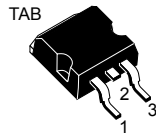
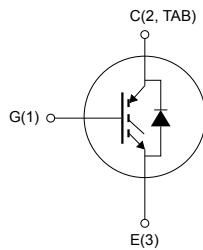


## Trench gate field-stop, 650 V, 20 A, M series low-loss IGBT


**D²PAK**


NG1E3C2T



### Features

- Maximum junction temperature:  $T_J = 175\text{ }^{\circ}\text{C}$
- High short-circuit withstand time
- $V_{CE(sat)} = 1.55\text{ V (typ.) @ } I_C = 20\text{ A}$
- Tight parameters distribution
- Low thermal resistance
- Soft and very fast-recovery antiparallel diode

### Applications

- Motor control
- UPS
- PFC
- General-purpose inverters

### 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.

#### Product status link

[STGB20M65DF2](#)

#### Product summary

|            |               |
|------------|---------------|
| Order code | STGB20M65DF2  |
| Marking    | G20M65DF2     |
| Package    | D²PAK         |
| Packing    | Tape and reel |

## 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol         | Parameter                                             | Value      | Unit |
|----------------|-------------------------------------------------------|------------|------|
| $V_{CES}$      | Collector-emitter voltage ( $V_{GE} = 0$ )            | 650        | V    |
| $I_C$          | Continuous collector current at $T_C = 25\text{ °C}$  | 40         | A    |
|                | Continuous collector current at $T_C = 100\text{ °C}$ | 20         | A    |
| $I_{CP}^{(1)}$ | Pulsed collector current                              | 80         | A    |
| $V_{GE}$       | Gate-emitter voltage                                  | $\pm 20$   | V    |
| $I_F$          | Continuous forward current at $T_C = 25\text{ °C}$    | 40         | A    |
|                | Continuous forward current at $T_C = 100\text{ °C}$   | 20         | A    |
| $I_{FP}^{(1)}$ | Pulsed forward current                                | 80         | A    |
| $P_{TOT}$      | Total power dissipation at $T_C = 25\text{ °C}$       | 166        | W    |
| $T_{STG}$      | Storage temperature range                             | -55 to 150 | °C   |
| $T_J$          | Operating junction temperature range                  | -55 to 175 | °C   |

1. Pulse width limited by maximum junction temperature.

**Table 2. Thermal data**

| Symbol     | Parameter                              | Value | Unit |
|------------|----------------------------------------|-------|------|
| $R_{thJC}$ | Thermal resistance junction-case IGBT  | 0.9   | °C/W |
| $R_{thJC}$ | Thermal resistance junction-case diode | 2.08  | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient    | 62.5  | °C/W |

## 2 Electrical characteristics

$T_C = 25\text{ °C}$  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 | $V_{GE} = 15\text{ V}$ , $I_C = 20\text{ A}$                            |      | 1.55 | 2.0  | V             |
|               |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 20\text{ A}$ ,<br>$T_J = 125\text{ °C}$ |      | 1.95 |      |               |
|               |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 20\text{ A}$ ,<br>$T_J = 175\text{ °C}$ |      | 2.1  |      |               |
| $V_F$         | Forward on-voltage                   | $I_F = 20\text{ A}$                                                     |      | 1.85 |      | V             |
|               |                                      | $I_F = 20\text{ A}$ , $T_J = 125\text{ °C}$                             |      | 1.65 |      |               |
|               |                                      | $I_F = 20\text{ A}$ , $T_J = 175\text{ °C}$                             |      | 1.55 |      |               |
| $V_{GE(th)}$  | Gate threshold voltage               | $V_{CE} = V_{GE}$ , $I_C = 500\text{ }\mu\text{A}$                      | 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         | $V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$                      |      |      | 250  | nA            |

**Table 4. Dynamic characteristics**

| Symbol    | Parameter                    | Test conditions                                                     | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|---------------------------------------------------------------------|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$ | -    | 1688 | -    | pF   |
| $C_{oes}$ | Output capacitance           |                                                                     | -    | 95   | -    |      |
| $C_{res}$ | Reverse transfer capacitance |                                                                     | -    | 35   | -    |      |
| $Q_g$     | Total gate charge            | $V_{CC} = 520\text{ V}$ , $I_C = 20\text{ A}$ ,                     | -    | 63   | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          | $V_{GE} = 0\text{ to }15\text{ V}$                                  | -    | 15   | -    |      |
| $Q_{gc}$  | Gate-collector charge        | (see Figure 29. Gate charge test circuit)                           | -    | 26   | -    |      |

