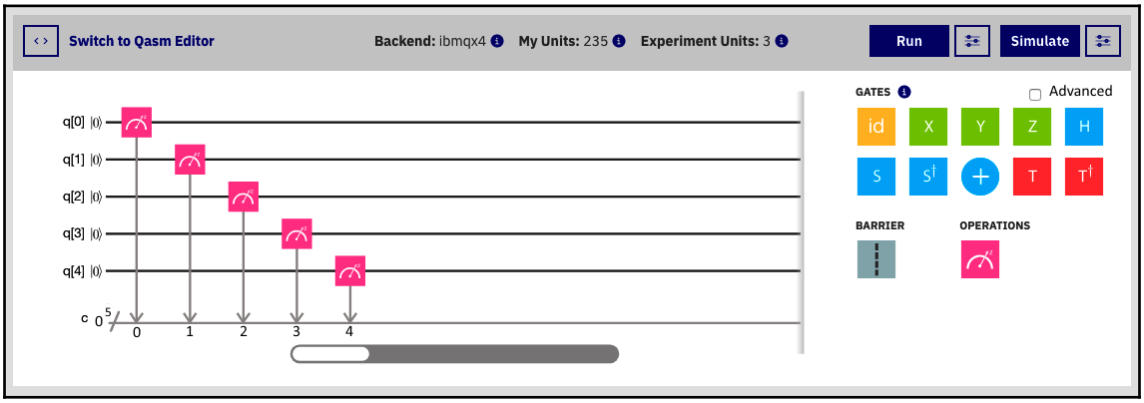
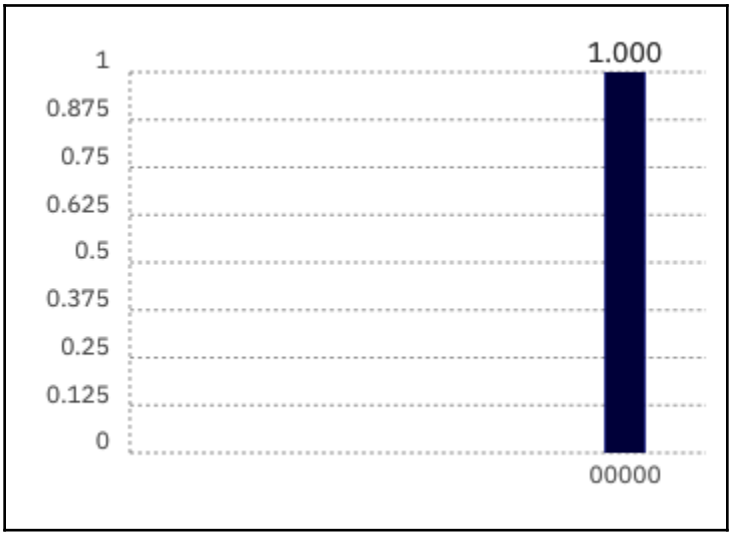
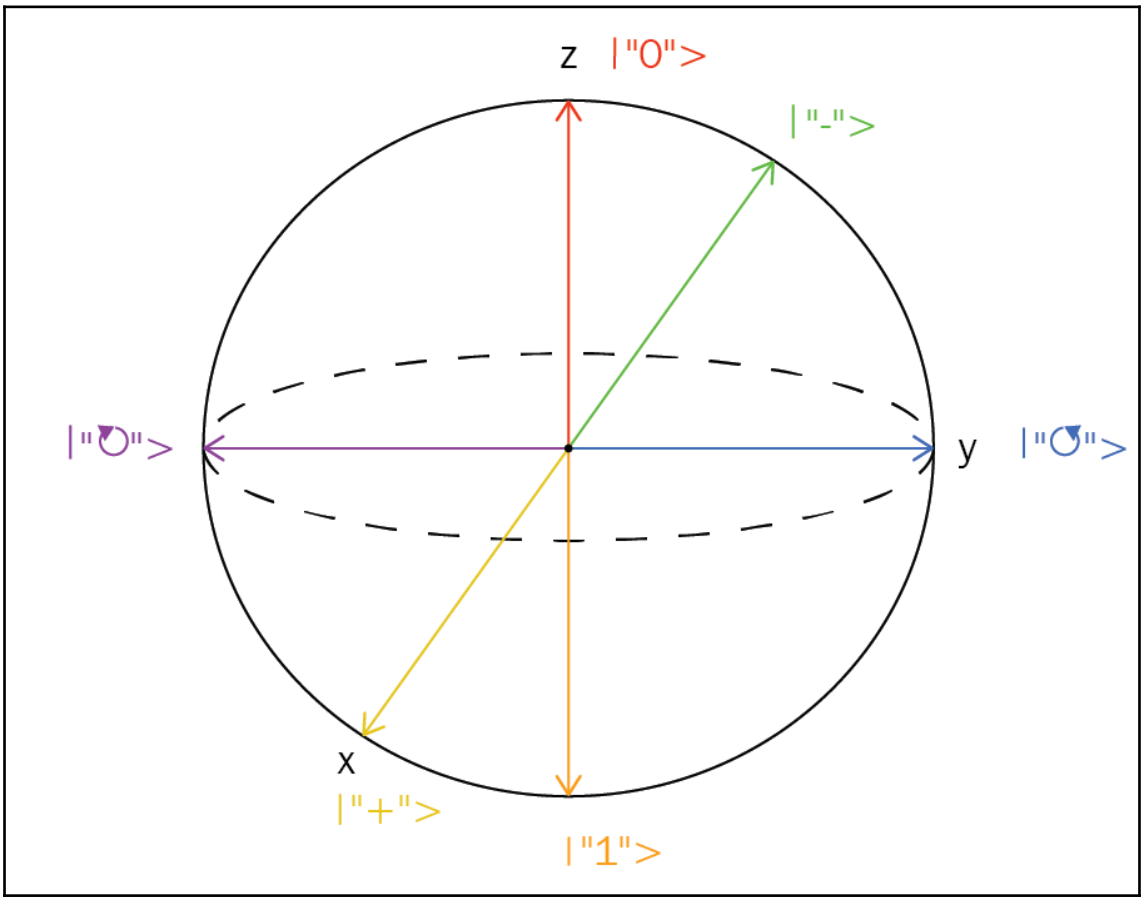
Chapter 1: What is Quantum Computing?





Chapter 2: Qubits



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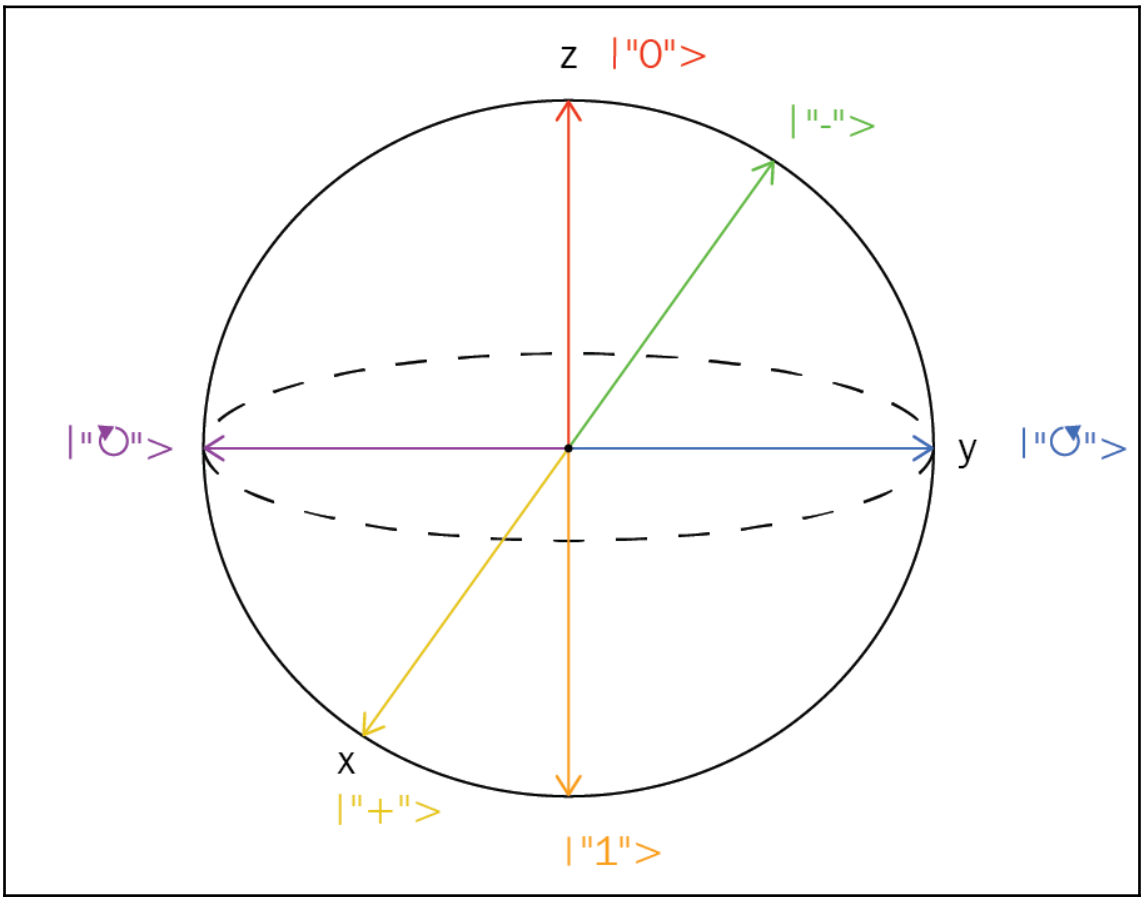
x: |"-"> to |"+">

z: |"1"> to |"0">
y: |"ʊ"> to |"ʊ">
x: |"-"> to |"+">
|"0">
|"1">
|"ʊ">
|"ʊ">
|"-">
|"+">

Chapter 3: Quantum States, Quantum Registers, and Measurement

No images

Chapter 4: Evolving Quantum States with Quantum Gates



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|"0">

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x: |"-"> to |"+">
|"0">

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
|"0"> to |"1"> :z
|"↻"> to |"↺"> :y
|"+"> to |"-"> :x

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
|"0">

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
|"0">

z: |"1"> to |"0">
y: |"ↄ"> to |"ↄ">
x: |"-"> to |"+">

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
|"0">

z: |"1"> to |"0">
y: |"ↄ"> to |"ↄ">
x: |"-"> to |"+">
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|"ↄ"> to |"ↄ"> :y
|"-"> to |"+"> :x

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
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z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
|"0">

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
|"0"> to |"1"> :z
|"↻"> to |"↺"> :y
|"+"> to |"-"> :x

z: |"1"> to |"0">
y: |"ↄ"> to |"ↄ">
x: |"-"> to |"+">

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
<|"0">

z: |"1"> to |"0">
y: |"ↄ"> to |"ↄ">
x: |"-"> to |"+">
|"0"> to |"1"> :z
|"ↄ"> to |"ↄ"> :y
|"-"> to |"+"> :x

z: |"1"> to |"0">
y: |"ↄ"> to |"ↄ">
x: |"-"> to |"+">
|"0"> to |"1">
|"ↄ"> to |"ↄ">
|"-"> to |"+">

z: |"1"> to |"0">
y: |"ↄ"> to |"ↇ">
x: |"-"> to |"+">
|"0">

z: |"1"> to |"0">
y: |"↺"> to |"↻">
x: |"-"> to |"+">
|"0">
|"1">
|"↻">
|"↺">
|"-">
|"+">

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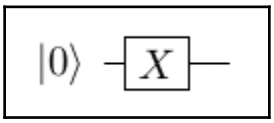
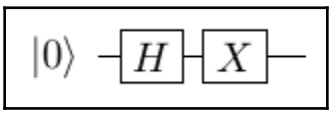
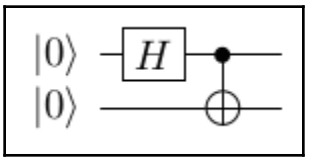
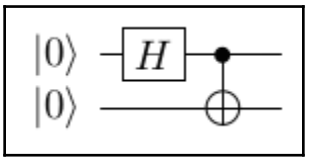
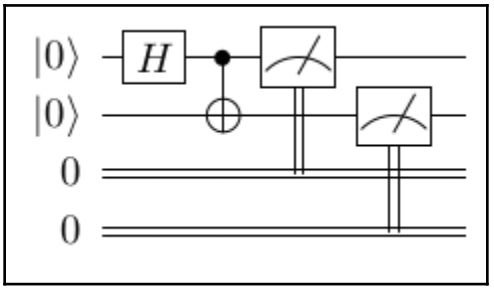
Chapter 5: Quantum Circuits

