

Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0V, I_C = 500\mu A$	
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.31	—	$V/^\circ\text{C}$	$V_{GE} = 0V, I_C = 1mA (25^\circ\text{C}-125^\circ\text{C})$	
R_G	Internal Gate Resistance	—	1.7	—	Ω	1MHz, Open Collector	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.00	2.35	V	$I_C = 33A, V_{GE} = 15V$	4, 5, 6, 8, 9
		—	2.45	2.85		$I_C = 50A, V_{GE} = 15V$	
		—	2.60	2.95		$I_C = 33A, V_{GE} = 15V, T_J = 125^\circ\text{C}$	
		—	3.20	3.60		$I_C = 50A, V_{GE} = 15V, T_J = 125^\circ\text{C}$	
$V_{GE(th)}$	Gate Threshold Voltage	3.0	4.0	5.0	V	$I_C = 250\mu A$	7, 8, 9
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-10	—	$mV/^\circ\text{C}$	$V_{CE} = V_{GE}, I_C = 1.0mA$	
g_{fe}	Forward Transconductance	—	41	—	S	$V_{CE} = 50V, I_C = 33A, PW = 80\mu s$	
I_{CES}	Collector-to-Emitter Leakage Current	—	5.0	500	μA	$V_{GE} = 0V, V_{CE} = 600V$	
		—	1.0	—	mA	$V_{GE} = 0V, V_{CE} = 600V, T_J = 125^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	1.30	1.70	V	$I_F = 15A, V_{GE} = 0V$	10
		—	1.20	1.60		$I_F = 15A, V_{GE} = 0V, T_J = 125^\circ\text{C}$	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	± 100	nA	$V_{GE} = \pm 20V, V_{CE} = 0V$	

Switching Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig
Q_g	Total Gate Charge (turn-on)	—	205	308	nC	$I_C = 33A$	17
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	70	105		$V_{CC} = 400V$	CT1
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	30	45		$V_{GE} = 15V$	
E_{on}	Turn-On Switching Loss	—	255	305	μJ	$I_C = 33A, V_{CC} = 390V$	CT3
E_{off}	Turn-Off Switching Loss	—	375	445		$V_{GE} = +15V, R_G = 3.3\Omega, L = 200\mu H$	
E_{total}	Total Switching Loss	—	630	750		$T_J = 25^\circ\text{C} \text{ ④}$	
$t_{d(on)}$	Turn-On delay time	—	30	40	ns	$I_C = 33A, V_{CC} = 390V$	CT3
t_r	Rise time	—	10	15		$V_{GE} = +15V, R_G = 3.3\Omega, L = 200\mu H$	
$t_{d(off)}$	Turn-Off delay time	—	130	150		$T_J = 25^\circ\text{C} \text{ ④}$	
t_f	Fall time	—	11	15	μJ	$I_C = 33A, V_{CC} = 390V$	CT3
E_{on}	Turn-On Switching Loss	—	580	700		$V_{GE} = +15V, R_G = 3.3\Omega, L = 200\mu H$	11, 13
E_{off}	Turn-Off Switching Loss	—	480	550		$T_J = 125^\circ\text{C} \text{ ④}$	WF1, WF2
E_{total}	Total Switching Loss	—	1060	1250	ns	$I_C = 33A, V_{CC} = 390V$	CT3
$t_{d(on)}$	Turn-On delay time	—	26	35		$V_{GE} = +15V, R_G = 3.3\Omega, L = 200\mu H$	12, 14
t_r	Rise time	—	13	20		$T_J = 125^\circ\text{C} \text{ ④}$	WF1, WF2
$t_{d(off)}$	Turn-Off delay time	—	146	165	pF	$I_C = 33A, V_{CC} = 390V$	CT3
t_f	Fall time	—	15	20		$V_{GE} = +15V, R_G = 3.3\Omega, L = 200\mu H$	12, 14
$t_{d(off)}$	Turn-Off delay time	—	146	165		$T_J = 125^\circ\text{C} \text{ ④}$	WF1, WF2
C_{ies}	Input Capacitance	—	3648	—	pF	$V_{GE} = 0V$	16
C_{oes}	Output Capacitance	—	322	—		$V_{CC} = 30V$	
C_{res}	Reverse Transfer Capacitance	—	56	—		$f = 1Mhz$	
$C_{oes \text{ eff.}}$	Effective Output Capacitance (Time Related) ⑤	—	215	—	pF	$V_{GE} = 0V, V_{CE} = 0V \text{ to } 480V$	15
$C_{oes \text{ eff. (ER)}}$	Effective Output Capacitance (Energy Related) ⑤	—	163	—			
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 150^\circ\text{C}, I_C = 150A$ $V_{CC} = 480V, V_p = 600V$ $R_g = 22\Omega, V_{GE} = +15V \text{ to } 0V$	3 CT2
t_{rr}	Diode Reverse Recovery Time	—	42	60	ns	$T_J = 25^\circ\text{C} \quad I_F = 15A, V_R = 200V,$	19
		—	74	120		$T_J = 125^\circ\text{C} \quad di/dt = 200A/\mu s$	
Q_{rr}	Diode Reverse Recovery Charge	—	80	180	nC	$T_J = 25^\circ\text{C} \quad I_F = 15A, V_R = 200V,$	21
		—	220	600		$T_J = 125^\circ\text{C} \quad di/dt = 200A/\mu s$	
I_{rr}	Peak Reverse Recovery Current	—	4.0	6.0	A	$T_J = 25^\circ\text{C} \quad I_F = 15A, V_R = 200V,$	19, 20, 21, 22
		—	6.5	10		$T_J = 125^\circ\text{C} \quad di/dt = 200A/\mu s$	

Notes:

① $R_{CE(on)}$ typ. = equivalent on-resistance = $V_{CE(on)}$ typ. / I_C , where $V_{CE(on)}$ typ. = 2.00V and $I_C = 33A$. I_D (FET Equivalent) is the equivalent MOSFET I_D rating @ 25°C for applications up to 150kHz. These are provided for comparison purposes (only) with equivalent MOSFET solutions.

