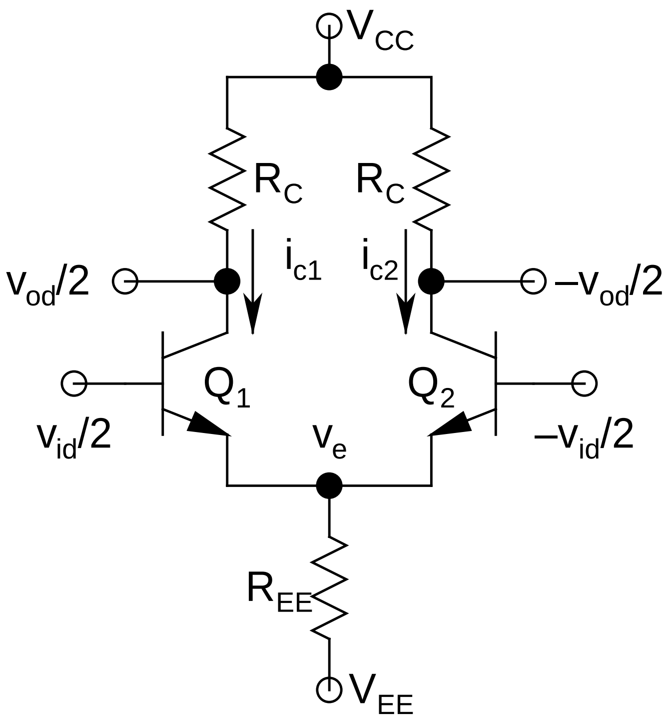
- ***The most important property of a DA is to be able to reject common-mode signals (noise), while amplifying the difference between the two signals applied at its two inputs***
- Characterized by a parameter known as the ***Common-Model Rejection Ratio*** (***CMRR***) (***expressed in dB***):

$$\text{CMRR} = 20\log_{10}(|A_{dm}/A_{cm}|)$$

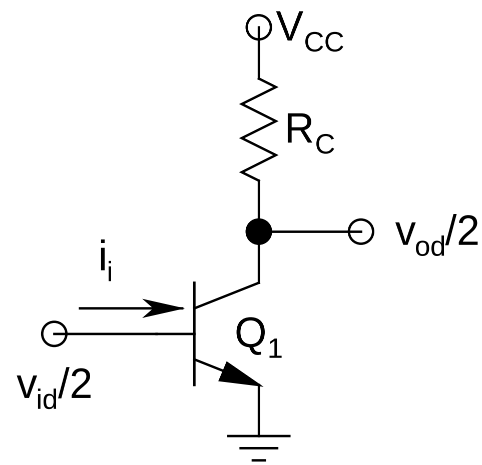
- ***Ideal (Desirable) Properties***:
  - $|A_{dm}| \rightarrow \infty$ ($\sim 10^3$-10^5)
  - $|A_{cm}| \rightarrow 0$ (< 1)
  - CMRR $\rightarrow \infty$ ($\sim$ 40-120 dB)

- ***The circuit has two inputs and two outputs***:
  - $\Rightarrow$ ***Four possible configurations***:
    - ***Single-ended i/p***, ***single-ended o/p***
    - ***Single-ended i/p***, ***double-ended o/p***
    - ***Double-ended i/p***, ***single-ended o/p***
    - ***Double-ended i/p***, ***double-ended o/p***
  - $\Rightarrow$ ***Tremendous flexibility***
    - ***Double-ended o/p eliminates the common-mode signal completely***
    - ***However, at some point in the circuit, needs to be converted to a single-ended o/p***
      - $\Rightarrow$ ***High CMRR is an absolute must***!

- ***Differential-Mode Half Circuit*: *Calculation of A_{dm}*:**



npn DA Under Pure Differential-Mode Input



Differential-Mode Half-Circuit

- ***Can be shown that $v_e = 0$ in three ways***:
  - ***From the symmetry of the circuit***:

    Equal and opposite voltages applied at the bases of Q_1 and Q_2

    $\Rightarrow$ ***The emitter potential v_e got to be an average of the inputs, which is zero***
  - $i_{c1} = g_{m1}(v_{id}/2 - v_e)$ and $i_{c2} = g_{m2}(-v_{id}/2 - v_e)$

    Since $g_{m1} = g_{m2}$, i_{c1} must equal $-i_{c2}$ (***circulating current***) (***this is again from symmetry***)

    $\Rightarrow v_e = 0$
  - ***Drawing the complete ac low-frequency hybrid-π model, and summing currents at the common-emitter node***:

    Show that $v_e = 0$
- ***Caution***: ***$v_e = 0$ will hold true only for a balanced DA***

- ***Thus, the left and right parts of the circuit become absolutely symmetrical***

  $\Rightarrow$ ***Either of the parts can be used***

  $\Rightarrow$ ***Leads to the differential-mode half-circuit***

- $g_{m1} = g_{m2} = g_m = I_{EE}/(2V_T)$, $r_{E1} = r_{E2} = r_E = 2V_T/I_{EE}$, and $r_{\pi 1} = r_{\pi 2} = r_\pi = \beta r_E$
- ***Can be easily identified to be a CE stage***

  $\Rightarrow A_{dm} = v_{od}/v_{id} = (v_{od}/2)/(v_{id}/2) = -R_C/r_E$

- ***Differential-mode input resistance***:

  $R_{id} = v_{id}/i_i = 2(v_{id}/2)/i_i = 2r_\pi$

- ***The simplicity of the analysis is simply mind-boggling***!