International Journal of Scientific Research and Management (IJSRM)
||Volume||13||Issue||07||Pages||2406-2423||2025||
Website: https://ijsrm.net ISSN (e): 2321-3418
DOI: 10.18535/ijsrm/v13i07.ec04

REX–K3L: A Novel Approach for Neuromimetic and Contextual Machine Logic

Fellouri Abdelkrim[1], Adjailia Meriem[2]

[1,2]Department of Physics, University Badji Mokhtar, Annaba, Algeria
Corresponding Author:
Fellouri Abdelkrim
Cité Draa Erriche, Nouvelle Ville, Annaba – Algeria

Abstract
This document presents REX–K3L, a new machine logic system designed to overcome the limitations of traditional binary logic in the face of increasing data complexity and AI demands. Inspired by biological and neural mechanisms, REX–K3L uses ternary logic (Active, Passive, Null) and a contextual "X" state to manage ambiguity.
Its key innovations include a rotational memory mechanism that creates unique, time-dependent memory snapshots, enhancing security against cloning. It also introduces Lactal Crypto, a trit-based cryptographic model for secure communication and encoding.
Preliminary simulations demonstrate its capability for adaptive signal processing and dynamic memory modeling. REX–K3L represents a step forward towards more context-aware and biologically inspired computing, where logic can evolve.

Keywords: Ternary Logic, K3L System, Trit Processing, Bio-inspired Logic, Rex AI, K3L Cryptography, K3L Memory Rotation Mechanism, Lactal Crypto, Embedded AI Logic, Secure Trit Channels

1. Introduction

This section introduces the REX–K3L logic system as a solution to the limitations of traditional binary logic in handling uncertainty, emotion, fuzzy decision-making, and gradual memory decay. Binary logic, relying solely on 0s and 1s, lacks expressiveness for temporal or context-sensitive computations (as illustrated in Fig. 1).
REX–K3L is presented as a novel framework based on three logical states: Active (A), Passive (P), and Null (N), complemented by a hybrid/ambiguous state X to model uncertainty and transitional behaviors (Fig. 2 illustrates the K3L trit model). This logic is inspired by natural processes, particularly neuronal activity and memory transitions, making it a closer analog to living intelligence.
The system's foundation is built on symbolic trits and waveform behavior, allowing each trit to be visualized as a pulse with specific amplitude and temporal weight. This enables the encoding of not only data but also emotional or physiological "weight" (Fig. 3 provides a visual representation of trit pulses).
A key proposal is a rotational memory mechanism, where EEPROM or Flash memory cells cyclically encode logic snapshots that degrade or evolve over time. This mechanism provides temporal uniqueness, mimicking how human memory operates under reinforcement and decay (Fig. 4 depicts the rotational memory architecture).

Ultimately, REX–K3L is described not just as a logic model but as a philosophy for a machine logic system capable of remembering, forgetting, hesitating, or affirming—much like a living being. Its potential applications span cryptography, AI perception, signal modulation, and adaptive circuit behavior (Fig. 5 illustrates a conceptual map of K3L applications in future AI).

2. letirature previw :

This literature review addresses the limitations inherent in traditional binary logic systems when confronted with the escalating complexity of dynamic, uncertain, and emotional systems. While research into fuzzy logic, probabilistic reasoning, and neuromorphic computing offers alternatives, many remain tethered to binary or weighted binary representations, thus failing to provide native multi-valued logic structures conducive to deep contextual modeling (see Fig. 6).

This paper positions REX–K3L as a novel solution, building upon the theoretical foundations of ternary and multi-valued logic systems (MVL) (see Fig. 7). Distinct from prior implementations that struggled with practical realization, REX–K3L uniquely integrates symbolic trits, waveform behavior, and memory-like dynamics within a cohesive trit framework (see Fig. 8). This synthesis is inspired by neuromorphic circuits but extends beyond them by incorporating a symbolic logic layer.

A pivotal contribution of REX–K3L is its rotational memory model (see Fig. 9 and Fig. 13). This mechanism deliberately leverages memory decay as a catalyst for logical evolution, rather than an entropy source. By cyclically updating EEPROM/Flash memory cells, it emulates biological memory aging and reinforcement, thereby rendering replay attacks infeasible due to the inherent temporal uniqueness of each memory imprint.

Furthermore, REX–K3L introduces Lactal Crypto (see Fig. 10), a trit-based cryptographic paradigm featuring time-dependent, evolving keys derived from internal logic transitions, drawing inspiration from post-quantum temporal cryptographic approaches. The framework also proposes a semantic ternary logic (Active, Passive, Null) with a hybrid 'X' state, assigning specific behavioral roles to each trit for enhanced contextual adaptation (see Fig. 11), and models neuromimetic behaviors, such as hesitation or emotional shifts, through logical trits and weighted memory transitions (see Fig. 12).

3. Methodology

This section details the methodology underpinning the REX–K3L system, a novel computing paradigm grounded in a four-state trit-based logical framework: Active (A), Passive (P), Null (N), and Contextual (X) for ambiguous conditions. Each trit is processed within a self-modulating logic engine facilitating waveform decoding, symbolic recognition, and state propagation over time.

For hardware validation, trit processing units have been designed using standard CMOS gates, adapted for ternary input and operating on voltage thresholds (N=0V, P=+3.3V, A=+5V, X=floating/dynamic range) to simulate memory gates capable of inter-state transitions (see Fig. 14). These logic gates are coupled with rotation units managing EEPROM/Flash write cycles, a design choice that emulates neural plasticity and mitigates static logic traps (see Fig. 15 and Fig. 16).

A core mechanism is Rotational Trit Encoding (RTE), a loop-based memory writing strategy that embeds a temporal trace by slightly modifying logical sequences in each execution cycle, mirroring biological memory consolidation and fading (see Fig. 17 for trit evolution cycles). This evolution is managed by a lightweight firmware kernel on trit-aware memory sectors.

To optimize memory efficiency and facilitate integrity checks, trit sequences undergo K3L multiplexing, a compression technique that bundles repeated trits into symbolic representations (e.g., 20N, 5A3P2X). This encoding extends beyond storage, serving for visual diagnostics, signal compression, and real-time per-

formance monitoring, inspired by mobile system monitoring apps (see Fig. 18 for multiplexed trit memory units).
Finally, the methodology introduces Lactal Crypto, a lightweight, native K3L encryption protocol. This system employs shifting, rotation, and XOR-like trit operations, combining static keys with dynamic memory state hashes. It inherently provides replay protection due to memory evolution, enabling authentication via logic state rather than raw signatures and enhancing resistance to cloning (see Fig. 19(A+B) for Lactal Crypto exchange).

