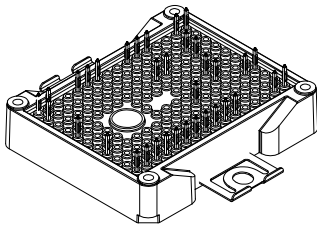
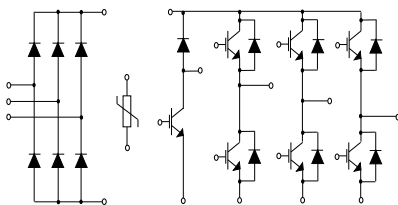


# ACEPACK™ 2 converter inverter brake, 1200 V, 35 A trench gate field-stop IGBT M series, soft diode and NTC


**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
  - 1200 V, 35 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 link

[A2C35S12M3-F](#)

### Product summary

<b>Order code</b>	A2C35S12M3-F
<b>Marking</b>	A2C35S12M3-F
<b>Package</b>	ACEPACK™ 2
<b>Leads type</b>	Press fit 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 ( $V_{GE} = 0$ )	1200	V
$I_C$	Continuous collector current ( $T_C = 100\text{ °C}$ )	35	A
$I_{CP}^{(1)}$	Pulsed collector current ( $t_p = 1\text{ ms}$ )	70	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$P_{TOT}$	Total power dissipation of each IGBT ( $T_C = 25\text{ °C}$ , $T_J = 175\text{ °C}$ )	250	W
$T_{JMAX}$	Maximum junction temperature	175	°C
$T_{Jop}$	Operating junction temperature range under switching conditions	-40 to 150	°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	$I_C = 1\text{ mA}$ , $V_{GE} = 0\text{ V}$	1200			V
$V_{CE(sat)}$ (terminal)	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}$ , $I_C = 35\text{ A}$		1.95	2.45	V
		$V_{GE} = 15\text{ V}$ , $I_C = 35\text{ A}$ , $T_J = 150\text{ °C}$		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	$V_{GE} = 0\text{ V}$ , $V_{CE} = 1200\text{ V}$			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	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$		2154		pF
$C_{oes}$	Output capacitance			164		pF
$C_{res}$	Reverse transfer capacitance			86		pF
$Q_g$	Total gate charge	$V_{CC} = 960\text{ V}$ , $I_C = 35\text{ A}$ , $V_{GE} = \pm 15\text{ V}$		163		nC
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600\text{ V}$ , $I_C = 35\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 1460\text{ A}/\mu\text{s}$		127		ns
$t_r$	Current rise time			18.5		ns
$E_{on}^{(1)}$	Turn-on switching energy			1.065		mJ

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 35\text{ A}$ ,		135		ns
$t_f$	Current fall time	$R_G = 10\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		133		ns
$E_{off}^{(2)}$	Turn-off switching energy	$dv/dt = 9000\text{ V}/\mu\text{s}$		1.83		mJ
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600\text{ V}$ , $I_C = 35\text{ A}$ ,		125		ns
$t_r$	Current rise time	$R_G = 10\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		20		ns
$E_{on}^{(1)}$	Turn-on switching energy	$di/dt = 1424\text{ A}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		1.79		mJ
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 35\text{ A}$ ,		140		ns
$t_f$	Current fall time	$R_G = 10\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		224		ns
$E_{off}^{(2)}$	Turn-off switching energy	$dv/dt = 7500\text{ V}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		2.85		mJ
$t_{SC}$	Short-circuit withstand time	$V_{CC} \leq 600\text{ V}$ , $V_{GE} \leq 15\text{ V}$ , $T_{jstart} \leq 150\text{ }^\circ\text{C}$	10			$\mu\text{s}$
$R_{THj-c}$	Thermal resistance junction-to-case	Each IGBT		0.55	0.60	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each IGBT, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot^\circ\text{C})$		0.70		$^\circ\text{C}/\text{W}$

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	1200	V
$I_F$	Continuous forward current ( $T_C = 100\text{ }^\circ\text{C}$ )	35	A
$I_{FP}^{(1)}$	Pulsed forward current ( $t_p = 1\text{ ms}$ )	70	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	$I_F = 35\text{ A}$	-	2.95	4.1	V
		$I_F = 35\text{ A}$ , $T_J = 150\text{ }^\circ\text{C}$	-	2.3		
$t_{rr}$	Reverse recovery time		-	200		ns
$Q_{rr}$	Reverse recovery charge	$I_F = 35\text{ A}$ , $V_R = 600\text{ V}$ ,	-	2.7		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current	$V_{GE} = \pm 15\text{ V}$ , $di_f/dt = 1460\text{ A}/\mu\text{s}$	-	43		A
$E_{rec}$	Reverse recovery energy		-	1.1		mJ

