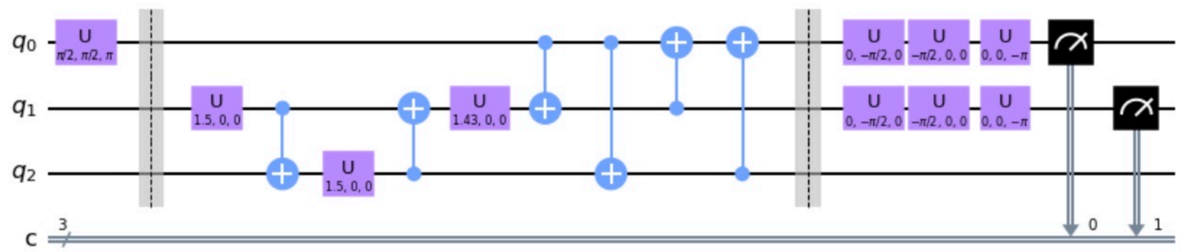
Y basis and θ_1 = 0.75

```
qc, sv = cloningcircuit(alice_bit = 0, alice_base = (np.pi/2), theta1=0.75)
display(qc.draw(output='mpl'))
displayresult(qc,sv,alice_bit=0)
```

```
0.75 0.7499109550624189 0.7146902134750834
```



- in circuit
- IonQ compatible Qiskit
- IonQ Native gates

$$U(\theta,0,0) = \begin{bmatrix} \cos(\frac{\theta}{2}) & -\sin(\frac{\theta}{2}) \\ \sin(\frac{\theta}{2}) & \cos(\frac{\theta}{2}) \end{bmatrix} = RY(\theta)$$

$$U(\theta,-\tfrac{\pi}{2},\tfrac{\pi}{2}) = \begin{bmatrix} \cos\frac{\theta}{2} & -i\sin\frac{\theta}{2} \\ -i\sin\frac{\theta}{2} & \cos\frac{\theta}{2} \end{bmatrix} = RX(\theta)$$

$$U(0,0,-\pi) = \begin{bmatrix} 1 & 0 \\ 0 & e^{-i\pi} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} = Z$$

$$U(0,-\tfrac{\pi}{2},0) = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ -e^{-i\pi/2} & e^{-i\pi/2} \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ i & -i \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 0 \\ 0 & e^{\pi i/2} \end{bmatrix}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} = TTH$$

$$\Bigg(\underbrace{\begin{bmatrix} 1 & 0 \\ 0 & e^{\pi i/4} \end{bmatrix}}_{T = P(\frac{\pi}{4})}\begin{bmatrix} 1 & 0 \\ 0 & e^{\pi i/4} \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & 0 \\ 0 & e^{\pi i/2} \end{bmatrix}}_{P(\frac{\pi}{2})}\Bigg)$$

$$U(\tfrac{\pi}{2},\tfrac{\pi}{2},\pi) = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & -e^{i\pi} \\ e^{i\pi/2} & e^{i(\frac{\pi}{2}+\pi)} \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix}$$

$$= \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} = HX$$

$$X = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} = GPi(\pi)$$

From Maslov:

$$H \overset{?}{=} RY(-\tfrac{\pi}{2})RX(\pi) = GPi2(-\tfrac{\pi}{2})GPi(\tfrac{\pi}{2}) = gpi2(-0.25)\ gpi(0.25)$$

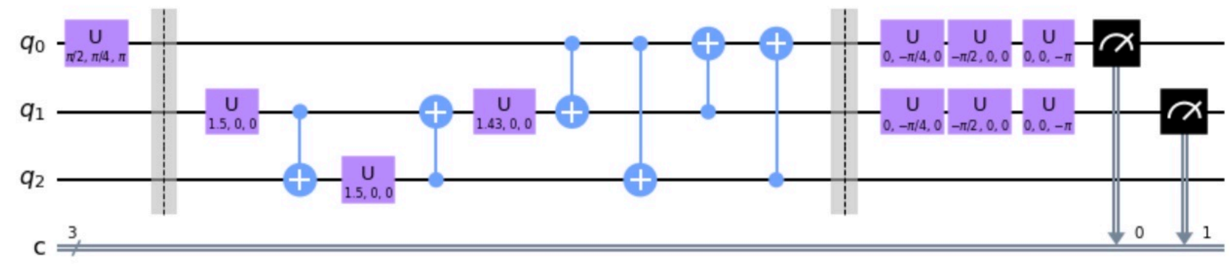
$$= RX(-\pi)RY(\pi/2) = GPi(-\tfrac{\pi}{2})GPi2(\tfrac{\pi}{2}) = gpi(-0.25)\ gpi2(0.25)$$

↑ Input as "# of turns"

Equatorial basis with $\phi = \pi/4$ and θ_1 = 0.75

```
qc, sv = cloningcircuit(alice_bit = 0, alice_base = (np.pi/4), theta1=0.75)
display(qc.draw(output='mpl'))
displayresult(qc,sv,alice_bit=0)
```

```
0.75 0.7499109550624189 0.7146902134750834
```



- in circuit
- IonQ compatible Qiskit
- IonQ Native gates

$$U(\theta,0,0) = \begin{bmatrix} \cos(\frac{\theta}{2}) & -\sin(\frac{\theta}{2}) \\ \sin(\frac{\theta}{2}) & \cos(\frac{\theta}{2}) \end{bmatrix} = RY(\theta)$$

$$U(\theta,-\tfrac{\pi}{2},\tfrac{\pi}{2}) = \begin{bmatrix} \cos\frac{\theta}{2} & -i\sin\frac{\theta}{2} \\ -i\sin\frac{\theta}{2} & \cos\frac{\theta}{2} \end{bmatrix} = RX(\theta)$$

$$U(\tfrac{\pi}{2},\tfrac{\pi}{4},\pi) = \begin{bmatrix} \cos\frac{\pi}{4} & -e^{i\pi}\sin(\frac{\pi}{4}) \\ e^{i\frac{\pi}{4}}\sin(\frac{\pi}{4}) & e^{i\frac{\pi}{4}+i\pi}\cos\frac{\pi}{4} \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & -e^{-i\pi} \\ e^{i\pi/4} & e^{5\pi i/4} \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ e^{i\pi/4} & -e^{i\pi/4} \end{bmatrix} = \underbrace{\frac{1}{\sqrt{2}}\underbrace{\begin{bmatrix} 1 & 0 \\ 0 & e^{i\pi/4} \end{bmatrix}}_{T}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}}_{H}$$

$$= TH$$

$$U(0,0,-\pi) = \begin{bmatrix} 1 & 0 \\ 0 & e^{-i\pi} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} = Z$$

$$U(0,-\tfrac{\pi}{4},0) = \begin{bmatrix} 1 & 0 \\ 0 & e^{-i\pi/4} \end{bmatrix} = TZ$$

$$X = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} = GPi(\pi)$$

From Maslov:

$$H \overset{?}{=} RY(-\tfrac{\pi}{2})RX(\pi) = GPi2(\tfrac{\pi}{2})GPi(\tfrac{\pi}{2}) = gpi2(-0.25)\ gpi(0.25)$$

$$= RX(-\pi)RY(\pi/2) = GPi(-\tfrac{\pi}{2})GPi2(\tfrac{\pi}{2}) = gpi(-0.25)\ gpi2(0.25)$$

Input as "# of turns"