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

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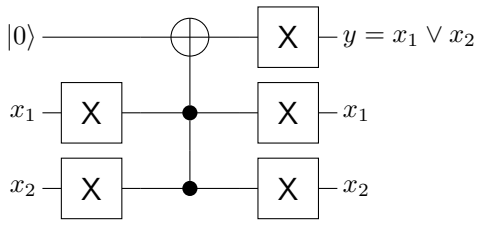
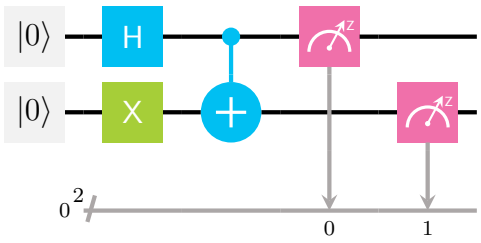
See https://github.com/matthias-wolff/tikz-quantumgates/blob/master/tikz-quantumgates.pdf for the latest version of this document.

Abstract

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




```
\documentclass{standalone}
\usepackage{tikz-quantumgates}
\begin{document}
  \centering
  \begin{tikzpicture}
    \node[anchor=east] at (-0.6,2) {$|0\rangle$};
    \node[anchor=east] at (-0.6,1) {$x_1$};
    \node[anchor=east] at (-0.6,0) {$x_2$};
    \qwire{0}{2}\qgateX{0}{1}\qgateX{0}{0}
    \qgateCNX{b}{1}{2}\qgateCNC{bt}{1}{1}\qgateCNC{t}{1}{0}
    \qgateX{2}{2}\qgateX{2}{1}\qgateX{2}{0}
    \node[anchor=west] at (3.2,2) {$y=x_1\vee x_2$};
    \node[anchor=west] at (3.2,1) {$x_1$};
    \node[anchor=west] at (3.2,0) {$x_2$};
  \end{tikzpicture}
\end{document}
```




```
\documentclass{standalone}
\usepackage{tikz-quantumgates}
\begin{document}
  \centering
  \begin{tikzpicture}
    \node[anchor=east] at (0.6,-0.3) {\footnotesize 0};
    \qzero[ibmqx]{0}{2}\qzero[ibmqx]{0}{1}
    \qgateH[ibmqx]{1}{2}\qgateX[ibmqx]{1}{1}\qmeasBh[ibmqx]{2}{1}{0}
    \qgateCNC[ibmqx]{b}{2}{2}\qgateCNX[ibmqx]{t}{2}{1}\qmeasB[ibmqx]{2}{0}
    \qmeasM[ibmqx]{3}{2}\qmeasR[ibmqx]{3}{1}\qmeasMB[ibmqx]{0}{3}{0}
    \qwire[ibmqx]{4}{2}\qmeasM[ibmqx]{4}{1}\qmeasMB[ibmqx]{1}{4}{0}
  \end{tikzpicture}
\end{document}
```

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1 Overview

1.1 List of Circuit Symbols

Standard	Option `ibmqx`	Command
		`\qwire[option]{x}{y}`
$\|0\rangle$	$\|0\rangle$	`\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}`
		`\qgateCNX[option]{cwires}{x}{y}`
		`\qgateCNR[option]{x}{y}`
		`\qgateCNC[option]{cwires}{x}{y}`
		`\qgateCNC*[option]{cwires}{x}{y}`
		`\qgateSWt[option]{x}{y}` (not an "official" IBM QX symbol)
		`\qgateSWR[option]{x}{y}` (not an "official" IBM QX symbol)

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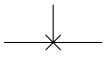
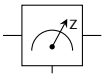
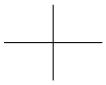
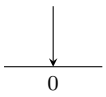
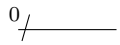
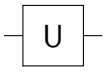
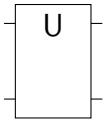
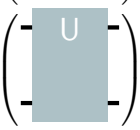
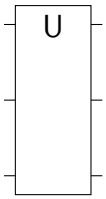
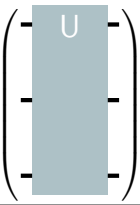
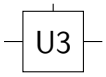
Standard	Option `ibmqx`	Command
		`\qgateSWb[option]{x}{y}` (not an "official" IBM QX symbol)
		`\qmeasM[option]{x}{y}`
		`\qmeasM*[option]{x}{y}{axis}{wires}`
		`\qmeasR[option]{x}{y}`
		`\qmeasMB[option]{b}{x}{y}`
		`\qmeasB[option]{x}{y}`
		`\qmeasBh[option]{b}{x}{y}`
		`\qgateU[option]{x}{y}{label}`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

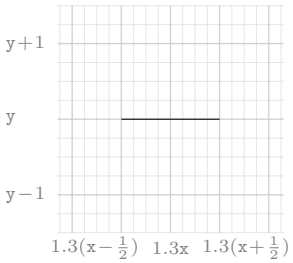
```
\qwire[option]{x}{y}
```

Draws a wire.

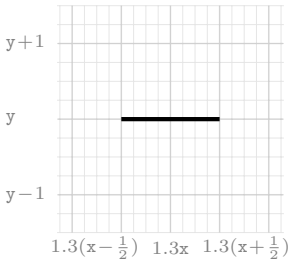
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qwire{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qwire[ibmqx]{0}{0}
\end{tikzpicture}
```

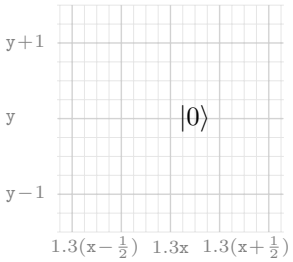
`\qzero[option]{x}{y}`

Draws the zero-state preparator.

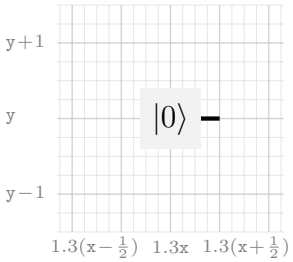
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qzero{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qzero[ibmqx]{0}{0}
\end{tikzpicture}
```

2.2 Single-Qubit Gate Symbols

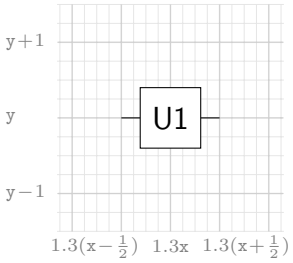
`\qgateU[option]{x}{y}{label}`

Draws a general single-qubit quantum gate.

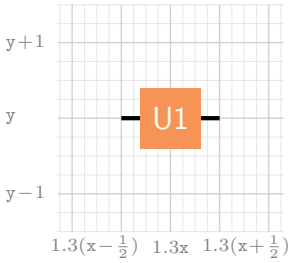
Parameters

`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 (`\qgateSx*x`, `y`).
`label`	Gate label.

Examples




```
\begin{tikzpicture}
  \qScalePaper
  \qgateU{0}{0}{U1}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateU[ibmqxA]{0}{0}{U1}
\end{tikzpicture}
```

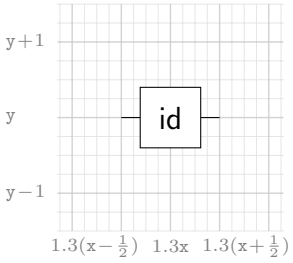
`\qgateID[option]{x}{y}`

Draws the identity gate.

