Lab4 - Simple Quantum Walk on a circle

Exercise T1 THEORY

We consider simple quantum walk example on a 4-point circle.

After applying H coin and the step gates, walker state changes according the following:

|position> ⊗ |0> becomes \( \frac{1}{\sqrt{2}} (|\text{position}-1> \otimes |0> + |\text{position}+1> \otimes |1>) \)

|position> ⊗ |1> becomes \( \frac{1}{\sqrt{2}} (|\text{position}-1> \otimes |0> - |\text{position}+1> \otimes |1>) \)

Calculate walker state after applying H coin and step gates once and twice.

Exercise Q1 QUIDE

Implement increment gate for two qbit x register in QUIDE. Observe that the gate acts on X register in a way:

|00>-> |01>-> |10>->|11>->|00> etc.
Exercise Q2 QUIDE
Implement decrement gate for two qbit x register in QUIDE. Observe that the gate acts on X register in a way:
\(|00\rangle \rightarrow |11\rangle \rightarrow |10\rangle \rightarrow |01\rangle \rightarrow |00\rangle \text{ etc.}

Exercise Q3 QUIDE
Implement quantum walk step on a 4-point circle according to the circuit:
Fill the table and check with your calculations from exercise 1

<table>
<thead>
<tr>
<th>Probability of finding walker at position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of steps</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

The exercise is a simple example of a walk, but more complex quantum walks can be used for image processing.

**Exercise I1 IBM**
Run IBM circuit implementing Toffoli gate with flips. Add more gates to build and test increment gate.

**Exercise I2 IBM (Optional)**
Using results from exercise I2 try to build decrement gate and perform one step of quantum walk. Compare results of the IBM simulator and real device.