CURRENT MIRRORS

**Goal:**

a) Design a simple current mirror capable of driving up to 10mA and find the Systematic gain error.

b) Design a 1:2 mirror of 20 mA of load handling capability.

c) Design a cascaded current mirror and find the $R_0$ and $g_m$ of the transistor used, when it enters active region. (i.e. the point where $V_{DS} = V_{GS} - V_t$).

**SIMPLE CURRENT MIRROR**

![Simple Current Mirror Diagram]
**Procedure:**

1) Connect the circuit elements as in figure.

2) Fix $I_{\text{driver}}$ by varying the $R_1$ resistance. Say, we fix it at 7 mA. (To find out the current, measure the current across any resistor and divide it by that resistance value - ohms law).

3) Now vary the resistance $R_2$ (which is a potentiometer) from min to max, say in 10 steps.

4) For each and every step varied, note down the readings of $I_{\text{load}}$ and $V_{DS}$ of $T_2$.

5) Note if the current in both the arms are the same (To find out the current, measure the current across any resistor and divide it by that resistance value - ohms law).

6) What is the maximum value of load resistance ($R_2$) that can be used in this circuit? (Here also make use of ohms law. You know that the maximum current that can be handled on the load arm is 10 mA. You also know that the maximum available voltage is 10 volts. So, you should be able to find out the maximum resistance assuming that $T_2$ becomes perfect short and there is no voltage drop across $T_2$)

7) Draw the graph of

![Graph of $I_{\text{load}}$ vs $V_{DS}$ of $T_2$](image)
8) Extrapolate the graph from the beginning of the saturation region and get the Early Voltage $V_A$. [Your answer should be in some 100s of volts]

9) From this calculate the Systematic gain error, when the transistor $T_2$ enters the linear region.

10) Find the $r_0$ of this Current mirror (from the slope), when the transistor $T_2$ leaves the linear region (i.e. the point where $V_{DS} = V_{GS} - V_t$).
1:2 CURRENT MIRROR

Set Up:

Procedure:

1) Fix the current through $R_1$. Say, 7 mA.

2) Now find the current through $R_2$. Is $I_{load}$ twice the value of $I_{driver}$?
   [If not, adjust R2]
Set Up:

Procedure:

1) Connect the circuit elements as in figure.
2) Fix I\textsubscript{driver} by varying the R\textsubscript{1} resistance. Say, we fix it at 7 mA.

3) Now vary the resistance R\textsubscript{2} (which is a potentiometer) from min to max, say in 10 steps.

4) For each and every step varied, note down the readings of I\textsubscript{load} and V\textsubscript{DS} of T\textsubscript{2} and T\textsubscript{4} combination (i.e. measure the voltage difference between the drain of T\textsubscript{2} and source of T\textsubscript{4}).

5) Note if the current in both the arms are the same (To find out the current, measure the current across any resistor and divide it by that resistance value - ohms law).

6) What is the maximum value of load resistance (R\textsubscript{2}) that can be used in this circuit? (Here also make use of ohms law. You know that the maximum current that can be handled on the load arm is 10 mA. You also know that the maximum available voltage is 10 volts. So, you should be able to find out the maximum resistance assuming that both T\textsubscript{2} and T\textsubscript{4} becomes perfect short and there are no voltage drops across both T\textsubscript{2} and T\textsubscript{4}).

7) Draw the graph of

\[ I_{\text{load}} \]

\[ V_{\text{DS}} \text{ across the T}_2 \text{ and T}_4 \text{ combination} \]

8) Extrapolate the graph from the beginning of the saturation region and get the Early Voltage V\textsubscript{A} for this setup.
9) From this calculate the Systematic gain error, when the T₂ and T₄ combination leaves the linear region.

10) Find the R₀ of this Current mirror (from the slope), when the T₂ and T₄ combination leaves the linear region. (i.e. the point where V_DS = V_GS – 2V_t).
    **Note:** We use 2V_t because there are two transistors in series!

11) Find the g_m of either T₄ or T₂. [Use the formula R₀ = r_o + r_o (1+g_mro)]
    [Your g_m must be closer to the value of g_m you obtained in your first experiment.]

12) What is the voltage across R₁ when the transistor combination T₂ and T₄ is in the midpoint of the triode region? [Calculate from the graph drawn] You need to think a bit, how to figure it out!

**RESULTS:**

a) The Systematic Gain Error of the Simple Current mirror is______.

b) The r_o of the given transistor is______.

c) The g_m of the given transistor is______.