

Quantum Subtractor:

$$\begin{aligned} & \sum_{j=0}^{1_n-1} \sqrt{p_j} |N - j - 1_n\rangle |0\rangle [\cos(\frac{\pi}{4}) |0\rangle + \sin(\frac{\pi}{4}) |1\rangle] \\ & + \sum_{j=1_n}^{N-1} \sqrt{p_j} |j - 1_n\rangle |1\rangle [\cos(\frac{\pi}{4}) |0\rangle + \sin(\frac{\pi}{4}) |1\rangle] \end{aligned}$$

Apply CCRY gates:

$$\begin{aligned} & \sum_{x=0}^{1_n-1} \sqrt{p_x} |N - x - 1_n\rangle |0\rangle (\cos \frac{\pi}{4} |0\rangle + \sin \frac{\pi}{4} |1\rangle) \\ & + \sum_{x=1_n}^{N-1} \sqrt{p_x} |x - 1_n\rangle |1\rangle \otimes (\cos \theta |0\rangle + \sin \theta |1\rangle) \end{aligned}$$

Where $\theta = \frac{\pi}{4} + 0.4c(x - 1_n)$ and c is a small number.