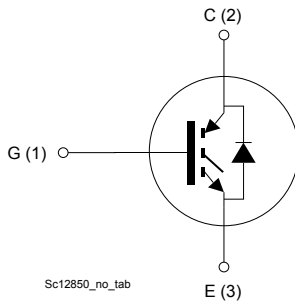


## Trench gate field-stop, M series, 650 V, 20 A, low-loss IGBT



TO-220FP



## Product status link

[STGF20M65DF2](#)

## Product summary

Order code	STGF20M65DF2
Marking	G20M65DF2
Package	TO-220FP
Packing	Tube

## Features

- High short-circuit withstand time
- $V_{CE(sat)} = 1.55 \text{ V (typ.) @ } I_C = 20 \text{ A}$
- Tight parameter distribution
- Safer paralleling
- 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.

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ )	650	V
$I_C^{(1)}$	Continuous collector current at $T_C = 25\text{ °C}$	40	A
$I_C^{(1)}$	Continuous collector current at $T_C = 100\text{ °C}$	20	A
$I_{CP}^{(2)}$	Pulsed collector current	80	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$I_F^{(1)}$	Continuous forward current at $T_C = 25\text{ °C}$	40	A
$I_F^{(1)}$	Continuous forward current at $T_C = 100\text{ °C}$	20	A
$I_{FP}^{(2)}$	Pulsed forward current	80	A
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ , $T_C = 25\text{ °C}$ )	2.5	kV
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	32.6	W
$T_{STG}$	Storage temperature range	-55 to 150	°C
$T_J$	Operating junction temperature range	-55 to 175	°C

1. Limited by maximum junction temperature.
2. Pulse width limited by maximum junction temperature.

**Table 2. Thermal data**

Symbol	Parameter	Value	Unit
$R_{thJC}$	Thermal resistance junction-case IGBT	4.6	°C/W
$R_{thJC}$	Thermal resistance junction-case diode	6.25	°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
		$V_{GE} = 15\text{ V}$ , $I_C = 20\text{ A}$ , $T_J = 125\text{ °C}$		1.95		
		$V_{GE} = 15\text{ V}$ , $I_C = 20\text{ A}$ , $T_J = 175\text{ °C}$		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	$V_{CE} = 400\text{ V}$ , $I_C = 20\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 12\ \Omega$ (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		$V_{CE} = 400\text{ V}$ , $I_C = 20\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 12\ \Omega$ , $T_J = 175\text{ }^\circ\text{C}$ (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	$V_{CC} = 400\text{ V}$ , $V_{GE} = 13\text{ V}$ , $T_{Jstart} = 150\text{ }^\circ\text{C}$	10		-	$\mu$ s	
		$V_{CC} = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ , $T_{Jstart} = 150\text{ }^\circ\text{C}$	6		-		

1. Including the reverse recovery of the diode.

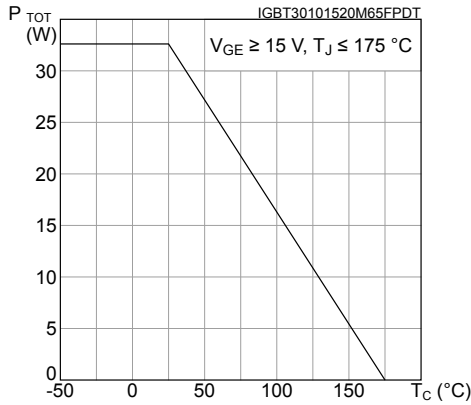
2. Including the tail of the collector current.

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

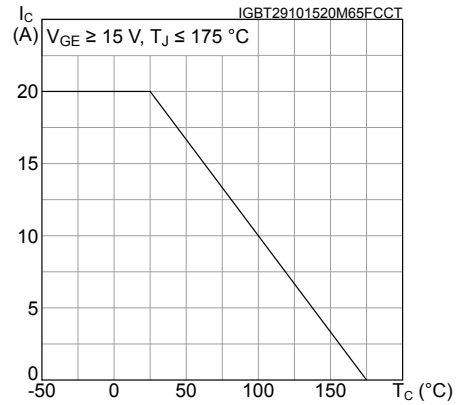
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit	
$t_{rr}$	Reverse recovery time	$I_F = 20\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ , $di/dt = 1000\text{ A}/\mu\text{s}$ (see Figure 28. Test circuit for inductive load switching)	-	166		ns	
$Q_{rr}$	Reverse recovery charge			-	690		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	$I_F = 20\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ , $T_J = 175\text{ }^\circ\text{C}$ , $di/dt = 1000\text{ A}/\mu\text{s}$ (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)

