

# The tikz-quantumgates Package: Drawing quantum circuits with TikZ

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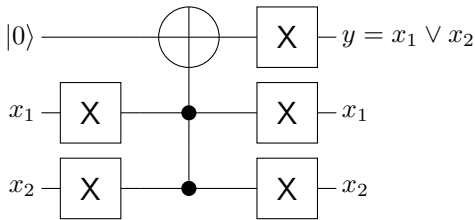
BTU Cottbus-Senftenberg

August 22, 2018

See <https://github.com/matthias-wolff/tikz-quantumgates/blob/master/tikz-quantumgates.pdf> for the latest version of this document.

## Abstract

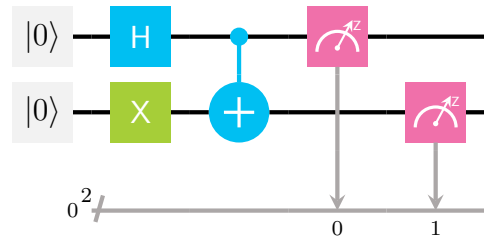
This package provides macros for drawing quantum gates and circuits with TikZ [1].



```

1 \documentclass{standalone}
2 \usepackage{tikz-quantumgates}
3 \begin{document}
4   \centering
5   \begin{tikzpicture}
6     \node[anchor=west] at (-0.6,2) {$|0\rangle$};
7     \node[anchor=west] at (-0.6,1) {$x_1$};
8     \node[anchor=west] at (-0.6,0) {$x_2$};
9     \qwire{0}{2}\qgateX{0}{1}\qgateX{0}{0}
10    \qgateCNC{b}{1}{2}\qgateCNC{bt}{1}{1}\qgateCNC{t}{1}{0}
11    \qgateX{2}{2}\qgateX{2}{1}\qgateX{2}{0}
12    \node[anchor=west] at (3.2,2) {$y=x_1 \vee x_2$};
13    \node[anchor=west] at (3.2,1) {$x_1$};
14    \node[anchor=west] at (3.2,0) {$x_2$};
15  \end{tikzpicture}
16 \end{document}

```



```

1 \documentclass{standalone}
2 \usepackage{tikz-quantumgates}
3 \begin{document}
4   \centering
5   \begin{tikzpicture}
6     \node[anchor=west] at (0.6,-0.3) {\footnotesize 0};
7     \qzero{ibmqx}{0}{2}\qzero{ibmqx}{0}{1}
8     \qgateH{ibmqx}{1}{2}\qgateX{ibmqx}{1}{1}\qmeasBh{ibmqx}{2}{1}{0}
9     \qgateCNC{ibmqx}{b}{2}{2}\qgateCNC{ibmqx}{t}{2}{1}\qmeasB{ibmqx}{2}{0}
10    \qmeasM{ibmqx}{3}{2}\qmeasR{ibmqx}{3}{1}\qmeasMB{ibmqx}{0}{3}{0}
11    \qwire{ibmqx}{4}{2}\qmeasM{ibmqx}{4}{1}\qmeasMB{ibmqx}{1}{4}{0}
12  \end{tikzpicture}
13 \end{document}


































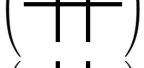








```

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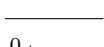



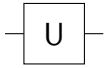

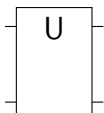
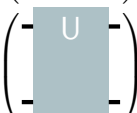
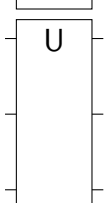
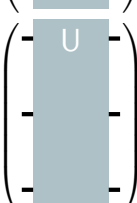
# 1 Overview

## 1.1 List of Circuit Symbols

| Standard  | Option ibmqx  | Command  |
|---|---|--|
|   |    | <code>\qwire[option]{x}{y}</code>                                      |
| $ 0\rangle$   |    | <code>\qzero[option]{x}{y}</code>                                      |
|    |    | <code>\qgateID[option]{x}{y}</code>                                    |
|    |    | <code>\qgateX[option]{x}{y}</code>                                     |
|    |    | <code>\qgateY[option]{x}{y}</code>                                     |
|    |    | <code>\qgateZ[option]{x}{y}</code>                                     |
|    |    | <code>\qgateH[option]{x}{y}</code>                                     |
|    |    | <code>\qgateS[option]{x}{y}</code>                                     |
|    |    | <code>\qgateSi[option]{x}{y}</code>                                    |
|   |   | <code>\qgateT[option]{x}{y}</code>                                     |
|  |  | <code>\qgateTi[option]{x}{y}</code>                                    |
|  |  | <code>\qgateUa[option]{x}{y}</code>                                    |
|  |  | <code>\qgateUb[option]{x}{y}</code>                                    |
|  |  | <code>\qgateUc[option]{x}{y}</code>                                    |
|  |  | <code>\qgateCNX[option]{cwires}{x}{y}</code>                           |
|  |  | <code>\qgateCNR[option]{x}{y}</code>                                   |
|  |  | <code>\qgateCNC[option]{cwires}{x}{y}</code>                           |
|  |  | <code>\qgateSWt[option]{x}{y}</code> (not an “official” IBM QX symbol) |
|  |  | <code>\qgateSWR[option]{x}{y}</code> (not an “official” IBM QX symbol) |
|  |  | <code>\qgateSWb[option]{x}{y}</code> (not an “official” IBM QX symbol) |
|  |  | <code>\qmeasM[option]{x}{y}</code>                                     |
|  |  | <code>\qmeasR[option]{x}{y}</code>                                     |

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| Standard  | Option <code>ibmqx</code>   | Command   |
|---|---|---|
|  |  | <code>\qmeasMB[option]{b}{x}{y}</code>  |
|  |  | <code>\qmeasB[option]{x}{y}</code>  |
|  |  | <code>\qmeasBh[option]{b}{x}{y}</code>  |
|  |  | <code>\qgateU[option]{x}{y}{label}</code> (not an “official” IBM QX symbol)   |
|  |  | <code>\qgateUu[option]{x}{y}{label}</code> (not an “official” IBM QX symbol)  |
|  |  | <code>\qgateUuu[option]{x}{y}{label}</code> (not an “official” IBM QX symbol) |

## 1.2 Installation

Download `tikz-quantumgates.sty` from [2] file into your project folder and include the package with `\usepackage{tikz-quantumgates}`.

## 2 Documentation of Commands

### 2.1 Wire and State Preparation Symbols

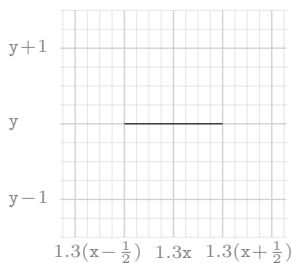
`\qwire[option]{x}{y}`

Draws a wire.

#### Parameters

- `option` Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- `x, y` Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x, y)`.

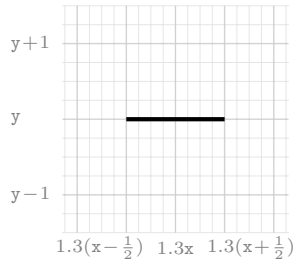
#### Examples



```

1 \begin{tikzpicture}
2   \qScalePaper
3   \qwire{0}{0}
4 \end{tikzpicture}

```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qwire[ibmqx]{0}{0}
4 \end{tikzpicture}
```

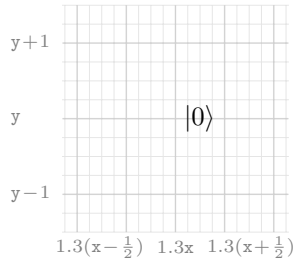
`\qzero[option]{x}{y}`

Draws the zero-state preparator.

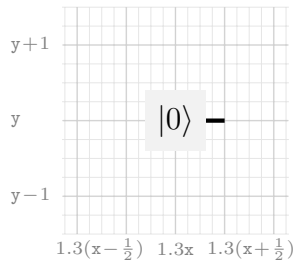
### Parameters

- option** Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- x, y** Position of symbol in schematic. The actual TikZ coordinates are  $(\backslash\text{qgateSx}*x, y)$ .

### Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qzero{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qzero[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## 2.2 Single-Qubit Gate Symbols

`\qgateU[option]{x}{y}{label}`

Draws a general single-qubit quantum gate.

### Parameters

- option** Omit for standard circuit styling or `ibmqxA, ..., ibmqxH` for IBM Q Experience circuit styling. The last letter of `ibmqx*` defines the color of the gate symbol:

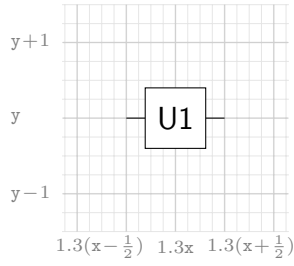
A B C D E F G H

If `ibmqx` is passed, `ibmqxG` will be used.

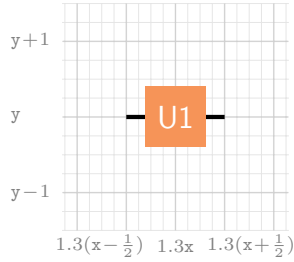
- x, y** Position of symbol in schematic. The actual TikZ coordinates are  $(\backslash\text{qgateSx}*x, y)$ .

- label** Gate label.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateU{0}{0}{U1}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateU[ibmqxA]{0}{0}{U1}
4 \end{tikzpicture}
```

