

# Silicon Carbide (SiC) MOSFET – EliteSiC, 22 mohm, 1200 V, M3S, D<sup>2</sup>PAK-7L

## NVBG022N120M3S

### Features

- Typ.  $R_{DS(on)} = 22\text{ m}\Omega$  @  $V_{GS} = 18\text{ V}$
- Ultra Low Gate Charge ( $Q_{G(tot)} = 142\text{ nC}$ )
- High Speed Switching with Low Capacitance ( $C_{oss} = 146\text{ pF}$ )
- 100% Avalanche Tested
- AEC-Q101 Qualified and PPAP Capable
- These Devices are RoHS Compliant

### Typical Applications

- Automotive On Board Charger
- Automotive DC/DC Converter for EV/HEV

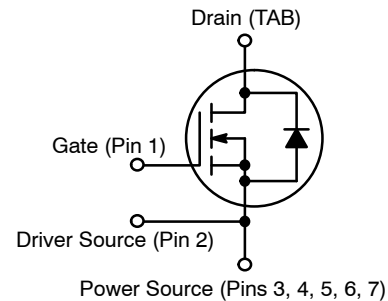
### MAXIMUM RATINGS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

| Parameter                                                                                               |                            |                             | Symbol         | Value       | Unit               |
|---------------------------------------------------------------------------------------------------------|----------------------------|-----------------------------|----------------|-------------|--------------------|
| Drain-to-Source Voltage                                                                                 |                            |                             | $V_{DSS}$      | 1200        | V                  |
| Gate-to-Source Voltage                                                                                  |                            |                             | $V_{GS}$       | -10/+22     | V                  |
| Recommended Operation Values of Gate-to-Source Voltage                                                  |                            | $T_C < 175^{\circ}\text{C}$ | $V_{GSop}$     | -3/+18      | V                  |
| Continuous Drain Current (Notes 2, 3)                                                                   | Steady State               | $T_C = 25^{\circ}\text{C}$  | $I_D$          | 100         | A                  |
| Power Dissipation (Note 2)                                                                              |                            |                             | $P_D$          | 441         | W                  |
| Continuous Drain Current (Notes 2, 3)                                                                   | Steady State               | $T_C = 100^{\circ}\text{C}$ | $I_D$          | 71          | A                  |
| Power Dissipation (Note 2)                                                                              |                            |                             | $P_D$          | 220         | W                  |
| Pulsed Drain Current (Note 4)                                                                           | $T_C = 25^{\circ}\text{C}$ |                             | $I_{DM}$       | 297         | A                  |
| Operating Junction and Storage Temperature Range                                                        |                            |                             | $T_J, T_{stg}$ | -55 to +175 | $^{\circ}\text{C}$ |
| Source Current (Body Diode)<br>$T_C = 25^{\circ}\text{C}, V_{GS} = -3\text{ V}$ (Note 2)                |                            |                             | $I_S$          | 89          | A                  |
| Single Pulse Drain-to-Source Avalanche Energy ( $I_{L(pk)} = 23.1\text{ A}, L = 1\text{ mH}$ ) (Note 5) |                            |                             | $E_{AS}$       | 267         | mJ                 |
| Maximum Temperature for Soldering (10 s)                                                                |                            |                             | $T_L$          | 270         | $^{\circ}\text{C}$ |

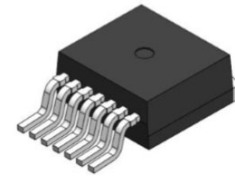
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Surface mounted on a FR-4 board using 1 in<sup>2</sup> pad of 2 oz copper.
2. The entire application environment impacts the thermal resistance values shown, they are not constants and are only valid for the particular conditions noted.
3. The maximum current rating is based on typical  $R_{DS(on)}$  performance.
4. Repetitive rating, limited by max junction temperature.
5.  $E_{AS}$  of 264 mJ is based on starting  $T_J = 25^\circ\text{C}$ ;  $L = 1\text{ mH}$ ,  $I_{AS} = 23.1\text{ A}$ ,  $V_{DD} = 100\text{ V}$ ,  $V_{GS} = 18\text{ V}$ .

| $V_{(BR)DSS}$ | $R_{DS(on)}\text{ MAX}$ | $I_D\text{ MAX}$ |
|---------------|-------------------------|------------------|
| 1200 V        | 30 m $\Omega$ @ 18 V    | 100 A            |

