-200	Master tempo for sync functions
Sync OSCs	On/Off	Mix all enabled oscillators vs single osc

Oscillator Enable/Disable

- **OSC1-4 Buttons**: Individual oscillator on/off
- **Visual Feedback**: Green buttons indicate active oscillators
- **CPU Optimization**: Disabled oscillators don't consume processing

Envelope Controls

- **Trigger All**: Activate ADSR attack phase for all enabled oscillators
- **Release All**: Force release phase for all oscillators
- **Individual Triggers**: Per-oscillator envelope control available in tabs

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Preset Management

Core Functions

Function	Description
Save Preset	Store complete synthesizer state
Load Preset	Restore saved configuration
Delete Preset	Remove preset file
Preset Info	View metadata and details
Refresh List	Update available presets

Preset Data Structure

Each preset contains:

- **Oscillator Settings**: Waveforms, frequencies, filters
- **ADSR Parameters**: Attack, Decay, Sustain, Release
- **Effect Configurations**: All psy effects settings
- **Modulation Connections**: Complete modulation matrix
- **Master Settings**: BPM, pitch shift, sync mode
- **Metadata**: Name, version, timestamp

Storage Format

- **File Format**: JSON
- **Location**: /presets/ directory
- **Naming**: {preset_name}.json
- **Versioning**: Built-in version tracking
- **Backup**: Manual file system backup recommended

Available Presets (Current Session)

The interface shows several example presets:

- **Danger**: Aggressive psytrance preset
- **forest**: Organic forest psy textures
- **leadbreaksecret**: Lead breakbeat combination

- **Psybreaksecret**: Psychedelic breakbeat fusion
- **Psybreak**: Standard psy-break template
- **Deep**: Deep progressive psytrance

Modulation Matrix (Negative Matrix)

Architecture

The modulation system allows any LFO to modulate multiple parameters simultaneously.

Sources

- **LFO1-4**: Individual LFO outputs from each oscillator

Targets

For each oscillator (OSC1-4):

- **FREQ**: Frequency modulation
- **CUTOFF**: Filter cutoff modulation
- **RESONANCE**: Filter resonance modulation
- **DELAY_TIME**: Delay time modulation
- **DELAY_AMOUNT**: Delay feedback modulation

Configuration

Parameter	Range	Effect
Source	LFO1-4, None	Modulation source selection
Target	Parameter list	Destination parameter
Amount	-100% to +100%	Modulation depth and polarity

Advanced Features

- **Bipolar Modulation**: Negative values invert modulation
- **Multiple Connections**: One source can modulate multiple targets
- **Real-time Updates**: Changes apply immediately

- **Preset Integration**: Modulation states saved with presets

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Oscillator Engine

Core Architecture

Each of the 4 oscillators is a complete synthesis engine with:

A. Waveform Generation

Waveform	Characteristics	Use Cases
Sine	Pure fundamental frequency	Bass, FM carrier
Saw	Rich harmonic content	Lead synth, aggressive sounds
Square	Odd harmonics only	Retro sounds, sub bass
Triangle	Softer than saw	Mellow leads, pads
Sample&Hold	Random stepped values	Glitch effects, modulation

B. Frequency Control

- **Range**: 50Hz - 5kHz
- **Resolution**: 1Hz steps
- **Modulation**: LFO and manual control
- **Octave Shift**: ±4 octaves per oscillator
- **Master Pitch**: Global transpose

C. Oscillator Mixing

- **Individual Mode**: Only first enabled oscillator plays
- **Sync Mode**: All enabled oscillators mixed equally
- **Phase Coherent**: Oscillators maintain phase relationships

Current Interface Example (OSC 1)

- **Waveform**: Sine wave selected
- **Frequency**: 271 Hz

- **Filter Type**: Lowpass
- **Cutoff**: Adjustable with real-time visual feedback
- **Resonance**: 1.5 setting shown

