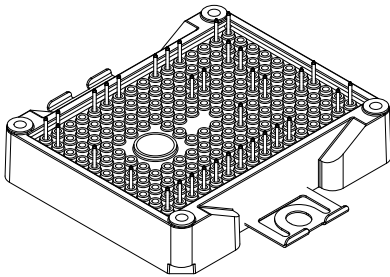
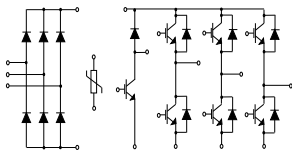


# ACEPACK™ 2 converter inverter brake, 650 V, 50 A trench gate field-stop IGBT M series, soft diode and NTC


**ACEPACK™ 2**


## Features

- ACEPACK™ 2 power module
  - DBC Cu Al<sub>2</sub>O<sub>3</sub> Cu
- Converter inverter brake topology
  - 1600 V, very low drop rectifiers for converter
  - 650 V, 50 A IGBTs and diodes
  - Soft and fast recovery diode
- Integrated NTC

## Applications

- Inverters
- Motor drives

## Description

This power module is a converter-inverter brake (CIB) topology in an ACEPACK™ 2 package with NTC, integrating the advanced trench gate field-stop technology from STMicroelectronics. This new IGBT technology represents the best compromise between conduction and switching loss, to maximize the efficiency of any converter system up to 20 kHz.



### Product status

A2C50S65M2

### Product summary

<b>Order code</b>	A2C50S65M2
<b>Marking</b>	A2C50S65M2
<b>Package</b>	ACEPACK™ 2
<b>Leads type</b>	Solder contact pins

# 1 Electrical ratings

## 1.1 Inverter stage

Limiting values at  $T_J = 25\text{ °C}$ , unless otherwise specified.

### 1.1.1 IGBTs

**Table 1. Absolute maximum ratings of the IGBTs, inverter stage**

Symbol	Description	Value	Unit
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0\text{ V}$ )	650	V
$I_C$	Continuous collector current ( $T_C = 100\text{ °C}$ )	50	A
$I_{CP}^{(1)}$	Pulsed collector current ( $t_p = 1\text{ ms}$ )	100	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$P_{TOT}$	Total power dissipation of each IGBT ( $T_C = 25\text{ °C}$ , $T_J = 175\text{ °C}$ )	208	W
$T_{JMAX}$	Maximum junction temperature	175	$^{\circ}\text{C}$
$T_{Jop}$	Operating junction temperature range under switching conditions	-40 to 150	$^{\circ}\text{C}$

1. Pulse width limited by maximum junction temperature

**Table 2. Electrical characteristics of the IGBTs, inverter stage**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage	$I_C = 1\text{ mA}$ , $V_{GE} = 0\text{ V}$	650			V
$V_{CE(sat)}$ (terminal)	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$		1.95	2.3	V
		$V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$ , $T_J = 150\text{ °C}$		2.3		V
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}$ , $I_C = 1\text{ mA}$	5	6	7	V
$I_{CES}$	Collector cut-off current	$V_{GE} = 0\text{ V}$ , $V_{CE} = 650\text{ V}$			100	$\mu\text{A}$
$I_{GES}$	Gate-emitter leakage current	$V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$			$\pm 500$	nA
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$		4150		pF
$C_{oes}$	Output capacitance			170		pF
$C_{res}$	Reverse transfer capacitance			80		pF
$Q_g$	Total gate charge	$V_{CC} = 520\text{ V}$ , $I_C = 50\text{ A}$ , $V_{GE} = \pm 15\text{ V}$		150		nC
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 300\text{ V}$ , $I_C = 50\text{ A}$ , $R_G = 6.8\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 2320\text{ A}/\mu\text{s}$		147		ns
$t_r$	Current rise time			17.5		ns
$E_{on}^{(1)}$	Turn-on switching energy			0.147		mJ

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 300\text{ V}$ , $I_C = 50\text{ A}$ ,		105		ns
$t_f$	Current fall time	$R_G = 6.8\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		133		ns
$E_{off}^{(2)}$	Turn-off switching energy	$dv/dt = 7400\text{ V}/\mu\text{s}$		1.36		mJ
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 300\text{ V}$ , $I_C = 50\text{ A}$ ,		147		ns
$t_r$	Current rise time	$R_G = 6.8\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		20		ns
$E_{on}^{(1)}$	Turn-on switching energy	$di/dt = 2010\text{ A}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		0.318		mJ
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 300\text{ V}$ , $I_C = 50\text{ A}$ ,		104		ns
$t_f$	Current fall time	$R_G = 6.8\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		194		ns
$E_{off}^{(2)}$	Turn-off switching energy	$dv/dt = 6000\text{ V}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		1.82		mJ
$t_{SC}$	Short-circuit withstand time	$V_{CC} \leq 360\text{ V}$ , $V_{GE} \leq 15\text{ V}$ , $T_{Jstart} \leq 150\text{ }^\circ\text{C}$	6			$\mu\text{s}$
$R_{THj-c}$	Thermal resistance junction-to-case	Each IGBT		0.65	0.72	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each IGBT, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot^\circ\text{C})$		0.79		$^\circ\text{C}/\text{W}$

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

### 1.1.2

#### Diode

Limiting values at  $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise specified.

