RS Control Suite — Provisional Patent Package

Magnetic Controller — ICF φ-Pulse Shaper — φ-Scheduler Module

Purpose. A single, self-contained specification that packages three related inventions with quick figures and short *Best Mode* sections suitable for provisional filings.

Global notation (used throughout). Golden ratio $\varphi = \dfrac{1+\sqrt{5}}{2}$. Recognition ratios $r_i := y_i/y_i^\star$ with declared targets $y_i^\star > 0$. Ledger cost

$$J(x) = \tfrac{1}{2}\left(x + \frac{1}{x}\right) - 1, \quad x > 0, \qquad J(1) = 0,\ J''(1) = 1.$$

A control period of length T is partitioned into L phase windows $W_0, \ldots, W_{L-1}$ with durations Δt_ℓ s.t. $\sum_\ell \Delta t_\ell = T$ and $\Delta t_{\ell+1}/\Delta t_\ell \in \{\varphi, \varphi^{-1}\}$ (φ-*commensurate*).

SPEC I — Magnetic Confinement Controller

Summary

A controller for magnetically confined plasma that minimizes a convex ledger over dimensionless recognition ratios, enforces φ-timed multi-actuator updates on an eight-phase schedule, and deploys actions only if a certificate (audit surface) passes. Implementations include periodic MPC and RL with a safety filter that guarantees φ-gating and certificate compliance.

Quick figure: control pipeline

Key definitions

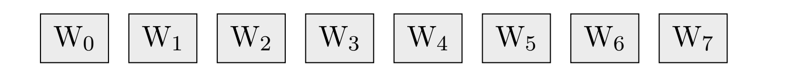
Recognition ratios: $r_i = y_i/y_i^\star$ over declared targets (T_e, T_i, n_e, q-profile metrics, shear proxy $\gamma_{E\times B}/\gamma^\star$, turbulence bands, impurity/radiated fractions).
φ-timed schedule: L=8 windows; actuator class assignment $\Pi(a) \subset \{0, \ldots, 7\}$.
Audit surface (certificate): fixed thresholds on disruptivity risk, impurity/radiation fractions, transport proxies, and tracking error; non-passing policies are auto-rejected/filtered.

Best Mode (preferred embodiment)

- **Actuators:** NBI (two phases for torque/shear), ECRH (two phases for core/edge), ICRH (single phase), RMP (single phase), pellets (single phase), gas puffing (single phase), shaping/VS (fast loop; updates gated).
- **Diagnostics:** Thomson, ECE, reflectometry, BES, SXR/bolometry, neutron rate, magnetic probes, loop voltage, equilibrium reconstructions.
- **Window map:** $\Pi(\text{pellet}) = \{0\}$, $\Pi(\text{RMP}) = \{2\}$, $\Pi(\text{ECRH}) = \{1, 5\}$, $\Pi(\text{ICRH}) = \{3\}$, $\Pi(\text{NBI}) = \{4, 7\}$, $\Pi(\text{Gas}) = \{6\}$.
- **Objective:** $\sum_i w_i J(r_i)$ with w_i set from sensitivity of a certified transport surrogate at $r = 1$.
- **Controller:** periodic MPC (N=10–30 steps, terminal set/cost 8-phase periodic); fallback RL with safety filter that solves the same constrained ledger problem online.
- **Certificate thresholds:** declare fixed θ for risk, impurities, radiated fraction, and tracking error; deployment only if $\mathcal{A} \le \theta$ for M consecutive windows.

Quick figure: eight-phase φ schedule

$$\Delta t_{\ell+1}/\Delta t_\ell \in \{\varphi, \varphi^{-1}\}, \quad \sum \Delta t_\ell = T$$



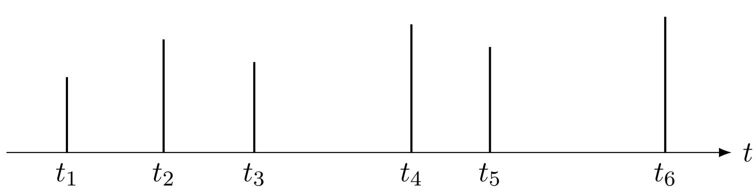
SPEC II — ICF φ-Pulse Shaping

Summary

An ICF pulse-shaping method that constructs φ-spaced sub-pulses and minimizes a *symmetry ledger* over normalized spherical-harmonic mode magnitudes $r_{\ell m} = |a_{\ell m}|/a^\star_\ell$ subject to energy/facility constraints. Deployment is certificate-gated. Residual asymmetry decreases at least geometrically with sub-pulse count within the admissible regime.

Quick figure: φ-spaced sub-pulse train

$$\frac{\Delta t_{k+1}}{\Delta t_k} \in \{\varphi, \varphi^{-1}\}$$



Key definitions

Symmetry coefficients: $a_{\ell m}$ from x-ray self-emission, radiography, or backlighter.