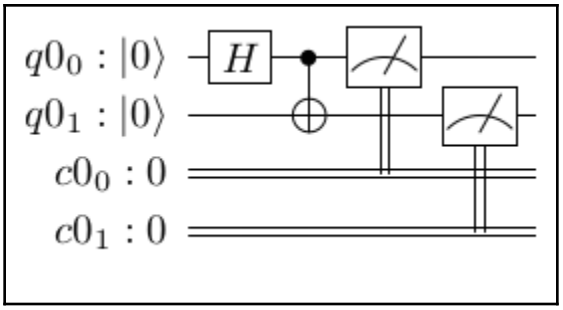


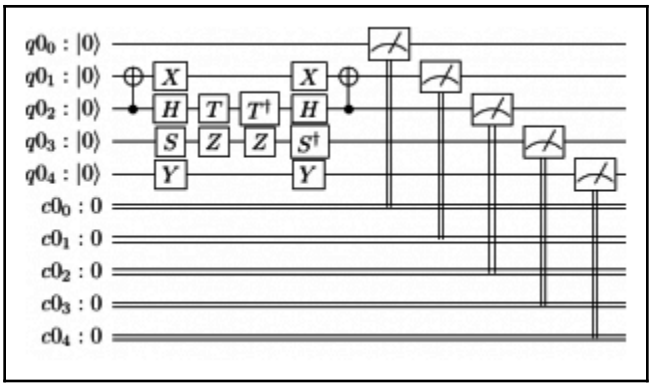








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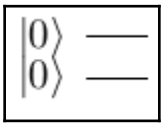
$q0_1 : |0\rangle$
$q0_2 : |0\rangle$
$q0_3 : |0\rangle$
$q0_4 : |0\rangle$
$c0_0 : 0$
$c0_1 : 0$
$c0_2 : 0$
$c0_3 : 0$
$c0_4 : 0$
X
H
T
$T^\dagger$
X
H
S
Z
Z
$S^\dagger$
Y
Y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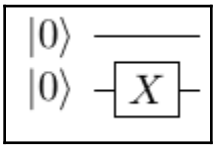
$|0\rangle$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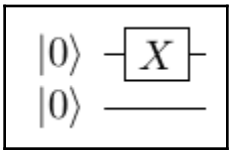
X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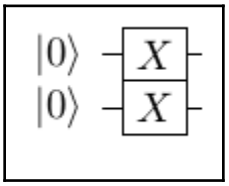
X
$|0\rangle$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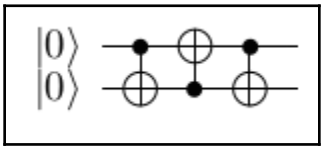
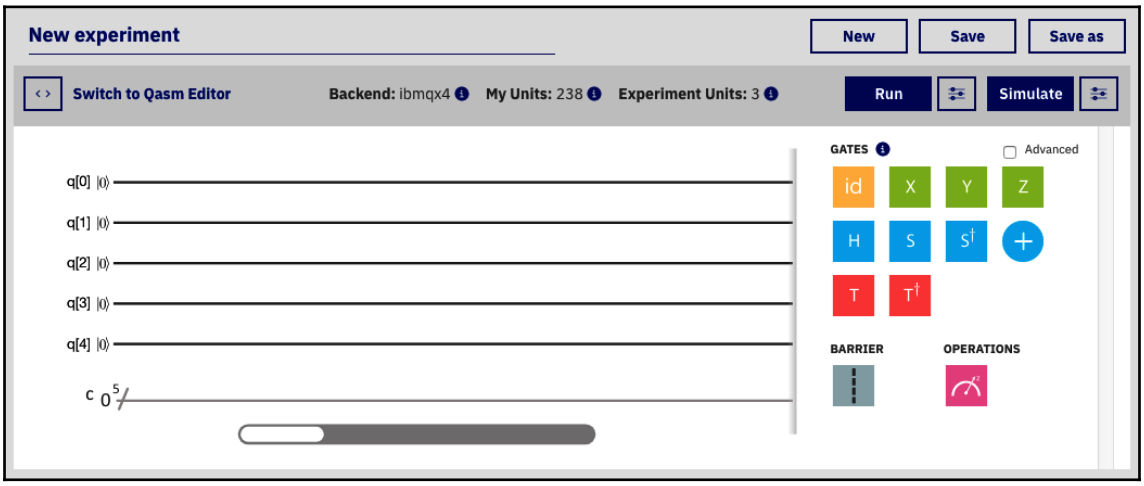
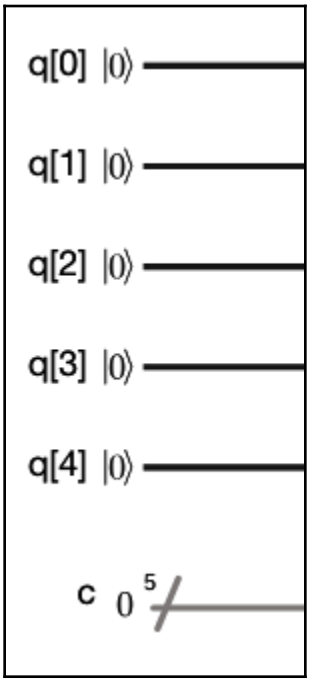
X


$|0\rangle$
$|0\rangle$

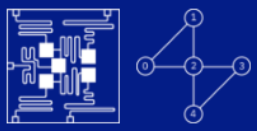
Chapter 6: The Quantum Composer





IBM Q 5 Tenerife [ibmqx4]

ACTIVE: USERS

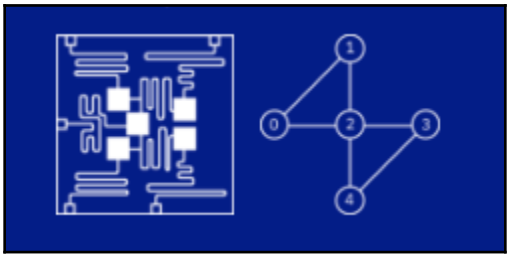


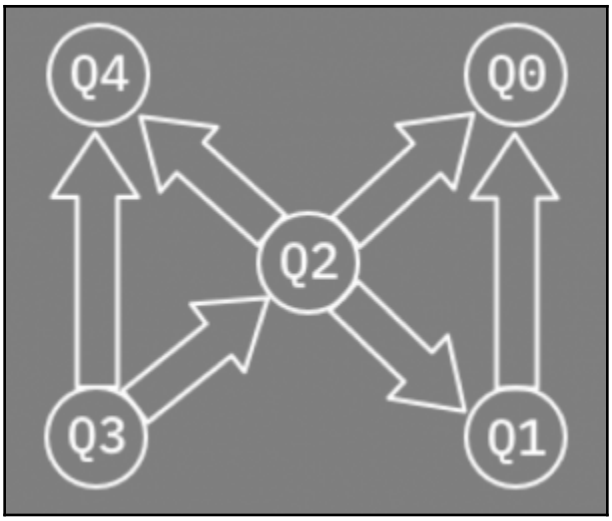
Last Calibration: 2018-06-28 02:59:35
Fridge Temperature: [] -

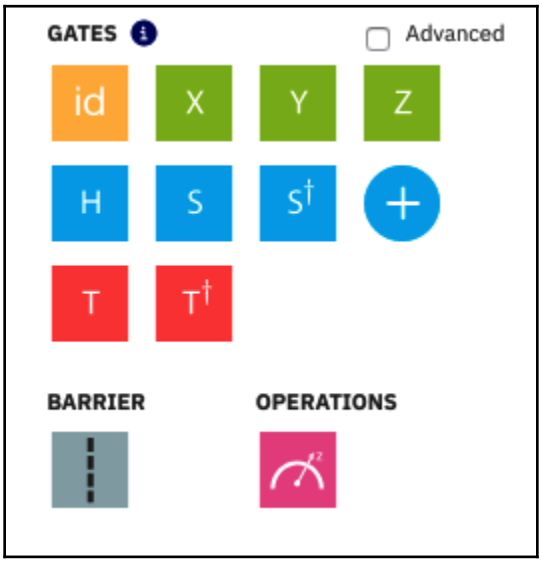
More details

	Q0	Q1	Q2	Q3	Q4
Frequency (GHz)	5.24	5.31	5.35	5.41	5.19
T1 (µs)	50.80	56.30	42.00	33.10	52.30
T2 (µs)	13.90	57.70	49.90	15.30	26.20
Gate error (10^{-3})	0.77	1.63	1.20	3.01	0.94
Readout error (10^{-2})	6.40	6.10	6.00	11.00	4.90
MultiQubit gate error (10^{-2})		CX1_0 2.82	CX2_0 2.76	CX3_2 11.93	CX4_2 5.68
			CX2_1 2.71	CX3_4 8.61	

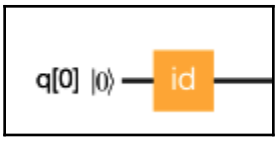
	Q0	Q1	Q2	Q3	Q4
Frequency (GHz)	5.24	5.31	5.35	5.41	5.19
T1 (µs)	50.80	56.30	42.00	33.10	52.30
T2 (µs)	13.90	57.70	49.90	15.30	26.20
Gate error (10^{-3})	0.77	1.63	1.20	3.01	0.94
Readout error (10^{-2})	6.40	6.10	6.00	11.00	4.90
MultiQubit gate error (10^{-2})		CX1_0 2.82	CX2_0 2.76	CX3_2 11.93	CX4_2 5.68
			CX2_1 2.71	CX3_4 8.61	

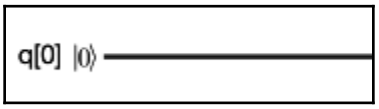



Q4
Q0
Q2
Q3
Q1

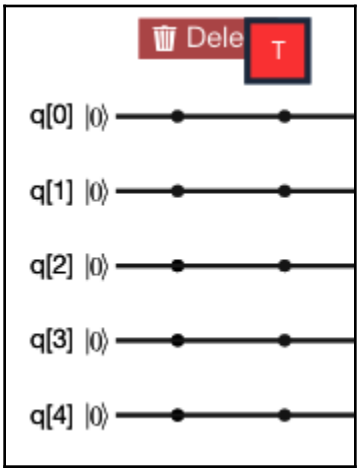

GATES
Advanced
id
X
Y
Z
H
S
S†
T
T†
BARRIER
OPERATIONS

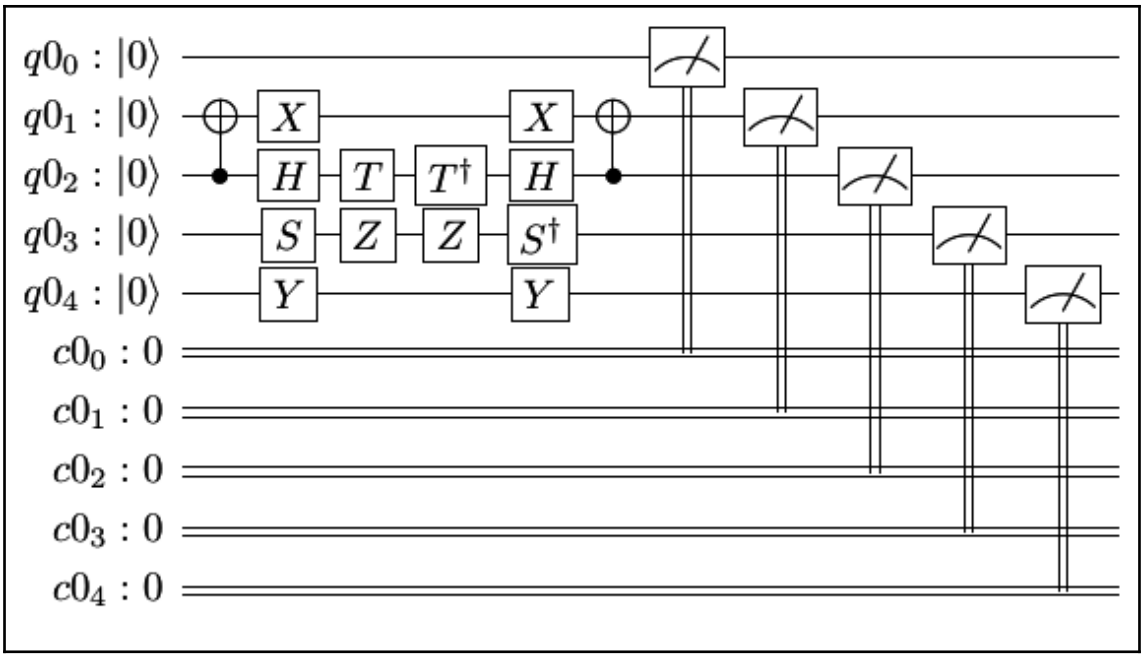
q[0] |0⟩
X
X

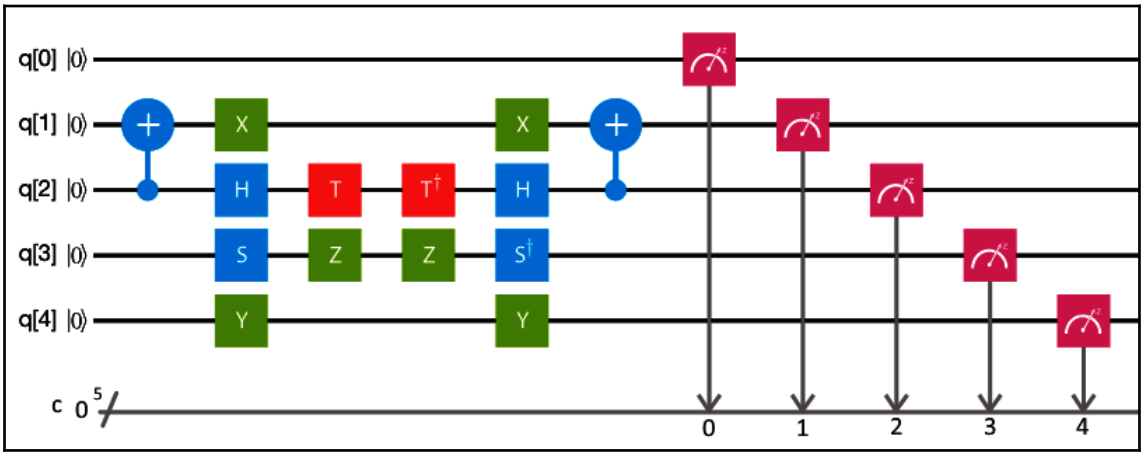

q[0] |0⟩
id

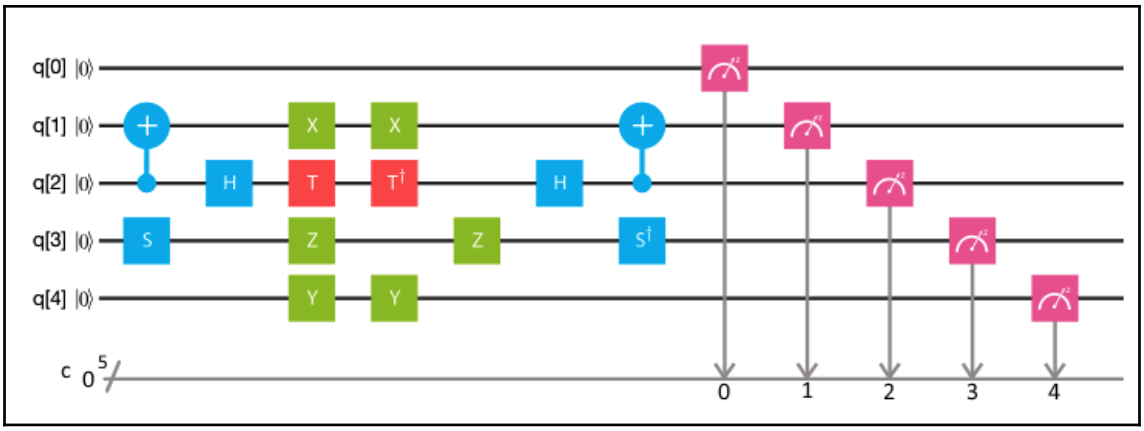

q[0] |0⟩

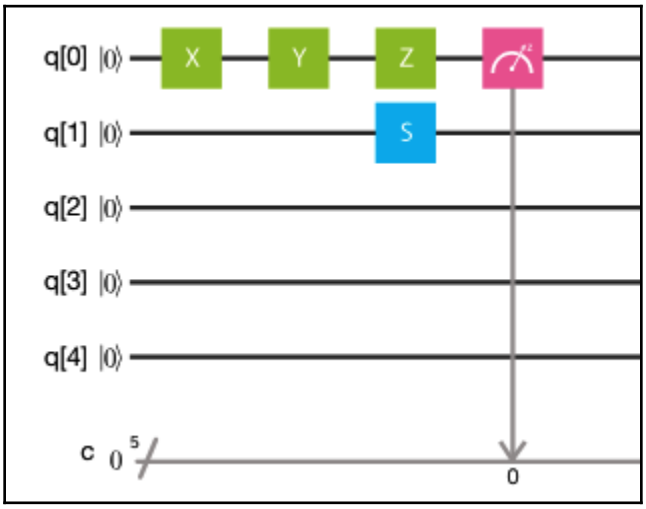
q[0] |0⟩
X
X

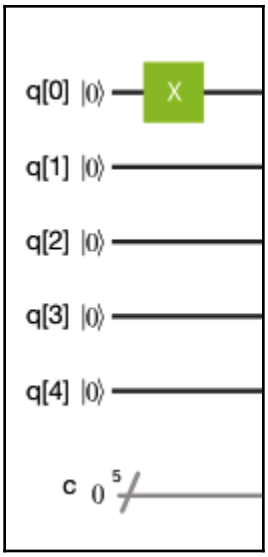

Dele
T
q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩


$q0_0 : |0\rangle$
$q0_1 : |0\rangle$
$q0_2 : |0\rangle$
$q0_3 : |0\rangle$
$q0_4 : |0\rangle$
$c0_0 : 0$
$c0_1 : 0$
$c0_2 : 0$
$c0_3 : 0$
$c0_4 : 0$
X
H
S
Y
T
Z
$T^\dagger$
Z
X
H
$S^\dagger$
Y


