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N-Channel Enhancement Mode Field Effect Transistor

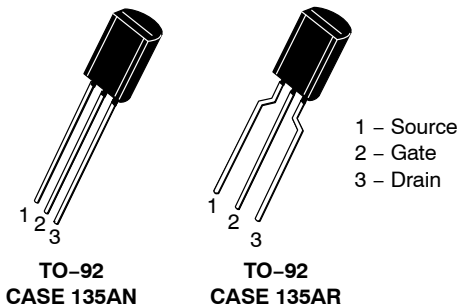
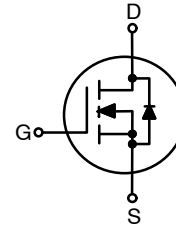
2N7000, 2N7002, NDS7002A

Description

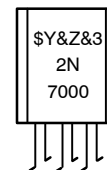
These N-channel enhancement mode field effect transistors are produced using onsemi's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while providing rugged, reliable, and fast switching performance. These products are particularly suited for low-voltage, low-current applications, such as small servo motor control, power MOSFET gate drivers, and other switching applications.

Features

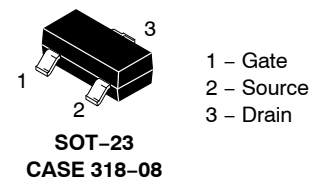
- High Density Cell Design for Low $R_{DS(on)}$
- Voltage Controlled Small Signal Switch
- Rugged and Reliable
- High Saturation Current Capability
- ESD Protection Level: HBM > 100 V, CDM > 2 kV
- This Device is Pb-Free and Halogen Free



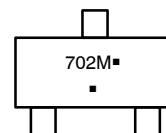
MARKING DIAGRAM



\$Y = onsemi Logo
 &Z = Assembly Plant Code
 &3 = Date Code
 2N7000 = Specific Device Code



MARKING DIAGRAM



702 = Specific Device Code
 M = Date Code
 ■ = Pb-Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information on page 7 of this data sheet.

2N7000, 2N7002, NDS7002A

ABSOLUTE MAXIMUM RATINGS Values are at $T_C = 25^\circ\text{C}$ unless otherwise noted.

| Symbol | Parameter | Value | | | Unit |
|-----------------------------------|---|------------|--------|------------|-------|
| | | 2N7000 | 2N7002 | NDS7002A | |
| V _{DSS} | Drain-to-Source Voltage | 60 | | | V |
| V _{DGR} | Drain-Gate Voltage (R _{GS} ≤ 1 MW) | 60 | | | V |
| V _{GSS} | Gate-Source Voltage – Continuous | ±20 | | | V |
| | Gate-Source Voltage – Non Repetitive (tp < 50 ms) | ±40 | | | |
| I _D | Maximum Drain Current – Continuous | 200 | 115 | 280 | mA |
| | Maximum Drain Current – Pulsed | 500 | 800 | 1500 | |
| P _D | Maximum Power Dissipation Derated above 25°C | 400 | 200 | 300 | mW |
| | | 3.2 | 1.6 | 2.4 | mW/°C |
| T _J , T _{STG} | Operating and Storage Temperature Range | -55 to 150 | | -65 to 150 | °C |
| T _L | Maximum Lead Temperature for Soldering Purposes, 1/16-inch from Case for 10 s | 300 | | | °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.

THERMAL CHARACTERISTICS Values are at $T_C = 25^\circ\text{C}$ unless otherwise noted.

| Symbol | Parameter | Value | | | Unit |
|-----------------|---|--------|--------|----------|---------------------------|
| | | 2N7000 | 2N7002 | NDS7002A | |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 312.5 | 625 | 417 | $^\circ\text{C}/\text{W}$ |

ELECTRICAL CHARACTERISTICS

Values are at $T_C = 25^\circ\text{C}$ unless otherwise noted.

| Symbol | Parameter | Conditions | Type | Min | Typ | Max | Unit |
|--------|-----------|------------|------|-----|-----|-----|------|
|--------|-----------|------------|------|-----|-----|-----|------|

OFF CHARACTERISTICS

| | | | | | | | |
|------------|---------------------------------|--|--------------------|----|---|------|---------------|
| BV_{DSS} | Drain-Source Breakdown Voltage | $V_{GS} = 0 \text{ V}, I_D = 10 \mu\text{A}$ | All | 60 | – | – | V |
| I_{DSS} | Zero Gate Voltage Drain Current | $V_{DS} = 48 \text{ V}, V_{GS} = 0 \text{ V}$ | 2N7000 | – | – | 1 | μA |
| | | $V_{DS} = 48 \text{ V}, V_{GS} = 0 \text{ V}, T_C = 125^\circ\text{C}$ | | – | – | 1 | mA |
| | | $V_{DS} = 60 \text{ V}, V_{GS} = 0 \text{ V}$ | 2N7002 | – | – | 1 | μA |
| | | $V_{DS} = 60 \text{ V}, V_{GS} = 0 \text{ V}, T_C = 125^\circ\text{C}$ | NDS7002A | – | – | 0.5 | mA |
| I_{GSSF} | Gate – Body Leakage, Forward | $V_{GS} = 15 \text{ V}, V_{DS} = 0 \text{ V}$ | 2N7000 | – | – | 10 | nA |
| | | $V_{GS} = 20 \text{ V}, V_{DS} = 0 \text{ V}$ | 2N7002 NDS7002A | – | – | 100 | |
| I_{GSSR} | Gate – Body Leakage, Reverse | $V_{GS} = -15 \text{ V}, V_{DS} = 0 \text{ V}$ | 2N7000 | – | – | -10 | nA |
| | | $V_{GS} = -20 \text{ V}, V_{DS} = 0 \text{ V}$ | 2N7002 NDS7002A | – | – | -100 | |

