

# Silicon Carbide (SiC) MOSFET – EliteSiC, 40 mohm, 1200 V, M3S, TO-247-3L

## NTHL040N120M3S

### Features

- Typ.  $R_{DS(on)} = 40 \text{ m}\Omega @ V_{GS} = 18 \text{ V}$
- Ultra Low Gate Charge ( $Q_{G(tot)} = 75 \text{ nC}$ )
- High Speed Switching with Low Capacitance ( $C_{oss} = 80 \text{ pF}$ )
- 100% Avalanche Tested
- This Device is Halide Free and RoHS Compliant with exemption 7a, Pb-Free 2LI (on second level interconnection)

### Typical Applications

- Solar Inverters
- Electric Vehicle Charging Stations
- UPS (Uninterruptible Power Supplies)
- Energy Storage Systems
- SMPS (Switch Mode Power Supplies)

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

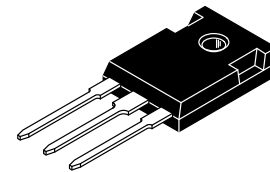
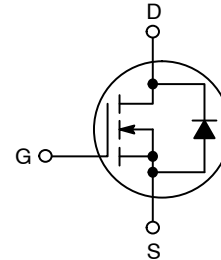
Parameter			Symbol	Value	Unit
Drain-to-Source Voltage			$V_{DSS}$	1200	V
Gate-to-Source Voltage			$V_{GS}$	-10/+22	V
Continuous Drain Current (Notes 1, 3)	Steady State	$T_C = 25^{\circ}\text{C}$	$I_D$	54	A
Power Dissipation (Note 1)			$P_D$	231	W
Continuous Drain Current (Notes 1, 3)	Steady State	$T_C = 100^{\circ}\text{C}$	$I_D$	38	A
Power Dissipation (Note 1)			$P_D$	115	W
Pulsed Drain Current (Note 2)	$T_C = 25^{\circ}\text{C}$		$I_{DM}$	134	A
Operating Junction and Storage Temperature Range			$T_J, T_{stg}$	-55 to +175	$^{\circ}\text{C}$
Source Current (Body Diode) $T_C = 25^{\circ}\text{C}, V_{GS} = -3\text{ V}$			$I_S$	45	A
Single Pulse Drain-to-Source Avalanche Energy (Note 4)			$E_{AS}$	143	mJ
Maximum Lead Temperature for Soldering (1/8" from case for 5 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. The entire application environment impacts the thermal resistance values shown, they are not constants and are only valid for the particular conditions noted.
2. Repetitive rating, limited by max junction temperature.
3. The maximum current rating is based on typical  $R_{DS(on)}$  performance.
4. EAS of 143 mJ is based on starting  $T_J = 25^\circ\text{C}$ ;  $L = 1 \text{ mH}$ ,  $I_{AS} = 16.9 \text{ A}$ ,  $V_{DD} = 100 \text{ V}$ ,  $V_{GS} = 18 \text{ V}$ .

$V_{(BR)DSS}$	$R_{DS(ON)} \text{ MAX}$	$I_D \text{ MAX}$
1200 V	54 m $\Omega @ 18 \text{ V}$	54 A

### N-CHANNEL MOSFET



TO-247-3LD  
CASE 340CX

### MARKING DIAGRAM



HL040N120M3S = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Lot Traceability

### ORDERING INFORMATION

Device	Package	Shipping
NTHL040N120M3S	TO-247-3L	30 Units / Tube

**Table 1. THERMAL CHARACTERISTICS**

Parameter	Symbol	Max	Unit
Junction-to-Case – Steady State (Note 1)	$R_{\theta JC}$	0.65	°C/W
Junction-to-Ambient – Steady State (Note 1)	$R_{\theta JA}$	40	

**Table 2. 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.

**Table 3. ELECTRICAL CHARACTERISTICS** ( $T_J = 25^\circ\text{C}$  unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
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**OFF-STATE CHARACTERISTICS**