ADSR Envelope

Parameters

Stage	Range	Function
Attack	1-5000ms	Time to reach full amplitude
Decay	1-5000ms	Time to fall to sustain level
Sustain	0-100%	Held amplitude level
Release	1-5000ms	Time to fade to silence

Interface Features

- **Individual Triggers**: Trigger and Release buttons per oscillator
- **Global Control**: Master Trigger All and Release All
- **Visual Feedback**: Real-time envelope shape in oscilloscope
- **Preset Integration**: All envelope settings saved with presets

Behavior

- **Linear Segments**: Predictable, musical response
- **Retriggerable**: New notes restart attack phase
- **Gate Dependent**: Sustain held while triggered
- **CPU Efficient**: Optimized mathematical implementation

Filter System

Filter Types

Type	Response	Frequency Range
Lowpass	Removes frequencies above cutoff	100Hz-8kHz
Highpass	Removes frequencies below cutoff	100Hz-8kHz
Bandpass	Allows narrow frequency band	100Hz-8kHz
Notch	Removes narrow frequency band	100Hz-8kHz
Comb	Multiple notches/peaks	100Hz-8kHz

Real-time Visualization

The Filter Frequency Response panel shows:

- **Live frequency response curve** in bright green
- **Cutoff frequency markers** for each active oscillator
- **dB scale** from -60dB to +6dB
- **Logarithmic frequency axis** from 10Hz to 22kHz
- **Color-coded oscillator indicators**

Parameters

- **Cutoff Frequency**: Primary filter control with visual feedback
- **Resonance**: 0.1-2.0, adds emphasis at cutoff
- **Modulation**: LFO and real-time control
- **Response**: 2nd-order Butterworth design

Psy Effects Suite

J. Psy Distortion

Advanced waveshaping for harmonic enhancement.

Types

- **Soft**: Tanh-based, musical saturation
- **Hard**: Hard clipping, aggressive sound

- **Tube**: Exponential curve, warm overdrive

Parameters

- **Drive**: 1.0-10.0 intensity control
- **Type**: Waveshaping algorithm selection

K. Psy Chorus

Multi-voice modulated delay for spacious sounds.

Parameters

Parameter	Range	Effect
Mix	0-100%	Wet/dry balance
Rate	0.1-5.0 Hz	LFO modulation speed
Depth	0-100%	Modulation intensity

Technical Features

- **3 Voices**: 120° phase-offset LFOs
- **Variable Delays**: 10ms, 13ms, 16ms base
- **Smooth Modulation**: Sinusoidal LFO

L. Psy Gate

Rhythmic amplitude modulation synchronized to BPM.

Parameters

- **Depth**: 0-100% gate intensity
- **Rate**: 1-32 (note divisions)
- **Pattern**: 16-step pre-programmed sequence

Pattern

[1,0,1,0, 1,0,1,1, 1,0,1,0, 1,1,0,1]

Full-on style psytrance gate pattern.

M. FM Synthesis

Frequency modulation for complex timbres.

Parameters

- **Amount**: 0-100% modulation depth
- **Ratio**: 0.1-8.0 carrier:modulator ratio

N. Forest Noise

Random burst generator for organic textures.

Parameters

- **Amount**: 0-100% noise level
- **Characteristics**: Short random bursts

LFO System

Architecture

Each oscillator includes an independent LFO with:

Interface Controls (Current Example)

- **LFO On/Off**: Toggle button with status indication
- **Mode Selection**: Hz/Sync dropdown menu
- **Rate Control**: 0.2 Hz shown in current interface
- **Sync Division**: Dropdown for tempo sync options
- **Depth Control**: Percentage-based modulation intensity

Modes

- **Hz Mode**: Direct frequency control (0.1-20 Hz)
- **Sync Mode**: Tempo-synchronized to master BPM

Sync Divisions

- **1/1**: Whole notes (very slow)
- **1/2**: Half notes
- **1/4**: Quarter notes (typical)

- **1/8**: Eighth notes
- **1/16**: Sixteenth notes (fast)

Delay Effects

Architecture

Per-oscillator digital delay with feedback control.

