Differential mode and common mode

Differential mode amplification ("Diff")

$$V_{out} = A_{Diff} (V_+ - V_-)$$

Common mode amplification ("CM")

$$V_{out} = A_{CM} \frac{1}{2} (V_+ + V_-)$$

Total amplification

$$V_{out} = \underbrace{A_{Diff} (V_+ - V_-)}_{\text{Desired}} + \underbrace{A_{CM} \frac{1}{2} (V_+ + V_-)}_{\text{Undesired}}$$

Ideal op amp: $A_{CM} = 0$

Example:

Assume $V_+ = V_- = 1.0\,V$

$\Rightarrow$ V_{out} should be zero but it is not due to A_{CM}

Why is $A_{CM} \neq 0$?

Common mode rejection ratio (CMRR)

$$CMRR = \frac{A_{Diff}}{A_{CM}} \qquad \left(\Rightarrow 20 \log \left(\frac{A_{Diff}}{A_{CM}}\right) dB\right)$$

⇒ We need to check if A_{CM} has an influence. A_{CM} will falsify result.

Example:

Consider op amp with $A_{Diff} = 100$ and $A_{CM} = 1$

CMRR = ? (100 or 40 dB)

Assume $V_- = 5.0V$ $V_+ = 5.005\,V$

$V_{out} = ?$

$V_{out} = A_{Diff}(V_+ - V_-) + A_{CM}\frac{1}{2}(V_+ + V_-) = 0.5V + 5V$

⇒ Result is not acceptable.

Further considerations

⇒ Some circuits are more sensitive and some circuits are less sensitive to A_{CM}.

⇒ Further discussion

⇒ Textbook

⇒ Advanced courses