

## Product Summary

| BV <sub>DSS</sub> | R <sub>DS(ON)</sub> MAX        | I <sub>D</sub><br>T <sub>C</sub> = +25°C |
|-------------------|--------------------------------|------------------------------------------|
| -40V              | 15mΩ @ V <sub>GS</sub> = -10V  | -55A                                     |
|                   | 23mΩ @ V <sub>GS</sub> = -4.5V | -50A                                     |

## Description

This MOSFET has been designed to meet the stringent requirements of automotive applications. It is qualified to AEC-Q101, supported by a PPAP and is ideal for use in:

- Reverse Polarity Protection
- Motor Control
- Power Management

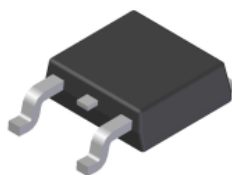
## Features and Benefits

- Rated to +175°C – Ideal for High Ambient Temperature Environments
- 100% Unclamped Inductive Switch (UIS) Test in Production
- Low On-Resistance
- Fast Switching Speed
- **Lead-Free Finish; RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **Qualified to AEC-Q101 Standards for High Reliability**
- **PPAP Capable (Note 4)**

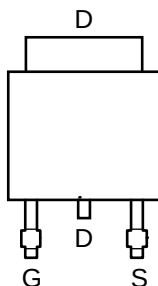
## Mechanical Data

- Case: TO252 (DPAK)
- Case Material: Molded Plastic, "Green" Molding Compound. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminal Connections: See Diagram
- Terminals: Finish – Matte Tin Finish Annealed over Copper Leadframe. Solderable per MIL-STD-202, Method 208 
- Weight: 0.33 grams (Approximate)

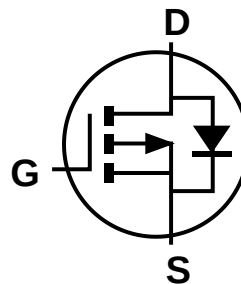
TO252 (DPAK)



Top View



Top View  
Pin-Out



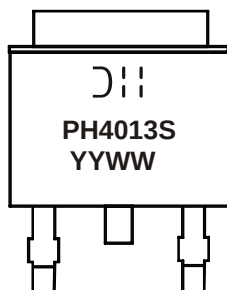
Equivalent Circuit

## Ordering Information (Note 5)

| Part Number     | Case         | Packaging         |
|-----------------|--------------|-------------------|
| DMPH4013SK3Q-13 | TO252 (DPAK) | 2,500/Tape & Reel |

- Notes:
1. EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant. All applicable RoHS exemptions applied.
  2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
  3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
  4. Automotive products are AEC-Q101 qualified and are PPAP capable. Refer to <https://www.diodes.com/quality/>.
  5. For packaging details, go to our website at <https://www.diodes.com/design/support/packaging/diodes-packaging/>.

## Marking Information



 = Manufacturer's Marking  
 PH4013S = Product Type Marking Code  
 YYWW = Date Code Marking  
 YY = Year (ex: 18 = 2018)  
 WW = Week (01 to 53)

**Maximum Ratings** (@  $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

| Characteristic                                                  |              |                                                         | Symbol    | Value      | Unit |
|-----------------------------------------------------------------|--------------|---------------------------------------------------------|-----------|------------|------|
| Drain-Source Voltage                                            |              |                                                         | $V_{DSS}$ | -40        | V    |
| Gate-Source Voltage                                             |              |                                                         | $V_{GSS}$ | $\pm 20$   | V    |
| Continuous Drain Current (Note 7) $V_{GS} = -10\text{V}$        | Steady State | $T_C = +25^\circ\text{C}$<br>$T_C = +100^\circ\text{C}$ | $I_D$     | -55<br>-40 | A    |
| Pulsed Drain Current (10 $\mu\text{s}$ Pulse, Duty Cycle = 1%)  |              |                                                         | $I_{DM}$  | -120       | A    |
| Maximum Body Diode Forward Current (Note 7)                     |              |                                                         | $I_S$     | -3.6       | A    |
| Pulsed Source Current (10 $\mu\text{s}$ Pulse, Duty Cycle = 1%) |              |                                                         | $I_{SM}$  | -120       | A    |
| Avalanche Current, $L = 0.1\text{mH}$ (Note 8)                  |              |                                                         | $I_{AS}$  | -40        | A    |
| Avalanche Energy, $L = 0.1\text{mH}$ (Note 8)                   |              |                                                         | $E_{AS}$  | 69         | mJ   |

