MOSFET Parameters

1. Introduction

- Metal Oxide Silicon Field Effect Transistor also referred to as MOSFETs, are used in circuits to switch or amplify voltages. It has three terminals and is a voltage-controlled device. What follows is the name of the MOSFET terminals:
    - Source
    - Gate
    - Drain

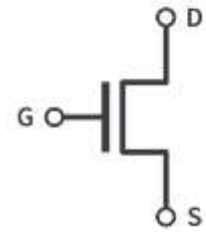

Figure1.1

2. Key Parameters

2.1.On state resistance, RDS (on)

When the MOSFET is in the on state, it indicates the resistance between the drain and source terminals. It determines the conduction loss; the lower the RDS (on) value, the lower the conduction loss.

2.2.Break down voltage

It indicates the highest voltage a MOSFET can hold between its drain and source when it is in the off state.

2.3.Threshold Voltage

The minimum voltage across a MOSFET's gate terminal that is required to provide current flow between the source and drain terminals is known as the gate threshold voltage (VGS (th)). The voltage level at which the transistor moves from the cutoff region to the active region is determined by it.

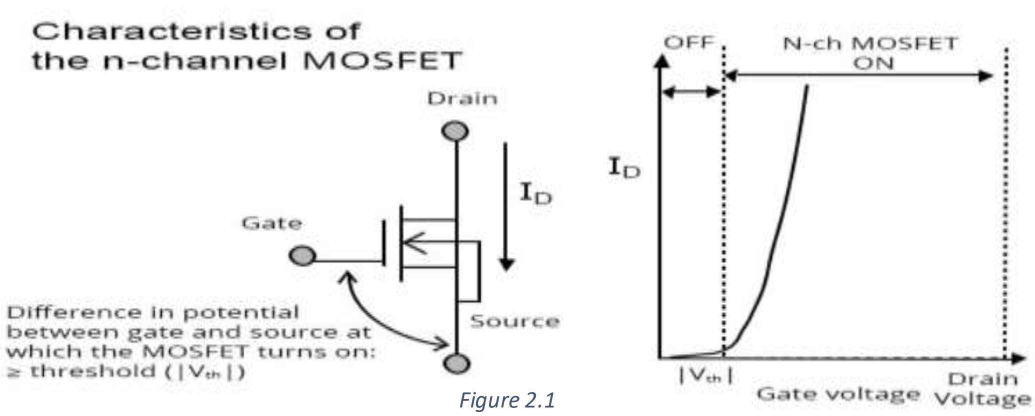

Figure 2.1

2.4.Total gate charge

It denotes the electric charge required by the gate driver to turn the device on/off

- Figure of Merit (FOM) is the product of RDS (on) and QG, which accounts for the conduction losses and switching losses of a MOSFET. Therefore, the efficiency of a MOSFET depends on both, the RDS (on) and the QG.

3. Operating regions

3.1.Cutoff Region: This region of the MOSFET is where no current flows because the applied voltage is less than the threshold voltage, which prevents the oxide layer from forming. The state is not in use.

3.2.Triode Region (Linear Region): The state is often referred to as partially conducting. Although there is a path for the current flow, it is not fully operational. This region has a moderate voltage.

3.3.Saturation Region: Because of the threshold voltage, a constant flow of current flows between the drain and source in this region of the MOSFET. In this instance, the MOSFET's state is ON.