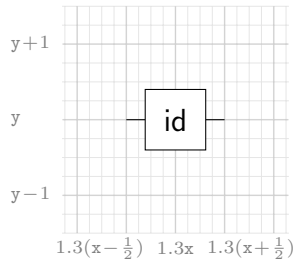
`\qgateID[option]{x}{y}`

Draws the identity gate.

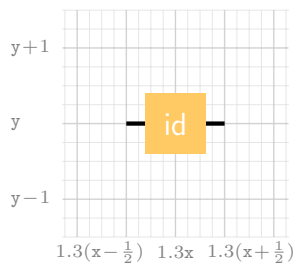
## Parameters

- `option`     Omit for standard circuit styling or `ibmqxA` for IBM Q Experience circuit styling.
- `x, y`       Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateID{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateID[ibmqxA]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$I \doteq \left( \begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & 0 \\ |1\rangle & 0 & 1 \end{array} \right) \quad \text{1} \quad \text{\texttt{\$}\displaystyle I\doteq\qgateOID \$}$$

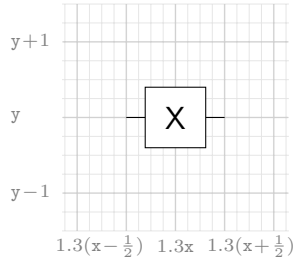
`\qgateX[option]{x}{y}`

Pauli-X gate.

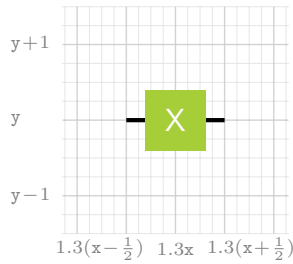
## Parameters

- option**     Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y**       Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateX{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateX[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$X \doteq \begin{pmatrix} & | & \langle 0| & \langle 1| \\ \hline |0\rangle & 0 & 1 \\ |1\rangle & 1 & 0 \end{pmatrix}$$

1 `\displaystyle X\doteq\qgateOX`

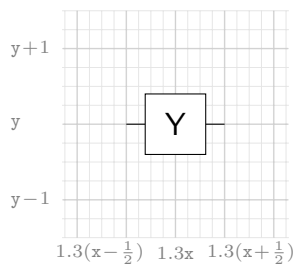
`\qgateY[option]{x}{y}`

Pauli-Y gate.

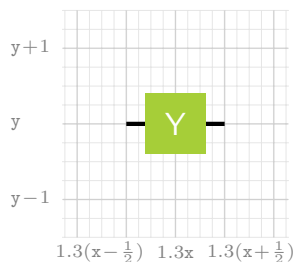
## Parameters

- option**     Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y**       Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateY{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateY[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$Y \doteq \begin{pmatrix} & | & \langle 0| & \langle 1| \\ \hline |0\rangle & 0 & -i \\ |1\rangle & i & 0 \end{pmatrix} \quad \text{1} \quad \text{\textcolor{violet}{$\displaystyle Y\doteq\qgate{0Y}$}}$$

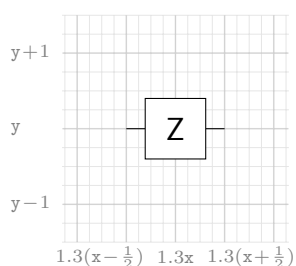
`\qgateZ[option]{x}{y}`

Pauli-Z gate.

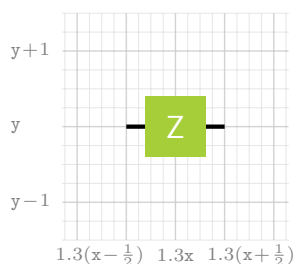
## Parameters

- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y**        Position of symbol in schematic. The actual TikZ coordinates are (`\qgateSx*x,y`).

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateZ{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateZ[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$Z \doteq \begin{pmatrix} & | & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & 0 \\ |1\rangle & 0 & -1 \end{pmatrix} \quad \text{1} \quad \text{\textcolor{violet}{$\displaystyle Z\doteq\qgate{0Z}$}}$$

`\qgateH[option]{x}{y}`

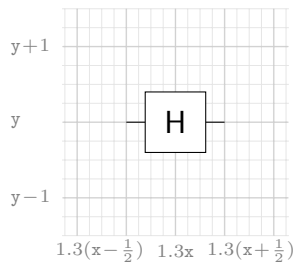
Hadamard gate.

## Parameters

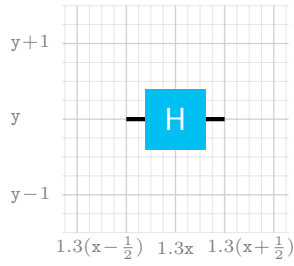
- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y**        Position of symbol in schematic. The actual TikZ coordinates are (`\qgateSx*x,y`).



## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateH{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateH[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$H \doteq \frac{1}{\sqrt{2}} \begin{pmatrix} & \langle 0| & \langle 1| \\ |0\rangle & 1 & 1 \\ |1\rangle & 1 & -1 \end{pmatrix}$$

```
1 $\displaystyle H\qgateOH$
```

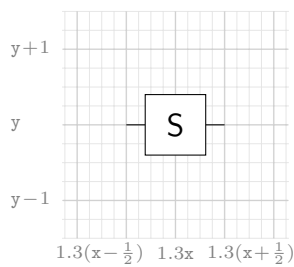
`\qgateS[option]{x}{y}`

S phase gate.

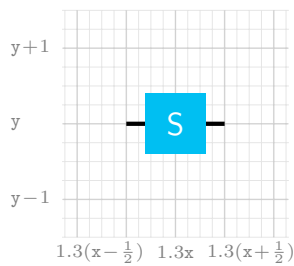
## Parameters

- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- x, y**        Position of symbol in schematic. The actual TikZ coordinates are (`\qgateSx*x, y`).

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateS{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateS[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$S = \sqrt{Z} \doteq \frac{1}{\sqrt{2}} \begin{pmatrix} | & \langle 0| & \langle 1| \\ |0\rangle & 1 & 0 \\ |1\rangle & 0 & i \end{pmatrix}$$

1 `\displaystyle S=\sqrt{Z}\doteq\qgateOS`

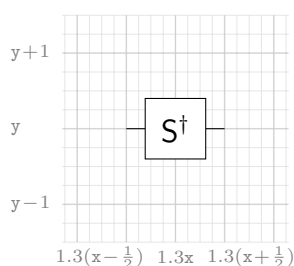
`\qgateSi[option]{x}{y}`

Inverse S phase gate.

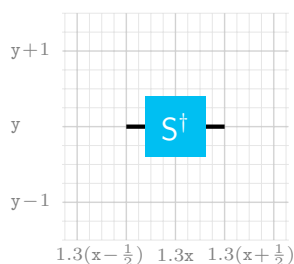
## Parameters

- `option`     Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- `x, y`       Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSi{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSi[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$S^\dagger \doteq \frac{1}{\sqrt{2}} \begin{pmatrix} | & \langle 0| & \langle 1| \\ |0\rangle & 1 & 0 \\ |1\rangle & 0 & -i \end{pmatrix}$$

1 `\displaystyle S^\dagger\doteq\qgateOSi`

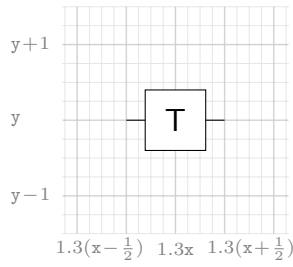
`\qgateT[option]{x}{y}`

T phase gate.