② $V_{CC} = 80\% (V_{CES})$, $V_{GE} = 20V$, $L = 28 \mu H$, $R_G = 22 \Omega$.

③ Pulse width limited by max. junction temperature.

④ Energy losses include "tail" and diode reverse recovery, Data generated with use of Diode 30ETH06.

⑤ $C_{oes \text{ eff.}}$ is a fixed capacitance that gives the same charging time as C_{oes} while V_{CE} is rising from 0 to 80% V_{CES} .

$C_{oes \text{ eff. (ER)}}$ is a fixed capacitance that stores the same energy as C_{oes} while V_{CE} is rising from 0 to 80% V_{CES} .

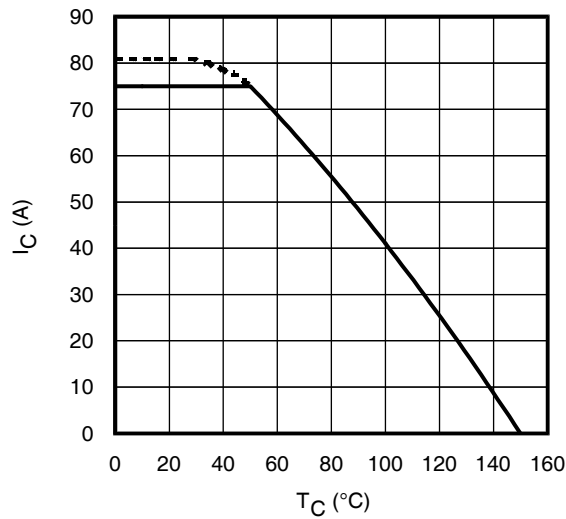


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

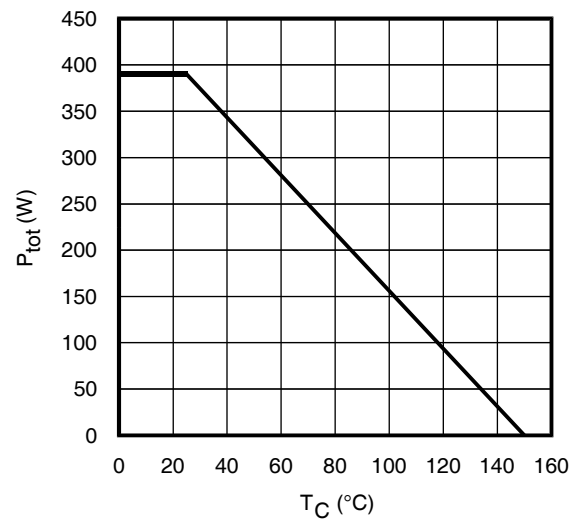


Fig. 2 - Power Dissipation vs. Case Temperature

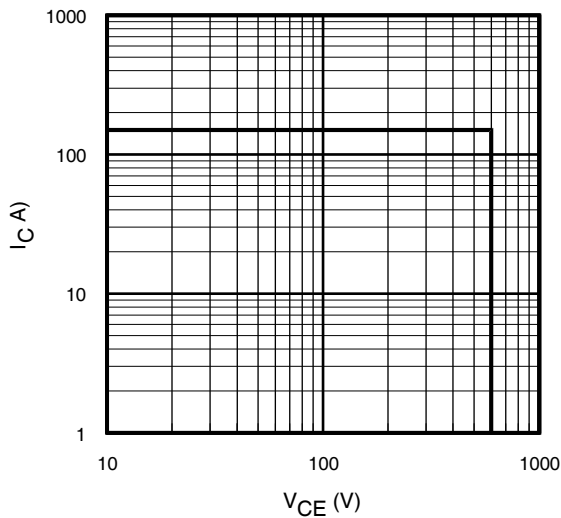


Fig. 3 - Reverse Bias SOA
 $T_J = 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

