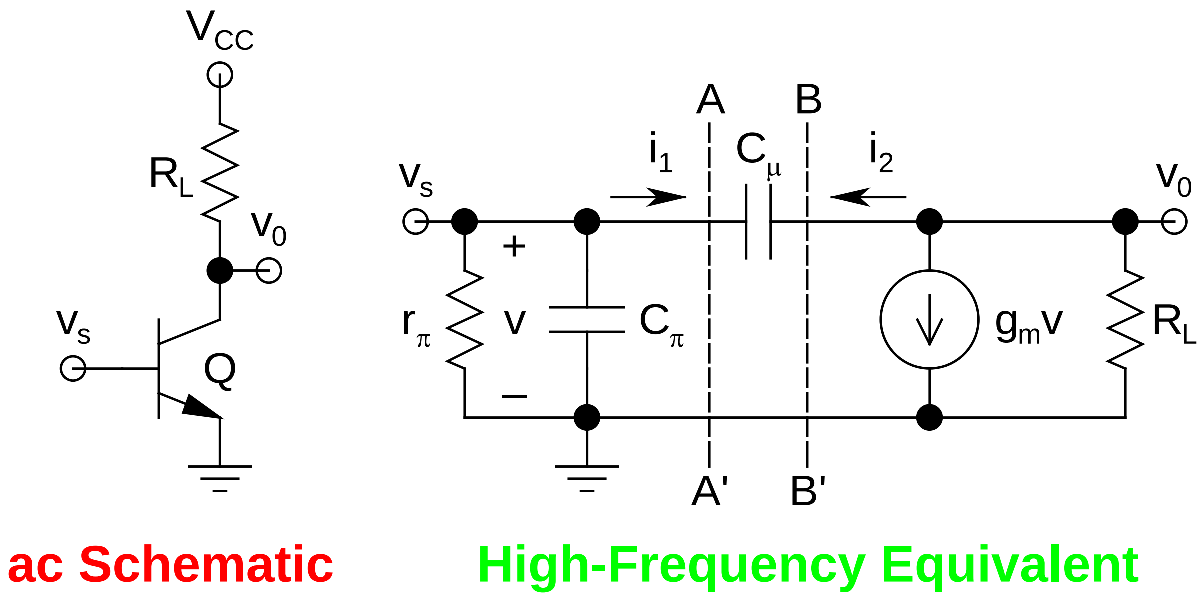


- ***Identify C_μ as the input-output coupling element***
- After ***application*** of the ***technique***, this ***coupling element*** will be ***removed*** by ***splitting*** it into ***two parts*** - ***one at input***, ***other at output***

- These ***two parts*** can be found by ***evaluating*** the ***impedances*** looking into the ***planes*** AA′ and BB′
- ***KCL at output node***:

  $g_m v + v_0/R_L + sC_\mu(v_0 - v) = 0$
- Noting that $v = v_s$, the ***voltage gain***:

  $A_v(s) = v_0/v_s = -\,g_m R_L(1 - sC_\mu/g_m)/(1 + sR_L C_\mu)$

  $\Rightarrow$ ***Midband or low-frequency gain***:

  $A_v(0) = -\,g_m R_L$

  This result can also be written from inspection

- ***Current entering plane AA′*:**

  $i_1 = sC_\mu(v - v_0) = sC_\mu[1 - A_v(s)]v$

- Hence, the ***admittance*** looking into the ***plane*** AA′:

  $y|_{AA'} = i_1/v = sC_\mu\left[1 - A_v(s)\right]$

- This ***admittance*** is ***capacitive*** in nature, and is known as the ***Miller Capacitance*** C_M:

  $C_M = C_\mu[1 - A_v(s)]$

- Now, since ***$A_v(s)$ is a function of frequency***, ***so would C_M*** $\Rightarrow$ ***Problem***!

