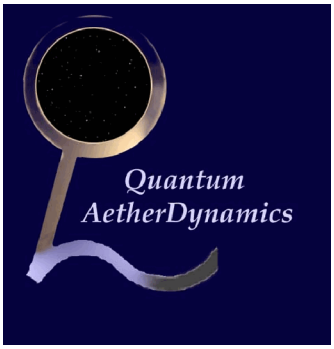

Quantum AetherDynamics Institute (QADI)

A Dimensional Audit of Electromagnetic Unit Systems: CGS, SI/MKS, and Quantum Measurement Units

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Version 1.0 – June 4, 2026

This article is published by the Quantum AetherDynamics Institute (QADI).

It develops the Aether Physics Model (APM)

Abstract

The transition from CGS electromagnetic units to SI/MKS introduced an explicit charge dimension and redistributed dimensional structure among Coulomb's constant, vacuum permittivity, vacuum permeability, capacitance, inductance, and conductance. This paper audits those relationships and shows that the named electromagnetic units form a closure family through Coulomb's constant. The relationship

$$k_C = c\,Cd\,\frac{\mu_0}{\epsilon_0}$$

is presented as a compact dimensional test of that family. The Quantum Measurement Unit (QMU) framework is then proposed as a replacement dimensional ontology in which the charge-domain structure is explicit rather than hidden in historically inherited SI/MKS unit conventions.

Keywords: Quantum Measurement Units; QMU; Aether Physics Model; dimensional analysis; electromagnetic units; Coulomb constant; vacuum permittivity; vacuum permeability; conductance; capacitance; inductance

1 Introduction

Modern electromagnetic metrology inherits its structure from several historical unit systems, including electrostatic CGS, electromagnetic CGS, Gaussian units, Heaviside–Lorentz units, and SI/MKS. These systems differ not only by numerical conversion factors, but also by how dimensional content is assigned to charge, field, current, permeability, permittivity, and Coulomb's constant.

In electrostatic CGS, Coulomb's constant is absorbed into the definition of charge. In SI/MKS, charge is made explicit and Coulomb's constant appears as a dimensional proportionality factor. This transition produced a practical engineering system, but it also obscured a structural relationship among several named electromagnetic units.

This paper evaluates the dimensional relationship among the following quantities:

$$k_C, \qquad \epsilon_0, \qquad \mu_0, \qquad C, \qquad L, \qquad Cd.$$

The central thesis is that these quantities form a single Coulomb-bound dimensional family. QMU is presented as an alternative dimensional ontology that restores this family to explicit ledger form.

2 Coulomb's Law in CGS and SI/MKS

In electrostatic CGS form, Coulomb's law is written as

$$F = \frac{q_1 q_2}{r^2}. \tag{1}$$

The proportionality constant is absorbed into the definition of charge.

In SI/MKS form, Coulomb's law is written as

$$F = k_C \frac{q_1 q_2}{r^2}, \tag{2}$$

where

$$k_C = \frac{1}{4\pi\epsilon_0}. \tag{3}$$

The introduction of an explicit charge dimension therefore places dimensional weight into k_C and ϵ_0. The purpose of this audit is to determine how that dimensional weight propagates through the related electromagnetic units.

3 Vacuum Impedance and the Permeability–Permittivity Ratio

The vacuum impedance is defined by

$$Z_0 = \sqrt{\frac{\mu_0}{\epsilon_0}}. \tag{4}$$

It follows immediately that

$$\frac{\mu_0}{\epsilon_0} = Z_0^2. \tag{5}$$

The electromagnetic wave-speed closure is

$$c = \frac{1}{\sqrt{\mu_0\epsilon_0}}, \tag{6}$$

and therefore

$$c^2 = \frac{1}{\mu_0\epsilon_0}. \tag{7}$$

Equations (4)–(7) show that μ_0, ϵ_0, Z_0, and c are not dimensionally independent.

