*陳志偉 B06901126電機五*

**Electrical Engineering Lab（topics on Communication System）**

**Lab3 Report**

1 a) By measuring the corresponding output, we observe that the first bit of circuit 1 is all 0 and the first bit of circuit 2 is all 1. So, quantum oracles 1 and 2 are constant functions. But the first bit of circuit 3 has two results, 1 and 0 which is a balanced function.

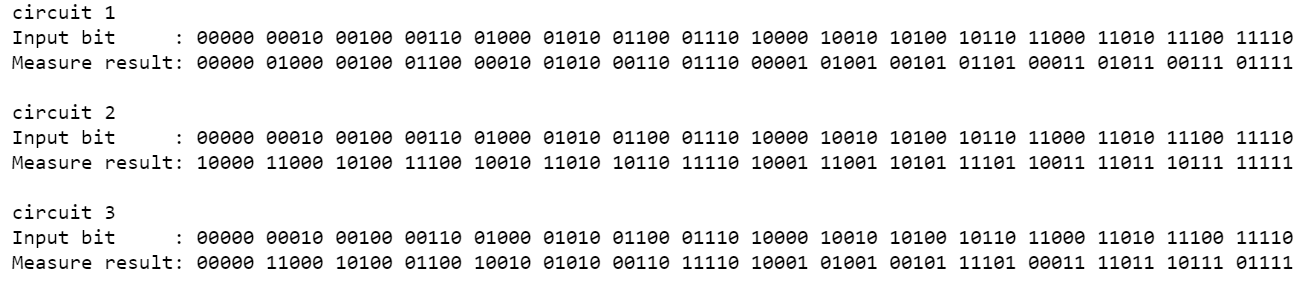
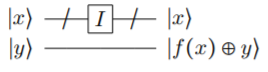


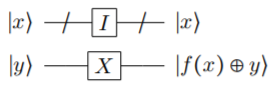
Figure 1a

1 b) By the result showing as *Figure 1b*, we confirm the following conclusions.

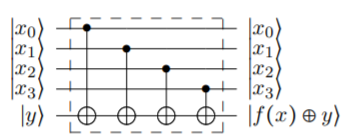
Quantum oracles 1 and 2 are constant functions, quantum oracle 3 is a balanced function.



Quantum oracle 1

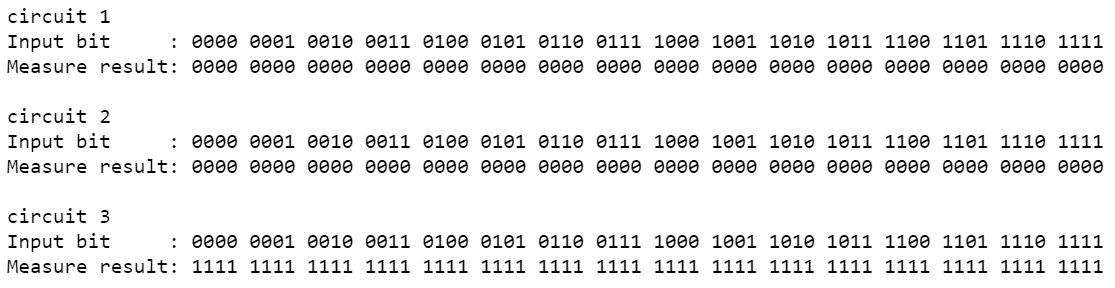


Quantum oracle 2



Quantum oracle 3

Figure 1b



2 a) Before pass thought Uf we have the arbitrary state show as Figure 2a, after pass though Uf we have the arbitrary state show as Figure 2b.

