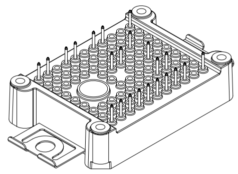
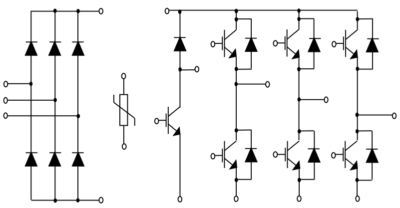
Datasheet

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_2O_3 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
A1C15S12M3

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

1 Electrical ratings

1.1 Inverter stage

Limiting values at T_J = 25 °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 °C	15	A
I_{CP} (1)	Pulsed collector current (t_p = 1 ms)	30	A
V_{GE}	Gate-emitter voltage	± 20	V
P_{TOT}	Total power dissipation of each IGBT (T_C = 25 °C, T_J = 175 °C)	142.8	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 mA, V_{GE} = 0 V	1200			V
$V_{CE(sat)}$ (terminal)	Collector-emitter saturation voltage	V_{GE} = 15 V, I_C= 15 A		1.95	2.45	V
		V_{GE} = 15 V, I_C = 15 A, T_J = 150 °C		2.3		V
$V_{GE(th)}$	Gate threshold voltage	V_{CE} = V_{GE}, I_C = 1 mA	5	6	7	V
I_{CES}	Collector cut-off current	V_{GE} = 0 V, V_{CE} = 1200 V			100	µA
I_{GES}	Gate-emitter leakage current	V_{CE} = 0 V, V_{GE} = ± 20 V			± 500	nA
C_{ies}	Input capacitance	V_{CE} = 25 V, f = 1 MHz, V_{GE} = 0 V		985		pF
C_{oes}	Output capacitance			118		pF
C_{res}	Reverse transfer capacitance			40		pF
Q_g	Total gate charge	V_{CC} = 960 V, I_C = 15 A, V_{GE} = ±15 V		71		nC
$t_{d(on)}$	Turn-on delay time	V_{CC} = 600 V, I_C = 15 A, R_G = 22 Ω, V_{GE} = ±15 V,di/dt = 820 A/µs		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 V, I_C = 15 A, R_G = 22 Ω, V_{GE} = ±15 V,dv/dt = 8200 V/µs		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 V, I_C = 15 A, R_G = 22 Ω, V_{GE} = ±15 V, di/dt = 690 A/µs, T_J = 150 °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 V, I_C = 15 A, R_G = 22 Ω, V_{GE} = ±15 V,dv/dt = 7000 V/µs, T_J = 150 °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} ≤ 600V, V_{GE} ≤ 15 V, T_{Jstart} ≤ 150 °C	10			µs
R_{THj-c}	Thermal resistance junction-to-case	Each IGBT		0.95	1.05	°C/W
R_{THc-h}	Thermal resistance case-to-heatsink	Each IGBT, λ_{grease} = 1 W/(m·°C)		0.90		°C/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 °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 at (T_C = 100 °C)	15	A
I_{FP}(1)	Pulsed forward current (t_p = 1 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 A	-	3.0	3.8	V
		I_F = 15 A, T_J = 150 °C	-	2.1		
t_{rr}	Reverse recovery time	I_F = 15 A, V_R = 600 V, V_{GE} = ±15 V, di_F/dt = 820 A/µs	-	190		ns
Q_{rr}	Reverse recovery charge		-	1.45		µC
I_{rrm}	Reverse recovery current		-	23		A
E_{rec}	Reverse recovery energy		-	0.55		mJ
t_{rr}	Reverse recovery time	I_F = 15 A, V_R = 600 V, V_{GE} = ±15 V, di_F/dt = 690 A/µs, T_J = 150 °C	-	400		ns
Q_{rr}	Reverse recovery charge		-	2.75		µC
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	°C/W
R_{THc-h}	Thermal resistance case-to-heatsink	Each diode, λ_{grease} = 1 W/(m·°C)	-	1.15		°C/W

