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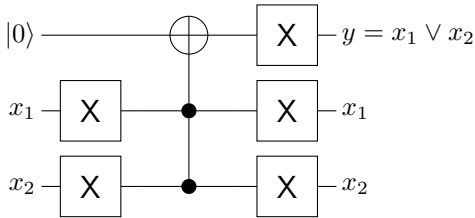# Drawing quantum circuits with TikZ

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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=east] at (-0.6,2) {$|0\rangle$};
7     \node[anchor=east] at (-0.6,1) {$x_1$};
8     \node[anchor=east] at (-0.6,0) {$x_2$};
9     \qwire{0}{2}\qgateX{0}{1}\qgateX{0}{0}
10    \qgateCNX{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}
```
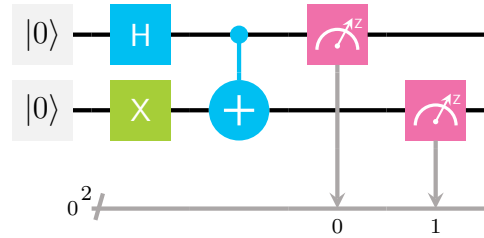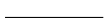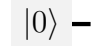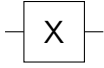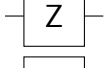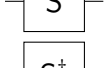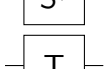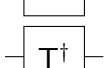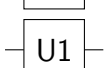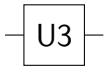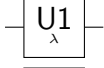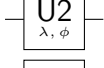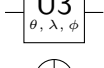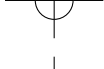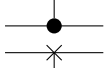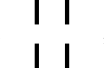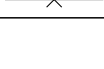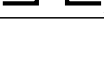


```
1 \documentclass{standalone}
2 \usepackage{tikz-quantumgates}
3 \begin{document}
4   \centering
5   \begin{tikzpicture}
6     \node[anchor=east] at (0.6,-0.3) {\footnotesize 0};
7     \qzero[ibmqx]{0}{2}\qzero[ibmqx]{0}{1}
8     \qgateH[ibmqx]{1}{2}\qgateX[ibmqx]{1}{1}\qmeasBh[ibmqx]{2}{1}{0}
9     \qgateCNC[ibmqx]{b}{2}{2}\qgateCNX[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}
```

1

Contents

1 Overview

1.1 List of Circuit Symbols

Standard	Option `ibmqx`	Command
		`\qwire[option]{x}{y}`
$\lvert 0 \rangle$	$\lvert 0 \rangle$	`\qzero[option]{x}{y}`
id	id	`\qgateID[option]{x}{y}`
X	X	`\qgateX[option]{x}{y}`
Y	Y	`\qgateY[option]{x}{y}`
Z	Z	`\qgateZ[option]{x}{y}`
H	H	`\qgateH[option]{x}{y}`
S	S	`\qgateS[option]{x}{y}`
$S^\dagger$	$S^\dagger$	`\qgateSi[option]{x}{y}`
T	T	`\qgateT[option]{x}{y}`
$T^\dagger$	$T^\dagger$	`\qgateTi[option]{x}{y}`
U1	U1	`\qgateUa[option]{x}{y}`
U2	U2	`\qgateUb[option]{x}{y}`
U3	U3	`\qgateUc[option]{x}{y}`
U1 $_\lambda$	U1 $_\lambda$	`\qgateUa*[option]{x}{y}{sublabel}`
U2 $_{\lambda,\phi}$	U2 $_{\lambda,\phi}$	`\qgateUb*[option]{x}{y}{sublabel}`
U3 $_{\theta,\lambda,\phi}$	U3 $_{\theta,\lambda,\phi}$	`\qgateUc*[option]{x}{y}{sublabel}`
$\oplus$	$+$	`\qgateCNX[option]{cwires}{x}{y}`
		`\qgateCNR[option]{x}{y}`
$\bullet$		`\qgateCNC[option]{cwires}{x}{y}`
$\times$		`\qgateSWt[option]{x}{y}` (not an "official" IBM QX symbol)
		`\qgateSWR[option]{x}{y}` (not an "official" IBM QX symbol)
$\times$		`\qgateSWb[option]{x}{y}` (not an "official" IBM QX symbol)

Standard	Option `ibmqx`	Command
		`\qmeasM[option]{x}{y}`
		`\qmeasM*[option]{x}{y}{axis}{wires}`
		`\qmeasR[option]{x}{y}`
		`\qmeasMB[option]{b}{x}{y}`
		`\qmeasB[option]{x}{y}`
		`\qmeasBh[option]{b}{x}{y}`
		`\qgateU[option]{x}{y}{label}` (not an "official" IBM QX symbol)
		`\qgateUu[option]{x}{y}{label}` (not an "official" IBM QX symbol)
		`\qgateUuu[option]{x}{y}{label}` (not an "official" IBM QX symbol)

Any gate can be equipped with control wires, e.g.

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

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 $(\qgateSx*x, y)$.

Examples


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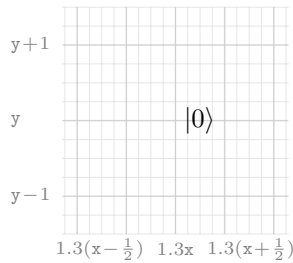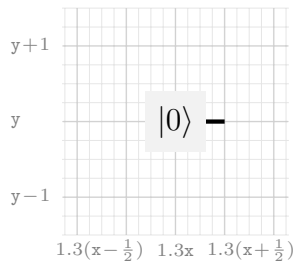


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qzero[ibmqx]{0}{0}
4 \end{tikzpicture}
```

2.2 Single-Qubit Gate Symbols

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

Draws a general single-qubit quantum gate.

5

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 $(\texttt{\textbackslash qgateSx*}x, y)$.
`label`	Gate label.

Examples
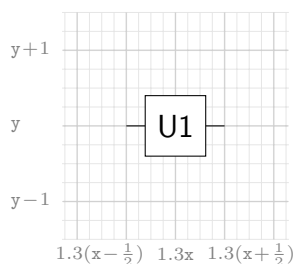

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateU{0}{0}{U1}
4 \end{tikzpicture}
```
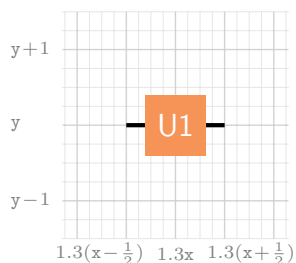


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateU[ibmqxA]{0}{0}{U1}
4 \end{tikzpicture}
```

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

Draws the identity gate.