Drain-to-Source Breakdown Voltage	$V_{(BR)DSS}$	$V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$	1200	–	–	V
Drain-to-Source Breakdown Voltage Temperature Coefficient	$V_{(BR)DSS}/T_J$	$I_D = 1\text{ mA}$ , referenced to $25^\circ\text{C}$ (Note 6)	–	0.3	–	V/°C
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{GS} = 0\text{ V}, V_{DS} = 1200\text{ V}$ $T_J = 25^\circ\text{C}$	–	–	100	$\mu\text{A}$
Gate-to-Source Leakage Current	$I_{GSS}$	$V_{GS} = +22/-10\text{ V}, V_{DS} = 0\text{ V}$	–	–	$\pm 1$	$\mu\text{A}$

**ON-STATE CHARACTERISTICS** (Note 2)

Gate Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}, I_D = 10\text{ mA}$	2.04	2.9	4.4	V
Drain-to-Source On Resistance	$R_{DS(on)}$	$V_{GS} = 18\text{ V}, I_D = 20\text{ A}, T_J = 25^\circ\text{C}$	–	40	54	m $\Omega$
		$V_{GS} = 18\text{ V}, I_D = 20\text{ A}, T_J = 175^\circ\text{C}$ (Note 6)	–	80	–	
Forward Transconductance	$g_{FS}$	$V_{DS} = 10\text{ V}, I_D = 20\text{ A}$ (Note 6)	–	16	–	S

**CHARGES, CAPACITANCES & GATE RESISTANCE**

Input Capacitance	$C_{ISS}$	$V_{GS} = 0\text{ V}, f = 1\text{ MHz}, V_{DS} = 800\text{ V}$ (Note 6)	–	1700	–	pF
Output Capacitance	$C_{OSS}$		–	80	–	
Reverse Transfer Capacitance	$C_{RSS}$		–	7	–	
Total Gate Charge	$Q_{G(TOT)}$	$V_{GS} = -3/18\text{ V}, V_{DS} = 800\text{ V}, I_D = 20\text{ A}$ (Note 6)	–	75	–	nC
Threshold Gate Charge	$Q_{G(TH)}$		–	4.4	–	
Gate-to-Source Charge	$Q_{GS}$		–	14	–	
Gate-to-Drain Charge	$Q_{GD}$		–	22	–	
Gate-Resistance	$R_G$	$f = 1\text{ MHz}$	–	3.8	–	$\Omega$

**SWITCHING CHARACTERISTICS**

Turn-On Delay Time	$t_{d(ON)}$	$V_{GS} = -3/18\text{ V}, V_{DS} = 800\text{ V}, I_D = 20\text{ A}, R_G = 4.7\text{ }\Omega$ Inductive load (Notes 5, 6)	–	13	–	ns
Rise Time	$t_r$		–	32	–	
Turn-Off Delay Time	$t_{d(OFF)}$		–	37	–	
Fall Time	$t_f$		–	11	–	
Turn-On Switching Loss	$E_{ON}$		–	412	–	$\mu\text{J}$
Turn-Off Switching Loss	$E_{OFF}$		–	74	–	
Total Switching Loss	$E_{tot}$		–	486	–	

