



## Features

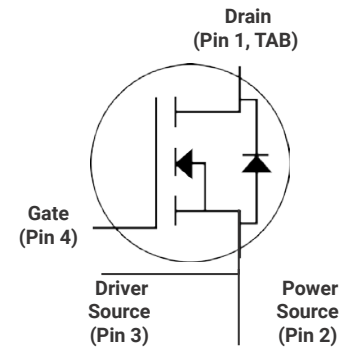
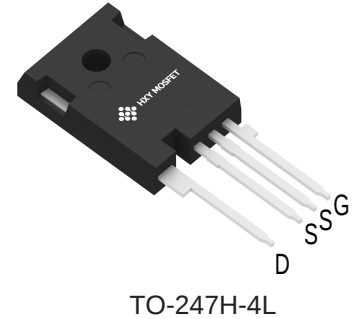
- 3rd generation SiC MOSFET technology
- Optimized package with separate driver source pin
- High blocking voltage with low on-resistance
- High-speed switching with low capacitances
- Fast intrinsic diode with low reverse recovery ( $Q_{rr}$ )
- Halogen free, RoHS compliant

## Benefits

- Reduce switching losses and minimize gate ringing
- Higher system efficiency
- Reduce cooling requirements
- Increase power density
- Increase system switching frequency

## Applications

- EV chargers
- Solar inverters
- UPS
- SMPS
- DC/DC converters



| Ordering Part Number | Package    | Qty(PCS) |
|----------------------|------------|----------|
| NVH4L025N065SC1      | TO-247H-4L | 30       |

## Maximum Ratings ( $T_c = 25^\circ\text{C}$ unless otherwise specified)

| Symbol         | Parameter                                                                    | Value       | Unit             | Note              |
|----------------|------------------------------------------------------------------------------|-------------|------------------|-------------------|
| $V_{DSmax}$    | Drain - Source Voltage                                                       | 650         | V                |                   |
| $V_{GSmax}$    | Gate - Source voltage                                                        | -8/+19      | V                | Note 1            |
| $I_D$          | Continuous Drain Current, $V_{GS} = 15\text{ V}$ , $T_c = 25^\circ\text{C}$  | 120         | A                | Fig. 19<br>Note 2 |
|                | Continuous Drain Current, $V_{GS} = 15\text{ V}$ , $T_c = 100^\circ\text{C}$ | 96          |                  |                   |
| $I_{D(pulse)}$ | Pulsed Drain Current, Pulse width $t_p$ limited by $T_{jmax}$                | 418         | A                |                   |
| $P_D$          | Power Dissipation, $T_c=25^\circ\text{C}$ , $T_j = 175^\circ\text{C}$        | 416         | W                | Fig. 20           |
| $T_j, T_{stg}$ | Operating Junction and Storage Temperature                                   | -40 to +175 | $^\circ\text{C}$ |                   |
| $T_L$          | Solder Temperature, 1.6mm (0.063") from case for 10s                         | 260         | $^\circ\text{C}$ |                   |
| $M_d$          | Mounting Torque, (M3 or 6-32 screw)                                          | 1<br>8.8    | Nm<br>lbf-in     |                   |

Note (1): Recommended turn off / turn on gate voltage  $V_{GS} = -4V \dots 0V / +15V$

Note (2): Package limited to 120 A



Electrical Characteristics ( $T_c = 25^\circ\text{C}$  unless otherwise specified)

| Symbol        | Parameter                                     | Min. | Typ. | Max. | Unit          | Test Conditions                                                                                                                                                                                                | Note           |
|---------------|-----------------------------------------------|------|------|------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| $V_{(BR)DSS}$ | Drain-Source Breakdown Voltage                | 650  |      |      | V             | $V_{GS} = 0\text{ V}, I_D = 100\text{ }\mu\text{A}$                                                                                                                                                            |                |
| $V_{GS(th)}$  | Gate Threshold Voltage                        | 1.8  | 2.3  | 3.6  | V             | $V_{DS} = V_{GS}, I_D = 15.5\text{ mA}$                                                                                                                                                                        | Fig. 11        |
|               |                                               |      | 1.9  |      | V             | $V_{DS} = V_{GS}, I_D = 15.5\text{ mA}, T_J = 175^\circ\text{C}$                                                                                                                                               |                |
| $I_{DSS}$     | Zero Gate Voltage Drain Current               |      | 1    | 50   | $\mu\text{A}$ | $V_{DS} = 650\text{ V}, V_{GS} = 0\text{ V}$                                                                                                                                                                   |                |
| $I_{GSS}$     | Gate-Source Leakage Current                   |      | 10   | 250  | nA            | $V_{GS} = 15\text{ V}, V_{DS} = 0\text{ V}$                                                                                                                                                                    |                |
| $R_{DS(on)}$  | Drain-Source On-State Resistance              | 10.5 | 15   | 21   | m $\Omega$    | $V_{GS} = 15\text{ V}, I_D = 55.8\text{ A}$                                                                                                                                                                    | Fig. 4,<br>5,6 |
|               |                                               |      | 20   |      |               | $V_{GS} = 15\text{ V}, I_D = 55.8\text{ A}, T_J = 175^\circ\text{C}$                                                                                                                                           |                |
| $g_{fs}$      | Transconductance                              |      | 42   |      | S             | $V_{DS} = 20\text{ V}, I_{DS} = 55.8\text{ A}$                                                                                                                                                                 | Fig. 7         |
|               |                                               |      | 40   |      |               | $V_{DS} = 20\text{ V}, I_{DS} = 55.8\text{ A}, T_J = 175^\circ\text{C}$                                                                                                                                        |                |
| $C_{iss}$     | Input Capacitance                             |      | 5011 |      | pF            | $V_{GS} = 0\text{ V}, V_{DS} = 400\text{ V}$<br>$f = 100\text{ KHz}$<br>$V_{AC} = 25\text{ mV}$                                                                                                                | Fig. 17,<br>18 |
| $C_{oss}$     | Output Capacitance                            |      | 289  |      |               |                                                                                                                                                                                                                |                |
| $C_{rss}$     | Reverse Transfer Capacitance                  |      | 31   |      |               |                                                                                                                                                                                                                |                |
| $C_{o(er)}$   | Effective Output Capacitance (Energy Related) |      | 357  |      |               |                                                                                                                                                                                                                | Note: 3        |
| $C_{o(tr)}$   | Effective Output Capacitance (Time Related)   |      | 516  |      |               |                                                                                                                                                                                                                | Note: 3        |
| $E_{oss}$     | $C_{oss}$ Stored Energy                       |      | 29   |      | $\mu\text{J}$ |                                                                                                                                                                                                                | Fig. 16        |
| $E_{ON}$      | Turn-On Switching Energy (Body Diode)         |      | 401  |      | $\mu\text{J}$ | $V_{DS} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}, I_D = 55.8\text{ A},$<br>$R_{G(ext)} = 5\text{ }\Omega, L = 57.6\text{ }\mu\text{H}, T_J = 175^\circ\text{C}$<br>FWD = Internal Body Diode of MOSFET | Fig. 25        |
| $E_{OFF}$     | Turn Off Switching Energy (Body Diode)        |      | 254  |      |               |                                                                                                                                                                                                                |                |
| $E_{ON}$      | Turn-On Switching Energy (External Diode)     |      | 234  |      | $\mu\text{J}$ | $V_{DS} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}, I_D = 55.8\text{ A},$<br>$R_{G(ext)} = 5\text{ }\Omega, L = 57.6\text{ }\mu\text{H}, T_J = 175^\circ\text{C}$<br>FWD = External SiC DIODE            | Fig. 25        |
| $E_{OFF}$     | Turn Off Switching Energy (External Diode)    |      | 303  |      |               |                                                                                                                                                                                                                |                |
| $t_{d(on)}$   | Turn-On Delay Time                            |      | 23   |      | ns            | $V_{DD} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}$<br>$I_D = 55.8\text{ A}, R_{G(ext)} = 5\text{ }\Omega, L = 57.6\text{ }\mu\text{H}$<br>Timing relative to $V_{DS}$<br>Inductive load                 | Fig. 26        |
| $t_r$         | Rise Time                                     |      | 32   |      |               |                                                                                                                                                                                                                |                |
| $t_{d(off)}$  | Turn-Off Delay Time                           |      | 57   |      |               |                                                                                                                                                                                                                |                |
| $t_f$         | Fall Time                                     |      | 15   |      |               |                                                                                                                                                                                                                |                |
| $R_{G(int)}$  | Internal Gate Resistance                      |      | 1.5  |      | $\Omega$      | $f = 1\text{ MHz}, V_{AC} = 25\text{ mV}$                                                                                                                                                                      |                |
| $Q_{gs}$      | Gate to Source Charge                         |      | 53   |      | nC            | $V_{DS} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}$<br>$I_D = 55.8\text{ A}$<br>Per IEC60747-8-4 pg 21                                                                                                   | Fig. 12        |
| $Q_{gd}$      | Gate to Drain Charge                          |      | 58   |      |               |                                                                                                                                                                                                                |                |
| $Q_g$         | Total Gate Charge                             |      | 188  |      |               |                                                                                                                                                                                                                |                |