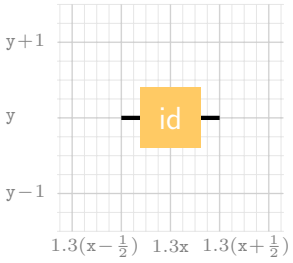
Parameters

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

Examples




```
\begin{tikzpicture}
  \qScalePaper
  \qgateID{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateID[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

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

```
$\displaystyle I\doteq\qgateOID $
```

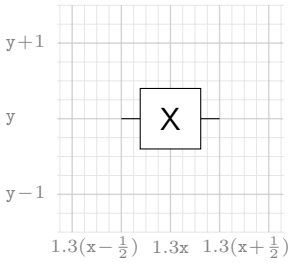
\qgateX[option]{x}{y}

Pauli-X gate.

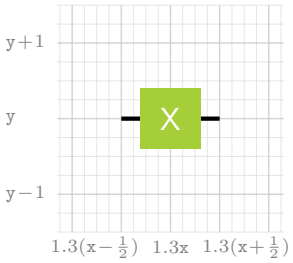
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateX{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateX[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

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

```
$\displaystyle X\doteq\qgateOX $
```

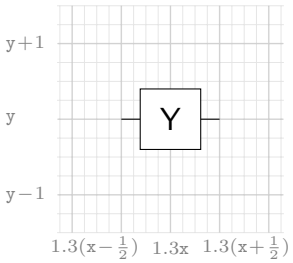
\qgateY[option]{x}{y}

Pauli-Y gate.

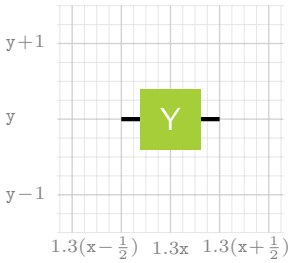
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateY{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateY[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

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

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

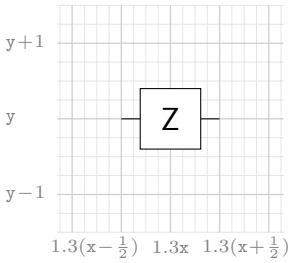
\qgateZ[option]{x}{y}

Pauli-Z gate.

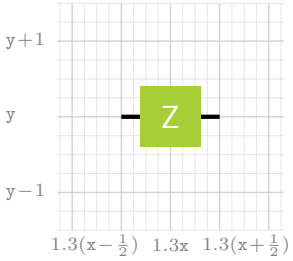
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateZ{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateZ[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

$$Z \doteq \begin{pmatrix} & \langle 0| & \langle 1| \\ |0\rangle & 1 & 0 \\ |1\rangle & 0 & -1 \end{pmatrix}$$

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

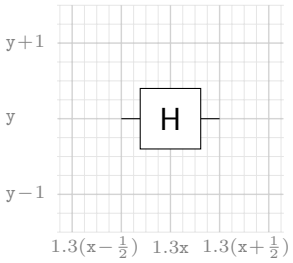
\qgateH[option]{x}{y}

Hadamard gate.

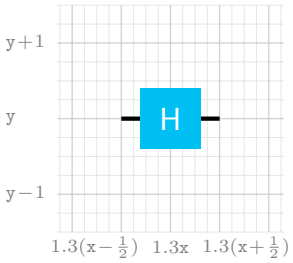
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateH{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateH[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

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

```
$\displaystyle H\doteq\qgateOH $
```

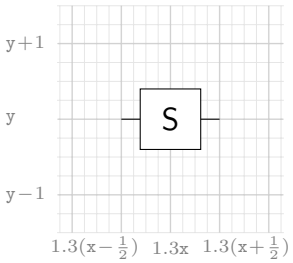
\qgateS[option]{x}{y}

S phase gate.

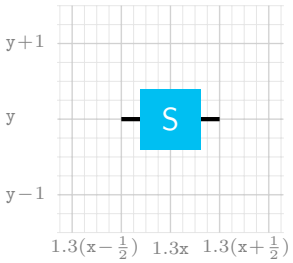
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateS{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateS[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

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

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

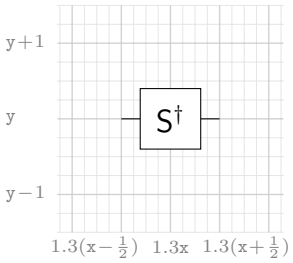
\qgateSi[option]{x}{y}

Inverse S phase gate.

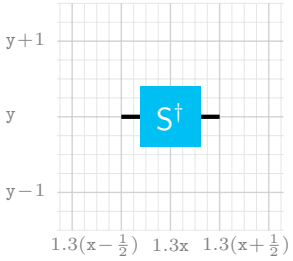
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateSi{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateSi[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

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

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

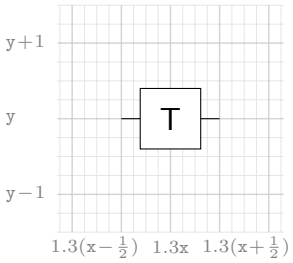
\qgateT[option]{x}{y}

T phase gate.

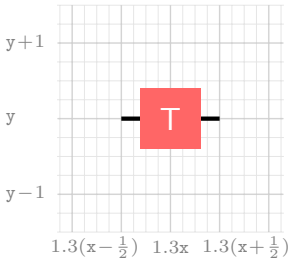
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateT{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateT[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

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

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

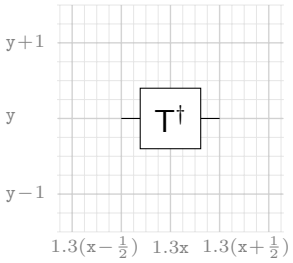
\qgateTi[option]{x}{y}

Inverse T phase gate.

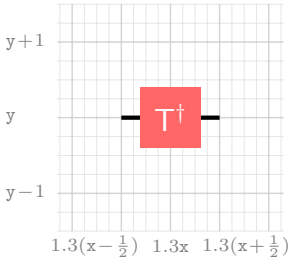
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateTi{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateTi[ibmqx]{0}{0}
\end{tikzpicture}
```

Gate Operator

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

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

2.3 Single-Qubit Physical Gate of IBM Q Experience

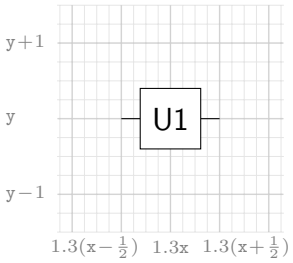
```
\qgateUa[option]{x}{y}
\qgateUa*[option]{x}{y}{sublabel}
```

U1 gate of IBM Q Experience.

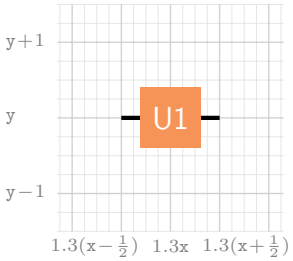
Parameters

`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)

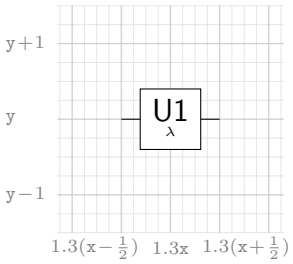
Examples



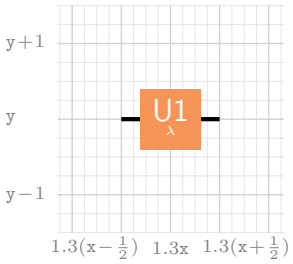

```
\begin{tikzpicture}
  \qScalePaper
  \qgateUa{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUa[ibmqx]{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUa*{0}{0}{$\lambda$}
\end{tikzpicture}
```




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

Gate Operator

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

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

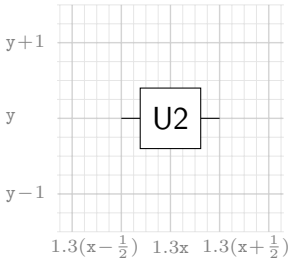
```
\qgateUb[option]{x}{y}
\qgateUb*[option]{x}{y}{sublabel}
```

U2 gate of IBM Q Experience.

