

## N-Channel Super Junction Power MOSFET IV

### General Description

The series of devices use advanced trench gate super junction technology and design to provide excellent  $R_{DS(ON)}$  with low gate charge. This super junction MOSFET fits the industry's AC-DC SMPS requirements for PFC, AC/DC power conversion, and industrial power applications.

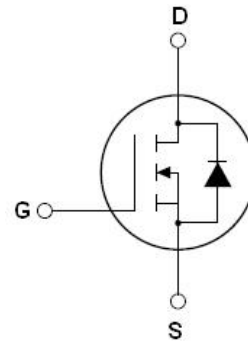
### Features

- Optimized body diode reverse recovery performance
- Low on-resistance and low conduction losses
- Small package
- Ultra Low Gate Charge cause lower driving requirements
- 100% Avalanche Tested
- ROHS compliant

### Application

- Power factor correction (PFC)
- Switched mode power supplies(SMPS)
- Uninterruptible Power Supply (UPS)
- LLC Half-bridge

|                        |     |    |
|------------------------|-----|----|
| $V_{DS\ min@T_{jmax}}$ | 650 | V  |
| $R_{DS(ON)TYP}$        | 350 | mΩ |
| ID                     | 10  | A  |
| Qg                     | 13  | nC |



Schematic diagram

### Package Marking And Ordering Information

| Device     | Device Package | Marking    |
|------------|----------------|------------|
| NCE60N390K | TO-252         | NCE60N390K |



TO-252

Table 1. Absolute Maximum Ratings ( $T_c=25^\circ\text{C}$ )

| Parameter  | Symbol          | Value      | Unit                |
|--|-----------------|------------|---------------------|
| Drain-Source Voltage ( $V_{GS}=0V$ )                             | $V_{DS}$        | 600        | V                   |
| Gate-Source Voltage ( $V_{DS}=0V$ ) AC ( $f>1\text{ Hz}$ )       | $V_{GS}$        | $\pm 30$   | V                   |
| Gate-Source Voltage ( $V_{DS}=0V$ ) DC                           | $V_{GS}$        | $\pm 20$   | V                   |
| Continuous Drain Current at $T_c=25^\circ\text{C}$               | $I_{D(DC)}$     | 10         | A                   |
| Continuous Drain Current at $T_c=100^\circ\text{C}$              | $I_{D(DC)}$     | 7          | A                   |
| Pulsed drain current (Note 1)                                    | $I_{DM(pluse)}$ | 30         | A                   |
| Maximum Power Dissipation( $T_c=25^\circ\text{C}$ )              | $P_D$           | 99         | W                   |
| Derate above $25^\circ\text{C}$                                  |                 | 0.66       | W/ $^\circ\text{C}$ |
| Avalanche current (Note 1)                                       | $I_{AS}$        | 2          | A                   |
| Drain Source voltage slope, $V_{DS} \leq 480\text{ V}$ ,         | $dv/dt$         | 50         | V/ns                |
| Reverse diode $dv/dt$ , $V_{DS} \leq 480\text{ V}, I_{SD} < I_D$ | $dv/dt$         | 15         | V/ns                |
| Operating Junction and Storage Temperature Range                 | $T_J, T_{STG}$  | -55...+175 | $^\circ\text{C}$    |

\* limited by maximum junction temperature

**Table 2. Thermal Characteristic**

| Parameter   | Symbol     | Value | Unit                        |
|---|------------|-------|-----------------------------|
| Thermal Resistance, Junction-to-Case (Maximum)    | $R_{thJC}$ | 1.51  | $^{\circ}\text{C}/\text{W}$ |
| Thermal Resistance, Junction-to-Ambient (Maximum) | $R_{thJA}$ | 62    | $^{\circ}\text{C}/\text{W}$ |