1.2 Brake stage

Limiting values at T_J = 25 °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 °C)	15	A
I_{CP}(1)	Pulsed collector current (t_p = 1 ms)	30	A
V_{GE}	Gate-emitter voltage	±20	V
P_{TOT}	Total power dissipation of each IGBT (T_C = 25 °C, T_J = 175 °C)	142.8	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 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 mA, V_{GE} = 0 V	1200			V
$V_{CE(sat)}$ (terminal)	Collector-emitter saturation voltage	V_{GE} = 15 V, I_C = 15 A		1.95	2.45	V
		V_{GE} = 15 V, I_C = 15 A, T_J = 150 °C		2.3		
$V_{GE(th)}$	Gate threshold voltage	V_{CE} = V_{GE}, I_C = 1 mA	5	6	7	V
I_{CES}	Collector cut-off current	V_{GE} = 0 V, V_{CE} = 1200 V			100	µA
I_{GES}	Gate-emitter leakage current	V_{CE} = 0 V, V_{GE} = ±20 V			± 500	nA
C_{ies}	Input capacitance	V_{CE} = 25 V, f = 1 MHz, V_{GE} = 0 V		985		pF
C_{oes}	Output capacitance			118		pF
C_{res}	Reverse transfer capacitance			40		pF
Q_g	Total gate charge	V_{CC} = 960 V, I_C = 15 A, V_{GE} = ±15 V		71		nC
$t_{d(on)}$	Turn-on delay time	V_{CC} = 600 V, I_C = 15 A, R_G = 22 Ω, V_{GE} = ±15 V,di/dt = 820 A/µs		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 V, I_C = 15 A, R_G = 22 Ω, V_{GE} = ±15 V,dv/dt = 8200 V/µs		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 V, I_C = 15 A, R_G = 22 Ω, V_{GE} = ±15 V, di/dt = 690 A/µs, T_J = 150 °C		122		ns
t_r	Current rise time			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 V, I_C = 15 A, R_G = 22 Ω, V_{GE} = ±15 V, dv/dt = 7000 V/μs, T_J = 150 °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} ≤ 600 V, V_{GE}≤ 15 V, T_{Jstart} ≤ 150 °C	10			μs
R_{THj-c}	Thermal resistance junction to case	Each IGBT		0.95	1.05	°C/W
R_{THc-h}	Thermal resistance case to heatsink	Each IGBT, λgrease = 1 W/(m·°C)		0.90		°C/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 at (T_C = 100 °C)	15	A
I_{FP}[(1)]	Pulsed forward current (t_p = 1 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(terminal)	Forward voltage	I_F = 15 A	-	3.0	3.8	V
		I_F = 15 A, T_J = 150 °C	-	2.1		
t_{rr}	Reverse recovery time	I_F = 15 A, V_R = 600 V, V_{GE} = ±15 V, di/dt = 820 A/µs	-	190		ns
Q_{rr}	Reverse recovery charge		-	1.45		µC
I_{rrm}	Reverse recovery current		-	23		A
E_{rec}	Reverse recovery energy		-	0.55		mJ
t_{rr}	Reverse recovery time	I_F = 15 A, V_R = 600 V, V_{GE} = ±15 V, di/dt = 690 A/µs, T_J = 150 °C	-	400		ns
Q_{rr}	Reverse recovery charge		-	2.75		µC
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	°C/W
R_{THc-h}	Thermal resistance case-to-heatsink	Each diode, λ_{grease} = 1 W/(m·°C)	-	1.15		°C/W

1.3 Converter stage

Limiting values at T_J = 25 °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 ms, T_C = 25 °C	315	A
	Forward surge current t_p = 10 ms, T_C = 150 °C	250	
I^2t	t_p = 10 ms, T_C = 25 °C	496	A^2s
	t_p = 10 ms, T_C = 150 °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 A	-	0.97	1.4	V
		I_F = 15 A, T_J = 150 °C	-	0.85		
I_R	Reverse current	T_J = 150 °C, V_R = 1600 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, λ_{grease} = 1 W/(m·°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_{25}	Resistance	T = 25 °C		5		kΩ
R_{100}	Resistance	T = 100 °C		493		Ω
ΔR/R	Deviation of R_{100}		-5		+5	%
$B_{25/50}$	B-constant			3375		K
$B_{25/80}$	B-constant			3411		K
T	Operating temperature range		-40		150	°C

