Report on Quantum Information and Quantum Machine Learning
Laboratory 1

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Chapter 1

Task 1: Quantum Gates and Basic Quantum Circuits

1.1 Quantum Circuit and Z-Type Projection Measurement

In this task, we analyzed the basic operation of quantum gates and simple quantum circuits. The first step was to set up a quantum circuit and measure the qubit state using the Z-type projection.

1.1.1 Quantum Circuit

Figure 1.1: Quantum circuit for Z-type projection measurement.

1.1.2 Probabilities Graph

The probabilities of measuring the qubit in the state $|0\rangle$ or $|1\rangle$ are shown in the graph below:

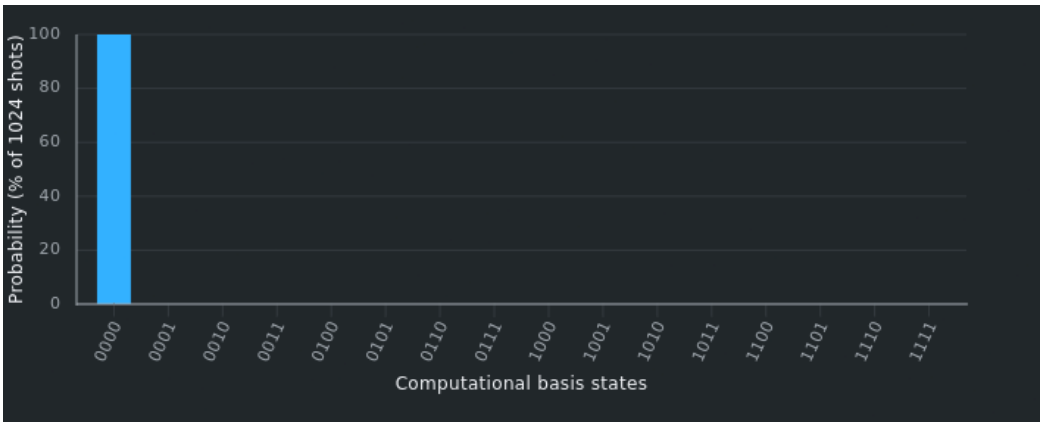

Figure 1.2: Probabilities graph for the measurement in the Z base.

1.1.3 Q-sphere Representation

The Q-sphere representation of the qubit state is displayed below:

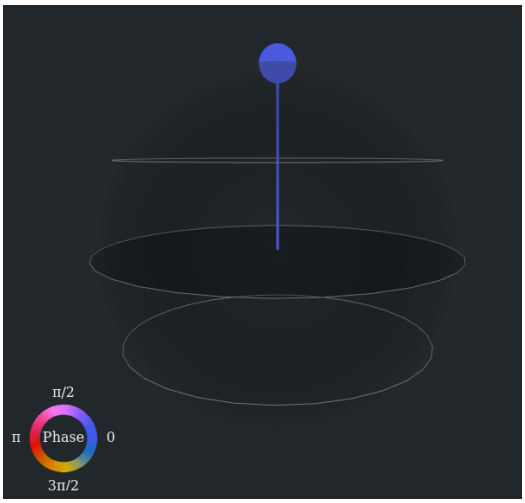

Figure 1.3: Q-sphere representation of the qubit state.

Chapter 2

Task 2: Quantum Gate X (Negation Gate)

In this task, we explored the operation of the quantum negation gate (X gate). The X gate inverts the state of the qubit, flipping $|0\rangle$ to $|1\rangle$ and vice versa.

2.0.1 Quantum Circuit

Figure 2.1: Quantum circuit with X gate applied.