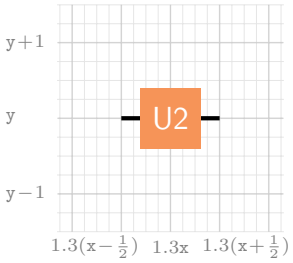
Parameters

`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 (`\qgateSx*x`, `y`).
`sublabel`	Sub-label, e. g. for gate parameters (starred version only)

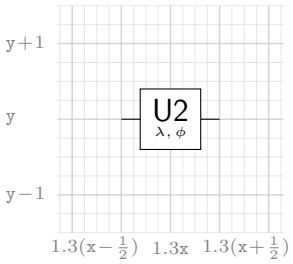
Examples



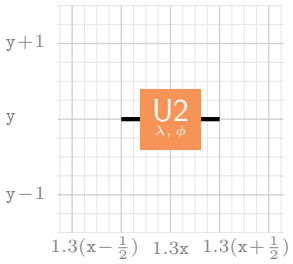

```
\begin{tikzpicture}
  \qScalePaper
  \qgateUb{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUb[ibmqx]{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUb*{0}{0}{$\lambda,\phi$}
\end{tikzpicture}
```




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

Gate Operator

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

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

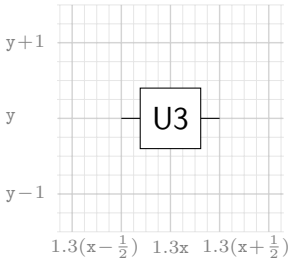
```
\qgateUc[option]{x}{y}
\qgateUc*[option]{x}{y}{sublabel}
```

U3 gate of IBM Q Experience.

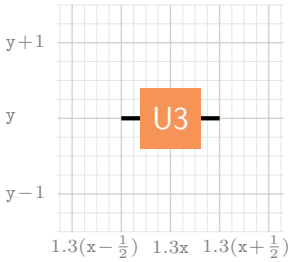
Parameters

`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)

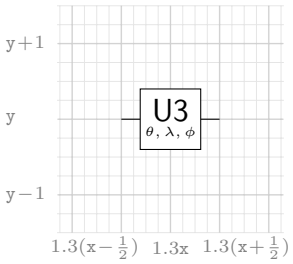
Examples



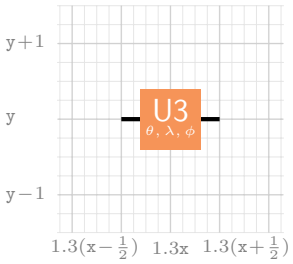

```
\begin{tikzpicture}
  \qScalePaper
  \qgateUc{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUc[ibmqx]{0}{0}
\end{tikzpicture}
```




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




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

Gate Operator

$$U3_{\lambda,\phi,\theta} \doteq \begin{pmatrix} & \langle 0| & \langle 1| \\ |0\rangle & \cos(\frac{\theta}{2}) & -\sin(\frac{\theta}{2})\mathrm{e}^{\lambda \mathrm{i}} \\ |1\rangle & \sin(\frac{\theta}{2})\mathrm{e}^{\phi \mathrm{i}} & \cos(\frac{\theta}{2})\mathrm{e}^{(\lambda+\phi)\mathrm{i}} \end{pmatrix}$$

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

2.4 Multiple-Qubit Gate Symbols

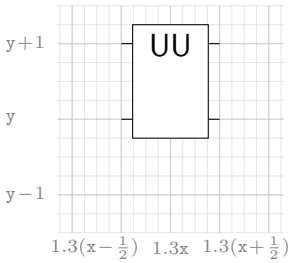
```
\qgateUu[option]{x}{y}{label}
```

General three-qubit gate.

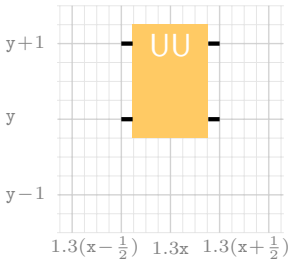
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUu{0}{0}{UU}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUu[ibmqxB]{0}{0}{UU}
\end{tikzpicture}
```

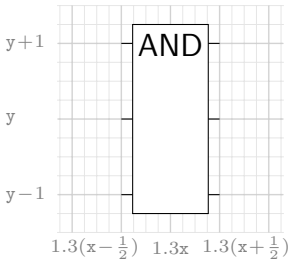
`\qgateUuu[option]{x}{y}{label}`

General three-qubit gate.

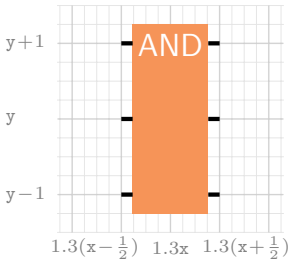
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUuu{0}{0}{AND}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateUuu[ibmqxA]{0}{0}{AND}
\end{tikzpicture}
```

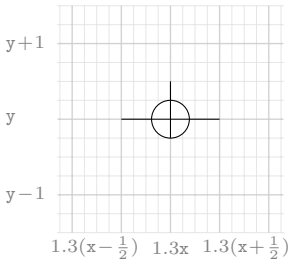
`\qgateCNX[option]{cwires}{x}{y}`

XOR symbol of controlled-NOT gate.

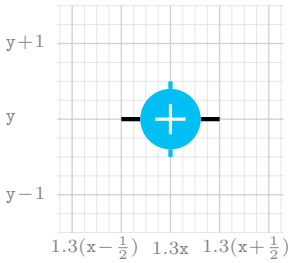
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateCNX{t}{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateCNX[ibmqx]{tb}{0}{0}
\end{tikzpicture}
```

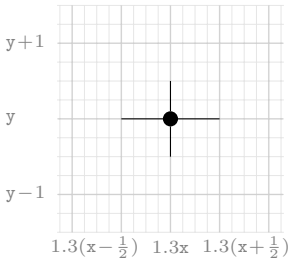
```
\qgateCNC[option]{cwires}{x}{y}
\qgateCNC*[option]{cwires}{x}{y}
```

Control qubit symbol of a controlled gate. Starred version draws inverse control.

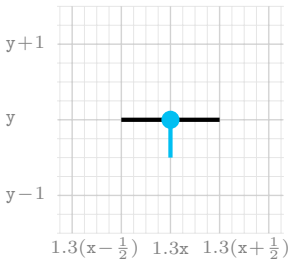
Parameters

`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`).

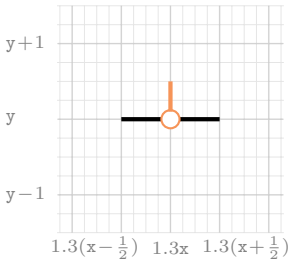
Examples




```
\begin{tikzpicture}
  \qScalePaper
  \qgateCNC{bt}{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateCNC[ibmqx]{b}{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateCNC*[ibmqxA]{t}{0}{0}
\end{tikzpicture}
```

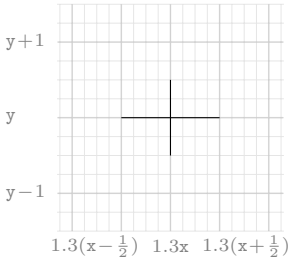
\qgateCNR[option]{x}{y}

Run-through qubit symbol of a controlled gate.

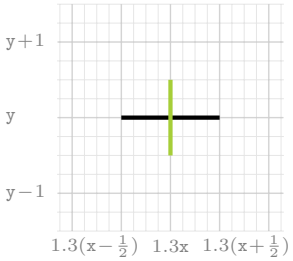
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateCNR{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateCNR[ibmqxC]{0}{0}
\end{tikzpicture}
```

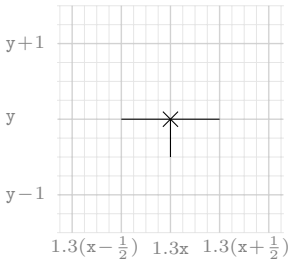
\qgateSWt[option]{x}{y}

Top qubit of a SWAP gate.

