$$F_8 = (F_4 \otimes I_2) T_2^8 (I_4 \otimes F_2) L_4^8 \tag{1}$$

$$= ((F_2 \otimes I_2) T_2^4 (I_2 \otimes F_2) L_2^4 \otimes I_2) T_2^8 (I_4 \otimes F_2) L_4^8 \tag{2}$$

There's always 2 on the bottom of the twiddle factor.

$$= ((F_2 \otimes I_4)(T_2^4 \otimes I_2)(I_2 \otimes F_2 \otimes I_2)(L_2^4 \otimes I_2) T_2^8 (I_4 \otimes F_2) \tag{3}$$

$$= ((F_2 \otimes I_4)(T_2^4 \otimes I_2)(I_2 \otimes F_2 \otimes I_2)(L_2^4 \otimes I_2) T_2^8 (I_4 \otimes F_2)(L_4^8 L_4^8) \tag{4}$$

and if we commute

$$L_2^4 = R_4 \tag{5}$$

$$L_4^8 = R_8 \tag{6}$$

Generalization

$$F_{2^t} = \prod_{c=1}^{t} (R_{2^{c-1}} \otimes I_{2^{t-c+1}})(T_2^{2c} \otimes I_{2^{t-c}})(R_{2^{c=1}} \otimes I_{2^{t-c+1}})(I_{2^{c-1}} \otimes F_2 \otimes I_{2^{t-c}}) R_{2^t} \tag{7}$$

Can be proven with induction

Now the twiddle is

$$(R_{2^{c-1}} \otimes I_{2^{t-c+1}})(T_2^{2c} \otimes I_{2^{t-c}})(R_{2^{c=1}} \otimes I_{2^{t-c+1}})(I_{2^{c-1}} \otimes F_2 \otimes I_{2^{t-c}}) = \tag{8}$$

$$(R_{2^{c-1}} \otimes I_{2^{t-c+1}})(T_2^{2c} \otimes I_{2^{t-c}})(R_{2^{c=1}} \otimes I_{2^{t-c+1}}) L_{2^{c-1}}^{2^t} (F_2 \otimes I_{2^{t-1}}) L^{2^t} L_2^{2^t} L_{2^{t-c}}^{2^t} = \tag{9}$$

$$L_{2^{t-c+1}}^{2^t} (R_{2^{c-1}} \otimes I_{2^{t-c+1}})(T_2^{2c} \otimes I_{2^{t-c}})(R_{2^{c=1}} \otimes I_{2^{t-c+1}}) L_{2^{c-1}}^{2^t} (F_2 \otimes I_{2^{t-1}}) L^{2^t} L_2^{2^t} = \tag{10}$$

$$(I_{2^{t-c+1}} \otimes R_{2^{c-1}}) L_2^{2^t} (I_{2^{t-c}} \otimes T_2^{2c}) L_{2^{t-1}}^{2^t} (I_{2^{t-c+1}} \otimes R_{2^{c=1}}) L_{2^{c-1}}^{2^t} (F_2 \otimes I_{2^{t-1}}) L^{2^t} L_2^{2^t} \tag{11}$$