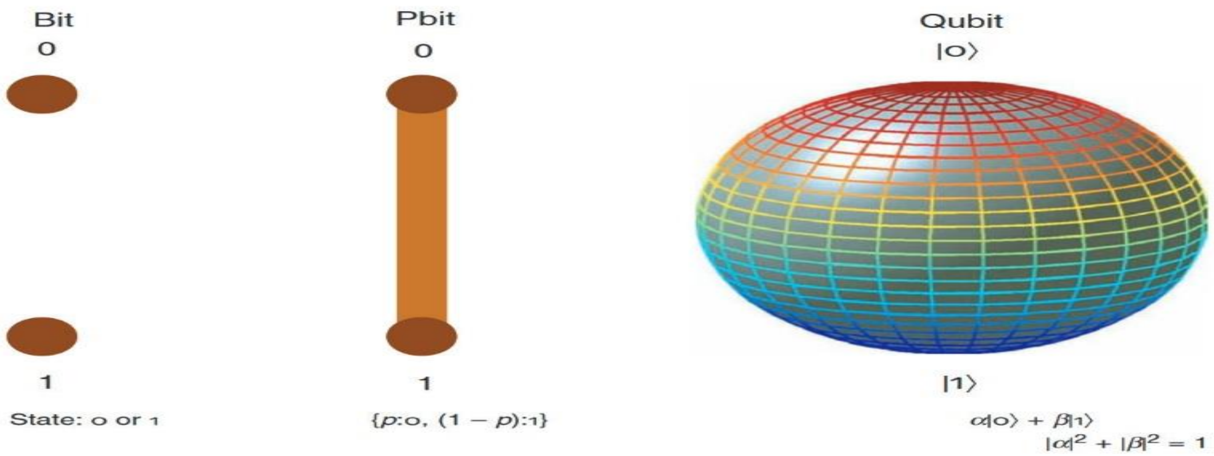
Workshop: Probabilistic Spin Logic (PSL)



The Future of Compute: From Deterministic to Stochastic

Conventional digital computing is hitting a power wall. As we push toward the edge, we need a new paradigm. Probabilistic Spin Logic (PSL) replaces rigid digital gates with inherent randomness, delivering 100,000x energy savings over conventional chips. By turning thermal noise into natural Monte Carlo sampling, PSL enables real-time Bayesian tasks that mirror brain-like uncertainty handling.

Core Principles of PSL Hardware

- **Thermal Noise as a Resource: PSL utilizes unstable nanomagnets that flip states naturally due to ambient heat, eliminating the need for complex random number generation circuits.**
- **Probabilistic p-bits: Unlike standard bits (0 or 1), p-bits fluctuate between states; their output probability is controlled by voltage inputs via a natural $\tanh$ relationship.**

- **Logic through Correlation: System logic arises from spin correlations rather than fixed gates, allowing for asynchronous, clockless operations.**
- **Zero Data Shuttling: Compute remains embedded within the nanomagnet arrays, eliminating the energy-heavy "von Neumann bottleneck."**

Technical Capabilities

- **Extreme Efficiency: Achieve high-speed processing with femtojoule operations and microwatt (μW) power consumption.**
- **High-Speed Inference: Nanomagnet arrays can process 1 trillion inferences per second.**
- **Proven Accuracy: Hardware simulations hit 98% accuracy on MNIST datasets.**
- **Edge AI Ready: Ideal for autonomous systems requiring "self-aware" forecasting and real-time decision-making.**

Workshop Roadmap (120 Minutes)

Session	Module	Focus Area
01	Introduction to PSL	Physics of unstable nanomagnets and thermal noise utilization.
02	The p-bit Architecture	Modeling voltage-controlled stochastic switching and tanh response.
03	Hardware Simulation	Implementing Monte Carlo sampling in logic-in-memory arrays.
04	Bayesian Deployment	Running 1T inference/sec simulations for weather and MNIST.
05	Practice & Q&A	Independent implementation and expert troubleshooting.

Participant Prerequisites

To ensure you are fully prepared for this simulation workshop, participants should possess the following foundational knowledge:

1. Mathematical Foundations

- **Probability & Statistics: Familiarity with probability distributions and the Law of Large Numbers.**
- **Linear Algebra: Understanding of matrix multiplication and coupling matrices**

2. Electronics & Spintronics

- **CMOS Fundamentals: Understanding of standard logic gates to appreciate how "inverted" probabilistic logic differs.**
- **Magnetism Basics: Awareness of magnetic moments and how thermal noise affects nanomagnet stability.**

3. Computation & Simulation Skills

- **Monte Carlo Methods: Foundational knowledge of algorithms that rely on repeated random sampling.**
- **Programming Proficiency: Proficiency in Python (NumPy) is essential for modeling p-circuits.**
- **Linux OS: Basic command-line familiarity is preferred for running simulation kernels.**

The Goal

This program, hosted at the Chennai Institute of Technology (Autonomous), is designed to bridge the gap between academic theory and industry-oriented applications. By mastering PSL, you are preparing for a career at the forefront of the semiconductor industry, contributing to technologies used by leaders like NVIDIA, Micron, and Marvell.