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# Silicon Carbide (SiC) MOSFET – EliteSiC, 23 mohm, 650 V, M3S, TOLL NTBL023N065M3S

## Features

- Typical  $R_{DS(on)} = 23\text{ m}\Omega @ V_{GS} = 18\text{ V}$
- Ultra Low Gate Charge ( $Q_{G(tot)} = 69\text{ nC}$ )
- High Speed Switching with Low Capacitance ( $C_{oss} = 152\text{ pF}$ )
- 100% Avalanche Tested
- This Device is Halide Free and RoHS Compliant with Exemption 7a, Pb-Free 2LI (on second level interconnection)

## Applications

- SMPS (Switching Mode Power Supplies)
- Solar Inverters
- UPS (Uninterruptable Power Supplies)
- Energy Storage
- Infrastructure

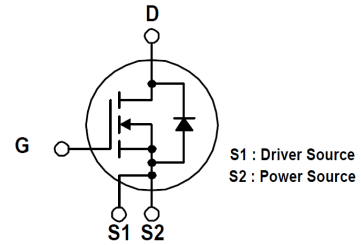
## MAXIMUM RATINGS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Parameter	Symbol	Value	Unit
Drain-to-Source Voltage	$V_{DSS}$	650	V
Gate-to-Source Voltage	$V_{GS}$	-8/+22	V
Continuous Drain Current	$T_C = 25^\circ\text{C}$	$I_D$	77 A
Power Dissipation		$P_D$	312 W
Continuous Drain Current	$T_C = 100^\circ\text{C}$	$I_D$	54 A
Power Dissipation		$P_D$	156 W
Pulsed Drain Current (Note 1)	$T_C = 25^\circ\text{C}$ $t_p = 100\text{ }\mu\text{s}$	$I_{DM}$	280 A
Continuous Source-Drain Current (Body Diode)	$T_C = 25^\circ\text{C}$ , $V_{GS} = -3\text{ V}$	$I_S$	46 A
	$T_C = 100^\circ\text{C}$ , $V_{GS} = -3\text{ V}$		27
Pulsed Source-Drain Current (Body Diode) (Note 1)	$T_C = 25^\circ\text{C}$ , $V_{GS} = -3\text{ V}$ , $t_p = 100\text{ }\mu\text{s}$	$I_{SM}$	274 A
Single Pulse Avalanche Energy ( $I_{LPK} = 19.6\text{ A}$ , $L = 1\text{ mH}$ ) (Note 2)	$E_{AS}$	192	mJ
Operating Junction and Storage Temperature Range	$T_J, T_{stg}$	-55 to +175	$^\circ\text{C}$
Lead Temperature for Soldering Purposes (1/8" from case for 10 s)	$T_L$	260	$^\circ\text{C}$

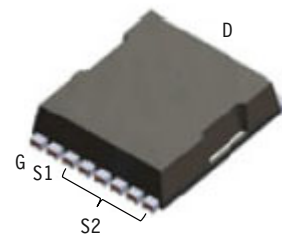
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Repetitive rating, limited by max junction temperature.
2.  $E_{AS}$  of 192 mJ is based on starting  $T_J = 25^\circ\text{C}$ ;  $L = 1\text{ mH}$ ,  $I_{AS} = 19.6\text{ A}$ ,  $V_{DD} = 100\text{ V}$ ,  $V_{GS} = 18\text{ V}$ .

$V_{DSS}$	$R_{DS(ON)}$ TYP	$I_D$ MAX
650 V	23 m $\Omega$ @ 18 V	77 A

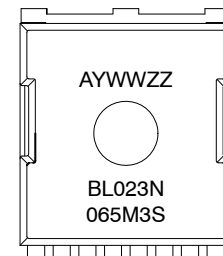


N-Channel MOSFET



H-PSOF8L  
CASE 100DC

## MARKING DIAGRAM



- A = Assembly Location
- Y = Year
- WW = Work Week
- ZZ = Assembly Lot Code
- BL023N065M3S = Specific Device Code

## ORDERING INFORMATION

See detailed ordering and shipping information on page 7 of this data sheet.

# NTBL023N065M3S

## THERMAL CHARACTERISTICS

Parameter	Symbol	Value	Unit
Thermal Resistance, Junction-to-Case (Note 3)	$R_{\theta JC}$	0.48	$^{\circ}\text{C}/\text{W}$
Thermal Resistance, Junction-to-Ambient (Note 3)	$R_{\theta JA}$	43	$^{\circ}\text{C}/\text{W}$

3. The entire application environment impacts the thermal resistance values shown, they are not constants and are only valid for the particular conditions noted.

## RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value	Unit
Operation Values of Gate-to-Source Voltage	$V_{GSop}$	-5...-3/+18	V

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

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

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

Drain-to-Source Breakdown Voltage	$V_{(BR)DSS}$	$V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$	650			V
Drain-to-Source Breakdown Voltage Temperature Coefficient	$\Delta V_{(BR)DSS} / \Delta T_J$	$I_D = 1\text{ mA}$ , Referenced to $25^{\circ}\text{C}$		89		$\text{mV}/^{\circ}\text{C}$
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 650\text{ V}, T_J = 25^{\circ}\text{C}$			10	$\mu\text{A}$
		$V_{DS} = 650\text{ V}, T_J = 175^{\circ}\text{C}$ (Note 5)			500	$\mu\text{A}$
Gate-to-Source Leakage Current	$I_{GSS}$	$V_{GS} = -8/+22\text{ V}, V_{DS} = 0\text{ V}$			$\pm 1$	$\mu\text{A}$

### ON CHARACTERISTICS

Drain-to-Source On Resistance	$R_{DS(on)}$	$V_{GS} = 18\text{ V}, I_D = 20\text{ A}, T_J = 25^{\circ}\text{C}$		23	32.6	m $\Omega$
		$V_{GS} = 18\text{ V}, I_D = 20\text{ A}, T_J = 175^{\circ}\text{C}$		34		
		$V_{GS} = 15\text{ V}, I_D = 20\text{ A}, T_J = 25^{\circ}\text{C}$		29		
		$V_{GS} = 15\text{ V}, I_D = 20\text{ A}, T_J = 175^{\circ}\text{C}$		37		
Gate Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}, I_D = 10\text{ mA}$	2		4	V
Forward Transconductance	$g_{FS}$	$V_{DS} = 10\text{ V}, I_D = 20\text{ A}$		14		S

### CHARGES, CAPACITANCES & GATE RESISTANCE

Input Capacitance	$C_{ISS}$	$V_{GS} = 0\text{ V}, f = 1\text{ MHz}, V_{DS} = 400\text{ V}$ (Note 5)		1950		pF
Output Capacitance	$C_{OSS}$			152		
Reverse Transfer Capacitance	$C_{RSS}$			13		
Total Gate Charge	$Q_{G(TOT)}$	$V_{GS} = -3/18\text{ V}, V_{DD} = 400\text{ V}, I_D = 20\text{ A}$ (Note 5)		69		nC
Gate-to-Source Charge	$Q_{GS}$			19		
Gate-to-Drain Charge	$Q_{GD}$			18		
Gate-Resistance	$R_G$	$f = 1\text{ MHz}$		4.0		$\Omega$

### SWITCHING CHARACTERISTICS

Turn-On Delay Time	$t_{d(ON)}$	$V_{GS} = -3/18\text{ V}, V_{DD} = 400\text{ V}, I_D = 20\text{ A}, R_G = 4.7\text{ }\Omega, T_J = 25^{\circ}\text{C}$ , (Notes 4, 5)		11		ns
Turn-Off Delay Time	$t_{d(OFF)}$			35		
Rise Time	$t_r$			15		
Fall Time	$t_f$			9.6		
Turn-On Switching Loss	$E_{ON}$			51		$\mu\text{J}$
Turn-Off Switching Loss	$E_{OFF}$			29		
Total Switching Loss	$E_{TOT}$			80		

# NTBL023N065M3S

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

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

Turn-On Delay Time	t <sub>d(ON)</sub>	V <sub>GS</sub> = -3/18 V, V <sub>DS</sub> = 400 V, I <sub>D</sub> = 20 A, R <sub>G</sub> = 4.7 Ω, T <sub>J</sub> = 175°C, (Notes 4, 5)		9.6		ns
Turn-Off Delay Time	t <sub>d(OFF)</sub>			41		
Rise Time	t <sub>r</sub>			14		
Fall Time	t <sub>f</sub>			12		
Turn-On Switching Loss	E <sub>ON</sub>			51		μJ
Turn-Off Switching Loss	E <sub>OFF</sub>			45		
Total Switching Loss	E <sub>TOT</sub>			96		

### SOURCE-TO-DRAIN DIODE CHARACTERISTICS

Forward Diode Voltage	V <sub>SD</sub>	V <sub>GS</sub> = -3 V, I <sub>SD</sub> = 20 A, T <sub>J</sub> = 25°C		4.5	6.0	V
		V <sub>GS</sub> = -3 V, I <sub>SD</sub> = 20 A, T <sub>J</sub> = 175°C		4.2		
Reverse Recovery Time	t <sub>RR</sub>	V <sub>GS</sub> = -3 V, I <sub>S</sub> = 20 A, di/dt = 1000 A/μs, V <sub>DS</sub> = 400 V (Note 5)		19		ns
Charge Time	t <sub>a</sub>			11		
Discharge Time	t <sub>b</sub>			8		
Reverse Recovery Charge	Q <sub>RR</sub>			97		nC
Reverse Recovery Energy	E <sub>REC</sub>			8.7		μJ
Peak Reverse Recovery Current	I <sub>RRM</sub>			11		A

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.

