

# Silicon Carbide (SiC) MOSFET – 22 mohm, 1200 V, M3S, TO-247-4L

## NVH4L022N120M3S

### Features

- Typ.  $R_{DS(on)}$  = 22 m $\Omega$  @  $V_{GS}$  = 18 V
- Ultra Low Gate Charge ( $Q_{G(tot)}$  = 151 nC)
- High Speed Switching with Low Capacitance ( $C_{OSS}$  = 244 pF)
- 100% Avalanche Tested
- AEC-Q101 Qualified and PPAP Capable
- This Device is Halide Free and RoHS Compliant with exemption 7a, Pb-Free 2LI (on second level interconnection)

### Typical Applications

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

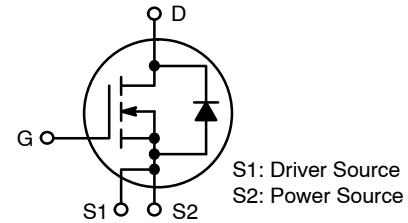
### MAXIMUM RATINGS ( $T_J$ = 25°C unless otherwise noted)

| 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                                     |                          | $T_C < 175^\circ\text{C}$<br>$V_{GSop}$ | -3/+18      | V                |   |
| Continuous Drain Current (Note 1)  | Steady State             | $T_C = 25^\circ\text{C}$                | $I_D$       | 68               | A |
|  |                          |   | $P_D$       | 352              | W |
| Power Dissipation (Note 1)   | Steady State             | $T_C = 100^\circ\text{C}$               | $I_D$       | 48               | A |
|  |                          |   | $P_D$       | 176              | W |
| Continuous Drain Current (Note 1)  | Steady State             | $T_C = 100^\circ\text{C}$               | $I_D$       | 48               | A |
| Power Dissipation (Note 1)   | Steady State             | $T_C = 100^\circ\text{C}$               | $P_D$       | 176              | W |
| Pulsed Drain Current (Note 2)  | $T_C = 25^\circ\text{C}$ |   | $I_{DM}$    | 246              | A |
| Operating Junction and Storage Temperature Range   |                          | $T_J, T_{stg}$                          | -55 to +175 | $^\circ\text{C}$ |   |
| Source Current (Body Diode)<br>$T_C = 25^\circ\text{C}$ $V_{GS} = -3$ V                    |                          | $I_S$                                   | 72          | A                |   |
| Single Pulse Drain-to-Source Avalanche Energy ( $I_{L(pk)} = 23.1$ A, $L = 1$ mH) (Note 3) |                          | $E_{AS}$                                | 267         | mJ               |   |
| Maximum Lead Temperature for Soldering (1/8" from case for 5 s)                            |                          | $T_L$                                   | 300         | $^\circ\text{C}$ |   |

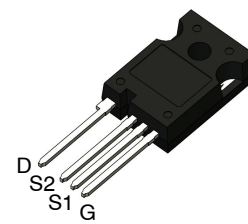
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

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.  $E_{AS}$  of 267 mJ is based on starting  $T_J = 25^\circ\text{C}$ ;  $L = 1$  mH,  $I_{AS} = 23.1$  A,  $V_{DD} = 100$  V,  $V_{GS} = 18$  V.

| $V_{(BR)DSS}$ | $R_{DS(ON)}$ MAX     | $I_D$ MAX |
|---------------|----------------------|-----------|
| 1200 V        | 30 m $\Omega$ @ 18 V | 68 A      |

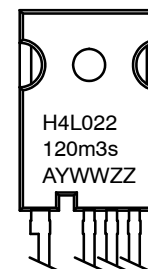


N-CHANNEL MOSFET



TO247-4L  
CASE 340CJ

### MARKING DIAGRAM



H4L022120M3S = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Lot Traceability

### ORDERING INFORMATION

| Device          | Package  | Shipping        |
|-----------------|----------|-----------------|
| NVH4L022N120M3S | TO247-4L | 30 Units / Tube |

# NVH4L022N120M3S

**Table 1. THERMAL CHARACTERISTICS**

| Parameter                                   | Symbol          | Max  | Unit |
|---|-----------------|------|------|
| Junction-to-Case – Steady State (Note 1)    | $R_{\theta JC}$ | 0.43 | °C/W |
| Junction-to-Ambient – Steady State (Note 1) | $R_{\theta JA}$ | 40   |      |

