forward-path gain:
\[ G_1(s)G_2(s)G_3(s)G_4(s)G_5(s) \]

closed-loop gains:
1. \( G_2(s)H_1(s) \)
2. \( G_4(s)H_2(s) \)
3. \( G_5(s)H_4(s) \)
4. \( G_2(s)G_3(s)G_4(s)G_5(s)G_6(s)G_7(s)G_8(s) \)

nontouching loops taken two at a time:
Loop 1 and loop 2: \( G_2(s)H_1(s)G_4(s)H_2(s) \)
Loop 1 and loop 3: \( G_2(s)H_1(s)G_5(s)H_4(s) \)
Loop 2 and loop 3: \( G_4(s)H_2(s)G_7(s)H_4(s) \)

Finally, the nontouching loops taken three at a time are as follows:
nontouching loops taken three at a time:
Loops 1, 2, and 3: \( G_2(s)H_1(s)G_4(s)H_2(s)G_7(s)H_4(s) \)

\[ \Delta = 1 - [G_2(s)H_1(s) + G_4(s)H_2(s) + G_7(s)H_4(s)] + G_2(s)G_3(s)G_4(s)G_5(s)G_6(s)G_7(s)G_8(s) \]

We form \( \Delta_1 \) by eliminating from \( \Delta \) those loop gains that touch the \( k \)th forward path as follows:

portion of \( \Delta \) not touching the forward path:
\[ \Delta_1 = 1 - G_7(s)H_4(s) \]

\[ G(s) = \frac{T_1\Delta_1}{\Delta} = \frac{[G_1(s)G_2(s)G_3(s)G_4(s)G_5(s)][1 - G_7(s)H_4(s)]}{\Delta} \]
Transfer function of complex system

\[ P_1 = G_1 G_2 G_3 G_4 G_5 G_6 , \quad P_2 = G_1 G_2 G_7 G_6 , \quad P_3 = G_1 G_2 G_5 G_4 G_8 . \]

The feedback loops are
\[
L_1 = -G_2 G_3 G_4 G_5 H_2 , \quad L_2 = -G_5 G_6 H_1 , \quad L_3 = -G_8 H_1 , \quad L_4 = -G_7 H_2 G_2 , \\
L_5 = -G_4 H_4 , \quad L_6 = -G_1 G_2 G_3 G_4 G_5 G_6 H_3 , \quad L_7 = -G_1 G_2 G_7 G_6 H_3 , \\
L_8 = -G_1 G_2 G_5 G_4 G_8 H_3 .
\]

Loop \( L_5 \) does not touch loop \( L_4 \) or loop \( L_7 \); loop \( L_3 \) does not touch loop \( L_4 \); and all other loops touch. Therefore the determinant is
\[
\Delta = 1 - (L_1 + L_2 + L_3 + L_4 + L_5 + L_6 + L_7 + L_8) \\
\quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad + (L_5 L_7 + L_5 L_4 + L_3 L_4).
\]

The cofactors are
\[
\Delta_1 = \Delta_3 = 1 \quad \text{and} \quad \Delta_2 = 1 - L_5 = 1 + G_4 H_4 .
\]

Finally, the transfer function is
\[
T(s) = \frac{Y(s)}{R(s)} = \frac{P_1 + P_2 \Delta_2 + P_3}{\Delta} .
\]