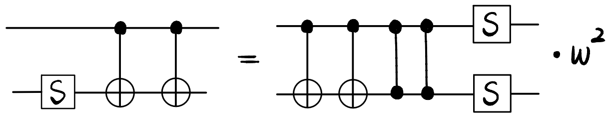
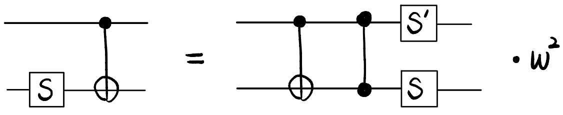
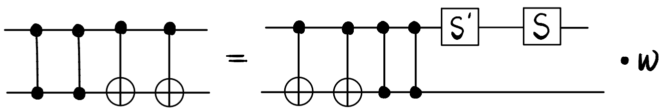
$R_{23}^{9'}$:



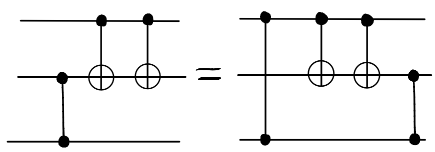
R_{23}^{4}:



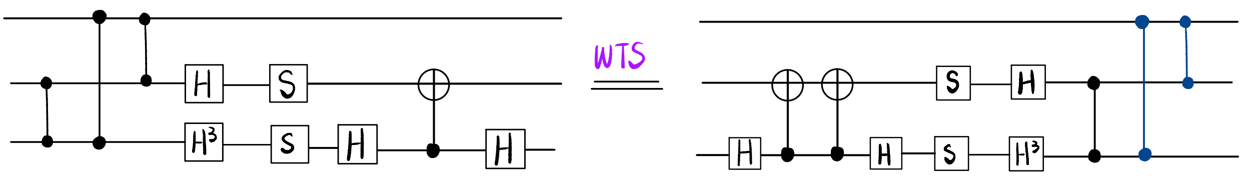
$R_{25}^{7'}$:



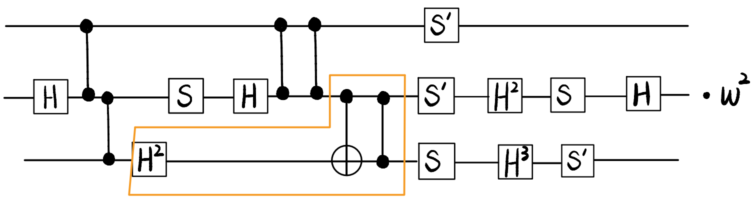
C_{16}^{36}:

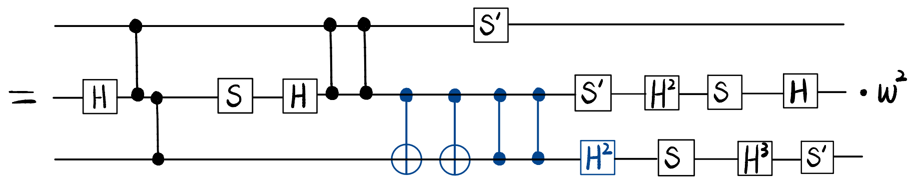


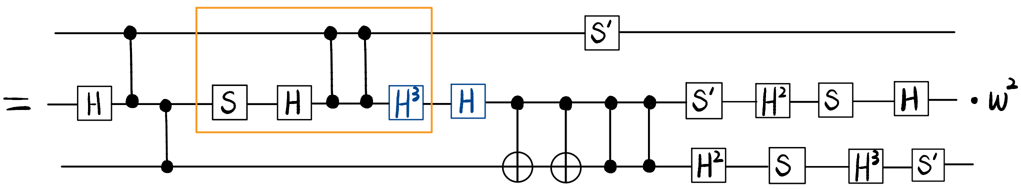
R_{59}:

