QQQX2.E72873
Electrically Isolated Semiconductor Devices - Component

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Electrically Isolated Semiconductor Devices - Component

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IXYS SEMICONDUCTOR GMBH E72873
Edisonstrasse 15
68623 Lampertheim, GERMANY

Electrically Isolated Semiconductor Device, Model(s) GBO25-12NO1, GBO25-16NO1

Power Switching Semi-Conductors, "ISOPLUS-247 package", Model(s) C, D, I or M followed by additional numbers and letters, followed by HI, HJ, HQ or HR.

Power Switching Semi-Conductors, "ISOPLUS-247 package", Model(s) CS or DS followed by up to 10 numbers and letters, followed by R.

Power Switching Semi-Conductors, "ISOPLUS-i4", Model(s) C, D, I or M followed by two letters, followed by additional numbers and letters, followed by FB, FC, FD or FE.

Power switching semi-conductors, "ISOPLUS-i4", Model(s) CS#

Power Switching Semi-Conductors, "ISOPLUS-i4", Model(s) CS, DH, DS followed by up to 15 numbers and letters, followed by F or F1.

Power switching semi-conductors, "ISOPLUS-i4", Model(s) DS#, DSE#, FBE#, FBO#, FBS#, FCC#, FCD#, FDC#, FDD#, FDI#, FDM#, FEE#, FID#, FII#, FIO#, FMD#, FMK#, FMM#, FRR#, FSS#, FUE#, FUO#, FUS#, IXBF#, IXDF#, IXEF#, IXFF#, IXGF#, IXKF#, IXLF#, IXSF#, IXUF#

Power Switching Semi-Conductors, "ISOPLUS220 package", Model(s) C, D, I or M followed by additional numbers and letters, followed by PI or PJ.

Power Switching Semi-Conductors, "ISOPLUS220 package", Model(s) CS, DS or DG followed by numbers and letters, followed by C.

Power switching semi-conductors, Model(s) 40370-32*

Power Switching Semi-Conductors, Model(s) C, D, I or M followed by two letters, followed by additional numbers and letters, followed by NA.

Power Switching Semi-Conductors, Model(s) C, D, I, and M followed by numbers and/or letters, followed by GU, GV, GW, GX, GY or GZ.

Power Switching Semi-Conductors, Model(s) C, D, I, and M followed by numbers and/or letters, followed by LA, LB, LC, or LD.

Power Switching Semi-Conductors, Model(s) CS followed by additional letters and/or numbers, followed by M.

Power Switching Semi-Conductors, Model(s) D followed by additional letters and/or numbers, followed by M.

Power Switching Semi-Conductors, Model(s) D, C, M or I followed by additional letters and/or numbers, followed by PN or PM.

Power Switching Semi-Conductors, Model(s) DS followed by additional letters and/or numbers, followed by M.

Power switching semi-conductors, Model(s) DSEI....P, DSEK....P

Power Switching Semi-Conductors, Model(s) GUO followed by numbers, followed by "-", followed by numbers, followed by NO1.

Power Switching Semi-Conductors, Model(s) ISOPLUS-264 Models C, D, I or M, followed by two letters, followed by additional numbers and letters, followed by KI, KJ, KK, KL, KM, KN ,KO, KP, KQ, KR, KS, KT, KU, KV. Models IXBL, IXFL, IXTL or LKK, followed by additional numbers and letters

Power Switching Semi-Conductors, Model(s) IX (single phase) followed by two numbers, followed by MB, followed by three numbers.

Power Switching Semi-Conductors, Model(s) IX (three phase) followed by two numbers, followed by MT, followed by three numbers.

Power Switching Semi-Conductors, Model(s) IX followed by additional letters and/or numbers, followed by M.

Power Switching Semi-Conductors, Model(s) M followed by two letters, followed by additional numbers and letters, followed by JA, JB, JC, JD or JE.

Power Switching Semi-Conductors, Model(s) MC and M followed by two letters, followed by additional numbers or letters, followed by VB or VC.

Power Switching Semi-Conductors, Model(s) MC, MD, MI or MM followed by two letters, followed by additional numbers and letters, followed by ED, EH, SF, or SH.

Power Switching Semi-Conductors, Model(s) MC, MD, MI or MM followed by two letters, followed by additional numbers and letters, followed by ML or MH.

Power Switching Semi-Conductors, Model(s) MC, MD, MI or MM followed by two letters, followed by additional numbers and letters, followed by TA, TB, TC, TD, TE, TF, or TG.

Power Switching Semi-Conductors, Model(s) MC, MD, MI or MM followed by two letters, followed by additional numbers and letters, followed by VA.

Power Switching Semi-Conductors, Model(s) MC, MD, MI or MM followed by two letters, followed by additional numbers and letters, followed by YA, YB, YC, YD, YE,YF, YI, YJ, YK or YL.

Power Switching Semi-Conductors, Model(s) MC, MD, MI, and MM followed by 8 to 10 alphanumeric characters, followed by MI.

Power Switching Semi-Conductors, Model(s) MC, MD, MI, and MM followed by 8 to 10 alphanumeric characters, followed by SA.

Power Switching Semi-Conductors, Model(s) MC, MD, MI, and MM followed by 8 to 11 alphanumeric characters, followed by CA, CB, CC, CD, CE, CF, CG, CH.

Power Switching Semi-Conductors, Model(s) MC, MD, MI, or MM followed by two letters, followed by additional numbers and letters, followed by KA, KB, KC, KD or KE.

Power Switching Semi-Conductors, Model(s) MC, MD, MI, or MM followed by two letters, followed by additional numbers or letters, ending with VH.

Power Switching Semi-Conductors, Model(s) MCC, MCD, MCK, MDC, or MDD followed by 120 through 200.*

Power Switching Semi-Conductors, Model(s) MCC, MCD, MDA, MDC, or MDD followed by numbers between 19 and 100.*

Power Switching Semi-Conductors, Model(s) MCC, MCD, MDC, or MDD followed by 170 through 350.*

Power switching semi-conductors, Model(s) MCC165*, MCC220*, MCC250*, MCC310*, MCD165*, MCD220*, MCD250*, MCD310*

Power switching semi-conductors, Model(s) MCO or MDO, followed by 400 through 650.*

Power switching semi-conductors, Model(s) MDC165*, MDC220*, MDC250*, MDC310*, MDD165*, MDD220*, MDD250*, MDD310*

Power Switching Semi-Conductors, Model(s) MDI followed by 90 through 1550*

Power switching semi-conductors, Model(s) MDI, MID or MII, followed by 20 through 150.*

Power Switching Semi-Conductors, Model(s) MEA, MEE, MEK, MPK or MEO followed by numbers between 50 and 240.*

Power Switching Semi-Conductors, Model(s) MEA, MEE, MEK, or MEO followed by 150 through 600.*

Power Switching Semi-Conductors, Model(s) MID followed by 90 through 1550*

Power Switching Semi-Conductors, Model(s) MIE followed by 90 through 1550*

Power Switching Semi-Conductors, Model(s) MII followed by 90 through 1550*

Power Switching Semi-Conductors, Model(s) MIO followed by 90 through 1550*

Power switching semi-conductors, Model(s) MIO, VIO or VMO, followed by 200 through 1200.*

Power switching semi-conductors, Model(s) MLO 100*, MLO 36*, MLO 50*, MLO 75*, MLO....7, MMO 36*, MMO 50*, MMO 75*

Power Switching Semi-Conductors, Model(s) MMO, MCO, MCD followed by additional numbers, followed by io1 or io6.