4. E<sub>ON</sub>/E<sub>OFF</sub> result is with body diode.

5. Defined by design, not subject to production test.

# NTBL023N065M3S

## TYPICAL CHARACTERISTICS

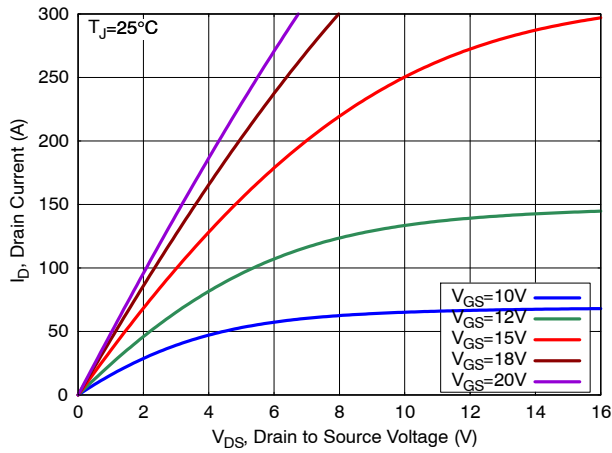


Figure 1. On-Region Characteristics

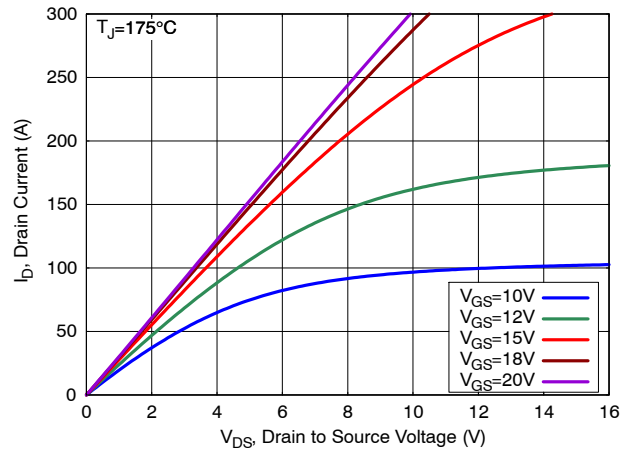


Figure 2. Output Characteristics

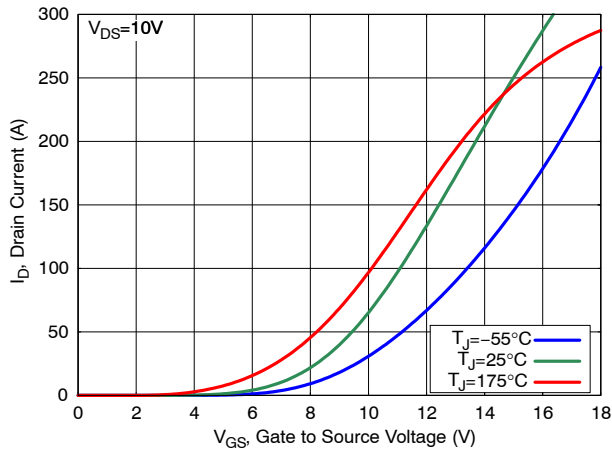


Figure 3. Transfer Characteristics

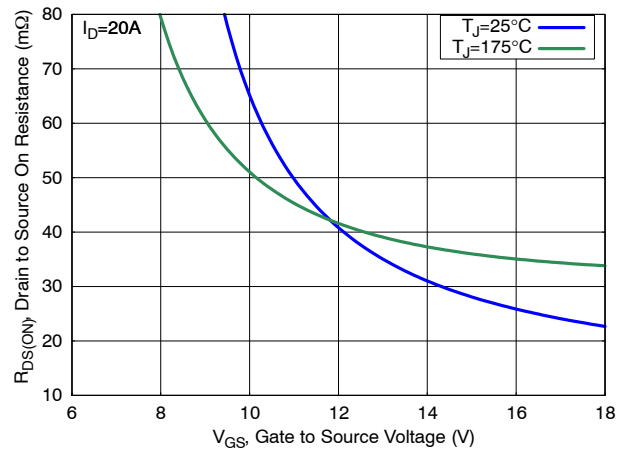