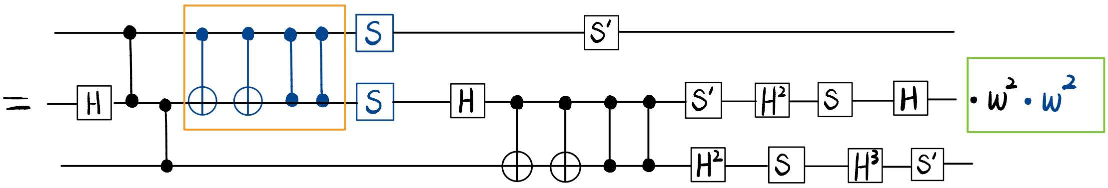


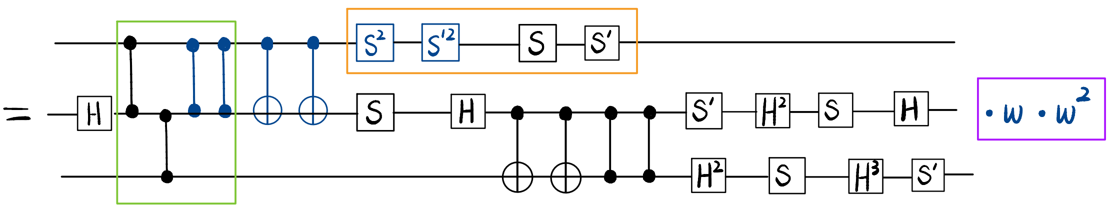
R_{59}.RHS =

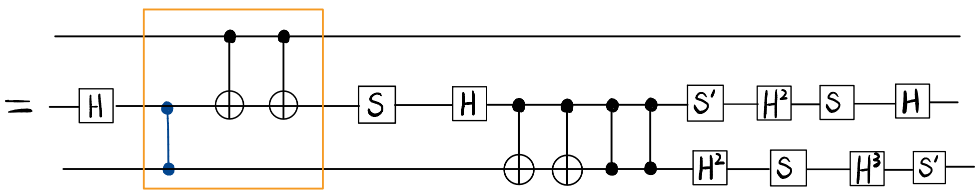


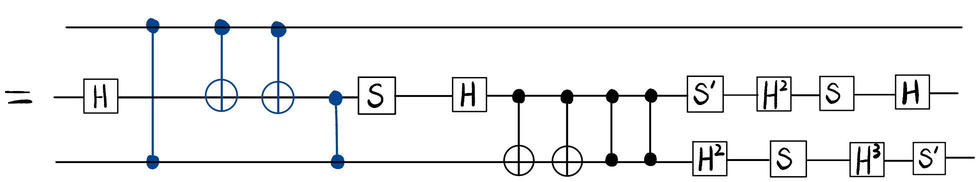




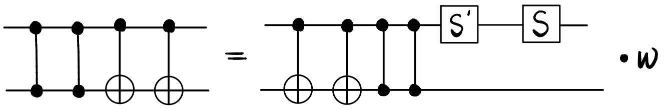




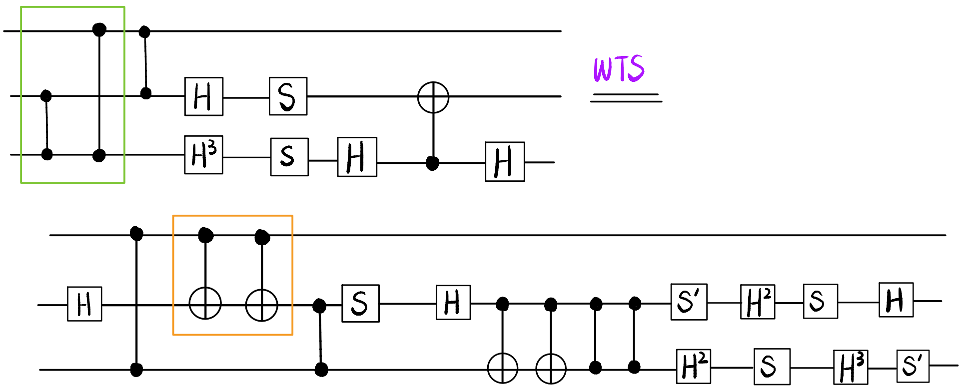




$R^{7'}_{25}$:

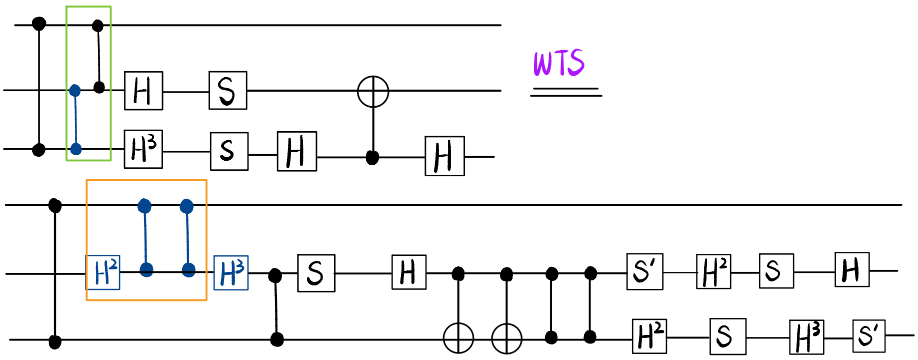


R_{59}:



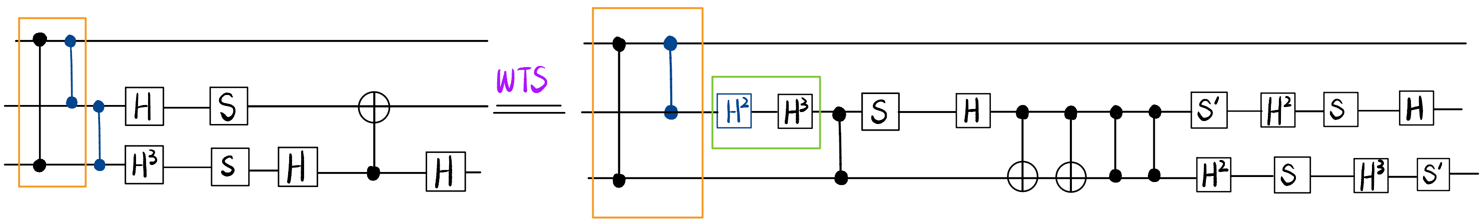
$\equiv$

R_{59}:



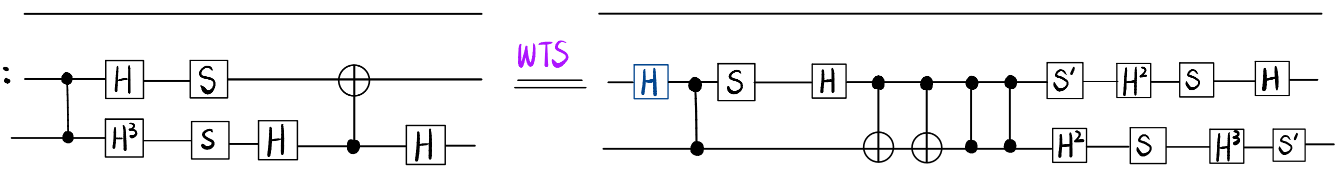
$\equiv$

R_{59}:

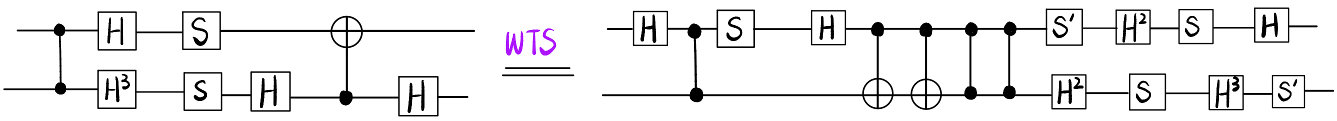


$\equiv$ We can stop here by citing two-qutrit Clifford completeness.