Parameters

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

Examples


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



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

Gate Operator

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

```
1  $\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

$$X \doteq \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 0 & 1 \\ |1\rangle & 1 & 0 \end{array} \right)$$

```
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}
```
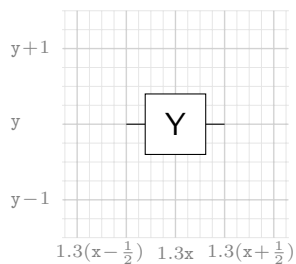


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateY[ibmqx]{0}{0}
4 \end{tikzpicture}
```

Gate Operator

$$Y \doteq \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 0 & -i \\ |1\rangle & i & 0 \end{array} \right)$$

```
1   $\displaystyle Y\doteq\qgateOY $
```

`\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}
```
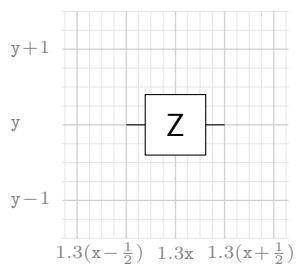


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateZ[ibmqx]{0}{0}
4 \end{tikzpicture}
```

Gate Operator

$$Z \doteq \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & 0 \\ |1\rangle & 0 & -1 \end{array} \right)$$

```
1  $\displaystyle Z\doteq\qgateOZ $
```

```
\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}
```
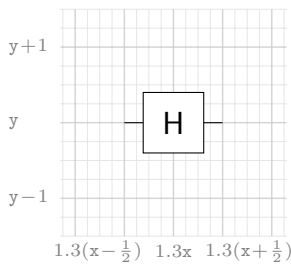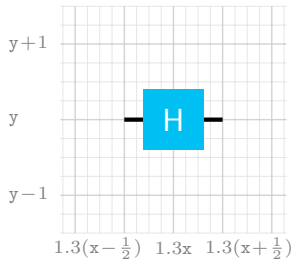


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateH[ibmqx]{0}{0}
4 \end{tikzpicture}
```

Gate Operator

$$H \doteq \frac{1}{\sqrt{2}} \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & 1 \\ |1\rangle & 1 & -1 \end{array} \right)$$

```
1 $\displaystyle H\doteq\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

y+1

y

S

y−1

1.3(x−$\frac{1}{2}$) 1.3x 1.3(x+$\frac{1}{2}$)

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

y+1

y

S

y−1

1.3(x−$\frac{1}{2}$) 1.3x 1.3(x+$\frac{1}{2}$)
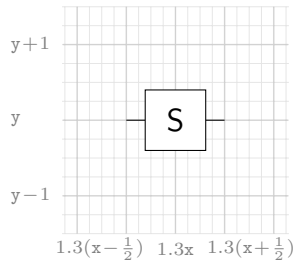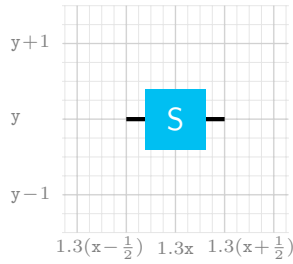
```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateS[ibmqx]{0}{0}
4 \end{tikzpicture}
```

Gate Operator

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

```
1 $\displaystyle S=\sqrt{Z}\doteq\qgateOS $
```
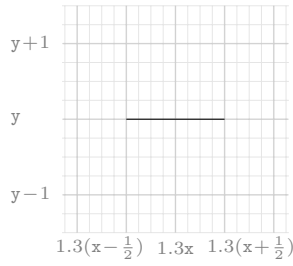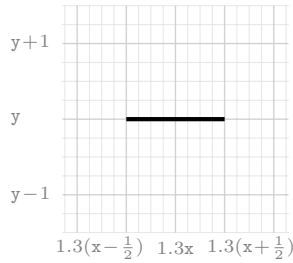
`\qgateSi[option]{x}{y}`

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

y+1

y

S†

y−1

1.3(x−$\frac{1}{2}$) 1.3x 1.3(x+$\frac{1}{2}$)

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

y+1

y

S†

y−1

1.3(x−$\frac{1}{2}$) 1.3x 1.3(x+$\frac{1}{2}$)

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

Gate Operator

$$S^\dagger \doteq \frac{1}{\sqrt{2}} \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & 0 \\ |1\rangle & 0 & -\mathrm{i} \end{array} \right)$$

```
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

$$T = \sqrt{S} \doteq \frac{1}{\sqrt{2}} \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & 0 \\ |1\rangle & 0 & \frac{1}{\sqrt{2}}(1+\mathrm{i}) \end{array} \right)$$

```
1 $\displaystyle T=\sqrt{S}\doteq\qgateOT $
```
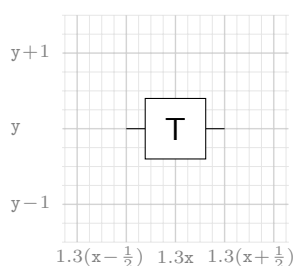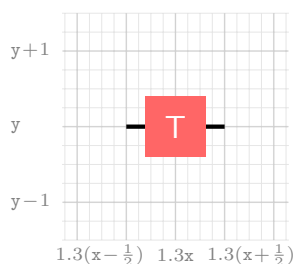
`\qgateTi[option]{x}{y}`

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).
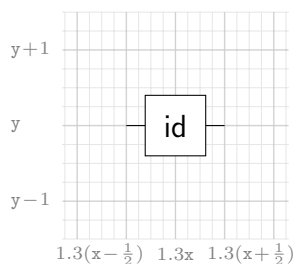
Examples


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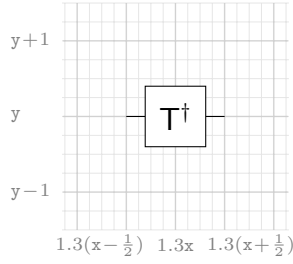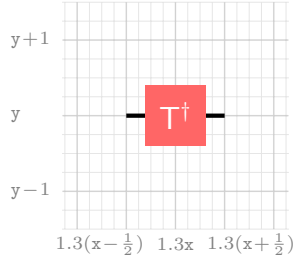


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateTi[ibmqx]{0}{0}
4 \end{tikzpicture}
```

Gate Operator

$$T^\dagger \doteq \frac{1}{\sqrt{2}} \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & 0 \\ |1\rangle & 0 & \frac{1}{\sqrt{2}}(1-\mathrm{i}) \end{array} \right)$$

```
1 $\displaystyle T^\dagger\doteq\qgateOTi $
```

2.3   Single-Qubit Physical Gate of IBM Q Experience

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

U1 gate of IBM Q Experience.

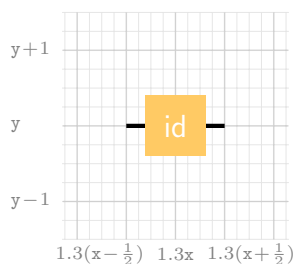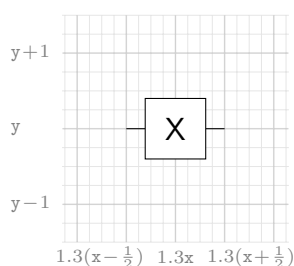**Parameters**

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).
sublabel	Sub-label, e. g. for gate parameters (starred version only)

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}
```

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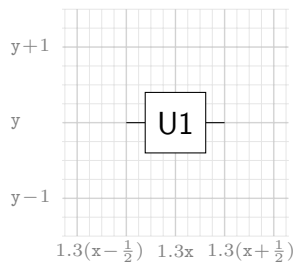


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUa*[ibmqx]{0}{0}{$\lambda$}
4 \end{tikzpicture}
```