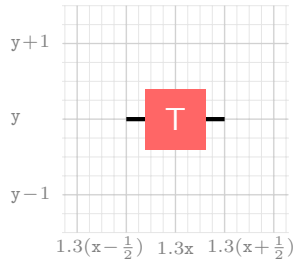
## Parameters

- `option`     Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- `x, y`       Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateT{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateT[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$T = \sqrt{S} \doteq \frac{1}{\sqrt{2}} \begin{pmatrix} | & \langle 0| & \langle 1| \\ \hline \langle 0| & 1 & 0 \\ \langle 1| & 0 & \frac{1}{\sqrt{2}}(1+i) \end{pmatrix}$$

```
1 $\displaystyle T=\sqrt{S}\doteq\qgateOT$
```

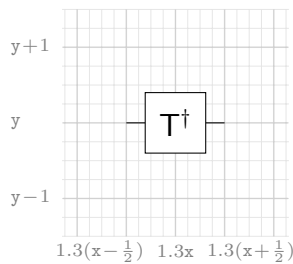
`\qgateTi[option]{x}{y}`

Inverse T phase gate.

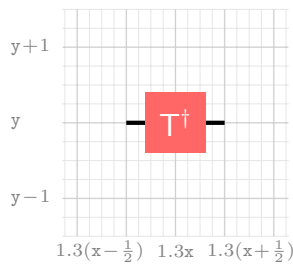
## Parameters

- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- x, y**        Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateTi{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateTi[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$T^\dagger \doteq \frac{1}{\sqrt{2}} \begin{pmatrix} & \langle 0| & \langle 1| \\ |0\rangle & 1 & 0 \\ |1\rangle & 0 & \frac{1}{\sqrt{2}}(1-i) \end{pmatrix} \quad \text{\texttt{\textbackslash doteq\qgateOTi}}$$

## 2.3 Single-Qubit Physical Gate of IBM Q Experience

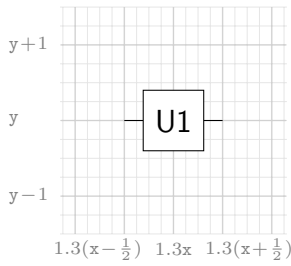
`\qgateUa[option]{x}{y}`

U1 gate of IBM Q Experience.

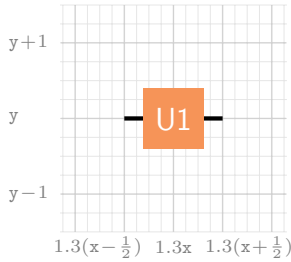
### Parameters

- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y**        Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

### Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUa{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUa[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$U1_\lambda \doteq \begin{pmatrix} & \langle 0| & \langle 1| \\ |0\rangle & 1 & 0 \\ |1\rangle & 0 & e^{i\lambda} \end{pmatrix} \quad \text{\texttt{\textbackslash doteq\qgateOUa}}$$

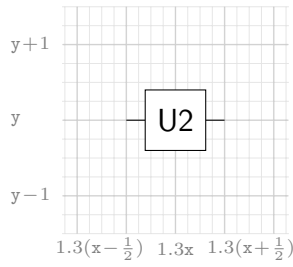
`\qgateUb[option]{x}{y}`

U2 gate of IBM Q Experience.

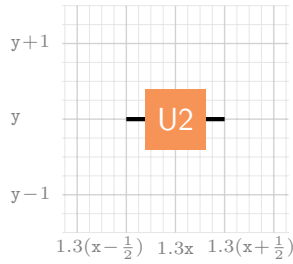
### Parameters

- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y**        Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUb{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUb[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$U_{2,\lambda,\phi} \doteq \frac{1}{\sqrt{2}} \begin{pmatrix} & \langle 0| & \langle 1| \\ |0\rangle & 1 & -e^{\lambda i} \\ |1\rangle & e^{\phi i} & e^{(\lambda+\phi)i} \end{pmatrix}$$

```
1 $\displaystyle U_{2,\{\lambda,\phi\}}\doteq\qgateUb $
```

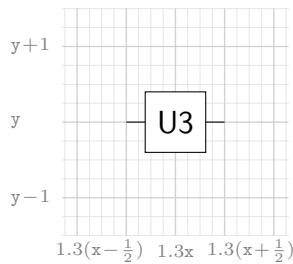
`\qgateUc[option]{x}{y}`

U3 gate of IBM Q Experience.

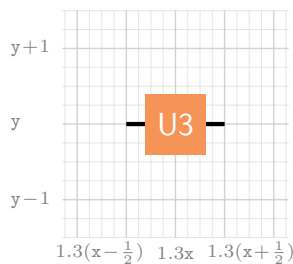
## Parameters

- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- x, y**        Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUc{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUc[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## Gate Operator

$$U_{3\lambda,\phi,\theta} \doteq \begin{pmatrix} & \langle 0| & \langle 1| \\ |0\rangle & \cos(\frac{\theta}{2}) & -\sin(\frac{\theta}{2})e^{\lambda i} \\ |1\rangle & \sin(\frac{\theta}{2})e^{\phi i} & \cos(\frac{\theta}{2})e^{(\lambda+\phi)i} \end{pmatrix} \quad \text{\texttt{\textbackslash displaystyle U3_{\lambda,\phi,\theta}\doteq\qgateUc}}$$

## 2.4 Multiple-Qubit Gate Symbols

`\qgateUu[option]{x}{y}{label}`

General three-qubit gate.

### Parameters

**option** Omit for standard circuit styling or `ibmqxA`, ..., `ibmqxH` for IBM Q Experience circuit styling. The last letter of `ibmqx*` defines the color of the gate symbol:

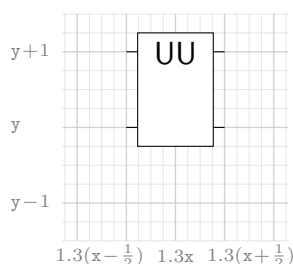
A B C D E F G H

If `ibmqx` is passed, `ibmqxG` will be used.

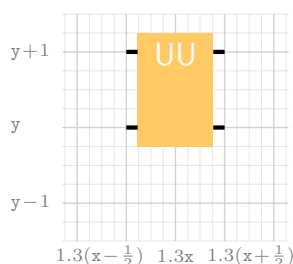
**x, y** Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x, y)`.

**label** Gate label.

### Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUu{0}{0}{UU}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUu[ibmqxB]{0}{0}{UU}
4 \end{tikzpicture}
```

`\qgateUuu[option]{x}{y}{label}`

General three-qubit gate.

### Parameters

**option** Omit for standard circuit styling or `ibmqxA`, ..., `ibmqxH` for IBM Q Experience circuit styling. The last letter of `ibmqx*` defines the color of the gate symbol:

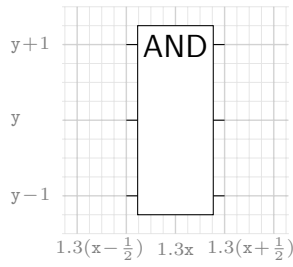
A B C D E F G H

If `ibmqx` is passed, `ibmqxG` will be used.

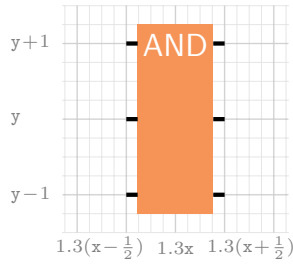
**x, y** Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x, y)`.

**label** Gate label.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUuu{0}{0}{AND}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUuu[ibmqxA]{0}{0}{AND}
4 \end{tikzpicture}
```

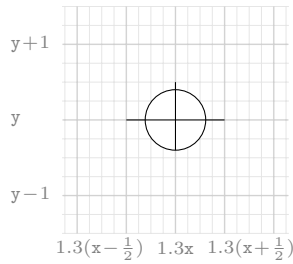
`\qgateCNX[option]{cwires}{x}{y}`

XOR symbol of controlled-NOT gate.