**Thermal Characteristics** (@  $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

| Characteristic                                   |              |  | Symbol          | Value       | Unit               |
|--------------------------------------------------|--------------|--|-----------------|-------------|--------------------|
| Total Power Dissipation (Note 6)                 |              |  | $P_D$           | 2.1         | W                  |
| Thermal Resistance, Junction to Ambient (Note 6) | Steady State |  | $R_{\theta JA}$ | 71          | $^\circ\text{C/W}$ |
| Total Power Dissipation (Note 7)                 |              |  | $P_D$           | 3.7         | W                  |
| Thermal Resistance, Junction to Ambient (Note 7) | Steady State |  | $R_{\theta JA}$ | 41          | $^\circ\text{C/W}$ |
| Thermal Resistance, Junction to Case             |              |  | $R_{\theta JC}$ | 1.7         |                    |
| Operating and Storage Temperature Range          |              |  | $T_J, T_{STG}$  | -55 to +175 | $^\circ\text{C}$   |

**Electrical Characteristics** (@  $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

| Characteristic                                | Symbol       | Min  | Typ  | Max       | Unit          | Test Condition                                                                      |
|-----------------------------------------------|--------------|------|------|-----------|---------------|-------------------------------------------------------------------------------------|
| <b>OFF CHARACTERISTICS (Note 9)</b>           |              |      |      |           |               |                                                                                     |
| Drain-Source Breakdown Voltage                | $BV_{DSS}$   | -40  | —    | —         | V             | $V_{GS} = 0\text{V}, I_D = -250\mu\text{A}$                                         |
| Zero Gate Voltage Drain Current               | $I_{DSS}$    | —    | —    | -1        | $\mu\text{A}$ | $V_{DS} = -40\text{V}, V_{GS} = 0\text{V}$                                          |
| Gate-Source Leakage                           | $I_{GSS}$    | —    | —    | $\pm 100$ | nA            | $V_{GS} = \pm 20\text{V}, V_{DS} = 0\text{V}$                                       |
| <b>ON CHARACTERISTICS (Note 9)</b>            |              |      |      |           |               |                                                                                     |
| Gate Threshold Voltage                        | $V_{GS(TH)}$ | -1.0 | —    | -3.0      | V             | $V_{DS} = V_{GS}, I_D = -250\mu\text{A}$                                            |
| Static Drain-Source On-Resistance             | $R_{DS(ON)}$ | —    | 10   | 15        | m $\Omega$    | $V_{GS} = -10\text{V}, I_D = -10\text{A}$                                           |
|                                               |              | —    | 15   | 23        |               | $V_{GS} = -4.5\text{V}, I_D = -8\text{A}$                                           |
| Diode Forward Voltage                         | $V_{SD}$     | —    | -0.7 | -1.2      | V             | $V_{GS} = 0\text{V}, I_S = -1\text{A}$                                              |
| <b>DYNAMIC CHARACTERISTICS (Note 10)</b>      |              |      |      |           |               |                                                                                     |
| Input Capacitance                             | $C_{iss}$    | —    | 4004 | —         | pF            | $V_{DS} = -20\text{V}, V_{GS} = 0\text{V}$<br>$f = 1\text{MHz}$                     |
| Output Capacitance                            | $C_{oss}$    | —    | 309  | —         |               |                                                                                     |
| Reverse Transfer Capacitance                  | $C_{rss}$    | —    | 229  | —         |               |                                                                                     |
| Gate Resistance                               | $R_g$        | —    | 3.5  | —         | $\Omega$      | $V_{DS} = 0\text{V}, V_{GS} = 0\text{V}, f = 1\text{MHz}$                           |
| Total Gate Charge ( $V_{GS} = -4.5\text{V}$ ) | $Q_g$        | —    | 31   | —         | nC            | $V_{DS} = -20\text{V}, I_D = -10\text{A}$                                           |
| Total Gate Charge ( $V_{GS} = -10\text{V}$ )  | $Q_g$        | —    | 67   | —         |               |                                                                                     |
| Gate-Source Charge                            | $Q_{gs}$     | —    | 13.2 | —         |               |                                                                                     |
| Gate-Drain Charge                             | $Q_{gd}$     | —    | 11   | —         |               |                                                                                     |
| Turn-On Delay Time                            | $t_{D(ON)}$  | —    | 9.9  | —         | ns            | $V_{GS} = -10\text{V}, V_{DD} = -20\text{V},$<br>$R_G = 3\Omega, I_D = -10\text{A}$ |
| Turn-On Rise Time                             | $t_R$        | —    | 32   | —         |               |                                                                                     |
| Turn-Off Delay Time                           | $t_{D(OFF)}$ | —    | 46   | —         |               |                                                                                     |
| Turn-Off Fall Time                            | $t_F$        | —    | 53   | —         |               |                                                                                     |
| Reverse Recovery Time                         | $t_{RR}$     | —    | 19.5 | —         | ns            | $I_F = -10\text{A}, di/dt = -100\text{A}/\mu\text{s}$                               |
| Reverse Recovery Charge                       | $Q_{RR}$     | —    | 11.6 | —         | nC            | $I_F = -10\text{A}, di/dt = -100\text{A}/\mu\text{s}$                               |