**Table 5. IGBT switching characteristics (inductive load)**

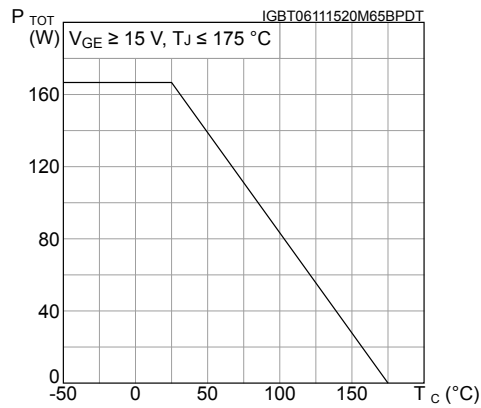
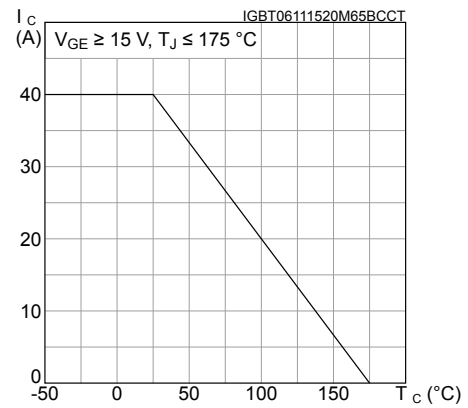
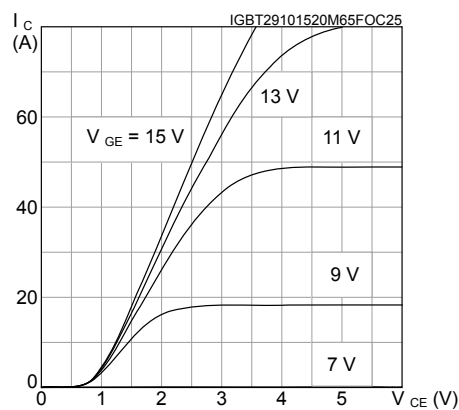
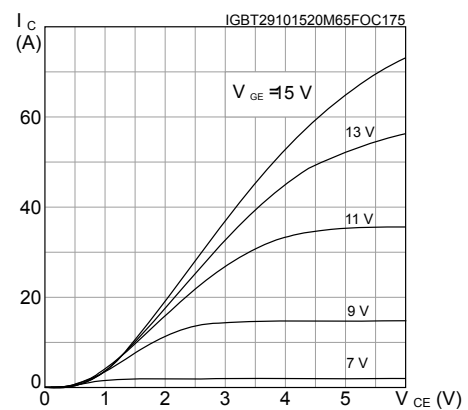
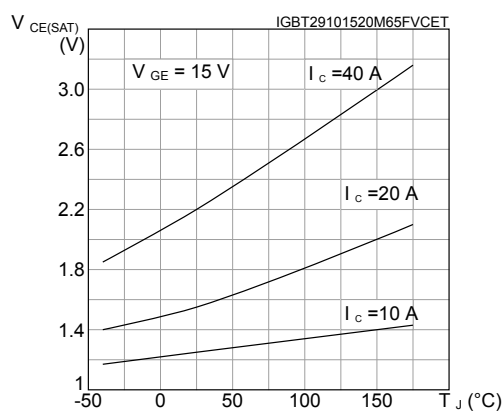
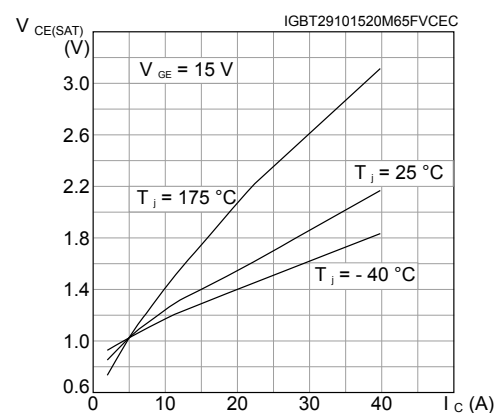
| Symbol          | Parameter                    | Test conditions                                                                                                                                                                                     | Min. | Typ. | Max. | Unit       |
|-----------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------------|
| $t_{d(on)}$     | Turn-on delay time           | $V_{CE} = 400\text{ V}$ , $I_C = 20\text{ A}$ ,<br>$V_{GE} = 15\text{ V}$ , $R_G = 12\ \Omega$<br>(see Figure 28. Test circuit for inductive load switching)                                        |      | 26   | -    | ns         |
| $t_r$           | Current rise time            |                                                                                                                                                                                                     |      | 10.8 | -    | ns         |
| $(di/dt)_{on}$  | Turn-on current slope        |                                                                                                                                                                                                     |      | 1409 | -    | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time          |                                                                                                                                                                                                     |      | 108  | -    | ns         |
| $t_f$           | Current fall time            |                                                                                                                                                                                                     |      | 65   | -    | ns         |
| $E_{on}^{(1)}$  | Turn-on switching energy     |                                                                                                                                                                                                     |      | 0.14 | -    | mJ         |
| $E_{off}^{(2)}$ | Turn-off switching energy    |                                                                                                                                                                                                     |      | 0.56 | -    | mJ         |
| $E_{ts}$        | Total switching energy       |                                                                                                                                                                                                     |      | 0.7  | -    | mJ         |
| $t_{d(on)}$     | Turn-on delay time           | $V_{CE} = 400\text{ V}$ , $I_C = 20\text{ A}$ ,<br>$V_{GE} = 15\text{ V}$ , $R_G = 12\ \Omega$ ,<br>$T_J = 175\text{ }^\circ\text{C}$<br>(see Figure 28. Test circuit for inductive load switching) |      | 28.4 | -    | ns         |
| $t_r$           | Current rise time            |                                                                                                                                                                                                     |      | 11.2 | -    | ns         |
| $(di/dt)_{on}$  | Turn-on current slope        |                                                                                                                                                                                                     |      | 1393 | -    | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time          |                                                                                                                                                                                                     |      | 107  | -    | ns         |
| $t_f$           | Current fall time            |                                                                                                                                                                                                     |      | 145  | -    | ns         |
| $E_{on}^{(1)}$  | Turn-on switching energy     |                                                                                                                                                                                                     |      | 0.3  | -    | mJ         |
| $E_{off}^{(2)}$ | Turn-off switching energy    |                                                                                                                                                                                                     |      | 0.85 | -    | mJ         |
| $E_{ts}$        | Total switching energy       |                                                                                                                                                                                                     |      | 1.15 | -    | mJ         |
| $t_{sc}$        | Short-circuit withstand time | $V_{CC} = 400\text{ V}$ , $V_{GE} = 13\text{ V}$ ,<br>$T_{Jstart} = 150\text{ }^\circ\text{C}$                                                                                                      | 10   |      | -    | $\mu$ s    |
|                 |                              | $V_{CC} = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ ,<br>$T_{Jstart} = 150\text{ }^\circ\text{C}$                                                                                                      | 6    |      | -    |            |