Power switching semi-conductors, Model(s) MMO....7

Power Switching Semi-Conductors, Model(s) MUBW, MWI or MKI followed by additional numbers and/or letters, followed by 7or 8, may be followed by T.

Power Switching Semi-Conductors, Model(s) MUBW, MWI, or MKI followed by additional numbers and /or letters, followed by 6K.

Power Switching Semi-Conductors, Model(s) MWI followed by additional numbers and/or letters, followed by 9.

Power Switching Semi-Conductors, Model(s) MWI followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power Switching Semi-Conductors, Model(s) VBBW followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VBE*, VBE.. .NO7

Power Switching Semi-Conductors, Model(s) VBEF followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power Switching Semi-Conductors, Model(s) VBH followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VBO or VUO, followed by 10 through 125.*

Power switching semi-conductors, Model(s) VBO or VUO, followed by 50 through 100.*

Power switching semi-conductors, Model(s) VBO...7, VBO...NO7, VBO13*, VBO14*, VBO15*, VBO16*, VBO17*, VBO18*, VBO19*, VBO20*, VBO21*, VBO22*, VBO23*, VBO24*, VBO25*, VBO26*, VBO27*, VBO28*, VBO29*, VBO30*, VBO31*, VBO32*, VBO33*, VBO34*, VBO35*, VBO36*, VCA....7, VCC....7, VCD....7, VCK....7, VCO....7

Power Switching Semi-Conductors, Model(s) VDD may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power Switching Semi-Conductors, Model(s) VDI followed by 90 through 1550*

Power switching semi-conductors, Model(s) VDI....P1, VDI100*, VDI25*, VDI50*, VDI75*, VEE*, VGO....7, VH013*, VH014*, VH015*, VH016*, VH017*, VH018*, VH019*, VH020*, VH021*, VH022*, VH023*, VH024*, VH025*, VH026*, VH027*, VH028*, VH029*, VH030*, VH031*, VH032*, VH033*, VH034*, VH035*, VH036*, VHF*, VHF....7, VHF13*, VHF14*, VHF15*, VHF16*, VHF17*, VHF18*, VHF19*, VHF20*, VHF21*, VHF22*, VHF23*, VHF24*, VHF25*, VHF26*, VHF27*, VHF28*, VHF29*, VHF30*, VHF31*, VHF32*, VHF33*, VHF34*, VHF35*, VHF36*, VHFD*, VHM...7, VHO....7

Power Switching Semi-Conductors, Model(s) VID followed by 90 through 1550*

Power Switching Semi-Conductors, Model(s) VID may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power switching semi-conductors, Model(s) VID....P1, VID100*, VID25*, VID50*, VID75*

Power Switching Semi-Conductors, Model(s) VIE followed by 90 through 1550*

Power Switching Semi-Conductors, Model(s) VII followed by 90 through 1550*

Power switching semi-conductors, Model(s) VII....7, VII....P1, VII100*, VII25*, VII50*, VII75*, VIO....P1, VK013*, VK014*, VK015*, VK016*, VK017*, VK018*, VK019*, VK020*, VK021*, VK022*, VK023*, VK024*, VK025*, VK026*, VK027*, VK028*, VK029*, VK030*, VK031*, VK032*, VK033*, VK034*, VK035*, VK036*, VKI....7, VKI....P1, VKM...7, VKO....7

Power Switching Semi-Conductors, Model(s) VMD may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power Switching Semi-Conductors, Model(s) VMH may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power Switching Semi-Conductors, Model(s) VMK, VMM, or VMO followed by numbers between 25 and 250.*

Power Switching Semi-Conductors, Model(s) VMM followed by 90 through 1550*

Power Switching Semi-Conductors, Model(s) VMM may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power switching semi-conductors, Model(s) VMO....P1, VTO....7

Power Switching Semi-Conductors, Model(s) VUB followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VUB*

Power Switching Semi-Conductors, Model(s) VUB, VUO, or VVZB followed by additional numbers and/or letters, followed by NO1, NOX or ioX, may be followed by T.

Power switching semi-conductors, Model(s) VUB...P1, VUB...PO1, VUBM....P1

Power Switching Semi-Conductors, Model(s) VUBW followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VUC*

Power Switching Semi-Conductors, Model(s) VUC15 may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power Switching Semi-Conductors, Model(s) VUC25 may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power Switching Semi-Conductors, Model(s) VUC36 may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power switching semi-conductors, Model(s) VUCB*, VUE*, VUE.. .NO7, VUI*, VUI....N7

Power Switching Semi-Conductors, Model(s) VUM followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VUM*, VUM.....N7

Power Switching Semi-Conductors, Model(s) VUM24 may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power Switching Semi-Conductors, Model(s) VUM33 may be followed by 15, 24, 25, 33, or 36, followed by 05, 12, 14, 16, 500, 1200, 1400, or 1600, may be followed by G02, E, N01, N, PH *

Power Switching Semi-Conductors, Model(s) VUO followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VUO*, VUO...7, VUO...NO7, VUO30*, VUO50*, VUO60*

Power Switching Semi-Conductors, Model(s) VVBW followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VVY*, VVY12*, VVY24*, VVY40*

Power Switching Semi-Conductors, Model(s) VVZ followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VVZ*, VVZ....7, VVZ12*, VVZ24*, VVZ40*

Power Switching Semi-Conductors, Model(s) VVZB followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VW2X*, VW3....7, VWI....P1

Power Switching Semi-Conductors, Model(s) VWM followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VWM....7

Power Switching Semi-Conductors, Model(s) VWO followed by additional numbers and/or letters, followed by A5, DL1, iol, io2, ioX, NO1, NO2, or NOX, may be followed by T

Power switching semi-conductors, Model(s) VWO....7, VZI....P1

Power switching semi-conductors, package SOT-227B, miniBloc, Model(s) DH1X*, DH2X*, DSEI*, DSEP*, DSI*, DSS*, IXDN*, IXEN*, IXFN*, IXGN*, IXKN*, IXLN*, IXSN*, IXTN*, IXUN*, VBE*, VBO*, VBS*

Semi-conductor diodes, thyristors, IGBTs or MOSFETS, "ISOPLUS-247 package", Model(s) IXDR%, IXER%, IXFR%, IXKR%

Semi-conductor diodes, thyristors, IGBTs or MOSFETS, "ISOPLUS220 package", Model(s) IXKC*

- Followed by up to 15 numbers and letters.

% - Followed by up to 10 numbers and letters.

* - May be followed by additional numbers or letters.

Marking: Company name or trademark IXYS , and model designation.

