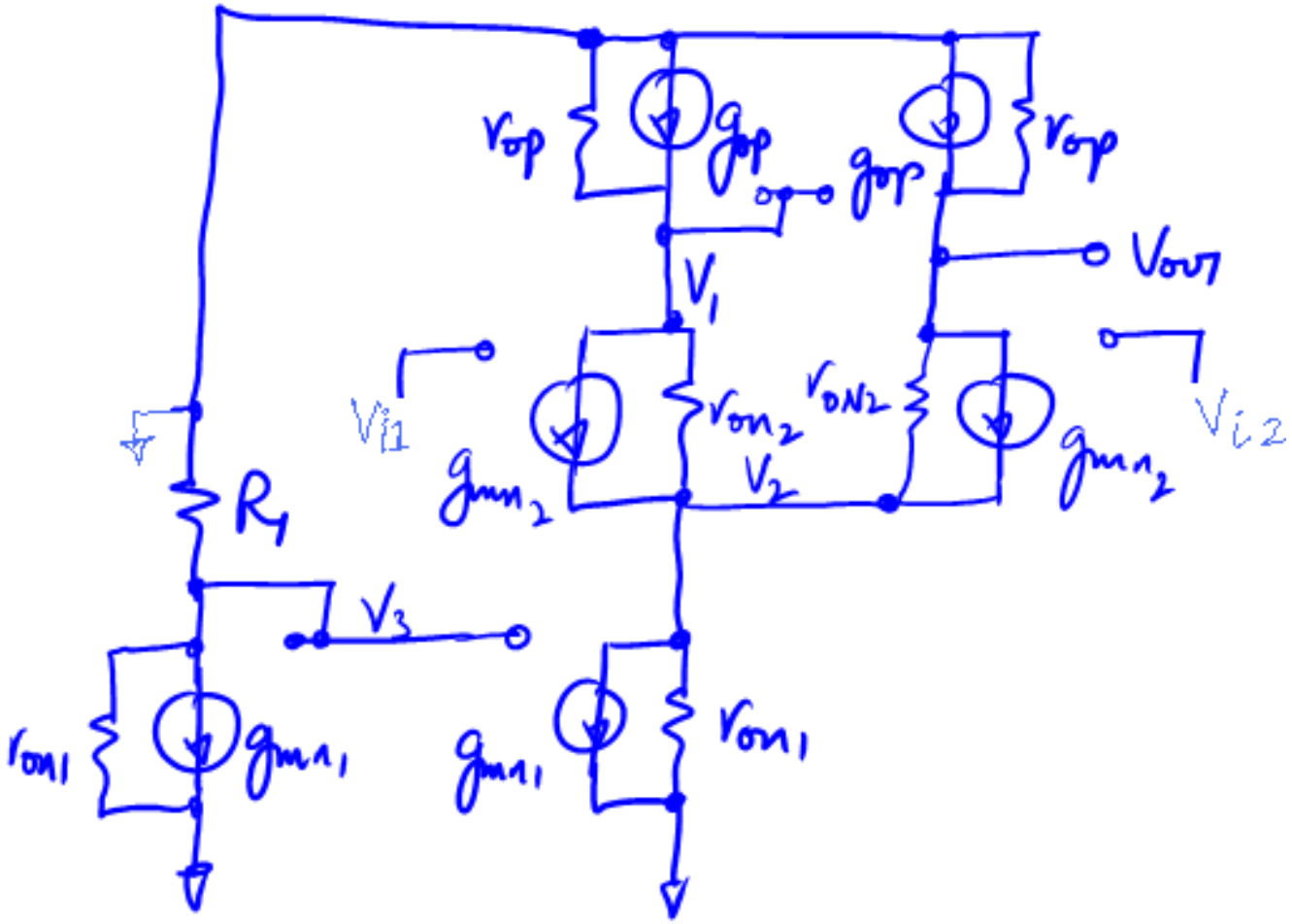
SIMPLE DIFFAMP GAIN ANALYSIS



Using Superposition for Vi1 and Vi2

CASE 1: Vout due to Vi1

```
Quit[];
```

```
eqns = {
       -V1/rop + gmp (-V1) == (V1 - V2)/ron2 + gmn2 (Vi1 - V2),
       -Vout/rop + gmp (-V1) == (Vout - V2)/ron2 + gmn2 (-V2),
       (V1 - V2)/ron2 + gmn2 (Vi1 - V2) + (Vout - V2)/ron2 + gmn2 (-V2) == 2 V2/ron1
 }
Solve[eqns, {V1, V2, Vout}]
```

