

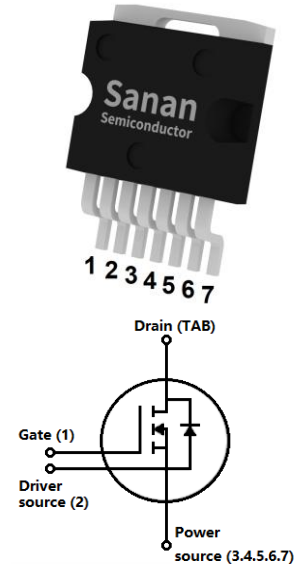
# 650V 35mΩ Silicon Carbide Power MOSFET

## Features

- High blocking voltage with low on-resistance
- High switching speed with low capacitance
- Very fast and robust intrinsic body diode with low reverse recovery
- Very low switching losses
- Excellent avalanche ruggedness
- RoHS compliant

## Benefits

- Greater system efficiency
- Reduced cooling requirements
- Increased power density
- Increased system switching frequency
- Easy to parallel and simple to drive



## Potential Applications

- Solar inverters
- Uninterrupted power supplies
- Switch mode power supplies
- Motor drives

Package Type: TO-263-7L



## Description

The Sanan Semiconductor 650V/35mΩ silicon carbide power MOSFET uses advanced SiC MOSFET technology with low on-resistance, low switching losses, and a high operation temperature of 175°C. It is suitable for use in high frequency circuits and provides a reduction in overall system size, increased efficiency and increased switching frequency. It has been widely used in applications including solar inverters, uninterrupted power supplies, switch mode power supplies, and motor drives. Using RoHS compliant components, it is qualified for use in industrial application.

## Product Specifications

| Device      | V <sub>DS</sub> | I <sub>D</sub> (25°C) | R <sub>(DS)on</sub> | Marking    |
|-------------|-----------------|-----------------------|---------------------|------------|
| SMS0650035P | 650V            | 60A                   | 35mΩ                | MS0650035P |

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**Table 1. Maximum Ratings**

( $T_C = 25^{\circ}\text{C}$ , unless otherwise specified)

| Parameter                                   | Symbol         | Value   | Unit               | Test conditions                           |
|---------------------------------------------|----------------|---------|--------------------|-------------------------------------------|
| Drain-source voltage                        | $V_{DSmax}$    | 650     | V                  | $V_{GS} = 0V, I_D = 100\mu A$             |
| Gate-source voltage, max. transient voltage | $V_{GSmax}$    | -10/+25 |                    | $t_p \leq 0.5\mu s, D < 1\%$              |
| Gate-source voltage, max. static voltage    | $V_{GSmax}$    | -8/+22  |                    |                                           |
| Gate-source voltage                         | $V_{GSop}$     | -5/+18  |                    | Recommended operation values              |
| Continuous drain current                    | $I_D$          | 60      | A                  | $V_{GS} = 18V$                            |
|                                             |                | 42      |                    | $V_{GS} = 18V, T_C = 100^{\circ}\text{C}$ |
| Pulsed drain current                        | $I_{D(pulse)}$ | 150     | A                  | Pulse width $t_p$ limited by $T_{jmax}$   |
| Power dissipation                           | $P_{tot}$      | 272     | W                  |                                           |
| Operating junction temperature              | $T_j$          | -55~175 | $^{\circ}\text{C}$ |                                           |
| Storage temperature                         | $T_{stg}$      | -55~175 | $^{\circ}\text{C}$ |                                           |
| Soldering temperature                       | $T_L$          | 260     | $^{\circ}\text{C}$ | 1.6mm from case for 10s                   |

**Table 2. Thermal Resistances**

| Parameter                                | Symbol        | Values |      |      | Unit                 | Test condition |
|------------------------------------------|---------------|--------|------|------|----------------------|----------------|
|                                          |               | Min.   | Typ. | Max. |                      |                |
| Thermal resistance from junction to case | $R_{th(j-c)}$ | /      | 0.46 | /    | $^{\circ}\text{C/W}$ |                |

**Table 3. Static Electrical Characteristics**

( $T_j = 25^\circ\text{C}$ , unless otherwise specified)

| Parameter                        | Symbol        | Values |      |      | Unit       | Test conditions                                         |
|----------------------------------|---------------|--------|------|------|------------|---------------------------------------------------------|
|                                  |               | Min.   | Typ. | Max. |            |                                                         |
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | 650    | /    | /    | V          | $V_{GS} = 0V, I_D = 100\mu A$                           |
| Gate threshold voltage           | $V_{GS(th)}$  | 1.8    | 2.8  | 4.2  |            | $V_{DS} = V_{GS}, I_D = 6.5mA$                          |
|                                  |               | /      | 2.1  | /    |            | $V_{DS} = V_{GS}, I_D = 6.5mA, T_j = 175^\circ\text{C}$ |
| Drain-source leakage current     | $I_{DSS}$     | /      | 1    | 50   | $\mu A$    | $V_{DS} = 650V, V_{GS} = 0V$                            |
| Gate-source leakage current      | $I_{GSS}$     | /      | 1    | 250  | nA         | $V_{GS} = 18V, V_{DS} = 0V$                             |
| Drain-source on-state resistance | $R_{DS(on)}$  | /      | 47   | /    | m $\Omega$ | $V_{GS} = 15V, I_D = 22A$                               |
|                                  |               | /      | 35   | 46   |            | $V_{GS} = 18V, I_D = 22A$                               |
|                                  |               | /      | 45   | /    |            | $V_{GS} = 18V, I_D = 22A, T_j = 175^\circ\text{C}$      |
| Transconductance                 | $g_{fs}$      | /      | 14   | /    | S          | $V_{DS} = 20V, I_D = 22A$                               |
|                                  |               | /      | 13   | /    |            | $V_{DS} = 20V, I_D = 22A, T_j = 175^\circ\text{C}$      |
| Internal gate resistance         | $R_{g(int)}$  | /      | 3.8  | /    | $\Omega$   | $f = 1MHz, V_{AC} = 25mV$                               |

**Table 4. Dynamic Electrical Characteristics**

( $T_j = 25^\circ\text{C}$ , unless otherwise specified)

| Parameter                      | Symbol           | Values |      |      | Unit | Test conditions                                                                                      |
|--------------------------------|------------------|--------|------|------|------|------------------------------------------------------------------------------------------------------|
|                                |                  | Min.   | Typ. | Max. |      |                                                                                                      |
| Input capacitance              | C <sub>iSS</sub> | /      | 1675 | /    | pF   | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 600V,<br>f = 100kHz, V <sub>AC</sub> = 25mV                  |
| Output capacitance             | C <sub>oSS</sub> | /      | 134  | /    |      |                                                                                                      |
| Reverse transfer capacitance   | C <sub>rSS</sub> | /      | 1    | /    |      |                                                                                                      |
| C <sub>oSS</sub> stored energy | E <sub>oSS</sub> | /      | 28   | /    | μJ   |                                                                                                      |
| Gate to source charge          | Q <sub>GS</sub>  | /      | 23   | /    | nC   | V <sub>DD</sub> = 400V, I <sub>D</sub> = 22A,<br>V <sub>GS</sub> = -5/+18V,<br>I <sub>GS</sub> = 1mA |
| Gate to drain charge           | Q <sub>GD</sub>  | /      | 20   | /    |      |                                                                                                      |
| Total gate charge              | Q <sub>G</sub>   | /      | 73   | /    |      |                                                                                                      |

**Table 5. Switching Characteristics**

( $T_j = 25^\circ\text{C}$ , unless otherwise specified)

| Parameter                 | Symbol       | Values |      |      | Unit    | Test conditions                                                                                                                |
|---------------------------|--------------|--------|------|------|---------|--------------------------------------------------------------------------------------------------------------------------------|
|                           |              | Min.   | Typ. | Max. |         |                                                                                                                                |
| Turn-on delay time        | $t_{d(on)}$  | /      | 10   | /    | ns      | $V_{DD} = 400V$ ,<br>$V_{GS} = -5/+18V$ , $I_D = 22A$ ,<br>$R_{G(ext)} = 2.4\Omega$ , $L = 110\mu H$ ,<br>$T_j = 25^{\circ}C$  |
| Rise time                 | $t_r$        | /      | 10   | /    |         |                                                                                                                                |
| Turn-off delay time       | $t_{d(off)}$ | /      | 26   | /    |         |                                                                                                                                |
| Fall time                 | $t_f$        | /      | 5    | /    |         |                                                                                                                                |
| Turn-on switching energy  | $E_{on}$     | /      | 12   | /    | $\mu J$ |                                                                                                                                |
| Turn-off switching energy | $E_{off}$    | /      | 33   | /    |         |                                                                                                                                |
| Turn-on delay time        | $t_{d(on)}$  | /      | 9    | /    | ns      | $V_{DD} = 400V$ ,<br>$V_{GS} = -5/+18V$ , $I_D = 22A$ ,<br>$R_{G(ext)} = 2.4\Omega$ , $L = 110\mu H$ ,<br>$T_j = 175^{\circ}C$ |
| Rise time                 | $t_r$        | /      | 9    | /    |         |                                                                                                                                |
| Turn-off delay time       | $t_{d(off)}$ | /      | 28   | /    |         |                                                                                                                                |
| Fall time                 | $t_f$        | /      | 6    | /    |         |                                                                                                                                |
| Turn-on switching energy  | $E_{on}$     | /      | 11   | /    | $\mu J$ |                                                                                                                                |
| Turn-off switching energy | $E_{off}$    | /      | 34   | /    |         |                                                                                                                                |

**Table 6. Reverse SiC Diode Characteristics**

( $T_j = 25^\circ\text{C}$ , unless otherwise specified)

| Parameter                        | Symbol                | Values |      |      | Unit          | Test conditions                                                                                                                               |
|----------------------------------|-----------------------|--------|------|------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
|                                  |                       | Min.   | Typ. | Max. |               |                                                                                                                                               |
| Diode forward voltage            | $V_{SD}$              | /      | 4.2  | /    | V             | $V_{GS} = -5\text{V}$ , $I_{SD} = 22\text{A}$                                                                                                 |
|                                  |                       | /      | 3.7  | /    |               | $V_{GS} = -5\text{V}$ , $I_{SD} = 22\text{A}$ ,<br>$T_j = 175^\circ\text{C}$                                                                  |
| Continuous diode forward current | $I_S$                 | /      | /    | 60   | A             | $V_{GS} = -5\text{V}$ , $T_C = 25^\circ\text{C}$                                                                                              |
| Diode pulse current              | $I_{S, \text{pulse}}$ | /      | /    | 150  | A             | $V_{GS} = -5\text{V}$ , pulse width $t_p$ limited by $T_{j\text{max}}$                                                                        |
| Reverse recovery time            | $t_{rr}$              | /      | 18   | /    | ns            | $V_{GS} = -5\text{V}$ , $I_{SD} = 22\text{A}$ ,<br>$V_R = 400\text{V}$ , $T_j = 25^\circ\text{C}$<br>$di_f/dt = 1.03\text{kA}/\mu\text{s}$    |
| Reverse recovery charge          | $Q_{rr}$              | /      | 0.18 | /    | $\mu\text{C}$ |                                                                                                                                               |
| Peak reverse recovery current    | $I_{rrm}$             | /      | 17   | /    | A             |                                                                                                                                               |
| Reverse recovery time            | $t_{rr}$              | /      | 18   | /    | ns            | $V_{GS} = -5\text{V}$ , $I_{SD} = 22\text{A}$ ,<br>$V_R = 400\text{V}$ , $T_j = 175^\circ\text{C}$ ,<br>$di_f/dt = 1.06\text{kA}/\mu\text{s}$ |
| Reverse recovery charge          | $Q_{rr}$              | /      | 0.20 | /    | $\mu\text{C}$ |                                                                                                                                               |
| Peak reverse recovery current    | $I_{rrm}$             | /      | 18   | /    | A             |                                                                                                                                               |

## Electrical Characteristic Diagrams

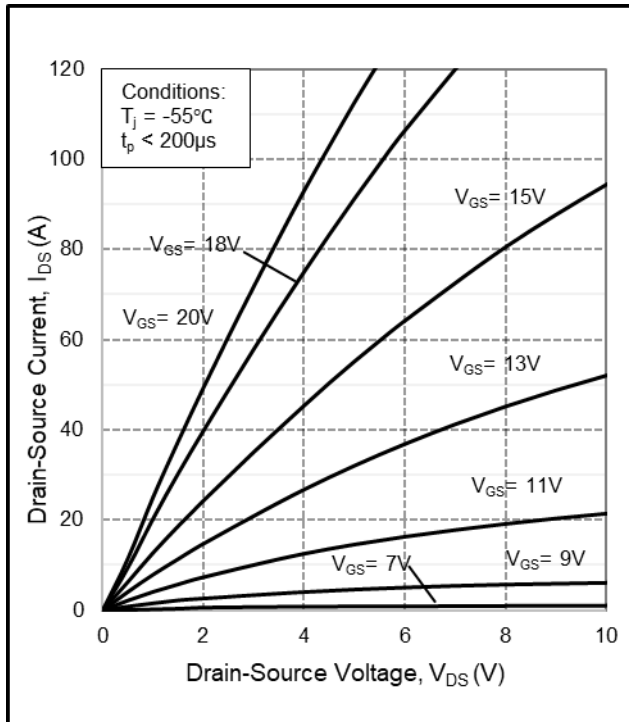


Figure 1. Output characteristics at  $T_j = -55^\circ\text{C}$

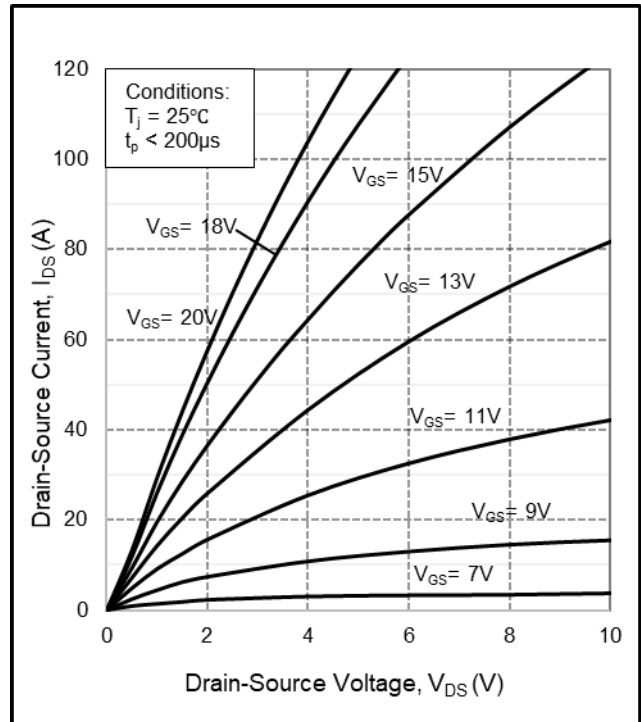


Figure 2. Output characteristics at  $T_j = 25^\circ\text{C}$

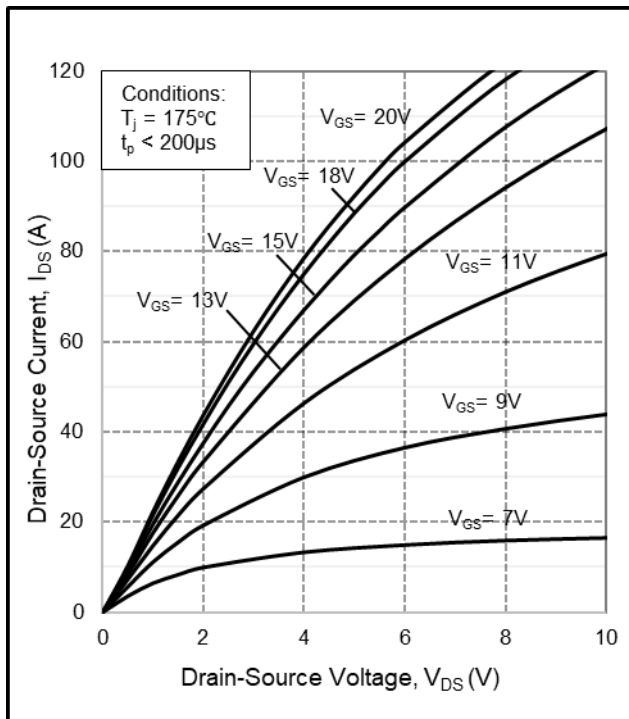


Figure 3. Output characteristics at  $T_j = 175^\circ\text{C}$

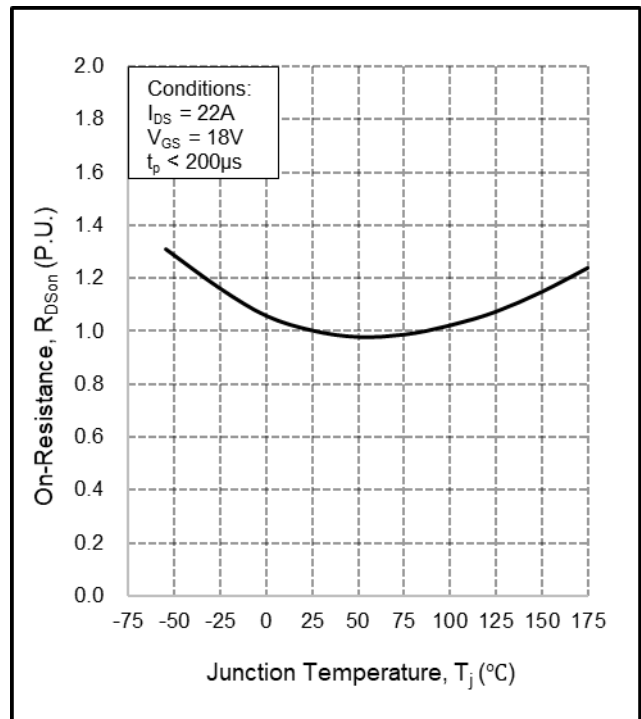


Figure 4. Normalized on-resistance vs. temperature

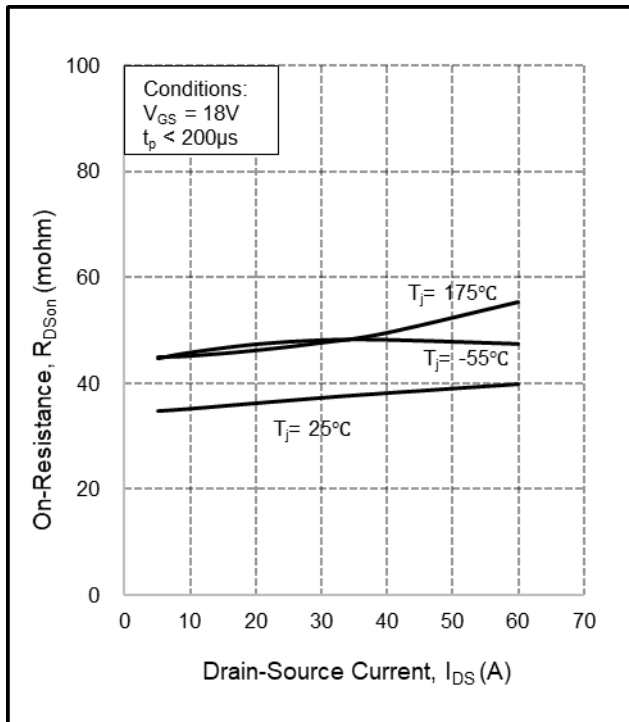


Figure 5. On-resistance vs. drain current for various temperatures

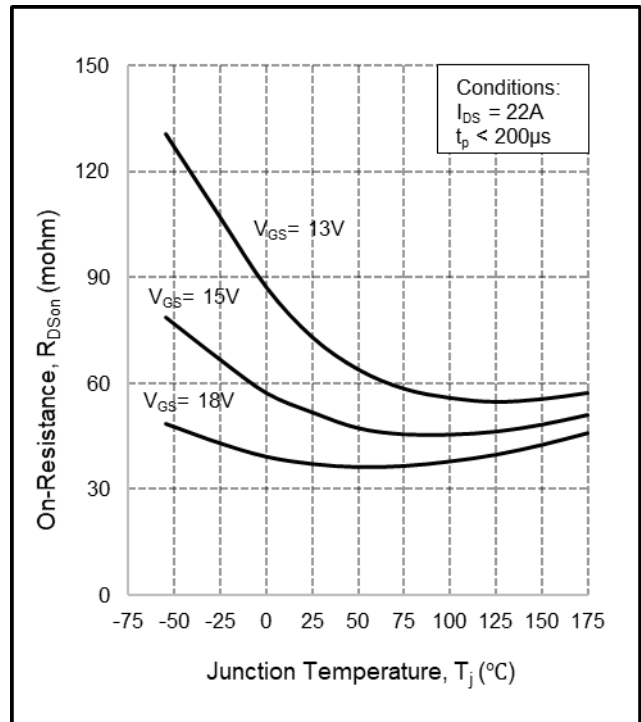


Figure 6. On-resistance vs. temperature for various gate voltages

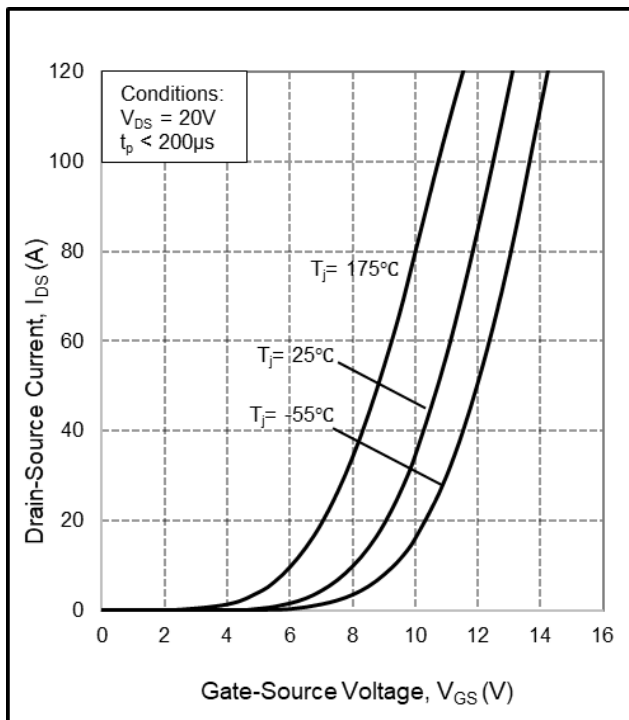


Figure 7. Transfer characteristic for various junction temperatures

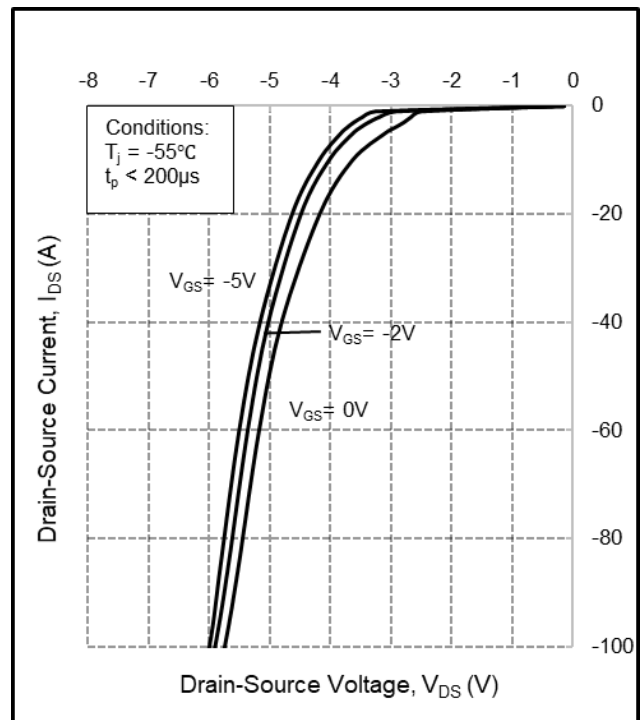


Figure 8. Body diode characteristic at  $T_J = -55^\circ\text{C}$

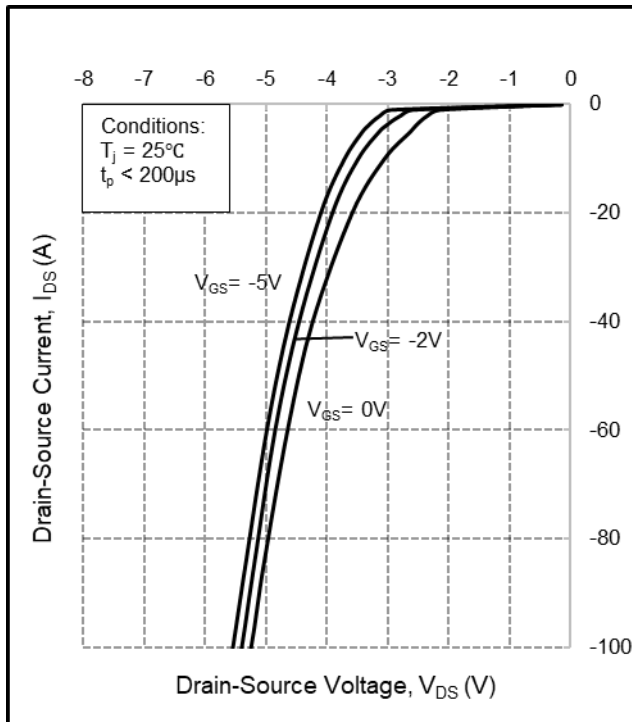


Figure 9. Body diode characteristic at  $T_j = 25^\circ\text{C}$

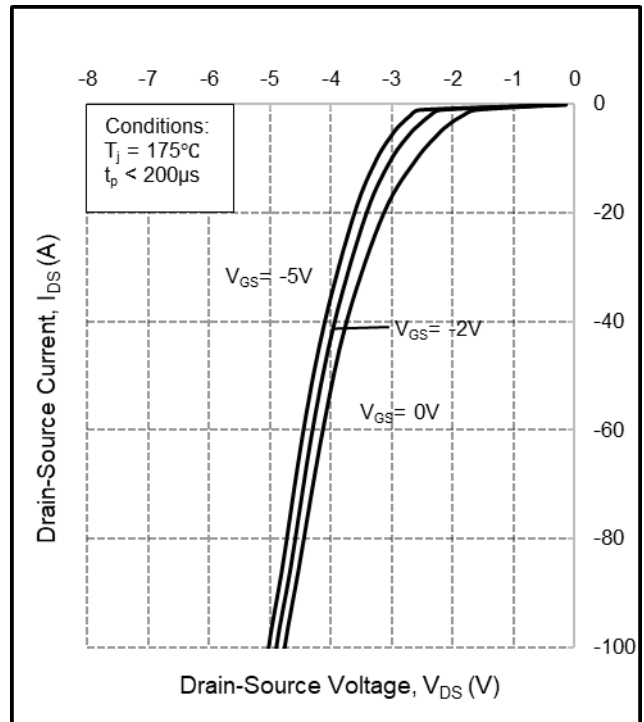


Figure 10. Body diode characteristic at  $T_j = 175^\circ\text{C}$

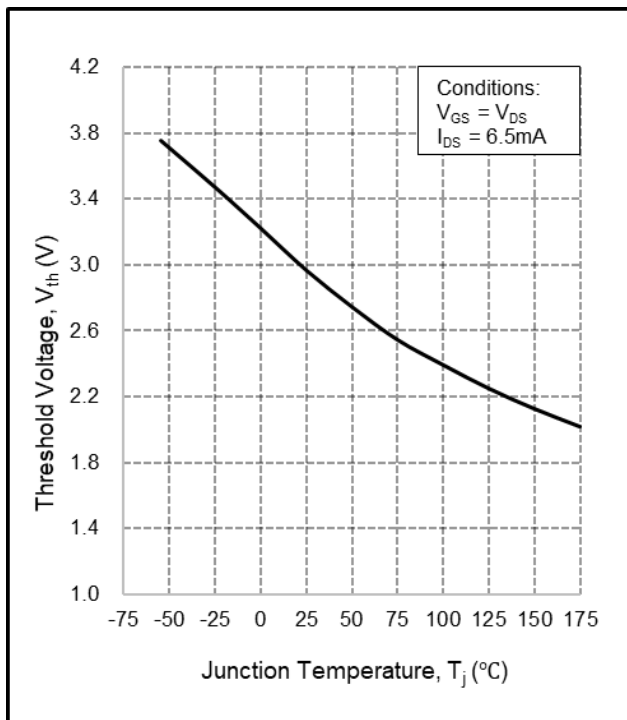


Figure 11. Threshold voltage vs. temperature

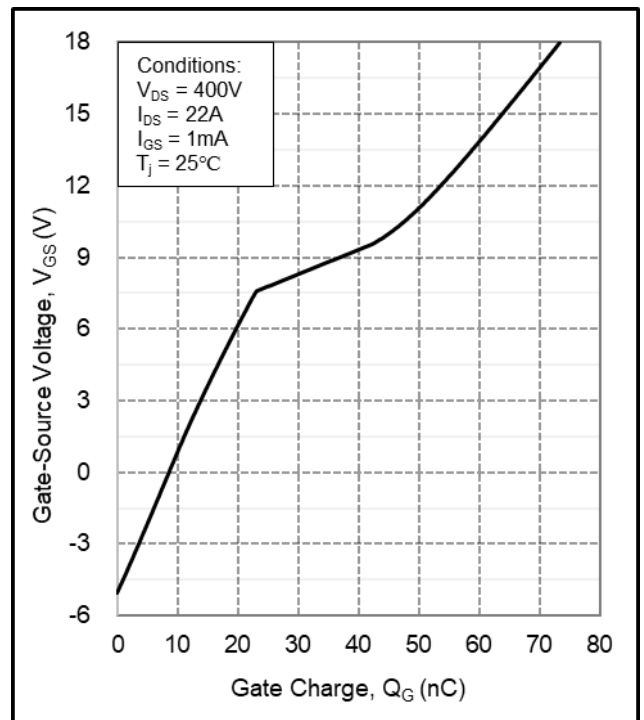


Figure 12. Gate charge characteristics

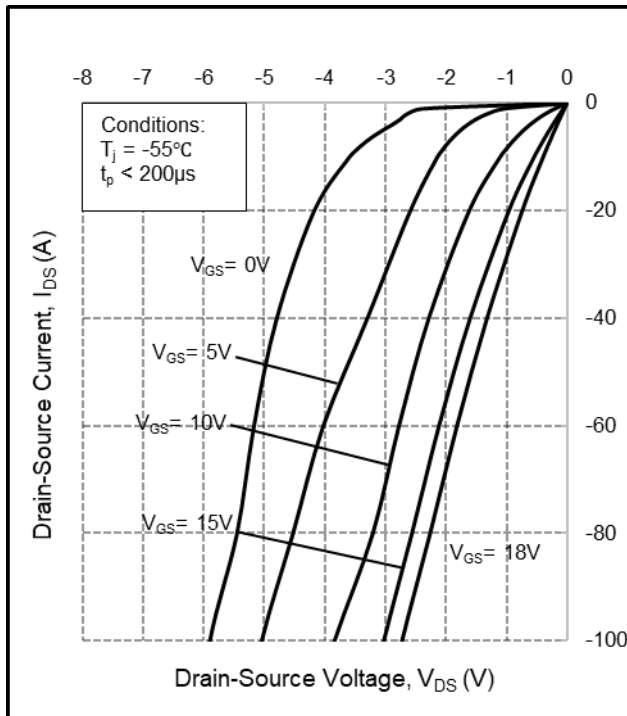


Figure 13. 3rd quadrant characteristic  
at  $T_j = -55^\circ\text{C}$

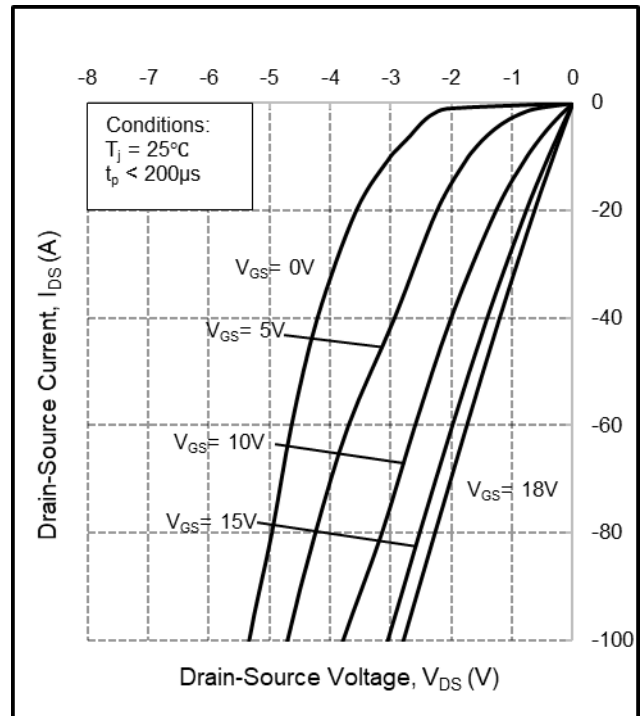


Figure 14. 3rd quadrant characteristic  
at  $T_j = 25^\circ\text{C}$

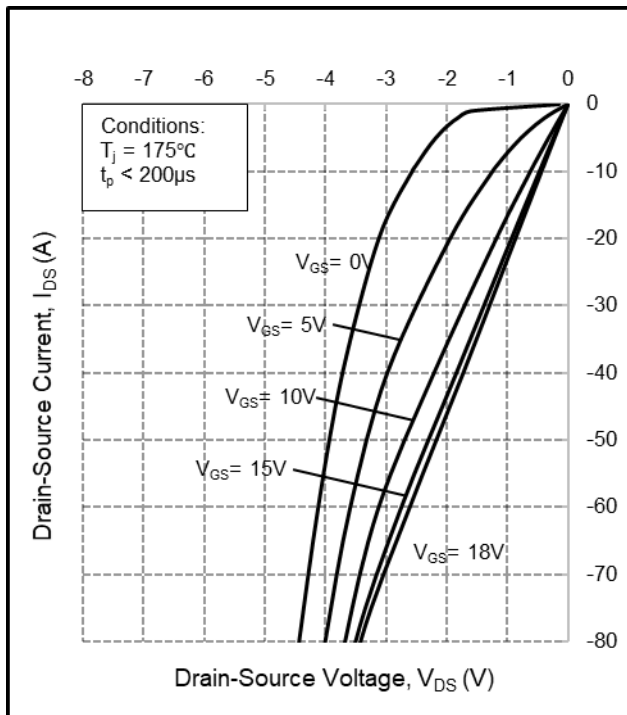


Figure 15. 3rd quadrant characteristic  
at  $T_j = 175^\circ\text{C}$

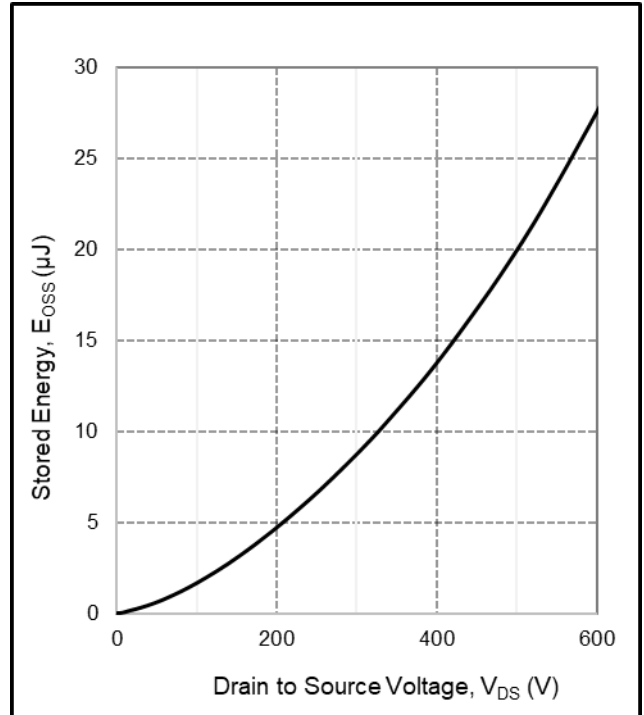


Figure 16. Output capacitor stored energy

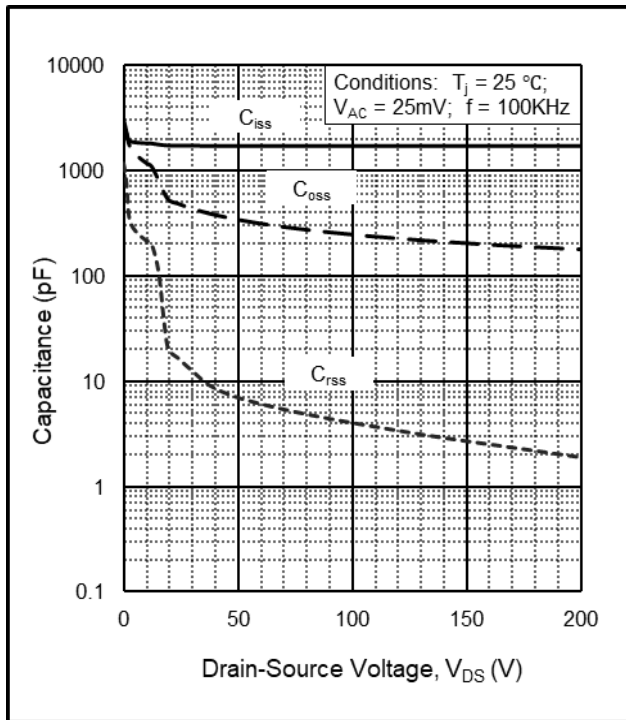


Figure 17. Capacitance vs. drain-source voltage  
(0 - 200V)

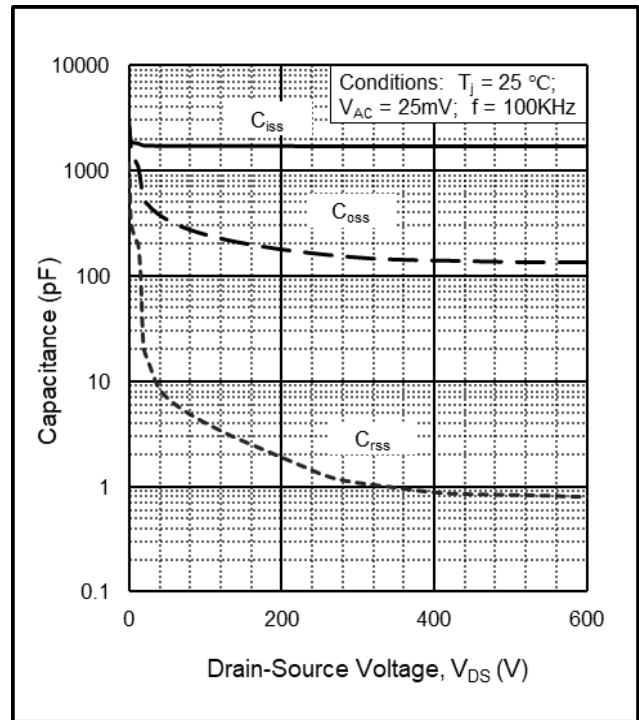


Figure 18. Capacitance vs. drain-source voltage  
(0 - 600V)

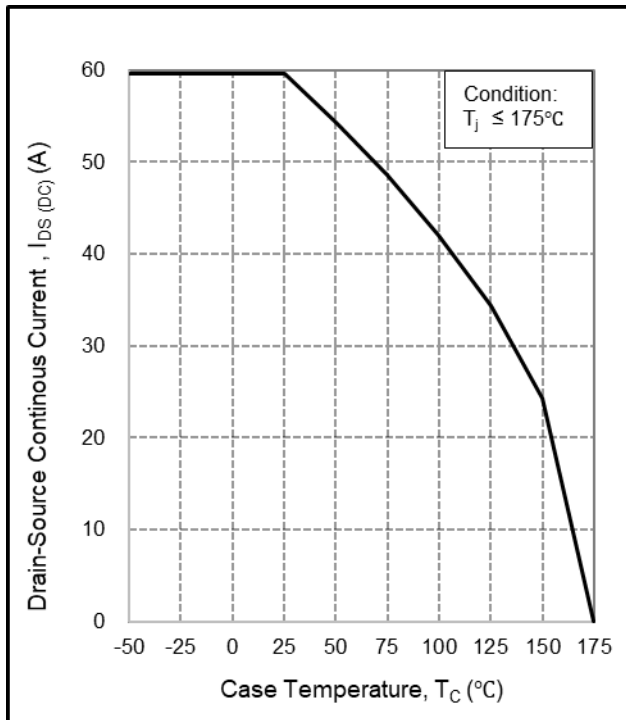


Figure 19. Continuous drain current derating  
vs. temperature

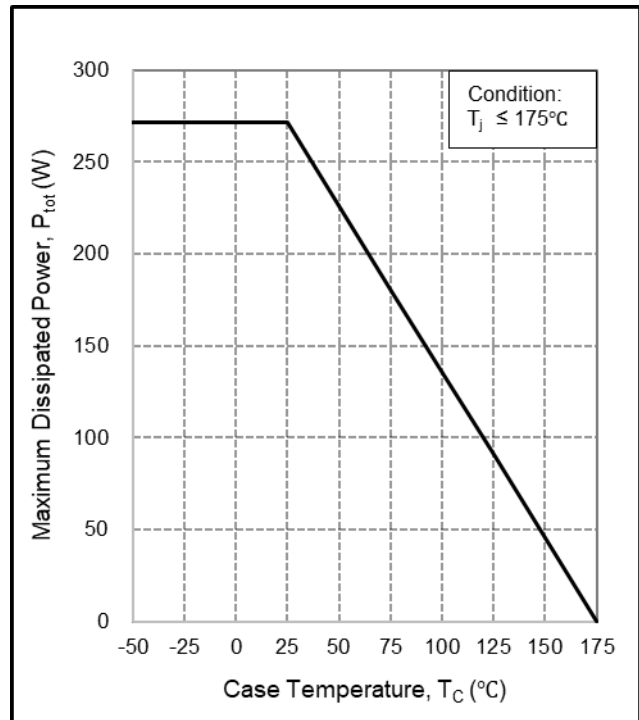


Figure 20. Maximum power dissipation derating  
vs. temperature

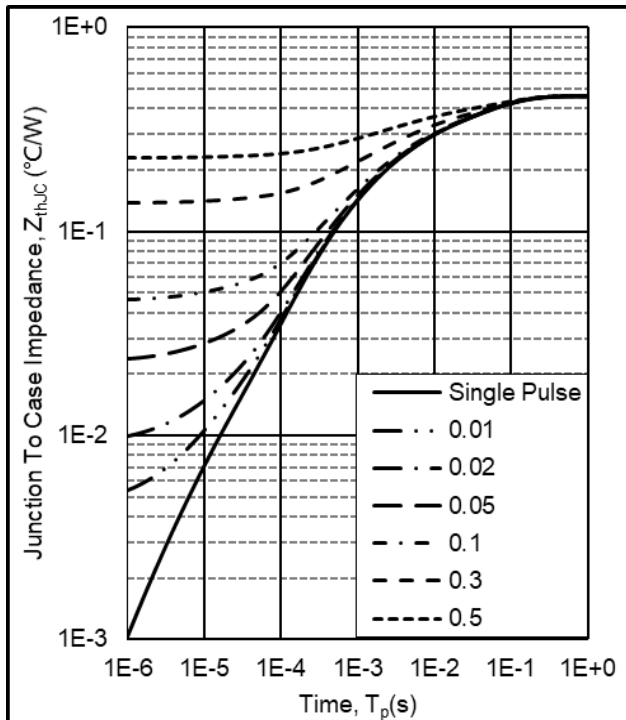


Figure 21. Transient thermal impedance  
(Junction - Case)

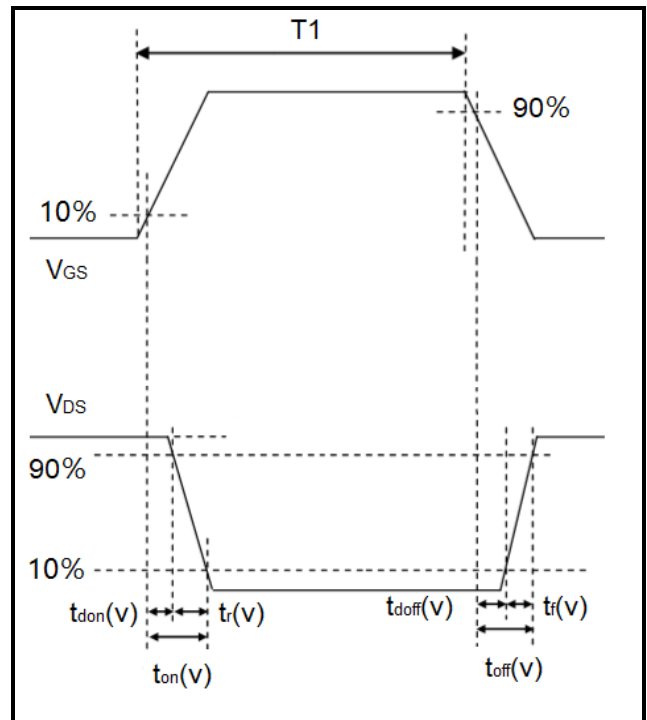


Figure 22. Switching times definition

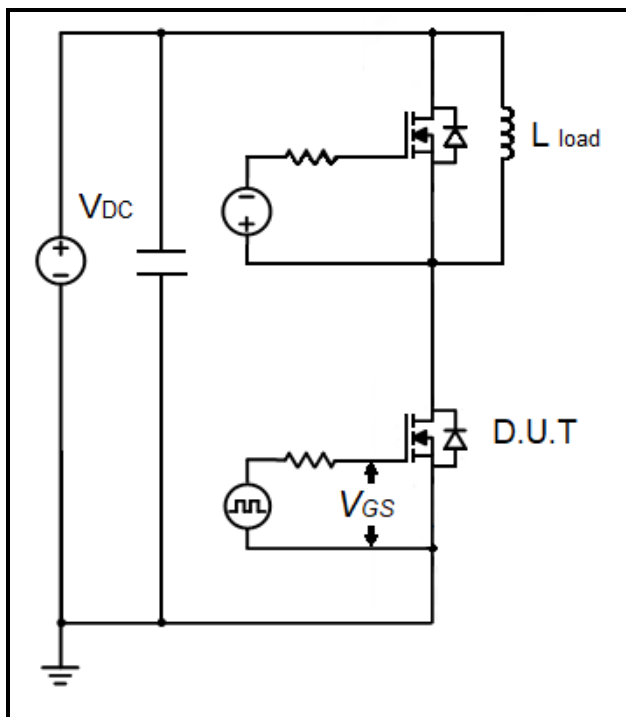
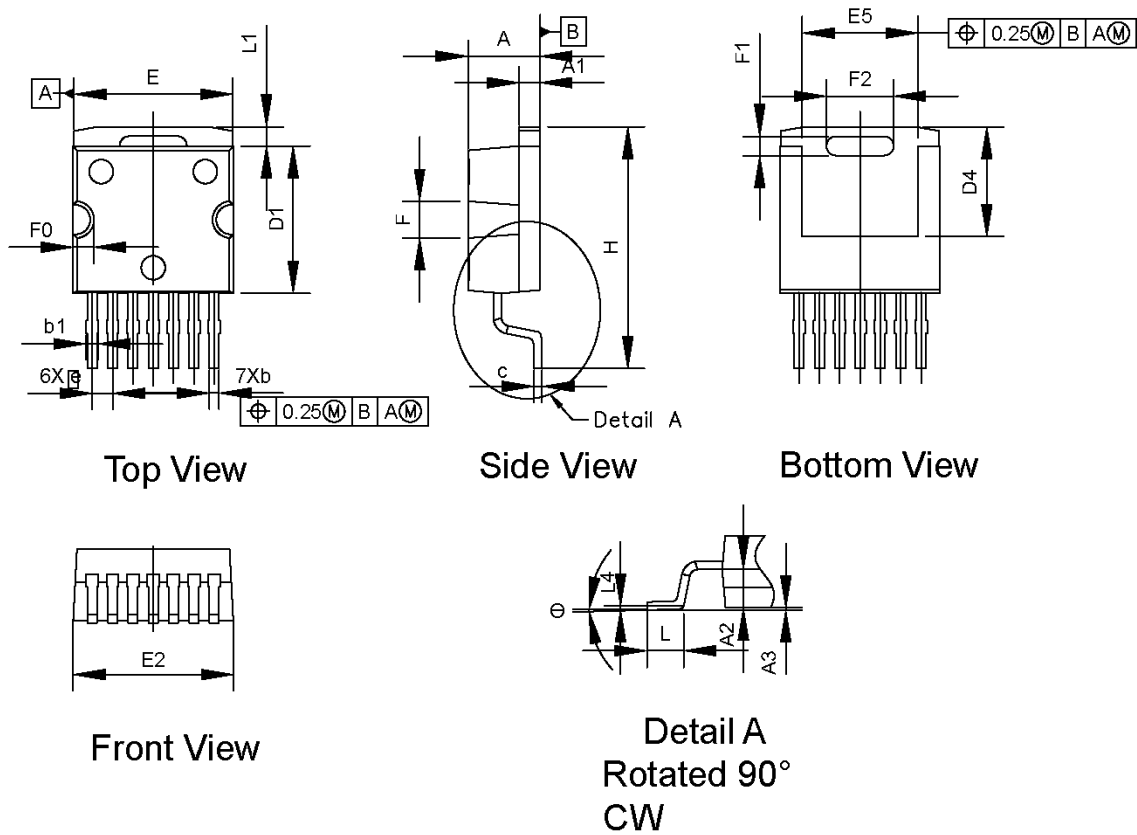


Figure 22. Clamped inductive switching waveform  
test circuit

## Package Information

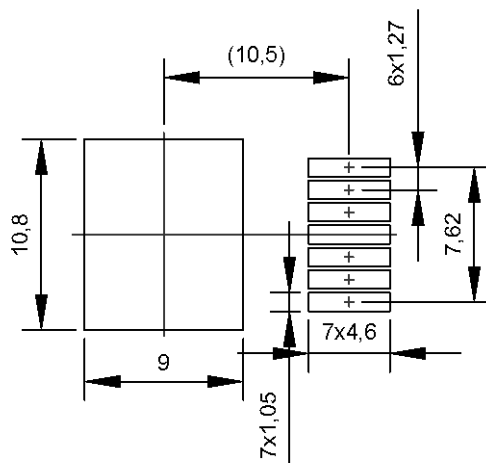


| Dimension unit: [mm] |          |       |       |
|----------------------|----------|-------|-------|
| Symbol               | Min      | Nom   | Max   |
| A                    | 4.30     | 4.50  | 4.70  |
| A1                   | 1.15     | 1.30  | 1.45  |
| A2                   | 2.20     | 2.40  | 2.90  |
| A3                   | 0.00     | 0.13  | 0.25  |
| b                    | 0.51     | 0.60  | 0.70  |
| b1                   | 0.60     | 0.76  | 0.85  |
| c                    | 0.45     | 0.50  | 0.60  |
| D1                   | 8.59     | 9.20  | 9.40  |
| D4                   | 6.86     | -     | -     |
| E                    | 9.66     | 9.90  | 10.28 |
| E2                   | 9.80     | 10.00 | 10.20 |
| E5                   | 6.72     | -     | 7.72  |
| e                    | 1.27 BSC |       |       |
| H                    | 14.70    | 15.30 | 15.90 |
| L                    | 2.00     | 2.30  | 2.60  |
| L1                   | -        | -     | 1.676 |
| L4                   | 0.25 BSC |       |       |

| Dimension unit: [mm] |         |     |     |
|----------------------|---------|-----|-----|
| Symbol               | Min     | Nom | Max |
| F                    | 2.3 REF |     |     |
| F0                   | 1.2 TYP |     |     |
| F1                   | 1.2 REF |     |     |
| F2                   | 4.2 REF |     |     |
| θ                    | 0°      | -   | 8°  |

## Recommended Solder Pad Layout

Note: All dimensions are in mm



**TO-263-7L**

## Ordering Information

|               |                   |
|---------------|-------------------|
| Part number   | SMS0650035P-ISARH |
| Package       | TO-263-7L         |
| Unit quantity | 800 EA            |
| Packing type  | Tape & Reel       |

## Important Notices – Read Carefully

Before you use our products, you are requested to carefully read this document and fully understand its contents. Sanan Semiconductor Co., Ltd. shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of Sanan's products.

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