Figure 4. On-Resistance vs. Gate Voltage

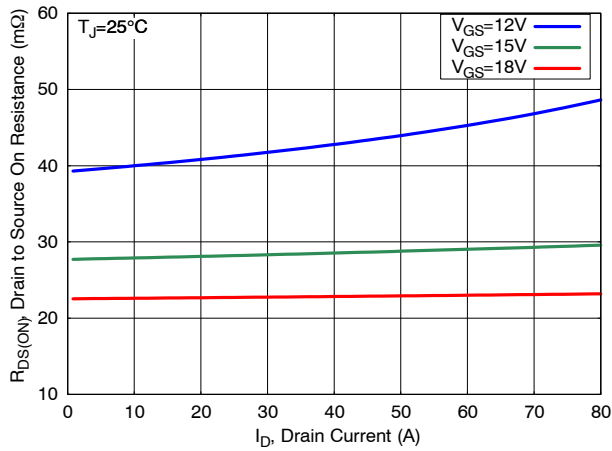


Figure 5. On-Resistance vs. Drain Current

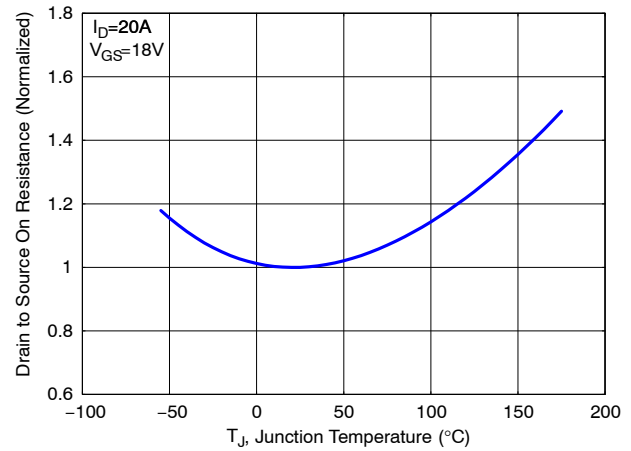


Figure 6. On-Resistance vs. Junction Temperature

# NTBL023N065M3S

## TYPICAL CHARACTERISTICS

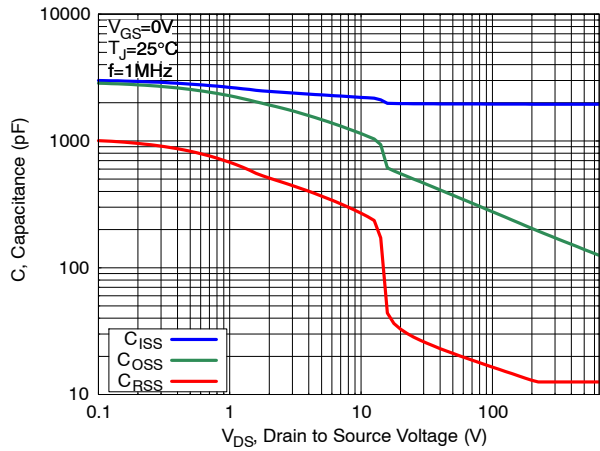


Figure 7. Capacitance Characteristics

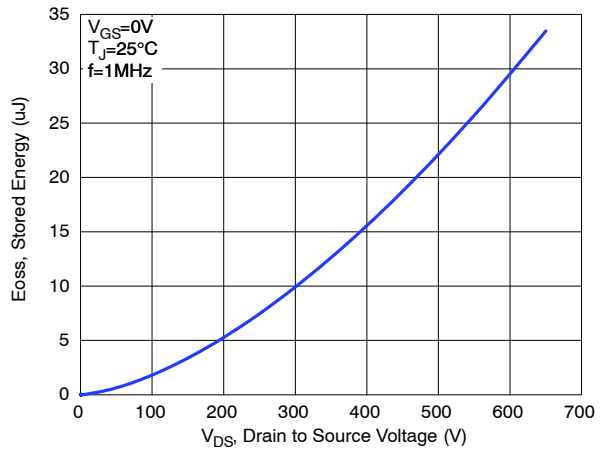


Figure 8. Stored Energy vs. Drain-to-Source Voltage