- Notes:
- Device mounted on FR-4 substrate PC board, 2oz copper, with minimum recommended pad layout.
  - Device mounted on FR-4 substrate PC board, 2oz copper, with 1inch square copper plate.
  - $I_{AS}$  and  $E_{AS}$  ratings are based on low frequency and duty cycles to keep  $T_J = +25^\circ\text{C}$ .
  - Short duration pulse test used to minimize self-heating effect.
  - Guaranteed by design. Not subject to product testing.

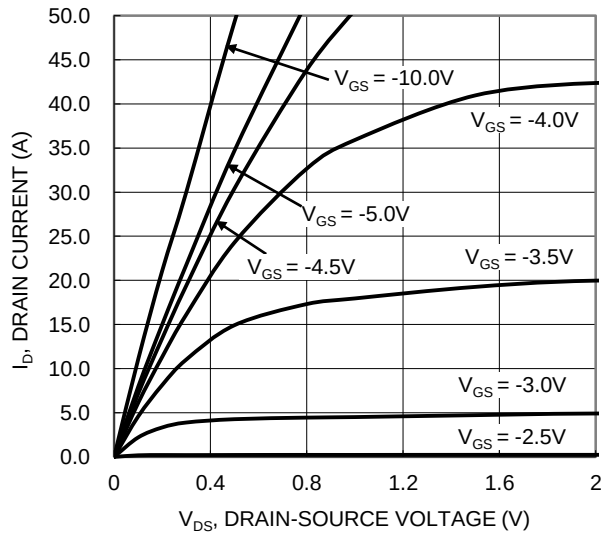


Figure 1. Typical Output Characteristic

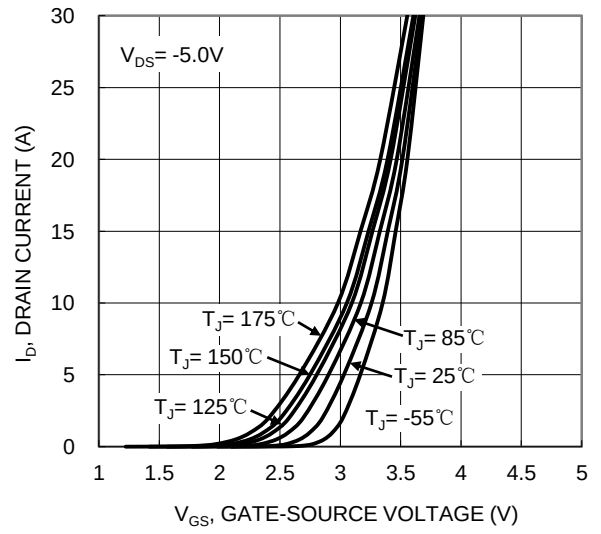


Figure 2. Typical Transfer Characteristic

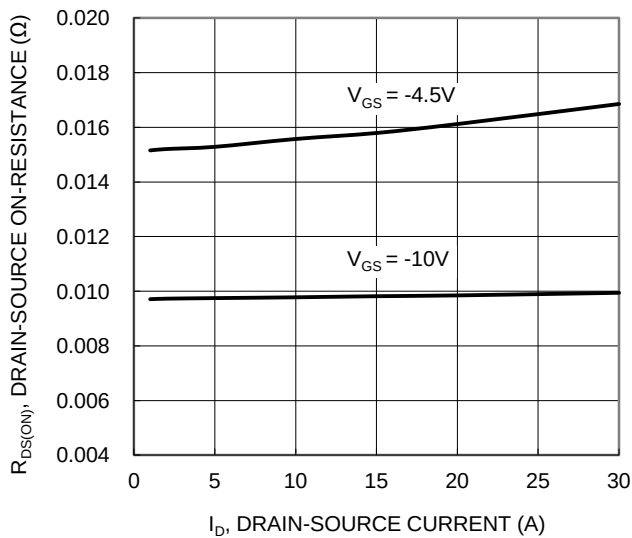