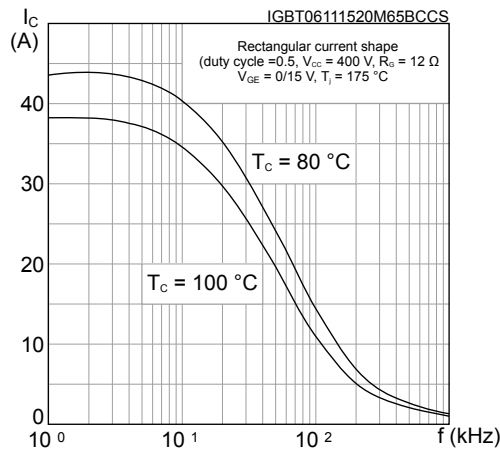
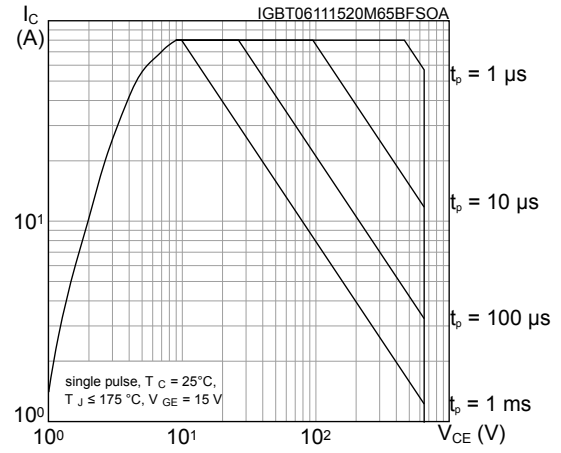
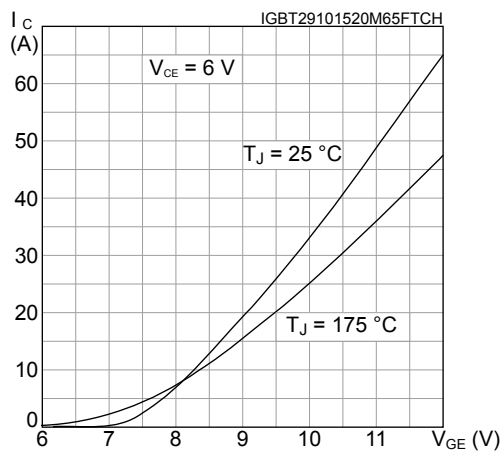
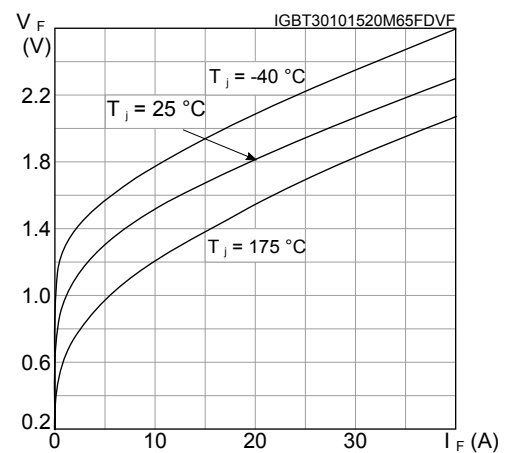
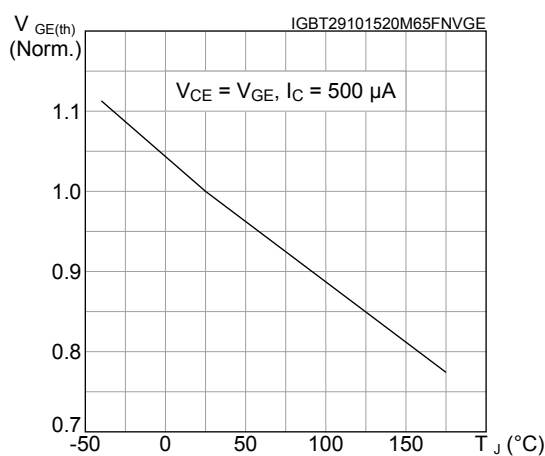
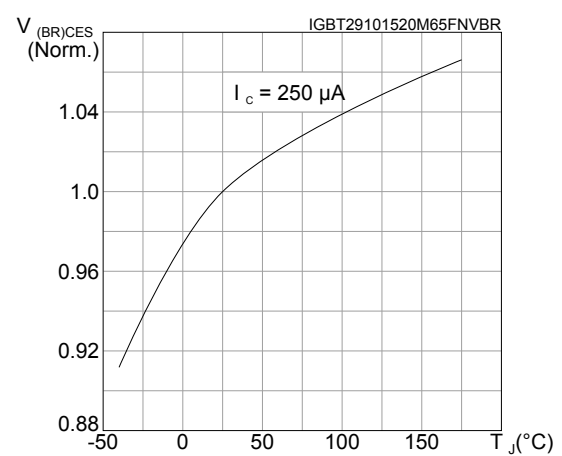
1. Including the reverse recovery of the diode.
2. Including the tail of the collector current.

