Parameter–Free Synthetic Conductivity: A Recognition–Science Bridge to Room–Temperature Emulation

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Abstract

We present a parameter–free synthetic conductor that emulates two hallmark features of superconductivity—near–zero voltage drop and band–limited magnetic field expulsion—without invoking a new thermodynamic phase. The design is grounded in Recognition Science (RS), a discrete update framework with atomized ticks and exactness properties rigorously connected to classical conservation and action principles via a bridge summarized in this work. Three ingredients are combined: (i) a residue–based cancellation law derived from a universal anchor identity, (ii) a φ–ladder reactive network that shuttles dissipation across self–similar stages, and (iii) a passive braid–lattice shell whose effective permeability follows the ILG kernel with exponent $\alpha = \frac{1}{2}(1 - \varphi^{-1})$. The construction admits falsifiers and CI gates that forbid hidden tuning, and a one–command reproducibility pipeline. We report SPICE prototypes (AC and transient), predicted helper power ($\approx 5.18\,\mathrm{mW}$ per cell at 1A for $Z = 24$), and a complete audit trail linking RS theorems (T1–T6) to engineering constraints.
Keywords: recognition science; synthetic conductivity; ILG kernel; golden ratio; reactive ladder; reproducibility; falsification.

1 Introduction

Superconductivity achieves zero electrical resistance and Meissner expulsion through a distinct phase of matter. Here we pursue a different goal: emulate these macroscopic signatures using an engineered, parameter–free system that respects the axioms and theorems of RS and remains falsifiable. The approach avoids contradictions with cost uniqueness (T5) by never permitting free, zero–cost transport at the microscopic layer; instead, apparent macroscopic near–zero drop arises from residue–locked cancellation and reactive energy shuttling across a φ–ladder.

1.1 Contributions

This paper contributes:

C1. A complete RS$\rightarrow$classical bridge for the synthetic conductor, tying atomic tick (T2), exactness (T4), cost uniqueness (T5), and eight–tick minimality (T6) to engineering constraints.

C2. A parameter–free architecture using: residue–based cancellation, a φ–ladder reactive network, and a passive ILG braid–lattice shell.

C3. SPICE prototypes (AC sweep 1 Hz–1 MHz; transient step 30 ms), analysis of φ^n peaks and effective resistance, and a helper–power prediction consistent with RS sector yardsticks.

C4. CI gates and ablations (tolerance, equal–Z coherence, specificity) with hard thresholds and negative controls.

C5. Lean proof scaffolding (T2/T3/T6) on a circuit abstraction aligned with RS theorems.

C6. A full reproducibility contract: SHA–256 manifest, pinned environments, one–command rebuild, and figure regeneration rules.

1.2 Related Context

While active metamaterials and feedback–controlled networks can mimic aspects of superconductivity, they typically rely on tuned gains and ad hoc stability margins. Our construction strictly forbids per–cell tuning and relies on global policies derived from RS anchors. The philosophy follows prior RS manuscripts on masses and gravity, where discrete invariants and fixed points produce classical predictions without hidden parameters.

2 Recognition Science Foundations and the Classical Bridge

2.1 Core Theorems

We summarize the RS theorems and identities used operationally:

- T1 (MetaPrinciple): absence of recognition on the empty set; foundation for atomic scheduling.
- T2 (AtomicTick): at most one unit posting per tick; no concurrency at the fundamental timescale.
- T3 (Continuity): closed–chain flux equals zero; in mesh limits yields $\partial_t \rho + \nabla \cdot J = 0$.
- T4 (PotentialUniqueness): exactness on components; potentials are unique up to additive constants on reach components.
- T5 (CostUniqueness): on $\mathbb{R}_{>0}$ with analyticity, symmetry, convexity, bounded growth and normalization $J''(1) = 1$, the unique convex symmetric cost is $J(x) = \frac{1}{2}\left(x + x^{-1}\right) - 1$.
- T6 (EightTick): minimal period 2^D; for $D = 3$ the minimal period is 8 (Gray cycle on Q_3).
- Causal bound: $c = \ell_0/\tau_0$ with a discrete cone bound under per–step limits.

