Deterministic Current Topology (DCT)

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A Wiring Architecture for RMS Integrity, Thermal Symmetry, and BOM Reduction

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1. Executive Statement

Modern electric machines are limited less by materials and more by **non-deterministic current distribution**.

Root Mean Square (RMS) values—used universally for design and safety—mask internal asymmetries that produce:

- Circulating currents
- Harmonic heating
- Uneven conductor loading
- Premature component stress

Deterministic Current Topology (DCT) introduces a wiring architecture that constrains current paths through **geometric and electrical symmetry**, ensuring that RMS energy corresponds to *useful work*, not internal loss.

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2. Problem Framing

Conventional motor systems rely on:

- Parallel conductors with unequal impedance paths
- Inverter-driven waveforms with harmonic content
- Post-facto compensation (control loops, filtering, thermal margining)

This results in:

$$\text{RMS} \neq \text{Effective Torque Contribution}$$

Instead:

- A portion of RMS current becomes **non-productive thermal load**
- Additional components are introduced to compensate:

    - Sensors
    - Filters
    - Control layers
    - Mechanical corrections

This increases **BOM, failure surfaces, and system entropy**.

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3. Core Principle

DCT shifts the design constraint from:

> “Control the current after distribution”

to:

> “Constrain the distribution so control is minimized”

3.1 Deterministic Path Enforcement

Each conductor path is designed such that:

- Path impedance is matched by geometry
- Loop areas are minimized and mirrored
- Phase relationships are physically constrained

Result:

- Equalized current sharing across conductors
- Suppression of circulating currents
- Reduction in harmonic amplification

3.2 RMS Alignment

Under DCT:

> RMS current becomes a *faithful representation* of mechanical output contribution

Not:

- A mixture of useful work + internal dissipation

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4. Architectural Characteristics

4.1 Symmetry as a Constraint (Not a Goal)

- Electrical symmetry is enforced structurally
- Not tuned via software after assembly

4.2 Reduced Interconnect Complexity

By eliminating redundant compensation paths:

- Fewer welds / joints
- Fewer parallel branch inconsistencies
- Reduced wiring variability

4.3 Thermal Coherence

Uniform current distribution yields:

- Even heat generation
- Predictable cooling requirements
- Higher allowable current density without hotspots

4.4 Harmonic Resilience

Geometry reduces:

- High-frequency circulating paths
- Eddy current amplification
- Parasitic coupling

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5. BOM Implications

DCT reduces or simplifies:

- Current balancing structures
- Excess sensing layers
- Harmonic filtering components
- Overbuilt thermal margins

Result:

> Lower part count + higher reliability + improved manufacturability

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6. Compatibility with Existing Systems

DCT is not a replacement for:

- Field-Oriented Control (FOC)
- PWM inverters
- Existing drive electronics

Instead:

> It provides a *higher-quality physical substrate* upon which these systems operate.

This allows:

- Reduced control complexity
- Improved efficiency at identical control strategies
- Easier compliance with efficiency standards

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7. Industry Positioning

Current industry approaches:

- Increase copper fill (flat wire, hairpin)
- Improve control algorithms
- Add compensation layers

DCT complements these by addressing:

> The underlying topology that defines how current is allowed to exist.

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8. Conceptual Analogy

A conventional system:

> A river forced into balance with pumps, gates, and sensors.

DCT:

> Terrain shaped such that the river naturally distributes evenly.

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9. Integration Pathways

DCT can be introduced through:

- Stator winding redesign
- Modular coil assemblies
- Symmetric bus routing in inverter-to-motor interfaces
- Standardized conductor geometries

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10. Alignment with AQUEM

Within the **AQUEM (Aqua's Quintessential Electromechanical Matrix)** framework:

- DCT acts as a **local invariance enforcer**
- Ensures each node maintains **energy symmetry integrity**
- Supports distributed systems where:
    - Measurement
    - Transmission
    - Actuation

all rely on **coherent current behavior**

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11. Closing Statement

The industry has optimized:

- Materials
- Control

- Manufacturing

Yet the **topology of current itself** remains under-constrained.

Deterministic Current Topology (DCT) proposes:

> That the most efficient system is not one that corrects imbalance—
> but one in which imbalance cannot meaningfully arise.