# NTHL040N120M3S

**Table 3. ELECTRICAL CHARACTERISTICS** ( $T_J = 25^\circ\text{C}$  unless otherwise specified) (continued)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
<b>SOURCE-DRAIN DIODE CHARACTERISTICS</b>						
Continuous Source-Drain Diode Forward Current	$I_{SD}$	$V_{GS} = -3\text{ V}, T_C = 25^\circ\text{C}$ (Note 6)	–	–	45	A
Pulsed Source-Drain Diode Forward Current (Note 2)	$I_{SDM}$		–	–	134	
Forward Diode Voltage	$V_{SD}$	$V_{GS} = -3\text{ V}, I_{SD} = 20\text{ A}, T_J = 25^\circ\text{C}$	–	4.5	–	V
Reverse Recovery Time	$t_{RR}$	$V_{GS} = -3/18\text{ V}, I_{SD} = 20\text{ A},$ $dI_S/dt = 1000\text{ A}/\mu\text{s}, V_{DS} = 800\text{ V}$ (Note 6)	–	17	–	ns
Reverse Recovery Charge	$Q_{RR}$		–	81	–	nC
Reverse Recovery Energy	$E_{REC}$		–	6.7	–	$\mu\text{J}$
Peak Reverse Recovery Current	$I_{RRM}$		–	9.3	–	A
Charge Time	$T_A$		–	9.5	–	ns
Discharge Time	$T_B$		–	7.7	–	ns

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.

5.  $E_{ON}/E_{OFF}$  result is with body diode.

