

# IGBT for Automotive Applications

650 V, 40 A

## AFGB40T65RQDN

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.

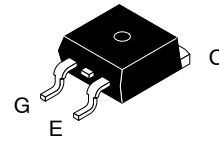
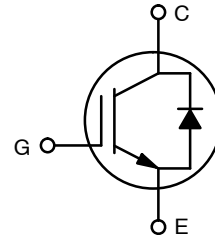
### Features

- Maximum Junction Temperature:  $T_J = 175^{\circ}\text{C}$
- Positive Temperature Coefficient for Easy Parallel Operation
- High Current Capability
- Low Saturation Voltage:  $V_{CE(Sat)} = 1.55\text{ V (Typ.) @ } I_C = 40\text{ A}$
- 100% of the Parts Tested for ILM (Note 2)
- High Input Impedance
- Fast Switching
- Tightened Parameter Distribution
- This Device is Pb-Free and RoHS Compliant

### Typical Applications

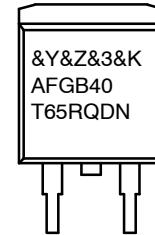
- E-compressor for HEV/EV
- PTC Heater for HEV/EV

$BV_{CES}$	$V_{CE(sat)}$ TYP	$I_C$
650 V	1.55 V	40 A



D2PAK  
3 LEAD  
CASE 418AJ

### MARKING DIAGRAM



- &Y = Logo
- &Z = Assembly Plant Code
- &3 = 3-Digit Date Code
- &K = 2-Digit Lot Traceability Code
- AFGB40T65RQDN = Specific Device Code

### ORDERING INFORMATION

Device	Package	Shipping†
AFGB40T65RQDN	D2PAK (TO-263)	800 Units / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

# AFGB40T65RQDN

## MAXIMUM RATINGS ( $T_C = 25^\circ\text{C}$ unless otherwise stated)

Parameter	Symbol	Value	Unit
Collector to Emitter Voltage	$V_{CES}$	650	V
Gate to Emitter Voltage Transient Gate to Emitter Voltage $T_{\text{pulse}} = 5 \mu\text{s}$ , $D < 0.10$	$V_{GES}$	$\pm 20$ $\pm 30$	V
Collector Current (Note 1) @ $T_C = 25^\circ\text{C}$ @ $T_C = 100^\circ\text{C}$	$I_C$	68 40	A
Pulsed Collector Current (Note 2)	$I_{LM}$	160	A
Pulsed Collector Current (Note 3)	$I_{CM}$	160	A
Diode Forward Current (Note 1) @ $T_C = 25^\circ\text{C}$ @ $T_C = 100^\circ\text{C}$	$I_F$	68 40	A
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, $t_p = 8.3 \text{ ms}$ , $T_C = 150^\circ\text{C}$ )	$I_{F, SM}$	136 118	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 @ $T_C = 25^\circ\text{C}$ @ $T_C = 100^\circ\text{C}$	$P_D$	339.37 169.68	W
Operating Junction and 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.

- Value limited by bond wire.
- $V_{CC} = 400 \text{ V}$ ,  $V_{GE} = 15 \text{ V}$ ,  $I_C = 120 \text{ A}$ ,  $R_G = 100 \Omega$ , Inductive Load, 100% Tested.
- Repetitive rating: pulse width limited by max. Junction temperature.

## THERMAL RESISTANCE RATINGS

Parameter	Symbol	Min	Typ	Max	Unit
Thermal Resistance Junction-to-Case, for IGBT	$R_{\theta JC}$	-	0.34	0.44	$^\circ\text{C/W}$
Thermal Resistance Junction-to-Case, for Diode	$R_{\theta JC}$	-	0.79	1.03	
Thermal Resistance Junction-to-Ambient	$R_{\theta JA}$	-	-	40	

# AFGB40T65RQDN

## ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise stated)

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

Collector-to-Emitter Breakdown Voltage, Gate-Emitter Short-Circuited	BV <sub>CES</sub>	V <sub>GE</sub> = 0 V, I <sub>C</sub> = 1 mA	650	-	-	V
Temperature Coefficient of Breakdown Voltage	ΔBV <sub>CES</sub> /ΔT <sub>J</sub>	V <sub>GE</sub> = 0 V, I <sub>C</sub> = 1 mA	-	0.62	-	V/°C
Collector-Emitter Cut-Off Current, Gate-Emitter Short-Circuited	I <sub>CES</sub>	V <sub>CE</sub> = V <sub>CES</sub> , V <sub>GE</sub> = 0 V	-	-	30	μA
Gate Leakage Current, Collector-Emitter Short-Circuited	I <sub>GES</sub>	V <sub>GE</sub> = V <sub>GES</sub> , V <sub>CE</sub> = 0 V	-	-	±400	nA