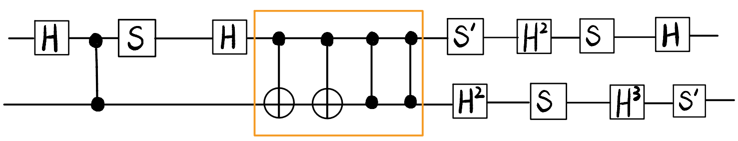
R_{59}:



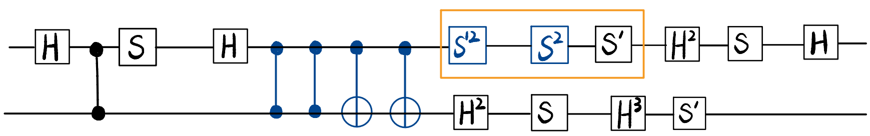
Hence R_{59}:



R_{59}. RHS :=

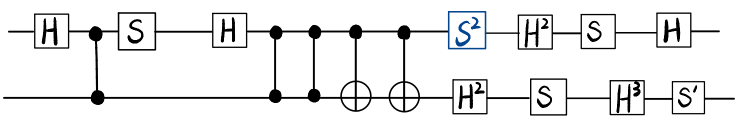


=

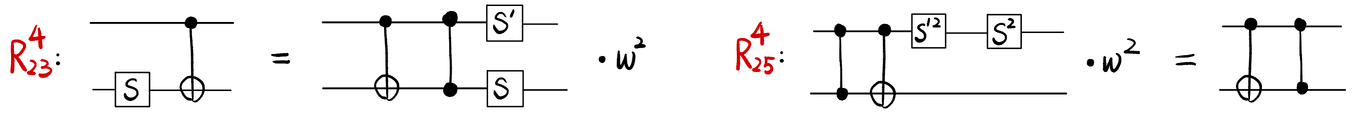


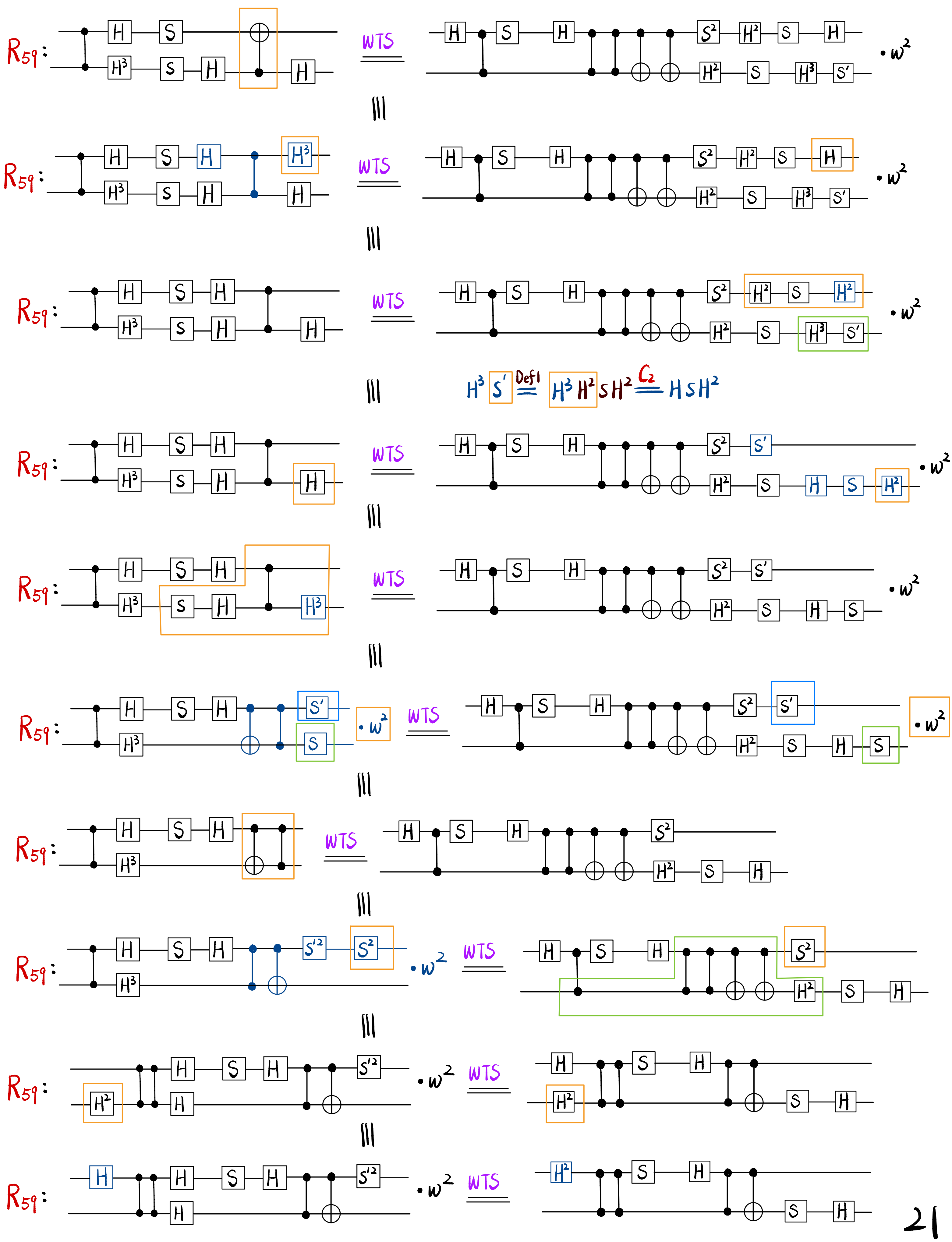
$\cdot w^2$

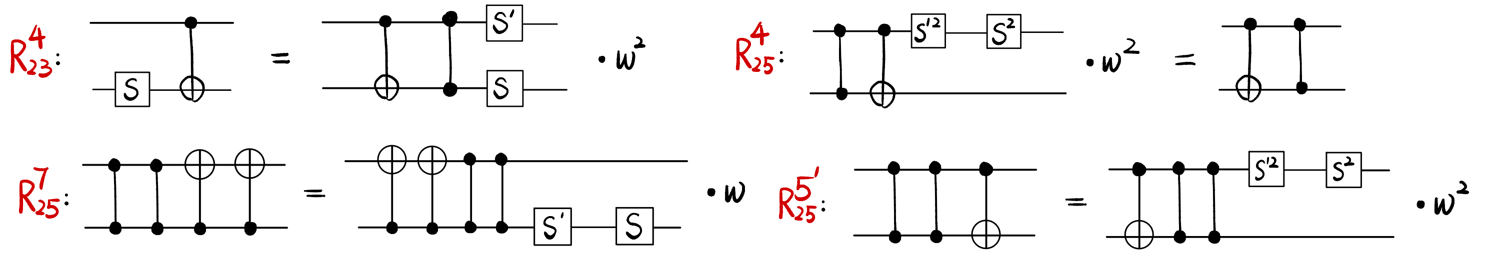
=

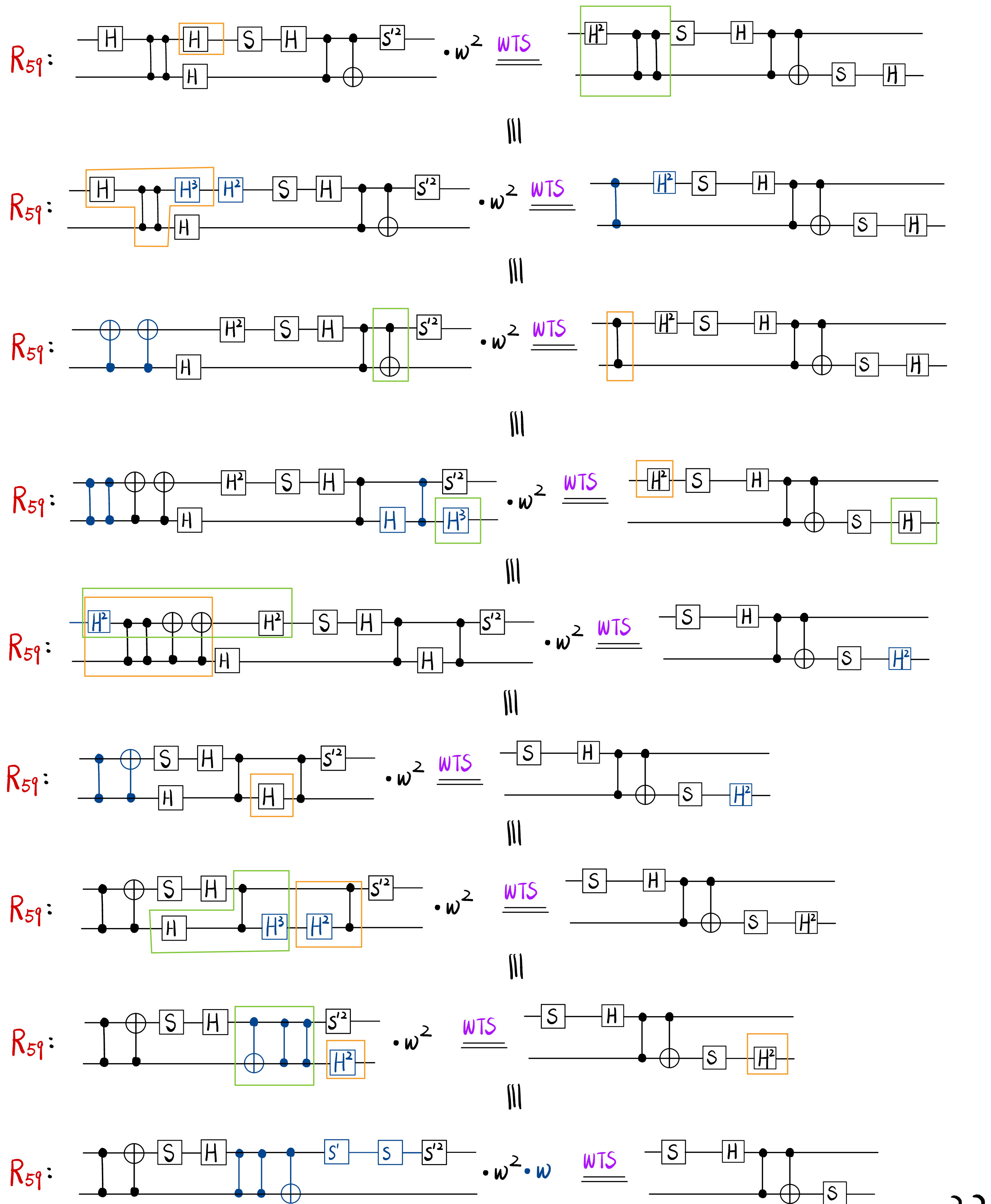


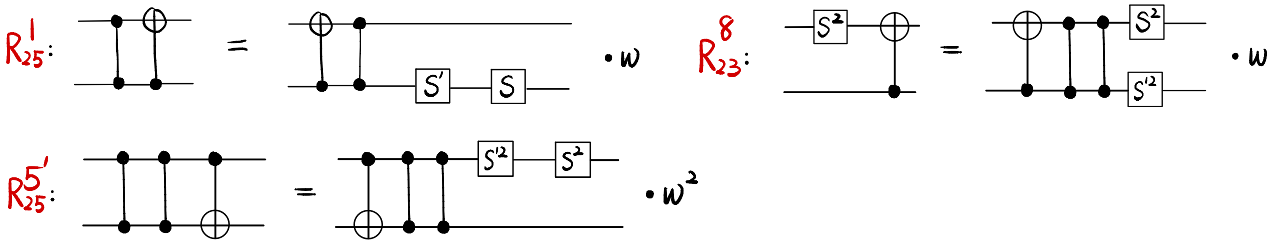
$\cdot w^2$

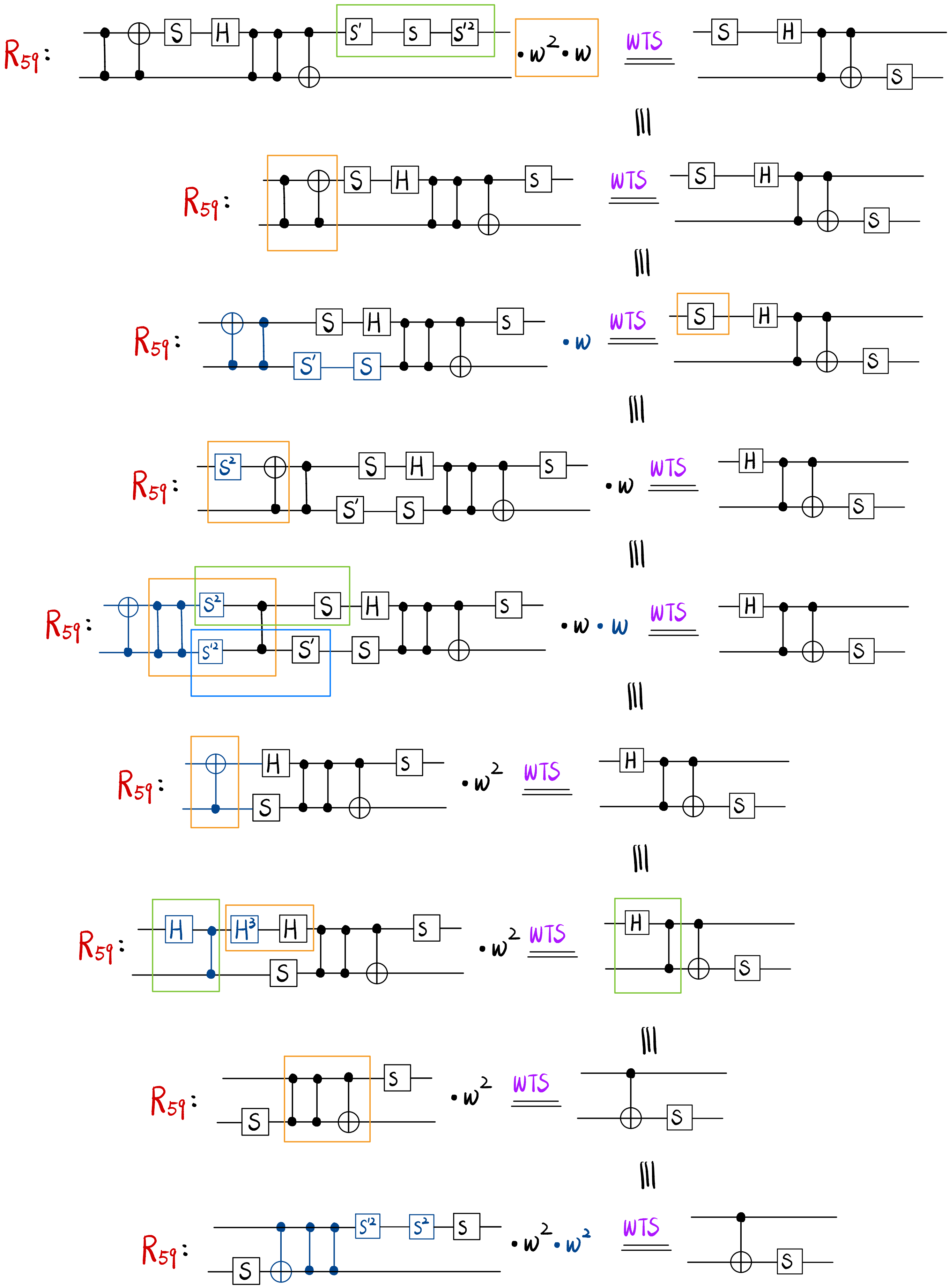

R^4_{23}:
S
=
S'
S
$\cdot w^2$
R^4_{25}:
S'^2
S^2
$\cdot w^2$
=