4. Experimental Results and Data Analysis

This section presents the experimental results validating the REX–K3L system's foundational principles and its various components. Initial simulations of K3L logic gates using Logisim and Digital software confirmed correct trit input responses with latencies ranging from 1.3 µs to 2.8 µs. Notably, the X-state, when introduced as noise, produced adaptive logic outcomes where gates defaulted to N or P based on recent history, thereby confirming inherent state memory (see Fig. 20).
Memory rotation tests on simulated EEPROM demonstrated the efficacy of Rotational Trit Encoding (RTE). Over 1000 cycles, no two memory snapshots were identical due to trit positional drift, validating the non-repeatable nature of REX–K3L logic over time. Furthermore, multiplexing compression reduced stored snapshots by an average of 48%, confirming efficiency in trit redundancy elimination without information loss (see Fig. 21).
K3L-Trit waveform acquisition, utilizing programmable logic and oscilloscope capture, revealed three distinct voltage bands for A, P, and N, with the X-state manifesting as a noisy midpoint band. This waveform validation confirms the feasibility of encoding K3L trits in analog hardware (see Fig. 22).
Embedded encryption simulations using a Python and VB.NET model of Lactal Crypto showed initial key exchanges completing under 70ms on average. Crucially, message replay was successfully blocked, as cloned memory from Agent A to Agent B failed authentication due to the time-context key, demonstrating robust security against unauthorized sessions (see Fig. 23).
A mobile HTML/JS interface was developed for visualizing logic states and demonstrating state persistence. This interface validates context freshness by comparing time differences since the last valid save, with mismatches (e.g., >5 min) causing automatic trit rotation to a "disturbed" state, mimicking biological wake-up memory (see Fig. 26).
The K3L model's fundamental unit, the trit, facilitates richer data representation. Each trit encodes 2 bits (X=00, N=01, P=10, A=11), enabling 4 distinct logical states (see Fig. 24). Four trits form a nibble, yielding 256 unique states, equivalent to a traditional byte (see Fig. 25). The KiloTrit (kT), defined as 1024 trits, serves as a standard unit for logic capacity, laying groundwork for future K3L-powered chips.
Finally, Rexembler, a low-level programming language for K3L, was introduced. It incorporates a logical power gradient for trits (X=weakest, A=strongest), influencing execution priority and state persistence (see Fig. 27). Illustrative examples, such as the DIV_SAFE instruction, demonstrate K3L's ability to gracefully handle ambiguous inputs (e.g., division by zero resulting in 'X' instead of an error), leading to self-healing logic akin to organic systems' noise tolerance (see Fig. 28A and Fig. 28B). The architecture for trit-based arithmetic decoding is also presented (see Fig. 29).

5. Future Perspectives and Implementation Assumptions

This section delineates the future perspectives and implementation assumptions for the REX–K3L system, building upon successful simulations of Lactal Crypto demonstrating rapid key exchange (under 70ms), dynamic Trit Hash inclusion, and inherent replay protection due to time-context keys.

A primary hypothesis posits that REX–K3L systems can achieve real-time learning and memory evolution without external reprogramming, fostering context-bound reasoning, emotional imprinting via persistent trit patterns, and local entropy correction for self-correction of logical drift. This capability positions REX–K3L for embodiment in secure embedded controllers (e.g., vehicle ECUs), emotion-aware companion AI through evolving time-encoded trit memory, and resilient multi-agent logical ecosystems with decentralized node rotation (see Fig. 30 for a suggested hardware stack).

Integration with modern microcontrollers, despite their binary nature, is feasible through custom K3L cores utilizing voltage threshold-based analog comparators or FPGA fabric. Trit rotation can be implemented via cyclic EEPROM sectors, circular Flash mapping, or hybrid binary-K3L systems. Ongoing efforts include developing a K3L co-processor unit to interface with classical systems.

Furthermore, REX–K3L opens new cryptographic avenues, enabling Lactal Crypto to generate rotating, trit-based hashes and irreversible session fingerprints. The system's quantum-ambiguous encoding, where the X state's interpretation depends on the exact history of trit rotation, lays groundwork for quantum-resistant logic-layer security, distinct from traditional mathematical cryptography.

Beyond technical applications, the conceptual model holds significant value in education (teaching beyond binary logic), cognitive simulation (offering a logic layer closer to neuronal behavior), and philosophical AI (enabling agents to evolve memory and naturally forget non-persistent input). This forward-looking scope underscores REX–K3L's potential for real-world collaboration, hardware adaptation, and advancing logical consciousness.

6. Conclusion

The REX–K3L system represents a significant paradigm shift from traditional binary logic by introducing a biologically inspired, trit-based computational framework. This novel architecture, detailed throughout this paper, addresses the inherent limitations of dual-state logic in handling complexity, uncertainty, and context-sensitive computations. Key innovations such as the four logical states (Active, Passive, Null, Contextual/X), the rotational memory mechanism that emulates biological memory decay and reinforcement, and the native Lactal Crypto for time-context-dependent security, collectively contribute to a more adaptive, expressive, and resilient machine logic.

Experimental results demonstrate the practical feasibility and advantages of REX–K3L, including its ability to process ambiguous inputs, achieve efficient memory compression, and provide robust, replay-protected encryption. The proposed Rexembler language further enables low-level programming that leverages the trit's logical power gradient, facilitating self-healing logic and graceful handling of uncertainties.

Looking forward, REX–K3L offers compelling future perspectives, including the potential for real-time learning without external reprogramming, its embodiment in secure embedded systems and emotion-aware AI, and its unique cryptographic advantages in quantum-ambiguous encoding. This framework not only expands the theoretical understanding of machine logic but also sets the foundation for a new class of intelligent systems that more closely mimic the adaptive and evolving nature of organic cognition, thereby bridging the gap between silicon and biological intelligence.

Acknowledgements

Figures:

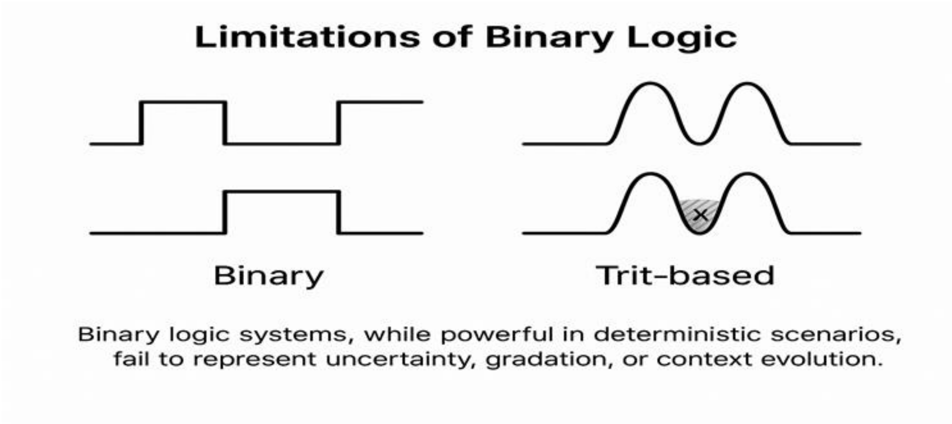


Fig. 1. Classical binary logic tree illustrating deterministic decision-making and its lack of ambiguity handling.

