Overview of Quantum Gates

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H gate

The H or Hadamard gate rotates the states $|0\rangle$ and $|1\rangle$ to $|+\rangle$ and $|-\rangle$, respectively. It is useful for making superpositions. As a Clifford gate, it is useful for moving information between the x and z bases.

Composer reference	Qasm reference	Learn more
	`h q[0];`	[Quantum gates: Hadamard and S]

CX gate

The controlled-X gate is also known as the controlled-NOT. It acts on a pair of qubits, with one acting as 'control' and the other as 'target. It performs an X on the target whenever the control is in state $|1\rangle$. If the control qubit is in a superposition, this gate creates entanglement.

Composer reference	Qasm reference	Learn more

Contents

	`cx q[0], q[1];`	[Quantum gates: Multiqubit gates]()

Id gate

The identity gate is actually the absence of a gate. It ensures that nothing is applied to a qubit for one unit of gate time.

Composer reference	**Qasm reference**
	`id q[0];`

U3 gate

One of the three physical gates. The three parameters allow the construction of any single qubit gate, Has a duration of one unit of gate time.

Composer reference	**Qasm reference**	**Learn more**
	`u3(pi/2,pi/2,pi/2) q[0];`	[Quantum gates: Other single-qubit gates]()

U2 gate

One of the three physical gates. The two parameters control two different rotations within the gate. Has a duration of one unit of gate time.

Composer reference	Qasm reference	Learn more
U2	`u2(pi/2,pi/2) q[0];`	Quantum gates: Other single-qubit gates

U1 gate

One of the three physical gates. Equivalent to Rz. This can be implemented by the control software, requiring no actual manipulation of the qubits, and so effectively has a duration of zero.

Composer reference	Qasm reference	Learn more
U1	`u1(pi/2) q[0];`	Quantum gates: Other single-qubit gates

Rx gate

The Rx gate requires a single parameter: an angle expressed in radians. On the Bloch sphere, this gate corresponds to rotating the qubit state around the x axis by the given angle.

Composer reference	Qasm reference	Learn more
Rx	`rx(pi/2) q[0];`	Quantum gates: Other single-qubit gates

Ry gate

The Ry gate requires a single parameter: an angle expressed in radians. On the Bloch sphere, this gate corresponds to rotating the qubit state around the y axis by the given angle.

Composer reference	Qasm reference	Learn more
Ry	`ry(pi/2) q[0];`	Quantum gates: Other single-qubit gates

Rz gate

The Rz gate requires a single parameter: an angle expressed in radians. On the Bloch sphere, this gate corresponds to rotating the qubit state around the z axis by the given angle.

Composer reference	Qasm reference	Learn more
Rz	`rz(pi/2) q[0];`	Quantum gates: Other single-qubit gates

X gate

The Pauli X gate has the property of flipping the $|0\rangle$ state to $|1\rangle$, and vice versa. It is equivalent to Rx for the angle π.

Composer reference	Qasm reference	Learn more

X	`x q[0];`	[Quantum gates: The Pauli operators]()

Y gate

The Pauli Y gate is equivalent to Ry for the angle π. It is also equivalent to the combined effect of X and Z.

Composer reference	Qasm reference	Learn more
Y	`y q[0];`	[Quantum gates: The Pauli operators]()

Z gate

The Pauli Z gate has the property of flipping the $|+\rangle$ to $|-\rangle$, and vice versa. It is equivalent to Rz for the angle π.

Composer reference	Qasm reference	Learn more
Z	`z q[0];`	[Quantum gates: The Pauli operators]()

S gate

The S gate is equivalent to Rz for the angle $\pi/2$. As a Clifford gate, it is useful for moving information between the x and y bases.

Composer reference	Qasm reference	Learn more
S	`s q[0];`	[Quantum gates: Hadamard and S]

Sdg gate

The inverse of the S gate. Equivalent to Rz for the angle $-\pi/2$. As a Clifford gate, it is useful for moving information between the x and y bases.