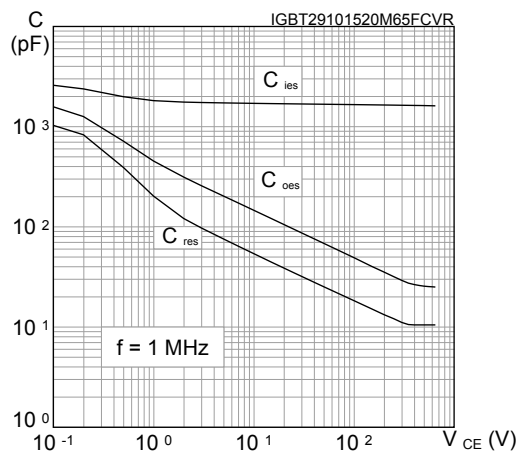
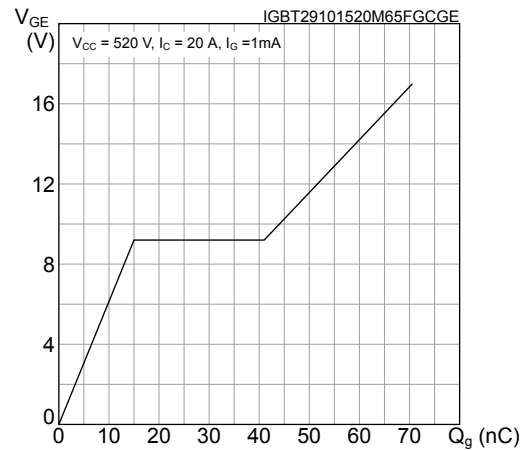
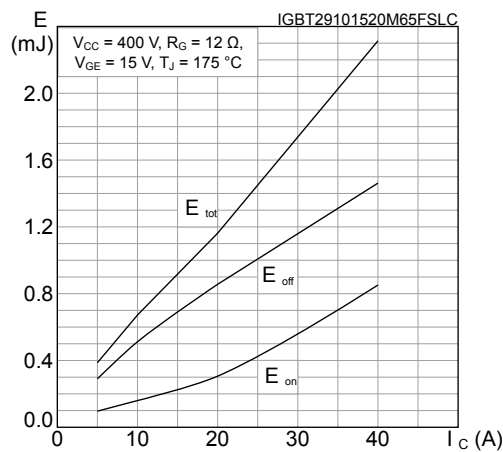
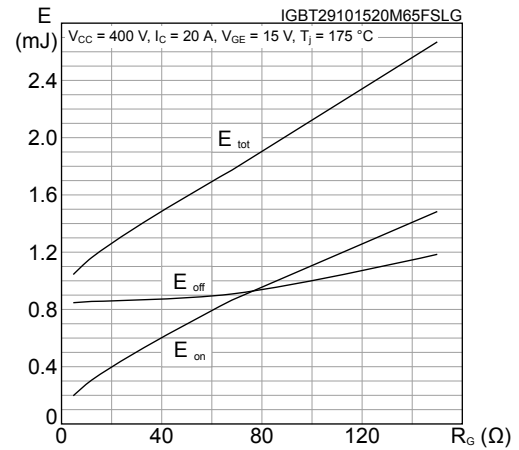
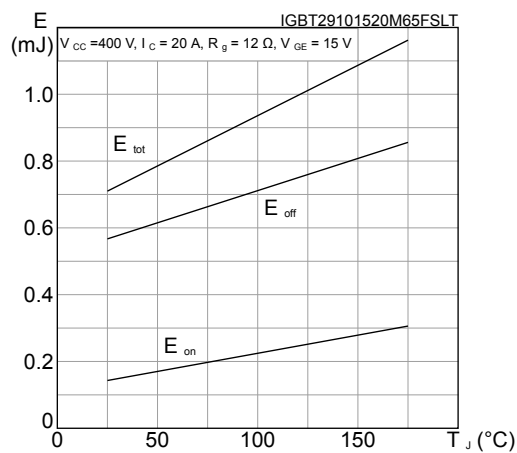
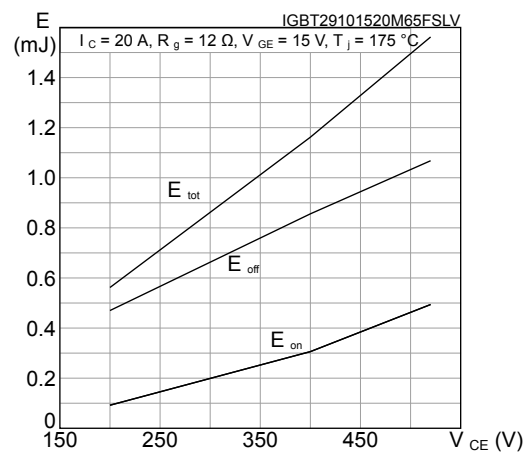
**Table 6. Diode switching characteristics (inductive load)**

