MOSFET Parameters

Tarek Mohamed

Alex Eagles

MOSFET Parameters

* Threshold Voltage (Vth)
* Drain-Source Voltage (VDS ​)
* Gate-Source Voltage (VGS ​)
* Drain Current (ID ​)
* On-Resistance (RDS(on))
* Maximum Power Dissipation (PD ​)
* Total Gate Charge (QG(Tot)​)
* Input Capacitance (Ciss ​)
* Reverse Transfer Capacitance (Crss ​)
* Safe Operating Area (SOA)

**Saturation Drain-Source Current (IDSS)**

It is the maximum current at the drain of the FET when the gate-source voltage VGS is zero.

It indicates the limiting current capacity of the equipment. If the current exceeds this value, the performance of the FET will be severely affected and may cause damage to the device.

**Threshold Voltage (Vth)**

is the minimum gate-to-source [voltage](https://en.wikipedia.org/wiki/Voltage) (VGS) that is needed to create a conducting path between the source and drain terminals. It is an important scaling factor to maintain power efficiency.

**Drain-Source Voltage (VDS ​)**

Represents the maximum voltage that can be applied across the drain and source terminals of a power transistor under turn-off conditions. When the applied voltage across the drain and source terminals exceeds the limit, it causes the power transistor to enter the breakdown region.

**Gate-Source Voltage (VGS​)**

is defined as the minimum voltage applied across the gate terminal of a [MOSFET](https://www.everythingpe.com/search/mosfets) to deliver current flow between source and drain terminals. It determines the voltage level at which the transistor transitions from the cutoff region to the active region.

When the gate voltage is below VGS(th), the transistor remains in the cutoff region, resulting in no current flow. Once the gate voltage exceeds VGS(th), the [MOSFET](https://www.everythingpe.com/search/mosfets) enters the active region, facilitating the conduction of current. In the active region, MOSFET can be used for amplifying and switching applications.

**Drain Current (ID ​)**

Drain current refers to the current flowing between the drain and source terminals of a device Defines the current-carrying capacity of the MOSFET.

**On-Resistance (RDS(on))**

The resistance value between the Drain and Source of a MOSFET during operation (ON) is called the ON Resistance (RDS(ON)).  
The smaller this value is, the lower the (power) loss.

A diagram of a voltage

Description automatically generated with medium confidence

**Maximum Power Dissipation (PD ​)**

The maximum amount of power the MOSFET can dissipate without damage.

Determines the thermal limits and reliability of MOSFET.

**Total Gate Charge (QG​)**

The Total Gate Charge (Qg) is the amount of charge that needs to be injected into the gate electrode to turn ON (drive) the MOSFET.  
The unit of Qg is the Coulomb (C), and if the total gate charge is large, it will take time to charge the capacitor necessary for turning ON the MOSFET, increasing switching loss. The smaller this value, the lower the switching loss and the higher the switching speed that can be achieved.

**Input Capacitance (Ciss ​)**

This is the input capacitance measured between the gate and source terminals with the drain shorted to the source for AC signals. Ciss is made up of the gate to drain capacitance Cgd in parallel with the gate to source capacitance Cgs, or Ciss = Cgs + Cgd. The input capacitance must be charged to the threshold voltage before the device begins to turn on, and discharged to the plateau voltage before the device

turns off. Therefore, the impedance of the drive circuitry and Ciss have a direct effect on the turn on and

turn off delays.

**Reverse Transfer Capacitance(Crss)**

This is the reverse transfer capacitance measured between the drain and gate terminals with the source connected to ground. The reverse transfer capacitance is equal to the gate to drain capacitance.  
res Crss = Cgd The reverse transfer capacitance, often referred to as the Miller capacitance, is one of the major parameters affecting voltage rise and fall times during switching. It also affects the turn-off delay time.

**Safe Operating Area (SOA)**

The safe operating area is the voltage and current conditions over which a MOSFET operates without permanent damage or degradation. The MOSFET must not be exposed to conditions outside the safe operating area even for an instant. Conventionally, MOSFETs were known for the absence of secondary breakdown, which was a failure mode specific to bipolar transistors.  
The safe operating area of a MOSFET was bound only by the maximum drain-source voltage, the maximum drain current, and a thermal limit between them. However, due to device geometry scaling, recent MOSFETs exhibit secondary breakdown. It is therefore necessary to determine whether the operating locus of the MOSFET is within the safe operating area.

Guidelines on selecting the right MOSFET for different applications.

**1. Determine the Application Type**

* **Switching Applications (e.g., power supplies, motor drives):**
  + Prioritize low On-Resistance (RDS(on)​) to minimize conduction losses.
  + Consider Gate Charge (QG​) and switching speed (input/output capacitance) for efficiency.
  + Ensure the MOSFET can handle the required Drain Current (ID​).
* **Linear Applications (e.g., amplifiers, regulators):**
  + Focus on MOSFETs with good thermal performance and a high Safe Operating Area (SOA).
  + Threshold Voltage (Vth​) should be chosen to match the operating conditions.

**2. Voltage Ratings**

* **Drain-Source Voltage (VDS ​)**:
  + Select a MOSFET with a VDS ​ rating at least 20-30% higher than the maximum voltage in the circuit to provide a safety margin.
  + For low-voltage applications, ensure the VDS ​ is low enough to minimize losses.
* **Gate-Source Voltage (VGS ​)**:
  + Ensure the MOSFET's VGS ​ threshold is suitable for the logic level used in the circuit (e.g., 5V or 3.3V logic).

**3. Current Handling**

* **Drain Current (ID​)**:
  + Choose a MOSFET with an ID rating that exceeds the maximum current expected in the application, typically by 50% or more to ensure reliability.
* **Pulsed Drain Current (IDM ​)**:
  + For applications involving pulsed or transient currents, ensure the MOSFET can handle peak currents without damage.

**4. Switching Speed**

* **Gate Charge (QG):**
  + Lower gate charge is essential for high-speed switching applications, reducing switching losses and allowing for faster operation.
  + In high-frequency circuits (e.g., DC-DC converters), prioritize MOSFETs with low total gate charge (QG(Tot)).
* **Input Capacitance (Ciss​)**:
  + Choose MOSFETs with low input capacitance for faster response times in high-speed circuits.

**5. Thermal Considerations**

* **Power Dissipation (PD ​)**:
  + Ensure the MOSFET's power dissipation rating can handle the heat generated during operation, considering both conduction and switching losses.
  + Consider using MOSFETs with enhanced thermal performance or package types that offer better heat dissipation.
* **RDS(on) and Junction Temperature (Tj(max)​)**:
  + Select a MOSFET with a low RDS(on) to minimize heat generation, especially important in high-power applications.
  + Ensure the MOSFET can operate within the specified junction temperature limits.

**6. Body Diode Performance**

* **Body Diode Forward Voltage (VSD ​)**:
  + For applications where the MOSFET's body diode will conduct (e.g., synchronous rectifiers), choose MOSFETs with low VSD ​ for better efficiency.
  + Consider reverse recovery characteristics if the diode will switch frequently.