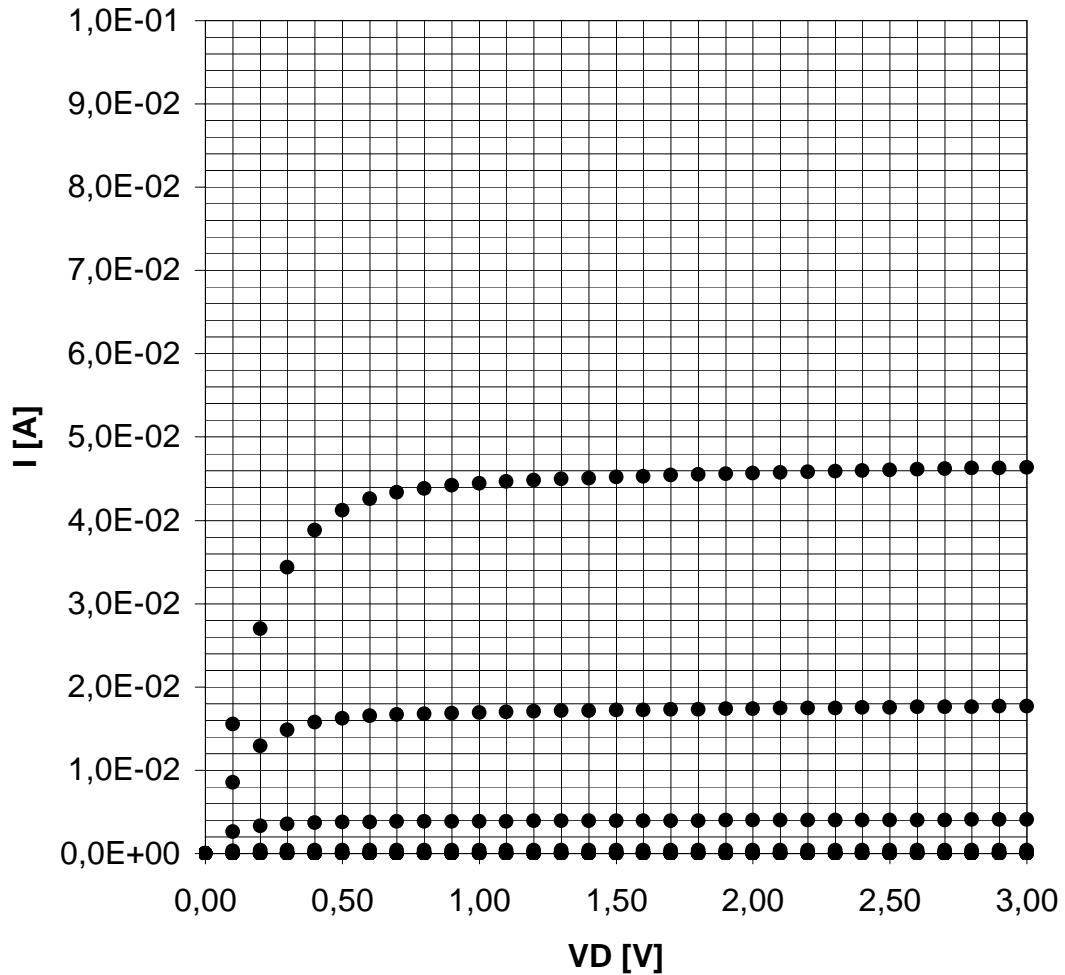


Name..... Code(4 characters)

Code(4 characters)

Physical electronics diagnostic exercise

MOSFET I-V Characteristics



The figure above displays the drain current, I , as a function of drain voltage, V_D , (source grounded) for an nMOSFET with gate voltages from 0 V up to 3 V in increments of 0.25 V. Use this data to model the device accurately enough to be able to predict within $\pm 20\%$ the value of the drain voltage when the drain is connected to +3 V with resistors in the range 3-30 Ω and for applying gate voltages between 0 V and 3 V.

Correction Name.....

Solution approaches

Failure

NOT being able to apply concepts/models/methods from the course on a problem in a sensible manner

Examples

- A suggested model that will result in VD-values outside the range 0 V- 3 V is not sensible. Not giving appropriate units is an example of this!
- Failure to take even a first step in handling the problem. Merely quoting a relevant equation is not a first step (no application made).
- Using a concept that cannot lead towards the solution of the problem; for example trying to apply a formula concerning breakdown in diodes to treat the problem.
- Describing/interpreting the problem in a way which is inconsistent with the text of the assignment.

Grade 3

being able to apply concepts/models/methods from the course on a problem in a sensible manner

Examples

- Quoting a formula/equation for current as a function of voltages for an appropriate transistor and starting to use it in the problem situation.
- Setting up an equivalent circuit for the situation and starting to draw conclusions from this.
- Using the data in the figure to determine parameters of an applied model (relevant for solving the problem).