Figure 3. NTC resistance vs temperature

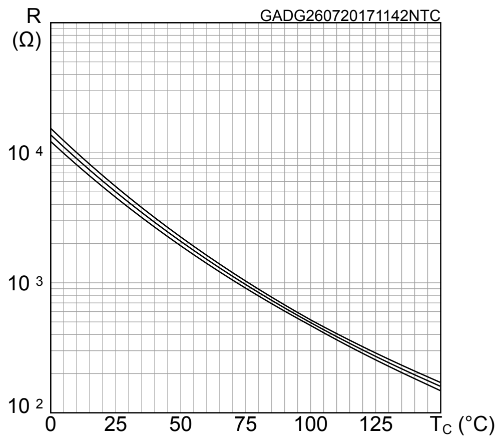
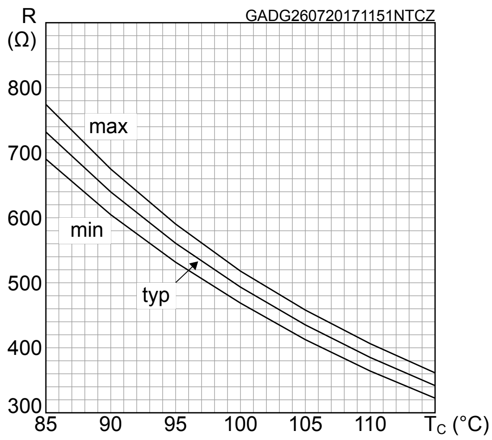


Figure 4. NTC resistance vs temperature, zoom



1.5 Package

Table 12. ACEPACK™ 1 package

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{isol}	Isolation voltage (AC voltage, t = 60 s)			2500	V
T_{stg}	Storage temperature	-40		125	°C
CTI	Comparative tracking index	200			
L_s	Stray inductance module P1 - EW loop		28.7		nH
R_s	Module single lead resistance , terminal to chip		3.9		mΩ