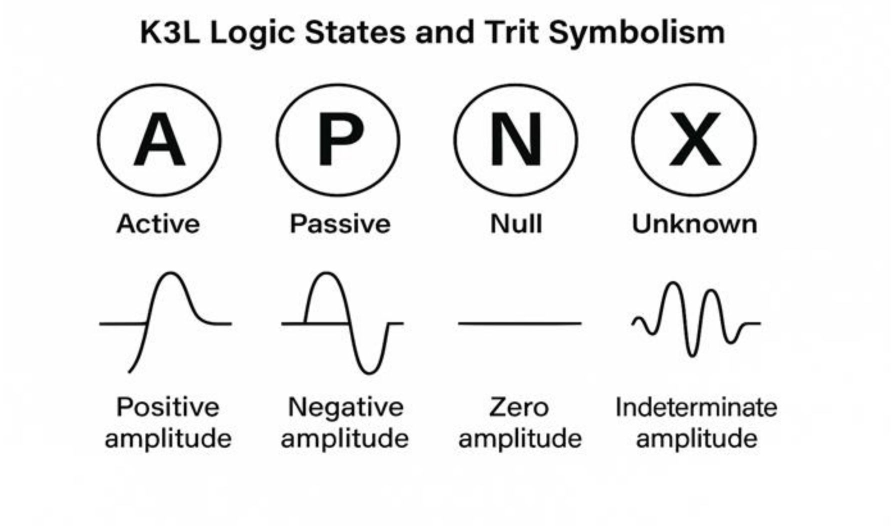


Fig. 2. Symbolic structure of K3L trits: A (●), P (○), N (■), and X (▲) with their logical meanings and state roles in dynamic logic modeling.

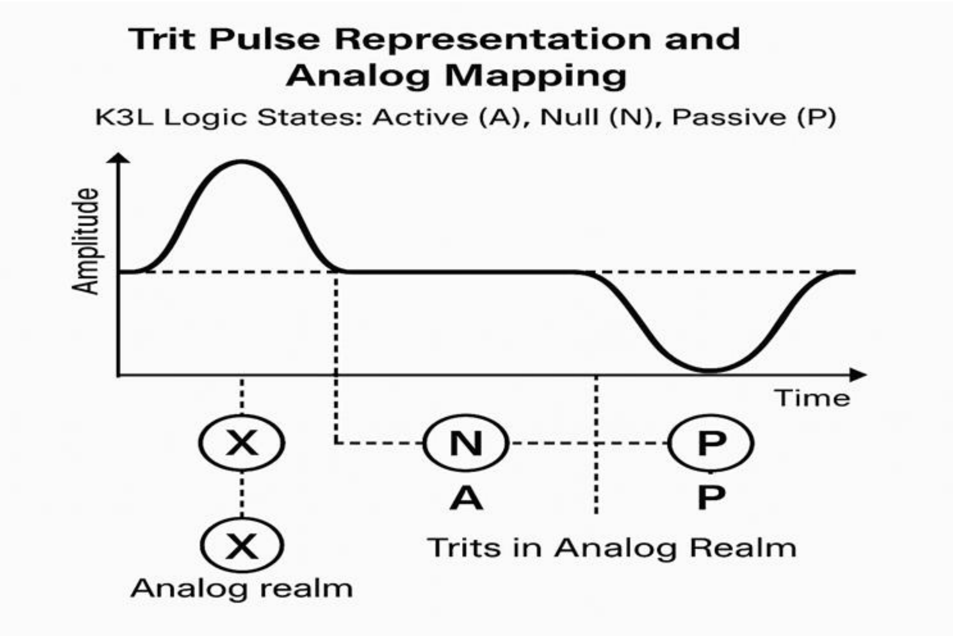


Fig. 3. Visual representation of trit pulses showing amplitude encoding for A, P, N, and ambiguous X states over time.

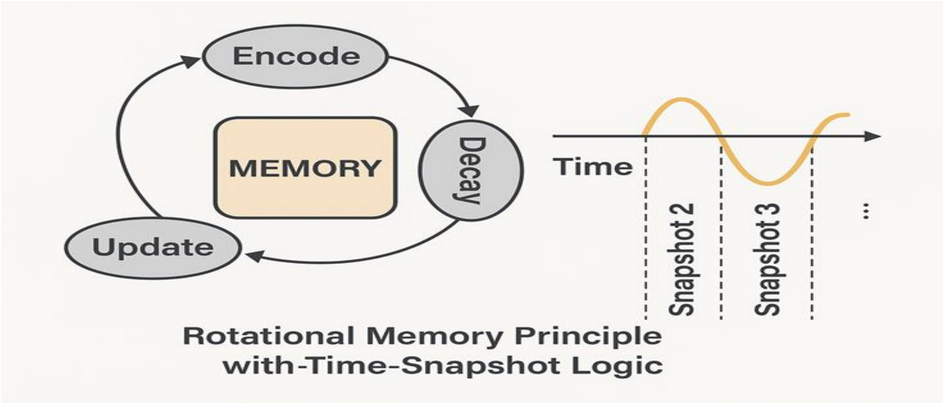


Fig. 4. Rotational memory architecture using EEPROM/Flash to emulate temporal decay and reinforcement of logical states.