Last Updated on 2017-12-08

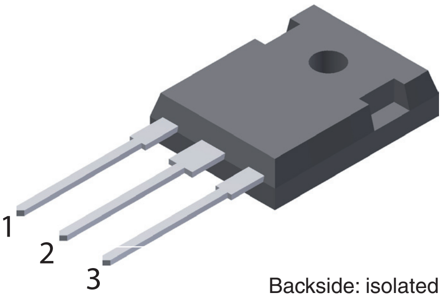
Questions? Print this page Terms of Use Page Top

Trench IGBT

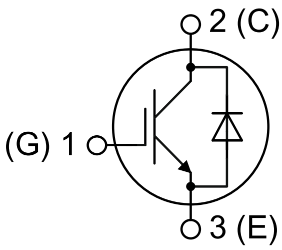
Copack

V_{CES} = 1200 V
I_{C25} = 72 A
$V_{CE(sat)}$ = 2.05 V

Part number
ITF48IF1200HR



Backside: isolated
E72873



Features / Advantages:

- Easy paralleling due to the positive temperature coefficient of the on-state voltage
- Fast Trench IGBT
  - very low $V_{CE(sat)}$
  - short circuit rated for 10 µsec.
  - very low gate charge
  - low EMI
  - square RBSOA @ 3x I_C
- Sonic™ diode
  - fast and soft reverse recovery
  - low operating forward voltage

Applications:

- Solar inverter
- Medical equipment
- Uninerruptible power supply
- Air-conditioning system
- Welding equipment
- Switched-mode and resonant-mode power supplies
- Inductive heating, cookers
- Pumps, Fans

Package: ISO247

- Isolation Voltage: 3600 V~
- Industry standard outline
- RoHS compliant
- Epoxy meets UL 94V-0
- Soldering pins for PCB mounting
- Backside: DCB ceramic
- Reduced weight
- Advanced power cycling

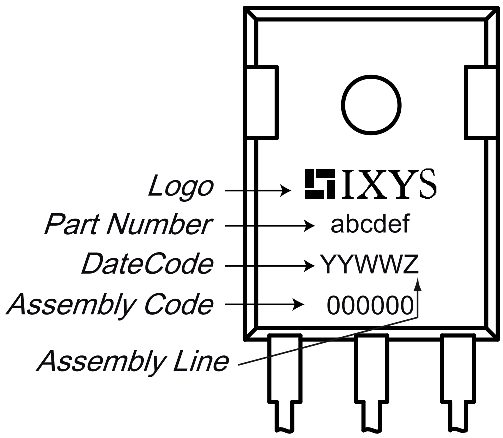
IGBT				Ratings		
Symbol	**Definitions**	**Conditions**		**min.**	**typ.**	**max.**	
V_{CE}	*collector emitter voltage*		T_{VJ} = 25°C			1200	V
V_{GES}	*max. DC gate voltage*		T_{VJ} = 25°C			±20	V
I_{C25} I_{C80} I_{C100}	*collector current*		T_C = 25°C T_C = 80°C T_C = 100°C			72 56 48	A A A
P_{tot}	*total power dissipation*		T_C = 25°C			390	W
$V_{CE(sat)}$	*collector emitter saturation voltage*	I_C = 40 A; V_{GE} = 15 V	T_{VJ} = 25°C T_{VJ} = 175°C		2.05 2.70	2.40	V V
$V_{GE(th)}$	*gate emitter threshold voltage*	I_C = 1.5 mA; $V_{GE} = V_{CE}$	T_{VJ} = 25°C	5.3	5.8	6.3	V
I_{CES}	*collector emitter leakage current*	$V_{CE} = V_{CES}$; V_{GE} = 0 V	T_{VJ} = 25°C T_{VJ} = 175°C		 1.5	0.25	mA mA
I_{GES}	*gate emitter leakage current*	V_{GE} = ±20 V				600	nA
Q_{Gon}	*total gate charge*	V_{CE} = 600 V; V_{GE} = 0/15 V; I_C = 40 A			175		nC
$t_{d(on)}$ t_r $t_{d(off)}$ t_f E_{on} E_{off} $E_{rec(off)}$	*turn-on delay time* *current rise time* *turn-off delay time* *current fall time* *turn-on energy per pulse* *turn-off energy per pulse* *reverse recovery losses at turn- off*	inductive load V_{CE} = 600 V; I_C = 40 A V_{GE} = 0/15 V; R_G = 12 Ω	T_{VJ} = 150°C		26 26 350 110 3.0 2.4 1.1		ns ns ns ns mJ mJ mJ
RBSOA I_{CM}	*reverse bias safe operating area*	V_{GE} = 15 V; V_{CEmax} = 1200 V	T_{VJ} ≤ 175°C			 160	 A
SCSOA t_{SC} I_{SC}	*short circuit safe operation area* *short circuit duration* *short circuit current*	V_{CE} = 600 V; V_{GE} = ±15 V R_G = 12 Ω; none repetitive	T_{VJ} ≤ 175°C		 140	 10	 μs A
R_{thJC}	*thermal resistance junction to case*					0.38	K/W
R_{thJH}	*thermal resistance junction to heatsink*	with heat transfer paste (IXYS test setup)			0.6		K/W

Diode							
V_{RRM}	*max. repetitive reverse voltage*		T_C = 25°C			1200	V
I_{F25} I_{F80} I_{F100}	*forward current*		T_C = 25°C T_C = 80°C T_C = 100°C			67 50 43	A A A
V_F	*forward voltage*	I_F = 30 A	T_{VJ} = 25°C T_{VJ} = 125°C		 1.95	2.20	V V
Q_{rr} I_{RM} t_{rr} E_{rec}	*reverse recovery charge* *max. reverse recovery current* *reverse recovery time* *reverse recovery losses*	V_R = 600 V $-di_F/dt$ = -1800 A/μs I_F = 40 A; V_{GE} = 0 V	T_{VJ} = 150°C		3.8 55 250 1.1		μC A ns mJ
R_{thJC}	*thermal resistance junction to case*					0.7	K/W
R_{thJH}	*thermal resistance junction to heatsink*	with heat transfer paste (IXYS test setup)			1.1		K/W

IXYS reserves the right to change limits, test conditions and dimensions. Data according ot IEC 60747 and per semiconductor unless otherwise specified 20160307a

Package ISO247			Ratings			
Symbol	**Definitions**	**Conditions**	**min.**	**typ.**	**max.**	
I_{RMS}	*RMS current*	per terminal			50	A
T_{stg}	*storage temperature*		-40		150	°C
T_{op}	*operation temperature*		-40		150	°C
T_{VJ}	*virtual junction temperature*		-40		175	°C
Weight				6		g
M_D F_C	*mounting torque* *mounting force with clip*		0.8 40		1.2 120	Nm N
$d_{Spp/App}$ $d_{Spb/Apb}$	*creepage distance on surface / striking distance through air*	terminal to terminal terminal to backside	2.7 4.1			mm mm
V_{ISOL}	*isolation voltage*	t = 1 second t = 1 minute — 50/60 Hz; RMS; I_{ISOL} < 1 mA		3600 3000		V V

Product Marking

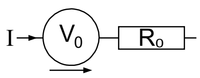


Part number

I = IGBT
T = IGBT Trench
F = Fast
48 = Current Rating [A]
IF = Copack
1200 = Reverse Voltage [V]
HR = ISO247 (3)