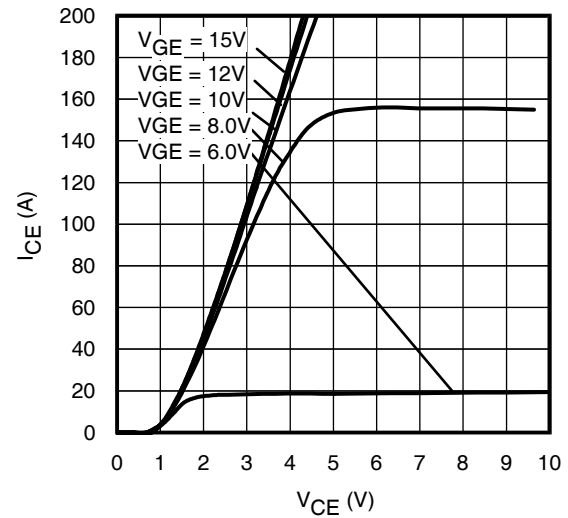


Fig. 4 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

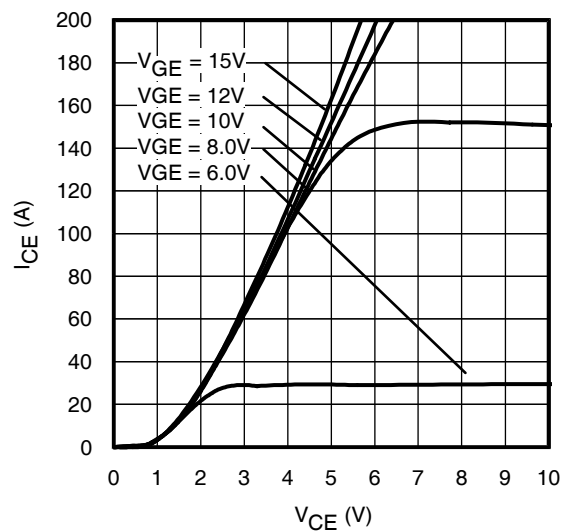


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

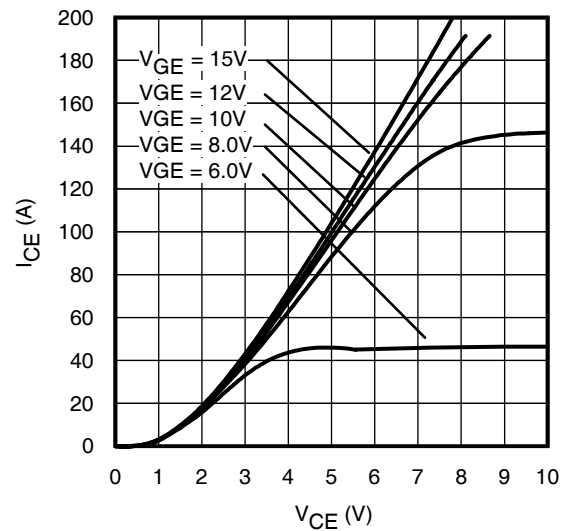


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 125^\circ\text{C}$; $t_p = 80\mu\text{s}$