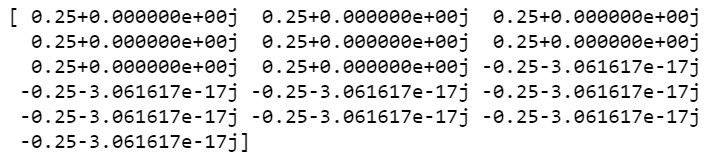


Figure 2a

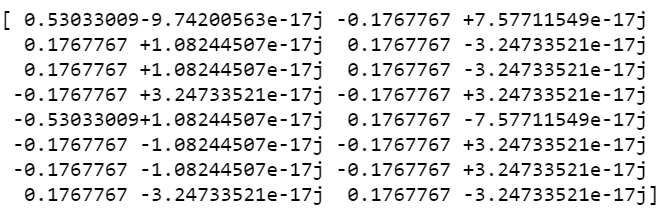
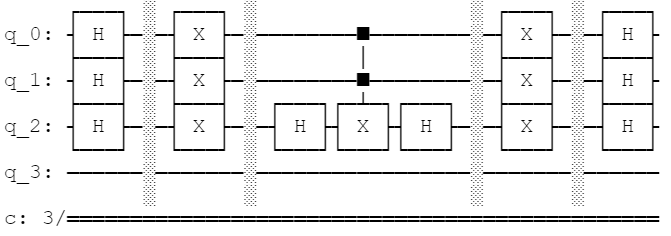


Figure 2b

2 b)

2 c) After apply times, where N = 8 and . We have the result of Figure 2c to measure ‘011’. Figure 2d show the result after apply 20 times.

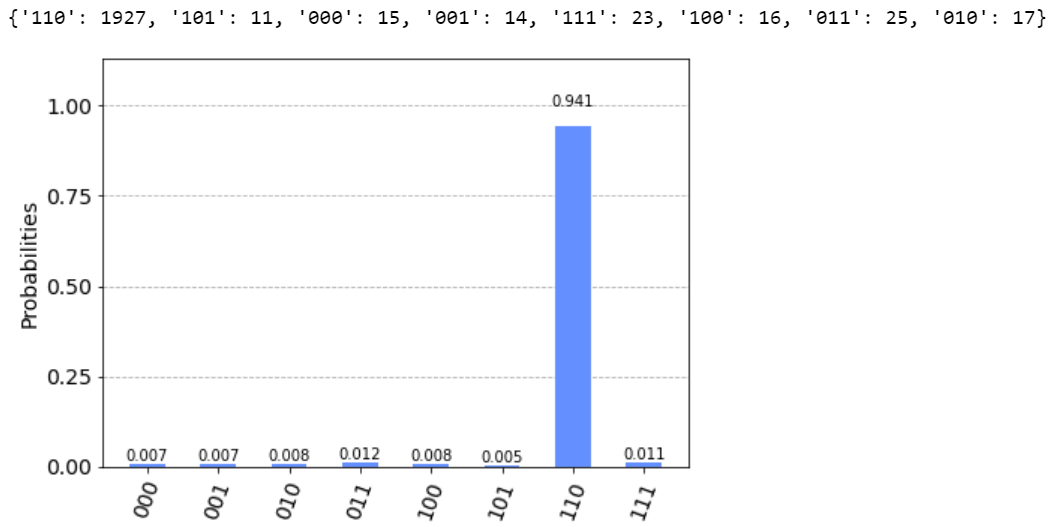


Figure 2c

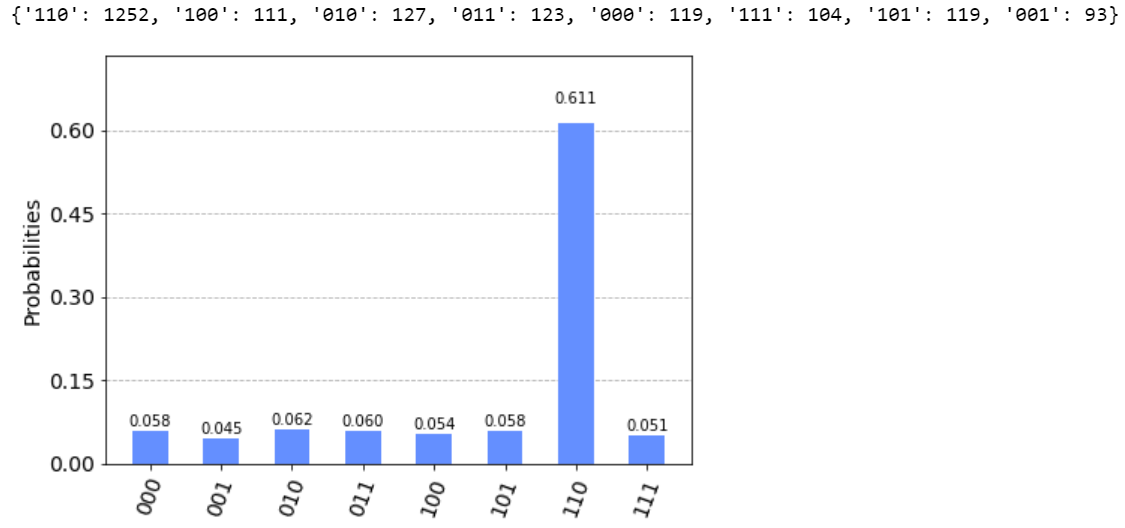
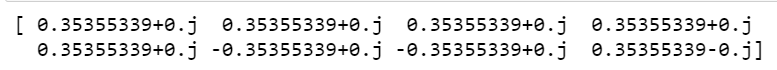