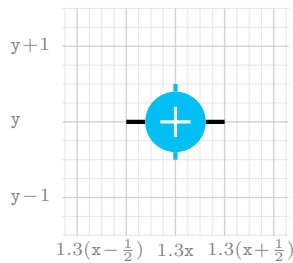
## Parameters

- option**     Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- cwires**     Control wires, `t` for top, `b` for bottom, and `tb` for both sides.
- x, y**        Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNX{t}{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNX[ibmqx]{tb}{0}{0}
4 \end{tikzpicture}
```

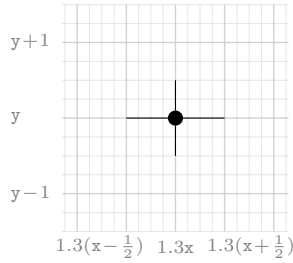
`\qgateCNC[option]{cwires}{x}{y}`

Control qubit symbol of controlled-NOT gate.

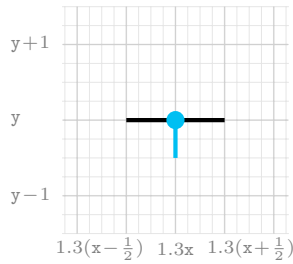
## Parameters

- option** Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- cwires** Control wires, `t` for top, `b` for bottom, and `tb` for both sides.
- x, y** Position of symbol in schematic. The actual TikZ coordinates are  $(\backslash\text{qgateSx}*x, y)$ .

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNC{bt}{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNC[ibmqx]{b}{0}{0}
4 \end{tikzpicture}
```

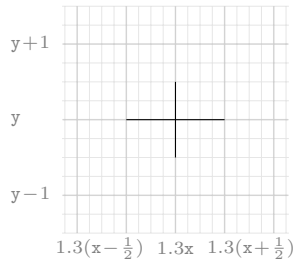
`\qgateCNR[option]{x}{y}`

Run-through qubit symbol of controlled-NOT gate.

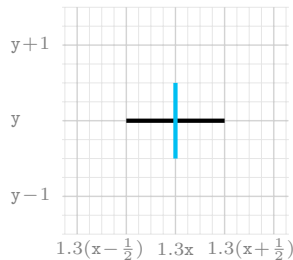
## Parameters

- option** Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- x, y** Position of symbol in schematic. The actual TikZ coordinates are  $(\backslash\text{qgateSx}*x, y)$ .

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNR{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNR[ibmqx]{0}{0}
4 \end{tikzpicture}
```

`\qgateSwT[option]{x}{y}`

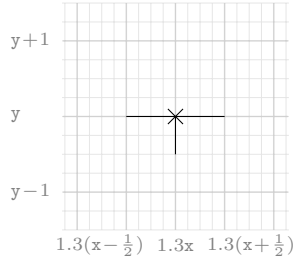
Top qubit of a SWAP gate.



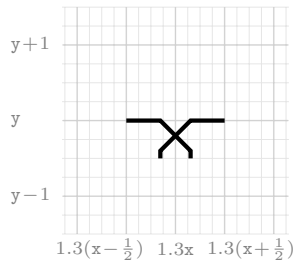
## Parameters

- option** Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y** Position of symbol in schematic. The actual TikZ coordinates are  $(\backslash\text{qgateSx}*x, y)$ .

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSWt{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSWt[ibmqx]{0}{0}
4 \end{tikzpicture}
```

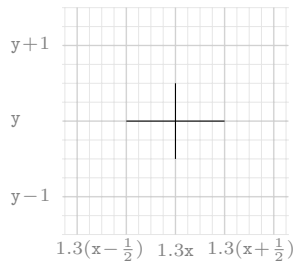
`\qgateSWR[option]{x}{y}`

Run-through qubit of a SWAP gate.

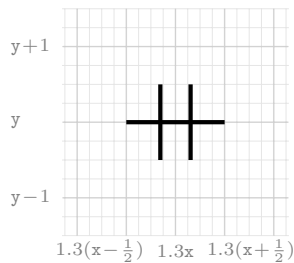
## Parameters

- option** Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y** Position of symbol in schematic. The actual TikZ coordinates are  $(\backslash\text{qgateSx}*x, y)$ .

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSWR{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSWR[ibmqx]{0}{0}
4 \end{tikzpicture}
```

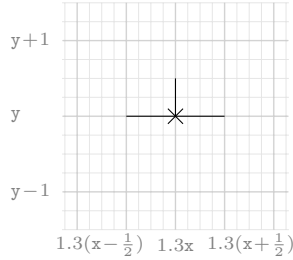
`\qgateSWb[option]{x}{y}`

Bottom qubit of a SWAP gate.

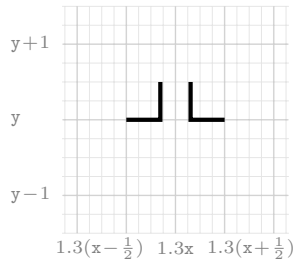
## Parameters

- option** Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- x, y** Position of symbol in schematic. The actual TikZ coordinates are  $(\backslash\text{qgateSx}*x, y)$ .

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSWb{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSWb[ibmqx]{0}{0}
4 \end{tikzpicture}
```

## 2.5 Measurement Symbols

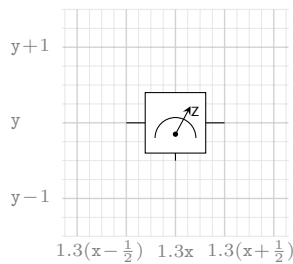
`\qmeasM[option]{x}{y}`

Measurement symbol.

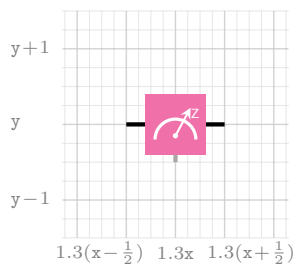
## Parameters

- option** Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- x, y** Position of symbol in schematic. The actual TikZ coordinates are  $(\backslash\text{qgateSx}*x, y)$ .

## Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasM{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasM[ibmqx]{0}{0}
4 \end{tikzpicture}
```

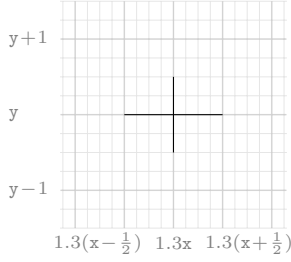
`\qmeaR[option]{x}{y}`

Measurement run-through qubit symbol.

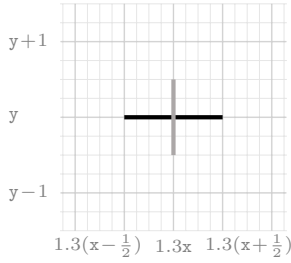
### Parameters

- option**     Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- x, y**       Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

### Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasR{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasR[ibmqx]{0}{0}
4 \end{tikzpicture}
```

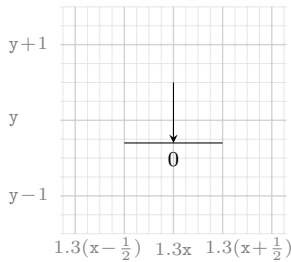
`\qmeasMB[option]{b}{x}{y}`

Measurement-joins-bus symbol.

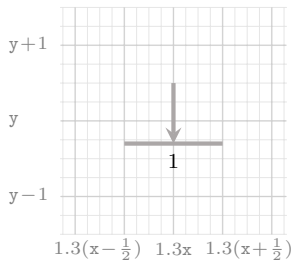
### Parameters

- option**     Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
- b**           Bit identifier on conventional bits bus.
- x, y**       Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

### Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasMB{0}{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasMB[ibmqx]{1}{0}{0}
4 \end{tikzpicture}
```

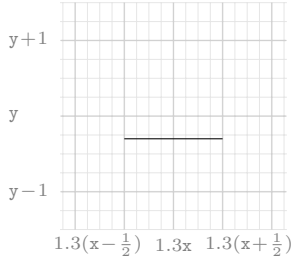
`\qmeaB[option]{x}{y}`

Measurement bus symbol.

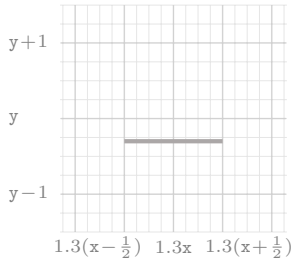
### Parameters

- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y**        Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

### Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasB{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasB[ibmqx]{0}{0}
4 \end{tikzpicture}
```

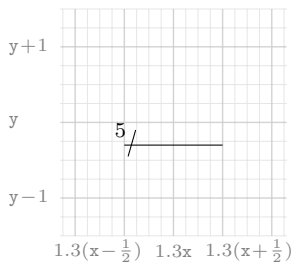
`\qmeaBh[option]{b}{x}{y}`

Measurement bus header symbol.