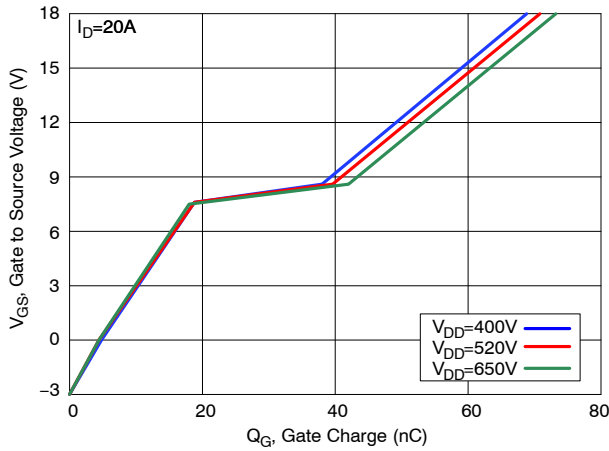


Figure 9. Gate Charge Characteristics

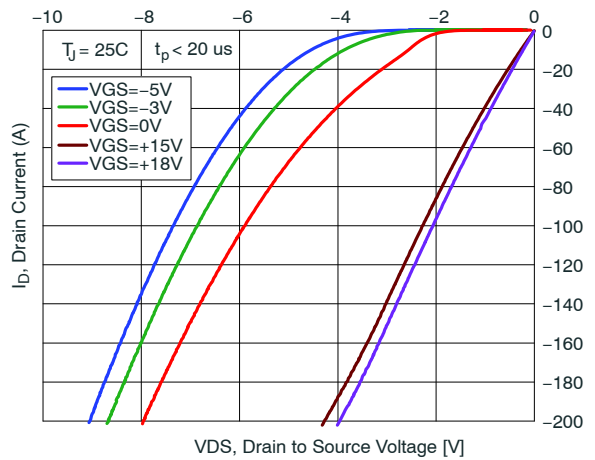


Figure 10. Reverse Conduction Characteristics

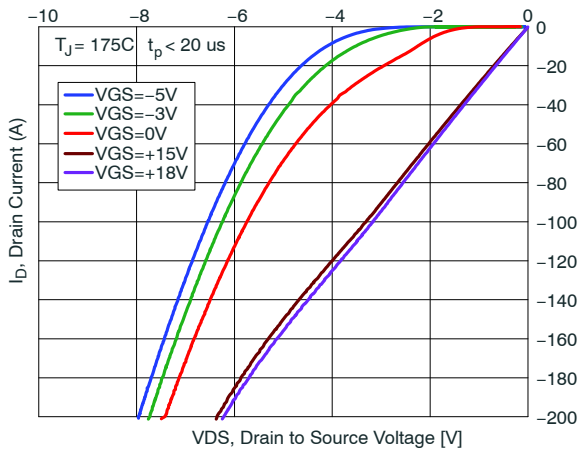


Figure 11. Reverse Conduction Characteristics

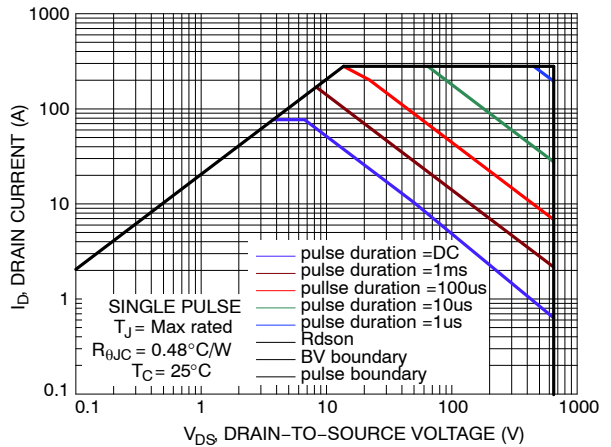


Figure 12. Safe Operating Area

TYPICAL CHARACTERISTICS

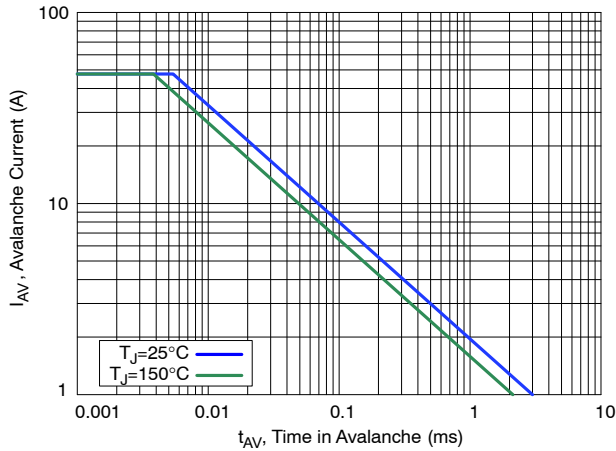


Figure 13. Avalanche Current vs. Pulse Time (UIS)