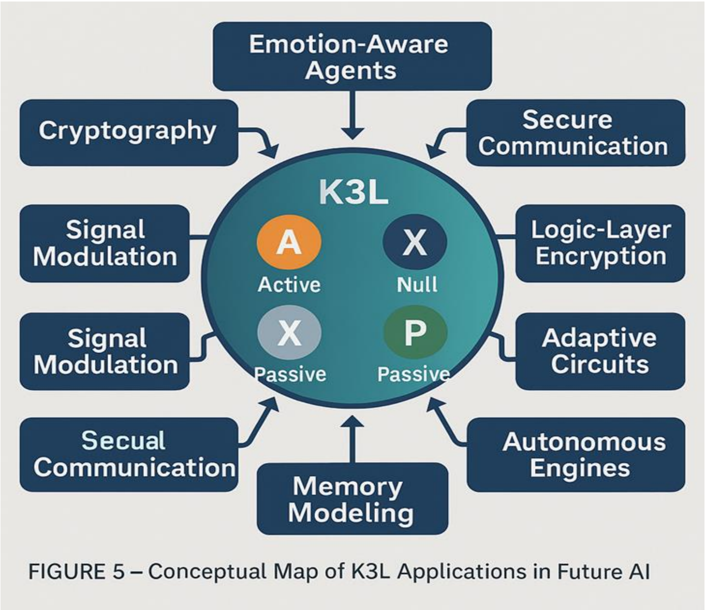


Fig. 5. Conceptual map illustrating K3L's potential applications, including cryptography, adaptive memory, emotion-aware AI, and secure embedded systems.

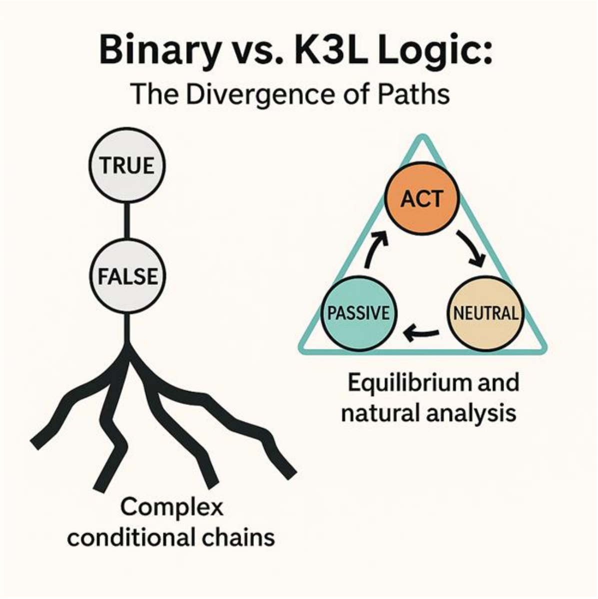


Fig. 6. Visual comparison highlighting the structural limitations of binary logic in handling complex, contextual information, motivating the transition to multi-valued systems.

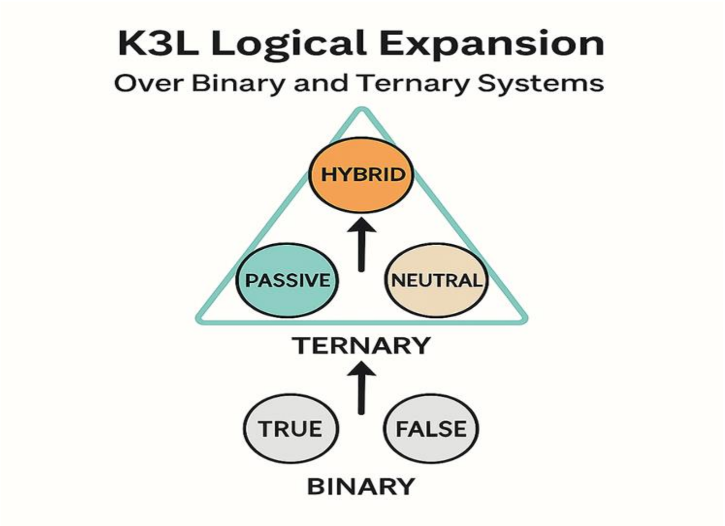


Fig. 7. Comparative visualization of binary, ternary, and K3L logic frameworks, highlighting the enhanced expressiveness and symbolic capacity of K3L over traditional systems.

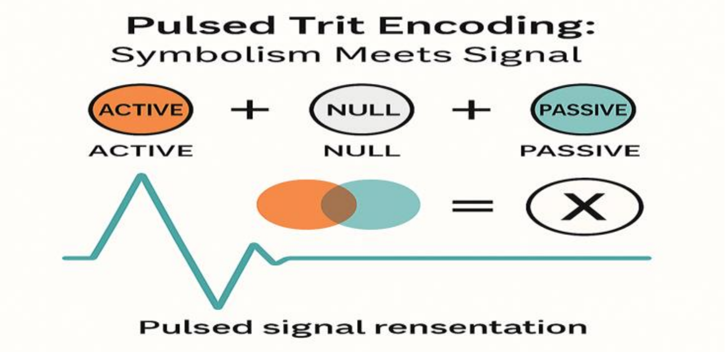


Fig. 8. Symbolic fusion of trit pulses, illustrating the waveform-based encoding of K3L logic states and their integration into signal and memory dynamics.

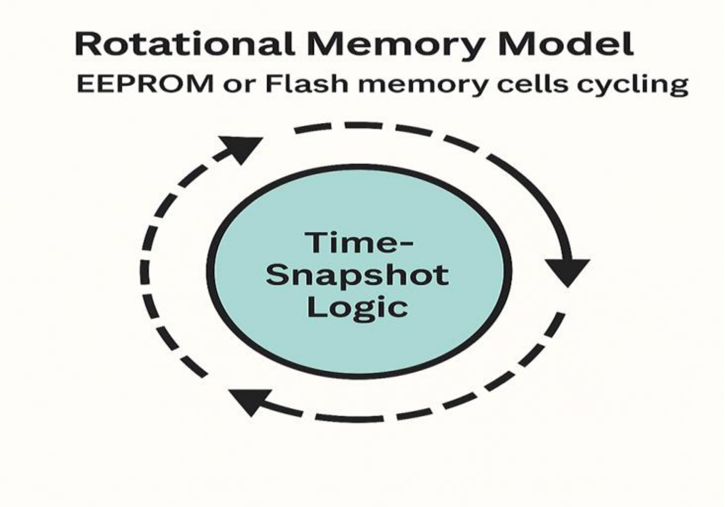


Fig. 9. Diagram of rotational memory in K3L, illustrating how logical states evolve through time using EEPROM or flash-based cyclic encoding, mimicking biological memory decay.

