Depolarization BB84

October 26, 2021

[2]:
```
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()
```

[3]:
```
from qiskit.providers.aer.noise import NoiseModel
from qiskit.providers.aer.noise.errors import pauli_error, depolarizing_error
from qiskit import *
from qiskit.visualization import plot_histogram
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline
```

[4]:
```
def get_noise_dep(p_m, p_g):
    error_m = pauli_error([('X',p_m),('I',1-p_m)])
    error_g1 = depolarizing_error(p_g,1)
    error_g2 = error_g1.tensor(error_g1)

    noise_model = NoiseModel()

    # measurement error is applied to measurements
    noise_model.add_all_qubit_quantum_error(error_m, "measure")
    # single qubit gate error is applied to x gates
    noise_model.add_all_qubit_quantum_error(error_g1, ["h","x","id"])
    # two qubit gate error is applied to cx gates
    noise_model.add_all_qubit_quantum_error(error_g2, ["cx"])
    return noise_model
```

[48]:
```
    bob_bits=[]
    from qiskit.tools.monitor import backend_monitor
```

```python
import matplotlib.pyplot as plt
from qiskit.tools.visualization import circuit_drawer
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=50
###########################################################################
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(digits)
###########################################################################
#print('List of Bit Stream to transfer over Quantum Channel')
#print(digits)
print('\n')
#n = len(digits)

###########################################################################
bob_bits=[]
from random import choice
m=0
n=50
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(m):
            qc.id(0)
            qc.barrier()
        qc.h(0)
```

```
            qc.barrier()
            qc.measure(q[0], c[0])
            #print(qc)
            # Perform a noise simulation
            counts = execute(qc,Aer.
↪get_backend('qasm_simulator'),noise_model=get_noise_dep(0.036,0.
↪00036),shots=1000).result().get_counts()
            #counts = result.get_counts(qc)
            %matplotlib inline
            #print(qc)
            #qc.draw(output='mpl')
            #plt.show()
            #print(counts)
            #plot_histogram(counts)

            itemMaxValue = max(counts.items(), key=lambda x : x[1])
            print(itemMaxValue)
            # Iterate over all the items in dictionary to find keys with max␣
↪value
            for key, value in counts.items():
                if value == itemMaxValue[1]:
                    bob_bits.append(value)

    print(bob_bits)
```

```
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
```

```
No of identity Gate: 10
('0', 978)
No of identity Gate: 20
('0', 977)
No of identity Gate: 30
('0', 964)
No of identity Gate: 40
('0', 961)
No of identity Gate: 50
('0', 966)
No of identity Gate: 60
('0', 958)
No of identity Gate: 70
('0', 956)
No of identity Gate: 80
('0', 979)
No of identity Gate: 90
('0', 966)
```

```
No of identity Gate: 100
('0', 970)
No of identity Gate: 110
('0', 959)
No of identity Gate: 120
('0', 967)
No of identity Gate: 130
('0', 968)
No of identity Gate: 140
('0', 964)
No of identity Gate: 150
('0', 964)
No of identity Gate: 160
('0', 976)
No of identity Gate: 170
('0', 955)
No of identity Gate: 180
('0', 954)
No of identity Gate: 190
('0', 967)
No of identity Gate: 200
('0', 974)
No of identity Gate: 210
('0', 964)
No of identity Gate: 220
('0', 963)
No of identity Gate: 230
('0', 959)
No of identity Gate: 240
('0', 968)
No of identity Gate: 250
('0', 964)
No of identity Gate: 260
('0', 976)
No of identity Gate: 270
('0', 962)
No of identity Gate: 280
('0', 962)
No of identity Gate: 290
('0', 970)
No of identity Gate: 300
('0', 959)
No of identity Gate: 310
('0', 960)
No of identity Gate: 320
('0', 965)
No of identity Gate: 330
('0', 958)
```

```
No of identity Gate: 340
('0', 965)
No of identity Gate: 350
('0', 966)
No of identity Gate: 360
('0', 966)
No of identity Gate: 370
('0', 953)
No of identity Gate: 380
('0', 951)
No of identity Gate: 390
('0', 962)
No of identity Gate: 400
('0', 963)
No of identity Gate: 410
('0', 970)
No of identity Gate: 420
('0', 956)
No of identity Gate: 430
('0', 962)
No of identity Gate: 440
('0', 962)
No of identity Gate: 450
('0', 973)
No of identity Gate: 460
('0', 970)
No of identity Gate: 470
('0', 958)
No of identity Gate: 480
('0', 963)
No of identity Gate: 490
('0', 954)
No of identity Gate: 500
('0', 970)
[978, 977, 964, 961, 966, 958, 956, 979, 966, 970, 959, 967, 968, 964, 964, 976,
955, 954, 967, 974, 964, 963, 959, 968, 964, 976, 962, 962, 970, 959, 960, 965,
958, 965, 966, 966, 953, 951, 962, 963, 970, 956, 962, 962, 973, 970, 958, 963,
954, 970]
```