q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
c 0 5
X
H
S
Y
T
Z
T†
Z
X
H
S†
Y
0
1
2
3
4


q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
c 0 5
H
S
X
T
Z
Y
T†
S†
0
1
2
3
4


q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
c 0 5
X
Y
Z
S
0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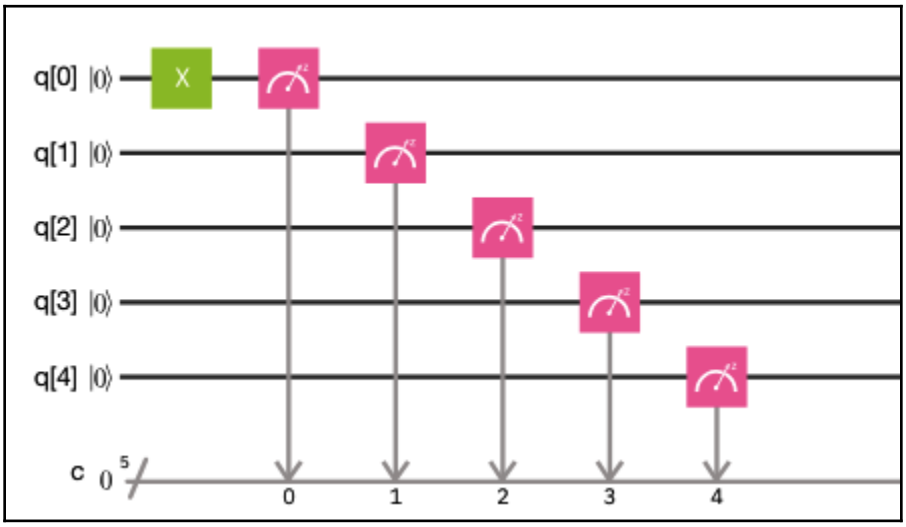
X
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
c 0 5


q[0] |0⟩
X
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
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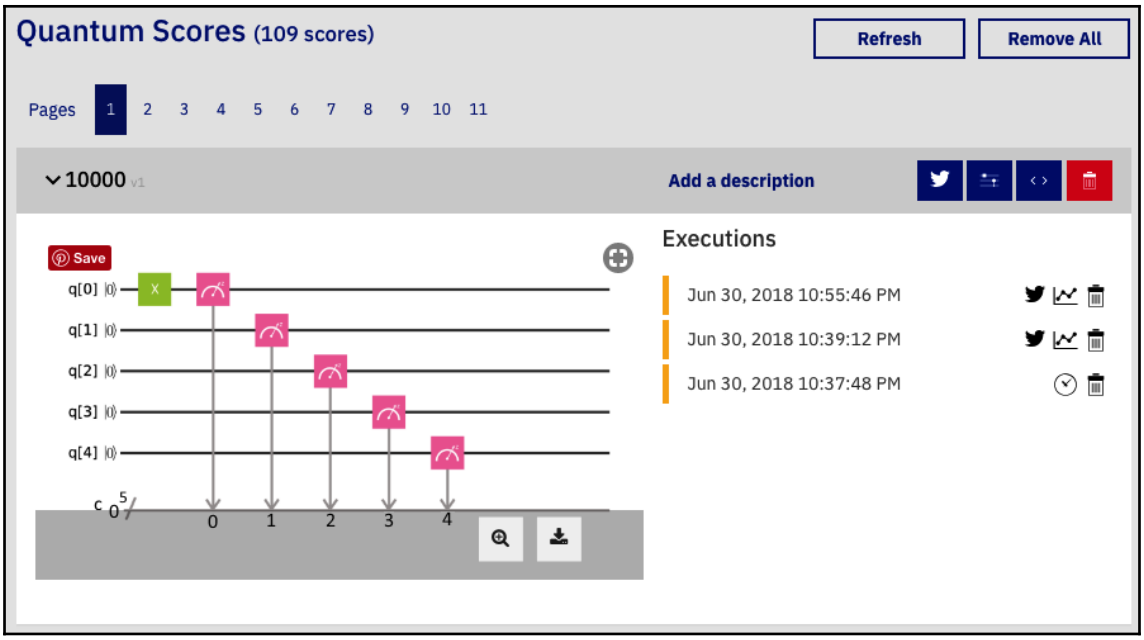
1
2
3
4

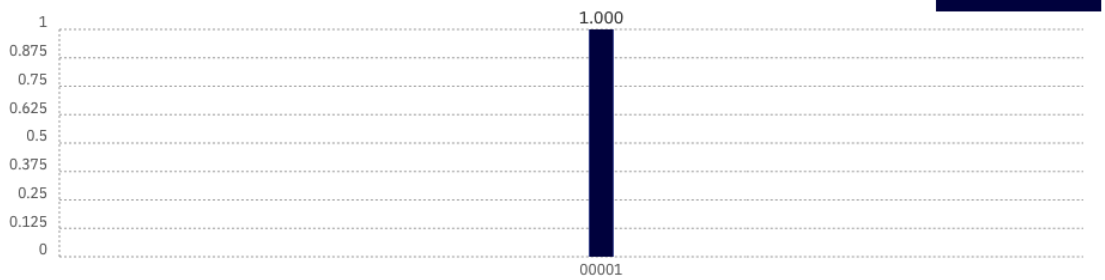

Quantum Scores (109 scores)
Refresh
Remove All
Pages 1 2 3 4 5 6 7 8 9 10 11
10000 v1
Add a description
Save
q[0]
q[1]
q[2]
q[3]
q[4]
c 5
0 1 2 3 4
Executions
Jun 30, 2018 10:55:46 PM
Jun 30, 2018 10:39:12 PM
Jun 30, 2018 10:37:48 PM

10000

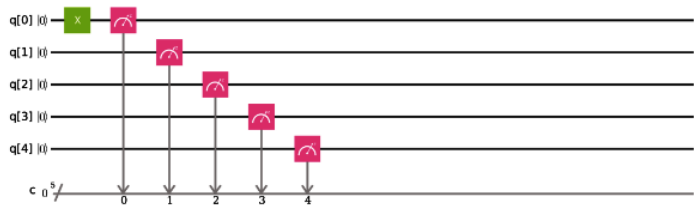
Device: Simulator

Quantum State: Computation Basis

Download CSV



Quantum Circuit



OPENQASM 2.0

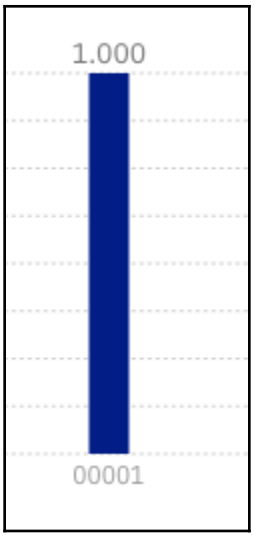
```
include "qelib1.inc";

qreg q[5];
creg c[5];

x q[0];
measure q[0] -> c[0];
measure q[1] -> c[1];
```

