Introduction to Quantum Information and Quantum Machine Learning

Laboratory - class 7

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Quantum pattern recognition by SWAP test

Quantum pattern recognition by SWAP test

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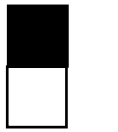
Quantum pattern recognition on real quantum processing units

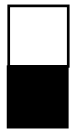
Quantum Machine Intelligence (2023) 5:16 , https://doi.org/10.1007/s42484-022-00093-x

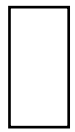
Using two-qubits states encoding the paterns (16 cases)

$$|-\rangle = H\otimes|1\rangle = \frac{1}{\sqrt{2}}(|0\rangle - |1\rangle)$$

$$|+\rangle = H\otimes|0\rangle = \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$$


$|\psi\rangle = |0\rangle$

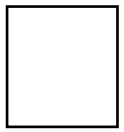

$|\psi\rangle = |1\rangle$

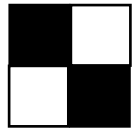

$|\psi\rangle = |-\rangle$

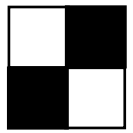
$|\psi\rangle = |+\rangle$

q1q0

$|\psi\rangle = |+\,+\rangle$


$|\psi\rangle = |-\,-\rangle$


$|\psi\rangle = |01\rangle$


$|\psi\rangle = |10\rangle$

$|\psi\rangle = |+0\rangle$

$|\psi\rangle = |+1\rangle$

$|\psi\rangle = |1\,+\rangle$

$|\psi\rangle = |0\,+\,\rangle$

$|\psi\rangle = |00\rangle$

$|\psi\rangle = |+\,-\rangle$

$|\psi\rangle = |11\rangle$

$|\psi\rangle = |-\,+\rangle$

$|\psi\rangle = |0\,-\rangle$

$|\psi\rangle = |-1\rangle$

$|\psi\rangle = |-0\rangle$

$|\psi\rangle = |1\,-\rangle$

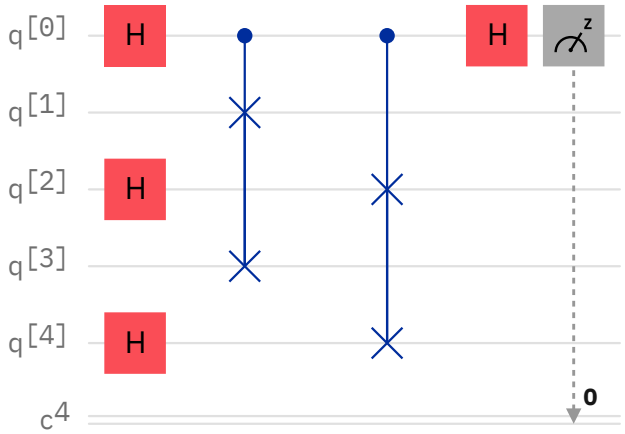
Quantum pattern recognition by SWAP test

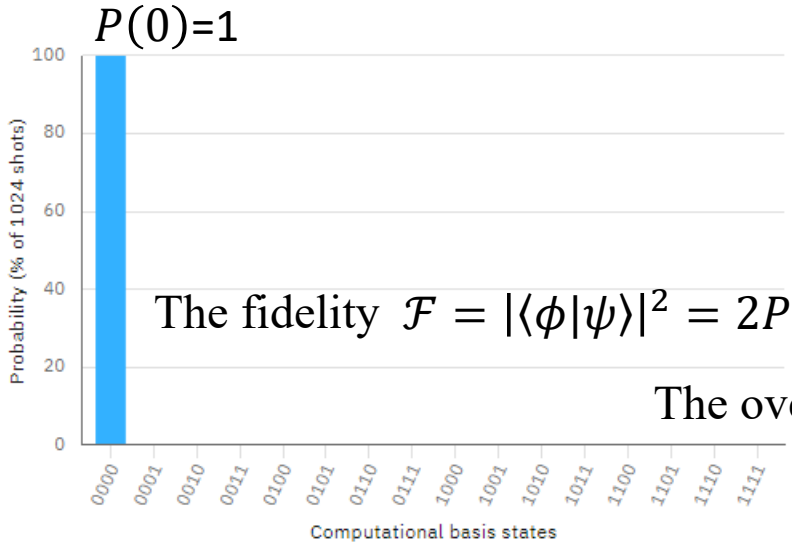
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |+0\rangle$





The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 2 - 1 = 1$

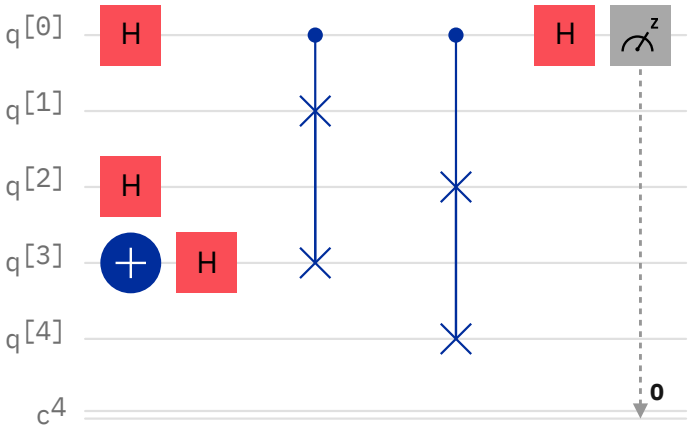
The overlap $L = \left|\sqrt{\mathcal{F}}\right| = 1$

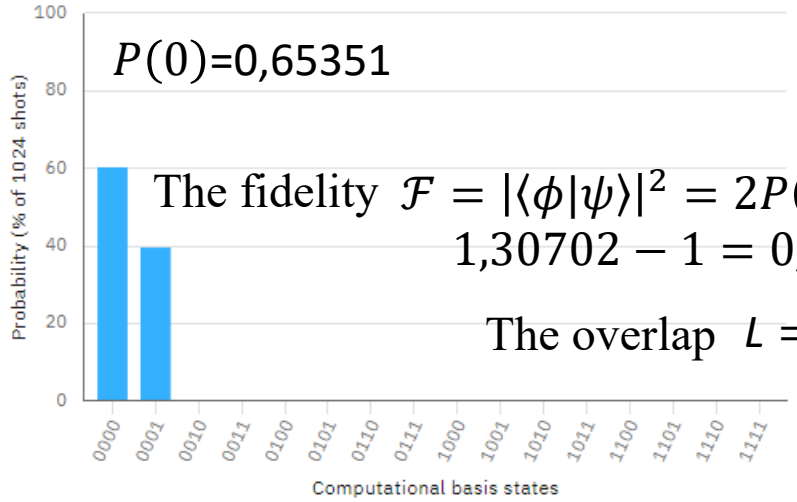
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |0-\rangle$





