Contents

Chapter 1

Part A

1.1 A Main Code

```
@qfunc
def main(cntrl: Output[QArray[QBit]], target: Output[QBit]) -> None:
    allocate(5, cntrl)
    allocate(1, target)
    control(ctrl=cntrl, operand=lambda: X(target))
```

✓ 0.0s

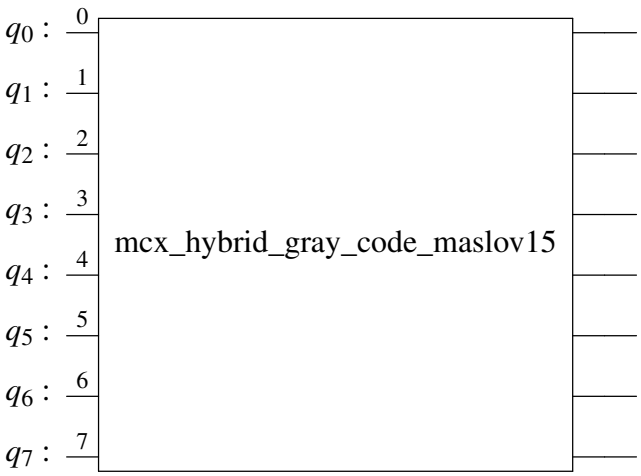
Figure 1.1: A Main Code

1.2 A.1 Code

```
quantum_model = create_model(main)
quantum_model_with_constraints_1 = set_constraints(
    quantum_model,Constraints(optimization_parameter='depth'),
)
quantum_program = synthesize(quantum_model_with_constraints_1)
circuit_width = QuantumProgram.from_qprog(quantum_program).data.width
circuit_depth = QuantumProgram.from_qprog(quantum_program).transpiled_circuit.depth
print('width: ',circuit_width)
print('depth',circuit_depth)
```

Figure 1.2: A-1 Code

1.3 A.1 Output

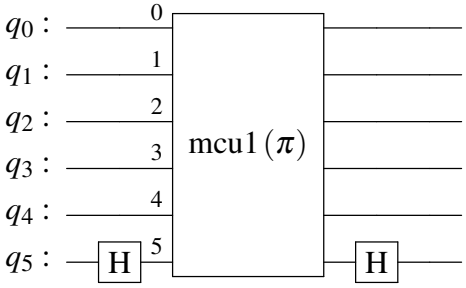


1.4 A.2 Code

```
quantum_model_with_constraints_2 = set_constraints(
    quantum_model,Constraints(optimization_parameter='width'),
)
quantum_program = synthesize(quantum_model_with_constraints_2)
circuit_width = QuantumProgram.from_qprog(quantum_program).data.width
circuit_depth = QuantumProgram.from_qprog(quantum_program).transpiled_circuit.depth
print('width: ',circuit_width)
print('depth',circuit_depth)
```

Figure 1.3: A-2 Code

1.5 A.2 Output

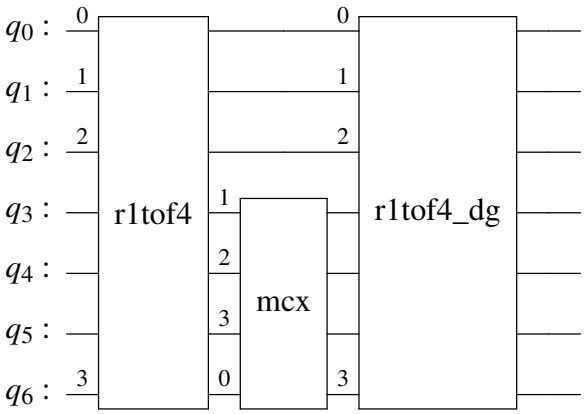


1.6 A.3 Code

```
quantum_model_with_constraints_3 = set_constraints(
    quantum_model,Constraints(optimization_parameter='depth',max_width=7),
)
quantum_program = synthesize(quantum_model_with_constraints_3)
circuit_width = QuantumProgram.from_qprog(quantum_program).data.width
circuit_depth = QuantumProgram.from_qprog(quantum_program).transpiled_circuit.depth
print('width: ',circuit_width)
print('depth',circuit_depth)
```

Figure 1.4: A-3 Code

1.7 A.3 Output



1.8 Output Result Differences

- **A1 Case:** Here, we focused on minimizing the depth of the circuit , resulting in shallow but wider circuit.In this case, we got Width = 8 and depth = 34. Means, 8 qubits are involved in simultaneous operation and 34 operations are needed to complete the circuit.
- **A2 Case:** Here, we focused on minimizing the width of the circuit, sacrificing the depth, resulting in deeper circuit. Here , we got width=6 and depth=117. Means, 6 qubits are involved in simultaneous operation and 117 operations are needed to complete the circuit , results in a deeper circuit.
- **A3 Case:** Here, we focused on a moderate circuit, balancing between width and depth optimization. In this case, we got width=6 and depth=51 , which is a balance of previous two case.

Chapter 2

Part B

2.1 B Main Code

```
@qfunc
def main(cntrl: Output[QArray[QBit]], target: Output[QBit]) -> None:
    allocate(20, cntrl)
    allocate(1, target)
    control(ctrl=cntrl, operand=lambda: X(target))
```

✓ 0.0s

Figure 2.1: B Main Code

2.2 B.1 Code

```
quantum_model = create_model(main)
quantum_model_with_constraints_1 = set_constraints(
    quantum_model,Constraints(optimization_parameter='depth'),
)
quantum_program = synthesize(quantum_model_with_constraints_1)
circuit_width = QuantumProgram.from_qprog(quantum_program).data.width
circuit_depth = QuantumProgram.from_qprog(quantum_program).transpiled_circuit.depth
print('width: ',circuit_width)
print('depth',circuit_depth)
```

✓ 7.3s

```
width:  30
depth 66
```

Figure 2.2: B-1 Code

2.3 B.2 Code

```
quantum_model = create_model(main)
quantum_model_with_constraints_1 = set_constraints(
    quantum_model,Constraints(optimization_parameter='width'),
)
quantum_program = synthesize(quantum_model_with_constraints_1)
circuit_width = QuantumProgram.from_qprog(quantum_program).data.width
circuit_depth = QuantumProgram.from_qprog(quantum_program).transpiled_circ
print('width: ',circuit_width)
print('depth',circuit_depth)
✓ 5.5s
```

Figure 2.3: B-2 Code

2.4 Output Result Differences

- **B1 Case:** Here, we focused on minimizing the depth of the circuit , resulting in shallow but wider circuit.In this case, we got Width = 30 and depth = 66. Means, 30 qubits are involved in simultaneous operation and 66 operations are needed to complete the circuit.
- **B2 Case:** Here, we focused on minimizing the width of the circuit, sacrificing the depth, resulting in deeper circuit. Here , we got width= 22 and depth=1894. Means, 22 qubits are involved in simultaneous operation and 1894 operations are needed to complete the circuit , results in a deeper circuit.