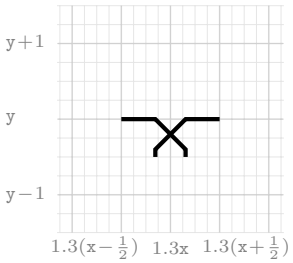
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateSWt{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateSWt[ibmqx]{0}{0}
\end{tikzpicture}
```

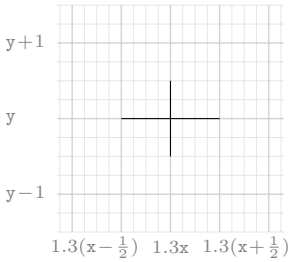
`\qgateSWR[option]{x}{y}`

Run-through qubit of a SWAP gate.

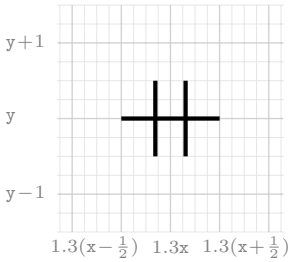
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateSWR{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateSWR[ibmqx]{0}{0}
\end{tikzpicture}
```

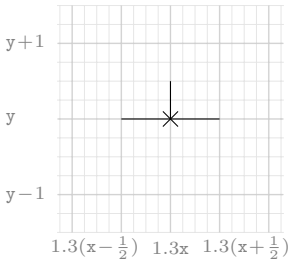
`\qgateSWb[option]{x}{y}`

Bottom qubit of a SWAP gate.

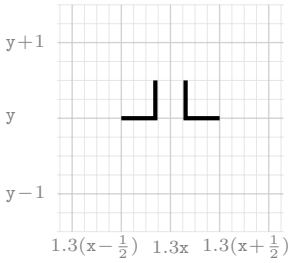
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateSWb{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qgateSWb[ibmqx]{0}{0}
\end{tikzpicture}
```

2.5 Measurement Symbols

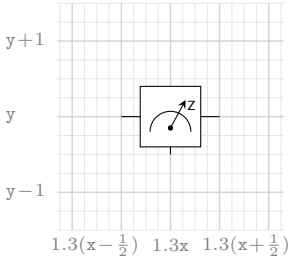
```
\qmeasM[option]{x}{y}
\qmeasM*[option]{x}{y}{axis}{wires}
```

Measurement symbol.

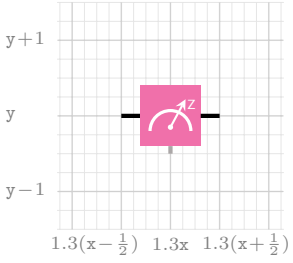
Parameters

`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).

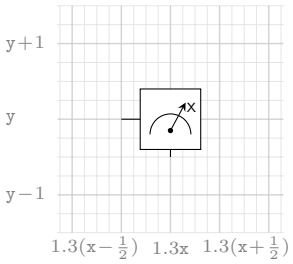
Examples



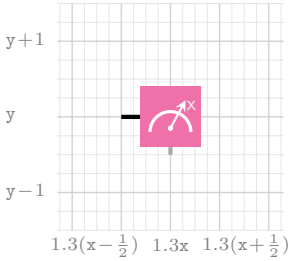

```
\begin{tikzpicture}
  \qScalePaper
  \qmeasM{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasM[ibmqx]{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasM*{0}{0}{X}{b}
\end{tikzpicture}
```




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

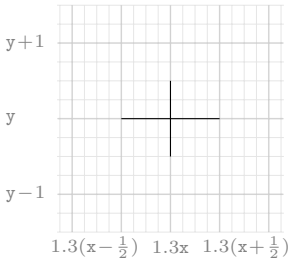
\qmeaR[option]{x}{y}

Measurement run-through qubit symbol.

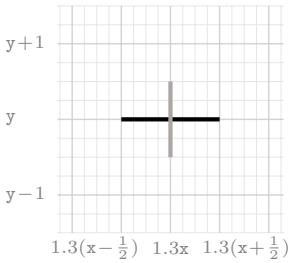
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasR{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasR[ibmqx]{0}{0}
\end{tikzpicture}
```

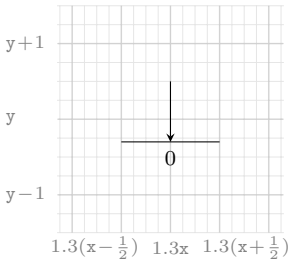
\qmeasMB[option]{b}{x}{y}

Measurement-joins-bus symbol.

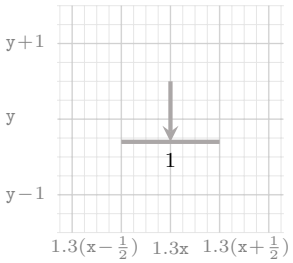
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasMB{0}{0}{0}
\end{tikzpicture}
```




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

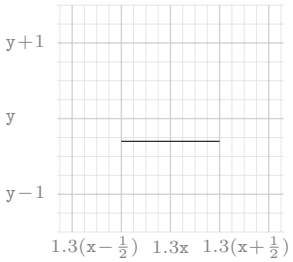
`\qmeaB[option]{x}{y}`

Measurement bus symbol.

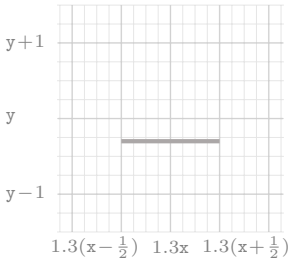
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasB{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasB[ibmqx]{0}{0}
\end{tikzpicture}
```

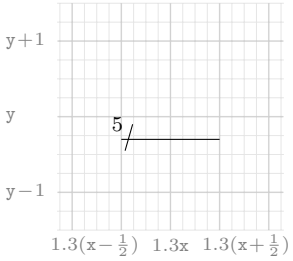
`\qmeaBh[option]{b}{x}{y}`

Measurement bus header symbol.

