

## 60 A, 650 V field stop trench gate IGBT with Ultrafast diode

Datasheet - production data

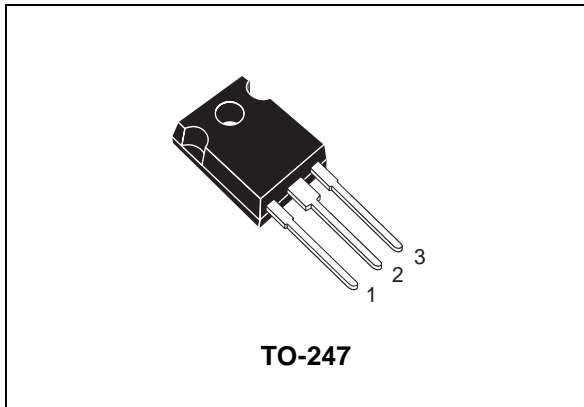
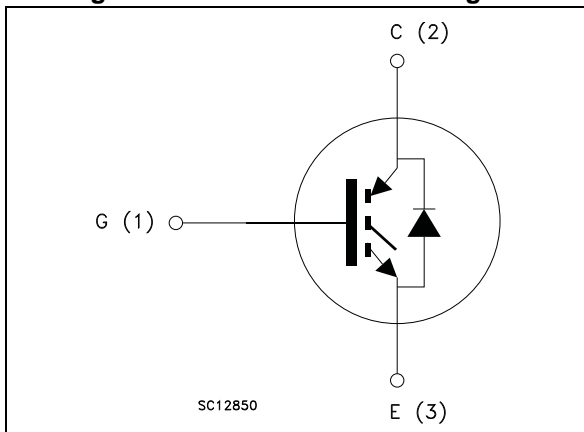


Figure 1. Internal schematic diagram



### Applications

- Photovoltaic inverters
- Uninterruptible power supply
- Welding
- Power factor correction
- High switching frequency converters

### Description

This device is an IGBT developed using an advanced proprietary trench gate and field stop structure. This IGBT is the result of a compromise between conduction and switching losses, maximizing the efficiency of high switching frequency converters. Furthermore, a slightly positive  $V_{CE(sat)}$  temperature coefficient and very tight parameter distribution result in easier paralleling operation.

### Features

- Very high speed switching
- Tight parameters distribution
- Safe paralleling
- Low thermal resistance
- 6  $\mu$ s short-circuit withstand time
- Ultrafast soft recovery antiparallel diode

Table 1. Device summary

Order code	Marking	Package	Packaging
STGW60H65DRF	GW60H65DRF	TO-247	Tube

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ )	650	V
$I_C$	Continuous collector current at $T_C = 25\text{ °C}$	120	A
$I_C$	Continuous collector current at $T_C = 100\text{ °C}$	60	A
$I_{CP}^{(1)}$	Pulsed collector current	240	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$I_F$	Continuous forward current at $T_C = 25\text{ °C}$	120	A
	Continuous forward current at $T_C = 100\text{ °C}$	60	
$I_{FP}^{(1)}$	Pulsed forward current	240	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	420	W
$t_{SC}$	Short-circuit withstand time at $V_{CC} = 400\text{ V}$ , $V_{GE} = 15\text{ V}$	6	$\mu\text{s}$
$T_{STG}$	Storage temperature range	- 55 to 175	$^{\circ}\text{C}$
$T_J$	Operating junction temperature		

1. Pulse width limited by maximum junction temperature and turn-off within RBSOA.

**Table 3. Thermal data**

Symbol	Parameter	Value	Unit
$R_{thJC}$	Thermal resistance junction-case IGBT	0.35	$^{\circ}\text{C}/\text{W}$
$R_{thJC}$	Thermal resistance junction-case diode	1.38	$^{\circ}\text{C}/\text{W}$
$R_{thJA}$	Thermal resistance junction-ambient	50	$^{\circ}\text{C}/\text{W}$

## 2 Electrical characteristics

$T_J = 25\text{ °C}$  unless otherwise specified.

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage ( $V_{GE} = 0$ )	$I_C = 2\text{ mA}$	650			V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}, I_C = 60\text{ A}$		1.9	2.4	V
		$V_{GE} = 15\text{ V}, I_C = 60\text{ A}$ $T_J = 125\text{ °C}$		2.1		
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}, I_C = 1\text{ mA}$		6.0		V
$I_{CES}$	Collector cut-off current ( $V_{GE} = 0$ )	$V_{CE} = 650\text{ V}$			25	$\mu\text{A}$
$I_{GES}$	Gate-emitter leakage current ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\text{ V}$			250	nA

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}, f = 1\text{ MHz},$ $V_{GE} = 0$		7150		pF
$C_{oes}$	Output capacitance		-	275	-	pF
$C_{res}$	Reverse transfer capacitance				140	
$Q_g$	Total gate charge	$V_{CC} = 400\text{ V}, I_C = 60\text{ A},$ $V_{GE} = 15\text{ V}$	-	217	-	nC
$Q_{ge}$	Gate-emitter charge		-	67	-	nC
$Q_{gc}$	Gate-collector charge		-	97	-	nC