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{rr}$	Reverse recovery time	$I_F = 35 \text{ A}$ , $V_R = 600 \text{ V}$ , $V_{GE} = \pm 15 \text{ V}$ , $di_F/dt = 1424 \text{ A}/\mu\text{s}$ , $T_J = 150 \text{ }^\circ\text{C}$	-	380		ns
$Q_{rr}$	Reverse recovery charge		-	6.8		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current		-	60		A
$E_{rec}$	Reverse recovery energy		-	3.2		mJ
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode	-	0.80	0.90	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1 \text{ W}/(\text{m}\cdot^\circ\text{C})$	-	0.75		$^\circ\text{C}/\text{W}$

## 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 ( $V_{GE} = 0$ )	1200	V
$I_C$	Continuous collector current ( $T_C = 100 \text{ }^\circ\text{C}$ )	35	A
$I_{CP}^{(1)}$	Pulsed collector current ( $t_p = 1 \text{ ms}$ )	70	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$P_{TOT}$	Total power dissipation of each IGBT ( $T_C = 25 \text{ }^\circ\text{C}$ , $T_J = 175 \text{ }^\circ\text{C}$ )	250	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	$I_C = 1 \text{ mA}$ , $V_{GE} = 0 \text{ V}$	1200			V
$V_{CE(sat)}$ (terminal)	Collector-emitter saturation voltage	$V_{GE} = 15 \text{ V}$ , $I_C = 35 \text{ A}$		1.95		V
		$V_{GE} = 15 \text{ V}$ , $I_C = 35 \text{ A}$ , $T_J = 150 \text{ }^\circ\text{C}$		2.3		
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}$ , $I_C = 1 \text{ mA}$	5	6	7	V
$I_{CES}$	Collector cut-off current	$V_{GE} = 0 \text{ V}$ , $V_{CE} = 1200 \text{ V}$			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	$V_{CE} = 25 \text{ V}$ , $f = 1 \text{ MHz}$ , $V_{GE} = 0 \text{ V}$		2154		pF
$C_{oes}$	Output capacitance			164		pF
$C_{res}$	Reverse transfer capacitance			86		pF

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$Q_g$	Total gate charge	$V_{CC} = 960\text{ V}$ , $I_C = 35\text{ A}$ , $V_{GE} = \pm 15\text{ V}$		163		nC
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600\text{ V}$ , $I_C = 35\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 1460\text{ A}/\mu\text{s}$		127		ns
$t_r$	Current rise time			18.5		ns
$E_{on}^{(1)}$	Turn-on switching energy			1.065		mJ
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 35\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $dv/dt = 9000\text{ V}/\mu\text{s}$		135		ns
$t_f$	Current fall time			133		ns
$E_{off}^{(2)}$	Turn-off switching energy			1.83		mJ
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600\text{ V}$ , $I_C = 35\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 1424\text{ A}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		125		ns
$t_r$	Current rise time			20		ns
$E_{on}^{(1)}$	Turn-on switching energy			1.79		mJ
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 35\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $dv/dt = 7500\text{ V}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		140		ns
$t_f$	Current fall time			224		ns
$E_{off}^{(2)}$	Turn-off switching energy			2.85		mJ
$t_{SC}$	Short-circuit withstand time	$V_{CC} \leq 600\text{ V}$ , $V_{GE} \leq 15\text{ V}$ , $T_{Jstart} \leq 150\text{ }^\circ\text{C}$	10			$\mu\text{s}$
$R_{THj-c}$	Thermal resistance junction-to-case	Each IGBT		0.55	0.60	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each IGBT, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot^\circ\text{C})$		0.70		$^\circ\text{C}/\text{W}$

