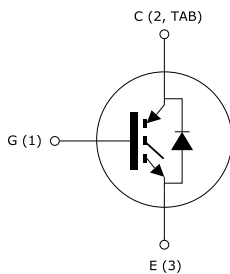
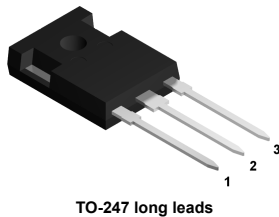


## Automotive-grade trench gate field-stop 650 V, 50 A low-loss M series IGBT in a TO-247 long leads package




### Product status link

[STGWA50M65DF2AG](#)

### Product summary

|            |                   |
|------------|-------------------|
| Order code | STGWA50M65DF2AG   |
| Marking    | G50M65DF2AG       |
| Package    | TO-247 long leads |
| Packing    | Tube              |

### Features

- AEC-Q101 qualified 
- Maximum junction temperature:  $T_J = 175\text{ }^\circ\text{C}$
- Low  $V_{CE(sat)} = 1.7\text{ V (typ.) @ } I_C = 50\text{ A}$
- Minimized tail current
- Tight parameter distribution
- Safer paralleling
- Low thermal resistance
- Soft and very fast-recovery antiparallel diode

### Applications

- Automotive motor control
- E-compressor
- Heating system

### Description

This device is an IGBT developed using an advanced proprietary trench gate field-stop structure. The device is part of the M series IGBTs, which represent an optimal balance between inverter system performance and efficiency where the low-loss and the short-circuit functionality is essential. Furthermore, the positive  $V_{CE(sat)}$  temperature coefficient and the tight parameter distribution result in safer paralleling operation.

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol         | Parameter  | Value      | Unit |
|----------------|--|------------|------|
| $V_{CES}$      | Collector-emitter voltage ( $V_{GE} = 0$ V)                          | 650        | V    |
| $I_C$          | Continuous collector current at $T_C = 25$ °C                        | 119        | A    |
|                | Continuous collector current at $T_C = 100$ °C                       | 79         |      |
| $I_{CP}^{(1)}$ | Pulsed collector current   | 207        | A    |
| $V_{GE}$       | Gate-emitter voltage   | $\pm 20$   | V    |
|                | Transient gate-emitter voltage ( $t_p \leq 10$ $\mu$ s, $D < 0.01$ ) | $\pm 30$   |      |
| $I_F$          | Continuous forward current at $T_C = 25$ °C                          | 103        | A    |
|                | Continuous forward current at $T_C = 100$ °C                         | 60         |      |
| $I_{FP}^{(1)}$ | Pulsed forward current ( $t_p \leq 1$ ms, $T_J < 175$ °C)            | 198        | A    |
| $P_{TOT}$      | Total power dissipation at $T_C = 25$ °C                             | 576        | W    |
| $T_{STG}$      | Storage temperature range  | -55 to 150 | °C   |
| $T_J$          | Operating junction temperature range                                 | -55 to 175 | °C   |

1. Pulse width is limited by maximum junction temperature.

**Table 2. Thermal data**

| Symbol     | Parameter                                   | Value | Unit |
|------------|---|-------|------|
| $R_{thJC}$ | Thermal resistance, junction-to-case, IGBT  | 0.26  | °C/W |
|            | Thermal resistance, junction-to-case, diode | 0.52  |      |
| $R_{thJA}$ | Thermal resistance, junction-to-ambient     | 50    | °C/W |

## 2 Electrical characteristics

$T_J = 25\text{ °C}$  unless otherwise specified.

**Table 3. Static characteristics**

| Symbol        | Parameter                            | Test conditions  | Min. | Typ. | Max.      | Unit          |
|---------------|--------------------------------------|--|------|------|-----------|---------------|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage  | $V_{GE} = 0\text{ V}$ , $I_C = 250\text{ }\mu\text{A}$               | 650  |      |           | V             |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$                         |      | 1.7  | 2         | V             |
|               |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$ , $T_J = 125\text{ °C}$ |      | 1.9  |           |               |
|               |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$ , $T_J = 175\text{ °C}$ |      | 2.1  |           |               |
| $V_F$         | Forward on-voltage                   | $I_F = 50\text{ A}$  |      | 2.1  | 2.6       | V             |
|               |                                      | $I_F = 50\text{ A}$ , $T_J = 125\text{ °C}$                          |      | 1.7  |           |               |
|               |                                      | $I_F = 50\text{ A}$ , $T_J = 175\text{ °C}$                          |      | 1.55 |           |               |
| $V_{GE(th)}$  | Gate threshold voltage               | $V_{CE} = V_{GE}$ , $I_C = 1\text{ mA}$                              | 5    | 6    | 7         | V             |
| $I_{CES}$     | Collector cut-off current            | $V_{GE} = 0\text{ V}$ , $V_{CE} = 650\text{ V}$                      |      |      | 25        | $\mu\text{A}$ |
| $I_{GES}$     | Gate-emitter leakage current         | $V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$                   |      |      | $\pm 250$ | nA            |