**Table 3. Electrical Characteristics (TA=25°C unless otherwise noted)**

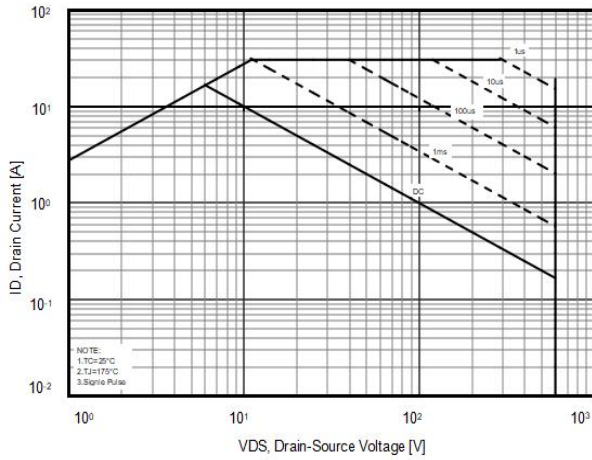
| Parameter                                  | Symbol       | Condition   | Min | Typ | Max       | Unit          |
|--|--------------|---|-----|-----|-----------|---------------|
| <b>On/off states</b>                       |              |   |     |     |           |               |
| Drain-Source Breakdown Voltage             | $BV_{DSS}$   | $V_{GS}=0V, I_D=250\mu A$                               | 600 |     |           | V             |
| Zero Gate Voltage Drain Current(Tc=25°C)   | $I_{DSS}$    | $V_{DS}=600V, V_{GS}=0V$                                |     |     | 1         | $\mu A$       |
| Zero Gate Voltage Drain Current(Tc=125°C)  | $I_{DSS}$    | $V_{DS}=600V, V_{GS}=0V$                                |     |     | 100       | $\mu A$       |
| Gate-Body Leakage Current                  | $I_{GSS}$    | $V_{GS}=\pm 20V, V_{DS}=0V$                             |     |     | $\pm 200$ | nA            |
| Gate Threshold Voltage                     | $V_{GS(th)}$ | $V_{DS}=V_{GS}, I_D=250\mu A$                           | 3   | 3.5 | 4         | V             |
| Drain-Source On-State Resistance           | $R_{DS(on)}$ | $V_{GS}=10V, I_D=5A$                                    |     | 350 | 390       | m $\Omega$    |
| <b>Dynamic Characteristics</b>             |              |   |     |     |           |               |
| Input Capacitance                          | $C_{iss}$    | $V_{DS}=50V, V_{GS}=0V,$<br>$F=1.0\text{MHz}$           |     | 440 |           | pF            |
| Output Capacitance                         | $C_{oss}$    |   |     | 32  |           | pF            |
| Reverse Transfer Capacitance               | $C_{rss}$    |   |     | 6   |           | pF            |
| Total Gate Charge                          | $Q_g$        | $V_{DS}=450V, I_D=5A,$<br>$V_{GS}=10V$                  |     | 13  |           | nC            |
| Gate-Source Charge                         | $Q_{gs}$     |   |     | 4.5 |           | nC            |
| Gate-Drain Charge                          | $Q_{gd}$     |   |     | 3   |           | nC            |
| Gate plateau voltage                       | $V_{gp}$     |   |     | 5.5 |           | V             |
| Intrinsic gate resistance                  | $R_G$        | $f = 1 \text{ MHz open drain}$                          |     | 42  |           | $\Omega$      |
| <b>Switching times</b>                     |              |   |     |     |           |               |
| Turn-on Delay Time                         | $t_{d(on)}$  | $V_{DD}=380V, I_D=5A,$<br>$R_G=1.7\Omega, V_{GS}=10V$   |     | 16  |           | nS            |
| Turn-on Rise Time                          | $t_r$        |   |     | 9   |           | nS            |
| Turn-Off Delay Time                        | $t_{d(off)}$ |   |     | 32  |           | nS            |
| Turn-Off Fall Time                         | $t_f$        |   |     | 16  |           | nS            |
| <b>Source- Drain Diode Characteristics</b> |              |   |     |     |           |               |
| Source-drain current(Body Diode)           | $I_{SD}$     | $T_C=25^{\circ}\text{C}$                                |     |     | 10        | A             |
| Pulsed Source-drain current(Body Diode)    | $I_{SDM}$    |   |     |     | 30        | A             |
| Forward On Voltage                         | $V_{SD}$     | $T_j=25^{\circ}\text{C}, I_{SD}=10A, V_{GS}=0V$         |     | 0.9 | 1.2       | V             |
| Reverse Recovery Time                      | $t_{rr}$     | $T_j=25^{\circ}\text{C}, I_F=5A,$<br>$di/dt=100A/\mu s$ |     | 220 |           | nS            |
| Reverse Recovery Charge                    | $Q_{rr}$     |   |     | 1.9 |           | $\mu\text{C}$ |
| Peak Reverse Recovery Current              | $I_{rrm}$    |   |     | 17  |           | A             |

