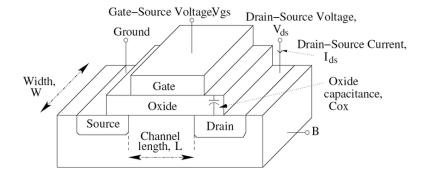
# MOSFETs: Parameters, Operating Regions, and Choosing The Right One

### Introduction

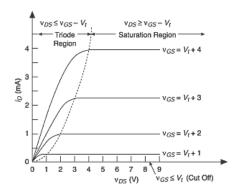
MOSFETs (metal-oxide-semiconductor field-effect transistors) are a type of field-effect transistors (FETs), that utilizes the controlled oxidation of silicon to switch or amplify electronic signals. MOSFETs are by far the most used transistors in electronic systems, as they are included in billions in memory chips and microprocessors. The next parts of this report will discuss the parameters, and operating regions of MOSFETs, and how to select the right MOSFET for different applications.

#### **Parameters**



- Threshold Voltage ( $v_i$ ): This is the minimum required gate-source voltage ( $v_{gs}$ ) to enable the MOSFET.
- Gate-Source Voltage ( $v_{gs}$ ): The gate-source voltage is used to describe the voltage difference between the gate, and the source terminals.
- **Drain-Source Voltage** ( $v_{ds}$ ): The drain-source voltage is used to describe the voltage difference between the gate, and the drain terminals. It is also used to define the operating region of the MOSFET.
- **Drain-Source Current** ( $i_{ds}$ ): This is the current flowing from the drain terminal to the source terminal. Its value is dependent on the gate-source voltage, and the drain-source voltage.
- On-Resistance ( $r_{ds}$ ): It is the resistance between the drain, and the source terminals when the MOSFET is fully on. It can also be used as an indicator for the power efficiency of the MOSFET.

## **Operating Regions**



- **Cutoff Region:** A MOSFET is said to be in the cutoff region when it acts as an open switch. This happens when the gate-source voltage is less than the threshold voltage  $v_{gs} < v_t$ , which results in no current flow between the drain and source terminals.
- **Triode Region:** In this region the MOSFET is on and operates like a variable resistor. This happens when the drain-source voltage is less than or equal to the difference between the gate-source voltage and the threshold voltage i.e.  $v_{ds} \le v_{gs} v_t$
- Saturation Region: This region is used to operate the MOSFET as an amplifier. This happens when the drain-source voltage is greater than or equal to the difference between the gatesource voltage and the threshold voltage  $v_{ds} \geq v_{gs} v_t$ . In this region the drain-source current is no longer dependent on the drain-source voltage, that's why amplifiers make use of this region.

## **Guidelines For Selecting The Right MOSFET**

MOSFETs are used in a lot of different applications, and selecting the right MOSFET for the right application is an essential thing. A lot of important factors like the maximum drain-source current  $i_{ds_{max}}$ , drain-source voltage  $v_{ds}$ , and the threshold voltage  $v_t$  play a crucial role in different applications. For example, for low-power applications, the MOSFET should have a low threshold voltage  $(v_t)$  and low on-resistance  $(r_{ds})$  to ensure efficient switching with minimal power loss. However for high-voltage applications, a high drain-source voltage  $v_{ds}$  is recommended, to ensure that the MOSFET can handle the required current without overheating.