**Table 2. ELECTRICAL CHARACTERISTICS** ( $T_J = 25^\circ\text{C}$  unless otherwise specified)

| Parameter   | Symbol            | Test Condition  | Min                | Typ  | Max     | Unit             |
|---|-------------------|---|--------------------|------|---------|------------------|
| <b>OFF-STATE CHARACTERISTICS</b>                          |                   |   |                    |      |         |                  |
| 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 $25^\circ\text{C}$  | -                  | 0.3  | -       | V/°C             |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$         | $V_{GS} = 0\text{ V}, V_{DS} = 1200\text{ V}$ <span style="margin-left: 20px;"><math>T_J = 25^\circ\text{C}</math></span> | -                  | -    | 100     | $\mu\text{A}$    |
| Gate-to-Source Leakage Current                            | $I_{GSS}$         | $V_{GS} = +22/-10\text{ V}, V_{DS} = 0\text{ V}$  | -                  | -    | $\pm 1$ | $\mu\text{A}$    |
| <b>ON-STATE CHARACTERISTICS</b> (Note 2)                  |                   |   |                    |      |         |                  |
| 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      | $\text{m}\Omega$ |
|   |                   | $V_{GS} = 18\text{ V}, I_D = 40\text{ A}, T_J = 175^\circ\text{C}$  | -                  | 47   | -       |                  |
| Forward Transconductance                                  | $g_{FS}$          | $V_{DS} = 10\text{ V}, I_D = 40\text{ A}$   | -                  | 34   | -       | S                |
| <b>CHARGES, CAPACITANCES &amp; GATE RESISTANCE</b>        |                   |   |                    |      |         |                  |
| Input Capacitance   | $C_{ISS}$         | $V_{GS} = 0\text{ V}, f = 1\text{ MHz}, V_{DS} = 800\text{ V}$  | -                  | 3175 | -       | $\text{pF}$      |
| Output Capacitance  | $C_{OSS}$         |   | -                  | 146  | -       |                  |
| Reverse Transfer Capacitance                              | $C_{RSS}$         |   | -                  | 12   | -       |                  |
| Total Gate Charge   | $Q_{G(TOT)}$      | $V_{GS} = -3/18\text{ V}, V_{DS} = 800\text{ V}, I_D = 40\text{ A}$   | -                  | 151  | -       | $\text{nC}$      |
| Threshold Gate Charge                                     | $Q_{G(TH)}$       |   | -                  | 20   | -       |                  |
| Gate-to-Source Charge                                     | $Q_{GS}$          |   | -                  | 34   | -       |                  |
| Gate-to-Drain Charge                                      | $Q_{GD}$          |   | -                  | 40   | -       |                  |
| Gate-Resistance   | $R_G$             |   | $f = 1\text{ MHz}$ | -    | 1.5     |                  |
| <b>SWITCHING CHARACTERISTICS</b>                          |                   |   |                    |      |         |                  |
| Turn-On Delay Time  | $t_{d(ON)}$       | $V_{GS} = -3/18\text{ V}, V_{DS} = 800\text{ V}, I_D = 40\text{ A}, R_G = 4.5\ \Omega$<br>Inductive Load (Note 4)         | -                  | 18   | -       | ns               |
| Rise Time   | $t_r$             |   | -                  | 24   | -       |                  |
| Turn-Off Delay Time                                       | $t_{d(OFF)}$      |   | -                  | 48   | -       |                  |
| Fall Time   | $t_f$             |   | -                  | 13   | -       |                  |
| Turn-On Switching Loss                                    | $E_{ON}$          |   | -                  | 490  | -       | $\mu\text{J}$    |
| Turn-Off Switching Loss                                   | $E_{OFF}$         |   | -                  | 221  | -       |                  |
| Total Switching Loss                                      | $E_{tot}$         |   | -                  | 711  | -       |                  |
| <b>SOURCE-DRAIN DIODE CHARACTERISTICS</b>                 |                   |   |                    |      |         |                  |
| Continuous Source-Drain Diode Forward Current             | $I_{SD}$          | $V_{GS} = -3\text{ V}, T_C = 25^\circ\text{C}$  | -                  | -    | 72      | A                |
| Pulsed Source-Drain Diode Forward Current (Note 2)        | $I_{SDM}$         |   | -                  | -    | 246     |                  |
| Forward Diode Voltage                                     | $V_{SD}$          | $V_{GS} = -3\text{ V}, I_{SD} = 40\text{ A}, T_J = 25^\circ\text{C}$  | -                  | 4.5  | -       | V                |

