

$$\begin{aligned}
r_{1,2}^3 &= r_{1,3}^2 (r_{3,3}^2)^* r_{3,2} + r_{1,2}^2 \\
&= 0^* 1 (\epsilon + (0 + 1) 0^* 1)^* (0 + 1) (00)^* + 0 (00)^* \\
&= 0^* 1 ((0 + 1) 0^* 1)^* (0 + 1) (00)^* + 0 (00)^*
\end{aligned}$$