**Table 4. Dynamic characteristics**

| Symbol    | Parameter                    | Test conditions   | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|---|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$   | -    | 4130 | -    | pF   |
| $C_{oes}$ | Output capacitance           |   | -    | 256  | -    | nF   |
| $C_{res}$ | Reverse transfer capacitance |   | -    | 85   | -    | nF   |
| $Q_g$     | Total gate charge            | $V_{CC} = 520\text{ V}$ , $I_C = 50\text{ A}$ , $V_{GE} = 0\text{ to }15\text{ V}$<br>(see Figure 28. Gate charge test circuit) | -    | 147  | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          |   | -    | 36   | -    | nC   |
| $Q_{gc}$  | Gate-collector charge        |   | -    | 62   | -    | nC   |

**Table 5. Switching characteristics (inductive load)**

| Symbol          | Parameter                 | Test conditions   | Min. | Typ. | Max. | Unit |
|-----------------|---------------------------|---|------|------|------|------|
| $t_{d(on)}$     | Turn-on delay time        | $V_{CC} = 400\text{ V}$ , $I_C = 50\text{ A}$ , $V_{GE} = 15\text{ V}$ ,<br>$R_G = 6.8\ \Omega$ (see Figure 27. Test circuit for inductive load switching)  | -    | 29.8 | -    | ns   |
| $t_r$           | Current rise time         |   | -    | 30.8 | -    | ns   |
| $E_{on}^{(1)}$  | Turn-on switching energy  |   | -    | 1.4  | -    | mJ   |
| $t_{d(off)}$    | Turn-off delay time       |   | -    | 143  | -    | ns   |
| $t_f$           | Current fall time         |   | -    | 145  | -    | ns   |
| $E_{off}^{(2)}$ | Turn-off switching energy |   | -    | 1.8  | -    | mJ   |
| $t_{d(on)}$     | Turn-on delay time        | $V_{CC} = 400\text{ V}$ , $I_C = 50\text{ A}$ , $V_{GE} = 15\text{ V}$ ,<br>$R_G = 6.8\ \Omega$ , $T_J = 175\text{ }^\circ\text{C}$<br>(see Figure 27. Test circuit for inductive load switching) | -    | 28   | -    | ns   |
| $t_r$           | Current rise time         |   | -    | 37   | -    | ns   |
| $E_{on}^{(1)}$  | Turn-on switching energy  |   | -    | 2.5  | -    | mJ   |
| $t_{d(off)}$    | Turn-off delay time       |   | -    | 158  | -    | ns   |
| $t_f$           | Current fall time         |   | -    | 255  | -    | ns   |
| $E_{off}^{(2)}$ | Turn-off switching energy |   | -    | 2.6  | -    | mJ   |

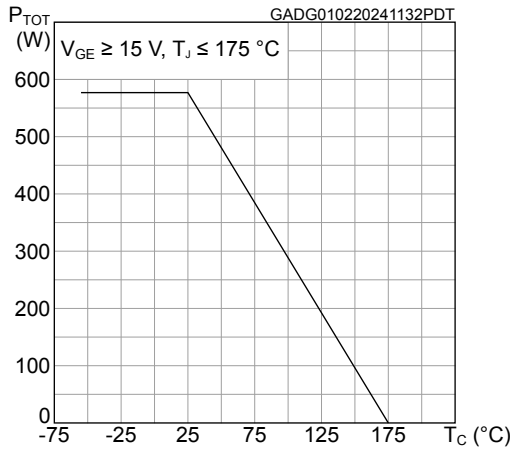
1. Including the reverse recovery of the diode.
2. Including the tail of the collector current.

**Table 6. Diode switching characteristics (inductive load)**

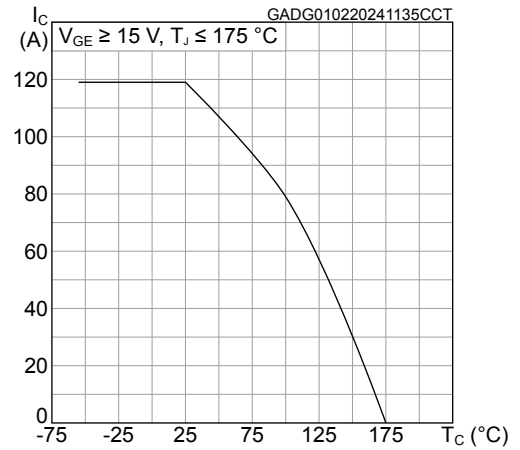
| Symbol       | Parameter  | Test conditions  | Min. | Typ.  | Max. | Unit                   |
|--------------|--|--|------|-------|------|------------------------|
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 50\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ ,<br>$di/dt = 1000\text{ A}/\mu\text{s}$ (see Figure 27. Test circuit for inductive load switching)  | -    | 121.6 | -    | ns                     |
| $Q_{rr}$     | Reverse recovery charge                                    |  | -    | 0.85  | -    | $\mu\text{C}$          |
| $I_{rrm}$    | Reverse recovery current                                   |  | -    | 14.2  | -    | A                      |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |  | -    | 610   | -    | $\text{A}/\mu\text{s}$ |
| $E_{rr}$     | Reverse recovery energy                                    |  | -    | 0.195 | -    | $\mu\text{J}$          |
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 75\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ ,<br>$di/dt = 1000\text{ A}/\mu\text{s}$ , $T_J = 175\text{ }^\circ\text{C}$<br>(see Figure 27. Test circuit for inductive load switching) | -    | 214   | -    | ns                     |
| $Q_{rr}$     | Reverse recovery charge                                    |  | -    | 3.3   | -    | $\mu\text{C}$          |
| $I_{rrm}$    | Reverse recovery current                                   |  | -    | 31    | -    | A                      |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |  | -    | 530   | -    | $\text{A}/\mu\text{s}$ |
| $E_{rr}$     | Reverse recovery energy                                    |  | -    | 0.867 | -    | $\mu\text{J}$          |