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

TYPICAL CHARACTERISTICS

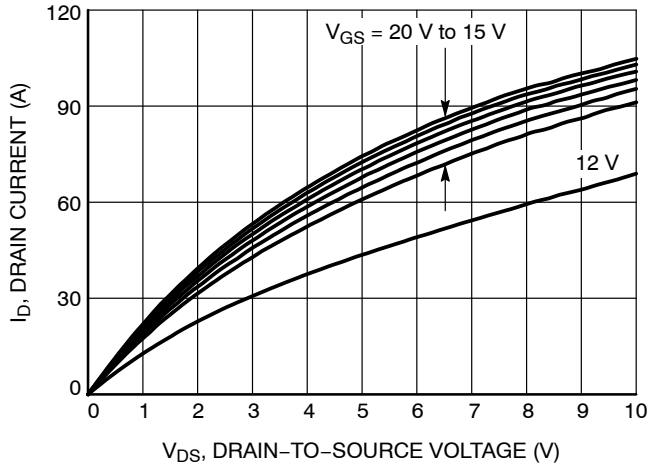


Figure 1. On-Region Characteristics

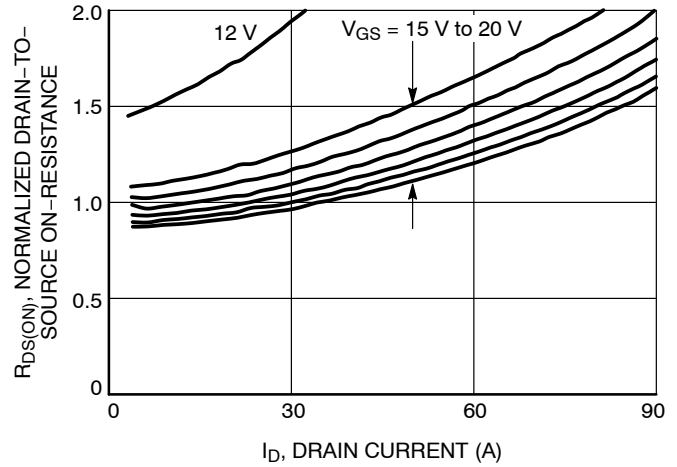


Figure 2. Normalized On-Resistance vs. Drain Current and Gate Voltage

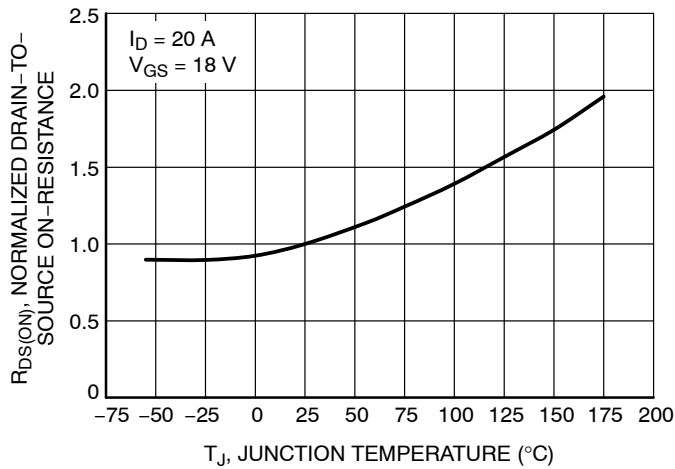


Figure 3. On-Resistance Variation with Temperature

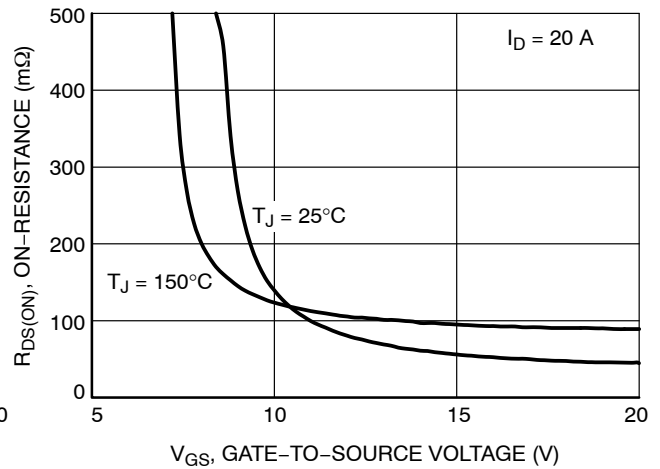