Composer reference	Qasm reference	Learn more
$S^\dagger$	`sdg q[0];`	[Quantum gates: Hadamard and S]

T gate

The T gate is equivalent to Rz for the angle $\pi/4$. Fault-tolerant quantum computers will compile all quantum programs down to just the T gate and its inverse, as well as the Clifford gates.

Composer reference	Qasm reference	Learn more
T	`t q[0];`	[Quantum gates: Other single-qubit gates]

Tdg gate

The inverse of the T gate, which is equivalent to Rz for the angle $-\pi/4$. Fault-tolerant quantum computers will compile all quantum programs down to just the T gate and its inverse, as well as the Clifford gates.

Composer reference	Qasm reference	Learn more
$T^\dagger$	`tdg q[0];`	Quantum gates: Other single-qubit gates

cH gate

The controlled-Hadamard gate, like the controlled-NOT, acts on a control and target qubit. It performs an H on the target whenever the control is in state $|1\rangle$.

Composer reference	Qasm reference	Learn more
cH	`ch q[0], q[1];`	Quantum gates: Multiqubit gates

cY gate

The controlled-Y gate, like the controlled-NOT, acts on a control and target qubit. It performs a Y on the target whenever the control is in state $|1\rangle$.

Composer reference	Qasm reference	Learn more

	`cy q[0], q[1];`	[Quantum gates: Multiqubit gates]()

cZ gate

The controlled-Z gate, like the controlled-NOT, acts on a control and target qubit. It performs a Z on the target whenever the control is in state $|1\rangle$.

Composer reference	**Qasm reference**	**Learn more**
	`cz q[0], q[1];`	[Quantum gates: Multiqubit gates]()

cRz gate

The controlled-Rz gate, like the controlled-NOT, acts on a control and target qubit. It performs a Rz rotation on the target whenever the control is in state $|1\rangle$.

Composer reference	**Qasm reference**
	`crz(pi/2) q[0] ,q[1];`

cU1 gate

The controlled-U1 gate, like the controlled-NOT, acts on a control and target qubit. It performs a Rz rotation on the target whenever the control is in state $|1\rangle$.

Composer reference	Qasm reference
	`cu1(pi/2) q[0],q[1];`

cU3 gate

The controlled-U3 gate, like the controlled-NOT, acts on a control and target qubit. It performs a Rz rotation on the target whenever the control is in state $|1\rangle$.

Composer reference	Qasm reference
	`cu3(pi/2,pi/2,pi/2) q[0],q[1];`

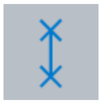
ccX gate

The ccX gate, commonly known as the Toffoli, has two control qubits and one target. At applies an X to the target only when both controls are in state $|1\rangle$.

Composer reference	Qasm reference	Learn more
	`ccx q[0], q[1], q[2];`	Quantum gates: Multiqubit gates

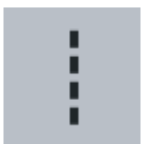
SWAP gate

The SWAP gate simply swaps the states of two qubits.

Composer reference	Qasm reference	Learn more
	`swap q[0], q[1];`	[Basic circuit identities: Swapping qubits]()

Barrier operation

To make your quantum program more efficient, the compiler will try to combine gates. The barrier is an instruction to the compiler to prevent these combinations being made.

Composer reference	Qasm reference
	`barrier q;`

$|0\rangle$ operation

The reset operation returns a qubit to state $|0\rangle$, irrespective of its state before the operation was applied. It is not a reversible operation.

Composer reference	Qasm reference
	`reset q[0];`

IF operation

The IF operation allows quantum gates to be conditionally applied, depending on the state of a classical register.

Composer reference	Qasm reference
	`if (c==0) x q[0];`

z measurement

Measurement in the standard basis, also known as the z basis or computational basis. Can be used to implement any kind of measurement when combined with other gates. It is not a reversible operation.

Composer reference	Qasm reference	Learn more
	`measure q[0];`	[The unique properties of qubits]