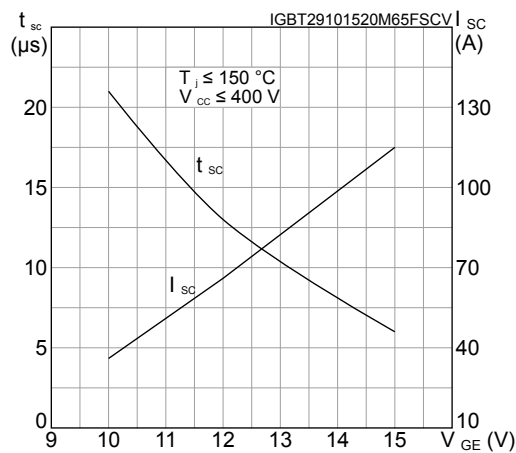
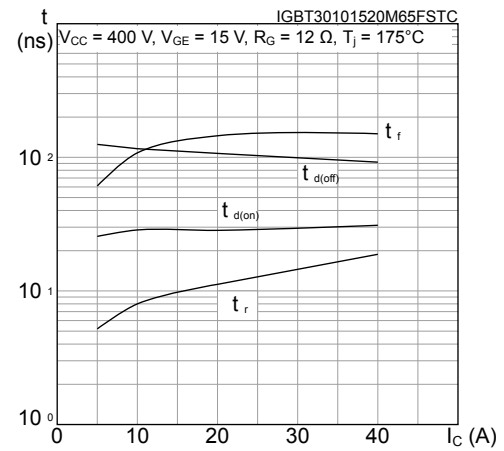
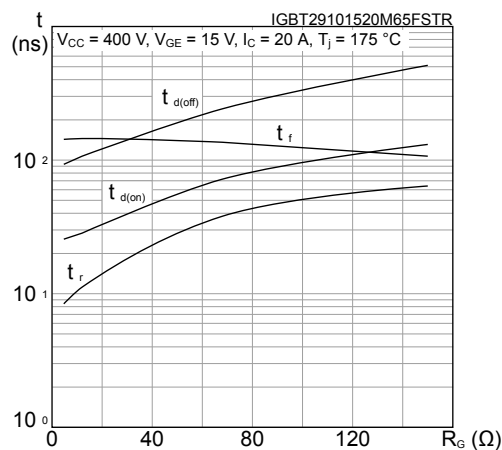
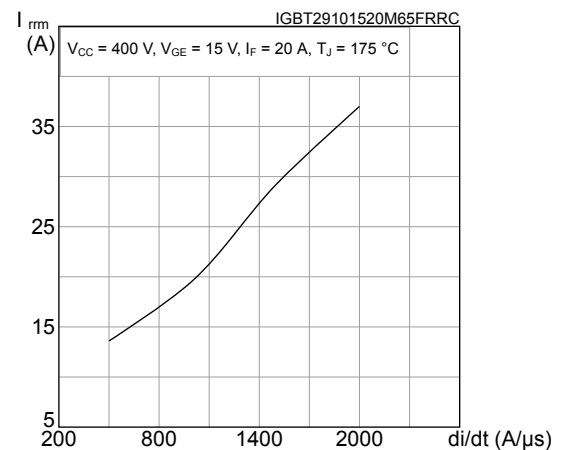
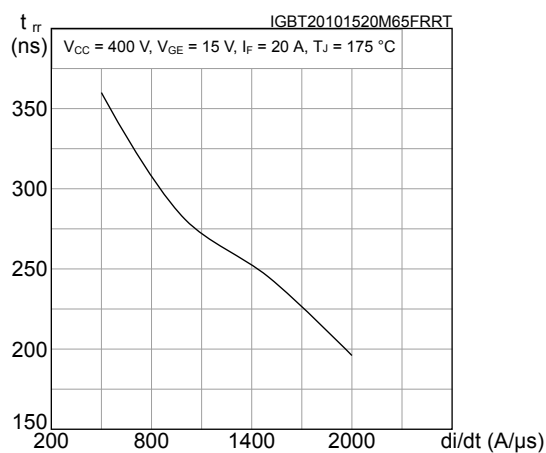
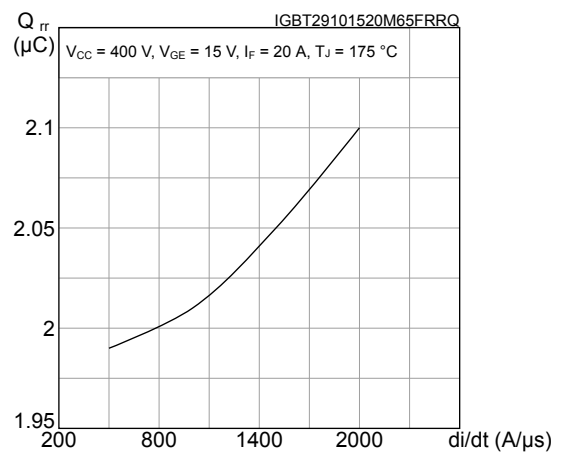
| Symbol       | Parameter                                                  | Test conditions                                                                                                                                                                                                   | Min. | Typ. | Max. | Unit       |
|--------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------------|
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 20\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ , $di/dt = 1000\text{ A}/\mu\text{s}$<br>(see Figure 28. Test circuit for inductive load switching)                                        | -    | 166  |      | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |                                                                                                                                                                                                                   | -    | 690  |      | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |                                                                                                                                                                                                                   | -    | 13.2 |      | A          |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |                                                                                                                                                                                                                   | -    | 769  |      | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |                                                                                                                                                                                                                   | -    | 81   |      | $\mu$ J    |
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 20\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ , $T_J = 175\text{ }^\circ\text{C}$ ,<br>$di/dt = 1000\text{ A}/\mu\text{s}$<br>(see Figure 28. Test circuit for inductive load switching) | -    | 281  |      | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |                                                                                                                                                                                                                   | -    | 2010 |      | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |                                                                                                                                                                                                                   | -    | 19.6 |      | A          |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |                                                                                                                                                                                                                   | -    | 370  |      | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |                                                                                                                                                                                                                   | -    | 215  |      | $\mu$ J    |