0.1 20 time Average

[ ]:

```
x =[10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170,␣
 ↪180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310, 320,␣
 ↪330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470,␣
 ↪480, 490, 500]
```

```
y1=[969, 965, 960, 957, 967, 977, 964, 957, 953, 967, 960, 959, 966, 978, 967,␣
 ↪973, 969, 958, 961, 974, 950, 965, 959, 962, 964, 960, 971, 960, 973, 953,␣
 ↪956, 968, 963, 972, 965, 961, 960, 958, 960, 960, 958, 965, 968, 962, 964,␣
 ↪965, 973, 954, 958, 963]
y2=[959, 962, 964, 962, 950, 961, 966, 961, 963, 962, 956, 963, 965, 959, 967,␣
 ↪968, 968, 970, 963, 964, 971, 964, 959, 973, 958, 964, 963, 947, 951, 964,␣
 ↪956, 952, 963, 961, 964, 959, 962, 966, 973, 966, 968, 975, 962, 964, 958,␣
 ↪960, 970, 950, 958, 959]
y3=[965, 960, 963, 960, 960, 976, 966, 966, 969, 960, 974, 967, 966, 972, 962,␣
 ↪960, 972, 963, 965, 955, 967, 966, 962, 968, 961, 966, 972, 945, 958, 967,␣
 ↪959, 959, 965, 964, 965, 970, 971, 965, 959, 963, 959, 962, 963, 968, 958,␣
 ↪959, 966, 968, 963, 962]
y4=[963, 967, 971, 955, 966, 966, 968, 970, 960, 955, 958, 967, 952, 955, 964,␣
 ↪959, 958, 971, 961, 964, 965, 973, 956, 954, 965, 958, 969, 970, 971, 960,␣
 ↪974, 960, 963, 971, 962, 960, 953, 968, 959, 960, 965, 953, 962, 961, 961,␣
 ↪961, 969, 957, 954, 959]
y5=[969, 968, 959, 962, 965, 967, 964, 968, 966, 971, 964, 964, 966, 957, 958,␣
 ↪959, 967, 953, 958, 969, 962, 965, 971, 962, 962, 958, 960, 957, 968, 958,␣
 ↪969, 961, 971, 969, 973, 971, 965, 953, 972, 956, 955, 972, 975, 959, 958,␣
 ↪973, 959, 957, 963, 968]
y6=[970, 965, 969, 965, 963, 967, 972, 964, 966, 961, 965, 968, 961, 974, 959,␣
 ↪954, 964, 966, 957, 963, 971, 972, 952, 962, 971, 964, 964, 967, 972, 957,␣
 ↪964, 965, 969, 957, 972, 964, 970, 957, 969, 973, 970, 948, 964, 967, 959,␣
 ↪965, 961, 974, 966, 972]
y7=[967, 971, 967, 974, 962, 957, 961, 970, 962, 951, 964, 966, 973, 966, 958,␣
 ↪967, 962, 961, 962, 970, 963, 964, 966, 958, 963, 970, 959, 967, 958, 968,␣
 ↪966, 972, 965, 969, 963, 976, 952, 967, 969, 965, 968, 975, 959, 968, 962,␣
 ↪952, 962, 963, 962, 960]
y8=[963, 967, 959, 961, 969, 968, 966, 963, 962, 974, 963, 970, 968, 960, 965,␣
 ↪961, 964, 961, 955, 967, 959, 967, 966, 970, 960, 958, 963, 953, 958, 964,␣
 ↪972, 961, 967, 963, 963, 964, 973, 971, 952, 960, 959, 965, 952, 960, 963,␣
 ↪959, 962, 964, 966, 961]
y9=[967, 959, 959, 956, 961, 961, 971, 965, 955, 962, 970, 962, 965, 962, 963,␣
 ↪959, 955, 956, 964, 964, 963, 959, 964, 962, 966, 970, 966, 962, 963, 967,␣
 ↪968, 954, 966, 966, 962, 956, 966, 957, 955, 986, 955, 959, 961, 961, 968,␣
 ↪952, 962, 962, 962, 974]
y10=[960, 968, 957, 969, 969, 970, 964, 963, 960, 956, 952, 974, 962, 959, 967,␣
 ↪958, 960, 966, 961, 964, 974, 971, 966, 961, 962, 964, 951, 959, 968, 956,␣
 ↪974, 964, 971, 964, 972, 963, 965, 959, 967, 941, 960, 969, 965, 964, 963,␣
 ↪972, 971, 962, 965, 965]
y11=[972, 952, 963, 967, 959, 957, 963, 966, 967, 964, 968, 962, 960, 962, 955,␣