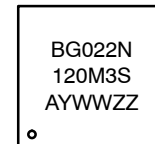


N-CHANNEL MOSFET



D<sup>2</sup>PAK-7L  
CASE 418BJ

### MARKING DIAGRAM



BG022N120M3S = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Lot Traceability

### ORDERING INFORMATION

| Device         | Package               | Shipping          |
|----------------|-----------------------|-------------------|
| NVBG022N120M3S | D <sup>2</sup> PAK-7L | 800 / Tape & Reel |

# THERMAL CHARACTERISTICS

| Parameter                                       | Symbol          | Max  | Unit |
|-------------------------------------------------|-----------------|------|------|
| Junction-to-Case – Steady State (Note 2)        | $R_{\theta JC}$ | 0.34 | °C/W |
| Junction-to-Ambient – Steady State (Notes 1, 2) | $R_{\theta JA}$ | 40   |      |

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

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------|--------|----------------|-----|-----|-----|------|
|-----------|--------|----------------|-----|-----|-----|------|

## 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 7) | –    | 0.3 | –       | V/°C          |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$         | $V_{GS} = 0\text{ V}, V_{DS} = 1200\text{ V}$                     | –    | –   | 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

|                               |              |                                                                               |      |      |     |                  |
|-------------------------------|--------------|-------------------------------------------------------------------------------|------|------|-----|------------------|
| Gate Threshold Voltage        | $V_{GS(TH)}$ | $V_{GS} = V_{DS}, I_D = 20\text{ mA}$                                         | 2.04 | 2.72 | 4.4 | V                |
| Recommended Gate Voltage      | $V_{GOP}$    |                                                                               | –3   | –    | +18 | V                |
| Drain-to-Source On Resistance | $R_{DS(on)}$ | $V_{GS} = 18\text{ V}, I_D = 40\text{ A}, T_J = 25^{\circ}\text{C}$           | –    | 22   | 30  | $\text{m}\Omega$ |
|                               |              | $V_{GS} = 18\text{ V}, I_D = 40\text{ A}, T_J = 175^{\circ}\text{C}$ (Note 7) | –    | 44   | –   |                  |
| Forward Transconductance      | $g_{FS}$     | $V_{DS} = 10\text{ V}, I_D = 40\text{ A}$ (Note 7)                            | –    | 34   | –   | S                |

## CHARGES, CAPACITANCES & GATE RESISTANCE

|                              |              |                                                                                |   |      |   |             |
|------------------------------|--------------|--------------------------------------------------------------------------------|---|------|---|-------------|
| Input Capacitance            | $C_{ISS}$    | $V_{GS} = 0\text{ V}, f = 1\text{ MHz}, V_{DS} = 800\text{ V}$ (Note 7)        | – | 3175 | – | $\text{pF}$ |
| Output Capacitance           | $C_{OSS}$    |                                                                                | – | 146  | – |             |
| Reverse Transfer Capacitance | $C_{RSS}$    |                                                                                | – | 14   | – |             |
| Total Gate Charge            | $Q_{G(TOT)}$ | $V_{GS} = -3/18\text{ V}, V_{DS} = 800\text{ V}, I_D = 40\text{ A}$ , (Note 7) | – | 142  | – | $\text{nC}$ |
| Threshold Gate Charge        | $Q_{G(TH)}$  |                                                                                | – | 11   | – |             |
| Gate-to-Source Charge        | $Q_{GS}$     |                                                                                | – | 16   | – |             |
| Gate-to-Drain Charge         | $Q_{GD}$     |                                                                                | – | 38   | – |             |
| Gate-Resistance              | $R_G$        | $f = 1\text{ MHz}$                                                             | – | 1.5  | – | $\Omega$    |

## SWITCHING CHARACTERISTICS

|                         |              |                                                                                                                             |   |     |   |               |
|-------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------|---|-----|---|---------------|
| Turn-On Delay Time      | $t_{d(ON)}$  | $V_{GS} = -3/18\text{ V}, V_{DS} = 800\text{ V}, I_D = 40\text{ A}, R_G = 4.5\text{ }\Omega$<br>inductive load (Notes 6, 7) | – | 18  | – | $\text{ns}$   |
| Rise Time               | $t_r$        |                                                                                                                             | – | 24  | – |               |
| Turn-Off Delay Time     | $t_{d(OFF)}$ |                                                                                                                             | – | 47  | – |               |
| Fall Time               | $t_f$        |                                                                                                                             | – | 14  | – |               |
| Turn-On Switching Loss  | $E_{ON}$     |                                                                                                                             | – | 485 | – | $\mu\text{J}$ |
| Turn-Off Switching Loss | $E_{OFF}$    |                                                                                                                             | – | 220 | – |               |
| Total Switching Loss    | $E_{tot}$    |                                                                                                                             | – | 705 | – |               |

