Generator-Mode Operation, Active Detuning Governors, and Responsible Disclosure for High-Gain Resonant Field Systems

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Abstract

If a resonant rotating-field system exhibits high gain (energy or force amplification), the dominant risks become runaway behavior and unsafe disclosure. This paper defines rigorous energy accounting for "generator mode" operation, specifies a safety governor based on intentional detuning (phase slip injection), and establishes a governance model for staged disclosure.

We formalize the thermodynamic conditions for self-sustaining operation, analyze runaway hazard modes, and prove that active detuning collapses system efficiency to prevent catastrophic failure. The framework is strictly data-gated: no claims of over-unity or novel effects are made absent verified measurements following the protocols of NM-0 (Foundation) and NM-1 (Engineering and Metrology).

Keywords: safety governor, detuning, phase slip, resonance collapse, energy accounting, runaway prevention, responsible disclosure, export control

1 Introduction

1.1 Motivation

This memo addresses two failure modes for high-gain resonant systems:

1. **Technical failure (runaway):** Loss of load or controller fault causes uncontrolled acceleration, leading to mechanical failure or worse.
2. **Social failure (premature disclosure):** Publishing results before adequate verification enables misuse or reputational damage.

Both failures must be prevented by design, not by caution alone.

1.2 Scientific Posture

All content in this paper is hypothesis-gated and measurement-gated:

- No claim of "over-unity" or novel effect is made.
- All hypotheses are formalized with falsifiers.
- Claims require auditable data products per NM-1 protocols.

1.3 Relationship to Project Architecture

- **NM-0 (Foundation):** Geometry, scheduling, resonance-map predictions.
- **NM-1 (Engineering):** Virtual rotor, metrology, null tests.
- **NM-2 (This paper):** Generator mode, safety governor, governance.

2 Energy Accounting

2.1 Power Flow Definitions

Definition 2.1 (Power Flows). *At any time t, the system has four power channels:*

$$P_{drive}(t) : \textit{Electrical input to drivers} \tag{1}$$
$$P_{stored}(t) : \textit{Rate of change of stored energy} \tag{2}$$
$$P_{thermal}(t) : \textit{Heat flow to/from environment} \tag{3}$$
$$P_{out}(t) : \textit{Harvested electrical output} \tag{4}$$

Energy conservation (first law) requires:

$$P_{\mathrm{drive}}(t) = P_{\mathrm{out}}(t) + P_{\mathrm{thermal}}(t) + \frac{d}{dt}E_{\mathrm{stored}}(t). \tag{5}$$

2.2 Generator Mode Definition

Definition 2.2 (Generator Mode). *The system operates in* generator mode *if, over a measurement interval $[t_1, t_2]$:*

$$\int_{t_1}^{t_2} P_{out}(t)\,dt > \int_{t_1}^{t_2} P_{drive}(t)\,dt + \delta E_{stored} \tag{6}$$

where $\delta E_{stored} = E_{stored}(t_1) - E_{stored}(t_2)$ accounts for any depletion of stored energy.

Remark 2.1. *This definition is* accounting-based*, not effect-based. It can be evaluated from measurements without assuming any particular physical mechanism.*

2.3 Self-Sustaining Threshold

Definition 2.3 (Self-Sustaining Operation). *The system is* self-sustaining *at time t if:*

$$P_{out}(t) > P_{drive}(t). \tag{7}$$

Self-sustaining operation implies that the output power exceeds the drive power required to maintain resonance. This is a **data-gated hypothesis**—it is defined precisely so that it can be tested and falsified.

2.4 Entropic Cooling Hypothesis

Hypothesis 2.1 (Entropic Cooling). *If a resonant system orders the vacuum (reduces vacuum entropy), it absorbs thermal energy from the environment:*

$$\Delta S_{vacuum} < 0 \implies \Delta Q_{env} < 0. \tag{8}$$

This is an empirically testable prediction: during high-resonance operation, the device temperature should *decrease* relative to a matched-heating control.