The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 1{,}30702 - 1 = 0{,}30702$

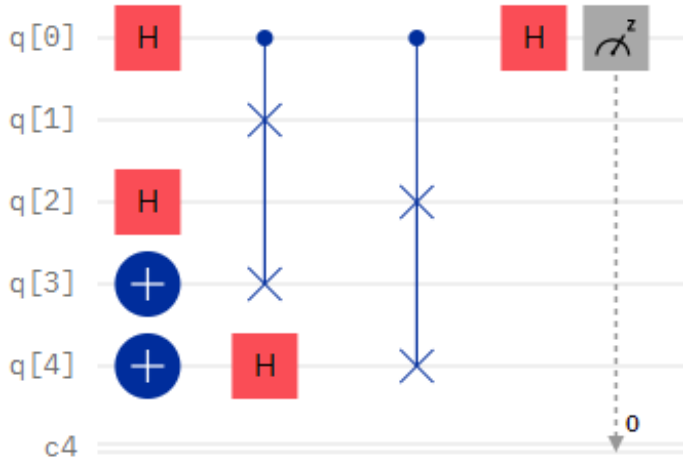
The overlap $L = \left|\sqrt{\mathcal{F}}\right| = 0{,}55409$

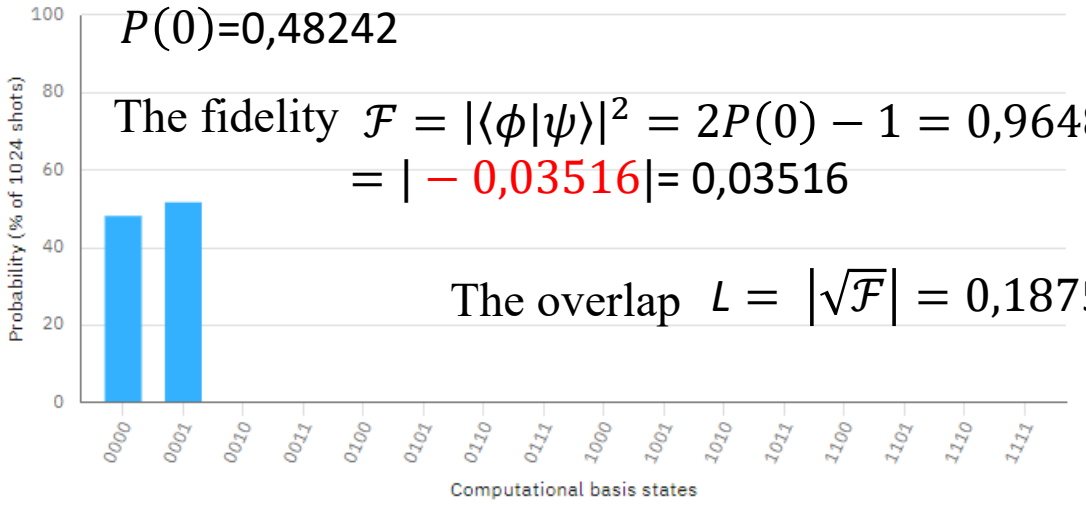
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |-1\rangle$





$P(0)$=0,48242

The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 0{,}96484 - 1$
$= |-0{,}03516| = 0{,}03516$

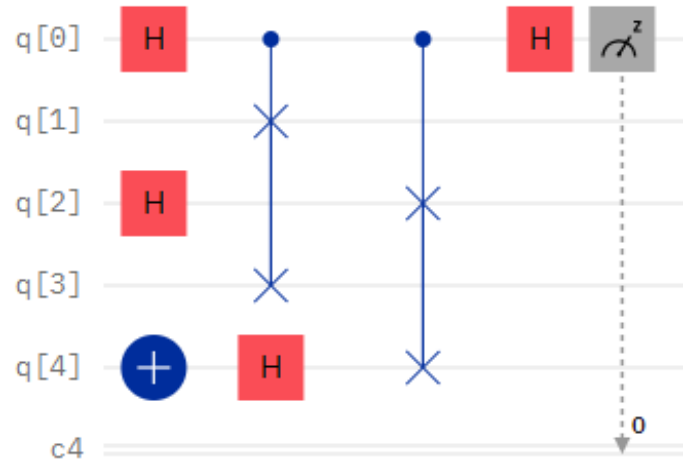
The overlap $L = |\sqrt{\mathcal{F}}| = 0{,}18751$

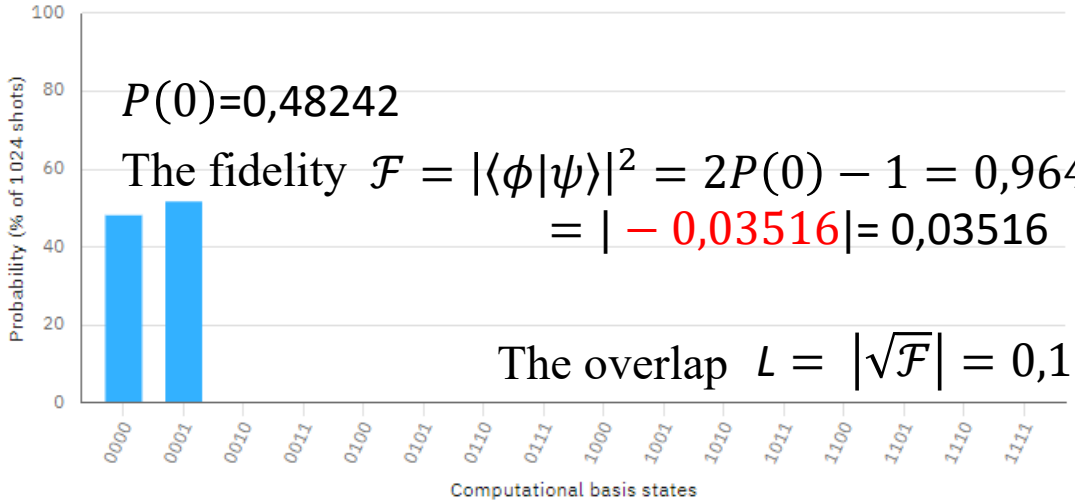
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |-0\rangle$





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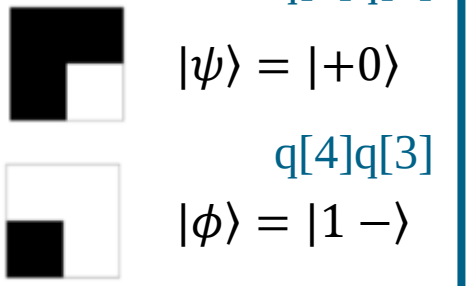
$= |-0{,}03516| = 0{,}03516$