## 2.1 Electrical characteristics (curves)

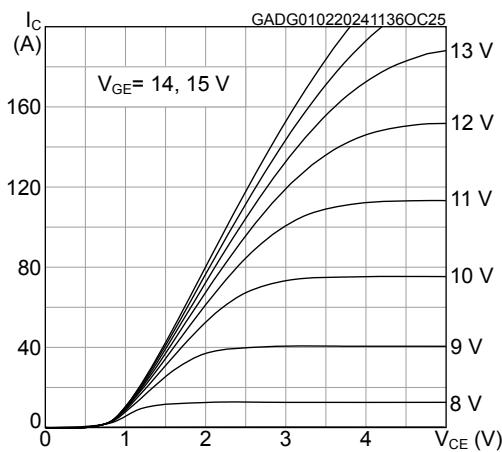
**Figure 1. Total power dissipation vs temperature**



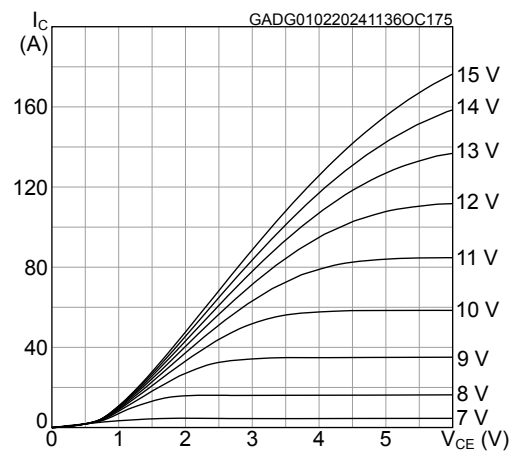
**Figure 2. Collector current vs temperature**



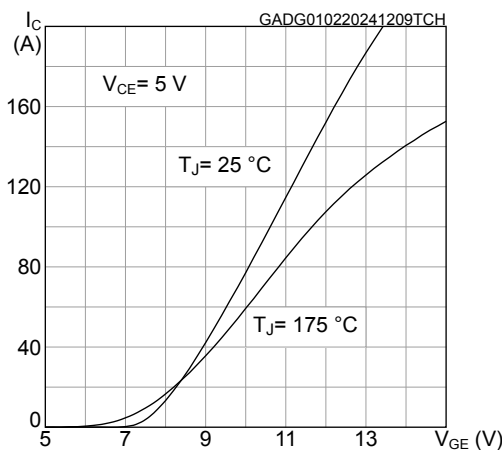
**Figure 3. Typical output characteristics ( $T_J = 25 \text{ }^\circ\text{C}$ )**



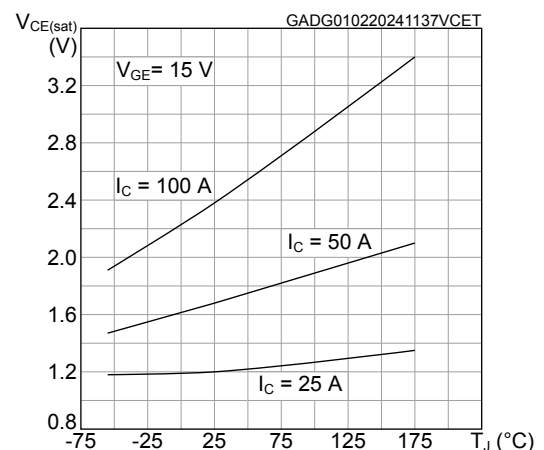
**Figure 4. Typical output characteristics ( $T_J = 175 \text{ }^\circ\text{C}$ )**



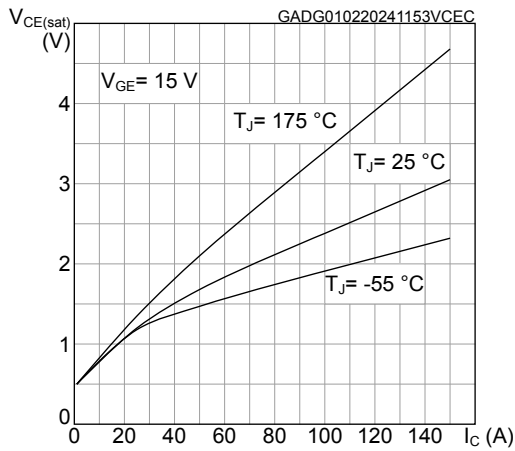
**Figure 5. Typical transfer characteristics**