Definition 2.4 (Entropic Cooling Predicate). *The entropic cooling condition is formalized as:*

$$\mathit{EntropicCooling}(\Delta S_{vac}, \Delta Q_{env}) \coloneqq (\Delta S_{vac} < 0) \to (\Delta Q_{env} < 0) \tag{9}$$

2.5 Vacuum Power Scaling

Hypothesis 2.2 (Vacuum Power Scaling). *The power output in generator mode scales with frequency f and metric gradient σ_∇:*

$$P_{vac} \propto f \cdot \sigma_\nabla. \tag{10}$$

This provides a testable prediction: output power should increase linearly with drive frequency at fixed resonance conditions.

2.6 Falsifiers and Disqualifiers

The generator-mode hypothesis is **falsified** if:

1. Apparent over-unity disappears under improved thermal/EMI controls.
2. The effect correlates only with sensor pickup channels (measurement artifact).
3. Matched-heating runs produce the same "output" signal.

3 Generator Architecture

3.1 System Block Diagram

The generator-mode system comprises:

1. **Core:** Virtual rotor (NM-1) generating rotating field.

2. **Pickup:** Secondary coil array (stator) around the core.
3. **Rectification:** AC-to-DC conversion of induced EMF.
4. **Buffer:** Energy storage (capacitor bank or battery).
5. **Load interface:** Grid-tie or resistive load.
6. **Controller:** Schedule generation, resonance lock, logging.
7. **Governor:** Safety system with detune/shutdown authority.

3.2 Startup Sequence

1. **Initialize:** External power brings system to idle.
2. **Resonance search:** Sweep through candidate frequencies (NM-0 resonance map).
3. **Lock detection:** Identify resonance peak via coherence metric.
4. **Load stabilization:** Connect load to provide braking.
5. **Self-power transition:** (Data-gated) If $P_{\text{out}} > P_{\text{drive}}$, reduce external power.

3.3 Load as Stabilizer

Theorem 3.1 (Load Stabilization)**.** *When the output load draws power, it acts as a stabilizing brake on the resonant system. Load disconnect removes this braking instantaneously.*

Argument. By Lenz's law, current drawn from the pickup coils creates a magnetic field opposing the rotating field, providing a restoring (damping) force proportional to load current. When load $= 0$, this damping vanishes. □

This is the fundamental hazard: loss of load $\Rightarrow$ loss of braking $\Rightarrow$ runaway.

4 Runaway Hazard Analysis

4.1 Runaway Signature

Definition 4.1 (Runaway Signature)**.** *A system exhibits the* runaway signature *if, when load approaches zero, the rotational proxy (RPM or field frequency) increases without bound:*

$$\mathit{RunawaySignature}(\mathit{load}, \omega) := (\mathit{load} = 0) \to \left(\frac{d\omega}{dt} > 0\right). \tag{11}$$

This signature distinguishes the hypothesized resonant generator from conventional generators, which slow down when unloaded.

4.2 Runaway Scenarios

Table 1: Runaway Hazard Enumeration

Scenario	Cause	Observable
Loss of load	Open circuit, load fault	$\omega \uparrow$, $I_{\text{load}} \to 0$
Controller fault	Stuck-on pulses	$\omega \uparrow$, pulse timing
Clock instability	Jitter blowup	ω erratic, coheren
Thermal runaway	Driver overheating	$T \uparrow$, current limi
Mechanical failure	Structural resonance	Vibration spike,

4.3 Runaway Detection Observables

The following observables indicate runaway onset:

1. Rapid rise of ω (RPM or field frequency).
2. Rising harmonic content / instability in resonance score.
3. Overcurrent or overvoltage events.
4. Strain/vibration spikes.

4.4 Safety Requirements

1. **Detection time:** Runaway must be detected within $t_{\text{det}} < 100$ ms.
2. **Mitigation time:** Resonance must be collapsed within $t_{\text{mit}} < 1$ s.
3. **Fail-safe:** Controller crash must result in detune (not drive continuation).

5 Active Detuning Governor

5.1 Governor Concept

Rather than relying on mechanical friction braking (which may be insufficient for high-gain systems), we use **active detuning**: intentionally inject phase slip to collapse the resonance condition.