Open in Composer

Edit in QASM Editor

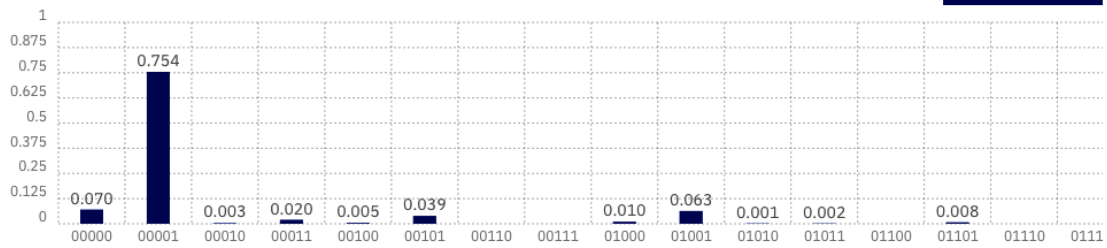


10000

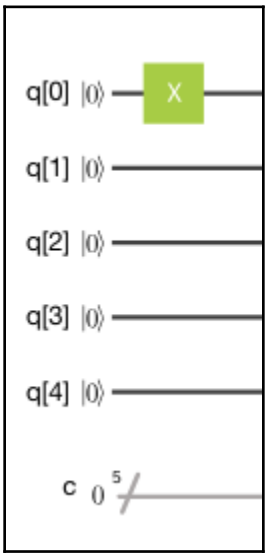
Device: ibmqx4

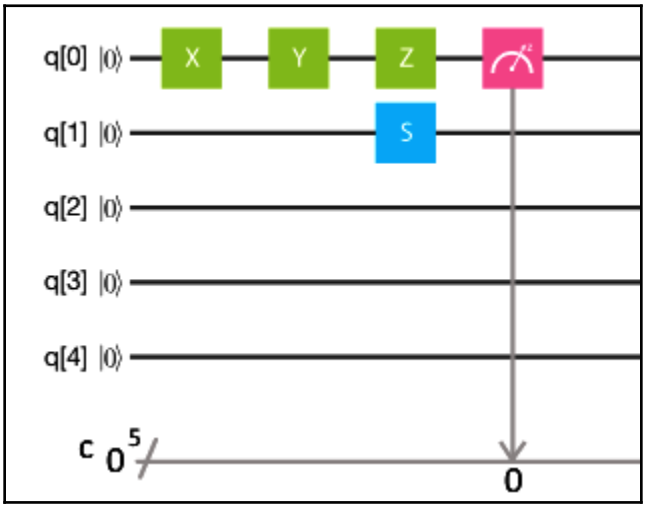
Quantum State: Computation Basis

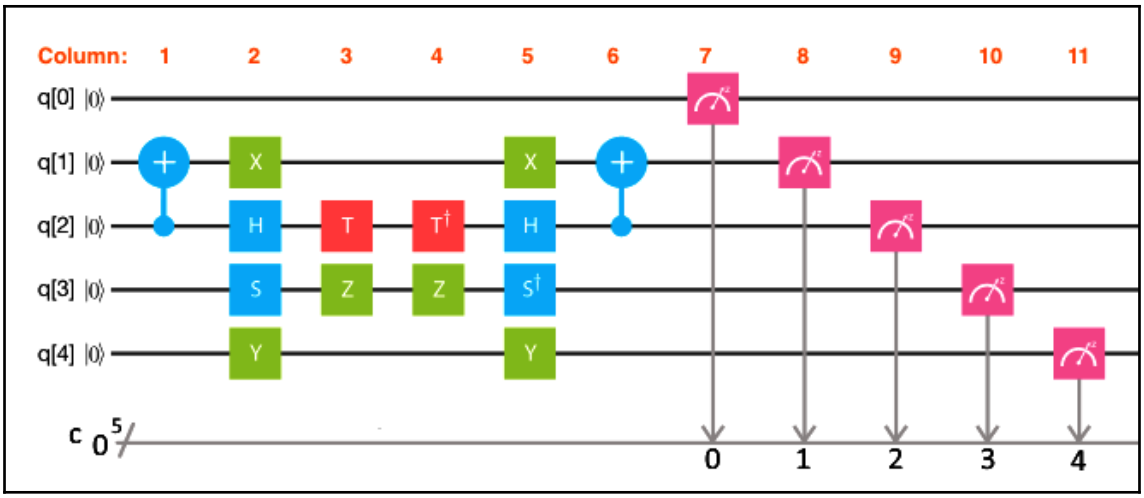
Download CSV

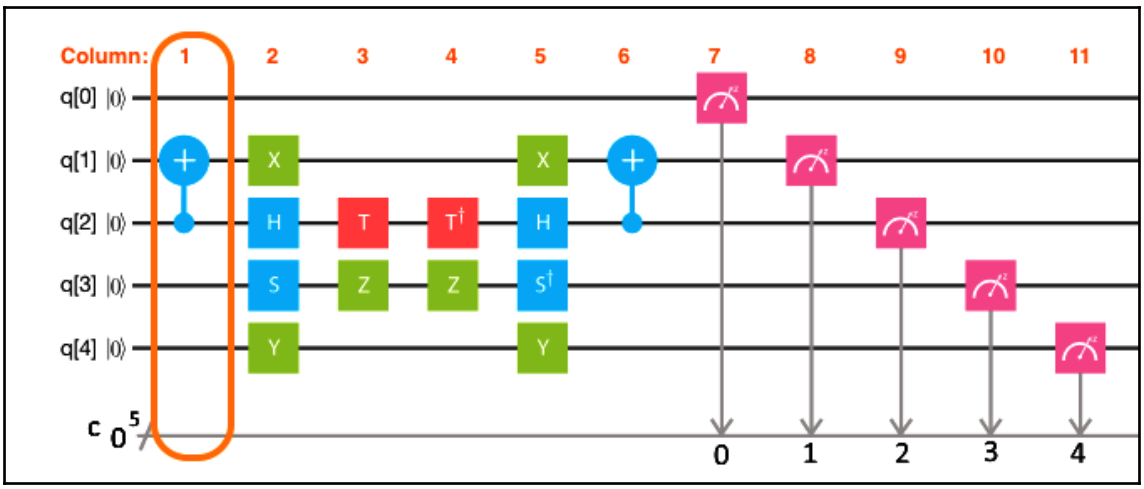


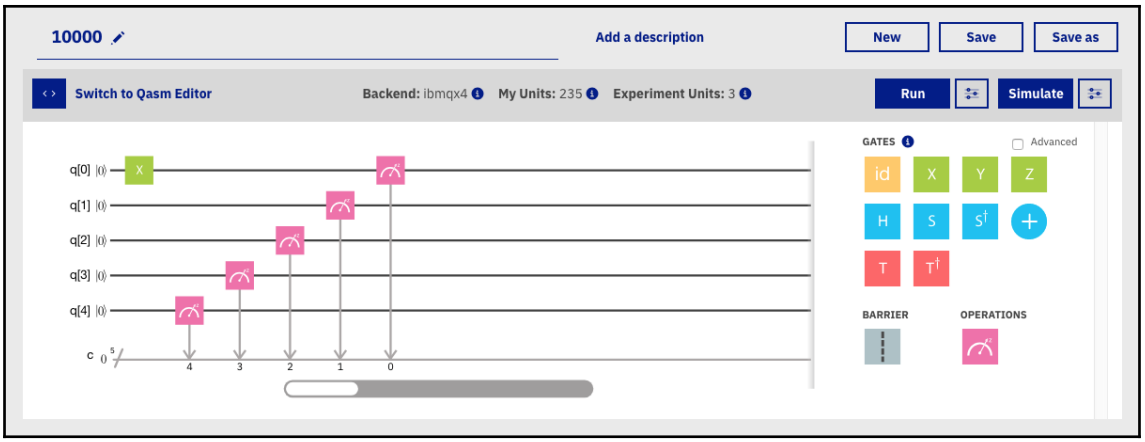
Chapter 7: Working with OpenQASM

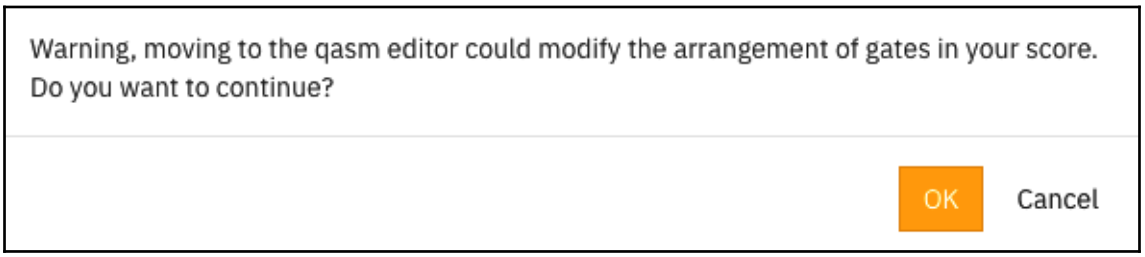


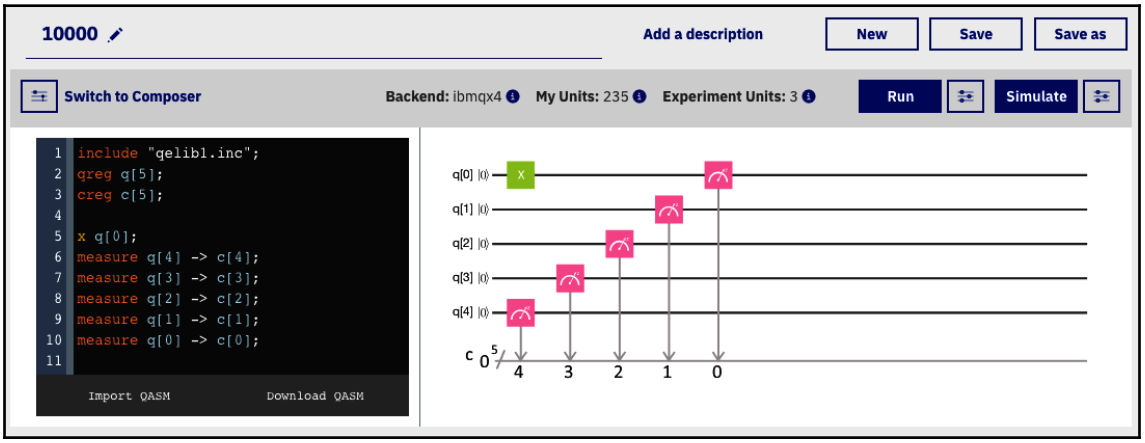


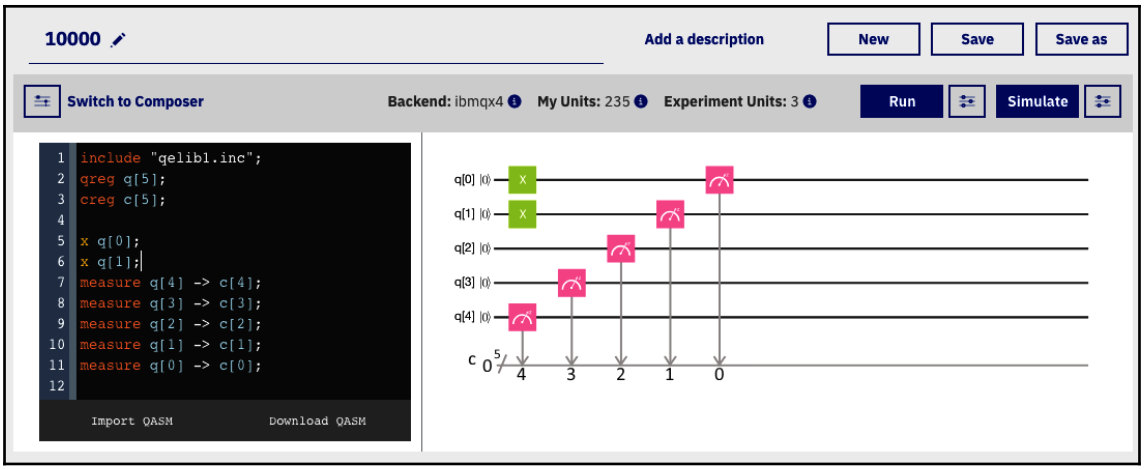

Column: 1 2 3 4 5 6 7 8 9 10 11
q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
X
H
S
Y
T
Z
T†
Z
X
H
S†
Y
c 0 5
0 1 2 3 4

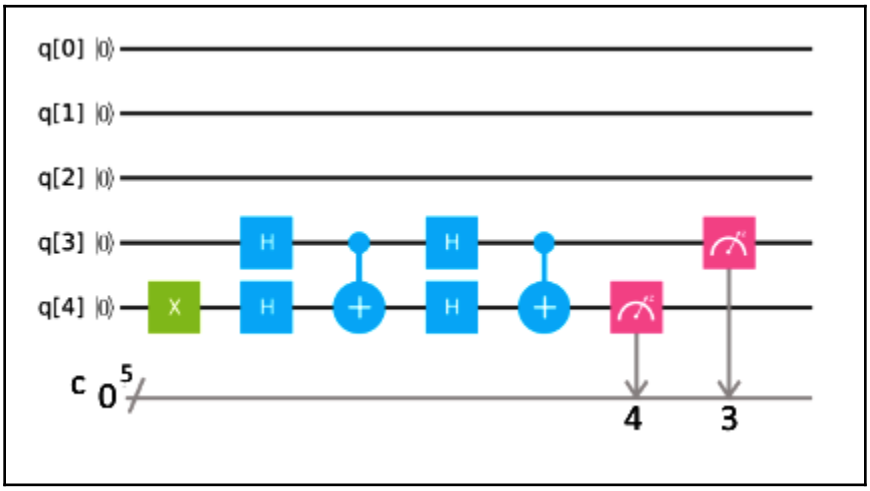

Column: 1 2 3 4 5 6 7 8 9 10 11
q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
X
H
S
Y
T
Z
T†
Z
X
H
S†
Y
c 0 5
0 1 2 3 4

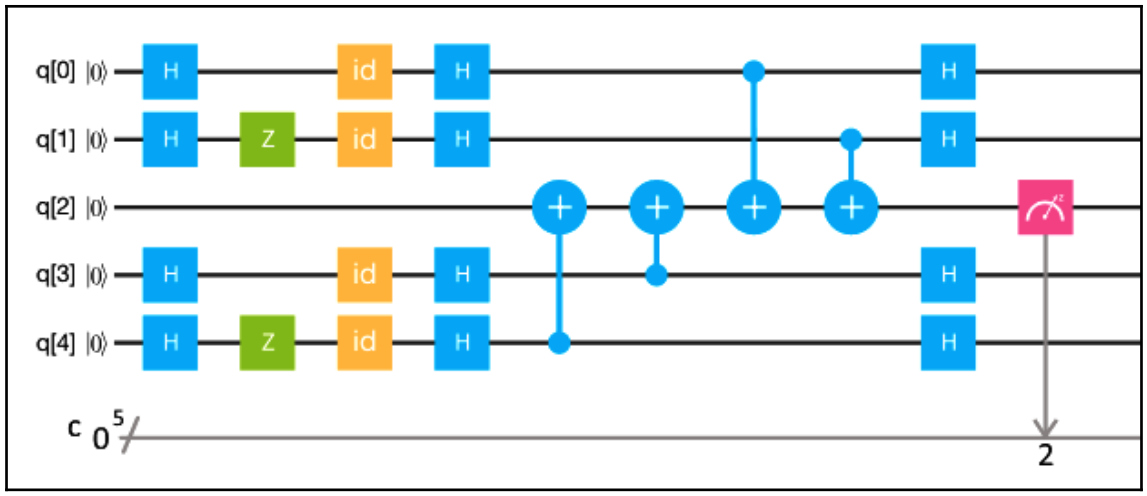

10000
Add a description
New
Save
Save as
Switch to Qasm Editor
Backend: ibmqx4
My Units: 235
Experiment Units: 3
Run
Simulate
GATES
Advanced
id
X
Y
Z
H
S
S†
T
T†
BARRIER
OPERATIONS
q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
c 0 5
4
3
2
1
0


Warning, moving to the qasm editor could modify the arrangement of gates in your score.
Do you want to continue?
OK
Cancel

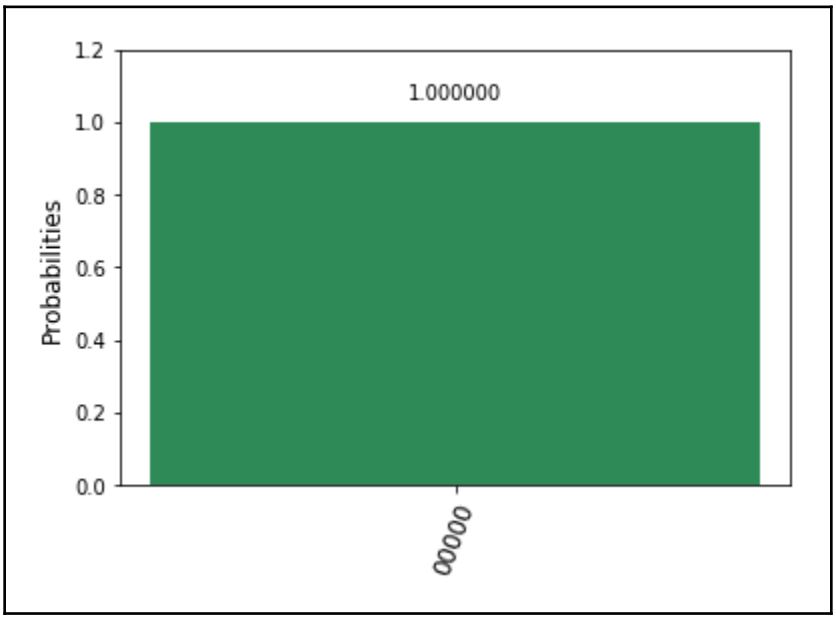

10000
Add a description
New
Save
Save as
Switch to Composer
Backend: ibmqx4
My Units: 235
Experiment Units: 3
Run
Simulate
include "qelib1.inc";
qreg q[5];
creg c[5];
x q[0];
measure q[4] -> c[4];
measure q[3] -> c[3];
measure q[2] -> c[2];
measure q[1] -> c[1];
measure q[0] -> c[0];
Import QASM
Download QASM
q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
c 0 5
4
3
2
1
0