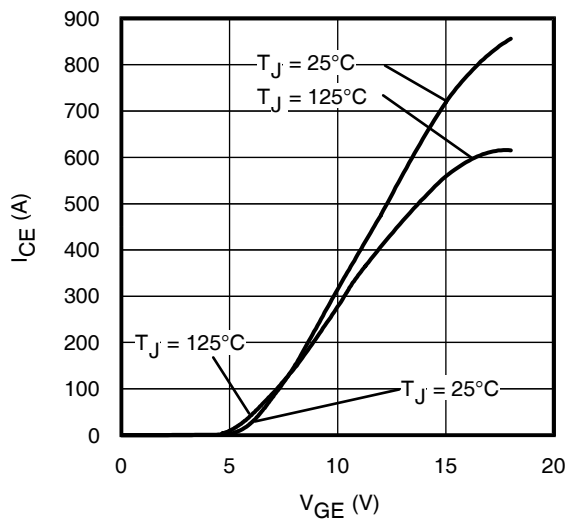


Fig. 7 - Typ. Transfer Characteristics
 $V_{CE} = 50V$; $t_p = 10\mu s$

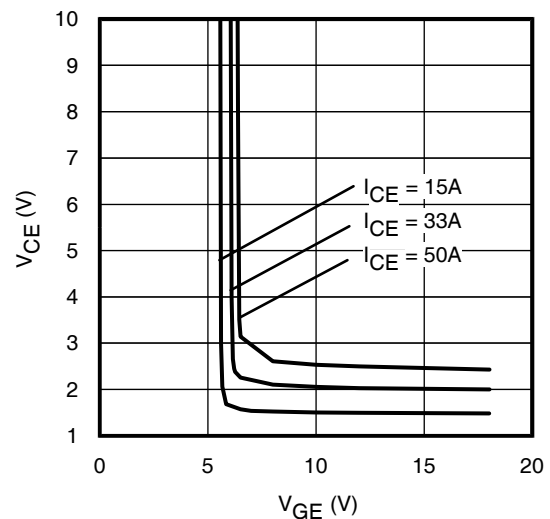


Fig. 8 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ C$

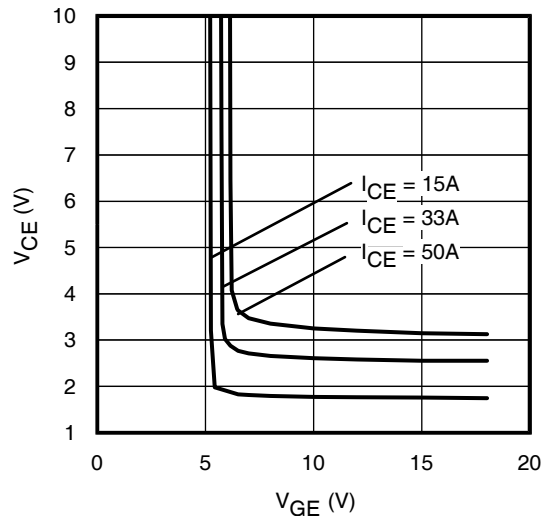


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = 125^\circ C$

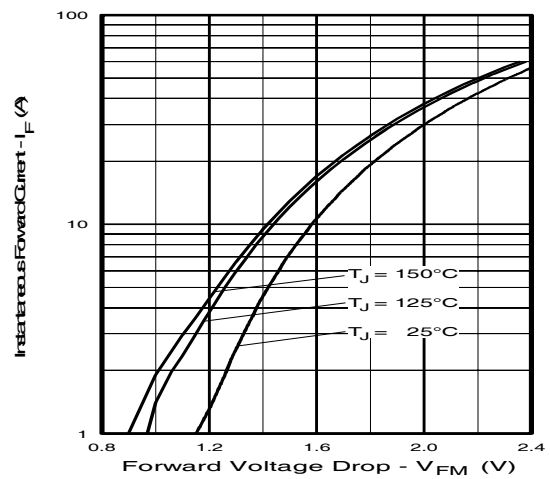


Fig. 10 - Maximum. Diode Forward Characteristics
 $t_p = 80\mu s$

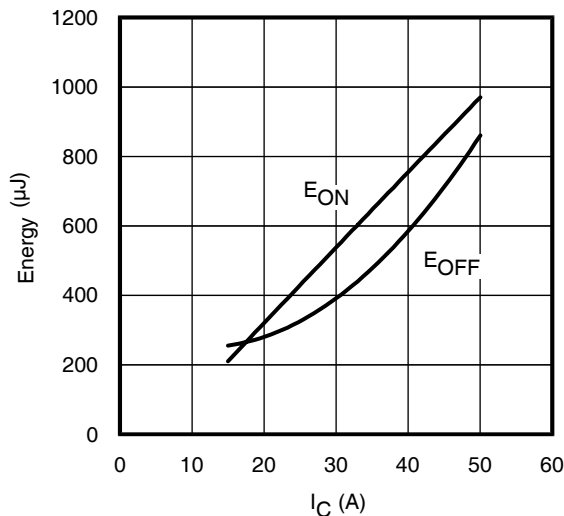


Fig. 11 - Typ. Energy Loss vs. I_C
 $T_J = 125^\circ C$; $L = 200\mu H$; $V_{CE} = 390V$; $R_G = 3.3\Omega$; $V_{GE} = 15V$.
Diode clamp used: 30ETH06 (See C.T.3)

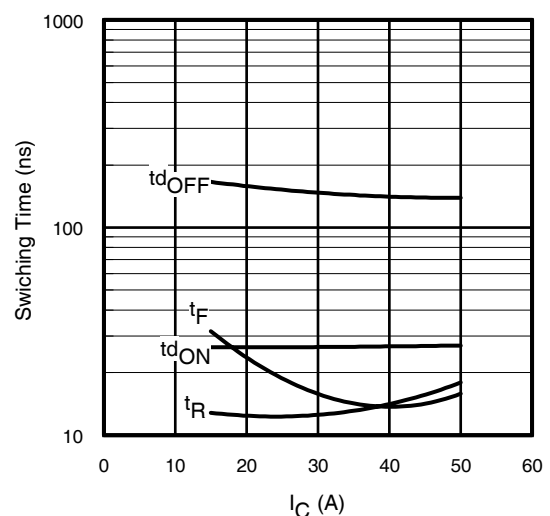


Fig. 12 - Typ. Switching Time vs. I_C
 $T_J = 125^\circ C$; $L = 200\mu H$; $V_{CE} = 390V$; $R_G = 3.3\Omega$; $V_{GE} = 15V$.
Diode clamp used: 30ETH06 (See C.T.3)

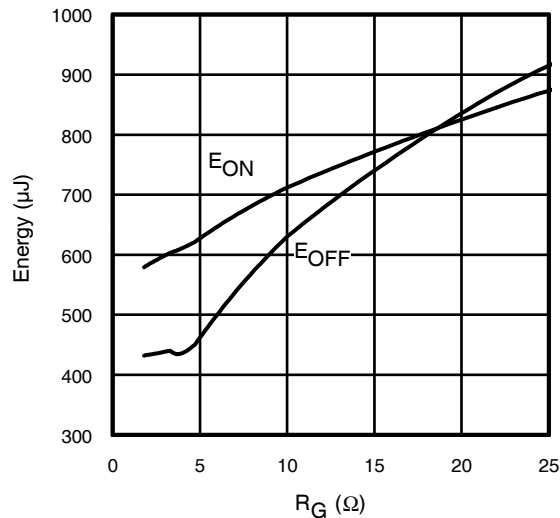


Fig. 13 - Typ. Energy Loss vs. R_G
 $T_J = 125^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 390\text{V}$; $I_{CE} = 33\text{A}$; $V_{GE} = 15\text{V}$
 Diode clamp used: 30ETH06 (See C.T.3)

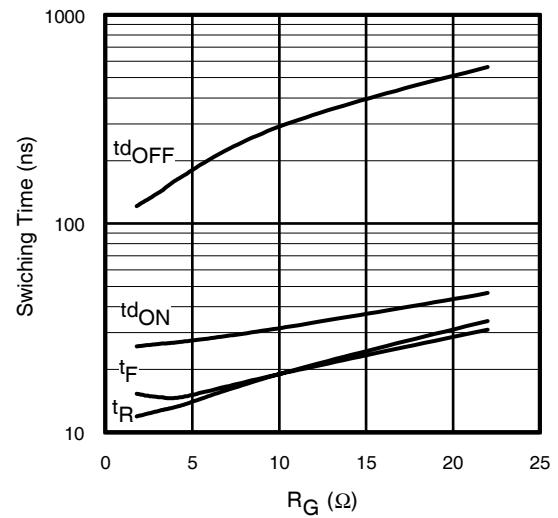
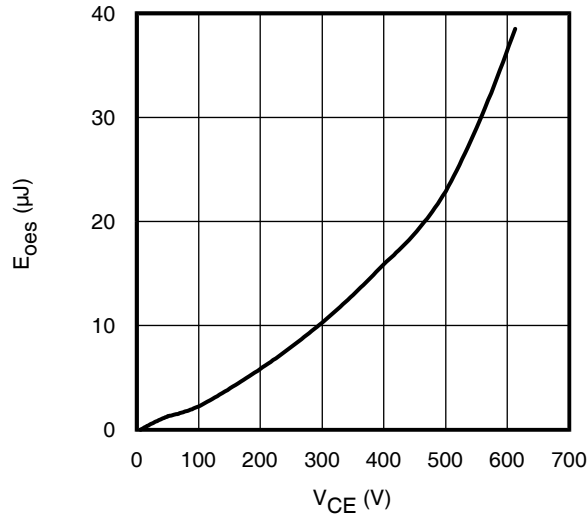