Note (3):  $C_{o(er)}$ , a lumped capacitance that gives same stored energy as  $C_{oss}$  while  $V_{ds}$  is rising from 0 to 400V

$C_{o(tr)}$ , a lumped capacitance that gives same charging time as  $C_{oss}$  while  $V_{ds}$  is rising from 0 to 400V



Reverse Diode Characteristics ( $T_c = 25^\circ\text{C}$  unless otherwise specified)

| Symbol                | Parameter                        | Typ. | Max. | Unit | Test Conditions                                                                                                                                   | Note          |
|-----------------------|----------------------------------|------|------|------|---------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| $V_{SD}$              | Diode Forward Voltage            | 4.7  |      | V    | $V_{GS} = -4\text{ V}, I_{SD} = 27.9\text{ A}, T_J = 25^\circ\text{C}$                                                                            | Fig. 8, 9, 10 |
|                       |                                  | 4.2  |      | V    | $V_{GS} = -4\text{ V}, I_{SD} = 27.9\text{ A}, T_J = 175^\circ\text{C}$                                                                           |               |
| $I_S$                 | Continuous Diode Forward Current |      | 79   | A    | $V_{GS} = -4\text{ V}, T_c = 25^\circ\text{C}$                                                                                                    |               |
| $I_{S, \text{pulse}}$ | Diode pulse Current              |      | 223  | A    | $V_{GS} = -4\text{ V}$ , pulse width $t_p$ limited by $T_{Jmax}$                                                                                  |               |
| $t_{rr}$              | Reverse Recover time             | 22   |      | ns   | $V_{GS} = -4\text{ V}, I_{SD} = 55.8\text{ A}, V_R = 400\text{ V}$<br>$\text{dif}/\text{dt} = 4000\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$ |               |
| $Q_{rr}$              | Reverse Recovery Charge          | 510  |      | nC   |                                                                                                                                                   |               |
| $I_{rm}$              | Peak Reverse Recovery Current    | 39   |      | A    |                                                                                                                                                   |               |
| $t_{rr}$              | Reverse Recover time             | 26   |      | ns   | $V_{GS} = -4\text{ V}, I_{SD} = 55.8\text{ A}, V_R = 400\text{ V}$<br>$\text{dif}/\text{dt} = 2500\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$ |               |
| $Q_{rr}$              | Reverse Recovery Charge          | 432  |      | nC   |                                                                                                                                                   |               |
| $I_{rm}$              | Peak Reverse Recovery Current    | 28   |      | A    |                                                                                                                                                   |               |

Thermal Characteristics

| Symbol          | Parameter                                   | Typ. | Unit                      | Test Conditions | Note    |
|-----------------|---------------------------------------------|------|---------------------------|-----------------|---------|
| $R_{\theta JC}$ | Thermal Resistance from Junction to Case    | 0.35 | $^\circ\text{C}/\text{W}$ |                 | Fig. 21 |
| $R_{\theta JA}$ | Thermal Resistance From Junction to Ambient | 40   |                           |                 |         |