 ↪973, 965, 959, 969, 961, 969, 972, 963, 959, 962, 969, 970, 975, 967, 960,␣
 ↪967, 958, 956, 962, 962, 967, 970, 965, 957, 966, 972, 962, 958, 962, 966,␣
 ↪960, 961, 970, 961, 971]
```

```
y12=[980, 966, 957, 965, 961, 966, 957, 967, 965, 965, 966, 960, 963, 967, 968,␣
 ↪957, 961, 957, 964, 955, 959, 969, 957, 965, 959, 964, 962, 955, 972, 960,␣
 ↪962, 961, 965, 958, 957, 960, 978, 957, 968, 957, 970, 966, 956, 955, 968,␣
 ↪961, 960, 955, 966, 962]
y13=[966, 953, 954, 966, 964, 960, 964, 971, 958, 964, 965, 962, 978, 967, 957,␣
 ↪959, 970, 965, 964, 967, 966, 955, 961, 958, 962, 961, 967, 969, 966, 962,␣
 ↪965, 964, 959, 960, 967, 964, 968, 963, 968, 964, 971, 952, 968, 977, 966,␣
 ↪965, 971, 962, 970, 969]
y14=[971, 966, 969, 958, 972, 965, 965, 962, 961, 958, 966, 968, 954, 963, 961,␣
 ↪967, 966, 970, 967, 957, 972, 962, 951, 962, 958, 960, 963, 965, 968, 970,␣
 ↪963, 961, 964, 963, 958, 971, 961, 970, 963, 961, 964, 965, 970, 960, 964,␣
 ↪958, 969, 969, 957, 969]
y15=[971, 968, 971, 957, 971, 959, 969, 964, 971, 962, 970, 960, 953, 959, 962,␣
 ↪962, 967, 967, 961, 960, 961, 973, 958, 958, 969, 956, 958, 971, 970, 963,␣
 ↪961, 953, 964, 976, 968, 969, 963, 970, 958, 956, 956, 963, 961, 965, 964,␣
 ↪962, 954, 969, 953, 962]
y16=[971, 959, 971, 964, 961, 968, 963, 965, 965, 967, 955, 981, 961, 948, 964,␣
 ↪969, 970, 959, 963, 964, 965, 967, 957, 961, 950, 972, 967, 965, 966, 949,␣
 ↪964, 963, 956, 962, 962, 968, 965, 965, 969, 963, 961, 964, 970, 960, 961,␣
 ↪960, 960, 967, 971, 969]
y17=[952, 962, 963, 976, 970, 952, 968, 956, 964, 958, 964, 960, 970, 966, 966,␣
 ↪965, 963, 963, 958, 960, 959, 963, 957, 966, 962, 961, 965, 959, 961, 969,␣
 ↪967, 964, 956, 954, 967, 963, 959, 955, 963, 964, 962, 966, 963, 971, 945,␣
 ↪972, 961, 954, 964, 967]
y18=[962, 965, 970, 959, 970, 975, 966, 966, 959, 958, 966, 959, 958, 963, 965,␣
 ↪970, 956, 965, 977, 965, 970, 956, 968, 971, 972, 955, 964, 957, 957, 966,␣
 ↪963, 961, 959, 971, 965, 965, 964, 962, 958, 956, 958, 964, 958, 963, 968,␣
 ↪969, 958, 964, 973, 959]
y19=[976, 958, 968, 969, 953, 962, 954, 964, 969, 952, 962, 967, 958, 960, 955,␣
 ↪968, 966, 957, 962, 967, 962, 962, 970, 968, 954, 954, 963, 970, 960, 961,␣
 ↪967, 963, 961, 973, 965, 958, 952, 953, 961, 965, 966, 959, 971, 958, 967,␣
 ↪960, 974, 962, 965, 963]
y20=[978, 977, 964, 961, 966, 958, 956, 979, 966, 970, 959, 967, 968, 964, 964,␣
 ↪976, 955, 954, 967, 974, 964, 963, 959, 968, 964, 976, 962, 962, 970, 959,␣
 ↪960, 965, 958, 965, 966, 966, 953, 951, 962, 963, 970, 956, 962, 962, 973,␣
 ↪970, 958, 963, 954, 970]

avagarge =[967.55,963.9,963.9,963.15,963.95,964.6,964.35,965.35,963.05,961.
 ↪85,963.35,965.3,963.35,963.05,962.35,964.2,963.9,962.05,962.95,964.2,964.
 ↪6,965.4,961.1,963.4,962.2,963,963.95,961.75,964.85,961.65,964.85,961.45,963.
 ↪05,965,964.9,964.75,963.5,961.6,963.1,962.25,963.35,963,963.4,963.35,962.
 ↪8,962.75,964.05,962.3,962.55,965.2]
```