2 Electrical characteristics (curves)

Figure 5. **IGBT output characteristics (V_{GE} = 15 V, terminal)**

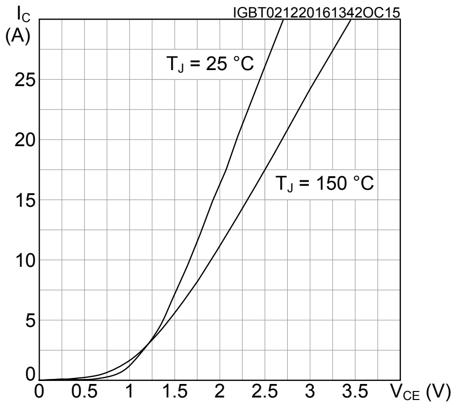


Figure 6. **IGBT output characteristics (T_J = 150 °C, terminal)**

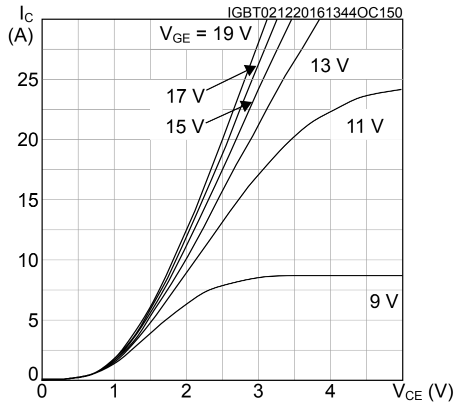


Figure 7. **IGBT transfer characteristics (V_{CE} = 15 V, terminal)**

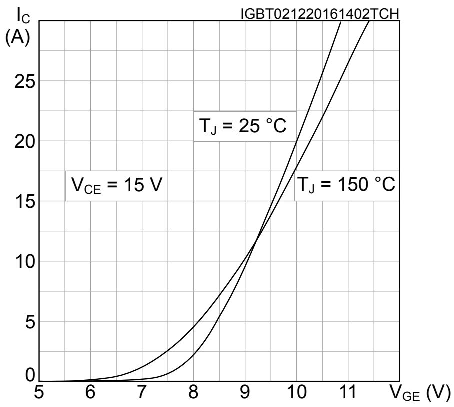


Figure 8. **IGBT collector current vs case temperature**

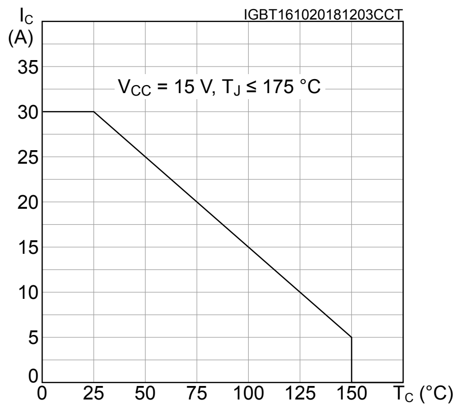


Figure 9. **Switching energy vs gate resistance**

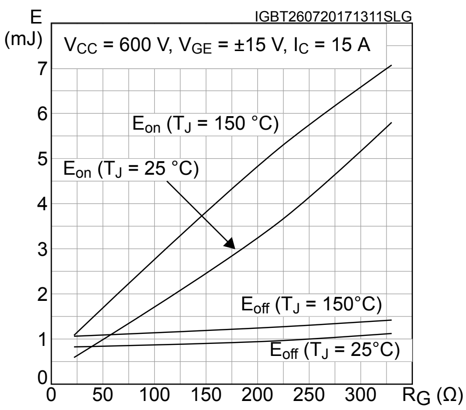


Figure 10. **Switching energy vs collector current**

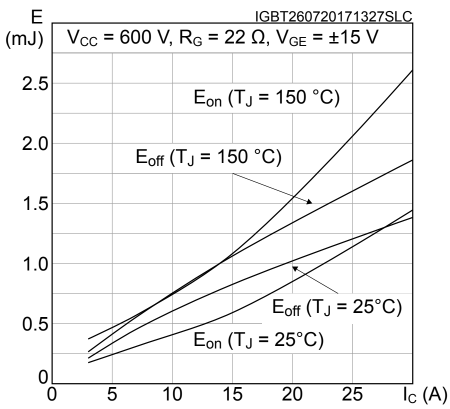


Figure 11. IGBT reverse biased safe operating area (RBSOA)

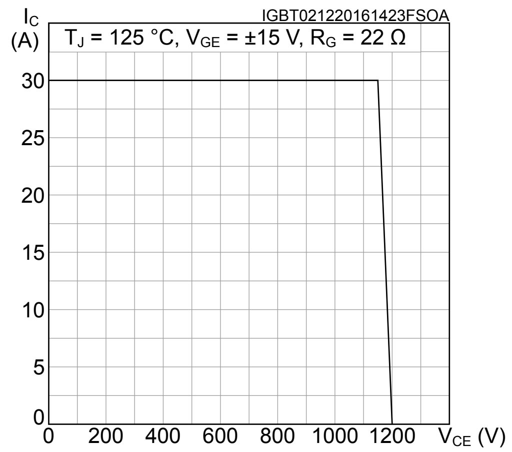


Figure 12. Diode forward characteristics (terminal)

