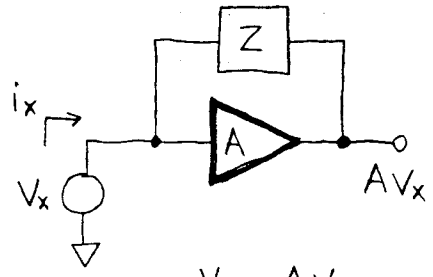
EE524 MILLER EFFECT

Consider any amplifier (not necessarily an op-amp) with gain A, and some impedance Z from input to output: what impedance does it "look like"?

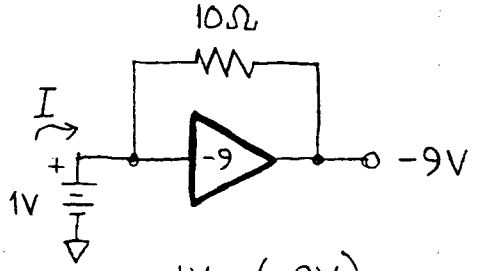


$$i_x = \frac{V_x - AV_x}{Z}$$

$$\boxed{\frac{V_x}{i_x} = \frac{Z}{(1-A)}}$$

Impedance is reduced by factor (1-A)

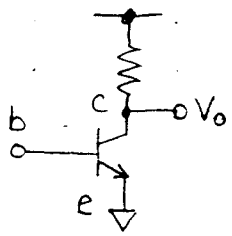
EXAMPLE: $Z = 10\Omega$ resistor
$A = -9$; $V_x = 1V$

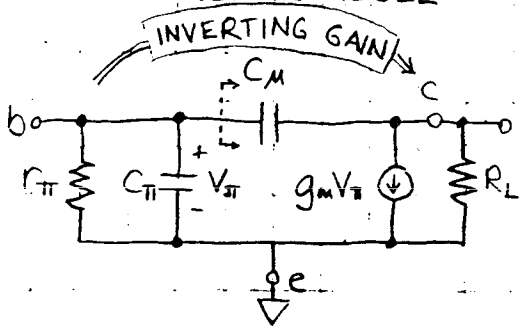


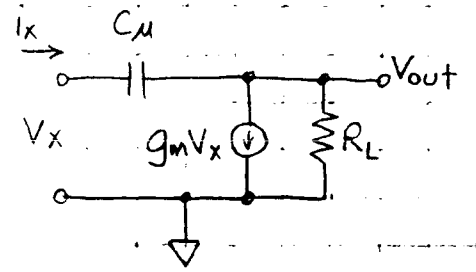
$$I = \frac{1V - (-9V)}{10\Omega} = 1A$$

Applying 1V causes 1A to flow: source "sees" a 1Ω resistor!
$1\Omega = 10\Omega / (1 - [-9])$

UNILATERAL MODEL (or DOMINANT POLE MODEL) of bipolar transistor with resistive load at high frequencies:
COMMON EMITTER ⇒ SMALL SIGNAL MODEL ⇒ APPARENT IMPEDANCE OF C_μ







Assuming current through C_μ is much less than $g_m V_x$, then

$$-V_{out} = -g_m R_L V_x$$

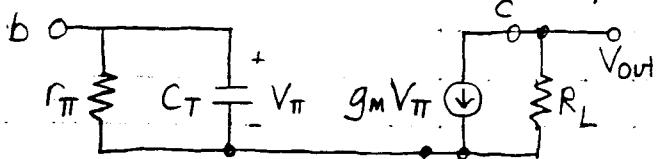
$$i_x = (V_x - [-g_m R_L V_x])\, s C_\mu$$

$$\boxed{\frac{V_x}{i_x} = \frac{1}{s(1+g_m R_L)C_\mu}}$$

INVERTING GAIN: $A = -g_m R_L$

C_μ IS "MILLER MULTIPLIED" BY $(1-A)$; APPEARS IN PARALLEL WITH C_π

Unilateral model (valid for input to output analysis only:



$$\boxed{C_T = C_\pi + (1+g_m R_L)C_\mu}$$