Gate Operator

$$U1_\lambda \doteq \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & 0 \\ |1\rangle & 0 & e^{\lambda i} \end{array} \right)$$

```
1 $\displaystyle U1_{\lambda}\doteq\qgateOUa $
```

```
\qgateUb[option]{x}{y}
\qgateUb*[option]{x}{y}{sublabel}
```
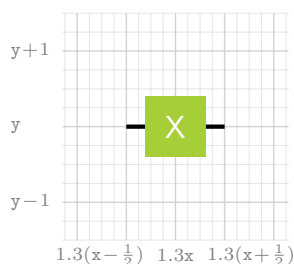
U2 gate of IBM Q Experience.
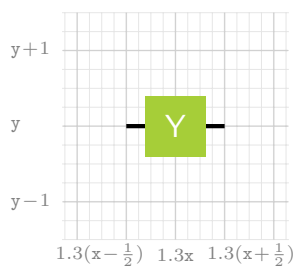
Parameters

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 $(\texttt{\textbackslash qgateSx*x}, y)$.
sublabel	Sub-label, e.g. for gate parameters (starred version only)

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}
```

13

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUb*{0}{0}{$\lambda,\phi$}
4 \end{tikzpicture}
```
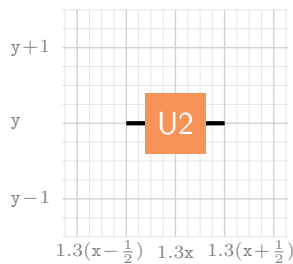


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUb*[ibmqx]{0}{0}{$\lambda,\phi$}
4 \end{tikzpicture}
```

Gate Operator

$$U2_{\lambda,\phi} \doteq \frac{1}{\sqrt{2}} \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & 1 & -e^{\lambda i} \\ |1\rangle & e^{\phi i} & e^{(\lambda+\phi) i} \end{array} \right)$$

```
1 $\displaystyle U2_{\lambda,\phi}\doteq\qgateOUb $
```

```
\qgateUc[option]{x}{y}
\qgateUc*[option]{x}{y}{sublabel}
```
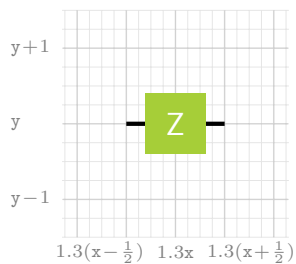
U3 gate of IBM Q Experience.

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).
sublabel	Sub-label, e. g. for gate parameters (starred version only)

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}
```

14

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUc*{0}{0}{$\theta,\lambda,\phi$}
4 \end{tikzpicture}
```

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUc*[ibmqx]{0}{0}{$\theta,\lambda,\phi$}
4 \end{tikzpicture}
```

Gate Operator

$$U3_{\lambda,\phi,\theta} \doteq \left(\begin{array}{c|cc} & \langle 0| & \langle 1| \\ \hline |0\rangle & \cos(\frac{\theta}{2}) & -\sin(\frac{\theta}{2})e^{\lambda i} \\ |1\rangle & \sin(\frac{\theta}{2})e^{\phi i} & \cos(\frac{\theta}{2})e^{(\lambda+\phi)i} \end{array} \right)$$

```
1 $\displaystyle U3_{\lambda,\phi,\theta}\doteq\qgateOUc $
```

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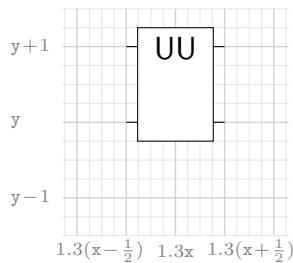
```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateUu{0}{0}{UU}
4 \end{tikzpicture}
```

```
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:

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
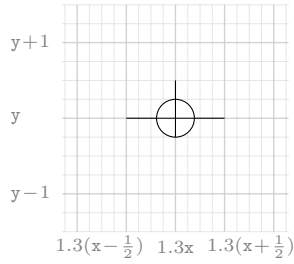

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNX{t}{0}{0}
4 \end{tikzpicture}
```



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

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

Control qubit symbol of a controlled 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 control wire:

A B C D E F G H

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

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
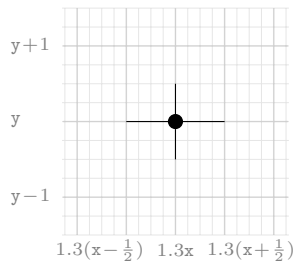

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNC{bt}{0}{0}
4 \end{tikzpicture}
```
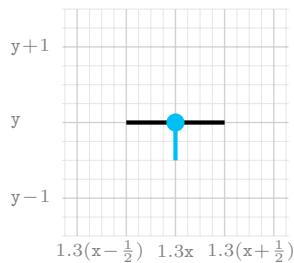


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNC[ibmqx]{b}{0}{0}
4 \end{tikzpicture}
```

\qgateCNR[option]{x}{y}

Run-through qubit symbol of a controlled 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 control wire:

A B C D E F G H

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

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

Examples


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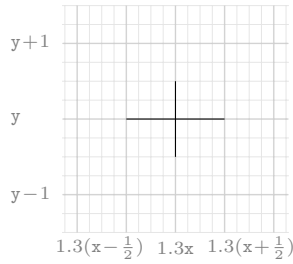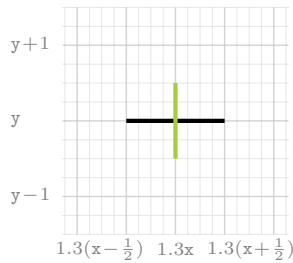


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNR[ibmqxC]{0}{0}
4 \end{tikzpicture}
```

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

Top qubit of a SWAP gate.
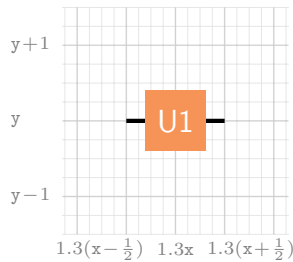
Parameters

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 $(\qgateSx*x, y)$.

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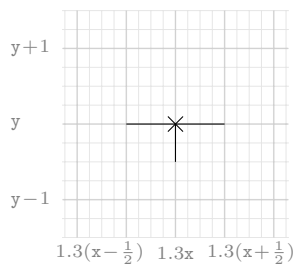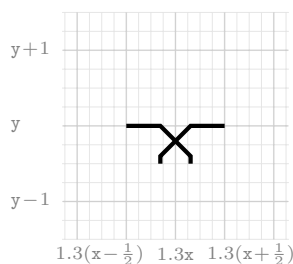
`\qgateSWR[option]{x}{y}`

Run-through qubit of a SWAP gate.

Parameters

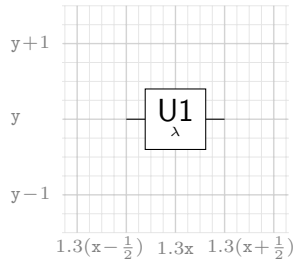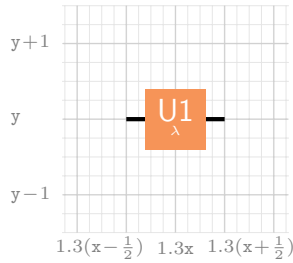|	
`option`	Omit for standard circuit styling or `ibmqx` for IBM Q Experience circuit styling.
`x, y`	Position of symbol in schematic. The actual TikZ coordinates are ($\qgateSx*x, y$).

Examples


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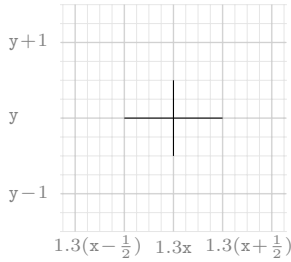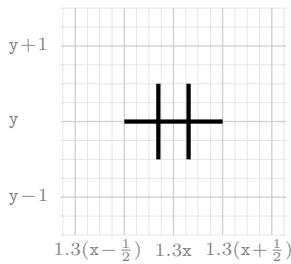


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSWR[ibmqx]{0}{0}
4 \end{tikzpicture}
```

`\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 ($\qgateSx*x, y$).