Figure 2d

2 d) By using ‘statevector\_simulator’, we get the following result. The sixth and seventh element of the vector is negative, so we sure that ‘101’ and ‘110’ have been flipped.

2 e) We need only one query to solve problem and we have the 50% of probability to get both ‘011’ and ‘101’ (Figure 2e). By using IBM’s real device, ‘101’ and ‘110’ also have a higher chance to measure.

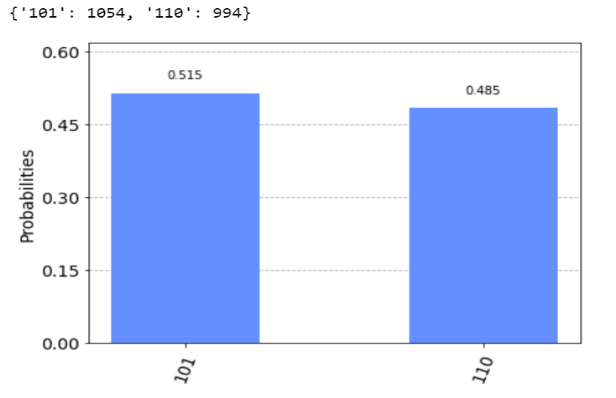


Figure 2e

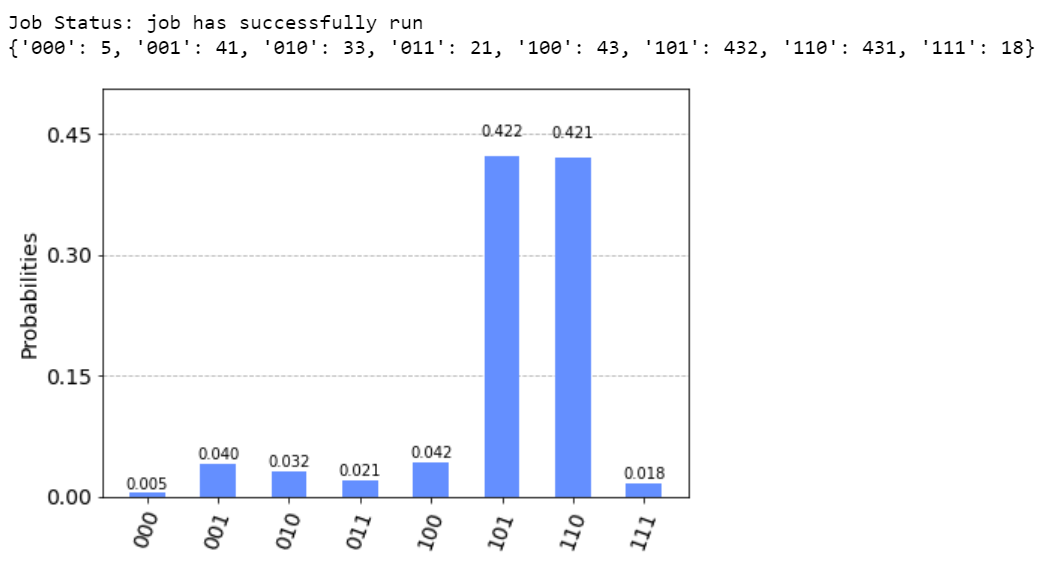


Figure 2f

2 f) From Figure 2g, ‘011’, ‘101’, ‘110’, ‘111’ have been flipped. But after measuring, we have the almost same probability to get all state.



