August, 2022 − Rev. 2

FETS

Junction Field Effect Transistors (JFETs)

STRUCTURE OF A MOSFET

Lateral Channel Design

Vertical Channel Design

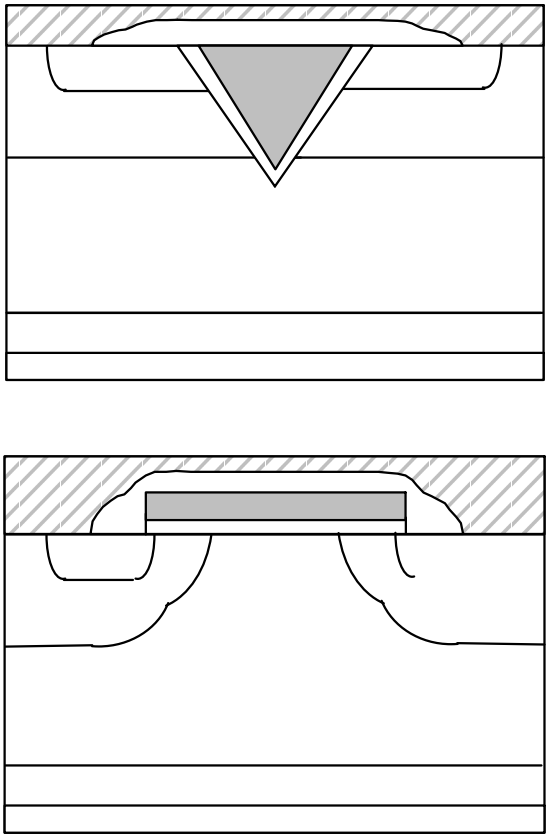


Figure 4. Vertical Channel Structure

CHARACTERISTICS OF MOSFET IN ON AND OFF STATE

OFF State

ON State

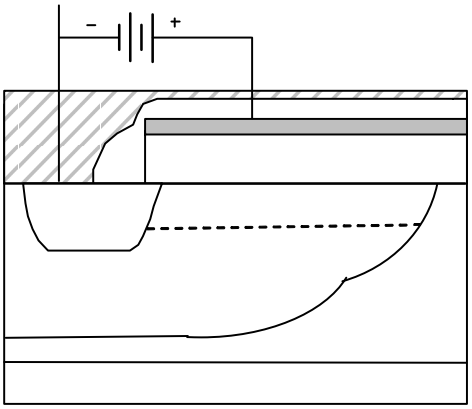


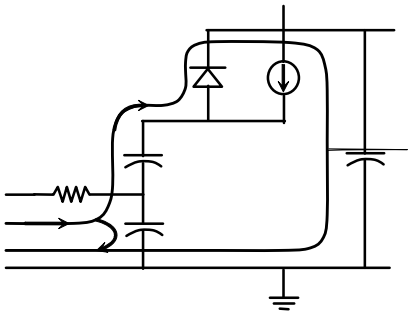
Figure 9. Inversion Layer Thickness Changes due to the Increase of the Drain−to−Source Voltage (V_{DD}) where $V_{DD1} < V_{GS} - V_{GS(th)}$, $V_{DD2} > V_{GS} - V_{GS(th)}$, I_{D2} (Saturation Current) > I_{D1}

User’s manual

Characteristics of Capacitance

-

$$C_{ds\ (per\ unit\ area)} = \frac{\sqrt{q\ k_s\ \varepsilon_o\ C_B}}{2\sqrt{V_{DS} + \phi_B}}$$



×

ε

×

ϕ

ϕ

$$C_{ds} \propto 1 \quad \sqrt{V_{DS}}.$$

Characteristics of the Gate Charge

-
-
-

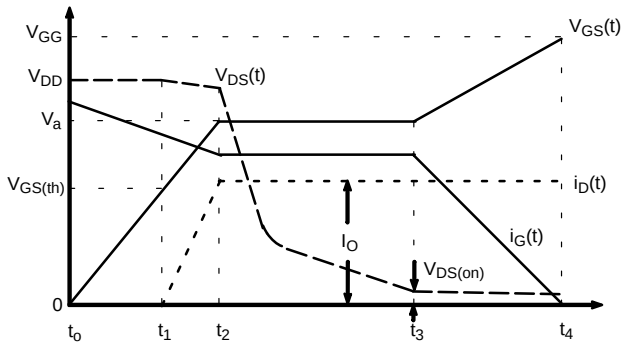


Figure 12. $V_{GS}(t)$, $I_G(t)$, $V_{DS}(t)$, $I_D(t)$ When Turned On

Figure 13. Equivalent Circuits of the MOSFET with Turn−on Divided into 4 Periods at the Diode−clamped Inductive Load Circuit

$$g_{fs}(T) = g_{fs}(25°C)\left(\frac{T}{300}\right)^{-2.3} \quad \text{(eq. 8)}$$