$$\left\{-\text{gmp V1}-\frac{\text{V1}}{\text{rop}}==\frac{\text{V1}-\text{V2}}{\text{ron2}}+\text{gmn2}\,(-\text{V2}+\text{Vi1}),\ -\text{gmp V1}-\frac{\text{Vout}}{\text{rop}}==-\text{gmn2 V2}+\frac{-\text{V2}+\text{Vout}}{\text{ron2}},\ \frac{\text{V1}-\text{V2}}{\text{ron2}}-\text{gmn2 V2}+\text{gmn2}\,(-\text{V2}+\text{Vi1})+\frac{-\text{V2}+\text{Vout}}{\text{ron2}}==\frac{2\,\text{V2}}{\text{ron1}}\right\}$$

$$\begin{aligned}\{\{\text{Vout}\to&-(-\text{gmn2 ron1 ron2 rop Vi1}-\text{gmn2}^2\,\text{ron1 ron2}^2\,\text{rop Vi1}-2\,\text{gmn2 gmp ron1 ron2 rop}^2\,\text{Vi1}-\\&2\,\text{gmn2 gmp ron2}^2\,\text{rop}^2\,\text{Vi1}-2\,\text{gmn2}^2\,\text{gmp ron1 ron2}^2\,\text{rop}^2\,\text{Vi1})/(2\,(\text{ron2}+\text{rop})\,(\text{ron1}+\\&\text{ron2}+\text{gmn2 ron1 ron2}+\text{rop}+\text{gmp ron1 rop}+\text{gmp ron2 rop}+\text{gmn2 gmp ron1 ron2 rop})),\\ \text{V1}\to&-(\text{gmn2 ron1 ron2 rop Vi1}+2\,\text{gmn2 ron2}^2\,\text{rop Vi1}+\text{gmn2}^2\,\text{ron1 ron2}^2\,\text{rop Vi1}+\\&2\,\text{gmn2 ron2 rop}^2\,\text{Vi1})/(2\,(\text{ron2}+\text{rop})\,(\text{ron1}+\text{ron2}+\text{gmn2 ron1 ron2}+\\&\text{rop}+\text{gmp ron1 rop}+\text{gmp ron2 rop}+\text{gmn2 gmp ron1 ron2 rop})),\\ \text{V2}\to&(\text{ron1 ron2}\,(\text{gmn2 ron2 Vi1}+\text{gmn2 rop Vi1}+\text{gmn2 gmp ron2 rop Vi1}+2\,\text{gmn2 gmp rop}^2\,\text{Vi1}))/\\&(2\,(\text{ron2}+\text{rop})\,(\text{ron1}+\text{ron2}+\text{gmn2 ron1 ron2}+\text{rop}+\\&\text{gmp ron1 rop}+\text{gmp ron2 rop}+\text{gmn2 gmp ron1 ron2 rop}))\}\}\end{aligned}$$

$$\frac{\text{Vout}}{\text{Vi1}}=(\text{gmn2 ron1 ron2 rop}+\text{gmn2}^2\,\text{ron1 ron2}^2\,\text{rop}+2\,\text{gmn2 gmp ron1 ron2 rop}^2+2\,\text{gmn2 gmp ron2}^2\,\text{rop}^2+2\,\text{gmn2}^2\,\text{gmp ron1 ron2}^2\,\text{rop}^2)/(2\,(\text{ron2}+\text{rop})\,(\text{ron1}+\text{ron2}+\text{gmn2 ron1 ron2}+\text{rop}+\text{gmp ron1 rop}+\text{gmp ron2 rop}+\text{gmn2 gmp ron1 ron2 rop}))$$

$$\text{Z}=\text{ron1}+\text{ron2}+\text{gmn2 ron1 ron2}$$

$$\text{Z1}=\frac{\text{rop}}{1+\text{rop gmp}}$$

$$\text{Zout}=\frac{\text{ron2 rop}}{\text{ron2}+\text{rop}}$$

$$\frac{\text{Vout}}{\text{Vi1}}=\frac{\text{gmn2 Zout}\,(\text{ron1}\,(1+\text{gmn2 ron2})+2\,\text{gmp rop Z})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}$$

