STORMING THE GATES: REFET Combined with Stable Stochastic Signal Generation for Post Deterministic Logic Gates:
A Simple Hybrid System to Aid Exotic Quantum Technology Development and Implementation
White Paper
EmergenceByDesign

Introduction

Modern digital systems have focused for decades on eliminating or correcting noise. However, noise in the form of quantum events, shot noise, 1/f noise, and random telegraph noise is fundamentally woven into the fabric of electronics. The Reliability-Failure Effect Transistor (REFET) leverages this intrinsic quantum-scale unpredictability, using standard MOSFETs operated at the edge of their reliability boundaries to produce controlled, reproducible, non-Gaussian stochastic signals. When combined with a stable, conventional stochastic signal source—such as those generated from ion chambers commonly used in smoke detectors—this hybrid system forms the foundation for low-cost, robust, post-deterministic logic gates. These gates can, in turn, serve as a practical and accessible test suite for verifying quantum states and supporting quantum technology development.

REFET Fundamentals

REFET technology harnesses the quantum-to-classical transition regime in inexpensive, commodity MOSFETs by biasing them just below the threshold where hot-carrier injection and random telegraph noise become significant. At this "Edge of Phenomena", stochastic charge carrier events within the silicon lattice and oxide manifest as sudden, state-shifting bursts and broadband noise. These effects can be detected, recorded, and used as entropy sources.
Unlike traditional approaches that filter out such fluctuations, a REFET circuit amplifies and stabilizes them, making the noise itself the signal. The result is a signal that captures both the randomness of thermal and quantum events and the emergent structure produced by feedback processes inside the device. The REFET platform is compact, low cost, and reproducible, requiring only a common N-channel MOSFET, a bias circuit, a high-impedance amplifier, and a data acquisition system.

The Hybrid Tandem Architecture

By combining a REFET with a standard, stable stochastic signal generator—such as a robust, low-cost ion chamber-based system proven with NIST-compliant standards—it is possible to synchronize or cross-trigger event detection. The stable source provides a continuous, relatively unbiased white noise floor. The REFET's metastable, critically-biased operation injects on-demand bursts of quantum-rooted entropy.

These two sources together enable construction of hybrid logic gates that:
Exhibit strong post-deterministic properties, where outputs are determined by correlated stochastic events rather than fixed voltages or currents.
Allow environmental and device state auditing, since the independence of both noise sources allows cross-validation.
Support advanced logic functions critical for quantum and post-quantum experiments, including probabilistic flips, physical random number generation, and complex logic like exclusive-or and physical-entropy-based signatures.

Applications for Quantum Testing and Verification

When deployed in tandem, REFET-based logic gates plus ion chamber stochastic sources offer the following capabilities for quantum experiments:
Low-cost, continuous monitoring of environment-induced entropy, reducing the risk of unseen bias or deterministic drift in experimental setups.
In-situ verification of quantum device behavior (e.g., state collapse, decoherence, entanglement) by correlating device events with independent, physical randomness signatures.
Construction of dynamically reconfigurable, unclonable physical memory functions for anti-tamper or authentication tasks in exotic quantum or analog computing elements.
Hybrid verification circuits for rapid, high-assurance checks on theoretical claims or experimental results, making quantum technology development more accessible, transparent, and statistically robust.

Comparison to Prior Art

REFET demonstrators differ from standard random number generators and RTN-based entropy sources by focusing on analog coherence and open-source reproducibility, not digital integration or cryptographic post-processing. The system is explicitly designed for ease of replication and educational use.
The use of affordable, robust, and off-the-shelf components (including smoke-detector-grade ion chambers and readily available MOSFETs) enables even modestly equipped laboratories to access physical phenomena previously restricted to high-budget or highly specialized environments.

Implementation and Experimental Design

A foundational REFET system consists of a commodity N-MOSFET (such as IRF540ZPBF), a biasing network allowing precise control of gate and drain voltages, an AC-coupled low-noise amplifier, a microcontroller with ADC for real-time data capture, and a stable ion-chamber system as the auxiliary stochastic source.
Properly tuned, the MOSFET device moves into a metastable regime where quantum-scale charge transitions are recorded and can be compared—through differential logic or cross-correlation—with the output of the stable noise source. This enables construction of hybrid stochastic logic gates for a variety of post-deterministic computational tasks.

Verification and Validation

Empirical tests with arrays of common N-channel MOSFETs show the REFET phenomenon reliably appears at device-specific critical voltages, producing heavy-tailed, broadband, non-Gaussian noise. These signals, when paired with traditional stochastic noise, pass rigorous statistical tests for randomness, uniqueness, and unpredictability. Environmental shielding, careful biasing, and real-time data analysis guard against electromagnetic or thermal confounds.

Scientific Impact and Future Directions

This hybrid architecture offers a dramatically lower barrier to entry for quantum state verification, reliable entropy generation, and robust cryptographic applications for research, education, and industry. By leveraging two independent, physically grounded stochastic sources, the system provides a practical toolset for both the advancement and validation of emerging quantum technologies and the democratization of their supporting infrastructure.

Licensing and Attribution

END OF WHITEPAPER