Module

RAEN Rotor Module

“Rotational-Array Electromagnetic Node (RAEN) Rotor Module”

Rotational-Array Electromagnetic Node Rotor Module for Field-Balanced Propulsion, Cooling, and Energy Transfer Systems

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ABSTRACT

A modular electromagnetic rotor configured as a multi-coil, multi-axis field actuator forming the fundamental unit of a distributed field-balancing engine. The RAEN Rotor Module comprises a stator-integrated winding pattern, gradient-controlled phase drives, thermal extraction interfaces, and optional optical or analog-feedback layers. The module may operate individually or as part of a lattice array to generate thrust, directional force, cooling, sensing, or mixed-mode field projection. Embodiments include planar rotors, stacked rotors, spherical rotors, and ring-type “hover tile” systems.

BACKGROUND

Traditional motors rely on fixed electromagnetic sequences optimized for torque, not field shaping. Cooling is typically passive, control is CPU-dependent, and modules do not natively cooperate in multi-node arrays.

Emerging distributed propulsion, high-density cooling, and field-balancing systems require:

1. **Real-time analog field correction**

2. **Low-latency thermal extraction**
3. **Arrayability — https://github.com/aquachroma/Omega_SDK**
4. **Balanced, low-noise force output**
5. **Feedback channels independent from CPU load**

The RAEN Rotor Module solves these requirements by integrating coil geometry, thermal layers, and analog balancers into a unified substrate.

SUMMARY

The RAEN Rotor Module is defined by:

- **8-coil or N-coil winding geometry**, distributed radially or tri-axially
- **Gradient-addressable power inputs** (PIG-I/O style)
- **Optional optical/thermal/field feedback layers**
- **Peltier-assisted or analog-assisted cooling interfaces**
- **Modularity**: tiles, rings, rotors, spherical shells
- **Array coherence**: each module acts as a field node in a larger RAEN lattice

The module can be used for:

- Hover/propulsion
- Directed cooling or convection
- Vibration management
- Field shaping
- Display or data routing
- Reactive sensing
- Power conversion

DETAILED DESCRIPTION

1. Rotor Geometry

The RAEN Rotor Module comprises:

- A rotor plate or drum (rigid, flexible, or composite)
- A stator stack or integrated winding cavity

- 8 coils (baseline) or N coils arranged in symmetrical distribution
- Optional ferromagnetic or paramagnetic inserts

Coil Arrangement

- 8-coil “compass rose” pattern
- 12-coil extended harmonic
- 16-coil high-resolution pattern
- Tri-coil or quad-coil minimal variants

Key advantage

The rotor no longer behaves as a simple torque engine — it becomes a **field shaper**.

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2. Gradient-Driven Power Input (RAEN Drive Method)

The RAEN module uses a **programmable impedance gradient (PIG-I/O)** to drive each coil:

- A smooth ramp instead of binary on/off
- Multiple coil-phase blends
- Lower acoustic noise
- Higher field fidelity
- Optional harmonic cancellation

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3. Thermal Interfaces

Each rotor module includes **one or more** of:

- Peltier tiles on the stator wall
- Heat-pipe channels in the substrate
- Optical thermal conduits
- Analog-gesture thermal balancers
- RAEN-Unified Substrate thermal vias

Purpose: Keep the substrate temperature stable for high-Q field operation.

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4. Optical + Field Feedback Layer

Optional layer comprising:

- Photodiodes or photocell ring
- Low-latency analog summing pathways
- Optical “return-to-zero” balancer circuits
- Lensed or waveguided optical tunnels

This allows *field self-correction* without CPU load.

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5. Multi-Module Lattice Integration

Rotor modules can be:

- Stacked vertically
- Arrayed as a 2D tile field
- Wrapped around a cylinder
- Distributed as a spherical shell

Each module exchanges:

- Thermal state
- Field gradient
- Analog phase data
- Power harmonics

The lattice behaves like a **distributed field machine, with respect to resonance**.

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6. Operating Modes

(a) Propulsion Mode

Coils are fired in a sweeping gradient, yielding:

- Vertical lift
- Lateral push
- Yaw/pitch/roll torque

(b) Cooling / Convection Mode

Rotor patterns optimized for airflow and high-frequency oscillations.

(c) Field Display Mode

Rotor outputs modulate light or EM flux; useful for screens, metasurfaces, and AR effects.

(d) Energy Collection Mode

Reverse-bias operation extracts rotational or ambient field energy.

(e) Sensing / Mapping Mode

Gradient sampling yields touchless pressure or thermal maps.