APPROXIMATIONS:

$$\frac{1}{\text{gmn2}}\ll\text{ron2}$$

$$\text{gmn2 ron2 ron1}\ll 2\,\text{gmp rop Z}$$

$$\frac{1}{\text{gmp}}\ll\text{rop}$$

$$\text{Z1}\ll\text{Z}$$

$$\frac{\text{Vout}}{\text{Vi1}}=\text{gmn2 Zout}$$

CASE 1: Vout due to Vi2

```
Quit[];
```

```
eqns = {
       -V1/rop + gmp (-V1) == (V1 - V2)/ron2 + gmn2 (-V2),
       -Vout/rop + gmp (-V1) == (Vout - V2)/ron2 + gmn2 (Vi2 - V2),
       (V1 - V2)/ron2 + gmn2 (-V2) + (Vout - V2)/ron2 + gmn2 (Vi2 - V2) == 2 V2/ron1
 }
Solve[eqns, {V1, V2, Vout}]
```

$$\left\{-\text{gmp}\,\text{V1}-\frac{\text{V1}}{\text{rop}}==\frac{\text{V1}-\text{V2}}{\text{ron2}}-\text{gmn2}\,\text{V2},\ -\text{gmp}\,\text{V1}-\frac{\text{Vout}}{\text{rop}}==\text{gmn2}\,(-\text{V2}+\text{Vi2})+\frac{-\text{V2}+\text{Vout}}{\text{ron2}},\right.$$
$$\left.\frac{\text{V1}-\text{V2}}{\text{ron2}}-\text{gmn2}\,\text{V2}+\text{gmn2}\,(-\text{V2}+\text{Vi2})+\frac{-\text{V2}+\text{Vout}}{\text{ron2}}==\frac{2\,\text{V2}}{\text{ron1}}\right\}$$

$$\begin{aligned}&\{\{\text{Vout}\to-(\text{gmn2}\,\text{ron1}\,\text{ron2}\,\text{rop}\,\text{Vi2}+2\,\text{gmn2}\,\text{ron2}^2\,\text{rop}\,\text{Vi2}+\\&\quad\text{gmn2}^2\,\text{ron1}\,\text{ron2}^2\,\text{rop}\,\text{Vi2}+2\,\text{gmn2}\,\text{ron2}\,\text{rop}^2\,\text{Vi2}+2\,\text{gmn2}\,\text{gmp}\,\text{ron1}\,\text{ron2}\,\text{rop}^2\,\text{Vi2}+\\&\quad2\,\text{gmn2}\,\text{gmp}\,\text{ron2}^2\,\text{rop}^2\,\text{Vi2}+2\,\text{gmn2}^2\,\text{gmp}\,\text{ron1}\,\text{ron2}^2\,\text{rop}^2\,\text{Vi2})/\\&\quad(2\,(\text{ron2}+\text{rop})\,(\text{ron1}+\text{ron2}+\text{gmn2}\,\text{ron1}\,\text{ron2}+\text{rop}+\text{gmp}\,\text{ron1}\,\text{rop}+\\&\quad\text{gmp}\,\text{ron2}\,\text{rop}+\text{gmn2}\,\text{gmp}\,\text{ron1}\,\text{ron2}\,\text{rop}))\},\\&\text{V1}\to(\text{gmn2}\,\text{ron1}\,\text{ron2}\,(1+\text{gmn2}\,\text{ron2})\,\text{rop}\,\text{Vi2})/(2\,(\text{ron2}+\text{rop})\\&\quad(\text{ron1}+\text{ron2}+\text{gmn2}\,\text{ron1}\,\text{ron2}+\text{rop}+\text{gmp}\,\text{ron1}\,\text{rop}+\text{gmp}\,\text{ron2}\,\text{rop}+\text{gmn2}\,\text{gmp}\,\text{ron1}\,\text{ron2}\,\text{rop})),\\&\text{V2}\to(\text{gmn2}\,\text{ron1}\,\text{ron2}\,(\text{ron2}+\text{rop}+\text{gmp}\,\text{ron2}\,\text{rop})\,\text{Vi2})/(2\,(\text{ron2}+\text{rop})\,(\text{ron1}+\text{ron2}+\\&\quad\text{gmn2}\,\text{ron1}\,\text{ron2}+\text{rop}+\text{gmp}\,\text{ron1}\,\text{rop}+\text{gmp}\,\text{ron2}\,\text{rop}+\text{gmn2}\,\text{gmp}\,\text{ron1}\,\text{ron2}\,\text{rop}))\}\}\end{aligned}$$