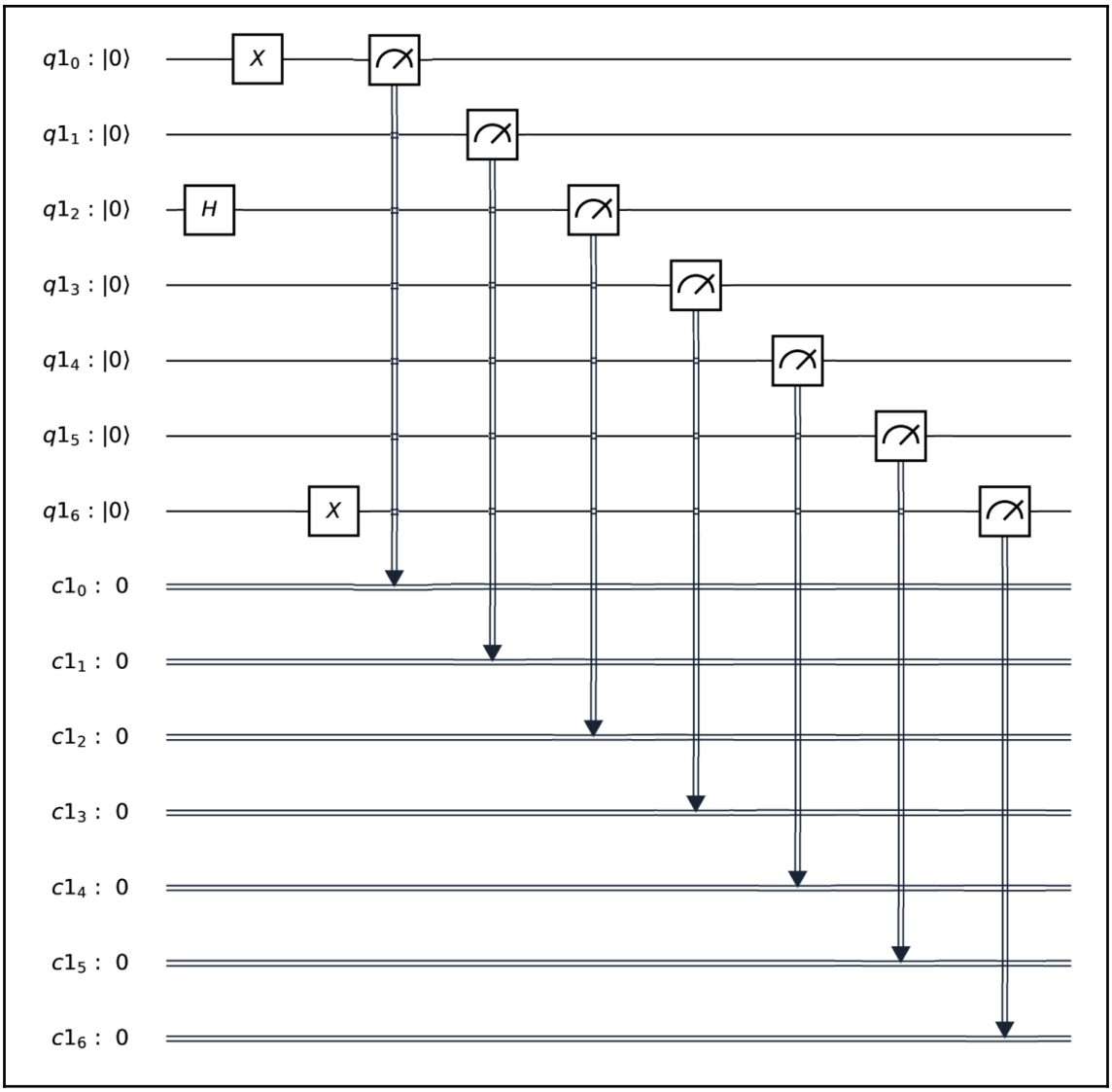

10000
Add a description
New
Save
Save as
Switch to Composer
Backend: ibmqx4
My Units: 235
Experiment Units: 3
Run
Simulate
include "qelib1.inc";
qreg q[5];
creg c[5];
x q[0];
x q[1];
measure q[4] -> c[4];
measure q[3] -> c[3];
measure q[2] -> c[2];
measure q[1] -> c[1];
measure q[0] -> c[0];
Import QASM
Download QASM
q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
c 0 5
4
3
2
1
0

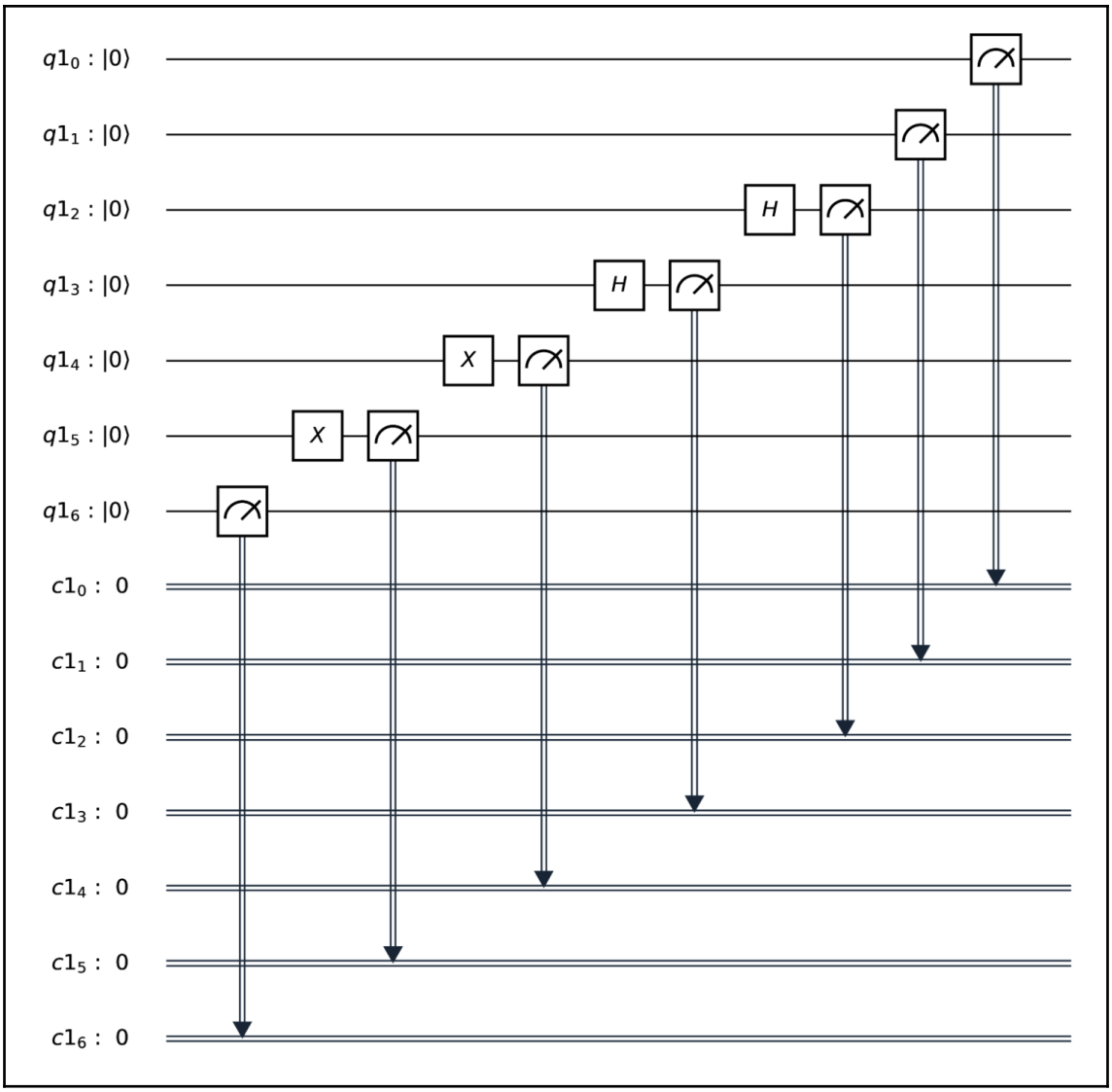

q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
X
H
H
H
H
c 0 5
4
3


q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
H
Z
id
c 0 5
2

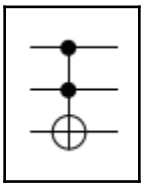
Chapter 8: Qiskit and Quantum Computer Simulation

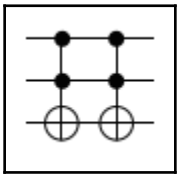


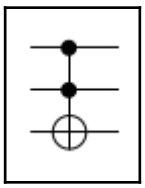

q1₀ : |0⟩
q1₁ : |0⟩
q1₂ : |0⟩
q1₃ : |0⟩
q1₄ : |0⟩
q1₅ : |0⟩
q1₆ : |0⟩
c1₀ : 0
c1₁ : 0
c1₂ : 0
c1₃ : 0
c1₄ : 0
c1₅ : 0
c1₆ : 0
X
H
X

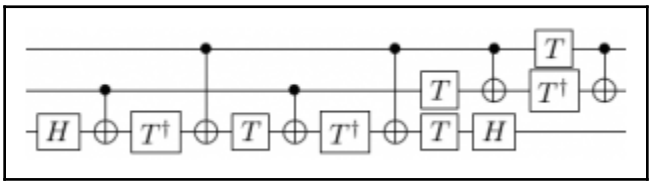

$q1_0 : |0\rangle$
$q1_1 : |0\rangle$
$q1_2 : |0\rangle$
$q1_3 : |0\rangle$
$q1_4 : |0\rangle$
$q1_5 : |0\rangle$
$q1_6 : |0\rangle$
$c1_0 : 0$
$c1_1 : 0$
$c1_2 : 0$
$c1_3 : 0$
$c1_4 : 0$
$c1_5 : 0$
$c1_6 : 0$
X
X
H
H

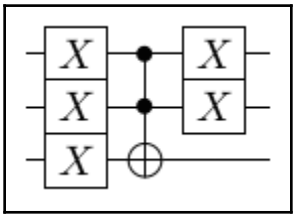
Chapter 9: Quantum AND (Toffoli) Gates and Quantum OR Gates