2.0.2 Probabilities Graph

The probabilities graph after applying the X gate is shown below:

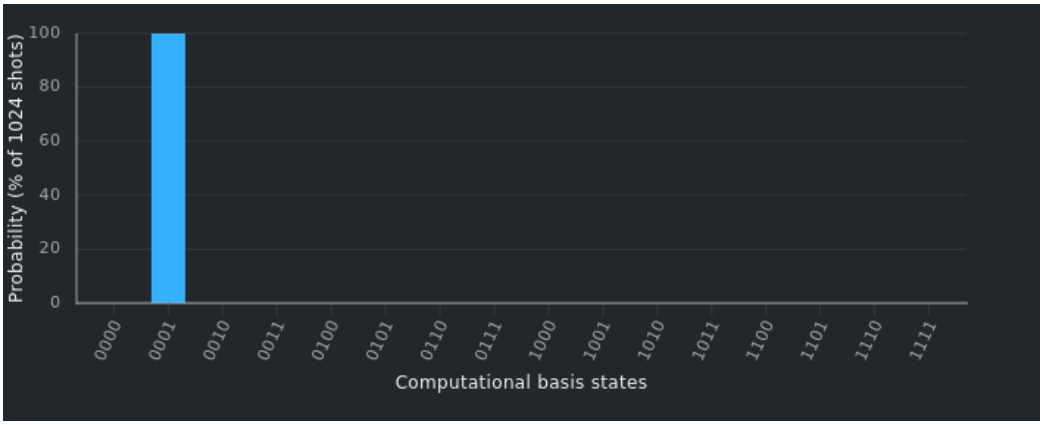

Figure 2.2: Probabilities graph for the measurement after applying the X gate.

2.0.3 Q-sphere Representation

The state on the Q-sphere after applying the X gate is shown in the figure below:

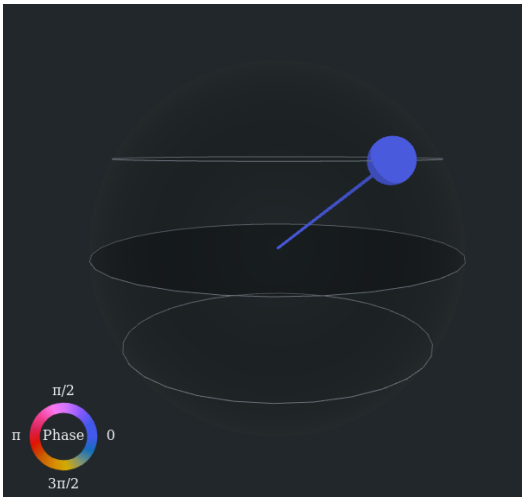

Figure 2.3: Q-sphere representation after applying the X gate.

Chapter 3

Task 3: Superposition of States with Hadamard Gate

The Hadamard gate (H gate) is used to create a superposition of quantum states. In this task, we applied the Hadamard gate to a qubit initially in the state $|0\rangle$, resulting in an equal superposition of $|0\rangle$ and $|1\rangle$.

3.0.1 Quantum Circuit

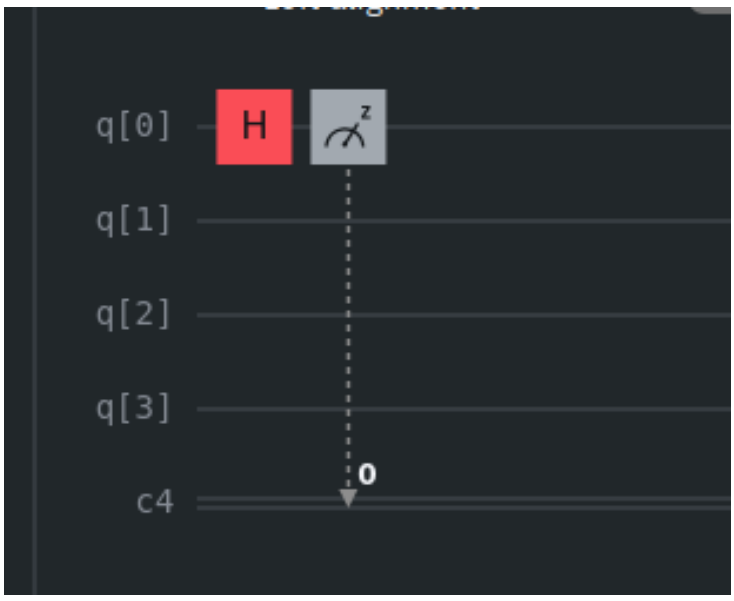

Figure 3.1: Quantum circuit with Hadamard gate applied.