The overlap $L = |\sqrt{\mathcal{F}}| = 0{,}18751$

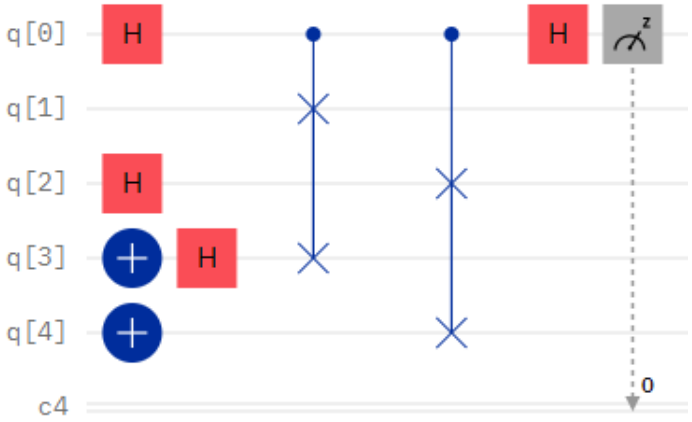


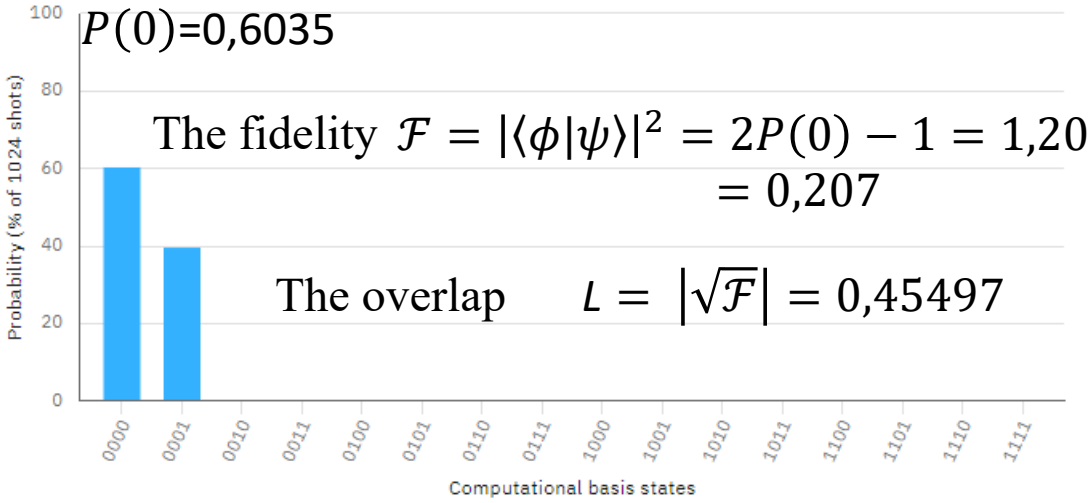
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |1-\rangle$

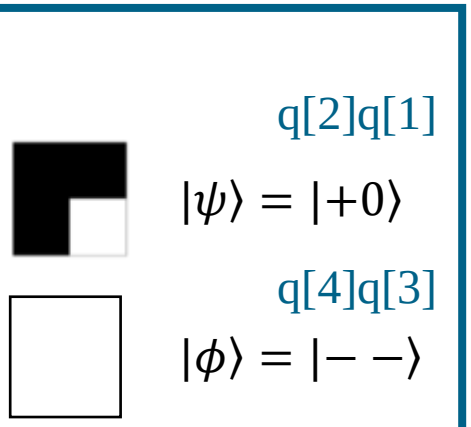




$P(0)$=0,6035

The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 1{,}207 - 1 = 0{,}207$

The overlap $L = |\sqrt{\mathcal{F}}| = 0{,}45497$

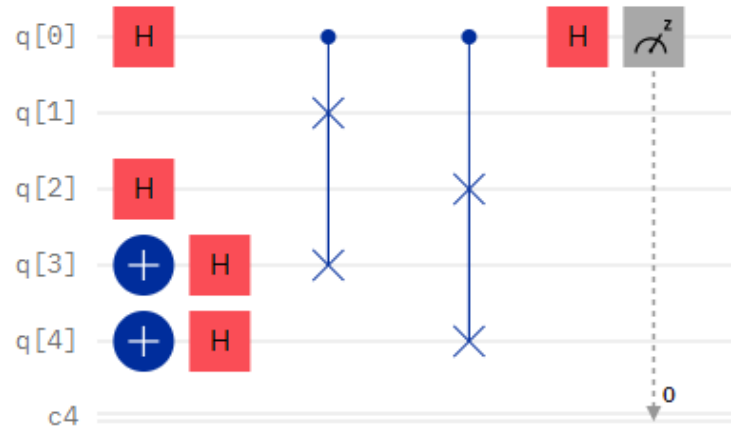


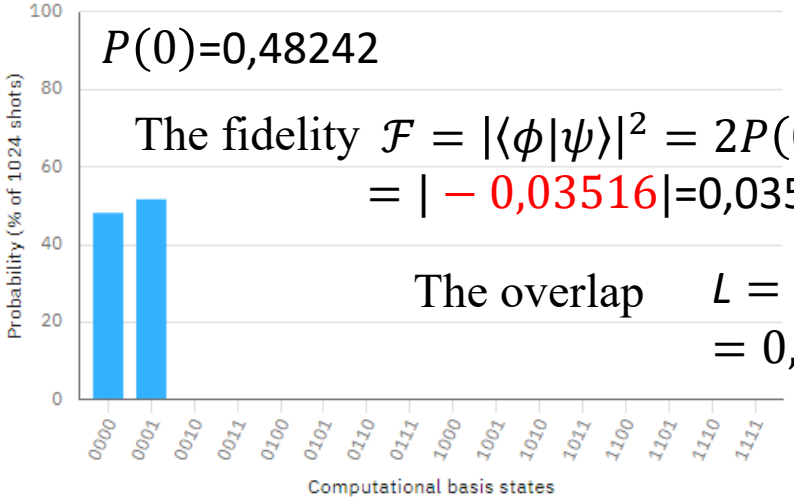
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |--\rangle$

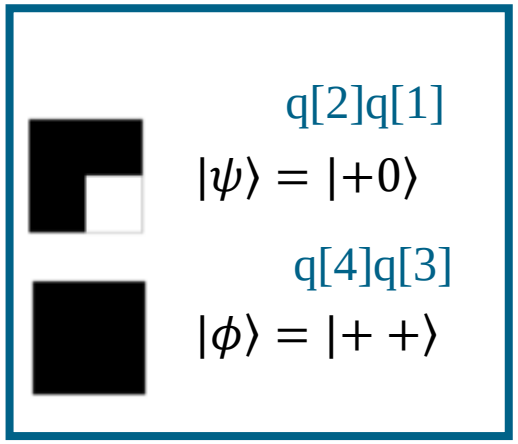




$P(0)$=0,48242

The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 0{,}96484 - 1 = |-0{,}03516| = 0{,}03516$