4 Coulomb–Conductance Closure

Define the conductance quantity Cd by

$$Cd = \frac{1}{4\pi Z_0}. \tag{8}$$

Using $Z_0^2 = \mu_0/\epsilon_0$, we obtain

$$c\,Cd\,\frac{\mu_0}{\epsilon_0} = c\left(\frac{1}{4\pi Z_0}\right) Z_0^2. \tag{9}$$

Thus,

$$c\,Cd\,\frac{\mu_0}{\epsilon_0} = \frac{cZ_0}{4\pi}. \tag{10}$$

Since

$$Z_0 = \mu_0 c, \tag{11}$$

we have

$$\frac{cZ_0}{4\pi} = \frac{\mu_0 c^2}{4\pi}. \tag{12}$$

Using $c^2 = 1/(\mu_0\epsilon_0)$, this becomes

$$\frac{\mu_0 c^2}{4\pi} = \frac{1}{4\pi\epsilon_0} = k_C. \tag{13}$$

Therefore,

$$\boxed{k_C = c\,Cd\,\frac{\mu_0}{\epsilon_0}}. \tag{14}$$

Equation (14) is the Coulomb–conductance closure. It explicitly binds Coulomb's constant, conductance, permeability, permittivity, and wave speed into one dimensional family.

4.1 Geometric Conductance

The factor 4π appears naturally in Coulomb's law because electrostatic charge distributes over spherical geometry.

To preserve geometric symmetry between Coulomb's constant and electromagnetic conductance, we define the geometric conductance

$$Cd = \frac{1}{4\pi Z_0}. \tag{15}$$

This definition removes the spherical geometry from the vacuum impedance in the same manner that Coulomb's constant removes the spherical geometry from vacuum permittivity:

$$k_C = \frac{1}{4\pi\epsilon_0}. \tag{16}$$

The two quantities therefore occupy analogous positions within the electromagnetic dimensional structure.

5 Capacitance and Inductance

Capacitance and inductance belong to the same closure family. In circuit form, the propagation relation is

$$v = \frac{1}{\sqrt{LC}}. \tag{17}$$

The vacuum electromagnetic propagation relation is

$$c = \frac{1}{\sqrt{\mu_0\epsilon_0}}. \tag{18}$$

The structural correspondence is therefore

$$LC \longleftrightarrow \mu_0\epsilon_0. \tag{19}$$

This correspondence places capacitance and inductance in the same dimensional network as permittivity and permeability. Since conductance also enters the Coulomb–conductance closure, the five named units

$$\{\epsilon_0,\ \mu_0,\ C,\ L,\ Cd\} \tag{20}$$

should be treated as members of one charge-domain unit family rather than as isolated definitions.

Table 1: Coulomb-Bound Electromagnetic Family

Quantity	SI Definition	Coulomb Relationship
Permittivity	ϵ_0	$k_C = 1/(4\pi\epsilon_0)$
Permeability	μ_0	$Z_0 = \sqrt{\mu_0/\epsilon_0}$
Conductance	Cd	$Cd = 1/(4\pi Z_0)$
Capacitance	C	$v = 1/\sqrt{LC}$
Inductance	L	$v = 1/\sqrt{LC}$

6 Graph Interpretation of Electromagnetic Units

The closure family may be represented as a connected graph in which nodes correspond to electromagnetic quantities and edges correspond to defining identities.

$$\epsilon_0 \leftrightarrow k_C \leftrightarrow Cd \leftrightarrow Z_0 \leftrightarrow \mu_0 \tag{21}$$

with additional propagation relationships

$$c \leftrightarrow (\mu_0, \epsilon_0). \tag{22}$$

The resulting structure is not a collection of isolated units but a connected dimensional network.

Proposition 6.1. *The electromagnetic closure family forms a connected dimensional graph.*

Proof. Every member of the family is reachable from every other member through a finite sequence of defining identities. Therefore the graph is connected. □

This graph interpretation motivates the QMU ontology developed below. Rather than representing units as isolated definitions, QMU treats physical quantities as vertices within a dimensional ledger whose relationships are explicitly recorded through closure, reciprocity, and equation authority Thomson [2025].

7 QMU Dimensional Ontology

The preceding sections identify a Coulomb-bound family of electromagnetic quantities within SI/MKS. The question then becomes whether an alternative dimensional ontology can represent this family more explicitly.

Quantum Measurement Units (QMU) were developed for that purpose. Rather than beginning with macroscopic base units, QMU begins with a small set of quantum-scale primitives from which all derived electromagnetic quantities are generated.