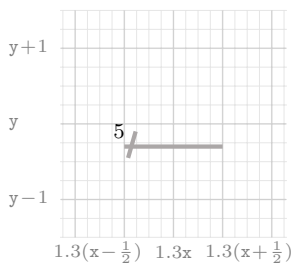
### Parameters

- option**      Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.  
**x, y**        Position of symbol in schematic. The actual TikZ coordinates are `(\qgateSx*x,y)`.

### Examples



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasBh{5}{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasBh[ibmqx]{5}{0}{0}
4 \end{tikzpicture}
```

## 2.6 Further Gate Operators

### CNOT Gate Operator

$$CNOT \doteq \left( \begin{array}{c|cccc} & |00\rangle & |01\rangle & |10\rangle & |11\rangle \\ \hline |00\rangle & 1 & 0 & 0 & 0 \\ |01\rangle & 0 & 1 & 0 & 0 \\ |10\rangle & 0 & 0 & 0 & 1 \\ |11\rangle & 0 & 0 & 1 & 0 \end{array} \right) \quad 1 \text{ }\$ \displaystyle CNOT \backslash \text{doteq} \backslash \text{qgateOCNOT} \$$$

### Toffoli (CCNOT) Gate Operator

$$CCNOT \doteq \left( \begin{array}{c|cccccccc} & |000\rangle & |001\rangle & |010\rangle & |011\rangle & |100\rangle & |101\rangle & |110\rangle & |111\rangle \\ \hline |000\rangle & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ |001\rangle & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ |010\rangle & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ |101\rangle & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ |100\rangle & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ |101\rangle & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ |110\rangle & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ |111\rangle & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{array} \right) \quad 1 \text{ }\$ \displaystyle CCNOT \backslash \text{doteq} \backslash \text{qgateOCCNOT} \$$$

## 3 The Package Source Code

```

1 %% == LaTeX PACKAGE tikz-quantumgates =====
2 %%   Drawing quantum circuits with TikZ
3 %%
4 %% Matthias Wolff, BTU Cottbus-Sentenberg
5 %% August 20, 2018
6 %%
7 %% References:
8 %% [1] T. Tantau. TikZ & PGF - Manual for Version 3.0.1a. 2015.
9 %%   http://mirror.ctan.org/graphics/pgf/base/doc/pgfmanual.pdf Retrieved
10 %%   July 22, 2018.
11 %%
12 %% TODO:
13 %% - Barrier symbols: \qbarrX
14
15 %% == REQUIRED PACKAGES =====
16
17 \RequirePackage{xifthen}
18 \RequirePackage{tikz}
19
20 %% == DEFINITIONS AND COLORS =====
21 \def\qgateSx{1.3}
22
23 \definecolor{ibmqxA}{HTML}{F69458} % IBM QX Ux gate
24 \definecolor{ibmqxB}{HTML}{FFCA64} % IBM QX id gate
25 \definecolor{ibmqxC}{HTML}{A6CE38} % IBM QX Pauli gates
26 \definecolor{ibmqxD}{HTML}{00BFF2} % IBM QX H, S, S' und CNOT gates
27 \definecolor{ibmqxE}{HTML}{FF6666} % IBM QX T und T' gates
28 \definecolor{ibmqxF}{HTML}{F070AA} % IBM QX measurement and if
29 \definecolor{ibmqxG}{HTML}{ADC1C6} % IBM QX barrier
30 \definecolor{ibmqxH}{HTML}{F2F2F2} % IBM QX |0> state
31 \definecolor{ibmqxI}{HTML}{ABA7A7} % IBM QX measurement wire
32
33 %% == COMMANDS =====
34
35 % Wire
36 \newcommand{\qwire}[3]{}{\%
37   \pgfmathsetmacro\x{\qgateSx*(#2)}
38   \pgfmathsetmacro\y{(#3)}
39   \ifthenelse{\isin{ibmqx}{#1}}{\%
40     \tikzset{lstyle/.style={ultra thick,line cap=butt}}

```

```

41 }{%
42   \tikzset{lstyle/.style={}}
43 }%
44 \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
45 }}
46
47 % Zero state preparator
48 \newcommand{\qzero}[3][]{\%
49   \pgfmathsetmacro\x{\qgateSx*(#2)}
50   \pgfmathsetmacro\y{(#3)}
51   \ifthenelse{\isin{ibmqx}{#1}}{%
52     \draw[ultra thick,line cap=butt] (\x+0.4,\y) -- (\x+\qgateSx/2,\y);
53     \draw[draw=none,fill=ibmqxH] (\x-0.4,\y-0.4) rectangle (\x+0.4,\y+0.4);
54     \node at (\x,\y){\large $\lvert 0 \rangle$};
55   }{%
56     \node[anchor=east] at (\x+\qgateSx/2,\y){$\lvert 0 \rangle$};
57   }%
58 }}
59
60 % General single-qubit gate
61 \newcommand{\qgateU}[4][]{\%
62   \pgfmathsetmacro\x{\qgateSx*(#2)}
63   \pgfmathsetmacro\y{(#3)}
64   \ifthenelse{\isin{ibmqx}{#1}}{%
65     \tikzset{lstyle/.style={ultra thick,line cap=butt}}
66     \ifthenelse{\equal{ibmqx}{#1}}{%
67       \tikzset{rstyle/.style={draw=none,fill=ibmqxG}}
68     }{%
69       \tikzset{rstyle/.style={draw=none,fill=#1}}
70     }
71     \tikzset{tstyle/.style={white}}
72   }{%
73     \tikzset{lstyle/.style={}}
74     \tikzset{rstyle/.style={fill=white}}
75     \tikzset{tstyle/.style={}}
76   }%
77   \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x-0.4,\y);
78   \draw[lstyle] (\x+0.4,\y) -- (\x+\qgateSx/2,\y);
79   \draw[rstyle] (\x-0.4,\y-0.4) rectangle (\x+0.4,\y+0.4);
80   \node[tstyle] at (\x,\y){\sf\large #4};
81 }}
82
83 % Identity gate
84 \newcommand{\qgateID}[3][]{\%
85   \ifthenelse{\isin{ibmqx}{#1}}{%
86     \qgateU[ibmqxB]{#2}{#3}{id}
87   }{%
88     \qgateU{#2}{#3}{id}
89   }%
90 }
91 \newcommand{\qgateOID}{\%
92   \def\ket##1{\scriptstyle\lvert##1\rangle}
93   \def\bra##1{\scriptstyle\langle##1\lvert}
94   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
95     & \bra{0} & \bra{1} \\ \hline
96     \ket{0} & 1 & 0 \\
97     \ket{1} & 0 & 1
98   \end{array}\right)
99 }
100
101 % Pauli-X gate
102 \newcommand{\qgateX}[3][]{\%
103   \ifthenelse{\isin{ibmqx}{#1}}{%
104     \qgateU[ibmqxC]{#2}{#3}{X}
105   }{%
106     \qgateU{#2}{#3}{X}
107   }%
108 }
109 \newcommand{\qgateOX}{\%
110   \def\ket##1{\scriptstyle\lvert##1\rangle}
111   \def\bra##1{\scriptstyle\langle##1\lvert}
112   \left(\hspace*{-0.4ex}\begin{array}{c|cc}

```

