BB84 Depolarization

October 24, 2021

[1]:

```
import numpy as np

# Importing standard Qiskit libraries
from qiskit import QuantumCircuit, transpile, Aer, IBMQ
from qiskit.tools.jupyter import *
from qiskit.visualization import *
from ibm_quantum_widgets import *
from qiskit.providers.aer import QasmSimulator

# Loading your IBM Quantum account(s)
provider = IBMQ.load_account()
```

[9]:

```
from qiskit import QuantumCircuit, execute, Aer
from qiskit.visualization import plot_histogram
import qiskit.providers.aer.noise as noise
# Error probabilities
res = []
r1=0.00
r2=0.5
while(r1 < r2 ):
    res.append(r1)
    r1 += 0.05
print(res)

for i in range(len(res)):
    prob_1 = prob_2 = float(res[i])
    print(prob_1)
    # Depolarizing quantum errors
    error_1 = noise.depolarizing_error(prob_1, 1)
    error_2 = noise.depolarizing_error(prob_2, 2)
    # Add errors to noise model
    noise_model = noise.NoiseModel()
    noise_model.add_all_qubit_quantum_error(error_1, ['u1', 'u2', 'u3'])
    noise_model.add_all_qubit_quantum_error(error_2, ['cx'])
    print(noise_model)
    # Get basis gates from noise model
    basis_gates = noise_model.basis_gates
```

```
from qiskit.tools.monitor import backend_monitor
from qiskit import *
from qiskit.visualization import plot_histogram
from random import randrange, seed, sample
from sys import argv, exit
import random
#data = int(input('ENTER LENGTH OF BIT STREAM (example 5 For 10110):'))
data=1
##########################################################################
print('|00>')
h=0
#h=int(input())
def bit_stream(p):
    key1 = ""
    for i in range(p):
        temp = str(random.randint(h,h))
        key1 += temp
    return(key1)

bitstream= bit_stream(data)
digits = [int(x) for x in str(bitstream)]
##########################################################################
#print('List of Bit Stream to transfer over Quantum Channel')
#print(digits)
print('\n')
#n = len(digits)
n=1
##########################################################################
bob_bits=[]
from random import choice
#m=0
for i in range(n):
    #m=m+10
    #print("No of identity Gate:",m)
    if digits[i] == 0:
        q = QuantumRegister(1, 'q')
        c = ClassicalRegister(1, 'c')
        qc = QuantumCircuit(q, c)
        qc.barrier()
        qc.h(0)
        qc.barrier()
        for j in range(10):
            qc.id(0)
            qc.barrier()
        qc.h(0)
        qc.barrier()
```

```
            qc.measure(q[0], c[0])
            #print(qc)
            # Perform a noise simulation
            result = execute(qc, Aer.
 ↪get_backend('qasm_simulator'),basis_gates=basis_gates,noise_model=noise_model,shots=1000).
 ↪result()
            counts = result.get_counts(qc)
            plot_histogram(counts)
            #print(qc)
            bits = (result.get_counts(qc))
            print(bits)
            #print(bits)
            #itemMaxValue = max(bits.items(), key=lambda x : x[1])
            #print(itemMaxValue)
            #print(bits.get('0'))
            #print('\n')
            #print("===========================================================")
```

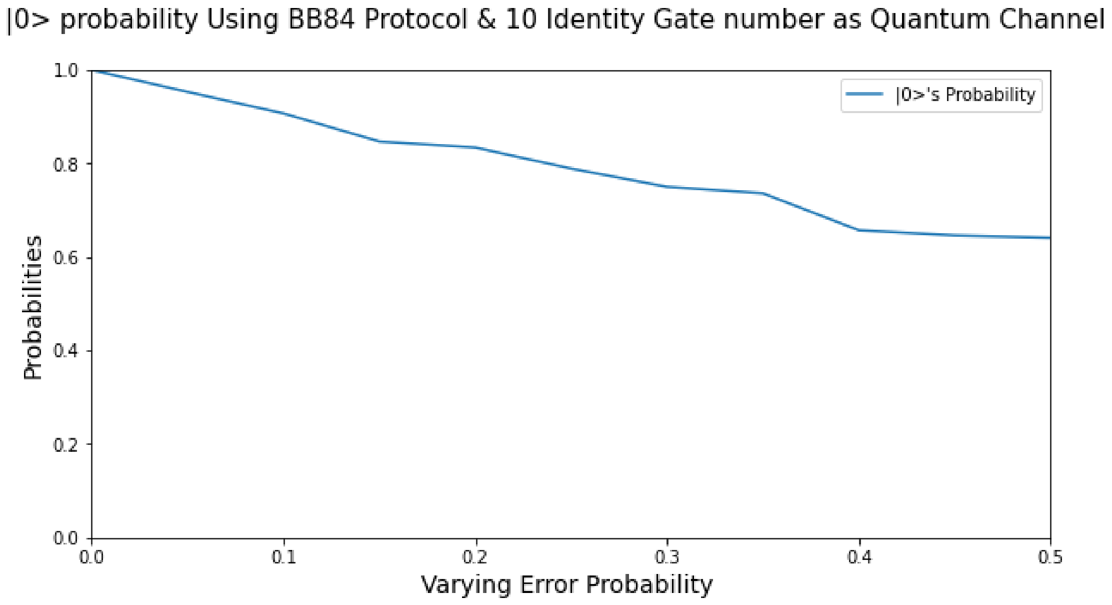
```
[0.0, 0.05, 0.1, 0.15000000000000002, 0.2, 0.25, 0.3, 0.35, 0.39999999999999997,
0.44999999999999996, 0.49999999999999994]
0.0
NoiseModel: Ideal
|00>


{'0': 1000}
0.05
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 47, '0': 953}
0.1
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 93, '0': 907}
0.15000000000000002
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 153, '0': 847}
0.2
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 166, '0': 834}
0.25
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 211, '0': 789}
0.3
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 250, '0': 750}
0.35
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 264, '0': 736}
0.39999999999999997
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>
```

```
{'1': 343, '0': 657}
0.44999999999999996
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 354, '0': 646}
0.49999999999999994
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['u2', 'u3', 'u1', 'cx']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'0': 641, '1': 359}
```

