Q-OFDM Scheme Implementation in Quantum Communication Protocol

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Abstract: Recent integration of Quantum Orthogonal Frequency Division Multiplexing (Q-OFDM) in communication protocol seems ground-breaking to address the solution of the challenges of less robustness, low quality spectral efficiency and low latency in the scheme. Mitigating the bit error rate (BER) is the additional advantage in such modern technology of communication. To investigate its effectiveness, the report proposes the Q-OFDM protocol with comparative analysis on the measured dataset with the reference communication (RC) scheme. The work encompasses Quirk-E simulation platform to obtain output dataset for numerous qubit states over two different rotational angles measured on x-axis ($20°$ and $45°$). The outcome indicates a significantly higher probability count of correctly measured quantum states for all experimental states of Q-OFDM protocol over RC scheme.

Keywords: Q-OFDM, RC, Quantum communication, QFT

Introduction

A notable progress in communication mechanism, introducing the quantum optimization principles by engaging the concept of entanglement and superposition in network protocol is offered by quantum communication. Quantum communication technique harness the effectiveness of information providing significantly faster bit transformation with high accuracy. The following design exploits uniform qubit states to revolutionize the technological adaptation by improving additional security in information transmission with optimized error probability. Such quantum protocol illustrates the communication scheme formation driving into the advance technology fusion with numerous sets of communication channels to quantum key distribution (QKD).

OFDM is beneficial to implement significant accuracy in qubit transition than conventional communication system [1]. OFDM specified channels carry more encoded information which is expected to organize desired computational task. It exhibits potential uniformity dealing with small channel imperfections by offering the alternate direction improving the reliability of communication networks.

Q-OFDM accelerates the traditional OFDM technique with advanced functioning by carefully reducing the BER. Q-OFDM imposes the error correction reliably over noise prone decoherence enveloping the signal in numerous frequency multiplexed domain. The process is considered to be a breakthrough to deliver faster and accurate bit transformation introducing QFT (Quantum Fourier Transform) and IQFT

(Inverse Quantum Fourier Transform) across the protocol to encode and decode the signal message respectively with a clear reduction of circuit complexity [2].

Related work

Anand and Kolusu explained a quantum circuit design in communication technology fusing CDMA with QFT-IQFT process to show improvement in terms of data security enabling the transformation of thee signal among multi-user aspects protecting data against eavesdropping [3]. Cao et al. [4] works on the QFT attached quantum teleportation technique permitting effective teleportation on encoded and decoded qubit states simultaneously. Mohammadbagherpoor et al. [5] finds the accuracy enrichment of estimated quantum phase by introducing QFT in measurement. The approach of distributed quantum key application for performance improvement of quantum communication has been revealed by Bahrini et al [6]. In their report, it has been shown that Q-OFDM assisted QKD ensures a protected network to developing an advanced quality and improved capacity of quantum channel. The work leads towards lowering of noise decoherence in encrypted network layers with application of QFT based distribution.

Key Contribution

Based on the survey carried out on the advent of Quantum mechanical paradigm, our work endeavours the pioneering conceptualization of Q-OFDM analogy that claims to verify the following scheme advancing analogical development in terms of accurate determination of probability count. Different input states have been considered to observe the performance metrics of Q-OFDM in comparison to RC scheme. The phase angles are simulated to validate the outcome as rotational aspects which is crucially instrumental to rectify the conditions of input states through adjustment of probability amplitude. The work replicates impactful robustness opening promising avenue on data transmission.

Method and Experiments

The transmission efficiency of the Q-OFDM protocol are illustrated against a standard RC scheme based on the probability of correct qubit transmission in the Quirk-E simulation platform. Quirk-E is an open-source quantum circuit simulator well equipped with a broad set of components for quantum computation modeling. Supporting up to 20 qubits, the simulator offers a relatively larger state space than traditional quantum mechanical composers, alongside real-time diagnostic displays—such as state amplitudes, Bloch spheres, and density matrices [7].

In present investigation, Quirk-E is said to be introduced to design a 4-qubit Q-OFDM schem inserting the QFT-IQFT mechanism. Phase rotation operators expressing quantum channel deterioration are placed between the IQFT and QFT operation prior to measurement. For comparison, the RC scheme imposes the same phase rotation operators directly to the 4-qubit input state in the absence of IQFT-QFT operations before measurement. The work is framed to exhibit that Q-OFDM outperforms the RC protocol in terms of the performance across CQDMP (correct qubit decoding measurement probability).