**Table 3. Absolute maximum ratings of the diode, inverter stage**

Symbol	Parameter	Value	Unit
$V_{RRM}$	Repetitive peak reverse voltage	650	V
$I_F$	Continuous forward current ( $T_C = 100\text{ }^\circ\text{C}$ )	50	A
$I_{FP}^{(1)}$	Pulsed forward current ( $t_p = 1\text{ ms}$ )	100	A
$T_{JMAX}$	Maximum junction temperature	175	$^\circ\text{C}$
$T_{Jop}$	Operating junction temperature range under switching conditions	-40 to 150	$^\circ\text{C}$

1. Pulse width limited by maximum junction temperature

**Table 4. Electrical characteristics of the diode, inverter stage**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$ (terminal)	Forward voltage	$I_F = 50\text{ A}$	-	1.85	2.65	V
		$I_F = 50\text{ A}$ , $T_J = 150\text{ }^\circ\text{C}$	-	1.65		
$t_{rr}$	Reverse recovery time	$I_F = 50\text{ A}$ , $V_R = 300\text{ V}$ , $V_{GE} = \pm 15\text{ V}$ , $di_F/dt = 2320\text{ A}/\mu\text{s}$	-	155		ns
$Q_{rr}$	Reverse recovery charge		-	2.32		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current		-	41		A
$E_{rec}$	Reverse recovery energy		-	0.53		mJ

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{rr}$	Reverse recovery time	$I_F = 50\text{ A}$ , $V_R = 300\text{ V}$ , $V_{GE} = \pm 15\text{ V}$ , $di_F/dt = 2010\text{ A}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$	-	270		ns
$Q_{rr}$	Reverse recovery charge		-	5.98		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current		-	62		A
$E_{rec}$	Reverse recovery energy		-	1.6		mJ
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode	-	1.0	1.1	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot^\circ\text{C})$	-	0.9		$^\circ\text{C}/\text{W}$

## 1.2 Brake stage

Limiting values at  $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise specified.

### 1.2.1 IGBT

**Table 5. Absolute maximum ratings of the IGBT, brake stage**

Symbol	Parameter	Value	Unit
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ )	650	V
$I_C$	Continuous collector current ( $T_C = 100\text{ }^\circ\text{C}$ )	50	A
$I_{CP}^{(1)}$	Pulsed collector current ( $t_p = 1\text{ ms}$ )	100	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$P_{TOT}$	Total power dissipation of each IGBT ( $T_C = 25\text{ }^\circ\text{C}$ , $T_J = 175\text{ }^\circ\text{C}$ )	208	W
$T_{JMAX}$	Maximum junction temperature	175	$^\circ\text{C}$
$T_{Jop}$	Operating junction temperature range under switching conditions	-40 to 150	$^\circ\text{C}$

1. Pulse width limited by maximum junction temperature

**Table 6. Electrical characteristics of the IGBT, brake stage**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage	$I_C = 1\text{ mA}$ , $V_{GE} = 0\text{ V}$	650			V
$V_{CE(sat)}$ (terminal)	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$ $V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$ , $T_J = 150\text{ }^\circ\text{C}$		1.95 2.3		V
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}$ , $I_C = 1\text{ mA}$	5	6	7	V
$I_{CES}$	Collector cut-off current	$V_{GE} = 0\text{ V}$ , $V_{CE} = 650\text{ V}$			100	$\mu\text{A}$
$I_{GES}$	Gate-emitter leakage current	$V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$			$\pm 500$	nA
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$		4150		pF
$C_{oes}$	Output capacitance			170		pF
$C_{res}$	Reverse transfer capacitance			80		pF
$Q_g$	Total gate charge	$V_{CC} = 520\text{ V}$ , $I_C = 50\text{ A}$ , $V_{GE} = \pm 15\text{ V}$		150		nC

