Error Correction 2

To build a fault-tolerant quantum computer, it is essential to extract information about quantum errors without destroying the state of the system. The surface code has become of major interest due to its ability to perform quantum non-demolition measurements and its scalability to any qubit network size.
We first take a look at the implementation of a parity check protocol (PCP) on two code qubits via the high-fidelity measurement of a third syndrome qubit. This is achieved by the deterministic entanglement of the two code qubits through measurement of the syndrome qubit in an either even or odd parity bell state which is conditioned on the syndrome qubit state. Another implementation allows for the simultaneous detection of both bit-flip and phase-flip errors on a pair of code qubits. This requires two syndrome qubits. Via XX and ZZ parity checks, the entangled state of the code qubits can be extracted without directly measuring it.
Another important feature for quantum computation is the reliability of quantum gates. These gates can be characterized by means of randomized benchmarking, where long sequences of quantum gates are applied to one or multiple qubits. By comparing the expected with the actual outcome, the fidelity of the gates can be extracted.