The overlap $L = |\sqrt{\mathcal{F}}| = 0{,}18751$

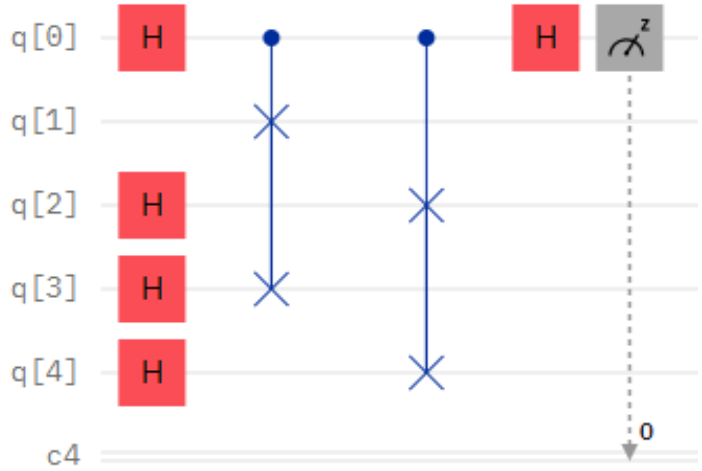


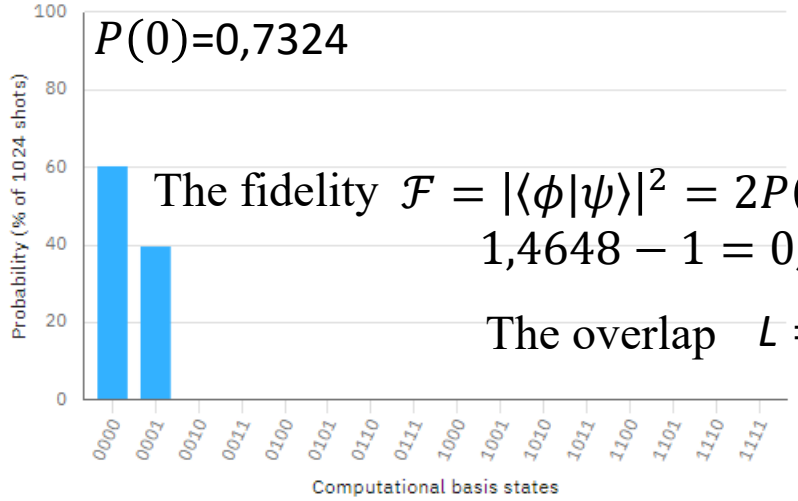
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

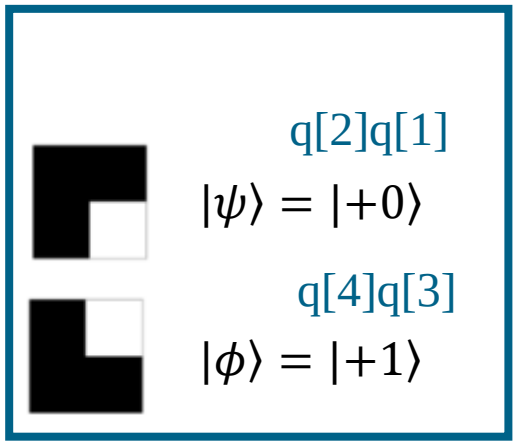
$|\phi\rangle = |+ +\rangle$





The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 1{,}4648 - 1 = 0{,}4648$

The overlap $L = \left|\sqrt{\mathcal{F}}\right| = 0{,}6817$

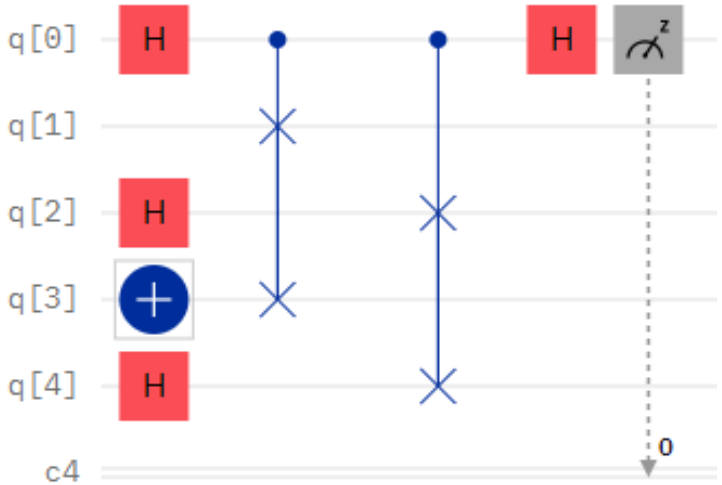


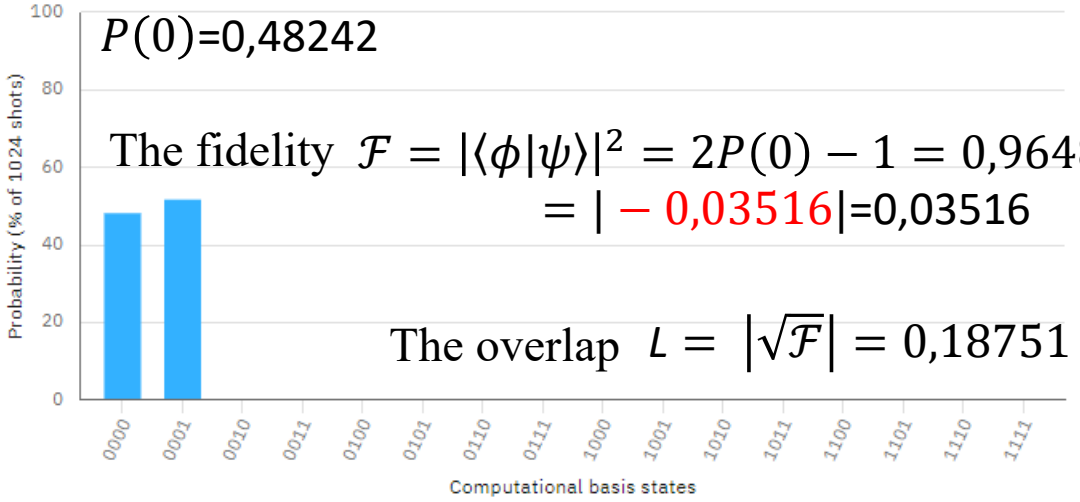
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |+1\rangle$





The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 0{,}96484 - 1 = |-0{,}03516| = 0{,}03516$