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 300\text{ V}$ , $I_C = 50\text{ A}$ , $R_G = 6.8\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 2320\text{ A}/\mu\text{s}$		147		ns
$t_r$	Current rise time			17.5		ns
$E_{on}^{(1)}$	Turn-on switching energy				0.147	
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 300\text{ V}$ , $I_C = 50\text{ A}$ , $R_G = 6.8\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $dv/dt = 7400\text{ V}/\mu\text{s}$		105		ns
$t_f$	Current fall time			133		ns
$E_{off}^{(2)}$	Turn-off switching energy				1.36	
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 300\text{ V}$ , $I_C = 50\text{ A}$ , $R_G = 6.8\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 2010\text{ A}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		147		ns
$t_r$	Current rise time			20		ns
$E_{on}^{(1)}$	Turn-on switching energy				0.318	
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 300\text{ V}$ , $I_C = 50\text{ A}$ , $R_G = 6.8\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $dv/dt = 6000\text{ V}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		104		ns
$t_f$	Current fall time			194		ns
$E_{off}^{(2)}$	Turn-off switching energy				1.82	
$t_{SC}$	Short-circuit withstand time	$V_{CC} \leq 360\text{ V}$ , $V_{GE} \leq 15\text{ V}$ , $T_{Jstart} \leq 150\text{ }^\circ\text{C}$	6			$\mu\text{s}$
$R_{THj-c}$	Thermal resistance junction-to-case	Each IGBT		0.65	0.72	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each IGBT, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot^\circ\text{C})$		0.79		$^\circ\text{C}/\text{W}$

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

## 1.2.2

### Diode

**Table 7. Absolute maximum ratings of the diode, brake stage**

Symbol	Parameter	Value	Unit
$V_{RRM}$	Repetitive peak reverse voltage	650	V
$I_F$	Continuous forward current ( $T_C = 100\text{ }^\circ\text{C}$ )	50	A
$I_{FP}^{(1)}$	Pulsed forward current ( $t_p = 1\text{ ms}$ )	100	A
$T_{JMAX}$	Maximum junction temperature	175	$^\circ\text{C}$
$T_{Jop}$	Operating junction temperature range under switching conditions	-40 to 150	$^\circ\text{C}$

1. Pulse width limited by maximum junction temperature.

**Table 8. Electrical characteristics of the diode, brake stage**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$ (terminal)	Forward voltage	$I_F = 50\text{ A}$	-	1.85		V
		$I_F = 50\text{ A}$ , $T_J = 150\text{ }^\circ\text{C}$	-	1.65		
$t_{rr}$	Reverse recovery time	$I_F = 50\text{ A}$ , $V_R = 300\text{ V}$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 2320\text{ A}/\mu\text{s}$	-	155		ns
$Q_{rr}$	Reverse recovery charge		-	2.32		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current		-	41		A
$E_{rec}$	Reverse recovery energy		-	0.53		mJ

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{rr}$	Reverse recovery time	$I_F = 50 \text{ A}$ , $V_R = 300 \text{ V}$ , $V_{GE} = \pm 15 \text{ V}$ , $di/dt = 2010 \text{ A}/\mu\text{s}$ , $T_J = 150 \text{ }^\circ\text{C}$	-	270		ns
$Q_{rr}$	Reverse recovery charge		-	5.98		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current		-	62		A
$E_{rec}$	Reverse recovery energy		-	1.6		mJ
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode	-	1.0	1.1	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1 \text{ W}/(\text{m}\cdot^\circ\text{C})$	-	0.9		$^\circ\text{C}/\text{W}$

### 1.3

## Converter stage

Limiting values at  $T_J = 25 \text{ }^\circ\text{C}$ , unless otherwise specified.

**Table 9. Absolute maximum ratings of the bridge rectifiers**

Symbol	Description	Value	Unit
$V_{RRM}$	Repetitive peak reverse voltage	1600	V
$I_F$	RMS forward current	50	A
$I_{FSM}$	Forward surge current $t_p = 10 \text{ ms}$ , $T_C = 25 \text{ }^\circ\text{C}$	450	A
	Forward surge current $t_p = 10 \text{ ms}$ , $T_C = 150 \text{ }^\circ\text{C}$	365	
$I^2t$	$t_p = 10 \text{ ms}$ , $T_C = 25 \text{ }^\circ\text{C}$	1012	$\text{A}^2\text{s}$
	$t_p = 10 \text{ ms}$ , $T_C = 150 \text{ }^\circ\text{C}$	666	
$T_{JMAX}$	Maximum junction temperature	175	$^\circ\text{C}$
$T_{Jop}$	Operating junction temperature range under switching conditions	-40 to 150	$^\circ\text{C}$