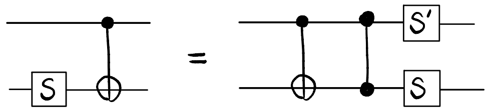

R_{59}:
H
S
H^3
WTS
S^2
H^2
S'
$\cdot w^2$
≡
$H^3 S' \overset{Def1}{=} H^3 H^2 S H^2 \overset{C_2}{=} H S H^2$

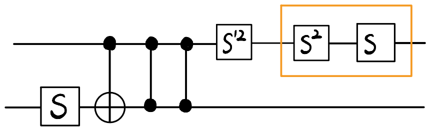
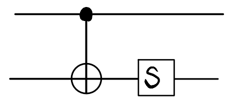

R423:
= · w2
R425:
· w2 =
R725:
= · w
R5'25:
= · w2


R59:
· w2
WTS
≡
R59:
· w2
WTS
≡
R59:
· w2
WTS
≡
R59:
· w2
WTS
≡
R59:
· w2
WTS
≡
R59:
· w2
WTS
≡
R59:
· w2
WTS
≡
R59:
· w2
WTS
≡
R59:
· w2 · w
WTS

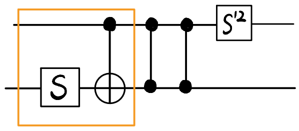
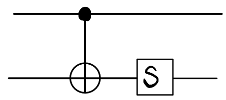

