

## General Description

The silicon carbide power MOSFET utilizes Oriental-Semi's advanced technology to achieve low on-resistance, low gate charge, low Qrr and excellent thermal performance by exploiting innovative properties of wide bandgap materials. It is engineered to minimize conduction loss and provide superior switching performance almost independent of temperature.

The silicon carbide power MOSFET provides high reliability and extremely high efficiency. It is targeted to improve application performance in frequency, energy efficiency, reliability, system size and weight reduction.

## Features

- High blocking voltage with low on-resistance
- High-speed switching with low capacitances
- IGBT-compatible driving voltage (15V for turn-on)
- Fast intrinsic diode with low reverse recovery (Qrr)
- Temperature independent turn-off switching losses
- Halogen free, RoHS compliant

## Applications

- On-board charger/PFC
- EV motor drive
- High voltage DC/DC converters
- Switch mode power supplies

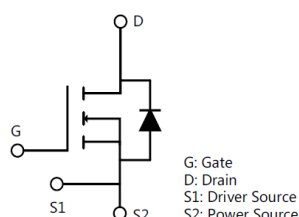
## Key Performance Parameters

| Parameter                         | Value | Unit       |
|-----------------------------------|-------|------------|
| $V_{DS}$                          | 650   | V          |
| $I_D$ , pulse                     | 183   | A          |
| $R_{DS(ON)}$ , typ @ $V_{GS}=18V$ | 25    | m $\Omega$ |
| $Q_g$                             | 83    | nC         |

## Marking Information

| Product Name      | Package     | Marking       |
|-------------------|-------------|---------------|
| OSQ65R025H4T2F_NB | TO247-4L-NL | OSQ65R025H4T2 |

## Package & Pin Information



**Absolute Maximum Ratings** at  $T_j=25^{\circ}\text{C}$  unless otherwise noted

| Parameter                                                          | Symbol                 | Value      | Unit               |
|--------------------------------------------------------------------|------------------------|------------|--------------------|
| Drain-source voltage                                               | $V_{DS}$               | 650        | V                  |
| Gate-source voltage (max static)                                   | $V_{GS}$               | -8/+22     | V                  |
| Gate-source voltage (recommended operating values)                 | $V_{GS}$               | -4/+18     | V                  |
| Continuous drain current <sup>1)</sup> , $T_C=25^{\circ}\text{C}$  | $I_D$                  | 64         | A                  |
| Continuous drain current <sup>1)</sup> , $T_C=100^{\circ}\text{C}$ |                        | 50         |                    |
| Pulsed drain current <sup>2)</sup>                                 | $I_{D, \text{ pulse}}$ | 183        | A                  |
| Power dissipation <sup>3)</sup> , $T_C=25^{\circ}\text{C}$         | $P_D$                  | 250        | W                  |
| Operation and storage temperature                                  | $T_{\text{stg}}, T_j$  | -55 to 175 | $^{\circ}\text{C}$ |

**Thermal Characteristics**

| Parameter                            | Symbol          | Min. | Typ. | Max. | Unit                 |
|--------------------------------------|-----------------|------|------|------|----------------------|
| Thermal resistance, junction-case    | $R_{\theta JC}$ |      | 0.46 | 0.60 | $^{\circ}\text{C/W}$ |
| Thermal resistance, junction-ambient | $R_{\theta JA}$ |      |      | 62   | $^{\circ}\text{C/W}$ |

**Electrical Characteristics** at  $T_j=25^{\circ}\text{C}$  unless otherwise specified

| Parameter                        | Symbol       | Min. | Typ. | Max.      | Unit          | Test condition                                                    |
|----------------------------------|--------------|------|------|-----------|---------------|-------------------------------------------------------------------|
| Drain-source breakdown voltage   | $BV_{DSS}$   | 650  |      |           | V             | $V_{GS}=0\text{ V}, I_D=100\text{ }\mu\text{A}$                   |
| Gate threshold voltage           | $V_{GS(th)}$ | 2.3  | 2.8  | 3.6       | V             | $V_{DS}=V_{GS}, I_D=10\text{ mA}$                                 |
| Drain-source on-state resistance | $R_{DS(ON)}$ |      | 25   | 33        | m $\Omega$    | $V_{GS}=18\text{ V}, I_D=40\text{ A}$                             |
|                                  |              |      | 32   |           |               | $V_{GS}=18\text{ V}, I_D=40\text{ A}, T_j=175^{\circ}\text{C}$    |
|                                  |              |      | 33   | 43        | m $\Omega$    | $V_{GS}=15\text{ V}, I_D=40\text{ A}$                             |
|                                  |              |      | 35   |           |               | $V_{GS}=15\text{ V}, I_D=40\text{ A}, T_j=175^{\circ}\text{C}$    |
| Transconductance                 | $g_{fs}$     |      | 29   |           | S             | $V_{DS}=20\text{ V}, I_D=40\text{ A}$                             |
| Gate-source leakage current      | $I_{GSS}$    |      |      | $\pm 100$ | nA            | $V_{GS}=-8\sim 22\text{ V}$                                       |
| Drain-source leakage current     | $I_{DSS}$    |      |      | 100       | $\mu\text{A}$ | $V_{DS}=650\text{ V}, V_{GS}=0\text{ V}$                          |
|                                  |              |      |      | 500       | $\mu\text{A}$ | $V_{DS}=650\text{ V}, V_{GS}=0\text{ V}, T_j=175^{\circ}\text{C}$ |
| Gate resistance                  | $R_G$        |      | 1.8  |           | $\Omega$      | $f=1\text{ MHz}$ , Open drain, $V_{AC}=25\text{ mV}$              |

### Dynamic Characteristics

| Parameter                    | Symbol       | Min. | Typ. | Max. | Unit          | Test condition                                                                                                                                                |
|------------------------------|--------------|------|------|------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Input capacitance            | $C_{iss}$    |      | 2262 |      | pF            | $V_{GS}=0\text{ V}$ ,<br>$V_{DS}=400\text{ V}$ ,<br>$f=1\text{ MHz}$ ,<br>$V_{AC}=25\text{ mV}$                                                               |
| Output capacitance           | $C_{oss}$    |      | 194  |      | pF            |                                                                                                                                                               |
| Reverse transfer capacitance | $C_{rss}$    |      | 3.7  |      | pF            |                                                                                                                                                               |
| $C_{oss}$ stored energy      | $E_{oss}$    |      | 19   |      | $\mu\text{J}$ |                                                                                                                                                               |
| Turn-on delay time           | $t_{d(on)}$  |      | 14.2 |      | ns            | $V_{GS}=-4/18\text{ V}$ ,<br>$V_{DS}=400\text{ V}$ ,<br>$R_G=5\ \Omega$ ,<br>$I_D=40\text{ A}$ ,<br>$L=120\ \mu\text{H}$ ,<br>$T_j=25\text{ }^\circ\text{C}$  |
| Rise time                    | $t_r$        |      | 15.8 |      | ns            |                                                                                                                                                               |
| Turn-off delay time          | $t_{d(off)}$ |      | 25   |      | ns            |                                                                                                                                                               |
| Fall time                    | $t_f$        |      | 6.7  |      | ns            |                                                                                                                                                               |
| Turn-on switching energy     | $E_{on}$     |      | 78.5 |      | $\mu\text{J}$ |                                                                                                                                                               |
| Turn-off switching energy    | $E_{off}$    |      | 56   |      | $\mu\text{J}$ | $V_{GS}=-4/18\text{ V}$ ,<br>$V_{DS}=400\text{ V}$ ,<br>$R_G=5\ \Omega$ ,<br>$I_D=40\text{ A}$ ,<br>$L=120\ \mu\text{H}$ ,<br>$T_j=175\text{ }^\circ\text{C}$ |
| Turn-on switching energy     | $E_{on}$     |      | 66   |      | $\mu\text{J}$ |                                                                                                                                                               |
| Turn-off switching energy    | $E_{off}$    |      | 61   |      | $\mu\text{J}$ |                                                                                                                                                               |

### Gate Charge Characteristics

| Parameter          | Symbol   | Min. | Typ. | Max. | Unit | Test condition                                                            |
|--------------------|----------|------|------|------|------|---------------------------------------------------------------------------|
| Total gate charge  | $Q_g$    |      | 83   |      | nC   | $V_{GS}=-4/18\text{ V}$ ,<br>$V_{DS}=400\text{ V}$ ,<br>$I_D=40\text{ A}$ |
| Gate-source charge | $Q_{gs}$ |      | 28.6 |      | nC   |                                                                           |
| Gate-drain charge  | $Q_{gd}$ |      | 17   |      | nC   |                                                                           |

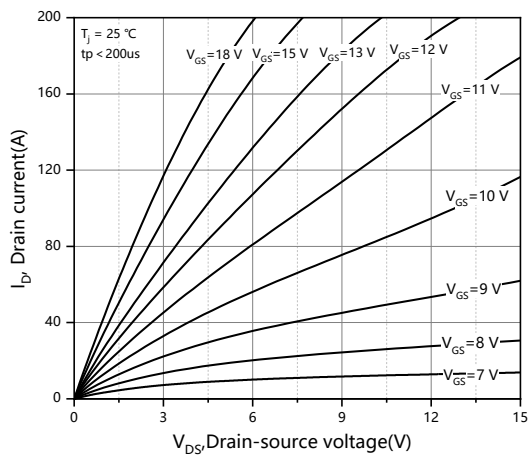
### Body Diode Characteristics

| Parameter                        | Symbol    | Min. | Typ. | Max. | Unit | Test condition                                                                                                                                    |
|----------------------------------|-----------|------|------|------|------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Diode forward voltage            | $V_{SD}$  |      | 4.1  |      | V    | $I_S=30\text{ A}$ ,<br>$V_{GS}=-4\text{ V}$ ,<br>$T_J=25\text{ }^{\circ}\text{C}$                                                                 |
|                                  |           |      | 3.6  |      | V    | $I_S=30\text{ A}$ ,<br>$V_{GS}=-4\text{ V}$ ,<br>$T_J=175\text{ }^{\circ}\text{C}$                                                                |
| Continuous diode forward current | $I_S$     |      | 64   |      | A    | $V_{GS}=-4\text{ V}$ ,<br>$T_J=25\text{ }^{\circ}\text{C}$                                                                                        |
| Reverse recovery time            | $t_{rr}$  |      | 14.2 |      | ns   | $V_{GS}=-4\text{ V}$ ,<br>$V_R=400\text{ V}$ ,<br>$I_S=40\text{ A}$ ,<br>$di/dt=3000\text{ A}/\mu\text{s}$ ,<br>$T_J=25\text{ }^{\circ}\text{C}$  |
| Reverse recovery charge          | $Q_{rr}$  |      | 170  |      | nC   |                                                                                                                                                   |
| Peak reverse recovery current    | $I_{rrm}$ |      | 21   |      | A    |                                                                                                                                                   |
| Reverse recovery time            | $t_{rr}$  |      | 26.3 |      | ns   | $V_{GS}=-4\text{ V}$ ,<br>$V_R=400\text{ V}$ ,<br>$I_S=40\text{ A}$ ,<br>$di/dt=1000\text{ A}/\mu\text{s}$ ,<br>$T_J=175\text{ }^{\circ}\text{C}$ |
| Reverse recovery charge          | $Q_{rr}$  |      | 200  |      | nC   |                                                                                                                                                   |
| Peak reverse recovery current    | $I_{rrm}$ |      | 12.3 |      | A    |                                                                                                                                                   |

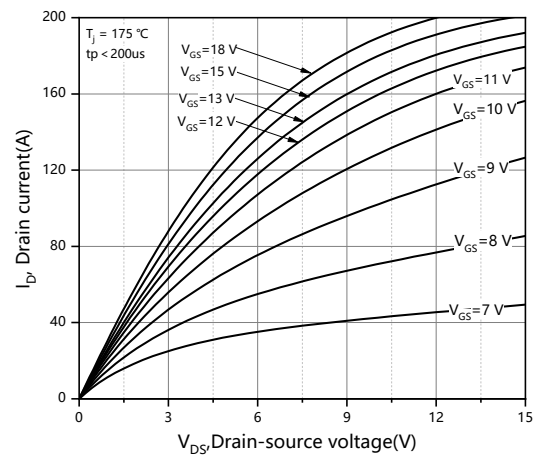
### Note

- 1) Calculated continuous current based on maximum allowable junction temperature.
- 2) Repetitive rating; pulse width limited by max. junction temperature.
- 3)  $P_d$  is based on max. junction temperature, using junction-case thermal resistance.

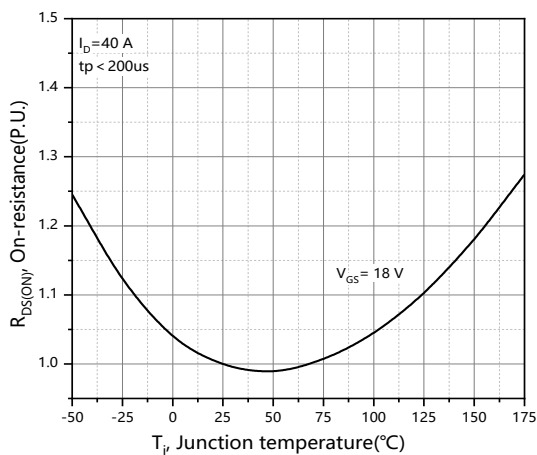
## Electrical Characteristics Diagrams



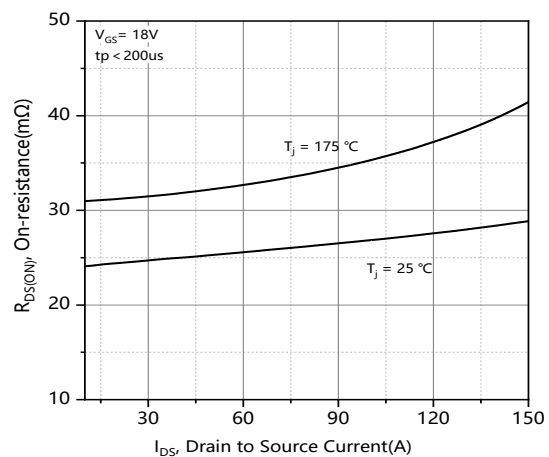
**Figure 1. Output characteristics  $T_j=25^{\circ}\text{C}$**



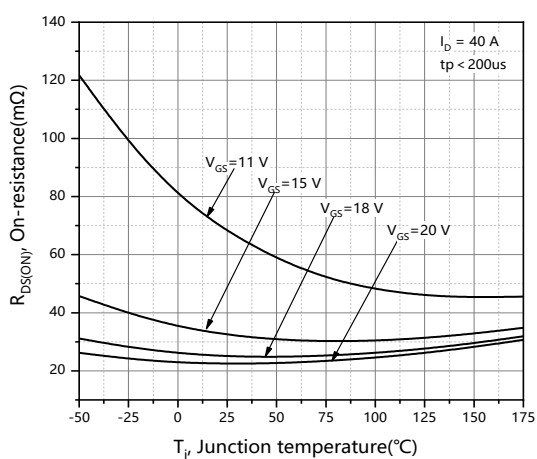
**Figure 2. Output characteristics  $T_j=175^{\circ}\text{C}$**



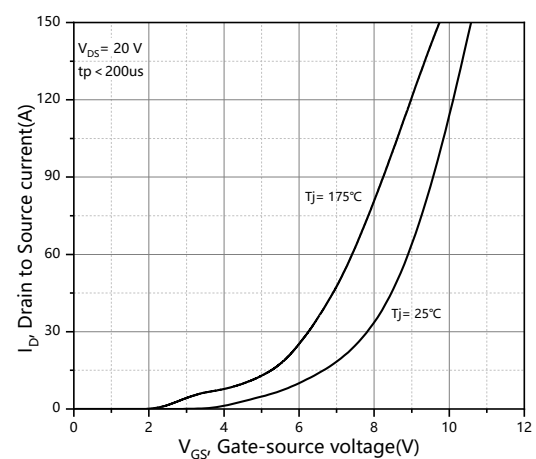
**Figure 3. Normalized on-resistance vs. temperature**



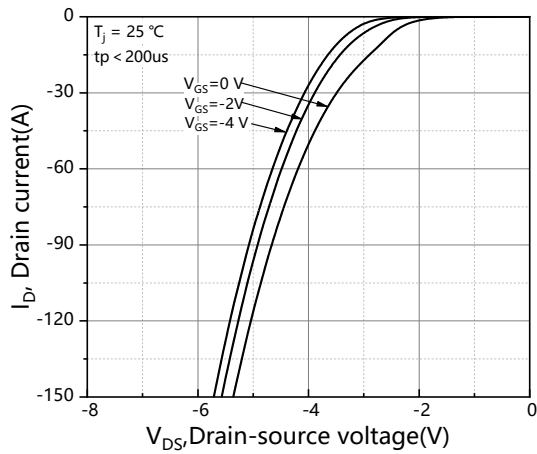
**Figure 4. On-resistance vs. drain current for various temperatures**



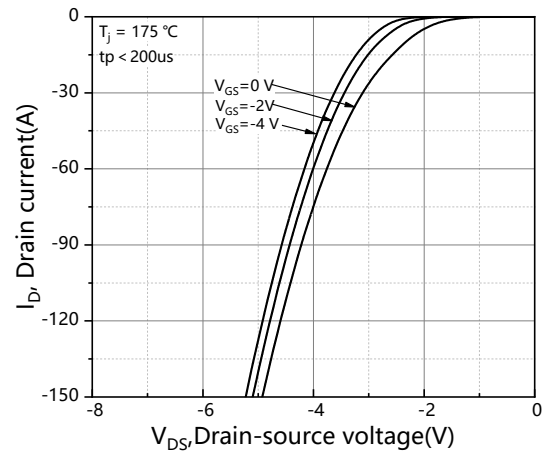
**Figure 5. On-resistance vs. temperature for various gate voltage**



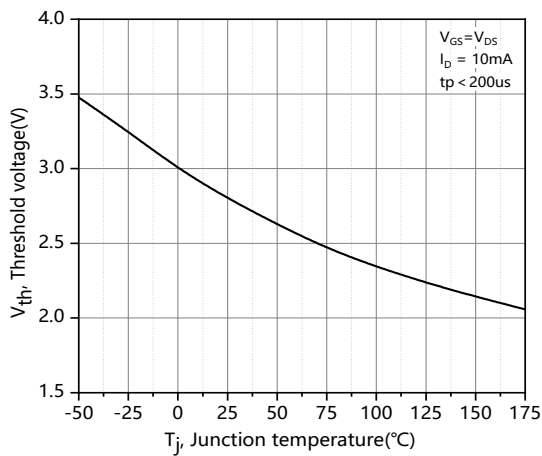
**Figure 6. Transfer characteristic for various junction temperatures**



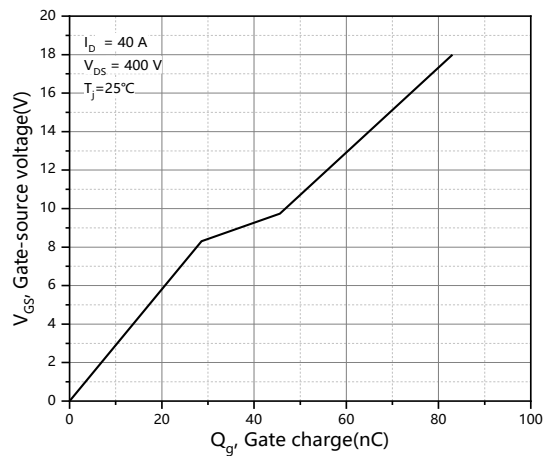
**Figure 7. Body diode characteristic at  $T_j = 25\text{ }^{\circ}\text{C}$**



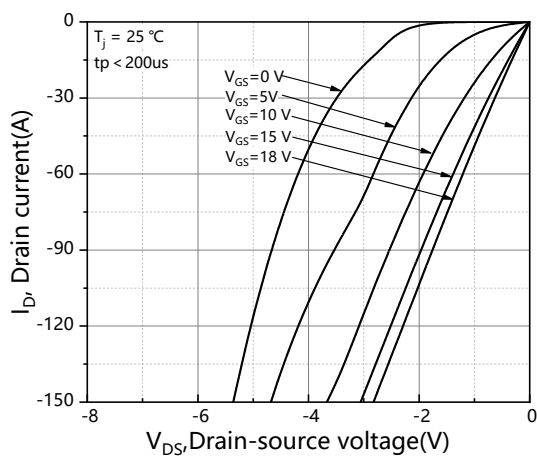
**Figure 8. Body diode characteristic at  $T_j = 175\text{ }^{\circ}\text{C}$**



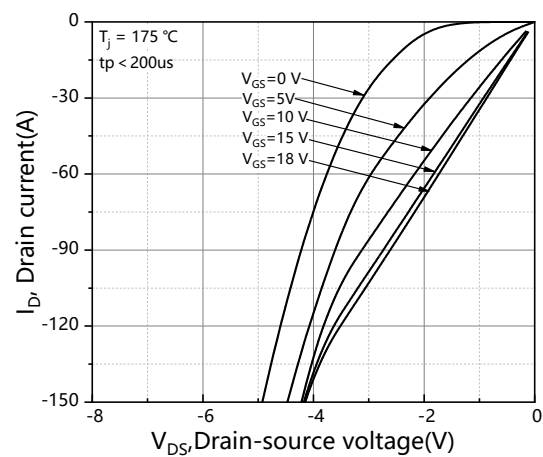
**Figure 9. Threshold voltage vs. temperature**



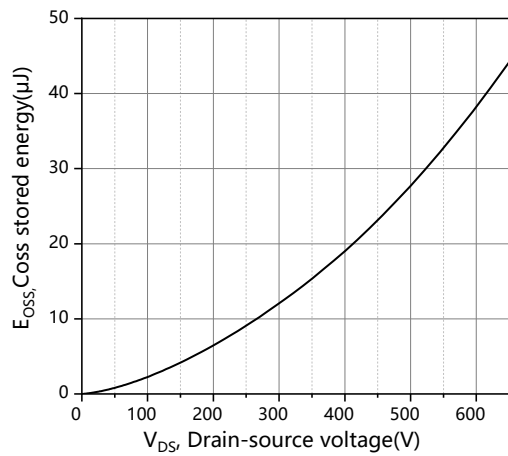
**Figure 10. Gate charge characteristic**



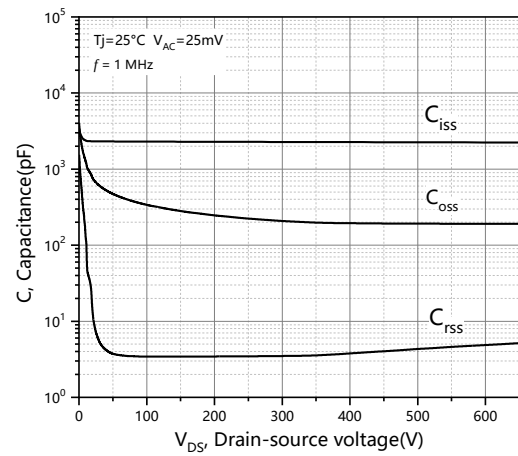
**Figure 11. 3rd quadrant characteristic  
at  $T_j = 25\text{ }^{\circ}\text{C}$**



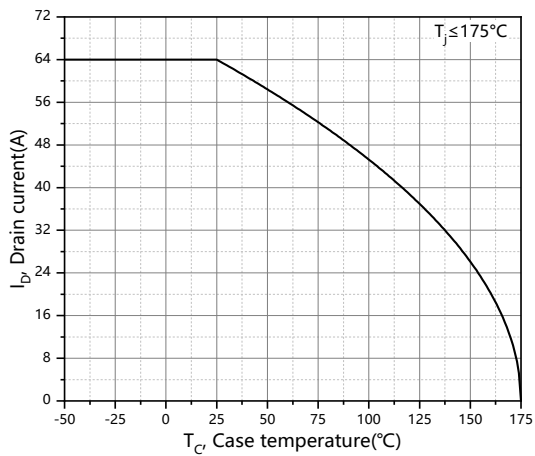
**Figure 12. 3rd quadrant characteristic  
at  $T_j = 175\text{ }^{\circ}\text{C}$**



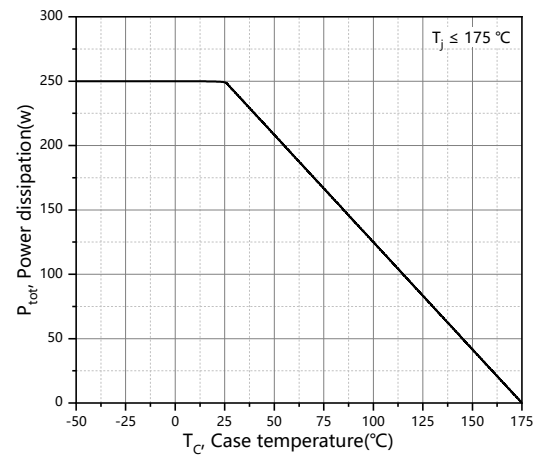
**Figure 13. Output capacitor stored energy**



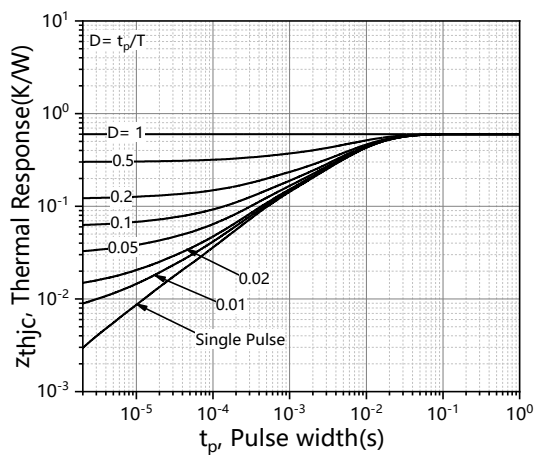
**Figure 14. Capacitances vs. drain-source voltage**



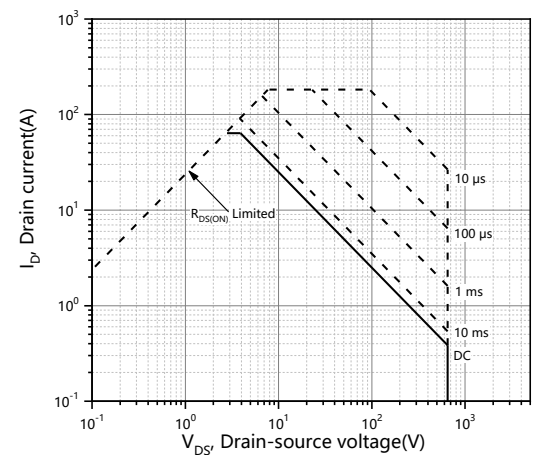
**Figure 15. Continuous drain current derating  
vs.case temperature**



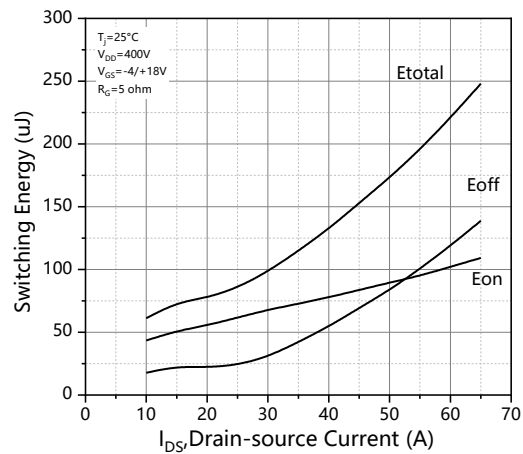
**Figure 16. Maximum power dissipation derating  
vs.case temperature**



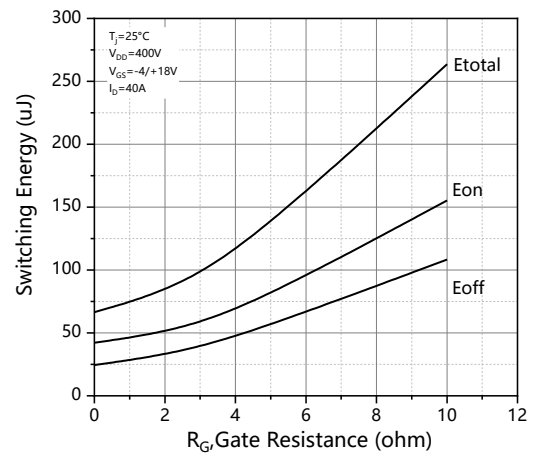
**Figure 17. Transient thermal impedance  
(junction - case)**



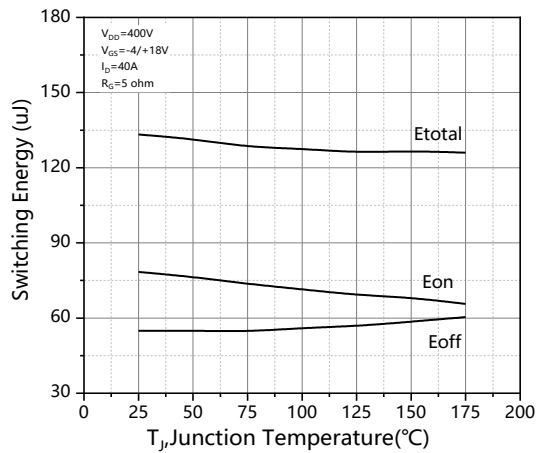
**Figure 18. Safe operating area**



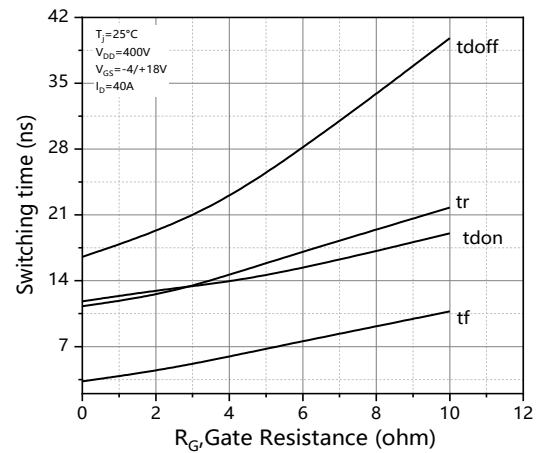
**Figure 19. Clamped inductive switching energy vs. drain current**



**Figure 20. Clamped inductive switching energy vs.  $R_G$**

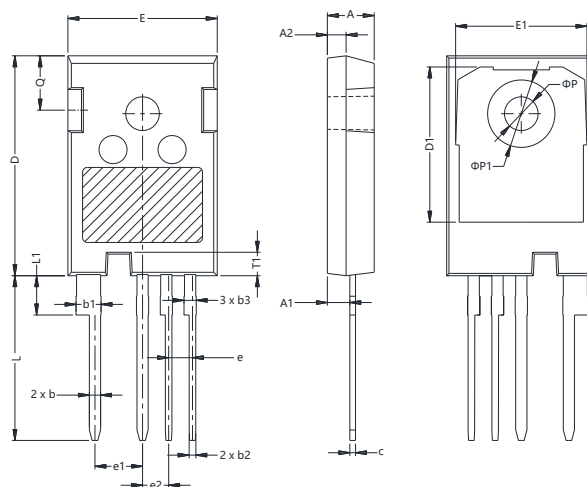


**Figure 21. Clamped inductive switching energy vs. temperature**



**Figure 22. Switching times vs.  $R_G$**

## Package Information



| Symbol | mm      |       |       |
|--------|---------|-------|-------|
|        | Min     | Nom   | Max   |
| A      | 4.80    | 5.00  | 5.20  |
| A1     | 2.21    | 2.41  | 2.61  |
| A2     | 1.80    | 2.00  | 2.20  |
| b      | 1.06    | 1.21  | 1.36  |
| b1     | 2.33    | 2.63  | 2.93  |
| b2     | 0.60    | 0.70  | 0.80  |
| b3     | 1.07    | 1.30  | 1.60  |
| c      | 0.51    | 0.61  | 0.75  |
| D      | 23.30   | 23.45 | 23.60 |
| D1     | 16.25   | 16.55 | 16.85 |
| E      | 15.74   | 15.94 | 16.14 |
| E1     | 13.72   | 14.02 | 14.32 |
| T1     | 2.35    | 2.50  | 2.65  |
| e      | 2.54BSC |       |       |
| e1     | 5.08BSC |       |       |
| e2     | 2.79BSC |       |       |
| Q      | 5.49    | 5.79  | 6.09  |
| L      | 17.27   | 17.57 | 17.87 |
| L1     | 3.99    | 4.19  | 4.39  |
| ΦP     | 3.40    | 3.60  | 3.80  |
| ΦP1    | 7.19REP |       |       |

Version : TO247-4L\_NL-P -package outline dimension

## Ordering Information

| Package Type  | Units/ Tube | Tubes/ Inner Box | Units/ Inner Box | Inner Boxes/ Carton Box | Units/ Carton Box |
|---------------|-------------|------------------|------------------|-------------------------|-------------------|
| TO247-4L-NL-P | 30          | 11               | 330              | 6                       | 1980              |

## Product Information

| Product           | Package     | Pb Free | RoHS | Halogen Free |
|-------------------|-------------|---------|------|--------------|
| OSQ65R025H4T2F_NB | TO247-4L_NL | yes     | yes  | yes          |

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