### ON CHARACTERISTICS

Gate-Emitter Threshold Voltage	V <sub>GE(th)</sub>	V <sub>GE</sub> = V <sub>CE</sub> , I <sub>C</sub> = 40 mA	3.75	4.90	6.05	V
Collector-Emitter Saturation Voltage	V <sub>CE(sat)</sub>	I <sub>C</sub> = 40 A, V <sub>GE</sub> = 15 V, T <sub>J</sub> = 25°C	-	1.55	1.82	V
		I <sub>C</sub> = 40 A, V <sub>GE</sub> = 15 V, T <sub>J</sub> = 175°C	-	1.90	-	V

### DYNAMIC CHARACTERISTICS

Input Capacitance	C <sub>ies</sub>	V <sub>CE</sub> = 30 V, V <sub>GE</sub> = 0 V, f = 1 MHz	-	2100	-	pF
Output Capacitance	C <sub>oes</sub>		-	71	-	
Reverse Transfer Capacitance	C <sub>res</sub>		-	9	-	
Gate Resistance	R <sub>g</sub>	FREQ = 1 MHz	-	14	-	Ω
Gate Charge Total	Q <sub>g</sub>	V <sub>CE</sub> = 400 V, I <sub>C</sub> = 40 A, V <sub>GE</sub> = 15 V	-	51	-	nC
Gate-Emitter Charge	Q <sub>ge</sub>		-	17	-	
Gate-Collector Charge	Q <sub>gc</sub>		-	14	-	

### SWITCHING CHARACTERISTICS, INDUCTIVE LOAD

Turn-On Delay Time	t <sub>d(on)</sub>	T <sub>J</sub> = 25°C, V <sub>CC</sub> = 400 V, I <sub>C</sub> = 20 A, R <sub>g</sub> = 3 Ω, V <sub>GE</sub> = 15 V, Inductive Load	-	21	-	ns	
Rise Time	t <sub>r</sub>		-	21	-		
Turn-Off Delay Time	t <sub>d(off)</sub>		-	77	-		
Fall Time	t <sub>f</sub>		-	94	-		
Turn-On Switching Loss	E <sub>on</sub>		T <sub>J</sub> = 25°C, V <sub>CC</sub> = 400 V, I <sub>C</sub> = 40 A, R <sub>g</sub> = 3 Ω, V <sub>GE</sub> = 15 V, Inductive Load	-	0.47	-	mJ
Turn-Off Switching Loss	E <sub>off</sub>			-	0.42	-	
Total Switching Loss	E <sub>ts</sub>			-	0.89	-	
Turn-On Delay Time	t <sub>d(on)</sub>	T <sub>J</sub> = 25°C, V <sub>CC</sub> = 400 V, I <sub>C</sub> = 40 A, R <sub>g</sub> = 3 Ω, V <sub>GE</sub> = 15 V, Inductive Load		-	22	-	ns
Rise Time	t <sub>r</sub>			-	45	-	
Turn-Off Delay Time	t <sub>d(off)</sub>			-	66	-	
Fall Time	t <sub>f</sub>			-	74	-	
Turn-On Switching Loss	E <sub>on</sub>		T <sub>J</sub> = 25°C, V <sub>CC</sub> = 400 V, I <sub>C</sub> = 40 A, R <sub>g</sub> = 3 Ω, V <sub>GE</sub> = 15 V, Inductive Load	-	1.18	-	mJ
Turn-Off Switching Loss	E <sub>off</sub>			-	0.75	-	
Total Switching Loss	E <sub>ts</sub>			-	1.93	-	
Turn-On Delay Time	t <sub>d(on)</sub>	T <sub>J</sub> = 175°C, V <sub>CC</sub> = 400 V, I <sub>C</sub> = 20 A, R <sub>g</sub> = 3 Ω, V <sub>GE</sub> = 15 V, Inductive Load		-	20	-	ns
Rise Time	t <sub>r</sub>			-	24	-	
Turn-Off Delay Time	t <sub>d(off)</sub>			-	96	-	
Fall Time	t <sub>f</sub>			-	192	-	
Turn-On Switching Loss	E <sub>on</sub>		T <sub>J</sub> = 175°C, V <sub>CC</sub> = 400 V, I <sub>C</sub> = 20 A, R <sub>g</sub> = 3 Ω, V <sub>GE</sub> = 15 V, Inductive Load	-	0.79	-	mJ
Turn-Off Switching Loss	E <sub>off</sub>			-	0.88	-	
Total Switching Loss	E <sub>ts</sub>			-	1.67	-	

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

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

Turn-On Delay Time	$t_{d(on)}$	$T_J = 175^\circ\text{C}$ , $V_{CC} = 400\text{ V}$ , $I_C = 40\text{ A}$ , $R_g = 3\ \Omega$ , $V_{GE} = 15\text{ V}$ , Inductive Load	–	24	–	ns
Rise Time	$t_r$		–	51	–	
Turn-Off Delay Time	$t_{d(off)}$		–	80	–	
Fall Time	$t_f$		–	152	–	
Turn-On Switching Loss	$E_{on}$		–	1.71	–	mJ
Turn-Off Switching Loss	$E_{off}$		–	1.37	–	
Total Switching Loss	$E_{ts}$		–	3.08	–	

