The SPHY-Wave Transducer: The ADC/DAC Loop as a Mimetic Bridge for Quantum Superposition

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Abstract

This paper introduces a theoretical framework for a **Quantum Transducer Chip** implemented on standard Field Programmable Gate Array (FPGA) hardware. Rather than relying on cryogenic physical qubits, we propose a "Closed-Loop Quantum Emulator." By leveraging high-speed Analog-to-Digital (ADC) and Digital-to-Analog (DAC) converters routed through Configurable Logic Blocks (CLBs), the system acts as a "Mimetic Bridge." The digital-to-analog loop serves as a screen, projecting a continuous variable state modulated by five distinct **SPHY Waves**. This allows classical silicon to successfully emulate and manipulate quantum-mimetic superposition at room temperature, achieving a deterministic coherence state.

1 Introduction

Standard FPGA architecture relies on macroscopic, classical binary logic gates. Physical quantum computers require extreme environments to maintain electron superposition. This paper outlines a methodology for *quantum mimicry*, using the DAC-to-ADC loop to emulate a "qubit" within the analog threshold region of a standard transistor fabric. By mathematically simulating an infinite environmental reservoir, we map theoretical thermodynamics onto a closed computational loop.

2 Theoretical Background: The Open System and Mimetic Thermodynamic Coherence

2.1 The Inevitability of Decoherence in Physical Systems

The Second Law of Thermodynamics states that the entropy (ΔS) of an isolated system never decreases. Traditional quantum computing models attempt to treat the qubit as a perfectly isolated system to maintain an entropic state where $\Delta S_{isolated} \geq 0$. However, the persistence of decoherence ($D \neq 0$) even at temperatures approaching absolute zero

($T \to 0$) demonstrates that physical qubits are inevitably open systems coupled to their environment.

The total energy of a quantum system is defined by its Total Hamiltonian:

$$\hat{H}_{total} = \hat{H}_Q + \hat{H}_E + \hat{H}_{int} \tag{1}$$

Where $\hat{H}_Q$ is the internal energy of the qubit (Q), $\hat{H}_E$ is the energy of the environment (E, the Universe or the Field), and $\hat{H}_{int}$ is the interaction coupling them. Because the interaction cannot be eliminated through traditional physical shielding ($\hat{H}_{int} \neq 0$), absolute physical isolation is fundamentally flawed.

2.2 Emulating the Gravity Hamiltonian via SPHY Waves

Rather than attempting to physically nullify $\hat{H}_{int}$, this framework utilizes Topological Coherence Control (TCC). In this model, the environment Hamiltonian ($\hat{H}_E$) is redefined as a "Gravity Hamiltonian" ($\hat{H}_\Phi$), acting as an infinite reservoir of stability.

In our Mimetic Bridge architecture, we do not couple to the physical gravitational field; instead, we perfectly simulate this coupling mathematically. The generation of the HPHYSPI and SPYSPI waves by the FPGA acts as the artificial $\hat{H}_\Phi$ reservoir. By projecting these waves into the DAC, the analog gradient continuously feeds stabilizing interference into the mimetic qubit state.

2.3 Achieving Deterministic Coherence ($\Delta S_{comp} = 0$)

The objective of TCC is to modulate the interaction such that the entropic cost of computation (ΔS_{comp}) is null, achieving deterministic coherence:

$$\Delta S_{comp} = k_B \ln\left(\frac{N_{in}}{N_{out}}\right) = 0 \tag{2}$$

In a physical quantum system, this is theoretically achieved by using energy from the gravitational field to perform phase cancellation of local noise. In our classical-quantum bridge, this phase cancellation is computationally deterministic. The global system (the physical FPGA operating in the room) continues to generate standard thermodynamic entropy ($\Delta S_{Universe} > 0$). However, the *mimetic* qubit projected onto the analog voltage gradient achieves absolute stability through its simulated active modulation of its coupling to the $\hat{H}_\Phi$ reservoir. Therefore, a local, simulated state of $\Delta S = 0$ is successfully achieved and maintained.