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	1200	V
$I_F$	Continuous forward current ( $T_C = 100\text{ °C}$ )	35	A
$I_{FP}^{(1)}$	Pulsed forward current ( $t_p = 1\text{ ms}$ )	70	A
$T_{JMAX}$	Maximum junction temperature	175	°C
$T_{Jop}$	Operating junction temperature range under switching conditions	-40 to 150	°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	$I_F = 35\text{ A}$	-	2.95		V
		$I_F = 35\text{ A}, T_J = 150\text{ °C}$	-	2.3		
$t_{rr}$	Reverse recovery time	$I_F = 35\text{ A}, V_R = 600\text{ V}, V_{GE} = \pm 15\text{ V},$ $di/dt = 1460\text{ A}/\mu\text{s}$	-	200		ns
$Q_{rr}$	Reverse recovery charge		-	2.7		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current		-	43		A
$E_{rec}$	Reverse recovery energy		-	1.1		mJ
$t_{rr}$	Reverse recovery time	$I_F = 35\text{ A}, V_R = 600\text{ V}, V_{GE} = \pm 15\text{ V},$ $di/dt = 1424\text{ A}/\mu\text{s}, T_J = 150\text{ °C}$	-	380		ns
$Q_{rr}$	Reverse recovery charge		-	6.8		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current		-	60		A
$E_{rec}$	Reverse recovery energy		-	3.2		mJ
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode	-	0.80	0.90	°C/W
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot\text{°C})$	-	0.75		°C/W

### 1.3 Converter stage

Limiting values at  $T_J = 25\text{ °C}$ , 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	70	A
$I_{FSM}$	Forward surge current, $t_p = 10\text{ ms}$ , $T_C = 25\text{ °C}$	450	A
	Forward surge current, $t_p = 10\text{ ms}$ , $T_C = 150\text{ °C}$	365	
$I^2t$	$t_p = 10\text{ ms}$ , $T_C = 25\text{ °C}$	1012	A <sup>2</sup> s
	$t_p = 10\text{ ms}$ , $T_C = 150\text{ °C}$	666	
$T_{JMAX}$	Maximum junction temperature	175	°C
$T_{Jop}$	Operating junction temperature range under switching conditions	-40 to 150	°C

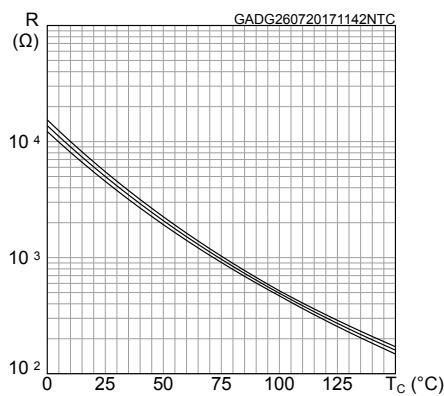
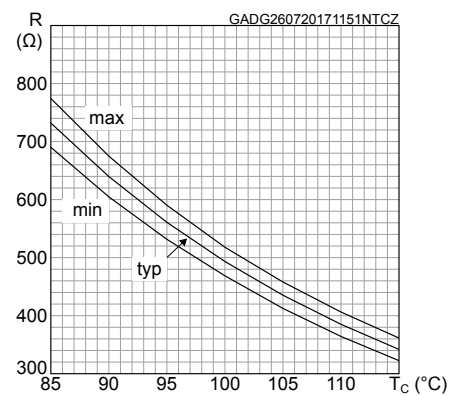
**Table 10. Electrical characteristics of the bridge rectifiers**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$ (terminal)	Forward voltage	$I_F = 35\text{ A}$	-	1.12	1.5	V
		$I_F = 35\text{ A}$ , $T_J = 150\text{ °C}$	-	1.02		
$I_R$	Reverse current	$T_J = 150\text{ °C}$ , $V_R = 1600\text{ V}$	-	1		mA
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode	-	1.00	1.10	°C/W
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1\text{ W/(m}\cdot\text{°C)}$	-	0.95		°C/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

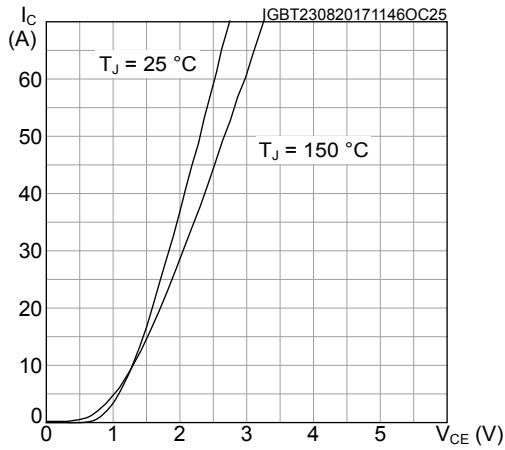
**Table 12. ACEPACK™ 2 package**

Symbol	Parameter	Min.	Typ.	Max.	Unit
V <sub>isol</sub>	Isolation voltage (AC voltage, t = 60 s)			2500	V
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

