ABSTRACT

This thesis proposes quantum error correction codes (QECCs) suitable for the quantum key distribution (QKD) over the longest distance Indonesia of 5300 km from Sabang to Merauke. Indonesia needs a QKD satellite-based system to cover the long distance of 5300 km, because it is impractical to use fiber optics. Optical fiber requires an amplifier to increase the transmission distance, since quantum systems (qubits) cannot be amplified, because it destroys the transmitted quantum states. However, satellite-based systems also face challenges in atmospheric turbulence causing QKD systems to experience high errors. Therefore, we propose the design of a QECC with a high coding rate to enhance the secret key generation of QKD.

This thesis involves three steps: (i) this thesis determines the required block length N for the proposed QECC scheme and evaluates its performance through computer simulations; (ii) this thesis considers quantum stabilizer codes with high coding rates, derived from classical QC-LDPC codes of the fifth generation of telecommunication (5G) New Radio (NR), which are known to have good performance in classical communications; (iii) this thesis uses the BB84 QKD protocol with QECC to demonstrate the applicability of the proposed quantum $[[9,4,3]]$ QC-LDPC codes that enhance the security framework of the system.

The proposed quantum $[[9,4,3]]$ QC-LDPC codes protect up to $K = 4$ qubits information, outperforming the capabilities of Shor codes. The result of computer simulations confirms that the proposed QECC outperforms existing Shor codes and uncoded systems with the same block-length $N = 9$ in terms of secret key rate (SKR), even in worst-case channel conditions. The result of this thesis is expected to introduce new possibilities for quantum codes derived from classical codes for QKD systems. The results of this thesis are also expected to contribute to the evolution of quantum communication research, emphasizing robustness and security for secure future communications in Indonesia.

Keywords: Quantum Error Correction Codes (QECC), Quantum QC-LDPC, Quantum Key Distribution (QKD), Quantum Satellite.