QMU begins from a compact set of quantum-scale primitives:

$$m_{\mathrm{e}}, \qquad \lambda_C, \qquad F_q, \qquad e^2, \qquad {e_{\mathrm{emax}}}^2. \tag{23}$$

The Aether unit is defined as

$$A_u = 16\pi^2 k_C. \tag{24}$$

The magnetic charge is

$$e_{\text{emax}}{}^2 = \frac{e^2}{8\pi\alpha}. \tag{25}$$

Magnetic flux is represented in QMU as

$$mflx = \frac{m_{\text{e}}\lambda_C{}^2 F_q}{e_{\text{emax}}{}^2}. \tag{26}$$

The numerator $m_{\text{e}}\lambda_C{}^2 F_q$ represents the rotational energy-length structure of the quantum domain, while the denominator introduces the magnetic charge geometry. The resulting unit occupies the canonical magnetic-flux position within the QMU ledger.

QMU does not treat electromagnetic units as historical artifacts. It treats each unit as a ledger object with a dimensional identity, reciprocal relationships, closure relationships, and equation relationships.

7.1 Resistance, Reactance, and Charge-Rank Compression

7.2 Magnetic-Charge Rank Separation

A notable consequence of the QMU ontology is the separation of resistance and magnetic flux by magnetic-charge rank.

Proposition 7.1 (Magnetic-Charge Rank Separation)**.** *Given*

$$mflx = \frac{m_{\text{e}}\lambda_C{}^2 F_q}{e_{\text{emax}}{}^2} \tag{27}$$

and

$$resn = \frac{m_{\text{e}}\lambda_C{}^2 F_q}{e_{\text{emax}}{}^4}, \tag{28}$$

then

$$\frac{mflx}{resn} = e_{\text{emax}}{}^2. \tag{29}$$

Thus magnetic flux and resistance differ by exactly one magnetic-charge rank.

Proof. Direct division yields

$$\frac{\frac{m_{\mathrm{e}}{\lambda_C}^2 F_q}{{e_{\mathrm{emax}}}^2}}{\frac{m_{\mathrm{e}}{\lambda_C}^2 F_q}{{e_{\mathrm{emax}}}^4}} = {e_{\mathrm{emax}}}^2. \tag{30}$$

The mechanical numerators cancel identically, leaving a single factor of magnetic charge. □

This separation suggests that quantities traditionally grouped under the SI/MKS impedance formalism may occupy distinct dimensional positions within the QMU ledger Thomson [2026].

In SI/MKS impedance theory, resistance and reactance are combined as

$$Z = R + jX. \tag{31}$$

In the QMU framework, built from the primitives $m_{\mathrm{e}}, \lambda_C, F_q, e^2, {e_{\mathrm{emax}}}^2$, resistance and magnetic flux are:

$$resn = \frac{m_{\mathrm{e}}{\lambda_C}^2 F_q}{{e_{\mathrm{emax}}}^4}, \qquad mflx = \frac{m_{\mathrm{e}}{\lambda_C}^2 F_q}{{e_{\mathrm{emax}}}^2}. \tag{32}$$

They share the same mechanical numerator but differ by a full magnetic-charge rank (${e_{\mathrm{emax}}}^2$) in the denominator. Thus,

$$resn = \frac{mflx}{{e_{\mathrm{emax}}}^2}, \qquad mflx = resn \cdot {e_{\mathrm{emax}}}^2. \tag{33}$$

The imaginary unit (j) in conventional impedance serves as the mathematical mechanism by which SI/MKS combines charge-rank-distinct quantities into a common impedance representation. Resistance and reactance are thereby expressed within a single operational framework despite originating from different dimensional structures.

From the QMU perspective, this construction is effective for calculation but does not preserve the underlying charge-rank distinction. The impedance formalism succeeds by projecting multiple electromagnetic domains into a common representation, whereas QMU retains those domains as separate ledger entities. In this sense, QMU exposes dimensional relationships that remain implicit within conventional impedance theory.

8 Ledger Closure

The fundamental QMU closure identity is Ledger One:

$$A_u \cdot curl = {F_q}^2 {\lambda_C}^2. \tag{34}$$

Since

$$F_q \lambda_C = c, \tag{35}$$

Ledger One may also be recognized as

$$A_u \cdot curl = c^2. \tag{36}$$

The Maxwell propagation constant is

$$c^2 = \frac{1}{\mu_0 \epsilon_0}. \tag{37}$$

Thus,

$$A_u \cdot curl = \frac{1}{\mu_0 \epsilon_0}. \tag{38}$$

Equation (38) is the bridge between the QMU ledger closure and the SI/MKS electromagnetic propagation constant.