Fig. 14 - Typ. Switching Time vs. R_G
 $T_J = 125^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 390\text{V}$; $I_{CE} = 33\text{A}$; $V_{GE} = 15\text{V}$
 Diode clamp used: 30ETH06 (See C.T.3)



**Fig. 15 - Typ. Output Capacitance
Stored Energy vs. V_{CE}**

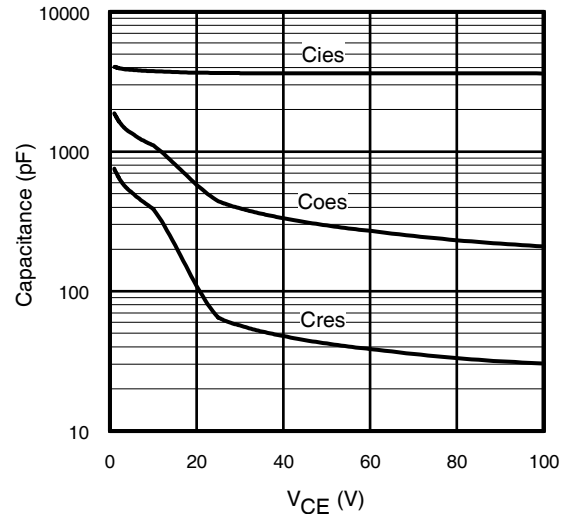


Fig. 16 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

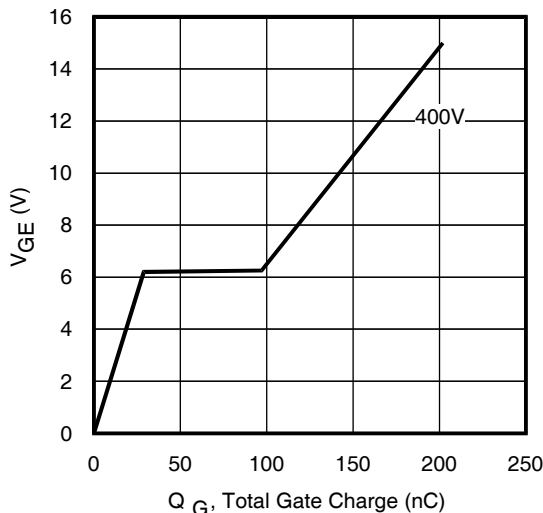
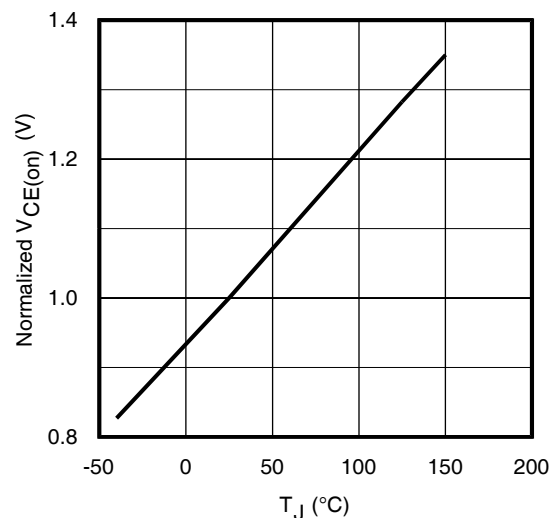


