Constructing quantum circuits

Turn a sequence of gates into a small, testable computational story.

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By the end, you'll be able to

- Write a circuit contract with initial state, gates and readout basis.
- Compare a predicted distribution with a seeded finite-shot sample.

Start with a contract

Before adding gates, specify the initial state, qubit ordering, intended transformation and measured output. "Create correlated bits" is incomplete: it does not identify the quantum state or the measurement basis.

For a Bell-state circuit, use this contract:

- Input: $|00\rangle$, q0 leftmost.
- Gates: H on q0, then CX from q0 to q1.
- Exact output: $(|00\rangle + |11\rangle)/\sqrt{2}$.
- Z readout: 00 and 11 with probability $1/2$ each.

L02 · INTERACTIVE LAB

Runs on your device

Quantum gate playground

Gates act on amplitudes. Build a small circuit one operation at a time and compare its exact predictions with repeated measurements.



MODEL · Ideal pure-state vector, complex double precision ORDER · q0 is the leftmost bit

Prediction: Apply H to q0, then CX from q0 to q1. Which two outcomes should disappear? Challenge: Create the Bell state, then undo the gates in reverse order. Where did the randomness go? Open the live experiment studio.

Verify at more than one level

First calculate the ideal state. Then compare the exact simulator distribution. Finally sample finite shots with a recorded seed. The first two check the model calculation; the third demonstrates sampling fluctuations.

The playground's Undo removes a gate from the circuit description and recomputes from the initial state. It is an editing operation, not a claim that a measured physical state can be reversed by deleting a line of history.

A deliberate defect

Move H to q1 but leave CX's direction unchanged. The control remains 0, so the result is $|0\rangle \otimes |+\rangle$, not a Bell state. Its nonzero Z outcomes are 00 and 01.

Repair the circuit and explain the root cause. This is more informative than simply trying gates until the bars look familiar.

Extend

Ask whether your test would detect a relative-phase error. A Z gate after Bell preparation leaves the Z counts unchanged but changes the state. Add X-basis evidence using the entanglement lab.

Reference: IBM Quantum — Bits, gates, and circuits.