ON CHARACTERISTICS

| | | | | | | | |
|--------------|------------------------|--|--------------------|-----|-----|-----|---|
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{DS} = V_{GS}, I_D = 1 \text{ mA}$ | 2N7000 | 0.8 | 2.1 | 3 | V |
| | | $V_{DS} = V_{GS}, I_D = 250 \mu\text{A}$ | 2N7002 NDS7002A | 1 | 2.1 | 2.5 | |

2N7000, 2N7002, NDS7002A

ELECTRICAL CHARACTERISTICS (continued)

Values are at $T_C = 25^\circ\text{C}$ unless otherwise noted.

| Symbol | Parameter | Conditions | Type | Min | Typ | Max | Unit |
|---------------------------|-----------------------------------|--|----------|-----|------|------|----------|
| ON CHARACTERISTICS | | | | | | | |
| $R_{DS(on)}$ | Static Drain–Source On–Resistance | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}$ | 2N7000 | – | 1.2 | 5 | Ω |
| | | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}, T_C = 125^\circ\text{C}$ | | – | 1.9 | 9 | |
| | | $V_{GS} = 4.5\text{ V}, I_D = 75\text{ mA}$ | | – | 1.8 | 5.3 | |
| | | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}$ | 2N7002 | – | 1.2 | 7.5 | |
| | | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}, T_C = 100^\circ\text{C}$ | | – | 1.7 | 13.5 | |
| | | $V_{GS} = 5\text{ V}, I_D = 50\text{ mA}$ | | – | 1.7 | 7.5 | |
| | | $V_{GS} = 5\text{ V}, I_D = 50\text{ mA}, T_C = 100^\circ\text{C}$ | | – | 2.4 | 13.5 | |
| | | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}$ | NDS7002A | – | 1.2 | 2 | |
| | | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}, T_C = 125^\circ\text{C}$ | | – | 2 | 3.5 | |
| | | $V_{GS} = 5\text{ V}, I_D = 50\text{ mA}$ | | – | 1.7 | 3 | |
| | | $V_{GS} = 5\text{ V}, I_D = 50\text{ mA}, T_C = 125^\circ\text{C}$ | | – | 2.8 | 5 | |
| $V_{DS(on)}$ | Drain–Source On–Voltage | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}$ | 2N7000 | – | 0.6 | 2.5 | V |
| | | $V_{GS} = 4.5\text{ V}, I_D = 75\text{ mA}$ | | – | 0.14 | 0.4 | |
| | | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}$ | 2N7002 | – | 0.6 | 3.75 | |
| | | $V_{GS} = 5.0\text{ V}, I_D = 50\text{ mA}$ | | – | 0.09 | 1.5 | |
| | | $V_{GS} = 10\text{ V}, I_D = 500\text{ mA}$ | NDS7002A | – | 0.6 | 1 | |
| | | $V_{GS} = 5.0\text{ V}, I_D = 50\text{ mA}$ | | – | 0.09 | 0.15 | |
| g_{FS} | Forward Transconductance | $V_{DS} = 10\text{ V}, I_D = 200\text{ mA}$ | 2N7000 | 100 | 320 | – | mS |
| | | $V_{DS} \geq 2 V_{DS(on)}, I_D = 200\text{ mA}$ | 2N7002 | 80 | 320 | – | |
| | | $V_{DS} \geq 2 V_{DS(on)}, I_D = 200\text{ mA}$ | NDS7002A | 80 | 320 | – | |

DYNAMIC CHARACTERISTICS

| | | | | | | | |
|-----------|------------------------------|--|--------------------|---|----|----|----|
| C_{iss} | Input Capacitance | $V_{DS} = 25\text{ V}, V_{GS} = 0\text{ V}, f = 1.0\text{ MHz}$ | All | – | 20 | 50 | pF |
| C_{oss} | Output Capacitance | | All | – | 11 | 25 | |
| C_{rss} | Reverse Transfer Capacitance | | All | – | 4 | 5 | |
| t_{on} | Turn–On Time | $V_{DD} = 15\text{ V}, R_L = 25\ \Omega, I_D = 500\text{ mA}, V_{GS} = 10\text{ V}, R_{GEN} = 25\ \Omega$ | 2N7000 | – | – | 10 | ns |
| | | $V_{DD} = 30\text{ V}, R_L = 150\ \Omega, I_D = 200\text{ mA}, V_{GS} = 10\text{ V}, R_{GEN} = 25\ \Omega$ | 2N7002 NDS7002A | – | – | 20 | |
| t_{off} | Turn–Off Time | $V_{DD} = 15\text{ V}, R_L = 25\ \Omega, I_D = 500\text{ mA}, V_{GS} = 10\text{ V}, R_{GEN} = 25\ \Omega$ | 2N7000 | – | – | 10 | ns |
| | | $V_{DD} = 30\text{ V}, R_L = 150\ \Omega, I_D = 200\text{ mA}, V_{GS} = 10\text{ V}, R_{GEN} = 25\ \Omega$ | 2N7002 NDS7002A | – | – | 20 | |