Fig. 17 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 33\text{A}$



**Fig. 18 - Normalized Typ. $V_{CE(on)}$
vs. Junction Temperature**
 $I_C = 33\text{A}$, $V_{GE} = 15\text{V}$

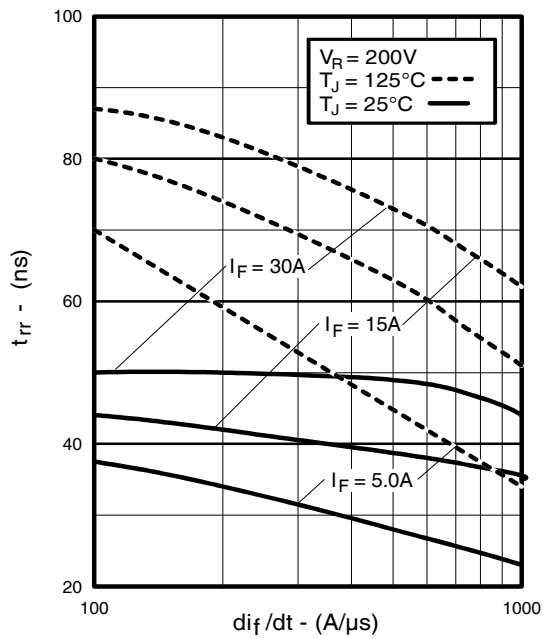


Fig. 19 - Typical Reverse Recovery vs. di_f/dt

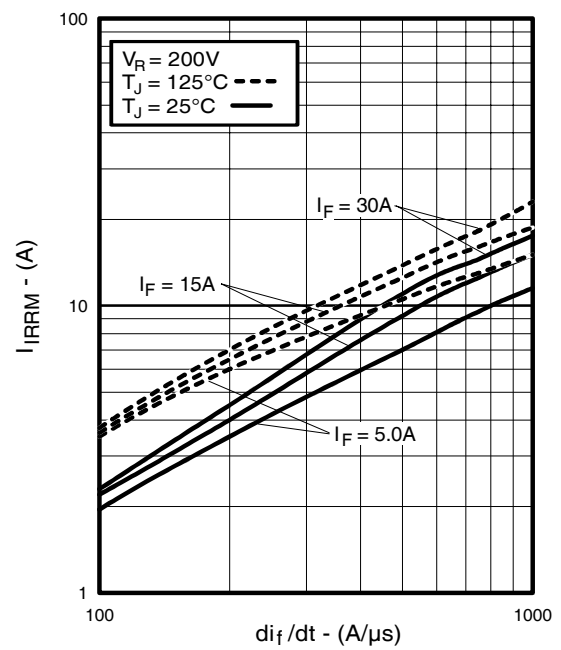


Fig. 20 - Typical Recovery Current vs. di_f/dt

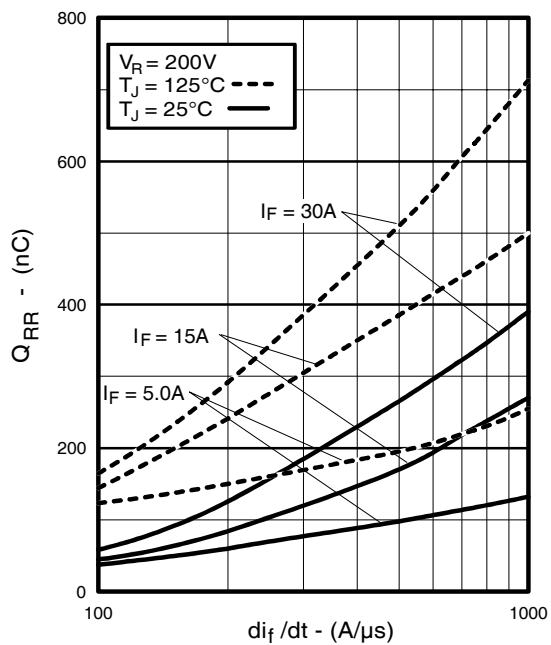


Fig. 21 - Typical Stored Charge vs. di_f/dt

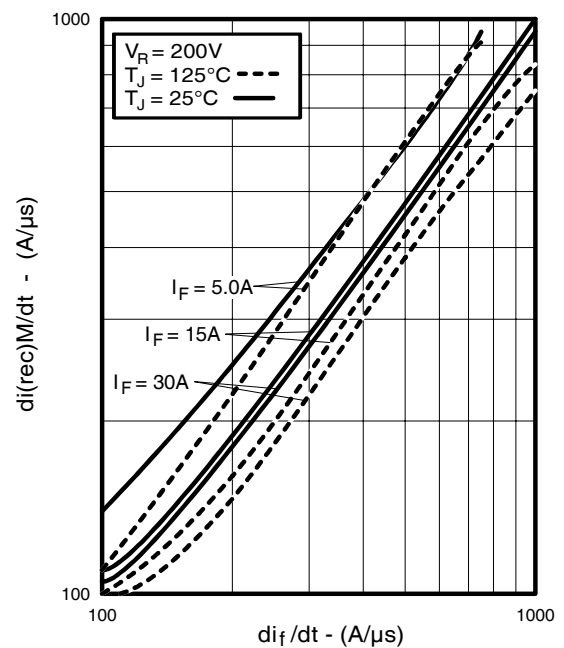