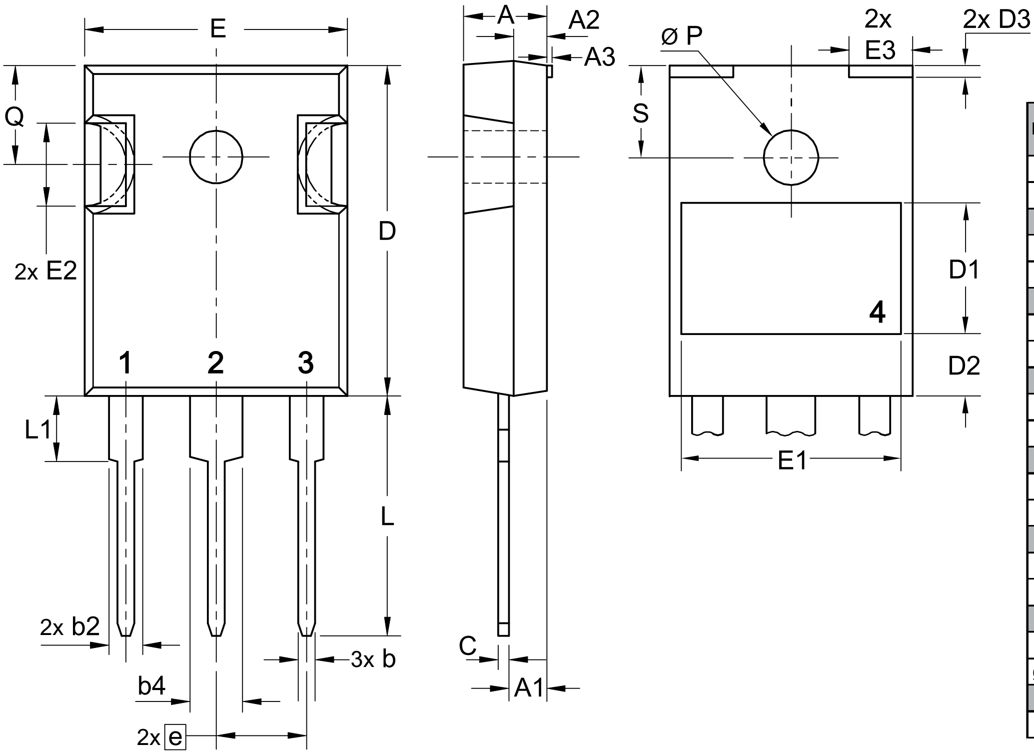
Ordering	Part Name	Marking on Product	Delivering Mode	Base Qty	Ordering Code
Standard	ITF48IF1200HR	ITF48IF1200HR	Tube	30	517181

Equivalent Circuits for Simulation **on die level* T_{VJ} = 175°C

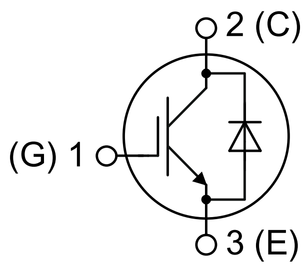


		IGBT	Diode	
$V_{0\ max}$	*threshold voltage*	0.88	1.2	V
$R_{0\ max}$	*slope resistance **	58	30	mΩ

Outlines ISO247



Dim.	Millimeter		Inches	
	min	max	min	max
A	4.70	5.30	0.185	0.209
A1	2.21	2.59	0.087	0.102
A2	1.50	2.49	0.059	0.098
A3	typ. 0.05		typ. 0.002	
b	0.99	1.40	0.039	0.055
b2	1.65	2.39	0.065	0.094
b4	2.59	3.43	0.102	0.135
c	0.38	0.89	0.015	0.035
D	20.79	21.45	0.819	0.844
D1	typ. 8.90		typ. 0.350	
D2	typ. 2.90		typ. 0.114	
D3	typ. 1.00		typ. 0.039	
E	15.49	16.24	0.610	0.639
E1	typ. 13.45		typ. 0.530	
E2	4.31	5.48	0.170	0.216
E3	typ. 4.00		typ. 0.157	
e	5.46 BSC		0.215 BSC	
L	19.80	20.30	0.780	0.799
L1	-	4.49	-	0.177
ø P	3.55	3.65	0.140	0.144
Q	5.38	6.19	0.212	0.244
S	6.14 BSC		0.242 BSC	