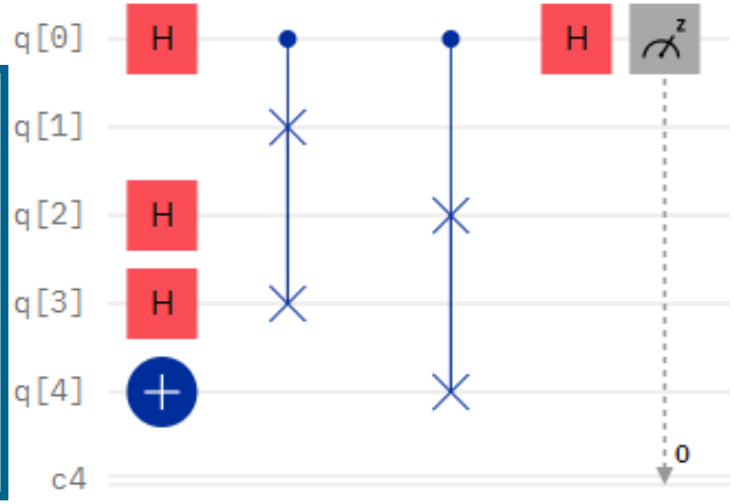
The overlap $L = \left|\sqrt{\mathcal{F}}\right| = 0{,}18751$

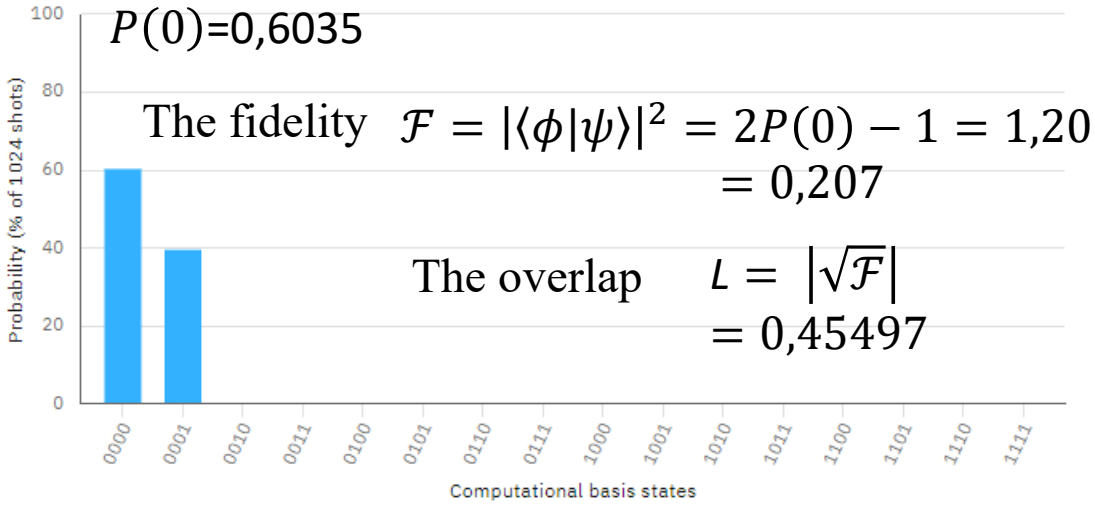
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |1+\rangle$



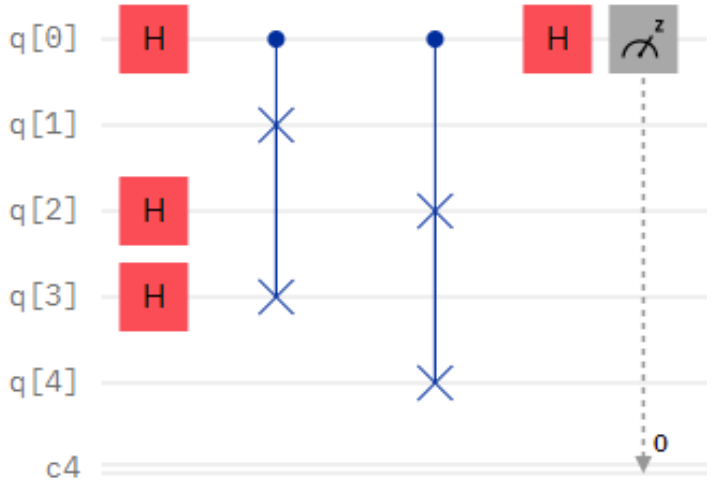


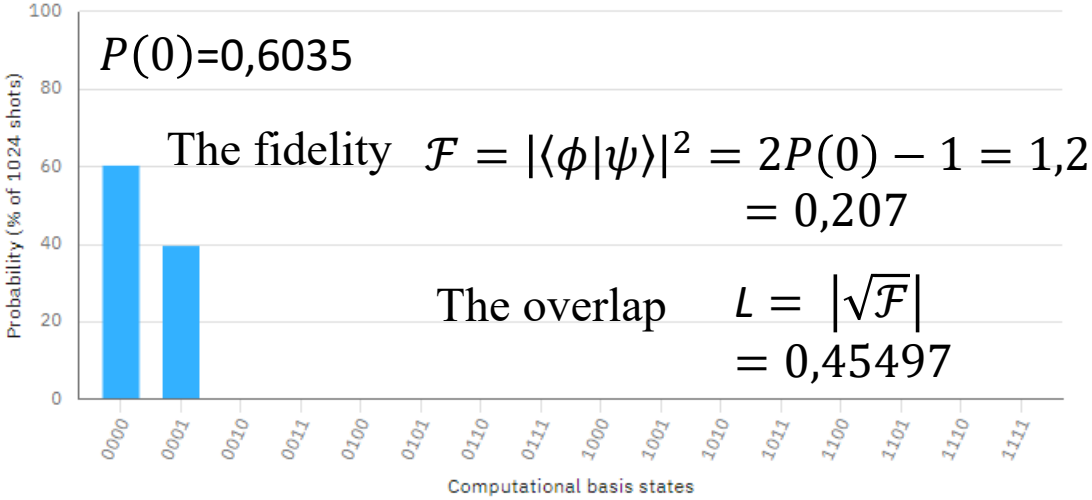
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |0+\rangle$