DRAIN–SOURCE DIODE CHARACTERISTICS AND MAXIMUM RATINGS

| | | | | | | |
|-------|---|----------|---|---|-----|----|
| I_S | Maximum Continuous Drain–Source Diode Forward Current | 2N7002 | – | – | 115 | mA |
| | | NDS7002A | – | – | 280 | |

2N7000, 2N7002, NDS7002A

ELECTRICAL CHARACTERISTICS (continued)

Values are at $T_C = 25^\circ\text{C}$ unless otherwise noted.

| Symbol | Parameter | Conditions | Type | Min | Typ | Max | Unit |
|---|---|--|----------|-----|------|-----|------|
| DRAIN-SOURCE DIODE CHARACTERISTICS AND MAXIMUM RATINGS | | | | | | | |
| I_{SM} | Maximum Pulsed Drain-Source Diode Forward Current | | 2N7002 | – | – | 0.8 | A |
| | | | NDS7002A | – | – | 1.5 | |
| V_{SD} | Drain-Source Diode Forward Voltage | $V_{GS} = 0\text{ V}, I_S = 115\text{ mA}$ (Note 1) | 2N7002 | – | 0.88 | 1.5 | V |
| | | $V_{GS} = 0\text{ V}, I_S = 400\text{ mA}$ (Note 1) | NDS7002A | – | 0.88 | 1.2 | |

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.

1. Pulse test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2\%$

TYPICAL PERFORMANCE CHARACTERISTICS

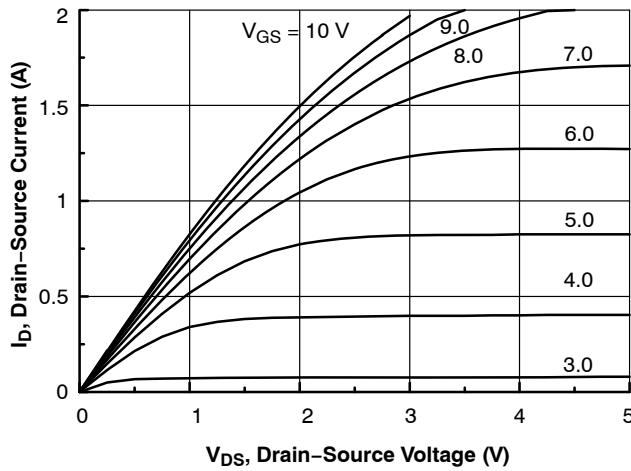


Figure 1. On-Region Characteristics

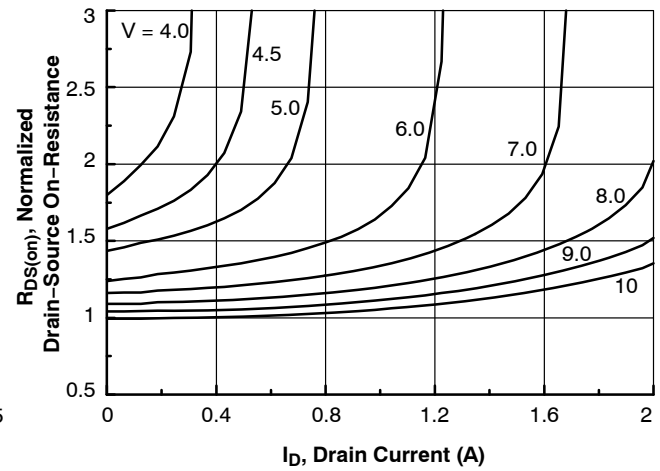


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current

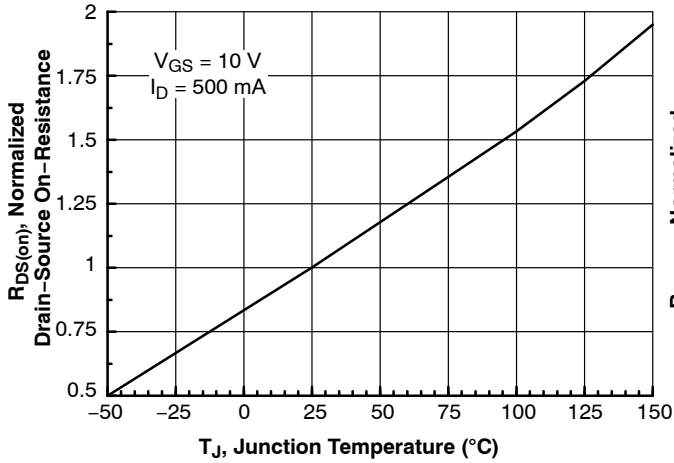


Figure 3. On-Resistance Variation with Temperature

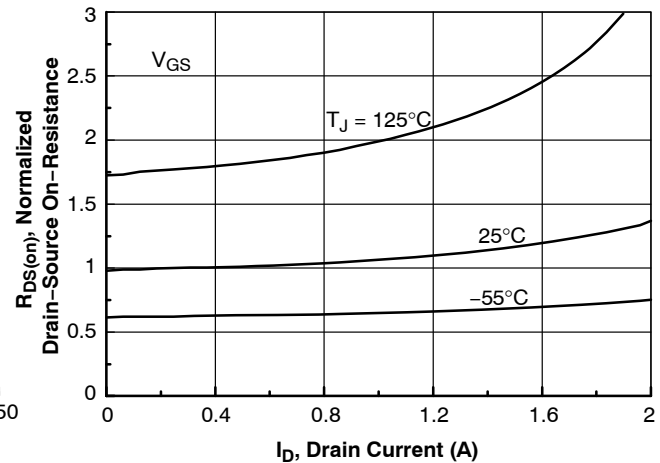


Figure 4. On-Resistance Variation with Drain Current and Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