$$\frac{\text{Vout}}{\text{Vi2}}=-(\text{gmn2}\,\text{ron1}\,\text{ron2}\,\text{rop}+2\,\text{gmn2}\,\text{ron2}^2\,\text{rop}+\text{gmn2}^2\,\text{ron1}\,\text{ron2}^2\,\text{rop}+2\,\text{gmn2}\,\text{ron2}\,\text{rop}^2+2\,\text{gmn2}\,\text{gmp}\,\text{ron1}\,\text{ron2}\,\text{rop}^2+2\,\text{gmn2}\,\text{gmp}\,\text{ron2}^2\,\text{rop}^2+2\,\text{gmn2}^2\,\text{gmp}\,\text{ron1}\,\text{ron2}^2\,\text{rop}^2)/(2\,(\text{ron2}+\text{rop})\,(\text{ron1}+\text{ron2}+\text{gmn2}\,\text{ron1}\,\text{ron2}+\text{rop}+\text{gmp}\,\text{ron1}\,\text{rop}+\text{gmp}\,\text{ron2}\,\text{rop}+\text{gmn2}\,\text{gmp}\,\text{ron1}\,\text{ron2}\,\text{rop}))$$

$$\text{Z}=\text{ron1}+\text{ron2}+\text{gmn2}\,\text{ron1}\,\text{ron2}$$

$$\text{Z1}=\frac{\text{rop}}{1+\text{rop}\,\text{gmp}}$$

$$\text{Zout}=\frac{\text{ron2}\,\text{rop}}{\text{ron2}+\text{rop}}$$

$$\frac{\text{Vout}}{\text{Vi2}}=\frac{-\text{gmn2}\,\text{Zout}\,(\text{Z}+\text{ron2}+2\,\text{rop}+2\,\text{gmp}\,\text{rop}\,\text{Z})}{2\,(1+\text{gmp}\,\text{rop})\,(\text{Z1}+\text{Z})}$$

Total Expression due to both sources:

$$\text{Vout} = \frac{\text{gmn2 Zout}\,(\text{ron1}\,(1+\text{gmn2 ron2})+2\,\text{gmp rop Z})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,\text{Vi1} - \frac{\text{gmn2 Zout}\,(\text{Z}+\text{ron2}+2\,\text{rop}+2\,\text{gmp rop Z})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,\text{Vi2}$$

$$= \frac{\text{gmn2 Zout}\,(2\,\text{gmp rop Z})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,\text{Vi1} + \frac{\text{gmn2 Zout}\,(\text{ron1}\,(1+\text{gmn2 ron2}))}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,\text{Vi1} - \frac{\text{gmn2 Zout}\,(2\,\text{gmp rop Z})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,\text{Vi2} - \frac{\text{gmn2 Zout}\,(\text{Z}+\text{ron2}+2\,\text{rop})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,\text{Vi2}$$

$$= \frac{\text{gmn2 Zout}\,(2\,\text{gmp rop Z})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,(\text{Vi1}-\text{Vi2}) + \frac{\text{gmn2 Zout}}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,(\text{Vi1}\,(\text{ron1}\,(1+\text{gmn2 ron2}))-\text{Vi2}\,(\text{ron1}+2\,\text{ron2}+\text{gmn2 ron1 ron2}+2\,\text{rop}))$$

$$= \frac{\text{gmn2 Zout}\,(2\,\text{gmp rop Z})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,(\text{Vi1}-\text{Vi2}) + \frac{\text{gmn2 Zout}\,(\text{ron1}\,(1+\text{gmn2 ron2}))}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,(\text{Vi1}-\text{Vi2}) - \frac{2\,\text{gmn2 Zout}\,(\text{ron2}+\text{rop})}{2\,(1+\text{gmp rop})\,(\text{Z1}+\text{Z})}\,\text{Vi2}$$