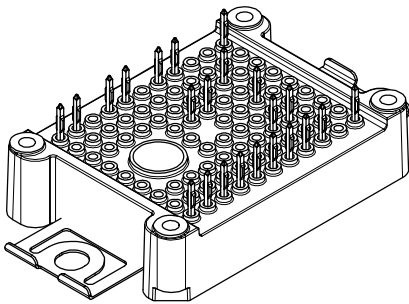
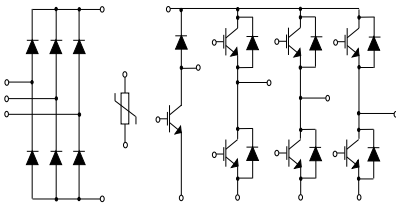


## ACEPACK™ 1 converter inverter brake, 1200 V, 15 A, trench gate field-stop M series IGBT with soft diode and NTC



ACEPACK™ 1



### Features

- ACEPACK™ 1 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, 15 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™ 1 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

[A1C15S12M3-F](#)

#### Product summary

Order code	A1C15S12M3-F
Marking	A1C15S12M3-F
Package	ACEPACK™ 1
Leads type	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 at $T_C = 100\text{ °C}$	15	A
$I_{CP}^{(1)}$	Pulsed collector current ( $t_p = 1\text{ ms}$ )	30	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$P_{TOT}$	Total power dissipation of each IGBT ( $T_C = 25\text{ °C}$ , $T_J = 175\text{ °C}$ )	142.8	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	$I_C = 1\text{ mA}$ , $V_{GE} = 0\text{ V}$	1200			V	
$V_{CE(sat)}$ (terminal)	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}$ , $I_C = 15\text{ A}$		1.95	2.45	V	
		$V_{GE} = 15\text{ V}$ , $I_C = 15\text{ A}$ , $T_J = 150\text{ °C}$		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	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$		985		pF	
$C_{oes}$	Output capacitance			118		pF	
$C_{res}$	Reverse transfer capacitance			40		pF	
$Q_g$	Total gate charge	$V_{CC} = 960\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = \pm 15\text{ V}$		71		nC	
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 820\text{ A}/\mu\text{s}$		120		ns	
$t_r$	Current rise time			14.5		ns	
$E_{on}^{(1)}$	Turn-on switching energy				0.59		mJ
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $dv/dt = 8200\text{ V}/\mu\text{s}$		115		ns	
$t_f$	Current fall time				84		ns
$E_{off}^{(2)}$	Turn-off switching energy				0.83		mJ

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit	
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $di/dt = 690\text{ A}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		122		ns	
$t_r$	Current rise time			17		ns	
$E_{on}^{(1)}$	Turn-on switching energy				1.08		mJ
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $dv/dt = 7000\text{ V}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		122		ns	
$t_f$	Current fall time				146		ns
$E_{off}^{(2)}$	Turn-off switching energy				1.06		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		0.95	1.05	$^\circ\text{C}/\text{W}$	
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each IGBT, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot^\circ\text{C})$		0.90		$^\circ\text{C}/\text{W}$	

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

**1.1.2**
**Diode**

 Limiting values at  $T_J = 25\text{ °C}$ , 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 ( $T_C = 100\text{ °C}$ )	15	A
$I_{FP}^{(1)}$	Pulsed forward current ( $t_p = 1\text{ ms}$ )	30	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 4. Electrical characteristics of the diode, inverter stage**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$ (terminal)	Forward voltage	$I_F = 15\text{ A}$	-	3.0	3.8	V
		$I_F = 15\text{ A}, T_J = 150\text{ °C}$	-	2.1		
$t_{rr}$	Reverse recovery time	$I_F = 15\text{ A}, V_R = 600\text{ V},$ $V_{GE} = \pm 15\text{ V}, di_F/dt = 820\text{ A}/\mu\text{s}$	-	190		ns
$Q_{rr}$	Reverse recovery charge		-	1.45		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current		-	23		A
$E_{rec}$	Reverse recovery energy		-	0.55		mJ
$t_{rr}$	Reverse recovery time		$I_F = 15\text{ A}, V_R = 600\text{ V},$ $V_{GE} = \pm 15\text{ V}, di_F/dt = 690\text{ A}/\mu\text{s},$ $T_J = 150\text{ °C}$	-	400	
$Q_{rr}$	Reverse recovery charge	-		2.75		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current	-		25		A
$E_{rec}$	Reverse recovery energy	-		1.2		mJ
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode		-	1.60	1.75
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot\text{°C})$	-	1.15		°C/W