### DIODE CHARACTERISTICS

Diode Forward Voltage	$V_F$	$T_J = 25^\circ\text{C}$ , $I_F = 40\text{ A}$	–	1.68	2.10	V
		$T_J = 175^\circ\text{C}$ , $I_F = 40\text{ A}$	–	1.75	–	

### DIODE SWITCHING CHARACTERISTIC, INDUCTIVE LOAD

Reverse Recovery Energy	$E_{REC}$	$T_J = 25^\circ\text{C}$ , $V_R = 400\text{ V}$ , $I_F = 20\text{ A}$ , $di_F/dt = 1000\text{ A}/\mu\text{s}$	–	59	–	$\mu\text{J}$
Diode Reverse Recovery Time	$T_{rr}$		–	40	–	ns
Diode Reverse Recovery Charge	$Q_{rr}$		–	413	–	nC
Reverse Recovery Energy	$E_{REC}$	$T_J = 25^\circ\text{C}$ , $V_R = 400\text{ V}$ , $I_F = 40\text{ A}$ , $di_F/dt = 1000\text{ A}/\mu\text{s}$	–	85	–	$\mu\text{J}$
Diode Reverse Recovery Time	$T_{rr}$		–	52	–	ns
Diode Reverse Recovery Charge	$Q_{rr}$		–	543	–	nC
Reverse Recovery Energy	$E_{REC}$	$T_J = 175^\circ\text{C}$ , $V_R = 400\text{ V}$ , $I_F = 20\text{ A}$ , $di_F/dt = 1000\text{ A}/\mu\text{s}$	–	203	–	$\mu\text{J}$
Diode Reverse Recovery Time	$T_{rr}$		–	73	–	ns
Diode Reverse Recovery Charge	$Q_{rr}$		–	984	–	nC
Reverse Recovery Energy	$E_{REC}$	$T_J = 175^\circ\text{C}$ , $V_R = 400\text{ V}$ , $I_F = 40\text{ A}$ , $di_F/dt = 1000\text{ A}/\mu\text{s}$	–	282	–	$\mu\text{J}$
Diode Reverse Recovery Time	$T_{rr}$		–	96	–	ns
Diode Reverse Recovery Charge	$Q_{rr}$		–	1334	–	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.

# AFGB40T65RQDN

## TYPICAL CHARACTERISTICS

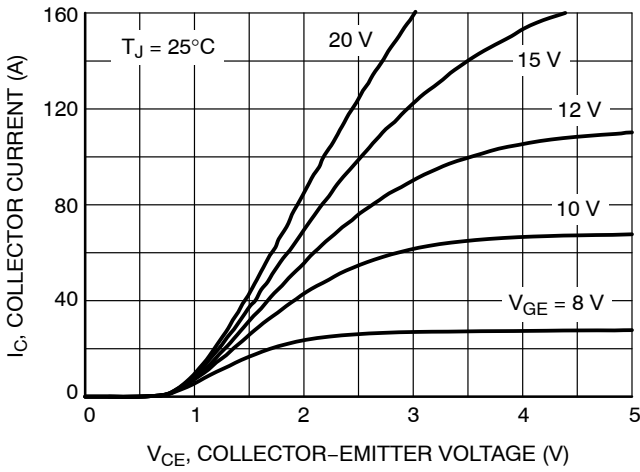


Figure 1. Typical Output Characteristics (25°C)

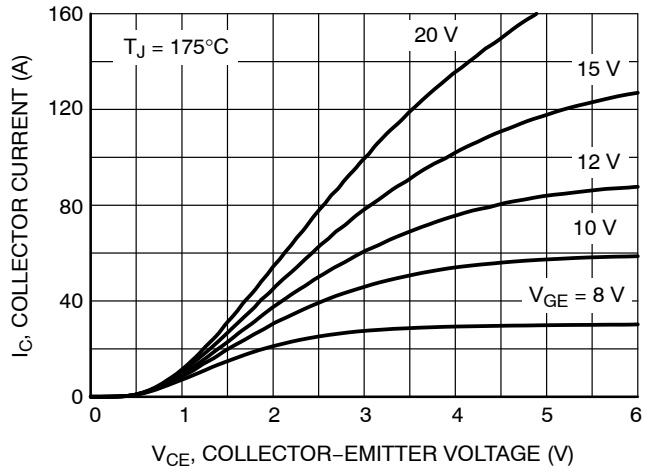


Figure 2. Typical Output Characteristics (175°C)