Notes 1.Repetitive Rating: Pulse width limited by maximum junction temperature

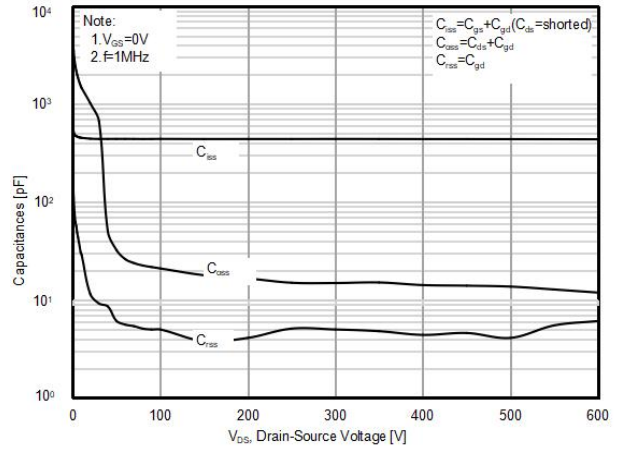
2.  $T_j=25^{\circ}\text{C}, V_{DD}=50V, V_G=10V, R_G=25\Omega$

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS (curves)

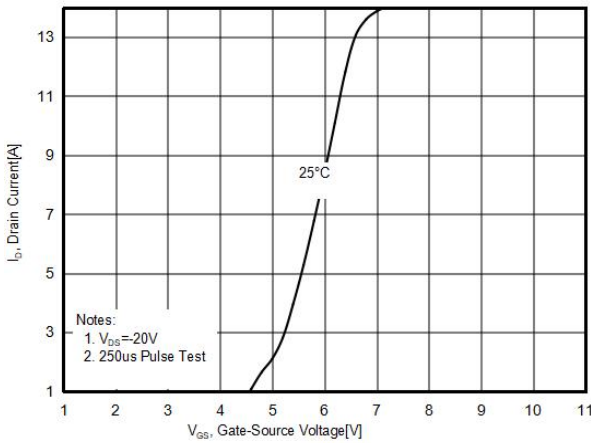
**Figure1. Safe operating area**



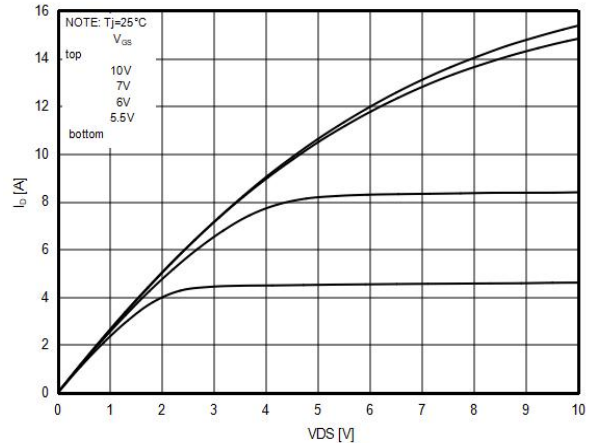
**Figure2. Capacitance**



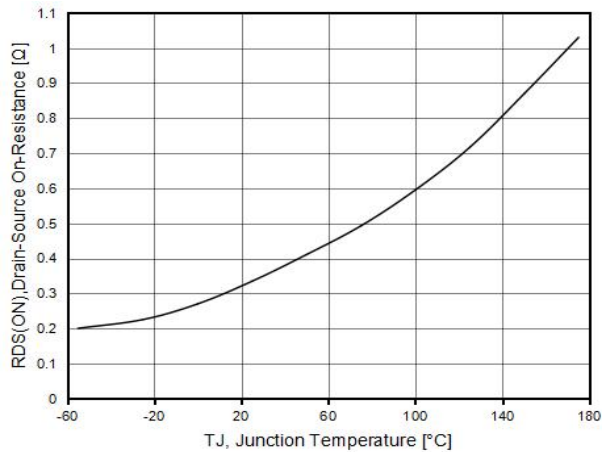
