HalfAdder_qiskit

December 21, 2020

1 Half Adder Quantum Circuit (v1.0)

The following is a quantum implementation of the classical Half Adder circuit. The image below is the classical implementation of a Half Adder with a XOR and AND gate for Sum and Carry respectively.

[7]:
```
from qiskit import *
from qiskit.tools.visualization import plot_bloch_multivector
from qiskit.tools.visualization import plot_histogram
```

1.0.1 Defining the Circuit

[14]:
```
quantReg = QuantumRegister(4)
classReg = ClassicalRegister(2)
circuit = QuantumCircuit(quantReg, classReg)
```

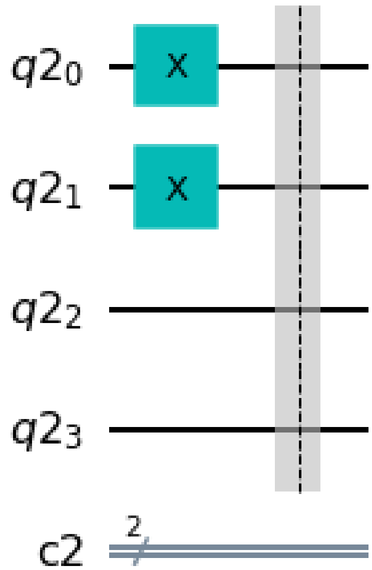
[15]:
```
circuit.x(0) #Comment out this line to make A = 0
circuit.x(1) #Comment out this line to make B = 0
circuit.barrier()
```

[15]:
```
<qiskit.circuit.instructionset.InstructionSet at 0x1c22a935580>
```

The above line allows the user to test out the different varitions for the Half Adder. By default it is set to A = 1 and B = 1. If the user wants to change the gates they will have to run the simulator and the output again.

[16]:
```
%matplotlib inline
circuit.draw(output = 'mpl')
```

[16]:

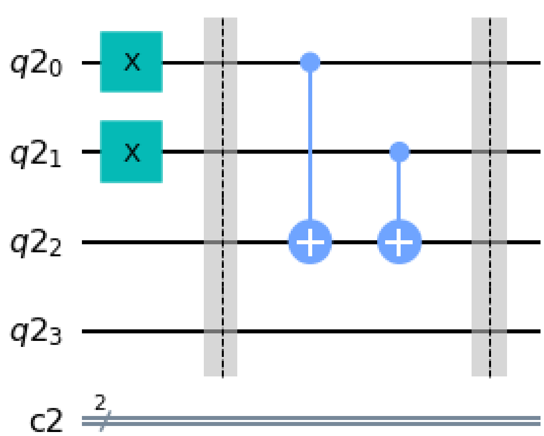


1.0.2 Performing the Sum Operation

In the classical working of the Half Adder, the Sum is calculated by XORing A and B. In a quantum circuit, the Controlled NOT (or CNOT for short) gate performs this operation

[17]:
```
circuit.cx(0,2)
circuit.cx(1,2)
circuit.barrier()
circuit.draw(output = 'mpl')
```

[17]:



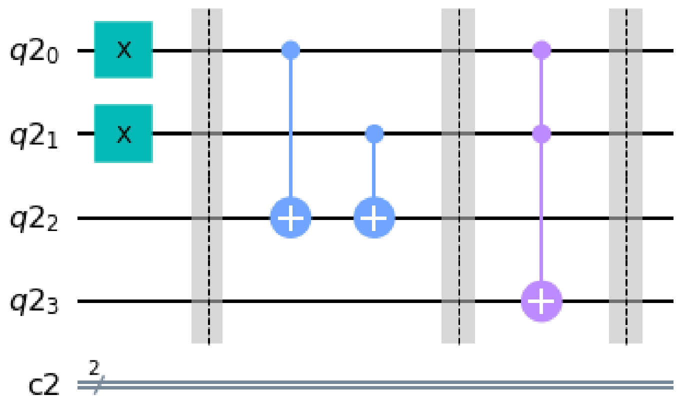
A trivial point to note is that `q_0 CX q_1 ~= q_0 XOR q_1`. The value of the XOR is stored in q_1. However, we don't want the value to be stored in q_1, we want seperate qubit to store it. So q_2 takes `q_1 XOR (q_0 XOR q_2)`. Since the default value of q_2 is 0 therefore q_1 XOR `(q_0 XOR q_2) = q_1 XOR (q_0 XOR 0) = (q_1 XOR q_0) XOR 0`. This does not affect the XOR result since if `(q_1 XOR q_0) = 0 then (q_1 XOR q_0) XOR 0 = 0` and the same applies for the 1 case.