- Here, we invoke the ***Miller Effect Approximation*** (MEA)
  - ***$A_v(s)$ is replaced by $A_v(0)$***, i.e., by its ***midband value***, which is a ***constant***
  - Thus, ***C_M becomes a constant*** with a value of

    $C_M = [1 – A_v(0)]C_\mu = (1 + g_m R_L)C_\mu$
- Thus, $C_M >> C_\mu$, since, in general, $g_m R_L >> 1$
- This effect is known as the ***Miller Effect Multiplication***
- ***Care***: ***The gain that multiplies C_μ is across its two ends***

- Similarly, ***current entering plane BB′***:

  $i_2 = sC_\mu(v_0 - v) = sC_\mu[1 - 1/A_v(s)]v_0$

- Hence, the ***admittance*** looking into the ***plane*** BB′:

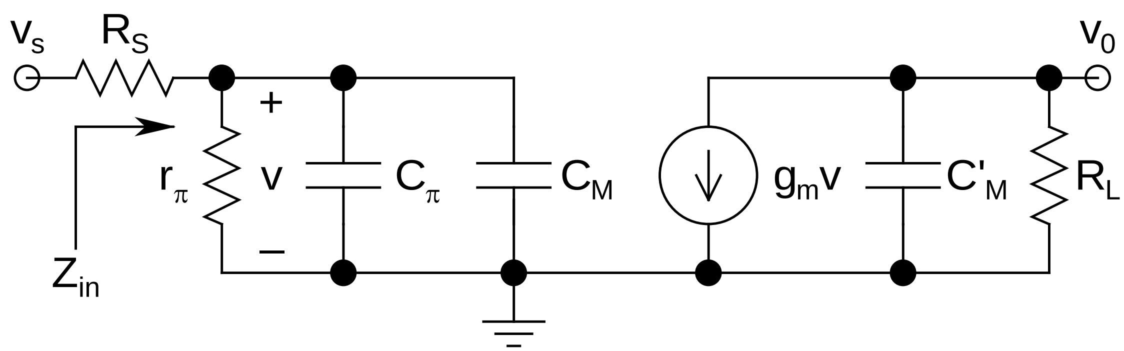
  $$y'\big|_{BB'} = i_2/v_0 = sC_\mu\left[1 - 1/A_v(s)\right]$$

- Again ***replacing*** $A_v(s)$ by $A_v(0)$, we get:

  $$C'_M = \left[1 - 1/A_v(0)\right]C_\mu = \left[1 + 1/(g_m R_L)\right]C_\mu$$

- In general, $g_m R_L >> 1 \Rightarrow C'_M \simeq C_\mu$

- C_μ can now be ***removed*** as the ***coupling element***, ***split into 2 parts*** C_M and C'_M, with C_M appearing in the ***input circuit*** and C'_M appearing in the ***output circuit***
- Now, ***include R_S*** - note that the circuit is ***completely decoupled*** now



Complete Circuit Including R_S

- $Z_{in} = r_\pi \| [1/(sC_T) = r_\pi/(1 + sr_\pi C_T)$

  $C_T = C_\pi + C_M$

$$\Rightarrow v = \frac{Z_{in}}{Z_{in} + R_S} v_s$$

$$= \frac{r_\pi}{(R_S + r_\pi)\left[1 + sr_\pi R_S C_T \big/ (R_S + r_\pi)\right]} v_s$$

$$v_0 = -g_m \left(R_L \,\|\, \frac{1}{sC'_M} \right) v = -\frac{g_m R_L}{1 + sR_L C'_M} v$$

- Thus:

$$A_v(s) = \frac{v_0}{v_s}$$

$$= -g_m R_L \frac{r_\pi}{R_S + r_\pi} \frac{1}{\left[1 + sR_S r_\pi C_T / \left(R_S + r_\pi\right)\right]\left(1 + sR_L C'_M\right)}$$

- ***Comparing*** this expression with

$$A_v(s) = \frac{A_{v0}}{\left(1 - s/p_1\right)\left(1 - s/p_2\right)}$$

we note that the ***denominator*** is already in a ***factorized form***

- A_{v0} = ***midband gain*** = $-\, g_m R_L r_\pi/(R_S + r_\pi)$
- The ***transfer function*** shows that the system has ***two negative real poles*** and ***no zero***

  $\Rightarrow$ ***Information regarding the zero is suppressed by this technique***

- Also, the ***two poles*** obtained by ***this technique*** are ***not identical*** to those obtained from the ***exact analysis***