Examples


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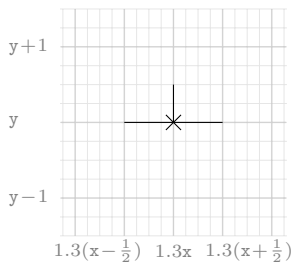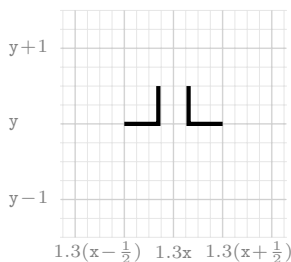


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateSWb[ibmqx]{0}{0}
4 \end{tikzpicture}
```

2.5   Measurement Symbols

```
\qmeasM[option]{x}{y}
\qmeasM*[option]{x}{y}{axis}{wires}
```
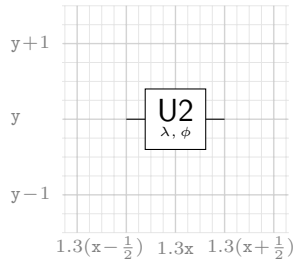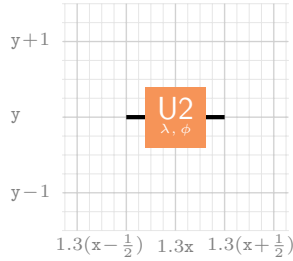
Measurement symbol.

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 ($\qgateSx*x, y$).
`axis`	Axis of measurement: X, Y, or Z (starred version only).
`wires`	Wires, `b` for bottom, `r` for right, and `br` for both (starred version only).
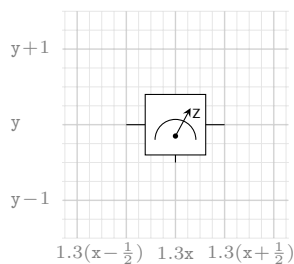
Examples


```
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}
```
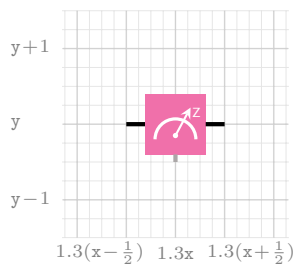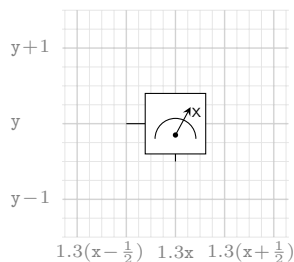


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasM*{0}{0}{X}{b}
4 \end{tikzpicture}
```
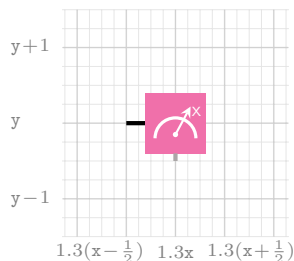


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasM*[ibmqx]{0}{0}{X}{b}
4 \end{tikzpicture}
```

```
\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 ($\mathtt{\backslash qgateSx*x}, y$).

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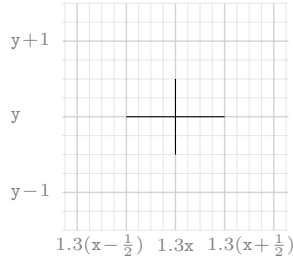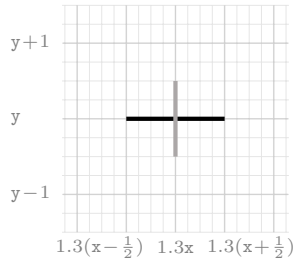
`\qmeasMB[option]{b}{x}{y}`

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 ($\mathtt{\backslash qgateSx*x}, y$).

Examples
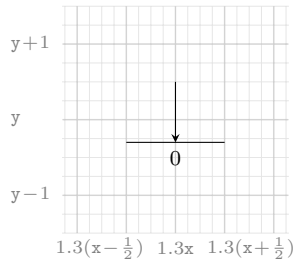

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasMB{0}{0}{0}
4 \end{tikzpicture}
```
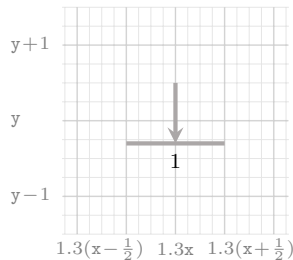


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasMB[ibmqx]{1}{0}{0}
4 \end{tikzpicture}
```
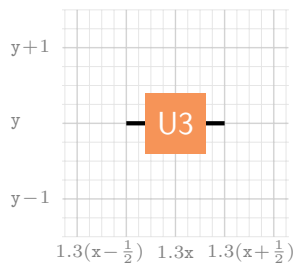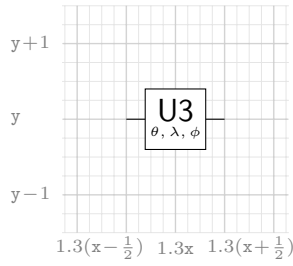
`\qmeaB[option]{x}{y}`

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
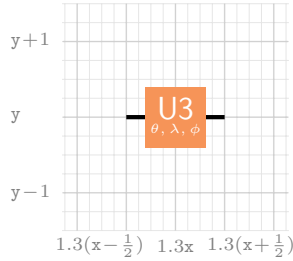


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasB{0}{0}
4 \end{tikzpicture}
```



```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasB[ibmqx]{0}{0}
4 \end{tikzpicture}
```
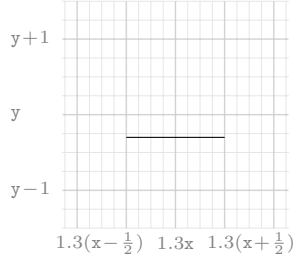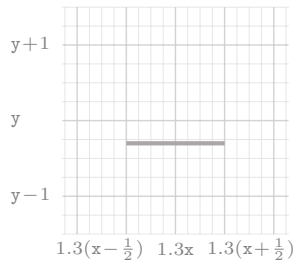
`\qmeaBh[option]{b}{x}{y}`

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 ($\qgateSx*x, y$).

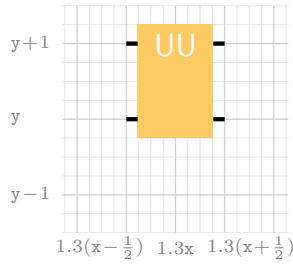**Examples**
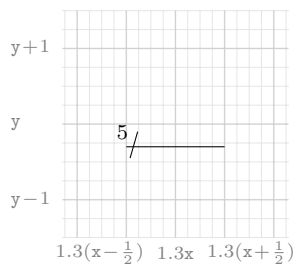

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasBh{5}{0}{0}
4 \end{tikzpicture}
```
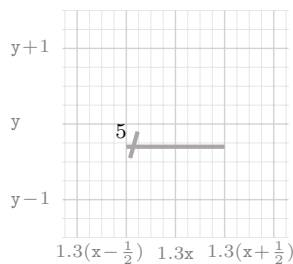