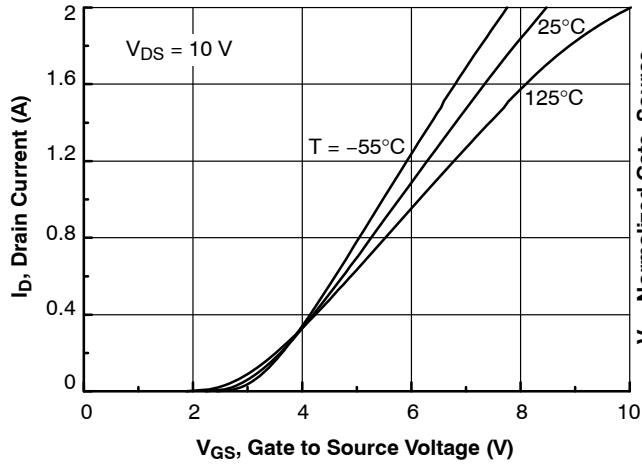


Figure 5. Transfer Characteristics

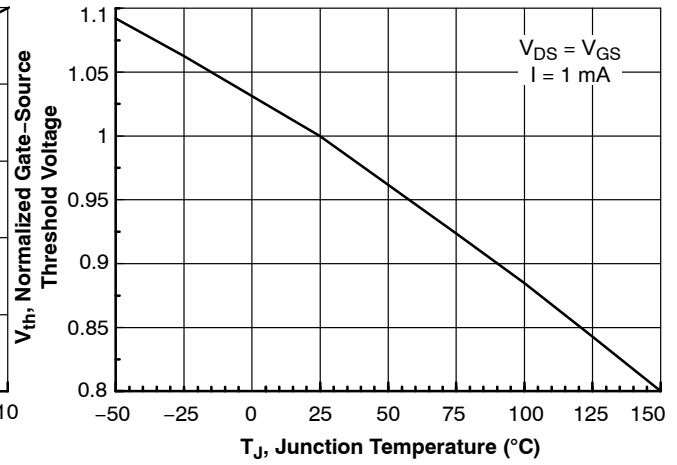


Figure 6. Gate Threshold Variation with Temperature

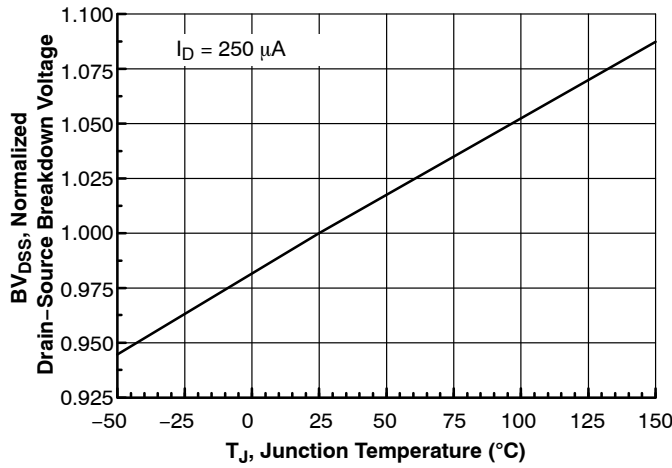


Figure 7. Breakdown Voltage Variation with Temperature

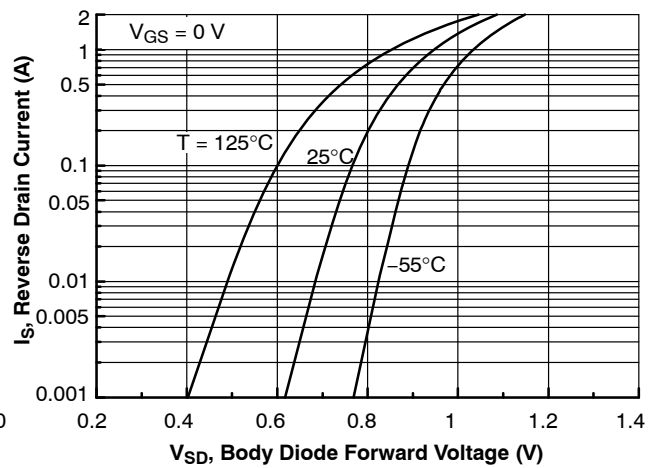


Figure 8. Body Diode Forward Voltage Variation with Temperature

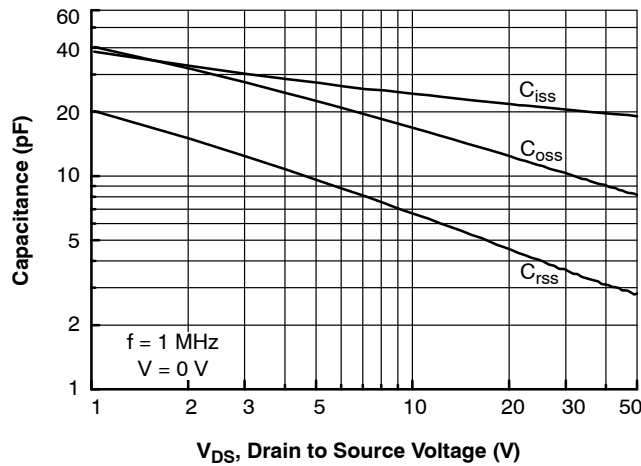


Figure 9. Capacitance Characteristics

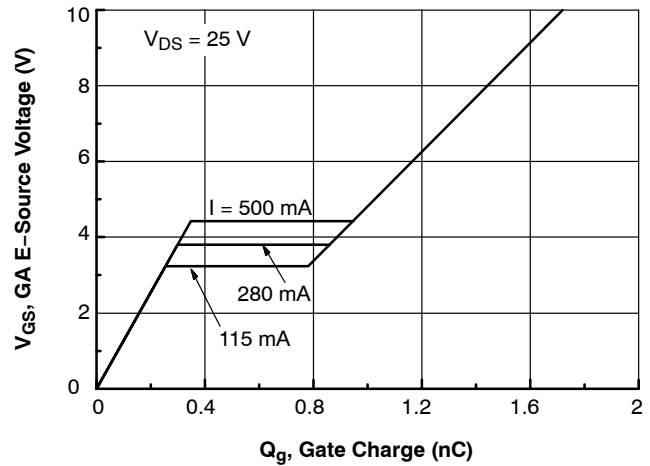