Definition 5.1 (Phase Slip). *A* phase slip *of magnitude $\delta\phi$ is an intentional timing error in the drive schedule, shifting pulses away from the optimal 8-tick alignment.*

5.2 Governor Function

Definition 5.2 (Governor Function). *The governor function outputs a phase slip command based on the rotational proxy ω and a limit $\omega_{\max}$:*

$$Governor(\omega, \omega_{\max}) := \begin{cases} \delta\phi_{detune} & \text{if } \omega > \omega_{\max} \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

where $\delta\phi_{detune} > 0$ is a fixed detune magnitude (e.g., 0.1 radians or 10% phase error).

5.3 Efficiency Collapse

Definition 5.3 (Efficiency Function). *The system efficiency under phase error $\delta\phi$ is modeled as:*

$$\eta(\delta\phi) := e^{-(\delta\phi)^2}. \tag{13}$$

This Gaussian roll-off captures the intuition that small phase errors cause quadratic efficiency loss, with rapid collapse for larger errors.

Theorem 5.1 (Detuning Stops Runaway). *If $\omega > \omega_{\max}$, then applying the governor function collapses efficiency below unity:*

$$\omega > \omega_{\max} \implies \eta\big(Governor(\omega, \omega_{\max})\big) < 1. \tag{14}$$

Proof. When $\omega > \omega_{\max}$, the governor outputs $\delta\phi = \delta\phi_{\text{detune}} > 0$. Then:

$$\eta(\delta\phi_{\text{detune}}) = e^{-(\delta\phi_{\text{detune}})^2} < e^0 = 1. \tag{15}$$

For $\delta\phi_{\text{detune}} = 0.1$:

$$\eta(0.1) = e^{-0.01} \approx 0.99. \tag{16}$$

Larger detune values (e.g., $\delta\phi = 0.5$) yield $\eta \approx 0.78$. □

Corollary 5.2 (Efficiency Floor). *To guarantee efficiency below any threshold η_{target}, choose:*

$$\delta\phi_{detune} \geq \sqrt{-\ln(\eta_{target})}. \tag{17}$$

For $\eta_{target} = 0.5$: $\delta\phi_{detune} \geq 0.83$ radians.

5.4 Governor State Machine

The governor operates as a state machine:

1. **NOMINAL:** $\omega < \omega_{\max}$; output $\delta\phi = 0$.
2. **DETUNE:** $\omega_{\max} \leq \omega < \omega_{\text{crit}}$; output $\delta\phi = \delta\phi_{\text{detune}}$.
3. **SHUTDOWN:** $\omega \geq \omega_{\text{crit}}$ or fault detected; output SHUTDOWN command.

Transitions: NOMINAL → DETUNE → SHUTDOWN (escalation ladder). Recovery: DETUNE → NOMINAL (if ω drops below $\omega_{\max} - \epsilon$).

5.5 Hardware Interlocks

In addition to the software governor, the following hardware interlocks are required:

1. **Independent watchdog:** Separate microcontroller monitors ω and triggers detune if main controller fails.
2. **Physical E-stop:** Manual emergency stop accessible to operator.
3. **Dump load / crowbar:** Resistive load that can be switched in to absorb excess energy.
4. **Default-safe behavior:** On loss of control signal, drivers default to detune pattern.

6 Operational Safety Protocols

6.1 Test Gating and Escalation

Experiments proceed through power levels with mandatory gates:

Table 2: Power Escalation Ladder

Level	Power	Gate Requirement	Resp[illegible]
L1	< 10 W	Basic safety check	3
L2	10–100 W	L1 complete, governor verified	5
L3	100–1000 W	L2 complete, remote operation	10
L4	> 1 kW	L3 complete, facility review	20

6.2 Facility and Personnel Safety

1. **Shielding:** Faraday enclosure; RF-absorbing materials if needed.
2. **Standoff distances:** No personnel within 2 m during L3+ operation.
3. **Remote operation:** All L3+ tests controlled from separate room.
4. **Electrical safety:** GFCI protection; lockout/tagout procedures.

6.3 Incident Response

1. **Automatic logging:** All sensor data preserved with tamper-evident checksums.
2. **Post-incident lockout:** System remains disabled until root-cause analysis complete.
3. **Root-cause workflow:** Standardized incident report template; independent review.