Figure 4. On-Resistance vs. Gate-to-Source Voltage

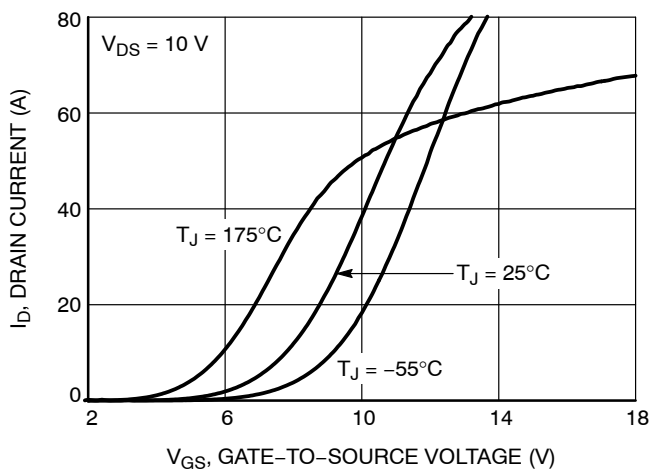


Figure 5. Transfer Characteristics

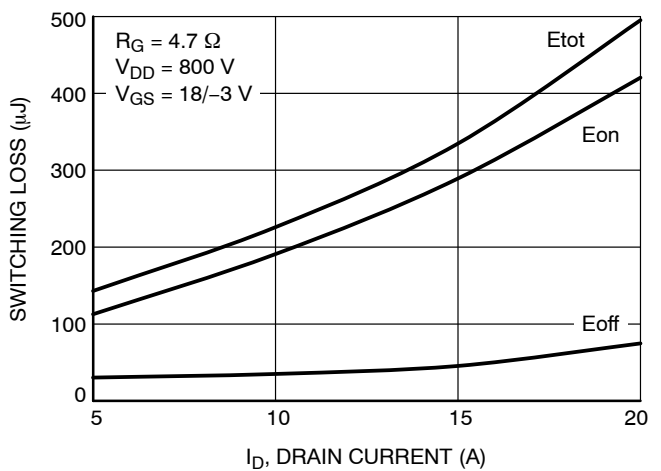


Figure 6. Switching Loss vs. Drain Current

TYPICAL CHARACTERISTICS

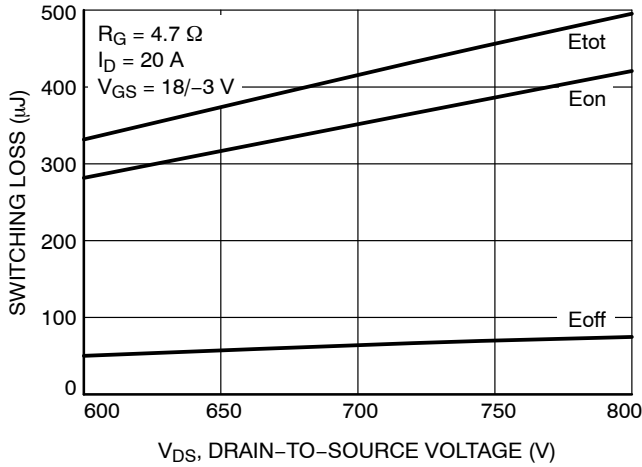


Figure 7. Switching Loss vs. Drain-to-Source Voltage

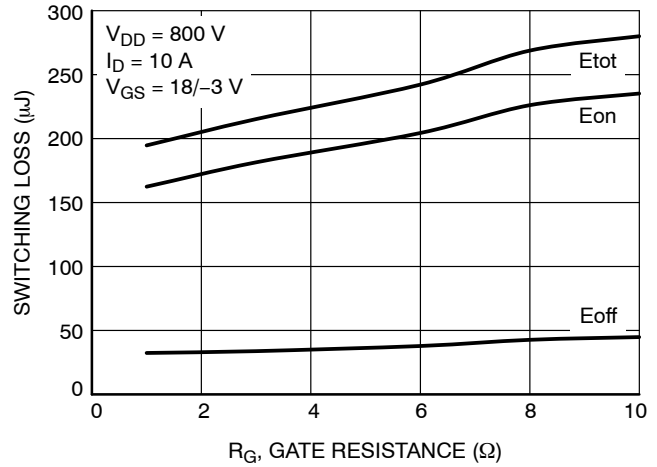