3.0.2 Probabilities Graph

The probabilities of measuring $|0\rangle$ and $|1\rangle$ after applying the Hadamard gate:

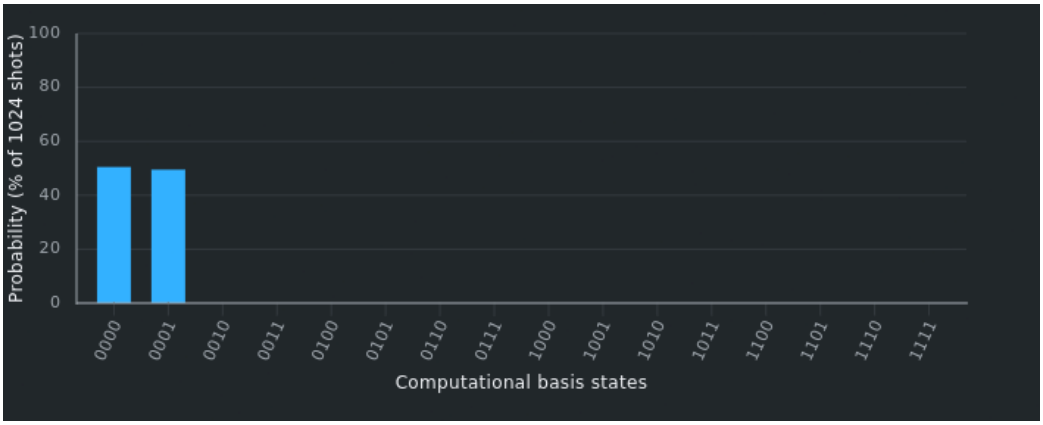

Figure 3.2: Probabilities graph after applying the Hadamard gate.

3.0.3 Q-sphere Representation

The Q-sphere representation of the qubit state after applying the Hadamard gate:

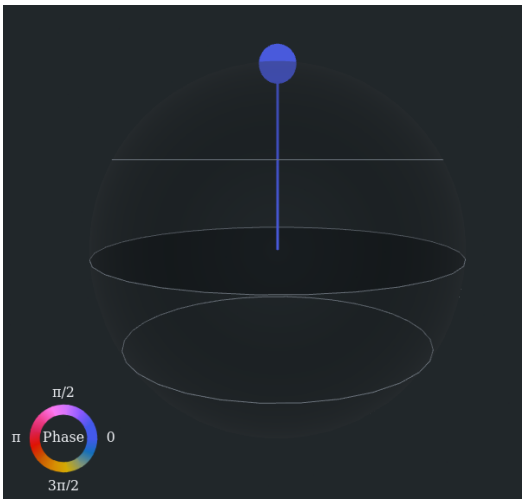

Figure 3.3: Q-sphere representation after applying the Hadamard gate.

Chapter 4

Task 4: State Tomography of One Qubit

In this task, we performed state tomography of a qubit by measuring it in the X, Y, and Z bases.

4.1 Measurement in the X Base

4.1.1 Quantum Circuit

Figure 4.1: Quantum circuit in the X Base.