## 2.1 Electrical characteristics (curves)

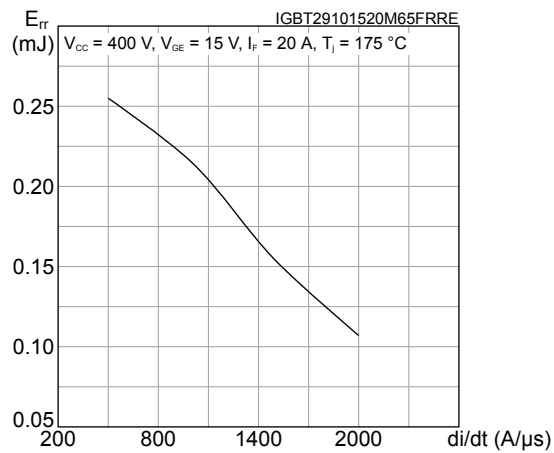
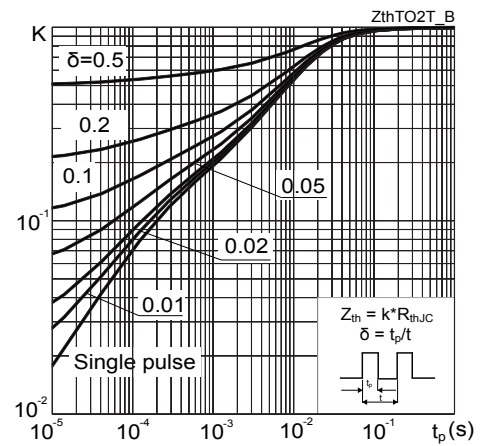
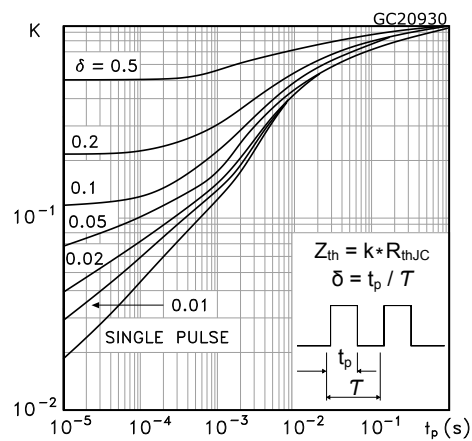
**Figure 1. Power dissipation vs case temperature**

**Figure 2. Collector current vs case temperature**

**Figure 3. Output characteristics (T\_J = 25 °C)**

**Figure 4. Output characteristics (T\_J = 175 °C)**

**Figure 5. V\_CE(sat) vs junction temperature**

**Figure 6. V\_CE(sat) vs collector current**


**Figure 7. Collector current vs switching frequency**

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

**Figure 9. Transfer characteristics**

**Figure 10. Diode  $V_F$  vs forward current**

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

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


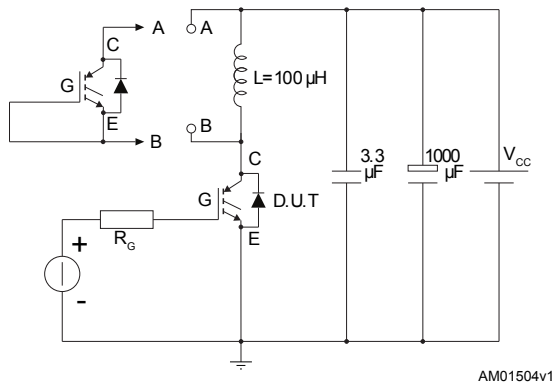
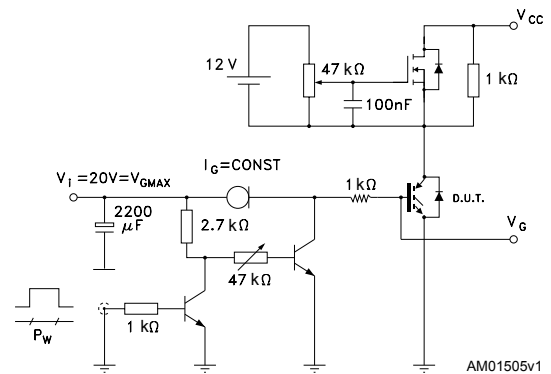
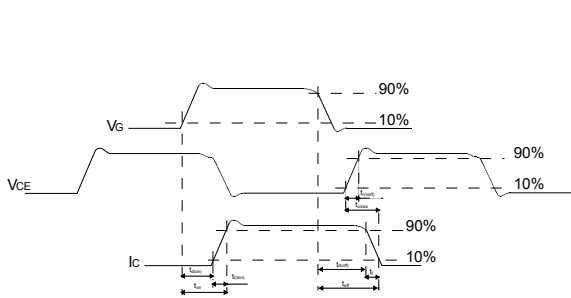
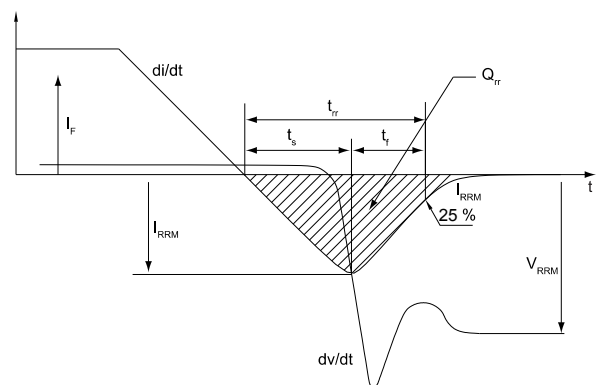
**Figure 13. Capacitance variations**