**Figure3. Transfer characteristics**



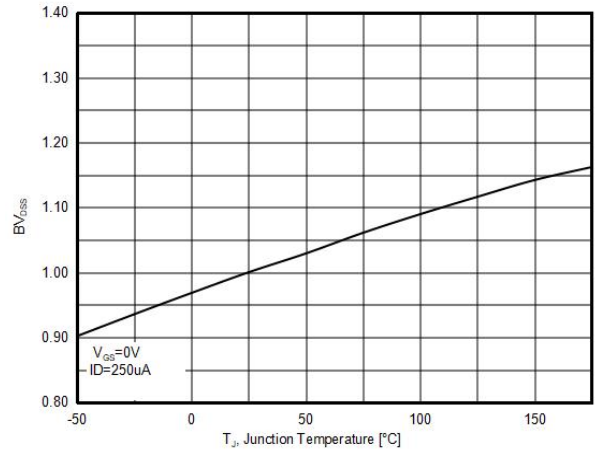
**Figure4. Output characteristics**



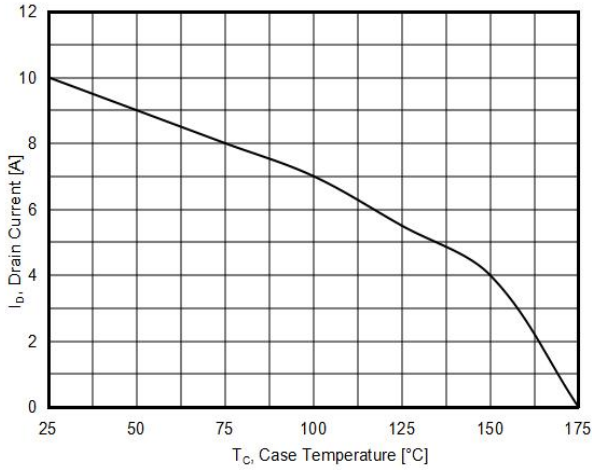
**Figure5. RDS(ON) vs Junction Temperature**



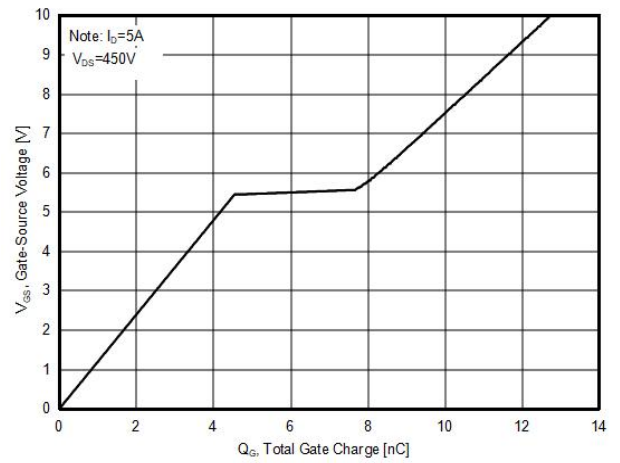
**Figure6. BVDS vs Junction Temperature**



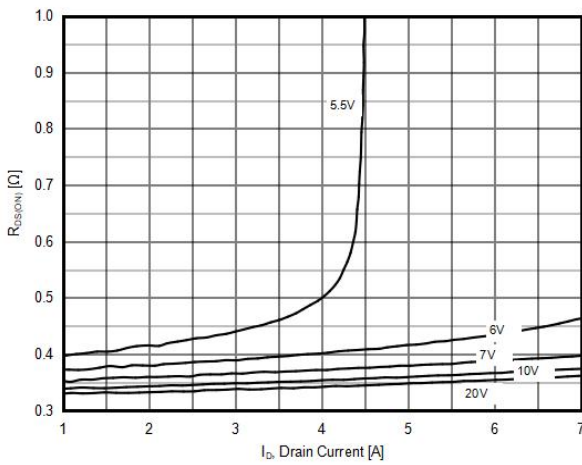
**Figure7. Maximum  $I_D$  vs Junction Temperature**



