Common-Base Configuration

- The input is applied to the emitter.
- The output is taken from the collector.
- Low input impedance.
- High output impedance.
- Very high voltage gain.
- No phase shift between input and output.
Calculations

Input impedance:
\[ Z_i = R_E \parallel r_e \]

Output impedance:
\[ Z_o = R_C \]

Voltage gain:
\[ V_o = -I_o R_C = -(-I_C)R_C = \alpha I_e R_C \]
\[ I_e = \frac{V_i}{r_e} \rightarrow V_o = \alpha \left( \frac{V_i}{r_e} \right) R_C \]
\[ A_v = \frac{V_o}{V_i \frac{R_C}{r_e}} = \frac{\alpha R_C}{r_e} \approx \frac{R_C}{r_e} \]

\( A_v \) positive… \( V_i \) and \( V_o \) in phase.

Current gain:

Assuming \( R_E >> r_e \)
\[ I_e = I_i \]
\[ I_o = -\alpha I_e = -\alpha I_i \]
\[ A_i = \frac{I_o}{I_i} = -\alpha \approx -1 \]
Example 5.8

Determine $r_e$, $Z_i$, $Z_o$, $A_v$, $A_i$
Common-Emitter Collector Feedback Configuration

- This is a variation of the common-emitter fixed-bias configuration
- Input is applied to the base
- Output is taken from the collector
- There is a 180° phase shift between input and output
Calculations

Output impedance:

\[ Z_o \approx R_C \parallel R_F \]

Voltage gain:

\[ I_o = \beta I_b + I' \]

For \( \beta I_b \gg I' \rightarrow I_o \approx \beta I_b \)

\[ V_o = -I_o R_C = -\left(\beta I_b\right) R_C \]

\[ I_b = \frac{V_i}{\beta r_e} \rightarrow V_o = -\beta \frac{V_i}{\beta r_e} R_C \]

\[ A_v = \frac{V_o}{V_i} = -\frac{R_C}{r_e} \]

Defining \( Z_o \)
Input impedance:

\[ Z_i = \frac{V_i}{I_i} , \quad V_o = -\frac{V_i}{r_e} R_C \]

\[ I' = \frac{V_o - V_i}{R_F} = \frac{V_o}{R_F} - \frac{V_i}{R_F} = -\frac{R_C V_i}{r_e R_F} - \frac{V_i}{R_F} = -\frac{1}{R_F} \left[ 1 + \frac{R_C}{r_e} \right] V_i \]

\[ V_i = I_b \beta r_e = (I_i + I')\beta r_e = I_i \beta r_e + I' \beta r_e \]

\[ V_i = I_i \beta r_e - \frac{1}{R_F} \left[ 1 + \frac{R_C}{r_e} \right] \beta r_e V_i \]

\[ \text{or} \quad V_i \left[ 1 + \frac{\beta r_e}{R_F} \left[ 1 + \frac{R_C}{r_e} \right] \right] = I_i \beta r_e \]

\[ Z_i = \frac{V_i}{I_i} = \frac{\beta r_e}{1 + \frac{\beta r_e}{R_F} \left[ 1 + \frac{R_C}{r_e} \right]} \]

\[ 1 + \frac{R_C}{r_e} \approx \frac{R_C}{r_e} \rightarrow Z_i = \frac{\beta r_e}{1 + \frac{\beta R_C}{R_F}} \]

\[ Z_i = \frac{r_e}{1 + \frac{R_C}{\beta R_F}} \]
Determining the current gain using the voltage gain

Current Gain \( A_i = \frac{I_o}{I_i} \), \( I_i = \frac{V_i}{Z_i} \), \( I_o = -\frac{V_o}{R_L} \)

\[
A_{i_L} = \frac{I_o}{I_i} = \frac{\frac{-V_o}{R_L}}{\frac{V_i}{Z_i}} = -\frac{V_o}{V_i} \cdot \frac{Z_i}{R_L}
\]

\[
A_{i_L} = -A_{v_L} \frac{Z_i}{R_L}
\]
Determining the current gain using the voltage gain

From example 5.2

\[ Z_i = 1.35 \, k\Omega. \]

\[ A_V = -368.76 \]

Current Gain

\[ A_i = \frac{I_o}{I_i}, \]

\[ I_i = \frac{V_i}{1.35k}, \quad I_o = -\frac{V_o}{6.8k} \]

\[ A_{iL} = \frac{I_o}{I_i} = \frac{-V_o}{6.8k} \cdot \frac{V_i}{1.35k} = -\frac{V_o}{V_i} \cdot \frac{1.35k}{6.8k} \]

\[ = -(368.76)\frac{1.35k}{6.8k} = 73.2 \]

or

\[ A_{iL} = -A_{vL} \frac{Z_i}{R_L} = -(368.76)\frac{1.35k}{6.8k} = 73.2 \]
Effect of $R_L$ and $R_S$

\[ A_{vNL} = \frac{V_o}{V_i}, \quad A_{vL} = \frac{V_o}{V_i} , \text{ with } R_L \]

\[ A_{vS} = \frac{V_o}{V_s}, \text{ with } R_L \text{ and } R_S \]
Effect of $R_L$ and $R_S$

\[ V_o = -\beta I_b (R_C \parallel r_o \parallel R_L) = -\beta I_b (R_C \parallel R_L), \quad I_b = \frac{V_i}{\beta r_e}, \]

\[ V_o = -\beta \left( \frac{V_i}{\beta r_e} \right) (R_C \parallel R_L) \quad \Rightarrow \quad A_{vL} = \frac{V_o}{V_i} = -\frac{(R_C \parallel R_L)}{r_e} \]
Effect of $R_L$ and $R_S$

Input impedance: $Z_i = R_B \parallel \beta r_e$

Output Impedance: $Z_o = R_C \parallel r_o$

To find overall gain: $V_i = \frac{Z_i V_s}{Z_i + R_s}$, $\frac{V_i}{V_S} = \frac{Z_i}{Z_i + R_s}$

$A_{vS} = \frac{V_o}{V_S} = \frac{V_o}{V_i} \cdot \frac{V_i}{V_S} = A_{vL} \frac{Z_i}{Z_i + R_s}$ \Rightarrow $A_{vS} = \frac{Z_i}{Z_i + R_s} A_{vL}$
• The Darlington circuit provides a very high current gain—the product of the individual current gains: $\beta_D = \beta_1 \beta_2$

• A Darlington transistor connection provides a transistor having a very large current gain, typically a few thousand.

• Darlington pairs are available as complete packages.

• A Darlington pair is sufficiently sensitive to respond to the small current.
DC Bias of Darlington Circuits

Base current:

\[ I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta_D R_E} \]

Emitter current:

\[ I_E = (\beta_D + 1)I_B \approx \beta_D I_B \]

Emitter voltage:

\[ V_E = I_E R_E \]

Base voltage:

\[ V_B = V_E + V_{BE} \]
When light falls on the LDR, its resistance reduces.
The bias voltage is supplied to the transistor and this voltage is enough to make the transistor and relay work.
A variable resistor is also connected on the base of transistor to adjust the sensitivity.