EE2019 Analog Systems & Lab

Note Title 2/12/2020

Input & Output Impedance

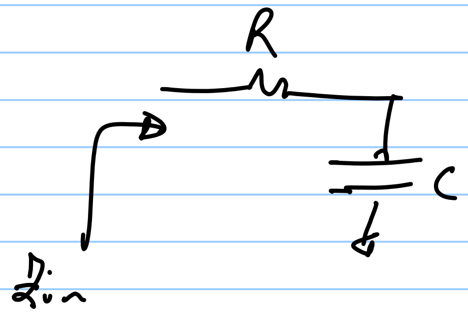
Impedence is ability to resist a signal & defined as

$Z = \frac{\Delta V}{\Delta I}$ → has both magnitude & phase

$Z = R$ for dc

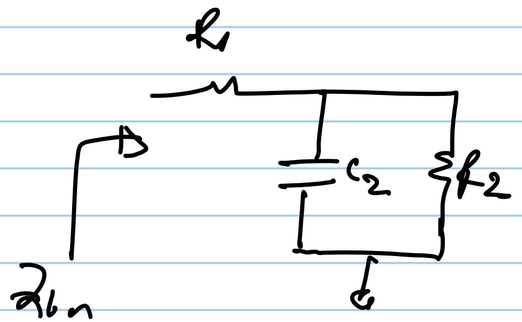
↑ resistance.

Z may be function of frequency



$$Z_{in} = R + \frac{1}{sC}$$

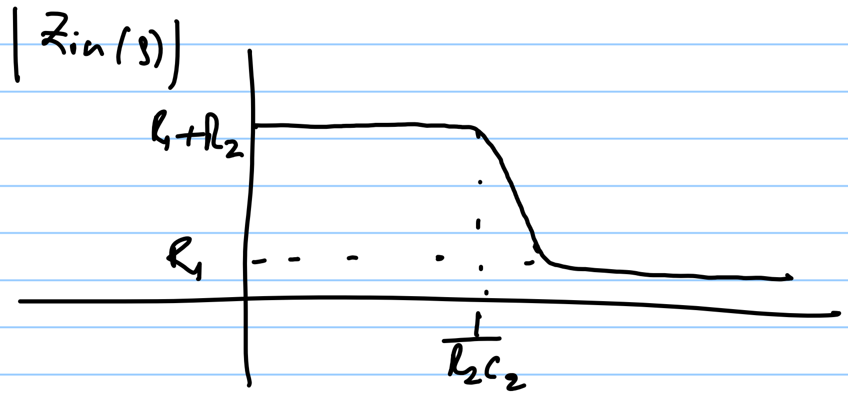
$$Z_{in}\Big|_{s=0} = \infty$$

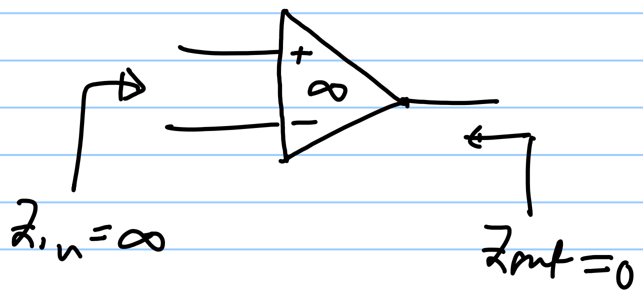


$$Z_{in}\Big|_{s=0} = R_1 + R_2$$

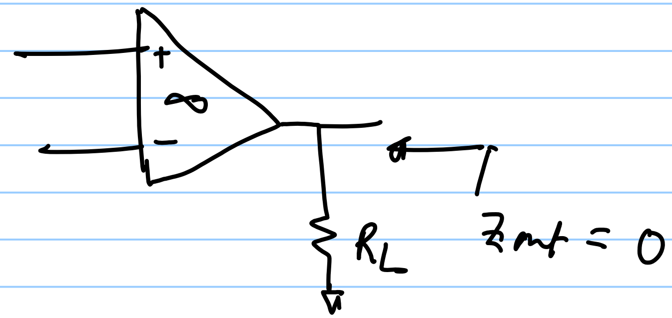
$$Z_{in}(s) = R_1 + \frac{1}{1/R_2 + sC_2}$$