4.1.2 Probabilities Graph

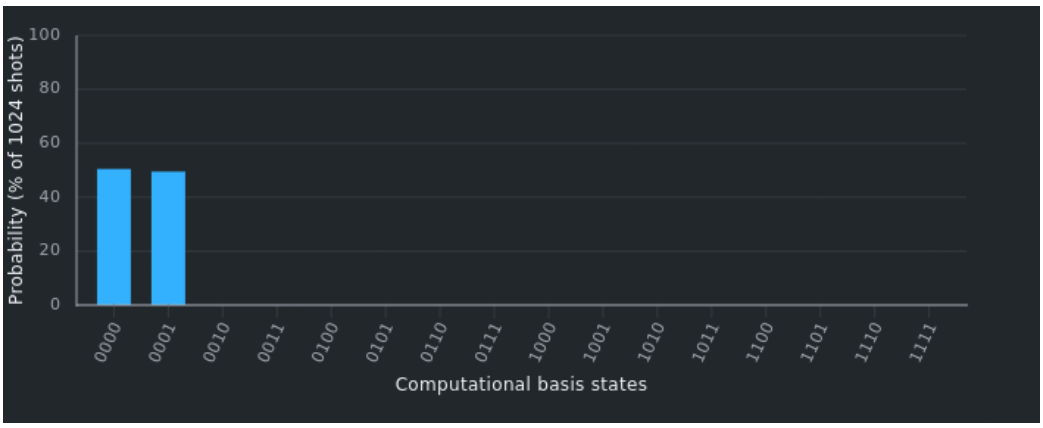

Figure 4.2: Probabilities graph in the X Base

4.1.3 Q-sphere Representation

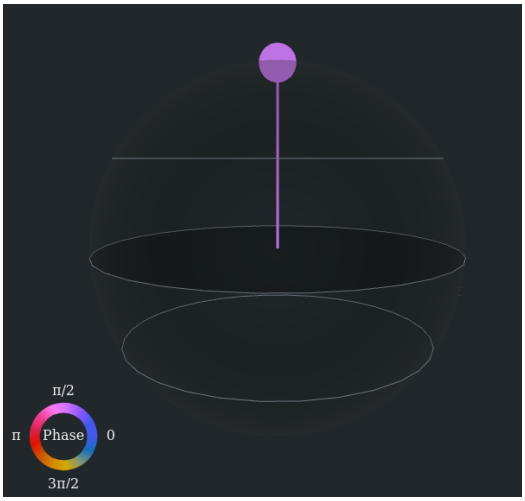

Figure 4.3: Q-sphere representation in the X Base

4.2 Measurement in the Y Base

4.2.1 Quantum Circuit

Figure 4.4: Quantum circuit in the Y Base.

4.2.2 Probabilities Graph

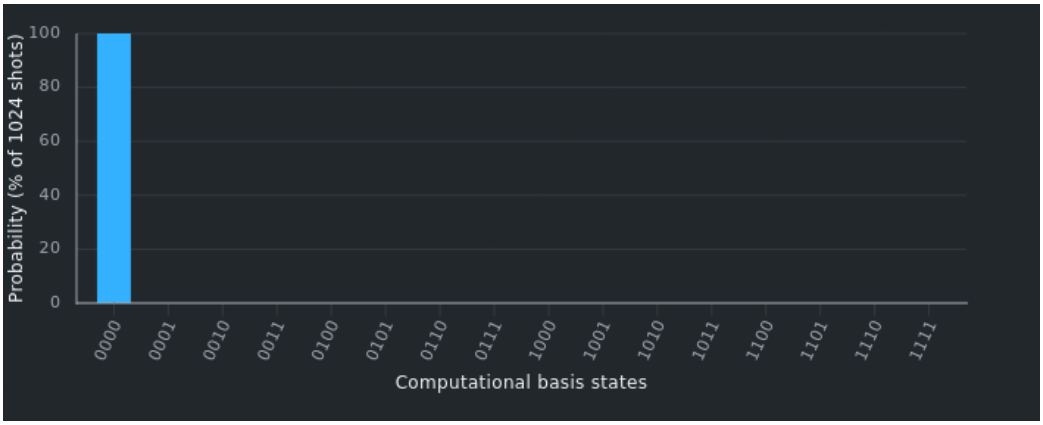

Figure 4.5: Probabilities graph in the Y Base.