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**Table 2. 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> |           |   |     |     |     |               |
| Reverse Recovery Time                     | $t_{RR}$  | $V_{GS} = -3/18\text{ V}$ , $I_{SD} = 40\text{ A}$ ,<br>$di_S/dt = 1000\text{ A}/\mu\text{s}$ , $V_{DS} = 800\text{ V}$ | -   | 22  | -   | ns            |
| Reverse Recovery Charge                   | $Q_{RR}$  |   | -   | 138 | -   | 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                            | $t_B$     |   | -   | 9   | -   | 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.

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

TYPICAL CHARACTERISTICS

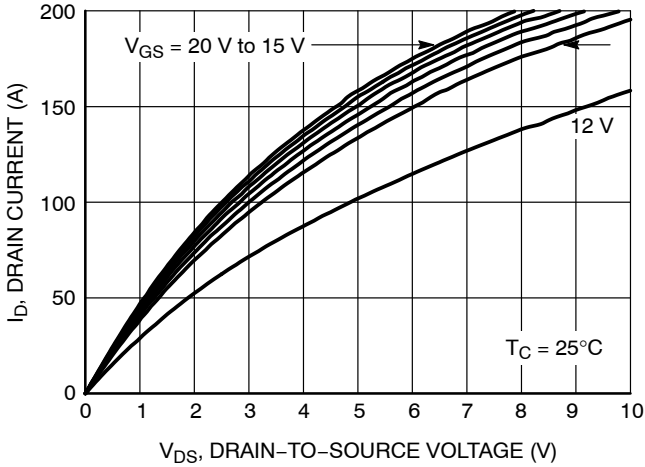


Figure 1. On-Region Characteristics

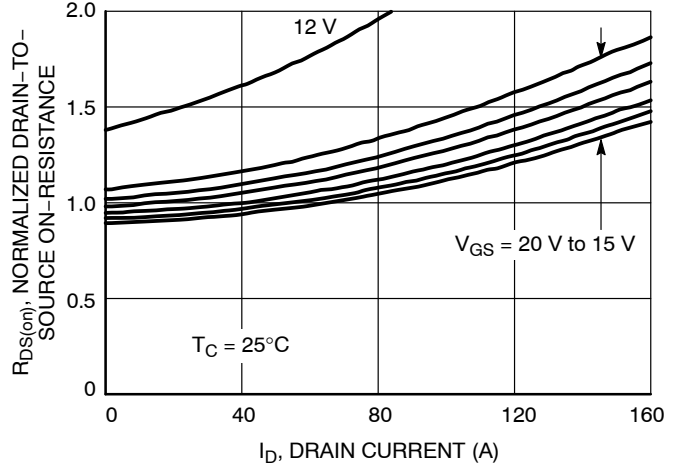


Figure 2. Normalized On-Resistance vs. Drain Current and Gate Voltage

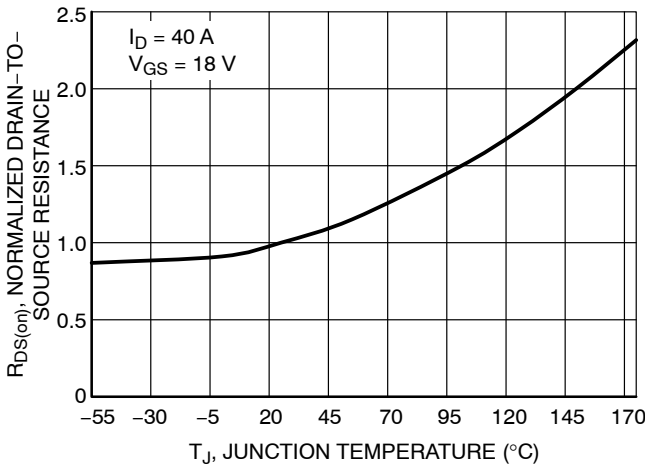


Figure 3. On-Resistance Variation with Temperature