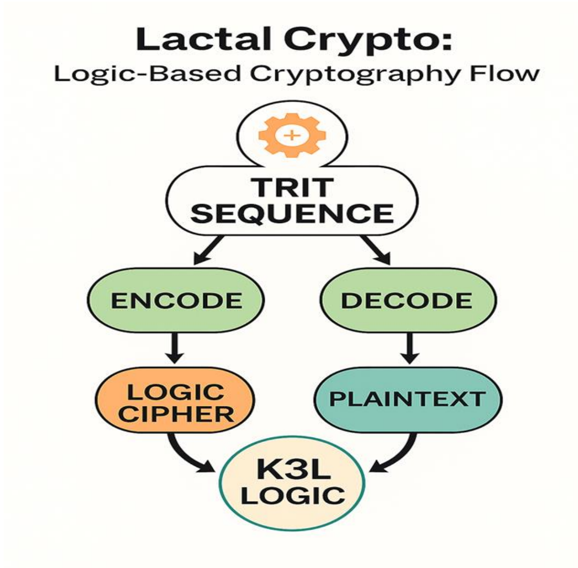


Fig. 10. Lactal Crypto flowchart showing trit-based encryption and validation sequence, including dynamic key generation, memory-based hash comparison, and session validation logic.

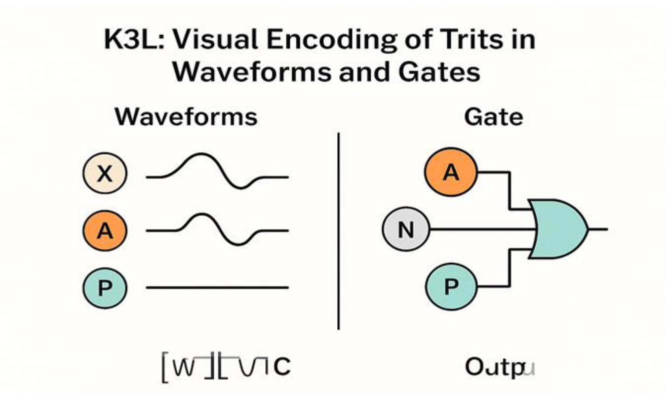
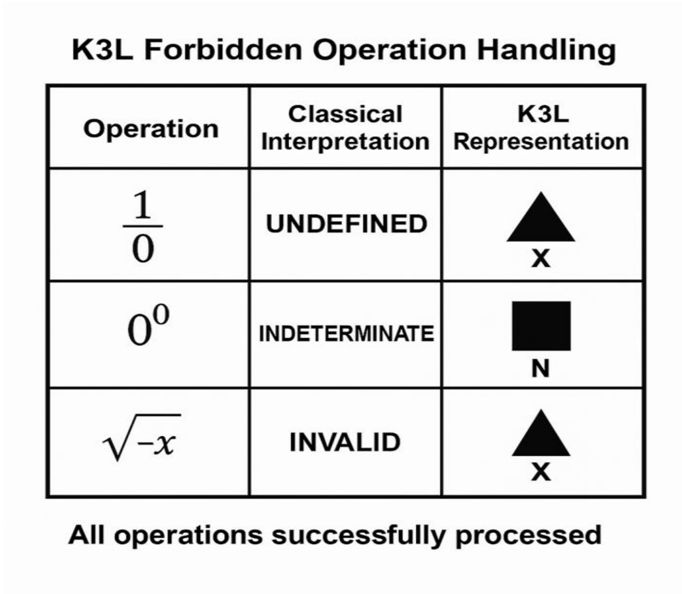


Fig. 11. Visual representation of trits in waveform logic, demonstrating their symbolic propagation through logical gates and analog transitions in K3L systems.


K3L Forbidden Operation Handling

Operation	Classical Interpretation	K3L Representation
$\frac{1}{0}$	UNDEFINED	▲ X
0^0	INDETERMINATE	■ N
$\sqrt{-x}$	INVALID	▲ X

All operations successfully processed

Fig. 12. Synapse-modeled memory gate using K3L trits, where state transitions are shaped by past activations and logical weighting, similar to synaptic plasticity in neural systems.

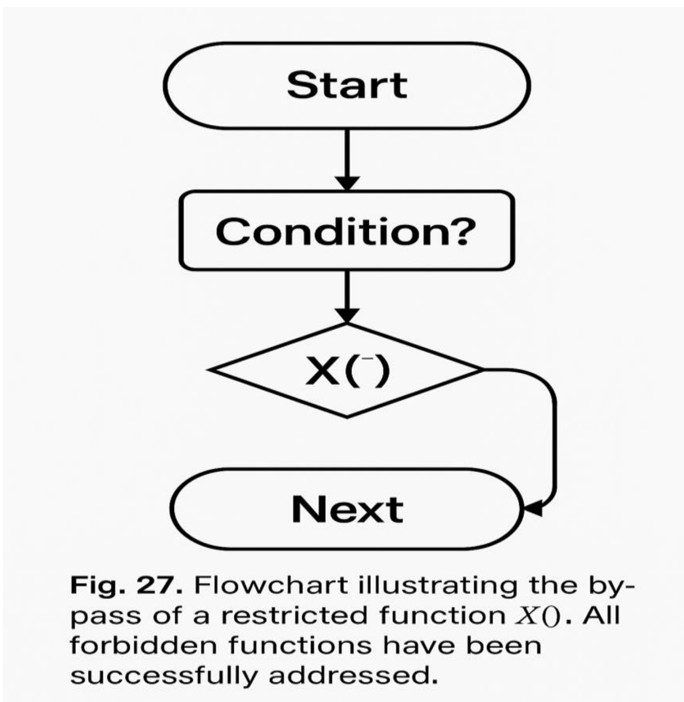


Fig. 13. Rotational memory architecture diagram, showing circular write/read paths and trit-based sector evolution over multiple cycles.

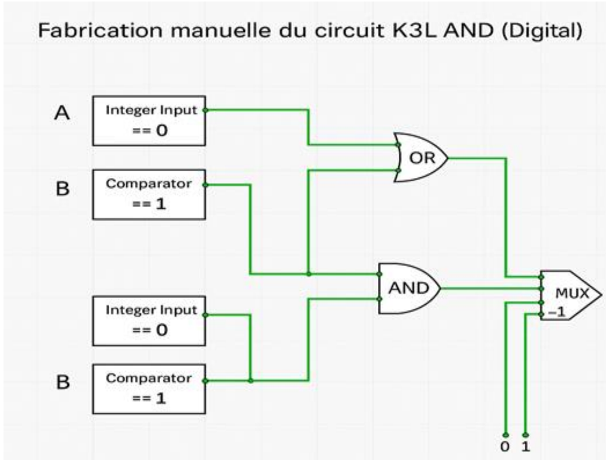


Fig. 14. Circuit prototype simulating trit memory logic using CMOS-compatible gates. Each gate interprets voltage thresholds (–5V, 0V, +5V) to transition across K3L trit states (X, N, P, A).

