2-loop Feedback Algebra

K is the one-hop open loop gain

G is the closed loop node-node gain

In[30]:=

$$K = \begin{pmatrix} 0 & 0 & C\,M\,P & 0 & 0 & P \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & C\,F & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 \end{pmatrix};$$

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G = Inverse[IdentityMatrix[6] - K];
MatrixForm[Simplify[G]]
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Out[32]//MatrixForm=

$$\begin{pmatrix} \frac{1}{1-C\,(F+M)\,P} & -\frac{C\,(F+M)\,P}{-1+C\,(F+M)\,P} & -\frac{C\,(F+M)\,P}{-1+C\,(F+M)\,P} & -\frac{P}{-1+C\,(F+M)\,P} & -\frac{P}{-1+C\,(F+M)\,P} & -\frac{P}{-1+C\,(F+M)\,P} \\ 0 & 1 & 0 & 0 & 0 & 0 \\ \frac{1}{1-C\,(F+M)\,P} & \frac{1}{1-C\,(F+M)\,P} & \frac{1}{1-C\,(F+M)\,P} & -\frac{P}{-1+C\,(F+M)\,P} & -\frac{P}{-1+C\,(F+M)\,P} & -\frac{P}{-1+C\,(F+M)\,P} \\ -\frac{C\,F}{-1+C\,(F+M)\,P} & -\frac{C\,F}{-1+C\,(F+M)\,P} & -\frac{C\,F}{-1+C\,(F+M)\,P} & \frac{-1+C\,M\,P}{-1+C\,(F+M)\,P} & -\frac{C\,F\,P}{-1+C\,(F+M)\,P} & -\frac{C\,F\,P}{-1+C\,(F+M)\,P} \\ 0 & 0 & 0 & 0 & 1 & 0 \\ -\frac{C\,F}{-1+C\,(F+M)\,P} & -\frac{C\,F}{-1+C\,(F+M)\,P} & -\frac{C\,F}{-1+C\,(F+M)\,P} & \frac{-1+C\,M\,P}{-1+C\,(F+M)\,P} & \frac{-1+C\,M\,P}{-1+C\,(F+M)\,P} & \frac{-1+C\,M\,P}{-1+C\,(F+M)\,P} \end{pmatrix}$$

In[34]:=

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MatrixForm[Simplify[G * (1 - P C (F + M))]]
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Out[34]//MatrixForm=

$$\begin{pmatrix} 1 & C\,(F+M)\,P & C\,(F+M)\,P & P & P & P \\ 0 & 1-C\,(F+M)\,P & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & P & P & P \\ C\,F & C\,F & C\,F & 1-C\,M\,P & C\,F\,P & C\,F\,P \\ 0 & 0 & 0 & 0 & 1-C\,(F+M)\,P & 0 \\ C\,F & C\,F & C\,F & 1-C\,M\,P & 1-C\,M\,P & 1-C\,M\,P \end{pmatrix}$$

In[42]:=

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(* This is the usual single branch TF measurement *)
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$$FPG = \frac{G[[4,5]]}{G[[6,5]]}$$

Out[42]=

$$\frac{C\,F\,P}{1 - C\,M\,P}$$

In[43]:=
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(* This is the Open Loop Gain *)
OLG = G[[1, 2]] / G[[3, 2]];
Simplify[OLG]
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Out[44]= $C\ (F + M)\ P$