Figure 3. Typical On-Resistance vs. Drain Current and Gate Voltage

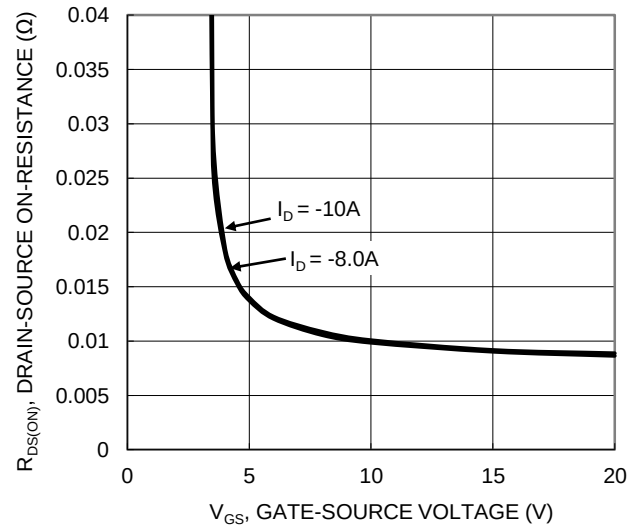


Figure 4. Typical Transfer Characteristic

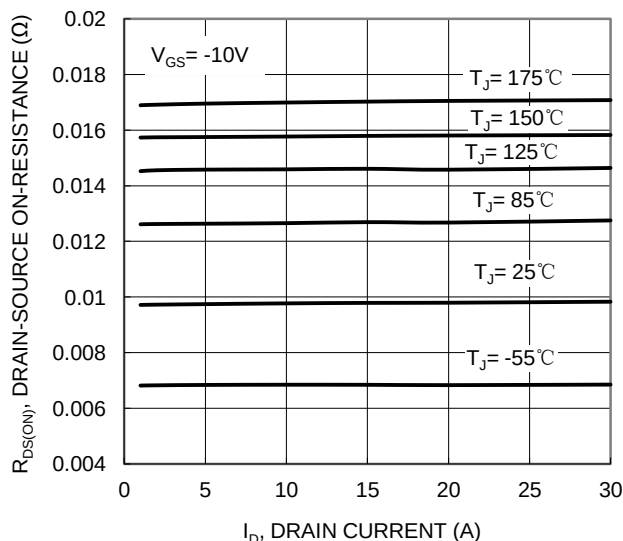


Figure 5. Typical On-Resistance vs. Drain Current and Temperature

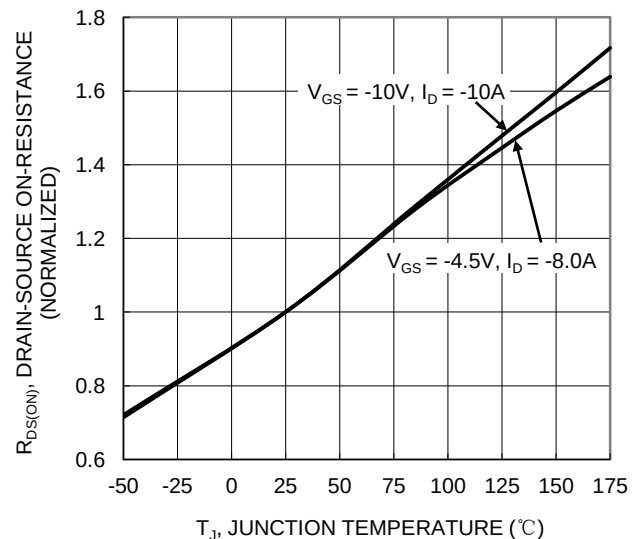


Figure 6. On-Resistance Variation with Temperature

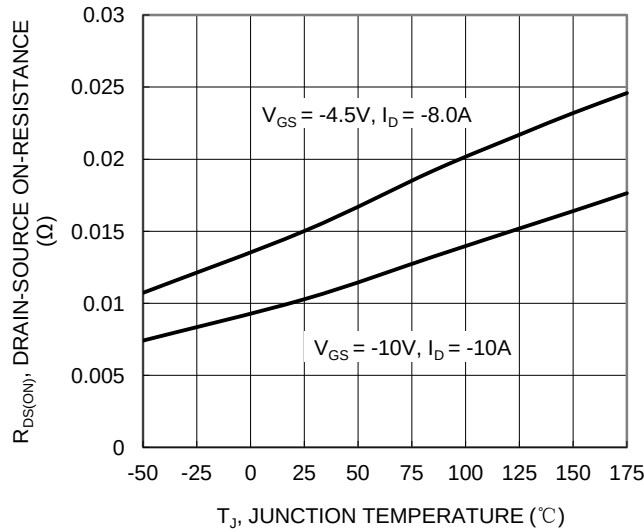


Figure 7. On-Resistance Variation with Temperature

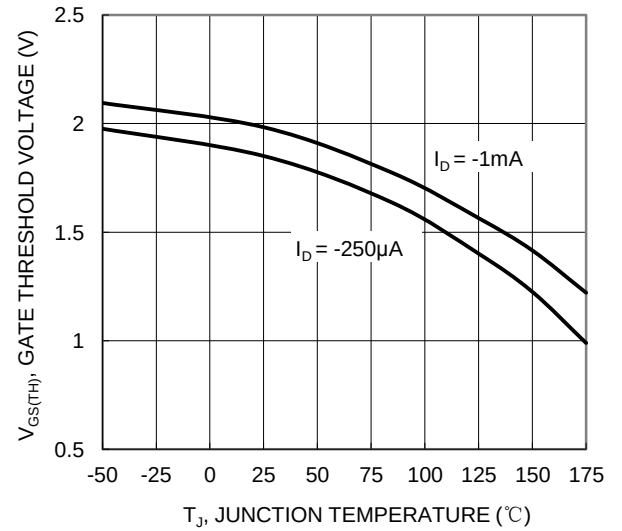


Figure 8. Gate Threshold Variation vs. Junction Temperature

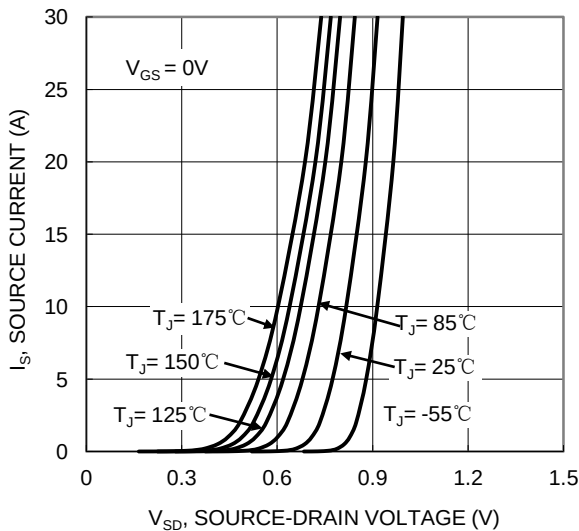


Figure 9. Diode Forward Voltage vs. Current