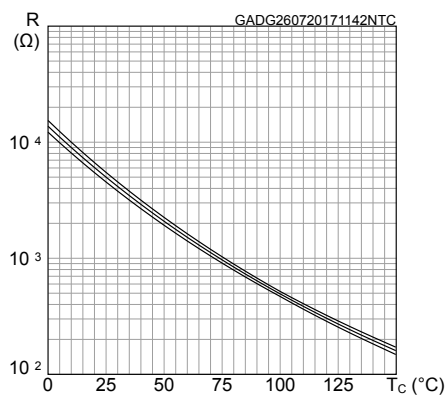
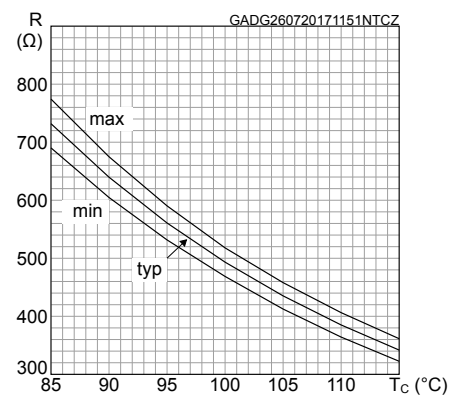
**Table 10. Electrical characteristics of the bridge rectifiers**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$ (terminal)	Forward voltage	$I_F = 50 \text{ A}$	-	1.23	1.6	V
		$I_F = 50 \text{ A}$ , $T_J = 150 \text{ }^\circ\text{C}$	-	1.14		
$I_R$	Reverse current	$T_J = 150 \text{ }^\circ\text{C}$ , $V_R = 1600 \text{ V}$	-	1		mA
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode	-	1.00	1.10	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1 \text{ W}/(\text{m}\cdot^\circ\text{C})$	-	0.95		$^\circ\text{C}/\text{W}$

## 1.4 NTC

**Table 11. NTC temperature sensor, considered as stand-alone**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
R <sub>25</sub>	Resistance	T = 25 °C		5		kΩ
R <sub>100</sub>	Resistance	T = 100 °C		493		Ω
ΔR/R	Deviation of R <sub>100</sub>		-5		+5	%
B <sub>25/50</sub>	B-constant			3375		K
B <sub>25/80</sub>	B-constant			3411		K
T	Operating temperature range		-40		150	°C

**Figure 1. NTC resistance vs temperature**

**Figure 2. NTC resistance vs temperature, zoom**


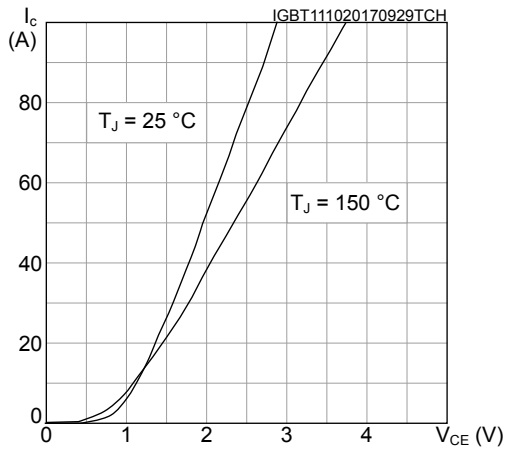
## 1.5 Package

**Table 12. ACEPACK™ 2 package**

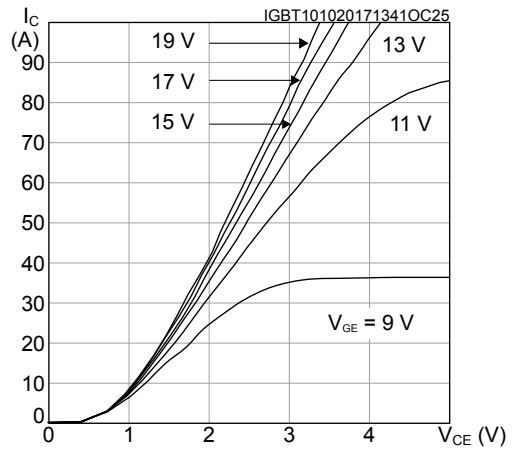
Symbol	Parameter	Min.	Typ.	Max.	Unit
V <sub>isol</sub>	Isolation voltage (AC voltage, t = 60 s)			2500	Vrms
T <sub>stg</sub>	Storage temperature	-40		125	°C
CTI	Comparative tracking index	200			
L <sub>s</sub>	Stray inductance module P1 - EW loop		33.5		nH
R <sub>s</sub>	Module single lead resistance, terminal to chip		3.6		mΩ

## 2 Electrical characteristics (curves)

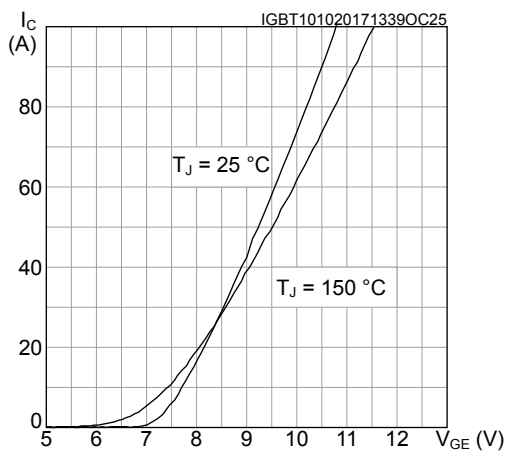
**Figure 3. IGBT output characteristics**  
( $V_{GE} = 15\text{ V}$ , terminal)