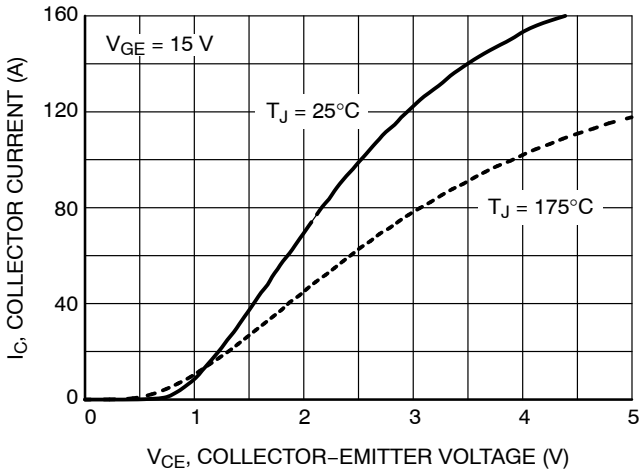


Figure 3. Typical Saturation Voltage Characteristics

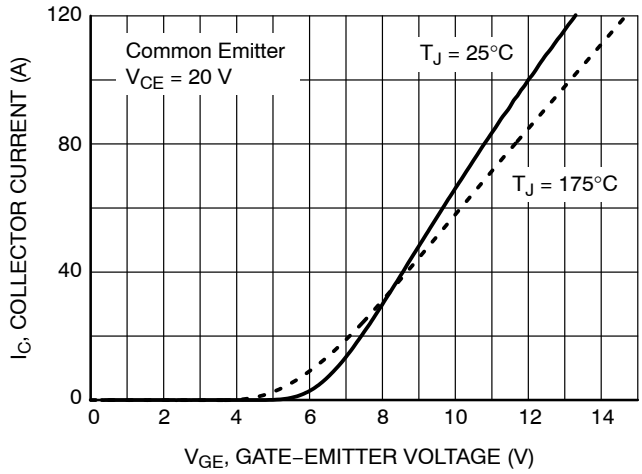


Figure 4. Typical Transfer Characteristics

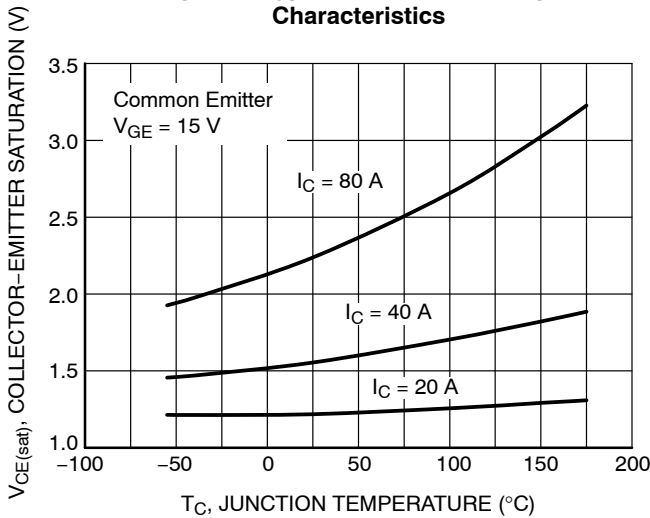


Figure 5. Saturation Voltage vs. Case

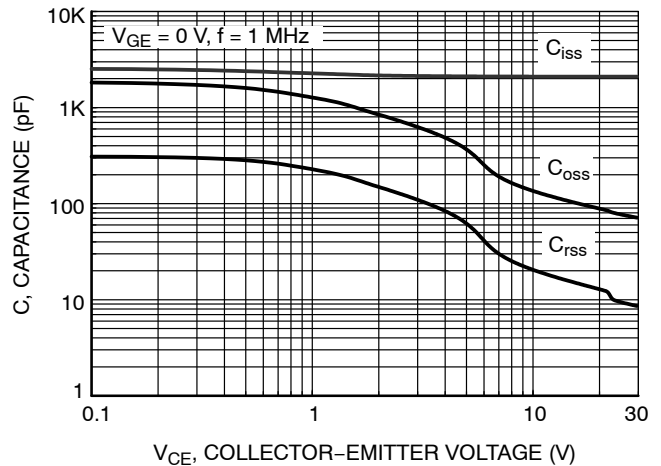


Figure 6. Capacitance Characteristics

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## TYPICAL CHARACTERISTICS (Continued)