## SOURCE-DRAIN DIODE CHARACTERISTICS

|                                                        |           |                                                                        |   |     |     |   |
|--------------------------------------------------------|-----------|------------------------------------------------------------------------|---|-----|-----|---|
| Continuous Source-Drain Diode Forward Current (Note 2) | $I_{SD}$  | $V_{GS} = -3\text{ V}, T_C = 25^{\circ}\text{C}$ (Note 7)              | – | –   | 89  | A |
| Pulsed Source-Drain Diode Forward Current (Note 4)     | $I_{SDM}$ |                                                                        | – | –   | 297 |   |
| Forward Diode Voltage                                  | $V_{SD}$  | $V_{GS} = -3\text{ V}, I_{SD} = 40\text{ A}, T_J = 25^{\circ}\text{C}$ | – | 4.5 | –   | V |

# NVBG022N120M3S

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

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------|--------|----------------|-----|-----|-----|------|
|-----------|--------|----------------|-----|-----|-----|------|

### SOURCE-DRAIN DIODE CHARACTERISTICS

|                               |           |                                                                                                                                     |   |     |   |               |
|-------------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------|---|-----|---|---------------|
| Reverse Recovery Time         | $t_{RR}$  | $V_{GS} = -3/18\text{ V}$ , $I_{SD} = 40\text{ A}$ ,<br>$di_S/dt = 1000\text{ A}/\mu\text{s}$ , $V_{DS} = 800\text{ V}$<br>(Note 7) | – | 23  | – | ns            |
| Reverse Recovery Charge       | $Q_{RR}$  |                                                                                                                                     | – | 146 | – | nC            |
| Reverse Recovery Energy       | $E_{REC}$ |                                                                                                                                     | – | 5   | – | $\mu\text{J}$ |
| Peak Reverse Recovery Current | $I_{RRM}$ |                                                                                                                                     | – | 13  | – | A             |
| Charge time                   | $t_A$     |                                                                                                                                     | – | 13  | – | ns            |
| Discharge time                | $t_B$     |                                                                                                                                     | – | 10  | – | 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.