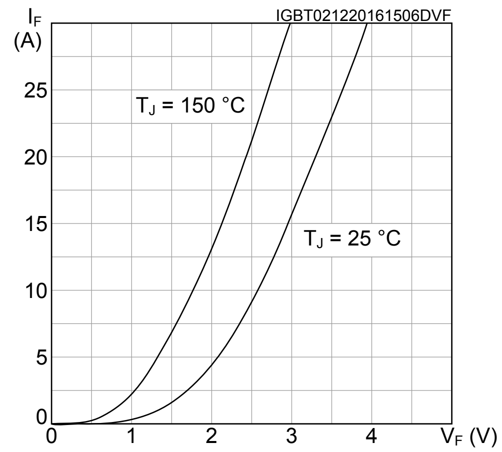


Figure 13. Diode reverse recovery energy vs diode current slope

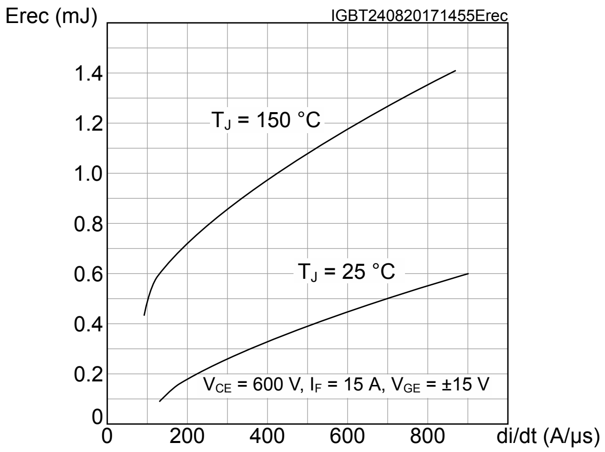


Figure 14. Diode reverse recovery energy vs forward current

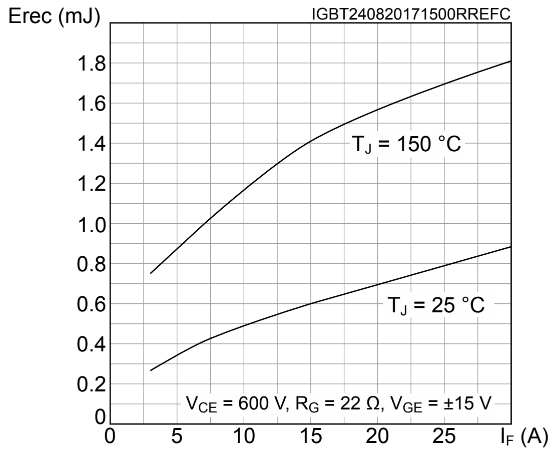


Figure 15. Diode reverse recovery energy vs gate resistance

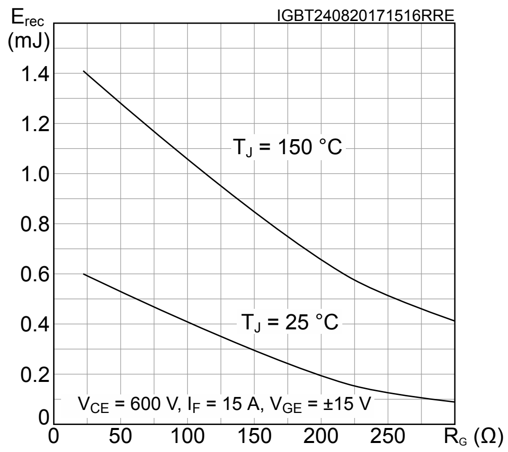


Figure 16. Converter diode forward characteristics (terminal)

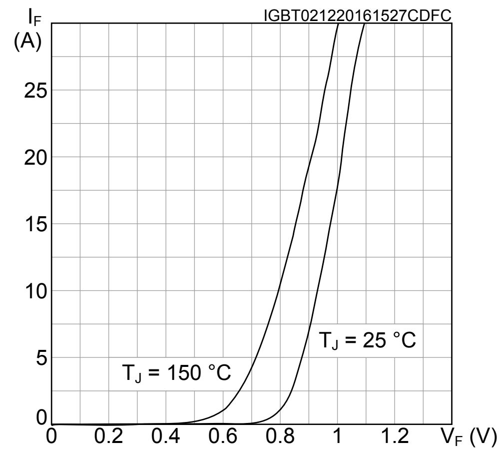


Figure 17. **IGBT thermal impedance**

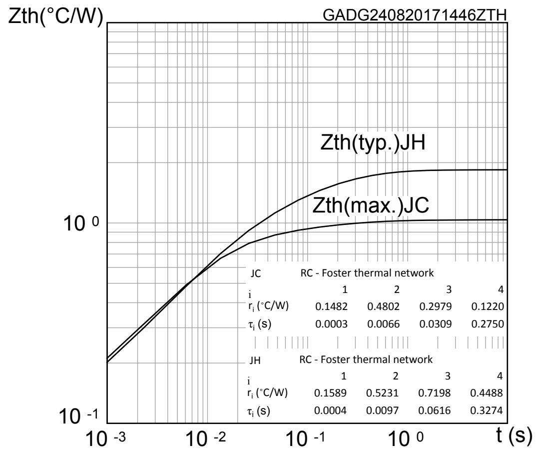
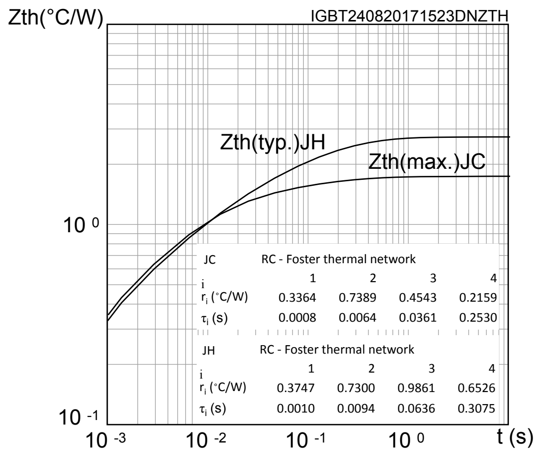