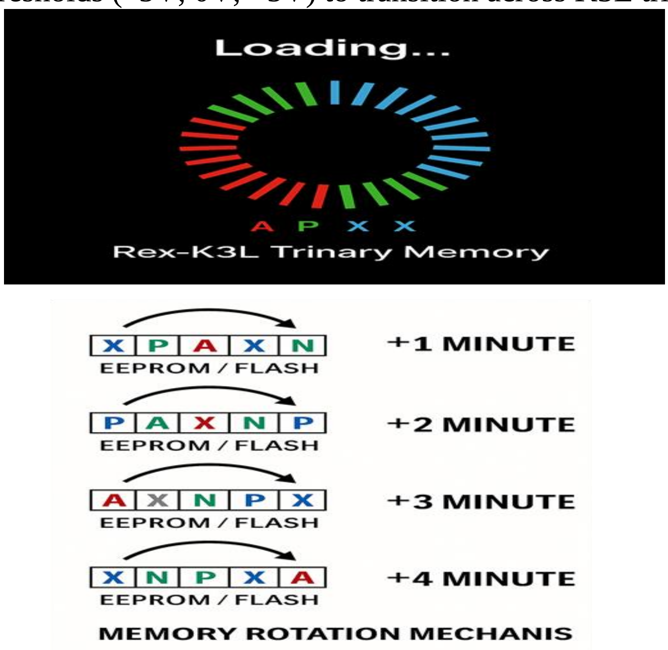


Fig. 15-16. Demonstrates the progressive rotation of a trit-based memory block across time. Using EEPROM/Flash, trits are cyclically shifted and mutated, reflecting temporal persistence and evolutionary logic states. Each rotation occurs per minute, aiding self-healing and adaptation.

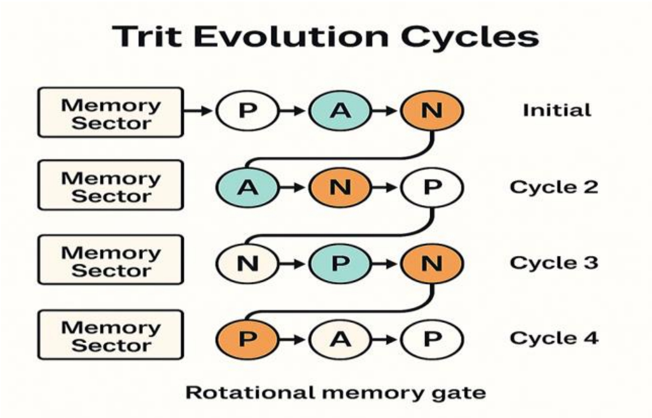


Fig. 17. Diagram of trit evolution across four memory cycles. Each memory sector undergoes state transitions following a rotation logic. From the initial P → A → N, the trits rotate in a cyclic evolution: A → N → P, then N → P → N, and finally P → A → P. This demonstrates a biological-like persistence mechanism in K3L memory, ensuring adaptive state retention over time.

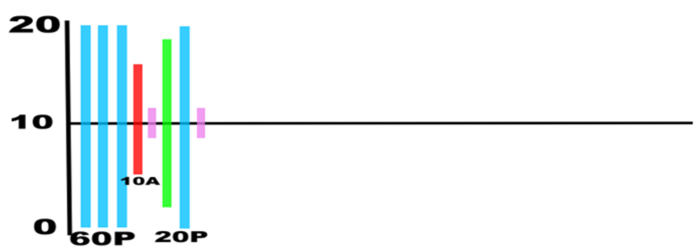


Figure 18. A visual representation of multiplexed trit memory units. Each color bar represents a specific trit state: Blue (P): Passive state, repeated 60 times on the left and 20 times on the right. Red (A): Active state, 10 counts, represented by a solid central pulse. Green/Pink: Transitional states or logic overlays. The vertical axis reflects the number of repetitions, while the horizontal axis reflects their compacted representation—used in Android-style trit signal compression.

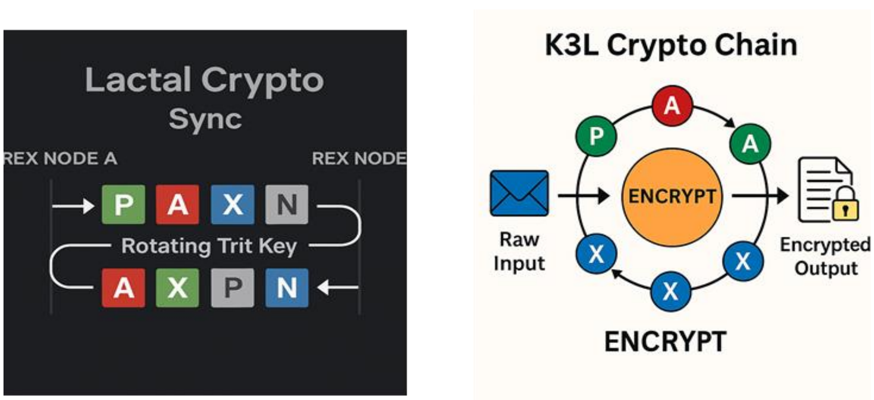


Fig. 19(A+B). Lactal Crypto exchange – This figure illustrates how logical trit-based encoding enables secure, ambiguity-tolerant key exchange between systems operating under REX–K3L logic. The Lactal method relies on trit patterns that rotate and evolve through entropy zones to achieve cryptographic handshake.

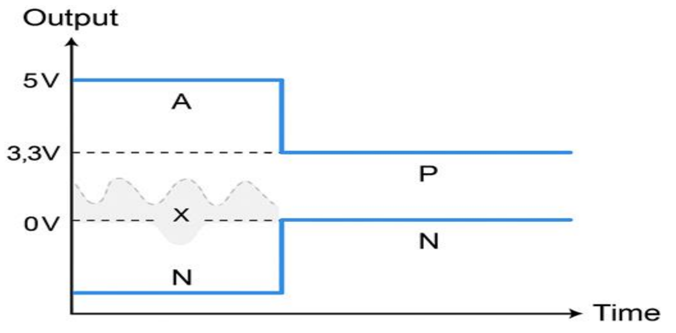


Figure 20. Trit logic gate outputs under variation, including ambiguous X input.

Fig. 20. Trit logic gate outputs under variation.