Figure 10. Gate Charge Characteristics

2N7000, 2N7002, NDS7002A

TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

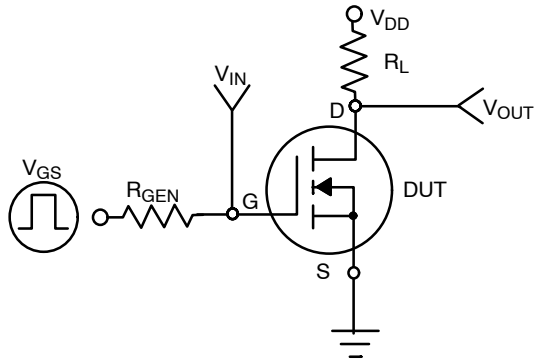


Figure 11. Switching Test Circuit

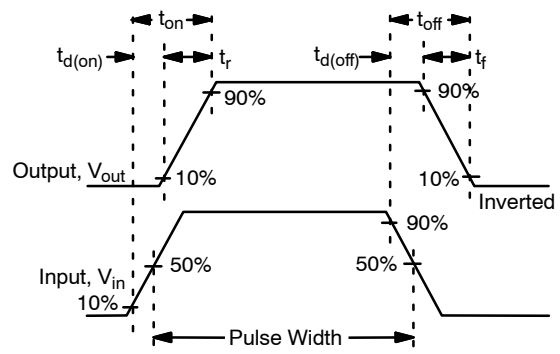


Figure 12. Switching Waveforms

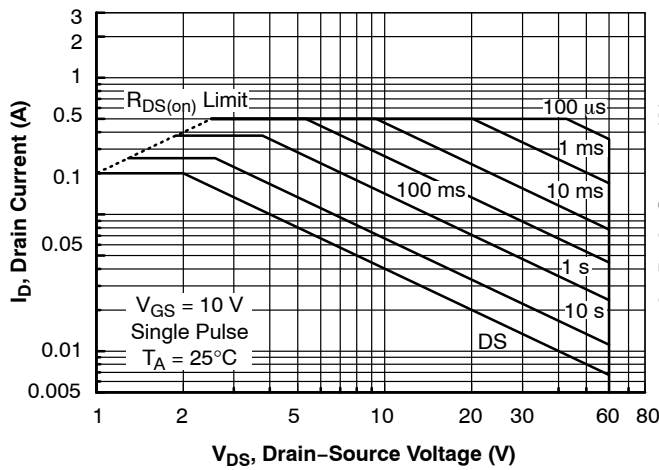


Figure 13. 2N7000 Maximum Safe Operating Area

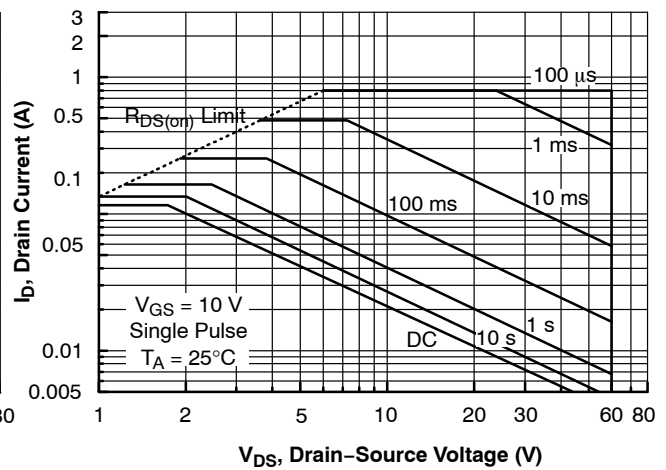


Figure 14. 2N7002 Maximum Safe Operating Area

