

# IGBT for Automotive Application

## 650 V, 40 A

### AFGHL40T65RQDN

Using novel field stop IGBT technology, onsemi's new series of FS4 IGBTs offer the optimum performance for automotive applications. This technology is Short circuit rated and offers high figure of merit with low conduction and switching losses.

#### Features

- Maximum Junction Temperature:  $T_J = 175^{\circ}\text{C}$
- Positive Temperature Co-efficient for Easy Parallel Operation
- High Current Capability
- Low Saturation Voltage:  $V_{CE(Sat)} = 1.6\text{ V (Typ.) @ } I_C = 40\text{ A}$
- 100% of the Parts Tested for  $I_{LM}$  (Note 2)
- High Input Impedance
- Fast Switching
- Tightened Parameter Distribution
- This Device is Pb-Free and RoHS Compliant

#### Typical Applications

- E-compressor for HEV/EV, PTC heater for HEV/EV

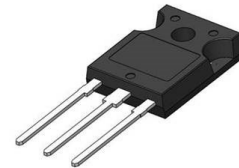
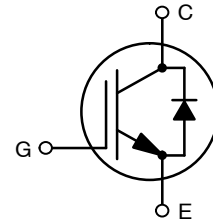
#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-to-Emitter Voltage	$V_{CES}$	650	V
Gate-to-Emitter Voltage	$V_{GES}$	$\pm 20$	V
Transient Gate-to-Emitter Voltage		$\pm 30$	
Collector Current (Note 1)	$I_C$	46	A
@ $T_C = 25^{\circ}\text{C}$		40	
@ $T_C = 100^{\circ}\text{C}$			
Pulsed Collector Current (Note 2)	$I_{LM}$	160	A
Pulsed Collector Current (Note 3)	$I_{CM}$	160	A
Diode Forward Current (Note 1)	$I_F$	46	A
@ $T_C = 25^{\circ}\text{C}$		40	
@ $T_C = 100^{\circ}\text{C}$			
Pulsed Diode Maximum Forward Current	$I_{FM}$	160	A
Non-Repetitive Forward Surge Current (Half-Sine Pulse, $t_p = 8.3\text{ ms}$ , $T_C = 25^{\circ}\text{C}$ ) (Half-Sine Pulse, $t_p = 8.3\text{ ms}$ , $T_C = 150^{\circ}\text{C}$ )	$I_{FM}$	170 150	A
Short Circuit Withstand Time $V_{GE} = 15\text{ V}$ , $V_{CC} = 400\text{ V}$ , $T_C = 150^{\circ}\text{C}$	$t_{SC}$	5	$\mu\text{s}$
Maximum Power Dissipation @ $T_C = 25^{\circ}\text{C}$ @ $T_C = 100^{\circ}\text{C}$	$P_D$	288 144	W
Operating Junction/Storage Temperature Range	$T_J, T_{STG}$	$-55$ to $+175$	$^{\circ}\text{C}$
Maximum Lead Temp. for Soldering Purposes, 1/8" from case for 5 seconds	$T_L$	265	$^{\circ}\text{C}$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Value limited by bond wire.
2.  $V_{CC} = 600\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 120\text{ A}$ ,  $R_G = 67\ \Omega$ , Inductive Load, 100% Tested.
3. Repetitive Rating: pulse width limited by max. Junction temperature.

40 A, 650 V,  
 $V_{CE(Sat)} = 1.6\text{ V (Typ.)}$



TO-247-3L  
CASE 340CX

#### MARKING DIAGRAM



A = Assembly Site  
WW = Work Week Number  
Y = Year of Production,  
Last Number  
ZZ = Assembly Lot Number  
AFGHL40T65RQDN = Specific Device Code

#### ORDERING INFORMATION

Device	Package	Shipping
AFGHL40T65RQDN	TO-247-3L (Pb-Free)	30 Units / Rail

# AFGHL40T65RQDN

## THERMAL CHARACTERISTICS

Rating	Symbol	Min	Typ	Max	Unit
Thermal Resistance Junction-to-Case, for IGBT	$R_{\theta JC}$	–	0.40	0.52	°C/W
Thermal Resistance Junction-to-Case, for Diode	$R_{\theta JC}$	–	0.86	1.12	
Thermal Resistance Junction-to-Ambient	$R_{\theta JA}$	–	–	40	

## ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
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### OFF CHARACTERISTICS