## 1.2 Brake stage

Limiting values at  $T_J = 25\text{ °C}$ , 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 ( $T_C = 100\text{ °C}$ )	15	A
$I_{CP}^{(1)}$	Pulsed collector current ( $t_p = 1\text{ ms}$ )	30	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$P_{TOT}$	Total power dissipation of each IGBT ( $T_C = 25\text{ °C}$ , $T_J = 175\text{ °C}$ )	142.8	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	$V_{GE} = 15\text{ V}$ , $I_C = 15\text{ A}$		1.95	2.45	V	
		$V_{GE} = 15\text{ V}$ , $I_C = 15\text{ A}$ , $T_J = 150\text{ °C}$		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	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$		985		pF	
$C_{oes}$	Output capacitance			118		pF	
$C_{res}$	Reverse transfer capacitance			40		pF	
$Q_g$	Total gate charge	$V_{CC} = 960\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = \pm 15\text{ V}$		71		nC	
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		120		ns	
$t_r$	Current rise time		$di/dt = 820\text{ A}/\mu\text{s}$		14.5		ns
$E_{on}^{(1)}$	Turn-on switching energy			0.59		mJ	
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		115		ns	
$t_f$	Current fall time		$dv/dt = 8200\text{ V}/\mu\text{s}$		84		ns
$E_{off}^{(2)}$	Turn-off switching energy			0.83		mJ	
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ ,		122		ns	
$t_r$	Current rise time		$di/dt = 690\text{ A}/\mu\text{s}$ , $T_J = 150\text{ °C}$		17		ns
$E_{on}$	Turn-on switching energy				1.08		mJ

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $dv/dt = 7000\text{ V}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$		122		ns
$t_f$	Current fall time			146		ns
$E_{off}$	Turn-off switching energy			1.06		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		0.95	1.05	$^\circ\text{C}/\text{W}$
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each IGBT, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot^\circ\text{C})$		0.90		$^\circ\text{C}/\text{W}$

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 ( $T_C = 100\text{ °C}$ )	15	A
$I_{FP}^{(1)}$	Pulsed forward current ( $t_p = 1\text{ ms}$ )	30	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
$V_F(\text{terminal})$	Forward voltage	$I_F = 15\text{ A}$	-	3.0	3.8	V
		$I_F = 15\text{ A}, T_J = 150\text{ °C}$	-	2.1		
$t_{rr}$	Reverse recovery time		-	190		ns
$Q_{rr}$	Reverse recovery charge	$I_F = 15\text{ A}, V_R = 600\text{ V},$	-	1.45		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current	$V_{GE} = \pm 15\text{ V}, di/dt = 820\text{ A}/\mu\text{s}$	-	23		A
$E_{rec}$	Reverse recovery energy		-	0.55		mJ
$t_{rr}$	Reverse recovery time		-	400		ns
$Q_{rr}$	Reverse recovery charge	$I_F = 15\text{ A}, V_R = 600\text{ V},$	-	2.75		$\mu\text{C}$
$I_{rrm}$	Reverse recovery current	$V_{GE} = \pm 15\text{ V}, di/dt = 690\text{ A}/\mu\text{s},$	-	25		A
$E_{rec}$	Reverse recovery energy	$T_J = 150\text{ °C}$	-	1.2		mJ
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode	-	1.60	1.75	°C/W
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot\text{°C})$	-	1.15		°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	30	A
$I_{FSM}$	Forward surge current $t_p = 10\text{ ms}$ , $T_C = 25\text{ °C}$	315	A
	Forward surge current $t_p = 10\text{ ms}$ , $T_C = 150\text{ °C}$	250	
$I^2t$	$t_p = 10\text{ ms}$ , $T_C = 25\text{ °C}$	496	A <sup>2</sup> s
	$t_p = 10\text{ ms}$ , $T_C = 150\text{ °C}$	312	
$T_{JMAX}$	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**

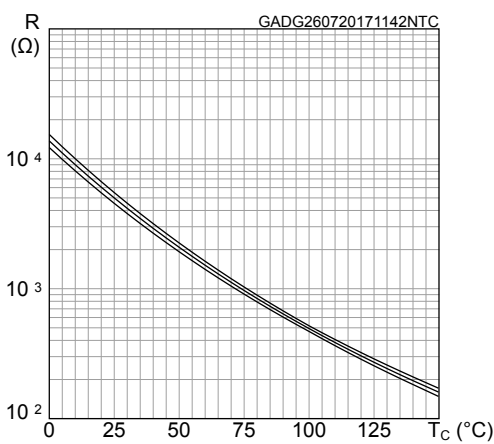
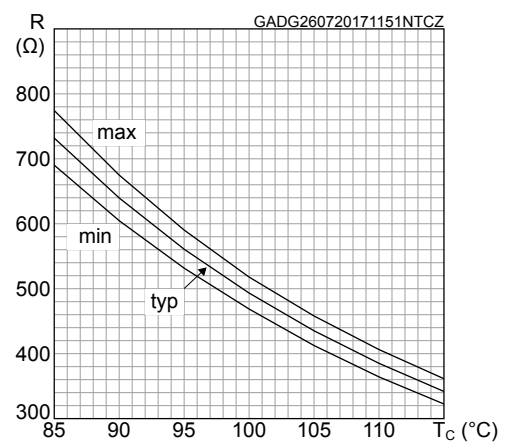
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$ (terminal)	Forward voltage	$I_F = 15\text{ A}$	-	1.0	1.4	V
		$I_F = 15\text{ A}$ , $T_J = 150\text{ °C}$	-	0.9		
$I_R$	Reverse current	$T_J = 150\text{ °C}$ , $V_R = 1600\text{ V}$	-	1		mA
$R_{THj-c}$	Thermal resistance junction-to-case	Each diode	-	1.20	1.35	°C/W
$R_{THc-h}$	Thermal resistance case-to-heatsink	Each diode, $\lambda_{grease} = 1\text{ W/(m}\cdot\text{°C)}$	-	1.15		°C/W