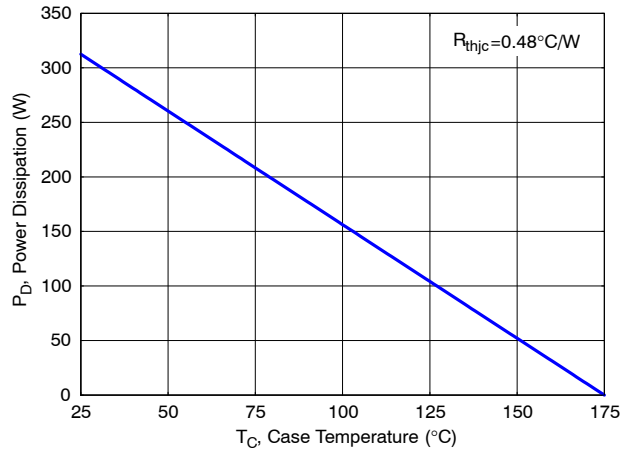


Figure 14. Maximum Power Dissipation vs. Case Temperature

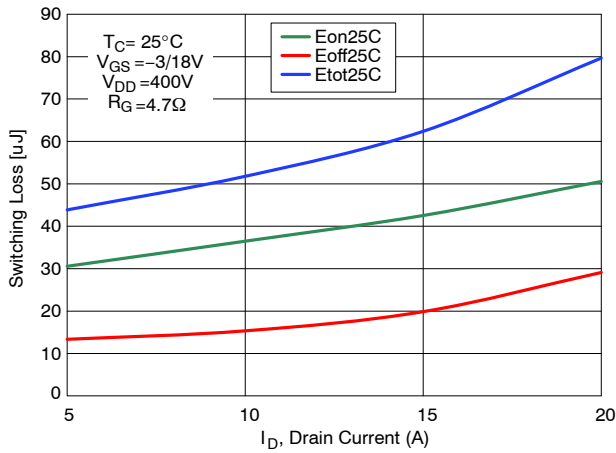


Figure 15. Switching Loss vs. Collector Current

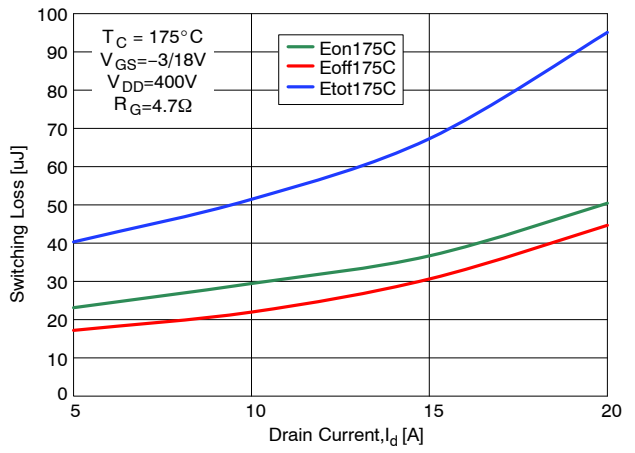


Figure 16. Switching Loss vs. Drain Current

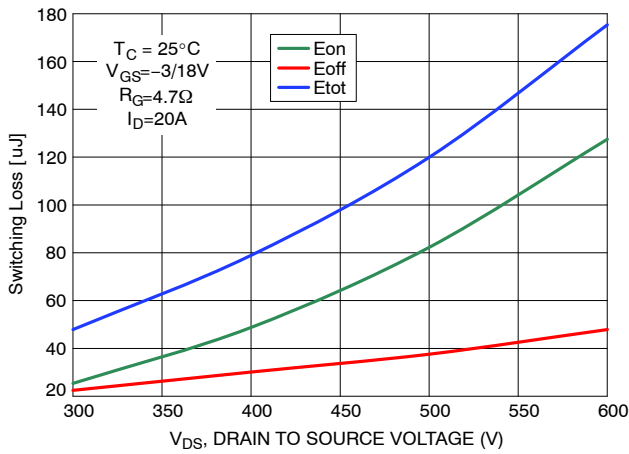


Figure 17. Switching Loss vs. Drain Voltage

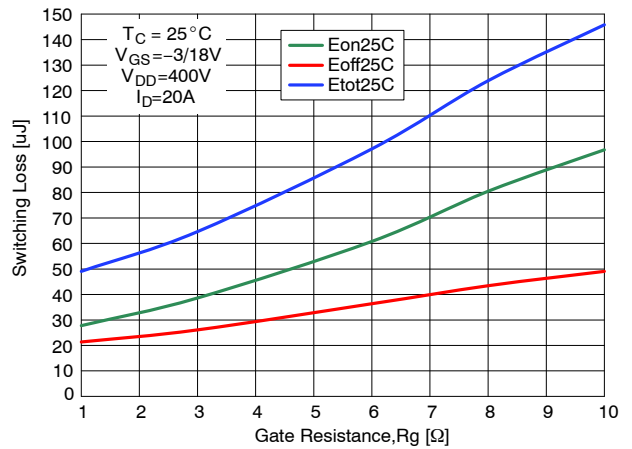


Figure 18. Switching Loss vs. Gate Resistance

# NTBL023N065M3S

## TYPICAL CHARACTERISTICS

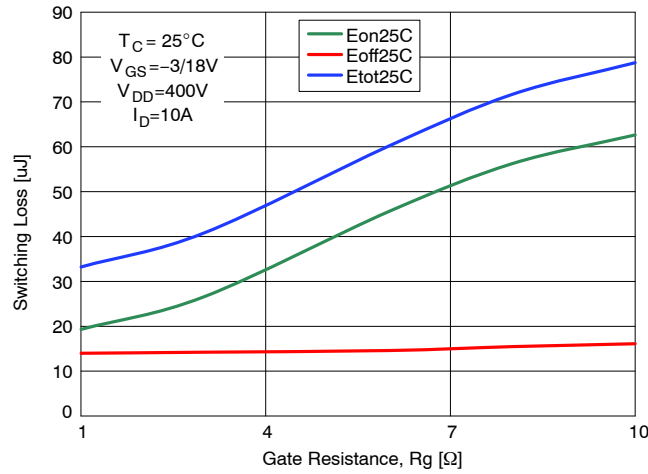


