Reduction formulae for negative rank $r<0$

If $\det Z \neq 0$ and $\det X \neq 0$. (If $\det Z = 0$, use DD reduction)

Start Passarino-Veltman reduction formula in matrix form:

$$\underbrace{\begin{pmatrix} 2m_0^2 & f_1 & f_2 & f_3 \\ f_1 & 2p_1\cdot p_1 & 2p_1\cdot p_2 & 2p_1\cdot p_3 \\ f_2 & & 2p_2\cdot p_2 & 2p_2\cdot p_3 \\ f_3 & & & 2p_3\cdot p_3 \end{pmatrix}}_{X} \begin{pmatrix} D_{0\cdots0\,1\cdots1\,2\cdots2\,3\cdots3} \\ D_{0\cdots0\,\underbrace{1\cdots1}_{n_1+1}\,2\cdots2\,3\cdots3} \\ D_{0\cdots0\,1\cdots1\,\underbrace{2\cdots2}_{n_2+1}\,3\cdots3} \\ D_{0\cdots0\,1\cdots1\,2\cdots2\,\underbrace{3\cdots3}_{n_3+1}} \end{pmatrix} = \begin{pmatrix} 2(d-3+2r+n_1+n_2+n_3)\,D_{\underbrace{0\cdots0}_{2(r+1)}\,1\cdots1\,2\cdots2\,3\cdots3} - C_{0\cdots0\,1\cdots1\,2\cdots2\,3\cdots3} \\ \vdots \\ \vdots \\ \vdots \end{pmatrix}$$

Multiply at left by $X^{-1} = \dfrac{1}{\det X}\tilde{X}$ and take first equation:

$$D_{\underbrace{0\cdots0}_{2r}\,\underbrace{1\cdots1}_{n_1}\,\underbrace{2\cdots2}_{n_2}\,\underbrace{3\cdots3}_{n_3}} = \frac{1}{\det X}\Bigg[\tilde{X}_{00}\Big(2(\overbrace{d-3}^{1-2\epsilon}+2r+n_1+n_2+n_3)\,D_{\underbrace{0\cdots0}_{2(r+1)}\,1\cdots1\,2\cdots2\,3\cdots3} - C_{\underbrace{0\cdots0}_{2r}\,\underbrace{1\cdots1}_{n_1}\,\underbrace{2\cdots2}_{n_2}\,\underbrace{3\cdots3}_{n_3}}(\hat{D}_0)\Big)$$

$$+\sum_{j=1}^{3}\tilde{X}_{0j}\Big(\delta_{n_j0}\,C_{0\cdots0\,\underbrace{1\cdots1}_{n_1(j)}\,\underbrace{2\cdots2}_{n_2(j)}}(\hat{D}_j) - C_{0\cdots0\,1\cdots1\,2\cdots2\,3\cdots3}(\hat{D}_0) - 2n_j\,D_{\hat{j}\,\underbrace{0\cdots0}_{2(r+1)}\,1\cdots1\,2\cdots2\,3\cdots3}\Big)\Bigg]$$

$\tilde{X}_{00} = 8\det Z$ ✓

$\tilde{X}_{0j} = -\sum_{n=1}^{3} 4\tilde{Z}_{jn}f_n$ ✓

If $\det X = 0$, Landau condition for leading singularity is satisfied.