■ SeamlessStep Engine v2.2 (SSE v2.2)

Real-time ADX v2.2 step-streaming playback core for Nano Ardule Drum System

Definition
SeamlessStep Engine v2.2 (SSE v2.2) is a lightweight real-time playback engine designed for the Nano Ardule Drum System. It streams ADX v2.2 (ADT / ADP) pattern data directly from SD storage while maintaining seamless transitions between patterns, without requiring full in-memory loading. This architecture ensures stable playback even on devices with limited SRAM, such as the ATmega328P (Arduino Nano).

Feature	Description
Format Compatibility	Fully supports ADX v2.2 (ADT → ADP conversion pipeline)
Memory Architecture	Step-level prefetch + Event Queue + Dual File Handle system
Transition Logic	Pre-opens and prefetches next ADP file one bar before end of current pattern
SRAM Footprint	Approx. 400 bytes (LCD + event queue + file buffers combined)
Latency	≤ 1 step (≈20 ms @118 BPM, 16T grid)
Target Hardware	Arduino Nano / Nano Every / ATmega series
Upward Compatibility	Designed to remain compatible with ADX v2.3 and higher

Implementation Notes
SSE v2.2 operates through a small event queue that buffers MIDI note events for each step. The engine maintains one SD file handle for the current ADP and another for the next pattern, ensuring that pattern transitions are completely gapless. The system uses a lookahead of approximately one quarter note (24 ticks) to prefetch and enqueue MIDI events. All reading occurs during inter-tick intervals, preventing timing jitter.

Technical Architecture Summary
Core Modules:
- Event Queue (ring buffer, 64 entries × 4 bytes)
- Step Prefetcher (reads next step and expands hits)
- Dual File Handler (current/next ADP)
- Timing Engine (BPM-based tick counter, PPQN=96)
- MIDI Output (Serial TX @31250 bps)

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