R^1_{25}:
$\cdot w$
R^8_{23}:
$\cdot w$
$R^{5'}_{25}$:
$\cdot w^2$

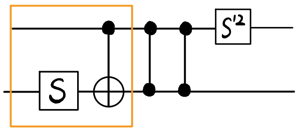
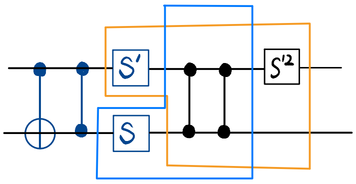

R_{59}:
$\cdot w^2 \cdot w$
WTS
$\cdot w$
$\cdot w \cdot w$
$\cdot w^2$
$\cdot w^2 \cdot w^2$

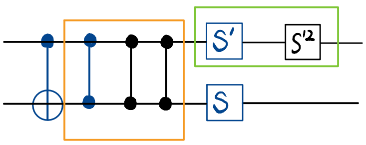
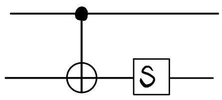
R^4_{23}:  $\cdot\, w^2$

R_{59}:  $\cdot\, w^2 \cdot w^2$ $\overset{\text{WTS}}{=}$ 

$\equiv$

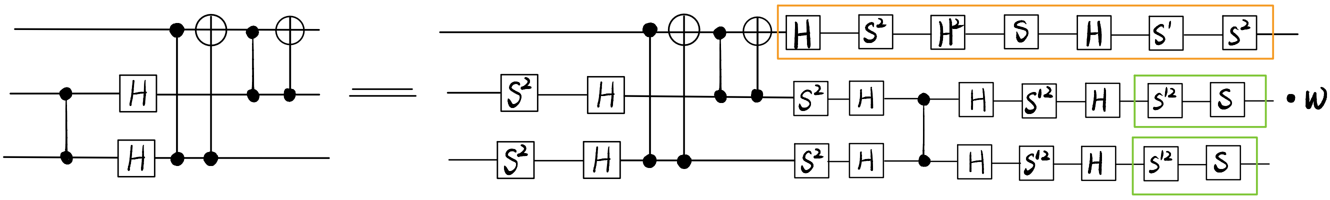
R_{59}:  $\cdot\, w$ $\overset{\text{WTS}}{=}$ 