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

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

TYPICAL CHARACTERISTICS

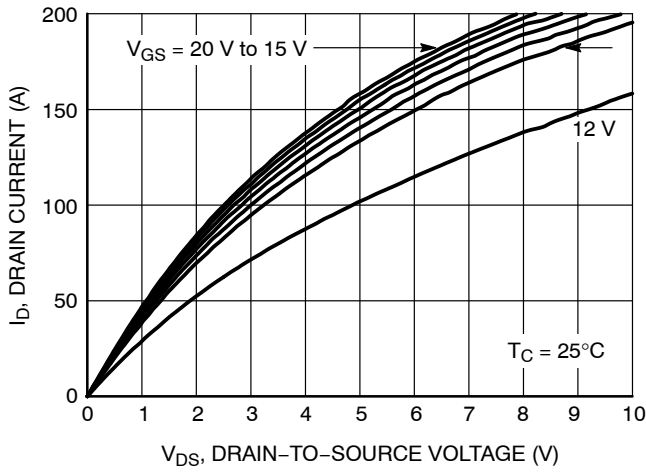


Figure 1. On-Region Characteristics

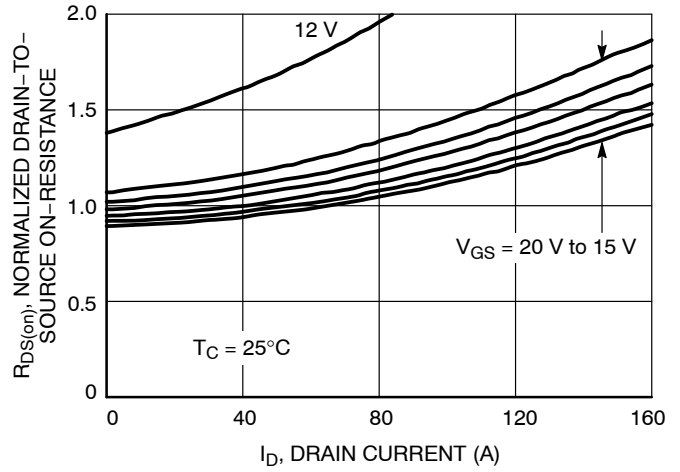


Figure 2. Normalized On-Resistance vs. Drain Current and Gate Voltage

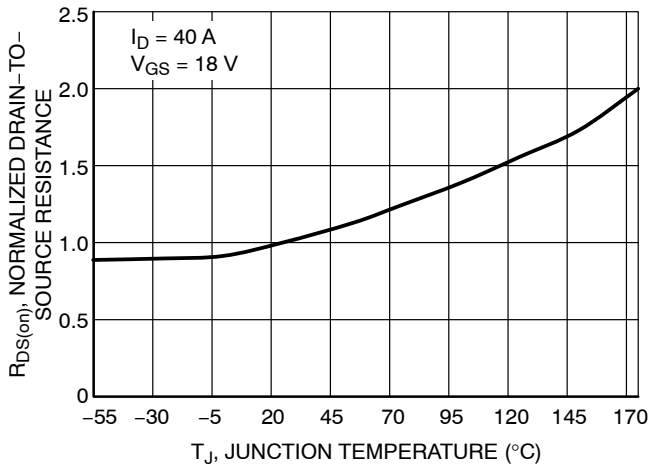


Figure 3. On-Resistance Variation with Temperature