**Figure 14. Gate charge vs gate-emitter voltage**

**Figure 15. Switching energy vs collector current**

**Figure 16. Switching energy vs gate resistance**

**Figure 17. Switching energy vs temperature**

**Figure 18. Switching energy vs collector emitter voltage**


**Figure 19. Short-circuit time and current vs  $V_{GE}$** 

**Figure 20. Switching times vs collector current**

**Figure 21. Switching times vs gate resistance**

**Figure 22. Reverse recovery current vs diode current slope**

**Figure 23. Reverse recovery time vs diode current slope**

**Figure 24. Reverse recovery charge vs diode current slope**




**Figure 25. Reverse recovery energy vs diode current slope**

**Figure 26. Thermal impedance for IGBT**

**Figure 27. Thermal impedance for diode**


### 3 Test circuits

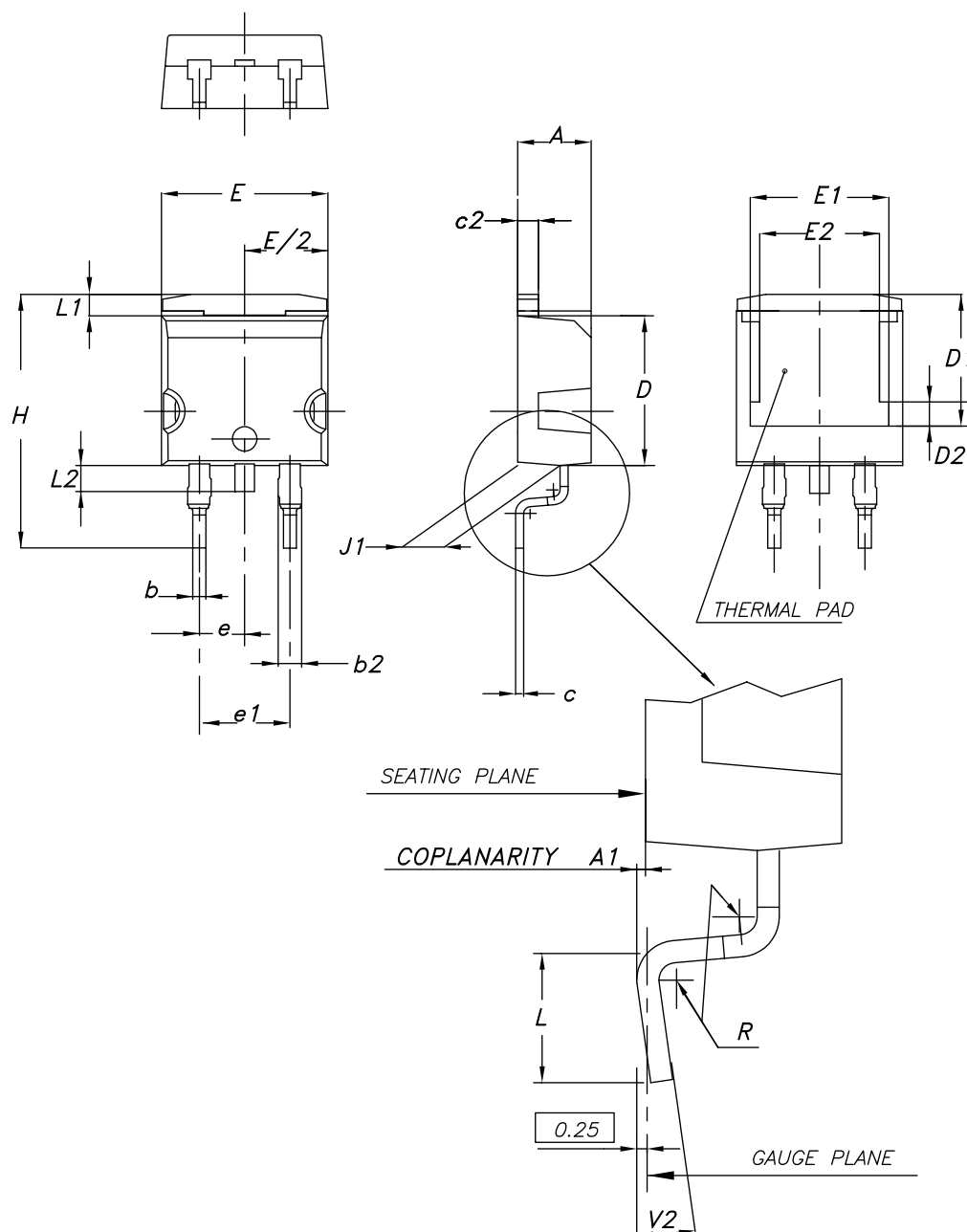
**Figure 28. Test circuit for inductive load switching**

**Figure 29. Gate charge test circuit**

**Figure 30. Switching waveform**

**Figure 31. Diode reverse recovery waveform**


## 4 Package information

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 D<sup>2</sup>PAK (TO-263) type A2 package information