**Table 6. Switching on/off (inductive load)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}, I_C = 60\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$		85		ns
$t_r$	Current rise time		-	33	-	ns
$(di/dt)_{on}$	Turn-on current slope				1800	
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}, I_C = 60\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$ $T_J = 125\text{ °C}$		82		ns
$t_r$	Current rise time		-	35	-	ns
$(di/dt)_{on}$	Turn-on current slope				1680	
$t_{r(Voff)}$	Off voltage rise time	$V_{CE} = 400\text{ V}, I_C = 60\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$		34		ns
$t_{d(off)}$	Turn-off delay time		-	178	-	ns
$t_f$	Current fall time				30	
$t_{r(Voff)}$	Off voltage rise time	$V_{CE} = 400\text{ V}, I_C = 60\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$ $T_J = 125\text{ °C}$		45		ns
$t_{d(off)}$	Turn-off delay time		-	205	-	ns
$t_f$	Current fall time				70	

**Table 7. Switching energy (inductive load)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CE} = 400\text{ V}, I_C = 60\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$	-	0.94	-	mJ
$E_{off}^{(2)}$	Turn-off switching losses			1.06		mJ
$E_{ts}$	Total switching losses			2.0		mJ
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CE} = 400\text{ V}, I_C = 60\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$ $T_J = 125\text{ }^\circ\text{C}$	-	1.48	-	mJ
$E_{off}^{(2)}$	Turn-off switching losses			1.4		mJ
$E_{ts}$	Total switching losses			2.88		mJ

1.  $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in [Figure 23](#). If the IGBT is offered in a package with a co-pack diode, the co-pack diode is used as external diode. IGBTs and diode are at the same temperature (25 °C and 125 °C).
2. Turn-off losses include also the tail of the collector current.

**Table 8. Collector-emitter diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$	Forward on-voltage	$I_F = 60\text{ A}$ $I_F = 60\text{ A}, T_J = 150\text{ }^\circ\text{C}$	-	3.7 2.2	4.8	V V
$t_{rr}$	Reverse recovery time	$I_F = 60\text{ A}, V_R = 400\text{ V},$ $di/dt = 1700\text{ A}/\mu\text{s}$	-	19	-	ns
$Q_{rr}$	Reverse recovery charge			200		nC
$I_{rrm}$	Reverse recovery current			15.5		A
$t_{rr}$	Reverse recovery time	$I_F = 60\text{ A}, V_R = 400\text{ V},$ $di/dt = 1630\text{ A}/\mu\text{s}$ $T_J = 125\text{ }^\circ\text{C}$	-	34	-	ns
$Q_{rr}$	Reverse recovery charge			780		nC
$I_{rrm}$	Reverse recovery current			46		A

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics ( $T_J = -40\text{ }^\circ\text{C}$ )

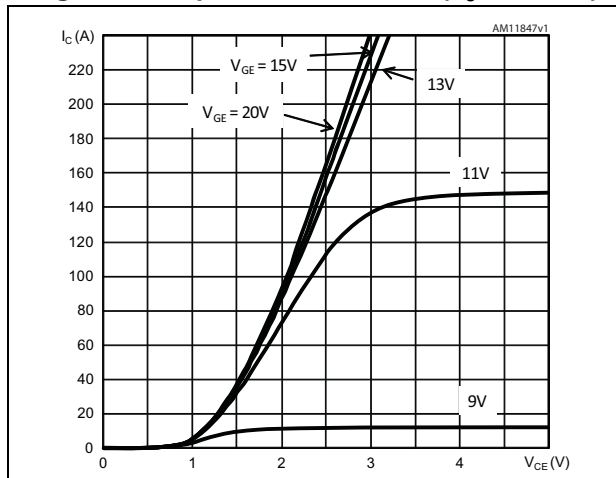


Figure 3. Output characteristics ( $T_J = 25\text{ }^\circ\text{C}$ )

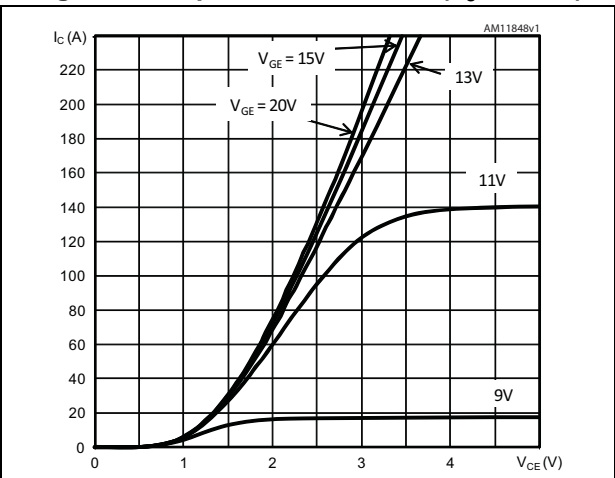


Figure 4. Output characteristics ( $T_J = 150\text{ }^\circ\text{C}$ )