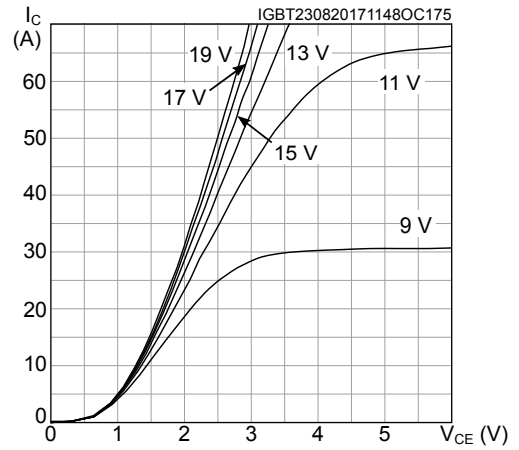


## 2 Electrical characteristics (curves)

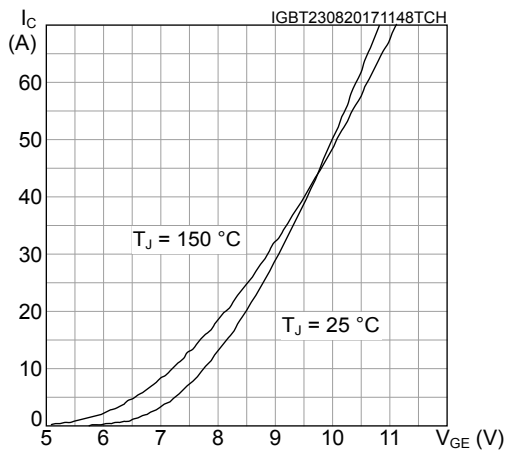
**Figure 3. IGBT output characteristics**  
( $V_{GE} = 15\text{ V}$ , terminal)



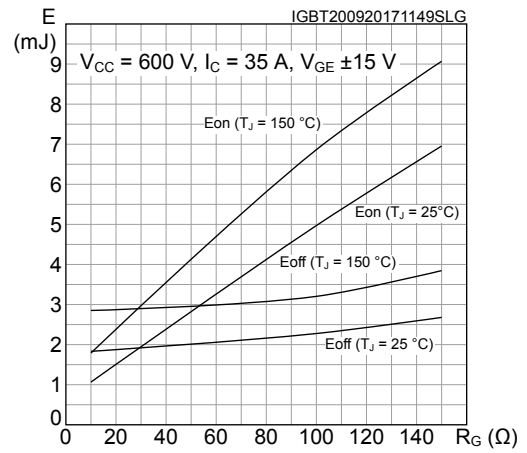
**Figure 4. IGBT output characteristics**  
( $T_J = 150\text{ °C}$ , terminal)



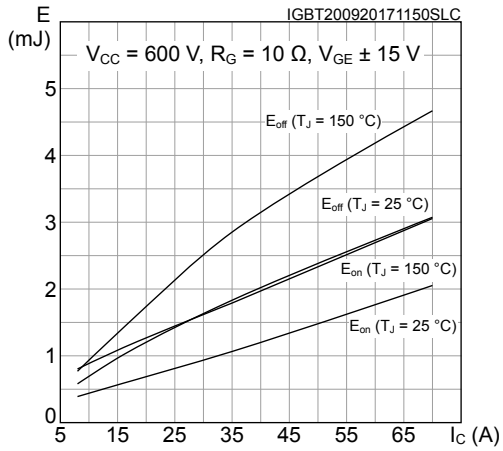
**Figure 5. IGBT output characteristics**  
( $V_{CE} = 15\text{ V}$ , terminal)



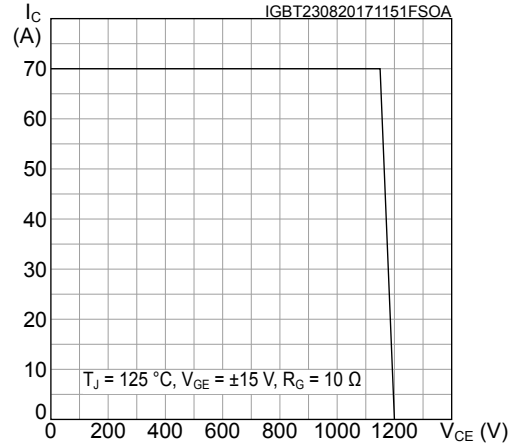
**Figure 6. Switching energy vs gate resistance**



