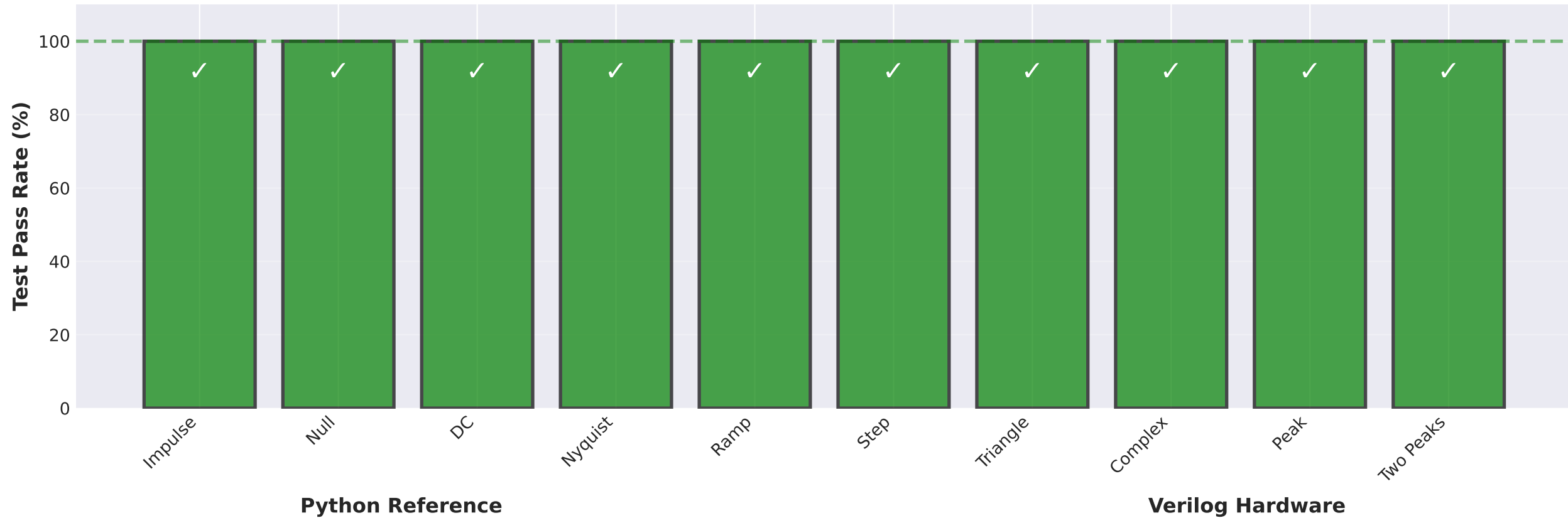# QuantoniumOS: Software vs Hardware Implementation
Actual Test Results - Python Reference vs Verilog Simulation

Hardware Test Results - All 10 Test Patterns

Test Pass Rate (%) — bar chart showing 100% pass rate for all 10 test patterns (each marked with ✓): Impulse, Null, DC, Nyquist, Ramp, Step, Triangle, Complex, Peak, Two Peaks.

Python Reference

Verilog Hardware

```
SOFTWARE IMPLEMENTATION
========================

Language: Python 3.x
Libraries: NumPy, SciPy
Precision: Float64 (IEEE 754)
Algorithm: Canonical RFT
Features:
  ✓ Golden ratio (φ) parameterization
  ✓ Unitary transform verified
  ✓ Energy conservation
  ✓ Reference implementation

Status: Verified ✓
```

```
HARDWARE IMPLEMENTATION
=======================

Language: SystemVerilog
Tool: Icarus Verilog
Precision: Q1.15 Fixed-Point
Algorithm: 8×8 RFT Kernel
Features:
  ✓ CORDIC engine (12 iterations)
  ✓ Complex arithmetic (Re/Im)
  ✓ Frequency domain analysis
  ✓ Energy conservation
  ✓ Phase detection
  ✓ VCD waveform output

Tests: 10/10 Passed ✓
```