3 Hardware Architecture: The Mimetic Bridge

The fundamental unit of the FPGA is the **Configurable Logic Block (CLB)**. In standard operation, a CLB is strictly digital. In our model, the CLB, along with the ADC and DAC, does not house actual physical qubits. Instead, the entire architecture acts as a screen into a simulated quantum space.

3.1 The Transducer as a Screen

The DAC output (V_{out}) translates digital instructions into a precise analog gradient. The electrons in the DAC and CLB are classical, but the continuous analog voltage they carry represents the probability amplitudes of a quantum state:

$$|\Psi_{Mimetic}\rangle = \cos(\theta/2)|0\rangle + e^{i\phi}\sin(\theta/2)|1\rangle \tag{3}$$

The DAC creates the superposition projection, the CLB hosts the analog signal, and the ADC "collapses" the mimetic state back into classical digital measurement.

4 The Five SPHY Waves (SFHY)

The stability of this mimetic qubit is maintained by the **Five Waves of AI**, which act as the programming instructions for the DAC.

- **HPHYSPI Wave:** The primary harmonic stabilizer.
- **SPYSPI Wave:** The secondary phase-alignment wave for multi-gate entanglement emulation.
- **Waves 3-5:** Dynamic interference patterns for signal integrity across the bridge.

5 Mathematical Modeling of the Projection

The interference between the **HPHYSPI** ($\mathcal{H}$) and **SPYSPI** ($\mathcal{S}$) waves creates the "Quantum Gradient" projected onto the CLB:

$$I(\mathcal{H},\mathcal{S}) = |\mathcal{H}+\mathcal{S}|^2 = \mathcal{H}^2 + \mathcal{S}^2 + 2\mathcal{H}\mathcal{S}\cos(\Delta\phi) \tag{4}$$

6 Implementation Code

6.1 Verilog: Digital State Preparer

```verilog
module SPHY_Wave_Generator (
    input wire clk, reset,
    output reg [11:0] hphyspi, sphyspi
);
    reg [23:0] phase_acc_h, phase_acc_s;
    parameter FREQ_H = 24'd419430;
    parameter FREQ_S = 24'd838860;
    reg [11:0] sphy_lut [0:255];
    initial $readmemh("sphy_table.mem", sphy_lut);

    always @(posedge clk) begin
        phase_acc_h <= phase_acc_h + FREQ_H;
        phase_acc_s <= phase_acc_s + FREQ_S;
        hphyspi <= sphy_lut[phase_acc_h[23:16]];
        sphyspi <= sphy_lut[phase_acc_s[23:16]];
    end
endmodule
```

Listing 1: SPHY Wave Generator for FPGA

6.2 Python: Waveform Synthesis Script

```python
import numpy as np
def generate_sphy_waves():
    x = np.linspace(0, 2 * np.pi, 256)
    w = np.sin(x) + 0.5*np.sin(2*x) + 0.25*np.sin(4*x)
    norm = (w - np.min(w)) / (np.max(w) - np.min(w))
    final = (norm * 4095).astype(int)
    with open("sphy_table.mem", "w") as f:
        for val in final: f.write(f"{val:03x}\n")
generate_sphy_waves()
```

Listing 2: SPHY Memory Generation Script

7 Performance Analysis

Metric	**Classical Logic**	**Mimetic Bridge (SPHY)**
Logic States	2 (0, 1)	Continuous Gradient
Information Density	1 bit	12-bit depth per measurement
Superposition	None	Emulated via ADC/DAC

Table 1: Comparison of Classical vs. SPHY-Wave Hardware.

8 Conclusion

By utilizing the ADC-DAC loop as a "Mimetic Bridge," we achieve a highly effective quantum emulator. The hardware remains classical, but the SPHY-wave modulation acts as a simulated environmental reservoir. This methodology successfully applies Okabe's Topological Coherence Control to classical silicon, allowing for advanced probabilistic logic with an emulated entropic cost of zero, circumventing the need for cryogenic physical qubits.

References

[1] Cohen, N. & Okabe, D. (2026). *The Five Waves of AI and Quantum-Mimetic Transduction.*

[2] Okabe, D. (2026). *Manifesto of Deterministic Coherence: Thermal Unification via the Field.*