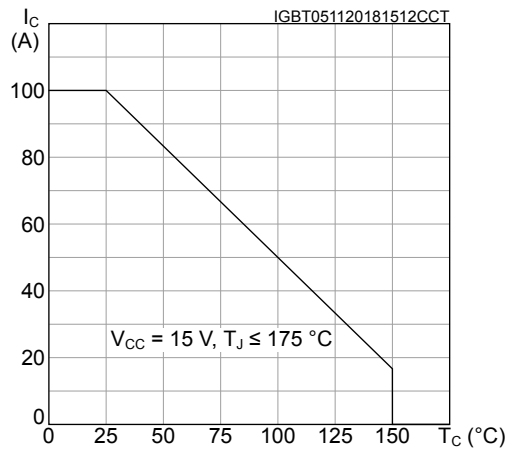
**Figure 4. IGBT output characteristics**  
( $T_J = 150\text{ °C}$ , terminal)



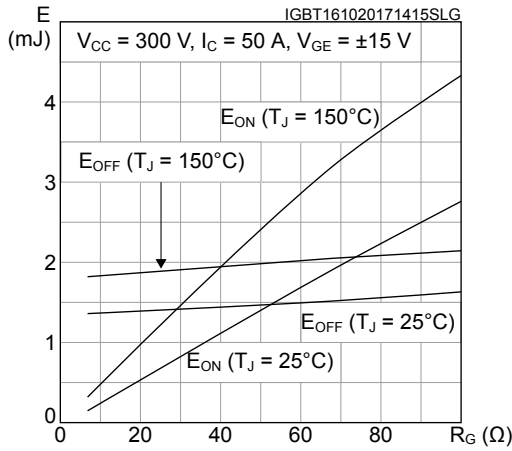
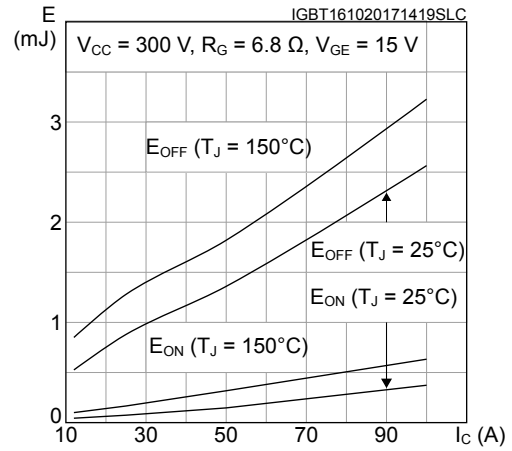
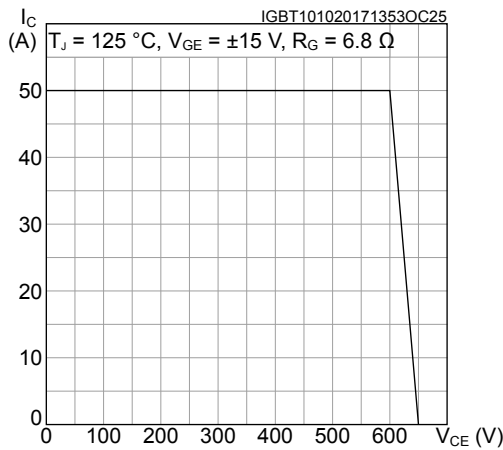
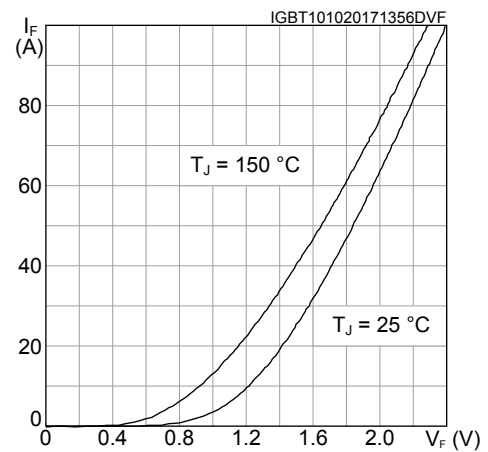
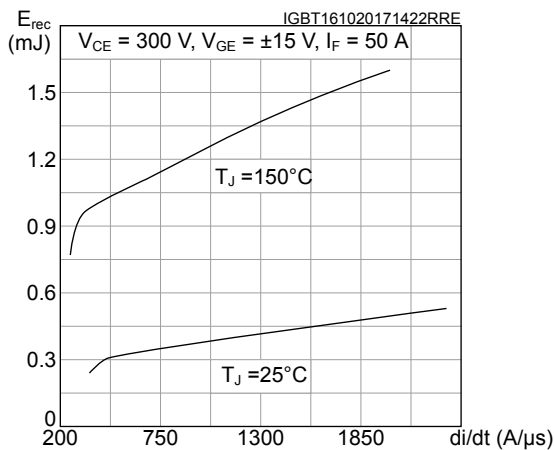
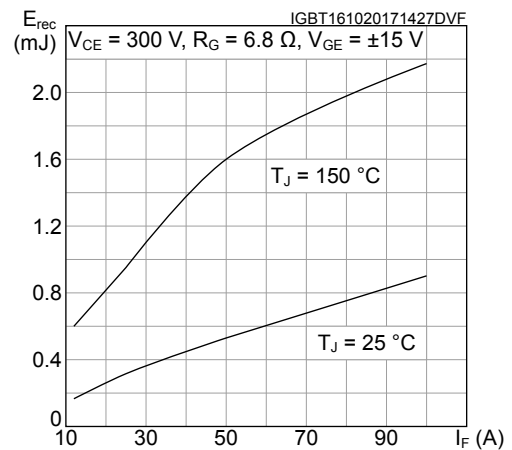
**Figure 5. IGBT transfer characteristics**  
( $V_{CE} = 15\text{ V}$ , terminal)