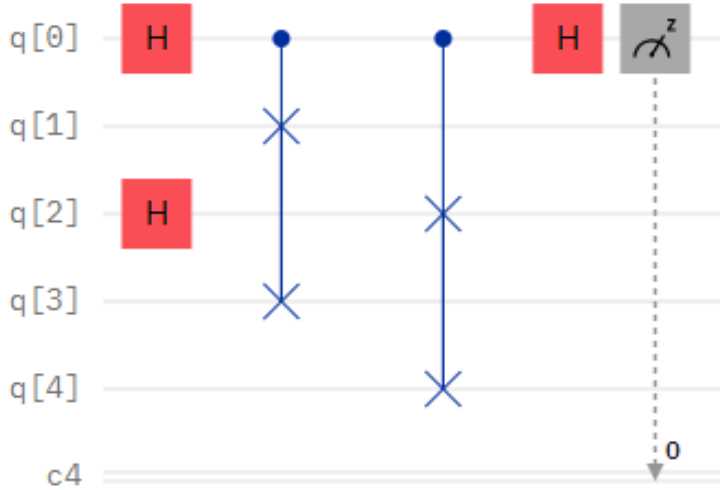


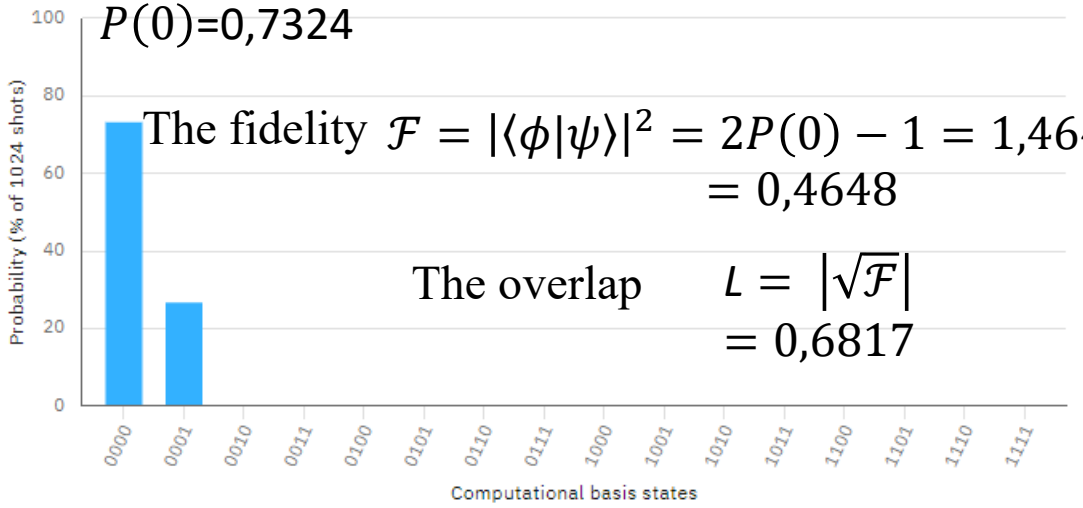
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |00\rangle$

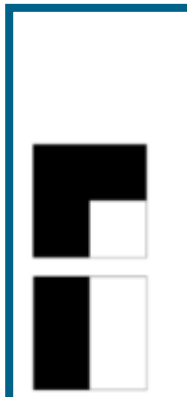




$P(0)$=0,7324

The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 1{,}4648 - 1 = 0{,}4648$

The overlap $L = |\sqrt{\mathcal{F}}| = 0{,}6817$

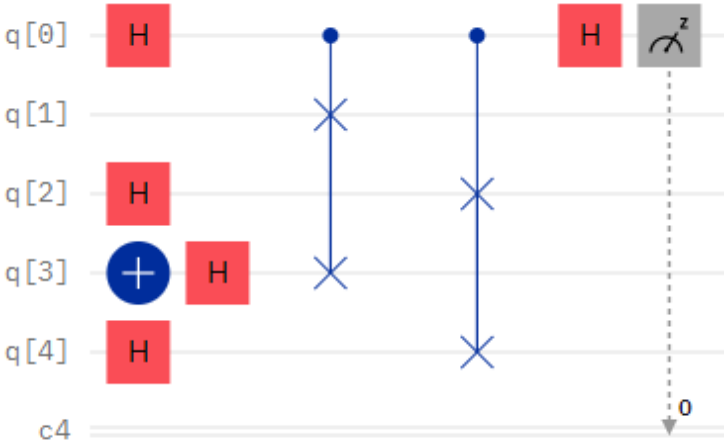


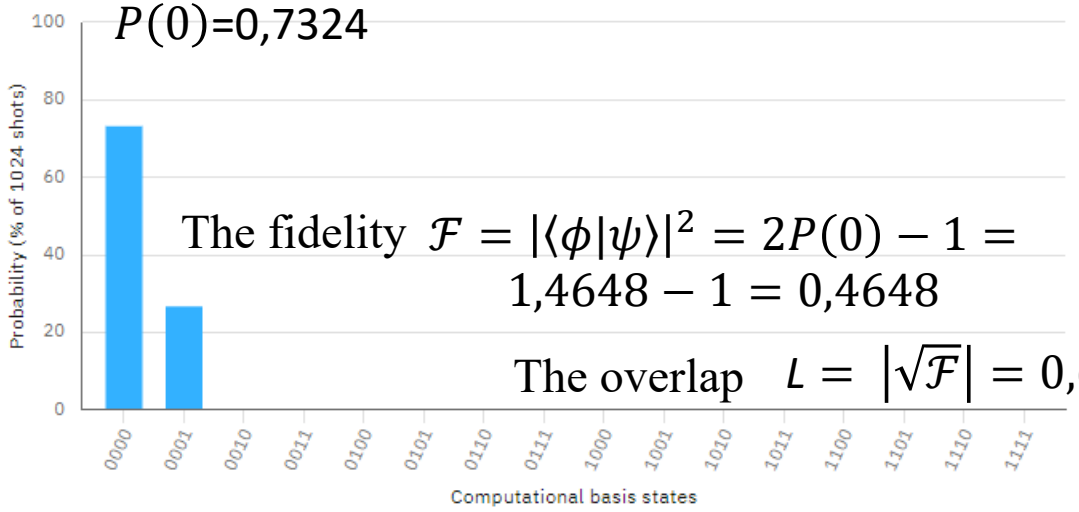
q[2]q[1]

$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |+-\rangle$





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q[2]q[1]