Figure 19. Switching Loss vs. Gate Resistance

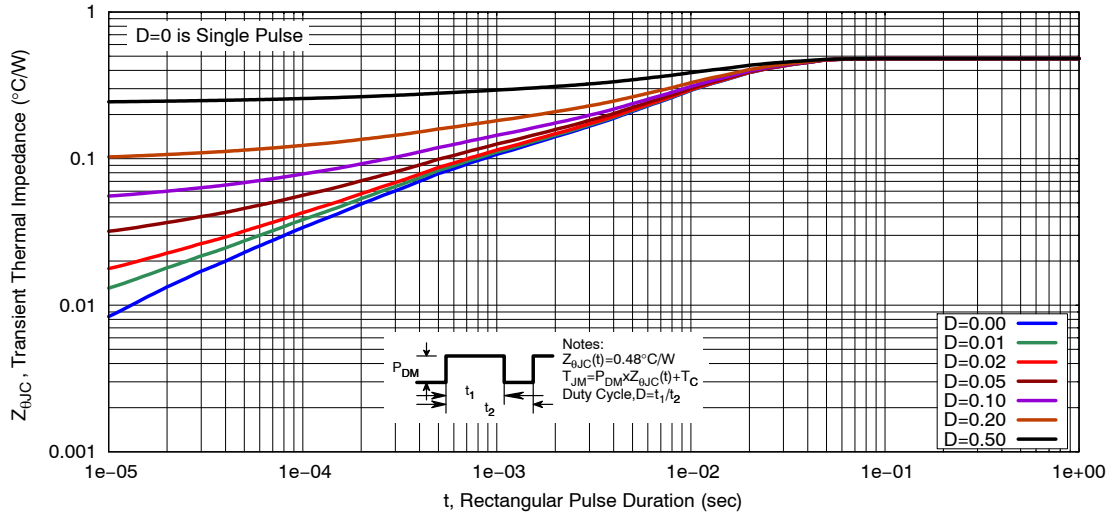


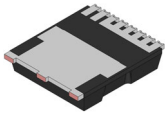
Figure 20. Thermal Response Characteristics

### DEVICE ORDERING INFORMATION

Device	Package	Shipping†
NTBL023N065M3S	H-PSOF8L	2000 / Tape & Reel

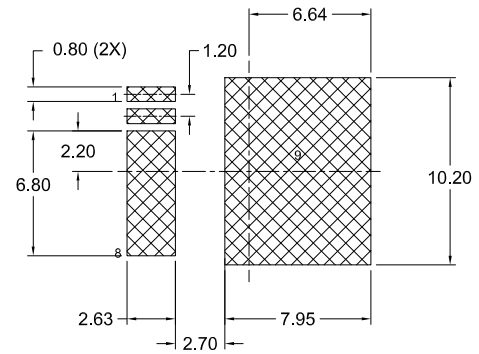
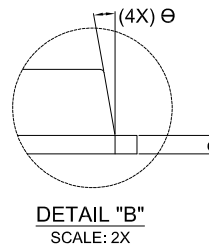
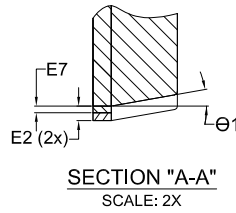
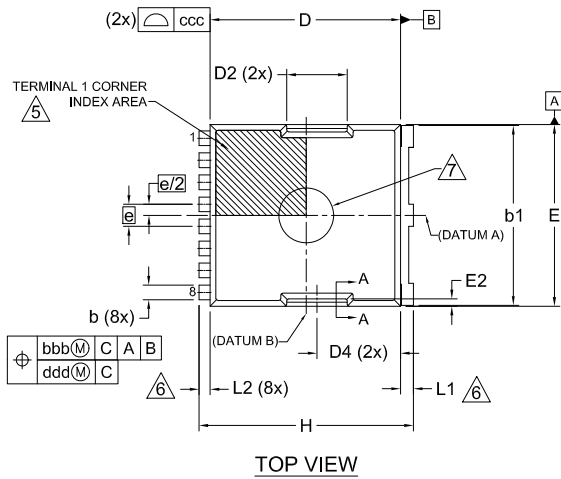
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