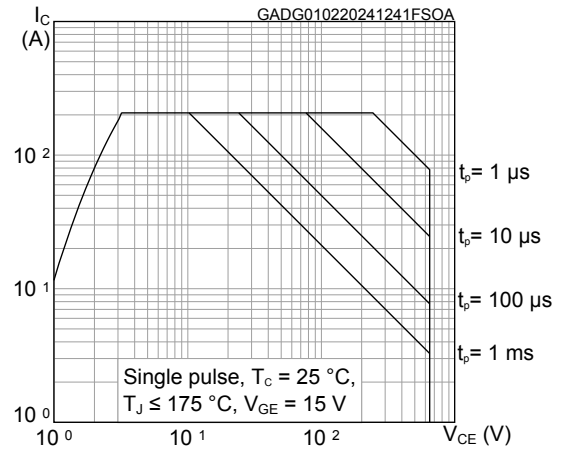
**Figure 6. Typical  $V_{CE(sat)}$  vs temperature**



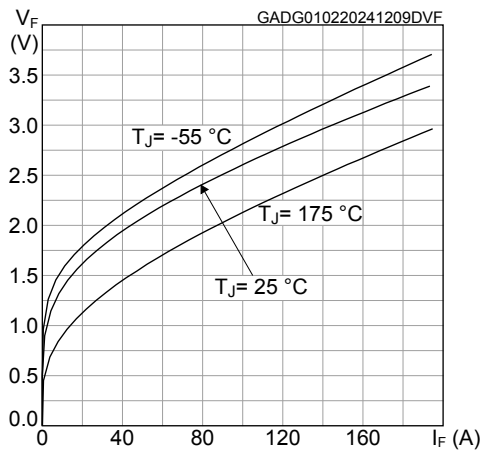
**Figure 7. Typical  $V_{CE(sat)}$  vs collector current**



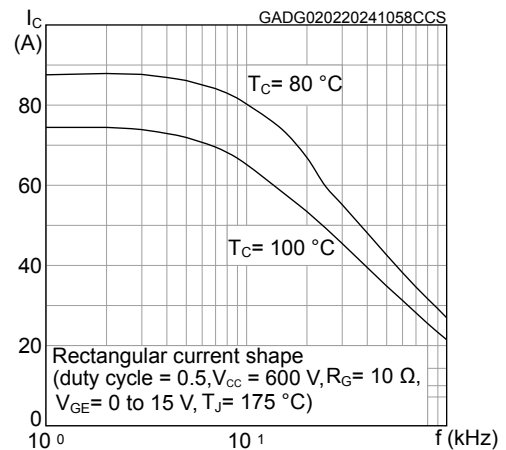
**Figure 8. Forward bias safe operating area**



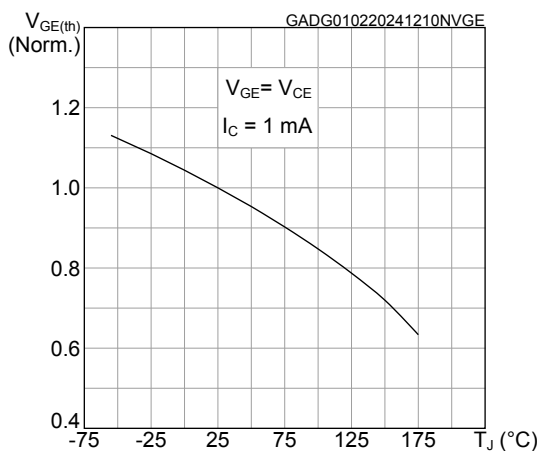
**Figure 9. Diode typical  $V_F$  vs forward current**



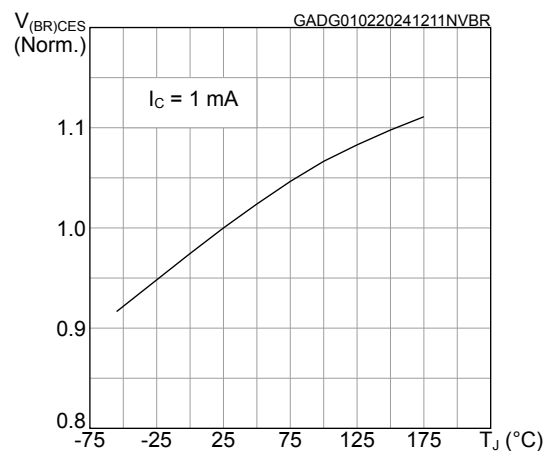
**Figure 10. Typical  $I_C$  vs switching frequency**



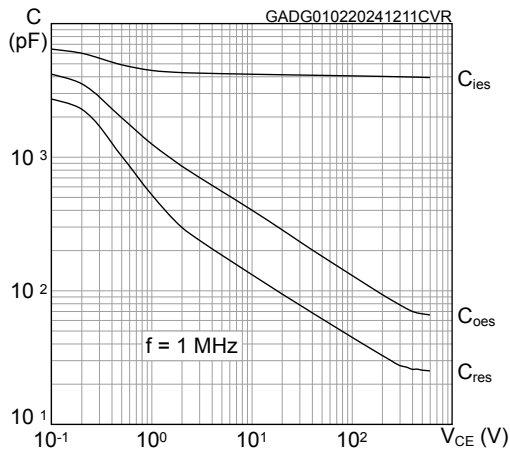
**Figure 11. Normalized  $V_{GE(th)}$  vs junction temperature**