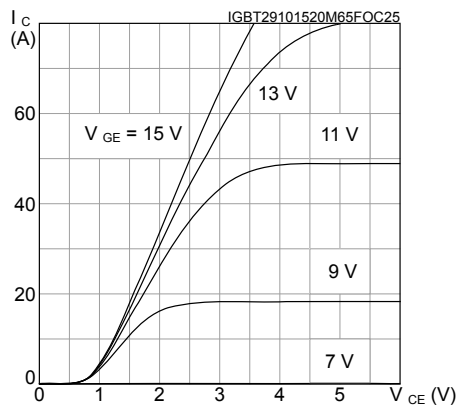
**Figure 1. Power dissipation vs case temperature**



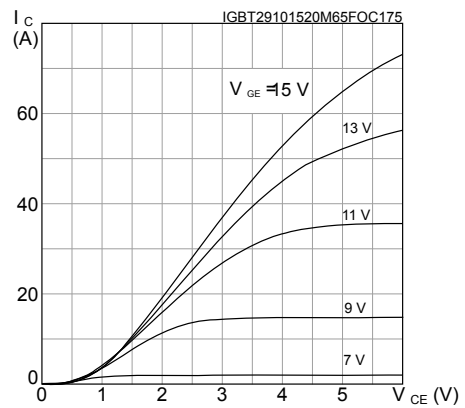
**Figure 2. Collector current vs case temperature**



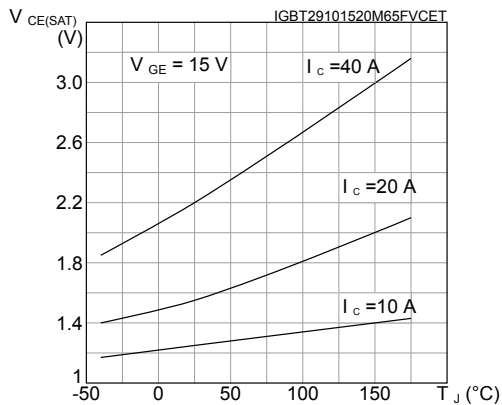
**Figure 3. Output characteristics (T<sub>J</sub> = 25 °C)**



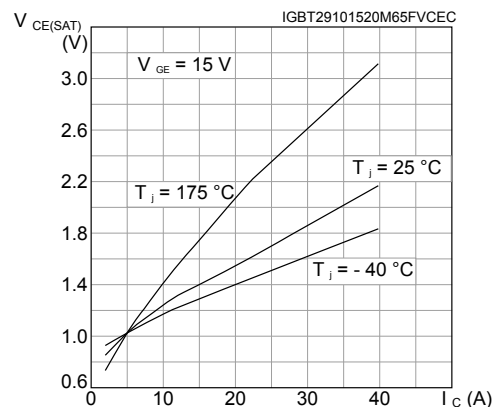
**Figure 4. Output characteristics (T<sub>J</sub> = 175 °C)**



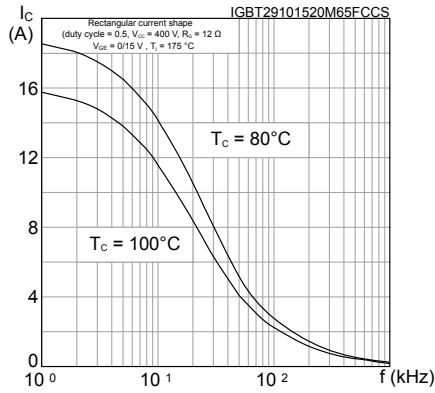
**Figure 5. V<sub>CE(sat)</sub> vs junction temperature**



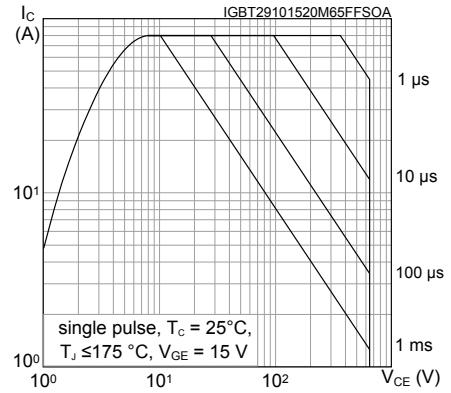
**Figure 6. V<sub>CE(sat)</sub> vs collector current**



