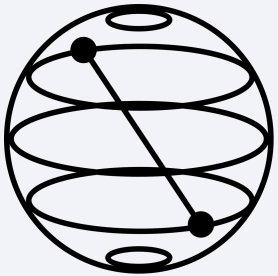


#14 Benchmarking noisy CX gates with QEC

Abhay Kamble

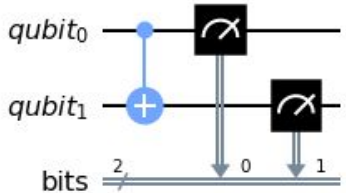
José Victor S. Scursulim

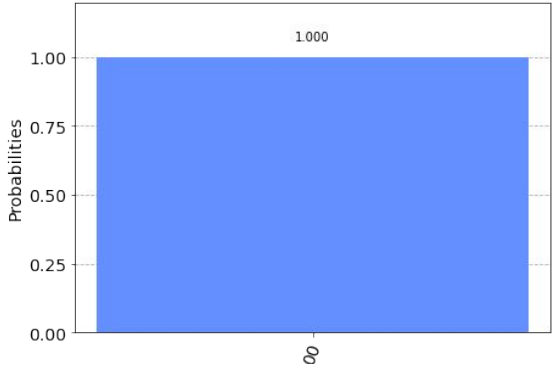
Mentor: James Wootton

CX Gates

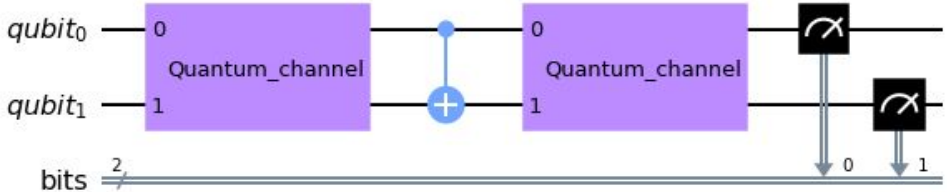
CX or CNOT gates have an important role in QEC protocols, they are behind the encoding and syndrome processes. Then, if we want to have success in detecting and correcting errors, we will need high quality CNOT gates.

Perfect CNOT gate

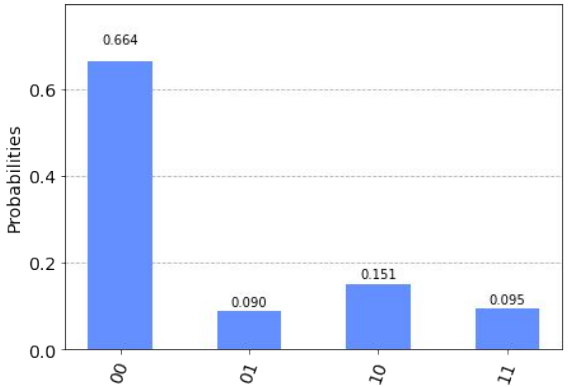




Example of a noisy CNOT gate



Output of the noisy CNOT gate in the example above. (p_error = 0.1)

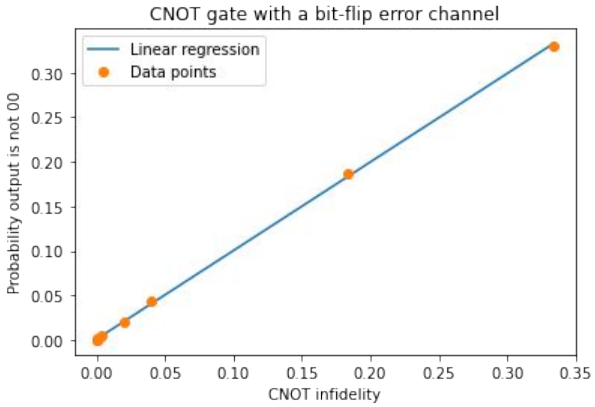


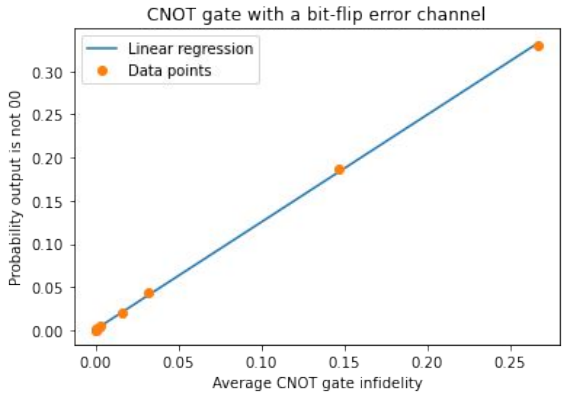
Introducing the problem

We can use process infidelity or average gate infidelity to have an idea of the CX gate performance. However, there are some scenarios where these metrics don't work very well, as discussed in arXiv:1808.03927v2.

Qiskit

	Error probability	00 Counts	01 Counts	10 Counts	11 Counts	p_00	p_not_00	Process infidelity	Average gate infidelity
0	0.000005	8192	0	0	0	1.000000	0.000000	0.000020	0.000016
1	0.000010	8192	0	0	0	1.000000	0.000000	0.000040	0.000032
2	0.000050	8188	1	1	2	0.999512	0.000488	0.000200	0.000160
3	0.000100	8186	1	3	2	0.999268	0.000732	0.000400	0.000320
4	0.000500	8167	5	13	7	0.996948	0.003052	0.001998	0.001599
5	0.001000	8152	9	19	12	0.995117	0.004883	0.003993	0.003194
6	0.005000	8034	39	80	39	0.980713	0.019287	0.019826	0.015860
7	0.010000	7841	96	172	83	0.957153	0.042847	0.039304	0.031443
8	0.050000	6660	388	707	437	0.812988	0.187012	0.183000	0.146400
9	0.100000	5486	785	1205	716	0.669678	0.330322	0.334000	0.267200





Another Approach

Qiskit

- We can use ‘Randomized Benchmarking’ to have an idea about the performance of the CX gate.

- Randomization benchmarking (RB) is a well-known technique to measure average gate performance by running sequences of random Clifford gates that should return the qubits to the initial state .

- We plan to explore various versions of Randomized Benchmarking to get an idea about the gate performance.

Goals and future work

Qiskit

- We want to study the effect of having a single imperfect CX gate within a perfect QEC protocol.
- From the results of our studies, we will try to define a new way to determine the quality and fidelity of a CX gate.
- Test different types of CX gates, like Loss-DiVincenzo CNOT and Floating Gate CNOT