ABSTRACT

Quantum communications are vulnerable to the error when interacting with the environment and are suffering from three kinds of error, i.e., qubit-flip (Pauli **X**), phase-flip (Pauli **Z**), and both qubit-flip and phase-flip (Pauli **Y**). The main difference between the classical and quantum communications is on the use of information representation, where the classical communications use bits ”0” and ”1”, while quantum communications use a quantum bit (qubit) ”$|\psi\rangle$” as a superposition of quantum basic states. This thesis proposes quantum accumulate codes protecting $k = 2$ information qubits using stabilizers derived from the classical accumulate codes because accumulators provide good performances and have low hardware complexity.

The proposed quantum accumulates codes become one of the codes close to the perfect quantum codes by satisfying both the quantum Hamming bound and quantum Singleton bound. This thesis first studies the encoding and decoding construction of quantum accumulate codes with 5 qubits to observe the behavior of quantum accumulate codes with small complexity while keeping good performance. The theoretical error performances are evaluated under quantum depolarizing channels.

This thesis has successfully constructed 5-qubit quantum accumulate codes for $k = 1$, as a starting point, resulting in the smallest perfect quantum codes, of which the performances have been verified using a series of computer simulations and found to agree with the theoretical quantum word error rate (QWER) for $k = 1$. This thesis has also successfully constructed 12-qubit quantum accumulate codes for $k = 2$ using several steps, where 10 stabilizers are obtained based on the classical double-accumulator. The validity of the codes is confirmed, but some similar syndromes are still found causing the QWER performances for $k = 2$ to be worse than the theoretical error of 12-qubit. This thesis found that: (i) the modulo 2 of the symplectic inner product (SIP) of any stabilizers should be zero and (ii) the reduced-row echelon form (RREF) parity check matrix of new quantum codes should be an integer or close to an integer. All related results of this thesis are expected to open the new ground of the development of quantum accumulate codes to be scaled and/or concatenated with the existing quantum codes.

Keywords: Accumulate, Quantum, Qubits, Syndrome.