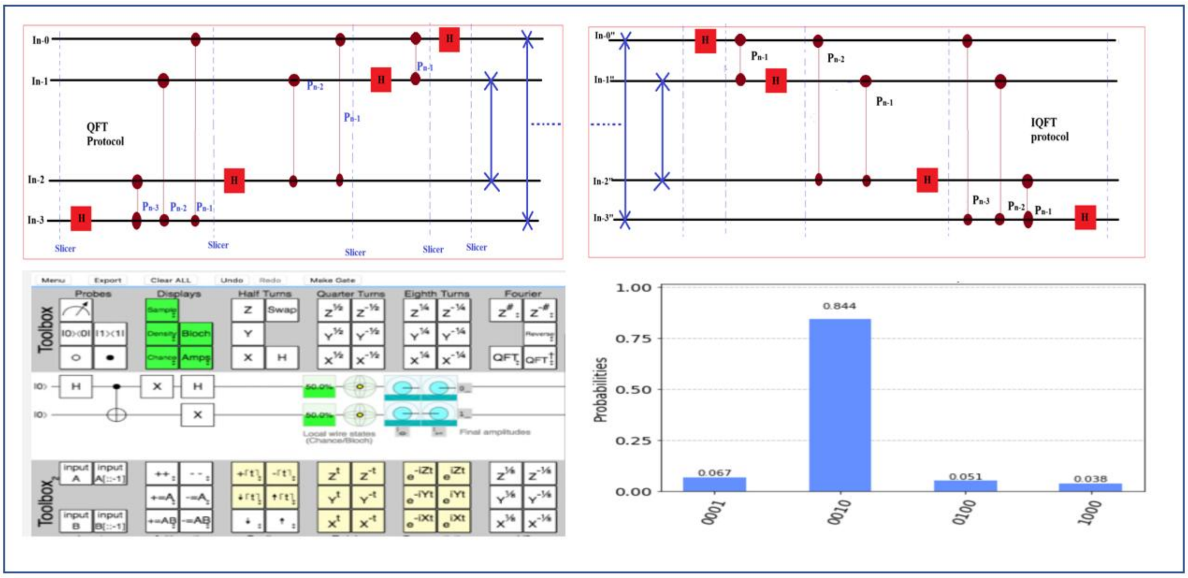

Fig.1 Pictorial illustration of QFT-IQFT design with implementation in Quirk-E simulation platform

Results and discussions

Qubit states are randomly chosen to employ on both Q-OFDM and RC scheme [8-9]. The rotational orientation is formed in projected circuit shown in Fig.1. Four Inputs (I-1, I-2, I-3 and I-4) are undergone in phase rotational displacement θ_t at angles 20^0 and 45^0 consecutively. Subsequent obtained CQDMP values are found in percentage. The measurement indicates the correctness probability of decoded output for respective input quantum states utilized in transition protocol. The comparison outcome has been given in Table.1 and Table.2.

Table-1 comparative study of measured CQDMP % of Q-OFDM and RC scheme for θ_t (=20^0) modelled on Bloch sphere

Input Quantum states	CQDMP% of Q-OFDM	CQDMP% of RC	Improvement obtained in Q-OFDM
$\|0000\rangle$	97.75	96.99	0.77%
$\|0011\rangle$	94.43	91.23	3.57%
$\|1011\rangle$	94.25	91.21	3.32%
$\|1100\rangle$	94.83	94.07	0.81%
$\|1110\rangle$	95.33	91.24	4.51%
$\|1111\rangle$	96.17	88.48	8.69%

Table-2 comparative study of measured CQDMP % of Q-OFDM and RC scheme for θ_t (=20^0) modelled on Bloch sphere

Input Quantum states	CQDMP% of Q-OFDM	CQDMP% of RC	Improvement obtained in Q-OFDM
$\|0000\rangle$	89.02	85.36	4.30%
$\|0011\rangle$	76.57	62.22	23.04%
$\|1011\rangle$	74.78	62.15	20.24%
$\|1100\rangle$	76.47	72.85	4.97%
$\|1110\rangle$	77.34	62.18	24.37%
$\|1111\rangle$	81.97	53.07	54.44%

The result derived from the dataset output clearly signifies accuracy improvement in amplitude probability count. The comparative data shows uniform nature that attributes the outperformance of QFT-IQFT driven Q-OFDM scheme for all input states of both rotational angles. Highest approximated CQDMP% in Table-1 is 8.69% which has been found in $|1111\rangle$ state whereas the percentage improvement extends up to 54.44% for the same state when it is measured for θ_t = 45^0. On the other hand, less amplitude fluctuation in CQDMP% is noted for small rotation in both schemes. But a dramatic variation has been encountered for relatively high θ_t that leads significant collapse of probability count for RC protocol. Such crucial disparity showcases the robustness Q-OFDM in mitigating the noise decoherence with correctness improvement in signal transmission.

Conclusion

A novel Q-OFDM transmission system has been undertaken by leveraging QFT modeling. The comparative analysis outcome accentuates improved transmission accuracy of the quantum driven procedure over traditional RC protocol. Randomly chosen qubits inputs have been allowed to go through rotational orientation distinctly at 20^0 and 45^0 phase angles. The outcome has been compiled through Quirk-E simulation, outcome of which displays efficient data transmission capability of Q-OFDM. A stark differentiation in the performance of Q-OFDM protocol is clearly observed that exhibits maximum 8.69% (for 20^0 phase angle rotation) and 54.44% (for 45^0 phase angle rotation) improvement in determined CQDMP% value that concludes enhanced stability and notable fidelity in the designed communication protocol.

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