$$Z_{in}(s)\Big|_{s\to\infty} = R_1$$

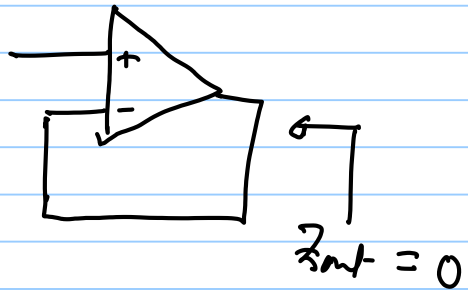




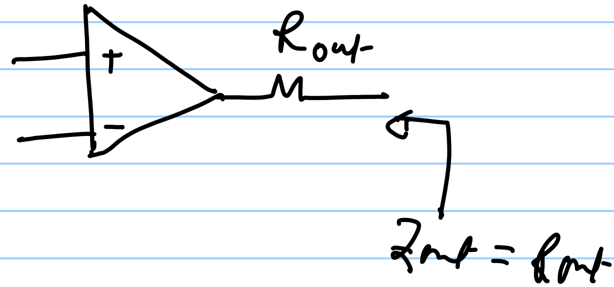
+
∞
−
$Z_{in} = \infty$
$Z_{out} = 0$



+
∞
−
R_L
$Z_{out} = 0$

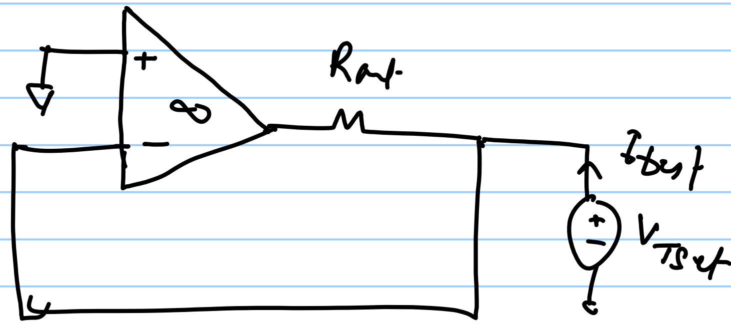


+
−
$Z_{out} = 0$

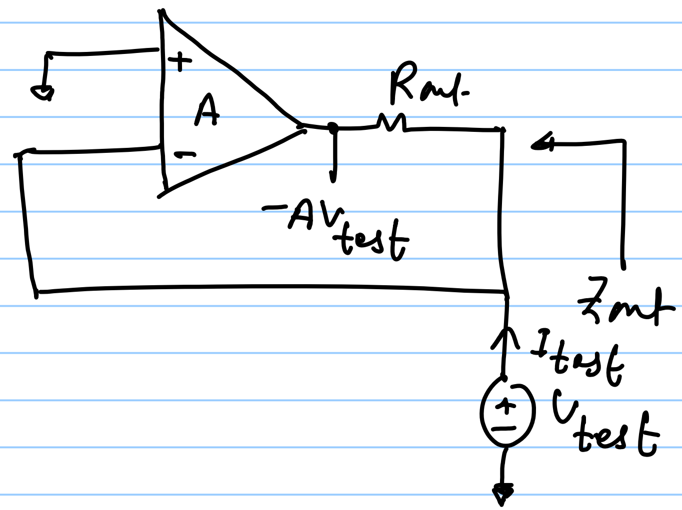


+
−
R_{out}
$Z_{out} = R_{out}$

$Z_{out} =$



$$Z_{out} = \frac{V_{Test}}{I_{Test}}$$



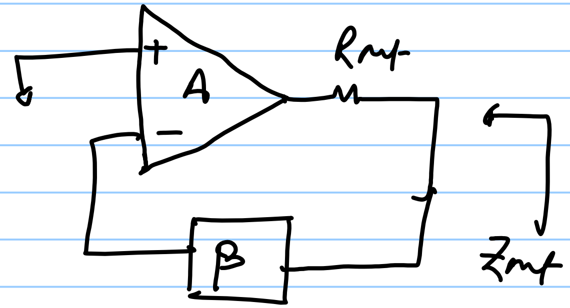
$$I_{test} = \frac{V_{test} - (-AV_{test})}{R_{out}} = \frac{V_{test}(1+A)}{R_{out}}$$

$$\frac{V_{test}}{I_{test}} = Z_{out} = \frac{R_{out}}{1+A} \approx \frac{R_{out}}{A} \quad \text{if } A >> 1$$

if $A \to \infty$

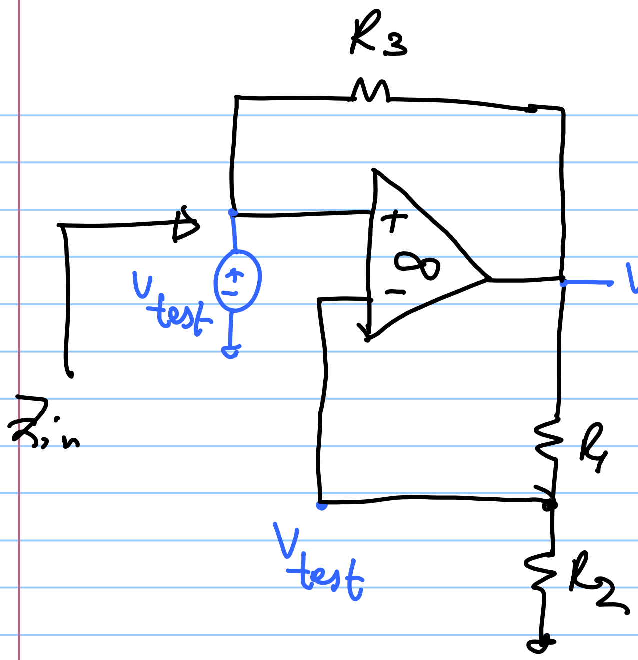
$Z_{out} \to 0$ as good as ideal voltage source.

Opamp with negative feedback reduce the output impedance by factor of loop gain