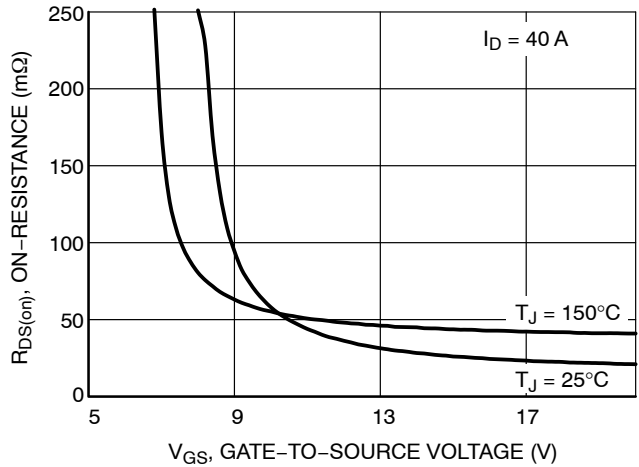


Figure 4. On-Resistance vs. Gate-to-Source Voltage

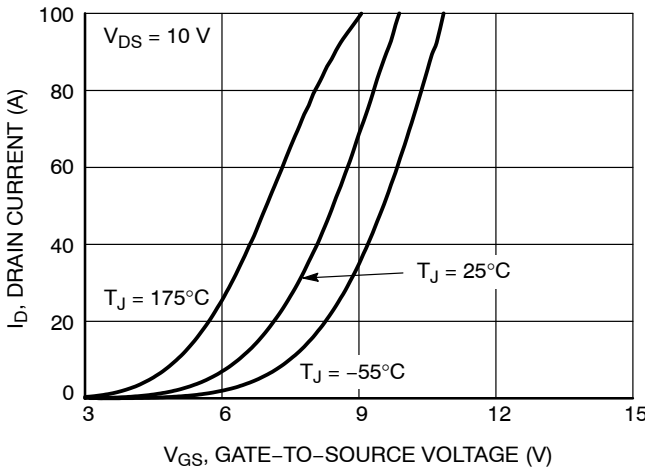


Figure 5. Transfer Characteristics

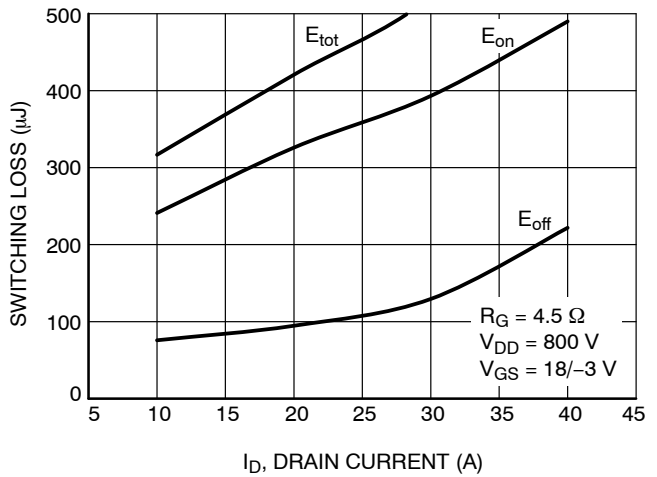


Figure 6. Switching Loss vs. Drain Current

# NVH4L022N120M3S

## TYPICAL CHARACTERISTICS (continued)

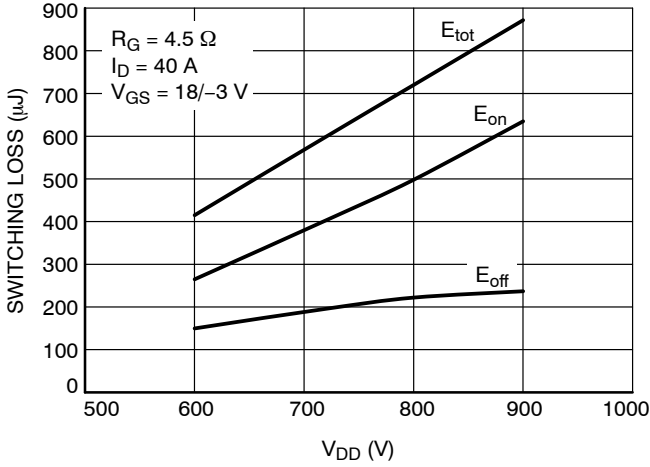


Figure 7. Switching Loss vs. Drain Voltage

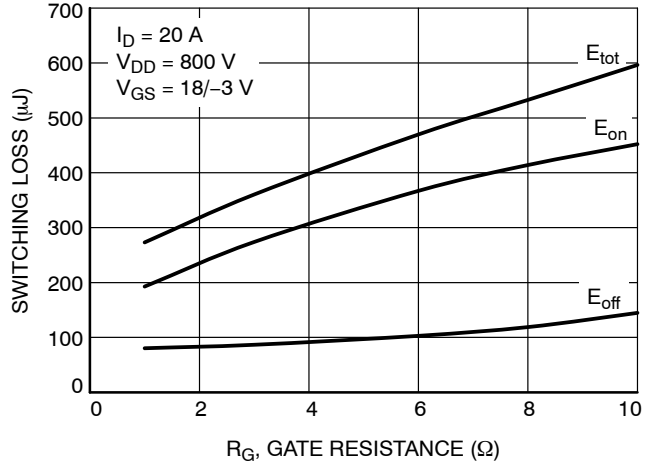


Figure 8. Switching Loss vs. Gate Resistance

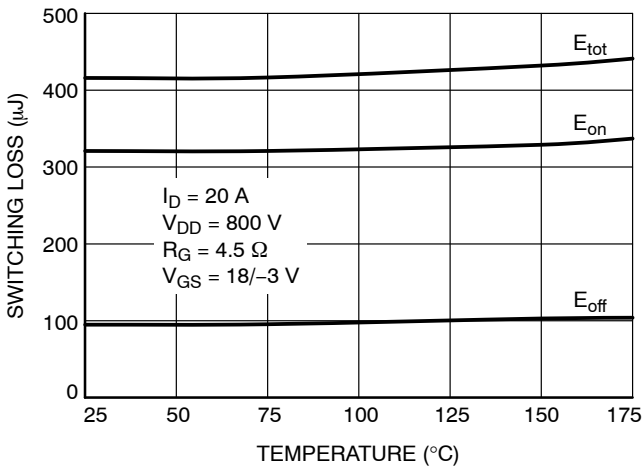