Figure 2g

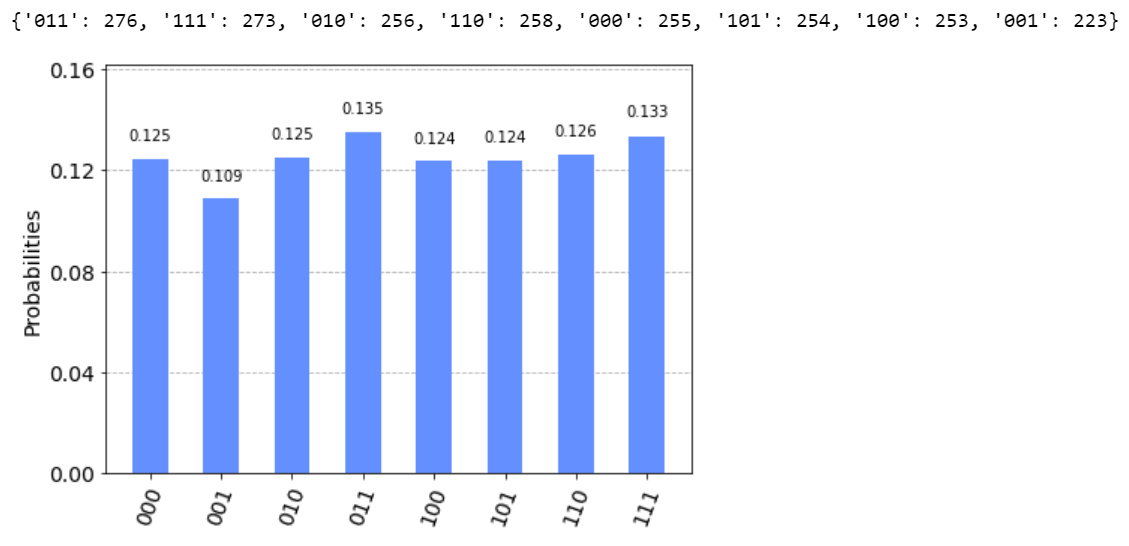