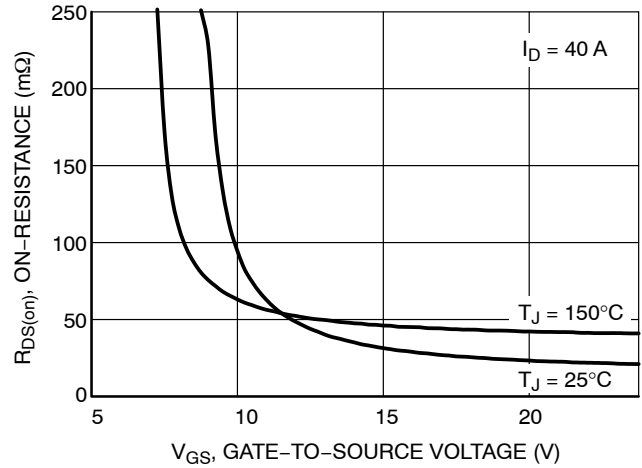


Figure 4. On-Resistance vs. Gate-to-Source Voltage

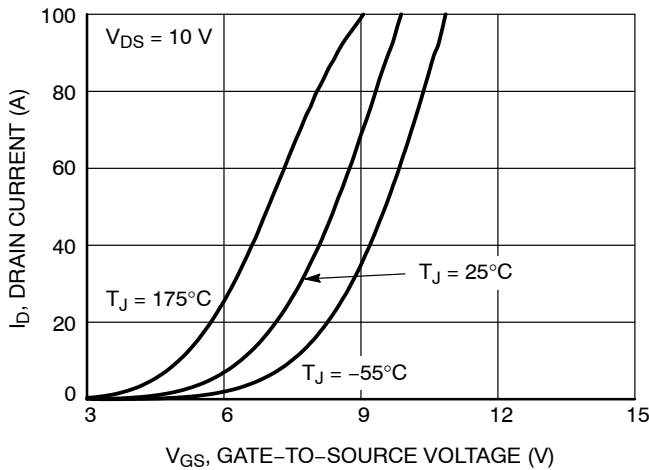


Figure 5. Transfer Characteristics

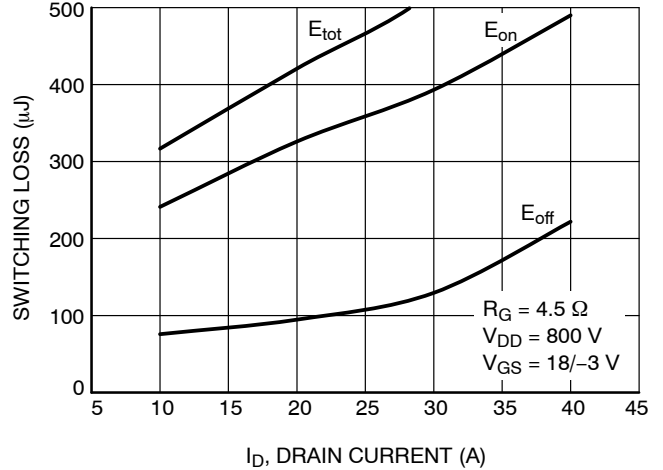


Figure 6. Switching Loss vs. Drain Current

TYPICAL CHARACTERISTICS

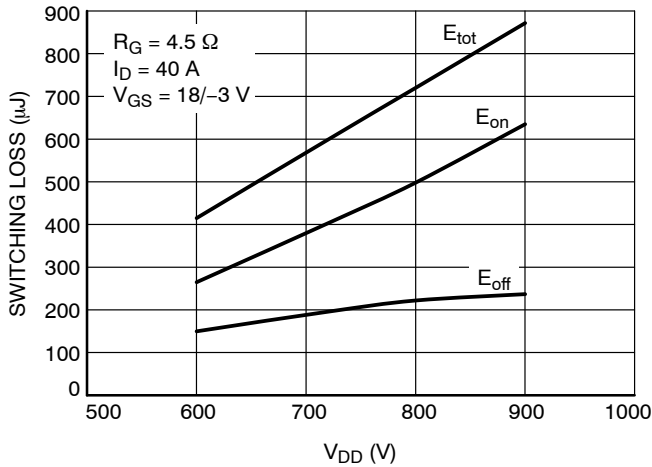


Figure 7. Switching Loss vs. Drain Voltage

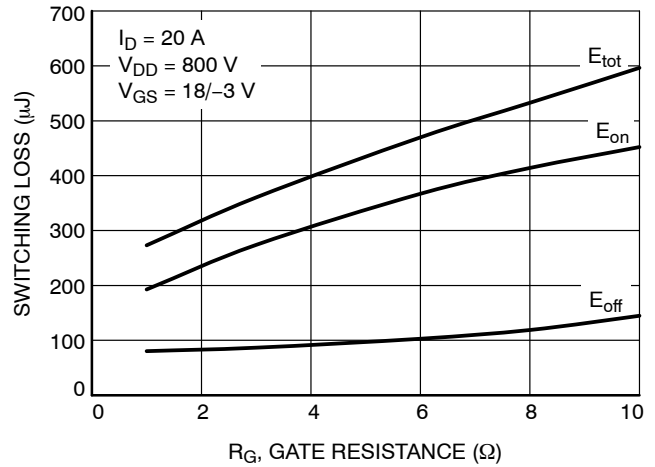