Collector-emitter Breakdown Voltage, Gate-emitter Short-circuited	$V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$	$BV_{CES}$	650	–	–	V
Temperature Coefficient of Breakdown Voltage	$V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$	$\frac{\Delta BV_{CES}}{\Delta T_J}$	–	0.50	–	V/°C
Collector-emitter Cut-off Current, Gate-emitter Short-circuited	$V_{GE} = 0\text{ V}, V_{CE} = V_{CES}$	$I_{CES}$	–	–	30	μA
Gate Leakage Current, Collector-emitter Short-circuited	$V_{GE} = V_{GES}, V_{CE} = 0\text{ V}$	$I_{GES}$	–	–	±400	nA

### ON CHARACTERISTICS

Gate-emitter Threshold Voltage	$V_{GE} = V_{CE}, I_C = 40\text{ mA}$	$V_{GE(th)}$	3.75	4.90	6.05	V
Collector-emitter Saturation Voltage	$V_{GE} = 15\text{ V}, I_C = 40\text{ A}, T_J = 25^\circ\text{C}$ $V_{GE} = 15\text{ V}, I_C = 40\text{ A}, T_J = 175^\circ\text{C}$	$V_{CE(sat)}$	– –	1.6 1.96	1.82 –	V

### DYNAMIC CHARACTERISTICS

Input Capacitance	$V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$	$C_{ies}$	–	2053	–	pF
Output Capacitance		$C_{oes}$	–	73	–	
Reverse Transfer Capacitance		$C_{res}$	–	9	–	
Gate Resistance	$f = 1\text{ MHz}$	$R_g$	–	16.5	–	Ω
Gate Charge Total	$V_{CC} = 400\text{ V}, I_C = 40\text{ A}, V_{GE} = 15\text{ V}$	$Q_g$	–	47	–	nC
Gate-Emitter Charge		$Q_{ge}$	–	15	–	
Gate-Collector Charge		$Q_{gc}$	–	12	–	

### SWITCHING CHARACTERISTICS, INDUCTIVE LOAD

Turn-on Delay Time	$T_J = 25^\circ\text{C}, V_{CC} = 400\text{ V},$ $I_C = 20\text{ A}, R_G = 2.5\text{ }\Omega,$ $V_{GE} = 15\text{ V}, \text{ Inductive Load}$	$t_{d(on)}$	–	21	–	ns
Rise Time		$t_r$	–	24	–	
Turn-off Delay Time		$t_{d(off)}$	–	88	–	
Fall Time		$t_f$	–	94	–	
Turn-on Switching Loss		$E_{on}$	–	0.47	–	mJ
Turn-off Switching Loss		$E_{off}$	–	0.43	–	
Total Switching Loss		$E_{ts}$	–	0.90	–	
Turn-on Delay Time	$T_J = 25^\circ\text{C}, V_{CC} = 400\text{ V},$ $I_C = 40\text{ A}, R_G = 2.5\text{ }\Omega,$ $V_{GE} = 15\text{ V}, \text{ Inductive Load}$	$t_{d(on)}$	–	26	–	ns
Rise Time		$t_r$	–	48	–	
Turn-off Delay Time		$t_{d(off)}$	–	77	–	
Fall Time		$t_f$	–	72	–	
Turn-on Switching Loss		$E_{on}$	–	1.14	–	mJ
Turn-off Switching Loss		$E_{off}$	–	0.74	–	
Total Switching Loss		$E_{ts}$	–	1.88	–	

# AFGHL40T65RQDN

## ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise noted) (Continued)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
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### SWITCHING CHARACTERISTICS, INDUCTIVE LOAD

Turn-on Delay Time	$T_J = 175^\circ\text{C}$ , $V_{CC} = 400\text{ V}$ , $I_C = 20\text{ A}$ , $R_G = 2.5\ \Omega$ , $V_{GE} = 15\text{ V}$ , Inductive Load	$t_{d(on)}$	–	24	–	ns
Rise Time		$t_r$	–	28	–	
Turn-off Delay Time		$t_{d(off)}$	–	112	–	
Fall Time		$t_f$	–	184	–	
Turn-on Switching Loss		$E_{on}$	–	0.74	–	mJ
Turn-off Switching Loss		$E_{off}$	–	0.93	–	
Total Switching Loss		$E_{ts}$	–	1.67	–	
Turn-on Delay Time	$T_J = 175^\circ\text{C}$ , $V_{CC} = 400\text{ V}$ , $I_C = 40\text{ A}$ , $R_G = 2.5\ \Omega$ , $V_{GE} = 15\text{ V}$ , Inductive Load	$t_{d(on)}$	–	26	–	ns
Rise Time		$t_r$	–	54	–	
Turn-off Delay Time		$t_{d(off)}$	–	90	–	
Fall Time		$t_f$	–	138	–	
Turn-on Switching Loss		$E_{on}$	–	1.62	–	mJ
Turn-off Switching Loss		$E_{off}$	–	1.40	–	
Total Switching Loss		$E_{ts}$	–	3.02	–	