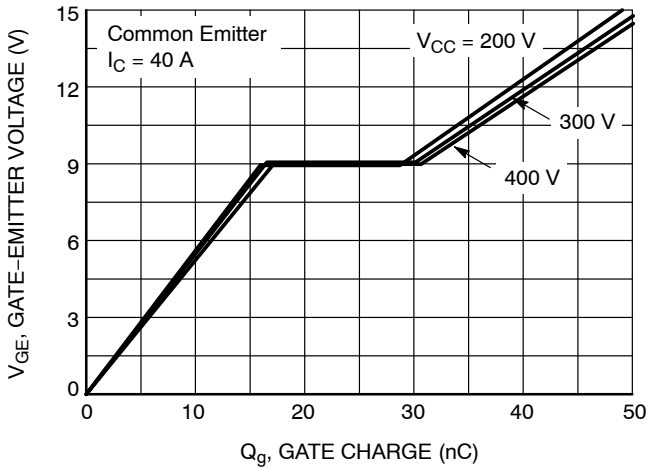


Figure 7. Gate Charge Characteristics

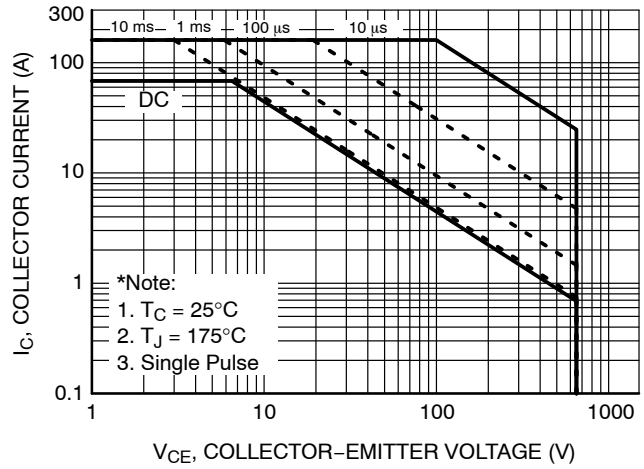


Figure 8. SOA Characteristics

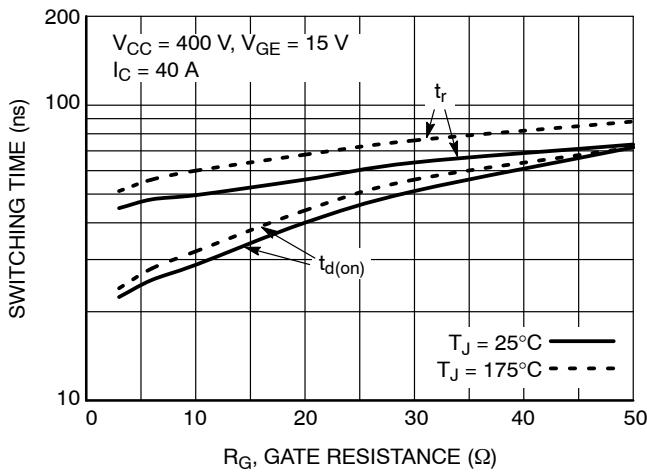


Figure 9. Turn-On Characteristics vs. Gate Resistance

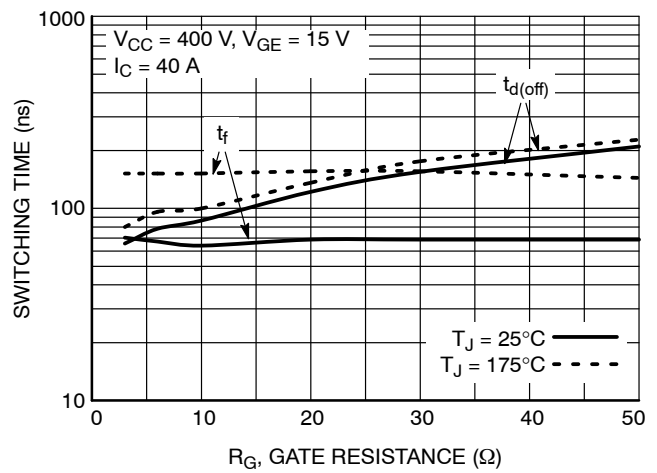


Figure 10. Turn-Off Characteristics vs. Gate Resistance

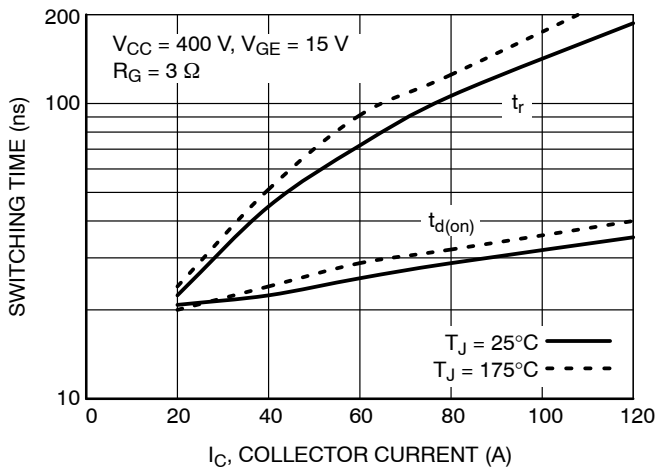


Figure 11. Turn-On Characteristics vs. Collector Current

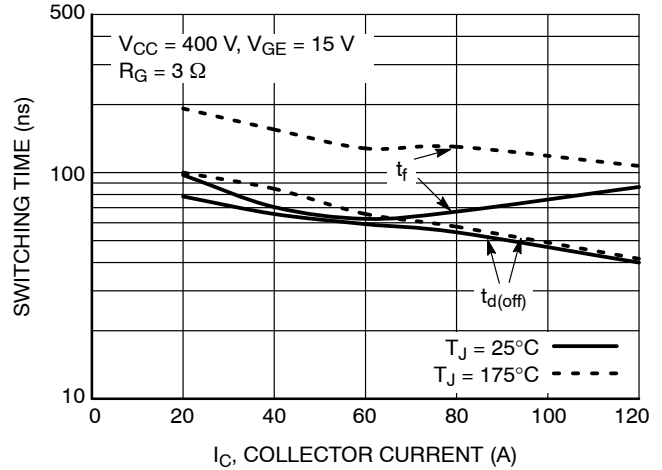


Figure 12. Turn-Off Characteristics vs. Collector Current

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## TYPICAL CHARACTERISTICS (Continued)