Figure 8. Switching Loss vs. Gate Resistance

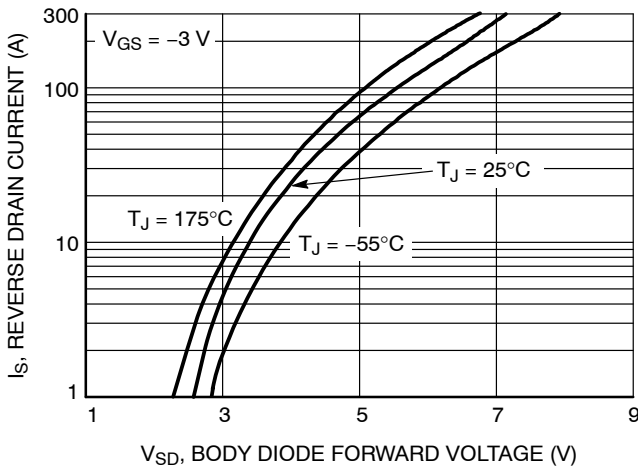


Figure 9. Diode Forward Voltage vs. Current

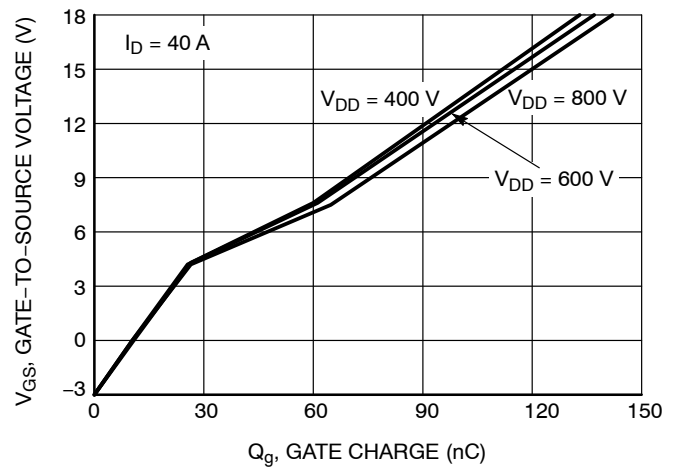


Figure 10. Gate-to-Source Voltage vs. Total Charge

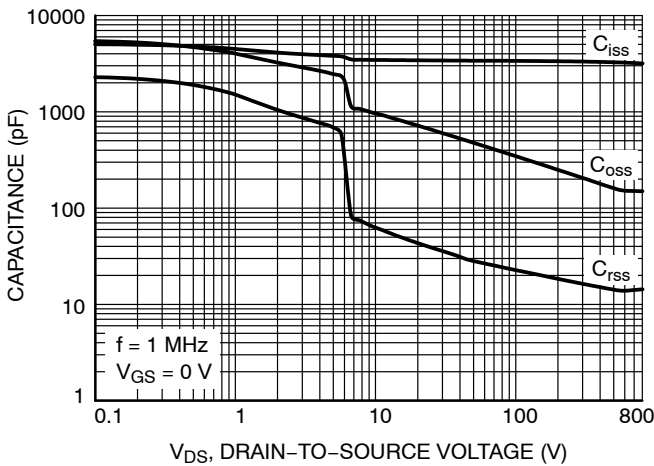


Figure 11. Capacitance vs. Drain-to-Source Voltage

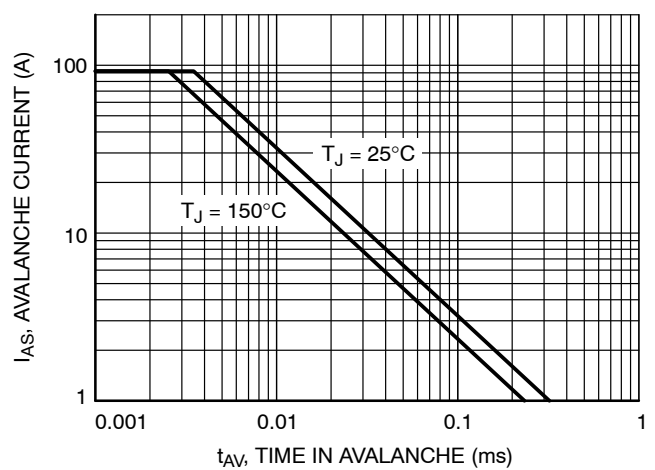


Figure 12. Unclamped Inductive Switching Capability

