**MOSFET Key Parameters and Operating Regions**

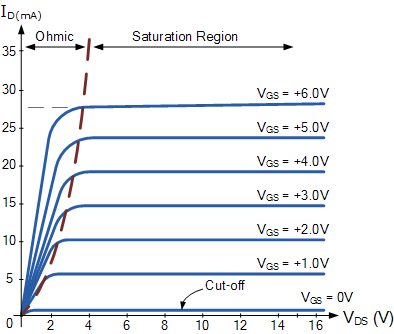
A diagram of a circuit diagram

Description automatically generated with medium confidence

MOSEFT “ Metal Oxide Semiconductor Field Effect Transistor” is a voltage-controlled device that is widely used for amplification and switching purposes. It consists of three terminals, Gate which controls the flow of current between the other two terminals, drain which us the output terminal where current flows out, and Source where the current enters the device. Both P-channel “PMOS” and N-channel “NMOS” are available.

* *MOSFET operating regions:*

*1) Cutoff Region:*

**When the Vgs (gate-source voltage ) < Vth (threshold voltage) , the magnitude of the current flowing through the MOSFET (Id) is negligible, nearly zero, and no conductive channel is formed between the drain and source, so it will function as an off / open switch.

*2) Ohmic/ linear Region:*

As Vgs increase beyond Vth, a channel between source and drain is formed allowing a current to pass through and increase linearly with increasing drain voltage ( Vds ), it is used as an amplifier.

*3) Saturation Region:*

Once the drain voltage (Vds) exceeds the pinch-off voltage (Vp) value the MOSFET is in the Saturation region and the current Ids will remain constant despite Vds increasing and it will function as a closed / ON switch.

* *MOSFET Key Parameters:*

These are the key parameters that have the most impact on how the MOSFET works.

1. *Vds(br) “drain-source breakdown voltage “* :

It is a specified voltage between the drain and the source which when reached or exceeded the MOSFET electrically burns down.

1. *Vgs(th) “threshold voltage” :*

It is the voltage between the gate and the source which causes the MOSFET to turn on/off and controls the operating regions.

1. *Id “ continuous drain current “ :* Max continuous current that the MOSFET can carry when ON.
2. *Rds(ON) “resistance between drain and source”:*

It is the key parameter in calculating conduction losses (Pd) and junction temperature (Tj).

Pd= Id^2 \* Rds(on)

As Rds increase, Vds increase, Tj increase (positive temperature coefficient).

1. *Idss “drain leakage current”:*

Current leaked while cutoff (Vgs=0), depends on Vgs(th) and Tj, as they increase Idss increases too.

1. *Idm “peak drain current”:*

Maximum drain current which can flow for only 10 microseconds or less, it changes with pulse duration and Vds,

*As pulse time increases, Idm decreases .*

1. *Rϑja/ Rϑjc :*

Thermal Resistance from junction to base or mountain base, it denotes the capability of the MOSFET to conduct the excessive heat out of it.

To calculate the temperature rise in a MOSFET, (Rϑja \* Pd) + Tamb = Tj

Rϑja: junction - ambient thermal resistance.

Pd: power dissipated across the MOSFET.

Tamb: ambient temperature where the circuit is working .

1. *Power dissipation:* it’s the total power lost.

Ptotal = Pconduction + Pswitch + Pgate + Pdiode

1. *Gate Capacitance :* Affects the device's switching speed, power consumption, and overall performance, particularly in high-frequency and digital circuits.

* *Choosing the right MOSFET for different applications:*

Choosing the right MOSFET involves aligning several factors and key parameters like the ones mentioned before to match the specific needs of the application to ensure best performance, efficiency, and reliability in the design circuit.

1. *N-MOS or P-MOS?*

*N-MOS : has lower on-resistance and faster switching times, commonly used for switching the negative side of a load.*

*P-MOS:* used for switching positive lads but has typically they have higher on-resistance and slow switching compared to N-MOS.

1. *Enhancement or depletion mode? ( E-MOSFET or D-MOSFET)*

E-MOSFET: the MOSFET is off when Vgs=0 and on when Vgs<Vth, more commonly used in general-purpose applications, particularly in digital and power electronics, due to their normally-off characteristic, high efficiency, and fast switching capabilities.

D-MOSFET: on when Vgs=0 (has a conduction channel by default) and applying negative Vgs for NMOS or positive Vgs for a PMOS reduces or turns on the conduction, typically used for specialized applications like constant current sources, analog signal processing, and circuits requiring a normally-on device, such as certain types of amplifiers and oscillators.

1. *Key electrical parameters*

Calculating the key parameters needed for the application’s circuit to ensure optimal and wanted performance and prevent electrical burns and shutdowns.

Includes the switching characteristics, thermal limits, all needed voltages, currents and resistances , and power dissipated.

1. The MOSFET size

The size/type of the device must be considered according to each application to ensure a good fit, heatsinking must also be considered for high-power MOSFETS.