Grade 4

connect more than one part of the course to the constructive treatment of a problem employing technically reasonable assumptions.

Example

Using both an equivalent circuit and an (analytical) equation for current as a function of voltage(s) for the transistor and stating non-obvious assumptions; e.g. that the model used is only applicable to dc (steady state) conditions

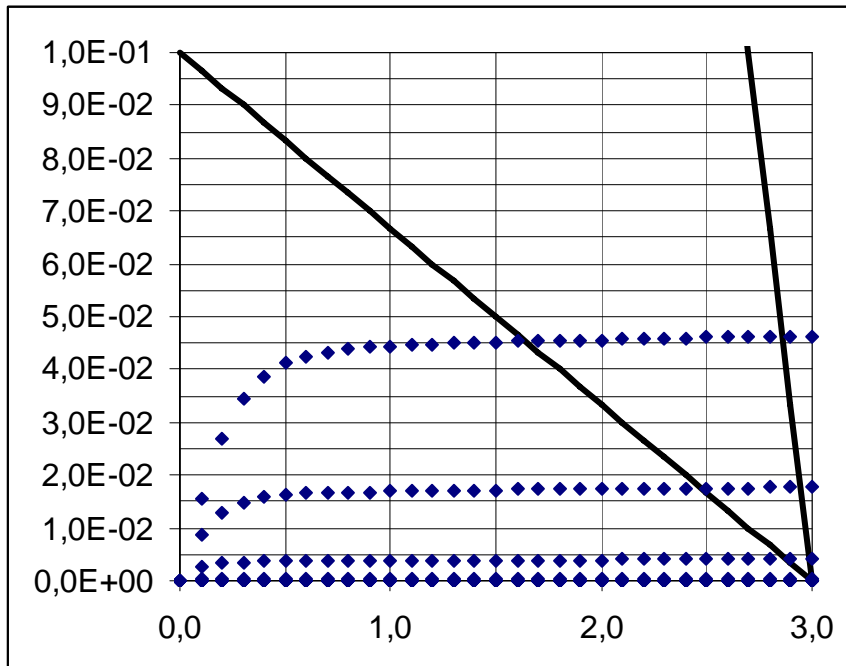
Grade 5

be able to evaluate alternative approaches to solving a problem, being able to discriminate what is more important in a particular context.

Example

Motivating the use of a model which is (as) simple (as possible), yet delivers what is asked for.

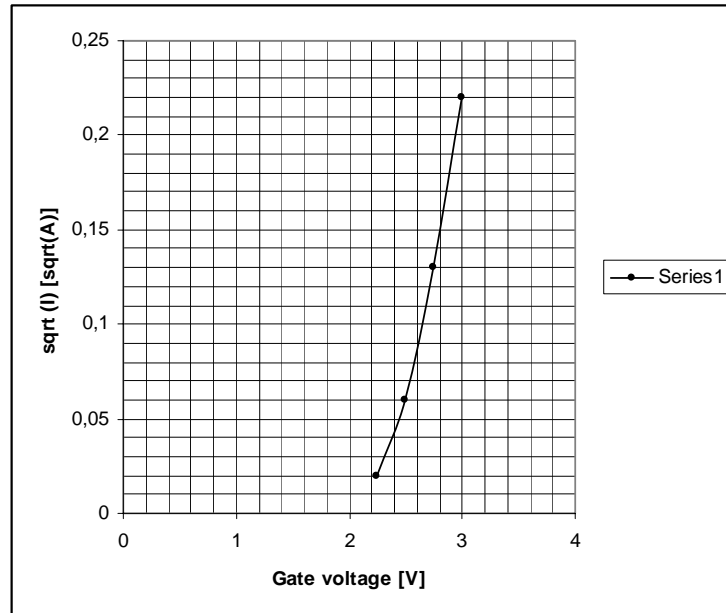
Suggestion for solution to the problem



The load lines for resistors in the range 3-30 Ω lie between the straight lines. We need to model I_D as a function of V_D and V_G in this range. We see that I_D is nearly independent with regards to V_D in this range, so we go for a simple expression of I_D determined by V_G only. According to any textbook we would expect a quadratic dependence of the current on the gate voltage in the saturation region on the form:

$$I_D = \frac{k}{2}(V_G - V_T)^2$$

If we plot the square-root of the current as a function of gate voltage, we should (hopefully) see a straight line with an extension intercepting the voltage axis at $V_G = V_T$. Plotting below gives a V_T of approximately 2,5 V and a k of $0,4 \text{ A/V}^2$.



Using this model for $V_G = 3 \text{ V}$ and an R of 30Ω we get a V_D of $1,5 \text{ V}$ where we can see in the graph with load-lines that the experimental result gives approximately $1,7 \text{ volts}$ which makes a result within 20%, and for $V_G = 2,75 \text{ V}$ and $R = 30 \Omega$ we end up with a V_D of $2,6 \text{ V}$ where the graph gives $2,5 \text{ V}$, so it looks quite OK in the range we are considering.