Figure 18. **Inverter diode thermal impedance**



3 Test circuits

Figure 19. Test circuit for inductive load switching

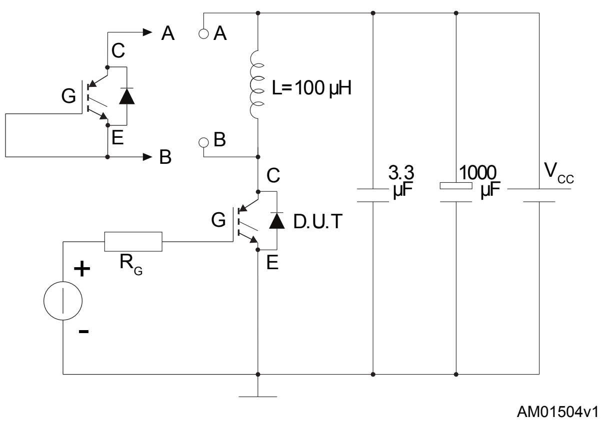


Figure 20. Gate charge test circuit

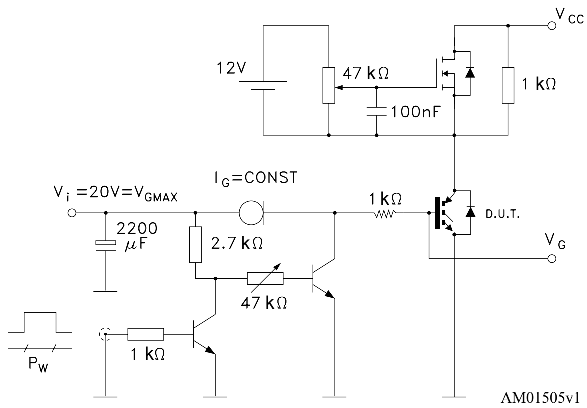


Figure 21. Switching waveform

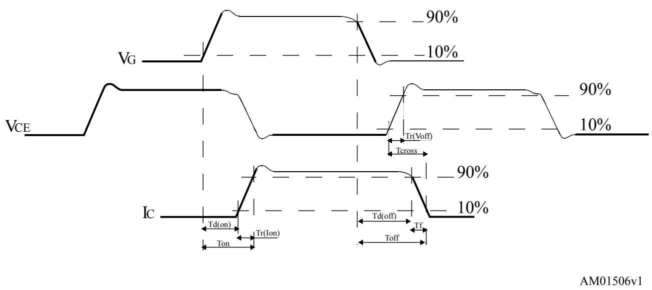
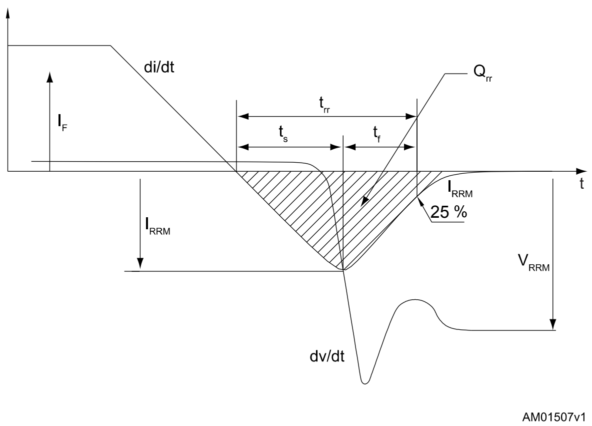