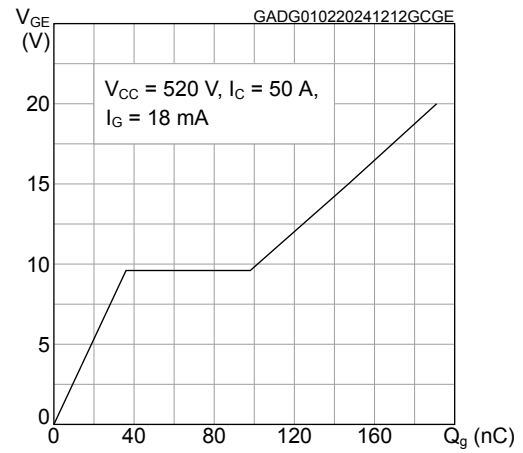
**Figure 12. Normalized  $V_{(BR)CES}$  vs junction temperature**



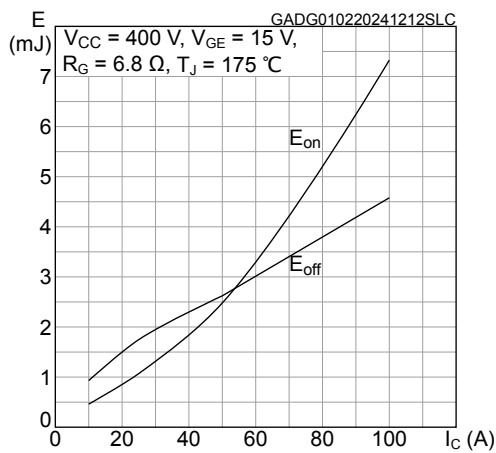
**Figure 13. Typical capacitance characteristics**



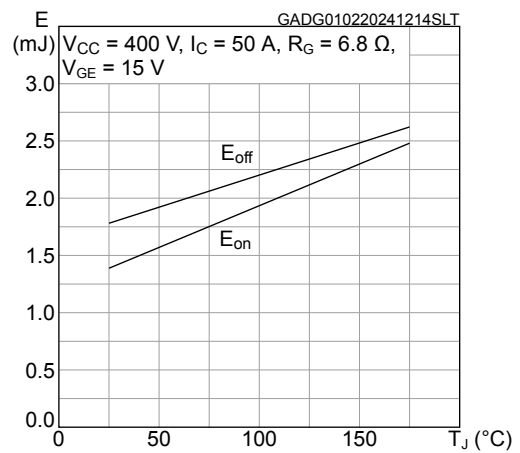
**Figure 14. Typical gate charge characteristics**



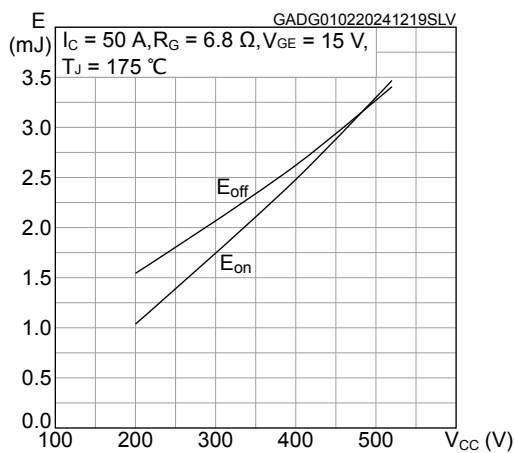
**Figure 15. Typical switching energy vs collector current**



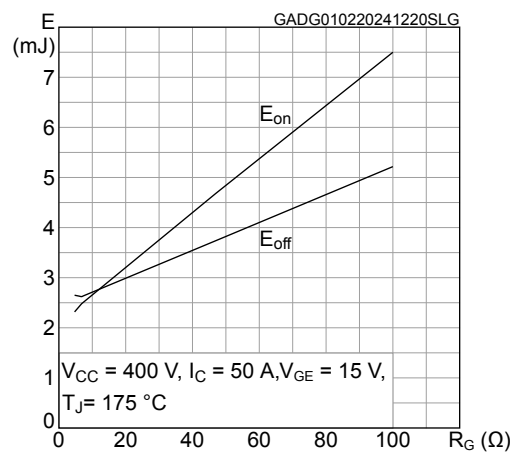
**Figure 16. Typical switching energy vs temperature**