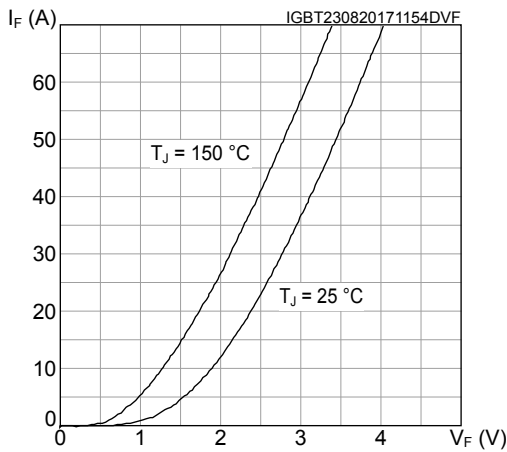
**Figure 7. Switching energy vs collector current**



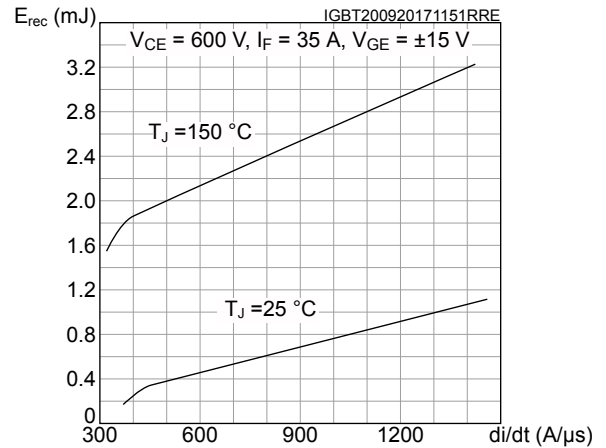
**Figure 8. IGBT reverse biased safe operating area (RBSOA)**



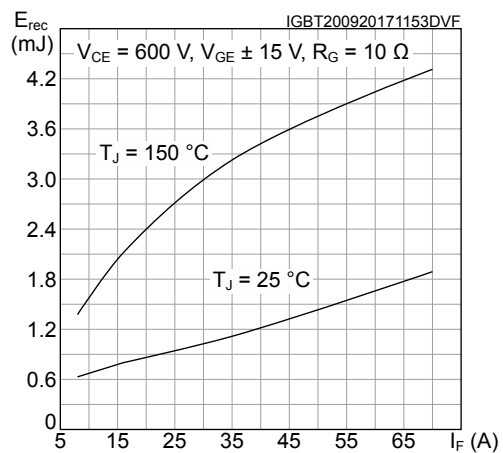
**Figure 9. Diode forward characteristics (terminal)**



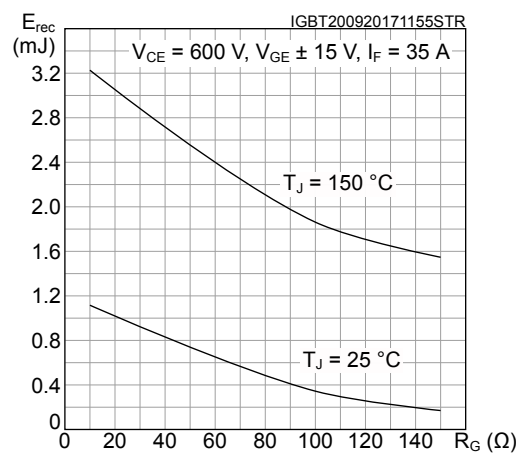
**Figure 10. Diode reverse recovery energy vs diode current slope**



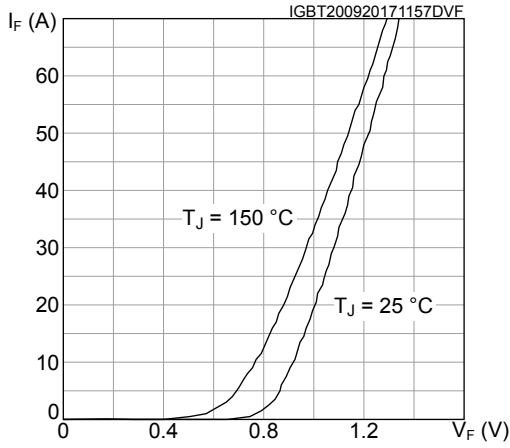
**Figure 11. Diode reverse recovery energy vs forward current**



