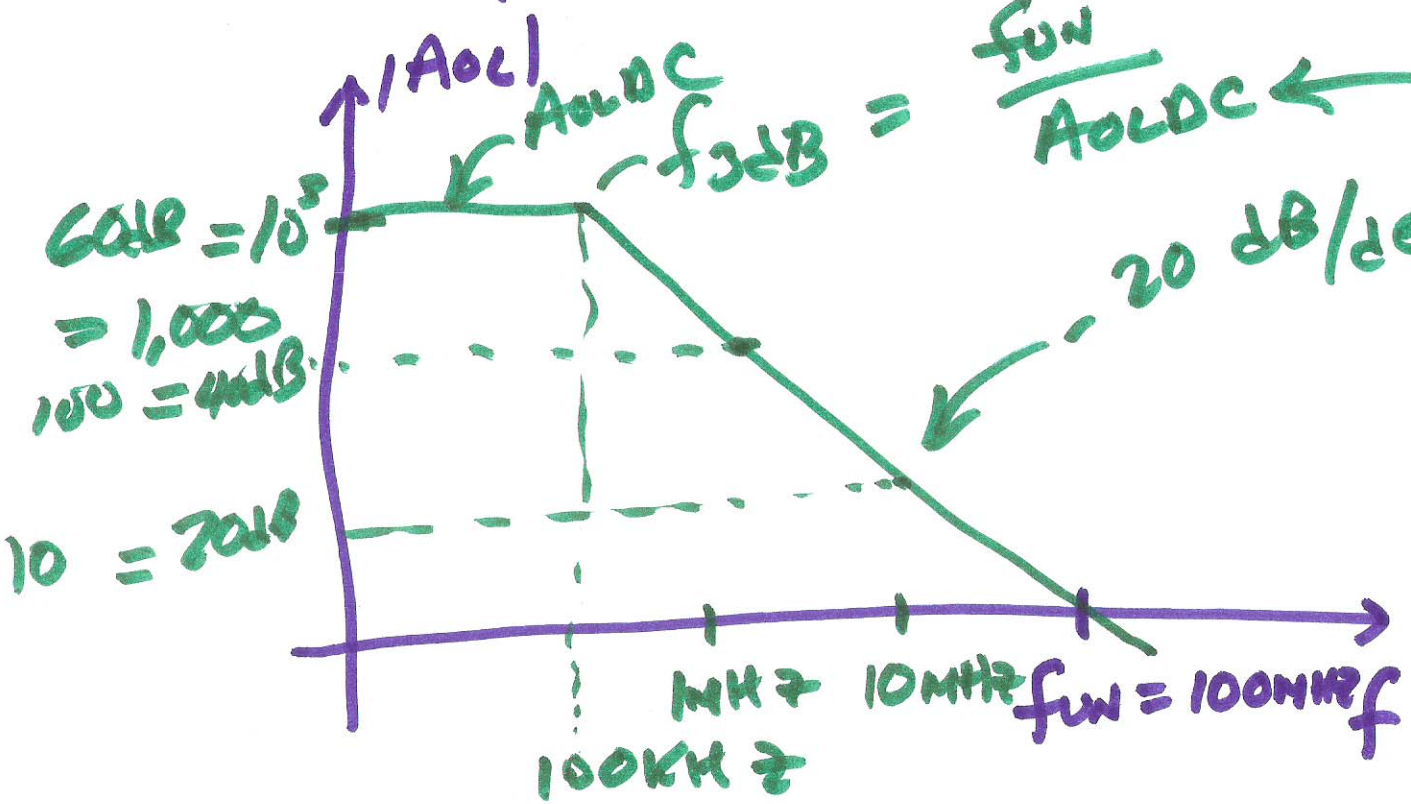
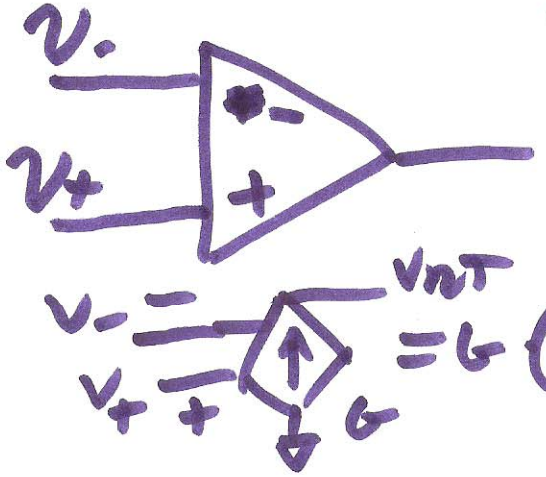
Op-Amps in data converters