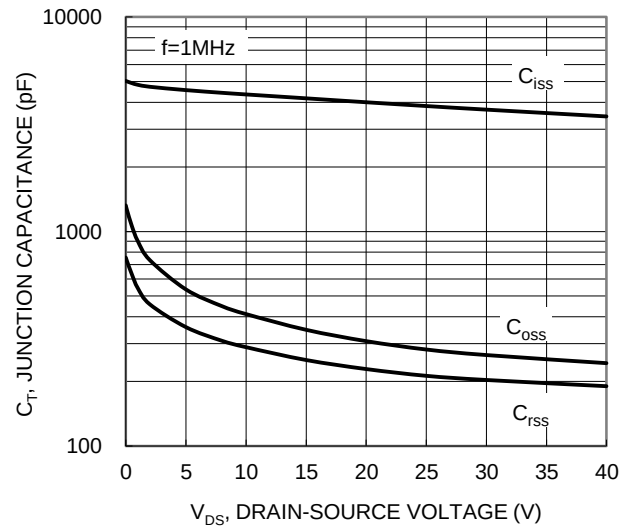


Figure 10. Typical Junction Capacitance

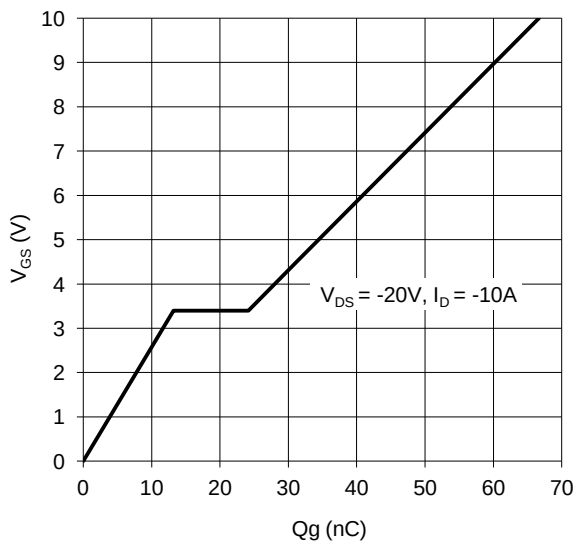


Figure 11. Gate Charge

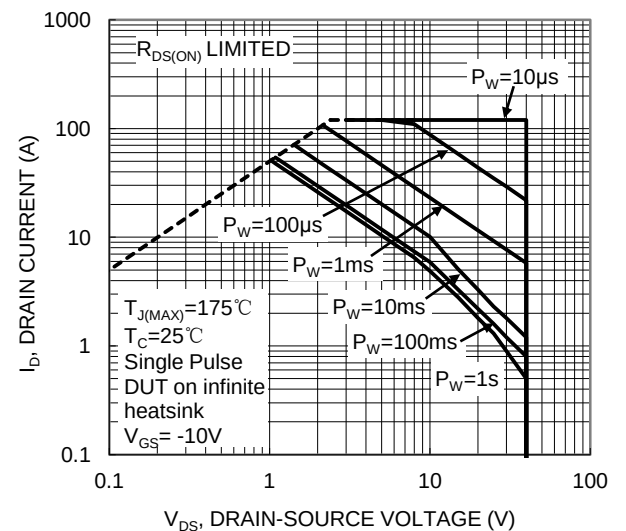


Figure 12. SOA, Safe Operation Area

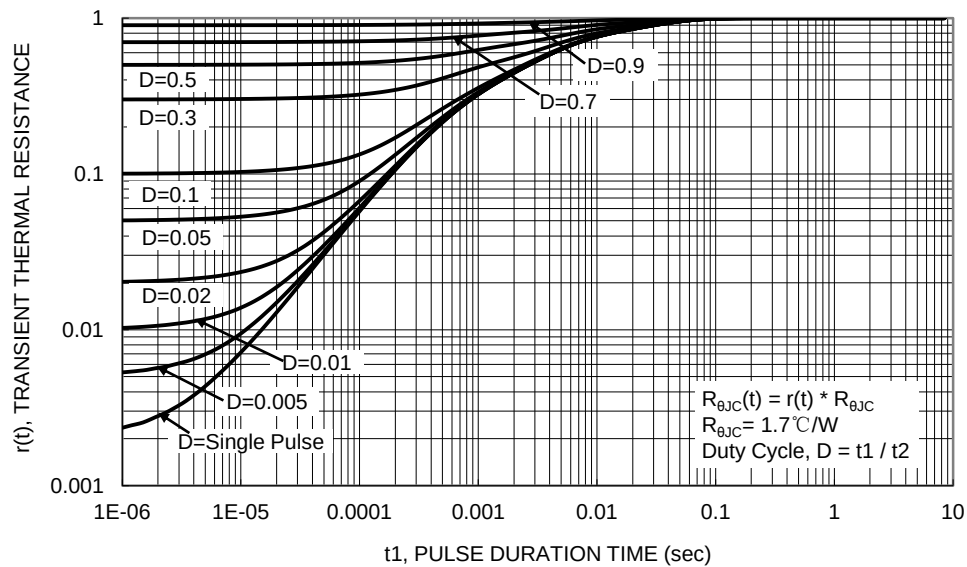
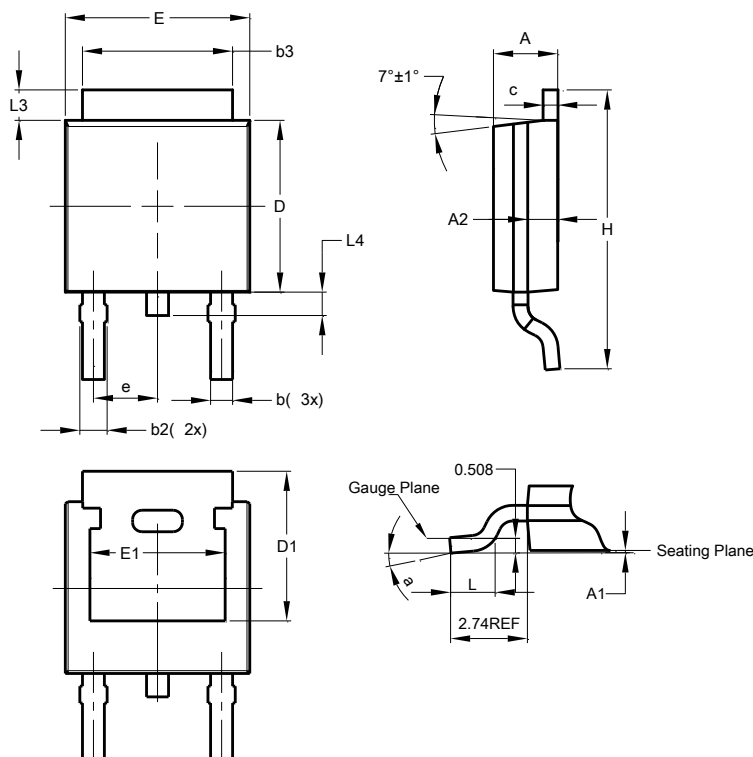


Figure 13. Transient Thermal Resistance

## Package Outline Dimensions

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

TO252 (DPAK)

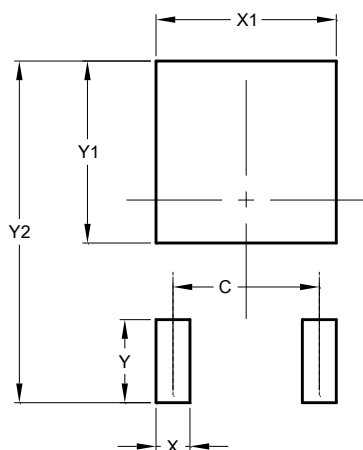


| TO252 (DPAK)         |      |       |       |
|----------------------|------|-------|-------|
| Dim                  | Min  | Max   | Typ   |