## Typical Performance

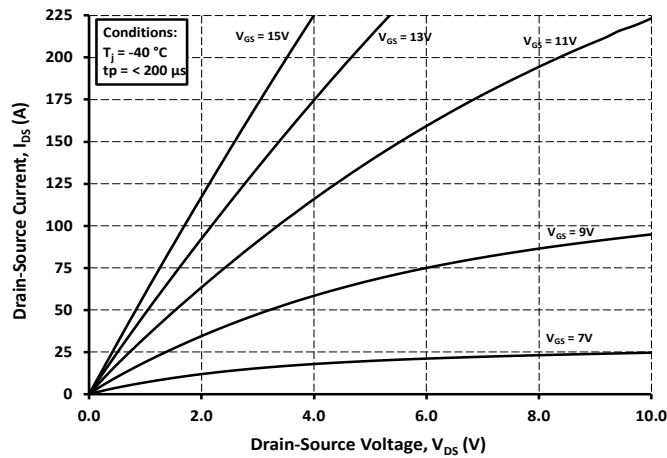


Figure 1. Output Characteristics  $T_j = -40^\circ\text{C}$

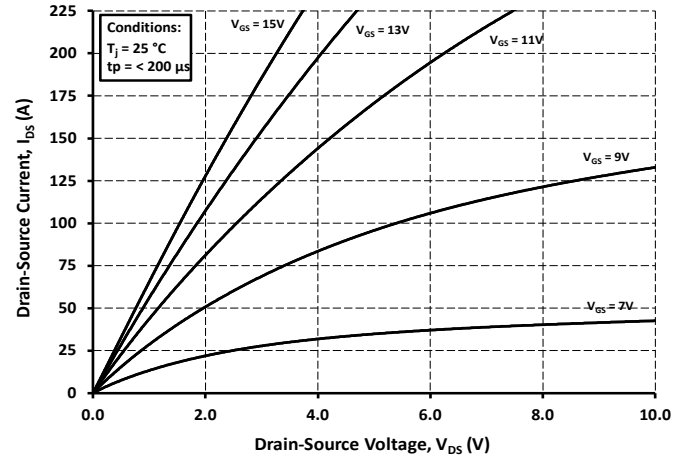


Figure 2. Output Characteristics  $T_j = 25^\circ\text{C}$

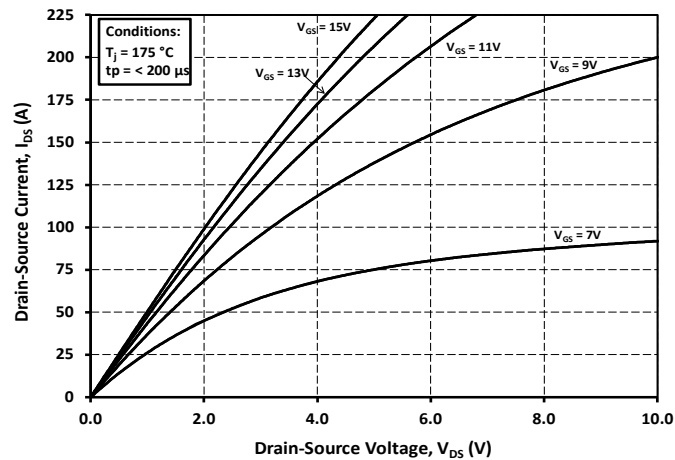


Figure 3. Output Characteristics  $T_j = 175^\circ\text{C}$

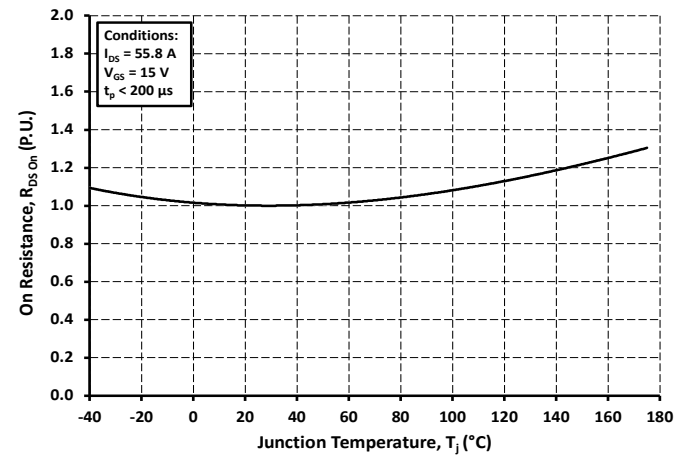


Figure 4. Normalized On-Resistance vs. Temperature

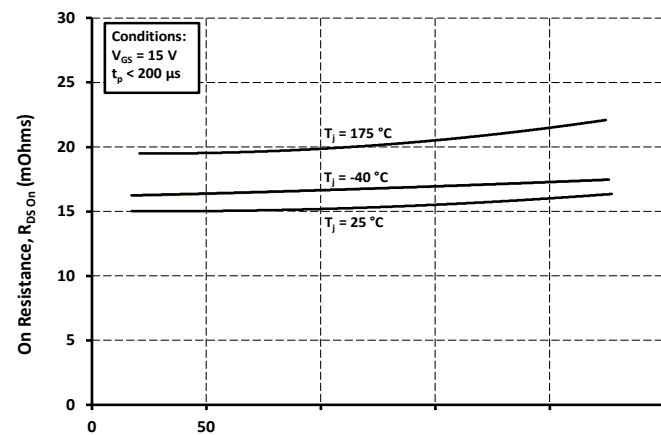


Figure 5. On-Resistance vs. Drain Current  
For Various Temperatures

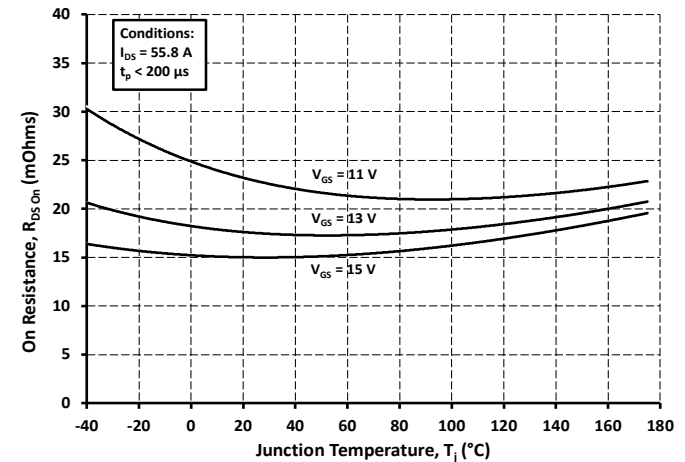