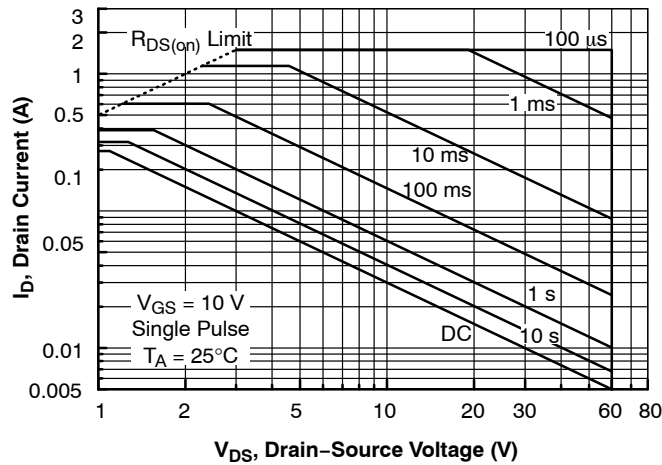


Figure 15. NDS7000A Maximum Safe Operating Area

2N7000, 2N7002, NDS7002A

TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

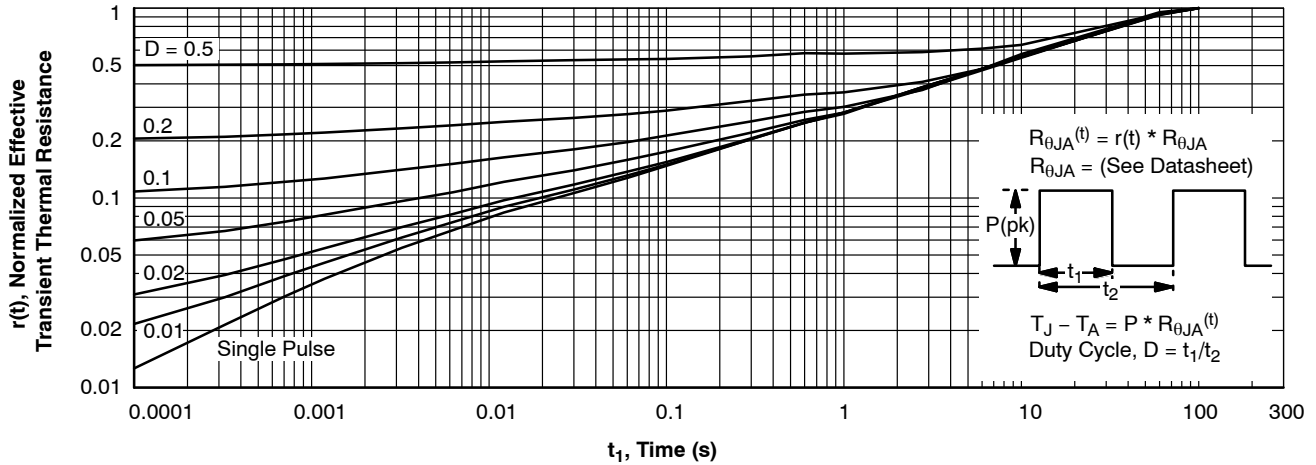


Figure 16. TO-92, 2N7000 Transient Thermal Response Curve

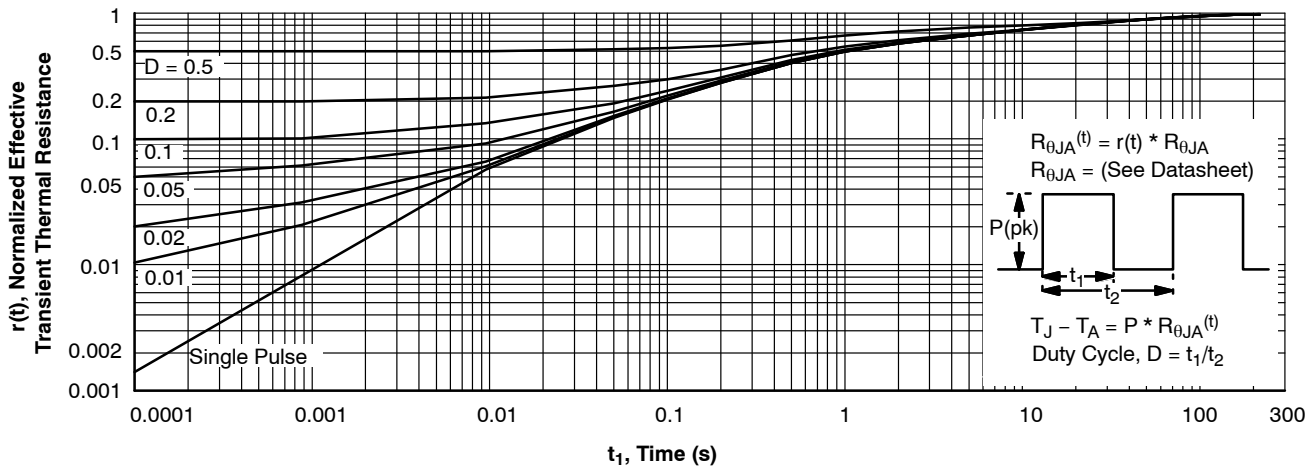


Figure 17. SOT-23, 2N7002 / NDS7002A Transient Thermal Response Curve

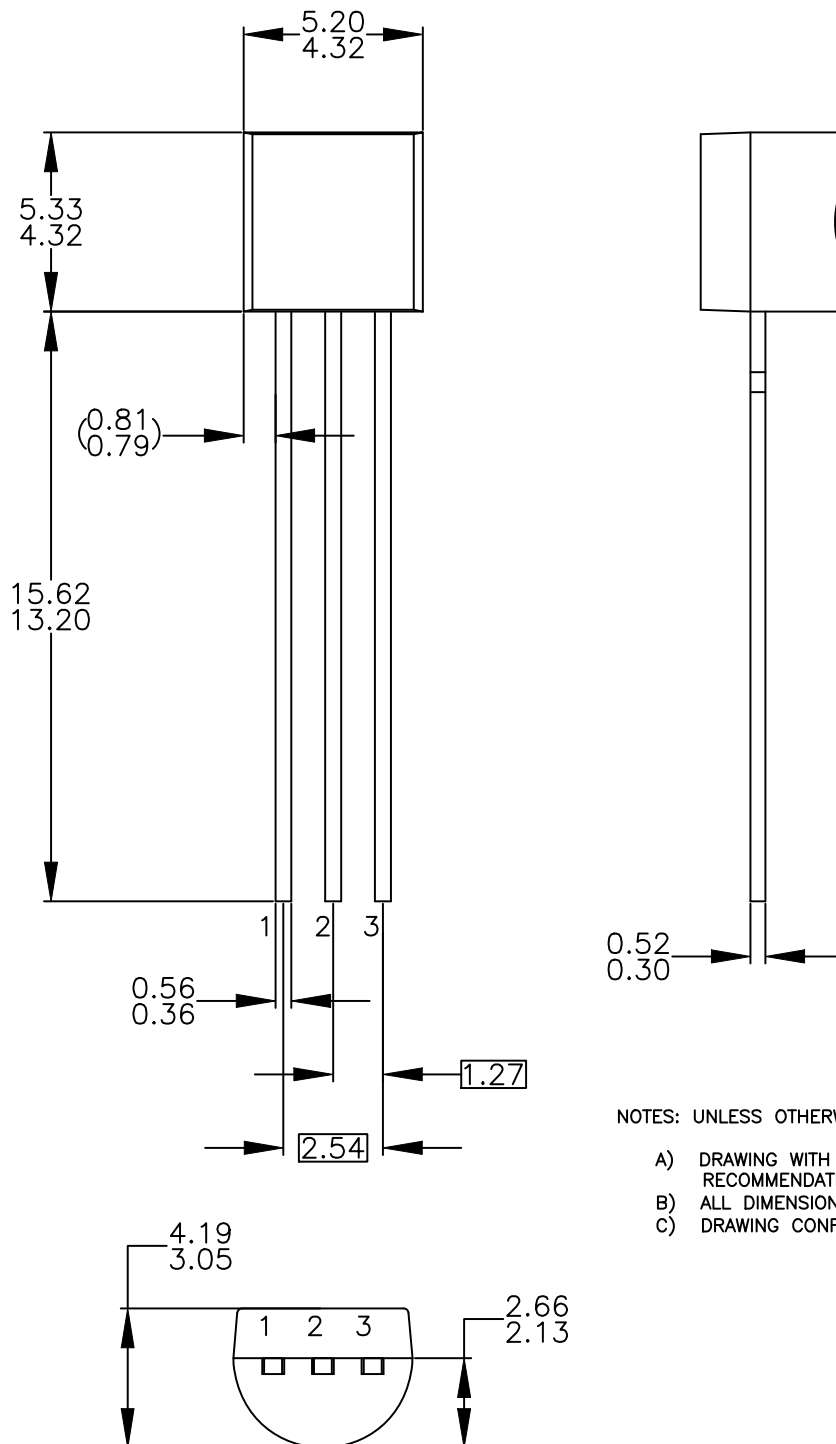
ORDERING INFORMATION

| Part Number | Marking | Package | Packing Method† | Min Order Qty / Immediate Pack Qty |
|-------------|---------|---------------------|-----------------|------------------------------------|
| 2N7000 | 2N7000 | TO-92 3L (Pb-Free) | Bulk | 10000 / 1000 |
| 2N7000-D74Z | | | Ammo | 2000 / 2000 |
| 2N7000-D75Z | | | Tape and Reel | 2000 / 2000 |
| 2N7000-D26Z | | | | 2000 / 2000 |
| 2N7002 | 702 | SOT-23 3L (Pb-Free) | Tape and Reel | 3000 / 3000 |
| NDS7002A | 712 | | | 3000 / 3000 |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