$$Z_{out} = \frac{R_{out}}{A\beta}$$

$A\beta \rightarrow$ loop gain



$V_o = \left(1 + \frac{R_1}{R_2}\right) v_{Test}$

$$I_{test} = \frac{v_{test} - \left(1 + \frac{R_1}{R_2}\right) v_{test}}{R_3}$$

$$= -\frac{R_1}{R_2 R_3} v_{test}$$

$$\frac{V_{test}}{I_{test}} = Z_{in} = -\frac{R_2 R_3}{R_1}$$

$R_3 \to Z_3$, $R_1 \to Z_1$, $R_2 \to Z_2$

$$Z_{in} = -\frac{Z_2 Z_3}{Z_1}$$

$Z_2 \to R_2$, $Z_3 \to R_3$

$Z_1 \to \frac{1}{sC_1}$

$Z_{in} = -R_2 R_3 (sC_1) = -R_2 R_3 C_1 s$ $\to$ negative Inductor

$L = -R_2 R_3 C_1$

$Z_2 \rightarrow \frac{1}{sC_2}$, $Z_3 \rightarrow \frac{1}{sC_3}$

$Z_1 = R_1$

$$Z_{in} = \frac{1}{-\frac{s^2 C_2 C_3}{R_1}} = -\frac{1}{R_1 C_2 C_3 s^2} = -\frac{1}{R_1 C_2 C_3 (j\omega)^2}$$

$$\boxed{Z_{in} = \frac{1}{R_1 C_2 C_3 \omega^2}}$$

$\rightarrow$ frequency dependent resistance.