IGBT

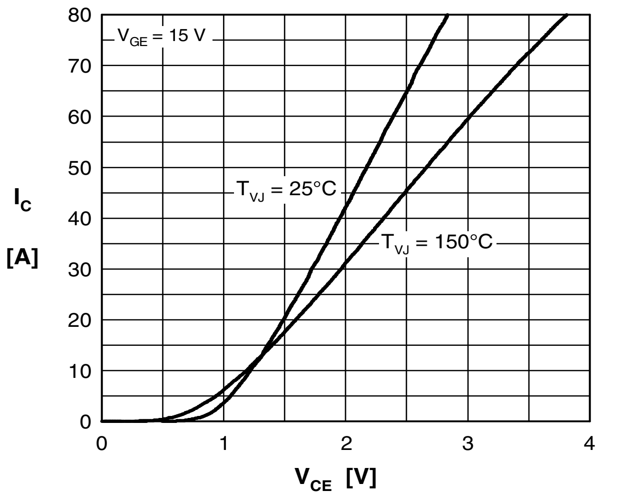


Fig. 1 Typ. output characteristics

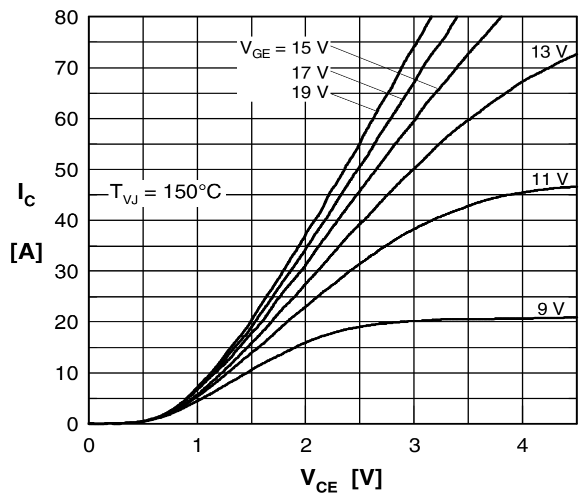


Fig. 2 Typ. output characteristics

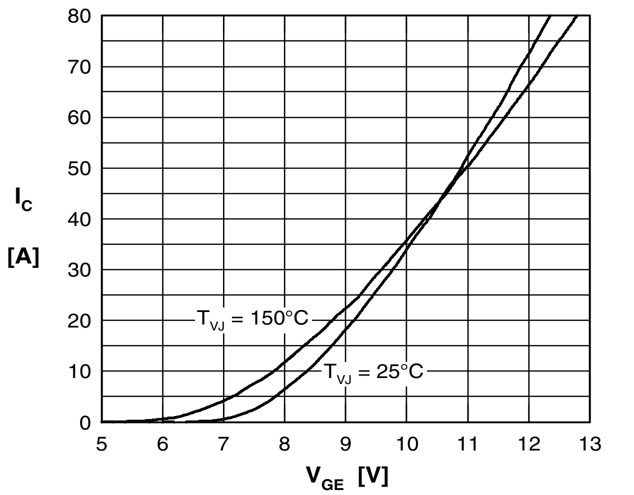


Fig. 3 Typ. transfer characteristics

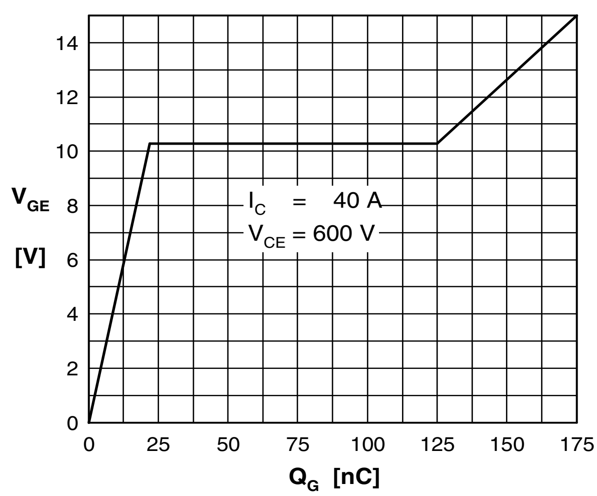


Fig. 4 Typ. turn-on gate charge

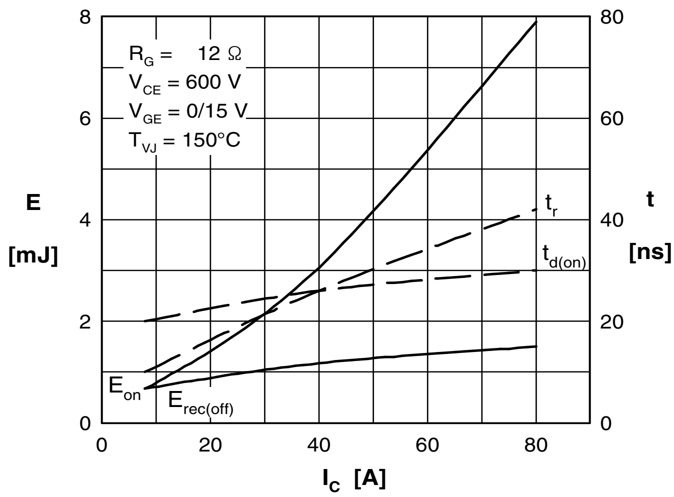


Fig. 5 Typ. turn-on energy & switching times versus collector current

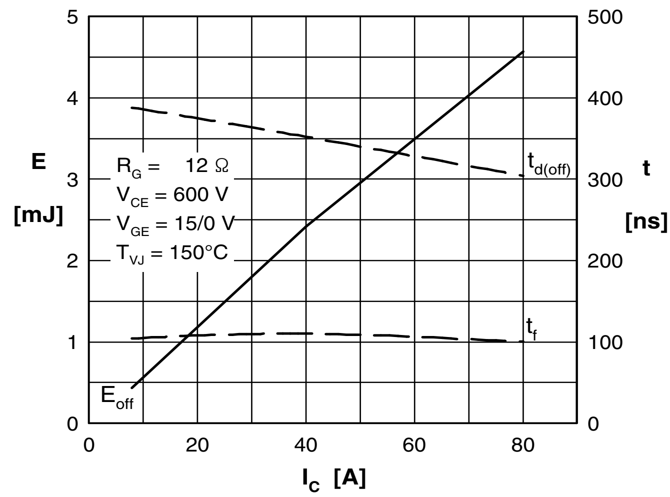


Fig. 6 Typ. turn-off energy & switching times versus collector current

IGBT

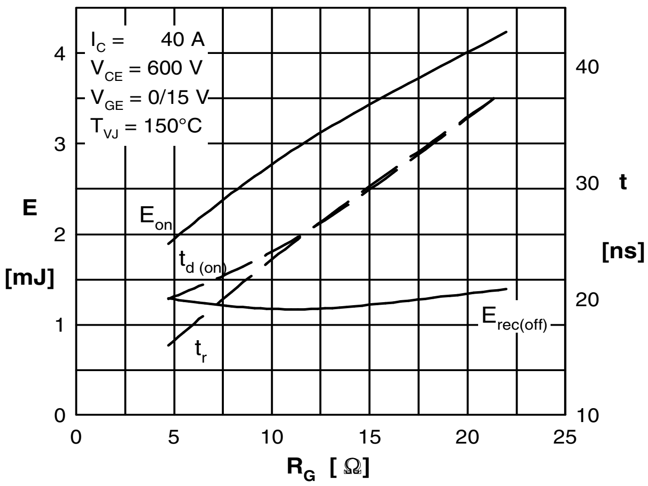


Fig. 7 Typ. turn-on energy and switching times versus gate resistor

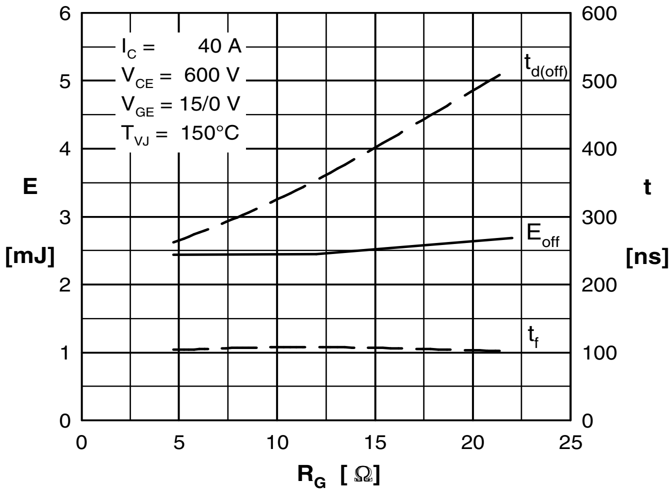


Fig. 8 Typ. turn-off energy and switching times versus gate resistor

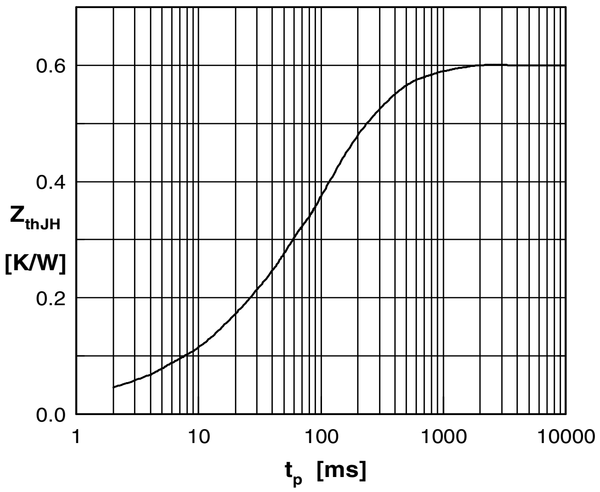


Fig. 9 Typ. transient thermal impedance

DIODE

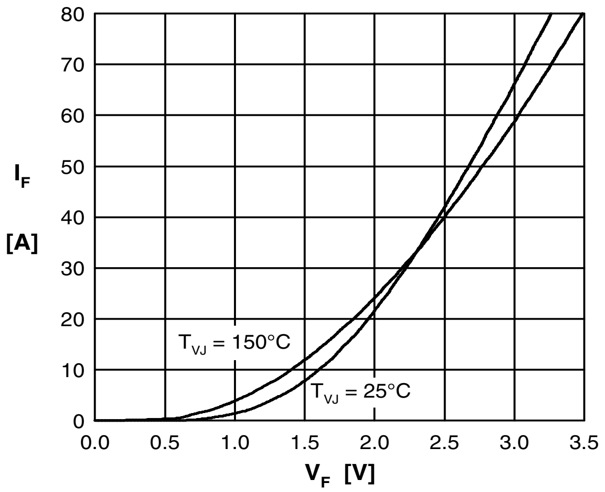


Fig. 10 Typ. forward characteristics

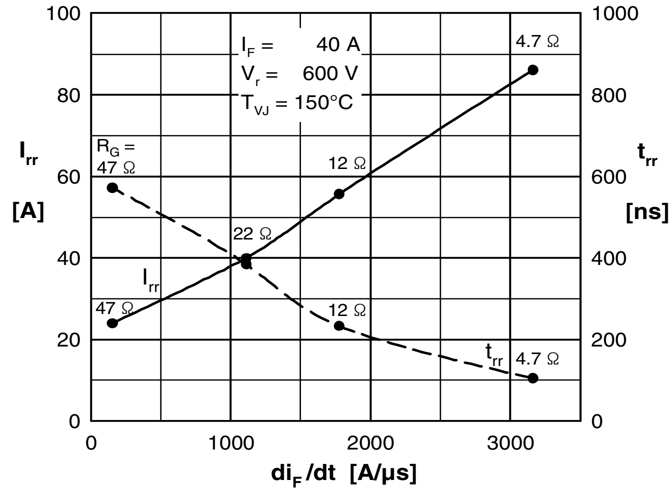


Fig. 11 Typ. reverse recovery characteristics

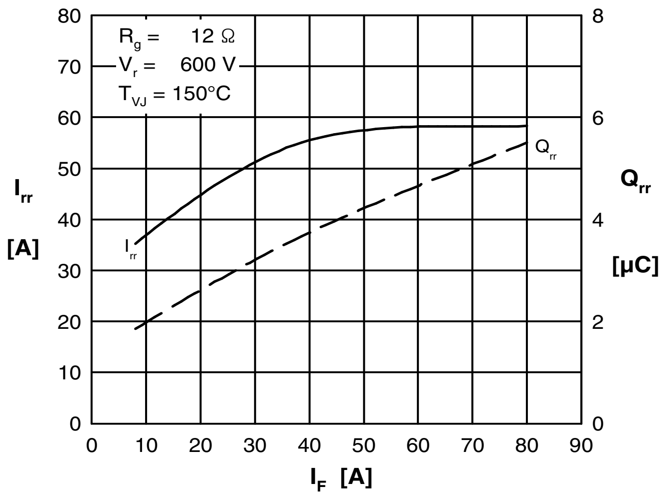


Fig. 12 Typ. reverse recovery characteristics

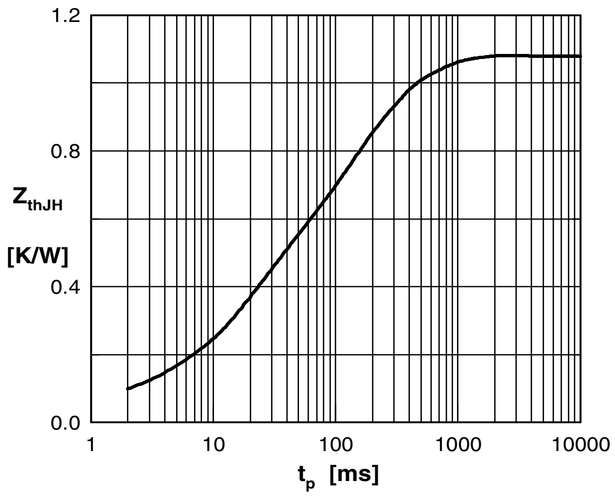


Fig. 13 Typ. transient thermal impedance

Forward-Biased, Reverse-Biased, and Short-Circuit Safe Operating Area of MOSFETs and IGBTs

Objectives

This document explains the operating conditions that a power semiconductor is supposed to work in without being damaged. Focus is set on the *Forward-Biased Safe Operating Area* (FBSOA), the *Reverse Biased, Safe Operating Area* (RBSOA) and the *Short-Circuit Safe Operating Area* (SCSOA).

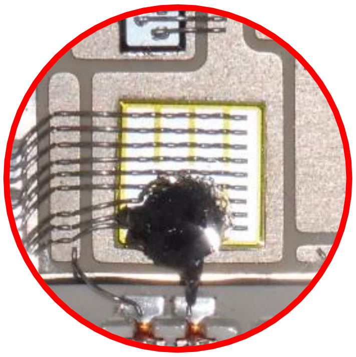


Figure 1. To be prevented – an IGBT destroyed by RBSOA-exceedance

Applications

The information compiled in this document is relevant for the power semiconductor itself and thus for all its applications.

Target Audience

This document is intended for all developers, design- and test-engineers involved in building power semiconductor applications.

Contact Information

For more information on the topic of safely operating power devices, contact the Littelfuse Power Semiconductor team of product and applications experts:

- PowerSemiSupport@Littelfuse.com

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Introduction

Power semiconductors like IGBTs, GTOs, thyristors, diodes, or bipolar junction transistors (BJT) have been developed into robust and reliable devices which can by now handle power levels into the MW-range and even beyond.

Despite these developments, they all have physical limitations which need to be known and respected to prevent damage to these components and the system they are mounted in. Depending on the instantaneous mode of operation, different conditions are described by a varying set of parameters, often referred to as operating area.

1. Safe Operating Area (SOA), also called Forward-Bias Safe Operating Area (FBSOA)

When a power semiconductor like an IGBT is used to conduct current in the predestined direction, the physical limits of the device to be considered include:

- the maximum collector current I_C,
- the saturation voltage V_{CEsat} across the device,
- the power generated by the product $I_C \cdot V_{CEsat}$, and
- the maximum junction temperature T_{VJ} allowed.

In cases where the power semiconductor is a MOSFET, dedicated to be operated in linear mode, the current can be influenced by tuning the gate-source-voltage accordingly. As a consequence, the drain-source-voltage V_{DS} of the devices changes which in turn impacts the losses. The device must dissipate these losses and the thermal impedance of the device poses the limits here.

For these operating conditions, the FBSOA-diagram features the forward voltage, the current and limits imposed by thermal development. Looking at Figure 2, it becomes obvious that growing losses can only be tolerated for shorter periods of time.

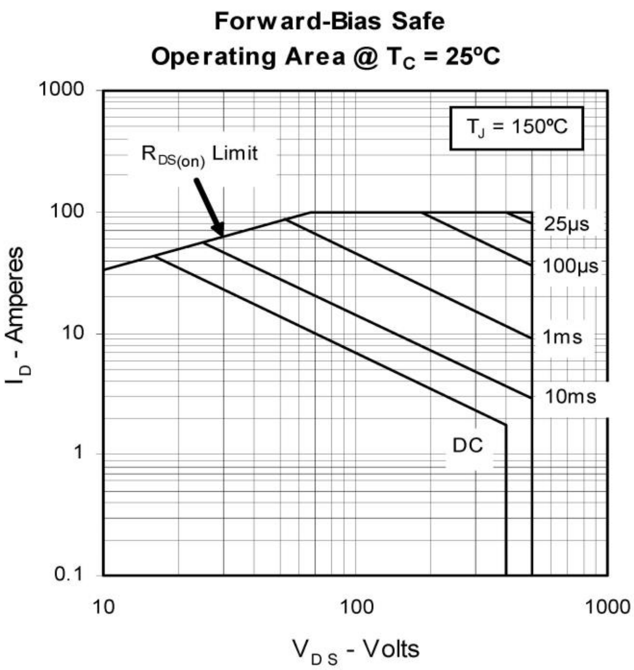

Figure 2. SOA Diagram for the IXTX46N50L

Any combination of forward voltage and current that is found below the correlating lines within the diagram is a legal point of operation as long as the junction temperature remains below the maximum limit and the duration of the loading is properly chosen. De-rating must be considered if the case temperature is different from the 25°C the diagram in Figure 2 refers to.