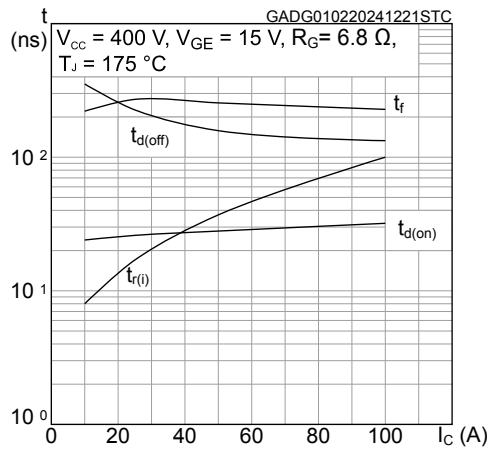
**Figure 17. Typical switching energy vs supply voltage**



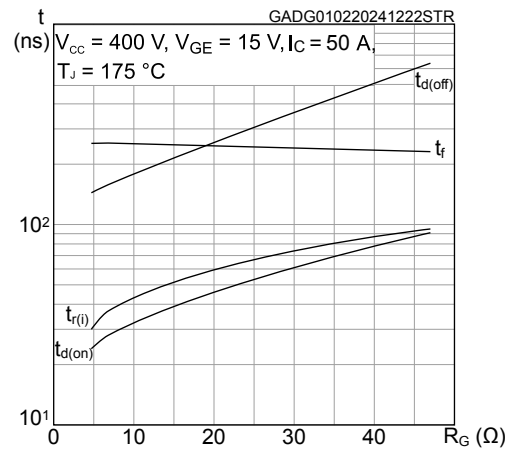
**Figure 18. Typical switching energy vs gate resistance**



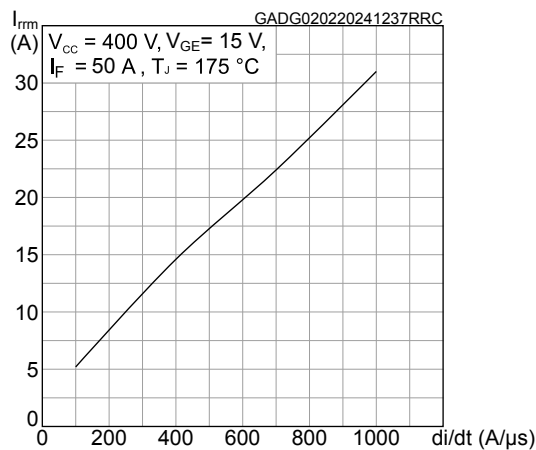
**Figure 19. Typical switching times vs collector current**



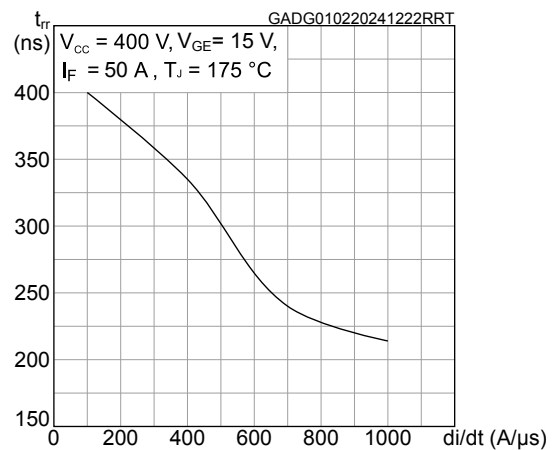
**Figure 20. Typical switching times vs gate resistance**



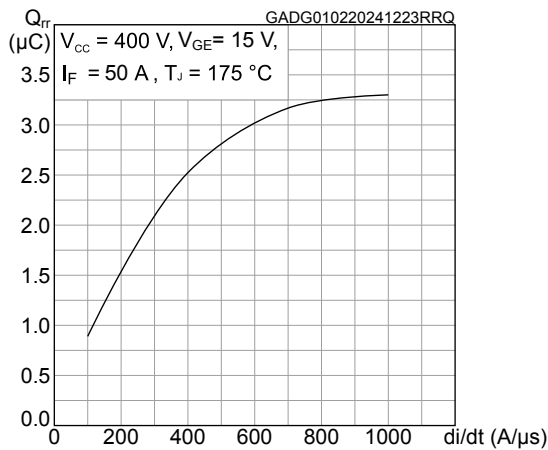
**Figure 21. Typical reverse recovery current vs diode current slope**