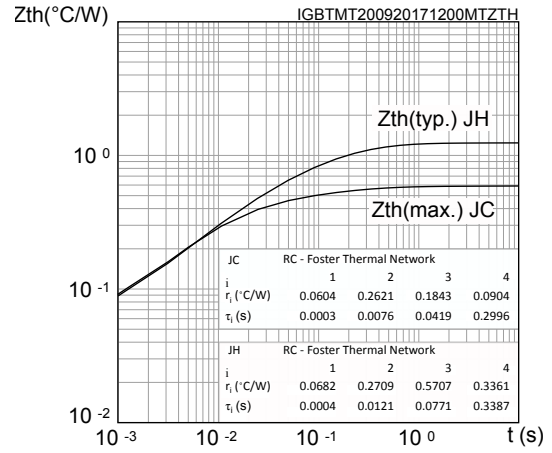
**Figure 12. Diode reverse recovery energy vs gate resistance**



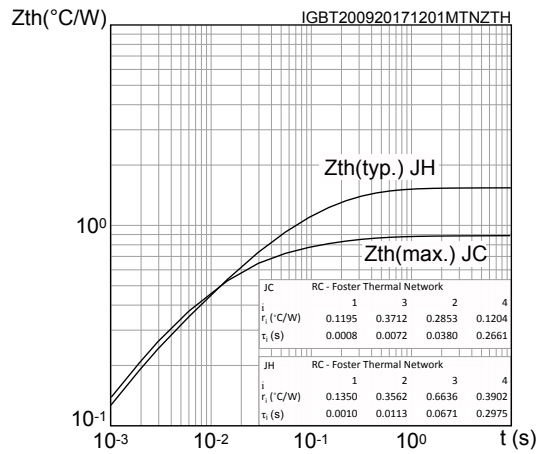
**Figure 13. Converter diode forward characteristics (terminal)**



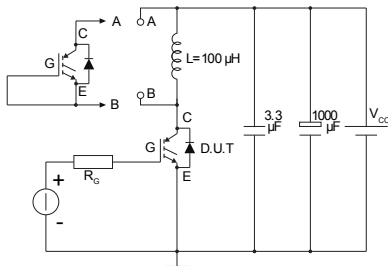
**Figure 14. IGBT thermal impedance**



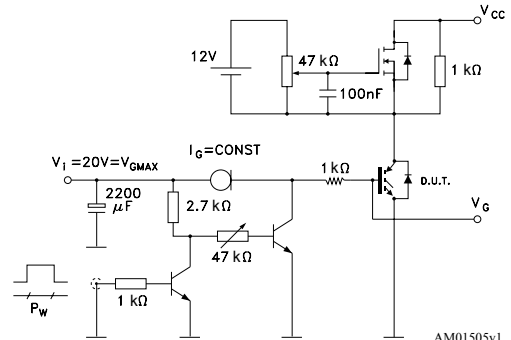
**Figure 15. Inverter diode thermal impedance**



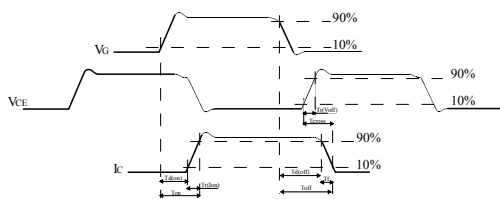
### 3 Test circuits

**Figure 16. Test circuit for inductive load switching**


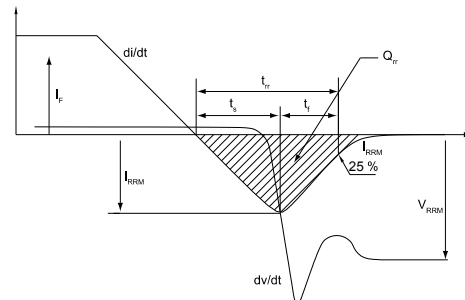
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**Figure 17. Gate charge test circuit**