Figure 22. Diode reverse recovery waveform



4 Topology and pin description

Figure 23. Electrical topology and pin description

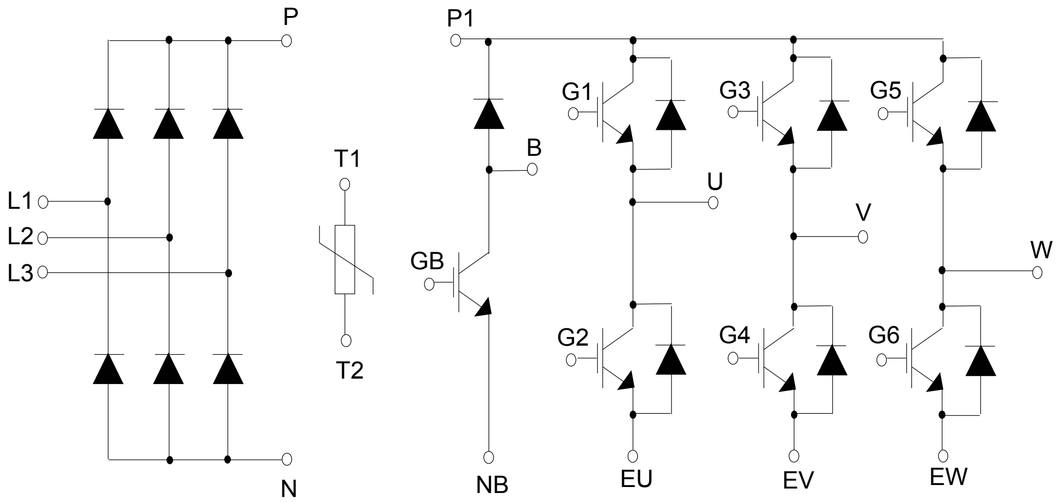
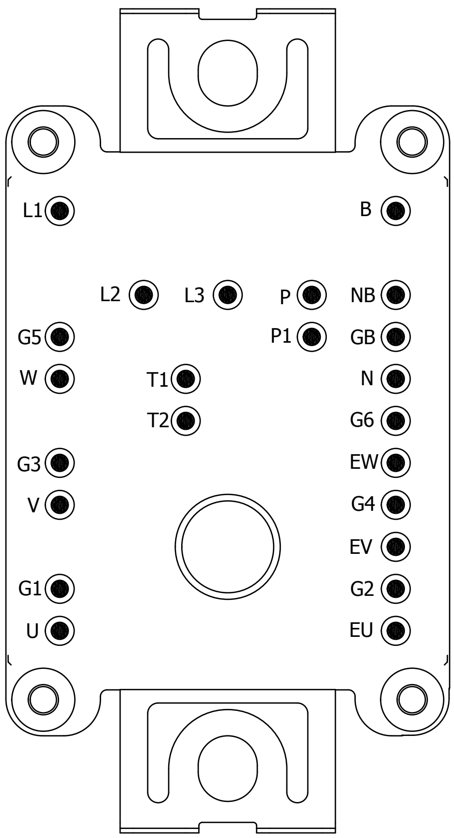