Symmetry ledger: $\mathcal{L}_{\text{sym}} = \sum_{\ell \in \mathcal{S}} w_\ell \sum_{m=-\ell}^{\ell} J\big(|a_{\ell m}|/a_\ell^\star\big)$, with declared $\mathcal{S}$ (e.g. $\{2, 4, 6\}$), targets $a_\ell^\star > 0$, and weights $w_\ell > 0$.
Certificate: thresholds on $\mathcal{L}_{\text{sym}}$, mode caps (e.g. $|a_{20}| \leq \tau_2$, $|a_{4m}| \leq \tau_4$), shock timing/bang-time windows, adiabat and preheat limits.

Best Mode (preferred embodiment)

- **Sub-pulses:** $K = 5$–8 pickets/ramps with raised-cosine template $s(\cdot)$; amplitudes A_k bounded by facility cone/ring allocations; total energy E_{tot} fixed.
- **Timing:** enforce $\Delta t_{k+1}/\Delta t_k \in \{\varphi, \varphi^{-1}\}$ within a declared drive window; per-ring micro-delays allowed if φ-commensurability preserved.
- **Mode set:** $\mathcal{S} = \{2, 4, 6\}$ with $a_\ell^\star$ set from prior symmetry campaigns; w_ℓ proportional to capsule-yield sensitivity.
- **Optimizer:** hydrodynamics surrogate with declared error bounds; optionally Bayesian update from low-energy surrogate shots; keep ledger, φ-spacing, and certificate fixed.
- **On-shot gating:** online symmetry proxies checked; certificate violation aborts remaining sub-pulses.

SPEC III — φ-Scheduler Module

Summary

A reusable scheduling module that partitions control periods into φ-commensurate windows, assigns actuators to phase sets, enforces update admissibility within windows, guarantees periodic invariance with bounded jitter, provides a qualitative interference bound, and exposes a controller-agnostic *Compliance API* with signed logs. Useful across domains (fusion, lasers, robotics, beamlines, power electronics).

Quick figure: scheduler architecture & API

Key definitions

φ-windows: L=8 default; optional superframe ST with φ-relations preserved inside each T.
Interference bound (qualitative): For band-limited cross-coupling, time-averaged bilinear cross-terms are reduced by a strict factor $\kappa \in (0, 1)$ relative to co-phased/equal-spaced baselines (window smoothness controls κ).
Compliance API: `BeginWindow(`ℓ`)`, `EndWindow(`ℓ`)`, `WindowIndex()`, `Allowed(`a`)`, `RequestUpdate(`a`,pay`
(admit/reject), `GetComplianceReport()` (cryptographically signed).

Best Mode (preferred embodiment)

- **Timing:** T linked to plant reference τ_{ref}; L=8; raised-cosine window edges; jitter $\leq 100\ \mu$s (magnetic) / 100 ps (ICF triggers).
- **Phase sets:** disjoint or minimally overlapping $\Pi(a)$ for actuators with strong cross-coupling; mandatory dwell δ_a enforced.
- **Compliance:** hardware timer/FPGA for edges; secure element for signature of logs; per-period attestation of φ-ratios and window adherence.
- **Integration:** controller-agnostic; third-party stacks must call API; noncompliant requests are rejected and logged.

Claims (outline — each spec provides an independent set)

- **Spec I (Magnetic Controller):** Method, System, and Non-transitory Medium claims covering ledger-objective over recognition ratios, φ-timed eight-phase actuation with assignments $\Pi(a)$, certificate-gated deployment, periodic MPC or RL with safety filter; dependent claims on actuators, diagnostics, specific ratios (critical gradients, shear), periodic terminal ingredients, robustness bounds.

- **Spec II (ICF φ-Pulse Shaper):** Method, System, and Medium claims covering φ-spaced sub-pulses, symmetry-ledger minimization over $|a_{\ell m}|/a^{\star}_{\ell}$, certificate thresholds, and a geometric convergence feature ($0 < \eta < 1$ qualitative); dependent claims on pulse templates, mode sets, facility constraints, online gating.

- **Spec III (φ-Scheduler):** Method, System, and Medium claims covering φ-commensurate windows, periodic invariance and interference bounds, and the Compliance API with signed logs; dependent claims on jitter bounds, superframes, window smoothness, hardware realization.

Enablement & best-mode checklist (for counsel)

- Equations/algorithms present (ledger J, ratios r, φ-windowing; symmetry ledger).
- Concrete mappings (actuator phase sets; pulse timing; API calls).
- Figures showing pipeline, schedule, pulse train, and module blocks.
- Best Mode sections for each spec: actuators/diagnostics & thresholds; K sub-pulses & mode set; timing/jitter & API/signing.