```

113      & \bra{0} & \bra{1} \\ \hline
114      \ket{0} &      0 &      1 \\
115      \ket{1} &      1 &      0 \\
116      \end{array} \! \! \right)
117 }}
118
119 % Pauli-Y gate
120 \newcommand\qgateY[3] [] {%
121   \ifthenelse{\isin{ibmqx}{#1}}{%
122     \qgateU[ibmqxC]{#2}{#3}{Y}
123   }{%
124     \qgateU{#2}{#3}{Y}
125   }%
126 }
127 \newcommand\qgateOY{%
128   \def\ket##1{\scriptstyle|##1\rangle}
129   \def\bra##1{\scriptstyle\langle ##1|}
130   \def\j{\mathrm{i}}
131   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
132     & \bra{0} & \bra{1} \\ \hline
133     \ket{0} & 0 & -\j \\
134     \ket{1} & \j & 0 \\
135   \end{array} \! \! \right)
136 }}
137
138 % Pauli-Z gate
139 \newcommand\qgateZ[3] [] {%
140   \ifthenelse{\isin{ibmqx}{#1}}{%
141     \qgateU[ibmqxC]{#2}{#3}{Z}
142   }{%
143     \qgateU{#2}{#3}{Z}
144   }%
145 }
146 \newcommand\qgateOZ{%
147   \def\ket##1{\scriptstyle|##1\rangle}
148   \def\bra##1{\scriptstyle\langle ##1|}
149   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
150     & \bra{0} & \bra{1} \\ \hline
151     \ket{0} & 1 & 0 \\
152     \ket{1} & 0 & -1 \\
153   \end{array} \! \! \right)
154 }}
155
156 % Hadamard gate
157 \newcommand\qgateH[3] [] {%
158   \ifthenelse{\isin{ibmqx}{#1}}{%
159     \qgateU[ibmqxD]{#2}{#3}{H}
160   }{%
161     \qgateU{#2}{#3}{H}
162   }%
163 }
164 \newcommand\qgateOH{%
165   \def\ket##1{\scriptstyle|##1\rangle}
166   \def\bra##1{\scriptstyle\langle ##1|}
167   \dfrac{1}{\sqrt{2}} \! \!
168   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
169     & \bra{0} & \bra{1} \\ \hline
170     \ket{0} & 1 & 1 \\
171     \ket{1} & 1 & -1 \\
172   \end{array} \! \! \right)
173 }}
174
175 % S phase gate
176 \newcommand\qgateS[3] [] {%
177   \ifthenelse{\isin{ibmqx}{#1}}{%
178     \qgateU[ibmqxD]{#2}{#3}{S}
179   }{%
180     \qgateU{#2}{#3}{S}
181   }%
182 }
183 \newcommand\qgateOS{%
184   \def\ket##1{\scriptstyle|##1\rangle}

```

```

185 \def\bra##1{\scriptstyle\langle ##1|}
186 \def\j{\mathrm{i}}
187 \dfrac{1}{\sqrt{2}}\!
188 \left(\hspace*{-0.4ex}\begin{array}{c|cc}
189 & \bra{0} & \bra{1} \\ \hline
190 \ket{0} & 1 & 0 \\
191 \ket{1} & 0 & \j
192 \end{array}\!\right)
193 }}
194
195 % Inverse S phase gate
196 \newcommand\qgateSi[3][]{\%
197 \ifthenelse{\isin{ibmqx}{#1}}{\%
198 \qgateU[ibmqxD]{#2}{#3}{S^\dagger$}
199 }{\%
200 \qgateU{#2}{#3}{S^\dagger$}
201 }%
202 }
203 \newcommand\qgate0Si{\%
204 \def\ket##1{\scriptstyle|##1\rangle}
205 \def\bra##1{\scriptstyle\langle ##1|}
206 \def\j{\mathrm{i}}
207 \dfrac{1}{\sqrt{2}}\!
208 \left(\hspace*{-0.4ex}\begin{array}{c|cc}
209 & \bra{0} & \bra{1} \\ \hline
210 \ket{0} & 1 & 0 \\
211 \ket{1} & 0 & -\j
212 \end{array}\!\right)
213 }}
214
215 % T phase gate
216 \newcommand\qgateT[3][]{\%
217 \ifthenelse{\isin{ibmqx}{#1}}{\%
218 \qgateU[ibmqxE]{#2}{#3}{T}
219 }{\%
220 \qgateU{#2}{#3}{T}
221 }%
222 }
223 \newcommand\qgate0T{\%
224 \def\ket##1{\scriptstyle|##1\rangle}
225 \def\bra##1{\scriptstyle\langle ##1|}
226 \def\j{\mathrm{i}}
227 \dfrac{1}{\sqrt{2}}\!
228 \left(\hspace*{-0.4ex}\begin{array}{c|cc}
229 & \bra{0} & \bra{1} \\ \hline
230 \ket{0} & 1 & 0 \\
231 \ket{1} & 0 & \frac{1}{\sqrt{2}}(1\!+\!\j)
232 \end{array}\!\right)
233 }}
234
235 % Inverse T phase gate
236 \newcommand\qgateTi[3][]{\%
237 \ifthenelse{\isin{ibmqx}{#1}}{\%
238 \qgateU[ibmqxE]{#2}{#3}{T^\dagger$}
239 }{\%
240 \qgateU{#2}{#3}{T^\dagger$}
241 }%
242 }
243 \newcommand\qgate0Ti{\%
244 \def\ket##1{\scriptstyle|##1\rangle}
245 \def\bra##1{\scriptstyle\langle ##1|}
246 \def\j{\mathrm{i}}
247 \dfrac{1}{\sqrt{2}}\!
248 \left(\hspace*{-0.4ex}\begin{array}{c|cc}
249 & \bra{0} & \bra{1} \\ \hline
250 \ket{0} & 1 & 0 \\
251 \ket{1} & 0 & \frac{1}{\sqrt{2}}(1\!-\!\j)
252 \end{array}\!\right)
253 }}
254
255 % U1 gate of IBM Q Experience
256 \newcommand\qgateUa[3][]{\%

```



```

257 \ifthenelse{\isin{ibmqx}{#1}}{%
258   \qgateU[ibmqxA]{#2}{#3}{U1}
259 }{%
260   \qgateU{#2}{#3}{U1}
261 }%
262 }
263 \newcommand\qgate0Ua{%
264   \def\ket##1{\scriptstyle|##1\rangle}
265   \def\bra##1{\scriptstyle\langle ##1|}
266   \def\j{\mathrm{e}}
267   \def\j{\mathrm{i}}
268   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
269     & \bra{0} & \bra{1} \\ \hline
270     \ket{0} & 1 & 0 \\
271     \ket{1} & 0 & e^{-\lambda j}
272   \end{array}\!\!\right)
273 }}
274
275 % U2 gate of IBM Q Experience
276 \newcommand\qgateUb[3]{}{%
277   \ifthenelse{\isin{ibmqx}{#1}}{%
278     \qgateU[ibmqxA]{#2}{#3}{U2}
279   }{%
280     \qgateU{#2}{#3}{U2}
281   }%
282 }
283 \newcommand\qgate0Ub{%
284   \def\ket##1{\scriptstyle|##1\rangle}
285   \def\bra##1{\scriptstyle\langle ##1|}
286   \def\j{\mathrm{e}}
287   \def\j{\mathrm{i}}
288   \renewcommand\arraystretch{1.4}
289   \dfrac{1}{\sqrt{2}}\!\!
290   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
291     & \bra{0} & \bra{1} \\ \hline
292     \ket{0} & 1 & -e^{-\lambda j} \\
293     \ket{1} & e^{-\phi j} & e^{-(\lambda+\phi)j}
294   \end{array}\!\!\right)
295 }}
296
297 % U3 gate of IBM Q Experience
298 \newcommand\qgateUc[3]{}{%
299   \ifthenelse{\isin{ibmqx}{#1}}{%
300     \qgateU[ibmqxA]{#2}{#3}{U3}
301   }{%
302     \qgateU{#2}{#3}{U3}
303   }%
304 }
305 \newcommand\qgate0Uc{%
306   \def\ket##1{\scriptstyle|##1\rangle}
307   \def\bra##1{\scriptstyle\langle ##1|}
308   \def\j{\mathrm{e}}
309   \def\j{\mathrm{i}}
310   \renewcommand\arraystretch{1.4}
311   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
312     & \bra{0} & \bra{1} \\ \hline
313     \ket{0} & \cos(\frac{\theta}{2}) & -\sin(\frac{\theta}{2})e^{-\lambda j} \\
314     \ket{1} & \sin(\frac{\theta}{2})e^{-\phi j} & \cos(\frac{\theta}{2})e^{-(\lambda+\phi)j}
315   \end{array}\!\!\right)
316 }}
317
318 % General two-qubit gate
319 \newcommand\qgateUu[4]{}{%
320   \pgfmathsetmacro\x{\qgateSx*(#2)}
321   \pgfmathsetmacro\y{(#3)}
322   \ifthenelse{\isin{ibmqx}{#1}}{%
323     \tikzset{style/.style={ultra thick,line cap=butt}}
324     \ifthenelse{\equal{ibmqx}{#1}}{%
325       \tikzset{rstyle/.style={draw=none,fill=ibmqxG}}
326     }{%
327       \tikzset{rstyle/.style={draw=none,fill=#1}}
328     }

```