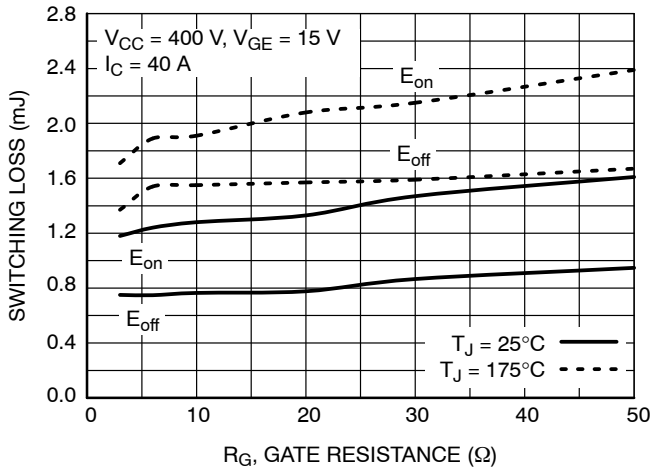


Figure 13. Switching Loss vs. Gate Resistance

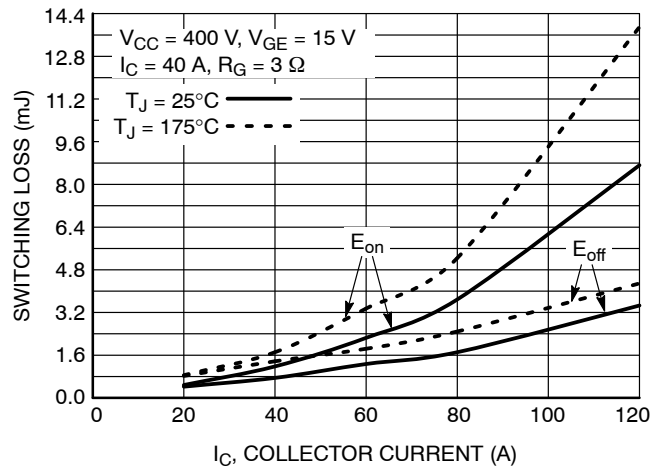


Figure 14. Switching Loss vs. Collector Current

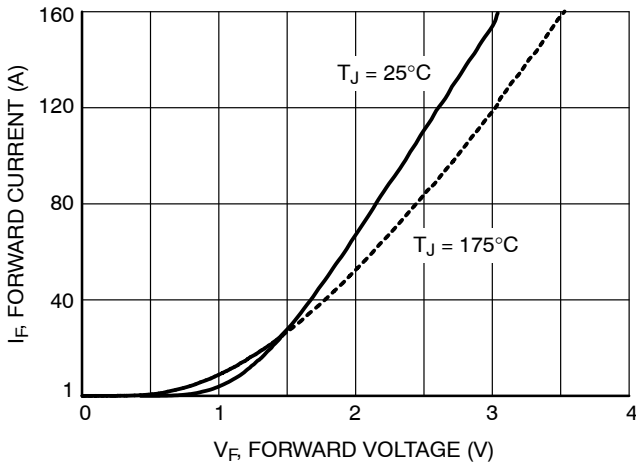


Figure 15. Forward Characteristics

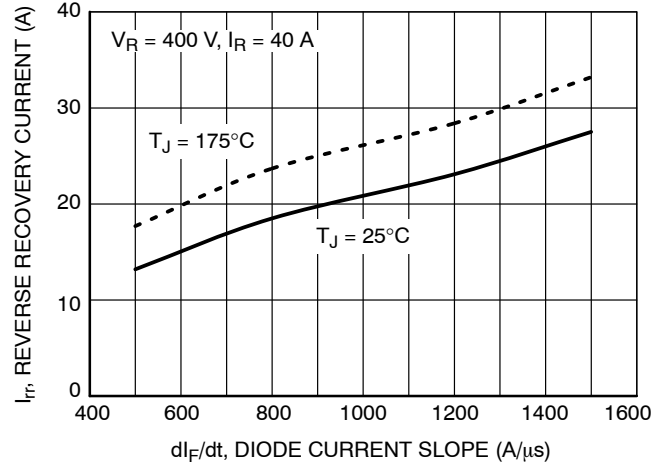


Figure 16. Reverse Recovery Current

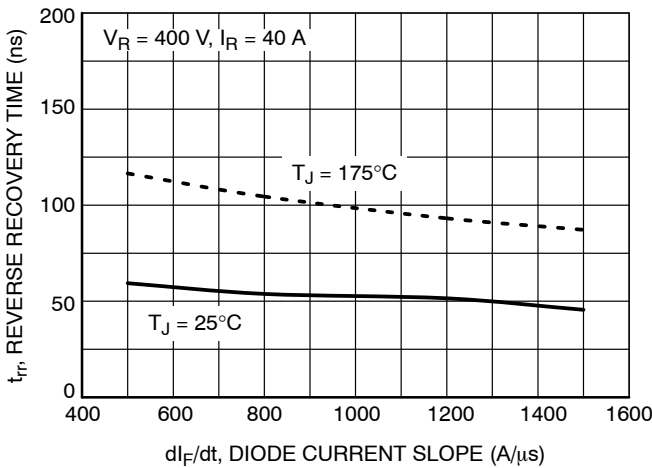


Figure 17. Reverse Recovery Time

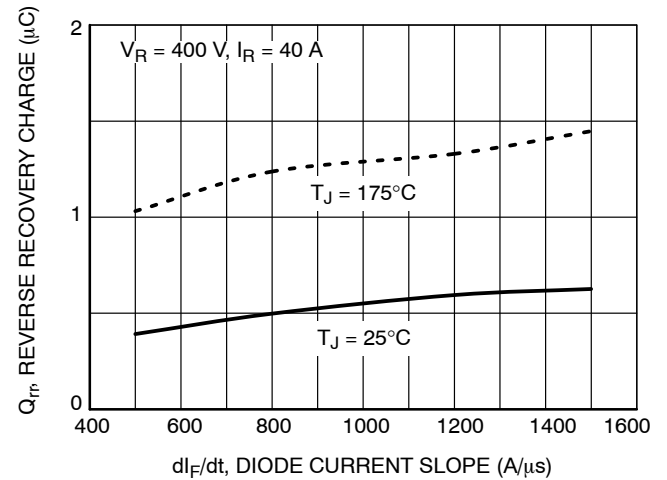


Figure 18. Stored Charge

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## TYPICAL CHARACTERISTICS (Continued)