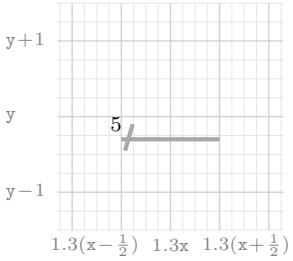
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasBh{5}{0}{0}
\end{tikzpicture}
```




```
\begin{tikzpicture}
  \qScalePaper
  \qmeasBh[ibmqx]{5}{0}{0}
\end{tikzpicture}
```

2.6 Further Gate Operators

CNOT Gate Operator

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

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

Toffoli (CCNOT) Gate Operator

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

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

2.7 Auxiliary Commands

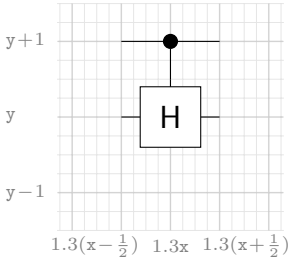
```
\qgateControl[option]{cwires}{x}{y}
```

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

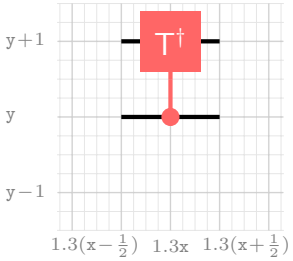
Parameters

`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




```
\begin{tikzpicture}
  \qScalePaper
  \qgateCNC{b}{0}{1}
  \qgateH{0}{0}\qgateControl{t}{0}{0}
\end{tikzpicture}
```




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

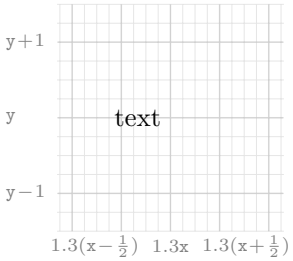
`\qnode[style]{x}{y}{label}`

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




```
\begin{tikzpicture}
  \qScalePaper
  \qnode[anchor=east]{0}{0}{text}
\end{tikzpicture}
```

3 The Package Source Code

```
%% == LaTeX PACKAGE tikz-quantumgates ========================================
%%    Drawing quantum circuits with TikZ
%%
%% Matthias Wolff, BTU Cottbus-Sentenberg
%% August 20, 2018
%%
%% References:
%% [1] T. Tantau. TikZ & PGF - Manual for Version 3.0.1a. 2015.
%%     http://mirror.ctan.org/graphics/pgf/base/doc/pgfmanual.pdf Retrieved
%%     July 22, 2018.
%%
%% TODO:
%%  - Barrier symbols: \qbarrX

%% == REQUIRED PACKAGES ======================================================

\RequirePackage{xifthen}
\RequirePackage{tikz}

%% == DEFINITIONS AND COLORS =================================================
\def\qgateSx{1.3}

\definecolor{ibmqxA}{HTML}{F69458}                                  % IBM QX Ux gate
\definecolor{ibmqxB}{HTML}{FFCA64}                                  % IBM QX id gate
\definecolor{ibmqxC}{HTML}{A6CE38}                                  % IBM QX Pauli gates
\definecolor{ibmqxD}{HTML}{00BFF2}                                  % IBM QX H, S, S' und CNOT gates
\definecolor{ibmqxE}{HTML}{FF6666}                                  % IBM QX T und T' gates
\definecolor{ibmqxF}{HTML}{F070AA}                                  % IBM QX measurement and if
\definecolor{ibmqxG}{HTML}{ADC1C6}                                  % IBM QX barrier
\definecolor{ibmqxH}{HTML}{F2F2F2}                                  % IBM QX |0> state
\definecolor{ibmqxI}{HTML}{ABA7A7}                                  % IBM QX measurement wire

%% == COMMANDS ===============================================================

% Wire
\newcommand{\qwire}[3][]{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
  }{%
    \tikzset{lstyle/.style={}}
  }%
  \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
}

% Zero state preparator
\newcommand{\qzero}[3][]{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \draw[ultra thick,line cap=butt] (\x+0.4,\y) -- (\x+\qgateSx/2,\y);
    \draw[draw=none,fill=ibmqxH] (\x-0.4,\y-0.4) rectangle (\x+0.4,\y+0.4);
    \node at (\x,\y){\large $|0\rangle$};
  }{%
    \node[anchor=east] at (\x+\qgateSx/2,\y){$|0\rangle$};
  }%
}

% General single-qubit gate
\newcommand\qgateU[4][]{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
    \ifthenelse{\equal{ibmqx}{#1}}{%
      \tikzset{rstyle/.style={draw=none,fill=ibmqxG}}
    }{%
      \tikzset{rstyle/.style={draw=none,fill=#1}}
    }
    \tikzset{tstyle/.style={white}}
  }{%
```

```
    \tikzset{lstyle/.style={}}
    \tikzset{rstyle/.style={fill=white}}
    \tikzset{tstyle/.style={}}
  }%
  \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x-0.4       ,\y);
  \draw[lstyle] (\x+0.4       ,\y) -- (\x+\qgateSx/2,\y);
  \draw[rstyle] (\x-0.4   ,\y-0.4) rectangle (\x+0.4,\y+0.4);
  \node[tstyle,anchor=center] at (\x,\y) {\sf\large #4};
}}

% Identity gate
\newcommand\qgateID[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxB]{#2}{#3}{id}
  }{%
    \qgateU{#2}{#3}{id}
  }%
}
\newcommand\qgateOID{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} & \bra{1} \\\hline
    \ket{0} &       1 &       0 \\
    \ket{1} &       0 &       1
  \end{array}\!\right)
}}

% Pauli-X gate
\newcommand\qgateX[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxC]{#2}{#3}{X}
  }{%
    \qgateU{#2}{#3}{X}
  }%
}
\newcommand\qgateOX{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} & \bra{1} \\\hline
    \ket{0} &       0 &       1 \\
    \ket{1} &       1 &       0
  \end{array}\!\right)
}}

% Pauli-Y gate
\newcommand\qgateY[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxC]{#2}{#3}{Y}
  }{%
    \qgateU{#2}{#3}{Y}
  }%
}
\newcommand\qgateOY{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \def\j{\mathrm{i}}
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            &  \bra{0} &  \bra{1} \\\hline
    \ket{0} &        0 &      -\j \\
    \ket{1} &       \j &        0
  \end{array}\!\right)
}}

% Pauli-Z gate
\newcommand\qgateZ[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxC]{#2}{#3}{Z}
  }{%
    \qgateU{#2}{#3}{Z}
  }%
```

```
}
\newcommand\qgateOZ{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} & \bra{1} \\\hline
    \ket{0} &       1 &       0 \\
    \ket{1} &       0 &      -1
  \end{array}\!\right)
}}

% Hadamard gate
\newcommand\qgateH[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxD]{#2}{#3}{H}
  }{%
    \qgateU{#2}{#3}{H}
  }%
}
\newcommand\qgateOH{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \dfrac{1}{\sqrt{2}}\!
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} & \bra{1} \\\hline
    \ket{0} &       1 &       1 \\
    \ket{1} &       1 &      -1
  \end{array}\!\right)
}}

% S phase gate
\newcommand\qgateS[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxD]{#2}{#3}{S}
  }{%
    \qgateU{#2}{#3}{S}
  }%
}
\newcommand\qgateOS{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \def\j{\mathrm{i}}
  \dfrac{1}{\sqrt{2}}\!
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} & \bra{1} \\\hline
    \ket{0} &       1 &       0 \\
    \ket{1} &       0 &      \j
  \end{array}\!\right)
}}

% Inverse S phase gate
\newcommand\qgateSi[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxD]{#2}{#3}{S$^\dagger$}
  }{%
    \qgateU{#2}{#3}{S$^\dagger$}
  }%
}
\newcommand\qgateOSi{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \def\j{\mathrm{i}}
  \dfrac{1}{\sqrt{2}}\!
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} &  \bra{1} \\\hline
    \ket{0} &       1 &        0 \\
    \ket{1} &       0 &      -\j
  \end{array}\!\right)
}}

% T phase gate
\newcommand\qgateT[3][]{%
```

```
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxE]{#2}{#3}{T}
  }{%
    \qgateU{#2}{#3}{T}
  }%
}
\newcommand\qgateOT{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \def\j{\mathrm{i}}
  \dfrac{1}{\sqrt{2}}\!
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} &                        \bra{1} \\\hline
    \ket{0} &       1 &                              0 \\
    \ket{1} &       0 & \frac{1}{\sqrt{2}}(1\!+\!\j)
  \end{array}\!\right)
}}