### DIODE CHARACTERISTICS

Diode Forward Voltage	$I_F = 40\text{ A}$ , $T_J = 25^\circ\text{C}$	$V_F$	–	1.72	2.20	V
	$I_F = 40\text{ A}$ , $T_J = 175^\circ\text{C}$		–	1.77	–	

### DIODE SWITCHING CHARACTERISTICS, INDUCTIVE LOAD

Reverse Recovery Energy	$I_F = 40\text{ A}$ , $di_F/dt = 1000\text{ A}/\mu\text{s}$ , $V_R = 400\text{ V}$ , $T_J = 25^\circ\text{C}$	$E_{rec}$	–	54	–	$\mu\text{J}$
Diode Reverse Recovery Time		$T_{rr}$	–	44	–	nS
Diode Reverse Recovery Charge		$Q_{rr}$	–	416	–	nC
Reverse Recovery Energy	$I_F = 40\text{ A}$ , $di_F/dt = 1000\text{ A}/\mu\text{s}$ , $V_R = 400\text{ V}$ , $T_J = 175^\circ\text{C}$	$E_{rec}$	–	224	–	$\mu\text{J}$
Diode Reverse Recovery Time		$T_{rr}$	–	89	–	nS
Diode Reverse Recovery Charge		$Q_{rr}$	–	1125	–	nC

