

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

Datasheet - production data

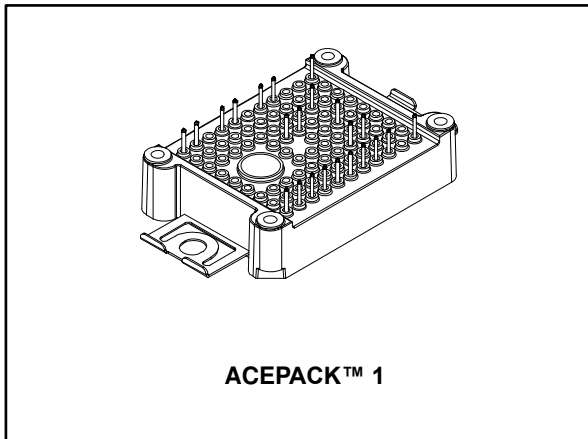
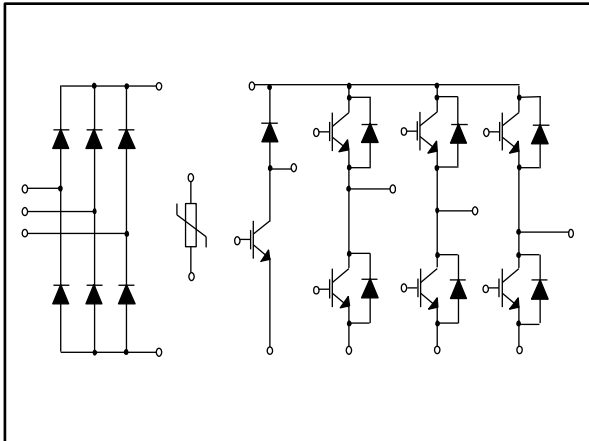


Figure 1: Internal electrical schematic



### 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
  - $V_{CE(sat)}$ : 1.95 V @  $I_C = 15$  A
  - 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.

Table 1: Device summary

Order code	Marking	Package	Leads type
A1C15S12M3	A1C15S12M3	ACEPACK™ 1	Solder contact pins

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# 1 Electrical ratings

## 1.1 Inverter stage

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

### 1.1.1 IGBTs

**Table 2: 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 IGBT ( $T_{JMAX} = 175\text{ °C}$ )	142.8	W
$T_{JMAX}$	Maximum junction temperature	175	°C
$T_{Jop}$	Operative temperature range under switching conditions	-40 to 150	°C

**Notes:**

<sup>(1)</sup>Pulse width limited by maximum junction temperature.

**Table 3: 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
$V_{CE(sat)}$	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	

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 22\ \Omega$ , $V_{GE} = \pm 15\text{ V}$ , $dv/dt = 8200\text{ V}/\mu\text{s}$ ;		115		ns
$t_f$	Current fall time			84		ns
$E_{off}^{(2)}$	Turn-off switching energy			0.83		mJ
$t_{d(on)}$	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		$^\circ\text{C}/\text{W}$

**Notes:**

(1) Including the reverse recovery of the diode.

(2) Including also the tail of the collector current.

**1.1.2 Diode**Limiting values at  $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise specified.**Table 4: 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 at ( $T_C = 100\text{ }^\circ\text{C}$ )	15	A
$I_{FF}^{(1)}$	Pulsed forward current	30	A
$T_{JMAX}$	Maximum junction temperature	175	$^\circ\text{C}$
$T_{Jop}$	Operative temperature range under switching conditions	-40 to 150	$^\circ\text{C}$

**Notes:**

(1) Pulse width limited by maximum junction temperature.

Table 5: Electrical characteristics of the diode, inverter stage

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>F</sub>	Forward voltage	I <sub>F</sub> = 15 A	-	3.0	3.8	V
		I <sub>F</sub> = 15 A, T <sub>J</sub> = 150 °C	-	2.1		
t <sub>rr</sub>	Reverse recovery time	I <sub>F</sub> = 15 A, V <sub>R</sub> = 600 V, V <sub>GE</sub> = ±15 V, di <sub>F</sub> /dt = 820 A/μs	-	190		ns
Q <sub>rr</sub>	Reverse recovery charge		-	1.45		μC
I <sub>rrm</sub>	Reverse recovery current		-	23		A
E <sub>rec</sub>	Reverse recovery energy		-	0.55		mJ
t <sub>rr</sub>	Reverse recovery time	I <sub>F</sub> = 15 A, V <sub>R</sub> = 600 V, V <sub>GE</sub> = ±15 V, di <sub>F</sub> /dt = 690 A/μs, T <sub>J</sub> = 150 °C	-	400		ns
Q <sub>rr</sub>	Reverse recovery charge		-	2.75		μC
I <sub>rrm</sub>	Reverse recovery current		-	25		A
E <sub>rec</sub>	Reverse recovery energy		-	1.2		mJ
R <sub>THj-c</sub>	Thermal resistance junction to case	Each diode	-	1.60	1.75	°C/W
R <sub>THc-h</sub>	Thermal resistance case to heatsink	Each diode, λ <sub>grease</sub> = 1 W/(m·°C)	-	1.15		°C/W

## 1.2 Brake stage

Limiting values at T<sub>j</sub> = 25 °C, unless otherwise specified.

### 1.2.1 IGBT

Table 6: Absolute maximum ratings of the IGBT, brake stage

Symbol	Parameter	Value	Unit
V <sub>CES</sub>	Collector-emitter voltage (V <sub>GE</sub> = 0)	1200	V
I <sub>c</sub>	Continuous collector current (T <sub>c</sub> = 100 °C)	15	A
I <sub>CP</sub> <sup>(1)</sup>	Pulsed collector current	30	A
V <sub>GE</sub>	Gate-emitter voltage	±20	V
P <sub>TOT</sub>	Total power dissipation	142.8	W
T <sub>JMAX</sub>	Maximum junction temperature	175	°C
T <sub>Jop</sub>	Operative temperature range under switching conditions	-40 to 150	°C

#### Notes:

<sup>(1)</sup>Pulse width limited by maximum junction temperature.

Table 7: 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
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15 \text{ V}$ , $I_C = 15 \text{ A}$		1.95	2.45	V
		$V_{GE} = 15 \text{ V}$ , $I_C = 15 \text{ A}$ , $T_J = 150 \text{ }^\circ\text{C}$		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	$V_{CE} = 25 \text{ V}$ , $f = 1 \text{ MHz}$ , $V_{GE} = 0 \text{ V}$		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	$V_{CC} = 600 \text{ V}$ , $I_C = 15 \text{ A}$ , $R_G = 22 \text{ } \Omega$ , $V_{GE} = \pm 15 \text{ V}$ , $di/dt = 820 \text{ A}/\mu\text{s}$		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	$V_{CC} = 600 \text{ V}$ , $I_C = 15 \text{ A}$ , $R_G = 22 \text{ } \Omega$ , $V_{GE} = \pm 15 \text{ V}$ , $dv/dt = 8200 \text{ V}/\mu\text{s}$ ;		115		ns
$t_f$	Current fall time			84		ns
$E_{off(2)}$	Turn-off switching energy			0.83		mJ
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 600 \text{ V}$ , $I_C = 15 \text{ A}$ , $R_G = 22 \text{ } \Omega$ , $V_{GE} = \pm 15 \text{ V}$ , $di/dt = 690 \text{ A}/\mu\text{s}$ , $T_J = 150 \text{ }^\circ\text{C}$		122		ns
$t_r$	Current rise time			17		ns
$E_{on}$	Turn-on switching energy			1.08		mJ
$t_{d(off)}$	Turn-off delay time	$V_{CC} = 600 \text{ V}$ , $I_C = 15 \text{ A}$ , $R_G = 22 \text{ } \Omega$ , $V_{GE} = \pm 15 \text{ V}$ , $dv/dt = 7000 \text{ V}/\mu\text{s}$ , $T_J = 150 \text{ }^\circ\text{C}$		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		$^\circ\text{C}/\text{W}$

**Notes:**<sup>(1)</sup>Including the reverse recovery of the diode.<sup>(2)</sup>Including the tail of the collector current.

1.2.2 Diode

Table 8: Absolute maximum ratings of the diode, brake stage

Symbol	Parameter	Value	Unit
V <sub>RRM</sub>	Repetitive peak reverse voltage	1200	V
I <sub>F</sub>	Continuous forward current at (T <sub>C</sub> = 100 °C)	15	A
I <sub>FP</sub> <sup>(1)</sup>	Pulsed forward current	30	A
T <sub>JMAX</sub>	Maximum junction temperature	175	°C
T <sub>Jop</sub>	Operative temperature range under switching conditions	-40 to 150	°C

Notes:

(1)Pulse width limited by maximum junction temperature.

Table 9: Electrical characteristics of the diode, brake stage

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>F</sub>	Forward voltage	I <sub>F</sub> = 15 A	-	3.0	3.8	V
		I <sub>F</sub> = 15 A, T <sub>J</sub> = 150 °C	-	2.1		
t <sub>rr</sub>	Reverse recovery time	I <sub>F</sub> = 15 A, V <sub>R</sub> = 600 V, V <sub>GE</sub> = ±15 V, di/dt = 820 A/μs	-	190		ns
Q <sub>rr</sub>	Reverse recovery charge		-	1.45		μC
I <sub>rrm</sub>	Reverse recovery current		-	23		A
E <sub>rec</sub>	Reverse recovery energy		-	0.55		mJ
t <sub>rr</sub>	Reverse recovery time		I <sub>F</sub> = 15 A, V <sub>R</sub> = 600 V, V <sub>GE</sub> = ±15 V, di/dt = 690 A/μs, T <sub>J</sub> = 150 °C	-	400	
Q <sub>rr</sub>	Reverse recovery charge	-		2.75		μC
I <sub>rrm</sub>	Reverse recovery current	-		25		A
E <sub>rec</sub>	Reverse recovery energy	-		1.2		mJ
R <sub>THj-c</sub>	Thermal resistance junction to case	Each diode		-	1.60	1.75
R <sub>THc-h</sub>	Thermal resistance case to heatsink	Each diode, λ <sub>grease</sub> = 1 W/(m·°C)	-	1.15		°C/W

1.3 Converter stage

Limiting values at T<sub>j</sub> = 25 °C, unless otherwise specified.

Table 10: Absolute maximum ratings of the bridge rectifiers

Symbol	Description	Value	Unit
V <sub>RRM</sub>	Repetitive peak reverse voltage	1600	V
I <sub>F</sub>	RMS forward current	30	A
I <sub>FSM</sub>	Forward surge current tp = 10 ms, T <sub>C</sub> = 25 °C	315	A
	Forward surge current tp = 10 ms, T <sub>C</sub> = 150 °C	250	
I <sup>2</sup> t	tp = 10 ms, T <sub>C</sub> = 25 °C	496	A <sup>2</sup> s
	tp = 10 ms, T <sub>C</sub> = 150 °C	312	
T <sub>JMAX</sub>	Maximum junction temperature	175	°C
T <sub>Jop</sub>	Operative temperature range under switching conditions	-40 to 150	°C

Table 11: Electrical characteristics of the bridge rectifiers

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>F</sub>	Forward voltage	I <sub>F</sub> = 15 A	-	1.0	1.4	V
		I <sub>F</sub> = 15 A, T <sub>J</sub> = 150 °C	-	0.9		
I <sub>R</sub>	Reverse current	T <sub>J</sub> = 150 °C, V <sub>R</sub> = 1600 V	-	1		mA
R <sub>THj-c</sub>	Thermal resistance junction to case	Each diode	-	1.20	1.35	°C/W
R <sub>THc-h</sub>	Thermal resistance case to heatsink	Each diode, λ <sub>grease</sub> = 1 W/(m·°C)	-	1.15		°C/W

## 1.4 NTC

Table 12: 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 2: NTC resistance vs. temperature

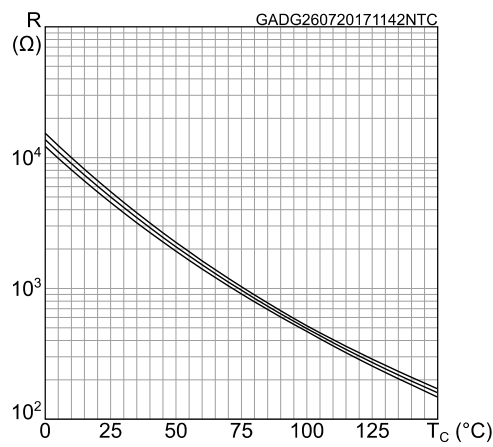
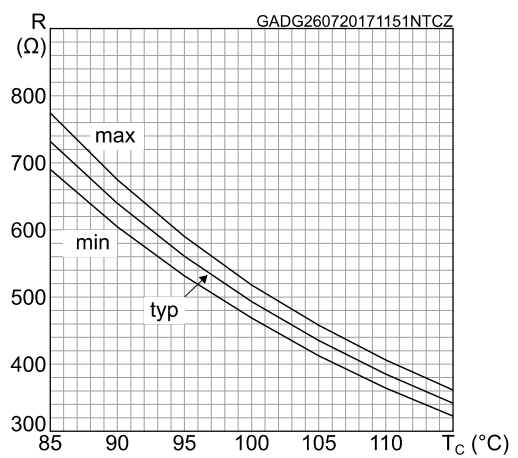


Figure 3: NTC resistance vs. temperature, zoom





## 1.5 Package

Table 13: ACEPACK™ 1 package

Symbol	Parameter	Min.	Typ.	Max.	Unit
V <sub>isol</sub>	Isolation voltage (AC voltage, t = 60 s)			2500	V
M <sub>d</sub>	Screw mounting torque	40		80	Nm
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 lead resistance, terminal to chip		3.9		mΩ

## 2 Electrical characteristics curves

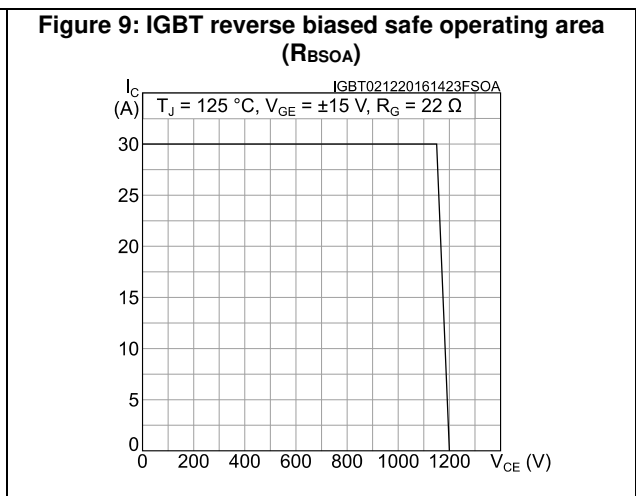
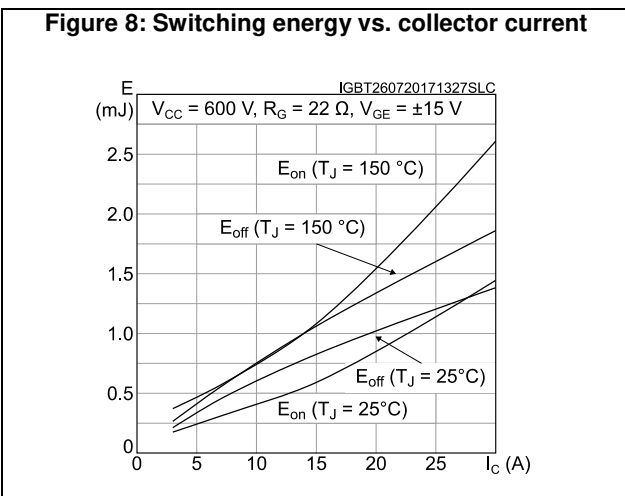
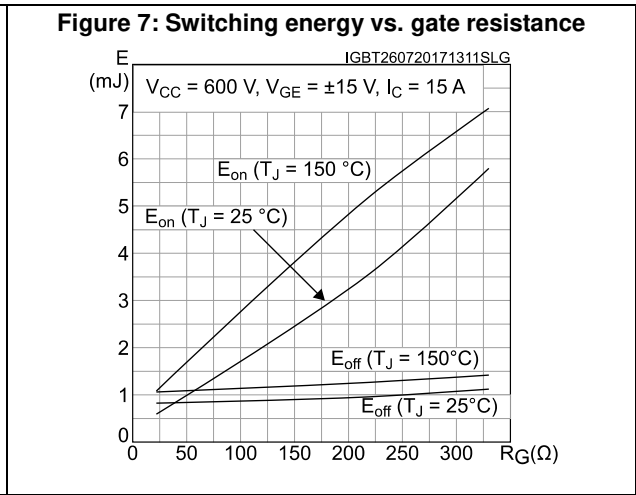
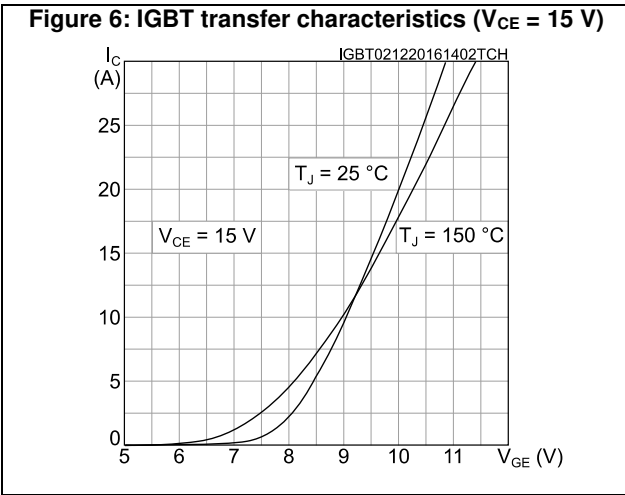
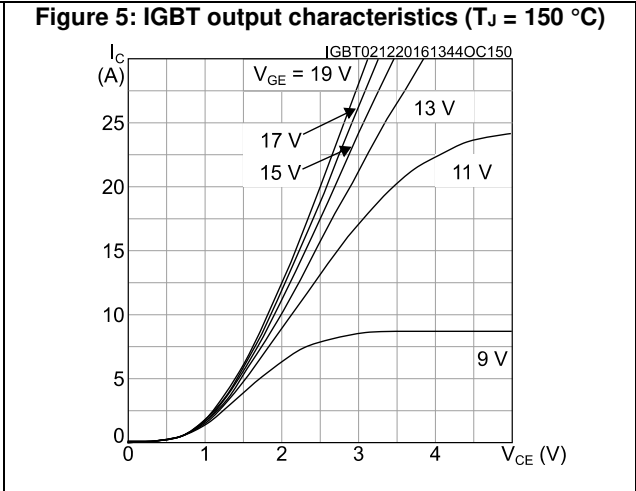
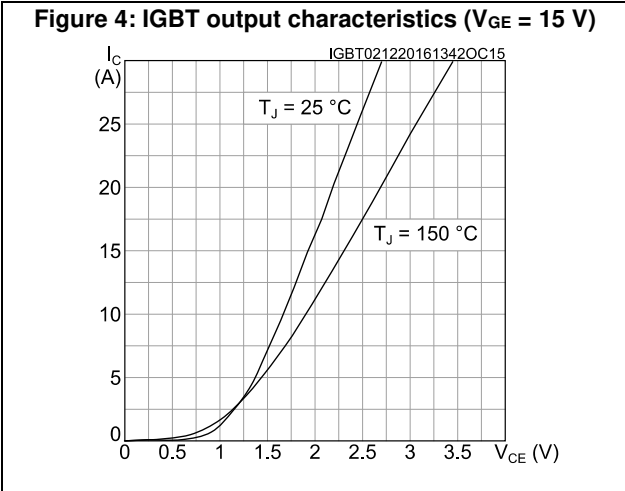


Figure 10: Diode forward characteristics

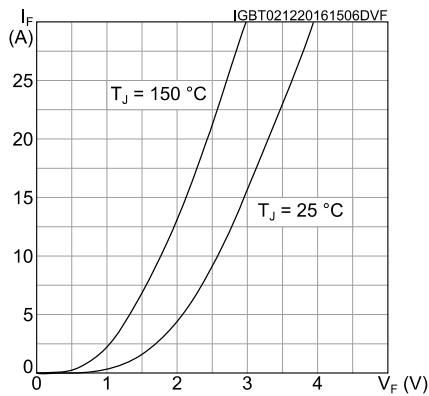


Figure 11: Diode reverse recovery energy vs. diode current slope

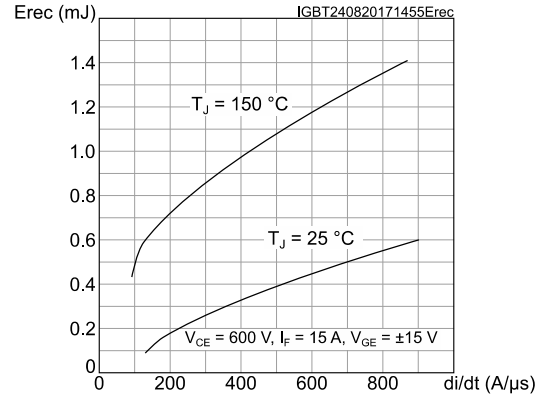


Figure 12: Diode reverse recovery energy vs. forward current

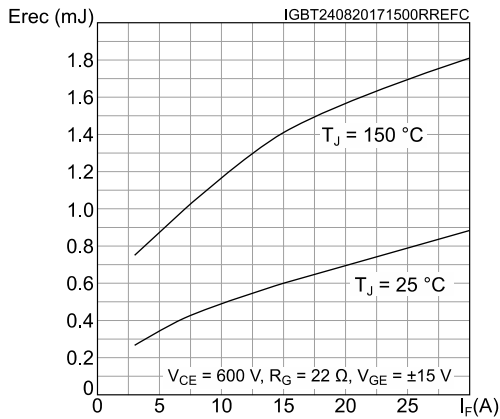


Figure 13: Diode reverse recovery energy vs. gate resistance

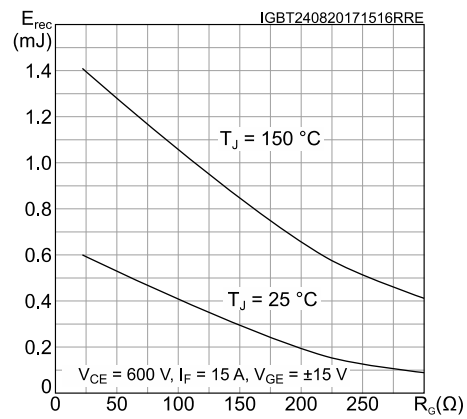


Figure 14: Converter diode forward characteristics

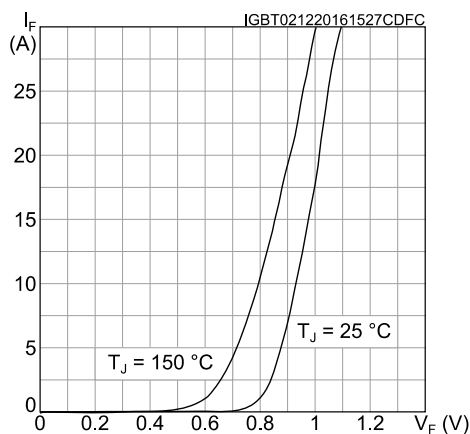


Figure 15: IGBT thermal impedance

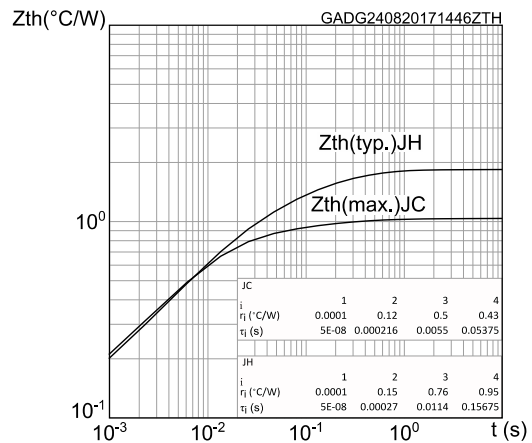
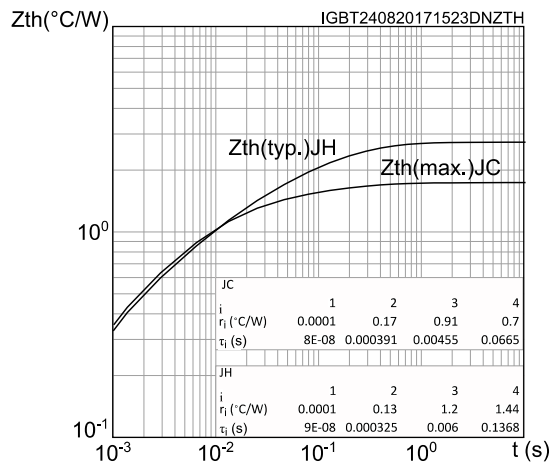
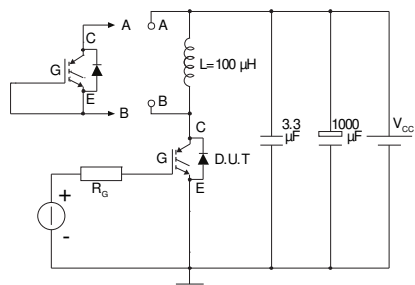


Figure 16: Inverter diode thermal impedance



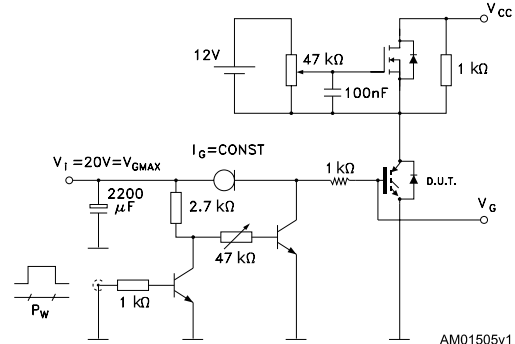
### 3 Test circuits

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



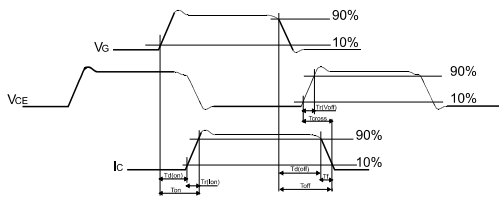
AM01504v1

**Figure 18: Gate charge test circuit**



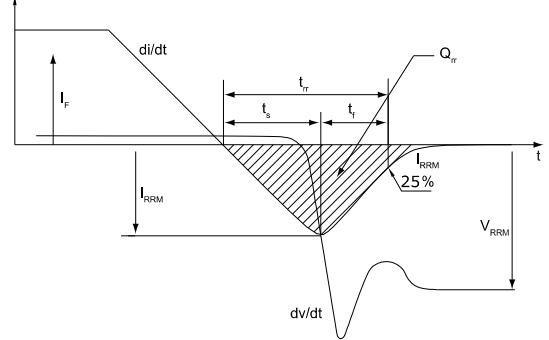
AM01505v1

**Figure 19: Switching waveform**



AM01506v1

**Figure 20: Diode reverse recovery waveform**



AM01507v1

# 4 Topology and pin description

Figure 21: Electrical topology and pin description

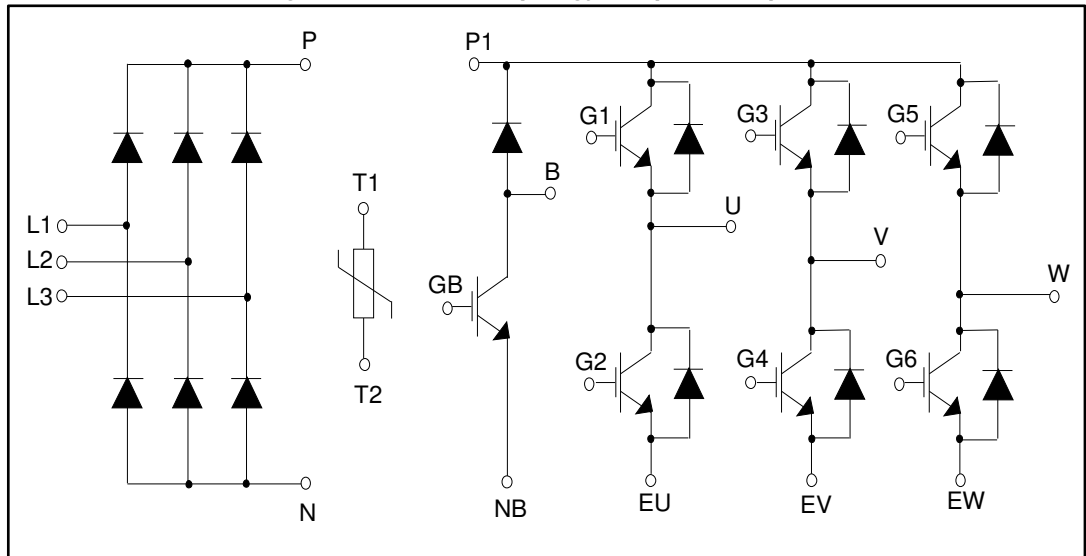
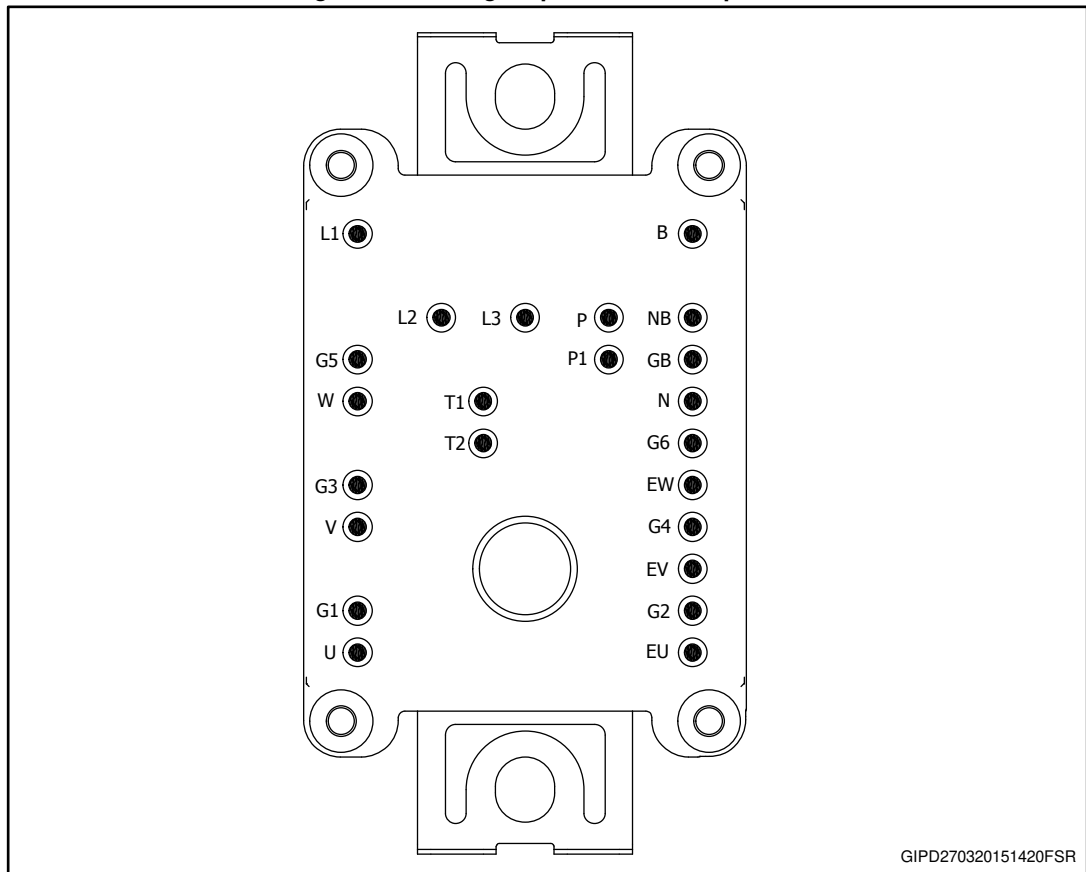


Figure 22: Package top view with CIB pinout



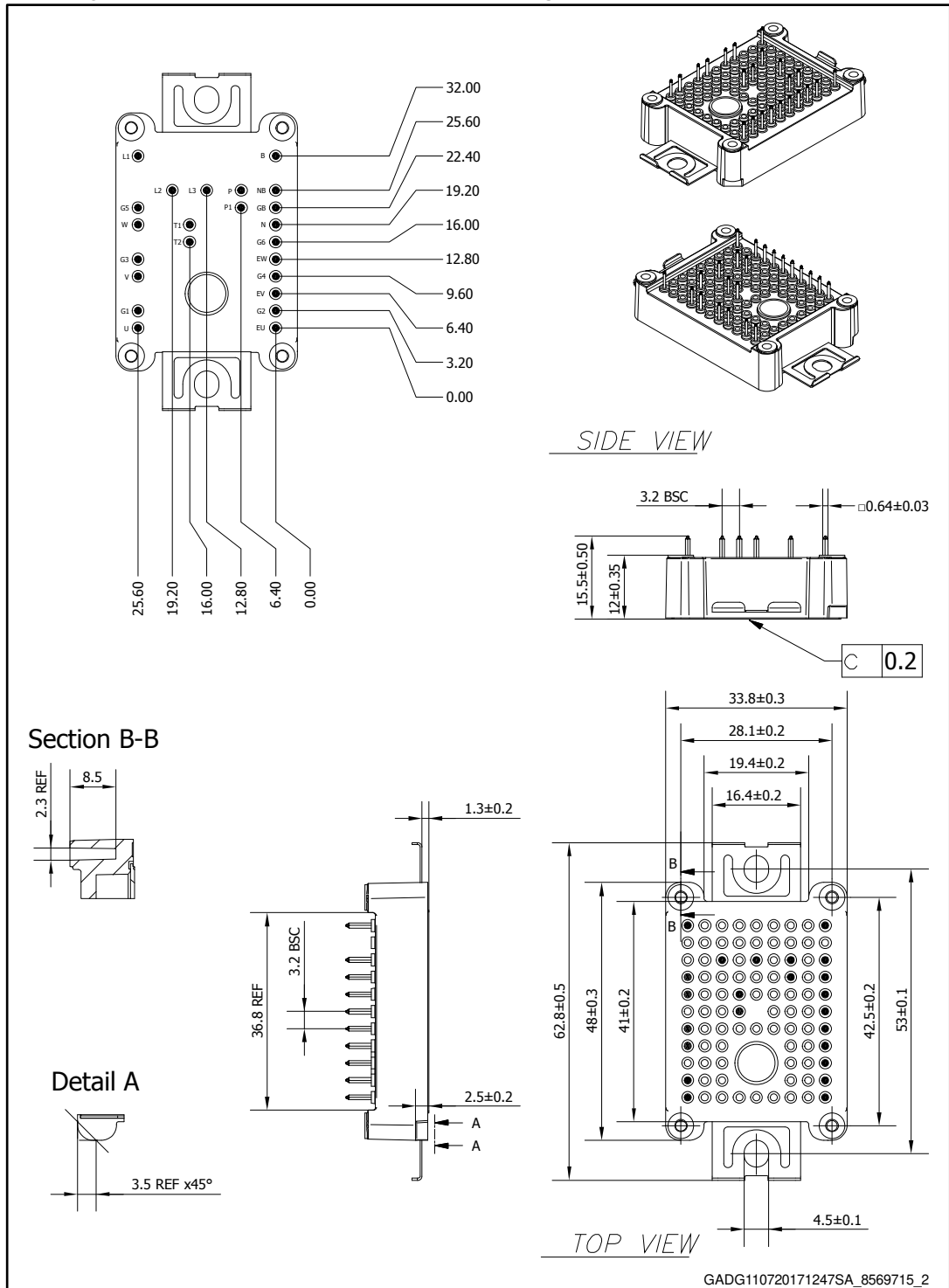
GIPD270320151420FSR

## 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™ 1 CIB solder pins package information

Figure 23: ACEPACK™ 1 CIB solder pins package outline (dimensions are in mm)



- 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.



## 6 Revision history

**Table 14: Document revision history**

Date	Revision	Changes
02-May-2016	1	Initial release.
10-Mar-2017	2	Added <i>Section 2: "Electrical characteristics curves" and Section 3: "Test circuits"</i> . Updated <i>Section 5.1: "ACEPACK™ 1 CIB solder pins package information"</i> . Minor text changes.
26-Jul-2017	3	Datasheet promoted from production data to preliminary data. Modified <i>Table 2: "Absolute maximum ratings of the IGBTs, inverter stage"</i> , <i>Table 3: "Electrical characteristics of the IGBTs, inverter stage"</i> , <i>Table 6: "Absolute maximum ratings of the IGBT, brake stage"</i> , <i>Table 7: "Electrical characteristics of the IGBT, brake stage"</i> , <i>Table 4: "Absolute maximum ratings of the diode, inverter stage"</i> , <i>Table 5: "Electrical characteristics of the diode, inverter stage"</i> , <i>Table 10: "Absolute maximum ratings of the bridge rectifiers"</i> , <i>Table 11: "Electrical characteristics of the bridge rectifiers"</i> , <i>Table 12: "NTC temperature sensor, considered as stand-alone"</i> , <i>Table 13: "ACEPACK™ 1 package"</i> . Modified <i>Figure 10: "IGBT thermal impedance"</i> and. Modified <i>Figure 22: "Package top view with CIB pinout"</i> . Modified <i>Section 5: "Package information"</i> . Minor text changes.
24-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: "Electrical characteristics of the IGBT, brake stage"</i> , <i>Table 9: "Electrical characteristics of the diode, brake stage"</i> , <i>Table 11: "Electrical characteristics of the bridge rectifiers"</i> , <i>Section 2: "Electrical characteristics curves"</i> . Minor text changes.
05-Oct-2017	5	Updated <i>Table 13: "ACEPACK™ 1 package"</i> , <i>Figure 15: "IGBT thermal impedance"</i> and <i>Figure 16: "Inverter diode thermal impedance"</i> . Minor text changes.

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