$$A_{OL}(f) = \frac{10^3}{1 + j \cdot \frac{f}{100KHz}}$$

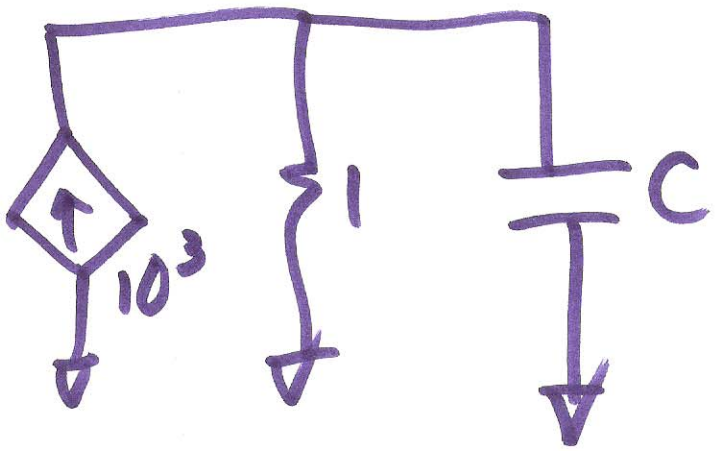


$V_{INT} =$

$V_{INT} = A_{OL}(f) \cdot (V_+ - V_-)$

$V_{INT} = G(V_+ - V_-)$

1)



$$f_{3dB} = \frac{1}{2\pi RC}$$

$f_{3dB} = 10^5$

$R = 1$

$$C = \frac{1}{2\pi \cdot 10^5}$$

$$= 159 \cdot 10^{-5}$$

$$= 159 \cdot 10^{-8}$$

$$= 1.59 \cdot 10^{-6}$$

$1.59\,\mu F$

$$\frac{10^3}{1 + jf/f_{3dB}}$$

$f_{3dB} = 100\,kHz$

2)