**Figure 32.** D<sup>2</sup>PAK (TO-263) type A2 package outline

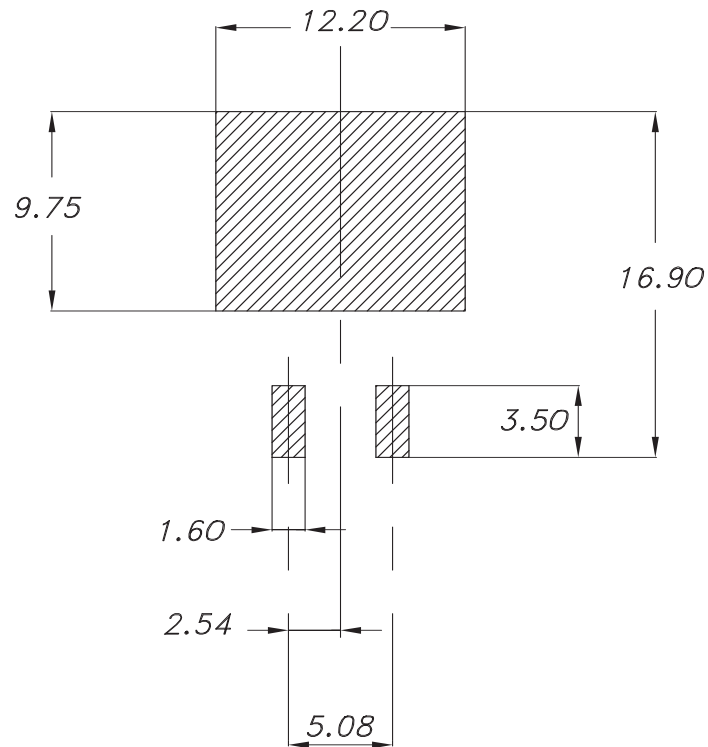


0079457\_A2\_27

**Table 7. D<sup>2</sup>PAK (TO-263) type A2 package mechanical data**

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    | 4.40  |      | 4.60  |
| A1   | 0.03  |      | 0.23  |
| b    | 0.70  |      | 0.93  |
| b2   | 1.14  |      | 1.70  |
| c    | 0.45  |      | 0.60  |
| c2   | 1.23  |      | 1.36  |
| D    | 8.95  |      | 9.35  |
| D1   | 7.50  | 7.75 | 8.00  |
| D2   | 1.10  | 1.30 | 1.50  |
| E    | 10.00 |      | 10.40 |
| E1   | 8.70  | 8.90 | 9.10  |
| E2   | 7.30  | 7.50 | 7.70  |
| e    |       | 2.54 |       |
| e1   | 4.88  |      | 5.28  |
| H    | 15.00 |      | 15.85 |
| J1   | 2.49  |      | 2.69  |
| L    | 2.29  |      | 2.79  |
| L1   | 1.27  |      | 1.40  |
| L2   | 1.30  |      | 1.75  |
| R    |       | 0.40 |       |
| V2   | 0°    |      | 8°    |

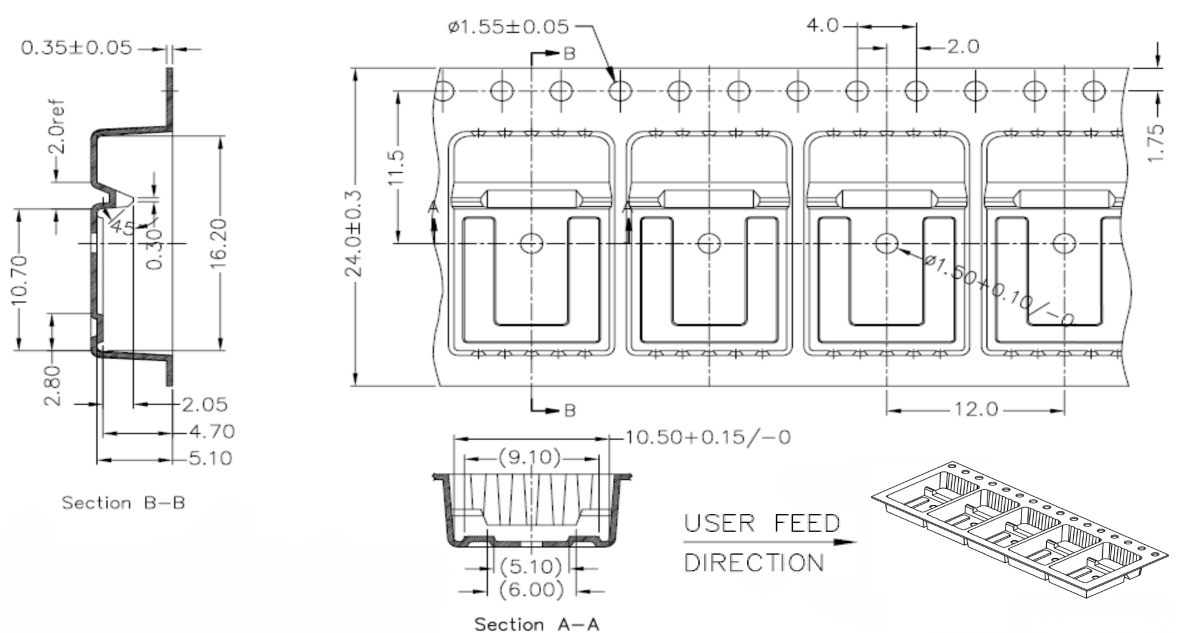
**Figure 33. D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)**



0079457\_Rev27\_footprint

## 4.2 D<sup>2</sup>PAK packing information

**Figure 34. D<sup>2</sup>PAK tape drawing (dimensions are in mm)**



DM01095771\_1

## Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes                                                                                                           |
|-------------|----------|-------------------------------------------------------------------------------------------------------------------|
| 05-Nov-2015 | 1        | First release.                                                                                                    |
| 14-Apr-2016 | 2        | Updated <i>Figure 13: "Normalized <math>V(BR)_{CES}</math> vs. junction temperature"</i> .<br>Minor text changes. |
| 08-Oct-2018 | 3        | Updated <i>Table 3. Static characteristics</i> .<br>Minor text changes                                            |
| 05-May-2025 | 4        | Updated <a href="#">Section 4: Package information</a> .<br>Minor text changes.                                   |

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