Interface Controls (Current Example)

- **Delay On/Off**: Toggle button with visual status
- **Amount Control**: 50% shown in current interface
- **Time Control**: 300ms delay time displayed

Parameters

Parameter	Range	Function
On/Off	Toggle	Delay enable/disable
Amount	0-100%	Feedback/wet level
Time	10-1000ms	Delay duration

Applications

- **Echo Effects**: Long delays, low feedback
- **Doubling**: Short delays (10-50ms)
- **Reverb Simulation**: Multiple short delays
- **Rhythmic Effects**: BPM-synchronized delays

Visualization Tools

Real-time Oscilloscope

The left visualization panel provides advanced waveform analysis:

Current Display Features

- **Time Domain**: Live signal waveform
- **Green Trace**: High-contrast signal visualization
- **Grid Overlay**: Precise amplitude and time reference
- **Amplitude Scale**: ±1.0 full-scale range
- **Time Base**: Millisecond precision (0-25ms shown)

Technical Specifications

- **Buffer Size**: 1024 samples (~23ms at 44.1kHz)
- **Update Rate**: 20 Hz refresh
- **Resolution**: Full 32-bit float precision

Filter Spectrum Analyzer

The right visualization panel shows real-time frequency analysis:

Current Display Features

- **Frequency Response**: Live filter curve visualization
- **OSC1 Cutoff Marker**: Red line at 1017Hz (current example)
- **Logarithmic Scale**: 10Hz to 22kHz frequency range
- **dB Scale**: -60dB to 0dB magnitude range
- **Professional Styling**: Dark theme with bright green trace

Color Coding

- **OSC1**: Red cutoff marker
- **OSC2**: Blue cutoff marker
- **OSC3**: Orange cutoff marker
- **OSC4**: Purple cutoff marker
- **Combined Response**: Bright green curve

Arpeggiator

Core Function

Automatic note sequence generation with customizable patterns.

Control Interface

- **Arp On/Off**: Toggle button with status indication
- **Mode Selection**: Hz/Sync dropdown
- **Rate Control**: Adjustable step rate
- **Sync Division**: Tempo subdivision selection

Pattern Programming

8-step sequence with per-step control:

- **Semitone Offset**: -24 to +24 per step
- **Octave Transpose**: -4 to +4 per step
- **Visual Layout**: Horizontal step arrangement
- **Real-time Updates**: Changes apply immediately

Interface Navigation

Tabbed Interface

The synthesizer uses a clean tabbed interface for oscillator control:

- **OSC 1-4 Tabs**: Individual oscillator parameter pages
- **Scrollable Content**: Full parameter access via scroll bars
- **Consistent Layout**: Standardized control arrangement
- **Visual Grouping**: Logical parameter organization

Control Sections (Per Oscillator Tab)

1. **A. Waveform**: Wave type selection
2. **B. Frequency**: Pitch control
3. **C. Filter Type**: Filter algorithm selection
4. **D. Cutoff Frequency**: Filter frequency control
5. **E. Resonance**: Filter emphasis control

6. **F. ADSR Envelope**: Complete envelope controls
7. **G. Delay**: Echo/feedback effects
8. **H. LFO**: Low-frequency oscillator controls
9. **I-N. Extended Parameters**: Advanced synthesis controls

Performance and System Requirements

Minimum System Requirements

- **OS**: Windows 7+, macOS 10.12+, Linux (Ubuntu 18.04+)
- **Python**: 3.7 or higher
- **RAM**: 512MB available memory
- **CPU**: Dual-core 2.0GHz minimum
- **Audio**: Any sounddevice-compatible audio interface
- **Display**: 1600x1000 minimum resolution