## 1.4 NTC

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

Symbol	Parameter	Test condition	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**


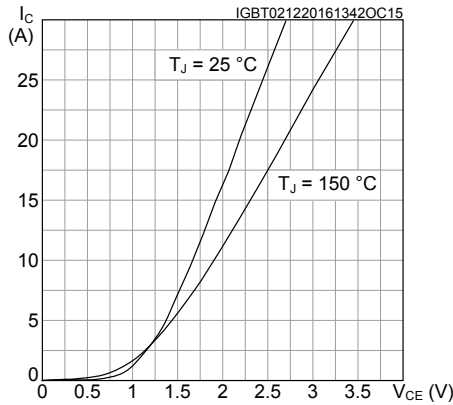
## 1.5 Package

**Table 12. ACEPACK™ 1 package**

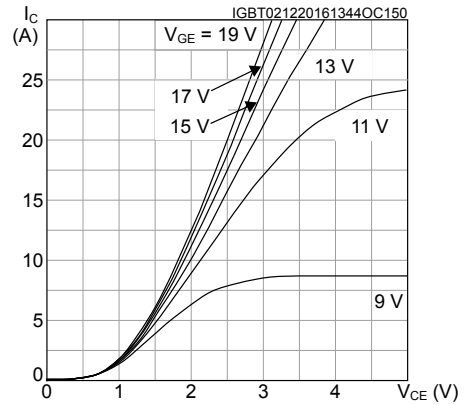
Symbol	Parameter	Min.	Typ.	Max.	Unit
V <sub>isol</sub>	Isolation voltage (AC voltage, t = 60 s)			2500	Vrms
T <sub>stg</sub>	Storage temperature	-40		125	°C
CTI	Comparative tracking index	200			
L <sub>s</sub>	Stray inductance module P1 - EW loop		28.7		nH
R <sub>s</sub>	Module single lead resistance , terminal-to-chip		3.9		mΩ

## 2 Electrical characteristics (curves)

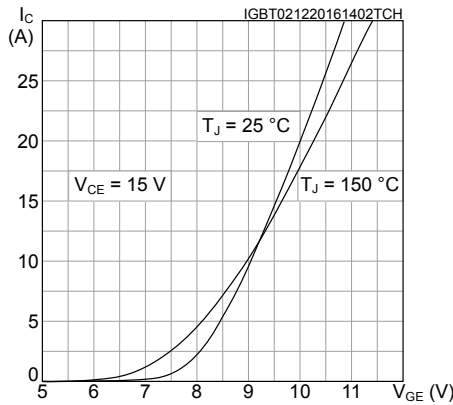
**Figure 3. IGBT output characteristics**  
( $V_{GE} = 15\text{ V}$ , terminal)



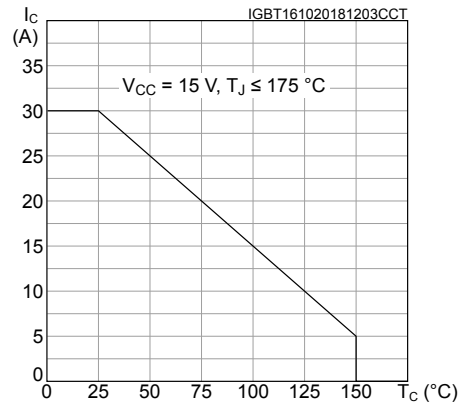
**Figure 4. IGBT output characteristics**  
( $T_J = 150\text{ }^\circ\text{C}$ , terminal)



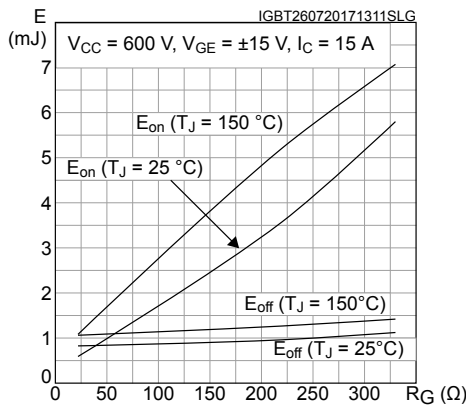
**Figure 5. IGBT transfer characteristics**  
( $V_{CE} = 15\text{ V}$ , terminal)