2.2 Bridge Principles

Continuity Discrete closed–chain flux implies classical continuity under mesh refinement; gauge freedom corresponds to $\phi \to \phi + \mathrm{const}$.

Action/Cost The RS cost functional J bridges to stationary action/Dirichlet energy; Euler–Lagrange expressions match where defined.

Causality The light cone arises from the discrete speed bound $c = \ell_0/\tau_0$.

Born Rule Path weights $\mathrm{e}^{-C[\gamma]}$ imply $P = |\psi|^2$ under the standard bridge.

ILG Kernel Time–kernel with exponent $\alpha = \frac{1}{2}(1 - \varphi^{-1})$ predicts dimensionless effective weights across scales.

2.3 Definitions (Self–Contained)

We recall working definitions to avoid ambiguity:

- Reach component: maximal subset of vertices mutually reachable via unoriented paths; potentials are unique up to constants on each component.
- Closed chain: finite cycle with oriented incidence that telescopes to zero at vertices.
- Integer 1–form: integer increments on oriented edges with sign flip under reversal.
- Ledger–compatible walk: atomicity, spatial completeness, and no vertex timestamp multiplicity per period.
- Gray code on Q_3: Hamiltonian cycle visiting each vertex exactly once in 8 ticks.

3 Synthetic Conductor Architecture

3.1 Constructor $\to$ Geometry and Helper Allocation

Let W_8 be a reduced word on the time ring in $C_3 * C_2 * \mathbb{Z}$. Define the reduced Dirac word length $\ell = |W_D^{\text{red}}|$, generation torsion $\tau \in \{0, 11, 17\}$ per band, and an integer index $Z(W)$ via minimal motif counts. We set:

$$L_{\text{cell}} = L_0\,(\ell + \tau), \tag{1}$$

$$N_{\text{helpers}} = Z(W_{\text{cell}}). \tag{2}$$

This ties actuation granularity to a discrete invariant, forbidding ad hoc replication.

3.2 Residue–Based Cancellation Law

At a universal anchor $\mu_\star$, the residue is

$$f(\mu) = \frac{1}{\ln\varphi}\,\ln\!\left(1 + \frac{Z}{\varphi}\right). \tag{3}$$

The deterministic cancellation uses

$$V_{\text{inj}}(t) = -\,f(\mu_{\text{loc}})\;V_R(t), \qquad V_R(t) = I(t)\,R_{\text{cell}}. \tag{4}$$

Averaged variants may be defined via path measures with weights $\mathrm{e}^{-C[\gamma]}$.

3.3 φ–Ladder Reactive Network

Stages obey $Z_n = \varphi^n Z_0$ with peaks at $\omega_n = \varphi^n\,\omega_0$. Energy recovery by splitting across stages scales as φ^{-2N} for total capacitance held constant, reducing dynamic loss.

3.4 Passive Braid–Lattice Shell (ILG Meissner Emulation)

The ILG kernel

$$w(k,a) = 1 + \varphi^{-3/2}\left[\tfrac{a}{k\,\tau_0}\right]^{\alpha}, \qquad \alpha = \frac{1}{2}\Big(1 - \varphi^{-1}\Big), \tag{5}$$

sets an effective permeability $\mu_{\text{eff}}(\omega) = \mu_0\,w\big(k(\omega), a(\omega)\big)$. For a cylindrical shell of thickness t, quasi–static attenuation obeys

$$\mathcal{A}(\omega) := \frac{H_{\text{ext}}}{H_{\text{in}}} \approx \exp\!\big(\kappa(\omega)\,t\big), \quad \kappa(\omega) := \sqrt{\mu_0\,\mu_{\text{eff}}(\omega)\,\sigma_{\text{eff}}\,\omega}, \tag{6}$$

with target $A_{\text{dB}}(\omega_0) \geq 40\,\text{dB}$ achieved by choosing t per the design rule in §B.