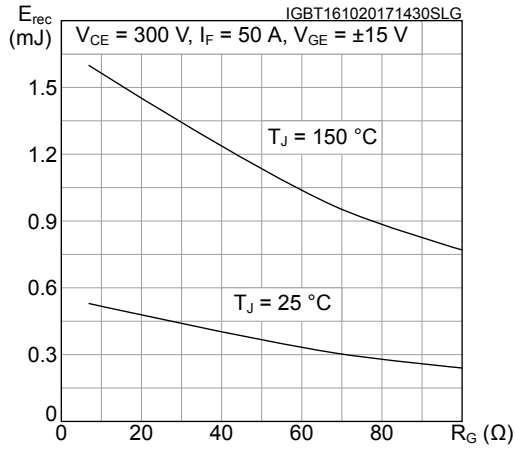
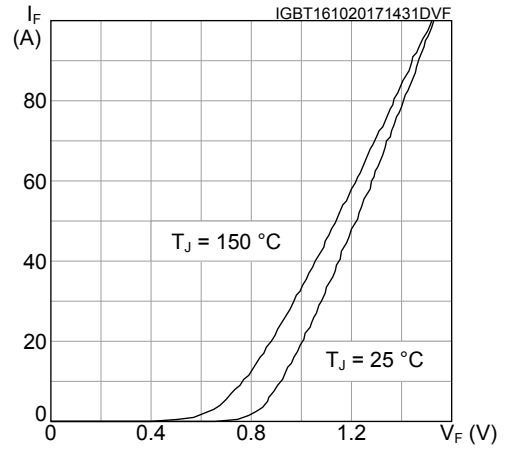
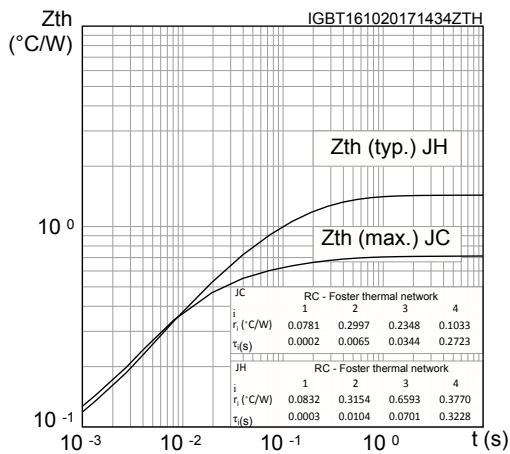
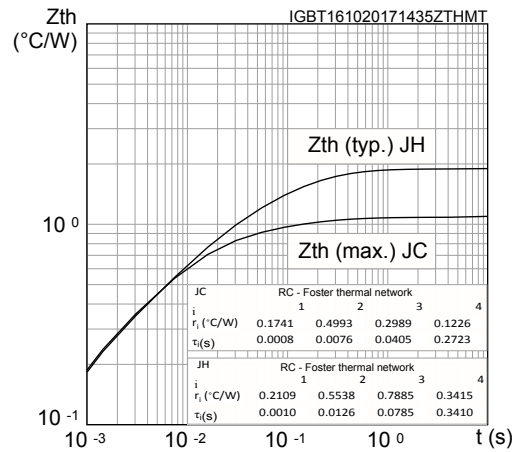