```

329 \tikzset{tstyle/.style={white}}
330 }{%
331 \tikzset{lstyle/.style={}}
332 \tikzset{rstyle/.style={fill=white}}
333 \tikzset{tstyle/.style={}}
334 }%
335 \draw[rstyle] (\x-0.5,\y-0.25) rectangle (\x+0.5,\y+1.25);
336 \draw[lstyle] (\x-\qgateSx/2,\y+1) -- (\x-0.5,\y+1);
337 \draw[lstyle] (\x+0.5,\y+1) -- (\x+\qgateSx/2,\y+1);
338 \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x-0.5,\y);
339 \draw[lstyle] (\x+0.5,\y) -- (\x+\qgateSx/2,\y);
340 \node[anchor=north,tstyle] at (\x,\y+1.25){\sf\large #4};
341 }}
342
343 % General three-qubit gate
344 \newcommand{\qgateUuu}[4][]{\{
345 \pgfmathsetmacro\x{\qgateSx*(#2)}
346 \pgfmathsetmacro\y{(#3)}
347 \ifthenelse{\isin{ibmqx}{#1}}{%
348 \tikzset{lstyle/.style={ultra thick,line cap=butt}}
349 \ifthenelse{\equal{ibmqx}{#1}}{%
350 \tikzset{rstyle/.style={draw=none,fill=ibmqxG}}
351 }{%
352 \tikzset{rstyle/.style={draw=none,fill=#1}}
353 }
354 \tikzset{tstyle/.style={white}}
355 }{%
356 \tikzset{lstyle/.style={}}
357 \tikzset{rstyle/.style={fill=white}}
358 \tikzset{tstyle/.style={}}
359 }%
360 \draw[rstyle] (\x-0.5,\y-1.25) rectangle (\x+0.5,\y+1.25);%
361 \draw[lstyle] (\x-\qgateSx/2,\y+1) -- (\x-0.5,\y+1);%
362 \draw[lstyle] (\x+0.5,\y+1) -- (\x+\qgateSx/2,\y+1);%
363 \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x-0.5,\y);%
364 \draw[lstyle] (\x+0.5,\y) -- (\x+\qgateSx/2,\y);%
365 \draw[lstyle] (\x-\qgateSx/2,\y-1) -- (\x-0.5,\y-1);%
366 \draw[lstyle] (\x+0.5,\y-1) -- (\x+\qgateSx/2,\y-1);%
367 \node[anchor=north,tstyle] at (\x,\y+1.25){\sf\large #4};%
368 }}
369
370 % CNOT gate XOR symbol
371 \newcommand{\qgateCNX}[4][]{\{
372 \pgfmathsetmacro\x{\qgateSx*(#3)}
373 \pgfmathsetmacro\y{(#4)}
374 \ifthenelse{\isin{ibmqx}{#1}}{%
375 \tikzset{lstyle/.style={ultra thick,line cap=butt}}
376 \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
377 \tikzset{rstyle/.style={draw=none,fill=ibmqxD}}
378 \tikzset{tstyle/.style={very thick,white}}
379 }{%
380 \tikzset{lstyle/.style={}}
381 \tikzset{cstyle/.style={}}
382 \tikzset{rstyle/.style={fill=white}}
383 \tikzset{tstyle/.style={}}
384 }%
385 \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x-0.4,\y);
386 \draw[lstyle] (\x+0.4,\y) -- (\x+\qgateSx/2,\y);
387 \draw[rstyle] (\x,\y) circle (0.4);
388 \ifthenelse{\isin{ibmqx}{#1}}{%
389 \draw[tstyle] (\x-0.2,\y) -- (\x+0.2,\y);
390 \draw[tstyle] (\x,\y-0.2) -- (\x,\y+0.2);
391 }{%
392 \draw[lstyle] (\x-0.4,\y) -- (\x+0.4,\y);
393 \draw[lstyle] (\x,\y-0.4) -- (\x,\y+0.4);
394 }
395 \ifthenelse{\isin{t}{#2}}{%
396 \draw[cstyle] (\x,\y+0.4) -- (\x,\y+0.5);
397 }{}
398 \ifthenelse{\isin{b}{#2}}{%
399 \draw[cstyle] (\x,\y-0.4) -- (\x,\y-0.5);
400 }{}

```

```

401 }}
402
403 % CNOT gate control qubit symbol
404 \newcommand\qgateCNC[4][]{\%
405 \pgfmathsetmacro\x{\qgateSx*(#3)}
406 \pgfmathsetmacro\y{(#4)}
407 \ifthenelse{\isin{ibmqx}{#1}}{\%
408 \tikzset{lstyle/.style={ultra thick,line cap=butt}}
409 \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
410 \tikzset{rstyle/.style={draw=none,fill=ibmqxD}}
411 \tikzset{tstyle/.style={white}}
412 \def\r{0.12}
413 }{\%
414 \tikzset{lstyle/.style={}}
415 \tikzset{cstyle/.style={}}
416 \tikzset{rstyle/.style={draw=none,fill=black}}
417 \tikzset{tstyle/.style={}}
418 \def\r{0.1}
419 }%
420 \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
421 \draw[rstyle] (\x, \y) circle (\r);
422 \ifthenelse{\isin{t}{#2}}{\%
423 \draw[cstyle] (\x,\y+0.1) -- (\x,\y+0.5);
424 }{}
425 \ifthenelse{\isin{b}{#2}}{\%
426 \draw[cstyle] (\x,\y-0.1) -- (\x,\y-0.5);
427 }{}
428 }}
429
430 % CNOT gate run-through qubit symbol
431 \newcommand\qgateCNR[3][]{\%
432 \pgfmathsetmacro\x{\qgateSx*(#2)}
433 \pgfmathsetmacro\y{(#3)}
434 \ifthenelse{\isin{ibmqx}{#1}}{\%
435 \tikzset{lstyle/.style={ultra thick,line cap=butt}}
436 \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
437 }{\%
438 \tikzset{lstyle/.style={}}
439 \tikzset{cstyle/.style={}}
440 }%
441 \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
442 \draw[cstyle] (\x, \y-0.5) -- (\x, \y+0.5);
443 }}
444
445 % Swap gate top qubit symbol
446 \newcommand\qgateSWt[3][]{\%
447 \pgfmathsetmacro\x{\qgateSx*(#2)}
448 \pgfmathsetmacro\y{(#3)}
449 \ifthenelse{\isin{ibmqx}{#1}}{\%
450 \draw[ultra thick,line cap=butt]
451 (\x-\qgateSx/2,\y) -- (\x-0.2,\y) -- (\x+0.2,\y-0.4) -- (\x+0.2,\y-0.5);
452 \draw[ultra thick,line cap=butt]
453 (\x+\qgateSx/2,\y) -- (\x+0.2,\y) -- (\x-0.2,\y-0.4) -- (\x-0.2,\y-0.5);
454 }{\%
455 \pgfmathsetmacro\w{0.1}
456 \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
457 \draw(\x-\w, \y-\w) -- (\x+\w, \y+\w);
458 \draw(\x-\w, \y+\w) -- (\x+\w, \y-\w);
459 \draw(\x, \y) -- (\x, \y-0.5);
460 }%
461 }}
462
463 % Swap gate run-through qubit symbol
464 \newcommand\qgateSWR[3][]{\%
465 \pgfmathsetmacro\x{\qgateSx*(#2)}
466 \pgfmathsetmacro\y{(#3)}
467 \ifthenelse{\isin{ibmqx}{#1}}{\%
468 \draw[ultra thick,line cap=butt] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
469 \draw[ultra thick,line cap=butt] (\x-0.2, \y+0.5) -- (\x-0.2, \y-0.5);
470 \draw[ultra thick,line cap=butt] (\x+0.2, \y+0.5) -- (\x+0.2, \y-0.5);
471 }{\%
472 \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);

```

