Experiment 3 Report

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Abstract

abstract here

Task 1

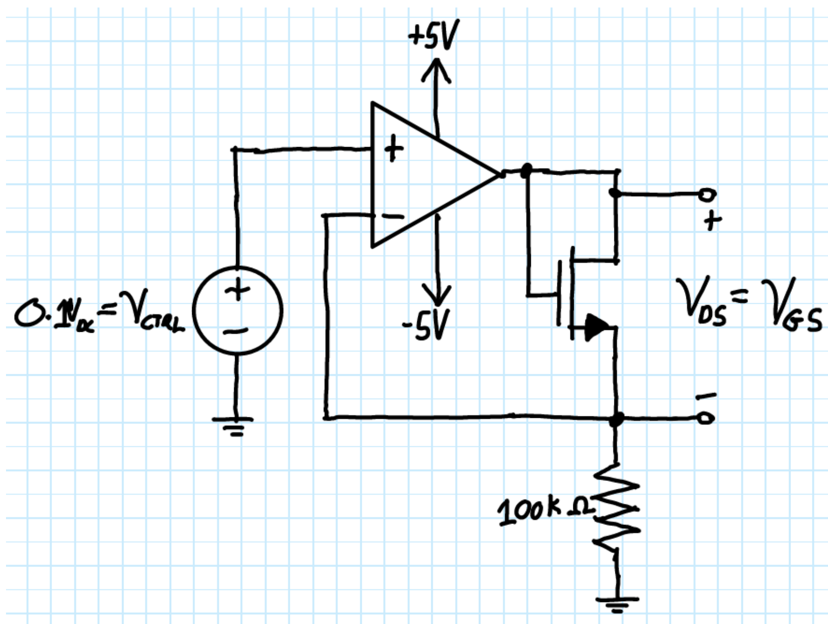
Objective

The objective of this task is to measure V_t by using an operational amplifier to self-adjust the gate-source voltage such that it is exactly V_t.

Procedure

This circuit is built around the ALD1106 quad PMOS transistor chip. This chip is very prone to being damaged through electrostatic discharge. Because of this, when working with this chip, a grounded antistatic wristband was worn.

Step 3-4
The circuit below was built



using a control voltage of 0.1V as to set a constant current through the transistor of 1μA.

Step 5
The voltage across the 100kΩ resistor was measured to ensure the value of the drain current was what was expected.

Step 6-7
The voltage v_{GS} was measured to be the threshold voltage of the transistor, then the circuit was built around the other 3 transistors present in the ALD1106 chip, and the threshold voltages were measured and recorded.

Step 8-9
These threshold voltages were then compared against the threshold voltages listed on the ALD1106 datasheet.

Results / Calculations

Step 5 When measuring the voltage across R_s, the 100kΩ resistor, the value measured was 99.3 mV.

Using:

$$V = IR \tag{1}$$

$$v_{Rs} = i_D * R_s \tag{2}$$

we can find the current i_D by rearranging and filling in known values:

$$i_D = \frac{v_{Rs}}{R_s} = \frac{99.3mV}{100k\Omega} = 0.993\mu A \tag{3}$$

which is very close to the desired current value $i_D = 1\mu A$.

Step 6-8

The threshold voltages V_t were measured for each transistor in the ALD1106 chip. The position description relies on the chip being placed with the divet on the top. Each of the transistors correspond to a corner of the chip when placed in this configuration, which is how they are described in the table below.

Transistor Position	V_t (v_{GS})
Top Left	0.607V
Bottom Left	0.611V
Top Right	0.600V
Bottom Right	0.608V

The transistors have very similar threshold voltages, differing by a maximum of 0.011V, or 1.8% of the average value.

Step 9

The datasheet for the ALD1106 chip states that the threshold voltage shall not be greater than 1V, not lower than 0.4V, and is typically 0.7V.[1]

These transistors' threshold voltages hover around 0.6V, which is slightly lower than typical, but definitely within a reasonable margin of the specifications.

Conclusions

In **Task 1**, an ALD1106 chip was tested to determine each of its component transistors' threshold voltages. The circuit was designed to have a very low drain current, which was effective in our physical circuit, measuring very close to the design specification. Each threshold voltage for the transistors were very similar to each other, and were within tolerance for the chip's design.

Task 2

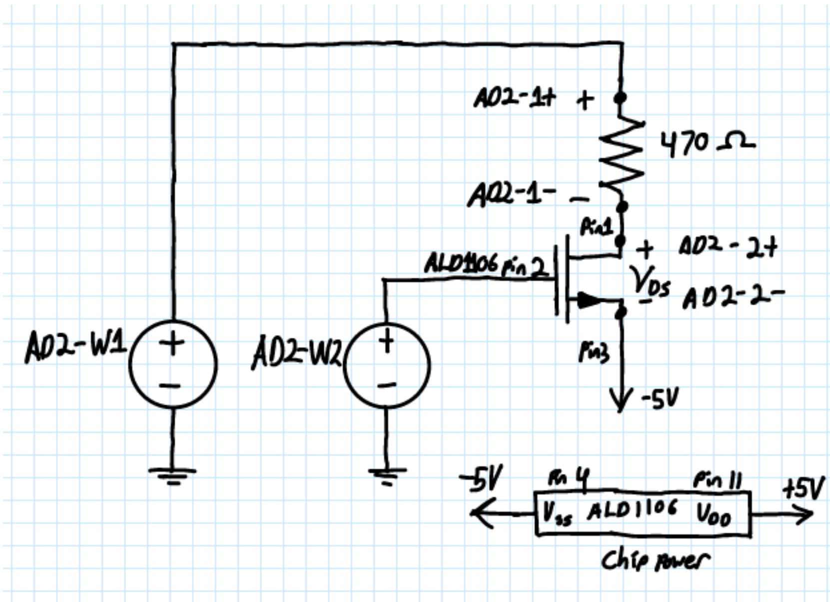
Objective

The objective of this task is to create multiple i_d - v_{DS} curves at various v_{GS} values, to calculate the transconductance parameter k_n for a transistor in the ALD1106 chip.