4.2.3 Q-sphere Representation

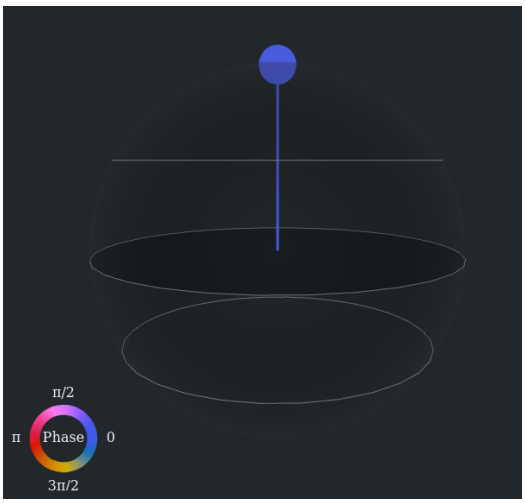

Figure 4.6: Q-sphere representation in the Y Base

4.3 Measurement in the Z Base

4.3.1 Quantum Circuit

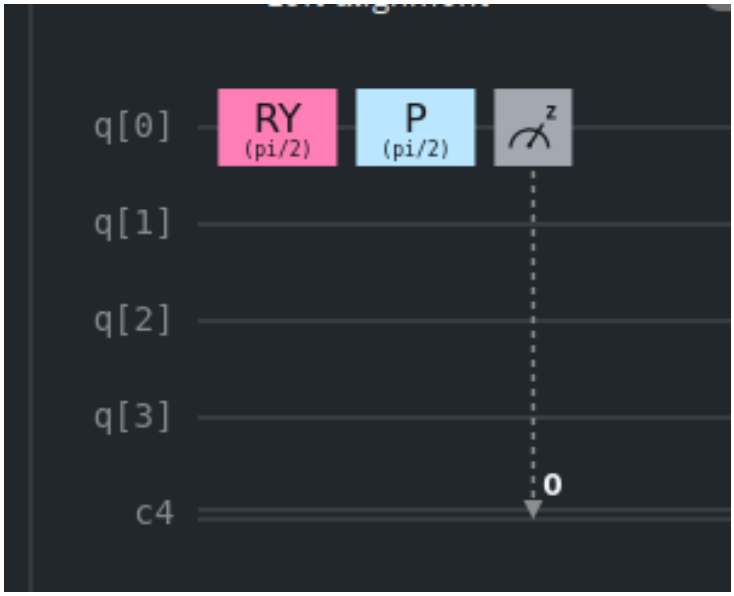

Figure 4.7: Quantum circuit in the Z Base.

4.3.2 Probabilities Graph

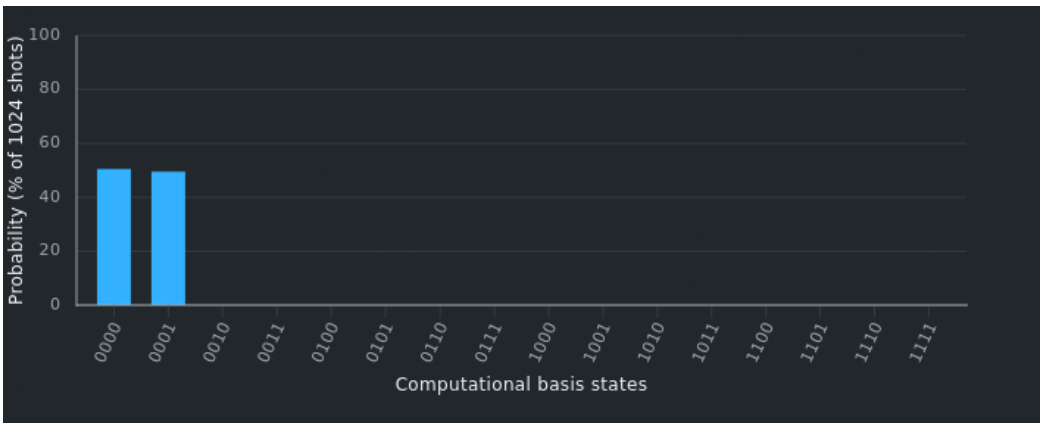

Figure 4.8: Probabilities graph in the Z Base.

4.3.3 Q-sphere Representation

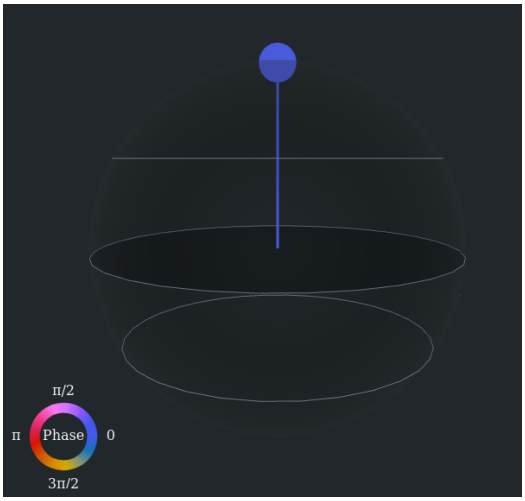

Figure 4.9: Q-sphere representation in the Z Base.