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qmeasBh[ibmqx]{5}{0}{0}
4 \end{tikzpicture}
```

2.6 Further Gate Operators

CNOT Gate Operator

$$CNOT \doteq \begin{pmatrix} & \langle 00| & \langle 01| & \langle 10| & \langle 11| \\ \hline |00\rangle & 1 & 0 & 0 & 0 \\ |01\rangle & 0 & 1 & 0 & 0 \\ |10\rangle & 0 & 0 & 0 & 1 \\ |11\rangle & 0 & 0 & 1 & 0 \end{pmatrix}$$

```
1 $\displaystyle CNOT\doteq\qgateOCNOT $
```

Toffoli (CCNOT) Gate Operator

$$CCNOT \doteq \begin{pmatrix} & \langle 000| & \langle 001| & \langle 010| & \langle 011| & \langle 100| & \langle 101| & \langle 110| & \langle 111| \\ \hline |000\rangle & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ |001\rangle & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ |010\rangle & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ |101\rangle & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ |100\rangle & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ |101\rangle & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ |110\rangle & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ |111\rangle & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$

```
1 $\displaystyle CCNOT\doteq\qgateOCCNOT $
```

2.7 Auxiliary Commands

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

Adds control wire(s) to any gate (except CNOT and measurement).

Parameters

option Omit for standard circuit styling or `ibmqxA`,...,`ibmqxH` for IBM Q Experience circuit styling. The last letter of `ibmqx*` defines the color control wire:
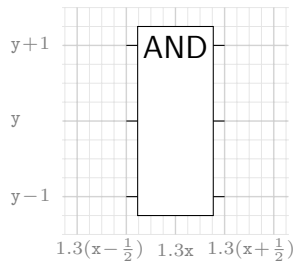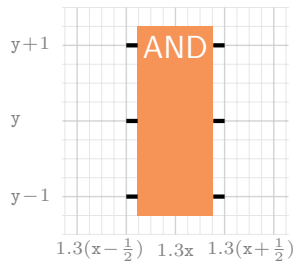
A B C D E F G H
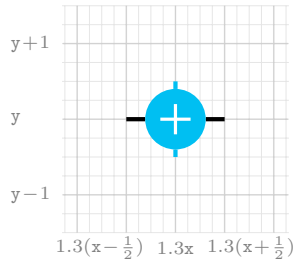
If `ibmqx` is passed, `ibmqxD` will be used.

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
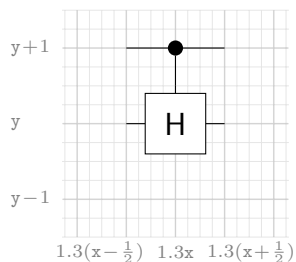

```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateCNC{b}{0}{1}
4   \qgateH{0}{0}\qgateControl{t}{0}{0}
5 \end{tikzpicture}
```
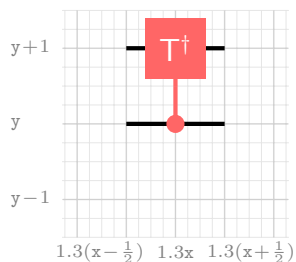


```
1 \begin{tikzpicture}
2   \qScalePaper
3   \qgateTi[ibmqx]{0}{1}\qgateControl[ibmqxE]{b}{0}{1}
4   \qgateCNC[ibmqxE]{t}{0}{0}
5 \end{tikzpicture}
```

```
\qnode[style]{x}{y}{label}
```

TikZ node in schematics coordinates.

Parameters

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

Examples
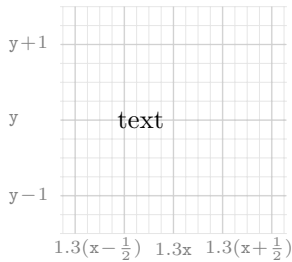