**Figure 22. Typical reverse recovery time vs diode current slope**



**Figure 23. Typical reverse recovery charge vs diode current slope**



**Figure 24. Typical reverse recovery energy vs diode current slope**

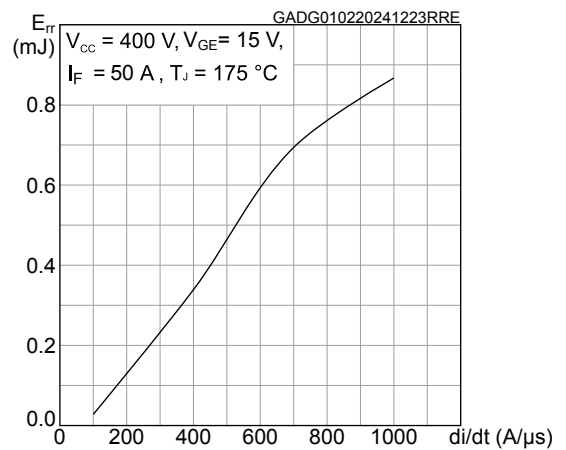




Figure 25. IGBT maximum transient thermal impedance

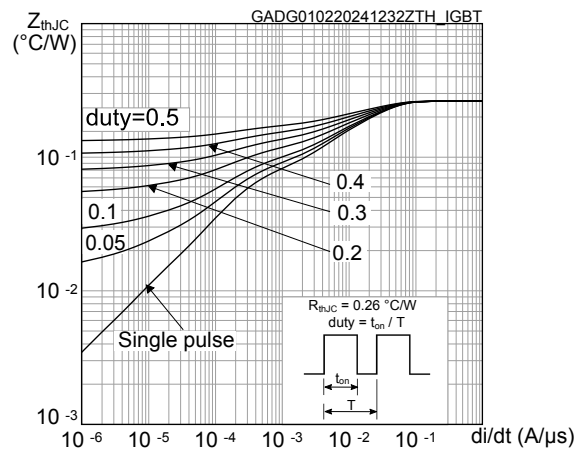
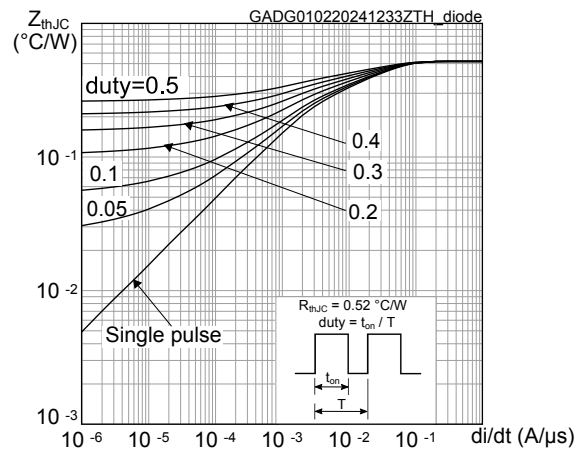
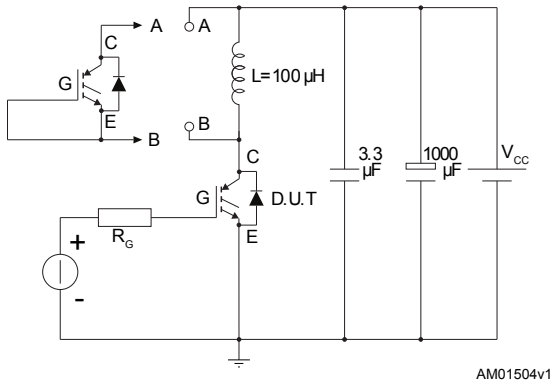
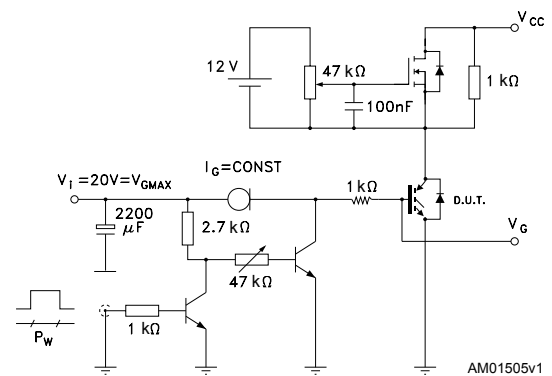
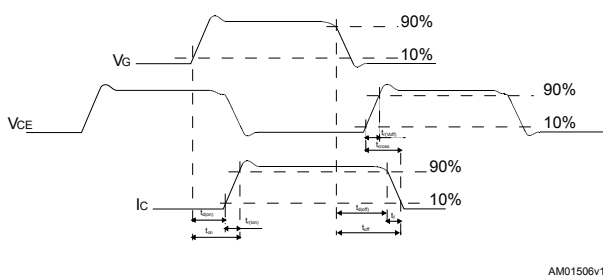
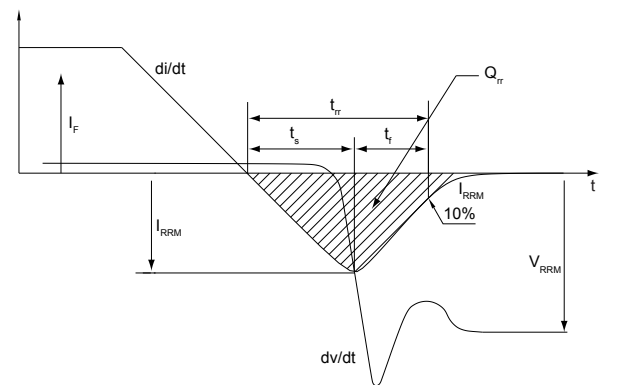