2. Reverse Biased Safe Operating Area (RBSOA)

Power semiconductors like IGBTs or MOSFETs can turn off a current rather quickly but not at infinite speed. As the switching procedure does take some time, transient phenomena happen that need to be considered.

During this short period, when the device turns from conducting into blocking mode, the Reverse Biased Safe Operating Area needs to be respected at any time.

The limits are given by the current which is turned off and the voltage that appears across the device. The plot in Figure 3 schematically displays a turn-off event in detail.

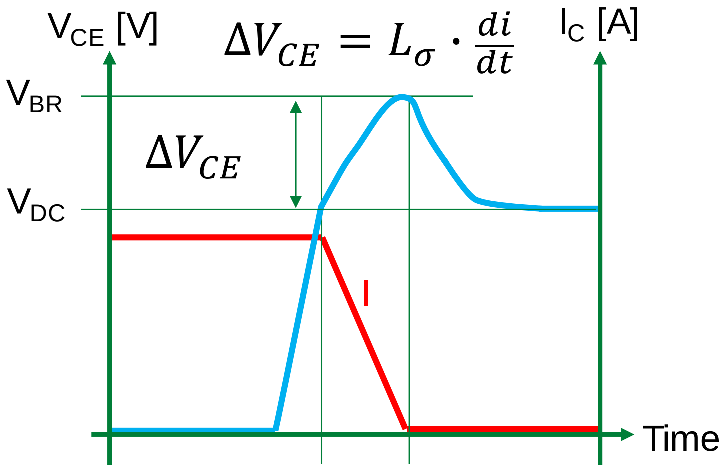

Figure 3. Voltage and current waveforms during a turn-off event

In the graph, it can clearly be seen that the voltage across the device first reaches the DC-link's voltage level before the current starts declining. Because of the current change rate di/dt and the inherently contained stray inductances L_σ, the voltage spike ΔV_{CE} is added on top of the DC-link voltage. If this spike exceeds the device's breakdown voltage V_{BR} – even for a very short period of time – the device will be destroyed.

The square-shaped Reverse Biased Safe Operating Area therefore is given by maximum current $I_{C,max}$ and the breakdown voltage V_{BR}, as depicted in Figure 4. Here too, the junction temperature poses a further limit.

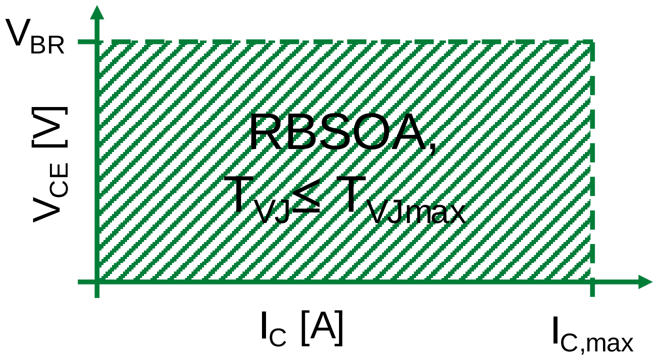

Figure 4. RBSOA-shape, limited by maximum current and breakdown voltage

3. Short-Circuit Safe Operating Area (SCSOA)

Devices that feature desaturation, like most IGBTs, can withstand short-circuit events for a distinct duration. Corresponding datasheets highlight this information as Short Circuit Safe Operating Area or SCSOA. Such a datasheet's excerpt is given in Figure 5.

SCSOA	*short circuit safe operating area*	V_{CEK} = 1200 V					
t_{SC}	*short circuit duration*	V_{CE} = 720 V; V_{GE} = ±15	T_{VJ} = 125°C			10	µs
I_{SC}	*short circuit current*	R_G = 6.8 Ω; non-repetitive			450		A

Figure 5. SCSOA information taken from the MDMA280UB1600PTED datasheet

The short circuit condition demands that the IGBT goes into desaturation. In this mode, no further charge carriers remain available which also limits the current. Typically, IGBTs limit the short-circuit current to about three to four times their rated current. In the example in Figure 5, the 160 A-device is expected to limit the short circuit current to 450 A. This situation is tolerable for 10 µs only and limited by thermal development.

4. Resulting challenges for the designer

Combining the two areas for Reverse Biased Safe Operation and Short Circuit Safe Operation into a single diagram reveals a gap between them, as pictured in Figure 6.

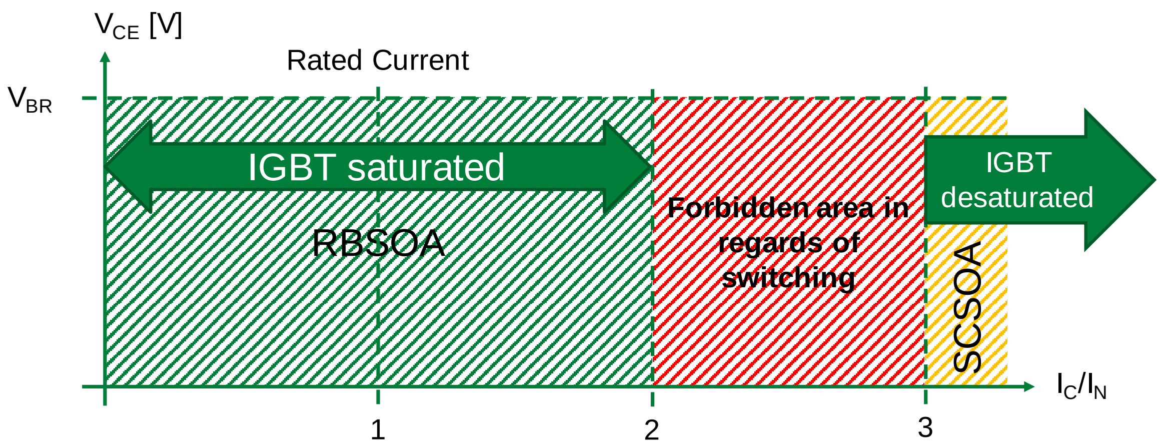

Figure 6. RBSOA, SCSOA, and the undefined region in between

Within the gap marked as forbidden area, located between twice and three times rated current, turning off the device is not allowed as it may lead to its destruction. The root cause of the destruction is found in very high local current densities, transiently forming during switching. The thermal limits in that case are reached already and additional burden due to switching losses leads to exceeding the limits. In turn, single cells on the chip fail and create a connection between collector and emitter. The current can no longer be turned off and the damage grows.

To overcome this situation, techniques to ensure that the IGBT reaches desaturation mode and enters the SCSOA can be used. The simplest way is to wait, instead of reacting on an overcurrent too quickly. Implementing a certain dead-time and fully exploit the 10 µs that the IGBT can withstand the conditions is a valid approach.

Further methods include the so-called 2-Level turn-off. The device is not turned off by immediately cancelling or even reversing the gate-emitter voltage. Instead, the gate-emitter voltage is first reduced to minimize the number of charge carriers available for current transport. This speeds up reaching the desaturation stage. A few microseconds later, when desaturation is reached, the gate-emitter voltage is set to zero or reversed. The device is then safely turned off within the SCSOA-specification.

This fact becomes particularly important when handling overcurrent situations.