| A                    | 2.19 | 2.39  | 2.29  |
| A1                   | 0.00 | 0.13  | 0.08  |
| A2                   | 0.97 | 1.17  | 1.07  |
| b                    | 0.64 | 0.88  | 0.783 |
| b2                   | 0.76 | 1.14  | 0.95  |
| b3                   | 5.21 | 5.46  | 5.33  |
| c                    | 0.45 | 0.58  | 0.531 |
| D                    | 6.00 | 6.20  | 6.10  |
| D1                   | 5.21 | -     | -     |
| e                    | -    | -     | 2.286 |
| E                    | 6.45 | 6.70  | 6.58  |
| E1                   | 4.32 | -     | -     |
| H                    | 9.40 | 10.41 | 9.91  |
| L                    | 1.40 | 1.78  | 1.59  |
| L3                   | 0.88 | 1.27  | 1.08  |
| L4                   | 0.64 | 1.02  | 0.83  |
| a                    | 0°   | 10°   | -     |
| All Dimensions in mm |      |       |       |

## Suggested Pad Layout

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

TO252 (DPAK)



| Dimensions | Value (in mm) |
|------------|---------------|
| C          | 4.572         |
| X          | 1.060         |
| X1         | 5.632         |
| Y          | 2.600         |
| Y1         | 5.700         |
| Y2         | 10.700        |

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