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

# AFGHL40T65RQDN

## TYPICAL CHARACTERISTICS

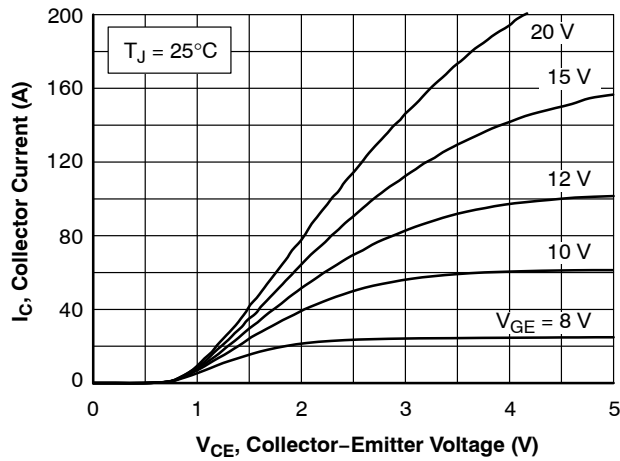


Figure 1. Typical Output Characteristics

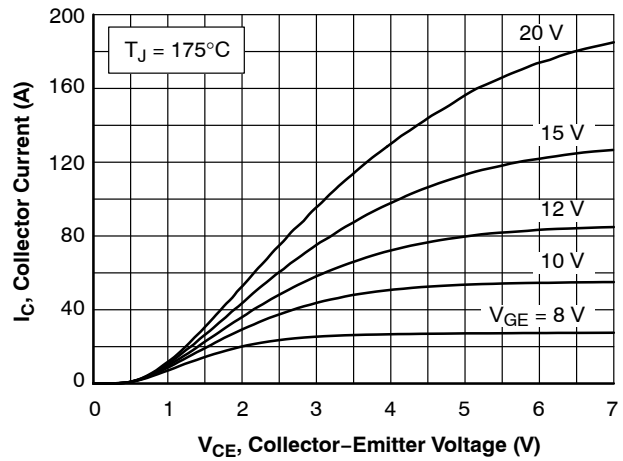


Figure 2. Typical Output Characteristics

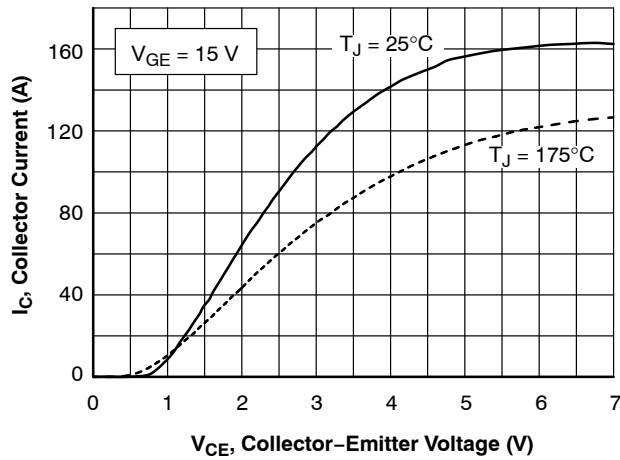


Figure 3. Typical Saturation Voltage Characteristics

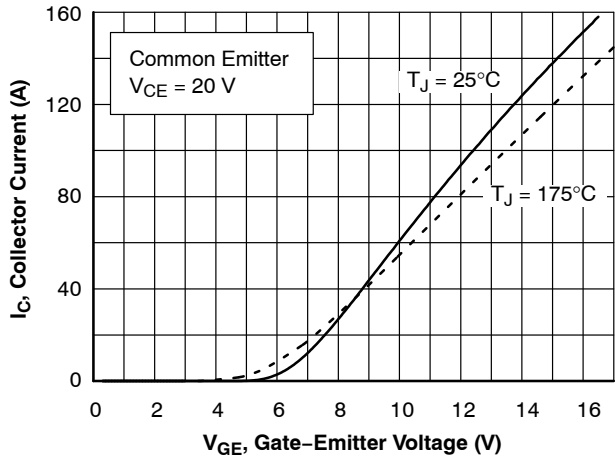


Figure 4. Typical Transfer Characteristics

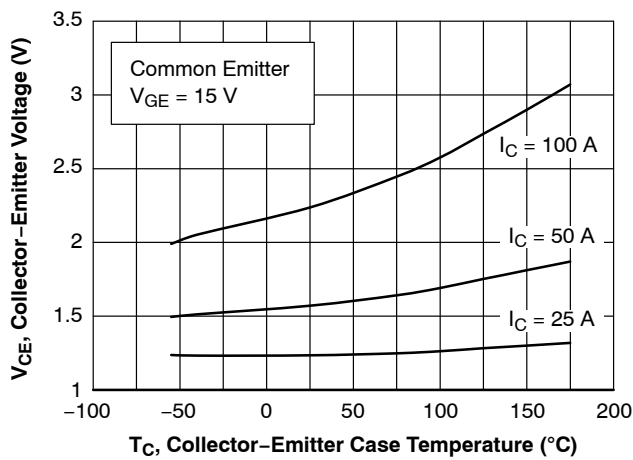


Figure 5. Saturation Voltage vs. Case Temperature at Variant Current Level

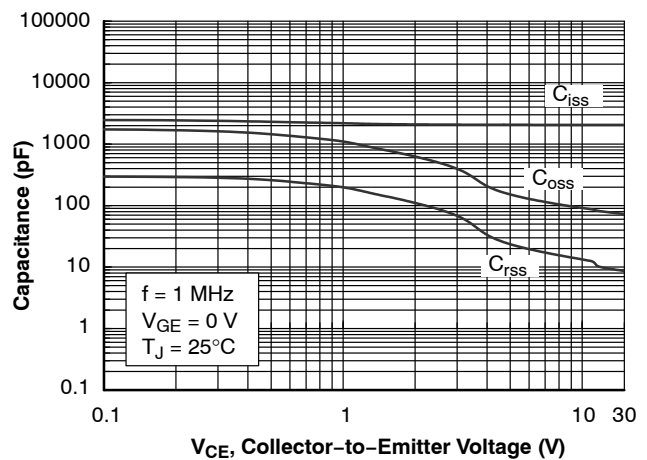


Figure 6. Capacitance Characteristics

TYPICAL CHARACTERISTICS (Continued)