$R_{59}.\mathrm{LHS} :=$  $\cdot\, w$ $\overset{R^4_{23}}{=}$  $\cdot\, w \cdot w^2$

$=$  $=$  $=: R_{59}.\mathrm{RHS}$

$\blacksquare$

R_{59}:

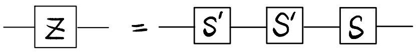


$\equiv$

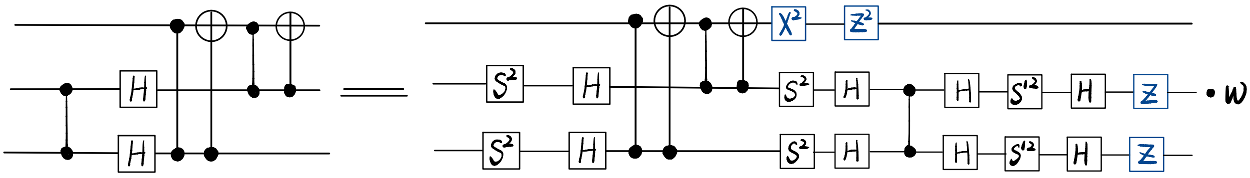
$HS^2H^2SH\, \boxed{S'S^2} \overset{R_{11}}{=\!=} \boxed{HS^2H^2SH}\, Z^2 \overset{R_7}{=\!=} X^2Z^2$

C_3: $S^3 = I$

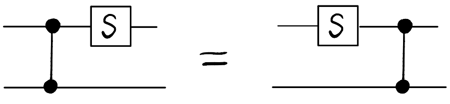
R_{10}:



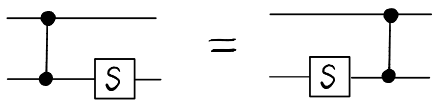
R_{59}:



C_7: (1)

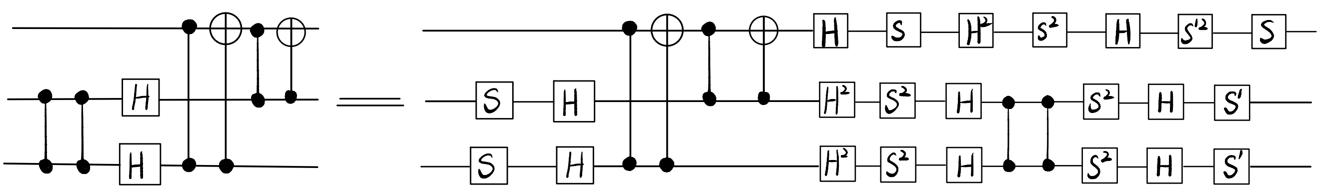


(2)

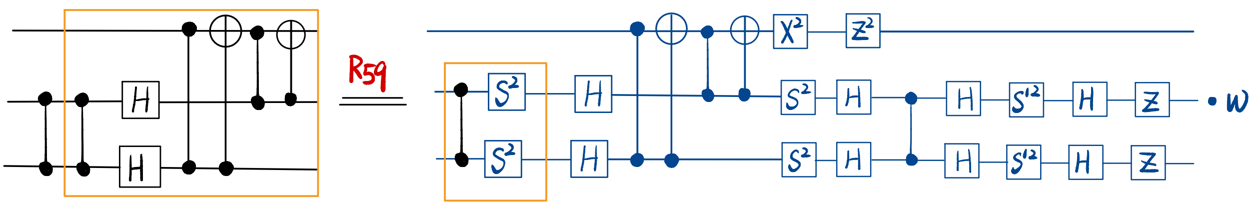


Lem D2 Def 0-2, Def 4-5, Def 7, $C_{0\text{-}8}$, C_{13}, C_{16}, R_5, R_7, R_8, R_9, R_{10}, R_{11}, R_{12}, R_{15}, R_{23}, R_{24}, R_{25} imply

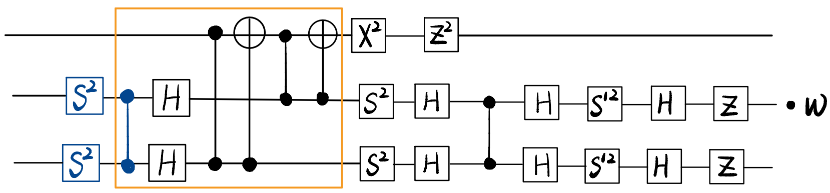
R_{60}:



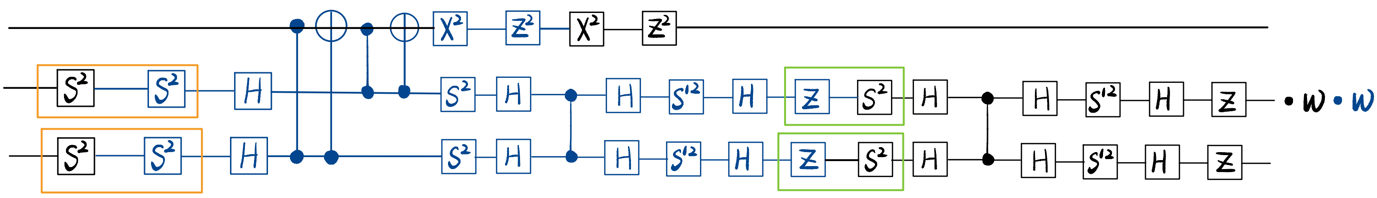
Proof: R_{60}.LHS :=



$\overset{C_7}{=\!=}$

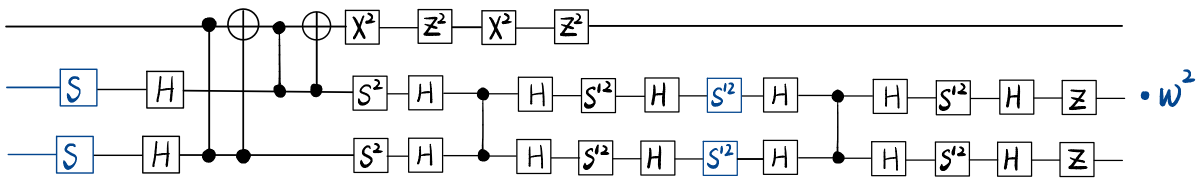


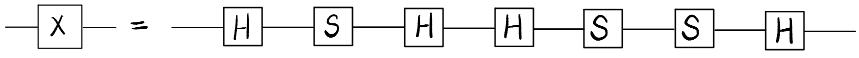
$\overset{R_{59}}{=\!=}$

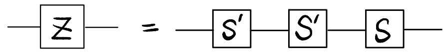


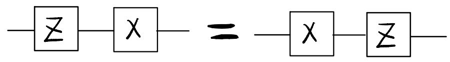
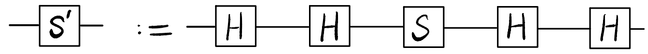
$ZS^2 \overset{R_{10}}{=\!=} S'^2\, \boxed{SS^2} \overset{C_3}{=\!=} S'^2$

$\overset{C_3}{\underset{R_{10}}{=\!=}}$

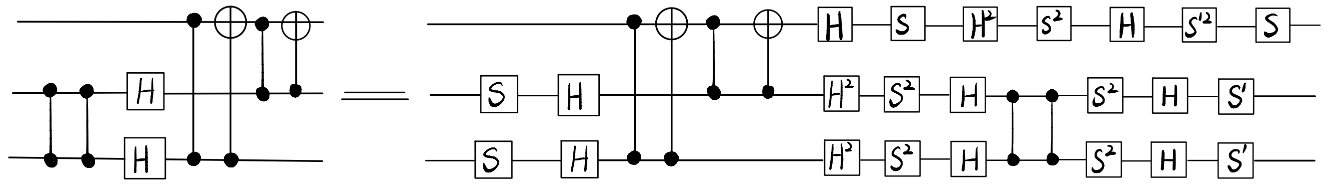


R5 :  R12 : $Z^3 = I$ R9 : $X^3 = I$

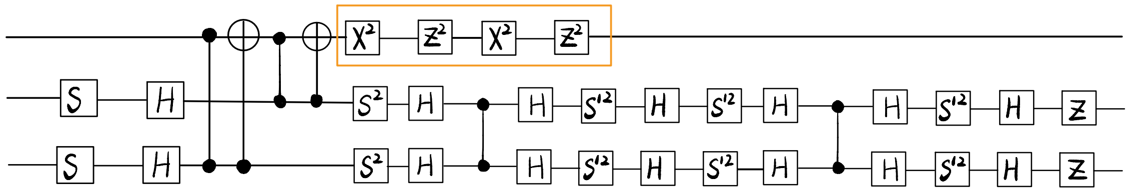
R10 :  C1 : $w^3 = 1$ C2 : $H^4 = I$ C3 : $S^3 = I$ C5 : $SS' = S'S$

R8 :  $\cdot\, w^2$ Def 1 : 

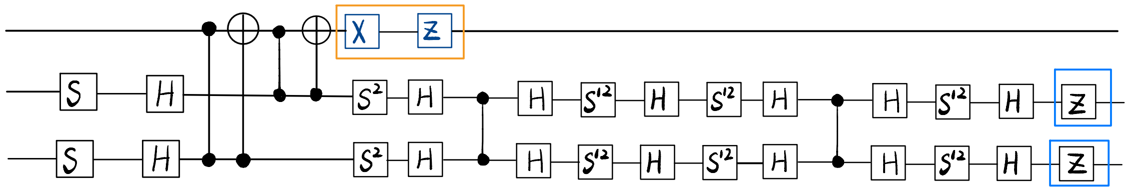
Lem D2

R60 : 

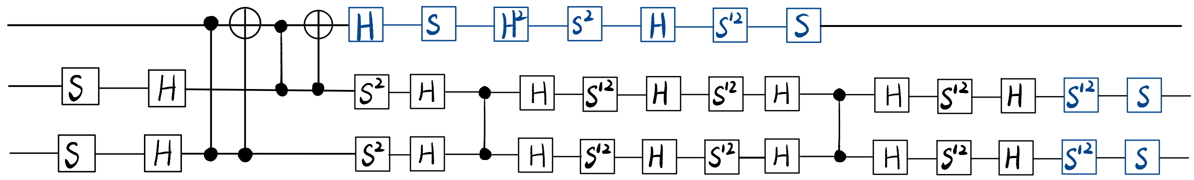
Proof cont.

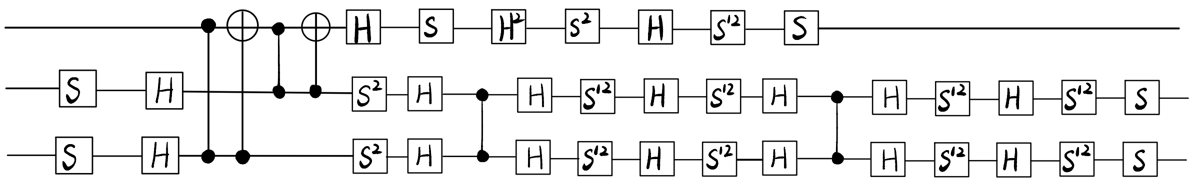
R60.LHS =  $\cdot\, w^2$

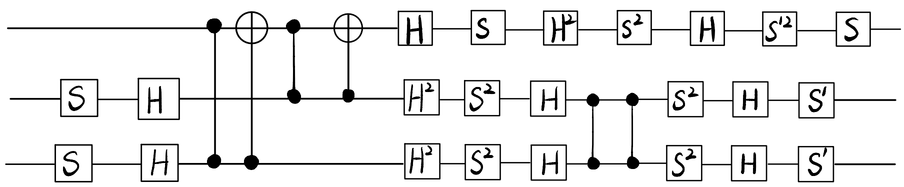
$$X^2 \boxed{Z^2 X^2} Z^2 \overset{R8}{=} X^2 Z X^2 \boxed{Z Z} \boxed{\cdot w^2 \cdot w^2} \overset{R12}{\underset{C_1}{=}} X^2 \boxed{Z X^2} \cdot w \overset{R8}{=} \boxed{X^2 X^2} Z \cdot w^2 \boxed{\cdot w^2 \cdot w} \overset{R9}{\underset{C_1}{=}} XZ \cdot w^2$$