**Figure 6. IGBT collector current vs case temperature**

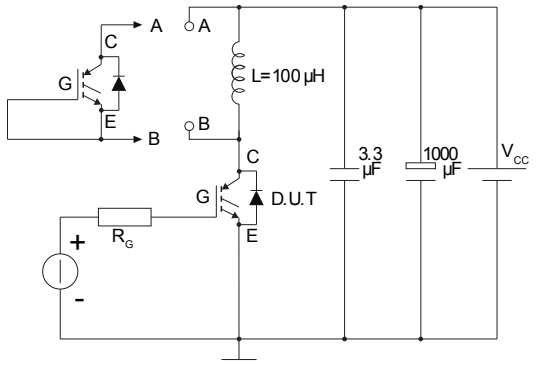
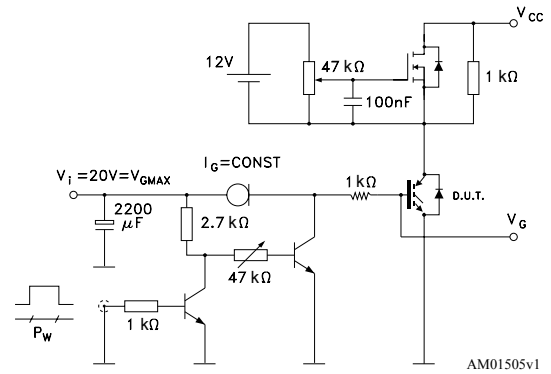
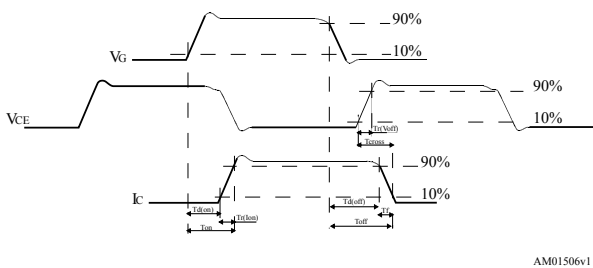
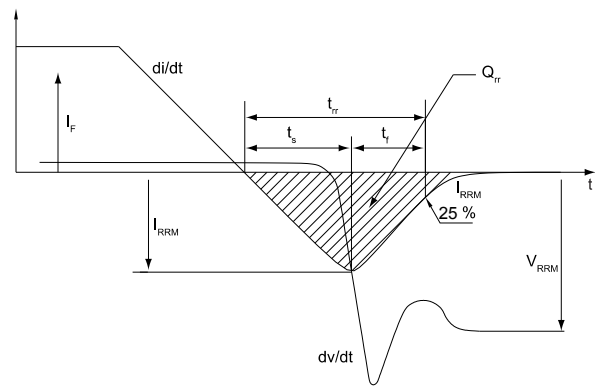




**Figure 7. Switching energy vs gate resistance**

**Figure 8. Switching energy vs collector current**

**Figure 9. IGBT reverse biased safe operating area (RBSOA)**

**Figure 10. Diode forward characteristics (terminal)**

**Figure 11. Diode reverse recovery energy vs diode current slope**

**Figure 12. Diode reverse recovery energy vs forward current**


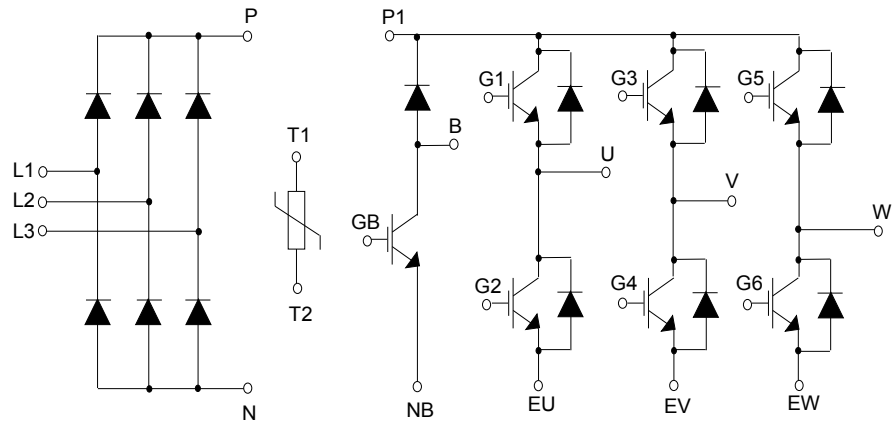
**Figure 13. Diode reverse recovery energy vs gate resistance**

**Figure 14. Converter diode forward characteristics (terminal)**

**Figure 15. IGBT thermal impedance**

**Figure 16. Inverter diode thermal impedance**


### 3 Test circuits

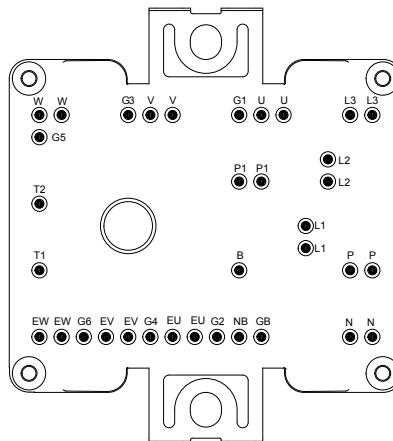
**Figure 17. Test circuit for inductive load switching**