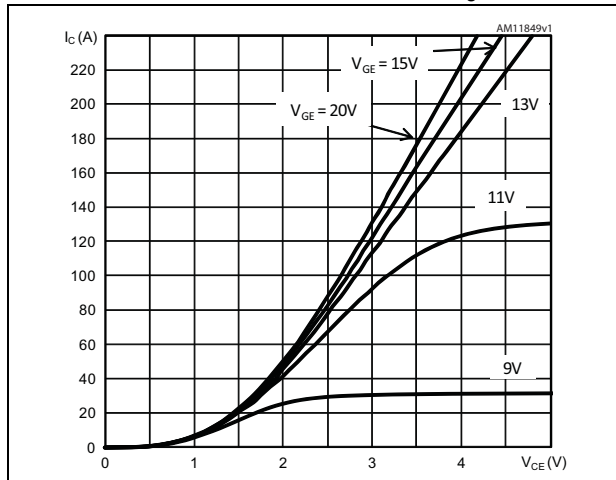


Figure 5. Transfer characteristics

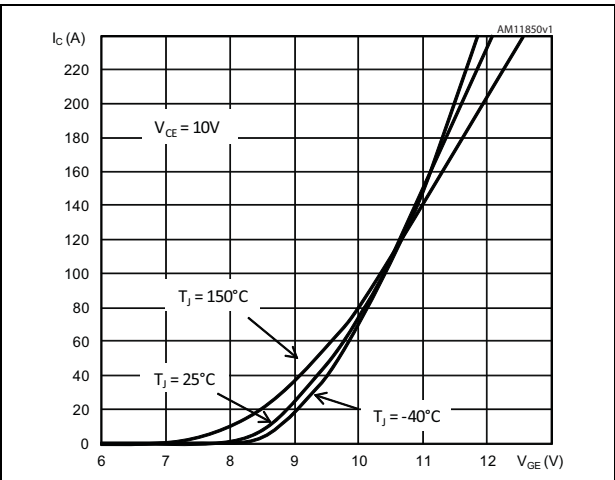


Figure 6.  $V_{CE(SAT)}$  vs. junction temperature

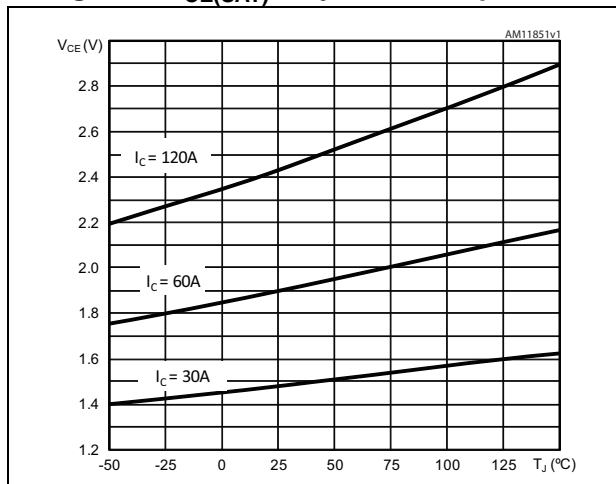


Figure 7.  $V_{CE(SAT)}$  vs. collector current

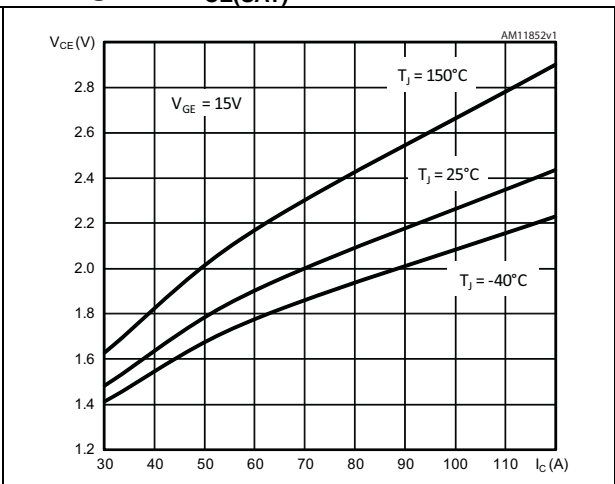


Figure 8. Normalized  $V_{GE(th)}$  vs. junction temperature

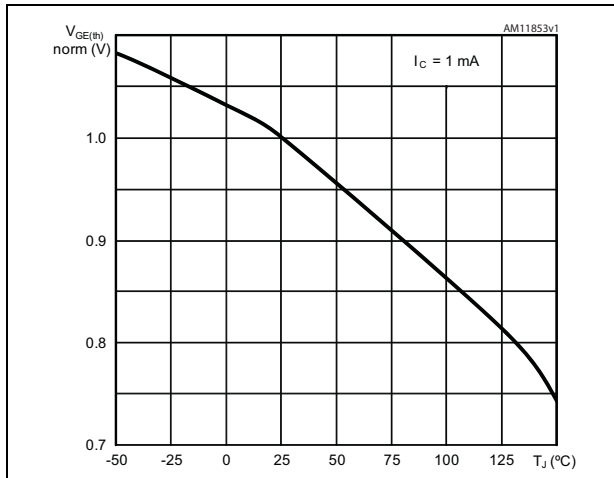


Figure 9. Gate charge vs. gate-emitter voltage

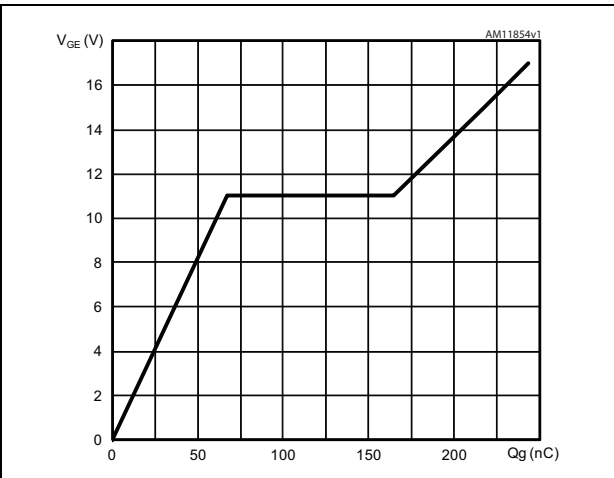


Figure 10. Capacitance variations ( $f = 1$  MHz,  $V_{GE} = 0$ )