$\overset{R8,\,R9}{\underset{C_1,\,R12}{=}}$  $\boxed{\cdot\, w^2 \cdot w^2}$

$$XZ \overset{R5}{\underset{R10}{=}} HSH^2S^2HS'^2S$$

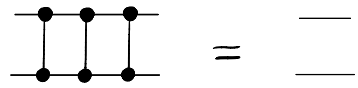
$\overset{R5,\,R10}{\underset{C_1,\,\text{Def }1}{=}}$  $\cdot\, w$

Hence,  $\cdot\, w$ $\overset{WTS}{=}$

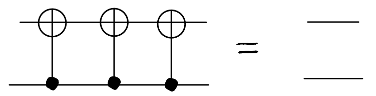


$C_1 : w^3 = 1$ $\quad C_2 : H^4 = I$ $\quad C_3 : S^3 = I$ $\quad C_5 : SS' = S'S$

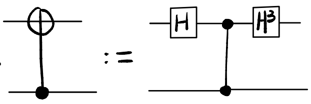
C_6 :



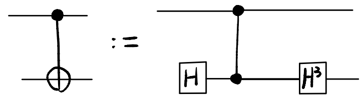
C_6^2 :



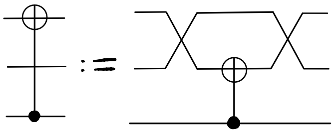
Def 2 :



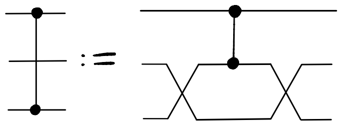
Def 4 :



Def 7 :

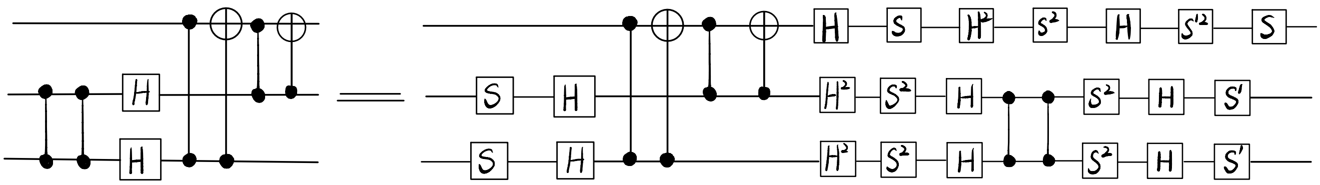


Def 5 :



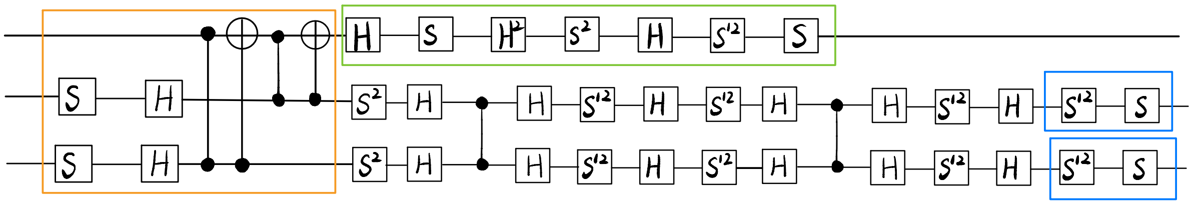
Lem D2

R_{60} :

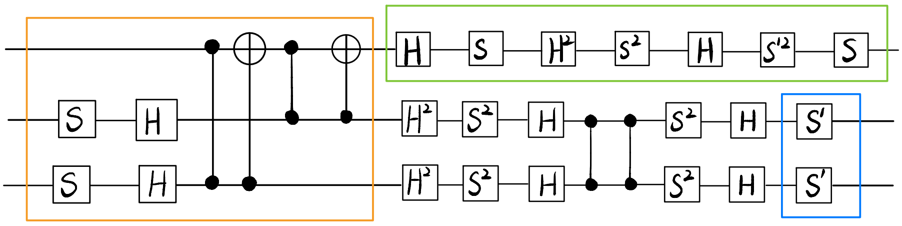


Proof cont.

R_{60}.LHS =



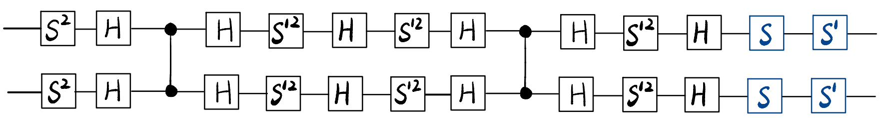
$\cdot w$ $\underline{\underline{\text{WTS}}}$



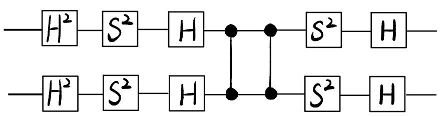
=: R_{60}. RHS.

C_2, C_3, C_5 ||| C_6^*, C_6^{2*}, Def 1, Def 2, Def 4–5, Def 7

R_{60}.LHS =



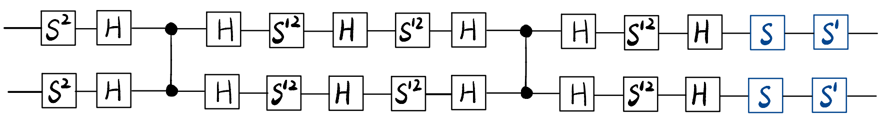
$\cdot w$ $\underline{\underline{\text{WTS}}}$



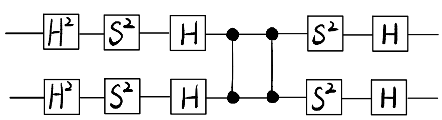
= R_{60}. RHS.

Hence, our problem is reduced to two-qutrit Clifford completeness :

R'_{60}.LHS =



$\cdot w$ $\underline{\underline{\text{WTS}}}$



= R'_{60}. RHS.

This completes the proof. $\square$