$$A_{fb} = \frac{f_{uw}}{A_{CL}} = f_{CL}$$

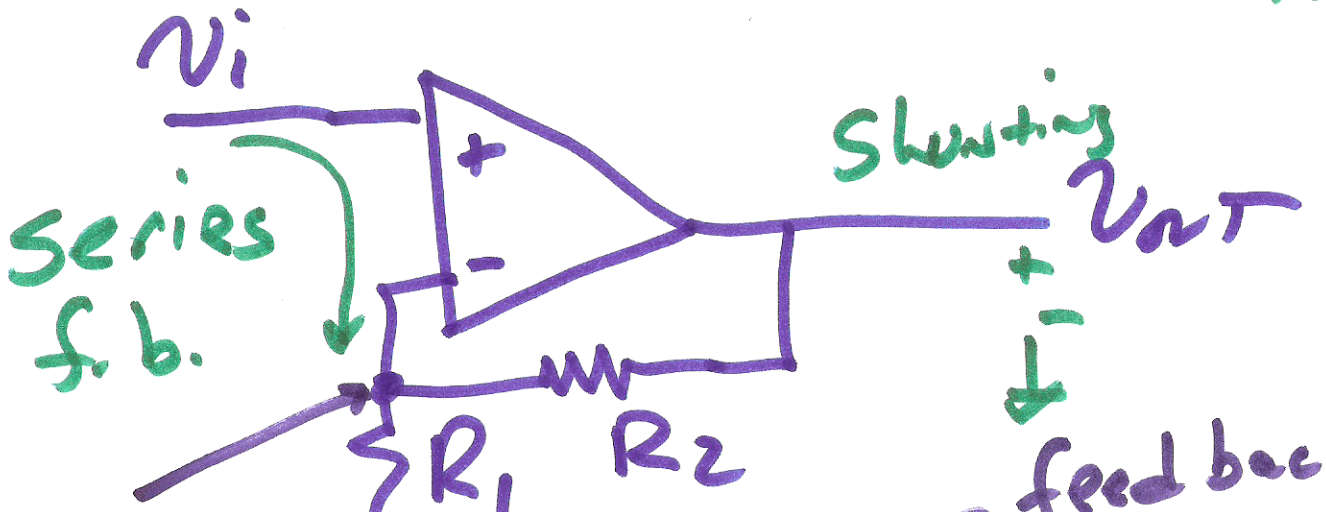
$$f_{uw} = A_{CL} \cdot f_{CL}$$

f_{CL} ← closed loop

Non-inverting topology

Series-shunt f.b. Amp

Voltage Amp $\frac{V_o}{V_i}$!

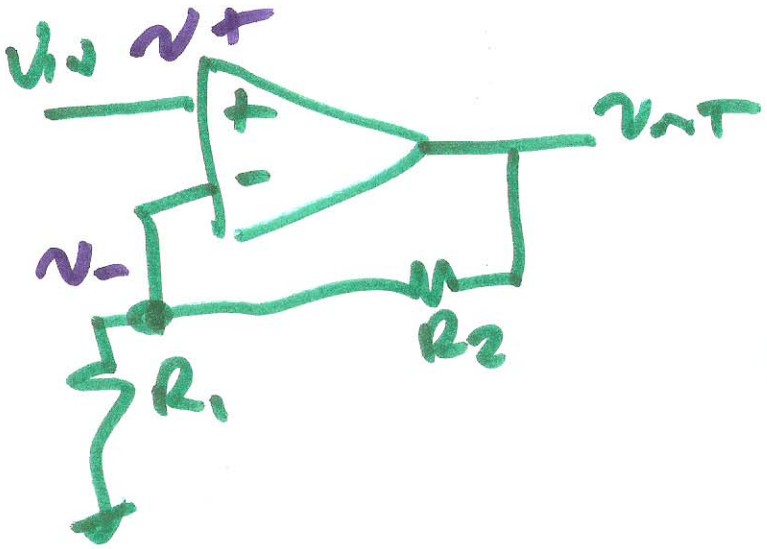


$$V_f = V_{out} \cdot \frac{R_1}{R_1 + R_2} = V_{out} \cdot \beta$$

($\frac{R_1}{R_1+R_2}$ = β)

3)

$$A_{OL}(f) \simeq \frac{A_{OLDC}}{1 + j\frac{f}{f_{3dB}}}, \quad f_{3dB} = \frac{f_{UN}}{A_{OLDC}}$$



$$\beta \cdot v_{OUT} = v_- \qquad v_{in} = v_+ - v_-$$

$$v_{OUT} = A_{OL}(f) \cdot (v_+ - v_-)$$

$$v_{OUT}\left(\frac{1}{A_{OL}(f)} + \beta\right) = v_{in}$$

$$A_{CL} = \frac{v_{OUT}}{v_{in}} = \frac{A_{OL}(f)}{1 + A_{OL}(f)\cdot\beta} \qquad \frac{1}{\frac{1}{A_{OL}} + \beta}$$

$$|A_{CL}| \simeq \frac{f_{UN}}{f}$$

$$\left|\frac{v_{OUT}}{v_{in}}\right| = |A_{CL}| = \frac{\frac{f_{UN}}{f}}{1 + \frac{f_{UN}}{f}\cdot\beta}$$

$$A_{CL} \simeq \frac{A_{OLDC}}{j\frac{f}{f_{3dB}}} = \frac{A_{OLDC}\cdot f_{3dB}}{f}$$

4)

$$A_{CL} = \frac{1}{\frac{1}{A_{OL}(f)} + \beta} = \frac{V_{OUT}}{V_{IN}}$$

$$= \frac{\frac{1}{\beta}}{1 + \frac{1}{\beta \cdot A_{OL}(f)}} \Leftarrow \text{ideal c.l. gain, } 1 + \frac{R_2}{R_1}$$