```

473 \draw(\x, \y-0.5) -- (\x, \y+0.5);
474 }%
475 }}
476
477 % Swap gate bottom qubit symbol
478 \newcommand\qgateSWb[3][]{\%
479 \pgfmathsetmacro\x{\qgateSx*(#2)}
480 \pgfmathsetmacro\y{(#3)}
481 \ifthenelse{\isin{ibmqx}{#1}}{\%
482 \draw[ultra thick,line cap=butt]
483 (\x-\qgateSx/2,\y) -- (\x-0.2,\y) -- (\x-0.2,\y+0.5);
484 \draw[ultra thick,line cap=butt]
485 (\x+\qgateSx/2,\y) -- (\x+0.2,\y) -- (\x+0.2,\y+0.5);
486 }{\%
487 \pgfmathsetmacro\w{0.1}
488 \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
489 \draw(\x-\w, \y-\w) -- (\x+\w, \y+\w);
490 \draw(\x-\w, \y+\w) -- (\x+\w, \y-\w);
491 \draw(\x, \y) -- (\x, \y+0.5);
492 }%
493 }}
494
495 % Measurement symbol
496 \newcommand\qmeasM[3][]{\%
497 \pgfmathsetmacro\x{\qgateSx*(#2)}
498 \pgfmathsetmacro\y{(#3)}
499 \ifthenelse{\isin{ibmqx}{#1}}{\%
500 \tikzset{lstyle/.style={ultra thick,line cap=butt}}
501 \tikzset{rstyle/.style={draw=none,fill=ibmqxF}}
502 \tikzset{tstyle/.style={white,very thick,line cap=butt}}
503 \tikzset{pstyle/.style={->,>=stealth,white,thick,line cap=butt}}
504 \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
505 }{\%
506 \tikzset{lstyle/.style={}}
507 \tikzset{rstyle/.style={fill=white}}
508 \tikzset{tstyle/.style={}}
509 \tikzset{pstyle/.style={->,>=stealth,line cap=butt}}
510 \tikzset{cstyle/.style={}}
511 }%
512 \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x-0.4,\y);
513 \draw[lstyle] (\x+0.4,\y) -- (\x+\qgateSx/2,\y);
514 \draw[rstyle] (\x-0.4,\y-0.4) rectangle (\x+0.4,\y+0.4);
515 \draw[tstyle] (\x+0.27,\y-0.2) arc (0:180:0.27);
516 \draw[pstyle] (\x,\y-0.15) -- (\x+0.2,\y+0.22);
517 \node[pstyle] at (\x+0.26,\y+0.15) {\tiny\sf Z};
518 \fill[pstyle] (\x,\y-0.15) circle (0.035);
519 \draw[cstyle] (\x,\y-0.4) -- (\x,\y-0.5);
520 }}
521
522 % Measurement run-through qubit symbol
523 \newcommand\qmeasR[3][]{\%
524 \pgfmathsetmacro\x{\qgateSx*(#2)}
525 \pgfmathsetmacro\y{(#3)}
526 \ifthenelse{\isin{ibmqx}{#1}}{\%
527 \tikzset{lstyle/.style={ultra thick,line cap=butt}}
528 \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
529 }{\%
530 \tikzset{lstyle/.style={}}
531 \tikzset{cstyle/.style={}}
532 }%
533 \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
534 \draw[cstyle] (\x,\y-0.5) -- (\x,\y+0.5);
535 }}
536
537 % Measurement-joins-bus symbol
538 \newcommand\qmeasMB[4][]{\%
539 \pgfmathsetmacro\x{\qgateSx*(#3)}
540 \pgfmathsetmacro\y{(#4)}
541 \ifthenelse{\isin{ibmqx}{#1}}{\%
542 \tikzset{cstyle/.style={>=stealth,ibmqxI,ultra thick,line cap=butt}}
543 }{\%
544 \tikzset{cstyle/.style={>=stealth}}

```

```

545 }%
546 \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
547 \draw[cstyle,->] (\x,\y+0.5) -- (\x,\y-0.3)
548   node[anchor=north,black] {\footnotesize #2};
549 }}
550
551 % Measurement bus symbol
552 \newcommand\qmeasB[3][]{\%
553   \pgfmathsetmacro\x{\qgateSx*(#2)}
554   \pgfmathsetmacro\y{(#3)}
555   \ifthenelse{\isin{ibmqx}{#1}}{\%
556     \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
557   }{\%
558     \tikzset{cstyle/.style={}}
559   }%
560   \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
561 }}
562
563 % Measurement bus head symbol
564 \newcommand\qmeasBh[4][]{\%
565   \pgfmathsetmacro\x{\qgateSx*(#3)}
566   \pgfmathsetmacro\y{(#4)}
567   \ifthenelse{\isin{ibmqx}{#1}}{\%
568     \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
569   }{\%
570     \tikzset{cstyle/.style={}}
571   }%
572   \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
573   \draw[cstyle](\x-\qgateSx/2+0.05,\y-0.45) -- (\x-\qgateSx/2+0.15,\y-0.1)
574     node[anchor=east,black] {\footnotesize #2};
575 }}
576
577 %% == OTHER GATE OPERATORS =====
578
579 \newcommand\qgateOCNOT{\%
580   \def\ket##1{\scriptstyle|##1\rangle}
581   \def\bra##1{\rotatebox{90}{\scriptstyle\langle ##1|}}
582   \left(\hspace*{-0.4ex}\begin{array}{c|cccc}
583     & \bra{00} & \bra{01} & \bra{10} & \bra{11} \\ \hline
584     \ket{00} & 1 & 0 & 0 & 0 \\
585     \ket{01} & 0 & 1 & 0 & 0 \\
586     \ket{10} & 0 & 0 & 0 & 1 \\
587     \ket{11} & 0 & 0 & 1 & 0 \\
588   \end{array}\!\!\right)
589 }}
590
591 \newcommand\qgateOCCNOT{\%
592   \def\ket##1{\scriptstyle|##1\rangle}
593   \def\bra##1{\rotatebox{90}{\scriptstyle\langle ##1|}}
594   \left(\hspace*{-0.4ex}\begin{array}{c|cccccccc}
595     & \bra{000} & \bra{001} & \bra{010} & \bra{011} & \bra{100} & \bra{101} & \bra{110} & \bra{111} \\ \hline
596     \ket{000} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
597     \ket{001} & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
598     \ket{010} & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
599     \ket{101} & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
600     \ket{100} & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
601     \ket{111} & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
602     \ket{110} & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
603     \ket{111} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
604   \end{array}\!\!\right)
605 }}
606
607 %% == AUXILIARY COMMANDS =====
608
609 \newcommand{\qScalePaper}{\%
610   \draw[help lines,xstep=\qgateSx/8,ystep=0.25,opacity=0.2] (-1.5,-1.5) grid (1.5,1.5);
611   \draw[help lines,line width=.6pt,xstep=\qgateSx/2,ystep=1,opacity=0.2] (-1.49,-1.5) grid (1.49,1.5);
612   \node[anchor=west,color=gray] at (-1,-1.7) {\scriptsize $\qgateSx(\texttt{x})\!-\!\frac{1}{2}$};
613   \node[anchor=west,color=gray] at (0,-1.7) {\scriptsize $\qgateSx(\texttt{x})$};
614   \node[anchor=west,color=gray] at (1,-1.7) {\scriptsize $\qgateSx(\texttt{x})\!+\!\frac{1}{2}$};
615   \node[anchor=west,color=gray] at (-2.3,-1) {\scriptsize $\texttt{y}\!-\!1$};
616   \node[anchor=west,color=gray] at (-2.3,0) {\scriptsize $\texttt{y}$};

```

```

617 \node[anchor=west ,color=gray] at (-2.3, 1 ) {\scriptsize $\texttt{y}\!+\!\!1$};
618 }
619
620 %% == EOF =====

```

## References

- [1] Till Tantau. Tikz & pgf - manual for version 3.0.1a. <http://mirror.ctan.org/graphics/pgf/base/doc/pgfmanual.pdf>, 2015. Retrieved: July 27, 2018.
- [2] Matthias Wolff. The `tikz-quantumgates` package: Drawing quantum circuits with TikZ. <https://github.com/matthias-wolff/tikz-quantumgates>, 2018. Retrieved: August 20, 2018.