```latex
1 \begin{tikzpicture}
2   \qScalePaper
3   \qnode[anchor=east]{0}{0}{text}
4 \end{tikzpicture}
```

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={}}
```

```latex
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 $|0\rangle$};
55    }{%
56      \node[anchor=east] at (\x+\qgateSx/2,\y){$|0\rangle$};
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|##1\rangle}
93    \def\bra##1{\scriptstyle\langle ##1|}
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|##1\rangle}
111    \def\bra##1{\scriptstyle\langle ##1|}
112    \left(\hspace*{-0.4ex}\begin{array}{c|cc}
113            & \bra{0} & \bra{1} \\\hline
114      \ket{0} &      0 &       1 \\
```

```latex
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}}
```

```latex
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\qgateOSi{{%
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\qgateOT{{%
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\qgateOTi{{%
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 \makeatletter
257 \newcommand\qgateUa{\@ifstar\qgateUaS\qgateUaN}
258 \makeatother
```

```latex
259 \newcommand\qgateUaN[3][]{% unstarred version
260   \ifthenelse{\isin{ibmqx}{#1}}{%
261     \qgateU[ibmqxA]{#2}{#3}{U1}
262   }{%
263     \qgateU{#2}{#3}{U1}
264   }%
265 }
266 \newcommand\qgateUaS[4][]{% starred version
267   \ifthenelse{\isin{ibmqx}{#1}}{%
268     \qgateU[ibmqxA]{#2}{#3}{\qgateSublabel{U1}{#4}}
269   }{%
270     \qgateU{#2}{#3}{\qgateSublabel{U1}{#4}}
271   }%
272 }
273 \newcommand\qgateOUa{{%
274   \def\ket##1{\scriptstyle|##1\rangle}
275   \def\bra##1{\scriptstyle\langle ##1|}
276   \def\e{\mathrm{e}}
277   \def\j{\mathrm{i}}
278   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
279           & \bra{0} &        \bra{1} \\\hline
280   \ket{0} &      1 &             0 \\
281   \ket{1} &      0 & \e^{\lambda\j}
282   \end{array}\!\right)
283 }}
284
285 % U2 gate of IBM Q Experience
286 \makeatletter
287 \newcommand\qgateUb{\@ifstar\qgateUbS\qgateUbN}
288 \makeatother
289 \newcommand\qgateUbN[3][]{% unstarred version
290   \ifthenelse{\isin{ibmqx}{#1}}{%
291     \qgateU[ibmqxA]{#2}{#3}{U2}
292   }{%
293     \qgateU{#2}{#3}{U2}
294   }%
295 }
296 \newcommand\qgateUbS[4][]{% starred version
297   \ifthenelse{\isin{ibmqx}{#1}}{%
298     \qgateU[ibmqxA]{#2}{#3}{\qgateSublabel{U2}{#4}}
299   }{%
300     \qgateU{#2}{#3}{\qgateSublabel{U2}{#4}}
301   }%
302 }
303 \newcommand\qgateOUb{{%
304   \def\ket##1{\scriptstyle|##1\rangle}
305   \def\bra##1{\scriptstyle\langle ##1|}
306   \def\e{\mathrm{e}}
307   \def\j{\mathrm{i}}
308   \renewcommand\arraystretch{1.4}
309   \dfrac{1}{\sqrt{2}}\!
310   \left(\hspace*{-0.4ex}\begin{array}{c|cc}
311           &     \bra{0} &              \bra{1} \\\hline
312   \ket{0} &           1 &        -\e^{\lambda\j} \\
313   \ket{1} & \e^{\phi\j} & \e^{(\lambda+\phi)\j}
314   \end{array}\!\right)
315 }}
316
317 % U3 gate of IBM Q Experience
318 \makeatletter
319 \newcommand\qgateUc{\@ifstar\qgateUcS\qgateUcN}
320 \makeatother
321 \newcommand\qgateUcN[3][]{%
322   \ifthenelse{\isin{ibmqx}{#1}}{% unstarred version
323     \qgateU[ibmqxA]{#2}{#3}{U3}
324   }{%
325     \qgateU{#2}{#3}{U3}
326   }%
327 }
328 \newcommand\qgateUcS[4][]{% starred version
329   \ifthenelse{\isin{ibmqx}{#1}}{% unstarred version
330     \qgateU[ibmqxA]{#2}{#3}{\qgateSublabel{U3}{#4}}
```

```latex
331      }{%
332        \qgateU{#2}{#3}{\qgateSublabel{U3}{#4}}
333      }%
334  }
335  \newcommand\qgateOUc{{%
336    \def\ket##1{\scriptstyle|##1\rangle}
337    \def\bra##1{\scriptstyle\langle ##1|}
338    \def\e{\mathrm{e}}
339    \def\j{\mathrm{i}}
340    \renewcommand\arraystretch{1.4}
341    \left(\hspace*{-0.4ex}\begin{array}{c|cc}
342             &                        \bra{0} &                                  \bra{1} \\\hline
343      \ket{0} &         \cos(\frac{\theta}{2}) &       -\sin(\frac{\theta}{2})\e^{\lambda\j} \\
344      \ket{1} & \sin(\frac{\theta}{2})\e^{\phi\j} & \cos(\frac{\theta}{2})\e^{(\lambda+\phi)\j}
345    \end{array}\!\right)
346  }}
347
348  % General two-qubit gate
349  \newcommand{\qgateUu}[4][]{{%
350    \pgfmathsetmacro\x{\qgateSx*(#2)}
351    \pgfmathsetmacro\y{(#3)}
352    \ifthenelse{\isin{ibmqx}{#1}}{%
353      \tikzset{lstyle/.style={ultra thick,line cap=butt}}
354      \ifthenelse{\equal{ibmqx}{#1}}{%
355        \tikzset{rstyle/.style={draw=none,fill=ibmqxG}}
356      }{%
357        \tikzset{rstyle/.style={draw=none,fill=#1}}
358      }
359      \tikzset{tstyle/.style={white}}
360    }{%
361      \tikzset{lstyle/.style={}}
362      \tikzset{rstyle/.style={fill=white}}
363      \tikzset{tstyle/.style={}}
364    }%
365    \draw[rstyle] (\x-0.5    ,\y-0.25) rectangle (\x+0.5,\y+1.25);
366    \draw[lstyle] (\x-\qgateSx/2,\y+1) -- (\x-0.5      ,\y+1);
367    \draw[lstyle] (\x+0.5       ,\y+1) -- (\x+\qgateSx/2,\y+1);
368    \draw[lstyle] (\x-\qgateSx/2,\y  ) -- (\x-0.    5  ,\y  );
369    \draw[lstyle] (\x+0.5       ,\y  ) -- (\x+\qgateSx/2,\y  );
370    \node[anchor=north,tstyle] at (\x,\y+1.25){\sf\large #4};
371  }}
372
373  % General three-qubit gate
374  \newcommand{\qgateUuu}[4][]{{%
375    \pgfmathsetmacro\x{\qgateSx*(#2)}
376    \pgfmathsetmacro\y{(#3)}
377    \ifthenelse{\isin{ibmqx}{#1}}{%
378      \tikzset{lstyle/.style={ultra thick,line cap=butt}}
379      \ifthenelse{\equal{ibmqx}{#1}}{%
380        \tikzset{rstyle/.style={draw=none,fill=ibmqxG}}
381      }{%
382        \tikzset{rstyle/.style={draw=none,fill=#1}}
383      }
384      \tikzset{tstyle/.style={white}}
385    }{%
386      \tikzset{lstyle/.style={}}
387      \tikzset{rstyle/.style={fill=white}}
388      \tikzset{tstyle/.style={}}
389    }%
390    \draw[rstyle] (\x-0.5    ,\y-1.25) rectangle (\x+0.5,\y+1.25);%
391    \draw[lstyle] (\x-\qgateSx/2,\y+1) -- (\x-0.5      ,\y+1);%
392    \draw[lstyle] (\x+0.5       ,\y+1) -- (\x+\qgateSx/2,\y+1);%
393    \draw[lstyle] (\x-\qgateSx/2,\y  ) -- (\x-0.5      ,\y  );%
394    \draw[lstyle] (\x+0.5       ,\y  ) -- (\x+\qgateSx/2,\y  );%
395    \draw[lstyle] (\x-\qgateSx/2,\y-1) -- (\x-0.5      ,\y-1);%
396    \draw[lstyle] (\x+0.5       ,\y-1) -- (\x+\qgateSx/2,\y-1);%
397    \node[anchor=north,tstyle] at (\x,\y+1.25){\sf\large #4};%
398  }}
399
400  % CNOT gate XOR symbol