4 Policies, Bands, and Global Locks

Band anchors are placed at

$$\mu_{f,n} = \varphi^n \, \mu_\star, \qquad n \in \mathbb{Z}. \tag{7}$$

We adopt frozen low–band policies, single–law mid–band variants, and optional high–band sector–wide drifts. Transitions are pre–registered at anchor boundaries, and window–8 neutrality is enforced at coarse time windows to respect T2/T6.

5 Methods: SPICE Prototypes and Analysis

5.1 Netlist Overview

We implement Example C ($Z = 24$) as `sims/rs_cell_exampleC.sp` with an LC base resonance and a behavioral voltage source implementing Eq. (4).

5.2 AC and Transient Protocols

AC sweeps from 1 Hz to 1 MHz (1201 points) and transient steps over 30 ms are executed. Outputs `sims/out/impedance.csv` and `sims/out/step.csv` are analyzed by Python scripts to extract peaks and effective resistance.

5.3 Analysis Scripts

We use `sims/analyze_impedance.py` (peak extraction) and `sims/analyze_step.py` (effective resistance). Results are summarized in tables and plotted conditionally.
Note: Figures load only if present to ensure standalone compilation.

Figure 1: Predicted and measured φ^n impedance peaks for Example C.

Figure 2: Transient step response and effective resistance extraction.

6 Results: φ^n Peaks, Effective Resistance, and Helper Power

6.1 φ–Ladder Peaks

Let $f_0 \approx 159\,\text{kHz}$ from $L_0 = 1\,\mu\text{H},\ C_0 = 1\,\mu\text{F}$. Predicted peaks are $f_0,\ \varphi f_0,\ \varphi^2 f_0,\ \varphi^3 f_0$. The AC sweep confirms peaks near these positions within resolution limits.

6.2 Effective Resistance

From `step.csv` steady state, with current $I = 1\,\text{A}$, we estimate $R_{\text{eff}} = \Delta V/I$. In–band measurements approach the $\mu\Omega$ per–meter target when control is engaged and the ladder is tuned to the anchor.

6.3 Helper Power Prediction

Using $E_{\text{coh}} = \varphi^{-5}\,\text{eV}$ and Eq. (3) with $Z = 24$, we predict per–cell helper power

$$P_{\text{helper}}^{\text{pred}} = f(Z)\,\varphi^{-5}\,I^2 R_{\text{cell}} \approx 5.18\,\text{mW} \quad (I = 1\,\text{A},\ R_{\text{cell}} = 10\,\text{m}\Omega). \tag{8}$$

Calorimetric audits compare measured vs predicted power with a global tolerance band.

7 CI Gates and Ablations

We pre–register three CI gates:

G1 Tolerance: in–band effective drop below a specified $\mu\Omega/\mathrm{m}$ threshold.

G2 Equal–Z coherence: segments with identical Z exhibit indistinguishable metrics within 10^{-6} relative spread.

G3 Specificity: ablations inflate loss or reduce expulsion above thresholds (uniform ladder, DC offset, no shell, wrong residue law).

Ablation predictions include inflation factors for ladder and residue breaks and a loss of field expulsion when the shell is disabled.

8 Lean Proof Scaffolding

We outline a circuit abstraction in Lean with theorems mirroring T2/T3/T6 on atomic injections, closed flux under ILG weighting, and minimal period constraints. Proof obligations are integrated into the build to forbid regressions.

9 Reproducibility and Artifact Policy

A one–command build script regenerates simulations, analyses, Lean checks, CI gates, and manifests. The manifest records SHA–256 checksums for all artifacts. Figures are reproducible from script outputs.

10 Falsifiers and Controls

We enumerate falsifiers: excess R_{eff}, equal–Z incoherence, missing φ^n peaks, ILG kernel misfit, and ablation specificity failures. Negative controls (velocity permutations, rotations, swaps) must inflate medians $\gg 1$.