Figure 24. Package top view with CIB pinout



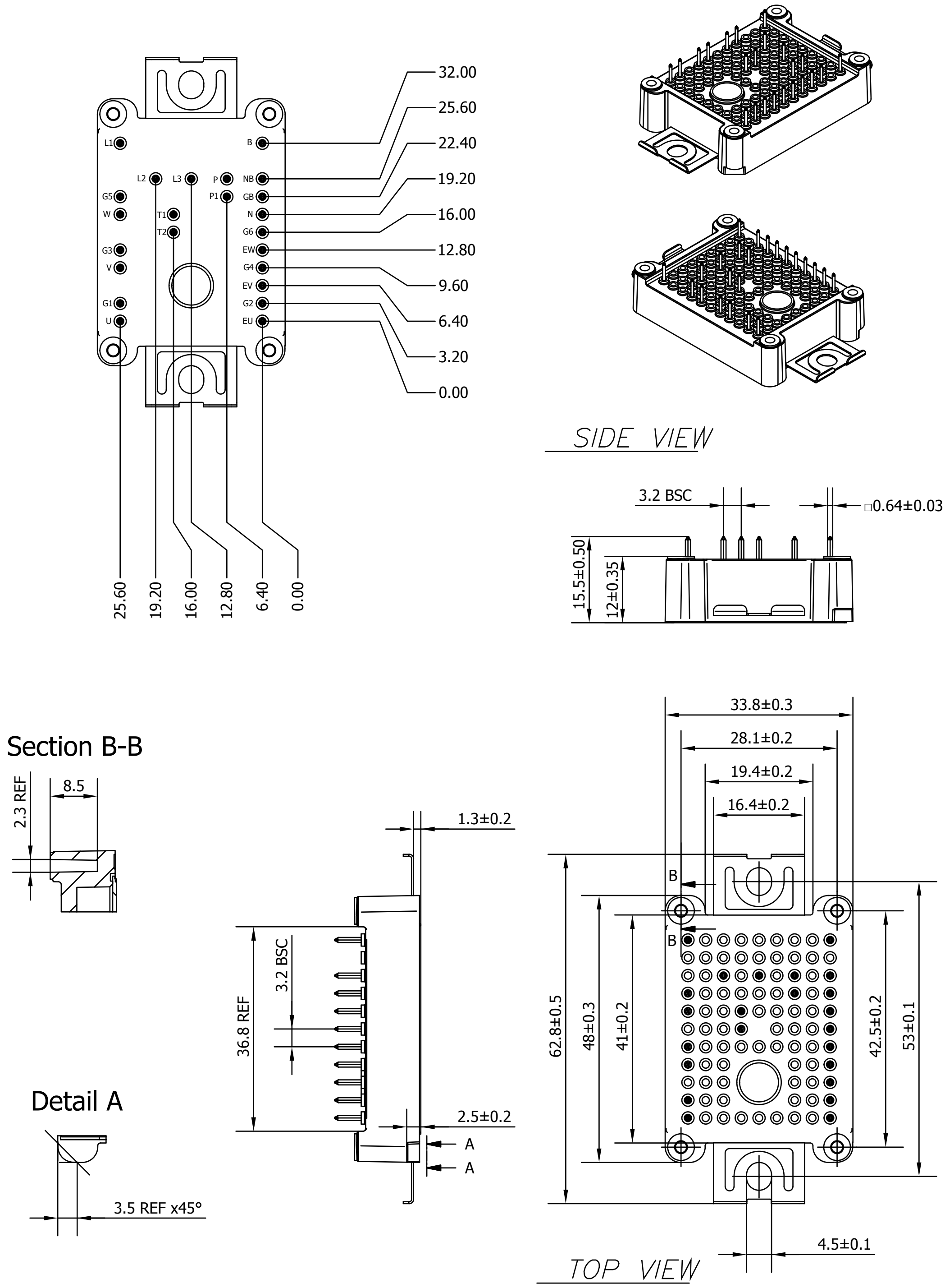
GIPD270320151420FSR

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. ECOPACK® is an ST trademark.

5.1 ACEPACK™ 1 CIB solder pins package information

Figure 25. ACEPACK™ 1 CIB solder 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.

Revision history

Table 13. Document revision history

Date	Revision	Changes
02-May-2016	1	Initial release.
10-Mar-2017	2	Added *Section 2: "Electrical characteristics curves"* and *Section 3: "Test circuits"*. Updated *Section 5.1: "ACEPACK™ 1 CIB solder pins package information"*. Minor text changes.
26-Jul-2017	3	Datasheet promoted from preliminary data to production data. Modified *Table 2: "Absolute maximum ratings of the IGBTs, inverter stage"*, *Table 3: "Electrical characteristics of the IGBTs, inverter stage"*, *Table 6: "Absolute maximum ratings of the IGBT, brake stage"*, *Table 7: "Electrical characteristics of the IGBT, brake stage"*, *Table 4: "Absolute maximum ratings of the diode, inverter stage"*, *Table 5: "Electrical characteristics of the diode, inverter stage"*, *Table 10: "Absolute maximum ratings of the bridge rectifiers"*, *Table 11: "Electrical characteristics of the bridge rectifiers"*, *Table 12: "NTC temperature sensor, considered as stand-alone"*, *Table 13: "ACEPACK™ 1 package"*. Modified *Figure 10: "IGBT thermal impedance"* and. Modified *Figure 22: "Package top view with CIB pinout"*. Modified *Section 5: "Package information"*. Minor text changes.
24-Aug-2017	4	Updated *Table 3: "Electrical characteristics of the IGBTs, inverter stage", Table 5: "Electrical characteristics of the diode, inverter stage", Table 7: "Electrical characteristics of the IGBT, brake stage", Table 9: "Electrical characteristics of the diode, brake stage", Table 11: "Electrical characteristics of the bridge rectifiers", Section 2: "Electrical characteristics curves"*. Minor text changes.
05-Oct-2017	5	Updated *Table 13: "ACEPACK™ 1 package"*, *Figure 15: "IGBT thermal impedance"* and *Figure 16: "Inverter diode thermal impedance"*. Minor text changes.
13-Feb-2018	6	Updated *Figure 16. IGBT thermal impedance* and *Figure 17. Inverter diode thermal impedance*. Removed maturity status indication from cover page. Minor text changes.
17-Oct-2018	7	Added Figure 8. IGBT collector current vs case temperature. Minor text changes

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