7 Governance and Responsible Disclosure

7.1 Disclosure Categories

Table 3: Disclosure Classification

Category	Content
Public	Geometry definitions, scheduling discipline, metrology protocols
Patent	Broad claims, high-level diagrams, operating principles
Trade Secret	Exact operating tables, PCB layouts, switching details

7.2 Replication Strategy

Replication proceeds as follows:

1. **Internal replication:** ≥ 3 independent builds within organization.
2. **NDA replication:** External parties under NDA with pre-registered protocols.
3. **Public release:** Only after reproducibility meets internal criteria.

7.3 Export Control Considerations

1. **Domestic-first filing:** All patents filed domestically before international.
2. **Counsel review:** Legal review before any international dissemination.
3. **ITAR/EAR awareness:** Monitor for potential dual-use classification.

7.4 Ethical Framework

1. **Safety by design:** Governor integration is mandatory, not optional.
2. **Misuse risk:** Explicit non-goal for weaponization applications.
3. **Transparency:** Null results published with same rigor as positive results.

8 Conclusion

This paper has established the safety and governance framework for high-gain resonant field systems operating in generator mode. The key contributions are:

1. **Energy accounting:** Rigorous definitions of power flows, generator-mode threshold, and self-sustaining operation.
2. **Falsifiable hypotheses:** Entropic cooling and vacuum power scaling, with explicit falsifiers.
3. **Hazard analysis:** Enumeration of runaway scenarios with detection observables and safety requirements.

4. **Active detuning governor:** Phase-slip-based efficiency collapse with proof that detuning prevents runaway.

5. **Operational protocols:** Power escalation ladder, facility safety, incident response.

6. **Governance model:** Disclosure categories, replication strategy, export control awareness.

The framework ensures that any claimed effects are rigorously verified before disclosure, and that safety measures are in place to prevent catastrophic failure during testing.

A Energy Accounting Worksheet

```
Run ID: ______________
Date: ______________

INPUTS:
  P_drive (avg, W): ______________
  Duration (s): ______________
  E_drive = P_drive x duration: ______________

STORED ENERGY:
  E_stored_start (J): ______________
  E_stored_end (J): ______________
  Delta_E_stored: ______________

OUTPUTS:
  P_out (avg, W): ______________
  E_out = P_out x duration: ______________

THERMAL:
  Delta_T_device (C): ______________
  Delta_T_environment (C): ______________
  Thermal anomaly (Y/N): ______________

BALANCE:
  E_drive + Delta_E_stored = __________ (input)
  E_out + E_thermal = __________ (output)
  Discrepancy: ______________

GENERATOR MODE (Y/N): ______________
```

B Governor State Machine

States:

- NOMINAL: Normal operation, $\delta\phi = 0$
- DETUNE: Active braking, $\delta\phi = \delta\phi_{\text{detune}}$
- SHUTDOWN: All drives disabled

Transitions:

1. NOMINAL → DETUNE: $\omega > \omega_{\max}$
2. DETUNE → NOMINAL: $\omega < \omega_{\max} - \epsilon$ for $t > t_{\text{hold}}$
3. DETUNE → SHUTDOWN: $\omega > \omega_{\text{crit}}$ OR fault detected
4. ANY → SHUTDOWN: E-stop pressed OR watchdog timeout

Pseudocode:

```
loop:
  w = read_rpm()
  fault = check_faults()

  if state == NOMINAL:
    if w > w_max:
      state = DETUNE
      set_phase_slip(dphi_detune)

  elif state == DETUNE:
    if w > w_crit or fault:
      state = SHUTDOWN
      disable_all_drives()
    elif w < w_max - eps for t_hold:
      state = NOMINAL
      set_phase_slip(0)

  elif state == SHUTDOWN:
    disable_all_drives()
    log_incident()
    wait_for_manual_reset()
```

C Redaction Checklist

Before external sharing, verify removal of:

- ☐ Exact operating frequency tables

- ☐ PCB layout files and Gerber data
- ☐ Driver schematic details
- ☐ Manufacturing tolerances
- ☐ Specific component part numbers
- ☐ Calibration constants
- ☐ Internal test results (unless publication-approved)

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