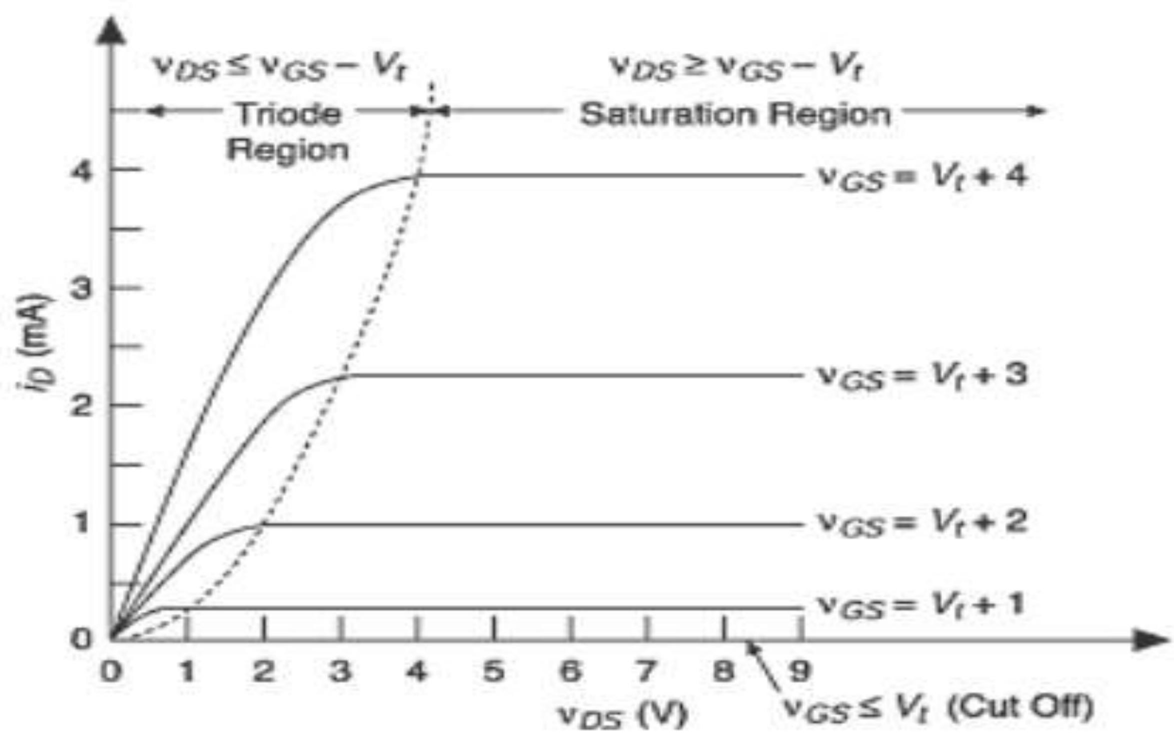

Figure 3.1

4. Guidelines on selecting the right MOSFET

The applications for which MOSFETs will be used should determine which ratings and characteristics are appropriate.

4.1 Drain-source breakdown voltage $V_{DS(BR)}$

A mosfet may be destroyed if the application voltage is higher than this threshold when the mosfet is in the off state. When selecting MOSFETs, consider VDS > Vsupply.

4.2 Gate-source threshold voltage V_{GS} Considerations

- the gate-source voltage is required to turn on the mosfet. This signal allowing the drain current flowing to the mosfet and this signal should be at least more than the threshold value only then the mosfet will turn on $V_{GS} > V_{GS\,(th)}$.

- This V_{GS} depends on the drain current which flows through mosfet and V_{DS}

- The following graph describes the transfer characteristics as the drain current is a function of a V_{GS}

- In order to minimize the resistance of the device at the current level of use and reduce loss, it is needed to increase V_{GS}.As shown

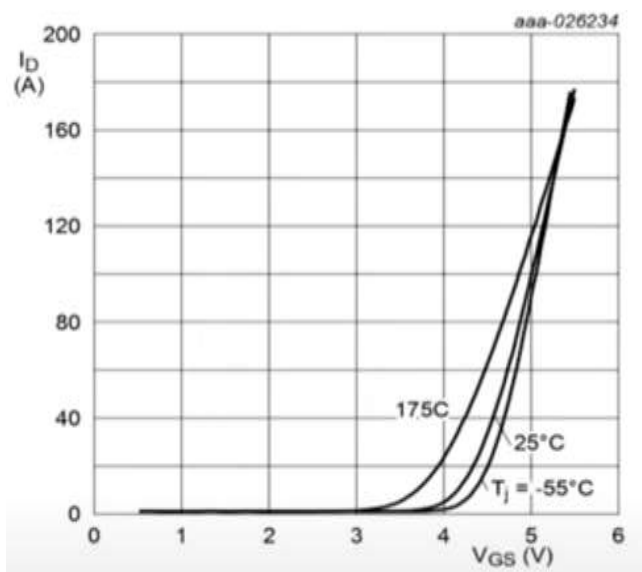

Figure 4.1

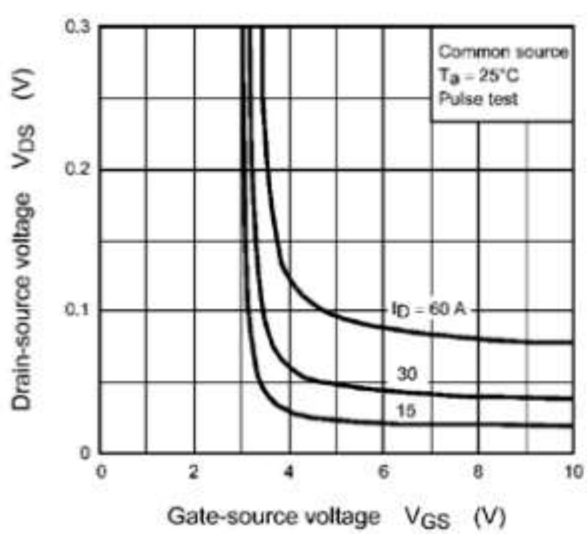

Figure 4.2

- Conversely, a high VGS value increases the drive loss at light loads for high frequency switching. Selecting the optimal gate voltage is therefore critical.