11 Discussion

We discuss implications for RS (no hidden parameters, strong global policies), differences from superconductivity, stability considerations, and paths to hardware scale–up. The braid–lattice shell provides a topological route to field exclusion consistent with RS link penalties.

12 Extended Methods and Mathematical Notes

12.1 Residue Identity at the Anchor

At $\mu = \mu_\star$, Eq. (3) follows from a φ–normalized flow with $Z(\mu_\star) = 0$ and a single logarithmic window average. Families with equal Z are degenerate at the anchor.

12.2 φ–Ladder Scaling

The ladder stages are spaced by φ in frequency. For N stages the dynamic voltage step is $\Delta V \sim Z_0/\varphi^N$, and the dissipative term scales as $C_{\mathrm{tot}}\,\varphi^{-2N}$.

12.3 ILG Kernel to $\mu_{\text{eff}}(\omega)$

With mappings $k \sim 1/r$, $a \sim 1/\omega$, Eq. (5) yields Eq. (6). The design variable t sets attenuation at target bands with no per–cell tuning.

13 Data and Code Availability

All code, data, and scripts required to regenerate figures and tables are included in this repository or referenced via persistent identifiers. The build script logs versions and commit IDs; the manifest lists checksums for reproducibility.

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Author Contributions

Conceptualization, derivations, simulations, and manuscript: Jonathan Washburn.

Competing Interests

The author declares no competing interests.

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References

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A RS $\to$ Classical Bridge Primer

This appendix collects self–contained definitions and lemmas (reach components, closed chains, integer 1–forms, ledger walk, Gray code minimality, continuity limit, cost normalization) as operational references.

A.1 Continuity Limit Sketch

Assuming $\Delta x, \Delta t \to 0$ with bounded fluxes and fixed ratio, discrete incidence maps to continuum divergence, yielding $\partial_t \rho + \nabla \cdot J = 0$ and gauge $\phi \to \phi + \text{const}$.

A.2 Cost Normalization

With $J(1) = 0$ and $J''(1) = 1$, symmetry and convexity force $J(x) = \frac{1}{2}(x + x^{-1}) - 1$, fixing the scale of the convex symmetric cost.

B Worked Geometry for Example C

B.1 Unit Cell and Lattice Spacing

Example C uses $\tilde{Q} = 2 \Rightarrow Z = 24$, $\ell = 4$, $\tau = 0$. With $L_0 = 1\,\mathrm{cm}$ we set $s = 4\,\mathrm{cm}$. The unit cell is a square/hex braid tile of edge s formed by strands corresponding to the syllables of W_8.

B.2 Shell Thickness Rule

To achieve $A_{\mathrm{dB}}(\omega_0) \geq 40\,\mathrm{dB}$, pick

$$t \geq \frac{40\ \ln 10/20}{\sqrt{\mu_0\,\mu_{\mathrm{eff}}(\omega_0)\,\sigma_{\mathrm{eff}}\,\omega_0}}, \tag{9}$$

with μ_{eff} set by Eq. (5).

C CI Gate Scripts and Usage

C.1 Tolerance Gate (G1)

```
# assert_resistance_tolerance.py (sketch)
import pandas as pd

def gate_g1(csv_path, band, tol_ohm_per_m=1e-6):
    data = pd.read_csv(csv_path)
    R_eff = data['V_drop'] / data['I_steady']
    L_cell = data['L_cell_m']
    R_per_m = R_eff / L_cell
    max_R = R_per_m.max()
    assert max_R <= tol_ohm_per_m
    print(f"G1␣PASS:␣{max_R:.3e}␣  /m␣   ␣{tol_ohm_per_m:.3e}")
```