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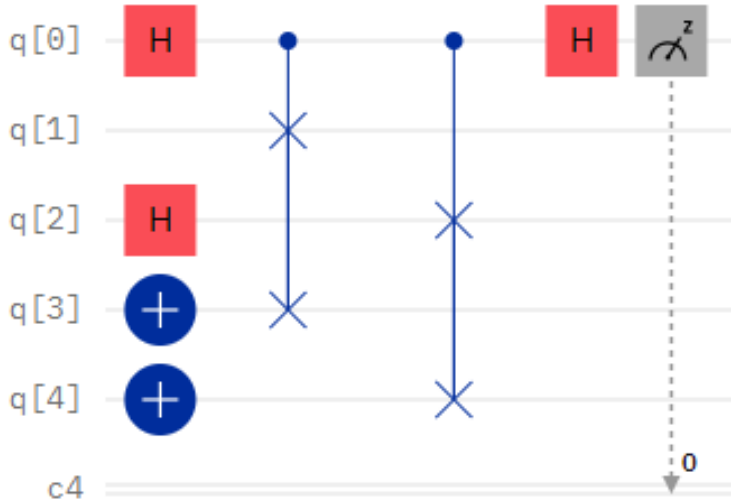
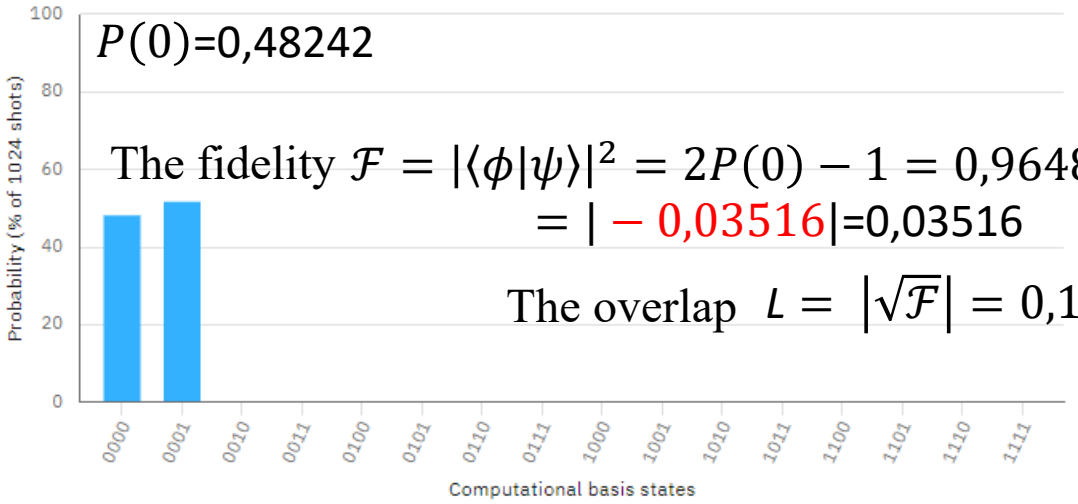
q[4]q[3]

$|\phi\rangle = |11\rangle$





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The fidelity $\mathcal{F} = |\langle\phi|\psi\rangle|^2 = 2P(0) - 1 = 0{,}96484 - 1$
$= |-0{,}03516|$=0,03516

The overlap $L = \left|\sqrt{\mathcal{F}}\right| = 0{,}18751$

q[2]q[1]

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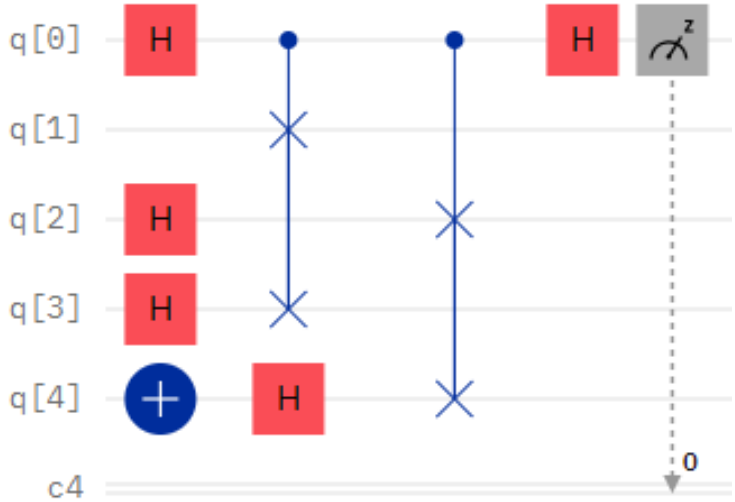
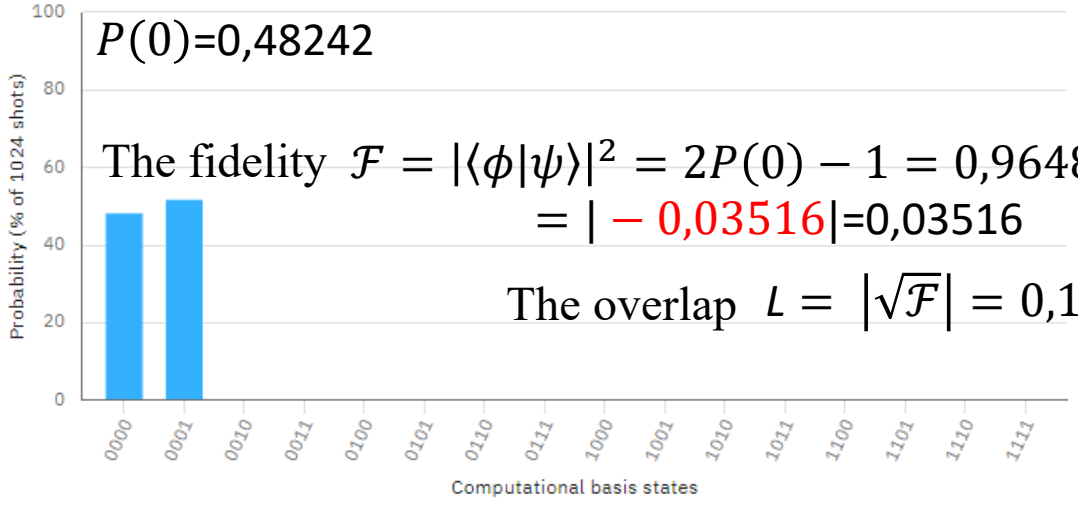
q[4]q[3]

$|\phi\rangle = |- +\rangle$





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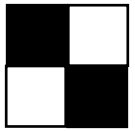