Figure 9. Switching Loss vs. Temperature

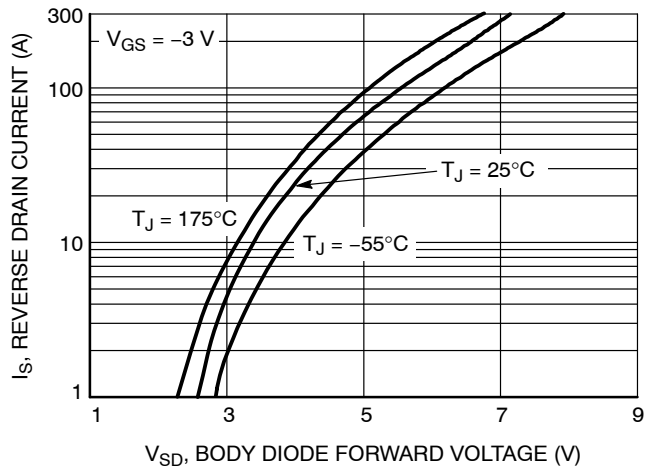


Figure 10. Diode Forward Voltage vs. Current

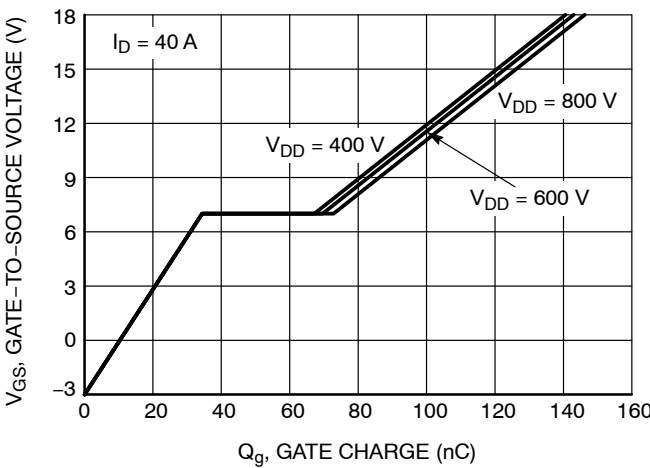


Figure 11. Gate-to-Source Voltage vs. Total Charge

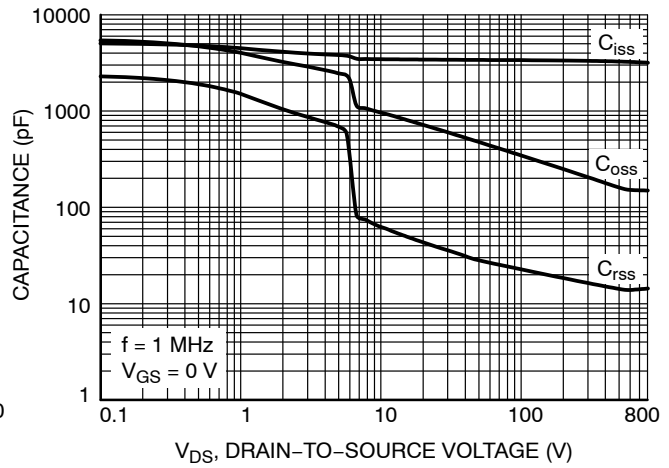
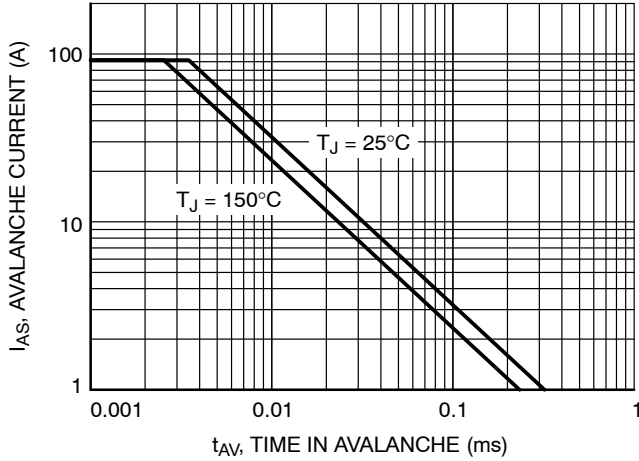


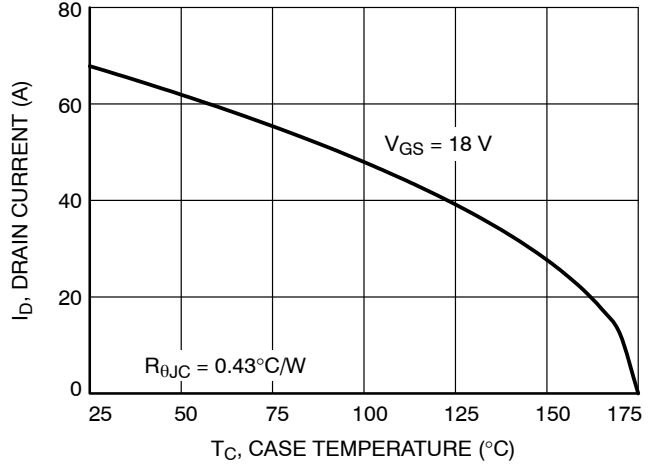
Figure 12. Capacitance vs. Drain-to-Source Voltage

# NVH4L022N120M3S

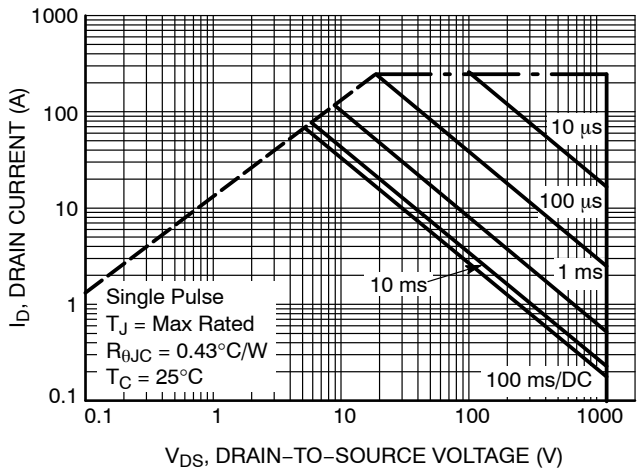
## TYPICAL CHARACTERISTICS (continued)



