

Multi qubit Gates

Aug 24, 2024

Last time:

CNOT or CX



CX (0,1)

I/P	O/P
$ 00\rangle$	$ 00\rangle$
$ 01\rangle$	$ 11\rangle$
$ 10\rangle$	$ 10\rangle$
$ 11\rangle$	$ 01\rangle$

$$|00\rangle = |0\rangle \otimes |0\rangle$$

CZ or CPHASE*

When ctrl'd bit is $|1\rangle$,

operate Z-gate on target bit

→ change sign/phase of the state

CX

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

CZ or CPHASE*

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$$

When ctrl bit is $|1\rangle$,

operate Z-gate on target bit

→ change sign/phase of the state

$CZ(0,1)$

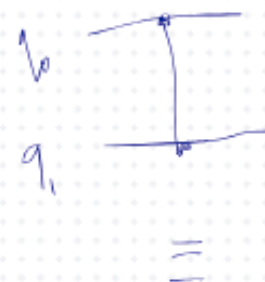
I	O
$ 00\rangle$	$ 00\rangle$
$ 01\rangle$	$ 01\rangle$
$ 10\rangle$	$ 10\rangle$
$ 11\rangle$	$- 11\rangle$

Read state / ket
Right to Left

Z-gate

$$\begin{aligned} Z|0\rangle &= |0\rangle \\ Z|1\rangle &= -|1\rangle \end{aligned}$$

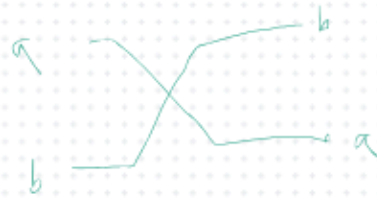
$$CZ(0,1) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$



Ex 6

Show $CZ(0,1)$
 $= CZ(1,0)$

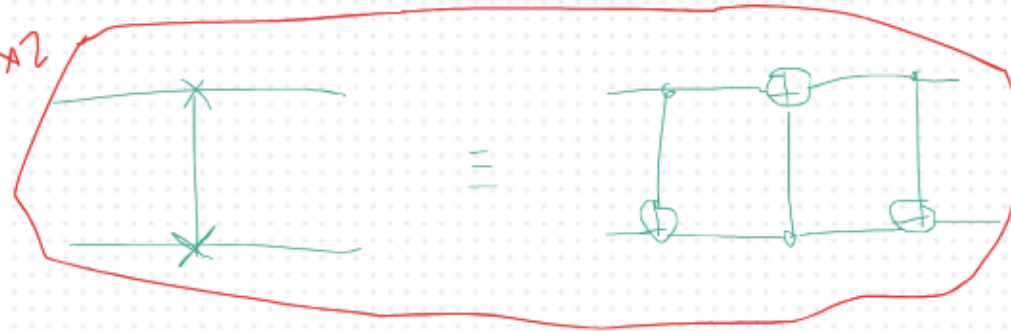
Swap



$$|01\rangle \rightarrow |10\rangle$$

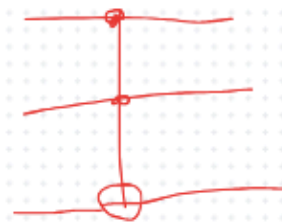
Symbol

Ex2

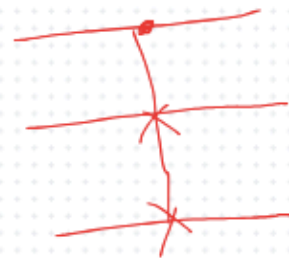


3-qubit gates

① Toffoli gate



② Fredkin gate



swap