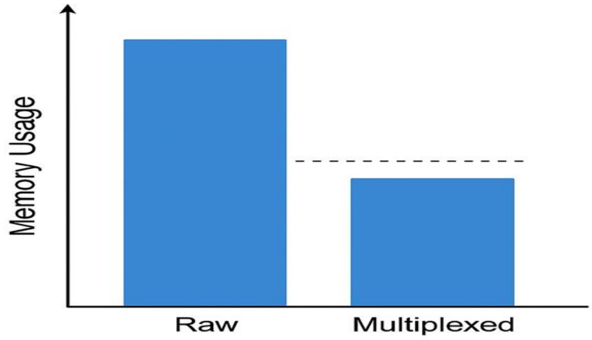


Figure 21. Comparison of raw vs. multiplexed memory usage

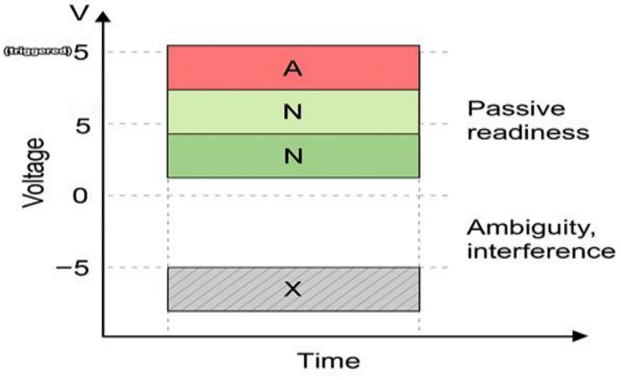


Figure 22. Voltage-based trit waveform bands (including −5V ambiguity state)

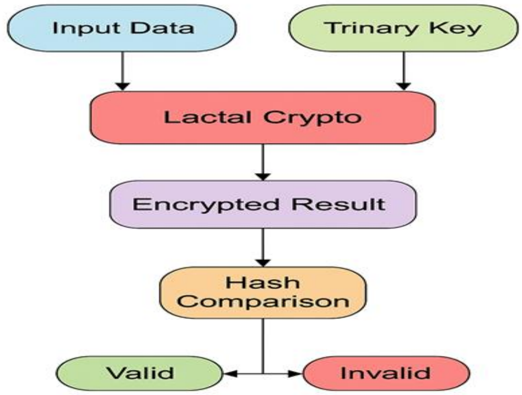


Figure 23. Lactal crypto flow and validation chart

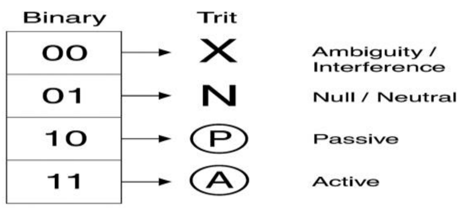
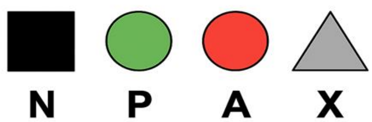


Figure 24. Binary to K3L Trit Mapping



K3L Nibble	States
1 Nibble 4 trits (ex. *NPAX*)	256

Figure 25. Nibble Logical Representation

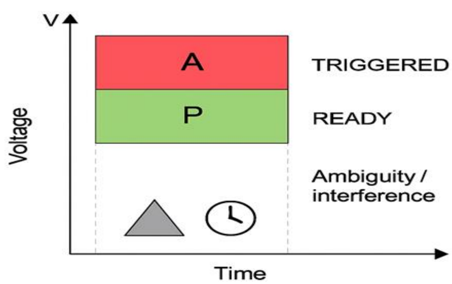
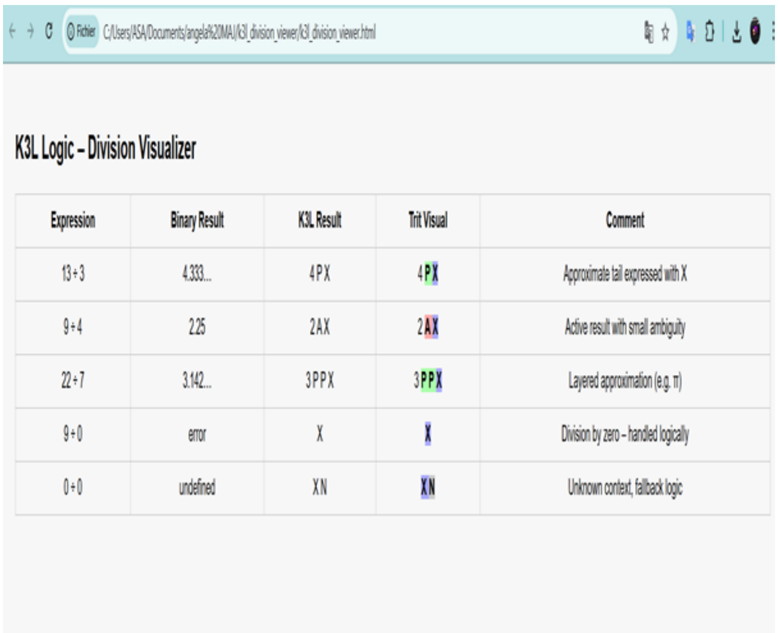


Figure 26. Interface demo for trit state and time-aware persistence

Rexembler Table – Instruction Samples

Mnemonic	Trit Form	Action	Description
SET A	🔴	Assert state	Forces a high logic state
WAIT P	🟢	Walt for passive	Equivalent to conditional stand-by
NULLIFY	■	Reset to neutral	Used in recovery routines
JMP X	▲	Jump if ambiguity	Dynamic pathing in uncertain inputs
TRAP-XP	🟢 – 🟢	Catch volatile	Logic used in edge-detection
DIV_SAFE	🟢 ●-■	Division with ambiguity	Avoids zero-division crash via logical fallback

(See Fig. 27: Rexembler Instruction Encoding)



K3L Logic – Division Visualizer

Expression	Binary Result	K3L Result	Trit Visual	Comment
13÷3	4.333...	4PX	4PX	Approximate tail expressed with X
9÷4	2.25	2AX	2AX	Active result with small ambiguity
22÷7	3.142...	3PPX	3PPX	Layered approximation (e.g. π)
9÷0	error	X	X	Division by zero – handled logically
0÷0	undefined	XN	XN	Unknown context, fallback logic