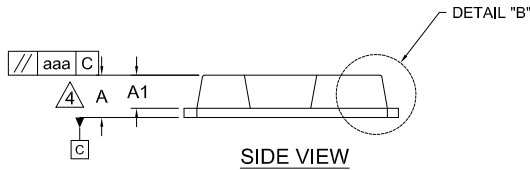


H-PSOF8L 9.90x10.38x2.30, 1.20P  
CASE 100DC  
ISSUE D

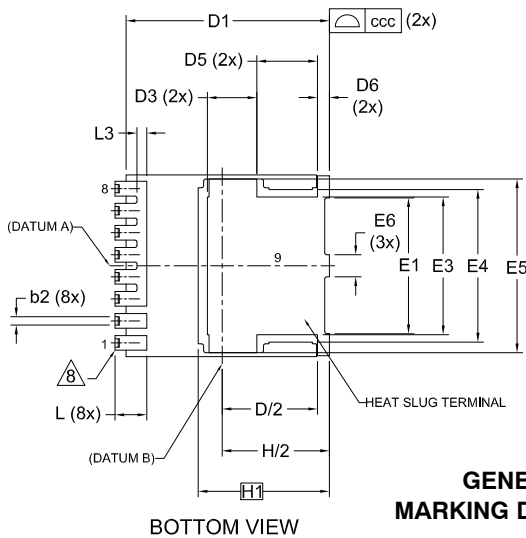
DATE 30 JUL 2024



LAND PATTERN RECOMMENDATION  
\*FOR ADDITIONAL INFORMATION ON OUR Pb-FREE STRATEGY AND SOLDERING DETAILS, PLEASE DOWNLOAD THE ONSEMI SOLDERING AND MOUNTING TECHNIQUES REFERENCE MANUAL, SOLDERRM/D.



- NOTES:
1. PACKAGE STANDARD REFERENCE: JEDEC MO-299, ISSUE B.
  2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2018.
  3. "e" REPRESENTS THE TERMINAL PITCH.
  4. THIS DIMENSION INCLUDES ENCAPSULATION THICKNESS "A1", AND PACKAGE BODY THICKNESS, BUT DOES NOT INCLUDE ATTACHED FEATURES, e.g., EXTERNAL OR CHIP CAPACITORS. AN INTEGRAL HEATSLUG IS NOT CONSIDERED AS ATTACHED FEATURE.
  5. A VISUAL INDEX FEATURE MUST BE LOCATED WITHIN THE HATCHED AREA.
  6. DIMENSIONS b1, L1, L2 APPLY TO PLATED TERMINALS.
  7. THE LOCATION AND SIZE OF EJECTOR MARKS ARE OPTIONAL.
  8. THE LOCATION AND NUMBER OF FUSED LEADS ARE OPTIONAL.



GENERIC MARKING DIAGRAM\*



XXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Assembly Lot Code

\*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	2.20	2.30	2.40
A1	1.70	1.80	1.90
b	0.70	0.80	0.90
b1	9.70	9.80	9.90
b2	0.35	0.45	0.55
c	0.40	0.50	0.60
D	10.28	10.38	10.48
D/2	5.09	5.19	5.29
D1	10.98	11.08	11.18
D2	3.20	3.30	3.40
D3	2.60	2.70	2.80
D4	4.45	4.55	4.65
D5	3.20	3.30	3.40
D6	0.55	0.65	0.75
E	9.80	9.90	10.00
E1	7.30	7.40	7.50
E2	0.30	0.40	0.50
E3	7.40	7.50	7.60
E4	8.20	8.30	8.40

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
E5	9.36	9.46	9.56
E6	1.10	1.20	1.30
E7	0.15	0.18	0.21
e	1.20 BSC		
e/2	0.60 BSC		
H	11.58	11.68	11.78
H/2	5.74	5.84	5.94
H1	7.15 BSC		
L	1.63	1.73	1.83
L1	0.60	0.70	0.80
L2	0.50	0.60	0.70
L3	0.43	0.53	0.63
theta	10° REF		
theta 1	10° REF		
aaa	0.20		
bbb	0.25		
ccc	0.20		
ddd	0.20		
eee	0.10		

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DESCRIPTION:	H-PSOF8L 9.90x10.38x2.30, 1.20P	PAGE 1 OF 1

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