Figure 8. Switching Loss vs. Gate Resistance

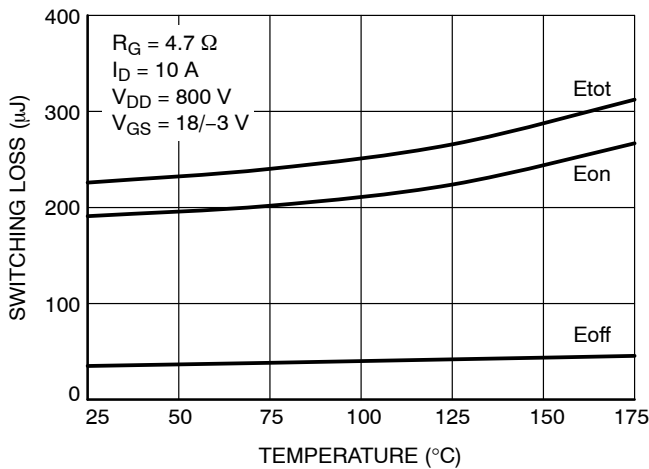


Figure 9. Switching Loss vs. Temperature

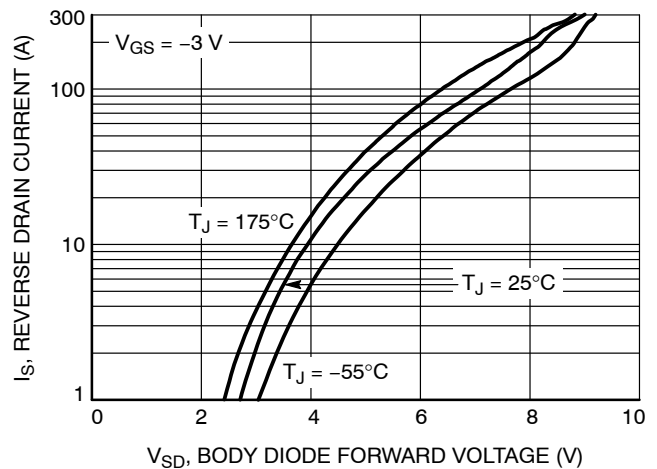


Figure 10. Reverse Drain Current vs. Body Diode Forward Voltage

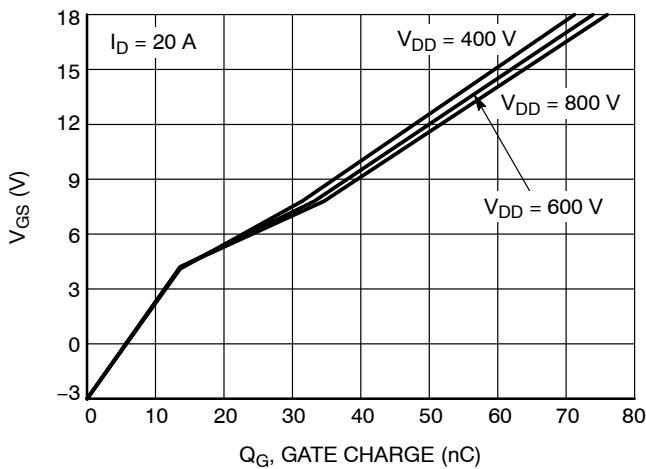


Figure 11. Gate-to-Source Voltage vs. Total Charge

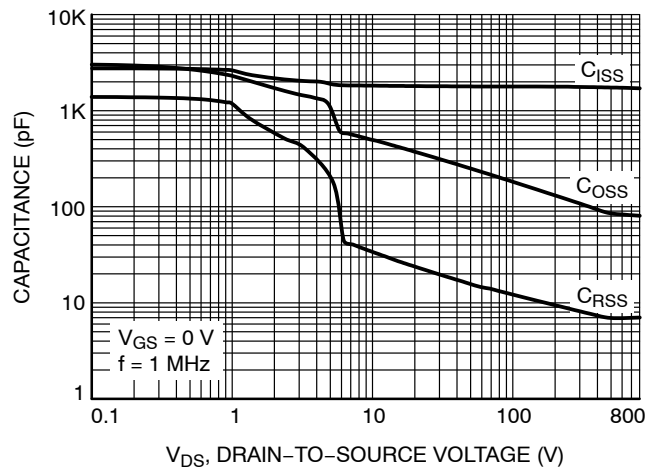