Recommended Specifications

- **CPU**: Quad-core 3.0GHz+ for multiple oscillators
- **RAM**: 2GB+ for smooth operation
- **Audio**: Professional audio interface for low latency
- **Display**: 1920x1080+ for optimal interface scaling

Performance Optimization

- **CPU Usage**: Typically 5-15% on modern systems
- **Latency**: 10-15ms with proper audio drivers
- **Memory**: Efficient buffer management
- **Real-time Priority**: Audio thread optimization

Workflow and Production Tips

Getting Started

1. **Enable Oscillators**: Click OSC buttons to activate desired oscillators
2. **Select Waveforms**: Choose appropriate wave types for your sound
3. **Set Frequencies**: Tune oscillators to musical intervals
4. **Configure Filters**: Set cutoff and resonance for desired timbre
5. **Shape Envelopes**: Adjust ADSR for musical expression
6. **Add Effects**: Apply psy effects for character
7. **Save Presets**: Store successful configurations

Psytrance Production Workflow

1. **Bass Foundation**: Use OSC1 with saw wave, lowpass filter
2. **Lead Synthesis**: High-frequency content with filter sweeps
3. **Rhythmic Elements**: Gate effects synchronized to BPM
4. **Texture Layers**: Forest noise and chorus for atmosphere
5. **Movement**: LFO modulation for dynamic interest

Advanced Techniques

- **Filter Automation**: Use LFO to cutoff for classic sweeps
- **Polyrhythms**: Different arpeggiator rates on multiple oscillators
- **Harmonic Layering**: Octave-related frequencies across oscillators
- **Effects Chains**: Combine multiple psy effects for complex textures

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Troubleshooting Guide

Common Issues and Solutions

Audio Problems

- **No Sound Output**: Check Start button, verify audio device selection
- **Audio Distortion**: Reduce oscillator levels, check for clipping
- **High Latency**: Adjust audio buffer settings, use ASIO drivers
- **Dropouts**: Close unnecessary applications, increase buffer size

Interface Issues

- **GUI Lag**: Disable visualizations when not needed
- **Control Response**: Restart application if controls become unresponsive
- **Display Problems**: Check minimum resolution requirements
- **Tab Navigation**: Use mouse wheel for scrolling in oscillator tabs

Preset Issues

- **Load Failures**: Verify file integrity and permissions
- **Save Problems**: Check write access to presets directory
- **Missing Presets**: Use Refresh button, verify file locations
- **Corrupted Data**: Restore from backup or recreate preset

Performance Optimization

- **High CPU Usage**: Disable unused oscillators and effects
- **Memory Issues**: Restart application periodically for cleanup
- **Real-time Performance**: Close visualization windows during recording

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File Management

Preset Organization

- **Directory Structure**: Organized in /presets/ folder
- **File Format**: Human-readable JSON format
- **Naming Convention**: Descriptive names recommended
- **Backup Strategy**: Regular folder backups recommended

Data Portability

- **Cross-Platform**: Presets work across Windows, macOS, Linux
- **Version Compatibility**: Forward and backward compatibility planned
- **Sharing**: Easy preset sharing via file exchange
- **Collaboration**: JSON format enables easy editing and merging

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Future Development

Planned Enhancements

- **MIDI Integration**: Hardware controller support
- **Additional Waveforms**: Custom wavetable support
- **Extended Effects**: Reverb, phaser, flanger
- **Pattern Sequencer**: Multi-bar pattern programming
- **Audio Export**: Direct WAV file rendering

Technical Improvements

- **Multi-threading**: Enhanced real-time performance
- **VST Plugin**: DAW integration capability
- **Mobile Versions**: iOS/Android adaptation
- **Network Features**: Multi-device synchronization

Documentation Version 1.0 - Enhanced 4-Oscillator Psy Trance Synthesizer
Created by Gabriel Trentini - NEGATIVE MATRIX
Interface Screenshot: Current Working Version