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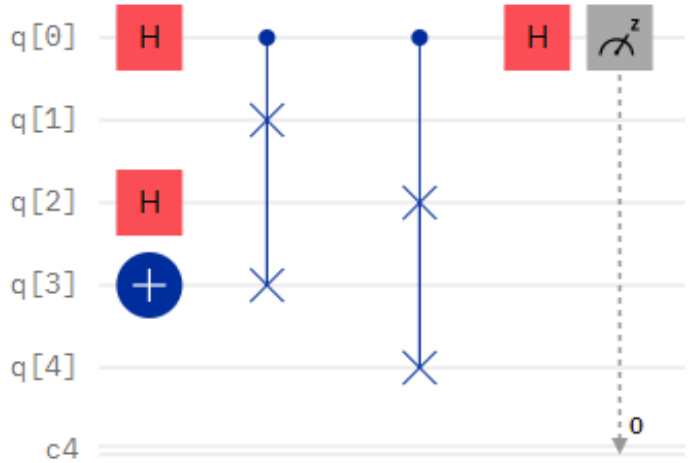
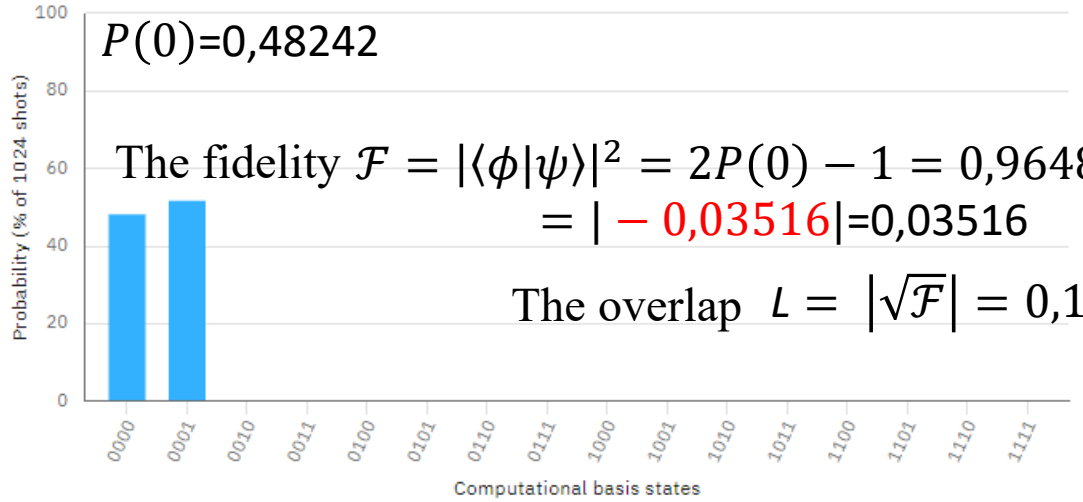
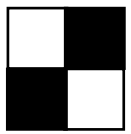
q[4]q[3]

$|\phi\rangle = |01\rangle$





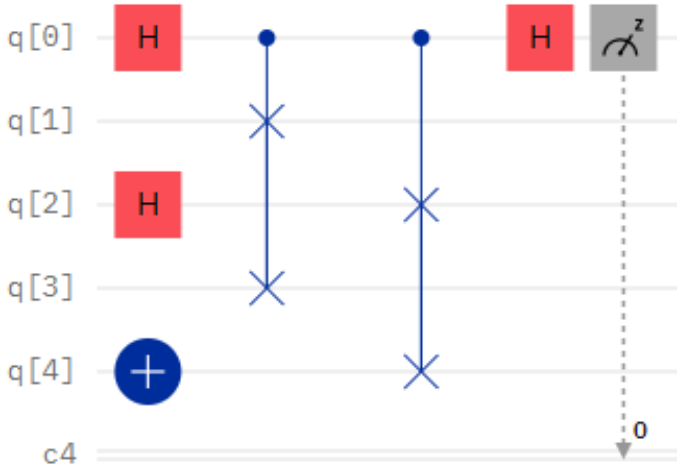


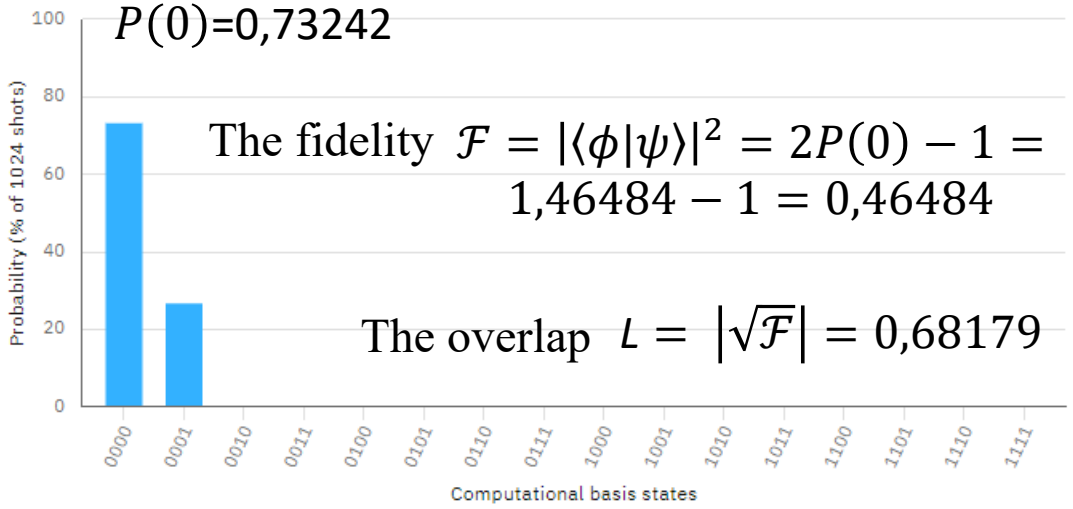
q[2]q[1]

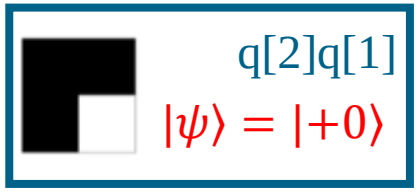
$|\psi\rangle = |+0\rangle$

q[4]q[3]

$|\phi\rangle = |10\rangle$

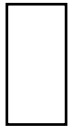




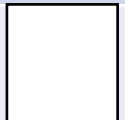
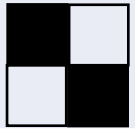
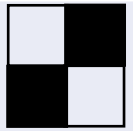


$|\psi\rangle = |0\rangle$

$|\psi\rangle = |1\rangle$


$|\psi\rangle = |-\rangle$

$|\psi\rangle = |+\rangle$

No	Image	*State* $\|\phi\rangle$	*Fidellity* $\mathcal{F}$	*Overlap* L	No	Image	*State* $\|\phi\rangle$	*Fidellity* $\mathcal{F}$	*Overlap* L
1		$\|+0\rangle$	1,00000	1,00000	9		$\|+1\rangle$	0,03516	0,18751
2		$\|0-\rangle$	0,30702	0,55409	10		$\|1+\rangle$	0,20700	0,45497
3		$\|-1\rangle$	0,03516	0,18751	11		$\|0+\rangle$	0,20700	0,45497
4		$\|-0\rangle$	0,03516	0,18751	12		$\|00\rangle$	0,4648	0,68170
5		$\|1-\rangle$	0,20700	0,45497	13		$\|+-\rangle$	0,4648	0,68170
6		$\|--\rangle$	0,03516	0,18751	14		$\|11\rangle$	0,03516	0,18751
7		$\|++\rangle$	0,46480	0,68170	15		$\|-+\rangle$	0,03516	0,18751
8		$\|01\rangle$	0,03516	0,18751	16		$\|10\rangle$	0,46482	0,68179

Tasks

Qiskit Implementation - TASKS

1. Using Quantum pattern recognition by SWAP test, make a test for:

1.a. Group 9.45 for pattern: $|\psi\rangle = |0\,-\rangle$

1.b. Group 11.45 for pattern: $|\psi\rangle = |00\rangle$

2. Presents the results in table (like on frame 11 this presentation)

The End