Figure 6. On-Resistance vs. Temperature  
For Various Gate Voltage



## Typical Performance

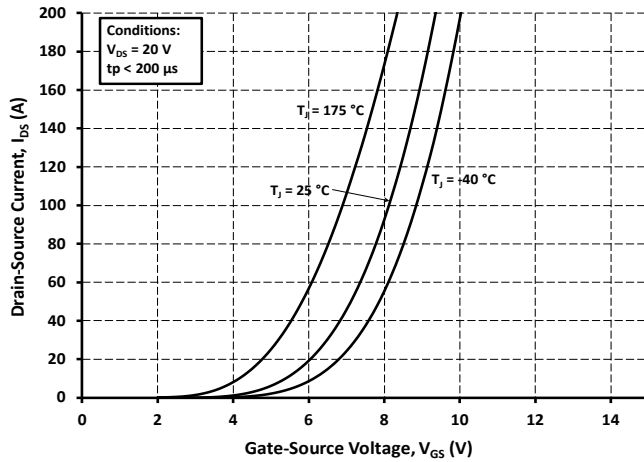


Figure 7. Transfer Characteristic for Various Junction Temperatures

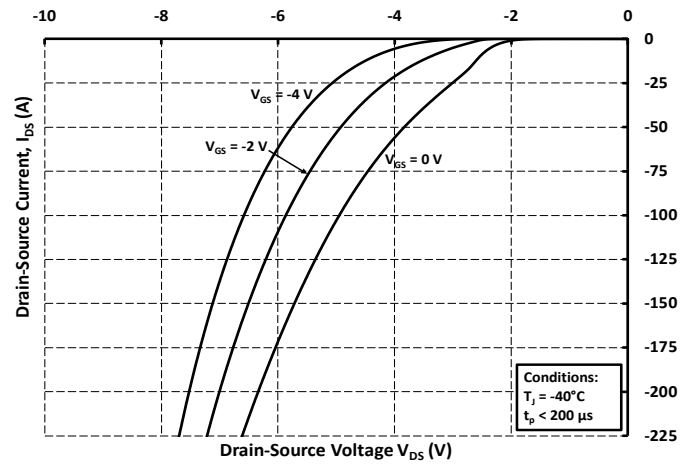


Figure 8. Body Diode Characteristic at  $-40\text{ °C}$

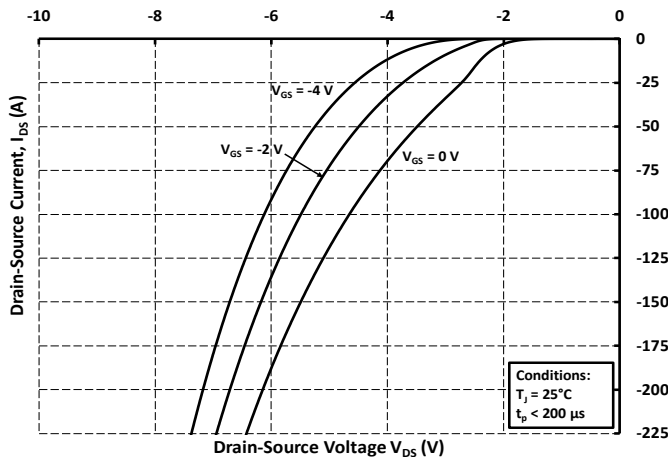


Figure 9. Body Diode Characteristic at  $25\text{ °C}$

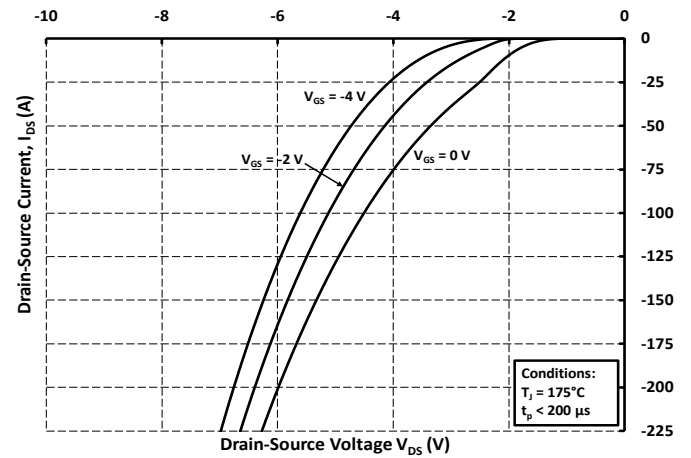


Figure 10. Body Diode Characteristic at  $175\text{ °C}$

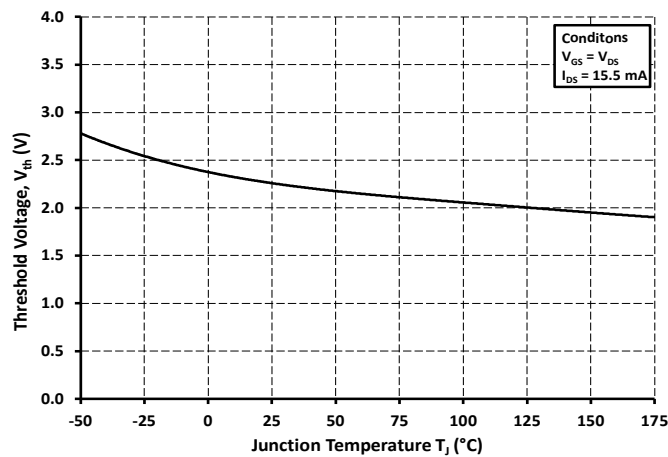


Figure 11. Threshold Voltage vs. Temperature