[5]:

```
import matplotlib.pyplot as plt
from matplotlib.ticker import (AutoMinorLocator, MultipleLocator)
fig, ax = plt.subplots(figsize=(10, 5))
fig.suptitle('|0> probability Using BB84 Protocol & 10 Identity Gate number as␣
 ↪Quantum Channel',fontsize=15)
# naming the x axis
plt.xlabel('Varying Error Probability ',fontsize=14)
# naming the y axis
plt.ylabel('Probabilities',fontsize=14)
# giving a title to my graph
# Set axis ranges; by default this will put major ticks every 25.
#ax.set_xlim(0, 300)
#ax.set_ylim(0, 1)
ax.set_xlim(0.0, 0.5)
ax.set_ylim(0., 1)
fig = plt.figure(figsize=(8,5))
# line 2 points
y2 = [1.000,0.953,0.907,0.847,0.834,0.789,0.750,0.736,0.657,0.646,0.641]
x2 = [0.0, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5]
# plotting the line 2 points
ax.plot(x2, y2, label = "|0>'s Probability")
#ax.axes.xaxis.set_ticks([])
# show a legend on the plot
ax.legend()
```

```
[5]: <matplotlib.legend.Legend at 0x7fbae447b0a0>
```



```
<Figure size 576x360 with 0 Axes>
```

```
[ ]:
```

```
[4]: from qiskit import QuantumCircuit, execute, Aer
from qiskit.visualization import plot_histogram
import qiskit.providers.aer.noise as noise
# Error probabilities
res = []
r1=0.00
r2=0.5
while(r1 < r2 ):
    res.append(r1)
    r1 += 0.05
print(res)

for i in range(len(res)):
    prob_1 = prob_2 = float(res[i])
    print(prob_1)
    # Depolarizing quantum errors
    error_1 = noise.depolarizing_error(prob_1, 1)
    error_2 = noise.depolarizing_error(prob_2, 2)
    # Add errors to noise model
    noise_model = noise.NoiseModel()
```

```
noise_model.add_all_qubit_quantum_error(error_1, ['u1', 'u2', 'u3'])
noise_model.add_all_qubit_quantum_error(error_2, ['cx'])
print(noise_model)
# Get basis gates from noise model
basis_gates = noise_model.basis_gates

from qiskit.tools.monitor import backend_monitor
from qiskit import *
from qiskit.visualization import plot_histogram
from random import randrange, seed, sample
from sys import argv, exit
import random
#data = int(input('ENTER LENGTH OF BIT STREAM (example 5 For 10110):'))
data=1
##########################################################################
print('|00>')
h=0
#h=int(input())
def bit_stream(p):
    key1 = ""
    for i in range(p):
        temp = str(random.randint(h,h))
        key1 += temp
    return(key1)

bitstream= bit_stream(data)
digits = [int(x) for x in str(bitstream)]
##########################################################################
#print('List of Bit Stream to transfer over Quantum Channel')
#print(digits)
print('\n')
#n = len(digits)
n=1
##########################################################################
bob_bits=[]
from random import choice
#m=0
for i in range(n):
    #m=m+10
    #print("No of identity Gate:",m)
    if digits[i] == 0:
        q = QuantumRegister(1, 'q')
        c = ClassicalRegister(1, 'c')
        qc = QuantumCircuit(q, c)
        qc.barrier()
        qc.h(0)
        qc.barrier()
```

```
            for j in range(10):
                qc.id(0)
                qc.barrier()
            qc.h(0)
            qc.barrier()
            qc.measure(q[0], c[0])
            #print(qc)
            # Perform a noise simulation
            result = execute(qc, Aer.
↪get_backend('qasm_simulator'),basis_gates=basis_gates,noise_model=noise_model,shots=1000).
↪result()
            counts = result.get_counts(qc)
            plot_histogram(counts)
            #print(qc)
            bits = (result.get_counts(qc))
            print(bits)
            #print(bits)
            #itemMaxValue = max(bits.items(), key=lambda x : x[1])
            #print(itemMaxValue)
            #print(bits.get('0'))
            #print('\n')
            #print("============================================================")
```

```
[0.0, 0.05, 0.1, 0.15000000000000002, 0.2, 0.25, 0.3, 0.35, 0.39999999999999997,
0.44999999999999996, 0.49999999999999994]
0.0
NoiseModel: Ideal
|00>


{'0': 1000}
0.05
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 45, '0': 955}
0.1
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>
```

```
{'1': 81, '0': 919}
0.15000000000000002
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 132, '0': 868}
0.2
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 182, '0': 818}
0.25
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'0': 787, '1': 213}
0.3
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'0': 750, '1': 250}
0.35
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 279, '0': 721}
0.39999999999999997
```

```
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'0': 674, '1': 326}
0.44999999999999996
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'1': 363, '0': 637}
0.49999999999999994
NoiseModel:
  Basis gates: ['cx', 'id', 'rz', 'sx', 'u1', 'u2', 'u3']
  Instructions with noise: ['cx', 'u3', 'u2', 'u1']
  All-qubits errors: ['u1', 'u2', 'u3', 'cx']
|00>


{'0': 612, '1': 388}
```

```
[ ]:
```