401  \newcommand\qgateCNX[4][]{{%
402    \pgfmathsetmacro\x{\qgateSx*(#3)}
```

```latex
403    \pgfmathsetmacro\y{(#4)}
404    \ifthenelse{\isin{ibmqx}{#1}}{%
405      \tikzset{lstyle/.style={ultra thick,line cap=butt}}
406      \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
407      \tikzset{rstyle/.style={draw=none,fill=ibmqxD}}
408      \tikzset{tstyle/.style={very thick,white}}
409      \def\R{0.4}
410    }{%
411      \tikzset{lstyle/.style={}}
412      \tikzset{cstyle/.style={}}
413      \tikzset{rstyle/.style={fill=white}}
414      \tikzset{tstyle/.style={}}
415      \def\R{0.25}
416    }%
417    \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x-\R        ,\y);
418    \draw[lstyle] (\x+\R        ,\y) -- (\x+\qgateSx/2,\y);
419    \draw[rstyle] (\x           ,\y) circle (\R);
420    \ifthenelse{\isin{ibmqx}{#1}}{%
421      \draw[tstyle] (\x-0.2,\y) -- (\x+0.2,\y);
422      \draw[tstyle] (\x,\y-0.2) -- (\x,\y+0.2);
423    }{%
424      \draw[lstyle] (\x-\R,\y) -- (\x+\R,\y);
425      \draw[lstyle] (\x,\y-\R) -- (\x,\y+\R);
426    }
427    \ifthenelse{\isin{t}{#2}}{%
428      \draw[cstyle] (\x,\y+\R) -- (\x,\y+0.5);
429    }{}
430    \ifthenelse{\isin{b}{#2}}{%
431      \draw[cstyle] (\x,\y-\R) -- (\x,\y-0.5);
432    }{}
433 }}
434
435 % CNOT gate control qubit symbol
436 \newcommand\qgateCNC[4][]{{%
437    \pgfmathsetmacro\x{\qgateSx*(#3)}
438    \pgfmathsetmacro\y{(#4)}
439    \ifthenelse{\isin{ibmqx}{#1}}{%
440      \tikzset{lstyle/.style={ultra thick,line cap=butt}}
441      \ifthenelse{\equal{ibmqx}{#1}}{%
442        \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
443        \tikzset{rstyle/.style={draw=none,fill=ibmqxD}}
444      }{%
445        \tikzset{cstyle/.style={#1,ultra thick,line cap=butt}}
446        \tikzset{rstyle/.style={draw=none,fill=#1}}
447      }
448      \tikzset{tstyle/.style={white}}
449      \def\r{0.12}
450    }{%
451      \tikzset{lstyle/.style={}}
452      \tikzset{cstyle/.style={}}
453      \tikzset{rstyle/.style={draw=none,fill=black}}
454      \tikzset{tstyle/.style={}}
455      \def\r{0.1}
456    }%
457    \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
458    \draw[rstyle] (\x           ,\y) circle (\r);
459    \ifthenelse{\isin{t}{#2}}{%
460      \draw[cstyle] (\x,\y+0.1) -- (\x,\y+0.5);
461    }{}
462    \ifthenelse{\isin{b}{#2}}{%
463      \draw[cstyle] (\x,\y-0.1) -- (\x,\y-0.5);
464    }{}
465 }}
466
467 % CNOT gate run-through qubit symbol
468 \newcommand\qgateCNR[3][]{{%
469    \pgfmathsetmacro\x{\qgateSx*(#2)}
470    \pgfmathsetmacro\y{(#3)}
471    \ifthenelse{\isin{ibmqx}{#1}}{%
472      \tikzset{lstyle/.style={ultra thick,line cap=butt}}
473      \ifthenelse{\equal{ibmqx}{#1}}{%
474        \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
```

```
475      }{%
476        \tikzset{cstyle/.style={#1,ultra thick,line cap=butt}}
477      }
478    }{%
479      \tikzset{lstyle/.style={}}
480      \tikzset{cstyle/.style={}}
481    }%
482    \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
483    \draw[cstyle] (\x        ,\y-0.5) -- (\x        ,\y+0.5);
484 }}
485
486 % Sawp gate top qubit symbol
487 \newcommand\qgateSWt[3][]{{%
488    \pgfmathsetmacro\x{\qgateSx*(#2)}
489    \pgfmathsetmacro\y{(#3)}
490    \ifthenelse{\isin{ibmqx}{#1}}{%
491      \draw[ultra thick,line cap=butt]
492        (\x-\qgateSx/2,\y) -- (\x-0.2,\y) -- (\x+0.2,\y-0.4) -- (\x+0.2,\y-0.5);
493      \draw[ultra thick,line cap=butt]
494        (\x+\qgateSx/2,\y) -- (\x+0.2,\y) -- (\x-0.2,\y-0.4) -- (\x-0.2,\y-0.5);
495    }{%
496      \pgfmathsetmacro\w{0.1}
497      \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
498      \draw(\x-\w,       \y-\w) -- (\x+\w,       \y+\w);
499      \draw(\x-\w,       \y+\w) -- (\x+\w,       \y-\w);
500      \draw(\x,          \y) -- (\x,        \y-0.5);
501    }%
502 }}
503
504 % Sawp gate run-through qubit symbol
505 \newcommand\qgateSWR[3][]{{%
506    \pgfmathsetmacro\x{\qgateSx*(#2)}
507    \pgfmathsetmacro\y{(#3)}
508    \ifthenelse{\isin{ibmqx}{#1}}{%
509      \draw[ultra thick,line cap=butt] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
510      \draw[ultra thick,line cap=butt] (\x-0.2,    \y+0.5) -- (\x-0.2,    \y-0.5);
511      \draw[ultra thick,line cap=butt] (\x+0.2,    \y+0.5) -- (\x+0.2,    \y-0.5);
512    }{%
513      \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
514      \draw(\x,       \y-0.5) -- (\x,       \y+0.5);
515    }%
516 }}
517
518 % Sawp gate bottom qubit symbol
519 \newcommand\qgateSWb[3][]{{%
520    \pgfmathsetmacro\x{\qgateSx*(#2)}
521    \pgfmathsetmacro\y{(#3)}
522    \ifthenelse{\isin{ibmqx}{#1}}{%
523      \draw[ultra thick,line cap=butt]
524        (\x-\qgateSx/2,\y) -- (\x-0.2,\y) -- (\x-0.2,\y+0.5);
525      \draw[ultra thick,line cap=butt]
526        (\x+\qgateSx/2,\y) -- (\x+0.2,\y) -- (\x+0.2,\y+0.5);
527    }{%
528      \pgfmathsetmacro\w{0.1}
529      \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
530      \draw(\x-\w,       \y-\w) -- (\x+\w,       \y+\w);
531      \draw(\x-\w,       \y+\w) -- (\x+\w,       \y-\w);
532      \draw(\x,          \y) -- (\x,        \y+0.5);
533    }%
534 }}
535
536 % Measurement symbol
537 \makeatletter
538 \newcommand\qmeasM{\@ifstar\qmeasMS\qmeasMN}
539 \makeatother
540 \newcommand\qmeasMN[3][]{
541    \qmeasMS[#1]{#2}{#3}{Z}{br}
542 }
543 \newcommand\qmeasMS[5][]{{%
544    \pgfmathsetmacro\x{\qgateSx*(#2)}
545    \pgfmathsetmacro\y{(#3)}
546    \ifthenelse{\isin{ibmqx}{#1}}{%
```

```
547      \tikzset{lstyle/.style={ultra thick,line cap=butt}}
548      \tikzset{rstyle/.style={draw=none,fill=ibmqxF}}
549      \tikzset{tstyle/.style={white,very thick,line cap=butt}}
550      \tikzset{pstyle/.style={->,>=stealth,white,thick,line cap=butt}}
551      \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
552   }{%
553      \tikzset{lstyle/.style={}}
554      \tikzset{rstyle/.style={fill=white}}
555      \tikzset{tstyle/.style={}}
556      \tikzset{pstyle/.style={->,>=stealth,line cap=butt}}
557      \tikzset{cstyle/.style={}}
558   }%
559   \draw[lstyle] (\x-\qgateSx/2,\y  ) -- (\x-0.4,\y);
560   \draw[rstyle] (\x-0.4    ,\y-0.4 ) rectangle (\x+0.4,\y+0.4);
561   \draw[tstyle] (\x+0.27   ,\y-0.2 ) arc (0:180:0.27);