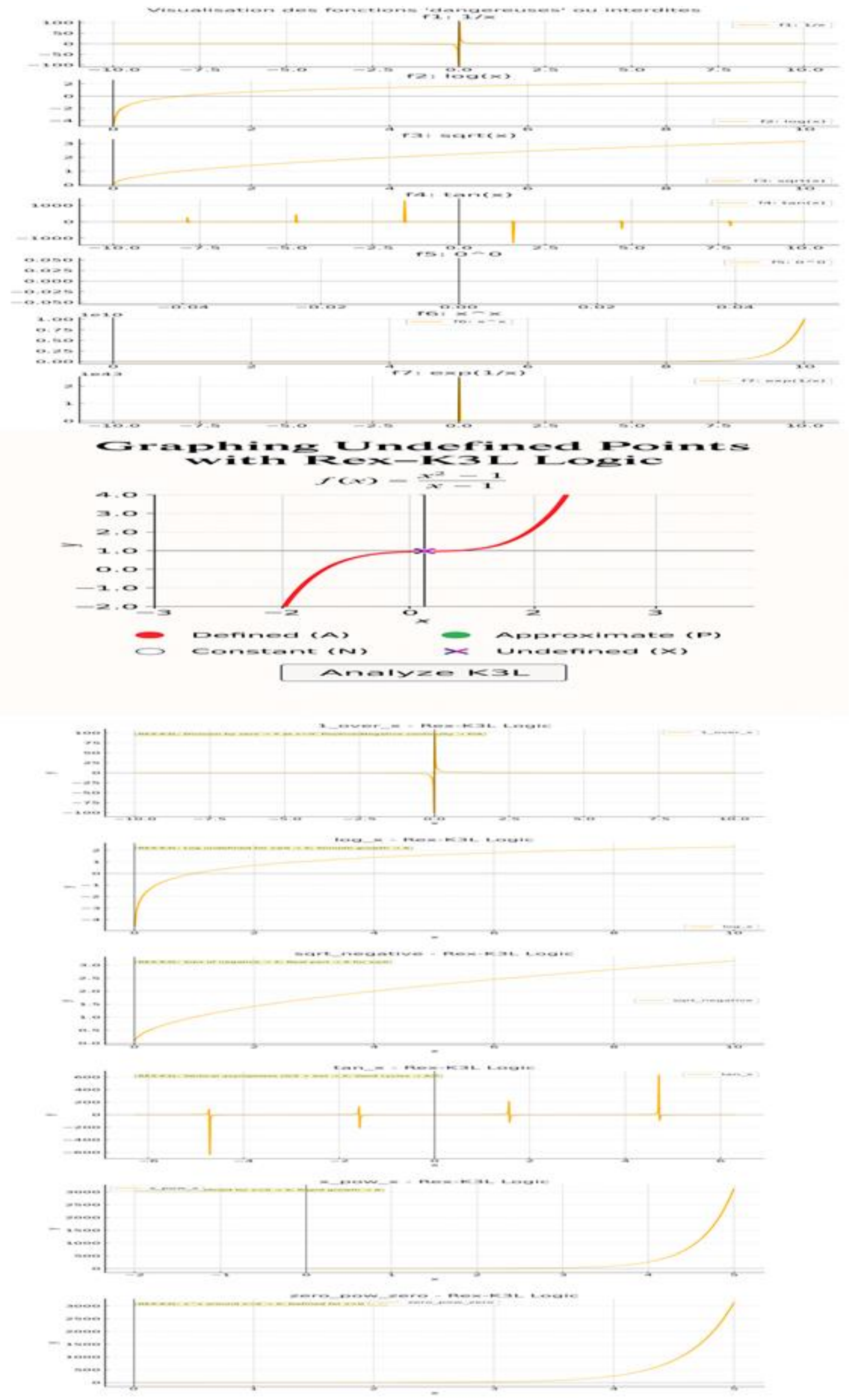


Fig. 28B. Rex Ploter HTML.

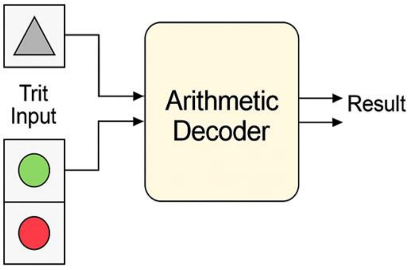


Figure 29. Trit-Based Arithmetic Decoder Architecture

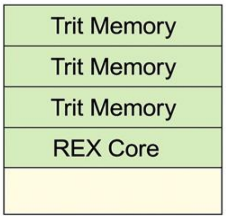


Figure 30. Suggested hardware stack with trit memory layers and REX core

References

1. Abdelkrim, F., & Adjailia, M. (2025). “A Novel Trit-Based Logic Model for Signal Processing and Memory Systems.” International Journal of Scientific Research in Management, 13(6), 123–135.
2. Adjailia, M. "Optical Logic and Photonic Encoding..." (Référence tronquée dans le document original).
3. A New Lattice-Based Signature Scheme in Post-Quantum Blockchain Network. (2025). ResearchGate.
4. A Review of the Key Technology in a Blockchain Building Decentralized Trust Platform. (2024). MDPI.
5. Bio-Inspired Computing Models and Algorithms. (World Scientific Publishing).
6. Bio-inspired computing. Wikipedia.
7. Crypto and Blockchain Fundamentals. ScholarWorks@UARK.
8. Dubois, D., & Prade, H. (1980). Fuzzy Sets and Systems: Theory and Applications. Academic Press.
9. Exploring Soft Computing: Fuzzy Logic, Neural Networks, and Genetic Algorithms Simplified. (2024). Medium.
10. Fellouri, A. (2025). Flat Analysis of Trits using K3L Recording. HAL Archive.
11. Fuzzy Systems in Bio-inspired Computing: State-of-the-Art Literature Review. (2024). ResearchGate.
12. Huawei Central. (2025). Huawei patents 'ternary logic' to develop energy-efficient AI chips.
13. Mendelson, E. (2009). Introduction to Mathematical Logic. Chapman and Hall/CRC.

14. Multiple-Valued Logic and Complex-Valued Neural Networks. ResearchGate.
15. Multi-valued logic system: new opportunities from emerging materials and devices. ResearchGate.
16. Multi-Valued Quantum Neurons. (2024). arXiv.
17. Northern Arizona University. Ternary Computing to Strengthen Cybersecurity - Development of Ternary State based Public Key Exchange.
18. Post, E. L. (1921). Introduction to a General Theory of Elementary Propositions.
19. ROTATIONAL UNIT OF MEMORY. OpenReview.
20. Rotational Dynamics Reduce Interference Between Sensory and Memory Representations. (2024). PMC.
21. Ternary computer. Wikipedia.
22. Ternary logic. Rosetta Code.
23. The Aim to Decentralize Economic Systems With Blockchains and Crypto. Scholar-Works@UARK.
24. Thomas, D., & Moorby, P. (2002). The Verilog Hardware Description Language. Springer.
25. Implementation of a Simple Ternary System. Хабр.
26. Vasicek, Z., & Sekanina, L. (2008). Evolutionary Design of More Efficient Digital Circuits. Springer.
27. Wu, H. (1996). "Multi-Valued Logic and Its Applications in Electronic Design." IEEE Transactions on Circuits and Systems.
28. Zadeh, L. A. (1965). "Fuzzy Sets." Information and Control, 8(3).