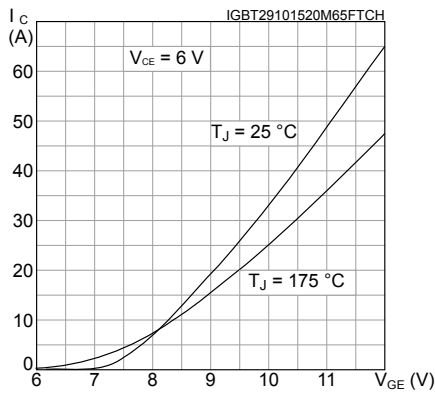
**Figure 7. Collector current vs switching frequency**



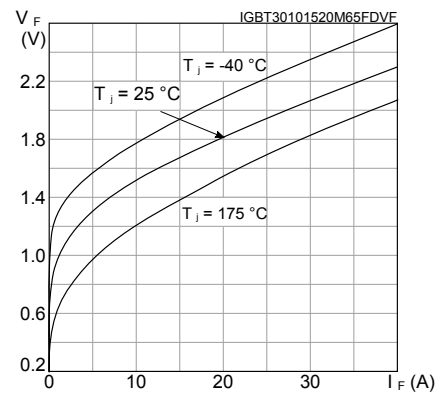
**Figure 8. Forward bias safe operating area**



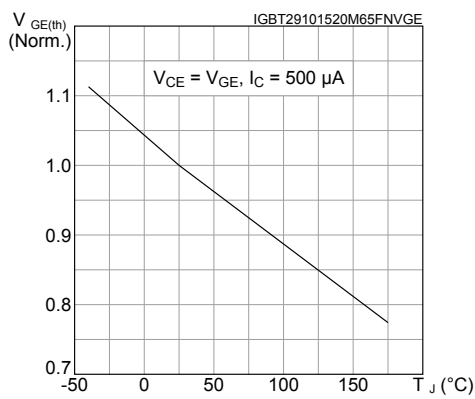
**Figure 9. Transfer characteristics**



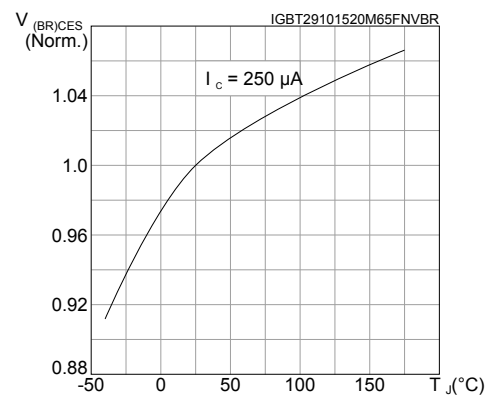
**Figure 10. Diode V<sub>F</sub> vs forward current**



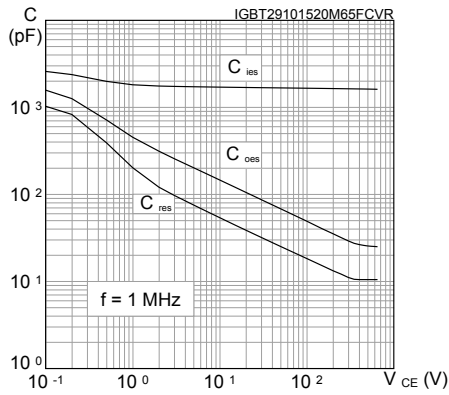
**Figure 11. Normalized V<sub>GE(th)</sub> vs junction temperature**



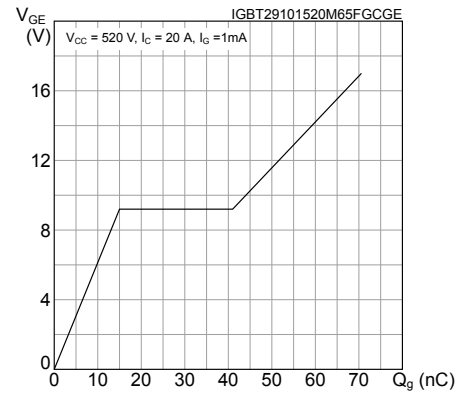
**Figure 12. Normalized V<sub>(BR)CES</sub> vs junction temperature**