Drain−Source Breakdown Voltage (BV_{DS} Breakdown Voltage Temperature Coefficient ($\Delta BV/\Delta TJ$)

–

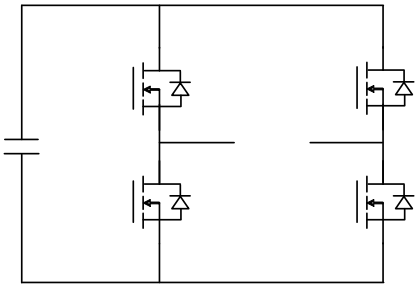


Figure 22. Motor Control Circuit

-
-
-
- θ
- θ
- θ

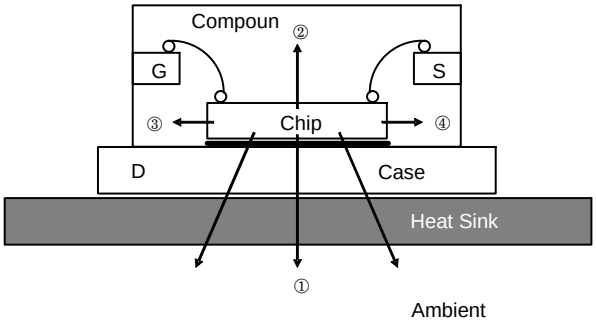


Figure 25. Thermal Discharge Path at Chip Junction

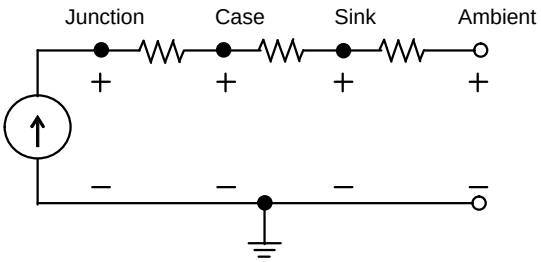


Figure 26. Circuit Based on Thermal Resistance

θ

$$R_{\theta JC}(t) = R_{\theta JC} \cdot D + (1 - D) \cdot S_{\theta JC}(t) \quad \text{(eq. 15)}$$

θ

θ

$$I_D(T_C) = \frac{T_{Jmax} - T_C}{R_{DS(on)}(T_{Jmax}) \cdot R_{\theta JC}} \quad \text{(eq. 16)}$$

$$\frac{1}{2} \cdot I_D$$

θ

$$I_{DM} = I_D(T_C = 25[°C]) \times 4 \quad \text{(eq. 17)}$$

Total Power Dissipation (P_D), Linear Derating Factor

$$P_D(T_C) = I_D^2(T_C) \cdot R_{DS(on)}(T_{Jmax}) = \frac{T_{Jmax} - T_C}{R_{\theta JC}} \quad \text{(eq. 18)}$$

$$\frac{1}{R_{\theta JC}} \quad \text{(eq. 19)}$$

Safe Operating Areas (SOA)

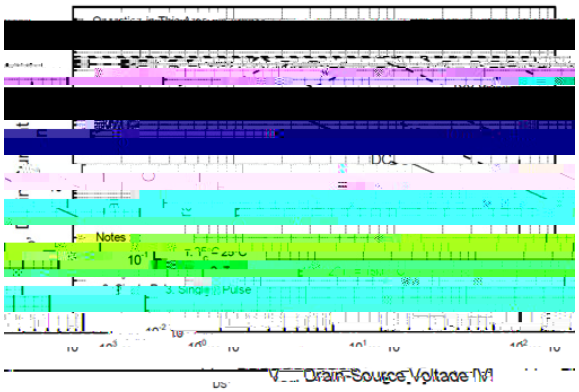


Figure 29. Maximum Safe Operating Area

$$I_D(T_C) = \frac{T_{Jmax} - T_C}{R_{DS(on)}(T_{Jmax}) \cdot R_{\theta JC}} \quad \text{(eq. 20)}$$

$$I_{DM} = I_D(T_C) \times 4 \quad \text{(eq. 21)}$$

The Upper Limit with Positive (+) Slope

The Upper Limit with Negative (−) Slope

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