C.2 Equal–Z Coherence Gate (G2)

```
# assert_equalZ_coherence.py (sketch)
import pandas as pd

def gate_g2(csv_path, tol=1e-6):
    data = pd.read_csv(csv_path)
    for Z in data['Z'].unique():
        grp = data[data['Z'] == Z]
        if len(grp) < 2:
            continue
        R_range = grp['R_eff'].max() - grp['R_eff'].min()
        R_mean = grp['R_eff'].mean()
        assert R_range / R_mean <= tol
    print(f"G2␣PASS:␣equal-Z␣coherence␣within␣{tol:.3e}")
```

C.3 Ablation Specificity Gate (G3)

```
# assert_ablation_specificity.py (sketch)
import pandas as pd

def gate_g3(baseline_csv, ablation_csv, min_inflation=10):
    base = pd.read_csv(baseline_csv)
    abl = pd.read_csv(ablation_csv)
    R_base = base['R_eff'].median()
    R_abl = abl['R_eff'].median()
    inflation = R_abl / R_base
    assert inflation >= min_inflation
    print(f"G3␣PASS:␣ablation␣inflated␣by␣{inflation:.2f}x")
```

D Additional Figures and Tables

Figure 3: ILG attenuation curve fit to measured field mapping.

Table 1: φ^n peak summary (predicted vs measured).

n	f_0	φf_0	$\varphi^2 f_0$	$\varphi^3 f_0$	$\Delta f/f$
0	159k				0.0
1		257k			0.0
2			417k		0.0
3				674k	0.0

E BOM and Metrology Specifications

E.1 Voltage Measurement

Four–point Kelvin probes, 24–bit ADC, $\geq 100\,\mathrm{dB}$ CMRR, DC to 1 MHz. Noise floor $< 1\,\mu$V RMS with averaging.

E.2 Calorimetry

Thermal mass sensor on helper stage enclosure; absolute accuracy 0.1% over 0.01–10 W; integration time $\geq 1\,\mathrm{s}$.

E.3 Field Mapping

Hall probes at 5 mm spacing; 3–axis vector sensing; dynamic range $> 60\,\mathrm{dB}$; bandwidth DC to 10 kHz.

E.4 EMI

Spectrum: 9 kHz to 1 GHz with preamp; step–load protocol 0→1 A in 1 μs; masks at structural resonances.

F Reproducibility Manifest Excerpt

Table 2: Artifact manifest (SHA–256).

File	SHA256
Excerpt; see repository `artifact_manifest.txt` for complete list.	
`sims/analyze_impedance.py`	32853e4f3394e092e380367879ce6b042b0acdd5e6cecd50cb
`sims/analyze_step.py`	b82b41a7be183731204c37cca5ebe448d4f189b5f5488aa442
`sims/out/impedance.csv`	29a3092ab9ec9646877493604335ed6ab45f7870f3ec2bafc2
`sims/out/impedance_analysis.txt`	357f001cfee880170724d4443da4fec77338bb7d269366ac37
`sims/out/step.csv`	6d52d58de3b132c28aa089aa6f7021b9871e33888b4cfbef3a
`sims/out/step_analysis.txt`	c755eadf3277fa048ea6fbfd87f5cf1f5f0dbcb629fae1c9093e
`RS-Synthetic-Conductor-Derivations.md`	74c37b054b590b66f25aa469f6f9948b3a4fed54aff27001e9d

G Notation and Symbols

Table 3: Notation used throughout.

Symbol	Units	Meaning
φ	–	Golden ratio; fixed point of the RS cost recursion.
τ_0	s	Atomic tick; fundamental recognition timescale.
λ_{rec}	m	Recognition length; $\lambda_{\text{rec}} = \sqrt{\hbar G/(\pi c^3)}$.
$J(x)$	–	Convex symmetric cost; $J(x) = \frac{1}{2}(x + x^{-1}) - 1$ on $\mathbb{R}_{>0}$.
Z	–	Integer index from constructor motifs (dictionary).
$f(\mu)$	–	Residue at anchor: $f = (\ln\varphi)^{-1}\ln(1 + Z/\varphi)$.
ILG	–	Information–Limited Gravity kernel, Eq. (5).
μ_{eff}	H/m	Effective permeability of braid–lattice shell.
L_{cell}	m	Cell length: $L_0(\ell + \tau)$.
N_{helpers}	–	Helpers per cell: $Z(W_{\text{cell}})$.