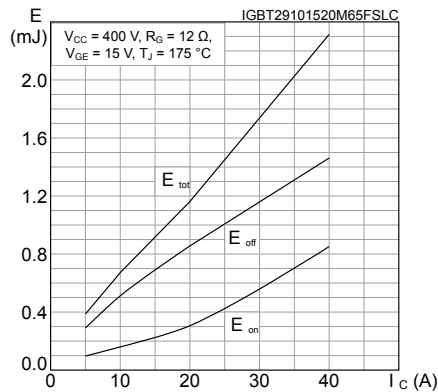
**Figure 13. Capacitance variations**



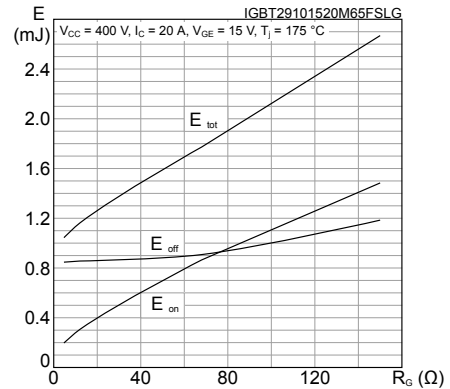
**Figure 14. Gate charge vs gate-emitter voltage**



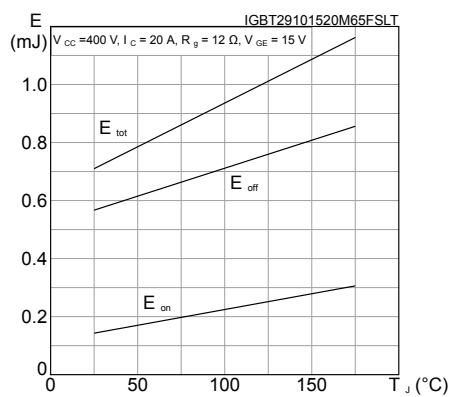
**Figure 15. Switching loss vs collector current**



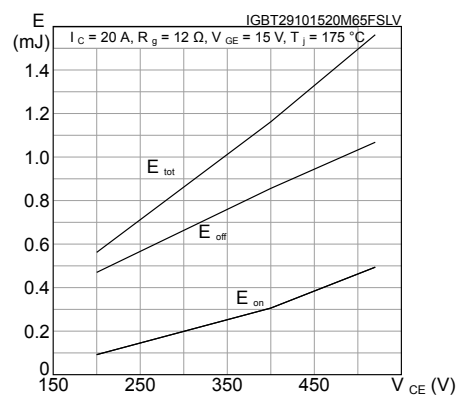
**Figure 16. Switching loss vs gate resistance**



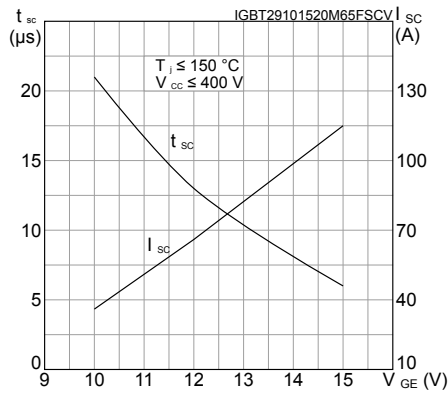
**Figure 17. Switching loss vs temperature**



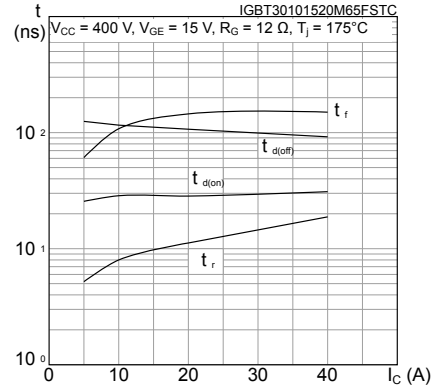
**Figure 18. Switching loss vs collector emitter voltage**