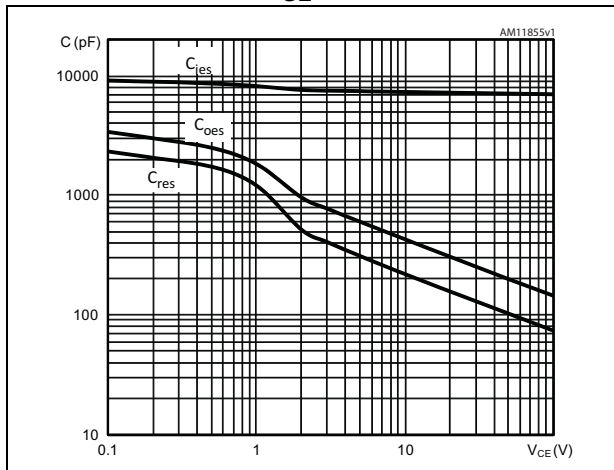


Figure 11. Switching losses vs. collector current

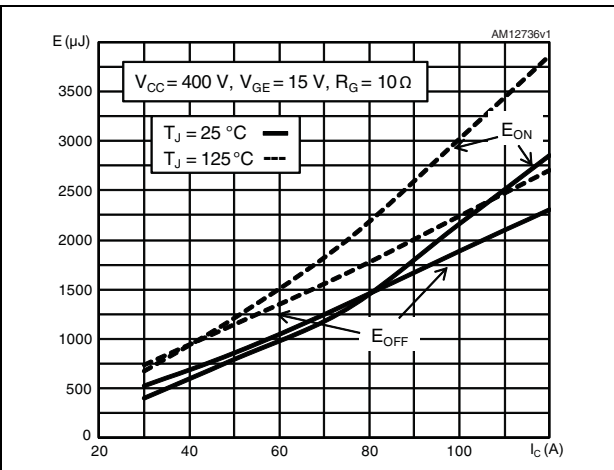


Figure 12. Switching losses vs. gate resistance

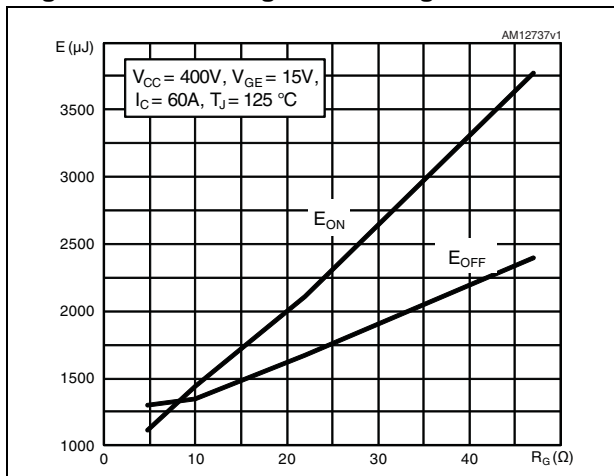


Figure 13. Switching losses vs. temperature

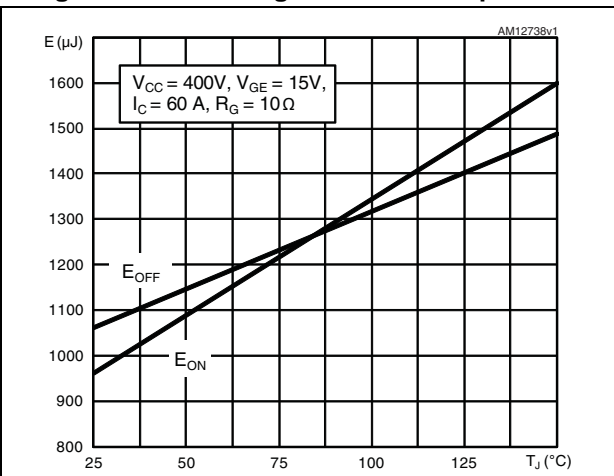


Figure 14. Turn-OFF SOA

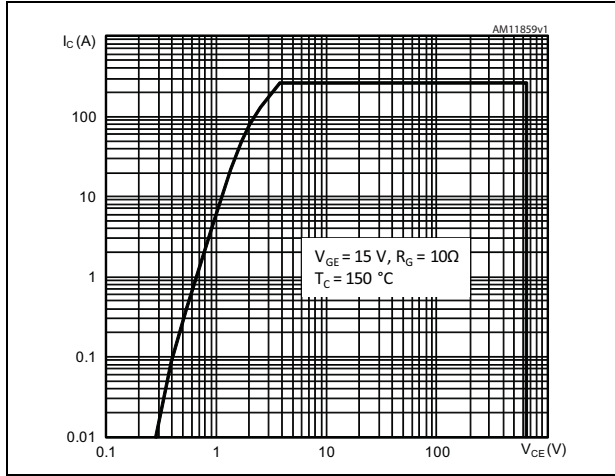


