Appendix for supplementary baseline circuits

Maksims Dimitrijevs[1][0000−0002−4225−7889], Maria Palchiha[2], and Abuzer Yakaryılmaz[1][0000−0002−2372−252X]

[1] Center for Quantum Computer Science, University of Latvia, Latvia
[2] Riga Purvciems Secondary School, Latvia
{maksims.dimitrijevs,abuzer.yakaryilmaz}@lu.lv

1 Supplementary baseline circuits (SAT and 2-qubit sanity check)

When we implemented the circuits for Lights Out on IQM devices, the measured distributions were close to uniform. To contextualize this result, we include two supplementary diagnostic baselines based on Grover's Search – a small circuit for SAT and a smaller 2-qubit Grover's Search instance. These baselines test whether the effects of Grover's search are observable on IQM in the case of small circuits.

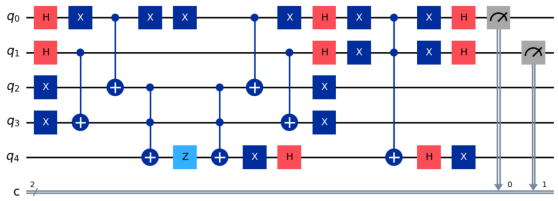

Fig. 1: Implementation of Grover's Search for a small SAT problem.

The circuit that we prepared is shown in Fig. 1. Here, q_0 and q_1 serve as the formula variables, and the SAT formula to solve is $(q_0) \wedge (\neg q_1)$. q_2 and q_3 store the calculated values for clauses, and q_4 is used to perform phase change. The expected output of the circuit is state `01` with probability 1.

In our experiments, one of the IQM devices provided output probabilities close to random output, so we decided to run an even smaller circuit with Grover's Search, just to verify that everything works properly (see Fig. 2). The circuit uses just two qubits and has only two two-qubit operations. The expected output is state `10` with probability 1.

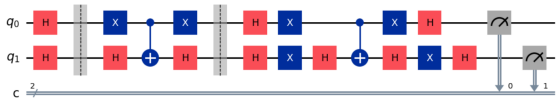

Fig. 2: Implementation of a small imitation of Grover's Search.

Table 1: Measured output distributions (1000 `shots` each) for the SAT baseline circuit. The first line contains the number of counts for the correct state `01`, together with relative frequency, and the second line contains the remaining counts. The data is shown for Sampler mode with *optimization_level* 3 and 0.

Device	opt=3			opt=0		
Emerald	**01: 409 (0.409)**			**01: 241 (0.241)**		
	00: 148	10: 135	11: 308	00: 210	10: 264	11: 285
Garnet	**01: 630 (0.630)**			**01: 509 (0.509)**		
	00: 105	10: 68	11: 197	00: 128	10: 190	11: 173
Sirius	**01: 258 (0.258)**			**01: 260 (0.260)**		
	00: 250	10: 237	11: 255	00: 263	10: 255	11: 222

2 Results for supplementary baseline circuits (SAT and 2-qubit sanity check)

To contextualize the near-uniform Lights Out results on IQM, we summarize the results of running the SAT circuit in Table 1 and small Grover's Search circuit in Fig. 3 on IQM devices, and on IBM devices in Table 2.

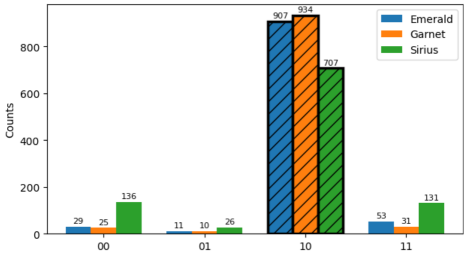

Fig. 3: Measured output distributions (1000 `shots` each) on IQM devices for supplementary diagnostic baseline 2-qubit circuit. Expected output is state `10`.

Table 2: Measured output distributions (4000 `shots` each) for the SAT baseline circuit. The first line contains the number of counts for the correct state `01`, together with relative frequency, and the second line contains the remaining counts. The data is shown for Sampler mode with *optimization_level* 3 and 0.

Device	opt=3	opt=0
ibm_marrakesh	**01: 3176 (0.794)**	**01: 2956 (0.739)**
	00: 347 10: 167 11: 310	00: 353 10: 267 11: 424
ibm_fez	**01: 2973 (0.743)**	**01: 1478 (0.370)**
	00: 346 10: 206 11: 475	00: 517 10: 475 11: 1530
ibm_torino	**01: 2954 (0.739)**	**01: 2424 (0.606)**
	00: 255 10: 208 11: 583	00: 780 10: 340 11: 456