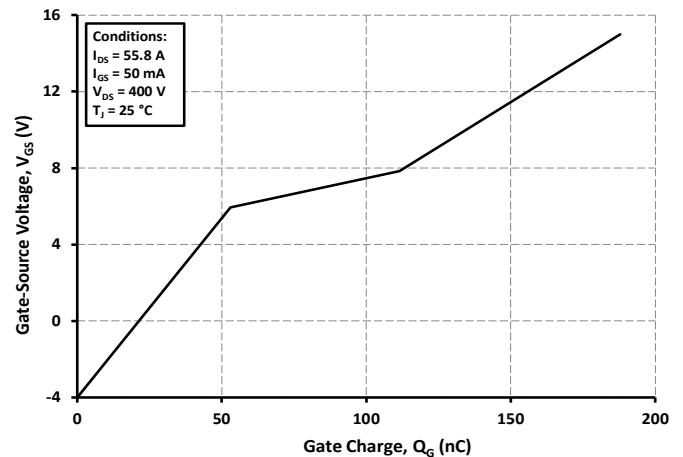


Figure 12. Gate Charge Characteristics



### Typical Performance

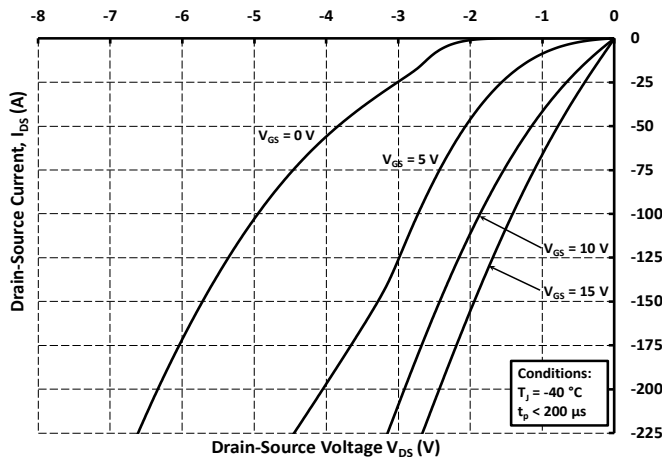


Figure 13. 3rd Quadrant Characteristic at -40 °C

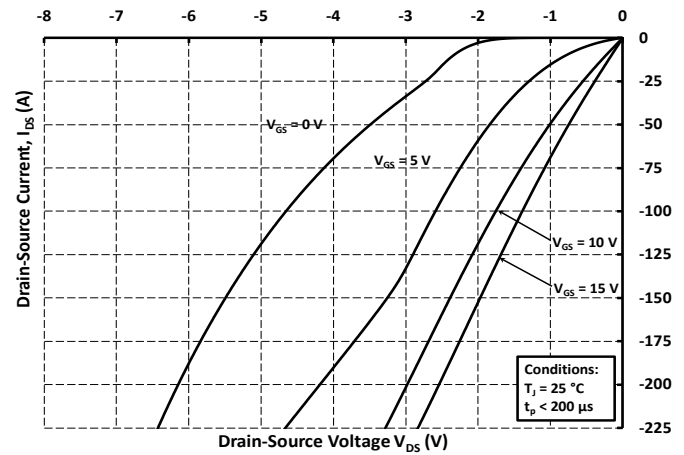


Figure 14. 3rd Quadrant Characteristic at 25 °C

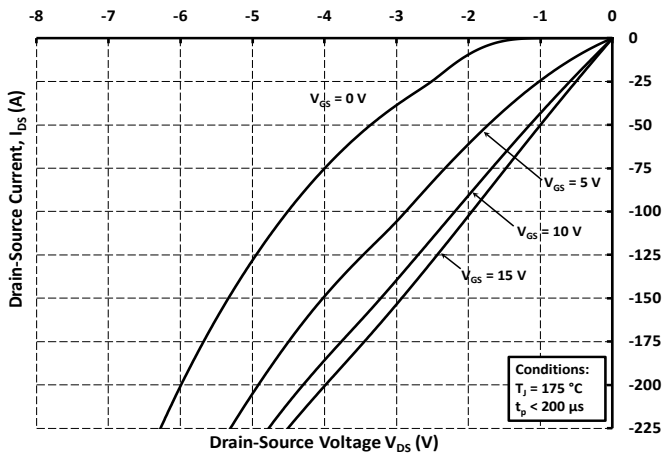


Figure 15. 3rd Quadrant Characteristic at 175 °C

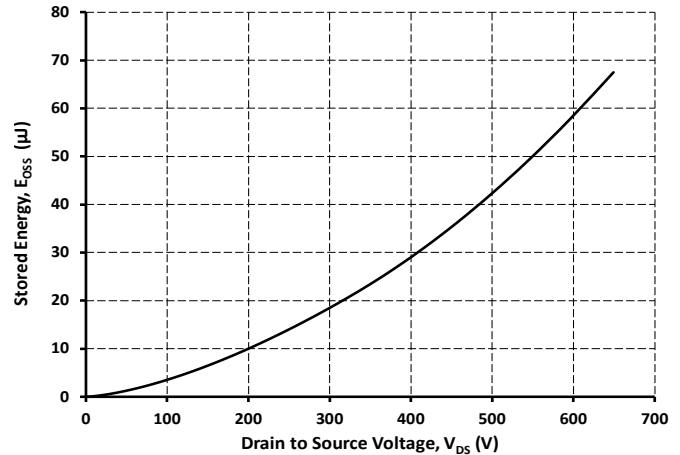


Figure 16. Output Capacitor Stored Energy

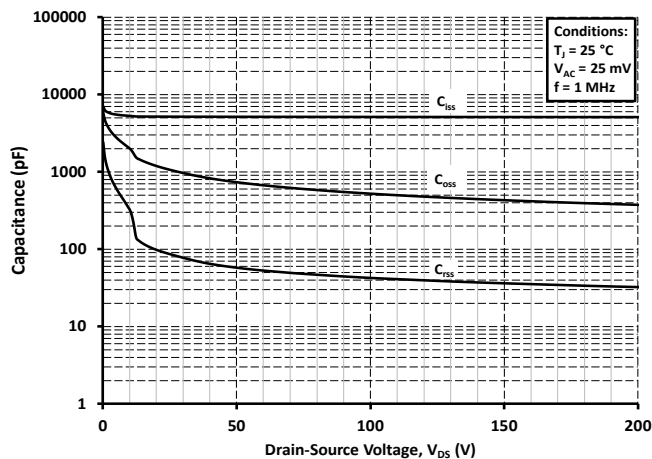


Figure 17. Capacitances vs. Drain-Source Voltage (0 - 200V)