Figure 15. Short circuit time & current vs.  $V_{GE}$

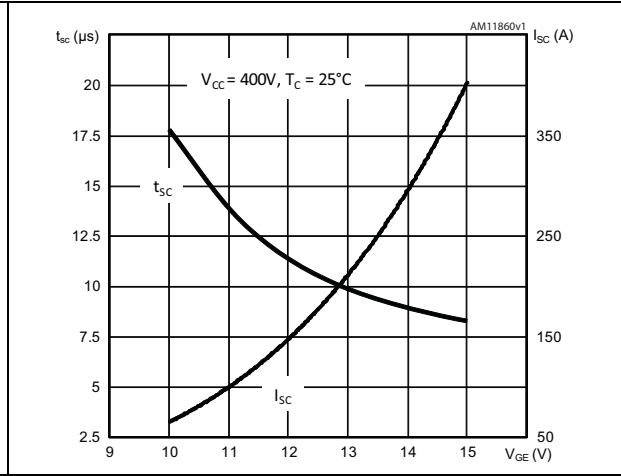


Figure 16. Diode forward current vs. forward voltage

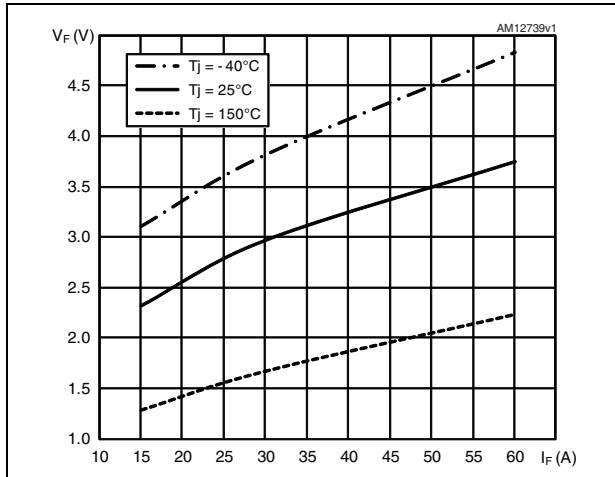


Figure 17. Diode forward current vs. junction temperature

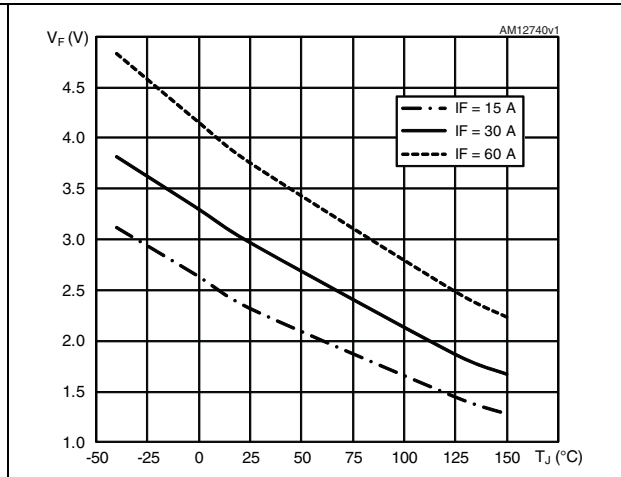


Figure 18. Reverse recovery current as a function of diode current slope

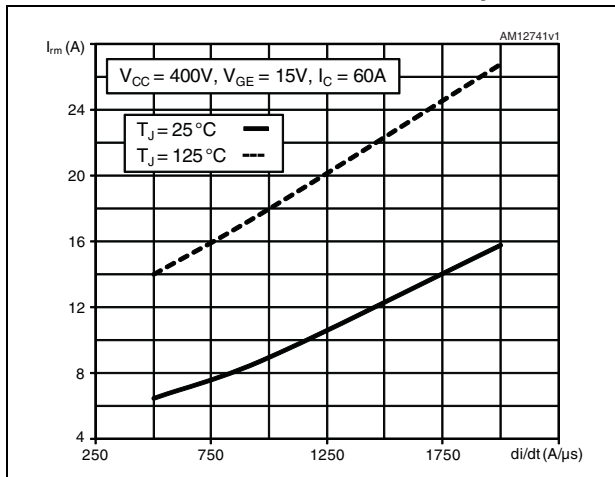