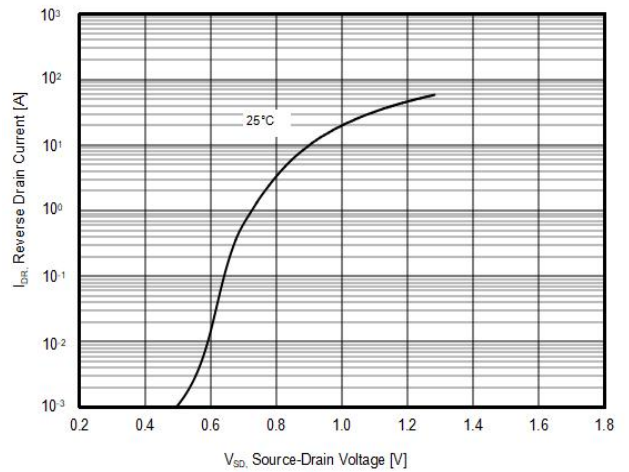
**Figure8. Gate charge waveforms**



**Figure9. Static drain-source on resistance**

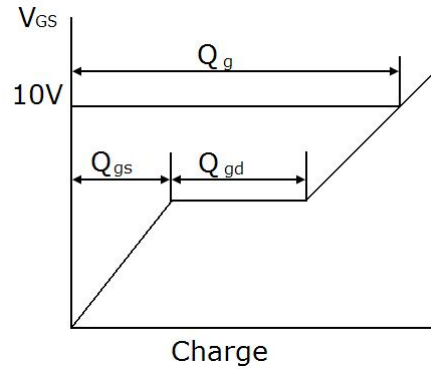
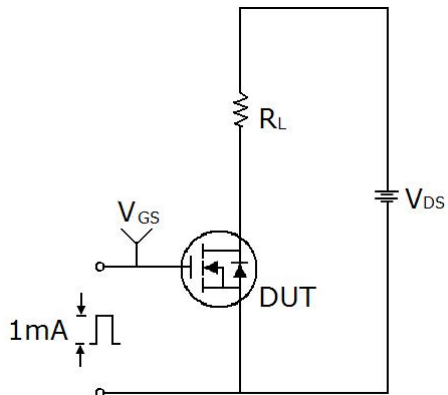


**Figure10. Source-Drain Diode Forward Voltage**

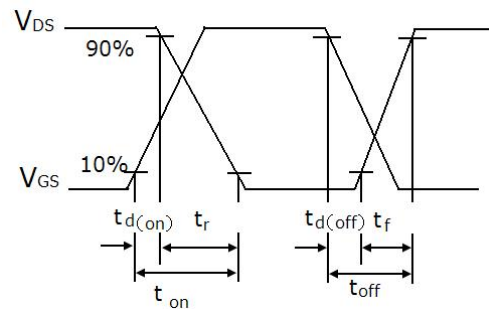
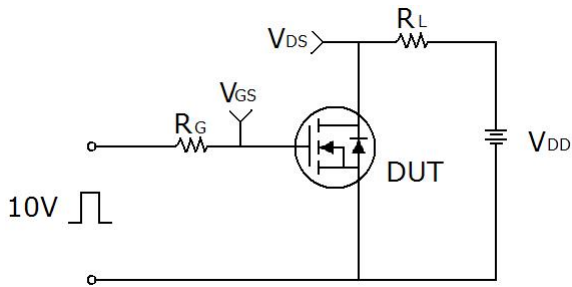


## Test circuit

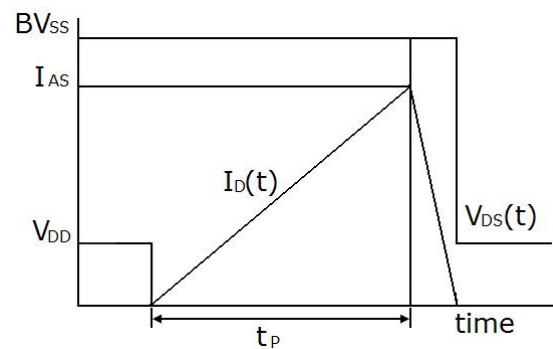
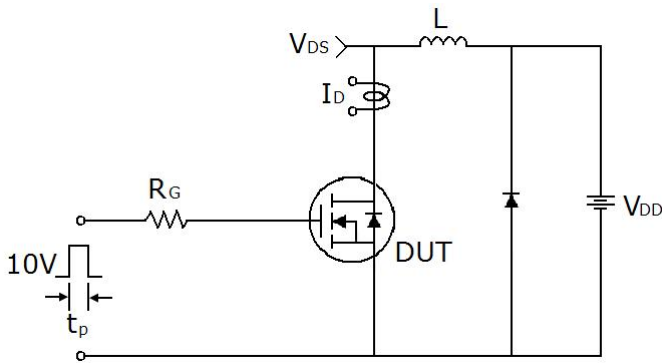
### 1) Gate charge test circuit & Waveform