9 Dimensional Audit Result

The Coulomb–conductance closure demonstrates that

$$k_C, \quad Cd, \quad \mu_0, \quad \epsilon_0, \quad c \tag{39}$$

are algebraically bound.

The propagation correspondence demonstrates that

$$C, \quad L, \quad \epsilon_0, \quad \mu_0 \tag{40}$$

belong to the same dimensional structure.

Together, these observations imply that the named electromagnetic units

$$\epsilon_0, \quad \mu_0, \quad C, \quad L, \quad Cd \tag{41}$$

should be analyzed as a single Coulomb-bound unit family.

In SI/MKS this family is distributed across separately named quantities. In QMU the corresponding relationships are represented as ledger relationships.

10 Electromagnetic Closure Theorem

The dimensional relationships among Coulomb's constant, vacuum permittivity, vacuum permeability, vacuum impedance, conductance, and the speed of light may be stated formally.

Theorem 10.1 (Electromagnetic Closure Family)**.** *Let*

$$\mathcal{E} = k_C, \epsilon_0, \mu_0, Z_0, c, Cd.$$

Then every element of $(\mathcal{E})$ may be generated from any two algebraically independent members.

Proof. The family is governed by the identities

$$k_C = \frac{1}{4\pi\epsilon_0}, \tag{42}$$

$$Z_0 = \sqrt{\frac{\mu_0}{\epsilon_0}}, \tag{43}$$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}, \tag{44}$$

and

$$Cd = \frac{1}{4\pi Z_0}. \tag{45}$$

Given any two independent quantities, the remaining members are obtained through algebraic substitution. Therefore the family is closed under dimensional generation. □

The theorem demonstrates that the named electromagnetic quantities do not constitute independent dimensional primitives. Instead they form a closed electromagnetic family generated by a smaller set of underlying relationships Jackson [1999], Sommerfeld [1952].

11 Discussion

The SI/MKS system is a successful engineering standard, but its electromagnetic sector preserves historical structure from CGS conversion. The addition of explicit charge dimensions did not produce a complete dimensional ontology of electromagnetic units. Instead, several quantities retained inherited structures tied to Coulomb's constant.

The QMU framework addresses this by treating units as members of a connected dimensional graph. In this graph, each physical quantity has a defined place in the ledger.

This does not merely add more named units. It changes the purpose of the unit system. SI/MKS is a measurement standard. QMU is a dimensional ontology.

12 Conclusion

A dimensional audit of the CGS-to-SI/MKS transition reveals that permeability, permittivity, capacitance, inductance, and conductance form a Coulomb-bound electromagnetic unit family.

The identity

$$k_C = c\, Cd\, \frac{\mu_0}{\epsilon_0}$$

makes this relationship explicit.

QMU provides a replacement dimensional ontology in which this closure structure is not hidden in conversion conventions, but represented directly through ledger identities and authority relationships.

Future work should extend this audit across the full QMU unit authority graph and identify additional closure families concealed by conventional unit systems.

A Charge-Rank Structure of Resistance and Magnetic Flux

QMU distinguishes between resistance and magnetic flux through their magnetic-charge rank.

$$resn = \frac{m_e {\lambda_C}^2 F_q}{{e_{\text{emax}}}^4} \tag{46}$$

$$mflx = \frac{m_e {\lambda_C}^2 F_q}{{e_{\text{emax}}}^2} \tag{47}$$

The two quantities therefore differ by a full magnetic-charge rank,

$$resn = \frac{mflx}{{e_{\text{emax}}}^2}. \tag{48}$$

This observation suggests that resistance and reactance may occupy distinct dimensional domains within the QMU ledger. A complete reformulation of impedance theory based on this distinction is left for future work.

Acknowledgments

The Quantum AetherDynamics Institute (QADI) is a private 501(c)(3) research institute developing the Aether Physics Model (APM) and Quantum Measurement Units (QMU) Thomson III [2025]. Publications and data are archived with DOIs in the AetherPhysics Zenodo community: zenodo.org/communities/aetherphysics.

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