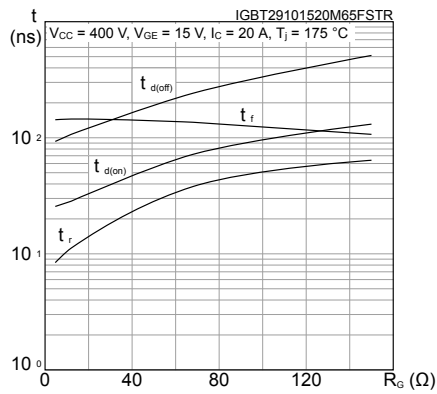
**Figure 19. Short-circuit time and current vs  $V_{GE}$**



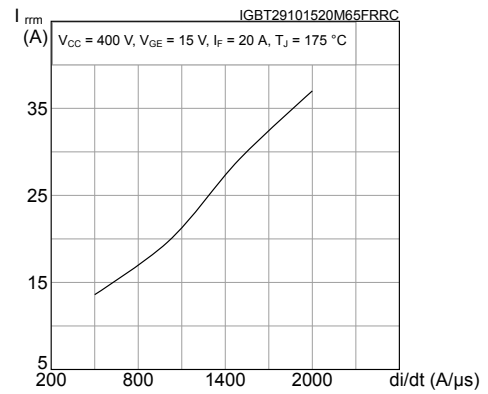
**Figure 20. Switching times vs collector current**



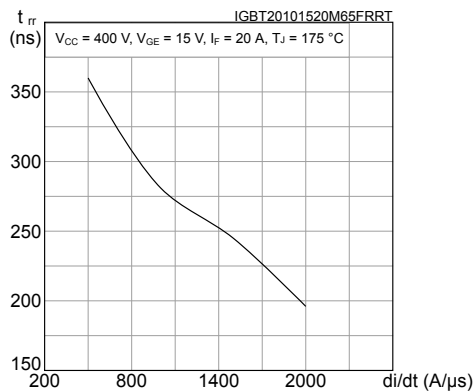
**Figure 21. Switching times vs gate resistance**



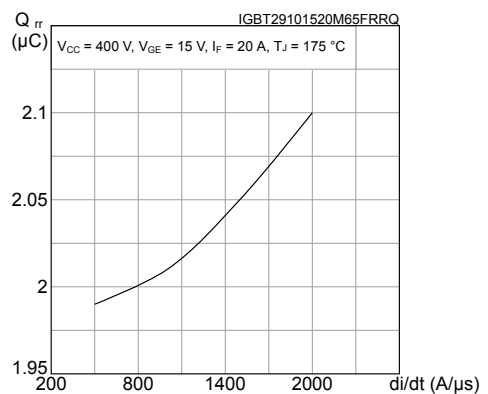
**Figure 22. Reverse recovery current vs diode current slope**