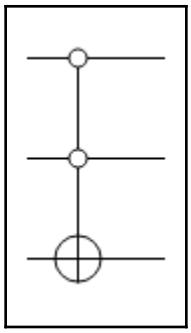


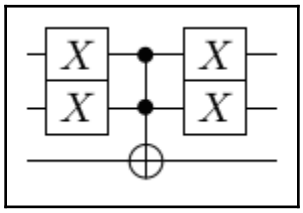


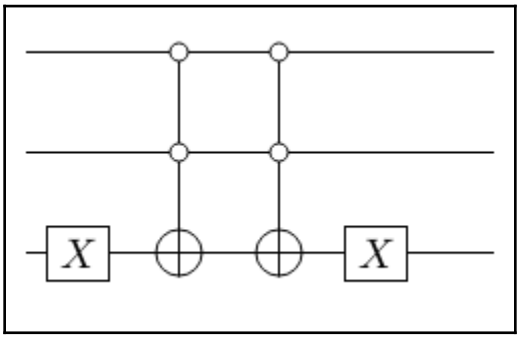


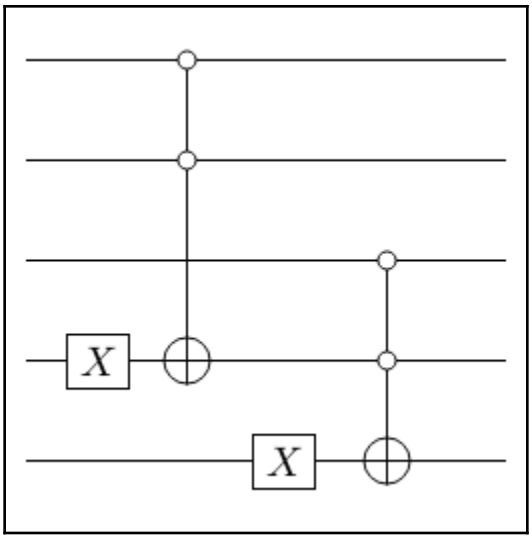


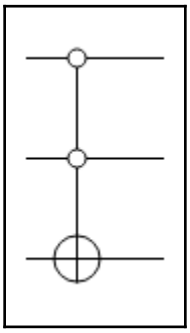


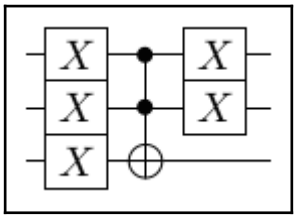


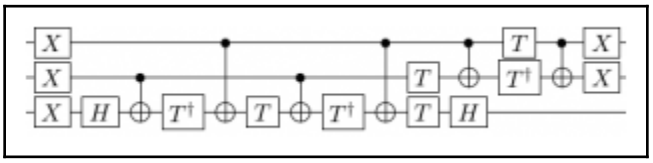

X
X
X
X

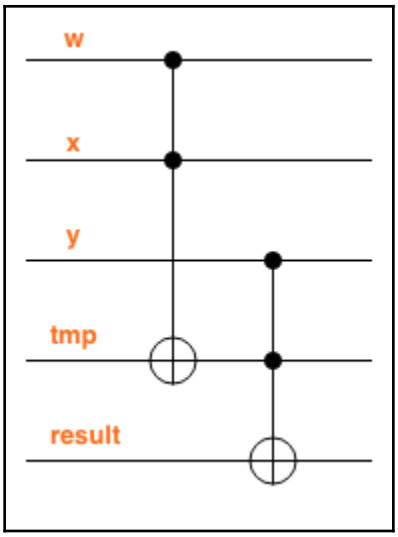

X
X

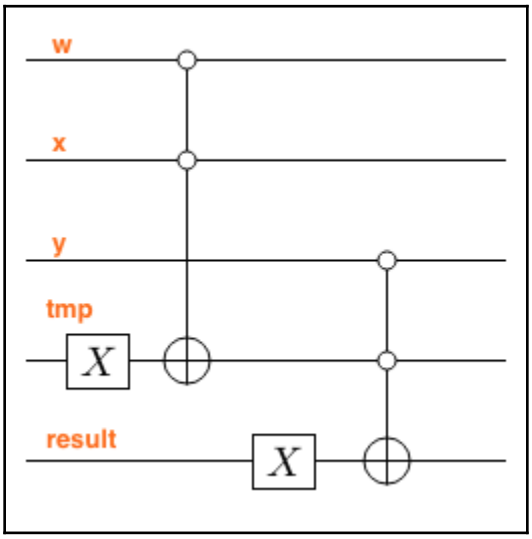

X
X

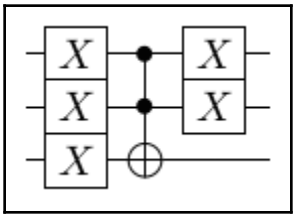


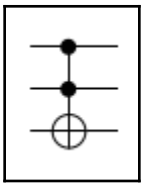

X
X
X
X
X

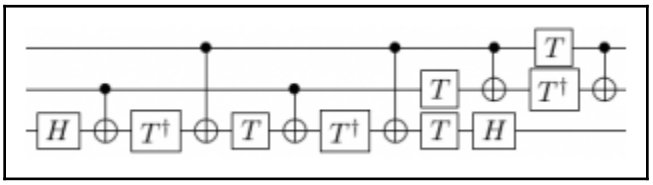

X
X
X
H
T†
T
T†
T
T
H
T
T†
X
X

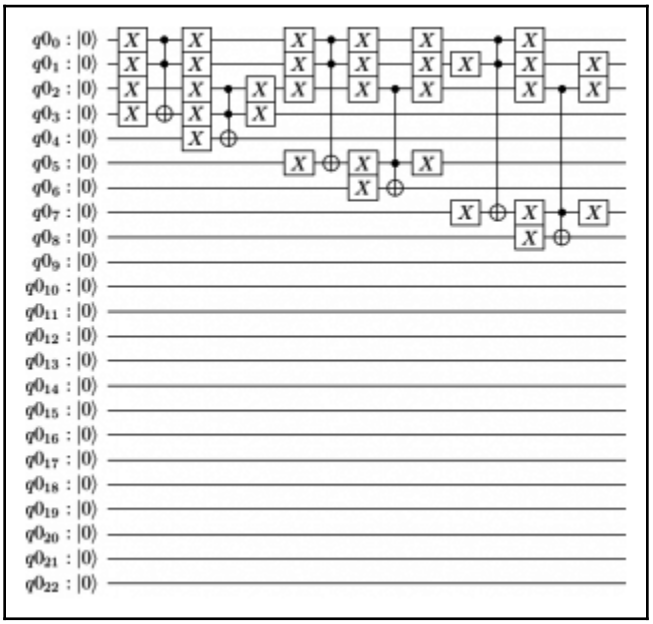

w
x
y
tmp
result

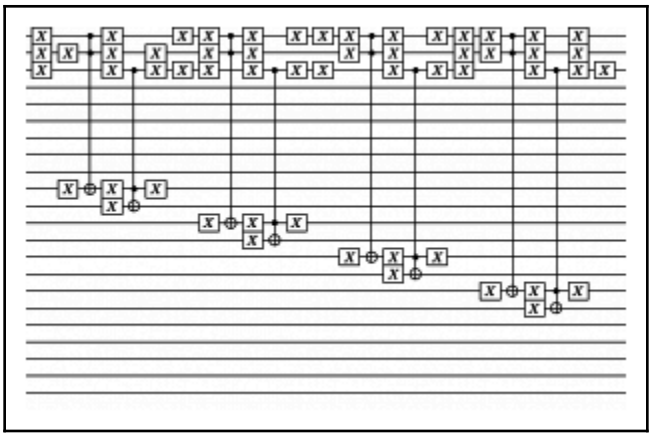

w
x
y
tmp
X
result
X

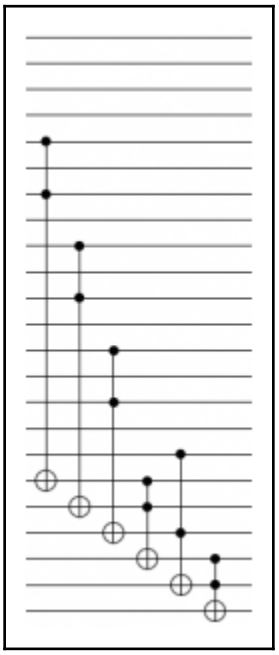

X
X
X
X
X



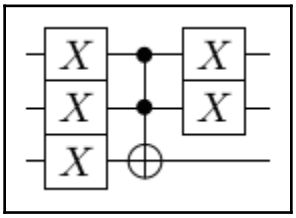

H
T†
T
T†
T
T
H
T
T†

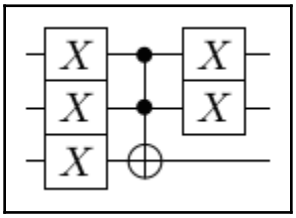

q0₀ : |0⟩
q0₁ : |0⟩
q0₂ : |0⟩
q0₃ : |0⟩
q0₄ : |0⟩
q0₅ : |0⟩
q0₆ : |0⟩
q0₇ : |0⟩
q0₈ : |0⟩
q0₉ : |0⟩
q0₁₀ : |0⟩
q0₁₁ : |0⟩
q0₁₂ : |0⟩
q0₁₃ : |0⟩
q0₁₄ : |0⟩
q0₁₅ : |0⟩
q0₁₆ : |0⟩
q0₁₇ : |0⟩
q0₁₈ : |0⟩
q0₁₉ : |0⟩
q0₂₀ : |0⟩
q0₂₁ : |0⟩
q0₂₂ : |0⟩