Figure 26. Diode maximum transient thermal impedance



### 3 Test circuits

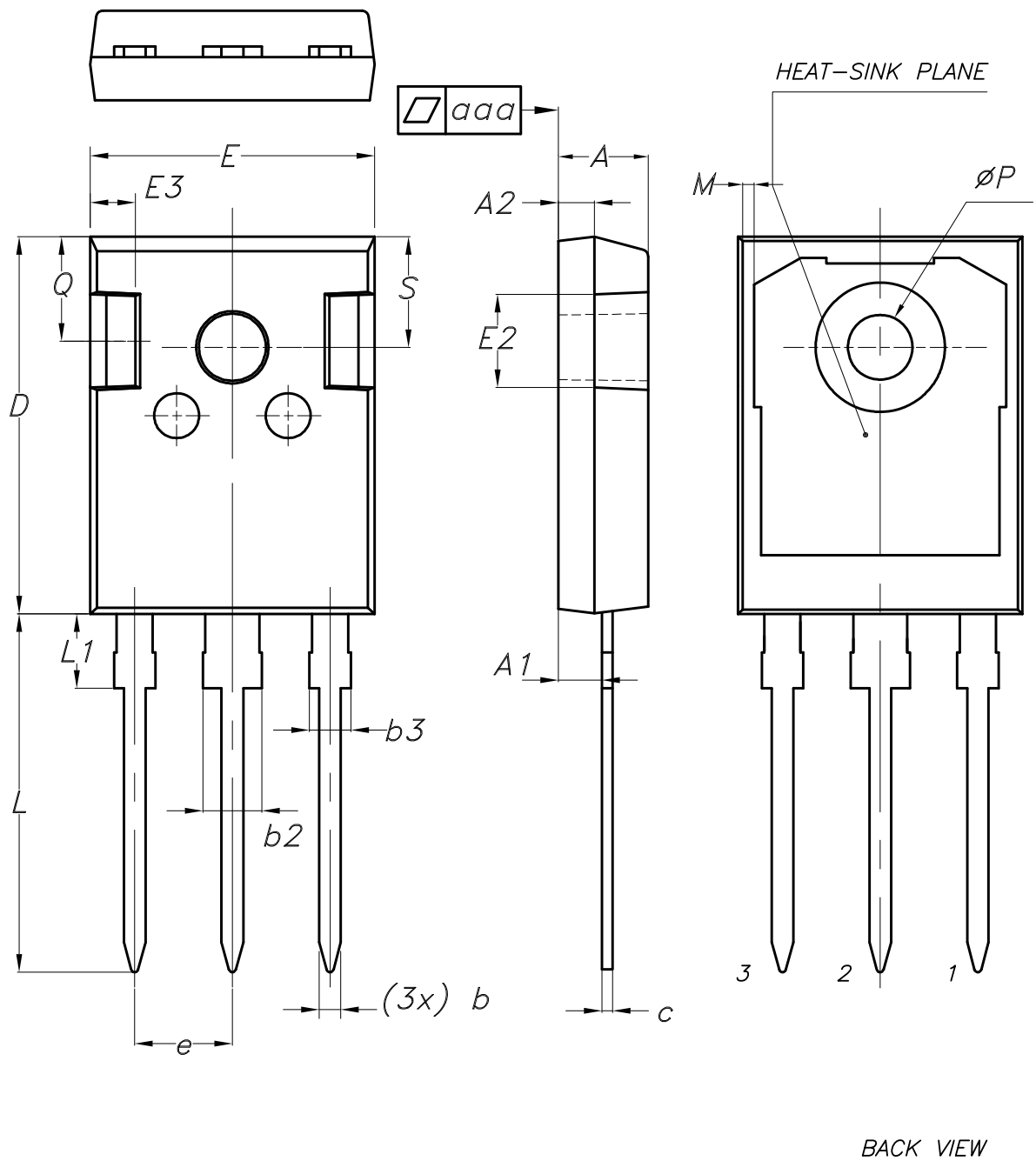
**Figure 27. Test circuit for inductive load switching**

**Figure 28. Gate charge test circuit**

**Figure 29. Switching waveform**

**Figure 30. Diode reverse recovery waveform**


## 4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK** packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

### 4.1 TO-247 long leads package information

Figure 31. TO-247 long leads package outline



8463846\_5

**Table 7. TO-247 long leads package mechanical data**

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.90  | 5.00  | 5.10  |
| A1   | 2.31  | 2.41  | 2.51  |
| A2   | 1.90  | 2.00  | 2.10  |
| b    | 1.16  |       | 1.26  |
| b2   |       |       | 3.25  |
| b3   |       |       | 2.25  |
| c    | 0.59  |       | 0.66  |
| D    | 20.90 | 21.00 | 21.10 |
| E    | 15.70 | 15.80 | 15.90 |
| E2   | 4.90  | 5.00  | 5.10  |
| E3   | 2.40  | 2.50  | 2.60  |
| e    | 5.34  | 5.44  | 5.54  |
| L    | 19.80 | 19.92 | 20.10 |
| L1   |       |       | 4.30  |
| M    | 0.35  |       | 0.95  |
| P    | 3.50  | 3.60  | 3.70  |
| Q    | 5.60  |       | 6.00  |
| S    | 6.05  | 6.15  | 6.25  |
| aaa  |       | 0.04  | 0.10  |

## Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes                       |
|-------------|----------|-------------------------------|
| 06-Feb-2024 | 1        | First release.                |
| 07-Feb-2024 | 2        | Modified title on cover page. |

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