% Inverse T phase gate
\newcommand\qgateTi[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxE]{#2}{#3}{T$^\dagger$}
  }{%
    \qgateU{#2}{#3}{T$^\dagger$}
  }%
}
\newcommand\qgateOTi{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \def\j{\mathrm{i}}
  \dfrac{1}{\sqrt{2}}\!
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} &                        \bra{1} \\\hline
    \ket{0} &       1 &                              0 \\
    \ket{1} &       0 & \frac{1}{\sqrt{2}}(1\!-\!\j)
  \end{array}\!\right)
}}

% U1 gate of IBM Q Experience
\makeatletter
\newcommand\qgateUa{\@ifstar\qgateUaS\qgateUaN}
\makeatother
\newcommand\qgateUaN[3][]{% unstarred version
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxA]{#2}{#3}{U1}
  }{%
    \qgateU{#2}{#3}{U1}
  }%
}
\newcommand\qgateUaS[4][]{% starred version
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxA]{#2}{#3}{\qgateSublabel{U1}{#4}}
  }{%
    \qgateU{#2}{#3}{\qgateSublabel{U1}{#4}}
  }%
}
\newcommand\qgateOUa{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \def\e{\mathrm{e}}
  \def\j{\mathrm{i}}
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            & \bra{0} &        \bra{1} \\\hline
    \ket{0} &       1 &              0 \\
    \ket{1} &       0 & \e^{\lambda\j}
  \end{array}\!\right)
}}

% U2 gate of IBM Q Experience
\makeatletter
\newcommand\qgateUb{\@ifstar\qgateUbS\qgateUbN}
\makeatother
```

```
\newcommand\qgateUbN[3][]{% unstarred version
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxA]{#2}{#3}{U2}
  }{%
    \qgateU{#2}{#3}{U2}
  }%
}
\newcommand\qgateUbS[4][]{% starred version
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \qgateU[ibmqxA]{#2}{#3}{\qgateSublabel{U2}{#4}}
  }{%
    \qgateU{#2}{#3}{\qgateSublabel{U2}{#4}}
  }%
}
\newcommand\qgateOUb{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \def\e{\mathrm{e}}
  \def\j{\mathrm{i}}
  \renewcommand\arraystretch{1.4}
  \dfrac{1}{\sqrt{2}}\!
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            &     \bra{0} &               \bra{1} \\\hline
    \ket{0} &           1 &       -\e^{\lambda\j} \\
    \ket{1} & \e^{\phi\j} & \e^{(\lambda+\phi)\j}
  \end{array}\!\right)
}}

% U3 gate of IBM Q Experience
\makeatletter
\newcommand\qgateUc{\@ifstar\qgateUcS\qgateUcN}
\makeatother
\newcommand\qgateUcN[3][]{%
  \ifthenelse{\isin{ibmqx}{#1}}{% unstarred version
    \qgateU[ibmqxA]{#2}{#3}{U3}
  }{%
    \qgateU{#2}{#3}{U3}
  }%
}
\newcommand\qgateUcS[4][]{% starred version
  \ifthenelse{\isin{ibmqx}{#1}}{% unstarred version
    \qgateU[ibmqxA]{#2}{#3}{\qgateSublabel{U3}{#4}}
  }{%
    \qgateU{#2}{#3}{\qgateSublabel{U3}{#4}}
  }%
}
\newcommand\qgateOUc{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\scriptstyle\langle ##1|}
  \def\e{\mathrm{e}}
  \def\j{\mathrm{i}}
  \renewcommand\arraystretch{1.4}
  \left(\hspace*{-0.4ex}\begin{array}{c|cc}
            &                              \bra{0} &                                                  \bra{1} \\\hline
    \ket{0} &            \cos(\frac{\theta}{2}) &       -\sin(\frac{\theta}{2})\e^{\lambda\j} \\
    \ket{1} & \sin(\frac{\theta}{2})\e^{\phi\j} & \cos(\frac{\theta}{2})\e^{(\lambda+\phi)\j}
  \end{array}\!\right)
}}

% General two-qubit gate
\newcommand{\qgateUu}[4][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
    \ifthenelse{\equal{ibmqx}{#1}}{%
      \tikzset{rstyle/.style={draw=none,fill=ibmqxG}}
    }{%
      \tikzset{rstyle/.style={draw=none,fill=#1}}
    }
    \tikzset{tstyle/.style={white}}
  }{%
```

```
    \tikzset{lstyle/.style={}}
    \tikzset{rstyle/.style={fill=white}}
    \tikzset{tstyle/.style={}}
  }%
  \draw[rstyle] (\x-0.5    ,\y-0.25) rectangle (\x+0.5,\y+1.25);
  \draw[lstyle] (\x-\qgateSx/2,\y+1) -- (\x-0.5       ,\y+1);
  \draw[lstyle] (\x+0.5       ,\y+1) -- (\x+\qgateSx/2,\y+1);
  \draw[lstyle] (\x-\qgateSx/2,\y  ) -- (\x-0.     5  ,\y  );
  \draw[lstyle] (\x+0.5       ,\y  ) -- (\x+\qgateSx/2,\y  );
  \node[anchor=north,tstyle] at (\x,\y+1.25){\sf\large #4};
}}

% General three-qubit gate
\newcommand{\qgateUuu}[4][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
    \ifthenelse{\equal{ibmqx}{#1}}{%
      \tikzset{rstyle/.style={draw=none,fill=ibmqxG}}
    }{%
      \tikzset{rstyle/.style={draw=none,fill=#1}}
    }
    \tikzset{tstyle/.style={white}}
  }{%
    \tikzset{lstyle/.style={}}
    \tikzset{rstyle/.style={fill=white}}
    \tikzset{tstyle/.style={}}
  }%
  \draw[rstyle] (\x-0.5    ,\y-1.25) rectangle (\x+0.5,\y+1.25);%
  \draw[lstyle] (\x-\qgateSx/2,\y+1) -- (\x-0.5       ,\y+1);%
  \draw[lstyle] (\x+0.5       ,\y+1) -- (\x+\qgateSx/2,\y+1);%
  \draw[lstyle] (\x-\qgateSx/2,\y  ) -- (\x-0.5       ,\y  );%
  \draw[lstyle] (\x+0.5       ,\y  ) -- (\x+\qgateSx/2,\y  );%
  \draw[lstyle] (\x-\qgateSx/2,\y-1) -- (\x-0.5       ,\y-1);%
  \draw[lstyle] (\x+0.5       ,\y-1) -- (\x+\qgateSx/2,\y-1);%
  \node[anchor=north,tstyle] at (\x,\y+1.25){\sf\large #4};%
}}

% CNOT gate XOR symbol
\newcommand\qgateCNX[4][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#3)}
  \pgfmathsetmacro\y{(#4)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
    \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
    \tikzset{rstyle/.style={draw=none,fill=ibmqxD}}
    \tikzset{tstyle/.style={very thick,white}}
    \def\R{0.4}
  }{%
    \tikzset{lstyle/.style={}}
    \tikzset{cstyle/.style={}}
    \tikzset{rstyle/.style={fill=white}}
    \tikzset{tstyle/.style={}}
    \def\R{0.25}
  }%
  \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x-\R        ,\y);
  \draw[lstyle] (\x+\R        ,\y) -- (\x+\qgateSx/2,\y);
  \draw[rstyle] (\x           ,\y) circle (\R);
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \draw[tstyle] (\x-0.2,\y) -- (\x+0.2,\y);
    \draw[tstyle] (\x,\y-0.2) -- (\x,\y+0.2);
  }{%
    \draw[lstyle] (\x-\R,\y) -- (\x+\R,\y);
    \draw[lstyle] (\x,\y-\R) -- (\x,\y+\R);
  }
  \ifthenelse{\isin{t}{#2}}{%
    \draw[cstyle] (\x,\y+\R) -- (\x,\y+0.5);
  }{}
  \ifthenelse{\isin{b}{#2}}{%
    \draw[cstyle] (\x,\y-\R) -- (\x,\y-0.5);
  }{}
```

