**Documentation for Running Shor’s Algorithm with Qiskit**

**1. Source of the Algorithm**

The implementation of Shor’s algorithm used in this project was sourced from the official Qiskit Textbook repository. The specific notebook containing the Shor's algorithm is available at the following GitHub link:

**GitHub Link:** [Shor’s Algorithm - Qiskit Textbook](https://github.com/Qiskit/textbook/blob/main/notebooks/ch-algorithms/shor.ipynb)

**2. Development Environment Setup**

To run Shor’s algorithm, the following setup was used:

* **IDE:** Visual Studio Code (VS Code)
* **Python Environment:** A virtual environment was created to ensure that the dependencies are isolated and compatible with the project.

**3. Setting Up the Virtual Environment**

Follow these steps to create a virtual environment in VS Code and activate it:

* Open VS Code and navigate to your project folder.
* Create a virtual environment by running the following command in the terminal:

bash

python -m venv venv

This creates a folder named venv in your project directory which contains the isolated environment.

* To activate the virtual environment:
  + On **Windows**:

bash

.\venv\Scripts\activate

* + On **macOS/Linux**:

bash

source venv/bin/activate

**4. Installing Required Packages**

The project relies on several libraries from Qiskit and other dependencies. These can be installed using pip by running the following command:

bash

pip install qiskit numpy matplotlib

* qiskit: The core library for quantum computing and working with quantum circuits.
* numpy: A fundamental package for scientific computing in Python, used for numerical operations.
* matplotlib: A plotting library for visualizing the results.

After running the above command, the necessary packages will be installed in your virtual environment.

**5. Imported Modules**

The following Python modules were imported in the Shor’s algorithm script:

python

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import qiskit

import numpy as np

import matplotlib.pyplot as plt

from qiskit import Aer, QuantumCircuit, transpile, assemble

from qiskit.aqua.algorithms import Shor

from qiskit.utils import QuantumInstance

from qiskit.providers.aer import AerSimulator

**Explanation of Modules:**

* **qiskit:** The core library for working with quantum circuits and algorithms.
* **numpy:** A fundamental package for scientific computing in Python, used for numerical operations.
* **matplotlib:** A plotting library for creating visualizations of the results.
* **Aer:** A provider in Qiskit used for simulating quantum circuits.
* **QuantumCircuit:** A class in Qiskit for creating quantum circuits.
* **Shor:** The implementation of Shor’s algorithm from Qiskit Aqua.
* **QuantumInstance:** Provides a convenient interface to execute quantum algorithms on a backend.

**6. Modifications to the Original Code**

* **Modifications:**
  + Adjusted the quantum circuit configurations to tailor the algorithm to my environment and experiment.
  + Changed parameters and added necessary setup steps to execute the algorithm on a local simulator.
* **Original Code Source:** The code was initially sourced from the Qiskit Textbook Shor’s algorithm notebook, but modifications were made to adapt the code to the specific quantum environment (simulator or real quantum device) used.

**7. Running Shor’s Algorithm**

After setting up the virtual environment and installing the required libraries, the following steps were followed to execute Shor’s algorithm:

1. **Create the Quantum Circuit:** A quantum circuit was created for the quantum operations involved in Shor's algorithm.
2. **Select the Backend:** The algorithm was run using a simulator. The AerSimulator was used in this case, but if a real quantum device is available, a real quantum backend can be chosen.
3. **Execution of the Algorithm:** Shor’s algorithm was executed with the provided input number (e.g., 15) on the chosen simulator. The result was the factorization of the input number.
4. **Result Analysis:** After execution, the results were analyzed, and the factors of the number were retrieved.
5. **Qiskit version:** 1.2.4

**8. Conclusion**

By following the above steps, Shor’s algorithm was successfully executed in a local virtual environment. The algorithm was run using Qiskit’s AerSimulator, and modifications were made to fine-tune the quantum circuit and execution settings. The results were displayed, showcasing the ability of Shor’s algorithm to factorize large numbers efficiently on a quantum computer.