AM01505v1

**Figure 18. Switching waveform**


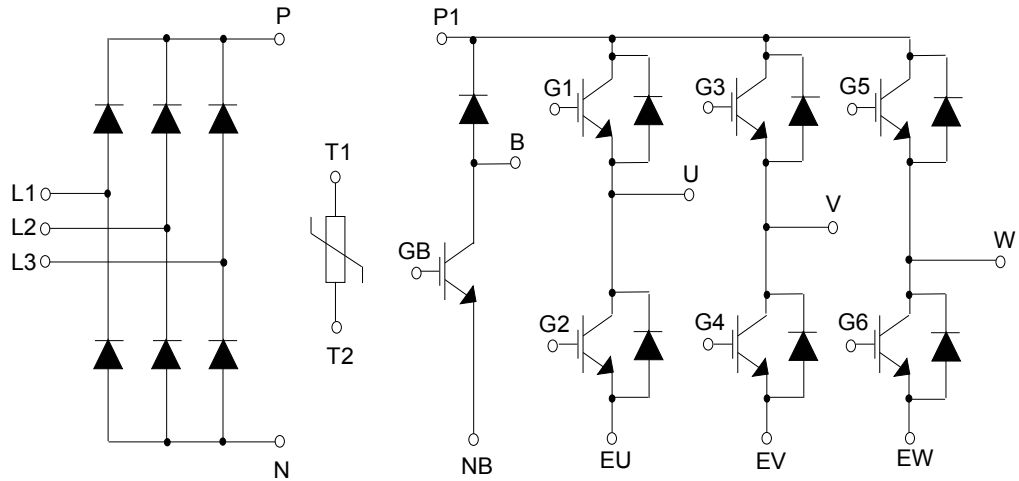
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**Figure 19. Diode reverse recovery waveform**


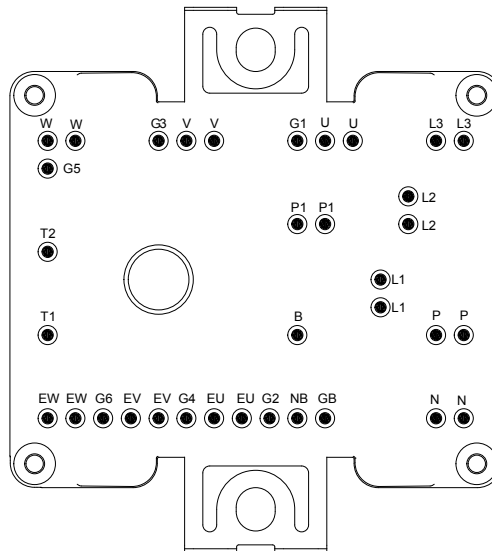
AM01507v1

## 4 Topology and pin description

**Figure 20. Electrical topology and pin description**



**Figure 21. Package top view with CIB pinout**

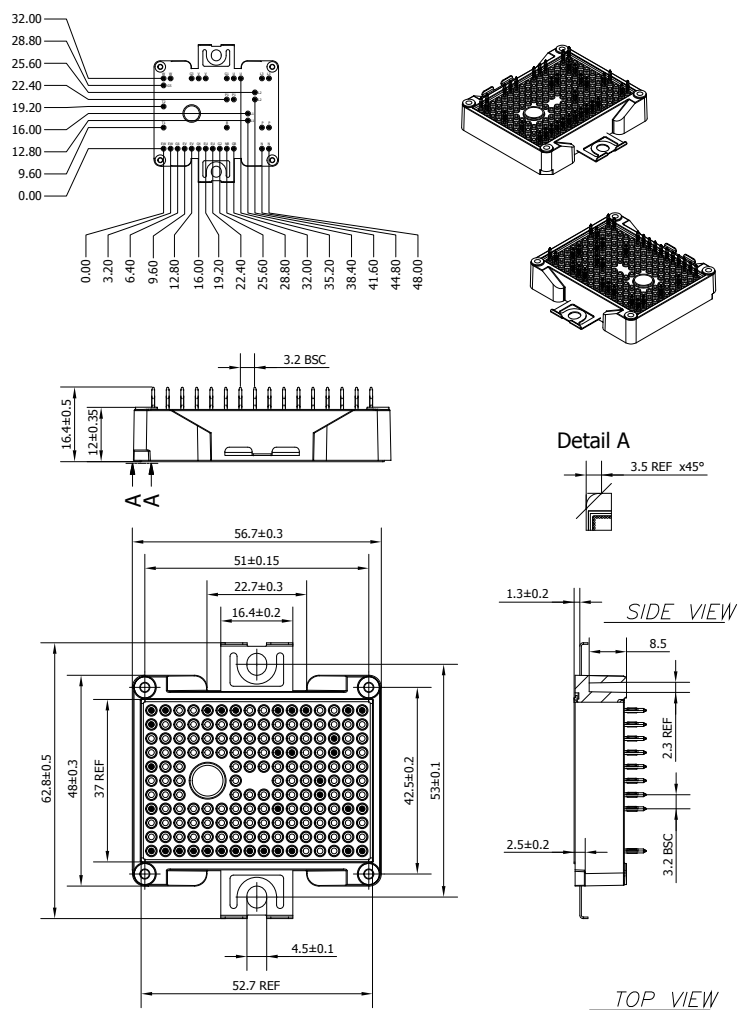


## 5 Package information

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.

