Sample Deviation Reporting Template

Strategy Used	J_c Impact	Error (%)
Harmonic-Loop	$\Delta J_c = 0.002$	0.08%

Electromagnetism Pillar - Calibration

Purpose

This document establishes the canonical calibration for the Electromagnetism pillar. It carries forward explicit derivations and constants from the foundation, provides detailed calibration strategies, and fixes the locked pillar calibration. This file serves as the definitive calibration reference for all Electromagnetism-related branches, just as the foundation documents serve as canonical references for the trunk.

Restating Foundation Anchors (Explicit)

From the Mathematical Bridge and Calibration foundations, the following constants and relations are carried forward:
- **Torsion Constant (T_s):**
  $T_s = \sigma_s c$
- **Shear Constant (σ_s):**
  $\sigma_s = (m_e^2 c^2) / (4\pi^2 \hbar)$
- **Loop Action Constant (S_0):** fixed at the electron Compton loop:
  $\oint A \, ds = \hbar$
- **Closure Index (J_c):** fractional tolerance governing loop stability.
- **Electron Anchor:** locks the global action scale.
- **Hydrogen Anchor:** locks wavelength/energy ladder (Balmer series).
- **Muon Anchor:** locks time/lifetime using circulation frequency Ω_μ.

These anchors are immutable at the foundation level and must be used without retuning downstream. ($\hbar$ is the reduced Planck constant, $1.0545718 \times 10^{-34}$ J·s). (Ω_μ is the circulation frequency proportional to muon lifetime, see Mathematical Bridge).

Calibration Strategy Options (scalings / normalized forms).

Three major strategies are defined at the pillar level:

1. **Charge-Normalized Strategy:**
   Equation: $q\_ref \propto \tau \cdot A\_disp$
   - Strength: aligns directly with Coulomb's constant.
   - Weakness: obscures composite loop structures; e.g., loop–loop interactions may deviate >1% from prediction.

2. **Field-Line Strategy:**
   Equation: $B \propto \tau \times \cos(\theta$.
   - Strength: emphasizes preferred-axis orientation.
   - Weakness: indirect normalization; multi-axis systems may require 10^2 additional computation steps.

3. **Harmonic-Loop Strategy:**
   Equation: $f\_n/n \propto \tau/\sigma$.
   - Strength: integrates naturally with photon harmonics.
   - Weakness: computationally intensive; solving $n \times (\tau/\sigma$ for $n > 10^4$ increases runtime by $\sim 10^2$.

Glossary of Key Variables

- **τ (Torsion parameter):** describes loop rotational stability; tied to σ_s and T_s.
- **σ (Shear constant):** governs tearing resistance of space; must be finite, non-zero.
- **A_disp (Display-Area):** the transverse obscured area of a propagating void; foundation observable.
- **ω_loop:** circulation frequency of a closed loop, proportional to energy content.

Strategy Comparison Table

Strategy	Equation	Best Use Case	Computational Cost	Foundation Tie-In
Charge-Normalized	$q\_ref = \tau \times A\_disp$	Classical fields	Low	Direct link to Coulomb's constant
Field-Line	$B \propto \tau \times \cos(\theta)$	Orientation studies	Medium	Preferred-axis torsion alignment
Harmonic-Loop	$f\_n = n \times (\tau/\sigma)$	Photon harmonics, composites	High	Loop harmonic derivations

Locked Pillar Calibration (Canonical—Vacuum)

Classical vacuum relations appear here only as limit checks/locks; the pillar's dynamics are derived from geometry with no new dimensional scales beyond $S_0 = \hbar$ (set once at the electron anchor; no retune).

- **Action lock:** $S_0 = \hbar$
- **Speed of light (SI lock):** c exact; $c = (\mu_0\, \varepsilon_0)^{(-1/2)}$
- **Vacuum constants (SI):** $k\_e = 1/(4\pi\, \varepsilon_0)$ and $\mu_0\, \varepsilon_0 = 1/c^2$
- **Coulomb field (vacuum):** $E(r) = (q / (4\pi\, \varepsilon_0\, r^2)) \cdot \hat{r}$
- **Maxwell limit (vacuum):** $\nabla\cdot E = \rho/\varepsilon_0$; $\nabla\cdot B = 0$; $\nabla\times E = -\partial B/\partial t$; $\nabla\times B = \mu_0\, \varepsilon_0\, \partial E/\partial t$
- **(Optional) Steady-current field:** $B(r) = (\mu_0 / 4\pi) \int (I\, dl \times \hat{r}) / r^2$ (Biot–Savart/Ampère, vacuum)
- ***Note:*** *In vacuum, μ_0 and ε_0 are constants (no geometry dependence). Use μ_eff, ε_eff only in media.*

Constant	Expression	Foundation Reference	Verification Source
k_e	$1 / (4\pi\, \varepsilon_0)$	Vacuum identity (SI)	CODATA 2022
μ_0	Vacuum constant (no geometry dependence)	Vacuum constant (SI); use μ_eff in media	CODATA/NIST
ε_0	Vacuum constant (no geometry dependence)	Vacuum constant (SI); use ε_eff in media	CODATA/NIST
c	$(\mu_0\, \varepsilon_0)^{(-1/2)}$	Vacuum identity (SI)	Precision interferometry / CODATA
$\mu_0\, \varepsilon_0$	$1 / c^2$	Vacuum identity (SI)	CODATA/NIST

Worked Example: Coulomb Constant

(Here S_0 = ħ is fixed at the electron anchor; no retune.)

We adopt vacuum μ_0, ε_0 and the identity $k_e = 1/(4\pi\, \varepsilon_0)$. Using CODATA 2022 values:

$k_e = 1/(4\pi\, \varepsilon_0) \approx 8.98755\times10^9\ \mathrm{N\cdot m^2/C^2}$.

We treat this as an acceptance target for pillar predictions. Any emergent/geometry mapping of permittivity/permeability belongs to effective parameters ε_{eff}, μ_{eff} in media, not to vacuum ε_0, μ_0.

Extended Locked Calibration Clarifications

- **Fine-Structure Constant Derivation:** $\alpha = e^2 / (4\pi\, \varepsilon_0\, \hbar\, c) \approx 1/137.036$, consistent with CODATA 2022.

- **Derived Constants:** The fine-structure constant ($\alpha \approx 1/137$) and Bohr magneton (μ_B) are not separately locked but derivable from the locked set (e, ħ, c, μ_0, ε_0).
- **Reporting Standard for Branch Deviations:** Any branch using an alternate calibration strategy must specify: (i) strategy used, (ii) impact on J_c, (iii) propagated error estimates.
- **Applicability Limits:** Locked calibration is validated for $E < 10^{12}$ V/m and r above atomic scales; extreme regimes must reference falsifiable predictions in the Verification Document.

Guidance for Branches

Branches should default to locked calibration. Alternate strategies may be explored but must be explicitly documented. All falsifiable predictions at the branch level must reference which calibration strategy is in use. Branches must also reverify locked parameters against updated CODATA/PDG standards at least every 2 years.