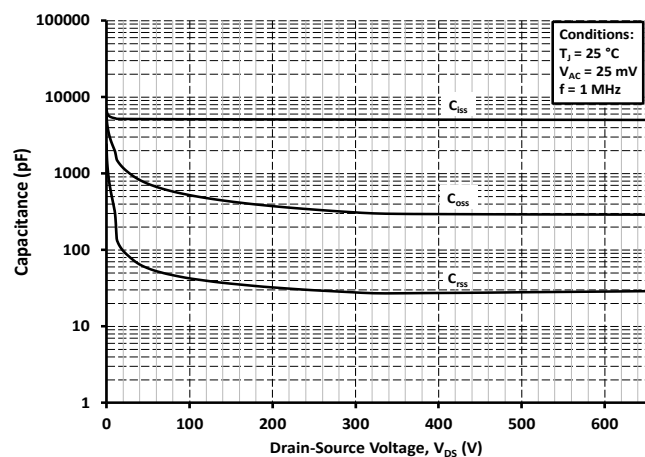


Figure 18. Capacitances vs. Drain-Source Voltage (0 - 650V)



## Typical Performance

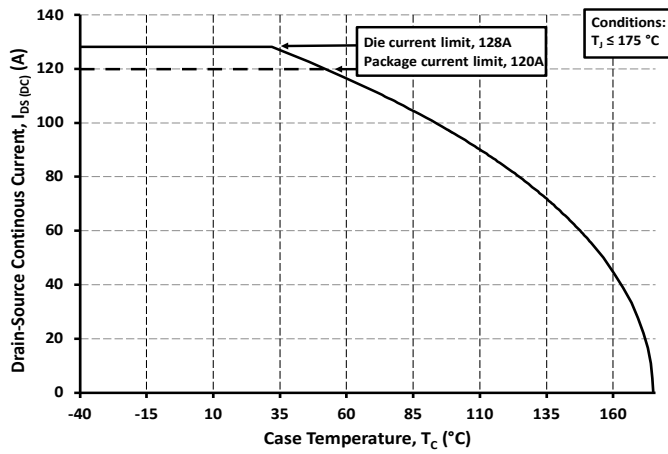


Figure 19. Continuous Drain Current Derating vs. Case Temperature

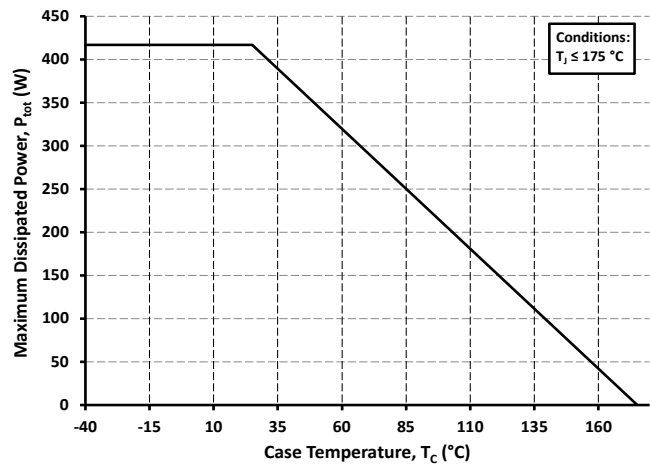


Figure 20. Maximum Power Dissipation Derating vs. Case Temperature

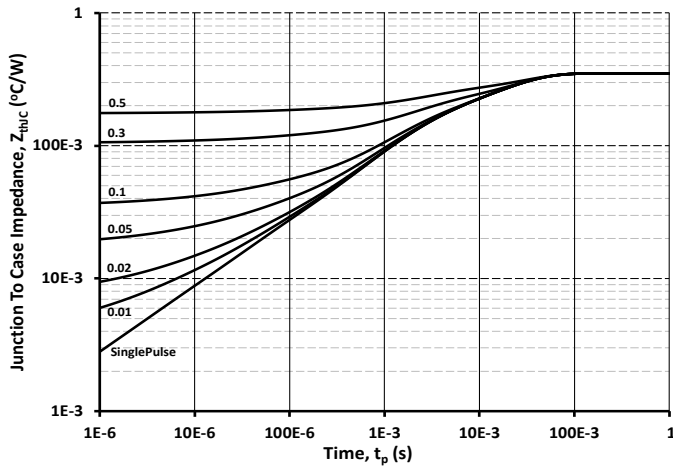


Figure 21. Transient Thermal Impedance (Junction - Case)

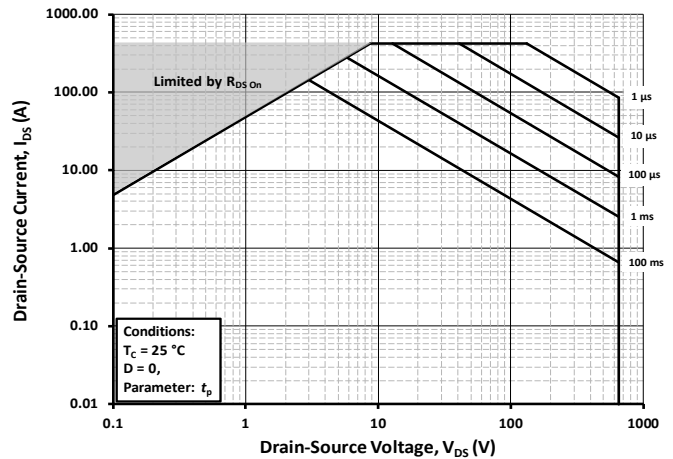


Figure 22. Safe Operating Area

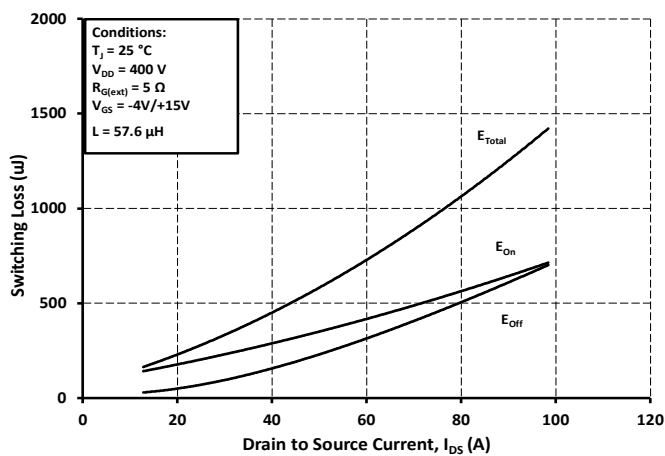


Figure 23. Clamped Inductive Switching Energy vs. Drain Current ( $V_{DD} = 400V$ )