Figure 12. Capacitance vs. Drain-to-Source Voltage

TYPICAL CHARACTERISTICS

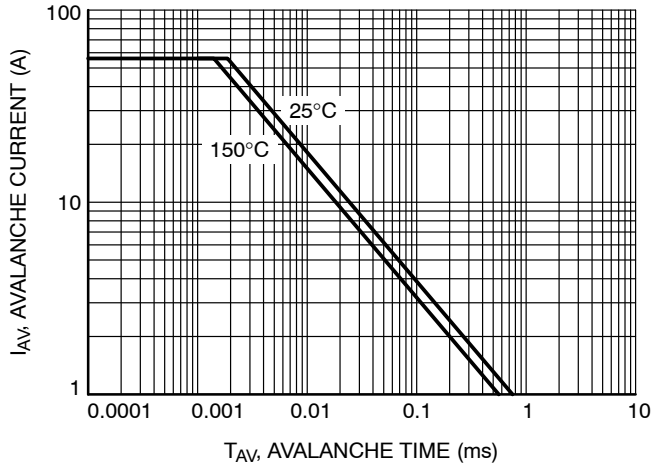


Figure 13. Unclamped Inductive Switching Capability

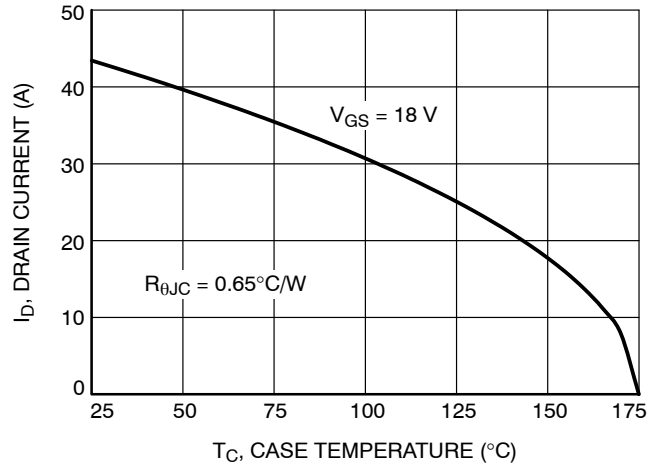


Figure 14. Maximum Continuous Drain Current vs. Case Temperature

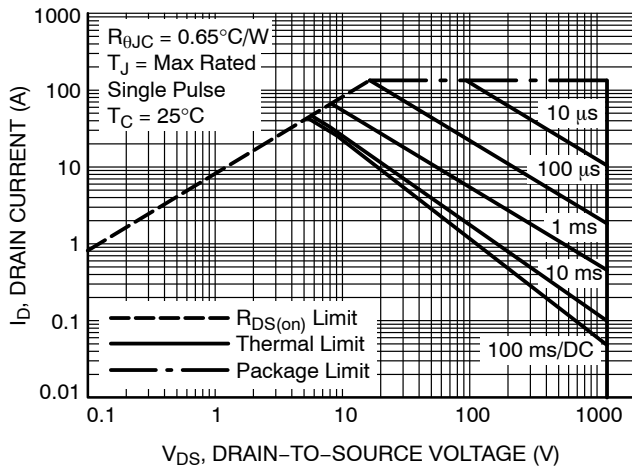


Figure 15. Safe Operating Area

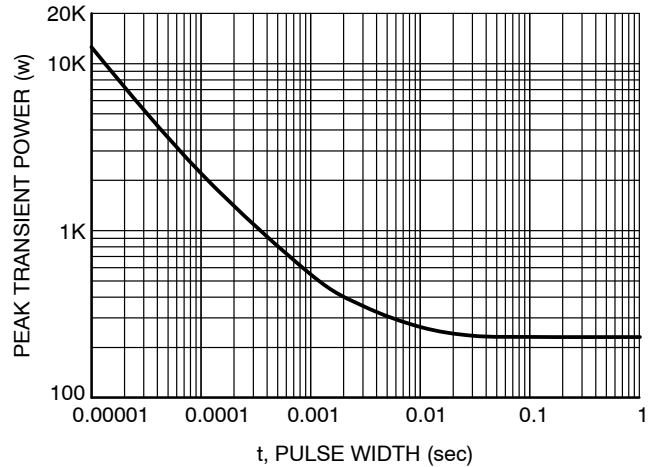