TO-92 3 4.825x4.76
CASE 135AN
ISSUE O

DATE 31 JUL 2016



NOTES: UNLESS OTHERWISE SPECIFIED

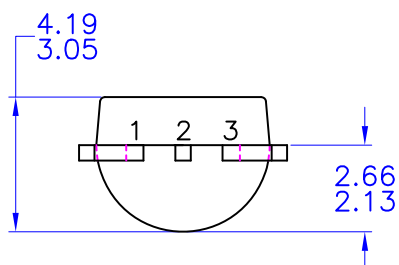
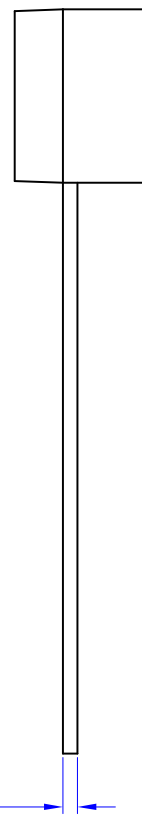
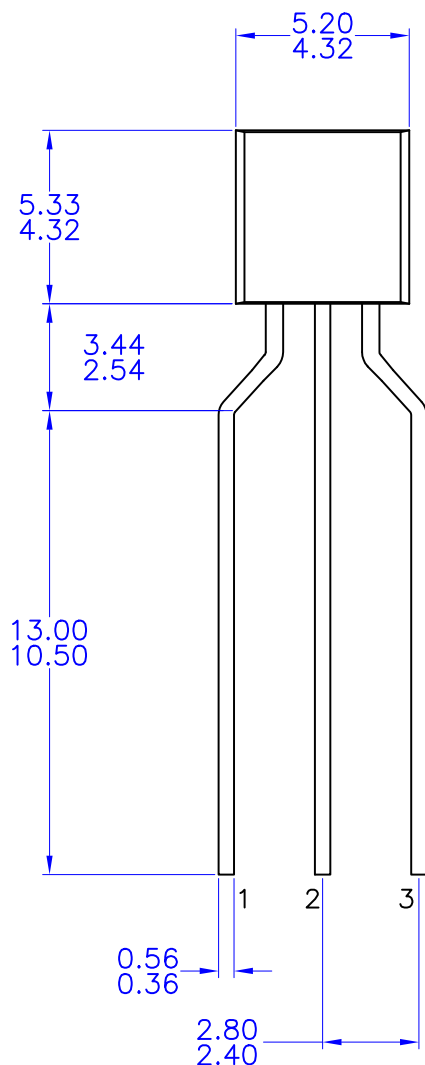
- A) DRAWING WITH REFERENCE TO JEDEC TO-92 RECOMMENDATIONS.
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DRAWING CONFORMS TO ASME Y14.5M-2009.

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TO-92 3 4.83x4.76 LEADFORMED
CASE 135AR
ISSUE O

DATE 30 SEP 2016



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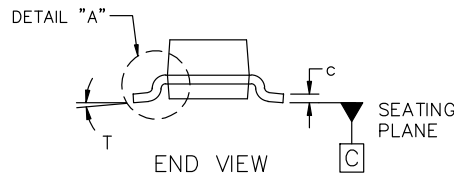
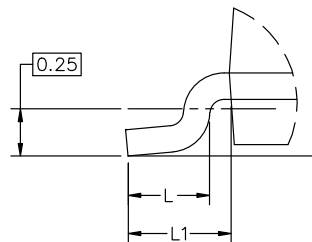
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SCALE 4:1

SOT-23 (TO-236) 2.90x1.30x1.00 1.90P
CASE 318
ISSUE AU

DATE 14 AUG 2024

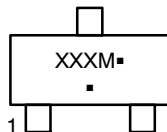


| MILLIMETERS | | | |
|-------------|------|------|------|
| DIM | MIN | NOM | MAX |
| A | 0.89 | 1.00 | 1.11 |
| A1 | 0.01 | 0.06 | 0.10 |
| b | 0.37 | 0.44 | 0.50 |
| c | 0.08 | 0.14 | 0.20 |
| D | 2.80 | 2.90 | 3.04 |
| E | 1.20 | 1.30 | 1.40 |
| e | 1.78 | 1.90 | 2.04 |
| L | 0.30 | 0.43 | 0.55 |
| L1 | 0.35 | 0.54 | 0.69 |
| HE | 2.10 | 2.40 | 2.64 |
| T | 0° | --- | 10° |

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2018.
2. CONTROLLING DIMENSIONS: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

GENERIC
MARKING DIAGRAM*



XXX = Specific Device Code
M = Date Code
▪ = 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.



RECOMMENDED
MOUNTING FOOTPRINT

* For additional information on our Pb-Free strategy and soldering details, please download the onsemi Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

STYLES ON PAGE 2

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|---|---|---|---|---|---|
| STYLE 1 THRU 5: CANCELLED | STYLE 6: PIN 1. BASE 2. EMITTER 3. COLLECTOR | STYLE 7: PIN 1. EMITTER 2. BASE 3. COLLECTOR | STYLE 8: PIN 1. ANODE 2. NO CONNECTION 3. CATHODE | | |
| STYLE 9: PIN 1. ANODE 2. ANODE 3. CATHODE | STYLE 10: PIN 1. DRAIN 2. SOURCE 3. GATE | STYLE 11: PIN 1. ANODE 2. CATHODE 3. CATHODE-ANODE | STYLE 12: PIN 1. CATHODE 2. CATHODE 3. ANODE | STYLE 13: PIN 1. SOURCE 2. DRAIN 3. GATE | STYLE 14: PIN 1. CATHODE 2. GATE 3. ANODE |
| STYLE 15: PIN 1. GATE 2. CATHODE 3. ANODE | STYLE 16: PIN 1. ANODE 2. CATHODE 3. CATHODE | STYLE 17: PIN 1. NO CONNECTION 2. ANODE 3. CATHODE | STYLE 18: PIN 1. NO CONNECTION 2. CATHODE 3. ANODE | STYLE 19: PIN 1. CATHODE 2. ANODE 3. CATHODE-ANODE | STYLE 20: PIN 1. CATHODE 2. ANODE 3. GATE |
| STYLE 21: PIN 1. GATE 2. SOURCE 3. DRAIN | STYLE 22: PIN 1. RETURN 2. OUTPUT 3. INPUT | STYLE 23: PIN 1. ANODE 2. ANODE 3. CATHODE | STYLE 24: PIN 1. GATE 2. DRAIN 3. SOURCE | STYLE 25: PIN 1. ANODE 2. CATHODE 3. GATE | STYLE 26: PIN 1. CATHODE 2. ANODE 3. NO CONNECTION |
| STYLE 27: PIN 1. CATHODE 2. CATHODE 3. CATHODE | STYLE 28: PIN 1. ANODE 2. ANODE 3. ANODE | | | | |

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