4.3 The continuous drain current I_D

- It is the maximum drain current which a mosfet can carry
- The drain current capability varies with the change junction temperature and V_{GS}
- When the junction temperature increases, the current handling capacity decreases exponentially as shown in the fig below

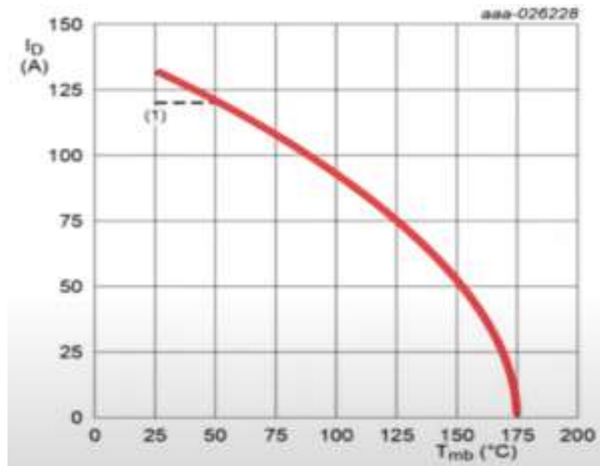

Figure 4.3

4.4 Drain-Source Resistance $R_{DS\ (on)}$

- $R_{DS\ (on)}$ increases if a V_{DS} of a mosfet increases for different mosfets.
- The mosfet is a positive temperature coefficient device so if the junction temperature of a mosfet increases the $R_{DS\ (on)}$ increases.
- The conduction loss can be calculated by this formula
  I_D^2 × $R_{DS\ (on)}$
  So, the conduction loss depends on it

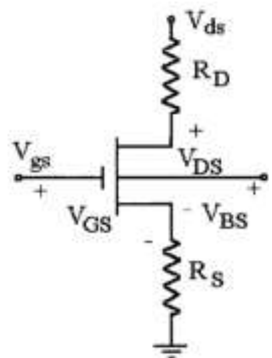

Figure 4.4

- When MOSFETs function in the linear region, or at a voltage lower than the pinch-off value, the on-state resistance is low.
  Thus, by using MOSFETs in the low VDS region, the on-state resistance can be reduced for switching applications.

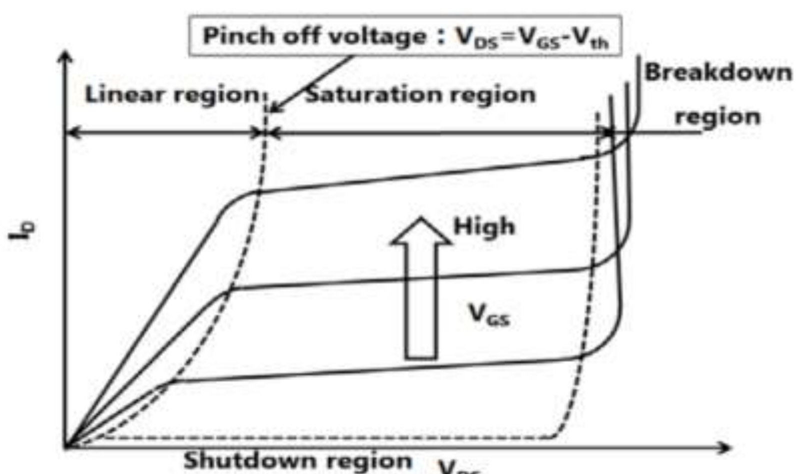

Figure 4.5

4.5 Drain Leakage Current I_{DSS}

- There is still current flowing through the mosfet even in the absence of a gate signal called a leakage current

- This leakage current depends on the drain to source voltage and junction temperature and its range should be as small as possible

- When the mosfet is off any junction temperature is rising in that case the leakage current of the mosfet increases so its conduction loss increases which eventually dissipates more power

4.6 Thermal Characteristics

It indicates the mosfet's ability to transfer high temperatures out of it. This formula is very useful for figuring out how much a mosfet's temperature has increased:

$(R_{JA} \times P_D) + T_{ambient} = T_J$

R_{JA}: the thermal resistance between junction to ambient

P_D: the power dissipation across mosfet which is addition of different power losses which are conduction power loss switching power loss gate charge loss and dead time loss

- **References**

- https://www.electronicsforu.com/buyers-guides/guide-to-select-power-mosfets
- https://www.geeksforgeeks.org/mosfet/
- https://toshiba.semicon-storage.com/info/application_note_en_20180726_AKX00064.pdf?did=13416