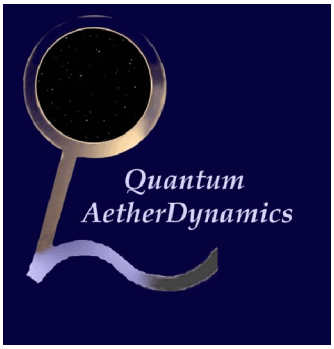

Quantum AetherDynamics Institute (QADI)

Potential Closure in QMU: A Josephson–Quantum Hall Ledger Interpretation of the Primary Current Standard

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It develops the Aether Physics Model (APM)

Abstract

A primary quantum current standard combining the Josephson and quantum Hall effects provides a closed metrological system linking frequency, conductance, and current. In conventional SI form, this is expressed as $I = (n/p)\, e f_J$, which compresses flux geometry and charge representation into a single relation.

This paper reformulates the system in Quantum Measurement Units (QMU), where electrical quantities are expressed in distributed charge. The Josephson–Hall system is shown to realize the identities $potn = freq/cond$ and $curr = potn/resn$, revealing that the current standard is fundamentally a potential closure governed by frequency and conductance geometry.

The SI expression is recovered as a measurement projection, while the QMU formulation provides a real-valued, geometrically explicit ledger.

1 Introduction

Recent advances in electrical metrology have demonstrated a primary quantum current standard based on the Josephson and quantum Hall effects. In SI units, this is written as

$$I = \left(\frac{n}{p}\right) e f_J, \tag{1}$$

where f_J is the Josephson frequency and n/p arises from the quantum Hall state.

This capability has recently been realized in programmable quantum current generators combining Josephson junctions, quantum Hall resistance, and superconducting amplification [1].

In SI form, magnetic flux geometry and charge representation are embedded within h and e. In Quantum Measurement Units (QMU), these roles are separated into distributed charge, magnetic flux, and frequency primitives [3, 2].

This paper demonstrates that the Josephson–Hall system is a direct realization of the identities

$$\boxed{potn = \frac{freq}{cond}, \qquad curr = \frac{potn}{resn}} \tag{2}$$

The primary quantum current standard is therefore a potential closure governed by frequency and conductance geometry, with current emerging as a derived quantity.

2 Scope and Intent

This work reformulates a completed experimental system within QMU.

It does not attempt to:

- Replace quantum mechanical descriptions,
- Address noise or decoherence,
- Provide a full AC circuit theory.

Those extensions are natural but outside present scope.

3 QMU Electrical Primitives

Electrical quantities in QMU are expressed in distributed magnetic charge:

$$curr = {e_{\text{emax}}}^2 F_q, \tag{3}$$

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

$$cond = \frac{{e_{\text{emax}}}^2}{m_e {\lambda_C}^2 F_q}, \tag{5}$$

$$mflx = \frac{m_e {\lambda_C}^2 F_q}{{e_{\text{emax}}}^2}, \tag{6}$$

$$potn = \frac{m_e {\lambda_C}^2 {F_q}^2}{{e_{\text{emax}}}^2}. \tag{7}$$

Here F_q is the QMU base quantum frequency, while f_J is the experimentally applied Josephson frequency.

These yield:

$$cond = \frac{1}{mflx}, \qquad potn = F_q \cdot mflx. \tag{8}$$

4 Fundamental Ledger Relations

$$potn = curr \cdot resn, \qquad potn = \frac{freq}{cond} \tag{9}$$

These relations show that potential is the central ledger quantity in QMU, linking transport to resistance and frequency to conductance geometry.

$$freq \longrightarrow potn \longrightarrow curr \tag{10}$$

5 SI and QMU Role Comparison

Role	**SI**	**QMU**
Josephson	Voltage standard	Frequency source
Hall effect	Resistance standard	Conductance geometry
Potential	Derived	Central closure
Current	Primary	Derived
Closure	$I = V/R$	$potn = freq/cond$, $curr = potn/resn$

Table 1: Structural comparison

6 Potential Closure from Josephson–Hall System

Josephson provides:

$$freq = f_J \tag{11}$$

Hall defines:

$$cond \to \left(\frac{p}{n}\right) cond \tag{12}$$

This transformation reflects a discrete modification of the underlying magnetic flux geometry. Since $cond = 1/mflx$, the Hall state (p/n) corresponds to a rescaling of the flux unit, $mflx \to (n/p)\, mflx$, indicating that conductance quantization arises from discrete geometric partitioning of magnetic flux. In this sense, the Hall plateau is not merely a transport property but a geometric constraint on flux structure. Thus:

$$potn = \left(\frac{n}{p}\right) f_J \cdot mflx \tag{13}$$

Thus, the quantized potential emerges from frequency interacting with a discretely structured flux geometry, rather than from direct charge transport.

7 Current Derivation

$$curr = \frac{potn}{resn} \tag{14}$$

$$curr = \left(\frac{n}{p}\right) {e_{\text{emax}}}^2 f_J \tag{15}$$

8 Ledger Diagram

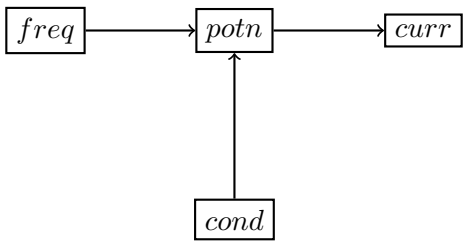

Figure 1: QMU ledger structure

9 Absence of Complex Impedance

In conventional theory, impedance combines resistive and reactive behavior using the imaginary unit.

In QMU, all electrical quantities share a distributed-charge basis. Conductance is directly tied to magnetic flux geometry, and no unit mismatch occurs. All relations remain real-valued. Phase behavior must therefore arise from explicit time dependence in frequency or geometry.

10 Implications

- Reconstruction of magnetic flux from measured frequency and potential
- Verification of conductance scaling as inverse flux geometry
- Exploration of real-valued time-dependent formulations

11 Conclusion

$$curr = \left(\frac{n}{p}\right) {e_{\text{emax}}}^2 f_J \tag{16}$$

This is the experimental realization of the general QMU current form $curr = {e_{\text{emax}}}^2 F_q$.

$$potn = \frac{freq}{cond}, \qquad curr = \frac{potn}{resn} \tag{17}$$

The SI expression is recovered as a projection, while the QMU formulation provides a real-valued ledger that foregrounds the underlying frequency–flux geometry governing the system.

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) [4]. Publications and data are archived with DOIs in the AetherPhysics Zenodo community: zenodo.org/communities/aetherphysics.

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