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

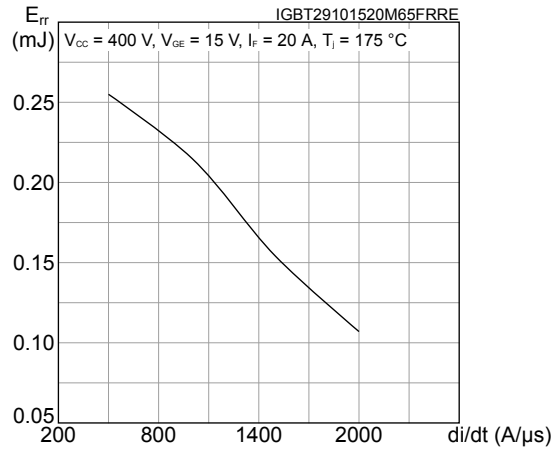


**Figure 24. Reverse recovery charge vs diode current slope**

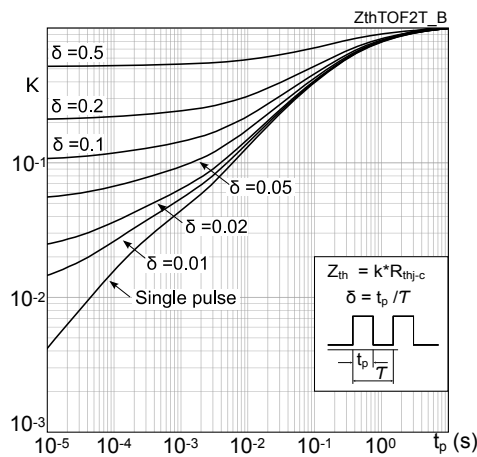




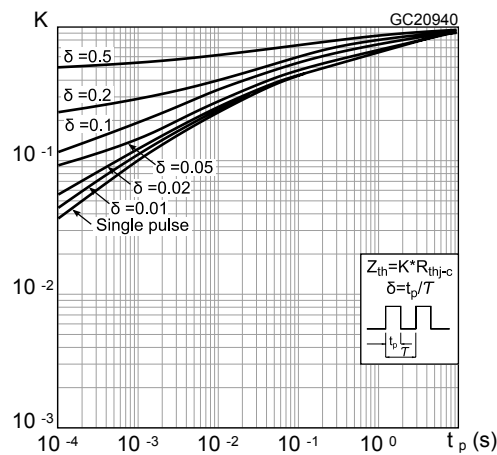
**Figure 25. Reverse recovery energy vs diode current slope**



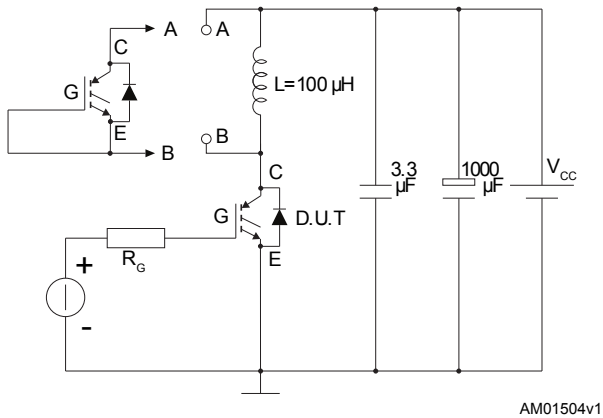
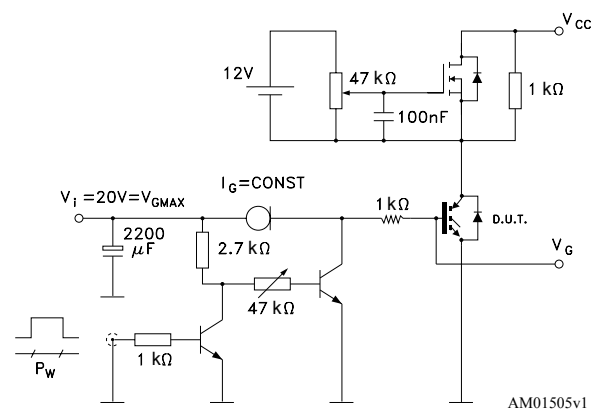
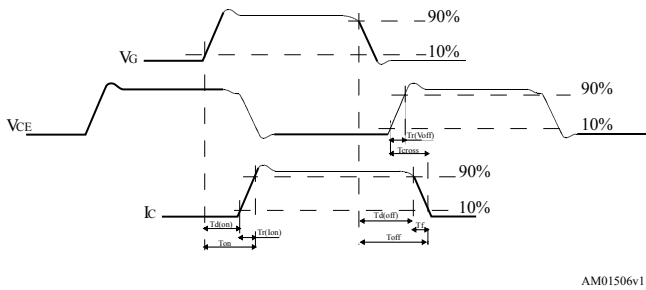
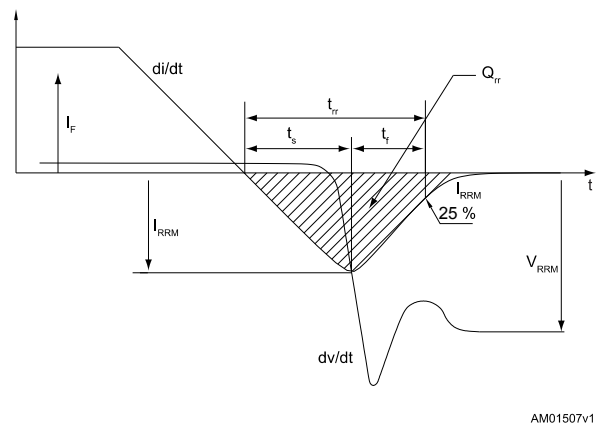
**Figure 26. Thermal impedance for IGBT**