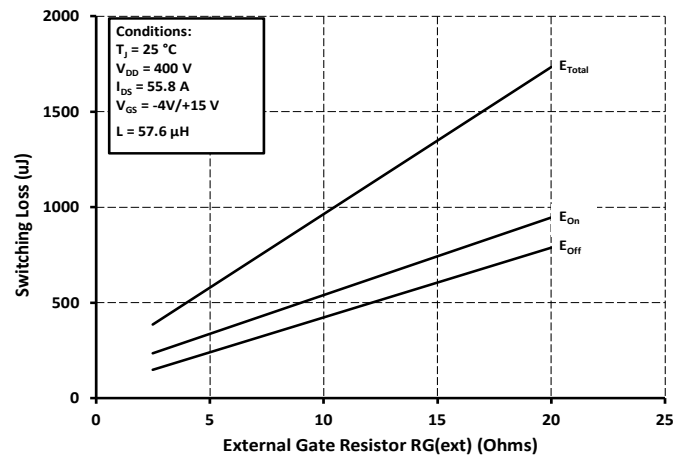


Figure 24. Clamped Inductive Switching Energy vs.  $R_{G(ext)}$



## Typical Performance

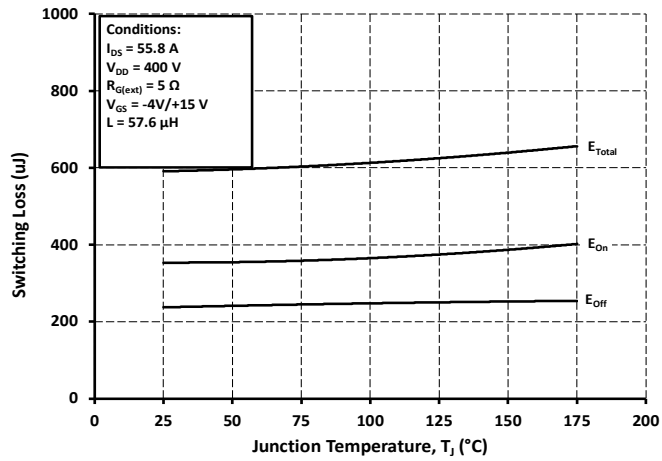


Figure 25. Clamped Inductive Switching Energy vs. Temperature

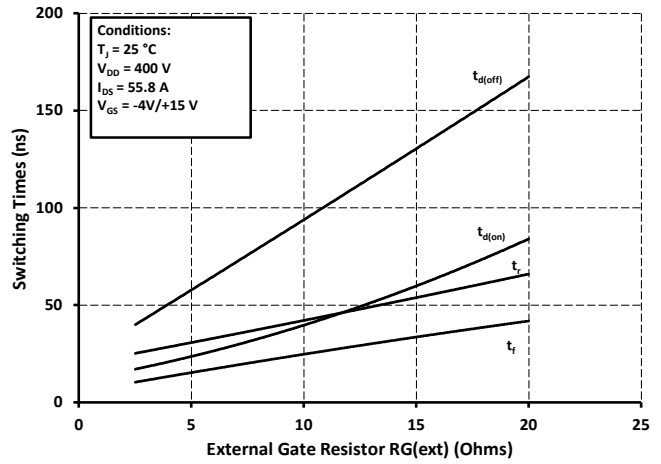


Figure 26. Switching Times vs.  $R_{G(ext)}$



## Test Circuit Schematic

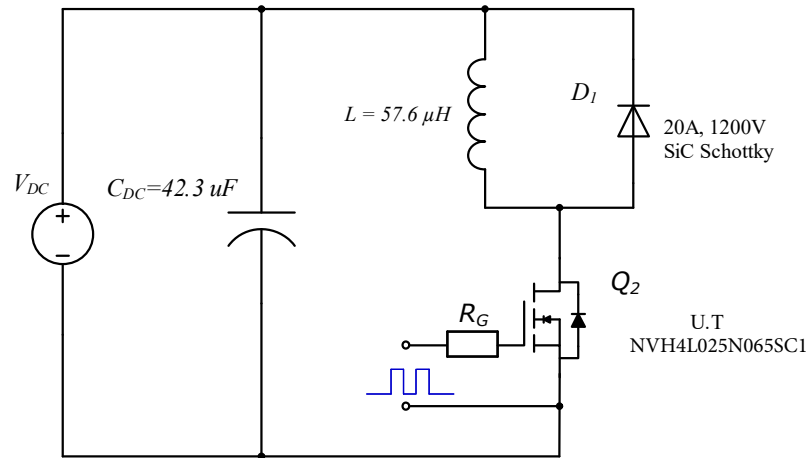


Figure 27. Clamped Inductive Switching  
Waveform Test Circuit

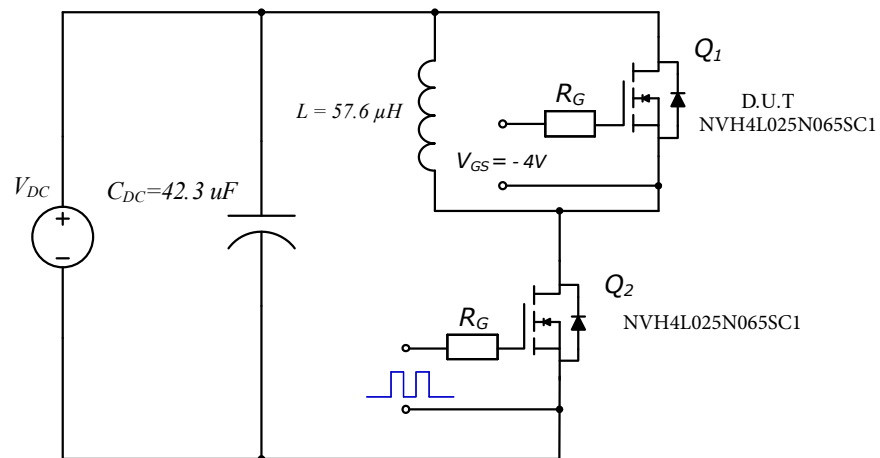
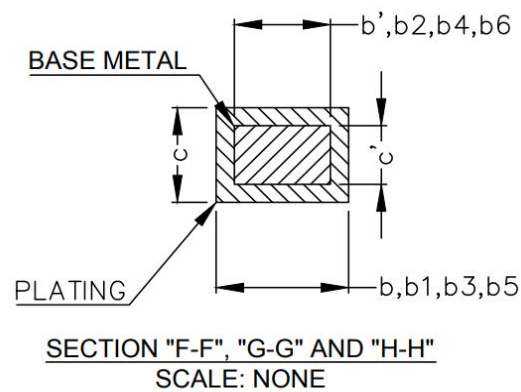
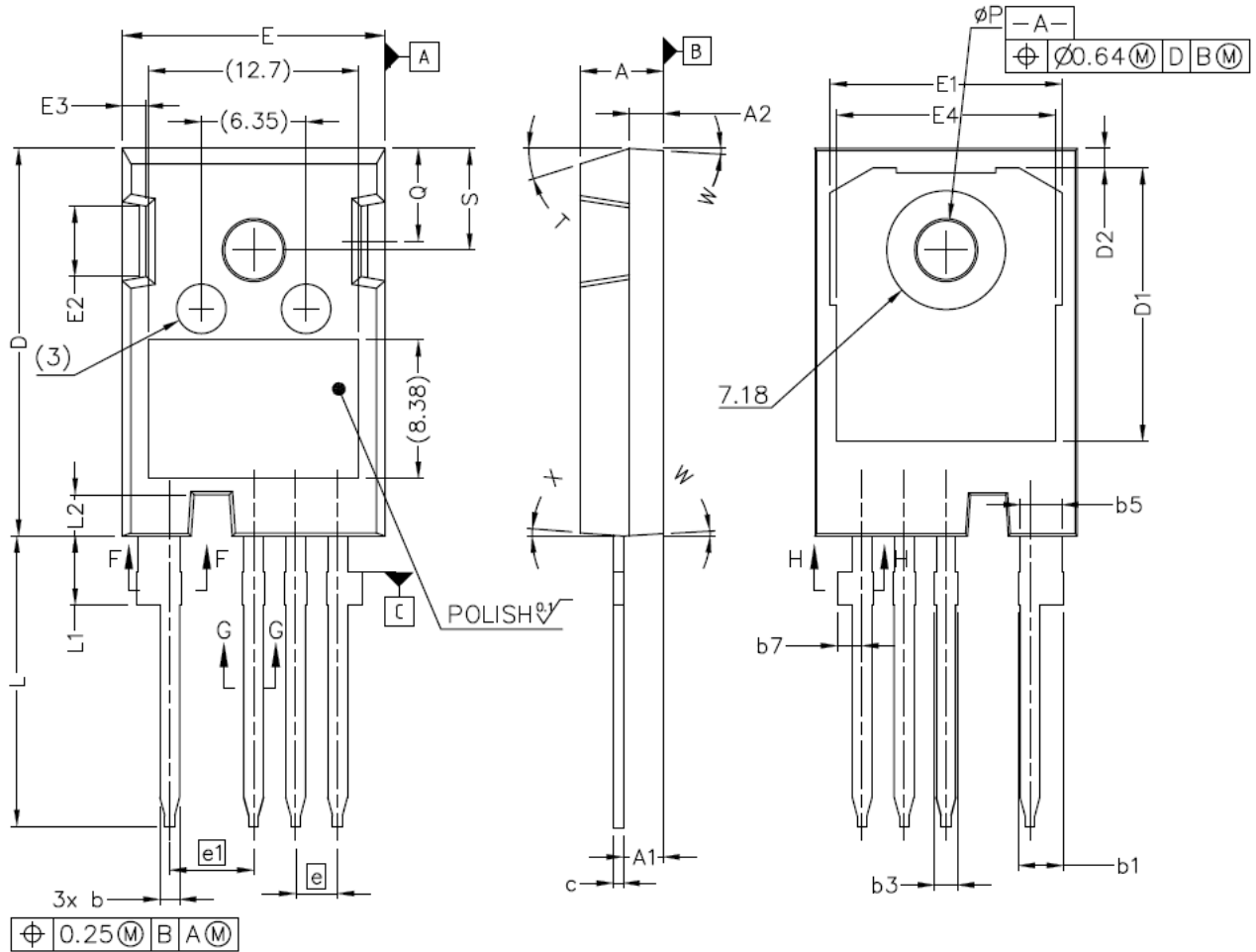


Figure 28. Body Diode Recovery Test Circuit



## Package Dimensions

Package TO-247H-4L





## Package Dimensions

### Package TO-247H-4L

NOTE ;

1. ALL METAL SURFACES: TIN PLATED, EXCEPT AREA OF CUT
2. DIMENSIONING & TOLERANCEING CONFIRM TO ASME Y14.5M-1994.
3. ALL DIMENSIONS ARE IN MILLIMETERS.  
ANGLES ARE IN DEGREES.
4. 'N' IS THE NUMBER OF TERMINAL POSITIONS

| SYM | MILLIMETERS |       |
|-----|-------------|-------|
|     | MIN         | MAX   |
| A   | 4.83        | 5.21  |
| A1  | 2.29        | 2.54  |