**Figure 18. Gate charge test circuit**

**Figure 19. Switching waveform**

**Figure 20. Diode reverse recovery waveform**


## 4 Topology and pin description

**Figure 21. Electrical topology and pin description**



**Figure 22. Package top view with CIB pinout**

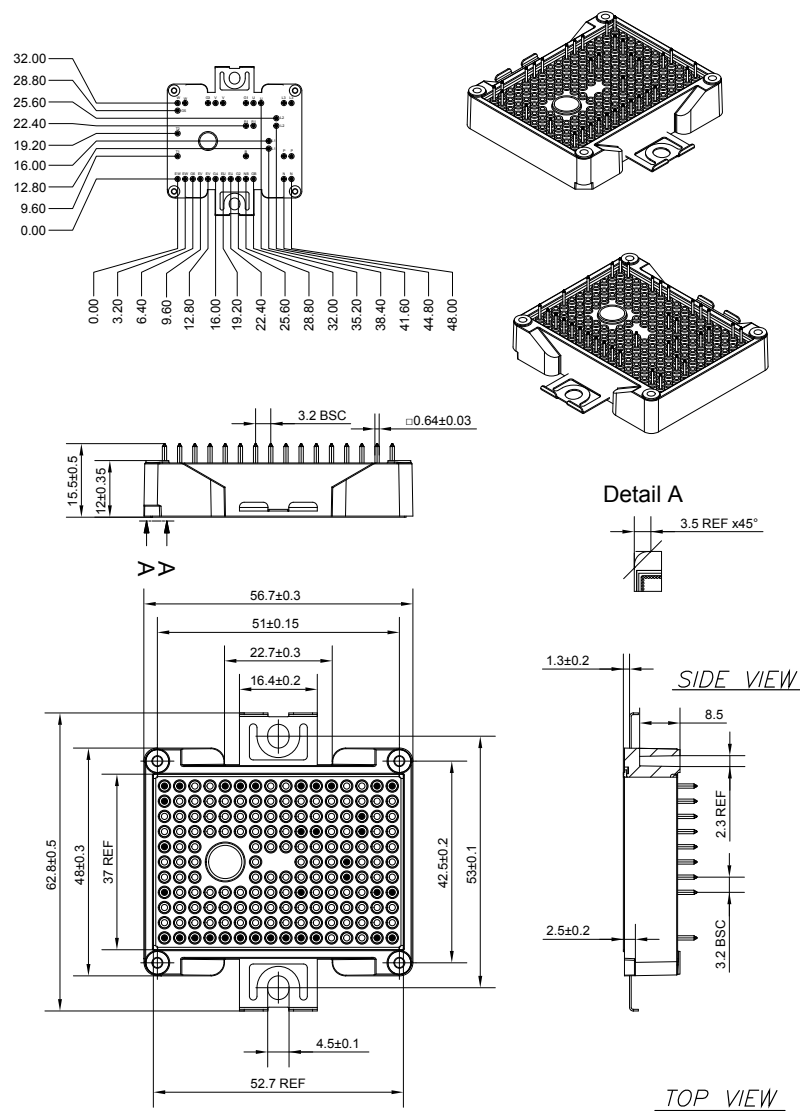


## 5 Package information

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.

### 5.1 ACEPACK<sup>™</sup> 2 CIB solder pins package information

**Figure 23. ACEPACK<sup>™</sup> 2 CIB solder pins package outline (dimensions are in mm)**



8569722\_ACEPACK2\_CIB\_solderable\_pins

- The lead size includes the thickness of the lead plating material.
- Dimensions do not include mold protrusion.
- Package dimensions do not include any eventual metal burrs.

## Revision history

**Table 13. Document revision history**

Date	Revision	Changes
16-Oct-2017	1	Initial release
02-Mar-2018	2	<p>Removed maturity status indication from cover page. The document status is production data.</p> <p>Updated features on cover page.</p> <p>Updated <a href="#">Table 10. Electrical characteristics of the bridge rectifiers.</a></p> <p>Updated <a href="#">Figure 15. IGBT thermal impedance</a> and <a href="#">Figure 16. Inverter diode thermal impedance.</a></p> <p>Updated <a href="#">Figure 23. ACEPACK™ 2 CIB solder pins package outline (dimensions are in mm).</a></p> <p>Minor text changes</p>
19-Nov-2018	3	<p>Added <a href="#">Section STPOWER LOGO</a> and <a href="#">Figure 6. IGBT collector current vs case temperature.</a></p>

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