### 5.1 ACEPACK™ 2 CIB press fit contact pins package information

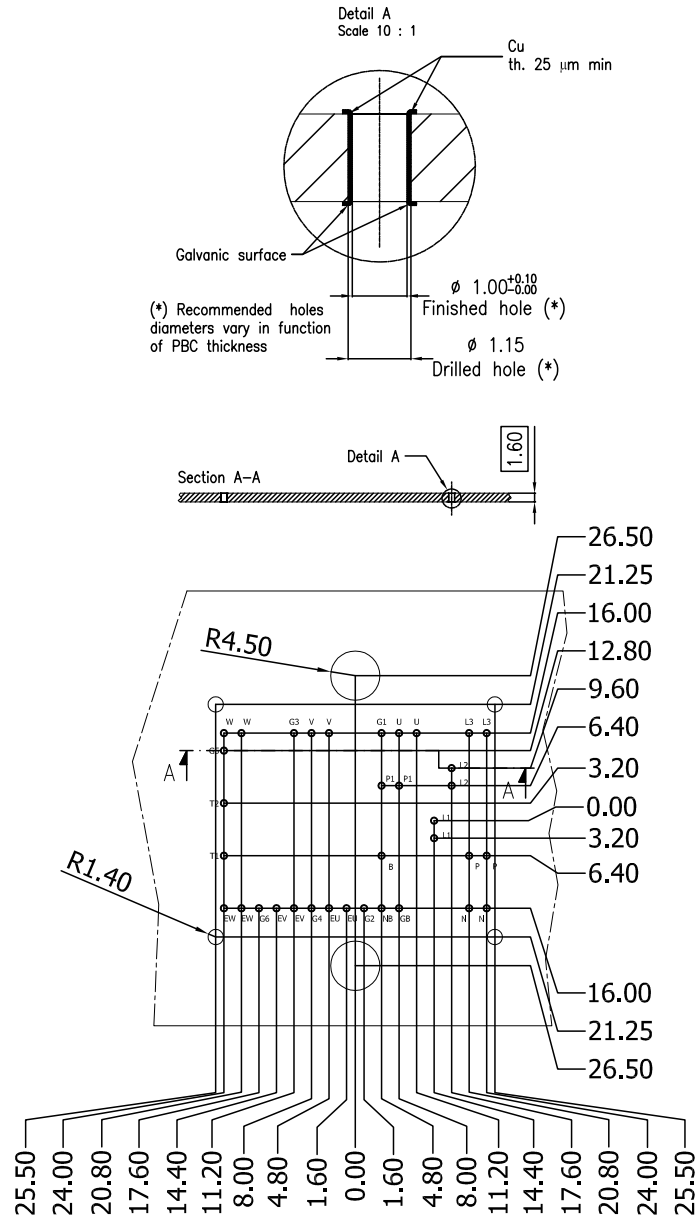
Figure 22. ACEPACK™ 2 CIB press fit contact pins package outline (dimensions are in mm)



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- 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.

**Figure 23. ACEPACK™ 2 CIB press fit contact pins recommended PCB holes layout (dimensions are in mm)**



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## Revision history

**Table 13. Document revision history**

Date	Revision	Changes
03-May-2016	1	Initial release.
22-Sep-2017	2	<p>Updated title, features and description in cover page.</p> <p>Updated <i>Table 1: "Device summary"</i>, <i>Section 1: "Electrical ratings"</i>, <i>Section 2: "Electrical characteristics curves"</i>, <i>Section 4: "Topology and pin description"</i> and <i>Section 5: "Package information"</i>.</p> <p>Minor text changes.</p>
22-Mar-2018	3	<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 14. IGBT thermal impedance</a> and <a href="#">Figure 15. Inverter diode thermal impedance</a>.</p> <p>Updated <a href="#">Section 5.1 ACEPACK™ 2 CIB press fit contact pins package information</a>.</p> <p>Minor text changes</p>



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