TYPICAL CHARACTERISTICS

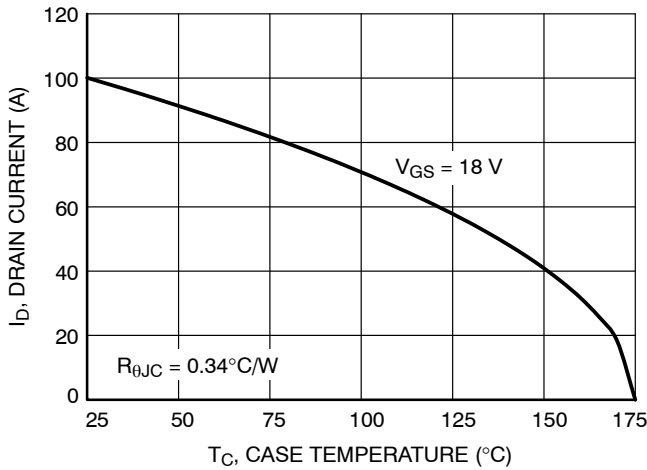


Figure 13. Maximum Continuous Drain Current vs. Case Temperature

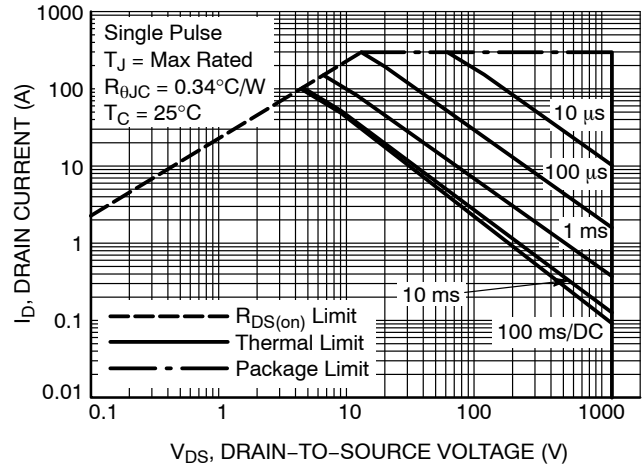


Figure 14. Safe Operating Area

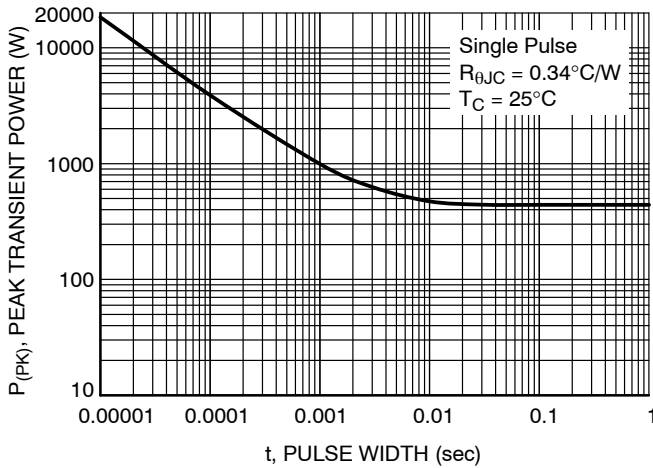


Figure 15. Single Pulse Maximum Power Dissipation

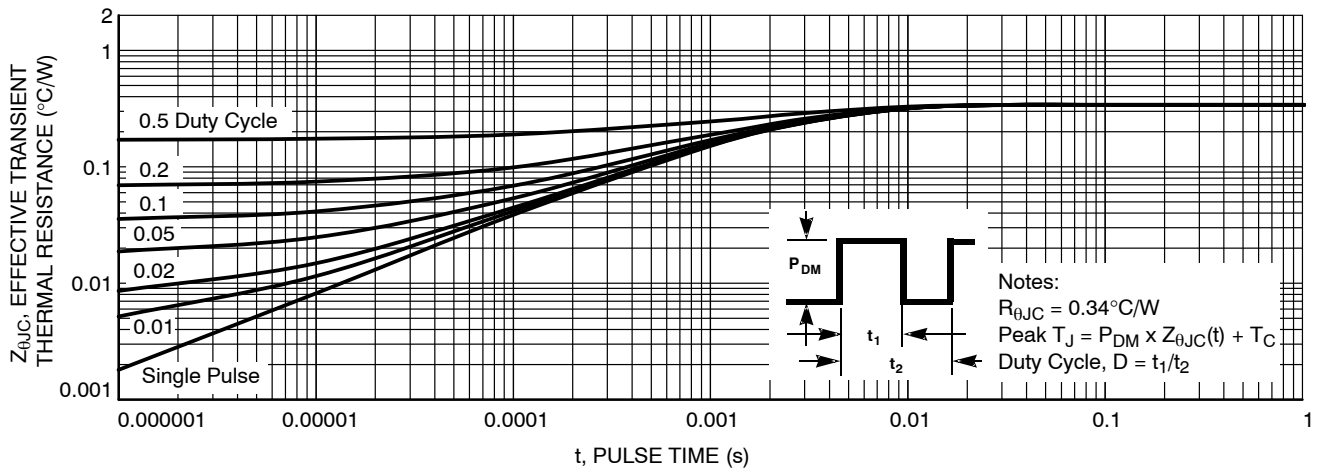
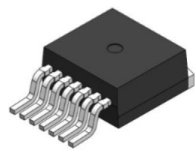