```
}}

% CNOT gate control qubit symbol
\makeatletter
\newcommand\qgateCNC{\@ifstar\qgateCNCS\qgateCNCN}
\makeatother
\newcommand\qgateCNCS[4][]{\qgateCNCint{#1}{#2}{#3}{#4}{inv}}%starred version
\newcommand\qgateCNCN[4][]{\qgateCNCint{#1}{#2}{#3}{#4}{}}   %unstarred version
\newcommand\qgateCNCint[5]{{%
  \pgfmathsetmacro\x{\qgateSx*(#3)}
  \pgfmathsetmacro\y{(#4)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
    \ifthenelse{\equal{ibmqx}{#1}}{%
      \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
      \ifthenelse{\equal{inv}{#5}}{%
        \tikzset{rstyle/.style={draw=ibmqxD,thick,fill=white}}
      }{%
        \tikzset{rstyle/.style={draw=none,fill=ibmqxD}}
      }
    }{%
      \tikzset{cstyle/.style={#1,ultra thick,line cap=butt}}
      \ifthenelse{\equal{inv}{#5}}{%
        \tikzset{rstyle/.style={draw=#1,thick,fill=white}}
      }{%
        \tikzset{rstyle/.style={draw=none,fill=#1}}
      }
    }
    \tikzset{tstyle/.style={white}}
    \def\r{0.12}
  }{%
    \tikzset{lstyle/.style={}}
    \tikzset{cstyle/.style={}}
      \ifthenelse{\equal{inv}{#5}}{%
        \tikzset{rstyle/.style={draw=black,fill=white}}
      }{%
        \tikzset{rstyle/.style={draw=none,fill=black}}
      }
    \tikzset{tstyle/.style={}}
    \def\r{0.1}
  }%
  \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
  \draw[rstyle] (\x           ,\y) circle (\r);
  \ifthenelse{\isin{t}{#2}}{%
    \draw[cstyle] (\x,\y+0.1) -- (\x,\y+0.5);
  }{}
  \ifthenelse{\isin{b}{#2}}{%
    \draw[cstyle] (\x,\y-0.1) -- (\x,\y-0.5);
  }{}
}}


% \newcommand\qgateCNC[4][]{{%
%   \pgfmathsetmacro\x{\qgateSx*(#3)}
%   \pgfmathsetmacro\y{(#4)}
%   \ifthenelse{\isin{ibmqx}{#1}}{%
%     \tikzset{lstyle/.style={ultra thick,line cap=butt}}
%     \ifthenelse{\equal{ibmqx}{#1}}{%
%       \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
%       \tikzset{rstyle/.style={draw=none,fill=ibmqxD}}
%     }{%
%       \tikzset{cstyle/.style={#1,ultra thick,line cap=butt}}
%       \tikzset{rstyle/.style={draw=none,fill=#1}}
%     }
%     \tikzset{tstyle/.style={white}}
%     \def\r{0.12}
%   }{%
%     \tikzset{lstyle/.style={}}
%     \tikzset{cstyle/.style={}}
%     \tikzset{rstyle/.style={draw=none,fill=black}}
%     \tikzset{tstyle/.style={}}
%     \def\r{0.1}
```

```
%   }%
%   \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
%   \draw[rstyle] (\x           ,\y) circle (\r);
%   \ifthenelse{\isin{t}{#2}}{%
%     \draw[cstyle] (\x,\y+0.1) -- (\x,\y+0.5);
%   }{}
%   \ifthenelse{\isin{b}{#2}}{%
%     \draw[cstyle] (\x,\y-0.1) -- (\x,\y-0.5);
%   }{}
% }}

% CNOT gate run-through qubit symbol
\newcommand\qgateCNR[3][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
    \ifthenelse{\equal{ibmqx}{#1}}{%
      \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
    }{%
      \tikzset{cstyle/.style={#1,ultra thick,line cap=butt}}
    }
  }{%
    \tikzset{lstyle/.style={}}
    \tikzset{cstyle/.style={}}
  }%
  \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
  \draw[cstyle] (\x       ,\y-0.5) -- (\x       ,\y+0.5);
}}

% Sawp gate top qubit symbol
\newcommand\qgateSWt[3][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \draw[ultra thick,line cap=butt]
      (\x-\qgateSx/2,\y) -- (\x-0.2,\y) -- (\x+0.2,\y-0.4) -- (\x+0.2,\y-0.5);
    \draw[ultra thick,line cap=butt]
      (\x+\qgateSx/2,\y) -- (\x+0.2,\y) -- (\x-0.2,\y-0.4) -- (\x-0.2,\y-0.5);
  }{%
    \pgfmathsetmacro\w{0.1}
    \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
    \draw(\x-\w,     \y-\w) -- (\x+\w,     \y+\w);
    \draw(\x-\w,     \y+\w) -- (\x+\w,     \y-\w);
    \draw(\x,           \y) -- (\x,       \y-0.5);
  }%
}}

% Sawp gate run-through qubit symbol
\newcommand\qgateSWR[3][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \draw[ultra thick,line cap=butt] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
    \draw[ultra thick,line cap=butt] (\x-0.2,   \y+0.5) -- (\x-0.2,   \y-0.5);
    \draw[ultra thick,line cap=butt] (\x+0.2,   \y+0.5) -- (\x+0.2,   \y-0.5);
  }{%
    \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
    \draw(\x,       \y-0.5) -- (\x,       \y+0.5);
  }%
}}

% Sawp gate bottom qubit symbol
\newcommand\qgateSWb[3][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \draw[ultra thick,line cap=butt]
      (\x-\qgateSx/2,\y) -- (\x-0.2,\y) -- (\x-0.2,\y+0.5);
    \draw[ultra thick,line cap=butt]
      (\x+\qgateSx/2,\y) -- (\x+0.2,\y) -- (\x+0.2,\y+0.5);
  }{%
```

```
    \pgfmathsetmacro\w{0.1}
    \draw(\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
    \draw(\x-\w,     \y-\w) -- (\x+\w,     \y+\w);
    \draw(\x-\w,     \y+\w) -- (\x+\w,     \y-\w);
    \draw(\x,           \y) -- (\x,       \y+0.5);
  }%
}}