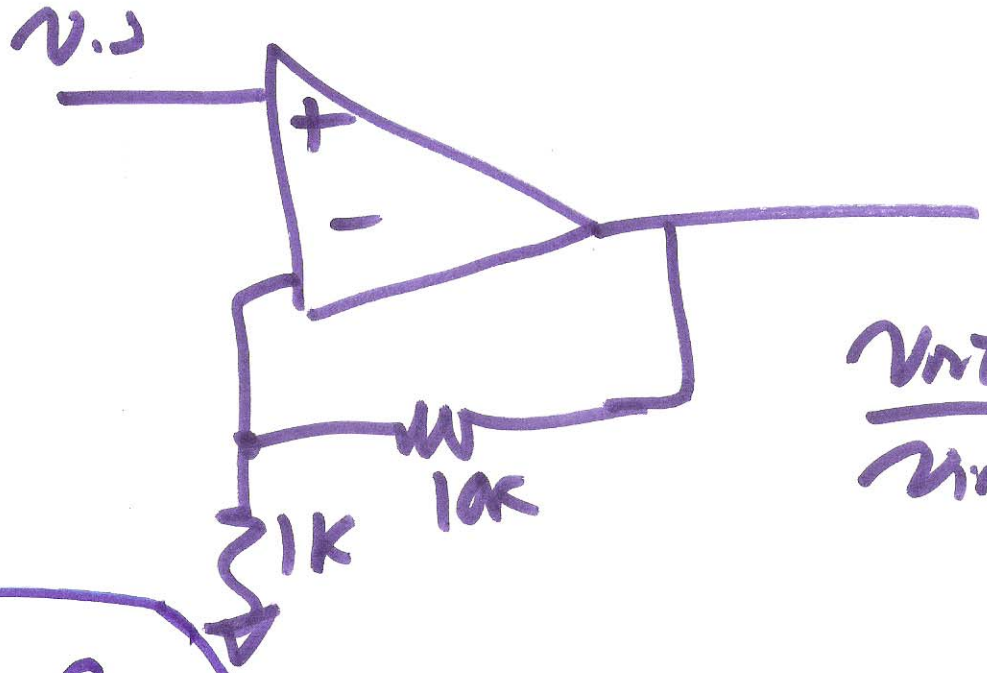
$$\Rightarrow A_{CLDC}, \quad A_{CL}(f) \simeq \frac{f_w}{j \cdot f}$$

$$\frac{R_1 + R_2}{R_1} = \frac{1}{\beta}$$

$$= \frac{A_{CLDC}}{1 + j \cdot f \cdot A_{CLDC}/f_w}$$

$$f_{3dB,CL} = \frac{f_w}{A_{CLDC}}$$

$f_{UN} = 100\,MHz$ find f_{3dB} for:



$$\frac{V_{out}}{V_{in}} = \frac{1K + 10K}{1K}$$

$$= 1 + \frac{10K}{1K}$$

$$A_{CL} = 11$$

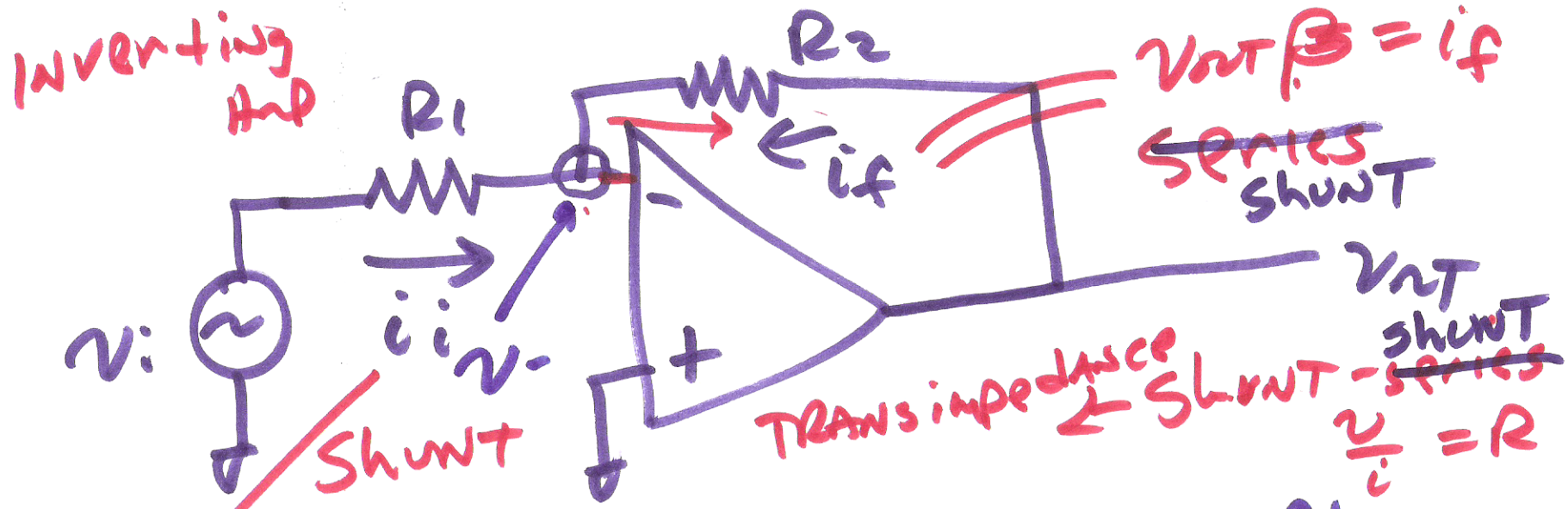
$$A_{CL} f_{3dB} = \frac{100\,MHz}{11}$$

$$f_{3dB}\Big|_{\text{closed loop}} = 9.091\,MHz$$

$$f_{CL}\Big|_{3dB} = \frac{f_{UN}}{A_{CL}}$$

Voltage Amp Series-Shunt

6)



$$\frac{v_i - v_-}{R_1} = -\frac{v_{NT} - v_-}{R_2}$$

$$\frac{v_i}{R_1} = i_i$$

$$\beta = 1/R_2$$

$$A_{CL} = \frac{v_{NT}}{i_i} = -\frac{1}{R_2}$$

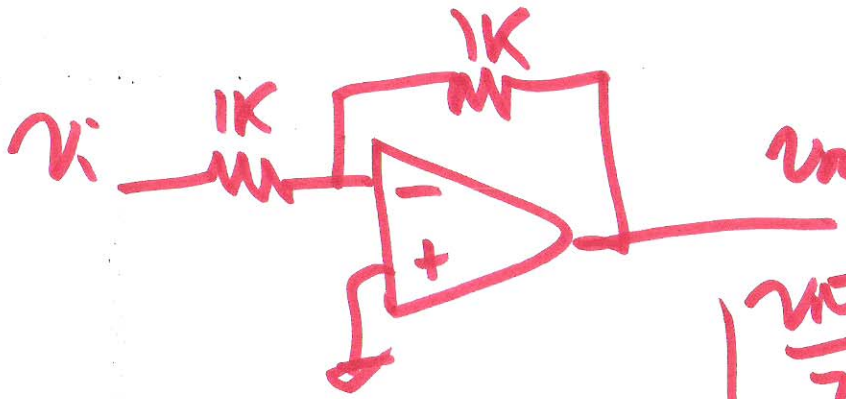
$$|A_{CL}| = \left|\frac{v_{NT}}{v_i}\right| = \frac{R_2}{R_1}$$

$$f_{3dB,CL} \cong \frac{R_1}{R_1+R_2} \cdot f_{UN}$$

$$GAIN \cdot BW = \frac{R_2}{R_1+R_2} \cdot f_{UN}$$

Voltage Amp $\left|\frac{v_{out}}{v_{in}}\right| = 1$

$f_{CL\,BW} = f_{UN}$



$\left|\frac{v_{out}}{v_i}\right| = 1$

$f_{CL\,BW} = \frac{f_{UN}}{2}$

8)