**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**


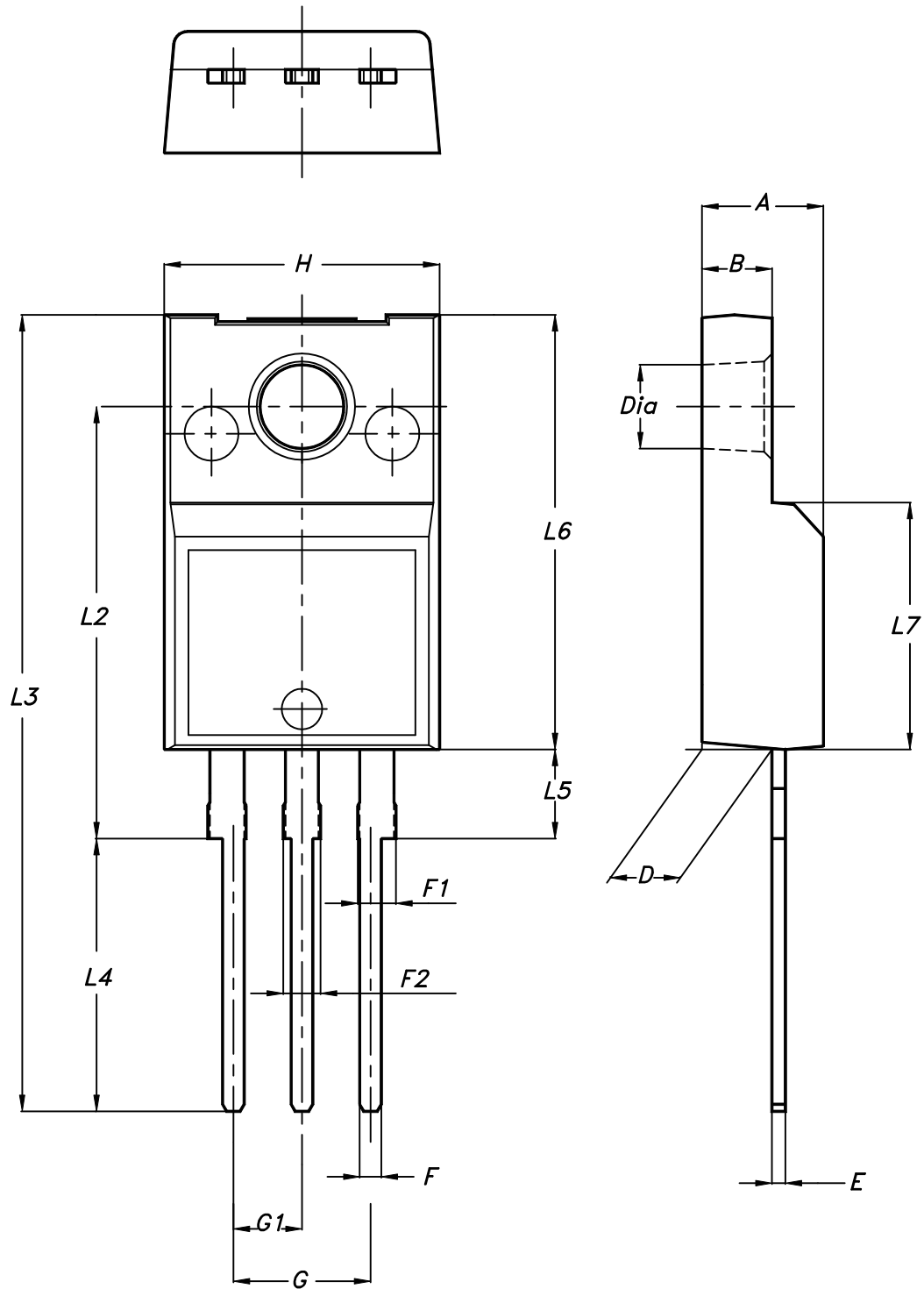
## 4 Package information

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

## 4.1 TO-220FP package information

Figure 32. TO-220FP package outline



7012510\_Rev\_12\_B

**Table 7. TO-220FP package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

## Revision history

**Table 8. Document revision history**

Date	Revision	Changes
02-Nov-2015	1	First release.
24-Feb-2016	2	Document status promoted from preliminary to production data
10-Mar-2016	3	Updated <i>Figure 13: "Normalized <math>V_{(BR)CES}</math> vs. junction temperature .</i> Minor text changes.
08-Oct-2018	4	Updated <a href="#">Table 3. Static characteristics.</a> Minor text changes

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