Figure 16. Junction-to-Case Transient Thermal Response

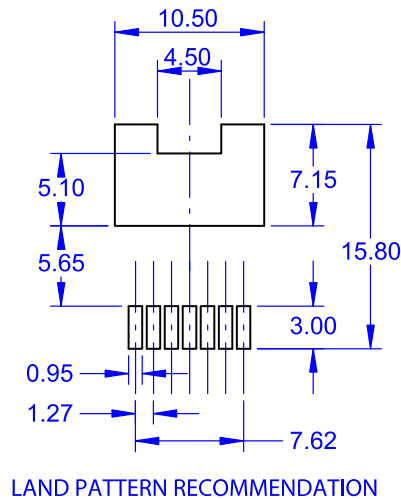
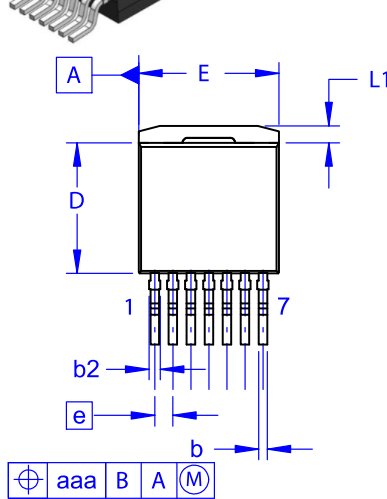
# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS



**D<sup>2</sup>PAK7 (TO-263-7L HV)**  
CASE 418BJ  
ISSUE B

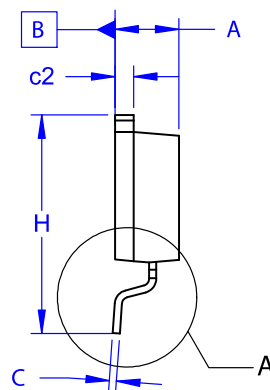
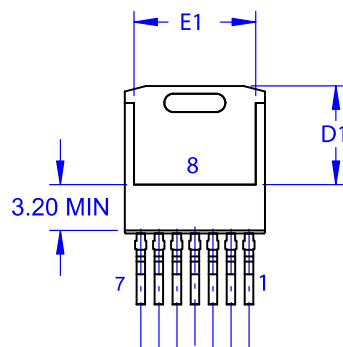
DATE 16 AUG 2019



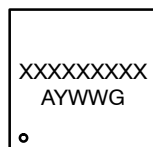
### NOTES:

- A. PACKAGE CONFORMS TO JEDEC TO-263 VARIATION CB EXCEPT WHERE NOTED.
- B. ALL DIMENSIONS ARE IN MILLIMETERS.
- C. OUT OF JEDEC STANDARD VALUE.
- D. DIMENSION AND TOLERANCE AS PER ASME Y14.5-2009.
- E. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR PROTRUSIONS.

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN         | NOM   | MAX   |
| A   | 4.30        | 4.50  | 4.70  |
| A1  | 0.00        | 0.10  | 0.20  |
| b2  | 0.60        | 0.70  | 0.80  |
| b   | 0.51        | 0.60  | 0.70  |
| c   | 0.40        | 0.50  | 0.60  |
| c2  | 1.20        | 1.30  | 1.40  |
| D   | 9.00        | 9.20  | 9.40  |
| D1  | 6.15        | 6.80  | 7.15  |
| E   | 9.70        | 9.90  | 10.20 |
| E1  | 7.15        | 7.65  | 8.15  |
| e   | ~           | 1.27  | ~     |
| H   | 15.10       | 15.40 | 15.70 |
| L   | 2.44        | 2.64  | 2.84  |
| L1  | 1.00        | 1.20  | 1.40  |
| L3  | ~           | 0.25  | ~     |
| aaa | ~           | ~     | 0.25  |

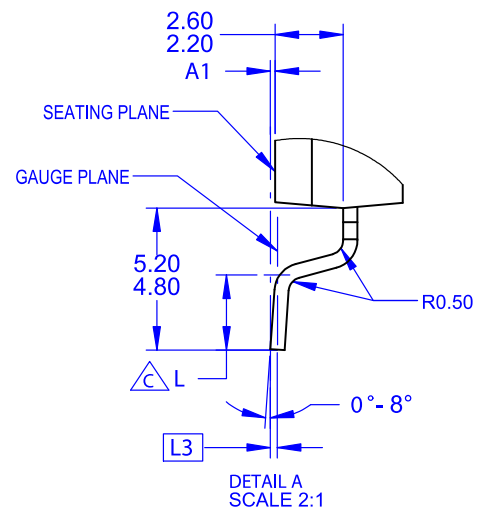


### GENERIC MARKING DIAGRAM\*



XXXX = 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.



|                         |                                         |                                                                                                                                                                                     |
|-------------------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| <b>DESCRIPTION:</b>     | <b>D<sup>2</sup>PAK7 (TO-263-7L HV)</b> | <b>PAGE 1 OF 1</b>                                                                                                                                                                  |

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