Figure 19. Reverse recovery time as a function of diode current slope

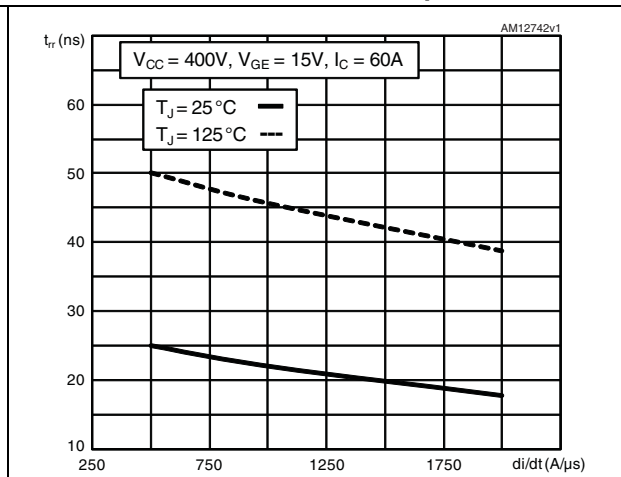


Figure 20. Reverse recovery charge as a function of diode current slope

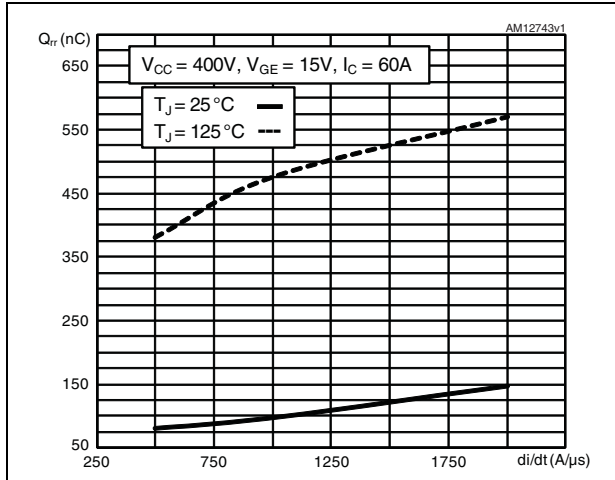


Figure 21. Maximum normalized  $Z_{th}$  junction to case (IGBT)

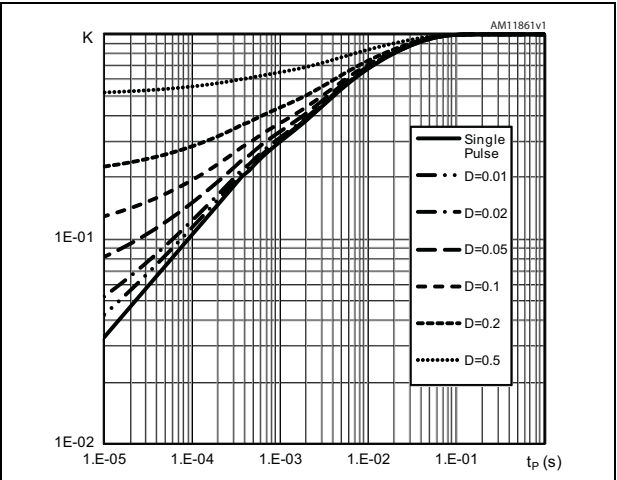
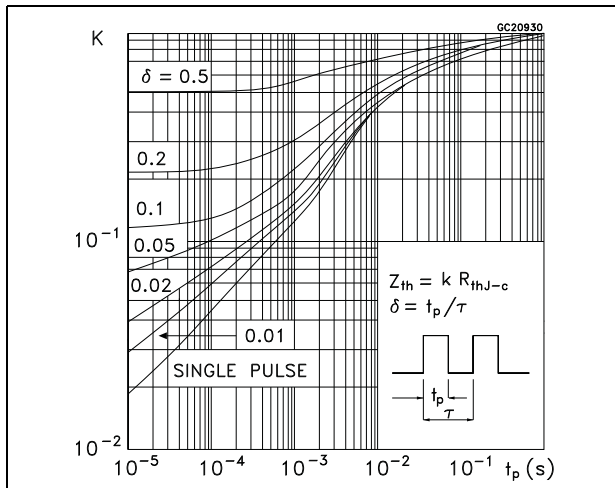