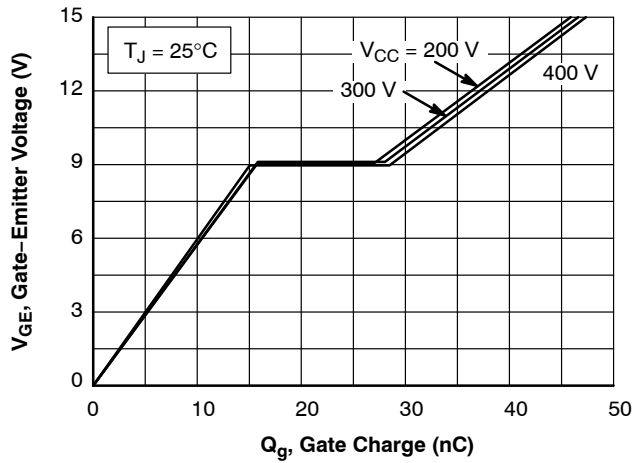


Figure 7. Gate Charge Characteristics

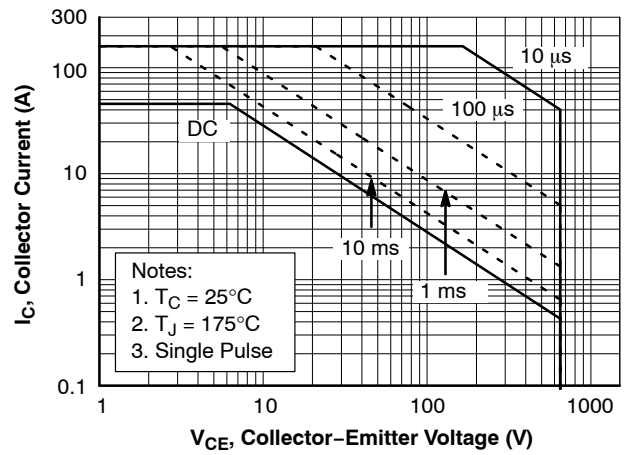


Figure 8. SOA Characteristics

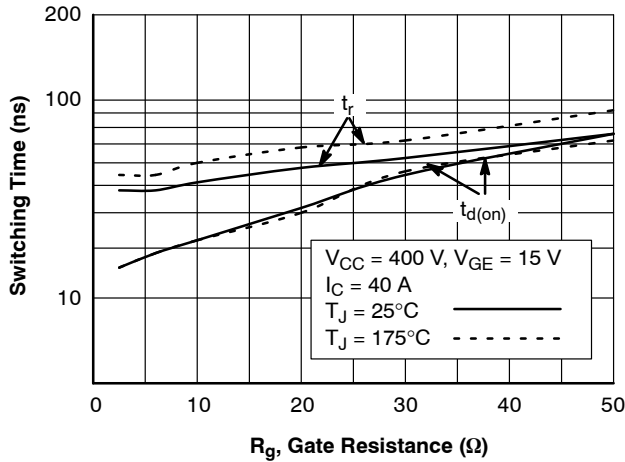


Figure 9. Turn-on Characteristics vs. Gate Resistance

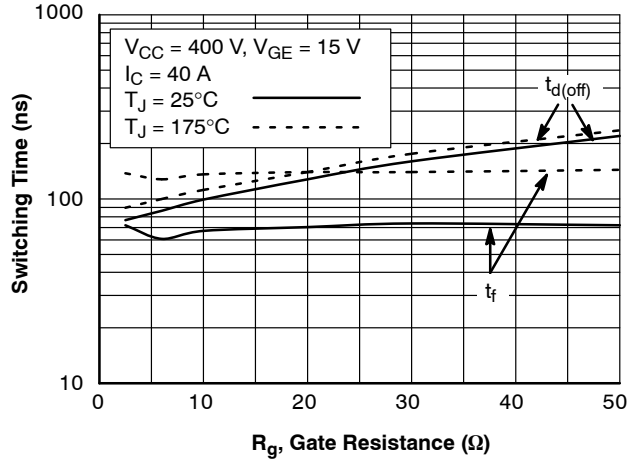


Figure 10. Turn-off Characteristics vs. Gate Resistance

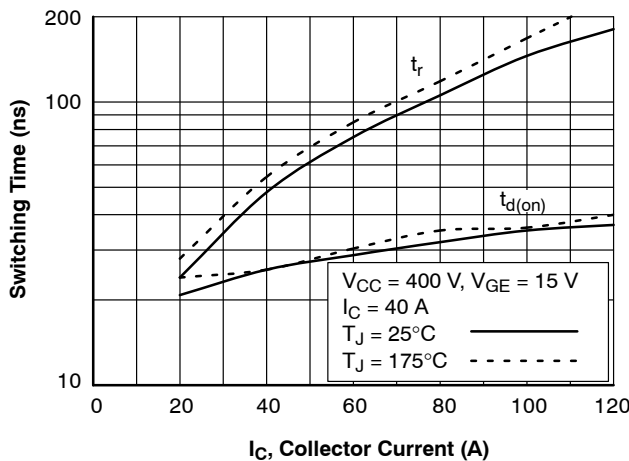


Figure 11. Turn-on Characteristics vs. Collector Current

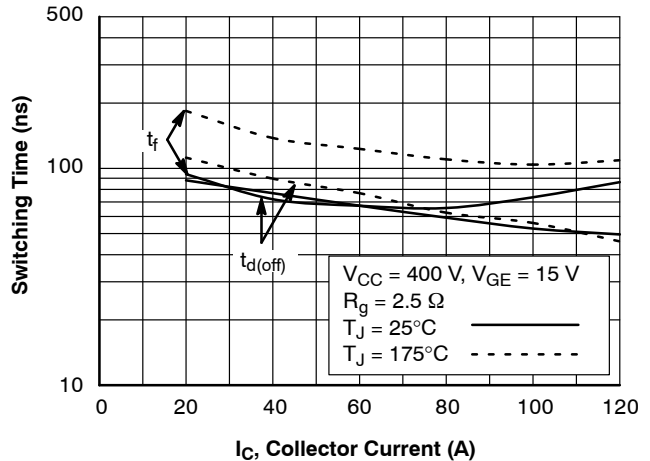


Figure 12. Turn-off Characteristics vs. Collector Current

TYPICAL CHARACTERISTICS (Continued)