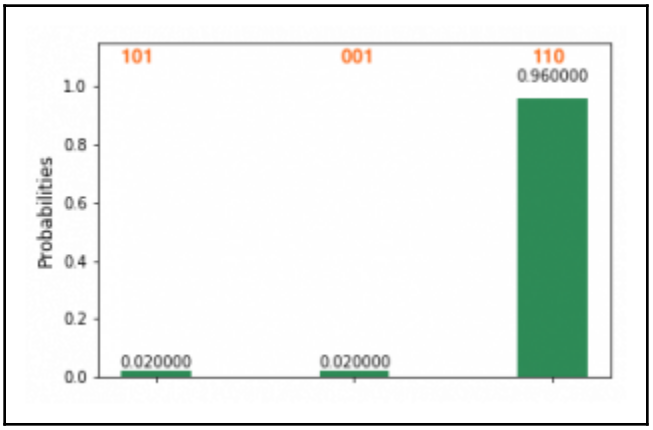




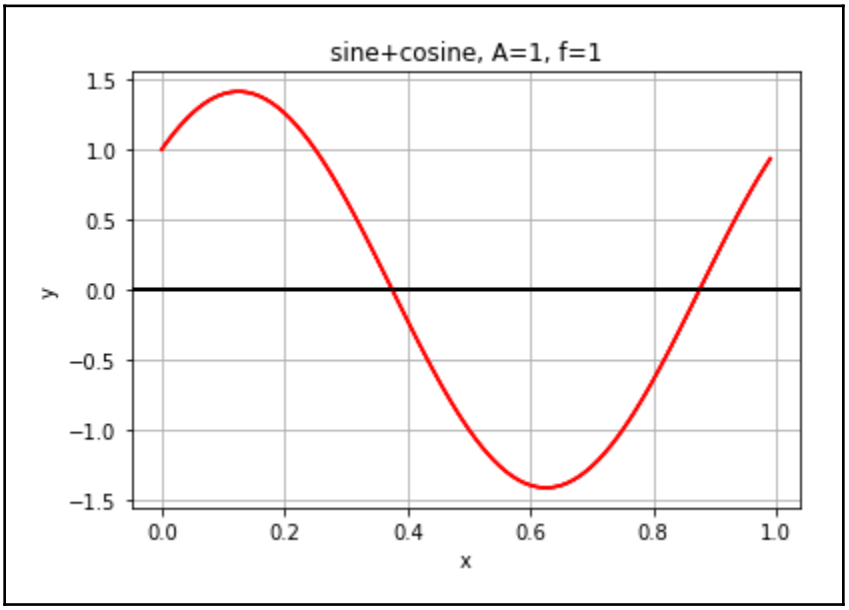
Chapter 10: Grover's Algorithm

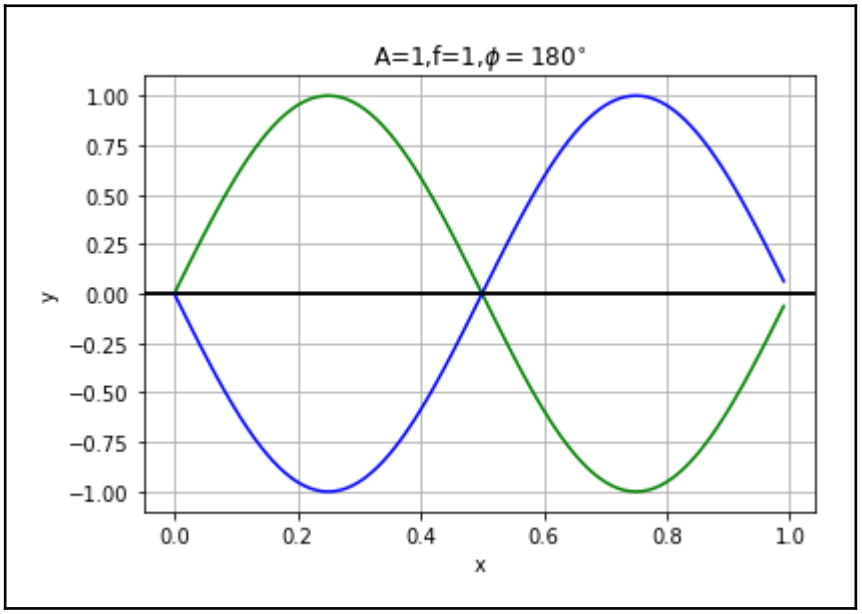


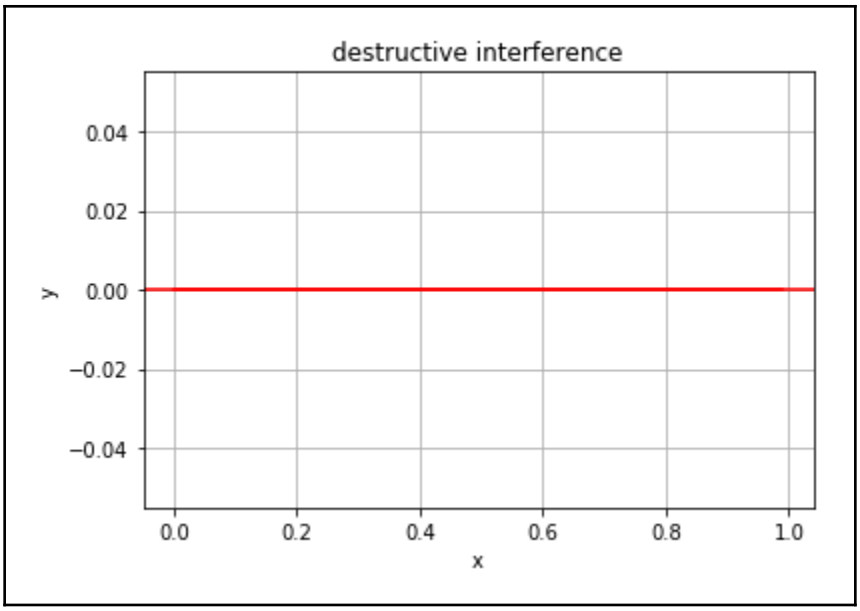


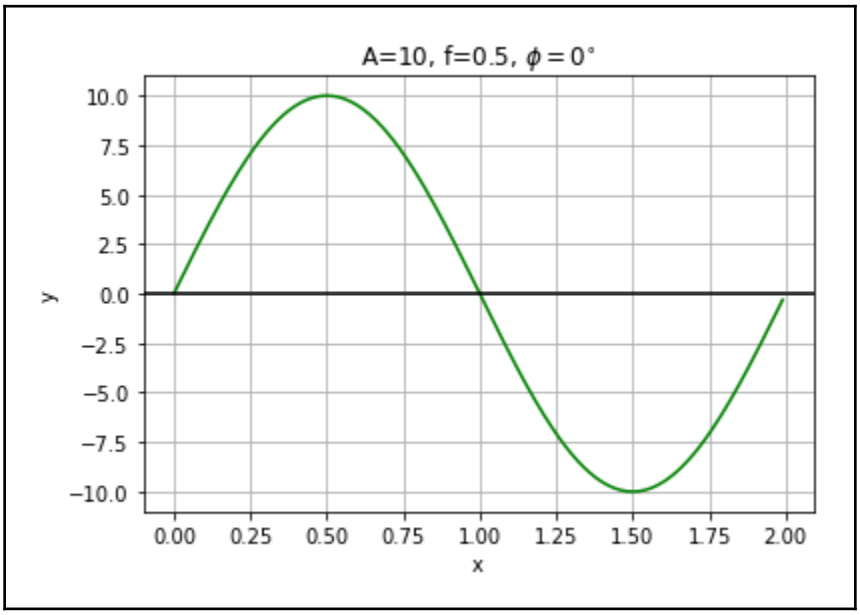


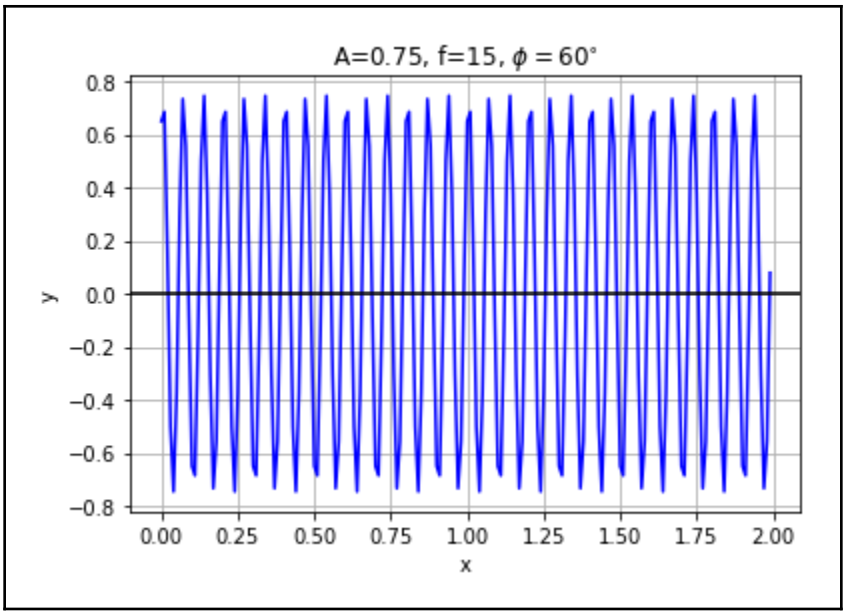
Chapter 11: Quantum Fourier Transform

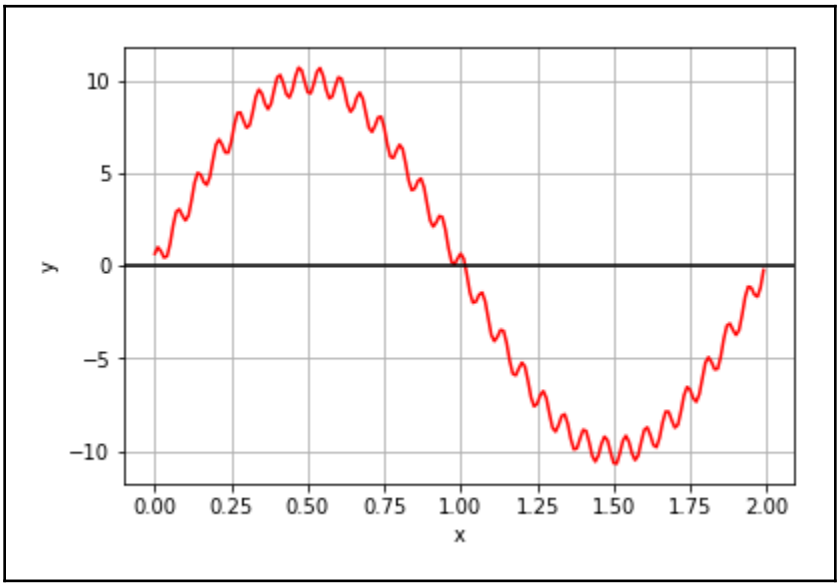


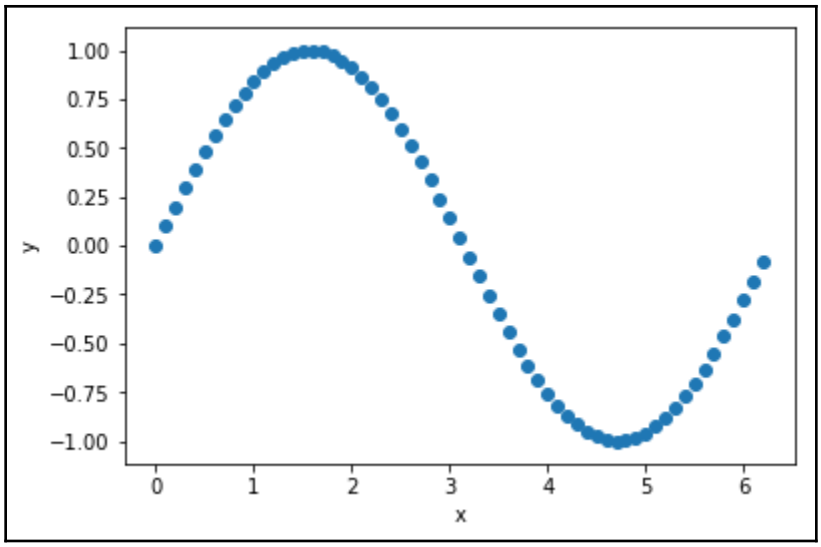


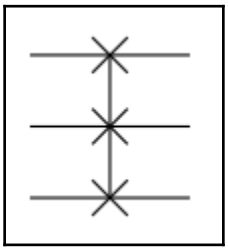

destructive interference
0.04
0.02
0.00
−0.02
−0.04
y
0.0
0.2
0.4
0.6
0.8
1.0
x

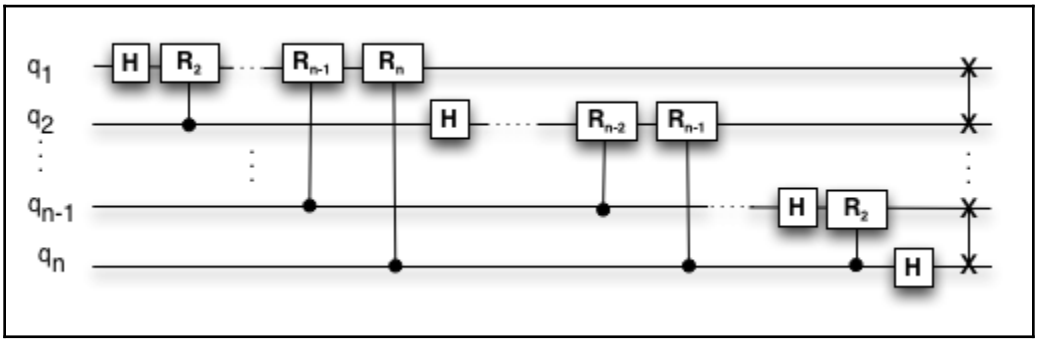

A=10, f=0.5, $\phi = 0°$
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0
y
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
x

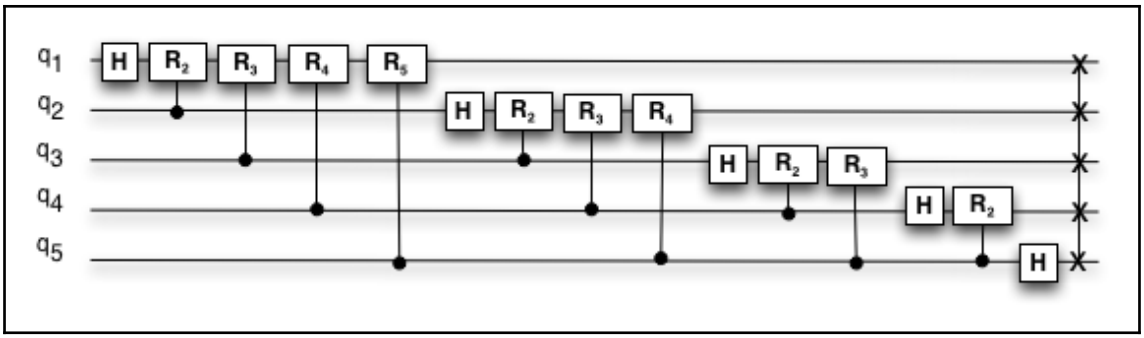

A=0.75, f=15, $\phi = 60^\circ$
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
y
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
x

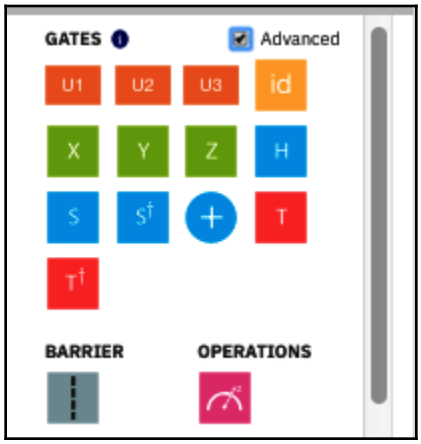

10
5
0
−5
−10
y
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
x

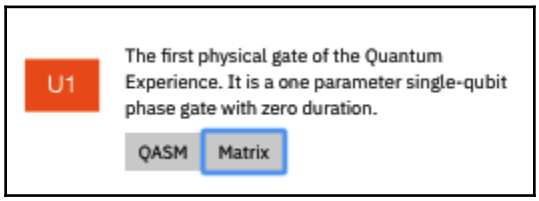

1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
y
0
1
2
3
4
5
6
x

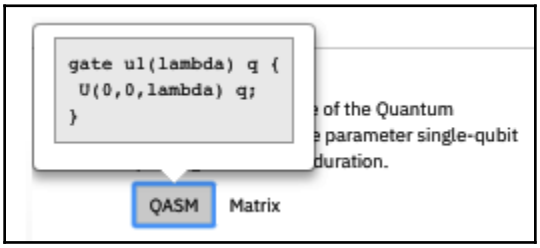


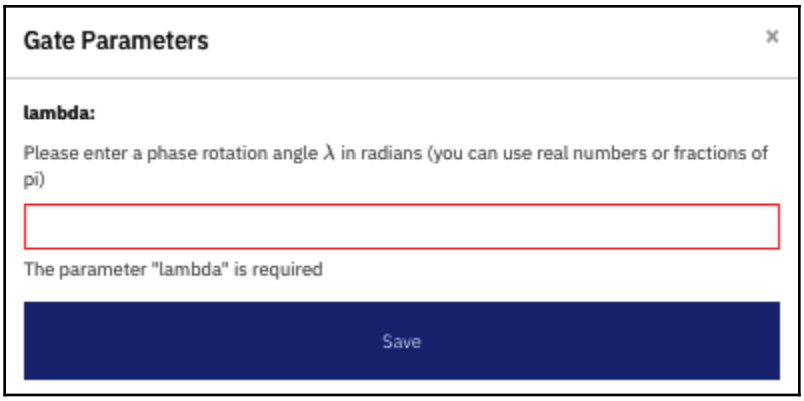

q_1
q_2
q_{n-1}
q_n
H
R_2
R_{n-1}
R_n
H
R_{n-2}
R_{n-1}
H
R_2
H

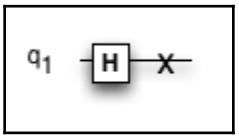

q1
q2
q3
q4
q5
H
R2
R3
R4
R5

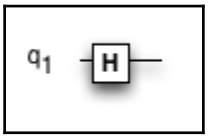

GATES
Advanced
U1
U2
U3
id
X
Y
Z
H
S
S†
T
T†
BARRIER
OPERATIONS

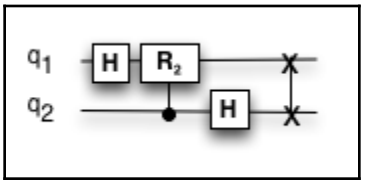

U1
The first physical gate of the Quantum Experience. It is a one parameter single-qubit phase gate with zero duration.
QASM
Matrix

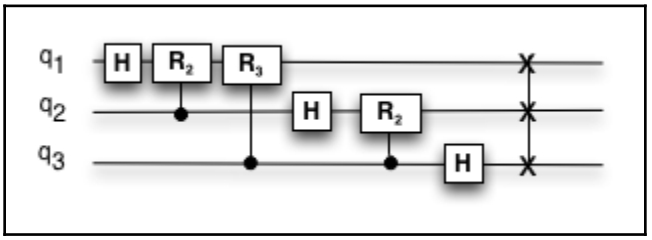

gate u1(lambda) q {
U(0,0,lambda) q;
}
of the Quantum
parameter single-qubit
duration.
QASM
Matrix


Gate Parameters
lambda:
Please enter a phase rotation angle λ in radians (you can use real numbers or fractions of pi)
The parameter "lambda" is required
Save