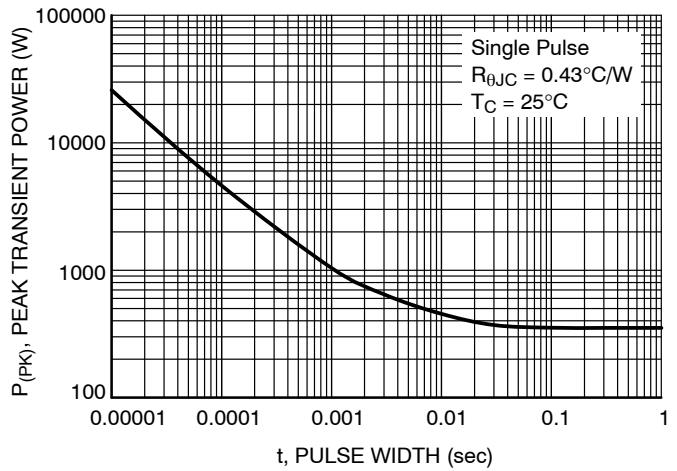
**Figure 13. Unclamped Inductive Switching Capability**



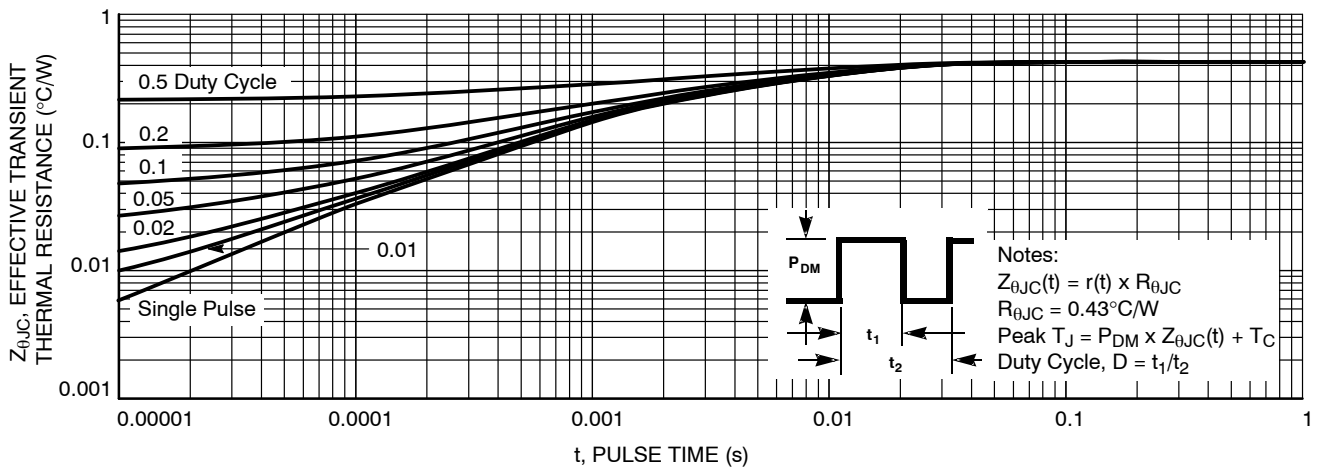
**Figure 14. Maximum Continuous Drain Current vs. Case Temperature**



