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E005: Simulation Engine Architecture

DIP-SMC-PSO Educational Series

January 25, 2026

Overview

This episode covers simulation engine architecture from the DIP-SMC-PSO project.

Part: Part1 Foundations
Duration: 15-20 minutes
Source: Comprehensive Presentation Materials

section0 Simulation Architecture Overview

Core Components:
- **SimulationRunner** – Main orchestration interface
- ‘src/core/simulation_runner.py‘ - Coordinates plant, controller, data logging
- **Unified Simulation Context** – State management
- ‘src/core/simulation_context.py‘ - Thread-safe state updates - 3 re-export locations (backward compatibility)
- **Batch Simulator** – Numba-accelerated parallel execution
- ‘src/core/vector_sim.py‘ - JIT compilation for performance
- **Integrators** – Numerical ODE solvers
- RK4, RK45, adaptive schemes - ‘src/core/integrators/‘

section0 Simulation Loop: Control Cycle

Execution Flow (100 Hz control rate):
[Visual diagram - see PDF]

section0 Real-Time Simulation Parameters

Default Configuration:

Parameter	**Value**
Time step (Δt)	0.01 s (100 Hz)
Simulation duration	10 s
Total steps	1000
Integrator	RK4 (4th-order Runge-Kutta)
Safety Guards:	
Max angle deviation	$\pm 45^\circ$
Max cart position	± 2.0 m
NaN detection	Enabled
Single simulation:	10-50 ms (depending on controller complexity)
*100 Monte Carlo runs:**	5-10 seconds (with Numba acceleration)

Resources

- **Repository:** `https://github.com/theSadeQ/dip-smc-pso.git`
- **Documentation:** See `docs/` directory
- **Getting Started:** `docs/guides/getting-started.md`

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