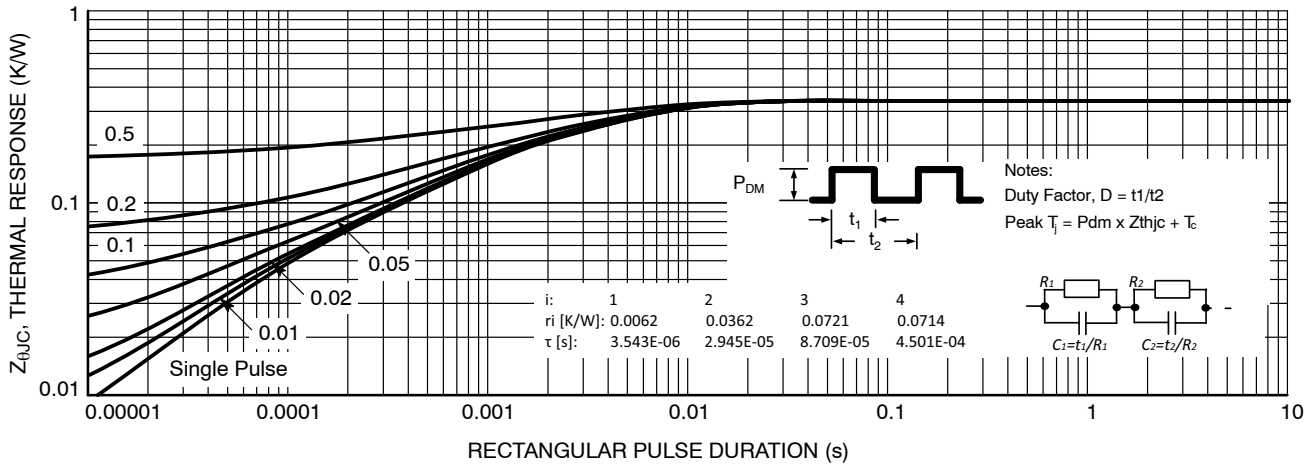


Figure 19. Transient Thermal Impedance of IGBT

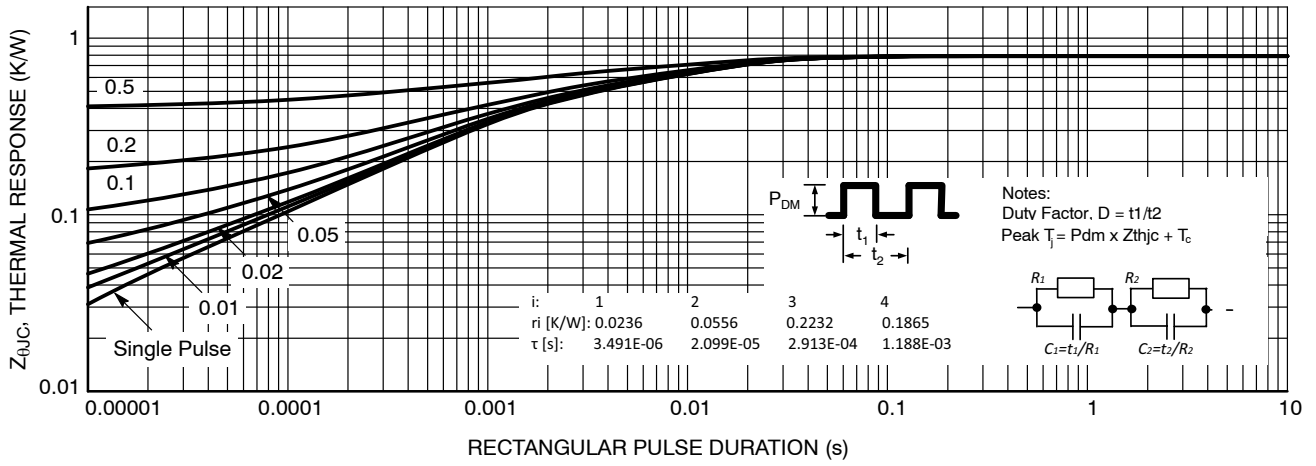


Figure 20. Transient Thermal Impedance of Diode



# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

ON Semiconductor®



SCALE 1:1

### D<sup>2</sup>PAK-3 (TO-263, 3-LEAD)

#### CASE 418AJ

#### ISSUE F

DATE 11 MAR 2021



#### RECOMMENDED MOUNTING FOOTPRINT

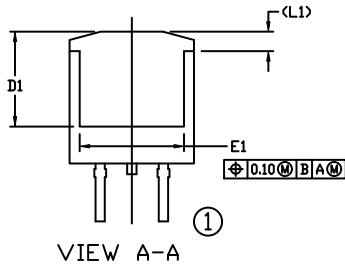
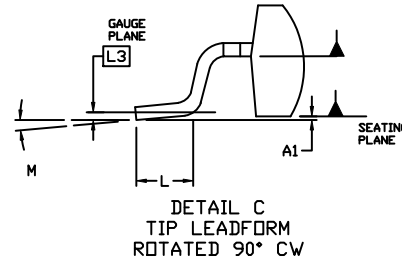
For additional information on our Pb-free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.



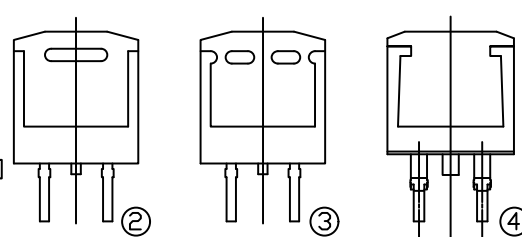
#### NOTES:

- DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
- CONTROLLING DIMENSION: INCHES
- CHAMFER OPTIONAL.
- DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005 PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
- THERMAL PAD CONTOUR IS OPTIONAL WITHIN DIMENSIONS E, L1, D1, AND E1.
- OPTIONAL MOLD FEATURE.
- ①, ② ... OPTIONAL CONSTRUCTION FEATURE CALL OUTS.