Figure 16. Single Pulse Maximum Power Dissipation

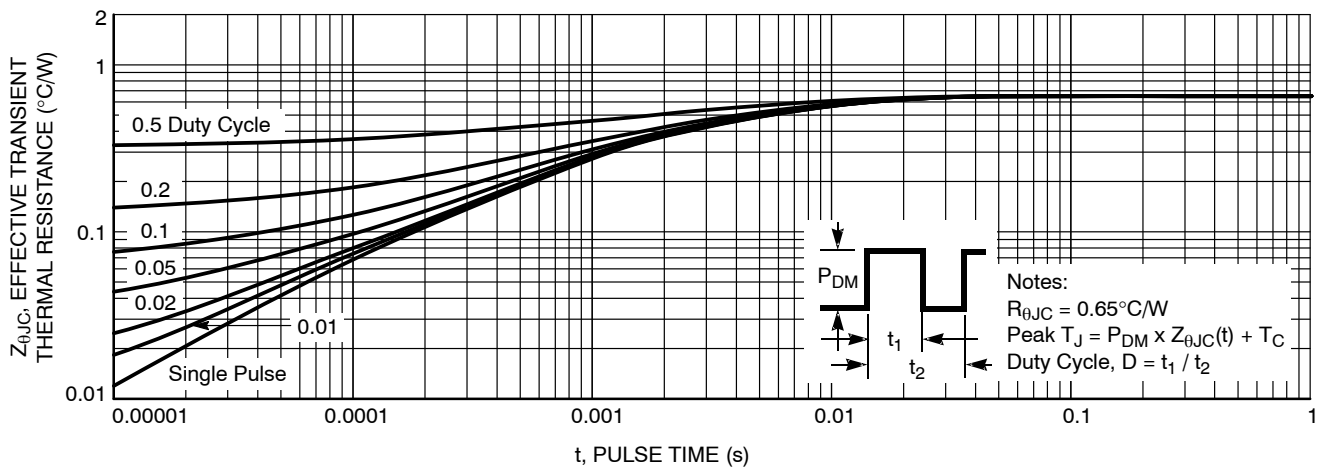
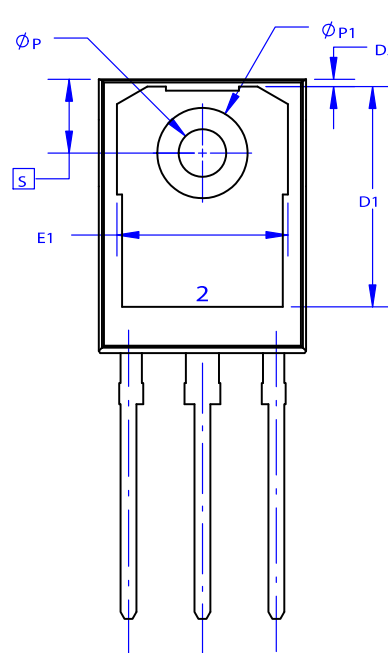
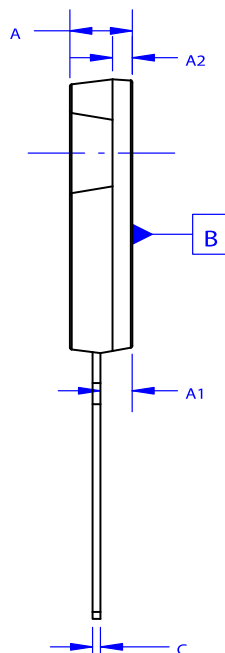
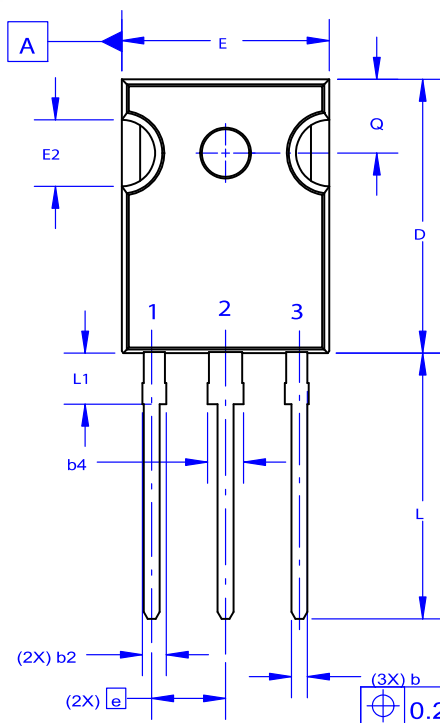
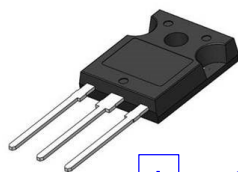


Figure 17. Junction-to-Case Transient Thermal Response

**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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