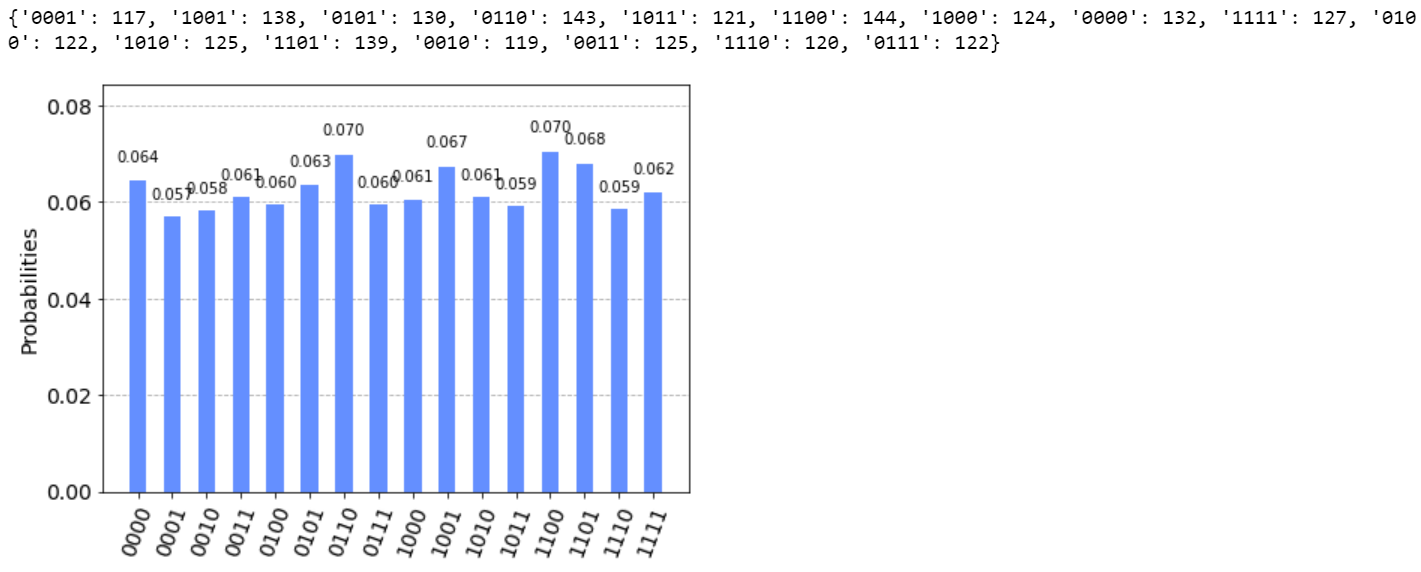
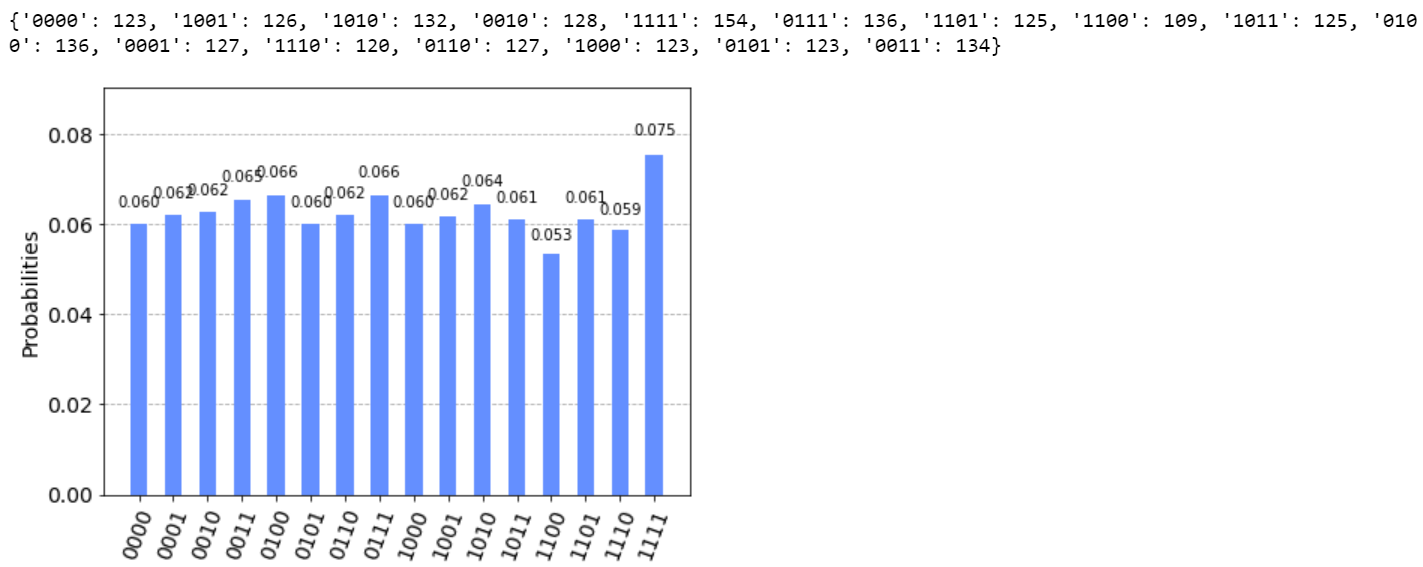