0.2 Map Plotting

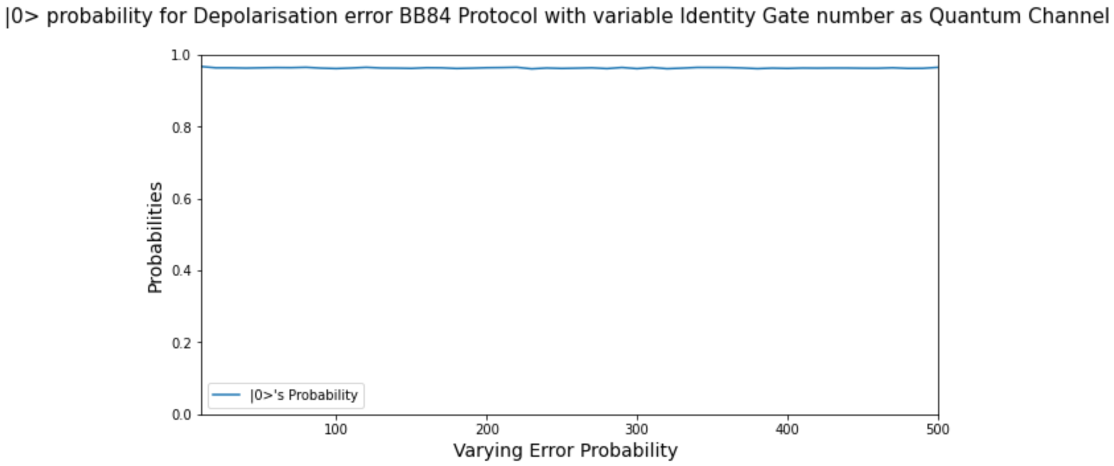
[61]:

```
%config InlineBackend.print_figure_kwargs={'facecolor' : "w"}
import matplotlib.pyplot as plt
from matplotlib.ticker import (AutoMinorLocator, MultipleLocator)
fig, ax = plt.subplots(figsize=(10, 5))
fig.suptitle('|0> probability for Depolarisation error BB84 Protocol with␣
 ↪variable 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(10, 500)
ax.set_ylim(0,1)
fig = plt.figure(figsize=(8,5))
# line 2 points
y1 = [0.96755,0.9639,0.9639,0.96315,0.96395,0.9646,0.96435,0.96535,0.96305,0.
 ↪96185,0.96335,0.9653,0.96335,0.96305,0.96235,0.9642,0.9639,0.96205,0.96295,0.
 ↪9642,0.9646,0.9654,0.9611,0.9634,0.9622,0.963,0.96395,0.96175,0.96485,0.
 ↪96165,0.96485,0.96145,0.96305,0.965,0.9649,0.96475,0.9635,0.9616,0.9631,0.
 ↪96225,0.96335,0.963,0.9634,0.96335,0.9628,0.96275,0.96405,0.9623,0.96255,0.
 ↪9652]
x1 = [10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160,␣
 ↪170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310,␣
 ↪320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460,␣
 ↪470, 480, 490, 500]

# plotting the line 2 points
ax.plot(x1, y1, label = "|0>'s Probability")
#ax.axes.xaxis.set_ticks([])
# show a legend on the plot
ax.legend()
```