% Measurement symbol
\makeatletter
\newcommand\qmeasM{\@ifstar\qmeasMS\qmeasMN}
\makeatother
\newcommand\qmeasMN[3][]{
  \qmeasMS[#1]{#2}{#3}{Z}{br}
}
\newcommand\qmeasMS[5][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
    \tikzset{rstyle/.style={draw=none,fill=ibmqxF}}
    \tikzset{tstyle/.style={white,very thick,line cap=butt}}
    \tikzset{pstyle/.style={->,>=stealth,white,thick,line cap=butt}}
    \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
  }{%
    \tikzset{lstyle/.style={}}
    \tikzset{rstyle/.style={fill=white}}
    \tikzset{tstyle/.style={}}
    \tikzset{pstyle/.style={->,>=stealth,line cap=butt}}
    \tikzset{cstyle/.style={}}
  }%
  \draw[lstyle] (\x-\qgateSx/2,\y  ) -- (\x-0.4,\y);
  \draw[rstyle] (\x-0.4    ,\y-0.4 ) rectangle (\x+0.4,\y+0.4);
  \draw[tstyle] (\x+0.27   ,\y-0.2 ) arc (0:180:0.27);
  \draw[pstyle] (\x        ,\y-0.15) -- (\x+0.2,\y+0.22);
  \node[pstyle] at (\x+0.28,\y+0.15) {\tiny\sf #4};
  \fill[pstyle] (\x        ,\y-0.15) circle (0.035);
  \ifthenelse{\isin{r}{#5}}{%
    \draw[lstyle] (\x+0.4,\y) -- (\x+\qgateSx/2,\y);%
  }{}
  \ifthenelse{\isin{b}{#5}}{%
    \draw[cstyle] (\x,\y-0.4 ) -- (\x,\y-0.5);%
  }{}
}}

% Measurement run-through qubit symbol
\newcommand\qmeasR[3][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{lstyle/.style={ultra thick,line cap=butt}}
    \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
  }{%
    \tikzset{lstyle/.style={}}
    \tikzset{cstyle/.style={}}
  }%
  \draw[lstyle] (\x-\qgateSx/2,\y) -- (\x+\qgateSx/2,\y);
  \draw[cstyle] (\x       ,\y-0.5) -- (\x       ,\y+0.5);
}}

% Measurement-joins-bus symbol
\newcommand\qmeasMB[4][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#3)}
  \pgfmathsetmacro\y{(#4)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{cstyle/.style={>=stealth,ibmqxI,ultra thick,line cap=butt}}
  }{%
    \tikzset{cstyle/.style={>=stealth}}
  }%
  \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
  \draw[cstyle,->] (\x,\y+0.5) -- (\x,\y-0.3)
    node[anchor=north,black] {\footnotesize #2};
```

```
}}

% Measurement bus symbol
\newcommand\qmeasB[3][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
  }{%
    \tikzset{cstyle/.style={}}
  }%
  \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
}}

% Measurement bus head symbol
\newcommand\qmeasBh[4][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#3)}
  \pgfmathsetmacro\y{(#4)}
  \ifthenelse{\isin{ibmqx}{#1}}{%
    \tikzset{cstyle/.style={ibmqxI,ultra thick,line cap=butt}}
  }{%
    \tikzset{cstyle/.style={}}
  }%
  \draw[cstyle](\x-\qgateSx/2,\y-0.3) -- (\x+\qgateSx/2,\y-0.3);
  \draw[cstyle](\x-\qgateSx/2+0.05,\y-0.45) -- (\x-\qgateSx/2+0.15,\y-0.1)
    node[anchor=east,black] {\footnotesize #2};
}}

%% == OTHER GATE OPERATORS ================================================

\newcommand\qgateOCNOT{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\rotatebox{90}{$\scriptstyle\langle ##1|$}}
  \left(\hspace*{-0.4ex}\begin{array}{c|cccc}
             & \bra{00} & \bra{01} & \bra{10} & \bra{11} \\\hline
    \ket{00} &        1 &        0 &        0 &        0 \\
    \ket{01} &        0 &        1 &        0 &        0 \\
    \ket{10} &        0 &        0 &        0 &        1 \\
    \ket{11} &        0 &        0 &        1 &        0
  \end{array}\!\right)
}}

\newcommand\qgateOCCNOT{{%
  \def\ket##1{\scriptstyle|##1\rangle}
  \def\bra##1{\rotatebox{90}{$\scriptstyle\langle ##1|$}}
  \left(\hspace*{-0.4ex}\begin{array}{c|cccccccc}
             & \bra{000} & \bra{001} & \bra{010} & \bra{011} & \bra{100} & \bra{101} & \bra{110} & \bra{111} \\\hline
    \ket{000} &         1 &         0 &         0 &         0 &         0 &         0 &         0 &         0 \\
    \ket{001} &         0 &         1 &         0 &         0 &         0 &         0 &         0 &         0 \\
    \ket{010} &         0 &         0 &         1 &         0 &         0 &         0 &         0 &         0 \\
    \ket{101} &         0 &         0 &         0 &         1 &         0 &         0 &         0 &         0 \\
    \ket{100} &         0 &         0 &         0 &         0 &         1 &         0 &         0 &         0 \\
    \ket{101} &         0 &         0 &         0 &         0 &         0 &         1 &         0 &         0 \\
    \ket{110} &         0 &         0 &         0 &         0 &         0 &         0 &         0 &         1 \\
    \ket{111} &         0 &         0 &         0 &         0 &         0 &         0 &         1 &         0
  \end{array}\!\right)
}}

%% == AUXILIARY COMMANDS ==================================================

% Control wires for gates
\newcommand\qgateControl[4][]{{%
  \pgfmathsetmacro\x{\qgateSx*(#3)}
  \pgfmathsetmacro\y{(#4)}
    \ifthenelse{\isin{ibmqx}{#1}}{%
    \ifthenelse{\equal{ibmqx}{#1}}{%
      \tikzset{cstyle/.style={ibmqxD,ultra thick,line cap=butt}}
    }{%
      \tikzset{cstyle/.style={#1,ultra thick,line cap=butt}}
    }
  }{%
    \tikzset{cstyle/.style={}}
```

```
  }%
  \ifthenelse{\isin{t}{#2}}{%
    \draw[cstyle] (\x,\y+0.4) -- (\x,\y+0.5);
  }{}
  \ifthenelse{\isin{b}{#2}}{%
    \draw[cstyle] (\x,\y-0.4) -- (\x,\y-0.5);
  }{}
}}

% TikZ node in circuit coordinate system
\newcommand\qnode[4][]{%
  \pgfmathsetmacro\x{\qgateSx*(#2)}
  \pgfmathsetmacro\y{(#3)}
  \node[anchor=center,#1] at (\x,\y) {#4};
}

%% == PACKAGE-INTERNAL COMMANDS ================================================

% Draw scale paper for documentations
\newcommand{\qScalePaper}{%
  \draw[help lines,xstep=(\qgateSx/8),ystep=0.25,opacity=0.2] (-1.5,-1.5) grid (1.5,1.5);
  \draw[help lines,line width=.6pt,xstep=(\qgateSx/2),ystep=1,opacity=0.2] (-1.49,-1.5) grid (1.49,1.5);
  \node[color=gray]              at (-1  ,-1.7) {\scriptsize $\qgateSx(\texttt{x}\!-\!\frac{1}{2})$};
  \node[color=gray]              at ( 0  ,-1.7) {\scriptsize $\qgateSx\texttt{x}$};
  \node[color=gray]              at ( 1  ,-1.7) {\scriptsize $\qgateSx(\texttt{x}\!+\!\frac{1}{2})$};
  \node[anchor=west ,color=gray] at (-2.3,-1  ) {\scriptsize $\texttt{y}\!-\!1$};
  \node[anchor=west ,color=gray] at (-2.3, 0  ) {\scriptsize $\texttt{y}$};
  \node[anchor=west ,color=gray] at (-2.3, 1  ) {\scriptsize $\texttt{y}\!+\!1$};
}

% Draw gate label with sub-label
\newcommand\qgateSublabel[2]{%
  {\renewcommand{\arraystretch}{0.4}%
  \begin{tabular}{c}#1\\\tiny #2\end{tabular}}%
}

%% == 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.