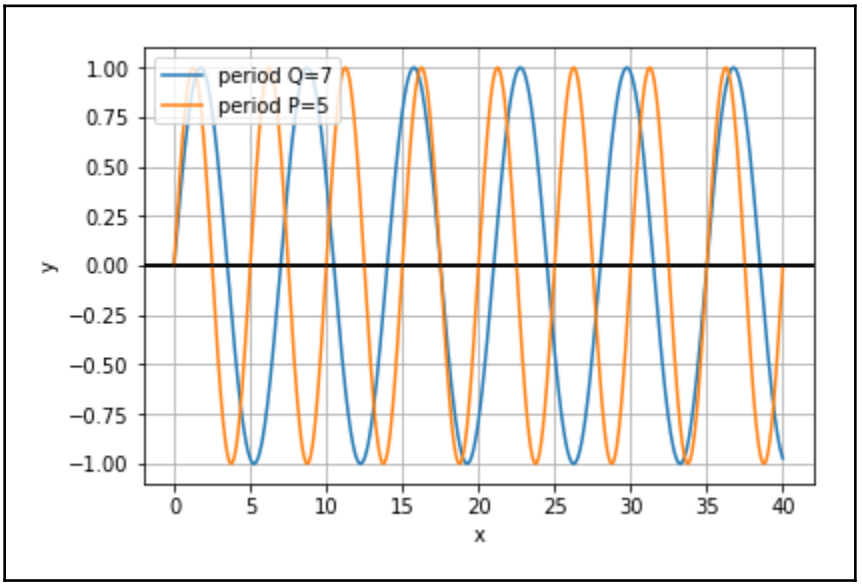

q1
H

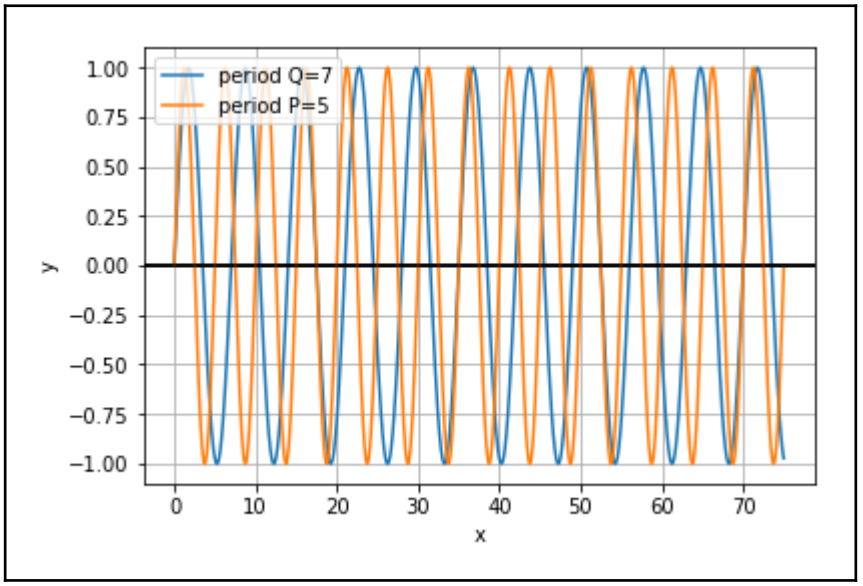

q1
H

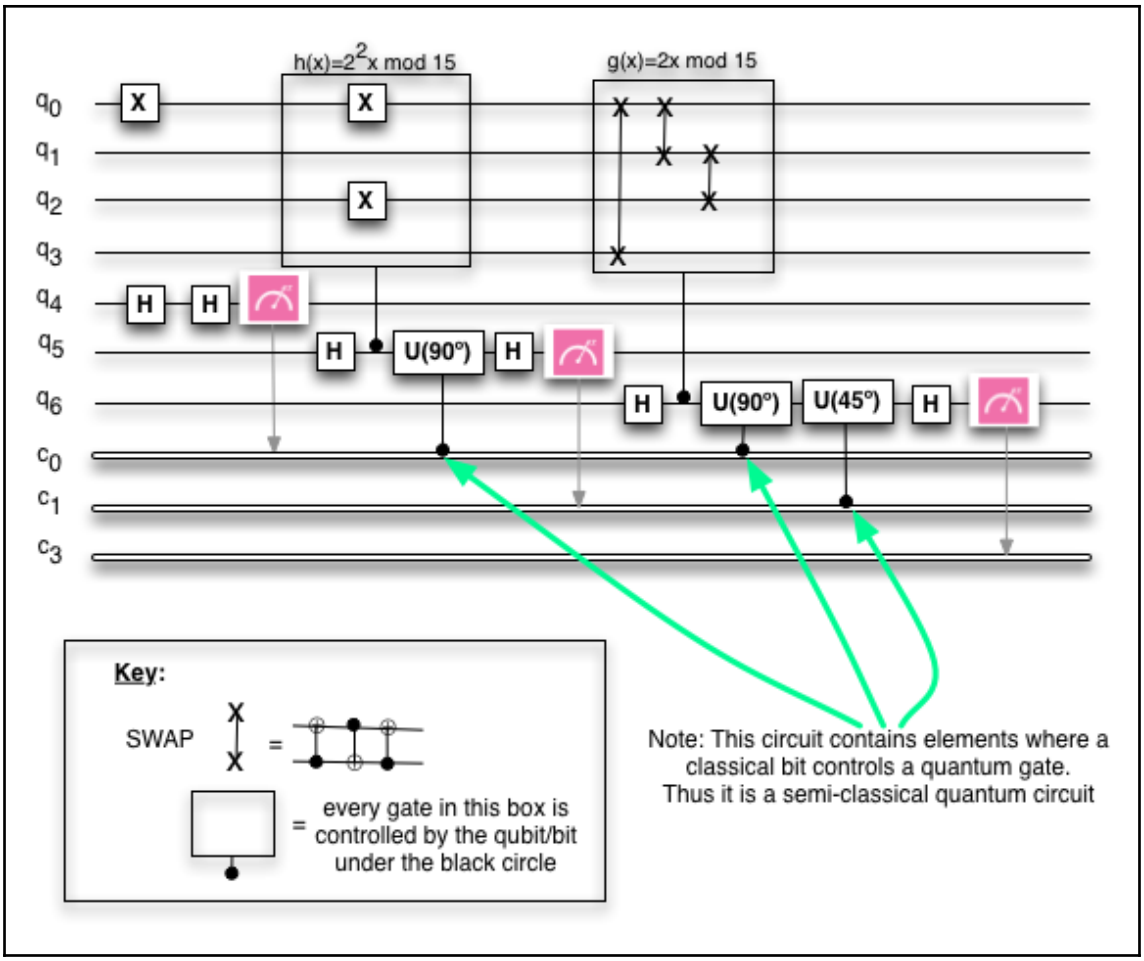

q1
q2
H
R2
H

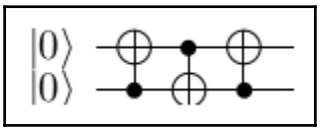

q1
q2
q3
H
R2
R3
H
R2
H

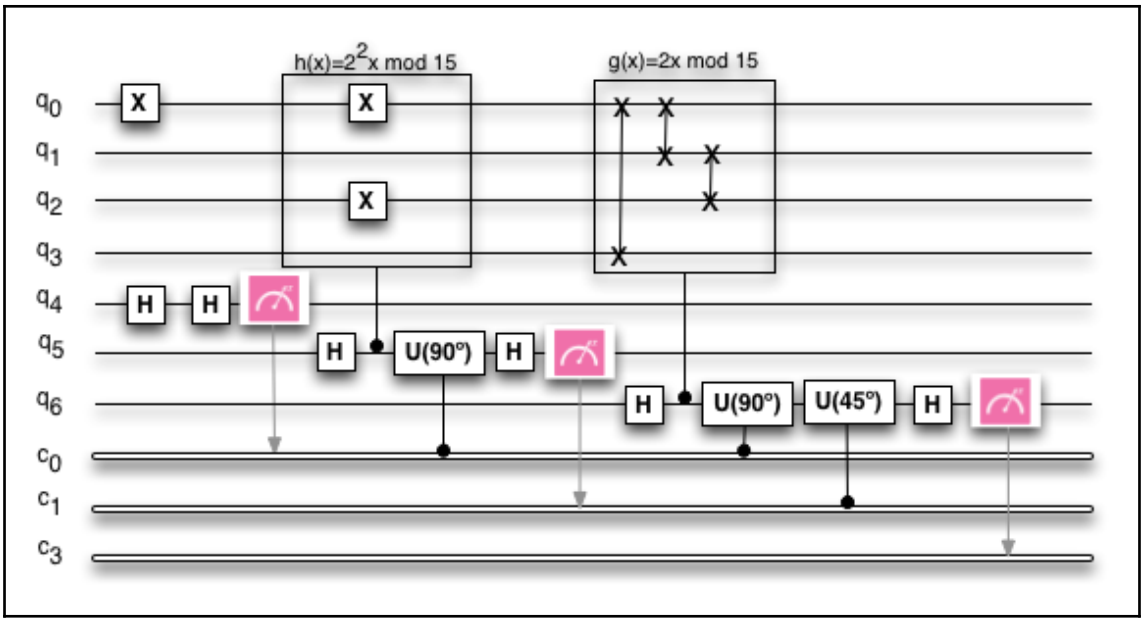
Chapter 12: Shor's Algorithm



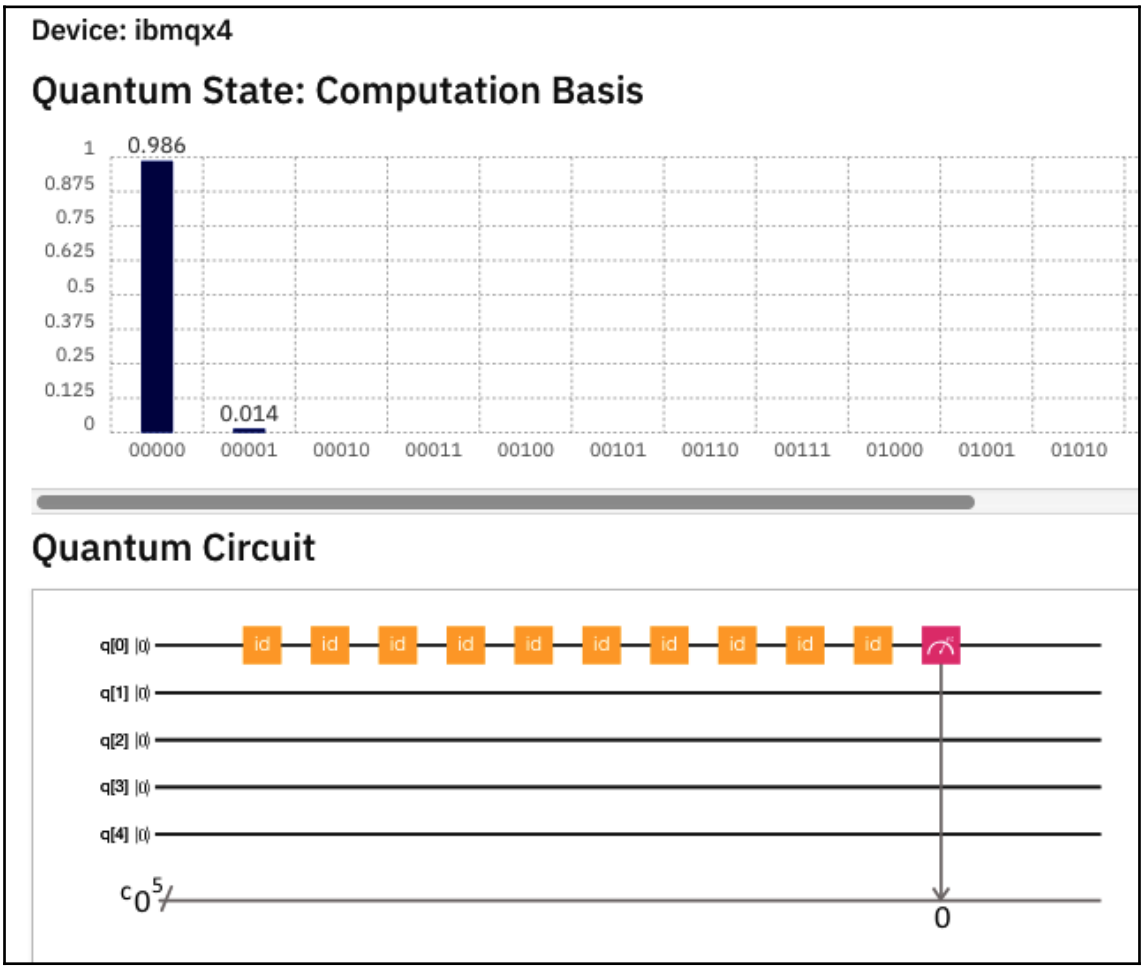



h(x)=2^2x mod 15
g(x)=2x mod 15
q0
q1
q2
q3
q4
q5
q6
c0
c1
c3
X
H
U(90°)
U(45°)
Key:
SWAP
=
every gate in this box is controlled by the qubit/bit under the black circle
Note: This circuit contains elements where a classical bit controls a quantum gate. Thus it is a semi-classical quantum circuit


|0⟩
|0⟩

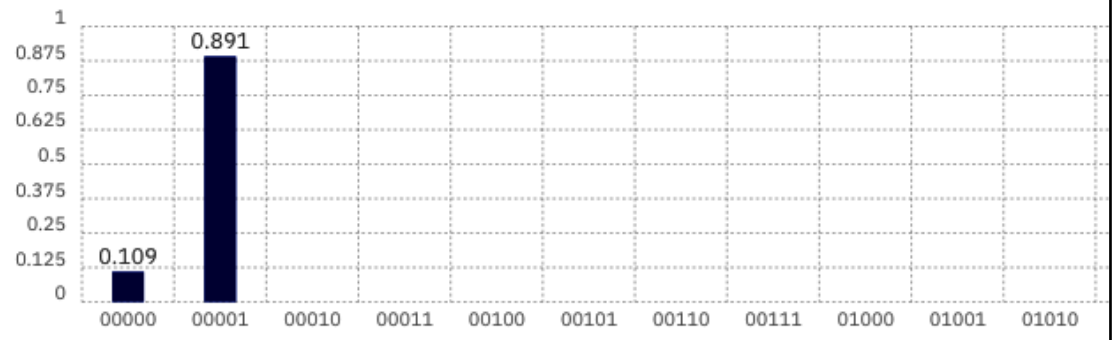

h(x)=2^2x mod 15
g(x)=2x mod 15
q0
q1
q2
q3
q4
q5
q6
c0
c1
c3
X
X
X
H
H
H
U(90°)
H
H
U(90°)
U(45°)
H

Chapter 13: Quantum Error Correction

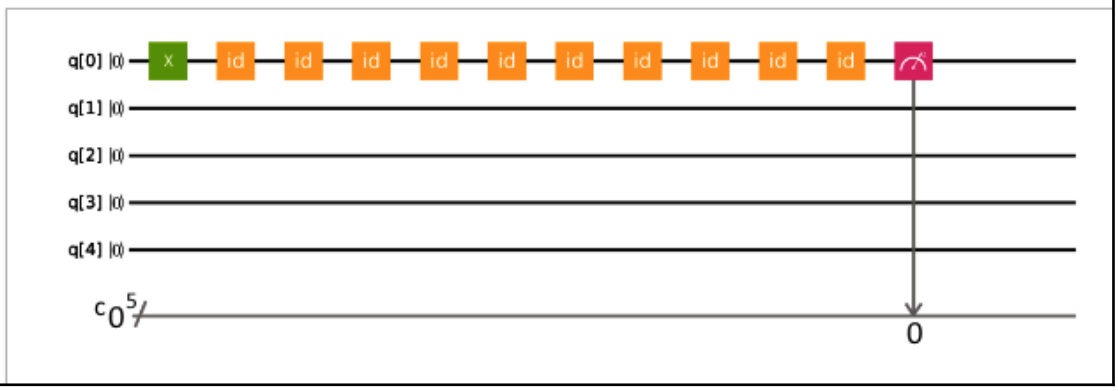


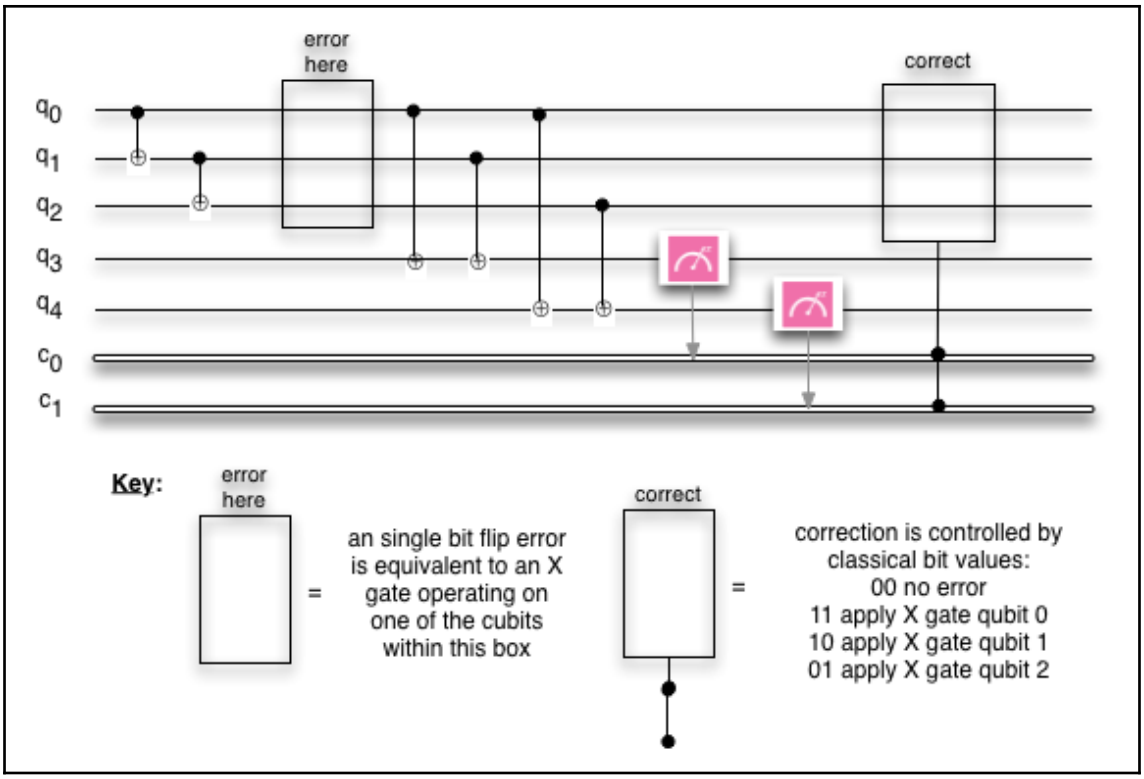
Device: ibmqx4

Quantum State: Computation Basis



Quantum Circuit




error here
correct
q_0
q_1
q_2
q_3
q_4
c_0
c_1
Key:
error here
=
an single bit flip error is equivalent to an X gate operating on one of the cubits within this box
correct
=
correction is controlled by classical bit values:
00 no error
11 apply X gate qubit 0
10 apply X gate qubit 1
01 apply X gate qubit 2

Chapter 14: Conclusion - The Future of Quantum Computing

No images