

# Lab2 Report

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## 1 Problem1

### 1.1 (a). Superdense Coding

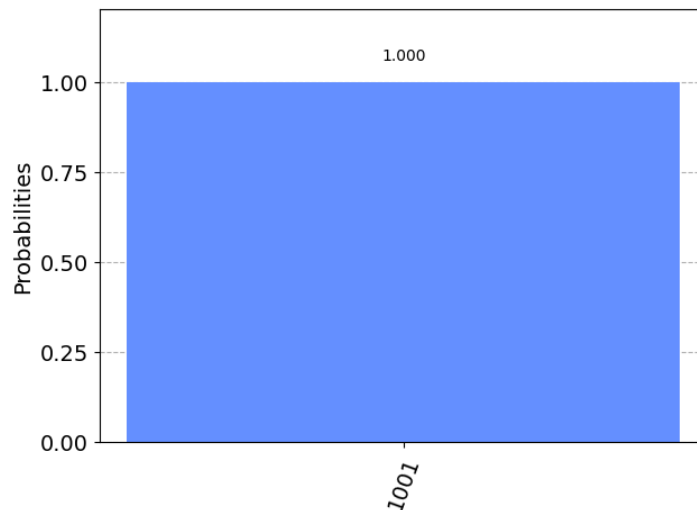


Figure 1: Result on local device

SER = 0 %, BER = 0% The relationship between SER and BER is **SER = BER**.

### 1.2 (b). Superdense Coding on Real Device

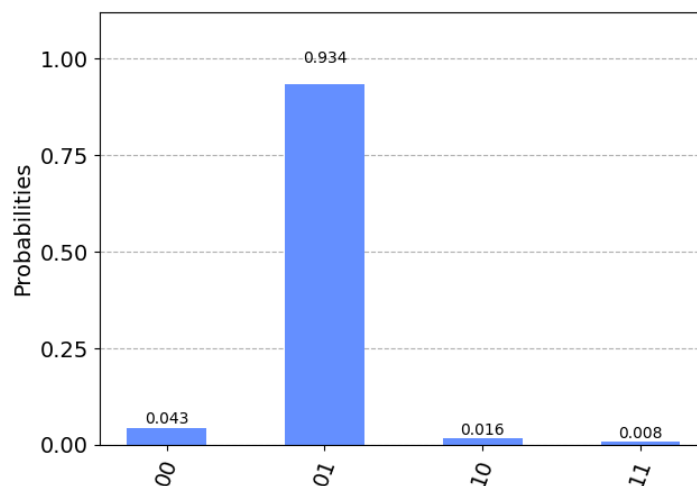


Figure 2: Results on real device

Note: I try to use 4-bit circuit on IBM device, but it shows errors that I can't fix it, so I reduce it to 2-bit.

On real device, SER = 6.6%, BER = 4.15%. The relationship between SER and BER is **SER > BER**

## 2 Problem2

### 2.1 (a). Verify the state received by Bob is the same as Alice's original state or not

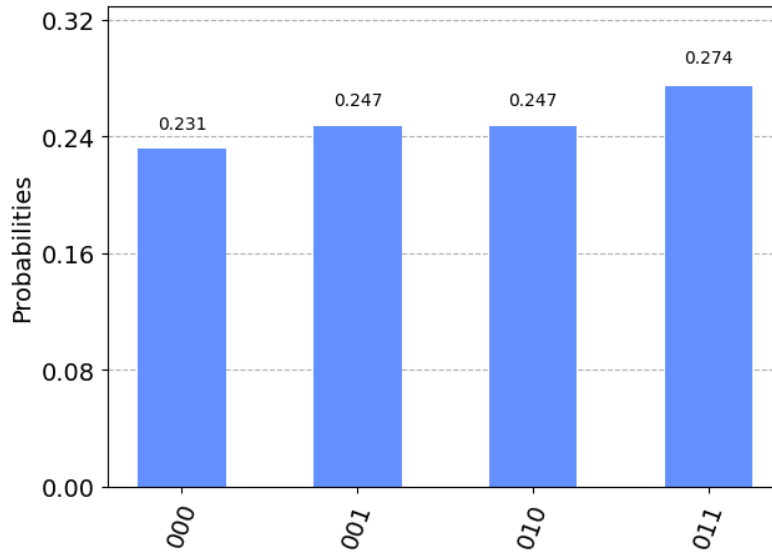


Figure 3: Method (ii): Using inverse operation

In above figure, we can see the q2 is always 0, so it means that the received state is the same with the original one.

### 2.2 (b). Entanglement Swapping

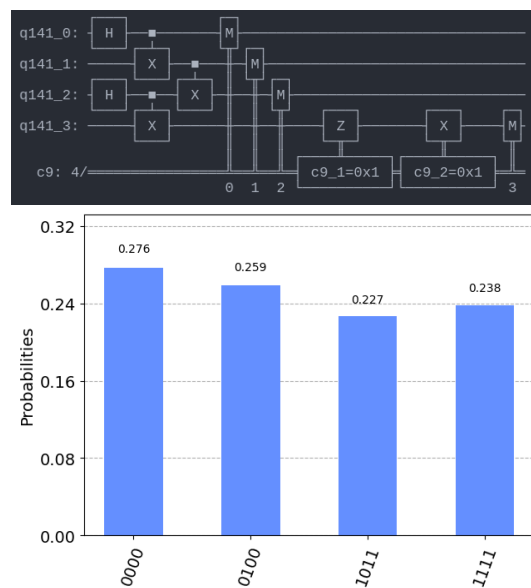


Figure 4: Entanglement Circuit and its measure result

We can see the first bit and the last bit in all the outputs of result are the same.

## 3 Problem3

### 3.1 (a). Probability of Eve's guess

Probability is around 40.43 %

```
def calculate_possibility(alice_key, bob_key):
    sum = 0
    num = sample(range(len(alice_key)), len(alice_key) // 2)
    for i in num:
        sum += 1 if alice_key[i] == bob_key[i] else 0
    return sum / len(alice_key)

p = calculate_possibility(alice_key, bob_key)
print("Probability is ", p*100, "%")
```

✓ 0.4s  
Probability is 40.42553191489361 %

Figure 5: Prob. of Eve's guess is correct

### 3.2 (b). Probability of Eve's guess when she changed the basis

Probability is around 54 %

```
eve_bases = randint(2, size=qn)
intercepted_message = intercept_message_Briedbart_basis(message, eve_bases)
print(eve_bases)
print("Eve's first chosen basis = %i" % alice_bases[0])
print(intercepted_message)
print("Eve's first intercepted message = %i" % intercepted_message[0])

count = 0
for i in range(qn):
    count += 1 if intercepted_message[i] == alice_bits[i] else 0

prob = count / len(alice_bits)
print("Probability is", prob*100, "%")
```

✓ 0.2s  
[1 0 0 0 0 1 1 1 1 0 0 1 0 0 1 0 0 0 1 1 1 1 0 1 0 1 1 1 0 1 1 1 1 0 0 1  
0 0 0 1 1 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 1 1 0 0 1 0 0 0 0 1 0 1 1  
1 1 1 0 1 1 1 1 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 1 1 1]  
Eve's first chosen basis = 0  
[0, 0, 1, 1, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 0, 1  
0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 0, 1, 0, 1, 0, 1, 1]  
Eve's first intercepted message = 0  
Probability is 54.0 %

Figure 6: Prob. of Eve's guess is correct when changing basis

## A Appendix

Q1: lab2q1.ipynb

Q2: lab2q2.ipynb

Q3: lab2q3.ipynb