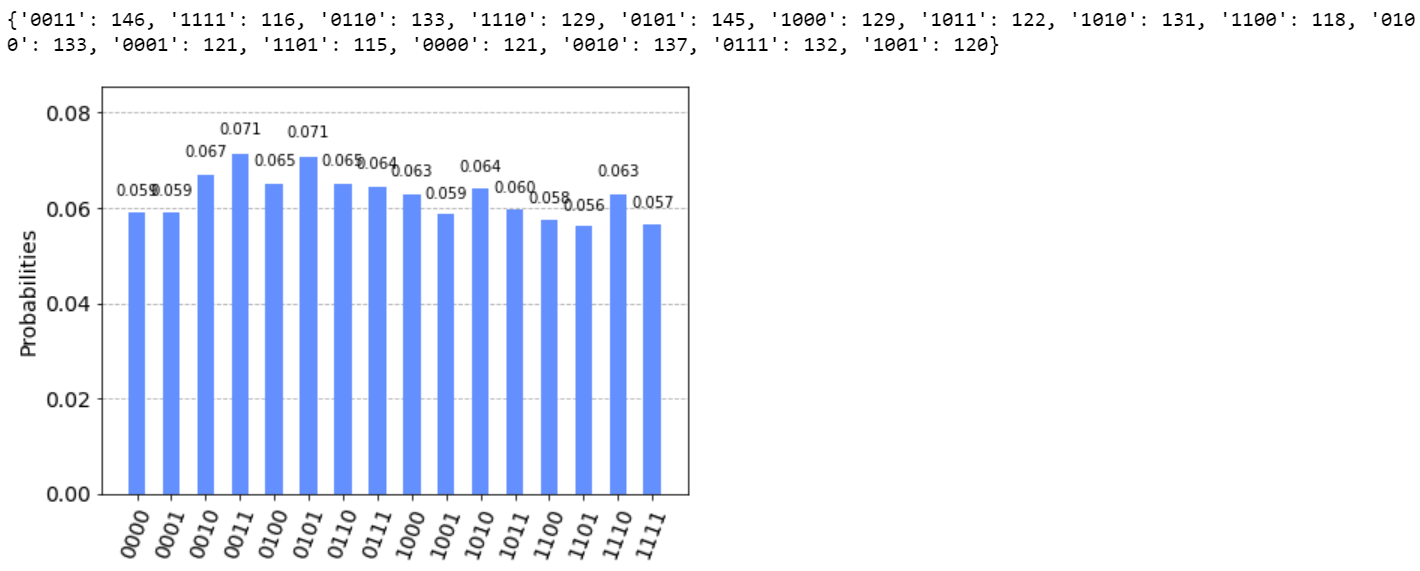
Figure 3

3) The following 3 Figures show the result of directly measuring the 3 circuits.



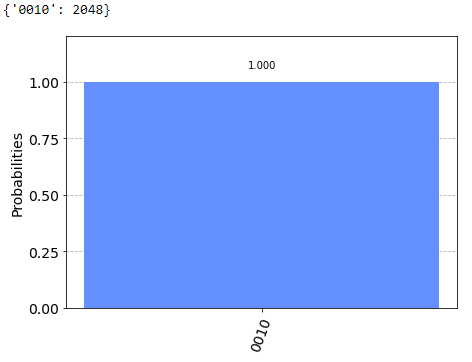
Result of measuring circuit 2

Result of measuring circuit 1

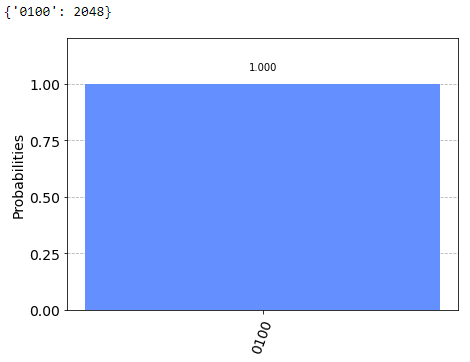


Result of measuring circuit 3

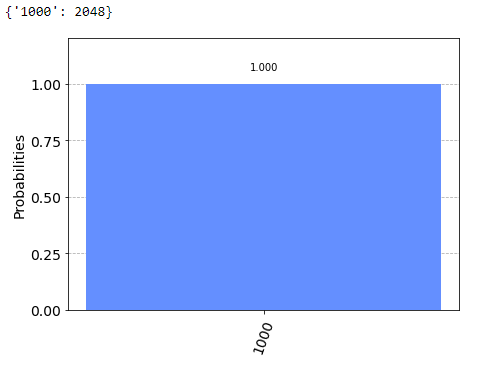
After apply QFT+N to 3 circuit, we have the following result.