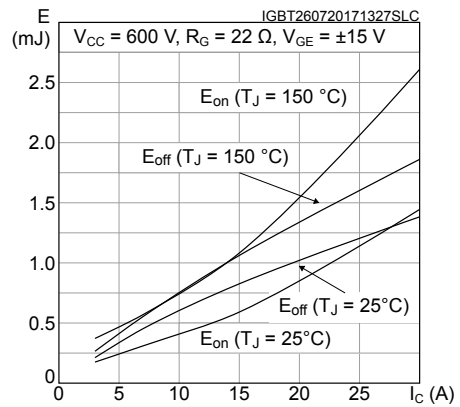
**Figure 6. IGBT collector current vs case temperature**



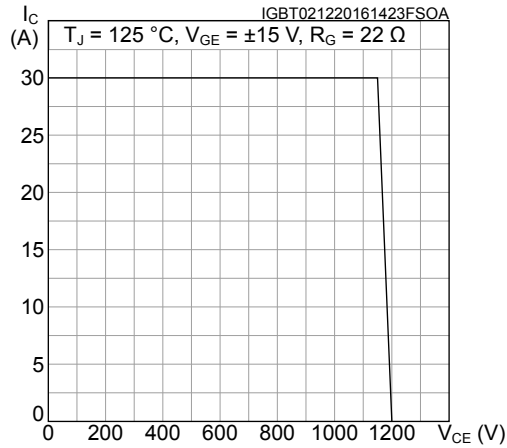
**Figure 7. Switching energy vs gate resistance**



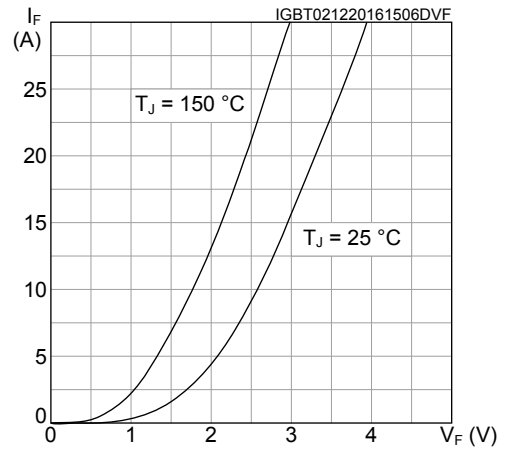
**Figure 8. Switching energy vs collector current**



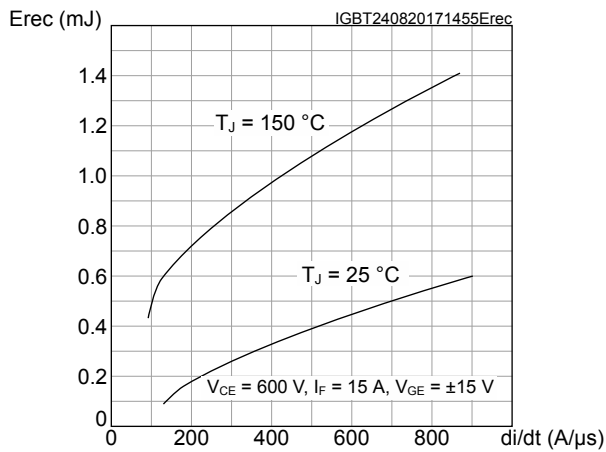
**Figure 9. IGBT reverse biased safe operating area (RBSOA)**



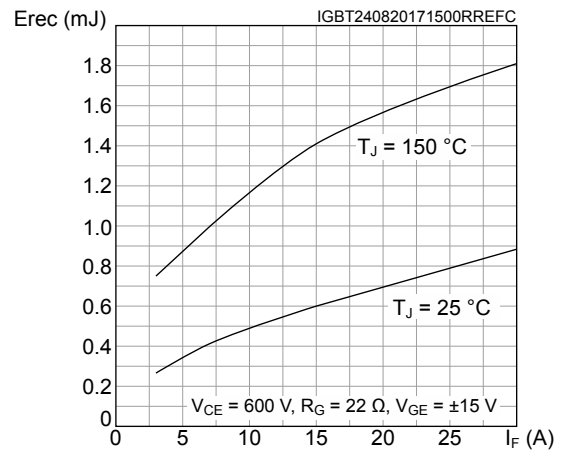
**Figure 10. Diode forward characteristics (terminal)**