[61]:

```
<matplotlib.legend.Legend at 0x7f2392b2aa90>
```



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

```
[53]: from statistics import mean
a = [[969, 965, 960, 957, 967, 977, 964, 957, 953, 967, 960, 959, 966, 978,␣
 ↪967, 973, 969, 958, 961, 974, 950, 965, 959, 962, 964, 960, 971, 960, 973,␣
 ↪953, 956, 968, 963, 972, 965, 961, 960, 958, 960, 960, 958, 965, 968, 962,␣
 ↪964, 965, 973, 954, 958, 963],
[959, 962, 964, 962, 950, 961, 966, 961, 963, 962, 956, 963, 965, 959, 967,␣
 ↪968, 968, 970, 963, 964, 971, 964, 959, 973, 958, 964, 963, 947, 951, 964,␣
 ↪956, 952, 963, 961, 964, 959, 962, 966, 973, 966, 968, 975, 962, 964, 958,␣
 ↪960, 970, 950, 958, 959],
[965, 960, 963, 960, 960, 976, 966, 966, 969, 960, 974, 967, 966, 972, 962,␣
 ↪960, 972, 963, 965, 955, 967, 966, 962, 968, 961, 966, 972, 945, 958, 967,␣
 ↪959, 959, 965, 964, 965, 970, 971, 965, 959, 963, 959, 962, 963, 968, 958,␣
 ↪959, 966, 968, 963, 962],
[963, 967, 971, 955, 966, 966, 968, 970, 960, 955, 958, 967, 952, 955, 964,␣
 ↪959, 958, 971, 961, 964, 965, 973, 956, 954, 965, 958, 969, 970, 971, 960,␣
 ↪974, 960, 963, 971, 962, 960, 953, 968, 959, 960, 965, 953, 962, 961, 961,␣
 ↪961, 969, 957, 954, 959],
[969, 968, 959, 962, 965, 967, 964, 968, 966, 971, 964, 964, 966, 957, 958,␣
 ↪959, 967, 953, 958, 969, 962, 965, 971, 962, 962, 958, 960, 957, 968, 958,␣
 ↪969, 961, 971, 969, 973, 971, 965, 953, 972, 956, 955, 972, 975, 959, 958,␣
 ↪973, 959, 957, 963, 968],
[970, 965, 969, 965, 963, 967, 972, 964, 966, 961, 965, 968, 961, 974, 959,␣
 ↪954, 964, 966, 957, 963, 971, 972, 952, 962, 971, 964, 964, 967, 972, 957,␣
 ↪964, 965, 969, 957, 972, 964, 970, 957, 969, 973, 970, 948, 964, 967, 959,␣
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[967, 971, 967, 974, 962, 957, 961, 970, 962, 951, 964, 966, 973, 966, 958,␣
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print(*map(mean, zip(*a)))
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```

0.3 Sir's Code

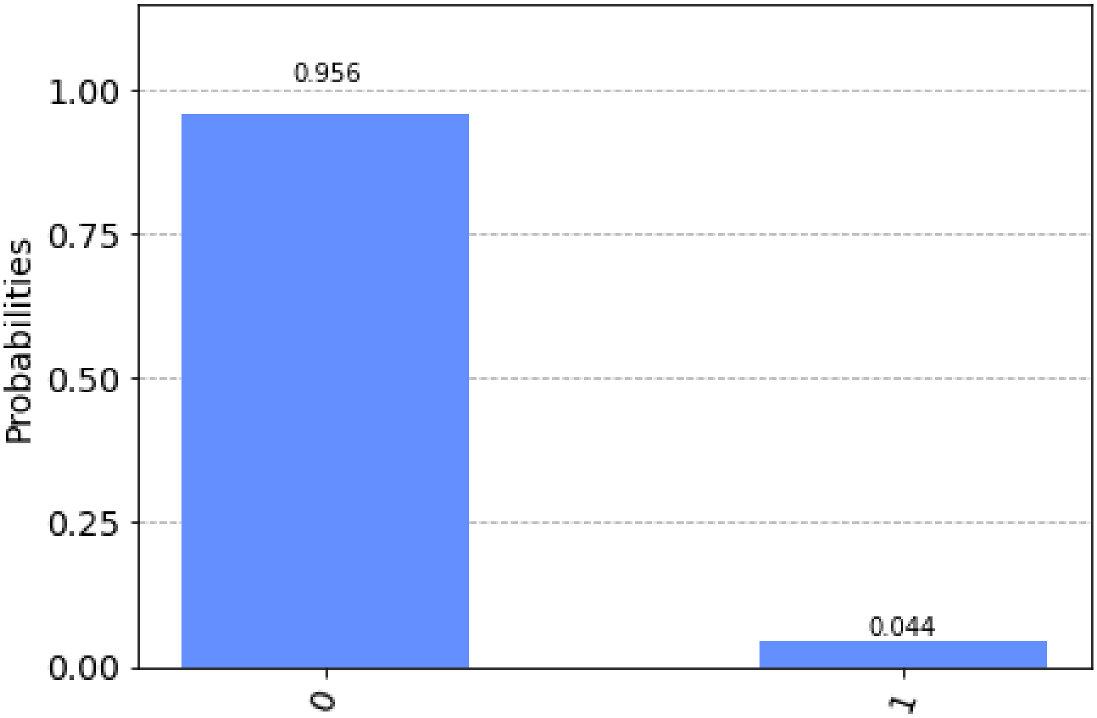
[58]:

```
qc = QuantumCircuit(1)
qc.h(0)
qc.barrier()
for i in range(10):
    qc.i(0)
    qc.barrier()
qc.h(0)
qc.measure_all()
print(qc)

counts = execute(qc,Aer.
 ↪get_backend('qasm_simulator'),noise_model=get_noise_dep(0.036,0.
 ↪00036),shots=2048).result().get_counts()
plot_histogram(counts)
```

```
                                                       »
   q_0:  H     I     I     I     I     I     I     I     I  »
                                                       »
meas: 1/                                        »
                                                                                   »
«
«   q_0:    I     I     H    M
«
«meas: 1/
«                                    0
```

[58]:

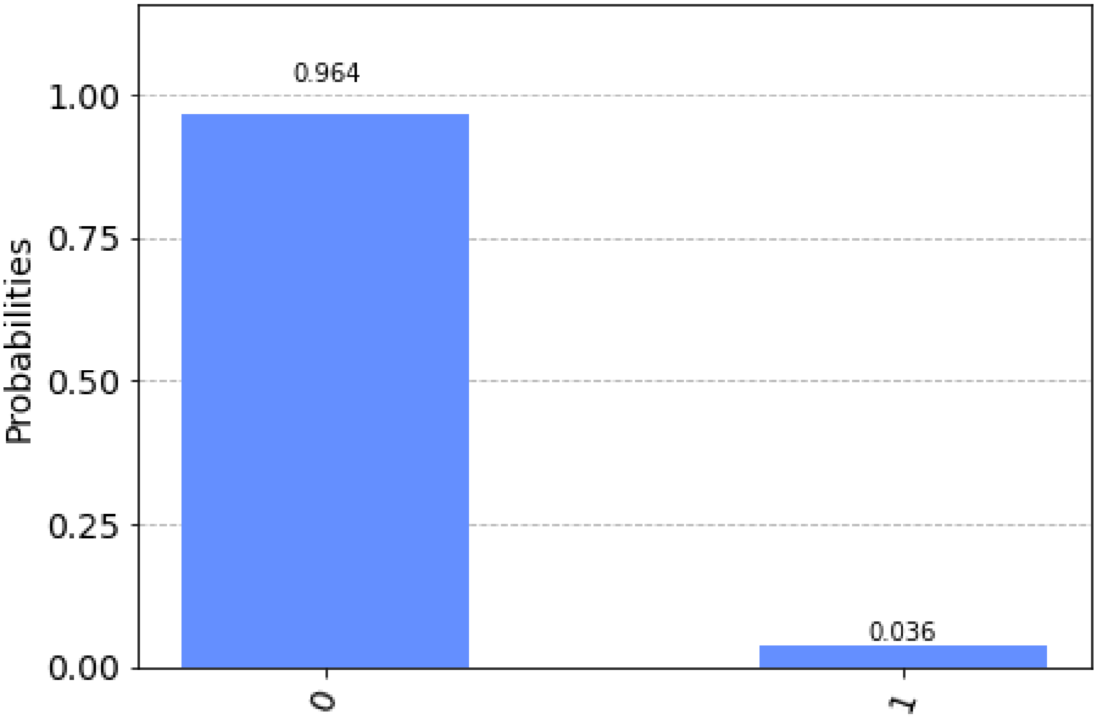


[64]:

```
qc = QuantumCircuit(1)
qc.h(0)
qc.barrier()
for i in range(10000):
    qc.i(0)
    qc.barrier()
qc.h(0)
qc.measure_all()
#print(qc)

counts = execute(qc,Aer.
 ↪get_backend('qasm_simulator'),noise_model=get_noise_dep(0.036,0.
 ↪00036),shots=2048).result().get_counts()
plot_histogram(counts)
```

[64]:

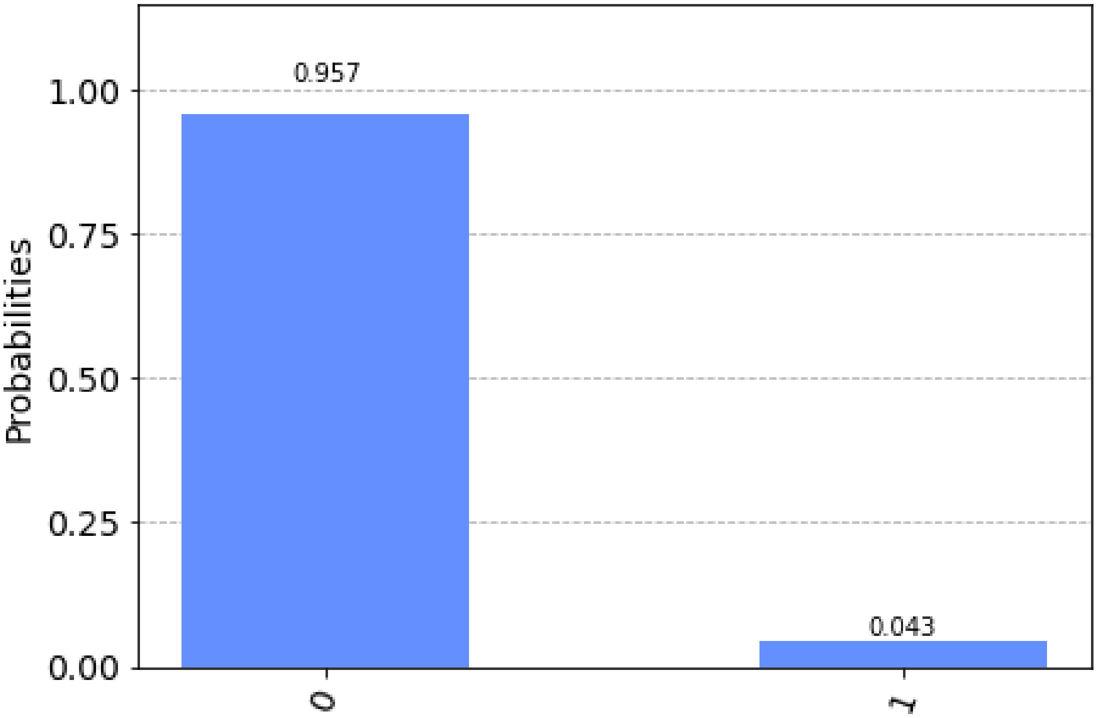


[5]:

```
qc = QuantumCircuit(1)
qc.h(0)
qc.barrier()
for i in range(500):
    qc.i(0)
    qc.barrier()
qc.h(0)
qc.measure_all()
#print(qc)

counts = execute(qc,Aer.
 ↪get_backend('qasm_simulator'),noise_model=get_noise_dep(0.036,0.
 ↪00036),shots=2048).result().get_counts()
plot_histogram(counts)
```

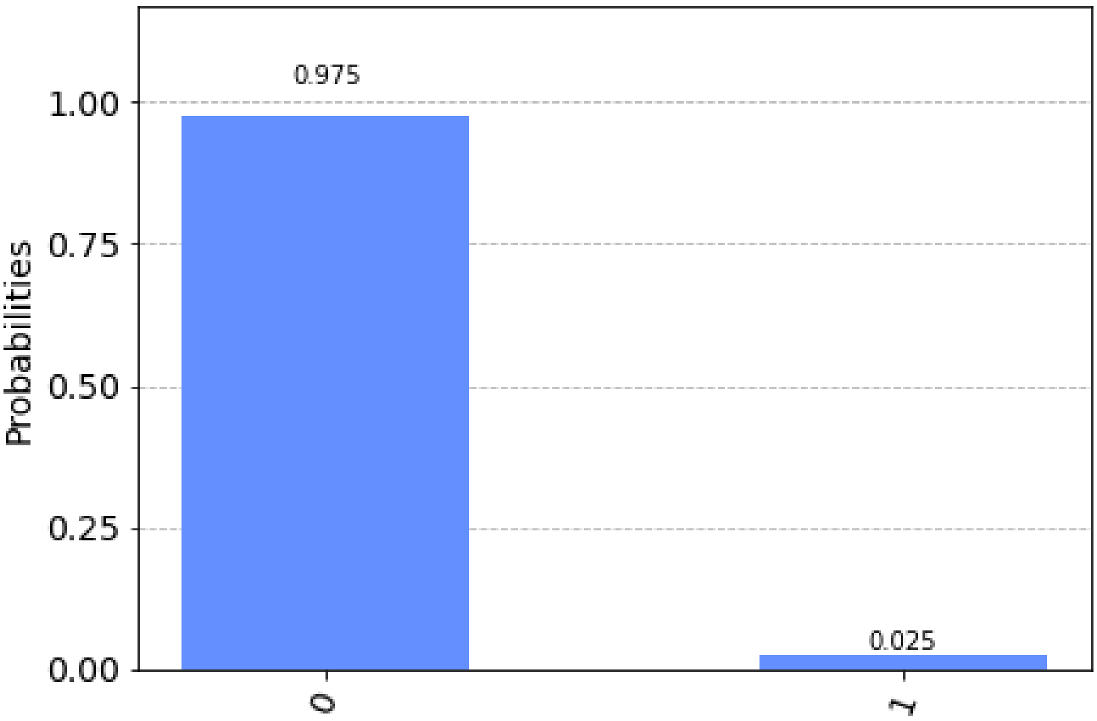
[5]:



[6]:
```
qc = QuantumCircuit(1)
qc.h(0)
qc.barrier()
for i in range(500):
    qc.i(0)
    qc.barrier()
qc.h(0)
qc.measure_all()
#print(qc)

counts = execute(qc,Aer.
 ↪get_backend('qasm_simulator'),noise_model=get_noise_dep(0.036,0.
 ↪00036),shots=1000).result().get_counts()
plot_histogram(counts)
```

[6]:


0.975
1.00
0.75
Probabilities
0.50
0.25
0.025
0.00
0
1

[ ]: