

## ● General Description

Through advanced trench and field stop technology to provide very low  $V_{CE(sat)}$ , low gate charge, and excellent switching performance.

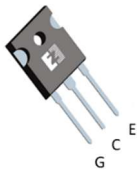
## ● Features

- Very low  $V_{CE(sat)}$
- Low switching power loss
- Low switching surge and noise
- Low thermal resistance
- High short circuit capability (10us)

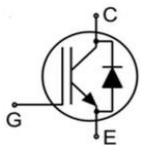
## ● Application

- Inverter
- Industrial motor drives
- Industrial power supplies

## ● Product Summary



TO-247


 $V_{CE}=1200V$ 
 $V_{CE(sat)}=1.65V$ 
 $I_C=40A$ 


## ● Ordering Information

|                           |                 |
|---------------------------|-----------------|
| Part NO.                  | ZMBG40N120SD1AC |
| Marking                   | BG40N120SD1A    |
| Packing information       | TUBE BULK       |
| Basic ordering unit (pcs) | 600             |

## ● Absolute Maximum Ratings ( $T_A=25^{\circ}C$ , unless otherwise specified)

| Parameter                      | Symbol        | Conditions                                     | Min. | Max. | Unit        |
|--------------------------------|---------------|------------------------------------------------|------|------|-------------|
| Collector-emitter voltage      | $V_{CE}$      |                                                | -    | 1200 | V           |
| Gate-emitter voltage           | $V_{GE}$      |                                                | -30  | 30   | V           |
| Continuous collector current   | $I_C$         | $V_{GE}=15V, T_C=25^{\circ}C$                  | -    | 80   | A           |
|                                | $I_C$         | $V_{GE}=15V, T_C=100^{\circ}C$                 | -    | 40   | A           |
| Pulsed collector current       | $I_{CM}$      | Pulsed; $t_p \leq 10 \mu s; T_C = 25^{\circ}C$ | -    | 160  | A           |
| Diode forward current          | $I_F$         | $V_{GE}=0V, T_C=25^{\circ}C$                   | -    | 80   | A           |
|                                |               | $V_{GE}=0V, T_C=100^{\circ}C$                  | -    | 40   | A           |
| Pulsed diode forward current   | $I_{F,pulse}$ | Pulsed; $t_p \leq 10 \mu s; T_C = 25^{\circ}C$ | -    | 160  | A           |
| Total power dissipation        | $P_D$         | $T_C=25^{\circ}C$                              | -    | 577  | W           |
| Total power dissipation        | $P_D$         | $T_A=25^{\circ}C$                              | -    | 3.8  | W           |
| Short circuit withstand time   | $T_{sc}$      | $V_{GE}=15 V, V_{CE}=800 V, T_J=150^{\circ}C$  | -    | 10   | us          |
| Operating junction temperature | $T_J$         |                                                | -55  | 175  | $^{\circ}C$ |
| Storage temperature            | $T_{STG}$     |                                                | -55  | 175  | $^{\circ}C$ |

### ● Thermal resistance

| Parameter                                 | Symbol     | Min. | Typ. | Max. | Unit |
|-------------------------------------------|------------|------|------|------|------|
| Thermal resistance, junction - case IGBT  | $R_{thJC}$ | -    | -    | 0.26 | °C/W |
| Thermal resistance, junction - case diode | $R_{thJC}$ | -    | -    | 0.5  | °C/W |
| Thermal resistance, junction - ambient    | $R_{thJA}$ | -    | -    | 40   | °C/W |
| Soldering temperature (total time<10s)    | $T_{sold}$ | -    | -    | 260  | °C   |

### ● Electronic Characteristics ( $T_J=25^{\circ}\text{C}$ , unless otherwise specified)

| Parameter                            | Symbol        | Condition                                          | Min. | Typ. | Max. | Unit    |
|--------------------------------------|---------------|----------------------------------------------------|------|------|------|---------|
| Collector-emitter breakdown voltage  | $BV_{CES}$    | $V_{GE}=0V, I_C=250\mu A$                          | 1200 | -    | -    | V       |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $V_{GE}=V_{CE}, I_C=1.5mA$                         | 4.8  | 5.8  | 6.8  | V       |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{GE}=0V, V_{CE}=1200V, T_J=25^{\circ}\text{C}$  | -    | -    | 10   | $\mu A$ |
|                                      |               | $V_{GE}=0V, V_{CE}=1200V, T_J=175^{\circ}\text{C}$ | -    | -    | 10   | mA      |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{GE}=\pm 30V, V_{CE}=0V$                        | -    | -    | 100  | nA      |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE}=15V, I_C=40A, T_J=25^{\circ}\text{C}$      | -    | 1.65 | 2.2  | V       |
|                                      |               | $V_{GE}=15V, I_D=40A, T_J=175^{\circ}\text{C}$     | -    | 2.2  | -    | V       |
| Forward transconductance             | $g_{FS}$      | $V_{CE}=20V, I_C=40A$                              | -    | 22   | -    | S       |
| Diode forward voltage                | $V_F$         | $I_F=40A, T_C=25^{\circ}\text{C}$                  | -    | 1.85 | 2.3  | V       |
|                                      |               | $I_F=40A, T_C=175^{\circ}\text{C}$                 | -    | 1.55 | 2    | V       |

### ● Dynamic characteristics ( $T_J=25^{\circ}\text{C}$ , unless otherwise specified)

| Parameter                        | Symbol    | Condition                                                                     | Min.        | Typ.  | Max. | Unit     |
|----------------------------------|-----------|-------------------------------------------------------------------------------|-------------|-------|------|----------|
| Input capacitance                | $C_{ies}$ | $f=100\text{KHz}, V_{CE}=600V, V_{GE}=0V$                                     | -           | 6350  | -    | pF       |
| Output capacitance               | $C_{oes}$ |                                                                               | -           | 52    | -    | pF       |
| Reverse transfer capacitance     | $C_{res}$ |                                                                               | -           | 13    | -    | pF       |
| Gate resistance                  | $R_g$     | $f=1\text{MHz}$                                                               | -           | 1.9   | -    | $\Omega$ |
| Total gate charge                | $Q_g$     | $V_{CC}=600V, I_C=40A, V_{GE}=15V$                                            | -           | 211.1 | -    | nC       |
| Gate-emitter charge              | $Q_{ge}$  |                                                                               | -           | 59.2  | -    | nC       |
| Gate-collector charge            | $Q_{gc}$  |                                                                               | -           | 83.2  | -    | nC       |
| Reverse Bias Safe Operating Area | RBSOA     | $T_J=25^{\circ}\text{C}, V_{CC}=1200V, I_C=160A, V_{GE}=15V/0V, R_g=10\Omega$ | Full Square |       |      | -        |

### ● Switching characteristics ( $T_J=25^{\circ}\text{C}$ )

| Parameter              | Symbol       | Condition                                                                                                                                      | Min. | Typ. | Max. | Unit |
|------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| Turn-on delay time     | $t_{d(on)}$  | $T_J=25^{\circ}\text{C}$<br>$V_{GE}=15/0\text{V}$ ,<br>$V_{CE}=600\text{V}$ ,<br>$R_G=6.2\Omega$ ,<br>$I_C=40\text{A}$ ,<br>$L=100\mu\text{H}$ | -    | 61   | -    | ns   |
| Turn-on rise time      | $t_r$        |                                                                                                                                                | -    | 107  | -    | ns   |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                | -    | 184  | -    | ns   |
| Turn-off fall time     | $t_f$        |                                                                                                                                                | -    | 155  | -    | ns   |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                | -    | 2.58 | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                | -    | 2.38 | -    | mJ   |
| Total switching energy | $E_{ts}$     |                                                                                                                                                | -    | 4.96 | -    | mJ   |

### ● Switching characteristics ( $T_J=175^{\circ}\text{C}$ )

| Parameter              | Symbol       | Condition                                                                                                                                       | Min. | Typ. | Max. | Unit |
|------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| Turn-on delay time     | $t_{d(on)}$  | $T_J=175^{\circ}\text{C}$<br>$V_{GE}=15/0\text{V}$ ,<br>$V_{CE}=600\text{V}$ ,<br>$R_G=6.2\Omega$ ,<br>$I_C=40\text{A}$ ,<br>$L=100\mu\text{H}$ | -    | 73   | -    | ns   |
| Turn-on rise time      | $t_r$        |                                                                                                                                                 | -    | 101  | -    | ns   |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                 | -    | 214  | -    | ns   |
| Turn-off fall time     | $t_f$        |                                                                                                                                                 | -    | 260  | -    | ns   |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                 | -    | 2.75 | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                 | -    | 3.1  | -    | mJ   |
| Total switching energy | $E_{ts}$     |                                                                                                                                                 | -    | 5.85 | -    | mJ   |

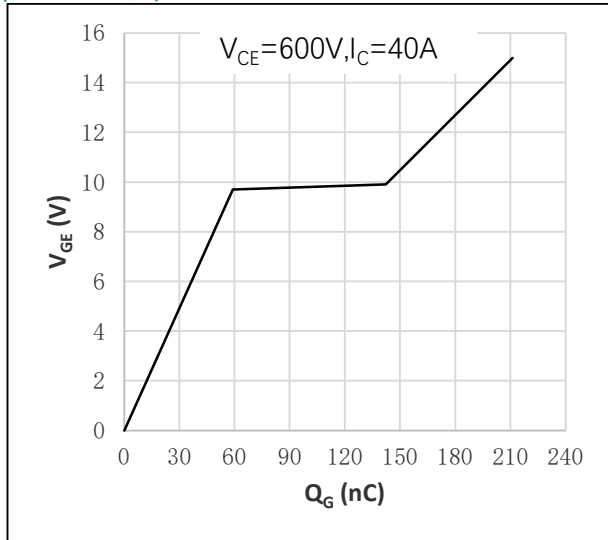
### ● Diode switching characteristics ( $T_J=25^{\circ}\text{C}$ )

| Parameter               | Symbol    | Condition                                                                                                 | Min. | Typ. | Max. | Unit          |
|-------------------------|-----------|-----------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| Reverse recovery time   | $t_{rr}$  | $T_J=25^{\circ}\text{C}$<br>$V_R=600\text{V}$ , $I_F=40\text{A}$ ,<br>$di_F/dt=520\text{A}/\mu\text{s}$ , | -    | 332  | -    | ns            |
| Reverse recovery charge | $Q_{rr}$  |                                                                                                           | -    | 3.0  | -    | $\mu\text{C}$ |
| Reverse recovery        | $I_{rrm}$ |                                                                                                           | -    | 25.4 | -    | A             |
| Reverse recovery energy | $E_{rr}$  |                                                                                                           | -    | 579  | -    | $\mu\text{J}$ |

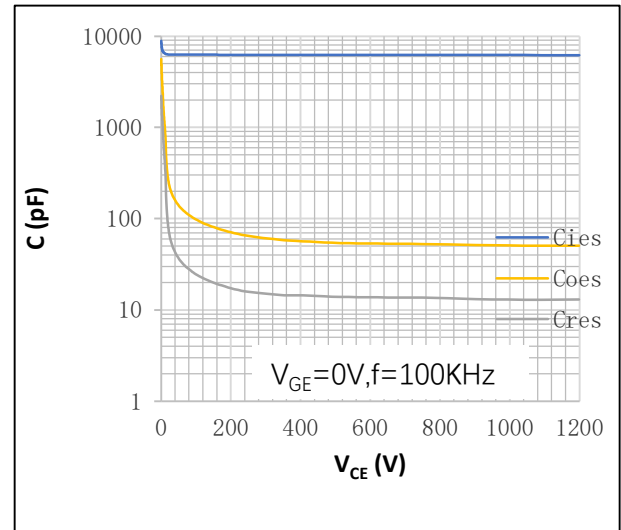
### ● Switching characteristics ( $T_J=175^{\circ}\text{C}$ )

| Parameter               | Symbol    | Condition                                                                                                  | Min. | Typ. | Max. | Unit          |
|-------------------------|-----------|------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| Reverse recovery time   | $t_{rr}$  | $T_J=175^{\circ}\text{C}$<br>$V_R=600\text{V}$ , $I_F=40\text{A}$ ,<br>$di_F/dt=520\text{A}/\mu\text{s}$ , | -    | 649  | -    | ns            |
| Reverse recovery charge | $Q_{rr}$  |                                                                                                            | -    | 9.2  | -    | $\mu\text{C}$ |
| Reverse recovery        | $I_{rrm}$ |                                                                                                            | -    | 42   | -    | A             |
| Reverse recovery energy | $E_{rr}$  |                                                                                                            | -    | 1790 | -    | $\mu\text{J}$ |

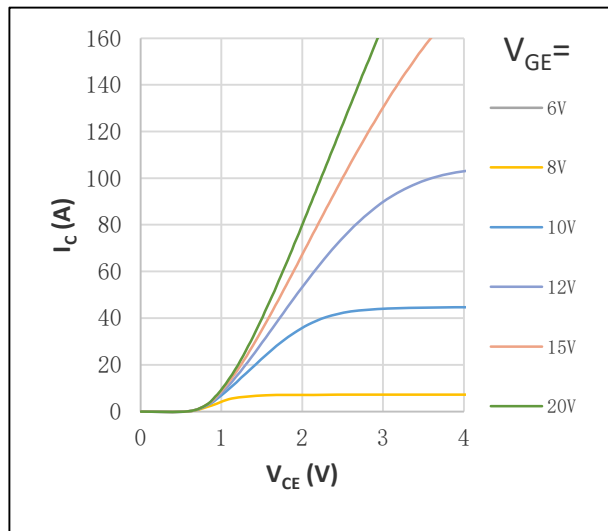
● Fig.1 Gate-emitter voltage as a function of gate charge;  
Typical values;  $T_j=25^\circ\text{C}$



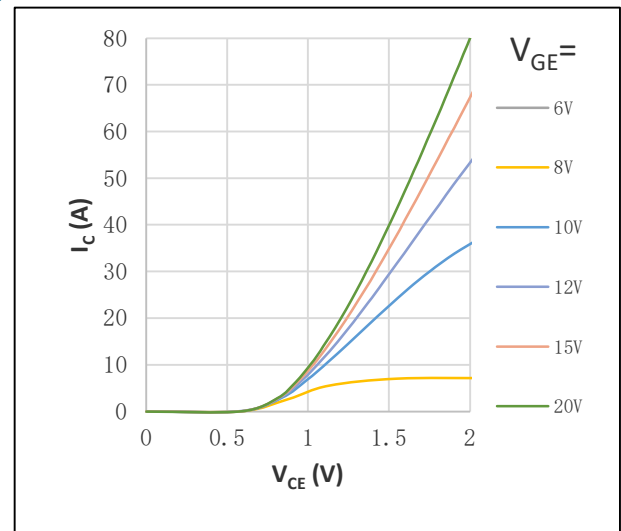
● Fig.2 Input, output and reverse transfer capacitances as a function of collector-emitter voltage; Typical values;  $T_j=25^\circ\text{C}$



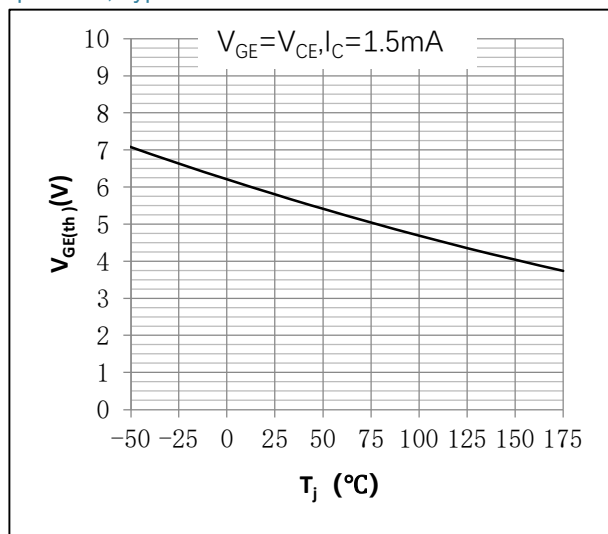
● Fig.3 Output characteristics: collector current as a function of collector-emitter voltage; Typical values;  $T_j=25^\circ\text{C}$



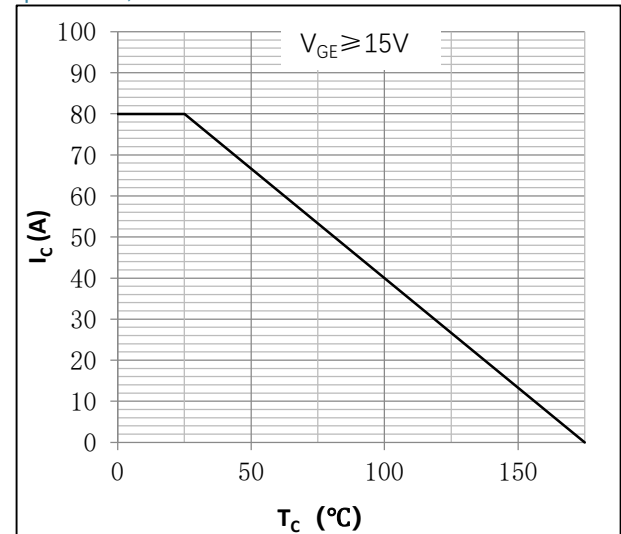
● Fig.4 Output characteristics: collector current as a function of collector-emitter voltage; Typical values: Expanded curve;  $T_j=25^\circ\text{C}$



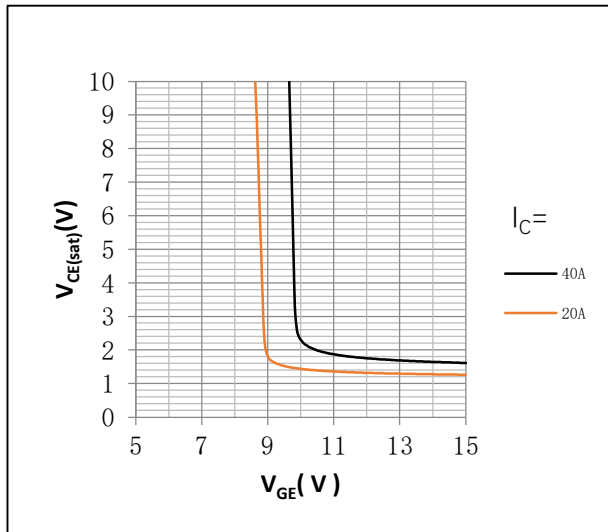
● Fig.5 Gate-emitter threshold voltage as a function of junction temperature; Typical values



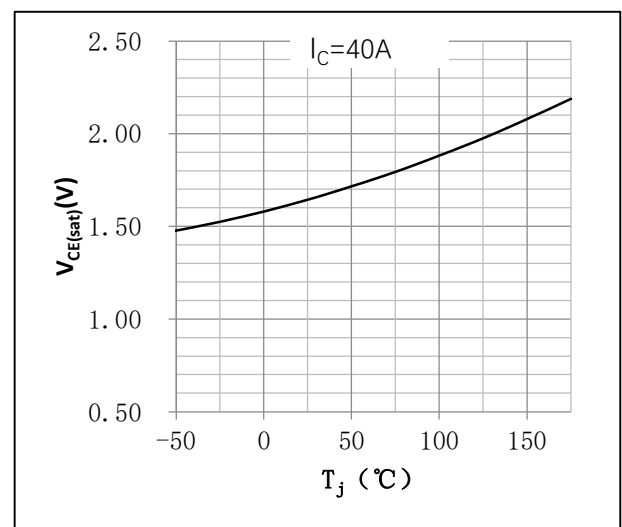
● Fig.6 Continuous collector current as a function of case temperature<sup>①</sup>; Calculative values



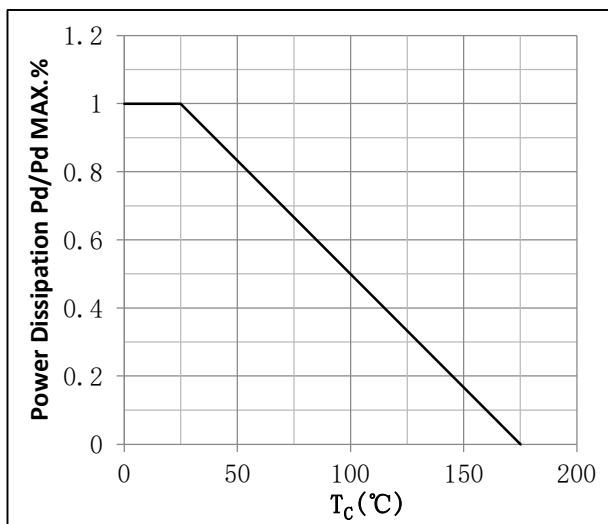
● Fig.7 Collector-emitter saturation voltage as a function of gate-emitter voltage; Typical values



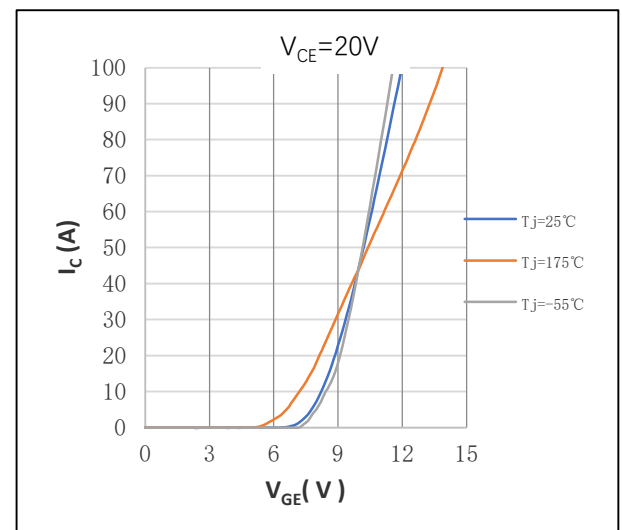
● Fig.8 Fig.6 Collector-emitter saturation voltage as a function of junction temperature; Typical values; T<sub>j</sub>=25°C



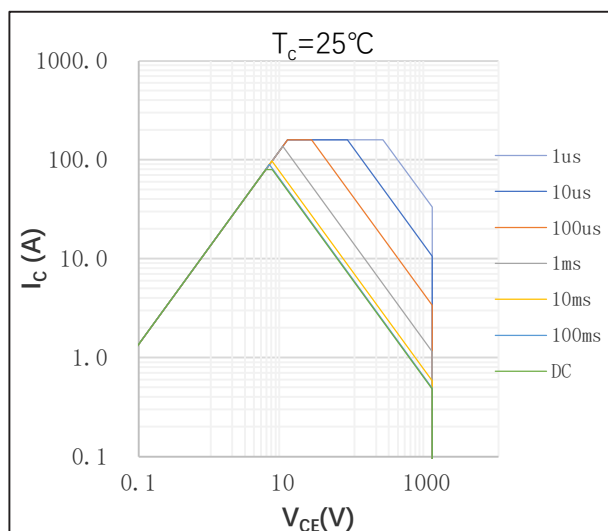
● Figure 9. Normalized total power dissipation as a function of case temperature; Calculative values Normalized Power Dissipation = P<sub>d</sub>/P<sub>d</sub>(25°C)



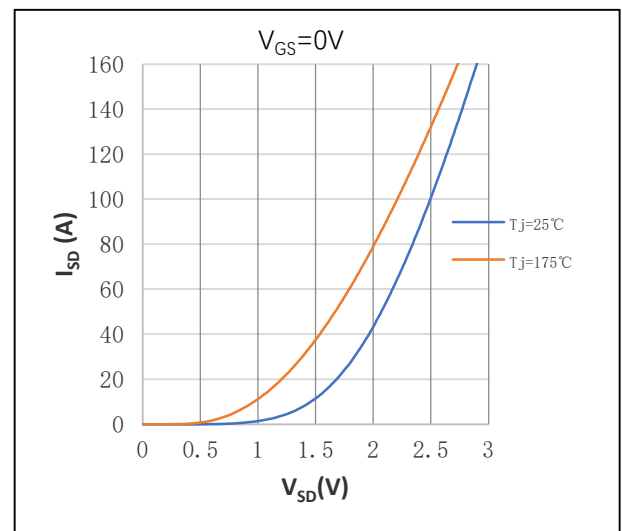
● Figure 10. Transfer characteristics: Collector current as a function of gate-emitter voltage; Typical values



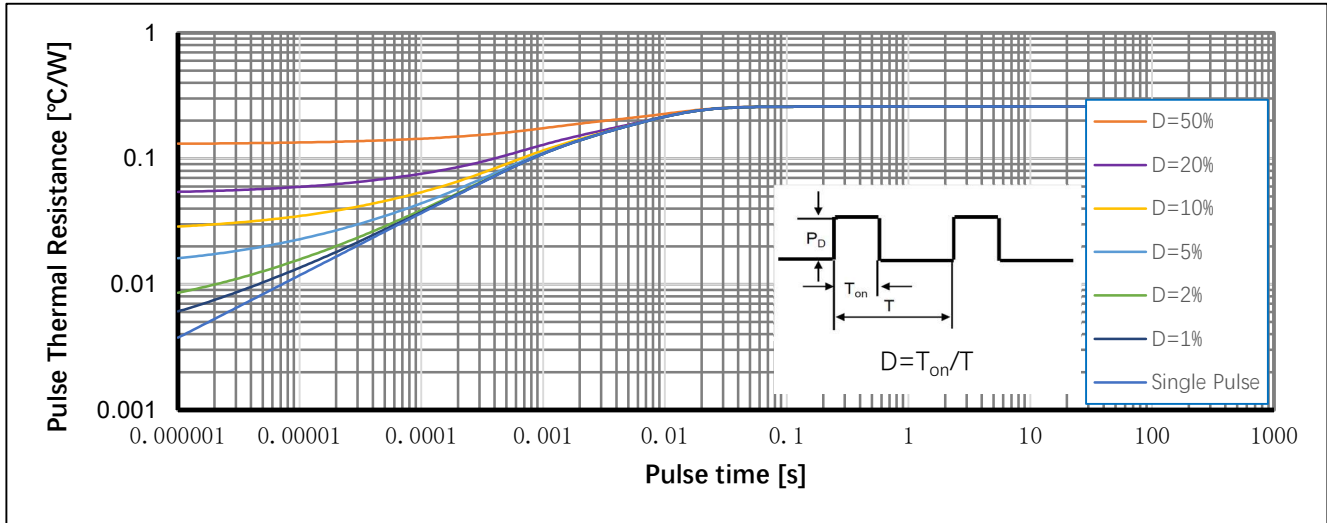
● Fig.11 Safe operating area: continuous and peak collector currents as a function of collector-emitter voltage; Calculative values



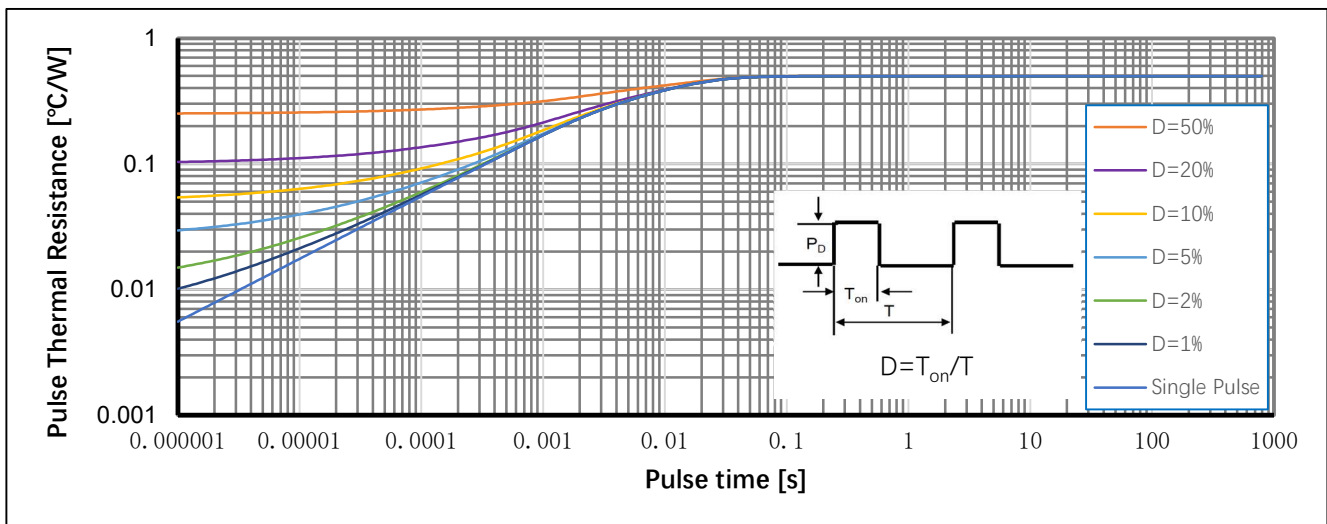
● Fig.12 Source (diode forward) current as a function of source-drain (diode forward) voltage; Typical values



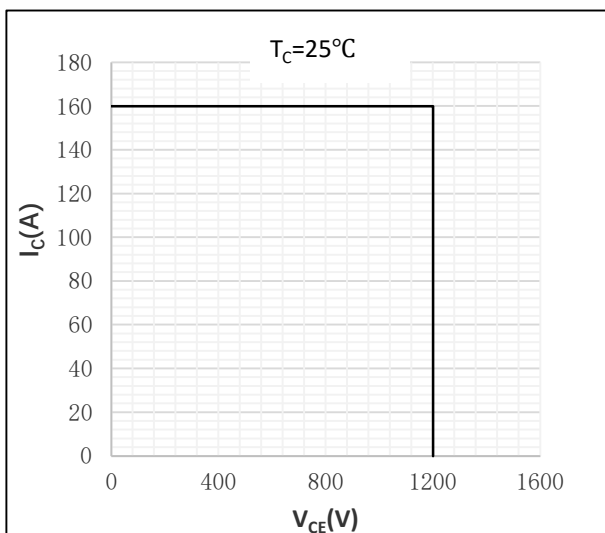
● Fig.13 Transient thermal impedance from junction to case -IGBT as a function of pulse duration; max values



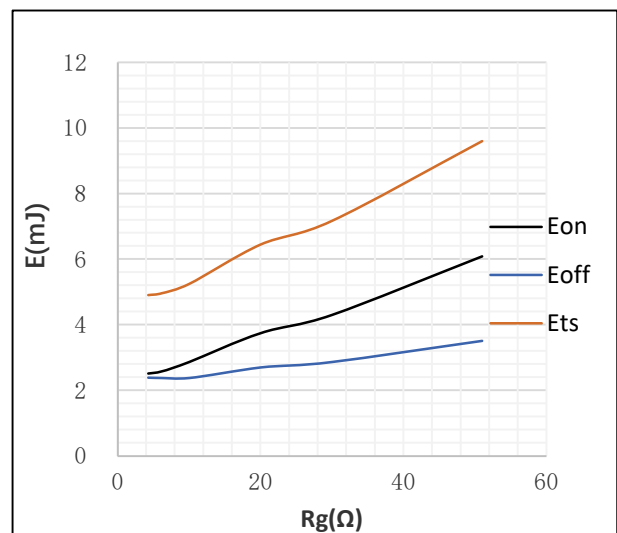
● Fig.14 Transient thermal impedance from junction to case -diode as a function of pulse duration; max values



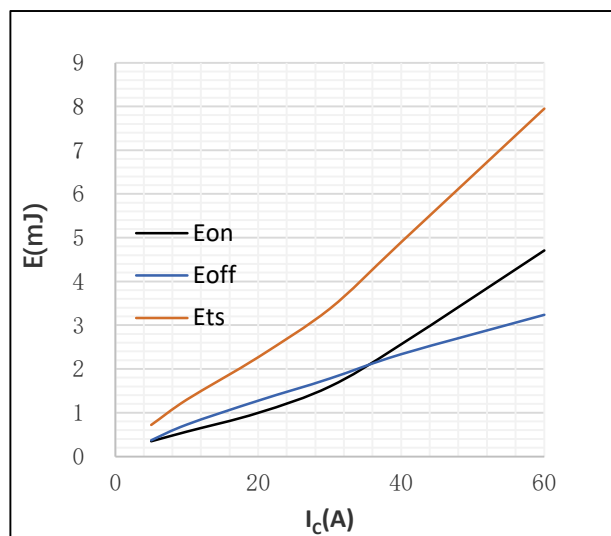
● Fig.15 Reverse bias safe operating area: peak collector currents as a function of collector-emitter voltage; Calculative values



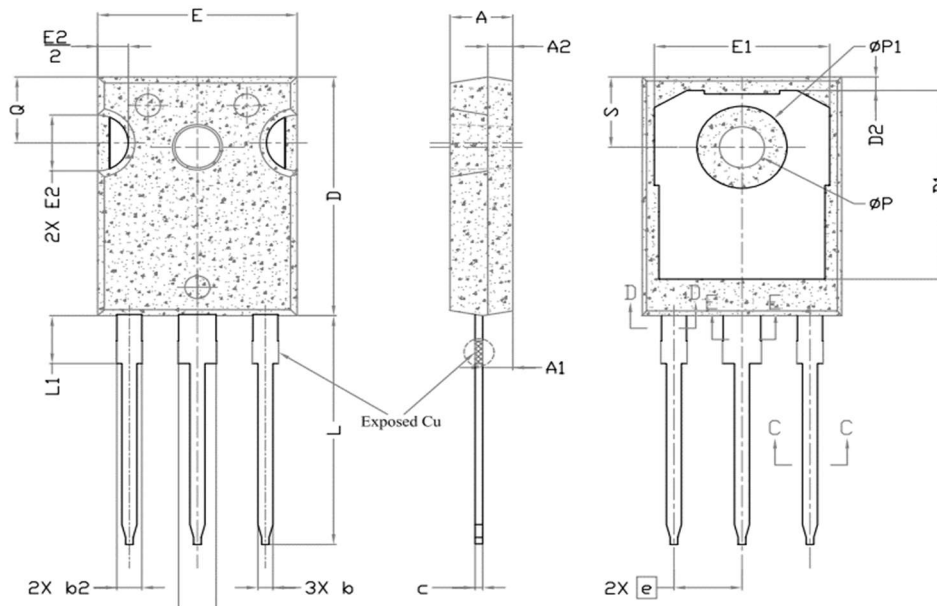
● Fig.16 Switching energy losses as a function of gate resistor; typical values



● Fig.16 Switching energy losses as a function of collector current; typical values



## ● Package Outline



| SYMBOL | DIMENSIONS |       |       | NOTES |
|--------|------------|-------|-------|-------|
|        | MIN.       | NOM.  | MAX.  |       |
| A      | 4.83       | 5.02  | 5.21  |       |
| A1     | 2.29       | 2.41  | 2.55  |       |
| A2     | 1.50       | 2.00  | 2.49  |       |
| b      | 1.12       | 1.20  | 1.33  |       |
| b1     | 1.12       | 1.20  | 1.28  |       |
| b2     | 1.91       | 2.00  | 2.39  | 6     |
| b3     | 1.91       | 2.00  | 2.34  |       |
| b4     | 2.87       | 3.00  | 3.22  | 6, 8  |
| b5     | 2.87       | 3.00  | 3.18  |       |
| c      | 0.55       | 0.60  | 0.69  | 6     |
| c1     | 0.55       | 0.60  | 0.65  |       |
| D      | 20.80      | 20.95 | 21.10 | 4     |
| D1     | 16.25      | 16.55 | 17.65 | 5     |
| D2     | 0.51       | 1.19  | 1.35  |       |
| E      | 15.75      | 15.94 | 16.13 | 4     |
| E1     | 13.46      | 14.02 | 14.16 | 5     |
| E2     | 4.32       | 4.91  | 5.49  | 3     |
| e      | 5.44BSC    |       |       |       |
| L      | 19.81      | 20.07 | 20.32 |       |
| L1     | 4.10       | 4.19  | 4.40  | 6     |
| ØP     | 3.56       | 3.61  | 3.65  | 7     |
| ØP1    | 7.19REF.   |       |       |       |
| Q      | 5.39       | 5.79  | 6.20  |       |
| S      | 6.04       | 6.17  | 6.30  |       |



## ● Note

① Practically the current will be limited by PCB, thermal design and operating temperature.  $V_{GE}=15V$ .

## ● Disclaimer

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## ● Revision History

| Version | Date       | Change                     |
|---------|------------|----------------------------|
| A       | 2024/10/31 | New                        |
| B       | 2025/8/15  | Update ICM and SOA         |
| C       | 2025/9/18  | Apply new datasheet format |
|         |            |                            |
|         |            |                            |