1.0.3 Performing the Carry Operation

In the classical working of the Half Adder, the Carry is calculated by ANDing A and B. In a quantum circuit, the Toffoli CCNOT or CCX for short) gate performs this operation.

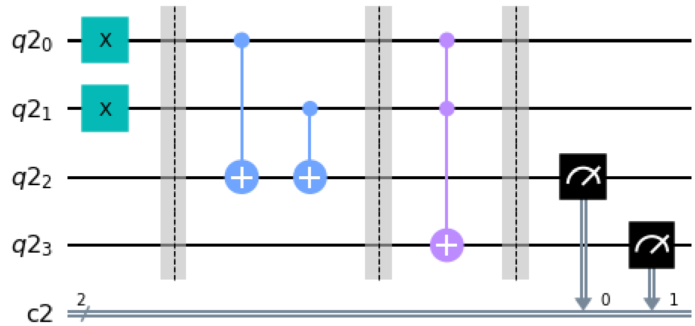
[19]:
```
circuit.ccx(0,1,3)
circuit.barrier()
circuit.draw(output = 'mpl')
```

[19]:



[20]:
```
circuit.measure(2,0)
circuit.measure(3,1)
circuit.draw(output = 'mpl')
```

[20]:



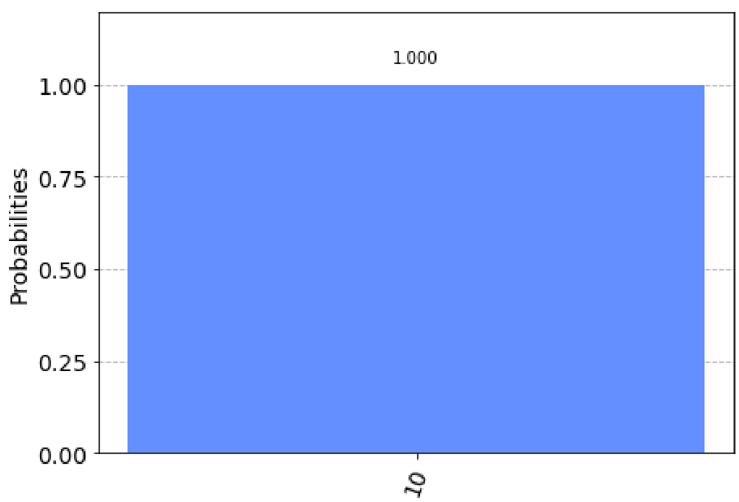
1.1 Results

[21]:
```
nativeSim = Aer.get_backend('qasm_simulator')
nativeResult = execute(circuit, backend = nativeSim).result()
counts = nativeResult.get_counts()
```

1.1.1 Histogram Visualization

[22]:
```
plot_histogram(counts)
```

[22]:

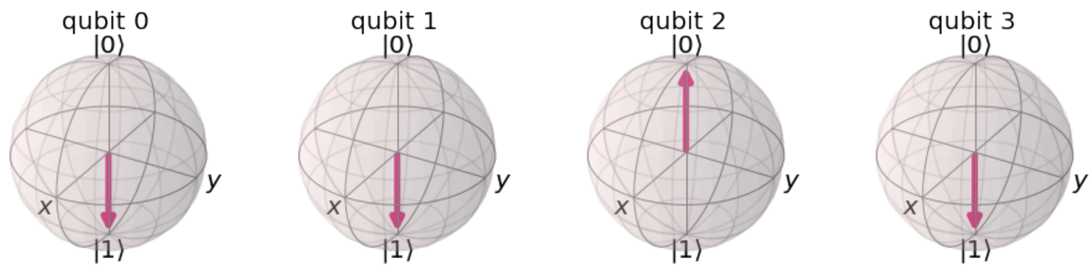


Since q_0 and q_1 are both 1 therefore 1 + 1 = 10 (S = 0 and C = 1). We got the correct result. Yayy!

1.1.2 Bloch Sphere Visualization

[26]:
```
nativeSVSim = Aer.get_backend('statevector_simulator')
nativeSVResult = execute(circuit, backend = nativeSVSim).result()
stateVector = nativeSVResult.get_statevector()
plot_bloch_multivector(stateVector)
```

[26]:



Quibits 2 and 3 are the Sum and the Carry respectively. Once again, the correct result but just in a different visual format.