**Figure 15. Safe Operating Area**



**Figure 16. Single Pulse Maximum Power Dissipation**



**Figure 17. Junction-to-Case Transient Thermal Response**

# MECHANICAL CASE OUTLINE

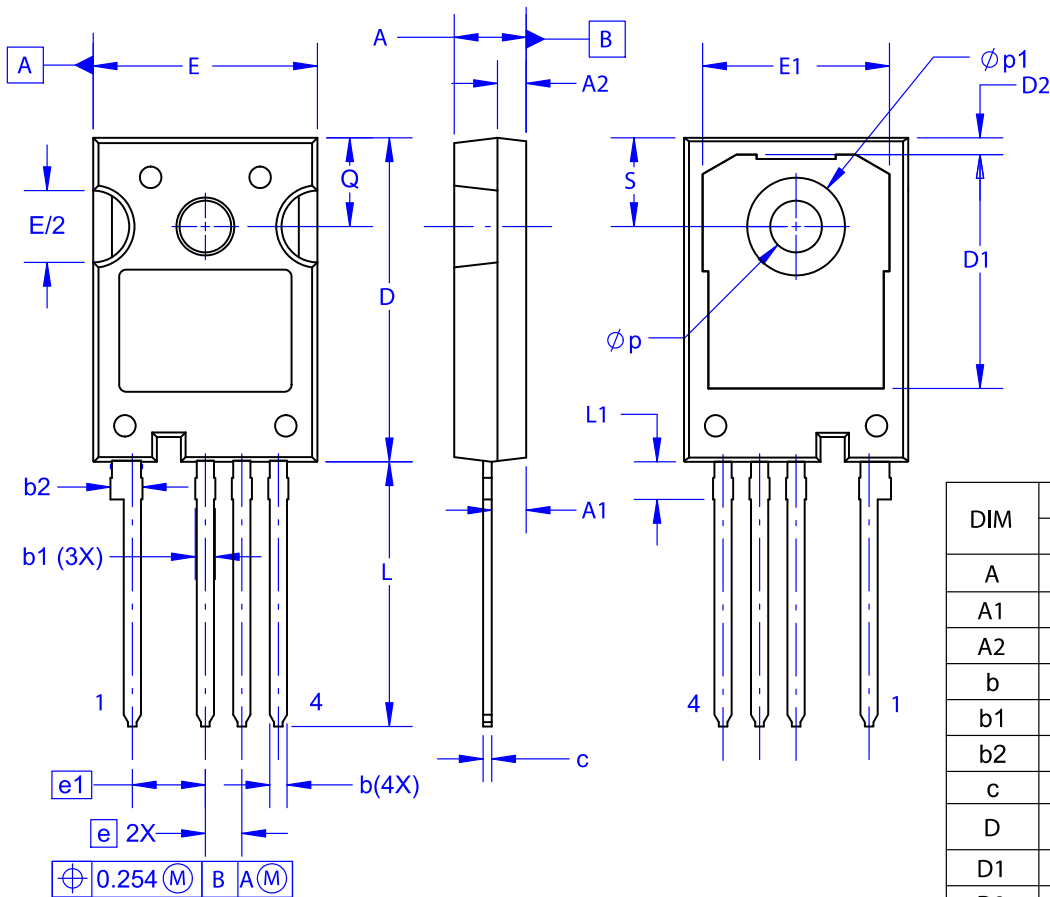
## PACKAGE DIMENSIONS

ON Semiconductor®



TO-247-4LD  
CASE 340CJ  
ISSUE A

DATE 16 SEP 2019



| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN         | NOM   | MAX   |
| A   | 4.80        | 5.00  | 5.20  |
| A1  | 2.10        | 2.40  | 2.70  |
| A2  | 1.80        | 2.00  | 2.20  |
| b   | 1.07        | 1.20  | 1.33  |
| b1  | 1.20        | 1.40  | 1.60  |
| b2  | 2.02        | 2.22  | 2.42  |
| c   | 0.50        | 0.60  | 0.70  |
| D   | 22.34       | 22.54 | 22.74 |
| D1  | 16.00       | 16.25 | 16.50 |
| D2  | 0.97        | 1.17  | 1.37  |
| e   | 2.54 BSC    |       |       |
| e1  | 5.08 BSC    |       |       |
| E   | 15.40       | 15.60 | 15.80 |
| E1  | 12.80       | 13.00 | 13.20 |
| E/2 | 4.80        | 5.00  | 5.20  |
| L   | 18.22       | 18.42 | 18.62 |
| L1  | 2.42        | 2.62  | 2.82  |
| p   | 3.40        | 3.60  | 3.80  |
| p1  | 6.60        | 6.80  | 7.00  |
| Q   | 5.97        | 6.17  | 6.37  |
| S   | 5.97        | 6.17  | 6.37  |

**NOTES:**

- A. NO INDUSTRY STANDARD APPLIES TO THIS PACKAGE.
- B. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.
- C. ALL DIMENSIONS ARE IN MILLIMETERS.
- D. DRAWING CONFORMS TO ASME Y14.5-2009.

|                         |                    |  |
|-------------------------|--------------------|--|
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