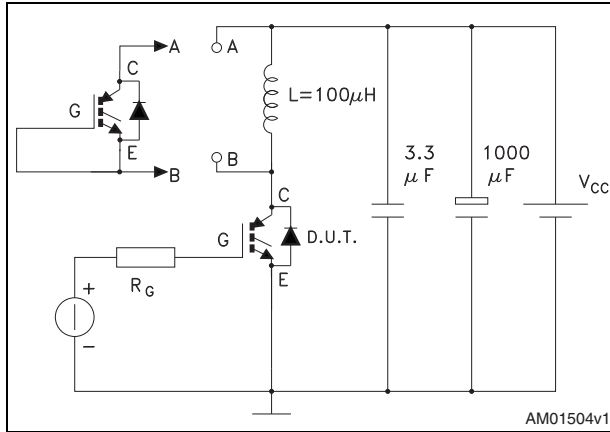
Figure 22. Maximum normalized  $Z_{th}$  junction to case (Diode)





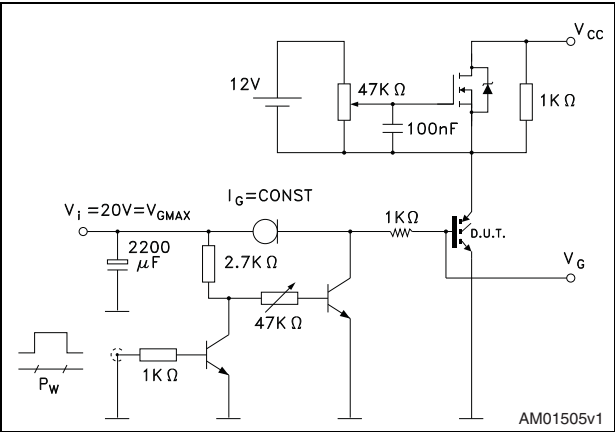
### 3 Test circuits

Figure 23. Test circuit for inductive load switching



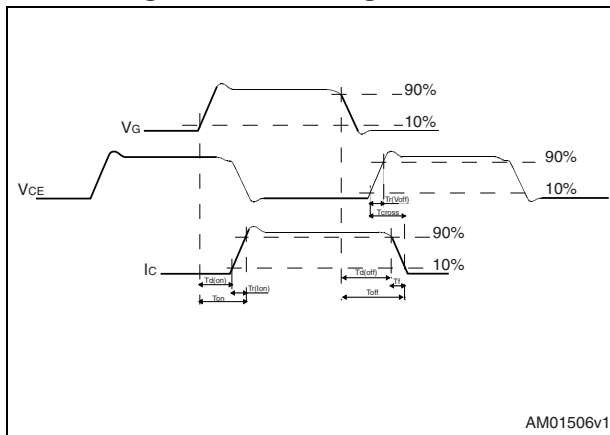
AM01504v1

Figure 24. Gate charge test circuit



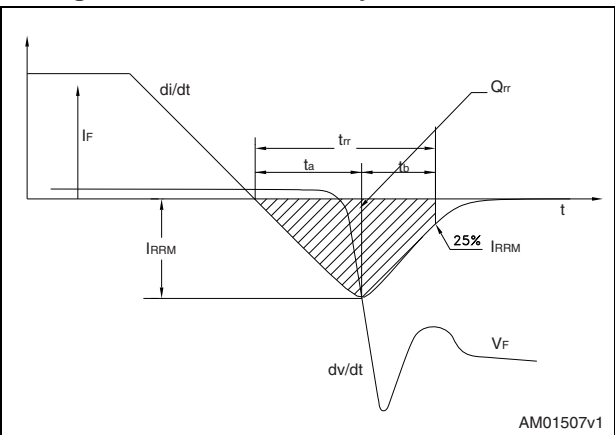
AM01505v1

Figure 25. Switching waveform



AM01506v1

Figure 26. Diode recovery time waveform



AM01507v1

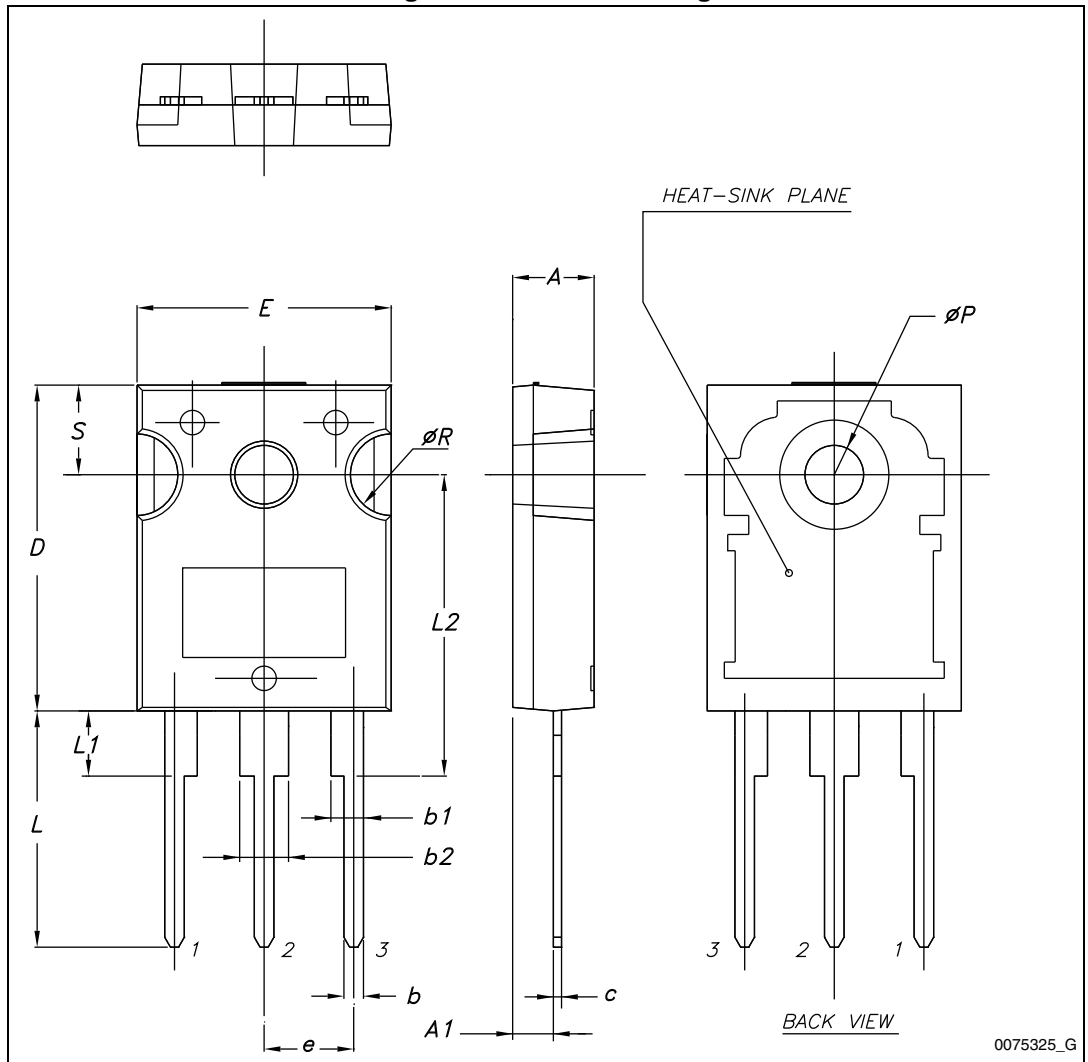
## 4 Package mechanical data

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.

**Table 9. TO-247 mechanical data**

Dim.	mm.		
	Min.	Typ.	Max.
A	4.85		5.15
A1	2.20		2.60
b	1.0		1.40
b1	2.0		2.40
b2	3.0		3.40
c	0.40		0.80
D	19.85		20.15
E	15.45		15.75
e	5.30	5.45	5.60
L	14.20		14.80
L1	3.70		4.30
L2		18.50	
ØP	3.55		3.65
ØR	4.50		5.50
S	5.30	5.50	5.70

Figure 27. TO-247 drawing



## 5 Revision history

Table 10. Document revision history

Date	Revision	Changes
11-Oct-2011	1	Initial release.
06-Jun-2012	2	Document status promoted from preliminary data production data. Added: <a href="#">Section 2.1: Electrical characteristics (curves) on page 5.</a>
19-Jun-2012	3	Updated parameters in <a href="#">Table 2.</a>
26-Jul-2012	4	Updated parameters in <a href="#">Table 2.</a>
21-Jan-2013	5	Modified $V_F$ test conditions, typ. and max values <a href="#">Table 8 on page 4.</a>
02-Apr-2013	6	Modified: <ul style="list-style-type: none"><li>– <math>P_{TOT}</math> value <a href="#">Table 2 on page 2.</a></li><li>– <math>E_{on}</math> and <math>E_{ts}</math> typical values <a href="#">Table 7 on page 4.</a></li></ul>

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