Fig. 22 - Typical $di_{(rec)M}/dt$ vs. di_f/dt

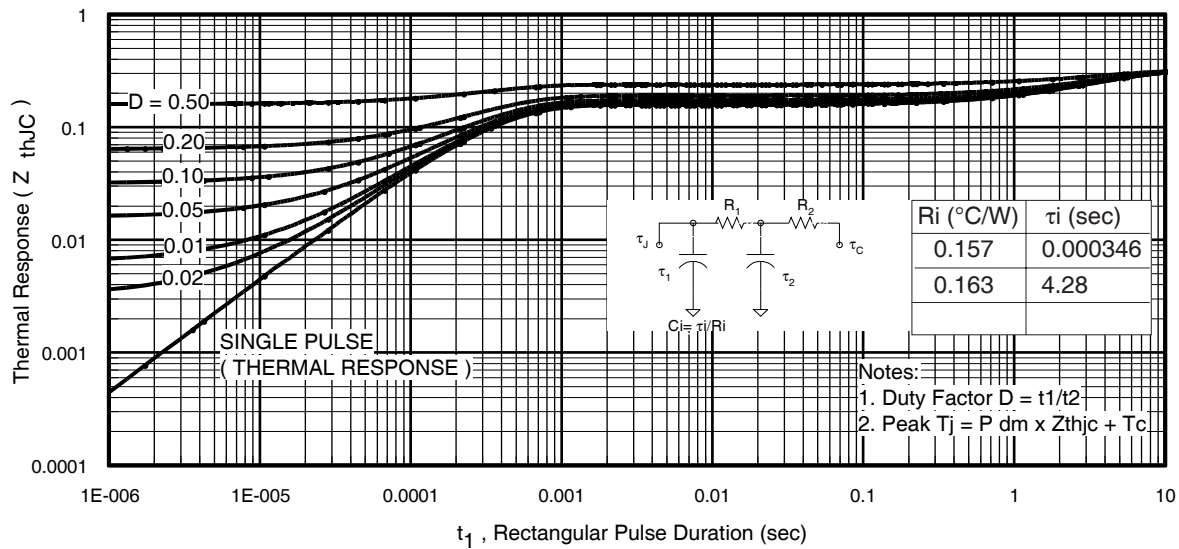


Fig 23. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

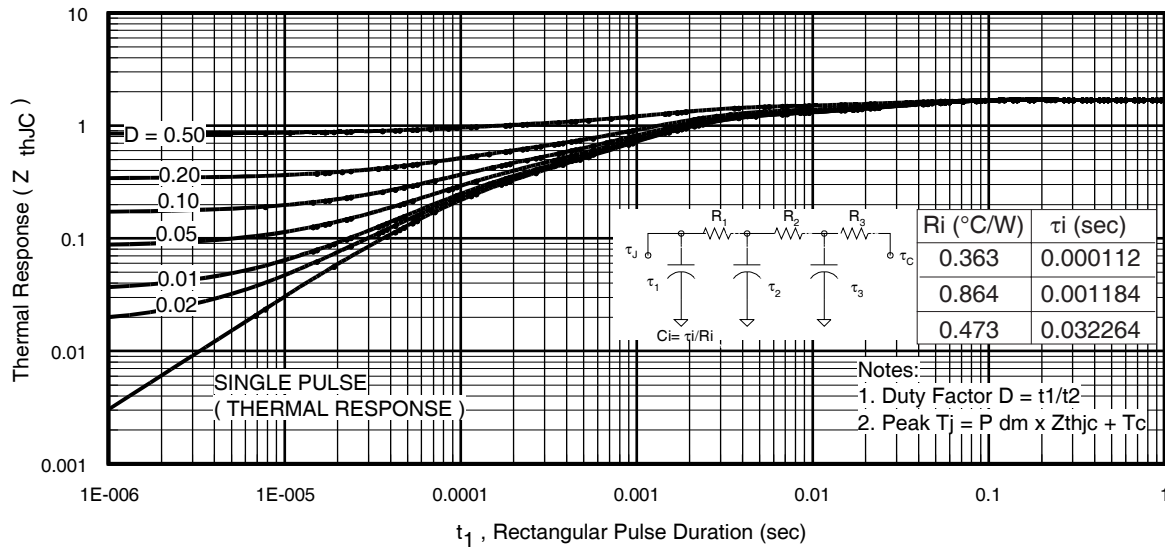


Fig. 24. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

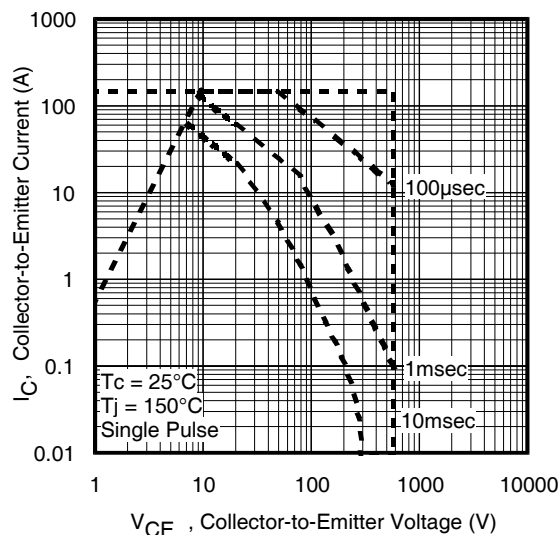


Fig. 25 - Forward SOA, $T_c = 25^\circ\text{C}$; $T_j \leq 150^\circ\text{C}$

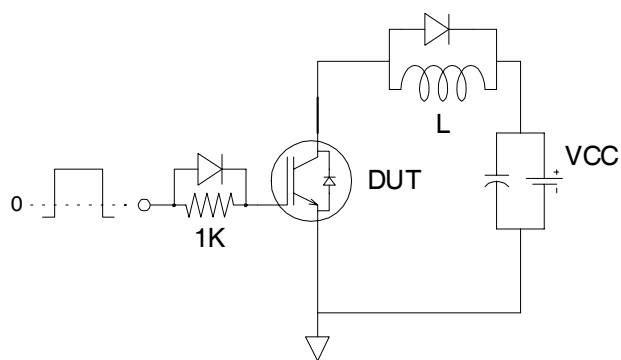


Fig.C.T.1 - Gate Charge Circuit (turn-off)