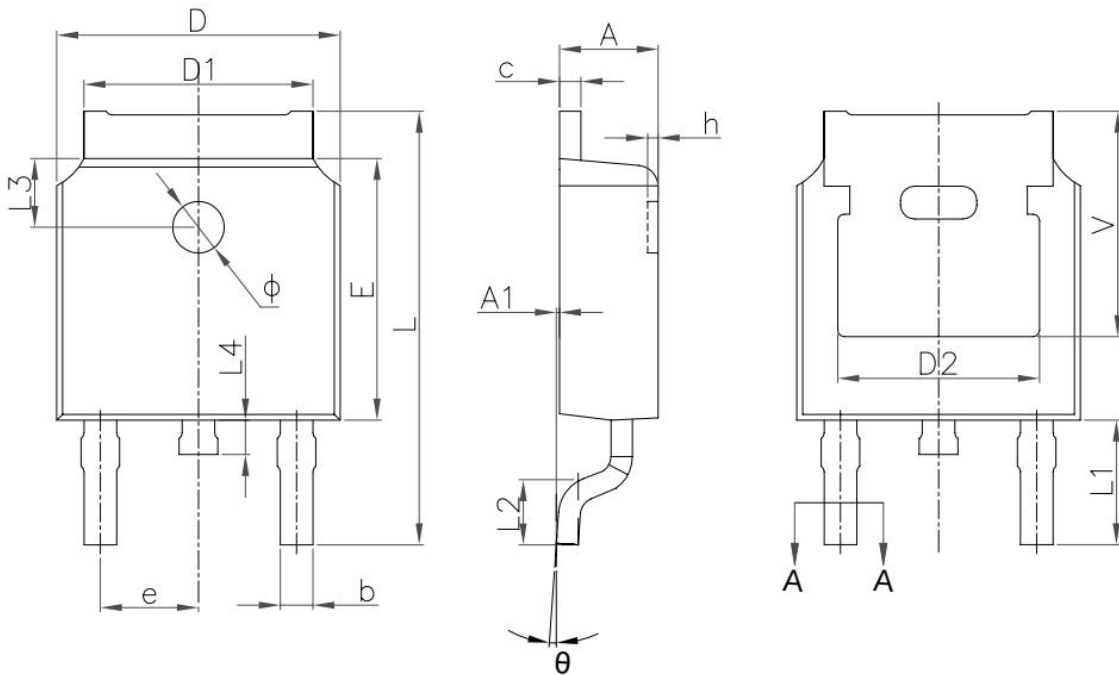
### 2) Switch Time Test Circuit:



### 3) Unclamped Inductive Switching Test Circuit & Waveforms



## TO-252-E Package Information



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min.                      | Max.  | Min.                 | Max.  |
| A      | 2.20                      | 2.40  | 0.087                | 0.094 |
| A1     | 0.00                      | 0.13  | 0.000                | 0.005 |
| b      | 0.66                      | 0.86  | 0.026                | 0.033 |
| b1     | 0.73                      | 0.79  | 0.029                | 0.031 |
| c      | 0.46                      | 0.58  | 0.018                | 0.023 |
| c1     | 0.50                      | 0.52  | 0.020                | 0.020 |
| D      | 6.50                      | 6.70  | 0.256                | 0.264 |
| D1     | 5.10                      | 5.46  | 0.201                | 0.215 |
| D2     | 4.83 REF                  |       | 0.19REF              |       |
| E      | 6.00                      | 6.20  | 0.236                | 0.244 |
| e      | 2.19                      | 2.39  | 0.086                | 0.094 |
| L      | 9.80                      | 10.40 | 0.386                | 0.409 |
| L1     | 2.90 REF                  |       | 0.11REF              |       |
| L2     | 1.40                      | 1.70  | 0.055                |       |
| L3     | 1.60 REF                  |       | 0.06REF              |       |
| L4     | 0.60                      | 1.00  | 0.024                | 0.039 |
| φ      | 1.10                      | 1.30  | 0.043                | 0.051 |
| θ      | 0°                        | 8°    | 0°                   | 8°    |
| h      | 0.00                      | 0.30  | 0.000                | 0.012 |

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