After apply QFT+N to circuit 3



After apply QFT+N to circuit 2



After apply QFT+N to circuit 1

4) Step 1: To show that is periodic, I write a python code and plot the result. From the result of Figure 4a, show that f(x) is periodic.

1. def f(a, x):
2. return a\*\*x % 15
3. a = 7
4. y = []
5. for i in range(25):
6. y.append(f(a, i))
7. plt.plot(y, marker = '\*')
8. plt.xticks(range(0, 25))
9. plt.xlabel('x')
10. plt.ylabel('a$^x$ mod 15')
11. plt.show()

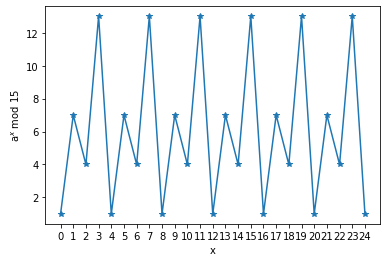


Figure 4a

Step 2: After measuring the second register, I get the result as Figure 4b match with ‘4’, ‘1’, ‘13’, ‘7’ in decimal. It actually same as the Figure 4a.

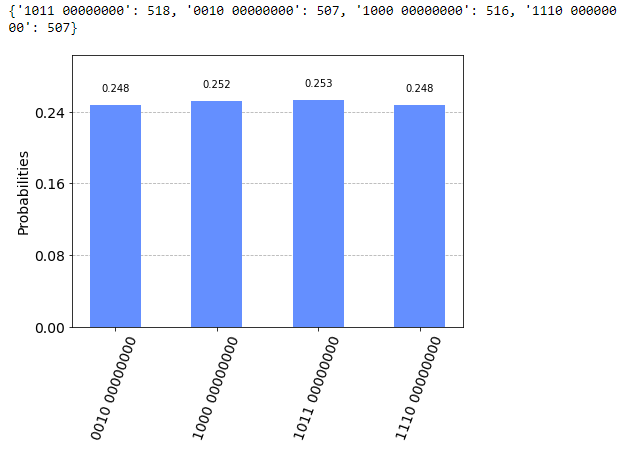


Figure 4b

Step 3: Figure 4c show the result of measuring both qr1 and qr2. There are 256 elements in the result, which is 2^8.

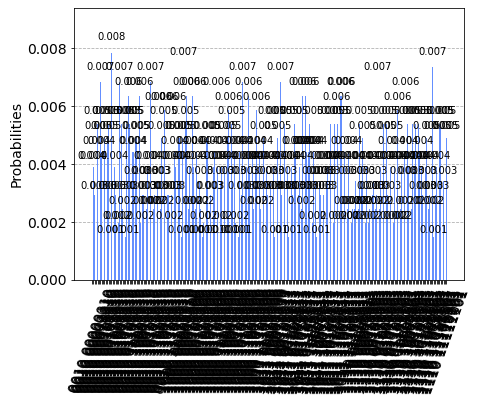


Figure 4c

Step 4: Figure 4d show the measure result after apply QFT+N and the given sample code.

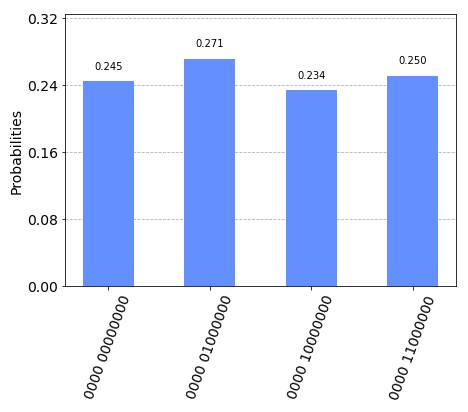
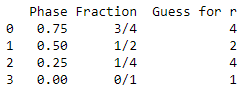


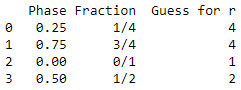
Figure 4d

 Step 5:

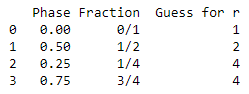
a = 13



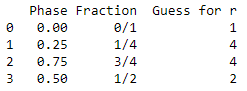
a = 11



a = 8



a = 2



a = 7

***Appendix***

All my code will update to my github’s repo: <https://github.com/finalwee/CommLab>