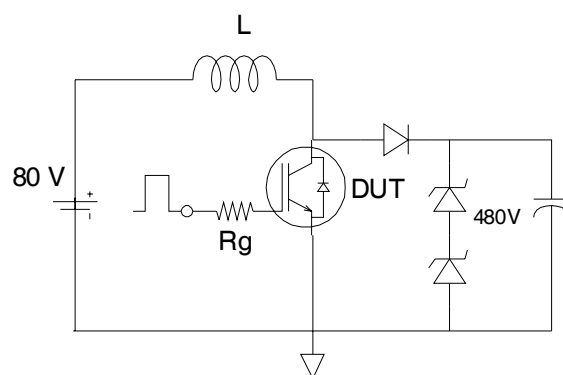


Fig.C.T.2 - RBSOA Circuit

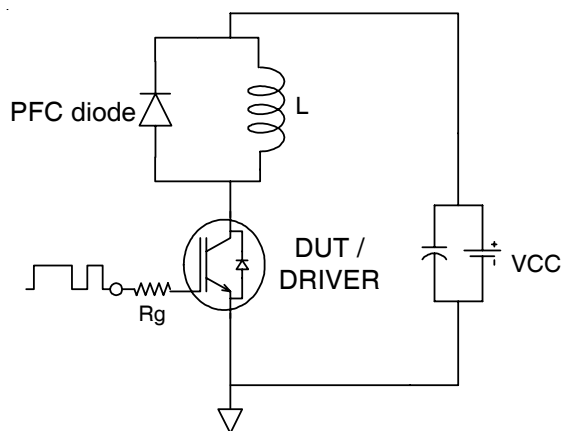


Fig.C.T.3 - Switching Loss Circuit

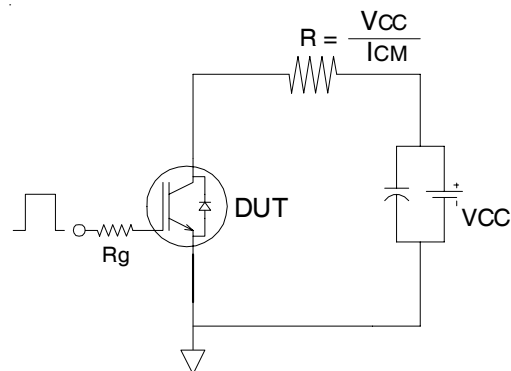


Fig.C.T.4 - Resistive Load Circuit

REVERSE RECOVERY CIRCUIT

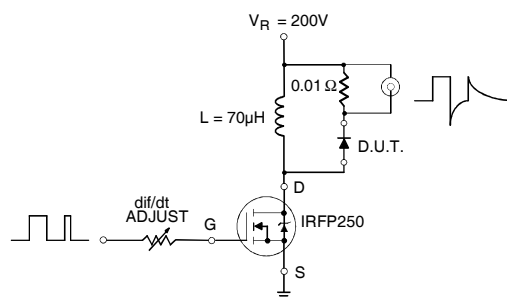


Fig. C.T.5 - Reverse Recovery Parameter Test Circuit

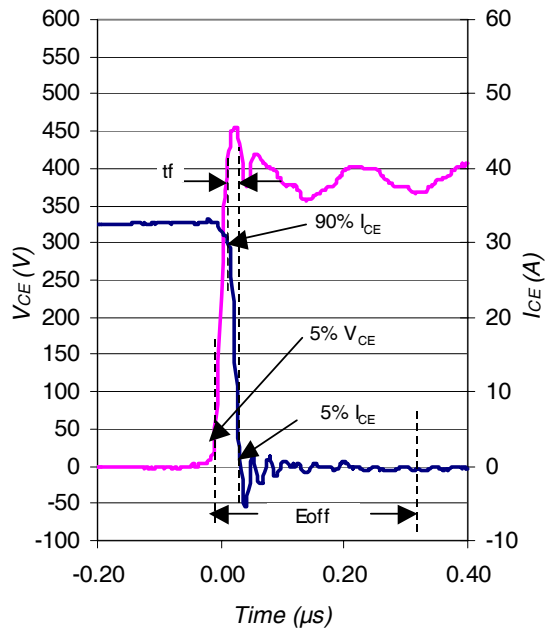


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 25^\circ\text{C}$ using Fig. CT.3

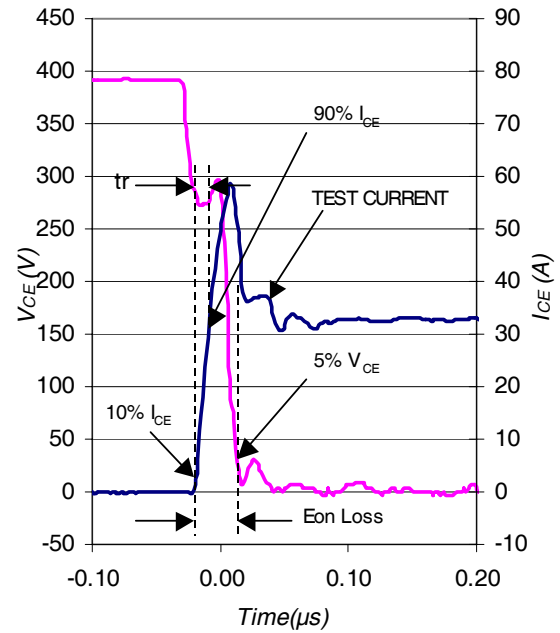


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 25^\circ\text{C}$ using Fig. CT.3

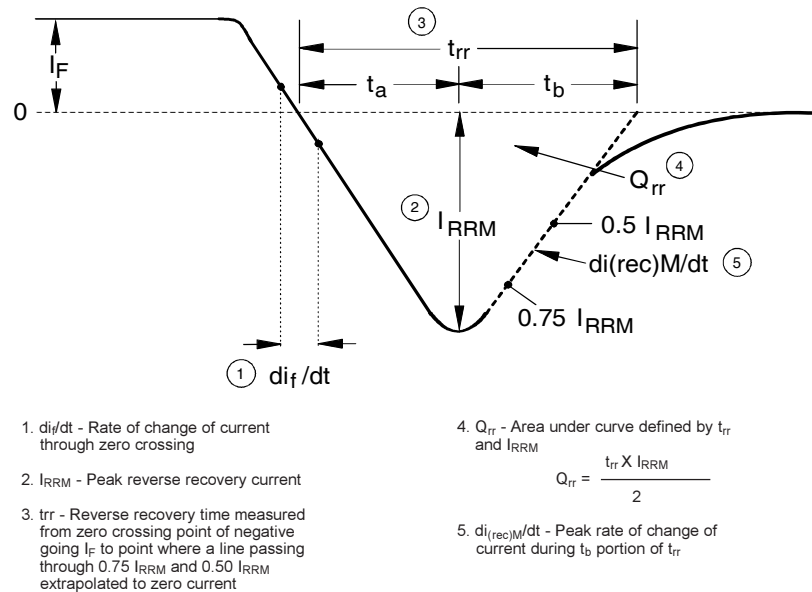
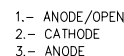


Fig. WF3 - Reverse Recovery Waveform and Definitions

TO-247AC Package Outline

International
IOR Rectifier



International
IOR Rectifier

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Note: For the most current drawings please refer to the IR website at:
<http://www.irf.com/package/>