DIM	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.160	0.190	4.06	4.83
A1	0.000	0.010	0.00	0.25
b	0.020	0.039	0.51	0.99
c	0.012	0.029	0.30	0.74
c2	0.045	0.065	1.14	1.65
D	0.330	0.380	8.38	9.65
D1	0.260	---	6.60	---
E	0.380	0.420	9.65	10.67
E1	0.245	---	6.22	---
e	0.100	BSC	2.54	BSC
H	0.575	0.625	14.60	15.88
L	0.070	0.110	1.78	2.79
L1	---	0.066	---	1.68
L2	---	0.070	---	1.78
L3	0.010	BSC	0.25	BSC
M	0*	8*	0*	8*

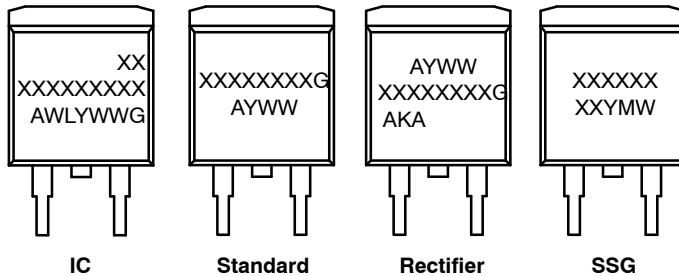


VIEW A-A



VIEW A-A  
OPTIONAL CONSTRUCTIONS

#### GENERIC MARKING DIAGRAMS\*



IC

Standard

Rectifier

SSG

- XXXXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- Y = Year
- WW = Work Week
- W = Week Code (SSG)
- M = Month Code (SSG)
- G = Pb-Free Package
- AKA = Polarity Indicator

\*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.

DOCUMENT NUMBER:	98AON56370E	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
DESCRIPTION:	D <sup>2</sup> PAK-3 (TO-263, 3-LEAD)	PAGE 1 OF 1

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