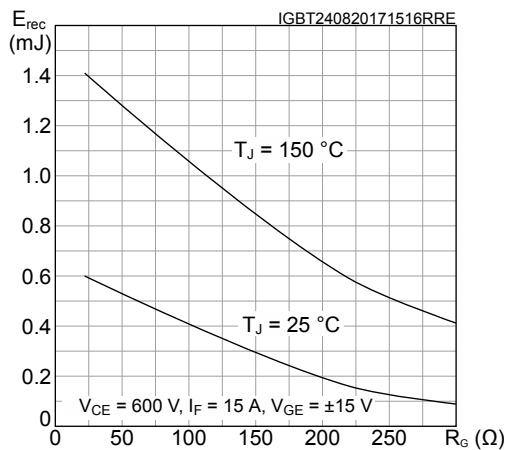
**Figure 11. Diode reverse recovery energy vs diode current slope**



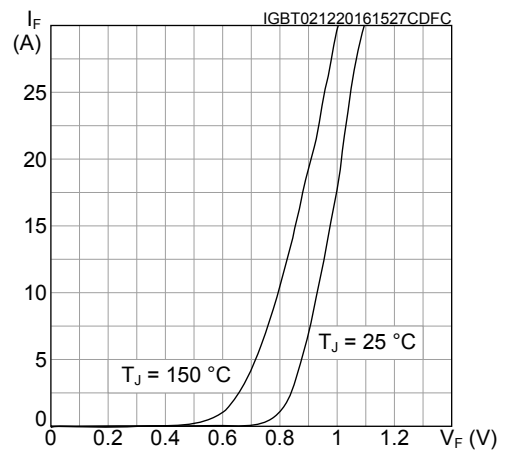
**Figure 12. Diode reverse recovery energy vs forward current**



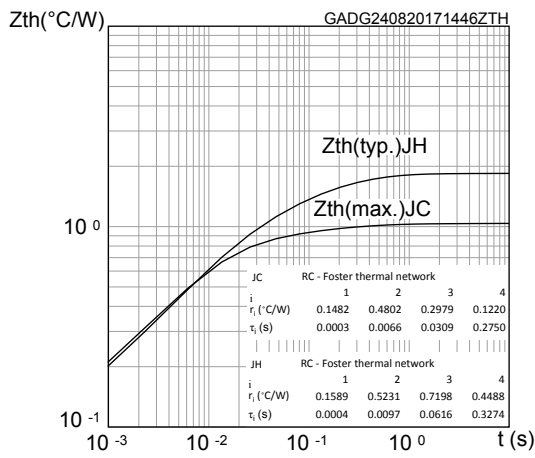
**Figure 13. Diode reverse recovery energy vs gate resistance**



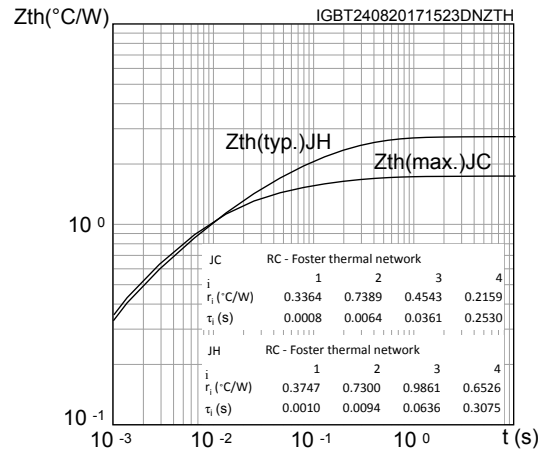
**Figure 14. Converter diode forward characteristics (terminal)**



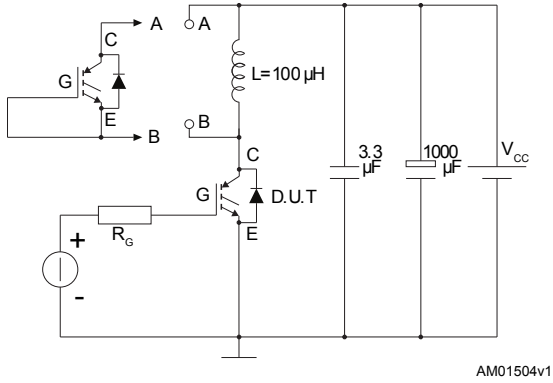
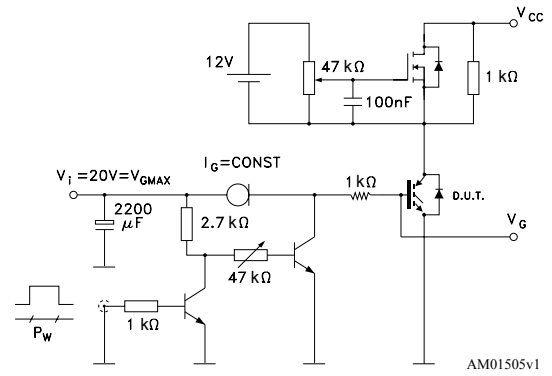
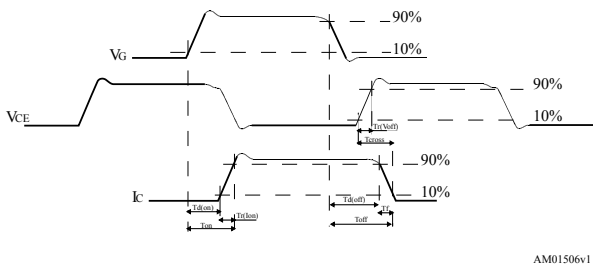
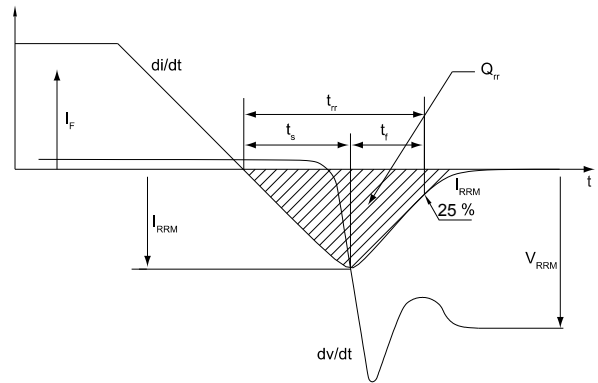
**Figure 15. IGBT thermal impedance**



**Figure 16. Inverter diode thermal impedance**

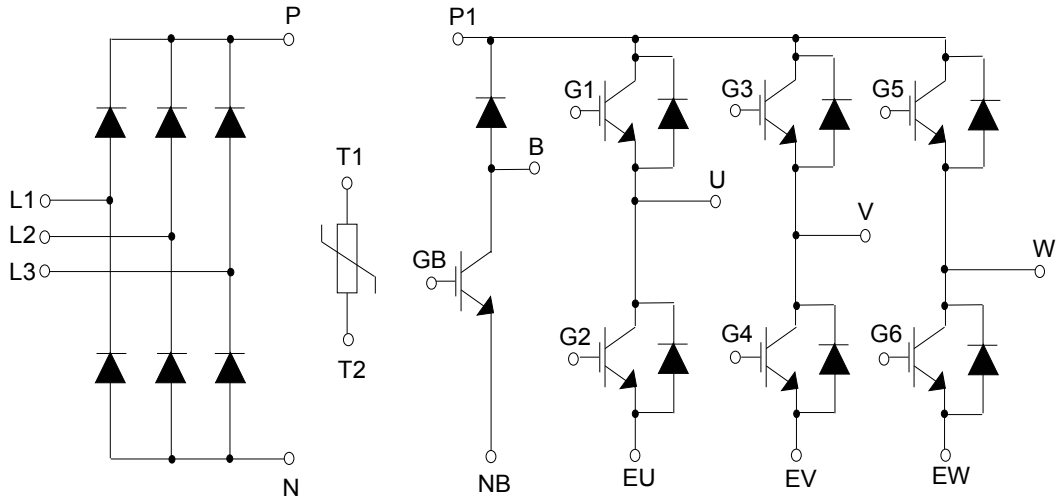


### 3 Test circuits

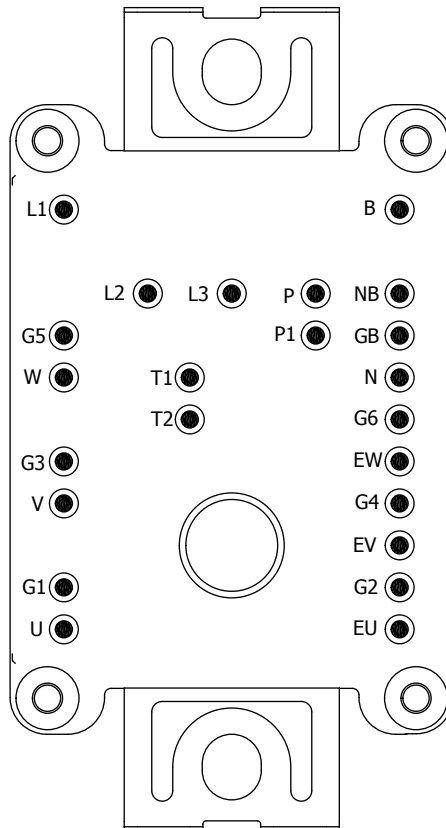
**Figure 17. Test circuit for inductive load switching**

**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**



GIPD270320151420FSR

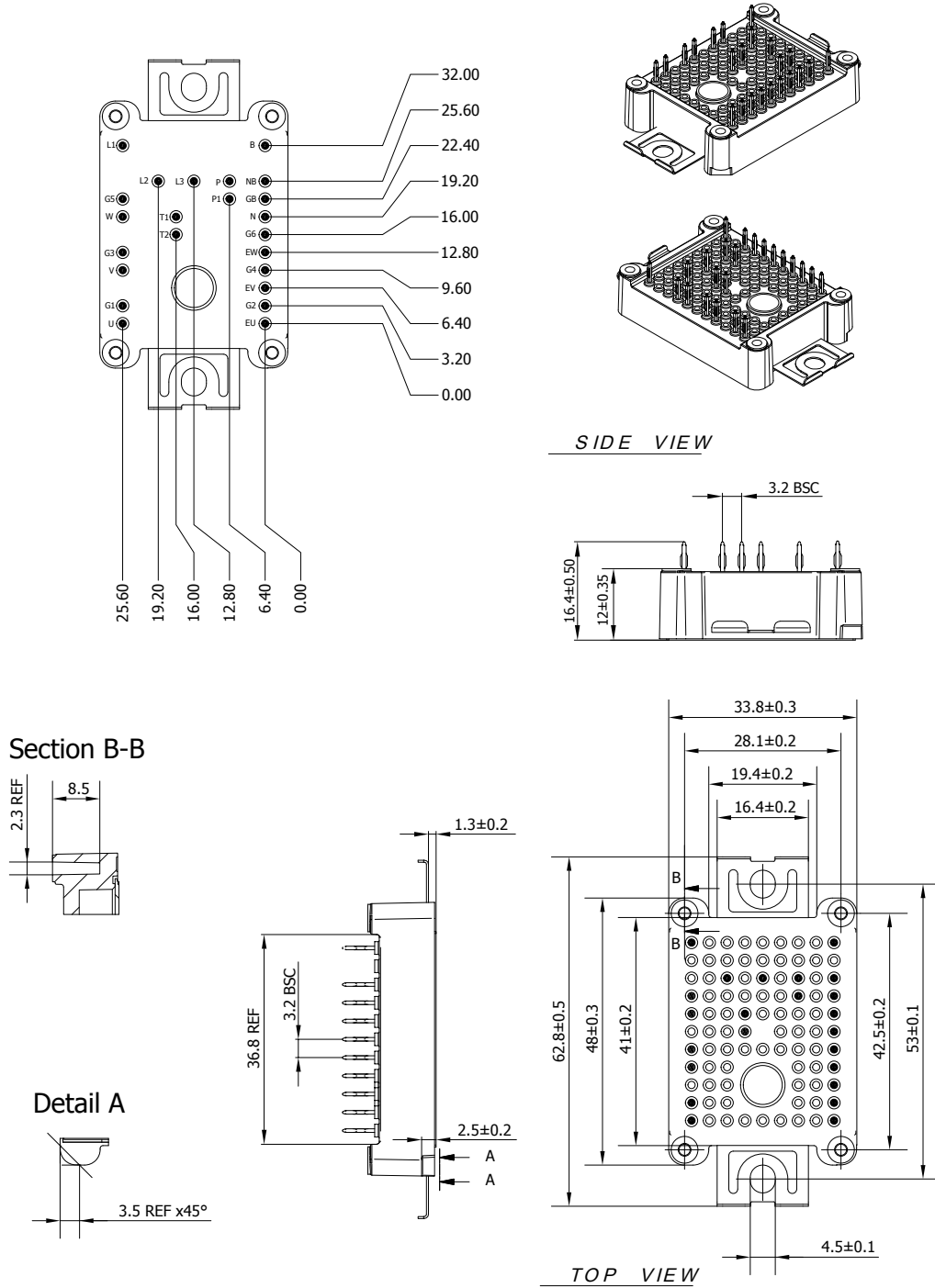
## **5**      **Package information**

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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™ 1 CIB press fit pins package information

Figure 23. ACEPACK™ 1 CIB press fit pins package outline (dimensions are in mm)

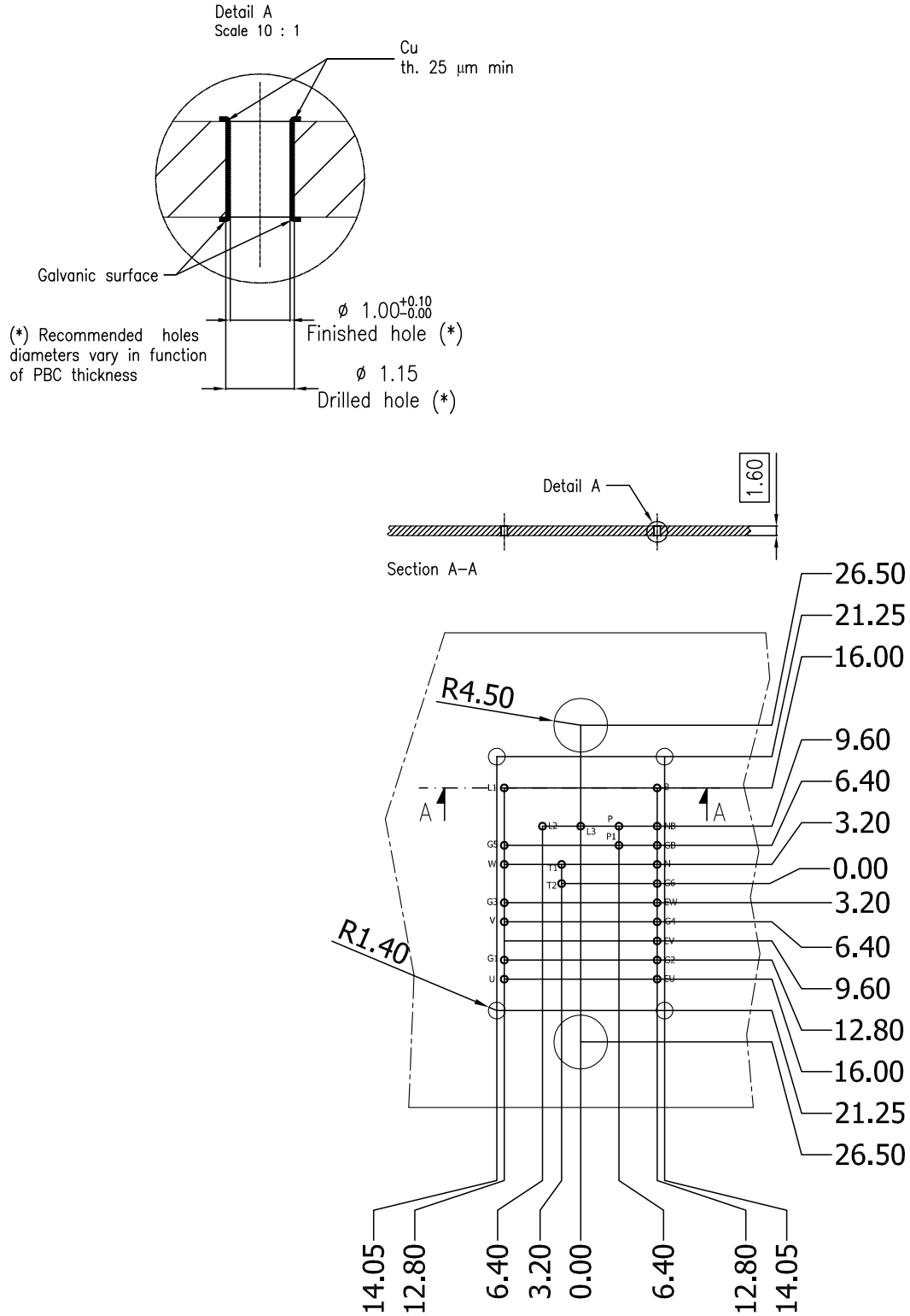


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- The lead size includes the thickness of the lead plating material.
- Dimensions do not include mold protrusion.
- Package dimensions do not include any eventual metal burrs.



Figure 24. ACEPACK™ 1 CIB press fit pins recommended PCB holes layout (dimensions are in mm)



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## Revision history

**Table 13. Document revision history**

Date	Revision	Changes
01-Feb-2016	1	Initial release.
03-Feb-2016	2	Updated <i>Table 3: "Electrical characteristics of the IGBTs, inverter stage"</i> . Minor text changes.
28-Jul-2017	3	Product status changed from preliminary to production data. Added <i>Electrical characteristics curves</i> . Minor text changes.
30-Aug-2017	4	Updated <i>Table 3: "Electrical characteristics of the IGBTs, inverter stage"</i> , <i>Table 5: "Electrical characteristics of the diode, inverter stage"</i> , <i>Table 7:</i> <i>"Electrical characteristics of the IGBT, brake stage"</i> , <i>Table 5: "Electrical</i> <i>characteristics of the diode, inverter stage"</i> , <i>Table 11: "Electrical</i> <i>characteristics of the bridge rectifiers"</i> , <i>Section 2: "Electrical characteristics</i> <i>curves"</i> . Minor text changes.
05-Oct-2017	5	Updated <i>Table 12. ACEPACK™ 1 package</i> , <i>Figure 21. IGBT thermal impedance</i> , <i>Figure 22. Inverter diode thermal impedance</i> and <i>Section 5.1 ACEPACK™ 1 CIB press fit pins package information</i> . Minor text changes.
15-Feb-2018	6	Removed maturity status indication from cover page. Updated <i>Figure 22. ACEPACK™ 1 CIB press fit pins package outline (dimensions are in mm)</i> and <i>Figure 23. ACEPACK™ 1 CIB press fit pins recommended PCB holes layout (dimensions are in mm)</i> . Minor text changes.
14-Nov-2018	7	Added <a href="#">Figure 6. IGBT collector current vs case temperature</a> . Minor text changes

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### Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: [info@moschip.ru](mailto:info@moschip.ru)

Skype отдела продаж:

moschip.ru

moschip.ru\_4

moschip.ru\_6

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