| A2  | 1.91        | 2.16  |
| b`  | 1.07        | 1.28  |
| b   | 1.07        | 1.33  |
| b1  | 2.39        | 2.94  |
| b2  | 2.39        | 2.84  |
| b3  | 1.07        | 1.60  |
| b4  | 1.07        | 1.50  |
| b5  | 2.39        | 2.69  |
| b6  | 2.39        | 2.64  |
| b7  | 1.30        | 1.70  |
| c`  | 0.55        | 0.65  |
| c   | 0.55        | 0.68  |
| D   | 23.30       | 23.60 |
| D1  | 16.25       | 17.65 |
| D2  | 0.95        | 1.25  |
| E   | 15.75       | 16.13 |

| SYM | MILLIMETERS |       |
|-----|-------------|-------|
|     | MIN         | MAX   |
| E1  | 13.10       | 14.15 |
| E2  | 3.68        | 5.10  |
| E3  | 1.00        | 1.90  |
| E4  | 12.38       | 13.43 |
| e   | 2.54 BSC    |       |
| e1  | 5.08 BSC    |       |
| N*  | 4           |       |
| L   | 17.31       | 17.82 |
| L1  | 3.97        | 4.37  |
| L2  | 2.35        | 2.65  |
| Ø P | 3.51        | 3.65  |
| Q   | 5.49        | 6.00  |
| S   | 6.04        | 6.30  |
| T   | 17.5° REF.  |       |
| W   | 3.5° REF.   |       |
| X   | 4° REF.     |       |





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