From a given setup, measurements from a destructive turn-off event seen in Figure 7 were analyzed:

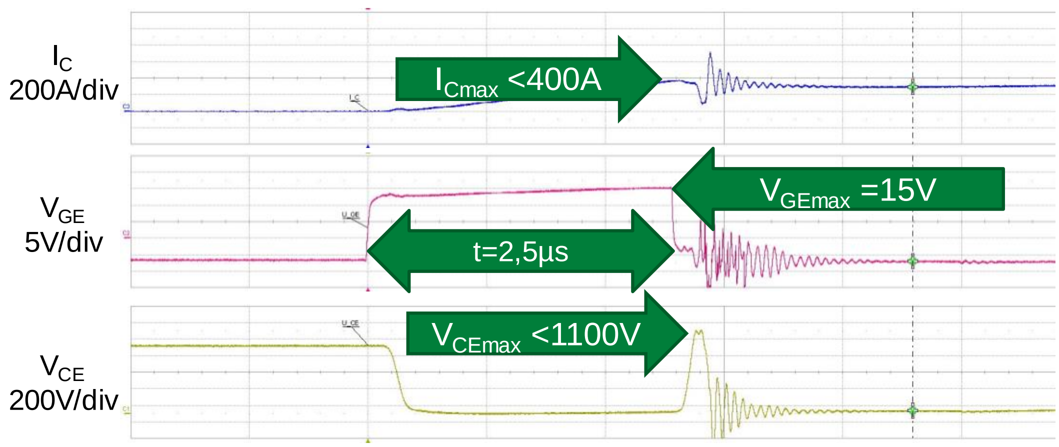

Figure 7. Measurement results from a destructive turn-off event

As the measurement reveals, the current turned off was well below the 450 A short-circuit limit. The gate-emitter-voltage was well-controlled, the time it took to turn off was below the 10 µs-limit and the overvoltage spike did not exceed the 1200 V the device is rated for. Still, the IGBT was destroyed, and the question raised, why so?

Entering the point of the turn-off into the diagram in Figure 6, the violation that happens becomes obvious in Figure 8:

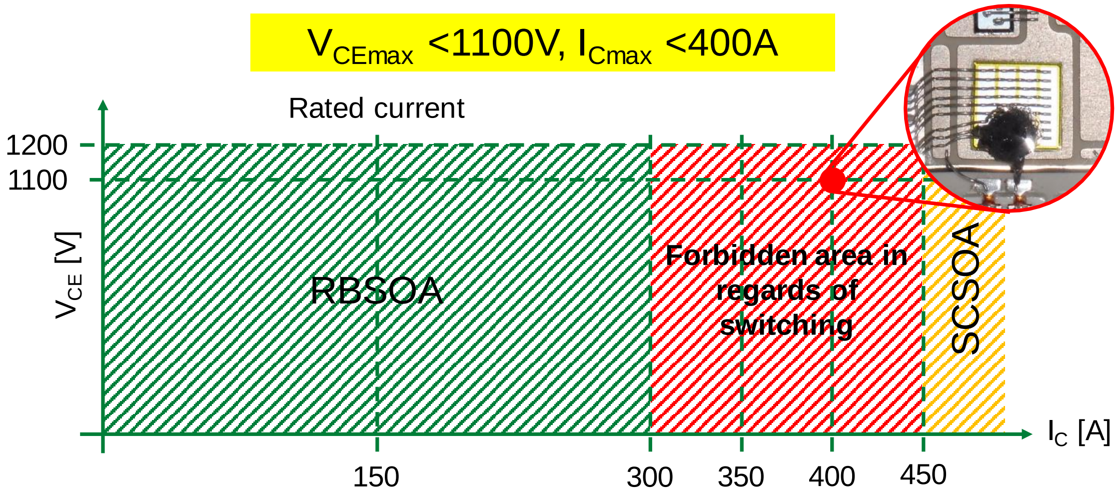

Figure 8. Locating the point of turn-off

Clearly, the switching event was done within the no-go-area with the destructive effect previously predicted.

To clear the situation, the control strategy for short circuit was changed. Instead of reacting on the overcurrent signal instantly and turn off after just 2.5 µs, a blanking time of about 6 µs was added.

Figure 9 represents the measurement done in the same setup.

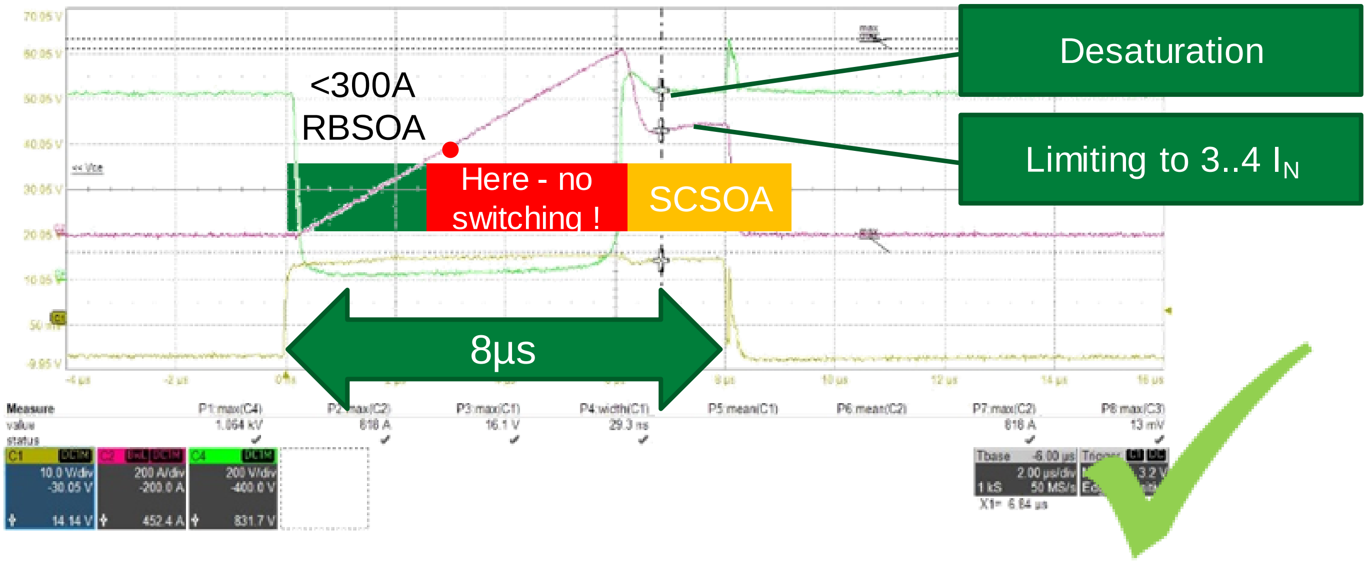

Figure 9. Properly turned off overcurrent or short-circuit event

While the red dot marks the former turn-off point, the current is now allowed to grow further. At first sight, this seems to worsen the situation as the losses and, as such, the chip temperature grows. However, after about 6 µs the IGBT reaches desaturation, enters the SCSOA and the turn-off after 8 µs is safely done without damaging the component.

MOSFETs, other than IGBTs, don't feature a dedicated SCSOA. At high currents, the MOSFET goes into linear operation as depicted in the FBSOA-diagram, so short-circuit and overcurrent events are covered by diagrams as given in Figure 2.

5. Conclusion

Handling overcurrent events, especially short circuit events, is challenging but manageable. Doing so while remaining within the given specifications can successfully be achieved.

Simply turning off a detected overcurrent as fast as possible may not be the best strategy as it may lead to damage caused by so-called RBSOA-exceedance. Ensuring that the IGBT reaches desaturation is a key factor in handling short circuit events with this technology.

For additional information please visit www.Littelfuse.com/powersemi