562   \draw[pstyle] (\x        ,\y-0.15) -- (\x+0.2,\y+0.22);
563   \node[pstyle] at (\x+0.28,\y+0.15) {\tiny\sf #4};
564   \fill[pstyle] (\x        ,\y-0.15) circle (0.035);
565   \ifthenelse{\isin{r}{#5}}{%
566      \draw[lstyle] (\x+0.4,\y) -- (\x+\qgateSx/2,\y);%
567   }{}
568   \ifthenelse{\isin{b}{#5}}{%
569      \draw[cstyle] (\x,\y-0.4 ) -- (\x,\y-0.5);%
570   }{}
571 }}
572
573 % Measurement run-through qubit symbol
574 \newcommand\qmeasR[3][]{{%
575   \pgfmathsetmacro\x{\qgateSx*(#2)}
576   \pgfmathsetmacro\y{(#3)}
577   \ifthenelse{\isin{ibmqx}{#1}}{%
578      \tikzset{lstyle/.style={ultra thick,line cap=butt}}
579      \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
580   }{%
581      \tikzset{lstyle/.style={}}
582      \tikzset{cstyle/.style={}}
583   }%
584   \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
585   \draw[cstyle] (\x        ,\y-0.5) -- (\x        ,\y+0.5);
586 }}
587
588 % Measurement-joins-bus symbol
589 \newcommand\qmeasMB[4][]{{%
590   \pgfmathsetmacro\x{\qgateSx*(#3)}
591   \pgfmathsetmacro\y{(#4)}
592   \ifthenelse{\isin{ibmqx}{#1}}{%
593      \tikzset{cstyle/.style={>=stealth,ibmqxI,ultra thick,line cap=butt}}
594   }{%
595      \tikzset{cstyle/.style={>=stealth}}
596   }%
597   \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
598   \draw[cstyle,->] (\x,\y+0.5) -- (\x,\y-0.3)
599      node[anchor=north,black] {\footnotesize #2};
600 }}
601
602 % Measurement bus symbol
603 \newcommand\qmeasB[3][]{{%
604   \pgfmathsetmacro\x{\qgateSx*(#2)}
605   \pgfmathsetmacro\y{(#3)}
606   \ifthenelse{\isin{ibmqx}{#1}}{%
607      \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
608   }{%
609      \tikzset{cstyle/.style={}}
610   }%
611   \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
612 }}
613
614 % Measurement bus head symbol
615 \newcommand\qmeasBh[4][]{{%
616   \pgfmathsetmacro\x{\qgateSx*(#3)}
617   \pgfmathsetmacro\y{(#4)}
618   \ifthenelse{\isin{ibmqx}{#1}}{%
```

```latex
619      \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
620    }{%
621      \tikzset{cstyle/.style={}}
622    }%
623    \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
624    \draw[cstyle](\x-\qgateSx/2+0.05,\y-0.45) -- (\x-\qgateSx/2+0.15,\y-0.1)
625      node[anchor=east,black] {\footnotesize #2};
626 }}
627
628 %% == OTHER GATE OPERATORS ================================================
629
630 \newcommand\qgateOCNOT{{%
631    \def\ket##1{\scriptstyle|##1\rangle}
632    \def\bra##1{\rotatebox{90}{$\scriptstyle\langle ##1|$}}
633    \left(\hspace*{-0.4ex}\begin{array}{c|cccc}
634            & \bra{00} & \bra{01} & \bra{10} & \bra{11} \\\hline
635     \ket{00} &        1 &        0 &        0 &        0 \\
636     \ket{01} &        0 &        1 &        0 &        0 \\
637     \ket{10} &        0 &        0 &        0 &        1 \\
638     \ket{11} &        0 &        0 &        1 &        0
639    \end{array}\!\right)
640 }}
641
642 \newcommand\qgateOCCNOT{{%
643    \def\ket##1{\scriptstyle|##1\rangle}
644    \def\bra##1{\rotatebox{90}{$\scriptstyle\langle ##1|$}}
645    \left(\hspace*{-0.4ex}\begin{array}{c|cccccccc}
646            & \bra{000} & \bra{001} & \bra{010} & \bra{011} & \bra{100} & \bra{101} & \bra{110} & \bra{111} \\\hline
647     \ket{000} &        1 &        0 &        0 &        0 &        0 &        0 &        0 &        0 \\
648     \ket{001} &        0 &        1 &        0 &        0 &        0 &        0 &        0 &        0 \\
649     \ket{010} &        0 &        0 &        1 &        0 &        0 &        0 &        0 &        0 \\
650     \ket{101} &        0 &        0 &        0 &        1 &        0 &        0 &        0 &        0 \\
651     \ket{100} &        0 &        0 &        0 &        0 &        1 &        0 &        0 &        0 \\
652     \ket{101} &        0 &        0 &        0 &        0 &        0 &        1 &        0 &        0 \\
653     \ket{110} &        0 &        0 &        0 &        0 &        0 &        0 &        0 &        1 \\
654     \ket{111} &        0 &        0 &        0 &        0 &        0 &        0 &        1 &        0
655    \end{array}\!\right)
656 }}
657
658 %% == AUXILIARY COMMANDS ================================================
659
660 % Control wires for gates
661 \newcommand\qgateControl[4][]{{%
662    \pgfmathsetmacro\x{\qgateSx*(#3)}
663    \pgfmathsetmacro\y{(#4)}
664      \ifthenelse{\isin{ibmqx}{#1}}{%
665      \ifthenelse{\equal{ibmqx}{#1}}{%
666        \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
667      }{%
668        \tikzset{cstyle/.style={#1,ultra thick,line cap=butt}}
669      }
670    }{%
671      \tikzset{cstyle/.style={}}
672    }%
673    \ifthenelse{\isin{t}{#2}}{%
674      \draw[cstyle] (\x,\y+0.4) -- (\x,\y+0.5);
675    }{}
676    \ifthenelse{\isin{b}{#2}}{%
677      \draw[cstyle] (\x,\y-0.4) -- (\x,\y-0.5);
678    }{}
679 }}
680
681 % TikZ node in circuit coordinate system
682 \newcommand\qnode[4][]{%
683    \pgfmathsetmacro\x{\qgateSx*(#2)}
684    \pgfmathsetmacro\y{(#3)}
685    \node[#1] at (\x,\y) {#4};
686 }
687
688 %% == PACKAGE-INTERNAL COMMANDS ================================================
689
690 % Draw scale paper for documentations
```

```
691 \newcommand{\qScalePaper}{%
692   \draw[help lines,xstep=(\qgateSx/8),ystep=0.25,opacity=0.2] (-1.5,-1.5) grid (1.5,1.5);
693   \draw[help lines,line width=.6pt,xstep=(\qgateSx/2),ystep=1,opacity=0.2] (-1.49,-1.5) grid (1.49,1.5);
694   \node[color=gray]               at (-1  ,-1.7) {\scriptsize $\qgateSx(\texttt{x}\!-\!\frac{1}{2})$};
695   \node[color=gray]               at ( 0  ,-1.7) {\scriptsize $\qgateSx\texttt{x}$};
696   \node[color=gray]               at ( 1  ,-1.7) {\scriptsize $\qgateSx(\texttt{x}\!+\!\frac{1}{2})$};
697   \node[anchor=west ,color=gray] at (-2.3,-1  ) {\scriptsize $\texttt{y}\!-\!1$};
698   \node[anchor=west ,color=gray] at (-2.3, 0  ) {\scriptsize $\texttt{y}$};
699   \node[anchor=west ,color=gray] at (-2.3, 1  ) {\scriptsize $\texttt{y}\!+\!1$};
700 }
701
702 % Draw gate label with sub-label
703 \newcommand\qgateSublabel[2]{%
704   {\renewcommand{\arraystretch}{0.4}%
705   \begin{tabular}{c}#1\\\tiny #2\end{tabular}}%
706 }
707
708 %% == 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.