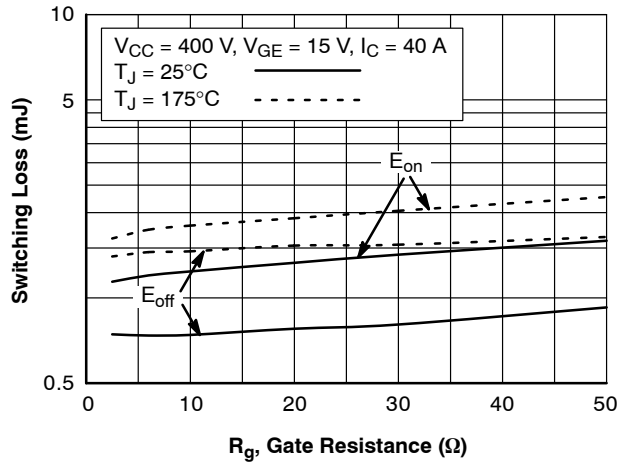


Figure 13. Switching Loss vs. Gate Resistance

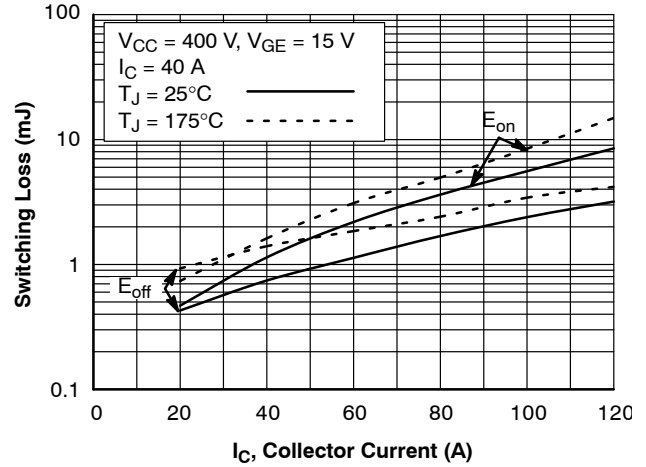


Figure 14. Switching Loss vs. Collector Current

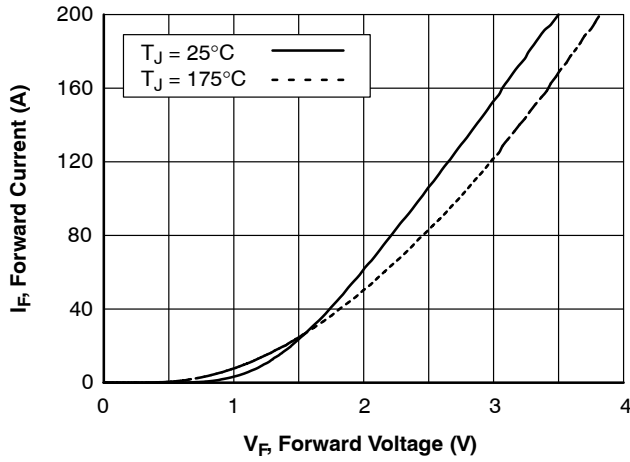


Figure 15. Forward Characteristics

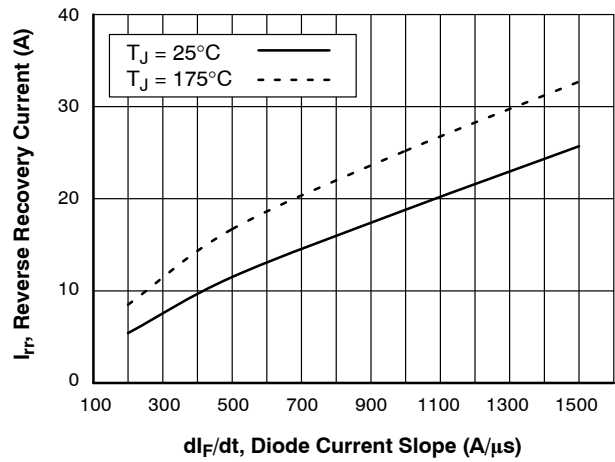


Figure 16. Reverse Recovery Current

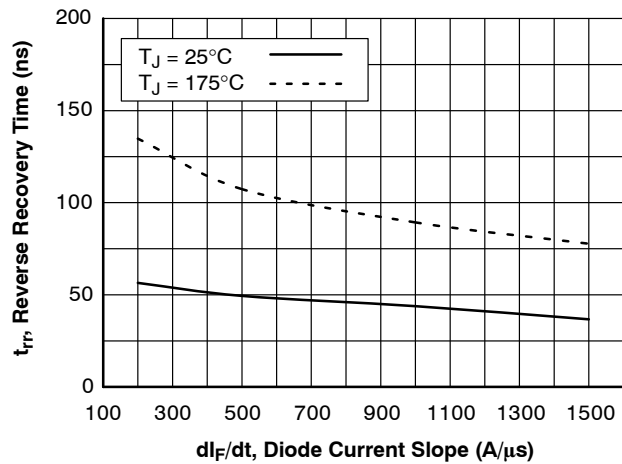


Figure 17. Reverse Recovery Time

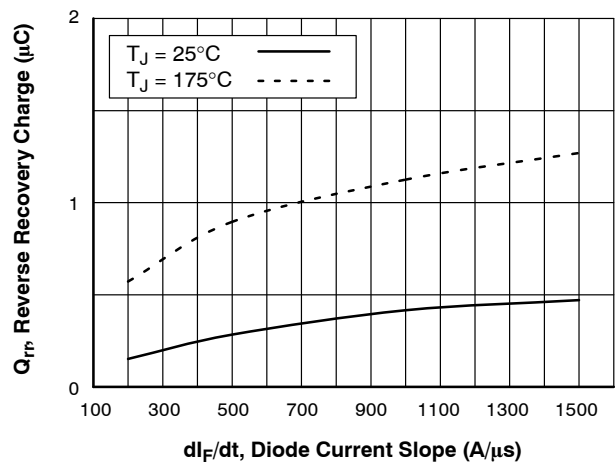


Figure 18. Stored Charge

TYPICAL CHARACTERISTICS (Continued)