Procedure

Step 1-3

The circuit below was built and connected to the Analog Discovery 2 using the ports described:



Step 4-10

The Analog Discovery 2 has a tracer function to compute I-V characteristic curves for various components.

The Tracer tool was opened in WaveForms. The following parameters were set:

- The device was set to “N-FET”.
- “No Adapter” was selected in the adapter menu.
- In the “Options” dropdown, “Emitter” was set to -5V.
- The “Measure” parameter was set to “Id/Vds”.
- The Curve Tracer was configured to measure v_{GS} from 0V to 5V in 500mV steps.
- The Curve Tracer was configured to sweep v_{RD} from 0V to 10V.
- “R_d” was set to 470Ω.

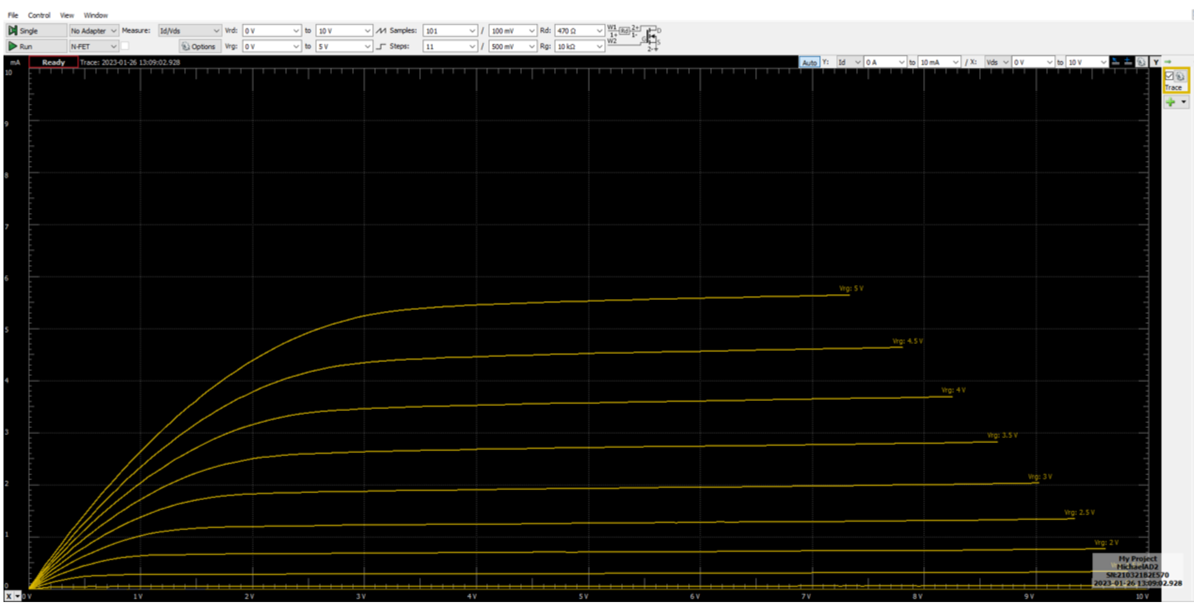
The tracer was then run to produce a graphical representation of the I-V characteristic of this transistor.

Step 11
The graph produced from **Step 10** was used to calculate the transconductance parameter, k_n.

Results / Calculations

Step 1-9 The circuit was implemented on a breadboard and measured through WaveForms.

Step 10
The following is the graph generated from WaveForms' tracer tool with the parameters defined in **Procedure**.



Step 11
Using the graph above, the transconductance parameter k_n can be calculated using:

$$i_{D(sat)} = \frac{k_n}{2} * (v_{GS} - V_t)^2 \tag{4}$$

where a point on any curve is taken in the saturation region.

Using the point on the curve where v_{GS} = 5V, i_D = 5.5 mA, and v_{DS} = v_{GS} - V_t = 4.293V, the value for k_n can be calculated. Note that v_{DS} does not actually matter for the calculation, however it is important in knowing that this point lies in the saturation region of operation. The threshold voltage V_t is used from **Task 1: step 6**.

With these values known, the equation becomes:

$$k_n = \frac{2i_D}{(v_{GS} - V_t)^2} = \frac{2 * 0.0055A}{(5V - 0.607V)^2} = 0.57\frac{mA}{V^2} \tag{5}$$

This is repeated for each v_{GS} curve, using the current i_D at the v_{DS} value equal to $v_{GS} - v_t$. The results follow:

v_{GS} (V)	i_D (mA)	k_n ($\frac{mA}{V^2}$)
0V	0 mA	DNE
0.5V	0 mA	DNE
1V	0.1 mA	1.2
1.5V	0.3 mA	0.75
2V	0.7 mA	0.721
2.5V	1.3 mA	0.7255
3V	1.9 mA	0.663
3.5V	2.7 mA	0.645
4V	3.5 mA	0.608
4.5V	4.5 mA	0.593
5V	5.5 mA	0.569

Conclusions

References

[1] *ALD1106 Quad N-Channel Matched Pair MOSFET Array Datasheet*. Rev. 2.1. Advanced Linear Devices, Inc. Nov. 2012.