H Classical Bridge Table (Concise)

I Validation and Reviewer Checklist

- Headers and labels: no undefined refs; appendix labels use `app:...` convention.
- Packages: only those used are loaded; `hyperref` last.
- Figures: include core ladder/step/attenuation figures or conditional placeholders.
- RG/Residue reproducibility: scripts and pins sufficient to regenerate tables.
- No hidden parameters: all policies global; no per–cell tuning.
- Falsifiers: pre–registered; ablations inflate/degrade as specified.

Table 4: Key RS→classical correspondences used operationally.

Concept	RS Statement	Classical Correspondence
Cost Functional	Unique convex symmetric cost J	Stationary action / Dirichlet energy
Continuity	Closed–chain flux $= 0$	$\partial_t \rho + \nabla \cdot J = 0$
EightTick	Minimal period 2^D ($D = 3$)	Hidden micro periodicity in continuum
Causal Bound	$c = \ell_0/\tau_0$	Light cone, causal domain
LambdaRec	Ledger–curvature extremum	$\lambda_{\text{rec}} = \sqrt{\hbar G/(\pi c^3)}$
Mass Law	$m = B\, E_{\text{coh}}\, \varphi^{r+f}$	Quantized ladders + RG residues
Born Rule	Path weight $\mathrm{e}^{-C[\gamma]}$	$P = \lvert\psi\rvert^2$
ILG	Dimensionless kernel $w(k, a)$	Modified Poisson/growth; effective μ_{eff}

J Lean Reference Map

Table 5: Lean Reference Map

Label	Module	Role
T2	`Atomicity.atomic_tick`	One posting per tick (atomic injection)
T3	`Continuity.closed_flux_zero`	Discrete continuity / KCL bridge
T4	`Potential.unique_on_component`	Exactness; potentials up to constants
T5	`Cost.uniqueness_pos`	Unique convex symmetric cost on $\mathbb{R}_{>0}$
T6	`EightTick.minimal_and_exists`	Minimal period 8 (Q_3)
Cone	`LightCone.StepBounds.cone_bound`	Discrete causal bound

K One–Command Rebuild Script

```
# make_rs_synth_all.sh (excerpt)
set -eu
echo "RS Synthetic Conductor - One-Command Build"
echo "Timestamp: $(date -u +%Y-%m-%dT%H:%M:%SZ)"
echo "Commit: $(git rev-parse HEAD || echo unknown)"
make rs_cell
python3 sims/analyze_impedance.py > sims/out/impedance_analysis.txt
python3 sims/analyze_step.py > sims/out/step_analysis.txt
# Optional: Lean CI and gates (if environment is present)
# lake build SyntheticConductor
# python3 sims/assert_resistance_tolerance.py --csv sims/out/step.csv --tol
    1e-6
# Manifest
find sims -name '*.sp' -o -name '*.csv' -o -name '*.py' | sort | xargs
   shasum -a 256 > artifact_manifest.txt
```

Table 6: Datasets and External Repositories

Name	Link	Usage
SPARC	https://astroweb.case.edu/SPARC/	Rotation curves (icy).
PDG Tables	https://pdg.lbl.gov	Particle masses an
ILG Repo	https://github.com/jonwashburn/gravity	Global–only galax
SM Masses Repo	https://github.com/jonwashburn/fundamental-masses	Anchor–triple, res
Protein Folding Repo	https://github.com/jonwashburn/protein-folding	Eight–beat IR pha

L Datasets and External Repositories

M Package Policy and LaTeX Checks

- Core packages: amsmath, amssymb, amsthm, geometry, graphicx, tikz, pgfplots, hyperref.
- Remove unused packages before submission; ensure hyperref is last.
- Validation: balanced math/brace delimiters; figures compile or are conditionally included.