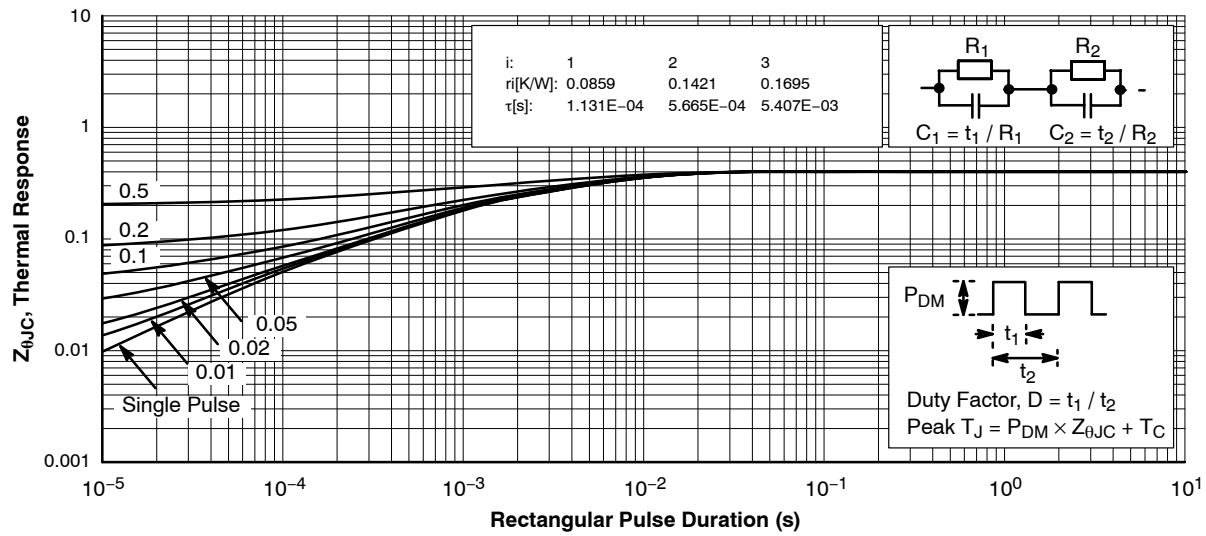


Figure 19. Transient Thermal Impedance of IGBT

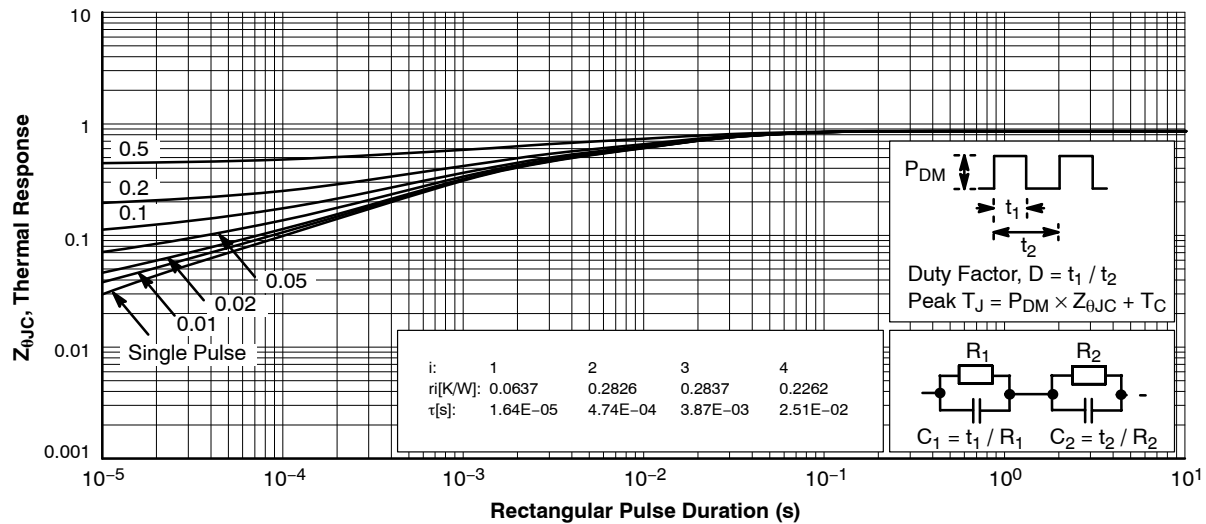
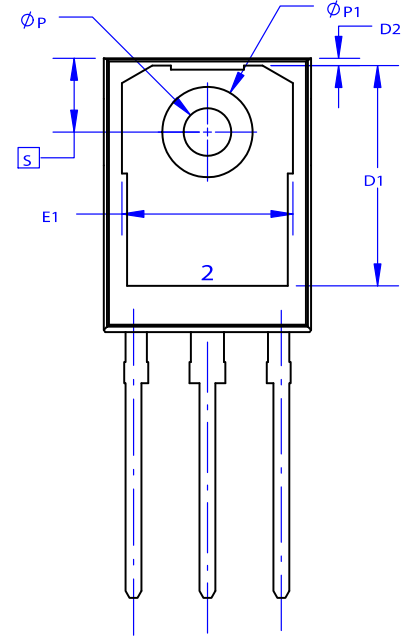
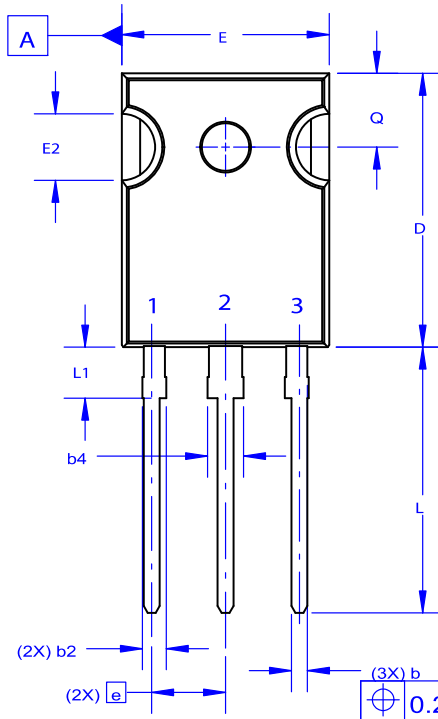


Figure 20. Transient Thermal Impedance of Diode

**TO-247-3LD**  
**CASE 340CX**  
**ISSUE A**

DATE 06 JUL 2020



NOTES: UNLESS OTHERWISE SPECIFIED.

- A. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.  
B. ALL DIMENSIONS ARE IN MILLIMETERS.  
C. DRAWING CONFORMS TO ASME Y14.5 - 2009.  
D. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.  
E. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.

**GENERIC**  
**MARKING DIAGRAM\***


XXXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

DIM	MILLIMETERS		
	MIN	NOM	MAX
A	4.58	4.70	4.82
A1	2.20	2.40	2.60
A2	1.40	1.50	1.60
D	20.32	20.57	20.82
E	15.37	15.62	15.87
E2	4.96	5.08	5.20
e	~	5.56	~
L	19.75	20.00	20.25
L1	3.69	3.81	3.93
ØP	3.51	3.58	3.65
Q	5.34	5.46	5.58
S	5.34	5.46	5.58
b	1.17	1.26	1.35
b2	1.53	1.65	1.77
b4	2.42	2.54	2.66
c	0.51	0.61	0.71
D1	13.08	~	~
D2	0.51	0.93	1.35
E1	12.81	~	~
ØP1	6.60	6.80	7.00

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